Meten = Weten

Lampen meten

Lichtsensoren, goniometers en meettechniek

Marcel van der Steen

Agenda

- Iets over mezelf
- Normen
- Luxmeters en spectrometers
- Goniometers
- Meetaanpak OliNo

Vragen tussendoor.

OliNo

- Naam OliNo → Olie, NEE
  - Eindige voorraden, desastreuze klimaateffecten
  - De oplossing: 100% duurzame energie en energiebesparing
- OliNo.org
  - Artikelen over LED, zonne-energie, windenergie, warmtepompen, elektrische auto's, energieopslag en energie-besparing (> 1000)
  - Professionele en onafhankelijke LED metingen (> 2200)
  - LampenPortal
- Fotogoniometrische meetopstellingen

Normen

- LM-79-08
  - IES (NA) (Illuminating Eng. Soc)
  - Measure SSL products in reproducible way
- EN 13032-4
  - 2013, CEN: 1st int. standard
- CIE S025
  - 2015, CIE collaboration with CEN, int. standard

Norm CIE S025

- Measured quantities covered:
  - Luminous flux and efficacy
  - Luminance
  - Colorimetric quantities (x,y, CCT, Duv, CRI, ..)
  - Appropriate test setups
  - Defines standard test conditions
  - Defines special requirements for
    - lab
    - Environment
    - Test instruments

Norm CIE S025

- Some examples:
- Standard test conditions and tolerance intervals:
  - ambient temperature: 25.0 deg C, +/- 1.2 deg C for LED lamps/lum
  - air movement: stationary, 0 to 0.25 m/s

Norm CIE S025

- Special requirements for measuring instruments:
  - calibration uncertainty for volt and ammeters: AC <= 0.2 % and DC <= 0.1 %
  - harmonic content of voltage supply: <= 1.5 %
  - Electric and photometric stabilization for the device under test: LED lamps and luminaires >= 30 min and relative difference of max and min values of previous 15 minutes < 0.5 %.
  - Spectral sensitivity photometer: V(λ) mismatch index f'_1 <= 3 % (f_x parameters defined in ISO/CIE 19476:2014)
  - Wavelength range and – uncertainty for spectroradiometer: 380-780 nm, <= 0.5 nm (k=2).
  - Photometric test distance for samples with a max luminous dimension D: beam angle >=90 deg ; >=5xD, beam angle >=60deg; >=10xD, narrow angular distribution or steep gradients: >=15xD, large non-luminous areas with maximum distance S: >= 15x(D+S)
  - Burning position: Measurement in specific burning position or correction to behavior of the device under test in the specified burning position.

Norm CIE S025

- Each standard test condition is subject to a set value and tolerance condition which is specified by a tolerance interval. Also measurement uncertainty must be included to define the acceptance interval.

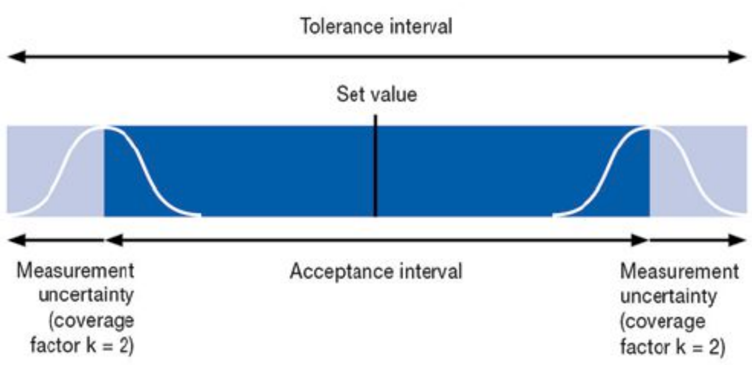


Figure 15: Relationship between set value, expanded measurement uncertainty, tolerance and acceptance interval. The definition of the tolerance interval does not take account of measurement uncertainty.

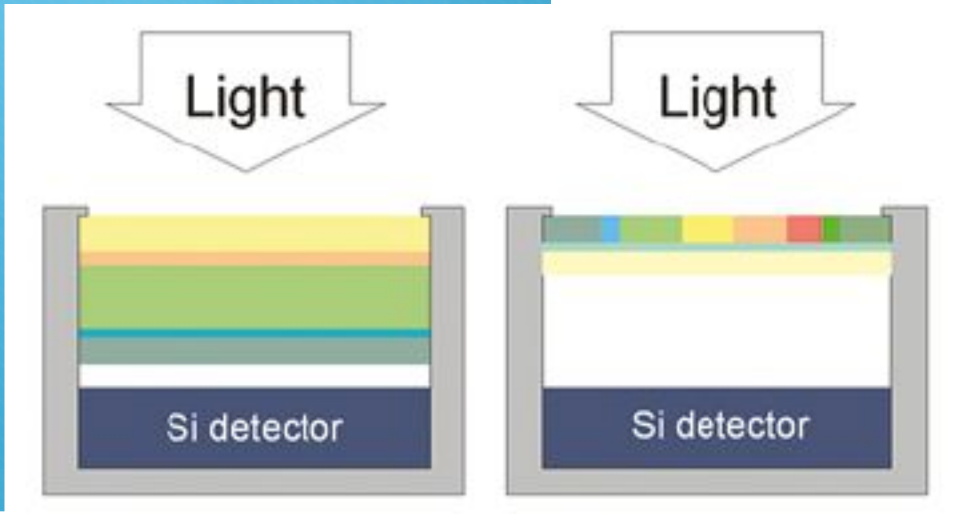
Laboratory Accreditation and Traceability

- ISO 9000 series
  - Not addressing correctness of meas or appropriateness of methods
- ISO/IES 17025
  - For labs calibrating measurements and test equipm.
  - Rigorous qual. mngmt
  - Adresses competence
  - Accreditation: third party involvement
  - Traceability: measurement result related to reference trough documented unbroken chain of calibrations (until NMI)

Photometer design

- Silicon photodiode + filter matching human eye response
  - Stack design type
  - Mosaic design type
- Advantages/ Disadvantages?

A simple photometer with a filter stack (left) and with a mosaic filter (right). Practical mosaic detectors may include some stack elements as well as mosaic elements.



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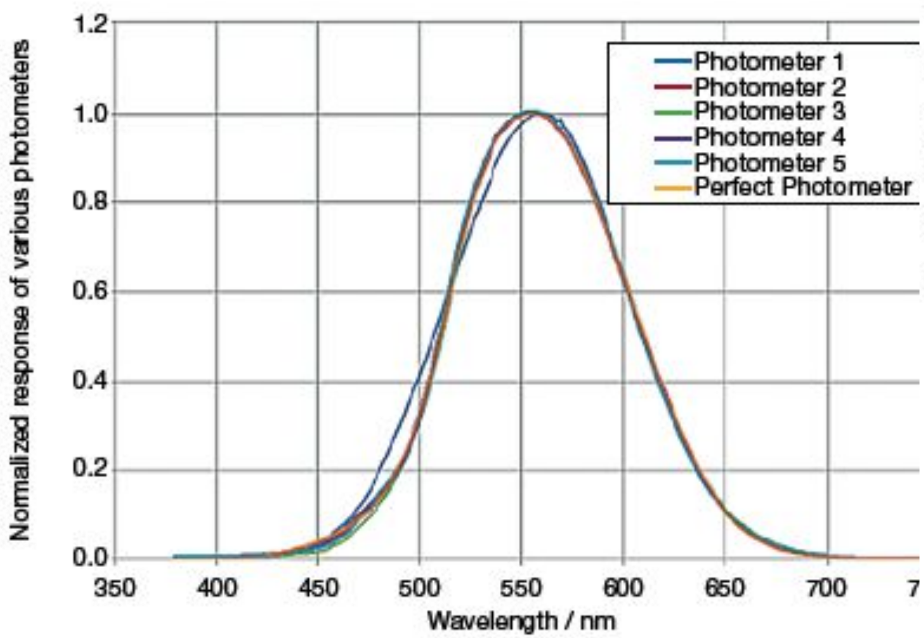
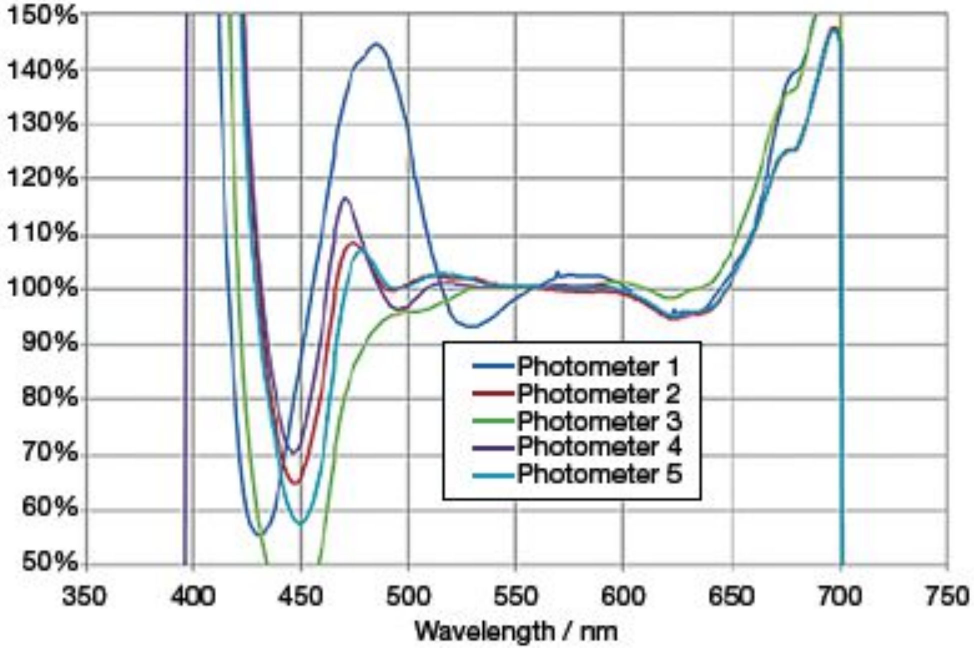
Photometer match

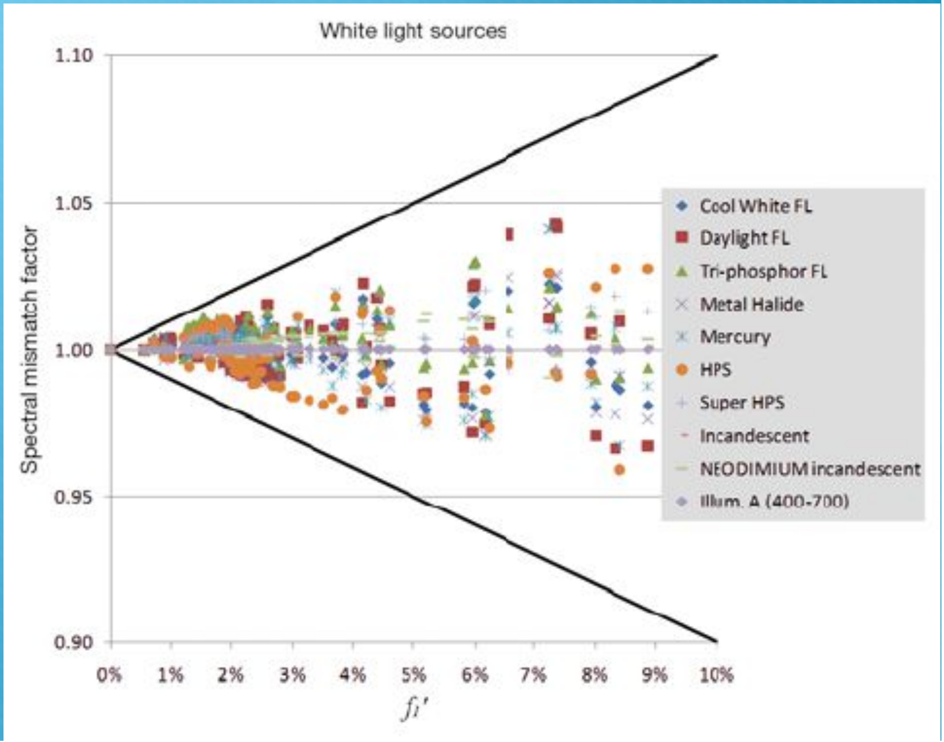
- Small differences with human eye sensitivity…





Photometer par f'_1

- Index of deviation between photom. Sens. and V_λ
- Broadband light sources → some correlation error vs f'_1



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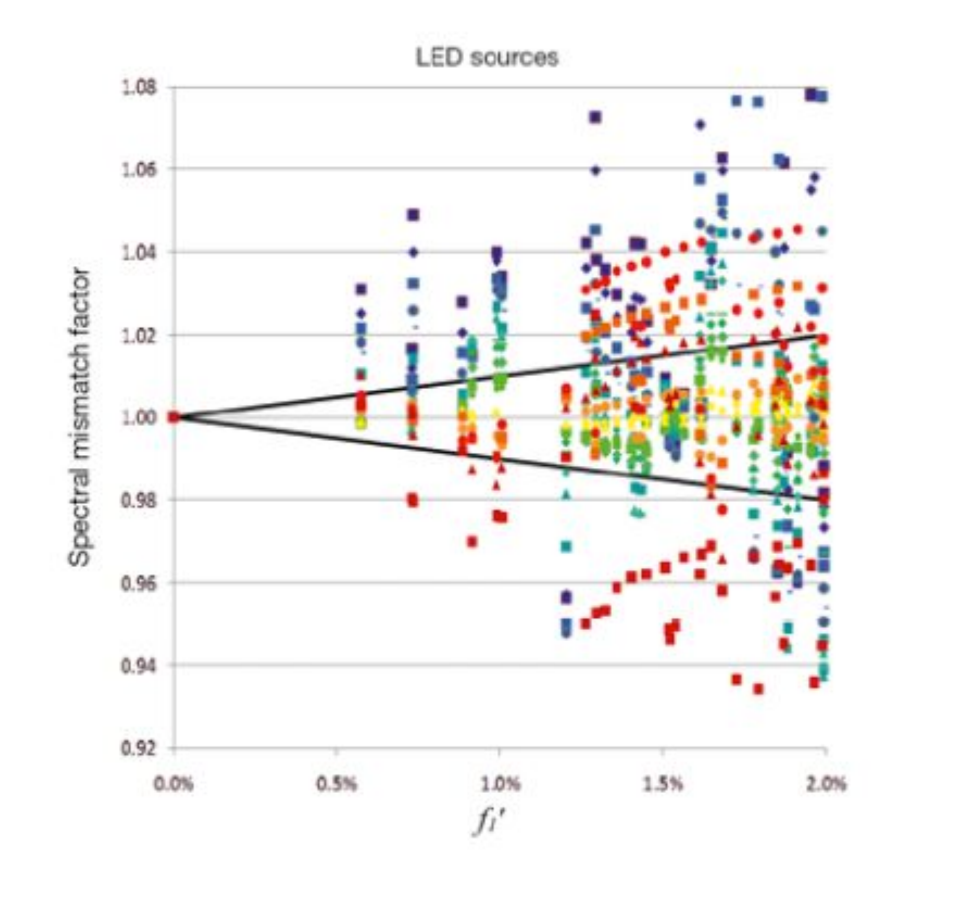
Spectral mismatch f'$_1$

- But for colored LEDs??
- What to do?
- Apply spectral misatch correction



ISO/CIE 19476:2014

- Parameters
- Easy…

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Welke luxmeter en waarom?

CRITERIA DIN 5032 DEEL 7

Criterium	Naam	Maximale afwijking (%) conform DIN 5032-7 klasse		
		A	B	C
V(λ) correctie	f1	3	6	9
UV-gevoeligheid	u	1	2	4
IR-gevoeligheid	r	1	2	4
Cosinusfout	f2	1,5	3	6
Afwijking lineariteit	f3	1	2	5
Afwijking aanwijzing	f4	3	4,5	7,5
Vermoeidheid (bij 1000lx)	f5	0,5	1	2
Temperatuurcoëfficiënt	α0, α25	0,2%/K	1%/K	2%/K
Frequentie afhankelijkheid van de lichtfluctuatie	f7	0,2	0,5	1
Justeerfout	f11	0,5	1	2
Maximale meetfout	ft	5	10	20

MOBILUX A USB LUXMETER
€1.195,00 ex btw

MAVOLUX B USB LUXMETER
€969,00 ex btw

MAVOLUX C USB LUXMETER
€599,00 ex btw

MAVOLUX C BASE LUXMETER
€379,00 ex btw

Spectroradiometer

- Vs Photometer (broadband with filter)
- Types: scanning and array
  - Scanning: large spectral range, low stray light
  - Array: fast (and cheaper)

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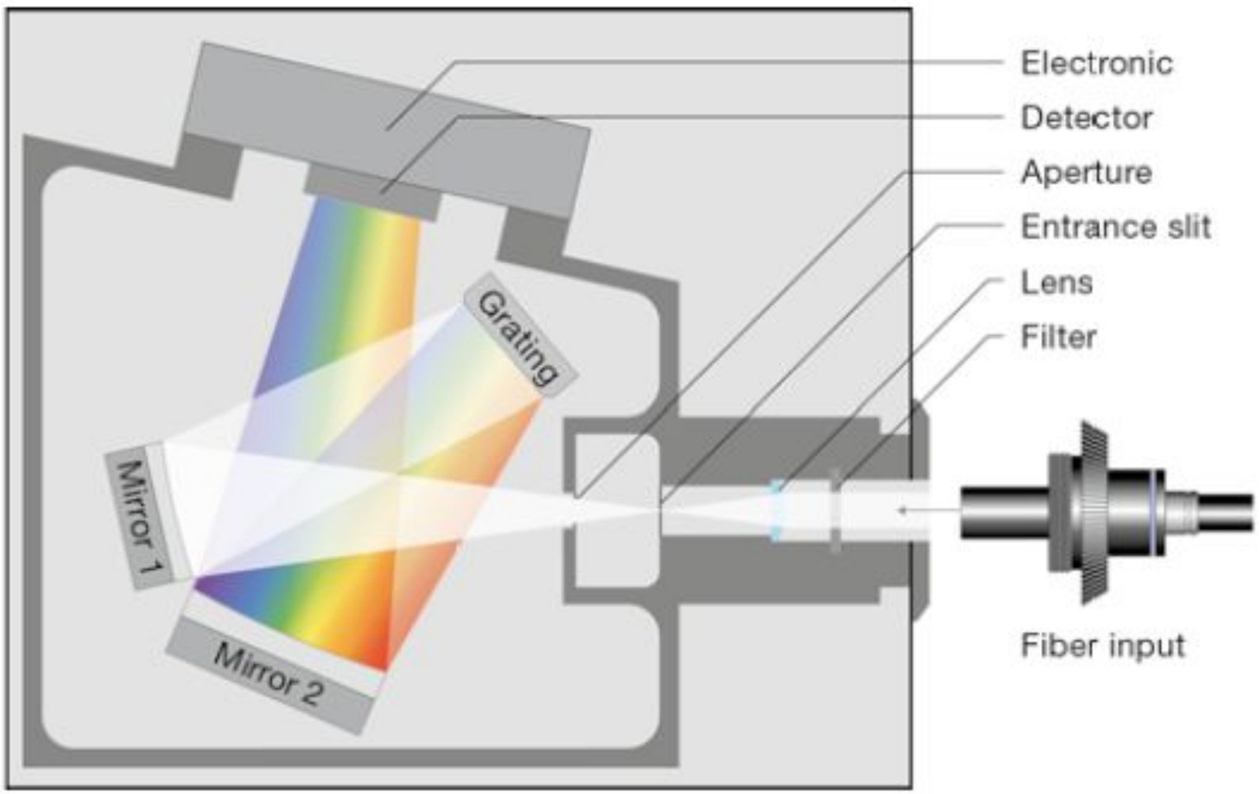
Array spectroradiometer

- Slit
- Grating
- Detector
  - CCD
  - Front/back
- Electronic



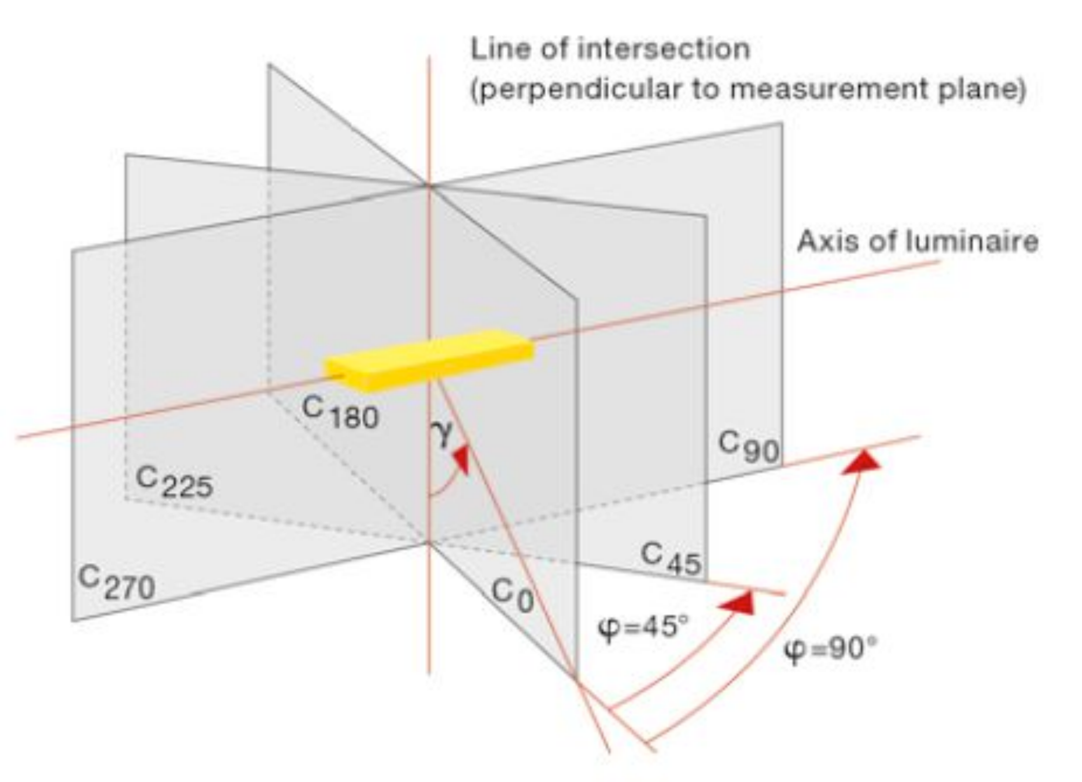
Selection criteria Spectro radiometer

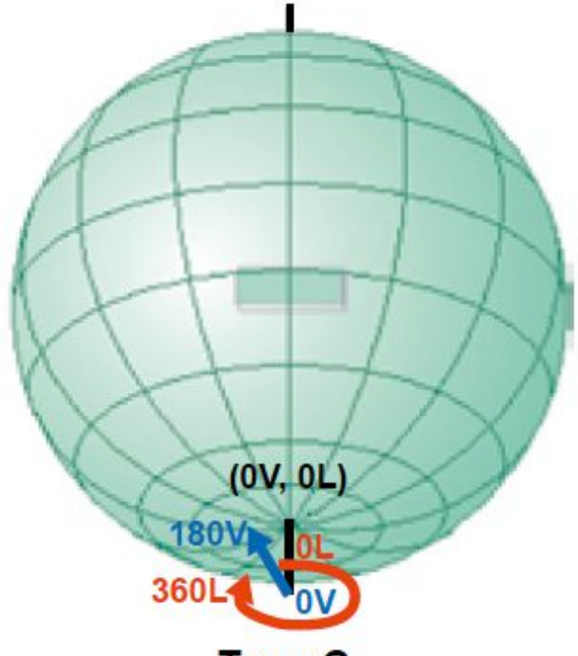
Specification	Criterion
Spectral resolution	Depends on the slit width, focal length, dispersion of the grating and the number of pixels of the detector. It should be less than 5 nm (ideally 3 nm). Measurements with poor spectral resolution can lead to errors, particularly for narrow band LEDs.
Wavelength accuracy	Should be better than ±0.5 nm. Wavelength deviations have a linear effect on peak and centroid wavelength. Errors of 1 nm also lead to similar deviations in calculating the dominant wavelength for red and blue LEDs.
Stray light rejection	Three to four orders of magnitude are the minimum requirement. Section 8.2 discusses examples of the wide-ranging effects of stray light. The influence of stray light might also depend on the wavelength range (see for example UV LEDs in Section 5.4).
Sensitivity	Sensitive detectors are required for testing LEDs in the mcd and mlm range because the optical probes for luminous intensity and luminous flux (diffuser or integrating sphere) result in a considerable loss of light. This criterion is also important with production applications (see Chapter 9)
Signal-to-noise ratio	Excellent signal-to-noise ratio of the detector is important for radiometry because the measured spectra are analyzed over the entire wavelength range and a noisy signal at the spectral extremes leads to errors. Cooled detectors are preferable because these significantly reduce thermal noise and guarantee long-term stability of the dark current.
Linearity	Linearity is an important factor for a spectroradiometer. Any change in the light power launched into the spectrometer must lead to a proportional change in the detector signal. Otherwise, the system is not suitable for radiometric measurements. Array spectrometers must have linearity over the entire specified range of integration times. Often software correction is used to improve this parameter.
Electronic dynamic range	There should be at least four orders of magnitude as in stray-light rejection, and this demands 15-bit analogue-to-digital electronics as a minimum.
Stability and robustness	Important especially when used continuously in rugged manufacturing environments.

Goniometers

- And integrating spheres?
- Lamp in center and sensor around
- Each direction make measurements
- Type A, B, C.
- C most used in general lighting

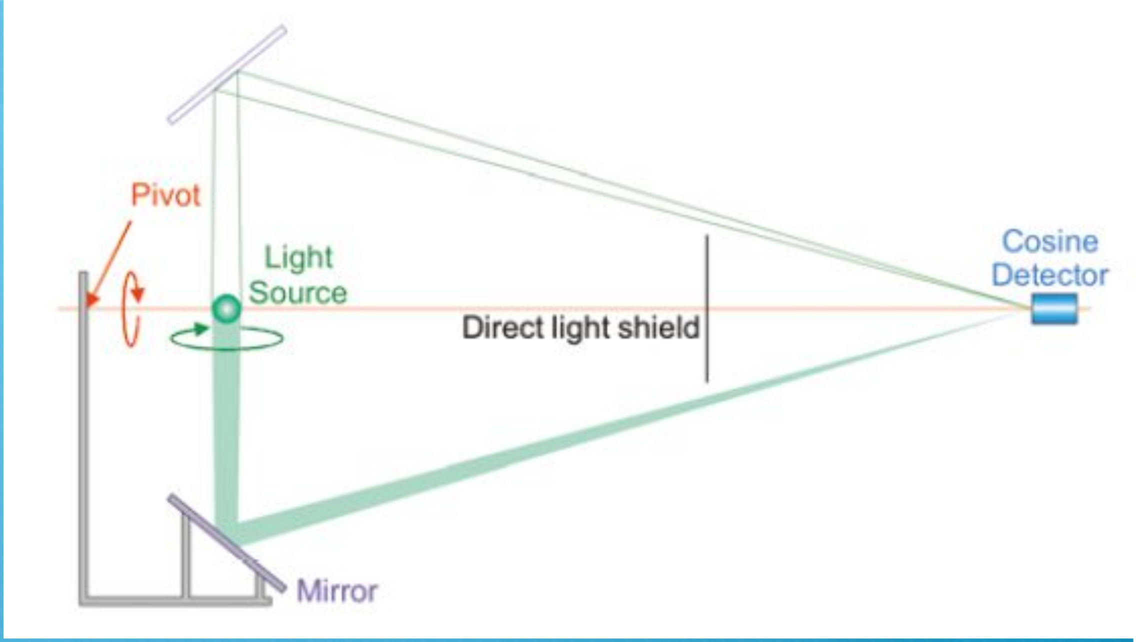
Type C: C, γ coordinate system





Type of goniometer

- Moving mirror
- Issues:
  - Polarizing light
  - Stray light
  - Cleanliness
- Best = turning type
- Issue: meas. dist.

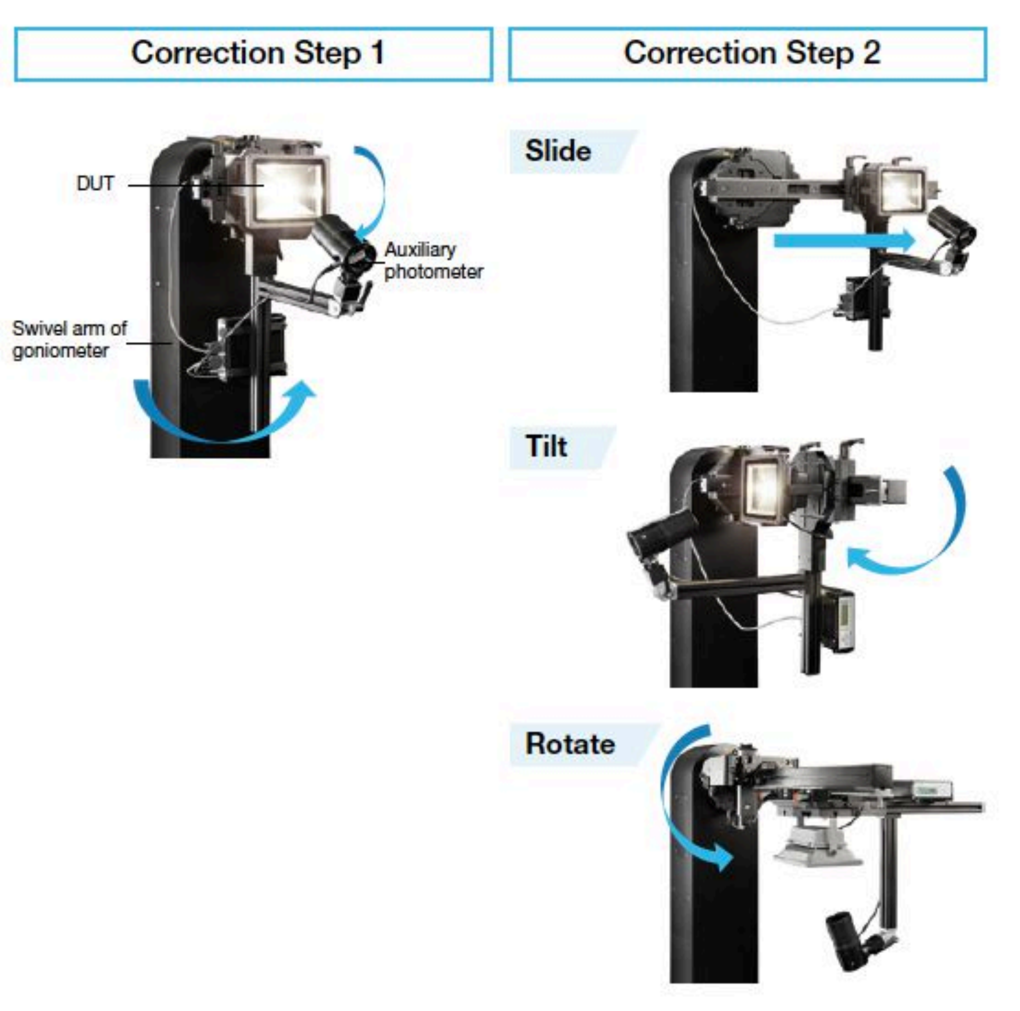


Type of goniometer

- Turning luminaire
  - Advantage
  - Disadvantage

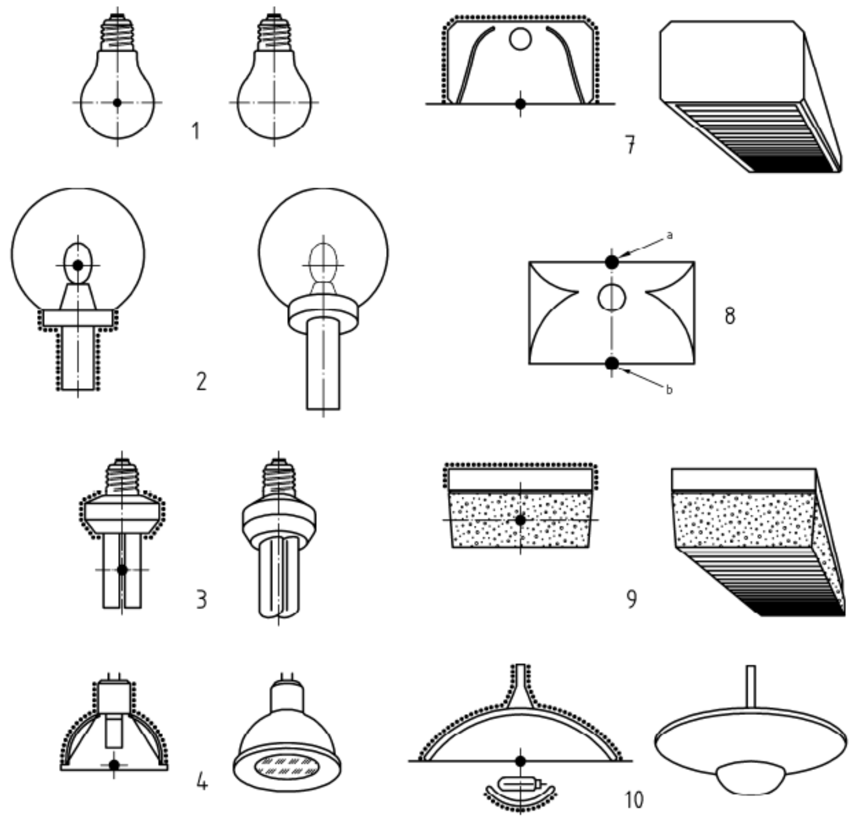
Auxiliary photometer method

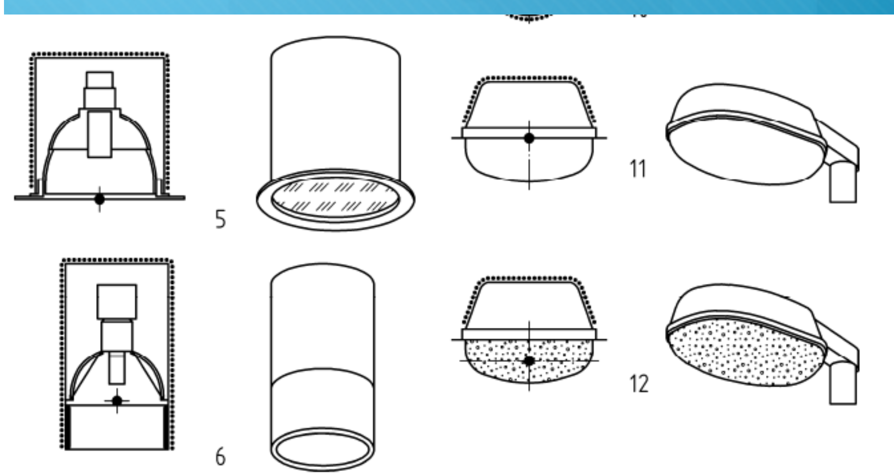
- Additional photomtr



Alignment source – photometric centre

- See also EN 13032-1:2012-6

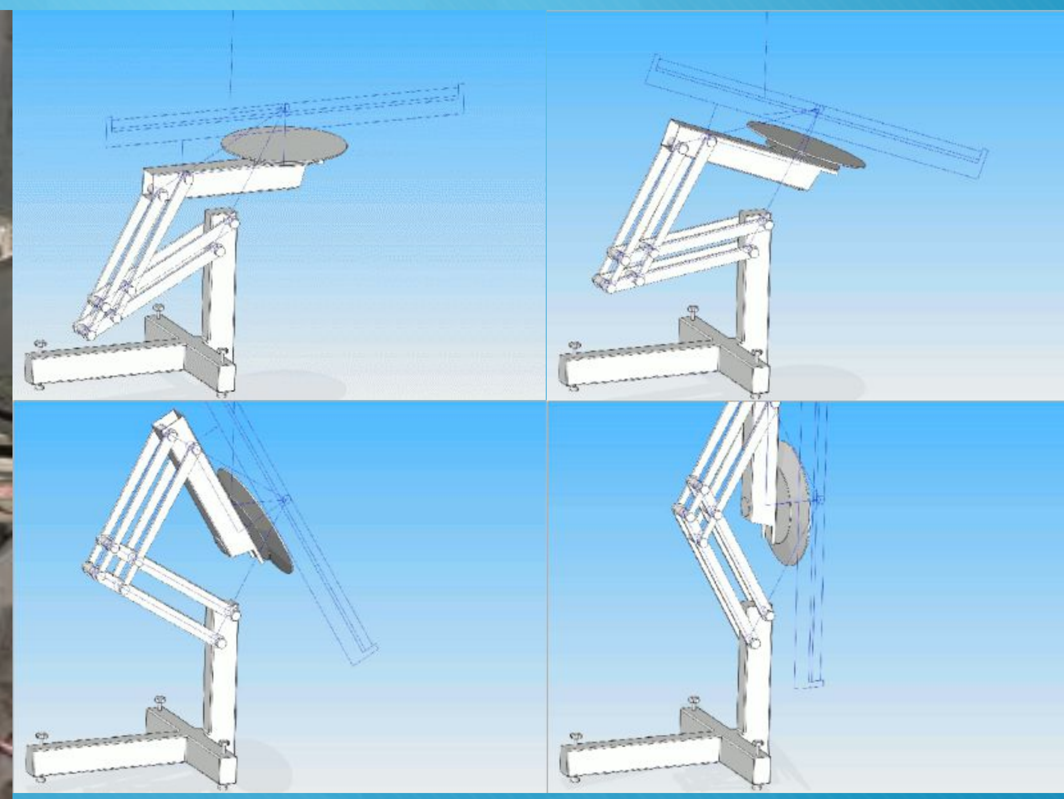




OliNo Gonio

- T-sensor
- Tripod/Photosensor
- Horn
- Robot
- Lamp
- Lamp board + fur
- Driving computer

OliNo’s goniometer positoning



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OliNo’s goniometer motors and movements

- Stepper motors
- Measure during move
  - Ask pos and meas lux
  - Assure constant speed?
  - Correct for misalignment pos and lux results?
  - Dependent on speed?

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OliNo’s goniometer positoning lamp

- Photometric centre
  - Align to turning point?
  - And when distance back lamp to photometric centre is more?

Deal with stray light

- Matte black curtains
- Horns with different FOV and baffles

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Deal with stray light

- Use fur
- Block lamp only

Temperature measurement

- T-sensor at height of DUT
- Within 1 m
- One left and one right
- DS18B20 calibrated 0.5degC
- Aansturing airco

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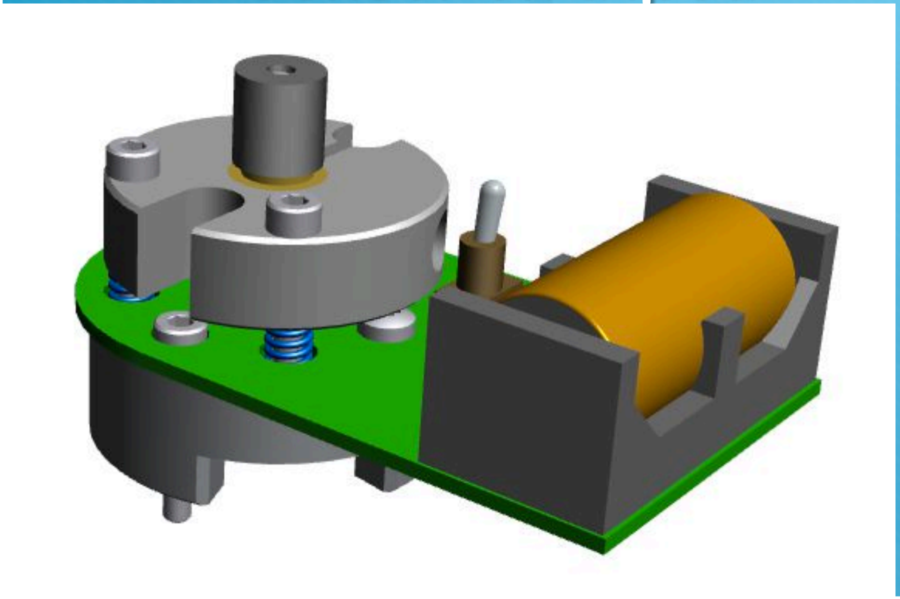
Holder

- On tripod
- Holds sensors/horn/simulation source

Alignment

- Alignment tool – centre round moving disk
- Sensor on tripod

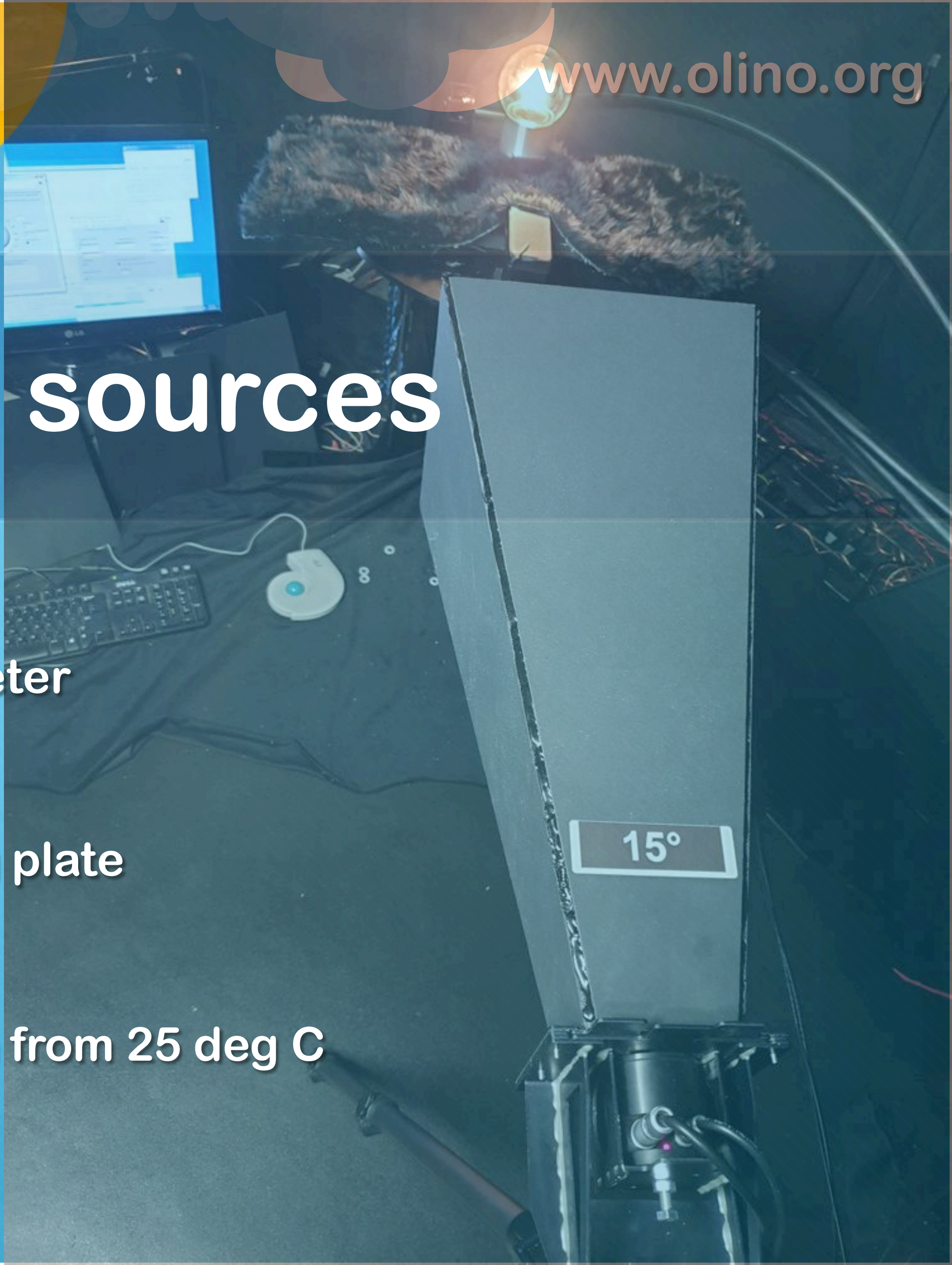


Big lamp measurements

- **Max distance 2.6 m and 4.2 m**
- **Distance recommended:**
  - **5xD, 10xD, 15xD**…
- How to measure big lamps?
- First: measure lumen
- Second: cover part and measure light distrib
- Advantage of small meas. distance?
- Measurable with spectrometer

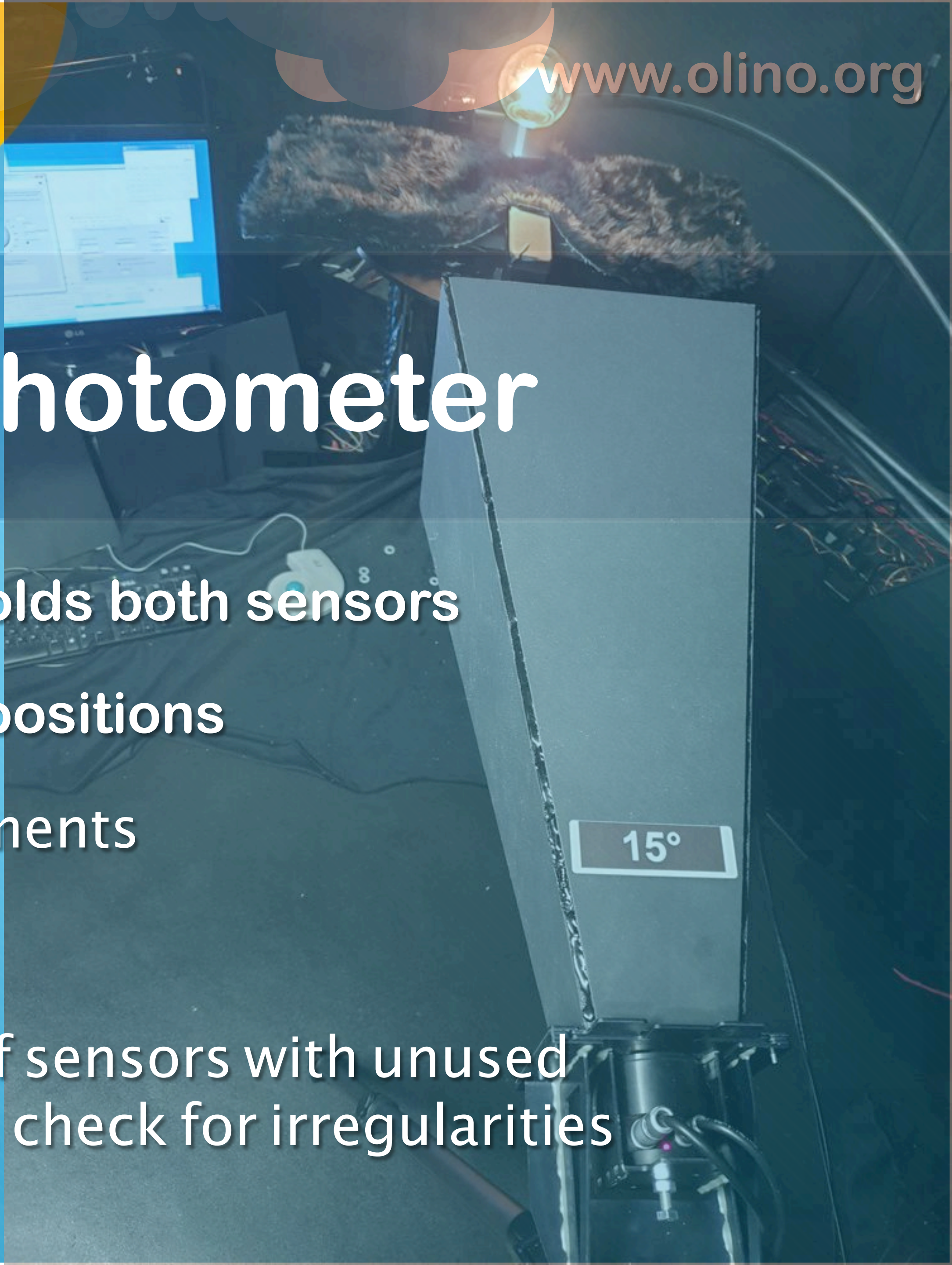
Inaccuracy sources

- Some ideas?
- Photometer/Spectrometer
- Distance
- Weight DUT → bending plate
- Inaccuracy positioning
- Temperature mismatch from 25 deg C
- Stray light
- Spectral mismatch

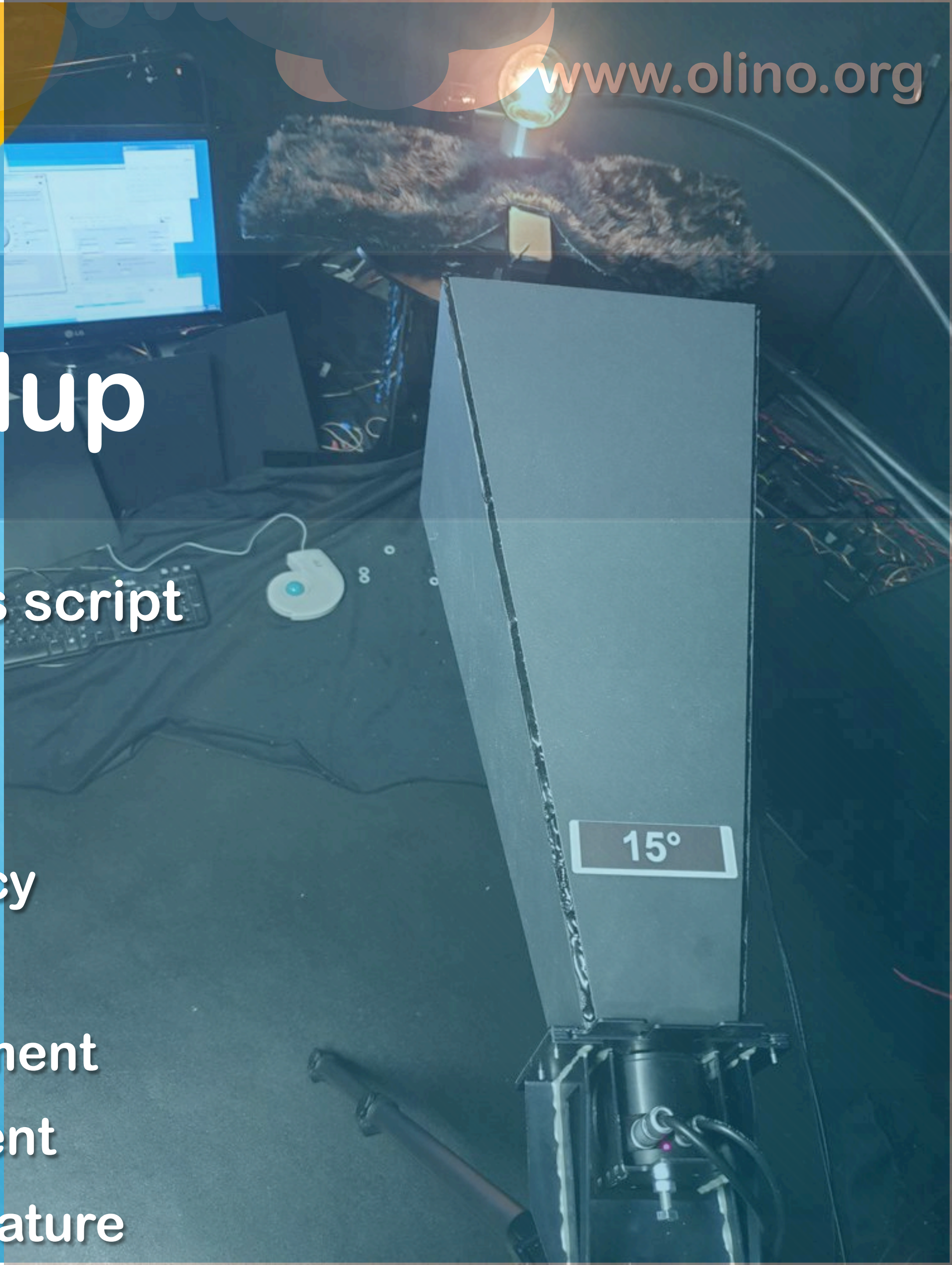


Check on photometer

- **Sensorholder --> holds both sensors**
- **Use both on same positions**
- Correlate measurements
- And?
- Do 4x / year check of sensors with unused illuminance sensor, check for irregularities



Script buildup



- Computer executes script
  - Inrush current
  - Startup
  - Voltage dependency
  - Luxmeasurement
  - Spectral measurement
  - 90-180 measurement
  - Flicker and temperature

Vragen