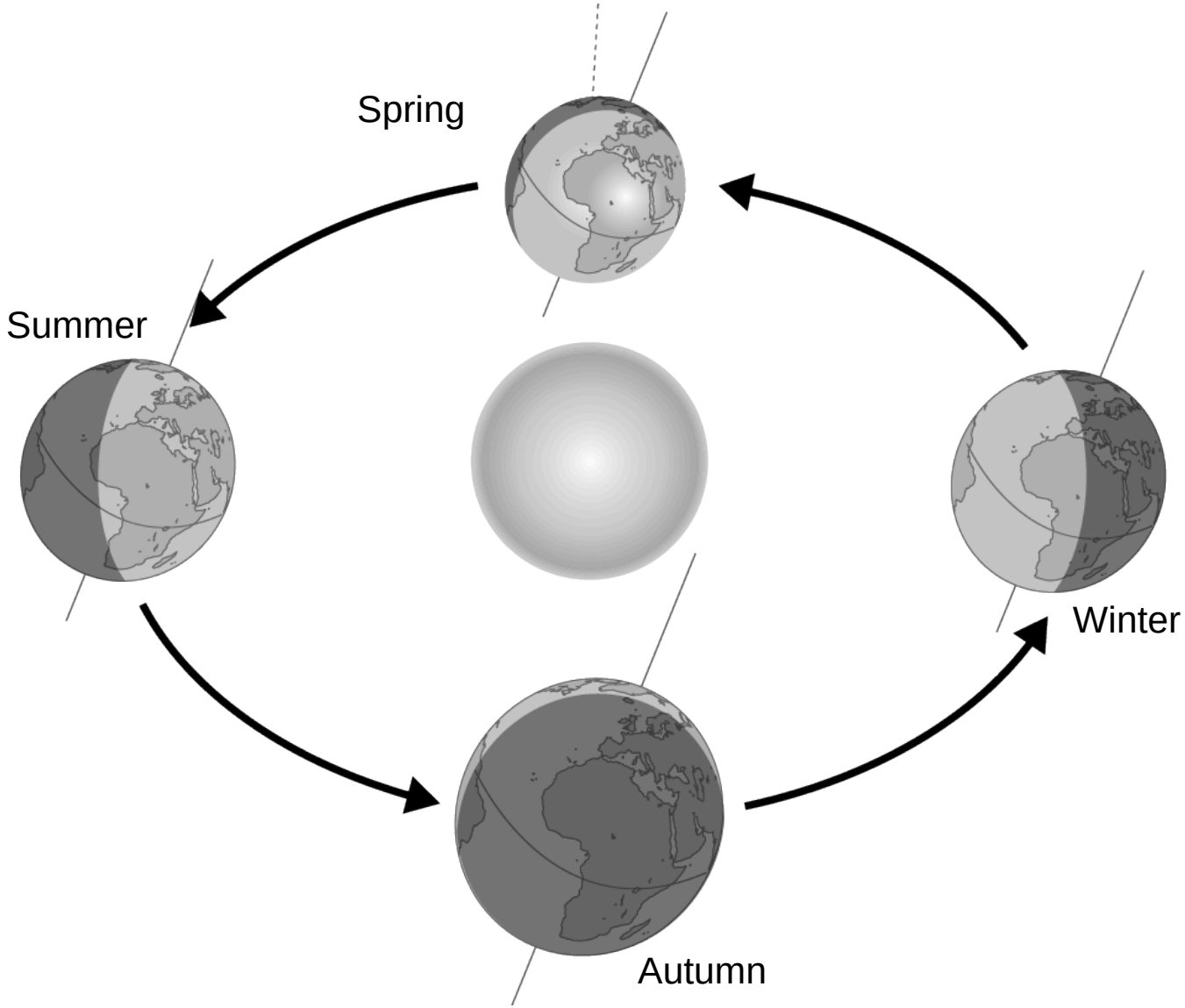
Novel Lighting Strategies for Optimizing Circadian and Sleep Health in Shiftwork Applications

Gena Glickman, Ph.D.
Center for Circadian Biology
University of California, San Diego
La Jolla, CA 92093

Daily and Seasonal Patterns of Light



Shiftwork

- 15 million individuals work outside regular 9-5 shift (U.S. Department of Labor)

- Increased risk of accident & injury (Folkard & Tucker, 2003)

- Myriad physiological & psychological consequences (Evans et al. 2013; Brown et al., 2009; Lawson et al., 2011)

- Compromised alertness, performance and health costs ~$200 billion annually (Kerin & Aguirre, 2005)

- Limited practical solutions

What causes the harm?

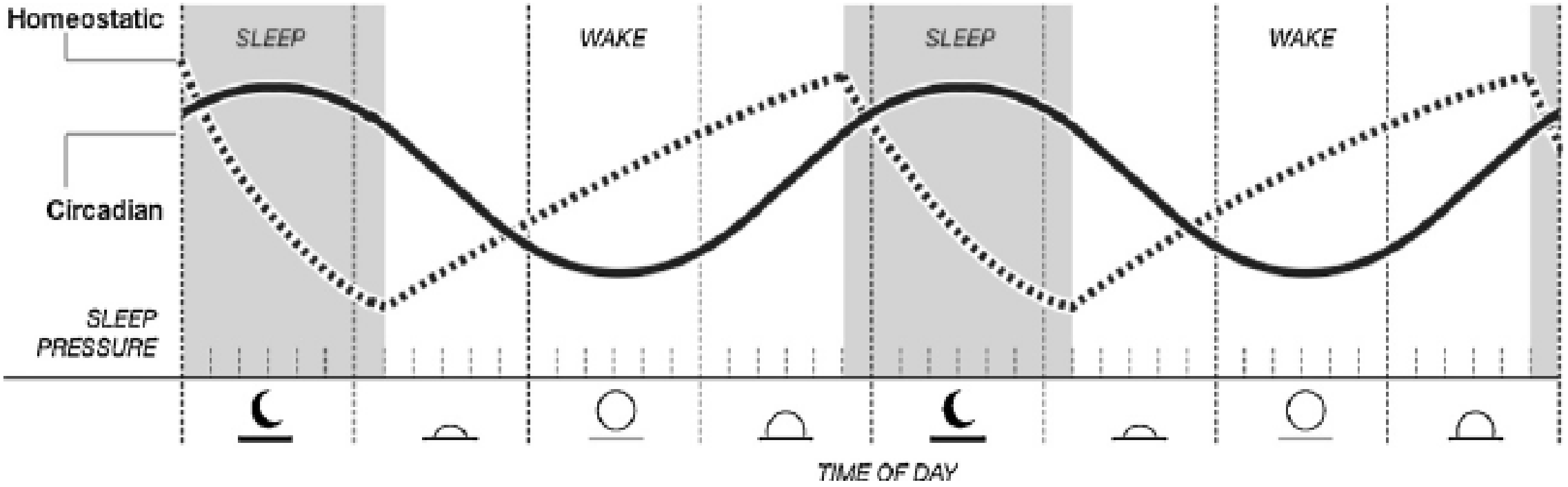
Three interconnected processes interact in the shiftworker:

- Circadian misalignment

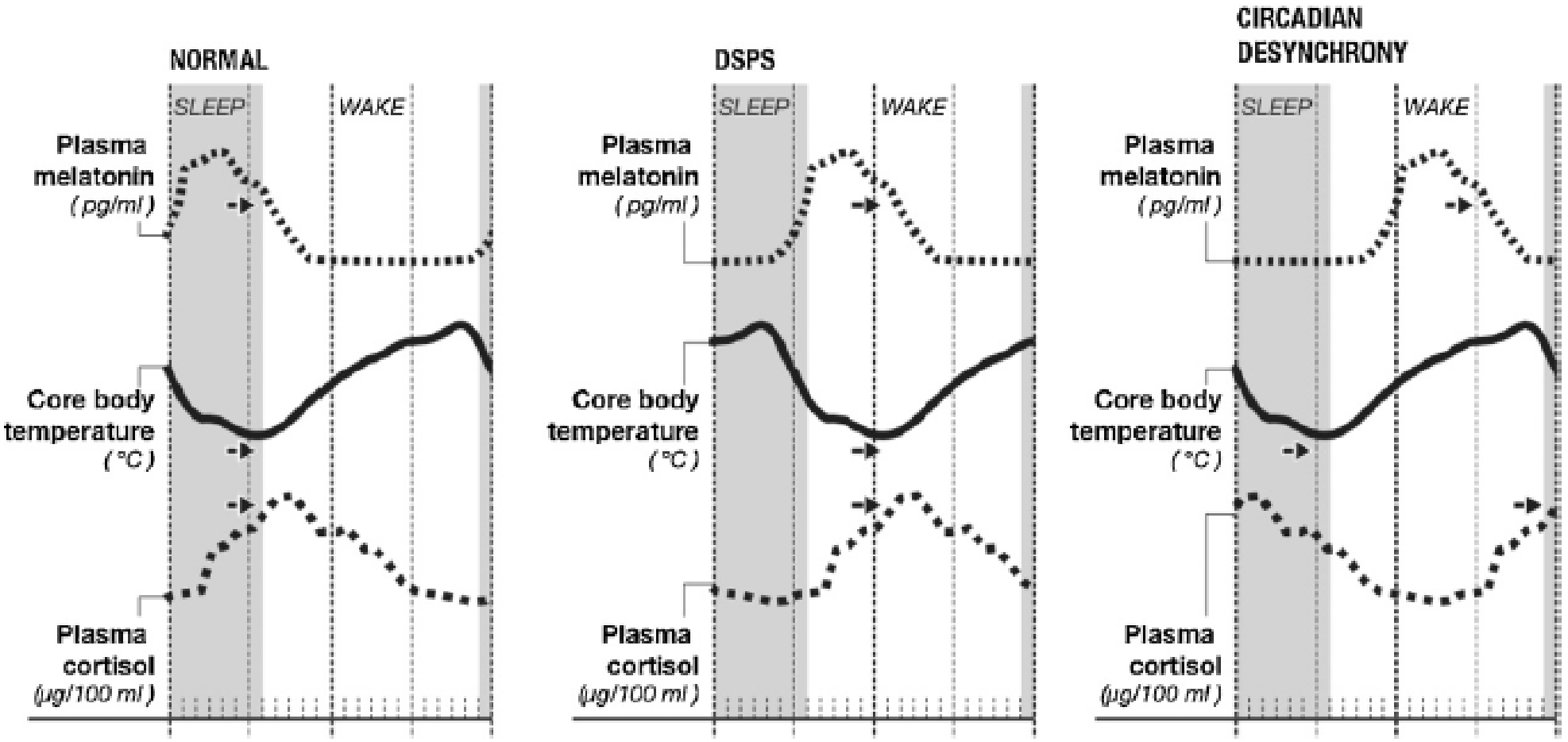
- Sleep deprivation

- Light at night

Two-Process Model of Sleep Regulation



Circadian Rhythms and Disturbances



Lighting Countermeasures for Shiftworkers

- Facilitate circadian adjustment

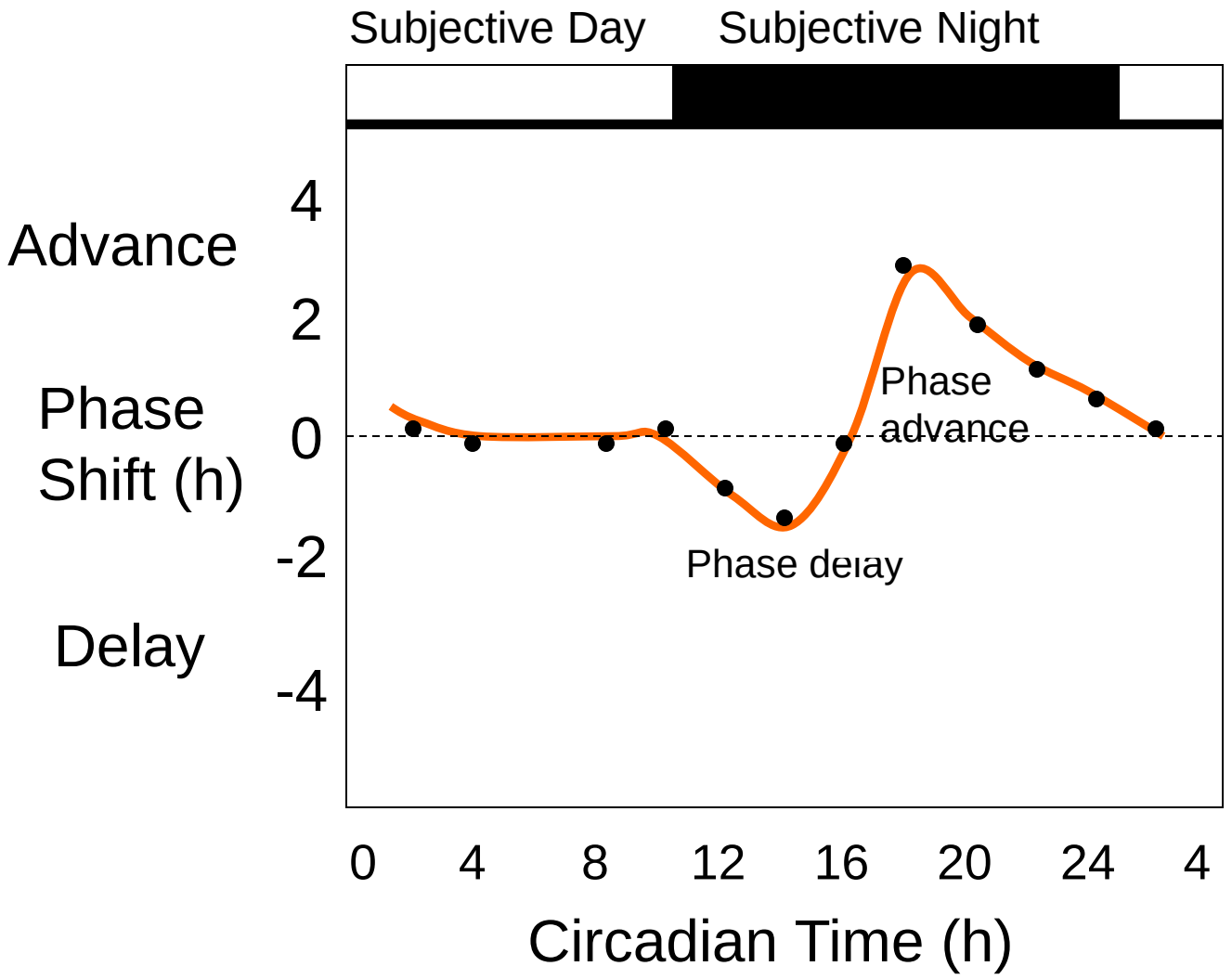
- Increase alertness/performance on-shift

- Increase sleep duration/quality

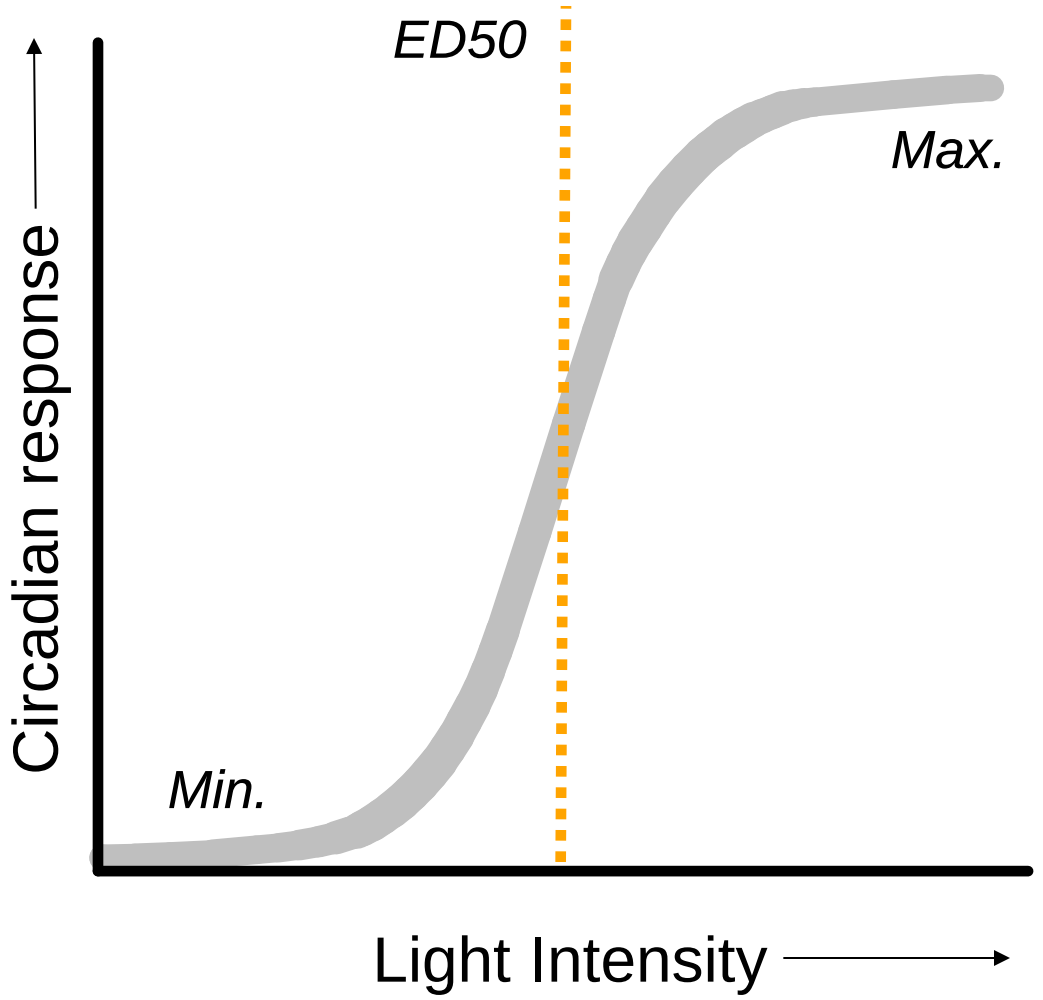
Elements Mediating the Effects of Light

- Timing
- Intensity
- Wavelength
- Duration
- Continuous/intermittent
- Directionality
- History/context

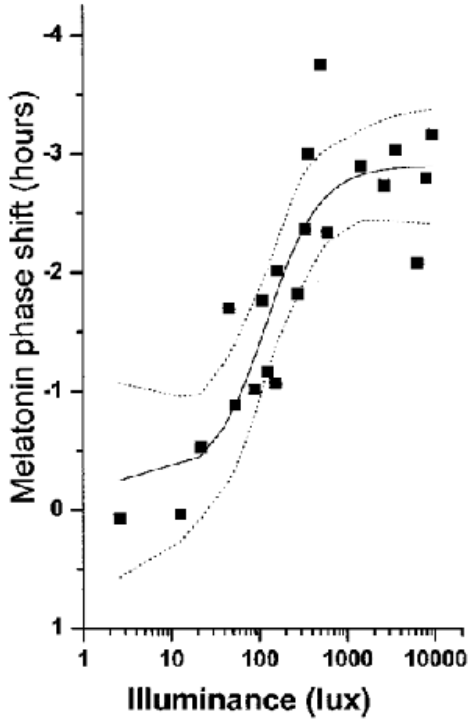
Circadian Effects of Light Depend on Timing

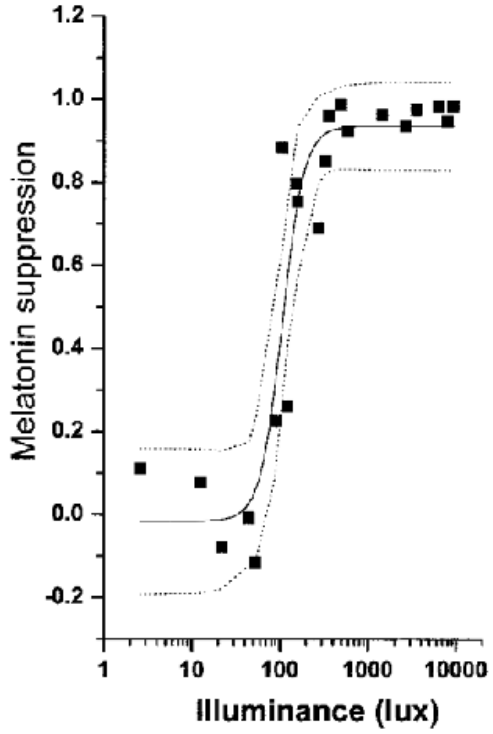


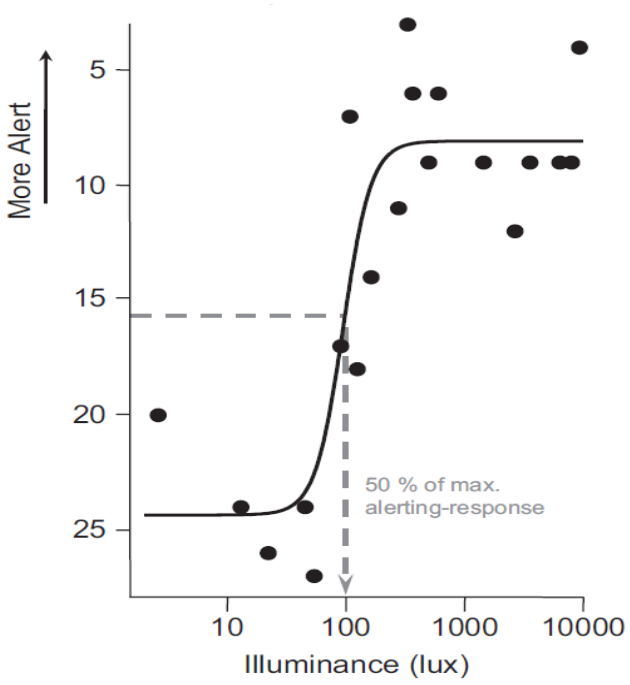
Dose-Response Function



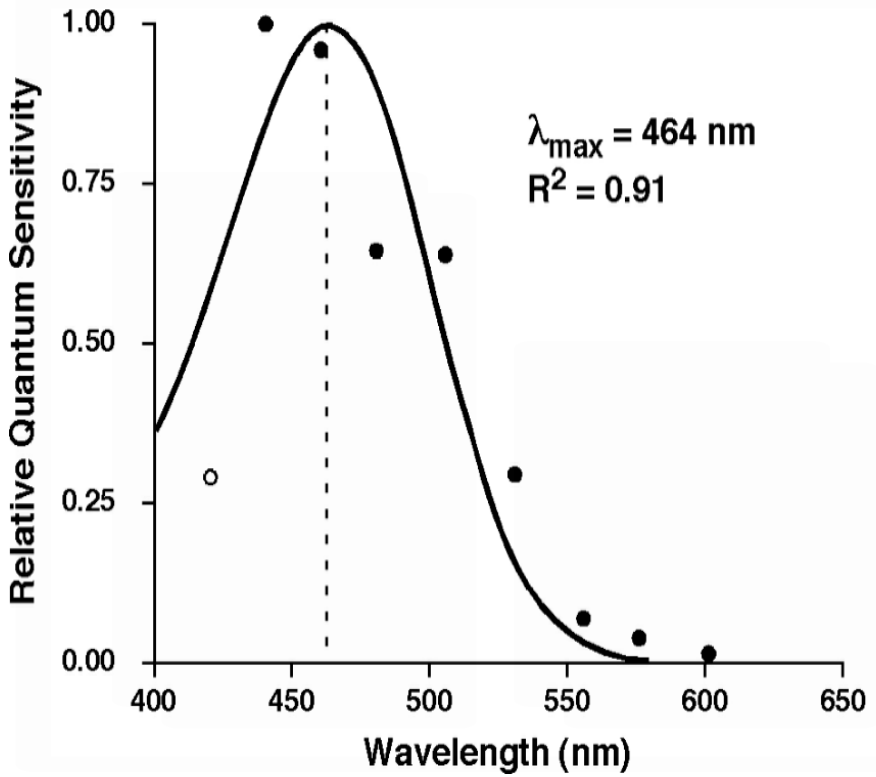
Dose Response for Biological Effects of Light

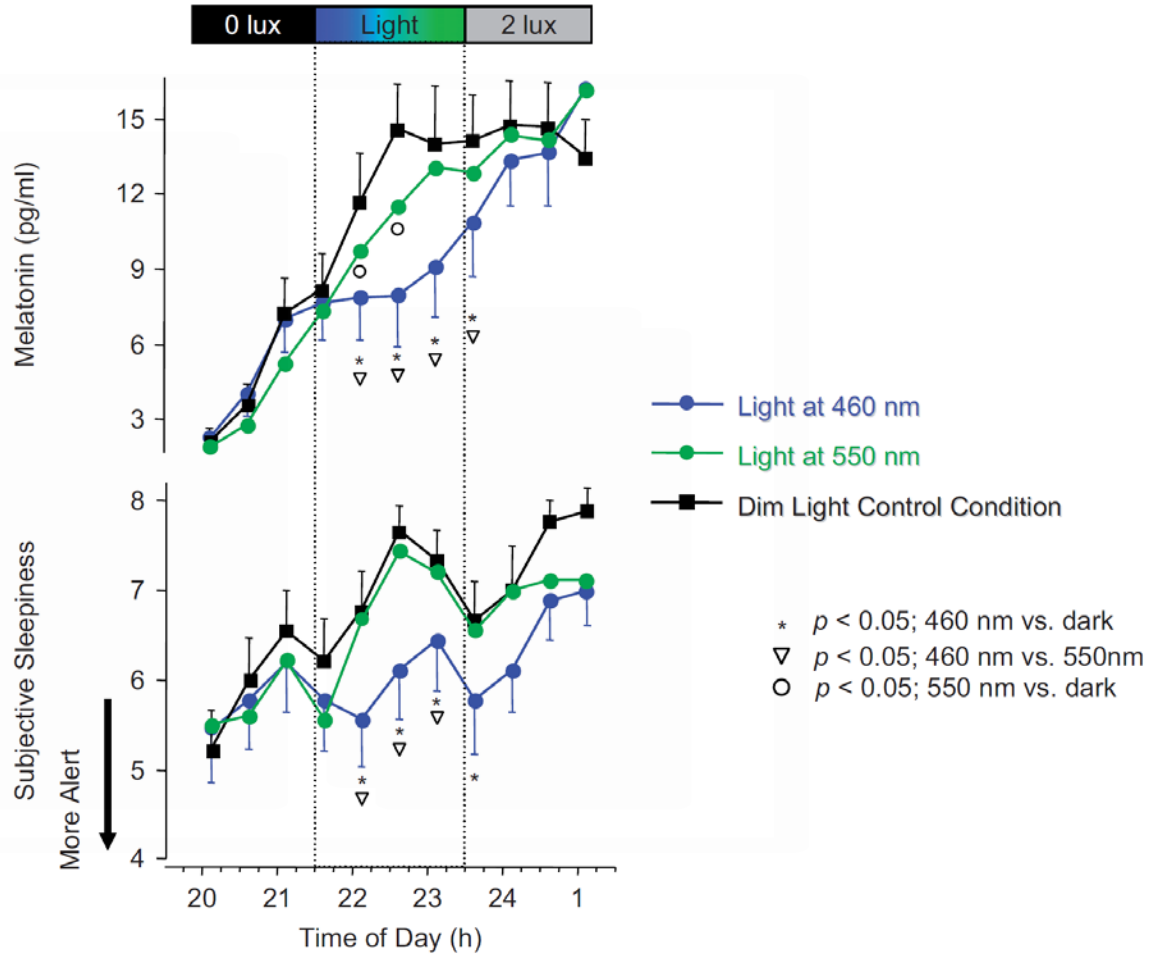






Biological Responses to Light Depend on Wavelength





Mediating Effects May Vary by Light Response

- Timing
- Intensity
- Wavelength
- Duration
- Continuous/intermittent
- Directionality
- History/context

American College of Emergency Physicians®
ADVANCING EMERGENCY CARE

Circadian Rhythms and Shift Work

Policy Resource and Education Paper (PREP), 2010

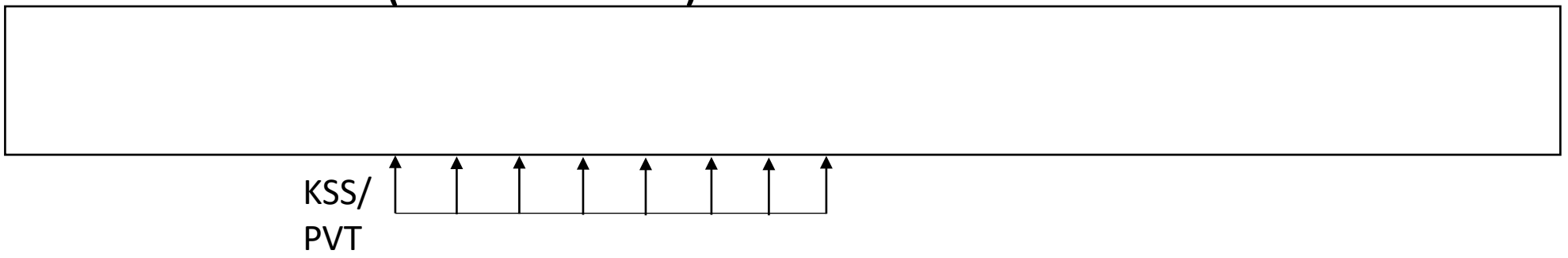
- "the single most important reason given for premature attrition from the field."
- Lack of guidance:

"Shifts should be scheduled, whenever possible, in a manner consistent with circadian principles. For most settings, scheduling isolated night shifts or relatively long sequences of night shifts is recommended."

Baseline assessment of sleep and circadian health in shiftworkers

Natural light patterns

Baseline assessment (2 weeks in N=30)



Study data:

Continuous actigraphy + photosensors, daily sleep diaries

Saliva, PVT, KSS, WHO HPQ, QLI, communication

Radiometric measurements

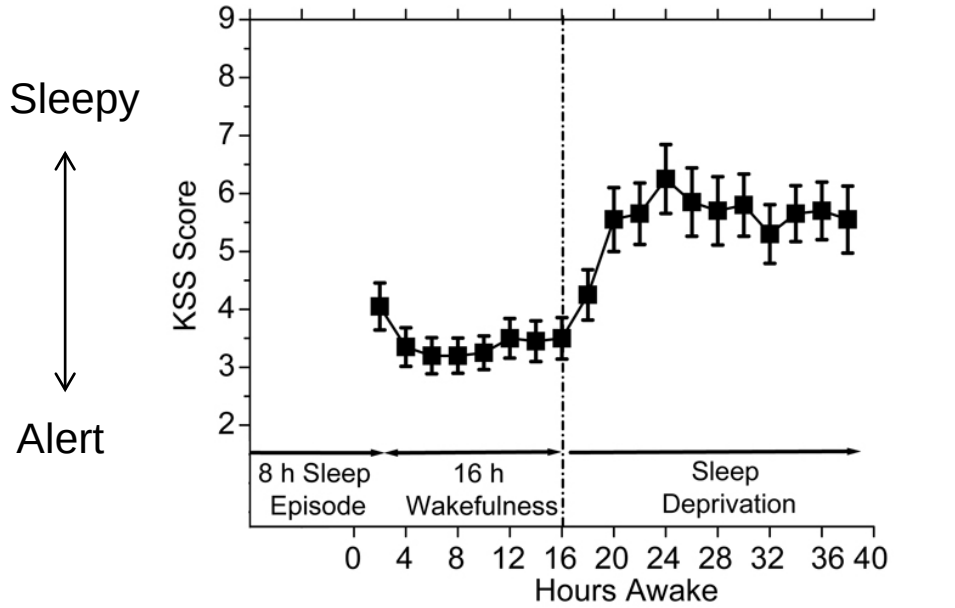
Actigraphy

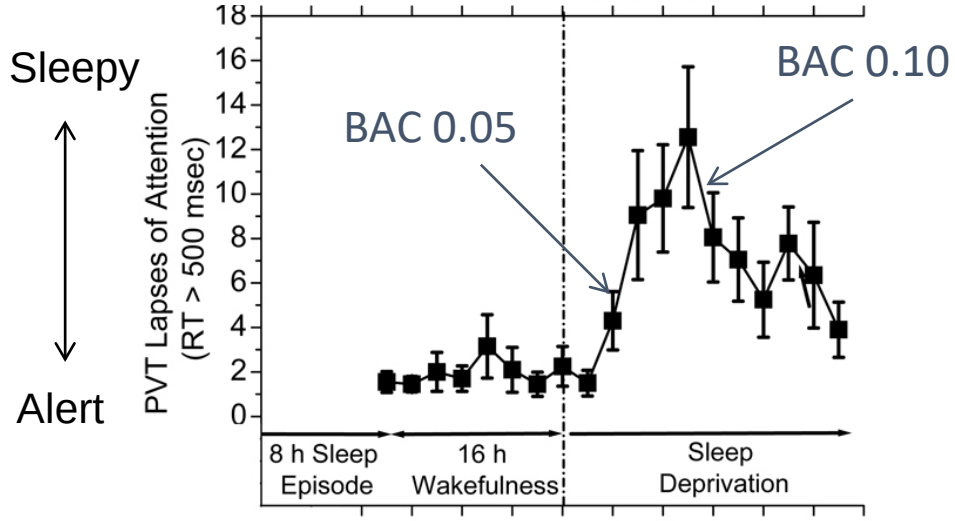
Real-time Assessment

Real-time Subjective Measures:
Karolinska Sleepiness Scale (KSS):

On a scale from 1 to 9, how alert do you feel?

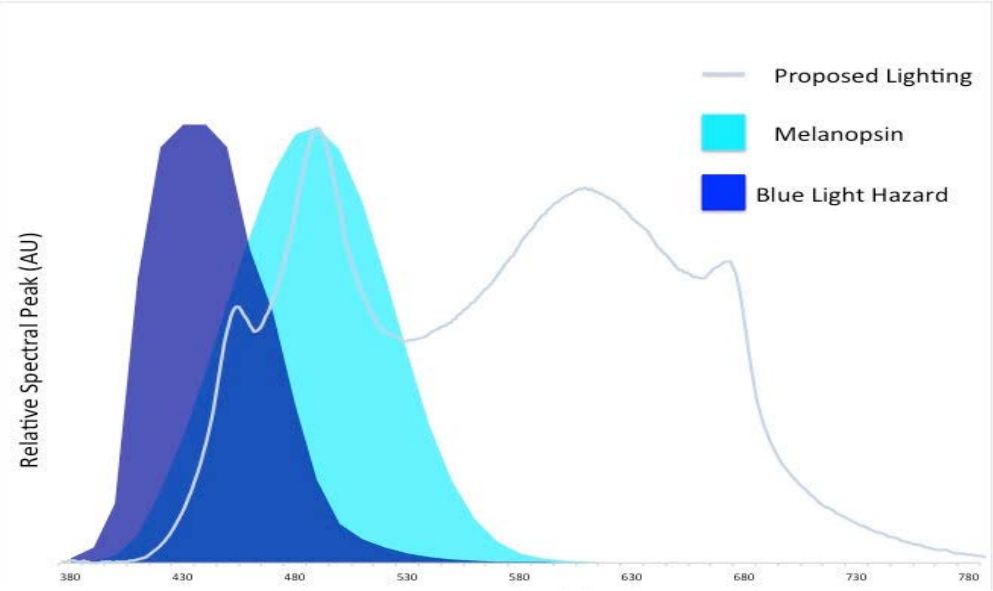
Real-time Objective Measures:
Psychomotor Vigilance Task (PVT)



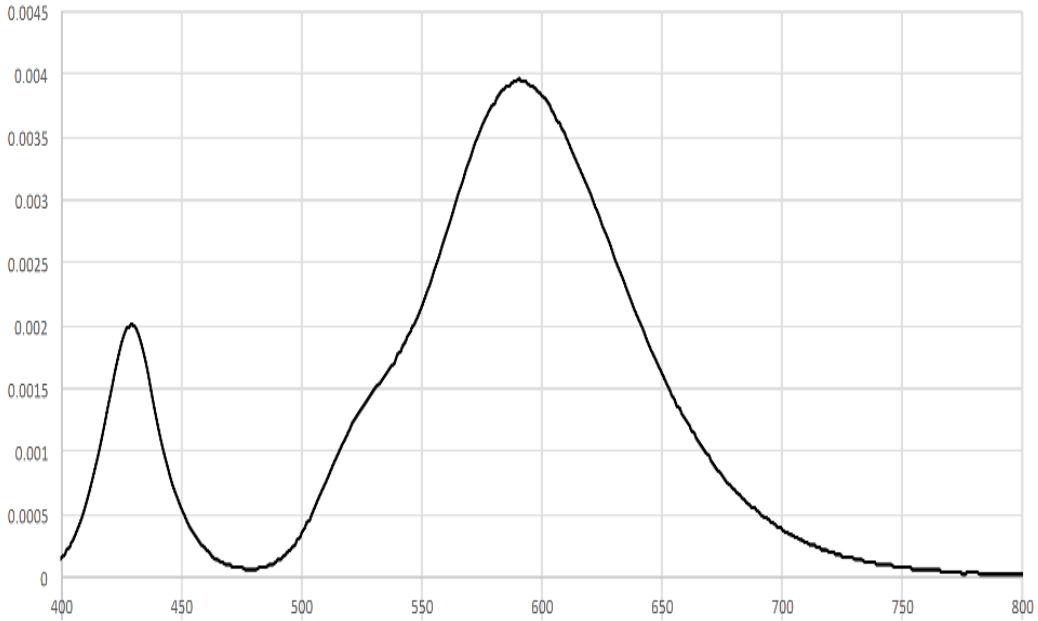


Van Dongen et al. *Sleep* (2003)

BIOS Skyblue, architectural

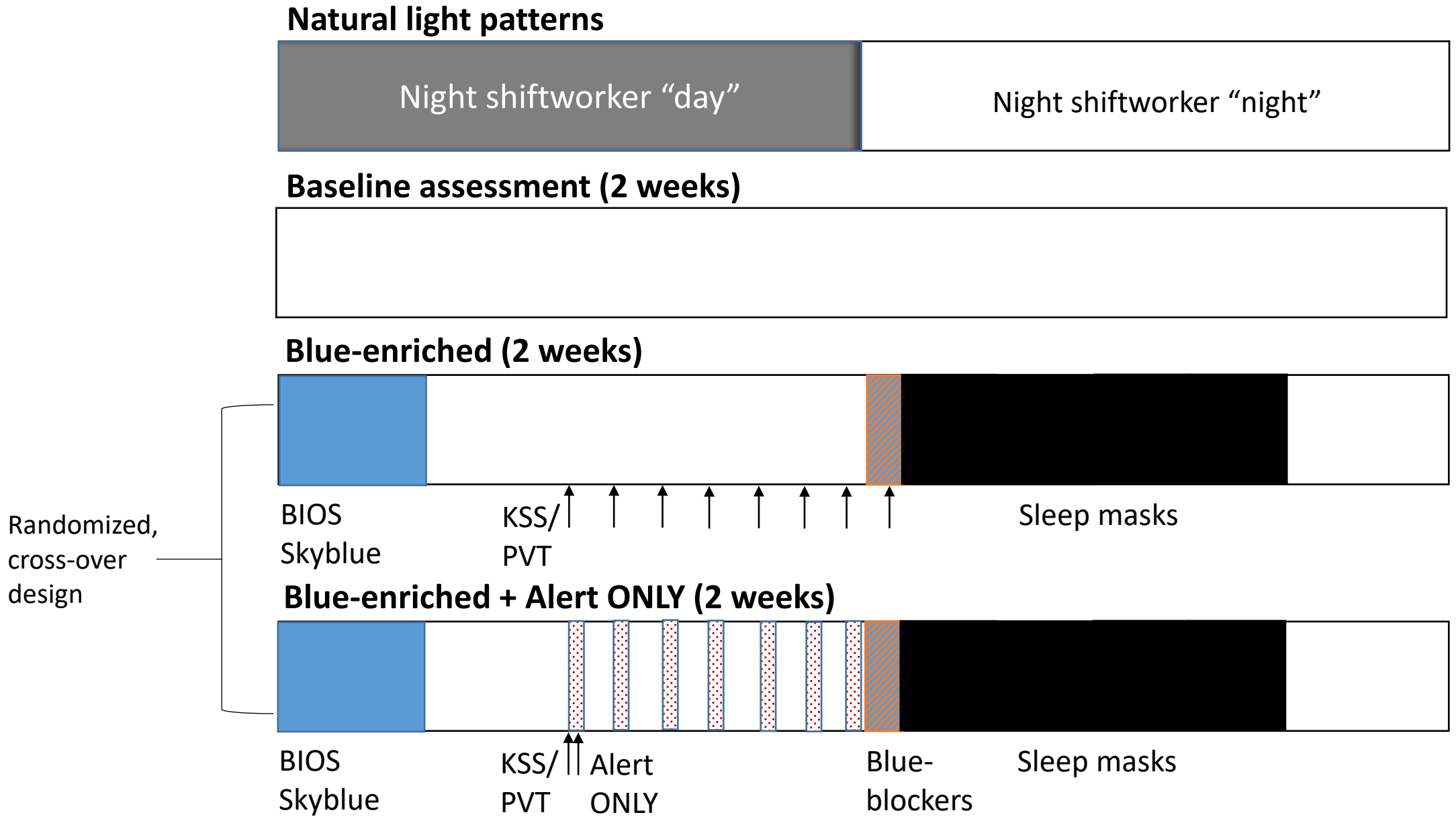


Alert ONLY, individual



Light Source	CCT (K)	Melanopic lux (m-lux)	Photopic lux (lux)	m-lux/lux	CRI
LA sky at 2 PM	5107	1.12e+3	662	1.69	100
3500K fluorescent	3562	50.4	100	0.504	75.2
BIOS Skyblue	3483	93	100	0.931	84.26
Alert ONLY	TBD	~30	100	~0.30	>80

Establish the efficacy of novel lighting strategies for optimizing circadian health, sleep and performance



Key Features of this Novel Lighting Intervention

Combines two evidence-based lighting interventions for two different light responses:

Circadian health- Carefully timed, BIOS 3500k light source; use of blue-depleted Alert ONLY light closer to desired sleep times; real-time assessment of need; blue-blockers and sleep masks

Alerting/safety- Light for alerting, but only in those with KSS >6 and/or increased RT on PVT

Minimizes light at night- BIOS Alert ONLY, based on need; blue blockers and sleep masks

Our Team

UCSD
Michael Gorman
Liz Harrison

BIOS
Robert Soler
Sean Wegart

flux
Michael Herf
Lorna Herf

Department of Energy
Brian Dotson
Robert Davis
Morgan Pattison