Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
National Metrology Institute

UV-LED radiation source (ULS)

for tracking stability and wavelength scale

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EMRP
European Metrology Research Programme
Programme of EURAMET
The EMRP is jointly funded by the EMRP participating countries within EURAMET and the European Union

UV-LED LIGHT SOURCE FOR TRACKING STABILITY

Objective:

develop a portable UV-LED radiation source for tracking stability and wavelength scale of a newly built UV array spectroradiometer system – ERMIS - by PMOD/WRC

Specification:

Irradiance stability: 0.5 %

WL accuracy: 0.01 nm

WL range: 300 – 350 nm

UV-LED LIGHT SOURCE FOR TRACKING STABILITY

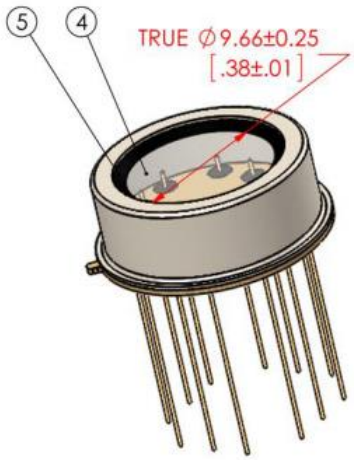
- **A multichip LED device (9 LEDs in single TO8 package), 300 nm to 365 nm (by SETi (Sensor Electronic Technology, Inc.) -- > ozone measurement region**
- A single LED, 365 nm (Nichia Corp.)
- A single LED, 375 nm (Nichia Corp.)
- A single LED, 405 nm (SETi)

Added in later phase of development to wider the spectral range and increase the signal level

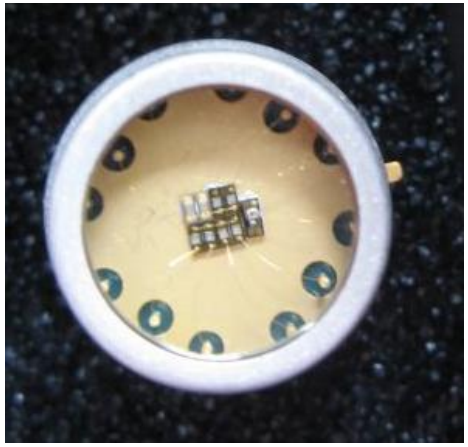
- All LEDs are operated at a nominal current of 20 mA
- Voltage of each LED is monitored for stability checking
- Temperature is kept stable 25±0.03 C° using peltier element with fan cooled heat-exchanger
- Operated using LabView on a Notebook and dedicated electronics

9-ELEMENT LED CHIP, 300 – 365 NM

- 9-element LED chip in single TO8 package of SETi (price ~2000 €)



Scale 3:1



Nominal WL-s:
2*303 nm
2*311 nm
2*319 nm
2*332 nm
1*364 nm

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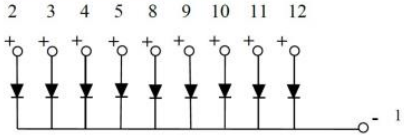
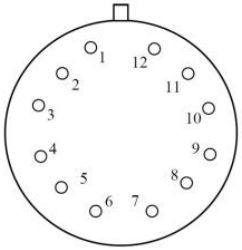
08/1

TO8 (9x1x1) pinout

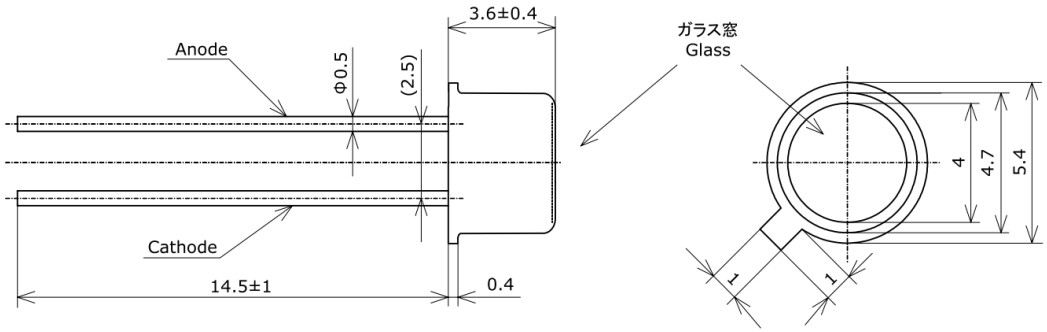


Top View:



Pin ##	Connection	WL, nm	Pin ##	Connection	WL, nm	Pin ##	Connection	WL, nm
1.	Cathode common		5.	Anode	310	9.	Anode	320
2.	Anode	300	6.			10.	Anode	330
3.	Anode	300	7.			11.	Anode	330
4.	Anode	310	8.	Anode	320	12.	Anode	365

365 NM, 375 NM AND 405 NM LEDs

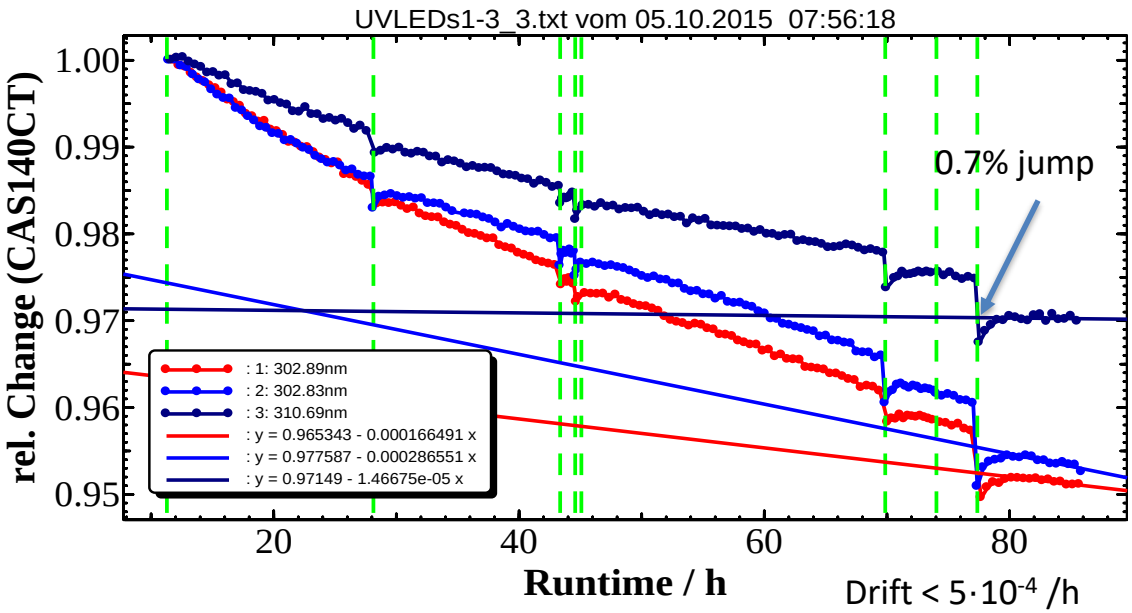


365 nm and 375 nm LEDs are from Nichia Corp,
405 nm LED isa from SETi
TO18 package

AGING MEASUREMENT WITH INTEGRATING SPHERE

- Initial measurements with 9-element LED attached to a 50 cm PTFE integrated sphere
  - Here shown are LEDs 1-3 (303 nm, 303 nm, 310 nm)

- The PTFE integrating sphere showed changes in its throughput under the UV-LED irradiation* (positiive drift) and a recovery without the irradiation manifested by jumps in the measured LED irradiance values after breaking the operation for several hours (marked by vertical green lines)

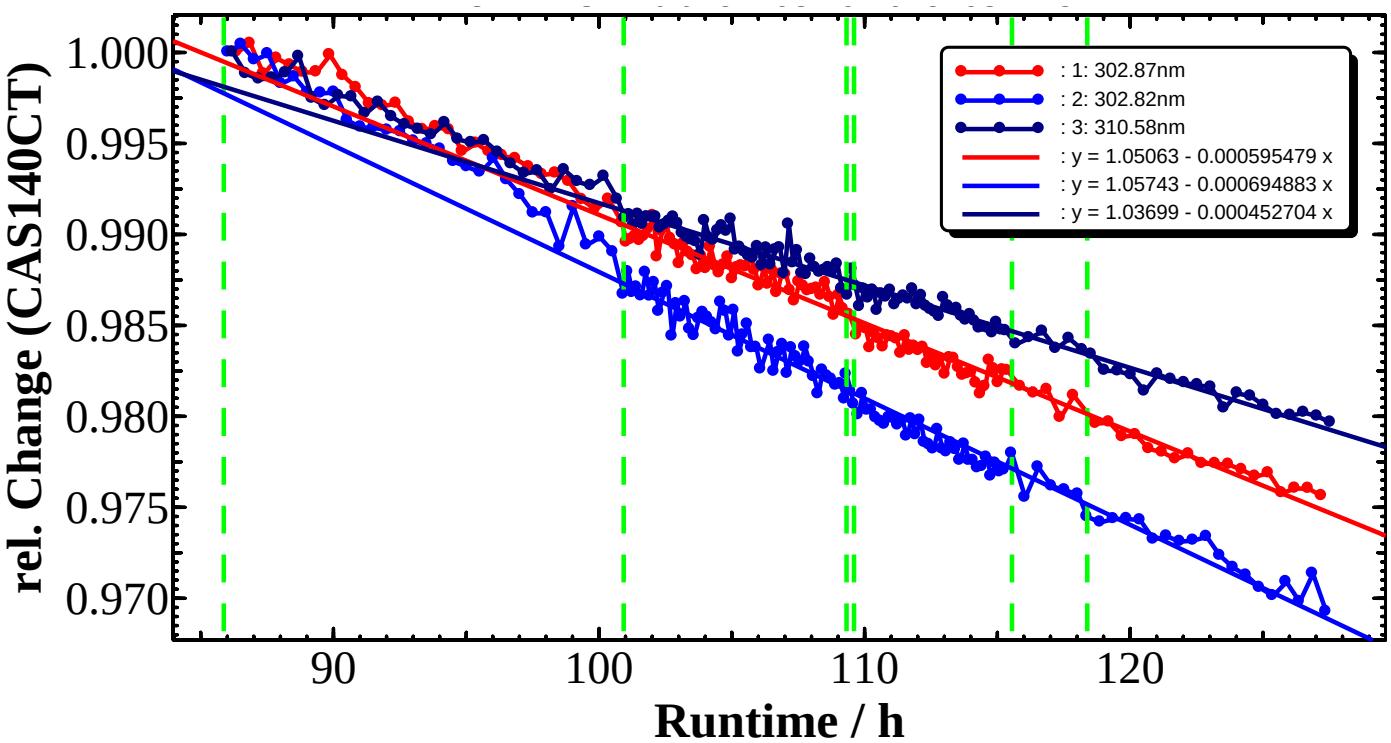


- LED's currents and temperature were stable and did not indicate any drift

* S. Nevas, P. Sperfeld, S. Teichert, A. Höpe, "Extraordinary changes in PTFE-based integrating-sphere properties under high levels of UV irradiation", in "Proceedings of NEWRAD 2008: 10th International Conference on New Developments and Applications in Optical Radiometry", (Daejeon 2008), pp. 333-334.

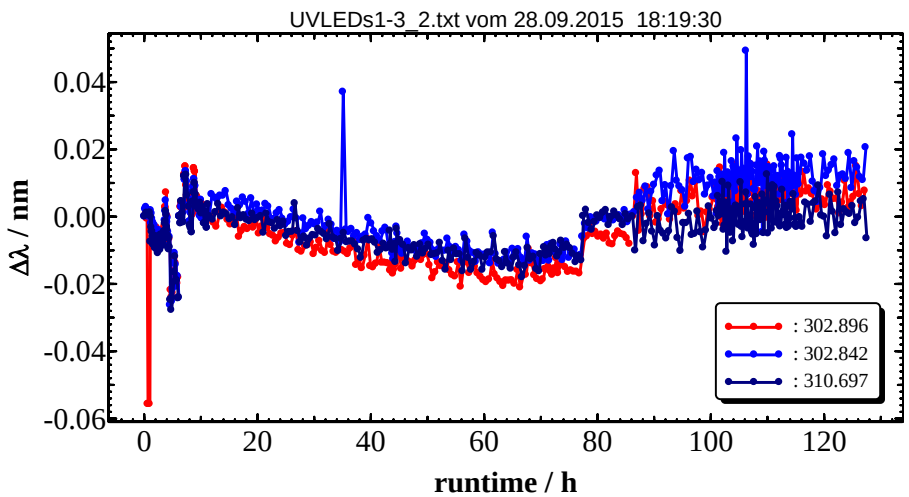
AGING MEASUREMENTS, FREE SPACE OPERATION

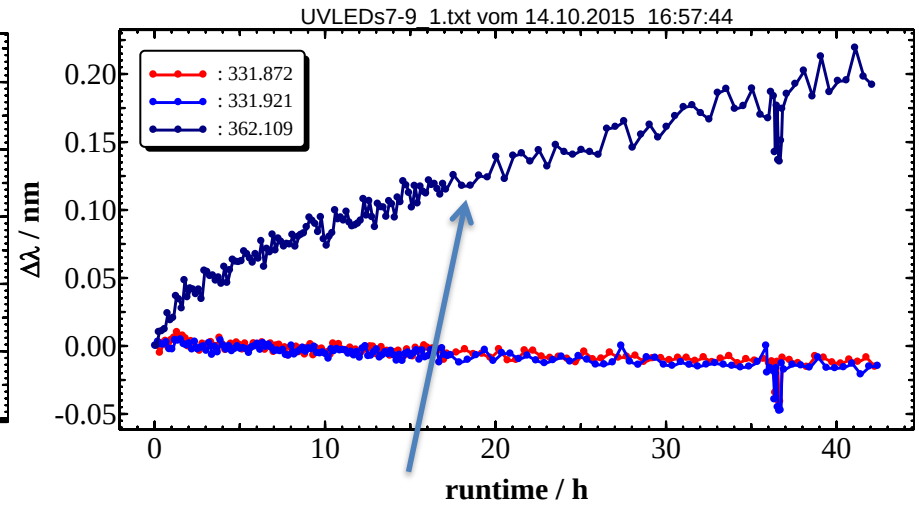
- Behavior of the same UV-LEDs when operated in free space: no more abrupt change of the measured values after pausing the operation for hours. Just a continuous drift of $5 \cdot 10^{-4}$/h after ca. 100 h operation time.
- Similar behaviour was seen for rest of the LEDs, though shorter burn in times were required.

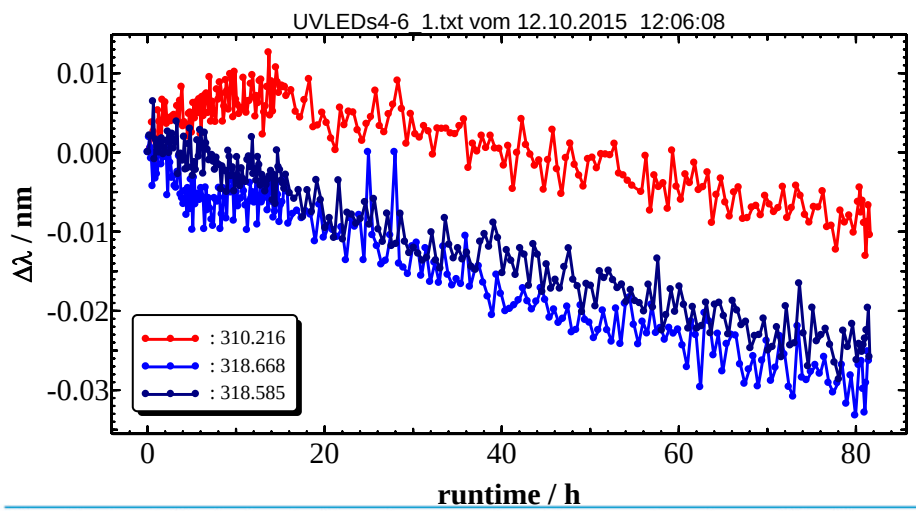


9-ELEMENT LED

- Wavelength stability of the LEDs during the burn-in time







- LED 364 nm shows different behaviour as compared to the other LEDs
- For 364 nm, drift: 0.004 nm/h
- For rest, drift: ~0.0005 nm/h

UV LED source, Updated design

- Each LED is driven by individual microchip-based current source
- 3 LEDs are added to cover wider spectral range and increase signal level
  - A single LED, 365 nm (Nichia Corp.)
  - A single LED, 375 nm (Nichia Corp.)
  - A single LED, 405 nm (SETi)
- Instead of integrating sphere a diffuser is used at the output
  - The residual non-uniformity is not an issue if reproducible coupling is provided

CURRENT DRIVER FOR LED

- Electric current supply for individual LEDs. To improve the temperature characteristics, the chips are fixed on the temperature controlled mount of the LED device

Supertex inc. CL

Simple 90V, 20mA, Temperature Compensated Constant Current LED Driver IC

Features

- 5.0 to 90V operating range (V_{A-B})
- 20mA ±10% at 5.0 - 90V
- 0.01%/°C typical temperature coefficient
- Available in TO-243AA (SOT-89), TO-252 (D-PAK), & TO-92 packages
- Can be paralleled for higher current

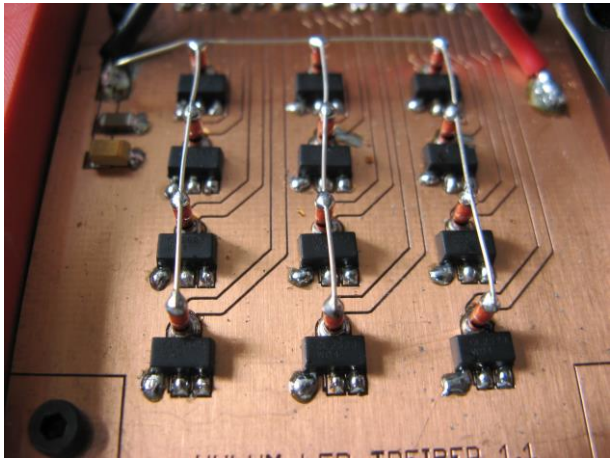
Applications

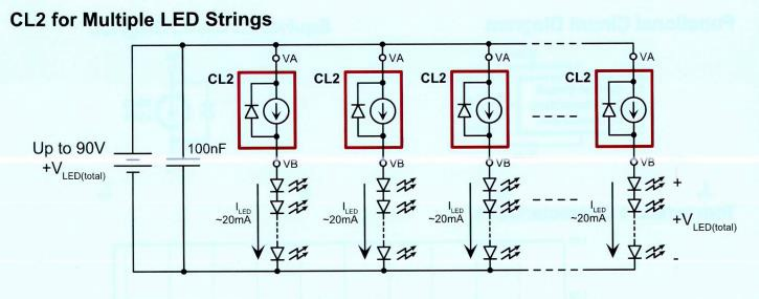
- LED driver
- Industrial lamp indicators
- Signage
- Accent lighting
- Automotive
- Constant current source
- Constant current sink

General Description

The Supertex CL2 is a high voltage, temperature compensate constant current source. The device is trimmed to provi a constant current of 20mA±10% at an input voltage of 5 - 90V. The device can be used as a two terminal consta current source or constant current sink.

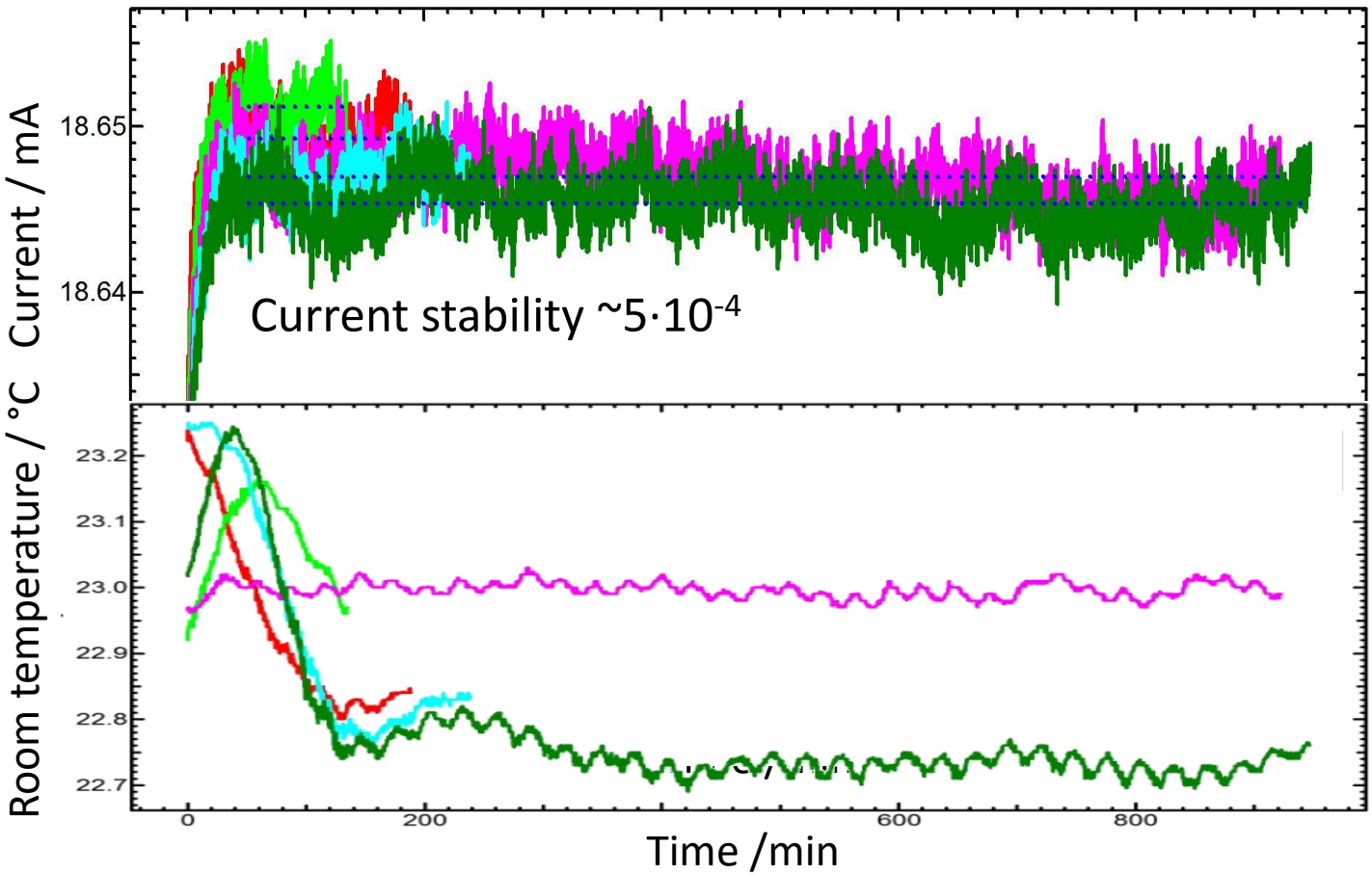
A typical application for the CL2 is to drive LEDs with a consta current of 20mA. Multiple CL2s can also be used in parallel provide higher currents such as 40mA, 60mA or 80mA. Tl device is available in TO-243AA (SOT-89), TO-252 (D-PAK and TO-92 packages.



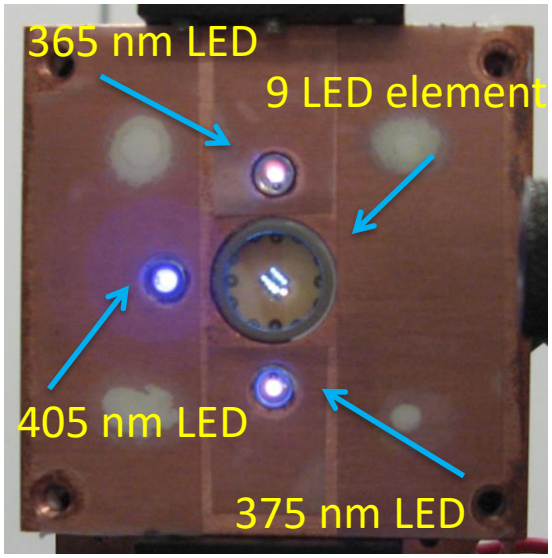


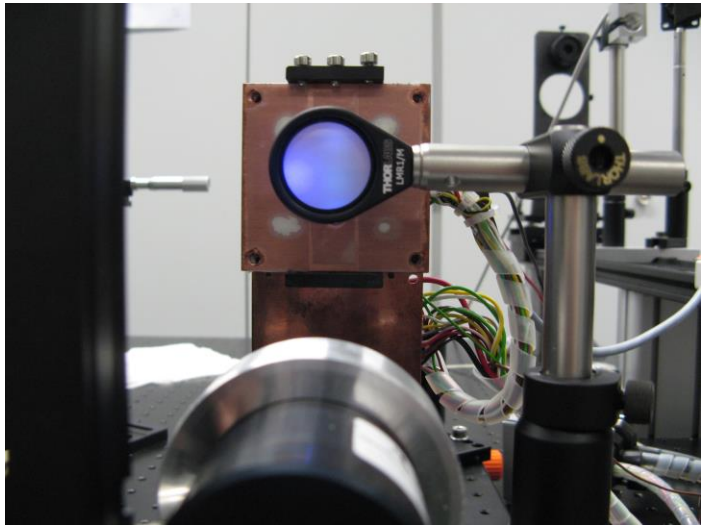
TEMPERATURE STABILITY OF LED DRIVER

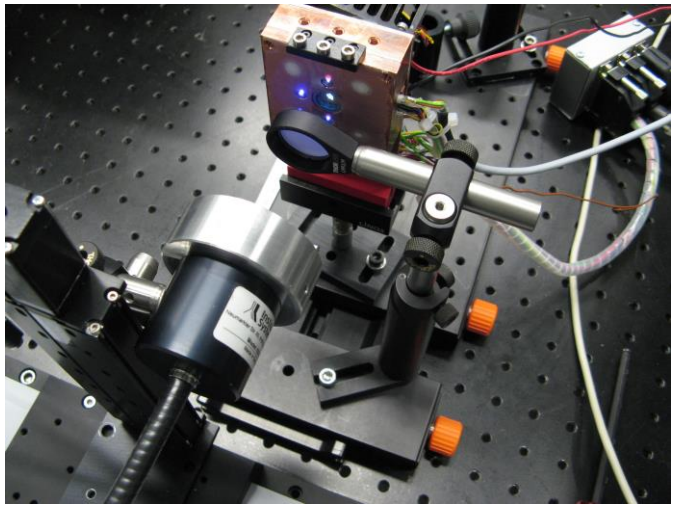
- Tests of single CL2 chip at room temperature, different runs (done within ENV03 “solarUV” project)



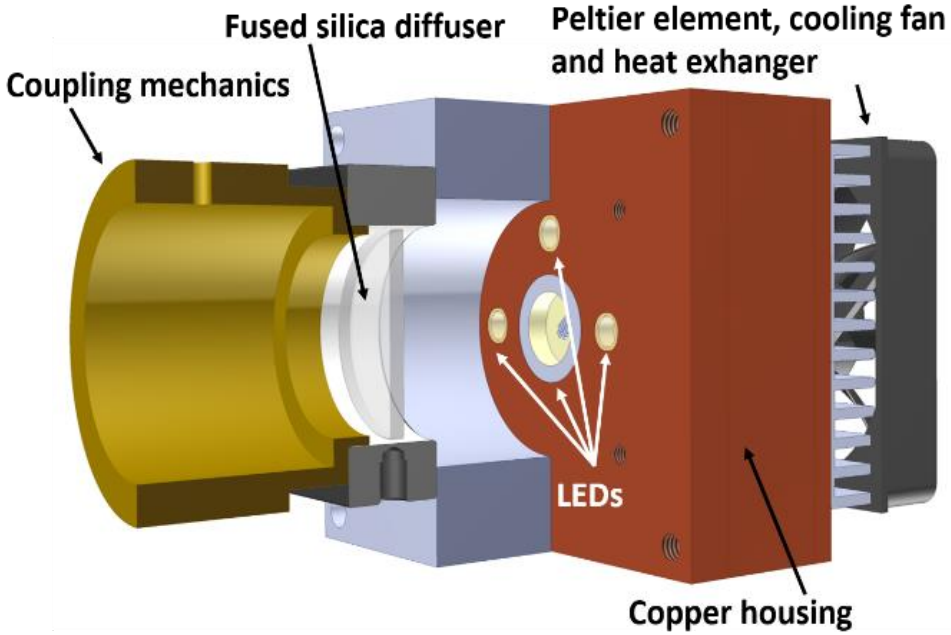
UV LED source, Testing phase

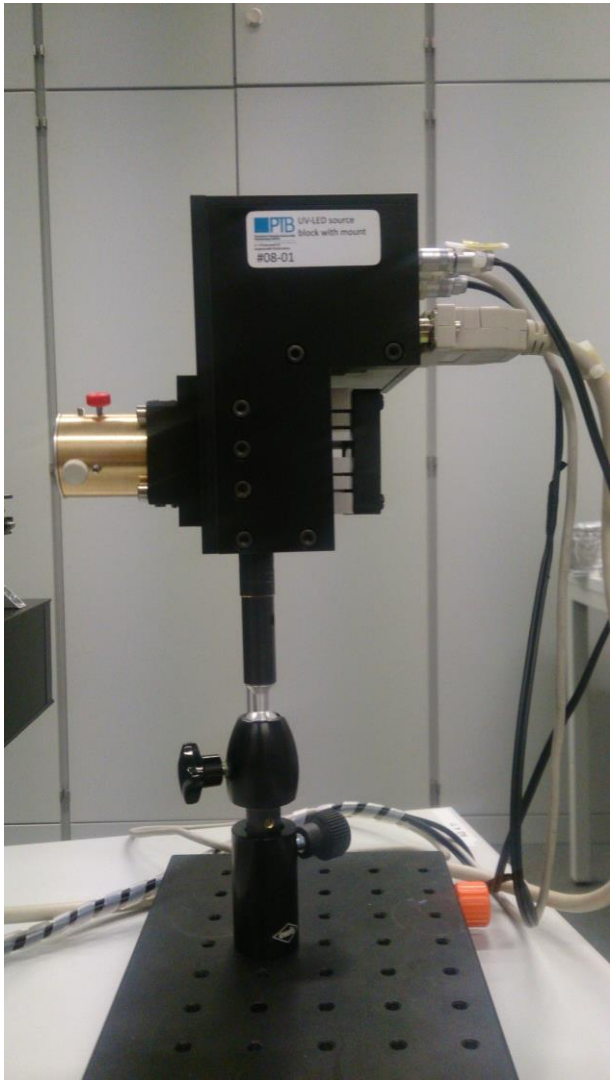




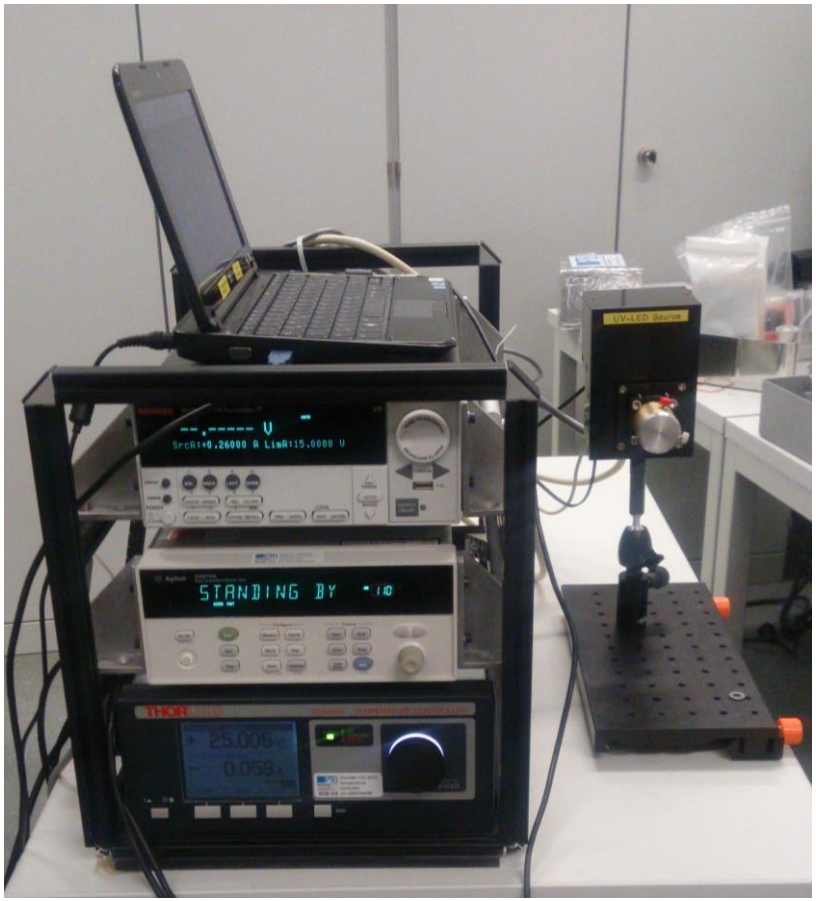


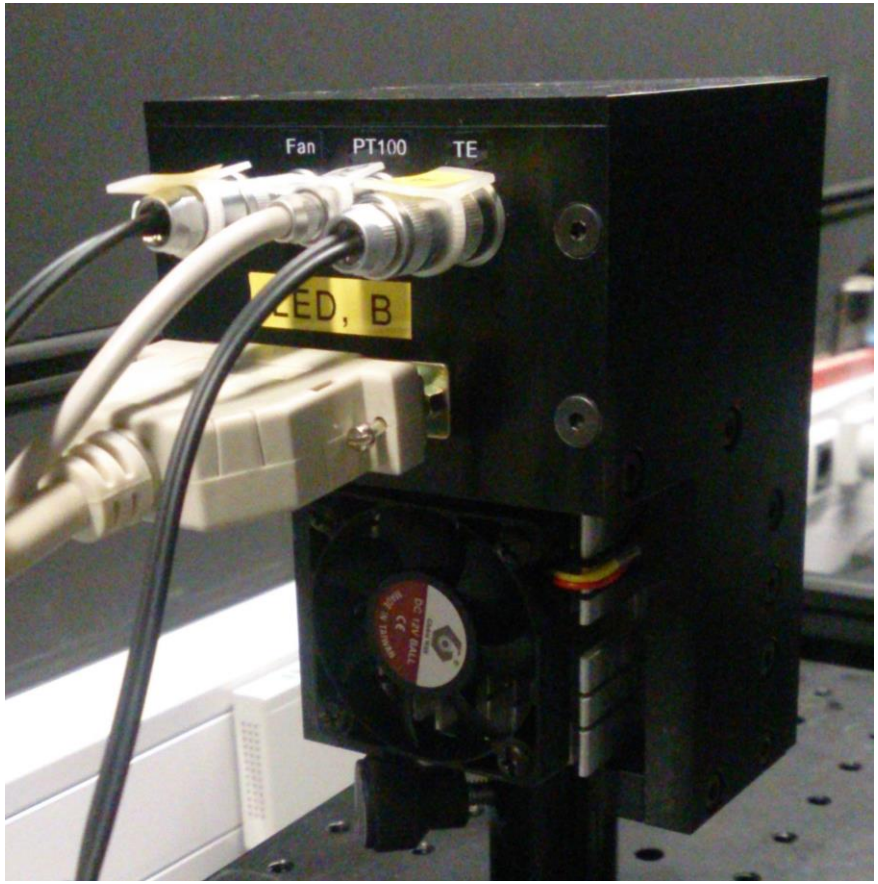
UV LED source, Design and Housing





UV LED source, Electronics and cabling



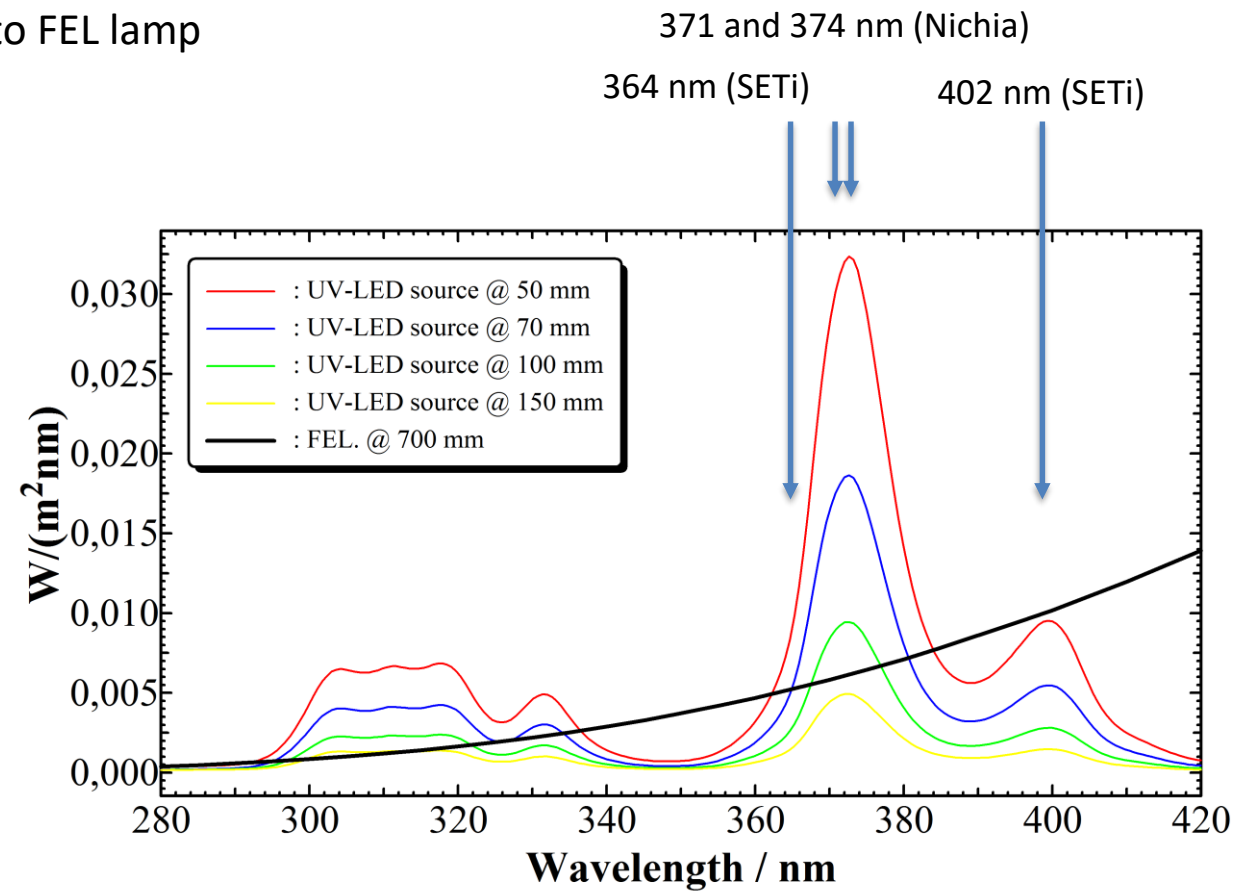


IRRADIANCE AT DIFFERENT DISTANCES

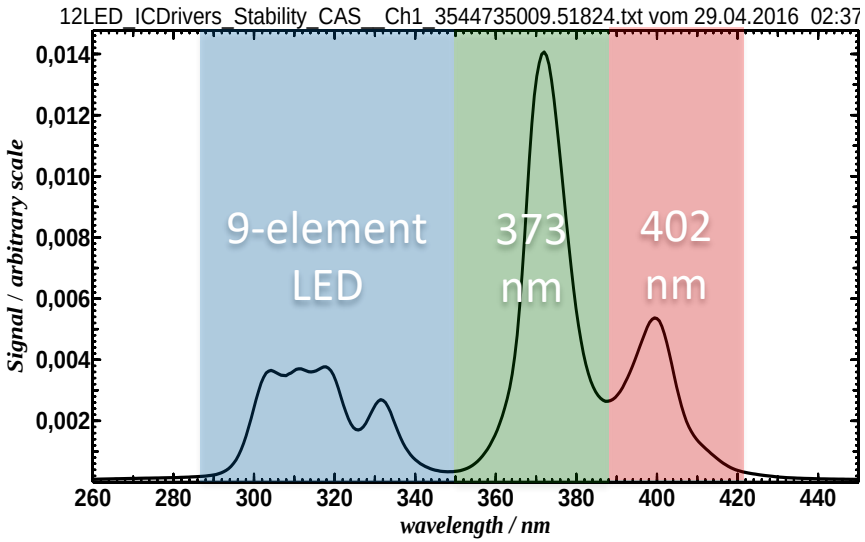
- 12 LEDs + diffused silica diffuser
- SETi 9-element chip at 364 nm is very weak
- Irradiance comparable to FEL lamp

Measured WL-s were:

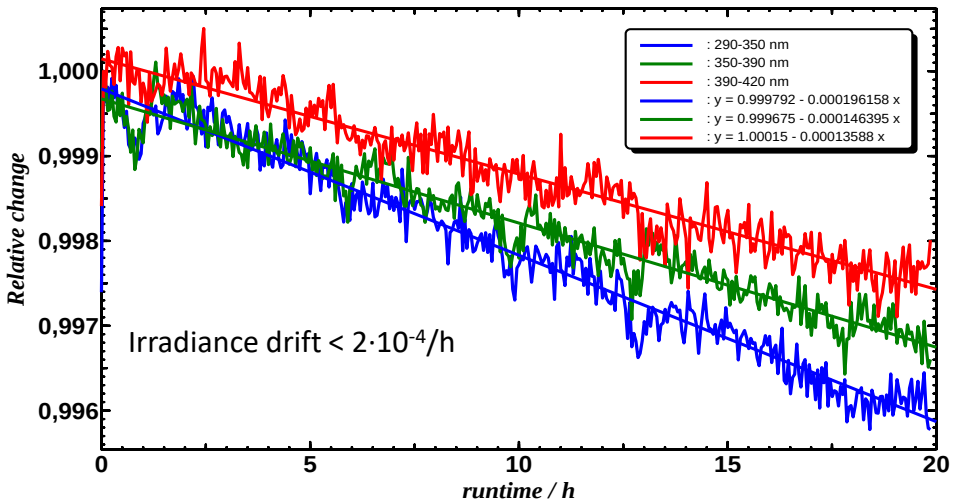
- 365 nm → 371 nm
- 375 nm → 374 nm
- 405 nm → 402 nm

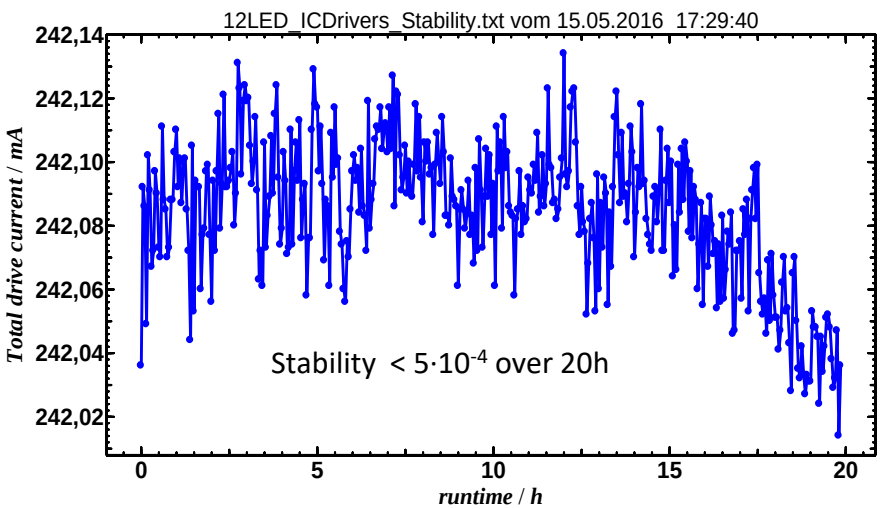


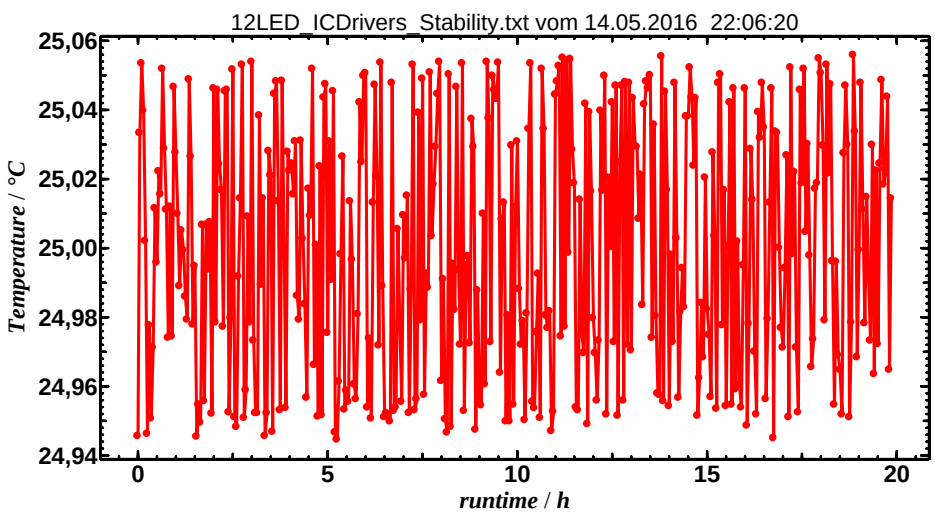
TEMPORAL STABILITY AND AGEING



Irradiance drift at diferent bands

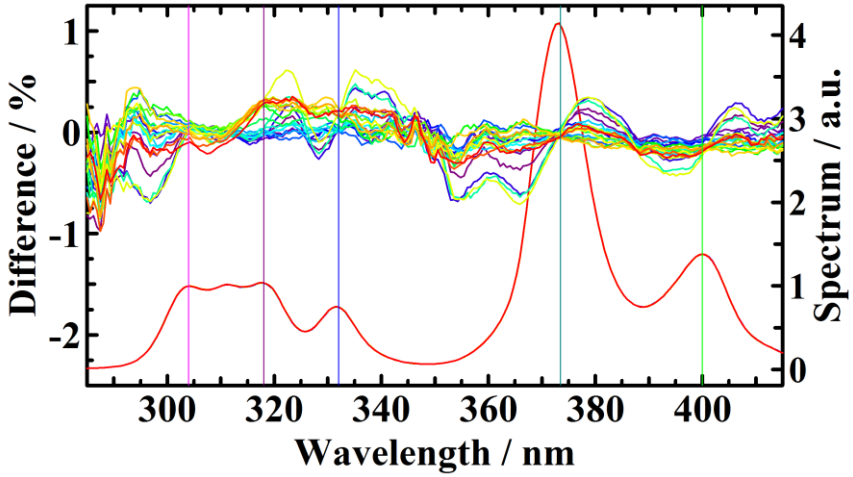






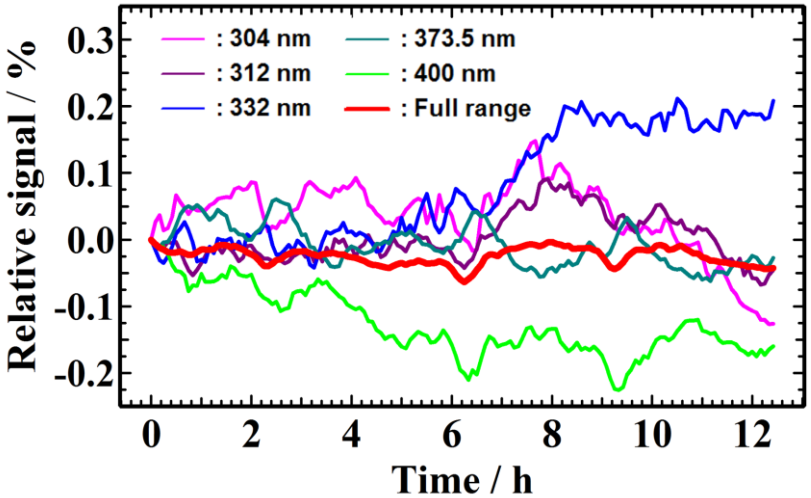
SPECTRAL STABILITY IN LABORATORY CONDITIONS

ULS spectrum and relative stability



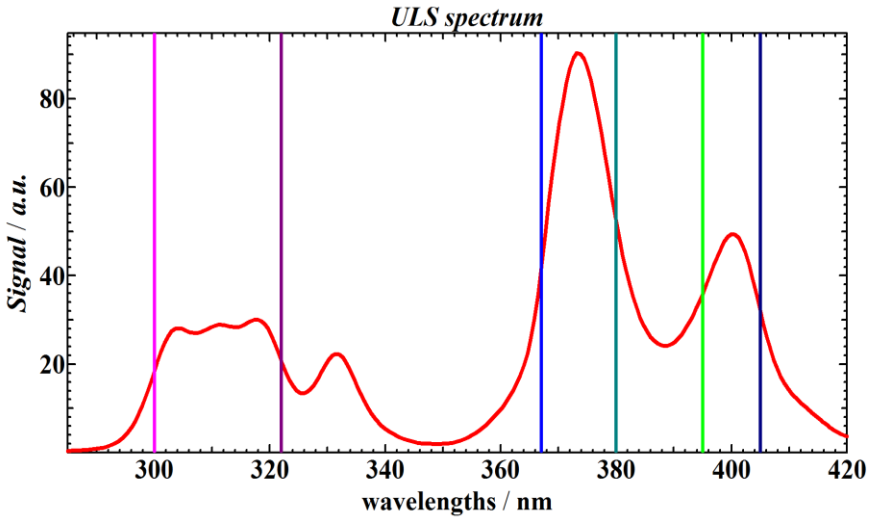
ULS spectrum (red line, right axis) and its relative stability (left axis) over 12h measurement period. Each coloured line represents measurement after 35 min interval.

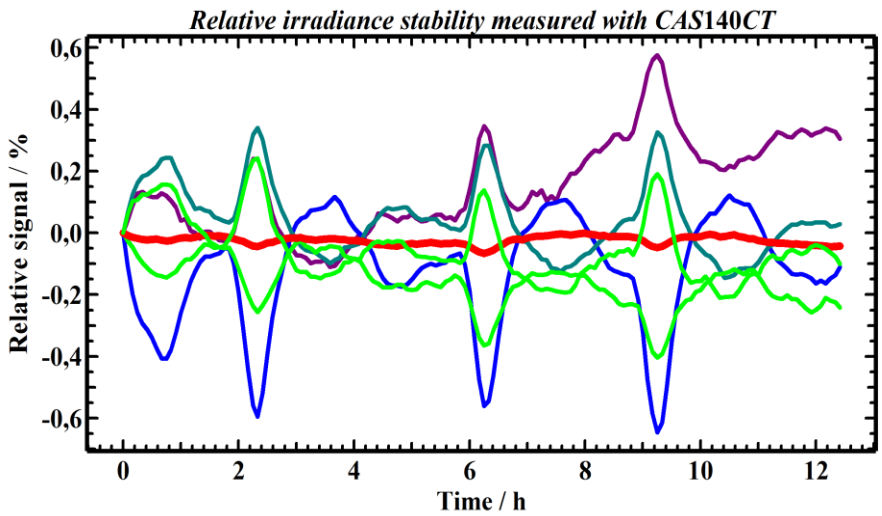
Relative irradiance stability measured with CAS140CT

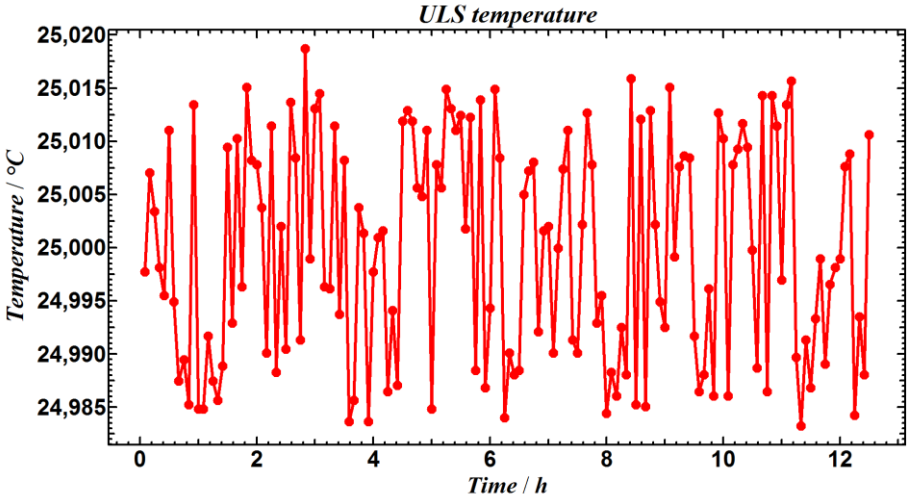


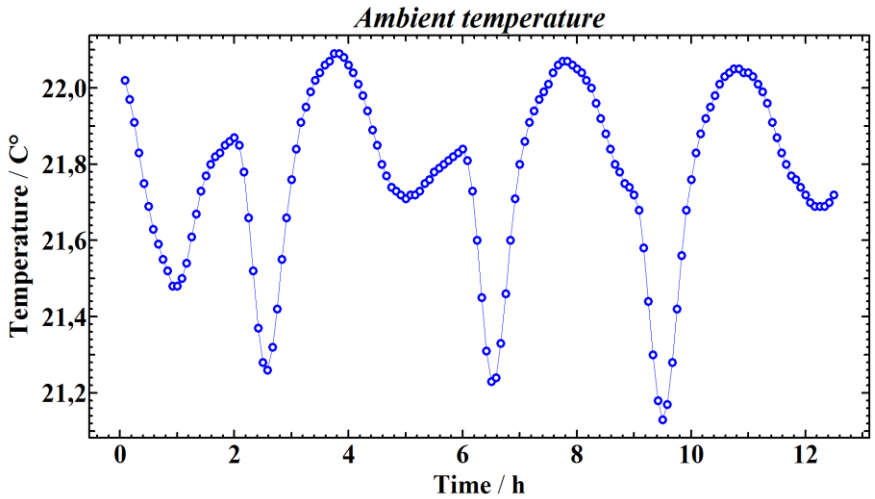
Relative irradiance stability at LED peak wavelengths (2 nm bandwidth) marked by vertical lines in left figure. Red curve shows irradiance changes integrated over 295 nm – 420 nm

SPECTRAL STABILITY IN LABORATORY CONDITIONS



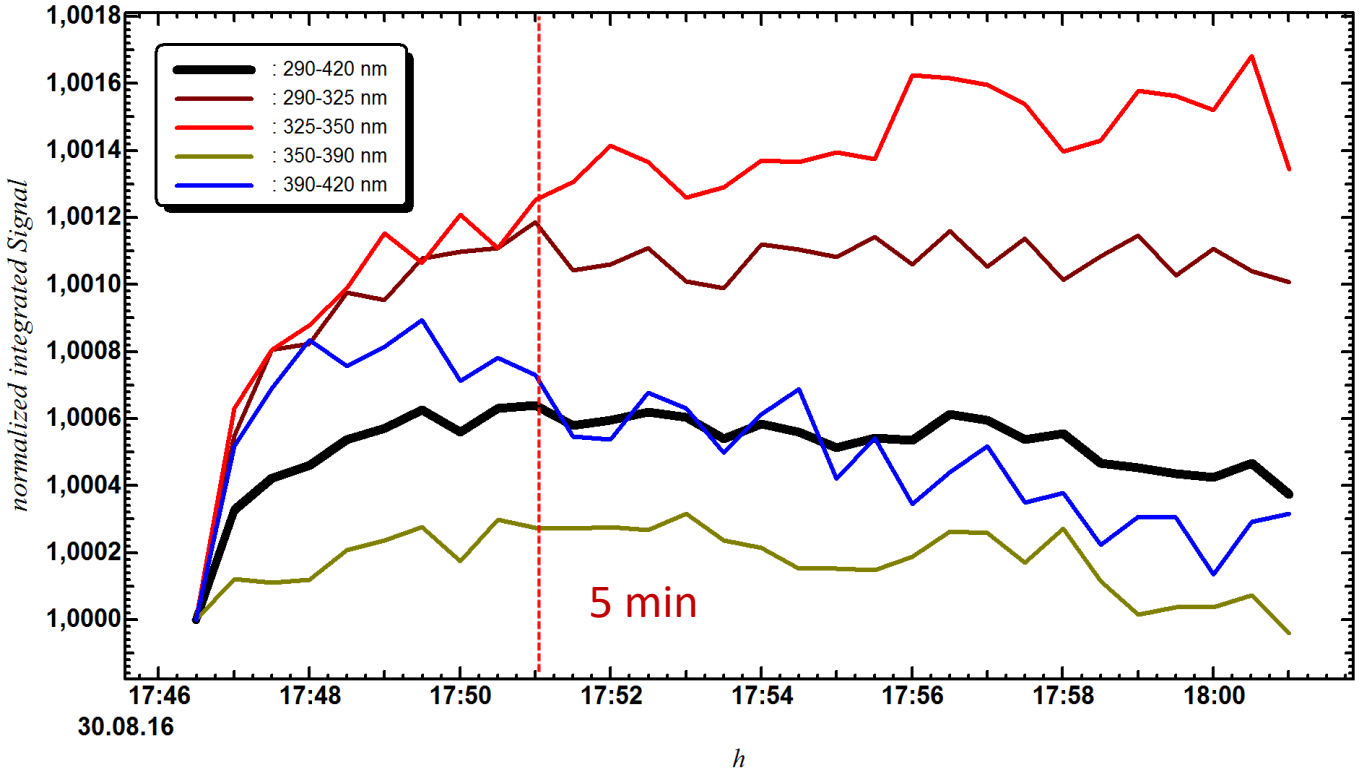






STABILIZATION TIME – INTEGRATED SPECTRAL INTENSITY

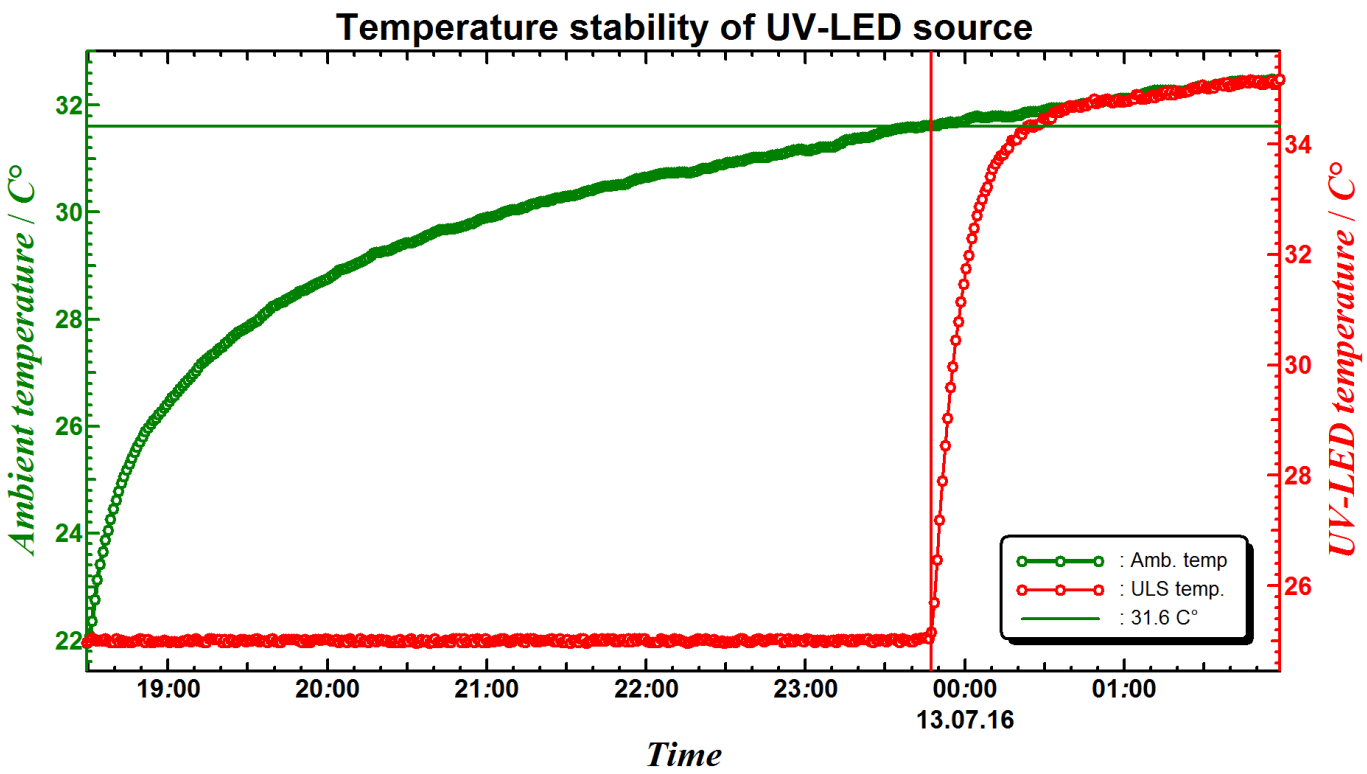
Integrated signal of spectral regions after LED switch-on at the temperature of 25 °C



After 5 minute operations stability is less than 0.05 %

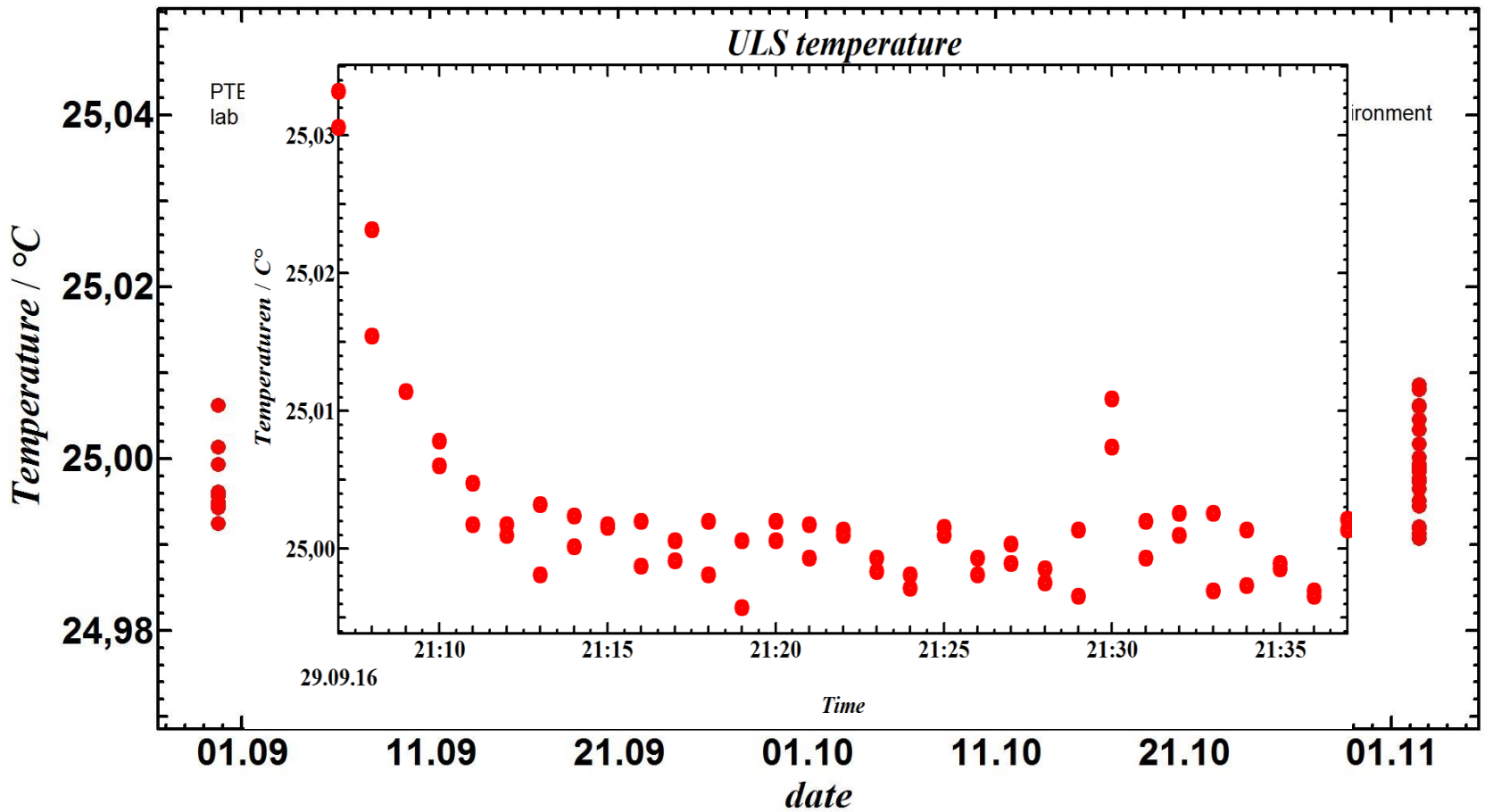
AMBIENT TEMPERATURE TEST

ULS can stabilize its temperature at ambient temperatures between ~15-31 degrees C°

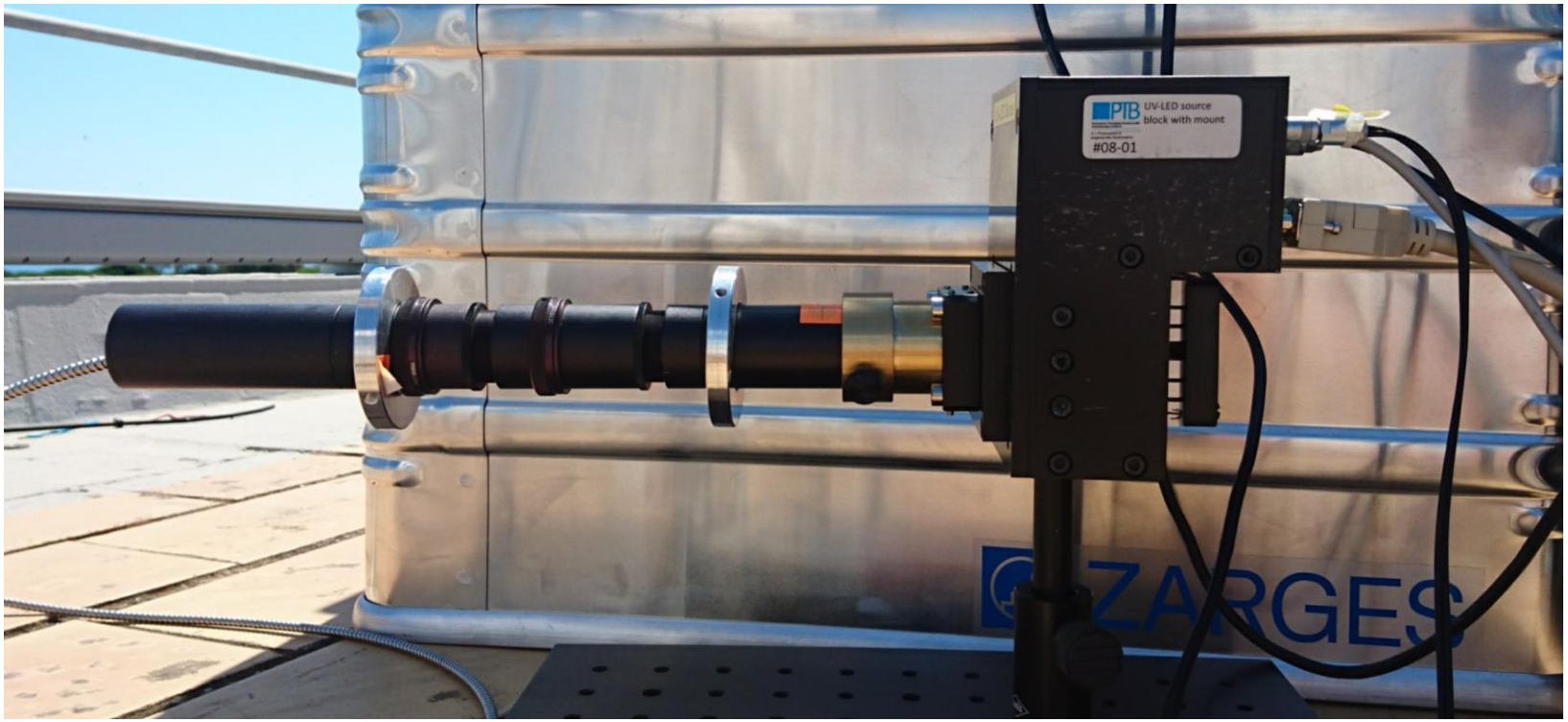


An example measurement when increasing the ambient temperature from RT

TEMPERATURE STABILITY OF ULS



ERMIS AND ULS, ON-GOING FIELD MEASUREMENTS



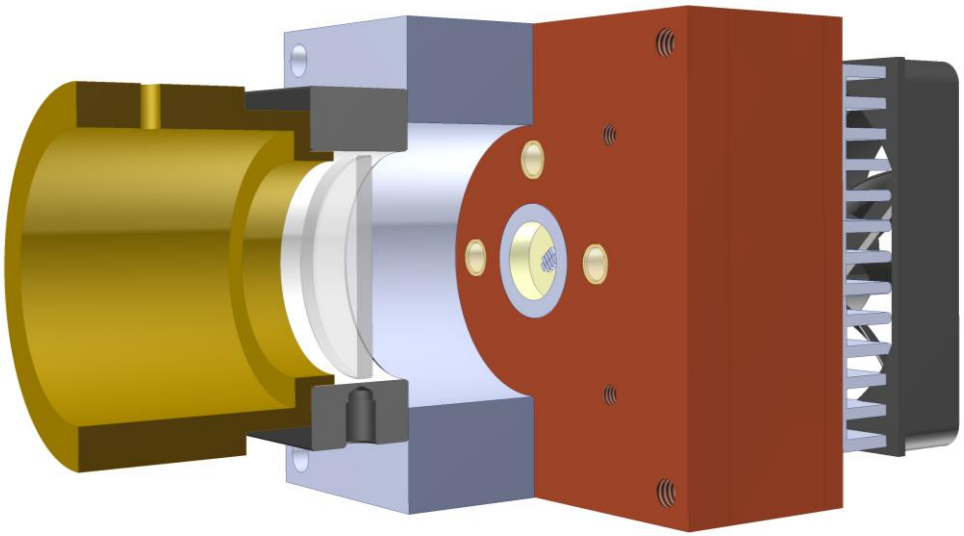
ERMIS telescope head attached to ULS

UV-LED SOURCE FOR TRACKING STABILITY

- Conclusions and work to do:
  - The performance of the individual UV-LED chips under laboratory conditions is very good, i.e. stable and reproducible values achieved after expected burn-in times
  - The irradiance values at 365 nm wavelength LEDs are problematic: not as high irradiance as expected (SETi) and not at correct wavelength (Nichia)
  - The integrating spheres change under the UV-LED irradiation and are, thus, not ideal for the monitor source application. Also temperature dependence of the PTFE-based materials may pose a problem
  - Initial field test measurements at Izana campaign indicated no problems in the operation of ULS
  - ULS is currently further tested with ERMIS in this measurement campaign

UV LED SOURCE FOR TRACKING STABILITY

- THANK YOU!



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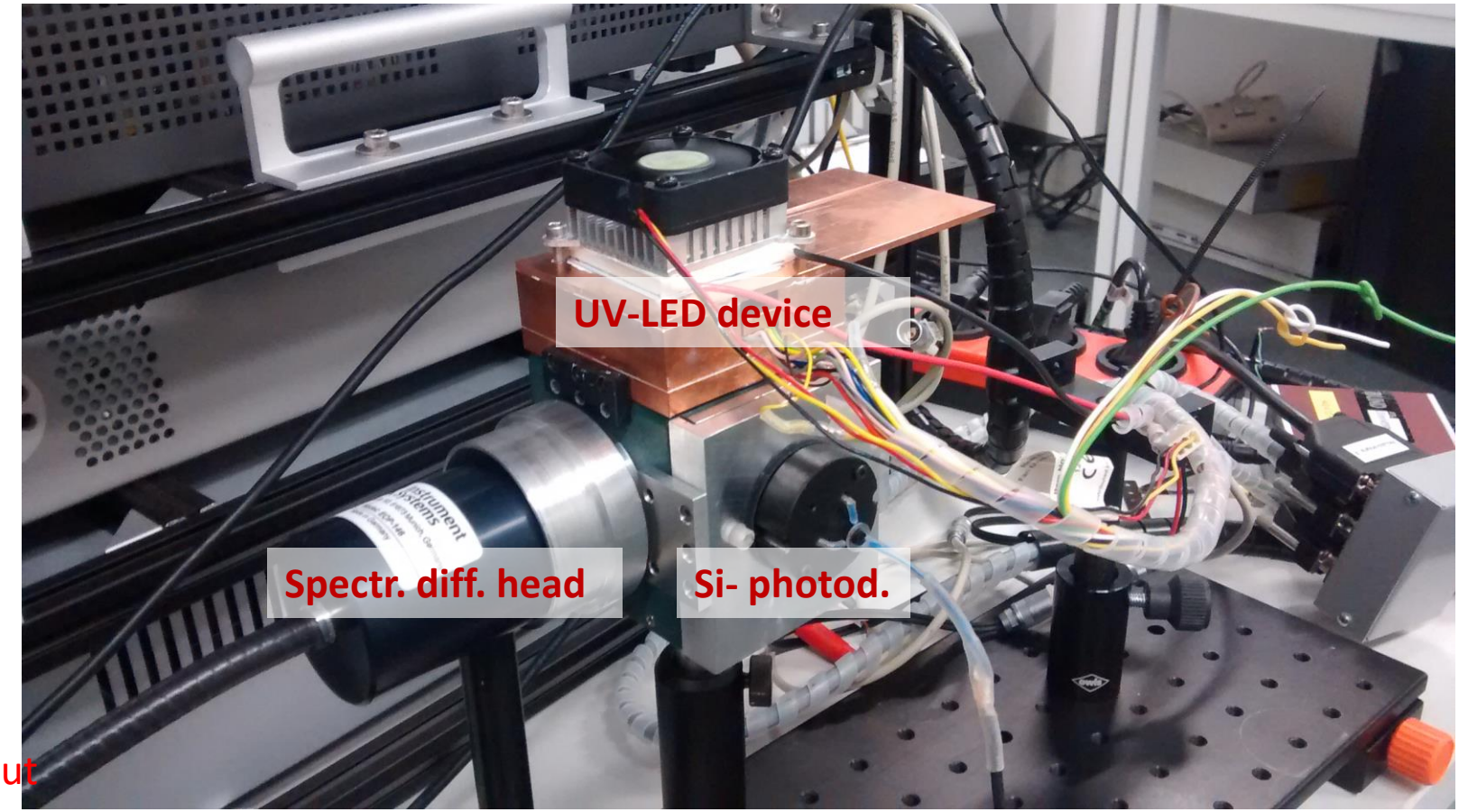
AGEING STUDIES OF 9-ELEMENT LED USING INTEGRATING SPHERE

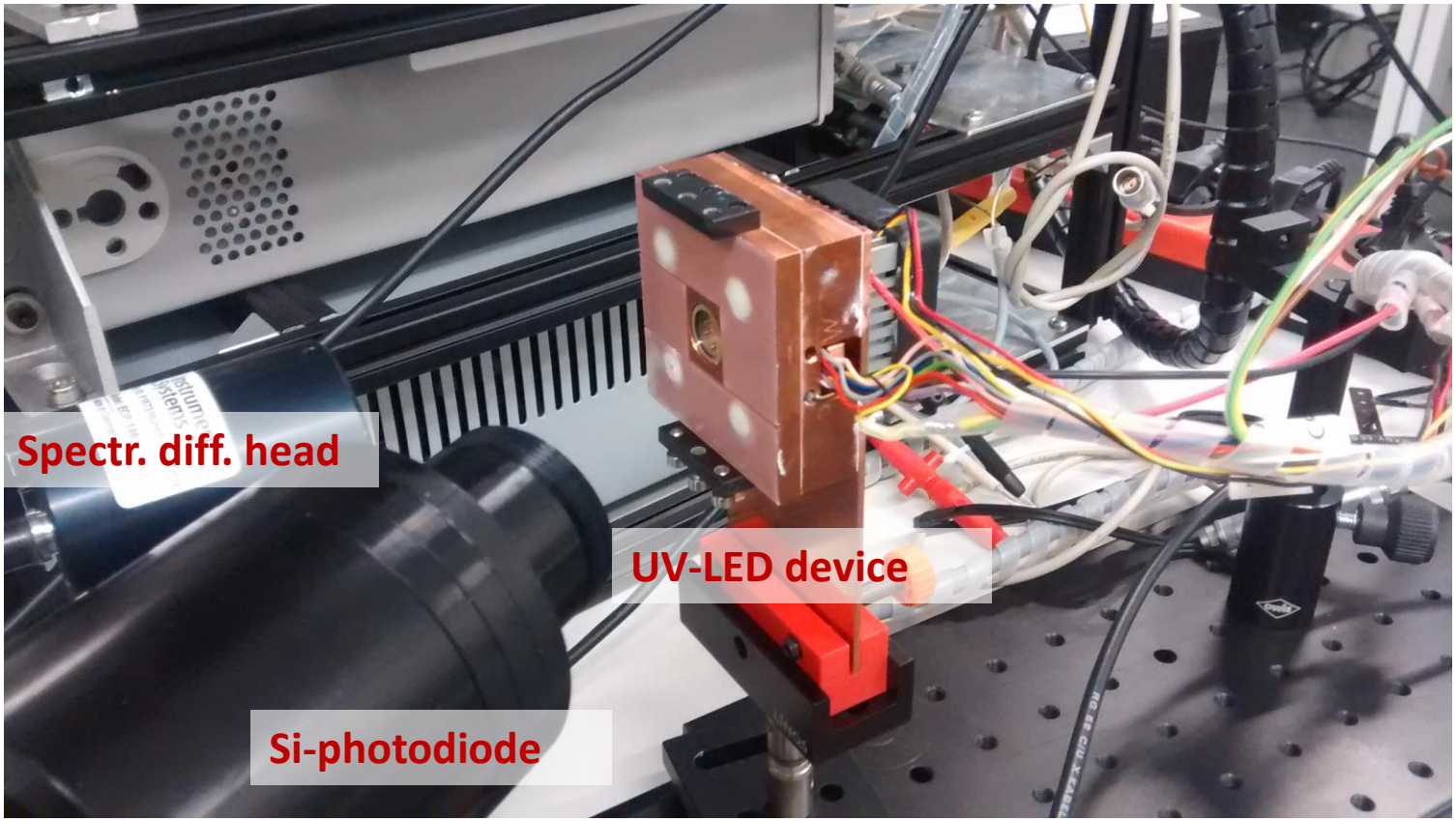
- The ageing studies started with the LED device attached to a 50 cm PTFE integrated sphere



Leave out

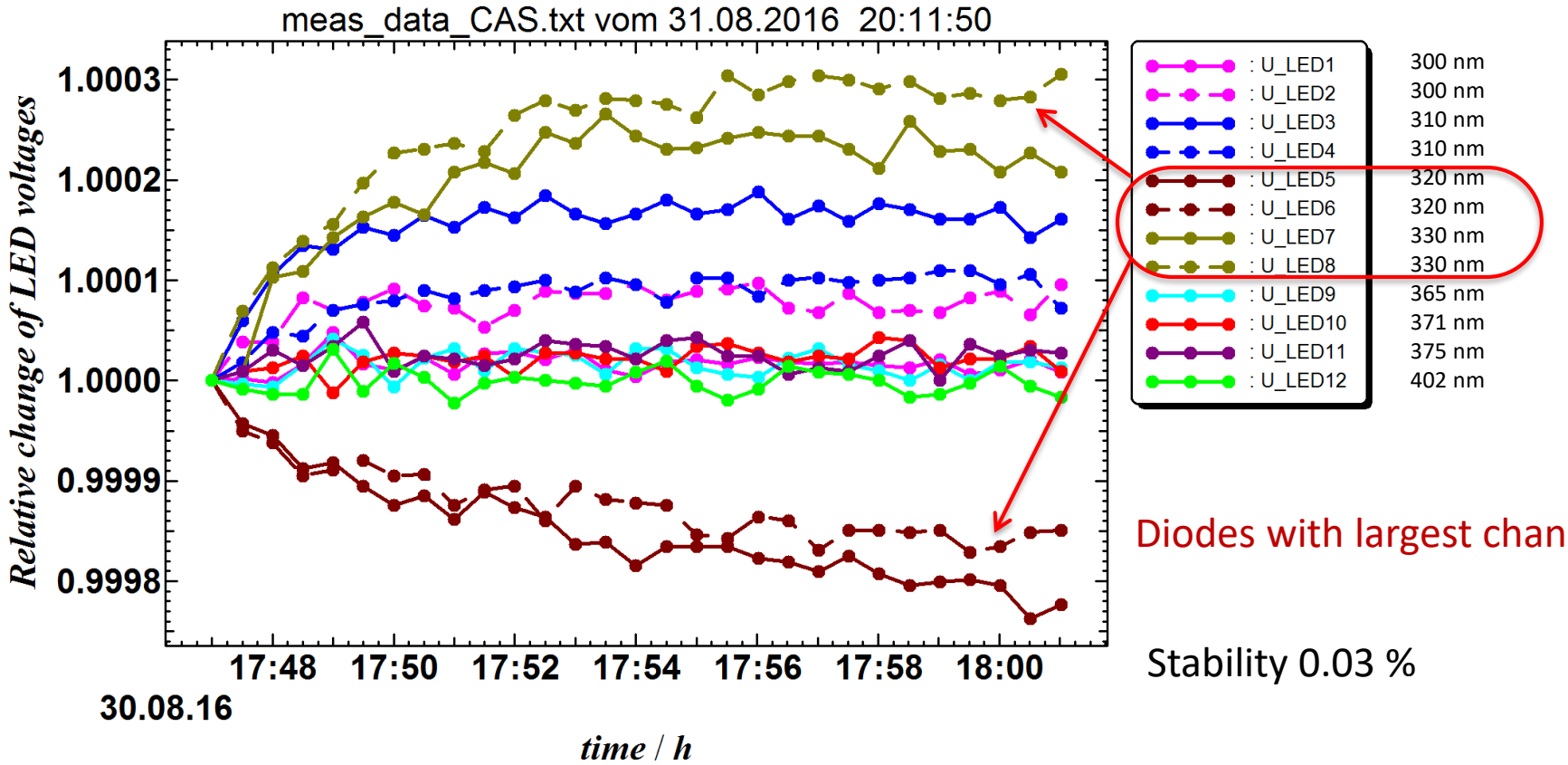
9-ELEMENT LED, FREE SPACE OPERATION

- Further burn-in of the LEDs was carried out without the integrating sphere



Leave out

STABILITY - LED VOLTAGES - ~10 MINUTES

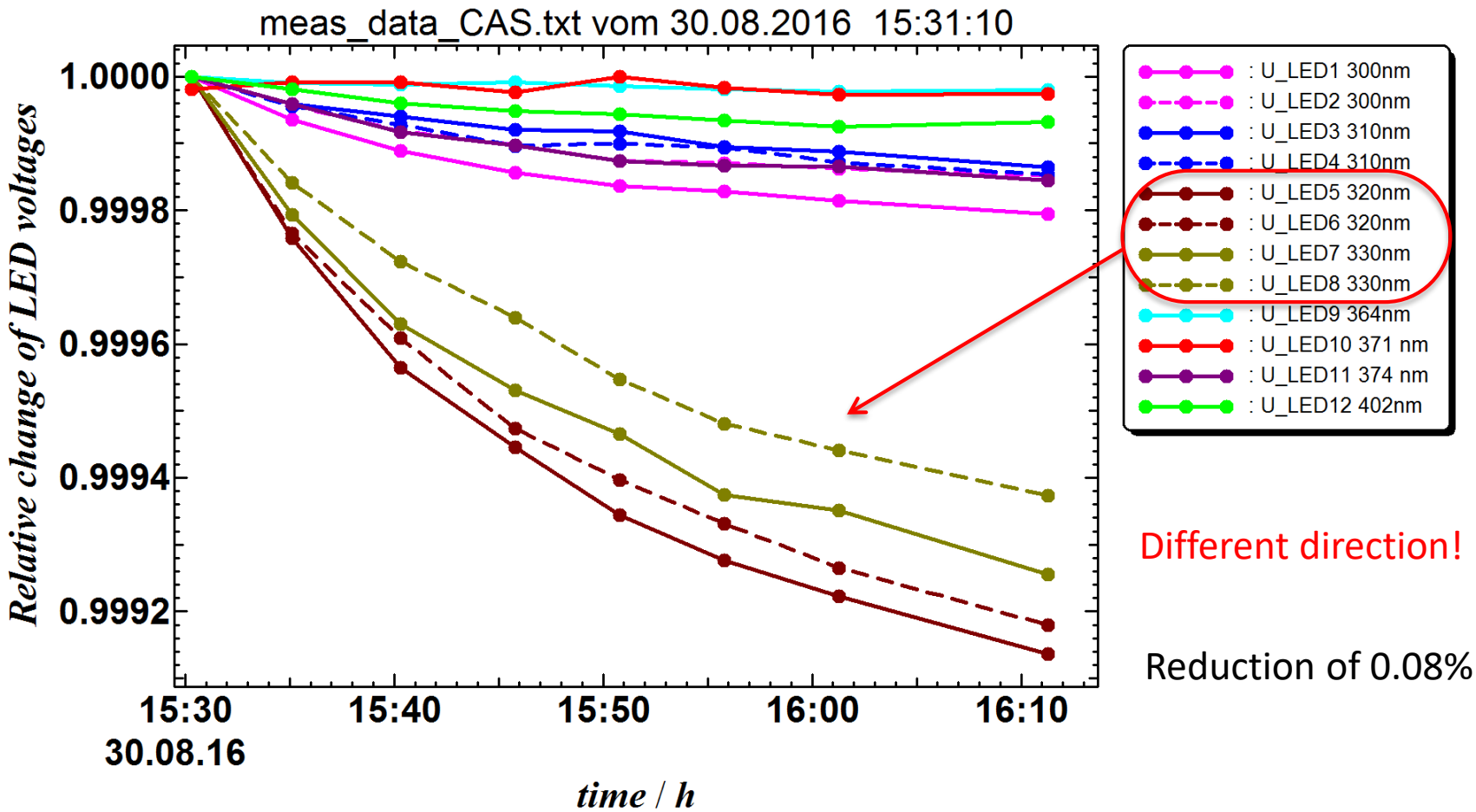


Diodes with largest change

Stability 0.03 %

Consider most recent data and outdoor measurements. Look Natalias data.

STABILIZATION TIME – LED VOLTAGES – 40 MINUTES



Different direction!

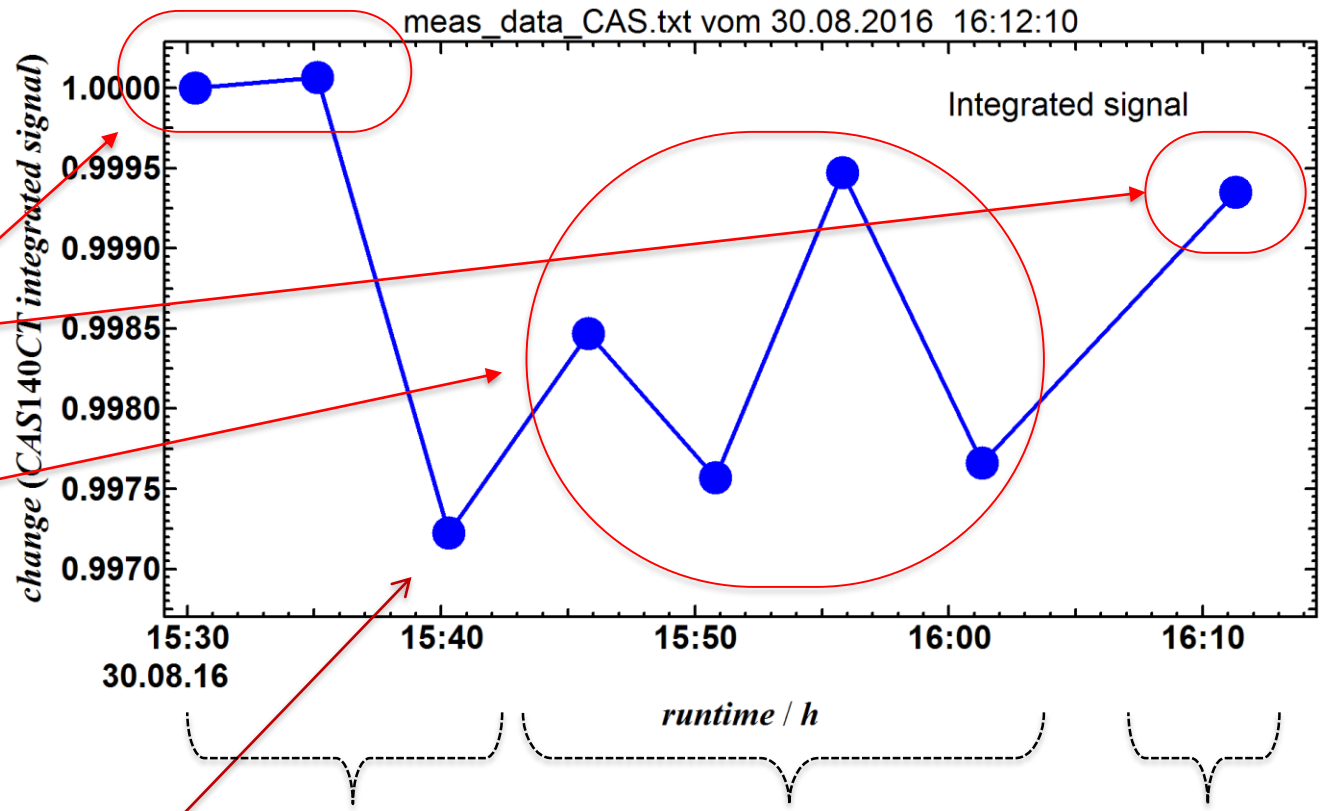
Reduction of 0.08%

REPEATABILITY – RE-INSERTIONS

Integrated signal
280 nm – 420 nm

0.06 % difference

Changes expected



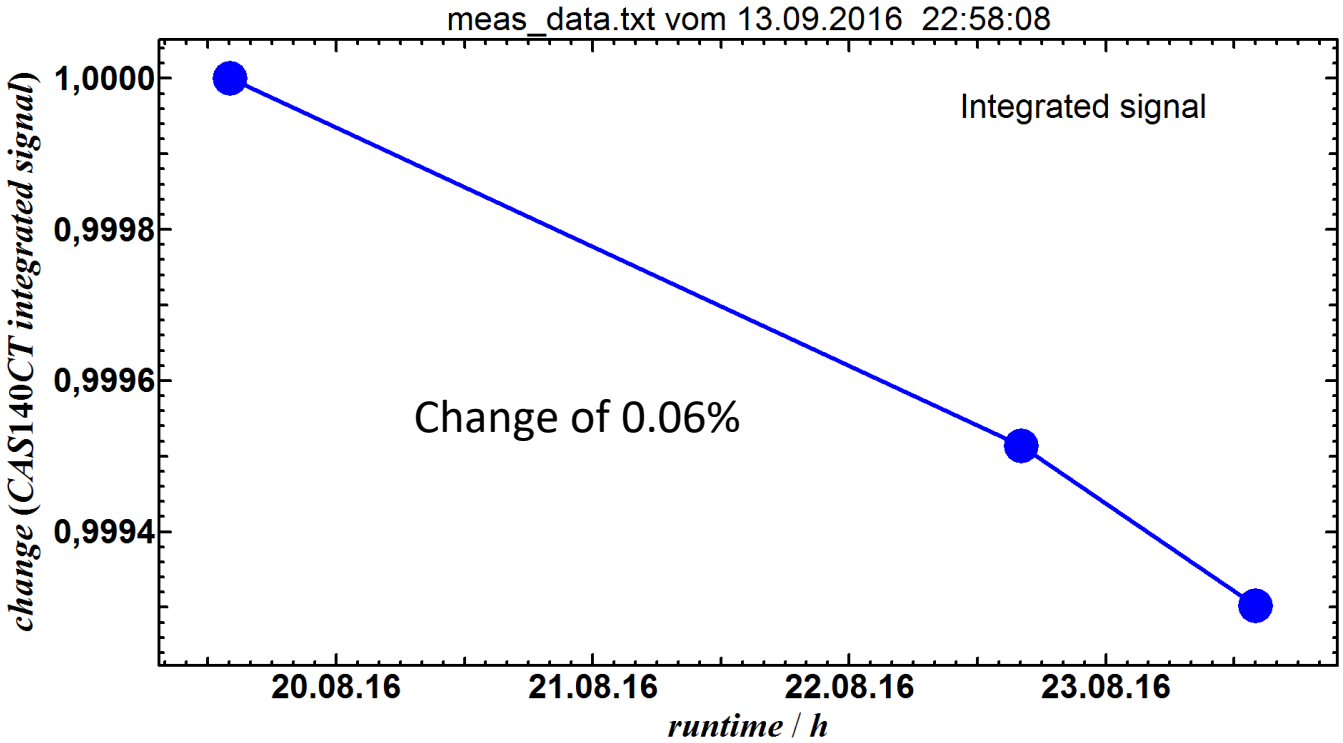
Probable misalignment
due to test tube shortness

Re-insertions

Re-insertions + rotations ±90°

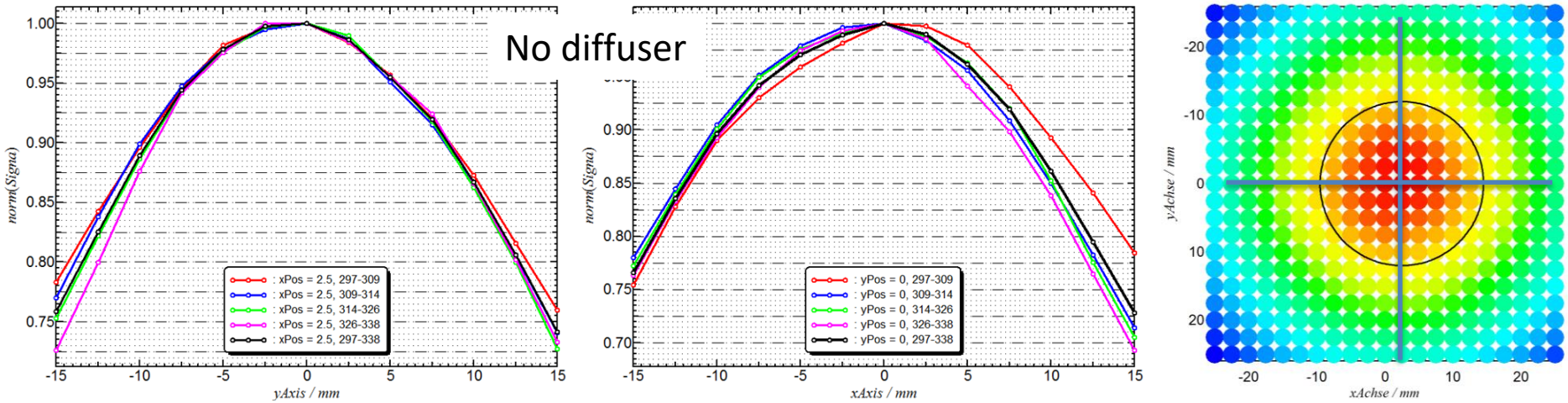
Re-insertion

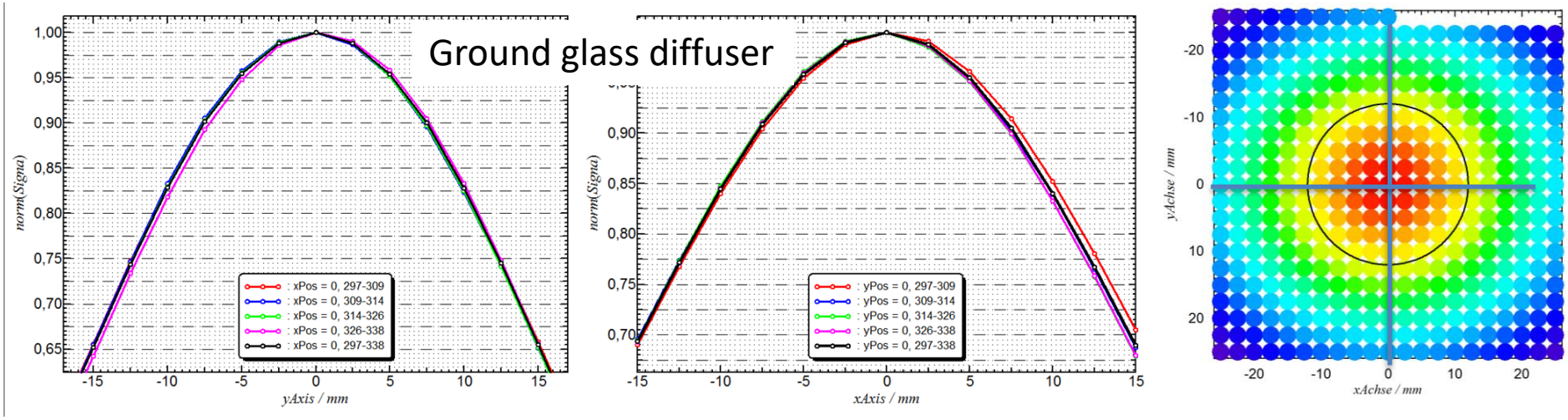
REPEATABILITY OVER 3 DAYS – FREE SPACE CONFIGURATION



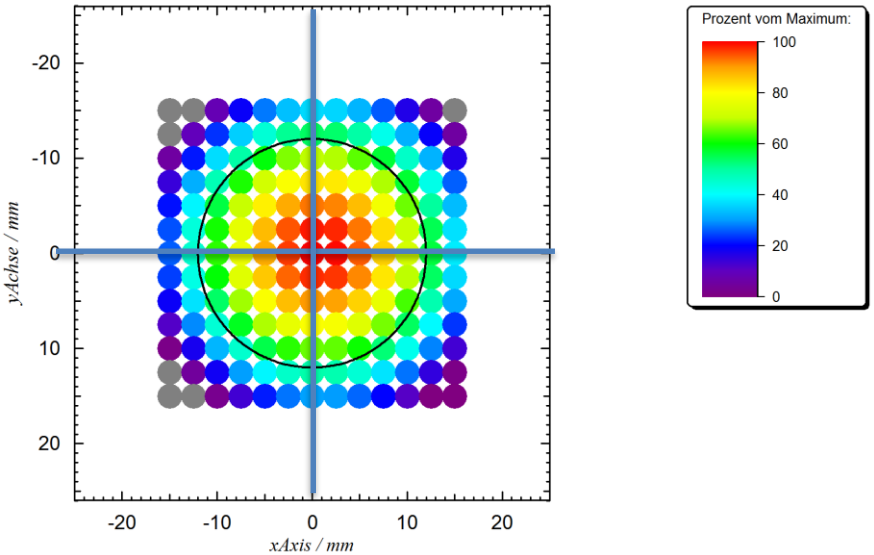
Project target isa 0.5% stability !

9-ELEMENT LED, SPATIAL VS SPECTRAL UNIFORMITY





SPATIAL AND SPECTRAL UNIFORMITY



An example using strong diffuser. It turned out to be transmitting insufficient amout of radiation. Thus weaker fused silica diffuser isa used instead.