

Academy of Architecture for Health On-line Professional Development

Research to Practice | Lighting for Improved Environment of Care Masters Studio Series

Tuesday, October 11, 2016

2:00 pm – 3:00 pm ET

1:00 pm – 2:00 pm CT

12:00 am – 1:00 pm MT

11:00 am – 12:00 pm PT

Moderator

John Kreidich

McCarthy Building Companies

Presenters

Mary Alcaraz, PE, LC, CEM, LEED BD + C, Senior Project Manager

The Children's Hospital of Philadelphia

Edward Clark, LEED AP BD + C, Sustainable Designer

ZGF Architects LLP

Karyn Gayle, MIES, EDAC, Vice President, Healthcare

Acuity Brands

Mariana Figueiro, PH.D., FIES, Professor & Program Director

Lighting Research Center – Rensselaer Polytechnic Institute



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Academy of Architecture for Health (AAH) On-line Professional Development

The Academy's multi-channel on-line approach provides emerging professionals, journeymen, and master professionals with convenient and economical opportunities to develop their chosen area of interest.

Masters Studio Series sessions are tailored to provide healthcare design professionals with sufficient exposure to jump-start interest in wanting to learn more.



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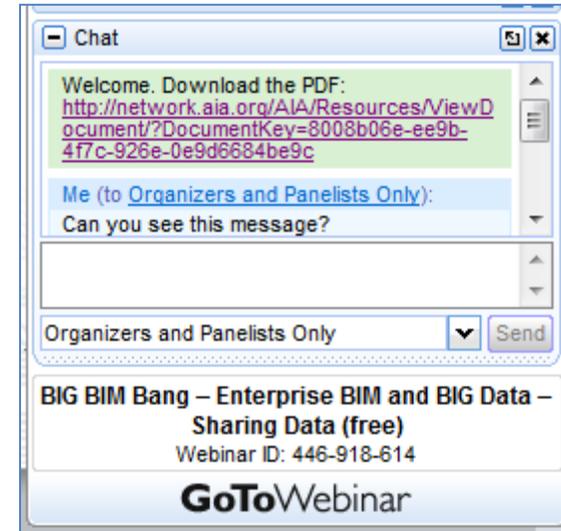
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Submit a question to the moderator via the chat box.



Content-related questions will be answered during the Q&A portion as time allows.

Tech support questions will be answered by AIA staff promptly.



The Presenters:

- **Karyn Gayle, MIES, EDAC, Vice President, Healthcare**
Acuity Brands
- **Mary Alcaraz, PE, LC, CEM, LEED BD + C, Senior Project Manager**
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Light Basics

Karyn Gayle EDAC, MIES
Vice President, Healthcare
Acuity Brands



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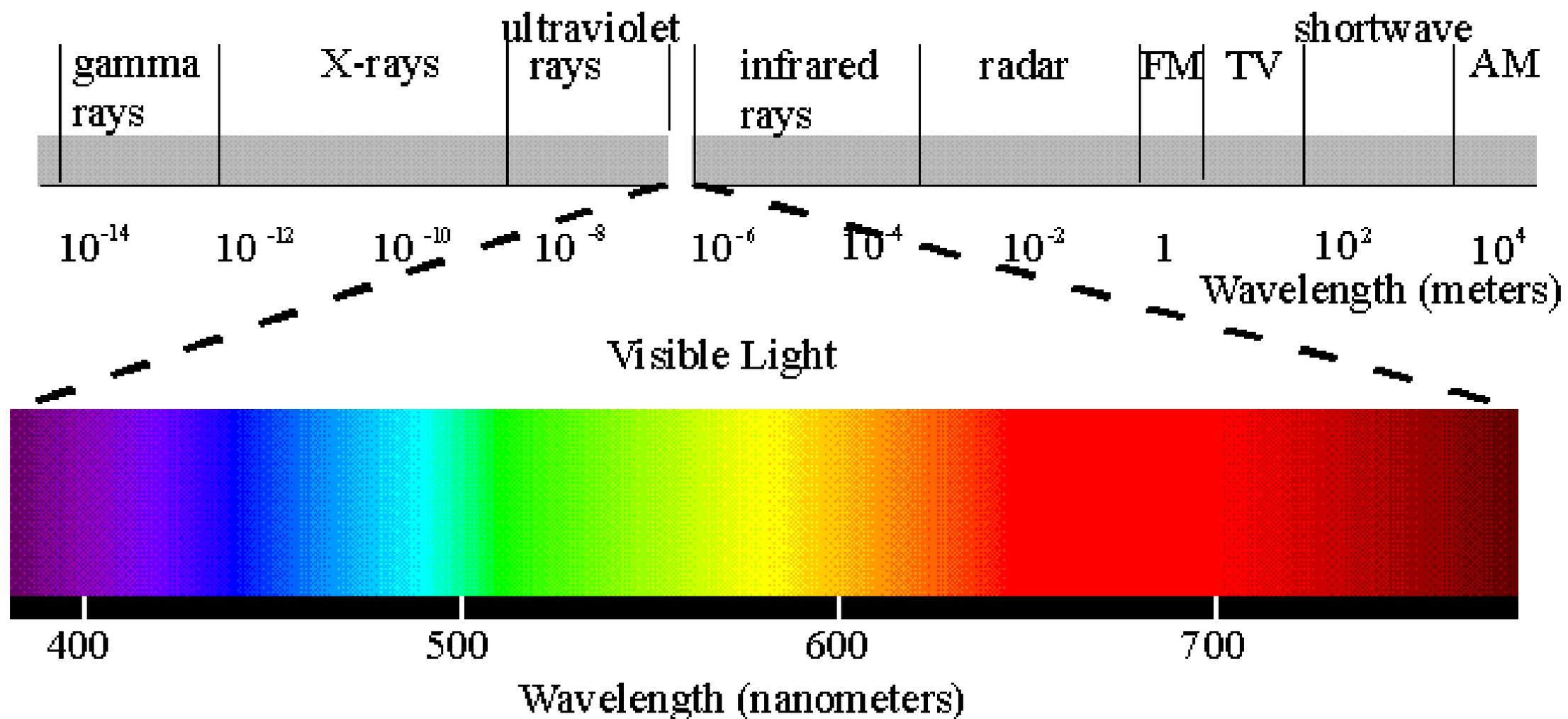
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A

The Science of Color Perception



Electromagnetic Spectrum



Light is Only Visible When it React with a Surface

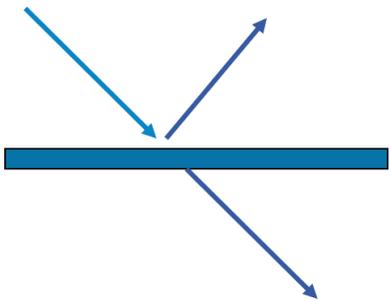
**When light hits an object
it can be:**

Reflected (ρ)

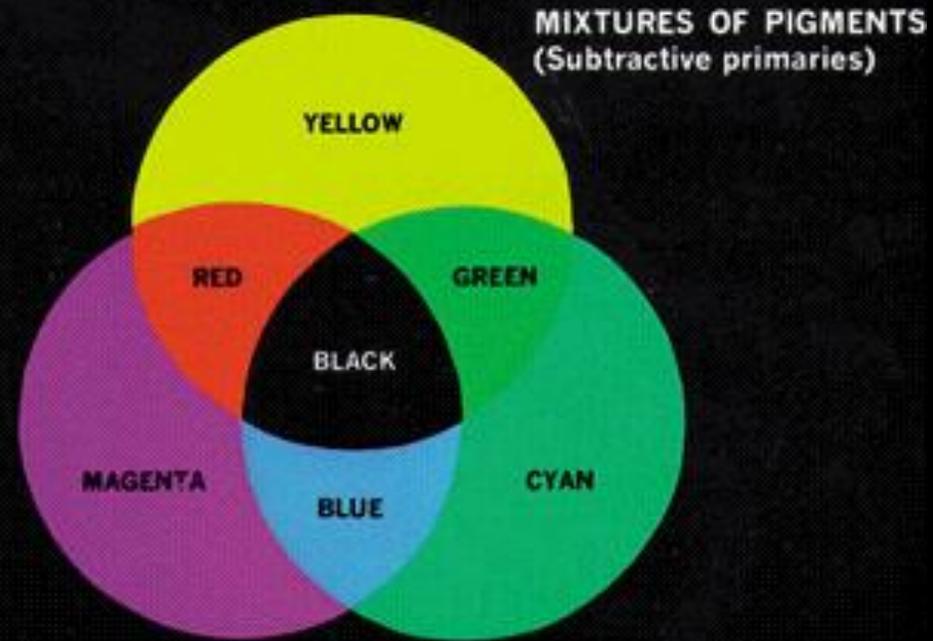
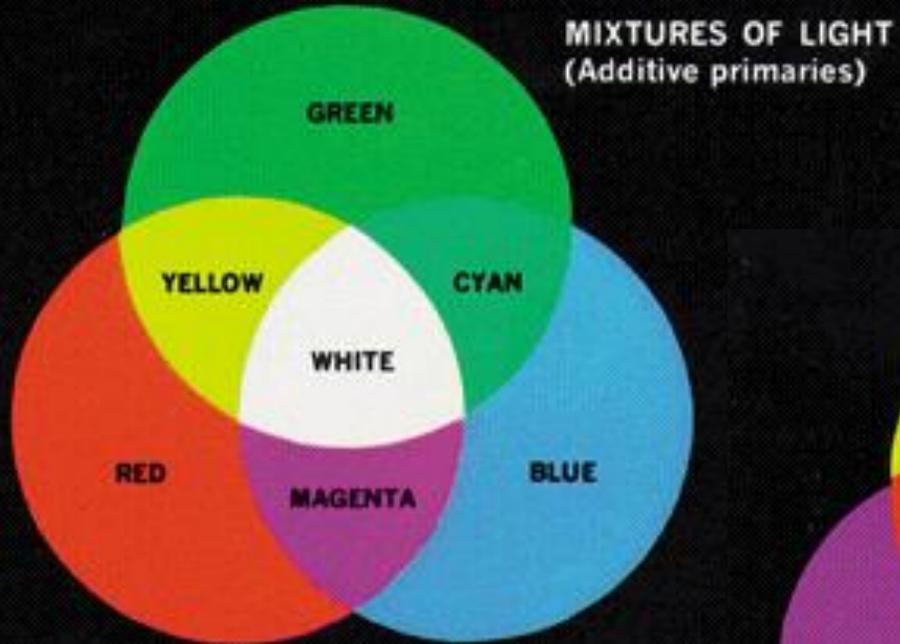
Transmitted (τ)

Absorbed (α)

$$\rho + \tau + \alpha = 100\%$$



Color Theory

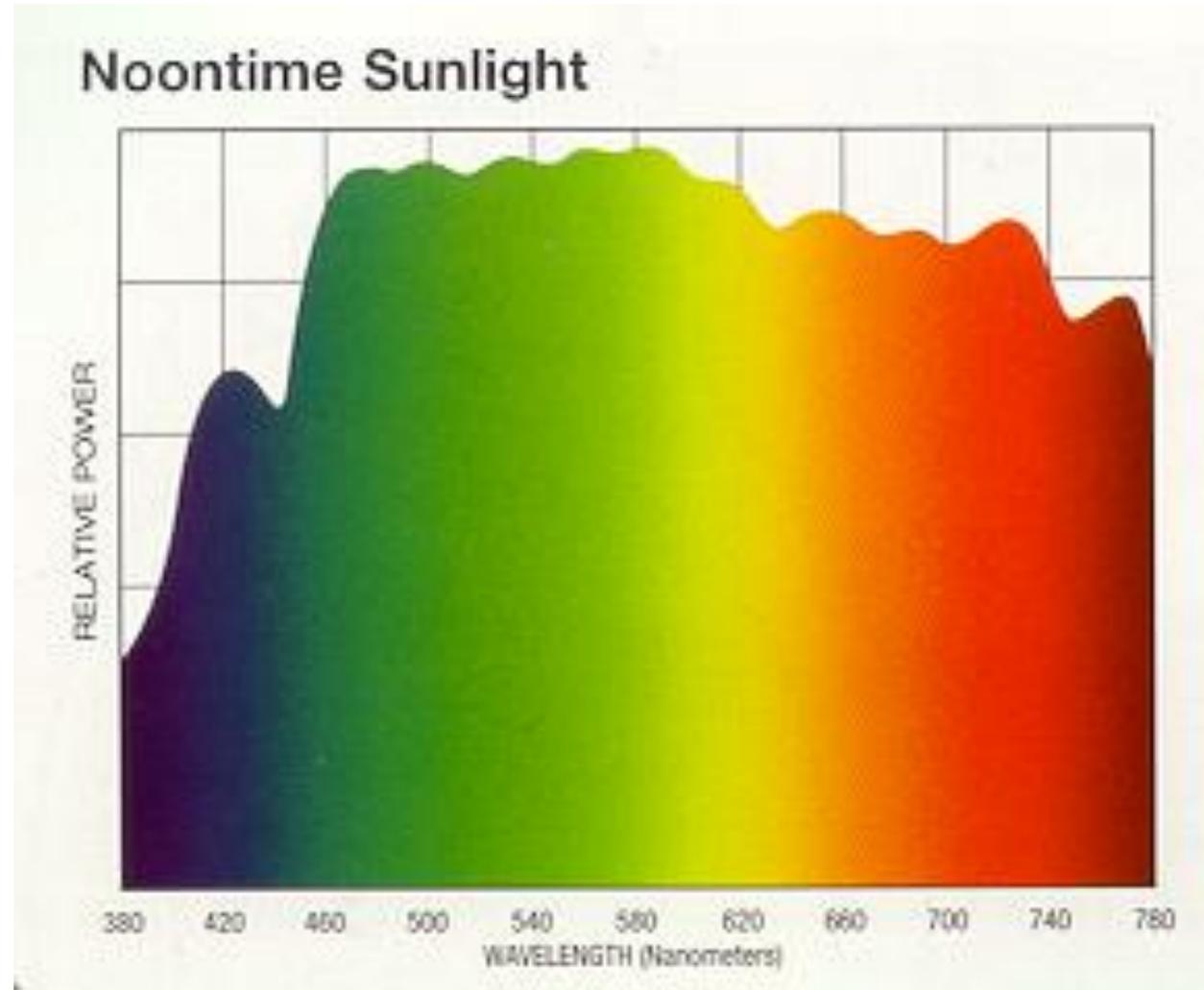


Primary Colors

Additive & Subtractive

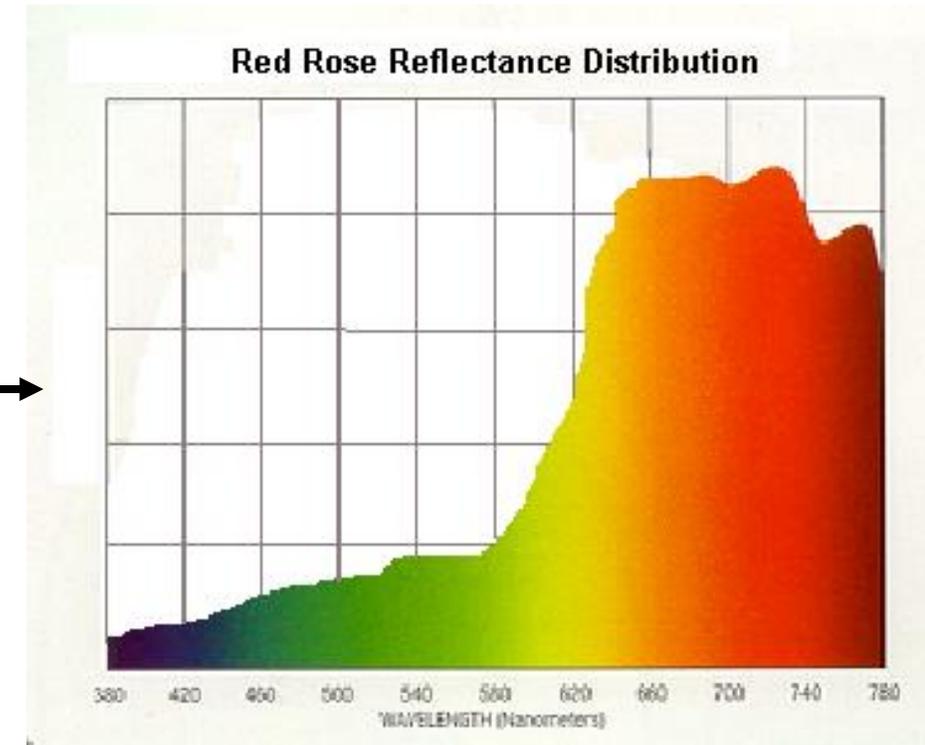


Spectral Power Distribution



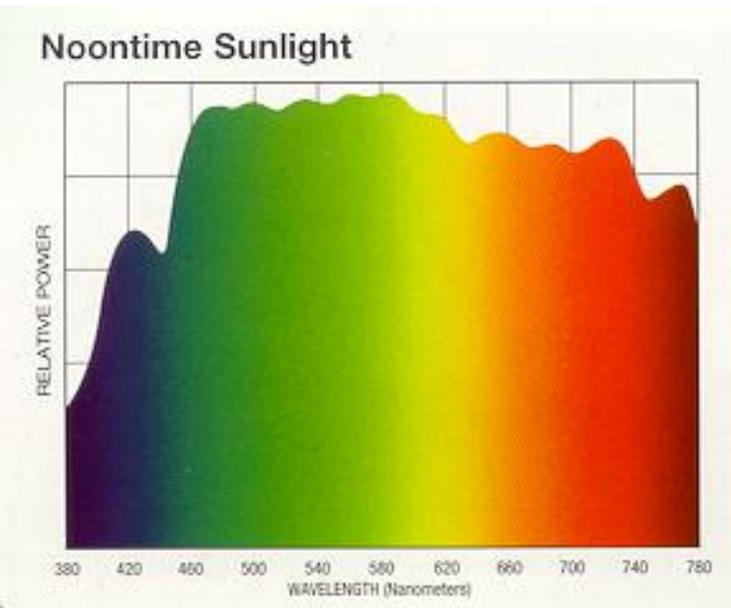
Objects and Light

Similar to a source emitting light, an object has a Spectral Reflectance Distribution

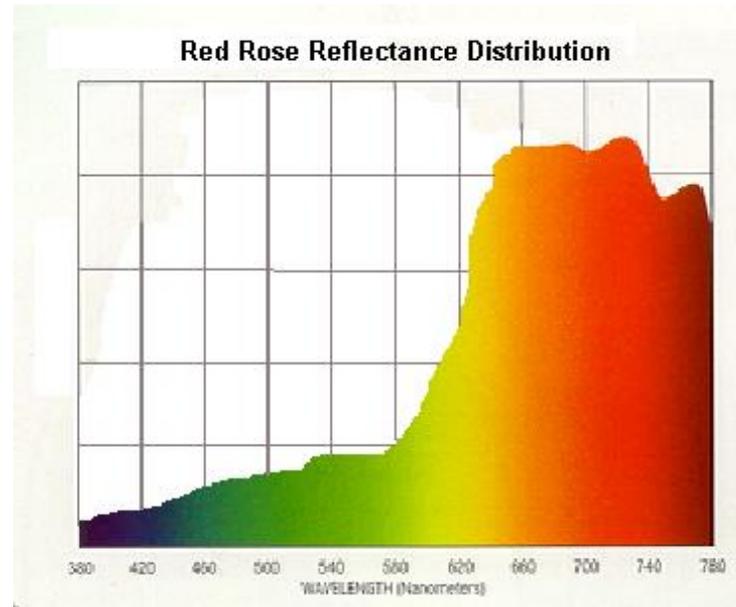


Objects and Light

The combination of the Spectral Power Distribution of the source and the Spectral Reflectance Distribution of the object determines the color the object appears.



X



=

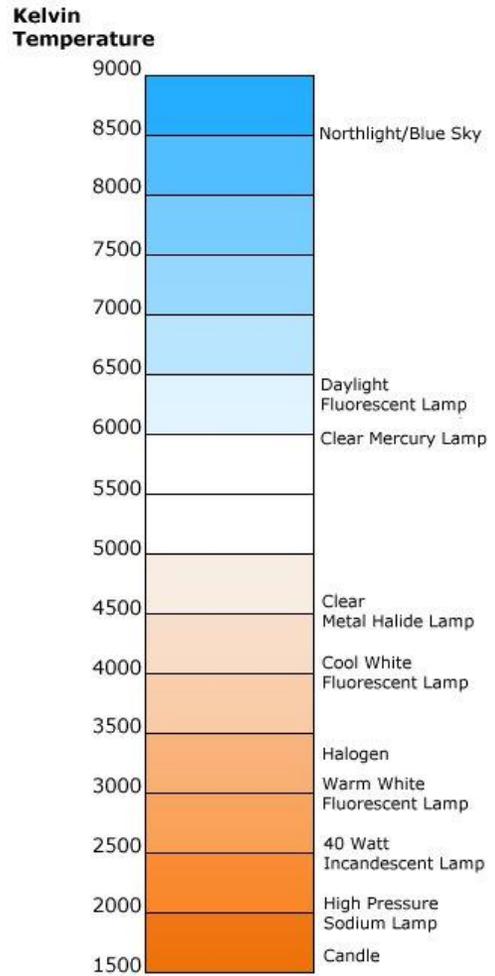


B

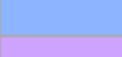
How to Evaluate Color Quality

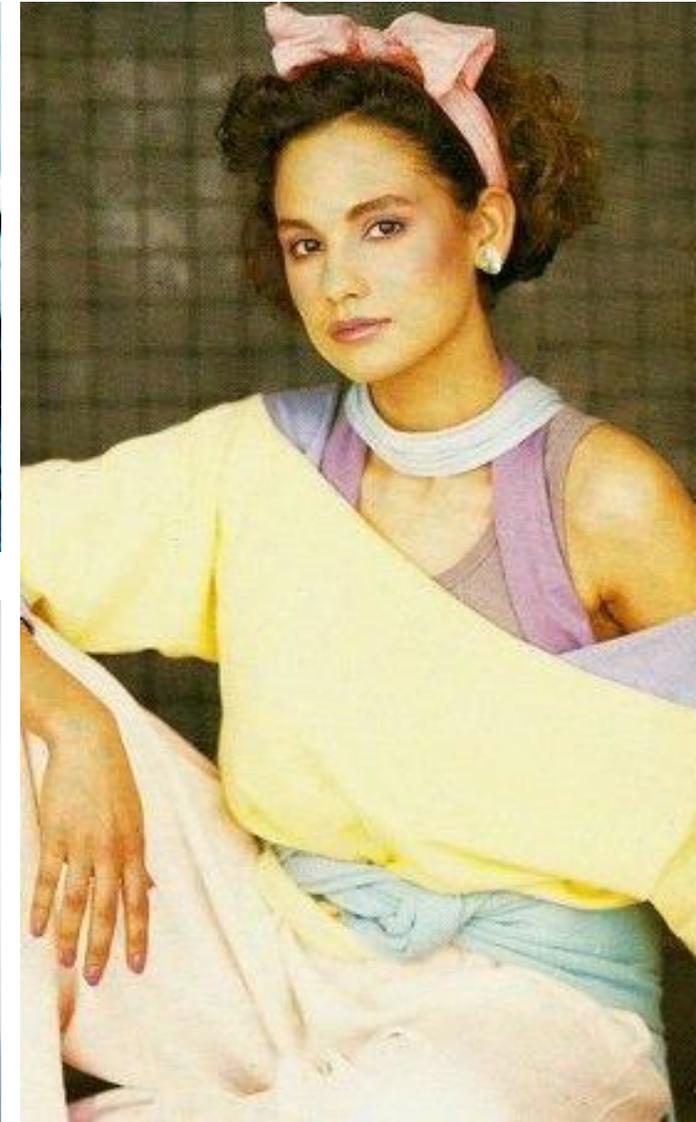


Correlated Color Temperature (CCT)



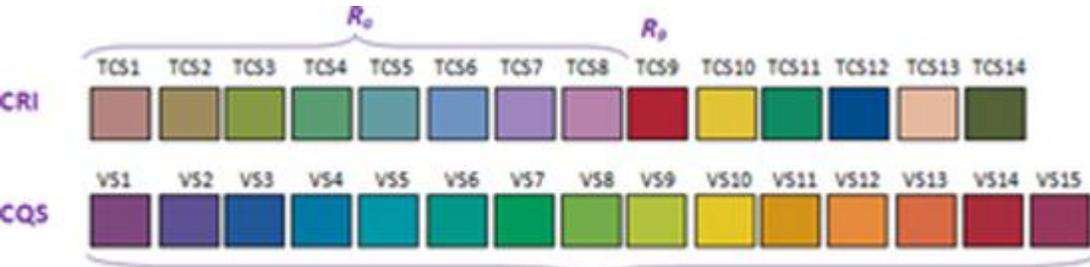
Color Rendering Index (CRI), Explained

Name	Appr. Munsell	Appearance under daylight	Swatch
TCS01	7,5 R 6/4	Light greyish red	
TCS02	5 Y 6/4	Dark greyish yellow	
TCS03	5 GY 6/8	Strong yellow green	
TCS04	2,5 G 6/6	Moderate yellowish green	
TCS05	10 BG 6/4	Light bluish green	
TCS06	5 PB 6/8	Light blue	
TCS07	2,5 P 6/8	Light violet	
TCS08	10 P 6/8	Light reddish purple	
TCS09	4,5 R 4/13	Strong red	
TCS10	5 Y 8/10	Strong yellow	
TCS11	4,5 G 5/8	Strong green	
TCS12	3 PB 3/11	Strong blue	
TCS13	5 YR 8/4	Light yellowish pink (skin)	
TCS14	5 GY 4/4	Moderate olive green (leaf)	
TCS15	1 YR 6/4	Asian skin	

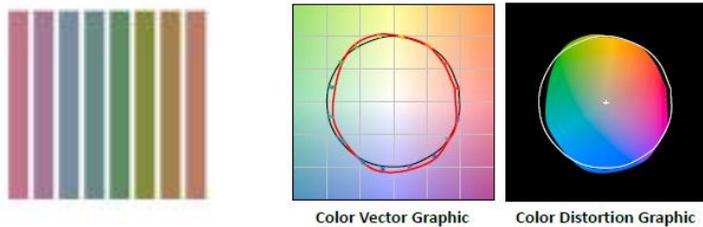
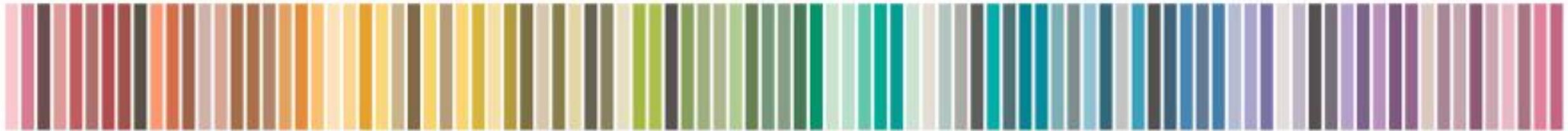


New Approaches to Color Quality Metrics

Color Quality Scale (CQS) – Color Fidelity



Proposed TM-30 – Color Fidelity (R_f) and Gamut/Saturation (R_g)



Courtesy of IES



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Courtesy of Arch Lighting
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CIE Diagram

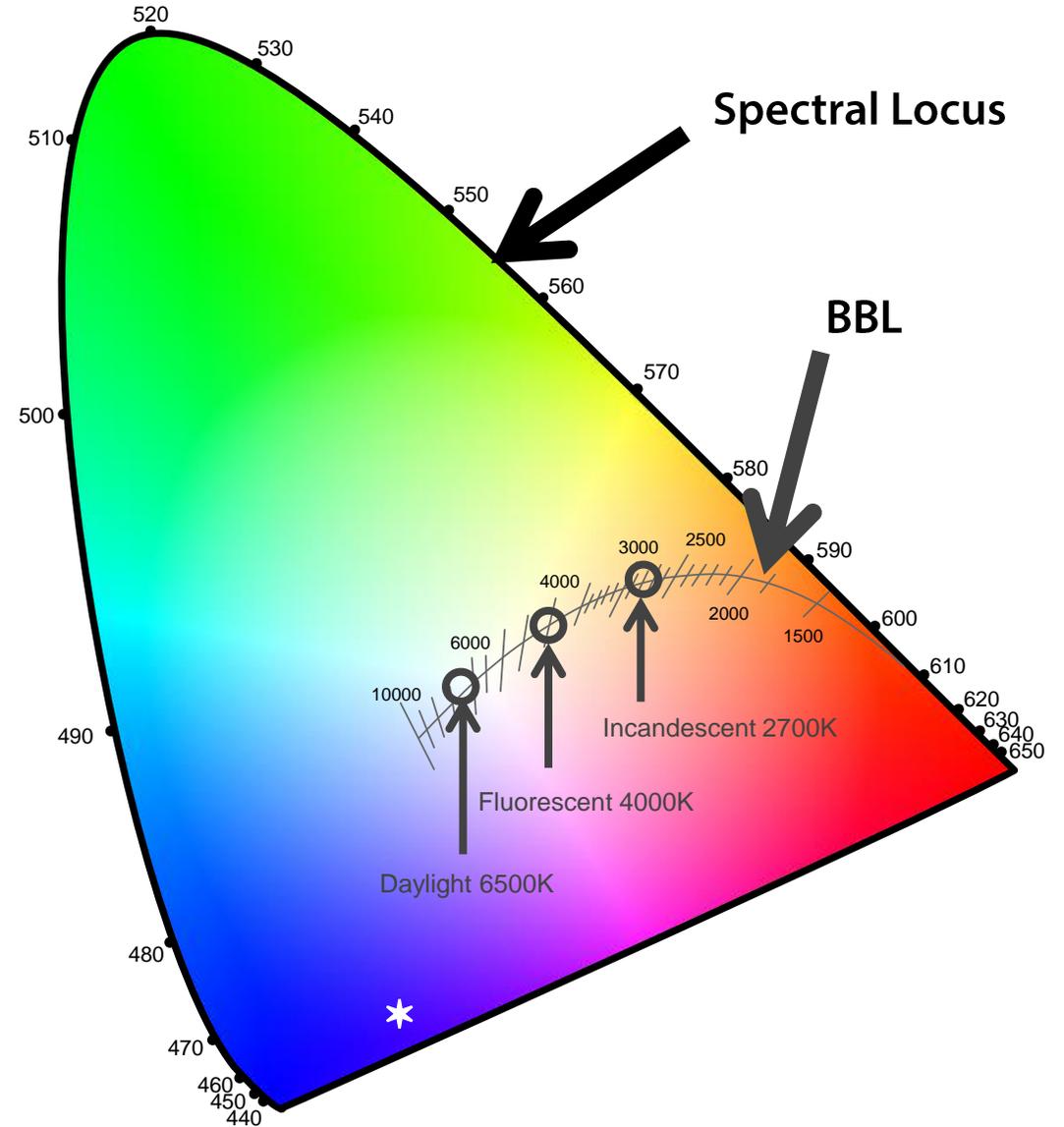
1931 Color Space

Outer edge shows the limits of our color sensitivity (Spectral Locus)

The curved line is the “black body curve” representing the different definitions of white light

White shades are shown on the Black Body Curve/Locus (BBL), measured in Correlated Color Temperature (CCT)

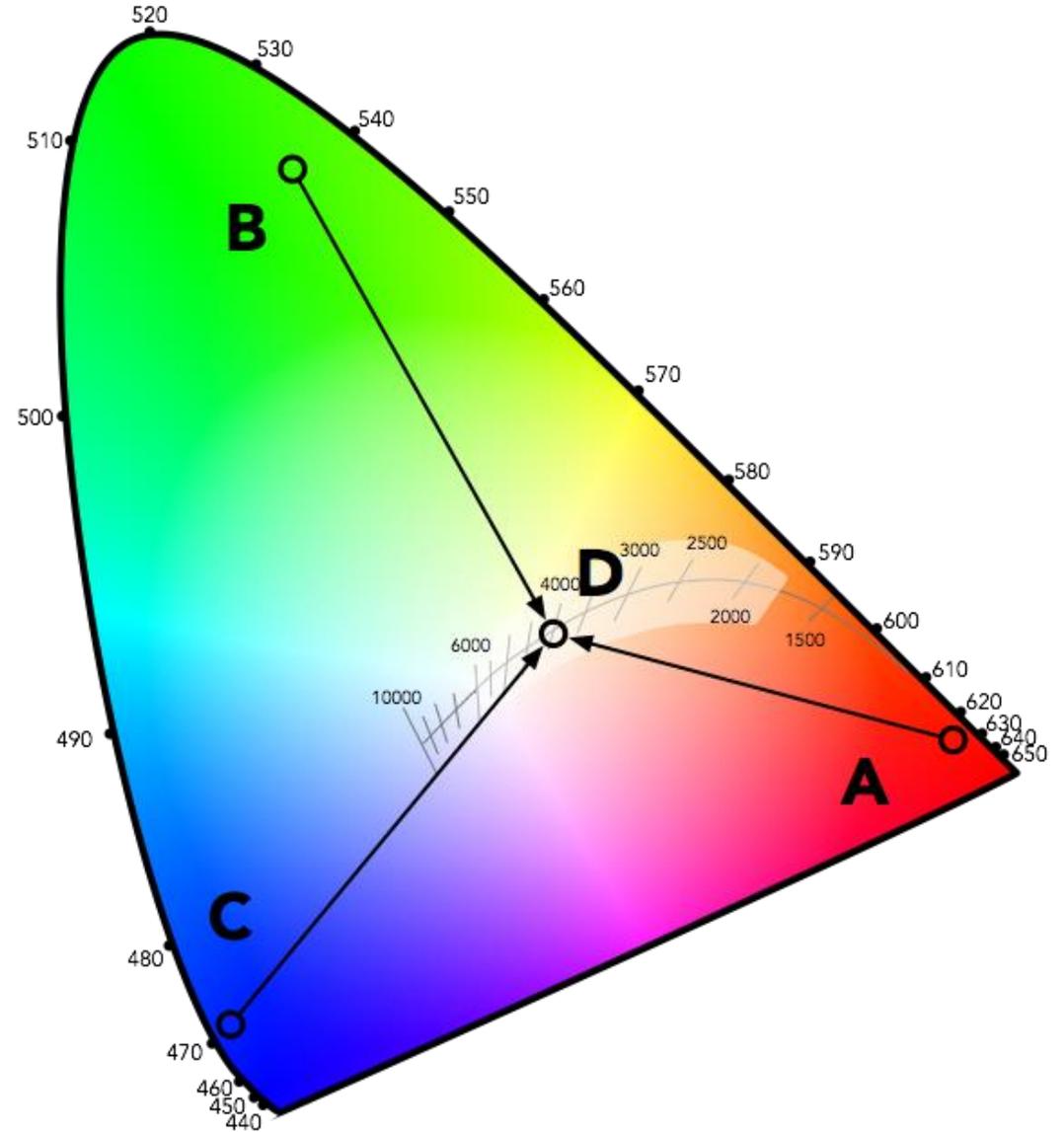
Pink or green tints of white are measured in Delta uv (Duv)



Color is Additive

$$R + B + G = \text{“White”}$$

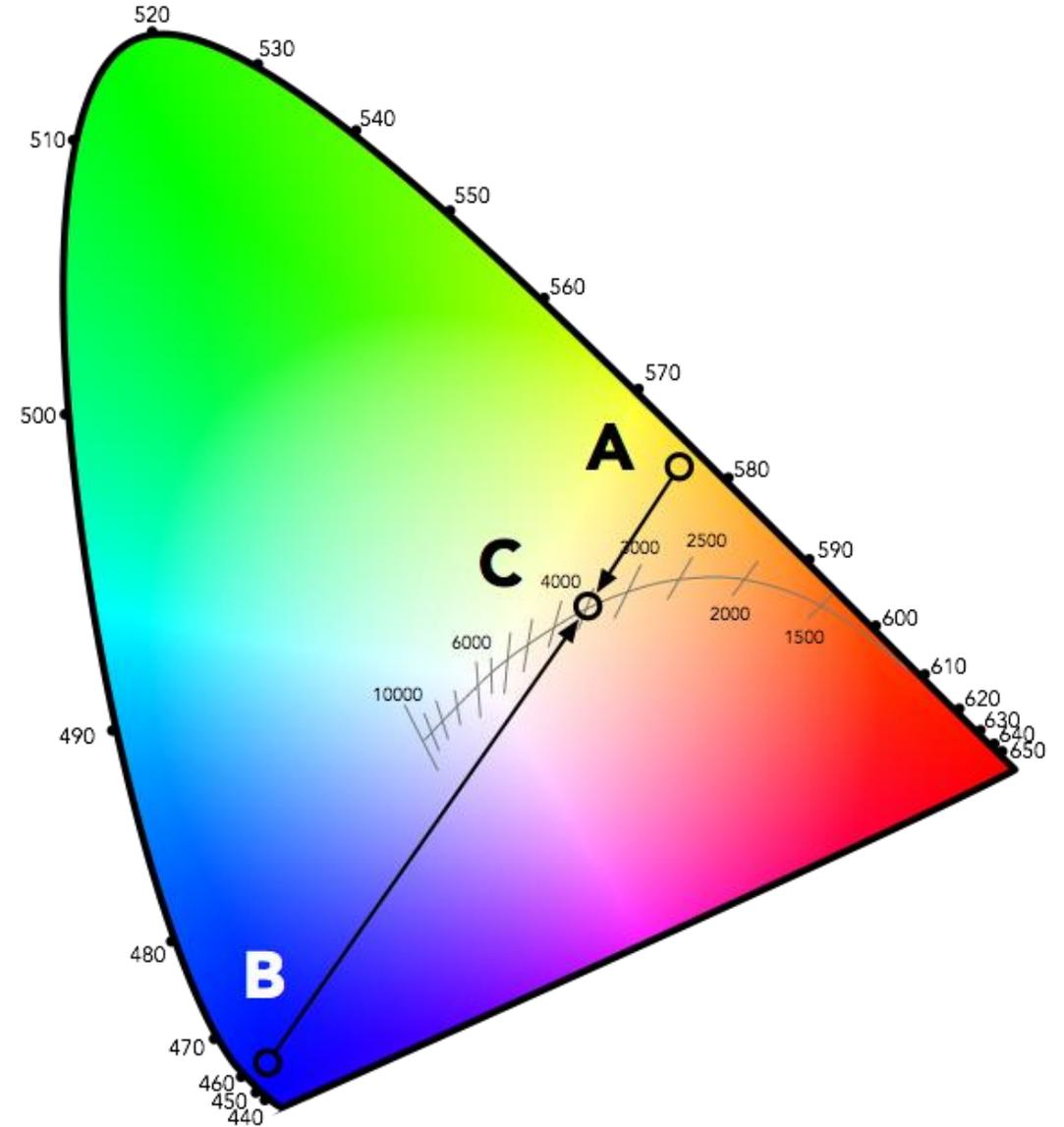
Light colors are additive, so adding Red, Green, and Blue gives you some shade of white



Color is Additive

B + Y = "White"

Blue plus Yellow gives you
some shade of white



Agenda

MARY ALCARAZ

01 Through a Patient's Eyes

MARIANA FIGUEIRO

02 More than Meets the Eye

KARYN GAYLE

03 Guiding Light

ED CLARK

04 Seeing the Light



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Through a Patient's Eyes

Mary Alcaraz PE, LC, CEM, LEED BD+C

Senior Project Manager

The Children's Hospital of Philadelphia



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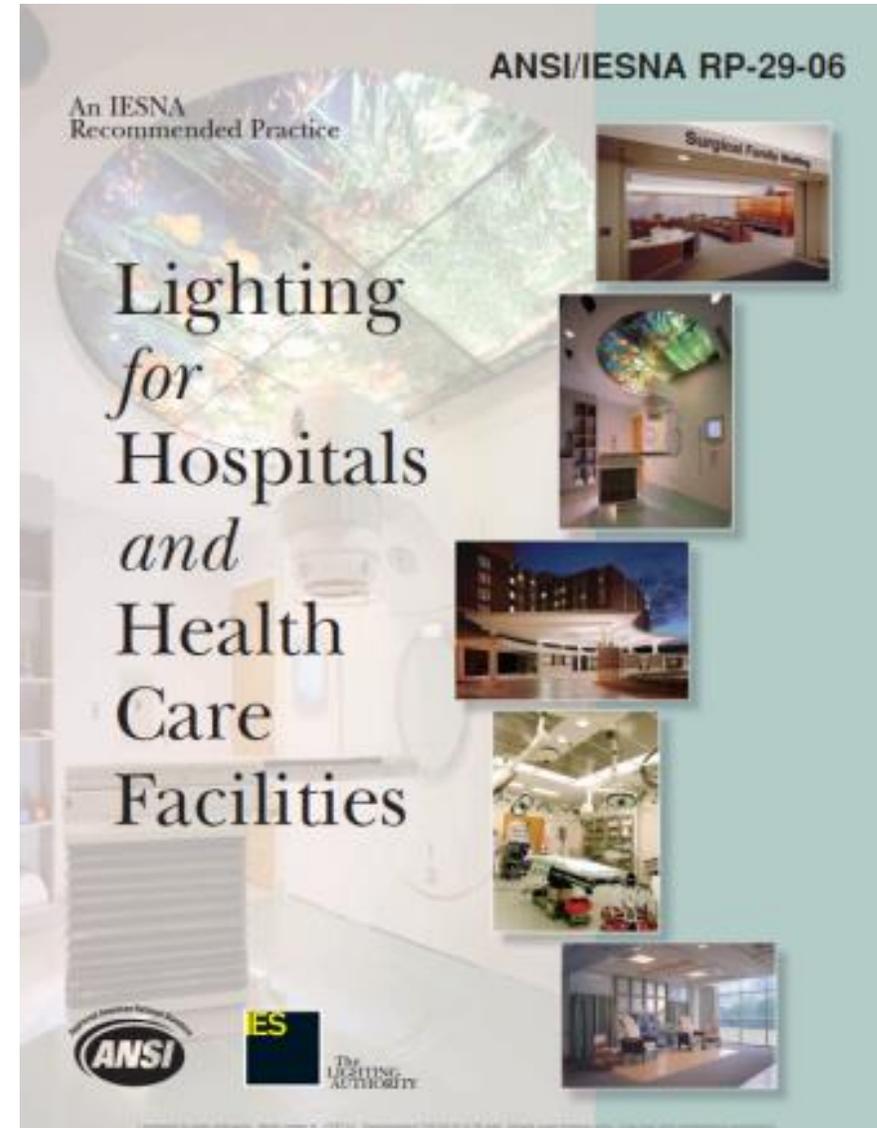
ANSI/IESNA RP-29 Healthcare Lighting

RP-29 Update Targeted 2016

Overall Experience

Safety

Health and Wellness



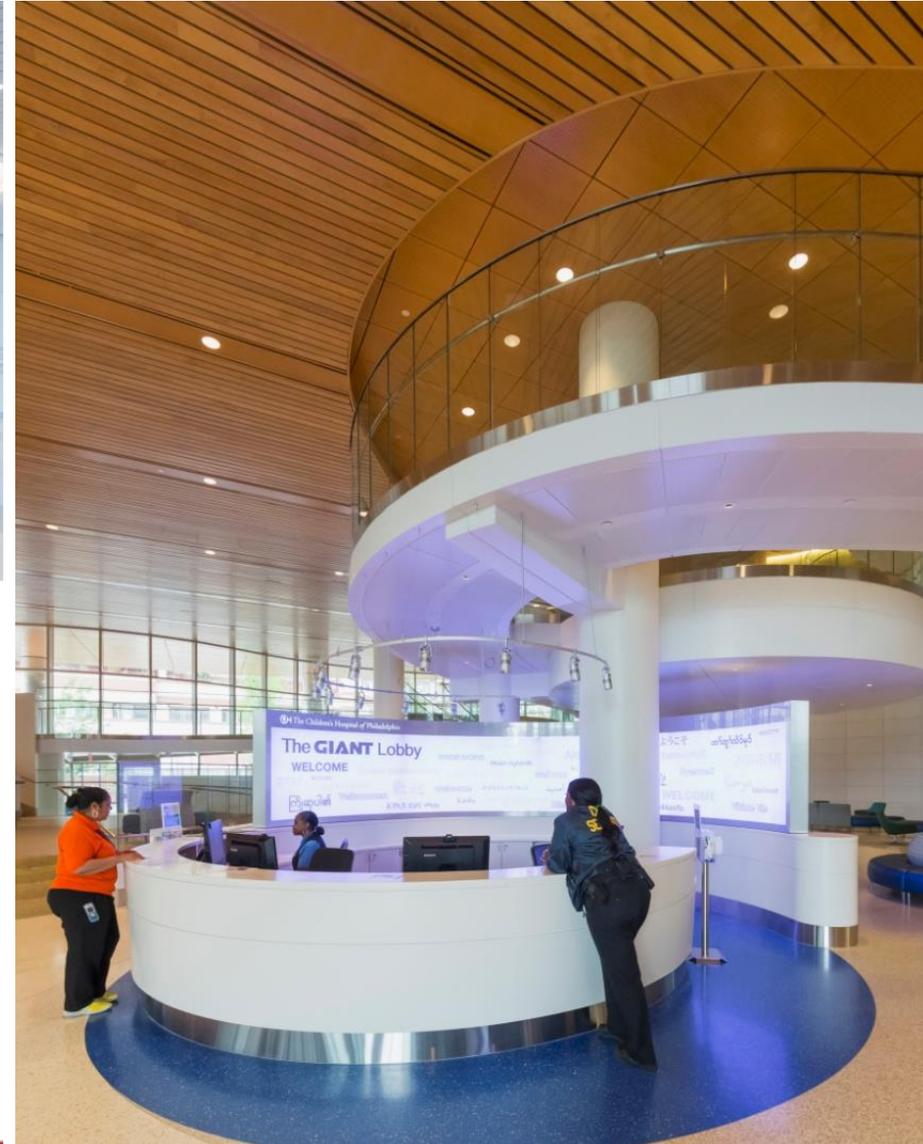
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Overall Experience

Wayfinding

“Consumers draw upon emotional cues and visual appeal to formulate a sense of trust. Healthcare is personal; developing a connection between the healthcare provider and the patient is important.”



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Overall Experience

Comfort

“Windows provide access to an important light source for patients and staff. Daylight and views provide orientation, a connection to the natural world, and help prevent boredom. Natural daylight aids in establishing appropriate biorhythms during recovery.”



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Safety

Infection Management

“Prevention of hospital-acquired infections (HAI) includes policy and procedures to minimize the risk of infection in healthcare facilities via human-to-human contact, human-to-surface contact, or airborne contact.”



A strategy that may be used to improve handwashing effectiveness is to have a proximity sensor trigger a timer that holds the light on for a prescribed time before turning off. Another strategy is to provide color changing timed light that changes color when the person has washed for the desired time limit.

Salley Whitman, NXT Health Patient Room 2020 Prototype



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Safety



Fall Prevention

“Falls most commonly occur at curbs, stairs, bathrooms, and between the bed and the bathroom. Patient rooms, more specifically the path between the bed and the bathroom, should be illuminated.”



Health and Wellness



“Quality lighting not only addresses the traditional goals of comfort, function, safety and aesthetics, but also has been shown to enhance the complete physical, mental, and social well-being of a person.”

King of Prussia Specialty Care Center – MRI Suite

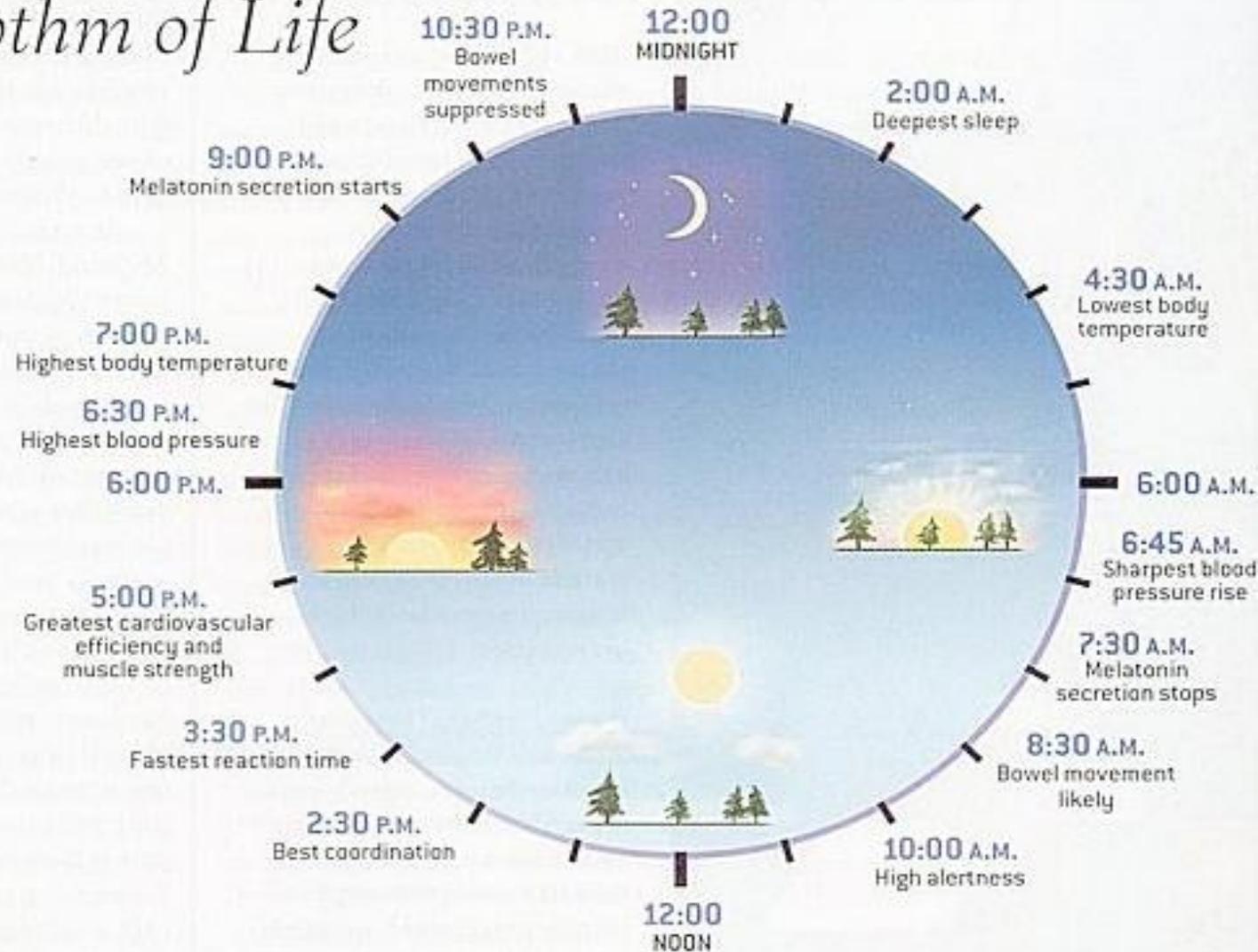


Circadian Systems and Human Psychology

“There is a growing body of research that indicates that light impacts non-visual systems as well as visual systems.”

The Rhythm of Life

THE CIRCADIAN CLOCK affects the daily rhythms of many physiological processes. The diagram at the right depicts the circadian patterns typical of someone who rises early in the morning, eats lunch around noon and sleeps at night. Although circadian rhythms tend to be synchronized with cycles of light and dark, other factors—such as ambient temperature, meal times, stress and exercise—can influence the timing as well. —K.W.



SOURCE: *The Body Clock: Guide to Better Health*, by Michael Smolensky and Lynne Lumborg, Henry Holt, 2000

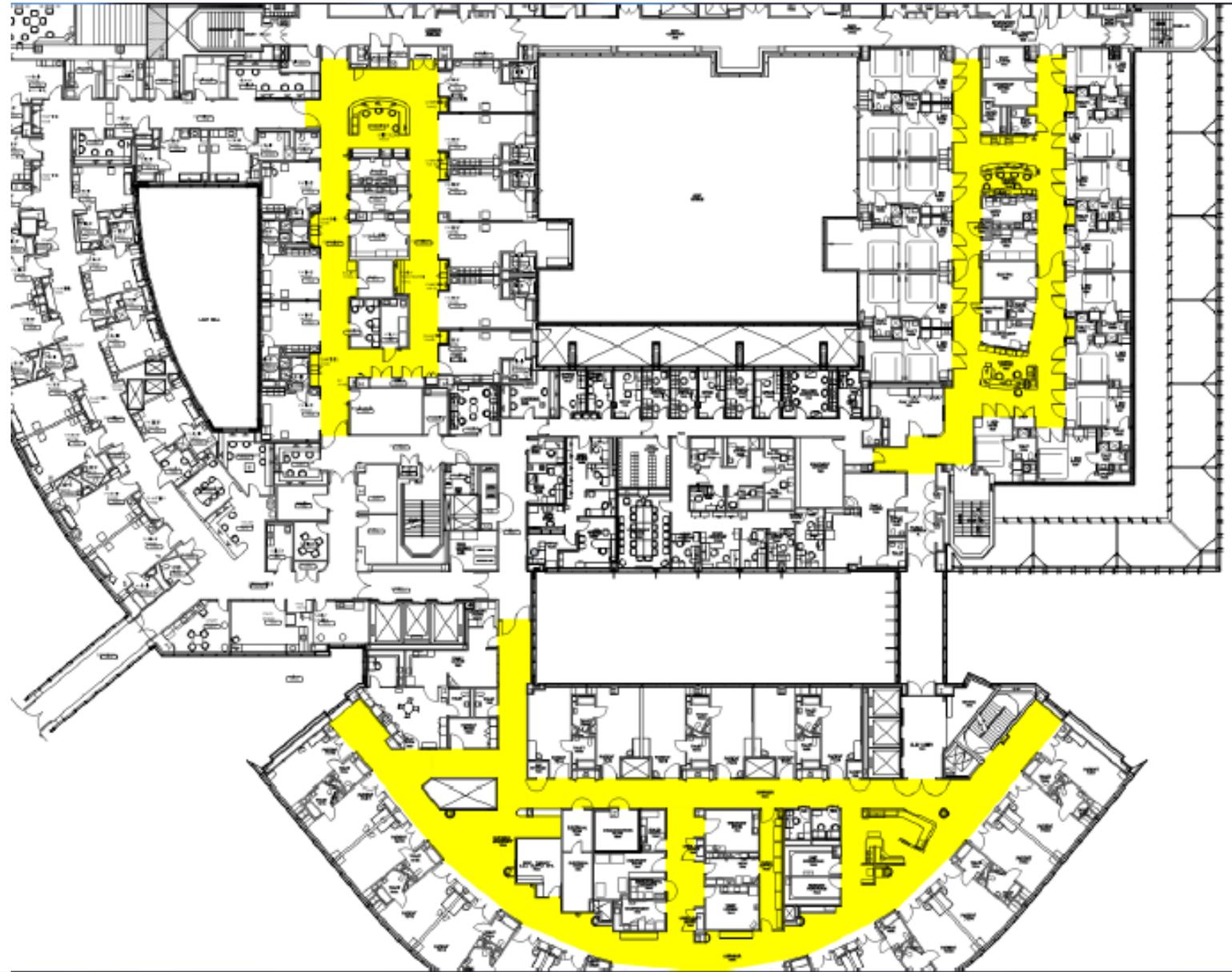


Health and Wellness

PICU Upgrades

Replace existing 2x2s with LEDs with Dimming driver and wireless controller

Wireless Dimmers for control at Nurse Stations



Health and Wellness

Medical Behavioral Unit

Patient Control over Color
Changing Light in Room

White Tunable LED Lighting

Daylight in Activity Spaces



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More Than Meets the Eye

Exploring the Physiological & Psychological Impact of Light on Health

Mariana Figueiro PhD

Professor, Program Director

Lighting Research Center, Rensselaer Polytechnic Institute



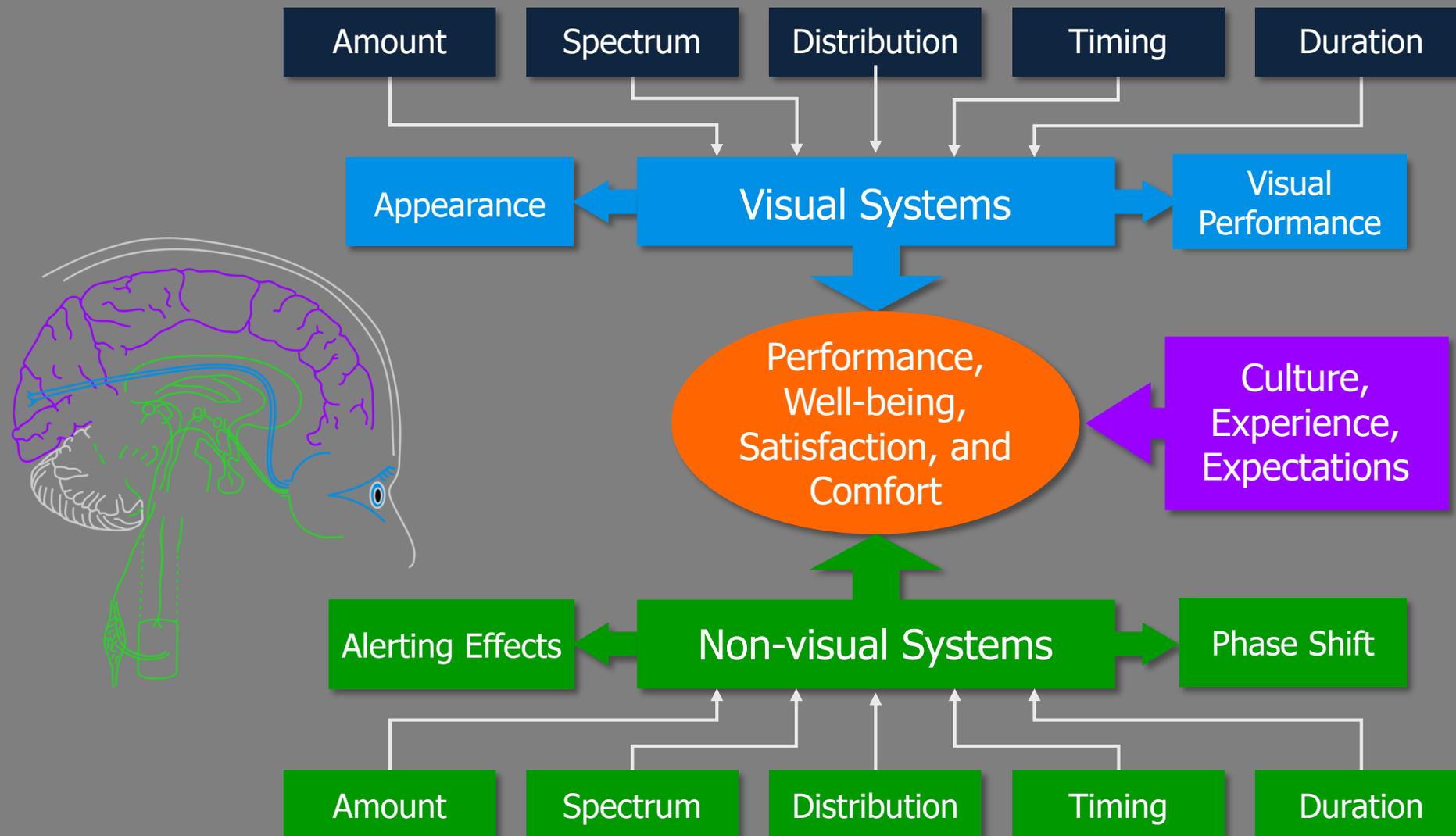
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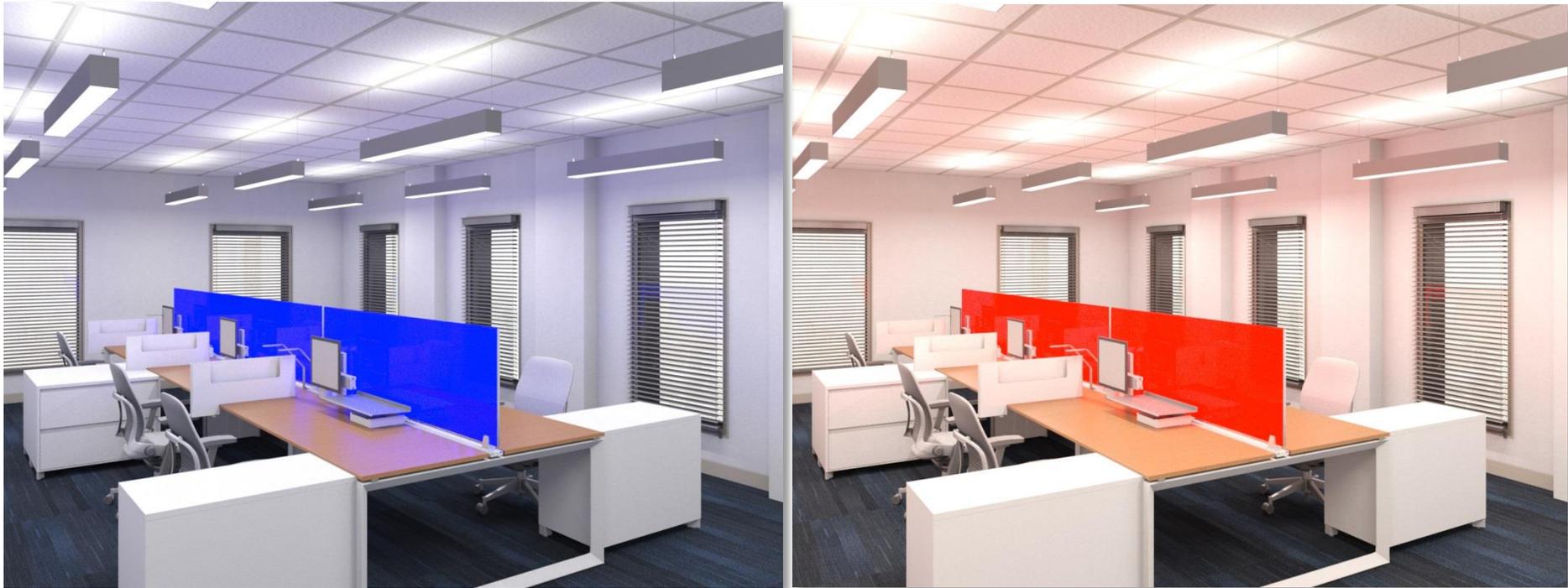
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Lighting affects three systems

Visual + non-visual + message



Alerting effects of light (e.g. = cup of coffee)



Sponsor: Office of Naval Research (N00014-11-1-0572)



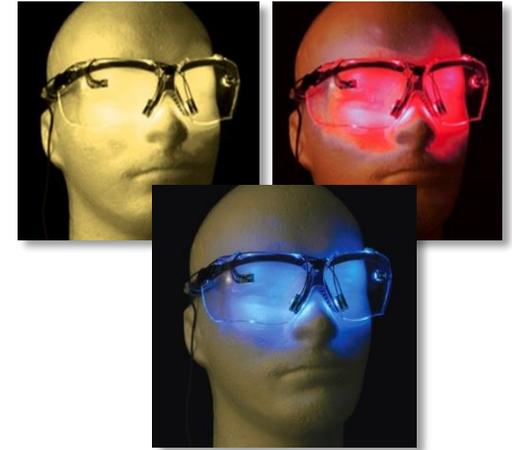
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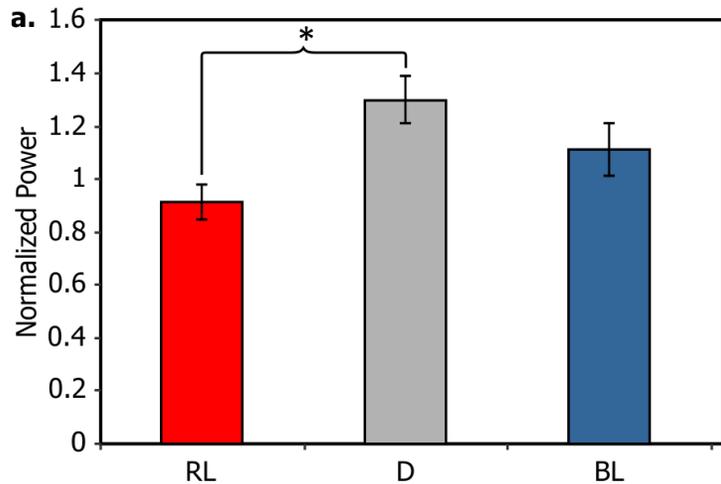
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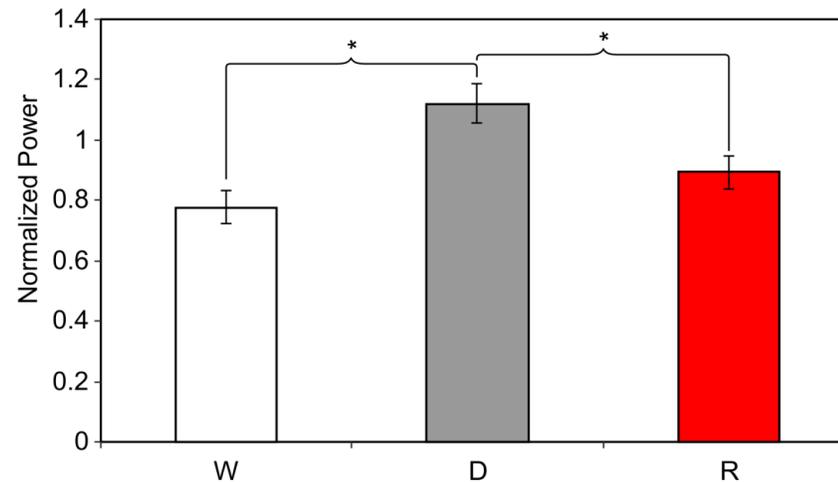
“Blue”, “white”, and “red” lights as alerting stimuli



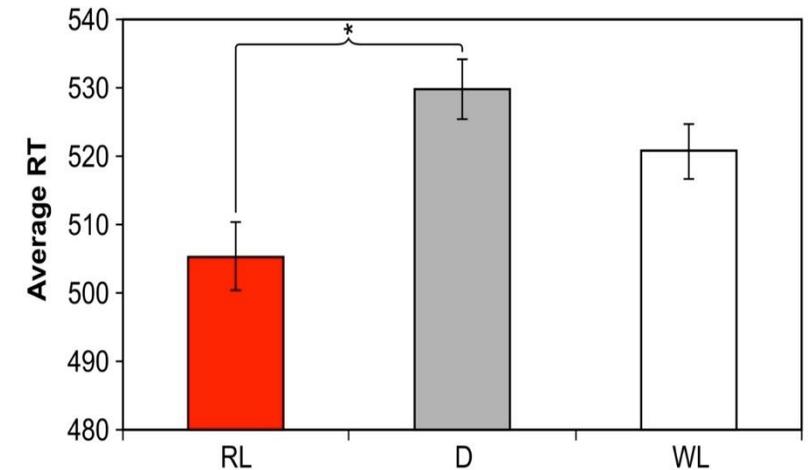
- Exposure to light increased measured of alertness (brain activities and self reports) at night and during the afternoon
- Only blue and white lights suppressed melatonin



Sahin L and Figueiro MG. Alerting effects of short-wavelength (blue) and long-wavelength (red) lights in the afternoon. *Physiology and Behavior*. 2013; 116: 1-7.



Sahin L, Wood BM, Plinick BA, Figueiro MG. Daytime light exposure: Effects on biomarkers, measures of alertness, and performance. *Behavioral Brain Research*. 2014; 274: 176-185. (Graphic above developed in study; not published in journal.)

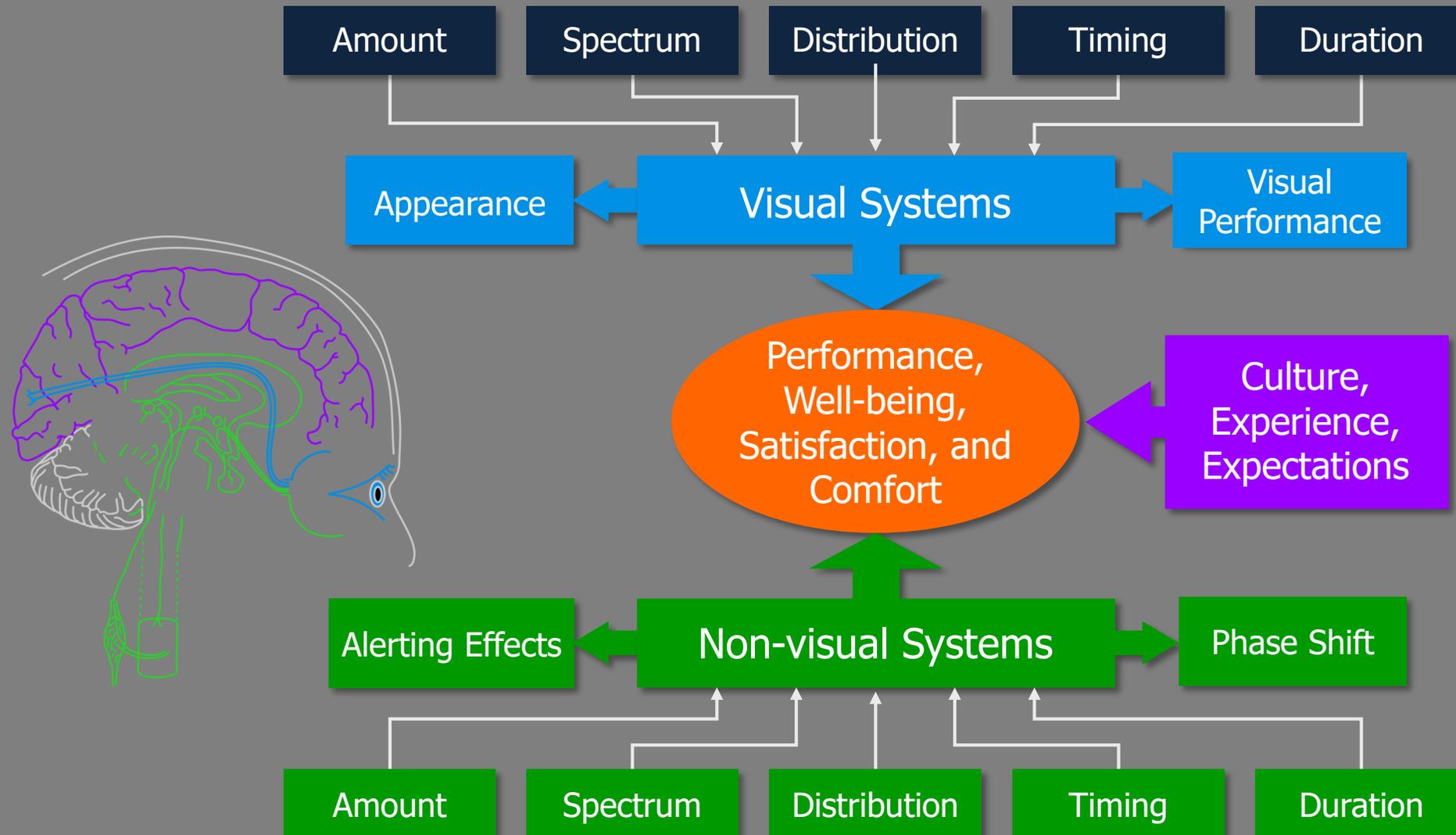


Sahin L, Wood BM, Plinick BA, Figueiro MG. Daytime light exposure: Effects on biomarkers, measures of alertness, and performance. *Behavioral Brain Research*, 2014, 274:176-185.



Lighting affects three systems

Visual + non-visual + message



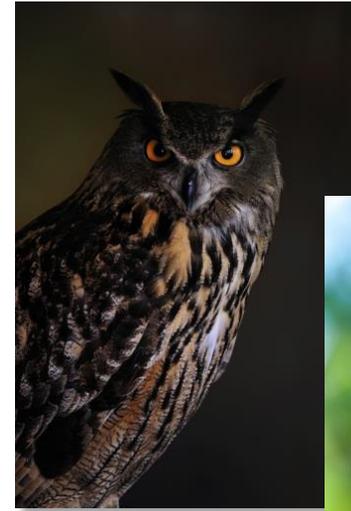
Phase shifting effects of light

- Promote entrainment in daytime staff and in patients
 - Morning light can promote entrainment of dayshift workers and of special populations (Alzheimer's disease patients, premature infants, cancer patients undergoing treatment)

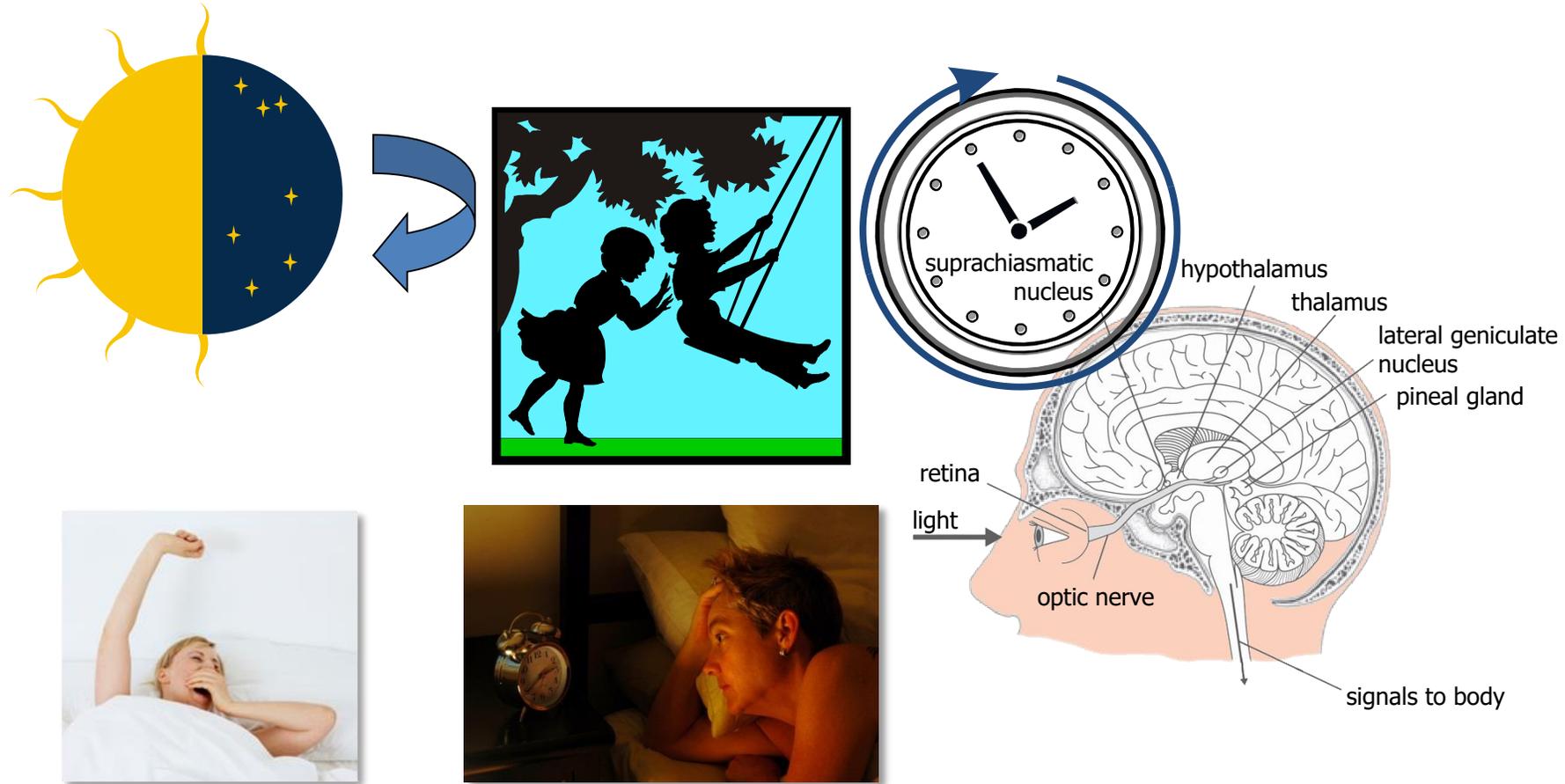


Circadian system

- Plants and animals exhibit patterns of behavioral and physiological changes over an approximately 24-hour cycle that repeat over successive days—these are circadian rhythms
- circa = about; dies = day
- Circadian rhythms are influenced by exogenous and endogenous rhythms



Light is the primary synchronizer of circadian rhythms to local position on Earth



Light is the primary synchronizer of circadian rhythms to local position on Earth ...also the major disruptor



Circadian disruption

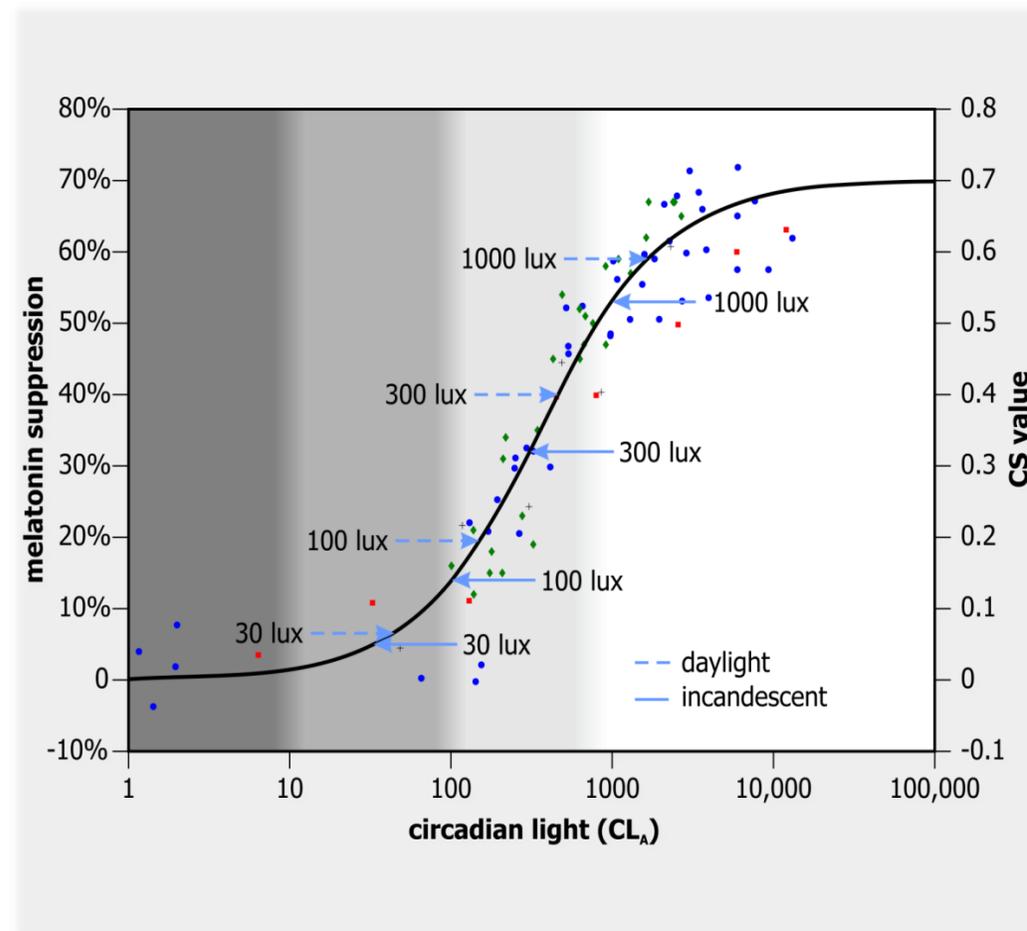
- Circadian disruption has been associated with:
 - Poor sleep and higher stress
 - Eismann et al., 2010
 - Increased anxiety and depression
 - Du-Quiton et al., 2009
 - Increased smoking
 - Kageyama et al., 2005
 - Cardiovascular disease
 - Young et al., 2007; Maemura et al., 2007
 - Type 2 diabetes
 - Kreier et al., 2007
 - Higher incidence of breast cancer
 - Schernhammer et al., 2001, Hansen, 2006



Circadian stimulus (CS)

Metric for quantifying effectiveness of light sources for activating the circadian system

- CS is equivalent to percent melatonin suppression after 1-h exposure to the light source
 - An indication of how effective the light source is for the circadian system
 - CL_A is calculated using the SPD and light level at the cornea
 - CS is calculated using transfer function
 - Caveat: does not take into account duration of exposure, photic history and is based on acute melatonin suppression (not phase shifting of the clock)
- Threshold = 0.1 CS; half max = 0.3 CS; saturation = 0.7 CS



Light therapy for bone marrow transplant patients

- Investigate the impact of a CS of 0.3 during the morning hours on:
 - Circadian markers (melatonin)
 - Fatigue
 - Depression
 - Sleep

Sponsor: Acuity Brands

National Cancer Institute

Collaborator: Dr. William Redd, Mt. Sinai Ichan
School of Medicine



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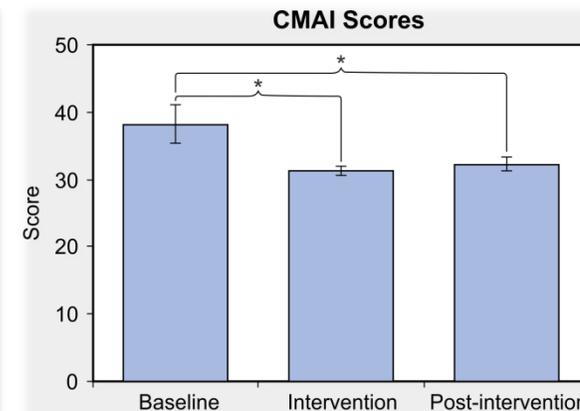
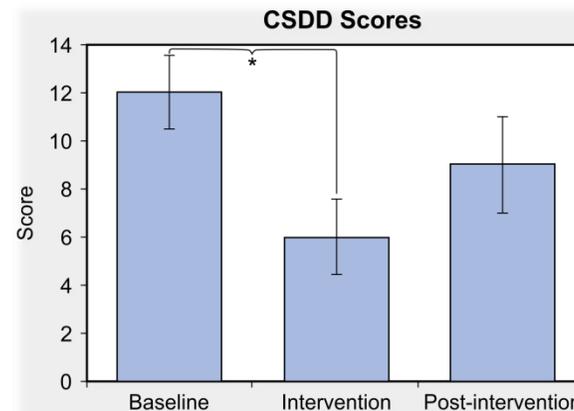
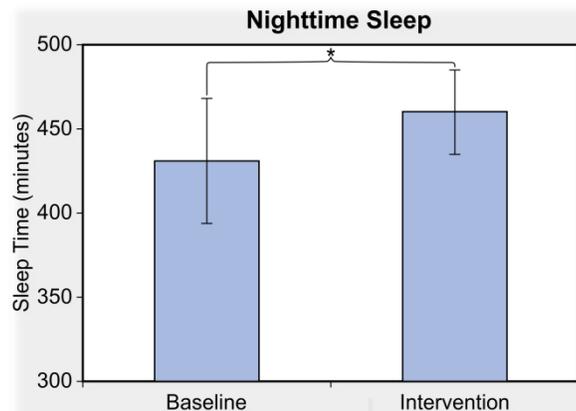
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Light therapy for promoting entrainment in persons with dementia

- Study tested the effectiveness of a tailored light treatment on sleep quality, agitation and depression in 14 patients with Alzheimer's disease and related dementias living in nursing homes
- High circadian stimulation ($CS > 0.3$) during daytime hours
 - 300-400 lux at the cornea from waking to 6 pm
 - Bluish-white light, CCT > 9000 K
- Results showed increase in sleep efficiency, total sleep time, reduction in agitation and depression

Product donation: GE Lighting



Sponsor: National Institute on Aging (R01AG034157)
Figueiro et al. 2014

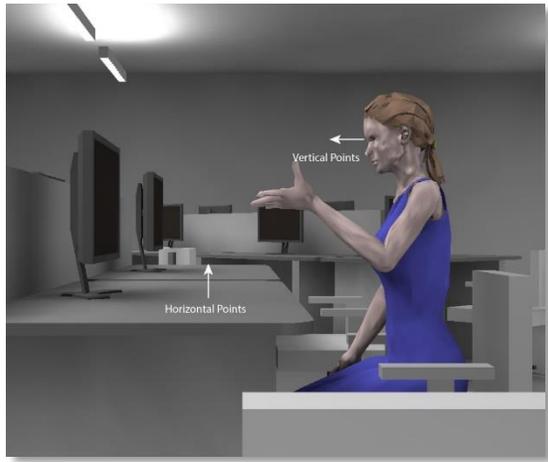


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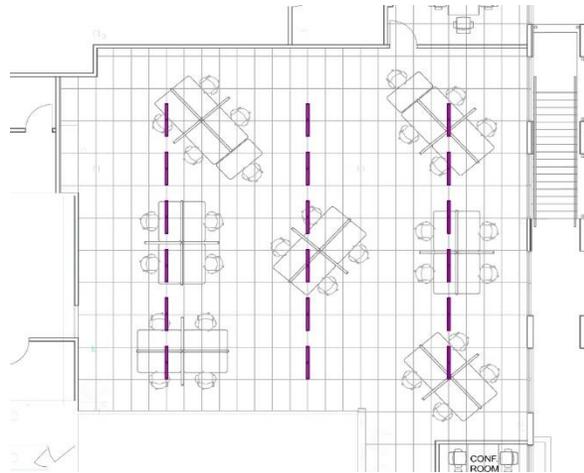
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How to calculate CS



Calculation Points

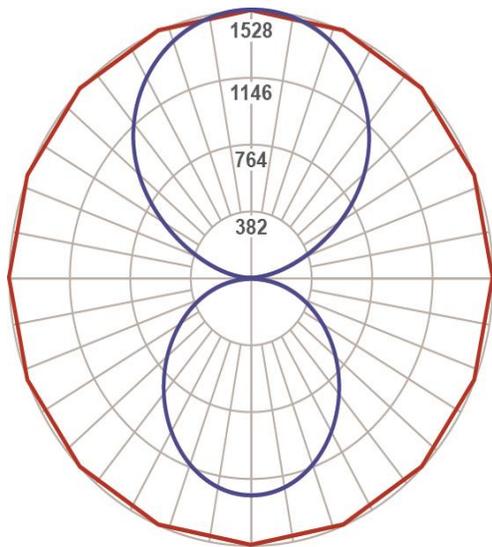


- Horizontal points measured at desk height
 - 2'-6" AFF
- Vertical points measured at eye height
 - Approx. 4'-0" AFF
 - Approx. 1'-0" from edge of desk
- Target horizontal illuminance
 - 400 lux
- Direct-indirect luminaires
- Typical office reflectances

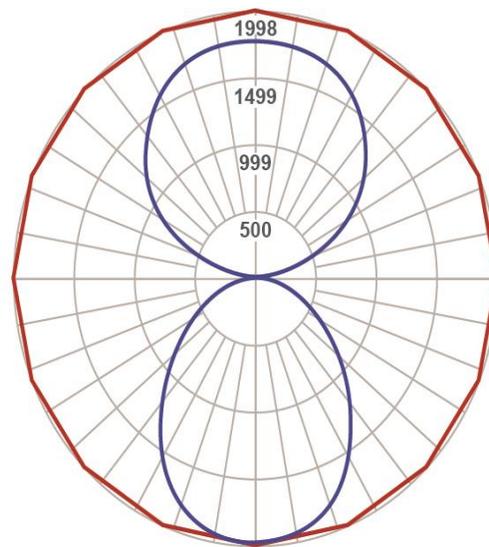


Pick the intensity distribution of the luminaire

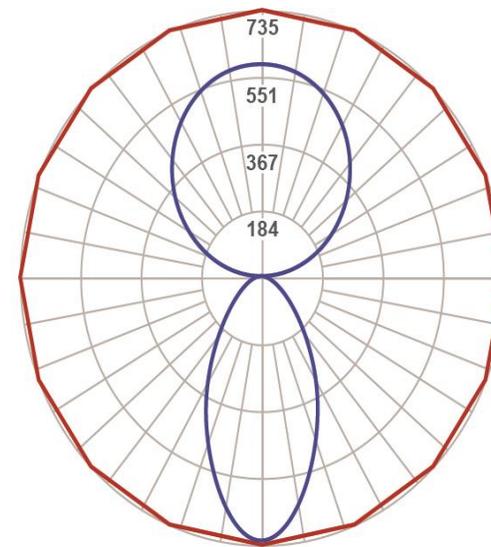
- The ideal ratio of vertical to horizontal illuminance was determined to be 7:10



Best ratio

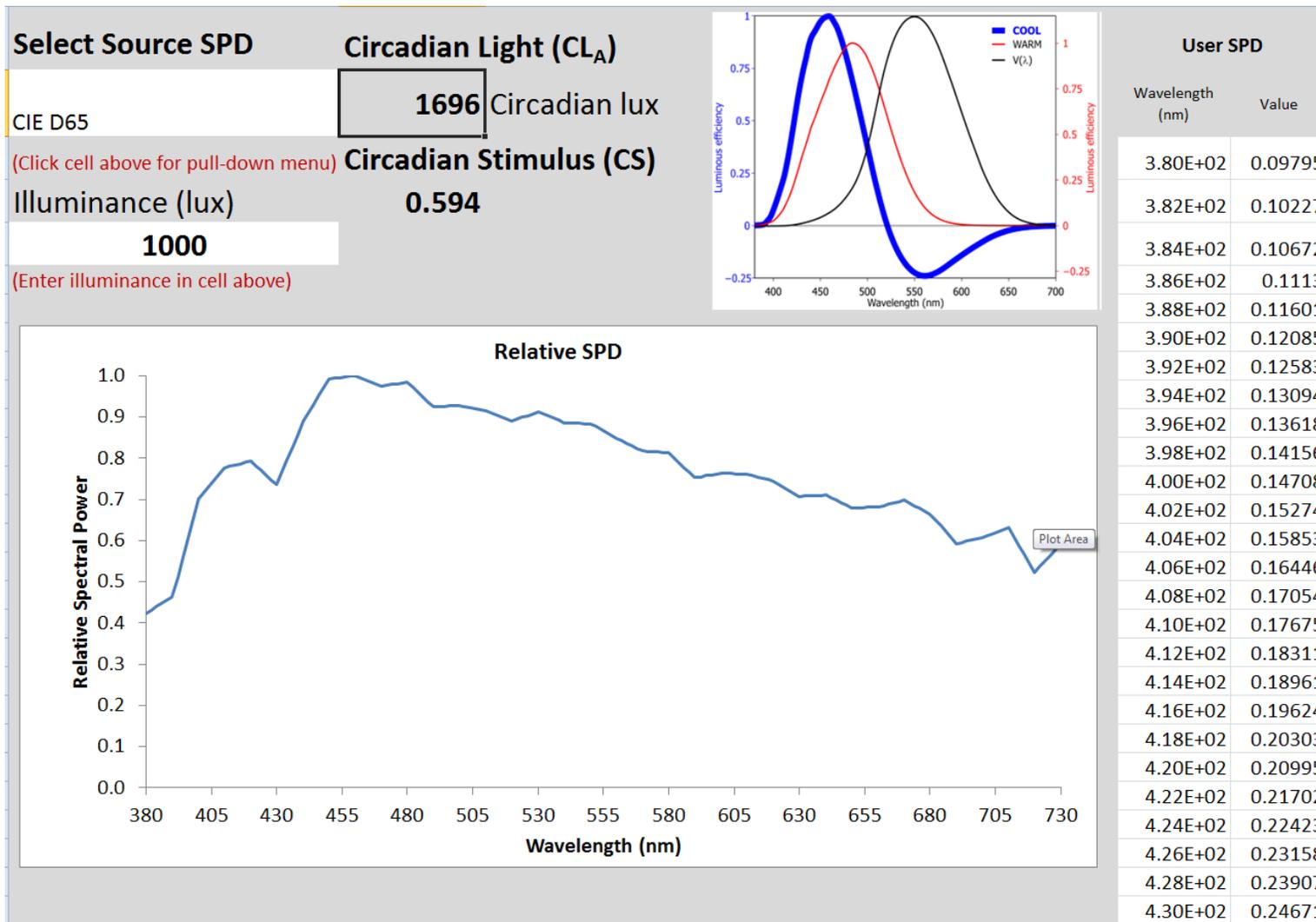


Medium ratio



Poor ratio





http://www.lrc.rpi.edu/resources/CircadianStimulusCalculator_April302016.xlsx



Use the CS calculator to determine CS

Light Level + Spectral Power Distribution + Distribution

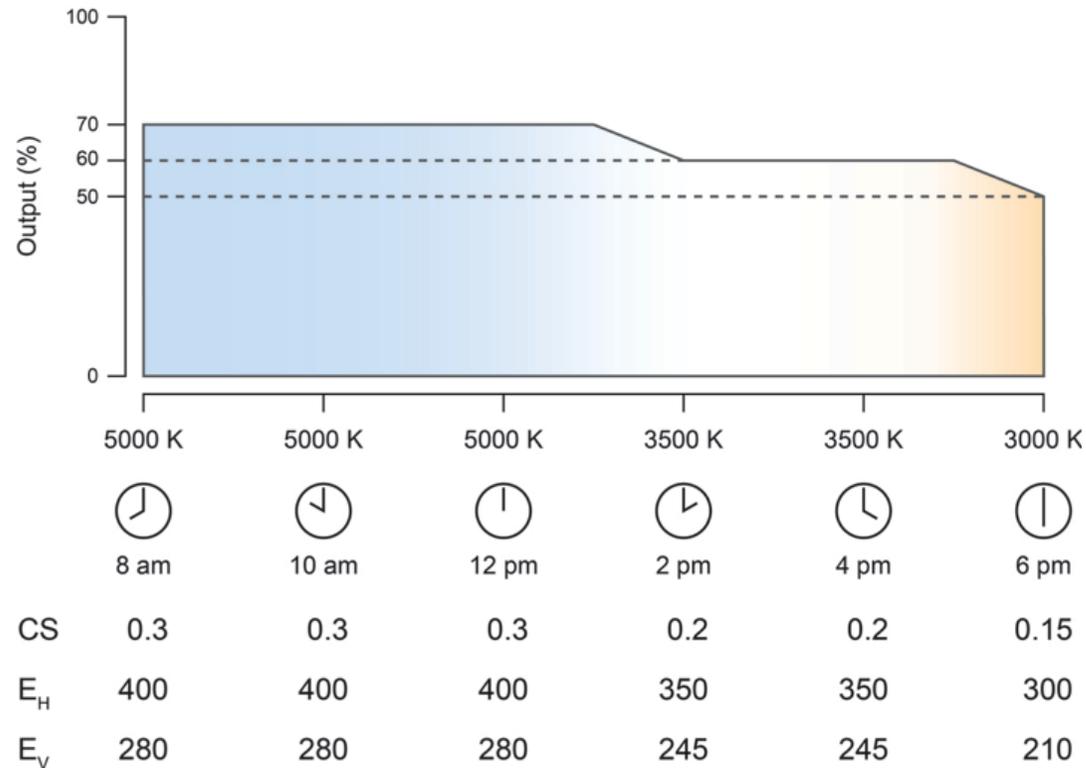
CCT	400 lux horizontal; 280 lux vertical			
	Manufacturer 1	Manufacturer 2	Manufacturer 3	Manufacturer 4
3000	0.17	0.30	0.30	-
3500	0.23	0.19	-	0.18
4000	0.23	0.24	-	0.27
4500	0.30	-	-	-
5000	0.32	0.32	0.32	-
5500	0.34	-	-	-
6000	0.36	-	-	-
6500	-	0.39	-	-
7000	-	0.39	-	-
7500	-	0.41	-	-
8000	-	0.42	-	-
8500	-	0.42	-	-
9000	-	0.43	-	-
9500	-	0.44	-	-
10000	-	0.45	-	-

- 400 lx horizontal
- Best ratio luminaire
- CS of 0.3 can be achieved with a warm color light source, depending on SPD



Pick a lighting control schedule: timing matters!

Light level and SPD

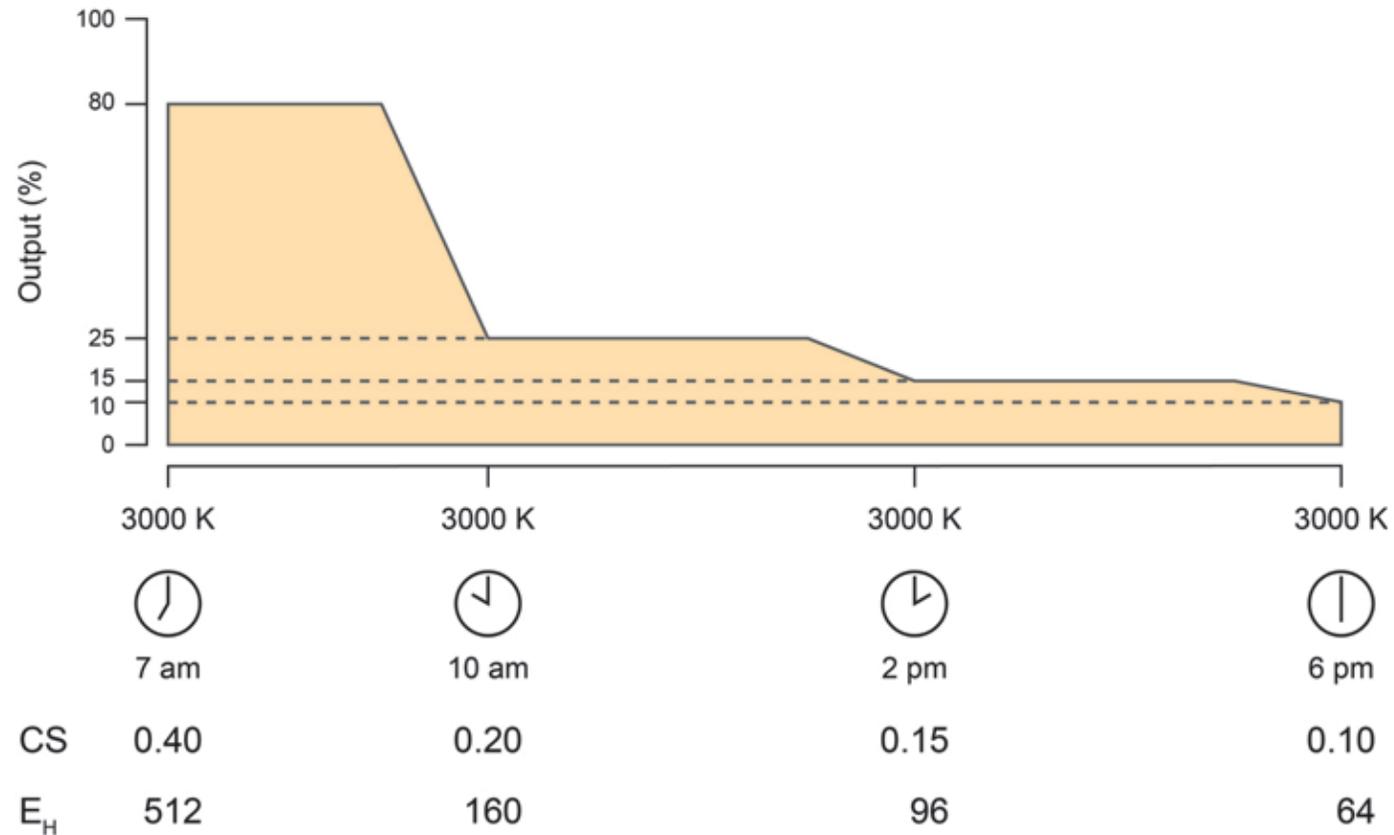


Both light level and SPD/CCT vary throughout the day to achieve 0.3 CS in the morning and 0.15 in the late afternoon



Pick a lighting control schedule: timing matters!

Light level only



Changes in CS can be achieved by simply increasing or decreasing the system's light output while keeping the same CCT

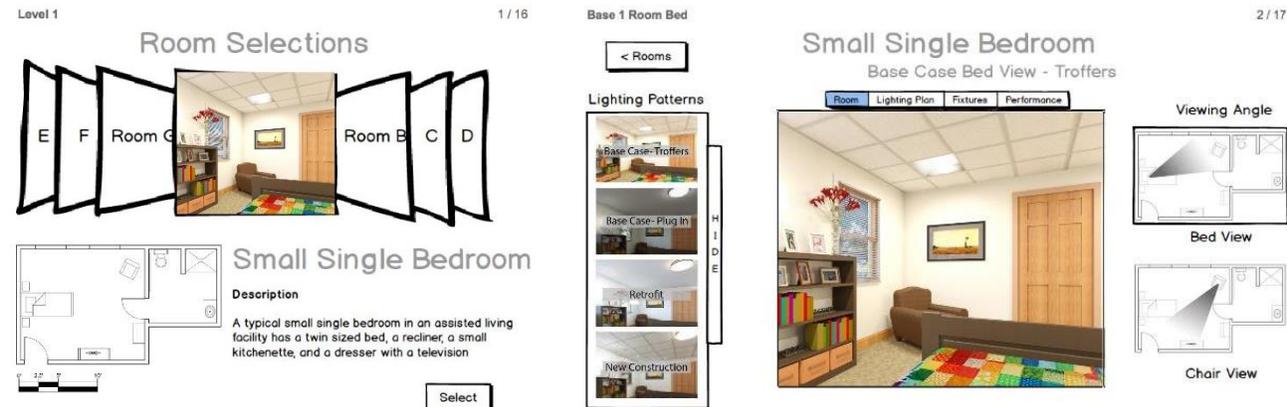


Lighting Patterns for Healthy Buildings

We developed a website detailing lighting design patterns for:

24-h lighting scheme for seniors' facilities

<http://lightingpatternsforhealthybuildings.org/>





Guiding Light

What You Need to Know About Lighting

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Acuity Brands



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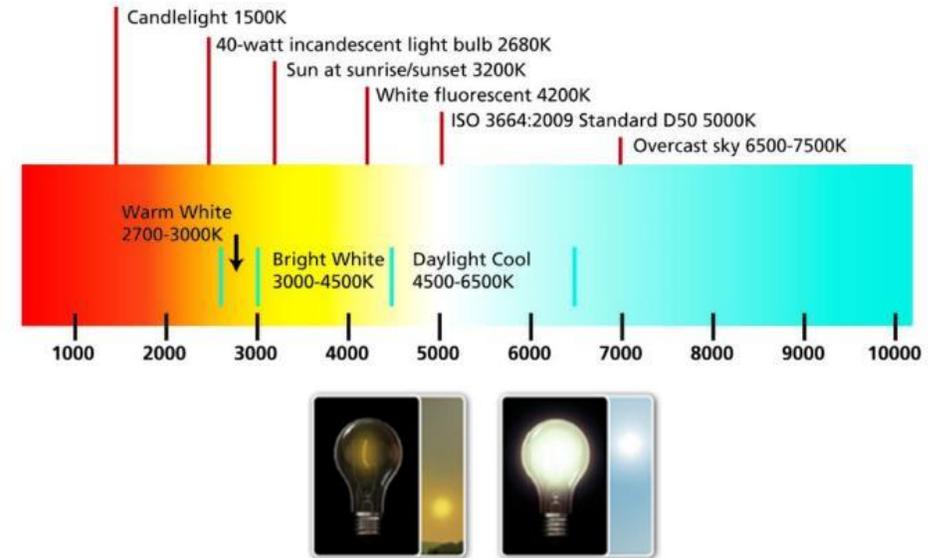
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LED Progression: From Static Color to Dynamic Experiences

- **“Tunable White” is becoming increasingly mainstream**
- **Spaces are being designed to include circadian stimulus**
- **Designers are moving from just dimming (changing intensity) to wanting total control of the Kelvin temperature, color consistency, warm dimming and color points**
- **Choosing a lamp CRI and CCT to best enhance the environment is no longer sufficient**



What is Warm Dimming?



Why use Warm Dimming?

Taps into our expectation that light sources “warm up” as intensity is reduced

Impacts ambience, mood, relaxation, intimacy

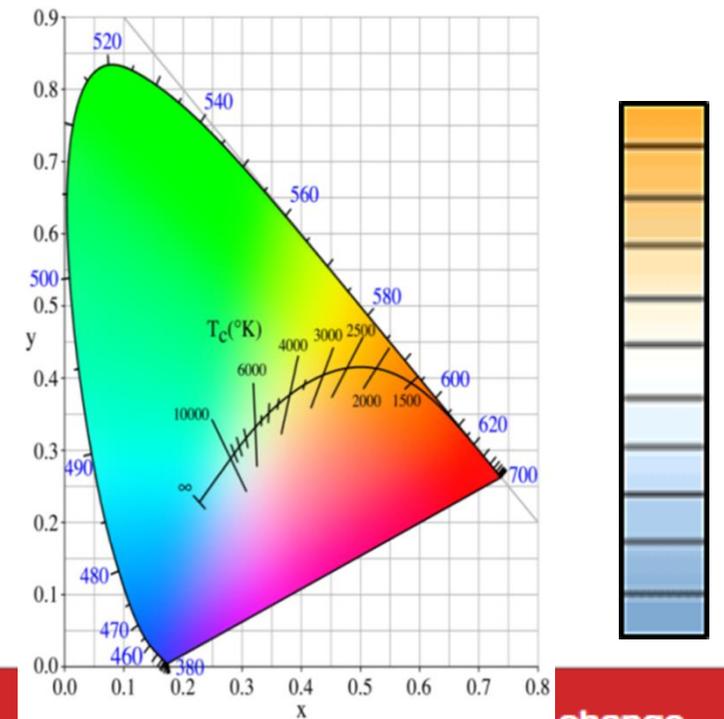


What is Tunable White?

Ability to adjust CCTs along a pre-specified range, i.e. 1800K to 6000K

This could be along the black body curve or vary from it

Shifts off the black body curve will cause the perceived color to shift to green or pinkish tint*



Why Use Tunable White?

Throughout the course of the day, the CCT can be varied, tuned in response to daylight or activities within the space

Create a different atmosphere or mood

Change the environment for retail displays and dressing rooms



What is Tunable Spectrum?

Excellent white light and ability to produce pastel/tinted color

Ability to have a range of CCT's at constant lumen output

Ability to dim along the black body or shift off the curve (via Duv control)

Opportunity to tune the color to enhance the surrounding space or create an effect

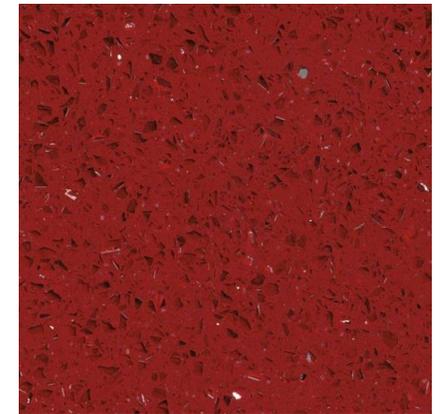
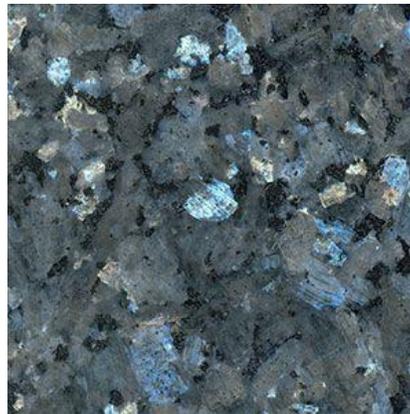


Why Use Tunable Spectrum?

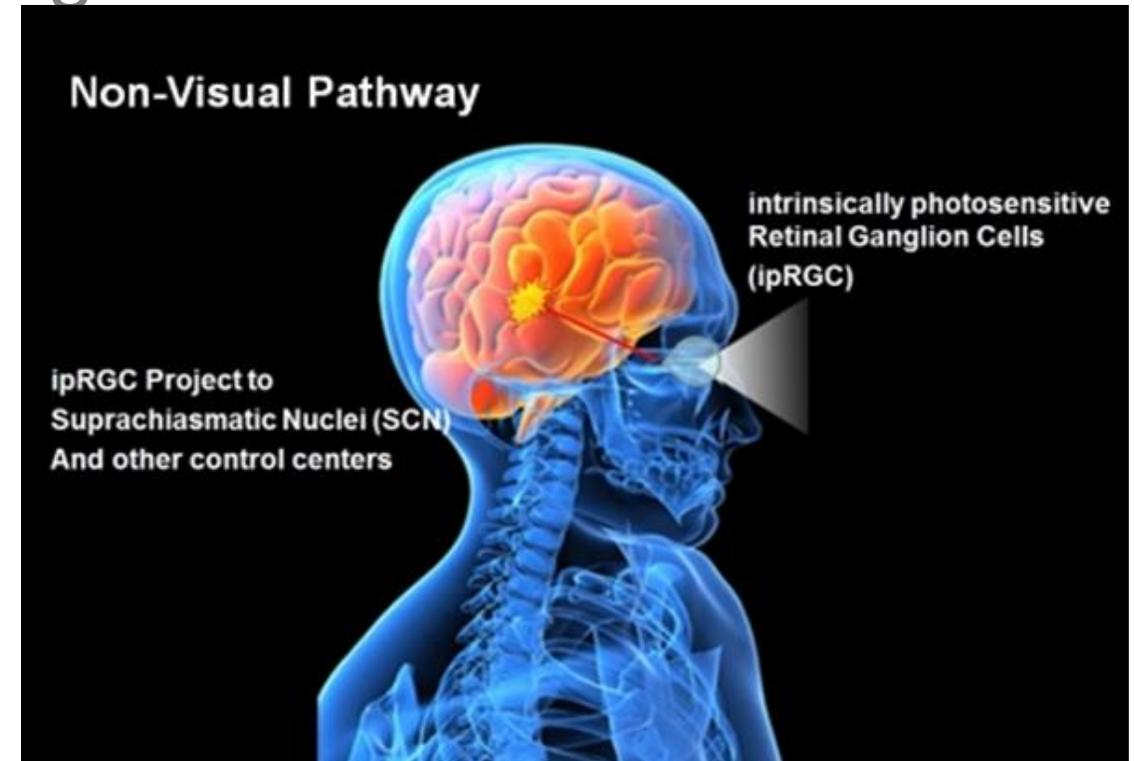
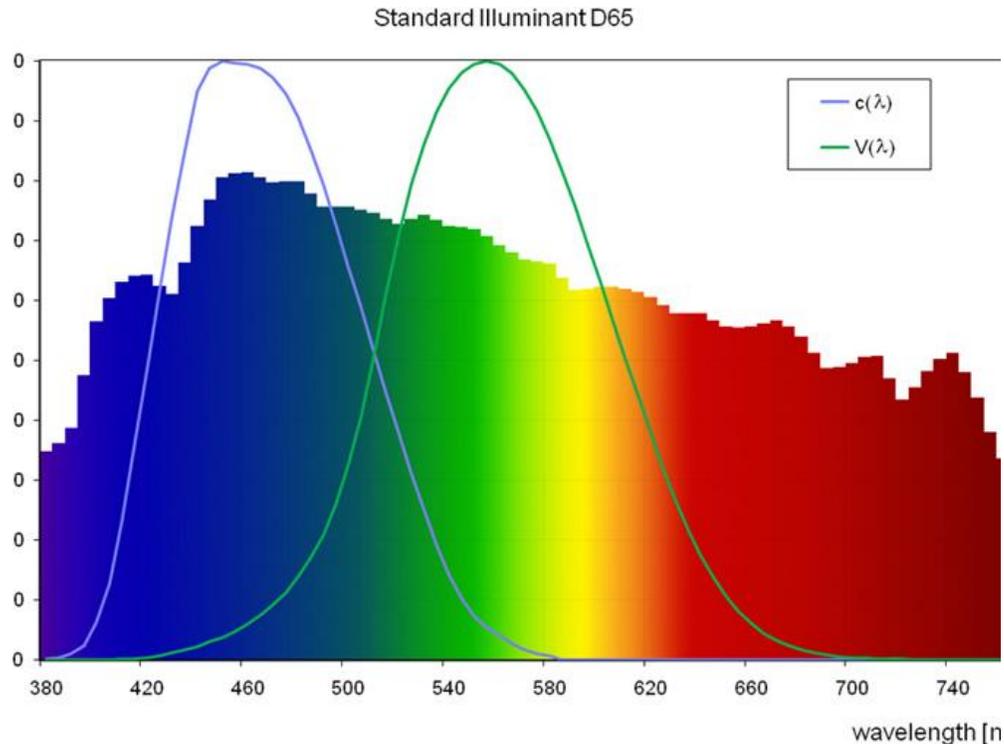
Delivers the ultimate in chromaticity control with high-quality white light and color selection.

Accentuate architectural features, colors, materials and finishes, but also skin, tissues, etc.

Tune the color to improve visual diagnosis



Tuning for Non-Visual Effects of Light



Adjusting the spectrum of the source to help to stimulate circadian rhythm

Circadian tuning is more than just modulating CCT

To stimulate circadian rhythm, need to enrich the appropriate wavelengths at different time of the day, 24-hour lighting design



Why Use Circadian Tuning?



Promote better health, quicker healing and improved sleep

Reduce agitation, night wandering, and improve sleep in Alzheimer's patients

Offset the impact of jet lag and foster alertness/calmness in sports teams by using targeted doses of circadian light in training and locker rooms





Seeing the Light

Research to Practice

Ed Clark

Sustainable Designer

ZGF Architects LLP

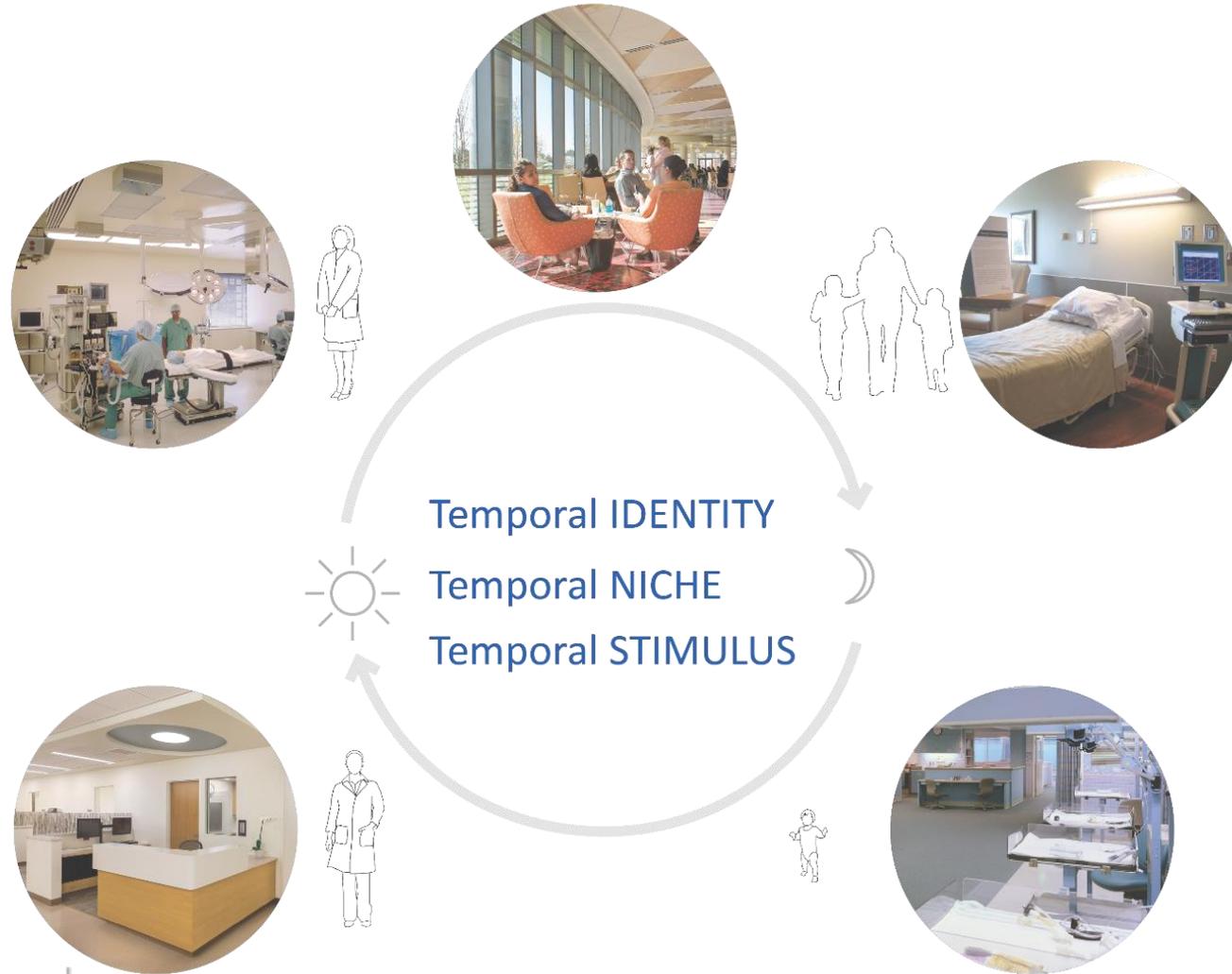


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Circadian Impactful Design..... is a PROCESS not a PRODUCT



Understand the Occupants – Where and When

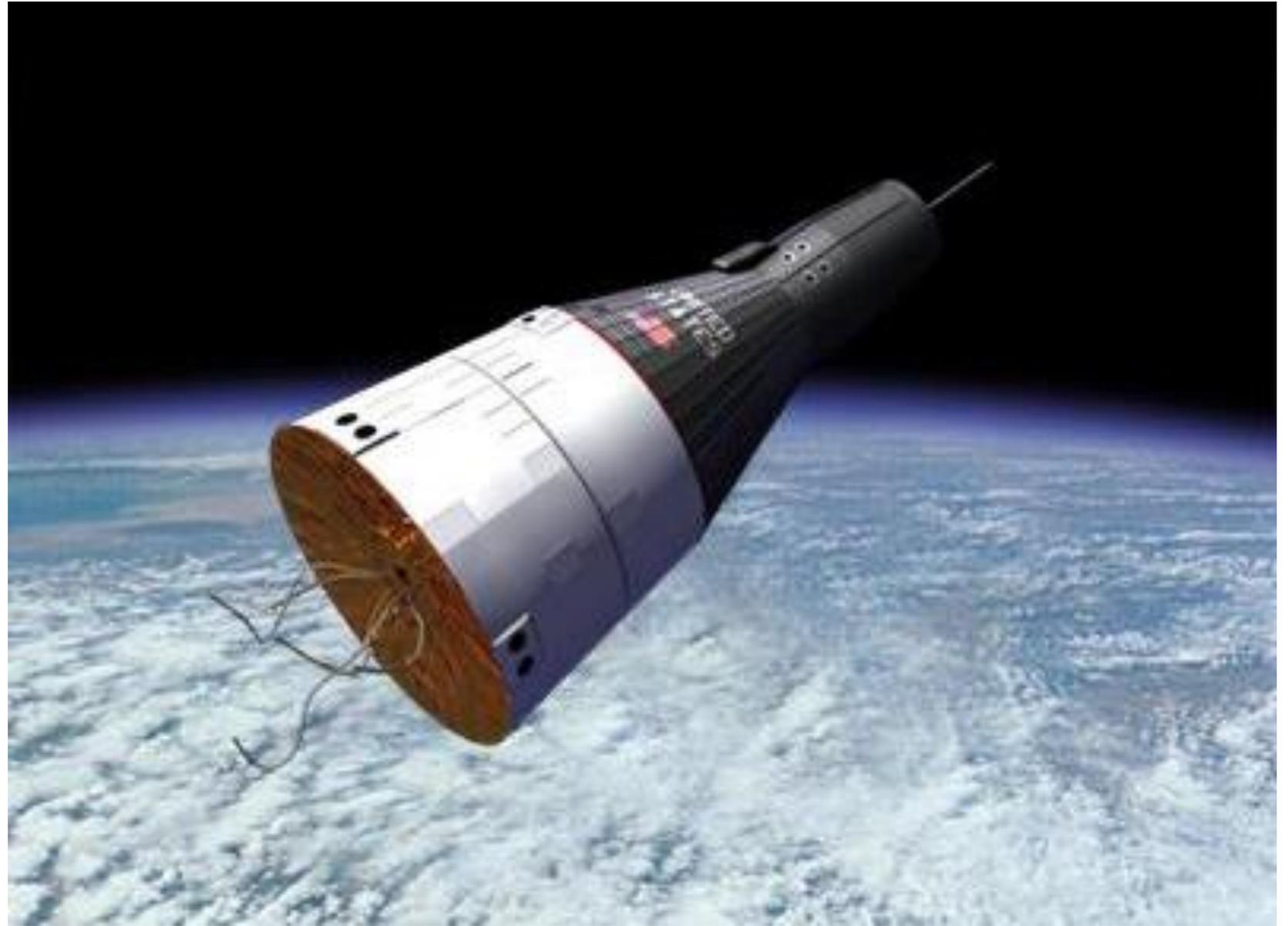
Floor 24: Utilization Map - Friday, 8:15



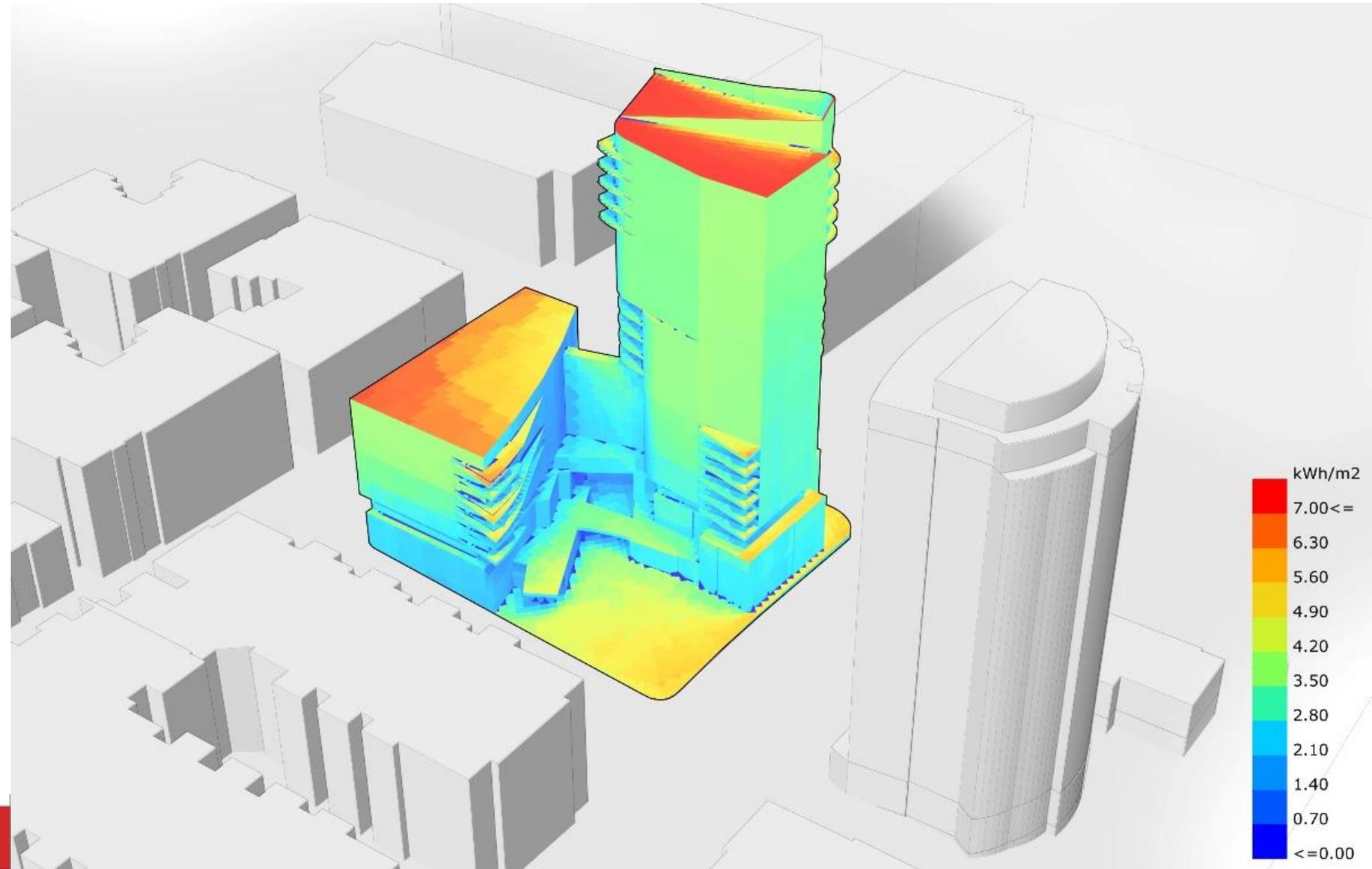
8:00 am



Understand the Site



Understand the Site



Understand the Site



http://www.nasa.gov/mission_pages/station/research/experiments/651.html



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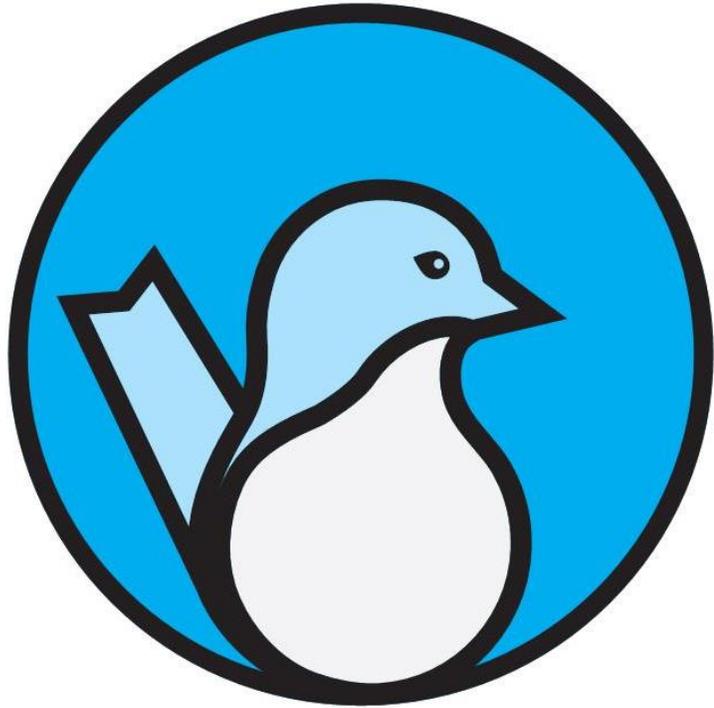
Materials Matter



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Design Analysis



**Co- Authored by
Mehlika Inanici Phd, Marty Brennan, Ed Clark**



http://faculty.washington.edu/inanici/Lark/Lark_home_page.html

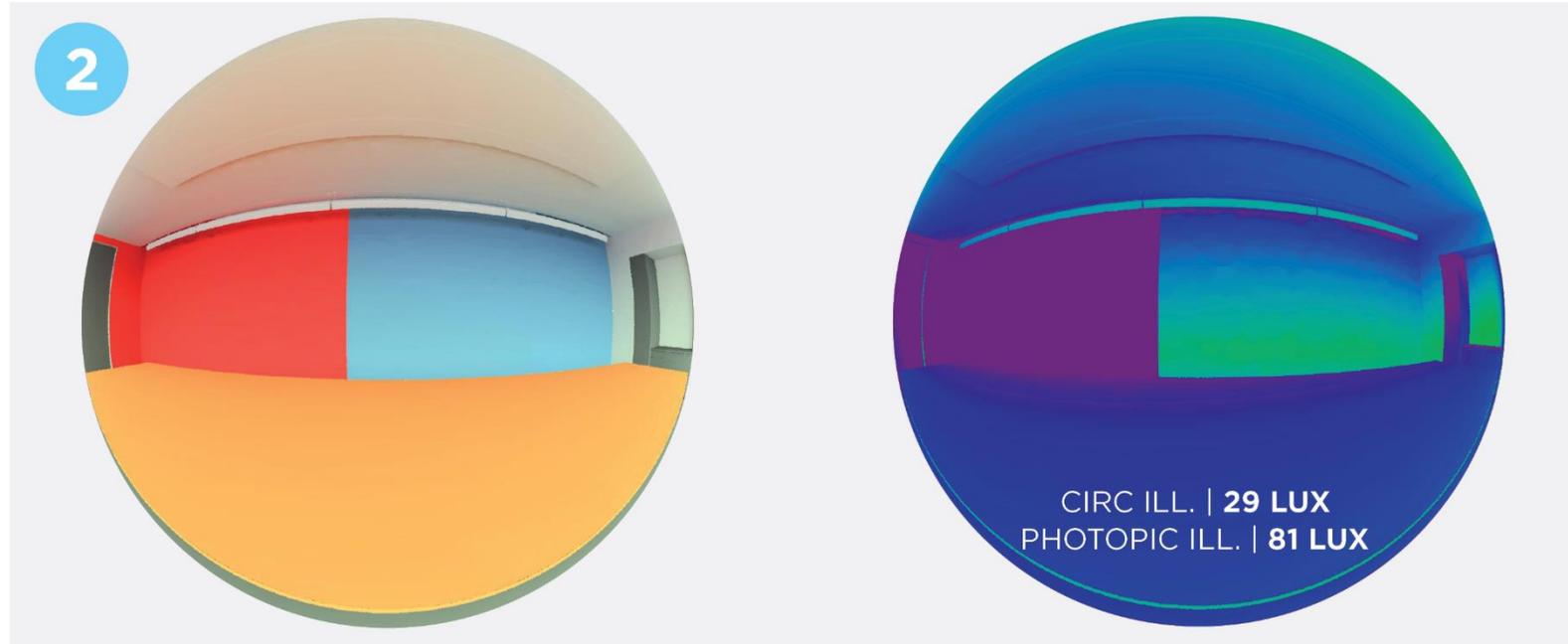
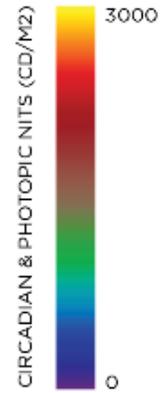
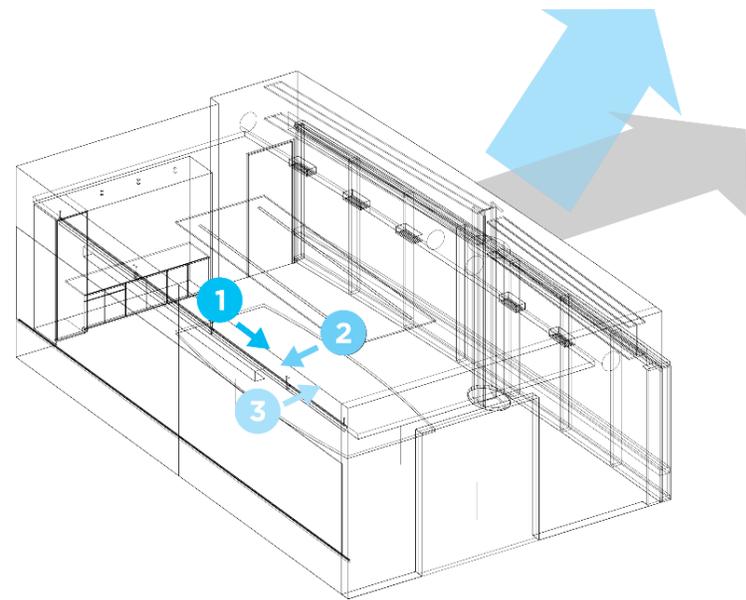
LARK
SPECTRAL LIGHTING



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Materials Matter



March 21, 15:00

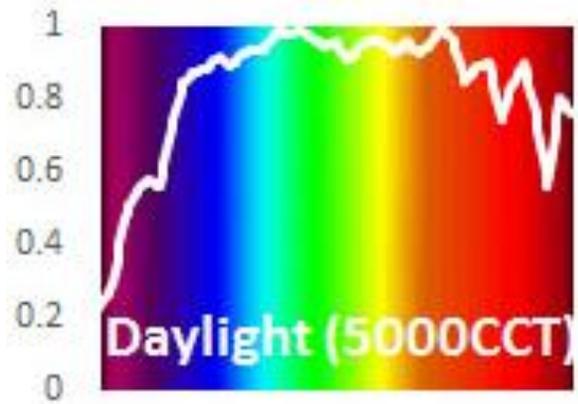
Partly Cloudy Sky Conditions
Correlated Color Temperature: 5000K



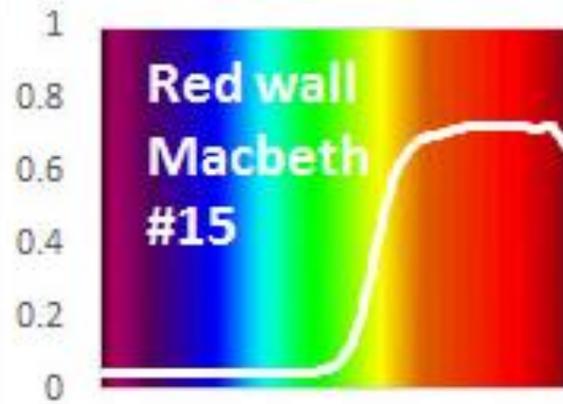
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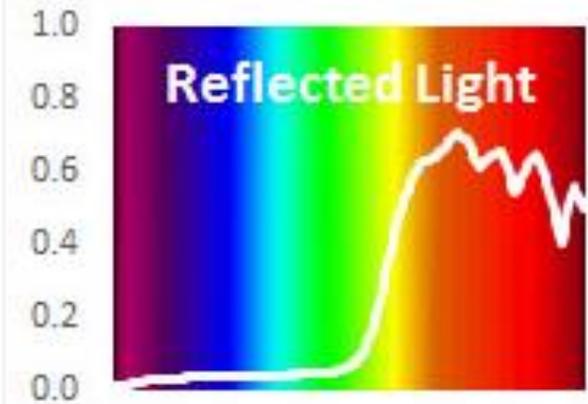
Materials Matter



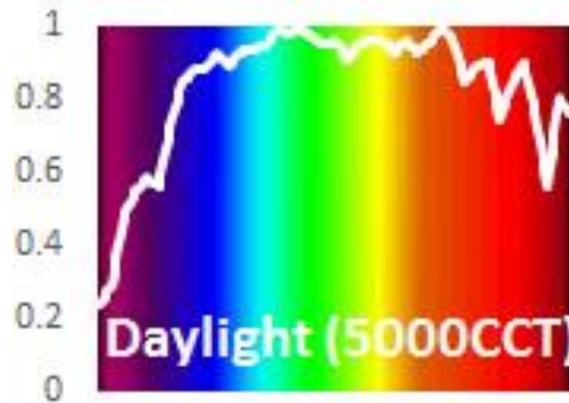
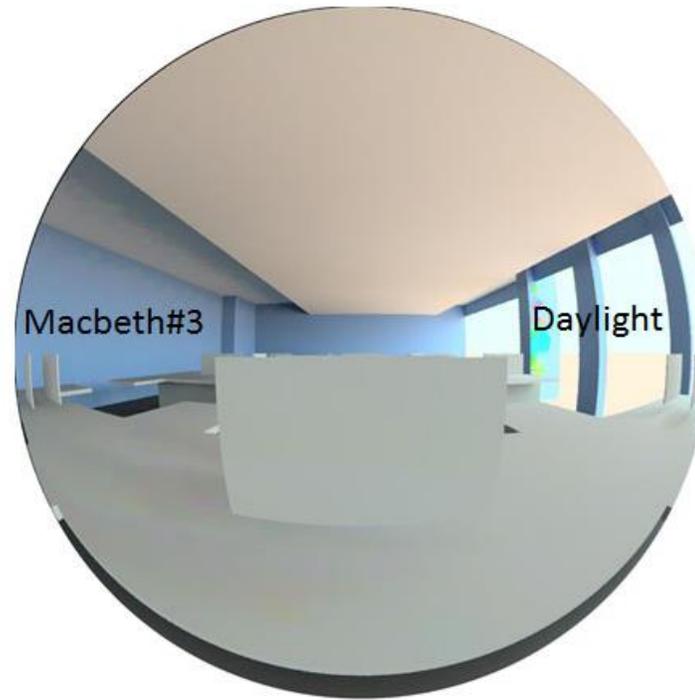
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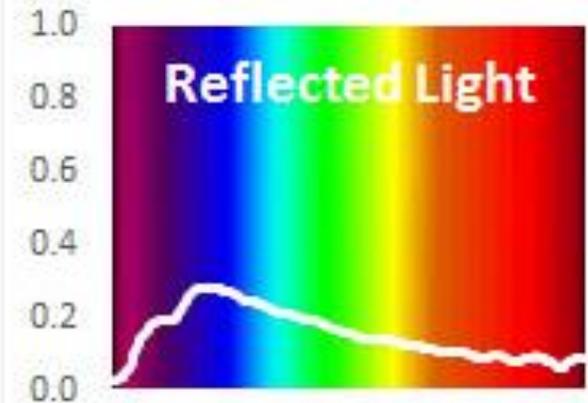
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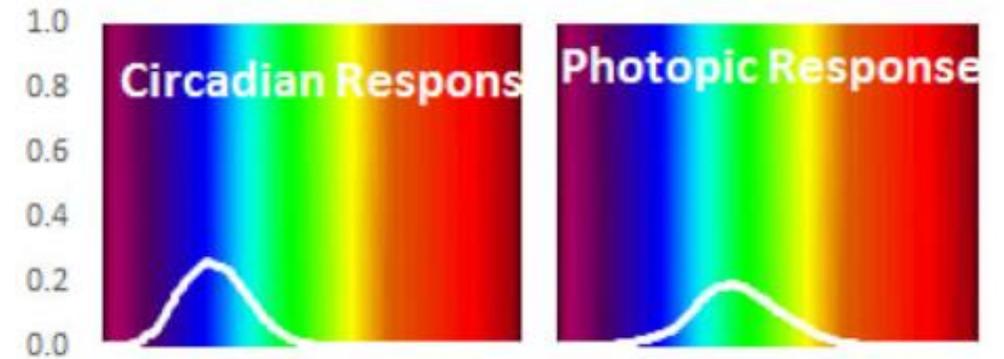
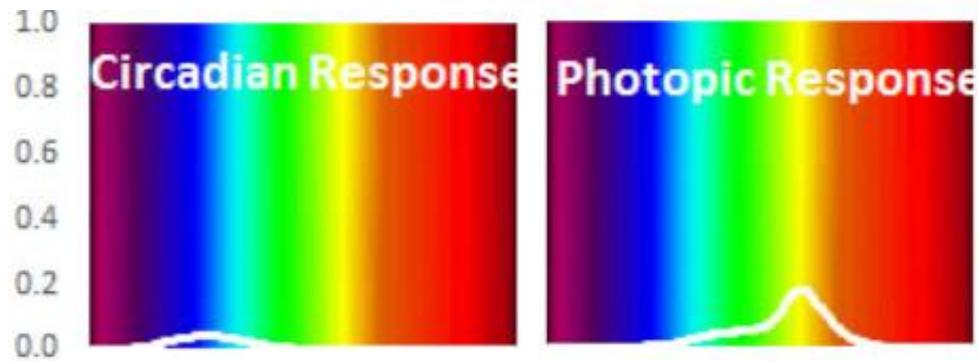
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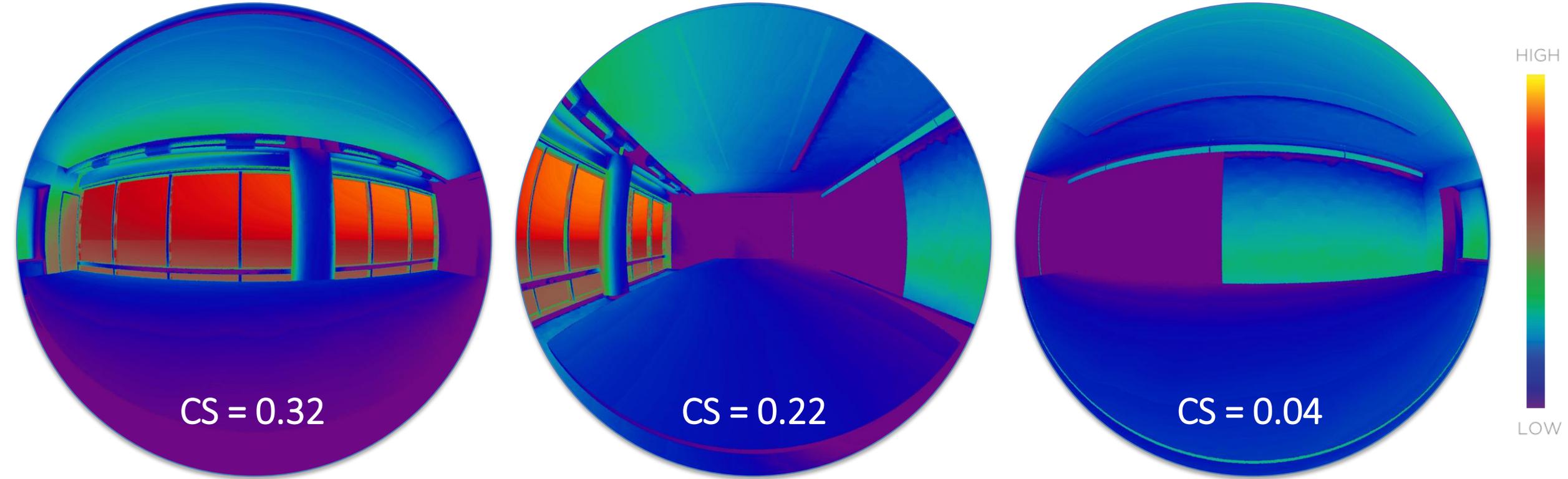


Materials Matter



Point of View Matters

March 21, 3pm - Partly Cloudy, 5000 CCT`

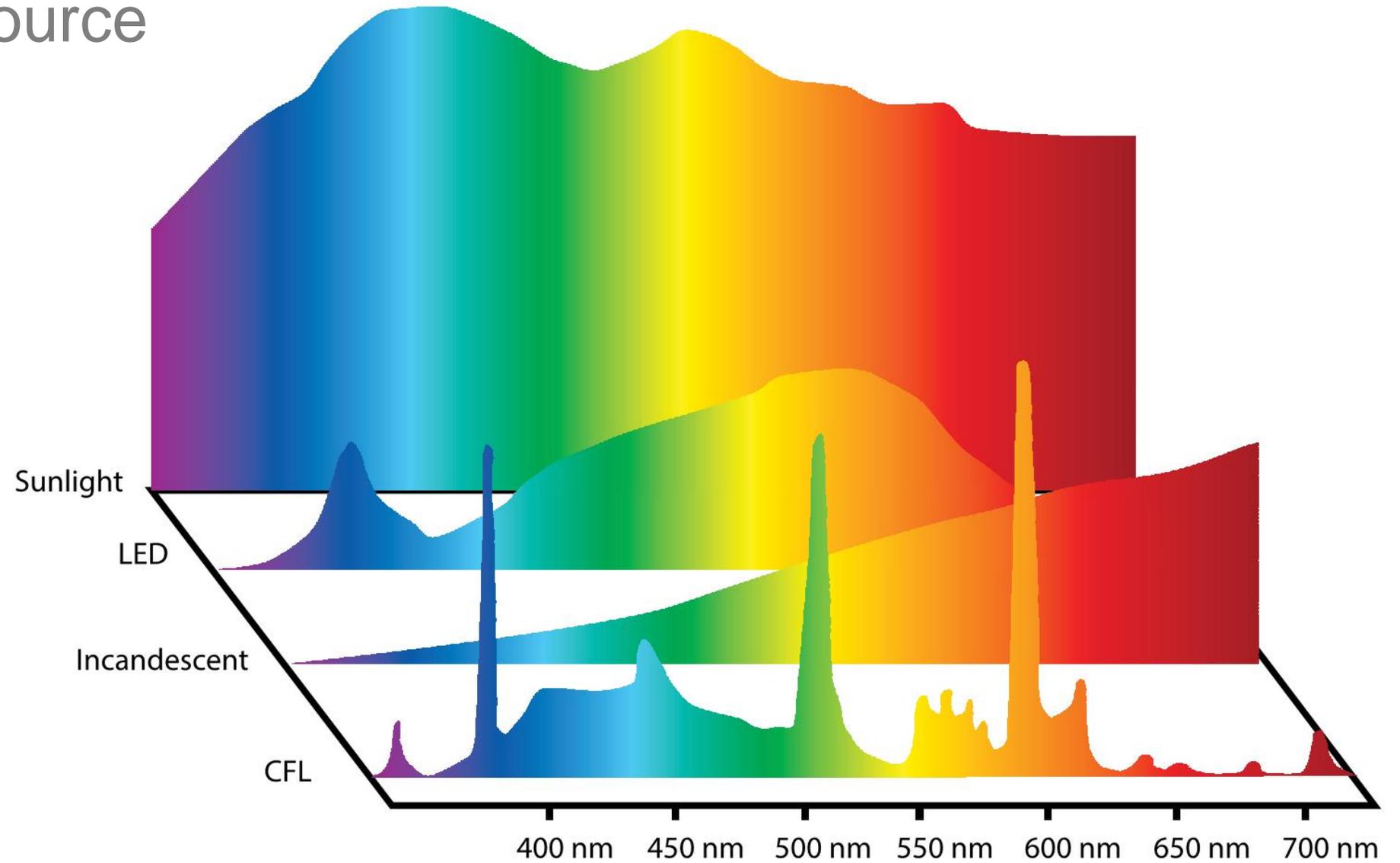


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CS = Circadian Stimulus

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Consider the Source



Consider the Source

Winter
Overcast Sky – 7000k



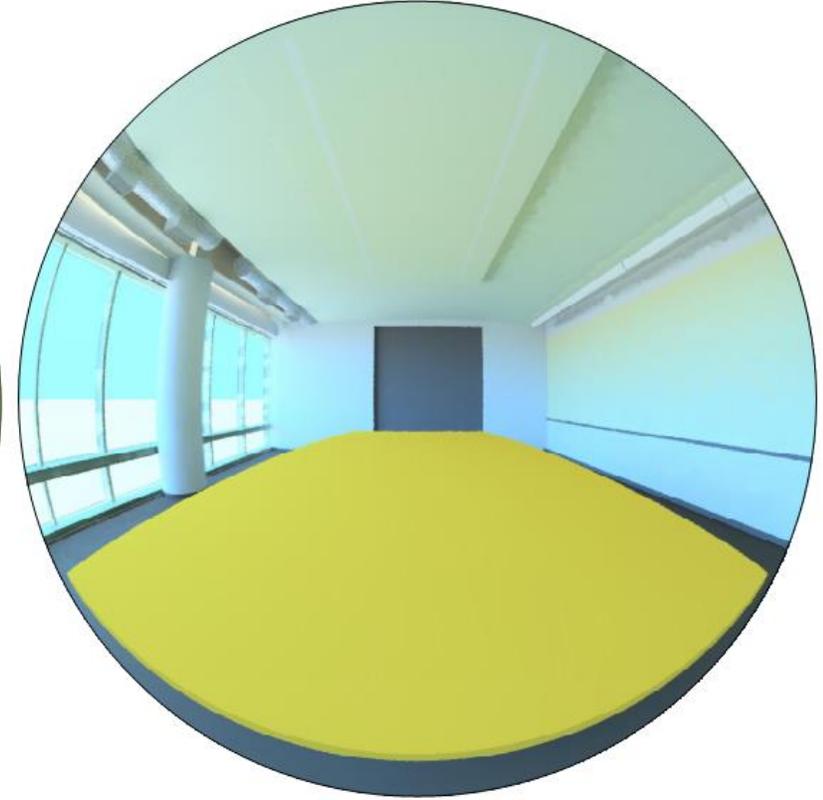
Photopic – 55 Lux

Spring
Partly Cloudy – 5000k



Photopic – 444 Lux

Summer
Clear Sky – 25000k



Photopic – 833 Lux

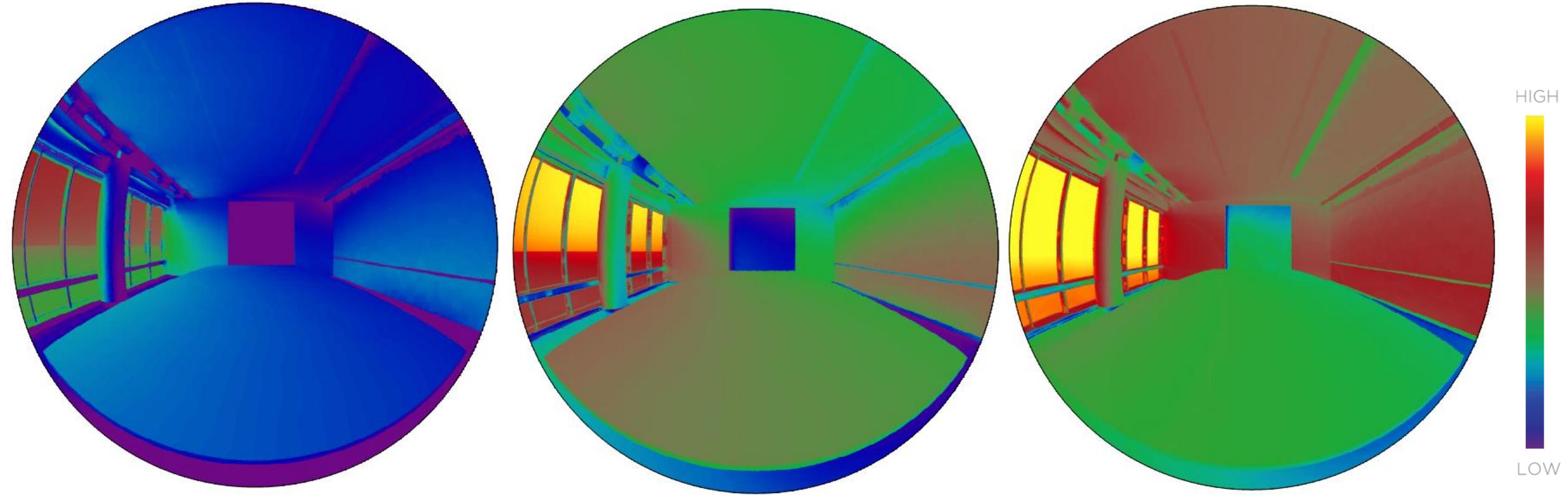


Consider the Source

Winter
Overcast Sky – 7000k

Spring
Partly Cloudy – 5000k

Summer
Clear Sky – 25000k



Consider the Source

\$



VS

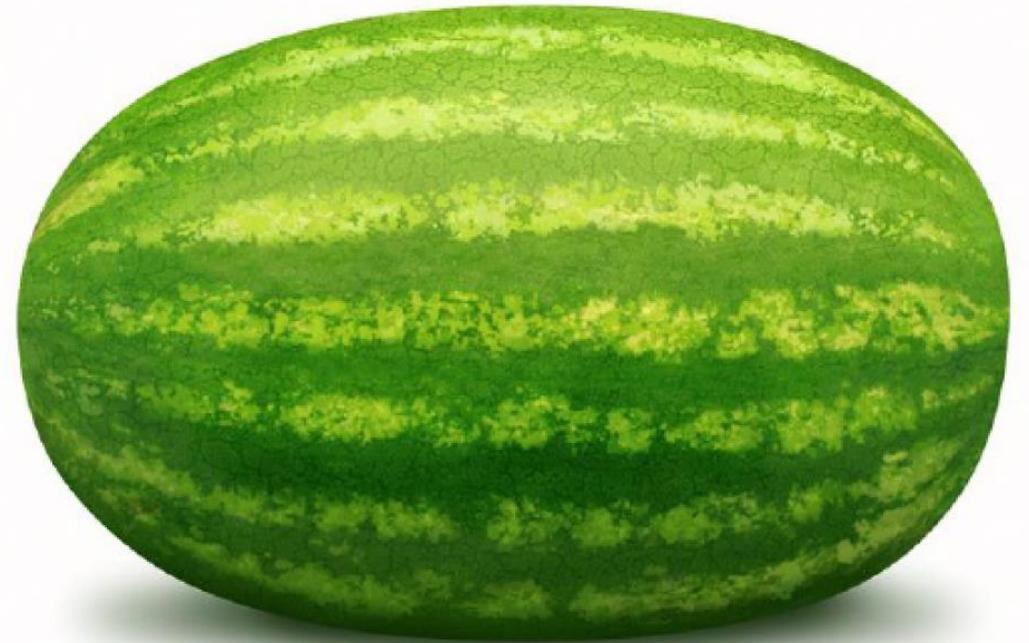
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Consider the Source

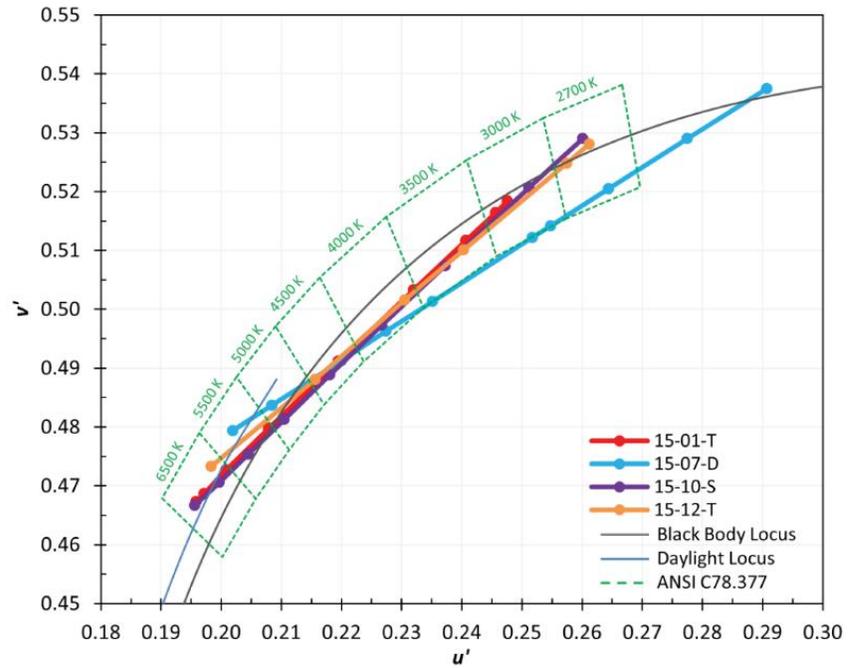


VS

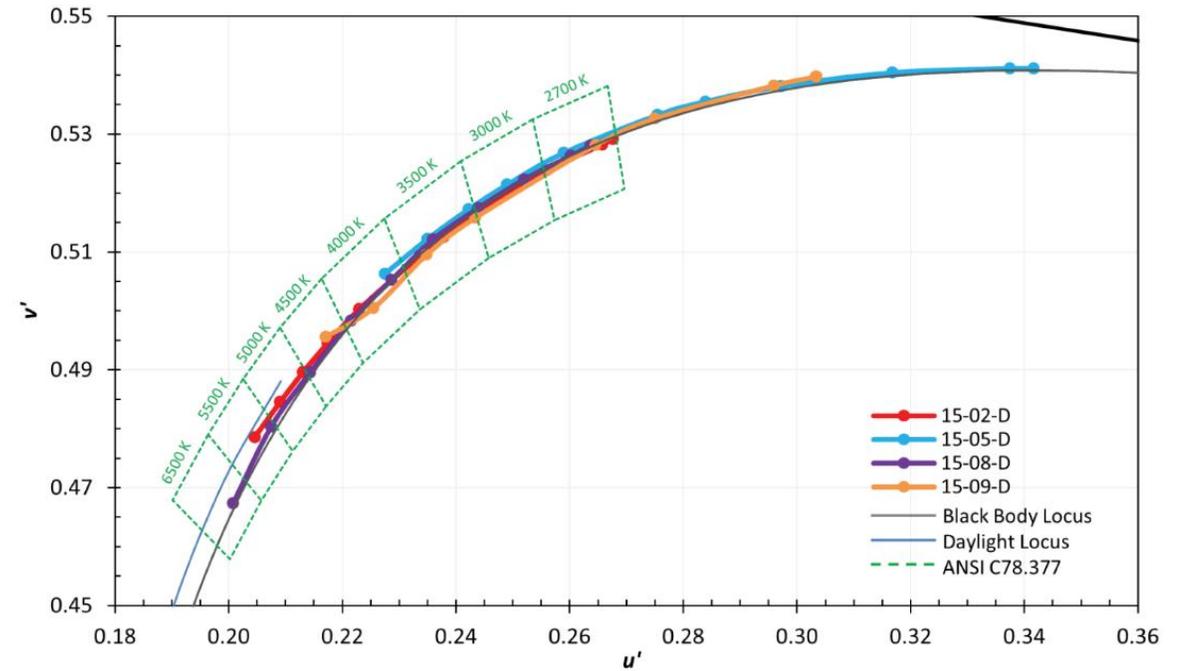


Consider the Source

LINEAR TUNING



NON-LINEAR TUNING

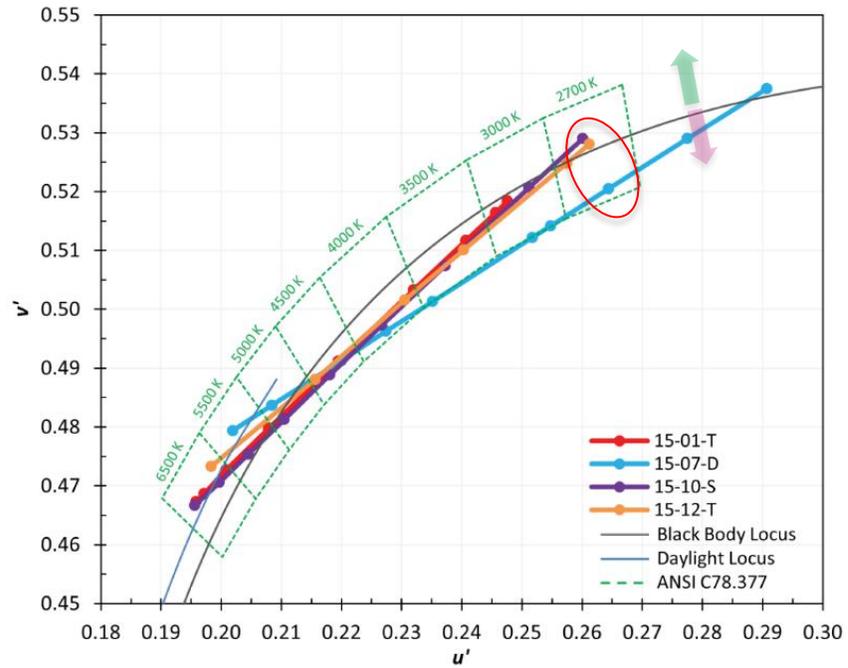


CALIPER REPORT 23 PHOTOMETRIC TESTING OF WHITE-TUNABLE LED LUMINAIRES, AUG 2015

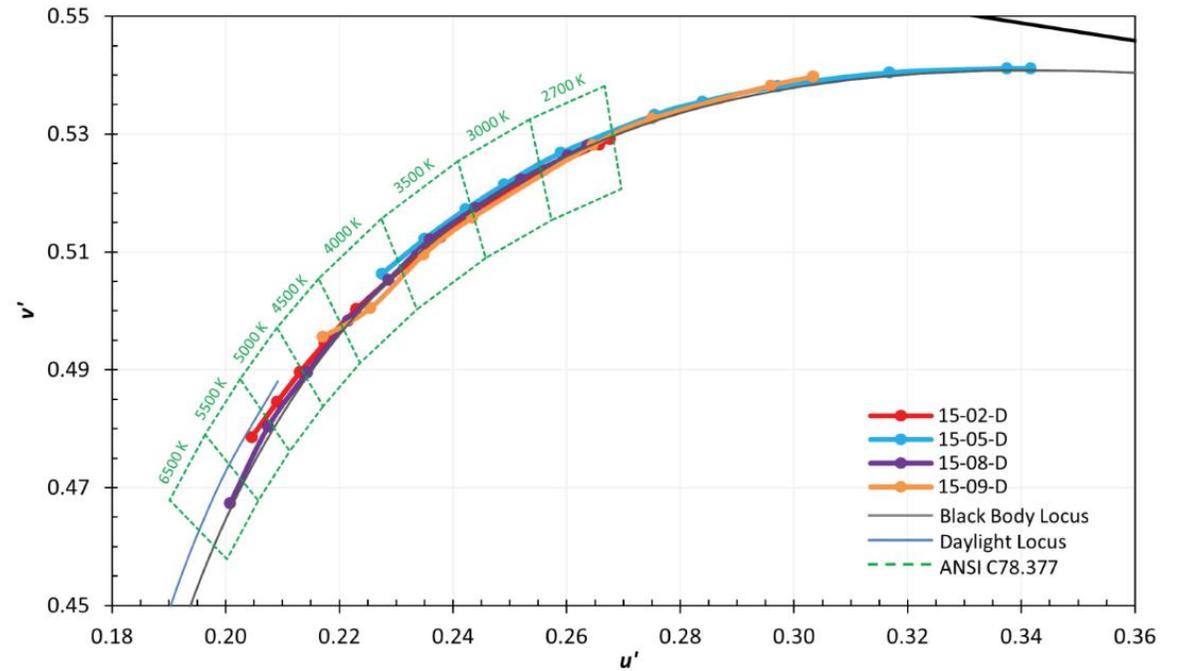


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LINEAR TUNING



NON-LINEAR TUNING



CALIPER REPORT 23 PHOTOMETRIC TESTING OF WHITE-TUNABLE LED LUMINAIRES, AUG 2015

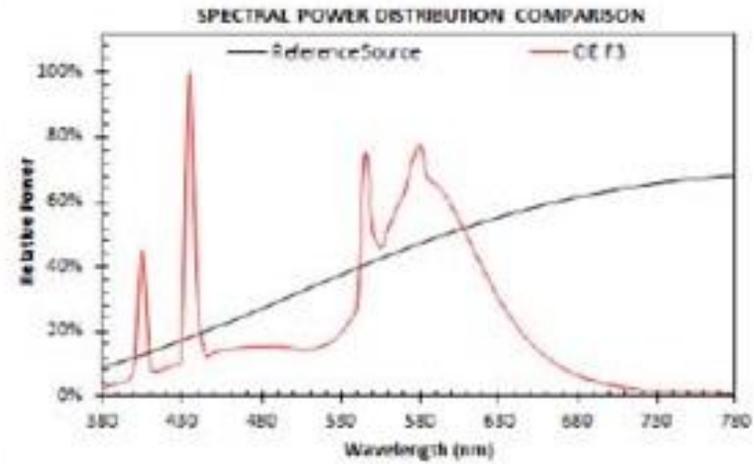


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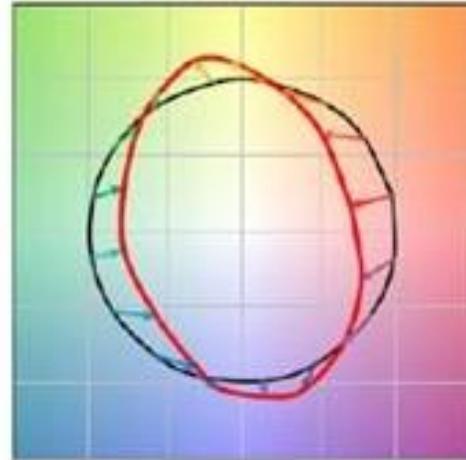
IES TM 30-15

Source:
CIE F3

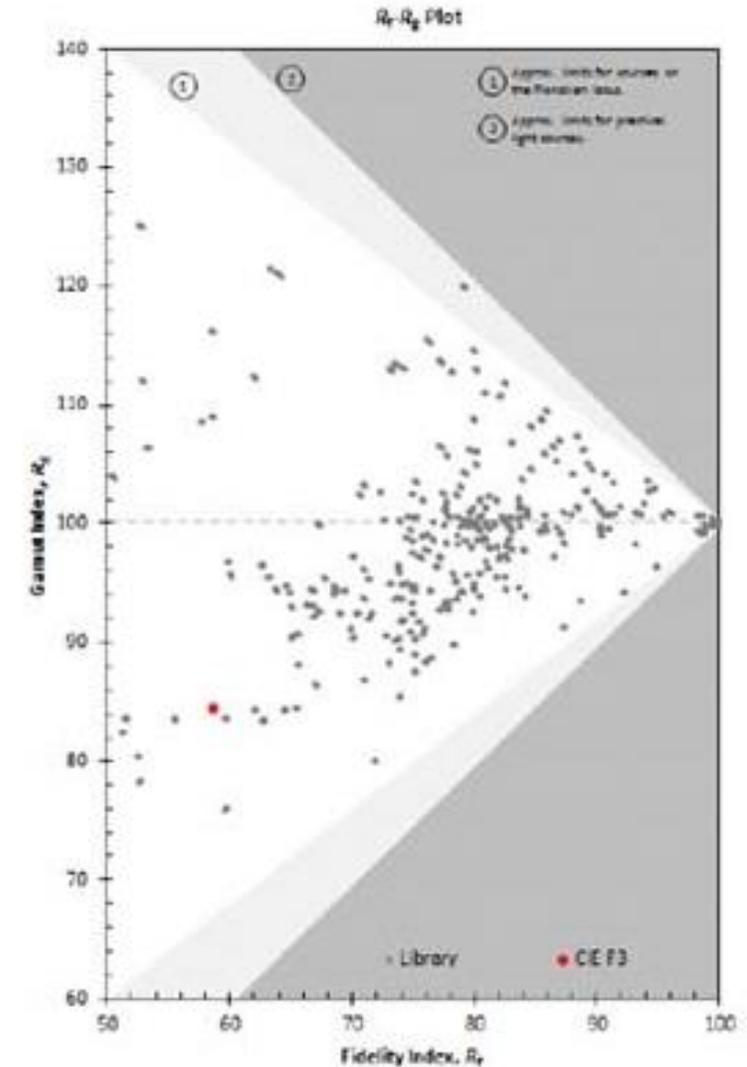
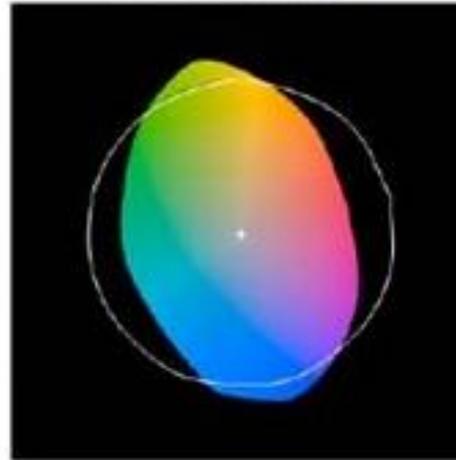
R_f	59
R_g	84
CCT (K)	3446
D_{uv}	0.0007
x	0.4091
y	0.3941
CIE R_a	57
	0



COLOR VECTOR GRAPHIC



COLOR DISTORTION GRAPHIC



Source from DOE+IES Webinar, September 15, 2015





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Spectral Power Distribution of BeveLED 2.0 at specified CCT



BLUE WASHING



Circadian Design – On the Boards



MBU Design PATIENT ROOM

Features

- Patient Headwall
- Physio Monitor Cabinet
- Canopy and Ceiling Treatment
- Family Space



Circadian Design – On the Boards



MBU Design LIGHTING CONCEPTS



Family and Visitor Lounge



Care Team Station



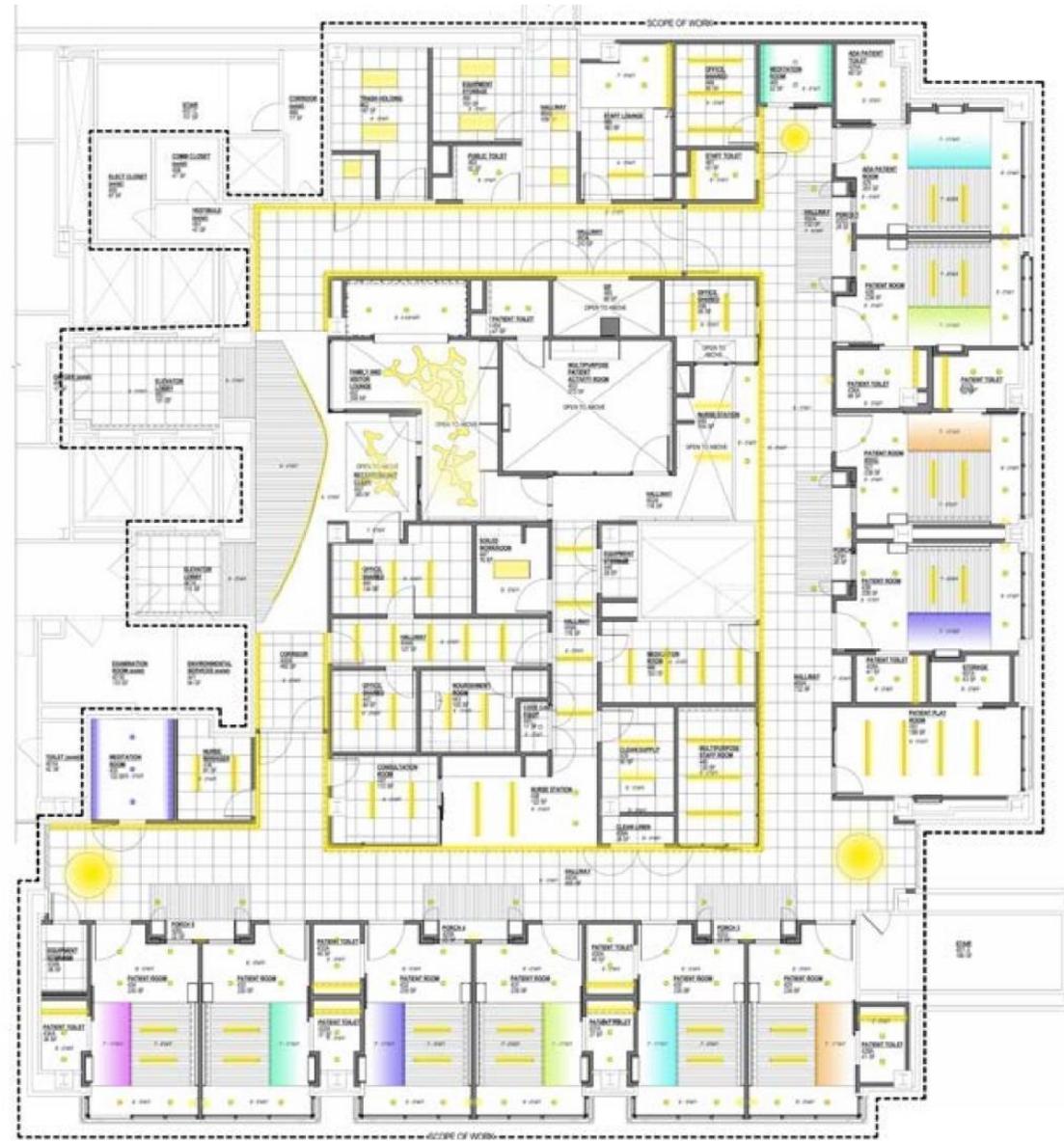
Colored LED Light Feature at Footwall



LED Lighting



Circadian Design – On the Boards



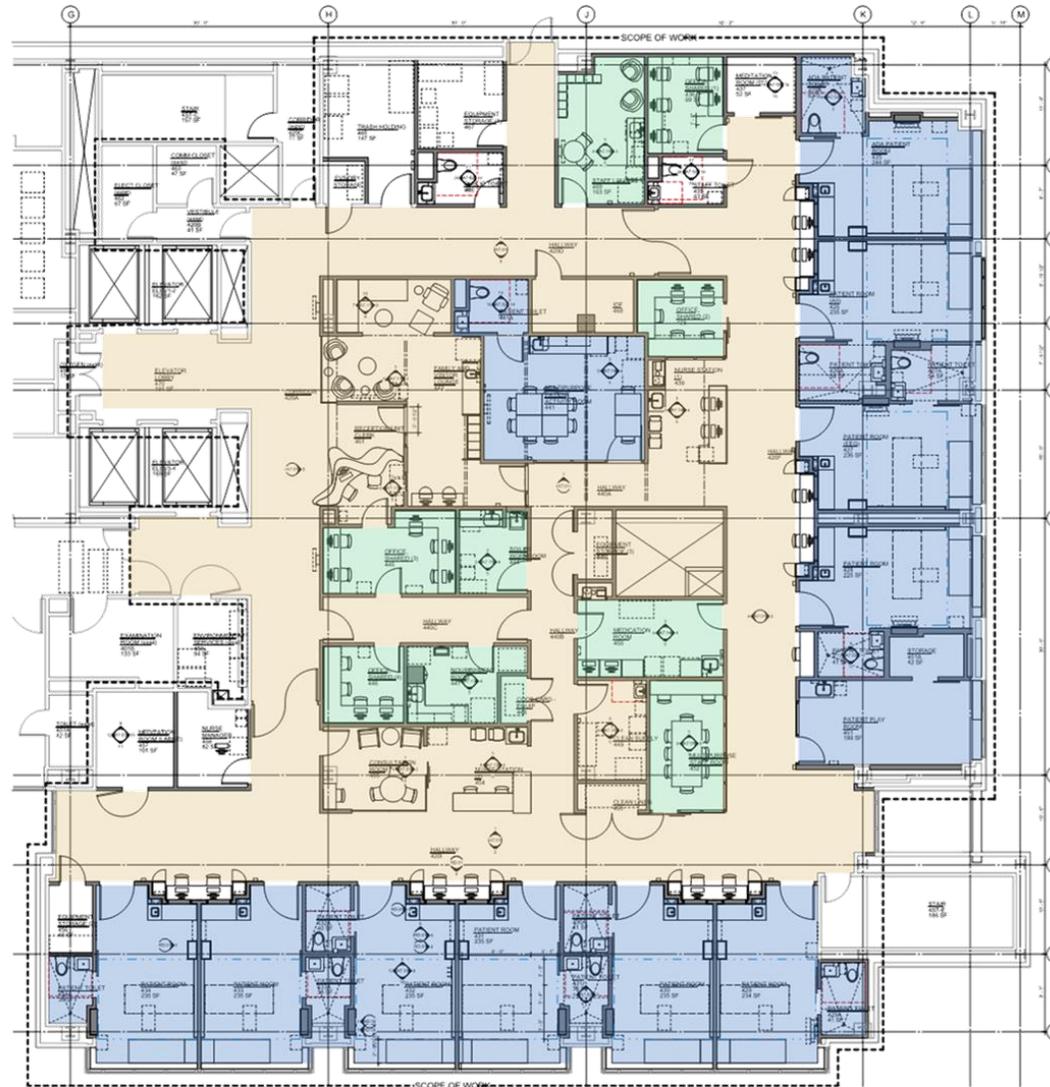
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Circadian Design – On the Boards

Features

- Patient-Focused Circadian Solutions
- Staff-Focused Circadian Solutions
- Experiential Solutions to Support Patients and Staff



Patient Focused Circadian Solutions

Goal: Circadian Rhythm Entrainment

Combination of Dimming with Color Shifting Fixtures

Example Schedule (Actual Schedule to Be Determined)
8 am - 12 pm - Cool CCT with High Illumination Levels
12 pm - 3 pm - Neutral CCT with Medium Illumination Levels
3 pm - 8 pm - Warm CCT with Medium Low Illumination Levels

Staff Focused Circadian Solutions

Goal: Circadian Rhythm Entrainment
Alerting Effect

Combination of Dimming with Color Shifting Fixtures

Example Schedule (Actual Schedule to Be Determined)
8 am - 12 pm - Cool CCT with High Illumination Levels
12 pm - 3 pm - Neutral CCT with Medium Illumination Levels
3 pm - 8 pm - Warm CCT with Medium Low Illumination Levels

This schedule should be adjusted to best fit staff shifts. The impact of behavior upon circadian entrainment should also be discussed with staff, especially those who work the night shift as well as rotating shift work.

Experiential Solutions to Support Patients and Staff

Goal: Experientially Support Occupant Schedules
Bias Schedule towards Patients
Serve as an Intermediate Space between the Patient and Staff

Combination of Dimming with Color Shifting Fixtures

Illumination levels and color controls should be time-clock based with a simple user override.

The shortened winter daylight hours will be expanded to be more aligned with the equinox daylight duration.

The schedule between the spring and fall equinoxes will default to actual sunrise and sunset.



Circadian Design Guidelines

Review the science – beyond cut sheets and industry white papers

Know the occupants and their patterns

Consider materiality

Understand the available resources in the occupied spaces

Prioritize the daylight resource, supplement with electric lights

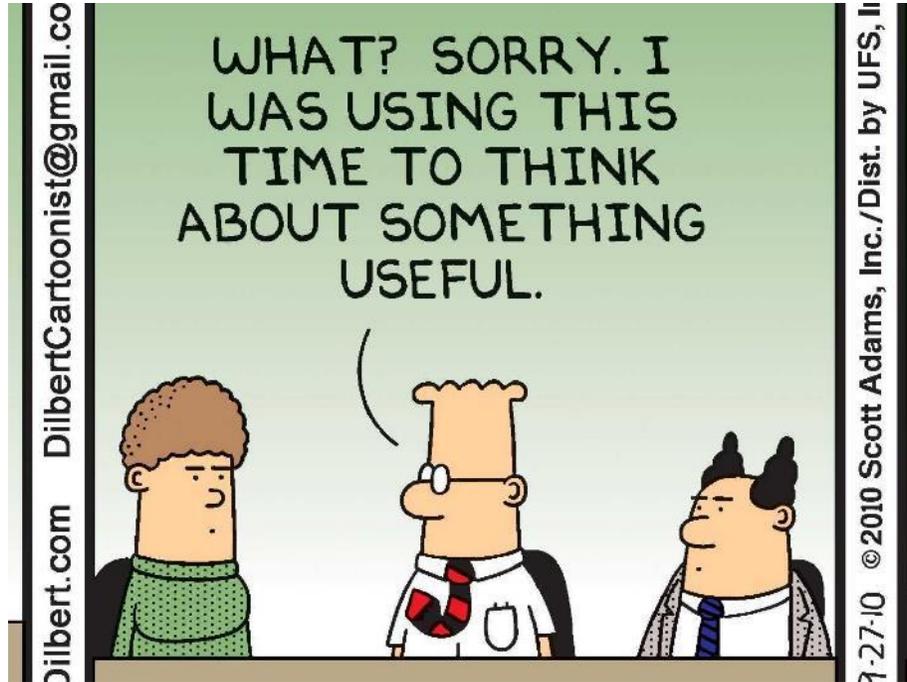
Illuminate the vertical plane

Ensure the resource is routinely available

Provide simple controls with user overrides



Time for Questions and Comments:



Thank you for joining us today!

This concludes the AIA/CES Course **Research to Practice | Lighting for Improved Environment of Care**. The webinar survey/report form URL is listed in the chat box *and* will be included in the follow-up email sent to you in the next hour. Earn 1 AIA LU/HSW.

Survey Link: <http://bit.ly/2dxuip1>

All attendees must report credit individually by completing the webinar survey/report form within the next 3 business days. Credit will automatically appear on your transcript within 2 weeks. **Tablet and smartphone users must copy down the above survey link.**

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12/13	Case Study Series	2015 AAH Design award winner and Case Study archive pilot: UCLA Surgery and Cancer Center
1/10	HC 101 series	Patient Safety Fundamentals for HC Architects – Part 2

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