

Optimizing Tunable Lighting for Human Health



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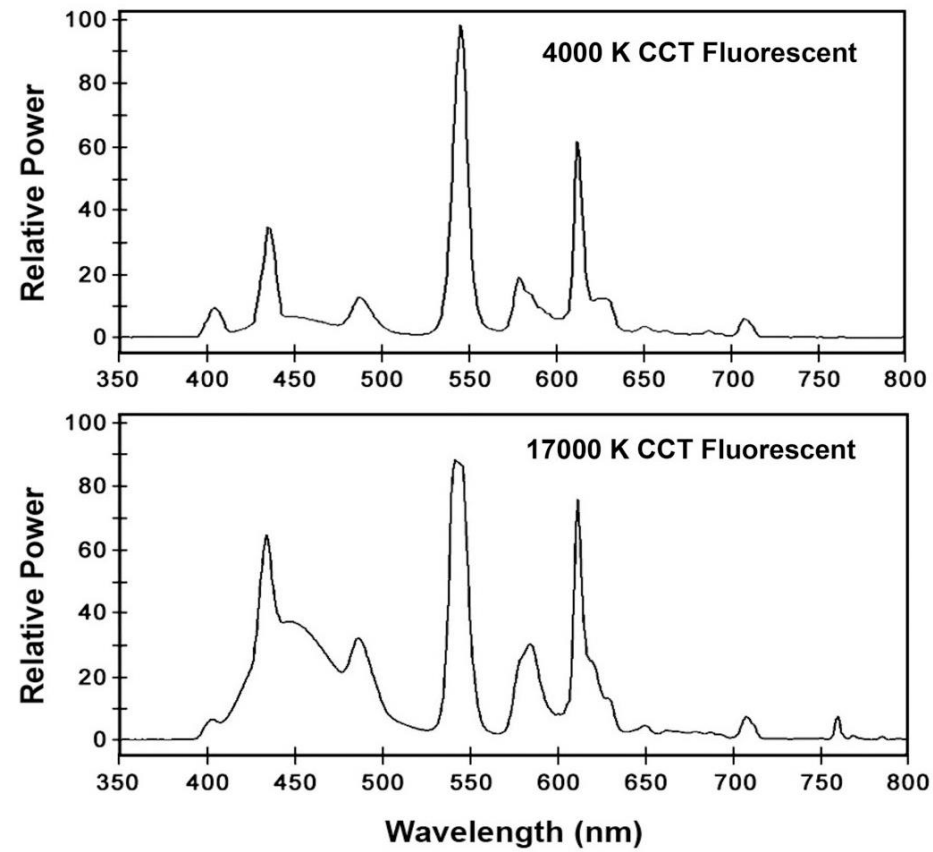
Randomized trial of polychromatic blue-enriched light for circadian phase shifting, melatonin suppression, and alerting responses



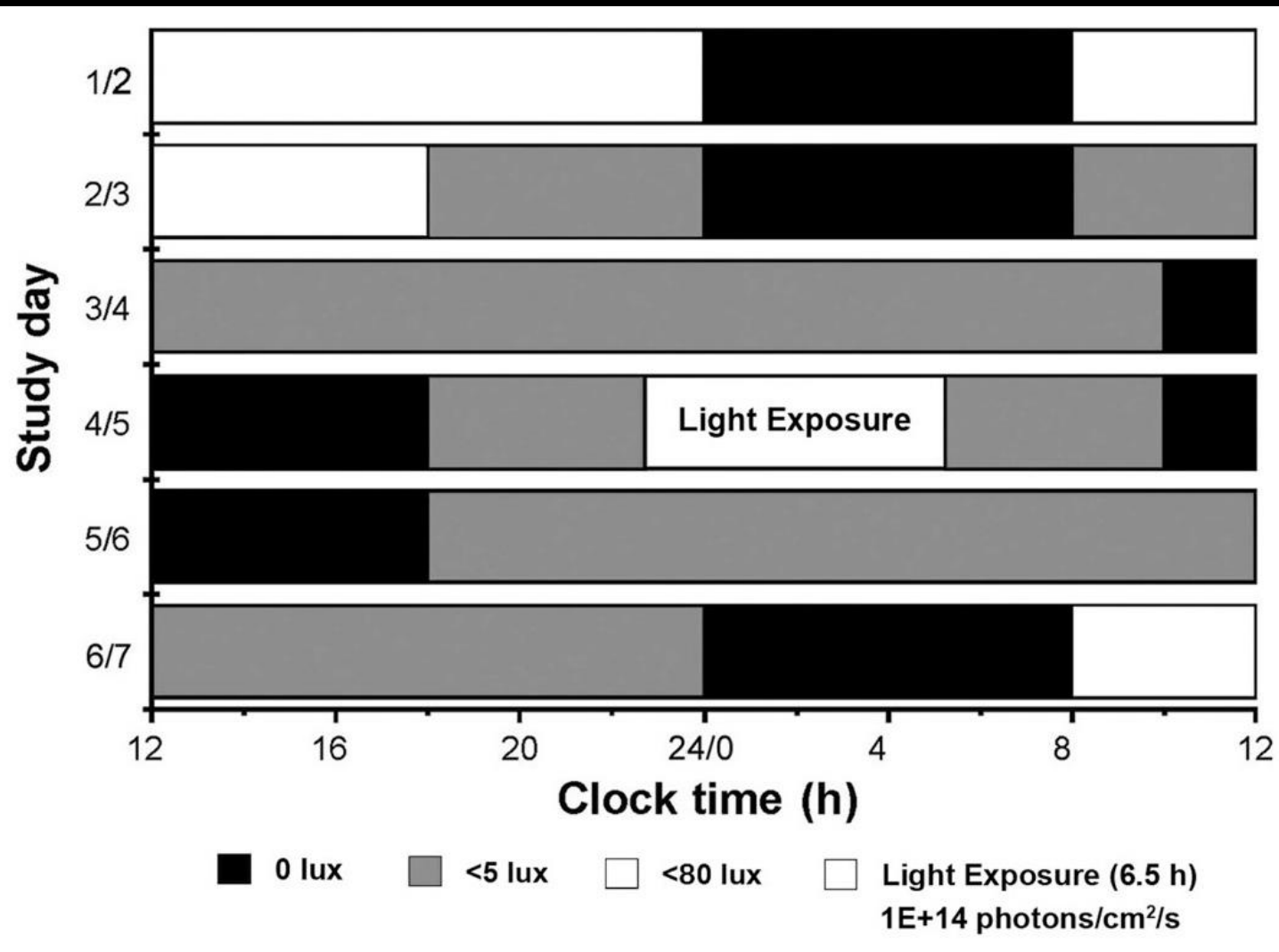
J.P. Hanifin^{a,*}, S.W. Lockley^b, K. Cecil^a, K. West^a, M. Jablonski^a, B. Warfield^a, M. James^a,
M. Ayers^a, B. Byrne^a, E. Gerner^a, C. Pineda^a, M. Rollag^a, G.C. Brainard^a

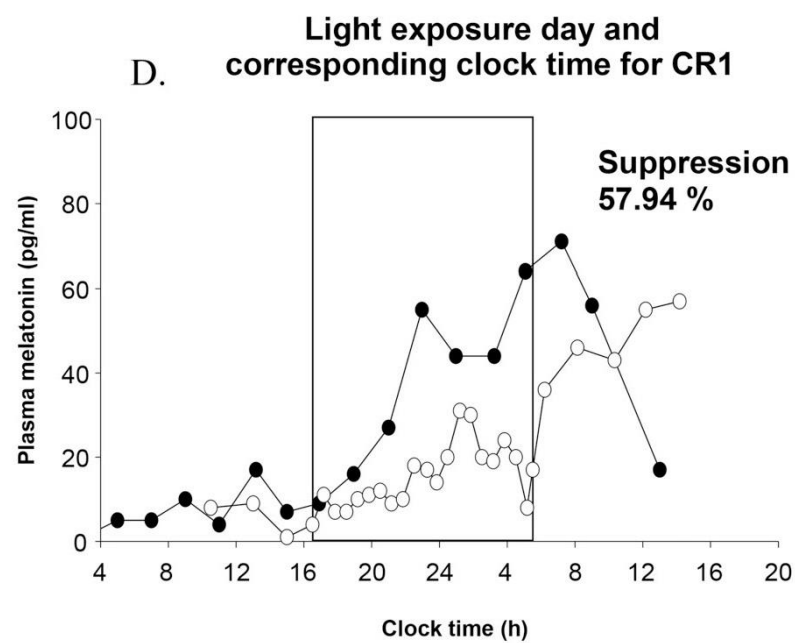
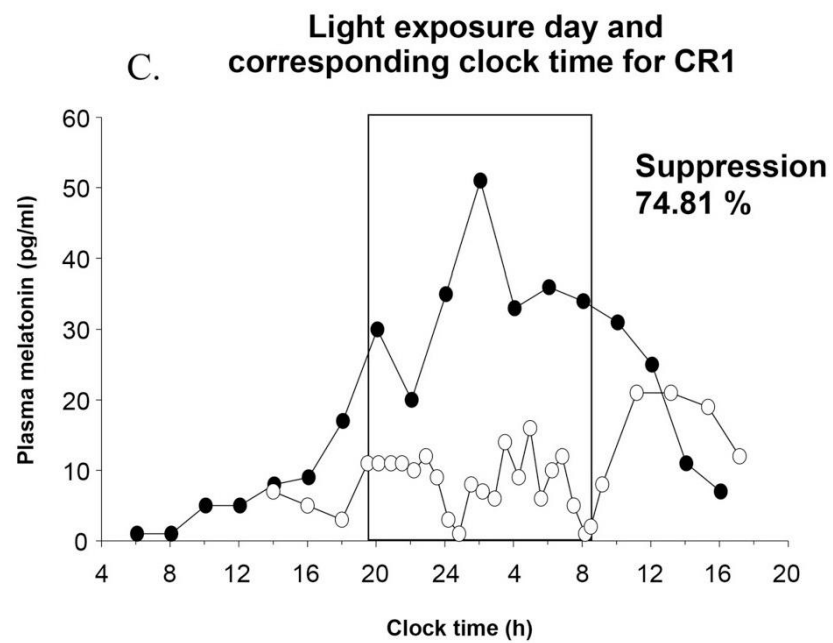
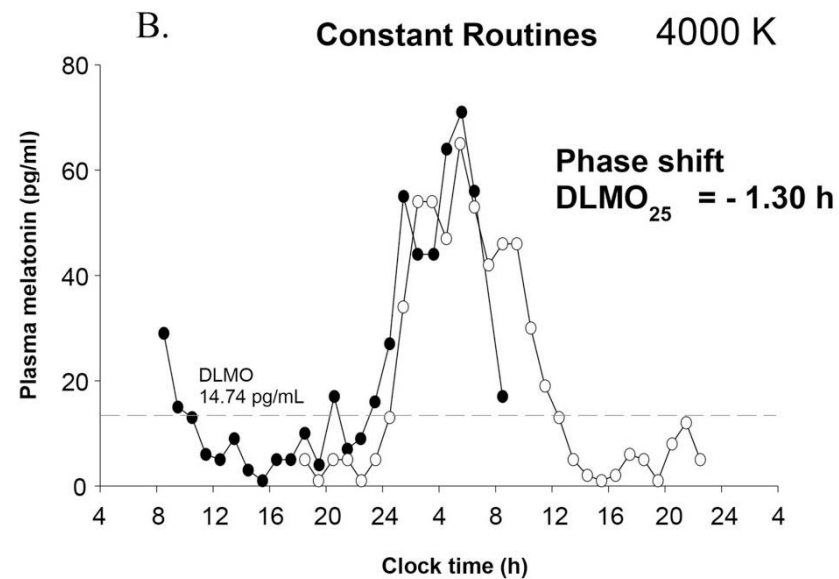
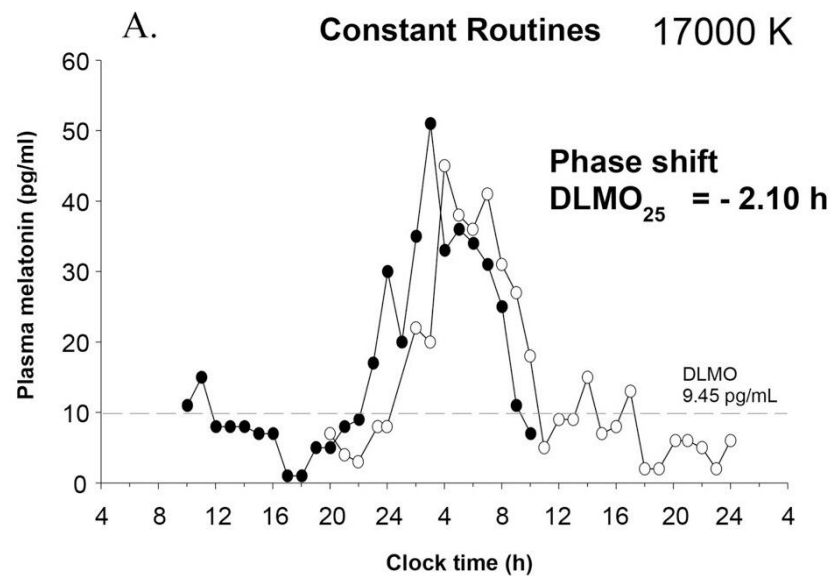
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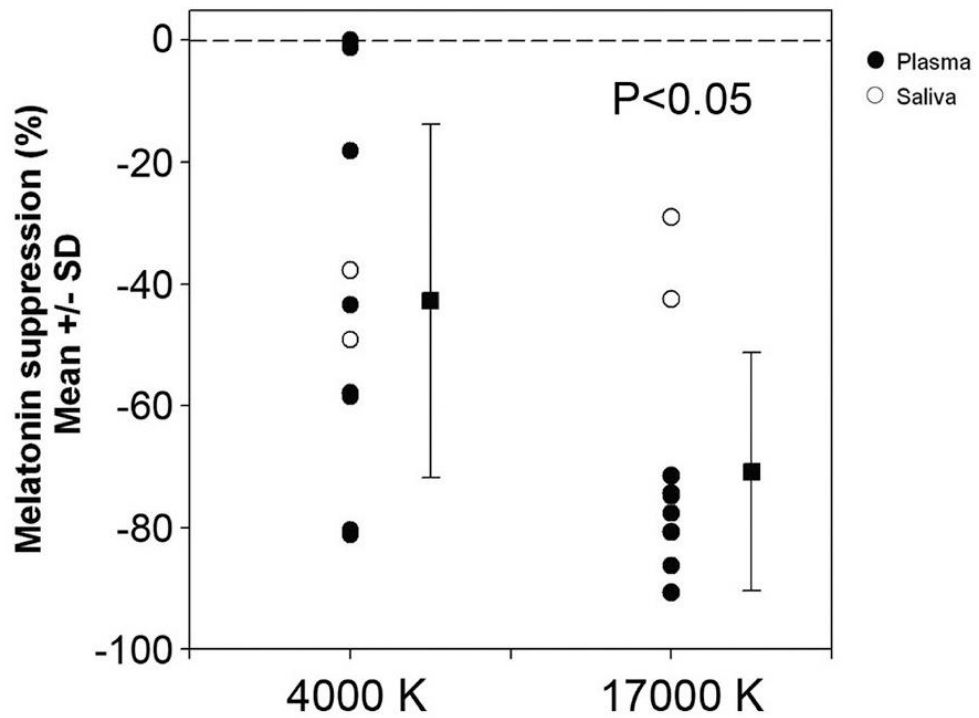


	Radiometric and Photometric Values (380 -780 nm inclusive)			Retinal Photopigment Weighted Illuminances (α -opic lux)				
	Photon Flux (photons/cm ² /s)	Irradiance (μ W/cm ²)	Photopic Illuminance (lux)	S Cone	Melanopsin ipRGC	Rod	M Cone	L Cone
4000K Light	1.01E+14	36.3	123	83	79	91	109	120
17000K Light	1.00E+14	39.0	96	190	133	122	107	96

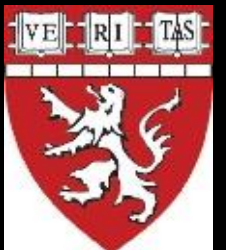
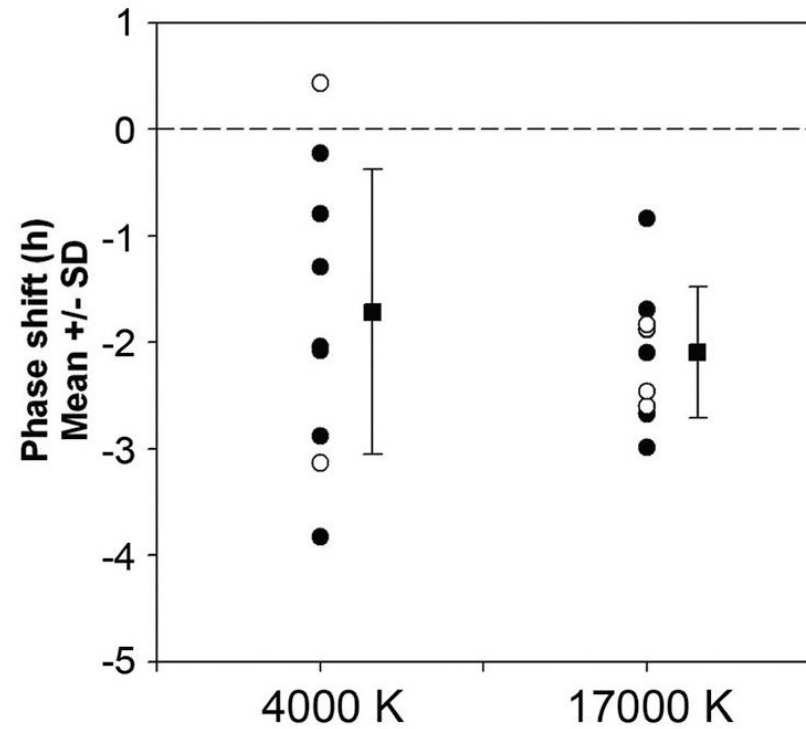




A. Melatonin suppression



B. Phase shift - DLMO



Influence of Daytime LED Light Exposure on Circadian Regulatory Dynamics of Metabolism and Physiology in Mice



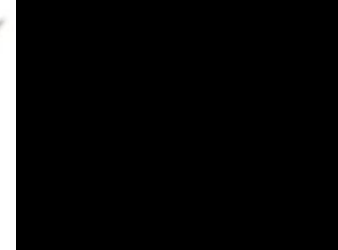
Robert T Dauchy,¹ David E Blask,¹ Aaron E Hoffman,²
Shulin Xiang,¹ John P Hanifin,⁴ Benjamin Warfield,⁴ George C Brainard,⁴
Murali Anbalagan,¹ Lynell M Dupepe,³ Georgina L Dobek,³
Victoria P Belancio,¹ Erin M Dauchy,⁵ and Steven M Hill¹

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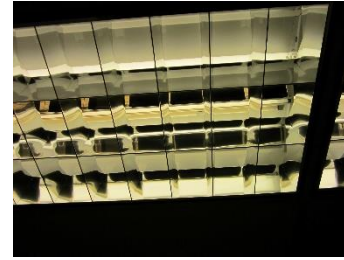
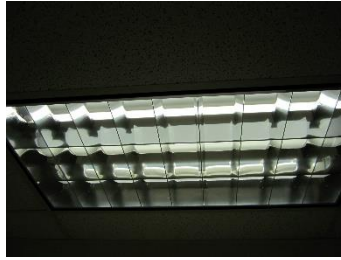
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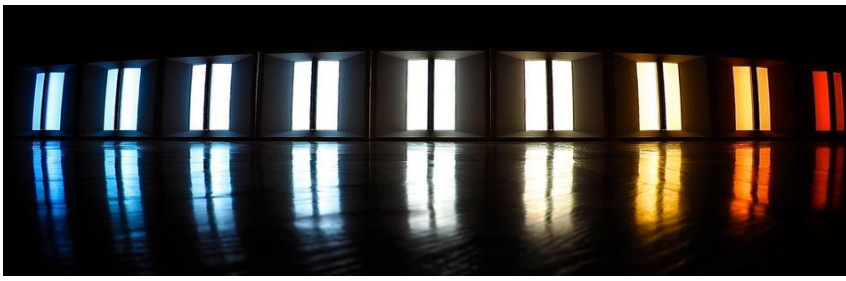
Summary



LED vs CWF:

- ◆ **Lower** dietary and water intake, and animal growth rates...
- ◆ **Amplification** of the melatonin signal ...
- ◆ **Slower** rates of animal metabolism and physiology...
- ◆ Factors associated with the **promotion of animal health and wellbeing...**
and may influence scientific outcomes...

Dauchy RT et al., 2019. *Comp Med* 69(5): 1-20



Objectives

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?

Project Partners and Roles



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

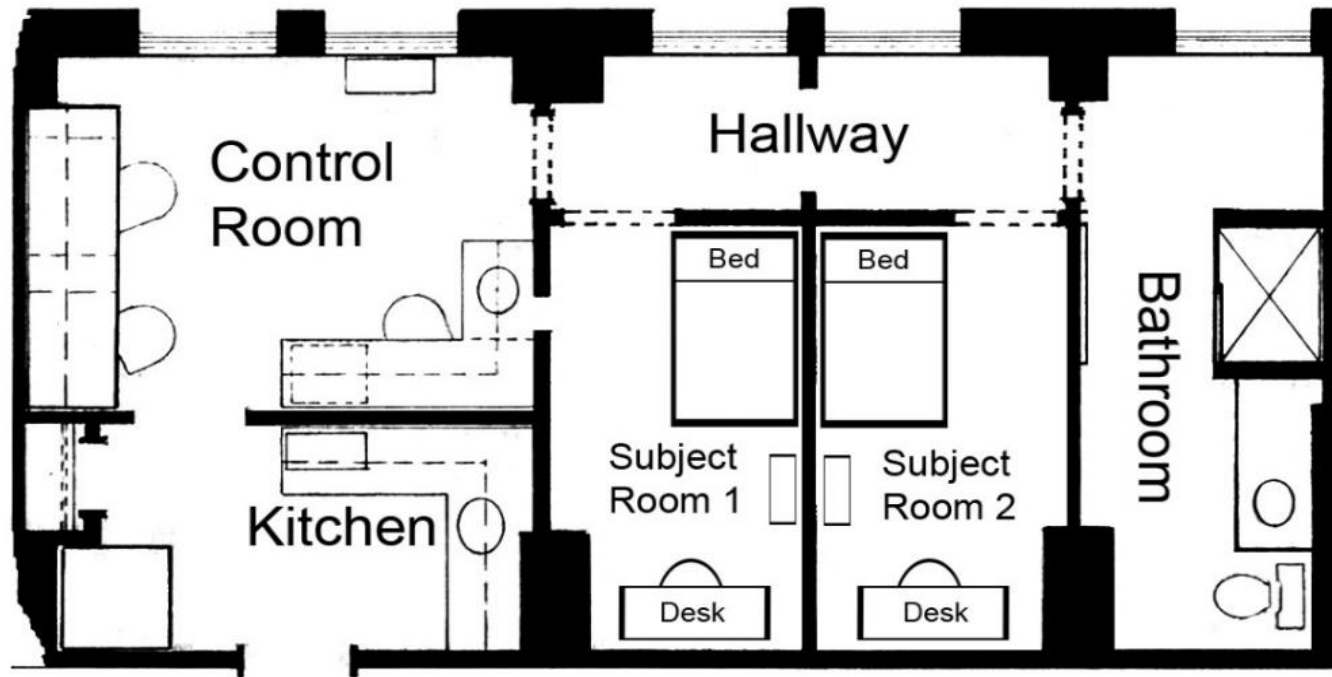


Robert Karlicek, Ph.D. and the LESA Center will guide the installation, programming and energy metering of the SSL system

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

Project Structure and Technology Description

- 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



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

Octa Light Player™

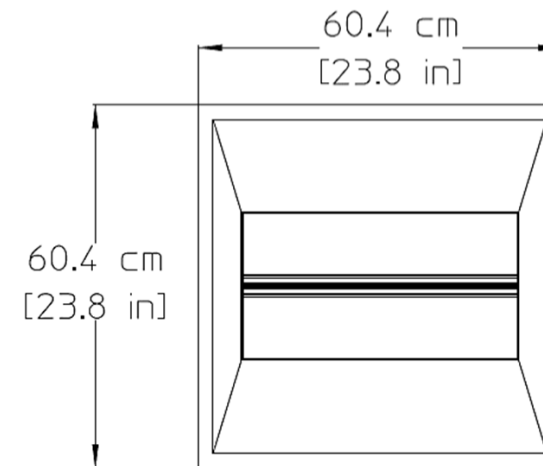
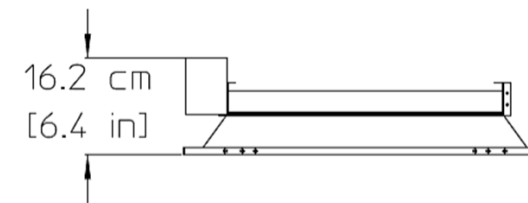
8-channel Light Synthesizer Luminaire
(built on CREE CR-22 frame)

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.

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.



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

Hypotheses

Compared to CWF light, SSL tunable lighting will:

- **advance onset of melatonin production**
- **increase the amplitude and duration of melatonin production**
- **optimize amounts of glucose, insulin, leptin and cortisol**
- **shorten sleep latency and improve sleep efficiency**

In addition, energy use of SSL and CWF lighting will be quantified and compared.

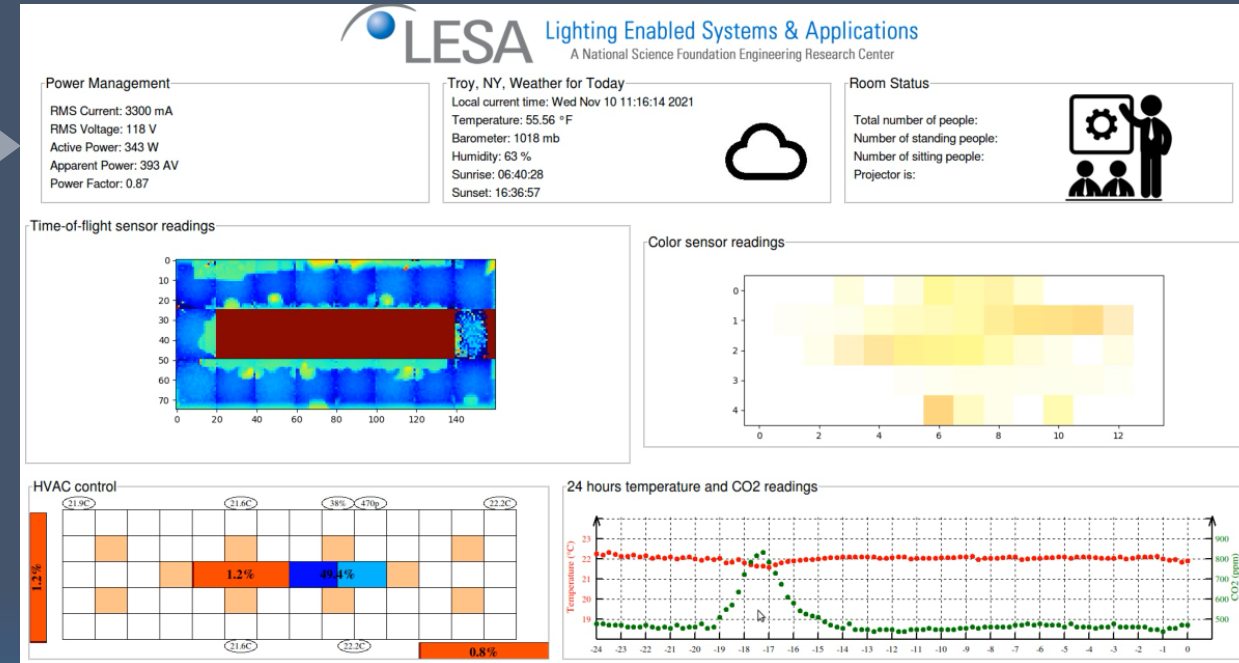


Spectral Power Distribution with Power Monitoring

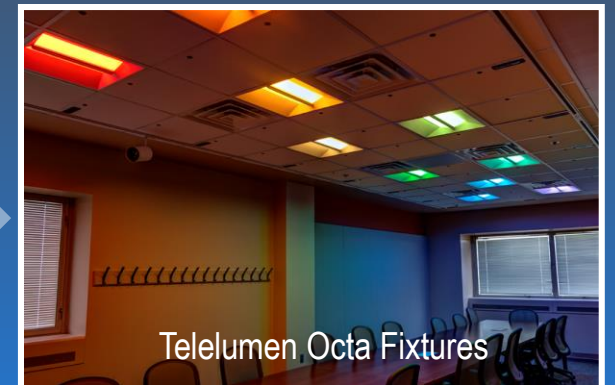
Power Management

RMS Current: 3300 mA
RMS Voltage: 118 V
Active Power: 343 W
Apparent Power: 393 AV
Power Factor: 0.87

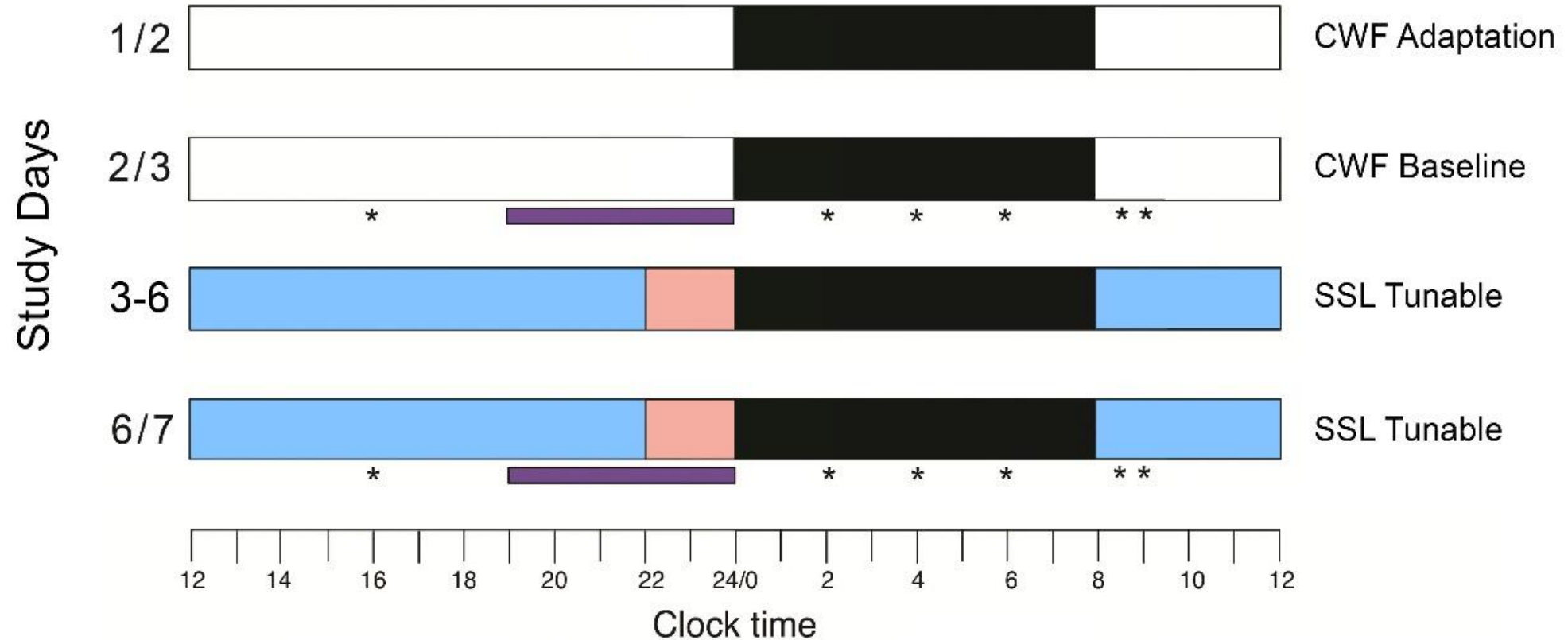
- Lighting System Energy use depends on the Spectral Power Distribution (SPD)
- Energy use monitored by fixture and over time, correlated with the SPD settings
- Energy impact of circadian lighting impacts can be monitored in real time



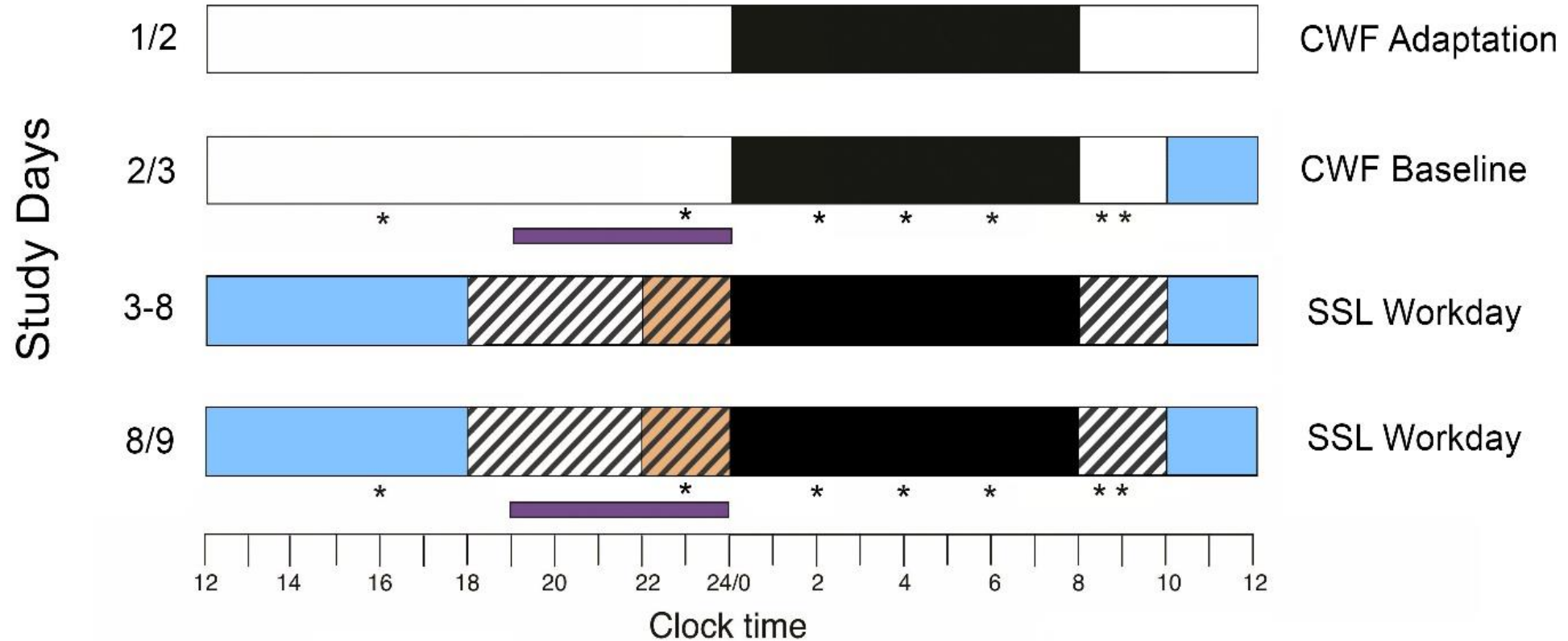
LESAS Smart
Conference Room
Testbed at RPI



Controlled Light Study (Crossover, N=12)



Naturalistic Light Study (Separate Cohorts, N=14)



Melatonin Sampling

* = additional sampling

CWF static room light
IES Office Standard 100 melanopic EDI

Darkness
Sleep Opportunity 0-1 melanopic EDI

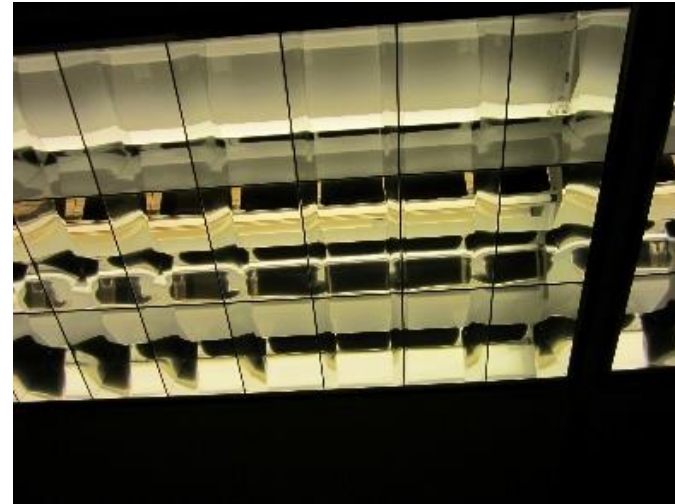
Blue-enriched SSL
Bright 250 melanopic EDI

Naturalistic Lighting Environment (NLE)

NLE filtered through blue-blocker lenses

Deliverables

This project will provide empirical data on the impact of tunable SSL exposures compared to conventional CWF light exposures on important aspects of metabolic, endocrine and sleep physiology that are objective measures of occupant health and well-being in indoor lighting environments such as offices, schools and hospitals.



LED vs CWF

Evidence Based Lighting

