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Volume 5

Department of Energy
FY 2025 Congressional Justification

Science

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FY 2025 Congressional Budget

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Table of Contents

DEPARTMENT OF ENERGY
Appropriation Summary
FY 2025
(Dollars in Thousands)

	FY 2023 Enacted [1],[2],[3]	FY 2024 Annualized CR	FY 2025 President's Budget [4]	FY 2025 President's Budget vs. FY 2023 Enacted $	%
Department of Energy Budget by Appropriation					
Energy Efficiency and Renewable Energy	3,460,000	3,460,000	3,118,000	-342,000	-9.9%
Electricity	350,000	350,000	293,000	-57,000	-16.3%
Cybersecurity, Energy Security and Emergency Response (270)	200,000	200,000	200,000	0	0.0%
Strategic Petroleum Reserve	207,175	207,175	241,169	+33,994	+16.4%
Naval Petroleum and Oil Shale Reserves	13,004	13,004	13,010	+6	+0.0%
SPR Petroleum Account	100	100	100	0	0.0%
Northeast Home Heating Oil Reserve	7,000	7,000	7,150	+150	+2.1%
Office of Petroleum Reserves	**227,279**	**227,279**	**261,429**	**+34,150**	**+15.0%**
Nuclear Energy (270)	1,623,000	1,623,000	1,440,660	-182,340	-11.2%
Fossil Energy and Carbon Management	890,000	890,000	900,000	+10,000	+1.1%
Uranium Enrichment Decontamination and Decommissioning (UED&D)	879,052	879,052	854,182	-24,870	-2.8%
Energy Information Administration	135,000	135,000	141,653	+6,653	+4.9%
Non-Defense Environmental Cleanup	358,583	358,583	314,636	-43,947	-12.3%
Science	8,100,000	8,100,000	8,583,000	+483,000	+6.0%
Office of Technology Transitions	22,098	22,098	27,098	+5,000	+22.6%
Office of Clean Energy Demonstrations	89,000	89,000	180,000	+91,000	+102.2%
Federal Energy Management Program	0	0	64,000	+64,000	N/A
Grid Deployment Office	0	0	101,870	+101,870	N/A
Office of Manufacturing & Energy Supply Chains	0	0	113,350	+113,350	N/A
Office of State and Community Programs	0	0	574,000	+574,000	N/A
Advanced Research Projects Agency - Energy	470,000	470,000	450,000	-20,000	-4.3%
Nuclear Waste Disposal Fund	10,205	10,205	12,040	+1,835	+18.0%
Departmental Administration	283,000	283,000	334,671	+51,671	+18.3%
Indian Energy Policy and Programs	75,000	75,000	95,000	+20,000	+26.7%
Inspector General	86,000	86,000	149,000	+63,000	+73.3%
Title 17 Innovative Technology Loan Guarantee Program	-136,018	-71,362	-184,558	-48,540	+35.7%
Advanced Technology Vehicles Manufacturing Loan Program	9,800	9,800	27,508	+17,708	+180.7%
Tribal Energy Loan Guarantee Program	4,000	4,000	6,300	+2,300	+57.5%
Total, Credit Programs	**-122,218**	**-57,562**	**-150,750**	**-28,532**	**+23.3%**
Energy Projects	221,969	221,969	0	-221,969	-100.0%
Critical and Emerging Technologies	0	0	5,000	+5,000	N/A
Total, Energy Programs	**17,357,968**	**17,422,624**	**18,061,839**	**+703,871**	**+4.1%**
Weapons Activities	17,116,119	17,116,119	19,848,644	+2,732,525	+16.0%
Defense Nuclear Nonproliferation	2,490,000	2,490,000	2,465,108	-24,892	-1.0%
Naval Reactors	2,081,445	2,081,445	2,118,773	+37,328	+1.8%
Federal Salaries and Expenses	475,000	475,000	564,475	+89,475	+18.8%
Total, National Nuclear Security Administration	**22,162,564**	**22,162,564**	**24,997,000**	**+2,834,436**	**+12.8%**
Defense Environmental Cleanup	7,025,000	7,025,000	7,059,695	+34,695	+0.5%
Other Defense Activities	1,035,000	1,035,000	1,140,023	+105,023	+10.1%
Defense Uranium Enrichment D&D	586,035	586,035	384,957	-201,078	-34.3%
Total, Environmental and Other Defense Activities	**8,646,035**	**8,646,035**	**8,584,675**	**-61,360**	**-0.7%**
Nuclear Energy (050)	150,000	150,000	150,000	0	0.0%
Total, Atomic Energy Defense Activities	**30,958,599**	**30,958,599**	**33,731,675**	**+2,773,076**	**+9.0%**
Southeastern Power Administration	0	0	0	0	N/A
Southwestern Power Administration	10,608	10,608	11,440	+832	+7.8%
Western Area Power Administration	98,732	98,732	100,855	+2,123	+2.2%
Falcon and Amistad Operating and Maintenance Fund	228	228	228	0	0.0%
Colorado River Basins Power Marketing Fund	0	0	0	0	N/A
Total, Power Marketing Administrations	**109,568**	**109,568**	**112,523**	**+2,955**	**+2.7%**
Federal Energy Regulatory Commission	0	0	0	0	N/A
Total, Energy and Water Development and Related Agencies	**48,426,135**	**48,490,791**	**51,906,037**	**+3,479,902**	**+7.2%**
Sale of the Gas Reserves	0	0	-95,000	-95,000	N/A
Excess Fees and Recoveries, FERC	-9,000	-9,000	-9,000	0	0.0%
Title XVII Loan Guar. Prog Section 1703 Negative Credit Subsidy Receipt	-14,000	-14,000	-2,051	+11,949	-85.4%
UED&D Fund Offset	-586,035	-586,035	-384,957	+201,078	-34.3%
Discretionary Funding by Appropriation	**47,817,100**	**47,881,756**	**51,415,029**	**+3,597,929**	**+7.5%**
DOE Budget Function	**47,817,100**	**47,881,756**	**51,415,029**	**+3,597,929**	**+7.5%**
NNSA Defense (050) Total	22,162,564	22,162,564	24,997,000	+2,834,436	+12.8%
Non-NNSA Defense (050) Total	8,796,035	8,796,035	8,734,675	-61,360	-0.7%
Defense (050)	*30,958,599*	*30,958,599*	*33,731,675*	+2,773,076	+9.0%
Science (250)	8,100,000	8,100,000	8,583,000	+483,000	+6.0%
Energy (270)	8,758,501	8,823,157	9,100,354	+341,853	+3.9%
Non-Defense (Non-050)	*16,858,501*	*16,923,157*	*17,683,354*	+824,853	+4.9%

[1] Funding does not reflect the mandated transfer of $99.75 million in FY 2023 from Naval Reactors to the Office of Nuclear Energy and the inclusion of the mandated transfer in the calculation of the rate of operations for FY 2024 for operation of the Advanced Test Reactor.

[2] Funding does not reflect the transfer of $20 million from the Office of Nuclear Energy to the Office of Science for Nuclear Facilities Oak Ridge National Laboratory Operations and Maintenance.

[3] FY 2023 Enacted levels for base funding includes $300 million for the Office of Nuclear Energy that was enacted in Division M, Additional Ukraine Supplemental Appropriations, of the Consolidated Appropriations Act, 2023 (P.L. 117-328).

[4] FY 2025 levels include the reallocation of $173 million in funding from Defense Environmental Cleanup to Weapons Activities to support the transition of oversight of the Savannah River Site to NNSA.

Science

Science

Science
(dollars in thousands)

FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
$8,100,000	$8,100,000	$8,583,000	+$483,000

Note:
- *FY 2023 Funding does not reflect the mandated transfer of $20 million from the Office of Nuclear Energy to the Office of Science for Nuclear Facilities Operations and Maintenance Oak Ridge National Laboratory.*

Proposed Appropriation Language
For Department of Energy expenses including the purchase, construction, and acquisition of plant and capital equipment, and other expenses necessary for science activities in carrying out the purposes of the Department of Energy Organization Act (42 U.S.C. 7101 et seq.), including the acquisition or condemnation of any real property or any facility or for plant or facility acquisition, construction, or expansion, and purchase of not more than [35] *35* passenger motor vehicles [including one ambulance for replacement only], [$8,100,000,000] *$8,583,000,000*, to remain available until expended: *Provided*, That of such amount, [$211,211,000] *$246,000,000* shall be available until September 30, [2025] *2026*, for program direction.

Explanation of Change
Proposed appropriation language updates reflect the funding and replacement of passenger motor vehicle levels.

Public Law Authorization
Science:
- Public Law 95-91, "Department of Energy Organization Act", 1977
- Public Law 102-486, "Energy Policy Act of 1992"
- Public Law 108-153, "21st Century Nanotechnology Research and Development Act 2003"
- Public Law 108-423, "Department of Energy High-End Computing Revitalization Act of 2004"
- Public Law 109-58, "Energy Policy Act of 2005"
- Public Law 110-69, "America COMPETES Act of 2007"
- Public Law 111-358, "America COMPETES Reauthorization Act of 2010"
- Public Law 115-246, "American Super Computing Leadership Act of 2017"
- Public Law 115-246, "Department of Energy Research and Innovation Act", 2018
- Public Law 115-368, "National Quantum Initiative Act", 2018
- Public Law 117-167, "CHIPS and Science Act", 2022
- Public Law 117-169, "Inflation Reduction Act of 2022"

Isotope R&D and Production:
- Public Law 101-101, "1990 Energy and Water Development Appropriations Act", establishing the Isotope Production and Distribution Program Fund
- Public Law 103-316, "1995 Energy and Water Development Appropriations Act", amending the Isotope Production and Distribution Program Fund to provide flexibility in pricing without regard to full-cost recovery

Workforce Development for Teachers and Scientists:
- Public Law 101-510, "DOE Science Education Enhancement Act of 1991"
- Public Law 103-382, "The Albert Einstein Distinguished Educator Fellowship Act of 1994"

Mission
The Office of Science's (SC) mission is to deliver scientific discoveries and major scientific tools to transform our understanding of nature and advance the energy, economic, and national security of the United States (U.S.).

Overview
SC is the Nation's largest Federal sponsor of basic research in the physical sciences and the lead Federal agency supporting fundamental scientific research for our Nation's energy future. SC is an established leader of the U.S. scientific discovery and innovation enterprise. Over the decades, SC investments and accomplishments in basic research and enabling research capabilities have provided the foundations for new technologies, businesses, and industries, making significant contributions to our nation's economy, national security, and quality of life. Select scientific accomplishments enabled by the SC programs are described in the program budget narratives. Additional descriptions of recent science discoveries can be found at https://science.osti.gov/Science-Features/Science-Highlights.

SC accomplishes its mission and advances national goals by supporting:

- *Science for energy, economic and national security*—building a foundation of scientific and technical knowledge to spur discoveries and innovations for advancing the Department's mission. SC supports a wide range of funding modalities from single principal investigators to large team-based activities to engage in fundamental research on energy production, conversion, storage, transmission, and use, and on our understanding of the earth systems.
- *The frontiers of science*—exploring nature's mysteries from the study of fundamental subatomic particles, atoms, and molecules that are the building blocks of the materials of our universe and everything in it to the DNA, proteins, and cells that are the building blocks of life. Each of the programs in SC supports research probing the most fundamental disciplinary questions.
- *The 21st Century tools of science*—providing the nation's researchers with 28 state-of-the-art national scientific user facilities, the most advanced tools of modern science, propelling the U.S. to the forefront of science, technology development, and deployment through innovation.

The FY 2025 Request for SC is $8,583.0 million, an increase of 6.0 percent above the FY 2023 Enacted level, to implement the Administration's objectives to advance bold, transformational leaps in U.S. Science and Technology (S&T), build a diverse and inclusive workforce of the future, and ensure America remains the global S&T leader for generations to come. The FY 2025 Request supports a balanced portfolio of basic scientific research probing some of the most fundamental questions in areas such as: fusion energy and plasma physics, nuclear energy, high energy; materials science and chemistry; biological and environmental systems; applied mathematics; next generation high-performance computing and simulation capabilities; artificial intelligence and machine learning; isotope production; and basic research to advance new accelerator and energy technologies.

The Request increases investments in Administration priorities including basic research on Artificial Intelligence (AI) and Machine Learning (ML), climate change and clean energy, including additional funding for the SC Energy Earthshots, and efforts to support underserved communities through the Reaching a New Energy Sciences Workforce (RENEW) and Funding for Accelerated, Inclusive Research (FAIR) initiatives. The SC Request supports ongoing investments in fusion development in support of the Long Range Plan (LRP) and Bold Decadal Vision for Commercial Fusion Energy. The Request continues support for the National Quantum Information Science (QIS) Research Centers for basic research and early-stage development to accelerate the advancement of QIS through vertical integration between systems, theory, hardware, and software. The Request continues investments in microelectronics and isotope production and research. These initiatives position SC to advance and address new research opportunities through collaborative, cross-program efforts.

FY 2023 Key Accomplishments
Advanced Scientific Computing Research
Delivering a Capable Exascale Computing Ecosystem for the Nation
- The Exascale Computing Project (ECP) met all of the project's key performance parameters in 2023 and successfully completed, documented, and closed out the project in FY 2024, under budget and ahead of schedule. The project

enabled the launch of exascale systems that use less than 20MW and created a modern, interoperable, and portable software ecosystem that addresses the needs of simulations, big data, and AI with numerous awards including 13 R&D 100 awards, 7 Gordon Bell finalists and prizes, and dozens of industry recognitions. ECP investments de-risked the jump to accelerated High Performance Computing (HPC) for a wide range of use cases in science and engineering. As a result, scores of companies, universities, and government labs from across the Nation have stood up compatible hardware and installed ECP software and applications - with many more leveraging ECP technologies through cloud service providers.

Industry Partners Leverage ECP to Launch Exascale Innovation Era

- One of the hallmarks of ECP has been collaboration with industry partners who have helped promote exascale computing and the successful integration of software technologies, applications, and hardware to deliver a fully capable exascale ecosystem. For example, GE Research is using Frontier for virtual testing of innovative new open fan jet engine designs to achieve greater fuel efficiency and advance towards their goal of reducing CO2 emissions by 20 percent over today's most efficient engines.

Interagency Partners Leverage Exascale and AI to Improve Cancer Outcomes

- ECP included a unique partnership with the National Cancer Institute as part of the Cancer Moonshot. A focus on this effort was to develop CANDLE (CANcer Distributed Learning Environment), an AI-based computer code that brings together DOE capabilities and cancer research to accelerate discovery of new cancer therapies and improve outcomes. The CANDLE framework was recognized with a 2023 R&D 100 Award and has also been used to research potential treatments for SARS-CoV-2 and to assess the performance of DOE's exascale computing systems.

Democratizing Quantum Control

- The quantum systems that hold great promise for scientific computing and networking are delicate, requiring sophisticated and often costly control electronics to achieve state-of-the-art performance. The Quantum Instrumentation Control Kit (QICK) board aims to change that. QICK board combines a commercial off-the-shelf programmable logic board with open-source software that can be adapted to any type of quantum experiment. Dozens of research groups are now using QICK board to advance research ranging from development of novel silicon-based qubits to qubit-based sensors for dark matter detection.

Basic Energy Sciences

Maintaining World-leadership in Scientific User Facilities

- Two major facility upgrade projects to maintain world-leading capabilities, Linac Coherent Light Source-II (LCLS-II) and Advanced Photon Source (APS)-Upgrade, attained significant milestones. Completed early in FY 2024, LCLS-II upgraded the world's first hard x-ray Free Electron Laser to deliver a million x-ray pulses per second with beams that are on average 10,000 times brighter than before the upgrade. This world record performance provides even greater fidelity on the structure and dynamics of quantum materials, catalysts, and biological systems, among others. The upgraded APS will be the Nation's first "4th generation" storage ring-based x-ray light source and offer users more coherent x-ray beams that are up to 500 times brighter, enabling completely new studies of complex systems (e.g., batteries, solar cells, biological systems) in real time and under real-world conditions. Notably, in April 2023 the APS stopped operations to install the upgraded storage ring with restart of operations planned about a year later.

Closing the loop on Photosystem II

- Light-driven oxidation of water to oxygen during natural photosynthesis is one of the most fundamental processes for life on Earth. For decades, researchers have studied this reaction for insights that could drive development of artificial photosynthetic systems for production of clean fuels and products. Now, the chemical structures during the final steps of light-driven conversion of water to oxygen have finally been characterized at room temperature using x-ray lasers, including LCLS. The results—the culmination of decades of research from hundreds of scientists—set the stage for more rapid development of artificial photosynthesis, a promising clean energy technology.

Rapidly and reproducibly disinfecting water with a nanostructured powder and sunlight

- Powder-based disinfection systems offer advantages for water sanitization but to date have been limited by low efficiency. Researchers demonstrated rapid (less than 1 minute) and nearly complete disinfection of water containing E. coli using a suspended nanostructured powder. The powder can be removed with a simple magnet and reused in a new contaminated water sample. This approach is easy to implement, has small-scale (e.g., personal use) to large-scale (e.g., wastewater treatment) applications, and may enable efficient removal of diverse water-borne pathogens.

10 years of cutting-edge research in energy storage

- Meeting the Nation's ambitious net-zero carbon emissions goals requires a generational leap in battery technology. Since 2013, the Argonne National Laboratory-led Joint Center for Energy Storage Research (JCESR), the Batteries and Energy Storage Energy Innovation Hub, has conducted ground-breaking research for beyond Li-ion batteries. After 10 years, JCESR concluded its efforts with over 1,000 journal papers, nearly 100 inventions, 34 patents, 3 startups, and, importantly, training for more than 330 students and postdocs who now have careers in academia, industry, and at DOE national laboratories. JCESR's pioneering work in data and AI/ML approaches for battery research are also now widely available to the research and industrial community as part of the Materials Project at Lawrence Berkeley National Laboratory (LBNL). Collectively, JCESR's accomplishments have accelerated the pace of progress in energy storage research.

Improving the synthesis and stability of promising solar cell materials under real world conditions.

- Solar cells based on mixed-halide perovskites offer dual benefits of greater efficiency and lower cost relative to existing technology but currently lack adequate stability to make them viable commercial products. Researchers from a BES-supported Energy Frontier Research Center developed a new method for making mixed halide-perovskite solar cell materials that enables better control of crystallization rate, yielding higher quality materials with dramatically improved stability and performance under real world conditions. This new synthetic approach overcomes a major limitation to performance and offers a new pathway to perovskite solar cells as a competitive commercial technology.

Biological and Environmental Research

Notable accomplishments in Biological Systems Science include:

- Discovery of lignin degradation with no oxygen needed highlights a breakthrough for bioprocessing of plant biomass and biomanufacturing. Lignin is a major component of plant biomass and is notoriously resistant to breakdown thereby hindering efficient use of plant biomass as biofuel/bioproduct feedstock. Recent results conclusively show that fungi can degrade lignin anaerobically (i.e., with no oxygen), a process previously thought not to be possible and very likely due to novel chemistry. The findings demonstrate a new path towards efficient breakdown of lignin as a prelude to producing more valuable energy related products from this famously recalcitrant material.
- A modification of the CRISPR-CAS system for precise genome editing has been developed for modifying individual members within a soil microbial community. The work has relevance for altering cellular metabolism during bioprocessing of plant biomass for bioenergy or bioproduct production. Species-specific, phage-based methods were developed to deliver CRISPR-CAS based genome editing machinery to specifically targeted microbes within a mixed microbial community, demonstrating the ability to modify microorganisms selectively for enhanced biotechnologies, including carbon management. The use of a phage-based system allows delivery of the CRISPR-CAS components only to those microorganisms susceptible to phage infection thereby allowing the researchers to target specific cells within mixed culture for editing.

Notable accomplishments in Earth and Environmental Systems Sciences include:

- Building more accurate and sophisticated climate models on faster computers is critical for addressing energy challenges involving extreme events e.g., grid resilience. DOE's Energy Exascale Earth System (E3SM) climate model is the first to run on an exascale computer, placing the U.S. as the global leader in high resolution prediction science. BER scientists developed a 3 km resolution climate prediction capability using the Frontier computer that allows for unprecedented scientific analyses for stakeholder applications. The team that developed the high-resolution atmospheric component of the climate model recently won the first-ever Association for Computing Machinery (ACM) Gordon Bell Prize for Climate Modelling at the International Conference for High Performance Computing, Networking, Storage and Analysis (SC23).
- Understanding and modeling changes in precipitation associated with urbanization and irrigation has a direct impact on the dynamics and vulnerabilities of water and energy systems due to climate extremes. Effects of large-scale urbanization were shown to suppress regional precipitation, while irrigation enhances most precipitation types. DOE's newly established Urban Integrated Field Laboratories will incorporate improved rainfall predictions that are needed to better describe impacts of climate and urban change on water and energy infrastructures while also fostering more equitable resource planning across diverse communities.

Fusion Energy Sciences

DIII-D National Fusion Facility Completes Highest-Powered Negative Triangularity Experiments.

- Researchers evaluated the performance and characteristics of negative triangularity-shaped plasmas in DIII-D in a 16-day experimental thrust that produced the highest-powered experiments of this kind worldwide. The cross-section of a plasma configured in a "negative triangularity" appears mirrored, resembling a backwards "D," as opposed to the more common configuration where the shape of the plasma takes the same "D" shape as the vacuum vessel. Plasmas in this configuration are less likely to impact the inner walls of the tokamak, potentially offering significant benefits for the design of future fusion power plants.

Exploring Reinforcement Learning to Control Nuclear Fusion Reactions.

- Using reinforcement learning methods, researchers developed a numerical model based on 15,000 plasma discharges from the DIII-D National Fusion Facility. The model predicts the evolution of DIII-D plasmas subject to controllable plasma parameters. The reinforcement learning method examined historic and real-time data to vary and control the plasma rotation velocity in search of optimal plasma stability. The method was successfully used to train a real-time controller for DIII-D's heating and momentum injection systems. This successful project is one of the first attempts to control a tokamak using reinforcement learning and shows promise that these methods could be used to also control other aspects of the plasma state.

Fusion temperatures in a small package.

- The researchers at PPPL, ORNL, and the private fusion company Tokamak Energy Ltd in the United Kingdom (UK) achieved a record 100-million-degree ion temperature (many times hotter than the core of our sun) in a device with a plasma volume equivalent to the cargo space of a crossover SUV through a first-of-the-kind international Collaborative Research and Development Agreement (CRADA). Overall, this work confirms that spherical tokamaks can achieve one of three conditions necessary for commercial fusion energy production in a smaller, and potentially more economical, device than other fusion configurations.

High Energy Physics

Most precise measurements of the muon magnetic anomaly from the g-2 experiment

- In August 2023, the Muon g-2 collaboration revealed its second result for the measurement of a quantity known as g-2, which bolsters the first result published by the collaboration in 2021. The new result is based on data taken in 2019 and 2020 and improves the precision by more than a factor of 2 compared to the first result. Since it is so precise, this measurement is particularly sensitive to the influence of new particles or forces beyond what is included in the Standard Model of particle physics; therefore, a factor of 2 improvement can exclude a large range of possible models of new physics or point the way to exactly where the next discovery lies. This leads to a total uncertainty of the experimental average for the muon magnetic anomaly of 190 parts-per-billion (ppb). This is the world's most precise measurement ever made at a particle accelerator.

Advances in dark energy studies were made in spectroscopic and imaging next-generation experiments.

- The Dark Energy Spectroscopic Instrument (DESI) experiment released its detection of baryon acoustic oscillation (BAO) signal in 2023 using the first two months of data. The measurement represents an early validation they are on target to achieve a high-significance BAO detection at sub-percent precision using the map of 40 million galaxies and their redshifts from the completed five-year survey. This will allow an exquisite determination of the effects of dark energy on the expansion history of the universe over the past 11 billion years.

Nuclear Physics

Shape-shifting nuclei illuminate nature's whimsy

- Using the new Facility for Rare Isotope Beams, researchers have made more than 210 rare-isotope beams for forty-six experiments involving 177 students, across 180 institutions in 50 countries. One exciting example is a high energy quantum state of sodium 32 (32Na) that exists for a full 24 millionths of a second, compared to nearly all high energy quantum states that decay instantaneously. Its existence could be explained by three different nuclear theories, one of which suggests it changes shape spontaneously from that of a squashed basketball to an American football. Discovering which theory comes closest is the subject of intense research to create new knowledge that will advance goals for non-proliferation, nuclear medicine, space exploration, and the discovery of new physics beyond our current understanding.

New tools to discover nature's recipe for quark-gluon soup

Scientists have proven the quark-gluon plasma from the early universe can be produced by smashing atoms at velocities near the speed of light, exhibiting spectacular phenomena. For example, a thin slice of this plasma just a femtometer (0.000000000000001 meter) thick can stop a quark or gluon from punching through it, even when these particles have giga-electron-volts of energy. How that happens is a question that scientists are ready to answer with completion and commissioning of the super Pioneering High Energy Nuclear Interaction eXperiment (sPHENIX) detector at the Relativistic Heavy Ion Collider (RHIC). New diagnostics have also been developed to determine the precise temperature of this spectacular environment within the nucleus by observing the sequential dissolution of a well-known set of particle states formed from different combinations of quarks. The stage is now set to tell how the quark-gluon soup gets made when the temperature gets to be 12 billion Kelvin as it was in the very early universe.

Mystery of mysteries: the nature of the neutrino

- We know the neutrino mass is small, but we do not know how small. The fact it has a mass at all is currently not explained by established physics theory. These unknowns, as well as whether the neutrino is its own anti-particle, may account for why there is more matter than ani-matter in the universe. To answer these unknowns, an ongoing international campaign to search for a rare decay called neutrinoless double beta decay— the decay of a nucleus in which two neutrons transform themselves into two protons, two electrons, but no neutrinos. Such a decay can only happen if the neutrino is indeed its own anti-particle. Recently, the Majorana Demonstrator experiment carried out at the Sanford Underground Research Facility (SURF) in South Dakota demonstrated that up to a limit of 8.3×10^{25} years, no such decay would be observed, setting a new limit for the follow-up global campaign which aims to improve the sensitivity to this decay by 1000 times.

Isotope R&D and Production

Newly Refurbished Hot Cells Produce Record Batch Size of Rare Cancer Therapeutic

- The recently renovated All-Purpose (AP) Hot Cells at Brookhaven National Laboratory (BNL) enabled a record-breaking achievement of the DOE IP Tri-Lab Ac-225 Research Effort for the provision of isotopes for innovative cancer research, producing the largest Ac-225 batch to date: 112 mCi of Ac-225 was produced of this rare isotope. Ac-225 shows stunning success in treating metastasized cancers but is in short supply. The Tri-Lab collaboration established reliable, routine Ac-225 production, demonstrating that the process is scalable, but had been constrained at the 50 mCi level due to insufficient radiochemical processing capacity at the target irradiation sites (BNL and Los Alamos National Laboratory [LANL]). The renovation of the AP Hot Cells was completed in 2023, and the BNL Medical Isotope Research and Production Program (MIRP) successfully and reliably produced monthly batches of Ac-225 since operations were authorized. With the AP Hot Cells, DOE can provide additional supply of Ac-225 to support clinical trials.

The DOE Isotope Program (DOE IP) Welcomes the University of Wisconsin-Madison and Texas A&M to the University Isotope Network (UIN)

- The University of Wisconsin-Madison (UWM) Cyclotron Research Group joined the DOE IP UIN for the production of research and "boutique" isotopes. Supported by DOE IP funding, the UWM Cyclotron Research Group developed three new production lines of medical isotopes used in medical imaging and cancer therapy (Manganese-52g, Bromine-77, and Yttrium-86) and are now in routine production and available through National Isotope Development Center (NIDC). The UWM Cyclotron Research group brings expertise in developing targets for isotope production using low energy cyclotrons and will serve as the target resource for the other cyclotrons sites with the UIN. Texas A&M Cyclotron Institute has developed Astatine-211 (At-211) production which is now available for routine regional distribution through NIDC. There are now six universities in the UIN.

Accelerator R&D and Production

- In FY 2023, the ARDAP program supported compact cryocooled superconducting accelerator R&D that will pave the way for industrial applications. Such accelerators have been shown to effectively destroy a wide variety of pollutants such as volatile organic compounds[a] and the "forever chemicals" called PFAS[b][c] found in many U.S. drinking water sources and in the blood of 97 percent of Americans.[d]

- In 2023, the BNL Accelerator Test Facility (ATF) provided more than 2,000 hours of beamtime to users who performed experiments that elucidated the origin of the remnant magnetic field in our galaxy,[e] demonstrated new techniques using ionic liquids to generate surgically-useful laser light,[f] and that is helping National Aeronautics and Space Administration (NASA) quantify the effects of solar radiation on space-borne electronics.[g]

Workforce Development for Teachers and Scientists

- DOE National Laboratory Based Activities - WDTS's four workforce training programs prepare U.S. students for science, technology, engineering, and mathematics (STEM) careers by providing hands-on research experiences and inclusive mentorship at 17 DOE national laboratories. A total of 1,280 undergraduate students from 2-/4-year colleges and universities, 131 graduate students, and 85 faculty from institutions historically underrepresented in research were supported. Among all the participants, approximately 34.1 percent were women, about a quarter came from 150 Minority Serving Institutions (MSIs), including 21 Historically Black Colleges and Universities (HBCUs), 1 Tribal College and University (TCU), and 101 Hispanic Serving Institution. More than 98 percent reported positive impacts to their educational and career goals, more than 92 percent would consider a career at DOE national laboratories.

- Reaching a New Energy Sciences Workforce (RENEW) - In FY 2023, WDTS established the first cohort of five WDTS RENEW Pathway Summer Schools for high school and early undergraduate students at 6 DOE national laboratories. In collaboration with SC research programs and Oak Ridge Institute for Science and Education, WDTS successfully led the first year of the SC portfolio level evaluation and assessment of the RENEW initiative. The preliminary assessment shows that the RENEW activities effectively reached diverse participants and institutions, especially those from historically underrepresented groups and communities in SC portfolio.

- National Science Bowl®(NSB) – In FY 2023, more than 2,700 middle school students (from 504 schools) and 5,200 high school students (from 941 schools) participated in 108 regional competitions, representing forty-nine U.S. States, the District of Columbia, and Puerto Rico. The NSB®continues to inspire young students nationwide to strive for high levels of academic success and follow their passions in STEM.

- Intentional Outreach and Engagement for Broadening Participation – In FY 2023, through multiple venues, WDTS actively engaged HBCUs, TCUs, MSIs, and community colleges for raising awareness, reducing barriers, and recruiting students and faculty from all walks of life, especially from underserved communities. WDTS successfully expanded model outreach practices, including mini-semester, student STEM ambassadors, and MSI faculty workshop, to more laboratories.

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[a] https://www.sciencedirect.com/science/article/abs/pii/S0969806X1730511X
[b] https://www.jlab.org/partnerships/blastpfas
[c] https://phys.org/news/2024-02-electron-eradicate-chemicals.html
[d] https://www.mdpi.com/1660-4601/12/6/6098
[e] https://www.bnl.gov/atf/docs/mapping-the-self-generated-magnetic-fields-due-to-thermal-weibel-instability.pdf
[f] https://journals.aps.org/prapplied/abstract/10.1103/PhysRevApplied.19.014052
[g] https://www.bnl.gov/atf/experiments/references/ae130.pdf

Science Laboratories Infrastructure

Line-Item Construction Projects

- Since FY 2006, the SLI program has invested nearly $1.2 billion to successfully complete 19 mission-enabling line-item construction projects that provided state-of-the-art science user support facilities, renovated and repurposed aged facilities, upgraded inadequate core infrastructure and systems, and removed excess (obsolete?) facilities. These investments began following an FY 2006 SC decision to modernize infrastructure across the SC-stewarded laboratory complex. With these investments, the SLI program constructed approximately 1.8 million gsf of new and modernized existing space. As a result, an estimated 3,050 laboratory users and researchers now occupy newly constructed and/or modernized buildings that better support scientific and technological innovation in a collaborative environment. SLI has been honored with 14 DOE Secretary's Achievement Awards for its contributions to the SC mission.

General Plant Projects (GPP) upgrades across SC Laboratories

- From FY 2016 through FY 2023, SLI has disbursed nearly $280 million in 49 laboratory core infrastructure improvement projects including $150 million in electrical and utility improvements, $57 million in building renovations, $44 million in safety and environmental projects, $20 million in sustainability/resilience and $8 million in other site improvement projects. Examples of FY 2023 SLI GPP investments in core infrastructure include the replacement of an emergency generator in the Waste Handling Facility at LBNL and conversion of the fossil fuel furnace serving the AUD-PSL buildings at PNNL to a hot water system using geothermal heat pumps.

Future Year Energy Program (FYEP)

(dollars in thousands)

	FY 2025 Request	FY 2026	FY 2027	FY 2028	FY 2029
Office of Science	8,583,000	8,780,409	8,982,358	9,188,953	9,400,298

Outyear Priorities and Assumptions

In the FY 2012 Consolidated Appropriations Act (P.L. 112-74), Congress directed DOE to include a future-years energy program (FYEP) in subsequent requests that reflects the proposed appropriations for five years. This FYEP shows outyear funding for each account for FY 2026–FY 2029. The outyear funding levels use the growth rates based on the Request level and match the outyear account totals published in the FY 2025 President's Budget for both the 050 and non-050 accounts. Actual future budget request levels will be determined as part of the annual budget process.

SC priorities in the outyears include the following:

- Increase investments in Administration priorities to advance bold, transformational leaps in U.S. S&T, build an inclusive and diverse workforce of the future, and ensure America remains the global S&T leader for generations to come.
- Ensure continued operations of all scientific user facilities.
- Continue to invest in infrastructure and utility upgrades at all national laboratories.
- Invest in ongoing and new line-item construction projects and major items of equipment to ensure the United States maintain world leading and state-of-the-art scientific user facilities.

Science
Funding by Congressional Control

(dollars in thousands)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted ($)	FY 2025 Request vs FY 2023 Enacted (%)
Advanced Scientific Computing Research					
ASCR Research	991,000	1,033,108	1,136,682	+145,682	+14.70%
17-SC-20 SC Exascale Computing Project (ECP)	77,000	–	–	-77,000	-100.00%
Construction					
24-SC-20 High Performance Data Facility	–	–	16,000	+16,000	–
Total, Construction	**–**	**–**	**16,000**	**+16,000**	**–**
Total, Advanced Scientific Computing Research	**1,068,000**	**1,033,108**	**1,152,682**	**+84,682**	**+7.93%**
Basic Energy Sciences					
BES Research	2,240,800	2,249,563	2,398,785	+157,985	+7.05%
Construction					
24-SC-10 HFIR Pressure Vessel Replacement (PVR), ORNL	–	–	6,000	+6,000	–
24-SC-12 NSLS-II Experimental Tools - III (NEXT-III), BNL	–	–	5,500	+5,500	–
21-SC-10 Cryomodule Repair & Maintenance Facility (CRMF), SLAC	10,000	9,000	20,000	+10,000	+100.00%
19-SC-14 Second Target Station (STS), ORNL	32,000	52,000	52,000	+20,000	+62.50%
18-SC-10 Advanced Photon Source Upgrade (APS-U), ANL	9,200	–	–	-9,200	-100.00%
18-SC-11 Spallation Neutron Source Proton Power Upgrade (PPU), ORNL	17,000	15,769	–	-17,000	-100.00%
18-SC-12 Advanced Light Source Upgrade (ALS-U), LBNL	135,000	57,300	–	-135,000	-100.00%
18-SC-13 Linac Coherent Light Source-II-High Energy (LCLS-II-HE), SLAC	90,000	120,000	100,000	+10,000	+11.11%
Total, Construction	**293,200**	**254,069**	**183,500**	**-109,700**	**-37.41%**
Total, Basic Energy Sciences	**2,534,000**	**2,503,632**	**2,582,285**	**+48,285**	**+1.91%**

(dollars in thousands)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted ($)	FY 2025 Request vs FY 2023 Enacted (%)
Biological and Environmental Research					
BER Research	908,685	835,644	926,225	+17,540	+1.93%
Construction					
24-SC-31 Microbial Molecular Phenotyping Capability (M2PC), PNNL	–	–	19,000	+19,000	–
Total, Construction	**–**	**–**	**19,000**	**+19,000**	**–**
Total, Biological and Environmental Research	**908,685**	**835,644**	**945,225**	**+36,540**	**+4.02%**
Fusion Energy Sciences					
FES Research	510,222	554,668	609,496	+99,274	+19.46%
Construction					
20-SC-61 Matter in Extreme Conditions (MEC) Petawatt Upgrade, SLAC	11,000	10,000	10,000	-1,000	-9.09%
14-SC-60 U.S. Contributions to ITER	242,000	240,000	225,000	-17,000	-7.02%
Total, Construction	**253,000**	**250,000**	**235,000**	**-18,000**	**-7.11%**
Total, Fusion Energy Sciences	**763,222**	**804,668**	**844,496**	**+81,274**	**+10.65%**
High Energy Physics					
HEP Research	868,000	820,301	825,768	-42,232	-4.87%
Construction					
18-SC-42 Proton Improvement Plan II (PIP-II), FNAL	120,000	125,000	125,000	+5,000	+4.17%
11-SC-40 Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment	176,000	251,000	280,000	+104,000	+59.09%
11-SC-41 Muon to Electron Conversion Experiment, FNAL	2,000	–	–	-2,000	-100.00%
Total, Construction	**298,000**	**376,000**	**405,000**	**+107,000**	**+35.91%**
Total, High Energy Physics	**1,166,000**	**1,196,301**	**1,230,768**	**+64,768**	**+5.55%**
Nuclear Physics					
NP Operation and Maintenance	755,196	676,203	723,091	-32,105	-4.25%

(dollars in thousands)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted ($)	FY 2025 Request vs FY 2023 Enacted (%)
Construction					
20-SC-52 Electron Ion Collider (EIC), BNL	50,000	95,000	110,000	+60,000	+120.00%
Total, Construction	**50,000**	**95,000**	**110,000**	**+60,000**	**+120.00%**
Total, Nuclear Physics	**805,196**	**771,203**	**833,091**	**+27,895**	**+3.46%**
Isotope R&D and Production					
IRP Research	85,451	132,651	135,000	+49,549	+57.99%
Construction					
20-SC-51 U.S. Stable Isotope Production and Research Center (SIPRC), ORNL	24,000	20,900	45,900	+21,900	+91.25%
24-SC-92 Clinical Alpha Radionuclide Producer (CARP), BNL	–	–	1,000	+1,000	–
24-SC-91 Radioisotope Processing Facility, ORNL	–	–	2,000	+2,000	–
Total, Construction	**24,000**	**20,900**	**48,900**	**+24,900**	**+103.75%**
Total, Isotope R&D and Production	**109,451**	**153,551**	**183,900**	**+74,449**	**+68.02%**
Accelerator R&D and Production					
ARDAP Research	27,436	29,175	31,273	+3,837	+13.99%
Total, Accelerator R&D and Production	**27,436**	**29,175**	**31,273**	**+3,837**	**+13.99%**
Workforce Development for Teachers and Scientists					
WDTS	42,000	42,100	43,100	+1,100	+2.62%
Total, Workforce Development for Teachers and Scientists	**42,000**	**42,100**	**43,100**	**+1,100**	**+2.62%**
Science Laboratories Infrastructure					
PILT	4,891	5,004	5,119	+228	+4.66%
Oak Ridge Landlord	6,559	6,910	7,032	+473	+7.21%
SLI F&I	13,900	32,104	50,029	+36,129	+259.92%
SLI Laboratory Operations Apprenticeship	–	–	5,000	+5,000	–
OR Nuclear Operations	26,000	46,000	46,000	+20,000	+76.92%

(dollars in thousands)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted ($)	FY 2025 Request vs FY 2023 Enacted (%)
Construction					
22-SC-71 Critical Infrastructure Modernization Project (CIMP) - ORNL	1,000	–	–	-1,000	-100.00%
22-SC-72 Thomas Jefferson Infrastructure Improvements (TJII) - TJNAF	1,000	–	–	-1,000	-100.00%
21-SC-71 Princeton Plasma Innovation Center (PPIC), PPPL	10,000	10,000	35,000	+25,000	+250.00%
21-SC-72 Critical Infrastructure Recovery & Renewal (CIRR), PPPL	4,000	10,000	20,000	+16,000	+400.00%
21-SC-73 Ames Infrastructure Modernization (AIM)	2,000	8,000	–	-2,000	-100.00%
20-SC-71 Critical Utilities Rehabilitation Project (CURP), BNL	26,000	–	–	-26,000	-100.00%
20-SC-72 Seismic and Safety Modernization (SSM), LBNL	27,500	35,000	18,000	-9,500	-34.55%
20-SC-73 CEBAF Renovation and Expansion (CEBAF), TJNAF	15,000	11,000	11,000	-4,000	-26.67%
20-SC-75 Large Scale Collaboration Center (LSCC), SLAC	21,000	–	–	-21,000	-100.00%
20-SC-77 Argonne Utilities Upgrade (AU2), ANL	8,000	8,000	3,000	-5,000	-62.50%
20-SC-78 Linear Assets Modernization Project (LAMP), LBNL	23,425	18,900	30,000	+6,575	+28.07%
20-SC-79 Critical Utilities Infrastructure Revitalization (CUIR), SLAC	25,425	30,000	20,000	-5,425	-21.34%
20-SC-80 Utilities Infrastructure Project (UIP), FNAL	20,000	35,000	45,000	+25,000	+125.00%
19-SC-74 - BioEPIC, LBNL	45,000	38,000	–	-45,000	-100.00%
Total, Construction	**229,350**	**203,900**	**182,000**	**-47,350**	**-20.65%**
Total, Science Laboratories Infrastructure	**280,700**	**293,918**	**295,180**	**+14,480**	**+5.16%**
Safeguards and Security					
S&S	184,099	200,000	195,000	+10,901	+5.92%
Total, Safeguards and Security	**184,099**	**200,000**	**195,000**	**+10,901**	**+5.92%**
Program Direction					
PD	211,211	236,700	246,000	+34,789	+16.47%
Total, Program Direction	**211,211**	**236,700**	**246,000**	**+34,789**	**+16.47%**
Total, Office of Science	**8,100,000**	**8,100,000**	**8,583,000**	**+483,000**	**+5.96%**

Note:

- *FY 2023 Funding does not reflect the mandated transfer of $20 million from the Office of Nuclear Energy to the Office of Science for Nuclear Facilities Operations and Maintenance Oak Ridge National Laboratory.*

SBIR/STTR funding:

- FY 2023 Enacted: SBIR $100,850,000 and STTR $14,182,000 (SC only)
- FY 2024 Annualized CR: SBIR $95,418,000 and STTR $13,424,000 (SC only)
- FY 2025 Request: SBIR $101,886,000 and STTR $14,329,000 (SC only)

Science
Inflation Reduction Act (IRA) Investments

The Office of Science was appropriated funds through the Inflation Reduction Act of 2022 (IRA).

(dollars in thousands)

Appropriated Funding Organization	FY 2022 IRA Supp.	Managing Organization
Advanced Scientific Computing Research		
ASCR Research	163,791	ASCR
Total, Advanced Scientific Computing Research	**163,791**	
Basic Energy Sciences		
BES Research	45,200	BES
21-SC-10 Cryomodule Repair & Maintenance Facility (CRMF), SLAC	20,000	BES
19-SC-14 Second Target Station (STS), ORNL	42,700	BES
18-SC-12 Advanced Light Source Upgrade (ALS-U), LBNL	96,600	BES
18-SC-13 Linac Coherent Light Source-II-High Energy (LCLS-II-HE), SLAC	90,000	BES
Total, Basic Energy Sciences	**294,500**	
Fusion Energy Sciences		
FES Research	14,000	FES
20-SC-61 Matter in Extreme Conditions (MEC) Petawatt Upgrade, SLAC	10,000	FES
14-SC-60 U.S. Contributions to ITER	256,000	FES
Total, Fusion Energy Sciences	**280,000**	
High Energy Physics		
HEP Research	132,633	HEP
18-SC-42 Proton Improvement Plan II (PIP-II), FNAL	10,000	HEP
11-SC-40 Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment	125,000	HEP
11-SC-41 Muon to Electron Conversion Experiment, FNAL	36,023	HEP
Total, High Energy Physics	**303,656**	
Nuclear Physics		
NP Operation and Maintenance	88,760	NP
20-SC-52 Electron Ion Collider (EIC), BNL	128,240	NP
Total, Nuclear Physics	**217,000**	
Isotope R&D and Production		
IRP Research	82,813	IRP

(dollars in thousands)

Appropriated Funding Organization	FY 2022 IRA Supp.	Managing Organization
20-SC-51 U.S. Stable Isotope Production and Research Center (SIPRC), ORNL	75,000	IRP
Total, Isotope R&D and Production	**157,813**	
Science Laboratories Infrastructure		
SLI F&I	65,890	SLI
21-SC-71 Princeton Plasma Innovation Center (PPIC), PPPL	10,000	SLI
21-SC-73 Ames Infrastructure Modernization (AIM)	17,850	SLI
20-SC-72 Seismic and Safety Modernization (SSM), LBNL	22,500	SLI
20-SC-73 CEBAF Renovation and Expansion (CEBAF), TJNAF	10,000	SLI
19-SC-74 - BioEPIC, LBNL	7,000	SLI
Total, Science Laboratories Infrastructure	**133,240**	
Total, Office of Science IRA Supp. Coordination	**1,550,000**	

- **Advanced Scientific Computing Research (ASCR) Research:** The goal of these investments is to reduce the lease-financed amounts on ASCR high performance computing systems during this period of historically high inflation. By funding larger down-payments on these systems, ASCR will save funds that otherwise would have been spent on higher interest payments. The Argonne Leadership Computing Facility received $54,100,000 to reduce future lease payments on the Aurora system by increasing the down payment on the system. The National Energy Research Scientific Computing Center (NERSC) received $52,678,000 to purchase the Perlmutter Phase 2 system outright (avoiding a high interest rate lease) and pay down the lease balance on the Perlmutter Phase I system. The Oak Ridge Leadership Computing Facility received $57,013,000 to contribute to purchase of the Frontier system outright (avoiding a high interest rate lease).

- **Basic Energy Sciences (BES) Research**: The goal of this investment is to provide funding for two major items of equipment projects. 1) NEXT-II funding enables the project to bundle many procurements scattered over 3 years into few expedited packages realizing significant savings and risks reduction. FY 2024 planned activities will continue R&D, prototyping, other supporting activities, and construction/equipment procurements. FY 2024 reflects the final year of funding for the project. 2) NSRC Recapitalization funding will reduce concerns of increasing labor, materials, and supply costs, sustain forward momentum, and reduce project risks by accelerating instrument contract awards. FY 2024 planned activities will continue design, other supporting activities, and equipment procurements. FY 2024 reflects the final year of funding for the project. The goal of this investment also provides Other Project Cost funding for two construction projects: 1) Cryomodule Repair & Maintenance Facility and 2) Linac Coherent Light Source-II-High Energy.

- **Cryomodule Repair & Maintenance Facility (CRMF):** The goal of this IRA investment is to enable the project to accelerate the procurement of the architectural and engineering design services and will expedite the design. FY 2024 planned activities will support completion of the detailed design of the facility, and technical specifications for the procurement of cryogenic systems equipment.

- **Second Target Station (STS):** The goal of this IRA investment is to help address inflation-driven concerns of increasing labor, materials, and supply costs, and sustain forward momentum and reduce project risks. FY 2024 planned activities will support continued planning, R&D, design, engineering, prototyping, and testing to advance the highest priority activities. Emphasis will be on advancing the instrument prototypes, target preliminary designs and material characterization, proton beam delivery magnets, neutron beam optics and choppers, neutron moderator, and accelerator designs and controls. A potential long lead procurement for civil construction site preparation to bring in new roads and perform site grading depends on progress of the conventional facility design and DOE review and approval of the plans and use of available funding.

- **Advanced Light Source Upgrade (ALS-U):** The goal of this IRA investment is to enable the project to significantly expedite procurements taking advantage of lower pricing and mitigate inflation uncertainties as well as schedule and technical risks, accelerating the funding profile resulting in reduced funding in the outyears. FY 2024 planned activities will continue to advance the remaining procurements for the Accumulator Ring and the Storage Ring, advance installation of the Accumulator Ring in the tunnel, start pre-staging and assembly of the Storage Ring rafts and components, as the vacuum systems, magnets and diagnostics instruments are received, in preparation for the year-long dark time during which the new Storage Ring will be installed in FY 2026. FY 2024 is the final year of funding for the project.

- **Linac Coherent Light Source-II-High Energy (LCLS-II-HE):** The goal of this IRA investment is to enable the project to expedite the design and long-lead procurements, by more than a year, significantly reducing the inflation uncertainties as well as schedule and technical risks. FY 2024 planned activities will support the production of cryomodules, continue with CD-3B procurements and begin the procurement of remaining scope including vendor supported completion of design efforts associated with the cryogenic distribution system, controls systems, and the low emittance injector beamline, and continue the R&D of the superconducting radiofrequency electron gun and initiating construction/installation contracts.

- **Fusion Energy Sciences (FES) Research:** IRA funding provides $14,000,000 to the Material Plasma Exposure eXperiment (MPEX) project which is being utilized to complete the MPEX Facility Enhancements scope, which will be completed in January 2024. At the time of the IRA funding, the MPEX Facility Enhancements represented the critical path for the project. This funding has allowed the project to proceed more quickly, reducing risk and completing critical project scope as early as possible.

- **Matter in Extreme Conditions Petawatt Upgrade (MEC-U):** IRA funding will be utilized to advance the preliminary design package in support of pursuing Critical Decision (CD)-2 (Approve Performance Baseline) currently planned for FY 2025. This funding will also allow the project team to develop a more thorough plan to proceed through CD-3 (Approve Start of Construction) and project execution.

- **U.S. Contributions to ITER:** IRA funding provides $66,000,000 for Cash Contributions to fulfill U.S. agreements to the ITER Organization from previous underfunding. The remaining $190,000,000 will continue to be used to significantly enhance the design and fabrication performance of project scope in FY 2023–2024 to include the funding activities associated with the Central Solenoid Module fabrication and shipment process and the design, fabrication, and delivery of Tokomak Cooling Water System components.

- **High Energy Physics (HEP) Research:** The goal of this investment is to advance five major items of equipment (MIEs): 1) High Luminosity Large Hadron Collider (HL-LHC) Accelerator; 2) HL-LHC A Toroidal LHC Apparatus (ATLAS) Detector; 3) HL-LHC Compact Muon Solenoid (CMS) Detector; 4) Accelerator Controls Operations Research Network (ACORN); and 5) Cosmic Microwave Background Stage 4 (CMB-S4). FY 2024 planned activities will support fabrication of the HL-LHC projects' components, since all projects are past CD-3. Funding for CMB-S4 and ACORN will support the development of their respective conceptual designs.

- **Proton Improvement Plan II:** The goal of this investment is to support and accelerate the procurement of long lead items that are part of the Accelerator Complex Infrastructure contract. All IRA funds should be expended before FY 2024.

- **Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment:** The goal of this investment is to support and accelerate the Far Site Conventional Facilities - Buildings and Site Infrastructure subproject. FY 2024 planned activities will support construction of surface building and outfitting of the underground caverns with utilities.

- **Muon to Electron Conversion Experiment:** The goal of this investment is for the majority of the remaining work for approximately two years supporting: project management; accelerator; solenoids; muon beamlines; tracker; calorimeter; cosmic ray veto; and trigger and data acquisition system. FY 2024 planned activities will support all remaining activities across the project with installation being the major activity.

- **Nuclear Physics (NP) Operation and Maintenance:** The goal of this investment is to advance four MIE projects. The MOLLER experiment at the Thomas Jefferson National Accelerator facility will measure the parity-violating asymmetry in polarized electron-electron (Møller) scattering. An anomalous amount of parity violation would signal new physics beyond our current understanding. IRA funding allows for long lead procurements to start in FY 2023 once CD-3a is achieved and sets the project for establishing its performance baseline in Q1 FY2024. Gamma-Ray Energy Tracking Array (GRETA) directly supports the NP mission by addressing the goal to understand the structure of nuclear matter, the processes of nuclear astrophysics, and the nature of the cosmos. A successful implementation of this detector will represent a major advance in gamma-ray tracking detector technology that will impact nuclear science, as well as detection techniques in homeland security and medicine. IRA funding allows for acceleration of module procurements. The High Rigidity Spectrometer (HRS) at FRIB will increase the scientific potential of state-of-the-art and community-priority devices, such as GRETA, and other ancillary detectors. The HRS will allow experiments with beams of rare isotopes at the maximum production rates for fragmentation or in-flight fission. This enhancement in experimental sensitivity provides access to critical isotopes not available otherwise. IRA funding supports conceptual design and, eventually, long lead procurement activities and establishing the project performance baseline. The Ton-Scale Neutrinoless Double Beta Decay (NLDBD) Program, implemented by deploying experiments instrumenting a large volume of a specially selected isotope to detect neutrino-less nuclear beta decays (where within a single nucleus, two neutrons decay into two protons and two electrons with no neutrinos emitted), directly supports NP's mission to explore all forms of nuclear matter. IRA funding supports the three competing technology collaborations (LEGEND, nEXO, and CUPID) to reach CD-1.

- **Electron Ion Collider**: The Electron-Ion Collider (EIC) construction project will provide unprecedented ability to x-ray the proton and discover how the mass of everyday objects is dynamically generated by the interaction of quark and gluon fields inside protons and neutrons. The EIC will maintain U.S. leadership in nuclear physics and in accelerator science and technology of colliders. IRA funding supports long lead procurements and preliminary engineering design ($128,240,000) as well as OPC research and development ($10,000,000).

- **Isotope R&D and Production (IRP) Research:** The goals of this investment include: advancement of critical infrastructure and development of production capabilities of isotopes currently not available in the U.S.; enhancement of current capabilities for optimization of isotope production and forming reserves of critical isotopes; and equipment to detritiate a legacy stockpile of contaminated heavy water for semiconductor and microelectronics manufacturing and reduce dependence on foreign supply. OPC funding for Radioisotope Production Facility (RPF) is provided at planned project profile level, optimizing schedule in the near term, and avoiding reductions in force.

- **Stable Isotope Production and Research Center (SIPRC):** Funding for SIPRC restores optimal planned funding in the near term, accelerating the completion date by about one year.

- **Science Laboratories Infrastructure (SLI) Facilities & Infrastructure:** The IRA funding provided for eleven general plant projects (GPPs) at eight laboratories. Ames National Laboratory replaced the helium recovery system and the failed HVAC system in Harley Wilhelm Hall. At Argonne National Laboratory, a waste heat recovery system from the Advanced Photon Source was installed. At Brookhaven National Laboratory, the electrical distribution system in the Physics Building (B510) was upgraded and aged portions of HVAC systems in mission critical buildings were replaced. At the Fermi National Accelerator Laboratory, improvements were made to the cooling system for the laboratory's communication system in Wilson Hall. The Pacific Northwest National Laboratory installed a high efficiency electric boiler system, new high efficiency air handlers, and new system ducting in the Life Sciences Laboratory. Princeton Plasma Physics Laboratory's fire alarm system was replaced and several other life safety improvements were made. At the Stanford Linear Accelerator Laboratory, aging cooling towers were replaced. Thomas Jefferson Accelerator Facility expanded the laydown yard.

- **Princeton Plasma Innovation Center (PPIC):** PPIC will provide a multi-purpose facility with modern, flexible, efficient, and agile research laboratories and office space to conduct research activities in support of multiple SC programs. IRA funding will be used for finalizing the design of new research building, long lead procurements, and site work.

- **Ames Infrastructure Modernization (AIM):** AIM will renovate building systems that are past their life expectancy and at greatest risk of failure in support of the SC mission. IRA funding will support detailed design and construction activities including elements of plumbing, building envelopes, and electrical.

- **Seismic and Safety Modernization (SSM):** SSM is planned to deliver approximately a 47,000 square foot new building at LBNL to address the mission need for seismically safe space for cafeteria, health services, and assembly in the event of a seismic or emergency situation. IRA funding will be used to perform abatement and demolition of existing facility (B54), installation of soil retaining walls to stabilize the site after demolition, foundations, and initial portion of vertical construction.

- **Continuous Electron Beam Accelerator Facility [CEBAF] Renovation and Expansion (CRE):** CRE will construct new space and modernize existing DOE owned space for both the CEBAF Center and the newly acquired Applied Research Center to advance the Thomas Jefferson National Accelerator Facility's (TJNAF) scientific research mission by providing the infrastructure foundation composed of technically equipped and functional workspaces that are flexible and sustainable. IRA funding will be used to support the completion of this critical construction project at TJNAF by renovating about 20 percent of the Applied Research Center.

- **Biological and Environmental Program Integration Center (BioEPIC):** BioEPIC is a 72,000 square foot laboratory and office building with planned anchor tenants from the Biosciences Area and Earth and Environmental Science Area. Integration of the planned science programs in this unique laboratory facility will leverage existing strengths and emerging technologies to allow significant progress in the understanding of how microbial communities respond to and shape environmental systems, a critical DOE mission. IRA funding will be used to accelerate the enclosure of the building to a state of being weathertight.

Advanced Scientific Computing Research

Overview
The Advanced Scientific Computing Research (ASCR) program's mission is to advance applied mathematics and computer science; deliver the most sophisticated computational scientific applications in partnership with disciplinary science; advance computing and networking capabilities; and develop future generations of computing hardware and software tools for science and engineering in partnership with the research community, including U.S. industry. ASCR supports state-of-the-art capabilities that enable scientific discovery through computation. ASCR's partnerships within the Office of Science (SC) and with the applied technology offices, other agencies, and industry are essential to these efforts. The Computer Science and Applied Mathematics activities in ASCR provide the foundation for increasing the capability of the national High Performance Computing (HPC) ecosystem by focusing on long-term research to develop innovative software, algorithms, methods, tools and workflows that anticipate future hardware challenges and opportunities as well as science applications and Department of Energy (DOE) mission needs. At the same time, ASCR partners with other disciplinary sciences to deliver some of the most advanced scientific computing applications in areas of strategic importance to SC, DOE, and the Nation. ASCR also deploys and operates world-class, open access HPC facilities and a high-performance network infrastructure for scientific research, including the unique expertise needed at the forefront of this strategic technology.

For over half a century, the U.S. has maintained world-leading computing capabilities through sustained investments in research, development, and regular deployment of new advanced computing systems and networks along with the applied mathematics and software technologies to effectively use them. The benefits of U.S. computational leadership have been enormous gains in increasing workforce productivity, accelerated progress in both science and engineering, advanced manufacturing techniques and rapid prototyping, and stockpile stewardship without testing.[a] Computational science allows researchers to explore, understand, and harness natural and engineered systems, which are too large, too complex, too dangerous, too small, or too fleeting to explore experimentally. Leadership in HPC has also played a crucial role in sustaining America's competitiveness. There is recognition that the nation that leads in HPC and trustworthy Artificial Intelligence (AI) and in the integration of the computing and data ecosystem will lead the world in developing innovative clean energy technologies, medicines, industries, supply chains, and military capabilities. The U.S. will also need to leverage investments in science for innovative new technologies, materials, and methods to strengthen our clean energy economy and ensure all Americans share the benefits from those investments. The next generation of breakthroughs in science will come from employing data-driven methods in AI at extreme scales coupled to the enormous increases in the volume and complexity of data generated by U.S. researchers and SC user facilities. The convergence of AI technologies with these existing investments creates a powerful accelerator for innovation and technology development and deployment. ASCR is in a pivotal position to leverage the exascale ecosystem and decades of basic research investments as well as industry partnerships to drive responsible development of AI technologies and AI enabled science in the national interest.

Quantum Information Science (QIS)—the ability to exploit intricate quantum mechanical phenomena to create fundamentally new ways of obtaining and processing information—is opening new vistas of science discovery and technology innovation that build on decades of investment across SC. DOE envisions a future in which the cross-cutting field of QIS increasingly drives scientific frontiers and innovations toward realizing the full potential of quantum-based applications, from computing to sensing, connected through a quantum internet. However, there is a need for bold approaches that better couple all elements of the technology innovation chain and combine talents across SC, universities, national labs, and the private sector in concerted efforts to enable the U.S. to lead the world into the quantum future.

Continued progress in the scientific utilization of microelectronics, especially the energy utilization of these devices for HPC and AI, underpins all ASCR's efforts. ASCR's strategy is to focus on technologies that build on expertise and core investments across SC, continuing mutually beneficial engagements with industry, the applied technology offices, other agencies, and the scientific community through connections made in the Exascale Computing Project (ECP); investing in small-scale testbeds; and increasing core research investments in Applied Mathematics and Computer Science.

[a] https://nap.nationalacademies.org/catalog/21886/future-directions-for-nsf-advanced-computing-infrastructure-to-support-us-science-and-engineering-in-2017-2020

ASCR's proposed activities will deliver on the promise of the exascale and AI-enabled science era to accelerate progress in delivering a clean energy future, understanding and addressing climate change, broadening the impact of our investments in science, and increasing the competitive advantage of U.S. industry.

Highlights of the FY 2025 Request

The FY 2025 Request for $1,152.7 million for ASCR is an increase of $84.7 million over the FY 2023 Enacted, and is well-aligned with Administration and Department priorities to advance responsible AI technology, critical and emerging technologies such as QIS and microelectronics. In addition, these investments continue to address the challenges of climate change to reach netzero through the Earthshots awards and contribute to better health outcomes in pandemic readiness through continued support for Cancer Moonshot. It also provides support to reduce barriers and inequities through workforce investments, facilitate adoption of accelerated HPC, and usher in the responsible AI and exascale science era to bolster industrial innovation.

Research

- The Request prioritizes delivering on the promise of the exascale and AI enabled science era including critical basic research investments in applied mathematics and computer science to merge the power of AI with exascale computing, develop tools that facilitate building foundation models useful for basic and applied science, and partnerships that build and use foundation models supporting new applications in science and energy, national security, and increased community preparedness. The Request also emphasizes applied mathematics, computer science, networking, hardware, and microelectronics research to advance and leverage energy-efficient advanced computing including quantum. Investments in support of the Energy Earthshot Research Centers provide the research underpinning the DOE's stretch goals. Increased or shifted efforts in both research and at the facilities will advance implementation of DOE's Integrated Research Infrastructure (IRI) to integrate DOE's unique data, user facilities, and computing resources. SC Microelectronics Science Research Centers will comprise a network of multiple team awards, with individual awards focused on a dimension related to a common research topic for each Center. The multidisciplinary teams will include researchers from universities, national laboratories, and industry. Materials, chemistries, devices, systems, architectures, algorithms, and software will be developed in a closely integrated fashion in a co-design innovation ecosystem. Strategic partnerships, both within DOE and at the interagency level, expand the impact of the ECP, AI, and accelerate scientific discovery through advanced computing (SciDAC), including to support national emergency preparedness and improved health (BRaVE). Underpinning all investments are increases in efforts to grow the necessary workforce through Reaching a New Energy Sciences Workforce (RENEW), FAIR, Computational Sciences Graduate Fellowship (CSGF), and Established Program to Stimulate Competitive Research (EPSCoR).

- The Request provides robust support for Advanced Computing Research's quantum investments and partnerships in the National Quantum Information Sciences Research Centers (NQISRCs), quantum internet, and testbeds. This support enables the recompetition/renewal of the NQISRCs and expansion of ASCR's regional quantum testbeds and user programs, which provide U.S. researchers with access to unique and commercial quantum computing and networking resources, and basic research in quantum information provide national leadership in quantum in coordination with relevant agencies.

Facility Operations

- FY 2025 Request supports increases for operations and competitive allocation of the Nation's exascale computing systems: Frontier at the Oak Ridge Leadership Computing Facility (OLCF), deployed in calendar year 2021; and Aurora at Argonne Leadership Computing Facility (ALCF), deployed in calendar year 2023. Increased funding also supports operations at the National Energy Research Scientific Computing Center (NERSC) and the Energy Sciences Network (ESnet). The Request supports advanced computing and AI testbeds at the facilities with competitive, merit reviewed, open access for researchers. ASCR facilities will maintain ECP software and technologies critical to HPC operations and users. In addition, increased funding supports: planning for NERSC-10, OLCF-6 and ALCF-4—including site preparations, long lead procurements, and vendor R&D partnerships—to address rising demand for computing and U.S. competitiveness in HPC and computational science; operation and expansion of IRI; and construction of a new High Performance Data Facility (HPDF), to strengthen and leverage SC's unparalleled research capabilities.

- The Request supports new IRI efforts to prioritize development of state-of-the-art real-time experimental/observational workflows and drive innovation in system architectures and services to inform planning for upgrades at the Facilities.

Projects

- The ECP project was successfully concluded in FY 2024 and no funding is included in the FY 2025 Request.

- The FY 2025 Request supports HPDF final design planning to establish cost, scope, and schedule in preparation for CD-2/3.

Advanced Scientific Computing Research
Funding

(dollars in thousands)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Advanced Scientific Computing Research				
Applied Mathematics Research	61,035	60,438	77,565	+16,530
Computer Sciences Research	60,667	86,267	86,736	+26,069
Computational Partnerships	95,875	77,405	93,449	-2,426
Advanced Computing Research	108,920	128,598	148,197	+39,277
Energy Earthshot Research Centers	12,500	15,000	12,500	–
Total, Mathematical, Computational, and Computer Sciences Research	**338,997**	**367,708**	**418,447**	**+79,450**
High Performance Production Computing	132,003	136,000	146,500	+14,497
Leadership Computing Facilities	430,000	441,000	475,195	+45,195
High Performance Network Facilities and Testbeds	90,000	88,400	93,540	+3,540
Integrated Research Infrastructure	–	–	3,000	+3,000
Total, High Performance Computing and Network Facilities	**652,003**	**665,400**	**718,235**	**+66,232**
17-SC-20, SC Exascale Computing Project	**77,000**	**–**	**–**	**-77,000**
Subtotal, Advanced Scientific Computing Research	**1,068,000**	**1,033,108**	**1,136,682**	**+68,682**
Construction				
24-SC-20 High Performance Data Facility	–	–	16,000	+16,000
Subtotal, Construction	**–**	**–**	**16,000**	**+16,000**
Total, Advanced Scientific Computing Research	**1,068,000**	**1,033,108**	**1,152,682**	**+84,682**

SBIR/STTR funding:

- FY 2023 Enacted: SBIR $10,112,000 and STTR $1,422,000
- FY 2024 Annualized CR: SBIR $10,775,000 and STTR $1,515,000
- FY 2025 Request: SBIR $12,046,000 and STTR $1,694,000

Advanced Scientific Computing Research
Explanation of Major Changes

	(dollars in thousands) FY 2025 Request vs FY 2023 Enacted
Mathematical, Computational, and Computer Sciences Research The Request significantly increases investments in trustworthy and responsible AI to develop tools that facilitate building foundation models useful for basic and applied science, including expanded partnerships with industry, academia, other agencies, and international allies. DOE will utilize its computing capabilities, AI testbeds, and research efforts to increase participation and retention of emerging research institutions and next generation researchers through EPSCoR, CSGF, FAIR and RENEW. Computer Science and Applied Mathematics activities will continue foundational and long-term basic research efforts that: explore and prepare for emerging technologies; develop new scalable energy efficient algorithms and software; address the challenges of data intensive science and emerging computing technologies, such as quantum information science; support the development of safe, secure, and trustworthy AI technologies and associated Privacy Enhancing Technologies; support a network of multiple team awards for the Microelectronics Science Research Centers, with individual awards focused on a dimension related to a common research topic for each Center; and will advance the IRI. Computational Partnerships supports partnerships across DOE and with other agencies to expand the impact of ECP and advance national goals with funding reduced to better align IRI efforts. The Advanced Computing Research activity will support the recompetition/renewal of the NQISRCs and quantum computing and networking testbeds, in close coordination with the other SC programs.	**+$79,450**
High Performance Computing and Network Facilities The increase prioritizes OLCF and ALCF to provide full operations and competitive allocation of the nation's Exascale Computing Systems, Frontier and Aurora. Both facilities will deploy and sustain ECP software and technologies critical to operations and will provide testbed resources to explore emerging technologies, including AI. In addition, funding supports the operation of the 125 petaflop NERSC-9 Perlmutter system. The increase also supports operations of all facilities—including power and cooling, equipment, staffing, testbeds, lease payments, user programs, outreach, and continued implementation of SC's IRI— as well as planning, site preparations and project efforts for NERSC-10 and LCF upgrades.	**+$66,232**
Exascale Computing The ECP was successfully completed in FY 2024.	**-$77,000**
Construction The FY 2025 Request supports the HPDF for the final design, and to establish the project cost, scope, and schedule.	**+$16,000**
Total, Advanced Scientific Computing Research	**+$84,682**

Basic and Applied R&D Coordination

Coordination across disciplines and programs is a cornerstone of the ASCR program. Partnerships within SC and National Nuclear Security Administration (NNSA) continue in advanced computing and applications. ASCR also has partnerships in QIS and AI within SC and is collaborations across DOE and with other agencies to expand the AI-enabled Exascale science era. Through the Networking and Information Technology R&D Subcommittee of the National Science and Technology Council (NSTC) Committee on Technology, ASCR coordinates with programs across the Federal Government. Future Advanced Computing technologies, Scientific Data, Large Scale Networking, High End Computing, AI, and QIS are coordinated with other agencies through the NSTC. In FY 2025, cross-agency interactions and collaborations continue in coordination with the Office of Science and Technology Policy.

Program Accomplishments

Delivering a Capable Exascale Computing Ecosystem for the Nation

The ECP met all of the project's key performance parameters in 2023 and successfully completed, documented and closed out the project in FY 2024, under budget and ahead of schedule. The project enabled the launch of exascale systems that use less than 20MW and created a modern, interoperable, and portable software ecosystem that addresses the needs of simulations, big data, and AI with numerous awards including 13 R&D 100 awards, 7 Gordon Bell finalists and prizes, and dozens of industry recognitions. For example, ECP's Extreme Scale Scientific Software Stack (E4S) provides easy access to over 100 HPC, AI, and data analytics packages and tools—all of which are ready for deployment for a variety of accelerated heterogenous HPC architectures, including systems with Graphical Processing Units (GPUs) from multiple vendors. This centralized, standardized, build-and-deploy framework addresses software issues and saves both time and money. It also, makes ECP software available to researchers across the Nation and lowers barriers to expanding user access to HPC and ECP software. These investments de-risked the jump to accelerated HPC for a wide range of use cases in science and engineering. As a result, scores of companies, universities, and government labs from across the Nation have stood up compatible hardware and installed ECP software and applications - with many more leverging ECP technologies through cloud service providers.[b]

Harnessing Exascale Toward Solving the Global Climate Crisis

The Gordon Bell Prize is a prestigious award given each year to recognize outstanding achievement in HPC. Starting in 2023, an additional Gordon Bell Prize for Climate Modeling will be awarded every year, for ten years, to recognize innovative parallel computing contributions toward solving the global climate crisis. The ECP's Energy Exascale Earth System Model (E3SM), a partnership with Biological and Environmental Research, was awarded the inaugural prize for work on an efficient and performance-portable implementation of a Simple Cloud Resolving E3SM Atmosphere Model (SCREAM). E3SM submitted performance results on Frontier, the first exascale computer, and benchmarked the model configuration used for scientific research. The paper outlines results which represent several firsts for a global cloud-resolving model (GCRM): first GCRM to run on an Exascale supercomputer, first GCRM to run at scale on both NVIDIA and AMD GPU systems, and first nonhydrostatic GCRM to exceed one simulated-year-per-day (SYPD) of full model throughput. SCREAM is a monumental advance that avoids the uncertainties and biases often associated with lower resolution models. For example, it captures the structure of important weather events, such as cyclones, atmospheric rivers, and cold air outbreaks, which are poorly captured by typical global cloud models. This marks the beginning of a revolution in DOE earth system modeling where unprecedentedly detailed and realistic simulations lead the way to more accurate predictions.

Industry Partners Leverage ECP to Launch Exascale Innovation Era

One of the hallmarks of ECP has been collaboration with industry partners who have helped promote exascale computing and the successful integration of software technologies, applications, and hardware to deliver a fully capable exascale ecosystem. For industry partners, exascale capabilities open pathways to explore promising new technologies and products and reduce time to commercialization. For example, GE Research is using Frontier for virtual testing of innovative new open fan jet engine designs to achieve greater fuel efficiency and advance their goal to reduce CO_2 emissions by 20 percent over today's most efficient engines. These simulations are computationally intensive, requiring significant resources to resolve the necessary length and timescales. With Frontier, researchers can simulate the movement of air and complex flow characteristics at full flight-scale conditions for the first time and reveal previously unresolvable details of operation. As a result, researchers gain insight into realistic performance from design options years ahead of building the physical system.

[b] https://www.exascaleproject.org/industry-and-agency-council/

Research investments can then be focused on the most promising designs, accelerating time to production and resulting in substantial cost-savings. This work also lays the foundation for design improvements crucial to advancing jet engine design toward alternative fuels like hydrogen and sustainable aviation fuels as well as new hybrid-electric technologies.

Interagency Partners Leverage Exascale to Improve Cancer Outcomes
ECP included a unique partnership with the National Cancer Institute as part of the Cancer Moonshot. A focus on this effort was to develop CANDLE (CANcer Distributed Learning Environment), an AI-based computer code that brings together DOE capabilities and cancer research to accelerate discovery of new cancer therapies and improve outcomes. This platform aims to address three challenges: understanding protein behaviors in tumor cells; understanding the relationship between tumors and drugs; and analyzing population-level biomedical records to extract new patterns and information. To address the third challenge, the Modeling Outcomes Using Surveillance Data and Scalable AI for Cancer (MOSSAIC) project, which applies natural language processing and deep learning algorithms, with uncertainty quantification and privacy preserving capabilities, to population-based cancer data from NCI's Surveillance, Epidemiology, and End Results (SEER) program. MOSSAIC efficiently reduced manual efforts while improving accuracy in the NCI SEER program, cutting costs for the SEER registries, and providing a trustworthy source of population-level cancer surveillance data, at closer to real-time, for use by the cancer research community. MOSSAIC is also leveraging OLCF's Frontier exascale system to develop privacy preserving federated learning tools that have the potential to substantially increase secure AI model development and sharing across the cancer community. The CANDLE framework was recognized with a 2023 R&D 100 Award and has been used to research potential treatments for SARS-CoV-2 and to assess the performance of DOE's exascale computing systems.

Accelerating Neuromorphic Computing
To address the current limitations and inefficiencies that inhibit large-scale neuromorphic computing, researchers at ORNL created SuperNeuro, a Python-based open software that provides AI practitioners with brain-like simulators that are fast and scalable on central and graphics processing platforms. Using matrix-based and agent-based modeling approaches, SuperNeuro allows for different workloads and provides the option of simulating the user's own spiking mechanisms in a human-interpretable manner. Compared with existing simulation platforms, SuperNeuro can be up to 300 times faster for small sparse networks and up to 3.4 times faster on large sparse and dense network, leveraging GPU computing to provide superior performance for neuroscience, spiking neural networks, or SNNs, and general-purpose computing workloads. SuperNeuro is also more adaptable and provides easy integration with other tools for SNN optimization that opens the possibilities for codesign of neuromorphic circuits. SuperNeuro was recognized with a 2023 R&D 100 award.

Proving Entanglement is Key to Quantum Advantage
For decades scientists have had theoretical evidence that quantum computers can solve problems that are too difficult for even today's exascale systems but the source of this advantage has been uncertain. Entanglement, a fundamental property of quantum systems, has been a key suspect but is a complex phenomenon that is difficult to pin down in today's noisy quantum systems. In work published in Physical Review Letters, a team of ASCR researchers have identified a computational problem that demonstrates a provable quantum speedup over any classical computation in which control of the quantum entanglement is directly responsible for causing the speedup. This research is a crucial step in realizing the potential of quantum computing by identifying the path to practical applications on real world system.

Democratizing Quantum Control
The quantum systems that hold great promise for scientific computing and networking are delicate, requiring sophisticated and often costly control electronics to achieve state-of the-art performance. This has erected a barrier to entry to newcomers to the field and limited the ability of even the best academic researchers to advance the frontiers of quantum information science. The Quantum Instrumentation Control Kit (QICK) board aims to change that. Initially developed at FNAL and brought to maturity with support from the ORNL-led Quantum Science Center, one of the five National Quantum Information Science Research Centers authorized by the 2018 National Quantum Initiative Act, the QICK board combines a commercial off-the-shelf programmable logic board with open-source software that can be adapted to any type of quantum experiment. Dozens of research groups in academia, National Laboratories, and industry are now using QICK board to advance their own research ranging from development of novel silicon-based qubits to qubit-based sensors for dark matter detection.

Advanced Scientific Computing Research
Mathematical, Computational, and Computer Sciences Research

Description
The Mathematical, Computational, and Computer Sciences Research subprogram supports research activities to effectively meet the SC HPC and computational science mission needs, including both data intensive and computationally intensive science. Computational and data intensive sciences coupled with Artificial Intelligence and Machine Learning (AI/ML) are central to progress at the frontiers of science and to our most challenging engineering problems, particularly for the Energy Earthshots climate science, and energy-efficient microelectronics. The Computer Science and Applied Mathematics activities in ASCR provide the foundation for increasing the capability of the national HPC ecosystem and scientific data infrastructure by focusing on long-term research to develop intelligent software, algorithms, and methods that anticipate future hardware challenges and opportunities as well as science needs. ASCR's partnerships with disciplinary science deliver some of the most advanced scientific computing applications in areas of strategic importance to the Nation and help realize the promise of the exascale and AI-enabled science era. Research efforts anticipate changes in hardware and rapidly developing capabilities such as AI and QIS, as well as science needs over the long term. ASCR's partnerships with vendors and discipline sciences are essential to these efforts. In part through continued funding for the EPSCoR, RENEW, and FAIR initiatives, ASCR will build stronger programs with underserved communities and emerging research institutions (ERIs) as well as HBCUs and MSIs, including investing in a more diverse and inclusive workforce.

Applied Mathematics Research
The FY 2025 Request for the Applied Mathematics activity supports basic research leading to fundamental mathematical advances and computational breakthroughs across DOE and SC missions. Basic research in scalable algorithms and libraries, multiscale and multi-physics modeling, methods that facilitate building foundational models for trustworthy and privacy preserving AI/ML, and efficient data analysis underpin all of DOE's computational and data-intensive science efforts. More broadly, the Request supports foundational research in problem formulation, multiscale modeling and coupling, mesh discretization, time integration, advanced solvers for large-scale linear and nonlinear systems of equations, methods that use asynchrony or randomness, uncertainty quantification, and optimization. Historically, advances in these methods have contributed as much, if not more, to gains in computational science than hardware improvements alone. Forward-looking efforts by this activity anticipate DOE mission needs from the closer coupling and integration of scientific modeling, data and scientific AI/ML with advanced computing, for enabling greater capabilities for scientific discovery, design, and decision-support in complex systems and new algorithms to support data analysis at the edge of experiments and instruments and protect the privacy of sensitive datasets. Industry often uses software developed with Applied Mathematics investments and integrate it with their own software.

Computer Science Research
The FY 2025 Request for the Computer Science activity supports long-term, basic research on the software infrastructure that is essential for the effective use of the most powerful HPC and networking systems in the country as well as the tools and data infrastructure to enable the incorporation of AI techniques and real-time exploration and understanding of extreme scale and complex data from both simulations and experiments. Additionally, Computer Science efforts play a key role in understanding gaps and future opportunities for the design of future computing systems that maintains U.S. leadership in high-performance, data-intensive, and AI computing. To support these goals, this activity includes support for foundational research in data analysis and visualization, data management and storage, distributed systems and resource management, programming models and tools enabling high performance and portability, program verification and testing, operating and runtime systems, advanced networking, hardware/software co-design, and energy-aware computer-science fundamentals. Hardware and software vendors often use software developed with ASCR Computer Science investments and integrate it with their own software. In addition, partnerships between mathematicians and computer scientists, jointly supported by this activity and Applied Mathematics, develops energy efficient algorithms and methods that scale from intelligent sensors to HPC to advance the Department's energy goals.

Computational Partnerships
The FY 2025 Request for the Computational Partnerships activity supports the Scientific Discovery through Advanced Computing, or SciDAC, program, which is a recognized leader for the employment of HPC for scientific discovery. Established in 2001, SciDAC involves ASCR partnerships with the other SC programs, other DOE program offices, and other

federal agencies in strategic areas with a goal to dramatically accelerate progress in scientific computing, including AI/ML, through deep collaborations between discipline scientists, applied mathematicians, and computer scientists. SciDAC does this by providing the intellectual resources in applied mathematics and computer science, expertise in algorithms and methods, and scientific software tools to advance scientific discovery through modeling, simulation, large-scale data analysis, and AI and scientific machine learning in areas of strategic importance to SC, DOE, and the Nation. These efforts include partnerships with industry, academia, other agencies, and international allies to utilize DOE's computing capabilities and AI testbeds to build foundation models that support new applications in science and energy.

This FY 2025 Request for this activity also supports the FAIR initiative, which provide focused investment on enhancing research on clean energy, climate, and related topics, including attention to emerging research institutions (ERIs), HBCUs and MSIs, underserved regions and communities, as well as Biopreparedness Research Virtual Environment (BRaVE) that advances collaborative research for epidemiology frameworks, computational modeling, and data management/integration in support of national biopreparedness and emergency challenges. BRaVE also supports the incorporation of AI/ML and HPC in cancer research in partnership with the National Cancer Institute.

<u>Advanced Computing Research</u>
This FY 2025 Request for the Advanced Computing Research activity supports efforts focused on development of emerging computing technologies such as QIS and neuromorphic computing as well as investments in microelectronics in partnership with the other SC program offices, Research and Evaluation Prototypes (REP), and ASCR-specific investments in cybersecurity and workforce including CSGF and the SC-wide RENEW initiative.

REP has a long history of partnering with U.S. vendors to develop future computing technologies and testbeds that push the state-of-the-art and enabling DOE researchers to better understand the challenges and capabilities of emerging technologies. In addition to REP, this activity supports ASCR's investments in the NQISRCs, as well as quantum computing testbeds and quantum internet testbeds.

Success in fostering and stewarding a highly skilled, diverse, equitable, and inclusive workforce is fundamental to SC's mission and key to also sustaining U.S. leadership in HPC and computational science. The high demand across DOE missions and the unique challenges of high-performance computational science and engineering led to the establishment of the CSGF in 1991. This program has delivered leaders in computational science both within the DOE national laboratories and across the private sector. With increasing demand for these highly skilled scientist and engineers, ASCR continues to partner with the NNSA to support the CSGF to increase the availability and diversity of a trained workforce for exascale computing, AI, and capabilities beyond Moore's Law such as QIS.

RENEW investments leverage SC's unique national laboratories, user facilities, and other research infrastructures to provide undergraduate and graduate training opportunities for emerging academic institutions and underserved Historically Black College and University (HBCU) or Minority Serving Institution (MSI) communities in the SC research portfolio.

SC Microelectronics Science Research Centers will comprise a network of multiple team awards, with individual awards focused on a dimension related to a common research topic for each Center. The multidisciplinary teams will include researchers from universities, national laboratories, and industry. Materials, chemistries, devices, systems, architectures, algorithms, and software will be developed in a closely integrated fashion in a co-design innovation ecosystem. The Request will support 2 to 3 ASCR research awards that would contribute to one of up to 4 cross-SC Research Centers.

<u>Energy Earthshot Research Centers</u>
The Department of Energy's Energy Earthshots will accelerate breakthroughs of more abundant, affordable, and reliable clean energy solutions within the decade to address the climate crisis. The FY 2025 Request support's ASCR's continued partnership with SC's Basic Energy Sciences (BES) and Biological and Environmental Research (BER) programs in the EERCs, a new modality of research launched in FY 2023, as well as directed fundamental research to bridge the R&D gaps and realize the stretch goals of the Energy Earthshots.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Mathematical, Computational, and Computer Sciences Research	**$338,997**	**$418,447**	**+$79,450**
Applied Mathematics Research	$61,035	$77,565	+$16,530
Funding continues to expand support of core research efforts in algorithms, libraries and methods that underpin high-end scientific simulations, scientific AI/ML techniques, and methods that help scientists extract insights from massive scientific datasets with an emphasis on foundational capabilities. Funding also supports the basic research needs for the EERCs and the transition of critical Applied Math efforts from the ECP into core research areas.		The Request will continue to expand support of innovative research efforts in algorithms, libraries and methods that underpin high-end scientific simulations, trustworthy and privacy enhancing scientific AI/ML techniques including methods that facilitate building foundation models useful for basic and applied science, and methods that help scientists extract insights from massive scientific datasets with an emphasis on foundational capabilities. The Request will continue partnerships between mathematicians and computer scientists to develop energy efficient algorithms and methods and investments in physics-informed, multiscale algorithms.	Funding will increase support for basic research that addresses foundational applied math challenges critical to enable science at the exascale era, and the development and evaluation of trustworthy and privacy-preserving AI methods integrating foundation models with task-specific data-driven capabilities.

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Computer Science Research	$60,667	$86,736	+$26,069
Funding continues support for core investments in software that improves the utility of HPC and advanced networks for science, including AI techniques, workflows, tools, data management, analytics and visualizations with strategic increases focused on critical tools, including AI, to enable an integrated computational and data infrastructure. Funding for this activity also continues long-term basic research efforts that explore and prepare for emerging technologies, such as quantum networking, specialized and heterogeneous hardware and accelerators, and QIS. Funding supports basic research needs of the EERCs, and transition of critical software efforts from the ECP into core research areas.		The Request will continue support for innovative investments in software that improves the utility of HPC and advanced networks for science, including AI techniques, workflows, tools, data management, analytics and visualizations with strategic increases focused on critical tools to facilitate building foundation models useful for basic and applied science and to enable an integrated research infrastructure. Funding for this activity will also continue long-term basic research efforts that explore and prepare for emerging technologies, such as quantum computing and networking, and other specialized and heterogeneous hardware and accelerators. In addition, funding will support partnerships between mathematicians and computer scientists to develop energy efficient scalable algorithms and methods.	Funding will increase support for basic research that addresses foundational computer science challenges critical to enable science at the exascale era and the development and evaluation of federated, trustworthy, privacy enhancing, AI methods integrating foundation models with task-specific data-driven capabilities.

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Computational Partnerships	$95,875	$93,449	-$2,426
Funding continues support for the SciDAC Institutes and partnerships with SC and DOE applications. Partnerships on scientific data, AI, QIS, and Advanced Computing continues. The partnership with NIH continues to leverage DOE infrastructure to ensure that data is widely available for SC's AI development efforts. Efforts focused on enabling widespread use of DOE HPC resources by Federal agencies in support of emergency preparedness and response are increased. BRaVE provides the cyber infrastructure, computational platforms, and next generation experimental research capabilities within a single portal allowing distributed networks of scientists to work together on multidisciplinary research priorities and/or national emergency challenges. This includes partnering with key agencies to understand their simulation and modeling capabilities, data management and curation needs, and identify and bridge gaps necessary for DOE to provide resources on short notice, as well as transitioning ECP capabilities, such as the on-going partnership with the National Cancer Institute. Also, the funding supports the FAIR initiative with new EPSCoR awards fostering partnerships with national laboratories to leverage unique capabilities of the DOE national laboratory system.		The Request will continue support for the SciDAC Institutes and partnerships with SC and DOE applications. Support for Advanced Computing will continue. Efforts focused on enabling widespread use of DOE HPC resources by Federal agencies in support of emergency preparedness and response will continue. BraVE will provide the cyber infrastructure, computational platforms, AI/ML, and next generation experimental research capabilities to allow networks of scientists to work together on multidisciplinary research priorities and/or national emergency challenges, such as the on-going partnership with the National Cancer Institute. Also, the Request will support the FAIR initiative.	Decrease reflects minor adjustments in the Advanced Computing portfolio to better align with ongoing Integrated Research Infrastructure initiative.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Advanced Computing Research $108,920	$148,197	+$39,277
Funding continues to support the NQISRCs, quantum computing testbed efforts, and regional quantum internet testbeds. Funds allow REP to continue strategic investments in emerging technologies, microelectronics, and development of a plan to sustain the software developed under ECP. Small investments in cybersecurity continue. Funding sustains increased support for the CSGF fellowship, in partnership with NNSA, supporting increased tuition costs, in order to increase the number of fellows focused on emerging technologies, and to expand the participation of groups, fields, and institutions that are under-represented in high end computational science. The goal of CSGF is to increase availability of a trained workforce for exascale computational science, AI at scale, and beyond Moore's Law capabilities such as QIS. Funding increases support for the RENEW initiative providing undergraduate and graduate training opportunities for students and academic institutions not currently well represented in the U.S. S&T ecosystem, including EPSCoR institutions and students, thus expanding the pipeline for ASCR research and facilities workforce needs.	The Request will continue to support quantum computing testbed efforts, and regional quantum internet testbeds. The Request allows REP to increase strategic investments in emerging technologies including AI-focused hardware, and continued support for hardening of critical software developed under ECP to enable science at the exascale era. Small investments in cybersecurity will continue. The Request will increase support for the CSGF fellowship, in partnership with NNSA, to support increased tuition costs and stipends, and to increase the number of fellows focused on AI, and to expand the participation of groups, fields, and institutions that are under-represented in high end computational science. The goal of CSGF is to increase availability of a trained workforce for the exascale and AI-enabled computational science era and beyond Moore's Law capabilities such as QIS. The Request will also continue support for the RENEW initiative to provide undergraduate and graduate training opportunities for students and academic institutions not currently well represented in the U.S. S&T ecosystem to expand the pipeline for ASCR research and facilities workforce needs. The NQISRCs will be recompeted, as authorized in the National Quantum Initiative Act. The Request will support 2 to 3 research awards that would contribute to one of up to 4 cross-SC Microelectronics Science Research Centers.	The Request will support increases for AI-focused hardware investments, Microelectronics Science Research Centers, and CSGF.NQISRCs will be recompeted.

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Energy Earthshot Research Centers	$12,500	$12,500	$ —
Funding supports a joint Funding Opportunity Announcement (FOA) to be released by the Office of Science (BES, ASCR, and BER) and the DOE Applied Technology Offices for the initial cohort of EERCs. Emphasis is on the current Earthshot topics and those announced by the Department prior to release of the FOA.		The Request continues to support the EERCs established jointly between Office of Science programs (BES, ASCR, and BER) with strong coordination the DOE Applied Technology Offices. EERC efforts will continue to inform foundational research investments in applied mathematics and computer science that address the longer-term challenges of the Energy Earthshots.	No change.

Note:

- *Funding for the subprogram above, includes 3.65 percent of research and development (R&D) funding for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, excluding facility operations.*

Advanced Scientific Computing Research
High Performance Computing and Network Facilities

Description

The High Performance Production Computing (HPC) and Network Facilities subprogram supports the construction and operations of forefront research computing, networking, and data user facilities to meet critical mission needs. The HPC activity supports the National Energy Research Scientific Computing Center (NERSC) at Lawrence Berkeley National Laboratory (LBNL), which provides HPC resources and large-scale storage to a broad range of SC researchers, and the High Performance Data Facility (HPDF) that will provide a managed computational and data resource to attack fundamental problems in science and engineering. The Leadership Computing activity supports the two Leadership Computing Facilities (LCFs) at Oak Ridge National Laboratory (ORNL) and Argonne National Laboratory (ANL), which provide diverse leading-edge HPC capabilities to the U.S. research and industrial communities. The High Performance Network Facilities and Testbeds activity supports the high performance network user facility, ESnet, which connects all DOE national laboratories and many sites to global research networks and delivers highly reliable data transport capabilities optimized for the requirements of large-scale science. Within the subprogram, facility operations include investments in upgrade projects. The core strength of the facilities is the dedicated staff who work to maximize user productivity and science impact, operate and maintain world-leading research computing, networking, and data infrastructure, while simultaneously executing major upgrade projects.

The HPC and Network Facilities subprogram investments are informed through formal collection of strategic user requirements for research computing and data management from stakeholders across SC and DOE, including the other SC research programs, SC scientific user facilities, DOE national laboratories, and other stakeholders. ASCR continues to observe an accelerating pace of innovation in computing technology through and beyond the exascale era.

Allocation of HPC resources to users follows the merit review public-access model used by all SC scientific user facilities. The Innovative and Novel Computational Impact on Theory and Experiment (INCITE) allocation program provides access to the LCFs; the ASCR Leadership Computing Challenge (ALCC) allocation program provides a path for critical DOE mission applications to access the LCFs and NERSC, and a mechanism to address urgent national emergencies and priorities.

In FY 2025, the facilities will continue implementation of DOE's Integrated Research Infrastructure (IRI) so that researchers can seamlessly and securely meld DOE's unique data, user facilities, and computing resources to accelerate discovery and innovation. At the dawn of the exascale science era, many researchers and collaborations strive to meld data, simulation, and AI tools in novel ways, some with strict operational demands. Agency and program leaders feel the urgency to bring the best-integrated science approaches to bear on our greatest challenges. Implementing the IRI vision requires the creation of an integrated research ecosystem that empowers researchers to rapidly accelerate time to insight.

<u>High Performance Production Computing</u>

The FY 2025 Request for this activity supports the NERSC user facility at LBNL to deliver high-end production computing resources and data services for the SC research community. More than 10,000 researchers conducting over 1,000 projects use NERSC annually to perform scientific research across a wide range of disciplines. NERSC users come from nearly every state in the U.S., with about half based in universities, approximately one-third in DOE laboratories, and other users from government laboratories, non-profits, small businesses, and industry. NERSC aids users entering the HPC arena for the first time, as well as those preparing leading-edge codes that harness the full potential of ASCR's HPC resources.

In FY 2025, NERSC will operate the 125 pf HPE/AMD/NVIDIA NERSC-9 system (Perlmutter), an AI-enabled GPU-CPU system, which came online in FY 2021. NERSC is a vital resource for the SC research community and is consistently oversubscribed, with requests exceeding capacity by a factor of 3–10. In addition, the diversity of data- and compute-intensive research workflows is expanding rapidly. As demand for HPC resources grows and diversifies, ASCR foresees the strategic need for operational resilience and software portability across its HPC resources. The FY 2025 Request also supports the NERSC-10 upgrade project, which is intended to provide SC with an innovative, flexible HPC platform to serve an even greater diversity of NERSC users and use cases. NERSC operations funding also contributes to expanding IRI to satisfy the unique requirements of state-of-the-art real-time experimental/observational workflows and data-integration intensive workflows across the SC user facilities.

In FY 2024, the HPC activity will continue planning for the HPDF project, which will serve as a foundation for the IRI. HPDF will provide a managed computational and data crucial resource to SC programs to attack fundamental problems in science and engineering that require nimble shared access to large data sets, increasingly aggregated from multiple sources and real-time analysis on streamed data directly from experiments or instruments.

Leadership Computing Facilities

The LCFs are national resources built to enable open scientific computational applications, including industry applications, that harness the full potential of extreme-scale leadership computing to accelerate discovery and innovation. The success of this effort is built on the gains made in the ECP, Research and Evaluation Prototypes (REP) and ASCR research efforts. The LCFs' experienced staff deploy cutting edge technologies and provide support to users, scaling tests, early science applications, and tool and library developers. Their efforts are critical enablers of partnerships to broaden the benefits of exascale computing for the Nation. Industry use of the LCFs, often prompt companies to expand their own HPC resources.

The FY 2025 Request for this activity supports operation and competitive allocation of the OLCF at ORNL, including the Nation's first exascale computing system, an HPE-Cray/AMD exascale system (Frontier), deployed in 2021. Funding also supports decommissioning of the 200 PF IBM/NVIDIA OLCF-4 system (Summit), expansion of the Quantum Computing User Program, IRI efforts, AI and advanced computing testbeds and supporting resources. The OLCF played a key role in successful completion of the ECP, including providing early access to exascale resources by industry and interagency partners, and supported multiple teams vying for ACM Gordon Bell Awards in 2022 and 2023.

The FY 2025 Request for this activity also supports operation and competitive allocation of the ALCF at ANL, including the Nation's second exascale system, an Intel/HPE-Cray system (Aurora) deployed in 2023 Funding also supports the 44 PF HPE/AMD/NVIDIA testbed (Polaris); an AI testbed program; IRI efforts, and supporting resources. ALCF's leadership in AI-enabled Exascale science was recognized by the 2022 ACM Gordon Bell Special Prize for HPC-based COVID-19 Research.

The ALCF and OLCF systems are architecturally distinct, consistent with DOE's strategy to manage enterprise risk, foster diverse capabilities that provide the Nation's HPC user community with the most effective resources, and expand U.S. competitiveness. The demand for 2024 INCITE allocations at the LCFs outpaced the available resources by a factor of three, 2023–2024 ALCC demand outpaced resources by a factor of five, and demand is expected to increase as ECP industry and interagency partners adopt ECP technologies as well as growing demand for AI resources. In addition, the LCFs play a key role in deploying IRI, with distinct challenges and resource requirements. Therefore, the LCFs have begun planning for upgrades that would expand capacity and capabilities to address both growing demand and expanded use cases. Meeting these challenges requires significant engagement with vendors to ensure availability of technologies that meet DOE mission needs. In FY 2025, the LCFs will continue planning for future upgrades, cultivate vendor partnerships to spur innovation of strategic value and drive U.S. competitiveness, and contribute to IRI.

High Performance Network Facilities and Testbeds

The FY 2025 Request for this activity supports ESnet, SC's high performance network user facility, providing world-leading wide-area network access for all of DOE. ESnet is widely recognized as a global leader in the research and education network community, with a multi-decade track record of developing innovative network architectures and services, and reliable operations designed for 99.9 percent uptime for connected sites. The current generation of the ESnet backbone network, ESnet6, provides a new era of data transport orchestration, automation, and programmability that is foundational to DOE's IRI. ESnet is the circulatory system that enables the DOE science mission. The ESnet backbone network spans the continental U.S. and the Atlantic Ocean, connecting all 17 DOE National Laboratories and dozens of DOE sites to 200+ research and commercial networks around the world, enabling many tens of thousands of scientists across the country to access data and research resources. ESnet supports the data transport needs of all SC user facilities. In FY 2025, ESnet will continue to invest in site resiliency improvements across the DOE complex and will leverage ESnet6 to develop advanced services to support DOE priority R&D thrusts, DOE's IRI, and cybersecurity.

Integrated Research Infrastructure

This activity supports the community governance and operations of DOE's IRI. In FY 2025 IRI Operations will commence with seating of the IRI Management Council and initial investments to build core IRI services.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
High Performance Computing and Network Facilities	**$652,003**	**$718,235**	**+$66,232**
High Performance Production Computing	$132,003	$146,500	+$14,497
Funding supports operations at the NERSC user facility, including user support, power, space, system leases, and staff. Funding also supports decommissioning of the Cori system; site preparations, design and long-lead procurements for the NERSC-10 upgrade; and full operations and allocation of Perlmutter. In addition, funding supports continued design of the HPDF.		The Request will support operations at the NERSC user facility, including user support, power, space, system leases, and staff. NERSC will deploy the exascale computing software and will prioritize sustaining ECP software and technologies critical to HPC operations and users as ECP concludes. The Request will also support activities such as site preparations, design and procurements for the NERSC-10 upgrade. In addition, funding will support early implementation of DOE’s IRI.	The increase will support site preparations, design and procurements for the NERSC-10 upgrade, early implementation efforts for DOE’s IRI, and sustaining ECP software and technologies critical to HCP operations and users.
National Energy Research Scientific Computing Center (NERSC)	*$130,000*	*$146,500*	*+$16,500*
Funding supports operations at the NERSC user facility, including user support, power, space, system leases, and staff. Funding supports decommissioning of the Cori system, site preparations, design and long-lead procurements for the NERSC-10 upgrade, and full operations and allocation of Perlmutter. In addition, funding supports continued design of the HPDF.		The Request will support operations at the NERSC user facility, including user support, power, space, system leases, and staff. NERSC will deploy the exascale computing software and will prioritize sustaining ECP software and technologies critical to HPC operations and users as ECP concludes. The Request will also support activities such as site preparations, design and procurements for the NERSC-10 upgrade, and full operations and allocation of the NERSC-9 Perlmutter system. In addition, funding will also support early implementation of DOE’s IRI.	The increase will support site preparations, design, and long-lead procurement for the NERSC-10 upgrade, early implementation efforts for DOE’s IRI, and sustaining ECP software and technologies critical to HPC operations and users.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
High Performance Data Facility, OPC *$2,003*	*$ —*	*-$2,003*
Funding supports planning and preconceptual R&D for the HPDF, including site selection and preliminary design activities.	The Request reflects the planned advancement of HPDF as a line item project in FY 2024, contingent on achievement of CD-1 in FY 2024.	No OPC funding is requested.
Leadership Computing Facilities $430,000	$475,195	+$45,195
Funding supports operations at the LCF facilities at ANL and ORNL, including user support, power, space, system leases, early access systems and testbeds, and operations staff. Funding supports operations and allocation of exascale systems at OLCF and ALCF.	The Request will support operations at the LCF facilities at ANL and ORNL, including user support, power, space, system leases, early access systems and testbeds, and staff. The Request will support operations and allocation of exascale systems at OLCF and ALCF as well as planning for future upgrades, vendor partnerships, and DOE's IRI. The LCFs will deploy and maintain ECP software and technologies critical to HPC operations and users.	Funding will support increased operating costs at both OLCF and ALCF to support allocation of the exascale systems, and payment of the Aurora system lease. Increase also supports planning for future upgrades, vendor partnerships, and DOE's IRI, as well as maintenance of ECP software and technologies critical to HPC operations and users.
Leadership Computing Facility at ANL *$175,000*	*$215,195*	*+$40,195*
Funding continues support for the operation and competitive allocation of the Theta and Polaris systems. The ALCF will complete acceptance of the ALCF-3 exascale system, Aurora, which deployed in calendar year 2022 and provides access for early science applications and the Exascale Computing Project. Competitive allocation of Aurora begins through ALCC for some exascale ready teams.	The Request will support start of operations and competitive allocation of the ALCF-3 exascale system, Aurora, which will deploy and maintain ECP software and technologies critical to HPC operations and users. The Request will also support continuing operation and competitive allocation of the ALCF systems as well as AI and advanced computing testbeds, planning for future upgrades, vendor partnerships, and early implementation of DOE's IRI.	Funding will support increased operating costs and system lease payments for the Aurora exascale system, including power, maintenance, and space costs. Increase also supports planning for future upgrades, vendor partnerships, and early implementation efforts for DOE's IRI, as well as maintenance of ECP software and technologies critical to HPC operations and users.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Leadership Computing Facility at ORNL *$255,000*	*$260,000*	*+$5,000*
Funding supports operations at the OLCF facility, including user support, power, space, system leases, maintenance, and staff. Funding also supports full operation and competitive allocation of the Frontier exascale system, Summit, and other testbeds.	The Request will support operations at the OLCF facility, including user support, power, space, maintenance, and staff. The Request will also support operation and competitive allocation of the Frontier exascale system and other AI and advanced computing testbeds. OLCF will deploy and maintain ECP software and technologies critical to HPC operations and users. Summit will be decommissioned at the end of calendar year 2024. Planning for OLCF-6 will begin, including vendor engagements. The Request also supports early implementation of DOE's IRI.	Funding will support operating costs for the Frontier exascale system. Also, funding will support planning for future upgrades, vendor partnerships, and early implementation efforts for DOE's IRI, as well as maintenance of ECP software and technologies critical to HPC operations and users.
High Performance Network Facilities and Testbeds $90,000	$93,540	+$3,540
Funding supports operations of ESnet at 99.9 percent reliability, including user support, operations and maintenance of equipment, fiber leases, R&D testbed, and staff. Funding continues development of advanced network services at the start of operations of the recently completed ESnet6 upgrade project to build the next generation network with new equipment, increased capacity, and an advanced programmable network architecture, in accordance with the project baseline	The Request will support operations of ESnet at 99.9 percent reliability, including user support, operations and maintenance of equipment, fiber leases, R&D testbed, and staff. Funding also supports site resiliency investments and early implementation of DOE's IRI.	The increase will support operations of ESnet and early implementation efforts for DOE's IRI.
Integrated Research Infrastructure $ —	$3,000	+$3,000
	The Request will support commencement of IRI community governance activities and initial investments to build core IRI services.	The increase will support initiation of IRI governance and early operations investments.

Note:
- *Funding for the subprogram above, includes 3.65 percent of research and development (R&D) funding for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, excluding facility operations.*

Advanced Scientific Computing Research
Construction

Description

SC and NNSA completed the Exascale Computing Project (ECP), which was an effort to develop and deploy an exascale-capable computing system with an emphasis on sustained performance for relevant applications and analytic computing to support DOE missions. The deployment of exascale systems at the LCFs, beginning in CY 2021, enabled the completion of all project KPPs, documentation, and close out activities. With the completion of the ECP, as well as upgrades at many of the other SC scientific user facilities, the Department recognized the need for a High Performance Data Facility (HPDF) to ensure the data from these scientific instruments would be accessible to the scientific community. In October 2023, ASCR determined site selection for HPDF. The HPDF will provide a crucial resource to SC programs to attack fundamental problems in science and engineering that require nimble shared access to large data sets, increasingly aggregated from multiple sources. The facility will be designed to dynamically configure computation, network resources and storage to access data at rest or in motion, supporting the use of well-curated datasets as well as near real-time analysis on streamed data directly from experiments or instruments.

24-SC-20, High Performance Data Facility

The FY 2025 Request includes $16,000,000 in Total Estimated Cost (TEC) funding for the HPDF. The preliminary Total Project Cost (TPC) range for this project is $300,000,000 to $500,000,000. The project received approval for CD-0, Approve Mission Need, on August 19, 2020. At that time, the scope of the project was broadly defined to include the potential for site preparation; construction or major upgrade of a data center facility; procurement of non-capital high performance computing, data storage, and local networking equipment; and non-recurring engineering activities with vendor partners to develop critical hardware and software components.

The HPDF will serve as a foundational element in enabling the DOE Integrated Research Infrastructure. HPDF will partner and operate in concert with other ASCR Facilities and potentially other DOE Laboratory computing resource providers to provide a high availability high performance computing and data ecosystem for a wide variety of applications. DOE envisions HPDF will have a “Hub-and-Spoke” model in which a Hub will host centralized resources and also enable high priority DOE mission applications at “Spoke” sites by deploying and orchestrating distributed infrastructure at the Spokes or other locations. The facility will be designed to dynamically configure computation, network resources and storage to access data at rest or in motion, supporting the use of well-curated datasets as well as near real-time analysis on streamed data directly from experiments or instruments.

As early as 2013, a subcommittee of the Advanced Scientific Computing Advisory Committee (ASCAC) cited the need for a Data Facility in its transmittal report noting that “(1) a data-intensive storage and analysis facility with common interfaces and workflows will be necessary, and that (2) building on present ASCR facilities, at least in the near-term, will provide both early successes—such as NERSC’s work with Joint Genome Institute (JGI)—and considerable economies. In addition, there is often considerable synergy between analysis and visualization of large computational and observational data sets.”

With the resurgence of AI/ML and explosion of data volumes and velocities at many scientific user facilities, SC programs and their Scientific User Facilities have proposed accelerating discovery by developing new techniques to steer experiments and facilities; creating computing environments that integrate heterogeneous data for novel analyses; automating and streamlining interpretation of datasets; and making data Findable, Accessible, Interoperable, and Reusable (the FAIR principles of open data). These goals require new designs of computing and data infrastructure that provide researchers with reliable, simple, seamless performance and alleviate burdens from User Facility staff.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Construction	**$77,000**	**$16,000**	**-$61,000**
17-SC-20, SC Exascale Computing Project	$77,000	$ —	-$77,000
Funding supports project management and final execution of applications and software technology to meet the specified KPPs that demonstrate the development of an exascale ecosystem, which is the target of the project.		FY 2024 was the last year of funding for the project, which was successfully completed in FY 2024.	FY 2024 was the final year of funding for the ECP.
24-SC-20, High Performance Data Facility	$ —	$16,000	+$16,000
No funding was appropriated in FY 2023 for this project.		The Request will support design and early Spokes partnerships for the HPDF project in preparation for CD-2.	Funding will support design activities and early Spokes partnerships.

Advanced Scientific Computing Research
Capital Summary

	(dollars in thousands)					
	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Capital Operating Expenses						
Capital Equipment	N/A	N/A	5,000	5,000	5,000	–
Total, Capital Operating Expenses	**N/A**	**N/A**	**5,000**	**5,000**	**5,000**	**–**

Capital Equipment

	(dollars in thousands)					
	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Capital Equipment						
Total, Non-MIE Capital Equipment	N/A	N/A	5,000	5,000	5,000	–
Total, Capital Equipment	**N/A**	**N/A**	**5,000**	**5,000**	**5,000**	**–**

Note:
- *The Capital Equipment table includes MIEs located at a DOE facility with a Total Estimated Cost (TEC) > $10M and MIEs not located at a DOE facility with a TEC >$2M.*

Advanced Scientific Computing Research
Construction Projects Summary

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
24-SC-20, High Performance Data Facility						
Total Estimated Cost (TEC)	293,000	-	-	-	16,000	+16,000
Other Project Cost (OPC)	8,076	2,000	2,003	4,000	-	-2,003
Total Project Cost (TPC)	**301,076**	**2,000**	**2,003**	**4,000**	**16,000**	**+13,997**
Total, Construction						
Total Estimated Cost (TEC)	**N/A**	**N/A**	**-**	**-**	**16,000**	**+16,000**
Other Project Cost (OPC)	**N/A**	**N/A**	**2,003**	**4,000**	**-**	**-2,003**
Total Project Cost (TPC)	**N/A**	**N/A**	**2,003**	**4,000**	**16,000**	**+13,997**

Note:

- *The current estimated TPC for the High Performance Data Facility is $304,933,000. In FY 2023, $1,930,000 in OPC funding was executed and is not reflected in this table.*

Advanced Scientific Computing Research
Scientific User Facility Operations

The treatment of user facilities is distinguished between two types: TYPE A facilities that offer users resources dependent on a single, large-scale machine; TYPE B facilities that offer users a suite of resources that is not dependent on a single, large-scale machine.

(dollars in thousands)

	FY 2023 Enacted	FY 2023 Current	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Scientific User Facilities - Type A					
National Energy Research Scientific Computing Center	**130,000**	**130,000**	**132,000**	**146,500**	**+16,500**
Number of Users	9,200	10,278	10,500	11,000	+1,800
Achieved Operating Hours	–	8,516	–	–	–
Planned Operating Hours	8,585	8,585	8,585	8,585	–
Unscheduled Down Time Hours	–	69	–	–	–
Argonne Leadership Computing Facility	**175,000**	**175,000**	**200,000**	**215,195**	**+40,195**
Number of Users	1,600	1,624	1,650	1,700	+100
Achieved Operating Hours	–	6,909	–	–	–
Planned Operating Hours	7,008	7,008	7,008	7,008	–
Unscheduled Down Time Hours	–	99	–	–	–
Oak Ridge Leadership Computing Facility	**255,000**	**255,000**	**241,000**	**260,000**	**+5,000**
Number of Users	1,700	1,744	1,750	1,800	+100
Achieved Operating Hours	–	6,965	–	–	–
Planned Operating Hours	7,008	7,008	7,008	7,008	–
Unscheduled Down Time Hours	–	43	–	–	–
Energy Sciences Network	**90,000**	**90,000**	**88,400**	**93,540**	**+3,540**
Achieved Operating Hours	–	8,760	–	–	–
Planned Operating Hours	8,760	8,760	8,760	8,760	–
Scientific User Facilities - Type B					

	FY 2023 Enacted	FY 2023 Current	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
		(dollars in thousands)			
High Performance Data Facility	**–**	**–**	**–**	**3,000**	**+3,000**
Total, Facilities	**650,000**	**650,000**	**661,400**	**718,235**	**+68,235**
Number of Users	12,500	13,646	13,900	14,500	+2,000
Achieved Operating Hours	–	31,150	–	–	–
Planned Operating Hours	31,361	31,361	31,361	31,361	–
Unscheduled Down Time Hours	–	211	–	–	–

Note:

- *Achieved Operating Hours and Unscheduled Downtime Hours will only be reflected in the Congressional budget cycle which provides actuals.*
- *Percent optimal operations defines what is achieved at this funding level. This includes staffing, up-to-date equipment and software, operations and maintenance, and appropriate investments to maintain world leadership.*

Advanced Scientific Computing Research
Scientific Employment

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Number of Permanent Ph.Ds (FTEs)	825	813	815	-10
Number of Postdoctoral Associates (FTEs)	365	341	345	-20
Number of Graduate Students (FTEs)	535	595	550	+15
Number of Other Scientific Employment (FTEs)	220	182	220	–
Total Scientific Employment (FTEs)	**1,945**	**1,931**	**1,930**	**-15**

Note:
- *Other Scientific Employment (FTEs) includes technicians, engineers, computer professionals and other support staff.*

24-SC-20, High Performance Data Facility
Thomas Jefferson National Accelerator Facility, TJNAF, and Lawrence Berkeley National Laboratory, LBNL
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary

The FY 2025 Request for the Office of Science (SC) High Performance Data Facility (HPDF) project is $16,000,000 of Total Estimated Cost (TEC) and $ — of Other Project Costs (OPC). The preliminary Total Project Cost (TPC) range for this project is $300,000,000 to $500,000,000. The preliminary TPC estimate for this project is $304,933,000.

In October 2023, the Department announced the selection of the HPDF hub, which will create a new scientific user facility specializing in advanced infrastructure for data-intensive science. The Thomas Jefferson National Accelerator Facility (Jefferson Lab) will be the HPDF Hub Director and the lead infrastructure will be located at Jefferson Lab. The project to build the Hub will be a partnership between Jefferson Lab and Lawrence Berkeley National Laboratory (LBNL), and the two labs will form a joint project team led by Jefferson Lab charged to create an integrated HPDF Hub design.

HPDF will serve as a foundational element in enabling the DOE Integrated Research Infrastructure (IRI) and will provide crucial resources to SC and DOE programs to attack fundamental problems in science and engineering that require nimble shared access to large data sets, increasingly aggregated from multiple sources. HPDF will partner and operate in concert with other ASCR Facilities and potentially other DOE Laboratory computing resource providers to provide a high availability high performance computing and data ecosystem for a wide variety of applications. DOE envisions HPDF will have a “Hub-and-Spoke” model in which a Hub will host centralized resources and also enable high priority DOE mission applications at “Spoke” sites by deploying and orchestrating distributed infrastructure at the Spokes or other locations. The facility will be designed to dynamically configure computation, network resources and storage to access data at rest or in motion, supporting the use of well-curated datasets as well as near real-time analysis on streamed data directly from experiments or instruments.

Significant Changes

The project was a new start in the FY 2024 Request. The most recent DOE Order 413.3B approved Critical Decision (CD) is CD-0, Approve Mission Need for a construction project with a conceptual scope and cost range, which was approved on August 19, 2020.

During FY 2023, the site for the HPDF Hub was selected via a merit review process. The FY 2024 Request will support conceptual design for the HPDF Hub project, an analysis of alternatives in preparation for CD-1, and potentially commencement of site preparation, contingent on achievement of CD-1 in FY 2024. The FY 2025 Request will support planning the final design and establishing the cost, scope, and schedule in preparation for CD-2/3 in late FY 2025.

Critical Milestone History

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
FY 2025	8/19/20	3Q FY 2024	4Q FY 2024	4Q FY 2025	3Q FY 2025	4Q FY 2025	4Q FY 2030

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout.

Project Cost History

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	4,000	290,000	294,000	10,933	10,933	304,933
FY 2025	4,000	290,000	294,000	10,933	10,933	304,933

Note:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*

2. Project Scope and Justification

Scope
At CD-0 the scope of the project was broadly defined to include the potential for site preparation; construction or major upgrade of a data center facility; procurement of non-capital HPC, data storage, and local networking equipment; and non-recurring engineering activities with vendor partners to develop critical hardware and software components. Since CD-0, the scope of the project has evolved to a "Hub and Spoke" model that will integrate centralized Hub and distributed Spoke resources to address mission essential streaming data and edge applications as a critical enabler of DOE's IRI.

The Hub infrastructure is characterized by high-availability, high-performance data-centric resources designed with geographically and operationally resilient active-active failover, with the lead infrastructure at Jefferson Lab and resilience infrastructure at LBNL. The Spokes infrastructure will be distributed data-centric infrastructure at or near the edge, for example at SC User Facilities, DOE national laboratories, and US research institutions. The Hub and Spokes will be tied together as a single, integrated facility through orchestration hardware, software, and services operated by the Hub lead institution, Jefferson Lab, and its partner, LBNL.

The project scope will comprise: design, acquisition, delivery, and commissioning of the Hub infrastructure at Jefferson Lab and LBNL; design, acquisition, delivery, and commissioning of a set of initial spokes; integration of HPDF infrastructure with ESnet and the ASCR HPC facilities including NERSC, ALCF, and OLCF; software development for core HPDF services and development of an operations team that will support the infrastructure and scientific users; data center site preparation, power, and cooling infrastructure at Jefferson Lab and LBNL.

Justification
As early as 2013, a subcommittee of the Advanced Scientific Computing Advisory Committee (ASCAC) cited the need for a Data Facility in its transmittal report, noting that "(1) a data-intensive storage and analysis facility with common interfaces and workflows will be necessary, and that (2) building on present Advanced Scientific Computing Research facilities, at least in the near-term, will provide both early successes—such as National Energy Research Scientific Computing Center's work with Joint Genome Institute (JGI)—and considerable economies. In addition, there is often considerable synergy between analysis and visualization of large computational and observational data sets."

With the growth of AI/ML and explosion of data volumes and velocities at many scientific user facilities, SC programs and their Scientific User Facilities have proposed accelerating discovery by developing new techniques to steer experiments and facilities; creating computing environments that integrate heterogeneous data for novel analyses; automating and streamlining interpretation of datasets; and making data Findable, Accessible, Interoperable, and Reusable (the FAIR principles of open data). These goals require new designs of computing and data infrastructure that provide researchers with reliable, simple, seamless performance and alleviate burdens from User Facility staff. Recent SC workshop reports and requirements reviews cite a number of challenges; Interaction with experiments in real time requires a service type that existing facilities do not provide such as the ability to guarantee a computing resource and quality of service during an experiment. AI/ML also requires the confluence of large well-curated datasets and the compute resources to perform net training activities. Currently, most analyses of experimental and simulation data are done post hoc, after the experiment or simulation has run. Controlling either extreme-scale simulation or experimental facilities with AI requires low-latency analysis and inference using high-volume, high-velocity data sets in real time. Traditional HPC systems are designed to efficiently execute large-scale simulations and focused on minimizing users' wait-times in batch queues. The SC IRI Architecture Blueprint Activity, a convening of over 160 DOE laboratory subject matter experts, identified the need for new high performance data infrastructure to advance these goals as part of a DOE's IRI vision.

The proposed HPDF will serve as a foundational element in enabling the DOE IRI; will provide crucial resources to SC programs to attack fundamental problems in science and engineering that require nimble shared access to large data sets, increasingly aggregated from multiple sources; will partner and operate in concert with other ASCR Facilities and potentially other DOE laboratory computing resource providers to provide a high availability high performance computing ecosystem for a wide variety of applications; will serve as a "Hub" enabling "Spoke" sites to deploy and orchestrate distributed infrastructure to enable high priority DOE mission applications.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, Program and Project Management for the Acquisition of Capital Assets.

Key Performance Parameters (KPPs)
In accordance with DOE Order 413.3B, the project will define preliminary KPPs at CD-1 and final KPPs at CD-2. The Threshold KPPs will represent the minimum acceptable performance that the project must achieve. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion. The Objective KPPs will represent the desired project performance.

Performance Measure	Threshold	Objective
Design/construct building	TBD	TBD
Instrumentation design/development	TBD	TBD

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
Design (TEC)			
FY 2024	1,000	1,000	—
FY 2025	3,000	3,000	3,500
Outyears	—	—	500
Total, Design (TEC)	**4,000**	**4,000**	**4,000**
Construction (TEC)			
FY 2025	13,000	13,000	13,000
Outyears	277,000	277,000	277,000
Total, Construction (TEC)	**290,000**	**290,000**	**290,000**
Total Estimated Cost (TEC)			
FY 2024	1,000	1,000	—
FY 2025	16,000	16,000	16,500
Outyears	277,000	277,000	277,500
Total, Total Estimated Cost (TEC)	**294,000**	**294,000**	**294,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Other Project Cost (OPC)			
Prior Years	1,930	1,930	–
FY 2023	1,930	1,930	–
FY 2024	7,000	7,000	7,933
FY 2025	–	–	2,927
Outyears	73	73	73
Total, Other Project Cost (OPC)	**10,933**	**10,933**	**10,933**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Project Cost (TPC)			
Prior Years	1,930	1,930	–
FY 2023	1,930	1,930	–
FY 2024	8,000	8,000	7,933
FY 2025	16,000	16,000	19,427
Outyears	277,073	277,073	277,573
Total, TPC	**304,933**	**304,933**	**304,933**

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	2,600	2,600	**N/A**
Design - Contingency	1,400	1,400	**N/A**
Total, Design (TEC)	**4,000**	**4,000**	**N/A**
Construction	188,500	188,500	**N/A**
Construction - Contingency	101,500	101,500	**N/A**
Total, Construction (TEC)	**290,000**	**290,000**	**N/A**
Total, TEC	**294,000**	**294,000**	**N/A**
Contingency, TEC	*102,900*	*102,900*	***N/A***
Other Project Cost (OPC)			
OPC, Except D&D	7,106	7,106	**N/A**
OPC - Contingency	3,827	3,827	**N/A**

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total, Except D&D (OPC)	**10,933**	**10,933**	**N/A**
Total, OPC	**10,933**	**10,933**	**N/A**
Contingency, OPC	*3,827*	*3,827*	***N/A***
Total, TPC	**304,933**	**304,933**	**N/A**
Total, Contingency (TEC+OPC)	***106,727***	***106,727***	***N/A***

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	—	—	1,000	—	293,000	294,000
	OPC	1,930	2,003	7,000	—	—	10,933
	TPC	1,930	2,003	8,000	—	293,000	304,933
FY 2025	TEC	—	—	1,000	16,000	277,000	294,000
	OPC	1,930	1,930	7,000	—	73	10,933
	TPC	1,930	1,930	8,000	16,000	277,073	304,933

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	4Q FY 2030
Expected Useful Life	TBD
Expected Future Start of D&D of this capital asset	TBD

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	**Current Total Estimate**	**Previous Total Estimate**	**Current Total Estimate**
Operations	N/A	TBD	N/A	TBD
Utilities	N/A	TBD	N/A	TBD
Maintenance and Repair	N/A	TBD	N/A	TBD
Total, Operations and Maintenance	N/A	TBD	N/A	TBD

Notes:

- *The project is likely to comprise both capital assets (refurbishment or build of data center space) and non-capital assets (IT components that comprise the computational and data management infrastructure). The expected useful life of the former is potentially 10–20 years, while the latter is 5–7 years.*
- *Life-Cycle costs will be performed as part of CD-1.*

7. D&D Information

The scope and nature of D&D activities will be determined at CD-1.

	Square Feet
New area being constructed by this project at [Lab]	TBD
Area of D&D in this project at [Lab]	TBD
Area at [Lab] to be transferred, sold, and/or D&D outside the project, including area previously "banked"	TBD
Area of D&D in this project at other sites	TBD
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously "banked"	TBD
Total area eliminated	TBD

8. Acquisition Approach

In conjunction with the HPDF project, Jefferson Lab will design, construct, and commission the Jefferson Laboratory Data Center (JLDC) building using Commonwealth of Virginia funds. The JLDC scope will contain construction of the building and the infrastructure work required for the HPDF project to take beneficial occupancy on the schedule necessitated by the HPDF project.

Basic Energy Sciences

Overview

The mission of the Basic Energy Sciences (BES) program is to support fundamental research to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels. BES research provides the scientific foundations for innovations in clean energy technologies and related national priorities, to mitigate the climate and environmental impacts of energy generation/use, and to support DOE missions in energy, environment, and national security. BES accomplishes its mission through excellence in scientific discovery and stewardship of world-class scientific user facilities that enable cutting-edge research and development.

The research disciplines that BES supports—condensed matter and materials physics, chemistry, geosciences, and aspects of biosciences—touch virtually every important aspect of energy resources, production, conversion, transmission, storage, efficiency, and waste mitigation, providing a knowledge base for achieving a secure and sustainable clean energy future. The BES Advisory Committee (BESAC) report, "A Remarkable Return on Investment in Fundamental Research,"[a] provides key examples of major technological, commercial, and national security impacts, including clean energy technologies, directly traceable to BES-supported basic research. This mission-relevance of BES research results from a long-standing strategic planning process, which encompasses BESAC reports, community workshops and reports, and rigorous program reviews. BES balances its research investments between discovery-oriented basic research and use-inspired basic research (e.g., Energy Frontier Research Centers [EFRCs], Energy Earthshot Research Centers [EERCs], and Energy Innovation Hubs).

BES scientific user facilities consist of complementary x-ray sources, neutron sources, and centers for research utilizing nanoscale science. Capabilities at BES facilities probe materials and chemical systems with ultrahigh spatial, temporal, and energy resolutions to investigate the critical functions of matter—transport, reactivity, excitations, and motion—to answer challenging science questions and to provide insights on the scientific basis for energy technologies. The above-noted BESAC report recounts the central role of user facilities in U.S. scientific and industrial leadership. During the COVID-19 pandemic, BES facilities were at the forefront of the research to understand the virus, provide therapeutics to combat it, and navigate supply chain issues. BES has a long history of delivering major construction projects on time and on budget, and of providing reliable availability and support to users for operating facilities. This record of accomplishment includes rigorous community engagement in planning and in performance assessment for operating facilities and construction.

Key to exploiting scientific discoveries for future clean energy systems is the ability to create new materials using forefront synthesis and processing techniques, to precisely define the atomic arrangements, and to design chemical processes. These innovations, based on principles revealed by fundamental science and using advanced computational, data science, and experimental tools, will enable better control of physical and chemical transformations and conversions of energy from one form to another for all energy technologies, carbon capture, and sustainable industries. Working closely with other DOE offices, BES research will evolve with awareness of technology challenges and will be disseminated to the broader community to translate federal investments to industrial impact.

BES is focused on enhancing research and user communities to include the full diversity of researchers, students, and institutions. Especially from underserved communities and regions, from across the Nation in order to establish the strongest scientific foundation in the BES ecosystem. Collectively, BES research and facilities provide a significant strategic advantage for the Nation to advance scientific frontiers while laying the foundation for future clean energy innovations and economic prosperity.

Highlights of the FY 2025 Request

The BES FY 2025 Request of $2,582.3 million is an increase of $48.3 million over FY 2023 Enacted.

Research

Guided by BESAC and Basic Research Needs workshop reports, the Request continues support for EERCs, EFRCs, the Batteries and Energy Storage and Fuels from Sunlight Energy Innovation Hub programs, and the National Quantum Information Science (QIS) Research Centers (NQISRCs). Continued funding for the Established Program to Stimulate

[a] https://science.osti.gov/~/media/bes/pdf/BESat40/BES_at_40.pdf

Competitive Research (EPSCoR), Reaching a New Energy Sciences Workforce (RENEW), and Funding for Accelerated, Inclusive Research (FAIR) will strengthen support of emerging research institutions, Historically Black Colleges and Universities (HBCUs) and Minority Serving Institutions (MSIs), and underserved communities and regions, advancing equity and inclusion in a more diverse and inclusive workforce.

- Support continues for research to provide foundational knowledge for clean energy technologies, with investments across the entire portfolio to accelerate innovation. This research will underpin the goals of the DOE Energy Earthshots.[b]
- Funding continues for muti-disciplinary microelectronics research in which materials, chemistries, devices, systems, architectures, algorithms, and software are developed in a closely integrated, co-design approach. As part of this portfolio, the Office of Science (SC) Microelectronics Science Research Centers will comprise a network of multiple team awards, with individual awards focused on a dimension related to a common research topic for each center. The multidisciplinary teams will include researchers from universities, national laboratories, and industry. Materials, chemistries, devices, systems, architectures, algorithms, and software will be developed in a closely integrated fashion in a co-design innovation ecosystem. The Request will support two to three BES research awards that would contribute to one of up to four cross-SC Research Centers.
- Funding increases for Artificial Intelligence and Machine Learning (AI/ML) to accelerate fundamental discoveries and to apply these techniques to user facility operations and interpretation of massive data sets.
- Both the NQISRCs and the Fuels from Sunlight Energy Innovation Hub program complete the initial five-year award periods and will be considered for recompetition/renewal.
- Support continues for QIS, including a robust core research portfolio to complement the NQISRCs; Biopreparedness Research Virtual Environment (BRaVE) to develop and expand capabilities at user facilities for responsiveness to biological threats; Accelerator Science and Technology to provide comprehensive, advanced innovations for BES accelerator-based facilities; basic science for critical materials; and Advanced Computing (with Advanced Scientific Computing Research [ASCR]), which includes computational materials and chemical sciences to deliver shared software infrastructure. BES will prioritize transitioning Exascale Computing Project researchers and software utilization into research efforts.
- BES supports RENEW, expanding targeted efforts, including a RENEW graduate fellowship, to broaden participation in underserved communities and advance equity, and inclusion in SC-sponsored research; and FAIR, improving capability in emerging research institutions, HBCUs and MSIs to perform and propose competitive research and building beneficial relationships with DOE national laboratories and facilities.

Facility Operations

The five BES-supported x-ray light sources, two neutron sources, and five Nanoscale Science Research Centers (NSRCs) are supported at 90 percent of the funding required for re-baselined, full operation—balancing safe, robust operations with user access. Preconceptual planning continues for future Advanced Photon Source (APS), Advanced Light Source (ALS), and Stanford Synchrotron Radiation Lightsource (SSRL) beamline Major Item of Equipment (MIE) projects.

Projects

Support continues for the Linac Coherent Light Source-II High Energy (LCLS-II-HE), Second Target Station (STS), Cryomodule Repair and Maintenance Facility (CRMF), High Flux Isotope Reactor (HFIR) Pressure Vessel Replacement (PVR), and National Synchrotron Light Source (NSLS)-II Experimental Tools-III (NEXT-III) line-item projects.

[b] https://www.energy.gov/energy-earthshots-initiative

Basic Energy Sciences
Funding

(dollars in thousands)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Basic Energy Sciences				
Scattering and Instrumentation Sciences Research	105,971	86,313	96,063	-9,908
Condensed Matter and Materials Physics Research	203,807	183,764	201,644	-2,163
Materials Discovery, Design, and Synthesis Research	97,097	79,147	87,547	-9,550
Established Program To Stimulate Competitive Research EPSCoR	25,000	25,000	25,000	–
Energy Frontier Research Centers - Materials	65,000	65,000	65,000	–
Energy Earthshot Research Centers - Materials	12,500	16,000	12,500	–
Energy Innovation Hubs - Materials	25,913	25,913	25,913	–
Computational Materials Sciences	13,492	13,492	13,492	–
Total, Materials Sciences and Engineering	**548,780**	**494,629**	**527,159**	**-21,621**
Fundamental Interactions Research	127,985	129,677	133,416	+5,431
Chemical Transformations Research	129,651	107,158	115,578	-14,073
Photochemistry and Biochemistry Research	130,877	113,714	118,035	-12,842
Energy Frontier Research Centers - Chemical	65,000	65,000	65,000	–
Energy Earthshot Research Centers - Chemical	12,500	16,000	12,500	–
Energy Innovation Hubs - Chemical	20,758	20,758	20,758	–
General Plant Projects - Chemical	1,000	1,000	1,000	–
Computational Chemical Sciences	13,492	13,492	13,492	–
Total, Chemical Sciences, Geosciences, and Biosciences	**501,263**	**466,799**	**479,779**	**-21,484**
X-Ray Light Sources	599,498	679,944	790,347	+190,849
High-Flux Neutron Sources	315,740	371,924	364,692	+48,952
Nanoscale Science Research Centers	153,409	146,801	164,422	+11,013
Other Project Costs	19,500	5,500	9,500	-10,000
Major Items of Equipment	50,000	25,000	–	-50,000

(dollars in thousands)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Scientific User Facilities, Research	52,610	58,966	62,886	+10,276
Total, Scientific User Facilities (SUF)	**1,190,757**	**1,288,135**	**1,391,847**	**+201,090**
Subtotal, Basic Energy Sciences	**2,240,800**	**2,249,563**	**2,398,785**	**+157,985**
Construction				
24-SC-10 HFIR Pressure Vessel Replacement (PVR), ORNL	–	–	6,000	+6,000
24-SC-12 NSLS-II Experimental Tools - III (NEXT-III), BNL	–	–	5,500	+5,500
21-SC-10 Cryomodule Repair & Maintenance Facility (CRMF), SLAC	10,000	9,000	20,000	+10,000
19-SC-14 Second Target Station (STS), ORNL	32,000	52,000	52,000	+20,000
18-SC-10 Advanced Photon Source Upgrade (APS-U), ANL	9,200	–	–	-9,200
18-SC-11 Spallation Neutron Source Proton Power Upgrade (PPU), ORNL	17,000	15,769	–	-17,000
18-SC-12 Advanced Light Source Upgrade (ALS-U), LBNL	135,000	57,300	–	-135,000
18-SC-13 Linac Coherent Light Source-II-High Energy (LCLS-II-HE), SLAC	90,000	120,000	100,000	+10,000
Subtotal, Construction	**293,200**	**254,069**	**183,500**	**-109,700**
Total, Basic Energy Sciences	**2,534,000**	**2,503,632**	**2,582,285**	**+48,285**

SBIR/STTR funding:

- FY 2023 Enacted: SBIR $35,557,000 and STTR $5,000,000
- FY 2024 Annualized CR: SBIR $31,789,000 and STTR $4,473,000
- FY 2025 Request: SBIR $33,770,000 and STTR $4,749,000

Basic Energy Sciences
Explanation of Major Changes

	(dollars in thousands) FY 2025 Request vs FY 2023 Enacted
Materials Sciences and Engineering Research will continue to support fundamental scientific opportunities for materials innovations. Research priorities include clean energy (e.g., hydrogen, direct air capture of CO_2, energy storage, and wind), microelectronics research, AI/ML, critical materials, computational materials sciences, BRaVE, QIS, strategic accelerator technology, FAIR, and RENEW. The Request also includes funding for continued support of the EFRCs, the Batteries and Energy Storage Energy Innovation Hub, the NQISRCs (recompetition/renewal), EPSCoR, and the EERCs.	**-$21,621**
Chemical Sciences, Geosciences, and Biosciences Research will continue to support fundamental scientific opportunities for innovations in chemistry, geosciences, and biosciences. Research priorities include clean energy (e.g., hydrogen, geothermal, and direct air capture of CO_2), AI/ML, microelectronics research, critical materials, computational chemical sciences (recompetition), QIS, FAIR, and RENEW. The Request also includes funding for continued support of the EFRCs, the Fuels from Sunlight Hubs (renewal), the NQISRCs (recompetition/renewal), and the EERCs.	**-$21,484**
Scientific User Facilities (SUF) The 12 BES user facilities are supported at 90 percent of the re-baselined funding level, balancing safe operation and user access. The facilities will continue to support the BRaVE initiative to maintain and enhance capabilities to tackle biological threats. Continued facilities research priorities include accelerator science and technology, expansion of AI/ML, and RENEW. The Request also provides Other Project Costs to support the HFIR-PVR and NEXT-III projects.	**+$201,090**
Construction The Request provides continuing support for the LCLS-II-HE, STS, CRMF, HFIR-PVR, and NEXT-III projects.	**-$109,700**
Total, Basic Energy Sciences	**+$48,285**

Basic and Applied R&D Coordination

As a program that supports fundamental scientific research relevant to many DOE mission areas, BES strives to build and maintain close connections with other DOE program offices. BES coordinates with DOE R&D programs through a variety of Departmental activities, including workshops, strategic planning activities, solicitation development, and program review, as elaborated below. BES also coordinates with DOE technology offices in the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) program, including topical area planning, solicitations, reviews, and award recommendations.

BES has robust interactions with DOE technology offices through formal and informal coordination activities. Formal coordination includes Joint Strategy Teams (JSTs) and Science and Energy Technology Teams (SETTs) that draw on expertise and capabilities stewarded by multiple DOE offices to address forefront energy challenges. BES participates in all eight of the Energy Earthshots. Historically, co-siting of research by BES and other DOE programs at the same institutions has facilitated close integration of basic and applied research. The DOE national laboratory system plays a crucial role in achieving this integration of basic and applied research.

Informal coordination includes BES program manager participation in intra-DOE information exchange and coordination on solicitations and participation in program reviews and project selections. These activities facilitate cooperation and coordination between BES and other parts of DOE, notably the energy technology offices.

Program Accomplishments

- In FY 2023, over 13,700 unique users accessed BES user facilities, [c] approximately 27 percent taking advantage of remote access, with approximately 13 percent of the users from emerging research institutions, HBCUs and MSIs.
- Two major facility upgrade projects to maintain world-leading capabilities, LCLS-II and APS-U, attained significant milestones. LCLS-II successfully achieved first light at the end of FY 2023 and the project was completed in early FY 2024. APS-U began installation of the upgraded storage ring.
- Led by one of DOE’s National QIS Research Centers, the Argonne Quantum Foundry was launched to provide the Nation’s QIS research community with high quality, standardized semiconductor materials, tools, and data, offering end-to-end solutions for design, testing, fabrication, and integration of new materials into quantum systems.
- The ANL-led Joint Center for Energy Storage Research (JCESR), the Batteries and Energy Storage Energy Innovation Hub, completed ten years of ground-breaking research for beyond lithium-ion batteries, with over 1,000 journal papers, nearly 100 inventions, 34 patents, and three startups, and, importantly, training for more than 330 students and postdoctoral fellows who now have careers in academia, industry, and at DOE national laboratories.
- EFRC researchers developed a new method for synthesizing mixed halide-perovskite solar cells that enables better control over the rate of crystallization, yielding higher quality materials with improved stability and performance under real world conditions.
- To understand photosynthesis, the final steps of light-driven oxidation of water to oxygen by photosystem II (PSII) were characterized at room temperature using x-ray lasers, including LCLS, revealing for the first time the atomic structure of intermediates in the final step of the PSII reaction cycle.
- Researchers demonstrated rapid and nearly complete disinfection of water containing *E. coli* using a suspended nanostructured powder exposed to direct sunlight. The powder could be removed with a simple magnet and reused in a new contaminated water sample.
- The combination of precise synthesis, operando characterization, and theory uncovered the dynamic behavior of catalytic active sites during a wide range of reactions, providing insights for designing more efficient catalysts and potentially reducing use of critical elements.
- Scientists have developed a nanoscale electron imaging method that unveils the effects of heat in materials with atomic resolution. Understanding thermal transport at this scale is of paramount importance to the field of energy conversion and quantum computing.

[c] Note that the number of users was less than prior fiscal years due to the APS outage for facility upgrades.

- First principles computations provided insight on why, surprisingly, adding salt in chemical vapor deposition of thin films used in electronics enables faster synthesis at lower temperature, with broad implications for optical, electrical, photovoltaic, and catalytic properties.
- Inspired by early experiments of Einstein and de Haas on ferromagnetism, cutting-edge imaging revealed ultrafast mechanical motion tied to a change in magnetic state in a layered material. This now measurable response enriches the toolbox for designing functional nanomechanical devices and other applications requiring ultra-precise and fast motion control.
- A tour de force of characterization tools (in situ nuclear magnetic resonance, x-ray scattering, and atomic force microscopy) has confirmed a long-held view of the multi-step crystallization process for materials with open atomic frameworks that are used in energy technologies from catalysis to carbon capture.
- Using LCLS along with quantum simulations of the reaction dynamics, for the first-time researchers directly imaged the transition state of a chemical reaction in real time, enabling better understanding of the point of no return in a chemical reaction.
- For the first time, a team of scientists demonstrated that x-rays could characterize materials at the single atom limit. This beamline combines x-rays from the APS with a scanning tunneling microscope to characterize metal and rare-earth atoms in molecular systems.
- Research led to a new software package—AtomAI—for analyzing images from electron and scanning probe microscopes that applies deep learning to conduct real-time analysis of atomic resolution data to understand materials behavior.
- The DOE EPSCoR program, designed to enhance geographic balance specifically addressing underserved communities in the DOE portfolio, transitioned to funding from SC's six major research programs. Significantly, EPSCoR added Puerto Rico and Guam to the portfolio. In FY 2023, SC provided $38 million for research at academic institutions in 21 EPSCoR states and jurisdictions. Beyond the EPSCoR program, SC strives to meet the 10 percent threshold encouraged by the CHIPS and Science Act of 2022.
- In use-inspired research, EPSCoR research led to discoveries in ion transport for extraction of metals for lithium- or sodium-ion batteries and desalination, machine learning methodologies for understanding synthesis, and new catalysts that enable sustainable hydrogen production.

Basic Energy Sciences
Materials Sciences and Engineering

Description

Materials are critical to nearly every aspect of energy generation, storage, transmission, and end-use, as well as numerous other critical technologies. Materials limitations are often a significant barrier to improved energy efficiencies, longer lifetimes of infrastructure and devices, or the introduction of new technologies for clean energy to tackle climate change. The Materials Sciences and Engineering subprogram supports research to provide the fundamental understanding and control of materials synthesis, properties, and performance that will enable solutions to wide-ranging challenges in clean energy generation, storage, and use, as well as opening new directions that are not foreseen based on existing knowledge. The research explores the origin of macroscopic material behaviors; their fundamental connections to atomic, molecular, and electronic structures; and their evolution as materials move from nanoscale building blocks to mesoscale systems. At the core of the subprogram is experimental, theoretical, computational, and instrumentation research that will enable the predictive discovery, design, and characterization of new materials with novel structures, functions, and properties.

To accomplish these goals, the portfolio includes three integrated research activities:

- **Scattering and Instrumentation Sciences Research**—Advancing science using new tools and techniques to characterize materials structure and dynamics across multiple length and time scales, including ultrafast science, and to correlate this data with materials performance under real world and extreme conditions.
- **Condensed Matter and Materials Physics Research**—Understanding the foundations of material functionality and behavior including electronic, magnetic, thermal, optical, and mechanical properties that result from material composition and quantum mechanics; and understanding the impact of external stimuli, including extreme environments, on material properties and performance.
- **Materials Discovery, Design, and Synthesis Research**—Developing the knowledge base and synthesis strategies to design and precisely assemble structures to control properties and enable discovery of new materials with unprecedented functionalities, including approaches that limit the need for critical materials, enable more effective polymer chemistries, and are learned from biological systems.

The Request continues the highest-priority fundamental research that supports the DOE mission, including research that will establish the foundational knowledge necessary to accelerate innovation to advance clean energy technologies and other national priorities. The portfolio emphasizes understanding of how to direct and control energy flow in materials systems over multiple time and length scales, and translation of this understanding to prediction of material behavior, transformations, and processes in challenging real-world systems. This will establish a foundational knowledge base for future advanced clean energy technologies and advanced industrial processes. The research supported by this subprogram explores new frontiers of emergent materials behavior; utilization of nanoscale control; and materials systems that are metastable or far from equilibrium to enable novel materials design and sustainable manufacturing. In clean energy-related research, emphasis is on carbon dioxide removal, low-carbon hydrogen production, and energy storage for both transportation and the grid. Also, critical materials research will provide foundational knowledge to enable secure and sustainable supply chains for key clean energy technologies.

Research activities in quantum materials emphasize the development of systems that realize unique properties required for QIS technologies. Materials science for microelectronics will provide the needed advances for future computing, sensors, detectors, and communication that are critical for national priorities in clean energy and for leadership in advanced research over a wide range of fields. An increasingly important aspect of materials research is the use of data science techniques to enhance the utility of both theoretical and experimental data for predictive design and discovery of materials. As an essential element of this research, this subprogram supports the development of advanced characterization tools, instruments, and techniques that can assess a wide range of space and time scales, especially in combination and under dynamic operando conditions to analyze non-equilibrium materials, conditions, and excited-state phenomena.

In addition to a diverse portfolio of single-investigator and small-group research projects, this subprogram supports Computational Materials Sciences, EFRCs, the Batteries and Energy Storage Hub program, and, in partnership with other SC programs, NQISRCs and EERCs. These research modalities support multi-investigator, multi-disciplinary research focused on forefront scientific challenges in support of the DOE clean energy mission.

This subprogram includes the DOE EPSCoR program to expand investments in early-stage clean energy and climate research for U.S. states and territories that do not historically have large federally-supported academic research programs, expanding DOE research opportunities to a broad and diverse scientific community. This subprogram also supports two additional activities aimed at cultivating an equitable and expanded science, technology, engineering, and math (STEM) education, engagement, and workforce ecosystem: the RENEW and FAIR initiatives. The RENEW initiative aims to broaden participation in underserved communities and advance equity and inclusion in SC-sponsored research. The FAIR initiative enhances research capacity for clean energy, climate, and related topics at emerging research institutions, HBCUs and MSIs.

Scattering and Instrumentation Sciences Research

Research in Scattering and Instrumentation Science supports innovative techniques and instrumentation development for advanced materials science research with scattering, spectroscopy, and imaging using electrons, neutrons, and x-rays, including development of science to understand ultrafast dynamics. These techniques provide precise and complementary information about the relationship among structure, dynamics, and properties, as evidenced by the major advances in materials sciences from DOE's world-leading electron, neutron, and x-ray scattering facilities. The importance of imaging and multimodal platforms to reveal the most critical features of a material has been a finding in several of the Basic Research Needs and BESAC reports. These tools and techniques are also critical in advancing understanding and discovery of novel quantum materials, including materials for next-generation systems to advance microelectronics and QIS. The tools and capabilities developed in this program are broadly applicable to other fields including chemistry, biology, and geoscience, and can be a key component in preparedness for biological threats.

The unique interactions of electrons, neutrons, and x-rays with matter enable a range of complementary tools with different sensitivities and resolution for the characterization of materials and other systems at length- and time-scales spanning many orders of magnitude. Included is the use of cryogenic environments to evaluate properties only occurring at low temperatures and to learn about processes and interfaces in materials that are damaged by the probes used to characterize them. As an example, to aid in the design of transformational new materials for clean energy technologies such as batteries, operando experiments contribute to understanding the atomic and nanoscale changes that lead to materials failure in non-equilibrium and extreme environments. Advances in cryogenic microscopy will support the BRaVE initiative since this instrumentation is heavily used to characterize biological systems.

Condensed Matter and Materials Physics Research

This activity supports fundamental experimental and theoretical research to discover, understand, and control novel phenomena in solid materials, generating scientific knowledge that is foundational to the BES mission. These electronic, magnetic, optical, thermal, and structural materials make up the infrastructure for clean energy technologies and innovations to tackle climate change impacts, as well as accelerator and detector technologies for SC facilities and other national priorities such as microelectronics and QIS. Also supported is research to understand the role of critical materials in determining material properties and functionality, so that they can be reduced or eliminated from key energy technology supply chains.

Experimental research in this program emphasizes discovery and characterization of materials' properties that have the potential to be exploited for new technological functionalities. Complementary theoretical research aims to explain such properties across a broad range of length- and time-scales. Theoretical research also includes development and integration of predictive theory and modeling for discovery of materials with targeted properties. Advanced computational and data science techniques, including AI/ML, are increasingly enabling knowledge to be extracted from large materials databases of theoretical calculations and experimental measurements. This program also supports the development of such databases as well as the computational tools that can take advantage of them.

This program continues to emphasize understanding and control of quantum materials whose properties result from interactions of the constituent electrons with each other, the atomic lattice, or light. The research advances the fundamental understanding of electronic, magnetic, thermal, and optical properties relevant to energy-efficient microelectronics and QIS. Activities also emphasize research to understand how materials respond to temperature, light, radiation, corrosive chemicals, and other environmental conditions.

In FY 2025, BES will continue to partner with other SC programs in the recompetition/renewal of the NQISRC funding as the original awards complete their five-year award period. Research supported by this program will include theory of materials for quantum applications in computing, communication, and sensing; device science for next-generation QIS systems, including interface science and modeling of materials performance; and synthesis, fabrication, and characterization of quantum materials, including integration into novel device architectures to explore QIS functionality.

In partnership with other SC programs, BES will continue activities to support multi-disciplinary basic research to accelerate the advancement of microelectronic technologies in a co-design innovation ecosystem, as called for by the Basic Research Needs for Microelectronics report.[d]

As part of this portfolio, the Office of Science Microelectronics Science Research Centers will comprise a network of multiple team awards, with individual awards focused on a dimension related to a common research topic for each Center. The multidisciplinary teams will include researchers from universities, national laboratories, and industry. Materials, chemistries, devices, systems, architectures, algorithms, and software will be developed in a closely integrated fashion in a co-design innovation ecosystem. The request will support two to three BES research awards that would contribute to one of up to four cross-SC Research Centers.

Materials Discovery, Design, and Synthesis Research

The predictive design, discovery, and development of new materials with desired properties has long been recognized as the engine that drives science frontiers and technology innovations. This activity aims to grow and maintain U.S. leadership in materials discovery by investing in advanced synthesis capabilities and by coupling these with state-of-the-art user facilities and advanced computational capabilities at DOE national laboratories, generating scientific knowledge that is foundational to the BES mission, including clean energy and tackling the impacts of climate change.

The BESAC report on transformative opportunities for discovery science reinforced the importance of the continued growth of synthesis science, recognizing the opportunity to realize targeted functionality in materials by controlling the synthesis and assembly of hierarchical architectures and beyond equilibrium matter. The FY 2025 Request continues support of materials discovery and synthesis research to understand the unique properties of critical materials, with the goal of reducing their use. Research directions will be inspired by recent BES reports, including low-carbon hydrogen and carbon dioxide removal. Understanding of synthesis science will enable design of new systems that are easier to efficiently convert into similar products with comparable or enhanced complexity, functionality, and value.

The portfolio supports fundamental research in solid-state chemistry to enable discovery of new functional materials and the development of new crystal growth methods and thin film deposition techniques to create complex materials with targeted structure and properties. In addition to research on chemical and physical synthesis processes, an important element of this portfolio is research to understand how to use bio-mimetic and biology-inspired approaches to design and synthesize novel materials with some of the unique properties found in nature.

Established Program to Stimulate Competitive Research (EPSCoR)

The DOE EPSCoR program funds early-stage research that supports DOE’s energy mission in states and territories with historically lower levels of federal academic research funding. Eligibility determination for the DOE EPSCoR program follows the National Science Foundation’s eligibility analysis. Managed by BES, the funding for the EPSCoR program is distributed among the six major research programs within SC per direction from the FY 2023 Enacted Appropriation.

The DOE EPSCoR program emphasizes research that will improve the capability of designated states and territories to conduct sustainable and nationally competitive fundamental and early-stage energy-related research; jumpstart research capabilities in designated states and territories through training scientists and engineers in energy-related areas; and build

[d] https://science.osti.gov/-/media/bes/pdf/reports/2019/BRN_Microelectronics_rpt.pdf

beneficial relationships between scientists and engineers in the designated jurisdictions and world-class national laboratories managed by the DOE.

Annual EPSCoR funding opportunities alternate between a focus on research performed in collaboration with the DOE national laboratories and a focus on larger-team implementation awards. The FY 2025 program will focus on implementation awards for development of research capacity and infrastructure, including equipment, for competitive research in EPSCoR jurisdictions. The technical scope will focus on the research topics supported by SC program offices and clean energy research broadly, expanding these important research communities. The program will continue to support other SC initiatives, including Early Career, RENEW, and FAIR.

Energy Frontier Research Centers

The EFRC research modality brings together the skills and talents of teams of investigators to combine discovery science and energy-relevant, basic research whose scope and complexity is beyond what is possible in standard single-investigator or small-group awards. These multi-investigator, multi-disciplinary centers foster, encourage, and accelerate basic research to enable transformative scientific advances and uncover new and innovative solutions to the most difficult problems in materials sciences. The EFRCs supported in this subprogram focus on: the design, discovery, synthesis, characterization, and understanding of novel, solid-state materials that convert energy into electricity; the understanding of materials and processes that are foundational for electrical energy storage; quantum materials and QIS; microelectronics; and materials for future nuclear energy and waste storage.

In FY 2025, BES will continue support for EFRC awards made in FY 2022 and FY 2024.

Energy Earthshot Research Centers

The EERC program was launched in FY 2023, building on the success of the EFRCs. Like the EFRCs, EERCs bring together multi-investigator, multi-disciplinary teams to perform energy-relevant research with a scope and complexity beyond what is possible in standard single-investigator or small-group awards. Beyond the scope of the EFRCs, the EERC program addresses the knowledge gaps that are key to realizing the stretch goals of the DOE Energy Earthshots,[e] with joint planning by SC and energy technology offices. The funding will focus on efforts to ensure that fundamental research and capabilities tackle the most challenging barriers identified in the applied research and development activities.

From a science perspective, many research gaps for the Energy Earthshots can provide a foundation for other clean energy technology challenges, including biotechnology, critical materials/minerals, energy-water, subsurface science, and materials and chemical processes under extreme conditions for nuclear applications. These gaps require multiscale computational and modeling tools, new AI/ML technologies, real-time characterization, including in extreme environments, and basic science to co-design processes and systems rather than individual materials, chemistries, and components. EERCs can cross-fertilize the ideas that emerge in one topic area to benefit others with similar challenges, accelerating scientific discovery as well as technology development.

The FY 2025 Request will continue support for the EERCs established in prior fiscal years.

Energy Innovation Hubs

The Batteries and Energy Storage Energy Innovation Hub program will continue to tackle forefront, basic scientific challenges for next-generation electrochemical energy storage. Energy Innovation Hubs focus on collaborative research to overcome key scientific barriers for major energy challenges that require large, multidisciplinary teams to provide the required science foundations and innovations. In FY 2025, BES will continue to support Batteries and Energy Storage Energy Innovation Hub awards initiated in prior years through an open recompetition of the program.

Computational Materials Sciences

Awards in this program focus on research leading to computational codes and associated experimental/computational databases for the design of materials with advanced functionalities. The research includes development of new ab initio theory, contributing the generated data to databases, as well as advanced characterization and controlled synthesis to

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[e] https://www.energy.gov/energy-earthshots-initiative

provide the data to validate the computational predictions. The computational codes are designed for DOE's leadership computational facilities to take advantage of today's exascale high-performance computers. This will result in open source, robust, experimentally validated, user-friendly software that captures the essential physics of relevant materials systems.

In FY 2025, BES will continue support for awards made in prior years.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Materials Sciences and Engineering	**$548,780**	**$527,159**	**-$21,621**
Scattering and Instrumentation Sciences Research	$105,971	$96,063	-$9,908
Funding continues to focus on the development and use of advanced characterization tools to address the most challenging fundamental questions in materials science, including quantum behavior and properties. The use of multiscale and multimodal techniques to extract information on multiple length and time scales is a growing emphasis, as is the development and application of cryogenic microscopy techniques to answer open questions in physical sciences. Advanced instrumentation research can be applied to diverse national priorities, including QIS, clean energy science, advanced manufacturing, and preparedness for biological threats. Funding supports the RENEW, FAIR, and Accelerate initiatives.		The Request will continue to focus on the development and use of advanced characterization tools, including the use of multiscale, multimodal, and cryogenic techniques to extract information on multiple length and time scales. Advanced instrumentation research can be applied to diverse national priorities, including QIS, clean energy science, advanced industrial processes, and preparedness for biological threats (cryogenic microscopy). The RENEW initiative expands targeting efforts to increase participation and retention of individuals from underserved communities, and from emerging research institutions, HBCUs and MSIs in SC research activities.	Reductions will target mature research topics in the portfolio to allow expanded investments in RENEW activities, which will emphasize basic energy sciences research topics and will provide research and training opportunities for emerging research individuals from underserved communities, and from emerging research institutions, HBCUs and MSIs.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Condensed Matter and Materials Physics Research $203,807	$201,644	-$2,163
Funding continues to emphasize the understanding and control of the fundamental properties of materials that are central to their functionality in a wide range of clean energy-relevant technologies, including critical materials/minerals, and for reduction of climate change impacts. Exploration of quantum materials remains a high priority, and particularly the role that these materials play in microelectronics, accelerators, and the broad emerging field of QIS. The program continues to partner with other SC program offices to support the NQISRCs that were initiated in FY 2020. Additional investments support the SC Energy Earthshots initiative, including the response of materials to environmental conditions, such as temperature, light, corrosive chemicals, and radiation, particularly in the context of future clean energy technologies.	The Request will continue to emphasize the understanding and control of the fundamental properties of materials, including critical materials, that are central to their functionality in a wide range of clean energy-relevant technologies. Exploration of quantum materials remains a high priority, and particularly the role that these materials play in microelectronics, accelerators, and QIS. The program will partner with other SC program offices in the recompetition of the NQISRCs as the original awards complete five years of research. Additional investments will support the SC Energy Earthshots initiative and awards as part of the Microelectronics Science Research Centers.	Expanded investments will focus on gaps in the current portfolio of condensed matter research that supports science foundations for DOE's Energy Earthshots. In addition, investments in AI/ML will aim to maximize the value of data in scientific discovery. Funding will support awards as part of the Microelectronics Science Research Centers. Reductions will target mature research topics in the portfolio.

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Materials Discovery, Design, and Synthesis Research	$97,097	$87,547	-$9,550
Funding continues support for the design, discovery, and synthesis of novel forms of matter with desired properties and functionalities with an emphasis on advancing the fundamental science relevant to future low-carbon manufacturing and reduction of climate change impacts, including innovative approaches to scalable assembly and integration of characterization and predictive modeling. Research continues to explore science-based solutions to materials criticality. Research on bio-mimetic and biologyinspired materials is relevant to energy technologies as well as other national priorities such as preparedness for and response to biological threats. Additional investments in these topical areas focus on support for the SC Energy Earthshots initiative.		The Request will continue support for the design, discovery, and synthesis of novel forms of matter with desired properties and functionalities with an emphasis on advancing the fundamental science relevant to future low-carbon industrial processes and clean energy technologies. Research on bio-mimetic and biology-inspired materials is relevant to energy technologies as well as other national priorities such as preparedness for and response to biological threats.	Reductions will target mature research topics in the portfolio.
Established Program to Stimulate Competitive Research (EPSCoR)	$25,000	$25,000	$ —
Funding continues to support early-stage R&D, including research that underpins DOE energy technology programs, the SC Energy Earthshots initiative, and innovations for climate science. Following the previous year's focus on State-National Laboratory Partnership awards, FY 2023 emphasizes Implementation Awards to larger multiple investigator teams that develop research capabilities in EPSCoR jurisdictions. The FY 2023 funding opportunity considers new and renewal proposals. Investment continues in early career research faculty from EPSCoR-designated jurisdictions and in coinvestment with other programs for awards to eligible institutions.		The Request will continue to support early-stage R&D, including research that underpins DOE energy technology programs, the SC Energy Earthshots initiative, and innovations for climate science. Following the previous year's focus on State-Lab partnership awards, FY 2025 will emphasize Implementation awards, larger multiple investigator teams that develop research capabilities, including investment in instrumentation, in EPSCoR jurisdictions. Investment will continue in early career research faculty from EPSCoR-designated jurisdictions and in co-investment with other initiatives such as FAIR, RENEW, and Energy Earthshots for awards to eligible institutions.	Funding will focus on Implementation Awards, with the aim to improve the capability of designated states and territories to conduct sustainable and nationally competitive fundamental and early-stage energy-related research.

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Energy Frontier Research Centers	$65,000	$65,000	$ —
Funding provides the fourth year of support for the four-year EFRC awards that were made in FY 2020 and the second year of support for awards that were made in FY 2022.		The Request will provide the fourth year of support for four-year EFRC awards that were made in FY 2022 and the second year of funding for awards made in FY 2024 in a broad range of topics relevant to clean energy and other national priorities.	Technical emphasis for the EFRC program will continue to include research directions identified in recent strategic planning activities related to clean energy, QIS, microelectronics, and other national priorities.
Energy Earthshot Research Centers	$12,500	$12,500	$ —
Funding supports a FOA to be released by SC (BES, ASCR, BER), in coordination with the DOE Technology Offices, for the initial cohort of EERCs. EERCs will bring together the multi-investigator, multi-disciplinary teams necessary to perform energy-relevant research that bridges the gap between basic research and applied research and development activities. They emphasize the innovations at the basic-applied interface required to advance the current Energy Earthshot topics and those announced by DOE prior to release of the FOA.		The Request will provide support for the EERCs that were initiated in prior fiscal years.	Funding will continue to support development of science foundations for DOE's Energy Earthshots.
Energy Innovation Hubs	$25,913	$25,913	$ —
Funding supports an open re-competition of the Batteries and Energy Storage Hub program.		The Request will support the third year of funding for new Batteries and Energy Storage Hub awards initiated in prior years through an open competition.	No change.

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request		Explanation of Changes FY 2025 Request vs FY 2023 Enacted	
Computational Materials Sciences	$13,492		$13,492		$ —
Funding continues research that focuses on development of computational codes and associated experimental and computational databases for the predictive design of functional materials. The research includes development of new ab initio theory, populating databases, and advanced characterization and controlled synthesis to validate the computational predictions. The goal is open source, validated software that uses today's DOE's leadership computational facilities and is poised to take advantage of tomorrow's exascale high-performance computers. BES plans to issue a FOA in FY 2023 to recompete awards made in FY 2019.		The Request will support the third year of funding for awards made in FY 2023 and the second year of funding for awards planned for FY 2024. The Request will continue to support research aimed at the development of open source, validated software that takes advantage of DOE's leadership computing facilities.		No change.	

Note:
- *Funding for the subprogram above, includes 3.65 percent of research and development (R&D) funding for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, excluding facility operations.*

Basic Energy Sciences
Chemical Sciences, Geosciences, and Biosciences

Description
Development of innovative clean energy technologies relies on understanding and ultimately controlling transformations of energy among forms and conversions of matter across multiple scales starting at the atomic level. The Chemical Sciences, Geosciences, and Biosciences subprogram supports research to discover fundamental knowledge of chemical reactivity and energy conversion foundational to energy-relevant chemical processes, such as catalysis, synthesis, separations, and light-driven chemical transformations. The research addresses how physical and chemical phenomena at the scales of electrons, atoms, and molecules control complex and collective behavior of macroscopic-scale energy and matter conversion systems. Fundamental knowledge developed through this subprogram can enable ground-breaking science to tailor chemical transformations with atomic and molecular precision. The challenge is to achieve predictive understanding of complex chemical, geochemical, and biochemical systems at the same level of detail now known for simpler molecular systems.

To address these challenges, the portfolio includes coordinated research activities in three areas:

- **Fundamental Interactions Research**—Discover the foundational factors controlling chemical reactivity and dynamics based on the understanding of fundamental quantum interactions in gases, condensed phases, and at interfaces.
- **Chemical Transformations Research**—Understand and control the mechanisms of chemical catalysis, synthesis, separation, stabilization, and transport in complex chemical and subsurface systems, from atomic to geologic scales.
- **Photochemistry and Biochemistry Research**—Elucidate the molecular mechanisms of the capture of light energy and its conversion into electrical and chemical energy through biological and chemical pathways.

The Request continues the highest-priority fundamental research, including scientific knowledge to accelerate innovation that can reduce climate change impacts and advance clean energy technologies, infrastructure, and a circular economy. Support will continue for research to discover and develop chemical processes for low-carbon, efficient, and circular approaches for advanced industrial processes and for reduced dependence on critical materials and minerals. Fundamental biochemistry will discover principles that could enable biomimetic and biohybrid clean energy systems and guide new biotechnology approaches. Research on molecular science will advance innovations for microelectronics and increase understanding of the phenomena relevant to QIS and quantum computing. Integration of data science and computational chemistry will provide tools and infrastructure needed for shared data repositories.

The subprogram advances fundamental science through a diverse portfolio of research including single investigators, small groups, and large multi-investigator, cross-disciplinary teams through EFRCs, the Fuels from Sunlight Energy Innovation Hub program, and Computational Chemical Sciences (CCS). The subprogram also partners across SC to support the NQISRCs and EERCs. This subprogram also supports two activities aimed at cultivating an equitable and expanded STEM education, engagement, and workforce ecosystem: the RENEW and FAIR initiatives. The RENEW initiative aims to broaden participation in underserved communities and regions and advance equity, and inclusion in SC-sponsored research. The FAIR initiative enhances research capacity for clean energy, climate, and related topics at emerging research institutions, HBCUs and MSIs.

Fundamental Interactions Research
This activity emphasizes structural and dynamical studies of atoms, molecules, and nanostructures, and the description of their interactions in full quantum detail. The goal is to achieve a complete understanding of reactive chemistry in the gas phase, in condensed phases, and at interfaces. This activity provides leadership for ultrafast chemistry and advances ultrafast tools and approaches to probe and control chemical processes. Research is conducted at the boundary of chemistry and physics to understand chemical, physical, and electron- and photon-driven processes at interfaces and in liquids. This activity also supports theory and computation for accurate descriptions of molecular reactions and chemical dynamics, optimal use of exascale computing facilities, and potential application of future quantum computers to computational quantum chemistry. These efforts provide the foundational knowledge and state-of-the-art experimental and computational tools necessary to advance the subprogram's research activities and the BES mission, including clean energy approaches that can reduce impacts contributing to climate change.

In FY 2025, BES will continue to partner with other SC programs in the recompetition/renewal of the NQISRC funding as the original awards complete their five-year award terms. Research in this program will advance the current state-of-the-art science and technology toward realizing the full potential of quantum-based applications, from computing to communication to sensing and may include cross-cutting research such as sensors, quantum emulators/simulators, and enabling technologies that can pave the path to quantum computing in the longer term.

Continuing ongoing activities, FY 2025 research in microelectronics will unravel the complex mechanisms of chemical reactions at interfaces to inform the design and synthesis of new materials.[f] Research in clean energy will address basic science for novel synthesis, processing, modeling, operando characterization, and validation approaches. The Fundamental Interactions activity will continue to advance data science and computational approaches for chemical sciences with a focus on computational chemistry tools to generate scientific knowledge foundational to the BES mission.

SC Microelectronics Science Research Centers will comprise a network of multiple team awards, with individual awards focused on a dimension related to a common research topic for each Center. The multidisciplinary teams will include researchers from universities, national laboratories, and industry. Chemistries, materials, devices, systems, architectures, algorithms, and software will be developed in a closely integrated fashion in a co-design innovation ecosystem. The request will support two to three BES research awards that would contribute to one of up to four cross-SC Research Centers.

Chemical Transformations Research

This activity seeks fundamental knowledge of chemical reactivity, matter and charge transport, and chemical separation and stabilization processes that are foundational for development of future clean energy technologies and for innovations to mitigate or adapt to climate change. Fundamental research in this activity spans catalysis science, separation science, heavy element chemistry, and geosciences. This research advances the understanding of charge transport and reactivity, which determine the kinetics of electrocatalytic, separation, and geochemical processes; identifies mechanisms for catalytic efficiency and selectivity, critical materials recovery, and sustainable conversion of energy resources; explores the influence of complex interfaces on chemical transformations; develops mechanistic insights needed to control reaction pathways in diverse catalytic, separation, and geological environments; and develops understanding of chemistry in subsurface and aqueous systems important in sustainable chemical processes.

In FY 2025, this activity will continue to support efforts central to transformative approaches for clean energy,[g] including predictive design of catalytic and separations processes for circular use of natural and synthetic resources with atom and energy efficiency.[h] In support of the Energy Earthshots initiative, this activity will focus on discovery and design of sustainable cycles for carbon and hydrogen–including enhanced carbon separation from dilute and concentrated sources and clean energy cycles of hydrogen generation, storage, and use–and provide fundamental knowledge of subsurface processes such as mineralization, crack propagation, and rock fracture to foster innovative clean energy subsurface technologies. Research will continue to address critical materials with a focus on novel approaches for resource identification and extraction, selective separation, and substitution of critical elements. Research will also investigate the unique quantum phenomena enabled by rare earth elements and actinides. The use of data science and AI/ML approaches will be emphasized to accelerate the generation and propagation of scientific knowledge foundational to the BES mission.

Photochemistry and Biochemistry Research

This activity supports research on the molecular mechanisms of light energy capture and its conversion into electrical and chemical energy in both natural and man-made systems. This mechanistic understanding can inspire strategies to control reaction pathways for clean energy conversions and to tackle climate change. This activity integrates research at the interface of chemistry, physics, and biology and plays a leadership role in the support of basic research in both natural photosynthesis and solar photochemistry. Research explores the dynamic mechanisms of charge transport and reactivity to understand absorption, transfer, and conversion of energy across spatial and temporal scales and redox interconversion of atoms and small molecules (e.g., carbon dioxide/methane, nitrogen/ammonia, and protons/hydrogen) important for clean fuels. Research aims to understand complex interfaces and aqueous environments in enzyme function, natural and artificial

[f] https://science.osti.gov/-/media/bes/pdf/reports/2019/BRN_Microelectronics_rpt.pdf

[g] https://science.osti.gov/-/media/bes/pdf/reports/2020/Transformative_Mfg_Brochure.pdf

[h] https://science.osti.gov/-/media/bes/pdf/reports/2020/Chemical_Upcycling_Polymers.pdf

membranes, and nano- to meso-scale structures. Research also examines the effects of ionizing radiation on chemical reactions in extreme environments, providing insights for remediation, fuel-cycle separation, and nuclear reactor design.

In FY 2025, research will continue to establish a molecular-level understanding of biochemical and photochemical processes. BES biochemistry and biophysics research will discover and design chemical processes and complex structures for innovations in clean energy technologies, microelectronics, and climate change mitigation, including bio-inspired and biohybrid systems with desired functions and properties. In support of the Energy Earthshots initiative, research includes new approaches for harnessing solar energy for chemical conversions, providing knowledge for carbon-neutral hydrogen production technologies and potentially for use of photo-driven quantum coherence to enhance fuel generation. Research will also address challenges for reducing use of critical and rare earth elements in light absorbers and catalysts. This activity supports the RENEW and FAIR initiatives to build strong programs at emerging research institutions, underserved communities, HBCUs and MSIs, and to enhance research on clean energy and climate.

Energy Frontier Research Centers

The EFRC research modality brings together the skills and talents of teams of investigators to combine discovery science and energy-relevant, basic research whose scope and complexity is beyond what is possible in standard single-investigator or small-group awards. These multi-investigator, multi-disciplinary centers foster, encourage, and accelerate basic research to enable transformative scientific advances and uncover new and innovative solutions to the most difficult problems in chemical sciences, geosciences, and biosciences. The EFRCs supported in this subprogram focus on the design, discovery, characterization, and control of chemical, biochemical, and geological processes for improved electrochemical conversion and storage of energy; the understanding of catalytic chemistry and biochemistry that are foundational for fuels, chemicals, separations, and upcycling; interdependent energy-water issues; QIS; future nuclear energy and the chemistry of waste processing; and the advanced interrogation and characterization of the earth's subsurface.

In FY 2025, BES will continue support for EFRC awards made in FY 2022 and FY 2024.

Energy Earthshot Research Centers

SC launched the EERC program in FY 2023, building on the success of the EFRCs. Like the EFRCs, EERCs bring together multi-investigator, multi-disciplinary teams to perform energy-relevant research with a scope and complexity beyond what is possible in standard single-investigator or small-group awards. Beyond the scope of the EFRCs, the EERC program addresses the knowledge gaps that are key to realizing the stretch goals of the DOE Energy Earthshots,[i] with joint planning by SC and energy technology offices. In FY 2025, the funding will focus efforts to ensure that fundamental research and capabilities tackle the most challenging barriers identified in the applied research and development activities.

From a science perspective, many research gaps for the Energy Earthshots can provide a foundation for other clean energy technology challenges, including biotechnology, critical materials/minerals, energy-water, subsurface science, and materials and chemical processes under extreme conditions for nuclear applications. These gaps require multiscale computational and modeling tools, new AI/ML technologies, real-time characterization, including in extreme environments, and basic science to co-design processes and systems rather than individual materials, chemistries, and components. EERCs can cross-fertilize the ideas that emerge in one topic to benefit others with similar challenges, accelerating scientific discovery as well as technology development.

Energy Innovation Hubs

Energy Innovation Hubs focus on collaborative research to overcome key scientific barriers for major energy challenges that require large, multidisciplinary teams to provide the required science foundations and innovations. The Fuels from Sunlight Hub program addresses both new directions and long-standing challenges identified in the report from the Liquid Solar Fuels Roundtable.[j]

The two Fuels from Sunlight Hub awards conduct fundamental research on key scientific challenges for solar fuels production that uses solar energy, water, and carbon dioxide as the only inputs. These awards received the final year of

[i] https://www.energy.gov/energy-earthshots-initiative

[j] https://science.osti.gov/-/media/bes/pdf/reports/2020/Liquid_Solar_Fuels_Report.pdf

funding for their initial five-year award term in FY 2024. As part of BES oversight, both projects have been evaluated via peer review on an annual basis since their initiation. Given the latest review results, the overall scientific and technological progress of both projects, and the distinct role of the Hub research in the BES portfolio, the Department will consider both awards for renewal in FY 2025 and make renewal determinations based on the outcome of external peer review. Renewals would allow the projects to capitalize on their achievements during the initial funding period and to further advance research efforts addressing critical needs in solar fuels development.

Computational Chemical Sciences

The CCS supports basic research to develop validated, open-source codes and associated experimental/computational databases for modeling and simulation of complex chemical processes and phenomena and that can take advantage of today's exascale high-performance computers. This research supports a publicly accessible website[k] of open source, robust, validated, user-friendly software that captures the essential physics and chemistry of relevant chemical systems. The goal is use of these codes/data by the broader research community and by industry to dramatically accelerate chemical research in the U.S.

In FY 2025, BES will recompete the CCS awards from FY 2021 and FY 2022. BES will prioritize transitioning Exascale Computing Project (ECP) researchers and use of ECP software for research in this recompetition.

General Plant Projects

General Plant Projects funding provides for minor new construction, for other capital alterations and additions, and for improvements to land, buildings, and utility systems to maintain the productivity and usefulness of DOE-owned facilities and to meet requirements for safe and reliable facilities operation.

[k] https://ccs-psi.org/

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Chemical Sciences, Geosciences, and Biosciences	**$501,263**	**$479,779**	**-$21,484**
Fundamental Interactions Research	$127,985	$133,416	+$5,431
Funding continues to develop forefront ultrafast approaches, with emphasis on the use of x-ray free electron lasers, including LCLS and its upgrades. Gasphase research continues studies of how reactive intermediates impact reaction pathways. Continued emphasis is placed on quantum phenomena underlying QIS, such as coherence and entanglement. Research expands efforts to understand and control chemical processes and quantum phenomena at the molecular level. In FY 2023, research continues to emphasize understanding and control of interfacial chemical conversion mechanisms for clean energy applications and of designing and synthesizing new materials relevant to microelectronics. This activity continues to develop advanced theoretical and computational approaches that can be scaled to operate on exascale computers. Development of data science methods increase to enable novel approaches for knowledge discovery. This activity provides continued support for the NQISRCs established in FY 2020.		The Request will continue to develop innovative ultrafast approaches, with emphasis on use of x-ray free electron lasers; determine how reactive intermediates affect reaction pathways; and characterize quantum phenomena underlying QIS. Research will also target the understanding and control of interfacial chemical conversion mechanisms and quantum phenomena to advance clean energy technologies, climate mitigation technologies (e.g., emissions mitigation), AI/ML, and microelectronics. This activity will generate and use advanced theoretical and computational approaches that can take advantage of exascale computing capabilities and data science methods for knowledge discovery. The program will partner with other SC program offices in the recompetition/renewal of the NQISRCs as the original awards complete five years of research. Additional investments will support awards as part of the Microelectronics Science Research Centers.	Expanded investments will include additional support for microelectronics and AI/ML. Investments will emphasize basic research related to clean energy and climate. Funding will support awards as part of the Microelectronics Science Research Centers. Reductions will target mature research topics in the portfolio.

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Chemical Transformations Research	$129,651	$115,578	-$14,073
Funding continues supporting fundamental research to understand catalytic mechanisms for thermo- and electro-chemical conversions important in clean energy and advanced manufacturing technologies, including chemical upcycling of polymers, and in innovations to reduce climate change impacts. Separation science research continues to focus on innovative mechanisms for high-efficiency processes, including reactive and electro-separations, and novel solvents. Heavy element research continues to deepen understanding of actinide speciation and reactivity and fundamental theories of f-electron systems. Geosciences research continues to elucidate subsurface phenomena, such as mineralization and rock fracture propagation under extreme subsurface conditions. Areas for increased emphasis include atomically precise synthesis of new catalysts and studies of chemical processes required to develop clean energy technologies: multiscale phenomena in extreme and constrained environments in the subsurface; separations and extraction of rare earth elements from complex and dilute mixtures; and alternative approaches that reduce use of critical elements.		The Request will continue fundamental research to understand catalytic mechanisms for thermo- and electro-chemical conversions and to develop atomically precise synthesis of catalysts important for clean energy and climate change mitigation. Research in separation science will continue to focus on innovative mechanisms for high-efficiency chemical separations and processes. Heavy element research will continue to advance understanding of actinide speciation and reactivity and f-electron systems. Geosciences research will continue to reveal subsurface phenomena, such as mineralization and rock fracture propagation, that can be foundational to climate mitigation strategies. Research will continue to advance the separations and extraction of rare earth elements from complex and dilute mixtures and the development of alternative approaches to reduce use of critical elements. Additional investments will support the SC Energy Earthshots initiative.	Reductions will target mature research topics in the portfolio. Expanded investments will include support for the SC Energy Earthshots initiative, including innovations in catalysis, geosciences, and separations. Investments will emphasize basic research related to clean energy, climate, and microelectronics.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Photochemistry and Biochemistry Research $130,877	$118,035	-$12,842
Funding continues support of core research to understand physical, chemical, biophysical, and biochemical processes of light energy capture and conversion. Studies of light absorption, energy transfer, charge transport, separation processes, and photocatalysis provides fundamental insights that can lead to innovations in the design of new clean energy systems and processes and in reduction of climate change impacts. Study of biochemical processes and structures provides a foundation for bio-inspired, biohybrid, and biomimetic systems with desired functions and properties, including design of efficient catalysts and reaction pathways. Solar fuels research continues to address the molecular mechanisms of photon capture, charge transport, product selectivity and separation from non-target molecules, and the reduction of critical elements in photoabsorbers and catalysts. Biological and chemical studies investigates how quantum phenomena affect energy conversion efficiency and fidelity. Funding supports the SC Energy Earthshots, FAIR, RENEW, and Accelerate initiatives.	The Request will continue research on physical, chemical, biophysical, and biochemical processes of light energy capture and conversion which could inspire innovations for clean energy and climate change mitigation. Biochemical studies can provide insights for bio-inspired and biohybrid systems with desired functions and properties, as well as for new strategies for artificial photosynthesis, carbon dioxide removal, and biotechnology. Solar fuels research will address molecular mechanisms of photon capture, charge transport, product selectivity, and reduced critical element use in photoabsorbers and catalysts. Biological and chemical studies will examine the role of quantum phenomena in energy conversion. The FAIR and RENEW initiatives continue efforts to increase participation and retention of researchers from underserved communities, as well as from emerging research institutions, HBCUs and MSIs in SC research activities. Additional investments will support the RENEW and SC Energy Earthshots initiatives.	Reductions will target mature research topics in the portfolio. Expanded investments will include support for the SC Energy Earthshots initiative including innovations in solar and bio-based fuels and other products and will broaden RENEW activities to provide research and training opportunities for emerging research institutions, HBCUs, MSIs and underserved communities.
Energy Frontier Research Centers $65,000	$65,000	$ —
Funding provides the final year of support for four-year EFRC awards that were made in FY 2020 and the second year of support for awards that were made in FY 2022.	The Request will provide the fourth year of support for four-year EFRC awards that were made in FY 2022 and the second year of funding for awards made in FY 2024 in a broad range of topics relevant to clean energy and other national priorities.	Technical emphasis for the EFRC program will continue to include research directions related to clean energy, QIS, microelectronics, and other national priorities.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Energy Earthshot Research Centers $12,500	$12,500	$ —
Funding supports a FOA to be released by SC (BES, ASCR, BER), in coordination with the DOE Technology Offices, for the initial cohort of EERCs. EERCs will bring together the multi-investigator, multi-disciplinary teams necessary to perform energy-relevant research that bridges the gap between basic research and applied research and development activities. They emphasize the innovations at the basic-applied interface required to advance the current SC Energy Earthshot topics and those announced by DOE prior to release of the FOA.	The Request will provide support for the EERCs that were initiated in prior fiscal years.	Funding will continue to support the development of science foundations for DOE's Energy Earthshots.
Energy Innovation Hubs $20,758	$20,758	$ —
Funding continues support of fundamental research to address both long-standing and emerging new scientific challenges for solar fuels generation. Research continues to focus on innovative artificial photosynthesis approaches to generate liquid fuels using only sunlight, carbon dioxide, and water as inputs. Experiment and theory are integrated for the design of processes, components, and systems for selective, stable, and efficient liquid solar fuels production for clean energy.	The two Hub awards will be considered for renewal of up to five years. Renewal would allow each project to capitalize on its achievements during the initial funding period and to further advance research efforts on solar fuels generation for clean energy, climate change mitigation, and sustainability. The Department will base its renewal decisions on research progress, external peer review, and programmatic priorities.	The research scope of the renewal projects will build on the accomplishments of the first phase of these Hub awards and continue fundamental research on innovative artificial photosynthesis approaches for liquid fuels generation using only sunlight, carbon dioxide, and water as inputs.
Computational Chemical Sciences $13,492	$13,492	$ —
Funding continues CCS awards made in FY 2021 and FY 2022, with ongoing research to develop public, open-source codes for future exascale computer platforms.	The Request continues funding to develop public, validated, open-source software that takes advantage of DOE's leadership computing facilities. BES plans to issue a FOA in FY 2025 to recompete awards made in FY 2021 and 2022. BES will prioritize transitioning ECP researchers and software utilization into these research efforts.	Funding will continue to support research focused on the development of computational codes and associated experimental and computational databases for the predictive design of chemical processes and assemblies.

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request		Explanation of Changes FY 2025 Request vs FY 2023 Enacted	
General Plant Projects	$1,000		$1,000		$ —
Funding supports minor facility improvements at Ames Laboratory.		The Request will support minor facility improvements at Ames National Laboratory.		No change.	

Note:

- *Funding for the subprogram above, includes 3.65 percent of research and development (R&D) funding for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, excluding facility operations.*

Basic Energy Sciences
Scientific User Facilities (SUF)

Description
The Scientific User Facilities subprogram supports operation of a geographically diverse suite of major research facilities that provide unique tools to thousands of researchers from a wide diversity of universities, industry, and government laboratories to advance a broad range of sciences. The BES user facilities portfolio consists of a complementary set of intense x-ray sources, neutron scattering facilities, and research centers for nanoscale science. These facilities allow researchers to probe materials in space, time, and energy with the resolution to interrogate the inner workings of matter to help understand the fundamental aspects of the natural world. Operated on an open access, competitive, merit review basis, scientists from every state can utilize the facilities' capabilities and sophisticated instrumentation.

The 12 BES scientific user facilities collectively contribute to important scientific results across basic and applied research in chemistry, physics, geology, materials science, environmental science, biology, and biomedical science that can lead to the discovery and design of advanced materials and novel chemical processes with broad societal impacts. Before the COVID-19 pandemic, more than 16,000 scientists and engineers in many fields of science and technology used BES scientific facilities annually. In FY 2023, user populations at most BES user facilities approached or exceeded pre-pandemic levels.

During the pandemic, user facilities were available mainly through remote access with the priority to support the development of potential therapeutic drugs and vaccines through structural studies of the proteins of the SARS-CoV-2 virus, which causes COVID-19. The BES facilities continue to support ongoing research efforts to evolve the tools and expertise needed for future public health challenges. In FY 2025, continued support to enhance user capabilities for research on biological threats is included in the BRaVE initiative.

User facilities conduct hundreds of experiments simultaneously around the clock, generating vast quantities of raw experimental data that must be stored and analyzed to translate the data into information to yield answers to important scientific questions. The data challenges continue to grow as new capabilities and advanced detector technologies come online. Data science and AI/ML methods coupled with advanced computing hardware are required to address these challenges and get the highest value data from user experiments. There are also AI/ML opportunities to improve the efficiency and reliability of accelerator and instrument operations. In FY 2025, there is increased investment to support the research needed to realize these opportunities in AI/ML.

Maintaining world-leading capabilities is crucial for competitiveness as advances in tools and instruments often drive scientific discovery. Major upgrades to BES facilities are supported through line-item construction and MIEs, including support for new/upgraded x-ray and neutron experimental stations and forefront nanoscience instrumentation. The subprogram also supports research in accelerator and detector development to explore technology options for the next generations of x-ray and neutron sources. Keeping BES accelerator-based facilities at the forefront requires continued, transformative advances in accelerator science and related technologies.

The FY 2025 Request supports user facilities at 90 percent of the operational budget requirements determined by the user facilities. Base requirements for operating user facilities continue to increase due to the steady rise in the cost of staff, utilities, maintenance, and materials; evolution of the user needs for remote use; increased data and computational costs; and transitioning of new capabilities from facility upgrades to operations. While requiring additional staff and capabilities, remote use of the facilities allows access to researchers from institutions, underserved regions, and companies that otherwise would not be able to take advantage of these resources to advance their programs and products. Funding at the 90 percent level will require a careful balance to meet costs to ensure safe, robust operations and world-leading user access.

<u>X-Ray Light Sources</u>
X-rays are an essential tool for studying the structure of matter and have long been used to see things that visible light cannot resolve, such as the arrangement of atoms in metals, semiconductors, biological molecules, and other materials and chemical systems. Beyond structure, x-rays are critical tools for assessing dynamics as materials and chemistries evolve. Large-scale light source facilities have vastly enhanced the utility of existing x-ray techniques such as diffraction, spectroscopy, and imaging, and have given rise to entirely new ways to do experiments that would not otherwise be

feasible with conventional x-ray machines. Owing to their broadly tunable wavelengths (from the infrared to hard x-rays), coherence, ultrafast pulses, and control of the polarization, light source facilities are incisive probes for advanced research in physical and chemical sciences, materials, metrology, geosciences, environmental sciences, and life sciences.

BES operates five light sources, including a free electron laser, the LCLS at SLAC, and four storage ring-based sources—the ALS at LBNL, the APS at ANL, SSRL at SLAC, and NSLS-II at BNL. BES provides funding to support facility operations, technical support, computational tools required to translate data into understanding of phenomena, and user program administration to enable cutting-edge research at these facilities, which are made available to all researchers with access determined via peer review of user proposals. All facilities have extensive outreach efforts to ensure that researchers have fair and equitable access for their science and engineering research regardless of the focus of their research (these are multidisciplinary research facilities), their geographical location, or the size of their institution.

Upgrade projects are underway for the APS, ALS, and LCLS to ensure ongoing world leadership for these facilities. Since completing construction of NSLS-II in FY 2015, the initial suite of seven beamlines has expanded to the current 29 beamlines with three under construction, and room for about 30 more. To adopt the most up-to-date technologies and provide the most advanced capabilities, BES has a phased approach to new beamlines at NSLS-II, as was done for other BES facilities. The NSLS-II Experimental Tools-II (NEXT-II) MIE project, started in FY 2020, provides three best-in-class beamlines to support the needs of the U.S. research community. In FY 2024, planning and conceptual design funds were requested for NEXT-III, a line-item construction project to deliver the next cadre of beamlines.

In FY 2025, preliminary planning will continue for future APS, ALS, and SSRL beamline MIEs.

<u>High-Flux Neutron Sources</u>
BES supports two neutron sources at ORNL, HFIR and SNS. Neutron sources are used to understand the factors that determine the properties and functions of matter and provide foundational insights for development of new materials and molecules with desired functionality. Thermal and cold neutrons are a unique tool for the study of atomic-scale structure and dynamics. The wavelength and energy of neutrons are similar to interatomic distances and elementary excitations in materials, allowing atomic-resolution studies of structure and an investigation of material dynamics. As they carry no charge, neutrons can assess bulk properties. Critically, neutrons can discriminate different isotopes of the same element, making them a unique probe to resolve, for example, the location of hydrogen atoms in organic and biological materials via isotope substitution of deuterium for hydrogen. In addition, their magnetic moments allow investigation of magnetism, important for electronic technologies and systems.

The HFIR generates neutrons via fission. HFIR operates at 85 megawatts and provides state-of-the-art facilities for neutron scattering, isotope production, materials irradiation, and neutron activation analysis. It is the world's leading production source of elements heavier than plutonium for medical, industrial, and research applications. There are 12 neutron scattering beamlines in the user program at HFIR, which include state-of-the-art instruments for spectroscopy, diffraction, imaging, and small angle scattering. In FY 2025, operations funding will continue to support efforts to replace the beryllium reflector at HFIR. In addition, funding is requested to continue planning, design, R&D, analysis, engineering, and prototyping to advance the replacement of the aging HFIR pressure vessel.

The SNS uses a different approach to produce neutron beams, where an accelerator generates proton pulses that strike a heavy-metal target such as mercury. As a result of impacts, cascades of neutrons are produced in a process known as spallation. The SNS is the world's brightest pulsed neutron facility, and presently offers 19 beamlines. This is a world-leading suite of instruments for very high-resolution spectroscopy and diffraction, reflectometry, spin echo, and small angle spectrometers. All the SNS instruments are in extreme demand by U.S. researchers and world-wide in a very broad range of scientific disciplines. Current construction projects at SNS focus on maintaining world-leadership for neutron scattering.

At both HFIR and SNS, investments will advance data science, AI/ML, and computing hardware to plan experiments, analyze data, and efficiently operate the accelerator, reactor, and beamlines. In addition, support will continue development of new tools for biopreparedness (under the BRaVE initiative).

Nanoscale Science Research Centers

Developments at the nanoscale are foundational for delivery of remarkable scientific discoveries that transform our understanding of energy and matter to advance national priorities and energy security. The NSRCs provide the tools and capabilities for experimental and computational research that lead to technology innovations, new experimental tools, and new computational and modelling capabilities. Distinct from the x-ray and neutron sources, NSRCs comprise a suite of smaller unique tools and platforms, as well as expert scientific staff that enable and advance probing, manipulating, and assembling single atoms, clusters of atoms, and molecular structures for transformative science.

The five NSRCs are the Center for Nanoscale Materials (CNM) at ANL, the Center for Functional Nanomaterials (CFN) at BNL, the Molecular Foundry (MF) at LBNL, the Center for Nanophase Materials Sciences (CNMS) at ORNL, and the Center for Integrated Nanotechnologies (CINT) at SNL and LANL. Each center has unique and distinct expertise and capabilities for synthesis and assembly; theory, modeling, and simulation; imaging and spectroscopy, including electron and scanning probe microscopy; and nanostructure fabrication and integration. Selected thematic areas include quantum materials, next generation semiconductors, nanoscale photonics, catalysis, and soft/biological materials. These facilities include clean rooms, nanofabrication resources (crucial for semiconductor and QIS research), one-of-a-kind signature tools, custom advanced instrumentation laboratories, and unique AI/ML and data science analytical capabilities. Operating funds ensure cutting-edge research capabilities, technical support, and administration of the user program, which serves academic, government, and industry researchers with open access determined through external peer review of user proposals.

Going forward, the NSRCs will continue to spearhead the development of flexible infrastructure and enabling capabilities for materials synthesis, device fabrication, metrology, modeling, and simulation. Investments will focus on evolving these capabilities to address the most pressing national needs, including clean energy and next generation tools, including AI/ML.

Other Project Costs

The total project cost (TPC) is comprised of total estimated cost (TEC) and OPC. TEC includes post-Critical Decision (CD)-1 costs for engineering; the acquisition of equipment; and construction/fabrication. OPC represents all other costs incurred during the initiation and definition phase for planning, conceptual design, research, and development, and during the execution phase for startup and commissioning. OPC is always funded via operating funds.

Major Items of Equipment

BES supports MIE projects to ensure the continual development and upgrade of major scientific facility capabilities, by fabricating upgraded and new stand-alone instruments and capabilities at X-Ray Light Sources, High-Flux Neutron Sources, and NSRCs.

Research

This activity supports research from conceptual studies of accelerator physics and instrumentation to their translation into components or techniques that improve BES user facilities and maintain international competitiveness. Production of beams with increased average flux/brightness and detection tools responsive to the high beam intensities are required components for the advancement of light and neutron sources. Research on superconducting undulators will focus on increasing magnetic fields and eliminating the use of liquid helium, reducing cost and environmental impact. Higher beam availability is needed to respond to the increasing number of facility users, requiring research on techniques to support multiple beamlines simultaneously. Detectors require higher computational capabilities per pixel, improved readout rates, radiation hardness, and better energy and temporal resolutions. Higher neutron-flux capabilities at the SNS will demand tight control of beam losses and detectors designed for advanced neutron imaging. BES coordinates with the SC Office of Accelerator R&D and Production on crosscutting research and technology areas.

Investments will continue to support the development of data science methods and tools to address data and information challenges. Funding continues for the RENEW initiative that provides undergraduate and graduate training at DOE national laboratories and user facilities for individuals from HBCUs and MSIs. Investment will also support the BRaVE initiative, which will maintain and evolve capabilities at user facilities related to responsiveness to biological threats.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Scientific User Facilities (SUF)	**$1,190,757**	**$1,391,847**	**+$201,090**
X-Ray Light Sources	$599,498	$790,347	+$190,849
Funding supports operations at five BES light sources (LCLS, APS, ALS, NSLS-II, and SSRL).		The Request will support operations at five BES light sources (LCLS, APS, ALS, NSLS-II, and SSRL). Development of capabilities for biopreparedness, computational techniques, and data will continue.	Funding will support LCLS, APS, ALS, NSLS-II and SSRL operations at 90 percent of required funding, accounting for inflation, supply chain costs, staffing support, remote operations, and costs for operation of new/upgraded capabilities.
High-Flux Neutron Sources	$315,740	$364,692	+$48,952
Funding supports operations at SNS and HFIR.		The Request will support operations at SNS and HFIR (including ongoing funding for maintenance of HFIR with the beryllium reflector replacement). Development of capabilities for biopreparedness, computational techniques, and data will continue.	Funding will support operations for SNS and HFIR at 90 percent of required funding, accounting for inflation, supply chain costs, staffing support, remote operations, and costs for operation of new/upgraded SNS capabilities.
Nanoscale Science Research Centers	$153,409	$164,422	+$11,013
Provides funding for five NSRCs (CFN, CNM, CNMS, MF, and CINT). The NSRCs continue to develop nanoscience and QIS-related research infrastructure and capabilities for materials synthesis, device fabrication, metrology, modeling and simulation.		The Request will provide funding for five NSRCs (CFN, CNM, CNMS, MF, and CINT). The NSRCs will continue to develop infrastructure and capabilities to maintain world-leading synthesis, device fabrication, characterization, modeling, and simulation.	Funding will support operations for the five NSRCs at 90 percent of required funding, accounting for inflation, supply chain costs, staffing support, remote operations, and other costs.
Other Project Costs	$19,500	$9,500	-$10,000
Funding supports OPC for the LCLS-II-HE project at SLAC, the STS project at ORNL, the APS-U project at ANL, and the CRMF project at SLAC. Funds also initiate OPC for the HFIR-PVR project at ORNL and the NEXT-III project at BNL.		The Request will support OPC for the HFIR-PVR project at ORNL and the NEXT-III project at BNL.	Funding will support the HFIR-PVR project at ORNL, and the NEXT-III project at BNL. OPC will support conceptual design and planning for these projects.

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Major Items of Equipment	$50,000	$ —	-$50,000
Funding continues the beamline project for NEXT-II at BNL and the recapitalization project for the NSRCs. Both projects received CD-2/3 approval in FY 2022.		No MIE funding is requested in FY 2025.	Final funding for the NEXT-II and NSRC Recapitalization MIE projects was requested in FY 2024.
Research	$52,610	$62,886	+$10,276
Funding supports high-priority research activities for advanced seeded FEL schemes that provide several orders of magnitude performance enhancement, detectors with high read out rate, optics that can handle high heat load and preserve the coherent wave front, and applications of data science techniques to accelerator optimization, control, prognostics, and data analysis. Research emphasizes transformative advances in accelerator science and technology that lead to significant improvements in very high brightness and high current electron sources and in high intensity proton sources. In addition, research expands to include enabling capabilities for response to biological threats and RENEW internships.		The Request will support high-priority research activities for accelerators, detectors, and applications of data science techniques to accelerator optimization, control, prognostics, and data analysis. Research will emphasize transformative advances in accelerator science and technology that lead to significant improvements in very high brightness and high current electron sources and in high intensity proton sources. In addition, research will expand to include enabling capabilities for data science/AI/ML and continue for response to biological threats and to increase the diversity of the research performers.	Funding will support investment in future accelerator and detector technologies to continue to provide the world's most comprehensive and advanced accelerator-based facilities for scientific research. Funding will expand investments in data science/AI/ML methods and tools to address data and information challenges at the BES user facilities, including accelerator control and experiment automation with real time data analysis.

Note:

- *Funding for the subprogram above, includes 3.65 percent of research and development (R&D) funding for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, excluding facility operations.*

Basic Energy Sciences
Construction

Description

Accelerator-based x-ray light sources, accelerator-based pulsed neutron sources, reactor-based neutron sources, and nanoscale science research centers are essential user facilities that enable critical DOE mission-driven science, including research in support of clean energy. These user facilities provide the academic, laboratory, and industrial research communities with the tools to fabricate, characterize, and develop new materials and chemical processes to advance basic and applied research, advancing chemistry, physics, earth science, materials science, environmental science, biology, and biomedical science. Regular investments in construction of new user facilities and upgrades to existing user facilities are essential to maintaining U.S. leadership in these research areas.

24-SC-10, HFIR Pressure Vessel Replacement (PVR), ORNL

The HFIR PVR project will replace the aging HFIR pressure vessel to extend facility lifetime, enable resumption of 100 MW operations, and enhance isotope production and scattering research. These upgrades will maintain a domestic high-flux, steady-state neutron source for diverse and critical missions. For example, in addition to the hundreds of neutron scattering users, isotope production supports research, clinical and medical uses, and federal and industrial applications, including NASA deep space missions. The project received CD-0, Approve Mission Need, on October 28, 2020, with a current preliminary Total Project Cost (TPC) range of $300,000,000–$740,000,000, updated by preliminary planning for the project. A combined CD-1, Approve Alternative Selection and Cost Range, and CD-3A, Approve Long Lead Procurements, is expected in 4Q FY 2026.

24-SC-12, NSLS-II Experimental Tools - III (NEXT-III), BNL

The NEXT-III project will provide a pathway for the construction of an additional suite of up to 12 beamlines that will be optimized to enhance the capability of NSLS-II. These beamlines will enable cutting-edge research in clean sustainable energy, sustainable manufacturing, carbon sequestration and storage, materials for environmental remediation, automated structure analysis of biological macromolecules, drug discovery, bio-preparedness, quantum materials, and quantum information science, as well as developing novel instrumentation and tools required to maintain the global competitiveness of the U.S. light sources. NEXT-III beamlines will also enable multimodal research for a larger, more diverse community to broaden industrial research and provide new avenues to introduce new users to synchrotron research, including those from under-represented institutions and regions. The project received CD-0, Approve Mission Need, on September 30, 2022, with a preliminary TPC range of $350,000,000–$500,000,000. CD-1, Approve Alternative Selection and Cost Range, is expected in 4Q FY 2024.

21-SC-10, Cryomodule Repair & Maintenance Facility (CRMF), SLAC

The CRMF project will provide a much-needed capability to maintain, repair, and test superconducting radiofrequency (SRF) accelerator components. These components include but are not limited to superconducting RF cavities and cryomodules that make up the new superconducting accelerator being constructed by the LCLS-II and LCLS-II-HE projects, high brightness electron injectors, and superconducting undulators. The facility will provide for the full disassembly and repair of the SRF cryomodule; the ability to disassemble, clean, and reassemble the SRF cavities and cavity string; testing capabilities for the full cryomodule; and separate testing capabilities for individual SRF cavities. To accomplish this, the project requires a building up to 24,000 gross square feet to contain the necessary equipment, tools, and fixtures, as well as a control room, clean rooms, and liquid helium distribution system. The project received CD-1, Approve Cost Range and Analysis of Alternatives, on October 11, 2023, with a current TPC range of $70,000,000–$98,000,000. A combined CD-2/3, Approve Performance Baseline and Approve Start of Construction, is expected in 1Q FY 2026.

19-SC-14, Second Target Station (STS), ORNL

The STS project will expand SNS capabilities for neutron scattering research by exploiting 0.7 MW of the 2.8 MW SNS accelerator proton beam power enabled by the PPU project. The STS will provide high brightness, cold neutrons complementary to the first target station (FTS). Instruments will feature advanced neutron optics, optimized geometry, and high resolution, advanced detectors, enabling new research opportunities. The project received CD-1, Approve Alternative Selection and Cost Range, on November 23, 2020, establishing the approved TPC range of $1,800,000,000–$3,000,000,000. CD-3A, Approve Long Lead Procurements, is expected in 4Q FY 2025.

18-SC-13, Linac Coherent Light Source-II-High Energy (LCLS-II-HE), SLAC

The LCLS-II-HE project will expand the capabilities of the LCLS to maintain U.S. leadership in ultrafast and ultrabright x-ray science. The project will increase the energy of the superconducting linac from 4 GeV to 8 GeV and thereby expand the high repetition rate operation (1 million pulses per second) into the hard x-ray regime (5-12 keV). The project received CD-3B, Approve Long Lead Procurements, on January 27, 2023. The project established an original TPC range of $290,000,000–$480,000,000, but due to maturing design efforts that identified additional costs across the project scope, and increases in the project's contingency to address several future risks, the TPC estimate has increased to $710,000,000. A combined CD-2/3, Approve Performance Baseline and Approve Start of Construction, is expected in 3Q FY 2024.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Construction	**$293,200**	**$183,500**	**-$109,700**
24-SC-10, HFIR Pressure Vessel Replacement (PVR), ORNL	$ —	$6,000	+$6,000
No funding is requested in FY 2023.		The Request will continue planning, design, R&D, analysis, engineering, and prototyping to advance design toward readiness for a combined CD-1/3A in 4Q FY 2026.	Funding will advance progress on the HFIR-PVR project.
24-SC-12, NSLS-II Experimental Tools - III (NEXT-III), BNL	$ —	$5,500	+$5,500
No funding is requested in FY 2023.		The Request will support activities to secure CD-3A approval, expected in 3Q FY 2025, to start long lead procurements of the first group of beamlines and continue with design of the second group of beamlines.	Funding will advance progress on the NEXT-III project.
21-SC-10, Cryomodule Repair & Maintenance Facility (CRMF), SLAC	$10,000	$20,000	+$10,000
Funding continues the initial design effort and initiate long-lead procurements and site preparations for civil construction upon associated CD approvals. CD-1 is expected for 4Q FY 2023 and CD-3A expected for 1Q FY 2024.		The Request will support the continuation of activities required to secure a combined CD-2/3 approval and initiation of construction contracts, expected in 1Q FY 2026.	Funding will advance progress on the CRMF project.

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request		Explanation of Changes FY 2025 Request vs FY 2023 Enacted
19-SC-14, Second Target Station (STS), ORNL	$32,000		$52,000	+$20,000
The project continues the activities of planning, R&D, and engineering to mature the project's preliminary design, scope, cost, schedule, and key performance parameters.		The Request will continue planning, R&D, design, engineering, prototyping, and testing to advance the highest-priority activities. Funding will also initiate a potential long lead procurement for civil construction site preparation upon associated CD approvals.		Funding will advance progress on the STS project.
18-SC-10, Advanced Photon Source Upgrade (APS-U), ANL	$9,200		$ —	-$9,200
Funding supports ongoing construction activities to include civil construction associated with the long beamline building. Dark time for installation is projected to begin 2Q FY 2023.		No funding is requested in FY 2025.		Final funding for this project was provided in FY 2023.
18-SC-11, Spallation Neutron Source Proton Power Upgrade (PPU), ORNL	$17,000		$ —	-$17,000
The project supports the installation of additional cryomodules and related radiofrequency systems, operation of the second PPU test target at increased power levels, and construction of the tunnel stub that will facilitate connection to the future STS.		No funding is requested in FY 2025.		Final funding for this project was requested in FY 2024.
18-SC-12, Advanced Light Source Upgrade (ALS-U), LBNL	$135,000		$ —	-$135,000
The project continues to advance construction activities.		No funding is requested in FY 2025.		Final funding for this project was requested in FY 2024.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
18-SC-13, Linac Coherent Light Source-II-High Energy (LCLS-II-HE), SLAC $90,000	$100,000	+$10,000
Funding supports engineering, design, R&D prototyping, continuing long lead procurements of construction items and preparation of the project baseline. Other tasks as required. A combined CD- 2/3 approval is expected for 2Q FY 2024 and CD-4 is expected for 2Q FY 2030.	Funding will support production of the cryomodules, continue long lead procurements, and begin remaining scope design efforts and initiate installation/construction contracts. Other tasks as required. A combined CD-2/3 approval is expected for 3Q FY 2024.	Funding will advance progress on the LCLS-II-HE project at SLAC and the three partner labs (Fermi National Accelerator Lab, Thomas Jefferson Lab, and Lawrence Berkeley National Lab).

Basic Energy Sciences
Capital Summary

	(dollars in thousands)					
	Total	**Prior Years**	**FY 2023 Enacted**	**FY 2024 Annualized CR**	**FY 2025 Request**	**FY 2025 Request vs FY 2023 Enacted**
Capital Operating Expenses						
Capital Equipment	N/A	N/A	80,698	57,394	56,641	-24,057
Minor Construction Activities						
General Plant Projects	N/A	N/A	3,400	22,040	31,228	+27,828
Accelerator Improvement Projects	N/A	N/A	14,010	81,169	55,682	+41,672
Total, Capital Operating Expenses	**N/A**	**N/A**	**98,108**	**160,603**	**143,551**	**+45,443**

Capital Equipment

	(dollars in thousands)					
	Total	**Prior Years**	**FY 2023 Enacted**	**FY 2024 Annualized CR**	**FY 2025 Request**	**FY 2025 Request vs FY 2023 Enacted**
Capital Equipment						
Major Items of Equipment						
Scientific User Facilities (SUF)						
NSLS-II Experimental Tools-II (NEXT-II), BNL	92,283	47,283	25,000	20,000	–	-25,000
NSRC Recapitalization	79,150	49,150	25,000	5,000	–	-25,000
Total, MIEs	N/A	N/A	50,000	25,000	–	-50,000
Total, Non-MIE Capital Equipment	N/A	N/A	30,698	32,394	56,641	+25,943
Total, Capital Equipment	**N/A**	**N/A**	**80,698**	**57,394**	**56,641**	**-24,057**

Note:
- *The Capital Equipment table includes MIEs located at a DOE facility with a Total Estimated Cost (TEC) > $10M and MIEs not located at a DOE facility with a TEC >$2M.*

Minor Construction Activities

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
General Plant Projects (GPP)						
GPPs (greater than $5M and $34M or less)						
Spallation Neutron Source Sample Environmental Building	700	–	–	–	700	+700
HFIR Guide Hall Extension	19,900	–	1,400	18,500	–	-1,400
HFIR Fabrication, Alignment & Manufacturing (FAM) Bldg., ORNL	1,540	–	–	1,540	–	–
Technical and Storage Space	9,528	–	–	–	9,528	+9,528
SLAC, SSRL, B120 Expansion for Beamline Upgrade	1,200	–	–	–	1,200	+1,200
SLAC, LCLS, Far Experimental Hall	14,800	–	–	–	14,800	+14,800
Total GPPs (greater than $5M and $34M or less)	N/A	N/A	1,400	20,040	26,228	+24,828
Total GPPs $5M or less	N/A	N/A	2,000	2,000	5,000	+3,000
Total, General Plant Projects (GPP)	**N/A**	**N/A**	**3,400**	**22,040**	**31,228**	**+27,828**
Accelerator Improvement Projects (AIP)						
AIPs (greater than $5M and $34M or less)						
3rd Harmonic Cavity, National Synchrotron Light Source-II	10,720	–	–	4,720	6,000	+6,000
Spallation Neutron Source Cold Box-Engineering	10,500	–	–	10,500	–	–
Cold Source Helium Refrigerator System	21,939	9,339	–	12,600	–	–
160kW Solid State Amplifier Hardware and Utilities - Phase 2 (APS)	11,934	–	5,967	5,967	–	-5,967
Flexon 2nd Endstation, LBNL	8,500	–	–	8,500	–	–
New SAX/WAX Beamline, LBNL	25,250	–	–	17,750	7,500	+7,500
ALARA lead shielding upgrade	9,405	–	–	–	9,405	+9,405
Roof block shielding upgrade	6,577	–	–	–	6,577	+6,577

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Total AIPs (greater than $5M and $34M or less)	N/A	N/A	5,967	60,037	29,482	+23,515
Total AIPs $5M or less	N/A	N/A	8,043	21,132	26,200	+18,157
Total, Accelerator Improvement Projects (AIP)	**N/A**	**N/A**	**14,010**	**81,169**	**55,682**	**+41,672**
Total, Minor Construction Activities	**N/A**	**N/A**	**17,410**	**103,209**	**86,910**	**+69,500**

Notes:

- *GPP activities $5M and less include design and construction for additions and/or improvements to land, buildings, replacements or addition to roads, and general area improvements. AIP activities $5M and less include minor construction at an existing accelerator facility.*
- *The Total funding for the HFIR Guide Hall Extension GPP project is approximately $19,900,000. This project, originally requested in FY 2021, has been delayed. Design efforts will be fully funded in FY 2023 and the remaining funds are requested in FY 2024.*
- *The Total funding for the Cold Source Helium Refrigerator System (AIP) project is $12,600,000. This project, originally requested in FY 2021, has been deferred until FY 2024.*
- *The Total funding for the SNS Cold Box-Engineering (AIP) project is $10,500,000. This project, originally requested in FY 2023, has been deferred until FY 2024.*
- *The Total funding for the 3rd Harmonic Cavity (AIP) project is $6,000,000. This project, originally requested in FY 2024, has been deferred until FY 2025.*
- *The Total funding for the SAX/WAX Beamline (AIP) project is $9,000,000. This project, originally requested in FY 2024, has been deferred with revised scope until FY 2025.*

Basic Energy Sciences
Construction Projects Summary

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
24-SC-10, HFIR Pressure Vessel Replacement (PVR), ORNL						
Total Estimated Cost (TEC)	675,000	-	-	-	6,000	+6,000
Other Project Cost (OPC)	44,000	-	3,000	3,000	5,000	+2,000
Total Project Cost (TPC)	**719,000**	**-**	**3,000**	**3,000**	**11,000**	**+8,000**
24-SC-12, NSLS-II Experimental Tools - III (NEXT-III), BNL						
Total Estimated Cost (TEC)	477,444	-	-	-	5,500	+5,500
Other Project Cost (OPC)	17,500	-	1,500	1,500	4,500	+3,000
Total Project Cost (TPC)	**494,944**	**-**	**1,500**	**1,500**	**10,000**	**+8,500**
21-SC-10, Cryomodule Repair & Maintenance Facility (CRMF), SLAC						
Total Estimated Cost (TEC)	88,800	22,000	10,000	9,000	20,000	+10,000
Other Project Cost (OPC)	5,700	3,700	1,000	1,000	-	-1,000
Total Project Cost (TPC)	**94,500**	**25,700**	**11,000**	**10,000**	**20,000**	**+9,000**
19-SC-14, Second Target Station (STS), ORNL						
Total Estimated Cost (TEC)	2,145,000	124,700	32,000	52,000	52,000	+20,000
Other Project Cost (OPC)	94,960	45,805	5,000	-	-	-5,000
Total Project Cost (TPC)	**2,239,960**	**170,505**	**37,000**	**52,000**	**52,000**	**+15,000**
18-SC-10, Advanced Photon Source Upgrade (APS-U), ANL						
Total Estimated Cost (TEC)	796,500	787,300	9,200	-	-	-9,200
Other Project Cost (OPC)	18,500	13,500	5,000	-	-	-5,000
Total Project Cost (TPC)	**815,000**	**800,800**	**14,200**	**-**	**-**	**-14,200**
18-SC-11, Spallation Neutron Source Proton Power Upgrade (PPU), ORNL						

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Total Estimated Cost (TEC)	257,769	225,000	17,000	15,769	-	-17,000
Other Project Cost (OPC)	13,798	13,798	-	-	-	-
Total Project Cost (TPC)	**271,567**	**238,798**	**17,000**	**15,769**	**-**	**-17,000**
18-SC-12, Advanced Light Source Upgrade (ALS-U), LBNL						
Total Estimated Cost (TEC)	562,000	369,700	135,000	57,300	-	-135,000
Other Project Cost (OPC)	28,000	28,000	-	-	-	-
Total Project Cost (TPC)	**590,000**	**397,700**	**135,000**	**57,300**	**-**	**-135,000**
18-SC-13, Linac Coherent Light Source-II-High Energy (LCLS-II-HE), SLAC						
Total Estimated Cost (TEC)	678,000	268,657	90,000	120,000	100,000	+10,000
Other Project Cost (OPC)	32,000	23,000	4,000	-	-	-4,000
Total Project Cost (TPC)	**710,000**	**291,657**	**94,000**	**120,000**	**100,000**	**+6,000**
Total, Construction						
Total Estimated Cost (TEC)	**N/A**	**N/A**	**293,200**	**254,069**	**183,500**	**-109,700**
Other Project Cost (OPC)	**N/A**	**N/A**	**19,500**	**5,500**	**9,500**	**-10,000**
Total Project Cost (TPC)	**N/A**	**N/A**	**312,700**	**259,569**	**193,000**	**-119,700**

Note:

- *The current estimated TPC for the STS project is $2,242,000,000. In FY 2023, an additional $2,040,000 in OPC funding was obligated that is not reflected in this table.*

Basic Energy Sciences
Scientific User Facility Operations

The treatment of user facilities is distinguished between two types: TYPE A facilities that offer users resources dependent on a single, large-scale machine; TYPE B facilities that offer users a suite of resources that is not dependent on a single, large-scale machine.

(dollars in thousands)

	FY 2023 Enacted	FY 2023 Current	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Scientific User Facilities - Type A					
Advanced Light Source	**74,934**	**75,434**	**101,693**	**118,439**	**+43,505**
Number of Users	1,500	1,602	1,496	1,224	-276
Achieved Operating Hours	–	3,763	–	–	–
Planned Operating Hours	3,880	–	2,915	2,938	-942
Advanced Photon Source	**173,142**	**173,642**	**168,891**	**201,758**	**+28,616**
Number of Users	3,440	3,932	1,760	1,845	-1,595
Achieved Operating Hours	–	3,067	–	–	–
Planned Operating Hours	3,152	–	2,013	1,852	-1,300
National Synchrotron Light Source II	**128,100**	**128,100**	**142,208**	**164,851**	**+36,751**
Number of Users	1,500	1,885	1,584	1,755	+255
Achieved Operating Hours	–	4,601	–	–	–
Planned Operating Hours	4,800	–	4,400	4,500	-300
Stanford Synchrotron Radiation Light Source	**48,242**	**48,679**	**64,752**	**80,982**	**+32,740**
Number of Users	1,100	599	1,980	1,710	+610
Achieved Operating Hours	–	1,756	–	–	–
Planned Operating Hours	3,316	–	4,970	4,590	+1,274
Linac Coherent Light Source	**175,080**	**177,080**	**202,400**	**224,317**	**+49,237**
Number of Users	600	322	880	990	+390
Achieved Operating Hours	–	1,526	–	–	–

	(dollars in thousands)				
	FY 2023 Enacted	**FY 2023 Current**	**FY 2024 Annualized CR**	**FY 2025 Request**	**FY 2025 Request vs FY 2023 Enacted**
Planned Operating Hours	3,200	–	5,720	6,750	+3,550
Spallation Neutron Source	**189,727**	**189,737**	**178,908**	**222,066**	**+32,339**
Number of Users	450	701	255	736	+286
Achieved Operating Hours	–	2,790	–	–	–
Planned Operating Hours	2,700	–	1,408	3,780	+1,080
High Flux Isotope Reactor	**126,013**	**126,013**	**193,016**	**142,626**	**+16,613**
Number of Users	290	474	352	382	+92
Achieved Operating Hours	–	2,935	–	–	–
Planned Operating Hours	2,700	–	2,904	2,548	-152
Scientific User Facilities - Type B					
Center for Nanoscale Materials	**30,519**	**30,519**	**28,737**	**33,881**	**+3,362**
Number of Users	730	850	682	702	-28
Center for Functional Nanomaterials	**27,114**	**27,614**	**25,760**	**28,419**	**+1,305**
Number of Users	630	655	616	639	+9
Molecular Foundry	**38,051**	**38,051**	**36,571**	**41,063**	**+3,012**
Number of Users	950	1,090	1,144	1,215	+265
Center for Nanophase Materials Sciences	**30,404**	**30,984**	**28,629**	**31,913**	**+1,509**
Number of Users	730	753	686	711	-19
Center for Integrated Nanotechnologies	**27,321**	**27,821**	**27,104**	**29,146**	**+1,825**
Number of Users	870	926	832	855	-15
Total, Facilities	**1,068,647**	**1,073,674**	**1,198,669**	**1,319,461**	**+250,814**
Number of Users	12,790	13,789	12,267	12,764	-26
Achieved Operating Hours	–	20,438	–	–	–
Planned Operating Hours	23,748	–	24,330	26,958	+3,210

Note:

- *Percent optimal operations defines what is achieved at this funding level. This includes staffing, up-to-date equipment and software, operations and maintenance, and appropriate investments to maintain world leadership.*

Scientific Employment

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Number of Permanent Ph.Ds (FTEs)	5,840	5,590	5,650	-190
Number of Postdoctoral Associates (FTEs)	1,670	1,540	1,540	-130
Number of Graduate Students (FTEs)	2,620	2,400	2,400	-220
Number of Other Scientific Employment (FTEs)	3,550	3,520	3,600	+50
Total Scientific Employment (FTEs)	**13,680**	**13,050**	**13,190**	**-490**

Note:

- Other Scientific Employment (FTEs) includes technicians, engineers, computer professionals and other support staff.

24-SC-10, HFIR Pressure Vessel Replacement (PVR), ORNL
Oak Ridge National Laboratory, ORNL
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary

The HFIR PVR project replaces the aging HFIR pressure vessel to extend facility lifetime, enable resumption of 100 MW operations, and enhance isotope production and scattering research. These upgrades will maintain a domestic high-flux, steady-state neutron source for diverse and critical missions. The FY 2025 Request for the HFIR Pressure Vessel Replacement (PVR), ORNL is $6,000,000 of Total Estimated Cost (TEC) funding and $5,000,000 of Other Project Costs (OPC) funding. The preliminary total project cost (TPC) range is estimated to be $300,000,000 to $740,000,000. This preliminary cost range encompassed the most feasible preliminary alternatives at CD-0, updated by preliminary planning for the project. Pending CD-1 reviews, the project's current preliminary TPC is $729,000,000.

Significant Changes

This project was initiated in the FY 2024 Request. The most recent DOE Order 413.3B approved Critical Decision (CD) is CD-0, Approve Mission Need, which was approved on October 28, 2020. A combined CD-1, Approve Alternative Selection and Cost Range, and CD-3A, Approve Long Lead Procurements, is expected 4Q FY 2026. This Construction Project Data Sheet (CPDS) is an update of the FY 2024 CPDS and does not include a new start for FY 2025.

During the initial design activities, the project's preliminary TPC range originally established at CD-0 was increased from $300,000,000 to $550,000,000, to $300,000,000 to $740,000,000. To ensure U.S. competitiveness and maintain world leading capabilities for HFIR's diverse and critical missions, the replacement pressure vessel will be redesigned to maximize neutron scattering and isotope production and will be constructed for the latest pressure vessel materials, increasing the initial estimated cost. The redesign of the pressure vessel coupled with DOE regulatory reviews and supply chain delays will require replacement of the beryllium reflector, further adding to the cost and required schedule.

FY 2023 funding initiated the alternatives analysis and preconceptual design activities. The FY 2024 Request will support planning, design, R&D, analysis, engineering, and potentially prototyping to advance the conceptual design with emphasis on design optimization, and material studies. The FY 2025 Request will continue FY 2024 activities with emphasis on the highest priority activities needed to advance the conceptual design toward readiness for CD-1 and potential long lead procurements in FY 2026.

A Federal Project Director with the appropriate level of certification will be assigned to this project prior to CD-1.

Critical Milestone History

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
FY 2025	10/28/20	4Q FY 2025	4Q FY 2026	4Q FY 2027	4Q FY 2030	4Q FY 2028	4Q FY 2036

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout.

Fiscal Year	Performance Baseline Validation	CD-3A
FY 2025	4Q FY 2027	4Q FY 2026

CD-3A – Approve Long-Lead Procurements, to reduce schedule and technical risk by procuring specialty materials and components early in the project lifecycle that can have a long-lead time from procurement to receipt.

Project Cost History

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	177,000	346,000	523,000	27,000	27,000	550,000
FY 2025	153,000	526,000	679,000	50,000	50,000	729,000

2. Project Scope and Justification

Scope

The HFIR-PVR project will replace the existing HFIR reactor pressure vessel with a modern, redesigned pressure vessel, enabling HFIR to continue providing world-class brightness and flux for a variety of critical mission objectives for decades to come.

Justification

HFIR provides state-of-the-art facilities for neutron scattering, isotope production, materials irradiation, and neutron activation analysis. HFIR, completed in 1965, is the world's most intense source of thermal neutrons for research. Due to its age, HFIR is at risk of falling behind reactors recently completed and in construction in Russia. The HFIR-PVR project will reduce the risk of potential reliance on foreign reactors for isotope production and for scientific research.

HFIR started operation in 1965 at 100 megawatts (MW), however its power was reduced to 85 MW in 1990 to extend the lifetime of the reactor pressure vessel. In 2019, the BES Advisory Committee (BESAC) was charged with assessing the long-term strategy for HFIR and the scientific justification for a U.S. reactor-based research facility. A key recommendation from the resulting July 2020 report, *The Scientific Justification for a U.S. Domestic High-Performance Reactor-Based Research Facility,*[l] is to replace the pressure vessel with enhanced capabilities for both in-reactor and beamline research.

The HFIR-PVR project will replace the aging HFIR pressure vessel to extend facility lifetime, resume 100 MW operations, and address the need for long-term availability of a high-flux, steady-state neutron source to maintain world-leading capabilities for its missions. HFIR-PVR will enable next-generation instrumentation for the neutron scattering user community; enhance isotope production for research, clinical and medical uses, and federal and industrial applications, including NASA deep space missions; and improve materials irradiation and neutron activation analysis capabilities.

Potential capability and capacity enhancements include: a ~20 percent increase in neutron flux for all missions resulting from the power ramp up from 85 MW to 100 MW operations, a further increase in the thermal neutron flux at beamlines by factors of two or more through optimization of the layout to improve the performance, and an increase in the overall number of beamlines for users. The 100 MW operations will increase isotope production and enhance throughput in instrumented materials irradiation experiments.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*.

[l] The Scientific Justification for a U.S. Domestic High-Performance Reactor-Based Research Facility, October 2020.

Key Performance Parameters (KPPs)
The KPPs are preliminary and may change as the project continues towards CD-2. At CD-2 approval, the KPPs will be baselined. The Threshold KPPs represent the minimum acceptable performance that the project must achieve. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion. The Objective KPPs represent the desired project performance.

Performance Measure	Threshold	Objective
Pressure Vessel Power Level Capability	85 MW	100 MW

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
Design (TEC)			
FY 2024	4,000	4,000	—
FY 2025	6,000	6,000	—
Outyears	143,000	143,000	153,000
Total, Design (TEC)	**153,000**	**153,000**	**153,000**
Construction (TEC)			
Outyears	526,000	526,000	526,000
Total, Construction (TEC)	**526,000**	**526,000**	**526,000**
Total Estimated Cost (TEC)			
FY 2024	4,000	4,000	—
FY 2025	6,000	6,000	—
Outyears	669,000	669,000	679,000
Total, Total Estimated Cost (TEC)	**679,000**	**679,000**	**679,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Other Project Cost (OPC)			
FY 2023	3,000	3,000	392
FY 2024	9,000	9,000	8,000
FY 2025	5,000	5,000	6,000
Outyears	33,000	33,000	35,608
Total, Other Project Cost (OPC)	**50,000**	**50,000**	**50,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Project Cost (TPC)			
FY 2023	3,000	3,000	392
FY 2024	13,000	13,000	8,000
FY 2025	11,000	11,000	6,000
Outyears	702,000	702,000	714,608
Total, TPC	**729,000**	**729,000**	**729,000**

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	117,000	137,000	**N/A**
Design - Contingency	36,000	40,000	**N/A**
Total, Design (TEC)	**153,000**	**177,000**	**N/A**
Construction	376,000	247,500	**N/A**
Construction - Contingency	150,000	98,500	**N/A**
Total, Construction (TEC)	**526,000**	**346,000**	**N/A**
Total, TEC	**679,000**	**523,000**	**N/A**
Contingency, TEC	*186,000*	*138,500*	***N/A***
Other Project Cost (OPC)			
Total, D&D	**6,400**	**5,600**	**N/A**
Conceptual Design	13,600	14,000	**N/A**
Start-up	20,000	2,400	**N/A**
OPC - Contingency	10,000	5,000	**N/A**
Total, Except D&D (OPC)	**43,600**	**21,400**	**N/A**
Total, OPC	**50,000**	**27,000**	**N/A**
Contingency, OPC	*10,000*	*5,000*	***N/A***
Total, TPC	**729,000**	**550,000**	**N/A**
Total, Contingency (TEC+OPC)	***196,000***	***143,500***	***N/A***

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	—	—	4,000	—	519,000	523,000
	OPC	—	3,000	9,000	—	15,000	27,000
	TPC	—	3,000	13,000	—	534,000	550,000
FY 2025	TEC	—	—	4,000	6,000	669,000	679,000
	OPC	—	3,000	9,000	5,000	33,000	50,000
	TPC	—	3,000	13,000	11,000	702,000	729,000

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	4Q FY 2036
Expected Useful Life	50 years
Expected Future Start of D&D of this capital asset	4Q FY 2086

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	Current Total Estimate	Previous Total Estimate	Current Total Estimate
Operations	N/A	TBD	N/A	TBD
Utilities	N/A	TBD	N/A	TBD
Maintenance and Repair	N/A	TBD	N/A	TBD
Total, Operations and Maintenance	N/A	TBD	N/A	TBD

7. D&D Information

At this stage of project planning and development, SC anticipates that there will be no new area being constructed in the construction project.

8. Acquisition Approach

The acquisition approach will be developed and matured as part of the acquisition strategy and alternatives analysis required for CD-1. DOE has determined that ORNL will acquire the HFIR-PVR project under the existing DOE Management and Operations (M&O) contract.

A Conceptual Design Report for the project will identify key design activities, requirements, and high-risk subsystem components to reduce cost and schedule risk to the project and expedite the startup. Project management systems are fully up to date, operating, and are maintained as an ORNL-wide resource.

ORNL will design and procure the key technical subsystem components. Some technical system designs may require research and development activities. Preliminary cost estimates for these components and systems will likely be based on operating experience of HFIR and vendor estimates, while some first-of-a-kind components may be based on expert judgement. Vendors and/or partner labs with the necessary capabilities will fabricate the technical equipment. ORNL will competitively bid and award all subcontracts based on best value to the government. The M&O contractor's performance will be evaluated through the annual laboratory performance appraisal process.

Lessons learned from other SC projects and other similar facilities will be exploited fully in planning and executing the HFIR-PVR project.

24-SC-12, NSLS-II Experimental Tools - III (NEXT-III), BNL
Brookhaven National Laboratory, BNL
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary
The NEXT-III project will provide a pathway for the construction of an additional suite of up to 12 beamlines that will be optimized to enhance the capability of NSLS-II. The FY 2025 Request for the NSLS-II Experimental Tools - III (NEXT-III) Project is $5,500,000 of Total Estimated Cost (TEC) funding and $4,500,000 of Other Project Cost (OPC) funding. The current preliminary total project cost (TPC) range is $350,000,000 to $500,000,000. The preliminary cost range encompasses the most feasible preliminary alternatives at this time. The current preliminary TPC for this project is $500,000,000.

Significant Changes
This project was initiated in the FY 2024 Request. The most recent DOE Order 413.3B approved Critical Decision (CD) is CD-0, Approve Mission Need, was approved on September 30, 2022. CD-1, Approve Alternative Selection and Cost Range, is expected in 4Q FY 2024. This Construction Project Data Sheet (CPDS) is an update of the FY 2024 CPDS and does not include a new start for FY 2025.

FY 2023 funding supported planning activities for this project. The FY 2024 Request will continue planning activities including development of plans for CD-1, any required R&D and the future CD-3A package, and initiates conceptual design activities, building on the activities planned in FY 2023. The FY 2025 Request will enable securing CD-3A approval to start long lead procurements of the first group of beamlines and continued design of the second group of beamlines. The project is considering a phased approach of subprojects with roughly three beamlines scoped under each subproject. Final execution plans for the project will be established at CD-1.

A Level III certified Federal Project Director will be assigned to this project prior to CD-1.

Critical Milestone History

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
FY 2025	9/30/22	3Q FY 2024	4Q FY 2024	3Q FY 2026	3Q FY 2028	4Q FY 2028	1Q FY 2036

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout.

Fiscal Year	Performance Baseline Validation	CD-3A	CD-3B
FY 2025	2Q FY 2026	3Q FY 2025	3Q FY 2026

CD-3A – Approve Long-Lead Procurements, plan to acquire long lead items and assembly for the 1st group of instruments.
CD-3B – Approve Long-Lead Procurements, plan to acquire long lead items and assembly for the 2nd group of instruments.

Project Cost History

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	38,000	442,000	480,000	20,000	20,000	500,000
FY 2025	38,000	442,000	480,000	20,000	20,000	500,000

2. Project Scope and Justification

Scope

The NEXT-III project will provide for the construction of up to 12 performance and enterprise beamlines that will be optimized to enhance the capability of NSLS-II to support multimodal research. Performance beamlines will be designed to push a given technique to or beyond the current state-of-the-art, offering extraordinary capabilities. These beamlines, together with complementary results from the enterprise beamlines, will enable cutting-edge research in clean sustainable energy, sustainable manufacturing, carbon sequestration and storage, materials for environmental remediation, automated structure-analysis of biological macromolecules, drug discovery, bio-preparedness, quantum material and quantum information science, as well as developing novel instrumentation and tools required to maintain the global competitiveness of the U.S. light sources such as adaptive x-ray optics and ultrafast detectors.

The enterprise beamlines will be designed to provide capabilities and techniques that are mature and have strong, well-established user communities. These beamlines will carry out more routine measurements and are typically highly automatable with a high throughput of experiments. These beamlines are also very useful for providing supporting information for projects which would also take data on a performance beamline. The enterprise beamlines will enable multimodal research for a larger more diverse community including researchers from under-represented communities.

Justification

The mission of BES is to support fundamental research to understand, predict, and ultimately control matter and energy at the electronic, atomic, and molecular levels to provide the foundations for new energy technologies and to support DOE's missions in energy, environment, and national security. To accomplish its mission, BES continually strives to enhance the ability to observe, measure, and understand the structure and properties of materials and the evolution of chemical and physical processes, including providing world-class user facilities with these capabilities. International competition in these research areas is fierce and scientific breakthroughs are often driven by the availability of novel tools and techniques.

A significant fraction of researchers world-wide who use x-ray storage-ring sources use low- and medium-energy x-rays. Low- and medium-energy x-rays are used to determine the structure of materials at atomic resolution, provide images at nanometer spatial resolution, are sensitive to features on the surface and in the bulk, and can operate in extremes of temperature, pressure, and applied magnetic field. The BES program constructed the NSLS-II storage ring light source to provide one of the world's brightest storage ring synchrotron sources of low- and medium-energy x-rays. Completed in FY 2015, NSLS-II has a total capacity of 60 beamlines, with only 28 beamlines (about 47 percent of the capacity) constructed and in current operation.

Because of the importance of development of new materials and other national priorities, failure to acquire the suite of new advanced tools made possible by the NEXT-III project would have serious repercussions on U.S. competitiveness.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets.*

Key Performance Parameters (KPPs)
The KPPs listed are conceptual and will be revised for CD-1 (as preliminary) and finalized at CD-2.

Performance Measure	Threshold	Objective
Performance beamlines	At least 3 or more beamlines capable of operating in the range of 0.1 to 20 KeV Energy Range with tunable spatial resolutions.	At least 5 or more beamlines capable of delivering 0.1-30 KeV energy range with tunable spatial resolutions.
Enterprise beamlines	At least 5 or more beamlines capable of micron to submicron spatial resolution for tomography and high-resolution diffraction and crystallography, all with multi-modal capabilities.	At least 7 or more beamlines capable of micron to submicron spatial resolution for tomography, high-resolution diffraction and crystallography, full-field x-ray imaging, high-energy x-ray scattering and imaging, all with multi-modal capabilities.

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
Design (TEC)			
FY 2024	2,556	2,556	1,500
FY 2025	3,000	3,000	2,500
Outyears	32,444	32,444	34,000
Total, Design (TEC)	**38,000**	**38,000**	**38,000**
Construction (TEC)			
FY 2025	2,500	2,500	2,100
Outyears	439,500	439,500	439,900
Total, Construction (TEC)	**442,000**	**442,000**	**442,000**
Total Estimated Cost (TEC)			
FY 2024	2,556	2,556	1,500
FY 2025	5,500	5,500	4,600
Outyears	471,944	471,944	473,900
Total, Total Estimated Cost (TEC)	**480,000**	**480,000**	**480,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Other Project Cost (OPC)			
FY 2023	1,500	1,500	361
FY 2024	4,000	4,000	3,800
FY 2025	4,500	4,500	4,300
Outyears	10,000	10,000	11,539
Total, Other Project Cost (OPC)	**20,000**	**20,000**	**20,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Project Cost (TPC)			
FY 2023	1,500	1,500	361
FY 2024	6,556	6,556	5,300
FY 2025	10,000	10,000	8,900
Outyears	481,944	481,944	485,439
Total, TPC	**500,000**	**500,000**	**500,000**

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	28,500	28,500	**N/A**
Design - Contingency	9,500	9,500	**N/A**
Total, Design (TEC)	**38,000**	**38,000**	**N/A**
Construction	115,200	115,200	**N/A**
Equipment	172,800	172,800	**N/A**
Construction - Contingency	154,000	154,000	**N/A**
Total, Construction (TEC)	**442,000**	**442,000**	**N/A**
Total, TEC	**480,000**	**480,000**	**N/A**
Contingency, TEC	*163,500*	*163,500*	***N/A***
Other Project Cost (OPC)			
R&D	4,000	4,000	**N/A**
Conceptual Planning	3,000	3,000	**N/A**
Conceptual Design	10,000	10,000	**N/A**

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
OPC - Contingency	3,000	3,000	**N/A**
Total, Except D&D (OPC)	**20,000**	**20,000**	**N/A**
Total, OPC	**20,000**	**20,000**	**N/A**
Contingency, OPC	*3,000*	*3,000*	***N/A***
Total, TPC	**500,000**	**500,000**	**N/A**
Total, Contingency (TEC+OPC)	***166,500***	***166,500***	***N/A***

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	—	—	2,556	—	477,444	480,000
	OPC	—	1,500	4,000	—	14,500	20,000
	TPC	—	1,500	6,556	—	491,944	500,000
FY 2025	TEC	—	—	2,556	5,500	471,944	480,000
	OPC	—	1,500	4,000	4,500	10,000	20,000
	TPC	—	1,500	6,556	10,000	481,944	500,000

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	1Q FY 2036
Expected Useful Life	15 years
Expected Future Start of D&D of this capital asset	1Q FY 2051

Related Funding Requirements
(dollars in thousands)

	Annual Costs		**Life Cycle Costs**	
	Previous Total Estimate	**Current Total Estimate**	**Previous Total Estimate**	**Current Total Estimate**
Operations	N/A	TBD	N/A	TBD
Utilities	N/A	TBD	N/A	TBD
Maintenance and Repair	N/A	TBD	N/A	TBD
Total, Operations and Maintenance	N/A	TBD	N/A	TBD

7. D&D Information

At this stage of project planning and development, SC anticipates no new area will be constructed for this project.

8. Acquisition Approach

NEXT-III will be acquired by BNL under the existing M&O contract managed by the Brookhaven Science Associates. Since completion of the NSLS-II User Facility in 2015, the BNL team has constructed many beamlines at the facility and has the requisite expertise and experience to deliver the project. The project will potentially be structured into several subprojects with about three beamlines scoped under each subproject. The phased acquisition of subprojects would be implemented through a combination of sub-contracts for purchase of turn-key systems, and specific instruments and components. Installations will be accomplished by utilizing in-house labor as well as subcontractors.

Lessons learned from other SC projects and other similar facilities are being exploited fully in planning and executing NEXT-III. The M&O contractor's performance will be evaluated through the annual laboratory performance appraisal process.

21-SC-10, Cryomodule Repair & Maintenance Facility (CRMF), SLAC
SLAC National Accelerator Laboratory, SLAC
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary

The CRMF project will provide a much-needed capability to maintain, repair, and test superconducting radiofrequency (SRF) accelerator components. The FY 2025 Request for the Cryomodule Repair and Maintenance Facility (CRMF) project at SLAC National Accelerator Laboratory is $20,000,000 of Total Estimated Cost (TEC) funding. This project has a preliminary Total Project Cost (TPC) range of $70,000,000 to $98,000,000. These cost ranges encompass the most feasible preliminary alternatives at this time. As the conceptual design of this project has matured, the current preliminary TPC estimate for this project is $94,500,000.

Significant Changes

CRMF was initiated in FY 2021. The most recent DOE Order 413.3B approved Critical Decision (CD) is CD-1, Approve Cost Range and Analysis of Alternatives, which was approved on October 11, 2023. The initial plan for a CD-3A is no longer being pursued as the approach to the cryogenic delivery system has changed and the project is planning for a combined CD-2/3 in 1Q FY 2026. This Construction Project Data Sheet (CPDS) is an update of the FY 2024 CPDS and does not include a new start for FY 2025.

FY 2023 funding supported the design of building infrastructure and technical systems and finalizing the design guidelines and specifications for cryogenics capabilities. The FY 2024 Request will support completion of the preliminary design of the facility and technical specifications for the cryogenic systems/equipment. The FY 2025 Request will support finalizing the design for the CRMF including the building, infrastructure, cryogenic system, and all the activities required to establish the performance baseline.

A Federal Project Director, certified to Level II, has been assigned to this project.

Critical Milestone History

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
FY 2025	12/6/19	8/24/23	10/11/23	1Q FY 2026	4Q FY 2025	1Q FY 2026	1Q FY 2030

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout.

Fiscal Year	Performance Baseline Validation
FY 2025	1Q FY 2026

Project Cost History

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	5,600	83,200	88,800	5,700	5,700	94,500
FY 2025	16,400	72,400	88,800	5,700	5,700	94,500

Note:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*

2. Project Scope and Justification

Scope
The preliminary scope of the CRMF project is to construct a building equipped with clean rooms, handling tools, and fixtures to support the repair, maintenance, and testing of superconducting radiofrequency (SRF) accelerator components. These components may include but are not limited to, SRF cavities and cryomodules, future capabilities for high brightness electron injectors, and superconducting undulators. The requirements will be refined as the project matures.

Justification
Through two current BES construction projects, LCLS-II and LCLS-II-HE, SC is making over a $1,800,000,000 capital investment in an SRF linac at SLAC to support the science mission of DOE. The LCLS-II project is providing a 4 GeV SRF-based linear accelerator containing 35 SRF cryomodules to accelerate the electrons. The LCLS-II-HE project will increase the energy of the superconducting linac to 8 GeV by providing an additional 20-23 SRF cryomodules of a similar design to those installed by the LCLS-II project, but operating at a higher accelerating gradient. SLAC has partnered with Fermi National Accelerator Laboratory (FNAL) and the Thomas Jefferson National Accelerator Facility (TJNAF) to provide the accelerating cryomodules. FNAL and TJNAF produce the cryomodules making use of specialized fabrication, assembly, and test capabilities available there. To make any repairs, SLAC must currently send the cryomodules cross country back to either FNAL or TJNAF at an increased risk of damage, cost, and schedule delays. This approach also assumes that either FNAL or TJNAF would have the maintenance capacity available when needed, typically requiring 6 to 12 months of advance notice to schedule maintenance or repairs.

The proposed CRMF is designed to meet these challenges and will provide the capability to repair, maintain, and test SRF accelerator components, primarily the SRF cryomodules that make up the new superconducting linac being constructed by the LCLS-II and LCLS-II-HE construction projects.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*.

Key Performance Parameters (KPPs)
The KPPs are preliminary and may change as the project continues towards CD-2. At CD-2 approval, the KPPs will be part of the approved performance baseline. The Threshold KPPs represent the minimum acceptable performance that the project must achieve. The Objective KPPs represent the desired project performance. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion.

Subsystem	Threshold	Objective
Building	~ 16,000 sq-ft building ready for occupancy	~ 24,000 sq-ft building ready for occupancy
Cleanrooms	ISO 4 cleanroom	ISO 4 and ISO 6 cleanrooms

Subsystem	Threshold	Objective
Cryomodule assembly capability	Infrastructure and equipment for cryomodule and cavity string disassembly and reassembly	Infrastructure and equipment for cryomodule and cavity string disassembly and reassembly
Cryogenic cooling capability	Infrastructure and cryogenic equipment to sustain the single cavity heat load during CM testing (2.3 g/s of liquid helium delivered to the Dewar at CRMF, as measured by liquid accumulation)	Infrastructure and cryogenic equipment to sustain the 8-cavity heat load during CM testing (11 g/s of liquid helium delivered to the Dewar at CRMF, as measured by liquid accumulation)
Cryomodule RF testing capability	Power amplifier capable to reach the power level needed to measure a cavity up to 21 MV/m in CM (with Q=2.7e10)	Power amplifier capable to reach the power level needed to measure a cavity up to 26 MV/m in CM (with Q=2.7e10)

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Estimated Cost (TEC)				
Design (TEC)				
Prior Years	2,000	2,000	—	—
Prior Years - IRA Supp.	300	300	—	—
FY 2023	1,600	1,600	—	—
FY 2024	7,800	7,800	9,200	300
FY 2025	4,700	4,700	4,700	—
Outyears	—	—	2,200	—
Total, Design (TEC)	**16,400**	**16,400**	**16,100**	**300**
Construction (TEC)				
Prior Years - IRA Supp.	19,700	19,700	—	—
FY 2023	8,400	8,400	—	—
FY 2024	1,200	1,200	—	11,000
FY 2025	15,300	15,300	21,000	8,700
Outyears	27,800	27,800	31,700	—
Total, Construction (TEC)	**72,400**	**72,400**	**52,700**	**19,700**
Total Estimated Cost (TEC)				
Prior Years	2,000	2,000	—	—
Prior Years - IRA Supp.	20,000	20,000	—	—
FY 2023	10,000	10,000	—	—
FY 2024	9,000	9,000	9,200	11,300
FY 2025	20,000	20,000	25,700	8,700
Outyears	27,800	27,800	33,900	—
Total, Total Estimated Cost (TEC)	**88,800**	**88,800**	**68,800**	**20,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Other Project Cost (OPC)				
Prior Years	3,000	3,000	1,457	–
Prior Years - IRA Supp.	700	700	–	–
FY 2023	1,000	1,000	1,504	700
FY 2024	1,000	1,000	150	–
FY 2025	–	–	896	–
Outyears	–	–	993	–
Total, Other Project Cost (OPC)	**5,700**	**5,700**	**5,000**	**700**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Project Cost (TPC)				
Prior Years	5,000	5,000	1,457	–
Prior Years - IRA Supp.	20,700	20,700	–	–
FY 2023	11,000	11,000	1,504	700
FY 2024	10,000	10,000	9,350	11,300
FY 2025	20,000	20,000	26,596	8,700
Outyears	27,800	27,800	34,893	–
Total, TPC	**94,500**	**94,500**	**73,800**	**20,700**

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	12,500	4,000	**N/A**
Design - Contingency	3,900	1,600	**N/A**
Total, Design (TEC)	**16,400**	**5,600**	**N/A**
Construction	31,700	28,700	**N/A**
Site Preparation	N/A	5,800	**N/A**
Equipment	24,200	24,400	**N/A**
Construction - Contingency	16,500	24,300	**N/A**
Total, Construction (TEC)	**72,400**	**83,200**	**N/A**
Total, TEC	**88,800**	**88,800**	**N/A**

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Contingency, TEC	*20,400*	*25,900*	***N/A***
Other Project Cost (OPC)			
Conceptual Planning	500	500	**N/A**
Conceptual Design	2,800	3,100	**N/A**
Start-up	1,200	1,100	**N/A**
OPC - Contingency	1,200	1,000	**N/A**
Total, Except D&D (OPC)	**5,700**	**5,700**	**N/A**
Total, OPC	**5,700**	**5,700**	**N/A**
Contingency, OPC	*1,200*	*1,000*	***N/A***
Total, TPC	**94,500**	**94,500**	**N/A**
Total, Contingency (TEC+OPC)	***21,600***	***26,900***	***N/A***

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	22,000	10,000	9,000	—	47,800	88,800
	OPC	3,700	1,000	1,000	—	—	5,700
	TPC	25,700	11,000	10,000	—	47,800	94,500
FY 2025	TEC	22,000	10,000	9,000	20,000	27,800	88,800
	OPC	3,700	1,000	1,000	—	—	5,700
	TPC	25,700	11,000	10,000	20,000	27,800	94,500

Note:

- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	1Q FY 2030
Expected Useful Life	25 years
Expected Future Start of D&D of this capital asset	1Q FY 2055

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	Current Total Estimate	Previous Total Estimate	Current Total Estimate
Operations, Maintenance and Repair	5,500	5,500	137,500	137,500

The estimate will be updated and additional details will be provided after CD-1, Approve Alternative Selection and Cost Range.

7. D&D Information

At this stage of project planning and development, SC is planning to construct a new building up to 24,000 gross square feet as part of this project.

	Square Feet
New area being constructed by this project at SLAC	16,000 – 24,000
Area of D&D in this project at SLAC	—
Area at SLAC to be transferred, sold, and/or D&D outside the project, including area previously "banked"	16,000 – 24,000
Area of D&D in this project at other sites	—
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously "banked"	—
Total area eliminated	—

8. Acquisition Approach

The CRMF Project will be sited at SLAC and is being acquired under the existing DOE M&O contract with Stanford University. SLAC has delivered several large construction projects and research facilities and has the requisite expertise to successfully deliver CRMF. SLAC, with support from partner laboratory expert staff, will complete the design of the technical systems. The acquisition of the CRMF building will be based on the design-build or design-bid-build methodology currently under evaluation. Selected subcontracted vendors, pre-qualified with the necessary capabilities, will fabricate the technical equipment. All contracts will be competitively bid and awarded based on best value to the government.

Lessons learned from other SC projects and other similar facilities will be exploited fully in planning and executing CRMF. The M&O contractor's performance will be evaluated through the annual laboratory performance appraisal process.

19-SC-14, Second Target Station (STS), ORNL
Oak Ridge National Laboratory, ORNL
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary

The STS project will design and build a new, very high brightness cold[m] neutron scattering capability to maintain U.S. competitiveness in providing world-leading neutron scattering user facilities. STS will offer unique beamlines to advance our understanding of the fundamental aspects of the natural world. The FY 2025 Request for the STS project is $52,000,000 of Total Estimated Cost (TEC) funding. This project has a preliminary Total Project Cost (TPC) range of $1,800,000,000 to $3,000,000,000. This cost range encompasses the most feasible preliminary alternatives. The current preliminary TPC estimate is $2,242,000,000.

Significant Changes

STS was initiated in FY 2019. The most recent DOE Order 413.3B approved Critical Decision (CD) is CD-1, Approve Alternative Selection and Cost Range, which was approved on November 23, 2020. CD-3A, Approve Long Lead Procurements, is expected in 4Q FY 2025. This Construction Project Data Sheet (CPDS) is an update of the FY 2024 CPDS and does not include a new start for FY 2025.

FY 2023 funding supported the planning, R&D, design, engineering, prototyping, and testing to mature the preliminary design, formalize the design interfaces between systems, and advance the selection and award of the construction manager/general contractor for the conventional facilities construction. FY 2023 efforts continued to focus on reduction of the TPC, including elimination of an office building from the project. The FY 2024 Request will support continued efforts to advance the highest priority activities with an emphasis on the accelerator optics, target assembly, moderator reflector assembly, and civil engineering. The FY 2025 Request will support continued planning, R&D, design, engineering, prototyping, and testing to advance the highest priority activities with emphasis on key project scope for the target vessel, shielding, moderator, and conventional facilities. A potential long lead procurement for civil construction site preparation depends on available funding.

A Federal Project Director, certified to level III, has been assigned to this project.

Critical Milestone History

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
FY 2025	1/7/09	4/30/21	11/23/20	4Q FY 2026	4Q FY 2029	4Q FY 2027	2Q FY 2037

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout.

[m] Neutrons can be described based on their wavelength and energy. Cold neutrons have lower energy (below 25 meV) and longer wavelengths (>0.2 nm) than thermal neutrons. Cold neutrons are best for characterizing materials with large atomic/molecular structures, such as polymers, biological materials, and magnetic materials. The wavelength of cold neutrons is similar to the activation energies for many solid-state excitations, molecular relaxations, and dynamic processes.

Fiscal Year	Performance Baseline Validation	CD-3A
FY 2025	4Q FY 2026	4Q FY 2025

CD-3A – Approve Long-Lead Procurements for the Construction Management/General Contractor (CM/GC) to perform site preparation for conventional civil construction.

Project Cost History

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	294,250	1,850,750	2,145,000	97,000	97,000	2,242,000
FY 2025	290,700	1,854,300	2,145,000	97,000	97,000	2,242,000

Note:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*

2. Project Scope and Justification

Scope

The STS project will design and build the new cold neutron scattering facility that comprises four primary elements: the neutron target and moderators; the accelerator systems; the instruments; and the conventional facilities. Costs for acceptance testing, integrated testing, and initial commissioning to demonstrate achievement of the KPPs are included in the STS scope. STS will be located in unoccupied space east of the existing SNS First Target Station (FTS). The project requires approximately 275,000 square feet of new buildings, making conventional facility construction a major contributor to project costs.

Justification

BES supports a diverse portfolio of large-scale user facilities including two neutron scattering facilities, the HFIR and the SNS, with the SNS FTS providing the world's brightest pulsed neutron scattering capability for thermal neutrons.[n] Currently, the U.S. lacks domestic capacity for research with lower energy, longer wavelength cold neutrons. Filling this gap is critical to maintaining U.S. competitiveness in world-leading neutron scattering research. The STS project will design and build a new, very high brightness, cold neutron scattering capability. The STS will provide unique beamlines to probe matter in space, time, and energy to advance understanding of the fundamental aspects of the natural world. Cold neutrons are best for characterizing materials with large atomic/molecular structures, enabling important scientific results across basic and applied research in chemistry, physics, materials and environmental science, advanced manufacturing, biology, and biomedical science. The research will support design of novel complex materials for energy systems, understanding of foundational phenomena for quantum materials, and enhanced biopreparedness.

STS will feature a very high-density proton beam that strikes a rotating solid tungsten target. The produced neutron beam illuminates compact moderators that will feed experimental beamlines. The neutron moderator system is geometrically optimized to deliver higher peak brightness of cold neutrons. The STS project will exploit 0.7 MW of the 2.8 MW accelerator proton beam power enabled by the PPU project. STS is designed to operate at 15 pulses/second simultaneously with FTS by using one out of every four proton pulses to produce cold neutron beams. FTS will operate at 45 pulses/second. An initial set of eight world-class instruments will feature advanced neutron optics, optimized geometry, and high resolution, advanced detectors, enabling new research opportunities and unprecedented levels of performance.

[n] Thermal neutrons have higher energy (at and above 25 meV) and shorter wavelengths (<0.2 nm) than cold neutrons. The wavelength of thermal neutrons is similar to the interatomic distances in materials, making them ideal for engineering materials, imaging, and determination of crystal structures.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*.

Key Performance Parameters (KPPs)
The KPPs are preliminary and may change as the project continues towards CD-2. At CD-2 approval, the KPPs will be baselined. The Threshold KPPs represent the minimum acceptable performance that the project must achieve. The Objective KPPs represent the desired project performance. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion.

Performance Measure	Threshold	Objective
Demonstrate independent control of the proton beam on the two target stations	Operate beam to FTS at 45 pulses/s, with no beam to STS. Operate beam to STS at 15 pulses/s, with no beam to FTS. Operate with beam to both target stations 45 pulses/s at FTS and 15 pulses/s at STS.	Operate beam to FTS at 45 pulses/s, with no beam to STS. Operate beam to STS at 15 pulses/s, with no beam to FTS. Operate with beam to both target stations 45 pulses/s at FTS and 15 pulses/s at STS.
Demonstrate proton beam power on STS at 15 Hz	100 kW beam power	700 kW beam power
Measure STS neutron brightness	peak brightness of 2×10^{13}n/cm^2/sr/Å/s at 5 Å	peak brightness of 2×10^{14}n/cm^2/sr/Å/s at 5 Å
Beamlines transitioned to operations	8 beamlines successfully passed the integrated functional testing per the transition to operations parameters acceptance criteria.	≥ 8 beamlines successfully passed the integrated functional testing per the transition to operations parameters acceptance criteria.

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Estimated Cost (TEC)				
Design (TEC)				
Prior Years	82,000	82,000	50,442	—
Prior Years - IRA Supp.	42,700	42,700	—	—
FY 2023	32,000	32,000	—	31,728
FY 2024	37,000	37,000	50,000	10,972
FY 2025	17,000	17,000	51,000	—
Outyears	80,000	80,000	96,558	—
Total, Design (TEC)	**290,700**	**290,700**	**248,000**	**42,700**
Construction (TEC)				
FY 2024	15,000	15,000	—	—
FY 2025	35,000	35,000	36,000	—
Outyears	1,804,300	1,804,300	1,818,300	—
Total, Construction (TEC)	**1,854,300**	**1,854,300**	**1,854,300**	**—**
Total Estimated Cost (TEC)				

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Estimated Cost (TEC)				
Prior Years	82,000	82,000	50,442	—
Prior Years - IRA Supp.	42,700	42,700	—	—
FY 2023	32,000	32,000	—	31,728
FY 2024	52,000	52,000	50,000	10,972
FY 2025	52,000	52,000	87,000	—
Outyears	1,884,300	1,884,300	1,914,858	—
Total, Total Estimated Cost (TEC)	**2,145,000**	**2,145,000**	**2,102,300**	**42,700**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Other Project Cost (OPC)			
Prior Years	45,805	45,805	32,772
FY 2023	7,040	7,040	14,500
FY 2024	–	–	2,500
FY 2025	–	–	3,806
Outyears	44,155	44,155	43,422
Total, Other Project Cost (OPC)	**97,000**	**97,000**	**97,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Project Cost (TPC)				
Prior Years	127,805	127,805	83,214	–
Prior Years - IRA Supp.	42,700	42,700	–	–
FY 2023	39,040	39,040	14,500	31,728
FY 2024	52,000	52,000	52,500	10,972
FY 2025	52,000	52,000	90,806	–
Outyears	1,928,455	1,928,455	1,958,280	–
Total, TPC	**2,242,000**	**2,242,000**	**2,199,300**	**42,700**

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	250,700	256,000	**N/A**
Design - Contingency	40,000	38,250	**N/A**
Total, Design (TEC)	**290,700**	**294,250**	**N/A**
Construction	1,299,300	1,477,000	**N/A**
Construction - Contingency	555,000	373,750	**N/A**
Total, Construction (TEC)	**1,854,300**	**1,850,750**	**N/A**
Total, TEC	**2,145,000**	**2,145,000**	**N/A**
Contingency, TEC	*595,000*	*412,000*	***N/A***
Other Project Cost (OPC)			
R&D	20,000	29,546	**N/A**
Conceptual Design	26,000	26,454	**N/A**
Start-up	32,000	22,000	**N/A**
OPC - Contingency	19,000	19,000	**N/A**
Total, Except D&D (OPC)	**97,000**	**97,000**	**N/A**
Total, OPC	**97,000**	**97,000**	**N/A**
Contingency, OPC	*19,000*	*19,000*	***N/A***
Total, TPC	**2,242,000**	**2,242,000**	**N/A**
Total, Contingency (TEC+OPC)	***614,000***	***431,000***	***N/A***

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	124,700	32,000	52,000	—	1,936,300	2,145,000
	OPC	45,805	5,000	—	—	46,195	97,000
	TPC	170,505	37,000	52,000	—	1,982,495	2,242,000
FY 2025	TEC	124,700	32,000	52,000	52,000	1,884,300	2,145,000
	OPC	45,805	7,040	—	—	44,155	97,000
	TPC	170,505	39,040	52,000	52,000	1,928,455	2,242,000

Note:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	2Q FY 2037
Expected Useful Life	25 years
Expected Future Start of D&D of this capital asset	2Q FY 2062

Related Funding Requirements
(dollars in thousands)

	Annual Costs		**Life Cycle Costs**	
	Previous Total Estimate	**Current Total Estimate**	**Previous Total Estimate**	**Current Total Estimate**
Operations, Maintenance and Repair	59,000	59,000	1,475,000	1,475,000

The numbers presented are the incremental operations and maintenance costs above the existing SNS facility without escalation. The estimate will be updated and additional details will be provided after CD-2, Approve Performance Baseline.

7. D&D Information

The new area being constructed in this project will not replace existing facilities.

	Square Feet
New area being constructed by this project at ORNL	~275,000
Area of D&D in this project at ORNL	—
Area at ORNL to be transferred, sold, and/or D&D outside the project, including area previously "banked"	~275,000
Area of D&D in this project at other sites	—
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously "banked"	—
Total area eliminated	—

8. Acquisition Approach

Based on the DOE determination at CD-1, ORNL is acquiring the STS project under the existing DOE M&O contract.

The M&O contractor prepared a Conceptual Design Report for the STS project and identified key design activities, requirements, and high-risk subsystem components to reduce cost and schedule risk to the project and expedite the startup. The necessary project management systems are fully up to date, operating, and are maintained as an ORNL-wide resource.

ORNL will design and procure the key technical subsystem components. Some technical system designs will require research and development activities. Preliminary cost estimates for most of these systems are based on SNS operating experience and vendor estimates, while some first-of-a-kind systems are based on expert judgement. Vendors and/or partner labs with the necessary capabilities will fabricate the technical equipment. ORNL will competitively bid and award all subcontracts based on best value to the government. The M&O contractor's performance will be evaluated through the annual laboratory performance appraisal process.

Lessons learned from other SC projects and other similar facilities are being exploited fully in planning and executing the STS.

18-SC-13, Linac Coherent Light Source-II-High Energy (LCLS-II-HE), SLAC
SLAC National Accelerator Laboratory, SLAC
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary

The LCLS-II-HE project will expand the capabilities of the LCLS to maintain U.S. leadership in ultrafast and ultrabright x-ray science. The project will increase the energy of the superconducting linac from 4 GeV to 8 GeV and thereby expand the high repetition rate operation (one million pulses per second) into the hard x-ray regime (5-12 keV). The FY 2025 Request for the LCLS-II-HE project is $100,000,000 of Total Estimated Cost (TEC) funding. At CD-1, this project established a preliminary Total Project Cost (TPC) range of $290,000,000 to $480,000,000. This cost range encompassed the most feasible preliminary alternatives. For the pending CD-2 reviews, the project's TPC estimate has exceeded the prior point estimate of $660,000,000 and now has reached $710,000,000, based on COVID-driven cost and schedule growth and additional risks.

Significant Changes

The LCLS-II-HE project was initiated in FY 2019. The most recent DOE Order 413.3B approved Critical Decision (CD) is CD-3B, Approve Long-Lead Procurements, which was approved on January 27, 2023, and was enabled by the investment of the IRA funds. The LCLS-II-HE project continues to be impacted by inflation and supply chain delays, impacting the initial cost, schedule, and project milestones assumptions. A combined CD-2/3 approval is projected for 3Q FY 2024; CD-4 is projected for 2Q FY 2030. This Construction Project Data Sheet (CPDS) is an update of the FY 2024 CPDS and does not include a new start for FY 2025.

FY 2023 funding supported finalizing the design and the performance baseline; continued with engineering, R&D, and injector gun prototyping; and initiated CD-3B long-lead procurements of cryogenic system components and transfer lines for the new superconducting electron gun and cryomodule production at the partner labs. The FY 2024 Request will continue support of the production of cryomodules, continue CD-3B procurements and begin the procurement of vendor-supported design efforts for the cryogenic distribution system, controls systems, and the low emittance injector beamline and related infrastructure; continue the R&D for the superconducting radiofrequency electron gun; and initiate construction/installation contracts. The FY 2025 Request will continue the construction and installation contracts, including the infrastructure systems for cryogenic transfer lines, water, mechanical and electrical, and pre-staging activities for start of the year-long LCLS Dark Time.

A Federal Project Director, certified to Level IV, has been assigned to this project.

Critical Milestone History

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
FY 2025	12/15/16	3/23/18	9/21/18	3Q FY 2024	2Q FY 2025	3Q FY 2024	2Q FY 2030

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout.

Fiscal Year	Performance Baseline Validation	CD-3A	CD-3B
FY 2025	3Q FY 2024	5/12/20	1/27/23

CD-3A – Approve Long-Lead Procurements for cryomodule associated parts and equipment.
CD-3B – Approve Long-Lead Procurements for SRF Injector cryogenic systems, Cryo Distribution Box, Optics for Experimental Systems, Controls Systems.

Project Cost History

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	80,400	597,600	678,000	32,000	32,000	710,000
FY 2025	59,000	619,000	678,000	32,000	32,000	710,000

2. Project Scope and Justification

Scope
The LCLS-II-HE project's scope increases the superconducting linac energy from 4 GeV to 8 GeV by installing additional cryomodules in the first kilometer of the existing linac tunnel. The electron beam, generated by a superconducting electron source, will be transported to the existing undulator hall to extend the x-ray energy to 12 keV and beyond. The project will also modify or upgrade existing infrastructure (process cooling water, power, electrical) in the last sector of the linac tunnel and the x-ray transport, optics, and diagnostics system. It will provide new or upgraded instrumentation to augment existing and planned capabilities.

Justification
International developments in X-ray facilities will challenge LCLS's world leadership position. The Shanghai Advanced Research Institute (SARI)XFEL in Shanghai, China, called SHINE, will match the high pulse rate for continuous operation and have double the electron energy enabled by the LCLS-II project, which allows production of shorter (i.e., harder) x-ray wavelength pulses compared to LCLS-II. The European X-ray Free Electron Laser (XFEL) at DESY in Hamburg, Germany has a higher electron energy than LCLS, and recent plans could extend the European XFEL from a pulsed operation mode to continuous operation. The continuous operation improves the stability of the electron beam and provides uniformly spaced pulses of x-rays or, if desired, the ability to customize the sequence of x-ray pulses provided to experiments to optimize the measurements being made. The European XFEL began operations in 2017, and SHINE is expected to begin in 2025. Both of these create a profound capability gap compared to LCLS.

In the face of this challenge to U.S. scientific leadership, extending the energy reach of x-rays beyond the upper limit of LCLS (5 keV) is a high priority. This expanded range to 12 keV will allow U.S. researchers to access x-ray wavelengths as short as one Ångstrom and probe earth-abundant elements that will be needed for large-scale deployment of photo-catalysts for electricity and fuel production. It also allows the study of strong spin-orbit coupling that underpins many aspects of quantum materials, and it reaches the biologically important selenium k-edge, used for protein crystallography.

The ability to observe and understand the structural dynamics of complex matter at the atomic scale, at ultrafast time scales, and in operational environments is critical to the nation's R&D enterprise and ability to develop the new advanced materials for new energy technologies. To achieve this objective, DOE needs a hard x-ray source capable of producing high energy ultrafast bursts with full spatial and temporal coherence at high repetition rates. This capability cannot be provided by any existing or planned light source.

The LCLS-II project was completed successfully in October 2023 and began operation in November 2023. LCLS-II is the first step to address this capability gap. With this upgrade, LCLS is currently the premier XFEL facility in the world at photon energies ranging from 200 eV up to approximately 5 keV. The cryomodule technology is a major advancement from prior designs that will allow continuous operation up to 1 MHz.

Over the past few years, the cryomodule design for the LCLS-II project has performed beyond expectations, providing the technical basis to double the electron beam energy. It is therefore possible to add additional acceleration capacity to double the electron beam energy from 4 GeV to 8 GeV in the LCLS-II-HE project. Calculations indicate that an 8 GeV linac will deliver a hard x-ray photon beam with peak energy of 12.8 keV, which will meet the mission need.

The LCLS-II-HE upgrade will provide world leading experimental capabilities for the U.S. research community by extending the x-ray energy from 5 keV to 12 keV and beyond.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*.

Key Performance Parameters (KPPs)
The KPPs are preliminary and may change as the project continues towards CD-2. At CD-2 approval, the KPPs will be baselined.

Performance Measure	Threshold	Objective
Superconducting linac electron beam energy	≥ 7 GeV	≥ 8 GeV
Electron bunch repetition rate	93 kHz	929 kHz
Superconducting linac charge per bunch	0.02 nC	0.1 nC
Photon beam energy range	250 to ≥ 8,000 eV	250 to ≥ 20,000 eV
High repetition rate capable, hard X-ray end stations	≥ 1	≥ 4
FEL photon quantity (10^{-3} BW)	$5x10^{8}$ (50x spontaneous @ 8 keV)	> 10^{11} @ 8 keV (200 mJ) or > $6x10^{9}$ @ 20.0 keV (20 mJ)

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Estimated Cost (TEC)				
Design (TEC)				
Prior Years	39,000	39,000	24,037	—
FY 2023	13,000	13,000	15,654	—
FY 2024	7,000	7,000	16,000	—
FY 2025	—	—	3,309	—
Total, Design (TEC)	**59,000**	**59,000**	**59,000**	**—**
Construction (TEC)				
Prior Years	139,657	139,657	99,472	—

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Estimated Cost (TEC)				
Prior Years - IRA Supp.	90,000	90,000	—	—
FY 2023	77,000	77,000	43,118	11,171
FY 2024	113,000	113,000	36,171	78,829
FY 2025	100,000	100,000	188,000	—
Outyears	99,343	99,343	162,239	—
Total, Construction (TEC)	**619,000**	**619,000**	**529,000**	**90,000**
Total Estimated Cost (TEC)				
Prior Years	178,657	178,657	123,509	—
Prior Years - IRA Supp.	90,000	90,000	—	—
FY 2023	90,000	90,000	58,772	11,171
FY 2024	120,000	120,000	52,171	78,829
FY 2025	100,000	100,000	191,309	—
Outyears	99,343	99,343	162,239	—
Total, Total Estimated Cost (TEC)	**678,000**	**678,000**	**588,000**	**90,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Other Project Cost (OPC)				
Prior Years	17,000	17,000	11,946	–
Prior Years - IRA Supp.	6,000	6,000	–	–
FY 2023	4,000	4,000	4,158	–
FY 2024	–	–	–	2,200
FY 2025	–	–	–	900
Outyears	5,000	5,000	9,896	2,900
Total, Other Project Cost (OPC)	**32,000**	**32,000**	**26,000**	**6,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Project Cost (TPC)				
Prior Years	195,657	195,657	135,455	–
Prior Years - IRA Supp.	96,000	96,000	–	–

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Project Cost (TPC)				
FY 2023	94,000	94,000	62,930	11,171
FY 2024	120,000	120,000	52,171	81,029
FY 2025	100,000	100,000	191,309	900
Outyears	104,343	104,343	172,135	2,900
Total, TPC	**710,000**	**710,000**	**614,000**	**96,000**

Note:

– *In FY 2021, the Office of Science reprogrammed $19,343,211.24 of prior year funds from this project to support the LCLS-II project at SLAC. The Prior Year Budget Authority in the table above reflects this reprogramming. Also in FY 2021, a total of $10,000,000 in current year and prior year funding was reprogrammed to the LCLS-II-HE project and additional funds are included in the outyears to maintain the project profile.*

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	55,500	73,400	**N/A**
Design - Contingency	3,500	7,000	**N/A**
Total, Design (TEC)	**59,000**	**80,400**	**N/A**
Construction	262,000	240,400	**N/A**
Site Preparation	2,000	2,000	**N/A**
Equipment	236,000	220,000	**N/A**
Construction - Contingency	119,000	135,200	**N/A**
Total, Construction (TEC)	**619,000**	**597,600**	**N/A**
Total, TEC	**678,000**	**678,000**	**N/A**
Contingency, TEC	*122,500*	*142,200*	***N/A***
Other Project Cost (OPC)			
R&D	10,000	9,000	**N/A**
Conceptual Planning	1,000	1,000	**N/A**
Conceptual Design	8,000	8,000	**N/A**
Start-up	7,000	6,700	**N/A**
OPC - Contingency	6,000	7,300	**N/A**
Total, Except D&D (OPC)	**32,000**	**32,000**	**N/A**
Total, OPC	**32,000**	**32,000**	**N/A**
Contingency, OPC	*6,000*	*7,300*	***N/A***
Total, TPC	**710,000**	**710,000**	**N/A**

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total, Contingency (TEC+OPC)	***128,500***	***149,500***	***N/A***

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	268,657	90,000	120,000	—	199,343	678,000
	OPC	23,000	4,000	—	—	5,000	32,000
	TPC	291,657	94,000	120,000	—	204,343	710,000
FY 2025	TEC	268,657	90,000	120,000	100,000	99,343	678,000
	OPC	23,000	4,000	—	—	5,000	32,000
	TPC	291,657	94,000	120,000	100,000	104,343	710,000

Note:

– *In FY 2021, the Office of Science reprogrammed $19,343,211.24 of prior year funds from this project to support the LCLS-II project at SLAC. The Prior Year Budget Authority in the table above reflects this reprogramming. Also in FY 2021, a total of $10,000,000 in current year and prior year funding was reprogrammed to the LCLS-II-HE project and additional funds are included in the outyears to maintain the project profile.*

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	2Q FY 2030
Expected Useful Life	25 years
Expected Future Start of D&D of this capital asset	2Q FY 2055

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	**Current Total Estimate**	**Previous Total Estimate**	**Current Total Estimate**
Operations, Maintenance and Repair	21,500	21,500	537,500	537,500

The numbers presented are the incremental operations and maintenance costs above the LCLS-II facility without escalation. The estimate will be updated and additional details will be provided after CD-2, Approve Project Performance Baseline.

7. D&D Information

At this stage of project planning and development, SC anticipates no new area will be constructed for this project.

8. Acquisition Approach

Based on the DOE determination at CD-1, SLAC is acquiring the LCLS-II-HE project under the existing DOE M&O contract.

SLAC has completed a Conceptual Design Report for the LCLS-II-HE and is completing the design and preparing for CD-2/3 approval. The necessary project management systems are fully operating and are maintained as a SLAC-wide resource.

SLAC is partnering with other laboratories for design and procurement of key technical subsystem components. Technical system designs require research and development activities. Preliminary cost estimates for these systems are based on actual costs from the LCLS-II project and other similar facilities, to the extent practicable. The M&O contractor is fully exploiting recent cost data in planning and budgeting for the project. SLAC or partner laboratory staff will complete the design of the technical systems. SLAC or subcontracted vendors with the necessary capabilities will fabricate the technical equipment. All subcontracts will be competitively bid and awarded based on best value to the government. The M&O contractor's performance will be evaluated through the annual laboratory performance appraisal process.

Lessons learned from the LCLS-II project and other similar facilities are exploited fully in planning and executing LCLS-II-HE.

Biological and Environmental Research

Overview

The Biological and Environmental Research (BER) program's mission is to support transformative science and scientific user facilities to achieve a predictive understanding of complex biological, Earth, and environmental systems for clean energy and climate innovation. This fundamental research, conducted at universities, DOE national laboratories, and other research institutions across the country, focuses on organisms and ecosystems that can influence U.S. energy systems and advance understanding of the relationships between energy, the environment, and climate science, from local to global scales. BER's support of basic research will contribute to a future of stable, reliable, and resilient energy sources and infrastructures that, in turn, contributes to evidence-based and equitable climate solutions. Research within BER can be categorized into biological systems and Earth and environmental systems. Biological systems research seeks to characterize and predictively understand microbial and plant systems using advanced genomics coupled with integrated experimental, analysis, and modeling techniques. Fundamental genomics-based understanding of the function of these systems underpins the ability to design new innovative processes for clean energy production, including the sustainable development of biofuels and other bioproducts, as well as new carbon management practices. Characterization and understanding of microbial communities will lead to improved understanding of the functioning and improved designs of bioenergy systems, that in turn will provide cost-effective alternatives to fossil fuel and will be resilient to climate change and other environmental perturbations. Earth and environmental systems research seeks to characterize and understand the interdependence among the climate, environment, and energy systems, which includes studies of atmospheric physics and chemistry, ecosystem ecology and biogeochemistry, and development and validation of ultra-high resolution Earth system models of rapidly changing and/or extreme phenomena that impact, e.g. electric grid reliability and resilience. These models integrate dynamic information on the biosphere, atmosphere, terrestrial land masses, oceans, sea and land ice, subsurface, energy technologies, infrastructure, and other relevant human components. To promote world-class research in these areas, BER supports user facilities that use the latest technologies to provide new observations and analyses of atmospheric, biological, and biogeochemical processes. In addition, BER research utilizes advanced computational simulation, and data analytics (including Artificial Intelligence [AI] and Machine Learning [ML]) to enable scientific discovery and technological solutions for extreme phenomena that impact the Nation's energy systems. Engagement with the scientific community and the federally chartered BER Advisory Committee informs all BER activities.

Over the last three decades, BER's scientific impact has been transformative. Mapping the human genome through the U.S. supported international Human Genome Project that DOE initiated in 1990 ushered in a new era of modern biotechnology and genomics-based systems biology. Today, researchers in the BER Genomic Sciences activity and the Joint Genome Institute (JGI) are using powerful genomics-based tools for plant and microbial systems biology to pursue the early-stage research that will lead to the development of dedicated bioenergy crops and microbial systems to produce a wide variety of renewable fuels, chemicals and materials underpinning clean energy technologies for a more carbon- neutral bioeconomy.

Since the 1950s, BER and its predecessor organizations have been critical contributors to the fundamental scientific understanding of climate change, including atmospheric, land, ocean, environmental, and human systems. BER research reduces the greatest uncertainties in model predictions such as those involving clouds, aerosols, and carbon, and is incorporating new climate and energy infrastructure observations from initiatives such as Urban Integrated Field Laboratories (UIFLs) and is providing climate and environmental change information critical for the Nation's energy strategies. DOE research has made advances in increasing the reliability and predictive capabilities of climate models using AI/ML, access to DOE's fastest computers, and validation based on a diversity of observations and other data sources. BER initiatives such as UIFLs, CRCs, and core research activities broaden participation in the BER ecosystem to make it more representative of our nation. BER investments build capacity and help train a new energy workforce at emerging research institutions, underserved communities, and Historically Black Colleges and Universities (HBCUs), and Minority Serving Institutions (MSIs).

Highlights of the FY 2025 Request

The FY 2025 Request of $945.2 million is an increase of $36.5 million over the FY 2023 Enacted level. BER will enhance its research on climate science with a new initiative focused on a high resolution prediction capability based on the interdependence of climate change with realistic scenarios of U.S. deployments in energy innovations, enhanced UIFLs and the network of climate centers, affiliated with emerging research institutions, underserved communities, and HBCU and

MSI; expanded investments in AI approaches for improving Earth and environmental system predictability; and continuing Earthshots research that focuses on science at the nexus of clean energy production and climate change. BER will enhance its systems biology research by continuing the Energy Earthshot Research Centers (EERCs) and expanding Earthshot research activities to bring together multi-disciplinary teams addressing innovative clean energy production and carbon management practices. These efforts will seek to rapidly remove barriers hampering the translation of basic science into technological solutions and speed development of new innovations in biotechnology, including development of sensor technologies to enable the translation of laboratory-scale results, such as in fabricated ecosystems, to broader-scale field ecosystems. BER will continue the Established Program to Stimulate Competitive Research (EPSCoR) and enhance investments in Reaching a New Energy Sciences Workforce (RENEW) and Funding for Accelerated, Inclusive Research (FAIR) initiative to build stronger programs with underserved communities and emerging research institutions as well as HBCUs and MSIs, including investing in a more diverse and inclusive workforce.

Research

- Within Genomic Sciences, the Biological Research Centers (BRCs) will provide new research both individually and through shared research themes, underpinning clean energy innovations and production of fuels, chemicals, and other products from sustainable biomass resources. The EERCs will continue efforts with a specific focus on translational research that lowers risks and speeds adoption of basic research results to industry for a broader, more carbon-neutral bioeconomy. The Biopreparedness Research Virtual Environment (BRaVE) will add additional functionality to its collaborative cyber infrastructure allowing distributed networks of scientists to work on multidisciplinary research priorities and/or national emergency challenges. The BRaVE effort includes enhanced low dose radiation research. Computational Biosciences efforts will support advanced computing to deploy a flexible multi-tier data and computational management architecture for microbiome system dynamics and behavior. Research in Biomolecular Characterization and Imaging Science will develop multi-modal and quantum information science (QIS)-enabled techniques to understand biological processes.
- BER will expand FAIR, which encompasses all BER activities, to provide focused investment on enhancing biological and environmental research and capacity building increasing the participation and engagement with groups in clean energy and climate research at emerging research institutions, underserved communities, and HBCUs and MSIs.
- Earth and Environmental Systems Sciences research will focus on improving the representation of physical, biogeochemical, and human processes to enhance the predictability of climate, Earth, and environmental systems. Environmental System Science will integrate physical and hydrobiogeochemical sciences to provide scale-aware predictive understanding of above- and below-surface terrestrial ecosystems. Atmospheric System Research will investigate cloud-aerosol-precipitation interactions, including urban and forested regions. Modeling research, in particular the DOE Exascale Energy Earth System Model (E3SM), will expand and continue activities to utilize advanced software and AI/ML for running on future DOE computer architectures. Exascale research activities will continue to build from the completed Exascale Computing Project (ECP), broadening software development for advanced computing and sustainability across current and future computing platforms. The Data Management effort will enhance data archiving and management capabilities, including use of AI research for environmental field data.
- RENEW, which encompasses all BER activities, expands targeted efforts, including a RENEW graduate fellowship to increase inclusion of emerging research institutions, underserved communities, and HBCUs, MSIs within BER research to broaden participation and advance equity and inclusion in SC-sponsored research.

Facility Operations

- The JGI will expand providing genome sequence data and analysis techniques for a wide variety of plants and microbial communities. ARM will continue new observations to advance Earth System models and atmospheric research, and to complement ARM's field observations of cloud-aerosol interactions, will initiate the Drizzle, Aerosol, and Cloud Observation (DRACO) chamber project with other project cost (OPC) funding to complement ARM's field observations of cloud-aerosol interactions. EMSL will provide analytical and imaging capabilities in support of BER's biological, environmental, and climate science priorities, and will embark on development of a capability for microbial molecular phenotyping.

Projects

- The BER FY 2025 Request includes $19.0 million to continue the Microbial Molecular Phenotyping Capability (M2PC) project at the Pacific Northwest National Laboratory.

Biological and Environmental Research
Funding

(dollars in thousands)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Biological and Environmental Research				
Genomic Science	328,685	298,935	316,420	-12,265
Biomolecular Characterization and Imaging Science	45,000	45,750	43,910	-1,090
Biological Systems Facilities & Infrastructure	90,000	85,550	93,565	+3,565
Total, Biological Systems Science	**463,685**	**430,235**	**453,895**	**-9,790**
Atmospheric System Research	36,000	38,584	35,750	-250
Environmental System Sciences	120,800	123,000	155,020	+34,220
Earth and Environmental Systems Modeling	115,500	108,000	114,610	-890
Earth and Environmental Systems Sciences Facilities and Infrastructure	172,700	135,825	166,950	-5,750
Total, Earth and Environmental Systems Sciences	**445,000**	**405,409**	**472,330**	**+27,330**
Subtotal, Biological and Environmental Research	**908,685**	**835,644**	**926,225**	**+17,540**
Construction				
24-SC-31 Microbial Molecular Phenotyping Capability (M2PC), PNNL	–	–	19,000	+19,000
Subtotal, Construction	**–**	**–**	**19,000**	**+19,000**
Total, Biological and Environmental Research	**908,685**	**835,644**	**945,225**	**+36,540**

SBIR/STTR funding:

- FY 2023 Enacted: SBIR $21,327,000 and STTR $2,999,000
- FY 2024 Annualized CR: SBIR $20,319,000 and STTR $2,857,000
- FY 2025 Request: SBIR $21,999,000 and STTR $3,094,000

Biological and Environmental Research
Explanation of Major Changes

	(dollars in thousands) FY 2025 Request vs FY 2023 Enacted
Biological Systems Science This activity ramps down efforts in secure biosystems design and microbial research on biofuels to prioritize early-stage science to understand mechanisms controlling the interplay of microbes and plants in soil systems for clean energy and carbon management initiatives. The BRCs will jointly provide new research underpinning bioenergy and bioproducts production from sustainable biomass through individual and multi-BRC collaborative efforts. The EERCs will continue and Science Foundations for Energy Earthshot research will be enhanced to continue to remove barriers to translating basic science innovations into clean energy and carbon management solutions. FAIR is enhanced and includes both clean energy and climate research at emerging research institutions, underserved communities, and HBCU and MSIs. Emerging technology capabilities to scale results from laboratory fabricated ecosystems to field ecosystems will be developed using integrated sensor networks, complementing efforts to understand processes governing soil-microbe-plant interactions controlling carbon turnover. Biotechnology to transform advanced manufacturing and accelerate innovations in emerging technologies will shift to other priority basic research supporting a growing bioeconomy. The initial pilot project to develop the scope of biopreparedness research scope BRaVE is completed while efforts in low dose radiation research are enhanced. New bioimaging, measurement, and characterization approaches including integrative platforms will continue at reduced levels. QIS research continues. JGI continues plant transformation research.	**-$9,790**
Earth and Environmental Systems Sciences The climate science initiative will advance an innovative capability able to evaluate risks to environmental, infrastructure, and human activities across America's rural landscapes based on multi-model-data fusion and response to climate extremes. Research continues to support increasingly higher-resolution Earth system modeling using exascale-class computers, focused on DOE missions for energy and infrastructure resilience and security. The enhanced investments in AI will accelerate high-resolution predictive capabilities across the DOE climate model-data-experiment enterprise. Environmental System Science will increase support of the Urban IFLs providing new data for informing climate and Earth system models. The support for the Energy Earthshot research activities will continue. RENEW increases by including additional emerging research institutions, underserved communities, and HBCU and MSIs within BER research to broaden participation and advance equity and inclusion in Office of Science-sponsored research, including through a RENEW graduate fellowship. The network of climate resilience centers that focuses on local to regional ecological and atmospheric risks and responses, is expanded. Using observations from the ARM facility, Atmospheric System Research will focus activities to advance knowledge and improve model representations of Earth's energy balance, critical to inform the design of climate-hardened energy infrastructures. ARM will continue operations at long-term sites, continue the mobile unit deployment in Tasmania, Australia, and initiate a mobile unit deployment in Baltimore, Maryland. A cloud chamber project effort will be initiated to inform cloud-aerosol processes based on ARM's field observations. EMSL will focus on biological and environmental molecular science and new technologies for microbial molecular phenotyping. Data management activities will enhance applying AI and ML to environmental field data.	**+$27,330**
Construction Design activities will continue for the Microbial Molecular Phenotyping Capability (M2PC) at the Pacific Northwest National Laboratory.	**+$19,000**
Total, Biological and Environmental Research	**+$36,540**

Basic and Applied R&D Coordination
BER research underpins the needs of DOE's energy and environmental missions and is coordinated through internal DOE mechanisms, and more broadly through the National Science and Technology Council (NSTC) and other committees of the Office of Science and Technology Policy (OSTP). BER research includes biological, Earth and environmental systems investments in theoretical, experimental, predictive modeling research, and science supporting renewable energy alternatives. Basic research on genomics, microbes and plants provides fundamental knowledge that can be used to develop new bioenergy crops and improved biofuel and bioproduct production processes that enable a more sustainable bioeconomy. Basic research on atmospheric and ecological processes is used to advance predictive capabilities and assess risks and resilience of energy systems. Coordination with other federal agencies on priority bioeconomy science needs, occurs through the Biomass Research and Development Board, a Congressionally mandated interagency group created by the Biomass Research and Development Act of 2000, as amended by the Energy Policy Act of 2005 and the Agricultural Act of 2014. Coordination of BER's climate, environment, geospatial, and Arctic investments occur within the NSTC Committee on Environment, most notably through the US Global Change Research Program. Coordination with OSTP and other federal agencies on short-term weather, seasonal, and short-term climate forecasts is conducted under the Interagency Council for Advancing Meteorological Services (ICAMS), chartered by OSTP in 2020 as part of the U.S. Weather Act of 2017. Furthermore, BER coordinates with DOE's applied energy offices through regular joint DOE working groups, program manager meetings, by participating in their internal program reviews and in joint principal investigator meetings and technical workshops.

BER supports some interagency projects to manage databases (such as the Protein Data Bank) through interagency awards and funding for complementary community resources (such as beamlines and cryo-electron microscopy), mostly with NIH and NSF. BER is a member of the advisory committee for DoD's BioMADE project researching synthetic biology applications.

All climate systems research activities within BER are dedicated to advancing predictive capabilities that inform the design and deployment of DOE's applied programs. The centerpiece of BER's modeling investments is the Energy Exascale Earth System Model, that has evolved to become the world's highest resolution Earth system model able to run on exascale computers, facilitating the scientific community in developing and testing system-level scientific concepts on the smallest scales. Other agencies, e.g., NOAA, NASA, the Navy, and NSF, are following developments in E3SM via both USGCRP and ICAMS. The Intelligence Community has demonstrated significant interest in E3SM, as a platform to incorporate their data to address national security problems. The E3SM research is tightly coordinated with BER's large scale experimental activities and has strong links to DOE applied programs and DOE Office of Policy.

Program Accomplishments
Notable accomplishments in *Biological Systems Science* include:

- *Improved molecular understanding of an enzyme with the fastest known rate of CO_2 fixation.* Advanced analysis techniques at SLAC enabled mechanistic understanding of a reductive carboxylase enzyme that facilitates new engineered techniques for this enzyme to capture CO_2 more efficiently and effectively from the air for conversion to products such as fuels and chemicals currently produced from petroleum.
- *Biologically engineered yeast that produces chemical bioproducts, making biofuel production more economical*. A yeast strain engineered at the Joint BioEnergy Institute produces triacetic acid lactone (TAL), a valuable co-product, from lignocellulose, potentially making combined production of biofuels and bioproducts more economically feasible.
- *New possibilities for bioprocessing of plant biomass and biomanufacturing - evidence of lignin degradation with no oxygen needed.* Researchers in association with JGI recently demonstrated conclusively that fungi can degrade lignin anaerobically (i.e., with no oxygen), a process not previously thought to be possible.
- *Understanding the role of plant exudates that influence soil microbiome communities associated with bioenergy crops.* Through advanced genomics techniques, researchers at Oak Ridge National Laboratory identified two microorganisms that are dependent on salicin, a plant exudate, potentially leading to mechanisms that can alter microbiome activity for beneficial plant growth.

- *Candidate genes identified in Camelina that control oilseed traits.* A collection of 222 Camelina sativa plants were re-sequenced in a collaboration among JGI, Hudson Alpha, and Arizona Genomics Institute. Genome wide association studies identified genes controlling seed size, fatty acid composition, and flowering time, providing tools for development of higher yielding bioenergy crops that require minimal fertilizer input.
- *Development of a modified CRISPR-CAS system for precise genome editing within a microbial community.* Species-specific, phage-based methods were developed to deliver CRISPR-CAS based genome editing machinery to targeted microbes, demonstrating a way to modify specific microbes within a mixed community for enhanced biotechnologies.

Notable accomplishments in *Earth and Environmental Systems Sciences* include:

- *Building the next generation of climate models – the first to run on the exascale Frontier computer, placing the U.S. as the global leader in high resolution prediction science.* BER scientists developed a 3 km resolution climate prediction capability that allows for unprecedented scientific analyses of extreme events on local scales needed for energy, such as the electrical grid and urban energy systems, and other stakeholder applications. As a testament from the international scientific community of the innovations achieved with E3SM to set the global standard for modeling and prediction, the DOE developer team recently won the first-ever Association for Computing Machinery (ACM) Gordon Bell Prize for Climate Modelling at the International Conference for High Performance Computing, Networking, Storage and Analysis (SC23) in Denver on November 16, 2023.
- *Improving weather and climate predictions using machine learning.* A newly designed machine learning algorithm, applied to cloud radar data from the Atmospheric Radiation Measurement User Facility, discovered more drizzle (i.e., fine particle precipitation) in marine stratus clouds than previous observing systems had detected, critical for improved accuracy of local to regional scale climate models. Drizzle dynamics exert significant control of the radiative properties of low warm clouds, influencing the rates of regional to global climate change.
- *Understanding and modeling changes in precipitation associated with urbanization and irrigation.* Effects of large-scale urbanization and irrigation on summer precipitation in the mid-Atlantic region indicated that urbanization suppresses precipitation, while irrigation enhances most precipitation types. This study reveals the effects of human activities on regional rainfall distribution.
- *Environmental impacts assessed with molecular characterization of wildfire smoke.* An ultra high-resolution, custom-built instrument at the DOE Environmental Molecular Sciences Laboratory User Facility was used to characterize organophosphorus compounds in wildfire smoke, and subsequently identify the severity of wildfire burns on landscapes and the impacts of wildfires on adjacent aquatic systems.
- *Observing increased nutrient availability from ecosystem warming.* The SPRUCE warming and CO_2 enrichment experiment in Minnesota has shown that whole-ecosystem warming has exponentially increased nutrient availability throughout the soil profile. Peatlands hold a large amount of global soil carbon storage and increased nutrient availability will impact this storage.

Biological and Environmental Research
Biological Systems Science

Description

The Biological Systems Science subprogram integrates advanced genomics research with computation and user facility capabilities for basic science on plant and microbial systems relevant to national priorities and DOE's mission in renewable energy and innovation in biotechnology underpinning novel clean energy, carbon management and biotechnology solutions needed to address the climate crisis.

<u>Genomic Science</u>

The Genomic Science activity supports basic research in foundational genomics, bioenergy, environmental genomics, and computational bioscience to reveal the fundamental principles that drive biological systems and enable the design of new biosystems relevant to DOE missions in renewable energy to discover the breakthroughs that will propel the Nation towards a more carbon neutral bioeconomy.

Foundational Genomics supports basic research on discovery and manipulation of genome structural, regulatory, and epigenetic controls to understand genotype to phenotype translations in microbes and plants. Researchers apply systems biology and biosystems design research to understand, predict, emulate, and design biological processes as a basis for new approaches to renewable biofuels and bioproducts, biotechnology, and low carbon biomanufacturing.

The DOE Bioenergy Research Centers (BRCs) provide a fundamental understanding of plants and microbes as a basis for developing sustainable innovative processes for clean bioenergy and a range of bioproducts from inedible lignocellulosic biomass. These multi-disciplinary, multi-institutional centers will accelerate the scientific groundwork necessary for a more bio-based economy that promises to yield new fuels, chemicals, materials, and other products from renewable resources.

Environmental Genomics supports research on understanding plants and soil microbial communities and their impact on environmental cycling and/or sequestration of carbon, nutrients, and contaminants. This includes studying natural and model microbiomes in environments relevant to bioenergy and environmental research.

Computational Biosciences supports systems biology research through the development of on-line, open access bioinformatics and modeling capabilities within the DOE Systems Biology Knowledgebase (KBase) and the National Microbiome Data Collaborative (NMDC). These integrated resources support large-scale collaborative data science investigations of plant and microbial systems to reveal biological processes that will accelerate the development of renewable fuels and bioproducts.

<u>Biomolecular Characterization and Imaging Science</u>

Biomolecular characterization and imaging science supports integrative approaches to detect, visualize, and measure biological processes to gain a predictive understanding of cellular function, critical for expanding the boundaries of bioengineering and bioenergy research. This effort includes innovative QIS-enabled imaging concepts and sensor/detector design based on correlated materials.

<u>Biological Systems Facilities and Infrastructure</u>

The DOE Joint Genome Institute is the only federally funded major genome sequencing center focused on genome discovery and analysis in plants and microbes for energy and environmental applications. This scientific user facility provides high-throughput DNA sequencing capabilities on organisms and groups of organisms to identify key genes that may link to biological function as a foundational basis for BER's basic bioenergy research efforts.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Biological Systems Science	**$463,685**	**$453,895**	**-$9,790**
Genomic Science	$328,685	$316,420	-$12,265
Foundational Genomics research supports new research on microorganisms with advantageous bioenergy and bioproduct traits. Biosystems design research accelerates the ability to design plants and microorganisms with specific beneficial low carbon clean energy, bioproduct and biomaterials production traits. New efforts provide emerging technologies to develop integrated automated sensors that scale from laboratory fabricated ecosystems to field ecosystems as part of the Accelerate initiative.		Foundational Genomics research prioritizes understanding the mechanisms controlling plant and microbial interactions in soils that underpin clean energy and carbon management initiatives. Funding in the Accelerate and Biotechnology to Transform Advanced Manufacturing initiatives shift to priority bioenergy/bioeconomy research. Biosystems design research continues efforts to accelerate the ability to design plants and microorganisms with specific beneficial low carbon clean energy, bioproduct and biomaterials production traits. Efforts will continue to support emerging technologies to develop integrated automated sensors that scale from laboratory fabricated ecosystems to field ecosystems. Support for research on a wide variety of microorganisms and plants with clean energy, carbon sequestration and bio-inspired bioproduct-relevant traits continues in order to broaden the range of platform organisms available for biotechnology use, underpinning innovations for clean energy and a more decarbonized bioeconomy.	Foundational Genomics efforts in Secure Biosystems Design and microbial biofuels research ramps down to fully fund efforts within the BRCs for clean energy and carbon management initiatives. The funding for Accelerate and Biotechnology to Transform Advanced Manufacturing initiatives will shift to other priority basic biofuels and bioproducts research supporting a growing bioeconomy. Emerging technologies will integrate *in situ* sensors, imaging, 'omics analysis, and autonomous controls and continuous data acquisition and analysis.
BER launches Energy Earthshot Research Centers to address key biological research challenges at the interface between currently supported basic research and applied research and development activities.		BER will expand Energy Earthshot research and continue Centers initiated in FY 2023 to include additional key biological research challenges at the interface between currently supported basic research and applied research supporting development	Funding will support additional research for the DOE Earthshot activities.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
	activities to help speed translation of basic discoveries to industry.	
Environmental Genomics continues plant functional genomics research to understand genotype to phenotype translations leading to beneficial bioenergy or bioproduct traits in potential bioenergy crops.	Environmental Genomics continues basic plant functional genomics research to understand genotype to phenotype translations leading to bioenergy crop improvement.	Funding will support efforts in plant genomics to extend advances in plant genome science by generating experimental evidence of gene function to improve productivity and sustainability of renewable feedstocks for fuels and chemical production.
Environmental microbiome science continues efforts to understand the functions of environmentally relevant microbial communities in a variety of ecosystems.	Environmental microbiome science continues efforts to understand the functions of environmentally relevant microbial communities controlling the cycling of carbon and nutrients in a variety of ecosystems.	Funding will support efforts in the ability to predictively understand the activity of microbial communities controlling carbon and nutrient cycling in relevant environmental microbiomes.
BRaVE expands to build out a computational platform and experimental workflow through which a distributed network of data and experimental capabilities can be accessed by multidisciplinary teams of scientists working together on urgent multiprogram priorities, including low dose radiation research.	BRaVE will continue to add functionality to its expanding computational platform and experimental workflows. BRaVE continues to build a distributed network of data and experimental capabilities that can be accessed by multidisciplinary teams of scientists working together on urgent multiprogram priorities and/or emergency situations. BRaVE will expand low dose radiation research efforts.	BRaVE efforts will continue to support burgeoning biopreparedness activities and expand low dose radiation research. The BRaVE pilot effort to develop the scope of biopreparedness research relevant to BER science concludes.
The FAIR initiative strengthens clean energy genomic research at HBCUs and MSIs, building partnerships with the DOE national labs.	The FAIR initiative will expand and include both environment and biology activities in BER at emerging research institutions, underserved communities, and HBCUs and MSIs, increasing partnerships with the DOE national laboratories in DOE mission science for, clean energy and climate research.	FAIR will encompass all environmental and biological BER activities and expand to support additional opportunities at emerging research institutions, underserved communities, and HBCU and MSIs.
Computational Bioscience supports research efforts within Genomic Science by providing bioinformatics, simulation and modeling capabilities through the KBase platform and within the NMDC. Both platforms	Computational Bioscience will support research efforts within Genomic Science by providing bioinformatics, simulation, and modeling capabilities through the KBase platform and within the NMDC.	Funding will support research and intergrative linkages among the bioinformatic platforms of KBase, NMDC and JGI supporting basic genomic science

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
continue integrative activities among each other within the Advanced Computing Initiative and with the JGI.	Both platforms will continue integrative activities with each other and with the JGI.	research underpinning bioenergy, biotechnology, and bioeconomy innovations.
The four BRCs continue with 5-year renewal to support multidisciplinary clean energy research underpinning a broader bio-based economy. The BRCs broaden their collaborative activities to accelerate plant and microbial genome engineering with AI/ML techniques to diversify the range of products that can be sustainably produced from plant biomass, expand understanding of plant-microbe interactions to create better agronomic practices for clean bioenergy production, develop new plant varieties with expanded capabilities for biofuels and bioproduct production and increase collaboration among the broader research community (including HBCUs) and within rural communities where new crop-based clean energy and bioproduct production could spark new industries and bioeconomy development.	The BRCs will broaden their collaborative activities to accelerate plant and microbial genome engineering with AI/ML techniques to diversify the range of products that can be sustainably produced from plant biomass, expand understanding of plant-microbe interactions to create better agronomic practices for clean bioenergy production, develop new plant varieties with expanded capabilities for biofuels and bioproduct production and increase collaboration among the broader research community (including emerging research institutions, underserved communities, and HBCU and MSIs) and within rural communities where new crop-based clean energy and bioproduct production could spark new industries and bioeconomy development.	The four BRCs will expand efforts on broad theme-based collaborative research requiring a multi-BRC approach to accelerate genome engineering for plants and microbes advance sustainability research through research on plant-microbe interactions, develop new plant varieties with an expanded range of biofuels and bioproducts, and engage a broader spectrum of the research community (including emerging research institutions, underserved communities, and HBCU and MSIs) and rural communities where this research could lead to new bioeconomy opportunities.
Funding supports early-stage R&D, including research that underpins DOE energy technology programs, the SC Energy Earthshots initiative, and innovations for climate science. Following the previous year's focus on State-National Laboratory Partnership awards, FY 2023 emphasizes Implementation Awards to larger multiple investigator teams that develop research capabilities in EPSCoR jurisdictions. Investment continues in early career research faculty from EPSCoR-designated jurisdictions and in co-investment with other programs for awards to eligible institutions.	Funding will support EPSCoR Implementation awards, larger multiple investigator teams that develop research capabilities, including investment in instrumentation, in EPSCoR jurisdictions.	Continued support for research in EPSCoR jurisdictions.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Biomolecular Characterization and Imaging Science $45,000	$43,910	-$1,090
New multimodal bioimaging research supports new capabilities to characterize, measure, visualize and test hypotheses on plant and microbial cell function and metabolism. Quantum-enabled science concepts for imaging techniques will continue.	New multimodal bioimaging research will provide new capabilities to characterize, measure, visualize and test hypotheses on plant and microbial cell function and metabolism. Quantum-enabled science concepts for imaging techniques will continue.	Funding will support multimodal bioimaging research activities. The decrease represents completion of a subset of awards.
Biological Systems Facilities & Infrastructure $90,000	$93,565	+$3,565
JGI provides users with high quality genome sequences and new analysis techniques for complex plant and microbiome samples. Integrative activities with KBase and the NMDC provides new crossplatform capabilities for users. Genome-based discovery efforts for natural product production in microbial isolates continues in concert with expanded metagenomics analysis techniques. The multi-year instrument and equipment refresh continues at a reduced pace to support the integrative activities with KBase and the NMDC.	JGI will provide users with high quality genome sequences and new analysis techniques for complex plant and microbiome samples. Integrative activities with KBase and the NMDC will provide new cross-platform capabilities for users. Genome-based discovery efforts for natural product production in microbial isolates continues in concert with expanded metagenomics analysis techniques. The multi-year instrument and equipment refresh will continue at a reduced pace to support the integrative activities with KBase and the NMDC. New plant transformation research will be conducted to explore needed techniques to transform a wider variety of plants for genome interrogation and design.	Funding will support expanded integrative efforts with KBase and the NMDC to provide new analysis capabilities for microbiome science. The continuing instrument and equipment refresh will be slowed to support the expanded integrative activities with KBase and the NMDC. Funding will also support a new plant transformation activity to provide the genomic tools to more broadly understand, modify, and design plants with beneficial traits for bioenergy and bioproducts.

Note:

- *Funding for the subprogram above, includes 3.65 percent of research and development (R&D) funding for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, excluding facility operations.*

Biological and Environmental Research
Earth and Environmental Systems Sciences

Description

The Earth and Environmental Systems Sciences subprogram supports fundamental research and scientific user facilities that enable enhanced predictability of dynamically changing climate, environmental, and Earth systems, in support of DOE's mission involving transformative science for energy and national security. This includes improving predictability of climate trends and extremes that influence the design and deployment of next generation energy systems, based on experimental and modeling research on atmospheric, terrestrial, and human components of the Earth system; modeling of oceanic and Great Lakes systems; studies involving the interdependence and perturbations involving cloud, aerosol, marine, ecological, hydrological, biogeochemical, and cryospheric processes; analysis of the vulnerabilities of energy infrastructures and communities to climate change and extreme events; and uncertainty quantification. This integrated portfolio extends from molecular-level to field-scales and spans time scales from sub-seasonal to centennial. The research makes use of DOE's major facilities, in particular the Atmospheric Radiation Measurement User Facility, Environmental Molecular Sciences Laboratory, and DOE's exascale-class computing. Investments emphasize the most difficult challenges limiting prediction certainty, including cloud-aerosol interactions; the role of biogeochemistry; and human activities as they couple with the natural system. The research is used to inform the design, development, financing, and deployment pathways of climate friendly technical energy solutions that promote social equity and enhance urban resilience in response to the climate crisis.

The subprogram prioritizes Energy Earthshot Research Centers and Earthshot research; the Established Program to Stimulate Competitive Research (EPSCoR); and Reaching a New Energy Sciences Workforce (RENEW) activities. Additionally, the subprogram will increase inclusion of emerging research institutions, underserved communities, and HBCUs and MSIs within BER research to broaden participation and advance equity and inclusion in Office of Science-sponsored research.

Atmospheric System Research

Atmospheric System Research (ASR) is the primary U.S. research activity addressing the main source of uncertainty in climate and Earth system models: the interdependence of clouds, aerosols, precipitation, and radiative transfer processes. These processes must be improved for models to inform appropriate deployment of energy systems. ASR coordinates with the Atmospheric Radiation Measurement Facility (ARM), using the facility's continuous long-term datasets that are collected from a variety of dynamical and turbulence conditions in climate-sensitive regions around the world.

Environmental System Sciences

Environmental System Science (ESS) supports research on physical and hydro-biogeochemical processes and variable geomorphology, from the subsurface to the top of the vegetative canopy. The activity combines process modeling with new multi-scale data spanning regions where surface changes are particularly impactful for energy and adaptability, including the Arctic, the midlatitude boreal zone, the Tropics, mountainous zones, urban and rural systems, and coastal regions. ESS coastal activities include the Delaware and Susquehanna River watersheds, the Great Lakes, and Puget sound. The four Urban Integrated Field Laboratories (IFLs) integrate field data within a next-generation Earth System Modeling framework. Funding also supports efforts to enhance accessibility and utility of data on greenhouse gas fluxes from natural systems, consistent with the National Strategy to Advance an Integrated U.S. Greenhouse Gas Measurement, Monitoring, and Information System.

Earth and Environmental Systems Modeling

Earth and Environmental Systems Modeling develops the physical, biogeochemical, and dynamical underpinning for fully coupled climate and Earth System Models (ESMs), in coordination and complementary with other Federal efforts and with a focus on weeks to decades timescales and on the variability of extreme phenomena that particularly impact energy systems. Using DOE's flagship Energy Exascale Earth System Model (E3SM) and other models, the Artificial Intelligence for Earth System Predictability (AI4ESP) effort motivates the radical acceleration of predictive capabilities across the DOE climate model-data-experiment enterprise, taking advantage of emerging AI/ML techniques, robust couplers, diagnostics, performance metrics, and use of DOE's exascale computers.

Earth and Environmental Systems Sciences Facilities and Infrastructure

The Earth and Environmental Systems Sciences Facilities and Infrastructure activity supports data management and two scientific user facilities for the Earth and environmental systems sciences communities. The scientific user facilities, ARM and EMSL, provide the broad scientific community with technical capabilities, scientific expertise, and unique information to facilitate cutting edge science in atmospheric and molecular science areas integral to BER's mission.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Earth and Environmental Systems Sciences	**$445,000**	**$472,330**	**+$27,330**
Atmospheric System Research	$36,000	$35,750	-$250
Funding for ASR continues research on clouds, aerosols, and thermodynamic processes, with a focus on data from the ARM fixed sites as well as recent field campaigns conducted in the Arctic during FY 2020 and data from the TRACER and SAIL campaigns. ASR continues to make use of data generated by Large Eddy Simulations at the ARM Oklahoma site.		ASR will continue research on clouds, aerosols, and thermodynamic processes, with a focus on data from the ARM long-term sites as well as data from the completed TRACER and SAIL campaigns, and the on-going campaigns Cape-K (Cloud and Precipitation Experiment at Kennaook) in Tasmania and CoURAGE (Coast-Urban-Rural Atmospheric Gradient Experiment) in Baltimore, Maryland. ASR will continue to make use of data generated by Large Eddy Simulations as part of ARM facility deployments. Scope will be expanded to include urban areas.	Analyses of data from the MOSAiC campaign are completed. Funding will continue to prioritize urban areas and coastal regions.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Environmental System Sciences $120,800	$155,020	+$34,220
Funding for ESS focuses research on permafrost and maintains investments in studies of boreal ecology and modeling hydrobiogeochemistry of watersheds and terrestrial-aquatic interfaces, with a focus on the coastal zones encompassed by the Delaware and Susquehanna watersheds and the Great Lakes, and Puget Sound. The Urban IFLs expand to support climate science. The NVCL is fully implemented and continues to provide access to the single portal to DOE lab climate capabilities. Funding initiates the network of climate centers focused on resilience. RENEW expands to provide undergraduate and graduate training opportunities for students and academic institutions not currently well represented in the U.S. S&T ecosystem.	ESS will begin a new climate initiative. The new research will advance a hybrid capability to evaluate risks to environmental, infrastructure, and human activities based on model-data fusion. ESS will continue research on permafrost, boreal ecology, and modeling hydrobiogeochemistry of watersheds and terrestrial-aquatic interfaces, with a focus on the coastal zones encompassed by the Delaware and Susquehanna watersheds and the Great Lakes, and Puget Sound. Urban IFLs will be enhanced to support and coordinate urban climate science. The NVCL will continue to serve as a portal that describes DOE lab climate science and resilience capabilities as well as training and outreach opportunities, to an audience that includes emerging research institutions, underserved communities, HBCUs, and MSIs interested in DOE climate science research for energy security. The network of climate resilience centers will increase. The RENEW initiative expands targeted efforts, including a RENEW graduate fellowship, to increase participation and retention of individuals from underserved communities in SC research activities. Funding will also support efforts on the accessibility and utility of data on greenhouse gas fluxes from natural systems, consistent with the National Strategy to Advance an Integrated U.S. Greenhouse Gas Measurement, Monitoring, and Information System.	The funding will initiate new climate research leading to a robust predictive capability for America's rural and semi-urban regions, with greater accuracy for use by a wide variety of energy stakeholders. The Urban IFLs will expand coordination and collaboration, with more integrated field data also designed for a next generation Earth System Modeling framework and create a science capability to advance climate and energy research as a unified co-dependent system. The increase broadens RENEW activities across BER. Funding will support new efforts enhancing accessibility and utility of data on greenhouse gas fluxes from natural systems, consistent with the National Strategy to Advance an Integrated U.S. Greenhouse Gas Measurement, Monitoring, and Information System.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Earth and Environmental Systems Modeling $115,500	$114,610	-$890
Funding for Earth and Environmental Systems Modeling focuses investments on further refinement of the science underpinning non-hydrostatic adaptive mesh modeling and incorporating the necessary software for deployment of the model onto more advanced exascale computing architectures. The E3SM version 2 incorporates AI and unsupervised learning capabilities and enables more sophisticated research based on higher model resolution, through the Integrative AI4ESP. The new version adds advanced capabilities for exploring cryosphere-ocean dynamics' impacts of climate variability on Antarctic ice shelf melting, continental ice sheet evolution and sea level rise, and the effects of changing water cycles on watershed and coastal hydrological systems. Funding also initiates foundational modeling for the offshore wind and hydrogen Energy Earthshots.	Earth and Environmental Systems Modeling will focus investments on further refinement of the science underpinning non-hydrostatic adaptive mesh modeling and incorporating the necessary software for deployment of the model onto more advanced exascale computing architectures. The E3SM will enhance AI/ML capabilities and enable more sophisticated science that demands higher model resolution and greater accuracy, through the Artificial Intelligence Framework for AI4ESP. As the ECP concludes, the exascale research activities will transition from the ECP to apply a broader software practice for advanced computing and sustainability across current and future computing platforms. The new E3SM version 3 will add advanced capabilities for exploring cryosphere-ocean dynamics' impacts of climate variability on Antarctic ice shelf melting, continental ice sheet evolution and sea level rise, the effects of changing water cycles on watershed and coastal hydrological systems, and new research involving urban systems. The Request will also support foundational modeling in support of Energy Earthshot topics requiring robust climate projections to inform the design and deployment of clean energy initiatives.	AI will enhance the efficiency and accuracy of climate predictions, for trends, modes of variability, and extreme events. The ECP research activities will continue to transition ECP researchers, software, and technologies into core research efforts. New investments enhance support for Earthshot topics, that focus on efficient design, deployment, and effectiveness of renewable and clean energy infrastructures to combat climate change. The reduction is due to completion of adaptive mesh capabilities for E3SM as applied to coastal simulations.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Funding focuses on core research in model intercomparisons and diagnostics. In addition, research incorporates limited fine scale physics and dynamics that can be applied to metrics for application to coastal zones (including the Great Lakes and Puget Sound), mid-latitude-Arctic interactions, and high-resolution studies of urban and urban-rural transition regions.	The Request will focus on core research in model intercomparisons and diagnostics. In addition, research will incorporate limited fine scale physics and dynamics that can be applied to metrics for application to coastal zones (including the Great Lakes and Puget Sound), and high-resolution studies of urban and urban-rural transition regions.	Research funding will place greater emphasis on highly heterogeneous and boundary regions, such as are found in large urban regions as well as coastal zones that encompass the mid-Atlantic, the Great Lakes, and Puget Sound.
Earth and Environmental Systems Sciences Facilities and Infrastructure $172,700	$166,950	-$5,750
Funding for ARM continues to provide new observations through long term measurements at fixed sites in Alaska, Oklahoma, and the Eastern North Atlantic site. An ARM mobile unit completes installation and begin operations in Alabama. The funding prioritizes all ARM activities for critical observations needed to improve the E3SM model. ARM continues and completes deployment of its second mobile facility to Colorado; and it prepares and deploys its first mobile facility to San Diego. Scientists are using the precipitation radars together with sophisticated meteorological instrumentation to learn more about cloud and aerosol interactions in a variety of geographic domains, including urbanized coastal regions and mountainous terrain. After rebaselining to meet FAA requirements, acceptance testing and evaluation are completed on the Air-ARM aircraft, including modifications to the air frame as needed to install numerous existing and new atmospheric aerosol, cloud, turbulence, and other sensors. The ARM support for the Urban IFL for climate science continues as well as continuing a multi-year instrumentation refresh.	ARM will continue to provide new observations through long term measurements at fixed sites in Alaska, Oklahoma, and the Eastern North Atlantic site. The ARM mobile unit in Alabama will be fully operational. The Request prioritizes all ARM activities for critical observations needed to improve the E3SM model. Scientists will use cloud and precipitation radars together with sophisticated meteorological instrumentation to learn more about cloud and aerosol interactions in a variety of geographic domains, including urban and forested regions. A second mobile unit deploys to Baltimore, Maryland in support of urban research. A third ARM unit will continue deployment to Tasmania to study cloud-aerosol interactions. Air-ARM will continue testing for research operations in FY 2026.	Funding will support ARM site operations, and mobile facilities operations. Two mobile units, one located in Tasmania, Australia and another in Baltimore, Maryland, will deliver new observations. After major investments in FY 2022 and FY 2023 to install the third ARM unit to Alabama, this capability will routinely collect data in support of community science. A cloud chamber project will be initiated to complement ARM's field observations of cloud-aerosol interactions. Reductions are due to the completion of the installation of the Alabama site.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
	BER will initiate the Drizzle, Aerosol, and Cloud Observation (DRACO) chamber project with other project cost (OPC) funding, a cloud chamber effort to complement ARM's field observations of cloud-aerosol interactions.	BER will initiate the new Drizzle, Aerosol, and Cloud Observation (DRACO) chamber project with other project cost (OPC) funding.
Funding for EMSL emphasizes new science that requires combinations of advanced technologies, such as mass spectrometry, live cell imaging, Quiet Wing, Dynamic Transmission Electron Microscopy, and high-performance computing. A multi-year instrumentation refresh continues. Other Project Cost support the microbial molecular phenotyping capability planned project.	EMSL will emphasize new science that requires combinations of advanced technologies, such as mass spectrometry, live cell imaging, Quiet Wing, Dynamic Transmission Electron Microscopy, and high-performance computing. The initial construction of microbial molecular phenotyping capability begins.	Funding will promote multi-disciplinary science using various combinations of EMSL's most sophisticated instrumentation. Reallocations within EMSL rebalances operations and research.
GPP funding provides for minor new construction, for other capital alterations and additions, and for improvements to land, buildings, and utility systems to maintain the productivity and usefulness of DOEowned facilities and to meet requirements for safe and reliable operation. In FY 2023 GPP supports improved cooling for High Performance Computing infrastructure at EMSL and remodeling EMSL laboratories to create lab spaces to co-locate capabilities that cross-cut EMSL's integrated research platforms.	GPP activities are completed.	Efforts are completed.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Funding for the Earth and Environmental Sciences Data Management activity enhances support to maintain existing and new critical software and data archives in support of ongoing experimental and modeling research. Essential data archiving and storing protocols, capacity, and provenance are maintained. Advanced analytical methodologies such as Machine Learning is used to improve the predictability of extreme events more rapidly using the combination of field observations with Earth system models.	The Earth and Environmental Sciences Data Management activity will continue support to maintain existing and new critical software and data archives in support of ongoing experimental and modeling research. Essential data archiving and storing protocols, capacity, and provenance will be maintained. Advanced analytical methodologies such as AI and Machine Learning will be enhanced and used to improve the predictability of extreme events more rapidly using the combination of field observations with Earth system models.	Increases associated with AI and machine learning will lead to greater efficiencies in model development, improved accuracy in predictions, and data gap filling in difficult-to-observed regions.

Note:

- *Funding for the subprogram above, includes 3.65 percent of research and development (R&D) funding for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, excluding facility operations.*

Biological and Environmental Research
Construction

Description

This subprogram supports line-item construction for the BER program. All Total Estimated Costs (TEC) are funded in this subprogram, including engineering, design, and construction. The FY 2025 Request of $19,000,000 continues the Microbial Molecular Phenotyping Capability project.

<u>24-SC-31, Microbial Molecular Phenotyping Capability (M2PC), PNNL</u>

The M2PC project will design and construct a new capability that will provide a range of 24,500 -50,000 gross square feet (GSF) of instrumentation and support spaces conducive for highly autonomous operations, with a target of 38,500 GSF. In addition, the M2PC design will include acquisition of analytical instrumentation and microbial culturing and characterization capabilities that will be modular and expandable, self-contained, and operate in an automated pod configuration. Capabilities will include a suite of 5 to 10 microbial culturing pods, 3 to 5 biological and functional assay pods, and 4 to 5 analytical phenotyping workflow pods. This new capability will position BER to take a global lead in answering the most pressing challenge in biology—generating molecular phenotypic data at a pace that matches the rapid developments in high throughput genome sequencing and synthesis. Applicability of this capability to BER interests in biofuels production, lignocellulose breakdown, and carbon/nutrient/elemental cycling, would create a knowledge ecosystem that would provide data to amplify BER’s genome engineering and biosystems design efforts, as well as mechanistic hydro-biogeochemistry modeling capabilities. In FY 2025, the TEC funding of $19,000,000 will be used to continue design activities associated with the facility, develop performance specifications for the vendor equipment, develop plans for integrating the facility with the equipment, and continue planning and development of contractual requirements for both the facility and vendor contracts.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Construction	**$ —**	**$19,000**	**+$19,000**
24-SC-31, Microbial Molecular Phenotyping Capability (M2PC), PNNL	$ —	$19,000	+$19,000
No funding was requested in FY 2023.		Funding will support the new M2PC project at PNNL.	Funding will continue to support the new M2PC project at PNNL.

Biological and Environmental Research
Capital Summary

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Capital Operating Expenses						
Capital Equipment	N/A	N/A	34,950	23,130	19,150	-15,800
Minor Construction Activities						
General Plant Projects	N/A	N/A	10,000	5,000	–	-10,000
Total, Capital Operating Expenses	**N/A**	**N/A**	**44,950**	**28,130**	**19,150**	**-25,800**

Capital Equipment

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Capital Equipment						
Major Items of Equipment						
Earth and Environmental Systems Sciences						
Atmospheric Radiation Measurement (ARM) Aerial Observation Capability (Air-ARM)	27,186	17,486	9,700	–	–	-9,700
Total, MIEs	N/A	N/A	9,700	–	–	-9,700
Total, Non-MIE Capital Equipment	N/A	N/A	25,250	23,130	19,150	-6,100
Total, Capital Equipment	**N/A**	**N/A**	**34,950**	**23,130**	**19,150**	**-15,800**

Note:

- *The Capital Equipment table includes MIEs located at a DOE facility with a Total Estimated Cost (TEC) > $10M and MIEs not located at a DOE facility with a TEC >$2M.*

Minor Construction Activities

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
General Plant Projects (GPP)						
GPPs (greater than $5M and $34M or less)						
HPC Infrastructure Upgrades (GPP HPC Upgrades [Refresh]), PNNL	5,000	–	5,000	–	–	-5,000
Project 2 - Crosscutting Capabilities (3020EMSL Remodel to Cross-Cut IRPs), PNNL	5,000	–	5,000	–	–	-5,000
Project 3 - Relocations (3020EMSL Remodel to Unpack and Relocate), PNNL	5,000	–	–	5,000	–	–
Total GPPs (greater than $5M and $34M or less)	N/A	N/A	10,000	5,000	–	-10,000
Total, General Plant Projects (GPP)	**N/A**	**N/A**	**10,000**	**5,000**	**–**	**-10,000**
Total, Minor Construction Activities	**N/A**	**N/A**	**10,000**	**5,000**	**–**	**-10,000**

Note:

- *GPP activities $5M and less include design and construction for additions and/or improvements to land, buildings, replacements or addition to roads, and general area improvements. AIP activities $5M and less include minor construction at an existing accelerator facility.*

Biological and Environmental Research
Major Items of Equipment Description(s)

Earth and Environmental Systems Sciences Facilities and Infrastructure:
Atmospheric Radiation Measurement Research Facility (ARM) – Air-ARM
The Air-ARM project is expected to complete in FY 2026 with CD-4 in December 2025. The Air-ARM project received CD-2/3 approval on November 12, 2018, with an original total project cost of $17,700,000. BER-supported scientists require high-quality and well-characterized in situ aircraft observations of aerosol and cloud microphysical properties and coincident dynamical and thermodynamic properties to continue to improve fundamental understanding of the physical and chemical processes that control the formation, life cycle, and radiative impacts of cloud and aerosol particles. To meet these needs, the ARM user facility has been using a dedicated large twin-turboprop Gulfstream-1 (G-1) aircraft to conduct weeks- to months-long intensive observational campaigns over a range of meteorological conditions and locations around the world. The G-1 aircraft used by ARM was built in 1961, was one of only 10 G-1's that remain in service worldwide and is at the end of its service life. BER retired and replaced the aircraft in FY 2019. The FY 2019 Enacted Budget included funding to replace the Battelle-owned G-1 aircraft that supported airborne data collection as part of ARM field campaigns. Since FY 2020, the newly acquired aircraft has undergone testing and evaluation, including modifications to the air frame needed to install numerous existing and new atmospheric aerosol, cloud, turbulence, and other sensors. Also, the aircraft will undergo ground-based and airborne testing to prepare it for scientific studies. Due to changes in FAA policies and procedures after the passage of the Aircraft Certification, Safety, and Accountability Act in December 2020, time required for the FAA to implement these new policies, and delays due to COVID, the total project cost has increased (+$9.7M), and planned research flight operations will be delayed until FY 2026**.**

Minor Construction Description(s)

General Plant Projects $5 Million to less than $30 Million

Outfitting of Research and Collaborations Spaces
General Plant Project Details

Project Name:	Project 3 – Relocations (3020EMSL Remodel to Unpack and Relocate), PNNL
Location/Site:	Pacific Northwest National Laboratory
Type:	GPP
Total Estimated Cost:	$5,000,000
Construction Design:	$0
Project Description:	EMSL developed plans to backfill a number of laboratory spaces from which both instrumentation and scientists were vacated as a result of their relocation from spring through fall of 2022 into the new Energy Sciences Capability (ESC) building at PNNL. Approximately 13,000 square feet equivalent of lab modules were relocated from EMSL to the ESC. EMSL identified strategic plans for reconfiguring and renovating this laboratory space during FY 2022. Through support provided in a FY 2023 general plant project (GPP), EMSL has been reconfiguring/renovating approximately half of the total square footage of these lab modules. A second GPP effort for reconfiguring/renovating the remaining lab modules and unpacking crowded laboratories in EMSL has been included in the FY 2024 President's budget request. Pending appropriation of funding in FY 2024, the second GPP project will complete activities related to reconfiguring/renovating the full 13,000 square feet equivalent of lab modules in EMSL.

Biological and Environmental Research
Construction Projects Summary

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
XX-SC-32, ARM Cloud Chamber, TBD						
Total Estimated Cost (TEC)	44,100	-	-	-	-	-
Other Project Cost (OPC)	2,600	-	-	-	1,000	+1,000
Total Project Cost (TPC)	**46,700**	**-**	**-**	**-**	**1,000**	**+1,000**
24-SC-31, Microbial Molecular Phenotyping Capability (M2PC), PNNL						
Total Estimated Cost (TEC)	107,000	-	-	-	19,000	+19,000
Other Project Cost (OPC)	5,000	-	250	950	-	-250
Total Project Cost (TPC)	**112,000**	**-**	**250**	**950**	**19,000**	**+18,750**
Total, Construction						
Total Estimated Cost (TEC)	**N/A**	**N/A**	**-**	**-**	**19,000**	**+19,000**
Other Project Cost (OPC)	**N/A**	**N/A**	**250**	**950**	**1,000**	**+750**
Total Project Cost (TPC)	**N/A**	**N/A**	**250**	**950**	**20,000**	**+19,750**

Biological and Environmental Research
Scientific User Facility Operations

The treatment of user facilities is distinguished between two types: TYPE A facilities that offer users resources dependent on a single, large-scale machine; TYPE B facilities that offer users a suite of resources that is not dependent on a single, large-scale machine.

(dollars in thousands)

	FY 2023 Enacted	FY 2023 Current	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Scientific User Facilities - Type B					
Environmental Molecular Sciences Laboratory	**64,750**	**64,624**	**45,435**	**65,000**	**+250**
Number of Users	750	682	750	775	+25
Joint Genome Institute	**90,000**	**89,836**	**85,550**	**93,565**	**+3,565**
Number of Users	2,300	2,373	2,350	2,380	+80
Atmospheric Radiation Measurement Research Facility	**87,000**	**86,452**	**78,440**	**88,200**	**+1,200**
Number of Users	1,200	1,157	1,200	1,200	–
Total, Facilities	**241,750**	**240,912**	**209,425**	**246,765**	**+5,015**
Number of Users	4,250	4,212	4,300	4,355	+105

Note:
- *Percent optimal operations defines what is achieved at this funding level. This includes staffing, up-to-date equipment and software, operations and maintenance, and appropriate investments to maintain world leadership.*

Biological and Environmental Research
Scientific Employment

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Number of Permanent Ph.Ds (FTEs)	1,750	1,805	1,785	+35
Number of Postdoctoral Associates (FTEs)	460	480	470	+10
Number of Graduate Students (FTEs)	640	685	685	+45
Number of Other Scientific Employment (FTEs)	430	435	435	+5
Total Scientific Employment (FTEs)	**3,280**	**3,405**	**3,375**	**+95**

Note:
- *Other Scientific Employment (FTEs) includes technicians, engineers, computer professionals and other support staff.*

24-SC-31, Microbial Molecular Phenotyping Capability (M2PC), PNNL
Pacific Northwest National Laboratory, PNNL
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary

The FY 2025 Request for the Microbial Molecular Phenotyping Capability (M2PC) project is $19,000,000 of Total Estimated Cost (TEC) funding. This Construction Project Data Sheet (CPDS) is an update of the FY 2024 CPDS for this project. The project will design and construct a new research capability for the M2PC that will be broadly available to the scientific community as part of an Office of Science User Facility. DOE approved Critical Decision (CD)-0 on April 28, 2021, and CD-1 on February 15, 2024, with a preliminary Total Project Cost (TPC) range of $80,000,000 to $122,000,000 and a CD-4 range of FY 2026 to FY 2029.

Significant Changes

DOE conducted both an Independent Project Review (IPR) and an Independent Cost Review (ICR) of the project in June 2023, as pre-requisites for a CD-1 decision. Through the development of the CD-1 materials and in response to comments from the IPR and ICR reviews, the project scope, schedule, and cost range have been further defined, as reflected in the tables below. The project TPC range is now $100,000,000 to $167,000,000, and the CD-4 range is now FY 2029 to FY 2032. In accordance with the tailoring requirements permitted by DOE's Project Management Order (DOE O 413.3B), the project is pursuing a tailoring strategy to combine CD-2 and CD-3.

In FY 2024, the project will begin design activities associated with the facility, the vendor equipment integration, and facility and equipment coordination design for the TEC funding of $10,000,000. The project will prepare for CD-2/3 for the OPC funding of $950,000.

In FY 2025, the TEC funding of $19,000,000 will be used to continue design activities associated with the facility, develop performance specifications for the vendor equipment, develop plans for integrating the facility with the equipment, and continue planning and development of contractual requirements for both the facility and vendor contracts.

A Federal Project Director with the appropriate certification of level II has been assigned to the project.

Critical Milestone History

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
FY 2025	4/28/21	6/30/22	2/15/24	3Q FY 2025	4Q FY 2026	3Q FY 2025	1Q FY 2032

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout

Project Cost History

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	11,000	104,000	115,000	5,000	5,000	120,000
FY 2025	29,000	88,000	117,000	5,000	5,000	122,000

2. Project Scope and Justification

Scope

The M2PC project will design and construct a new capability that will provide a range of 24,500–50,000 gross square feet (GSF) of instrumentation and support spaces conducive for highly autonomous operations, and a target of 38,500 GSF. In addition, the M2PC design will include acquisition of analytical instrumentation and microbial culturing and characterization capabilities that will be modular and expandable, self-contained, and operate in an automated pod configuration. Capabilities will include a suite of 5 to 10 microbial culturing pods, 3 to 5 biological and functional assay pods, and 4 to 5 analytical phenotyping workflow pods.

Justification

Within the Biological and Environmental Research (BER) program, basic research to gain a predictive understanding of biological systems provides the foundation for harnessing and integrating the latest biosystems design techniques with data science and multi-scale modeling approaches. This effort will advance a burgeoning bioeconomy, enable prediction of the future state of the Earth system, and provide transformative science and technology solutions to enable DOE to meet its energy and environmental challenges. Toward systems-level understanding, BER-supported research has increasingly embraced the integration of multi-omics analyses together with phenotypic characterization of microbial isolates and communities to determine the function of expressed genes and pathways.

While the number of microbial isolates and chassis microbes interrogated is expanding rapidly along with advances in next generation genome sequencing and synthesis, incomplete and constrained genome annotation limits the ability to understand and model the range of activities and functions of individual microbes, engineered microbial consortia with bio-industrial potential or ecological relevance, and microbial communities from natural soil environments. Specifically, there is a significant gap in the ability of the scientific community to identify proteins and biochemical pathways of unknown function in microbes at the single-cell to microbial-community scales, in part because the phenotypes of microbes change rapidly due to environmental factors and perturbations. To address this gap, BER proposes a research capability for a Microbial Molecular Phenotyping Capability that would be broadly available to the scientific community as part of a DOE Office of Science User Facility.

An emphasis on coupled high-throughput autonomous experimental and multimodal analytical capabilities would be the primary components of the instrumentation part of the M2PC. These capabilities would be integrated with, and amplify, existing BER data platforms within the DOE JGI, the NMDC, and the KBase to speed the discovery of new protein functions and metabolic pathways in microbial systems, including fungi, algae, bacteria, protists, archaea, and viruses.

This new capability will position BER to take a global lead in answering the most pressing challenge in biology—generating molecular phenotypic data at a pace that matches the rapid developments in high throughput genome sequencing and synthesis, and it will advance the DOE mission to ensure America’s security and prosperity by addressing energy and environmental challenges through transformative science and technology solutions. Applicability of this capability to BER interests in biofuels production, lignocellulose breakdown, and carbon/nutrient/elemental cycling, would create a knowledge ecosystem that would provide data to amplify BER’s genome engineering and biosystems design efforts, as well as mechanistic hydro-biogeochemistry modeling capabilities.

While the Office of Science is exempt from DOE O 413.3B, Program and Project Management for the Acquisition of Capital Assets, the M2PC project intends to deploy a certifiable earned value management system and be conducted in accordance with the project management principles of DOE O 413.3B.[a]

Key Performance Parameters (KPPs)
The KPPs are preliminary and may change as the project continues towards CD-2. At CD-2 approval, the KPPs will be baselined. The Threshold KPPs represent the minimum acceptable performance that the project must achieve. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion. The Objective KPPs represent the desired project performance.

Performance Measure	Threshold	Objective
Demonstrate high-throughput (HTP) Culturing	Capacity to operate with 500 Experiments/Week*	Capacity to operate with 2,000 Experiments/Week*
Demonstrate HTP Microbiome Culturing	Capacity to operate with 100 Microbiome Experiments/Week	Capacity to operate with 500 Microbiome Experiments/Week
Demonstrate HTP Assaying and Phenotyping	Capacity to obtain 1,000,000 Multi-Modal Analytical Measurements/Month	Capacity to obtain 3,000,000 Multi-Modal Analytical Measurements/Month
Remote Capability to Access Operations	Demonstrate that remote users can run pre-defined EMSL protocols to be executed autonomously within M2PC across culturing, assaying, and analyses**	Demonstrate remote users can perform dynamic experimental intervention with help from EMSL staff by modifying an executed protocol during the experimental timeframe**
Total Building Size (GSF)	24,500 sq. ft.	50,000 sq. ft.
*A microbiome start is an experiment consisting of a mix of 2-8 microbial species cultured under a defined set of conditions. **Protocol settings will have built-in acceptable safe operating ranges for selection within established instrument specifications from vendors, EMSL protocol best-practices, and PNNL EH&S safe research operating windows.		

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
Design (TEC)			
FY 2024	10,000	10,000	10,000
FY 2025	19,000	19,000	19,000
Total, Design (TEC)	**29,000**	**29,000**	**29,000**
Construction (TEC)			
Outyears	88,000	88,000	88,000
Total, Construction (TEC)	**88,000**	**88,000**	**88,000**
Total Estimated Cost (TEC)			
FY 2024	10,000	10,000	10,000

[a] Memorandum For Office of Science Associate Directors, From W.F. Brinkman, Director, Office of Science, "Office of Science is Exempt from DOE Order 413.3B, Program and Project Management for the Acquisition of Capital Assets," dated February 2, 2011.

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
FY 2025	19,000	19,000	19,000
Outyears	88,000	88,000	88,000
Total, Total Estimated Cost (TEC)	**117,000**	**117,000**	**117,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Other Project Cost (OPC)			
FY 2023	250	250	250
FY 2024	950	950	950
Outyears	3,800	3,800	3,800
Total, Other Project Cost (OPC)	**5,000**	**5,000**	**5,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Project Cost (TPC)			
FY 2023	250	250	250
FY 2024	10,950	10,950	10,950
FY 2025	19,000	19,000	19,000
Outyears	91,800	91,800	91,800
Total, TPC	**122,000**	**122,000**	**122,000**

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	20,500	7,700	**N/A**
Design - Contingency	8,500	3,300	**N/A**
Total, Design (TEC)	**29,000**	**11,000**	**N/A**
Construction	66,000	72,700	**N/A**

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Construction - Contingency	22,000	31,300	**N/A**
Total, Construction (TEC)	**88,000**	**104,000**	**N/A**
Total, TEC	**117,000**	**115,000**	**N/A**
Contingency, TEC	*30,500*	*34,600*	***N/A***
Other Project Cost (OPC)			
OPC, Except D&D	3,900	4,000	**N/A**
Conceptual Design	1,100	1,000	**N/A**
Total, Except D&D (OPC)	**5,000**	**5,000**	**N/A**
Total, OPC	**5,000**	**5,000**	**N/A**
Contingency, OPC	***N/A***	*N/A*	***N/A***
Total, TPC	**122,000**	**120,000**	**N/A**
Total, Contingency (TEC+OPC)	***30,500***	***34,600***	***N/A***

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	—	—	10,000	—	105,000	115,000
	OPC	—	250	950	—	3,800	5,000
	TPC	—	250	10,950	—	108,800	120,000
FY 2025	TEC	—	—	10,000	19,000	88,000	117,000
	OPC	—	250	950	—	3,800	5,000
	TPC	—	250	10,950	19,000	91,800	122,000

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	1Q FY 2032
Expected Useful Life	50 years
Expected Future Start of D&D of this capital asset	1Q FY 2082

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	Current Total Estimate	Previous Total Estimate	Current Total Estimate
Operations	N/A	223	N/A	11,150
Utilities	N/A	145	N/A	7,250
Maintenance and Repair	N/A	331	N/A	16,550
Total, Operations and Maintenance	N/A	699	N/A	34,950

7. D&D Information

The new area being constructed in this project is not replacing existing facilities.

	Square Feet
New area being constructed by this project at PNNL	24,500-50,000
Area of D&D in this project at PNNL	—
Area at PNNL to be transferred, sold, and/or D&D outside the project, including area previously "banked"	—
Area of D&D in this project at other sites	—
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously "banked"	24,500-50,000
Total area eliminated	—

8. Acquisition Approach

The Acquisition Strategy for the M2PC project was reviewed and approved as part of the CD-1 process. It will include two major acquisitions: the research equipment vendor and facility contract. Both acquisitions will be best value source selections timed to support CD-2/3. The research equipment vendor will provide a turn-key solution (design, procurement, installation, fabrication, assembly, testing, KPP verification, training, etc.) for the high-throughput microbial molecular phenotyping capability needed to meet the research-related KPPs. The facility will be procured via a design-build strategy. It will house and provide utilities to operate the research equipment and will meet the facility space KPP.

Fusion Energy Sciences

Overview

The mission of the Fusion Energy Sciences (FES) program is to expand the fundamental understanding of matter at very high temperatures and densities and to build the scientific foundation needed to develop a fusion energy source. In addition, the FES mission includes advancing the basic research needed to solve fundamental science and technology gaps towards the development of fusion power as a clean energy source in the U.S using diverse set of tools and strategic approaches. This approach includes fulfilling the fusion energy mission by a shift in the balance of research toward the Long-Range Plan (LRP) Fusion Materials and Technology (FM&T) gaps, which connects the three science drivers: Sustain a Burning Plasma, Engineer for Extreme Conditions, and Harness Fusion Energy. SC supports U.S. participation in ITER to provide U.S. scientists access to a burning plasma experimental facility aligned with the goals of the LRP. The DIII-D National Fusion Facility and the National Spherical Torus Experiment-Upgrade (NSTX-U) facility are world-leading Office of Science (SC) user facilities for experimental research, used by scientists from national laboratories, universities, and industry research groups, to optimize magnetic confinement regimes. Complementing this effort are Inertial Fusion Energy (IFE) collaboration hubs to support strategic growth of inertial confinement approaches. Fusion Innovation Research Engine (FIRE) centers address critical scientific and technology gaps and bring together discovery science, innovation, and translational research in partnership through small group research collaboration with multiple public and private partners. Partnerships with the fusion private sector can accelerate viability of fusion energy by combining efforts to resolve common scientific and technological challenges via the Innovation Network for Fusion Energy (INFUSE) voucher program and the Fusion Development Milestone Program established by FES in support of the Administration's Bold Decadal Vision (BDV) for developing the foundation for commercializing fusion energy. FES supports significant efforts in fusion theory and simulation to predict and interpret the complex behavior of plasmas as self-organized systems that complement these experimental activities. FES also supports a Scientific Discovery through Advanced Computing (SciDAC) portfolio, in partnership with the Advanced Scientific Computing Research (ASCR) program. U.S. scientists use international partnerships to conduct research on overseas tokamaks and stellarators with unique capabilities. The development of novel materials and technologies that can withstand enormous heat and neutron exposure and breed the fuel that makes fusion a self-sustaining energy source is important for the design basis of a fusion pilot plant (FPP). The Material Plasma Exposure eXperiment (MPEX) facility will unravel knowledge gaps in plasma-material interactions.

The FES program supports discovery plasma science and technology in research areas such as plasma astrophysics, high-energy-density laboratory plasmas (HEDLP), and low-temperature plasmas. Practical applications of plasmas are found in plasma processing, nanomaterial synthesis, and plasma medicine. Some of this research is carried out through partnerships and/or coordination with the National Science Foundation (NSF) and the National Nuclear Security Administration (NNSA).

The FES program invests in several SC cross-cutting initiatives such as artificial intelligence and machine learning (AI/ML), quantum information science (QIS), microelectronics, and advanced computing. In addition, with continued funding for the Established Program to Stimulate Competitive Research (EPSCoR), the Reaching a New Energy Sciences Workforce (RENEW), and the Funding for Accelerated, Inclusive Research (FAIR) initiatives, FES will build strategic programs to enhance inclusion and advance belonging, accessibility, justice, equity, and diversity in SC-sponsored research at emerging research institutions and underserved communities, Historically Black Colleges and Universities (HBCU), and Minority Serving Institutions (MSI).

The 2020 Fusion Energy Sciences Advisory Committee (FESAC) LRP report entitled "Powering the Future: Fusion and Plasmas"[a] as well as reports from the National Academies of Sciences, Engineering, and Medicine (NASEM) and community workshops inform FES program directions and activities. Fusion energy is a critical clean energy and climate technology that can contribute to the global challenge of meeting the climate crisis and can help bolster the research and development (R&D) and industrial innovation that will build the Nation's future economic competitiveness as emphasized in the "Multi-Agency research and Development Priorities for the FY 2025 Budget" from the Office of Management and Budget (OMB) and the Office of Science and Technology Policy (OSTP).[b]

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[a] https://science.osti.gov/-/media/fes/fesac/pdf/2020/202012/FESAC_Report_2020_Powering_the_Future.pdf

[b] https://www.whitehouse.gov/wp-content/uploads/2023/08/FY2025-OMB-OSTP-RD-Budget-Priorities-Memo.pdf

Restructure

The FES budget re-structuring identified here is the first step towards a re-alignment of the FES program to align with the Administration's Bold Decadal Vision and recommendations outlined in the FESAC LRP. Three overall goals are envisioned in this budget re-structure: flexibility, balance, and strategy. The budget re-structure provides flexibility that allows the fusion and plasma science and technology communities activities that map to the FESAC LRP three science drivers: Sustain a burning plasma, Engineer for extreme conditions, and Harness fusion power. The new budget re-structure also provides balance by organizing new activities that are consistent with the priorities identified in the FESAC LRP. Finally, the new FES budget re-structuring is strategic: it has several strategic cross-threads including Fusion Workforce Pathways, Public-Private Partnerships, and Facility Operations. Below is a brief description of each new activity, which are defined as the new FES fusion and plasma research pillars.

Theory and Simulation: This activity is not new; however, it complements a foundational understanding of how to sustain a burning plasma by leveraging AI/ML to address FESAC LRP and a physics basis for an FPP. In addition, this activity will support single-investigator research to coordinated, strategic activities under the new FIRE centers supporting topics such as advanced simulation for design and optimization, digital twin, and whole-facility modeling.

Fusion Materials and Internal Components: The FESAC LRP stated that to realize fusion energy, a shift towards addressing FM&T gaps was critical. This activity brings focus to areas such as plasma-facing components, structural fusion materials, blanket materials, actuators, functional, and enabling materials (e.g., plasma heating component materials, sensor materials, etc.)

Emergent Plasma Concepts: A key step of the new FES budget structure is the re-alignment of activities toward being more inclusive of diverse plasma confinement concepts that now include linear plasma systems such as field-reverse configuration, axisymmetric mirrors, and plasma pinches. The goal is that as tokamaks and other configurations reach more mature designs and are translated, FES will support new innovative concepts that emerge. This element includes the growing IFE activities and other innovative IFE approaches. The FESAC LRP stated that investments should be balanced over time towards emerging approaches as a mitigation strategy towards accelerated paths in realizing fusion energy. This activity also emphasizes the remaining key physics gaps in topics such as predicting the dynamic behavior of burning plasmas, alpha-particle heating, self-sustaining pathways, steady-state scenarios, enhanced performance, stability and control in burning plasma scenarios, predicting transient behavior, understanding turbulence and instabilities, and addressing core-edge coupling and its relationship with sustainable confinement conditions in a burning plasma environment.

Closing the Fusion Cycle: Understanding the behavior of the tritium radioisotope and interaction with its environment is one of the key challenges to realizing scalable fusion energy. This activity has breadth in fundamental technology questions focused on breeding tritium, harnessing fusion power, balance of plant, remote handling, and safety systems. Enabling technologies such as magnet systems, fueling and heating systems, neutronics for fusion systems, shielding, radiation hardened sensing, novel waste management and recycling, and fuel cycle promotes innovation from breeding to management.

Discovery Plasma Science and Technology: The FES program supports a broad spectrum of science and technology research in plasma discovery including HEDLP, industrial plasmas, foundational plasma physics, astrophysics, interfacial plasmas, thermal and non-thermal plasma technology, QIS, advanced microelectronics processing, and materials discovery with plasma-enhanced technologies and plasma medicine.

Other Subprograms and Activities: This activity supports items that cross-cut FES and threads the whole program including fusion workforce pathways, public-private partnerships, and facility operations.

Highlights of the FY 2025 Request
The FY 2025 Request of $844.5 million is an increase of $81.3 million over the FY 2023 Enacted with key elements listed below. The Request is aligned with recommendations in the recent FESAC LRP and the Administration's BDV. The FY 2025 Request includes:

Research

- DIII-D research: Characterize and exploit innovative heating and current drive sources relevant for power plants including development of high-confinement, steady-state operating scenarios.
- NSTX-U research: Support collaborative research including optimization for the aspect ratio for an FPP. Continue installation of remaining diagnostics and prioritize strategic FM&T initiatives.
- Partnerships with the private sector: For the Milestone development program, support the second phase of research activities of the teams that successfully met their initial milestones; continue to support the INFUSE program and initiate a pilot program to perform open research on private fusion and plasma science and technology facilities.
- Inertial Fusion Energy (IFE): Enhance research activities to implement the priority research opportunities that came out of the 2022 IFE Basic Research Needs (BRN) Workshop.
- FIRE Centers: Strengthen support for the multi-institutional, multi-disciplinary R&D centers to address critical science and technology gaps outlined in the LRP and supporting public & private FPP efforts. The FY 2025 Request updates programmatic planning for the R&D centers from the FY 2024 Request having multiple centers (instead of only four) in four technical areas including advanced simulation, fusion materials, blanket/fuel cycle and enabling technologies.
- International Collaborations: Continue to exploit international, long-pulse facilities by multi-institutional teams, and complete fabrication and installation of advanced diagnostic systems on new world-leading facilities.
- Discovery Plasma Science and Technology: Continue support for basic plasma science collaborative facilities, HEDLP research/facilities, QIS, microelectronics and expand plasma-based technology research.
- AI/ML: Support multi-disciplinary teams applying AI/ML for science discovery, data analysis, model extraction, plasma control, analysis of extreme-scale simulations, and data-enhanced prediction and control.
- EPSCoR, RENEW, and FAIR: Invest in a more diverse and inclusive workforce. Broaden participation and engagement with underserved communities as well as build capacity at emerging research institutions, HBCUs, and MSIs.

Facility Operations

- DIII-D operations: Support 16 weeks of facility operations, which is 90% of optimal operations, operate with a new divertor allowing higher plasma performance, and complete ongoing machine and infrastructure improvements.
- NSTX-U recovery and operations: Continue the recovery and repair activities including machine assembly and continue to support commissioning in preparation for plasma operations.

Projects

- U.S. hardware development and delivery to ITER: Support the continued design, fabrication, and delivery of U.S. in-kind hardware systems, including the continued fabrication, testing, and delivery of the Central Solenoid magnet modules, tokamak cooling water, tokamak exhaust processing, electron and ion heating transmission lines, diagnostics, tokamak fueling, disruption mitigation, vacuum auxiliary, and roughing pumps.
- Petawatt laser facility upgrade for HEDLP and IFE science: Support design activities for a world-leading upgrade to the Matter in Extreme Conditions (MEC) instrument on the Linac Coherent Light Source-II (LCLS-II) facility at SLAC National Accelerator Laboratory (SLAC).
- Major Item of Equipment (MIE) project for plasma-material interaction research: Continue to support the Material Plasma Exposure eXperiment (MPEX) MIE project, which includes the design, fabrication, installation, and commissioning of the MPEX linear plasma device, and associated facility modification and reconfiguration.

Other

- General Plant Projects/General Purpose Equipment (GPP/GPE): Support infrastructure improvements and repairs at the Princeton Plasma Physics Laboratory (PPPL) and other DOE laboratories.

Fusion Energy Sciences
Proposed FY 2025 Budget Structure

	(dollars in thousands)	
	Subprogram A1 (old) (25 PR)	**Subprogram A2 (new)**
FY 2025 Budget Structure		
Fusion Energy Sciences		
Subprogram A1 (old)		
Burning Plasma Science: Foundations		
Advanced Tokamak		
DIII-D		
Research	56,000	–
Operations	73,600	–
Enabling R&D	3,000	–
Fusion Energy R&D Centers: Enabling Technologies	10,000	–
Small-scale Experimental Research	3,000	–
Total, Advanced Tokamak	**145,600**	–
Spherical Tokamak		
NSTX-U		
Research	38,100	–
Operations	53,250	–
Small-scale Experimental Research	3,000	–
Total, Spherical Tokamak	**94,350**	–
Theory & Simulation		
Theory	21,000	–
SciDAC	23,143	–
Fusion Energy R&D Centers: Advanced Simulation for Design/Optimization	10,000	–
Advanced Computing FES	2,000	–
Total, Theory & Simulation	**56,143**	–
GPPGPE Infrastructure	**1,000**	–
Public-Private Partnerships		

	(dollars in thousands)	
	Subprogram A1 (old) (25 PR)	**Subprogram A2 (new)**
Fusion Development Milestone Program	30,000	–
Innovation Network for Fusion Energy INFUSE	5,000	–
Total, Public-Private Partnerships	**35,000**	–
Artificial Intelligence and Machine Learning	17,586	–
Inertial Fusion Energy (IFE)	**18,000**	–
Total, Burning Plasma Science: Foundations	**367,679**	–
Burning Plasma Science: Long Pulse		
Long Pulse: Tokamak	20,000	–
Long Pulse: Stellarators		
Superconducting Stellarator Research	6,000	–
Compact Stellarator Research	4,000	–
Total, Long Pulse: Stellarators	**10,000**	–
Materials & Fusion Nuclear Science		
Fusion Nuclear Science	20,000	–
Fusion energy R&D Centers: Structural/Plasma Facing Materials	20,000	–
Materials Research	20,000	–
Fusion Energy R&D Centers: Blanket/Fuel Cycle	20,000	–
Total, Materials & Fusion Nuclear Science	**80,000**	–
Projects		
Material Plasma Exposure Experiment MPEX MIE	25,000	–
Future Facility Studies	**3,797**	–
Total, Burning Plasma Science: Long Pulse	**138,797**	–
Burning Plasma Science: High Power		
ITER Research		
ITER Research	2,000	–
Total, Burning Plasma Science: High Power	**2,000**	–
Discovery Plasma Science		
Plasma Science Frontiers		
General Plasma Science	22,168	–

	(dollars in thousands)	
	Subprogram A1 (old) (25 PR)	**Subprogram A2 (new)**
High Energy Density Lab Plasmas	20,000	–
Total, Plasma Science Frontiers	**42,168**	–
Measurement Innovation	**3,000**	–
Quantum Information Science		
Quantum Information Science Research	7,500	–
Quantum Information Science Centers	2,500	–
Total, Quantum Information Science	**10,000**	–
Advanced Microelectronics FES		
Microelectronics Centers FES	15,000	–
Advanced Microelectronics FES	5,000	–
Total, Advanced Microelectronics FES	**20,000**	–
Other FES Research		
FES Other	5,852	–
Total, Other FES Research	**5,852**	–
FES - Reaching a New Energy Sciences Workforce (RENEW)	**12,000**	–
FES - Funding for Accelerated, Inclusive Research (FAIR)	**6,000**	–
FES - Established Program to Stimulate Competitive Research (EPSCoR)	**2,000**	–
Total, Discovery Plasma Science	**101,020**	–
Subtotal, Fusion Energy Sciences	**609,496**	–
Construction		
20-SC-61 Matter in Extreme Conditions (MEC) Petawatt Upgrade, SLAC	**10,000**	–
14-SC-60 U.S. Contributions to ITER		
ITER In-Kind Hardware	160,000	–
ITER Cash Contributions	65,000	–
Total, 14-SC-60 U.S. Contributions to ITER	**225,000**	–
Subtotal, Construction	**235,000**	–
Total, Fusion Energy Sciences	**844,496**	–

	(dollars in thousands)	
	Subprogram A1 (old) (25 PR)	**Subprogram A2 (new)**
Subprogram A2 (new)		
Fusion and Plasma Research		
Theory and Simulation		
Theory	–	21,000
Scientific Discovery through Advanced Computing (SciDAC)	–	23,143
FIRE Centers: Advanced Simulation for Design and Optimization	–	10,000
Advanced Computing	–	2,000
Artificial Intelligence & Machine Learning (AI/ML)	–	17,586
Total, Theory and Simulation	–	**73,729**
Fusion Materials and Internal Components		
Materials Research	–	20,000
FIRE Centers: Structural and Plasma Facing Materials	–	20,000
Fusion Materials Projects		
Materials Plasma Exposure eXperiment (MPEX)	–	25,000
Total, Fusion Materials and Internal Components	–	**65,000**
Emergent Plasma Concepts		
DIII-D Research	–	56,000
National Spherical Torus Experiment-Upgrade (NSTX-U) Research	–	38,100
Small-Scale Experimental Research		
Advanced Tokamak Small Scale Experimental Research	–	3,000
Spherical Tokamak Small Scale Experimental Research	–	3,000
Total, Small-Scale Experimental Research	–	**6,000**
Long Pulse: Tokamak	–	20,000
Inertial Fusion Energy (IFE)	–	18,000
Superconducting Stellarator Research	–	6,000
Compact Stellarator Research	–	4,000
Measurement Innovation	–	3,000
Future Facilities Studies	–	3,797
ITER Research	–	2,000

	(dollars in thousands)	
	Subprogram A1 (old) (25 PR)	**Subprogram A2 (new)**
Total, Emergent Plasma Concepts	–	**156,897**
Closing the Fusion Cycle		
Fusion Nuclear Science	–	20,000
FIRE Centers: Blanket and Fuel Cycle	–	20,000
Enabling R&D	–	3,000
FIRE Centers: Enabling Technologies	–	10,000
Total, Closing the Fusion Cycle	–	**53,000**
Discovery Plasma Science and Technology		
High Energy Density Lab Plasmas (HEDLP)	–	20,000
General Plasma Science and Technology		
General Plasma Science Research	–	22,168
Total, General Plasma Science and Technology	**–**	**42,168**
Advanced Microelectronics		
Microelectronics Research	–	5,000
Microelectronics Centers	–	15,000
Total, Advanced Microelectronics	–	**20,000**
Quantum Information Science (QIS)		
Quantum Information Science Research	–	7,500
Quantum Information Science Centers	–	2,500
Total, Quantum Information Science (QIS)	–	**10,000**
Discovery Plasma Science Projects		
Matter in Extreme Conditions (MEC) OPC		
Total, Discovery Plasma Science and Technology	–	**30,000**
Public Private Partnerships		
Innovation Network for Fusion Energy (INFUSE) Program	–	5,000
Fusion Development Milestone Program	–	30,000
Total, Public Private Partnerships	–	**35,000**
Fusion Workforce Pathways		
Reaching a New Energy Sciences Workforce (RENEW)	–	12,000

	(dollars in thousands)	
	Subprogram A1 (old) (25 PR)	**Subprogram A2 (new)**
Funding for Accelerated, Inclusive Research (FAIR)	–	6,000
Established Program to Stimulate Competitive Research (EPSCoR)	–	2,000
Total, Fusion Workforce Pathways	–	**20,000**
Other Research		
Other Research		
Other	–	5,852
Fusion Infrastructure	–	1,000
Total, Other Research	–	**6,852**
Total, FES Research	–	**482,646**
Fusion Facility Operations		
DIII-D Operations	–	73,600
National Spherical Torus Experiment-Upgrade (NSTX-U) Operations	–	53,250
Total, Fusion Facility Operations	–	**126,850**
Construction		
Matter in Extreme Conditions (MEC) Petawatt Upgrade	–	**10,000**
U.S. Contributions to ITER Project		
ITER In-Kind Hardware Contributions	–	160,000
ITER Cash Contribution	–	65,000
Total, ITER	–	**225,000**
Total, Projects	–	**235,000**
TOTAL, Fusion Energy Sciences	**–**	**844,496**
Total, Program A	**844,496**	**844,496**

SBIR/STTR funding:

- FY 2023 Enacted: SBIR $10,921,000 and STTR $1,536,000
- FY 2024 Annualized CR: SBIR $12,357,000 and STTR $1,741,000
- FY 2025 Request: SBIR $14,254,000 and STTR $2,005,000

Fusion Energy Sciences
Explanation of Major Changes

	(dollars in thousands) FY 2025 Request vs FY 2023 Enacted
Fusion and Plasma Research	**+$482,646**
Funding for DIII-D Research will continue to focus efforts on developing the scientific foundation and operating scenarios for a burning plasma. Funding for NSTX-U Research will maintain collaborative research at other facilities and establish new strategic FM&T initiatives. The Request continues support for the Fusion Development Milestone Program. The Request enhances funding for the FIRE R&D centers on Structural/Plasma Facing Materials, Blanket/Fuel Cycle, Enabling Technologies, and Advanced Simulation for Design and Optimization to address the FESAC LRP gaps. In addition, the Request updates programmatic planning for the R&D centers from FY 2024 by having multiple centers (instead of only four) in the four technical areas identified above. The Request continues support for IFE science and technology in IFE-Science and Technology Accelerated Research (STAR) hubs and increases support for AI/ML research in areas such as control theory, materials design, and disruption mitigation research. The Request expands high-priority international collaboration activities and establish new ones, for both tokamaks and stellarators that support burning plasma studies for U.S. scientists. The Request supports continuation of the MPEX MIE project. The Request also supports Future Facilities Studies program focusing on new strategic experimental facilities addressing scientific and technological gaps identified in the FESAC LRP. For General Plasma Science, the Request emphasizes user research on collaborative research facilities at universities and national laboratories including the Facility for Laboratory Reconnection Experiments (FLARE) at PPPL and expands work in emerging plasma technology topics. For HEDLP, the Request continues MEC instrument support and research on the ten LaserNetUS networked facilities. Support for SC-wide Microelectronics Science Research Centers will emphasize convergence of plasma technology and advanced microelectronic materials. For QIS, the Request supports the core research portfolio stewarded by FES and the National QIS Research Centers. The RENEW initiative expands targeting efforts to increase participation and retention of individuals from underrepresented groups. Support continues for FAIR and the EPSCoR program. The Request initiates a new pilot program for fusion community to perform research on private fusion and plasma science facilities.	
Fusion Facility Operations	**+$126,850**
The Request continues to support the recovery activities for the NSTX-U program, including the installation of remaining diagnostics and commissioning in preparation for plasma operations. Funding for DIII-D operations will support 16 weeks of facility operations, operate with a new divertor allowing higher plasma performance, and complete ongoing machine and infrastructure improvements.	
Construction	**-18,000**
FES will continue to support design activities for the MEC-U. The U.S. Contributions to ITER project will continue design, fabrication, and delivery of hardware, including continued fabrication and delivery of the central solenoid superconducting magnet modules. The Request supports funding for construction financial contributions to the ITER Organization (IO).	
Total, Fusion Energy Sciences	**+$81,274**

Basic and Applied R&D Coordination

FES participates in coordinated intra- and inter-agency initiatives within DOE and with other federal agencies on science and technology issues related to fusion and plasma science. Within SC, FES operates the MEC instrument at the SLAC LCLS user facility operated by the Basic Energy Sciences (BES) program, supports high-performance computing research with ASCR, uses the BES-supported High Flux Isotope Reactor (HFIR) facility at Oak Ridge National Laboratory (ORNL) for fusion materials irradiation research, and supports the construction of a high field magnet vertical test facility at the Fermi National Accelerator Laboratory with the High Energy Physics (HEP) program. Within DOE, FES manages a joint program with NNSA in HEDLP science and continues to coordinate research activities with the Advanced Research Projects Agency-Energy (ARPA-E). FES also supports the fusion crosscutting team focusing on the BDV. Outside DOE, FES coordinates basic plasma science research with NSF. The joint programs with NNSA and NSF involve coordination of solicitations, peer reviews, and workshops.

Program Accomplishments

Integrated Core-Pedestal Simulation Identifies Attractive Regimes for Sustained Operation of a High Gain Tokamak.
Achieving a fusion gain factor (Q) of greater than unity is a key feat necessary for a working reactor. Researchers at ORNL have combined and optimized multiple heating and current drive methods to achieve broad equilibrium profiles capable of achieving a sustained, high gain operation while avoiding deleterious plasma instabilities. The developed scenarios are high-performance, optimized for core transport and plasma stability using a multitude of high-performance computing codes coupled together within a single framework. This state-of-the-art, modular, integrated simulation workflow is applicable to future FPP designs, guiding the engineering and development of such a device towards reactor-relevance.

Milestone Program: Public-private partnerships to advance fusion energy.
The Milestone-Based Fusion Development Program was announced in 2022, and in May 2023 the eight teams selected for award negotiations were announced. The award mechanism for this first-of-a-kind Milestone program will be Technology Investment Agreements (TIAs), which offer flexible intellectual property and other terms that are more amenable to private industry participation. The eight teams selected under this program include a variety of approaches, including tokamaks, stellarators, inertial fusion energy, and alternates.

First definitive demonstration of magnetorotational instability in the laboratory.
Magnetorotational instability (MRI) is thought to be the mechanism in the accretion disk around a black hole or a young star. For the accretion or accumulation of plasma particles to occur to form a new star, angular momentum must be transferred from the inner parts of the accretion disk to the outer parts. In the last thirty years, a large body of evidence suggested that MRI-driven turbulence is likely to play a role in accretion. However, all that evidence has been theoretical or computational. Recently, Princeton University and PPPL researchers have demonstrated in a laboratory experiment that MRI does exist in nature, with properties consistent with theoretical and computational predictions.

Steady-state operation demonstrated in an optimized stellarator.
The first demonstration of high-power, steady-state stellarator operation was achieved at the Wendelstein 7-X (W7-X) experiment with a total discharge length of 500 seconds and a total injected energy of 1.3 GigaJoules. This is a key step in validating the physics and engineering needed to manage the steady-state flows of energy in future power plants. As expected, the water cooled divertors reached steady-state temperatures well below design limits, which paves the way for future 30-minute pulses with even higher input power. U.S. contributions to W7-X were critical to this successful result, including delivery of magnetic field coils to control the heat loads, diagnostics, and the associated personnel to monitor plasma parameters, theory, and computational codes to develop the plasma scenario, and core leadership in developing the scientific plan leading to this substantial advancement.

Further progress in U.S. Contributions to ITER project.
The U.S. contributions to ITER project is the largest capital investment in the FES portfolio and is an essential contribution to the international effort to demonstration of the first burning plasma tokamak device at power plant scale. The U.S. contributions to ITER project successfully delivered Central Solenoid Magnet Modules 4 and 5 to the ITER Organization (IO), continued work on Tritium Exhaust Processing system prototypes, and further advanced the Vacuum Auxiliary system design.

Description

This subprogram advances our scientific understanding, utilizing both modeling/computation and experimental results from domestic and international devices, of how to control and sustain a burning plasma. It supports the development of the required materials and technology that can withstand the harsh fusion environment to make fusion a future energy source as well as building a foundation of a competitive fusion power industry in the U.S. through partnerships with the private sector that can take advantage of this research activity. In addition, it supports research that explores the fundamental properties and complex behavior of matter in the plasma state to understand the plasma universe and to learn how to control and manipulate plasmas for a broad range of applications. A key capability that helps to address the scientific gaps in the program will be the FIRE centers which are expected to be collaborative activities involving a number of institutions.

Theory and Simulation

The Theory and Simulation activity supports research on foundational theory to advance the scientific understanding of the behavior of fusion plasmas, and multi-institutional interdisciplinary efforts under the SciDAC program, in partnership with ASCR, to accelerate scientific discovery in fusion plasma science and technology by capitalizing on SC investments in leadership-class computing systems. This activity also includes research and investments in enhanced data infrastructure capabilities under Advanced Computing and the FIRE centers for advanced simulations, which addresses critical scientific gaps within the design of FPP concepts in coordination with the other FIRE centers.

This program supports the application of AI/ML techniques encompassing multiple FES areas in partnership with data and computational scientists through the establishment of multi-institutional, interdisciplinary collaborations.

Fusion Materials and Internal Components

The selection of materials for any future fusion device is foundational. Every component, from the innermost chamber walls to the outer framework, requires a variety of materials that can withstand a range of conditions, including heat, particle exposure, and neutron fluxes. The Fusion Materials and Internal Components program aims to build a scientific understanding of how materials' properties change while also focusing on predicting how materials will behave in these advanced devices, ensuring their durability and effectiveness in the challenging fusion environment. To address some of the larger and more difficult challenges, FIRE centers have been initiated under this program.

The MPEX MIE project, which is a new U.S. materials experimental capability initiated in FY 2019, will enable solutions for new plasma-facing materials, including exposing irradiated samples, for understanding materials degradation in the fusion nuclear environment.

Emergent Plasma Concepts

The Emergent Plasma Concepts (EPC) activity supports a diversity of approaches to confinement of plasmas in fusion energy systems. EPC addresses the FESAC LRP Sustain a Burning Plasma FT&S driver with an inclusive and broad approach. This element will include traditional confinement approaches including toroidal systems such as tokamaks (advanced, spherical) and stellarators. As these approaches address physics and technology gaps outlined by the FESAC LRP and CPP reports and are translated to development programs, novel approaches, such as linear plasma concepts (field-reverse configuration, axisymmetric mirrors, and plasma pinches), will be nurtured and expanded. This element also includes the growing IFE activities and other innovative IFE approaches. EPC also addresses the FESAC LRP recommendation that the program be balanced over time toward emerging approaches to accelerate the path in realizing fusion energy. This activity also emphasizes the remaining key physics gaps for toroidal confinement approaches in topics such as predicting the dynamic behavior of burning plasmas, alpha-particle heating, self-sustaining pathways, steady-state scenarios, enhanced performance, stability, and control in burning plasma scenarios, predicting transient behavior, understanding turbulence and instabilities, and addressing core-edge coupling and its relationship with sustainable confinement conditions in a burning plasma environment.

The DIII-D user facility at General Atomics is the largest magnetic fusion research experiment in the U.S. Its flexibility to explore various operating regimes makes it a world-leading tokamak research facility. Its focus will continue to be building the scientific foundation and operating regimes to sustain a burning plasma in a fusion device. The NSTX-U user facility at PPPL, when all recovery activities are completed, will be the highest performing ST in the world. For now, this activity will continue to focus its attention on conducting collaborative research on other machines but also begin preparation for full operation soon of NSTX-U.

The Advanced Tokamak (AT) Small-Scale Experimental Research activity supports a broad range of activities focused on closing gaps in the scientific and technical basis for the tokamak approach to fusion energy. An AT is an integrated fusion energy system that achieves a stationary plasma state by maximizing plasma performance within stability limits by a comprehensive optimization of plasma parameters.

The Spherical Tokamak (ST) Small-Scale Experimental Research activity supports experimental studies and physics model validation efforts involving both domestic and international facilities. Additionally, small-scale ST plasma research involving high-risk, high-reward experimental efforts are supported that may either greatly simplify or significantly enhance the ST concept.

The Long-Pulse Tokamak activity supports interdisciplinary teams from multiple U.S. institutions for collaborative research aimed at advancing the scientific and technology basis for sustained long-pulse burning plasma operation in tokamaks. Collaborative research on international facilities with capabilities not available in the U.S. aims at building the science and technology required to control, sustain, and predict a burning plasma, as described in the FESAC LRP. Multidisciplinary teams work together to close the underlying S&T gaps that underpin the design of future FPPs, especially in the areas of plasma-material interactions, transients' control, and current drive for steady-state operation. The team approach provides unique training experiences for the next generation of fusion scientists, as well as the opportunity to establish international collaborations in new areas.

The Inertial Fusion Energy (IFE) activity supports the development of the scientific foundations and technologies for IFE. Key areas of research informed by the 2022 IFE BRN workshop include increasing laser efficiency and the damage threshold of optics and crystals, reducing laser-plasma Instabilities, improving target robustness with respect to ignition and evaluating implosion sensitivities, demonstrating high-volume techniques for spherical capsule fabrication, using simulation and modeling tools to predict the gain in IFE-relevant target designs, and developing advanced radiation-hardened diagnostics at high repetition rates. The IFE Science & Technology Accelerated Research (IFE-STAR) innovation hubs and single investigators grants will advance these research activities. The IFE program will also leverage the FIRE centers.

The Superconducting Stellarator Research activity supports research on stellarators, which offer the potential of steady-state confinement regimes without transient events such as disruptions. The participation of U.S. researchers on Wendelstein 7-X (W7-X) in Germany provides an opportunity to develop and assess divertor configurations for long-pulse, high-performance stellarators, including a U.S. supplied pellet fueling injector for quasi-steady-state plasma experiments. U.S. researchers will play key roles in developing the operational scenarios and hardware configuration for high-power, steady-state operation. Domestic compact stellarator research is focused on improvement of the stellarator magnetic confinement concept through quasi-symmetric shaping of the toroidal magnetic field.

The Measurement Innovation activity supports the development of world-leading transformative and innovative diagnostic techniques and their application to new, unexplored, or unfamiliar plasma regimes or scenarios.

The Future Facilities Studies activity supports studies and research for required facilities that are critical to the development of fusion energy and address needs of both the public and private sectors.

The ITER Research activity supports the organization of a U.S. ITER research team so that the fusion community can be ready on day one to benefit from the scientific and technological opportunities offered by ITER. Building such a team was also among the highest recommendations in the recent FESAC LRP. A Basic Research Needs workshop was held in FY 2022 to identify the highest-priority research and engagement opportunities for the U.S. to maximize the benefit of its participation in ITER. In addition, this activity supports the efficient dissemination of ITER data in support of FPP activities.

Closing the Fusion Cycle

Within a fusion power system, essential engineering systems are vital for energy production, including power capture, fueling, waste management, and reliable operation. The Closing the Fusion Cycle activity aims to build the scientific understanding necessary to engineer these systems. Simultaneously, the program addresses the challenges of integrating these systems effectively, with the overarching goal of realizing practical fusion power. To address some of the larger and more difficult challenges, FIRE centers, virtual small group research collaborations, have been initiated under this part of the program.

To harness power from fusion, specific plasma conditions must be achieved, which is supported by engineering systems that enable plasma formation, ignition, and sustainment. The Enabling Technologies activity seeks to advance systems that currently support FES research facilities, develop the next generation systems, and develop new systems. The focus is on supporting more optimized plasma conditions, a critical step toward unlocking the potential of fusion energy. To address some of the larger and more difficult challenges, FIRE centers which are virtual small group research collaborations have also been initiated under this part of the program.

Discovery Plasma Science and Technology

Discovery Plasma Science and Technology (DPST) research supports activities in high energy density laboratory plasmas (HEDLP), foundational plasma science research, transformational plasma science technology, innovation in advanced microelectronics, and efforts in the convergence of plasmas and quantum information science.

Research in HEDLP is directed at exploring the behavior of plasmas at extreme conditions of temperature, density, and pressure including relativistic high energy density (HED) plasmas and intense beam physics, magnetized HED plasma physics, ionized HED atomic physics, HED hydrodynamics, warm dense matter, nonlinear optics of plasmas and laser-plasma interactions, laboratory astrophysics, and diagnostics for HEDLP. This activity also includes LaserNetUS, a geographically distributed network of ten high-intensity laser facilities that provides students and scientists with broad access to unique facilities and enabling technologies and advances the frontiers of high energy density and laser science research.

General Plasma Science and Technology (GPST) focuses on the frontiers of basic and low-temperature plasma science, including dynamical processes in laboratory, space, and astrophysical plasmas, such as magnetic reconnection, dynamo, shocks, turbulence cascade, structures, waves, flows and their interactions; behavior of dusty plasmas, non-neutral, single component matter or antimatter plasmas, and ultra-cold neutral plasmas. Whereas basic and low-temperature plasma science seeks to perform experiments into new regimes and develop accurate theoretical descriptions of the complex emergent behavior of the plasma state through validation, plasma astrophysics translates these fundamental discoveries to a better understanding of space and the cosmos, while low temperature plasma science translates discoveries into societal benefits.

DPST research stewards' world-class plasma science experiments and collaborative research facilities at small and intermediate scales. This effort maintains collaborations with NNSA and NSF.

Transformational plasma science technology includes frontier research in interfacial plasmas, plasma medicine, thermal and non-thermal plasma applications, atmospheric plasmas, plasmas for agriculture and enhanced energy systems, and the interaction of emerging plasmas and their environments.

The Advanced Microelectronics activity supports discovery plasma research in a multi-disciplinary, co-design framework to accelerate plasma-based microelectronics fabrication and advance the development of microelectronic technologies. The direction of the Advanced Microelectronics efforts is informed by the FESAC LRP, the NASEM Plasma 2020 decadal survey report, a FY 2022 workshop on plasma science for microelectronics nanofabrication, and the Creating Helpful Incentives to Produce Semiconductors for America (CHIPS) and Science Act of 2022.

The Quantum Information Science (QIS) activity supports basic research in QIS that can have a transformative impact on FES mission areas, including fusion and discovery plasma science, as well as research that takes advantage of unique FES-enabled capabilities to advance QIS development.

Public-Private Partnerships

Resilient public-private partnerships (PPPs) will foster bridges between the public and private sectors to address foundational gaps and accelerate fusion toward viability. Within this PPP framework, the Innovation Network for Fusion Energy (INFUSE) provides private-sector fusion companies with access to world-class expertise and capabilities at DOE's national laboratories and U.S. universities to overcome critical scientific and technological hurdles. The Fusion Development Milestone Program aims to accelerate progress toward the development of commercial fusion energy through PPPs, with near-term goals of delivering preconceptual designs and technology roadmaps for a FPP and enabling significant performance improvements of FPP concepts. A new activity initiated in FY 2025 will support a Private Facility Research Program which offers the opportunity for fusion community researchers to conduct open scientific studies on privately constructed facilities for the mutual benefit of all parties. Uniquely, this program aims to advance fusion and plasma science and technology through the open dissemination of S&T results and datasets acquired from world-leading private experimental facilities.

Fusion Workforce Pathways

This activity supports the RENEW, FAIR, and EPSCoR initiatives to provide research and student training opportunities with academic institutions underserved in the U.S. Science and Technology ecosystem and aligns with a recommendation in the FESAC LRP. In addition, these initiatives expand efforts to build capacity in emerging research institutions and HBCUs and MSIs, as well as invest in underserved communities for a more diverse and inclusive workforce.

Other Research

This activity supports the Postdoctoral Research Program, FESAC, multiple fusion and plasma science outreach programs, the U.S. Burning Plasma Organization, critical general infrastructure and environmental monitoring at PPPL and other DOE laboratories, and other programmatic activities.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Burning Plasma Science: Foundations	**$345,122**	**$ —**	**$ —**
Advanced Tokamak	$134,122	$ —	$ —
Funding supports 20 weeks of operations at the DIII-D facility, which is 90 percent of optimal. Research continues to exploit innovative current drive systems to assess their potential as actuators for a fusion pilot plant and to optimize plasma performance. Upgrades include increasing electron cyclotron power, completing the installation of the high-field-side lower hybrid current drive system and commencing experiments, and increasing the power of the neutral beam injection system. Funding continues to support research in high-temperature superconducting magnet technology, plasma heating and current drive, plasma fueling, and other enabling technologies for fusion. Funding continues support for small-scale AT experiments.			

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Spherical Tokamak	$107,000	$ —	$ —
Funding for operations supports the remaining NSTX-U Recovery fabrication and machine reassembly activities and begins supporting the commissioning of auxiliary heating systems in preparation for plasma operations. Research efforts focus on studies utilizing a variety of domestic and international spherical tokamak facilities; these studies are aligned with the mission of the NSTX-U program, which contributes to the development of the design basis for a next-step FPP. Funding continues supporting small-scale ST studies dedicated to simplifying and reducing the capital cost of future fusion facilities.			
Theory & Simulation	$50,500	$ —	$ —
Funding supports efforts at universities, national laboratories, and private industry focused on the fundamental theory of magnetically confined plasmas and the development of a predictive capability for magnetic fusion. Funding supports the SciDAC portfolio with emphasis on whole-facility modeling, in alignment with the LRP recommendations. It also provides a consistent set of high-fidelity tools for design and performance assessment of FPP concepts. Funding also supports Advanced Computing, including investments in enhanced data infrastructure capabilities to address the growing data needs of fusion research.			

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
GPP-GPE Infrastructure	$1,500	$ —	$ —
Funding supports infrastructure improvements, repair, maintenance, and environmental monitoring at PPPL and other DOE laboratories.			
Public-Private Partnerships	$31,000	$ —	$ —
Funding continues to support the INFUSE program, providing the private sector with access to DOE developed capabilities at both national laboratories and universities. Funding also continues support for a milestone-based fusion development program through partnerships with the private sector.			
Artificial Intelligence and Machine Learning (AI/ML)	$11,000	$ —	$ —
Funding supports a competitive solicitation to identify multi-institutional collaborations focused on deploying AI/ML applications across FES program elements.			
Inertial Fusion Energy (IFE)	$10,000	$ —	$ —
Funding supports the new IFE program focused on the priority research opportunities in scientific foundations and technologies that were identified in the FY 2022 Basic Research Needs Workshop for IFE.			
Burning Plasma Science: Long Pulse	**$81,000**	**$ —**	**$ —**
Long Pulse: Tokamak (old)	$15,000	$ —	$ —
Funding supports the second budget period for U.S. teams conducting research on international facilities, which helps close key gaps in the design basis for an FPP.			

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Long Pulse: Stellarators	$7,500	$ —	$ —
In the next W7-X experimental campaign, funding supports research on turbulent transport, stability and edge physics, and boundary and scrape-off-layer physics. Funding also supports experiments on domestic stellarators in regimes relevant to the mainline stellarator magnetic confinement efforts.			
Materials & Fusion Nuclear Science	$56,500	$ —	$ —
Funding supports research activities in these areas, consistent with the recommendations of the FESAC Long-Range Plan. This includes continued development of critical technologies for an FPP, such as plasma-facing components, structural and functional materials. Funding also continues to support research into advanced manufacturing technologies consistent with the SC initiative in this area. Finally, funding supports the MPEX MIE project, with efforts focused on construction following the combined baselining and start of construction that was received on August 22, 2022.			
Future Facilities Studies	$2,000	$ —	$ —
Funding supports the Future Facilities Studies activity to conduct design studies for an integrated fusion plant, e.g., an FPP, consistent with the FESAC Long-Range Plan recommendation.			
Burning Plasma Science: High Power	**$2,000**	**$ —**	**$ —**
ITER Research	$2,000	$ —	$ —
Funding supports the highest-priority research and engagement opportunities identified in the Basic Research Needs workshop that was held in FY 2022.			

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Discovery Plasma Science	**$82,100**	**$ —**	**$ —**
Plasma Science and Technology	$46,000	$ —	$ —
General Plasma Science	*$19,000*	*$ —*	*$ —*
Funding supports core research at the frontiers of basic and low temperature plasma science, as well as operations of and user-led experiments on collaborative research facilities.			
High Energy Density Laboratory Plasmas	*$27,000*	*$ —*	*$ —*
Funding supports basic and translational science, MEC and LaserNetUS operations and user support, and the SC-NNSA joint program.			
Measurement Innovation	$2,915	$ —	$ —
Funding supports the development of innovative and transformative diagnostics.			
Quantum Information Science	$10,000	$ —	$ —
Funding supports priority research opportunities identified in the 2018 Roundtable Workshop Report. It also continues to support the SC QIS Research Centers.			
Advanced Microelectronics	$5,000	$ —	$ —
Funding supports high priority research and the continuation of laboratory awards made through a competitive lab call and review in FY 2021.			
Other FES Research	$4,185	$ —	$ —
Funding supports programmatic activities such as the FES Postdoctoral Research Program, the FES Fusion and Plasma Science Outreach programs, USBPO, peer reviews for FES solicitations and project activities, and FESAC.			

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Reaching a New Energy Sciences Workforce (RENEW)	$6,000	$ —	$ —
Funding supports the RENEW initiative to provide undergraduate and graduate training opportunities for students and academic institutions under-represented in the U.S. S&T ecosystem and aligns with a recommendation in the FESAC LRP.			
Funding for Accelerated, Inclusive Research (FAIR)	$2,000	$ —	$ —
Funding supports the Funding for Accelerated, Inclusive Research (FAIR) initiative, which provides focused investment on enhancing research on clean energy, climate, and related topics at minority serving institutions, including attention to underserved and environmental justice communities.			
Accelerate Innovations in Emerging Technologies	$4,000	$ —	$ —
Funding supports the Accelerate initiative, which supports scientific research to accelerate the transition of science advances to energy technologies.			
Established Program to Stimulate Competitive Research (EPSCoR)	$2,000	$ —	$ —
FY 2023 EPSCoR funding emphasizes Implementation Awards to larger multiple investigator teams. Investment continues in early career research faculty from EPSCoR-designated jurisdictions and in co-investment with other programs for awards to eligible institutions.			

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Fusion and Plasma Research	**$ —**	**$482,646**	**+$482,646**
Theory and Simulation	$ —	$73,729	+$73,729
Funding supports efforts at universities, national laboratories, and private industry focused on the fundamental theory of magnetically confined plasmas and the development of a predictive capability for magnetic fusion.		The Request will continue to support efforts at universities, national laboratories, and private industry focused on the fundamental theory of fusion plasmas.	
Funding supports the SciDAC portfolio with emphasis on whole-facility modeling, in alignment with the LRP recommendations. It also provides a consistent set of high-fidelity tools for design and performance assessment of FPP concepts.		The Request will continue to support the SciDAC portfolio selected in FY 2023. The FIRE centers for advanced simulations will continue to develop and apply predictive simulation tools to enable commercially relevant FPP designs.	Research efforts in theory and SciDAC will focus on the highest-priority activities, including continuing support of the SciDAC portfolio. The funding increase will strengthen the FIRE centers for advanced simulations.
Funding also supports Advanced Computing, including investments in enhanced data infrastructure capabilities to address the growing data needs of fusion research.		The Request will continue to support Advanced Computing, including investments in enhanced data infrastructure capabilities.	No change.
Funding supports a competitive solicitation to identify multi-institutional collaborations focused on deploying AI/ML applications across FES program elements.		The Request will continue to support research in cross-cutting interdisciplinary fusion energy and plasma science research.	Funding increase will support additional team awards to advance FPP design efforts, exploit SC's Integrated Research Infrastructure, and plan for fusion and plasma "spokes" for SC's High Performance Data Facility.
Fusion Materials and Internal Components	$ —	$65,000	+$65,000
Funding supports research activities in these areas, consistent with the recommendations of the FESAC Long-Range Plan. This includes continued development of critical technologies for an FPP, such as plasma-facing components, structural and functional materials, and breeding-blanket and tritium-handling systems. Funding also continues to support research into advanced manufacturing technologies consistent with the SC initiative in this area. Finally, funding supports the MPEX		The Request will enable growth in the key area of materials which is critical in developing the scientific foundation for fusion energy. The Request will continue to support the FIRE centers for structural and plasma facing materials which will focus their efforts on addressing the scientific and technical gaps identified in the FESAC LRP as well as in recent community workshops. The Request will also continue to support the MPEX MIE project,	Funding increase will support the FIRE centers for structural and plasma facing materials, which are vital in establishing U.S. R&D capabilities to address the scientific/technical gaps in these programs. Funding for the MPEX project will support the project's approved cost/schedule baseline.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
MIE project, with efforts focused on construction following the combined baselining and start of construction that was received on August 22, 2022.	consistent with the approved baseline for the project.	
Emergent Plasma Concepts $ —	$156,897	+$156,897
Research continues at DIII-D to exploit innovative current drive systems to assess their potential as actuators for a fusion pilot plant and to optimize plasma performance. Upgrades include increasing electron cyclotron power, completing the installation of the high-field-side lower hybrid current drive system and commencing experiments, and increasing the power of the neutral beam injection system.	The Request will support research at DIII-D needed for ITER and a future FPP, and training opportunities for the next generation of fusion researchers.	Funding will support research aligned with the FESAC LRP including DIII-D enhancements.
Funding for operations supports the remaining NSTX-U Recovery fabrication and machine reassembly activities and begins supporting the commissioning of auxiliary heating systems in preparation for plasma operations. Research efforts focus on studies utilizing a variety of domestic and international spherical tokamak facilities; these studies are aligned with the mission of the NSTX-U program, which contributes to the development of the design basis for a next-step FPP.	The Request will support research efforts that strengthen the scientific foundation of the ST concept including laying the ground work for the initiation of NSTX-U research activities.	Research funding will focus on the highest-priority scientific objectives.
Funding continues support for small-scale experimental research.	The Request continues to support the small-scale AT and ST experiments.	The funding increase will support AT small-scale experimental operations and enhancements.
Funding supports the second budget period for U.S. teams conducting research on international facilities, which helps close key gaps in the design basis for an FPP.	The Request will support U.S. consortia conducting research on international facilities with capabilities not available in the U.S. The activity will target extensions of U.S. expertise in strategic areas of burning plasmas, plasma technology, and model validation.	The funding increase will support expansion of research elements on superconducting facilities.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Funding supports the new IFE program focused on the priority research opportunities in scientific foundations and technologies that were identified in the FY 2022 Basic Research Needs Workshop for IFE.	The Request will support the priority research opportunities identified in the FY 2022 Basic Research Needs Workshop (BRN) for IFE.	The funding increase will enhance support for the existing IFE-STAR hubs.
In the next W7-X experimental campaign, funding supports research on turbulent transport, stability and edge physics, and boundary and scrape-off-layer physics. Funding also supports experiments on domestic stellarators in regimes relevant to the mainline stellarator magnetic confinement efforts.	The Request will support W7-X pellet fueling experiments with a goal of sustaining plasmas for extended duration. Data from various W7-X diagnostic systems will be analyzed to support optimizing future operations. Support for the domestic stellarator devices will continue.	The funding increase will support control of plasma turbulence using a W7-X pellet fueling injector, and reduction of plasma turbulence in quasi-helically symmetric experiments. State-of-the-art diagnostic systems will be enhanced to pursue key physics questions. Funding for domestic stellarator research will also be increased.
Funding supports the development of innovative and transformative diagnostics.	The Request will continue to support the development of innovative and transformative diagnostics.	Funding will support highest-priority activities.
Funding supports the Future Facilities Studies activity to conduct design studies for an integrated fusion plant, e.g., an FPP, consistent with the FESAC Long-Range Plan recommendation.	The Request will support conducting scoping studies and research to help define requirements for future fusion facilities.	The funding increase will support R&D and scoping studies activities for future fusion facilities.
Funding supports the highest-priority research and engagement opportunities identified in the ITER Research Basic Research Needs workshop that was held in FY 2022.	The Request will continue supporting the highest-priority research and engagement opportunities identified in the ITER Research BRN workshop that was held in FY 2022, as well as supporting the dissemination of ITER data in support of FPP activities.	No change.
Closing the Fusion Cycle $ —	$53,000	+$53,000
Funding supports research activities in these areas, consistent with the recommendations of the FESAC Long-Range Plan. This includes continued development of critical technologies for an FPP, such as breeding-blanket and tritium-handling systems.	The Request will enable growth in the key areas of fusion nuclear science and enabling R&D which are critical in developing the scientific foundation for fusion energy. The Request will continue to support the FIRE centers for blanket/fuel cycle and enabling technologies which will focus their efforts on	The funding increase will support the FIRE centers for blanket/fuel cycle and enabling technologies.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Funding continues to support research in high temperature superconducting magnet technology, plasma heating and current drive, plasma fueling, and other enabling technologies for fusion.	addressing the scientific and technical gaps identified in the FESAC LRP as well as in recent community workshops.	
Discovery Plasma Science and Technology $ —	$72,168	+$72,168
Funding supports basic and translational science, MEC and LaserNetUS operations and user support, and the SC-NNSA joint program.	The Request will continue to support basic and translational science, MEC and LaserNetUS operations and user support, and the SC-NNSA joint program.	Funding will support highest-priority activities.
Funding supports core research at the frontiers of basic and low temperature plasma science, as well as operations of and user-led experiments on collaborative research facilities.	The Request will continue to support core research at the frontiers of basic and low-temperature plasma science, as well as operations of midscale collaborative research facilities and external collaborations on these facilities.	The funding will broaden the research and operations of midscale collaborative research facilities in General Plasma Science and Technology.
Funding supports high priority research and the continuation of laboratory awards made through a competitive lab call and review in FY 2021.	The Request will support priority research opportunities identified in the recent workshop on plasma science for microelectronics nanofabrication.	The funding will enhance support for the plasma science needed for advanced microelectronics R&D.
Funding supports priority research opportunities identified in the 2018 Roundtable Workshop Report. It also continues to support the SC QIS Research Centers.	The Request will continue to support core research awards selected in FY 2024 in QIS as well as support for the recompetition/renewal of the National QIS Research Centers.	No change.
Public-Private Partnerships $ —	$35,000	+$35,000
Funding continues to support the INFUSE program, providing the private sector with access to DOE developed capabilities at both national laboratories and universities. Funding also continues support for a milestone-based fusion development program through partnerships with the private sector.	The Request will support public-private partnerships through the Fusion Development Milestone Program and the INFUSE program, both of which connect the private sector to DOE developed capabilities at national laboratories and universities. A new Private Facility Research pilot program will be initiated which will offer the opportunity for publicly	The funding increase will support the second phase of the Fusion Development Milestone Program, enabling enhanced experiments to continue de-risking an array of approaches to fusion. Funding will continue to support the INFUSE program. It will also support the new Private Facility Research pilot program.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
	funded researchers to conduct open scientific studies on privately constructed facilities for the mutual benefit of all parties.	
Fusion Workforce Pathways $ —	$20,000	+$20,000
Funding supports the RENEW initiative to provide undergraduate and graduate training opportunities for students and academic institutions under-represented in the U.S. S&T ecosystem and aligns with a recommendation in the FESAC LRP.	The Request will continue to support targeted efforts to increase participation and retention of individuals from underrepresented groups in FES research activities, including a RENEW graduate fellowship.	The funding increase will broaden RENEW activities within the FES research portfolio.
Funding supports the Funding for Accelerated, Inclusive Research (FAIR) initiative, which provides focused investment on enhancing research on clean energy, climate, and related topics at minority serving institutions, including attention to underserved and environmental justice communities.	The Request will continue to support the FAIR initiative efforts to increase participation and retention of individuals from underrepresented institutions in FES research activities.	The funding will enhance support of the FAIR initiative within the FES research portfolio.
Funding supports the Accelerate initiative, which supports scientific research to accelerate the transition of science advances to energy technologies.	The Request includes no funding for this activity.	Support for highest-priority activities will be continued through other parts of the FES portfolio.
FY 2023 EPSCoR funding emphasizes Implementation Awards to larger multiple investigator teams. Investment continues in early career research faculty from EPSCoR-designated jurisdictions and in co-investment with other programs for awards to eligible institutions.	The Request will support EPSCoR State-National Laboratory Partnership awards and early career awards.	No change.
Other Research $ —	$6,852	+$6,852
Funding supports programmatic activities such as the FES Postdoctoral Research Program, the FES Fusion and Plasma Science Outreach programs, USBPO, peer reviews for FES solicitations and project activities, and FESAC.	The Request will continue to support programmatic activities such as the FES Postdoctoral Research Program, the FES Fusion and Plasma Science Outreach programs, the U.S. Burning Plasma Organization, peer reviews and project activities, and FESAC.	The funding increase will support the highest priority programmatic activities

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Funding supports infrastructure improvements, repair, maintenance, and environmental monitoring at PPPL and other DOE laboratories.	The Request will continue to support infrastructure improvements, repair, maintenance, and environmental monitoring at PPPL and other DOE laboratories.	Funding will support highest-priority activities.

Note:
- *Funding for the subprogram above, includes 3.65 percent of research and development (R&D) funding for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, excluding facility operations.*
- *FY 2023 funding amounts are populated in the current structure, only FY 2025 is populated in the proposed restructure.*

Fusion Energy Sciences
Fusion Facility Operations

Description

The DIII-D National Fusion Facility and the National Spherical Torus Experiment-Upgrade (NSTX-U) facility are world-leading Office of Science (SC) user facilities for experimental research, used by scientists from national laboratories, universities, and industry research groups, to optimize magnetic confinement regimes. The operation of these facilities addresses the FESAC Long-Range Plan Fusion Science & Technology recommendation to “utilize research operations on DIII-D and NSTX-U, and collaborate with other world-leading facilities, to ensure that Fusion Pilot Plant (FPP) design gaps are addressed in a timely manner.” Gaps that can be addressed by the operation of the FES user facilities include low aspect ratio physics, disruption avoidance and mitigation, plasma control, core-edge integration, steady state burning plasma scenario development, and plasma facing component integration, including assessment of liquid metal approaches. These facilities also represent a valuable resource for the private fusion energy sector to resolve science and technology challenges associated with their confinement concepts. In addition, they play a significant role in training the next generation of diverse and inclusive fusion scientists and preparing the U.S. research community to take full advantage of ITER operations.

<u>DIII-D Operations</u>
The DIII-D scientific user facility at General Atomics is the largest, most adaptable, magnetic confinement facility in the U.S. DIII-D has been in operation since 1986 and investments in the facility include regular refurbishments, upgrades, and enhancements have maintained its status as a world-leading fusion research facility. DIII-D is a normal aspect ratio tokamak and focuses on the Advanced Tokamak (AT) path to fusion energy. The AT is an integrated fusion energy system that simultaneously achieves a stationary plasma state characterized by high plasma pressure, high fractions of self-generated plasma current, adequate heat and particle confinement, and levels of heat and particle exhaust compatible with plasma-facing surfaces. DIII-D can sustain plasmas at temperatures relevant to burning plasma conditions. Its extensive set of advanced diagnostic systems and extraordinary flexibility to explore various operating regimes make it a world-leading tokamak research facility with an important role in closing science and technology gaps. In FY 2023, it supported 700 onsite and remote users from 95 institutions and 18 countries. It also engaged 30 faculty members and 139 students, including 35 undergraduate students. FY 2025 Request will support 16 weeks of operations, operation with a new divertor allowing higher plasma performance, the completion of ongoing facility and infrastructure enhancements, research needed for ITER and a future FPP, and training opportunities for the next generation of fusion researchers. Longer-term, the facility will focus on integrated core-edge solutions for the FPP, burning plasma transport and performance optimizations, plasma stability control solutions, validation of simulation predictions, assessment of compatibility of viable FPP scenarios with relevant first wall materials, and the viability of negative triangularity shaped plasmas for FPPs.

<u>National Spherical Torus Experiment-Upgrade (NSTX-U) Operations</u>
The National Spherical Torus Experimental Upgrade (NSTX-U) scientific user facility at Princeton Plasma Physics Laboratory (PPPL) is used to explore the unique advantageous properties of a magnetically confined plasma configuration called a Spherical Tokamak (ST). Specifically, a ST is shaped like a cored apple. NSTX-U will operate with toroidal magnetic fields as high as one Tesla and confine superheated plasmas with internal currents as high as two megaamperes. NSTX-U is the world’s most powerful ST, with external heating of approximately 19 megawatts. Previous experiments and high-fidelity simulations have shown that STs may offer higher energy confinement than other fusion devices at fusion relevant conditions. In NSTX-U, if existing NSTX results can be extended experimentally to near fusion conditions, then the ST may serve as the optimal configuration for building a next step FPP, which is the primary goal of the FES Bold Decadal Vision. Additionally, NSTX-U aims to test if higher normalized plasma pressure limits observed in STs can be sustained in higher performance plasmas. If so, it would enable higher fusion power in a given volume (reduced device size) and higher achievable bootstrap current, which reduces the need for external current drive, and hence, reduces the recirculated power in a future energy source (improved economics). Combining an upgraded neutral beam heating system with unique ST plasma properties, NSTX-U is also an ideal test bed for studying interactions between plasma waves and fast fuel ions in ways that are relevant to burning plasma science. To effectively measure and control these ST plasmas, NSTX-U is outfitted with roughly three dozen unique plasma diagnostic systems that are operated by PPPL as well as many collaborators from other National Laboratories, Universities, and Industry partners. In FY 2025, support will continue the recovery and repair activities including machine assembly as well as preparation for plasma operations.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Burning Plasma Science: Foundations	**$345,122**	**$ —**	**$ —**
Advanced Tokamak	$134,122	$ —	$ —
Funding supports 20 weeks of operations at the DIII-D facility, which is 90 percent of optimal. Research continues to exploit innovative current drive systems to assess their potential as actuators for a fusion pilot plant and to optimize plasma performance. Upgrades include increasing electron cyclotron power, completing the installation of the high-field-side lower hybrid current drive system and commencing experiments, and increasing the power of the neutral beam injection system. Funding continues to support research in high-temperature superconducting magnet technology, plasma heating and current drive, plasma fueling, and other enabling technologies for fusion. Funding continues support for small-scale AT experiments.			

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Spherical Tokamak	$107,000	$ —	$ —
Funding for operations supports the remaining NSTX-U Recovery fabrication and machine reassembly activities and begins supporting the commissioning of auxiliary heating systems in preparation for plasma operations. Research efforts focus on studies utilizing a variety of domestic and international spherical tokamak facilities; these studies are aligned with the mission of the NSTX-U program, which contributes to the development of the design basis for a next-step FPP. Funding continues supporting small-scale ST studies dedicated to simplifying and reducing the capital cost of future fusion facilities.			
Fusion Facility Operations	**$ —**	**$126,850**	**+$126,850**
DIII-D Operations	$ —	$73,600	+$73,600
Funding supports 20 weeks of operations at the DIII-D facility, which is 90 percent of optimal. Research continues to exploit innovative current drive systems to assess their potential as actuators for a fusion pilot plant and to optimize plasma performance. Upgrades include increasing electron cyclotron power, completing the installation of the high-field-side lower hybrid current drive system and commencing experiments, and increasing the power of the neutral beam injection system.		The Request will support 16 weeks of operations in FY 2025 at the DIII-D facility. The program will also support facility and infrastructure enhancements.	The funding increase will support DIII-D enhancements.

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
National Spherical Torus Experiment-Upgrade (NSTX-U) Operations $ —	$53,250	+$53,250
Funding for operations supports the remaining NSTX-U Recovery fabrication and machine reassembly activities and begins supporting the commissioning of auxiliary heating systems in preparation for plasma operations.	The Request for operations funding will support NSTX-U Recovery fabrication and machine reassembly activities and continue to support commissioning in preparation for plasma operations.	Operations funding, consistent with the baseline, will support the continuation of the NSTX-U Recovery activities.

Note:

- *Funding for the subprogram above, includes 3.65 percent of research and development (R&D) funding for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, excluding facility operations.*
- *FY 2023 funding amounts are populated in the current structure, only FY 2025 is populated in the proposed restructure.*

Fusion Energy Sciences
Construction

Description

This subprogram supports all line-item construction projects for the FES program. All Total Estimated Costs (TEC) are funded in this subprogram.

20-SC-61 Matter in Extreme Conditions (MEC) Petawatt Upgrade, SLAC

The MEC Petawatt Upgrade project will provide a collaborative user facility that utilizes the LCLS-II light source and is focused on High-Energy-Density Science that will maintain U.S. leadership in the field of high intensity lasers. The project received Critical Decision-1 (CD-1), "Approve Alternative Selection and Cost Range," on October 4, 2021. The FY 2025 Request of $10,000,000 will support preliminary design activities. The estimated total project cost range is $264,000,000 to $461,000,000. CD-2, Approve Performance Baseline, is expected in 1Q FY 2026.

14-SC-60 U.S. Contributions to ITER

The ITER facility, currently under construction in Saint Paul-lez-Durance, France. is more than 75 percent complete to First Plasma. ITER is designed to provide fusion power output approaching reactor levels of hundreds of megawatts, sustained as a burning plasma for hundreds of seconds. ITER is a necessary step toward developing a carbon-free fusion energy pilot plant and will help keep the U.S. competitive internationally. Construction of ITER is a collaboration among the U.S., European Union, Russia, Japan, India, Korea, and China, governed under an international agreement (the "ITER Joint Implementing Agreement"). As a co-owner of ITER, the U.S. contributes in-kind hardware components and financial contributions for the ITER Organization (IO) management and overhead (e.g., design integration, nuclear licensing, quality control, safety, overall project management, and installation and assembly of the components provided by the U.S. and other Members). The U.S. also has over 50 nationals employed by the IO and working at the site.

An independent review of CD-2, "Approve Performance Baseline," for the U.S. Contributions to ITER—First Plasma subproject (SP-1) was completed in November 2016 and then subsequently approved by the Project Management Executive on January 13, 2017, with a total project cost of $2,500,000,000. Responding to Congressional direction in the FY 2021 Appropriations Act, the project was baselined in December 2023 and achieved CD-2/3B, which includes a rebaseline of SP-1 scope, baseline of Post-First Plasma (SP-2) scope, and financial contributions for the project to CD-4, "Approve Project Completion". SP-1 scope is currently over 75 percent complete and will include the delivery of the completed Central Solenoid Magnet System, Steady-state Electrical Network, and Disruption Mitigations System. SP-1 also contains a portion of design and fabrication for the remaining nine systems scope associated with SP-2 and will deliver the balance of completed work to include the Tritium Exhaust Processing System, Ion Cyclotron Heating and Electron Cyclotron Heating Systems, diagnostics, and roughing pumps.

The FY 2025 Request of $225,000,000 will support the continued systems design, fabrication, and delivery of in-kind hardware, and financial contributions for IO construction operations. The revised baseline is $6,500,000,000, which includes all U.S. in-kind hardware and financial construction contributions through the completion of the ITER project. Upon baselining in December 2023, the TPC range will no longer exist, and reporting will be to the approved TPC of $6,500,000,000. ITER Organization will be providing an updated baseline to the ITER council in the FY 2024 timeframe. U.S. Contributions to ITER are estimated to remain within the TPC of $6,500,000.

The U.S. in-kind contribution represents 9.09 percent (1/11th) of the overall ITER project but will provide access to 100 percent of the science and engineering associated with what will be the largest magnetically confined burning plasma experiment ever created. The U.S. involvement in ITER will help to advance the promise of carbon-free, inherently safe, and abundant fusion energy

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Major Changes FY 2025 Request vs FY 2023 Enacted
Construction	**$253,000**	**$235,000**	**-$18,000**
20-SC-61, Matter in Extreme Conditions (MEC) Petawatt Upgrade, SLAC	$11,000	$10,000	-$1,000
Funding supports design activities and preparation for developing a project performance baseline.		The Request will continue to support design activities and preparation for developing a project performance baseline.	Funding will support critical preparation activities for developing the performance baseline.
14-SC-60, U.S. Contributions to ITER (Historical)	$242,000	$225,000	-$17,000
Funding supports continued design and fabrication of in-kind hardware systems and requested construction financial contributions.		The Request will support continued design and fabrication of in-kind hardware systems and requested construction financial contributions.	Funding will support design and fabrication of in-kind hardware and fulfill the U.S. obligations for financial contributions to the ITER Organization.

Fusion Energy Sciences
Capital Summary

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Capital Operating Expenses						
Capital Equipment	N/A	N/A	22,443	41,500	38,700	+16,257
Minor Construction Activities						
General Plant Projects	N/A	N/A	1,500	1,000	1,000	-500
Total, Capital Operating Expenses	**N/A**	**N/A**	**23,943**	**42,500**	**39,700**	**+15,757**

Capital Equipment

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Capital Equipment						
Major Items of Equipment						
Fusion and Plasma Research						
Material Plasma Exposure eXperiment (MPEX)	188,179	103,456	14,000	25,000	22,200	+8,200
Total, MIEs	N/A	N/A	14,000	25,000	22,200	+8,200
Total, Non-MIE Capital Equipment	N/A	N/A	8,443	16,500	16,500	+8,057
Total, Capital Equipment	**N/A**	**N/A**	**22,443**	**41,500**	**38,700**	**+16,257**

Note:

- The Capital Equipment table includes MIEs located at a DOE facility with a Total Estimated Cost (TEC) > $10M and MIEs not located at a DOE facility with a TEC >$2M.

Fusion Energy Sciences
Minor Construction Activities

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
General Plant Projects (GPP)						
Total GPPs $5M or less	N/A	N/A	1,500	1,000	1,000	-500
Total, General Plant Projects (GPP)	**N/A**	**N/A**	**1,500**	**1,000**	**1,000**	**-500**
Total, Minor Construction Activities	**N/A**	**N/A**	**1,500**	**1,000**	**1,000**	**-500**

Note:
- *GPP activities $5M and less include design and construction for additions and/or improvements to land, buildings, replacements or addition to roads, and general area improvements. AIP activities $5M and less include minor construction at an existing accelerator facility.*

Fusion Energy Sciences
Major Items of Equipment Description(s)

Burning Plasma Science: Long Pulse MIEs:

Material Plasma Exposure eXperiment (MPEX)

FES is developing a first-of-a-kind, world-leading experimental capability to explore solutions to the plasma-materials interactions challenge. This device, known as MPEX, will be located at ORNL and will enable dedicated studies of reactor-relevant plasma-material interactions at a scale not previously accessible to the fusion program. The overall goal of this project is to create a new class of fusion materials science enabling the study of the combined effects of fusion-relevant heat, particle, and neutron fluxes for the first time anywhere in the world. The project received CD-2/3 "Approve Performance Baseline/Start of Construction" on August 22, 2022, with a TPC of $201,000,000. The FY 2025 Request includes $22,200,000 in TEC funding and $2,800,000 in Other Project Costs (OPC) funding and allow the project to execute the approved performance baseline. MPEX scope includes the design, fabrication, installation, and commissioning of the MPEX linear plasma device, as well as associated facility and infrastructure modifications and reconfiguration.

Fusion Energy Sciences
Construction Projects Summary

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
20-SC-61, Matter in Extreme Conditions (MEC) Petawatt Upgrade, SLAC						
Total Estimated Cost (TEC)	448,700	44,487	11,000	10,000	10,000	-1,000
Other Project Cost (OPC)	12,300	6,900	-	-	-	-
Total Project Cost (TPC)	**461,000**	**51,387**	**11,000**	**10,000**	**10,000**	**-1,000**
14-SC-60, U.S. Contributions to ITER						
Total Estimated Cost (TEC)	6,429,698	2,353,617	242,000	240,000	225,000	-17,000
Other Project Cost (OPC)	70,302	70,302	-	-	-	-
Total Project Cost (TPC)	**6,500,000**	**2,423,919**	**242,000**	**240,000**	**225,000**	**-17,000**
Total, Construction						
Total Estimated Cost (TEC)	**N/A**	**N/A**	**253,000**	**250,000**	**235,000**	**-18,000**
Other Project Cost (OPC)	**N/A**	**N/A**	**-**	**-**	**-**	**-**
Total Project Cost (TPC)	**N/A**	**N/A**	**253,000**	**250,000**	**235,000**	**-18,000**

Fusion Energy Sciences
Scientific User Facility Operations

The treatment of user facilities is distinguished between two types: TYPE A facilities that offer users resources dependent on a single, large-scale machine; TYPE B facilities that offer users a suite of resources that is not dependent on a single, large-scale machine.

(dollars in thousands)

	FY 2023 Enacted	FY 2023 Current	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Scientific User Facilities - Type A					
DIII-D National Fusion Facility	**130,000**	**124,001**	**128,600**	**129,600**	**-400**
Number of Users	700	714	700	625	-75
Achieved Operating Hours	–	788	–	–	–
Planned Operating Hours	800	788	560	640	-160
Unscheduled Down Time Hours	–	256	–	–	–
National Spherical Torus Experiment-Upgrade	**104,000**	**99,498**	**85,007**	**91,350**	**-12,650**
Number of Users	300	336	373	339	+39
Total, Facilities	**234,000**	**223,499**	**213,607**	**220,950**	**-13,050**
Number of Users	1,000	1,050	1,073	964	-36
Achieved Operating Hours	–	788	–	–	–
Planned Operating Hours	800	788	560	640	-160
Unscheduled Down Time Hours	–	256	–	–	–

Notes:
- *Achieved Operating Hours and Unscheduled Downtime Hours will only be reflected in the Congressional budget cycle which provides actuals.*
- *Percent optimal operations defines what is achieved at this funding level. This includes staffing, up-to-date equipment and software, operations and maintenance, and appropriate investments to maintain world leadership.*

Fusion Energy Sciences
Scientific Employment

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Number of Permanent Ph.Ds (FTEs)	1,025	1,055	1,141	+116
Number of Postdoctoral Associates (FTEs)	126	122	141	+15
Number of Graduate Students (FTEs)	341	356	380	+39
Number of Other Scientific Employment (FTEs)	1,530	1,576	1,703	+173
Total Scientific Employment (FTEs)	**3,022**	**3,109**	**3,365**	**+343**

Note:
- *Other Scientific Employment (FTEs) includes technicians, engineers, computer professionals and other support staff.*

20-SC-61 Matter in Extreme Conditions (MEC) Petawatt Upgrade, SLAC
SLAC National Accelerator Laboratory, SLAC
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary

The FY 2025 Request for the Matter in Extreme Conditions (MEC) Petawatt Upgrade project is $10,000,000 of Total Estimated Cost (TEC) funding. The project has a preliminary estimated Total Project Cost (TPC) range of $264,000,000 to $461,000,000. Currently, this cost range encompasses the most feasible preliminary alternatives.

The future MEC Petawatt user facility will be a premier research facility to conduct experiments in the field of High Energy Density Plasmas. It will utilize the Linac Coherent Light Source II (LCLS-II) X-Ray Free-Electron Laser (XFEL) beam at SLAC to probe and characterize plasmas and extreme states of matter.

Significant Changes

The MEC Petawatt Upgrade project was initiated in FY 2019. The project achieved CD-1, "Approve Alternative Selection and Cost Range," on October 4, 2021, and initiated the TEC-funded preliminary design phase.

FY 2023 funding allowed the project to advance design of the civil construction required to support the new facility including tunneling. The FY 2024 Request will advance the design of the test chamber that interfaces with the LCSL-II XFEL. FY 2025 Request will advance the design of the Petawatt and Kilojoule (KJ) lasers and their support systems. The Project will also develop the cost and schedule basis to support baselining efforts planned for the first quarter of FY 2026.

A Level III Federal Project Director has been assigned to the MEC Petawatt Upgrade project.

Critical Milestone History

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
FY 2025	1/4/19	3/9/21	10/4/21	1Q FY 2026	Q1 FY 2026	1Q FY 2026	1Q FY 2033

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout.

Project Cost History

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	55,487	393,213	448,700	12,300	12,300	461,000
FY 2025	85,487	363,213	448,700	12,300	12,300	461,000

Note:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*

2. Project Scope and Justification

Scope

The scope of the MEC Petawatt Upgrade project includes the development of a user facility that couples long-pulse (1 KJ or higher) and short-pulse (1 petawatt or higher) drive lasers to an X-ray source, as well as a second target chamber that will accommodate laser-only fusion and material science experiments. The lasers will be placed in a dedicated MEC experimental hall (located at the end of the LCLS-II Far Experimental Hall), composed of an access tunnel, experimental hall, control room, and associated safety systems and infrastructure.

Justification

The FES mission is to build the scientific foundations needed to develop a fusion energy source and to expand the fundamental understanding of matter at very high temperatures and densities. To meet this mission, there is a scientific need for a petawatt or greater laser facility, which is currently not available in the U.S. The National Academies of Sciences, Engineering, and Medicine (NASEM) 2017 report titled "Opportunities in Intense Ultrafast Lasers: Reaching for the Brightest Light"[c] found that about 80 percent to 90 percent of the high-intensity laser systems are overseas, and all the highest-power lasers currently under construction or already built are overseas as well. The report made five recommendations that would improve the nation's position in the field, including a recommendation for DOE to plan for at least one large-scale, open-access, high-intensity laser facility that leverages other major science infrastructures in the DOE complex.

The NASEM report focuses on high-intensity, pulsed petawatt-class lasers (1 petawatt is 10^{15} watts). Laser beams of this intensity can drive nuclear reactions, heat matter to mimic conditions found in stars, and create electron-positron plasmas. In addition to discovery-driven science, petawatt-class lasers can generate particle beams with potential applications in medicine, intense neutron and gamma ray beams for homeland security applications, directed energy for defense applications, and radiation for extreme ultraviolet lithography.

Co-location of high-intensity lasers with existing infrastructure such as particle accelerators has been recognized as a key advantage of the U.S. laboratories over the Extreme Light Infrastructure concept in Europe. A laser facility with high-power, high-intensity beam parameters that is co-located with hard X-ray laser probing capabilities (i.e., with an X-ray wavelength that allows atomic resolution) will provide the required diagnostic capabilities for fusion discovery science and related fields. Recent research on ultrafast pump-probe experiments using the LCLS at the SLAC National Accelerator Laboratory has demonstrated exquisite ultrafast measurements of the material structural response to radiation. The upgrade includes the petawatt laser beam and the long-pulse laser beam. The latter is required to compress matter to densities relevant to planetary science and fusion plasmas. The MEC Petawatt Upgrade will have the potential to address some Inertial Fusion Energy (IFE) questions including spherical capsule ablator materials and high-repetition rate IFE targets tracking and engagement.

FES is pursuing development of a new world-class petawatt laser capability to meet the FES mission and address the recommendations from the NASEM report.

The project will be conducted utilizing the project management principles described in DOE Order 413.3B*, Program and Project Management for the Acquisition of Capital Assets*.

Key Performance Parameters (KPPs)

The KPPs are preliminary and may change during design phase as the project continues towards CD-2. At CD-2 approval, the KPPs will be baselined. The Threshold KPPs represent the minimum acceptable performance that the project must achieve. The Objective KPPs represent the desired project performance. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion. The project is in the conceptual design phase, and the KPPs reflect the types of parameters being considered and are notional at this stage.

[c] https://www.nap.edu/catalog/24939/opportunities-in-intense-ultrafast-lasers-reaching-for-the-brightest-light

Performance Measure	Threshold	Objective
Optical Laser Systems		
▪ High repetition rate short pulse laser	▪ 30 Joules of energy ▪ 300 fs pulse length ▪ 1 Hz frequency	▪ 150 Joules of energy ▪ 150 fs pulse length ▪ 10 Hz frequency
▪ High energy long pulse laser	▪ 200 Joules of energy on target ▪ 10 ns pulse length 1 shot per 60 minutes	▪ 1000 Joules of energy on target ▪ 10 ns pulse length 1 shot per 30 minutes
X-ray Beam Delivery		
▪ Photon energy	▪ 5-25 keV energy delivered to target center	▪ 5-45 keV of energy delivered to target center

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Estimated Cost (TEC)				
Design (TEC)				
Prior Years	34,487	34,487	23,487	—
Prior Years - IRA Supp.	10,000	10,000	—	—
FY 2023	11,000	11,000	8,539	10,000
FY 2024	10,000	10,000	10,000	—
FY 2025	10,000	10,000	10,000	—
Outyears	10,000	10,000	23,461	—
Total, Design (TEC)	**85,487**	**85,487**	**75,487**	**10,000**
Construction (TEC)				
Outyears	363,213	363,213	363,213	—
Total, Construction (TEC)	**363,213**	**363,213**	**363,213**	**—**
Total Estimated Cost (TEC)				
Prior Years	34,487	34,487	23,487	—
Prior Years - IRA Supp.	10,000	10,000	—	—
FY 2023	11,000	11,000	8,539	10,000
FY 2024	10,000	10,000	10,000	—
FY 2025	10,000	10,000	10,000	—
Outyears	373,213	373,213	386,674	—
Total, Total Estimated Cost (TEC)	**448,700**	**448,700**	**438,700**	**10,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Other Project Cost (OPC)				
Prior Years	6,900	6,900	6,900	–
Outyears	5,400	5,400	5,400	–
Total, Other Project Cost (OPC)	**12,300**	**12,300**	**12,300**	**–**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Project Cost (TPC)				
Prior Years	41,387	41,387	30,387	–
Prior Years - IRA Supp.	10,000	10,000	–	–
FY 2023	11,000	11,000	8,539	10,000
FY 2024	10,000	10,000	10,000	–
FY 2025	10,000	10,000	10,000	–
Outyears	378,613	378,613	392,074	–
Total, TPC	**461,000**	**461,000**	**451,000**	**10,000**

Note:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	62,587	42,587	**N/A**
Design - Contingency	22,900	22,900	**N/A**
Total, Design (TEC)	**85,487**	**65,487**	**N/A**
Construction	129,093	129,093	**N/A**
Equipment	118,076	138,076	**N/A**
Construction - Contingency	116,044	116,044	**N/A**
Total, Construction (TEC)	**363,213**	**383,213**	**N/A**
Total, TEC	**448,700**	**448,700**	**N/A**
Contingency, TEC	*138,944*	*138,944*	***N/A***
Other Project Cost (OPC)			
R&D	350	350	**N/A**

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Conceptual Planning	4,650	4,650	**N/A**
Conceptual Design	1,900	1,900	**N/A**
Other OPC Costs	3,800	3,800	**N/A**
OPC - Contingency	1,600	1,600	**N/A**
Total, Except D&D (OPC)	**12,300**	**12,300**	**N/A**
Total, OPC	**12,300**	**12,300**	**N/A**
Contingency, OPC	*1,600*	*1,600*	***N/A***
Total, TPC	**461,000**	**461,000**	**N/A**
Total, Contingency (TEC+OPC)	***140,544***	***140,544***	***N/A***

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	44,487	11,000	10,000	—	383,213	448,700
	OPC	6,900	—	—	—	5,400	12,300
	TPC	51,387	11,000	10,000	—	388,613	461,000
FY 2025	TEC	44,487	11,000	10,000	10,000	373,213	448,700
	OPC	6,900	—	—	—	5,400	12,300
	TPC	51,387	11,000	10,000	10,000	378,613	461,000

Note:

- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	1Q FY 2033
Expected Useful Life	30 years
Expected Future Start of D&D of this capital asset	1Q FY 2063

Related Funding Requirements
(dollars in thousands)

	Annual Costs		**Life Cycle Costs**	
	Previous Total Estimate	**Current Total Estimate**	**Previous Total Estimate**	**Current Total Estimate**
Operations, Maintenance and Repair	TBD	21,200	TBD	636,000

7. D&D Information

The new area being constructed for this project is under analysis at this time.

	Square Feet
New area being constructed by this project at SLAC..	TBD
Area of D&D in this project at SLAC..	TBD
Area at SLAC to be transferred, sold, and/or D&D outside the project, including area previously “banked”	TBD
Area of D&D in this project at other sites	TBD
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously “banked”	TBD
Total area eliminated	TBD

8. Acquisition Approach

FES is proposing that the MEC-U project be acquired by Stanford University under the SLAC Management and Operations (M&O) Contract (DE-AC02-76-SF00515) for DOE. The acquisition of large research facilities is within the scope of the DOE contract for the management and operations of SLAC and consistent with the general expectation of the responsibilities of DOE M&O contractors.

SLAC does not currently possess all the necessary core competencies to design, procure and build the laser systems. To address this, SLAC will collaborate with Lawrence Livermore National Laboratory (LLNL) and University of Rochester—Laboratory for Laser Energetics (LLE) as partners through signed Memorandum of Agreements to perform significant portions of the MEC-U laser systems scope of work. Memorandum Purchase Orders will be used to define work scopes and budgets with LLNL as funds become available. Any work accomplished through LLE will be completed using the standard DOE format university agreements. Procurements authorized by the partner institutions will utilize the approved DOE purchasing systems.

14-SC-60 U.S. Contributions to ITER
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary

The FY 2025 Request for the U.S. ITER project is $225,000,000 of Total Estimated Cost (TEC) funding. The Total Project Cost (TPC) for the U.S. Contributions to ITER (U.S. ITER) project is $6,500,000,000. In FY 2023, the entire U.S. ITER project was baselined, with a top-end cost range of $6,500,000,000, and includes SP-1 and SP-2 scope, as well as the total construction cash contribution. Sections of this Construction Project Data Sheet (CPDS) have been tailored accordingly to reflect the unique nature of the U.S. ITER project. Fusion energy is expected to provide a carbon-free, inherently safe energy source that will significantly contribute to the development of a commercial fusion energy pilot plant.

Significant Changes

The U.S. ITER project was initiated in FY 2006. On January 13, 2017, U.S. ITER SP-1 achieved both Critical Decision (CD)-2, "Approve Performance Baseline," and CD-3, "Approve Start of Construction." CD-4, "Project Completion," for SP-1 is currently planned for December 2028.

In response to Congressional direction articulated in the Consolidated Appropriations Act 2021 to baseline the entire project, the full requirement to complete the U.S. Contributions to ITER project was baselined in December 2023.
The U.S. baselined the entire U.S. Contributions to ITER project, including re-baselining SP-1 and the baselining of SP-2 as a result of the IO rebaselining for the overall project due to COVID and first-of-a-kind component delivery delays, material specification and fabrication issues as well as quality challenges.

The Inflation Reduction Act provided $256,000,000 to the U.S. ITER project. $66,000,000 was utilized to provide for Cash Contributions to fulfill U.S. agreements to the ITER Organization (IO). The remaining $190,000,000 will be used to significantly enhance the design and fabrication performance of project scope in FY 2023–2024 to include the full funding of the Central Solenoid agent and the Tokomak Cooling Water System (within SP-1).
In FY 2023, two Central Solenoid Modules (CSM) were delivered and accepted by the IO. In addition, progress continued on the Tokomak Cooling Water System with all major fabrication contracts being awarded. The U.S. ITER project obligated more than $1,700,000,000 through the end of FY 2023, of which more than 80 percent is to U.S. industry, universities, and DOE laboratories.

In FY 2024, two more CSMs will be delivered bringing the total to five of seven that make up the Central Solenoid Magnet (including one spare). Additionally in FY 2024, the first fabrication contracts will be awarded for the Electron Cyclotron Heating system.

The FY 2025 Request of $225,000,000 will support the continued design and fabrication of multiple in-kind hardware systems including the Ion Cyclotron Heating system and diagnostic systems. Additionally, the FY 2025 Request will fund Construction Cash contributions to the IO.

A Federal Project Director with level I certification has been assigned to this Project and is currently pursuing higher-level certification.

Critical Milestone History

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	CD-3	CD-4
FY 2025	7/5/05	–	1/25/08	12/12/2023	12/12/2023	1Q FY 2040

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout.

Fiscal Year	Performance Baseline Validation	CD-1 Cost Range Update	CD-1R	CD-3A	CD-3B	CD-4A
FY 2025	1/13/17	1/13/17	1/13/17	1/13/17	12/12/23	1Q FY 2040

CD-1R – Approve Alternative Selection and Cost Range, Revised
CD-3A – Approval of the project starting construction of original 2017 approved baseline.
CD-3B - Approval of the project starting construction under the 2023 approved baseline.
CD-4A - Completion of In-kind Hardware Scope.

Project Cost History

At the time of CD-1 approval in January 2008, the preliminary cost range was $1,450,000,000 to $2,200,000,000. Until 2016, however, it was not possible to confidently baseline the project due to delays early in the international ITER construction schedule. Various factors (e.g., schedule delays, design and scope changes, funding constraints, regulatory requirements, risk mitigation, and inadequate project management and leadership issues in the IO at that time) affected the project cost and schedule. Shortly after the arrival of the new Director General in March 2015, the overall ITER Project was baselined for cost and schedule.

In response to a 2013 Congressional request, a DOE SC Independent Project Review (IPR) Committee assessed the project and determined that the existing cost range estimate of $4,000,000,000 to $6,500,000,000 would likely encompass the final TPC (includes SP-1, SP-2, and Cash Contributions). In preparation for baselining SP-1, based on the results of an Independent Project Review, the acting Director for the Office of Science updated the lower end of this range to reflect updated cost estimates, resulting in the current approved CD-1 Revised (CD-1R) range of $4,700,000,000 to $6,500,000,000.

FY 2023 reflects only SP-1 and associated cash contributions. Beginning in FY 2024, the entire U.S. ITER Project was baselined per Congressional direction in the Consolidated Appropriations Act, 2021. The TPC for the entire project is projected to be $6,500,000,000.

In December 2023, per Congressional direction, the project was baselined and achieved CD-2/3B for the entire scope with a Total Project Cost of $6,500,000,000. The FY 2025 Request of $225,000,000 will support the continued systems design, fabrication, and delivery of in-kind hardware, and financial contributions for IO construction operations.

U.S. Contributions to ITER In-kind Hardware and Construction Cash Contributions
(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Cash Contributions	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	439,243	4,663,877	1,326,578	6,429,698	70,302	70,302	6,500,000
FY 2025	439,243	4,677,455	1,313,000	6,429,698	70,302	70,302	6,500,000

2. Project Scope and Justification

ITER, currently one of the largest science experiments in the world, is a major fusion research facility under construction in St. Paul-lez-Durance, France by an international partnership of seven Members or domestic agencies, specifically, the U.S., China, the European Union, India, Korea, Japan, and the Russian Federation. ITER is co-owned and co-governed by the seven Members. For the U.S. The Energy Policy Act of 2005 (EPAct 2005), Section 972(c)(5)(C) authorized U.S. participation in ITER. The Agreement on the Establishment of the ITER International Fusion Energy Organization for the Joint Implementation of the ITER Project (Joint Implementation Agreement or JIA), signed on November 21, 2006, provides the legal framework for the four phases of the program: construction, operation, deactivation, and decommissioning. The JIA is a Congressional-Executive Hybrid Agreement. The other six Members entered the project by treaty. The IO is a designated international legal entity located in France.

Scope

U.S. Contributions to ITER – Construction Project Scope

The overall U.S. ITER project includes three major elements:

- In-kind Hardware systems (13 in total), built under the responsibility of the U.S., and then shipped to the ITER site for IO assembly, installation, and operation. Included in this element is cash provided in-lieu of U.S. In-kind component contributions to adjust for certain reallocations of hardware contributions between the U.S. and the IO.
- Funding to the IO to support common expenses, including ITER research and development (R&D), design and construction integration, overall project management, nuclear licensing, IO staff and infrastructure, IO-provided hardware, on-site assembly/installation/testing of all ITER components, installation, safety, quality control, and operation.
- Other project costs, including R&D (other than mentioned above) and conceptual design-related activities.

Justification

The purpose of ITER is to investigate and conduct research in the “burning plasma” regime—a performance region that exists beyond the current experimental state of the art. Creating a self-sustaining burning plasma will provide essential scientific knowledge necessary for practical fusion power. There are two planned experimental outcomes expected from ITER. The first is to investigate the fusion process in the form of a "burning plasma," in which the heat generated by the fusion process exceeds that supplied from external sources (i.e., self-heating). The second is to sustain the burning plasma for a long duration (e.g., several hundred to a few thousand seconds), during which time equilibrium conditions can be achieved within the plasma and adjacent structures. ITER will provide a sustained burning plasma for long-term experimentation which is a necessary step toward developing a fusion pilot plant.

Although not classified as a Capital Asset, the U.S. ITER project is being conducted following project management principles of DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets,* to the greatest extent possible.

Key Performance Parameters (KPPs)

The U.S. Contributions to the ITER Project will not deliver an integrated operating facility, but rather in-kind hardware contributions, which represent a portion of the international ITER facility. The U.S. ITER project defines project completion as delivery and IO acceptance of the U.S. in-kind hardware.

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Estimated Cost (TEC)				
Design (TEC)				
Prior Years	439,243	439,243	439,243	—
Total, Design (TEC)	**439,243**	**439,243**	**439,243**	**—**
Construction (TEC)				
Prior Years	1,277,877	1,277,877	1,045,072	—
Prior Years - IRA Supp.	190,000	190,000	—	—
FY 2023	172,000	172,000	81,387	43,449
FY 2024	170,000	170,000	170,000	—
FY 2025	160,000	160,000	160,000	—
Outyears	2,707,578	2,707,578	3,030,996	146,551
Total, Construction (TEC)	**4,677,455**	**4,677,455**	**4,487,455**	**190,000**
Cash Contributions (TEC)				
Prior Years	380,497	380,497	380,497	—
Prior Years - IRA Supp.	66,000	66,000	—	—
FY 2023	70,000	70,000	70,000	63,086
FY 2024	70,000	70,000	70,000	—
FY 2025	65,000	65,000	65,000	—
Outyears	661,503	661,503	661,503	2,914
Total, Cash Contributions (TEC)	**1,313,000**	**1,313,000**	**1,247,000**	**66,000**
Total Estimated Cost (TEC)				
Prior Years	2,097,617	2,097,617	1,864,812	—
Prior Years - IRA Supp.	256,000	256,000	—	—
FY 2023	242,000	242,000	151,387	106,535
FY 2024	240,000	240,000	240,000	—
FY 2025	225,000	225,000	225,000	—
Outyears	3,369,081	3,369,081	3,692,499	149,465
Total, Total Estimated Cost (TEC)	**6,429,698**	**6,429,698**	**6,173,698**	**256,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Other Project Cost (OPC)				
Prior Years	70,302	70,302	70,302	–
Total, Other Project Cost (OPC)	**70,302**	**70,302**	**70,302**	**–**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Project Cost (TPC)				
Prior Years	2,167,919	2,167,919	1,935,114	–
Prior Years - IRA Supp.	256,000	256,000	–	–
FY 2023	242,000	242,000	151,387	106,535
FY 2024	240,000	240,000	240,000	–
FY 2025	225,000	225,000	225,000	–
Outyears	3,369,081	3,369,081	3,692,499	149,465
Total, TPC	**6,500,000**	**6,500,000**	**6,244,000**	**256,000**

Notes:
- *The entire project was baselined in December 2023 with a TPC of $6,500,000,000.*
- *All Appropriations to date for the U.S. Contributions to ITER project include both funding for SP-1 and funding for Cash Contributions, as well as for work associated with the new overall In-kind Hardware baseline.*
- *Obligations and costs through FY 2023 reflect actuals; obligations and costs for FY 2024 and the outyears are estimates.*

4. Details of Project Cost Estimate

The overall U.S. Contributions to ITER project has an approved revised CD-1R. Cost Range (CD-1R). In 2016, DOE chose to divide the project hardware scope into two distinct subprojects (First Plasma SP-1, and Post-First Plasma or SP-2) so that an initial portion of the project that was mature enough to baseline could be accomplished. The baseline for SP-1 In-kind Hardware ($2,500,000,000) was approved in January 2017. In December 2023, per Congressional direction, the project was baselined and achieved CD-2/3B.

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	439,243	439,243	573,660
Design - Contingency	N/A	N/A	122,365
Total, Design (TEC)	**439,243**	**439,243**	**696,025**
Construction	3,317,455	3,720,360	**N/A**
Equipment	N/A	N/A	1,362,521

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Construction - Contingency	1,360,000	943,517	371,152
Total, Construction (TEC)	**4,677,455**	**4,663,877**	**1,733,673**
Cash Contributions	1,313,000	1,017,000	**N/A**
Cash Contributions Contingency	N/A	309,578	**N/A**
Total, Cash Contributions (TEC)	**1,313,000**	**1,326,578**	**N/A**
Total, TEC	**6,429,698**	**6,429,698**	**2,429,698**
Contingency, TEC	*1,360,000*	*1,253,095*	*493,517*
Other Project Cost (OPC)			
OPC, Except D&D	70,302	70,302	70,302
Total, Except D&D (OPC)	**70,302**	**70,302**	**70,302**
Total, OPC	**70,302**	**70,302**	**70,302**
Contingency, OPC	***N/A***	*N/A*	***N/A***
Total, TPC	**6,500,000**	**6,500,000**	**2,500,000**
Total, Contingency (TEC+OPC)	***1,360,000***	***1,253,095***	***493,517***

Notes:

- *In the table above, the previous total estimate includes cash contributions estimate to align with the TPC budget request. The "Original Validated Baseline" reflects SP-1 only.*
- *Current total estimated design reflects work done prior to CD-2/3. SP-2 design work is accounted for in TEC Construction as part of SP-1 scope approved at CD-2/3.*

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	2,353,617	242,000	240,000	—	3,594,081	6,429,698
	OPC	70,302	—	—	—	—	70,302
	TPC	2,423,919	242,000	240,000	—	3,594,081	6,500,000
FY 2025	TEC	2,353,617	242,000	240,000	225,000	3,369,081	6,429,698
	OPC	70,302	—	—	—	—	70,302
	TPC	2,423,919	242,000	240,000	225,000	3,369,081	6,500,000

6. Related Operations and Maintenance Funding Requirements

The U.S. Contributions to ITER operations phase is to begin with initial integrated commissioning activities with an assumed useful life of 30 to 35 years. The fiscal year in which commissioning activities begin depends on the international ITER project schedule, which currently indicates 2025. As a result of COVID-19 and other known delays, the overall ITER project is being re-baselined to update cost and schedule estimates.

Start of Operation or Beneficial Occupancy	1Q FY 2040
Expected Useful Life	35 years
Expected Future Start of D&D of this capital asset	1Q FY 2075

7. D&D Information

Since ITER is being constructed in France by a coalition of countries and will not be a DOE asset, the "one-for-one" requirement is not applicable to this project.

The U.S. Contributions to ITER decommissioning phase is assumed to begin no earlier than 30 years after the start of operations. The deactivation phase is also assumed to begin no earlier than 30 years after operations begin and will continue for a period of five years. The U.S. is responsible for 13 percent of the total decommissioning and deactivation cost; this requirement will be collected and escrowed out of research Operations funding.

8. Acquisition Approach

The U.S. ITER Project Office (USIPO) at Oak Ridge National Laboratory, with its two partner laboratories (Princeton Plasma Physics Laboratory and Savannah River National Laboratory), will procure and deliver in-kind hardware in accordance with the Procurement Arrangements established with the IO. The USIPO will subcontract with a variety of research and industry sources for design and fabrication of its ITER components, ensuring that designs are developed that permit fabrication, to the maximum extent possible, to use fixed-price subcontracts (or fixed-price arrangement documents with the IO) based on performance specifications, or more rarely, on build-to-print designs. USIPO will use cost-reimbursement type subcontracts only when the work scope precludes accurate and reasonable cost contingencies being gauged and established beforehand. USIPO will use best value, competitive source-selection procedures to the maximum extent possible, including foreign firms on the tender/bid list when necessary. Such procedures shall allow for cost and technical trade-offs during source selection. For the large-dollar-value subcontracts (and critical path subcontracts as appropriate), USIPO will utilize unique subcontract provisions to incentivize cost control and schedule performance. In addition, where it is cost effective and it reduces risk, the USIPO will participate in common procurements led by the IO or request the IO to perform activities that are the responsibility of the U.S.

High Energy Physics

Overview

The High Energy Physics (HEP) program's mission is to understand how the universe works at its most fundamental level by discovering the elementary constituents of matter and energy, probing the interactions between them, and exploring the basic nature of space and time. HEP accomplishes its mission through excellence in scientific discovery in particle physics, and through stewardship of world-class scientific user facilities that enable cutting-edge research and development (R&D). HEP continues to deliver major construction projects on time and on budget and provides users with reliably available operating facilities. HEP's work allows the U.S. to remain a global leader in international particle physics research and collaboration.

Our current understanding of the elementary constituents of matter and energy and the forces that govern them is described by the Standard Model of particle physics. However, experimental measurements suggest that the Standard Model is incomplete, and that new physics may be discovered by future experiments. The May 2014 report of the Particle Physics Project Prioritization Panel (P5), "Building for Discovery: Strategic Plan for U.S. Particle Physics in the Global Context,"[a] continues to guide the U.S. Department of Energy (DOE) and National Science Foundation (NSF) as the ten-year strategic plan for U.S. high energy physics in the context of a 20-year global vision. The 2014 P5 report identified five intertwined science drivers of particle physics that provide compelling lines of inquiry with great promise to discover what lies beyond the Standard Model:

- Use the Higgs boson as a new tool for discovery;
- Pursue the physics associated with neutrino mass;
- Identify the new physics of dark matter;
- Understand cosmic acceleration: dark energy and inflation; and
- Explore the unknown: new particles, interactions, and physical principles.

In December 2022, DOE and NSF charged the High Energy Physics Advisory Panel (HEPAP) to assemble a new P5 subpanel to formulate a ten-year plan for the field. At the December 2023 HEPAP meeting, the subpanel presented the new 2023 P5 report, "Exploring the Quantum Universe: Pathways to Innovation and Discovery in Particle Physics," which HEPAP then unanimously approved. The 2023 report was released too late in the year to impact FY 2025 formulation. However, the first Recommendation of the report strongly reiterates the importance of completing major HEP projects initiated over the previous decade, which are supported in the FY 2025 Request. DOE is studying the 2023 P5 report and will prepare a response to the recommendations and develop an implementation plan.

The HEP program enables scientific discovery and supports cutting edge R&D in five focused subprograms:

- Energy Frontier Experimental Physics, where researchers accelerate particles to the highest energies ever made by humanity and collide them to produce and study the fundamental constituents of matter.
- Intensity Frontier Experimental Physics, where researchers use a combination of intense particle beams and highly sensitive detectors to make extremely precise measurements of particle properties, to study some of the rarest interactions predicted by the Standard Model, and to search for new physics.
- Cosmic Frontier Experimental Physics, where researchers use naturally occurring cosmic particles and phenomena to reveal the nature of dark matter, understand the cosmic acceleration caused by dark energy and inflation, infer certain neutrino properties, and explore the unknown.
- Theoretical, Computational, and Interdisciplinary Physics provides the framework to explain experimental observations and gain a deeper understanding of nature.
- The Advanced Technology R&D subprogram fosters fundamental research into particle acceleration and detection techniques and instrumentation.

Innovative research methods and enabling technologies that emerge from R&D into artificial intelligence/machine learning (AI/ML), quantum information science (QIS), microelectronics, accelerators, and instrumentation will advance scientific

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[a] https://science.osti.gov/~/media/hep/hepap/pdf/May-2014/FINAL_P5_Report_053014.pdf

knowledge in high energy physics and in a broad range of related fields, advancing DOE's strategic goals for science. Many of the advanced technologies, research tools, and analysis techniques originally developed for high energy physics have proved widely applicable to other scientific disciplines as well as for health services, national security, and the private sector.[b]

Highlights of the FY 2025 Request

The FY 2025 Request of $1,230.8 million is an increase of $64.8 million over the FY 2023 Enacted, and will focus resources on the highest priorities in fundamental research, operation and maintenance of scientific user facilities, facility upgrades, and projects identified in the 2014 P5 report.

Research

The Request will provide continued support for HEP core competencies in theoretical and experimental activities and world-leading advanced technology R&D in pursuit of discovery science. Through continued funding for the Established Program to Stimulate Competitive Research (EPSCoR) program and the Reaching a New Energy Sciences Workforce (RENEW) and Funding for Accelerated, Inclusive Research (FAIR) initiatives, HEP will build stronger programs with underserved communities and regions, as well as emerging research institutions, Historically Black Colleges and Universities (HBCUs) and Minority Serving Institutions (MSIs), investing in a more diverse and inclusive workforce. Funding will shift from the Accelerate initiative to other priority cross-cutting initiatives across the Office of Science (SC):

- AI/ML: Tackle the challenges of extracting particle signatures from HEP experimental and simulated data with increasingly high volumes and complexity; seek solutions for operating accelerators and detectors in real-time and extremely high data rate environments; and address cross-cutting challenges in coordination with DOE investments in AI/ML efforts.
- QIS: Co-development of quantum information, theory, and technology aligned with HEP science drivers and exploring new capabilities in quantum sensing and computing. HEP will support the recompetition/renewal of the Superconducting Quantum Materials and Systems (SQMS) Center led by the Fermi National Accelerator Laboratory (FNAL), one of SC's National QIS Research Centers.
- Microelectronics: Accelerate R&D into sensor materials, detector devices, advances in front-end electronics, and integrated sensor/processor architectures, including adaptation to high-radiation, or cryogenic temperature, or low radioactive background environments.
- Accelerator Science and Technology Initiative (ASTI): Longer-term R&D focused on future facilities and capabilities, to maintain a leading position in key accelerator technologies that define SC's competitive advantage.
- Advanced Computing: Enable broader access to exascale computing resources by providing support for researchers to develop and adapt scientific codes for high performance on modern computing architectures.

Facility Operations

HEP supports two scientific user facilities, the Fermilab Accelerator Complex and the Facility for Advanced Accelerator Experimental Tests II (FACET-II). These facilities will operate 5,180 and 3,120 hours, respectively, while addressing critical upgrades, improvements, and deferred maintenance. HEP also supports laboratory-based accelerator and detector test facilities, and supports the maintenance and operations of large-scale experiments and facilities that are not based at a DOE national laboratory, such as the U.S. A Toroidal LHC Apparatus (ATLAS) and Compact Muon Solenoid (CMS) detectors at the Large Hadron Collider (LHC) at the European Organization for Nuclear Research (CERN) in Geneva, Switzerland; Sanford Underground Research Facility (SURF) in Lead, South Dakota; Vera C. Rubin Observatory in Chile; and Dark Energy Spectroscopic Instrument (DESI) at the Mayall telescope in Kitt Peak, Arizona.

Projects

The Request will increase support for the Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment (LBNF/DUNE-US) and Proton Improvement Plan II (PIP-II) construction projects. The Request will also increase support for four Major Item of Equipment (MIE) projects: 1) Accelerator Controls Operations Research Network (ACORN), 2) Cosmic Microwave Background Stage 4 (CMB-S4), 3) High Luminosity Large Hadron Collider (HL-LHC) ATLAS Detector Upgrade, and 4) HL-LHC CMS Detector Upgrade Projects.

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[b] https://science.osti.gov/hep/-/media/hep/pdf/files/pdfs/hep_benefits_v2.pdf

High Energy Physics
Funding

(dollars in thousands)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
High Energy Physics				
Energy Frontier, Research	76,833	67,848	59,283	-17,550
Energy Frontier, Facility Operations and Experimental Support	54,000	52,800	57,285	+3,285
Energy Frontier, Projects	50,000	35,700	33,700	-16,300
Total, Energy Frontier Experimental Physics	**180,833**	**156,348**	**150,268**	**-30,565**
Intensity Frontier, Research	72,644	64,394	55,679	-16,965
Intensity Frontier, Facility Operations and Experimental Support	194,555	188,411	209,530	+14,975
Intensity Frontier, Projects	6,000	10,199	10,000	+4,000
Total, Intensity Frontier Experimental Physics	**273,199**	**263,004**	**275,209**	**+2,010**
Cosmic Frontier, Research	51,552	47,512	36,301	-15,251
Cosmic Frontier, Facility Operations and Experimental Support	56,550	57,056	57,210	+660
Cosmic Frontier, Projects	1,000	9,000	4,500	+3,500
Total, Cosmic Frontier Experimental Physics	**109,102**	**113,568**	**98,011**	**-11,091**
Theoretical, Computational, and Interdisciplinary Physics, Research	171,746	166,246	186,714	+14,968
Total, Theoretical, Computational, and Interdisciplinary Physics	**171,746**	**166,246**	**186,714**	**+14,968**
Advanced Technology R&D, Research	80,871	68,861	57,856	-23,015
Advanced Technology R&D, Facility Operations and Experimental Support	52,249	52,274	57,710	+5,461
Total, Advanced Technology R&D	**133,120**	**121,135**	**115,566**	**-17,554**
Subtotal, High Energy Physics	**868,000**	**820,301**	**825,768**	**-42,232**
Construction				
18-SC-42 Proton Improvement Plan II (PIP-II), FNAL	120,000	125,000	125,000	+5,000

(dollars in thousands)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
11-SC-40 Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment	176,000	251,000	280,000	+104,000
11-SC-41 Muon to Electron Conversion Experiment, FNAL	2,000	–	–	-2,000
Subtotal, Construction	**298,000**	**376,000**	**405,000**	**+107,000**
Total, High Energy Physics	**1,166,000**	**1,196,301**	**1,230,768**	**+64,768**

SBIR/STTR funding:

- FY 2023 Enacted: SBIR $13,911,000 and STTR $1,956,000
- FY 2024 Annualized CR: SBIR $12,450,000 and STTR $1,751,000
- FY 2025 Request: SBIR $11,831,000 and STTR $1,664,000

High Energy Physics
Explanation of Major Changes

	(dollars in thousands) FY 2025 Request vs FY 2023 Enacted
Energy Frontier Experimental Physics The Request will emphasize research that focuses on high-priority topics that search for new physics, refresh U.S.-based computing infrastructure, and continue fabrication activities for the HL-LHC ATLAS and CMS Detector Upgrade projects, as planned. The HL-LHC Accelerator Upgrade Project received final planned funding in FY 2023, which results in decreased funding for the HL-LHC Upgrade projects in this Request.	**-30,565**
Intensity Frontier Experimental Physics The Request will increase support for the Fermilab Accelerator Complex to operate 5,180 hours, while expanding user access, reducing deferred maintenance, and advancing modernization efforts. The Request will increase support for the ACORN MIE. Research support will focus on early physics results from the Short-Baseline Neutrino (SBN) program and high-priority topics that search for new physics.	**+2,010**
Cosmic Frontier Experimental Physics The Request will support the CMB-S4 MIE and provide operations funding for the Vera C. Rubin Observatory. Research support will fund the highest priorities of the Administration and SC focused on exploiting the physics capabilities of new facilities and experiments.	**-11,091**
Theoretical, Computational, and Interdisciplinary Physics The Request will increase support to broaden the RENEW and FAIR initiatives, to develop and retain AI/ML scientific workforce at the national laboratories, and to build AI/ML capacity and computational infrastructure for the broader HEP community.	**+14,968**
Advanced Technology R&D The Request will support FACET-II to operate 3,120 hours. Research support will fund the highest priorities of the Administration and SC focused on cross-cutting advanced technology R&D in coordination with other SC programs and increased access and utilization of accelerator and detector test facilities at the DOE national laboratories.	**-17,554**
Construction The Request will increase support and continue the approach to LBNF/DUNE-US in accordance with DOE Order 413.3B which reorganized the project's scope into five independent subprojects for improved planning and management control. Support increases for PIP-II, and decreases for Mu2e as the project completes funding in FY 2023.	**+107,000**
Total, High Energy Physics	**+64,768**

Basic and Applied R&D Coordination

The HEP General Accelerator R&D (GARD) research activity within the Advanced Technology R&D subprogram provides the fundamental building blocks of accelerator technology needed for the HEP mission, as well as those of several other SC programs. The GARD activity is based on input from the community, including high-level advice on long term facility goals from HEPAP and P5, and more detailed technical advice developed through a series of Roadmap Workshops. As a source of innovation for many new scientific capabilities with broader applications, the GARD activity is coordinated with other SC programs and other federal agencies to optimize synergy and foster strong U.S. capability in this key technology area.

The HEP QIS research activity has coordinated partnerships with the Department of Defense's Office of Basic Research as well as the Air Force's Office of Scientific Research on synergistic research connecting foundational theory research with quantum error correction and control systems for sensors, and a partnership with the Department of Commerce's National Institute of Standards and Technology on quantum metrology and quantum sensor development for experimental discovery along HEP science drivers and for improving understanding of fundamental constants. Furthermore, the SC National QIS Research Center (NQISRC) effort is a partnership across all SC programs and engages industry to inform use-inspired research and connect to applied and development activities.

Program Accomplishments

Most precise measurements of the muon magnetic anomaly from the g-2 experiment (Intensity Frontier Experimental Physics)

Muons have a quantum mechanical property called spin, which causes them to act like a tiny magnet. When placed in a magnetic field, the muon's internal magnet processes, much like the wobble of a spinning top. The speed of this wobble is determined by a quantity known as the magnetic moment, which scientists represent with the letter "g". At the simplest level of our theoretical understanding, g equals 2. However, the value of g is sensitive to all known (and unknown) elementary particles that can pop in and out of existence for a short moment of time and lead to a small deviation from 2, hence the name g-2. The Muon g-2 collaboration revealed its second result for g-2, which bolsters the first result published by the collaboration in 2021. The new result is based on data taken in 2019 and 2020 and improves the precision by more than a factor of 2 compared to the first result. Both the total statistical and systematic uncertainties improved by factors of 2.2. This leads to a total uncertainty of the experimental average for the muon magnetic anomaly of 190 parts-per-billion (ppb). This is the world's most precise measurement ever made at a particle accelerator. While the statistical uncertainty will continue to significantly improve with plenty more data to be analyzed in the upcoming years, the total systematic uncertainty of 70 ppb has already surpassed the original proposal goal of 100 ppb—a major achievement for the experiment.

LBNF/DUNE-US project team gets approval for next phase of construction in South Dakota (Construction)

The FNAL-hosted LBNF/DUNE is an enormous international scientific effort to address some of the most pressing questions in particle physics today including the matter-antimatter asymmetry in our universe. The LBNF/DUNE-US project represents a new model of international partnership and support for large scientific efforts. Over the past year the project made significant progress, achieving five DOE critical decision approvals to proceed to the next stages of construction, including baselining the first two of five subprojects and receiving long-lead procurement authority for the third and fourth subprojects. The DUNE experiment will send the world's most intense high-energy neutrino and anti-neutrino beams from FNAL in Batavia, Illinois, to huge underground particle detectors, 800 miles away at the Sanford Underground Research Facility (SURF) in Lead, South Dakota. More than 1,400 scientists and engineers at over 200 institutions in 37 countries are working on the preparations for the experiment.

U.S. achieves major milestone with the delivery of quadrupole magnets to CERN (Energy Frontier Experimental Physics)

In coordination with the international community, including the U.S., CERN is upgrading LHC in Switzerland to increase the particle collision rate, or luminosity, by a factor of at least five to precisely measure the Higgs boson and explore new physics beyond its current reach. DOE is contributing to the high-luminosity accelerator upgrade project (HL-LHC AUP), hosted at FNAL, by designing, fabricating, and delivering ten high-field quadrupole focusing magnets that will allow particle beams to collide at higher intensities at the upgraded machine's interaction points. The U.S. is the world leader in this high-field accelerator technology and these magnets are the culmination of over ten years of R&D. The first of these magnet elements made its transatlantic voyage to CERN in November 2023, thereby achieving a major milestone in the DOE-supported HL-LHC AUP.

Advances in dark energy studies were made in spectroscopic and imaging next-generation experiments (Cosmic Frontier Experimental Physics)
The Dark Energy Spectroscopic Instrument (DESI) experiment released its first detection of the baryon acoustic oscillation (BAO) signal in 2023. Dark energy, discovered in the late 1990's, causing the acceleration of the expansion of the universe, is one of the big unsolved questions in physics and cosmology. Data from the first two months of the survey, including all four object types, were used to study the evolution of large-scale structure. The BAO peak was detected at 5σ confidence in the luminous red galaxy sample, which is comparable to the one from the precursor BOSS experiment's full 5-year data sample. DOE's DESI, managed by the Lawrence Berkeley National Laboratory, is the world's premier multi-object spectrograph and the first Stage IV dark energy project to take data, DESI is installed and operating on the National Science Foundation's (NSF) Mayall telescope at Kitt Peak National Observatory near Tucson, AZ.

Gordon Bell Prize awarded to international team for particle-in-cell simulations on exascale-class supercomputers (Advanced Technology R&D)
The Association for Computing Machinery (ACM) named a 16-member team drawn from French, Japanese, and U.S. institutions, including Lawrence Berkeley National Laboratory, as recipient of the 2022 ACM Gordon Bell Prize for their project, "Pushing the Frontier in the Design of Laser-Based Electron Accelerators with Groundbreaking Mesh-Refined Particle-In-Cell Simulations on Exascale-Class Supercomputers." Particle-in-Cell (PIC) simulation is a technique within high-performance computing used to model the motion of charged particles, or plasma. PIC has applications in many areas, including nuclear fusion, accelerators, space physics, and astrophysics. The very recent introduction of exascale-class computers has expanded the horizons of PIC simulations and makes this year's winning project especially exciting. The team used a first-of-kind mesh-refined (MR) massively parallel PIC code for kinetic plasma simulations optimized on SC's Frontier, Summit, and Perlmutter supercomputers. The major improvements in their PIC code over existing state-of-the-art approaches included a groundbreaking mesh refinement capability that provides between 1.5x to 4x savings in computing requirements, which is a significant step towards a new era in the modelling of laser-plasma interactions.

FNAL particle accelerator achieves world record beam power (Intensity Frontier Experimental Physics)
The Fermilab Accelerator Complex produces and delivers particle beams to various particle physics experiments for scientists to learn more about neutrinos, muons, and other building blocks of nature. Over many years they collect large data sets that provide information on the nature of the universe. With more data, the potential for discovery increases. The size of the data sets depends on the total beam delivery to each experiment. Scientists maximize beam delivery by operating particle accelerators around the clock at the highest beam intensity possible and delivering the largest number of beam pulses with the highest number of protons per second. On May 22, 2023, FNAL accelerator experts set a beam power record of 0.96 megawatts (MW). This one-hour beam power record achieved was 7 percent higher than the previous record, as a result of increasing the rate of beam delivery. The cycle time of the Fermilab Main Injector for delivery of 120 GeV beam was reduced from 1.2 seconds to 1.13 seconds by exploiting the capabilities of the existing system and improving beam manipulation techniques. Increasing Fermilab beam power is critical to achieving the ultimate science objectives of the LBNF/DUNE program.

High Energy Physics
Energy Frontier Experimental Physics

Description

The Energy Frontier Experimental Physics subprogram's focus is to support the U.S. researchers participating in the international LHC program. The LHC hosts two large multi-purpose particle detectors, ATLAS and CMS, which are partially supported by DOE and NSF and are used by large international collaborations of scientists. U.S. researchers participating in the LHC program, including the next generation of scientists and engineers, are one of the largest collaborating groups at the LHC and account for approximately 20 percent and 25 percent of the ATLAS and CMS collaborations, respectively. Correspondingly, they play critical leadership roles in all aspects of each experiment. Data collected by ATLAS and CMS are used to address three of the five science drivers as explained below:

- *Use the Higgs boson as a new tool for discovery.*
  In the Standard Model of particle physics, the Higgs boson is a key ingredient responsible for generating the mass for fundamental particles. Experiments at the LHC continue to actively measure the Higgs's properties to establish its exact character and to discover if there are additional effects that are the result of new physics beyond the Standard Model.
- *Explore the unknown: new particles, interactions, and physical principles.*
  Researchers at the LHC probe for evidence of what lies beyond the Standard Model such as supersymmetry, mechanisms for black hole production, extra dimensions, and other exotic phenomena. The upgraded LHC detectors will be increasingly more sensitive to potential deviations from the Standard Model that may be exposed by the highest energy collisions in the world.
- *Identify the new physics of dark matter.*
  LHC collisions may possibly produce dark matter particles, and their general properties may be inferred through the behavior of the accompanying normal matter. This "indirect" detection of dark matter is complementary to the ultra-sensitive direct detection experiments in the Cosmic Frontier and Intensity Frontier Experimental Physics subprograms.

<u>Research</u>

The Energy Frontier Experimental Physics subprogram's Research activity supports groups at U.S. academic and research institutions and national laboratories. These groups, as part of the ATLAS and CMS collaborations, typically have a broad portfolio of responsibilities and leadership roles in support of R&D, experimental design, fabrication, commissioning, operations, and maintenance, and performing scientific simulations and data analyses. This activity also supports Advanced Computing to advance the development of capabilities for exascale computing used by HEP researchers for data analyses.

<u>Facility Operations and Experimental Support</u>

The U.S. LHC Detector Operations supports the maintenance of U.S.-supplied detector systems for the ATLAS and CMS detectors in the LHC at CERN, and the U.S.-based computer infrastructure used by U.S. physicists to analyze LHC data, including the Tier 1 computing centers at Brookhaven National Laboratory (BNL) and FNAL. The Tier 1 centers provide around-the-clock support for the worldwide LHC Computing Grid; are responsible for storing a portion of raw and processed data; perform large-scale data reprocessing; and store the corresponding output.

<u>Projects</u>

CERN is implementing a major upgrade to the LHC machine to increase the particle collision rate by a factor of at least five, to explore new physics beyond its current reach. Through the HL-LHC Accelerator Upgrade Project, HEP is contributing to this upgrade by constructing and delivering the next-generation of superconducting accelerator components, where U.S. scientists have critical expertise that, in the longer-term, can lead to developing innovative technologies for future proposed accelerator facilities. After the upgrade, the HL-LHC collisions will lead to very challenging conditions in which the ATLAS and CMS detectors must operate. As a result, the HL-LHC ATLAS and HL-LHC CMS Detector Upgrades are critical investments to enable the experiments to operate for an additional decade and collect at least a factor of ten more data.

High Energy Physics
Energy Frontier Experimental Physics

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Energy Frontier Experimental Physics	**$180,833**	**$150,268**	**-$30,565**
Research	$76,833	$59,283	-$17,550
Funding supports the Advanced Computing initiative and continues to support U.S. leadership roles in all aspects of the ATLAS and CMS experimental programs. This includes the analyses of the large physics datasets collected during the LHC run, as well as scientific personnel support for the HL-LHC ATLAS and CMS Detector upgrade activities.		The Request will continue supporting the leading roles and key contributions by U.S. researchers in all aspects of the ATLAS and CMS experimental programs. The Request will support the Advanced Computing initiative to transition data-intensive simulations and analyses to SC high-performance computing.	Funding will prioritize support on high-priority research topics that search for new physics during the present LHC run, key contributions to the HL-LHC detector upgrades, and critical U.S. commitments to the ATLAS and CMS experiments.
Facility Operations and Experimental Support	$54,000	$57,285	+$3,285
Funding continues to support ATLAS and CMS detector maintenance and operations activities at CERN and the U.S.-based computing infrastructure and resources required to collect, store, and analyze the large volume of LHC data from the LHC run.		The Request will continue supporting ongoing ATLAS and CMS detector maintenance and operations activities at CERN and data taking using the U.S.-based computing infrastructure and resources.	Funding will increase to support the critically needed refreshment of U.S.-based computing infrastructure and resources to continue efficiently collecting, storing, and analyzing the large volume of data from the ongoing LHC run.
Projects	$50,000	$33,700	-$16,300
Funding supports the production of quadrupole magnets and crab cavities for the HL-LHC Accelerator Upgrade, and ramp-up of fabrication activities for the HL-LHC ATLAS and CMS Detector Upgrades.		The Request will support fabrication activities for the HL-LHC ATLAS and the HL-LHC CMS Detector Upgrades.	Within the requested funding, the HL-LHC Detector Upgrade projects will continue fabrication activities. The HL-LHC Accelerator Upgrade received its final funding in FY 2023.

Note:
- *Funding for the subprogram above, includes 3.65 percent of research and development (R&D) funding for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, excluding facility operations.*

High Energy Physics
Intensity Frontier Experimental Physics

Description

The Intensity Frontier Experimental Physics subprogram supports the investigation of some of the rarest processes in nature. This HEP subprogram relies on high-power beams or other intense sources such as reactors to make precision measurements of fundamental particle properties. These measurements probe for new phenomena that are not directly observable at the Energy Frontier, because either they occur at much higher energies and their effects may only be indirectly observed, or their interactions are too weak for detection in high-background conditions. Data collected from Intensity Frontier experiments are used to address three of the five science drivers as explained below:

- *Pursue the physics associated with neutrino mass.*
  Of all known particles, neutrinos are perhaps the most enigmatic and elusive. HEP researchers working at U.S. facilities discovered all the three known varieties of neutrinos. HEP supports research into fundamental neutrino properties that may reveal important clues about the unification of forces and the very early history of the universe.
- *Explore the unknown: new particles, interactions, and physical principles.*
  Several observed phenomena are not described by the Standard Model, including the imbalance of matter and antimatter in the universe today. Precision measurements of the properties of known particles may reveal information about what new particles and forces might explain these discrepancies and whether the known forces unify at energies beyond the reach of the LHC.
- *Identify the new physics of dark matter.*
  The lack of experimental evidence from the current generation of dark matter detectors has led to proposed theoretical models with new particles and forces that rarely interact with normal matter. Experiments outfitted with highly efficient detectors and inserted within intense accelerator beams at national laboratories offer an opportunity to explore these models in a controlled laboratory setting.

<u>Research</u>

This Activity supports groups at U.S. academic and research institutions and national laboratories. These groups, as part of scientific collaborations, typically have a broad portfolio of responsibilities and leadership roles in support of R&D, experimental design, fabrication, commissioning, operations, and maintenance, and they perform scientific simulations and physics data analyses. This activity also supports Advanced Computing to ensure broad access to exascale computing resources for HEP researchers.

The largest component of the Intensity Frontier subprogram is the support for research in accelerator-based neutrino physics centered at FNAL with multiple experiments running concurrently in two separate neutrino beams with different beam energies. The Neutrinos at the Main Injector (NuMI) beam is used by the NuMI Off-Axis ν_e Appearance (NOvA) long-baseline neutrino experiment to detect oscillations between different types of neutrinos through 810 km of earth in a far detector in Ash River, Minnesota. The Booster Neutrino Beam is used by the Short-Baseline Neutrino (SBN) program at FNAL to definitively address measurements of additional neutrino types beyond the three currently described in the Standard Model. LBNF/DUNE will be the centerpiece of a U.S. hosted world-leading neutrino research facility, using the world's most intense neutrino beam and large, sensitive underground detectors to make transformative discoveries.

The Research activity includes efforts to search for rare physics processes. The Muon g-2 experiment at FNAL studies the anomalous magnetic moment of the muon, which is very sensitive to new physics beyond the standard model. The Mu2e experiment at FNAL will search for extremely rare muon decays that, if detected, will provide clear evidence of new physics. The Tokai-to-Kamioka (T2K) long-baseline neutrino experiment in Japan is complementary to NOvA, and a combined measurement from these two experiments will offer the best to date available information on neutrino oscillations prior to LBNF/DUNE. At the High Energy Accelerator Research Organization (KEK) in Tsukuba, Japan, the Belle II experiment searches for new physics produced in electron-positron collisions at the SuperKEKB accelerator.

<u>Facility Operations and Experimental Support</u>

This Activity supports several distinct facility operations and experimental activities, the largest of which is the Fermilab Accelerator Complex User Facility. This activity includes the operations of all accelerators and beamlines at FNAL, the operation of the detectors that use those accelerators, the computing support needed by both the accelerators and detectors, and scientific collaboration support. General Plant Project (GPP) and Accelerator Improvement Project (AIP) funding supports improvements to FNAL facilities.

HEP has a cooperative agreement with the South Dakota Science and Technology Authority (SDSTA), a quasi-state agency created by the State of South Dakota for the operation of the SURF. Experiments supported by DOE, NSF, and other government and private entities are conducted there, including the HEP-supported LZ experiment. SURF will be the home of the DUNE far site detectors being built by the LBNF/DUNE project. The SURF cooperative agreement provides basic services to LBNF/DUNE, as well as other experiments located at the site; and supports critical infrastructure upgrades.

Projects

In support of LBNF/DUNE, a lease with SDSTA provides the framework for DOE and FNAL to construct federally funded buildings and facilities on non-federal land and to establish a long-term (multi-decade) arrangement for DOE and FNAL to use SDSTA space to host the DUNE neutrino detector. Other Project Costs (OPC) have been identified by the LBNF/DUNE project and DOE for the cost of SURF services used by LBNF/DUNE beyond the basic operational support covered by the SURF cooperative agreement mentioned above.

FNAL will upgrade its outdated accelerator control system with a modern system, which is maintainable, sustainable, and capable of utilizing advances in AI/ML to create a high-performance accelerator for the future. The Accelerator Controls Operations Research Network (ACORN) MIE is critical as the control system of the Fermilab Accelerator Complex initiates particle beam production; controls beam energy and intensity; steers particle beams to their ultimate destination; measures beam parameters; and monitors beam transport through the complex to ensure safe, reliable, and effective operations.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Intensity Frontier Experimental Physics	**$273,199**	**$275,209**	**+$2,010**
Research	$72,644	$55,679	-$16,965
Funding supports core research efforts in all phases of experiments: data collection, analysis, and dissemination; pre-operations activities for Mu2e, and science planning and development for LBNF/DUNE. Funding also supports the Advancing Computing initiative to support new software and networking technologies, which will be developed to transport and analyze very large neutrino datasets on exascale computers.		The Request will continue supporting the leading roles and key contributions by U.S. researchers on ongoing experiments (NOvA, SBN program, Belle II, and T2K), on future projects (Mu2e and DUNE), and design and planning for dark matter concepts. The Request will support the Advanced Computing initiative to transition data-intensive simulations and analyses to SC high-performance computing.	Funding will prioritize support on analyzing early research results from the SBN Program, high-priority research topics that search for new physics from ongoing experiments, and critical U.S. commitments to Mu2e and DUNE.
Facility Operations and Experimental Support	$194,555	$209,530	+$14,975
Funding supports SURF operations and infrastructure improvements, and the continued fabrication and installation of the SBND experiment and operations of ICARUS as part of the SBN program. The Fermilab Accelerator Complex support includes a baseline change request to increase support for a GPP, the Target Systems Integration Building (TSIB). Additional funds are needed to complete the project due to inflation. Support for Special Process Spares are provided for efficient recovery from unexpected downtime.		The Request will continue supporting the Fermilab Accelerator Complex including funding for detector and computing operations, scientific collaboration support, and minor GPPs; Special Process Spares for efficient recovery from unexpected downtime; and SURF operations and infrastructure improvements.	Funding will increase to support the Fermilab Accelerator Complex to deliver more particle beams at peak power; to expand user access to detector systems, scientific computing, and experimental data; to reduce deferred maintenance; and to advance modernization efforts.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Projects $6,000	$10,000	+$4,000
Funding supports the ACORN MIE system design and other related engineering activities, and OPC execution support costs at SURF for LBNF/DUNE such as electric power for excavation and construction.	The Request will support the ACORN MIE system design and other related engineering activities required to reach CD-2.	Funding will increase to support ACORN MIE power supply systems design and the integration of AI/ML into the control system. The LBNF/DUNE OPC for support costs at SURF is reduced as planned.

Note:

- *Funding for the subprogram above, includes 3.65 percent of research and development (R&D) funding for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, excluding facility operations.*

High Energy Physics
Cosmic Frontier Experimental Physics

Description

The Cosmic Frontier Experimental Physics subprogram uses measurements of naturally occurring cosmic particles and observations of the universe to probe fundamental physics questions and offer new insight about the nature of dark matter, cosmic acceleration in the forms of dark energy and inflation, neutrino properties, and other phenomena. The activities in this subprogram use diverse tools and technologies to carry out experiments typically not sited at national laboratories but at ground-based observatories and facilities, space-based missions, and detectors deep underground to address four of the five science drivers as described below:

- *Identify the new physics of dark matter.*
  Experimental evidence reveals that dark matter accounts for five times as much matter in the universe as ordinary matter. A staged series of direct-detection experiments search for the leading theoretical candidate particles using multiple technologies to cover a wide range in mass with increasing sensitivity. Accelerator-based dark matter searches performed in the Intensity Frontier and the Energy Frontier subprograms are complementary to these experiments.
- *Understand cosmic acceleration: dark energy and inflation.*
  The nature of dark energy, which drives the accelerating expansion of the universe, continues as one of the most perplexing questions in science. A staged series of experiments to carry out imaging and spectroscopic surveys of galaxies will determine the nature of dark energy. The cosmic microwave background (CMB), the oldest observable light in the universe, informs researchers about the era of inflation, the rapid expansion in the early universe shortly after the Big Bang. Researchers use measurements of this ancient CMB signal and light from distant galaxies to map the acceleration of the universe over time and to unravel the nature of dark energy and inflation.
- *Pursue the physics associated with neutrino mass.*
  The study of the largest physical structures in the universe may reveal the properties of particles with the smallest known cross section: neutrinos. Experiments studying dark energy and the CMB will put constraints on the number of neutrino species and their masses, complementary to the ultra-sensitive measurements made in the Intensity Frontier.
- *Explore the unknown: new particles, interactions, and physical principles.*
  High-energy cosmic rays and gamma rays probe energy scales well beyond what may be produced with man-made particle accelerators, albeit not in a controlled experimental setting. Searches for new phenomena and indirect signals of dark matter in these surveys may yield surprising discoveries about the fundamental nature of the universe.

Research

The Cosmic Frontier Experimental Physics subprogram's Research activity supports groups at U.S. academic and research institutions and national laboratories. These groups, as part of scientific collaborations, typically have a broad portfolio of responsibilities and leadership roles in support of R&D, experimental design and optimization, fabrication, commissioning, and operations as well as performing scientific simulations and data analyses for these experiments. The research makes use of advanced and high-performance computing resources.

Two complementary next-generation, dark energy Stage 4 experiments provide increased precision in measuring the history of the expansion of the universe. The DESI collaboration is carrying out a five-year survey to make light-spectrum measurements of 40 million galaxies and quasars that span over two-thirds of the history of the universe. The Vera C. Rubin Observatory will carry out a ten-year wide-field, ground-based optical and near-infrared imaging Legacy Survey of Space and Time (LSST) that will be used by the Dark Energy Science Collaboration (DESC). Together the datasets will enable studies on whether acceleration of the expansion of the universe is due to an unknown force, a cosmological constant, or if Einstein's General Theory of Relativity breaks down at large distances.

The next-generation CMB-S4 experiment, with its unprecedented sensitivity and precision, will enable researchers to peer into the inflationary era in the early moments of the universe, at a time scale unreachable by other types of experiments.

The Lunar Surface Electromagnetics Experiment Night (LuSEE-Night) is a pathfinder space mission for studies of the Cosmic Dark Ages, which is the period in the universe after the CMB and when stars and galaxies start to form. It will measure the long wavelength radio signal from the far side of the moon during the lunar night and place the most sensitive constraints to date and potentially discover the Cosmic Dark Ages signal.

Two next-generation, dark matter particle search experiments use complementary technologies to search for weakly interacting massive particles (WIMP) over a wide range of masses, with LZ searching for heavier WIMPs and Super Cryogenic Dark Matter Search at Sudbury Neutrino Observatory Laboratory (SuperCDMS-SNOLAB) sensitive to lighter WIMPs. A third experiment, the Axion Dark Matter Experiment Generation-2 (ADMX-G2), searches for axions, another type of possible dark matter particles. In addition, planning efforts are continuing for potential small project concepts that use new technologies and search for dark matter in areas not previously investigated.

Facility Operations and Experimental Support

This activity supports the DOE share of expenses necessary to carry out the successful operating phase of Cosmic Frontier experiments, including instrumentation maintenance, operation, data collection, and data processing and serving. HEP conducts planning reviews to ensure readiness as each experiment transitions from project fabrication to science operations, and periodic reviews during the operations phase.

The DESI instrumentation is mounted on the NSF Mayall Telescope at Kitt Peak National Observatory with both the instrumentation and telescope operations supported by DOE. The Vera C. Rubin Observatory is located in Chile, using the DOE-provided three billion-pixel LSST camera (LSSTCam). DOE and NSF are full partners in the Rubin facility operations. SLAC National Accelerator Laboratory (SLAC) manages the Rubin U.S. Data Facility and the LSSTCam during operations as part of DOE's responsibilities.

The LZ, SuperCDMS-SNOLAB, and ADMX-G2 dark matter experiment are located 1.5 km underground in the SURF in Lead, South Dakota; 2 km underground at the Sudbury Neutrino Observatory in Sudbury, Canada; and at the University of Washington in Seattle, WA, respectively.

Projects

The next-generation CMB-S4 project is being planned as a partnership with NSF, with DOE roles led by Lawrence Berkeley National Laboratory. CMB-S4 will consist of an array of small and large telescopes working in concert at two locations, the NSF Amundsen-Scott South Pole Station and the Atacama high desert in Chile. Both arrays are required to reach full science capabilities. The project is developing a design that will carry out the science goals within the available infrastructure and logistics capabilities at these sites.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Cosmic Frontier Experimental Physics	**$109,102**	**$98,011**	**-$11,091**
Research	$51,552	$36,301	-$15,251
Funding supports continued research activities on the ADMX-G2, DESI, LZ, and SuperCDMS-SNOLAB experiments, physics preparation for the Vera C. Rubin Observatory, the associated DESC for LSST, and design and planning for new dark matter concepts.		The Request will continue supporting the leading roles and key contributions by U.S. researchers on the dark matter experiments (ADMX-G2, LZ, and SuperCDMS-SNOLAB), on dark energy science (DESI and Vera C. Rubin Observatory), and design and planning for CMB-S4 and the dark matter concepts.	Funding will prioritize support on analyzing early research results from Vera C. Rubin Observatory and the SuperCDMS-SNOLAB experiment, high-profile research topics that search for new physics from ongoing experiments, and critical U.S. commitments to CMB-S4.
Facility Operations and Experimental Support	$56,550	$57,210	+$660
Funding supports continued operations of DESI, LZ, ADMX-G2, and the start of operations for SuperCDMS-SNOLAB. Commissioning and preoperations planning efforts continue for the Vera C. Rubin Observatory and the DESC planning for the LSST survey.		The Request will support continued operations of DESI, LZ, ADMX-G2, the start of full operations of SuperCDMS-SNOLAB. Vera C. Rubin Observatory final commissioning activities and the start of the science survey will be carried out FY 2025. LuSEE-Night final commissioning activities will be carried out.	Funding will increase to ramp up to full operations of the Vera C. Rubin Observatory, support full operations for SuperCDMS SNOLAB experiment and LZ experiments, and continue support for DESI and ADMX-G2 operations.
Projects	$1,000	$4,500	+$3,500
Funding supports engineering and design efforts for the CMB-S4 project.		The Request will support engineering and design efforts for the CMB-S4 project.	Funding will increase to ramp up design activities for the CMB-S4.

Note:

- *Funding for the subprogram above, includes 3.65 percent of research and development (R&D) funding for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, excluding facility operations.*

Description

The Theoretical, Computational, and Interdisciplinary Physics subprogram provides the mathematical, phenomenological, computational, and technological framework to understand and extend our knowledge of the dynamics of particles and fields, and the nature of space and time. This research is essential for proper interpretation and understanding of the experimental research activities described in other HEP subprograms, and cuts across all five science drivers and the Energy, Intensity, Cosmic Frontier Experimental Physics, and Advanced Technology R&D subprograms.

Theory

The HEP theory activity supports world-leading Research groups at U.S. academic and research institutions and national laboratories, which play important roles in addressing the leading research areas discussed above. Laboratory groups are typically more focused on data-driven theoretical investigations and precise calculations of experimentally observable quantities. University groups usually focus on building models of physics beyond the Standard Model and studying their phenomenology, as well as on formal and mathematical theory.

Computational HEP

The Computational HEP activity supports advanced computing research and development (R&D) targeting challenges that extend the boundaries of scientific discovery to regions not otherwise accessible by experiments, observations, or traditional theory. Computation is necessary at all stages of HEP science, from planning and constructing accelerators and detectors, to theoretical modeling, to supporting computationally intensive experimental research and large-scale data analysis for scientific discovery. The activity supports the multi-laboratory HEP Center for Computational Excellence (CCE) to advance HEP computing by developing common software tools and enabling HEP science on the latest architectures in high performance computing platforms and exascale systems. Computational HEP partners with ASCR, including the Scientific Discovery through Advanced Computing (SciDAC) activity, to optimize the HEP computing ecosystem for the near- and long-term future. Computational traineeships develop the technical expertise of engineers and scientists critical to delivering HEP discovery science. University participation and Computational HEP Traineeships ensure technical expertise needed to deliver HEP scientific discoveries. This activity supports the Advanced Computing initiative to enable broader access to exascale computing resources by providing support for researchers to develop and adapt scientific codes for high performance on modern computing architectures.

Quantum Information Science

The HEP QIS activity supports the National Quantum Strategy's science first policy through the National QIS Research Centers and individual research grants, applying HEP techniques to QIS and vice versa. The objectives are to support QIS research and technology development that extends the scientific reach of existing HEP programs beyond currently achievable, or uses HEP experimental and theoretical techniques to improve the understanding of the theoretical and practical capabilities and limitations of complex quantum systems. The five National QIS Research Centers, jointly supported across SC programs, apply concepts and technology from core research to QIS and foster collaborative partnerships in support of the SC mission. HEP is the lead program supporting the Superconducting Quantum Materials and Systems (SQMS) Center led by the Fermi National Accelerator Laboratory and composed of over 400 collaborators from national laboratories, academia, and industry. SQMS is focused on extending the lifetime of quantum states to reduce error rates in quantum computing and enable the construction and deployment of quantum sensors for precision measurements.

Artificial Intelligence and Machine Learning

The HEP AI/ML activity supports research to tackle challenges not possible with more traditional computing due to increasingly high data volumes and complexity or to make connections across the experimental, theoretical and technical HEP frontiers. Priorities include advancing HEP research through development and applications of AI/ML for more efficient processing of large datasets, modeling and mitigation of systematic uncertainties, and improved operations of particle accelerators and detectors. The Activity also supports research that seeks to use unique aspects of HEP such as datasets or theory to improve understanding of fundamental AI/ML techniques and their potential and limitations. HEP supports the development of an advanced AI/ML workforce through these university and lab-based research programs that provide students with experience developing and using cutting edge AI/ML techniques to conduct HEP discovery science. The HEP

AI/ML research activity is conducted in coordination with DOE and SC programs, other federal agencies, and the private sector.

Broadening Engagement in HEP

This activity supports:

- Reaching a New Energy Sciences Workforce (RENEW) initiative, expanding targeted efforts, including a RENEW graduate fellowship, to broaden participation in underserved communities and advance equity and inclusion in SC-sponsored research.
- Funding for Accelerated, Inclusive Research (FAIR), improving capability in emerging research institutions, underserved communities, HBCUs and MSIs to perform and propose competitive research and building beneficial relationships with DOE national laboratories and facilities.
- DOE Established Program to Stimulate Competitive Research (EPSCoR), which strengthen investments in U.S. states and territories that do not historically have large federally-supported academic research programs, and reach communities and institutions which are under-represented in the HEP portfolio. Funding for EPSCoR within the HEP program will focus on EPSCoR State-National Laboratory Partnership awards to promote single PI and small group interactions with the unique capabilities of the DOE national laboratory system.
- Other activities that broaden engagement with DOE national laboratories including:
    - Science Accelerating Girls' Engagement (SAGE) Journey internships, which provide hands-on experiences working with teams of engineers, scientists, and other professional staff at the DOE national laboratories.
    - Veteran Applied Laboratory Occupational Retraining, which provides Junior Reserve Officer Training Corps high school cadets and veterans, who are starting their civilian careers valuable, hands-on training experiences and full-time technical career placement at the DOE national laboratories.
    - African School of Fundamental Physics and Application (African School of Physics). The primary goals of the African School of Physics increase the number of African students who pursue careers in physics and build an international collaborative network consisting of African and international researchers. The African School of Physics also provides hands-on experience working with scientists on research projects at the DOE national laboratories.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Theoretical, Computational, and Interdisciplinary Physics	**$171,746**	**$186,714**	**+$14,968**
Research	$171,746	$186,714	+$14,968
Theory	*$54,050*	*$36,170*	*-$17,880*
Funding supports world-leading theoretical particle physics research at U.S. universities and national laboratories and the Advanced Computing initiative.		The Request will continue supporting world-leading theoretical particle physics research at U.S. universities and national laboratories.	Funding will prioritize support for theoretical investigations to unlock the mysteries of neutrinos and dark matter.
Computational HEP	*$14,130*	*$15,026*	*+$896*
Funding supports the multi-laboratory HEP CCE, HEP-ASCR SciDAC partnerships, and the Traineeship Program in Computational HEP.		The Request will continue supporting advanced computing R&D for HEP scientific discovery, in partnership with ASCR SciDAC, and the Traineeship Program in Computational HEP. The Request will also support the Advanced Computing initiative.	Funding increase will provide support for the Advanced Computing initiative and prioritize support for university research and training, and on enabling HEP scientists to carry out their research on high performance computing platforms and exascale systems.
Quantum Information Science	*$50,566*	*$50,566*	*$ —*
Funding supports interdisciplinary HEP-QIS consortia and lab programs for focused research at the intersection of HEP and QIS. Funding also supports SQMS as part of the National QIS Research Centers in partnership with other SC program offices.		The Request will continue supporting interdisciplinary HEP QIS consortia and the recompetition/renewal of the SQMS National QIS Research Center.	No changes.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Artificial Intelligence and Machine Learning *$40,000*	*$63,952*	*+$23,952*
Funding supports AI/ML research and development to improve HEP physics and build an AI/ML community around cross-cutting challenges that fulfill the HEP mission, including "seed" awards to explore emerging opportunities.	The Request will continue supporting AI/ML research into ambitious applications of advanced methods through multi-institutional, interdisciplinary collaborations and into improved understanding of fundamental techniques for effective user facility operations and interpretation of massive data sets. The Request will support investments in the HEP AI ecosystem to broaden participation in HEP research.	The increase will provide support to develop and retain AI/ML scientific workforce at the national laboratories and to build AI/ML capacity and computational infrastructure for the broader HEP community.
Broadening Engagement in HEP *$13,000*	*$21,000*	*+$8,000*
Funding supports the RENEW and FAIR initiatives which expand targeted efforts to increase participation and retention of under-represented individuals and institutions in SC research activities. Dedicated funding for EPSCoR expands participation in HEP research, particularly at historically under-represented institutions.	The Request will continue supporting the HEP participation in the RENEW and FAIR initiatives. The Request will support EPSCoR Implementation awards, larger multiple investigator teams that develop research capabilities, including investment in instrumentation, in EPSCoR jurisdictions; SAGE Journey Internships; and Veteran Applied Laboratory Occupational Retraining.	The increase will support the RENEW and FAIR initiatives.

Note:

- *Funding for the subprogram above, includes 3.65 percent of research and development (R&D) funding for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, excluding facility operations.*

Description
The Advanced Technology R&D subprogram fosters cutting-edge basic research in the physics of particle beams, accelerator technology R&D, and R&D for particle and radiation detection. These activities are necessary for continued progress in high energy physics.

General Accelerator R&D
The HEP General Accelerator R&D (GARD) activity supports the science underlying the technologies used in particle accelerators, colliders, and storage rings, as well as the fundamental physics of charged particle beams. Long-term research goals include developing technologies to enable breakthroughs in particle accelerator performance, size, cost, beam energy, beam intensity, and control. The GARD activity supports groups at U.S. academic and research institutions and national laboratories performing research activities categorized into five areas: 1) accelerator and beam physics; 2) advanced acceleration concepts; 3) particle sources and targetry; 4) radio-frequency acceleration technology; and 5) superconducting magnets and materials. DOE published a report in early 2023 from a community study establishing a technology roadmap for the accelerator and beam physics thrust.[c]

SC's state-of-the-art facilities attract the world's leading researchers, bringing knowledge and ideas that enhance U.S. science and create high technology jobs. As competing accelerator-based facilities are built abroad, they are beginning to draw away scientific and technical talent. Sustaining world-class accelerator-based SC facilities requires continued, transformative advances in accelerator science and technology, and a workforce capable of performing leading accelerator research for future application. In coordination with the Office of Accelerator R&D and Production, the SC Accelerator Science and Technology Initiative (ASTI) will address these needs by reinforcing high-risk, high-reward accelerator R&D that will invest in SC facilities to stay at the global forefront and develop a world-leading workforce to build and operate future generations of facilities.

The GARD activity supports the graduate Traineeship Program for Accelerator Science and Engineering to revitalize education, training, and innovation in the physics of particle accelerators for the benefit of HEP and other SC programs that rely on these enabling technologies. The Traineeship Program is aimed at university and national laboratory partnerships to provide the academic training and research experience needed to meet DOE's anticipated workforce needs, including the highly successful U.S. Particle Accelerator School. HEP holds a competition for traineeship awards for graduate level students to increase workforce development in areas of critical need. These traineeships leverage existing GARD research activities as well as the capabilities and assets of DOE laboratories.

Detector R&D
The Detector R&D activity supports the development of the next generation instrumentation and particle and radiation detectors necessary to maintain U.S. scientific leadership in a worldwide experimental endeavor that is broadening into new research areas, utilizing emerging technologies such as quantum sensors and real-time AI/ML in the front-end electronics. To meet this challenge, HEP aims to foster an appropriate balance between incremental, near-term, low-risk detector R&D and transformative, long-term, high-risk detector R&D, while training the next generation of instrumentation experts. The Detector R&D activity consists of groups at U.S. academic and research institutions and national laboratories performing research into the fundamental physics underlying the interactions of particles and radiation in detector materials. This activity also supports technology development that turns these insights into cutting-edge detectors.

The Detector R&D activity supports the graduate Traineeship Program for HEP Instrumentation to address critical, targeted workforce development in fields of interest to the DOE mission. The program is aimed at university and national laboratory partnerships to provide the academic training and research experience needed to meet DOE's anticipated workforce needs to include emerging research institutions and underserved communities. HEP held a competition for traineeship awards for graduate level students to revitalize education, training, and innovation in the physics of particle detectors and next generation instrumentation for the benefit of HEP and other SC and DOE programs that rely on these enabling technologies.

[c] https://science.osti.gov/hep/-/media/hep/pdf/2022/ABP_Roadmap_2023_final.pdf

These traineeship awards leverage existing Detector R&D research activities as well as the capabilities and assets of DOE laboratories.

SC is in a unique position to both play a critical role in the advancement of microelectronic technologies over the coming decades, and to benefit from the resultant capabilities in detection, edge computing, and communications. Five SC programs—ASCR, Basic Energy Sciences, Fusion Energy Sciences, HEP, and Nuclear Physics—are working together to advance microelectronics technologies. This activity is focused on establishing the foundational knowledge base for future microelectronics technologies for sensing, computing, and communication that are complementary to quantum computing. Radiation and particle detection specifically will benefit from detector materials R&D, device R&D, advances in front-end electronics, and integrated sensor/processor architectures.

Facility Operations and Experimental Support

This activity supports GARD laboratory experimental and test facilities: Berkeley Lab Laser Accelerator (BELLA), the laser-driven plasma wakefield acceleration facility at Lawrence Berkeley National Laboratory (LBNL); FACET-II, the beam-driven plasma wakefield acceleration facility at SLAC National Accelerator Laboratory (SLAC); Argonne Wakefield Accelerator (AWA) in structure-based advanced acceleration concepts; and superconducting radio-frequency accelerator and magnet facilities at FNAL. This activity also supports detector test beam and fabrication facilities at FNAL and the microsystems laboratory at LBNL.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Advanced Technology R&D	**$133,120**	**$115,566**	**-$17,554**
Research	$80,871	$57,856	-$23,015
General Accelerator R&D	*$54,342*	*$35,327*	*-$19,015*
Funding supports capitalizing on the science opportunities at the newly completed FACET-II facility and the second beamline at BELLA; other accelerator R&D activities at DOE national laboratories and universities, including ASTI efforts in superconducting magnet and SRF; and the Traineeship Program for Accelerator Science and Technology. The funding also supports the Accelerate initiative.		The Request will continue supporting world-leading accelerator R&D activities at DOE national laboratories and universities, the ASTI initiative, and the Traineeship Program for Accelerator Science and Engineering.	Funding will prioritize support in key strategic research topics recommended by the community technology roadmaps, and on increasing participation in accelerator science training. Funding will shift from the Accelerate initiative to other priority cross-cutting initiatives while maintaining support for priority accelerator R&D themes across the Office of Science.
Detector R&D	*$26,529*	*$22,529*	*-$4,000*
Funding supports world-leading, innovative Detector R&D; advanced microelectronics technologies and AI/ML implementations; and the Traineeship Program in HEP Instrumentation.		The Request will continue supporting world-leading, innovative Detector R&D, advanced microelectronics technologies and AI/ML implementations, and the Traineeship Program in HEP Instrumentation.	Funding will prioritize support for developing emerging and potentially transformative technologies and on increasing participation in scientific instrumentation training.
Facility Operations and Experimental Support	$52,249	$57,710	+$5,461
Funding supports testing and beam time for experiments at the accelerator test facilities at Argonne National Laboratory, FNAL, LBNL and SLAC; and detector and test beam facilities at FNAL. The funding supports facility operations for FACET-II.		The Request will support testing and beam time for experiments at the accelerator and detector test facilities at Argonne National Laboratory, FNAL, LBNL and SLAC including expanded opportunities at the upgraded facilities at FACET-II and BELLA.	Funding will support increased user access to FACET-II at SLAC and to cryogenic, magnet, and SRF testing at FNAL; new two-beam laser wakefield acceleration experiments at LBNL; and modernization of the detector facilities at FNAL.

Note:

- *Funding for the subprogram above, includes 3.65 percent of research and development (R&D) funding for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, excluding facility operations.*

High Energy Physics
Construction

Description

This subprogram supports all line-item construction for the entire HEP program. All Total Estimated Costs (TEC) are funded in this subprogram, including engineering, design, and construction.

<u>18-SC-42, Proton Improvement Plan II (PIP-II), FNAL</u>

The PIP-II project will enhance the Fermilab Accelerator Complex to enable it to deliver higher-power proton beams to the neutrino-generating target for groundbreaking discovery in neutrino physics. The project is constructing an 800 megaelectronvolt (MeV) superconducting radio-frequency (SRF) proton linear accelerator and beam transfer line. The PIP-II project is also modifying the existing FNAL Booster, Recycler, and Main Injector synchrotrons downstream from the new linear accelerator to accept the increased beam intensity. Some of the new components and the cryoplant will be provided through international, in-kind contributions. PIP-II received Critical Decision (CD)-3 approval on April 18, 2022, with a Total Project Cost (TPC) of $978,000,000. The CD-4 milestone date is 1Q FY 2033.

<u>11-SC-40, Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment, FNAL</u>

The LBNF/DUNE-US construction project is a federal, state, private, and international partnership developing and implementing the technologies of particle accelerators and detectors to enable world-leading research into the fundamental physics of neutrinos, which are the most ubiquitous particles in the universe while at the same time among the most mysterious. LBNF/DUNE will study the transformations of muon neutrinos that occur as they travel from FNAL, where they are produced in a high-energy proton beam, to a large detector in South Dakota, 800 miles away from FNAL. The experiment will analyze the rare, flavor-changing transformations of neutrinos in flight, from one lepton flavor to another, which are expected to help explain the fundamental physics of neutrinos and the puzzling imbalance of matter and antimatter that enables our existence in a matter-dominated universe.

The LBNF/DUNE-US project is a national flagship particle physics initiative and will be the first-ever large-scale, international science facility hosted by the U.S. The LBNF/DUNE-US project consists of two multinational collaborative efforts. LBNF is responsible for the beamline at FNAL and other experimental and civil infrastructure at FNAL and at the SURF in South Dakota. DUNE is an international scientific collaboration responsible for defining the scientific goals and technical requirements for the beam and detectors, as well as the design, construction and commissioning of the detectors and subsequent research.

DOE's High Energy Physics program manages both of these efforts as a single, line-item construction project—LBNF/DUNE-US. The LBNF, with DOE/FNAL leadership and participation by a small number of international partners including CERN, will construct a megawatt-class neutrino source and related facilities at FNAL (the "Near Site"), as well as underground caverns and cryogenic facilities in South Dakota (the "Far Site") needed to house the DUNE detectors. DUNE has international leadership and participation by over 1,400 scientists and engineers from over 200 institutions in over 30 countries. DOE will fund about half of DUNE under the name DUNE-US.

The LBNF/DUNE-US project received approval for CD-1RR (Update cost range, reaffirm the alternative selection, and approve a new tailoring strategy for baselining the project in five subprojects) on February 16, 2023, with a TPC Point Estimate of $3,277,000,000. The five subprojects are:

- Far Site Conventional Facilities – Excavation (FSCF-EXC)
- Far Site Conventional Facilities – Buildings and Site Infrastructure (FSCF-BSI)
- Far Detectors and Cryogenic Infrastructure (FDC)
- Near Site Conventional Facilities and Beamline (NSCF+B)
- Near Detector (ND)

The TPC Point Estimate will be refined as the project matures and each subproject is baselined. As each subproject is baselined, the aggregate of the baselined subproject TPCs must be below the upper end of the approved cost range. When the last subproject is baselined, the LBNF/DUNE-US TPC will be the aggregate of all subproject TPCs plus any contingency being held by the parent LBNF/DUNE-US project.

11-SC-41, Muon to Electron Conversion Experiment, FNAL

Mu2e, under construction at FNAL, will search for evidence that a muon can undergo direct (neutrinoless) conversion into an electron, a process that would violate lepton flavor conservation and probe new physics at energy scales beyond the collision energy of the Large Hadron Collider. If observed, this major discovery would signal the existence of new particles or new forces beyond the Standard Model. The Mu2e project completed civil construction of the underground detector housing and the surface building for the experiment in 2017. External factors negatively impacted the performance of the Mu2e project and through a review and evaluation by an Independent Cost Review and an Independent Project Review, a Baseline Change Proposal for the Mu2e project was approved on December 21, 2022, which supported a new TPC of $315,700,000. The CD-4 milestone date for project completion is January 2028. The FY 2022 Inflation Reduction Act provided $40,023,000 and the project received its final funding in the FY 2023 Enacted Appropriation.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request		Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Construction	**$298,000**		**$405,000**	**+$107,000**
18-SC-42, Proton Improvement Plan II (PIP-II), FNAL	$120,000		$125,000	+$5,000
Funding supports initiation of civil construction for the balance of the linear accelerator facilities as well as continuation of procurement and fabrication of technical systems.		The Request will support continuation of construction of the linac building and the fabrication and testing of production RF cavities, cryomodules, and other technical systems.		Funding will increase and support a ramp-up of construction for the linear accelerator facilities.
11-SC-40, Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment, FNAL	$176,000		$280,000	+$104,000
Funding supports continuation of the Far Site civil construction activities for excavation of the underground equipment caverns and connecting drifts (tunnels). Design activities will be completed for the far site detectors and cryogenics systems and the beamline design will be finalized.		The Request will continue the construction of FSCF-BSI; continue installation of far detector components at FDC; and continue design and prototyping activities for NSCF+B and ND. NSCF+B activities will also include preparations to award construction subcontracts for the facilities. NSCF+B site preparation work will continue to provide a temporary construction entrance to the FNAL site		Funding will increase to support all five of the subprojects.
11-SC-41, Muon to Electron Conversion Experiment, FNAL	$2,000		$ —	-$2,000
Funding supports continued implementation of corrective actions due to schedule delays caused by pandemic response at FNAL and collaborating universities, and by fabrication delays for the tracking detector and two superconducting magnets being fabricated by a vendor.		No funding is requested for this activity.		The Mu2e project received final funding in FY 2023.

High Energy Physics
Capital Summary

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Capital Operating Expenses						
Capital Equipment	N/A	N/A	73,620	58,200	56,700	-16,920
Minor Construction Activities						
General Plant Projects	N/A	N/A	4,000	4,200	7,640	+3,640
Total, Capital Operating Expenses	**N/A**	**N/A**	**77,620**	**62,400**	**64,340**	**-13,280**

High Energy Physics
Capital Equipment

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Capital Equipment						
Major Items of Equipment						
Energy Frontier Experimental Physics						
High Luminosity Large Hadron Collider Accelerator Upgrade Project	259,952	229,952	30,000	–	–	-30,000
High Luminosity Large Hadron Collider ATLAS Upgrade Project	183,485	120,785	10,000	16,200	16,200	+6,200
High Luminosity Large Hadron Collider CMS Upgrade Project	158,550	102,838	10,000	19,500	17,500	+7,500
Intensity Frontier Experimental Physics						
Accelerator Controls Operations Research Network	113,000	–	–	5,000	10,000	+10,000
Cosmic Frontier Experimental Physics						
Cosmic Microwave Background - Stage 4	349,000	–	–	9,000	4,500	+4,500
Total, MIEs	N/A	N/A	50,000	49,700	48,200	-1,800
Total, Non-MIE Capital Equipment	N/A	N/A	23,620	8,500	8,500	-15,120
Total, Capital Equipment	**N/A**	**N/A**	**73,620**	**58,200**	**56,700**	**-16,920**

Note:
- *The Capital Equipment table includes MIEs located at a DOE facility with a Total Estimated Cost (TEC) > $10M and MIEs not located at a DOE facility with a TEC >$2M.*

High Energy Physics
Minor Construction Activities

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
General Plant Projects (GPP)						
GPPs (greater than $5M and $34M or less)						
Target Systems Integration Building	6,900	2,900	4,000	–	–	-4,000
Total GPPs (greater than $5M and $34M or less)	N/A	N/A	4,000	–	–	-4,000
Total GPPs $5M or less	N/A	N/A	–	4,200	7,640	+7,640
Total, General Plant Projects (GPP)	**N/A**	**N/A**	**4,000**	**4,200**	**7,640**	**+3,640**
Total, Minor Construction Activities	**N/A**	**N/A**	**4,000**	**4,200**	**7,640**	**+3,640**

Note:

- *GPP activities $5M and less include design and construction for additions and/or improvements to land, buildings, replacements or addition to roads, and general area improvements. AIP activities $5M and less include minor construction at an existing accelerator facility.*
- *The Target Systems Integration Building includes $10,000,000 of redirected funds obligated in FY 2022 that brings the total project amount to $16,900,000 consistent with the baseline change approval.*

High Energy Physics
Major Items of Equipment Description(s)

Energy Frontier Experimental Physics MIEs:
High-Luminosity Large Hadron Collider Accelerator Upgrade Project (HL-LHC Accelerator Upgrade Project)
The HL-LHC Accelerator Upgrade Project received CD-3 approval on December 21, 2020. Following the major upgrade, the CERN LHC machine will further increase the particle collision rate by at least a factor of five to explore new physics beyond its current reach. This project is delivering components for which U.S. scientists have critical expertise: interaction region focusing quadrupole magnets, and special superconducting radiofrequency cavities that can generate transverse electric fields. The magnets are being assembled at LBNL, BNL, and FNAL, exploiting special expertise and unique capabilities at each laboratory. The project was stalled by shutdowns at the national laboratories due to COVID-19 and increased costs, which resulted in a rebaseline review of the project. The new Total Estimated Cost (TEC) of $259,952,000 was approved on March 20, 2023. Due to the $38,355,000 provided in the FY 2022 Inflation Reduction Act, and the project receiving its final funding in the FY 2023 Enacted Appropriation, the FY 2025 Request includes no additional funding for the project.

High-Luminosity Large Hadron Collider ATLAS Detector Upgrade Project (HL-LHC ATLAS)
The HL-LHC ATLAS Detector Upgrade Project received CD-2/3 approval on January 31, 2023, with a TPC of $200,000,000. The ATLAS detector will integrate a higher amount of data per run by at least a factor of ten compared to the period prior to the HL-LHC upgrades, making the physical conditions in which the detectors run very challenging. To operate for an additional decade in these new conditions, the ATLAS detector requires upgrades to the silicon pixel and strip tracker detectors, the muon detector systems, the calorimeter detectors and associated electronics, as well as the trigger and data acquisition systems. The ATLAS and CMS detectors are technically configured similarly but largely differ in the type of tracker subsystem, calorimeter, muon detector subsystem, and trigger employed by each experiment. The National Science Foundation (NSF) approved support for a Major Research Equipment and Facility Construction (MREFC) project in FY 2020 to provide different scope to the HL-LHC ATLAS detector upgrade. DOE and NSF are coordinating their contributions to avoid duplication. The FY 2025 Request for TEC funding of $16,200,000 will focus on ramping up fabrication activities of U.S.-built deliverables for the project.

High-Luminosity Large Hadron Collider CMS Detector Upgrade Project (HL-LHC CMS)
The HL-LHC CMS project received CD-2/3c approval on April 4, 2023, with a TPC of $200,000,000. The CMS detector will integrate a higher amount of data per run by at least a factor of ten compared to the period prior to the HL-LHC upgrades, making the physical conditions in which the detectors run very challenging. To operate for an additional decade in these new conditions, the CMS detector requires upgrades to the silicon pixel tracker detectors, the outer tracker detector, the muon detector systems, the calorimeter detectors and associated electronics, the trigger and data acquisition systems, and the addition of a novel timing detector. The ATLAS and CMS detectors are technically configured similarly but largely differ in the type of tracker subsystem, calorimeter, muon detector subsystem, and trigger employed by each experiment. NSF approved support for a MREFC Project in FY 2020 to provide different scope to the HL-LHC CMS detector upgrade. DOE and NSF are coordinating their contributions to avoid duplication. The FY 2025 Request for TEC funding of $17,500,000 will focus on ramping up fabrication activities of U.S.-built deliverables for the project.

Intensity Frontier Experimental Physics MIE:
Accelerator Controls Operations Research Network (ACORN)
The ACORN project received CD-0 approval on August 28, 2020, with an estimated cost range of $100,000,000 to $142,000,000. This project will replace FNAL's outdated accelerator control system with a modern system which is maintainable, sustainable, and capable of utilizing advances in Artificial Intelligence and Machine Learning to create a high-performance accelerator for the future. The control system of the Fermilab Accelerator Complex initiates particle beam production; controls beam energy and intensity; steers particle beams to their ultimate destination; measures beam parameters; and monitors beam transport through the complex to ensure safe, reliable, and effective operations. ACORN will provide FNAL with an accelerator control system that will be compatible with PIP-II. FNAL plans to collaborate with other national labs that have experience with accelerator control systems. This project is expected to receive CD-1 approval in FY 2024. The FY 2025 Request for TEC funding of $10,000,000 will fund system design and other related engineering activities.

Cosmic Frontier Experimental Physics MIE:

Cosmic Microwave Background Stage 4 (CMB-S4)

The CMB-S4 project received CD-0 approval on July 25, 2019, with an estimated cost range of $320,000,000 to $395,000,000. The project is expected to be carried out as a partnership with NSF, with DOE as the lead agency. The distribution of scope is under discussion. The project consists of fabricating an array of small and large telescopes at two locations: the NSF Amundsen-Scott South Pole Station and the Atacama high desert in Chile. LBNL was selected in August 2020 to lead the efforts in providing the DOE scope for the project. The FY 2025 Request for TEC funding of $4,500,000 will support engineering and design efforts.

High Energy Physics
Construction Projects Summary

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
18-SC-42, Proton Improvement Plan II (PIP-II), FNAL						
Total Estimated Cost (TEC)	891,200	260,000	120,000	125,000	125,000	+5,000
Other Project Cost (OPC)	86,800	73,594	-	-	-	-
Total Project Cost (TPC)	**978,000**	**333,594**	**120,000**	**125,000**	**125,000**	**+5,000**
11-SC-40, Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment						
Total Estimated Cost (TEC)	3,163,335	979,781	176,000	251,000	280,000	+104,000
Other Project Cost (OPC)	113,665	101,625	4,000	4,000	-	-4,000
Total Project Cost (TPC)	**3,277,000**	**1,081,406**	**180,000**	**255,000**	**280,000**	**+100,000**
11-SC-41, Muon to Electron Conversion Experiment, FNAL						
Total Estimated Cost (TEC)	292,023	290,023	2,000	-	-	-2,000
Other Project Cost (OPC)	23,677	23,677	-	-	-	-
Total Project Cost (TPC)	**315,700**	**313,700**	**2,000**	**-**	**-**	**-2,000**
Total, Construction						
Total Estimated Cost (TEC)	**N/A**	**N/A**	**298,000**	**376,000**	**405,000**	**+107,000**
Other Project Cost (OPC)	**N/A**	**N/A**	**4,000**	**4,000**	**-**	**-4,000**
Total Project Cost (TPC)	**N/A**	**N/A**	**302,000**	**380,000**	**405,000**	**+103,000**

High Energy Physics
Scientific User Facility Operations

The treatment of user facilities is distinguished between two types: TYPE A facilities that offer users resources dependent on a single, large-scale machine; TYPE B facilities that offer users a suite of resources that is not dependent on a single, large-scale machine.

(dollars in thousands)

	FY 2023 Enacted	FY 2023 Current	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Scientific User Facilities - Type A					
Fermilab Accelerator Complex	**152,984**	**145,376**	**146,232**	**166,850**	**+13,866**
Number of Users	2,700	2,395	2,395	2,800	+100
Achieved Operating Hours	–	2,486	–	–	–
Planned Operating Hours	5,740	5,320	2,940	5,180	-560
Unscheduled Down Time Hours	–	3,567	–	–	–
Facility for Advanced Accelerator Experimental Tests II (FACET II)	**15,500**	**15,500**	**14,155**	**17,640**	**+2,140**
Number of Users	120	144	144	144	+24
Achieved Operating Hours	–	1,596	–	–	–
Planned Operating Hours	3,300	3,360	3,120	3,120	-180
Unscheduled Down Time Hours	–	2,414	–	–	–
Total, Facilities	**168,484**	**160,876**	**160,387**	**184,490**	**+16,006**
Number of Users	2,820	2,539	2,539	2,944	+124
Achieved Operating Hours	–	4,082	–	–	–
Planned Operating Hours	9,040	8,680	6,060	8,300	-740
Unscheduled Down Time Hours	–	5,981	–	–	–

Note:

- *Achieved Operating Hours and Unscheduled Downtime Hours will only be reflected in the Congressional budget cycle which provides actuals.*
- *Percent optimal operations defines what is achieved at this funding level. This includes staffing, up-to-date equipment and software, operations and maintenance, and appropriate investments to maintain world leadership.*

High Energy Physics
Scientific Employment

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Number of Permanent Ph.Ds (FTEs)	785	785	707	-78
Number of Postdoctoral Associates (FTEs)	400	380	335	-65
Number of Graduate Students (FTEs)	530	540	424	-106
Number of Other Scientific Employment (FTEs)	1,635	1,540	1,570	-65
Total Scientific Employment (FTEs)	**3,350**	**3,245**	**3,036**	**-314**

Note:
- *Other Scientific Employment (FTEs) includes technicians, engineers, computer professionals and other support staff.*

18-SC-42, Proton Improvement Plan II (PIP-II), FNAL
Fermi National Accelerator Laboratory, FNAL
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

<u>Summary</u>
The FY 2025 Request for the Proton Improvement Project II (PIP-II) is $125,000,000 of Total Estimated Cost (TEC) funding. The project has an approved Total Project Cost (TPC) of $978,000,000.

The PIP-II project will enhance the Fermilab Accelerator Complex to enable it to deliver higher-power proton beams to the neutrino-generating target for groundbreaking discovery in neutrino physics. The project will design and construct an 800 megaelectronvolt (MeV) superconducting radio frequency (SRF) proton linear accelerator and beam transfer line. The PIP-II project also will modify the existing Fermi National Accelerator Laboratory (FNAL) Booster, Recycler, and Main Injector synchrotrons downstream from the new linear accelerator to accept the increased beam intensity. Some of the new components and the cryo-plant will be provided through international, in-kind contributions.

<u>Significant Changes</u>
This project was initiated in FY 2018. The most recent DOE Order 413.3B Critical Decision (CD) is CD-3 (Approve Construction), approved on April 18, 2022. The planned date for CD-4, Project Completion, is 1Q FY 2033.

Anticipated in-kind technical contributions from international partners total $330,000,000 (equivalent to DOE costing). Legally binding agreements with all countries but France have been signed to cover the planned work. The legally binding agreement with France has been drafted and signatures are expected in 2024. Non-binding Project Planning Documents (PPDs) that provide additional technical details beyond those provided in the legally binding agreements are being signed by the international partners. As of January 2022, PPDs have been signed with Italian, Polish, and UK partner institutions. The PPD with the India's Department of Atomic Energy laboratories is expected to be signed late 2024.

Civil construction costs and the construction contingency estimate increased relative to previous estimates due to market conditions whereas increase in the total cost was offset by refinement of the technical equipment estimate.

The FY 2023 Enacted Appropriations supported initiation of civil construction as well as developing prototypes of superconducting RF cavities, cryomodules, and the accelerator's other technical systems. The FY 2024 Request supports the completion of the cryogenic plant building, the continuation of the linac building civil construction, and the continued development of prototypes of the superconducting RF cavities and the cryomodules that hold them. The FY 2025 Request will support continuation of construction of the linac building and the fabrication and testing of production RF cavities, cryomodules, and other technical systems.

A civil construction injury accident in May 2023 delayed linac civil construction until December 2023 for investigations and strengthening of the hazard identification and mitigation processes, consuming several months of schedule contingency and $2,000,000,000 of cost contingency. Civil construction is now on the project's critical path; the CD-4 milestone date has not changed. An Independent Project Review (IPR) planned in spring 2024 will reassess the contingencies and remaining risks.

A Federal Project Director (FPD) has been assigned to this project and has approved this construction project datasheet. The FPD has a Level III certification.

Critical Milestone History

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
FY 2025	11/12/15	7/23/18	7/23/18	12/14/20	4/18/22	4/18/22	1Q FY 2033

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout.

Fiscal Year	Performance Baseline Validation	CD-3A
FY 2025	12/14/20	3/16/21

CD-3A – Approve long-lead procurement of niobium for superconducting radio frequency (SRF) cavities and other long lead components for SRF cryomodules

Project Cost History

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	135,895	755,305	891,200	86,800	86,800	978,000
FY 2025	135,895	755,305	891,200	86,800	86,800	978,000

2. Project Scope and Justification

Scope

Specific scope elements of the PIP-II project include construction of (a) the superconducting radio frequency (SRF) linac, (b) cryoplant to support SRF operation, (c) beam transfer line, (d) modifications to the Booster, Recycler and Main Injector synchrotrons, and (e) conventional facilities:

a) 800-MeV Superconducting H^- linac consisting of a 2.1 MeV warm (normal-conducting) front-end injector and five types of SRF cryomodules that are continuous wave capable but operating initially in pulsed mode. The cryomodules include Half Wave Resonator cavities (HWR) at 162.5 MHz, two types of Single Spoke Resonator cavities (SSR1 and SSR2) at 325 MHz, Low-Beta and High-Beta elliptical cavities at 650 MHz (LB-650 and HB-650). The warm front-end injector consists of an H^- ion source, Low Energy Beam Transport (LEBT), Radiofrequency Quadrupole (RFQ) and Medium Energy Beam Transport (MEBT) that prepare the beam for injection into the SRF cryomodules. The scope includes the associated electronic power sources, instrumentation, and controls to support linac operation.

   The PIP-II Injector Test Facility at FNAL is an R&D prototype for the low-energy proton injector at the front-end of the linac, consisting of H^- ion source, LEBT, RFQ, MEBT, HWR, and one SSR1 cryomodule. It was developed to reduce technical risks for the project, with participation and in-kind contributions from the India Department of Atomic Energy (DAE) Labs. The Test Facility has successfully completed its program and has been converted to a cryomodule test stand for testing the cryomodules for the project.

b) Cryoplant with storage and distribution system to support SRF linac operation. The cryoplant is an in-kind contribution by the India DAE Labs that is similar to the cryoplant being designed and constructed for a high-intensity superconducting proton accelerator project in India.[d]
c) Beam Transfer Line from the linac to the Booster Synchrotron, including accommodation of a beam dump and future delivery of beam to the FNAL Muon Campus.
d) Modification of the Booster, Recycler and Main Injector synchrotrons to accommodate a 50 percent increase in beam intensity and construction of a new injection area in the Booster to accommodate 800-megaelectronvolt (MeV) injection.
e) Civil construction of conventional facilities, including housings, service buildings, roads, access points and utilities with the special capabilities required for the linac and beam transport line. A portion of the civil construction scope comprises the ECF subproject. That subproject scope includes the cryogenics plant building and site work. The ECF subproject total estimated cost is $36,000,000; it was initiated in FY 2020 and will be completed in FY 2024. If the ECF subproject is completed for less than its full budget, DOE may authorize redistribution of subproject funds to the PIP-II project contingency for remaining project risks.

Significant pieces of the linac and cryogenic scope (a and b above) will be delivered as in-kind international contributions not funded by DOE. These include assembly and/or fabrication of linac SRF components and the cryoplant. The rationale or motivation behind these contributions are institutional and/or industrial technical capability, and interest in SRF technology, as well as interest in LBNF/DUNE. The construction phase scope of in-kind contributions is divided between U.S. DOE national laboratories, India Department of Atomic Energy (DAE) Labs, Italy National Institute for Nuclear Physics (INFN) Labs, French Atomic Energy Commission (CEA) and National Center for Scientific Research (CNRS)-National Institute of Nuclear and Particle Physics (IN2P3) Labs, UK Science & Technology Facilities Council (STFC) Labs, and Wroclaw University of Science and Technology in Poland, tentatively as indicated in the following table of Scope Responsibilities for PIP-II.

Construction-phase Scope Responsibilities for PIP-II Linac RF Components

Components	Quan-tity	Freq. (MHz)	SRF Cavities	Responsibility for Cavity Fabrication	Responsibility for Module Assembly	Responsibility for RF Amplifiers	Cryogenic Cooling Source and Distribution System
RFQ	1	162.5	N/A	N/A	U.S. DOE (LBNL)	U.S. DOE (FNAL)	N/A
HWR Cryomodule	1	162.5	8	U.S. DOE (ANL)	U.S. DOE (ANL)	U.S. DOE (FNAL)	India DAE Labs, Poland WUST
SSR1 Cryomodule	2	325	16	U.S. DOE (FNAL), India DAE Labs	U.S. DOE (FNAL)	India DAE Labs	India DAE Labs, Poland WUST
SSR2 Cryomodule	7	325	35	France CNRS (IN2P3 Lab)	U.S. DOE (FNAL)	India DAE Labs	India DAE Labs, Poland WUST
LB-650 Cryomodule	9	650	36	Italy INFN (LASA)	France CEA (Saclay Lab)	India DAE Labs	India DAE Labs, Poland WUST
HB-650 Cryomodule	4	650	24	UK STFC Labs	UK STFC Labs, U.S. DOE (FNAL)	India DAE Labs	India DAE Labs, Poland WUST

Justification

The PIP-II project will enhance the Fermilab Accelerator Complex by providing the capability to deliver higher-power proton beams to the neutrino-generating target that serves the LBNF/DUNE program for groundbreaking discovery in neutrino physics, a major field of fundamental research in high energy particle physics. Increasing the neutrino beam intensity requires increasing the proton beam power on target. PIP-II will raise the proton beam power from 800 kW to 1,200 kW over an energy range of 60-120 GeV and will enable the eventual increase to 2,400 kW with upgrades to the Booster accelerator. The PIP-II project will provide more flexibility for future science-driven upgrades to the entire accelerator complex and increase the system's overall reliability by addressing some of the accelerator complex's elements that are far beyond their design life.

[d] See Section 8.

PIP-II was identified as one of the highest priorities in the 10-year strategic plan for U.S. High Energy Physics developed by the High Energy Physics Program Prioritization Panel (P5) and unanimously approved by the High Energy Physics Advisory Panel (HEPAP), advising DOE and NSF, in 2014.[e]

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*.

Key Performance Parameters (KPPs)
The Threshold KPPs represent the minimum acceptable performance that the project must achieve. The Objective KPPs represent the desired project performance. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion.

Performance Measure	Threshold	Objective
Linac Beam Energy	H- beam will be accelerated to 600 MeV.	H- beam will be accelerated to 700 MeV. Linac systems required for 800 MeV will be installed and tested.
Linac Beam Intensity	H- beam will be delivered to the beam absorber at the end of the linac.	H- beam with intensity of 1.3 x 10^{12} particles per pulse at 20 Hz pulse-repetition rate will be delivered to the Beam Transfer Line absorber.
Booster, Recycler and Main Injector Synchrotron Upgrades	Upgrades of the Booster, Recycler and Main Injector Synchrotrons, required to support delivery of 1.2 MW onto the LBNF target, will be installed and tested without beam.	Linac beam will be injected into and circulated in the Booster.

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Estimated Cost (TEC)				
Design (TEC)				
Prior Years	135,895	135,895	135,895	—
Total, Design (TEC)	**135,895**	**135,895**	**135,895**	**—**
Construction (TEC)				
Prior Years	114,105	114,105	37,298	—
Prior Years - IRA Supp.	10,000	10,000	—	—
FY 2023	120,000	120,000	58,668	1,293
FY 2024	125,000	125,000	125,000	8,707
FY 2025	125,000	125,000	125,000	—
Outyears	261,200	261,200	399,339	—
Total, Construction (TEC)	**755,305**	**755,305**	**745,305**	**10,000**
Total Estimated Cost (TEC)				

[e] "Building for Discovery: Strategic Plan for U.S. Particle Physics in the Global Context," HEPAP, 2014.

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Estimated Cost (TEC)				
Prior Years	250,000	250,000	173,193	—
Prior Years - IRA Supp.	10,000	10,000	—	—
FY 2023	120,000	120,000	58,668	1,293
FY 2024	125,000	125,000	125,000	8,707
FY 2025	125,000	125,000	125,000	—
Outyears	261,200	261,200	399,339	—
Total, Total Estimated Cost (TEC)	**891,200**	**891,200**	**881,200**	**10,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Other Project Cost (OPC)			
Prior Years	73,594	73,594	73,419
FY 2023	–	–	1
FY 2024	–	–	174
Outyears	13,206	13,206	13,206
Total, Other Project Cost (OPC)	**86,800**	**86,800**	**86,800**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Project Cost (TPC)				
Prior Years	323,594	323,594	246,612	–
Prior Years - IRA Supp.	10,000	10,000	–	–
FY 2023	120,000	120,000	58,669	1,293
FY 2024	125,000	125,000	125,174	8,707
FY 2025	125,000	125,000	125,000	–
Outyears	274,406	274,406	412,545	–
Total, TPC	**978,000**	**978,000**	**968,000**	**10,000**

Note:
- *Prior Years and FY 2023 reflect actual costs; remaining years are cost estimates.*

4. **Details of Project Cost Estimate**

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	135,895	135,895	146,314
Design - Contingency	N/A	N/A	30,686
Total, Design (TEC)	**135,895**	**135,895**	**177,000**
Construction	177,000	151,000	124,009
Site Preparation	13,000	13,000	12,783
Equipment	403,760	433,905	378,705
Construction - Contingency	161,545	157,400	198,703
Total, Construction (TEC)	**755,305**	**755,305**	**714,200**
Total, TEC	**891,200**	**891,200**	**891,200**
Contingency, TEC	*161,545*	*157,400*	*229,389*
Other Project Cost (OPC)			
R&D	67,117	67,117	67,117
Conceptual Planning	8,324	8,324	8,324
Conceptual Design	2,855	2,855	2,855
OPC - Contingency	8,504	8,504	8,504
Total, Except D&D (OPC)	**86,800**	**86,800**	**86,800**
Total, OPC	**86,800**	**86,800**	**86,800**
Contingency, OPC	*8,504*	*8,504*	*8,504*
Total, TPC	**978,000**	**978,000**	**978,000**
Total, Contingency (TEC+OPC)	***170,049***	***165,904***	***237,893***

5. **Schedule of Appropriations Requests**

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	260,000	120,000	125,000	—	386,200	891,200
	OPC	73,594	—	—	—	13,206	86,800
	TPC	333,594	120,000	125,000	—	399,406	978,000
FY 2025	TEC	260,000	120,000	125,000	125,000	261,200	891,200
	OPC	73,594	—	—	—	13,206	86,800
	TPC	333,594	120,000	125,000	125,000	274,406	978,000

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	1Q FY 2033
Expected Useful Life	20 years
Expected Future Start of D&D of this capital asset	1Q FY 2053

FNAL will operate the PIP-II linac as an integral part of the entire Fermilab Accelerator Complex. Related funding estimates for operations, utilities, maintenance, and repairs are incremental to the balance of the FNAL accelerator complex for which the present cost of operation, utilities, maintenance, and repairs is approximately $100,000,000 annually.

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	**Current Total Estimate**	**Previous Total Estimate**	**Current Total Estimate**
Operations	4,000	4,000	80,000	80,000
Utilities	3,000	3,000	60,000	60,000
Maintenance and Repair	2,000	2,000	40,000	40,000
Total, Operations and Maintenance	9,000	9,000	180,000	180,000

7. D&D Information

The new area being constructed in this project is not replacing existing facilities.

	Square Feet
New area being constructed by this project at FNAL	127,676
Area of D&D in this project at FNAL	—
Area at FNAL to be transferred, sold, and/or D&D outside the project, including area previously "banked"	—
Area of D&D in this project at other sites	—
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously "banked"	127,676
Total area eliminated	—

The one-for-one replacement will be met through banked space. A waiver from the one-for-one requirement to eliminate excess space at FNAL to offset PIP-II and other projects was approved by DOE Headquarters on November 12, 2009. The waiver identified and transferred to FNAL 575,104 square feet of excess space to accommodate new facilities including Mu2e, LBNF, DUNE, and other facilities, planned or anticipated for future experiments, from space that was banked at other DOE facilities. The PIP-II Project is following all current DOE procedures for tracking and reporting space utilization.

8. Acquisition Approach

DOE is acquiring the PIP-II project through Fermi Research Alliance (FRA), the Management and Operating (M&O) contractor responsible for FNAL, rather than have the DOE compete a contract for fabrication to a third party. FRA has a strong relationship with the high energy physics community and its leadership, including many FNAL scientists and engineers. This arrangement will facilitate close cooperation and coordination for PIP-II with an experienced team of project leaders managed by FRA, which will have primary responsibility for oversight of all subcontracts required to execute the project. The arrangement is expected to include subcontracts for the purchase of components from third party vendors as well as delivery of in-kind contributions from non-DOE partners.

Project partners will deliver significant pieces of scope as in-kind international contributions, not funded by U.S. DOE. The rationale or motivation behind these contributions are institutional and/or industrial technical capability, long-standing collaborations in the physics programs at FNAL that PIP-II will support, and interest in SRF technology. Scientific institutions from several countries, tabulated below, are engaged in discussion of potential PIP-II scope contributions within the framework of international, government-to-government science and technology agreements.

Scientific Agencies and Institutions Discussing Potential Contributions of Scope for PIP-II

Country	Funding Agency	Institutions
U.S.	Department of Energy	Fermi National Accelerator Laboratory; Lawrence Berkeley National Laboratory; Argonne National Laboratory
India	Department of Atomic Energy	Bhabha Atomic Research Centre, Mumbai; Inter University Accelerator Centre, New Delhi; Raja Ramanna Centre for Advanced Technology, Indore; Variable Energy Cyclotron Centre, Kolkata
Italy	National Institute for Nuclear Physics	Laboratory for Accelerators and Applied Superconductivity, Milan
France	Atomic Energy Commission National Center for Scientific Research	Saclay Nuclear Research Center; National Institute of Nuclear & Particle Physics, Paris
UK	Science & Technology Facilities Council	Daresbury Laboratory
Poland	Wroclaw University of Science and Technology	Wroclaw University of Science and Technology

For example, joint participation by U.S. DOE and the India DAE in the development and construction of high intensity superconducting proton accelerator projects at FNAL and in India is codified in Annex I to the "Implementing Agreement between DOE and Indian Department of Atomic Energy in the Area of Accelerator and Particle Detector Research and Development for Discovery Science for High Intensity Proton Accelerators," signed in January 2015 by the U.S. Secretary of Energy and the India Chairman of DAE. FNAL and DAE Labs subsequently developed a "Joint R&D Document" outlining the specific roles and goals of the collaborators during the R&D phase of the PIP-II project. This R&D agreement is expected to lead to a similar agreement for the construction phase, describing roles and in-kind contributions. DOE and FNAL are developing similar agreements with Italy, France, and the UK for PIP-II.

SC is putting mechanisms into place to facilitate joint consultation between the partnering funding agencies, such that coordinated oversight and actions will ensure the success of the overall program. SC is successfully employing similar mechanisms for international partnering for the DOE LBNF/DUNE-US project and for DOE participation in LHC-related projects hosted by CERN.

Domestic engineering and construction subcontractors will perform the civil construction at FNAL. FNAL is utilizing a firm fixed-price contract for architectural-engineering services to complete all remaining designs for conventional facilities with an option for construction support. The general construction subcontract has been placed on a firm-fixed-price basis, and work has begun at the laboratory.

All subcontracts will be competitively bid and awarded based on best value to the government. Fermi Site Office provides contract oversight for FRA's plans and performance. Project performance metrics for FRA are included in the M&O contractor's annual performance evaluation and measurement plan.

11-SC-40, Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment, FNAL
Fermi National Accelerator Laboratory, FNAL
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary

The FY 2025 Request for Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment (LBNF/DUNE-US) is $280,000,000 of Total Estimated Cost (TEC) funding.

The LBNF/DUNE-US scope is organized into five subprojects for improved planning and management control.

The five subprojects are:

- Far Site Conventional Facilities – Excavation (FSCF-EXC)
- Far Site Conventional Facilities – Buildings and Site Infrastructure (FSCF-BSI)
- Far Detectors and Cryogenic Infrastructure (FDC)
- Near Site Conventional Facilities and Beamline (NSCF+B)
- Near Detector (ND)

Significant Changes

The CD-1 Reaffirmation (CD-1RR) was approved on February 16, 2023, and established a cost range of $3,160,000,000 to $3,677,000,000. At the time of CD-1RR approval, the Total Project Cost (TPC) Point Estimate was $3,277,000,000. This TPC Point Estimate was for planning purposes and will be refined as the project matures and each subproject is baselined. The aggregate of the new baselined subproject TPCs must be below the upper end of the approved cost range. When the last subproject is baselined, the LBNF/DUNE-US TPC will be the aggregate of all subproject TPCs plus any contingency being held by the parent LBNF/DUNE-US project.

The FSCF-EXC subproject was the first subproject to be approved for baseline and start of construction (CD-2/3) in August 2022. The FSCF-BSI achieved CD-2/3 approval in March 2023. The FDC subproject, which obtained CD-3a approval in February 2023, is expected to achieve CD-2/3 approval in FY 2024. In addition, NSCF+B subproject achieved CD-3a approval in March 2023 with a combined CD-2/3 approval planned for FY 2025. The Near Detector Subproject is expected to be the last subproject to be baselined.

FY 2023 Enacted Appropriations funding supported continued excavation of the far detector caverns long-lead procurement items for FDC and NSCF+B, and site preparation activities for NSCF+B; initiated procurements of FSCF-BSI infrastructure including HVAC, electric, plumbing, etc.; and funded design and other planning efforts for FDC, NSCF+B and ND in preparation for baseline and approval of construction.

The FY 2024 Request will support activities that include completing excavation of the far detector caverns; construction of FSCF-BSI; beginning installation of far detector components for FDC and manufacturing of components; continuing design and other planning efforts for NSCF+B and ND; and continuing site preparation of the conventional facilities of NSCF+B.

The FY 2025 Request will continue to support the construction of FSCF-BSI, the installation of far detector components at FDC, and the design and prototyping activities for NSCF+B and ND. NSCF+B activities will also include preparations to award construction subcontracts for the facilities. NSCF+B site preparation work will continue to provide a temporary construction entrance to the FNAL site.

A Federal Project Director with a certification level 4 is assigned to this project and has approved this CPDS.

Critical Milestone History

	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
LBNF/DUNE-Overall	1/8/10	11/5/15	11/5/15	2Q FY 2026	4Q FY 2026	3Q FY 2027	4Q FY 2035
Far Site Conventional Facilities-Excavation	–	–	–	8/19/22	12/31/20	8/19/22	1Q FY 2027
Far Site Conventional Facilities-Buildings and Site Infrastructure	–	–	–	3/25/23	11/20/20	3/25/23	4Q FY 2028
Far Detectors and Cryogenic Infrastructure	–	–	–	4Q FY 2024	8/10/23	4Q FY 2024	2Q FY 2033
Near Site Conventional Facilities and Beamline	–	–	–	1Q FY 2026	3Q FY 2026	1Q FY 2026	1Q FY 2034
Near Detector	–	–	–	2Q FY 2026	4Q FY 2026	3Q FY 2027	4Q FY 2035

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout.

	Performance Baseline Validation	CD-1R	CD-1RR	CD-3A	CD-3B
LBNF/DUNE-Overall	4Q FY 2025	11/5/15	2/16/23	1Q FY 2026	–
Far Site Conventional Facilities-Excavation	8/19/22	—	2/16/23	10/27/21	–
Far Site Conventional Facilities-Buildings and Site Infrastructure	3/25/23	—	2/16/23	–	–
Far Detectors and Cryogenic Infrastructure	4Q FY 2024	—	2/16/23	2/21/23	2Q FY 2024
Near Site Conventional Facilities and Beamline	3Q FY 2025	—	2/16/23	3/25/23	1Q FY 2025
Near Detector	4Q FY 2025	—	2/16/23	–	–

CD-1R – Refresh of CD-1 approval for the new Conceptual Design.

CD-1RR – Update cost range, reaffirm the alternative selection, and approve a new tailoring strategy for baselining the project in multiple subprojects.

CD-3A – Approve initial construction and long lead procurements in order to mitigate risks and avoid delays. The CD-3A scope for the Far Detectors and Cryogenic Infrastructure subproject is long-lead procurement of certain components of the detector electronics, photon detectors, and the anode plane assemblies. The CD-3A scope for the Near Site Conventional Facilities and Beamline subproject is long-lead procurement of shielding and accelerator kicker components, early fabrication of magnetic horn components, and wetlands work that must be completed before the corresponding USACE permit expires.

<u>Project Cost History</u>

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	550,447	2,616,888	3,167,335	109,665	109,665	3,277,000
FY 2025	569,694	2,593,641	3,163,335	113,665	113,665	3,277,000

Notes:
- *The project is Pre-CD-2 for some subprojects. All estimates are preliminary. The approved TPC range for CD-1RR is $3,160,000,000 to $3,677,000,000.*
- *No construction, other than site preparation and approved long-lead procurement, will be performed prior to validation of the Performance Baseline and approval of CD-3 for each subproject.*

2. Project Scope and Justification

<u>Scope</u>

The LBNF/DUNE-US construction project is a federal, state, private, and international partnership developing and implementing the technologies of particle accelerators and detectors to enable world-leading research into the fundamental physics of neutrinos, which are the most ubiquitous and among the most mysterious particles in the universe. Neutrinos are intimately involved in nuclear decay processes and high energy nuclear reactions. LBNF/DUNE will study the transformations of muon neutrinos into electron neutrinos, which occur as muon neutrinos travel to large detectors in South Dakota, 800 miles away from FNAL, where they are produced in a high-energy beam. The experiment will analyze the rare transformations of neutrinos in flight which are expected to help explain the fundamental physics of neutrinos and the puzzling matter-antimatter asymmetry that enables our existence in a matter-dominated universe.

LBNF/DUNE will be composed of a neutrino beam created by new construction as well as modifications to the existing Fermilab Accelerator Complex, massive neutrino detectors (up to 40,000 tons in total) and associated cryogenics infrastructure located in one or more large underground caverns to be excavated at least 800 miles “downstream” from the neutrino source at the SURF. A much smaller neutrino detector will be installed at FNAL for monitoring the neutrino beam near its source. A primary beam of protons will produce a neutrino beam directed into a target for converting the protons into a secondary beam of particles (pions and muons) that decay into neutrinos, followed by a decay tunnel hundreds of meters long where the decay neutrinos will emerge and travel through the earth to the massive detector. The Neutrinos at the Main Injector (NuMI) beam at FNAL is an existing example of this type of configuration for a neutrino beam facility. The new LBNF beam line will provide a neutrino beam of greater intensity than the NuMI beam and would point to far detector modules at a greater distance than is used with NuMI experiments.

For the LBNF/DUNE-US project, FNAL will be responsible for design, construction, and operation of the major components of facilities which enable the DUNE research program including: the primary proton beam, neutrino production target, focusing structures, decay pipe, absorbers and corresponding beam instrumentation; the conventional facilities and experiment infrastructure on the FNAL site required for the near detector; and the conventional facilities and experiment infrastructure at SURF for the large detectors including the cryostats and cryogenics systems. LBNF/DUNE-US provides detector components for the DUNE research program and supports the installation and integration of detector components provided by international partners.

Justification
As part of implementation of High Energy Physics Advisory Panel (HEPAP)-Particle Physics Project Prioritization Panel (P5) recommendations the LBNF/DUNE-US project comprises a national flagship particle physics initiative and consists of two multinational collaborative efforts:

- LBNF is responsible for the beamline and other experimental and civil infrastructure at FNAL and at SURF in South Dakota. SURF is currently operated by the South Dakota Science and Technology Authority (SDSTA), an agency of the State of South Dakota, and hosts experiments supported by DOE, NSF, and major research universities.

- DUNE is an international scientific collaboration responsible for defining the scientific goals and technical requirements for the beam and detectors, as well as the design, fabrication of detector components and subsequent research program. The U.S. contributes to DUNE along with other international funding agencies. DOE and FNAL host the international DUNE research program.

DOE's High Energy Physics program manages both activities as a single, line-item construction project—LBNF/DUNE-US. LBNF, with DOE/FNAL leadership and minority participation by international partners including CERN, will construct a megawatt-class neutrino source and related facilities at FNAL (the "Near Site"), as well as underground caverns and cryogenic facilities in South Dakota (the "Far Site") needed to house the DUNE detectors. DUNE has international leadership and participation of over 1,400 scientists and engineers from over 200 institutions in over 30 countries. DOE will fund approximately one half of the DUNE detectors. This excludes the cryostats that hold the detectors. The cryostats will be provided by CERN. The project continues to refine the development of the design and cost estimates as the U.S. DOE contributions to the multinational effort now are better understood. The cost estimate for DOE contributions will be updated as planning continues in preparation for baselining each subprojects.

FNAL and DOE have confirmed contributions to LBNF documented in international agreements from CERN, the UK, and other international partners. Discussions are ongoing with other countries for additional contributions. For the DUNE detectors, the collaboration put in place a process to complete a technical design of the detectors and divide the work of building the detectors between the collaborating institutions. The review of the detector design with a complete set of funding responsibilities by the Long Baseline Neutrino Committee began in 2019, and development of the set of funding responsibilities has made significant progress and continues to advance. Commitments for detector contributions and associated planning are being finalized in advance of each relevant subproject. SC will manage all DOE contributions to the facility and the detectors according to DOE Order 413.3B, and FNAL will provide unified project management reporting.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*.

Key Performance Parameters (KPPs)
The KPPs are preliminary and will be finalized and approved with each subproject.

The Threshold KPPs represent the minimum acceptable performance that the project must achieve. The Objective KPPs represent the desired project performance. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion. KPPs for each subproject are finalized with the approval of relevant subproject CD-2.

Performance Measure	Threshold	Objective
Far Site Conventional Facilities – Excavation (FSCF-EXC)	1) Provide power capacity at the 4850L capable of supporting 10 MW demand. 2) Provide a ventilation route capable of exhausting 200,000 Cubic Feet per Minute though the spray chamber.	All Threshold KPPs

Performance Measure	Threshold	Objective
	3) Complete the Ross Shaft brow enlargement and the excavation of all ancillary spaces and access drifts to create a minimum of 71,500 Gross Square Feet (GSF). 4) Complete the excavation of three caverns with the following volumes including all required ground support, shotcrete placement and networked geotechnical monitoring system: a. North cavern (102,000 Cubic Yards (CY)) b. South cavern (102,000 CY) c. Central utility cavern (46,800 CY) 5) Provide a minimum of 170,000 GSF of concrete floor.	
Far Site Conventional Facilities – Buildings and Site Infrastructure (FSCF-BSI)	1) 1200A at 12.47kV power capacity installed in the CUC (sufficient to support four cryostats/detectors). 2) Power distribution at 120/240V, 480V, and 4160V installed at the 4850L to support two detectors, along with all general use power installed at the 4850L and 4910L. 3) Heat rejection cooling tower installed with 2,000-ton (7 MW) rejection capacity (sufficient to support four detectors. 4) 1,600 ton (5.6 MW) chilled water capacity installed to support two detectors and all general cooling loads at the 4850L.	Expanded power distribution and chilled water systems installed to support four cryostats/detectors. This adds 400 tons (1.4 MW) for a total of 2000 tons (7 MW) of chilled water capacity and transformers/power distribution specific to detectors 3 and 4.
Far Detector – Horizontal Drift Detector Components	Fabricate, deliver to SURF, and install the deliverables as specified in the detailed FDC subproject Threshold KPPs for the Horizontal Drift detector providing coverage for at least 95 percent of the detector volume. This includes: the Anode Plane Assemblies, High Voltage field cage structures and Cathode Planes; TPC electronics; components of the Photon Detector System; and purity monitors for one horizontal-drift Liquid Argon (LAr) TPC. Deliver and install the corresponding detector parts, DAQ servers and services outside the cryostat.	Fabricate, deliver to SURF, and install the deliverables as specified in the detailed FDC subproject Objective KPPs for the Horizontal Drift Detector providing full (100 percent) coverage.
Far Detector – Vertical Drift Detector Components	Fabricate, deliver to SURF, and install the deliverables as specified in the detailed FDC subproject threshold KPPs for the Vertical Drift Detector providing coverage for at least 95 percent of the detector volume. This includes: the Charge Readout Planes for the bottom drift volume, High Voltage field cage structures; electronics for the readout of the bottom charge readout planes; components of the Photon Detector System; and purity monitors for one vertical-drift LAr TPC. Deliver and install the corresponding detector parts, DAQ servers and services outside the cryostat.	Fabricate, deliver to SURF, and install the deliverables specified in the detailed FDC subproject Objective KPPs for the Vertical Drift Detector providing full (100 percent) coverage.

Performance Measure	Threshold	Objective
Far Site Cryogenic Infrastructure	1) Design, procure, install and commission the Nitrogen refrigeration system capable of providing 300 kW cooling capacity to the detector modules. 2) Install and commission the surface receiving facilities for the cryogenic liquids. 3) Install and commission the Argon purification, circulation, regeneration and Argon condensers system for two cryostat detectors. 4) Install and test internal cryogenics for Gaseous Argon/LAr distribution. 5) Provide operational readiness clearance for the operation of the cryogenic systems and for filling with LAr the first two cryostats. 6) Set up the contract with options to procure the necessary amount of LAr for each of the Far Detectors (Horizontal and Vertical drift) LAr TPC modules per FDC Requirements. Commit funds for the procurement of 30 percent of the LAr for each of the two far detectors.	In addition to the threshold KPPs: 1) Commit the funds for the procurement of the remaining 70 percent of the LAr for the two Far detectors. 2) Procure the required Liquid Xenon (10 ppm) required to improve light collection efficiency for the Vertical Drift Detector.

Performance Measure	Threshold	Objective
Far Site Far Detector Integration* *Note that the KPPs defined for Far Detector Horizontal and Vertical Detector Components and the Cryogenic Infrastructure are pre-requisites to the KPPs for the Far Detector Integration.	1) Prior to the final closure of the cryostat, demonstrate, at room temperature, continuous readout of the TPC electronics and of the photon detector system through the data acquisition system for one week with a live time of at least 50 percent and a minimum of 95 percent fully functional electronic readout channels. 2) Close both cryostats in preparation for purging/filling Purge and fill both cryostats to minimum level (30 percent) and demonstrate LAr recirculation and purification.	1) Prior to the final closure of the two cryostats, demonstrate, at room temperature, continuous readout of the TPC electronics and of the photon detector system through the data acquisition system for one week with a live time of at least 90 percent and a minimum of 99 percent fully functional electronic readout channels. 2) Purge and fill both cryostats to maximum level (100 percent) and demonstrate LAr recirculation and purification. 3) Establish an electrical field in the drift volume of at least 250 V/cm with a live time of at least 80 percent. 4) Demonstrate that all the channels can continue to be read out in each detector module after the cryostats are filled. Observe signals from cosmic ray tracks with the charge and light detection systems. Demonstrate coincidences between TPC and photon detector signals. Perform measurements of the electron lifetime in LAr using the purity monitors for each of the two cryostats.

Performance Measure	Threshold	Objective
Near Site Conventional Facilities and Beamline (NSCF+B)	1) Primary Beamline: • Conventional facilities and beamline constructed to be capable of 2.4MW operation • Beamline under vacuum with all magnets ramped on 120 GeV operations cycle 2) Neutrino Beamline: • Conventional facilities constructed to support 2.4MW proton beam • Target Hall to support a three-horn focusing system optimized for oscillation science • Decay Region minimum 635 ft in length • Shielding and absorber constructed to support 2.4MW operation • Horns, target, radioactive water system, and beam windows fabricated for 1.2 MW proton beam • Operation of target pile, decay pipe, horn, and absorber cooling systems • Two-horn focusing system pulsed in situ to 240kA • Target cooling system flow demonstrated in situ • Target shield pile sealed to outside air 3) ND Complex: • Cavern space with minimum volume of 700,000 cubic ft • Power infrastructure has a capacity of 2,700kVA running load • Cooling infrastructure includes a minimum of 650 tons of chiller capacity	1) Primary Beamline: • 120GeV protons delivered to the absorber with the target removed 2) Neutrino Beamline: • Three horns pulsed in situ to 300kA • Muons observed downstream of absorber 3) Near Detector Complex • All threshold KPPs
Near Detector	Hardware installed for a neutrino beam monitor capable of detecting a 1 percent shift in the horn current within a period of one week of nominal 1.2MW exposure with performance verified by simulation.	Using parts and components provided by both the project and in-kind by international partners: 1) Deliver a LAr Time Projection Chamber (TPC) detector system capable of measuring neutrino interactions in argon at the near site with similar performance as specified for the Far Detector to directly support long-baseline physics measurements in the DUNE FD 2) Ability to move the LAr TPC near detector system to an off-axis location 3) Ability to monitor the on-axis neutrino beam when the LAr TPC near detector system is off-axis

3. **Financial Schedule**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Estimated Cost (TEC)				
Design (TEC)				
Prior Years	443,713	443,713	391,688	—
FY 2023	107,501	107,501	61,004	—
FY 2024	9,570	9,570	106,852	—
FY 2025	8,910	8,910	10,150	—
Total, Design (TEC)	**569,694**	**569,694**	**569,694**	**—**
Construction (TEC)				
Prior Years	411,068	411,068	265,900	—
Prior Years - IRA Supp.	125,000	125,000	—	—
FY 2023	68,499	68,499	108,156	2,563
FY 2024	241,430	241,430	313,873	122,437
FY 2025	271,090	271,090	248,329	—
Outyears	1,476,554	1,476,554	1,532,383	—
Total, Construction (TEC)	**2,593,641**	**2,593,641**	**2,468,641**	**125,000**
Total Estimated Cost (TEC)				
Prior Years	854,781	854,781	657,588	—
Prior Years - IRA Supp.	125,000	125,000	—	—
FY 2023	176,000	176,000	169,160	2,563
FY 2024	251,000	251,000	420,725	122,437
FY 2025	280,000	280,000	258,479	—
Outyears	1,476,554	1,476,554	1,532,383	—
Total, Total Estimated Cost (TEC)	**3,163,335**	**3,163,335**	**3,038,335**	**125,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Other Project Cost (OPC)			
Prior Years	101,625	101,625	92,481
FY 2023	4,000	4,000	993
FY 2024	4,000	4,000	9,264
FY 2025	–	–	2,497
Outyears	4,040	4,040	8,430

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Other Project Cost (OPC)			
Total, Other Project Cost (OPC)	**113,665**	**113,665**	**113,665**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Project Cost (TPC)				
Prior Years	956,406	956,406	750,069	–
Prior Years - IRA Supp.	125,000	125,000	–	–
FY 2023	180,000	180,000	170,153	2,563
FY 2024	255,000	255,000	429,989	122,437
FY 2025	280,000	280,000	260,976	–
Outyears	1,480,594	1,480,594	1,540,813	–
Total, TPC	**3,277,000**	**3,277,000**	**3,152,000**	**125,000**

Note:
- *Prior years and FY 2023 reflect actual costs; remaining years are cost estimates.*

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	555,102	528,377	**N/A**
Design - Contingency	14,592	22,070	**N/A**
Total, Design (TEC)	**569,694**	**550,447**	**N/A**
Construction	1,362,798	1,344,860	**N/A**
Equipment	571,488	571,488	**N/A**
Construction - Contingency	659,355	700,540	**N/A**
Total, Construction (TEC)	**2,593,641**	**2,616,888**	**N/A**
Total, TEC	**3,163,335**	**3,167,335**	**N/A**
Contingency, TEC	*673,947*	*722,610*	***N/A***
Other Project Cost (OPC)			
R&D	16,000	16,000	**N/A**
Conceptual Planning	44,958	44,958	**N/A**
Conceptual Design	31,977	31,977	**N/A**

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Other OPC Costs	17,840	13,540	**N/A**
OPC - Contingency	2,890	3,190	**N/A**
Total, Except D&D (OPC)	**113,665**	**109,665**	**N/A**
Total, OPC	**113,665**	**109,665**	**N/A**
Contingency, OPC	*2,890*	*3,190*	***N/A***
Total, TPC	**3,277,000**	**3,277,000**	**N/A**
Total, Contingency (TEC+OPC)	***676,837***	***725,800***	***N/A***

Notes:
- *Each subproject will have a validated baseline at the time of each subproject's CD-2 approval.*
- *Construction involves excavation of caverns at SURF, 4,850 ft. below the surface, for technical equipment including particle detectors and cryogenic systems and construction of the housing for the neutrino-production beam line and the near detector.*
- *Technical equipment in the DOE scope, estimated here, will be supplemented by in-kind contributions of additional technical equipment, for the accelerator beam and particle detectors, from non-DOE partners as described in Section 2.*
- *"Other OPC Costs" include execution support costs including electrical power for construction* and equipment installation.

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	979,781	176,000	251,000	—	1,760,554	3,167,335
	OPC	101,625	4,000	4,000	—	40	109,665
	TPC	1,081,406	180,000	255,000	—	1,760,594	3,277,000
FY 2025	TEC	979,781	176,000	251,000	280,000	1,476,554	3,163,335
	OPC	101,625	4,000	4,000	—	4,040	113,665
	TPC	1,081,406	180,000	255,000	280,000	1,480,594	3,277,000

Note:
- *All estimates are preliminary.*

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	4Q FY 2035
Expected Useful Life	20 years
Expected Future Start of D&D of this capital asset	4Q FY 2055

Operations and maintenance funding of this experiment will become part of the existing Fermilab Accelerator Complex Users Facility. Annual related funding estimates include the incremental cost of 20 years of full operation, utilities, maintenance, and repairs with the accelerator beam on. The estimates also include operations and maintenance for the remote site of the large detector. New operations and maintenance estimates were developed in 2022 based on a new study and detailed estimating. Current estimate represents an average annual cost in FY 2022 dollars.

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	**Current Total Estimate**	**Previous Total Estimate**	**Current Total Estimate**
Operations	22,000	22,000	440,000	440,000
Utilities	6,000	6,000	120,000	120,000
Maintenance and Repair	14,000	14,000	280,000	280,000
Total, Operations and Maintenance	42,000	42,000	840,000	840,000

7. D&D Information

The new area being constructed in this project is replacing existing facilities.

	Square Feet
New area being constructed by this project at FNAL	79,100
New area being constructed by this project at Sanford Underground Research Facility (SURF)	185,700
Area of D&D in this project at FNAL	—
Area at FNAL to be transferred, sold, and/or D&D outside the project, including area previously "banked"	79,100
Area of D&D in this project at other sites	—
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously "banked"	185,700
Total area eliminated	—

The new facility square footage estimates are based on the current design and updating the calculation to be consistent with DOE's real estate guidance. New facilities information will be identified and reported in accordance with DOE guidance.

8. Acquisition Approach

The Acquisition Strategy, approved as part of CD-1-RR, documents the acquisition approach. DOE is acquiring design, construction, fabrication, and operation of LBNF through FRA, the M&O contractor responsible for FNAL. FRA and FNAL, through the LBNF Project based at FNAL, is responsible to DOE to manage and complete construction of LBNF at both the near and remote site locations. FRA and FNAL are assigned oversight and management responsibility for execution of the international DUNE research program, to include management of the DOE contributions to DUNE. The basis for this choice and strategy is that:

- FNAL is the site of the only existing neutrino beam facility in the U.S. and, in addition to these facilities, provides a source of existing staff and expertise to be utilized for beamline and detector construction.
- FNAL can best ensure that the design, construction, and installation of key LBNF and DUNE components are coordinated effectively and efficiently with other research activities at FNAL.
- FNAL has a DOE-approved procurement system with established processes and acquisition expertise needed to obtain the necessary components and services to build the scientific hardware, equipment and conventional facilities for the accelerator beamline, and detectors for LBNF and DUNE.
- FNAL has extensive experience in managing complex construction, fabrication, and installation projects involving multiple national laboratories, universities, and other partner institutions, building facilities both on-site and at remote off-site locations.
- FNAL, through the LBNF Project, has established a close working relationship with SURF and the SDSTA, organizations that manage and operate the remote site for the far detector in Lead, South Dakota.

- FNAL has extensive experience with management and participation in international projects and international collaborations, including most recently the LHC and CMS projects at CERN, as well as in the increasingly international neutrino experiments and program.

The LBNF/DUNE-US construction project is a federal, state, private and international partnership. Leading the LBNF/DUNE-US Project, FNAL will collaborate and work with many institutions, including other DOE national laboratories (e.g. BNL, LBNL and SLAC), dozens of universities, foreign research institutions, and the SDSTA. FNAL will be responsible for overall project management, Near Site conventional facilities, and the beamline. FNAL will work with SDSTA to complete the conventional facilities construction at the SURF needed to house and outfit the DUNE far detector. With the DUNE collaboration, FNAL is also responsible for technical and resource coordination to support the DUNE far and near detector design and construction. DOE will be providing in-kind contributions to the DUNE collaboration for detector systems, as agreed upon with the international DUNE collaboration.

International participation in the design, construction, and operation of LBNF and DUNE will be essential because the field of High Energy Physics is international by nature; necessary talent and expertise are globally distributed, and DOE does not have the procurement or technical resources to perform all of the required construction and fabrication work. Contributions from other nations will be predominantly through the delivery of components built in their own countries by their own researchers. DOE negotiates agreements in cooperation with the Department of State on a bilateral basis with all contributing nations to specify their expected contributions and the working relationships during the construction and operation of the experiment.

DOE provides funding for the LBNF/DUNE-US Project directly to FNAL and collaborating DOE national laboratories via approved financial plans, and under management control of the LBNF/DUNE-US Project Office at FNAL, which will also manage and control DOE funding to the combination of university subcontracts and direct fixed-price vendor procurements that are anticipated for the design, fabrication, and installation of LBNF and DUNE technical components. All actions will perform in accordance with DOE approved procurement policies and procedures.

FNAL staff, or by subcontract, temporary staff working directly with FNAL personnel, will perform much of the neutrino beamline component design, fabrication, assembly, and installation. The acquisition approach includes both new procurements based on existing designs, and re-purposed equipment from the Fermilab Accelerator Complex. For some highly specialized components, FNAL will have the Rutherford Appleton Laboratory (RAL) in the United Kingdom design and fabricate the components. RAL is a long-standing FNAL collaborator who has proven experience with such components.

FNAL has chosen the Construction Manager/General Contractor (CM/GC) model to execute the delivery of LBNF conventional facilities at the SURF Far Site. The Laboratory contracted with an architect/engineer (A/E) firm for design of LBNF Far Site conventional facilities at SURF and with a CM/GC subcontractor to manage the construction of LBNF Far Site facilities. FNAL selected this strategy to reduce risk, enhance quality and safety performance, provide a more collaborative approach to construction, and offer the opportunity for reduced cost and shortened construction schedules, via options for the CM/GC to self-perform or competitively bid subcontract award packages. FNAL determined that excavation scope should be openly competed as provided by the subcontract. An excavation subcontract was awarded within budget and excavation construction activities began in FY 2021.

For the LBNF Near Site conventional facilities at FNAL, the laboratory will subcontract with an A/E firm for design and plan to utilize a traditional design-bid-build construction method supported by additional procurements for preconstruction and construction phase services from a professional construction management firm.

For the LBNF Far Site conventional facilities at SURF, DOE entered into a land lease with SDSTA on May 20, 2016, covering the area on which the DOE-funded facilities housing and supporting the LBNF and DUNE detector will be built. The lease and related realty actions provide the framework for DOE and FNAL to construct federally-funded buildings and facilities on non-federal land, and to establish a long-term (multi-decade) arrangement for DOE and FNAL to use SDSTA space to host the DUNE experiment. Modifications and improvements to the SDSTA infrastructure to support the LBNF/DUNE-US project are costed to the project. Repairs and improvements for the overall facility are costed to the cooperative agreement between HEP and SDSTA for general operation of the facility. Protections for DOE's real property interests in these infrastructure tasks are acquired through the lease with SDSTA, contracts, and other agreements such as easements. DOE plans for FNAL to have responsibility for managing and operating the LBNF and DUNE far detector and facilities for a useful lifetime of 20 years and may contract with SDSTA for day-to-day management and maintenance services. At the end of useful life, federal regulations permit transfer of ownership to SDSTA, which is willing to accept ownership as a condition for the lease. FNAL developed an appropriate decommissioning plan prior to lease signing.

Nuclear Physics

Overview

The mission of the Nuclear Physics (NP) program is to explore the nature of matter: its basic constituents and how they interact to form the elements and the properties we observe. Solving this mystery involves discovering, exploring, and understanding all forms of nuclear matter. This understanding benefits society in numerous fields: energy, climate, commerce, medicine, and national security.

Understanding all forms of nuclear matter requires an enormous range of both theoretical approaches and experimental capabilities. Theoretical approaches to further our understanding are based largely on calculations of the interactions of quarks and gluons described by the theory of Quantum Chromodynamics (QCD). Experimental approaches use large accelerators at scientific user facilities to collide particles at nearly the speed of light, producing short-lived forms of nuclear matter for investigation.

Highlights of the FY 2025 Request

The FY 2025 Request for $833.1 million is an increase of $27.9 million over the FY 2023 Enacted and supports forefront fundamental nuclear physics research; operations, maintenance, and upgrades of scientific user facilities; and projects.

Research

NP is the primary steward of the nation's fundamental nuclear physics research portfolio, providing approximately 95 percent of the U.S. investment in this area. Primary fundamental research thrusts include:

- Characterizing the quark-gluon plasma at the Relativistic Heavy Ion Collider (RHIC) and the Large Hadron Collider (LHC)
- Exploring the fundamental structure of nucleons at the sub-femtometer scale at the Continuous Electron Bean Accelerator Facility (CEBAF) and the future Electron-Ion Collider (EIC)
- Probing the limits of nuclear existence and the process for heavy element production in stars at the Facility for Rare Isotope Beams (FRIB) and the Argonne Tandem Linac Accelerator System (ATLAS)
- Discovery of whether the neutrino is its own anti-particle via neutrino-less double beta decay (NLDBD)
- Research on the strong force in many-body systems leading to precision predictions from QCD of nuclear properties and nuclear reactions via Scientific Discovery Through Advanced Computing (SciDAC)
- Curation of reliable, accurate Nuclear Data for basic nuclear research and nuclear technologies
- Niche capabilities and unique "hands-on" experiences in nuclear science at NP University Centers of Excellence
- Participation in the RENEW and FAIR initiatives to broaden participation and inclusion in NP research

Facility Operations

Funding supports the NP scientific user facilities at roughly 90 percent optimal funding, enabling world-class science:

- RHIC operates 3,100 hours for the super Pioneering High Energy Nuclear Interaction eXperiment (sPHENIX).
- CEBAF operates 3,170 hours for the highest priority 12 GeV experiments.
- ATLAS operates 5,900 hours for compelling research in nuclear structure and astrophysics.
- FRIB operates 3,700 hours discovering and characterizing nuclei at the extremes of the nuclear chart.

Projects

The Request for Construction and Major Items of Equipment (MIEs) includes:

- Preliminary engineering and design (PED) for the EIC, which will provide unprecedented ability to x-ray the proton and discover how the mass of everyday objects is dynamically generated by the interaction of quark and gluon fields inside protons and neutrons. The EIC was the highest priority for facility construction in the 2023 Long Range Plan for Nuclear Physics (LRP) and will maintain U.S. leadership in nuclear physics and accelerator technology.
- Support for management and PED for the Ton Scale NLDBD (TS-NLDBD) program. TS-NLDBD will investigate whether the neutrino is its own anti-particle by searching for a rare nuclear decay predicted to happen once in 10^{28} years and was identified as the highest priority for experiment construction in the 2023 NSAC LRP.
- Continuation of the High Rigidity Spectrometer (HRS) research project at FRIB to maximize the rate of rare neutron-rich nuclei of central importance for understanding the synthesis of heavy elements in cosmic events.

Nuclear Physics
Funding

	(dollars in thousands)			
	FY 2023 Enacted	**FY 2024 Annualized CR**	**FY 2025 Request**	**FY 2025 Request vs FY 2023 Enacted**
Nuclear Physics				
Medium Energy, Research	59,083	50,055	50,592	-8,491
Medium Energy, Operations	149,834	138,620	147,244	-2,590
Total, Medium Energy Physics	**208,917**	**188,675**	**197,836**	**-11,081**
Heavy Ion, Research	46,149	45,474	43,349	-2,800
Heavy Ion, Operations	182,087	166,993	181,126	-961
Heavy Ion, Projects	20,000	2,850	2,850	-17,150
Total, Heavy Ion Physics	**248,236**	**215,317**	**227,325**	**-20,911**
Low Energy, Research	77,651	75,159	72,334	-5,317
Low Energy, Operations	128,579	120,401	135,646	+7,067
Low Energy, Projects	23,940	9,259	5,259	-18,681
Total, Low Energy Physics	**230,170**	**204,819**	**213,239**	**-16,931**
Theory, Research	67,873	67,392	84,691	+16,818
Total, Nuclear Theory	**67,873**	**67,392**	**84,691**	**+16,818**
Subtotal, Nuclear Physics	**755,196**	**676,203**	**723,091**	**-32,105**
Construction				
20-SC-52 Electron Ion Collider (EIC), BNL	50,000	95,000	110,000	+60,000
Subtotal, Construction	**50,000**	**95,000**	**110,000**	**+60,000**
Total, Nuclear Physics	**805,196**	**771,203**	**833,091**	**+27,895**

SBIR/STTR funding:
- FY 2023 Enacted: SBIR $8,336,000 and STTR $1,173,000
- FY 2024 Annualized CR: SBIR $7,061,000 and STTR $993,000
- FY 2025 Request: SBIR $7,378,000 and STTR $1,037,000

Nuclear Physics
Explanation of Major Changes

	(dollars in thousands) FY 2025 Request vs FY 2023 Enacted
Medium Energy Physics The Request provides support for the CEBAF accelerator complex to support 3,170 operating hours (89 percent optimal funding). The Request includes support to participate in the SC initiatives for QIS, AI/ML, and Microelectronics.	**-11,081**
Heavy Ion Physics The Request provides funding for the RHIC accelerator complex for a 3,100 hour run (95 percent optimal funding). The Request supports science with sPHENIX, which studies high rate jets of particles at RHIC. Funding supports heavy ion nuclear physics at universities and national laboratories. The Request includes support the SC initiatives for QIS and AI/ML. The Request continues other project costs (OPC) for the EIC, which will enable scientists to play a leading role in R&D and the development of scientific instrumentation and accelerator components for the EIC. The Request also supports EPSCoR implementation grants and early career awards in EPSCoR jurisdictions.	**-20,911**
Low Energy Physics The Request provides support for operations of two low energy user facilities: the ATLAS facility, which operates for 5,900 hours (90 percent optimal funding), and FRIB, which provides beam time for 3,700 hours (90 percent of optimal funding). The Request sustains operations of the 88-Inch Cyclotron for a limited in-house nuclear science program and an electronics irradiation capability. Funding supports nuclear structure and astrophysics at universities and national laboratories. Funding continues for the HRS to exploit the fast beam capabilities at FRIB and for the TSNLDBD experiment.	**-16,931**
Nuclear Theory Funding supports theory research efforts at laboratories and universities, the U.S. Nuclear Data Program, specialized Lattice QCD computing hardware at Thomas Jefferson National Accelerator Facility (TJNAF), and participation in the SciDAC program. The Request supports QIS, quantum computing, and AI/ML. Increased funding supports the RENEW initiative to provide undergraduate and graduate training opportunities for students and academic institutions not currently well represented in the U.S. science and technology (S&T) ecosystem, including a RENEW graduate fellowship. The FAIR initiative increases to provide focused investment on enhancing emerging research institutions, underserved communities, and Historically Black Colleges and Universities (HBCUs), and Minority Serving Institutions (MSIs) communities.	**+16,818**
Construction The Request provides funding for the EIC to continue Project Engineering and Design activities and execute long-lead procurements.	**+60,000**
Total, Nuclear Physics	**+27,895**

Basic and Applied R&D Coordination

The NP mission supports the pursuit of unique opportunities for R&D integration and coordination with other DOE Program Offices, Federal agencies, and non-Federal entities, including coordination on forefront computing resources and technical expertise through the SciDAC projects and Lattice QCD research (ASCR and HEP); cross-section and decay data relevant clean energy initiatives, materials science, and nuclear forensics through the U.S. Nuclear Data Program (Federal Bureau of Investigation [FBI], National Nuclear Security Administration [NNSA], Nuclear Energy [NE], FES and BES); capabilities and techniques to test electronics for radiation sensitivity (NASA and DOD); technological advances relevant to clean energy and the development of advanced fuel cycles for next generation nuclear reactors (NE); advanced cost-effective accelerator technology and particle detection techniques for medical diagnostics and treatment (National Institutes of Health [NIH]); accelerator research and enhancing U.S.-based supply chains for critical accelerator technologies (ARDAP); and research in developing neutron, gamma, and particle beam sources with applications in cargo screening (NNSA, DHS, and the FBI).

Program Accomplishments

Shape-shifting nuclei illuminate nature's whimsy

Using the new Facility for Rare Isotope Beams, researchers have made more than 210 rare-isotope beams for forty-six experiments involving 177 students, across 180 institutions in 50 countries. One exciting example is an isomer of sodium 32 (^{32}Na) —a fleeting variant of the ^{32}Na nucleus with a half-life of only 24 microseconds having the exact same number of protons and neutrons as ^{32}Na — but different internal energy states. Isomers are interesting in general for their potential application in creating nuclear clocks or nuclear batteries. But this isomer is even more interesting because it exists right at the nexus of three nuclear theories which all purport to explain its origin: one theory suggests the ^{32}Na isomer owes its existence to its nature as a shape shifter— a nucleus which can change spontaneously e.g. from being oblate (like a squashed basketball) to prolate (like an American football); one theory predicts that with ten extra neutrons beyond the normal number of eleven neutrons in a stable sodium nucleus (^{22}Na), the shell structure which protons and neutrons ordinarily arrange themselves has become deformed; and one theory suggests this isomer is something altogether different— a highly excited spherical super version of "everyday" ^{32}Na. Discovering which theory comes closest is currently the subject of intense research to systematically uncover the whimsy with which nature allows neutrons and protons to form nuclei, thereby creating new knowledge and technology to advance non-proliferation, nuclear medicine, space exploration, and the discovery of new physics beyond our current understanding.

New tools to discover nature's recipe for quark-gluon soup

It's easy to imagine that when the universe was microseconds old and extremely hot, things looked a bit different. There were no protons and neutrons but only a soup of quarks and gluons now known as a quark-gluon plasma (QGP). Scientists have proven the QGP exists, and they know it exhibits spectacular phenomena. For example, a thin slice of quark-gluon plasma of order a femtometer (.000000000000001 meter) thick can "stop" a quark or gluon attempting to "punch through it" with more than 100 giga-electron-volts of energy. How does that happen? Good question. And one which scientists are now tooled up to answer with the completion and successful commissioning of the sPHENIX detector at RHIC. Unlike previous detectors, advanced strategies for streaming readout and on-the-fly analysis will allow sPHENIX to acquire data on the above phenomenon, known as "jet quenching" at a pace never before achieved, affording unprecedented precision in comparison with "control data" where the QGP is known not to be produced. In addition, scientists have developed new "pop-up thermometers" to tell the precise temperature of the quark-gluon soup under various conditions by observing the sequential dissolution of bound states of bottom & antibottom quarks called the Upsilon family of states. The exciting stage is now set to zero in on precisely how nature does what it does when the temperature gets to be "12 billion Kelvin in the shade".

Mystery of mysteries: the nature of the neutrino

We have all answered the question before, "which one of these does not belong with the others". When it comes to subatomic particles, the answer would have to be the neutrino. Despite the fact there are trillions passing through our bodies every second, we have no idea why its mass is so small compared with other particles. In fact, we know its mass is small but not how small, and beyond that, the fact it has a mass at all is currently not explained by accepted particle theory. Those questions, as well as whether the neutrino is its own anti-particle and might account for why there is more matter than ani-matter in the universe are the target of an ongoing international campaign to search for a rare decay called neutrinoless double beta decay— the decay of a nucleus in which two neutrons transform themselves into two protons and two electrons (charge has to be conserved)—but no neutrinos. That can only happen if the neutrino is its own antiparticle.

Recently, the Majorana Demonstrator experiment carried out at the Sanford Underground Research Facility (SURF) demonstrated that up to a half-life limit of 8.3 X 10^{25} years, no such decay is observed, setting a new bar for the follow-up global campaign which aims for a limit 1000 times more stringent. One next generation precursor experiment, LEGEND-200, is already underway. It is a collaboration of scientists from Germany, Italy, and the United States urgently focused on demonstrating viability to meet the next challenge.

A New Spin on Deuterium-Tritium Fusion

Scientists at Lawrence Livermore National Laboratory and Institut de Physique Nucléaire d'Orsay (IPN Orsay) in France have recently performed nuclear theory calculations from first principles to predict the rate of nuclear fusion of deuterium and tritium in a spin-polarized plasma. These calculations accurately reproduce the previously measured cross-sections for un-polarized fusion which demonstrates that the theory is accurate. The new calculations have important implications for the exploration of novel avenues to advance the science and commercialization of nuclear fusion energy because, if fusion fuels can be made in a spin-polarized manner, the efficiency of fusion energy systems— a major factor in their viability as a commercial power source—can be made much higher, while simultaneously using less materials to gain the same overall output.

Nuclear Physics
Medium Energy Physics

Description

The Medium Energy Physics subprogram focuses primarily on experimental tests of the theory of the strong interaction, known as Quantum Chromodynamics (QCD). According to QCD, all observed nuclear particles, collectively known as hadrons, arise from the strong interaction of quarks, antiquarks, and gluons. The protons and neutrons inside nuclei are the best-known examples of hadrons. QCD, although difficult to solve computationally, predicts what hadrons exist in nature, and how they interact and decay. Specific questions addressed within this subprogram include:

- What is the internal landscape of the protons and neutrons (collectively known as nucleons)?
- What does QCD predict for the properties of strongly interacting matter?
- What is the role of gluons and gluon self-interactions in nucleons and nuclei?

Scientists use various experimental approaches to determine the distribution of up, down, and strange quarks, their antiquarks, and gluons within protons and neutrons, as well as clarifying the role of gluons in confining the quarks and antiquarks within hadrons. Experiments that scatter electrons off protons, neutrons and nuclei are used to elucidate the effects of the quark and gluon spins within nucleons, and the effect of the nuclear medium on the quarks and gluons. The subprogram also supports experimental searches for higher-mass "excited states" and exotic hadrons predicted by QCD, as well as studies of their various production mechanisms and decay properties.

The Medium Energy subprogram supports research at the Continuous Electron Beam Accelerator Facility (CEBAF) at Thomas Jefferson National Accelerator Facility (TJNAF). In addition, the subprogram provides support for spin physics research at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL), which is the only collider in the world that can provide polarized proton beams.

CEBAF provides high quality beams of polarized electrons that allow scientists to extract information on the quark and gluon structure of protons and neutrons from measurements of how the electrons scatter when they collide with nuclei. CEBAF also uses highly-polarized electrons to make very challenging precision measurements that may reveal processes that violate a fundamental symmetry of nature, called parity, in order to search for physics beyond what is currently described by the Standard Model of particle physics. These capabilities are unique in the world. Research at RHIC using colliding beams of spin-polarized protons, is providing information on the spin of the proton in a kinematic range complementary to that at CEBAF to extend present knowledge beyond the kinematic boundaries accessible at CEBAF alone Complementary, focused experiments that require different capabilities can be conducted at the High Intensity Gamma-Ray Source (HIGS) at the Triangle Universities Nuclear Laboratory (TUNL), a University Center of Excellence; Fermi National Accelerator Laboratory (FNAL); European laboratories; and elsewhere. The Research and Engineering Center (REC) of the Massachusetts Institute of Technology (MIT) has specialized infrastructure used to develop and fabricate advanced instrumentation and accelerator equipment for the nuclear physics community.

A high scientific priority for this community is addressing an outstanding grand challenge question of modern physics: how the fundamental properties of the proton such as its mass and spin are dynamically generated by the extraordinarily strong color fields resulting from dense systems of gluons in nucleons and nuclei. The EIC, to be located at BNL, plans to address this science. Scientists and accelerator physicists from the Medium Energy subprogram are strongly engaged and play significant leadership roles in the development of the scientific agenda and implementation of the EIC.

Transformative accelerator R&D efforts advanced approaches in SRF technology and accelerator science aimed at improving the operations of existing facilities and developing next-generation facilities for nuclear physics. Nuclear physicists participate in activities related to quantum information science (QIS) and quantum computing (QC), in coordination with other SC research programs. NP-specific efforts include R&D on quantum sensors to enable precision NP measurements, development of quantum sensors based on atomic-nuclear interactions, and development of quantum computing algorithms applied to quantum mechanical systems and NP topical problems. Scientists develop cutting-edge techniques based on artificial intelligence and machine learning (AI/ML) of relevance to nuclear science research and accelerator facility operations. Scientists participate in the SC initiative on microelectronics research and development, emphasizing unique microelectronics that survive in cryogenic and high radiation environments.

The Request also continues support for honoraria for awards, including the Enrico Fermi Awards and the Ernest Orlando Lawrence Awards. NP supports RENEW, expanding targeted efforts, including a RENEW graduate fellowship, to broaden participation in underserved communities and advance equity, and inclusion in SC-sponsored research; and FAIR, improving capability in emerging research institutions, HBCUs and MSIs to perform and propose competitive research and building beneficial relationships with DOE national laboratories and facilities.

Research

The Research activity supports high priority research at universities, TJNAF, BNL, ANL, LANL, and LBNL and carries out high priority experiments at CEBAF, RHIC, and elsewhere. Scientists conduct research to advance knowledge and to identify and develop the science opportunities and goals for next generation instrumentation and facilities, primarily for CEBAF and the EIC. Scientists participate in the development and implementation of targeted advanced instrumentation, including state-of-the-art detectors for experiments that may also have application in areas such as medical imaging instrumentation in coordination with NIH and homeland security. Scientists are engaged in experimental QIS research. Researchers participate in the development of scientific and experimental plans for the EIC.

TJNAF scientists and university groups play leadership roles in new experiments in the 12 GeV scientific program, and are engaged in commissioning experiments, instrumentation development, and data taking. Scientists at several national laboratories are engaged in planning for the construction of the EIC and its scientific instrumentation. ANL researchers continue precise measurements of the electric dipole moments of laser-trapped atoms as part of an intensive world-wide effort to set limits on QCD parameters and contribute to the search for possible explanations of the excess of matter over antimatter in the universe. LANL scientists continue to lead an experiment at Fermi lab to study whether anti-quarks are in orbit about the spin axis of the proton. Research groups at BNL and LBNL play leading roles in RHIC data analysis critical for determining the spin structure of the proton. Researchers at TJNAF are developing high current, polarized electron sources for next generation NP facilities.

Accelerator R&D research at universities and laboratories advance technology and core competencies essential for improving operations of the complex user facilities or developing new facilities within the NP program, including the development of transformative technology for the Nation such as, efficient, and cost-effective cryogenic systems, high gradient SRF cavities, and novel in-situ plasma processing of cryomodules. Researchers are also engaged in developing ML techniques focused on improving efficiencies of accelerator operations.

Operations

The Operations activity provides accelerator operations funding for CEBAF, which boasts unique features of continuous wave polarized beam to four experimental halls and serves over 1,800 U.S. and international users. Funding for this activity supports a team of accelerator physicists at TJNAF that operate CEBAF, as well as for power costs of operations and maintenance of the 12 GeV CEBAF. The highest priority investments in cryomodule refurbishment, spares and critical maintenance are supported to address and improve machine performance and reliability. The Request supports high priority accelerator improvements, and high priority capital equipment for research and facility instrumentation. Targeted efforts in developing advances in SRF technology to improve operations of the existing machine continue. The core competency in SRF technology plays a crucial role in supporting DOE projects and facility operations outside of nuclear physics and has broad applications from medicine to homeland security. TJNAF also has developed award-winning cryogenics techniques that have led to more cost-effective operations at TJNAF and several other SC facilities; their cryogenics expertise benefitted several SC superconducting accelerator projects. TJNAF accelerator physicists help train the next generation of accelerator physicists, enabled in part by a close partnership with nearby universities and other institutions with accelerator physics expertise. Accelerator scientists play critical roles in the design development of the EIC. The subprogram provides Experimental Support for scientific and technical staff, as well as for critical materials and supplies needed for the implementation, integration, assembly, and operation of the large and complex CEBAF experiments.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Medium Energy Physics	**$208,917**	**$197,836**	**-$11,081**
Research	$59,083	$50,592	-$8,491
Funding continues to support core research. Scientists, resident at TJNAF, RHIC, universities, and other national laboratories, will participate in high priority experiments to acquire data; develop, implement, and maintain scientific instrumentation; analyze data and publish experimental results; and train students in nuclear science and accelerator science. Funding supports analysis of RHIC polarized proton beam data to learn more about the origin of the proton's spin. Funding supports the development of detector design to be used at the EIC and further develop the scientific program. Funding continues to support researchers to pursue transformative accelerator science to improve operations of current and future NP facilities including applications of AI/ML. Research on Microelectronics is continued to study detector materials, devices, advances in front-end electronics, and integrated sensor/processor architectures. Scientists conduct research on quantum sensors to enable precision NP measurements, development of quantum sensors based on atomic-nuclear interactions. Funding supports the Accelerate Innovations in Emerging Technologies (Accelerate) initiative.		The Request will continue to support core research. Scientists, resident at TJNAF, RHIC, universities, and other national laboratories, will participate in high priority experiments to acquire data; develop, implement, and maintain scientific instrumentation; analyze data and publish experimental results; and train students in nuclear science and accelerator science. The Request will support continued analysis of RHIC polarized proton beam data to learn more about the origin of the proton's spin. The Request will support the development of detector design to be used at the EIC and further develop the scientific program. The Request will continue to support researchers to pursue transformative accelerator science to improve operations of current and future NP facilities including applications of AI/ML. Research on Microelectronics will continue to study detector materials, devices, advances in front-end electronics, and integrated sensor/processor architectures. Scientists will conduct research on quantum sensors to enable precision NP measurements, development of quantum sensors based on atomic-nuclear interactions.	The Request will support high priority core scientific workforce at universities and national laboratories conducting research related to CEBAF, RHIC, EIC, and other facilities.

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Operations	$149,834	$147,244	-$2,590
Funding for operations of the CEBAF facility supports the continuation of the high priority experiments in the 12 GeV science program. Funding provides 4,100 operational hours (96 percent optimal funding) for research, tuning, and beam studies. Funding supports CEBAF operations, including mission readiness of the accelerator, all power and consumables of the site, cryogenics plant, activities to reduce helium consumption, activities to improve accelerator performance and reliability, high priority facility and instrumentation capital equipment, high priority accelerator improvement and GPP projects, and the key computing capabilities for data taking and analysis. Funding supports maintenance of critical core competencies and accelerator scientists, engineers, and technicians, and operations staff. Funding supports targeted facility capital equipment and accelerator improvements to modernize SRF equipment. Lab GPP investments advance the most urgent components of the Campus Strategy for infrastructure. Funding also supports the participation of accelerator scientists in accelerator R&D activities, including those for the EIC.		The Request for operations of the CEBAF facility will support the continuation of the high priority experiments in the 12 GeV science program. The Request will provide 3,170 operational hours (89 percent optimal funding) for research, beam development, and beam studies. The Request will support CEBAF operations, including mission readiness of the accelerator, all power and consumables of the site, cryogenics plant, activities to reduce helium consumption, activities to improve accelerator performance and reliability, high priority facility and instrumentation capital equipment, high priority accelerator improvement and GPP projects, and the key computing capabilities for data taking and analysis. The Request will support maintenance of critical core competencies and accelerator scientists, engineers, and technicians, and operations staff. The Request will support targeted facility capital equipment and accelerator improvements to modernize SRF equipment. Lab GPP investments will advance the most urgent components of the Campus Strategy for infrastructure. The Request will support the participation of accelerator scientists in accelerator R&D activities, including those for the EIC.	The decrease in funding will support the highest priority equipment and efforts to improve CEBAF reliability and performance.

Note:

- *Funding for the subprogram above, includes 3.65 percent of research and development (R&D) funding for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, excluding facility operations.*

Nuclear Physics
Heavy Ion Physics

Description

The Heavy Ion Physics subprogram focuses on studies of nuclear matter at extremely high densities and temperatures, directed primarily at answering overarching questions in nuclear physics, including:

- What are the phases of strongly interacting matter, and what roles do they play in the cosmos?
- What governs the transition of quarks and gluons into pions and nucleons?
- What determines the key features of QCD and their relation to the nature of gravity and space-time?

At the Relativistic Heavy Ion Collider (RHIC), scientists continue to pioneer the study of condensed quark-gluon matter at the extreme temperatures, characteristic of the infant universe. With careful measurements, scientists are accumulating data that offer insights into the processes early in the creation of the universe, and how protons, neutrons, and other bits of normal matter developed from that plasma. Important avenues of investigation are directed at learning more about the physical characteristics of the QGP including exploring the energy loss mechanism for quarks and gluons traversing the plasma, determining the speed of sound in the plasma, establishing the threshold conditions (minimum nucleus mass and energy) under which the plasma can be formed, and discovering whether a critical point exists demonstrating a first order phase transition between normal nuclear matter and the QGP. RHIC places heavy ion research at the frontier of discovery in nuclear physics and the facility has roughly 1,000 users. Scientists exploit enhancements to the Solenoid Tracker at RHIC (STAR) detector and the super Pioneering High Energy Nuclear Interaction eXperiment (sPHENIX) detector.

A high scientific priority for the U.S. nuclear science community has been understanding how the fundamental properties of the proton such as its mass and spin are dynamically generated. The answer to this question is key to addressing an outstanding grand challenge problem of modern physics: how QCD, the theory of the strong force that explains all strongly interacting matter in terms of points-like quarks interacting via the exchange of gluons, acts in detail to generate the “macroscopic” properties of protons and neutrons. In 2018, a National Academies study gave a strong endorsement to a U.S.-based EIC, and BNL is partnering with TJNAF to design and establish the EIC at BNL. Scientists and accelerator physicists from the Heavy Ion and the Medium Energy sub-programs are partnering to advance the EIC, both playing significant leadership roles in the development of the scientific agenda and implementation of the EIC.

Over the course of the construction and implementation of the EIC, RHIC operations funding will decrease as scientific staff, engineers and technicians move from RHIC operations to the EIC project. These individuals represent the scientific and technical workforce that are essential to the operations of a complex facility like RHIC and eventually, the EIC. They have critical core competencies in collider operations that cannot easily be replaced; their support is embedded in the EIC total project cost, and they represent the core facility operations force of RHIC and the EIC. Throughout the EIC project, the temporary reprioritization of funds from the collider facility operations budget to the construction budget will reduce the amount of “new funds” needed to implement the EIC, enabling a cost-effective path forward to the implementation of this world-leading facility.

Scientists working in Heavy Ion physics leverage discovery opportunities in sensing, simulation, and computing at the intersections of nuclear physics and QIS. Core competencies exist at NP facilities in the areas of beam and collider physics, hadron beam cooling, high field superconducting magnets, SRF, and ion source technologies. AI/ML applications are pursued to optimize operation of the complex accelerators and detectors at user facilities in the NP program. Accelerator scientists also pursue accelerator science aimed at improving the operations of existing facilities. The objectives of the RENEW and FAIR Initiatives are pursued within the Heavy Ion subprogram.

Collaboration at the LHC at CERN provides U.S. researchers the opportunity to investigate states of matter under substantially different initial conditions than those provided by RHIC. Data collected by the A Large Ion Collider Experiment (ALICE), Compact Muon Solenoid (CMS), and ATLAS detectors confirm that the QGP discovered at RHIC is also seen at the higher energy, and comparisons of results from LHC to those from RHIC have led to important new insights.

Research
This activity supports high priority research at universities and at BNL, LBNL, LANL, and Oak Ridge National Laboratory (ORNL) to participate in efforts at RHIC and the LHC. NP fully supports U.S. commitments to the LHC "common funds," fees based on the level of U.S. scientist participation in the LHC program and the use of LHC computing capabilities. U.S. scientists work with their international peers in developing and implementing upgrades to the LHC scientific instrumentation. One such proposed upgrade is the CMS minimum ionizing particle timing detector (MTD) to enhance particle identification. Heavy Ion research also supports the NQISRCs in partnership with the other SC programs.

The university and national laboratory research groups support personnel and graduate students for taking data within the RHIC heavy ion program, analyzing data, publishing results, developing, and implementing scientific equipment, and planning for future experiments. BNL, LBNL, and ORNL provide computing infrastructure for petabyte-scale data analysis and state-of-the-art facilities for detector and instrument development. Scientists participate in the development of a world-leading scientific program for the future EIC.

Researchers engage in transformative accelerator R&D efforts, including advancements in ion source developments, SRF technology, and hadron beam cooling. Scientists develop cutting-edge techniques based on AI/ML of relevance to nuclear science research, accelerator facility operations and automated machine operations. Additionally, NP is supporting technical development at the intersections between real-time ML and control and the optimization of accelerator systems operations and detector design using AI/ML models.

This subprogram supports the DOE Established Program to Stimulate Competitive Research (EPSCoR), which funds research in states and territories with historically lower levels of Federal academic research funding. In FY 2025, the EPSCoR program will focus on EPSCoR implementation awards for development of research capacity and infrastructure, including equipment, for competitive research in EPSCoR jurisdictions, and continued support of early career awards.

Operations
The Heavy Ion Operations activity supports the operations and power costs of the RHIC accelerator complex at BNL. Staff provides key experimental support, including operation of the scientific equipment associated with the RHIC program. The Request will support high priority capital equipment and accelerator improvement projects at RHIC to promote enhanced and robust operations, such as upgrades to key accelerator infrastructure that will eventually be repurposed for operation of EIC. sPHENIX is the key instrument for the last RHIC data taking campaign and enables scientists to study how the near-perfect QGP liquid arises from the strongly interacting quarks and gluons from which it is formed.

Funding for RHIC operations continues to be reprioritized to EIC as scientific staff and experienced accelerator collider engineers and technicians move from RHIC operations to the EIC project. These individuals represent the scientific and technical workforce that are essential to the operations of a complex facility like RHIC and eventually, the EIC. They have critical core competencies in collider operations that cannot easily be replaced. The temporary reprioritization of funds from the collider facility operations budget to the construction budget will prioritize funding needed to implement the EIC, enabling a cost-effective path forward to the implementation of this world-leading facility.

RHIC operations allow for symbiotic, parallel, cost-effective operations of the Brookhaven Linac Isotope Producer Facility (BLIP), supported by the DOE Isotope Program to produce research and commercial isotopes critically needed by the Nation, and of the NASA Space Radiation Laboratory Program supported by NASA for the study of space radiation effects applicable to human space flight as well as electronics.

Projects
Other project costs (OPC) for the EIC support scientists and accelerator physicists to advance the conceptual design and conduct accelerator and detector R&D. Integration of laboratory core competencies and participation from across the national laboratory complex and universities continues. Accelerator and detector R&D focuses on reduction of technical risks and value engineering.

Nuclear Physics
Heavy Ion Physics

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Heavy Ion Physics	**$248,236**	**$227,325**	**-$20,911**
Research	$46,149	$43,349	-$2,800
Funding supports scientists resident at RHIC, universities, and other national laboratories to develop, fabricate, implement, and maintain scientific instrumentation; participate in experimental runs to acquire data; analyze data and publish experimental results; develop scientific plans and instrumentation for the EIC; and train students in nuclear science. U.S. scientists will participate in the high priority heavy ion efforts and instrumentation upgrades at the international ALICE, CMS, and ATLAS LHC experiments. Funding supports accelerator R&D relevant to NP programmatic needs. Research activities support the NQISRCs and AI/ML aimed at applications of artificial neural networks to nuclear physics research and the optimization of accelerator performance.		The Request will support scientist's resident at RHIC, universities, and other national laboratories to develop, fabricate, implement, and maintain scientific instrumentation; participate in experimental runs to acquire data; analyze data and publish experimental results; develop scientific plans and instrumentation for the EIC; and train students in nuclear science. U.S. scientists will participate in the high priority heavy ion efforts and instrumentation upgrades at the international ALICE, CMS, and ATLAS LHC experiments. The Request will support accelerator R&D relevant to NP programmatic needs. Research activities support the recompetition/renewal of the NQISRCs, and AI/ML aimed at applications of artificial neural networks to nuclear physics research and the optimization of accelerator performance. Funding supports EPSCoR implementation grants and early career awards.	Funding will continue to support high priority core scientific workforce at universities and national laboratories to enhance high priority research at RHIC, the LHC, and for EIC science and detector development. Continued support for research in EPSCoR jurisdictions.

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Operations	$182,087	$181,126	-$961
Funding supports RHIC operations at 2,400 hours (96 percent optimal funding) limited by installation of the new sPHENIX detector. Funding supports the RHIC accelerator complex, including mission readiness and development of the experimental halls and instrumentation, mission readiness of the suite of accelerators, all power and consumables of the site, cryogenics plant, activities to reduce helium consumption, high priority facility and instrumentation capital equipment, high priority accelerator improvement projects, and computing capabilities for data taking and analysis. Support will provide critical core competencies and accelerator scientists, engineers, and technicians, for collider operations. Accelerator scientists conduct research aimed at improving the operations of the RHIC accelerator complex.		The Request will support RHIC operations at 3,100 hours (95 percent optimal funding). The Request will support the RHIC accelerator complex, including mission readiness and development of the experimental halls and instrumentation, mission readiness of the suite of accelerators, all power and consumables of the site, cryogenics plant, activities to reduce helium consumption, high priority facility and instrumentation capital equipment, high priority accelerator improvement projects, and computing capabilities for data taking and analysis. Support will provide critical core competencies and accelerator scientists, engineers, and technicians, for collider operations. Accelerator scientists conduct research aimed at improving the operations of the RHIC accelerator complex.	The Request for RHIC operations will support operations to continue the science programs with STAR and sPHENIX. Reprioritization of effort to support EIC continues.
Projects	$20,000	$2,850	-$17,150
The experienced scientists and engineers skilled in collider operations continue to transition from RHIC operations to support EIC activities.		EIC OPC funds will support continued design efforts as well and research and development to increase technical readiness as the project prepares for CD-2.	OPC support of EIC activities will continue at an anticipated lower rate as research and development activities wind down and preliminary design is advanced.

Note:

- *Funding for the subprogram above, includes 3.65 percent of research and development (R&D) funding for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, excluding facility operations.*

Nuclear Physics
Nuclear Theory

Description

The Nuclear Theory subprogram provides the theoretical support needed to interpret the wide range of data obtained from the experimental nuclear science subprograms and to advance new ideas and hypotheses that identify potential areas for future experimental investigations. One major theme of theoretical research is the development of an understanding of the mechanisms and effects of quark confinement and deconfinement. A quantitative description of these phenomena through QCD is one of this subprogram's greatest intellectual challenges. New theoretical and computational tools are also being developed by the community to describe nuclear many-body phenomena; these approaches will likely also see important applications in condensed matter physics and in other areas of the physical sciences. Another major research area is nuclear astrophysics, which includes efforts to understand the origins of the elements in the cosmos and what the nature of the neutrino may reveal about the evolution of the early universe.

This subprogram supports the Institute for Nuclear Theory (INT) at the University of Washington and the FRIB Theory Alliance at Michigan State University. It also supports topical collaborations within the university and national laboratory communities to address only the highest priority topics in nuclear theory that merit a concentrated, team-based theoretical effort.

The U.S. Nuclear Data Program (USNDP) aims to provide current, accurate, and authoritative data to workers in basic and applied areas of nuclear science and engineering. It addresses this goal primarily through maintaining and providing public access to extensive nuclear physics databases. These databases are an important national and international resource, and they currently serve approximately five million retrievals of nuclear data annually. The USNDP also addresses important gaps in nuclear data through targeted experiments and the development and use of theoretical models. The program is managed by the National Nuclear Data Center (NNDC) at BNL. The NNDC is designated as an SC Public Reusable Research (PuRe) Data Resource, a designation commensurate with high standards of data management, resource operation, and scientific impact. NP leads an interagency working group including the NNSA, NE, DOE IP, and other federal agencies to coordinate targeted experimental efforts.

Nuclear theorists also conduct research related to QIS and quantum computing (QC), including R&D on quantum sensors to enable precision measurements, development of quantum sensors based on atomic-nuclear interactions, R&D on nuclear physics techniques to enhance qubit coherence times, and development of quantum computing algorithms applied to quantum mechanical systems and NP topical problems. In partnership with other SC programs, NP continues its role in jointly stewarding NQISRCs which focus on building the fundamental tools necessary for the United States to create quantum computers.

Scientists continue to develop cutting-edge techniques based on AI/ML to accelerate discovery in nuclear science research and incorporate next generation AI advances at the nexus of experiment, simulation, and theory.

The Nuclear Theory subprogram supports and leverages lattice quantum chromodynamics (LQCD) calculations that are critical for understanding and interpreting many of the experimental results from RHIC, LHC, and CEBAF. NP supports LQCD computing needs for dedicated computational resources with investments at TJNAF.

The Nuclear Theory subprogram also supports SciDAC, a collaborative program with ASCR that partners scientists and computer experts in research teams to address major scientific challenges that require supercomputer facilities performing at current technological limits.

The Nuclear Theory subprogram supports the RENEW initiative to provide undergraduate and graduate training opportunities for students and academic institutions not currently well represented in the U.S. S&T ecosystem. The Request includes funding for RENEW in the theory subprogram as well as the other NP subprograms with the distribution dependent on peer review results of topical proposals.

Research

This activity supports high priority research at ANL, BNL, LANL, LBNL, Lawrence Livermore National Laboratory (LLNL), ORNL, TJNAF, and universities. This research advances our fundamental understanding of nuclear physics, interpreting the results of experiments carried out under the auspices of the experimental nuclear physics program, and identifies and explores compelling new areas of research. The Request continues support of topical collaborations within available funds to bring together theorists to address specific emerging and high-priority theoretical challenges. NP will prioritize transitioning ECP researchers, software, and technologies into core research efforts and DOE priority research areas as ECP concludes.

The Request supports research related to QIS and QC to provide technological and computational advances relevant to NP and other fields. The Nuclear Science Advisory Committee published a report[a] in October 2019 to articulate further priority areas in QIS/QC where unique opportunities exist for nuclear physics contributions.

Support continues for the fourth year of SciDAC-5 awards initiated in FY 2022. In addition to addressing specific problems relevant for nuclear physics research, SciDAC projects continue to serve as critical research for highly trained scientists who can address national needs. A new round of topical collaborations awarded in FY 2023 is supported for a third year of these efforts.

Funding for AI/ML research continues in FY 2025 to develop cutting-edge techniques based on AI of relevance to nuclear science research.

The Request supports the activities of the USNDP to collect, evaluate, and disseminate nuclear physics data for basic nuclear research and for applied nuclear technologies and their development, providing for world-leading acquisition and dissemination of high-quality data for public consumption. U.S. efforts focus on improving the completeness and reliability of data already archived that is used for industry and for a variety of Federal missions, and the USNDP expands the effort to conduct experiments needed to address gaps in the data archives deemed of high priority and urgency. NP will collaborate with other Federal Agencies, including NNSA, NE, DHS, and DOE IP, that are members of the NP-led Inter-Agency Nuclear Data Working Group, to carry out experimental measurements.

This activity also supports the FAIR initiative which will provide focused investment on building institutional research capacity at HBCUs, MSIs and emerging research institutions.

[a] "*Nuclear Physics and Quantum Information Science*" Nuclear Science Advisory Committee, October 2015 (https://science.osti.gov/~/media/np/nsac/pdf/2015LRP/2015_LRPNS_091815.pdf).

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Nuclear Theory	**$67,873**	**$84,691**	**+$16,818**
Research	$67,873	$84,691	+$16,818
Funding supports high priority QIS efforts. LQCD computing investments continue at TJNAF. High priority theoretical research at universities and national laboratories is supported for the interpretation of experimental results obtained at NP facilities, and the exploration of new ideas and hypotheses that identify potential areas for future experimental investigations. Theorists focuses on applying QCD to a wide range of problems from nucleon structure and hadron spectroscopy, through the force between nucleons, to the structure of light nuclei. Advanced dynamic calculations to describe relativistic nuclear collisions and nuclear structure and reactions continues to focus on activities related to the research program at the upgraded 12 GeV CEBAF facility, the research program at FRIB, and ongoing and planned RHIC experiments. Funding supports the second year of SciDAC-5 grants and the first year of theory topical collaborations. Funding supports investments in an initiative to develop cutting-edge AI/ML techniques of relevance to nuclear science research, and accelerator facility operations.		The Request will support high priority QIS efforts. LQCD computing investments continue at TJNAF. Funding will support high priority theoretical research at universities and national laboratories for the interpretation of experimental results obtained at NP facilities, and the exploration of new ideas and hypotheses that identify potential areas for future experimental investigations. Theorists will focus on applying QCD to a wide range of problems from nucleon structure and hadron spectroscopy, through the force between nucleons, to the structure of light nuclei. Advanced dynamic calculations to describe relativistic nuclear collisions and nuclear structure and reactions will continue to focus on activities related to the research program at the upgraded 12 GeV CEBAF facility, the research program at FRIB, and ongoing and planned RHIC experiments. The Request will support the fourth year of SciDAC-5 grants, as well as the third year of theory topical collaborations. Funding will target investments in an initiative to develop cutting-edge AI/ML techniques of relevance to nuclear science research, and accelerator facility operations.	Funding will support the highest priority research in nuclear theory, growth of the FAIR and RENEW initiatives, transition of ECP related activities to core, and DOE priority research areas.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
This activity also supports the RENEW initiative to provide undergraduate and graduate training opportunities for students and academic institutions not currently well represented in the U.S. S&T ecosystem. Funding also supports the FAIR initiative.	The RENEW initiative expands targeted efforts to increase participation and retention of individuals from underrepresented groups in SC research activities, including a RENEW graduate fellowship. The Request will grow support for the FAIR initiative. Within available resources, NP will prioritize transitioning ECP researchers, software, and technologies into core research efforts and DOE priority research areas as ECP concludes.	
Funding continues the expanded USNDP efforts to collect, evaluate, and disseminate nuclear physics data for basic nuclear research and for applied nuclear technologies and their development initiated in FY 2022.	The Request will continue the expanded USNDP efforts to collect, evaluate, and disseminate nuclear physics data for basic nuclear research and for applied nuclear technologies and their development.	Funding will support nuclear data efforts of the USNDP.

Note:

- *Funding for the subprogram above, includes 3.65 percent of research and development (R&D) funding for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, excluding facility operations.*

Nuclear Physics
Low Energy Physics

Description
The Low Energy Physics subprogram includes activities in Nuclear Structure and Nuclear Astrophysics and Fundamental Symmetries.

Nuclear Structure and Nuclear Astrophysics

Questions associated with Nuclear Structure and Nuclear Astrophysics include:

- What is the nature of the nuclear force that binds protons and neutrons into stable nuclei and rare isotopes? What is the origin of simple patterns in complex nuclei? What is the nature of neutron stars and dense nuclear matter?
- What are the origins of the elements in the cosmos? What are the nuclear reactions that drive stars and stellar explosions?

The Nuclear Structure and Nuclear Astrophysics activities address these questions through support of research to develop a comprehensive description of nuclei using beams of stable and rare isotopes to yield new insights and reveal new nuclear phenomena. The activities also measure the cross sections of the nuclear reactions that power stars and lead to spectacular stellar explosions, which are responsible for the synthesis of the elements.

ATLAS at ANL is an SC scientific user facility serving approximately 350 scientists per year. ATLAS is the world's premiere facility for stable beams, providing high-quality beams of all the stable elements up to uranium. Selected beams of short-lived nuclei are produced at ATLAS using the Neutron-generator Upgrade to the Californium Rare Ion Breeder Upgrade (nuCARIBU) ion source. The facility nurtures an expert core competency in scientific instrumentation development and accelerator science, the latter through development of SRF cavities relevant to next generation high-performance linacs. ATLAS stewards the Center for Accelerator Target Science (CATS), a national asset providing critical targets for the community. Investments to increase ATLAS capabilities including a Multi-User Upgrade (MUU) are underway to address high user demand.

FRIB at Michigan State University (MSU), an SC scientific user facility since FY 2020, provides beams of rare isotopes to test the limits of nuclear existence and advance understanding of the atomic nucleus and the evolution of the cosmos. FRIB's reach will be enhanced by the GRETA MIE, which will provide new opportunities to discover and characterize key nuclei for electric dipole moment searches, and open new areas of study in nuclear astrophysics. The High Rigidity Spectrometer (HRS) will exploit FRIB's fast beam capabilities, enabling the most sensitive experiments with the most neutron-rich nuclei. Scientists participate in AI/ML research, conducting R&D targeting automated optimization of accelerator availability, performance, and operation, as well as software development enabling AI/ML-driven discovery. The Low Energy subprogram also supports the objectives of the RENEW and FAIR Initiatives.

Scientists participate in the international effort to discover and characterize new "super heavy" elements in the periodic table. U.S. researchers played a prominent role in the discovery of Elements 115, 117, and 118, and Element 117 was named Tennessine to acknowledge the leadership role of the U.S. in these efforts. Research is ongoing to characterize these new elements and to discover Element 120. NP supports operations of the LBNL 88-Inch Cyclotron for an in-house program studying the properties of newly discovered elements as well as conducting searches for new super-heavy elements. DOD and NASA exploit capabilities at the 88-Inch Cyclotron to develop radiation-resistant electronics for their missions.

Three university Centers of Excellence are supported within the Low Energy subprogram, each with specific goals and unique physics programs: the Cyclotron Institute at Texas A&M University (TAMU), the Triangle Universities Nuclear Laboratory (TUNL) at Duke University, and the Center for Experimental Nuclear Physics and Astrophysics (CENPA) at the University of Washington.

Fundamental Symmetries

Questions related to Fundamental Symmetries of nature addressed in low energy nuclear physics experiments include:

- What is the nature of neutrinos, what are their masses, and what role have they played in creating the imbalance between matter and antimatter in our universe? Is there evidence from the electric-dipole moments of atomic nuclei and the neutron that indicate our current understanding of the fundamental laws governing nuclear physics is incomplete?
- Will precise measurements in electron scattering and the decay of nuclei indicate the existence of forces that were present at the dawn of the universe, and disappeared from view as the universe evolved?

The Fundamental Symmetries activities address these questions through precision studies using neutron and electron beams and decays of nuclei, including beta decay, double-beta decay, and neutrino-less double beta decay (NLDBD). U.S. scientists are world leaders in neutrino science and NP is the SC steward of neutrino mass measurements and NLDBD. Often in partnership with NSF, NP has invested in neutrino experiments, playing critical roles in international experiments that depend on U.S. leadership for their ultimate success: e.g., the Cryogenic Underground Observatory for Rare Events (CUORE), the Karlsruhe Tritium Neutrino Experiment (KATRIN), and Project 8. In partnership with NSF, NP also participates in the international LEGEND-200 experiment. The NSAC 2023 LRP recommended “the United States lead an international consortium that will undertake a neutrinoless double beta decay campaign, featuring the expeditious construction of ton-scale experiments, using different isotopes and complementary techniques.” NLDBD can only occur if neutrinos are their own anti-particles. The observation of such events would have profound, game changing consequences for present understanding of the physical universe. NP has invested in R&D on candidate technologies for next–generation ton-scale experiments, including crystals of enriched germanium (LEGEND-1000), liquid xenon (nEXO), and lithium molybdenate crystals (CUPID). The Request will provide support for ton-scale research based on one or more of these technologies to progress toward CD-1, Approve Alternative Selection and Cost Range. The NLDBD MIE received CD-0, Approval of Mission Need, in November 2018.

The MOLLER MIE will measure the parity-violating asymmetry in electron-electron scattering at CEBAF which is uniquely sensitive to the possible existence of new as-yet unforeseen particles. Evidence for electric dipole moments of the neutron and atoms violate time reversal invariance and would shed light on the matter/anti-matter imbalance in the universe. Beams of cold and ultracold neutrons with the dedicated Fundamental Neutron Physics Beamline (FNPB) at the Spallation Neutron Source (SNS) are used to study fundamental properties of neutrons.

Scientists engaged in Fundamental Symmetries research are particularly well positioned with their expertise in rare signal detection, to engage in research on QIS and QC. They contribute to R&D on quantum sensors to enable precision NP measurements, development of quantum sensors based on atomic-nuclear interactions, and development of quantum computing algorithms applied to quantum mechanical systems and NP topical problems.

<u>Nuclear Structure and Nuclear Astrophysics Research</u>

This activity supports high priority research groups at ANL, LBNL, LLNL, and ORNL, and at universities. Scientists develop, fabricate, and use specialized instrumentation at ATLAS, and participate in the acquisition and analysis of data. Scientists design, fabricate, install, and commission instrumentation at FRIB. The Request supports researchers at other facilities to help lead the FRIB scientific mission. Progress continues on the GRETA MIE, although no new funds are requested in FY 2025, as well as the HRS. Scientists participate in research to characterize and discover new super-heavy elements at international facilities and the 88-Inch Cyclotron. The Request supports the university Centers of Excellence at TUNL and TAMU for the conduct of nuclear structure and nuclear astrophysics experiments. Accelerator scientists participate in transformative accelerator R&D, developing next generation SRF cavities and ion sources for accelerators. Scientists utilize AI/ML advances to improve machine performance and reliability and accelerate scientific discovery.

<u>Fundamental Symmetries Research</u>

The activity supports high priority research at BNL, LANL, LBNL, LLNL, ORNL, Pacific Northwest National Laboratory, and SLAC National Accelerator Laboratory, and at universities. R&D continues efforts exploring whether shift moments are an indicator of new physics. Engineering and design efforts continue for international ton-scale NLDBD research, along with targeted R&D. Progress continues on the MOLLER MIE, although no new funds are requested in FY 2025. Scientists participate in R&D for Project 8 and in the operations of the KATRIN experiment to provide a measurement of the neutrino mass. University Centers of Excellence at TUNL, CENPA, and TAMU with unique capabilities are exploited to advance research in Fundamental Symmetries. Researchers conduct NP research of relevance to QIS, with a focus on novel quantum sensors.

Nuclear Structure and Nuclear Astrophysics Operations
The activity supports facility and operations costs associated with ATLAS, FRIB, and the 88-Inch Cyclotron Funding provides support for the operations and power costs of the ATLAS, and targeted support for high priority accelerator and scientific instrumentation capital equipment, accelerator improvement projects, and experimental support. The ATLAS core competency in accelerator science is maintained. Critical efforts to address facility oversubscription and increase available beam time continue with the implementation of the cost-effective MUU Accelerator Improvement Project.

The Request supports FRIB operations to provide a reliable source of rare isotopes using in-flight production methods. The Request supports beam time for the highest priority experiments, improvements to scientific instrumentation and experimental capabilities, and accelerator enhancements to support progress towards reaching full power.

The Request also sustains operations of the 88-Inch Cyclotron for a focused in-house nuclear physics program which includes characterization and searches for new elements and nuclear data measurements.

Nuclear Physics
Low Energy Physics

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Low Energy Physics	**$230,170**	**$213,239**	**-$16,931**
Research	$77,651	$72,334	-$5,317
Funding supports high priority university and laboratory nuclear structure and nuclear astrophysics efforts at ATLAS and installation and commissioning of instrumentation for the FRIB scientific program. Funding targets research for critical FRIB scientific personnel to lead the scientific program at FRIB. Scientists continue to participate in the characterization of recently discovered elements and search for new ones. Research will continue at the university-based Centers of Excellence at TUNL, CENPA, and TAMU. Scientists utilize AI/ML that can promote automated platforms to improve machine performance and reliability and advance detector design and data processing.		The Request will support high priority university and laboratory nuclear structure and nuclear astrophysics efforts at ATLAS and FRIB. Scientists will participate in the characterization of recently discovered elements and search for new ones. Research will continue at the university-based Centers of Excellence at TUNL, CENPA, and TAMU. Scientists utilize AI/ML that can promote automated platforms to improve machine performance and reliability and advance detector design and data processing.	The Request will support the highest priority research efforts and essential workforce at universities and national laboratories, with a focus on conducting experiments at ATLAS and FRIB.
High priority research in NLDBD will continue with a strategic mix of efforts for selection in FY 2023. Funding supports U.S. participation in the operations of the international KATRIN experiment.		High priority research in NLDBD will continue with a strategic mix of efforts for selection in FY 2024. The Request will continue support for U.S. participation in the operations of the international KATRIN experiment.	The Request will support the highest priority research efforts and essential workforce at universities and national laboratories.

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Operations	$128,579	$135,646	+$7,067
ATLAS operates for 5,950 hours (96 percent of optimal funding). Funding supports operations, staff, maintenance, and high priority accelerator improvement projects and capital equipment for the facility and scientific instrumentation, including the development of a multi-user capability. Funding also supports the second year of operations at FRIB for 3,600 hours (99 percent of optimal funding) to execute the first full year of the scientific program. Funding continues operations of the 88-Inch Cyclotron for high priority experiments studying newly discovered elements.		ATLAS will operate for 5,900 hours (90 percent of optimal funding). The Request will fund operations, staff, maintenance, and high priority accelerator improvement projects and capital equipment for the facility and scientific instrumentation, including the development of a multi-user capability. The Request will also support the second year of operations at FRIB for 3,700 hours (90 percent of optimal funding) to execute the first full year of the scientific program. Funding will sustain operations of the 88-Inch Cyclotron for high priority experiments studying newly discovered elements.	Request will support FRIB, ATLAS, and additional nuclear physics research hours at the 88-Inch Cyclotron for element discovery.
Projects	$23,940	$5,259	-$18,681
Funding continues support for the GRETA MIE, MOLLER MIE, NLDBD MIE, and the HRS research project. The GRETA and MOLLER MIEs received their final funding allocation.		The Request will continue support for the NLDBD MIE and the HRS research project.	The GRETA and MOLLER MIEs complete their baselined and planned funding profiles with the FY 2023 Enacted Appropriations.

Note:
- *Funding for the subprogram above, includes 3.65 percent of research and development (R&D) funding for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, excluding facility operations.*

Description

This subprogram supports all line-item construction for the entire NP program. All TECs are funded in this subprogram, including engineering, design, and construction. OPC's are funded in the relevant subprograms. The FY 2025 Request continues the construction effort for the EIC, which will be located at BNL. The estimated TPC range for the EIC project is $1.7 billion to $2.8 billion, with a point estimate of $2.419 billion. BNL has teamed with TJNAF to lead the development and implementation of the EIC. The EIC scope includes an electron injector, rapid cycling synchrotron, an electron storage ring, modifications to one of the two RHIC ion rings, one interaction region with a detector, support buildings, and other infrastructure. Future improvements not part of the project scope would further develop a second interaction region and acquire for it a detector. The project is expected to attract international collaboration and contributions.

20-SC-52, Electron Ion Collider EIC, BNL

The EIC project will increasingly rely on RHIC scientists, engineers, and technicians as RHIC activities ramp down. This workforce with critical core competencies in collider operations remains essential to RHIC now and eventually EIC operations. They cannot easily be replaced. The temporary reprioritization of funds from the collider facility operations budget to the construction budget will supplement funding needed to implement the EIC, enabling a cost-effective path forward to the implementation of this world-leading facility.

Since the release of the 2002 LRP for Nuclear Science, a high priority for the U.S. nuclear science community has been understanding how the fundamental properties of the proton, such as its mass and spin, are dynamically generated by the extraordinarily strong color fields resulting from dense systems of gluons in nucleons and nuclei. The answer to this question is key to addressing an outstanding grand challenge problem of modern physics: how quantum chromodynamics, the theory of the strong force, which explains all strongly interacting matter in terms of points like quarks interacting via the exchange of gluons, acts to generate the "macroscopic" properties of protons and neutrons. The 2023 LRP for Nuclear Science recommended "…the expeditious completion of the EIC as the highest priority for facility construction." A National Academies study, charged to independently assess the impact, uniqueness, and merit of the science that would be enabled by U.S. construction of an electron-ion collider, gave a strong endorsement to a U.S.-based EIC, and recognized its critical role in maintaining U.S. leadership in nuclear science and accelerator R&D. Scientists and accelerator physicists from both the Medium Energy and Heavy Ion subprograms are actively engaged in the development of the scientific agenda, design of the facility and development of scientific instrumentation related to a proposed EIC. Critical Decision-0 (CD-0), Approve Mission Need, was received on December 19, 2019, followed by CD-1, Approve Alternative Selection and Cost Range on June 29, 2021.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Construction	**$50,000**	**$110,000**	**+$60,000**
20-SC-52 Electron Ion Collider (EIC), BNL	$50,000	$110,000	+$60,000
Funding continues TEC support for the EIC. The funds are for engineering and design to reduce technical risk after completion of the conceptual design. RHIC operations includes a “reprioritization” of expert workforce from the RHIC facilities operations budget to support both the EIC OPC and TEC request.		The Request will continue TEC funding for the EIC. The funds will be used for engineering and design to reduce technical risk after completion of the conceptual design and limited long lead procurements. RHIC operations includes a “reprioritization” of expert workforce from the RHIC facilities operations budget to support the EIC OPC and TEC request.	The increased funding will support additional engineering and design efforts and limited long lead procurements. These additional efforts will help align the establishment of the performance baselines and start of construction with the completion of the RHIC science program.

Nuclear Physics
Capital Summary

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Capital Operating Expenses						
Capital Equipment	N/A	N/A	34,988	20,307	16,307	-18,681
Minor Construction Activities						
General Plant Projects	N/A	N/A	2,642	2,642	1,642	-1,000
Accelerator Improvement Projects	N/A	N/A	5,211	5,211	5,211	–
Total, Capital Operating Expenses	**N/A**	**N/A**	**42,841**	**28,160**	**23,160**	**-19,681**

Capital Equipment

	(dollars in thousands)					
	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Capital Equipment						
Low Energy Physics						
Gamma-Ray Energy Tracking Array (GRETA), LBNL	57,700	42,200	15,500	–	–	-15,500
High Rigidity Spectrometer	122,550	39,080	3,000	6,259	3,259	+259
MOLLER	47,220	43,220	4,000	–	–	-4,000
Ton-Scale Neutrinoless Double Beta Decay (NLDBD) MIE	634,490	10,800	1,440	3,000	2,000	+560
Total, Non-MIE Capital Equipment	N/A	N/A	34,988	20,307	16,307	–
Total, Capital Equipment	**N/A**	**N/A**	**34,988**	**20,307**	**16,307**	**-18,681**

Notes:
- *The Capital Equipment table includes MIEs located at a DOE facility with a Total Estimated Cost (TEC) > $10M and MIEs not located at a DOE facility with a TEC >$2M.*
- *The High Rigidity Spectrometer (HRS) is not an MIE, but a research project supported on a cooperative agreement with Michigan State University.*
- *The current estimated TEC for the GRETA MIE is $57,580,000. In FY 2023 $120,000 was redirected to OPC funding not reflected in this table.*
- *The current estimated TEC for the NLDBD MIE is $633,050,000. In FY 2023 $1,440,000 was redirected to OPC funding not reflected in this table.*

Minor Construction Activities

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
General Plant Projects (GPP)						
GPPs (greater than $5M and $34M or less)						
nEDM Experimental Building 2 (EB-2)	2,000	–	1,000	1,000	–	-1,000
Total GPPs (greater than $5M and $34M or less)	N/A	N/A	1,000	1,000	–	-1,000
Total GPPs $5M or less	N/A	N/A	1,642	1,642	1,642	–
Total, General Plant Projects (GPP)	**N/A**	**N/A**	**2,642**	**2,642**	**1,642**	**-1,000**
Accelerator Improvement Projects (AIP)						
Total AIPs $5M or less	N/A	N/A	5,211	5,211	5,211	–
Total, Accelerator Improvement Projects (AIP)	**N/A**	**N/A**	**5,211**	**5,211**	**5,211**	**–**
Total, Minor Construction Activities	**N/A**	**N/A**	**7,853**	**7,853**	**6,853**	**-1,000**

Notes:

- *GPP activities $5M and less include design and construction for additions and/or improvements to land, buildings, replacements or addition to roads, and general area improvements. AIP activities $5M and less include minor construction at an existing accelerator facility.*
- *Please note that the nEDM experiment was cancelled in the fall of 2023, eliminating the need for the EB-2.*

Nuclear Physics
Major Items of Equipment Description(s)

Low Energy Physics: Nuclear Structure and Nuclear Astrophysics MIE and Research Project:

Gamma-Ray Energy Tracking Array (GRETA) MIE

GRETA directly supports the NP mission by addressing the goal to understand the structure of nuclear matter, the processes of nuclear astrophysics, and the nature of the cosmos. A successful implementation of this detector will represent a major advance in gamma-ray tracking detector technology that will impact nuclear science, as well as detection techniques in homeland security and medicine. GRETA will provide unprecedented gains in detection sensitivity, addressing several high priority scientific topics, including how weak binding and extreme proton-to-neutron asymmetries affect nuclear properties and how the properties of nuclei evolve with changes in excitation energy and angular momentum. GRETA will provide transformational improvements in efficiency, peak-to-total ratio, and higher position resolution than the current generation of detector arrays. In particular, the capability of reconstructing the position of the interaction with millimeter resolution will fully exploit the physics opportunities of FRIB. With GRETA, beam-times necessary for the proposed experiments will be significantly shortened, allowing for some experiments that would otherwise not be feasible at all. GRETA received CD-0 approval on September 15, 2015, and CD-1 approval on October 4, 2017. The project received CD-3A approval for long lead procurements on August 16, 2018, and CD-2/3 on October 7, 2020, with a TPC of $58,300,000. The FY 2023 Enacted appropriation represented the last year of planned funding for the GRETA MIE. CD-4 is scheduled for March 2028.

High Rigidity Spectrometer (HRS) Research Project

The HRS at FRIB will increase the scientific potential of state-of-the-art and community-priority devices, such as GRETA, and other ancillary detectors. FRIB is the world's premier rare-isotope beam facility capable of producing approximately 80 percent of the isotopes predicted to exist. The scientific impact of the FRIB fast beam science program will be enhanced by luminosity gain factors of between two and one hundred for neutron-rich isotopes, with the largest gains for the most neutron-rich species, by construction of the HRS. The HRS will allow experiments with beams of rare isotopes at the maximum production rates for fragmentation or in-flight fission. This enhancement in experimental sensitivity provides access to critical isotopes not available otherwise. The 2023 NSAC LRP recognized that the HRS will push the study of unstable nuclei toward the driplines, increasing the scientific reach of FRIB. The HRS is being funded through a cooperative agreement with MSU and is not a capital asset (MIE). HRS received CD-0 approval in November 2018, and CD-1 in September 2020, with a TPC range of $85,000,000 to $111,400,000. The FY 2025 Request for the HRS of $3,259,000 will support the management team, coordination of collaboration activities and allow preliminary engineering and design work towards future critical decision points.

Low Energy Physics: Fundamental Symmetries MIEs:

Measurement of a Lepton-Lepton Electroweak Reaction (MOLLER) MIE

The MOLLER experiment directly supports the NP mission by measuring the parity-violating asymmetry in polarized electron-electron (Møller) scattering. This extremely small asymmetry is predicted to be on the order of 35 parts per billion (ppb), which requires unprecedented experimental techniques employed for this experiment. CD-0 was approved December 2016. CD-1 was approved in December 2020 with a TPC range of $42,000,000 to $60,100,000. MOLLER achieved CD-3A in Q2 of FY 2023. The project is working on preliminary engineering and design in advance of a combined CD-2/3 planned in Q1 of FY 2024. CD-4 is expected in Q4 of FY2027. The MOLLER experiment is an ultra-precise measurement of the weak mixing angle using Møller scattering which will improve on existing measurements by a factor of five, yielding the most precise measurement of the weak mixing angle at low or high energy anticipated over the next decade. This new result would be sensitive to the interference of the electromagnetic amplitude with new neutral current amplitudes as weak as approximately 10^{-3} G_F (Fermi Factor) from as yet undiscovered dynamics beyond the Standard Model. The resulting reach for scientific discovery is far greater, for at least a decade, than any existing or proposed experiment which searches for new physics signaled by a departure from the expected before vs after conservation of flavor, charge and parity in fundamental particle interactions, and yields a unique window to new physics at MeV and multi-TeV scales, complementary to direct searches at high energy colliders such as the Large Hadron Collider (LHC). The FY 2023 Enacted appropriation represented the last year of planned funding for the MOLLER MIE.

Ton-Scale Neutrino-less Double Beta Decay (NLDBD) Program MIE

The Ton-Scale NLDBD Program, implemented by deploying experiments instrumenting a large volume of a specially selected isotope to detect neutrino-less nuclear beta decays (where within a single nucleus, two neutrons decay into two protons and two electrons with no neutrinos emitted), directly supports NP's mission to explore all forms of nuclear matter. NLDBD can only occur if neutrinos are their own anti-particles and the observation of "lepton number violation" in such neutrino-less beta decay events would have profound consequences for present understanding of the physical universe. For example, one exciting prospect is that the observation of NLDBD would elucidate the mechanism, completely unknown at present, by which the mass of the neutrino is generated. The observation of lepton number violation would also have major implication for the present-day matter/anti-matter asymmetry which has perplexed modern physics for decades. Several demonstrator efforts using smaller volumes of isotopes and various technologies (bolometry in tellurium dioxide crystals, light collection in liquid xenon, charge collection in enriched germanium-76) have been in progress for several years, and all are in the process of delivering new state-of-the-art lifetime limits for neutrino-less double beta decay which are of order a few times 10^{25} years. The goal of the ton-scale program is to reach a lifetime limit of 10^{28} years with high confidence. For reference, the "lifetime limit" discussed is the time one might have to wait to observe neutrino-less double beta decay if observing a single nucleus only. Fortunately, in the ton of isotope planned for the ton-scale neutrino-less double beta decay experiments there are many trillions of nuclei. Thus, such decays, if they exist, should be observable on a much more reasonable timescale (five to ten years) similar to other large modern physics experiments. NLDBD received CD-0 approval in November 2018 with a TPC range of $215,000,000 to $250,000,000. The FY 2025 Request of $2,000,000 will support the management teams, collaboration activities, and preliminary engineering and design.

Nuclear Physics
Construction Projects Summary

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
20-SC-52, Electron Ion Collider (EIC), BNL						
Total Estimated Cost (TEC)	2,126,000	154,240	50,000	95,000	110,000	+60,000
Other Project Cost (OPC)	292,450	69,450	20,000	2,850	2,850	-17,150
Total Project Cost (TPC)	**2,418,450**	**223,690**	**70,000**	**97,850**	**112,850**	**+42,850**
Total, Construction						
Total Estimated Cost (TEC)	**N/A**	**N/A**	**50,000**	**95,000**	**110,000**	**+60,000**
Other Project Cost (OPC)	**N/A**	**N/A**	**20,000**	**2,850**	**2,850**	**-17,150**
Total Project Cost (TPC)	**N/A**	**N/A**	**70,000**	**97,850**	**112,850**	**+42,850**

Nuclear Physics
Scientific User Facility Operations

The treatment of user facilities is distinguished between two types: TYPE A facilities that offer users resources dependent on a single, large-scale machine; TYPE B facilities that offer users a suite of resources that is not dependent on a single, large-scale machine.

(dollars in thousands)

	FY 2023 Enacted	FY 2023 Current	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Scientific User Facilities - Type A					
Relativistic Heavy Ion Collider	**182,087**	**182,045**	**166,993**	**181,126**	**-961**
Number of Users	1,010	1,053	1,010	1,010	–
Achieved Operating Hours	–	1,641	–	–	–
Planned Operating Hours	2,400	2,400	–	3,100	+700
Continuous Electron Beam Accelerator Facility	**149,834**	**147,942**	**138,620**	**147,244**	**-2,590**
Number of Users	1,730	1,904	1,730	1,800	+70
Achieved Operating Hours	–	3,306	–	–	–
Planned Operating Hours	4,100	4,100	2,240	3,170	-930
Facility for Rare Isotope Beams	**98,388**	**98,388**	**90,086**	**103,336**	**+4,948**
Number of Users	650	902	755	755	+105
Achieved Operating Hours	–	3,948	–	–	–
Planned Operating Hours	3,600	3,600	2,142	3,700	+100
Argonne Tandem Linac Accelerator System	**24,350**	**24,350**	**23,464**	**25,110**	**+760**
Number of Users	340	299	340	340	–
Achieved Operating Hours	–	5,769	–	–	–
Planned Operating Hours	5,950	5,950	2,880	5,900	-50
Total, Facilities	**454,659**	**452,725**	**419,163**	**456,816**	**+2,157**
Number of Users	3,730	4,158	3,835	3,905	+175
Achieved Operating Hours	–	14,664	–	–	–

(dollars in thousands)

	FY 2023 Enacted	FY 2023 Current	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Planned Operating Hours	16,050	16,050	7,262	15,870	-180

Notes:
- *Achieved Operating Hours and Unscheduled Downtime Hours will only be reflected in the Congressional budget cycle which provides actuals.*
- *Percent optimal operations defines what is achieved at this funding level. This includes staffing, up-to-date equipment and software, operations and maintenance, and appropriate investments to maintain world leadership.*

Nuclear Physics
Scientific Employment

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Number of Permanent Ph.Ds (FTEs)	856	860	810	-46
Number of Postdoctoral Associates (FTEs)	366	372	355	-11
Number of Graduate Students (FTEs)	524	529	496	-28
Number of Other Scientific Employment (FTEs)	1,023	1,028	1,000	-23
Total Scientific Employment (FTEs)	**2,769**	**2,789**	**2,661**	**-108**

Note:
- *Other Scientific Employment (FTEs) includes technicians, engineers, computer professionals and other support staff.*

20-SC-52 Electron Ion Collider (EIC), BNL
Brookhaven National Laboratory, BNL
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary

The EIC project will acquire facilities, infrastructure, systems, and equipment that will enable scientists to investigate the basic building blocks of nuclei and how quarks and gluons, the particles inside neutrons and protons, interact dynamically via the strong force to generate the fundamental properties of neutrons and protons, such as mass and spin. The FY 2025 Request for the EIC is $110,000,000 of TEC funding and $2,850,000 of OPC funding. The current TPC range is $1,700,000,000 to $2,800,000,000. The preliminary TPC estimate for the project is $2,418,450,000.

Significant Changes

The EIC was initiated in FY 2020. The project most recently received Critical Decision (CD)-1, Approve Alternative Selection and Cost Range, on June 29, 2021. The estimated completion date (CD-4) is 1Q FY 2035 and includes schedule contingency recommended by peer review. In addition, the preliminary TPC in this PDS reflects continued elaboration of the project scope and the point estimate remains within the cost range. The project expects CD-2, Approve Performance Baseline, in Q3 FY 2025.

In FY 2023, the EIC team focused on preliminary design of the infrastructure, collider machine, and detector instrumentation. Research and development to increase technical readiness for certain detector and technical scope and fostering relations with potential in-kind contributors continued. The team developed a list of possible long-lead procurements for a CD-3A, Approve Long Lead Procurement, planned in Q2 FY 2024. Through the Inflation Reduction Act (IRA) the project received $10,000,000 OPC and $128,240,000 TEC at the end of FY 2022. The IRA funds will support architect-engineering services for infrastructure, designs for the collider machine and detector instrumentation, and following a CD-3A, long lead procurements. IRA funds will reduce the peak requests for new funding. FY 2024 activities include completing planning and design for conventional infrastructure and technical systems, research and development to increase technical readiness for certain detector and technical scope, executing approved CD-3A scope, and pursuing agreements with potential in-kind contributors. FY 2025 funding will support final research and development, design, and constructability adjustments, to validate technical assumptions and to reduce project risk, followed by the start of construction.

A Federal Project Director (FPD) has been assigned to this project and has approved this project data sheet. The FPD is certified at Level 3, and the accrual of qualifications for Level 4 certification is in process.

Critical Milestone History

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
FY 2025	12/19/19	01/12/21	6/29/2021	3Q FY 2025	3Q FY 2025	3Q FY 2025	1Q FY 2035

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout.

Fiscal Year	Performance Baseline Validation	CD-3A	CD-3B
FY 2025	TBD	3Q FY 2024	1Q FY 2025

CD-3A – Approve Long-Lead Procurements, for specialty materials procurement, including electrical infrastructure, magnets, refrigerators for the satellite cryogenics plant, and components for the injector, radio frequency power amplifier, and the detector.

Project Cost History

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	256,000	1,870,000	2,126,000	292,450	292,450	2,418,450
FY 2025	256,000	1,870,000	2,126,000	292,450	292,450	2,418,450

Note:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*

2. Project Scope and Justification

Scope

The scope of this project is to design and build the EIC at BNL that will fulfill the scientific gap as identified in the 2023 NSAC LRP. BNL is partnering with TJNAF in the implementation of the EIC. The EIC will have performance parameters that include a high beam polarization of greater than 70 percent from both electrons and light ions, and the capability to accommodate ion beams from deuterons to the heaviest stable nuclei. The EIC will also have variable center of mass energies from 20 to 100 GeV and upgradable to 140 GeV, high collision luminosity from 10^{33} -10^{34} $cm^{-2}s^{-1}$, one detector and one interaction region at project completion, and the capacity to accommodate a second interaction region and a second detector.

The scope also includes a new electron injection system and storage ring while taking full advantage of the existing infrastructure by modifying the existing hadron facility of the RHIC infrastructure at BNL.

The electron system will include a highly polarized room temperature photo-electron gun and a 400 MeV linac to be installed in an existing available straight section of the RHIC tunnel. It will include a transfer line that brings the electrons into the storage ring at the energy of 5 to 18 GeV that will be installed in the existing 2.4-mile circular RHIC tunnel.

Modifications to the existing hadron system include the injection, transfer line and storage ring to increase beam energy to 275 GeV. It will include a strong-hadron-cooling system to reduce and maintain the hadron beam emittance to the level needed to operate with the anticipated luminosity of 10^{33} -10^{34} $cm^{-2}s^{-1}$.

The interaction region will have superconducting final focusing magnets, crab cavities, and spin rotators to provide longitudinally polarized beams for collisions, where the outgoing particles will be collected by one detector.

An enhanced 2 K liquid helium cryogenic plant is provided for the superconducting radiofrequency cavities, with enhanced water-cooling capacity and cooling towers and chillers to stabilize the environment in the existing tunnel. Civil construction will also include electrical systems, service buildings, and access roads.

It is anticipated that non-DOE funding sources such as international collaborators and the State of New York, will contribute $250 million to the EIC Project ($100 million from New York state, and $150 million from international collaborators). The timeframe for commitments by non-DOE contributors will vary throughout the life of the project and become more certain as planning for the project progresses. All non-DOE funding sources will be closely coordinated with the Office of Nuclear Physics and will be incorporated into the project through the change control process once baselined.

Justification

The last four NSAC LRP reports have supported the EIC with recommendations ranging from investing in accelerator research and development (R&D) in the 2002 NSAC LRP, to reducing technical risks in the 2007 NSAC LRP, to the actual construction of a U.S.-based EIC in the 2015 NSAC LRP. The 2023 NSAC LRP for Nuclear Science recommended the EIC as the highest priority for new facility construction. Consistent with that vision, in 2016 NP commissioned a National Academies of Sciences, Engineering, and Medicine study by an independent panel of experts to assess the uniqueness and scientific merit of such a facility. The report, released in July 2018, strongly supports the scientific case for building a U.S. based EIC, documenting that an EIC will advance the understanding of the origins of nucleon mass, the origin of the spin properties of nucleons, and the behavior of gluons.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets.*

Key Performance Parameters (KPPs)

The KPPs are preliminary and may change prior to setting the performance baseline at CD-2. The Threshold KPPs represent the minimum acceptable performance that the project must achieve for success. The Objective KPPs represent the project performance stretch goal. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Approve Project Completion.

Performance Measure	Threshold	Objective
Center-of-Mass	Center-of-mass energy measured in the range of 20 GeV- 100 GeV.	Center-of-mass energy measured in the range of 20 GeV- 140 GeV.
Accelerator	Accelerator installed and capable of delivering beams of protons and a heavy nucleus such as Au.	Ability to deliver a versatile choice of beams from protons and light ions to heavy ions such as Au.
Detector	Detector installed and ready for beam operations.	Inelastic scattering events in the e-p and e-A collisions measured in Detector.
Polarization	Hadron beam polarization of > 50 percent and electron beam polarization of > 40 percent measured at E_{cm} = 100 GeV.	Hadron beam polarization of > 60 percent and electron beam polarization of > 50 percent measured at E_{cm} = 100 GeV.
Luminosity	Luminosity for e-p collisions measured up to 1.0×10^{32} cm^{-2} s^{-1}.	Luminosity greater than 1.0×10^{33} cm^{-2} s^{-1}.

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Estimated Cost (TEC)				
Design (TEC)				
Prior Years	26,000	26,000	25,500	—
Prior Years - IRA Supp.	70,000	70,000	—	—
FY 2023	50,000	50,000	49,500	50,000
FY 2024	75,000	75,000	74,000	20,000
FY 2025	35,000	35,000	34,000	—
Outyears	—	—	3,000	—
Total, Design (TEC)	**256,000**	**256,000**	**186,000**	**70,000**
Construction (TEC)				
Prior Years - IRA Supp.	58,240	58,240	—	—
FY 2024	20,000	20,000	20,000	58,240
FY 2025	75,000	75,000	70,000	—
Outyears	1,716,760	1,716,760	1,721,760	—
Total, Construction (TEC)	**1,870,000**	**1,870,000**	**1,811,760**	**58,240**
Total Estimated Cost (TEC)				
Prior Years	26,000	26,000	25,500	—
Prior Years - IRA Supp.	128,240	128,240	—	—
FY 2023	50,000	50,000	49,500	50,000
FY 2024	95,000	95,000	94,000	78,240
FY 2025	110,000	110,000	104,000	—
Outyears	1,716,760	1,716,760	1,724,760	—
Total, Total Estimated Cost (TEC)	**2,126,000**	**2,126,000**	**1,997,760**	**128,240**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Other Project Cost (OPC)				
Prior Years	59,450	59,450	56,500	–
Prior Years - IRA Supp.	10,000	10,000	–	–
FY 2023	20,000	20,000	21,500	10,000
FY 2024	2,850	2,850	2,000	–
FY 2025	2,850	2,850	3,000	–
Outyears	197,300	197,300	199,450	–

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Other Project Cost (OPC)				
Total, Other Project Cost (OPC)	**292,450**	**292,450**	**282,450**	**10,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Project Cost (TPC)				
Prior Years	85,450	85,450	82,000	–
Prior Years - IRA Supp.	138,240	138,240	–	–
FY 2023	70,000	70,000	71,000	60,000
FY 2024	97,850	97,850	96,000	78,240
FY 2025	112,850	112,850	107,000	–
Outyears	1,914,060	1,914,060	1,924,210	–
Total, TPC	**2,418,450**	**2,418,450**	**2,280,210**	**138,240**

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	173,000	173,000	**N/A**
Design - Contingency	83,000	83,000	**N/A**
Total, Design (TEC)	**256,000**	**256,000**	**N/A**
Construction	1,262,000	1,262,000	**N/A**
Construction - Contingency	608,000	608,000	**N/A**
Total, Construction (TEC)	**1,870,000**	**1,870,000**	**N/A**
Total, TEC	**2,126,000**	**2,126,000**	**N/A**
Contingency, TEC	*691,000*	*691,000*	***N/A***
Other Project Cost (OPC)			
R&D	84,150	97,450	**N/A**
Conceptual Design	11,000	11,000	**N/A**
Other OPC Costs	197,300	184,000	**N/A**
Total, Except D&D (OPC)	**292,450**	**292,450**	**N/A**
Total, OPC	**292,450**	**292,450**	**N/A**
Contingency, OPC	***N/A***	*N/A*	***N/A***
Total, TPC	**2,418,450**	**2,418,450**	**N/A**

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total, Contingency (TEC+OPC)	***691,000***	***691,000***	***N/A***

Note:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	154,240	50,000	95,000	—	1,826,760	2,126,000
	OPC	69,450	20,000	2,850	—	200,150	292,450
	TPC	223,690	70,000	97,850	—	2,026,910	2,418,450
FY 2025	TEC	154,240	50,000	95,000	110,000	1,716,760	2,126,000
	OPC	69,450	20,000	2,850	2,850	197,300	292,450
	TPC	223,690	70,000	97,850	112,850	1,914,060	2,418,450

6. Related Operations and Maintenance Funding Requirements

Over the course of the acquisition of the EIC, experienced RHIC scientists, engineers, and technicians will assume EIC project responsibilities. A gradual transition will balance the need for the scientific experts to continue to support RHIC while ramping up the EIC project. These individuals represent the scientific and technical workforce that are essential to the operations of a complex facility like RHIC and eventually, the EIC. They have critical core competencies in collider operations that cannot easily be replaced, and they represent the core facility operations force of RHIC and the EIC. In the FY 2025 Request, RHIC Operations includes a "reprioritization" of the expert workforce from the RHIC facility operations budget to support the project under the EIC OPC and TEC request. The temporary reprioritization of funds from the facility operations budget to the construction budget will reduce the amount of "new funds" needed to implement the EIC, enabling a cost-effective path forward to the implementation of this world-leading facility. As the EIC nears CD-4 when the machine will be restarted, the scientists, engineers and technicians that are needed to operate the EIC will be transferred back to the facility operations budget.

Start of Operation or Beneficial Occupancy	Q1 FY 2035
Expected Useful Life	50 years
Expected Future Start of D&D of this capital asset	Q1 FY 2085

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	Current Total Estimate	Previous Total Estimate	Current Total Estimate
Operations, Maintenance and Repair	167,000	167,000	13,500,000	13,500,000

7. D&D Information

As part of the upgrade and renovation of the existing accelerator facilities, up to 150,000 square feet of new industrial space will be built as service buildings to house mechanical and electrical equipment. The new area being constructed in this project is not replacing existing facilities.

	Square Feet
New area being constructed by this project at BNL	150,000
Area of D&D in this project at BNL	0
Area at BNL to be transferred, sold, and/or D&D outside the project, including area previously "banked"	N/A
Area of D&D in this project at other sites	N/A
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously "banked"	N/A
Total area eliminated	0

8. Acquisition Approach

SC selected Brookhaven National Laboratory (BNL) as the site for the EIC on January 9, 2020. NP approved the Acquisition Strategy in conjunction with CD-1. DOE will utilize the expertise of the Management and Operating contractors at BNL and TJNAF to manage the project including the design, fabrication, monitoring cost and schedule, and delivering the technical performance specified in the KPPs. A certified Earned Value Management System based on those that already exist at both laboratories and will evaluate project progress and ensure consistency with DOE Order 413.3B, Program and Project Management for the Acquisition of Capital Assets.

Isotope R&D and Production

Overview

The DOE Isotope Program's (DOE IP) mission is to:

- Produce and/or distribute stable isotopes and radioisotopes in short supply or unavailable in the United States, including related isotope services;
- Maintain mission readiness of critical national facilities, equipment, and core competencies needed to manufacture isotopes and ensure the U.S. is prepared to respond to supply chain gaps during a national crisis;
- Conduct R&D to develop transformative isotope production, separation, and enrichment technologies to enable federal, academic, and industrial innovation, research, and emerging technologies;
- Nurture an inclusive and diverse domestic workforce with unique and world-leading core competencies; and
- Mitigate U.S. dependence on foreign supplies of isotopes and promote robust domestic supply chains for U.S. economic resilience.

The DOE IP produces high priority radioactive and stable isotopes that are in short supply for the Nation or represent a supply chain risk due to reliance on countries that have been identified as "sensitive" by the DOE for policy reasons. The DOE IP is typically the only, or one of few, global producers for these isotopes. Isotopes are high priority, enabling commodities of strategic importance for the Nation and essential in medical diagnosis and treatment, discovery science, national security, advanced manufacturing, semiconductor manufacturing, space exploration, communications, biology, quantum information science, clean energy, and other fields. The DOE IP works closely with industry to ensure availability of isotopes for their economic stability and growth, and facilitates commercialization of isotope production to the domestic private sector. DOE IP continues operations during national emergencies to mitigate disruptions in isotope supply chains. DOE IP mitigates disruptions in supply chains critical to federal agencies, industry, and research during times of national crisis, such as the COVID-19 pandemic and the Russian invasion on Ukraine.

The DOE IP oversees the irradiation of targets at particle accelerators and nuclear research reactors at national laboratories and universities, which are then processed in radiochemical equipment to extract radioisotopes of interest; DOE IP also oversees extraction of radioisotopes from legacy waste or inventories to reduce waste disposition while providing a valuable product. DOE IP manages federal inventories of isotopes for the Nation, such as helium-3 (He-3), which is essential for cryogenics, quantum information science (QIS), fusion energy, and national security applications.

The DOE IP is responsible for the repository of stable isotopes that was produced by the calutrons developed as part of the Manhattan Project. The calutrons, mass spectrometers used for electromagnetic ion separation, ceased operations in 1998, which left the U.S. with no broad isotope enrichment capability. The U.S. inventory of stable isotopes is limited, requiring the U.S. to rely on foreign countries (mainly Russia) for critical stable isotopes. One of the DOE IP's highest priorities is to develop modern stable isotope enrichment capabilities to rebuild domestic manufacturing capabilities, replenish inventories, and promote U.S. economic resilience, prosperity, and competitiveness.

The DOE IP supports a world-leading R&D program in innovative isotope production, enrichment, and chemical separations. Isotope manufacturing and R&D activities provide collateral benefits for training and workforce development, and promotion of a future U.S.-based expertise relevant to clean energy, accelerator science, nuclear engineering, nuclear physics, isotope enrichment, and radiochemistry. These disciplines are foundational, not only to isotope production and processing, but they also underpin many essential aspects of basic and applied nuclear and radiochemical science R&D and production activities develop and employ techniques and platform technologies in artificial intelligence (AI), machine learning (ML), robotics, and advanced manufacturing.

The FY 2025 Request supports mission readiness of facilities, expert staff, and related equipment focused on addressing isotope shortages; innovative research; and new capabilities to meet the Nation's growing demand for isotopes. Customer collections from sales will pay for the actual production and distribution of the isotope and related services. Isotopes sold to commercial customers and allied foreign entities will be priced at full-cost recovery or market price (whichever is higher). Isotope pricing for domestic research will be reduced to promote innovation and scientific advances.

Highlights of the FY 2025 Request

The FY 2025 Request for $183.9 million is an increase of $74.4 million over the FY 2023 Enacted. In FY 2025, the DOE IP anticipates mounting supply disruptions of critical and high-impact isotopes. Supply chains are increasingly vulnerable since the Russian invasion of Ukraine. Demand in both radio and stable isotopes continues to increase for high priority national applications and technologies such as nuclear batteries, power sources, clean energy technologies, semiconductor and microelectronics manufacturing, quantum computing, next generation advanced fission and fusion reactors, and medical treatment and diagnosis of cancer and other infectious diseases.

The FY 2025 Request increases support for operations of all isotope production facilities to 85 percent optimal and supports essential workforce to respond more efficiently to fill gaps in critical isotope supply chains. A newly refurbished low energy medical cyclotron at Brookhaven National Laboratory (BNL) will ramp up to increase the availability of actinium-225, a medical isotope that is showing success in treating metastasized cancers. The Request provides support to address high priority deferred maintenance and single point failures to increase safe, robust, and reliable operations across production sites. FY 2025 funding supports increased staffing at the National Isotope Development Center (NIDC), the business arm of the DOE IP, to address the rapidly increasing interfaces with the domestic and allied international stakeholder community.

The FY 2025 Request includes support for the start of operations of the Stable Isotope Production Facility (SIPF) Major Item of Equipment (MIE) to operate the Nation's first full-scale and modern gas centrifuge cascade for enrichment of stable isotopes; SIPF will first produce xenon-129 (Xe-129) for polarized lung imaging and diagnosis of infectious disease. Scientists and engineers will assemble and commission new electromagnetic ion separation (EMIS) devices to enrich high priority stable isotopes. The Program will advance towards the development of a heavy water inventory, enabled by Inflation Reduction Act (IRA) funding. The DOE IP will address high risk isotopes, including helium-3 for quantum computing and strontium-90 for nuclear batteries and medical applications.

The DOE IP will re-prioritize research and development investments in FY 2025, focusing on the development of isotopes with the deepest impact to the lives of U.S. taxpayers and U.S. national security. The Reaching a New Energy Sciences Workforce (RENEW) and Funding for the Accelerated, Inclusive Research (FAIR) initiatives will increase to continue DOE IP efforts to advance equity and inclusion of underserved communities and emerging research institutions as well as HBCUs and MSIs in SC-sponsored research. The DOE IP involvement in the Biopreparedness Research Virtual Environment (BRaVE) will enhance national preparedness with investment in equipment and research to produce isotopes for biology, biomedicine, and that strengthen the Nation's response when in a pandemic or other medical emergency. Investments in microelectronics will support research to produce isotopes needed for semiconductor manufacturing. The Request includes continued support of research to advance the production of isotopes of interest for quantum computing.

In FY 2025 the Facility for Rare Isotope Beams (FRIB) harvesting effort at Michigan State University (MSU) will complete the transition to routine operations and will extract and process rare isotopes from the FRIB beam dump for research purposes. The Request increases support for the University Isotope Network (UIN), which recently expanded to include the University of Wisconsin-Madison and Texas A&M University.

The FY 2025 Request includes $45.9 million in Total Estimated Cost (TEC) funding to advance the Stable Isotope Production and Research Center (SIPRC). DOE, in coordination with Oak Ridge National Laboratory (ORNL), held a groundbreaking in October 2022 for the SIPRC, which will expand the nation's capability to enrich stable isotopes for medical, industrial, and research applications, mitigating U.S. dependence on sensitive countries. The Request continues design for the Radioisotope Processing Facility (RPF) to address a lack of available radiochemical processing equipment to mitigate U.S. dependency on sensitive foreign supply chains of radioisotopes. Funding supports preliminary engineering design for the Clinical Alpha Radionuclide Producer (CARP) facility retrofit and equipment, to increase availability of high demand medical isotopes and address disruptions in global isotope supply chains.

Isotope R&D and Production
Funding

(dollars in thousands)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Isotope R&D and Production				
Isotopes, Research	38,827	57,288	43,629	+4,802
Isotopes, Operations	46,624	75,363	91,371	+44,747
Subtotal, Isotope R&D and Production	**85,451**	**132,651**	**135,000**	**+49,549**
Construction				
20-SC-51 U.S. Stable Isotope Production and Research Center (SIPRC), ORNL	24,000	20,900	45,900	+21,900
24-SC-92 Clinical Alpha Radionuclide Producer (CARP), BNL	–	–	1,000	+1,000
24-SC-91 Radioisotope Processing Facility, ORNL	–	–	2,000	+2,000
Subtotal, Construction	**24,000**	**20,900**	**48,900**	**+24,900**
Total, Isotope R&D and Production	**109,451**	**153,551**	**183,900**	**+74,449**

Basic and Applied R&D Coordination

Coordination and integration are vital in ensuring that critical isotopes are available to achieve the mission of federal agencies and organizations, industrial applications, and enable federal R&D goals. Isotopes are vital to federal agencies, including the National Institutes of Health (NIH), National Aeronautics and Space Administration (NASA), Department of Defense (DoD), Office of the Director of National Intelligence (ODNI), National Institute of Standards and Technology (NIST), Federal Bureau of Investigations (FBI), Department of Agriculture, Department of Homeland Security (DHS), National Science Foundation (NSF), and DOE. DOE IP conducts the biennial Workshop on Federal Isotope Supply and Demand to collect 5-year projections from all federal agencies to ensure adequate supply and evidence-based Program priorities. DOE IP effectively coordinates and communicates on isotope supply and demand at the federal level through participation in Federal and Interagency Working Groups, White House Office of Science and Technology Policy (OSTP) Subcommittees, National Security Council meetings, and White House Small Group and Inter Policy Committees; the DOE IP also leads the Interagency Group on He-3 to determine an annual federal allocation of He-3 from reserves in support of federal missions. DOE IP interacts closely and partners frequently with other DOE Offices on domestic supply chains of valuable isotopes; a few examples are the extraction of americium-241 for batteries from plutonium waste streams (NNSA); the provision of He-3 for cryogenics from tritium beds (NNSA); the detritiation of heavy water from legacy stockpiles and the provision of strontium-90 from legacy inventories from Environmental Management (EM); the extraction of promethium-147 for nuclear batteries from plutonium-238 waste streams (NE); and the recovery of krypton-85 for semiconductor manufacturing during spent fuel reprocessing (NE). In all these examples, the only other producer of these isotopes is Russia.

The DOE IP, along with the NIDC, meet throughout the year with industrial stakeholders to gauge the health of global supply chains. The Program also attends industry-organized meetings and roundtables to report on supply chain stability and sets up a Program booth at expositions at professional society meetings to promote communication and conduct outreach. The DOE IP is in the process of establishing a new Federal Advisory Committee, the Isotope R&D and Production Advisory Committee (IRDPAC), to provide guidance to the Program and aid in the development of priorities and long-range plans. Membership diversity will be balanced for demographics, disciplines, and stakeholder interests.

While the DOE IP is not responsible for the production of molybdenum-99, which is a widely used isotope in diagnostic medical imaging in the Nation, it works closely with NNSA, the lead entity responsible for domestic molybdenum-99 production, offering technical and management support. SIPRC will produce molybdenum-98 and molybdenum-100, precursors to certain molybdenum-99 production routes to ensure domestic supply chain resilience.

Program Accomplishments

Iridium-192 Domestic Supply Chain Underway to Mitigate DOD and other Reliance on Sensitive Countries

Iridium-192 (Ir-192) enables timely on-site radiography of metal welds to identify weaknesses in the same manner as an X-ray examines human skeletal structure. 100% of this Ir-192 has been sourced from foreign countries for over 20 years, including heavy reliance on sensitive countries. By working with ORNL and a U.S. company, DOE IP has arranged to restart domestic supply of this vital material, which will meet 30-50% of the U.S. market. This will support ongoing radiography inspections for Department of Defense ship building, piping for electrical energy plants, as well as bridge & railroad systems. Reducing foreign reliance is even more important as demand for radiography is increasing in the presence of green energy projects and expanding space exploration.

Cutting-edge System to Transform Most Any Metal into a Spherical Powder

ORNL's Stable Isotope Materials and Chemistry Group has installed a newly designed, cutting-edge system to transform most any metal into a spherical powder. To date, 25 unique elements and 5 alloys have been transformed into metal powders including uncommon elements that have important applications for our nation. Each powder sphere is nearly identical from particle to particle. While these metals are technically still solid, the powder grains roll like tiny ball bearings giving nearly any material the behavior of a free-flowing liquid. Unlike traditional powders, these can be injected or pumped to enable automated materials handling for advanced manufacturing processes. This emergent flow property is also enabling new concepts for nuclear batteries for defense and space initiatives. Handling solids like liquids is opening new capabilities for medical isotope production research. Improved production of powerful isotopes will better enable new cancer treatments.

Innovative Approach to Supplying Scandium-44, a Medically Relevant Diagnostic Isotope
Scandium-44 (Sc-44) is a promising medical isotope for positron emission tomography (PET) imaging allowing doctors to identify cancer, heart disease, and other conditions. The isotope can be produced through the radioactive decay of titanium-44 (Ti-44), and since it decays much more slowly than Sc-44, the same batch of Ti-44 can theoretically produce enough Sc-44 for many years of PET scans. The challenge has been to reliably and repeatably separate Sc-44 from Ti-44 in a hospital setting. BNL researchers have developed a new solution by synthesizing a chemical compound to attach the Ti-44 on a resin and fill a cylinder with it. By passing a specific liquid through the resin filled cylinder they found they were able to remove the Sc-44 and leave the Ti-44 behind on the resin. The invention is called a radioisotope generator since the process can be repeated as more scandium-44 is produced each day; and its portability and simplicity make it ideal for a hospital setting, where generators for other isotopes are already in use. The DOE IP supports this and other research and development efforts on Sc-44 radioisotope production at several facilities. DOE IP's goal is to make several scandium radioisotopes routinely and widely available in the near-term. With BNL's innovative approach, Sc-44 is one step closer to being evaluated for use in medical procedures.

Domestic Supply Chains Established for Biomedical Research
DOE IP established domestic production of many isotopes in response to the Russian war induced radioisotope supply chain disruption. Two examples include the production of iron-59 (Fe-59) and manganese-54 (Mn-54) which were commonly sourced from Russia prior to 2022. MURR has established routine production of these isotopes, and they are now offered for sale to the Nation through the DOE IP. Both isotopes are commonly used in biomedical research. Fe-59 is used in vitro and in vivo analyses of iron uptake, metabolism, and excretion studies. Mn-54 is a radioisotope commonly used as a radiotracer in biomedical research as well as environmental remediation. MURR is now supporting nationwide availability of these radioisotopes, establishing new domestic supply chains for these novel products.

Getting Purer Berkelium, Faster Than Ever
Berkelium's (Bk) primary use is in heavy element research to enable basic discovery science. Its most stable isotope, Bk-249, played a significant role in the creation and subsequent discovery of super-heavy element 117, tennessine (Tn). However, researchers often need better ways to extract individual heavy metal elements, called actinides, to obtain purer end products. A new separation technique developed by researchers at ORNL has accomplished just that and produced the world's purest Bk-249 to date. The new method is also much faster and easier to employ than previous methods, reducing the processing time from eight weeks to just eight days. The technique has synergies with other missions within the Federal Complex in that separation of individual actinides is essential for improving nuclear fuel recycling and nuclear waste management. Further research could lead to amplification of the production of other rare heavy actinide isotopes like einsteinium (Es) and fermium (Fm), the supply of which is currently dictated by the production cadence of other isotopes.

Isotope R&D and Production

Description

The DOE IP consists of three main components: research, operations, and line-item construction projects.

Research

Research funding at national laboratories and universities for both stable and radioisotopes supports core research groups, competitive research opportunities, SC research initiatives, operations mission readiness of the university facilities (a core competency of staff and maintained equipment for isotope production), university research projects, Other Project Costs (OPC) of construction projects, and workforce development. Core research aims to develop new production pathways or improve the efficiency, reliability, and/or cost-effectiveness of existing processes.

The DOE IP supports core research groups at Argonne National Laboratory (ANL), Brookhaven National Laboratory (BNL), Los Alamos National Laboratory (LANL), ORNL, and Pacific Northwest National Laboratory (PNNL) to conduct innovative research for novel or advanced production and chemical separation techniques for critical isotopes. Core research support is also provided to the UIN institutions; these universities provide domestic supply chains primarily to strengthen the Nation's research competitiveness and play an important role in workforce development. The UIN is currently comprised of the University of Washington (UW) Cyclotron, the University of Missouri Research Reactor (MURR), FRIB Isotope Harvesting at MSU, University of Alabama-Birmingham (UAB), University of Wisconsin-Madison (UWM), and Texas A&M University (TAMU). These universities have unique capabilities, such as the UW and TAMU multi-particle cyclotrons, where full-scale production of the alpha-emitter astatine-211 has been developed for cancer therapy. MURR boasts the highest flux university research reactor in the United States, and DOE IP uses MURR to produce multiple isotopes, including lutetium-177 for cancer therapy research. The UAB cyclotron includes four beamlines and associated target stations to produce a variety of radioisotopes, and has hot cells designated for the preparation of human use and preclinical radiopharmaceuticals. Harvesting of isotopes from the beam dump of the nuclear physics facility, FRIB, is an innovative approach to repurpose unwanted waste into valuable assets for U.S. research. The UWM cyclotron distributes a variety of isotopes and provides target fabrication expertise for the UIN.

A priority of the DOE IP is to develop a broad national stable isotope enrichment core competency as enriched stable isotopes are foundational to many applications, including the production of all radioisotopes. The production of each enriched stable isotope requires an intense research campaign. Core research funding for stable isotopes is provided to both ORNL and PNNL. In addition, machines are designed and optimized for isotopes of interest for quantum computing as part of the SC QIS Initiative. The development of Atomic Vapor Laser Ion Separation (AVLIS) at Lawrence Livermore National Laboratory is supported to promote clean energy by considering isotopically tailored low activation materials for fusion and fast fission nuclear reactors, and enrichment of isotopes that can yield fuel cycle cost savings and reduced nuclear waste.

Competitive research funds to universities and national laboratories support targeted activities, including research to develop novel isotopes of interest to U.S. stakeholders and establish domestic isotope supply chains. An example is heavy water (hydrogen replaced with deuterium), last produced domestically in 1981. Deuterium is disassociated from heavy water and is used in deuterated drugs products, biomedical research, fusion energy research, and semiconductor manufacturing. Foreign supply is fragile, and the DOE IP is developing technology to detritiate legacy heavy water at Savannah River National Laboratory (SRNL). Other examples of competitive research topics include the production of isotopes for next-generation advanced fission reactors (including molten salt) and fusion reactors, innovative medical isotopes, new sources of helium-3 for cryogenics, rare isotopes for nuclear forensics, critical nuclear data measurements, radioisotope enrichment technology, targetry, modular automated systems, robotics, and the application of machine learning and artificial intelligence to isotope production.

Another high priority area of research is the development of transformative medical isotopes to both diagnose and treat disease, reducing cancer mortality. Globally, there is escalating interest in alpha and beta emitters for revolutionary cancer and infectious disease therapy and diagnostics. The DOE IP is typically the sole global source for many of these isotopes or leading the way in innovative research and manufacturing to make them available. DOE IP remains committed to the production of alpha-emitters, including Ac-225. The ability to meet U.S. demand will require expansion of radiochemical processing infrastructure. Support for OPC for the Clinical Alpha Radionuclide Producer facility (CARP) advances new chemical processing capabilities at BNL, so that additional life-saving isotopes can be provided to U.S. patients, reducing cancer mortality. In coordination with the NIH, the DOE IP supports the basic science research that facilitates the transition of novel radioisotopes and targeted delivery agents from the laboratory to use in clinical trials for both diagnosis and treatment of disease.

As part of the SC BRaVE Initiative, national preparedness is enhanced with equipment and research to produce medical isotopes pertinent to biology, biomedicine, and the diagnosis and treatment of infectious disease to increase performance and response times during times of national crisis. Participation in the Microelectronics initiative enables a close examination of the isotopes that are needed for semiconductor manufacturing and subsequent research to consider the technology and radiochemistry needed for their production. Training and development opportunities for students and post-docs are a priority for DOE IP to promote a vibrant, inclusive, and diverse workforce essential for isotope production. DOE IP participates in the RENEW initiative to expand targeted efforts, including a RENEW graduate fellowship, to broaden participation in underserved communities, and advance equity and inclusion at emerging research institutions, HBCUs and MSIs. Participation in the SC FAIR initiative provides opportunities for research, bolstered with investments in equipment and infrastructure at emerging research institutions, HBCUs and MSIs, including attention to underserved communities.

DOE IP sponsors workshops at professional society meetings to promote communication of advances in isotope availability, research & development, and production, and invests in the Nation's future nuclear chemistry and biomedical researchers through support for the Nuclear Chemistry Summer School (NCSS) program. The NCSS, jointly supported with SC's Basic Energy Sciences (BES) and Nuclear Physics (NP) programs, consists of an intensive six-week program of formal accredited lectures on the fundamentals of nuclear science, radiochemistry, and their applications in related fields, as well as laboratory practicums focusing on state-of-the-art instrumentation and technology used routinely in basic and applied nuclear science.

<u>Facility Operations</u>
Facility operations supports activities at national labs: mission readiness at reactor, accelerator, and enrichment facilities; mission readiness supports the core group of expert staff required to manage, operate, and maintain the facilities and related equipment to produce isotopes, and the investments required to ensure safe, cost-effective, and reliable operations. Facility operations also supports equipment for chemical processing (such as hot cells and glove boxes); pre-operations of stable isotope equipment; inventory management and dispensing activities; management and maintenance of advanced manufacturing capabilities; operations support and assembly; and support of the NIDC, the business arm of the DOE IP.

The DOE IP relies on the Isotope Production Facility (IPF) at LANL and the Brookhaven Linac Isotope Producer (BLIP) facility at BNL; both are proton accelerators that, in combination, provide year-round continuous availability of medical radioisotopes. The IPF operates concurrently with the NNSA Los Alamos Neutron Science Center facility and BLIP operates concurrently with the Relativistic Heavy Ion Collider, and soon the Electron Ion Collider. The LEAF at ANL is the only electron accelerator in the Program and provides unique pathways for producing medical radioisotopes. The DOE IP utilizes the capabilities of two research reactors, the High Flux Isotope Reactor (HFIR) at ORNL stewarded by the SC Office of Basic Energy Sciences and the Advanced Test Reactor at INL, stewarded by the Office of Nuclear Energy. Related chemical processing and handling equipment is supported at these sites. In addition, processing capabilities are supported at PNNL for targeted isotopes such as strontium-90 for batteries and medical applications, radium-226 to produce Ac-225, and lead-212 isotope generators for cancer treatments. At the Y-12 National Security Complex, DOE IP supports the preparation and packaging of lithium isotopes and uranium-235 for industry and research, and americium-241 for nuclear sources and batteries is recovered from NNSA plutonium processes at the LANL Plutonium Facility. He-3 for cryogenics is extracted from NNSA-owned tritium beds at the Savannah River Site, and the radioisotope separator at INL enriches radioisotopes for nuclear forensics. Individual electromagnetic ion separators are assembled and operated at ORNL as the country awaits SIPRC to provide substantial capability.

The NIDC is located at ORNL and is responsible for the day-to-day business operations for the DOE IP, including sales, contract negotiation, marketing assessments, public outreach, quality control, packaging, and transportation. The NIDC arranges for regular and frequent interfaces between DOE IP and industrial, academic, and medical communities to ensure that strategies are evidence-based and informed by stakeholder interactions. Furthermore, the DOE IP formally canvasses the broad federal community for isotope demands every other year to align priorities with evidence-based program evaluations.

The DOE IP provides over 260 stable isotopes from inventory, produces a few stable isotopes, and produces ~100 radioisotopes in short supply for the Nation. Some examples of produced isotopes by the DOE IP are:

- actinium-225, actinium-227, astatine-211, cerium-134, scandium-47, scandium-44, holmium-166m, tungsten-188, lutetium-177, strontium-89, strontium-90, tin-117m, vanadium-48, manganese-52, manganese-54, gold-199, cobalt-55, and cobalt-60 for cancer therapy and imaging diagnostics
- californium-252 for nuclear reactor start-up, oil and gas exploration and production well logging
- arsenic-73, iron-52, iron-59, and zinc-65 as tracers in metabolic studies
- barium-133 for quantum computing research, medical standards, and industrial sources
- berkelium-249, americium-243, uranium-238, plutonium-242, plutonium-244, californium-249, californium-251, einsteinium-254, and curium-248 for use as targets for discovery of new super heavy elements
- bismuth-213, lead-212, lead-203, astatine-211, copper-67, thorium-227, thorium-228, radium-223, and radium-224 for cancer and infectious disease therapy and research
- cadmium-109 for X-ray fluorescence imaging and environmental research
- fermium-257 for heavy element chemistry research
- helium-3 for cryogenics and radiation detection
- lithium-6 neutron detectors for homeland security applications
- iridium-192, selenium-75 for industrial radiography
- silicon-32 for oceanography and climate modeling
- ytterbium-171 for quantum memory
- ytterbium-176 as feedstock for isotopes that treat prostate cancer
- nickel-63 for explosives detection
- strontium-90, promethium-147, americium-241, and thulium-170 for nuclear batteries and power sources

It can take decades for an economically and technically viable commercial market to be developed for any novel isotope. The DOE IP works closely with industry to commercialize technology and promote domestic independent producers in a smooth transition that does not disrupt supply and/or prohibit research. At that point, the DOE IP stops production to not compete with the domestic industry. Examples in which domestic commercial production now exists include strontium-82 for cardiac heart imaging and germanium-68 for medical diagnostics.

<u>Projects</u>

DOE IP-supported research demonstrated the feasibility of new EMIS and gas centrifuge (GC) technologies and re-established a prototype general enriched stable isotope production capability in the U.S. The subsequent SIPF Major Item of Equipment (MIE) at ORNL establishes the first full-scale GC cascade to enrich stable isotopes. The implementation of SIPF nears its planned completion in FY 2025 and shifts to operations to produce enriched xenon-129. Xenon-129 has demonstrated effectiveness in polarized lung imaging and there is currently no U.S. production capability. This isotope has also garnered the interest of the medical community in monitoring lung function and damage from infectious diseases such as COVID-19.

The DOE IP is implementing three projects to mitigate U.S. dependency on isotope supply chains from sensitive countries and fill gaps in rare medical isotope supplies The SIPRC project re-establishes large-scale stable isotope enrichment in the United States to compete with those of Russia and China. The Radioisotope Production Facility will meet the critical need to remove U.S. dependence on Russia for high-impact radioisotopes. The CARP facility makes available highly sought-after cancer therapeutics and diagnostics.

Isotope R&D and Production

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Isotope R&D and Production	**$109,451**	**$183,900**	**+$74,449**
Isotopes, Research	$38,827	$43,629	+$4,802
Funding supports high impact R&D activities at universities and national laboratories leading to advanced, innovative, and novel isotope production and processing technologies, increasing the availability of isotopes in short supply and promote U.S. economic resilience. The priority R&D remains on the development of full-scale processing and technology capabilities for the production of alpha- and beta-emitters for cancer therapy, of which the DOE IP is a global leader, and to promote their transition to medical applications. Funding maintains the University Isotope Network to perform the R&D necessary to enable routine production. Research to develop enrichment capability for new stable isotopes of importance, including isotopes for clean energy and quantum computing is maintained. Participation in the Advanced Manufacturing initiative continues with innovative isotope production technology that can facilitate commercial engagement and the promotion of domestic supply chains, such as "desktop" inkjet printing of production targets. Support for the DOE IP Traineeship Program with a goal to increase the diversity of the workforce as part of RENEW increases in FY 2023. Research increases for the BRaVE initiative in partnership with the University of Missouri to address a single point failure in reactor isotope processing and create tech-savvy jobs in an underserved rural area of Missouri with the implementation of the Radioisotope Science Center at		Core research supports the highest impact R&D activities at universities and national laboratories to strengthen the Nation's scientific and technical strengths. Competitive research focusses on efforts to urgently establish domestic supply chains that have been disrupted by the Russian invasion of Ukraine. Six universities participate in the UIN to produce unique isotopes and promote workforce development. Efforts to develop isotopes for clean energy applications and quantum computing continue. Participation in the SC initiatives RENEW and FAIR, BRaVE, and Microelectronics increases. Research funding enables support of the Nuclear Chemistry Summer School and participation in the SC Early Career Awards Program. Support for OPC activities of the CARP facility, to increase availability of rare medical isotopes that are revolutionizing cancer therapy.	The increase supports prioritized, evidence-based research activities that will improve or develop innovative isotope production, enrichment, and processing technology with the goal of increasing domestic supplies of critical isotopes for medicine, and national security. Specific activities include continued support of the Nuclear Chemistry Summary School and participation in the SC Early Career Awards Program; and OPC support for CARP conceptual design activities; support for RENEW and FAIR increases.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
MURR. Design for the ORNL RPF project continues to advance needed chemical processing infrastructure at ORNL. Research to advance isotope harvesting capabilities and expertise at FRIB are roughly maintained. Funding supports participation in the Accelerate initiative which supports scientific research to accelerate the transition of isotope science advances to clinical trials. Also, funding supports the FAIR initiative which provides focused investment on enhancing isotope research on clean energy, climate, and related topics at minority serving institutions, including attention to underserved and environmental justice regions.		
Isotopes, Operations $46,624	$91,371	+$44,747
Funding supports mission readiness (~80 percent optimum) of the growing portfolio of isotope production and processing sites and nurtures critical core competencies in isotope production and development, promoting robust domestic supply chains for cancer therapy and other applications. Support maintains NIDC activities to interface with the growing stakeholder community and rapidly expanding isotope portfolio. Funding continues to support electromagnetic separation technology optimized to heavy elements, enriched radioisotope separation technology, extraction of valuable isotopes from legacy Mark 18-A.	The Request will support increased mission readiness at all production and processing sites to 85 percent enabling the Program to fill gaps in isotope supply chains and develop new domestic sources of critical isotopes. Funding will continue to support EMIS implementation and operations, and development of other enrichment core competencies. The SIPF, the first full-scale gas centrifuge cascade for enriching stable isotopes, will begin operation. The newly refurbished cyclotron at BNL transitions to routine operations. Investments target high priority single point failures at the production sites as well as deferred maintenance.	The funding increase will support mission readiness to increase from approximately 80 to 85 percent. Evidence-based activities will support increased readiness to produce stable isotopes and establish a core competence in stable isotope operations; additional staff commission and operate new machines. The SIPF will begin producing Xe-129 for the diagnosis of infectious lung diseases. The new BNL cyclotron ramps up production of Ac-225 for the treatment of metastasized cancers. NIDC will add staff to keep pace with growing inquiries. Support will increase for the inventory management and unique dispensing of stable isotopes in special forms. Support will increase for the extraction of isotopes from the Mark 18-A legacy targets. Increased funding will address the highest priority efforts in a backlog of deferred maintenance and performance improvements to increase safe, reliable, and efficient operations.

Isotope R&D and Production
Construction

Description

The DOE Isotope Program (DOE IP) works with federal agencies and industry to mitigate disruptions in critical isotope supply chains from the ongoing Russian invasion of Ukraine and subsequent sanctions. DOE IP is investing in new capabilities to meet U.S. demand and reduce dependence on sensitive countries. These new facilities will allow the United States to increase processing capability and expand production of critical isotopes.

24-SC-91, Radioisotope Processing Facility (RPF)

To mitigate radioisotope dependence on geopolitically sensitive countries, and to meet U.S. demand for critical isotopes and establish domestic supply chains, it is critical to expand U.S. radioisotope processing capacity at the Radioisotope Processing Facility (RPF) at ORNL. The RPF is planned as a Hazard Category 2 nuclear facility outfitted with specialized equipment able to process the higher specific activity targets that are irradiated in a reactor, such as HFIR. The project received CD-0, Approve Mission Need, approval on April 29, 2021. The project is working to achieve CD-1/3A, Approve Alternative Selection and Cost Range, planned for FY 2024. The CD-0 approved TPC range is $310,000,000 to $615,000,000.

24-SC-92, Clinical Alpha Radionuclide Producer (CARP)

The Clinical Alpha Radionuclide Producer (CARP) will allow the U.S. to be competitive with geopolitically sensitive countries in the production of innovative medical isotopes to diagnose and treat cancer and ensure that U.S. taxpayers have access to life-saving medical treatments and diagnostics. Once operational, CARP will significantly increase the amount of radioisotopes that the U.S. can process, the batch sizes, and the concurrent chemical processing activities at the Brookhaven Linac Isotope Producer (BLIP). The CARP facility will include specialized chemical processing equipment and building modifications at BNL for the processing of accelerator-irradiated targets. CARP will cost-effectively repurpose an existing nuclear Hazard Category 3 Building and outfits it with hot-cells and supporting equipment. Not only will CARP allow the domestic establishment of new accelerator-produced isotopes currently only produced outside of the U.S., but it will also enable an increase in the availability of highly sought-after alpha-emitting isotopes to decrease cancer mortality. CARP received CD-0, Approve Mission Need, approval on December 5, 2022, with a CD-0 approved TPC range of $60,000,000 to $80,000,000.

20-SC-51, U.S. Stable Isotope Production and Research Center (SIPRC)

The Stable Isotope Production and Research Center (SIPRC) will reinstate versatile, large-scale stable isotope enrichment capacity in the United States. Russia is the major producer of most stable isotopes and China is an emerging leader. The current capacity within the U.S. is insufficient to meet the Nation’s growing demands and the current inventory of stable isotopes is being depleted. SIPRC will address U.S. stable isotope needs in an economical and operationally efficient manner. Once constructed, SIPRC will provide critical isotopes for industry, medicine, and national security. The SIPRC line-item construction project will expand gas centrifuge isotope separation and EMIS production capability. SIPRC received CD-1, Approve Alternative Selection and Cost Range, and Subproject-1 CD-3A, Approve Long Lead Procurement, approvals on November 4, 2021. The project received approval for Subproject-1 CD-3B, Approve Long Lead Procurement, on July 19, 2023. The Total Project Cost (TPC) point estimate is $325,000,000 with a preliminary TPC range of $187,000,000 to $338,000,000, approved at CD-1. Impacts of rising construction costs and supply chain challenges were assessed and validated at evidence-based peer reviews in 4Q FY 2023.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Construction	**$24,000**	**$48,900**	**$24,900**
24-SC-91, Radioisotope Processing Facility (RPF)	$ —	$2,000	+$2,000
No funding requested.		The Request will support TEC of the RPF at ORNL. RPF will address a lack of available radiochemical processing infrastructure within the DOE IP complex for reactor target processing which inhibits production of critical isotopes. RPF will mitigate U.S. dependence on foreign radioisotope supply chains.	The increase will provide TEC funding to support preliminary engineering design.
24-SC-92, Clinical Alpha Radionuclide Producer (CARP)	$ —	$1,000	+$1,000
No funding requested.		The Request will support TEC of the CARP at BNL. CARP will enable the domestic establishment of new accelerator-produced isotopes currently only produced outside of the United States and will allow increase availability of highly sought after alpha-emitting isotopes to decrease cancer mortality and meet U.S. demand.	The increase will provide TEC funding to support engineering design to repurpose an existing facility at BNL and will add chemical processing equipment.
20-SC-51, U.S. Stable Isotope Production and Research Center (SIPRC)	$24,000	$45,900	+$21,900
Funding supports the continuation of engineering design and approved long lead procurements of the U.S. SIPRC.		Funding will continue design and construction of the U.S. SIPRC at ORNL, according to project plans, to provide large scale stable isotope production capacity for the Nation and mitigate U.S. dependence on foreign capabilities.	TEC funding will prioritize construction for the conventional facility and procurement of EMIS components, while continuing design of gas centrifuges.

Isotope R&D and Production
Capital Summary

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Capital Operating Expenses						
Capital Equipment	N/A	N/A	2,000	9,100	3,029	+1,029
Minor Construction Activities						
General Plant Projects	N/A	N/A	–	–	3,042	+3,042
Accelerator Improvement Projects	N/A	N/A	–	–	3,029	+3,029
Total, Capital Operating Expenses	**N/A**	**N/A**	**2,000**	**9,100**	**9,100**	**+7,100**

Isotope R&D and Production
Construction Projects Summary

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
24-SC-91, Radioisotope Processing Facility, ORNL						
Total Estimated Cost (TEC)	569,900	-	-	-	2,000	+2,000
Other Project Cost (OPC)	15,600	13,600	1,000	1,000	-	-1,000
Total Project Cost (TPC)	**585,500**	**13,600**	**1,000**	**1,000**	**2,000**	**+1,000**
24-SC-92, Clinical Alpha Radionuclide Producer (CARP), BNL						
Total Estimated Cost (TEC)	69,000	-	-	-	1,000	+1,000
Other Project Cost (OPC)	10,500	-	585	2,000	1,000	+415
Total Project Cost (TPC)	**79,500**	**-**	**585**	**2,000**	**2,000**	**+1,415**
20-SC-51, U.S. Stable Isotope Production and Research Center (SIPRC), ORNL						
Total Estimated Cost (TEC)	289,800	87,000	24,000	20,900	45,900	+21,900
Other Project Cost (OPC)	5,600	3,200	-	-	-	-
Total Project Cost (TPC)	**295,400**	**90,200**	**24,000**	**20,900**	**45,900**	**+21,900**
Total, Construction						
Total Estimated Cost (TEC)	**N/A**	**N/A**	**24,000**	**20,900**	**48,900**	**+24,900**
Other Project Cost (OPC)	**N/A**	**N/A**	**1,585**	**3,000**	**1,000**	**-585**
Total Project Cost (TPC)	**N/A**	**N/A**	**25,585**	**23,900**	**49,900**	**+24,315**

Notes:

- *The total preliminary TPC for the U.S. Stable Isotope Production and Research Center (SIPRC) of $295,400,000 does not include $29,600,000 ($24,000,000 TEC and $5,600,000 OPC) included in the Nuclear Physics program for prior years. The full preliminary total for SIPRC, combining the Nuclear Physics and Isotope R&D and Production funding, is $325,000,000. This project is not baselined.*
- *The total preliminary TPC for the Radioisotope Processing Facility (RPF) of $614,406,000 does not include $594,000 in OPC funding included in the Nuclear Physics program for prior years. The full CD-0 approved total for RPF, combining the Nuclear Physics and Isotope R&D and Production funding, is $615,000,000. This project is not baselined.*

Isotope R&D and Production
Scientific Employment

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Number of Permanent Ph.Ds (FTEs)	41	57	72	+31
Number of Postdoctoral Associates (FTEs)	30	34	36	+6
Number of Graduate Students (FTEs)	33	45	49	+16
Number of Other Scientific Employment (FTEs)	103	140	215	+112
Total Scientific Employment (FTEs)	**207**	**276**	**372**	**+165**

Note:
- *Other Scientific Employment (FTEs) includes technicians, engineers, computer professionals and other support staff.*

24-SC-91, Radioisotope Processing Facility (RPF)
Oak Ridge National Laboratory, ORNL
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary

The FY 2025 Request for the Radioisotope Processing Facility (RPF) is $2,000,000 of Total Estimated Cost (TEC) funding. The preliminary Total Project Cost (TPC) point estimate is $425,300,000 with a CD-0 approved TPC range of $310,000,000 to $615,000,000.

Significant Changes

This project data sheet (PDS) is an update of the FY 2024 PDS; this project is not a new start in FY 2025. The most recent DOE Order 413.3B approved Critical Decision (CD) is CD-0, Approve Mission Need, which was approved on April 29, 2021. The project is working to achieve CD-1/3A, Approve Alternative Selection and Cost Range, planned for FY 2024.

Other Project Cost (OPC) activities related to conceptual design and research and development come to completion in FY 2024; the Inflation Reduction Act (IRA) and FY 2023 Enacted Appropriation fully funded activities which will finalize the conceptual design of the facility, modular hot cell units, and radiochemical equipment in preparation for CD-1/3A. The IRA support avoided reallocation of dedicated project staff, reduced project risks, and enabled early value engineering. TEC funding in FY 2025 will support the highest priority engineering design activities related to the facility design and the modular hot cell units.

A Federal Project Director (FPD) with certification Level I has been assigned to RPF.

Critical Milestone History

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
FY 2025	4/29/21	3Q FY 2024	3Q FY 2024	4Q FY 2027	TBD	4Q FY 2027	4Q FY 2034

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout.

Fiscal Year	Performance Baseline Validation	CD-3A	CD-3B
FY 2025	4Q FY 2027	3Q FY 2024	N/A

CD-3A – Approve Long-Lead Procurements (Modular Hot Cell Units and related equipment)

Project Cost History

This project has a pre-CD-1 preliminary point estimate of $425,300,000 and a CD-0 approved Total Project Cost (TPC) range of $310,000,000 to $615,000,000. The table below reflects the upper cost of the TPC range as there is not yet a baseline. No construction, excluding approved long-lead procurement, will be performed until the project performance baseline has been validated and CD-3 has been approved.

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	48,500	536,500	585,000	30,000	30,000	615,000
FY 2025	38,300	536,700	575,000	40,000	40,000	615,000

Notes:

- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*
- *Since project is at CD-0, the funding estimates correlate to the upper end of the estimated TPC range.*

2. Project Scope and Justification

Scope

The scope of this project includes design and construction of a new Hazard Category 2 radioisotope processing facility, approximately 60,000 square feet, and the specialized equipment for chemically processing radioisotopes, with particular focus on irradiated reactor targets. RPF will be a purely technical facility (i.e., minimal office and staff amenities), and located on the Oak Ridge National Laboratory (ORNL) main campus. The design is planned to support up to eight new radioisotope production lines and be equipped with sufficient hot cells grouped to support these new product lines and research. Facility design concepts will include separate bays needed to support reconfigurable heavy shielding for transloading of irradiated targets and waste handling and storage of radioactive materials. The facility will be designed to incorporate other operations required to successfully produce isotopes such as staging and repair of manipulators and other equipment as well as the supporting infrastructure necessary for efficient operations such as cranes to assist in moving casks within the facility. The facility design will address how current Good Manufacturing Practices (cGMP) compliance will be assured. Construction of the proposed facility will also integrate “safety by design”, “quality by design”, and “safeguards by design” standards to ensure safe and efficient future operations.

Justification

RPF is critical to the Nation and to the DOE Isotope Program (DOE IP) within SC’s Office of Isotope R&D and Production. Radioisotopes are commodities essential for energy, medical, space, environmental, and national security applications and for basic research. Currently, radioisotope chemical processing capacity at appropriate hazard category facilities, and outfitted with specialized equipment such as hot cells, glove boxes and supporting laboratories, is the limiting factor for increasing domestic radioisotope production and establishing U.S. independence from foreign supplies of reactor produced isotopes. Without additional radiochemical processing capabilities for isotope separations, especially in proximity to the HFIR at Oak Ridge National Lab, the United States will remain dependent on isotope supply chains from geopolitically sensitive countries such as Russia, putting high priority applications critical to industry, scientific and technical strength, medicine, and national security at risk. RPF will provide radioisotope chemical processing capacity to meet the near-and long-term needs of the nation, therefore promoting U.S. economic growth and resilience, as well as reducing dependence on foreign supply.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*, and all appropriate project management requirements will be met.

Key Performance Parameters (KPPs)

Preliminary Key Performance Parameters (KPPs) are defined at CD-1 and may change as each subproject continues towards

CD-2, Approve Performance Baseline. CD-1 approval is expected later in 2024. At CD-2 approval, the KPPs will be baselined. The Threshold KPPs represent the minimum acceptable performance that the project must achieve. The Objective KPPs represent the desired project performance. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion.

Performance Measure	Threshold	Objective
Design/construct building	TBD	TBD
Instrumentation design/development	TBD	TBD

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
Design (TEC)			
FY 2024	8,500	8,500	8,500
FY 2025	2,000	2,000	2,000
Outyears	27,800	27,800	27,800
Total, Design (TEC)	**38,300**	**38,300**	**38,300**
Construction (TEC)			
Outyears	536,700	536,700	536,700
Total, Construction (TEC)	**536,700**	**536,700**	**536,700**
Total Estimated Cost (TEC)			
FY 2024	8,500	8,500	8,500
FY 2025	2,000	2,000	2,000
Outyears	564,500	564,500	564,500
Total, Total Estimated Cost (TEC)	**575,000**	**575,000**	**575,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Other Project Cost (OPC)				
Prior Years	3,594	3,594	2,557	–
Prior Years - IRA Supp.	10,600	10,600	–	–
FY 2023	1,000	1,000	893	5,419
FY 2024	–	–	961	3,842
FY 2025	–	–	183	1,339
Outyears	24,806	24,806	24,806	–
Total, Other Project Cost (OPC)	**40,000**	**40,000**	**29,400**	**10,600**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Project Cost (TPC)				
Prior Years	3,594	3,594	2,557	–
Prior Years - IRA Supp.	10,600	10,600	–	–
FY 2023	1,000	1,000	893	5,419
FY 2024	8,500	8,500	9,461	3,842
FY 2025	2,000	2,000	2,183	1,339
Outyears	589,306	589,306	589,306	–
Total, TPC	**615,000**	**615,000**	**604,400**	**10,600**

Note:
- *Since project is still at CD-0, the funding estimates in the tables above correlate to the upper end of the estimated TPC range.*

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	27,000	35,000	**N/A**
Design - Contingency	11,300	13,500	**N/A**
Total, Design (TEC)	**38,300**	**48,500**	**N/A**
Construction	370,000	360,000	**N/A**
Construction - Contingency	166,700	176,500	**N/A**
Total, Construction (TEC)	**536,700**	**536,500**	**N/A**
Total, TEC	**575,000**	**585,000**	**N/A**
Contingency, TEC	*178,000*	*190,000*	***N/A***
Other Project Cost (OPC)			
Conceptual Design	12,194	12,194	**N/A**
Start-up	17,806	9,306	**N/A**
OPC - Contingency	10,000	8,500	**N/A**
Total, Except D&D (OPC)	**40,000**	**30,000**	**N/A**
Total, OPC	**40,000**	**30,000**	**N/A**
Contingency, OPC	*10,000*	*8,500*	***N/A***
Total, TPC	**615,000**	**615,000**	**N/A**
Total, Contingency (TEC+OPC)	***188,000***	***198,500***	***N/A***

Note:
- *Since project is at CD-0, the funding estimates correlate to the upper end of the estimated TPC range.*

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	—	—	8,500	—	576,500	585,000
	OPC	14,194	1,000	—	—	14,806	30,000
	TPC	14,194	1,000	8,500	—	591,306	615,000
FY 2025	TEC	—	—	8,500	2,000	564,500	575,000
	OPC	14,194	1,000	—	—	24,806	40,000
	TPC	14,194	1,000	8,500	2,000	589,306	615,000

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	4Q FY 2034
Expected Useful Life	—
Expected Future Start of D&D of this capital asset	—

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	Current Total Estimate	Previous Total Estimate	Current Total Estimate
Operations	N/A	TBD	N/A	TBD
Utilities	N/A	TBD	N/A	TBD
Maintenance and Repair	N/A	TBD	N/A	TBD
Total, Operations and Maintenance	N/A	TBD	N/A	TBD

7. D&D Information

	Square Feet
New area being constructed by this project at ORNL	~60,000
Area of existing facility(ies) being replaced..	0
Area of any additional D&D space to meet the "one-for-one" requirement	0

8. Acquisition Approach

The ORNL Management and Operating (M&O) contractor, UT Battelle, will perform the acquisition for this project, overseen by the DOE Oak Ridge National Laboratory Site Office. The M&O contractor will consider various acquisition approaches and project delivery methods prior to achieving CD-1 and will be responsible for awarding and administering all subcontracts related to this project. Its annual performance evaluation and measurement plan will include project performance metrics on which it will be evaluated.

24-SC-92, Clinical Alpha Radionuclide Producer (CARP)
Brookhaven National Laboratory, BNL
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary

The FY 2025 Request for the 24-SC-92, Clinical Alpha Radionuclide Producer (CARP) facility is $2,000,000, including $1,000,000 of Total Estimated Cost (TEC) funding and $1,000,000 of Other Project Costs (OPC) funding. The current Total Project Cost (TPC) pre-conceptual point estimate is $74,000,000 with CD-0 approved TPC range of $60,000,000 to $80,000,000.

Significant Changes

This project data sheet (PDS) is an update of the FY 2024 PDS; this project is not a new start in FY 2025. The most recent DOE Order 413.3B approved Critical Decision (CD) is CD-0, Approve Mission Need, which was approved on December 5, 2022. In FY 2025, OPC funding will continue conceptual design activities for both the facility modification as well as the hot cell and radiochemical equipment conceptual design. In FY 2025, TEC funding will support preliminary design activities for both the facility and the hot cell and radiochemical equipment.

A Federal Project Director (FPD) with certification Level II has been assigned to the BNL CARP.

Critical Milestone History

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
FY 2025	12/5/22	TBD	4Q FY 2026	4Q FY 2027	TBD	4Q FY 2027	4Q FY 2031

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout.

Fiscal Year	Performance Baseline Validation	CD-3A	CD-3B
FY 2025	4Q FY 2027	4Q FY 2026	N/A

CD-3A – Approve Long-Lead Procurements (Facility Utility Infrastructure Equipment)

Project Cost History

The table below reflects the upper cost of the TPC range as there is not yet a baseline. No construction, excluding approved long-lead procurement, will be performed until the project performance baseline has been validated and CD-3 has been approved.

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	6,500	63,500	70,000	10,000	10,000	80,000
FY 2025	6,000	64,000	70,000	10,000	10,000	80,000

2. Project Scope and Justification

Scope

The scope of this project includes design and construction activities to retrofit an already existing 7,000 square feet uncontaminated building at Brookhaven National Lab (BNL) that was designed and once operated as a Hazard Category 3 facility, as well as the associated instrumentation and equipment. The proposed facility will be equipped with hot cells, glove boxes, and equipment sufficient in number, space, and capability to support processing of irradiated accelerator targets, as well as Quality Assurance/Quality Control (QA/QC) and shipping and distribution activities. The facility design will address how current Good Manufacturing Practices (cGMP) compliance will be assured. The proposed modifications will also integrate safety, quality, and safeguards standards to ensure safe and efficient future operations.

Justification

CARP, a facility to increase the availability of innovative medical isotopes to diagnose and treat cancer, is essential to the Nation and to the DOE Isotope Program (DOE IP) within SC's Office of Isotope R&D and Production. This facility will enable radiochemistry capabilities to better meet U.S. demand, especially for medical isotopes, and mitigate supply chain interruptions for critical radioisotopes. Radioisotope processing needs to be performed in facilities that carry a Hazard Category designation. The nuclear facility hazard category defines the maximum quantity and type of radioactive material that can be present within a facility. This facility will allow radioisotope processing operations up to and including the Hazard Category 3 level, resulting in significant increases on the amount of material that can be processed, larger batch sizes, and more concurrent processing activities. Isotope production and processing at one of the DOE IP radioisotope production flagship facilities, the Brookhaven Linac Isotope Producer (BLIP), will benefit significantly and allow DOE IP to meet the anticipated demand for radioisotopes for research, medical therapy and diagnosis, commercial applications, and national security, therefore promoting U.S. economic growth and stability. The ability of BLIP to continue to process its irradiated targets will also help decrease U.S. dependence for radioisotopes on other countries, such as Russia.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*, and all appropriate project management requirements will be met.

Key Performance Parameters (KPPs)

Preliminary Key Performance Parameters (KPPs) are defined at CD-1 and may change as the project continues towards CD-2, Approve Performance Baseline. CD-1 approval is expected in 2026. At CD-2 approval, the KPPs will be baselined. The Threshold KPPs represent the minimum acceptable performance that the project must achieve. The Objective KPPs represent the desired project performance. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion.

Performance Measure	Threshold	Objective
Design/construct building	TBD	TBD
Instrumentation design/development	TBD	TBD

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
Design (TEC)			
FY 2024	1,000	1,000	1,000
FY 2025	1,000	1,000	1,000

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
Outyears	4,000	4,000	4,000
Total, Design (TEC)	**6,000**	**6,000**	**6,000**
Construction (TEC)			
Outyears	64,000	64,000	64,000
Total, Construction (TEC)	**64,000**	**64,000**	**64,000**
Total Estimated Cost (TEC)			
FY 2024	1,000	1,000	1,000
FY 2025	1,000	1,000	1,000
Outyears	68,000	68,000	68,000
Total, Total Estimated Cost (TEC)	**70,000**	**70,000**	**70,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Other Project Cost (OPC)			
FY 2023	585	585	84
FY 2024	1,500	1,500	2,001
FY 2025	1,000	1,000	1,000
Outyears	6,915	6,915	6,915
Total, Other Project Cost (OPC)	**10,000**	**10,000**	**10,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Project Cost (TPC)			
FY 2023	585	585	84
FY 2024	2,500	2,500	3,001
FY 2025	2,000	2,000	2,000
Outyears	74,915	74,915	74,915
Total, TPC	**80,000**	**80,000**	**80,000**

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	4,000	4,500	**N/A**
Design - Contingency	2,000	2,000	**N/A**
Total, Design (TEC)	**6,000**	**6,500**	**N/A**
Construction	43,000	42,500	**N/A**
Construction - Contingency	21,000	21,000	**N/A**
Total, Construction (TEC)	**64,000**	**63,500**	**N/A**
Total, TEC	**70,000**	**70,000**	**N/A**
Contingency, TEC	*23,000*	*23,000*	***N/A***
Other Project Cost (OPC)			
Conceptual Design	4,000	4,000	**N/A**
Start-up	3,000	3,000	**N/A**
OPC - Contingency	3,000	3,000	**N/A**
Total, Except D&D (OPC)	**10,000**	**10,000**	**N/A**
Total, OPC	**10,000**	**10,000**	**N/A**
Contingency, OPC	*3,000*	*3,000*	***N/A***
Total, TPC	**80,000**	**80,000**	**N/A**
Total, Contingency (TEC+OPC)	***26,000***	***26,000***	***N/A***

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	—	—	1,000	—	69,000	70,000
	OPC	—	—	1,500	—	8,500	10,000
	TPC	—	—	2,500	—	77,500	80,000
FY 2025	TEC	—	—	1,000	1,000	68,000	70,000
	OPC	—	585	1,500	1,000	6,915	10,000
	TPC	—	585	2,500	2,000	74,915	80,000

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	4Q FY 2031
Expected Useful Life	—
Expected Future Start of D&D of this capital asset	—

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	Current Total Estimate	Previous Total Estimate	Current Total Estimate
Operations	TBD	TBD	TBD	TBD
Utilities	TBD	TBD	TBD	TBD
Maintenance and Repair	TBD	TBD	TBD	TBD
Total, Operations and Maintenance	TBD	TBD	TBD	TBD

7. D&D Information

The new area being constructed in this project is not replacing existing facilities.

	Square Feet
New area being constructed by this project at BNL	N/A
Area of D&D in this project at BNL	N/A
Area at BNL to be transferred, sold, and/or D&D outside the project, including area previously "banked"	N/A
Area of D&D in this project at other sites	N/A
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously "banked"	N/A
Total area eliminated	N/A

8. Acquisition Approach

The BNL Management and Operating (M&O) contractor, Brookhaven Science Associates, will perform the acquisition for this project, overseen by the DOE Brookhaven National Laboratory Site Office. The M&O contractor will consider various acquisition approaches and project delivery methods prior to achieving CD-1 and will be responsible for awarding and administering all subcontracts related to this project. Its annual performance evaluation and measurement plan will include project performance metrics on which it will be evaluated.

20-SC-51, U.S. Stable Isotope Production and Research Center (SIPRC)
Oak Ridge National Laboratory, ORNL
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary
The FY 2025 Request for the U.S. Stable Isotope Production and Research Center (SIPRC) is $45,900,000 of Total Estimated Cost (TEC) funding. The current Total Project Cost (TPC) point estimate is $325,000,000 with a preliminary TPC range of $187,000,000 to $338,000,000.

Significant Changes
This project data sheet (PDS) is an update of the FY 2024 PDS; the project is not a new start in FY 2025. The most recent DOE Order 413.3B approved Critical Decisions (CD) are CD-1, "Approve Alternative Selection and Cost Range" and Subproject 1 (SP-1) CD-3B, "Approve Long-Lead Procurements", which was approved on July 19, 2023, as a risk mitigation strategy due to significant increases in lead times for critical EMIS magnet components. SIPRC is not baselined but the approval of CD-2/3, Approve Performance Baseline and Approve Start of Construction for SIPRC SP-1, is anticipated in the first half of FY 2024 that will authorize the start of SP-1 Construction-related activities.

The Inflation Reduction Act (IRA) funding received in FY 2022 optimized project performance through FY 2024 and will be expended by early FY 2025. The FY 2025 Request will continue support for construction activities that include completing funding for the phased conventional construction award as well as the procurement of equipment based on known designs of technologies developed under previous efforts. FY 2025 PED funding will support the completion of design activities related to the gas centrifuge scope as Subprojects 2 and 3 prepare for CD-2/3.

The shift in schedule reflects impacts from construction-related supply chain challenges and advancing project maturity through preliminary engineering design.

The KPP's of SP-1 have been adjusted to enable phased implementation of EMIS units as they are completed.

A Federal Project Director (FPD) with certification Level III has been assigned to the SIPRC.

Critical Milestone History

	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
SIPRC Project	1/4/19	2/26/21	11/4/21	4Q FY 2026	4Q FY 2026	4Q FY 2026	3Q FY2032
SIPRC SP-1 - Facility and EMIS	1/4/19	2/26/21	11/4/21	1Q FY 2024	1Q FY 2024	2Q FY 2024	4Q FY2030
SIPRC SP-2 - Mo-100 Cascade	1/4/19	2/26/21	11/4/21	4Q FY 2026	4Q FY 2026	4Q FY 2026	3Q FY 2032
SIPRC SP-3 - Test Cascade Infrastructure	1/4/19	2/26/21	11/4/21	4Q FY 2026	4Q FY 2026	4Q FY 2026	2Q FY 2032

Notes:
- *Dates shown in the SIPRC Project row in table above correspond to the latest subproject date (broken out by subproject in rows below).*
- *The estimated schedules shown are preliminary.*

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout.

	Performance Baseline Validation	CD-3A	CD-3B
SIPRC Project	4Q FY 2026	11/4/21	7/19/23
SIPRC SP-1 - Facility and EMIS	1Q FY 2024	11/4/21	7/19/23
SIPRC SP-2 - Mo-100 Cascade	4Q FY 2026	1Q FY 2026	N/A
SIPRC SP-3 - Test Cascade Infrastructure	4Q FY 2026	1Q FY 2026	N/A

Note:

- *Dates shown in the SIPRC Project row in table above correspond to the latest subproject date (broken out by subproject below). Dates shown for CD-3C are anticipated.*

CD-3A for Subproject 1 – Approve Long-Lead Procurements (EMIS components and Facility Site Preparation)
CD-3B for Subproject 1 – Approve Long-Lead Procurements (Additional EMIS components)
CD-3A for Subproject 2 – Approve Long-Lead Procurements (Additional GC components)
CD-3A for Subproject 3 – Approve Long-Lead Procurements (Additional GC components)

Project Cost History

This project is at CD-1/3A with a preliminary point estimate of $325,000,000 and Total Project Cost (TPC) range of $187,000,000 to $338,000,000. No construction, excluding for approved long-lead procurement, will be performed until the project performance baseline has been validated and CD-3 has been approved.

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	36,000	276,800	312,800	12,200	12,200	325,000
FY 2025	31,000	282,800	313,800	11,200	11,200	325,000

2. Project Scope and Justification

Scope

The scope of this project includes design and construction of a building, approximately 64,000 square feet, and associated instrumentation and equipment for enriching isotopes. Electromagnetic isotope separator systems and gas centrifuge cascades will be designed and installed in this new facility to promote operational, cost and security effectiveness, with space for future growth. The planned facility will include adequate space for test stands and prototype systems development and will be a purely technical facility (i.e., minimal office and staff amenities), and located on the Oak Ridge National Laboratory (ORNL) main campus. Gas centrifuges and electromagnetic separators are based on existing designs leveraging prior projects and R&D supported by the DOE Isotope Program (DOE IP). The laboratory considered the optimal number of production systems for each type of technology as part of the alternatives analysis for CD-1.

<u>Justification</u>

SIPRC is essential to the Nation and to the DOE Isotope Program (DOE IP) within SC's Office of Isotope R&D and Production. The facility will expand the only broad U.S. stable isotope production capability to enable multiple production campaigns of enriched stable isotopes. SIPRC will use innovative technology to establish domestic supply chains of critical stable isotopes and nurture domestic core competencies in enrichment technologies using centrifuges and electromagnetic ion separators. This will provide domestic supply chains of critical isotopes for industry, medicine, and national security and mitigate U.S. dependencies on foreign suppliers, a critical need which has been magnified by the Russian invasion of Ukraine and the development of a stable isotope production facility in China. The current capacity within the U.S. is insufficient to meet the Nation's growing demands and the current inventory of stable isotopes is being depleted. The SIPRC project will provide an adequately sized building and transformative technology to address our Nation's stable isotope needs in a more economical and operationally efficient manner.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*, and all appropriate project management requirements will be met.

<u>Key Performance Parameters (KPPs)</u>

Preliminary Key Performance Parameters (KPPs) are defined at CD-1 and may change as each subproject continues towards CD-2, Approve Performance Baseline. CD-1 approval was received November 4, 2021. At CD-2 approval, the KPPs will be baselined. The Threshold KPPs represent the minimum acceptable performance that the project must achieve. The Objective KPPs represent the desired project performance. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion.

Summary of preliminary KPPs is indicated below.

Performance Measure	Threshold	Objective
Design/construct building	SP-1 – Facility and EMIS: Beneficial occupancy of the facility obtained.	SP-1 – Facility and EMIS: Beneficial occupancy of the facility obtained.
Instrumentation design/development	SP-1 – Facility and EMIS: Ninety percent (90 percent) of the EMIS machines complete a functional operability demonstration of individual EMIS machines running with gas for 4 hours.	SP-1 – Facility and EMIS: One hundred percent (100 percent) of the EMIS machines complete a functional operability demonstration of individual EMIS machines running with gas for 4 hours.
	SP-2 – Mo-100 Cascade: a. The SIPRC project will complete the validation and verification (V&V) of the controls system with the completed documentation of the process. b. The SIPRC project will complete documented system leak tests with results meeting the requirements laid out in the systems requirements documents. c. The SIPRC project will complete a mechanical operability test of the completed production GCIS cascade.	SP-2 – Mo-100 Cascade: The SIPRC project will complete a 100Mo gas test of the constructed cascade using molybdenum hexafluoride gas. Evidence of completion will be the report on the results of the gas test.

Performance Measure	Threshold	Objective
	SP-3 – Test Cascade Infrastructure: a. The SIPRC project will complete the V&V of the controls system with the completed documentation of the process. b. The SIPRC project will complete documented system leak tests with results meeting the requirements laid out in the systems requirements documents.	SP-3 – Test Cascade Infrastructure: The SIPRC project will successfully complete an operability test of the TCI's feed and withdrawal system using a defined gas. The system must be able to flow gas at the planned flow rate range per the systems requirements document and withdraw the gas from the system piping into cold traps. Evidence of completion will be a report on the results of this test.

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Estimated Cost (TEC)				
Design (TEC)				
Prior Years	21,000	21,000	6,033	—
FY 2023	6,000	6,000	5,673	—
FY 2024	—	—	1,000	—
FY 2025	4,000	4,000	—	—
Outyears	—	—	18,294	—
Total, Design (TEC)	**31,000**	**31,000**	**31,000**	**—**
Construction (TEC)				
Prior Years	15,000	15,000	—	—
Prior Years - IRA Supp.	75,000	75,000	—	—
FY 2023	18,000	18,000	9,977	—
FY 2024	20,900	20,900	7,000	75,000
FY 2025	41,900	41,900	45,023	—
Outyears	112,000	112,000	145,800	—
Total, Construction (TEC)	**282,800**	**282,800**	**207,800**	**75,000**
Total Estimated Cost (TEC)				
Prior Years	36,000	36,000	6,033	—
Prior Years - IRA Supp.	75,000	75,000	—	—
FY 2023	24,000	24,000	15,650	—
FY 2024	20,900	20,900	8,000	75,000
FY 2025	45,900	45,900	45,023	—
Outyears	112,000	112,000	164,094	—

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Estimated Cost (TEC)				
Total, Total Estimated Cost (TEC)	**313,800**	**313,800**	**238,800**	**75,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Other Project Cost (OPC)			
Prior Years	8,800	8,800	3,435
FY 2023	–	–	1,465
FY 2024	–	–	2,535
Outyears	2,400	2,400	3,765
Total, Other Project Cost (OPC)	**11,200**	**11,200**	**11,200**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Project Cost (TPC)				
Prior Years	44,800	44,800	9,468	–
Prior Years - IRA Supp.	75,000	75,000	–	–
FY 2023	24,000	24,000	17,115	–
FY 2024	20,900	20,900	10,535	75,000
FY 2025	45,900	45,900	45,023	–
Outyears	114,400	114,400	167,859	–
Total, TPC	**325,000**	**325,000**	**250,000**	**75,000**

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	25,000	30,000	**N/A**
Design - Contingency	6,000	6,000	**N/A**
Total, Design (TEC)	**31,000**	**36,000**	**N/A**

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Construction	232,000	200,000	**N/A**
Construction - Contingency	50,800	76,800	**N/A**
Total, Construction (TEC)	**282,800**	**276,800**	**N/A**
Total, TEC	**313,800**	**312,800**	**N/A**
Contingency, TEC	*56,800*	*82,800*	***N/A***
Other Project Cost (OPC)			
Conceptual Design	8,800	8,000	**N/A**
Start-up	1,500	2,500	**N/A**
OPC - Contingency	900	1,700	**N/A**
Total, Except D&D (OPC)	**11,200**	**12,200**	**N/A**
Total, OPC	**11,200**	**12,200**	**N/A**
Contingency, OPC	*900*	*1,700*	***N/A***
Total, TPC	**325,000**	**325,000**	**N/A**
Total, Contingency (TEC+OPC)	***57,700***	***84,500***	***N/A***

5. Schedule of Appropriations Requests[a]

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	111,000	24,000	20,900	—	156,900	312,800
	OPC	8,800	—	—	—	3,400	12,200
	TPC	119,800	24,000	20,900	—	160,300	325,000
FY 2025	TEC	111,000	24,000	20,900	45,900	112,000	313,800
	OPC	8,800	—	—	—	2,400	11,200
	TPC	119,800	24,000	20,900	45,900	114,400	325,000

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	3Q FY2032
Expected Useful Life	30 years
Expected Future Start of D&D of this capital asset	3Q FY2062

Note:

- *Start of Operations reflects the initiation of phased implementation of operations for the EMIS units.*

[a] The project does not have CD-2 approval; FY 2025 schedules and costs are estimates consistent with the updated preliminary point estimate.

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	**Current Total Estimate**	**Previous Total Estimate**	**Current Total Estimate**
Operations	33,295	33,295	1,106,807	1,106,807
Utilities	4,053	4,053	133,735	133,735
Maintenance and Repair	2,992	2,992	90,458	90,458
Total, Operations and Maintenance	40,340	40,340	1,331,000	1,331,000

Note:
- *Life Cycle Costs includes escalation.*

7. D&D Information

	Square Feet
New area being constructed by this project at ORNL	64,000
Area of existing facility(ies) being replaced	0
Area of any additional D&D space to meet the “one-for-one” requirement	0

The new area being constructed in this project is not replacing existing facilities. Any existing space that is freed up from consolidating activities into SIPRC will likely be repurposed.

8. Acquisition Approach

The ORNL Management and Operating (M&O) contractor, UT Battelle, will perform the acquisition for this project, overseen by the DOE Oak Ridge National Laboratory Site Office. The M&O contractor will be responsible for awarding and administering all subcontracts related to this project. Its annual performance evaluation and measurement plan will include project performance metrics on which it will be evaluated.

Isotope Production and Distribution Program Fund

Overview

The Department of Energy's (DOE) Isotope Production and Distribution Program Fund provides a revolving account for the DOE Isotope Program (DOE IP) to enable the production of critical isotopes in short supply to the Nation and develops robust domestic supply chains to meet federal missions, facilitates emerging technology, and promotes the Nation's economic prosperity and technical competitiveness. The DOE IP produces and sells radioactive and stable isotopes, byproducts, surplus materials, and related isotope services worldwide to federal agencies, universities, and industry. One of the DOE IP's priorities is to mitigate the Nation's dependency on isotope supply chains from geopolitically sensitive countries. The National Isotope Development Center (NIDC) manages contractual obligations with customers, marketing, and isotope production coordination.

The Department supplies isotopes and related services to the Nation under the authority of the Atomic Energy Act of 1954, which specifies the role of the U.S. Government in isotope distribution. The Isotope Production and Distribution Program Fund was established by the 1990 Energy and Water Development Appropriations Act (Public Law 101-101) and amended by the 1995 Energy and Water Development Appropriations Act (Public Law 103-316). Funding for this revolving fund is provided by the annual appropriations from the Science appropriation account (through the Office of Isotope R&D and Production Program [IRP or DOE IP]) and collections from isotope sales; both are needed to maintain the supplies of critical isotopes. Isotopes sold to commercial customers are priced to recover the full cost of production or the market price, whichever is higher. Research isotopes are sold at a reduced price to ensure that the high priority research does not become cost prohibitive. The revolving fund allows continuous and smooth operations of isotope production, sales, and distribution independent of the federal budget cycle and fluctuating sales revenue. It also enables the DOE IP to operate during times of national crisis, such as COVID-19 and the Russian invasion of Ukraine. An external contractor conducts an independent cost review of the fund's revenues and expenses annually.

Annual appropriations in the DOE IP program support payments into the revolving fund to maintain mission-readiness of facilities, including the support of core scientists and engineers need to produce and process isotopes, and the maintenance and enhancement of isotope facilities and capabilities to ensure reliable production and provide novel isotopes in high demand and short supply. In addition, appropriated funds provide support for R&D activities associated with development of new production and processing techniques for isotopes and workforce development in isotope production and chemical processing. Appropriated funding also supports infrastructure refurbishment and enhancements in capabilities to quickly respond to isotope supply chain disruptions, as well as construction funds for ongoing line-item projects. Customer revenues offset the costs of producing, dispensing, packaging, and shipping isotopes; these revenues are also deposited into the revolving fund. About 90 percent of the total resources in the revolving fund are used for operations, maintenance, isotope production, and R&D for new isotope production techniques, with approximately 10 percent available for process improvements, unanticipated changes in revenue, manufacturing equipment, capability and infrastructure upgrades, and capital equipment such as assay equipment, glove boxes, and shipping containers needed to ensure on-time deliveries.

In FY 2024, an estimated total of $237.4 million will be deposited into the revolving fund. This consists of the FY 2024 President's Budget Request of $173 million that will be paid into the revolving fund from the Isotope R&D and Production program, plus anticipated collections by NIDC of $64.4 million to recover costs related to isotope production and isotope services. In FY 2024, the DOE IP expects to sell over 125 different radioactive and stable isotopes to a broad range of research and commercial customers, including major pharmaceutical companies, industrial stakeholders, and researchers at hospitals, national laboratories, other federal agencies, universities, and private companies.

Highlights of the FY 2025 Request

In FY 2025, the Department foresees continued strong growth in isotope demand, including alpha and beta emitters for novel cancer therapy and medical diagnostics; stable isotopes to enable high-discovery science, emerging technologies in medicine and national security; isotopes for quantum information science; isotopes to promote clean energy, including fusion energy; and isotopes for nuclear batteries, semiconductor manufacturing, and power supplies. The Program continues to focus on developing U.S. independence from Russian isotope supply chains and enabling the DOE IP to be proactive and target high-risk supply chains effectively to ensure that the U.S. has access to isotopes for discovery science, essential industrial applications, Administration priorities, and to combat cancer.

The DOE IP program's FY 2025 Request is $183.9 million, an increase of $74.4 million over FY 2023 Enacted. In FY 2025, we also anticipate additional collections by NIDC to recover costs related to isotope production and isotope services. Revolving fund resources will be used to address the following priorities in the program:

- Promote world-leading core competencies for isotope production to address gaps in supply chains and the provision of innovative, rare isotopes for high priority applications.
- Support facilities with a high degree of mission readiness so that they can operate safely, reliably, and efficiently to respond to crisis situations and fill gaps in isotope supply chains.
- Introduce novel and critical isotopes to the Nation through cutting-edge research and advanced manufacturing to facilitate emerging technology and applications (medicine, quantum computing, clean energy, nuclear batteries), promoting U.S. economic prosperity and technical strengths.
- Mitigate U.S. dependence on foreign supply chains and promote domestic production capabilities with technology transfer.
- Advance and expand transformative, domestic stable isotope enrichment capabilities.
- Enhance isotope processing capabilities to address a lack of radiochemical processing capacity limiting the availability of new isotopes, mitigating single point failures to increase the Nation's preparedness for reacting to global supply chain disruptions.
- Address targeted, high priority critical equipment needs to increase operational reliability of facilities by addressing single point failures, increasing spare components, and replacing obsolete equipment.

Program Accomplishments

Newly Refurbished Hot Cells Produce Record Batch Size of Rare Cancer Therapeutic

The recently renovated All-Purpose (AP) Hot Cells at Brookhaven National Laboratory (BNL) enabled a record-breaking achievement of the DOE IP Tri-Lab Ac-225 Research Effort, the largest Ac-225 batch to date: 112 mCi of Ac-225 was produced and made available for innovative cancer therapy. Ac-225 shows stunning success in treating metastasized cancers but is in short supply. The Tri-Lab collaboration established reliable, routine Ac-225 production, demonstrating that the process is scalable, but had been constrained at the 50 mCi level due to insufficient radiochemical processing capacity at the target irradiation sites (BNL and Los Alamos National Laboratory [LANL]). The renovation of the AP Hot Cells was completed in 2023, and the BNL Medical Isotope Research and Production Program (MIRP) successfully and reliably produced monthly batches of Ac-225 since operations were authorized. With the AP Hot Cells, DOE can provide additional supply of Ac-225 to support clinical trials.

The DOE IP Welcomes the University of Wisconsin-Madison and Texas A&M to the University Isotope Network (UIN)

The University of Wisconsin-Madison (UWM) Cyclotron Research Group joined the DOE IP UIN for the production of research and "boutique" isotopes. Supported by DOE IP funding, the UWM Cyclotron Research Group developed three new production lines of medical isotopes (Manganese-52g, Bromine-77, and Yttrium-86) and are now in routine production and available through NIDC. The UWM Cyclotron Research group brings expertise in developing targets for isotope production using low energy cyclotrons and will serve as the target resource for the other cyclotrons sites with the UIN. Texas A&M Cyclotron Institute has developed Astatine-211 (At-211) production which is now available for routine regional distribution through NIDC. There are now six universities in the UIN.

Accelerator R&D and Production

Overview

The Accelerator R&D and Production (ARDAP) program's mission is to coordinate Office of Science (SC) accelerator R&D; advance accelerator science and technology relevant to the Department, other Federal Agencies, and U.S. industry; foster public-private partnerships and other collaborative R&D activities to develop, demonstrate, and enable the commercial deployment of accelerator technology; support the development of a skilled, diverse, and inclusive workforce; and provide access to accelerator design and engineering resources. The overarching goal is to ensure a robust pipeline of innovative accelerator technology, train an expert and diverse workforce representative of the Nation, and reduce significant supply chain risks by reshoring critical accelerator technology. By ensuring the supply of leading accelerator technology and facilities, ARDAP supports physical science research that provides the foundations for innovative technologies for clean energy, medicine, security, and new tools to help clean up the environment and safeguard our water and food supplies.

As the lead office in the Accelerator Science and Technology Initiative, ARDAP coordinates accelerator R&D across SC and initiates new partnerships to move technologies from basic R&D into use at U.S. science facilities and into commercial products that benefit all Americans. These activities allow the U.S. to continue to provide the world's most comprehensive and advanced scientific research facilities and stimulate high technology sectors of the U.S. economy.[a]

The ARDAP program is organized into two subprograms: Accelerator Stewardship, and Accelerator Production.

Accelerator Stewardship

The Accelerator Stewardship subprogram supports cross-cutting basic R&D; facilitates access to unique state-of-the-art SC accelerator R&D infrastructure for the private sector and other users to operate a dedicated user facility for accelerator R&D and train new generations of scientists and engineers; and supports use-inspired accelerator technology R&D aimed at discovery science, medical, industrial, security, and environmental applications. The Accelerator Stewardship subprogram also supports development of software and material properties databases commonly used for accelerator design.

Research activities in cross-cutting accelerator technologies include superconducting magnets and accelerators, beam physics, data science-based accelerator controls, simulation software, new particle sources, advanced laser technology, and other transformative research. The Accelerator Stewardship subprogram will foster early-stage collaboration among academia, DOE national laboratories, and U.S. industry, reducing the time to commercialization. Research activities are informed by the requirements of both future SC facilities and the requirements for other applications.

Accelerator Production

The Accelerator Production subprogram supports public-private partnerships and other collaborative arrangements among academia, industry, and the DOE national laboratories to address targeted supply chain risk areas for SC scientific facilities. Increasing the capabilities of domestic accelerator technology suppliers to produce components and innovate will in turn strengthen the SC mission to conduct world-leading scientific research. Focus areas include advanced superconducting wire and cable, superconducting radiofrequency (RF) cavities, and high efficiency RF power sources for accelerators.

[a] Broadly speaking, the impact of particle accelerator technology is discussed in "Accelerators for America's Future", ed. W. Henning, C. Shank, (2010), available at https://science.osti.gov/-/media/hep/pdf/accelerator-rd-stewardship/Report.pdf. A detailed listing of the awards made by the Accelerator Stewardship program and their goals may be found at https://science.osti.gov/ardap/Funding-Opportunities/Awarded-RD-Activities.

Highlights of the FY 2025 Request

The FY 2025 Request for $31.3 million is an increase of $3.8 million over the FY 2023 Enacted, and will focus resources on fundamental research, operation and maintenance of a scientific user facility, and production of accelerator technologies in domestic industry. The FY 2025 Request will support:

- Innovative research, development, and deployment of accelerator technology, the implementation of the first consortium-based approach to accelerator R&D, and workforce development;
- Public-private partnerships to develop technologies that include advanced superconducting wire and cable, superconducting accelerators, and advanced radiofrequency power sources for accelerators;
- An increase in the Funding for Accelerated, Inclusive Research (FAIR) initiative, which will provide focused investment on enhancing research on clean energy, climate, and related topics at emerging research institutions, Historically Black Colleges and Universities (HBCUs), Minority Serving Institutions (MSIs) and underserved communities and regions.
- ARDAP's participation in the Reaching a New Energy Sciences Workforce (RENEW) initiative, which will expand targeted efforts, including a RENEW graduate fellowship, to broaden participation, especially in underserved communities, and advance equity and inclusion in SC-sponsored research.

The FY 2025 Request will support operations of the Brookhaven National Laboratory (BNL) Accelerator Test Facility (ATF) for 2,100 hours.

Accelerator R&D and Production
Funding

(dollars in thousands)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Research	21,436	21,241	23,508	+2,072
Facility Operations	6,000	7,934	7,765	+1,765
Total, Accelerator R&D and Production	**27,436**	**29,175**	**31,273**	**+3,837**

SBIR/STTR funding:

- FY 2023 Enacted: SBIR $686,000 and STTR $96,000
- FY 2024 Annualized CR: SBIR $667,000 and STTR $94,000
- FY 2025 Request: SBIR $608,000 and STTR $86,000

Basic and Applied R&D Coordination
The ARDAP program advances cross-cutting accelerator technology R&D and supply chain risk reduction efforts that support the mission of multiple SC programs and other federal agencies. The ARDAP program was developed based on input from accelerator R&D experts from DOE, other federal agencies, universities, national laboratories, and the private sector to help identify specific research areas and supply chain gaps where investments would have sizable impacts beyond the SC research mission.[b] This program is closely coordinated with Basic Energy Sciences, Fusion Energy Sciences, High Energy Physics, Nuclear Physics, the Isotope R&D and Production program, and partner agencies to ensure federal stakeholders have input in crafting funding opportunity announcements, reviewing applications, and evaluating the efficacy and impact of funded activities. These R&D and facility investments are guided through the participation of applied agencies in merit and facility operations reviews. In addition, to ensure R&D is aimed at a commercially viable product, accelerator R&D collaborations are expected to involve a U.S. company to guide the early-stage R&D.

Use-inspired accelerator R&D for medical applications has been closely coordinated with the National Institutes of Health/National Cancer Institute (NIH/NCI); ultrafast laser technology R&D with the Department of Defense (DOD) and the National Aeronautics and Space Administration (NASA); and microwave and high power accelerator R&D coordinated with the National Nuclear Security Administration (NNSA) and DOD, the Department of Homeland Security's Domestic Nuclear Detection Office in the Countering Weapons of Mass Destruction Office (DHS/CWMD), and the National Science Foundation/Mathematical and Physical Sciences (NSF/MPS) Division.

Compact accelerator technology is widely used in medical and security applications, and in May 2019 DOE, NCI, DOD, DHS, and NNSA co-sponsored a Basic Research Needs Workshop on Compact Accelerators for Security and Medicine[c] to establish research priorities for accelerator R&D in this critical area. This workshop has inspired follow-on funding opportunities at those agencies in addition to informing use-inspired basic R&D investments by ARDAP.

Laser technology is widely used in scientific research and applications, and in August 2023 DOE, NSF, and DOD co-sponsored a Basic Research Needs Workshop on Laser Technology to identify priority research directions and synergies amongst federal programs and with the private sector. The report, due in early 2024, will help inform laser technology R&D for years to come.

Program Accomplishments
In FY 2023, the Accelerator Stewardship and Accelerator Development subprograms funded 70 institutions, including 29 private companies, and nine DOE national laboratories. The funded R&D efforts resulted in seven patents, five PhDs, more than 44 publications, and more than 65 conference papers.

Technology translation activities have included collaborative R&D on proton therapy delivery systems (joint with Varian Medical Systems), advanced proton sources for therapy (joint with ProNova Solutions), advanced detectors for cancer therapy (joint with Best Medical International), advanced microwave source development (joint with Communications & Power Industries, L3Harris, and General Atomics), advanced laser technology development (with IPG Photonics and General Atomics), and technical design studies for high power accelerators for wastewater treatment (joint with Metropolitan Water Reclamation District of Greater Chicago, the Air Force Research Laboratory, and General Atomics). Public-private partnerships have begun with U.S. companies Radiation Monitoring Devices and Communications & Power Industries to strengthen key domestic suppliers of accelerator technology.

The BNL-ATF user facility provided 2,021 user hours in FY 2023, supporting a range of basic R&D and commercial technology development, and providing a training ground for the next generation of scientists. The facility supported 21 active experiments. Since 2014, BNL-ATF has provided more than 22,804 user beamtime hours.

[b] https://www.osti.gov/servlets/purl/1863553
[c] https://science.osti.gov/-/media/hep/pdf/Reports/2020/CASM_WorkshopReport.pdf

Accelerator R&D and Production

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Accelerator R&D and Production	**$27,436**	**$31,273**	**+$3,837**
Accelerator Stewardship	$21,554	$26,191	+$4,637
Research	*$15,554*	*$18,426*	*+$2,872*
Funding supports new research activities at laboratories, universities, and in the private sector on cross-cutting accelerator technologies such as superconducting magnets and accelerators, beam physics, data analytics-based accelerator controls, new particle sources, advanced laser technology R&D, and transformative R&D. Funding also supports the FAIR initiative to provide focused investment on enhancing research and workforce development at HBCUs, MSIs and emerging research institutions.		The Request will support new research activities at laboratories, universities, and in the private sector on cross-cutting accelerator technologies such as superconducting magnets and accelerators, beam physics, data analytics-based accelerator controls, new particle sources, advanced laser technology R&D, and transformative R&D. The Request will increase support for the FAIR initiative and ramps up support for the RENEW initiative, providing focused investment on enhancing research capabilities and workforce development at HBCUs, MSIs, and emerging research institutions.	The funding will increase the RENEW and FAIR initiatives, which will support workforce development and research capacity building in accelerator science and engineering, focusing resources on HBCUs, MSIs, and emerging research institutions to diversify the workforce. A robust program of cross-cutting basic R&D in accelerator and laser technology will continue. This R&D will continue to provide new accelerator technologies for science, medicine, security, and industry, and strengthen U.S. competitiveness in these areas.
Facility Operations and Experimental Support	*$6,000*	*$7,765*	*+$1,765*
Funding supports the BNL-ATF operations at optimal levels.		The Request will support the BNL-ATF operations for the maximum number of user hours and permit progress addressing deferred maintenance issues that adversely impact facility availability.	Funding will support 2,100 hours.

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Accelerator Production	$5,882	$5,082	-$800
Research	*$5,882*	*$5,082*	*-$800*
Funding supports increase for partnerships and collaborative R&D efforts to develop additional suppliers for critical accelerator technologies for SC scientific facilities. Increased investments allow technology transfer to proceed faster and across a broader range of component and subsystem technologies. Critical areas include advanced superconducting wire and cable, superconducting RF cavities and associated components, and high efficiency radiofrequency power sources for accelerators. Research partnerships to industrialize technologies for water purification, groundwater decontamination, and wastewater treatment begin.		The Request will support public private partnerships and collaborative R&D efforts to work with and strengthen domestic suppliers for critical accelerator technologies for SC scientific facilities. Critical areas supported will include advanced superconducting wire and cable, superconducting RF cavities and associated components, and high efficiency RF power sources for accelerators.	A robust program of business sector studies, partnerships, and collaborative R&D efforts will continue, providing strategic insights into how to advance accelerator technology for both public and private industry benefit. Some awards will not renew and new partnerships and collaborations will be added if turnover allows.

Note:

- *Funding for the subprogram above, includes 3.65 percent of research and development (R&D) funding for the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, excluding facility operations.*

Accelerator R&D and Production
Scientific User Facility Operations

The treatment of user facilities is distinguished between two types: TYPE A facilities that offer users resources dependent on a single, large-scale machine; TYPE B facilities that offer users a suite of resources that is not dependent on a single, large-scale machine.

(dollars in thousands)

	FY 2023 Enacted	FY 2023 Current	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Scientific User Facilities - Type A					
Accelerator Test Facility	**6,410**	**7,028**	**8,344**	**8,175**	**+1,765**
Number of Users	87	90	112	88	+1
Achieved Operating Hours	–	2,021	–	–	–
Planned Operating Hours	1,900	1,900	2,100	2,100	+200
Unscheduled Down Time Hours	–	350	–	–	–
Total, Facilities	**6,410**	**7,028**	**8,344**	**8,175**	**+1,765**
Number of Users	87	90	112	88	+1
Achieved Operating Hours	–	2,021	–	–	–
Planned Operating Hours	1,900	1,900	2,100	2,100	+200
Unscheduled Down Time Hours	–	350	–	–	–

Notes:
- *Achieved Operating Hours and Unscheduled Downtime Hours will only be reflected in the Congressional budget cycle which provides actuals.*
- *The Accelerator Test Facility will undergo an Accelerator Readiness Review in FY 2023, necessitating a reduction in planned operating hours as extensive preparation and review activities take place.*
- *Percent optimal operations defines what is achieved at this funding level. This includes staffing, up-to-date equipment and software, operations and maintenance, and appropriate investments to maintain world leadership.*

Accelerator R&D and Production
Scientific Employment

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Number of Permanent Ph.Ds (FTEs)	14	14	15	+1
Number of Postdoctoral Associates (FTEs)	4	5	5	+1
Number of Graduate Students (FTEs)	23	25	26	+3
Number of Other Scientific Employment (FTEs)	23	24	26	+3
Total Scientific Employment (FTEs)	**64**	**68**	**72**	**+8**

Note:
- *Other Scientific Employment (FTEs) includes technicians, engineers, computer professionals and other support staff.*

Workforce Development for Teachers and Scientists

Overview

The mission of the Workforce Development for Teachers and Scientists (WDTS) program is to ensure that Department of Energy (DOE) has a sustained pipeline for the science, technology, engineering, and mathematics (STEM) workforce. Accomplishing this mission depends on continued support for undergraduate internships, graduate thesis research opportunities, and visiting faculty research appointments; administration of the Albert Einstein Distinguished Educator Fellowship for K–12 STEM teachers for the federal government; annual, nationwide middle and high school science competitions culminating in the National Science Bowl® finals in Washington, D.C; and pathway programs to expand training opportunities for broadening participation. These activities support the development of the next generation of scientists, engineers, and technical professionals to address challenges on energy, environment, and national security.

WDTS activities rely significantly on long-standing partnerships with DOE's 17 national laboratories, which employ more than 30,000 individuals with STEM backgrounds. The DOE laboratory system provides access to leading scientific expertise, world-class scientific user facilities, capabilities, and resources, and large-scale, multidisciplinary, interdisciplinary, and transdisciplinary research programs unavailable in universities or industry. WDTS leverages these assets to provide authentic hands-on research and discovery learning opportunities for students and educators in support of the DOE workforce development mission.

Highlights of the FY 2025 Request

The FY 2025 Request of $43.1 million is an increase of $1.1 million over the FY 2023 Enacted. The FY 2025 Request prioritizes funding for workforce training programs that attract and train students and educators for STEM learning and authentic research experiences at DOE laboratories and expands the opportunities to individuals from new emerging research communities in STEM, including Historically Black Colleges and Universities (HBCUs), Tribal Colleges and Universities (TCUs), Minority Serving Institutions (MSIs), and community colleges. The Request continues support for the Reaching a New Energy Sciences Workforce (RENEW) initiative, which will build creative pathways to connect students and educators from new emerging research communities in STEM to DOE workforce training opportunities. The Request continues strong support for undergraduate internships, graduate thesis research, and visiting faculty program to help sustain a skilled workforce pipeline. The Request continues support for the technology infrastructure modernization and evaluation activity, which is critically important for evidence-based management practice to sustain the workforce training programs at DOE laboratories. It also prioritizes support for the DOE National Science Bowl®, a signature STEM competition testing middle and high school students' knowledge in science and mathematics. By encouraging and preparing students to pursue STEM careers, these programs address the DOE's STEM mission critical workforce pipeline needs required to advance science innovation and energy, environment, and national security.

Workforce Development for Teachers and Scientists
Funding

(dollars in thousands)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Workforce Development for Teachers and Scientists				
Science Undergraduate Laboratory Internship (SULI)	15,700	15,700	14,000	-1,700
Community College Internship Program (CCI)	2,200	2,200	2,300	+100
Visiting Faculty Program (VFP)	2,100	2,100	2,100	–
Office of Science Graduate Student Research (SCGSR) Program	5,000	5,000	5,500	+500
Reaching a New Energy Sciences Workforce (RENEW)	10,000	10,000	12,000	+2,000
Internships and Visiting Faculty Activities at DOE Labs	**35,000**	**35,000**	**35,900**	**+900**
Albert Einstein Distinguished Educator Fellowship	**1,200**	**1,200**	**1,200**	**–**
National Science Bowl	**3,000**	**3,100**	**3,100**	**+100**
Technology Development and On-Line Application	**700**	**700**	**700**	**–**
Evaluation	**600**	**600**	**700**	**+100**
Outreach	**1,500**	**1,500**	**1,500**	**–**
Total, Workforce Development for Teachers and Scientists	**42,000**	**42,100**	**43,100**	**+1,100**

Program Accomplishments

Science Undergraduate Laboratory Internship (SULI) — In FY 2023, approximately 1,111 placements were supported, of which 18.8 percent were from MSIs and approximately 37.8 percent were women. Among the participants, more than 98 percent reported positive impacts to their educational and career goals, more than 92 percent would consider a career at DOE national laboratories, and 99.5 percent would recommend SULI to their peers. As in prior years, participants continue to make notable contributions to research projects as evidenced by co-authorship in peer reviewed journals, patents, and/or presentations at scientific meetings.

Community College Internship Program (CCI) — In FY 2023, WDTS supported 144 CCI placements, with 54.9 percent from MSIs. Among the participants, 100 percent would recommend CCI to their peers and 100 percent reported positive impacts to their educational and career goals. More than 94 percent of participants reported that they would consider a job or career at DOE national laboratories.

Visiting Faculty Program (VFP) — In FY 2023, WDTS supported a total of 85 faculty and 25 student VFP placements, and of these participants, 62.4 percent of the faculty were from MSIs and 26.0 percent from HBCUs. Among the faculty participants, 14.1 percent were Black or African American and 17.6 percent were women. All VFP Faculty participants reported a positive impact on their careers, and all expressed interest in continuing their research collaboration. All participants would recommend VFP to their peers.

Office of Science Graduate Student Research (SCGSR) Program — During FY 2023, the two solicitations from FY 2022 resulted in a total of 131 new awards with 28.6 percent going to female graduate students. The first of the two annual solicitations of FY 2023 produced 60 new awards and the second solicitation was released in August, currently under review and selection. Starting late FY 2022, the SCGSR program implemented an increase of the current monthly stipend of active awardees due to increasing housing and other general living costs, for which the program received positive feedback from its communities. The increased stipend level will enable the SCGSR program to attract more diverse applicants, particularly those from new emerging research communities, and advance SC's diversity, equity, inclusion, and accessibility objectives for the energy sciences workforce.

Reaching a New Energy Sciences Workforce (RENEW) — In FY 2023, WDTS, established the first cohort of five WDTS RENEW Pathway Summer Schools for high school and early undergraduate students at Ames National Laboratory, Argonne National Laboratory, Fermi National Accelerator Laboratory, Brookhaven National Laboratory, Oak Ridge National Laboratory, and Pacific Northwest National Laboratory. WDTS expanded research collaboration opportunities with DOE national laboratories for enhancing research capacity and innovating STEM teaching and learning for faculty from higher education institutions emerging in research and STEM (including all HBCUs). The expansion led to nearly 30 percent increase of faculty participation in the VFP program. Furthermore, in collaboration with SC research programs, DOE national laboratories, and Oak Ridge Institute for Science and Education (ORISE), WDTS successfully led the evaluation and assessment of the RENEW initiative. The above efforts are ongoing and will inform the further development of the RENEW initiative.

Albert Einstein Distinguished Educator Fellowship (AEF) — In FY 2023, one WDTS-sponsored AEF participant held a WDTS office appointment and five were placed in Congressional offices. Nine other teachers were sponsored by the following Federal agencies: Library of Congress, Department of Defense, Department of Homeland Security, U.S. Geological Survey, National Aeronautics and Space Administration, and National Science Foundation. The AEF Program continues to equip teachers with access to a national network of education leaders and programs, a better understanding of the challenges and possibilities in STEM education, and a renewed passion for making a significant contribution to the educational community.

National Science Bowl®(NSB) — In FY 2023, more than 2,700 middle school students (from 504 schools) and 5,200 high school students (from 941 schools) participated in 108 regional competitions. Forty-nine U.S. States, the District of Columbia, and Puerto Rico were represented at regionals. More than 2,000 volunteers also participated in the local and national competitions. In May 2023, 47 middle school teams and 68 high school teams competed in the National Science

Bowl® Championship Finals at William F. Bolger Center in Potomac, Maryland, which featured a live web-streaming broadcast of the event to a broad public audience. The NSB continued to inspire young students nationwide to continue striving for high levels of academic success and to follow their passions in STEM, and hopefully, to consider a career to support the DOE mission.

Technology Development and On-Line Application — In FY 2023, the upgrade of the online platform initiated in FY 2022 continues and the transition of the online application modules for individual programs is mostly complete. The upgrade development for system integration with responsive design consideration is expected to continue into the first quarter of FY 2024. The upgrade will significantly increase cybersecurity and modernization of the online technology supporting all WDTS programs. The phase-one improvement of pre- and post-surveys for SULI, CCI, and VFP is completed; major features are developed to support mentors at DOE national laboratories, including mentor profile, mentor surveys, and a mentor resource center. New modules using the data analysis and visualization capability have been developed and have demonstrated their usefulness in producing annual program data summary reports to all host DOE national laboratories, compiling data for WDTS evaluation projects, and producing information to address inquiries from internal and external stakeholders.

Evaluation — In FY 2023, WDTS, in collaboration with ORISE, made progress towards building a comprehensive evaluation portfolio to support evidence-based management of workforce development programs and initiatives in WDTS and SC. The program completed a set of evaluation projects based on pre- and post-survey of program participants, including assessing how undergraduate internships affected participants on their STEM skills/knowledge, career goals, and diversity and inclusion, and outcome analysis of where they are. The program also completed a study of mentoring based on newly completed mentor surveys, which provided insights on support needed for mentoring. WDTS completed both the internal and external review of a proposed longitudinal evaluation study plan of the impacts of WDTS-sponsored undergraduate internship programs at DOE national laboratories and preparation for implementation is ongoing. An important evaluation activity is to coordinate with SC research programs on the assessment and evaluation of the RENEW initiative, leveraging the knowledge, infrastructure, and capabilities built through the evaluation activity and plan for the current WDTS programs.

Outreach — In FY 2023, in collaboration with ORISE, DOE laboratories, and higher education institutions, WDTS supported and co-hosted a series of virtual events (Application Assistance Workshops, IGNITE Off, Virtual Internship Fair, Virtual Intern Panel and Networking, and Virtual Graduate Student Recruitment Fair) to actively engage HBCUs, TCUs, MSIs, community colleges, and to enable equitable access to workforce training opportunities by all. In addition to virtual events, WDTS conducted in-person workshops or panels at HBCUs and conferences serving large membership of students and faculty from underserved and minority groups. The outcome of the WDTS annual proposal call resulted in a comprehensive set of outreach activities led by DOE host laboratories. They focus on: expanding model outreach practices “mini-semester” over winter break and training past participants to serve as WDTS program “ambassadors” on social media and at in-person events at their home institutions; introducing faculty from institutions - in the research enterprise to unique lab capabilities and facilities; promoting best practices for inclusive mentoring; and raising awareness of DOE, SC, and WDTS opportunities among the professional societies with a strong focus on individuals and institutions from emerging research communities.

Workforce Development for Teachers and Scientists

Description

Activities at the DOE Laboratories

WDTS supports activities such as the SULI, CCI, VFP, and SCGSR programs, and RENEW. One of the primary goals of these programs is to prepare students to enter STEM careers that are especially relevant to the DOE mission. By providing hands-on research experiences at DOE laboratories under the direction of scientist/engineer mentors, these activities provide workforce training opportunities for participants to engage in authentic research and discovery learning. WDTS activities are aligned with the Administration's goals for preparing a highly skilled and diverse future U.S. workforce.

SULI places students from two- and four-year undergraduate institutions as paid interns in science and engineering research activities at DOE laboratories, working with laboratory staff scientist and engineer mentors on projects related to ongoing research programs. Appointments are for ten weeks during the summer term and 16 weeks during the fall and spring terms.

CCI places community college students as paid interns in technological activities at DOE laboratories, working under the supervision of a laboratory technician or researcher mentor. CCI provides dedicated technical training for community college students who are interested in technical careers and provides a pathway for those who plan to pursue further educational objectives beyond community college.

The original VFP goal was to increase the research competitiveness of faculty members at U.S. institutions of higher education historically underserved in the research community, including all HBCUs. As part of the RENEW initiative, VFP opportunities have been expanded for both enhancing research capacity and innovating STEM teaching and learning at faculty members' home institutions through extended research collaboration with DOE national laboratories. Appointments are for 10 weeks in the summer, fall, and spring terms.

SCGSR's goal is to prepare graduate students for STEM careers critically important to the SC mission by providing graduate thesis research opportunities at DOE laboratories. The SCGSR program provides supplemental awards for graduate students to pursue part of their graduate thesis research at a DOE laboratory or facility in areas that address scientific challenges central to the SC mission, including convergence topics of interest to multiple SC research programs. U.S. graduate students pursuing Ph.D. degrees in physics, chemistry, materials sciences, non-medical biology, mathematics, computer or computational sciences, or specific areas of environmental sciences aligned with the SC mission, are eligible for research awards to conduct part of their graduate thesis research at a DOE laboratory or facility in collaboration with a DOE laboratory scientist. Research award terms range from three months to one year.

As an active participant in the SC-wide RENEW initiative, WDTS coordinates with SC research programs and DOE national laboratories to develop SC mission research focused training opportunities for undergraduate and graduate students from population groups and academic institutions not currently well represented in the U.S. S&T ecosystem. WDTS has a unique role to play by significantly expanding SC reach to students and educators at all levels, especially those from emerging research communities in STEM, and building creative pathways to better prepare them for STEM learning and career based on rigorous evaluation and assessment.

Albert Einstein Distinguished Educator Fellowship

The Albert Einstein Distinguished Educator Fellowship Act of 1994 charges DOE with administering a fellowship program for elementary and secondary school mathematics and science teachers that focuses on bringing teachers' real-world expertise to government to help inform federal STEM education programs. Selected teachers spend 11 months in a Federal agency or a Congressional office. WDTS manages the Albert Einstein Distinguished Educator Fellowship Program for the Federal government. SC sponsors placement opportunities in WDTS and in Congressional offices. Other Federal agencies sponsor placement opportunities in their own offices. Participating agencies include the National Science Foundation, National Aeronautics and Space Administration, the Library of Congress, the Department of Defense, the U.S. Geological Survey, and the Department of Homeland Security. The Fellows provide educational expertise, years of teaching experience, and personal insights to these offices to advance Federal science, mathematics, and technology education programs.

National Science Bowl®

The DOE National Science Bowl® is a nationwide academic competition testing students' knowledge in all areas of mathematics and science, including energy. High school and middle school students are quizzed in a fast-paced, question-and-answer format. Approximately 325,000 students have participated in the National Science Bowl® throughout its 33-year history, and it is one of the Nation's largest science competitions. WDTS manages the National Science Bowl® and sponsors the National Science Bowl® finals competition. Regional competitions rely upon volunteers and are supported by numerous local organizations, both public and private.

Technology Development and On-Line Application

This activity modernizes on-line systems used to manage application solicitations, review applications, and facilitate data collection, curation, and compilation to support evaluation for WDTS programs. A project to develop, build, and launch new online application and program support systems continues, with evolving new elements that improve accessibility to applicants, advance program oversight and assessment by WDTS program staff, and allow more efficient management and execution of programs by DOE laboratory staff.

Evaluation

This activity supports work to assess whether WDTS programs meet established goals. This is accomplished through triennial reviews of its program performers, of WDTS itself, and of program performance. These reviews involve peer reviews and Federal Advisory Committee-commissioned Committee of Visitors reviews. In addition, as an important part of assessing STEM workforce training programs, activities are supported to measure short-term program outcomes and assess longer-term program impact. The supported activities include the compilation and analysis of data and other materials, including pre- and post-participation surveys, participant deliverables, notable outcomes (publications, presentations, patents, etc.), and longitudinal participant tracking/outcome analysis. WDTS is also tracking and reporting how its programs, and activities at DOE labs and SC scientific user facilities, fulfill program goals and objectives. In support of the RENEW initiative, the knowledge, infrastructure, and capabilities built through the evaluation activity for the current WDTS programs is leveraged to help set the goals and craft strategies for assessing the new activities, in coordination with SC research programs and offices.

Outreach

WDTS engages in outreach activities, some in cooperation with other DOE program offices and select federal agencies, to widely publicize its opportunities. The WDTS website (https://science.osti.gov/wdts) is the most widely used tool for prospective program participants to obtain information about WDTS, and it provides a gateway to accessing the online applications for the WDTS programs. To help diversify the applicant pool and provide equitable access, outreach is conducted via multiple venues, with intentional brand messaging, such as hosting panels for and giving presentations to targeted stakeholder groups, sharing information with professional societies, and using virtual platforms to host internship and career fairs. WDTS leverages SC's social media resources to amplify the program opportunities to a broad range of stakeholders, including SC research grantees, scientific professional societies, HBCUs and other MSIs, and community colleges with a focus on emerging research communities. WDTS annually solicits proposals from DOE host laboratories and facilities to develop and execute outreach activities aimed at recruiting more diverse, equitable, and inclusive applicant and participant pools for WDTS laboratory-based programs, and to encourage WDTS program participants to pursue careers supporting the SC and DOE mission, including staffing needs at DOE national laboratories. The Laboratory Equipment Donation Program (LEDP) is operated under Outreach and provides excess laboratory equipment to STEM faculty at accredited post-secondary educational institutions. Through the General Services Administration Energy Asset Disposal System, DOE sites identify excess equipment, and colleges and universities can then search for equipment of interest and apply via the website. The equipment is free, but the receiving institutions pay for shipping costs.

Workforce Development for Teachers and Scientists

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Workforce Development for Teachers and Scientists	**$42,000**	**$43,100**	**+$1,100**
Activities at the DOE Laboratories	$35,000	$35,900	+$900
Science Undergraduate Laboratory Internship (SULI)	*$15,700*	*$14,000*	*-$1,700*
Funding for SULI supports approximately 1,035 students with an increased allocation per participant. Over the years, the cost of supporting interns at DOE national laboratories has increased and the housing cost has more than doubled in many places. In addition, increased support is necessary to keep the program competitive in terms of the financial support (stipend and allowance for housing/travel) to individual interns in comparison to other internships programs (such as those supported by NSF and other agencies).		The Request for SULI will support approximately 923 students.	Funding will support 112 fewer students due to prioritizing other programs below.
Community College Internship Program (CCI)	*$2,200*	*$2,300*	*+$100*
Funding for CCI supports approximately 167 students with an increased allocation per participant. Over the years, the cost of supporting interns at DOE national laboratories has increased and the housing cost has more than doubled in many places. In addition, increased support is necessary to keep the program competitive in terms of the financial support to individual interns in comparison to other internships programs (such as those supported by NSF and other agencies).		The Request for CCI will support approximately 174 students.	Funding will support 7 more students.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Visiting Faculty Program (VFP) $2,100	*$2,100*	*$ —*
Funding for the VFP supports approximately 66 faculty and 32 students with an increased allocation per participant. Over the years, the cost of supporting visiting faculty members at DOE national laboratories has increased and the housing cost has more than doubled in many places. In addition, increased support is necessary to keep the program competitive in terms of the financial support to individual faculty members in comparison to similar programs.	The Request for the VFP will support approximately 66 faculty and 32 students.	No change.
Office of Science Graduate Student Research (SCGSR) Program $5,000	*$5,500*	*+$500*
Funding for the SCGSR program supports approximately 190 graduate students. Targeted priority research areas will be informed by SC's workforce training needs studies.	The Request for the SCGSR program will support approximately 168 graduate students. As the cost of living to conduct graduate thesis research at DOE national laboratories and program administration will continue to increase, increased support will be necessary to keep the program competitive in terms of the financial support to individual graduate awardees in comparison to similar programs. The Request supports a new international research collaboration allowance to provide opportunities for SCGSR awardees to access unique international expertise and/or instrumentation and gain hands-on experience conducting research in an international environment.	Funding will support about 14 more SCGSR participants as well as international research experience to equip U.S. graduate students with the skills and knowledge to succeed professionally in a globally competitive environment.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Reaching a New Energy Sciences Workforce (RENEW) *$10,000*	*$12,000*	*+$2,000*
Funding supports continued implementation of the FY 2022 RENEW initiative and a planned growth of the existing workforce training programs/activities. Building upon the core science and technology capabilities at DOE national laboratories, the RENEW Pathway Summer Schools will enable equitable access to the best expertise and tools for discovery science driven learning in STEM. WDTS RENEW Pathways for faculty from underrepresented institutions will include 1) the expansion of the existing VFP program to non-summer terms for extended engagement for faculty capacity building in research and 2) the addition of a new parallel track for VFP with the goal of helping faculty enhance and innovate their STEM teaching at home institution for better STEM learning and preparedness in STEM. WDTS' RENEW pathways will build and strengthen partnerships between DOE national laboratories and MSIs, two-year colleges, and other colleges and universities nationwide.	The Request will support the RENEW initiative and a planned growth of the existing workforce training programs/activities. WDTS will continue support for the evaluation of SC RENEW traineeship programs and WDTS RENEW Pathway Summer Schools for High School and Early Undergraduate Students at DOE National Laboratories as well as the RENEW Pathways for faculty programs.	Funding will support an increase in the number of awards at MSIs and for individuals from emerging research communities, including the evaluation efforts for existing and new SC RENEW traineeship awards, the WDTS RENEW Pathway programs, and about 20 additional faculty to have extended research collaboration with DOE national laboratories for summer, fall, and spring terms.
Albert Einstein Distinguished Educator Fellowship $1,200	$1,200	$ —
Funding supports 6 Fellows.	The Request will support 5 Fellows due to increased cost for hosting Fellows and administrating programs.	The funding will support 1 fewer Fellow.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
National Science Bowl® $3,000	$3,100	+$100
Funding provides support to sponsor the National Finals and provide central management of over 110 virtual and in-person regional events, involving more than 14,000 students from all fifty states, the District of Columbia, Puerto Rico, and the U.S. Virgin Islands.	The Request will support the National Finals and provide central management of over 110 virtual and in-person regional events, involving more than 14,000 students from all fifty states, the District of Columbia, Puerto Rico, and the U.S. Virgin Islands.	The new venue for the National Finals in Leesburg, Virginia will have increased costs for staging and supply storage for the competitions, lodging, meals, and transportation.
Technology Development and On-Line Application $700	$700	$-
Funding continues development and operation of the on-line systems and support new development to meet the evolving needs of the programs.	The Request will continue development and operation of the on-line systems and support new development to meet the evolving needs of the programs. The online application and review system is the backbone infrastructure for the application, review, laboratory placement, award/participation management, outreach, and evaluation of WDTS workforce training programs at DOE national laboratories.	No change.

(dollars in thousands)

FY 2023 Enacted	FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Evaluation $600	$700	+$100
Funding supports a comprehensive evaluation portfolio with short- and longer-term projects for assessing WDTS program performance and producing knowledge to inform evidence-based management and evaluation practice.	The Request will support a comprehensive evaluation portfolio with short- and longer-term projects for assessing WDTS program performance and producing knowledge to inform evidence-based management and evaluation practice.	An increase of funding will establish and execute a comprehensive evaluation portfolio in support of workforce development programs and activities.
Outreach $1,500	$1,500	$ —
Funding supports outreach activity proposal solicitations from DOE host labs and facilities. WDTS will maintain support of activities such as those that promote diversity, equity, and inclusion; and/or prioritize recruitment of STEM students to DOE research and development workforce mission relevant fields of study, and particularly to fields related to SC research programs. Support continues for the LEDP program.	The Request will support outreach activity proposal solicitations from DOE host labs and facilities. WDTS will maintain support of activities such as those that promote diversity, equity, and inclusion; and/or prioritize recruitment of STEM students to DOE research and development workforce mission-relevant fields of study, and particularly to fields related to SC research programs. Support will continue for the LEDP program.	No change.

Science Laboratories Infrastructure

Overview

The Science Laboratories Infrastructure (SLI) program's mission is to support scientific and technological innovation at the Office of Science (SC) national laboratories by funding enabling infrastructure and fostering safe, efficient, reliable, resilient, and environmentally responsible operations. The SLI program's main priorities are improving SC's existing physical assets (including major utility systems), transitioning to carbon-free energy through electrification and energy efficiency upgrades, and providing new modern facilities that enable efficiency and collaboration for the evolving science mission. The SLI program funds line-item construction projects; General Plant Projects (GPP) (minor construction less than $30 million); Payments in Lieu of Taxes (PILT) to local communities around the Argonne, Brookhaven, and Oak Ridge National Laboratories (ANL, BNL, and ORNL); Nuclear Operations at ORNL; landlord responsibilities across the Oak Ridge Reservation; and will support a Laboratory Operations Apprenticeship program that SC proposed in the FY 2024 Request.

SC manages an infrastructure portfolio worth nearly $31.8 billion, across 10 national laboratories, with nearly 24 million gross square feet (gsf) of about 1,600 government-owned buildings and trailers. SC assets at the national laboratories include major research and user facilities, laboratory and office buildings, support facilities, and a vast network of utilities and other support facilities that form the backbone of each site. Delivering the SC mission requires significant stewardship of research facilities and the renovation and replacement of enabling infrastructure, including buildings and support infrastructure.

SC laboratories conduct annual assessments of the condition, utilization, and mission readiness of their buildings and support infrastructure. In FY 2022, the assessments rated 43 percent of the general-purpose buildings substandard or inadequate to meet mission needs. In addition, 71 percent of the utility systems were rated as substandard or inadequate while 35 percent of the remaining support infrastructure was rated as substandard or inadequate. The substandard and inadequate condition of facilities results in operational inefficiencies, reduced resiliency and reliability, unplanned outages, costly repairs, and elevated safety risks. In collaboration with SC programs and the laboratories, the SLI program plans and executes modernization and revitalization projects to manage risks and reduce the impacts of these deficiencies on the SC mission.

SC and the laboratories integrate the assessment results with scientific mission needs through the development of comprehensive Campus Strategies during the bi-annual laboratory planning process. To support current and future capabilities and infrastructure, each laboratory's Campus Strategy[a] identifies activities and infrastructure investments, such as line-item construction and GPPs, as part of asset life-cycle management. SC leadership uses these Campus Strategies, and its own evaluation of infrastructure needs, to inform the SLI budget requests.

In FY 2023, SC invested nearly $861 million in maintenance, repair, and construction to sustain and enhance its general-purpose infrastructure. These investments stemmed from a variety of funding sources, including Federal appropriations for line-item construction, GPPs, laboratory overhead funding of Institutional GPPs (IGPPs), and maintenance and repair activities. The SLI investments in line-item construction and GPPs provide the critical backbone of laboratory operations and are key elements of this overall investment strategy.

Highlights of the FY 2025 Request

The FY 2025 Request of $ 295.2 million is an increase of $ 14.5 million over the FY 2023 Enacted. The 2025 Request continues to focus on improving infrastructure across the SC national laboratory complex and supports eight ongoing construction projects:

1. Princeton Plasma Innovation Center at Princeton Plasma Physics Laboratory (PPPL);
2. Critical Infrastructure Recovery & Renewal at Princeton Plasma Physics Laboratory (PPPL);
3. Seismic and Safety Modernization project at Lawrence Berkeley National Laboratory (LBNL);
4. CEBAF Renovation and Expansion project at Thomas Jefferson National Accelerator Facility (TJNAF);
5. Argonne Utilities Upgrade project at Argonne National Laboratory (ANL);

[a] https://science.osti.gov/-/media/lp/pdf/laboratory-planning-process/FY-2022-ALPs-for-Web.pdf

6. Linear Assets Modernization Project at Lawrence Berkeley National Laboratory (LBNL);
7. Critical Utilities Infrastructure Revitalization Project at SLAC National Accelerator Laboratory (SLAC); and
8. Utilities Infrastructure Project at Fermi National Accelerator Laboratory (FNAL).

These ongoing line-item projects will replace, upgrade, and improve utility systems and facilities to improve resilience, sustainability, carbon free electricity, and provide new laboratory space with the necessary performance capabilities to support SC's evolving mission.

SLI annually evaluates enabling infrastructure needs for all laboratories. The FY 2025 Request also includes funding for GPPs, which are an essential component of our infrastructure modernization portfolio. GPPs address urgent, targeted, and emerging, high risk enabling infrastructure and utility needs across SC laboratories and facilities such as building HVAC systems, chilled water plants, electrical systems components (switches/transformers), fire safety, emergency generators, site security improvements, office/laboratory modernization, etc. GPPs are the most expedient resource for avoiding unplanned and disruptive interruptions, costly emergency repairs, damage to our highly sophisticated science tools, as well as increasing resilience, correcting inadequate/unsafe working conditions, and eliminating inefficient and costly operations that impede research activities. SLI evaluates GPP proposals using annual assessment results (mentioned above) and multiple criteria including mission impact, readiness, cost savings (including energy and water), environmental, safety, and health issues, sustainability (including contributions to net zero initiatives), resilience, and reliability. The increase in the minor construction threshold to $30 million makes the use of GPPs the appropriate vehicle for addressing more of the critical revitalization and emergency repair needs.

The FY 2025 Request will support an expansion of a Laboratory Operations Apprenticeship program that will be piloted in FY 2024. The apprenticeship program will ensure the next generation of diverse highly skilled trade and craft employees are ready to replace the critical aging and retiring workforce found throughout the SC laboratory complex. A unique and highly skilled craft and trade workers are required to build and maintain critical infrastructure and operations at SC laboratories A SC Laboratory Operations Apprenticeship Program will develop a pipeline of highly and uniquely skilled employees to ensure continued infrastructure operations and maintenance for the many scientific user facilites. The program would be initiated as pilot SC apprenticeship program as a means to develop the processes and procedures to successfully administer apprenticeship programs for these workforce skills

Science Laboratories Infrastructure
Funding

(dollars in thousands)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Science Laboratories Infrastructure				
Payment In Lieu of Taxes (PILT)	4,891	5,004	5,119	+228
OR Landlord	6,559	6,910	7,032	+473
Facilities and Infrastructure	13,900	32,104	50,029	+36,129
Laboratory Operations Apprenticeship	–	–	5,000	+5,000
Oak Ridge Nuclear Operations	26,000	46,000	46,000	+20,000
Subtotal, Science Laboratories Infrastructure	**51,350**	**90,018**	**113,180**	**+61,830**
Construction				
22-SC-71 Critical Infrastructure Modernization Project (CIMP) - ORNL	1,000	–	–	-1,000
22-SC-72 Thomas Jefferson Infrastructure Improvements (TJII) - TJNAF	1,000	–	–	-1,000
21-SC-71 Princeton Plasma Innovation Center (PPIC), PPPL	10,000	10,000	35,000	+25,000
21-SC-72 Critical Infrastructure Recovery & Renewal (CIRR), PPPL	4,000	10,000	20,000	+16,000
21-SC-73 Ames Infrastructure Modernization (AIM)	2,000	8,000	–	-2,000
20-SC-71 Critical Utilities Rehabilitation Project (CURP), BNL	26,000	–	–	-26,000
20-SC-72 Seismic and Safety Modernization (SSM), LBNL	27,500	35,000	18,000	-9,500
20-SC-73 CEBAF Renovation and Expansion (CEBAF), TJNAF	15,000	11,000	11,000	-4,000
20-SC-75 Large Scale Collaboration Center (LSCC), SLAC	21,000	–	–	-21,000
20-SC-77 Argonne Utilities Upgrade (AU2), ANL	8,000	8,000	3,000	-5,000

(dollars in thousands)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
20-SC-78 Linear Assets Modernization Project (LAMP), LBNL	23,425	18,900	30,000	+6,575
20-SC-79 Critical Utilities Infrastructure Revitalization (CUIR), SLAC	25,425	30,000	20,000	-5,425
20-SC-80 Utilities Infrastructure Project (UIP), FNAL	20,000	35,000	45,000	+25,000
19-SC-74 - BioEPIC, LBNL	45,000	38,000	–	-45,000
Subtotal, Construction	**229,350**	**203,900**	**182,000**	**-47,350**
Total, Science Laboratories Infrastructure	**280,700**	**293,918**	**295,180**	**+14,480**

Science Laboratories Infrastructure
Explanation of Major Changes

	(dollars in thousands) FY 2025 Request vs FY 2023 Enacted
Infrastructure Support The Request increases funding for GPPs to address targeted and emerging high-priority infrastructure needs across the SC complex and continues a Laboratory Operations Apprenticeship to support trade and craft employee development.	**+61,830**
Construction Funding supports 8 ongoing line-item projects at ANL, FNAL, LBNL, PPPL, SLAC, and TJNAF.	**-47,350**
Total, Science Laboratories Infrastructure	**+14,480**

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Program Accomplishments
Line-Item Construction Projects
Since FY 2006, the SLI program has invested nearly $1.2 billion to successfully complete 19 mission-enabling line-item construction projects that provided state-of-the-art science user support facilities, renovated, and repurposed aged facilities, upgraded inadequate core infrastructure and systems, and removed excess facilities. These investments began following an FY 2006 SC decision to modernize infrastructure across the SC-stewarded laboratory complex. With these investments, the SLI program constructed approximately 1.8 million gsf of new and modernized existing space. As a result, an estimated 3,050 laboratory users and researchers now occupy newly constructed and/or modernized buildings that better support scientific and technological innovation in a collaborative environment. SLI has been honored with 14 DOE Secretary's Achievement Awards for its contributions to the SC mission.

GPP upgrades across SC Laboratories
From FY 2016 through FY 2023, SLI has funded nearly $280 million in 49 laboratory core infrastructure improvement projects including $150 million in electrical and utility improvements, $57 million in building renovations, $44 million in safety and environmental projects, $20 million in sustainability/resilience and $8 million in other site improvement projects. Examples of FY 2023 SLI GPP investments in core infrastructure include the replacement of an emergency generator in the Waste Handling Facility at LBNL and conversion of the fossil fuel furnace serving the AUD-PSL buildings at PNNL to a hot water system using geothermal heat pumps.

Science Laboratories Infrastructure
Infrastructure Support

Description
The Infrastructure Support subprogram invests in enabling infrastructure and specific laboratory operations. The Facilities and Infrastructure activity is critical for upgrading and replacing enabling infrastructure systems (e.g., utility systems, site-wide services, and general-purpose facilities) to improve reliability, resilience, efficiency, and performance, as well as to address emerging needs or end-of-life requirements. This subprogram also supports nuclear operations at ORNL, stewardship-type needs (e.g., roads and grounds maintenance) across the Oak Ridge Reservation, the expansion of a Laboratory Operations Apprenticeship program, and Payments In Lieu of Taxes (PILT).

Facilities and Infrastructure
This activity supports minor construction investments (general plant projects of less than $34 million) that address urgent and emerging core infrastructure needs. SC laboratories conduct annual condition assessments of their core infrastructure to determine the investment targets for these basic systems that form the backbone of their campuses. SLI maintains an active and integrated list of critical core infrastructure investment priorities across all 10 laboratories. Projects are rigorously evaluated for mission dependency and readiness; cost savings (including energy and water cost savings); remediation of environmental, safety, and health issues; sustainability (including net zero initiatives); resilience; and reliability. The highest priority projects are selected for funding based on the totality of these criteria and availability of funds.

Oak Ridge Nuclear Operations
This activity supports critical DOE nuclear operations required to safely operate ORNL's non-reactor nuclear facilities (i.e., Buildings 7920, 7930, 3525, and 3025E) and the associated support facilities. These facilities support a variety of users including SC programs, the National Nuclear Security Administration, the Office of Nuclear Energy (NE), and other federal agencies. This funding provides general operations support, maintenance and repair of hot cells and supporting systems and ensures compliance with safety standards and procedures.

OR Landlord
This activity supports landlord responsibilities, including infrastructure, for the 24,000-acre Oak Ridge Reservation and DOE facilities in the city of Oak Ridge, Tennessee. The funding supports maintenance of roads, grounds, other infrastructure, and support and improvement of environmental protection, safety, and health.

Payment In Lieu of Taxes (PILT)
This activity supports SC stewardship responsibilities for PILT. The Department is authorized to provide discretionary payments to state and local government authorities for real property that is not subject to taxation because it is owned by the United States Federal Government and operated by the Department. Under this authorization, PILT is provided to communities around ANL, BNL, and ORNL to compensate for lost tax revenues for land removed from local tax rolls. PILT payments are negotiated between the Department and local governments based on land values and tax rates.

Laboratory Operations Apprenticeship
This activity supports an expansion of a Laboratory Operations Apprenticeship program that will be piloted in FY 2024. The apprenticeship program is focused on preparing and training the next generation of diverse highly skilled trade and craft employees, to replace the critical aging and retiring workforce found throughout the SC laboratory complex.

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Infrastructure Support	**$51,350**	**$113,180**	**+$61,830**
Facilities and Infrastructure	$13,900	$50,029	+$36,129
Funding supports the replacement of the emergency generator at the LBNL Hazardous Waste Building, the Steam to Hot Water Conversion project in the Physical Sciences Laboratory at PNNL and the Storm Water Reuse project at TJNAF.		The Request will continue to support the highest priority enabling infrastructure needs across the SC complex. Projects being considered are: Building 680 Upgrade Entrance Portal at BNL (Design), Bethel Valley Central Campus 4000 Area 2.4kv to 13.8kV Upgrade at ORNL, Reactive Power Compensation at SLAC, Building 450 Chillers Upgrade – Phase 2 at ANL, Building 202 Smart Labs Energy Retrofit at ANL, South Campus Building Gas to Electric Conversion at PNNL, Excess Non Accelerator Facilities Demolition Phase 1 at Fermi, and Building 362 Smart Labs Energy Retrofit at ANL.	Increased funding will support at least eight new general plant projects at multiple laboratories, addressing some of the highest risks and needs for operations.
Oak Ridge Nuclear Operations	$26,000	$46,000	+$20,000
Funding supports critical nuclear operations and provides funding to manage ORNL's nuclear facilities.		The Request will support the general operations of ORNL's non-reactor nuclear facilities by the Office of Science.	Increased funding reflects a transfer of budget authority and responsibilities from NE in FY 2024. It will provide the full amount needed to support critical activities needed to operate the non-reactor nuclear facilities at ORNL.
OR Landlord	$6,559	$7,032	+$473
Funding continues support of landlord responsibilities across the Oak Ridge Reservation. Activities include maintenance of roads, grounds, and other infrastructure; and support and improvement of environmental protection, safety, and health.		The Request will continue to support landlord responsibilities across the Oak Ridge Reservation and in Oak Ridge. Activities include maintenance of roads, grounds, other infrastructure, and support and improvement of environmental protection, safety, and health.	Funding will support OR landlord requirements.

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Payment In Lieu of Taxes (PILT)	$4,891	$5,119	+$228
Funding supports PILT payments to communities around ANL, BNL, and ORNL.		The Request will provide funding for PILT payments to communities around ANL, BNL, and ORNL.	Funding will support anticipated PILT requirements.
Laboratory Operations Apprenticeship	$ —	$5,000	+$5,000
No funding requested or appropriated in FY 2023.		The Request will support a program for technician- and craft-level apprenticeships in the SC complex.	Funding will expand the Laboratory Operations Apprenticeship program that will be initiated in FY 2024.

Science Laboratories Infrastructure
Construction

Description

The SLI program funds line-item projects to maintain and enhance the general-purpose infrastructure at SC laboratories. SLI's infrastructure modernization construction projects are focused on the accomplishment of long-term science goals and strategies at each SC laboratory. The SLI program's main objectives are improvement of SC's physical assets and facilities modernization funding to enable emerging science opportunities. Modernizing enabling infrastructure at the SC national laboratories will ensure the critical support infrastructure meets the needs of the future science initiatives and world class user facilities, and will provide more efficient, resilient, reliable, environmentally sound, and safe laboratory operations.

The FY 2025 Request includes funding for eight ongoing line-item construction projects:

1. Princeton Plasma Innovation Center at PPPL;
2. Critical Infrastructure Recovery & Renewal at PPPL;
3. Seismic and Safety Modernization at LBNL;
4. CEBAF Renovation and Expansion at TJNAF;
5. Argonne Utilities Upgrade at ANL;
6. Linear Assets Modernization Project at LBNL;
7. Critical Utilities Infrastructure Revitalization at SLAC; and
8. Utilities Infrastructure Project at FNAL.

This Request includes no new line-item construction projects.

<u>21-SC-71, Princeton Plasma Innovation Center, PPPL</u>

The Princeton Plasma Innovation Center (PPIC) will provide a multi-purpose facility to PPPL to include; space for offices and remote collaboration, medium bay research labs for diagnostics and fabrication, and research activities to meet the SC mission and fulfill the research needs of the Fusion Energy Sciences (FES), Advanced Scientific Computing Research (ASCR), and Basic Energy Sciences (BES) programs.

PPIC received its most recent DOE Order 413.3B Critical Decision approval, CD-1, Approve Alternative Selection and Cost Range, on January 22, 2021. The project anticipates its CD-2, Approve Performance Baseline, review in the first quarter of FY 2025, which is subject to change consistent with its pre-CD-2 status. The current preliminary TEC range for this project is $97,500,000 to $117,500,000 and the preliminary Total Project Cost (TPC) range is $99,700,000 to $115,300,000. These cost ranges encompass the most feasible preliminary alternative at this time. The preliminary TEC point estimate for this project is $107,500,000 and the preliminary TPC point estimate for this project is $109,700,000.

<u>21-SC-72, Critical Infrastructure Recovery & Renewal, PPPL</u>

The Critical Infrastructure Recovery & Renewal (CIRR) project at PPPL will revitalize critical infrastructure that supports the PPPL campus. Upgrades that may be completed as part of the CIRR project include: the electrical distribution system; standby power; chilled water generation and distribution; distribution networks for steam, compressed air, sanitary waste, and condenser, storm, canal, and potable water; HVAC systems; and communication systems.

CIRR received its most recent DOE Order 413.3B Critical Decision (CD) approval, CD-1, Approve Alternative Selection and Cost Range, on February 24, 2021. The project anticipates its CD-3A, Approve Long-Lead Procurement and Early Site Preparation, review in the second quarter of FY 2025, which is subject to change with its pre-CD-2 status. The current preliminary TEC range for this project is $80,100,000 to $96,000,000. The preliminary TPC range for this project is $81,800,000 to $97,700,000 and These cost ranges encompass the most feasible preliminary alternatives at this time. The preliminary TEC point estimate is $87,300,000 and the TPC point estimate for this project is $89,000,000.

20-SC-72, Seismic and Safety Modernization, LBNL
The Seismic and Safety Modernization (SSM) project will address seismic safety issues and emergency response capabilities at LBNL. Specifically, it will provide modern facilities with the large congregation areas needed for emergency response, continuity of operations that meet today's building code standards. The project also collocates related functions such as a Cafeteria and Health Services.

SSM received its most recent DOE Order 413.3B Critical Decision (CD) approval, CD-2/3, Approve Performance Baseline and Start of Construction, on December 7, 2023. The next anticipated CD is CD-4 for the project is fourth quarter FY 2028.This project had a preliminary TEC range of $112,800,000 to $183,300,000 and a preliminary TPC range of $116,600,000 to $188,500,000. The TEC point estimate for this project is $141,000,000 and the TPC point estimate for this project is $145,000,000.

20-SC-73, CEBAF Renovation and Expansion, TJNAF
The CEBAF Renovation and Expansion (CRE) project will renovate existing space and provide new research, administrative, and support service space to accommodate SC's mission. The CEBAF center at TJNAF is experiencing frequent failures in their utility systems; with the completion of the ARC facility transfer to SC, renovation of the ARC and CEBAF facilities to consolidate and accommodate operational as well as visitor/educational functions efficiently will allow TJ to provide current and future needs.

CRE received its most recent DOE Order 413.3B Critical Decision (CD) approval, CD-1, Approve Alternative Selection and Cost Range, on March 18, 2020. The project estimates its CD-2/3A, Approve Performance Baseline and Start of Construction activities in ARC, review by the second quarter of FY 2025. This project is pre-CD-2; therefore, schedule estimates are subject to change. This project has a preliminary TEC range of $46,600,000 to $99,500,000 and a preliminary TPC range of $69,300,000 to $102,800,000. These cost ranges encompass the most feasible preliminary alternatives at this time. The preliminary TEC point estimate for this project is $87,000,000 and the preliminary TPC point estimate for this project is $90,300,000.

20-SC-77, Argonne Utilities Upgrade, ANL
The Argonne Utilities Upgrade (AU2) project at ANL will revitalize and selectively upgrade ANL's existing major utility systems to increase the reliability, capability, and safety of ANL's infrastructure to meet the DOE's mission. The project will focus on systems such as steam, water, sanitary sewer, chilled water, and electrical systems.

AU2 received its most recent DOE Order 413.3B Critical Decision (CD) approval, CD-3A, Approve Site Preparation Activities, on September 14, 2023. The project estimates its CD-2, Approve Baseline, review in the second quarter of FY 2030. This project is pre-CD-2; therefore, schedule estimates are subject to change. The preliminary TEC range for this project is $172,000,000 to $290,250,000. The preliminary TPC range for this project is $173,000,000 to $291,250,000. These cost ranges encompass the most feasible preliminary alternatives at this time. The preliminary TEC point estimate is $215,000,000 and the TPC point estimate for this project is $216,000,000.

20-SC-78, Linear Assets Modernization Project, LBNL
The Linear Assets Modernization Project (LAMP) at LBNL will upgrade high priority utility systems to increase the reliability, capability, resiliency, and safety of LBNL's infrastructure to meet the DOE's mission. The project will upgrade utility systems including, but not limited to, domestic water, natural gas, storm drain, sanitary sewer, electrical, and communications.

LAMP received its most recent DOE Order 413.3B Critical Decision (CD) approval, CD-1, Approve Alternative Selection and Cost Range, on April 13, 2022. The project anticipates its CD-3A, Approve Long-Lead Procurement and Early Site Preparation, review in the first quarter of FY 2026. This project is pre-CD-2; therefore, schedule estimates are subject to change. The preliminary TEC range for this project is $164,000,000 to $376,000,000. The preliminary TPC range for this project is $170,000,000 to $386,000,000. These cost ranges encompass the most feasible preliminary alternatives at this time. The preliminary TEC is $236,000,000 and the preliminary TPC estimate for this project is $242,000,000.

20-SC-79, Critical Utilities Infrastructure Revitalization, SLAC

The Critical Utilities Infrastructure Revitalization (CUIR) project's primary objective is to close enabling infrastructure gaps to support multi-program science missions as technologies, instruments, experimental parameters, sensitivities, and complexity associated with evolving science demand increases required reliability, resiliency, and service levels in electrical, mechanical, and civil systems site wide. The CUIR project will address the critical campus-wide utility and infrastructure issues by replacing, repairing, and modernizing the highest risk water/fire protection, sanitary sewer, storm drain, electrical, and cooling water system deficiencies.

CUIR received its most recent DOE Order 413.3B Critical Decision (CD) approval, CD-3A, approve Long-Lead Procurement and Early Site Preparation, on May 8, 2023. The next anticipated CD is CD-2/3 for the overall project is third quarter FY 2029. This project is pre-CD-2; therefore, schedule estimates are subject to change. The preliminary TEC range for this project is $160,000,000 to $306,000,000. The preliminary TPC range for this project is $164,500,000 to $310,500,000. These cost ranges encompass the most feasible preliminary alternatives at this time. The preliminary TEC estimate is $204,000,000 and the preliminary TPC estimate for this project is $208,500,000.

20-SC-80, Utilities Infrastructure Project, FNAL

The Utilities Infrastructure Project (UIP) at FNAL will modernize the highest risk to major utility systems across the FNAL campus. Specifically, this project will upgrade the industrial cooling water system, potable water distribution system, sanitary sewer and storm collection systems, natural gas distribution system, electrical distribution system, and the Central Utility Building. Selected portions of the systems at highest risk of failure will be modernized to assure safe, reliable, and efficient service to mission critical facilities. In addition, component upgrades will also increase capacity, reliability, and personnel safety at critical utilities.

UIP received its most recent DOE Order 413.3B Critical Decision (CD) approval, CD-1, Approve Alternative Selection and Cost Range, on February 23, 2022. CD-3A Long-Lead Procurement and Early Site Preparation review and approval is planned in fourth quarter of FY 2024. The last of three subprojects anticipates its CD-2, Approve Performance Baseline, review in the third quarter of FY 2029. This project is pre-CD-2; therefore, schedule estimates are subject to change. The preliminary TEC range for this project is $248,000,000 to $403,000,000 and the preliminary TPC range of $252,000,000 to $411,000,000. These cost ranges encompass the most feasible preliminary alternatives at this time. The preliminary TEC estimate is $310,000,000 and the preliminary TPC estimate for this project $314,000,000.

Science Laboratories Infrastructure
Construction

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Construction	**$229,350**	**$182,000**	**-$47,350**
21-SC-71, Princeton Plasma Innovation Center, PPPL	$10,000	$35,000	+$25,000
Funding will support ongoing PED activities and initiate construction activities.		The Request will support the continuation of construction activities.	Funding will advance construction activities.
21-SC-72, Critical Infrastructure Recovery & Renewal, PPPL	$4,000	$20,000	+$16,000
Funding will support ongoing PED activities and initiate construction and associated activities.		The Request will support the continuation of construction activities.	Funding will advance construction activities.
21-SC-73, Ames Infrastructure Modernization	$2,000	$ —	-$2,000
Funding will support ongoing PED and construction activities.		The FY 2024 Request included final funding for this project.	No funding requested in FY 2025.
20-SC-71, Critical Utilities Rehabilitation Project, BNL	$26,000	$ —	-$26,000
Funding will support ongoing construction activities.		Final funding for this project was received in FY 2023.	Final funding for this project was received in FY 2023.
20-SC-72, Seismic and Safety Modernization, LBNL	$27,500	$18,000	-$9,500
Funding will support construction and associated activities.		The Request will provide final funding for this project and support continuation of construction activities.	Funding Request will provide final funding for this project in FY 2025 and support continuation construction activities.

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request		Explanation of Changes FY 2025 Request vs FY 2023 Enacted
20-SC-73, CEBAF Renovation and Expansion, TJNAF	$15,000		$11,000	-$4,000
Funding will support ongoing PED and construction activities.		The Request will support partial construction activities.		Funding will advance construction activities.
20-SC-75, Large Scale Collaboration Center, SLAC	$21,000		$ —	-$21,000
Funding will support ongoing construction activities.		Final funding for this project was received in FY 2023.		Final funding for this project was received in FY 2023.
20-SC-77, Argonne Utilities Upgrade, ANL	$8,000		$3,000	-$5,000
Funding will support ongoing PED activities.		The Request will support construction activities.		Funding will support completion of design activities, and startup of construction activities.
20-SC-78, Linear Assets Modernization Project, LBNL	$23,425		$30,000	+$6,575
Funding will support ongoing PED activities and early construction activities.		The Request will support construction activities.		Funding will support completion of design activities, and startup of construction activities.
20-SC-79, Critical Utilities Infrastructure Revitalization, SLAC	$25,425		$20,000	-$5,425
Funding will support ongoing PED activities and initiate early construction activities.		The Request will support construction activities.		Funding will support completion of design activities, and startup of construction activities.
20-SC-80, Utilities Infrastructure Project, FNAL	$20,000		$45,000	+$25,000
Funding will support ongoing PED activities and initiate early construction activities.		The Request will support construction activities.		Funding will support completion of design activities, and startup of construction activities.
19-SC-74, BioEPIC, LBNL	$45,000		$ -	-$45,000
Funding will support ongoing construction activities.		The FY 2024 Request included final funding for this project.		No funding requested in FY 2025.

Science Laboratories Infrastructure
Capital Summary

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Capital Operating Expenses						
Minor Construction Activities						
General Plant Projects	N/A	N/A	13,700	32,104	50,029	+36,329
Total, Capital Operating Expenses	**N/A**	**N/A**	**13,700**	**32,104**	**50,029**	**+36,329**

Science Laboratories Infrastructure
Minor Construction Activities

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
General Plant Projects (GPP)						
GPPs (greater than $5M and $34M or less)						
Bethel Valley Central Campus 4000 Area 2.4kv to 13.8 kV Upgrade at ORNL	9,690	–	–	–	9,690	+9,690
Reactive Power Compensation at SLAC	15,769	–	–	–	15,769	+15,769
Chiller Replacement (Building. 450) at ANL	15,820	–	–	6,530	9,290	+9,290
Steam to Hydronics Conversion Project at PNNL	5,400	–	5,400	–	–	-5,400
Emergency Generator Upgrades, Phase 1 at LBNL	5,500	–	5,500	–	–	-5,500
HVAC Upgrade Life Sciences Laboratory (Bldg.331) at PNNL	6,000	–	–	6,000	–	–
Power Quality Compensation Equipment Installation at SLAC	8,300	–	–	8,300	–	–
Electrical Component Replacement 88 Inch Cyclotron User (Bldg B88) at LBNL	6,000	–	–	6,000	–	–
Total GPPs (greater than $5M and $34M or less)	N/A	N/A	10,900	26,830	34,749	+23,849
Total GPPs $5M or less	N/A	N/A	2,800	5,274	15,280	+12,480
Total, General Plant Projects (GPP)	**N/A**	**N/A**	**13,700**	**32,104**	**50,029**	**+36,329**
Total, Minor Construction Activities	**N/A**	**N/A**	**13,700**	**32,104**	**50,029**	**+36,329**

Note:

- *GPP activities $5M and less include design and construction for additions and/or improvements to land, buildings, replacements or addition to roads, and general area improvements. AIP activities $5M and less include minor construction at an existing accelerator facility.*

Science Laboratories Infrastructure
Institutional General Plant Projects (IGPP)

	Total	FY 2023 Enacted	FY 2024 Request	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Institutional General Plant Projects (IGPP)					
IGPPs (greater than or equal to $5M and less than $30M)					
Space Renovation Program - Bldg. 360 Area (Buildings 369 and 368), ANL	5,000	5,000	—	—	-5,000
High Voltage Substation Resilience and Redundancy Upgrades, ANL	12,950	—	12,950	—	—
B725 SDCC 1.2 MW Power & Cooling Upgrades, BNL	12,900	—	12,900	—	—
Switch Station SW-A3 Improvements, LBNL	21,000	21,000		—	-21,000
Sitewide Retaining Wall Improvements, LBNL	9,500	—	9,500	—	—
B77 CNC Machine Replacement, LBNL	6,600	—	6,600	—	—
B62 Highbay Renovation, LBNL	10,000	—	10,000	—	—
Modular HPC Data Center, LBNL	25,000	—	25,000	—	—
B86 HVAC Modernization, LBNL	16,000	—	16,000	—	—
B66 4th Floor Lab Upgrades, LBNL	10,000	—	—	10,000	+10,000
B84 Heating Electrification, LBNL	12,000	—	—	12,000	+12,000
Shuttle Shelter Modernizations, LBNL	5,000	—	—	5,000	+5,000
Fire Alarm Panel Replacements, LBNL	10,000	—	—	10,000	+10,000
B80 HVAC Modernization, LBNL	10,000	—	—	10,000	+10,000
B2 HVAC Modernization, LBNL	10,000	—	—	10,000	+10,000
Install Fire Pump Houses at 13J and 68 Water Tanks, LBNL	6,000	—	—	6,000	+6,000
Bldg. 3501 Sewage Treatment Plant Lift Station,ORNL	9,600	9,600	—	—	-9,600
Vehicle Charging Stations Installation, ORNL	6,000	—	6,000	—	—
Modernize B7600 (Experimental Gas Cooled Reactor - EGCR) Campus Utility, ORNL	9,600	—	9,600	—	—
Expand B7996 Melton Valley Warehouse, ORNL	11,000	—	11,000	—	—
Replace 4521 Cooling Tower, ORNL	9,600	—	9,600	—	—
Renovate B4500N Library, ORNL	13,000	—	13,000	—	—
Improve Melton Valley Campus South Access and Parking, ORNL	9,600	—	9,600	—	—
Replace Bethel Valley Campus Vehicle Bridge, ORNL	7,000	—	7,000	—	—
Improve Bethel Valley Campus Parking, ORNL	5,200	—	5,200	—	—
Modernize B4508, ORNL	11,900	—	—	11,900	+11,900
Improve B7667 Low Level Waste Site, ORNL	10,200	—	—	10,200	+10,200
Improve B7603 Basement and B7608 Vault, ORNL	10,200	—	—	10,200	+10,200
Modernize B4500N Wing 1, ORNL	12,000	—	—	12,000	+12,000

Construct Multiprogram Office Building #2, ORNL	11,000	—	—	11,000	+11,000
Construct Bethel Valley Central Campus Support Facility, ORNL	12,000	—	—	12,000	+12,000
Modernize 2000/3000 Area Utilities, ORNL	9,600	—	—	9,600	+9,600
300 Area Office, PNNL	9,483	9,483	—	—	-9,483
318 Hot Water Piping Upgrade, PNNL	8,000	8,000	—	—	-8,000
Advanced Secure Communications, PNNL	24,700	24,700	—	—	-24,700
318 HVAC Upgrade, PNNL	8,500	—	8,500	—	—
General Purpose Lab, PNNL	24,000	—	24,000	—	—
Secure Physical Sciences, PNNL	28,000	—	28,000	—	—
331 Research Support Office, PNNL	12,500	—	12,500	—	—
PNNL Physical Access Control System Upgrade, PNNL	10,000	—	—	10,000	+10,000
PNNL Richland North Central Infrastructure, PNNL	6,200	—	—	6,200	+6,200
Secure Computational and Data Sciences, PNNL	29,250	—	—	29,250	+29,250
Shipping and Receiving Replacement, PNNL	15,000	—	—	15,000	+15,000
East Campus Site & Utilities Improvement Project (ESUI), SLAC	10,000	10,000	—	—	-10,000
Total IGPPs (greater than or equal to $5M and less than $30M)	525,083	87,783	236,950	200,350	+112,567
Total IGPPs less than $5M	68,911	33,470	15,693	19,748	-13,722
Total, Institutional General Plant Projects (IGPP)	**593,994**	**121,253**	**252,643**	**220,098**	**+98,845**

Note:
- *Institutional General Plant Projects (IGPPs) are indirect funded minor construction activities that are general institutional in nature and address general purpose, site-wide needs.*

Science Laboratories Infrastructure
Construction Projects Summary

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
22-SC-71, Critical Infrastructure Modernization Project (CIMP) - ORNL						
Total Estimated Cost (TEC)	409,000	1,000	1,000	–	–	-1,000
Other Project Cost (OPC)	4,000	2,000	–	–	–	–
Total Project Cost (TPC)	**413,000**	**3,000**	**1,000**	**–**	**–**	**-1,000**
22-SC-72, Thomas Jefferson Infrastructure Improvements (TJII) - TJNAF						
Total Estimated Cost (TEC)	67,000	1,000	1,000	–	–	-1,000
Other Project Cost (OPC)	1,000	1,000	–	–	–	–
Total Project Cost (TPC)	**68,000**	**2,000**	**1,000**	**–**	**–**	**-1,000**
21-SC-71, Princeton Plasma Innovation Center (PPIC), PPPL						
Total Estimated Cost (TEC)	107,500	17,900	10,000	15,000	35,000	+25,000
Other Project Cost (OPC)	2,190	1,913	–	–	–	–
Total Project Cost (TPC)	**109,690**	**19,813**	**10,000**	**15,000**	**35,000**	**+25,000**
21-SC-72, Critical Infrastructure Recovery & Renewal (CIRR), PPPL						
Total Estimated Cost (TEC)	87,300	2,150	4,000	10,000	20,000	+16,000
Other Project Cost (OPC)	1,700	1,392	–	–	–	–
Total Project Cost (TPC)	**89,000**	**3,542**	**4,000**	**10,000**	**20,000**	**+16,000**
21-SC-73, Ames Infrastructure Modernization (AIM)						
Total Estimated Cost (TEC)	30,000	20,000	2,000	8,000	–	-2,000
Other Project Cost (OPC)	1,000	507	–	–	–	–
Total Project Cost (TPC)	**31,000**	**20,507**	**2,000**	**8,000**	**–**	**-2,000**

	(dollars in thousands)					
	Total	**Prior Years**	**FY 2023 Enacted**	**FY 2024 Annualized CR**	**FY 2025 Request**	**FY 2025 Request vs FY 2023 Enacted**
20-SC-71, Critical Utilities Rehabilitation Project (CURP), BNL						
Total Estimated Cost (TEC)	92,000	66,000	26,000	–	–	-26,000
Other Project Cost (OPC)	1,000	1,000	–	–	–	–
Total Project Cost (TPC)	**93,000**	**67,000**	**26,000**	**–**	**–**	**-26,000**
20-SC-72, Seismic and Safety Modernization (SSM), LBNL						
Total Estimated Cost (TEC)	141,000	55,500	27,500	40,000	18,000	-9,500
Other Project Cost (OPC)	3,550	2,911	200	–	–	-200
Total Project Cost (TPC)	**144,550**	**58,411**	**27,700**	**40,000**	**18,000**	**-9,700**
20-SC-73, CEBAF Renovation and Expansion (CEBAF), TJNAF						
Total Estimated Cost (TEC)	87,000	24,000	15,000	11,000	11,000	-4,000
Other Project Cost (OPC)	3,900	1,492	600	–	–	-600
Total Project Cost (TPC)	**90,900**	**25,492**	**15,600**	**11,000**	**11,000**	**-4,600**
20-SC-74, Craft Resources Support Facility (CRSF), ORNL						
Total Estimated Cost (TEC)	40,000	40,000	–	–	–	–
Other Project Cost (OPC)	1,000	850	–	–	100	+100
Total Project Cost (TPC)	**41,000**	**40,850**	**–**	**–**	**100**	**+100**
20-SC-75, Large Scale Collaboration Center (LSCC), SLAC						
Total Estimated Cost (TEC)	55,000	43,000	21,000	–	–	-21,000
Other Project Cost (OPC)	2,000	504	400	950	146	-254
Total Project Cost (TPC)	**57,000**	**43,504**	**21,400**	**950**	**146**	**-21,254**
20-SC-77, Argonne Utilities Upgrade (AU2), ANL						
Total Estimated Cost (TEC)	215,000	11,000	8,000	8,007	3,000	-5,000
Other Project Cost (OPC)	1,000	1,000	–	–	–	–
Total Project Cost (TPC)	**216,000**	**12,000**	**8,000**	**8,007**	**3,000**	**-5,000**

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
20-SC-78, Linear Assets Modernization Project (LAMP), LBNL						
Total Estimated Cost (TEC)	236,000	11,400	23,425	18,900	30,000	+6,575
Other Project Cost (OPC)	6,000	3,263	–	–	–	–
Total Project Cost (TPC)	**242,000**	**14,663**	**23,425**	**18,900**	**30,000**	**+6,575**
20-SC-79, Critical Utilities Infrastructure Revitalization (CUIR), SLAC						
Total Estimated Cost (TEC)	204,000	9,500	25,425	35,075	20,000	-5,425
Other Project Cost (OPC)	4,389	2,672	–	–	250	+250
Total Project Cost (TPC)	**208,389**	**12,172**	**25,425**	**35,075**	**20,250**	**-5,175**
20-SC-80, Utilities Infrastructure Project (UIP), FNAL						
Total Estimated Cost (TEC)	310,000	11,500	20,000	45,000	45,000	+25,000
Other Project Cost (OPC)	4,000	2,050	–	–	–	–
Total Project Cost (TPC)	**314,000**	**13,550**	**20,000**	**45,000**	**45,000**	**+25,000**
19-SC-73, Translational Research Capability (TRC), ORNL						
Total Estimated Cost (TEC)	93,500	93,500	–	–	–	–
Other Project Cost (OPC)	1,500	1,400	–	100	–	–
Total Project Cost (TPC)	**95,000**	**94,900**	**–**	**100**	**–**	**–**
19-SC-74, BioEPIC, LBNL						
Total Estimated Cost (TEC)	165,000	82,000	45,000	38,000	–	-45,000
Other Project Cost (OPC)	2,200	1,536	–	–	–	–
Total Project Cost (TPC)	**167,200**	**83,536**	**45,000**	**38,000**	**–**	**-45,000**
Total, Construction						
Total Estimated Cost (TEC)	**N/A**	**N/A**	**229,350**	**228,982**	**182,000**	**-47,350**
Other Project Cost (OPC)	**N/A**	**N/A**	**1,200**	**1,050**	**496**	**-704**

(dollars in thousands)

	Total	Prior Years	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Total Project Cost (TPC)	**N/A**	**N/A**	**230,550**	**230,032**	**182,496**	**-48,054**

Notes:

- *The current estimated TPC for the PPIC project is $109,960,000.00. In FY 2023 an additional $10,000 in OPC funding was obligated that is not reflected in this table.*
- *The current estimated TPC for the SSM project is $145,000,000.00. In FY 2023 an additional $450,000 in OPC funding was obligated that is not reflected in this table.*
- *The current estimated TPC for the CUIR project is $208,500,000.00. In FY 2023 an additional $11,000 in OPC funding was obligated that is not reflected in this table.*

21-SC-71, Princeton Plasma Innovation Center, PPPL
Princeton Plasma Physics Laboratory, PPPL
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary
The FY 2025 Request for the Princeton Plasma Innovation Center (PPIC) project is $35,000,000 of Total Estimated Cost (TEC) funding. The TEC range for this project is $97,500,000 to $117,500,000. The preliminary Total Project Cost (TPC) range for this project is $99,700,000 to $115,300,000. Currently, these cost ranges encompass the most feasible preliminary alternatives. The preliminary TPC estimate for this project is $109,700,000.

This project will provide a multi-purpose facility with modern, flexible, efficient, and agile research laboratories and office space to conduct plasma research activities in support of multiple SC programs.

The most recent DOE Order 413.3B approved Critical Decision (CD) is CD-1, Approve Alternative Selection and Cost Range, which was approved on January 22, 2021.

A Federal Project Director with the appropriate certification level was assigned to this project.

Significant Changes
This project completed a conceptual design in August of 2020 and the construction industry has experienced significant cost escalation and the future of work has evolved to include teleworking. These changes have resulted in lower square footage needs for office space but also account for escalation in the cost to deliver the same amount of laboratory square footage. The revised preliminary TPC point estimate of $109,700 reflects an increase from the previous point estimate of $98,500,000 and range of $80,500,000 to $98,500,000.

This Construction Project Data Sheet (CPDS) is an update to the FY 2024 CPDS and is not a new start for FY 2025. FY 2025 funds will support construction activities after the appropriate CD approvals.

Critical Milestone History

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
FY 2025	9/9/19	8/25/20	1/22/21	1Q FY 2025	3Q FY 2024	1Q FY 2025	4Q FY 2028

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout.

Fiscal Year	Performance Baseline Validation	CD-3A
FY 2025	1Q FY 2025	3Q FY 2024

CD-3A – Long Lead Procurements and Site Preparation Activities

Project Cost History

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	8,900	87,400	96,300	2,200	2,200	98,500
FY 2025	12,000	95,500	107,500	2,200	2,200	109,700

Notes:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*
- *Other Project Costs (OPC) are funded through laboratory overhead.*

2. Project Scope and Justification

Scope

The Princeton Plasma Innovation Center (PPIC) is envisioned as a 50,000 to 75,000 gross square feet (gsf) multi-story office, reflecting reduced office space based on future of work changes, and laboratory building at Princeton Plasma Physics Laboratory (PPPL) to serve as a single new multi-use facility that will house space for offices, medium bay research labs for diagnostics and fabrication, remote experiment participation and collaboration, and research support. It is anticipated a review and approval for long-lead procurements (e.g., mechanical equipment, electrical equipment, structural steel, etc.) and site preparation (e.g., installation of geothermal wells) for CD-3A will occur in 3Q FY 2024.

Justification

To advance the plasma science and fusion frontier in support of the DOE mission, PPPL requires new or enhanced facilities and infrastructure to foster innovation to make fusion energy a practical reality and further U.S. economic competitiveness. The primary SC program relevant to the PPIC project is FES, and the primary core capability is Plasma and Fusion Energy Sciences. The missions of SC's ASCR and BES programs are also relevant mission needs for the PPIC with second order effect to Large Scale User Facilities/Advanced Instrumentation and Systems Engineering and Integration.

PPPL plays a key role in assisting FES achieve its strategic goals. PPPL carries out experiments and computer simulations of the behavior of plasma, with sufficient temperature to generate fusion reactions. PPPL's aims to be a leading center for future fusion concepts through industry collaborations that develop new modeling and measurement techniques to improve understanding of plasma processes and that develop innovations for the next generation microelectronics.

PPIC will enhance the configuration of PPPL infrastructure to accommodate future scientific efforts and address the lack of adequate laboratory infrastructure, modern collaboration space, and modern office infrastructure

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets.*

Key Performance Parameters (KPPs)

The KPPs are preliminary and may change as the project continues towards CD-2. At CD-2 approval, the KPPs will be baselined. The Threshold KPPs represent the minimum acceptable performance that the project must achieve. The Objective KPPs represent the desired project performance. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion.

Performance Measure	Threshold	Objective
Multi-Story Building	50,000 gsf	75,000 gsf

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Estimated Cost (TEC)				
Design (TEC)				
Prior Years	7,900	7,900	1,114	—
Prior Years - IRA Supp.	1,000	1,000	—	—
FY 2023	3,100	3,100	—	3,075
FY 2024	—	—	5,286	25
FY 2025	—	—	2,500	—
Total, Design (TEC)	**12,000**	**12,000**	**8,900**	**3,100**
Construction (TEC)				
Prior Years - IRA Supp.	9,000	9,000	—	—
FY 2023	6,900	6,900	—	—
FY 2024	15,000	15,000	1,000	6,900
FY 2025	35,000	35,000	33,000	—
Outyears	29,600	29,600	54,600	—
Total, Construction (TEC)	**95,500**	**95,500**	**88,600**	**6,900**
Total Estimated Cost (TEC)				
Prior Years	7,900	7,900	1,114	—
Prior Years - IRA Supp.	10,000	10,000	—	—
FY 2023	10,000	10,000	—	3,075
FY 2024	15,000	15,000	6,286	6,925
FY 2025	35,000	35,000	35,500	—
Outyears	29,600	29,600	54,600	—
Total, Total Estimated Cost (TEC)	**107,500**	**107,500**	**97,500**	**10,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Other Project Cost (OPC)			
Prior Years	1,913	1,913	1,913
FY 2023	10	10	10
Outyears	277	277	277
Total, Other Project Cost (OPC)	**2,200**	**2,200**	**2,200**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Project Cost (TPC)				
Prior Years	9,813	9,813	3,027	–
Prior Years - IRA Supp.	10,000	10,000	–	–
FY 2023	10,010	10,010	10	3,075
FY 2024	15,000	15,000	6,286	6,925
FY 2025	35,000	35,000	35,500	–
Outyears	29,877	29,877	54,877	–
Total, TPC	**109,700**	**109,700**	**99,700**	**10,000**

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	9,500	7,900	**N/A**
Design - Contingency	2,500	1,000	**N/A**
Total, Design (TEC)	**12,000**	**8,900**	**N/A**
Construction	75,600	72,000	**N/A**
Construction - Contingency	19,900	15,400	**N/A**
Total, Construction (TEC)	**95,500**	**87,400**	**N/A**
Total, TEC	**107,500**	**96,300**	**N/A**
Contingency, TEC	*22,400*	*16,400*	***N/A***
Other Project Cost (OPC)			
Conceptual Planning	300	300	**N/A**
Conceptual Design	1,700	1,700	**N/A**
OPC - Contingency	200	200	**N/A**
Total, Except D&D (OPC)	**2,200**	**2,200**	**N/A**
Total, OPC	**2,200**	**2,200**	**N/A**
Contingency, OPC	*200*	*200*	***N/A***
Total, TPC	**109,700**	**98,500**	**N/A**
Total, Contingency (TEC+OPC)	***22,600***	***16,600***	***N/A***

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	17,900	10,000	15,000	—	53,400	96,300
	OPC	1,929	—	—	—	271	2,200
	TPC	19,829	10,000	15,000	—	53,671	98,500
FY 2025	TEC	17,900	10,000	15,000	35,000	29,600	107,500
	OPC	1,913	10	—	—	277	2,200
	TPC	19,813	10,010	15,000	35,000	29,877	109,700

Notes:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*
- *Other Project Costs (OPC) are funded through laboratory overhead.*

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	4Q FY 2028
Expected Useful Life	50 years
Expected Future Start of D&D of this capital asset	4Q FY 2078

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	**Current Total Estimate**	**Previous Total Estimate**	**Current Total Estimate**
Operations	1,336	1,336	46,774	46,774
Utilities	198	198	6,936	6,936
Maintenance and Repair	1,518	1,518	53,154	53,154
Total, Operations and Maintenance	3,052	3,052	106,864	106,864

7. D&D Information

The new area being constructed in this project is not replacing existing facilities.

	Square Feet
New area being constructed by this project at PPPL	50,000-75,000
Area of D&D in this project at PPPL	13,400
Area at PPPL to be transferred, sold, and/or D&D outside the project, including area previously "banked"	None[b]
Area of D&D in this project at other sites	None
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously "banked"	None
Total area eliminated	13,400

8. Acquisition Approach

The PPPL Management and Operating (M&O) Contractor, Princeton University, is performing the acquisition for this project, overseen by the Princeton Site Office. The M&O contractor is responsible for awarding and managing all subcontracts related to this project. Project performance metrics will be performed by in-house management and Project Controls.

[b] With the implementation of OMB's Reduce the Footprint initiative, DOE no longer maintains the space bank. Footprint is managed using the Facility Information Management System, with decisions on additions and offsets made in accordance with the DOE Real Property Efficiency Plan.

21-SC-72, Critical Infrastructure Recovery & Renewal, PPPL
Princeton Plasma Physics Laboratory, PPPL
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary

The FY 2025 Request for the Critical Infrastructure Recovery & Renewal (CIRR) project is $20,000,000 of Total Estimated Cost (TEC) funding. The preliminary TEC range for this project is $80,100,000 to $96,000,000. The preliminary Total Project Cost (TPC) range for this project is $81,800,000 to $97,700,000. Currently, these cost ranges encompass the most feasible preliminary alternatives. The preliminary TPC estimate for this project is $89,000,000.

Princeton Plasma Physics Laboratory's (PPPL's) increasingly unreliable, and antiquated utility infrastructure is negatively impacting laboratory operations. Scientific productivity is dependent on a capable, available, flexible, maintainable, reliable, and resilient support infrastructure. This project will provide critical infrastructure needed to operate the laboratory missions safely and efficiently. These systems will be modern and energy efficient, reducing the operating cost and improving the resilience of the facilities.

The most recent DOE Order 413.3B Critical Decision (CD) is CD-1, Approve Alternative Selection and Cost Range, which was approved on February 24, 2021.

A Federal Project Director working towards the appropriate certification level is assigned to this project.

Significant Changes

This Construction Project Data Sheet (CPDS) is an update to the FY 2024 CPDS and is not a new start for FY 2025. FY 2025 funds will continue to fund construction after the appropriate critical decisions.

A transformer replacement, which was originally identified as critical infrastructure needed to operate the laboratory missions safely and efficiently, and therefore identified as CIRR scope, has experienced significant deterioration and increased risk of failure. Because of these increased risks to operations and ease of executing independently as a complete and usable project, the transformer replacement has been removed from the project and accelerated for faster delivery.

Critical Milestone History

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
FY 2025	9/16/19	2/23/21	2/23/21	3Q FY 2025	2Q FY 2025	3Q FY 2025	2Q FY 2028

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout.

Fiscal Year	Performance Baseline Validation	CD-3A
FY 2025	3Q FY 2025	2Q FY 2025

CD-3A – Approve Long-Lead Procurements and Site Preparation Activities

Project Cost History

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	9,950	77,350	87,300	1,700	1,700	89,000
FY 2025	9,950	77,350	87,300	1,700	1,700	89,000

Notes:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*
- *Other Project Costs (OPC) are funded through laboratory overhead.*

2. Project Scope and Justification

Scope

The CIRR project at PPPL will revitalize critical infrastructure that supports the PPPL campus to ensure reliability and resilience. Upgrades that may be completed as part of the CIRR project include: the electrical distribution system; standby power; chilled water generation and distribution; distribution networks for steam, compressed air, sanitary waste, and condenser, storm, canal, and potable water; HVAC systems; and communication systems. The scientific activities that require reliable and resilient utilities include National Spherical Torus Experiment-Upgrade (NSTX-U), Facility for Laboratory Reconnection Experiments (FLARE), and Lithium Tokamak Experiment-Beta (LTX-β).

The specifics of long-lead electrical equipment procurement will be reviewed and approved in support of CD-3A.

Justification

PPPL is a key DOE contributor to plasma science and directly supports the DOE mission to make fusion energy a practical reality and further U.S. economic competitiveness. To maintain system operability, it is essential to have reliable infrastructure in place. The current systems are past their useful life, obsolete, unreliable, and inefficient. Portions of the current system are part of the original infrastructure built in 1958. To maintain current missions and enable future ones, the infrastructure must be upgraded with modern, efficient, and reliable systems.

CIRR will deliver modern and resilient general-purpose infrastructure which will be more reliable, efficient, and sustainable and meet current industry standards. For example, replacing the obsolete hot deck/cold deck HVAC system will not only result in repair savings, but will generate energy savings as well. Every element of this project will be designed to consider the best available and most efficient technology and employ artificial intelligence systems to enhance operations and maintenance of new systems and equipment.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets.*

Key Performance Parameters (KPPs)

The KPPs are preliminary and may change as the project continues towards CD-2. At CD-2 approval, the KPPs will be baselined. The Threshold KPPs represent the minimum acceptable performance that the project must achieve. The Objective KPPs represent the desired project performance. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion.

Performance Measure	Threshold	Objective
Chilled Water Generation	▪ Improve configuration and efficiency of the Central Chilled Water Plant to ensure distribution of 1,200 tons of cooling capacity to the site.	▪ N/A
Communications Distribution Network	▪ Improve data infrastructure cabling and components by replacing existing copper cable with 2,000 linear feet of cat 6 cable. ▪ Provide 2,500 linear feet of 48 strand network fiber cable connected to the PU Computer Center. ▪ Provide 15,000 linear feet of 24 strand fiber optic cable to support site wide communication.	▪ Threshold plus upgrade additional communication system components to improve security, reliability, and flexibility.
Electrical Distribution & Standby Power	▪ Create redundancy and improve mission readiness of the primary electrical distribution system in the 138 kV Yard. ▪ Provide site-wide capacity of standby generation at 3,500 KW. ▪ Upgrade 8 Substations for priority buildings and facilities.	▪ Increase site-wide capacity of standby generation up to 4,350 KW. ▪ Upgrade up to 10 substations for additional buildings/facilities to improve flexibility for maintenance and operations.
HVAC Systems	▪ Upgrade 8 HVAC system equipment for priority buildings on C-Site and D-Site.	▪ Upgrade up to 14 HVAC system equipment for additional buildings to meet sustainability goals and improve maintenance and operations.
Underground Distribution Network	▪ Replace all failed critical underground piping, valves, and components for campus utilities. ▪ Replace 1,700 linear feet of electrical feeders (26kv) for improved reliability. ▪ Upgrade 9,500 sqft. of Storm Retention Basin liner.	▪ Threshold plus upgrade additional underground system components to improve maintenance and reliability.

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
Design (TEC)			
Prior Years	2,150	2,150	31
FY 2023	4,000	4,000	324
FY 2024	3,800	3,800	5,000
FY 2025	—	—	4,595
Total, Design (TEC)	**9,950**	**9,950**	**9,950**
Construction (TEC)			
FY 2024	6,200	6,200	—
FY 2025	20,000	20,000	15,000
Outyears	51,150	51,150	62,350
Total, Construction (TEC)	**77,350**	**77,350**	**77,350**
Total Estimated Cost (TEC)			
Prior Years	2,150	2,150	31
FY 2023	4,000	4,000	324
FY 2024	10,000	10,000	5,000
FY 2025	20,000	20,000	19,595
Outyears	51,150	51,150	62,350
Total, Total Estimated Cost (TEC)	**87,300**	**87,300**	**87,300**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Other Project Cost (OPC)			
Prior Years	1,392	1,392	1,392
Outyears	308	308	308
Total, Other Project Cost (OPC)	**1,700**	**1,700**	**1,700**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Project Cost (TPC)			
Prior Years	3,542	3,542	1,423
FY 2023	4,000	4,000	324
FY 2024	10,000	10,000	5,000
FY 2025	20,000	20,000	19,595
Outyears	51,458	51,458	62,658
Total, TPC	**89,000**	**89,000**	**89,000**

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	7,600	7,600	**N/A**
Design - Contingency	2,350	2,350	**N/A**
Total, Design (TEC)	**9,950**	**9,950**	**N/A**
Construction	59,500	59,500	**N/A**
Construction - Contingency	17,850	17,850	**N/A**
Total, Construction (TEC)	**77,350**	**77,350**	**N/A**
Total, TEC	**87,300**	**87,300**	**N/A**
Contingency, TEC	*20,200*	*20,200*	***N/A***
Other Project Cost (OPC)			
Conceptual Planning	200	200	**N/A**
Conceptual Design	1,300	1,300	**N/A**
OPC - Contingency	200	200	**N/A**
Total, Except D&D (OPC)	**1,700**	**1,700**	**N/A**
Total, OPC	**1,700**	**1,700**	**N/A**
Contingency, OPC	*200*	*200*	***N/A***
Total, TPC	**89,000**	**89,000**	**N/A**
Total, Contingency (TEC+OPC)	***20,400***	***20,400***	***N/A***

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	2,150	4,000	10,000	—	71,150	87,300
	OPC	1,352	—	—	—	348	1,700
	TPC	3,502	4,000	10,000	—	71,498	89,000
FY 2025	TEC	2,150	4,000	10,000	20,000	51,150	87,300
	OPC	1,392	—	—	—	308	1,700
	TPC	3,542	4,000	10,000	20,000	51,458	89,000

Notes:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*
- *Other Project Costs (OPC) are funded through laboratory overhead.*

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	2Q FY 2028
Expected Useful Life	50 years
Expected Future Start of D&D of this capital asset	N/A

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	Current Total Estimate	Previous Total Estimate	Current Total Estimate
Operations	1,100	1,100	55,000	55,000
Utilities	N/A	N/A	N/A	N/A
Maintenance and Repair	1,000	1,000	50,000	50,000
Total, Operations and Maintenance	2,100	2,100	105,000	105,000

7. D&D Information

This project replaces critical infrastructure components; no new construction area is anticipated to be constructed in this project and it will not replace existing facilities.

	Square Feet
New area being constructed by this project at PPPL	None
Area of D&D in this project at PPPL	None
Area at PPPL to be transferred, sold, and/or D&D outside the project, including area previously "banked"	None
Area of D&D in this project at other sites	None
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously "banked"	None
Total area eliminated	None

8. Acquisition Approach

The PPPL Management and Operating (M&O) Contractor, Princeton University, will perform the acquisition for this project, overseen by the Princeton Site Office. The M&O Contractor will be responsible for awarding and managing all subcontracts related to the project. Project performance metrics will be performed by in-house management and Project Controls.

20-SC-72, Seismic and Safety Modernization, LBNL
Lawrence Berkeley National Laboratory, LBNL
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary

The FY 2025 Request for the Seismic and Safety Modernization (SSM) project is $18,000,000 of Total Estimated Cost (TEC) funding. The TEC range for this project is $112,800,000 to $183,300,000. The preliminary Total Project Cost (TPC) range for this project is $116,600,000 to $188,500,000. Currently, these cost ranges encompass the most feasible preliminary alternatives. The TPC estimate for this project is $145,000,000.

The most recently approved DOE Order 413.3B Critical Decision (CD) is CD-2/3 on December 7, 2023, to Approve Performance Baseline and Start of Construction. The project received $22,500,000 in Inflation Reduction Act (IRA) funding, which has been obligated and should be fully costed by FY 2024, to increase the TPC and initiate long lead procurement and site preparation to mitigate the risks of escalation.

A Federal Project Director with the appropriate certification level has been assigned to this project.

Significant Changes

This Construction Project Data Sheet (CPDS) is an update to the FY 2024 CPDS and is not a new start for FY 2025. FY 2025 funds will support the highest priority construction activities.

Critical Milestone History

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
FY 2025	12/21/22	6/17/19	01/13/23	12/7/2023	10/1/21	12/7/23	4Q FY 2028

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout.

Note:
- *CD-0 was originally approved on 9/6/2018, and has been updated to remove seismic upgrades to the firehouse.*
- *CD-1 was originally approved in 2019 and has been updated to reflect the current cost range.*

Fiscal Year	Performance Baseline Validation	CD-3A
FY 2025	12/7/23	01/13/23

CD-3A – Approve Long-Lead Procurement and Site Preparation Activities.

Project Cost History

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	12,000	129,000	141,000	4,000	4,000	145,000
FY 2025	12,000	129,000	141,000	4,000	4,000	145,000

Notes:
- *Other Project Costs (OPC) are funded through laboratory overhead.*

2. Project Scope and Justification

Scope

The SSM project will construct a new 47,700 (approximately) gross square feet facility on the existing cafeteria site to house the cafeteria, health services and operational support services (human resources, conferencing, and other potential groups) to meet the requirements of Risk Category III of the California Building Code (CBC).

Justification

LBNL executes 22 of the Office of Science's (SC'S) 24 core capabilities and the mission of multiple SC program offices, including ASCR, BER, BES, and HEP programs. LBNL is located on a 202-acre site in the hills above the University of California, Berkeley campus, employs approximately 3,400 full time employees, and is home to five SC national user facilities: the Advanced Light Source, the Energy Sciences Network, the Joint Genome Institute, the Molecular Foundry, and the National Energy Research Scientific Computing Center. In FY 2016, over 11,000 researchers used these facilities, representing roughly one third of the total for all SC user facilities. In pursuing the SC mission, LBNL leverages collaborative science to bring together teams of individuals with different fields of expertise to work together on common solutions to the SC mission. However, these research activities must be executed with a unique caution since LBNL is located less than one mile from the Hayward Fault and less than 25 miles from the San Andreas Fault, which would both pose a life safety risk to employees, visitors, and guests during a significant seismic event.

The U.S. Geological Survey's earthquake forecast, the third Uniform California Earthquake Rupture Forecast, states a 98 percent probability of a 6.0 magnitude or higher earthquake in the San Francisco Bay Area before 2043. Recent engineering evaluations from a San Francisco Bay Area structural engineering firm have identified significant and extensive seismic safety hazards in critical LBNL support buildings, including the Cafeteria and Health Services. Structural deficiencies identified in these buildings will likely cause significant structural damage with life safety hazards during a magnitude 6.0+ earthquake on the Hayward Fault or a magnitude 8.3 earthquake on the San Andreas Fault and will impede LBNL's ability to resume operations.

The SSM project will address seismic safety issues and emergency response capabilities, specifically related to facilities with large congregation areas as well as transportation capabilities that are necessary for emergency response personnel and maintaining continuity of operations. Demolition of the existing cafeteria and site preparation activities were initiated prior to CD-2 under the CD-3A authorization to minimize risks and schedule delays and ultimately allow for construction of a new, more sustainable, and operationally resilient facility. Additional supporting functions such as utilities or site modifications may be included in the project as deemed necessary.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*.

Key Performance Parameters (KPPs)
At CD-2 approval, the KPPs were baselined. The Threshold KPPs represent the minimum acceptable performance that the project must achieve. The Objective KPPs represent the desired project performance. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion.

Performance Measure	Threshold	Objective
New Facility to include a Cafeteria, Health Services & Operational Support Services	▪ 35,000 gross square feet (gsf). ▪ Meet requirements of Risk Category III of the CBC.	▪ 60,000 gsf ▪ N/A

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Estimated Cost (TEC)				
Design (TEC)				
Prior Years	12,000	12,000	8,801	—
FY 2023	—	—	113	—
FY 2024	—	—	3,086	—
Total, Design (TEC)	**12,000**	**12,000**	**12,000**	**—**
Construction (TEC)				
Prior Years	21,000	21,000	—	—
Prior Years - IRA Supp.	22,500	22,500	—	—
FY 2023	27,500	27,500	500	4,374
FY 2024	40,000	40,000	16,400	18,126
FY 2025	18,000	18,000	45,000	—
Outyears	—	—	44,600	—
Total, Construction (TEC)	**129,000**	**129,000**	**106,500**	**22,500**
Total Estimated Cost (TEC)				
Prior Years	33,000	33,000	8,801	—
Prior Years - IRA Supp.	22,500	22,500	—	—
FY 2023	27,500	27,500	613	4,374
FY 2024	40,000	40,000	19,486	18,126
FY 2025	18,000	18,000	45,000	—
Outyears	—	—	44,600	—
Total, Total Estimated Cost (TEC)	**141,000**	**141,000**	**118,500**	**22,500**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Other Project Cost (OPC)			
Prior Years	2,911	2,911	2,911
FY 2023	650	650	650
Outyears	439	439	439
Total, Other Project Cost (OPC)	**4,000**	**4,000**	**4,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Project Cost (TPC)				
Prior Years	35,911	35,911	11,712	–
Prior Years - IRA Supp.	22,500	22,500	–	–
FY 2023	28,150	28,150	1,263	4,374
FY 2024	40,000	40,000	19,486	18,126
FY 2025	18,000	18,000	45,000	–
Outyears	439	439	45,039	–
Total, TPC	**145,000**	**145,000**	**122,500**	**22,500**

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	10,300	10,300	**N/A**
Design - Contingency	1,700	1,700	**N/A**
Total, Design (TEC)	**12,000**	**12,000**	**N/A**
Construction	108,000	108,000	**N/A**
Construction - Contingency	21,000	21,000	**N/A**
Total, Construction (TEC)	**129,000**	**129,000**	**N/A**
Total, TEC	**141,000**	**141,000**	**N/A**
Contingency, TEC	*22,700*	*22,700*	***N/A***
Other Project Cost (OPC)			
Conceptual Planning	300	600	**N/A**
Conceptual Design	2,500	2,200	**N/A**
OPC - Contingency	1,200	1,200	**N/A**

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total, Except D&D (OPC)	**4,000**	**4,000**	**N/A**
Total, OPC	**4,000**	**4,000**	**N/A**
Contingency, OPC	*1,200*	*1,200*	***N/A***
Total, TPC	**145,000**	**145,000**	**N/A**
Total, Contingency (TEC+OPC)	***23,900***	***23,900***	***N/A***

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	55,500	27,500	40,000	—	18,000	141,000
	OPC	2,911	250	—	—	839	4,000
	TPC	58,411	27,750	40,000	—	18,839	145,000
FY 2025	TEC	55,500	27,500	40,000	18,000	—	141,000
	OPC	2,911	650	—	—	439	4,000
	TPC	58,411	28,150	40,000	18,000	439	145,000

Notes:

- *Other Project Costs (OPC) are funded through laboratory overhead.*

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	4Q FY 2028
Expected Useful Life	50 years
Expected Future Start of D&D of this capital asset	4Q FY 2078

Related Funding Requirements
(dollars in thousands)

	Annual Costs		**Life Cycle Costs**	
	Previous Total Estimate	**Current Total Estimate**	**Previous Total Estimate**	**Current Total Estimate**
Operations	N/A	N/A	N/A	N/A
Utilities	53	53	2,658	2,658
Maintenance and Repair	318	318	15,882	15,882
Total, Operations and Maintenance	371	371	18,540	18,540

7. D&D Information

The new area being constructed in this project is replacing existing facilities.

	Square Feet
New area being constructed by this project at LBNL	35,000 - 60,000
Area of D&D in this project at LBNL	13,605
Area at LBNL to be transferred, sold, and/or D&D outside the project, including area previously "banked"	None
Area of D&D in this project at other sites	None
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously "banked"	None
Total area eliminated	13,605

8. Acquisition Approach

The LBNL Management and Operating (M&O) Contractor, University of California, will perform the acquisition for this project, overseen by the Berkeley Site Office. The M&O contractor is responsible for awarding and managing all subcontracts related to this project. Project performance metrics will be performed by in-house management and Project Controls.

20-SC-73, CEBAF Renovation and Expansion, TJNAF
Thomas Jefferson National Accelerator Facility, TJNAF
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary
The FY 2025 Request for the Continuous Electron Beam Accelerator Facility (CEBAF) Renovation and Expansion (CRE) project is $11,000,000. The preliminary Total Estimated Cost (TEC) range for this project is $46,600,000 to $99,500,000. The preliminary Total Project Cost (TPC) range for this project is $69,300,000 to $102,800,000. Currently, these cost ranges encompass the most feasible preliminary alternatives. The preliminary TPC estimate for this project is $90,300,000.

The CEBAF center at TJNAF has inadequate utility systems that are experiencing frequent failures.
This project will renovate 95,000 to 247,000 gross square feet (gsf) of existing space in the CEBAF center and the Applied Research Center (ARC) space for visitors, users, research, education, and support and upgrade utility systems that are at the end of their useful life. To accommodate ongoing operations during the project, the ARC renovation will be executed prior to the CEBAF renovation.

A Federal Project Director with the appropriate certification has been assigned to this project.

Significant Changes
The most recent DOE Order 413.3B Critical Decision (CD) is CD-1, Approve Alternative Selection and Cost Range, which was approved on March 18, 2020. FY 2025 funds will support design activities, and construction and associated activities.

Critical Milestone History

Fiscal Year	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
FY 2025	7/20/18	10/16/19	3/18/20	2Q FY 2025	2Q FY 2025	2Q FY 2026	2Q FY 2031

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout.

Fiscal Year	Performance Baseline Validation	CD-3A	CD-3B
FY 2025	2Q FY 2025	2Q FY 2025	2Q FY 2026

CD-3A – Approve start of construction activities in ARC.
CD-3B – Approve Start of Remaining Construction Activities in CEBAF

Project Cost History

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	7,000	80,000	87,000	3,300	3,300	90,300
FY 2025	9,500	77,500	87,000	3,300	3,300	90,300

Notes:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*
- *Other Project Costs (OPC) are funded through laboratory overhead.*

2. Project Scope and Justification

Scope
The scope of the CRE project will include renovating 95,000 to 247,000 gsf of office and laboratory space (including acquisition of the ARC) for 120 to 200 research, education, and support staff. The renovation will include reconfiguration to provide more functional, flexible, and efficient spaces that meet current code standards. CRE will replace the mechanical systems in the existing CEBAF Center, which have exceeded their service life and experienced multiple failures. The CRE project will be designed to support climate resilience by accounting for projected changes in temperature and precipitation, energy and water efficiency, and enhanced monitoring of assets to reduce the risk of failure. The renovated building will meet modern building performance standards, including energy conservation, green building principles, and sustainable design, including provisions for approximately 100 geothermal wells. Upon completion, SC will relocate administrative and support staff from the Service Support Center (SSC) (leased space) and CEBAF into the ARC, and TJNAF will dedicate the CEBAF Center to scientific staff which will collectively and efficiently address functional workspace needs for TJNAF staff and users.

Justification
With nearly 1,600 users, TJNAF supports one of the largest nuclear physics user communities in the world. The expanded scientific scope associated with the 12 GeV upgrade (e.g., double the energy with simultaneous delivery to four experimental halls) is creating more and larger collaborations, requiring more technical workshops, and resulting in more visitors to the Laboratory. The Laboratory expects staff and user population to increase two percent per year for the next ten years and will soon exceed available space, which is already near capacity. Further, TJNAF is actively pursuing several large multi-program transfer projects such as the cryomodules and cryogenics plants for Linac Coherent Light Source (LCLS)-I, LCLS-II-High Energy, Facility for Rare Isotope Beams (FRIB), and the Utilities Upgrade Project (UUP) that will require additional staffing. TJNAF will continue to play a key role in the design and development of emerging SC initiatives.

Currently, TJNAF is lacking technically equipped and functional space to accommodate advanced scientific research and major missions on the immediate horizon. The existing CEBAF Center is well beyond full capacity. The current occupant density of this building is 110 gsf per occupant which is significantly below the DOE standard of 180 gsf per occupant. In addition, utility systems at the CEBAF center are inadequate, failing, and inefficient for the existing usage.

As part of TJNAF's strategic campus plan, CRE will deliver more efficient, collaborative, and functional workspaces that consolidates the Laboratory workforce scattered over several leased buildings into a single center. The project consolidates workers currently housed in the ARC and SSC leased spaces to efficiently addresses functional workspace needs, allows leases to be discontinued, and reduces the cost to sustain existing buildings and infrastructure. This project will provide upgraded laboratories and additional space for visitors, users, research, education, and support especially for new science capabilities such as 12 GeV and upcoming Electron Ion Collider (EIC) at BNL.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*.

Key Performance Parameters (KPPs)
The KPPs are preliminary and may change as the project continues towards CD-2. At CD-2 approval, the KPPs will be baselined. The Threshold KPPs represent the minimum acceptable performance that the project must achieve. The Objective KPPs represent the desired project performance. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion.

Performance Measure	Threshold	Objective
CEBAF Center/ARC Renovation	95,000 gsf	247,000 gsf

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Estimated Cost (TEC)				
Design (TEC)				
Prior Years	6,000	6,000	4,472	—
FY 2023	2,000	2,000	887	—
FY 2024	1,000	1,000	3,551	—
FY 2025	500	500	590	—
Total, Design (TEC)	**9,500**	**9,500**	**9,500**	**—**
Construction (TEC)				
Prior Years	8,000	8,000	—	—
Prior Years - IRA Supp.	10,000	10,000	—	—
FY 2023	13,000	13,000	—	—
FY 2024	10,000	10,000	—	3,000
FY 2025	10,500	10,500	6,000	3,000
Outyears	26,000	26,000	61,500	4,000
Total, Construction (TEC)	**77,500**	**77,500**	**67,500**	**10,000**
Total Estimated Cost (TEC)				
Prior Years	14,000	14,000	4,472	—
Prior Years - IRA Supp.	10,000	10,000	—	—
FY 2023	15,000	15,000	887	—
FY 2024	11,000	11,000	3,551	3,000
FY 2025	11,000	11,000	6,590	3,000
Outyears	26,000	26,000	61,500	4,000
Total, Total Estimated Cost (TEC)	**87,000**	**87,000**	**77,000**	**10,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Other Project Cost (OPC)				
Prior Years	1,492	1,492	1,492	–
Outyears	1,808	1,808	1,808	–
Total, Other Project Cost (OPC)	**3,300**	**3,300**	**3,300**	**–**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs	IRA Supp. Costs
Total Project Cost (TPC)				
Prior Years	15,492	15,492	5,964	–
Prior Years - IRA Supp.	10,000	10,000	–	–
FY 2023	15,000	15,000	887	–
FY 2024	11,000	11,000	3,551	3,000
FY 2025	11,000	11,000	6,590	3,000
Outyears	27,808	27,808	63,308	4,000
Total, TPC	**90,300**	**90,300**	**80,300**	**10,000**

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	8,500	6,000	**N/A**
Design - Contingency	1,000	1,000	**N/A**
Total, Design (TEC)	**9,500**	**7,000**	**N/A**
Construction	62,000	63,000	**N/A**
Construction - Contingency	15,500	17,000	**N/A**
Total, Construction (TEC)	**77,500**	**80,000**	**N/A**
Total, TEC	**87,000**	**87,000**	**N/A**
Contingency, TEC	*16,500*	*18,000*	***N/A***
Other Project Cost (OPC)			
Conceptual Planning	2,700	2,700	**N/A**
Conceptual Design	600	600	**N/A**
Total, Except D&D (OPC)	**3,300**	**3,300**	**N/A**
Total, OPC	**3,300**	**3,300**	**N/A**

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Contingency, OPC	***N/A***	*N/A*	***N/A***
Total, TPC	**90,300**	**90,300**	**N/A**
Total, Contingency (TEC+OPC)	***16,500***	***18,000***	***N/A***

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	24,000	15,000	11,000	—	37,000	87,000
	OPC	1,492	600	—	—	1,208	3,300
	TPC	25,492	15,600	11,000	—	38,208	90,300
FY 2025	TEC	24,000	15,000	11,000	11,000	26,000	87,000
	OPC	1,492	—	—	—	1,808	3,300
	TPC	25,492	15,000	11,000	11,000	27,808	90,300

Notes:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*
- *Other Project Costs (OPC) are funded through laboratory overhead.*

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	2Q FY 2031
Expected Useful Life	50 years
Expected Future Start of D&D of this capital asset	N/A

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	**Current Total Estimate**	**Previous Total Estimate**	**Current Total Estimate**
Operations	288	288	14,400	14,400
Utilities	432	432	21,600	21,600
Maintenance and Repair	1,008	1,008	50,400	50,400
Total, Operations and Maintenance	1,728	1,728	86,400	86,400

7. D&D Information

The new area being constructed in this project is not replacing existing facilities.

	Square Feet
New area being constructed by this project at TJNAF	up to 47,000
Area of D&D in this project at TJNAF	None
Area at TJNAF to be transferred, sold, and/or D&D outside the project, including area previously "banked"	None[c]
Area of D&D in this project at other sites	None
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously "banked"	None
Total area eliminated	None

8. Acquisition Approach

The TJNAF Management and Operating (M&O) contractor, Jefferson Science Associates, will perform the acquisition for this Design-Bid-Build project, overseen by the Thomas Jefferson Site Office. The M&O contractor will be responsible for awarding and administering all subcontracts related to this project. Its annual performance evaluation and measurement plan will include project performance metrics on which it will be evaluated.

[c] With the implementation of OMB's Reduce the Footprint initiative, DOE no longer maintains the space bank. Footprint is managed using the Facility Information Management System, with decisions on additions and offsets made in accordance with the DOE Real Property Efficiency Plan.

20-SC-77, Argonne Utilities Upgrade, ANL
Argonne National Laboratory, ANL
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary

The FY 2025 Request for the Argonne Utilities Upgrade (AU2) project is $3,000,000 of Total Estimated Cost (TEC) funding. The preliminary TEC range for this project is $172,000,000 to $290,250,000. The preliminary Total Project Cost (TPC) range for this project is $173,000,000 to $291,250,000. Currently, these cost ranges encompass the most feasible preliminary alternatives. The preliminary TPC estimate for this project is $216,000,000.

AU2 is proposed to revitalize and selectively upgrade ANL's existing major utility systems including steam, water, sanitary sewer, chilled water, and electrical systems.

The most recent DOE Order 413.3B Critical Decision (CD) is CD-3A, Approve Site Preparation, which was approved on September 14, 2023.

A Federal Project Director working towards the appropriate certification level was assigned to this project.

Significant Changes

This Construction Project Data Sheet (CPDS) is an update to the FY 2024 CPDS and does not include a new start for FY 2025. FY 2025 funds will support design and preparatory construction activities.

Preliminary plans for the generation of steam included a new boiler fueled by natural gas, with potential to convert to hydrogen if it became viable. However, to avoid enduring dependence on fossil fuel, existing boilers will be enhanced until a carbon free electricity solution is determined.

Critical Milestone History

	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
AU2 - Overall, ANL	5/17/19	10/30/20	7/1/21	2Q FY 2030	1Q FY 2030	2Q FY 2030	4Q FY 2034
AU2 - Chilled Water Plant , ANL	–	–	–	2Q FY 2026	1Q FY 2026	2Q FY 2027	4Q FY 2030
AU2 - Steam Plant and Utility Piping, ANL	–	–	–	2Q FY 2030	1Q FY 2030	2Q FY 2030	4Q FY 2034

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout.

	Performance Baseline Validation	CD-3A
AU2 - Overall, ANL	3Q FY 2024	N/A
AU2 - Chilled Water Plant , ANL	2Q FY 2026	9/14/23

	Performance Baseline Validation	CD-3A
AU2 - Steam Plant and Utility Piping, ANL	2Q FY 2030	N/A

CD-3A – Long Lead Procurements and Site Preparation Activities.

Project Cost History

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	37,500	177,500	215,000	1,000	1,000	216,000
FY 2025	45,500	169,500	215,000	1,000	1,000	216,000

Notes:

- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*
- *Other Project Costs (OPC) are funded through laboratory overhead.*

2. Project Scope and Justification

Scope

The preliminary scope of the AU2 project includes upgrading failing 1940s-era utilities across the ANL campus. These utilities include steam, water, sanitary sewer, chilled water, and electrical systems. To facilitate its execution, the AU2 project is comprised of two subprojects consisting of scope needed to achieve complete and usable assets. Subproject 1 (SP-1) is Chilled Water and Utility Piping: consists of site preparation and demolition via approval of CD-3A followed by construction of a new chilled water plant when CD-3 is authorized. Subproject 2 (SP-2) is Steam and Utility Piping: consists of construction modernization and enhancement of an existing boiler, replacement, and modernization of several major utility systems, including steam and condensate, domestic water, canal water and sewer systems.

Justification

An efficient, maintainable, and reliable infrastructure is critical to the success and mission capability of ANL's research facilities. Revitalizing and upgrading the near century old major utility systems—including steam, water, sanitary sewer, chilled water, and electrical systems—is a mission need for ANL to overcome current limitations in meeting modern demands. For example, steam is a critical infrastructure for Argonne facilities; the Advanced Photon Source (APS) is dependent on the steam utility for holding extremely tight temperature and humidity ranges required for beam line operations and stability. Improving the performance and resilience of utilities would not only allow major pieces of scientific equipment to operate more efficiently and effectively with modern engineered controls but also prevent catastrophic climate related damage to both buildings and equipment.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets.*

Key Performance Parameters (KPPs)

The KPPs are preliminary and may change as the project continues towards CD-2. At CD-2 approval, the KPPs will be baselined. The Threshold KPPs represent the minimum acceptable performance that the project must achieve. The Objective KPPs represent the desired project performance. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion.

Performance Measure	Threshold	Objective
Chilled Water and Utility Piping (Cooling Systems)	▪ Construct a new 6,300 ton chilled water plant with N+1 reliability ▪ Repair, replace or construct new distribution piping for 5,000 linear feet of utility piping	▪ Upgrade equipment and controls at the 371, 450, and 528 chilled water plants. ▪ Repair fire domestic water tanks. ▪ Potential capacity upgrades, new equipment, equipment replacements, and various other utility system reliability projects to increase reliability of laboratory internal utilities.
Steam and Utility Piping (Steam & Condensate, Water Supply, Sewer)	▪ Modernize and enhance one (1) existing boiler in Building 108 ▪ Repair, replace or construct new distribution piping for 2,500 linear feet of utility piping	▪ Modernize and enhance existing one to three additional boilers in Building 108. ▪ Repair, replace or construct new distribution piping for up to 15,000 linear feet of utility piping and support structures (e.g., vaults, pipe supports, valves, culverts, etc.). ▪ Install between 50 and 250 new smart meters.

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
Design (TEC)			
Prior Years	11,000	11,000	4,086
FY 2023	8,000	8,000	3,149
FY 2024	6,000	6,000	14,800
FY 2025	—	—	5,000
Outyears	20,500	20,500	18,465
Total, Design (TEC)	**45,500**	**45,500**	**45,500**
Construction (TEC)			
FY 2024	2,007	2,007	—
FY 2025	3,000	3,000	—
Outyears	164,493	164,493	169,500
Total, Construction (TEC)	**169,500**	**169,500**	**169,500**
Total Estimated Cost (TEC)			
Prior Years	11,000	11,000	4,086
FY 2023	8,000	8,000	3,149
FY 2024	8,007	8,007	14,800

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
FY 2025	3,000	3,000	5,000
Outyears	184,993	184,993	187,965
Total, Total Estimated Cost (TEC)	**215,000**	**215,000**	**215,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Other Project Cost (OPC)			
Prior Years	1,000	1,000	1,000
Total, Other Project Cost (OPC)	**1,000**	**1,000**	**1,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Project Cost (TPC)			
Prior Years	12,000	12,000	5,086
FY 2023	8,000	8,000	3,149
FY 2024	8,007	8,007	14,800
FY 2025	3,000	3,000	5,000
Outyears	184,993	184,993	187,965
Total, TPC	**216,000**	**216,000**	**216,000**

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	36,400	30,000	**N/A**
Design - Contingency	9,100	7,500	**N/A**
Total, Design (TEC)	**45,500**	**37,500**	**N/A**
Construction	135,600	142,000	**N/A**
Construction - Contingency	33,900	35,500	**N/A**
Total, Construction (TEC)	**169,500**	**177,500**	**N/A**

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total, TEC	**215,000**	**215,000**	**N/A**
Contingency, TEC	*43,000*	*43,000*	***N/A***
Other Project Cost (OPC)			
Conceptual Planning	1,000	1,000	**N/A**
Total, Except D&D (OPC)	**1,000**	**1,000**	**N/A**
Total, OPC	**1,000**	**1,000**	**N/A**
Contingency, OPC	***N/A***	*N/A*	***N/A***
Total, TPC	**216,000**	**216,000**	**N/A**
Total, Contingency (TEC+OPC)	***43,000***	***43,000***	***N/A***

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	11,000	8,000	8,007	—	187,993	215,000
	OPC	1,000	—	—	—	—	1,000
	TPC	12,000	8,000	8,007	—	187,993	216,000
FY 2025	TEC	11,000	8,000	8,007	3,000	184,993	215,000
	OPC	1,000	—	—	—	—	1,000
	TPC	12,000	8,000	8,007	3,000	184,993	216,000

Notes:

- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*
- *Other Project Costs (OPC) are funded through laboratory overhead.*

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	SP-1: 4Q FY 2030 SP2: 4Q FY 2034
Expected Useful Life	50 years
Expected Future Start of D&D of this capital asset	SP-1: 4Q FY 2080 SP-2: 4Q FY 2084

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs[d]	
	Previous Total Estimate	**Current Total Estimate**	**Previous Total Estimate**	**Current Total Estimate**
Operations	2,955	2,955	147,750	147,750
Utilities	4,423	4,423	221,150	221,150
Maintenance and Repair	739	739	36,950	36,950
Total, Operations and Maintenance	8,117	8,117	405,850	405,850

7. D&D Information

The new area being constructed in this project is not replacing existing facilities.

	Square Feet
New area being constructed by this project at ANL	None
Area of D&D in this project at ANL	None
Area at ANL to be transferred, sold, and/or D&D outside the project, including area previously "banked"	None[e]
Area of D&D in this project at other sites	None
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously "banked"	None
Total area eliminated	None

8. Acquisition Approach

The ANL Management and Operating (M&O) Contractor, UChicago Argonne, LLC, will perform the acquisition for this project, overseen by the Argonne Site Office. The M&O contractor is responsible for awarding and managing all subcontracts related to this project. Project performance metrics will be performed by in-house management and Project Controls.

[d] Life-Cycle costs will be performed as part of CD-1.

[e] With the implementation of OMB's Reduce the Footprint initiative, DOE no longer maintains the space bank. Footprint is managed using the Facility Information Management System, with the decisions on additions and offsets made in accordance with the DOE Real Property Efficiency Plan.

20-SC-78, Linear Assets Modernization Project, LBNL
Lawrence Berkeley National Laboratory, LBNL
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary

The FY 2025 Request for the Linear Assets Modernization Project (LAMP) is $30,000,000 of Total Estimated Cost (TEC) funding. The preliminary TEC range for this project is $164,000,000 to $376,000,000. The preliminary Total Project Cost (TPC) range for this project is $170,000,000 to $386,000,000. Currently, these cost ranges encompass the most feasible preliminary alternatives. The preliminary TPC estimate for this project is $242,000,000.

LAMP will upgrade high priority utility systems to increase the reliability, capability, resilience, and safety of LBNL's infrastructure to meet DOE's mission. The project will upgrade utility systems, including, but not limited to, domestic water, natural gas, storm drain, sanitary sewer, electrical, and communication.

The most recent DOE Order 413.3B Critical Decision (CD) for LAMP, CD-1, Approve Alternative Selection and Cost Range, was for the entire project and was approved on April 13, 2022.

A Level 2 Federal Project Director, working towards the appropriate certification level, was assigned to this project at CD-1.

Significant Changes

This Construction Project Data Sheet (CPDS) is an update to the FY 2024 CPDS and is not a new start for FY2025. FY 2025 funds will support the activities of the design-build contractor after the appropriate CD approval.

Critical Milestone History

20-SC-78 Linear Assets Modernization Project, LBNL

	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
LAMP - Overall, LBNL	5/17/19	4/13/22	4/13/22	2Q FY 2027	2Q FY 2027	2Q FY 2027	4Q FY 2031
LAMP - Grizzly Sub - Lawrence Corridor, LBNL	–	–	–	3Q FY 2026	2Q FY 2026	3Q FY 2026	3Q FY 2029
LAMP - McMillan and East Canyon Corridors, LBNL	–	–	–	2Q FY 2027	2Q FY 2027	2Q FY 2027	4Q FY 2031

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout.

20-SC-78 Linear Assets Modernization Project, LBNL

	Performance Baseline Validation	CD-3A
LAMP - Overall, LBNL	2Q FY 2027	1Q FY 2026
LAMP - Grizzly Sub - Lawrence Corridor, LBNL	3Q FY 2026	1Q FY 2026
LAMP - McMillan and East Canyon Corridors, LBNL	2Q FY 2027	–

CD-3A – Approve Long-Lead Procurements and Site Preparation Activities.

<u>Project Cost History</u>

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	50,000	186,000	236,000	6,000	6,000	242,000
FY 2025	50,000	186,000	236,000	6,000	6,000	242,000

Notes:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*
- *Other Project Costs (OPC) are funded through laboratory overhead.*

2. Project Scope and Justification

<u>Scope</u>
LAMP will upgrade the highest priority utility systems to increase the reliability, capability, and safety of LBNL's infrastructure to meet the DOE's mission. The utility systems include, but are not limited to, domestic water, natural gas, storm drain, sanitary sewer, electrical, and communication.

The project will aim to upgrade the most critical utility components considering operational risk and efficiencies, redundancy, utility bundling, and capacity needed for strategic growth including expanding the primary switching substation at Grizzly Peak to power the NERSC to full capacity and meet future lab power needs. LAMP will implement a multi-system approach for the renewal and improvement of LBNL's utility assets, considering geographical limitations as well as potential synergies with nearby sustainment and improvement projects, that provide opportunities for enhancement.

To facilitate its execution, LAMP is comprised of two subprojects that individually achieve complete and usable assets. The Grizzly Substation/Lawrence Corridor Subproject will increase the Lab's primary electrical substation capacity by installing new switch stations and systems capable of supporting all existing and future lab loads, distributing power for advanced supercomputing needs (NERSC), and upgrading multiple utility systems including IT/communications, natural gas, compressed air, sanitary sewer, and storm drain/hydraugers, providing for overall increased reliability and ease of maintenance. The East Canyon-McMillan Subproject will establish common utility corridors for high voltage duct banks which will segregate lines and upgrade multiple utility systems, including IT/communication, natural gas, compressed air, domestic water, sanitary sewer, and storm drain/ hydraugers providing for overall increased reliability and ease of maintenance.

Justification

SC uses the capabilities of LBNL to execute 23 of the 24 core capabilities and the mission of multiple SC program offices, including ASCR, BER, BES, and HEP. The SC mission and multiple scientific programs require increased reliability, capability, and safety of LBNL's utility infrastructure. Utility infrastructure represents almost half of LBNL's large, deferred maintenance backlog and represents a significant capability gap in LBNL's ability to provide reliable and safe services to meet DOE's mission needs. Existing infrastructure is insufficient to support planned facility modernization and growth. Without a modern utility infrastructure backbone, future growth of the science mission at LBNL may not be achievable. For these reasons, direct infrastructure investment is necessary to address deferred maintenance reduction, restore operational reliability, increase resiliency, and provide the backbone necessary for scientific advancements.

LBNL has begun measures to strengthen the laboratory's resilience to outages due to planned safety outages or natural phenomena such as earthquakes, wildfires, and extreme weather.

LAMP will deliver modern and resilient general-purpose infrastructure which will be more efficient and sustainable. For example, the underground utility corridors will not only be upgraded to the best available technology but will be designed to be maintainable and monitored using artificial intelligence to enable predictive maintenance. The first sub-project of the LAMP project will enable an optimized NERSC-10 upgrade which will play a central role in breakthrough science.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets.*

Key Performance Parameters (KPPs)

The KPPs are preliminary and may change as the project continues towards CD-2. At CD-2 approval, the KPPs will be baselined. The Threshold KPPs represent the minimum acceptable performance that the project must achieve. The Objective KPPs represent the desired project performance. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion.

Performance Measure	Threshold	Objective
Storm Drainage System, Hydrauger/ Slope Stability	Install 1,000 Linear Feet of hydraugers.	Install up to 2,500 Linear Feet of hydraugers. (Lawrence Corridor).
		Install up to 3,000 Linear Feet of hydraugers. (East Canyon/McMillan Corridor).
Sanitary Sewer	Install 150 Linear Feet of pipe.	Install up to 2,500 Linear Feet of pipe. (Lawrence Corridor).
		Install up to 3,500 Linear Feet of pipe. (McMillan Corridor).
		Install up to 1,000 Linear Feet of pipe along the electrical distribution loop corridors. (McMillan Corridor).
High Pressure City Water	Install 1,500 Linear Feet of pipe.	Install up to 3,500 Linear Feet of pipe. (East Canyon Corridor).
		Install up to 2,000 Linear Feet of pipe along the electrical distribution loop corridors. (McMillan Corridor).
Communications & Data	Install 2,600 Linear Feet of ductbank.	Install up to 4,000 Linear Feet of ductbank with manholes and cables. (Lawrence Corridor).
		Install up to 2,500 Linear Feet of ductbank with manholes and cables. (East Canyon Corridor).
		Install up to 1,500 Linear Feet of ductbank with manholes and cables along the electrical distribution loop corridors. (East Canyon Corridor).
		Install up to 1,500 Linear Feet of ductbank with manholes and cables. (McMillan Corridor).

Performance Measure	Threshold	Objective
		Install up to 5,000 Linear Feet of ductbank with manholes and cables along the electrical distribution loop corridors. (McMillan Corridor).
Electrical Distribution/Grizzly Substation	Expand the Grizzly Substation to 70 MW capacity.	Expand the Grizzly Substation up to 150 MW capacity with two redundant lines with SCADA for new equipment.
		Provide a new SCADA Control Building.
		Provide two remote SCADA Control Rooms.
		Provide SCADA remote control and monitoring of existing and new circuit breakers.
		Install up to 400 Linear Feet of electrical feeders segregating lines 1 and 2 for SW-A1.
		Install SCADA for existing 115kV equipment.
Electrical Distribution/Grizzly Substation (Con't)	Install 1,500 Linear Feet of electrical feeders segregating lines 1 and 2. (Lawrence Corridor).	Install up to 3,500 Linear Feet of electrical feeders segregating lines 1 and 2.
		Feed B59 (NERSC) with up to 80 MW of electrical power with 3,500 Linear Feet of redundant and segregated lines.
		Install up to 2,000 Linear Feet of electrical feeders and Pad Mounted Switches for electrical distribution loops, segregating lines 1 and 2.
		Provide SCADA remote control and monitoring of existing and new circuit breakers.
	Install 1,200 Linear Feet of electrical feeders segregating lines 1 and 2. (East Canyon/McMillan Corridor).	Install up to 2,600 Linear Feet of electrical feeders segregating lines 1 and 2. (East Canyon Corridor).
		Install up to 5,700 Linear Feet of electrical feeders and Pad Mounted Switches for electrical distribution loops, segregating lines 1 and 2. (East Canyon Corridor).
		Provide SCADA remote control and monitoring of existing and new circuit breakers. (East Canyon Corridor).
	Install 1,200 Linear Feet of electrical feeders segregating lines 1 and 2. (East Canyon/McMillan Corridor) (Con't).	Install up to 2,200 Linear Feet of electrical feeders segregating lines 1 and 2. (McMillan Corridor).
		Install up to 6,300 Linear Feet of electrical feeders and Pad Mounted Switches for electrical distribution loops, segregating lines 1 and 2. (McMillan Corridor).
		Provide SCADA remote control and monitoring of existing and new circuit breakers. (McMillan Corridor).
Natural Gas	Install 200 Linear Feet of pipe.	Install up to 1,000 Linear Feet of pipe. (Lawrence Corridor).
		Install up to 2,500 Linear Feet of pipe. (McMillan Corridor).
		Install up to 2,000 Linear Feet of pipe along the electrical distribution loop corridors. (McMillan Corridor).
Compressed Air	Not Applicable	Install up to 3,500 Linear Feet of pipe. (Lawrence Corridor).
		Install up to 3,500 Linear Feet of pipe. (East Canyon Corridor).
		Install up to 2,500 Linear Feet of pipe. (McMillan Corridor).
		Install up to 1,500 Linear Feet of pipe along the electrical distribution loop corridors. (McMillan Corridor).

Performance Measure	Threshold	Objective
Controls/Artificial Intelligence	Not Applicable	Install up to 40 Smart Meters for new wet utility construction. (Lawrence Corridor).
		Provide integration with SCADA. (Lawrence Corridor).
		Provide integration with Microgrid enhancement. (Lawrence Corridor).
		Install up to 60 Smart Meters for new wet utility construction. (East Canyon Corridor).
		Install up to 50 Smart Meters for new wet utility construction. (McMillan Corridor).
		Provide integration with SCADA. (East Canyon/McMillan Corridors).
		Provide integration with Microgrid enhancement. (East Canyon/McMillan Corridors).

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
Design (TEC)			
Prior Years	11,400	11,400	5,936
FY 2023	22,600	22,600	4,504
FY 2024	—	—	5,000
FY 2025	—	—	12,000
Outyears	16,000	16,000	22,560
Total, Design (TEC)	**50,000**	**50,000**	**50,000**
Construction (TEC)			
FY 2023	825	825	—
FY 2024	18,900	18,900	—
FY 2025	30,000	30,000	—
Outyears	136,275	136,275	186,000
Total, Construction (TEC)	**186,000**	**186,000**	**186,000**
Total Estimated Cost (TEC)			
Prior Years	11,400	11,400	5,936
FY 2023	23,425	23,425	4,504
FY 2024	18,900	18,900	5,000
FY 2025	30,000	30,000	12,000
Outyears	152,275	152,275	208,560
Total, Total Estimated Cost (TEC)	**236,000**	**236,000**	**236,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Other Project Cost (OPC)			
Prior Years	3,263	3,263	3,263
Outyears	2,737	2,737	2,737
Total, Other Project Cost (OPC)	**6,000**	**6,000**	**6,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Project Cost (TPC)			
Prior Years	14,663	14,663	9,199
FY 2023	23,425	23,425	4,504
FY 2024	18,900	18,900	5,000
FY 2025	30,000	30,000	12,000
Outyears	155,012	155,012	211,297
Total, TPC	**242,000**	**242,000**	**242,000**

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	38,500	38,500	**N/A**
Design - Contingency	11,500	11,500	**N/A**
Total, Design (TEC)	**50,000**	**50,000**	**N/A**
Construction	144,000	144,000	**N/A**
Construction - Contingency	42,000	42,000	**N/A**
Total, Construction (TEC)	**186,000**	**186,000**	**N/A**
Total, TEC	**236,000**	**236,000**	**N/A**
Contingency, TEC	*53,500*	*53,500*	***N/A***
Other Project Cost (OPC)			
Conceptual Design	2,610	2,610	**N/A**
Start-up	2,190	2,190	**N/A**
OPC - Contingency	1,200	1,200	**N/A**
Total, Except D&D (OPC)	**6,000**	**6,000**	**N/A**
Total, OPC	**6,000**	**6,000**	**N/A**
Contingency, OPC	*1,200*	*1,200*	***N/A***

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total, TPC	**242,000**	**242,000**	**N/A**
Total, Contingency (TEC+OPC)	***54,700***	***54,700***	***N/A***

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	11,400	23,425	18,900	—	182,275	236,000
	OPC	3,263	—	—	—	2,737	6,000
	TPC	14,663	23,425	18,900	—	185,012	242,000
FY 2025	TEC	11,400	23,425	18,900	30,000	152,275	236,000
	OPC	3,263	—	—	—	2,737	6,000
	TPC	14,663	23,425	18,900	30,000	155,012	242,000

Notes:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*
- *Other Project Costs (OPC) are funded through laboratory overhead.*

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	4Q FY 2031
Expected Useful Life	50 years
Expected Future Start of D&D of this capital asset	N/A

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	**Current Total Estimate**	**Previous Total Estimate**	**Current Total Estimate**
Operations	1,200	1,200	60,000	60,000
Utilities	12	12	600	600
Maintenance and Repair	3,000	3,000	150,000	150,000
Total, Operations and Maintenance	4,212	4,212	210,600	210,600

7. D&D Information

This project replaces critical infrastructure components; no new construction area is anticipated to be constructed in this project and it will not replace existing facilities.

	Square Feet
New area being constructed by this project at LBNL	None
Area of D&D in this project at LBNL	None
Area at LBNL to be transferred, sold, and/or D&D outside the project, including area previously "banked"	None[f]
Area of D&D in this project at other sites	None
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously "banked"	None
Total area eliminated	None

8. Acquisition Approach

The LBNL Management and Operating (M&O) Contractor, University of California will perform the acquisition for this project, overseen by the Berkeley Site Office. The M&O contractor is responsible for awarding and managing all subcontracts related to this project. Project performance metrics will be performed by in-house management and Project Controls.

[f] With the implementation of OMB's Reduce the Footprint initiative, DOE no longer maintains the space bank. Footprint is managed using the Facility Information Management System, with the decisions on additions and offsets made in accordance with the DOE Real Property Efficiency Plan.

20-SC-79, Critical Utilities Infrastructure Revitalization, SLAC
SLAC National Accelerator Laboratory, SLAC
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary

The FY 2025 Request for the Critical Utilities Infrastructure Revitalization (CUIR) project is $20,000,000 of Total Estimated Cost (TEC) funding. The preliminary Total Estimated Cost (TEC) range for this project is $160,000,000 to $306,000,000. The preliminary Total Project Cost (TPC) range for this project is $164,500,000 to $310,500,000. Currently, these cost ranges encompass the most feasible preliminary alternatives. The preliminary TPC estimate for this project is $208,500,000.

The primary objective of this project is to close utilities infrastructure gaps, such as utility piping breaks, power fluctuations, faults, and cooling water interruptions, to support multi-program science missions at SLAC. Evolving technologies, instruments, experimental parameters, sensitivities, and complexity require increased reliability, resiliency, and service levels in electrical, mechanical, and civil systems site wide. The CUIR project will address the critical campus-wide utility and infrastructure issues by replacing, repairing, and modernizing the highest risk water/fire protection, sanitary sewer, storm drain, electrical, and cooling water system deficiencies. These needs have been identified through condition assessments, inspections, and recommendations from subject matter experts responsible for stewardship of the systems.

This project was initiated in FY 2020 Enacted Appropriations. The most recent DOE Order 413.3B approved Critical Decision (CD) is CD-3A, Approve Long-Lead Procurement and Early Site Preparation, which was approved on May 8, 2023.

A Federal Project Director working towards the appropriate certification level was assigned to this project.

Significant Changes

This Construction Project Data Sheet (CPDS) is an update to the FY 2024 CPDS and does not include a new start for FY 2025. FY 2025 funds will support construction activities after the appropriate CD approvals.

Critical Milestone History

	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
CUIR - Overall, SLAC	5/17/19	4/15/21	1/21/22	3Q FY 2029	1Q FY 2029	3Q FY 2029	1Q FY 2035
CUIR - Critical Electrical Work, SLAC	–	–	–	4Q FY 2025	2Q FY 2025	4Q FY 2025	4Q FY 2027
CUIR - Linac Utilities and Equipment, SLAC	–	–	–	4Q FY 2026	2Q FY 2026	4Q FY 2025	4Q FY 2030
CUIR - Sitewide Utilities, SLAC	–	–	–	3Q FY 2029	1Q FY 2029	3Q FY 2029	1Q FY 2035

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout.

	Performance Baseline Validation	CD-3A
CUIR - Overall, SLAC	3Q FY 2029	5/8/23
CUIR - Critical Electrical Work, SLAC	–	5/8/23

CD-3A – Approve Long-Lead Procurements and Site Preparation Activities.

Project Cost History

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	13,000	191,000	204,000	4,500	4,500	208,500
FY 2025	13,000	191,000	204,000	4,500	4,500	208,500

Notes:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*
- *Other Project Costs (OPC) are funded through laboratory overhead.*

2. Project Scope and Justification

Scope
CUIR's preliminary scope is to update major electrical gear, instrumentation, and cooling water systems for the two-mile long klystron gallery and accelerator housing constructed in 1962. Additionally, it will upgrade underground domestic water/fire protection, sanitary sewer, and storm drain systems site-wide. To facilitate its execution, CUIR is comprised of 3 subprojects to achieve complete and usable assets: Critical Electrical Work Subproject to replace and upgrade electrical components at greatest risk of failure or substandard performance of the Linac; Linac Utilities and Equipment Subproject to replace and reconfigure various electrical and mechanical equipment components and domestic/fire water piping; Sitewide Utilities Subproject to replace waveguide water heat exchangers, controls, and pumps.

Justification
SLAC is currently implementing a Campus Strategy designed to support the DOE Science Mission, increase reliability, and minimize costs through safe, effective, resilient, and efficient operations. The objective of the CUIR project is to reduce risks and close the capability gaps identified in SLAC's infrastructure assessments and surveys as they relate to storm water, sanitary sewer, domestic water/fire protection, electrical, and cooling water systems.

Disruptions caused by power fluctuations, faults, and cooling water interruptions, and utility piping breaks have frequently impacted science research site wide. Electrical systems, pumps, and motors fail, valves on piping systems freeze, and there are inoperable or unsafe electrical components that require broad outages to respond and repair. Workarounds and administrative controls have been placed on existing equipment and systems because they are underrated, not operating as intended, or not designed/operational for today's science needs, which results in create tremendous inefficiencies and safety concerns, and sub-optimized operations.

The CUIR project will reduce operational risks in critical infrastructure and utility support systems for all science programs and will retire $18,000,000 in deferred maintenance. These existing reliability gaps will continue to impede the operational efficiency, reliability, productivity, and competitive viability in science programs and other related science research breakthroughs until they are filled.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets.*

Key Performance Parameters (KPPs)

The KPPs are preliminary and may change as the project continues towards CD-2. At CD-2 approval, the KPPs will be baselined. The Threshold KPPs represent the minimum acceptable performance that the project must achieve. The Objective KPPs represent the desired project performance. The Objective KPPs are shown adjacent to the applicable Threshold KPPs in the following charts. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion.

Performance Measure	Threshold	Objective
Subproject 1: Critical Electrical System Improvements		
	Install one (1) substation to provide 3.5MVA power *	None
	Install three (3) 12kV feeder pathways and cables *	Install eight (8) 12kV feeder pathways and cables
	Install one (1) 230kV 60MVA (or larger) transformer *	Install two (2) 230kV 65MVA transformers **
	Install one (1) medium voltage switchgear at Sector 4 to allow feeder cable selection* Install two (2) medium voltage switchgear at the MSS to allow feeder cable selection*	None
	Replace monitoring equipment to provide monitoring and supervisory control input at nine (9) substation relay doors with one (1) integration hub.	Replace monitoring equipment to provide monitoring and supervisory control input at twelve (12) substation relay doors with one (1) integration hub. Integrate data from the substation, backup generator and transformer into the data-analytics platform
** Electrical equipment required to deliver noted threshold scope will be acquired upon approval of CD-3A* *** Electrical equipment necessary to deliver noted objective scope, which may be acquired after approval of CD-3A to provide project team adequate time to integrate objective scope into Subproject 1 outage planning and construction schedule development*.		
Subproject 2: Critical Civil Utilities Replacement and Upgrades		
	Replace 12,000 linear feet of domestic/fire water piping. Install submeters, flow and pressure sensors at two (2) domestic water main branches.	Replace 18,000 linear feet of domestic/fire water piping. Install submeters, flow and pressure sensors at four (4) domestic water main branches.

Performance Measure	Threshold	Objective
	Replace 2,700 linear feet of water main, laterals, and valves. Install five (5) backflow preventors and five (5) fire hydrants. Install submeter flow and pressure sensors at one (1) domestic water key node.	None
	Replace 1,000 linear feet of sanitary sewer piping. Install sensors to measure sewage flow, Total Dissolved Solids (TDS) at two (2) effluent stations.	Install sensors to measure sewage flow, Total Dissolved Solids (TDS) at five (5) existing effluent stations.
	Replace or re-line 5,000 linear feet of storm drain piping.	Replace or re-line 10,000 linear feet of storm drain piping.
	Data Analytics Plan to enhance monitoring and operation performance for utility systems.	Data Analytics Plan to integrate substation and water-cooling system monitor output into recommended data-analytics platform.
	None	Replace and reconfigure medium-voltage equipment for four (4) Variable Voltage Substations (VVS) and replace low voltage gear at five (5) substations.
	None	Replace 4,500LF of 12kV cables in PEP region.
	None	Replace low voltage sections for ten (10) K-subs, ten (10) VVS and sixteen (16) Motor Control Centers (MCC).
Subproject 3: Subproject 3: Critical Mechanical Utilities Upgrades		
	Replace eleven (11) Waveguide water heat exchangers, controls, and pumps.	None
	Replace four (4) Klystron water heat exchangers, four (4) controls, and four (4) pumps.	Replace 1,000 KF of Klystron piping system.
	Replace eleven (11) Accelerator, Klystron, and Waveguide monitoring devices.	None
	Install two (2) natural gas main meters, replace six (6) existing BTU energy meter, and integrate each into data analytics platform.	Install four (4) main meters and eight (8) submeters for natural gas, replace twelve (12) energy BTU meters and integrate each into the data analytics platform.
	None	Replace ten (10) programmable logic controller (PLC) to provide Data Analytics input.

Performance Measure	Threshold	Objective
	None	Integrate substation and water-cooling system monitor output into data-analytics platform.

3. **Financial Schedule**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
Design (TEC)			
Prior Years	5,000	5,000	6,158
FY 2023	—	—	3,121
FY 2024	—	—	560
FY 2025	—	—	500
Outyears	8,000	8,000	2,661
Total, Design (TEC)	**13,000**	**13,000**	**13,000**
Construction (TEC)			
Prior Years	4,500	4,500	2,500
FY 2023	25,425	25,425	800
FY 2024	35,075	35,075	30,000
FY 2025	20,000	20,000	20,000
Outyears	106,000	106,000	137,700
Total, Construction (TEC)	**191,000**	**191,000**	**191,000**
Total Estimated Cost (TEC)			
Prior Years	9,500	9,500	8,658
FY 2023	25,425	25,425	3,921
FY 2024	35,075	35,075	30,560
FY 2025	20,000	20,000	20,500
Outyears	114,000	114,000	140,361
Total, Total Estimated Cost (TEC)	**204,000**	**204,000**	**204,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Other Project Cost (OPC)			
Prior Years	2,672	2,672	2,672
FY 2023	11	11	11

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Other Project Cost (OPC)			
FY 2024	100	100	100
FY 2025	250	250	250
Outyears	1,467	1,467	1,467
Total, Other Project Cost (OPC)	**4,500**	**4,500**	**4,500**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Project Cost (TPC)			
Prior Years	12,172	12,172	11,330
FY 2023	25,436	25,436	3,932
FY 2024	35,175	35,175	30,660
FY 2025	20,250	20,250	20,750
Outyears	115,467	115,467	141,828
Total, TPC	**208,500**	**208,500**	**208,500**

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	11,300	11,400	**N/A**
Design - Contingency	1,700	1,600	**N/A**
Total, Design (TEC)	**13,000**	**13,000**	**N/A**
Construction	151,000	152,000	**N/A**
Construction - Contingency	40,000	39,000	**N/A**
Total, Construction (TEC)	**191,000**	**191,000**	**N/A**
Total, TEC	**204,000**	**204,000**	**N/A**
Contingency, TEC	*41,700*	*40,600*	***N/A***
Other Project Cost (OPC)			
Conceptual Planning	4,500	3,200	**N/A**
Conceptual Design	N/A	1,300	**N/A**
Total, Except D&D (OPC)	**4,500**	**4,500**	**N/A**
Total, OPC	**4,500**	**4,500**	**N/A**

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Contingency, OPC	***N/A***	*N/A*	***N/A***
Total, TPC	**208,500**	**208,500**	**N/A**
Total, Contingency (TEC+OPC)	***41,700***	***40,600***	***N/A***

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	9,500	25,425	35,075	—	134,000	204,000
	OPC	2,672	50	—	—	1,778	4,500
	TPC	12,172	25,475	35,075	—	135,778	208,500
FY 2025	TEC	9,500	25,425	35,075	20,000	114,000	204,000
	OPC	2,672	11	100	250	1,467	4,500
	TPC	12,172	25,436	35,175	20,250	115,467	208,500

Notes:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*
- *Other Project Costs (OPC) are funded through laboratory overhead.*

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	1Q FY 2035
Expected Useful Life	Average 30 years (based system)
Expected Future Start of D&D of this capital asset	N/A

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	**Current Total Estimate**	**Previous Total Estimate**	**Current Total Estimate**
Operations	8,673	8,673	260,176	260,176
Utilities	10,487	10,487	314,624	314,624
Maintenance and Repair	8,461	8,461	253,833	253,833
Total, Operations and Maintenance	27,621	27,621	828,632	828,632

7. D&D Information

The new area being constructed in this project is not replacing existing facilities.

	Square Feet
New area being constructed by this project at SLAC	None
Area of D&D in this project at SLAC	None
Area at SLAC to be transferred, sold, and/or D&D outside the project, including area previously "banked"	None[g]
Area of D&D in this project at other sites	None
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously "banked"	None
Total area eliminated	None

8. Acquisition Approach

The SLAC Management and Operating (M&O) contractor, Stanford University, will perform the acquisition for this project, overseen by the Stanford Site Office. The M&O contractor is responsible for awarding and managing all subcontracts related to this project. The M&O contractor is evaluating various acquisition alternatives and project delivery methods. Potential acquisition and project delivery methods include, but are not limited to, firm-fixed-price contracts for design-bid-build, construction management, and design-build subcontracts. The M&O contractor will also evaluate potential benefits of using single or multiple contracts to procure materials, equipment, construction, commissioning, and other project scope elements. Its annual performance and evaluation measurement plan will include project performance metrics for SLAC on which it will be evaluated.

[g] With the implementation of OMB's Reduce the Footprint initiative, DOE no longer maintains the space bank. Footprint is managed using the Facility Information Management System, with decisions on additions and offsets made in accordance with the DOE Real Property Efficiency Plan.

20-SC-80, Utilities Infrastructure Project, FNAL
Fermi National Accelerator Laboratory, FNAL
Project is for Design and Construction

1. Summary, Significant Changes, and Schedule and Cost History

Summary

The FY 2025 Request for the Utilities Infrastructure Project (UIP) is $45,000,000 of Total Estimated Cost (TEC) funding. The preliminary Total TEC range for this project is $248,000,000 to $403,000,000. The preliminary Total Project Cost (TPC) range for this project is $252,000,000 to $411,000,000. Currently, these cost ranges encompass the most feasible preliminary alternatives. The preliminary TPC estimate for this project is $314,000,000.

This project will modernize and upgrade obsolete and deteriorated utilities infrastructure at Fermi National Accelerator Laboratory (FNAL) and provide resiliency, reliability, and increased safety of operations to ensure the infrastructure can continue supporting the Laboratory's scientific missions. Major elements include modernization of the existing central utility building including an expansion to provide a new chilled water capacity to support current and future chilled water capacity, hot water, and low conductivity water systems. Additionally, the Kautz Road substation will be modernized to enhance its reliability and reduce safety risks. Both the modernization of the central utility building and the electrical substation are scheduled for construction during FNAL's FY 2027–2029 Long Accelerator Shutdown. The balance of the project will revitalize aging linear utilities across the FNAL site including sanitary sewers, domestic water, industrial cooling water, natural gas, and electrical feeders and equipment is in the early planning stages.

The most recent DOE Order 413.3B approved Critical Decision (CD) is CD-1, Approve Alternative Selection and Cost Range, which was approved on February 23, 2022.

A Federal Project Director is working towards the appropriate certification level assigned to this project at CD-1.

Significant Changes

This Construction Project Data Sheet (CPDS) is an update to the FY 2024 CPDS and is not a new start for FY2025.
FY 2025 funds will support construction activities after the appropriate CD approvals.

Critical Milestone History

	CD-0	Conceptual Design Complete	CD-1	CD-2	Final Design Complete	CD-3	CD-4
UIP - Overall, FNAL	5/17/19	–	2/23/22	3Q FY 2029	4Q FY 2030	3Q FY 2029	3Q FY 2034
UIP - New Chill Water Plant, Cent Utility Build Upgrades, FNAL	–	–	–	4Q FY 2025	2Q FY 2025	4Q FY 2025	4Q FY 2030
UIP - Kautz Road Substation Replacement, FNAL	–	–	–	1Q FY 2026	4Q FY 2025	1Q FY 2026	3Q FY 2030
UIP - Linear Utilities, FNAL	–	–	–	3Q FY 2029	4Q FY 2030	3Q FY 2029	3Q FY 2034

CD-0 – Approve Mission Need for a construction project with a conceptual scope and cost range; **Conceptual Design Complete** – Actual date the conceptual design was completed (if applicable); **CD-1** – Approve Alternative Selection and Cost Range; **CD-2** – Approve Performance Baseline; **Final Design Complete** – Estimated/Actual date the project design will be/was complete(d); **CD-3** – Approve Start of Construction; **D&D Complete** – Completion of D&D work; **CD-4** – Approve Start of Operations or Project Closeout.

	Performance Baseline Validation	CD-3A
UIP - Overall, FNAL	3Q FY 2029	4Q FY 2024
UIP - New Chill Water Plant, Cent Utility Build Upgrades, FNAL	4Q FY 2025	4Q FY 2024
UIP - Kautz Road Substation Replacement, FNAL	1Q FY 2026	1Q FY 2025
UIP - Linear Utilities, FNAL	TBD	TBD

CD-3A – Approve Long-Lead Procurements and Site Preparation Activities.

Project Cost History

(dollars in thousands)

Fiscal Year	TEC, Design	TEC, Construction	TEC, Total	OPC, Except D&D	OPC, Total	TPC
FY 2024	43,800	266,200	310,000	4,000	4,000	314,000
FY 2025	40,750	269,250	310,000	4,000	4,000	314,000

Notes:
- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*
- *Other Project Costs (OPC) are funded through laboratory overhead.*

2. Project Scope and Justification

Scope

The UIP's preliminary scope includes upgrading the highest risk major utility systems across the FNAL campus. Specifically, this project will first evaluate and identify the condition and risks of failure and inadequate performance of the industrial cooling water system, potable water distribution system, sanitary sewer and storm collection systems, natural gas distribution system, electrical distribution system, Kautz Road Substation, and the Central Utility Building. Selected portions of the systems with the highest risk of impact to operations will then be replaced or upgraded to assure safe, reliable, and efficient service to mission critical facilities. As such, the project will perform upgrades to obsolete, end-of-life components, which will increase capacity, reliability, and personnel safety for critical utilities. A review and approval for long-lead procurements (e.g., mechanical, and electrical equipment) and site preparation in support of CD-3A is planned in FY 2024.

To facilitate its execution, UIP is comprised of three subprojects consisting of scope needed to achieve complete and usable assets. Subproject 1: the New Chilled Water Plant and Central Utility Plant Upgrades Subproject plans to 1) expand the existing Central Utility Building to provide chilled water capacity to support current and future loads, and 2) modernize the existing section of the Central Utility Building systems such as hot water and low conductivity water systems. Subproject 2: the Kautz Road Substation Replacement Subproject plans to enhance the reliability of the Kautz Road Substation and reduce safety risks to personnel by replacing aging infrastructure, facilitating energy control, and reducing arc-flash incident energies. The primary construction phase of Subprojects 1 and 2 need to occur during FNAL's FY 2027–2029 Long Accelerator Shutdown to minimize disruption to the accelerator complex. Subproject 3: the Linear Utilities Replacement Subproject preliminary plans to revitalize aging linear utilities across the FNAL site including sanitary sewers, domestic water, industrial cooling water, natural gas, and electrical feeders and equipment. These improvements plan to enhance system reliability and reduce deferred maintenance.

Justification

DOE's Office of Science (SC) advances new experiments, international partnerships, and research programs to transform the understanding of nature and to advance U.S. energy, economic and national security interests. This mission requires the modernization and upgrades of obsolete and severely deteriorated utilities infrastructure at FNAL. SC has identified recapitalization of FNAL's Central Utilities Building and distributed site utility infrastructure to as a priority need ensure the stewardship of SC's investments and to provide modern, world-class facilities for scientific experiments and research.

Although there has been substantial investment in recent years to modernize and construct new research facilities at FNAL, much of FNAL's utility infrastructure serving these facilities is over 50 years old, is beyond useful life and suffering from failures, decreased reliability, lack of redundancy, and limitations in capacity. As such, there is an urgent need to revitalize and selectively upgrade FNAL's existing major utility systems to ensure reliable service, meet capacity requirements, and enable readiness of facilities critical to the research mission.

The UIP will deliver modern and resilient enabling infrastructure. The project includes installation of a combination of data collection and artificial intelligent monitoring systems that adjust to trends, predict failures, and react to extreme weather events, such as automatically transferring power to minimize impacts to mission critical scientific operations. Additionally, modern utility systems will be more efficient and sustainable.

The project is being conducted in accordance with the project management requirements in DOE Order 413.3B, *Program and Project Management for the Acquisition of Capital Assets*.

<u>Key Performance Parameters (KPPs)</u>

The KPPs are preliminary and may change as the project continues towards CD-2. At CD-2 approval, the KPPs will be baselined. The Threshold KPPs represent the minimum acceptable performance that the project must achieve. The Objective KPPs represent the desired project performance. Achievement of the Threshold KPPs will be a prerequisite for approval of CD-4, Project Completion.

Performance Measure	Threshold	Objective
Chilled Water Plant and CUB Upgrades	• Construct an addition to CUB for chilled water production (5,000 tons cooling capacity) • Install conventional oil-lubricated chillers • Refurbish the existing Central Utility Building envelope • Replace mechanical infrastructure in the CUB to support the Wilson Hall footprint area • Refurbish existing boiler	▪ Increase chilled water production to 6,000 tons cooling capacity. ▪ Upgrade chillers to magnetic bearing ▪ Upgrade existing CUB envelope ▪ Install environmentally sustainable improvements to CUB
Kautz Road Substation	▪ Replace/ Upgrade the KRS to improve arc flash safety requirements ▪ Replace T-85 Transformer	• Upgrade bus duct to cable bus Replace and repair Main Injector feeders from KRS
Linear Utilities Replacement	▪ Revitalize 5 miles of the Industrial Cooling Water system.	▪ Revitalize 16 miles of the Industrial Cooling Water system.
	▪ Revitalize 5 miles of the Domestic Water System (DWS).	▪ Revitalize 19 miles of the Domestic Water System (DWS).
	▪ Revitalize 3.5 miles of the Sanitary Sewer systems.	▪ Revitalize 11 miles of the Sanitary Sewer System.

Performance Measure	Threshold	Objective
	▪ Revitalize 2 miles of underground Natural Gas lines.	▪ Revitalize 22 miles of underground Natural Gas lines.
	▪ Revitalize 2 miles of electrical distribution feeders and associated unit substations, transformers, etc.	▪ Revitalize 65 miles of electrical distribution feeders and associated unit substations, transformers, etc. ▪ Provide Electrical Code upgrades to Master Substation ▪ Revitalize 100 percent of the High-Pressure Sodium exterior lights along sidewalks, roads, and parking lots with LED.

3. Financial Schedule

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Estimated Cost (TEC)			
Design (TEC)			
Prior Years	11,500	11,500	870
FY 2023	11,000	11,000	3,740
FY 2024	4,300	4,300	18,355
FY 2025	—	—	4,270
Outyears	13,950	13,950	13,515
Total, Design (TEC)	**40,750**	**40,750**	**40,750**
Construction (TEC)			
FY 2023	9,000	9,000	—
FY 2024	40,700	40,700	18,000
FY 2025	45,000	45,000	27,900
Outyears	174,550	174,550	223,350
Total, Construction (TEC)	**269,250**	**269,250**	**269,250**
Total Estimated Cost (TEC)			
Prior Years	11,500	11,500	870
FY 2023	20,000	20,000	3,740
FY 2024	45,000	45,000	36,355
FY 2025	45,000	45,000	32,170
Outyears	188,500	188,500	236,865
Total, Total Estimated Cost (TEC)	**310,000**	**310,000**	**310,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Other Project Cost (OPC)			
Prior Years	2,050	2,050	2,050
Outyears	1,950	1,950	1,950
Total, Other Project Cost (OPC)	**4,000**	**4,000**	**4,000**

(dollars in thousands)

	Budget Authority (Appropriations)	Obligations	Costs
Total Project Cost (TPC)			
Prior Years	13,550	13,550	2,920
FY 2023	20,000	20,000	3,740
FY 2024	45,000	45,000	36,355
FY 2025	45,000	45,000	32,170
Outyears	190,450	190,450	238,815
Total, TPC	**314,000**	**314,000**	**314,000**

4. Details of Project Cost Estimate

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total Estimated Cost (TEC)			
Design	33,500	36,100	**N/A**
Design - Contingency	7,250	7,700	**N/A**
Total, Design (TEC)	**40,750**	**43,800**	**N/A**
Construction	225,000	221,300	**N/A**
Construction - Contingency	44,250	44,900	**N/A**
Total, Construction (TEC)	**269,250**	**266,200**	**N/A**
Total, TEC	**310,000**	**310,000**	**N/A**
Contingency, TEC	*51,500*	*52,600*	***N/A***
Other Project Cost (OPC)			
Conceptual Planning	880	880	**N/A**
Conceptual Design	1,170	1,170	**N/A**
OPC - Contingency	1,950	1,950	**N/A**
Total, Except D&D (OPC)	**4,000**	**4,000**	**N/A**
Total, OPC	**4,000**	**4,000**	**N/A**
Contingency, OPC	*1,950*	*1,950*	***N/A***

(dollars in thousands)

	Current Total Estimate	Previous Total Estimate	Original Validated Baseline
Total, TPC	**314,000**	**314,000**	**N/A**
Total, Contingency (TEC+OPC)	***53,450***	***54,550***	***N/A***

5. Schedule of Appropriations Requests

(dollars in thousands)

Fiscal Year	Type	Prior Years	FY 2023	FY 2024	FY 2025	Outyears	Total
FY 2024	TEC	11,500	20,000	45,000	—	233,500	310,000
	OPC	2,050	—	—	—	1,950	4,000
	TPC	13,550	20,000	45,000	—	235,450	314,000
FY 2025	TEC	11,500	20,000	45,000	45,000	188,500	310,000
	OPC	2,050	—	—	—	1,950	4,000
	TPC	13,550	20,000	45,000	45,000	190,450	314,000

Notes:

- *This project has not received CD-2 approval; therefore, funding estimates are preliminary.*
- *Other Project Costs (OPC) are funded through laboratory overhead.*

6. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy	3Q FY 2034
Expected Useful Life	30 years
Expected Future Start of D&D of this capital asset	N/A

Related Funding Requirements
(dollars in thousands)

	Annual Costs		Life Cycle Costs	
	Previous Total Estimate	**Current Total Estimate**	**Previous Total Estimate**	**Current Total Estimate**
Operations	287	287	8,610	8,610
Utilities	577	577	17,310	17,310
Maintenance and Repair	287	287	8,610	8,610
Total, Operations and Maintenance	1,151	1,151	34,530	34,530

7. D&D Information

The new area being constructed in this project is not replacing existing facilities.

	Square Feet
New area being constructed by this project at FNAL	10,000 – 30,000
Area of D&D in this project at FNAL	None
Area at FNAL to be transferred, sold, and/or D&D outside the project, including area previously "banked"	None[h]
Area of D&D in this project at other sites	None
Area at other sites to be transferred, sold, and/or D&D outside the project, including area previously "banked"	None
Total area eliminated	None

8. Acquisition Approach

The FNAL Management and Operating (M&O) contractor, FNAL Research Alliance LLC, will perform the acquisition for this project, overseen by the FNAL Site Office. The M&O contractor is responsible for awarding and managing all subcontracts related to this project. Project performance metrics will be performed by in-house management and Project Controls.

[h] With the implementation of OMB's Reduce the Footprint initiative, DOE no longer maintains the space bank. Footprint is managed using the Facility Information Management System, with decisions on additions and offsets made in accordance with the DOE Real Property Efficiency Plan.

Safeguards and Security

Overview

The SC Safeguards and Security (S&S) program is designed to ensure appropriate security measures are in place to support the SC mission requirements of open scientific research and to protect critical assets within these SC laboratories. Accomplishing this mission depends on providing physical security tools, processes, and cyber security controls that will mitigate current and future threats to the laboratories' employees, nuclear and special nuclear materials, classified and sensitive information, hazardous materials, mission essential functions and facilities using risk-based decision process. Threats to these SC high-consequence assets and capabilities come from an array of evolving sources being followed by the DOE's Office of Intelligence/Counterintelligence, National intelligence agencies and local law enforcement agencies to include transnational terrorists, domestic terrorists, criminals, disgruntled employees, malevolent insiders motivated for financial or ideological reasons, and foreign national visitors with the malicious intent of performing espionage. To counter these threats and support operations, the physical security program continually looks to leverage the latest security technologies and tactics, to include artificial intelligence (AI) systems and software to enhance program performance and efficiency in addressing threats. The SC S&S program also provides funding for cybersecurity for the laboratories' information technology systems to protect SC mission systems, computers, networks, and data from unauthorized access and virtual incursion from many of these same threats.

Highlights of the FY 2025 Request

The FY 2025 Request for S&S is $195.0 million, an increase of $11 million over the FY 2023 Enacted. The FY 2025 Request will prioritize the retention of existing security in the physical security funding allocation. SC will also maintain the current capability of the HSPD-12 credentialing effort focused on high-priority actions to support the screening of the uncleared personnel population have access to the highest risk assets at SC sites (e.g., information technology networks).

The FY 2025 Request includes $83.3 million in Cybersecurity to address long-standing gaps in infrastructure, operations, and compliance to ensure adequate detection, mitigation, and recovery from cyber intrusions and attacks against DOE laboratories. Funding in this Request supports the implementation of Executive Order 14028 requirements for Multi-Factor Authentication (MFA) to the maximum extent possible, Encryption of data both at rest and in transit, Cloud Strategy/Security, Improved Logging, Supply Chain Management, and Zero Trust Infrastructure to address the continued attacks on our IT infrastructure by increasingly more sophisticated adversaries both from traditional adversaries such as Russia, China and North Korea, but also from adversaries attempting to profit from intellectual property at the Labs to the Personally Identifiable Information (PII) of DOE personnel.

Description

The S&S program is organized into seven program elements:

1. Protective Forces
2. Security Systems
3. Information Security
4. Cybersecurity
5. Personnel Security
6. Material Control and Accountability
7. Program Management

<u>Protective Forces</u>

The Protective Forces program element supports security officers that control access and protect S&S interests, along with their related equipment and training. Protective Forces at SC laboratories, and their coordinated efforts with federal and local law enforcement agencies, are our first line of defense against any violent attack against DOE personnel. This includes responding to, reporting, and defending against any number of events, including those resembling the nearly 600 mass shootings in the United States that have occurred since 2020. Activities within this program element include access control and security response operations as well as physical protection of the Department's critical assets and SC facilities. The Protective Force response and deployment configurations at SC laboratories reflect some of the most advanced tactical operator skills within the US government, which are necessitated due to the inherent consequences of protecting weapons grade nuclear materials, critical program assets, and classified information. Additionally, the Protective Forces mission includes providing effective response to emergency situations, random prohibited article inspections, security alarm monitoring, and performance testing of the protective force response to various event scenarios.

Security Systems

Detection and delay of potential threats at SC facilities is made possible by security systems that provide SC sites with advanced notification to save lives and protect DOE property, classified information, and other national security interests. The Security Systems program element provides the backbone of the physical protection of Departmental personnel, material, equipment, property, and facilities through the deployment of various systems. Systems currently deployed at SC sites include, but are not limited to, Homeland Security Presidential Directive 12 (HSPD-12) and local credentials, entry control points, fences, barriers, lighting, sensors, surveillance devices, access control systems, and power systems. In addition, the continued use of AI-based technologies provides further enhanced performance with respect to sites' abilities to detect, identify, track, and classify physical security threats, to include people and vehicles, at and within the site perimeter.

Information Security

The Information Security program element provides support to ensure that sensitive and classified information is accurately, appropriately, and consistently identified, reviewed, marked, protected, transmitted, stored, and ultimately destroyed. Specific activities within this element include management, planning, training, and oversight for maintaining security containers and combinations, marking documents, and administration of control systems, operations security, special access programs, technical surveillance countermeasures, and classification and declassification determinations. In particular, the classification area of this program element has experienced a significant increase in the volume of work as a result of SC's growth in national security activities and federal requirements to digitize millions of pages of scientific working documents.

Cybersecurity

The Cybersecurity program element develops and maintains a comprehensive program for ten national laboratories and four dedicated offices. There are numerous advanced persistent threats (APTs) from countries such as China, Russia, and North Korea with the goals of disrupting vital DOE SC missions and stealing critical research intellectual property in the areas of Material Science, High Performance Computing and Basic Energy Science. The risks from these APTs include not only disrupting the missions of SC and stealing intellectual property, but also acquiring PII of the members of both the Federal and contractor workforce. This program element's goals are to enable mission and science, align cyber funding for risk reduction, strengthen security posture by embracing new security designs, and offer unified guidance and cybersecurity procedures. The Cybersecurity program element responds to cyber incidents by supporting the activities needed for incident management, prosecution, and investigation of cyber intrusions. The program element supports both disaster recovery and incident recovery, as well as notifications within the cybersecurity community. Based on DOE directives, the DOE cybersecurity program management, site initiatives, and infrastructure management comprise the final component of the Cybersecurity program element.

Personnel Security

The Personnel Security program element is critical for identifying predictors of potentially dangerous or destructive behavior and encompasses the processes for employee suitability and security clearance determinations at each site to ensure that individuals are trustworthy and eligible for access to classified information or material. Additionally, this program element addresses the process of vetting the vast uncleared contractor workforce that have physical and/or logical access to federal facilities, information, and personnel. This element also includes the management of security clearance programs, adjudications, security education, awareness programs for Federal and contractor employees. Lastly, the program also processes the large number of foreign visitors that engage with the ten Science laboratories to thwart known Nation State information and intelligence collection efforts.

Material Control and Accountability (MC&A)

The MC&A program element provides assurance that Departmental materials are properly controlled and accounted for at all times. This performance of this program element includes, but is not limited to, testing performance and assessing the levels of protection, control, and accountability required for the types and quantities of materials at each facility; documenting facility plans for materials control and accountability; assigning authorities and responsibilities for MC&A

functions; and establishing programs to detect and report occurrences such as material theft, the loss of control or inability to account for materials, or evidence of malevolent acts.

<u>Program Management</u>
The Program Management program element coordinates the management of Protective Forces, Security Systems, Information Security, Personnel Security, and MC&A to achieve and ensure appropriate levels of protections and integration are in place through performance assurance activities such as self-assessments, maintenance, and performance testing. In addition, this program element includes the performance of vulnerability and/or risk assessments, which provide a technical basis for the integrated security program at the site and the need for acceptance of any associated residual risks.

Safeguards and Security
Funding

(dollars in thousands)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Safeguards and Security				
Protective Forces	52,341	53,911	54,300	+1,959
Security Systems	24,693	35,812	31,640	+6,947
Information Security	5,660	5,830	5,800	+140
Cybersecurity	81,260	83,697	83,260	+2,000
Personnel Security	9,055	9,327	9,000	-55
Material Control and Accountability	2,965	3,054	3,000	+35
Program Management	8,125	8,369	8,000	-125
Total, Safeguards and Security	**184,099**	**200,000**	**195,000**	**+10,901**

Safeguards and Security
Explanation of Major Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Safeguards and Security	**$184,099**	**$195,000**	**+$10,901**
Protective Forces	$52,341	$54,300	+$1,959
Funding supports security officers and their required equipment and training necessary to maintain proper protection levels at all SC laboratories.		The Request will maintain support for security officers and their required equipment, and at some sites, advanced armament specifically analyzed and required to combat advanced threats to our weapons grade nuclear materials. Additionally, the request will support training for these perishable skills; thereby, ensuring the readiness of our security officers at all SC laboratories.	Funding will support sustained levels of operations and training at increased overhead, inflation, and contractually obligated Cost of Living Adjustments for Protective Forces.
Security Systems	$24,693	$31,640	+$6,947
Funding supports security systems in place as well as continued implementation of security modifications that address both the revised DBT and Science and Technology Policy.		The Request will maintain support for the security systems in place as well as continued implementation of security modifications and enhancements that support the deterrence, sensing, and assessment of an array of threats to our range of assets.	Funding increases will address sustained levels of operations at increased overhead and inflation rates.

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Information Security	$5,660	$5,800	+$140
Funding supports personnel, equipment, and systems necessary to ensure sensitive and classified information is safeguarded at SC laboratories.		The Request will maintain support for the personnel, equipment, training, and systems necessary to ensure the growing SC mission and associated sensitive and classified information is safeguarded at SC laboratories.	Funding will support sustained levels for Information Security activities at increased overhead and inflation rates.
Cybersecurity	$81,260	$83,260	+$2,000
Funding supports investments in cyber infrastructure and cyber capability including new cyber tools, incident response enhancements, cyber workforce development, data protections, and protections for unique SC facilities and capabilities that cannot be protected with commercial tools. Additionally, the funding continues implementation of Executive Order 14028 requirements at both federal and Management & Operating sites to build out Maximum MFA, Maximum Encryption, Cloud Strategy/Security, Improved Logging and Supply Chain Management, Zero Trust Infrastructure, Secure Critical Software, Controlled Unclassified Information protections, participate in the Department of Homeland Security Continuous Diagnostics and Monitoring program, build out Industrial Control Systems protections, and protect Government Furnished Equipment on foreign travel.		The Request will support investments in cyber infrastructure and cyber capability including new cyber tools, incident response enhancements, cyber workforce development, data protections, and protections for unique SC facilities and capabilities that cannot be protected with commercial tools. Additionally, the Request will continue implementation of Executive Order 14028 requirements at both federal and Management & Operating sites to build out Maximum MFA, Maximum Encryption, Cloud Strategy/Security, Improved Logging and Supply Chain Management, Zero Trust Infrastructure, Secure Critical Software, Controlled Unclassified Information cyber protections, participate in the Department of Homeland Security Continuous Diagnostics and Monitoring program, build out Industrial Control Systems protections, and protect Government Furnished Equipment on foreign travel.	Funding will support sustained efforts to continue implementing Executive Order 14028 requirements to include Zero Trust Infrastructure at increased overhead and inflation rates.

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Personnel Security	$9,055	$9,000	-$55
Funding supports Personnel Security efforts at SC laboratories as well as SC Headquarters security investigations.		The Request will continue support for processing of clearances and the vetting of uncleared personnel of the large workforce at SC laboratories as well as SC Headquarters security investigations. Also, the request will support the processing of the large number of foreign visitors that engage with the ten Science laboratories, which is vital to thwarting known Nation State information and intelligence collection efforts.	Funding will provide sustained support for personnel security.
Material Control and Accountability	$2,965	$3,000	+$35
Funding supports functions ensuring Departmental materials are properly controlled and accounted for at all times.		The Request will continue to support functions ensuring Departmental materials are properly controlled and accounted for at all times and to detect and report occurrences such as material theft, the loss of control or inability to account for materials, or evidence of malevolent acts.	Funding will provide sustained support for MC&A activities at increased overhead and inflation rates.
Program Management	$8,125	$8,000	-$125
Funding supports oversight, administration, and planning for security programs at SC laboratories and provides integration of all security elements and security procedures protecting SC Research missions.		The Request will continue support for oversight, administration, analysis, and planning for security programs at SC laboratories and provides integration of all security elements and security procedures protecting SC Research missions. In addition, the request will ensure all security programs and elements will continue to perform as designed through on-going testing and assurance activities.	Funding will provide sustained support for Program Management activities.

Program Direction

Overview

The Office of Science (SC) Program Direction (PD) budget supports the highly skilled federal workforce needed to develop and oversee SC investments and Administration priorities in basic research on climate change and clean energy, advanced computing, cybersecurity, fundamental science to transform manufacturing, quantum information sciences, artificial intelligence and machine learning (AI/ML), biopreparedness, critical materials, fusion energy, isotope research and production, and construction and operation of scientific user facilities, all critical for the American scientific enterprise.

SC continues to increase investments in sophisticated and experienced scientific and technical program and project managers, as well as experts in acquisition, finance, legal, construction management, and environmental, safety, and health oversight. SC continues to update its business processes for awards management and research related activities to ensure its extramural research programs are inclusive, broadening participation, especially from underserved communities and emerging research institutions (as defined in the Creating Helpful Incentives to Produce Semiconductors [CHIPS] and Science Act), from across the nation.

<u>Headquarters</u>

The SC Headquarters (HQ) includes the seven SC program offices (Advanced Scientific Computing Research, Basic Energy Sciences, Biological and Environmental Research, Fusion Energy Sciences, High Energy Physics, Nuclear Physics, and Accelerator R&D and Production), Isotope R&D and Production, Workforce Development for Teachers and Scientists, Project Assessment, and Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) Offices, as well as several human resource (HR) management functions including Shared Service Center (SSC), and HQ-based field management functions.

<u>Consolidated Service Center</u>

The Consolidated Service Center (CSC) provides business management to support SC's federal responsibilities, including financial management and grant and contract processing.

<u>Site Offices</u>

SC Site Offices provide contract management and critical support for the scientific mission execution at the ten SC national laboratories. This includes day to-day business management; approvals to operate hazardous facilities; safety and security oversight; leases; property transfers; sub-contracts; and activity approvals required by laws, regulations, and DOE policy.

<u>Office of Scientific and Technical Information</u>

Office of Scientific and Technical Information (OSTI) fulfills the Department's responsibilities for providing public access to the unclassified results of its research investments and limited access to classified research results. DOE researchers produce over 50,000 research publications, datasets, software, and patents annually. OSTI's physical and electronic collections exceed one million research outputs from the 1940s to the present, providing access to the results of DOE's research investments.

Highlights of the FY 2025 Request

The FY 2025 Request is $246.0 million and will support a total level of approximately 845 full-time equivalents (FTEs). The Request supports a pay raise of 2 percent. The Request focuses on increasing federal staff at Headquarters and Field to meet the challenges of the significant increase in workload associated with current and new initiatives, the broad scope of emerging science and technology, new security requirements, improved oversight, innovative outreach and communication, and the incorporation of data analytics into existing business systems. SC will continue to review, analyze, and prioritize mission requirements and identify those organizations and functions aligning with Administration and Department program objectives and SC strategic goals.

Program Direction
Funding

(dollars in thousands)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Program Direction				
Salaries and Benefits	159,319	178,985	183,910	+24,591
Travel	3,076	3,500	4,000	+924
Support Services	28,517	31,005	32,960	+4,443
Other Related Expenses	14,344	16,000	17,920	+3,576
Working Capital Fund	5,955	7,210	7,210	+1,255
Total, Program Direction	**211,211**	**236,700**	**246,000**	**+34,789**
Federal FTE	800	835	845	+45

Program Direction

Activities and Explanation of Changes

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
Program Direction	**$211,211**	**$246,000**	**+$34,789**
Salaries and Benefits	$159,319	$183,910	+$24,591
The funding supports 800 FTEs to perform scientific oversight, program and project management, essential operations support associated with science program portfolio management, and support for the Office of the Chief Human Capital Officer operating the SSC and supporting HR Advisory Offices. The funding supports costs associated with Federal employee benefits, including health insurance costs and retirement allocations in Federal Employees Retirement System.		The Request will support salaries and benefits costs associated with 845 FTEs to perform scientific oversight, program and project management, essential operations support associated with science program portfolio management, and support for the Office of the Chief Human Capital Officer operating the SSC and supporting HR Advisory Offices.	The increase will support a 2 percent pay raise and the projected salary and benefit requirements for the requested FTE levels to meet the challenges of the significant increase in workload associated with increased mission demands.
Travel	$3,076	$4,000	+$924
The funding supports facility visits where the use of electronic telecommunications is not practical for mandated on-site inspections and facility operations reviews. Ensuring scientific management, compliance, safety oversight, and external review of research funding across all SC programs requires staff to travel, since SC senior program managers are not co-located with grantees or at national laboratories.		The Request will support facility visits where the use of electronic telecommunications is not practical for mandated on-site inspections and facility operations reviews. Ensuring scientific management, compliance, safety oversight, and external review of research funding across all SC programs requires staff to travel, since SC senior program managers are not co-located with grantees or at national laboratories.	The increase in travel reflects the return to work with travel to conferences and site visits while continuing videoconferencing instead of travel, where possible.

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request		Explanation of Changes FY 2025 Request vs FY 2023 Enacted
The funding also supports travel for the SC Federal Advisory Committees, which will include over 170 representatives from universities, national laboratories, and industry, representing a diverse balance of disciplines, professional experience, and geography. Each of the six advisory committees provides valuable, independent advice to the Department regarding the complex scientific and technical issues that arise in the planning, management, and implementation of SC programs.		The Request will support travel for the SC Federal Advisory Committees, which will include over 170 representatives from universities, national laboratories, and industry, representing a diverse balance of disciplines, professional experience, and geography.		
The funding continues to support the PCAST advisory committee travel.		The Request will support the PCAST advisory committee travel.		
Support Services	$28,517		$32,960	+$4,443
The funding supports select administrative and professional services including: support for the SBIR/STTR program; grants and contract processing and close-out activities; accessibility to DOE's corporate multi-billion dollar R&D program through information systems managed and administered by OSTI; travel processing; correspondence control; select reports or analyses directed toward improving the effectiveness, efficiency, and economy of services and processes; and safeguards and security oversight functions.		The Request will support select administrative and professional services including: support for the SBIR/STTR program; grants and contract processing and close-out activities; accessibility to DOE's corporate multi-billion dollar R&D program through information systems managed and administered by OSTI; travel processing; correspondence control; select reports or analyses directed toward improving the effectiveness, efficiency, and economy of services and processes; and safeguards and security oversight functions.		The increase will support the projected support service contract requirements.
The funding supports essential information technology infrastructure; necessary upgrades to SC's financial management system; ongoing operations and maintenance of information technology systems; and safety management support.		The Request will support essential information technology infrastructure; necessary upgrades to SC's financial management system; ongoing operations, maintenance, and enhancement of information technology systems; and safety management support.		

(dollars in thousands)

FY 2023 Enacted		FY 2025 Request	Explanation of Changes FY 2025 Request vs FY 2023 Enacted
The funding supports federal staff training and education to maintain appropriate certification and update skills.		The Request will fund federal staff training and education to maintain appropriate certifications and update skills.	
Other Related Expenses	$14,344	$17,920	+$3,576
The funding supports fixed requirements associated with rent, utilities, and telecommunications; building and grounds maintenance; computer/video maintenance and support; IT equipment leases, purchases, and maintenance; and site-wide health care units. The funding also supports miscellaneous purchases for supplies, materials, and subscriptions.		The Request will support fixed requirements associated with rent, utilities, and telecommunications; building and grounds maintenance; computer/video maintenance and support; the purchasing, leasing and maintenance of IT equipment and systems to support customers' evolving needs; and site-wide health care units. It will also include miscellaneous purchases for supplies, materials, and subscriptions.	The increase will support the projected fixed requirements for FY 2025.
Working Capital Fund	$5,955	$7,210	+$1,255
The funding supports a portion of the SC contribution to the Working Capital Fund for business lines: building occupancy, supplies, printing and graphics, health services, corporate training services, and corporate business systems. SC research programs also contribute to Working Capital Fund.		The Request will support a portion of the SC contribution to the Working Capital Fund for business lines: building occupancy, copy services, supplies, printing and graphics, health services, corporate training services, mail and translation, pension studies, procurement management, and Program Management Career Development. SC research programs also will contribute to the Working Capital Fund.	The increase will support the projected Working Capital Fund requirements for FY 2025.

Program Direction
Funding Detail

(dollars in thousands)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Technical Support				
System review and reliability analyses	1,421	1,450	1,670	+249
Management Support				
Automated data processing	11,638	13,060	14,100	+2,462
Training and education	705	710	815	+110
Reports and analyses, management, and general administrative services	14,753	15,785	17,055	+2,302
Total, Management Support	**27,096**	**29,555**	**31,970**	**+4,874**
Total, Support Services	**28,517**	**31,005**	**33,640**	**+5,123**
Other Related Expenses				
Rent to GSA	847	909	1,043	+196
Rent to others	2,220	2,370	2,720	+500
Communications, utilities, and miscellaneous	3,537	3,709	4,050	+513
Other services	927	1,689	1,835	+908
Operation and maintenance of facilities	1,389	1,496	1,610	+221
Supplies and materials	651	691	745	+94
Equipments	4,773	5,136	5,837	+1,064
Total. Other Related Expenses	**14,344**	**16,000**	**17,840**	**+3,496**
Working Capital Fund	**5,955**	**7,210**	**7,210**	**+1,255**

Public Access

The Department of Energy fulfills Legislative and Executive requirements to provide public access to scholarly publications and digital data resulting from DOE research funding. Enabling authorization and subsequent legislation requires DOE to provide public access to unclassified R&D results through SC's Office of Scientific and Technical Information (OSTI). The DOE Public Access Plan, originally required by a 2013 Office of Science and Technology Policy (OSTP) memorandum, added peer-reviewed, final accepted manuscripts to the types of unclassified scientific and technical information already made publicly accessible. The Plan also required the submission of data management plans and provided guidelines for preserving and ensuring access to digital research data. In 2022, OSTP updated its public access guidance to agencies, requiring new agency plans for providing immediate access to accepted manuscripts, rather than the 12-month embargo in the 2013 memorandum; immediate access to data underlying publications; and wide adoption of persistent identifiers (PIDs) for research outputs, research awards and contracts, and researchers themselves. PIDs promote research integrity, reproducibility, and discoverability.

DOE will implement its new data management and sharing plan[a] requirements through internal policy directive, with requirements specified in national labs' management and operating contracts and annual performance plans, and in the terms and conditions of DOE financial assistance awards. DOE-funded researchers are required to submit final accepted manuscripts, which will be publicly accessible via the official agency repository, DOE PAGES (Public Access Gateway for Energy and Science), developed and hosted by OSTI. DOE is among the top agencies implementing public access, with over 180,000 scholarly publications added to DOE PAGES since 2014. DOE is a leader in the federal government in assigning persistent identifiers and will expand PIDs for researchers, their outputs, and organizations.

[a] https://www.energy.gov/sites/default/files/2023-07/DOE%20Public%20Access%20Plan%202023%20-%20Final.pdf

Science
Facilities Maintenance and Repair

The Department's Facilities Maintenance and Repair activities are tied to its programmatic missions, goals, and objectives. The Facilities Maintenance and Repair activities funded by the budget and displayed below and are intended to ensure that the scientific community has the facilities required to conduct cutting edge scientific research now and, in the future, to meet Department of Energy (DOE) goals and objectives.

Costs for Direct-Funded Maintenance and Repair (including Deferred Maintenance Reduction)

	(dollars in thousands)			
	FY 2023 Planned Cost	**FY 2023 Actual Cost**	**FY 2024 Planned Cost**	**FY 2025 Planned Cost**
Brookhaven National Laboratory	6,863	5,437	6,298	6,437
Lawrence Berkeley National Laboratory	21,850	1,145	500	500
Oak Ridge Institute for Science and Education	569	498	-	4,400
Oak Ridge National Laboratory	33,009	23,950	24,669	25,409
Oak Ridge Office	5,376	5,031	5,054	5,152
Office of Scientific and Technical Information	569	787	827	868
SLAC National Accelerator Laboratory	-	5,106	5,259	5,417
Thomas Jefferson National Accelerator Facility	81	269	277	285
Total, Direct-Funded Maintenance and Repair	**68,317**	**42,223**	**42,884**	**48,468**

General purpose infrastructure includes multiprogram research laboratories, administrative and support buildings, as well as cafeterias, power plants, fire stations, utilities, roads, and other structures. Together, the Office of Science (SC) laboratories have over 1,600 operational buildings and real property trailers, with nearly 24 million gross square feet of space.

Generally, facilities maintenance and repair expenses are funded through an indirect overhead charge. In some cases, however, a laboratory may charge maintenance directly to a specific program. One example would be when maintenance is performed in a building used only by a single program. Such direct-funded charges are not directly budgeted.

Indirect-Funded Maintenance and Repair (including Deferred Maintenance Reduction)

Facilities maintenance and repair activities funded indirectly through overhead charges at SC laboratories are displayed in the table below. Since this funding is allocated to all work done at each laboratory, the cost of these activities is charged to funding from SC and other DOE organizations, as well as other Federal agencies and other entities doing work at SC laboratories. Maintenance reported to SC for non-SC laboratories is also shown. The figures are total projected costs across all SC laboratories.

Costs for Indirect-Funded Maintenance and Repair (including Deferred Maintenance Reduction)

(dollars in thousands)

	FY 2023 Planned Cost	FY 2023 Actual Cost	FY 2024 Planned Cost	FY 2025 Planned Cost
Ames Laboratory	2,900	3,214	3,200	3,200
Argonne National Laboratory	57,734	54,173	55,800	57,500
Brookhaven National Laboratory	42,158	35,711	42,150	43,077
Fermi National Accelerator Laboratory	21,167	28,151	30,000	35,000
Lawrence Berkeley National Laboratory	49,904	46,713	59,568	53,031
Oak Ridge Institute for Science and Education	731	1,320	753	776
Oak Ridge National Laboratory and Y-12	64,356	76,931	79,239	81,616
Oak Ridge Office	2,559	2,033	2,435	2,494
Pacific Northwest National Laboratory	14,172	13,341	12,728	13,682
Princeton Plasma Physics Laboratory	7,285	7,898	8,040	8,150
SLAC National Accelerator Laboratory	21,128	17,450	17,974	18,513
Thomas Jefferson National Accelerator Facility	9,004	9,853	9,274	9,552
Total, Indirect-Funded Maintenance and Repair	**293,098**	**296,788**	**321,161**	**326,591**

Science
Report on FY 2023 Expenditures for Maintenance and Repair

This report responds to the requirements established in Conference Report (H.Rep.108-10) accompanying Public Law 108-7 (pages 886–887), which requires the DOE to provide an annual year-end report on maintenance expenditures to the Committees on Appropriations. This report compares the actual maintenance expenditures in FY 2023 to the amount planned for FY 2023, including Congressionally directed changes.

Total Costs for Maintenance and Repair

(dollars in thousands)

	FY 2023 Planned Costs	FY 2023 Actual Costs
Ames Laboratory	2,900	3,214
Argonne National Laboratory	57,734	54,173
Brookhaven National Laboratory	49,021	41,148
Fermi National Accelerator Laboratory	21,167	28,151
Lawrence Berkeley National Laboratory	71,754	47,858
Oak Ridge Institute for Science and Education	1,300	1,818
Oak Ridge National Laboratory and Y-12	97,365	100,881
Oak Ridge Office	7,935	7,064
Office of Scientific and Technical Information	569	787
Pacific Northwest National Laboratory	14,172	13,341
Princeton Plasma Physics Laboratory	7,285	7,898
SLAC National Accelerator Laboratory	21,128	22,556
Thomas Jefferson National Accelerator Facility	9,085	10,122
Total Costs for Maintenance and Repair	**361,415**	**339,011**

Science
Excess Facilities

Excess Facilities are facilities no longer required to support the Department's needs, present or future missions or functions, or the discharge of its responsibilities. The table below reports the funding to deactivate and dispose of excess infrastructure, including stabilization and risk reduction activities at high-risk excess facilities. These activities result in surveillance and maintenance cost avoidance and reduced risk to workers, the public, the environment, and programs. This includes reductions in costs related to maintenance of excess facilities (including high-risk excess facilities) necessary to minimize the risk posed by those facilities prior to disposition. SC has no direct funded excess facilities costs to report.

Costs for Indirect-Funded Excess Facilities

	(dollars in thousands)			
	FY 2023 Planned Cost	**FY 2023 Actual Cost**	**FY 2024 Planned Cost**	**FY 2025 Planned Cost**
Argonne National Laboratory	550	571	590	610
Brookhaven National Laboratory	330	477	290	1,000
Fermi National Accelerator Laboratory	1,500	-	3,760	2,000
Lawrence Berkeley National Laboratory	200	1,029	750	1,250
Oak Ridge National Laboratory	1,492	1,439	1,537	1,500
SLAC National Accelerator Laboratory	650	597	210	162
Total, Indirect-Funded Excess Facilities	**4,722**	**4,113**	**7,137**	**6,522**

Science
Research and Development

(dollars in thousands)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted
Basic	6,374,837	6,232,583	6,726,470	+351,633
Applied	–	–	–	–
Subtotal, R&D	6,374,837	6,232,583	6,726,470	+351,633
Equipment	251,699	205,531	192,498	-59,201
Construction	1,255,013	1,332,335	1,302,932	+47,919
Total, R&D	**7,881,549**	**7,770,449**	**8,221,900**	**+340,351**

Science
Small Business Innovative Research/Small Business Technology Transfer (SBIR/STTR)

(dollars in thousands)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 Request	FY 2025 Request vs FY 2023 Enacted	
Office of Science					
Advanced Scientific Computing Research					
SBIR	10,112	10,775	12,046	+1,934	+17.95%
STTR	1,422	1,515	1,694	+272	+17.95%
Basic Energy Sciences					
SBIR	35,557	31,789	33,770	-1,787	-5.62%
STTR	5,000	4,473	4,749	-251	-5.61%
Biological and Environmental Research					
SBIR	21,327	20,319	21,999	+672	+3.31%
STTR	2,999	2,857	3,094	+95	+3.33%
Fusion Energy Sciences					
SBIR	10,921	12,357	14,254	+3,333	+26.97%
STTR	1,536	1,741	2,005	+469	+26.94%
High Energy Physics					
SBIR	13,911	12,450	11,831	-2,080	-16.71%
STTR	1,956	1,751	1,664	-292	-16.68%
Nuclear Physics					
SBIR	8,336	7,061	7,378	-958	-13.57%
STTR	1,173	993	1,037	-136	-13.70%
Accelerator R&D and Production					
SBIR	686	667	608	-78	-11.69%
STTR	96	94	86	-10	-10.64%
Total, Office of Science SBIR	**100,850**	**95,418**	**101,886**	**+1,036**	**+1.09%**
Total, Office of Science STTR	**14,182**	**13,424**	**14,329**	**+147**	**+1.10%**

Note:
- *The other DOE programs SBIR/STTR funding amounts are listed in the other DOE budget volumes.*
- *Starting in FY 2023, Scientific User Facility operations funding is excluded from SBIR/STTR contribution.*

DEPARTMENT OF ENERGY
Funding by Site Detail
TAS_0222 - Science - FY 2025
(Dollars in Thousands)

	FY 2023 Enacted	FY 2024 Annualized CR	FY 2025 President's Budget
Ames Laboratory			
Research - Basic Energy Sciences	15,840	15,240	15,240
Basic Energy Sciences	15,840	15,240	15,240
Research - Fusion Energy Sciences	100	0	0
Fusion Energy Sciences	100	0	0
Research - High Energy Physics	1,645	1,645	1,645
High Energy Physics	1,645	1,645	1,645
21-SC-73, Ames Infrastructure Modernization	2,000	8,000	0
Construction - Science Laboratories Infrastructure	2,000	8,000	0
Science Laboratories Infrastructure	2,000	8,000	0
Safeguards and Security - SC	2,871	2,809	3,477
Total Ames Laboratory	**22,456**	**27,694**	**20,362**
Ames Site Office			
Program Direction - SC	687	975	1,004
Total Ames Site Office	**687**	**975**	**1,004**
Argonne National Laboratory			
Research - Advanced Scientific Computing Research	167,746	210,338	225,533
Advanced Scientific Computing Research	167,746	210,338	225,533
Research - Basic Energy Sciences	267,602	256,521	298,444
18-SC-10, Advanced Photon Source Upgrade (APS-U), ANL	9,200	0	0
Construction - Basic Energy Sciences	9,200	0	0
Basic Energy Sciences	276,802	256,521	298,444
Research - Biological & Environmental Research	46,379	51,999	49,538
Biological and Environmental Research	46,379	51,999	49,538
Research - Fusion Energy Sciences	623	700	750
Fusion Energy Sciences	623	700	750
Research - High Energy Physics	17,993	17,593	15,035
High Energy Physics	17,993	17,593	15,035
Operations and Maintenance - Nuclear Physics	35,878	32,802	36,970
Nuclear Physics	35,878	32,802	36,970
Research - Accelerator R&D and Production	0	315	315
Accelerator R&D and Production	0	315	315
Facilities and Infrastructure (SLI)	0	9,586	9,290
20-SC-77, Argonne Utilities Upgrade, ANL (20-SC-79)	8,000	8,000	3,000
Construction - Science Laboratories Infrastructure	8,000	8,000	3,000
Science Laboratories Infrastructure	8,000	17,586	12,290
Safeguards and Security - SC	18,335	14,934	14,934
Total Argonne National Laboratory	**571,756**	**602,788**	**653,809**
Argonne Site Office			
Program Direction - SC	4,119	4,994	5,111
Total Argonne Site Office	**4,119**	**4,994**	**5,111**
Berkeley Site Office			
Program Direction - SC	3,275	4,350	4,467

DEPARTMENT OF ENERGY
Funding by Site Detail
TAS_0222 - Science - FY 2025
(Dollars in Thousands)

	FY 2023	FY 2024	FY 2025
Total Berkeley Site Office	**3,275**	**4,350**	**4,467**
Brookhaven National Laboratory			
Research - Advanced Scientific Computing Research	2,643	2,495	2,495
Advanced Scientific Computing Research	2,643	2,495	2,495
Research - Basic Energy Sciences	235,066	222,836	228,111
24-SC-12, Future NSLS-II Experimental Tools - III (NEXT-III)	0	0	5,500
Construction - Basic Energy Sciences	0	0	5,500
Basic Energy Sciences	235,066	222,836	233,611
Research - Biological & Environmental Research	19,884	19,614	19,805
Biological and Environmental Research	19,884	19,614	19,805
Research - Fusion Energy Sciences	2,409	2,409	2,409
Fusion Energy Sciences	2,409	2,409	2,409
Research - High Energy Physics	61,996	64,425	63,254
11-SC-40, Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment	4,900	10,000	10,000
Construction - High Energy Physics	4,900	10,000	10,000
High Energy Physics	66,896	74,425	73,254
Operations and Maintenance - Nuclear Physics	218,721	186,351	202,779
20-SC-52, Electron Ion Collider, BNL	50,000	95,000	110,000
Construction - Nuclear Physics	50,000	95,000	110,000
Nuclear Physics	268,721	281,351	312,779
Research - Accelerator R&D and Production	6,395	8,644	8,801
Accelerator R&D and Production	6,395	8,644	8,801
20-SC-71, Critical Utilities Rehabilitation Project, BNL	26,000	0	0
Construction - Science Laboratories Infrastructure	26,000	0	0
Science Laboratories Infrastructure	26,000	0	0
Safeguards and Security - SC	22,930	19,755	20,064
Total Brookhaven National Laboratory	**650,944**	**631,529**	**673,218**
Brookhaven Site Office			
Program Direction - SC	4,583	5,484	5,630
Total Brookhaven Site Office	**4,583**	**5,484**	**5,630**
Chicago Operations Office			
Research - Biological & Environmental Research	0	89,201	129,240
Biological and Environmental Research	0	89,201	129,240
Total Chicago Operations Office	**0**	**89,201**	**129,240**
Consolidated Business Center			
Payment In Lieu of Taxes	4,891	5,004	5,119
Oak Ridge Landlord	6,559	6,910	7,032
Science Laboratories Infrastructure	11,450	11,914	12,151
Safeguards and Security - SC	6,035	5,684	5,816
Program Direction - SC	35,706	38,049	39,387
Total Consolidated Business Center	**53,191**	**55,647**	**57,354**
Fermi National Accelerator Laboratory			
Research - Advanced Scientific Computing Research	1,778	0	0
Advanced Scientific Computing Research	1,778	0	0

	FY 2023	FY 2024	FY 2025
Research - High Energy Physics	356,323	324,368	334,598
18-SC-42, Proton Improvement Plan II (PIP-II), FNAL	120,000	125,000	125,000
11-SC-40, Long Baseline Neutrino Facility/Deep Underground Neutrino Experiment	171,100	241,000	270,000
11-SC-41, Muon to Electron Conversion Experiment, FNAL	2,000	0	0
Construction - High Energy Physics	293,100	366,000	395,000
High Energy Physics	649,423	690,368	729,598
Research - Accelerator R&D and Production	23	0	0
Accelerator R&D and Production	23	0	0
20-SC-80, Utilities Infrastructure Project, FNAL (20-SC-82)	20,000	35,000	45,000
Construction - Science Laboratories Infrastructure	20,000	35,000	45,000
Science Laboratories Infrastructure	20,000	35,000	45,000
Safeguards and Security - SC	14,527	12,374	13,284
Total Fermi National Accelerator Laboratory	**685,751**	**737,742**	**787,882**
Fermi Site Office			
Program Direction - SC	4,514	5,435	5,581
Total Fermi Site Office	**4,514**	**5,435**	**5,581**
Idaho National Laboratory			
Research - Basic Energy Sciences	2,100	2,100	2,100
Basic Energy Sciences	2,100	2,100	2,100
Research - Fusion Energy Sciences	2,600	2,800	1,500
Fusion Energy Sciences	2,600	2,800	1,500
Total Idaho National Laboratory	**4,700**	**4,900**	**3,600**
Idaho Operations Office			
Research - Basic Energy Sciences	369	369	369
Basic Energy Sciences	369	369	369
Total Idaho Operations Office	**369**	**369**	**369**
Lawrence Berkeley National Laboratory			
Research - Advanced Scientific Computing Research	218,226	242,352	257,992
24-SC-20, High Performance Data Facility	0	0	5,000
Advanced Scientific Computing Research	218,226	242,352	262,992
Research - Basic Energy Sciences	175,121	200,400	227,205
18-SC-12, Advanced Light Source Upgrade (ALS-U), LBNL	135,000	57,300	0
Construction - Basic Energy Sciences	135,000	57,300	0
Basic Energy Sciences	310,121	257,700	227,205
Research - Biological & Environmental Research	168,612	182,724	189,827
Biological and Environmental Research	168,612	182,724	189,827
Research - Fusion Energy Sciences	1,750	1,750	1,386
Fusion Energy Sciences	1,750	1,750	1,386
Research - High Energy Physics	60,023	60,912	49,990
High Energy Physics	60,023	60,912	49,990
Operations and Maintenance - Nuclear Physics	38,315	21,084	24,227
Nuclear Physics	38,315	21,084	24,227
Research - Accelerator R&D and Production	430	0	2,092
Accelerator R&D and Production	430	0	2,092
Facilities and Infrastructure (SLI)	5,500	6,000	0
20-SC-72, Seismic and Safety Modernization, LBNL	27,500	35,000	18,000

	FY 2023	FY 2024	FY 2025
20-SC-78, Linear Assets Modernization Project, LBNL (20-SC-80)	23,425	18,900	30,000
19-SC-74, Biological & Environmental Program Integration Center (BioEPIC), LBNL	45,000	38,000	0
Construction - Science Laboratories Infrastructure	95,925	91,900	48,000
Science Laboratories Infrastructure	101,425	97,900	48,000
Safeguards and Security - SC	13,950	12,505	13,520
Total Lawrence Berkeley National Laboratory	**912,852**	**876,927**	**819,239**
Lawrence Livermore National Laboratory			
Research - Advanced Scientific Computing Research	6,722	3,047	3,047
Advanced Scientific Computing Research	6,722	3,047	3,047
Research - Basic Energy Sciences	1,252	712	712
Basic Energy Sciences	1,252	712	712
Research - Biological & Environmental Research	32,467	28,293	27,739
Biological and Environmental Research	32,467	28,293	27,739
Research - Fusion Energy Sciences	8,643	9,377	13,900
Fusion Energy Sciences	8,643	9,377	13,900
Research - High Energy Physics	2,425	2,146	1,382
High Energy Physics	2,425	2,146	1,382
Operations and Maintenance - Nuclear Physics	2,062	2,062	1,946
Nuclear Physics	2,062	2,062	1,946
Research - Accelerator R&D and Production	93	0	645
Accelerator R&D and Production	93	0	645
Total Lawrence Livermore National Laboratory	**53,664**	**45,637**	**49,371**
Los Alamos National Laboratory			
Research - Advanced Scientific Computing Research	1,782	3,263	3,263
Advanced Scientific Computing Research	1,782	3,263	3,263
Research - Basic Energy Sciences	25,576	25,477	26,558
Basic Energy Sciences	25,576	25,477	26,558
Research - Biological & Environmental Research	33,365	38,459	40,808
Biological and Environmental Research	33,365	38,459	40,808
Research - Fusion Energy Sciences	483	1,750	2,900
Fusion Energy Sciences	483	1,750	2,900
Research - High Energy Physics	2,075	1,990	1,730
High Energy Physics	2,075	1,990	1,730
Operations and Maintenance - Nuclear Physics	9,688	9,688	10,443
Nuclear Physics	9,688	9,688	10,443
Research - Accelerator R&D and Production	0	0	613
Accelerator R&D and Production	0	0	613
Total Los Alamos National Laboratory	**72,969**	**80,627**	**86,315**
National Renewable Energy Laboratory			
Research - Advanced Scientific Computing Research	0	535	535
Advanced Scientific Computing Research	0	535	535
Research - Basic Energy Sciences	9,303	9,303	9,328
Basic Energy Sciences	9,303	9,303	9,328
Research - Biological & Environmental Research	6,805	3,045	2,120
Biological and Environmental Research	6,805	3,045	2,120
Total National Renewable Energy Laboratory	**16,108**	**12,883**	**11,983**

DEPARTMENT OF ENERGY
Funding by Site Detail
TAS_0222 - Science - FY 2025
(Dollars in Thousands)

	FY 2023	FY 2024	FY 2025
Oak Ridge Institute for Science & Education			
Research - Biological & Environmental Research	1,348	2,398	1,828
Biological and Environmental Research	1,348	2,398	1,828
Research - Fusion Energy Sciences	20	0	850
Fusion Energy Sciences	20	0	850
Operations and Maintenance - Nuclear Physics	455	455	455
Nuclear Physics	455	455	455
Safeguards and Security - SC	3,690	3,623	3,588
Total Oak Ridge Institute for Science & Education	**5,513**	**6,476**	**6,721**
Oak Ridge National Laboratory			
Research - Advanced Scientific Computing Research	251,831	247,643	266,643
17-SC-20, SC Exascale Computing Project (ECP)	77,000	0	0
Advanced Scientific Computing Research	328,831	247,643	266,643
Research - Basic Energy Sciences	381,174	430,583	438,461
24-SC-10, HFIR Pressure Vessel Replacement (PVR), ORNL	0	0	6,000
19-SC-14, Second Target Station (STS), ORNL	32,000	52,000	52,000
18-SC-11, Spallation Neutron Source Proton Power Upgrade (PPU), ORNL	17,000	15,769	0
Construction - Basic Energy Sciences	49,000	67,769	58,000
Basic Energy Sciences	430,174	498,352	496,461
Research - Biological & Environmental Research	93,265	98,571	75,081
Biological and Environmental Research	93,265	98,571	75,081
Research - Fusion Energy Sciences	27,821	40,891	34,770
14-SC-60, U.S. Contributions to ITER (U.S. ITER)	242,000	240,000	225,000
Construction - Fusion Energy Sciences	242,000	240,000	225,000
Fusion Energy Sciences	269,821	280,891	259,770
Research - High Energy Physics	1,830	1,660	2,907
High Energy Physics	1,830	1,660	2,907
Operations and Maintenance - Nuclear Physics	16,627	12,530	14,262
Nuclear Physics	16,627	12,530	14,262
Research - Accelerator R&D and Production	0	62	62
Accelerator R&D and Production	0	62	62
Oak Ridge Nuclear Operations	26,000	46,000	46,000
Facilities and Infrastructure (SLI)	0	0	9,690
22-SC-71, Critical Infrastructure Modernization Project, ORNL	1,000	0	0
Construction - Science Laboratories Infrastructure	1,000	0	0
Science Laboratories Infrastructure	27,000	46,000	55,690
Safeguards and Security - SC	38,805	39,350	39,359
Total Oak Ridge National Laboratory	**1,206,353**	**1,225,059**	**1,210,235**
Oak Ridge National Laboratory Site Office			
Program Direction - SC	7,626	7,864	8,061
Total Oak Ridge National Laboratory Site Office	**7,626**	**7,864**	**8,061**
Office of Scientific & Technical Information			
Research - Fusion Energy Sciences	6	0	4
Fusion Energy Sciences	6	0	4
Facilities and Infrastructure (SLI)	200	0	0
Science Laboratories Infrastructure	200	0	0

	FY 2023	FY 2024	FY 2025
Safeguards and Security - SC	2,251	2,258	2,258
Program Direction - SC	12,829	14,074	14,932
Total Office of Scientific & Technical Information	**15,286**	**16,332**	**17,194**
Pacific Northwest National Laboratory			
Research - Advanced Scientific Computing Research	3,664	2,764	2,764
Advanced Scientific Computing Research	3,664	2,764	2,764
Research - Basic Energy Sciences	28,356	28,356	28,406
Basic Energy Sciences	28,356	28,356	28,406
Research - Biological & Environmental Research	168,205	128,807	155,830
24-SC-31, Microbial Molecular Phenotyping Capability (M2PC), PNNL	0	0	19,000
Biological and Environmental Research - Construction	0	0	19,000
Biological and Environmental Research	168,205	128,807	174,830
Research - Fusion Energy Sciences	1,413	1,513	1,500
Fusion Energy Sciences	1,413	1,513	1,500
Research - High Energy Physics	1,850	1,750	1,585
High Energy Physics	1,850	1,750	1,585
Operations and Maintenance - Nuclear Physics	818	818	818
Nuclear Physics	818	818	818
Facilities and Infrastructure (SLI)	5,400	6,000	0
Science Laboratories Infrastructure	5,400	6,000	0
Safeguards and Security - SC	19,958	17,529	18,184
Total Pacific Northwest National Laboratory	**229,664**	**187,537**	**228,087**
Pacific Northwest Site Office			
Program Direction - SC	6,125	6,255	6,416
Total Pacific Northwest Site Office	**6,125**	**6,255**	**6,416**
Princeton Plasma Physics Laboratory			
Research - Fusion Energy Sciences	63,775	65,339	60,597
Fusion Energy Sciences	63,775	65,339	60,597
21-SC-71, Princeton Plasma Innovation Center, PPPL	10,000	10,000	35,000
21-SC-72, Critical Infrastructure Recovery & Renewal, PPPL	4,000	10,000	20,000
Construction - Science Laboratories Infrastructure	14,000	20,000	55,000
Science Laboratories Infrastructure	14,000	20,000	55,000
Safeguards and Security - SC	6,839	6,037	6,567
Total Princeton Plasma Physics Laboratory	**84,614**	**91,376**	**122,164**
Princeton Site Office			
Program Direction - SC	2,135	2,322	2,372
Total Princeton Site Office	**2,135**	**2,322**	**2,372**
Sandia National Laboratories			
Research - Advanced Scientific Computing Research	16,171	14,912	14,912
Advanced Scientific Computing Research	16,171	14,912	14,912
Research - Basic Energy Sciences	24,601	24,453	25,434
Basic Energy Sciences	24,601	24,453	25,434
Research - Biological & Environmental Research	15,394	10,031	11,948
Biological and Environmental Research	15,394	10,031	11,948

	FY 2023	FY 2024	FY 2025
Research - Fusion Energy Sciences	1,735	1,935	2,285
Fusion Energy Sciences	1,735	1,935	2,285
Research - High Energy Physics	115	100	85
High Energy Physics	115	100	85
Total Sandia National Laboratories	**58,016**	**51,431**	**54,664**
Savannah River National Laboratory			
Research - Basic Energy Sciences	1,100	1,100	1,100
Basic Energy Sciences	1,100	1,100	1,100
Research - Fusion Energy Sciences	900	500	2,000
Fusion Energy Sciences	900	500	2,000
Total Savannah River National Laboratory	**2,000**	**1,600**	**3,100**
SLAC National Accelerator Laboratory			
Research - Advanced Scientific Computing Research	450	0	0
Advanced Scientific Computing Research	450	0	0
Research - Basic Energy Sciences	259,242	299,104	342,700
21-SC-10, Cryomodule Repair and Maintenance Facility, SLAC	10,000	9,000	20,000
18-SC-13, Linac Coherent Light Source-II-High Energy (LCLS-II-HE), SLAC	90,000	120,000	100,000
Construction - Basic Energy Sciences	100,000	129,000	120,000
Basic Energy Sciences	359,242	428,104	462,700
Research - Biological & Environmental Research	7,783	6,936	3,416
Biological and Environmental Research	7,783	6,936	3,416
Research - Fusion Energy Sciences	5,288	7,500	6,585
20-SC-61, Matter in Extreme Conditions (MEC) Petawatt Upgrade, SLAC	11,000	10,000	10,000
Construction - Fusion Energy Sciences	11,000	10,000	10,000
Fusion Energy Sciences	16,288	17,500	16,585
Research - High Energy Physics	97,474	91,341	89,285
High Energy Physics	97,474	91,341	89,285
Operations and Maintenance - Nuclear Physics	1,166	1,166	1,440
Nuclear Physics	1,166	1,166	1,440
Research - Accelerator R&D and Production	100	806	1,098
Accelerator R&D and Production	100	806	1,098
Facilities and Infrastructure (SLI)	0	8,300	15,769
20-SC-75, Large Scale Collaboration Center, SLAC (19-SC-75)	21,000	0	0
20-SC-79, Critical Utilities Infrastructure Revitalization, SLAC (20-SC-81)	25,425	30,000	20,000
Construction - Science Laboratories Infrastructure	46,425	30,000	20,000
Science Laboratories Infrastructure	46,425	38,300	35,769
Safeguards and Security - SC	8,890	8,072	8,687
Total SLAC National Accelerator Laboratory	**537,818**	**592,225**	**618,980**
Thomas Jefferson National Accelerator Facility			
Research - Advanced Scientific Computing Research	0	669	669
24-SC-20, High Performance Data Facility	0	0	11,000
Advanced Scientific Computing Research	0	669	11,669
Research - Basic Energy Sciences	0	0	200
Basic Energy Sciences	0	0	200
Operations and Maintenance - Nuclear Physics	165,854	149,769	157,522
Nuclear Physics	165,854	149,769	157,522
Research - Accelerator R&D and Production	427	81	911

DEPARTMENT OF ENERGY
Funding by Site Detail
TAS_0222 - Science - FY 2025
(Dollars in Thousands)

	FY 2023	FY 2024	FY 2025
Accelerator R&D and Production	427	81	911
Facilities and Infrastructure (SLI)	2,750	0	0
22-SC-72, Thomas Jefferson Infrastructure Improvements, TJNAF	1,000	0	0
20-SC-73, CEBAF Renovation and Expansion, TJNAF (19-SC-73)	15,000	11,000	11,000
Construction - Science Laboratories Infrastructure	16,000	11,000	11,000
Science Laboratories Infrastructure	18,750	11,000	11,000
Safeguards and Security - SC	5,987	5,402	6,323
Total Thomas Jefferson National Accelerator Facility	**191,018**	**166,921**	**187,625**
Thomas Jefferson Site Office			
Program Direction - SC	2,218	2,411	2,468
Total Thomas Jefferson Site Office	**2,218**	**2,411**	**2,468**
Undesignated Lab/Plant/Installation			
Research - Advanced Scientific Computing Research	85,078	107,451	112,451
Advanced Scientific Computing Research	85,078	107,451	112,451
Research - Basic Energy Sciences	372,075	279,458	330,774
Basic Energy Sciences	372,075	279,458	330,774
Research - Biological & Environmental Research	93,918	31,240	82,239
Biological and Environmental Research	93,918	31,240	82,239
Research - Fusion Energy Sciences	54,842	25,148	0
Fusion Energy Sciences	54,842	25,148	0
Research - High Energy Physics	40,602	46,848	49,002
High Energy Physics	40,602	46,848	49,002
Operations and Maintenance - Nuclear Physics	63,551	56,378	49,129
Nuclear Physics	63,551	56,378	49,129
Research - Accelerator R&D and Production	6,916	6,258	1,116
Accelerator R&D and Production	6,916	6,258	1,116
Workforce Development for Teachers & Scientists	42,000	42,100	43,100
Facilities and Infrastructure (SLI)	50	2,218	15,280
Laboratory Operations Internship	0	0	5,000
Science Laboratories Infrastructure	50	2,218	20,280
Safeguards and Security - SC	19,031	49,668	38,939
Total Undesignated Lab/Plant/Installation	**778,063**	**646,767**	**727,030**
Washington Headquarters			
Research - Biological & Environmental Research	0	138	138
Biological and Environmental Research	0	138	138
Research - Fusion Energy Sciences	0	0	3,296
Fusion Energy Sciences	0	0	3,296
Research - Isotope R&D and Production	85,451	132,651	135,000
20-SC-51, U.S. Stable Isotope Production and Research Center (SIPRC), ORNL	24,000	20,900	45,900
24-SC-92, Clinical Alpha Radionuclide Producer (CARP), BNL	0	0	1,000
24-SC-91, Radioisotope Processing Facility (RPF), ORNL	0	0	2,000
Construction - Isotope R&D and Production	24,000	20,900	48,900
Isotope R&D and Production	109,451	153,551	183,900
Program Direction - SC	125,195	141,272	147,277
Total Washington Headquarters	**234,646**	**294,961**	**334,611**

Grants

	FY 2023	FY 2024	FY 2025
Research - Advanced Scientific Computing Research	234,909	197,639	246,378
Advanced Scientific Computing Research	234,909	197,639	246,378
Research - Basic Energy Sciences	442,023	453,551	423,643
Basic Energy Sciences	442,023	453,551	423,643
Research - Biological & Environmental Research	221,260	144,188	136,668
Biological and Environmental Research	221,260	144,188	136,668
Research - Fusion Energy Sciences	337,814	393,056	474,764
Fusion Energy Sciences	337,814	393,056	474,764
Research - High Energy Physics	223,649	205,523	215,270
High Energy Physics	223,649	205,523	215,270
Operations and Maintenance - Nuclear Physics	202,061	203,100	223,100
Nuclear Physics	202,061	203,100	223,100
Research - Accelerator R&D and Production	13,052	13,009	15,620
Accelerator R&D and Production	13,052	13,009	15,620
Total Grants	**1,674,768**	**1,610,066**	**1,735,443**
Total Funding by Site for TAS_0222 - Science	**8,100,000**	**8,100,000**	**8,583,000**

GENERAL PROVISIONS—DEPARTMENT OF ENERGY

Sec. 301.

(a) No appropriation, funds, or authority made available by this title for the Department of Energy shall be used to initiate or resume any program, project, or activity or to prepare or initiate Requests For Proposals or similar arrangements (including Requests for Quotations, Requests for Information, and Funding Opportunity Announcements) for a program, project, or activity if the program, project, or activity has not been funded by Congress.

(b)

(1) Unless the Secretary of Energy notifies the Committees on Appropriations of both Houses of Congress at least 3 full business days in advance, none of the funds made available in this title may be used to—

(A) make a grant allocation or discretionary grant award totaling $1,000,000 or more;

(B) make a discretionary contract award or Other Transaction Agreement totaling $1,000,000 or more, including a contract covered by the Federal Acquisition Regulation;

(C) issue a letter of intent to make an allocation, award, or Agreement in excess of the limits in subparagraph (A) or (B); or

(D) announce publicly the intention to make an allocation, award, or Agreement in excess of the limits in subparagraph (A) or (B).

(2) The Secretary of Energy shall submit to the Committees on Appropriations of both Houses of Congress within 15 days of the conclusion of each quarter a report detailing each grant allocation or discretionary grant award totaling less than $1,000,000 provided during the previous quarter.

(3) The notification required by paragraph (1) and the report required by paragraph (2) shall include the recipient of the award, the amount of the award, the fiscal year for which the funds for the award were appropriated, the account and program, project, or activity from which the funds are being drawn, the title of the award, and a brief description of the activity for which the award is made.

(c) The Department of Energy may not, with respect to any program, project, or activity that uses budget authority made available in this title under the heading "Department of Energy--Energy Programs", enter into a multiyear contract, award a multiyear grant, or enter into a multiyear cooperative agreement unless—

(1) the contract, grant, or cooperative agreement is funded for the full period of performance as anticipated at the time of award; or

(2) the contract, grant, or cooperative agreement includes a clause conditioning the Federal Government's obligation on the availability of future year budget authority and the Secretary notifies the Committees on Appropriations of both Houses of Congress at least 3 days in advance.

(d) Except as provided in subsections (e), (f), and (g), the amounts made available by this title shall be expended as authorized by law for the programs, projects, and activities specified in the "Final Bill" column in the "Department of Energy" table included under the heading "Title III--Department of Energy" in the explanatory statement described in section 4 (in the matter preceding division A of this consolidated Act).

(e) The amounts made available by this title may be reprogrammed for any program, project, or activity, and the Department shall notify the Committees on Appropriations of both Houses of Congress at least 30 days prior to the use of any proposed reprogramming that would cause any program, project, or activity funding level to increase or decrease by more than $5,000,000 or 10 percent, whichever is less, during the time period covered by this Act.

(f) None of the funds provided in this title shall be available for obligation or expenditure through a reprogramming of funds that—

(1) creates, initiates, or eliminates a program, project, or activity;

(2) increases funds or personnel for any program, project, or activity for which funds are denied or restricted by this Act; or

(3) reduces funds that are directed to be used for a specific program, project, or activity by this Act.

(g)

(1) The Secretary of Energy may waive any requirement or restriction in this section that applies to the use of funds made available for the Department of Energy if compliance with such requirement or restriction would pose a substantial risk to human health, the environment, welfare, or national security.

(2) The Secretary of Energy shall notify the Committees on Appropriations of both Houses of Congress of any waiver under paragraph (1) as soon as practicable, but not later than 3 days after the date of the activity to which a requirement or restriction would otherwise have applied. Such notice shall include an explanation of the substantial risk under paragraph (1) that permitted such waiver.

(h) The unexpended balances of prior appropriations provided for activities in this Act may be available to the same appropriation accounts for such activities established pursuant to this title. Available balances may be merged with funds in the applicable established accounts and thereafter may be accounted for as one fund for the same time period as originally enacted.

(i) Subsections (d), (e), and (f) shall not apply to funds made available in this Act for applied energy research, development, demonstration, and commercial application that are utilized pursuant to section 1001 of the Energy Policy Act of 2005 (42 U.S.C. 16391). Administration and selection of awards pursuant to such section will be in coordination with the offices that oversee the appropriations accounts to which the relevant funding was originally appropriated.

Sec. 302. Funds appropriated by this or any other Act, or made available by the transfer of funds in this Act, for intelligence activities are deemed to be specifically authorized by the Congress for purposes of section 504 of the National Security Act of 1947 (50 U.S.C. 3094) during fiscal year 2024 until the enactment of the Intelligence Authorization Act for fiscal year 2023.

Sec. 303. None of the funds made available in this title shall be used for the construction of facilities classified as high-hazard nuclear facilities under 10 CFR Part 830 unless independent oversight is conducted by the Office of Enterprise Assessments to ensure the project is in compliance with nuclear safety requirements.

Sec. 304. None of the funds made available in this title may be used to approve critical decision-2 or critical decision-3 under Department of Energy Order 413.3B, or any successive departmental guidance, for construction projects where the total project cost exceeds $100,000,000, until a separate independent cost estimate has been developed for the project for that critical decision.

Sec. 305. Notwithstanding section 161 of the Energy Policy and Conservation Act (42 U.S.C. 6241), upon a determination by the President in this fiscal year that a regional supply shortage of refined petroleum product of significant scope and duration exists, that a severe increase in the price of refined petroleum product will likely result from such shortage, and that a draw down and sale of refined petroleum product would assist directly and significantly in reducing the adverse impact of such shortage, the Secretary of Energy may draw down and sell refined petroleum product from the Strategic Petroleum Reserve. Proceeds from a sale under this section shall be deposited into the SPR Petroleum Account established in section 167 of the Energy Policy and Conservation Act (42 U.S.C. 6247), and such amounts shall be available for obligation, without fiscal year limitation, consistent with that section.

Sec. 306. No funds shall be transferred directly from "Department of Energy--Power Marketing Administration--Colorado River Basins Power Marketing Fund, Western Area Power Administration" to the general fund of the Treasury in the current fiscal year.

Sec. 307. None of the funds made available in this title may be used to support a grant allocation award, discretionary grant award, or cooperative agreement that exceeds $100,000,000 in Federal funding unless the project is carried out through internal independent project management procedures.

Sec. 308. From the unobligated balances of amounts made available to the Department of Energy to carry out activities to improve the resilience of the Puerto Rican electric grid under Public Law 117-328, thirty-five hundredths of one percent of the amounts made available under that section shall be transferred no later than September 30, 2025, to the Office of Inspector General of the Department of Energy to carry out the provisions of the Inspector General Act of 1978, to remain available until expended: Provided, That any amounts so transferred that were previously designated by the Congress as an emergency requirement pursuant to the Balanced Budget and Emergency Deficit Control Act of 1985 or a concurrent resolution on the budget are designated by the Congress as an emergency requirement pursuant to section 251(b)(2)(A)(i) of the Balanced Budget and Emergency Deficit Control Act of 1985: Provided further, That such amounts shall be available only if the President designates such amount as an emergency requirement pursuant to section 251(b)(2)(A)(i).

TITLE V—GENERAL PROVISIONS

SEC. 501. None of the funds appropriated by this Act may be used in any way, directly or indirectly, to influence congressional action on any legislation or appropriation matters pending before Congress, other than to communicate to Members of Congress as described in 18 U.S.C. 1913. SEC.

502. None of the funds made available by this Act may be used in contravention of Executive Order No. 12898 of February 11, 1994 (Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations).

SEC. 503. (a) None of the funds made available in this Act may be used to maintain or establish a computer network unless such network blocks the viewing, down loading, and exchanging of pornography.

(b) Nothing in subsection (a) shall limit the use of funds necessary for any Federal, State, Tribal, or local law enforcement agency or any other entity carrying out criminal investigations, prosecution, or adjudication activities.