Empowering the Built Environment with Human Centric Lighting

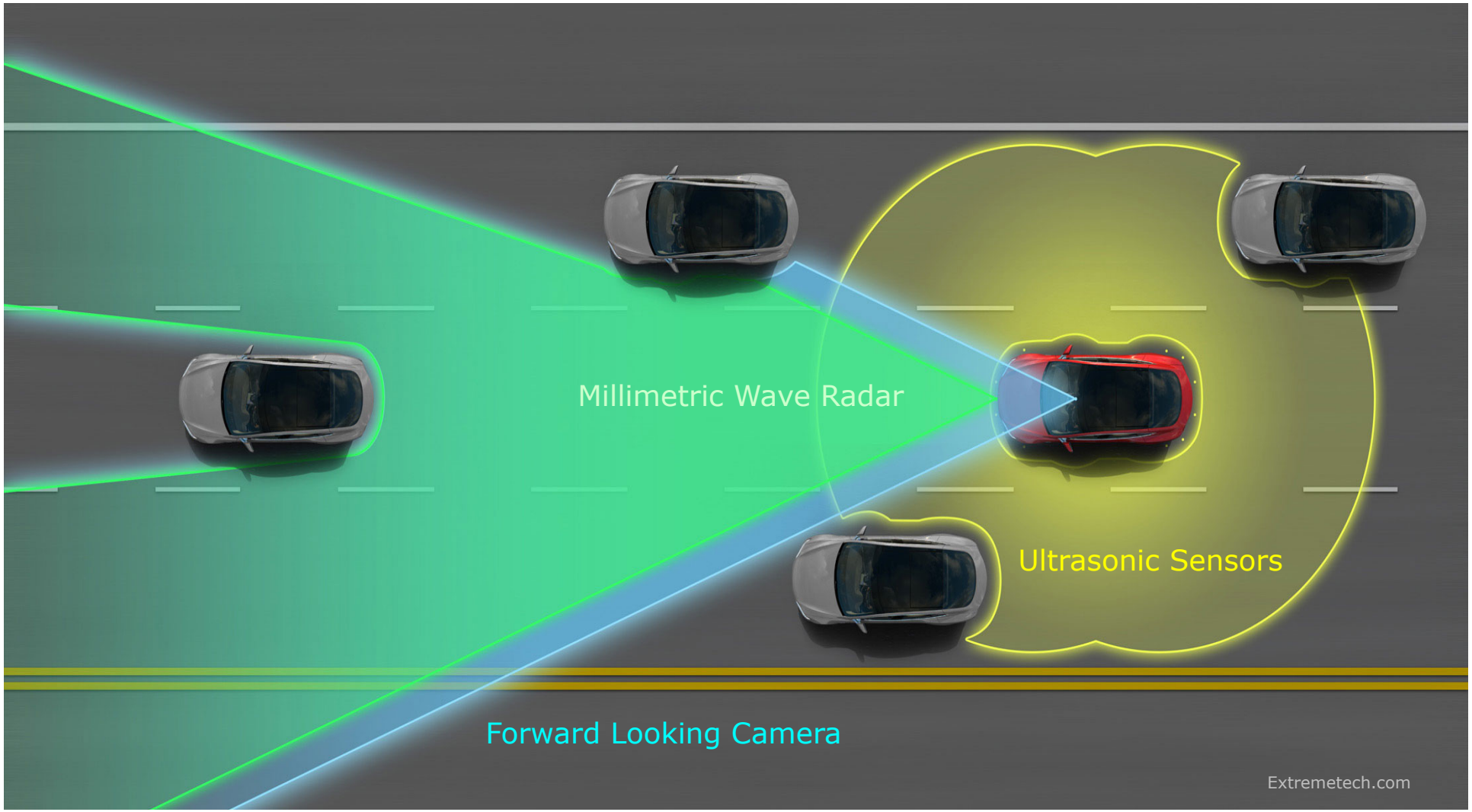
Swissphotonics/SSSL Joint Workshop
From Daylight to Lighting 4.0
Monday, November 6th 2017
EMPA NEST, Dübendorf (Switzerland)

Prof. Dr Jean-Louis Scartezzini
Ali Motamed, Marta Benedetti
Solar Energy and Building Physics Laboratory
Ecole Polytechnique Fédérale de Lausanne

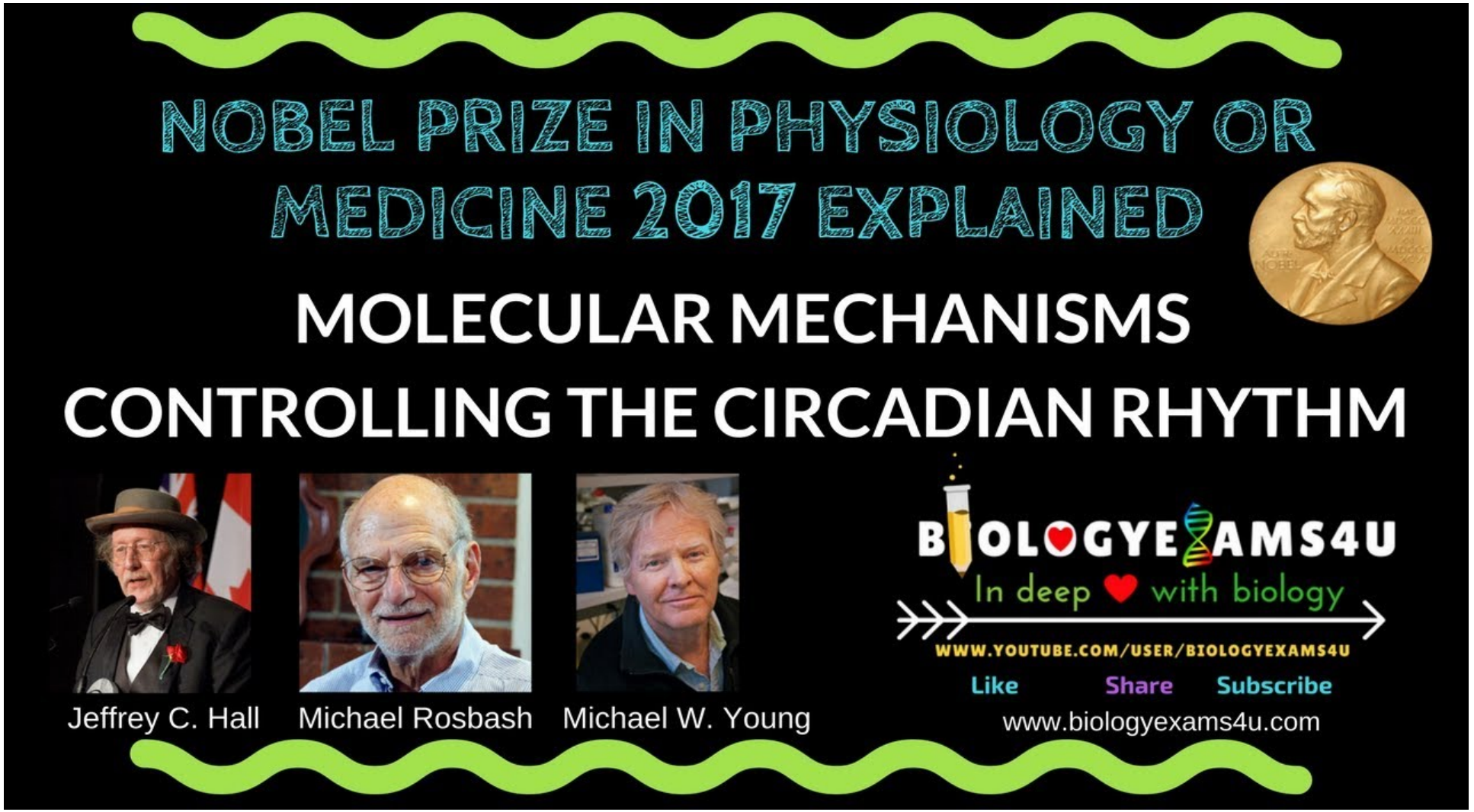
LESO-PB
LABORATOIRE D'ENERGIE SOLAIRE
PHYSIQUE DU BÂTIMENT

EPFL
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Self-Driving Car – Advanced Autopilot Sensors



Recent Progress in Chronobiology

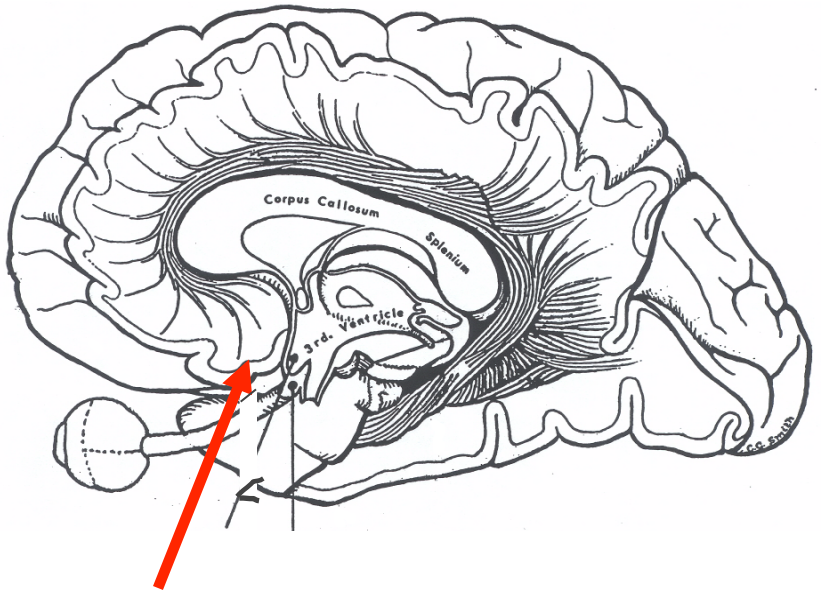


Circadian Rhythm

External 24 hours
Solar Light-Dark Cycle

Most stable Time Cue
(> 4 Billion Years)

Internal Biological
Clock in Humans

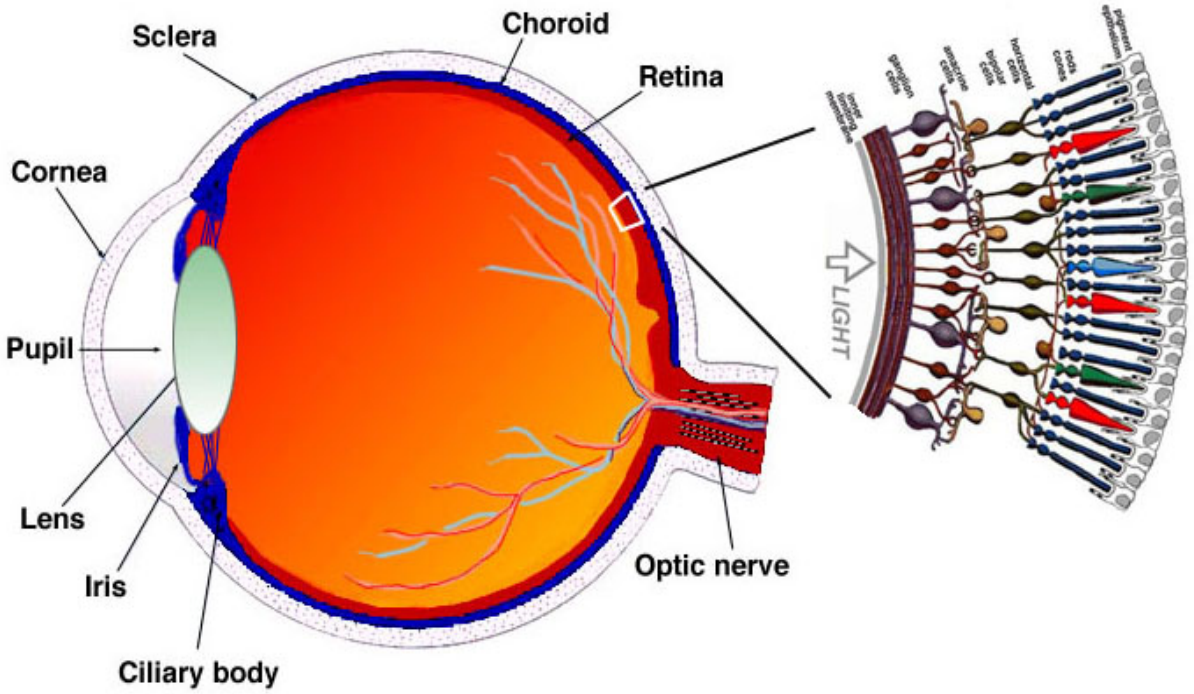


Suprachiasmatic Nucleus

Approximately
but not exactly 24 hours

Human Eye System

Visual & Non-Image Forming Photoreceptors



Visual System
Rods & Cones

Non-Visual System
Ganglion Cells

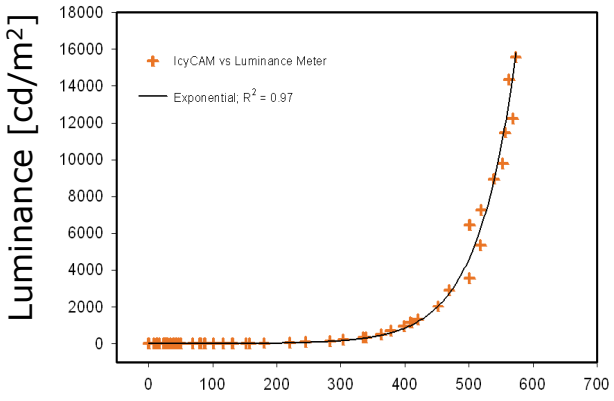
Circadian Rhythm
Sleep/Wake States
Hormons Regulation
Pupillary Reflex

Human Centric Sensing & Control

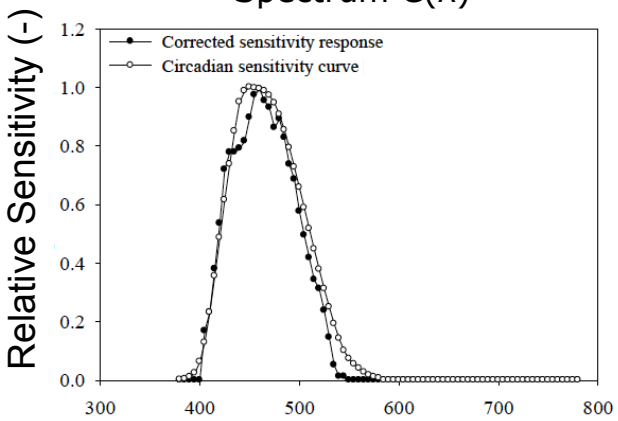
High Dynamic Range Vision Sensor (IcyCAM/CSEM)

- 132dB Dynamic Range (Humans : 90dB)
- Fisheye Lens (135° x 110°)
- 32-bit 500 MHz DSP Chip
- Photopic & Circadian Optical Filters
- Embedded Glare Rating (UGR, CGI, DGP)

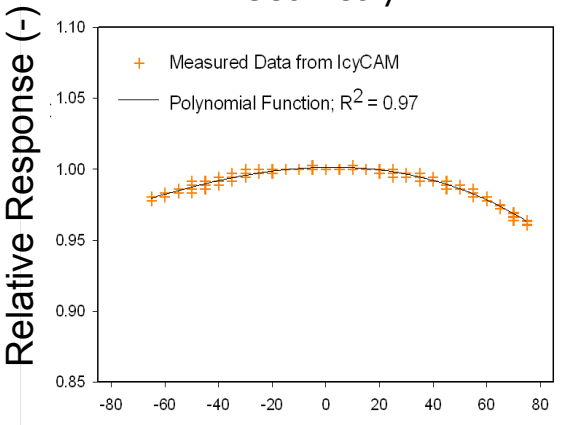
Photometry



Spectrum C(λ)



Geometry



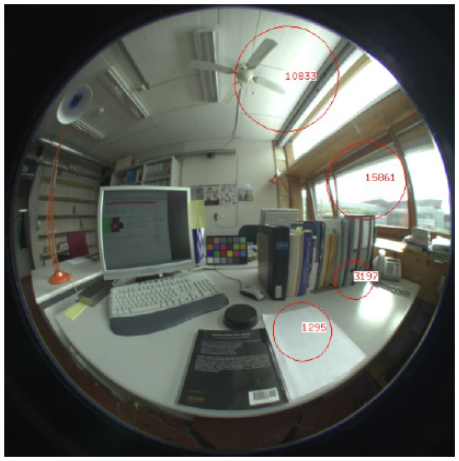
LESO-PB
LABORATOIRE D'ENERGIE SOLAIRE
PHYSIQUE DU BÂTIMENT

EPFL
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Human Centric Sensing & Control

Embedded Discomfort Glare Rating

Market Edition
(VIP/CSEM)



Luminance Mapping

Glare Sources Mapping

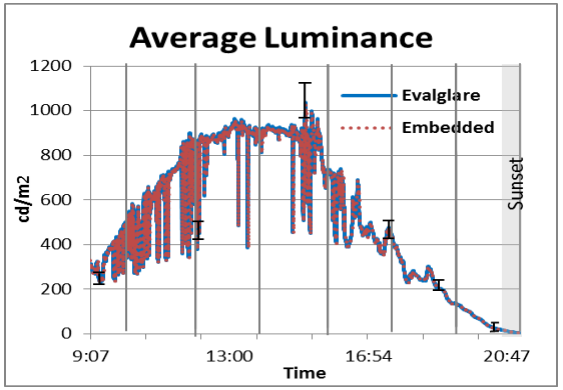
Glare Rating

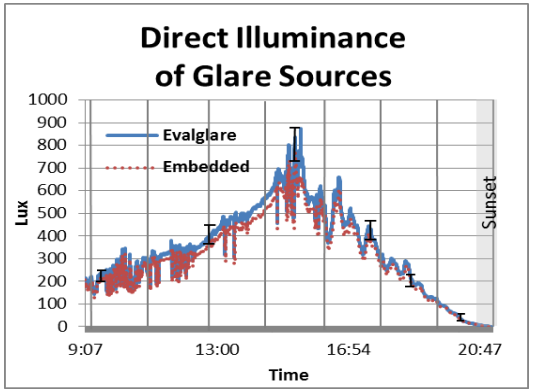
DGI Daylight Glare Index (1972)
CGI CIE Glare Index (1982)
UGR Unified Glare Rating (1992)
DGP Daylight Glare Probability (2006)

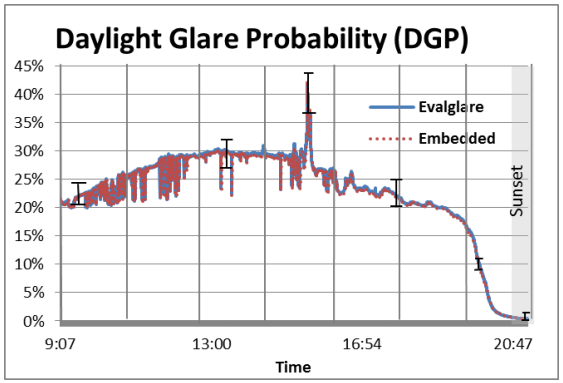
Human Centric Sensing & Control

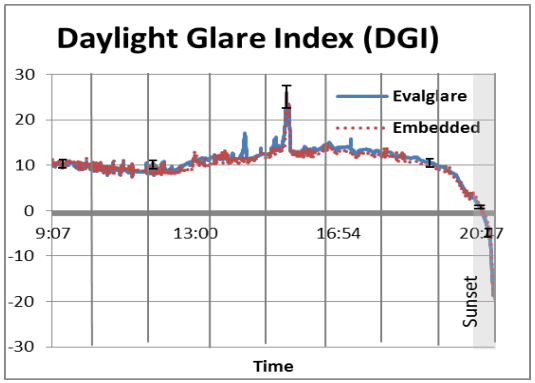
Discomfort Glare Rating – Empirical Validation

Experimental Comparison with Evalglare Method (Wienold 2004)





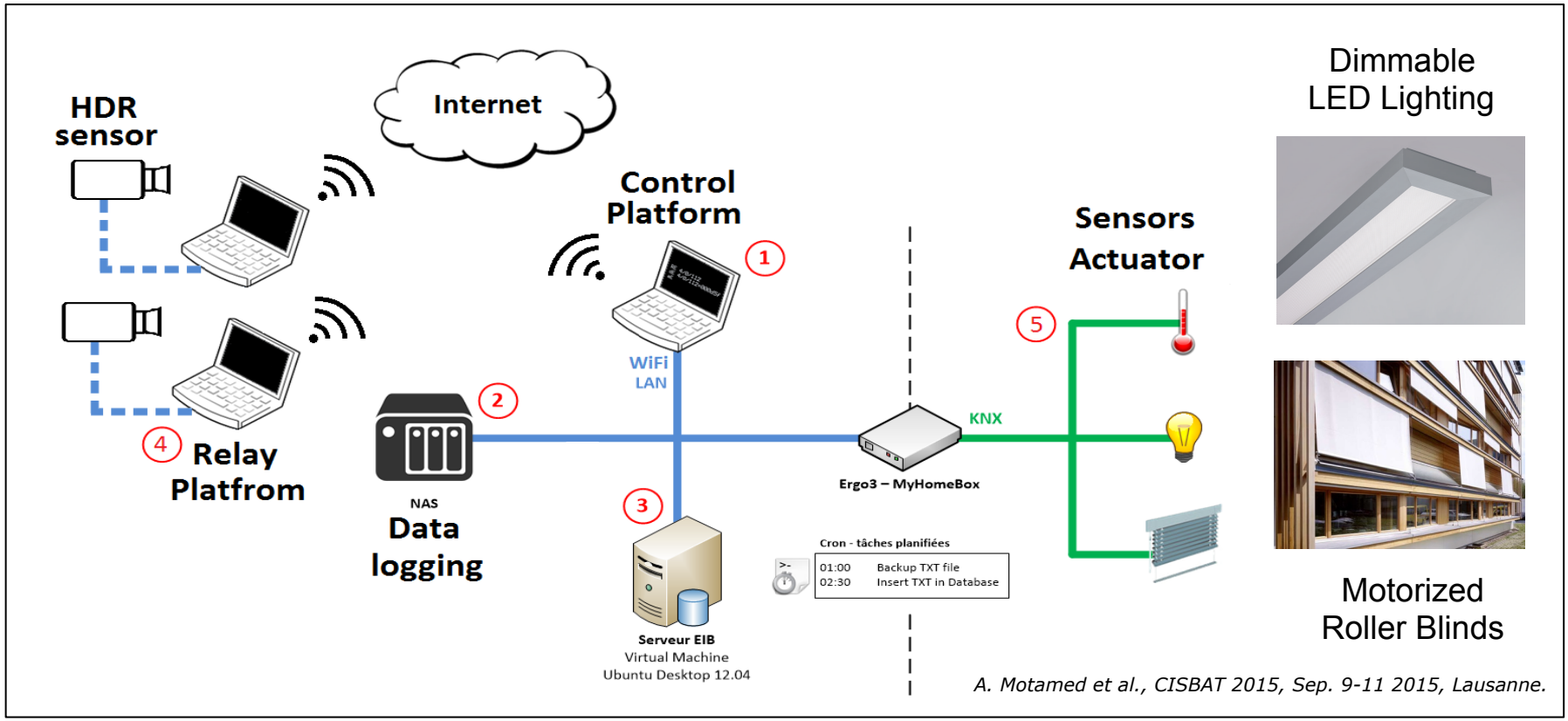




RMSE	
L_{AVE}	E_v
0.9 %	8.9 %
DGP	DGI
2.5 %	6.7 %

Human Centric Lighting

Integrated Sun Shadings & Lighting Control Platform

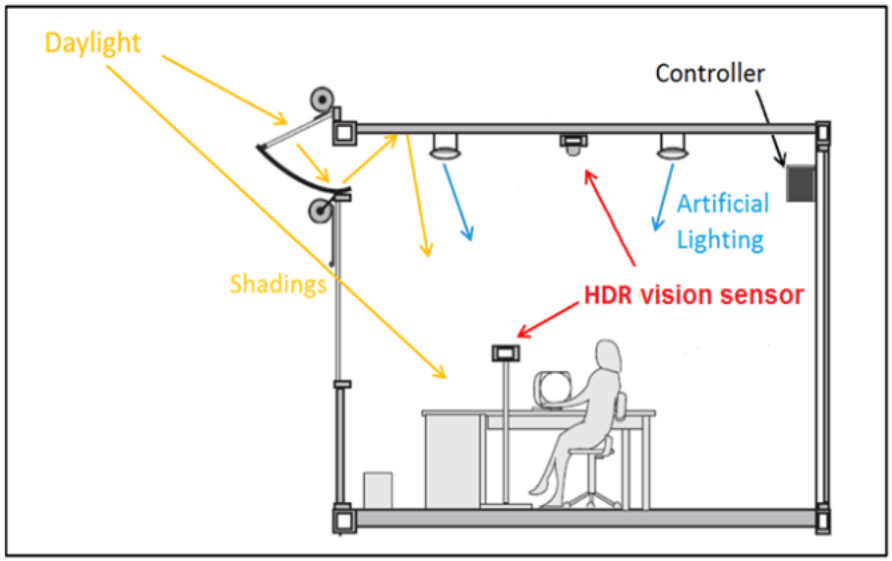


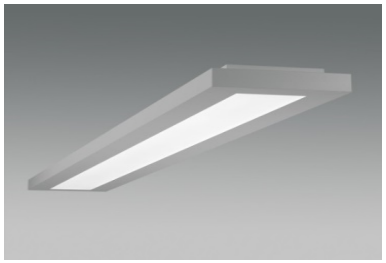
Human Centric Lighting

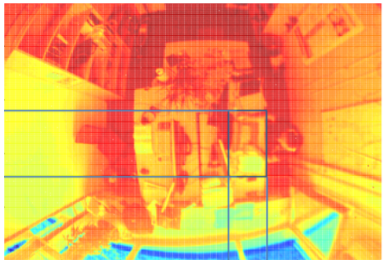
'In Situ' Monitoring in LESO Experimental Building

- Mobile Textile Blinds and Dimmable LED Lighting (KNX/DALI)
- Two Monitoring Periods in LESO Office Room (Advanced Room)
- Comparison with 'Best-Practice' Lighting Controller (Reference Room)

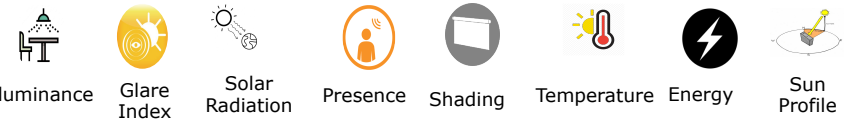
Glare Rating







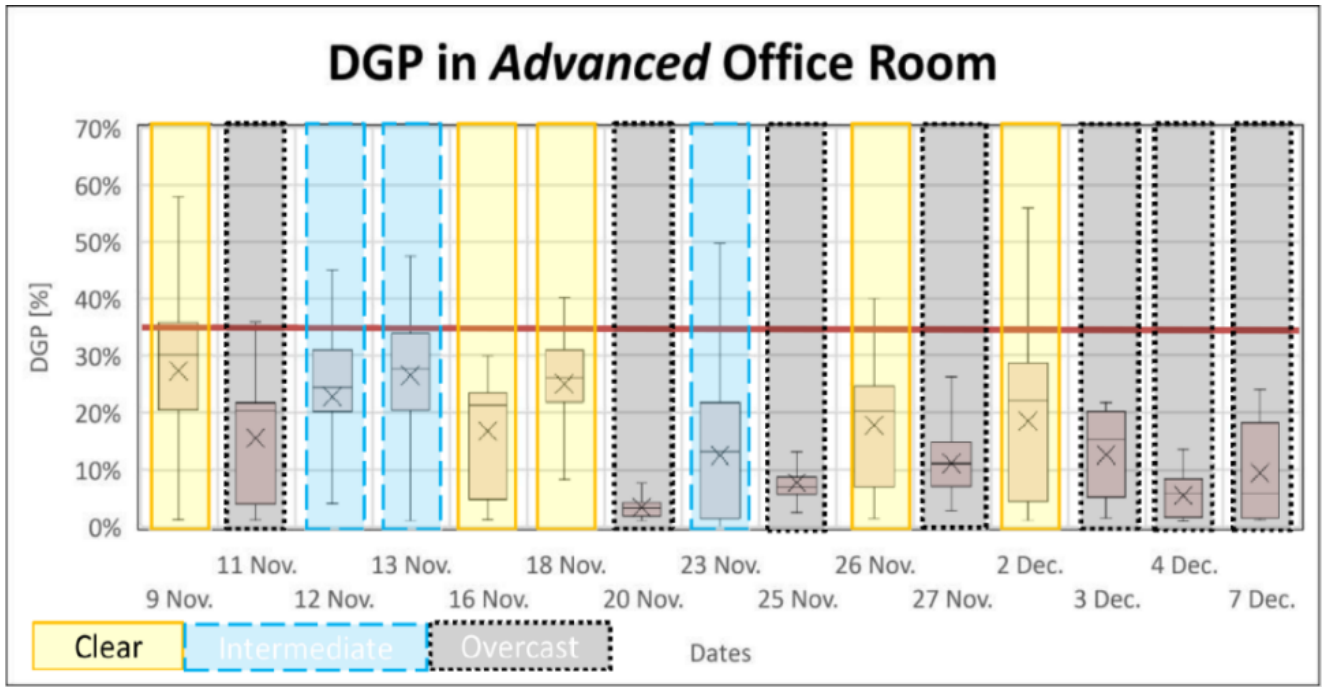
Workplane Illuminance
User Presence



Human Centric Lighting

Short-Term Field Study (15 Days, 30 Subjects)

- Improvement of Visual Comfort & Performance at Workspace
- Overall 32% Lighting Electricity Savings (LPD_{AVE} < 1.5 W/m^2)

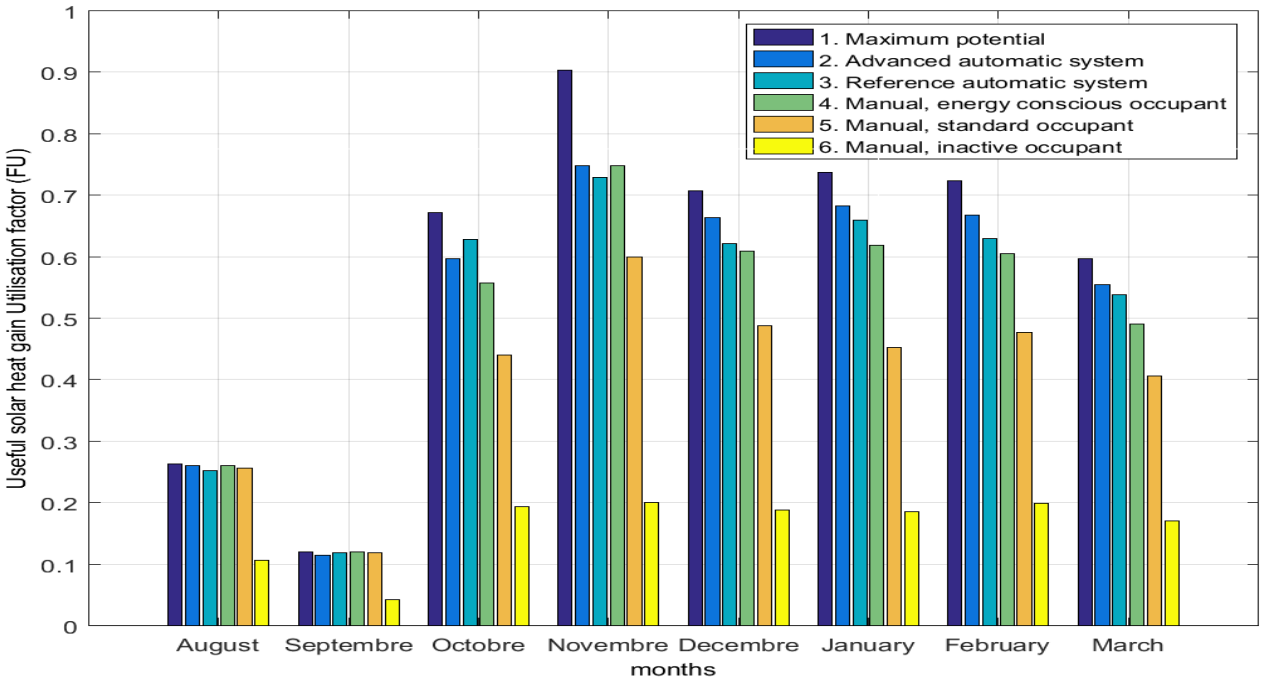


A. Motamed et al., Energy and Buildings 149, 2017.

Human Centric Lighting

Long-Term Field Study (8 Months, 4 Subjects)

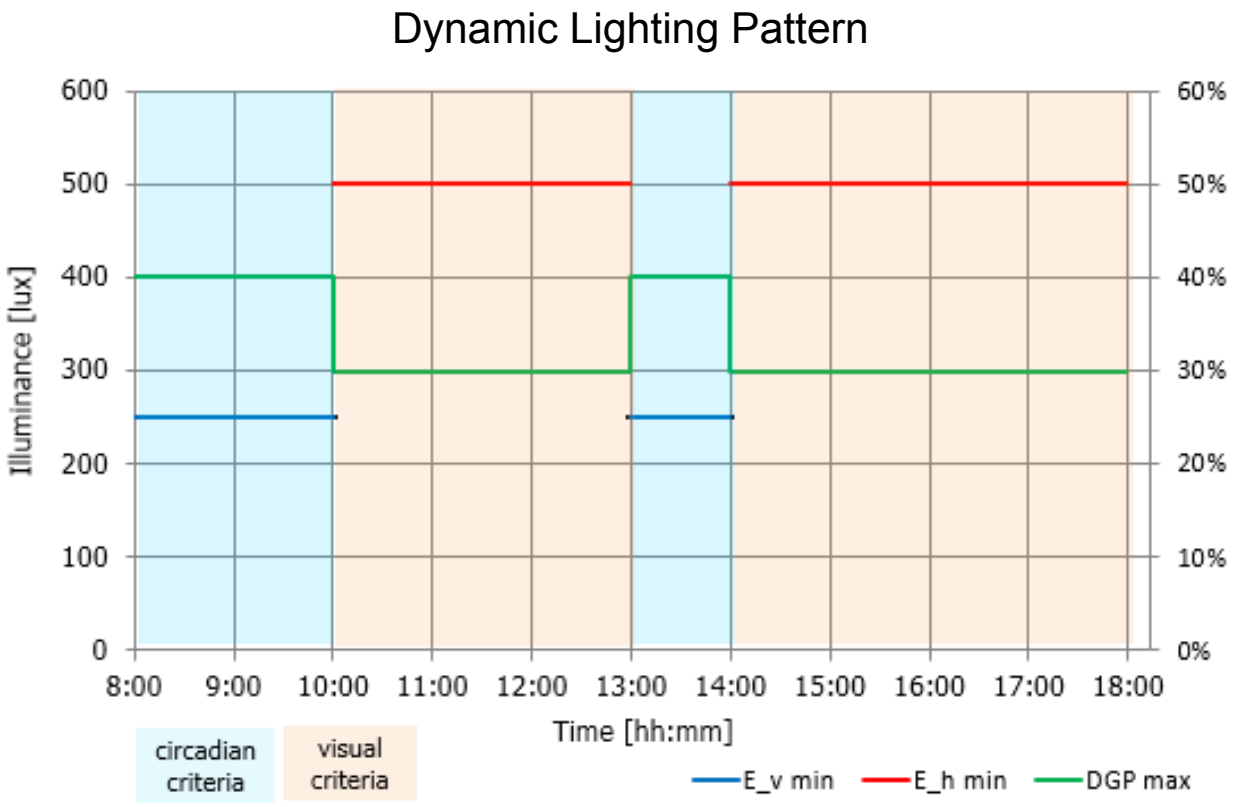
- Increase of Solar Gain during Wintertime (Lower Heating Load)
- Avoidance of Solar Gain during Summertime (Lower Cooling Load)
- Mitigation of Energy Performance Gap (70% vs. Standard Occupant)



A. Motamed, PhD Thesis, EPFL, 2017.

Human Centric Lighting

Integration of Non-Image Forming Effects of Light in Sun Shadings and Electric Lighting Control

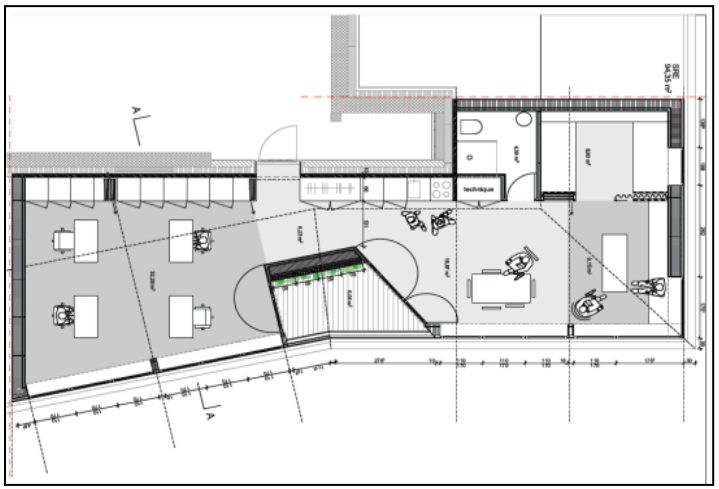


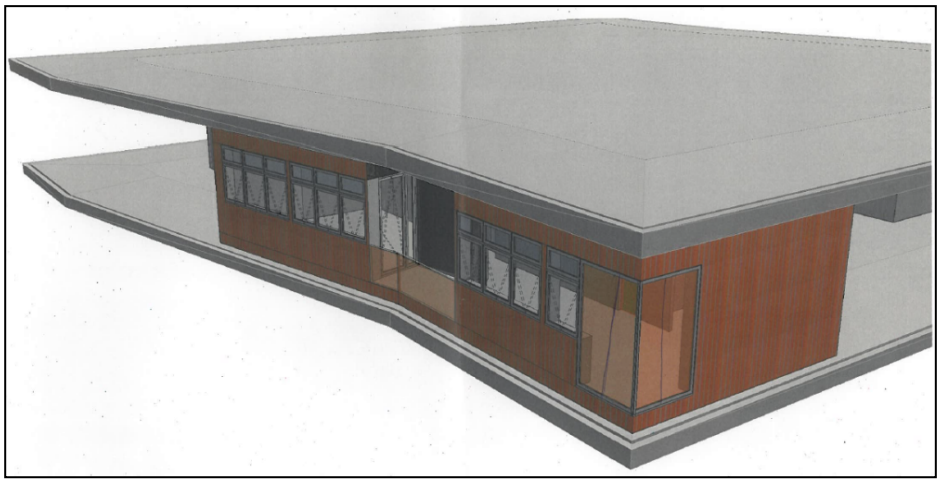
M. Benedetti et al., CISBAT 2017, EPFL, Sep. 6-8 2017.

Human Centric Lighting

Human Building Interaction
Energy Efficient Building Envelope

- NEST SolAce Unit Construction and Operation (2018-2020)
- SCCER FEEB&D Phase II TechTransfer (Work/Living Space)
- Colored Solar PV Panels (SwissINSO) & Dynamic Glazing (BASF)
- Circadian LED Lighting (Regent, Griesser) & HDR Vision Sensors (CSEM)





J.-L. Scartezzini et al., NEST Unit from EPFL Researchers „SolAce | Reconfort", 2015.

Conclusion

- Human-Centric Lighting based on HDR Vision Sensing & Control (Sun Shadings & Electric Lighting)
- Short-Term & Long-Term 'In Situ' Monitoring in the LESO Office Building (Advanced & Reference Room)
- Field Studies with Human Subjects for Visual Comfort & Performance (Glare Rating, Acuity Tests, Global Surveys)
- Significant Savings of Electric Lighting & Back-up Heating Demand compared to 'Best Practice' (COP 21, ES 2050)
- Mitigation of Glare Risks & Upturn of Office Lighting Conditions (Glare Index, Workplane Illuminance)
- Exciting Prospect for Human-Centric Lighting based on Circadian Lighting (Dynamic Lighting Pattern)

Any
Question ?

Thank you
For your
Attention