How to measure a telescope transmission ?

Collimated Beam Projector status

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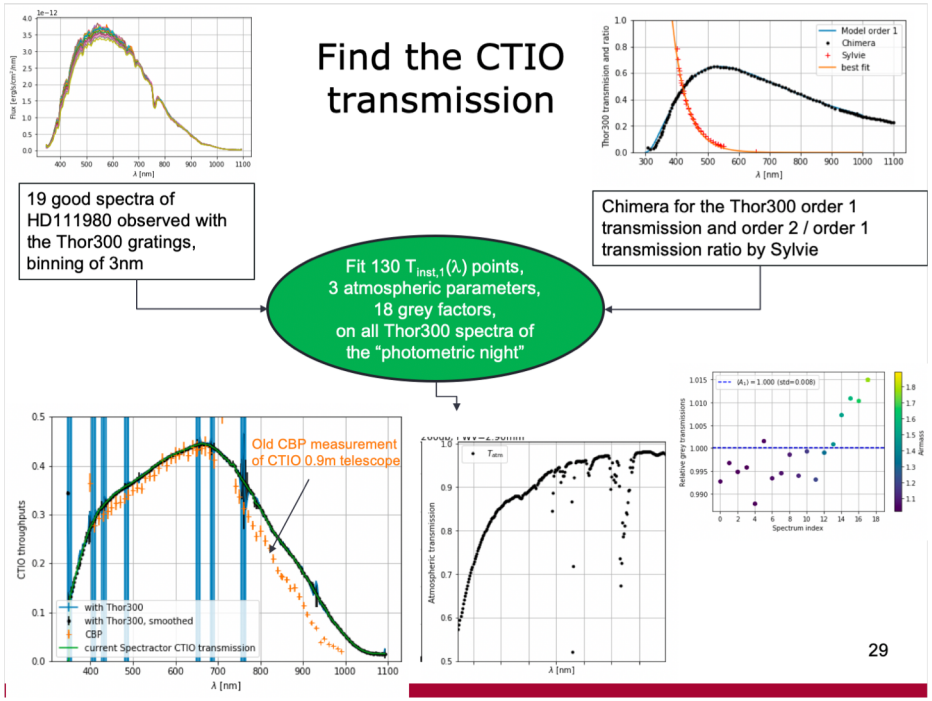
Harvard Team : Sasha Brownsberger , Christopher Stubbs, Elana Urbach

Why working on a CBP ?

- Auxtel objective : measure the atmospheric transmission at VRO site
- StarDice objective : transfer a calibrated LED light to standard stars

⇒ Crucial to know the instrumental transmission

⇒ Very difficult to get it from sky data only



Slide presented at last Rubin-LSST-France meeting

Why a CBP ? What is a CBP ? How ?

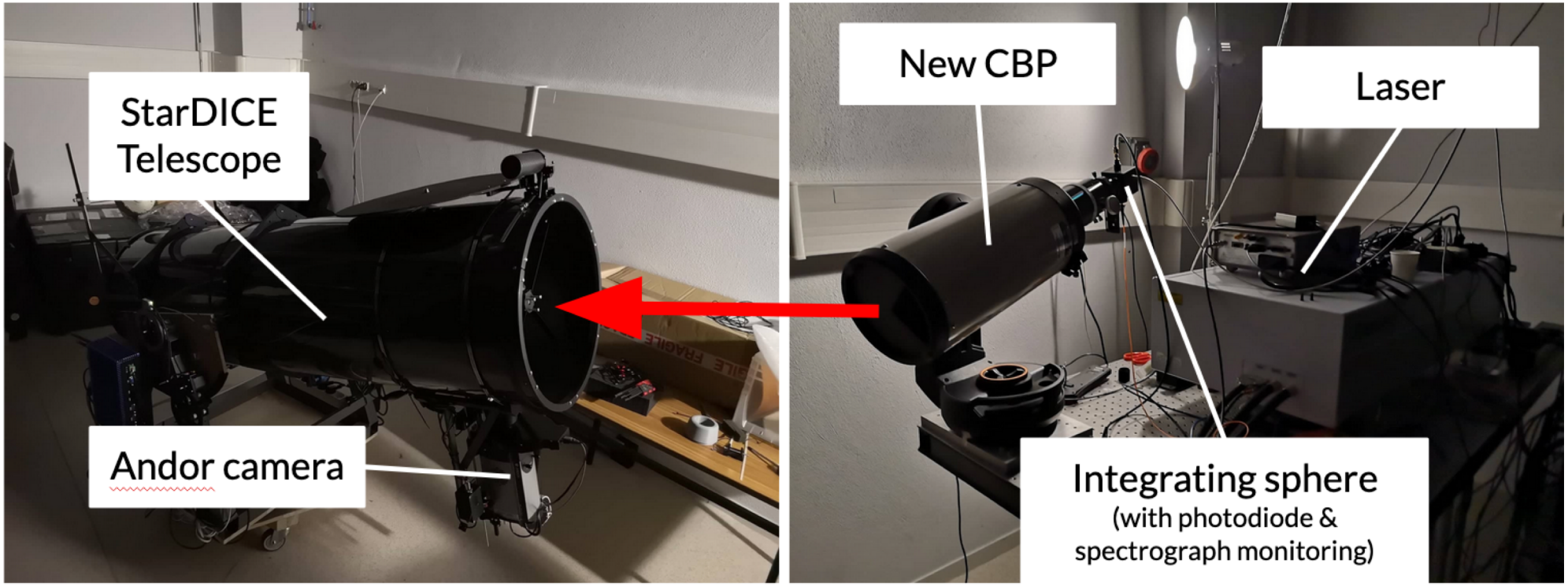
- Why ? To measure a telescope transmission at <1% across visible spectrum (StarDice, VRO, AuxTel, ZTF, etc.)

- What ? CBP, a Collimated Beam Projector, which is able to shoot a known quantity of photons at a known wavelength in a parallel beam (to mimic a monochromatic star of known flux)

- How ? Collaboration with Harvard (Christopher Stubbs and LPNHE)

How do you build a CBP ?

General recipe : put a powerful point source of known flux and wavelength at the focus of a telescope



CBP evolution : April 2021

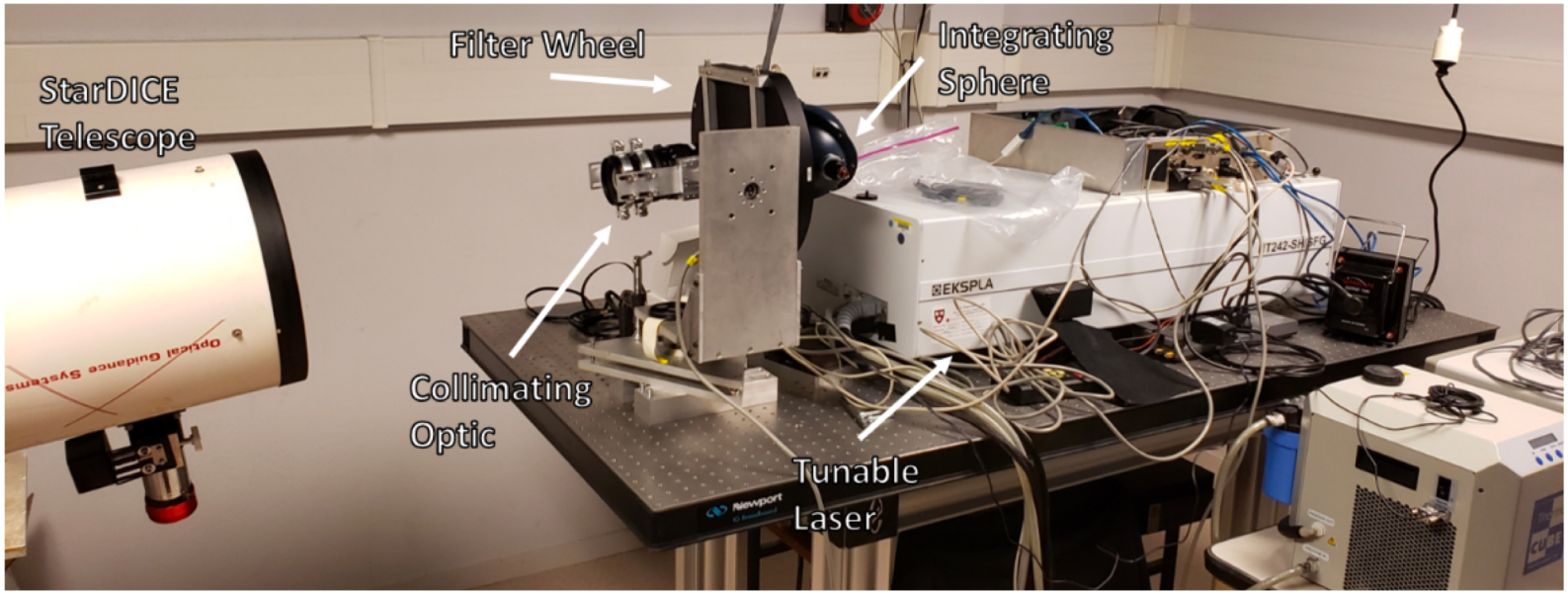
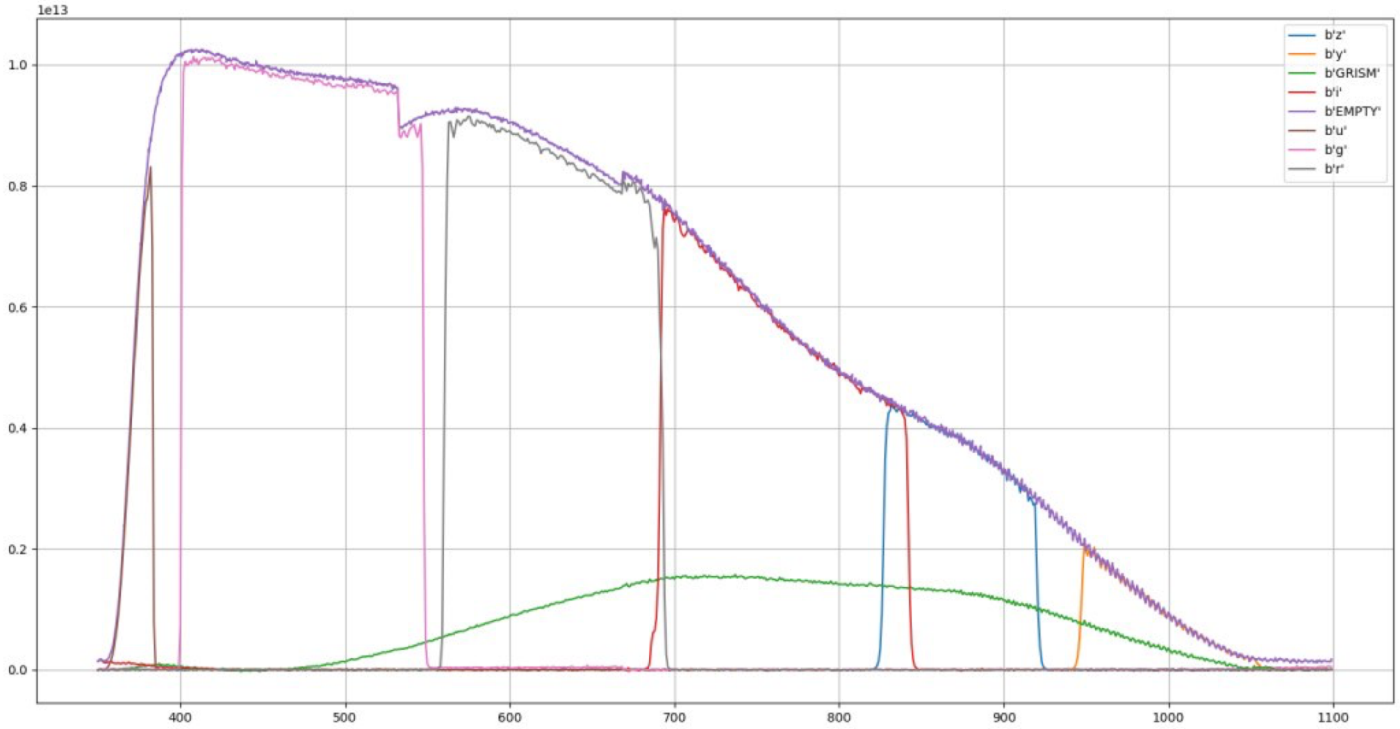


Fig 1 An image of the CBP installed in the StarDICE lab at LPNHE. The arrangement roughly mimics that expected during StarDICE operation at the Observatoire de Haute Provence.

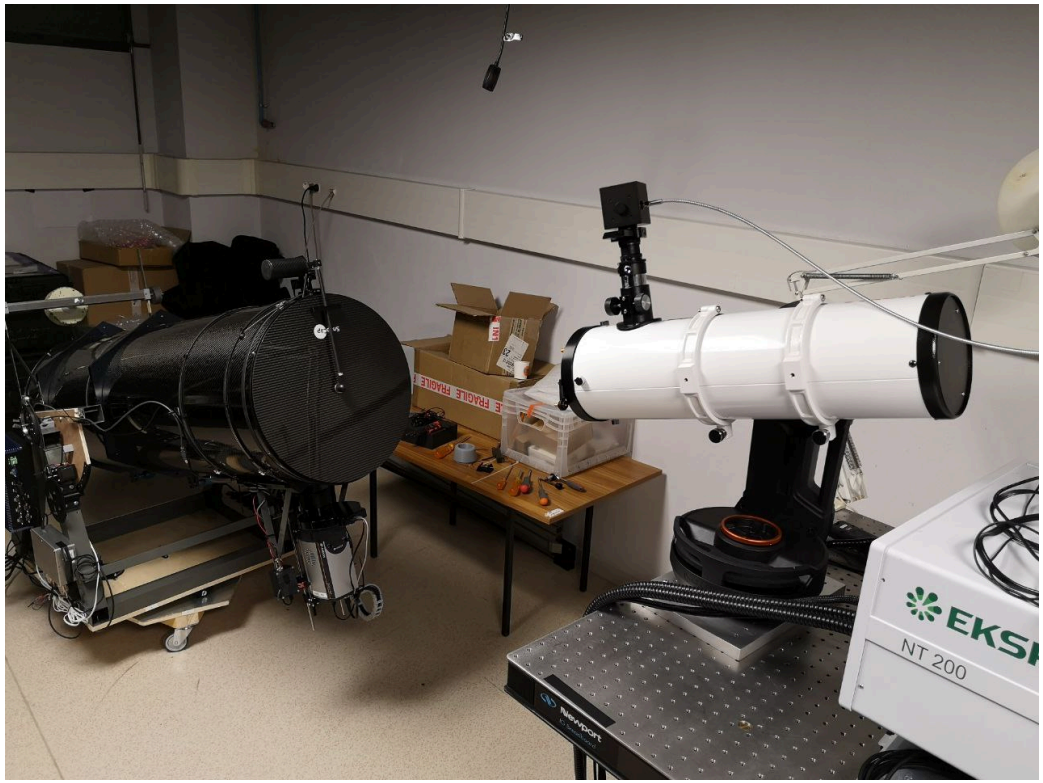
First CBP/DESC paper in the publication process !

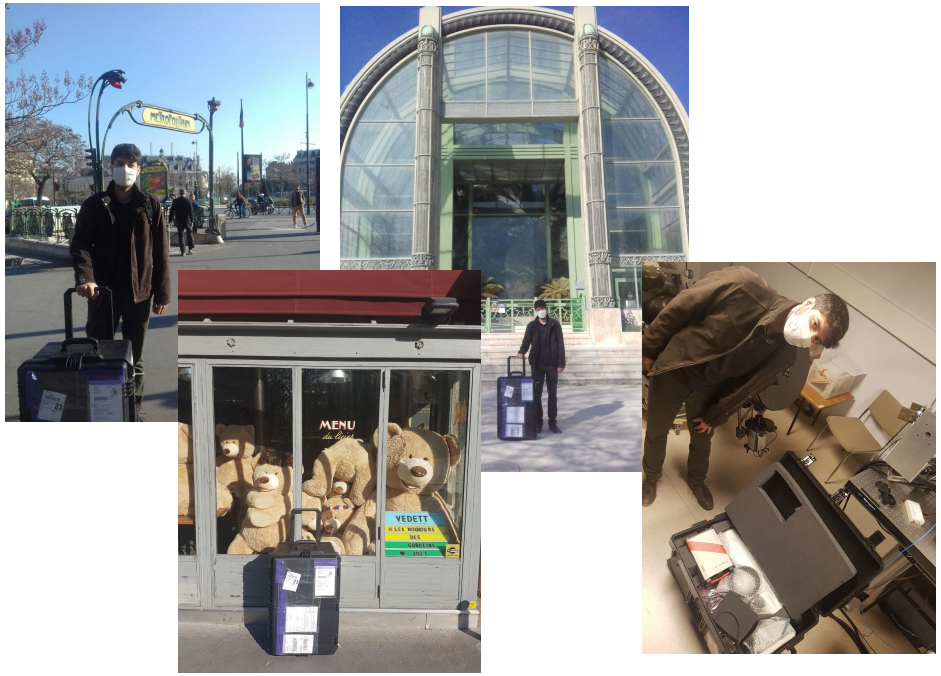
Preliminary CBP and StarDice transmissions



Caption : StarDice telescope transmission measured with the April 2021 version of the CBP.

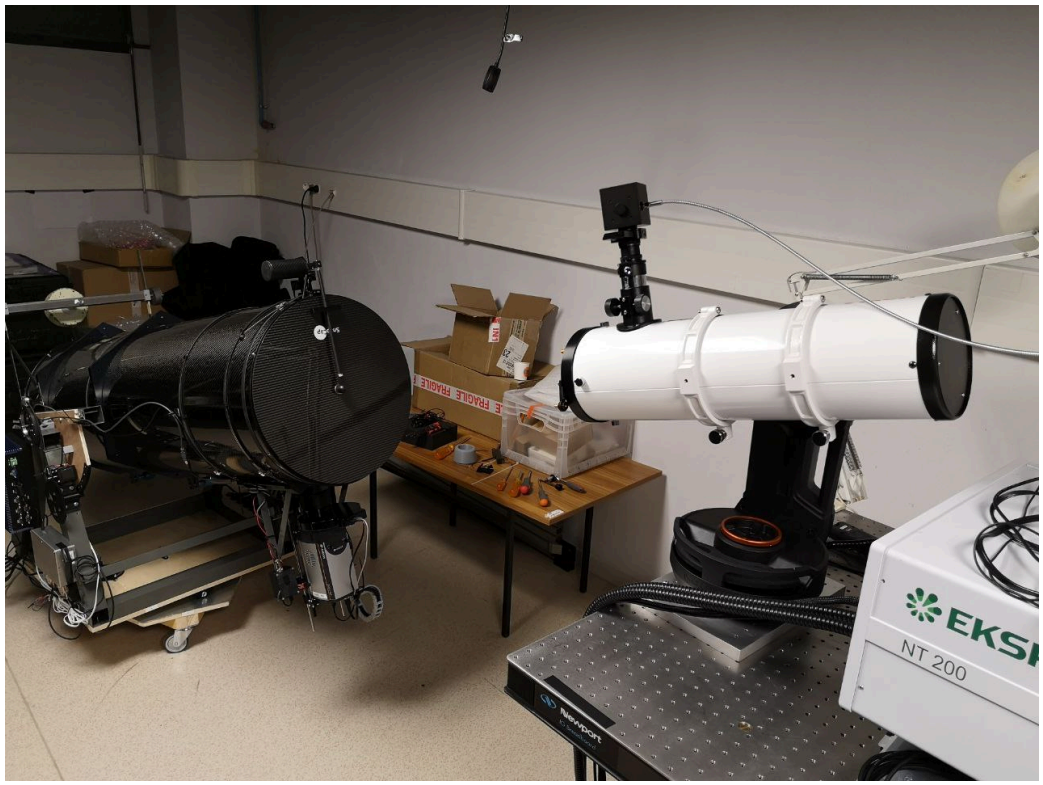
CBP evolution : May 2021

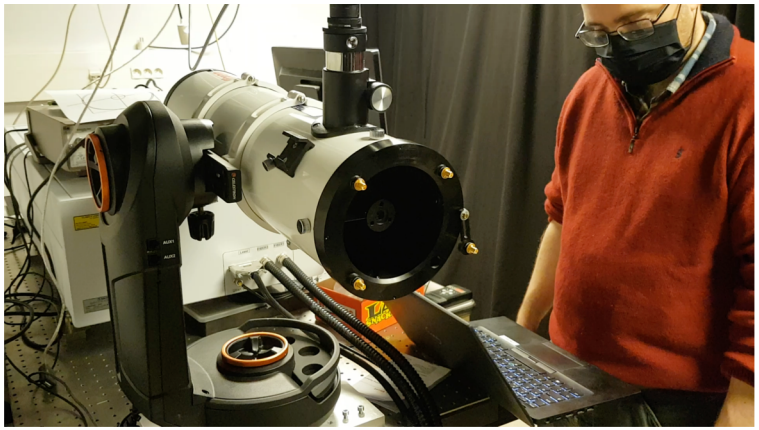


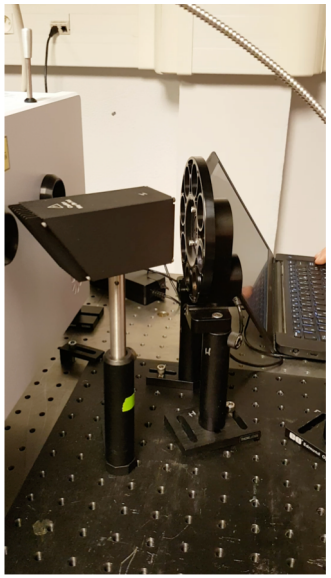


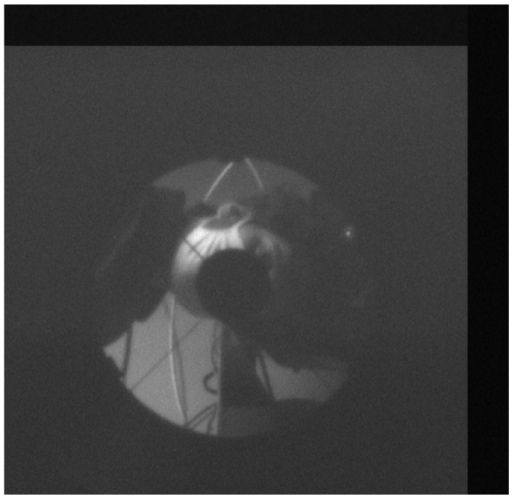
New StarDice telescope, new StarDice camera, new CBP optics, new CBP mount, new laser… shipped from the US during the pandemia…

CBP evolution : May 2021

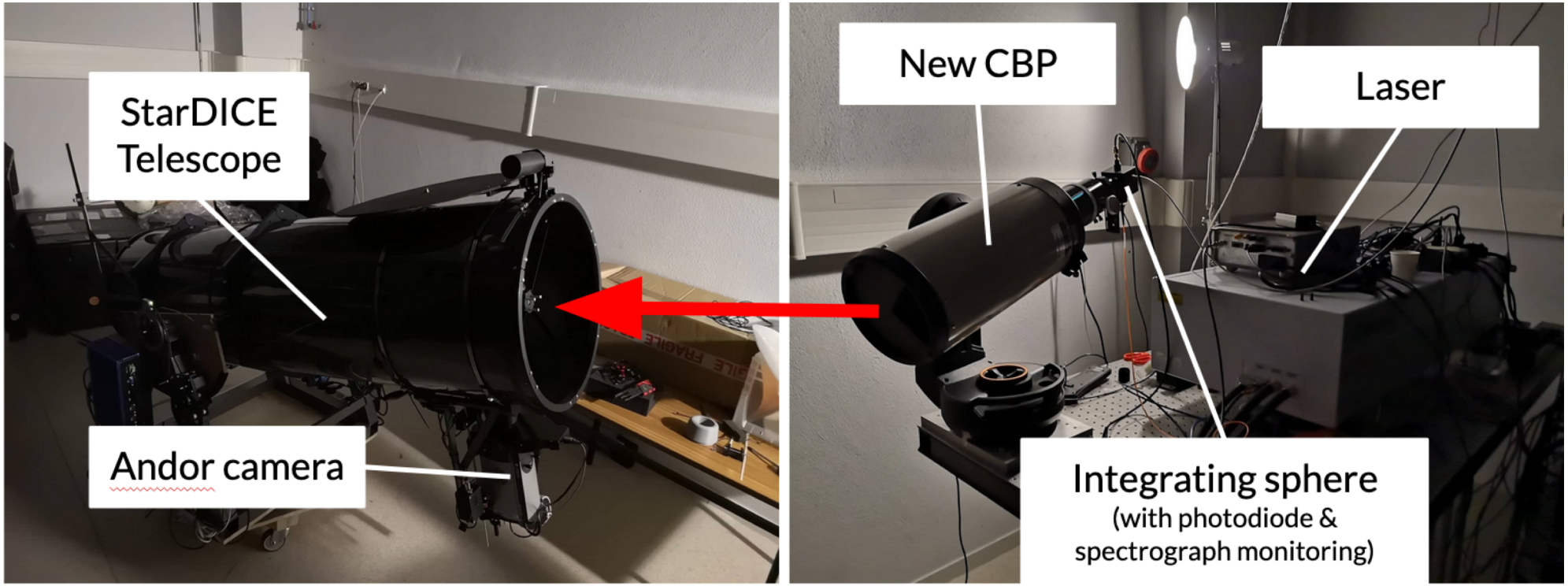








CBP evolution : September 2021

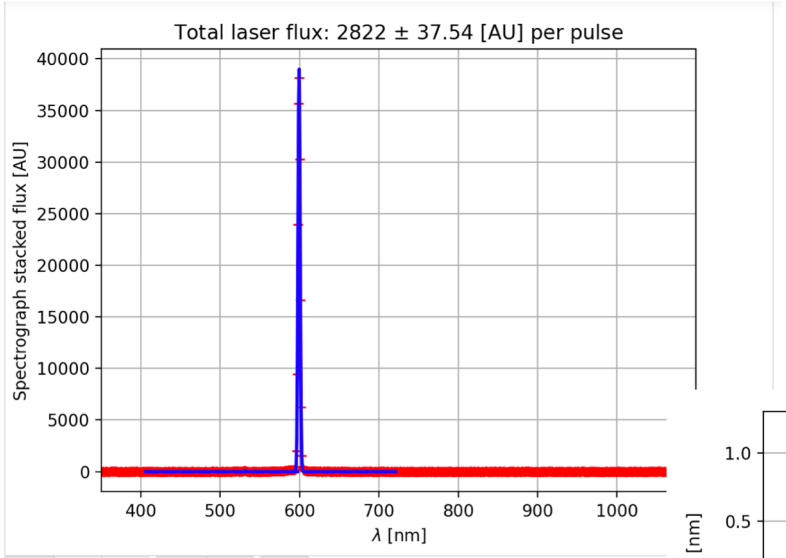


New new CBP optics !

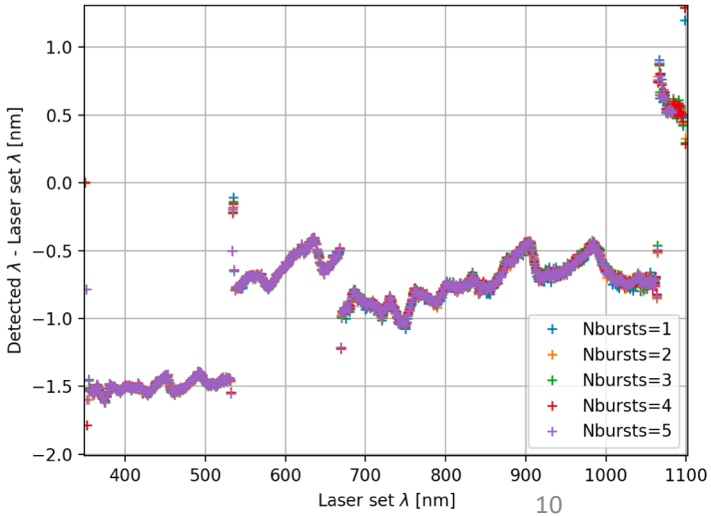
How do you monitor the photons ?

Wavelength : with a fiber collecting the light in the integrating sphere and shooting it into a calibrated spectrograph

=> recalibration of the laser wavelength <1nm



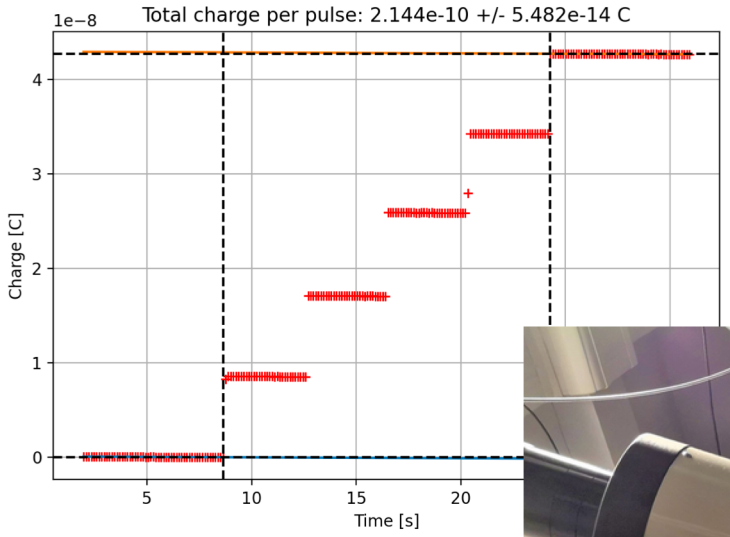
Line	Tabulated nm	Detected nm	Shift nm	FWHM nm	Amplitude
LL532	532.0	530.9835	-1.0164753	2.6846395	100.29906
L600	600.0	599.41156	-0.58844966	3.0481155	39382.18
L600^(2)	1200.0	1195.1426	-4.857392	1.8666929	6.098692

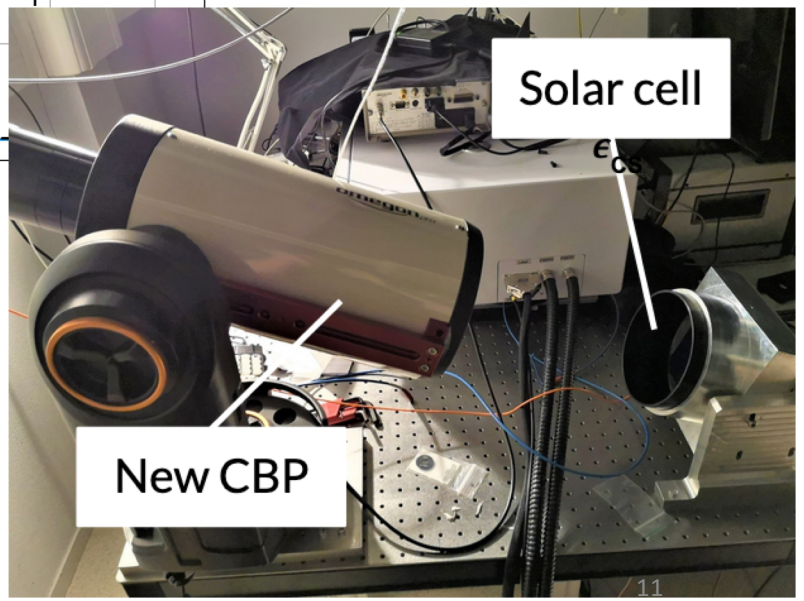


How do you monitor the photons ?

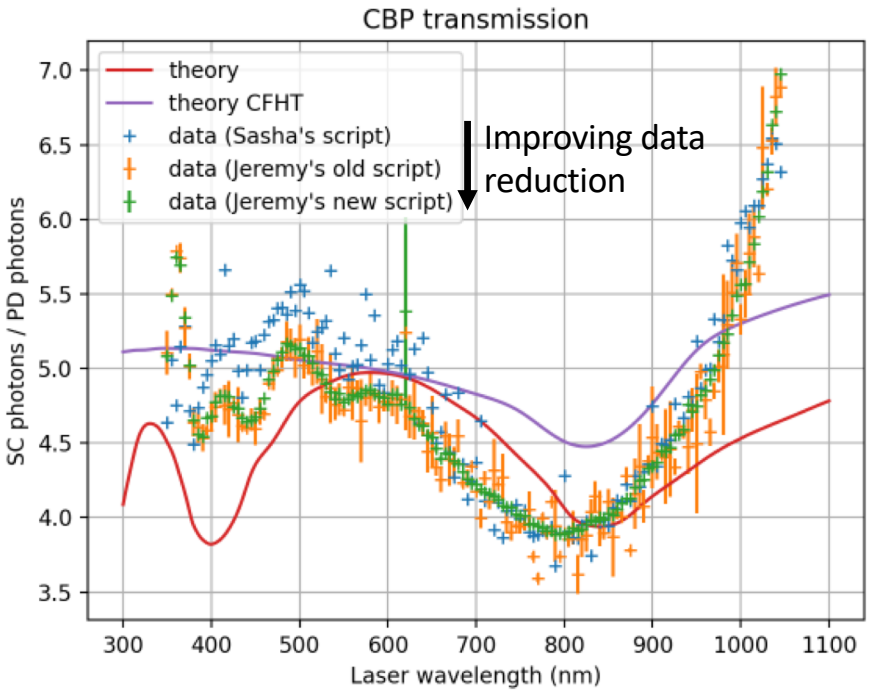
Flux :

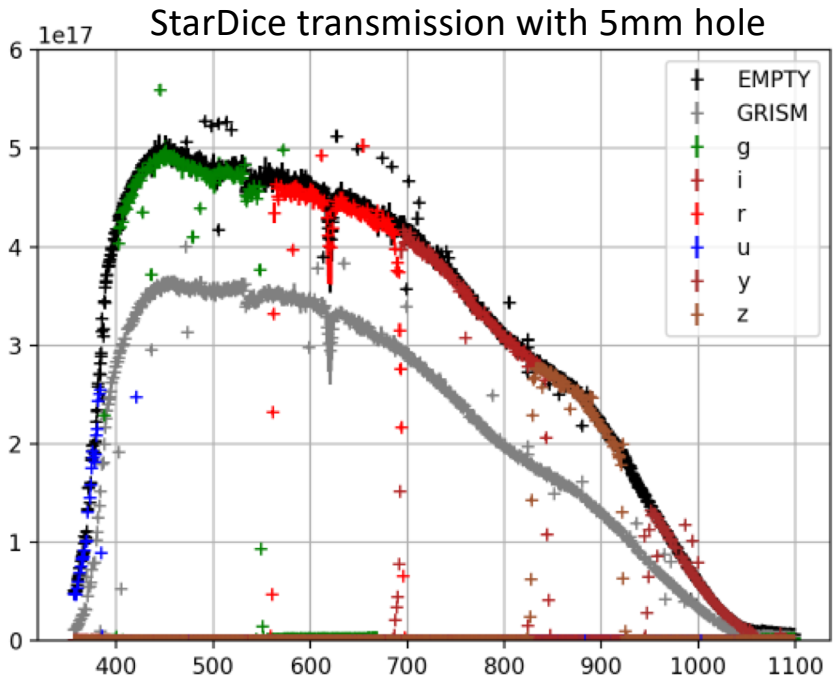
- with a photodiode on the integrating sphere and plugged to a charge-meter (better than permil)
- **with a large NIST-calibrated solar cell to get optics transmission => our main tsk since July 2021 !**





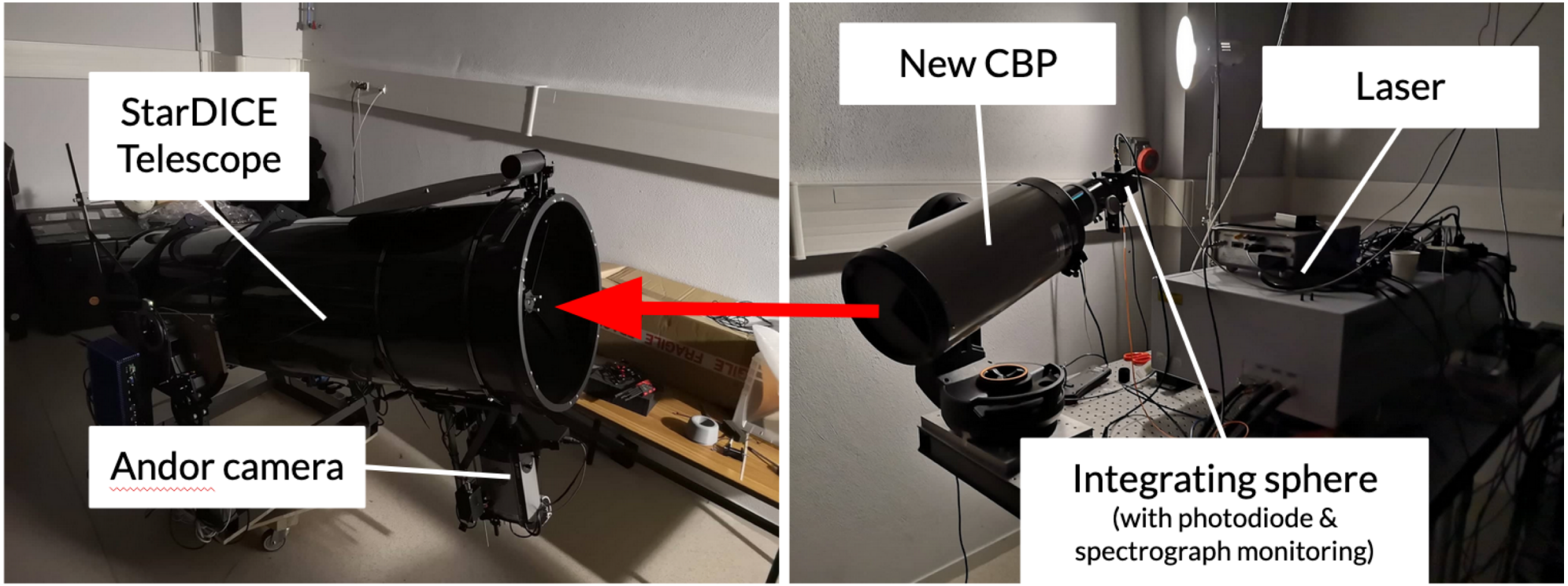
Preliminary CBP and StarDice transmissions



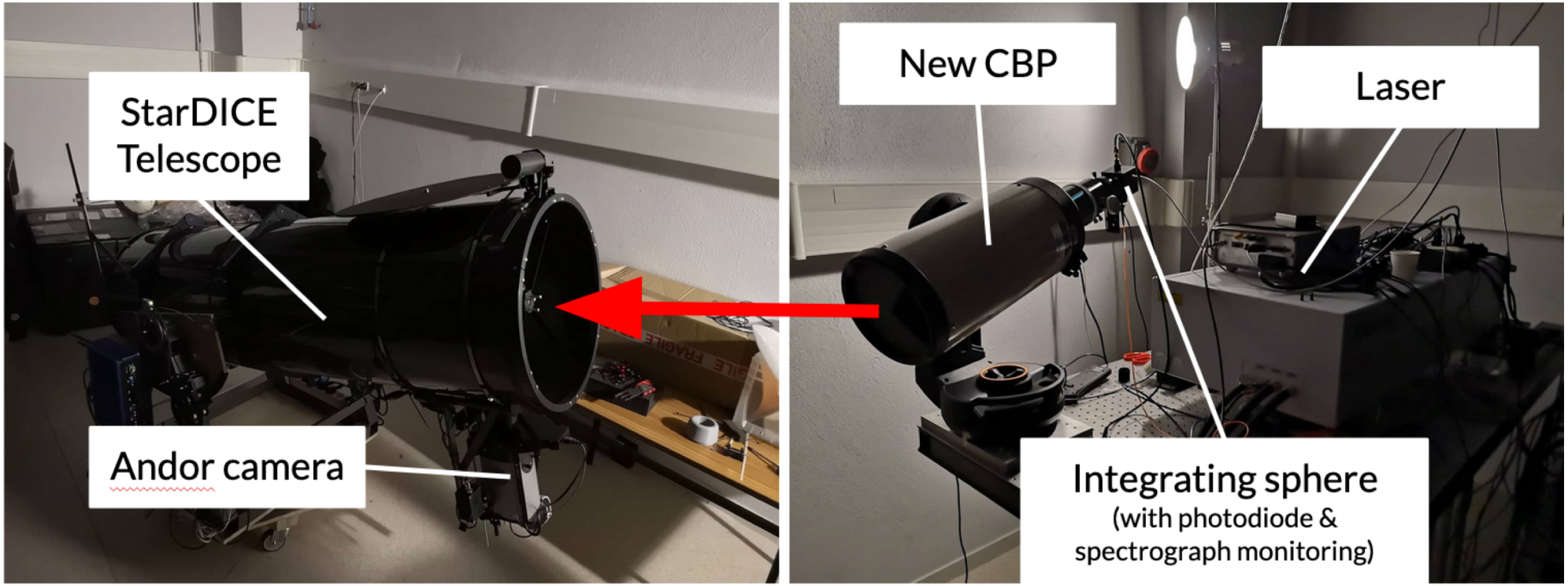


Caption : The StarDice telescope transmission has been measured with the 5mm hole, photometry is just a np.sum() of the image after bias subtraction. It has been normalized by the new CBP transmission in photons/C (which currently has a processing accident at 620nm). The GRISM curve has no sense here because the hole image is too large.

CBP evolution : September 2021

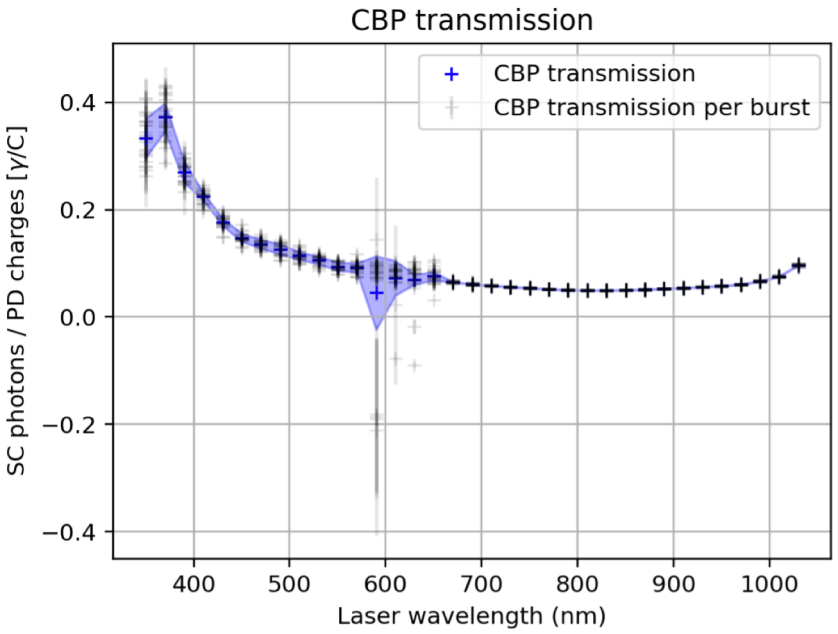


CBP evolution : November 2021

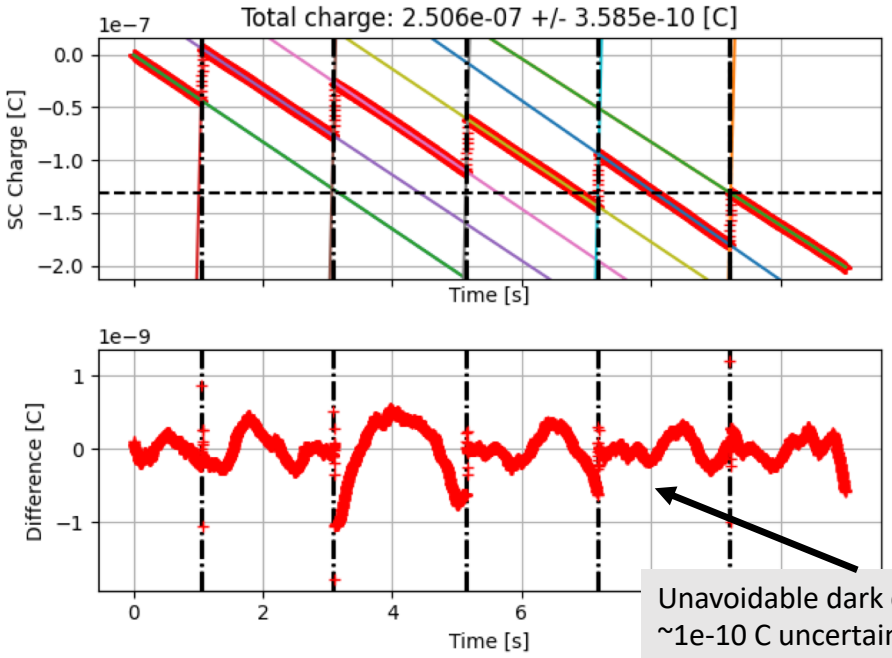


CBP evolution : November 2021

Switch to a « per burst » analysis having fine burst timings and finer algorithms



Model of the dark current with Gaussian Process (see P-F. Léget DESC School tutorial)



Plans for future

- **Redo and redo everything fighting the dark current !**

- Evaluate the systematics (in particular for the solar cell calibration)
- Measure the StarDice telescope => before end of winter
- Write a DESC paper !

- Characterize a portable CBP, the CBP-Lite which is in development at Harvard (with a more practical light source and with Kélian !)
- Remeasure the StarDice telescope
- Measure other telescopes : AuxTel, ZTF-II, etc.
- Apply our experience to make the VRO CBP alive !