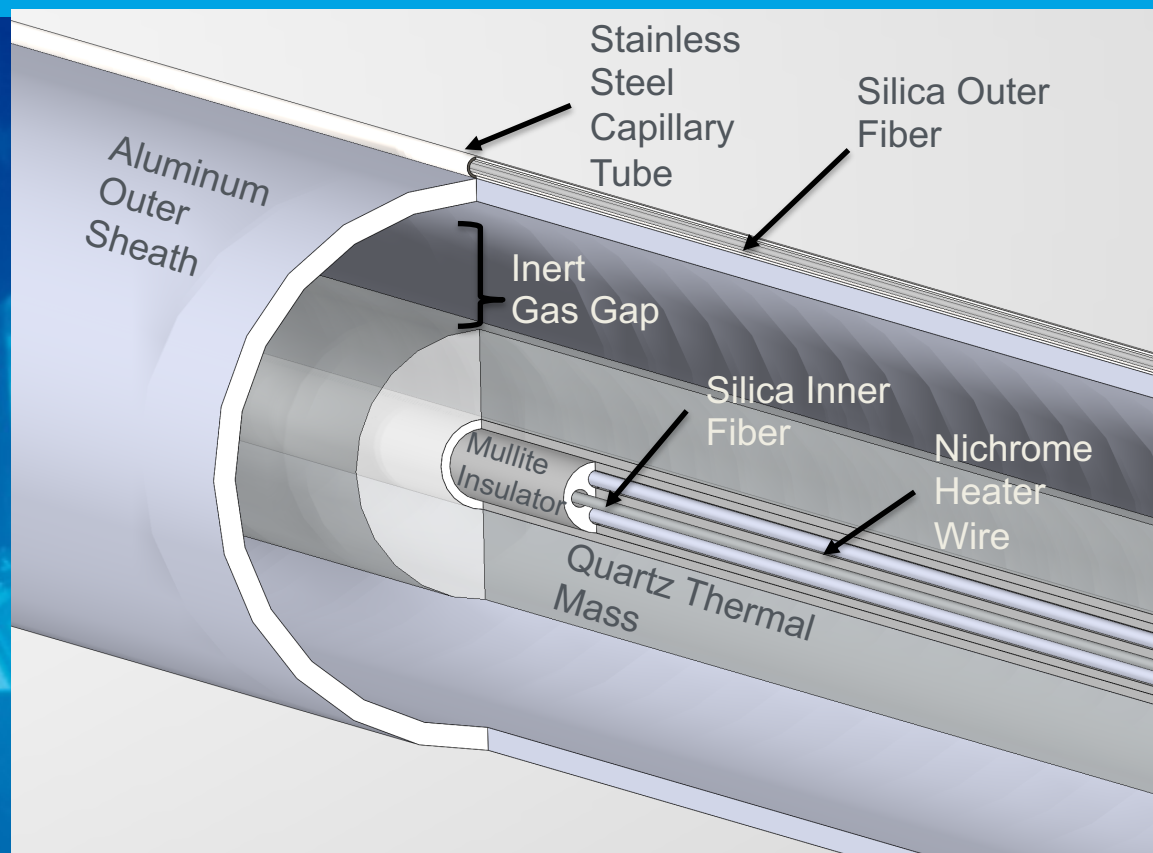


# Development of an Optical Fiber Based Gamma Thermometer



Advanced Sensors and Instrumentation  
Annual Webinar

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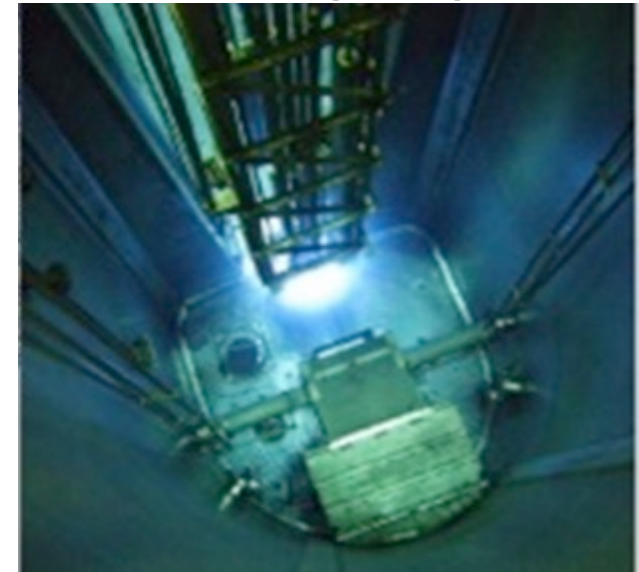
# Objective

- Develop an optical fiber-based gamma thermometer (OFBGT) in order to determine the power distribution in a reactor core by using statistical data analytic methods
  - An OFBGT measures the  $\Delta T$  along the axial length of the sensor which can be used to infer core power distribution using response functions generated by MCNP ( $\Delta T$  is measured by optical fiber)
  - We are demonstrating this measurement technique in both the Ohio State University Research Reactor (OSURR) and the Texas A&M TRIGA Reactor
- Participants: The Ohio State University, Texas A&M University, INL

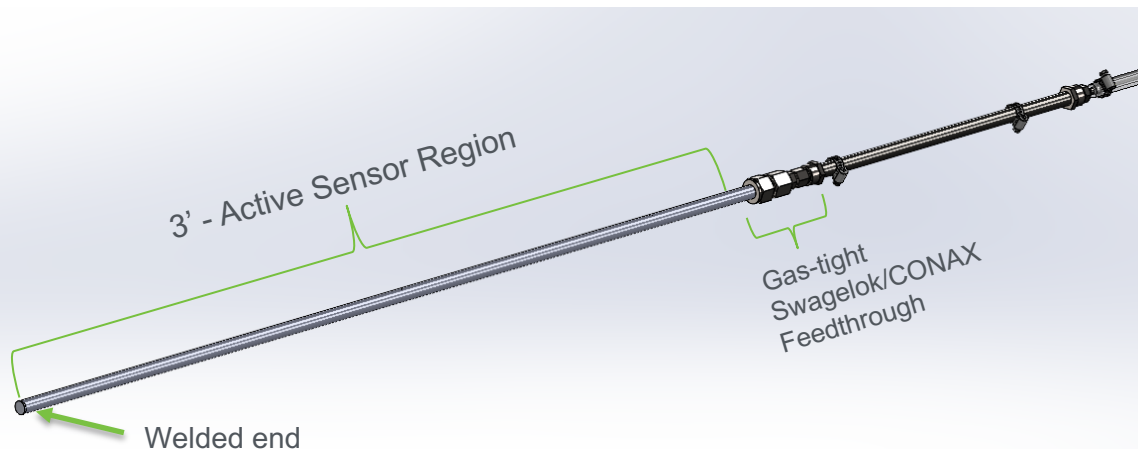
## OSURR



## TAMU TRIGA



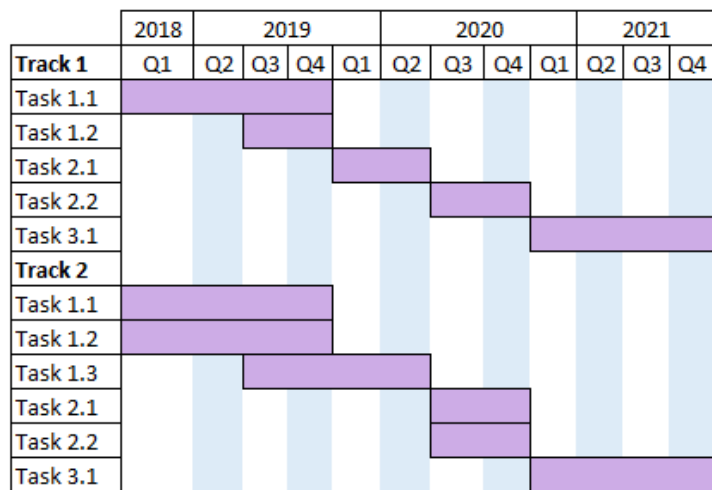
## OFBGT



# Schedule

- Track 1: Build OFBGs and test them in a University Research Reactor
  - Year 1
    - Task 1.1: Design OFBGs ✓
    - Task 1.2: Design and build irradiation test rigs ✓
  - Year 2
    - Task 2.1: Construct OFBGs\*
    - Task 2.2: Test OFBGs with silica fiber in OSURR and TAMURR\*
  - Year 3
    - Task 3.1: Repeat Tasks 2.1 and 2.2 for OFBGs with sapphire fiber

\*Have been delayed due to COVID-19 restrictions



- Track 2: Modeling and Data Analytics
  - Year 1
    - Task 1.1: Create modeled(MCNP and ANSYS) OFBG data for irradiation facilities ✓
    - Task 1.2: Develop methods and algorithms to process OFBG data using modeled data ✓
    - Task 1.3: Apply data analysis methods to MCNP OFBG data to predict power distributions ✓
  - Year 2
    - Task 2.1: Apply data analysis methods to test data for OFBG with silica fiber ✓
    - Task 2.2: Refine the models and data analysis methods (in progress)
  - Year 3
    - Task 3.1 Repeat Tasks 2.1 and 2.2 for data for OFBGs with sapphire



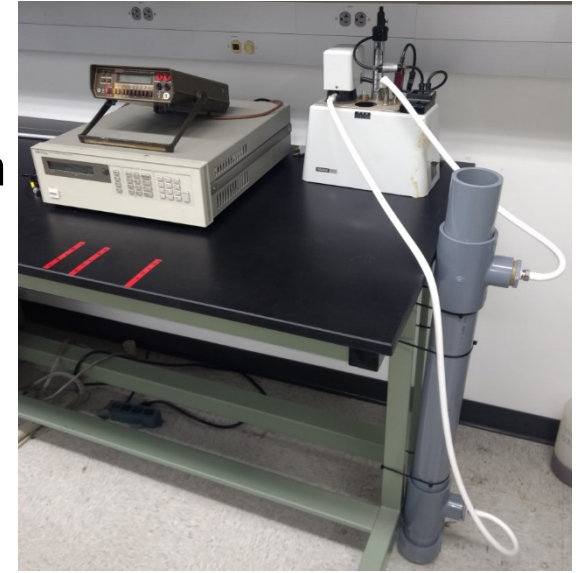
# Summary of accomplishments

- Track 1
  - Constructed a back-fill station and a calibration station
  - Established the construction and assembly techniques for the OFBGT
- Track 2
  - Implemented an iterative step into the data analytic method
  - Demonstrated the ability to infer the 2D power distribution in the TRIGA
  - Developed the uncertainty quantification technique
- 2 papers published
  - Analytical thermal modeling paper
  - Data Analytic method paper
- One paper under review
- Provisional Patent submitted

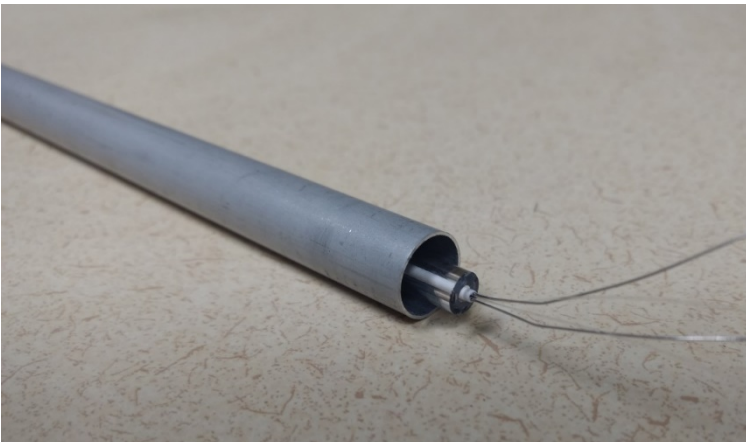
# Track 1 Accomplishments

- Back-fill station allows us to pull vacuum on the OFBGT and then fill with 1 atm of inert gas before sealing off compression feedthrough
- Calibration station allows one to calibrate based on both different energy deposition rates and coolant temperatures
- OFBGT construction progress can be seen below; remaining steps involve attaching feedthrough and welding the bottom.

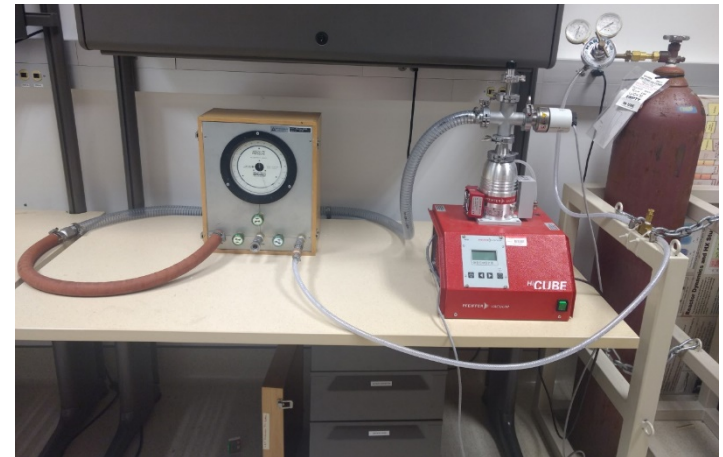
**Calibration Station**



**OFBGT Construction Progress**



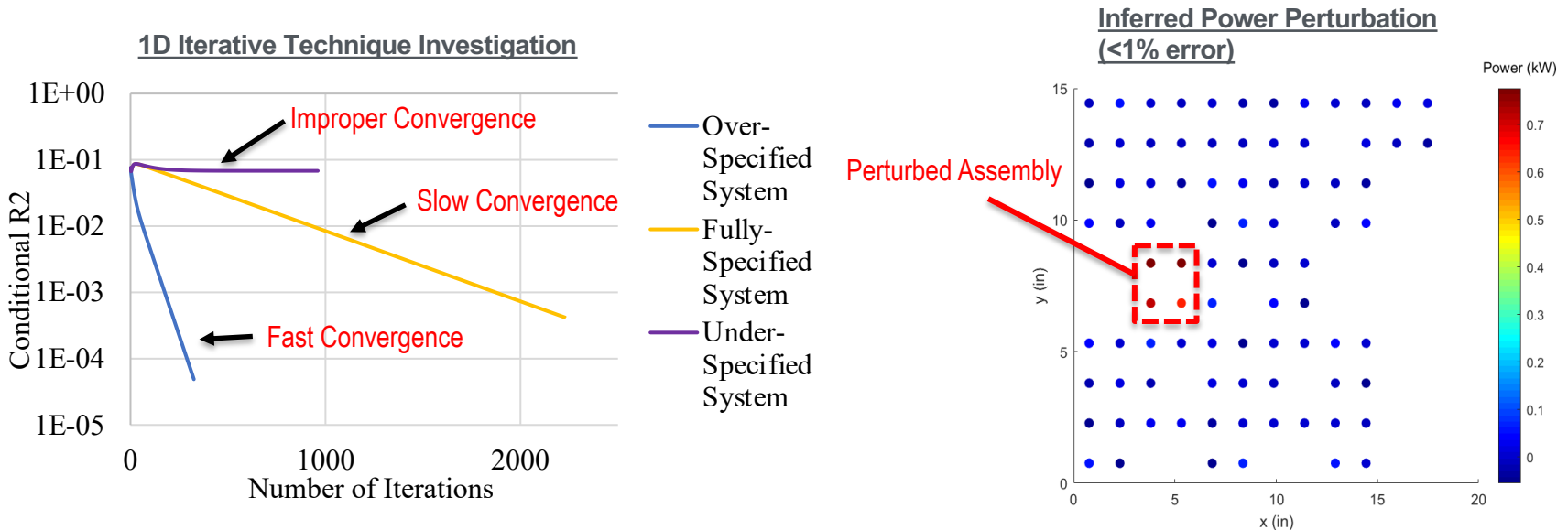
**Back-fill Station**





# Track 2 Accomplishments

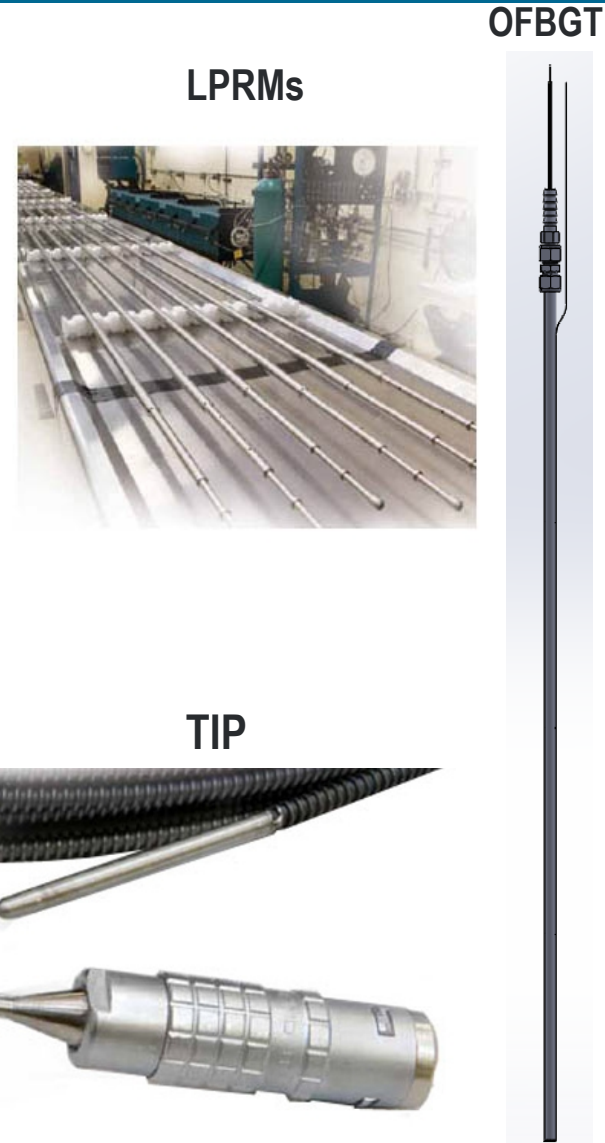
- Implemented an iterative step into the data analytic method to make the solution consistent, and thus more accurate
  - We have investigated this iterative technique in 1D and realized the importance of over-specification
- Demonstrated the ability to infer the 2D power distribution in the TRIGA based on simulated OFBGT data
  - We consider a simulated perturbed power distribution, and infer based on the simulated OFBGT array response
  - Error in the inferred power distribution is  $<1\%$  for all data points
- Developed the uncertainty quantification technique tailored to our specific method
  - Accounts for the dependence introduced into the system from the iterations



# Technology Impact

*Describe how this technology:*

- *The OFBGT allows one to obtain significantly more data points than previously implemented thermocouple GTs*
  - *This also enables the capability of power inferencing*
  - *As a more basic application, OFBGTs can be used to calibrate LPRMs in BWRs, instead of TIPs*
- *This work supports the DOE mission by addressing the demand for sensors for “big data” acquisition*
- *An array of OFBGTs in a commercial reactor would enable high fidelity 3D power monitoring*
- *The sensor could be commercialized by utilization of reactor qualified materials, laser welding, and drift correction techniques*



# Conclusion

- An OFBGT measures the  $\Delta T$  along the axial length of the sensor which can be used to infer power distribution using response functions generated by MCNP ( $\Delta T$  is measured by optical fiber)
- We have developed and demonstrated the data analytic methods necessary to infer power distribution based on the OFBGT response
- We have designed and constructed a calibration station and back-fill station for the OFBGTs
- We are in the process of constructing the OFBGTs
- We plan to test an OFBGT at the OSURR in 12/2020, and test an effective OFBGT array in 3/2021
- Questions?