

A grayscale architectural rendering of a modern interior space. The room features large, irregularly placed windows on the walls, allowing bright light to enter and create strong shadows on the floor. A staircase with a glass railing is visible on the right side of the frame. The overall atmosphere is bright and airy, emphasizing the concept of a 'daylit space'.

EXPERIENCING A DAYLIT SPACE:

PHYSIOLOGICAL, VISUAL AND PERCEPTUAL DYNAMICS OF DAYLIGHTING

Marilyne Andersen

Professor of Sustainable Construction | Head of LIPID Lab
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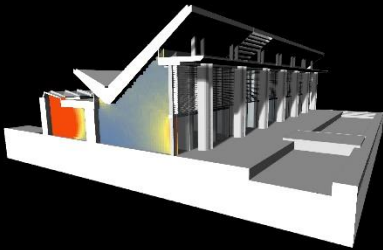


Image credit: StevenRutledge



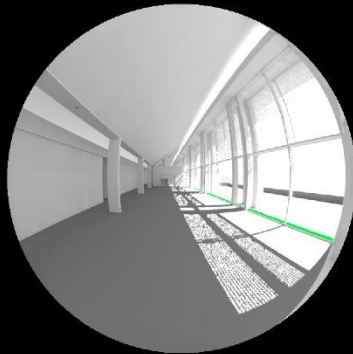
mainstream performance metrics

task performance



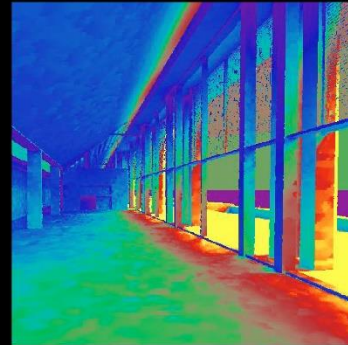
illumination

visual comfort



glare risk

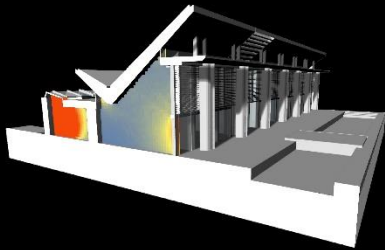
energy



solar gains

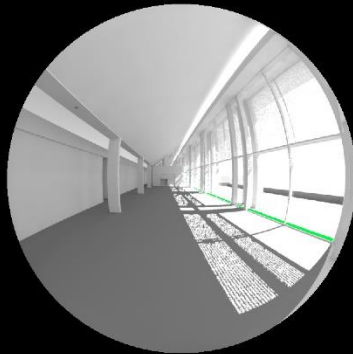
mainstream performance metrics

task performance



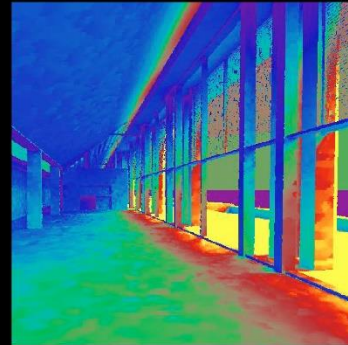
illumination

visual comfort



glare risk

energy



solar gains

human factors



health?

behavior?

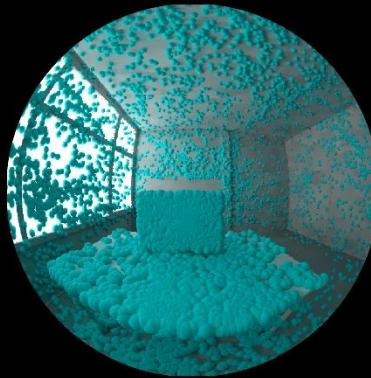
perception?

human-centered design factors

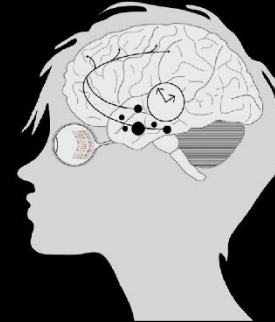
visual delight



visual responsive comfort



health potential



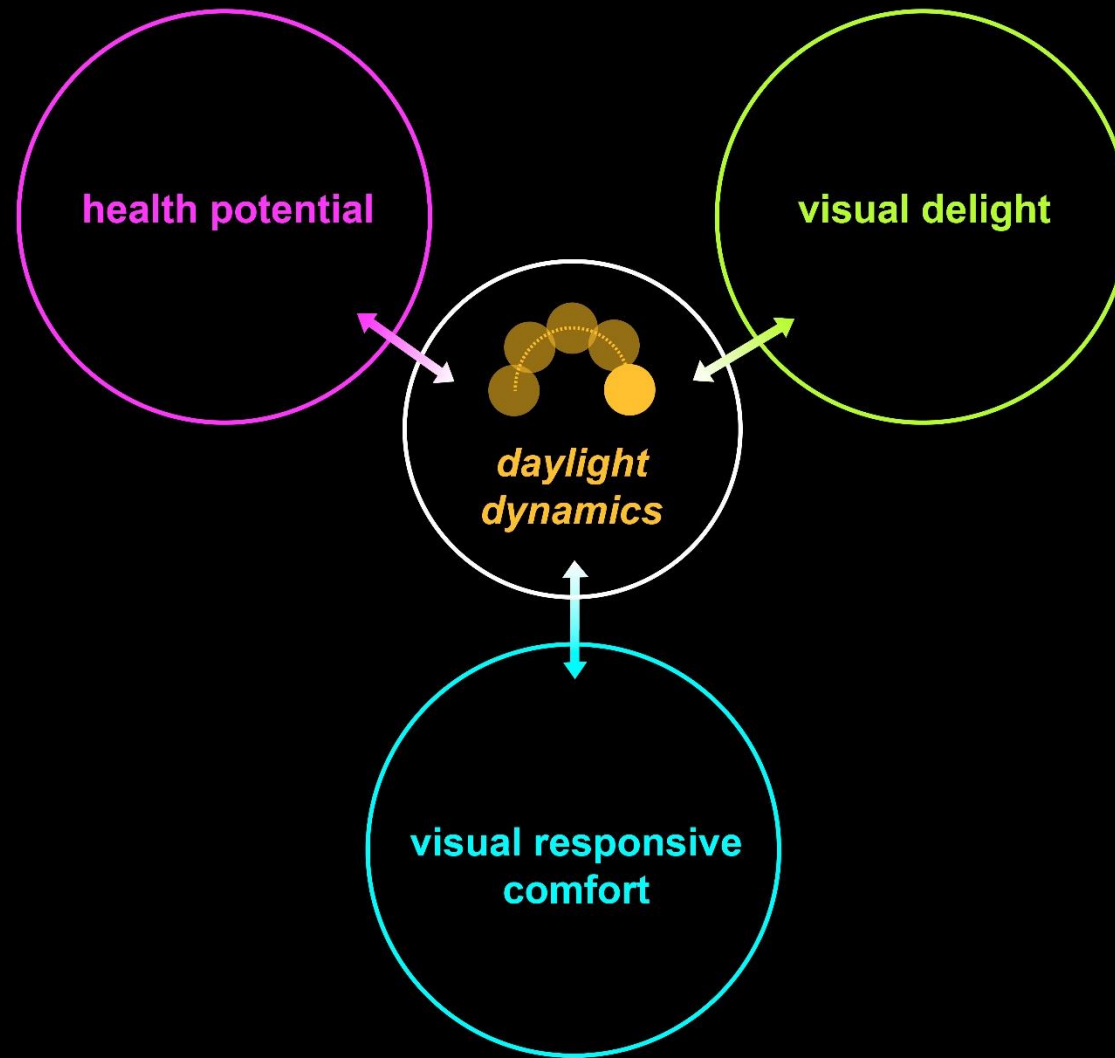
human factors



health?

behavior?

perception?



daylight in architecture



Arabic museum
Jean Nouvel



Serpentine pavilion
Toyo Ito



Neugebauer house
Richard Meier & Partners



Toledo glass museum
SANAA



First unitarian church
Louis Kahn



Menil gallery
Renzo Piano

daylight in architecture



Arabic museum
Jean Nouvel



Serpentine pavilion
Toyo Ito



Neugebauer house
Richard Meier & Partners



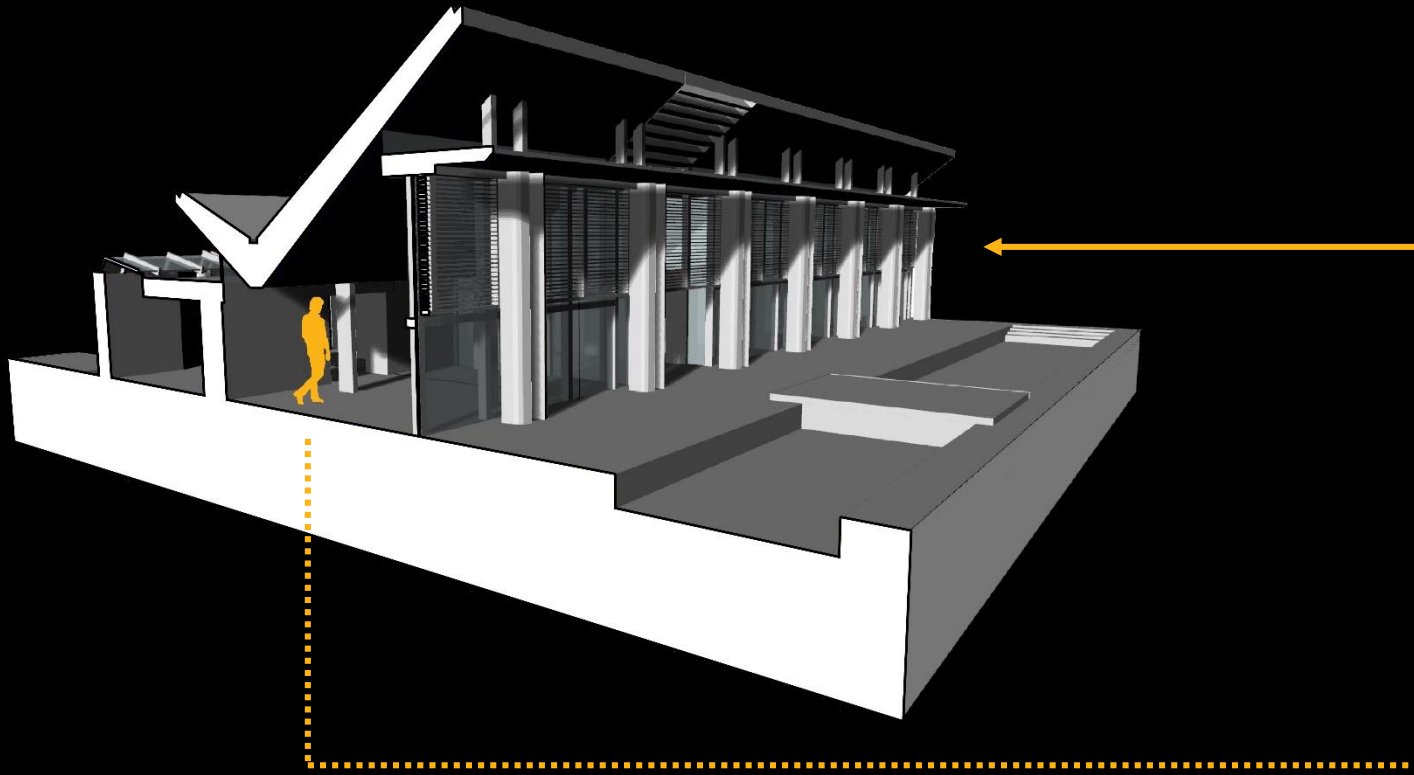
Toledo glass museum
SANAA



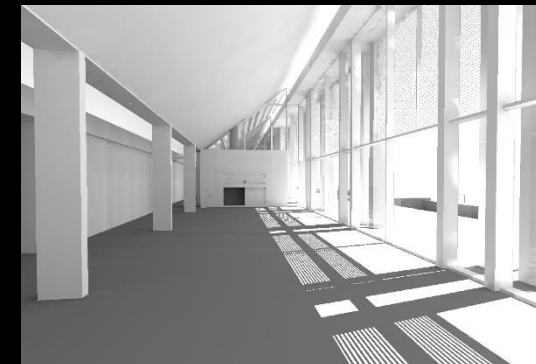
First unitarian church
Louis Kahn



Menil gallery
Renzo Piano



Neugebauer house
Richard Meier & Partners

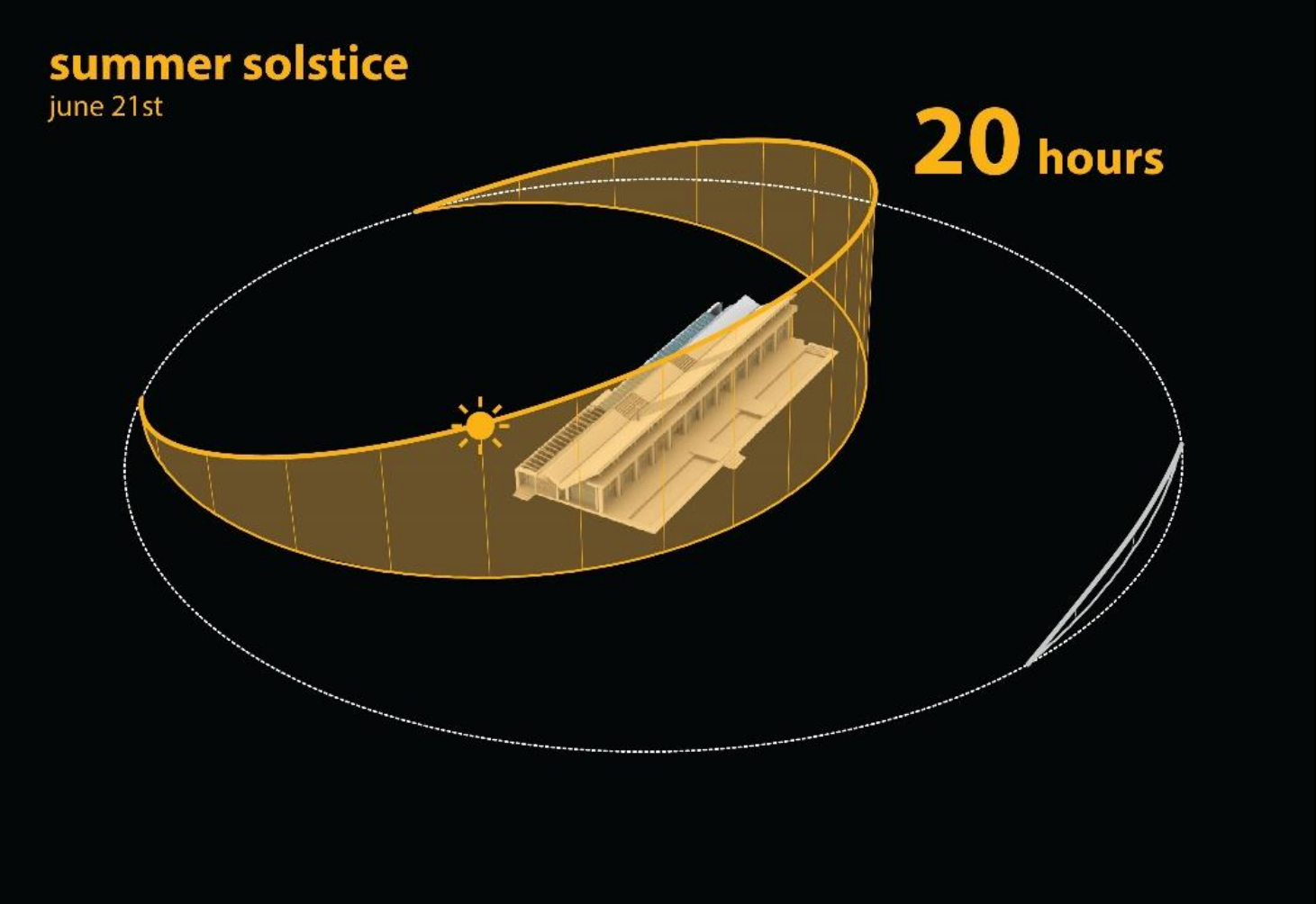


High dynamic range (HDR) rendering

latitude 64.13° N



latitude 64.13° N



01:30



04:30



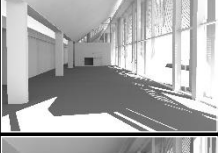
07:30



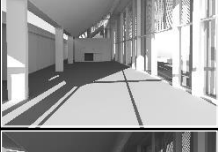
10:30



13:30



16:30

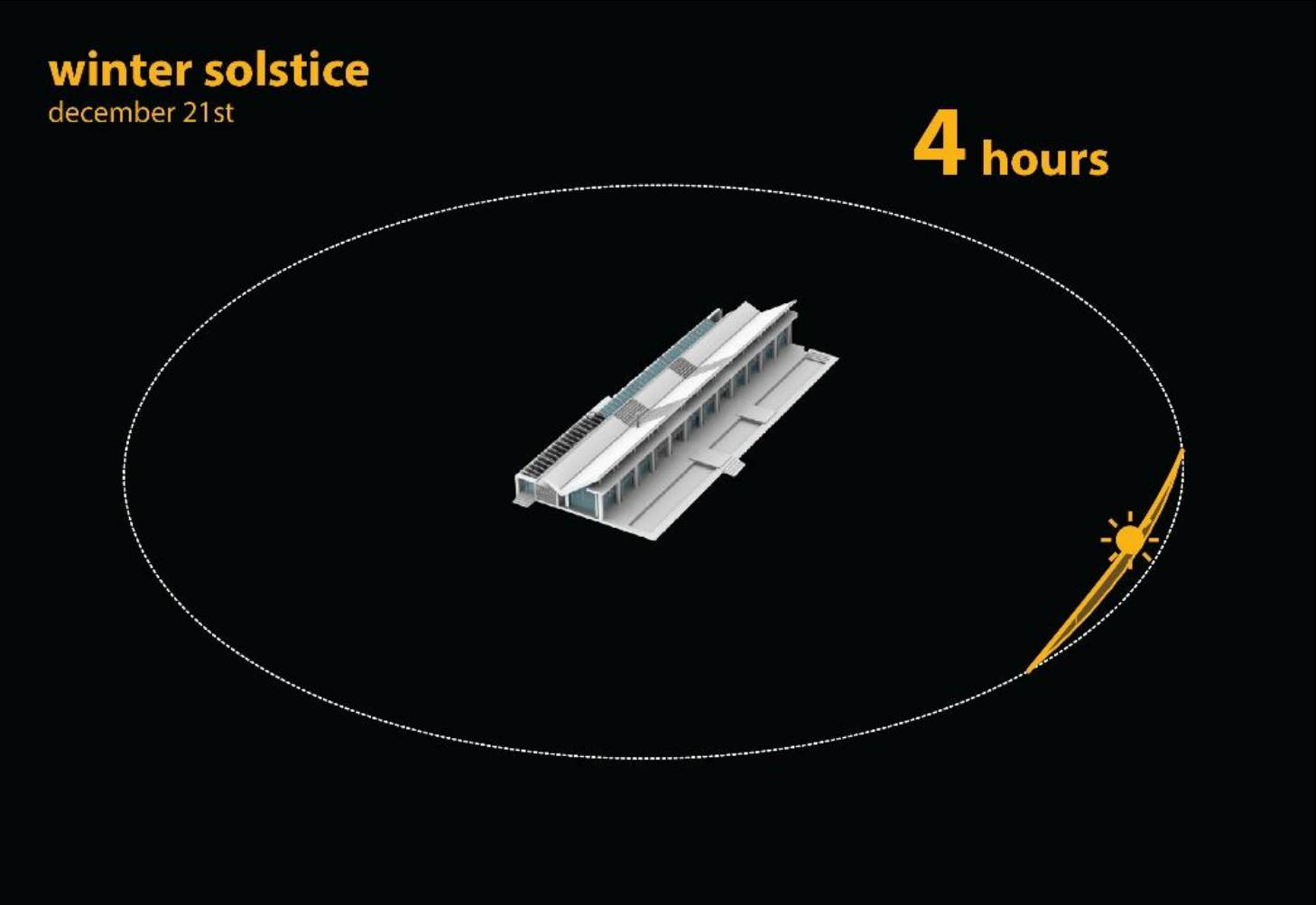


19:30



22:30

latitude 64.13° N



01:30



04:30



07:30



10:30



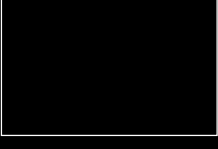
13:30



16:30



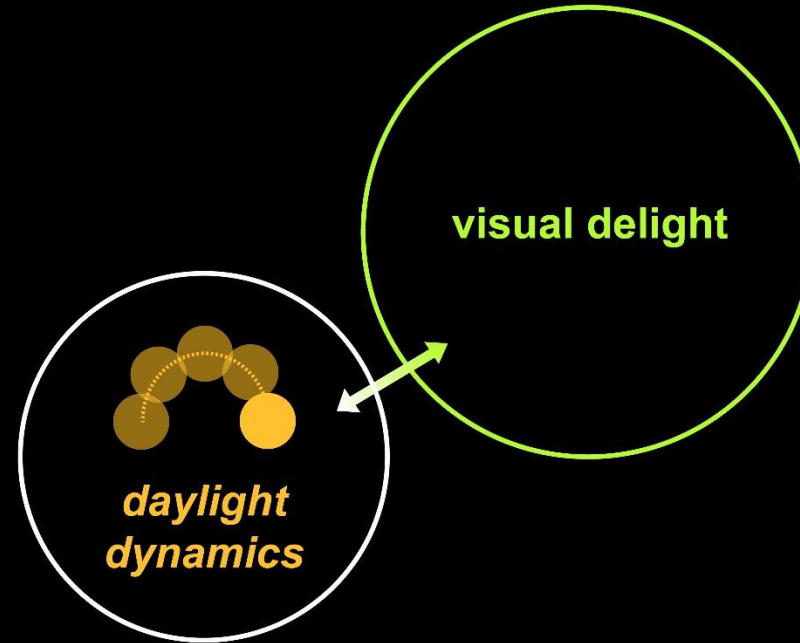
19:30



22:30



Siobhan Rockcastle
PhD student



visual delight:

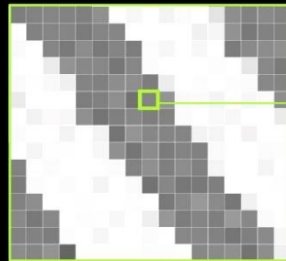
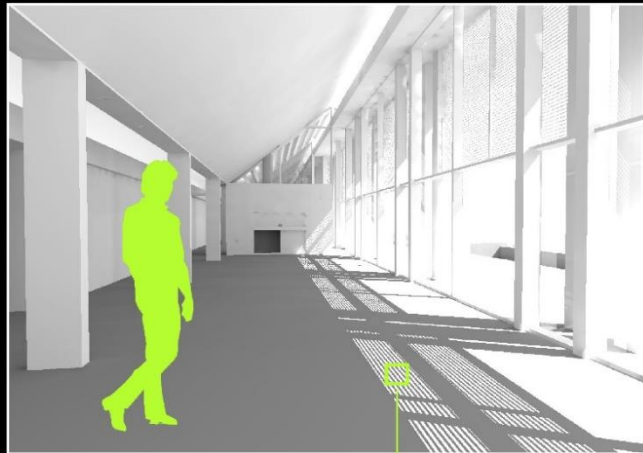
A measure of compositional variation across the field of view, linked to impressions of excitement in dynamic daylit environments.

visual delight

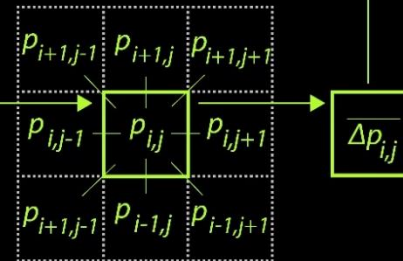
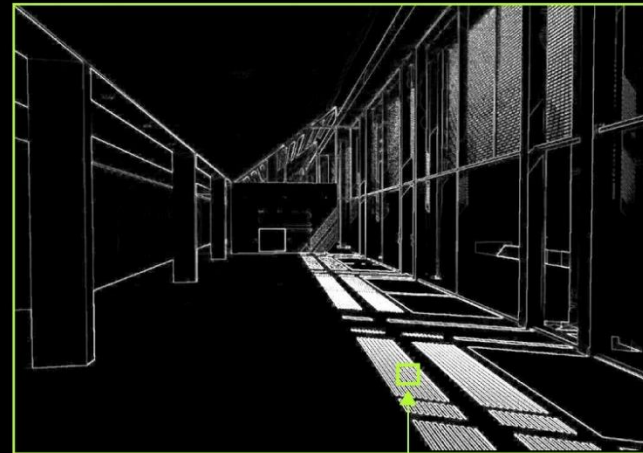
calculated using spatial contrast

- a measure of compositional complexity based on localized differences in brightness*
- linked to impressions of excitement and relaxation

luminance map



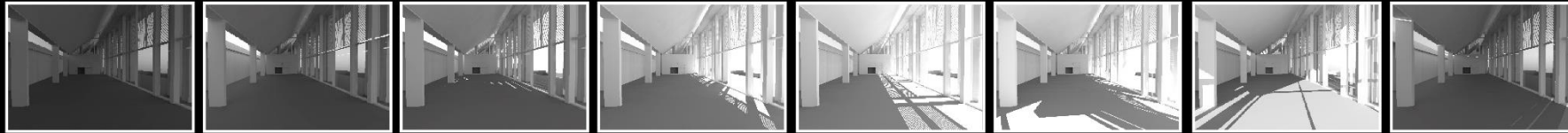
spatial contrast



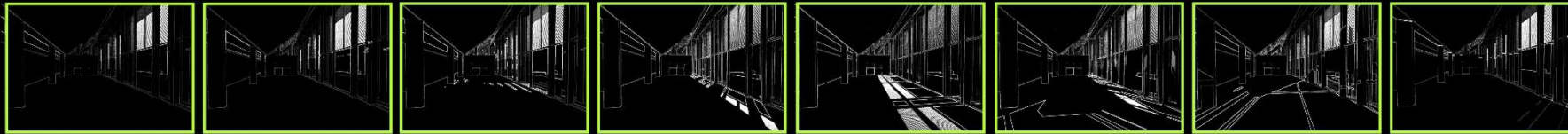
*Rockcastle S., Andersen M., *Measuring the Dynamics of Contrast and Light Variability in Architecture: A Proof of Concept Methodology*, Building and Environment, vol 81, November 2014, 320-333

visual delight

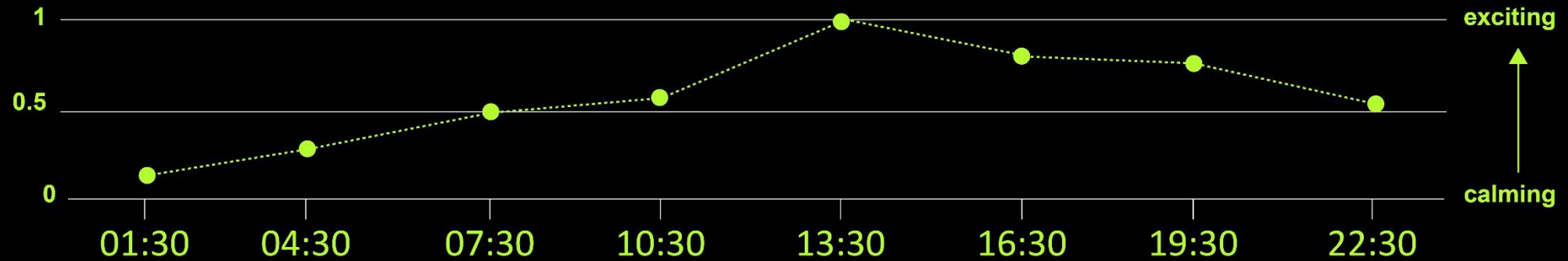
dynamic performance



luminance map



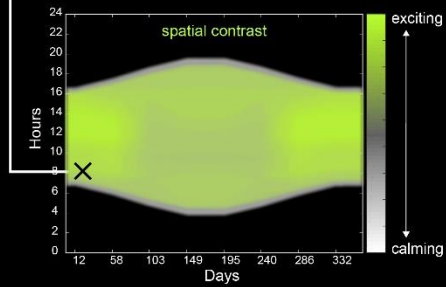
spatial contrast



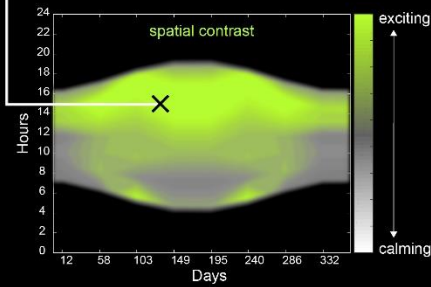
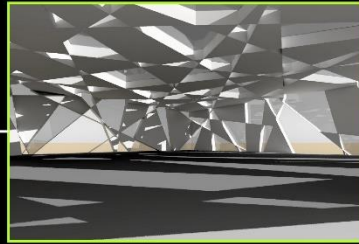
visual delight

dynamic spatial and temporal performance

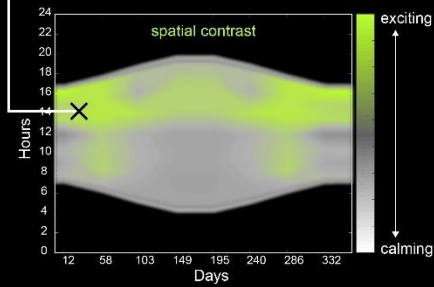
exciting



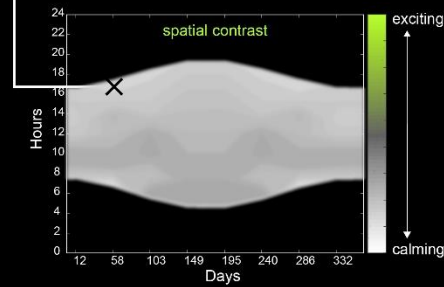
exciting



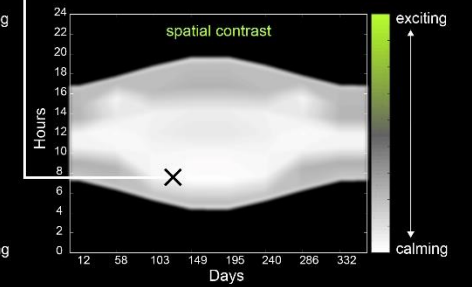
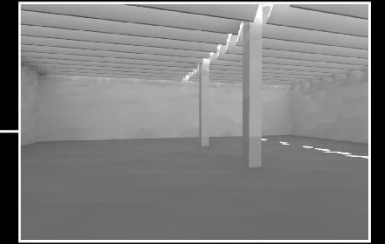
exciting



calming

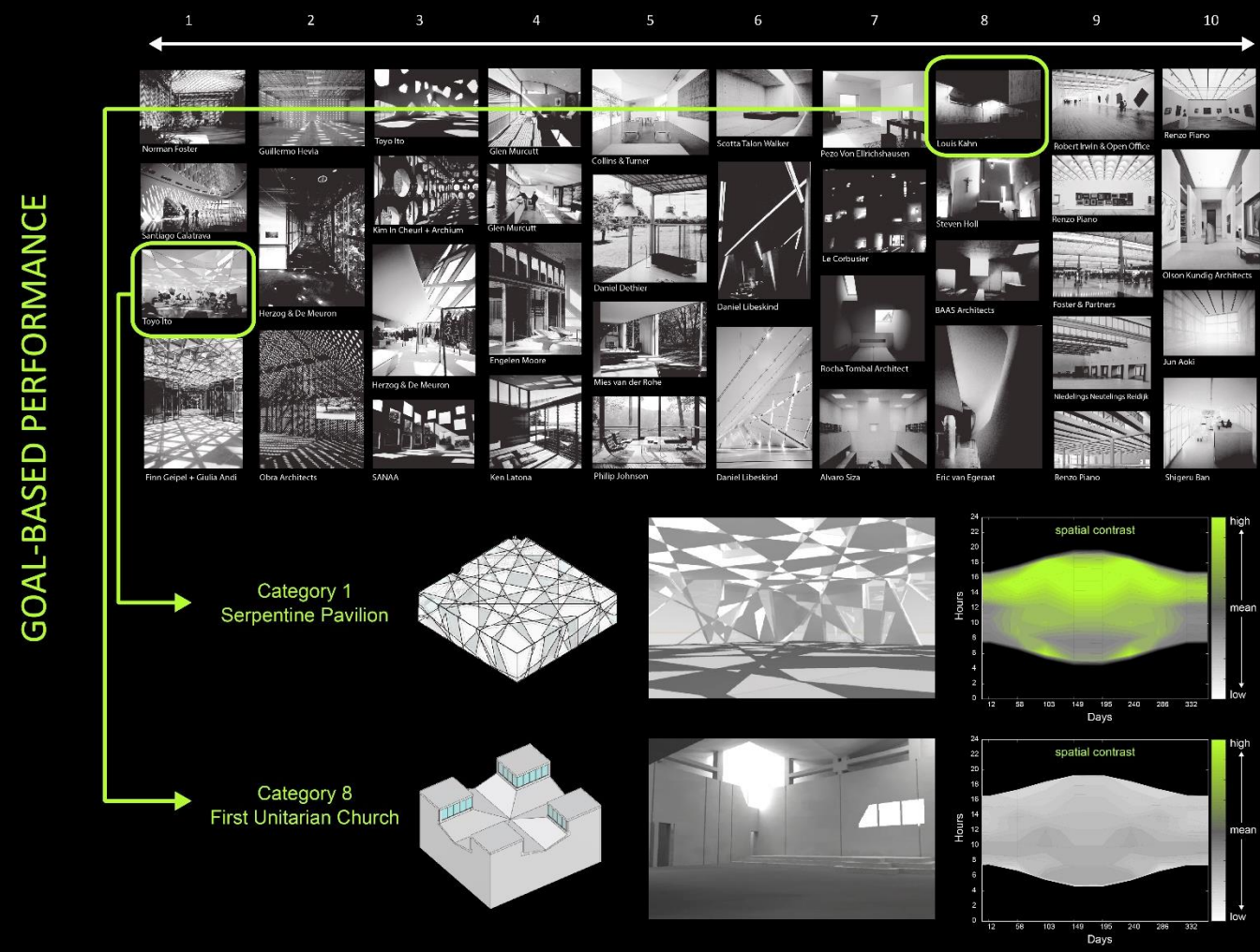


calming

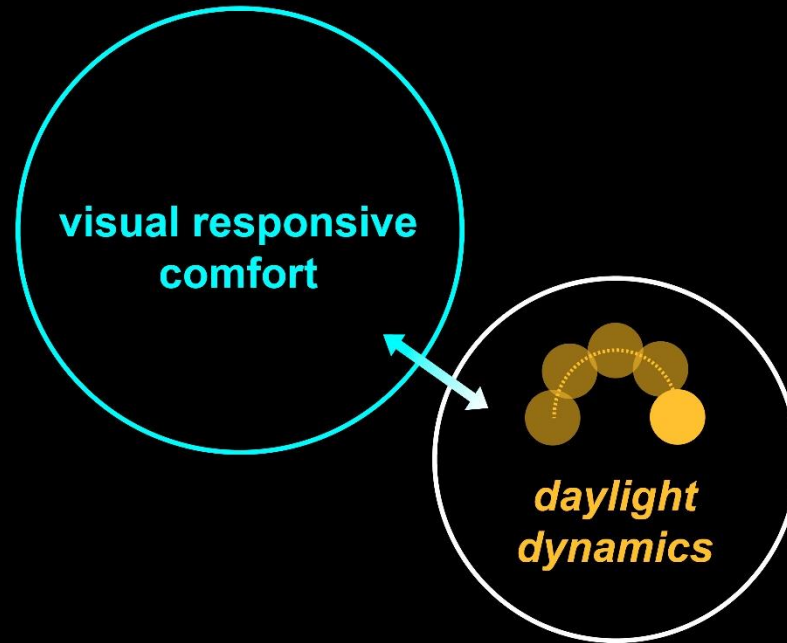


visual delight

comparative goal-based performance





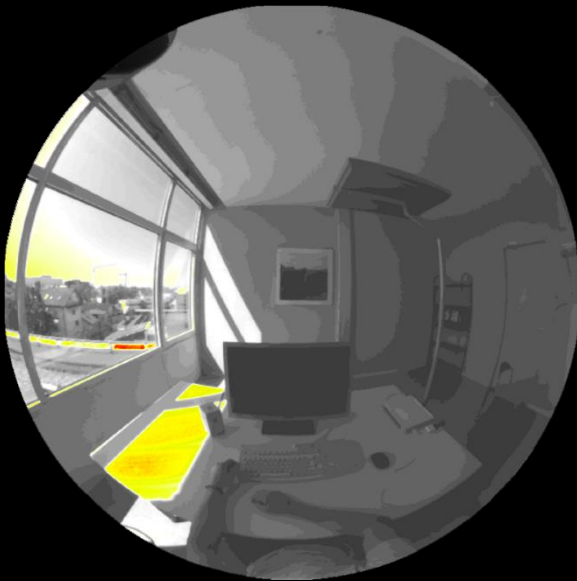


Mandana Sarey Khanie
post doctoral researcher

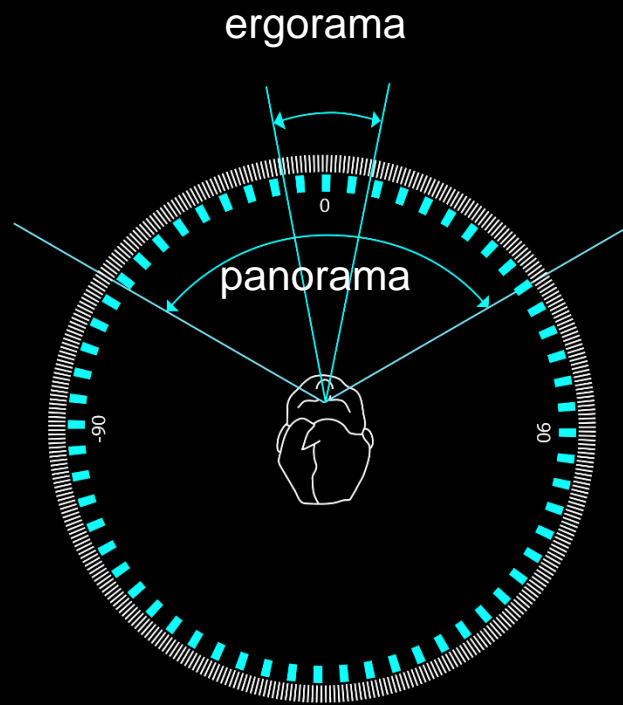
visual responsive comfort:

This measure identifies the shift of view direction as a response to discomforting brightness across the field of view.

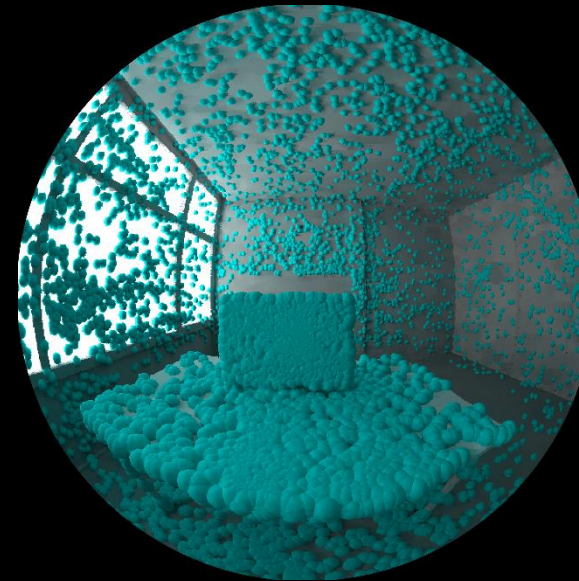
responsive comfort



perceived light



field of view

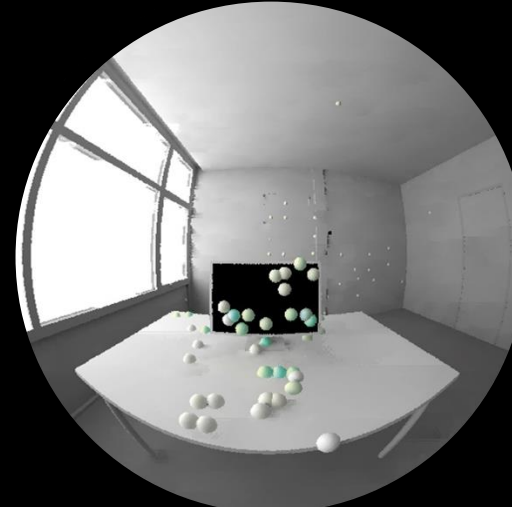


gaze response

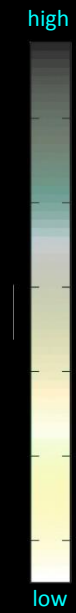
responsive comfort



gaze tracker



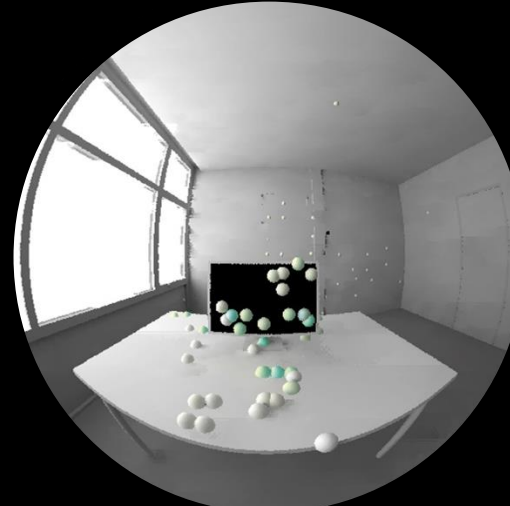
gaze response



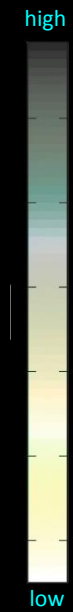
responsive comfort



gaze tracker



gaze response

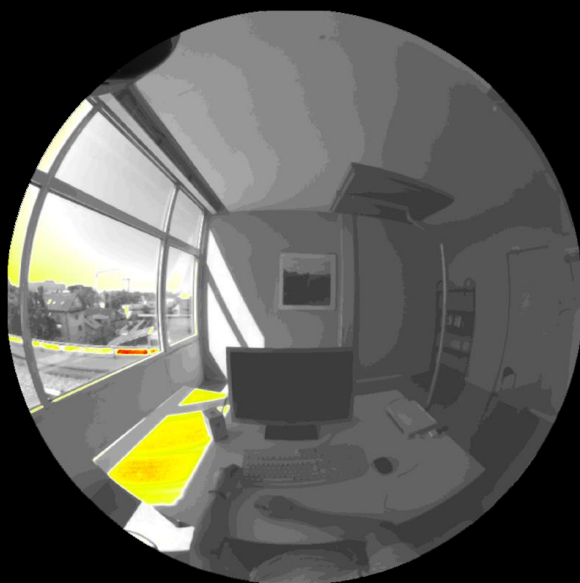


luminance cameras

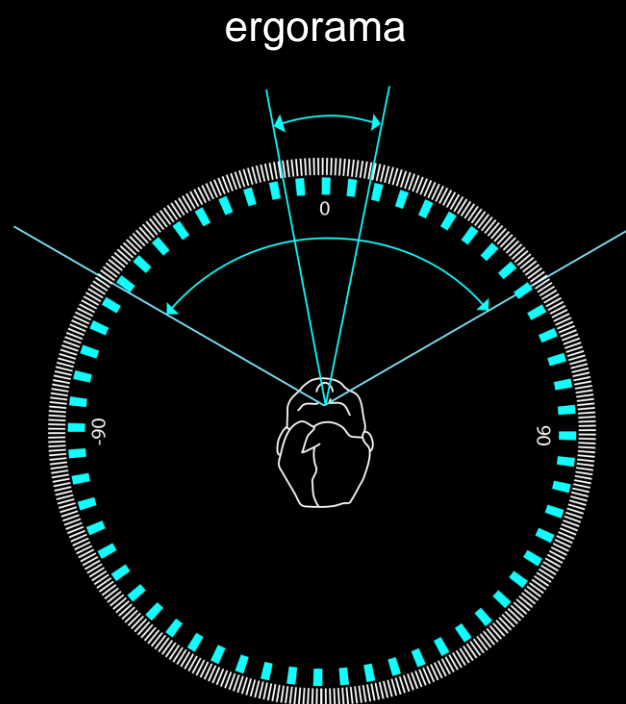


270° visual span

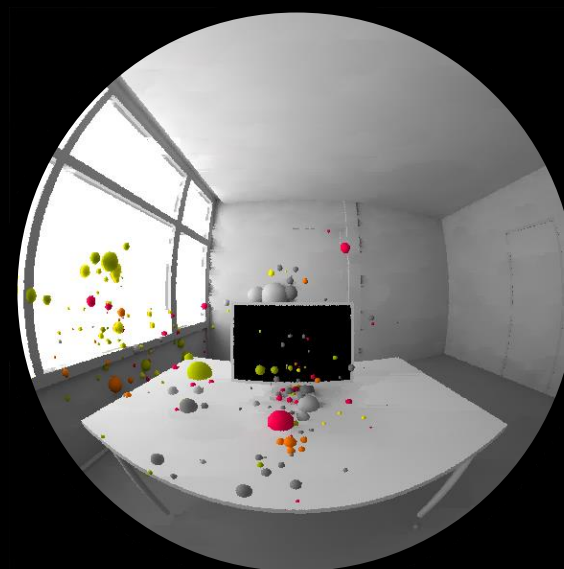
responsive comfort



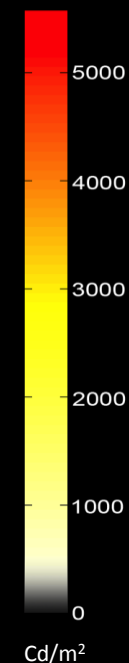
perceived light



field of view

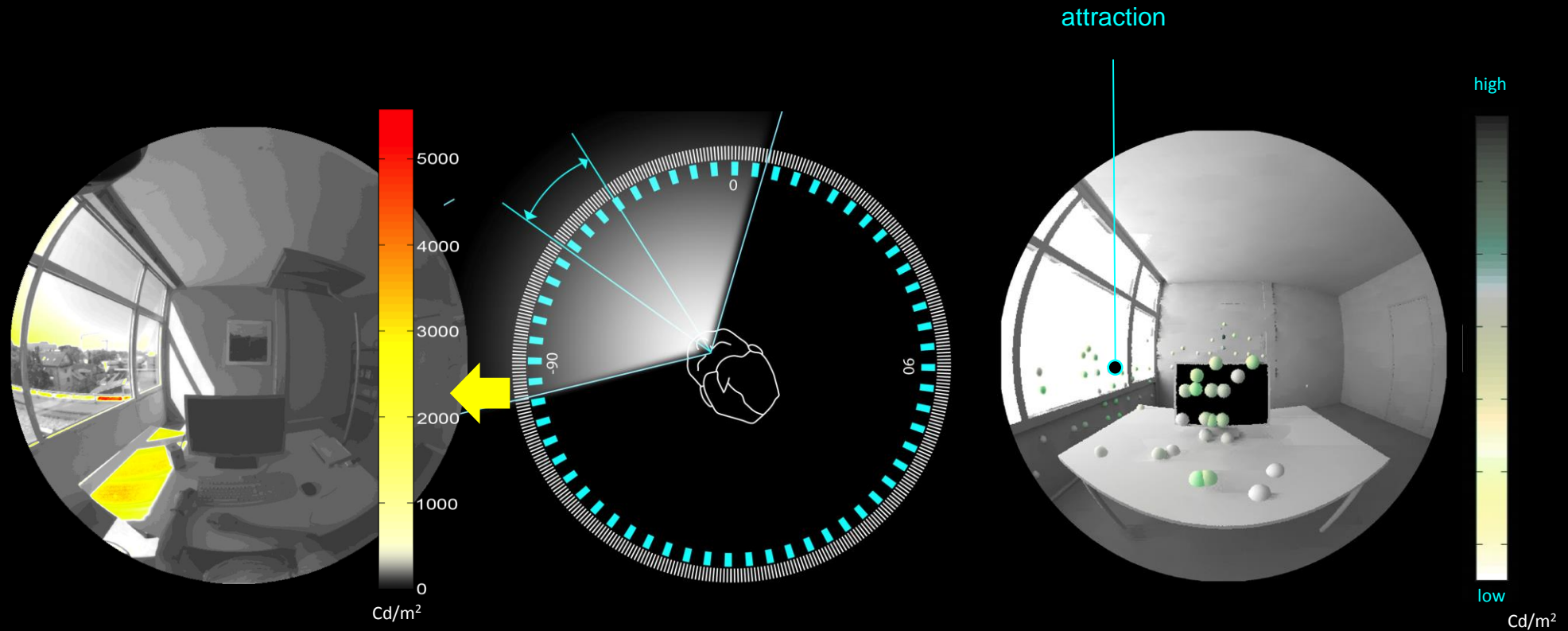


talking on a phone



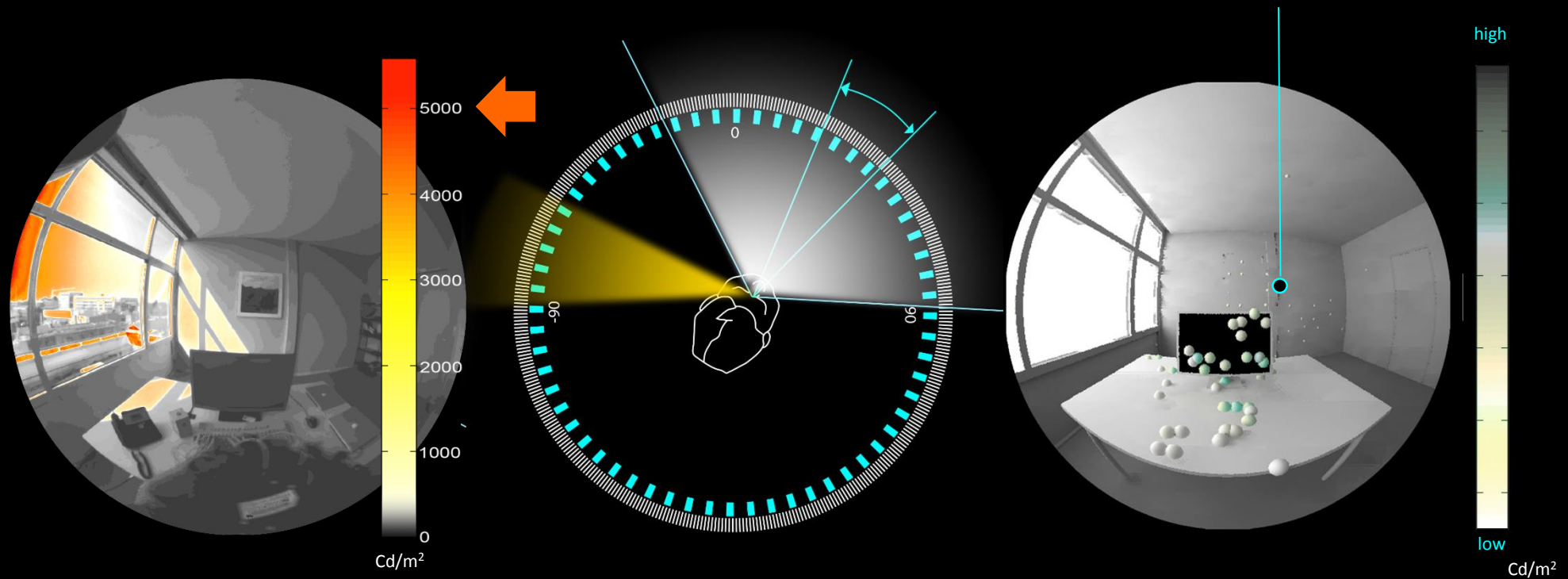
responsive comfort

some brightness/visual interest in the field of view can cause attraction



responsive comfort

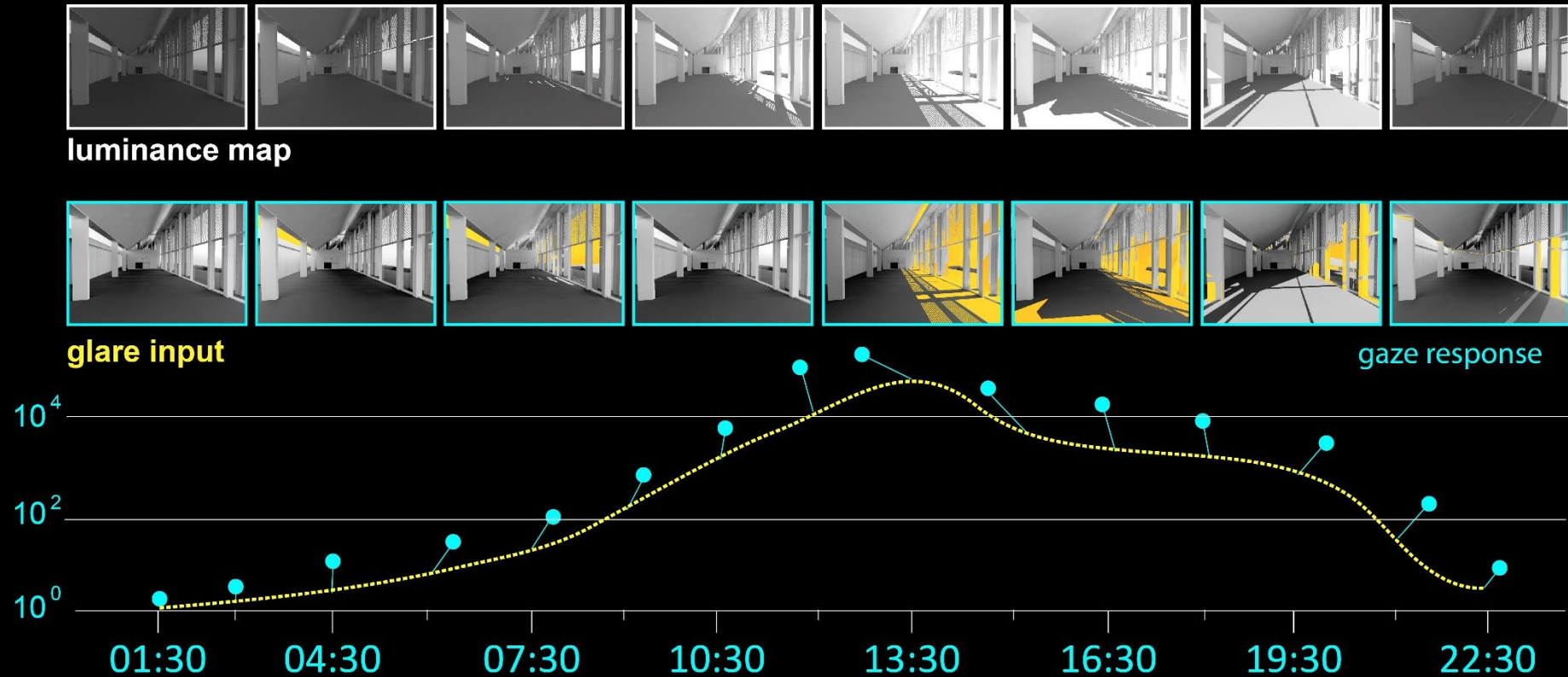
whereas ... excess brightness can cause avoidance

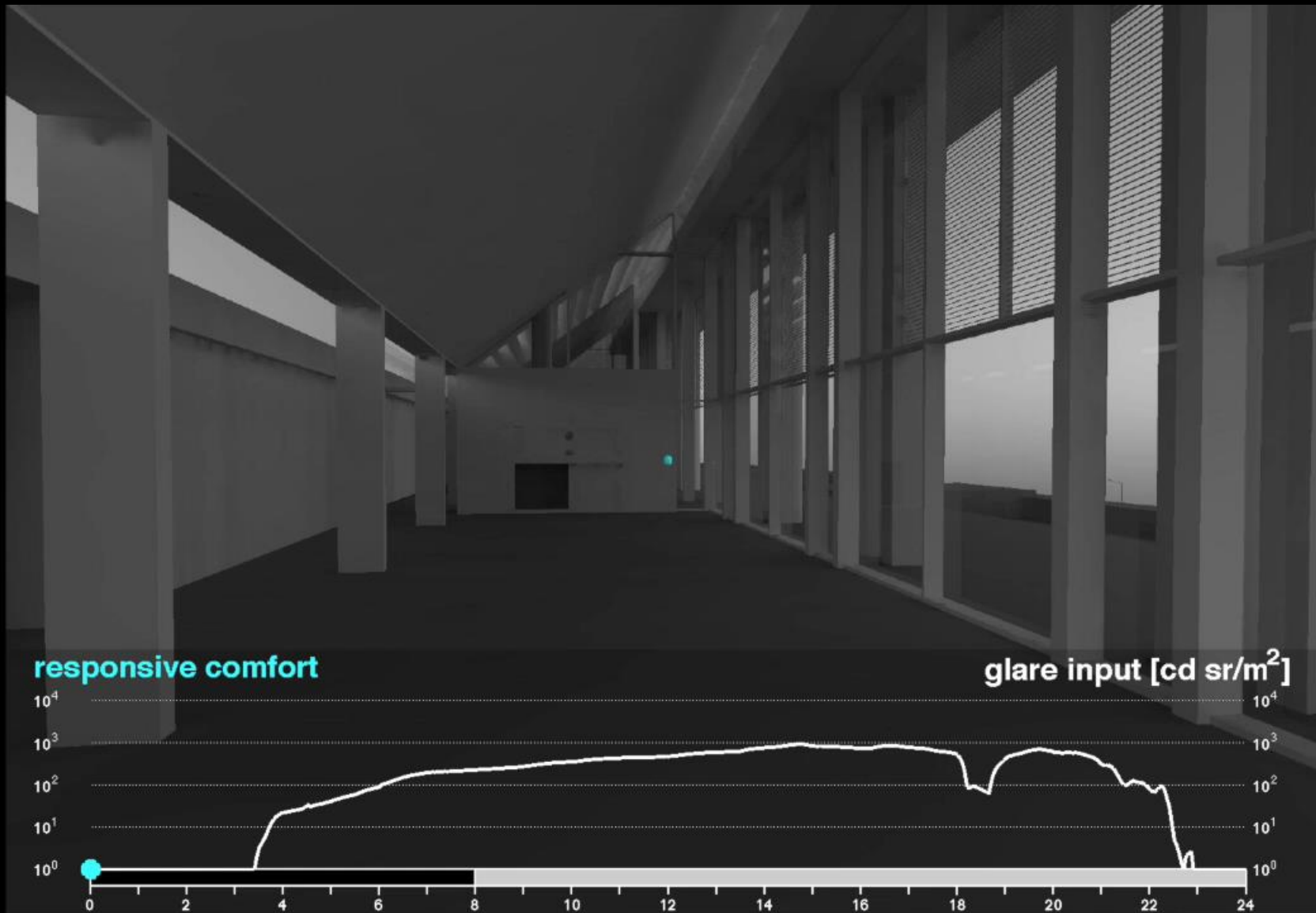


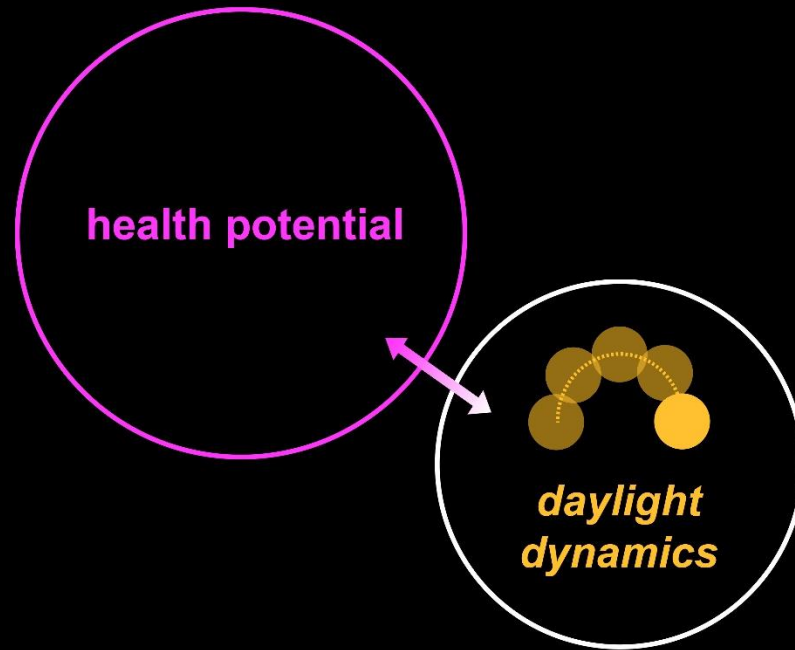
responsive comfort

responsive comfort

- predicting gaze responses (avoidance or attraction) as a function of glare input





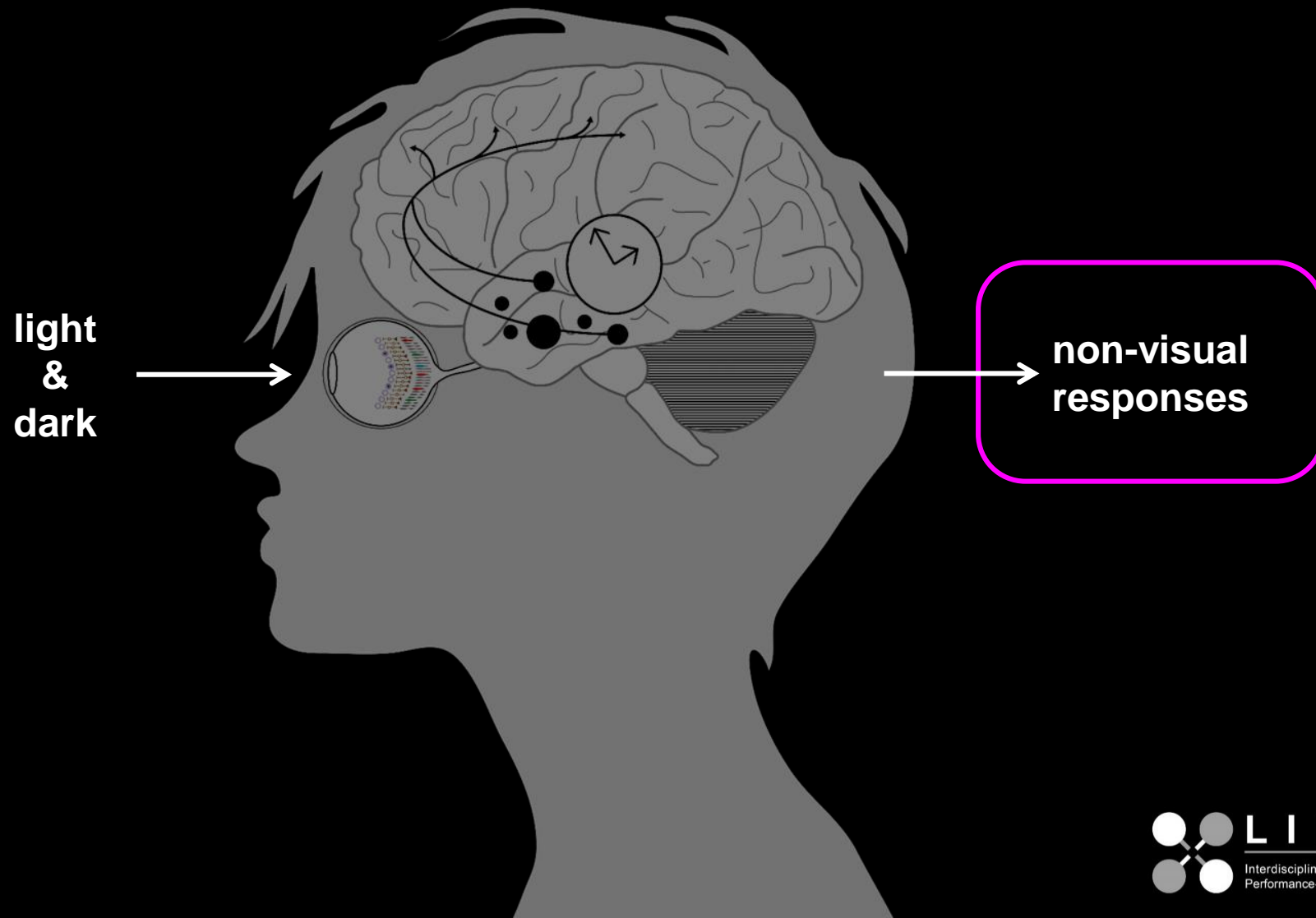


María Lovísa Ámundadóttir
PhD student

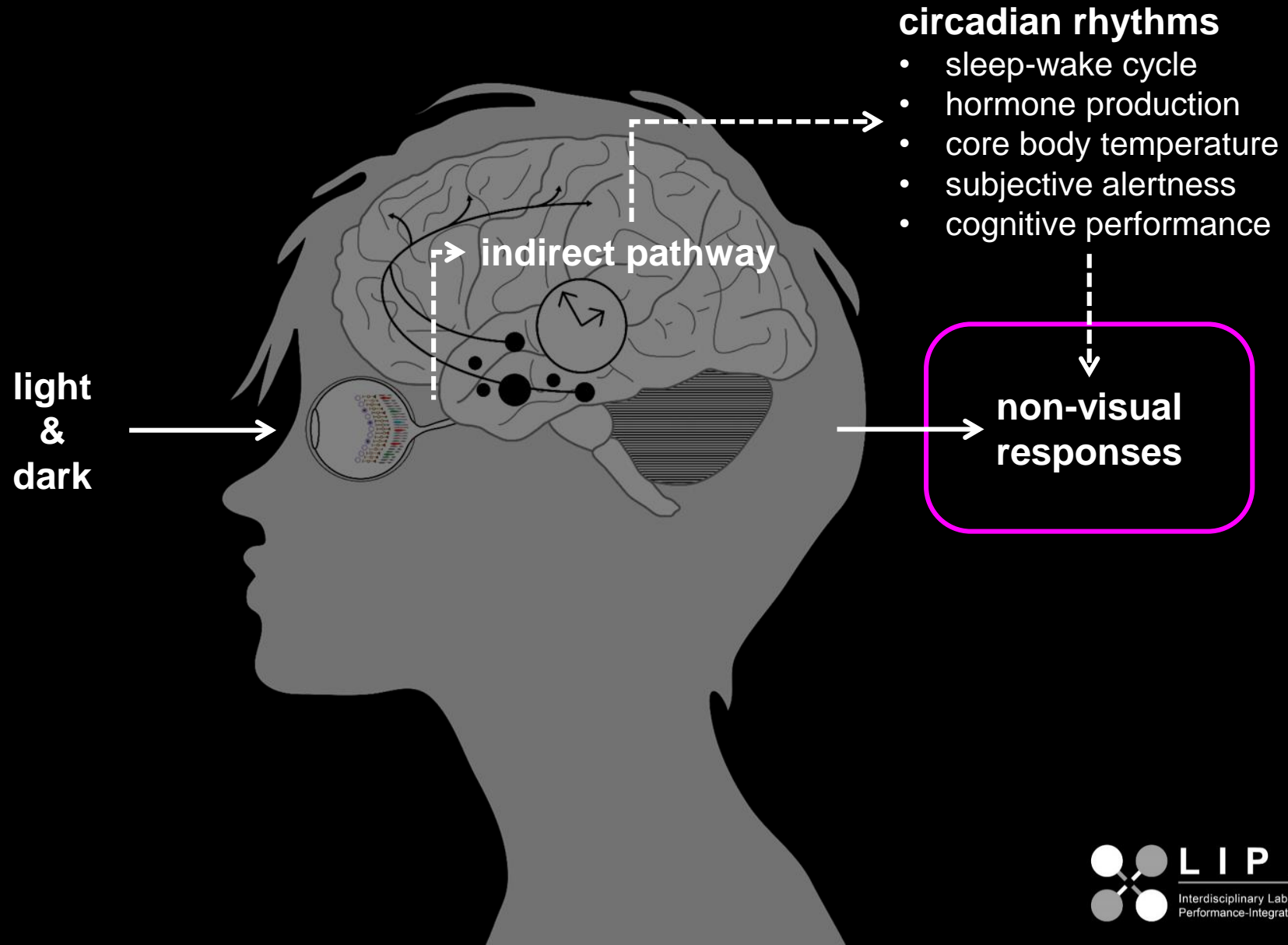
health potential:

A measure which assesses the potential of ocular light exposure to promote health benefits induced by nonvisual responses.

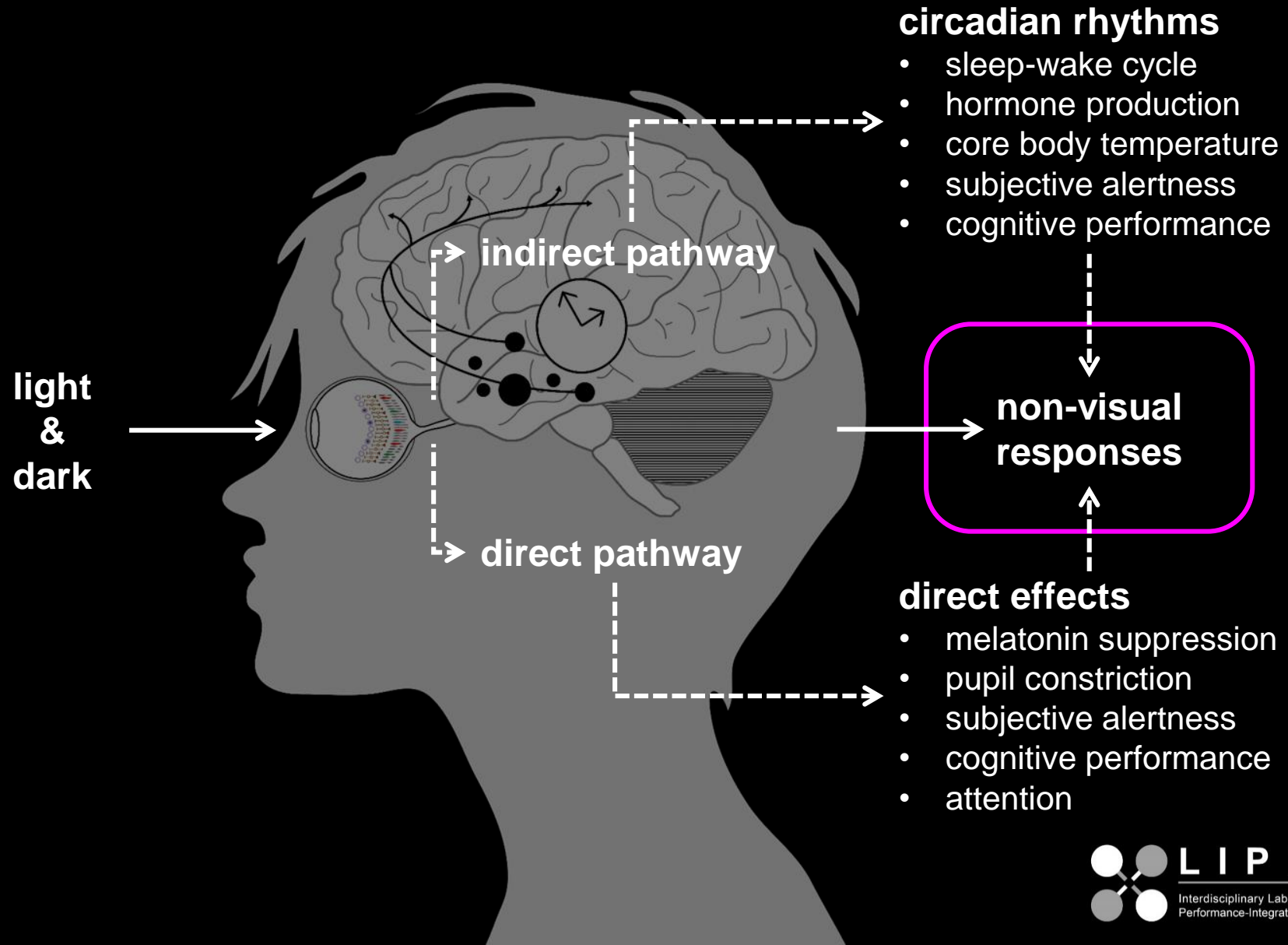
health potential



health potential



health potential

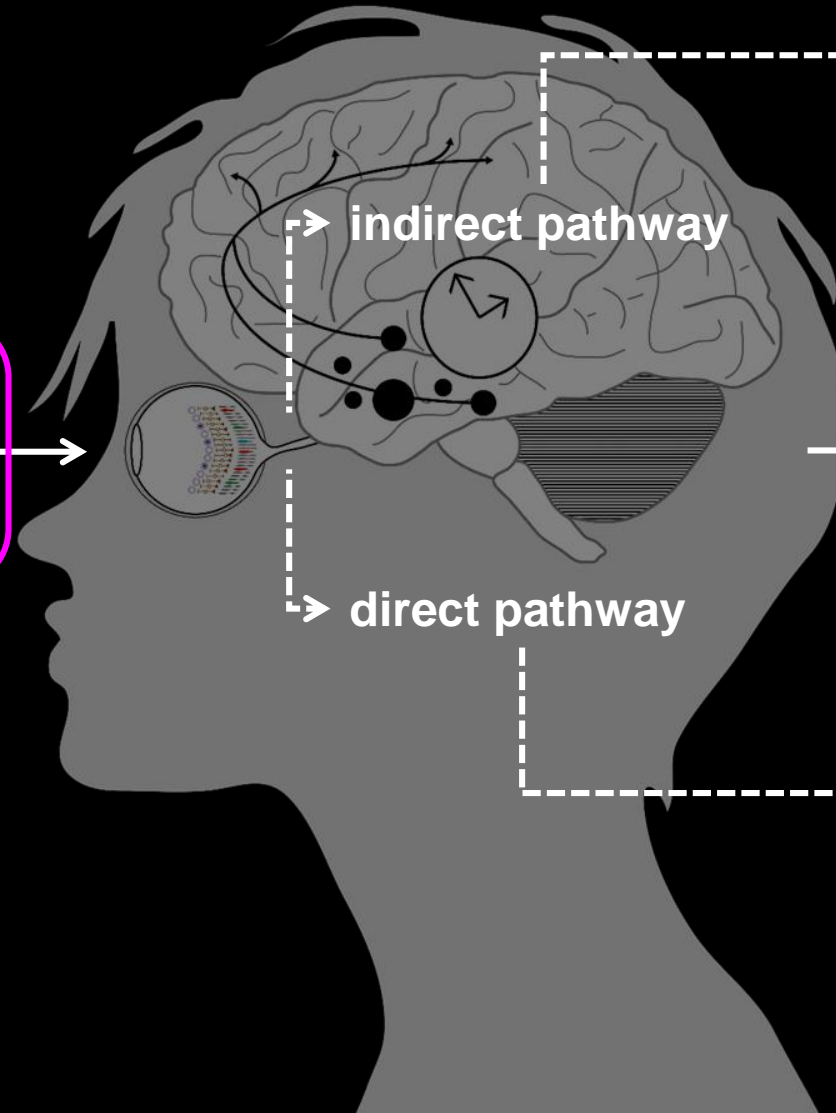


health potential

factors

- intensity
- wavelength
- duration
- timing
- history

light
&
dark



circadian rhythms

- sleep-wake cycle
- hormone production
- core body temperature
- subjective alertness
- cognitive performance

non-visual
responses

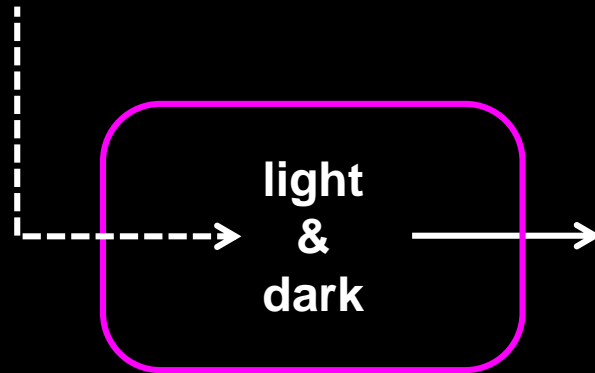
direct effects

- melatonin suppression
- pupil constriction
- subjective alertness
- cognitive performance
- attention

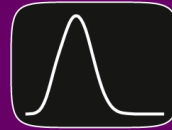
health potential

factors

- intensity
- wavelength
- duration
- timing
- history



higher levels are more effective



blue light is more effective



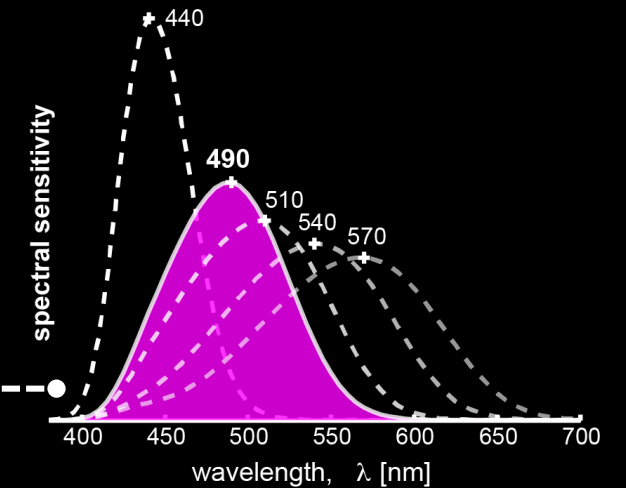
brief intermittent pulses are also effective



timing of circadian rhythm



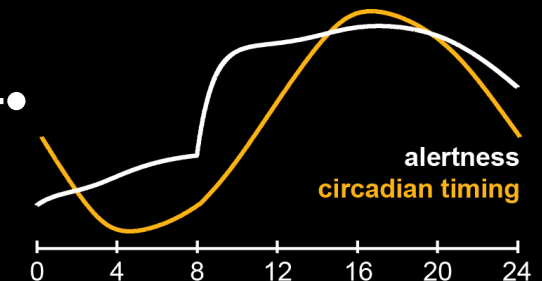
adaption to changes in light exposure



continuous



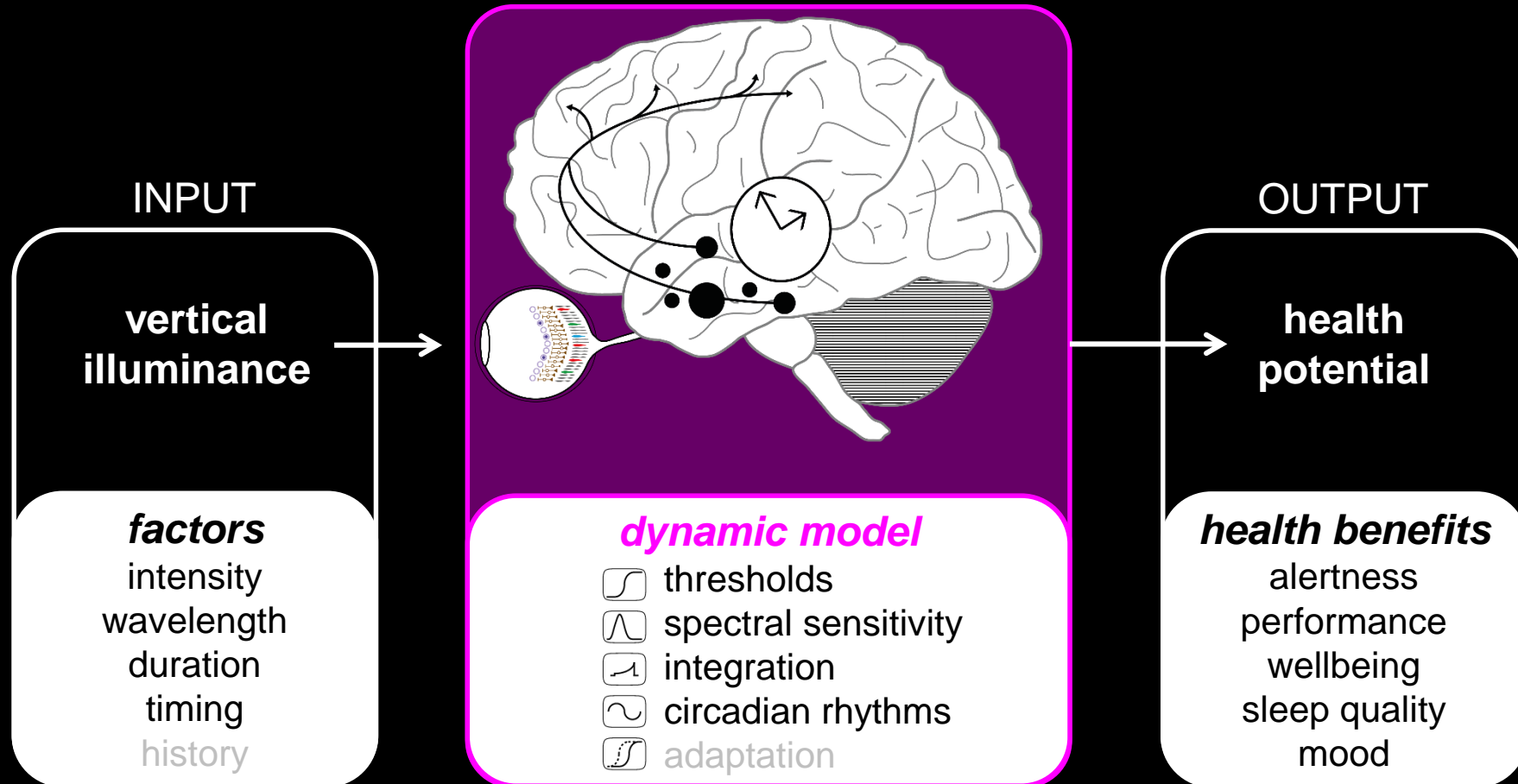
intermittent



health potential

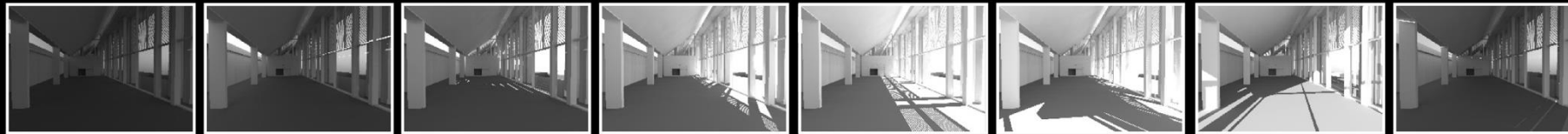
dynamic model

- that can predict the potential health benefits and risks of ocular light exposure



health potential

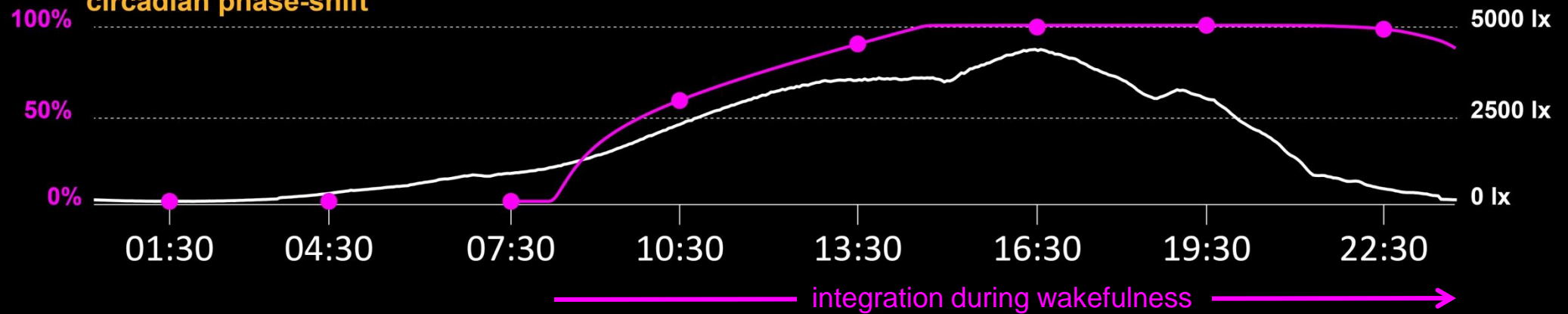
dynamic model



lux input

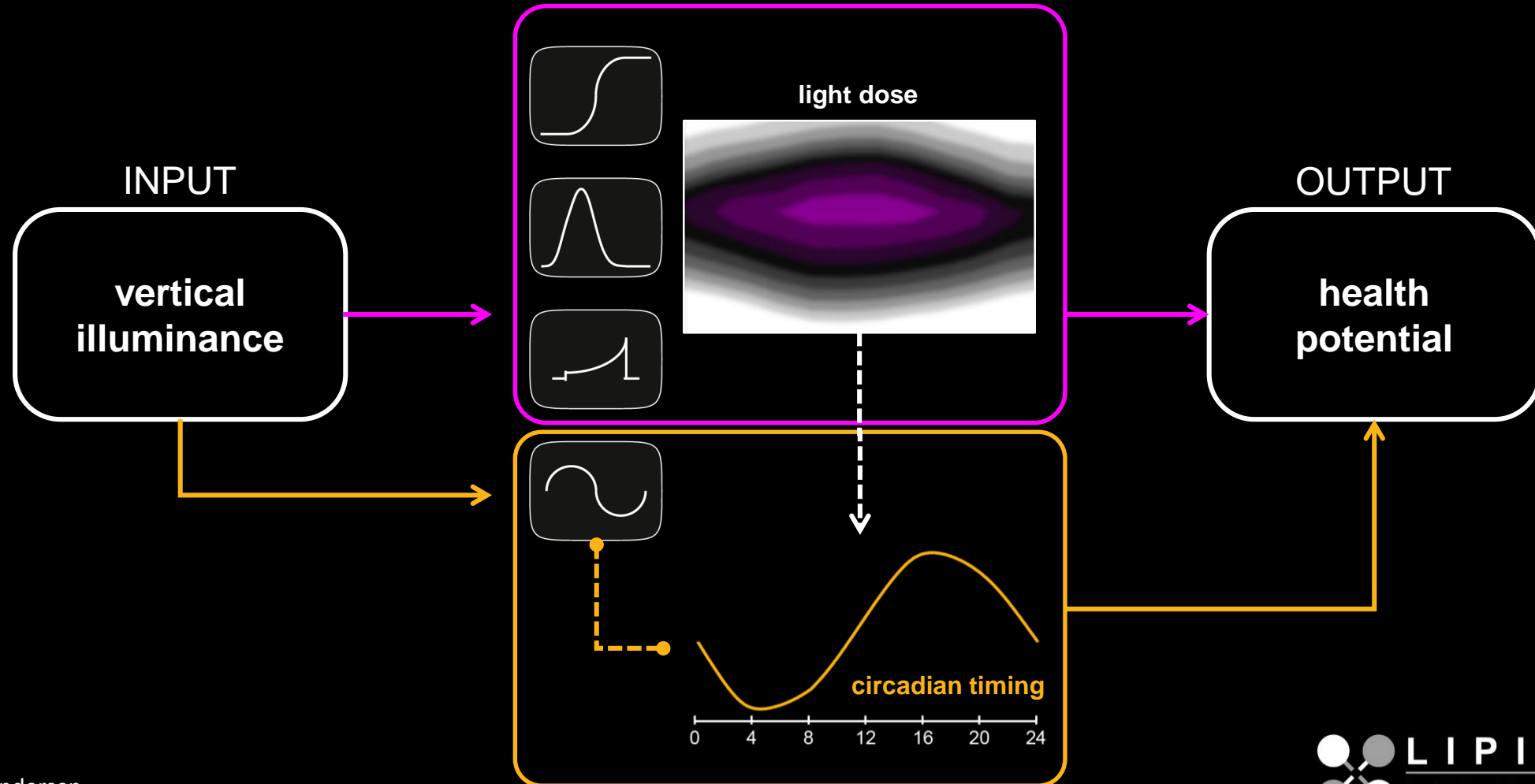


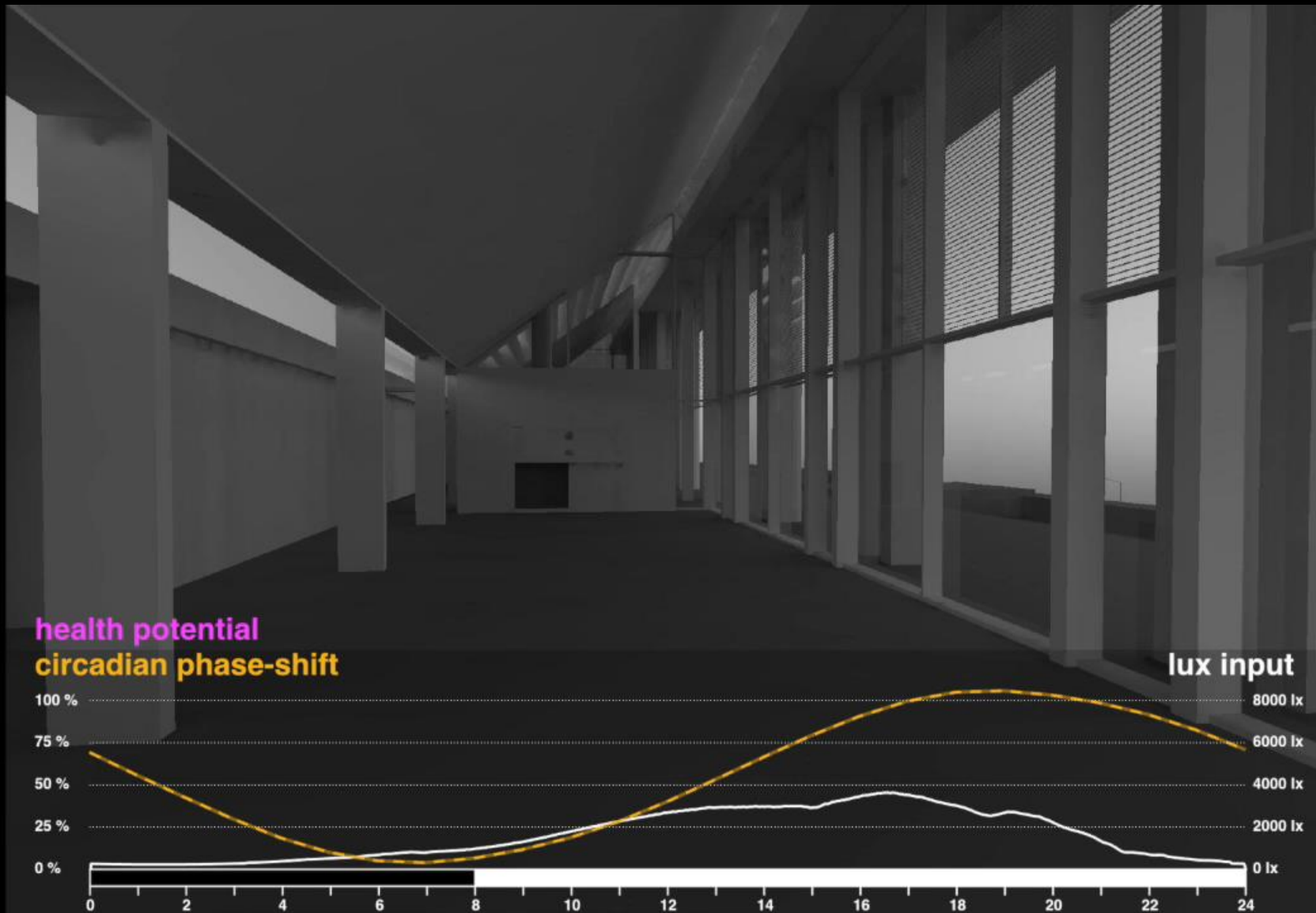
health potential
circadian phase-shift



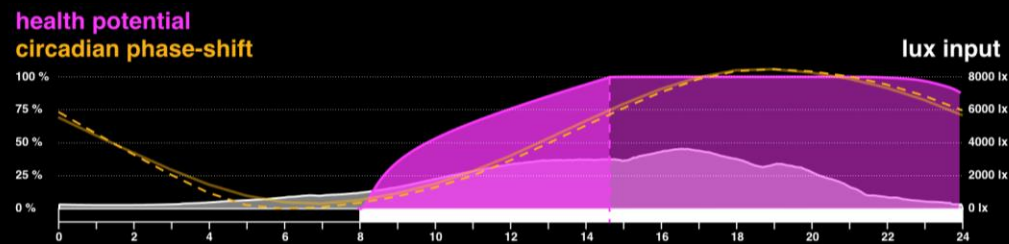
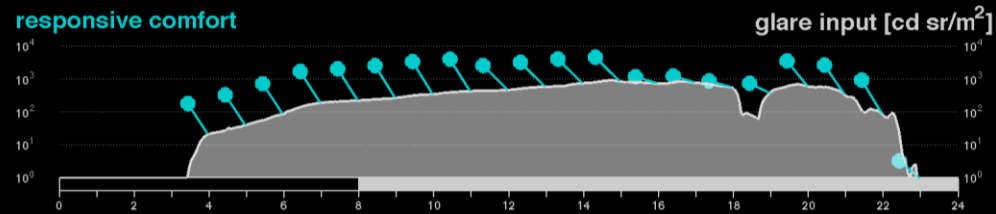
health potential

- evaluate health potential of vertical illuminance based on program use and occupant profile
- maximize the daily light dose without disturbing the timing of circadian rhythms

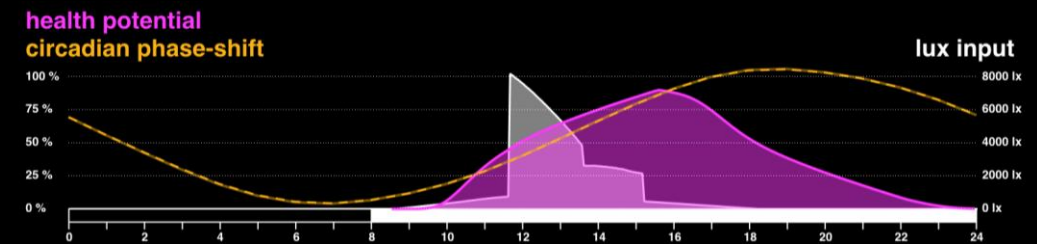
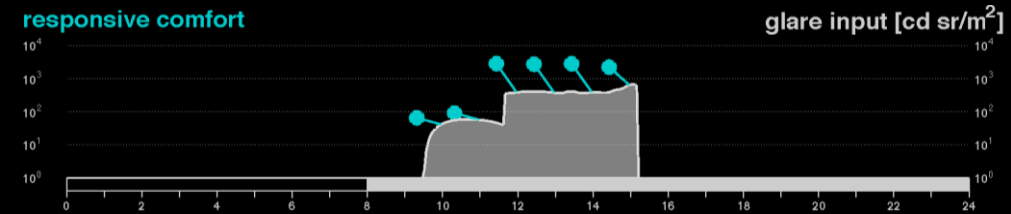




june 21st



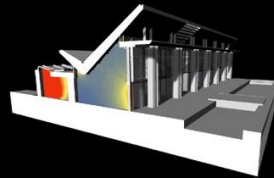
december 21st



task performance

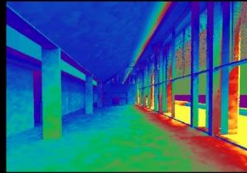
energy

MAINSTREAM



sensor plan

illuminance (lux)



envelope &
occupancy info

balance point calc

visual responsive
comfort

visual delight

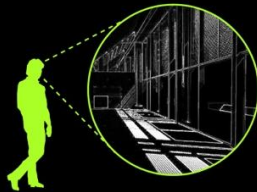
health potential

HUMAN-CENTERED



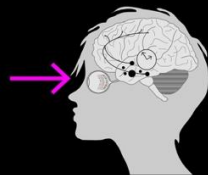
view positison/
view direction

vertical illuminance (lux)
luminance map (cd/m2)



view position/
view direction

luminance map (cd/m2)

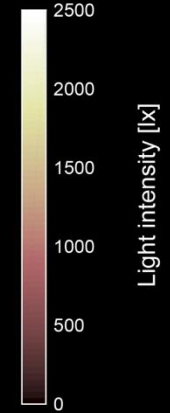
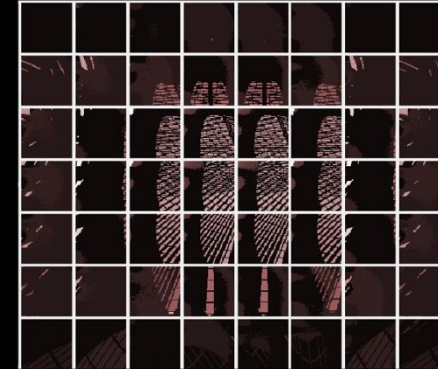
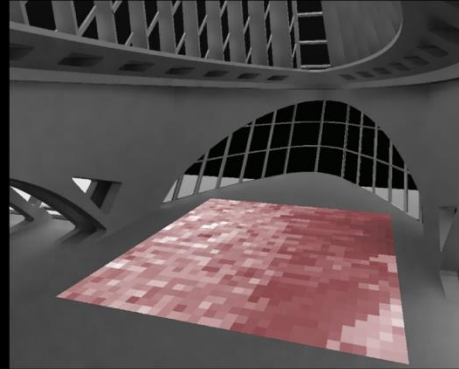
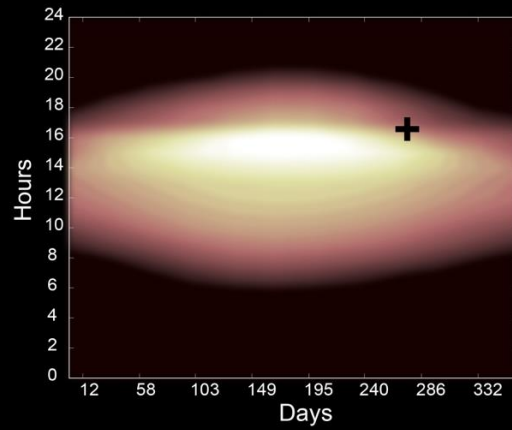


ocular light exposure

vertical illuminance (lux)
sleep/wake time

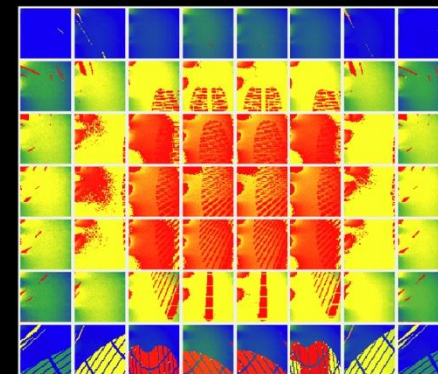
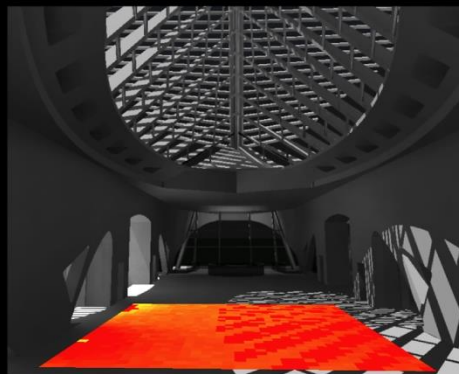
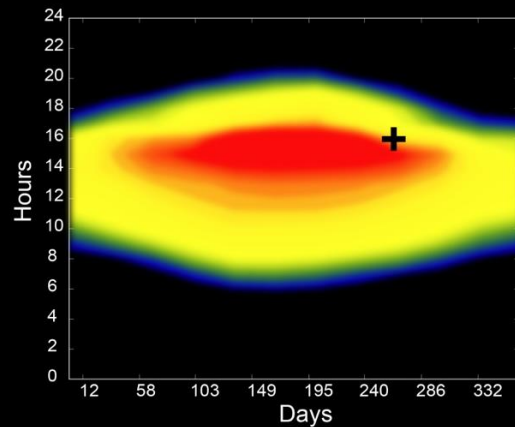
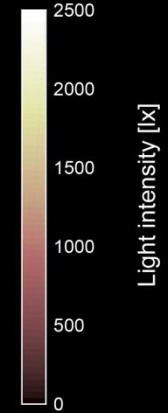
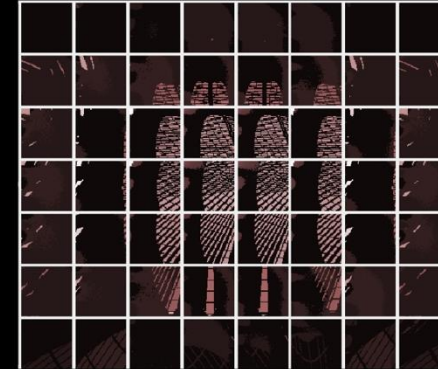
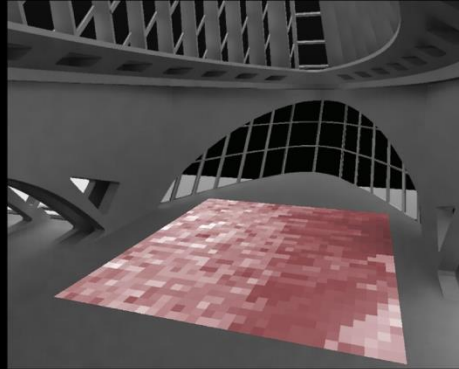
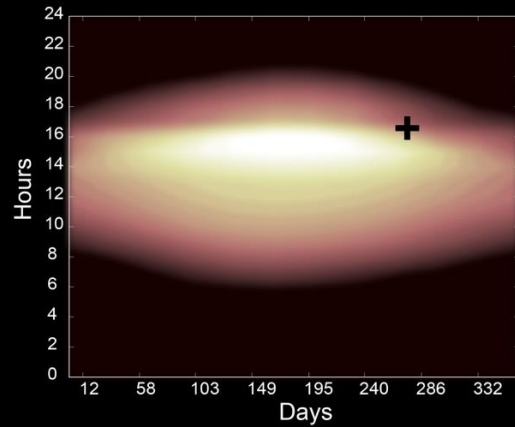
evaluating daylight performance

temporal vs. spatial / annual vs. instantaneous



evaluating daylight performance

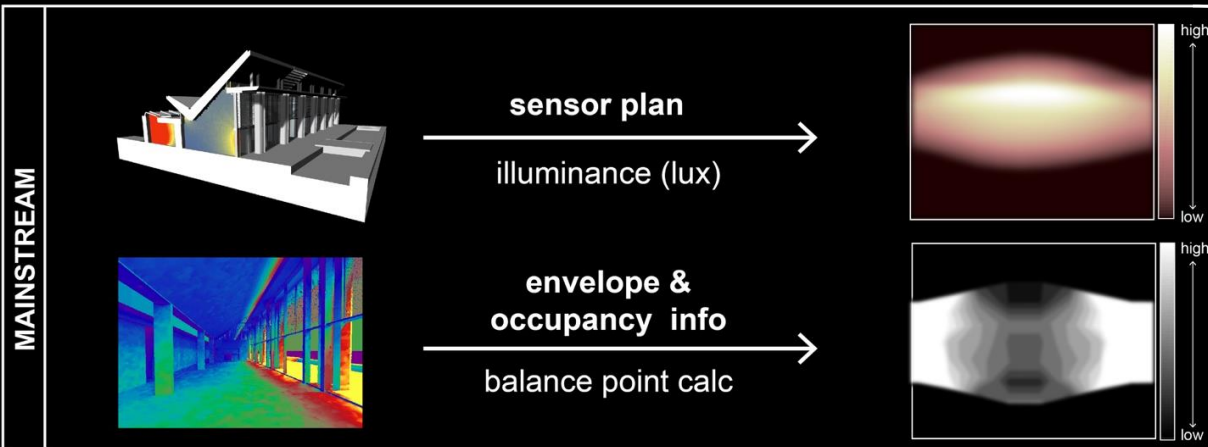
temporal vs. spatial / annual vs. instantaneous / absolute vs. goal-based



task performance

energy

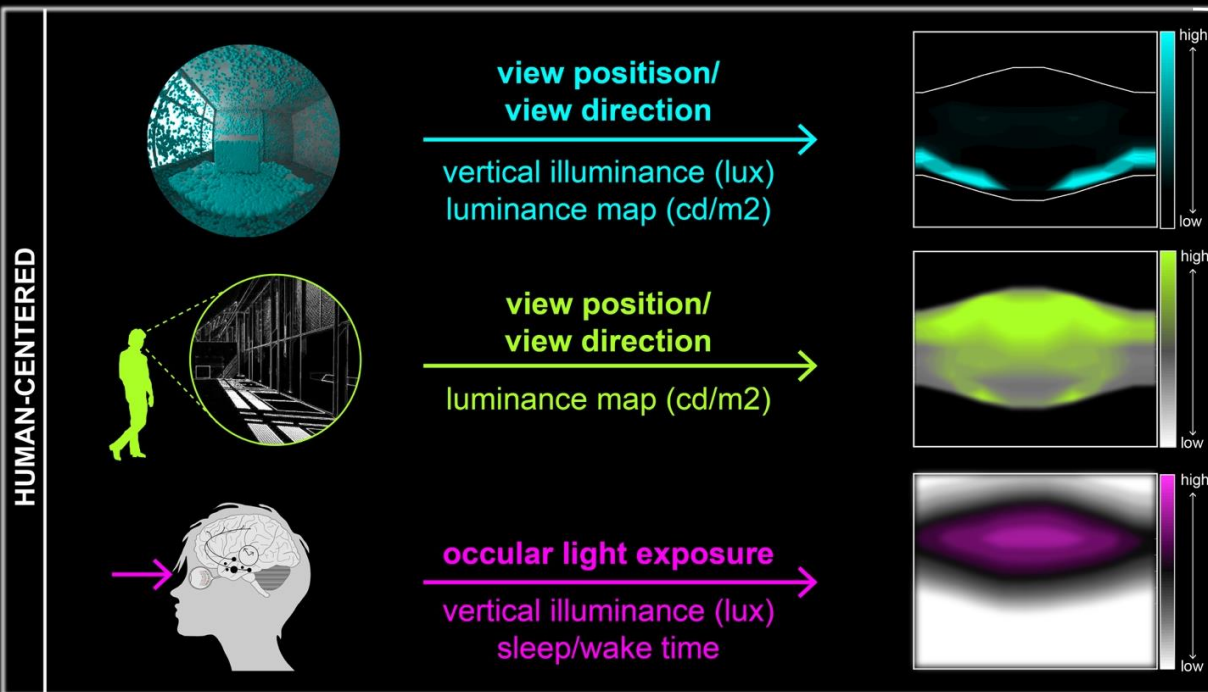
absolute performance



visual responsive comfort

visual delight

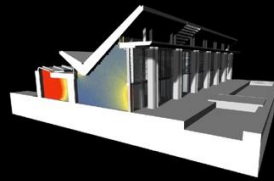
health potential



task performance

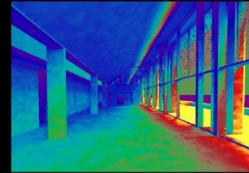
energy

MAINSTREAM



sensor plan

illuminance (lux)



envelope &
occupancy info

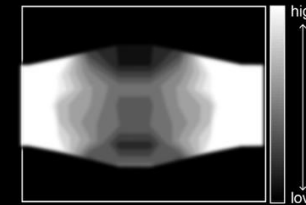
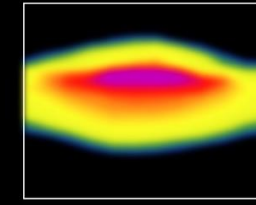
balance point calc

absolute
performance



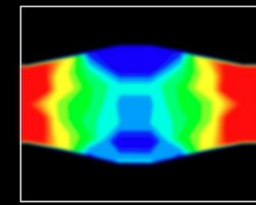
high
low

-task thresholds
-design intent



high
low

-envelope
-occupant factors

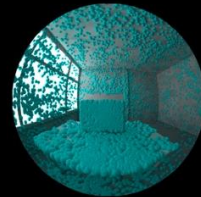


visual responsive
comfort

visual delight

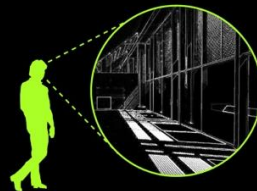
health potential

HUMAN-CENTERED



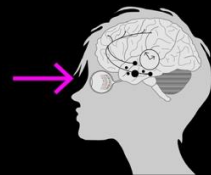
view position/
view direction

vertical illuminance (lux)
luminance map (cd/m2)



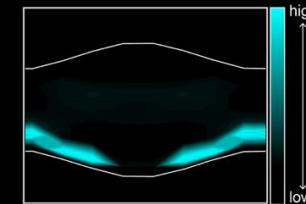
view position/
view direction

luminance map (cd/m2)



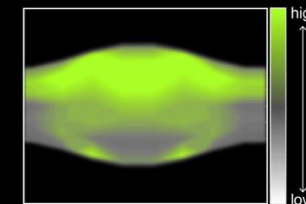
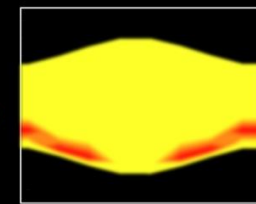
ocular light exposure

vertical illuminance (lux)
sleep/wake time



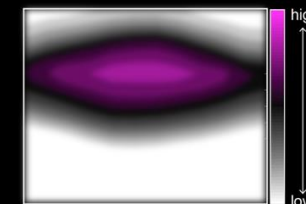
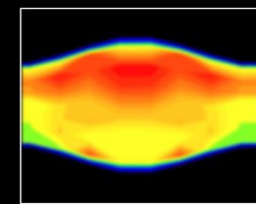
high
low

-program use
-gaze allocation



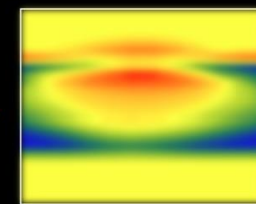
high
low

-program use
-design intent



high
low

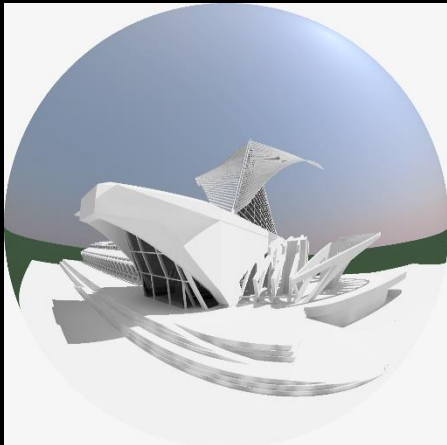
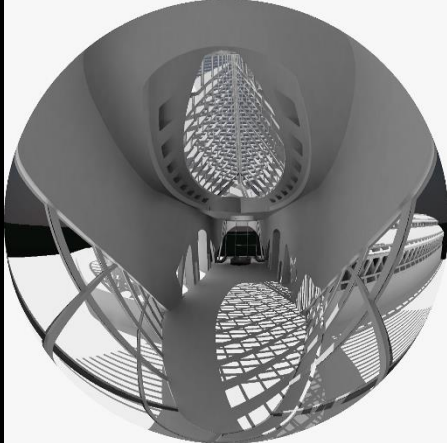
-program use
-occupant factors



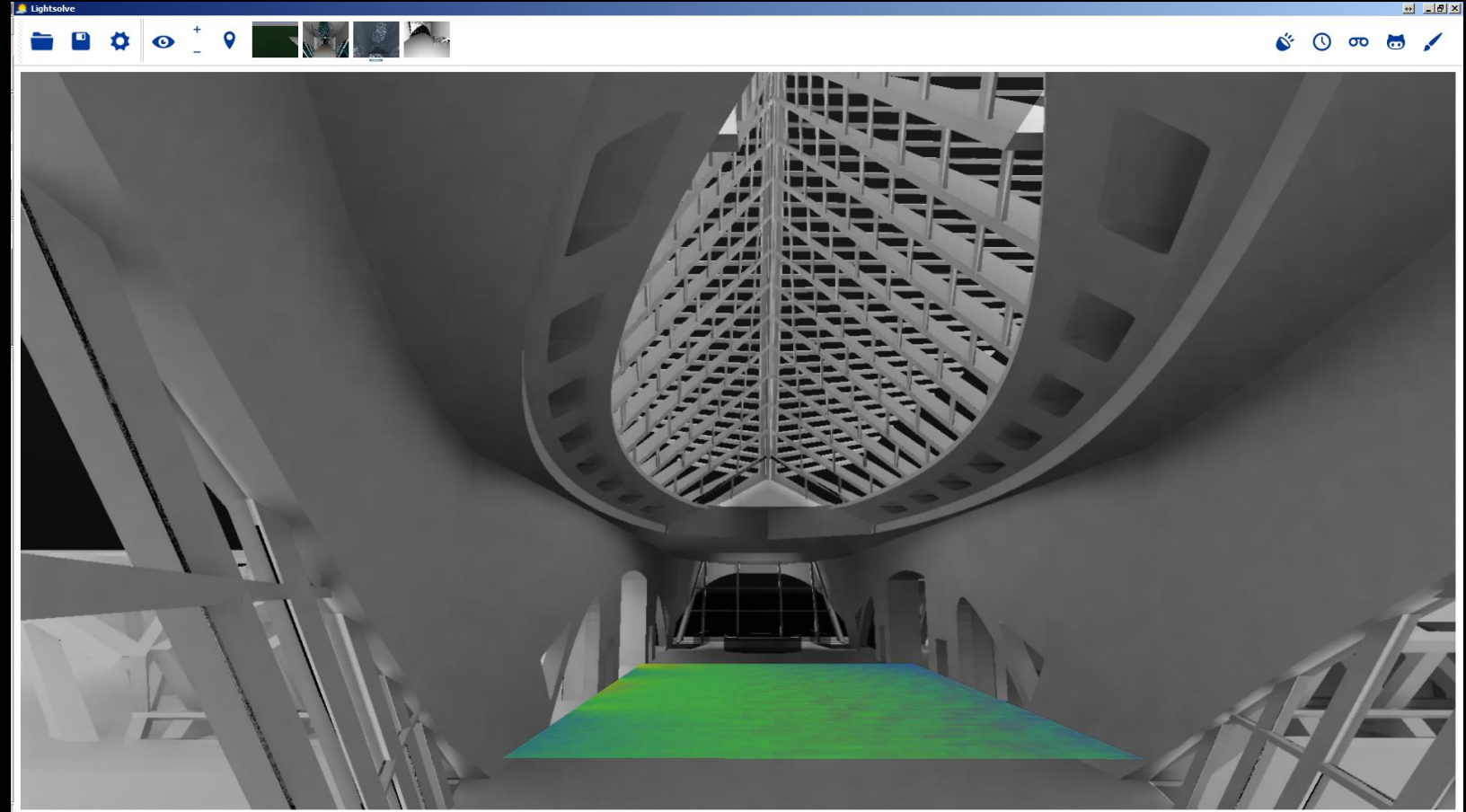
meets goal
too high
too low

lightsolve approach

Milwaukee Art Museum
Santiago Calatrava



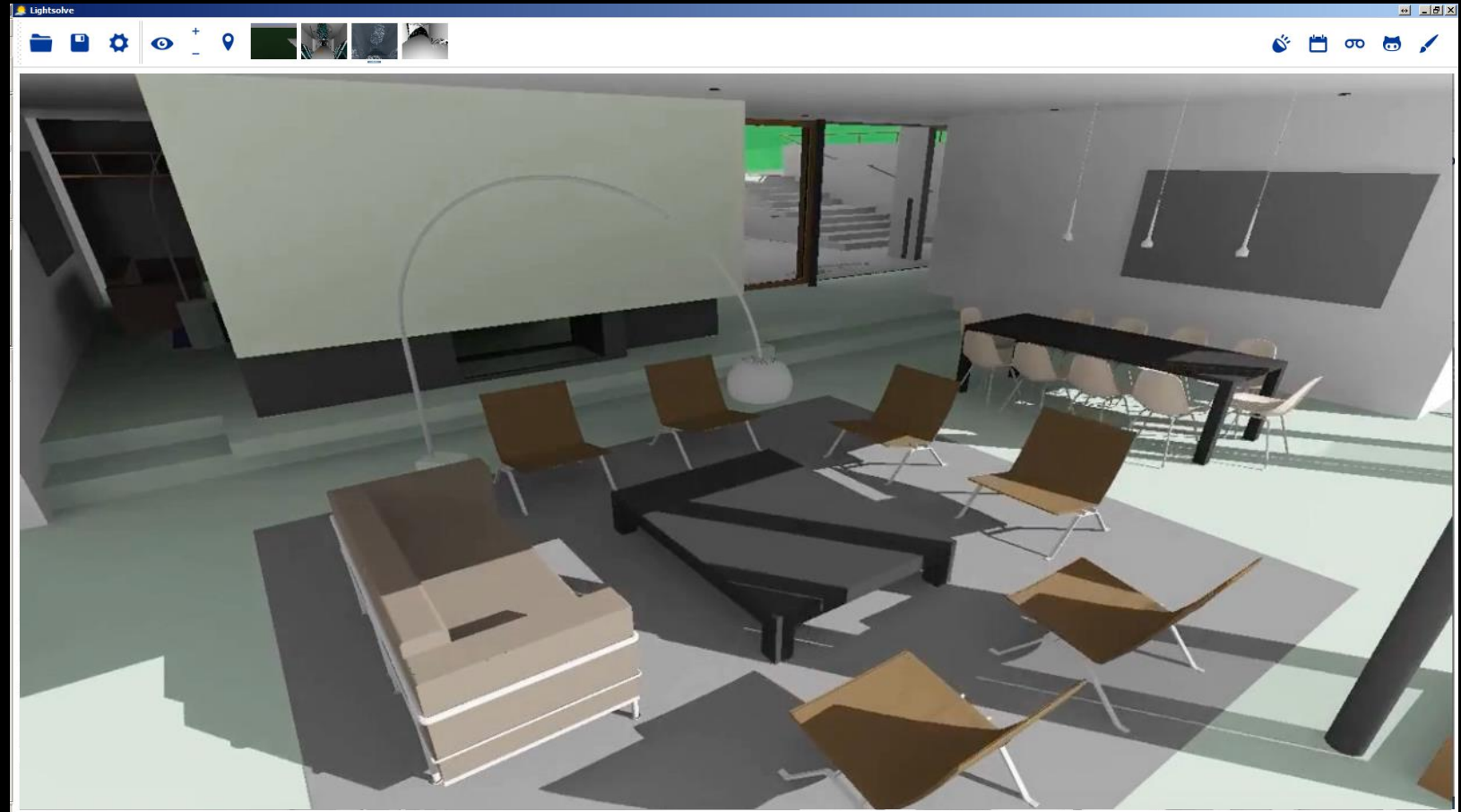
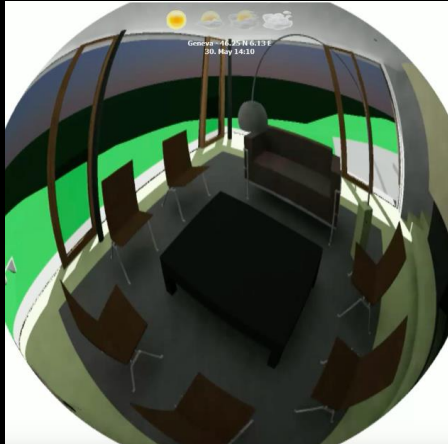
walkthrough
interior & exterior



daylight renderings and analysis
increased reactivity from Nvidia GPU-based renderer (Optix)

lightsolve approach

Single family house
Switzerland



time lapse

w/ pre-computed instantaneous daylight renderings

lightsolve approach

Single family house
Switzerland



daylight performance analysis
w/ sensors of varying nature & renderings on the fly

lightsolve.epfl.ch

Lightsolve
daylight at the service of architecture

LIPID
Interdisciplinary Laboratory of
Performance-Integrated Design

EPFL
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

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[Quick Start Guide v1.0.0 \[.pdf\]](#)

[WIN version](#)

[MAC OS X version](#)

[LIPID OBJ Exporter SketchUp Extension](#)

Lightsolve is a **beta software** being developed by LIPID EPFL for academic and research purposes. The application bundle is provided for free, "as is" and without warranties to students, researchers and practitioners interested in testing the tool. It is intended primarily for academic use and to collect feedback as it has not yet been fully validated.

Despite not as accurate as professional daylighting tools, Lightsolve provides plausible illuminance values in reasonable time. It also allows daylighting performance to be assessed by students during one exercise session, rather than a dedicated project.

Screenshots & Animations

<http://lightsolve.epfl.ch/>

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<http://lipid.epfl.ch/>

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