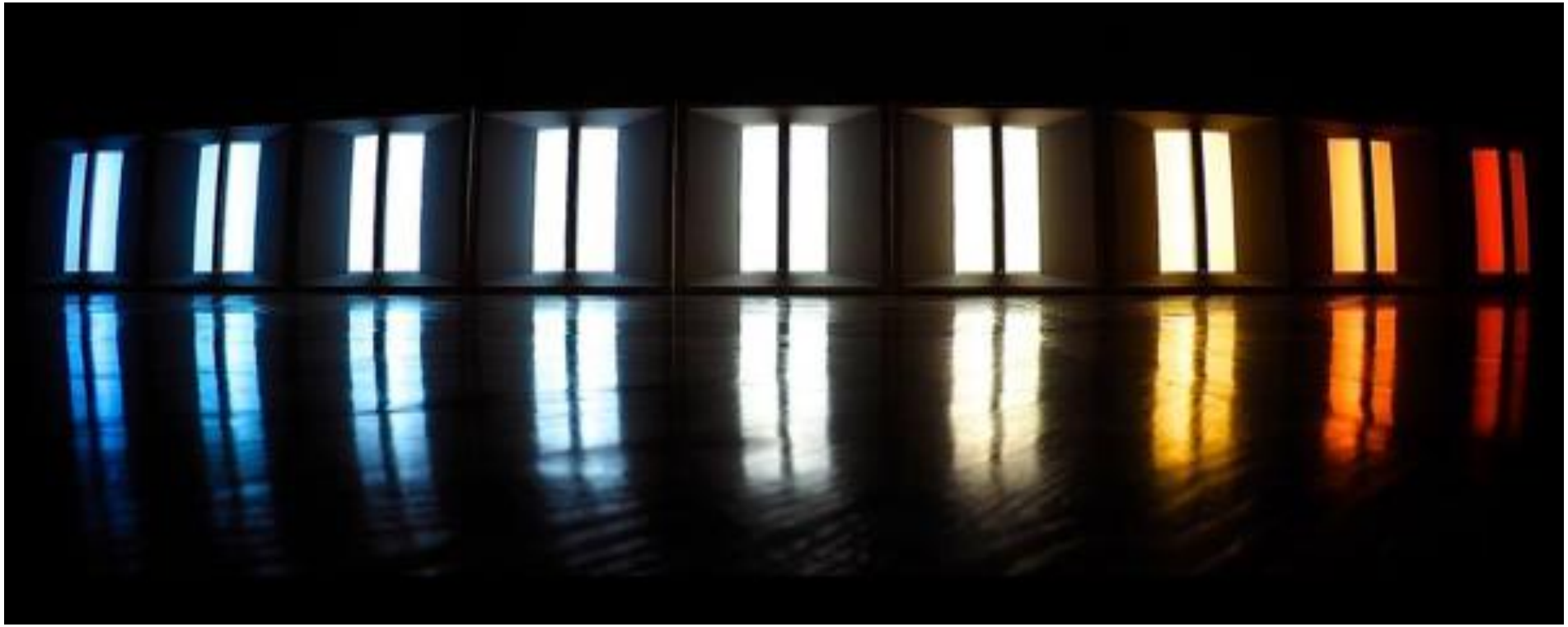
Optimizing Tunable Lighting for Human Health



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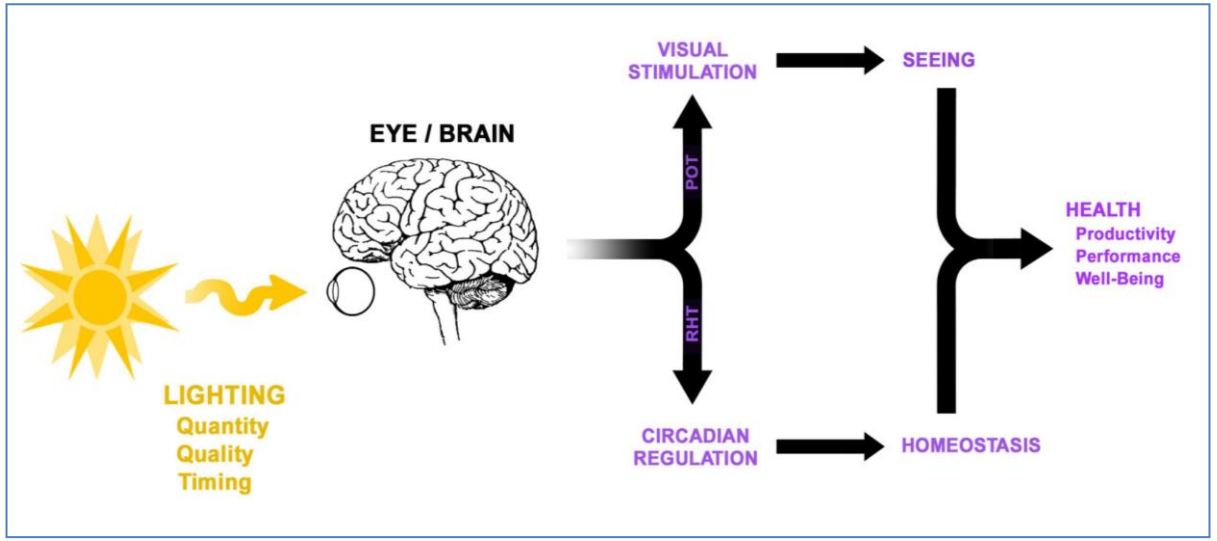
Project Summary

Objective and outcome

The goal of this project is to establish the potential link between lighting and human health for users of SSL tunable lighting systems. The following research questions will be addressed using quantified characteristics of metabolic, endocrine functions and sleep physiology:

- What is the impact of SSL tunable lighting on occupant health and well-being in an indoor space?
- Can the impact of SSL tunable lighting on occupant health and well-being be sustained under more normal, uncontrolled circumstances when subjects are exposed to public and domestic light exposures?



Team and Partners

Tulane University

Rensselaer Polytechnic Institute

TELELUMEN
The Recording and Playback of Light

Stats

Performance Period: 10/1/21 to 12/31/24

DOE budget: $1,347k, Cost Share: $377k

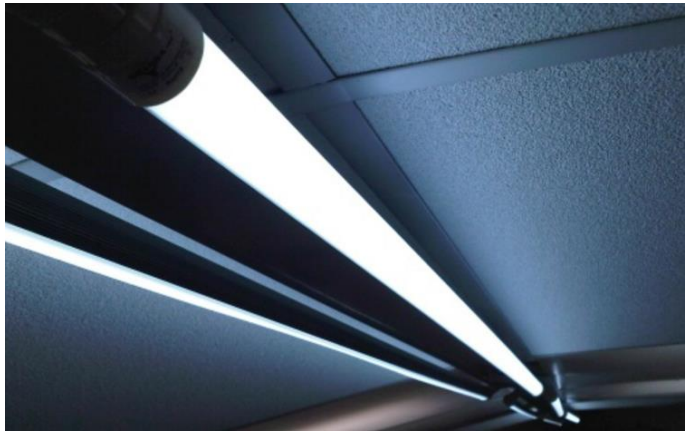
Milestone 1: Project Planning completed

Milestone 2: Literature Review completed

Milestone 3: Light Research Laboratory Setup completed

Team

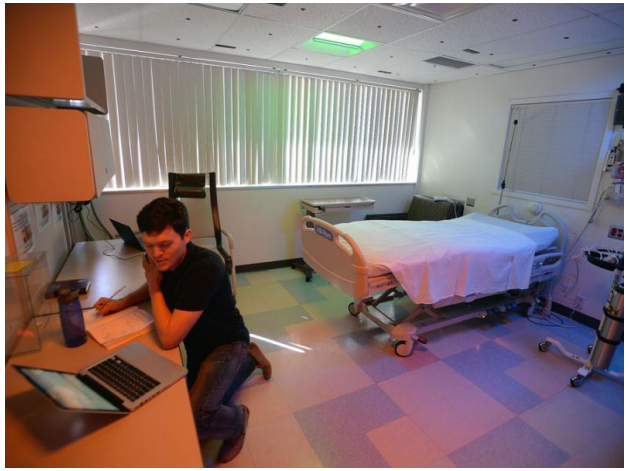
Tulane University



David Blask, MD, PhD and Robert Dauchy, MS will guide and oversee assay of metabolic biomarkers

- Groundbreaking studies on how light effects human tumor growth
- Robust body of research on LED vs CWF light exposure in animals

Rensselaer Polytechnic Institute



Robert Karlicek, Ph.D. and the LESA Center will guide the installation, programming and energy metering of the SSL system

- LESA Center is a graduated NSF Research Center with strong engineering team
- Multiple patents on light technologies

Problem

- The DOE anticipates that by 2030, LEDs will reach 80% of all lighting sales, saving Americans $26 billion per year in electricity costs.

- The adoption of color tunable systems may reduce some of the overall SSL efficiency under the guise of providing improved health and wellness to occupants.

- There remains a lack of data regarding the possible positive impacts of daytime tunable SSL lighting on health and wellness.

Alignment and Impact

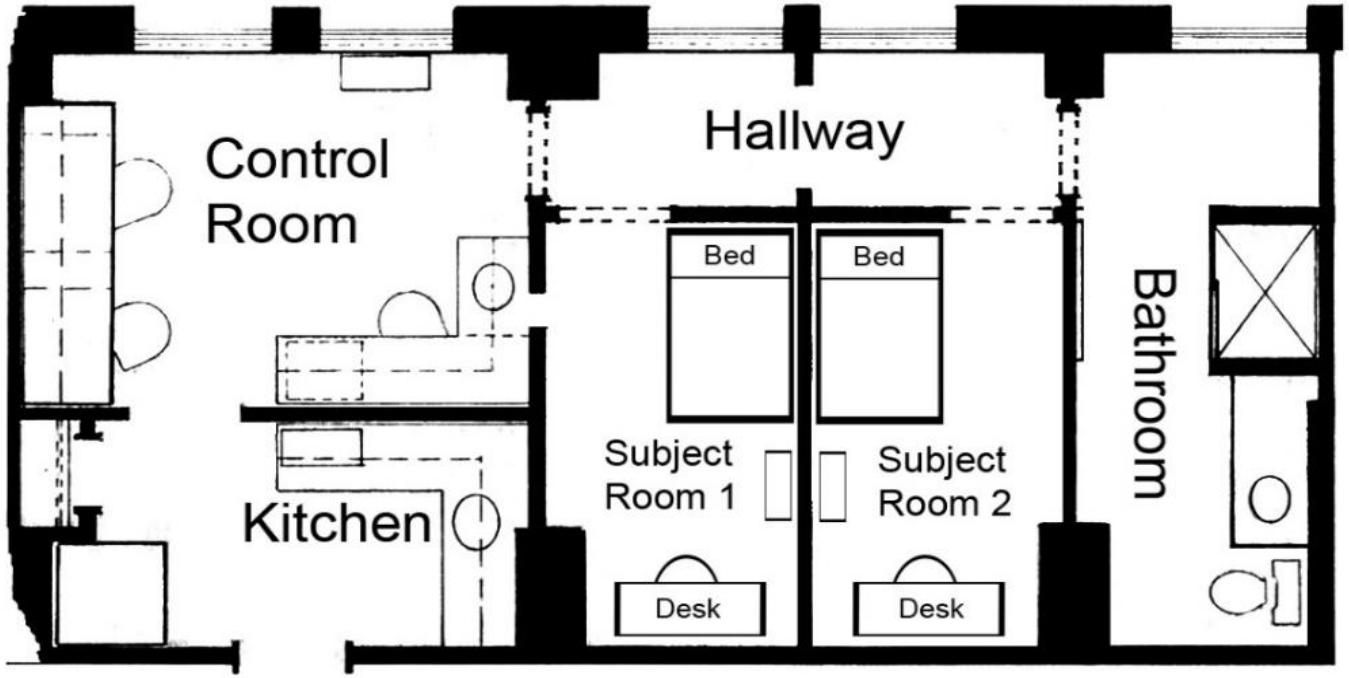
- There is conflicting information regarding the health impacts and the potential for improving occupant's health with respect to the desired spectral components and irradiances of the light source.

- Optimized lighting systems for health impacts meeting current healthy building standards may use more energy than those meeting current illumination specifications.

- This project has the potential to be a critical step forward in the drive to convert office lighting to solid state technologies.

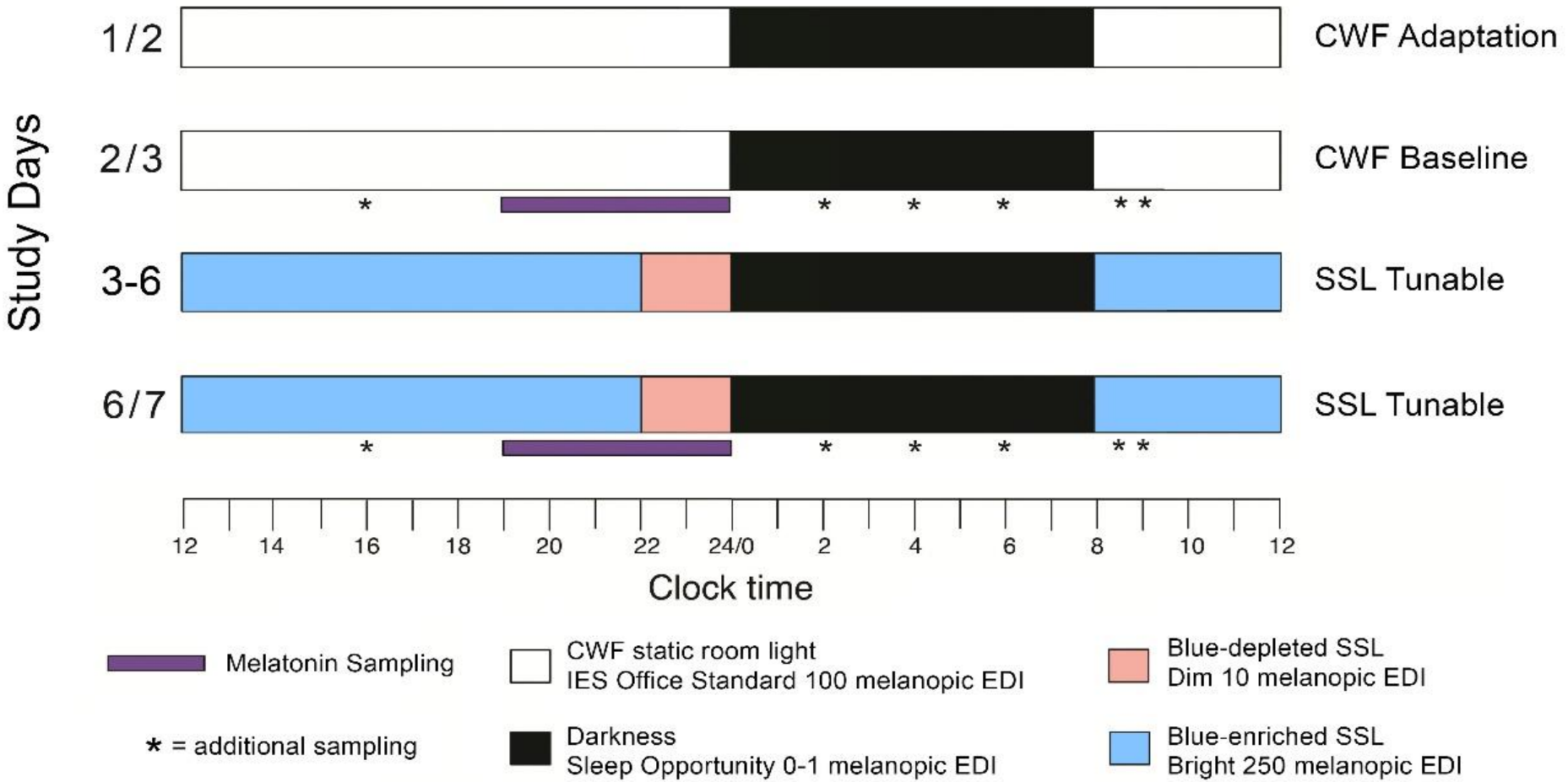
Approach

- Quantify characteristics of human metabolic, endocrine and sleep physiology affected by tunable SSL versus fluorescent lighting in 1) a controlled laboratory study and 2) a naturalistic study



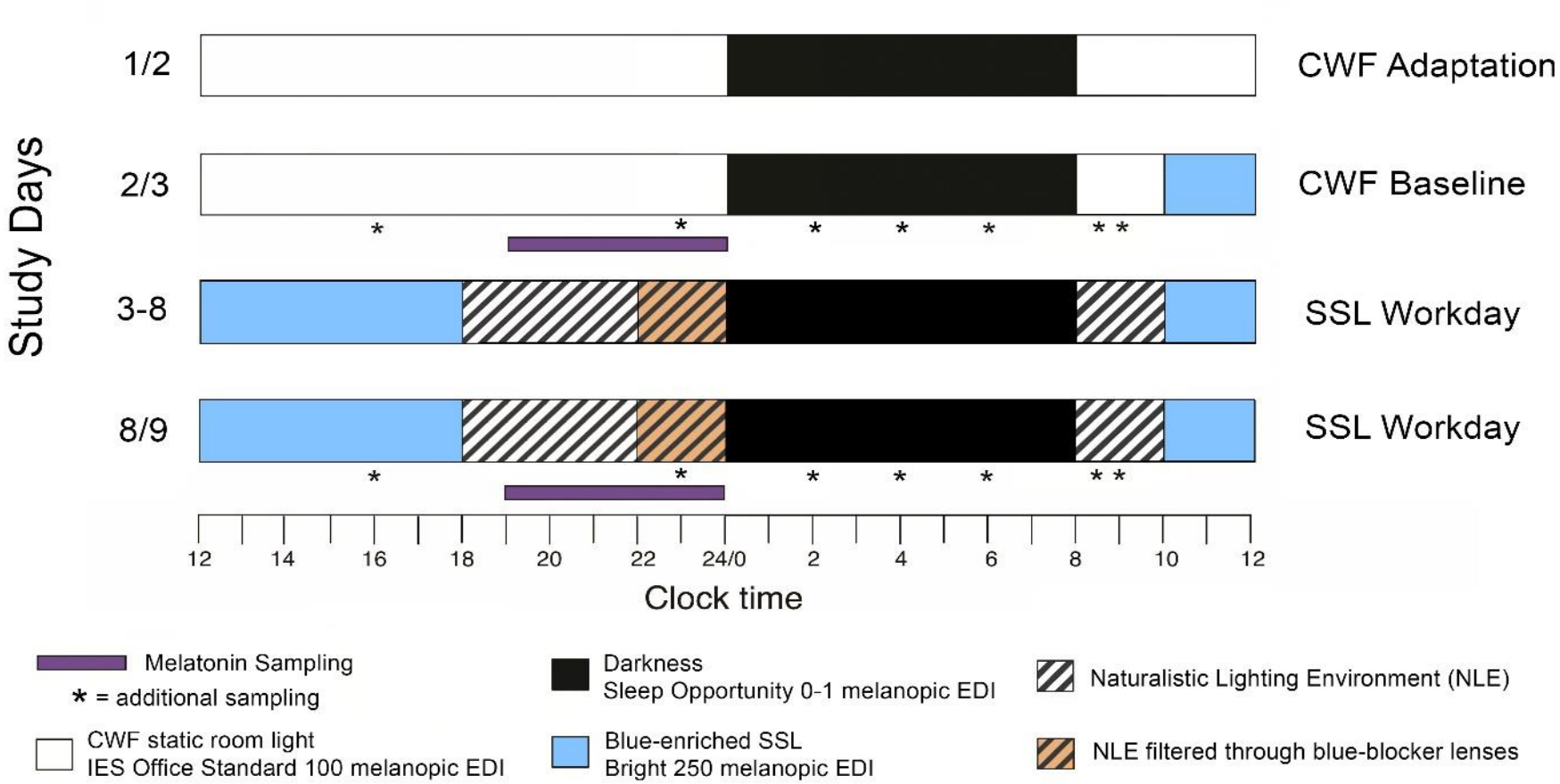
Approach

Controlled Light Study (Crossover, N=12)



Approach

Naturalistic Light Study (Separate Cohorts, N=14)



Approach

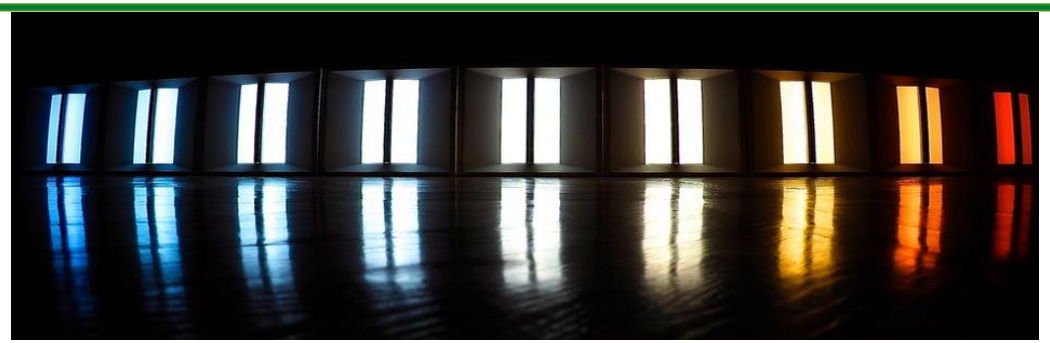
Independent variables and their experimental values

Independent Variable	Built-in Ceiling Lighting
Lighting Type	SSL tunable: 250 melanopic EDI SSL light, bright combined with 10 melanopic EDI SSL light, dim CWF: 100 melanopic EDI (office standard illuminance)
Exposure Times	Study 1: Daily for 16 hours Study 2: Daily for 8 hours

Approach

Octa Light Player™

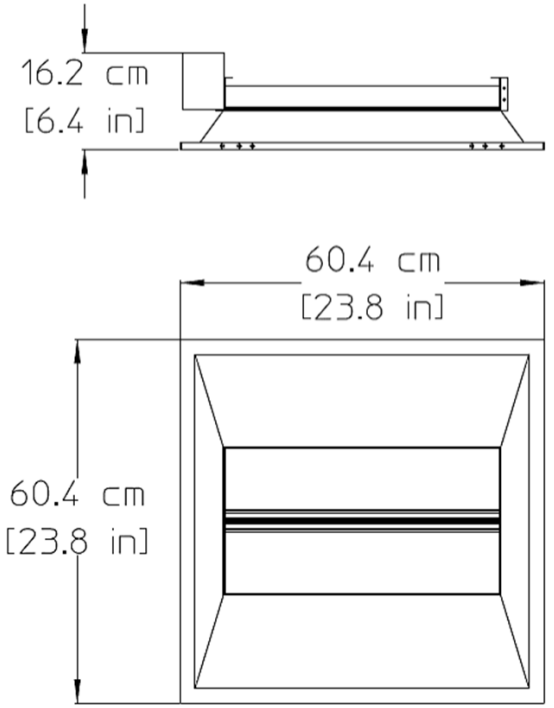
8-channel Light Synthesizer Luminaire
(built on CREE CR-22 frame)



Product Description

- 8-channel, full-spectrum, dynamic lighting of 2,000 lumens across the entire color temperature range of 1500K to 50000K with high color rendering

- Optional LED channels with peak wavelengths from near UV to near IR allow a very broad variety of SPD to be synthesized.



Specifications
Color channels: 8 (various wavelength options from 365nm to 940nm)
CCT range: 1,500K to 50,000K
Lumen output: >2,000, >90 Rf(TM30)
PWM dimming: 1000:1
PWM frequency: 32 kHz
Data and Control: Ethernet
Network protocol: TCP/IP, UDP, DHCP
Input Voltage: 100-240 VAC
(277 VAC for NA only)
0.5A max, 50/60Hz
Weight: 5 kg (11 lbs)
Warranty: 1 year
Mounting: Ceiling, bench, cabinet

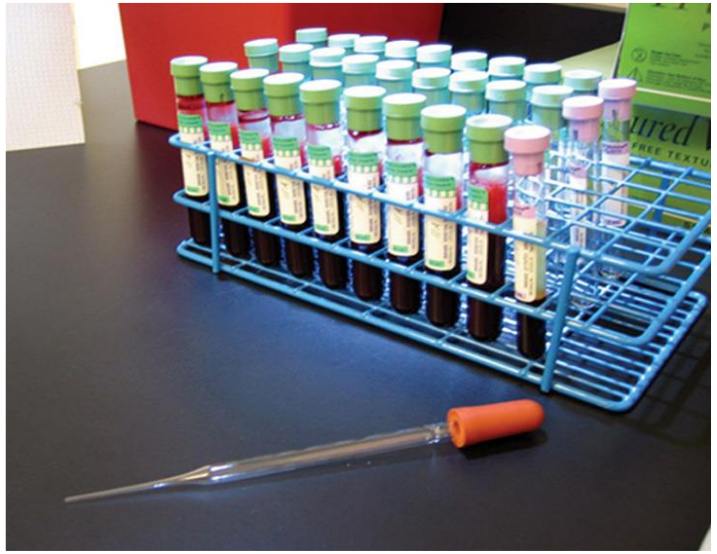
Telelumen Spectral Match Technology

- Octa synthesizer is meant to be driven by Telelumen Lumenscript Editor Software for maximum capability. Together the software and Octa hardware can generate most SPDs within the visible range to extract the full potential of programmed illumination changing with time.

- This software allows custom SPD manipulation and illumination matching for playback on a luminaire. Sophisticated match algorithms convert SPDs into LED channel drive vectors without complex input from the user.

Approach

Dependent Variables



- increase the amplitude and duration of melatonin production
- advance onset of melatonin production
- optimize amounts of glucose, insulin, leptin and cortisol
- shorten sleep latency and improve sleep efficiency
- quantify energy use of SSL and CWF lighting

Progress and Future Work

Project Goals/Milestones Completed

- Task/Milestone 1 – Overall Project Management and Planning (ongoing)
- Task/Milestone 2 – Review of Existing Literature and Experimental Results (submitted 12/22)
- Task/Milestone 3 – Experimental Setup (submitted 12/22)

Progress and Future Work

Project Goals/Milestones Completed

- **Task/Milestone 3 – Experimental Setup**

  Go/No-Go Decision Point: Complete LRL setup and IRB approval

  -IRB Appovals Obtained

  -Luminaires Installed and Characterized

Progress and Future Work

Photographs of the Tunable SSL lighting system in each location:

Room 1

Bath

Hallway

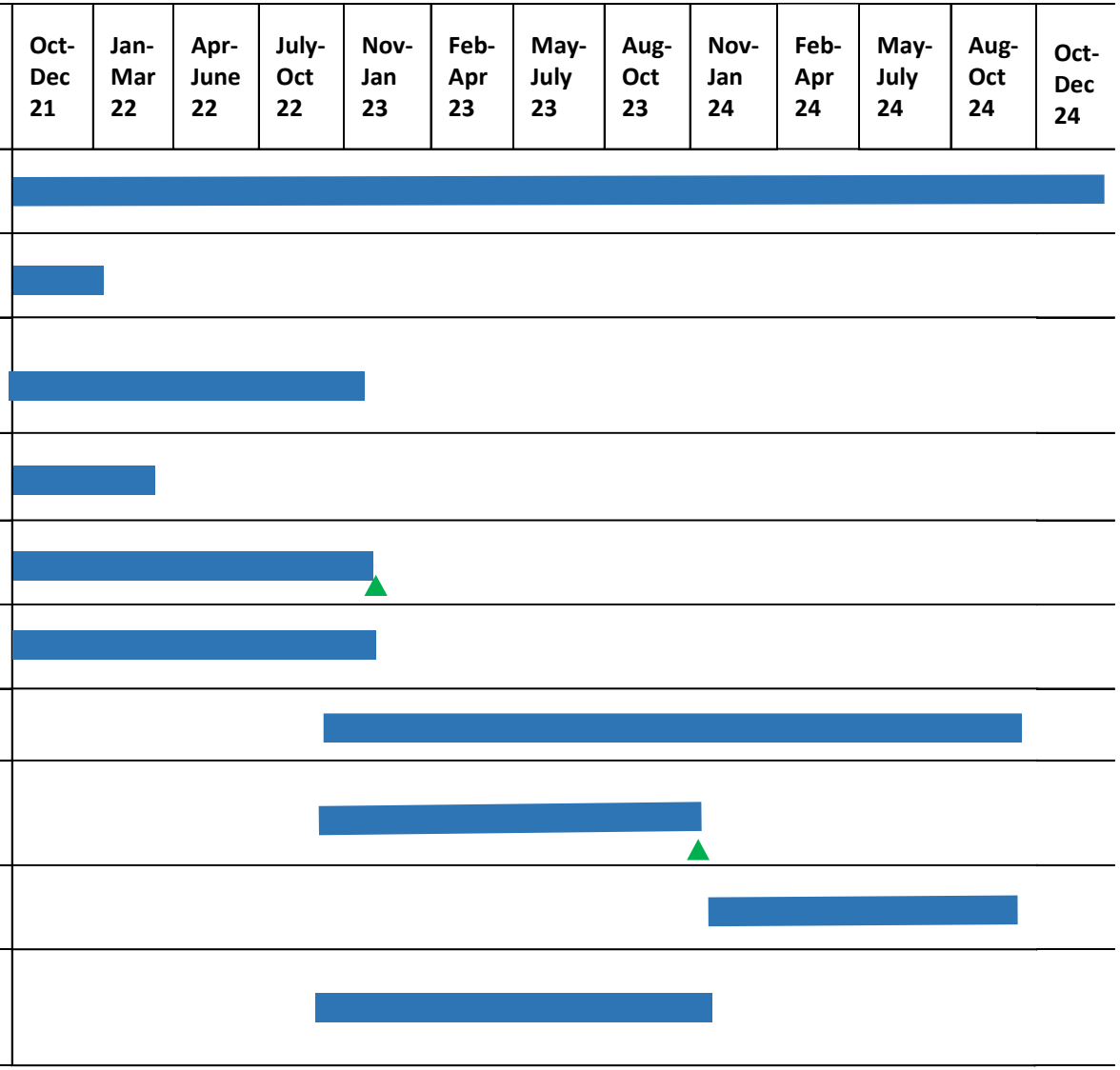
Progress and Future Work

Total Radiometric and Photometric Output of each lighting condition:

	Radiometric and Photometric Values (380 - 780 nm inclusive)			Retinal Photopigment Weighted Illuminances (α-opic lux)				
	Log Photon Irradiance (s-1.m-2)	Irradiance ($\mu W/cm^2$)	Photopic Illuminance (lux)	S Cone	Melanopsin ipRGC	Rod	M Cone	L Cone
Room 1 CFL (100 mEDI)	18.13	49	178	97	100	117	158	174
Room 2 SSL (250 mEDI)	18.47	108	300	233	250	259	282	299
Room 2 SSL (10 mEDI)	17.37	8	22.5	5.7	10	11.8	17.5	23

Project Execution

Task Name	Start	Finish
Task 1.0: Overall Project Management and Planning	10/1/21	12/31/24
Milestone: Project planning completed	10/1/21	12/31/21
Task 2.0: Review of Existing Literature and Experimental Results	10/1/21	12/22/22
Milestone: Literature review completed	10/1/21	12/22/22
Task 3.0: Experiment Setup Go-No Go Decision Point 1	10/1/21	12/31/22
Milestone: Light Research Laboratory setup completed	10/1/21	12/31/22
Task 4.0: Experiment Performance	11/1/23	9/31/24
Subtask 4.1: Controlled Light Study Go-No Go Decision Point 2	1/1/23	12/31/23
Subtask 4.2: Naturalistic Light Study	1/1/23	9/31/24
Milestone: Controlled Exposures Completed and Naturalistic Light Study Exposures Initiated	1/1/23	12/31/23



Progress and Future Work

Obstacles

- Task/Milestone 3 – Experimental Setup
  - -Luminaires delayed (supply chain issues)
  - -Local contractors had limited availability
  - -Install complicated by needed configuration change
- Task/Milestone 4 – Experiment Performance
  - -Supply chain issues continue
  - -Scheduling complicated due to projects using LRL
  - -Recruiting in post-pandemic environment

Thank You

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