Developments in Photometry and Radiometry

CIE Australia, Sydney 2023

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CIE D2:

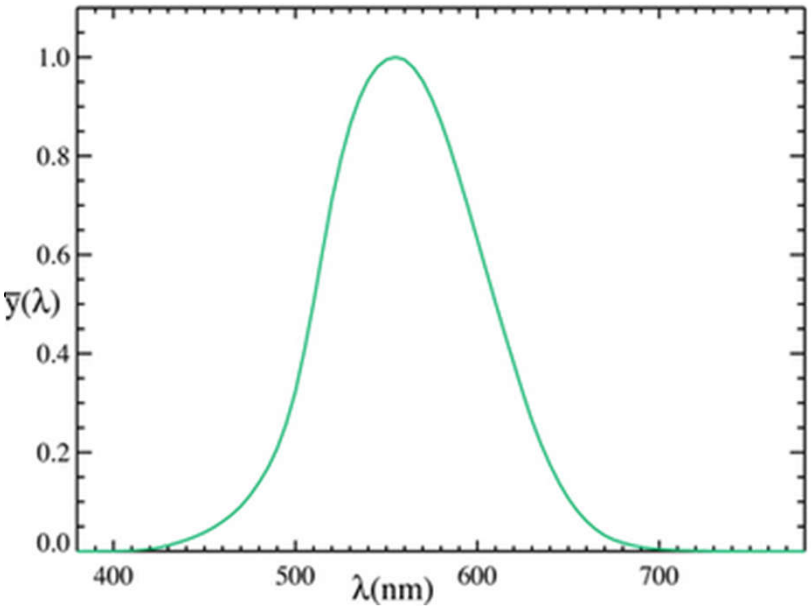
physical measurement of light and radiation

Radiometry – measurement of radiant power (energy per unit time) for various geometries and wavelengths.

Photometry - eye (or photometer mimicking the eye) is the detector, visible range (V_λ, CIE 1931).

Photometer – detector weighted by the spectral efficacy of the eye:

- via filters matching V_λ;
- via spectral measurement and numerical integration.
- measures illuminance (flux per unit area)



Spectral mismatch between V_λ and photometer may be important.

Measurement:

Radiometric power (energy per unit time): unit watt

- determined spectrally, absolute by electrical substitution.

Photometric equivalent is luminous flux: unit lumen

Photometric base unit candela (luminous intensity, unit lumen/steradian)

- source property, determines illuminance (lm/m^2) at an object

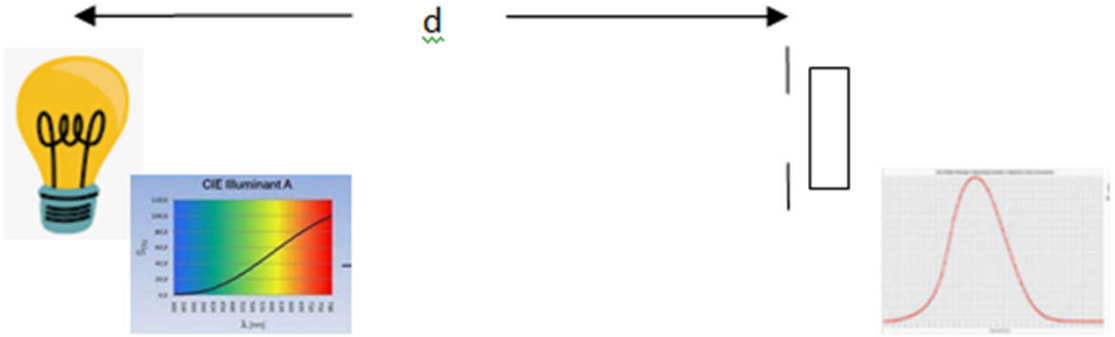
History

- standard candles > tungsten lamps by visual comparison + $1/d^2$
- 1922 reference source based on a particularly stable lamp at NIST adopted (became CIE Illuminant A)
- 1931 CIE V_λ adopted as luminous efficacy for photopic conditions
- 1967 Candela defined as fraction of luminous intensity of a blackbody operating at the melting point of platinum
- 1979 Candela redefined as 1/683 of radiant intensity at wavelength of maximum luminous efficacy (555 nm in air).

In 2019, equivalence of radiometric/photometric units defined as 683 lumen per watt at wavelength of maximum luminous efficacy. Candela remains as the SI base unit for photometry.

Note: Need V_λ to transfer to full visible range.

Photometric calibrations



Photometer

- V_λ spectral response
- aperture defines area
- measures illuminance

Source CCT 2856 K

- specialist incandescent lamps
- moderately fragile
- degrade with time
- high-current power supply

Spectral mismatch

- not true black-body distribution
- not perfect V_λ

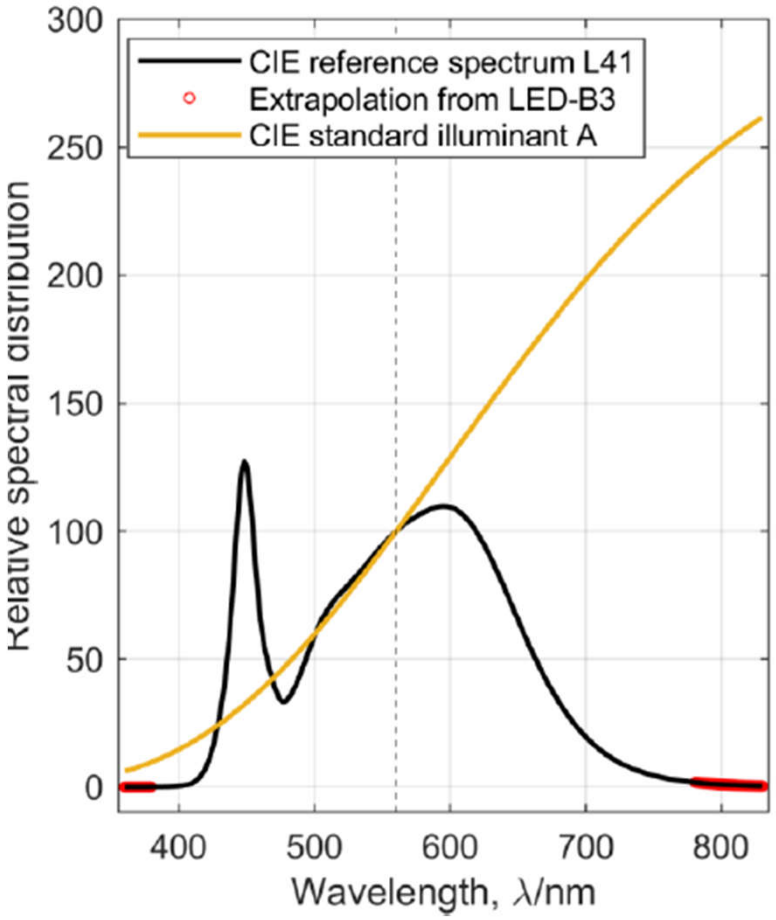
LED lighting now supplanting incandescent sources for general lighting

- blue LED emitters with a phosphor coating
- robust
- low power

⇨ new calibration reference spectrum CIE L41

CIE L41 reference spectrum

(CIE 251-2023)



- synthetic , tabulated values .
- representative of typical blue LED-phosphor lamps.
- CCT 4103 K

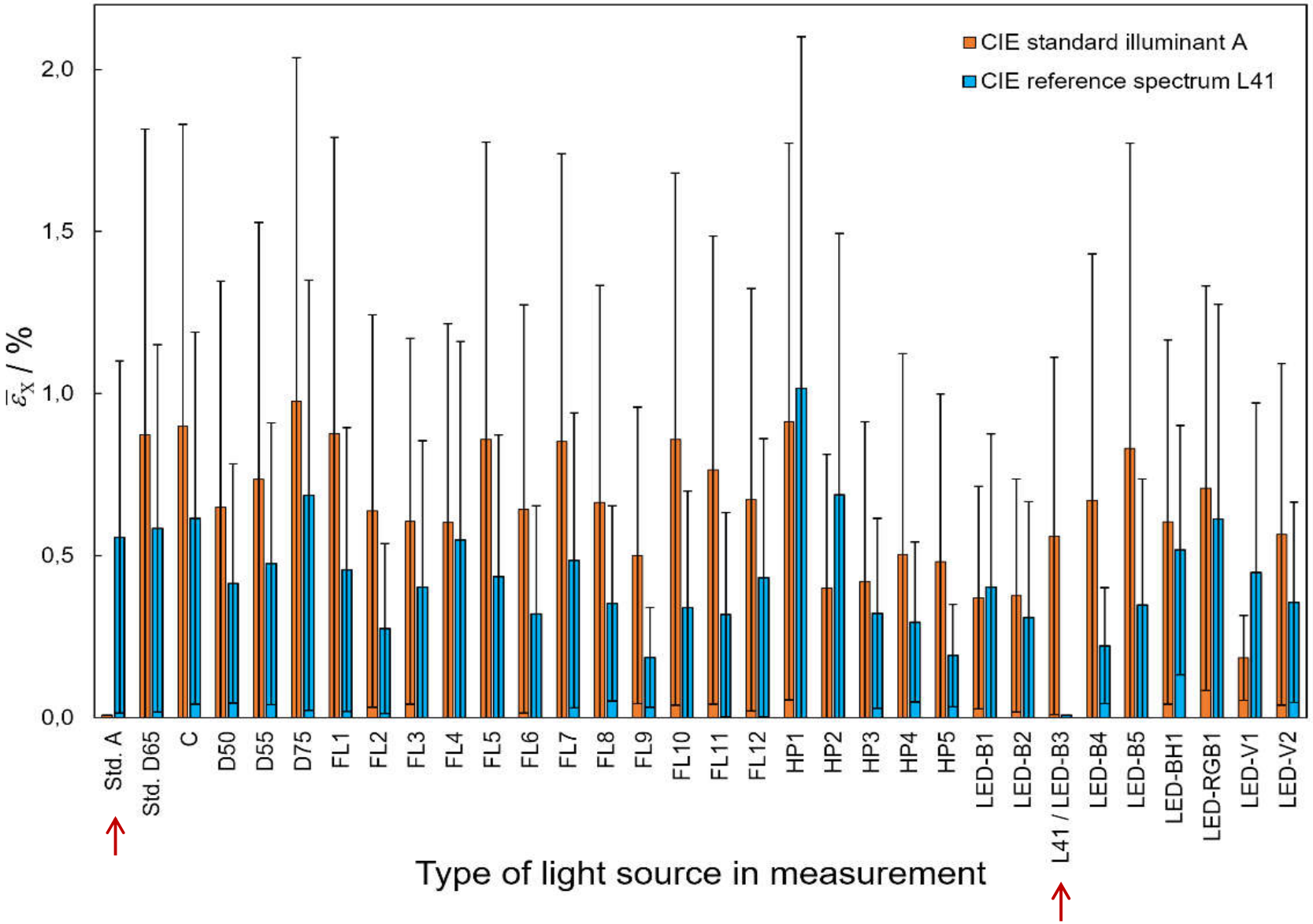
Sources available for luminous flux and illuminance illuminance-response calibrations.

Spectral mismatch corrections can be applied as for CIE Source A calibrations.

CIE 251-2023 compares CIE Source A *vs* L41 calibration of a number of photometers for various CIE Reference Illuminants.

Calibration with L41 vs CIE Illuminant A

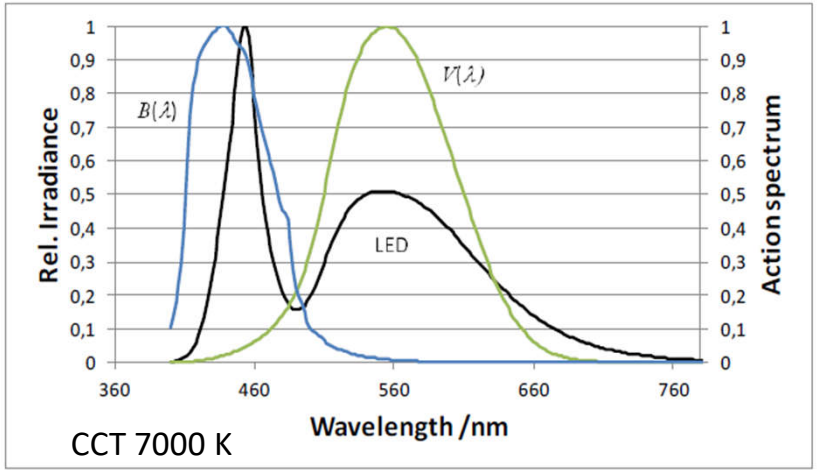
107 real photometers f_1' values 0.5% - 8.8%

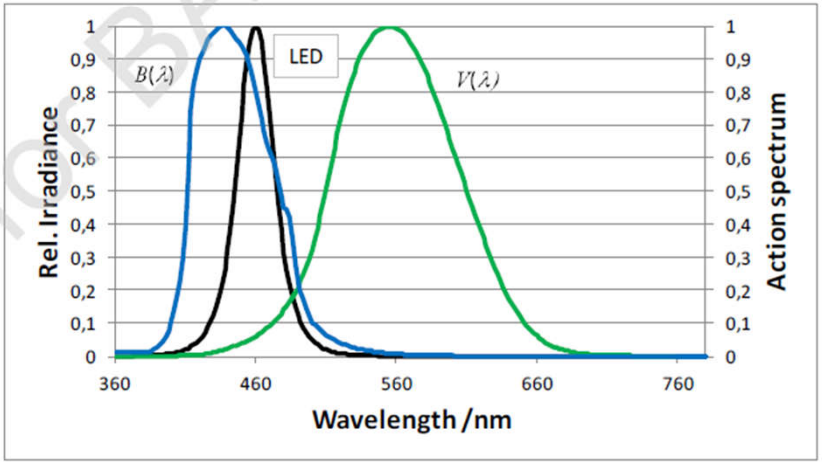


(Spectral mis-match correction for actual source not applied)

Blue light hazard

Exposure limits based on luminance (brightness) and time of exposure





White LED lighting

- BLH:Luminous ratio 0.65
- high flux : 5000 lm = 9 W
- radiated into large solid angle
- moderate surface area

-> hazard negligible.

Blue LED

- BLH:Luminous ratio 9.7
- low flux : 100 mW radiated ~ 3 lm
- radiated into small solid angle
- small emitting area (undiffused)

-> may be hazardous if viewed at close distance.