EURAMET
European Association of National Metrology Institutes

EMRP
European Metrology Research Programme
Programme of EURAMET

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Characterization of light-emitting diodes in the solar UV spectral range

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EMRP ENV03
Traceability for surface spectral solar ultraviolet radiation

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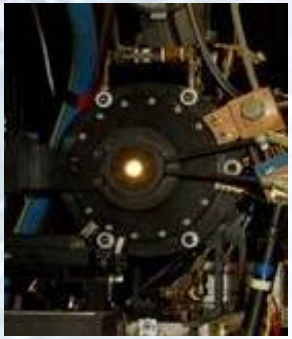
b.) Bundesamt für Metrologie METAS, Bern-Wabern, Switzerland
c.) Physikalisch-Meteorologisches Observatorium Davos, World Radiation Center, Davos, Switzerland

Project Objectives

- Enhance the reliability of spectral solar UV radiation measured at the Earth surface
- Improved traceability, improved methodologies, improved devices
- Uncertainties better than 2% in the wavelength region 300 nm – 400 nm (current state of the art is 5%)
- Develop techniques and devices for using cost-effective array-spectroradiometers for solar UV measurements

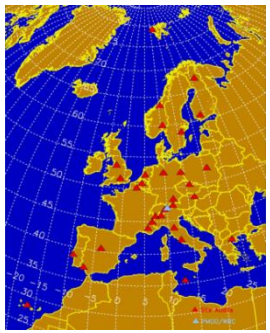


Primary Irradiance Standard Black Body (PTB)

Transfer Standard

Reference Spectroradiometer QASUME (PMOD WRC)

End-User Devices



Calibrated UV Network

Project Structure

WP	WP Name	WP Leader	Active JRP Partners
WP1	Spectral Irradiance Traceability	Saulius Nevas	**PTB**, METAS, SFI Davos, VSL, Kipp
WP2	Array Spectroradiometer Characterisation	Peter Blattner	**METAS**, Aalto, LNE, PTB, PMOD/WRC, VSL, REG(IMU)
WP3	Improvement of Reference Spectroradiometers	Marek Šmíd	**CMI**, INRIM, PTB, PMOD/WRC
WP4	New Technologies	Petri Kärhä	**Aalto**, CMI, METAS, INRIM, LNE, PTB, PMOD/WRC, CMS, Kipp, REG(IMU)
WP5	Impact	Julian Gröbner	**PMOD/WRC**, All
WP6	Management	Julian Gröbner	**PMOD/WRC**, All

WP1 – Spectral Irradiance Traceability

- Task 1.1

  Detector-based traceability chain using an absolute radiometer and tuneable UV laser facility (PTB)

- **Task 1.2**

  Development of a highly stable portable monitoring source powered by LEDs (PTB, METAS, SFI Davos, Kipp)

- Task 1.3

  Compact laser-induced high-flux UV source as metrology light source for field applications (VSL, Kipp)

Motivation Task 1.2

- Use of spectroradiometers for solar UV measurements requires **monitoring sources** that are
  - compact
  - portable
  - robust
  - stable

- Tungsten halogen lamps are typically used for this purpose

- Can an alternative be found based on commercially available **UV-LEDs?**
  - spectral range of 280 nm – 400 nm
  - aging rates of 0.05% / hour or less (drift in irradiance)
  - minimum spectral irradiance of

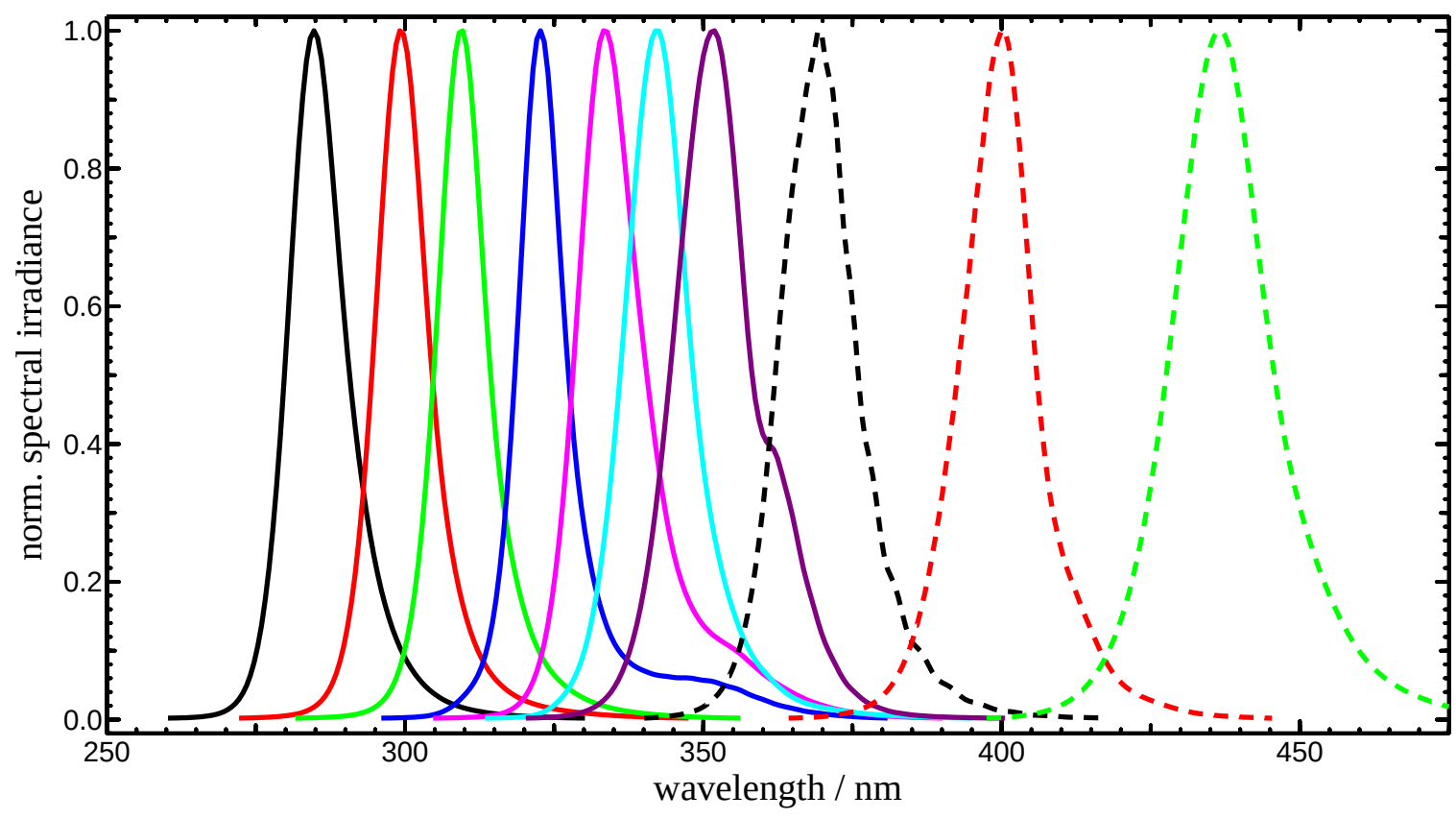
    1 (mW / m^2) / nm $\lambda \leq 330$ nm

    5 (mW / m^2) / nm $\lambda > 330$ nm

LEDs used in this study

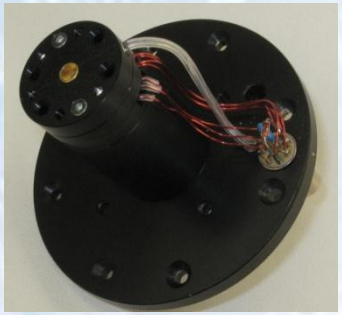
- 12 different types from 285 nm – 437 nm peak wavelength
- 3 LEDs of each type
- package type: TO-18
- emission window: flat

source: http://www.roithner-laser.com

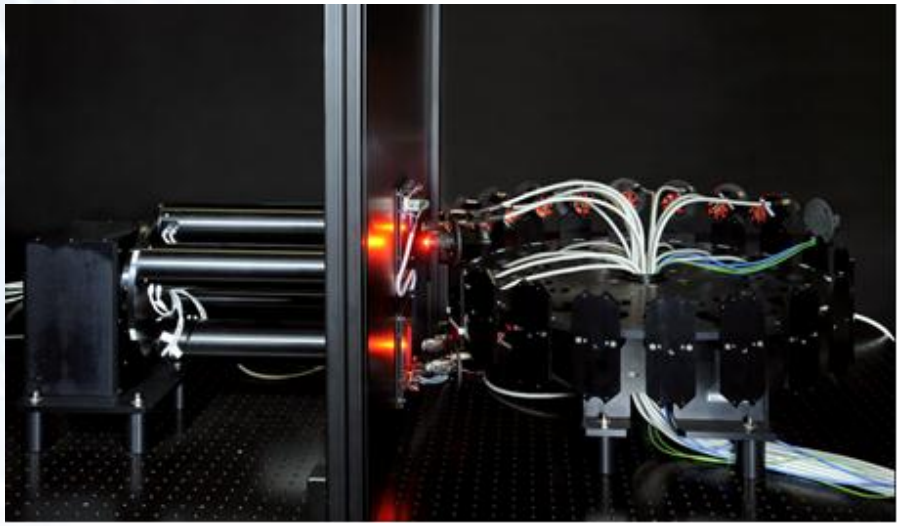


FWHM: 9 – 18 nm

Pre-aging and stability study



temperature stabilized LED holder



computer controlled rotary stages

<u>detectors:</u>
Si photodiode
array spectroradiometer

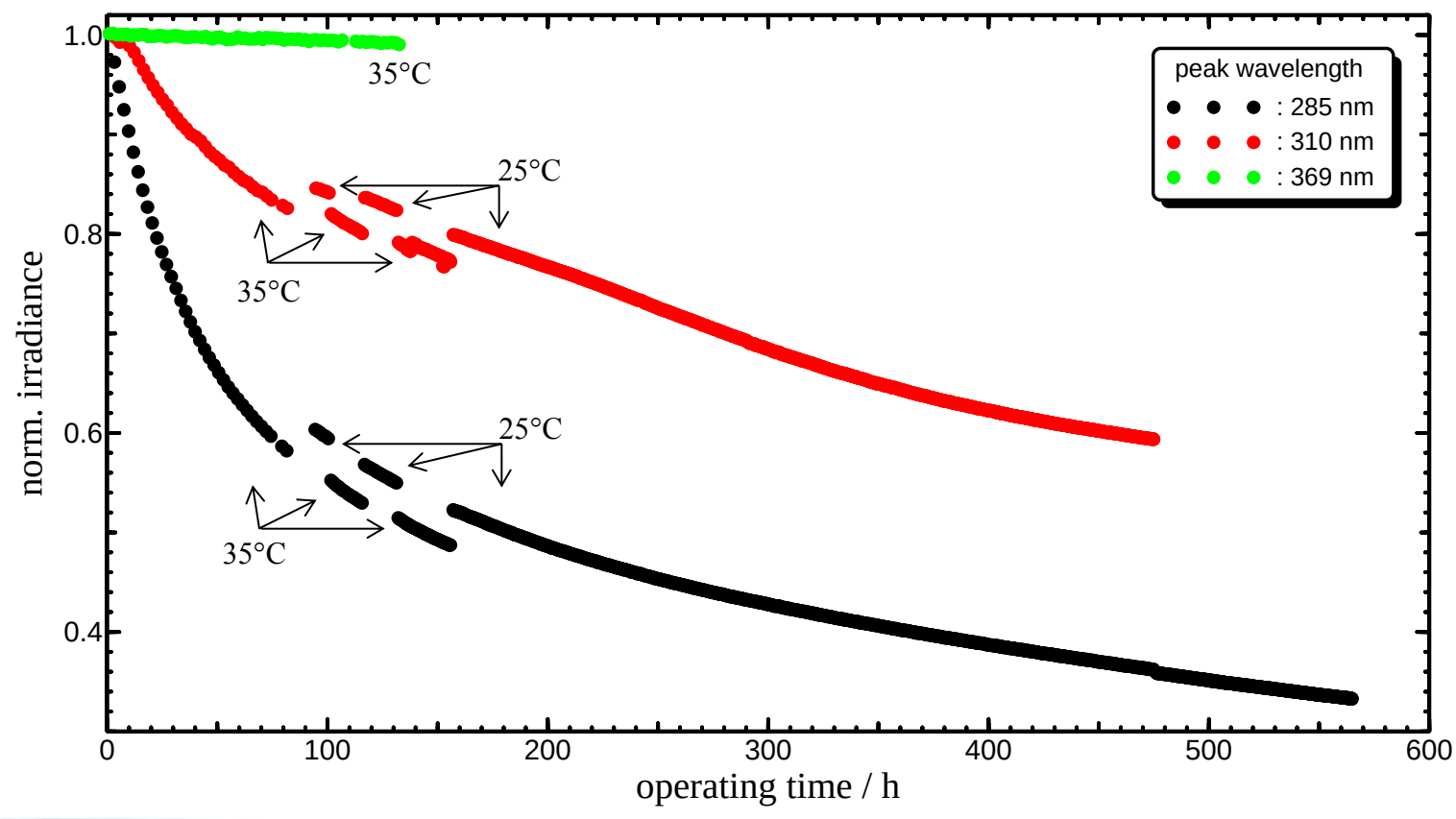
Fully automated setup to record:

- current
- voltage
- temperature
- irradiance

Goals:

- find operating conditions
- pre-aging of the devices
- determine stability (drift in irradiance)
- selection of best performing devices

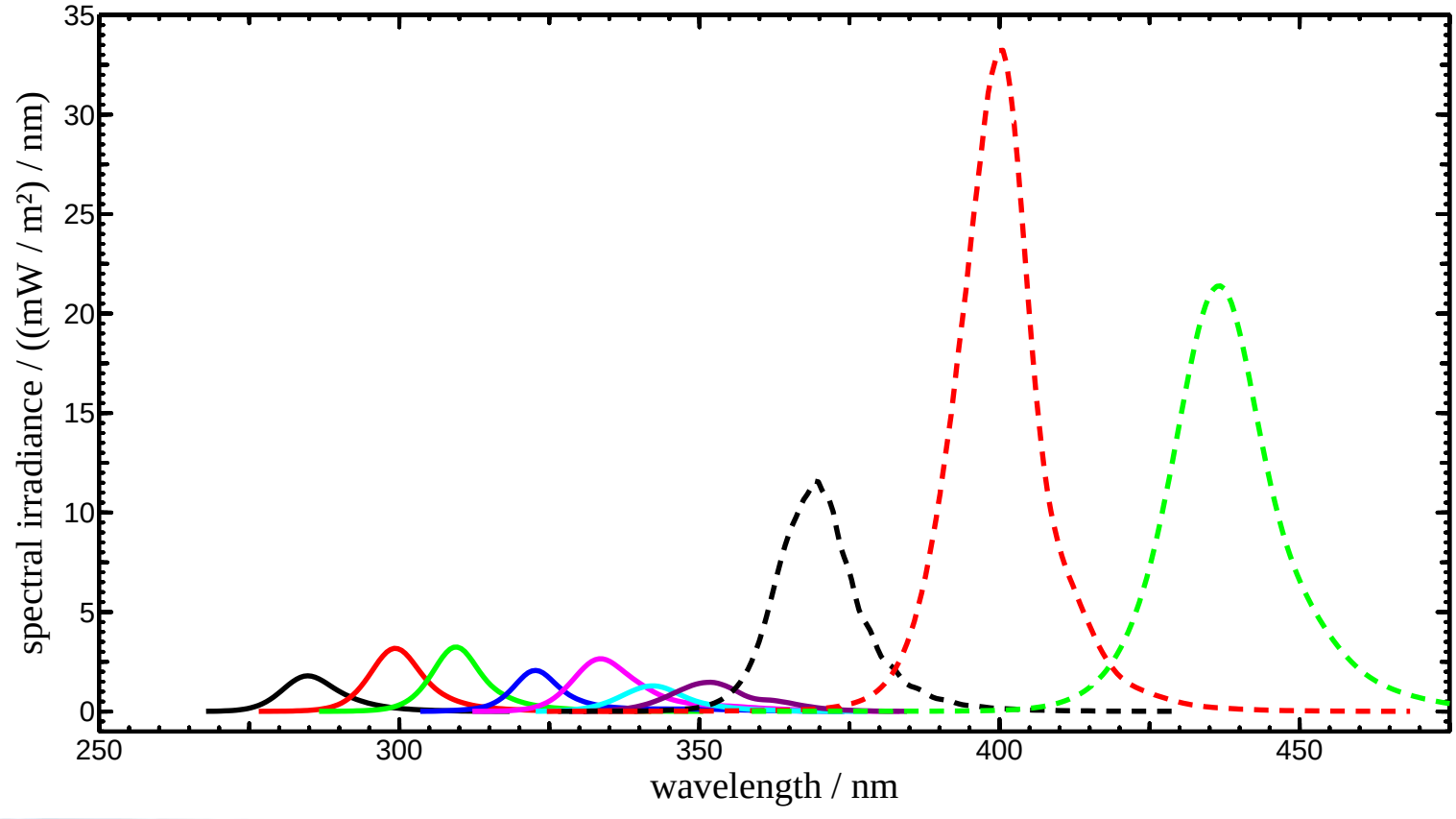
Aging behavior



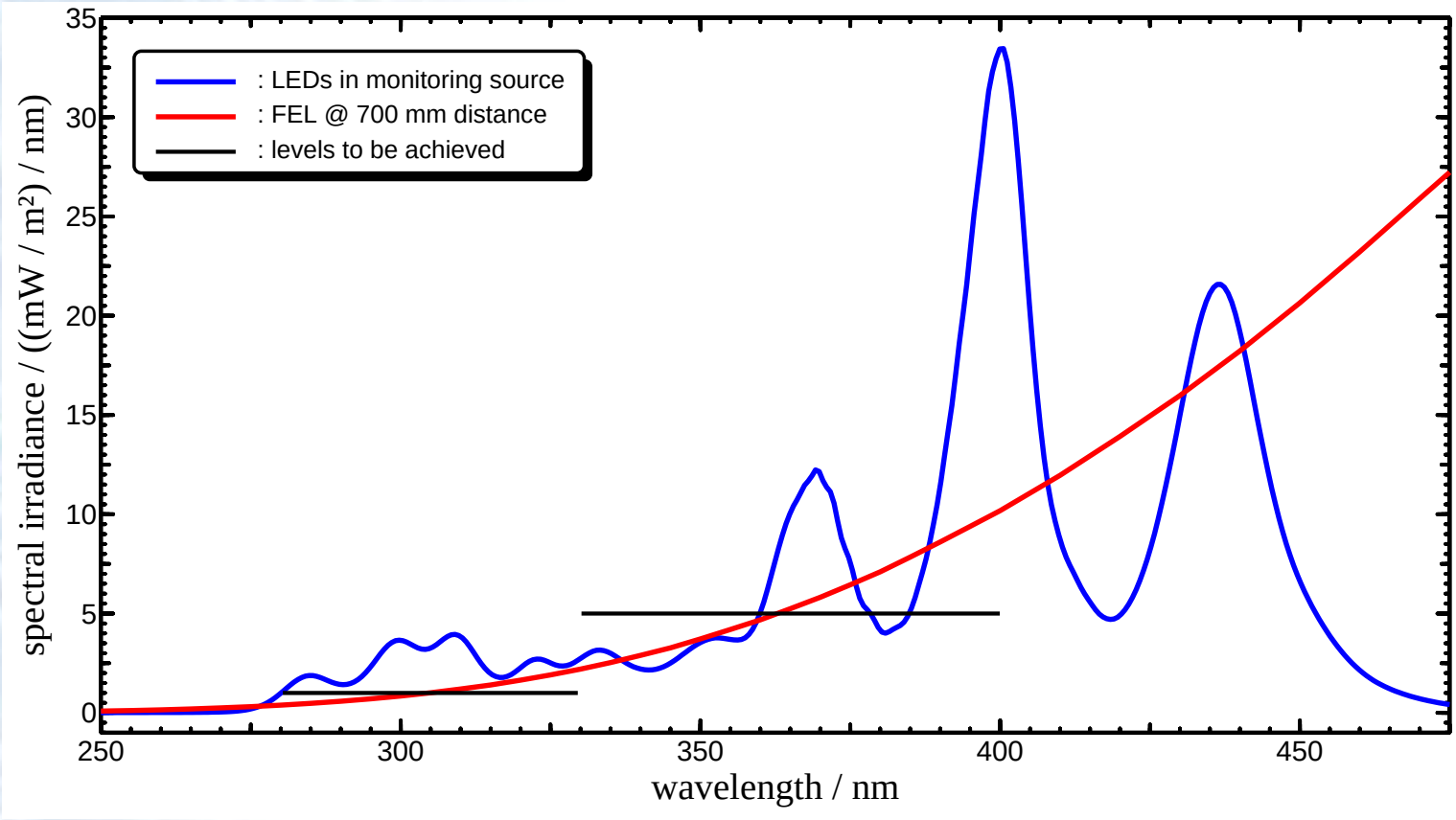
Drift in irradiance after pre-aging

name	peak wavelength	pre-aging time	temperature	drift after pre-aging required: 0.05% / h or less
UVTOP 280 #1	285 nm	565 h	25°C	-0.08% / h
UVTOP 295 #1	299 nm	402 h	25°C	-0.05% / h
UVTOP 310 #1	310 nm	476 h	25°C	-0.05% / h
UVTOP 315 #2	323 nm	120 h	25°C	+0.02% / h
UVTOP 325 #2	333 nm	101 h	25°C	-0.03% / h
UVTOP 335 #3	342 nm	134 h	35°C	-0.04% / h
UVTOP 345 #2	352 nm	120 h	25°C	-0.02% / h
UVTOP 355 #1	369 nm	134 h	35°C	-0.01% / h
LED405 #1	401 nm	120 h	25°C	< -0.01% / h
LED435 #1	437 nm	120 h	25°C	-0.02 % / h

Expected irradiance levels after pre-aging

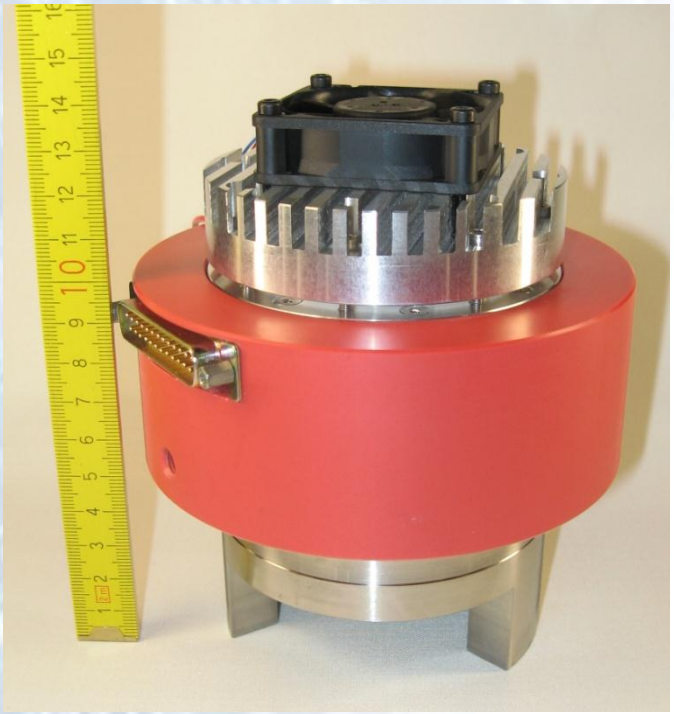


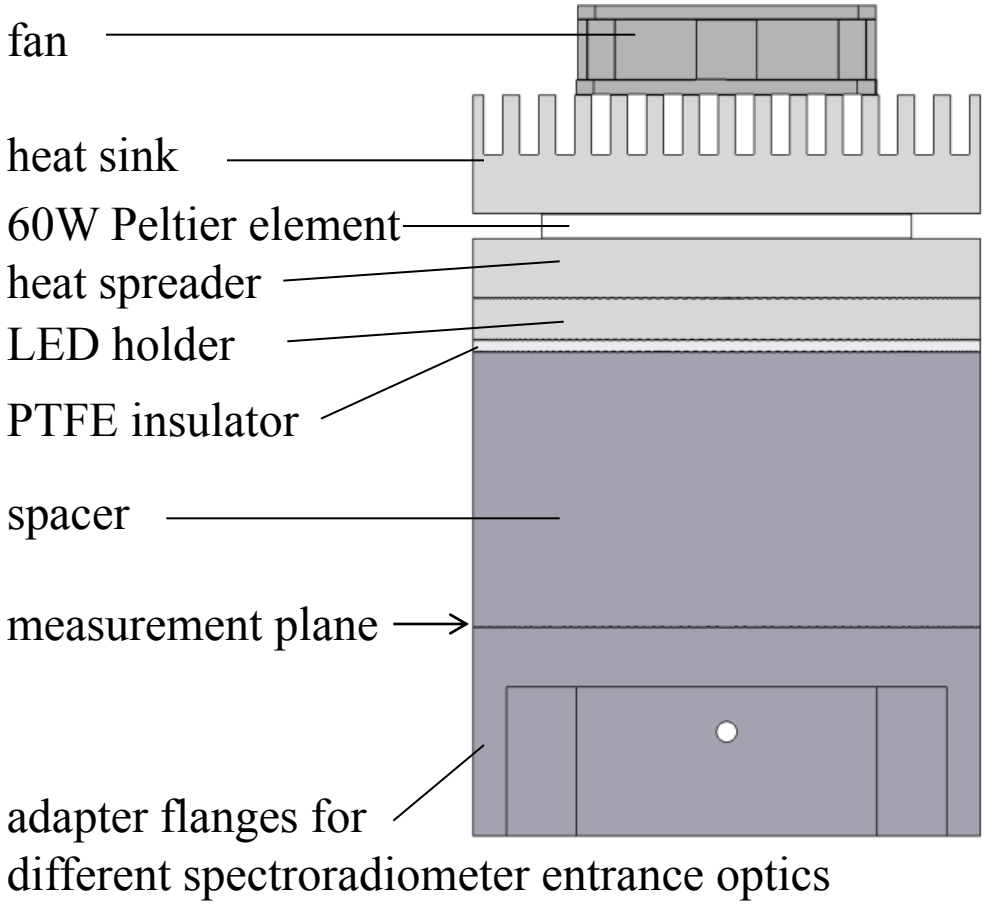
Expected irradiance levels after pre-aging



two LEDs with 352nm, 342 nm discarded

UV-LED monitoring source





- 10 UV-LEDs in series
- distance to measurement plane: 50mm
- 2 PT100 for reference and temperature controller

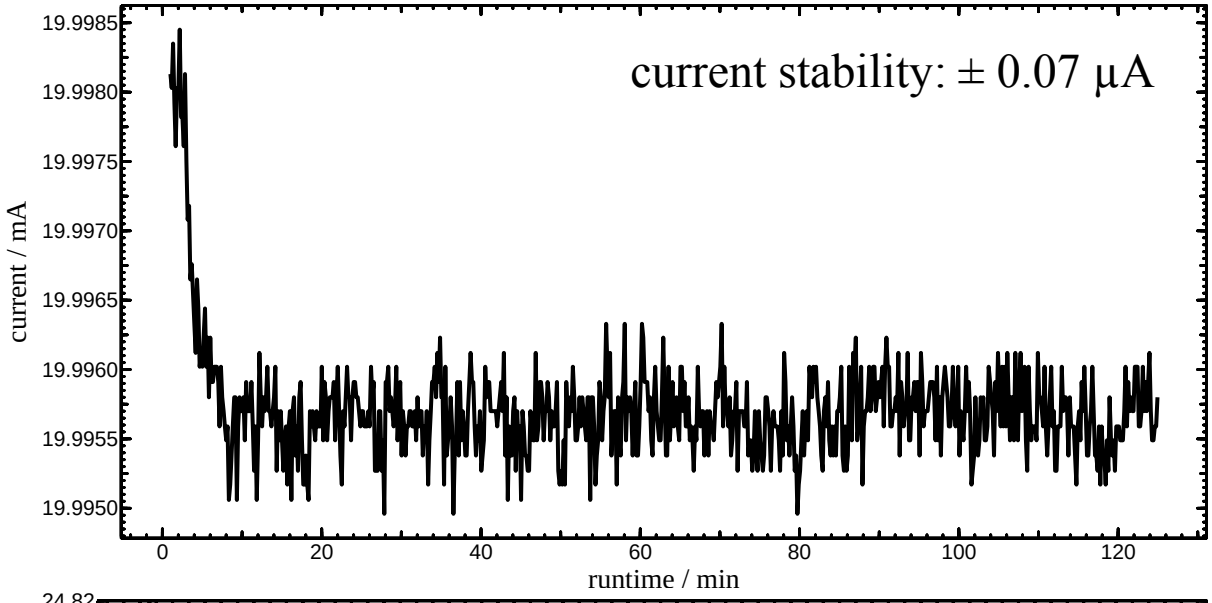
UV-LED monitoring source

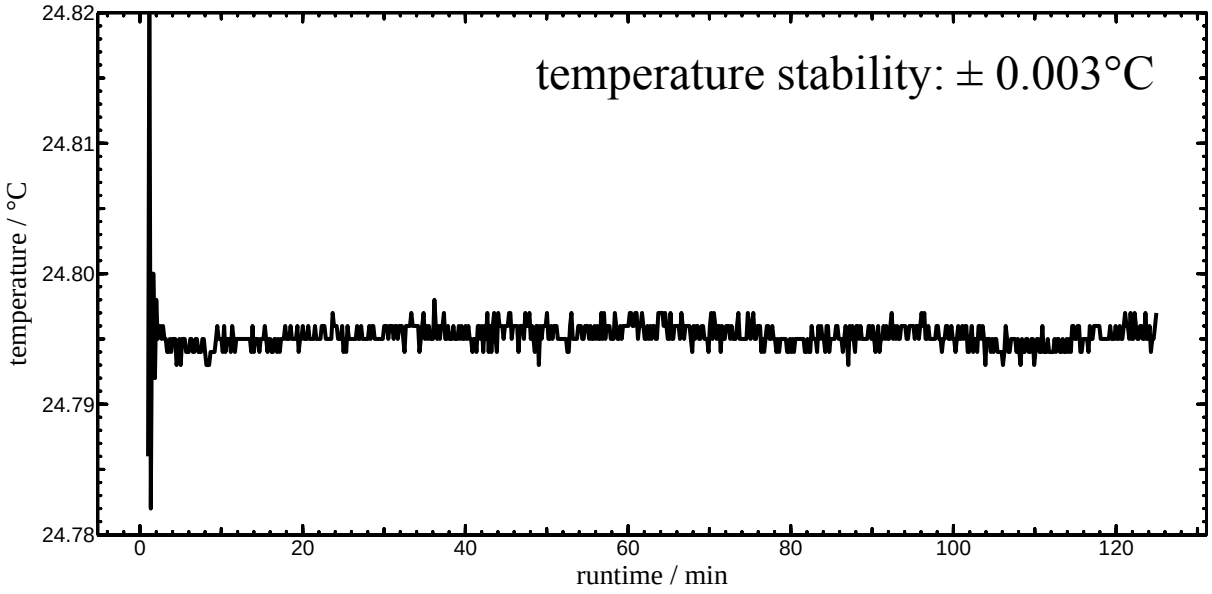
current source
I = 20 mA

20ch DMM
voltages, current, temp.

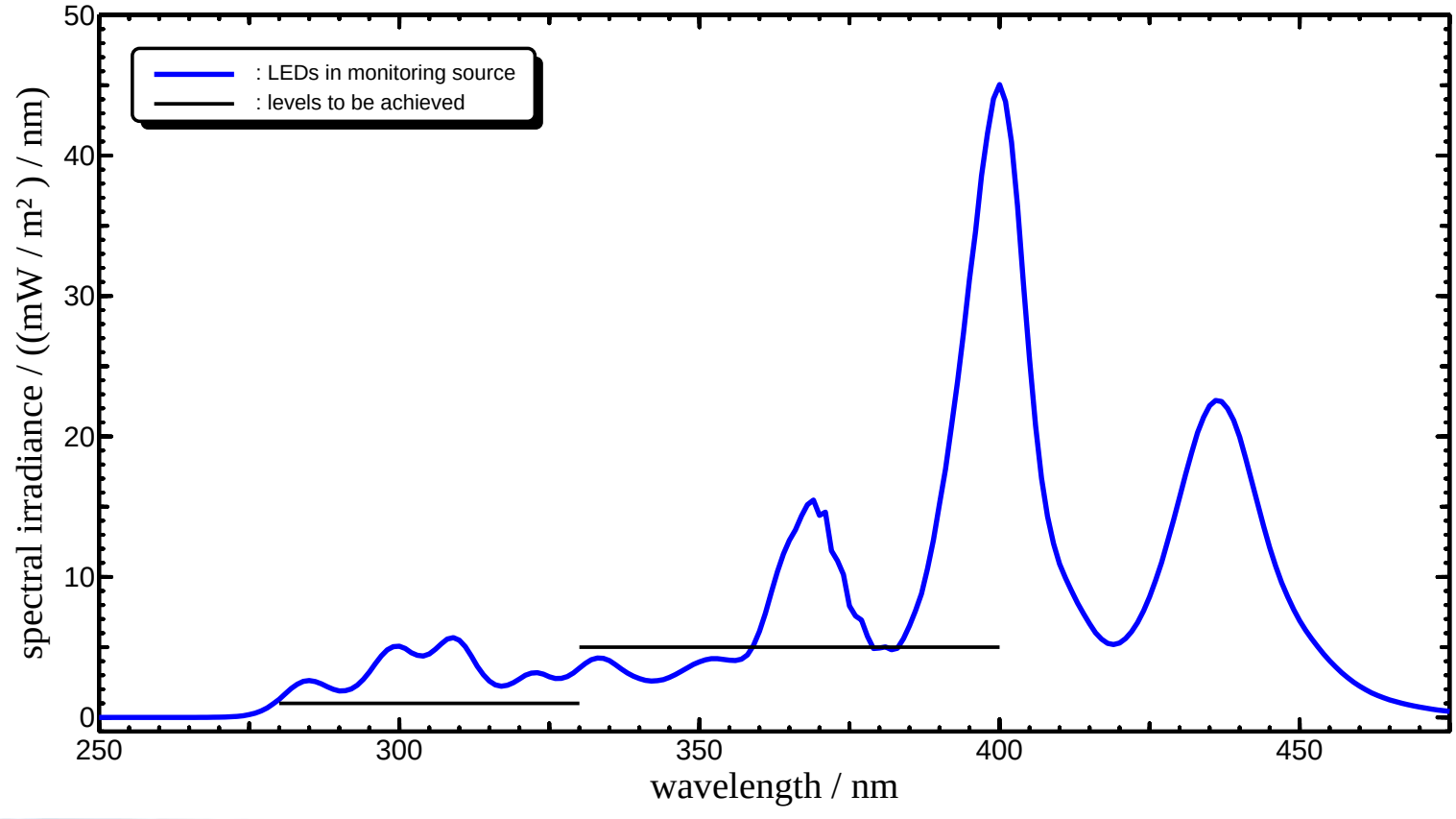
temperature controller
T = 25°C

Performance of the UV-LED source





Performance of the UV-LED source



measured with reference spectroradiometer QASUME

Field experiments

PMOD started in April on La Réunion

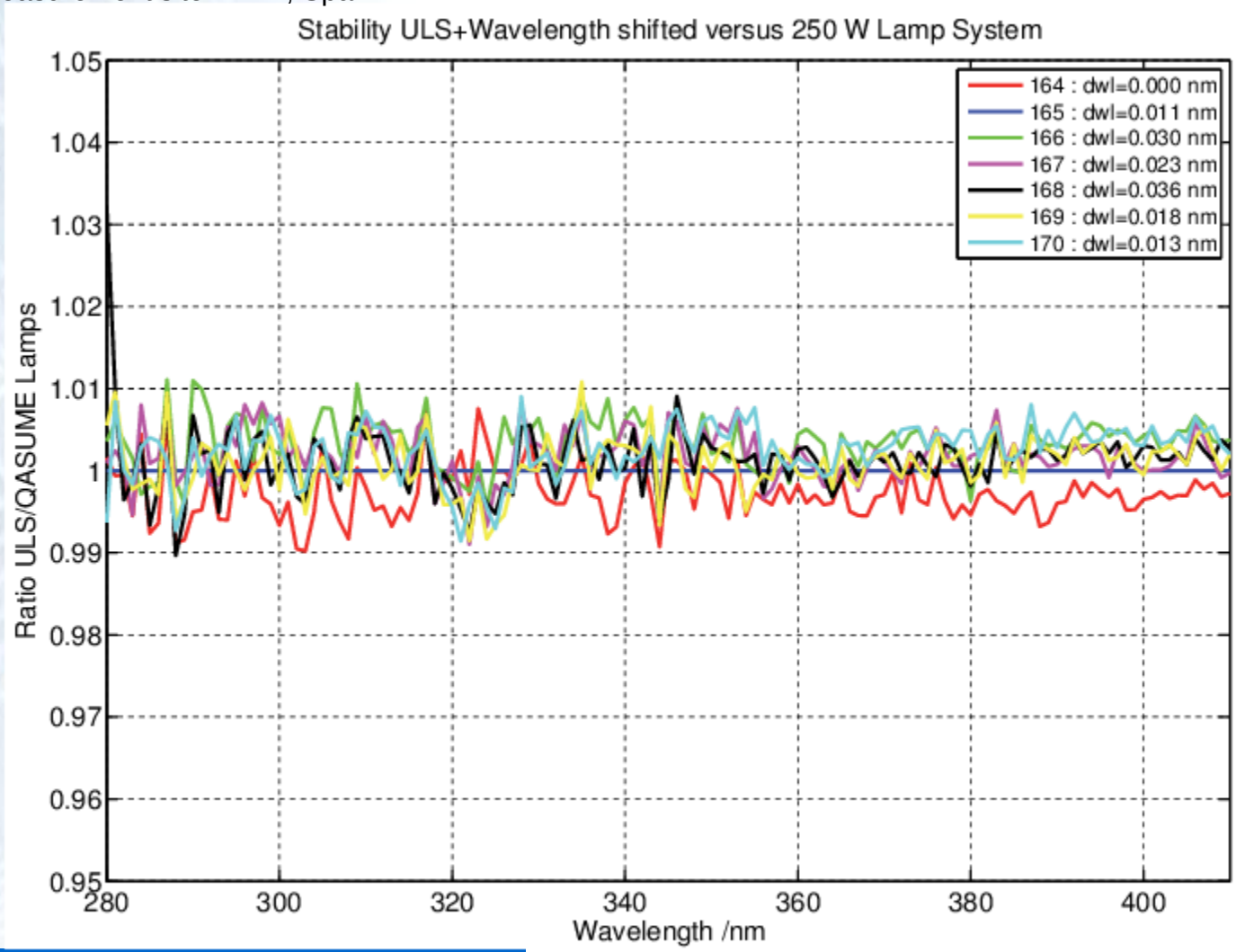
source: http://de.wikipedia.org/wiki/Réunion

The UV-LED source was and will be tested in the measurement missions with QASUME at European solar-UV network measurement sites during April - October 2013

Field experiments

Stability of the UV-LED source

LEDs at 35°C, measurement site: INTA, Spain



Summary

- UV-LEDs selected after pre-aging
- drift in irradiance in desired range (< 0.05% / h) for almost all devices
- prototype of UV-LED monitoring source has been built
- first experiments with prototype successful
- field experiments already in progress and are very promising

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