MeLi Dos

Metrology for wearable light loggers and optical radiation dosimeters


## Quick overview of the subject

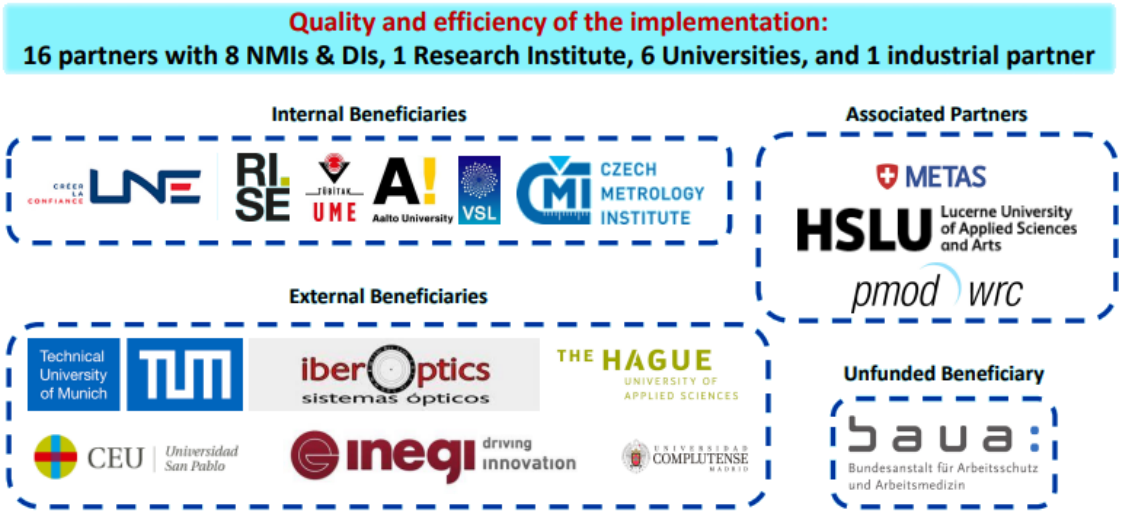
Until recently, our idea about light has been associated with the function of vision and indoor illumination has been measured with units that most people in the field probably know: lux, lumen and others are derived from our brightness sensitivity to radiation. About 30 years ago, it was discovered that the light entering through our eyes influences our health, our psychology, and our behaviour, including circadian rhythms, sleep-wake cycles, cognitive functions and neuroendocrine balance. Previously unknown photoreceptors in the human eye not involved in vision, so called intrinsically photosensitive retinal ganglion cells (ipRGCs), were discovered around the turn of the millennium, supporting this finding. Light is a complex multidimensional stimulus. The responses elicited by exposure to natural or artificial light depend on many factors, including spectral composition, intensity, spatial distribution, duration, and temporal dynamics, as well as timing and individual factors such as light history, age, and health status.

The invention of electric lighting has led people to spend more time indoors during the day and stay awake later at night. However, the intensity of artificial light is only a small fraction of daylight (a fifth of a cloudy sky and far less than 1% on a sunny afternoon), while its spectral composition differs mainly in the proportion of blue light. Measured vertically at the eye level, and with effects of the eyelid and the pupil dimension, it is even harder to compare to usual measurements of natural light. The previously mentioned “non-visual” photoreceptors (ipRGCs) contain a photo-pigment called melanopsin mainly sensitive in the blue-cyan part of visible light spectrum. The cells send signals the specific locations in the brain to synchronize the master clock and adjust it to the daily 24-hour cycle which in turn relays this information to the entire body. The implications for health and well-being are far-reaching, as it is becoming more and more apparent that mental and physical health are interconnected. From altered mood and wakefulness to sleep deprivation and more serious health problems such as heart disease, psychiatric disorders and cancer, all can be associated in part with chrono-disruption, alteration of our physiological balance due to inadequate reception of light.

Although the study of light sources can be carried out in laboratories under controlled conditions, the light that humans receive in real environmental conditions is very different due, for example, to the placement of luminaires, windows, paintings, furniture, behaviour, etc. The world of wearable sensors has seen a recent boom in quantity and diversity, and monitoring light doses with wearable light loggers was an obvious answer to the issue of understanding human-light interaction in real life setting. This difference between laboratory and real conditions is also an issue for solar UV radiation measurements, which is a raising health risk as people spend more time outdoors due to the increase in hotter, sunnier days due climate change. Though UV dose measurements is more mature as a field, proper, consistent characterisation of optoelectronics-based solar UV dosimeters remains an issue.

# MeLiDos identity and goals

The MeLiDos project's main goals are to address the shortcomings of current practices involving light logging devices by providing a systematic, metrology-based approach to both characterisation and use. Sixteen entities from ten countries, dedicated to research and development, have come together through the MeLiDos project, supported by EURAMET (European Association of National Metrology Institutes), to tackle this issue.




**It is worth highlighting the following objectives of the project:**

- To develop and validate **new characterisation methods** and **define a validated set of quality indices for wearable optical radiation dosimeters**, with a focus on ranges relevant to daily life (visible and UV).
- **To develop data analysis methods to verify and increase the quality of data**, as well as to establish the correlation between different datasets to improve reproducibility and make comparisons from different devices more reliable.
- **To analyse use cases for wearable light loggers based on end user needs, and to then produce recommendations based on those needs on i) (meta-)data model and data formats, summary metrics and on ii) the practical use of light loggers**, including device placement, compliance and quality control.
- **To evaluate the performance of new portable devices able to measure spatially resolved photobiological quantities** and to compare them with spatially averaging devices, to determine relevancy depending on use case.

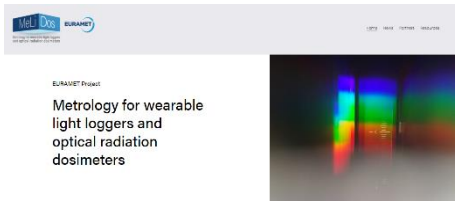
**Expected outcomes and impact:**

The primary output of the project is the creation of good lighting practice guidelines for use by researchers, architects, lighting installers, health professionals and consumers in particular. The aim is to be able to calculate and interpret in a simple way whether the visible light received indoors is in accordance with the light needed for the correct functioning of biorhythms and circadian balance. The UV radiation measurements will be used from the results obtained to propose improvements in the protection of outdoor workers.

Ultimately, the goal is to get a better understanding of the effects of light on human physiology for better global health and wellbeing.

# The project's dissemination activities so far

The **activities** by the members of the MeLiDos consortium are making visible the objectives:

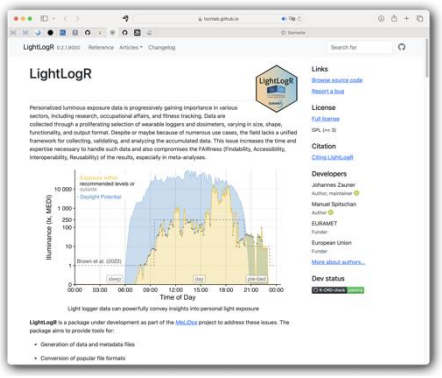



A Project webpage: https://www.melidos.eu/ has been created by the Technical University of Munich (TUM). It will be continuously updated during the course of the project.

Members of the MeLiDos consortium gave presentations at the Quadrennial Session of the CIE, September 15-23, 2023, and interacted with potential stakeholders, in particular at the first live meeting of the closely related JTC 20 of CIE which some members of the consortium are part of.
In November, stakeholders and experts in different areas covered by the project met to enrich the members of the consortium in the development of the tasks. Early progress was presented, and collaboration proposals were extended by several stakeholders.
https://lnkd.in/dabBNd3Q

63 students from 2 schools participated in the Science week of the Universidad CEU San Pablo on November the 6th and 17th, 2023.

During two days in September (12th&13th) the Bundesanstalt für Arbeitsschutz und Arbeitsmedizin (BAuA) hosted a workshop on effects of light beyond vision in Dortmund. It was a pleasure to have such distinct researchers here and discuss the recent research as well as open questions related to this topic.
We hope that our discussions will go on and lead to more exchange and cooperation in the future.




The software package LightLogR for the R software kicks of the development of a software ecosystem to facilitate working with wearable light logger data, analysing it, and making it FAIR (findable, accessible, interoperable, and reusable). LightLogR is a work in development by the Technical University of Munich (TUM) that already supports a range of essential features for import from common devices, handling gaps and irregularities, calculating metrics, and visualizations. This makes LightLogR an ideal addition to a light logger related workflow – have a look and get in touch!

➔ https://tscnlab.github.io/LightLogR/

In addition, several presentations of the project have been made by the consortium members to their respective national lighting groups

## Upcoming events

The consortium members will be present at the Light+Building conference in March 2024, and at the NEWRAD 2024 conference. A publication presenting the subject in more details will also be made in Science Direct.

For further information, please contact us through our website.

**Reference readings:**

CIE S 026:2018: “CIE System for Metrology of Optical Radiation for ipRGC-Influenced Responses to Light”

EN 12464-1: “Light and lighting – Lighting of work places – Part1: Indoor work places”

Luke L A Price, Ljiljana Udovičić, Thomas Behrens, Alwin van Drongelen, Anne Helene Garde, Koen Hogenelst, Marie Aarrebo Jensen, Marina Khazova, Kamila Nowak, Sylvia Rabstein, Erik Romanus, Agnieszka Wolska, Linking the non-visual effects of light exposure with occupational health, *International Journal of Epidemiology*, Volume 48, Issue 5, October 2019, Pages 1393–1397, https://doi.org/10.1093/ije/dyz131

Münch, M.; Wirz-Justice, A.; Brown, S.A.; Kantermann, T.; Martiny, K.; Stefani, O.; Vetter, C.; Wright, K.P., Jr.; Wulff, K.; Skene, D.J. The Role of Daylight for Humans: Gaps in Current Knowledge. *Clocks & Sleep* **2020**, *2*, 61-85. https://doi.org/10.3390/clockssleep2010008

BROWN, Timothy M., BRAINARD, George C., CAJOCHEN, Christian, *et al.* Recommendations for daytime, evening, and nighttime indoor light exposure to best support physiology, sleep, and wakefulness in healthy adults. *PLoS biology*, 2022, vol. 20, no 3, p. e3001571.

## Acknowledgements:

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EURAMET. Neither the European Union nor the granting authority can be held responsible for them.

The project has received funding from the European Partnership on Metrology, co-financed from the European Union’s Horizon Europe Research and Innovation Programme and by the Participating States.

EUROPEAN PARTNERSHIP

Co-funded by the European Union

METROLOGY PARTNERSHIP

EURAMET