Aalto University School of Electrical Engineering

PHOTOMETRY GROUPE

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INTRODUCTION:

Radiometry and photometry describe the propagation of energy by radiation through space. Radiometry treats this problem in a purely physical way, in terms of energy or power and the geometry within which the propagation takes place, in photometry the same problem is described, but on the visual effect on human eye.

Wavelength range = [380 : 830] nm

Call light

Aim of Photometry : measuring light in such a way that the results correlate as closely as possible with the visual sensation that would be experienced by a standard human eyes.

Photometric quantities:

Three types of human vision :

1. Photopic → when eye is adapted to high luminance level
2. Scotopic → when eye is adapted to low luminance level
3. Mesopic → when eye is adapted to intermediate level of luminance

- ***V(λ)*, DESCRIBE RELATIVE SPECTRA SENSITIVITY OF THE AVERAGE HUMAN EYE**

- **FOR PHOTOPIC AT 555 (nm) [2-degree field of angle]**

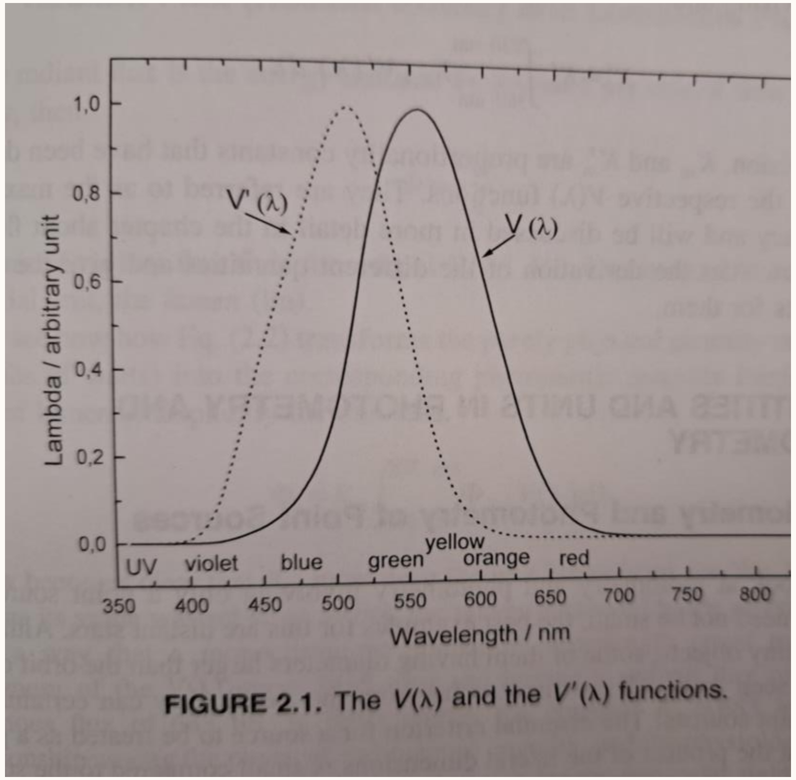


FIGURE 2.1. The V(λ) and the V'(λ) functions.

- **AND SCOTOPIC → *V'(λ)* → 507 (nm)**

- **NO SPECIAL FUNCTION FOR MESOPIC REGION HAS YET BEEN DEFINED.**

GEOMETRICAL QUANTITIES :

1- plane angle:

Light sources emit in all directions in space (except laser)

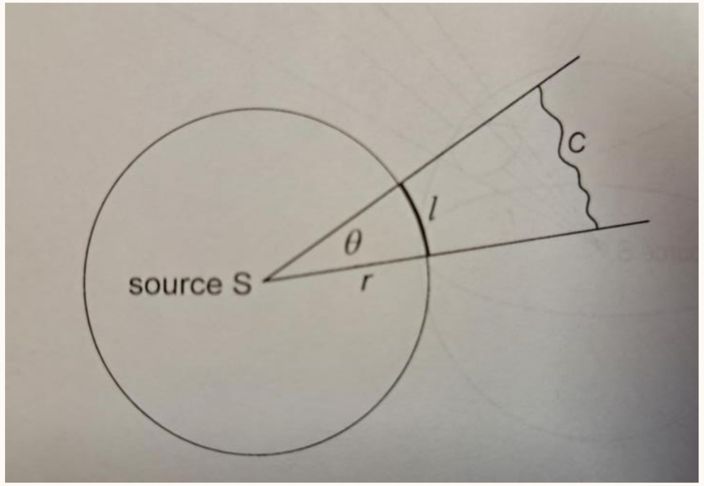
✓ Solid angle and plane angle define similarity

$$\text{(radian) } \theta = \frac{l}{r}$$

2- solid angle

✓ Passing into 3D space, the solid angle is the ratio of the area of part of sphere to the square of radius of sphere

$$(steradian)\Omega = \frac{A}{r^2}$$



PHOTOMETRY VERSUS RADIOMETRY :

$$x_{e,\lambda} = \frac{dx_e}{d\lambda}$$

$$x_v = k_m \int_{380}^{830} x_{e,\lambda} v(\lambda)\, \mathrm{d}\lambda$$

- X can be any of the following quantities : flux, energy , irradiance, radiance or intensity

RADIANT FLUX (RADIANT POWER) AND LUMINOUS FLUX:

- The radiant flux is the energy radiated by a source per unit of time:
- Q → energy

$$\Phi = \frac{dQ}{dt}$$

Unit of Φ → watt (W) = $^{J}/_{s}$

$$\Phi_v = k_m \int_{380}^{830} \phi_{e,\lambda} \, V(\lambda) d\lambda$$

k_m =683 lm/W

lm(lumen)

(lm/W)

W

ACTIVITIES:

CUSTOMERS CALIBRATION:

RESEARCH PROJECTS:

RESEARCH PROJECTS:

I. RevStdLED
II. Hidyn

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RevStdLED:

Different properties of light sources, like spectral mismatch correction factor is determined using ratio of integral spectral irradiance

Mismatch Correction Factor (MMF) = F

In general , whenever we have a reference spectrum, we will have mismatch correction factor

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- $E_{\mathrm{e}}(\lambda) = [1 + \delta(\lambda)\, u_{\mathrm{c}}(\lambda)]E(\lambda),$

- $\delta(\lambda) = \sum_{i=0}^{N} \gamma_i f_i(\lambda)$,

- $f_i(\lambda) = \sqrt{2}\sin\left[i\left(2\pi\frac{\lambda-\lambda_1}{\lambda_2-\lambda_1}\right)+\phi_i\right]$

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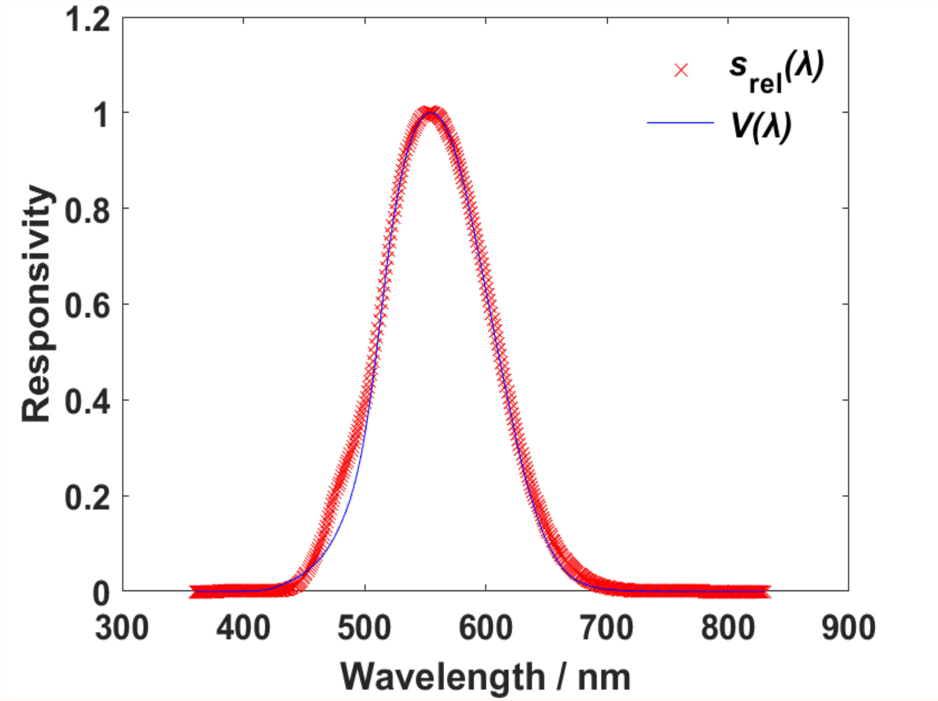
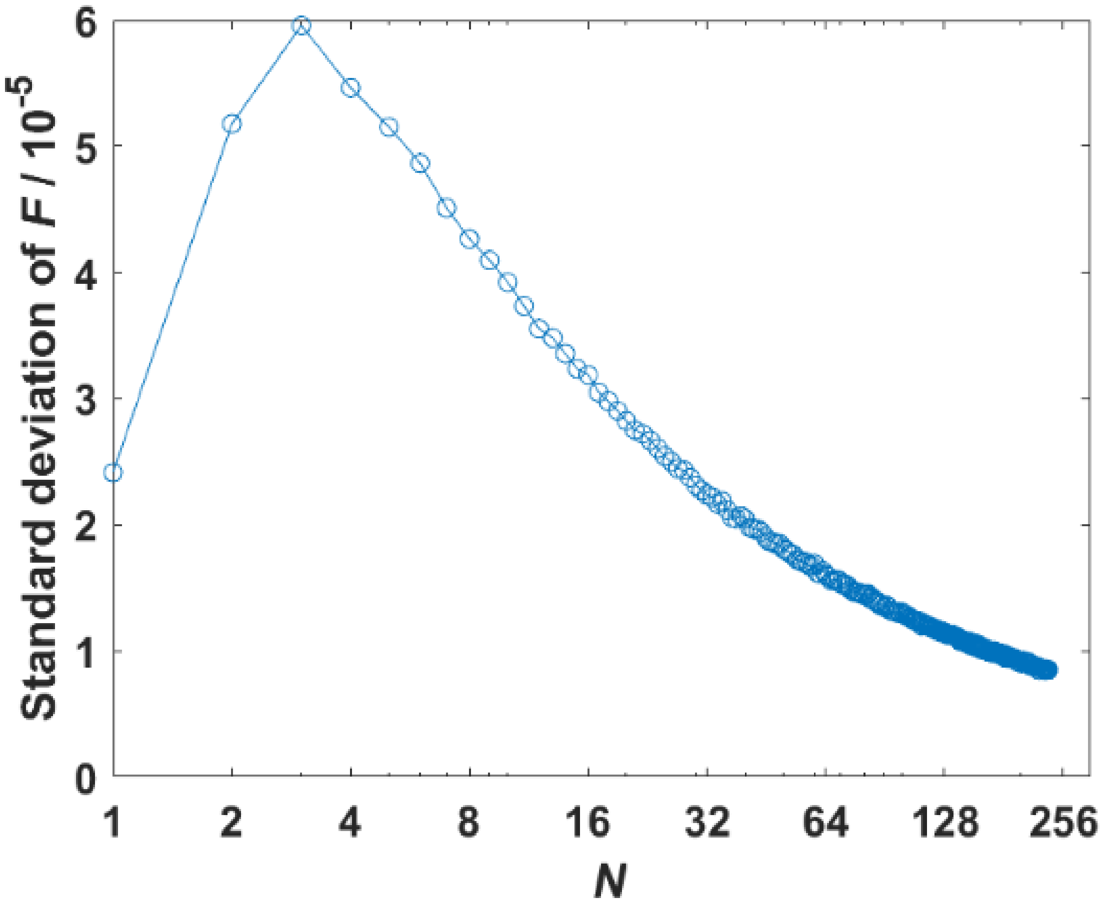


$$F = \frac{\int E_e(\lambda)V(\lambda)\,d\lambda}{\int E_e(\lambda)s_{rel}(\lambda)\,d\lambda} \ ,$$

- Monte Carlo Simulation (MC):
- On ϕ_i
- Calculate Standard deviation



Hidyn:

Luminance distribution measurements with high dynamic rang (HDR) are required by various applications like, measurement of new LED or laser-based car headlights.

HDR measurements are achieved by post-processing image sequences , but standardization and uncertainty statements are usually absent

- WP1→ we are responsible for doing the HDR luminance measurements of the high-contrast luminance reference standard source (done by others) at defined positions with at least three HDR imaging systems.
- The parameters required to assess the uncertainty budget will be determined and reported for each measurements.

- WP2 → aim develop a model i.e. an algorithm generating an HDR-luminance image from a sequences of multiple low dynamic range (LDR) images.
- measurement uncertainties.

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CUSTOMER CALIBRATIONS:

I. Illuminance
II. luminance

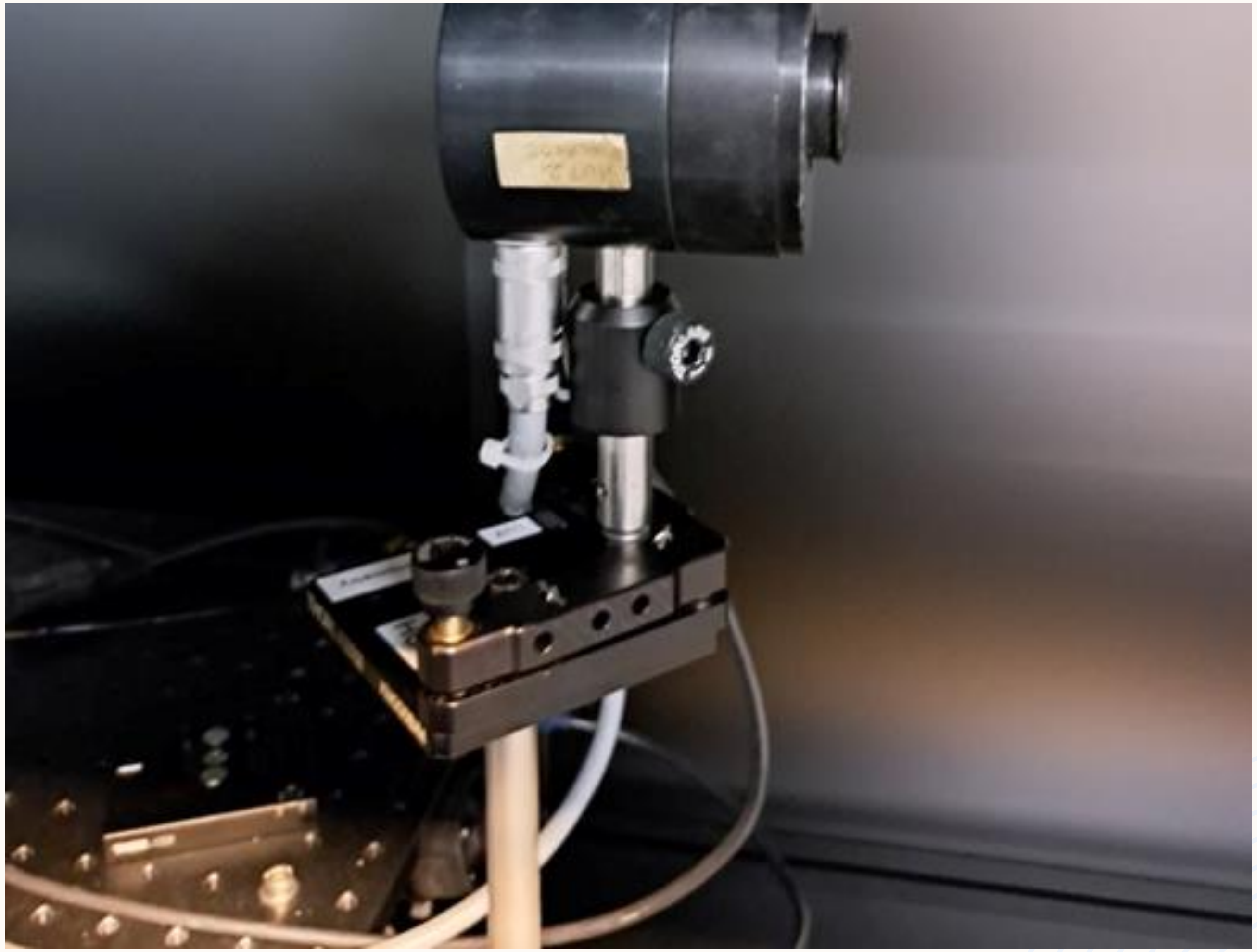
UVFR-5:

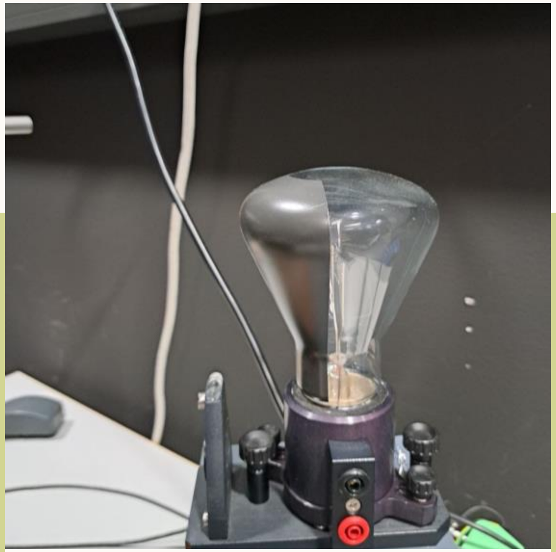
- The reference photometer consists of a trap detector, a $V(\lambda)$ filter, a copper oven for temperature stabilization of the filter, and a precision aperture

STANDARD PHOTOMETERS:

HUT-1	HUT-2	LM-1 & LM-2
is normally used only for maintaining the illuminance responsivity scale	is used for customer calibrations.	are used as sphere photometers in luminous flux measurements

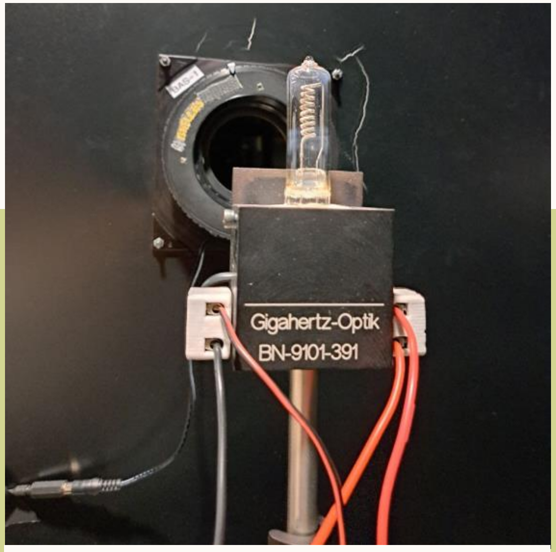
HUT-2





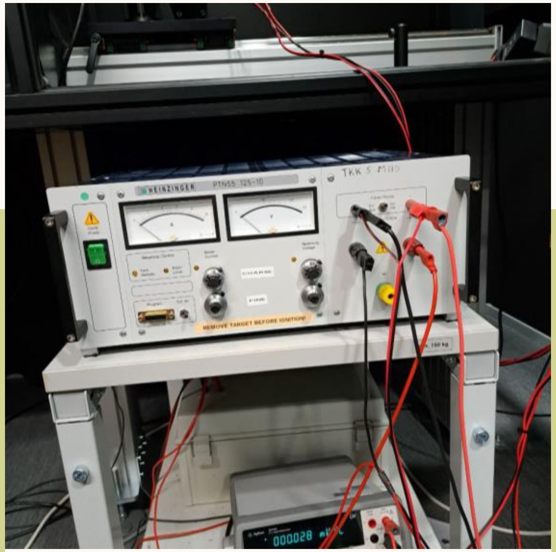
OSRAM Wi41/G

cds9905



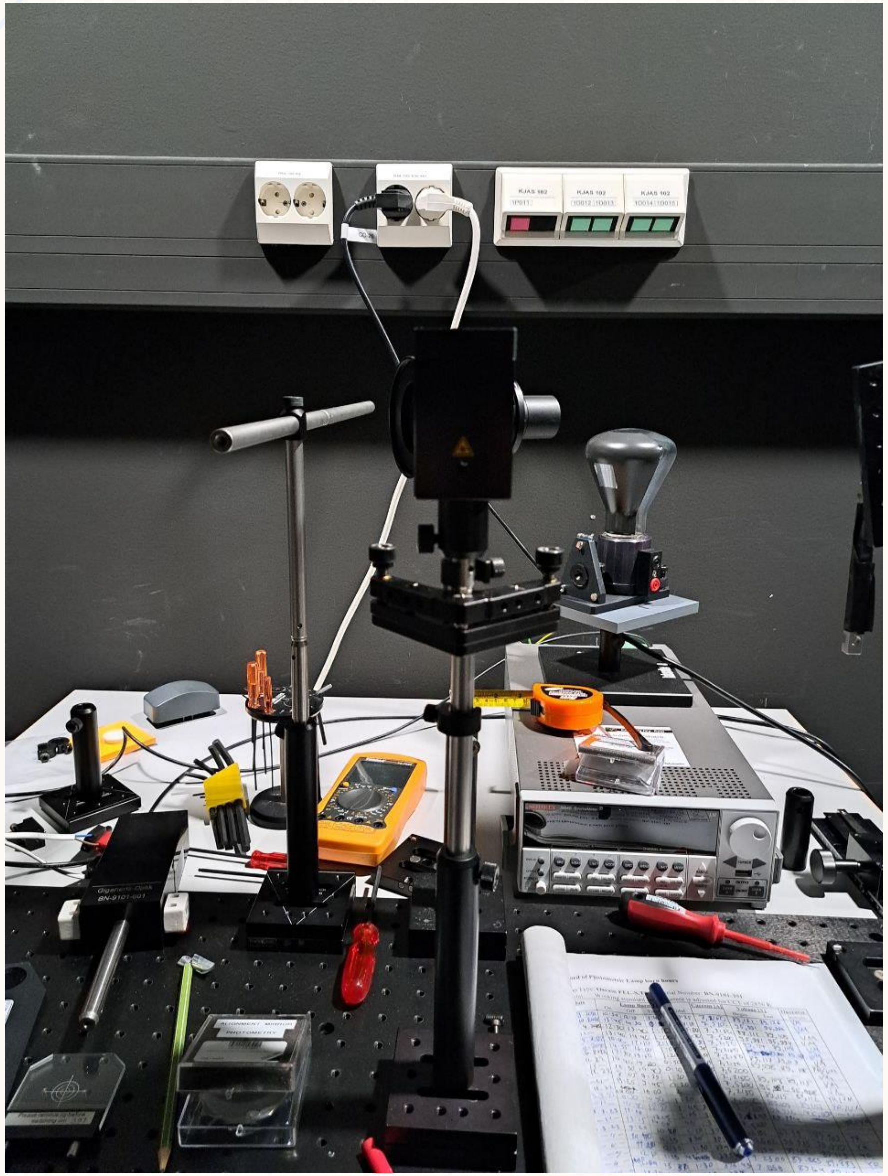
OSRAM SYLVANIA

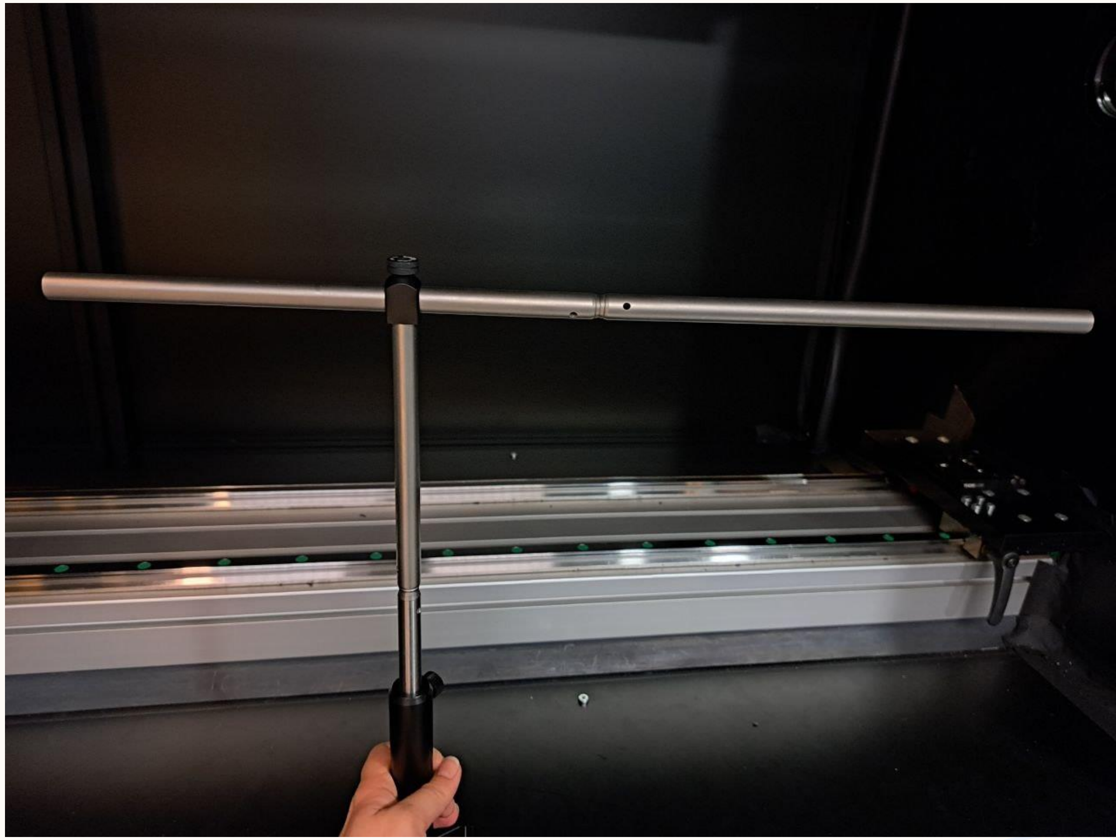
FEL_391

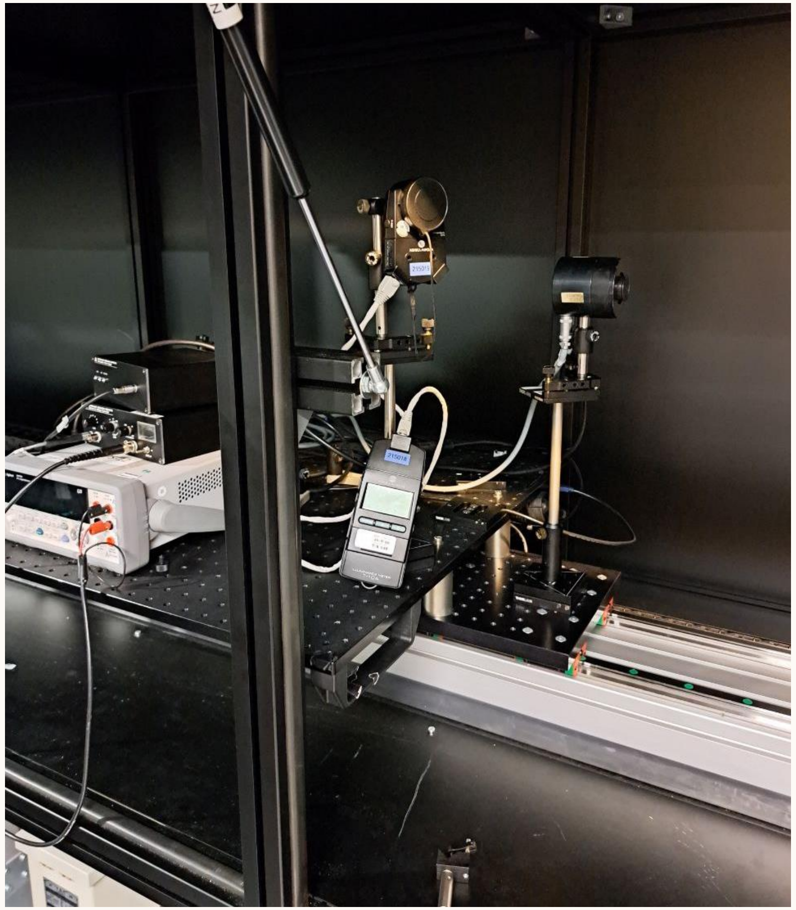


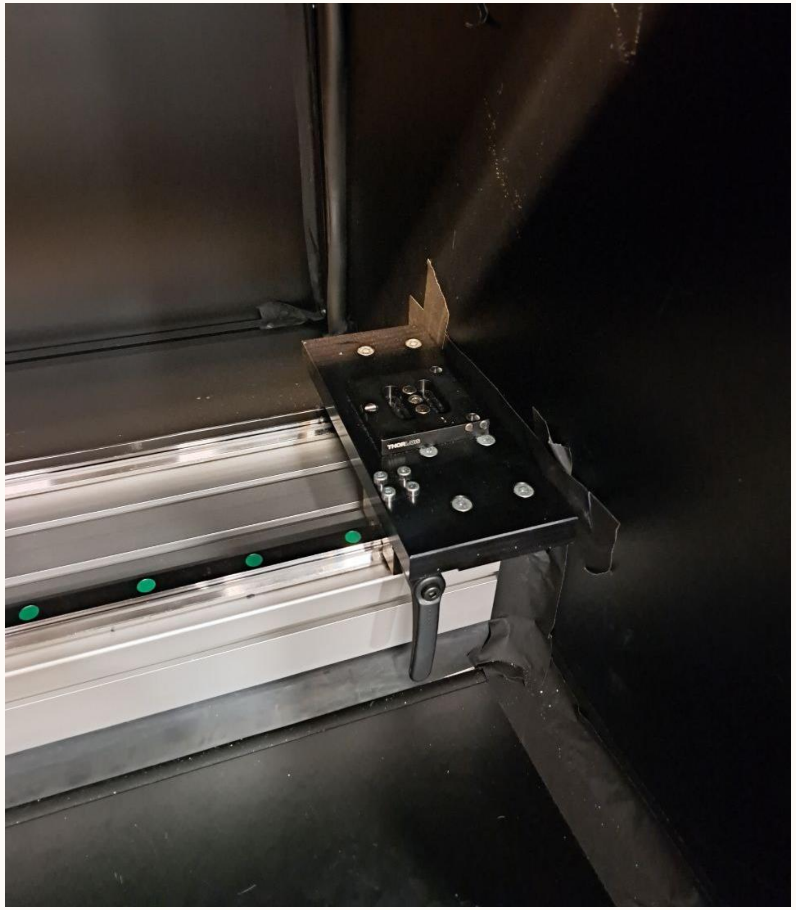
POWER SUPPLY

Light source	Osram Wi41/G cds9905	Osram Sylvania T6 FEL-391
Current [A]	5.9200	7.1700
Illuminance range [lx]	5 – 1100	25 – 5000










Setup
Measurement
SET DATABASE
DVM
GPIB0::20:
DVM type
HP34401A
DVM name
HPS-12
CVC device
MRI-CVC-5
Photometer
HUT-2
Signal samples
15
Measurement path and file
\\work.org.aalto.fi\t405\...inance customer\Measurement files
T-R 1247_Orion_standard_2
Comments
T-R 1247_ orion _standard_2
Light source: FEL-391 @ 2856 K
Electronic shutter with opening of 50 mm @ 25 cm from the lamp
Customer: Orion
HPS-12 and MRI-CVC-5
Calibrated device: Illuminance meter w/ offset of 7,9 mm
Device's model: TES-1336A
Offset of the HUT-2 9,635 mm
Reference point 500,02+-0,05 mm from lamp reference
Ambient temperature
23,9
Relative humidity
29
Init measurements
Distance
COM15
Distance monitor
3654.314
Photom. dist.
0
DUT
8,282
Photom. offset
3
DUT offset
6,8
Offset
-4,482
Shutter
COM3
MANUAL
Shutter
QUIT
Manual shutter


Setup
Measurement
Illuminance level
10
DUT distance
Photometer dist.
3658,79
3654,31
DUT dark
DUT dark deviation
0
0
DUT reading
DUT deviation
9,99
0,01
DUT range
CVC Gain
1e0
1e7
Meas reference
Close file
Illuminance / lx
(dark current uncorr)
Time
1,21
V
8735
8835
Avg. signal [V]
std. dev. [%]
Illuminance [lx]
Correction factor
1,21054E+0
0,550251
9,99348
1,00035
Distance
Distance monitor
COM15
3654.314
Photom. dist.
DUT
0
8,282
Photom. offset
DUT offset
3
6,8
Offset
-4,482
Shutter
COM3
MANUAL
Shutter
QUIT
Manual shutter

UNCERTAINTY BUDGET:

Table 1. Calibration uncertainty.

Illuminance level [lx]	500		100		10		1		0.1	
Gain	10^2	10^1	10^1	10^0	10^0	10^{-1}	10^{-1}	10^{-2}	10^{-2}	10^{-3}
Component	**Relative standard uncertainty [%]**									
Reference illuminance	0.7	0.7	0.7	0.7	0.8	0.8	0.9	0.9	0.9	0.9
Stability of source	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Reference distance (2 mm)	0.2	0.2	<0.1	<0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.1
Resolution of display	0.6	<0.1	0.3	0.1	0.3	<0.1	0.3	<0.1	0.3	<0.1
Combined standard uncertainty	0.9	0.7	0.8	0.7	0.9	0.8	1.0	0.9	1.0	1.0
Expanded uncertainty ($k = 2$)	1.9	1.5	1.5	1.4	1.7	1.6	1.9	1.8	1.9	1.9

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MEASUREMENT:

Table 2. Calibration results.

Illuminance level [lx]	Reference illuminance [lx]	DUT reading [lx]	Gain	Correction factor
0,1	0,09589	100,6	10^{-3}	0,953 ± 0,015
0,1	0,09589	10,0	10^{-2}	0,959 ± 0,016
1	0,9554	100,6		0,960 ± 0,014
1	0,9654	10,0	10^{-1}	0,965 ± 0,015
10	9,659	100,5		0,961 ± 0,012
10	9,659	10,0	10^{0}	0,966 ± 0,013
100	96,09	100,6		0,955 ± 0,010
100	96,09	10,0	10^{1}	0,961 ± 0,011
500	484,2	50,3		0,963 ± 0,010
500	489,0	5,0	10^{2}	0,978 ± 0,015

LUMINANCE:


KONICA MINOLTA
CS-2000
THORLABS INC

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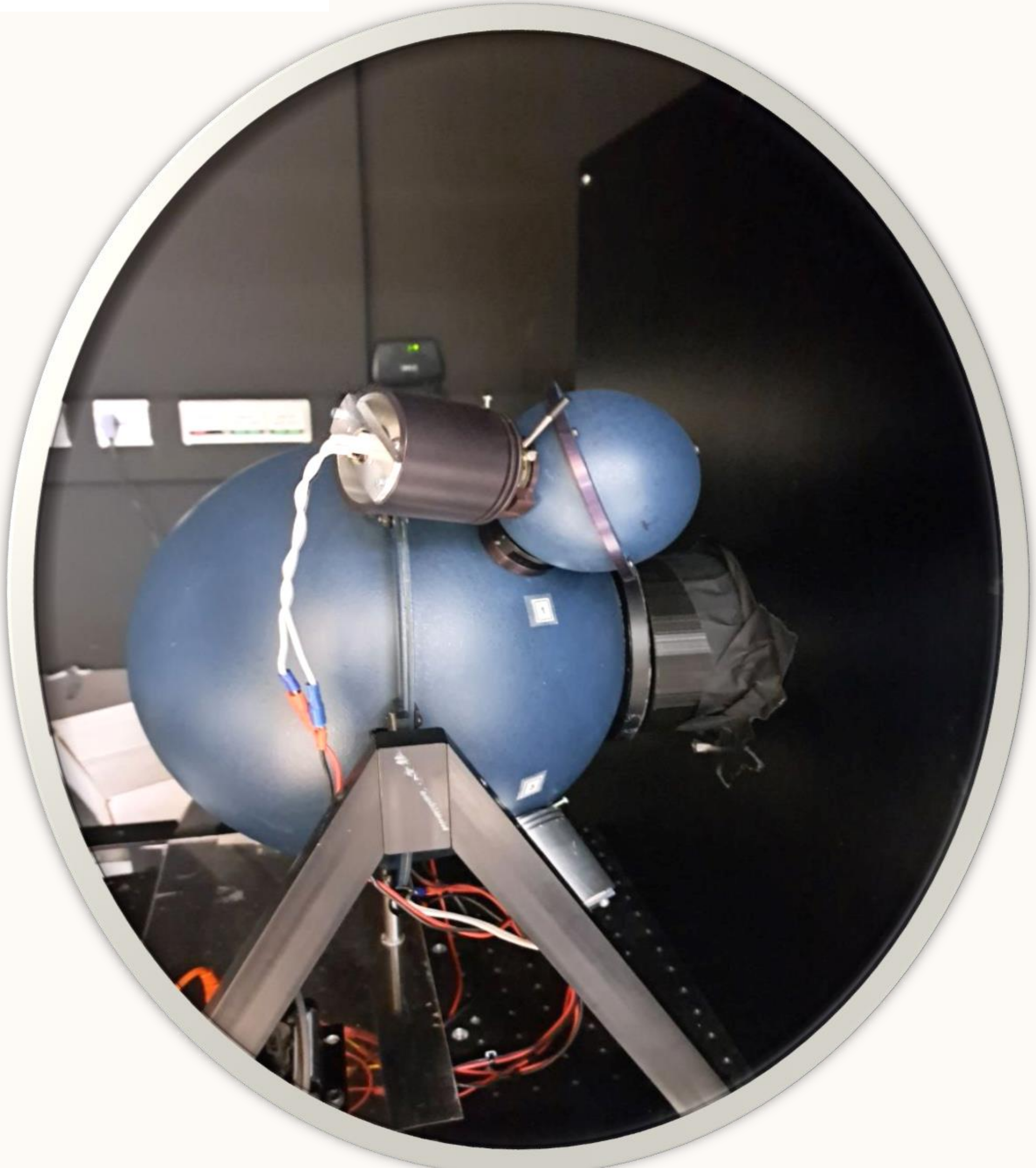
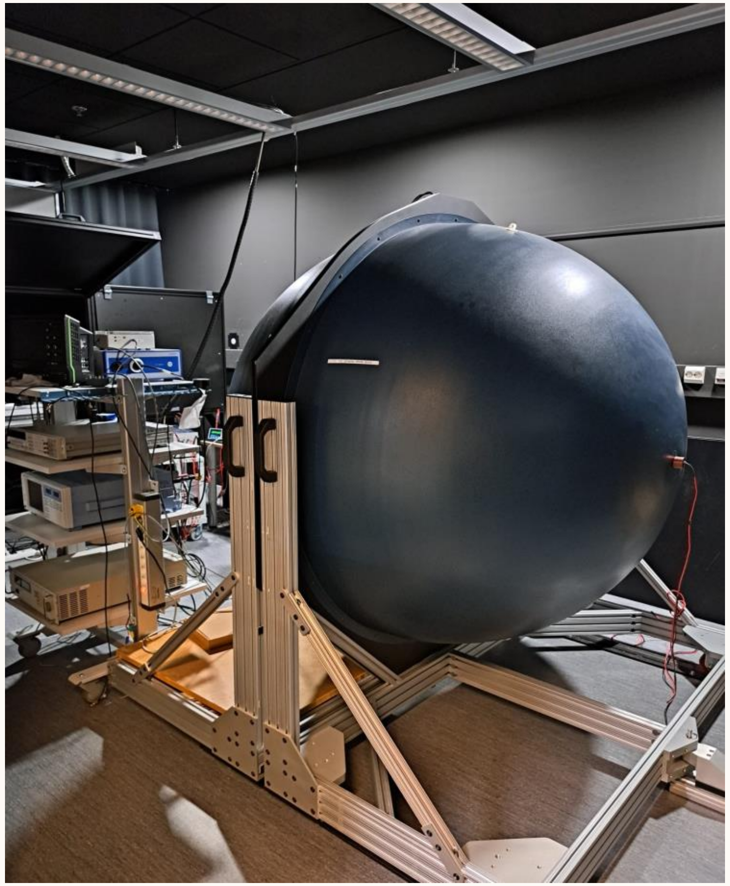
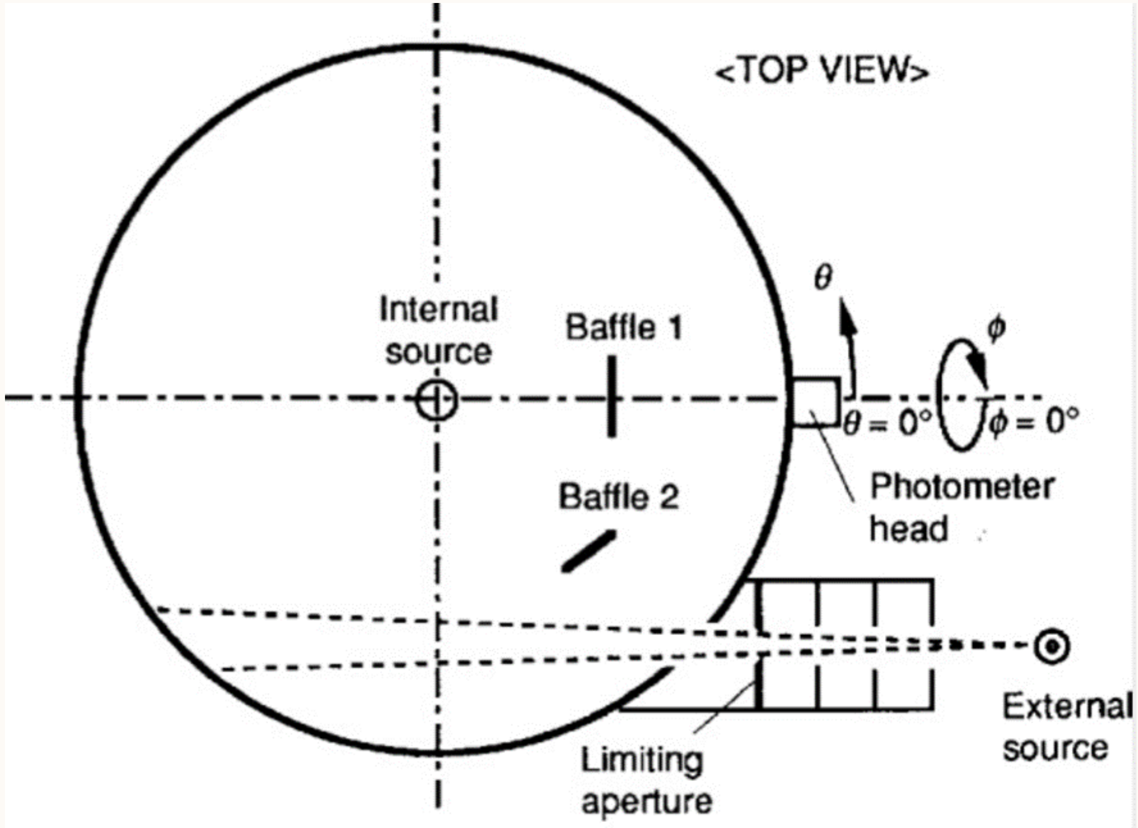


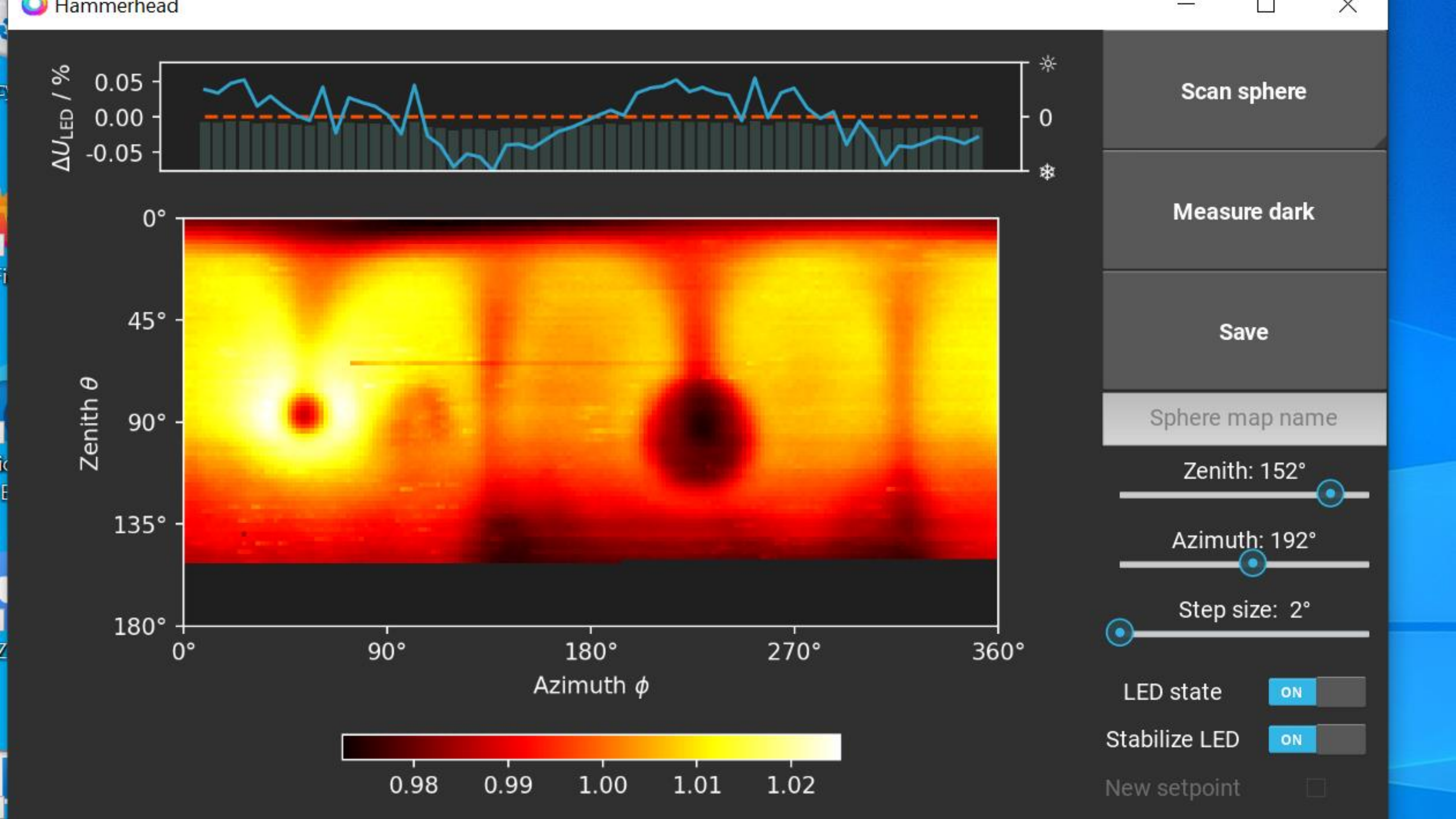
INTEGRATING SPHERE:



- New method for realizing a luminous flux unit has been developed at NIST With **integrating sphere**

❖ The basic principle of this method ⇨ calibrating **the total flux of a lamp inside** the sphere against the known **amount of flux introduced from a source outside** the sphere through an opening





Hammerhead
ΔU_{LED} / %
0.05
0.00
-0.05
0
Zenith θ
0°
45°
90°
135°
180°
0°
90°
180°
270°
360°
Azimuth ϕ
0.98
0.99
1.00
1.01
1.02
Scan sphere
Measure dark
Save
Sphere map name
Zenith: 152°
Azimuth: 192°
Step size: 2°
LED state
ON
Stabilize LED
ON
New setpoint

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SUMMARY

The primary aim of photometry is measure visible radiation, in such a way that the results correlate as close as possible with what the visual sensation would be of a normal human observer exposed to that radiation.

Activities are divided to Customer calibration that are done mostly every 2 years.

Our project that now a days manly about Uncertainty and coding

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THANK YOU

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