StarDICE @ OHP

LSST - France : Calibration photométrique

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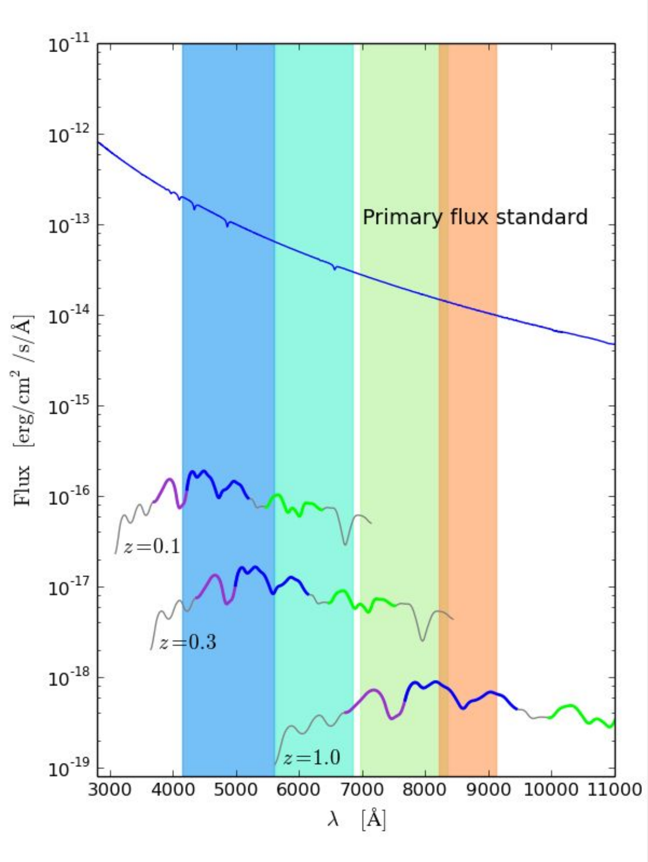
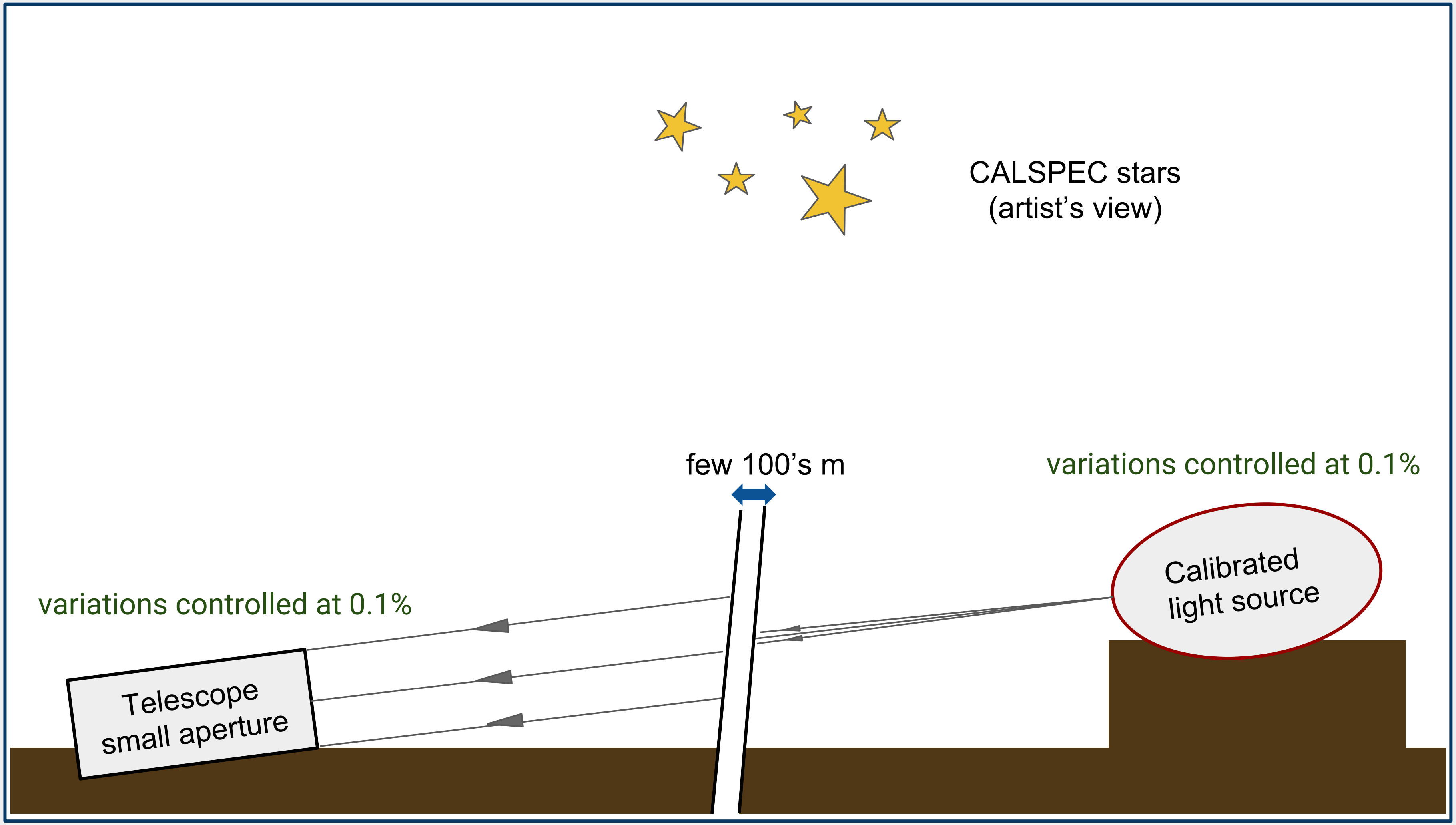
StarDICE experiment: Some reminders

- Currently 0.5 % uncertainty on broadband SNe Ia flux in the optical range
- Coming from uncertainty on WD primary flux standards
- Necessity to lower this uncertainty to 0.1%
- Difficult to do with theoretical modelizations : stars are complex objects



→ Confront astrophysical and laboratory standards flux calibration

Idea : Use a point-like source on site



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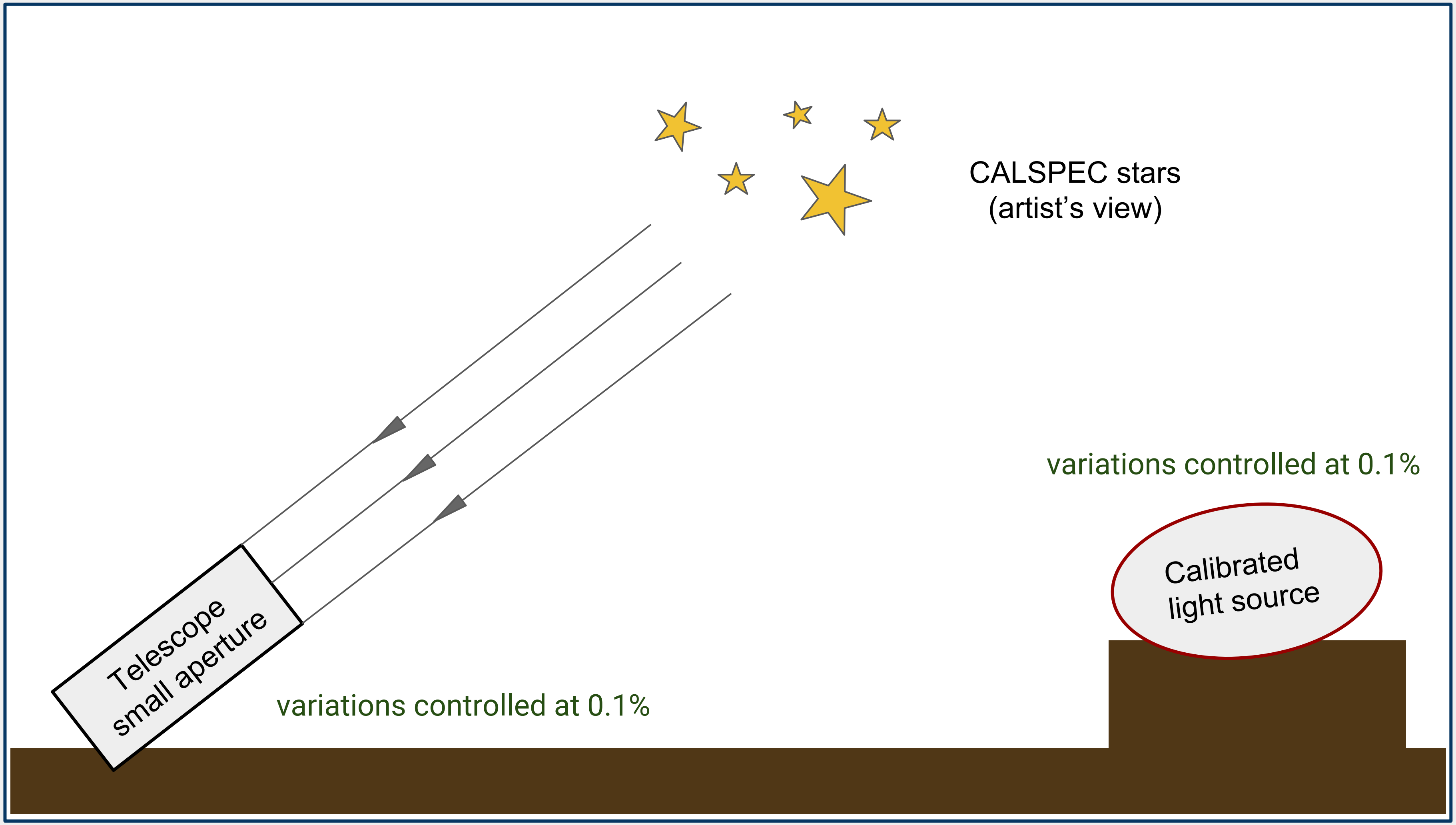

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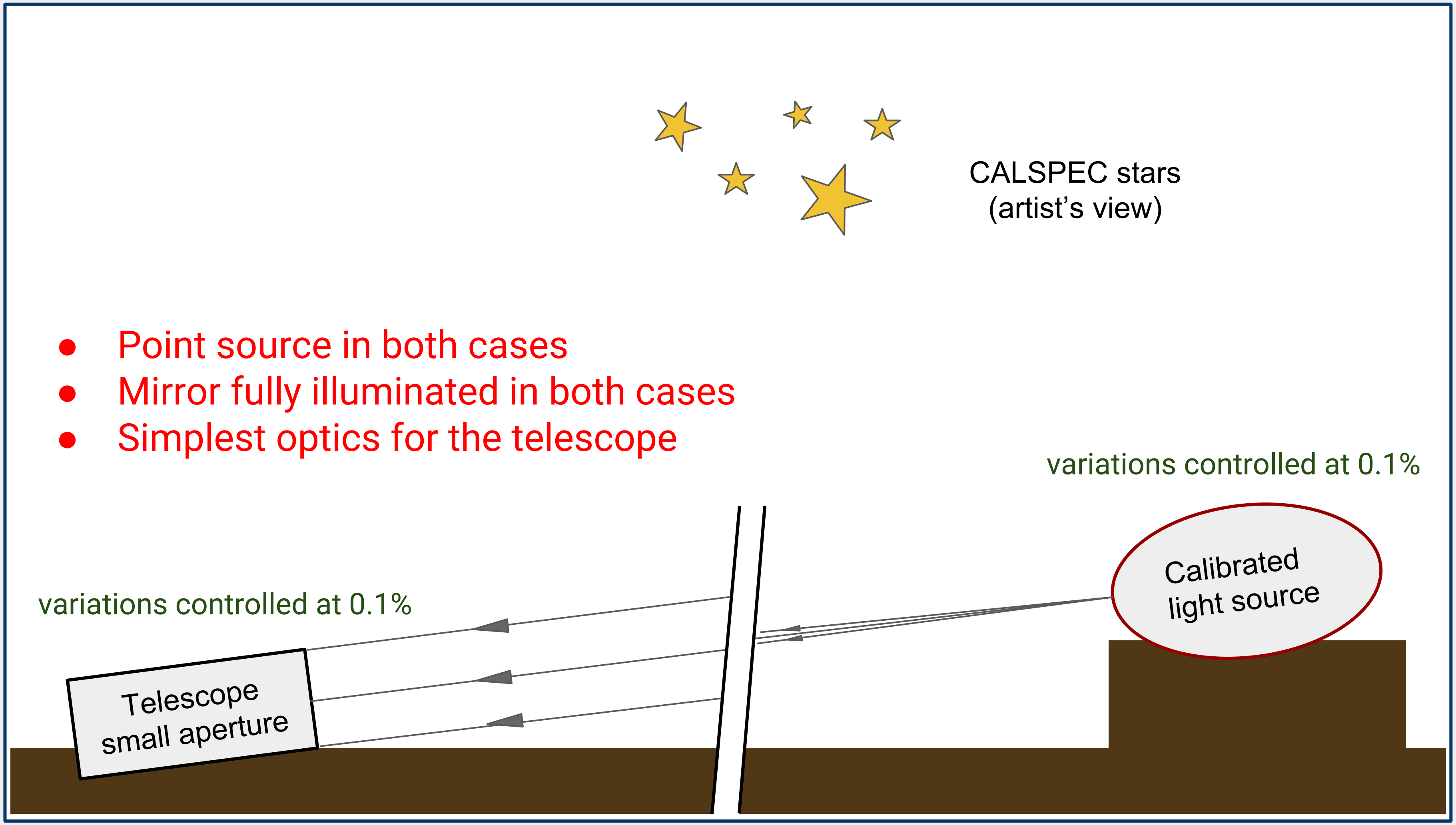
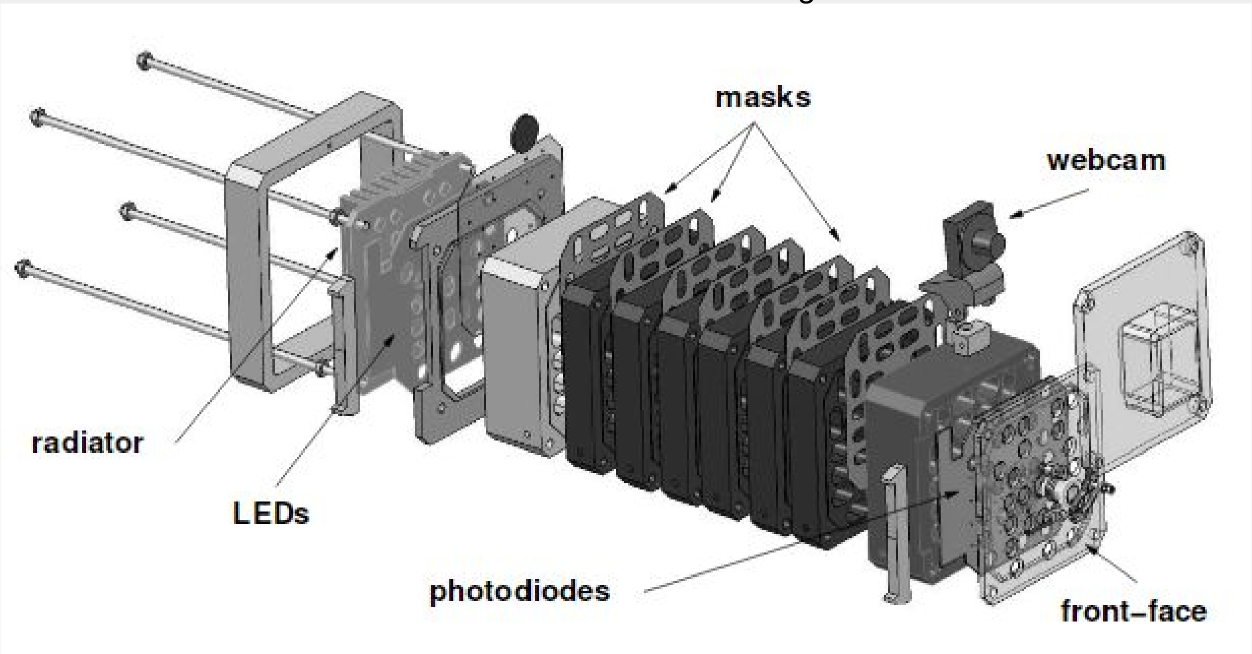


- Point source in both cases
- Mirror fully illuminated in both cases
- Simplest optics for the telescope

The source : DICE

Regnault et al.2015



- 24 LEDs ($d\lambda/\lambda$ = 7%) from near-IR to near-UV
- Temperature, iLED (...) are monitored

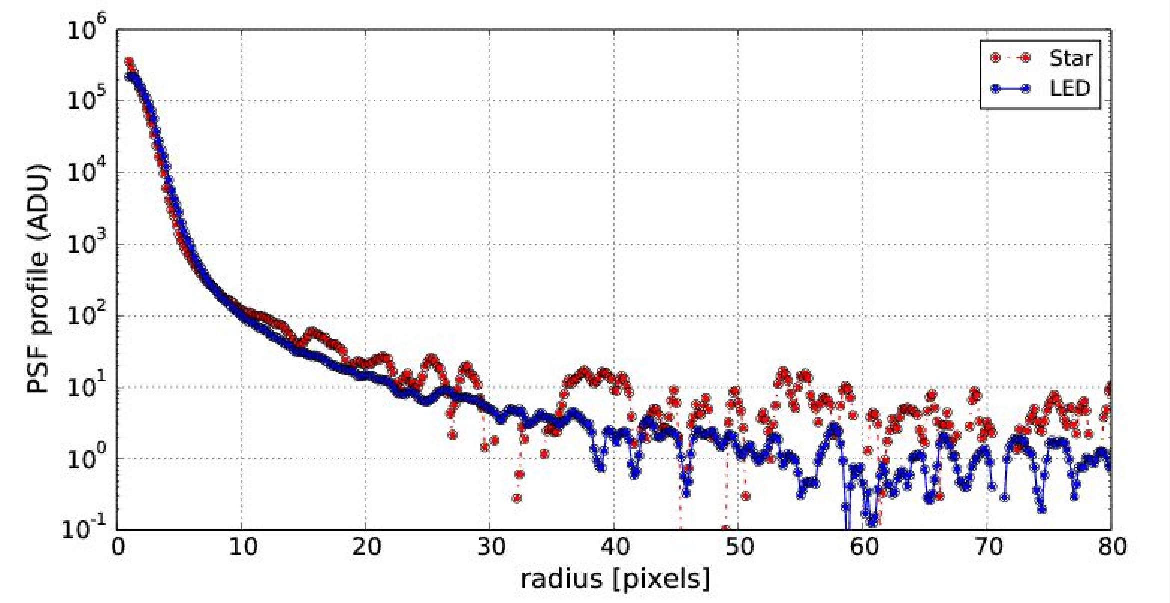
The detector

Newton telescope
Mirror reflectivity in computation

Fully characterized (QE + filters transmission ...)
Gain stable at the 0.05% level

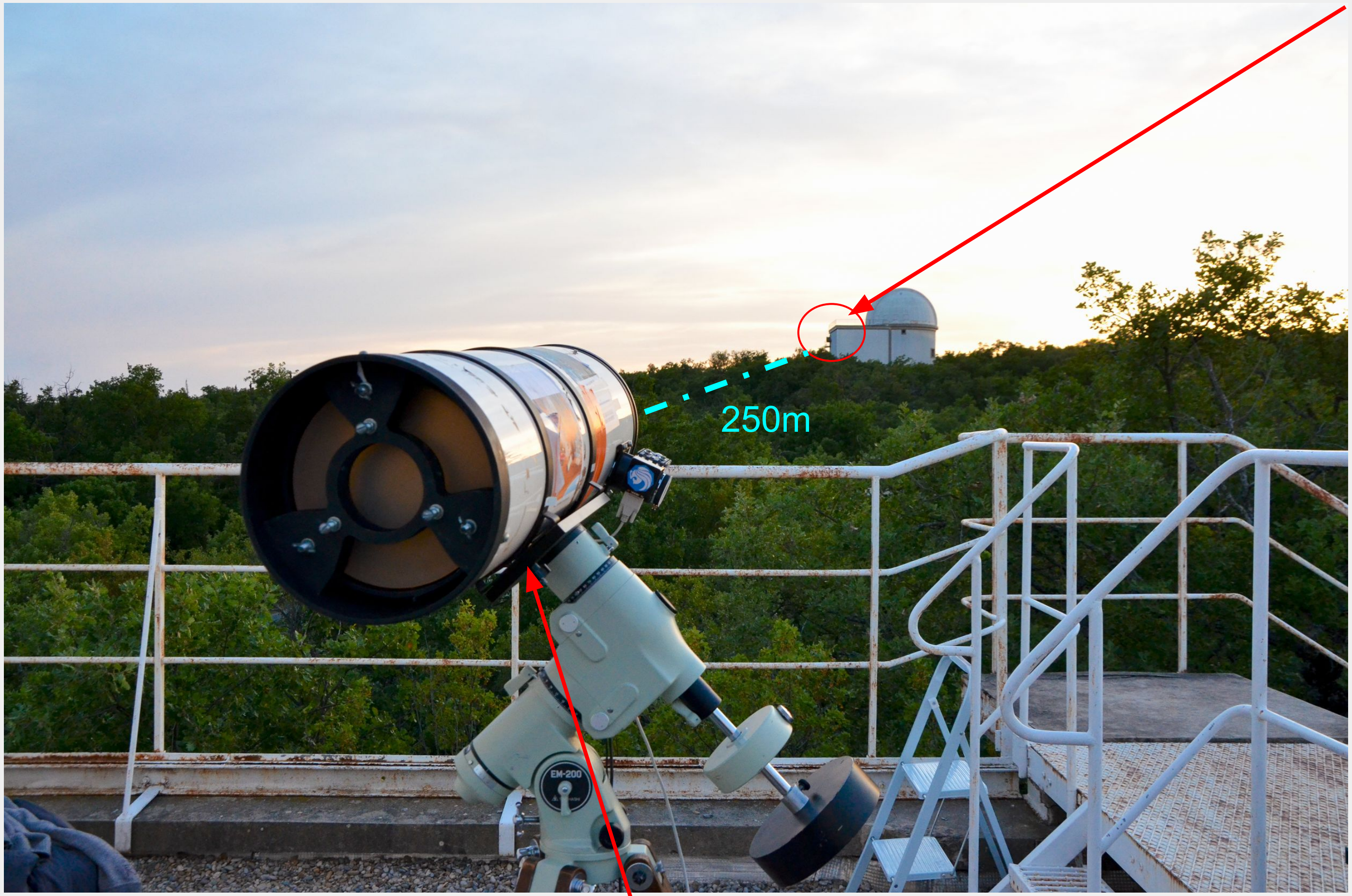
2016/05 : First Run @ OHP

Proof of concept : choose at convenient site to observe our LEDs as point-like sources.



LEDs and stars have similar shapes

07/07/2016 : Second Run



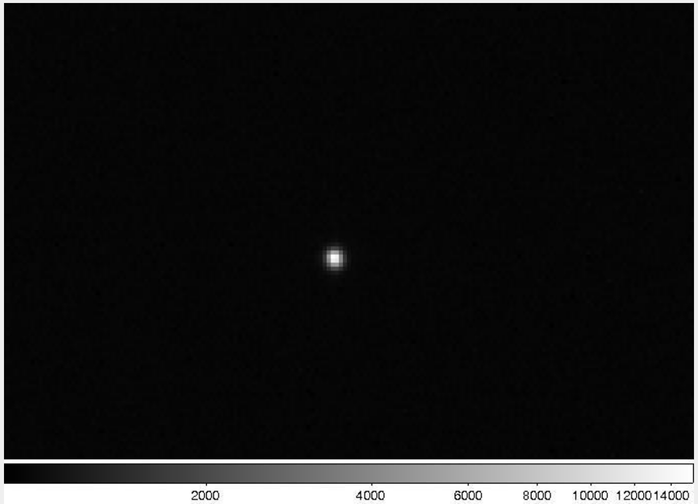
Dataset

- We took tens of images of each LED supplied with low currents : mag > 6

Image of LED #1

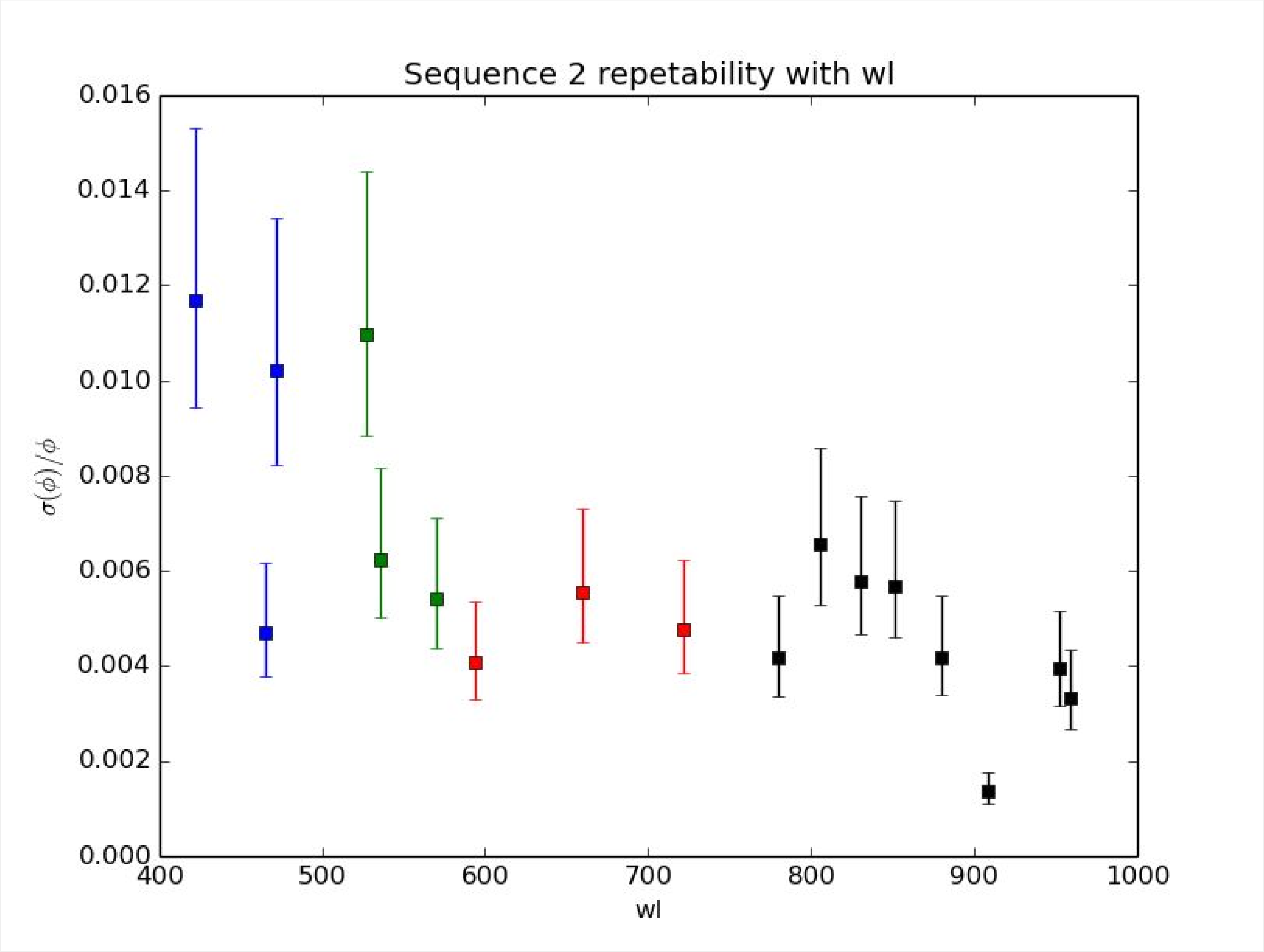
- We took tens of images of a CALSPEC star : HD165459 - V mag = 6.9

Image of HD165459



First results : stability

Each point : variability of a given LED over 10 measurements



Stability of the full line of sight : 0.5%

Reminder of the goal

Compare, in a given filter:

atmospheric transmission, a model for a specific night brought by S. Dagoret-Campagne

$$\varphi_{star} = \int \lambda A(\lambda) T(\lambda) S_{star}(\lambda) d\lambda$$

Instrument transmission

Star SED

$$\varphi_{LED} = \int \lambda A'(\lambda) T(\lambda) C(\lambda, T) d\lambda$$

atmospheric transmission along the line of sight ~1

LED SED, unknown temperature dependency

Reminder of the goal

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Instrument transmission

Star SED

Current work

$$\varphi_{LED} = \int \lambda A'(\lambda) T(\lambda) C(\lambda, T) d\lambda$$

atmospheric transmission along the line of sight ~1

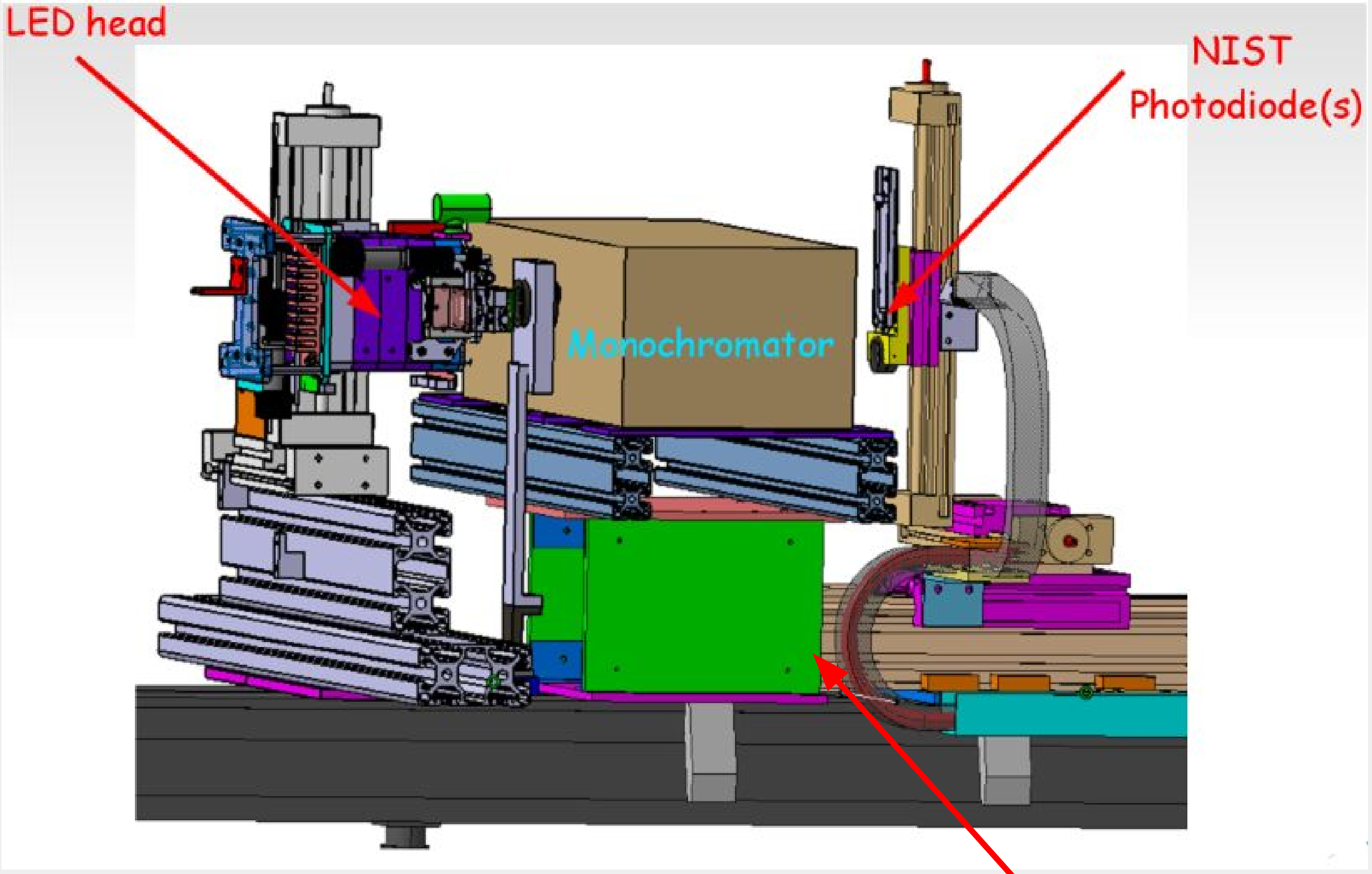
LED SED, unknown temperature dependency

DICE originally designed for another purpose

Original design	Current purpose
Produce flat calibration frames for MegaCam	Make an artificial star of Mag > 6
Required intensity (iLED):	Required intensity (iLED):
~10 mA	~10 µA
	Lowest possible current (at the expense of its stability)

Calibration of the low-flux source

Step 1 : Calibration bench



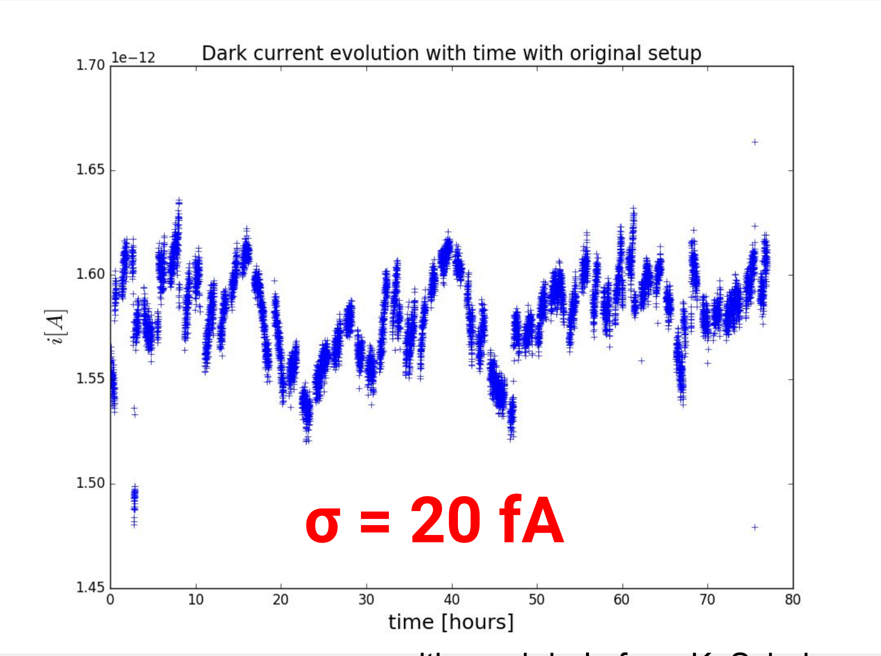
Bench also originally designed for 1000x higher fluxes

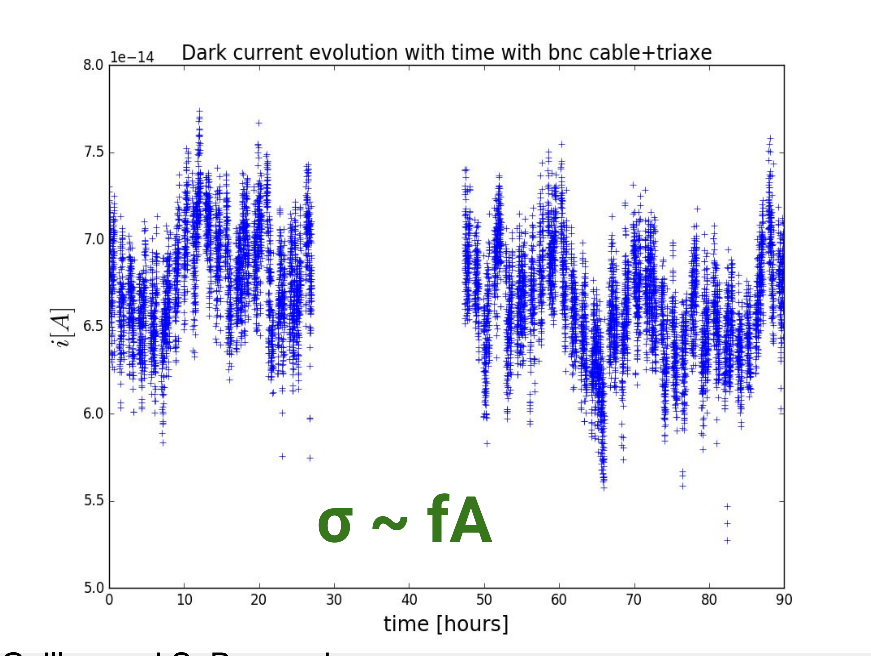
Bench noise improvements

Measurements of the dark photo-current produced by the NIST photodiode

pedestal level ~ pA

pedestal level ~ 50 fA





with much help from K. Schahmaneche, L. Le Guillou and S. Bongard

Signal : O(10pA) for LEDs at low fluxes → noise/signal < 0.1% with this bench

Step 2 : Temperature dependence

- Obtain a spectrophotometric model of the LEDs at OHP's night typical temperatures

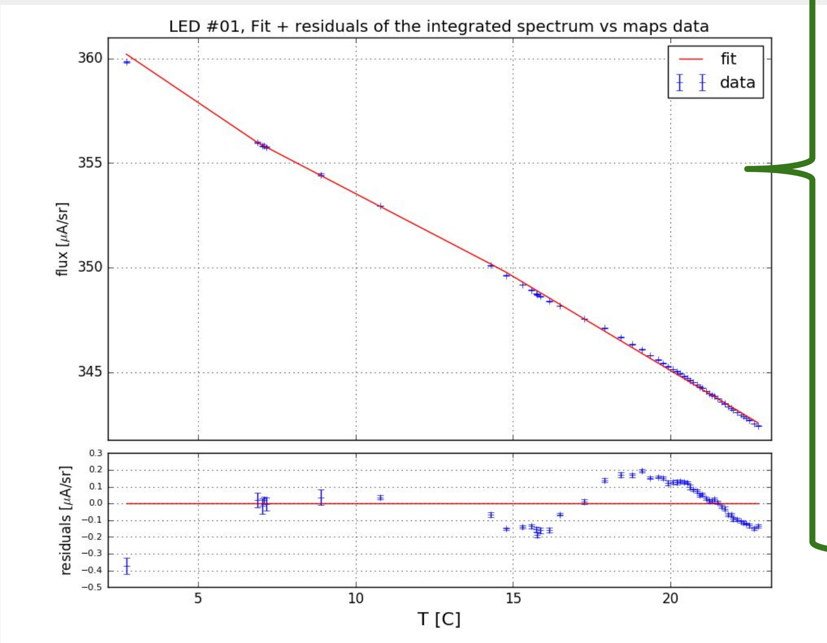
$$C(\lambda, T)$$

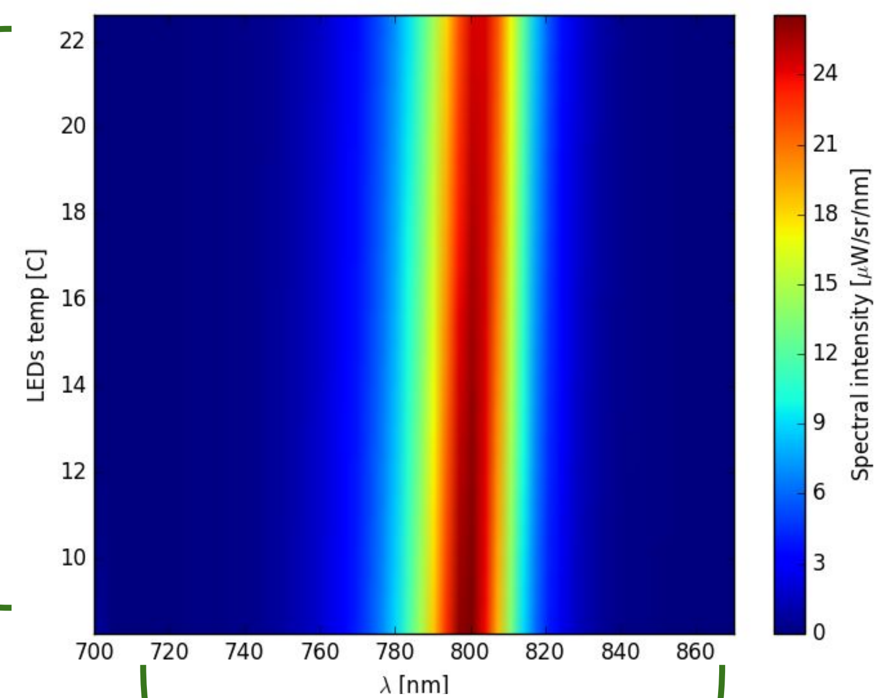
- Problem : Cooling the LED-head at temperatures btw 10°C & 20°C w/o changing the temperature of the bench devices (monochromator & NIST)

- Solution : Using a Peltier cooler on the LED-head

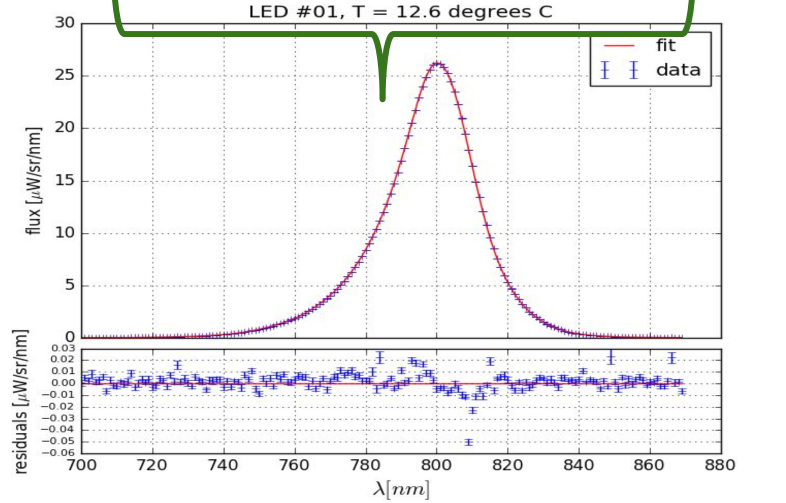
- Currently taking data from low flux LEDs:
  - Spectra at different T using a monochromator for the shape of the spectra.
  - Beam maps of the integrated flux at different T to get the normalization of the spectra.

High flux model





Flux evolution w/ temperature (integrated)



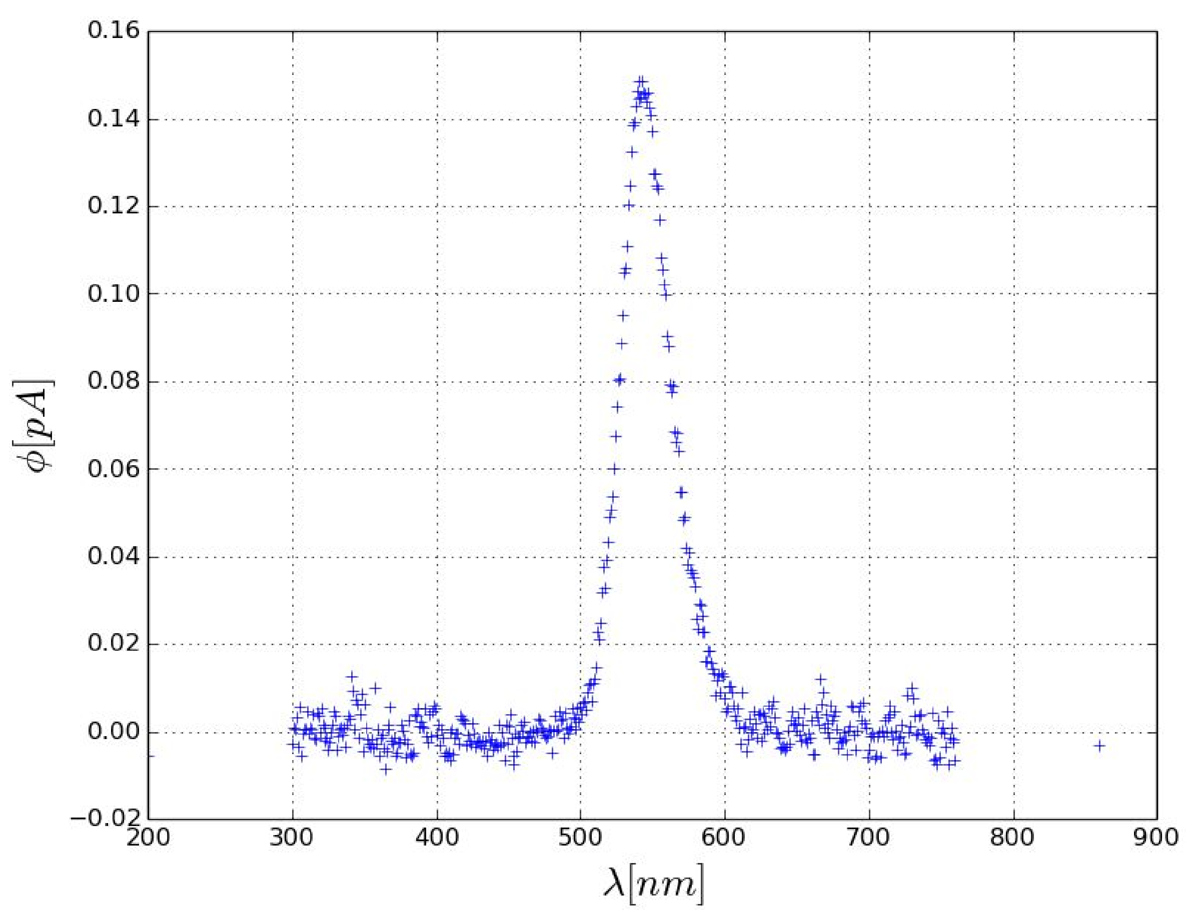
Evolution with wavelength (at 12.6°C)

An incomplete model at low flux

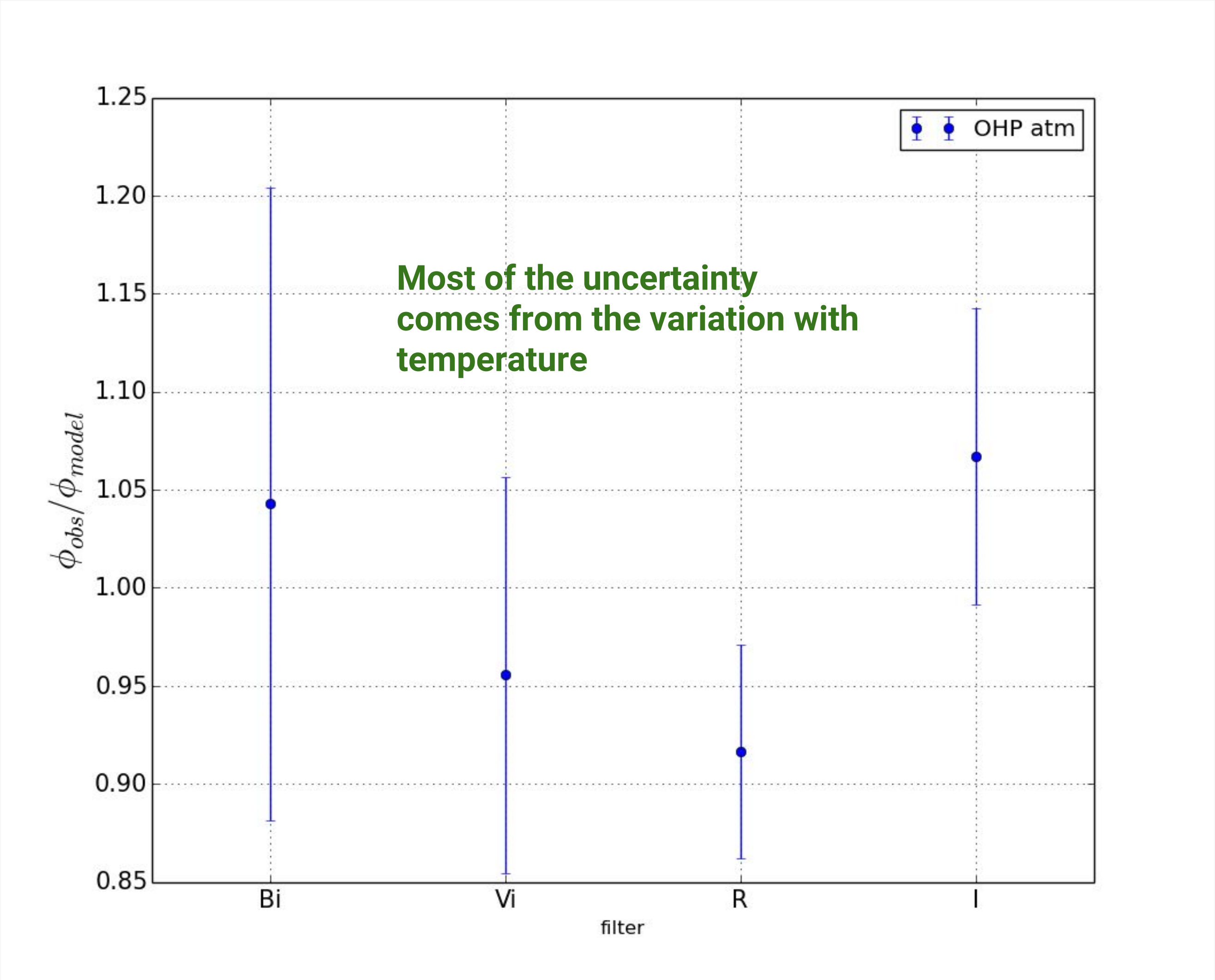
Currently taking measurements...

Typical example:

NIST photocurrent - flux of a LED through monochromator - dλ = 1nm



Comparison of the zeropoints



Conclusions

LED-CALSPEC flux comparison at ~10% → will be dramatically lowered at the end of the weak : **concept validated**

- Complete the spectrophotometric model (this week)
- Study of the atmosphere above the OHP site (3rd run, this spring)
- → Calibration at the % level (end 2017)
- R&D for a new low-flux stable light source
- Automation of the telescope-source system
  - New camera (just arrived) + new telescope (funded)