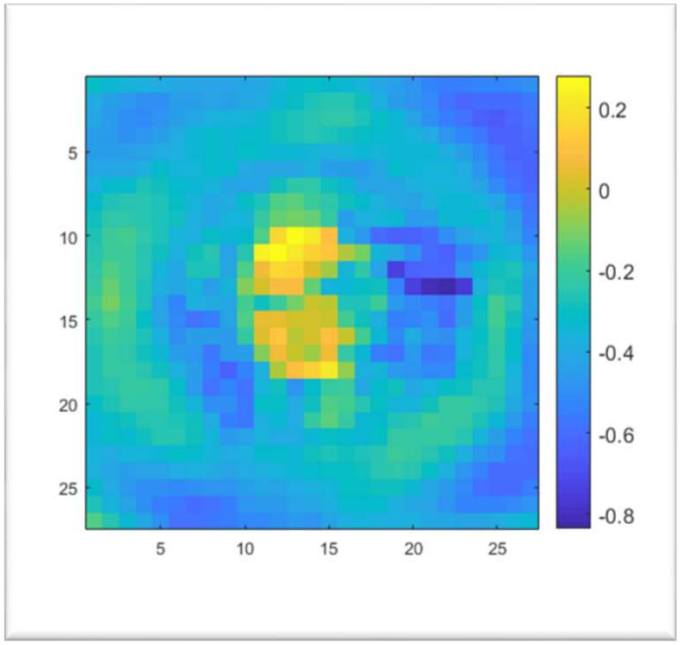


MegaCam filters measurements @ LMA

B. SASSOLAS, B. LAGRANGE, D. FOREST, L. PINARD, D. HOFMAN, G. CAGNOLI,
Laboratoire des Matériaux Avancés – Villeurbanne

M. BETOULE, N. REGNAULT
LPNHE - Paris

Motivations

Technical developments of an optical bench for the transmission spectrum measurement on large optics

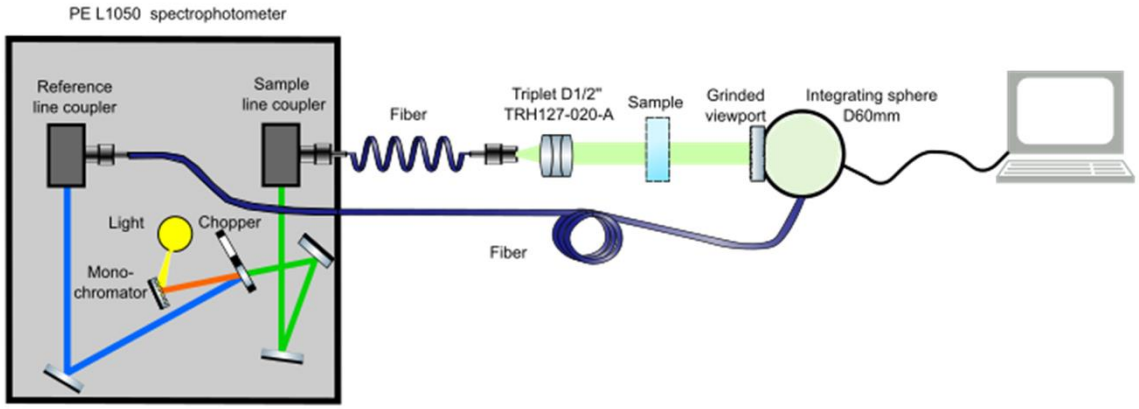
Full characterization of the optical response of the *ugriz* bandpass filters wrt :

- the location on the surface : optical response uniformity
- the angle of incidence (AOI): optical response shift

Assessment of the impact of the actual filter response on the observation

Experimental setups

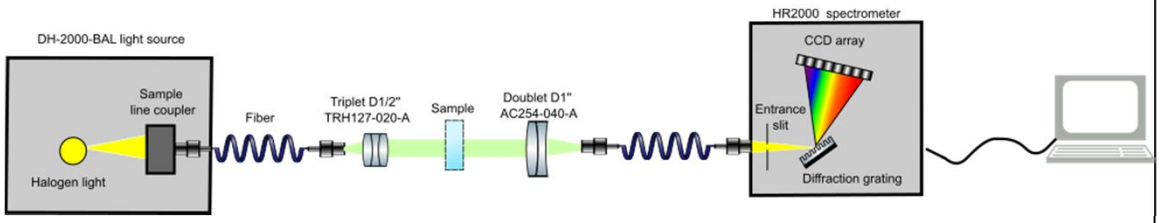
- **Perkin-Elmer L1050 setup**



Pros :
- High reliability
- 0.1 nm spectral resolution
- Wide spectral range (175-3300nm)
- Oblique incidence (integrating sphere)
- Wavelength calibration

Cons :
- Slow
- Low sensitivity (integrating sphere)

- **Ocean Optics HR2000+ setup**



Pros :
- Fast
- Compact
- Spectral range (300-1000nm)

Cons :
- Low SNR
- Normal incidence only (fibers alignment issue)
- Low spectral resolution

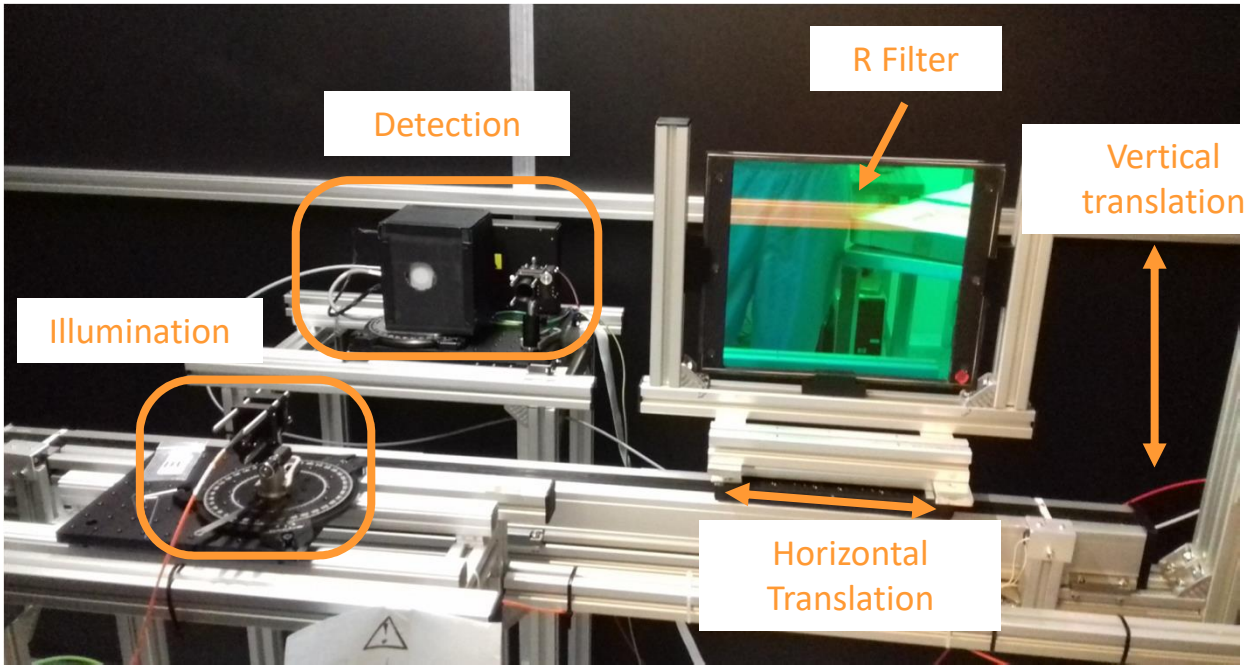
- Same illumination conditions in both setups (∅6mm pencil beam)
- Different characteristics but consistent results

→ In order to scan 5 filters over a 260x260mm² area we have to define a protocol using both configurations with some **trade-off between time, accuracy, relevance**.

Some pictures

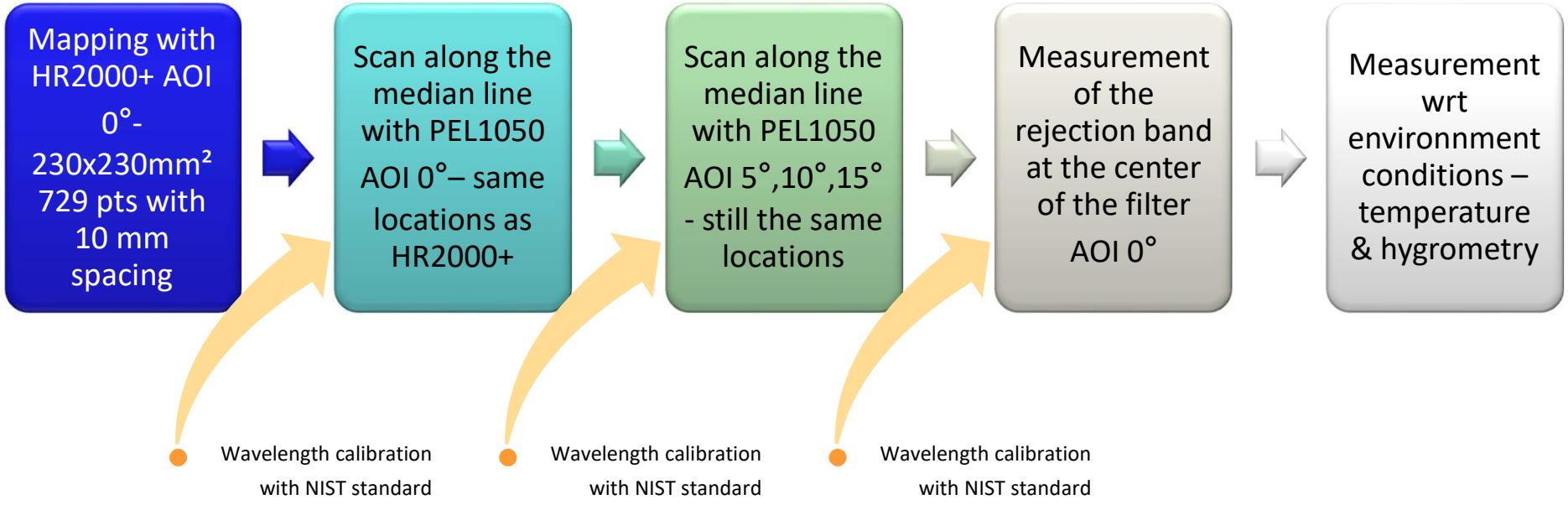
Mechanical frame inside the ISO3 cleanroom

Bench enclosure

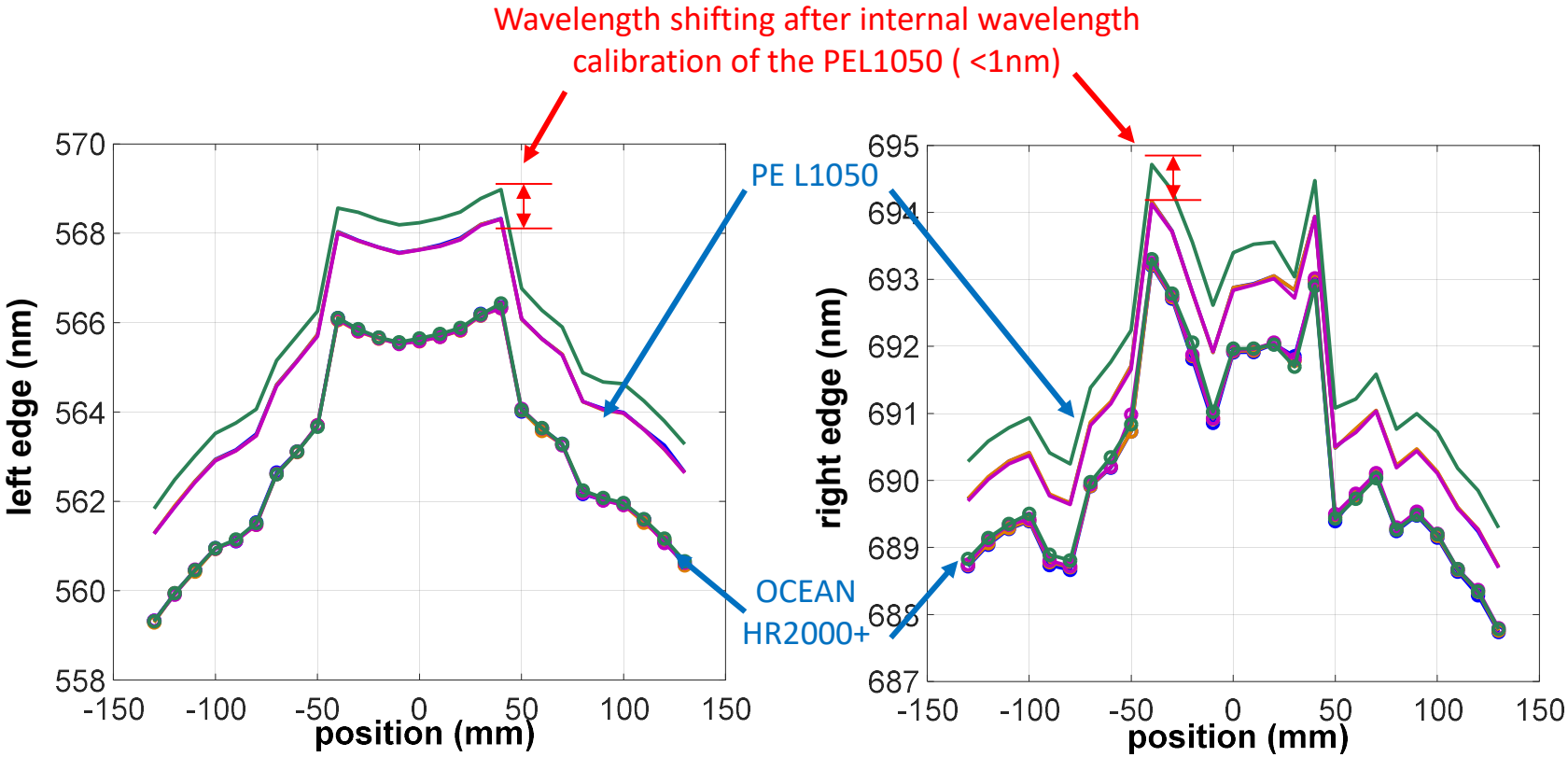


R-filter and optical setups

Measurement protocol outline

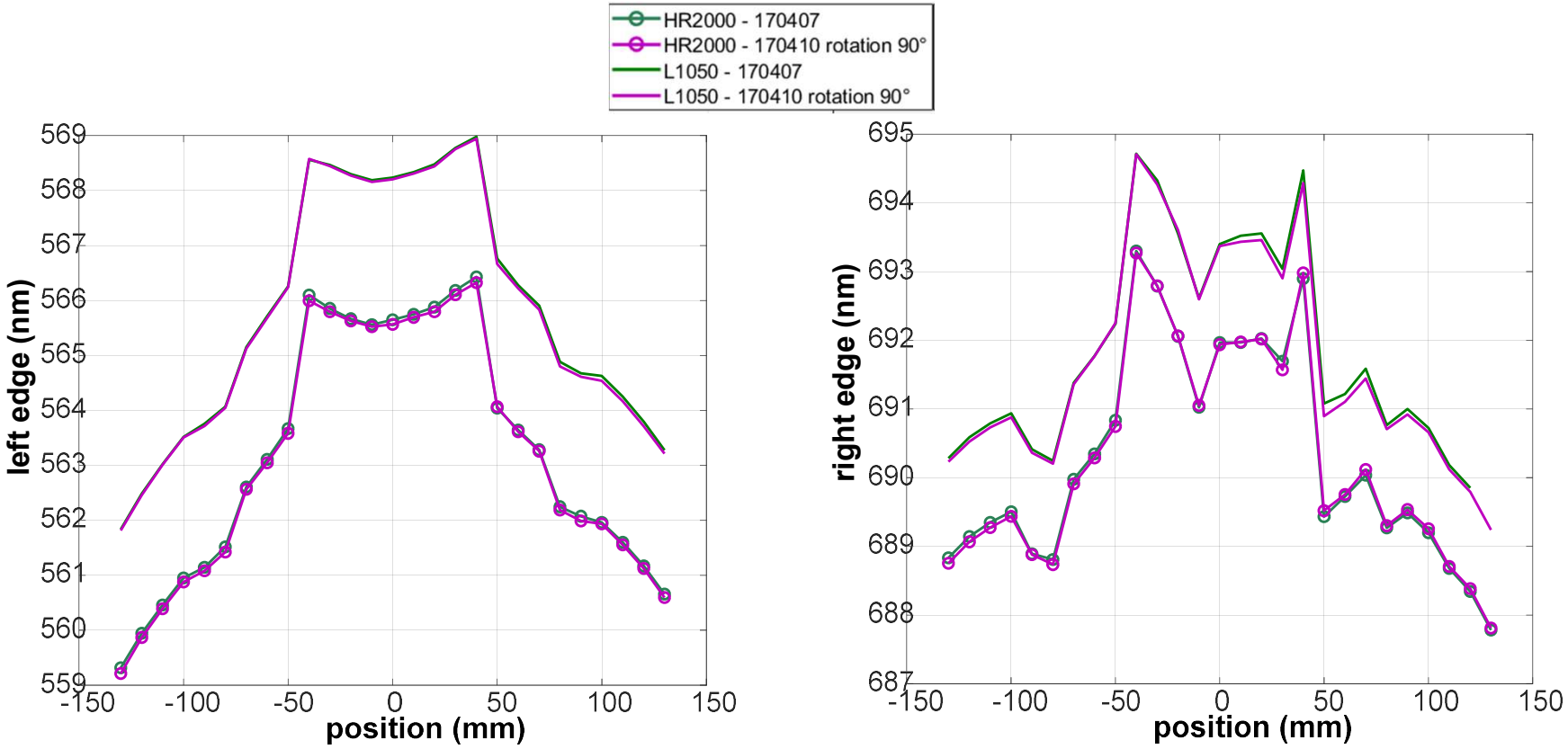


Comparison btw OCEAN HR2000+ and PE L1050 setups at AOI 0°



- R-Filter measured along the median at 4 different days with both setups
- Installation and alignment on the first day only
- Reproductibilty < +/-0.1Å and < +/-0.05Å for OCEAN HR2000+ and PE L1050 setups respectively
- Wavelength calibration with a standard is mandatory to achieve subnanometer wavelength accuracy and reproductibility

Alignment and positioning procedure reliability

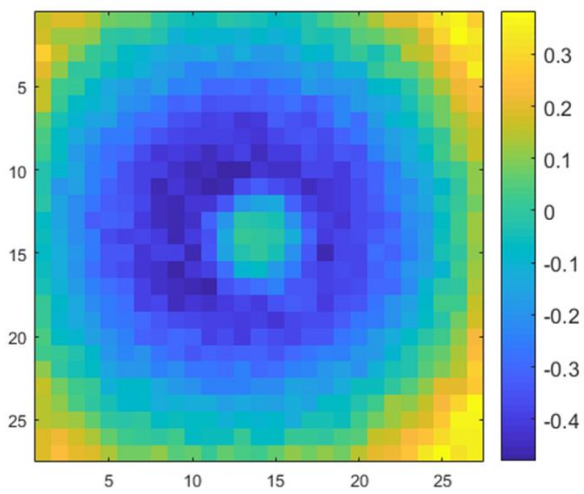


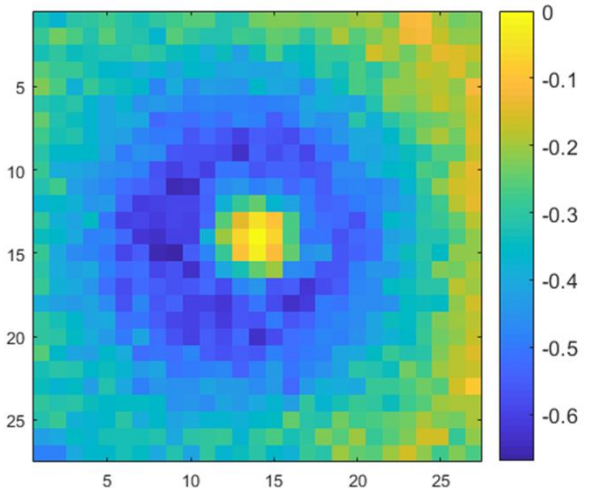
- R-filter same median measured twice (before and after 90° rotation) at normal incidence
- Alignment performed for each filter installation
- Reproductibilty < +/-0.1Å for OCEAN HR2000+ and PE L1050 setups

Uniformity of the bandpass edges positions

Left edge | **Right edge**

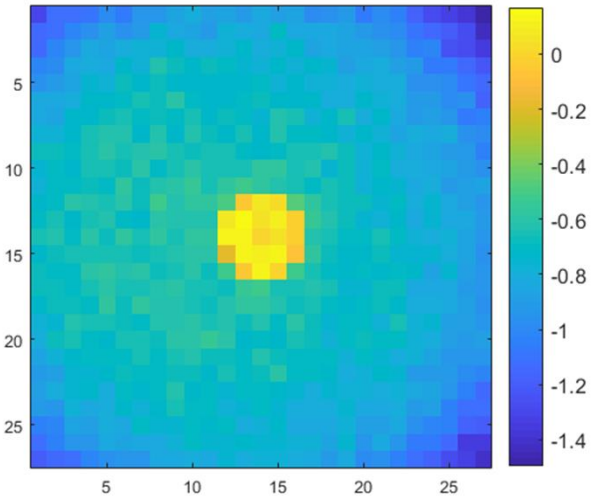
U-band

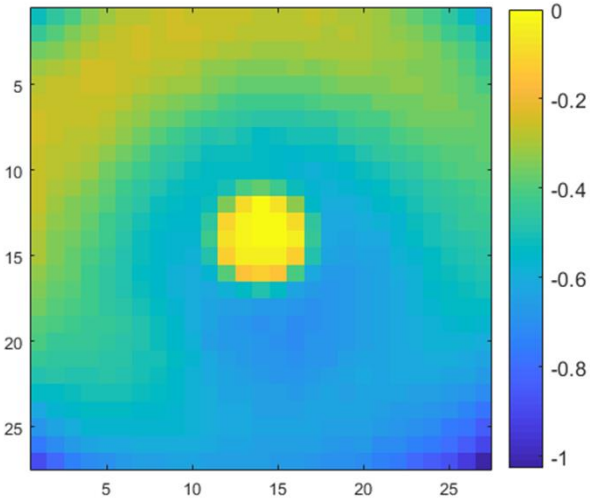




Left : ~0.8% PTV
Right : ~0.7% PTV

G-band





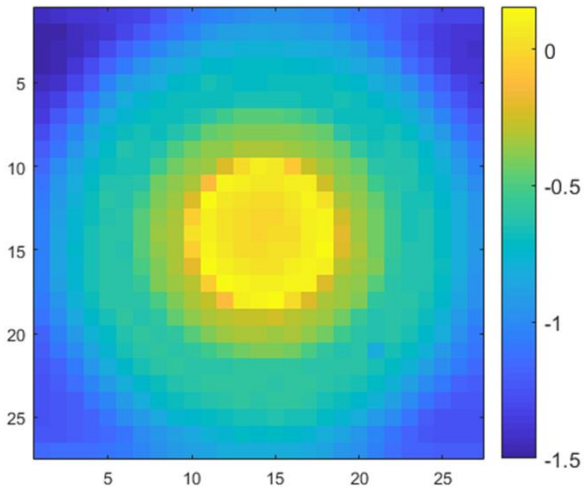
Left : ~1.5% PTV
Right : ~1% PTV

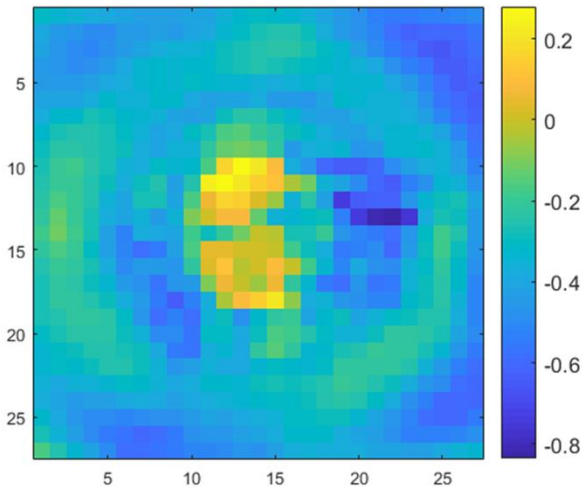
Colorbar unit in %

Uniformity of the bandpass edges positions

Left edge | **Right edge**

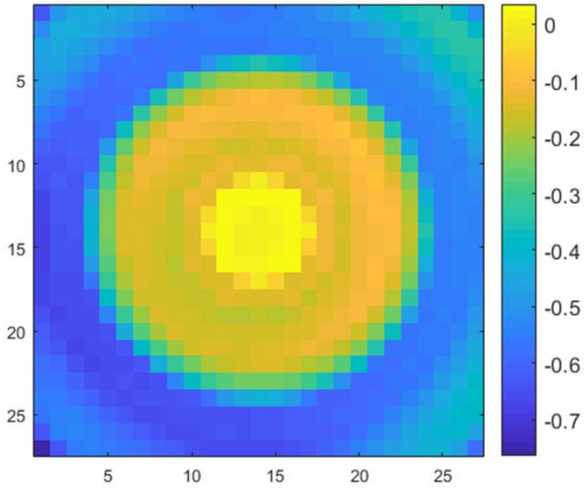
R-band

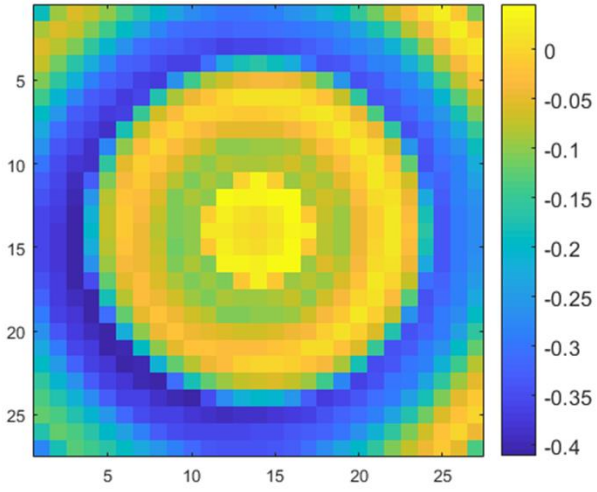




Left : ~1.5% PTV
Right : ~1% PTV

I2-band





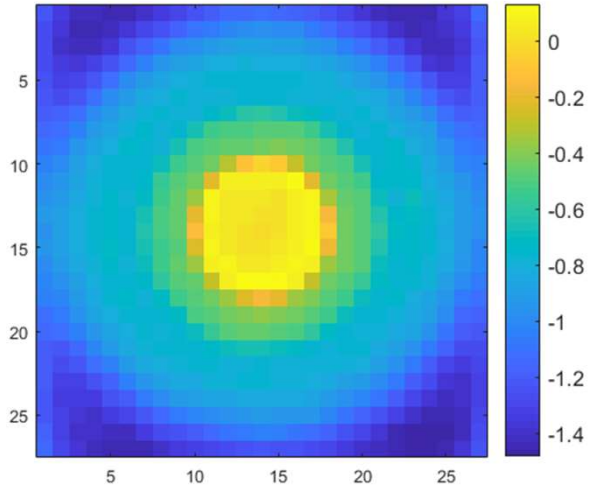
Left : ~0.8% PTV
Right : ~0.4% PTV

Colorbar unit in %

Uniformity of the bandpass edges positions

Left edge

Z-band



Left : ~1.5% PTV

Conclusions :

- The edge position dependence is mainly radial
- Small deviations are well highlighted as for the right edge of the *r* filter
- The left and right edge variations look independent

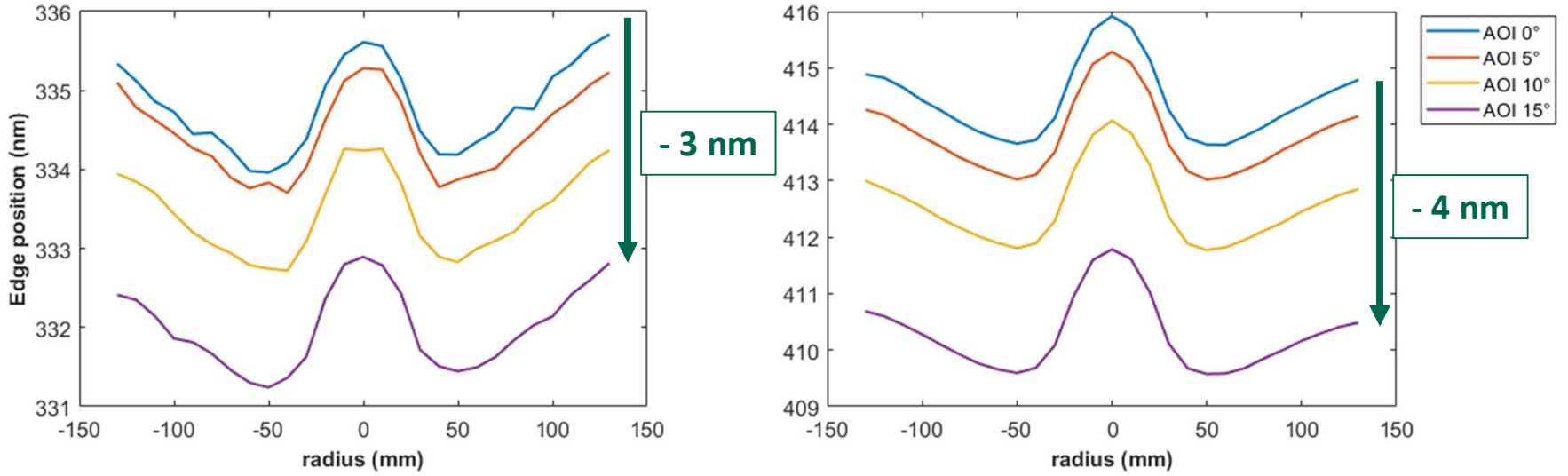
  Bandpass filter structure = a longwave-pass filter +shortwave-pass filter ?

Colorbar unit in %

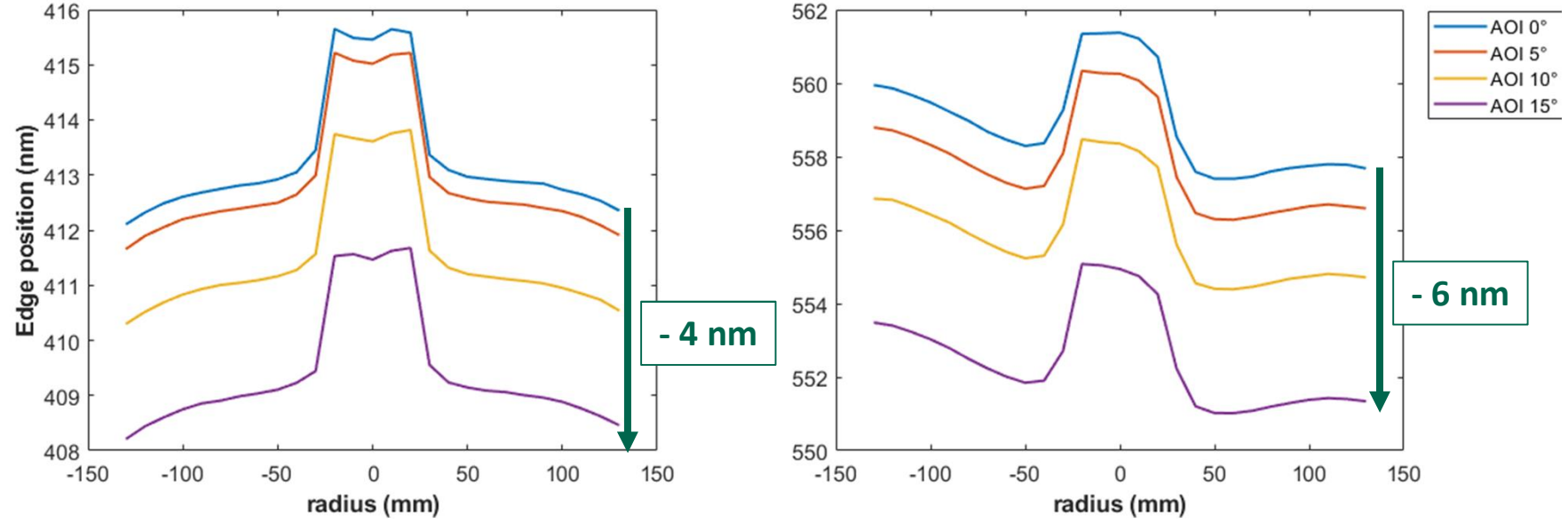
Evolution wrt AOI

Left edge | **Right edge**

U-band



G-band

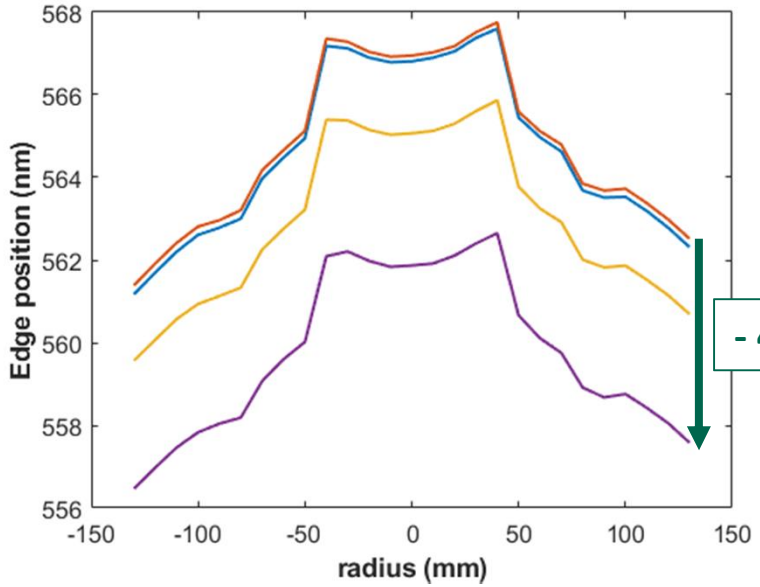


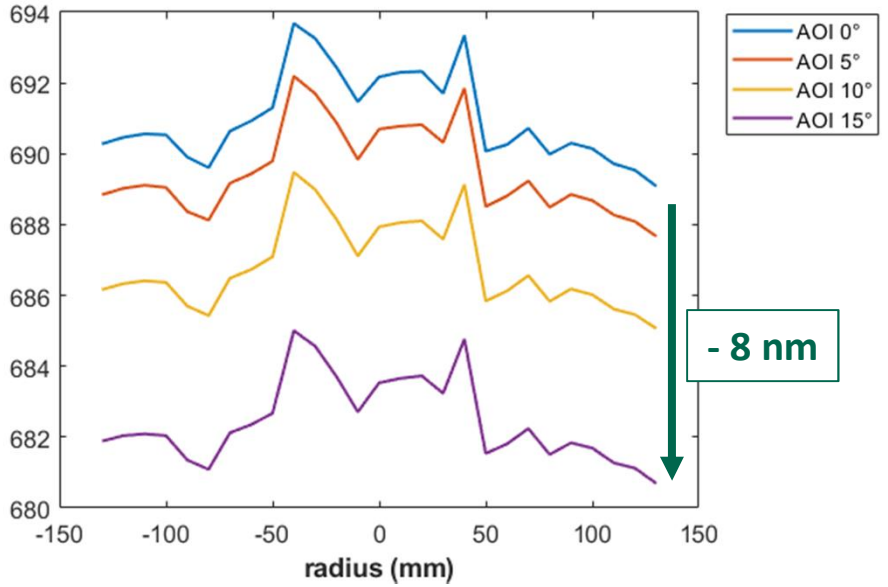
Wavelength corrected thanks to the Didymium standard

Evolution wrt AOI

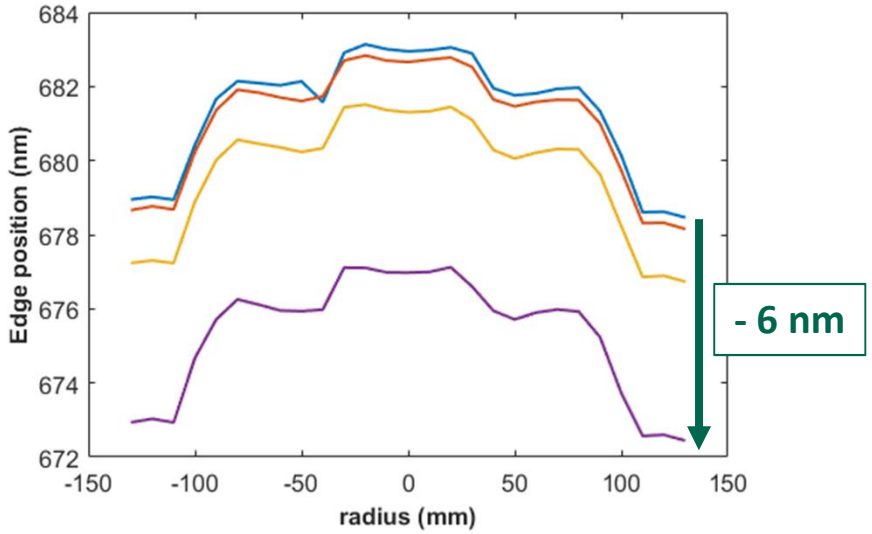
Left edge | **Right edge**

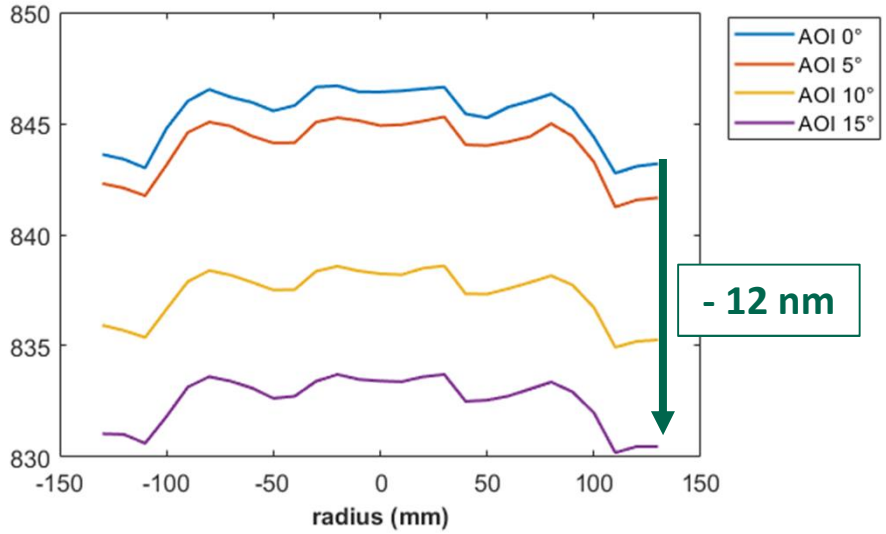
R-band





I2-band

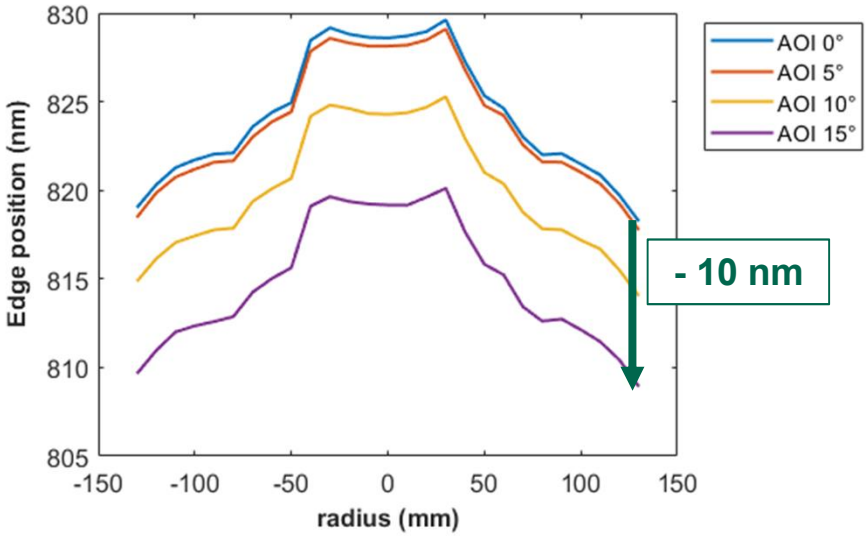




Wavelength corrected thanks to the Didymium standard

Evolution wrt AOI

Z-band



Wavelength corrected thanks to the Didymium standard

Conclusions :

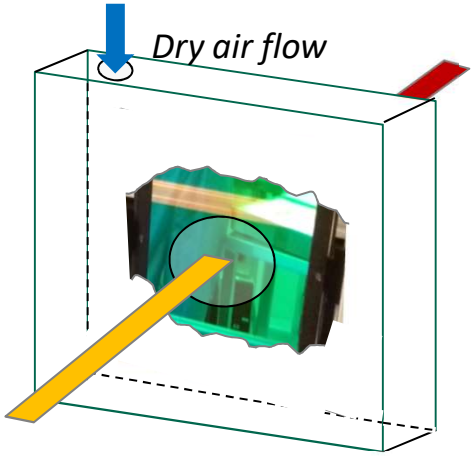
- The variation profile along the median is not impacted by the change of AOI
- Typical blueshift of the bandpass position with increasing AOI
- Uneven shape of the R-band profile confirmed with the L1050 setup

  ➡ Consistent with the uniformity map measured with the HR2000+ setup
- Different sensitivities of the left and right edges according to the AOI

  ➡ Consistent with a longwave-pass filter / shortwave-pass filter structure

Air humidity influence

- Coating can be sensitive to the humidity : wavelength shifting wrt to humidity
- Humidity in the cleanroom and at the summit are very different : ~50% vs ~0% resp.
- Measurement of the bandpass shift in dry conditions : filter installed in an enclosure with dry air flow



Transmission spectrum measured at the filter's center (through viewport)

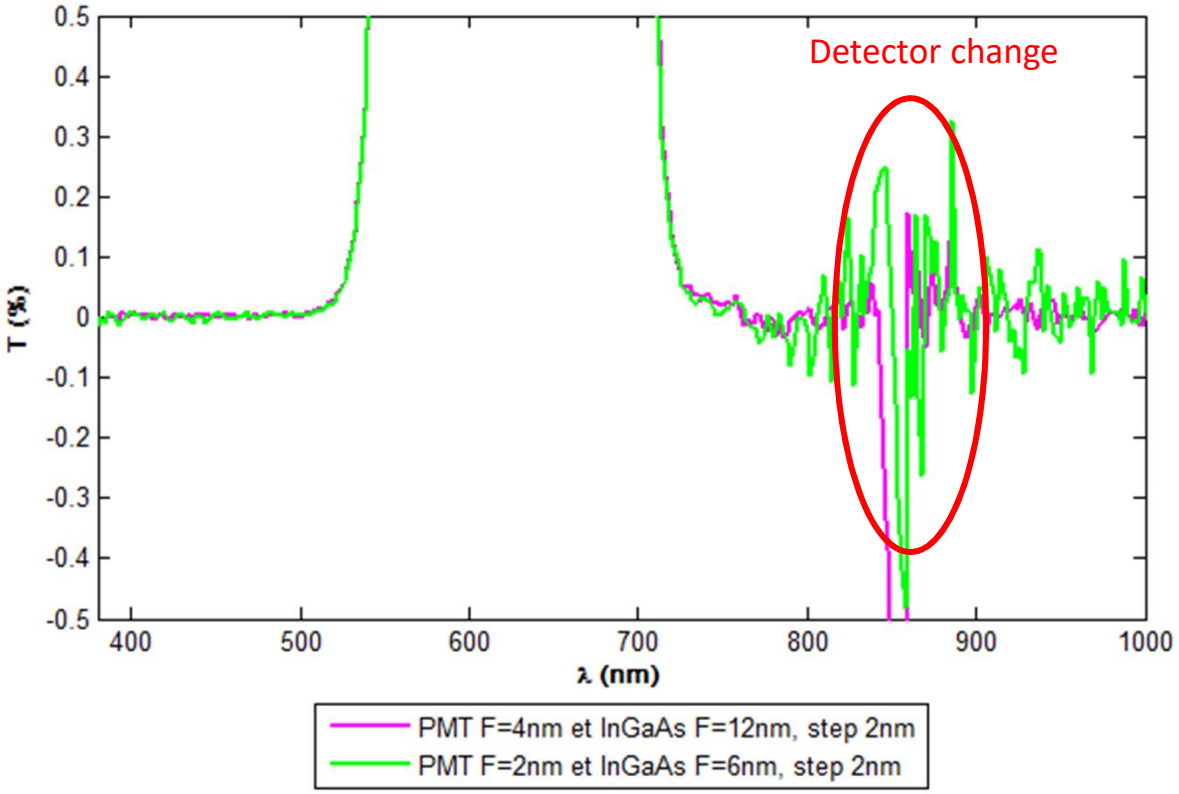
	u		*g*		*r*		*i2*		*z*	
Relative Humidity	**50%**	**1%**	**50%**	**1%**	**50%**	**1%**	**50%**	**1%**	**50%**	**1%**
Left edge (nm)	335.51	335.51	415.77	415.76	566.69	566.69	683.49	683.49	831.45*	831.58†
Right edge (nm)	411.20 *	411.20 *	564.45	564.44	692.06	692.09	843.59	843.59		

The measurements were carried out with the HR2000+ setup at the center of the filters. No wavelength correction have been applied. Results are given here with ±0.01 nm rms, except for results with * and whith † which are ±0.02 nm rms and ±0.03 nm rms respectively.

➡ **Bandpass position not sensitive to the humidity**

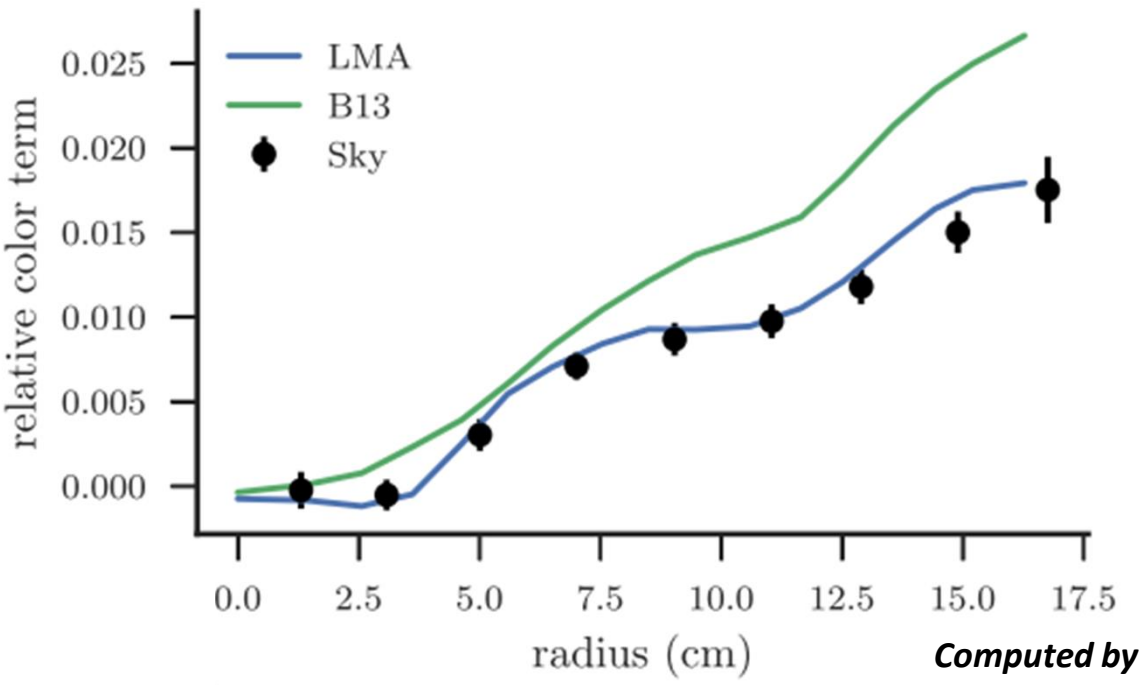
Light leaks measurements

R-filter



- Leaks measurements in the 380-500nm range is straightforward
- Some issue near 860 nm due to low signal (low efficiency) of the PMT
- Method to be optimized but the spectrophotometer does not stand fine tuning … still in progress

A relevant result for the Science



Computed by M. Betoule

Color terms between stellar measurements conducted at the center of the MegaPrime focal plane and a circular average of stellar measurements at other radii. This figure is an update of Figure 7 in Betoule et al. (2013). Dots figures actual on sky measurements while curves corresponds to expectations synthesized from the above model (blue) or the previously published transmission curves (green).

ToDo list

- Assessment of the temperature influence
- Light leaks measurements
- Delivery of the new release of the SNLS data taking into account the actual filter transmission maps
- Comparison between the performances achieved with the present setup and the requirements for LSST : experimental upgrades

SPARE SLIDES

Some definitions

The left and right edge positions for each spectral measurement are defined according to the equations (1) and (2) respectively

$$\lambda_l = \bar{\lambda} - \frac{\Delta\lambda}{2} \tag{1}$$

$$\lambda_r = \bar{\lambda} + \frac{\Delta\lambda}{2} \tag{2}$$

where $\bar{\lambda}$ is the central wavelength of the bandpass defined as

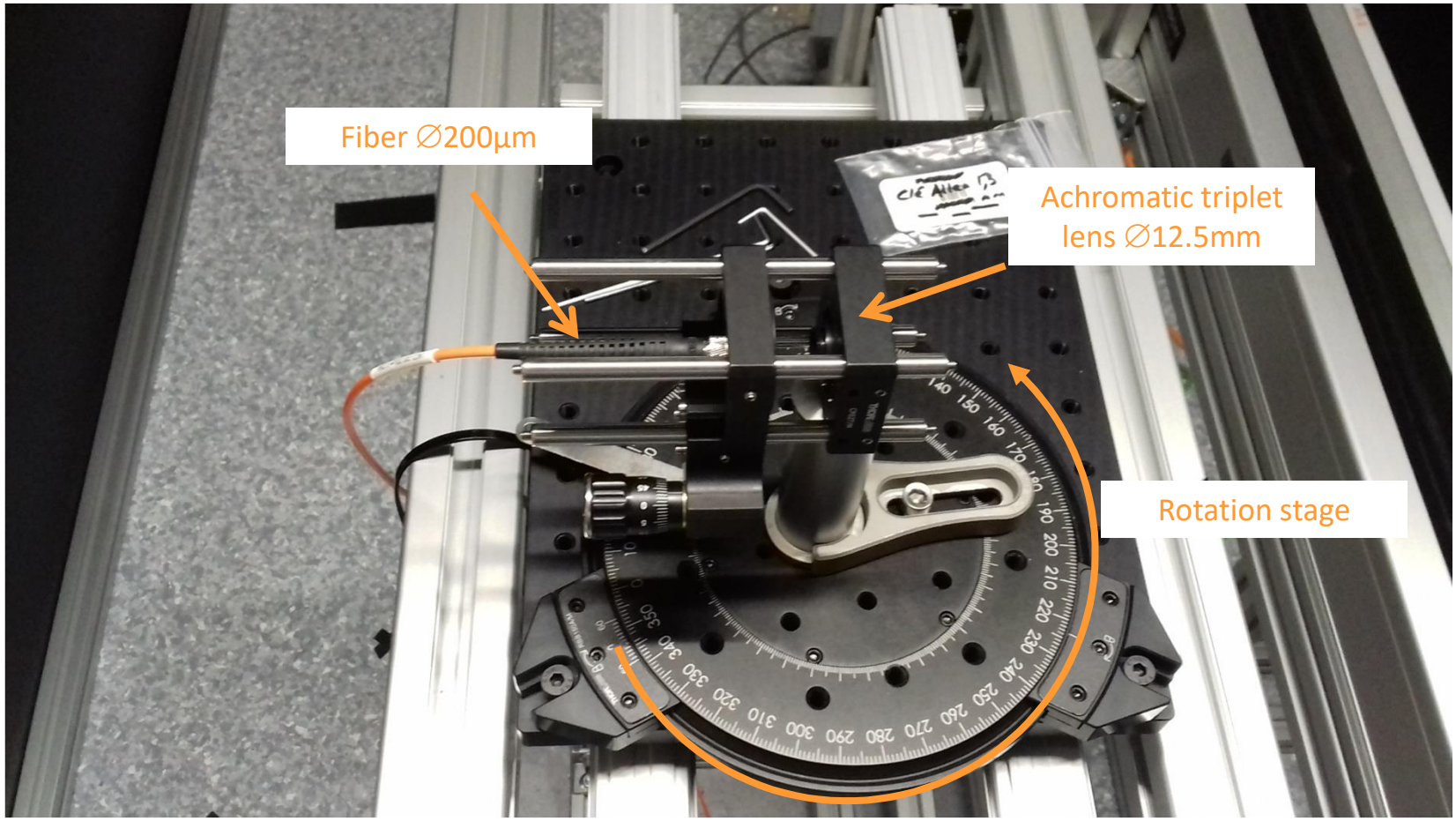
$$\bar{\lambda} = \frac{\sum_{\lambda_{min}}^{\lambda_{max}} \lambda T(\lambda)}{\sum_{\lambda_{min}}^{\lambda_{max}} T(\lambda)} \tag{3}$$

and $\Delta\lambda$ is the filter bandwidth computed as follows:

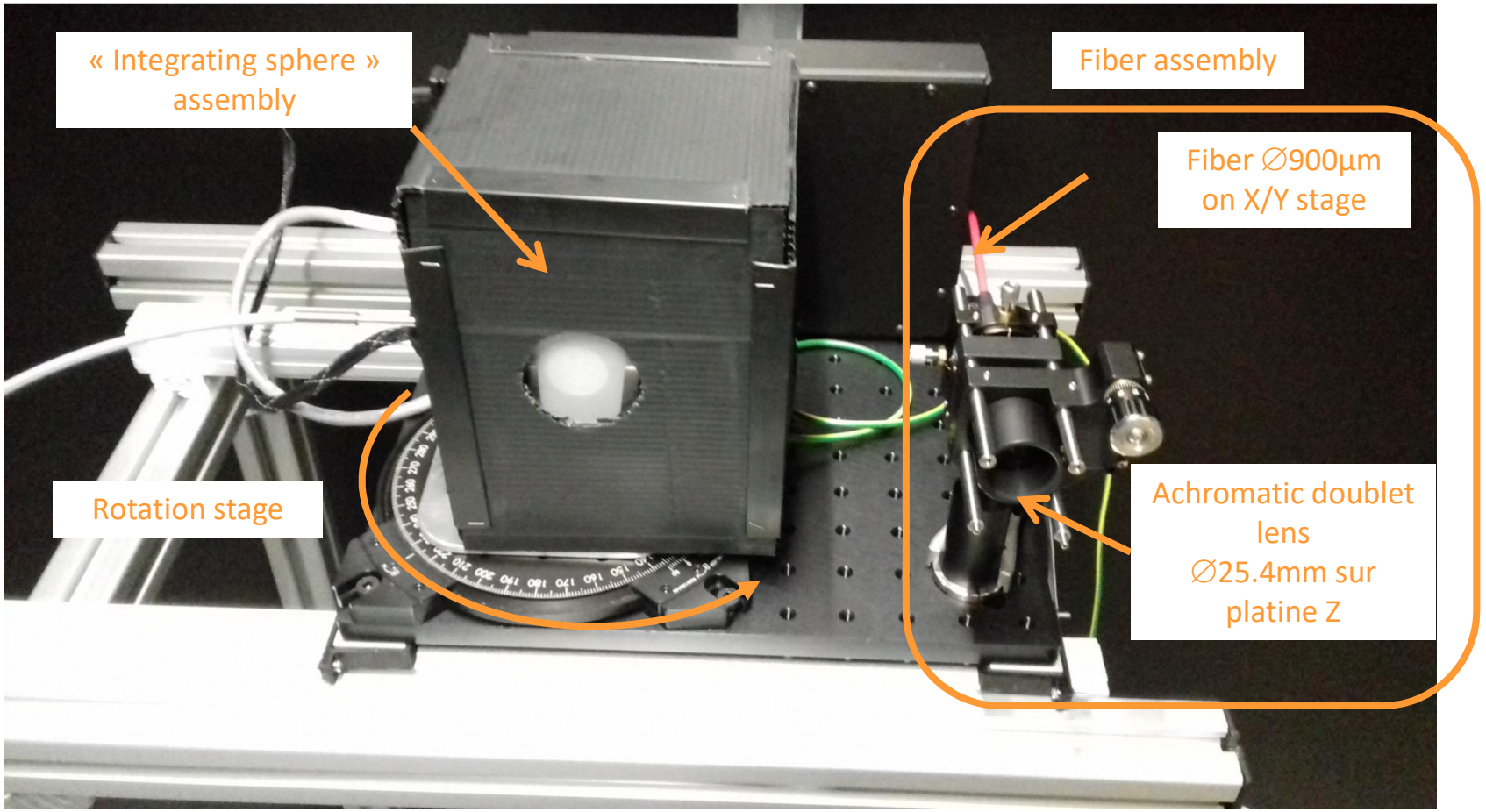
$$\Delta\lambda = 4\frac{\sum_{\lambda_{min}}^{\lambda_{max}} |\lambda - \bar{\lambda}| T(\lambda)}{\sum_{\lambda_{min}}^{\lambda_{max}} T(\lambda)} \tag{4}$$

More robust than the Full Width at Half Maximum

Illumination stage



Detection stage



« Integrating sphere » assembly : works with high performance Perkin Elmer L1050 spectrophotometer

Fiber assembly : works with compact OCEAN OPTICS HR2000 spectrometer