

PlanetS



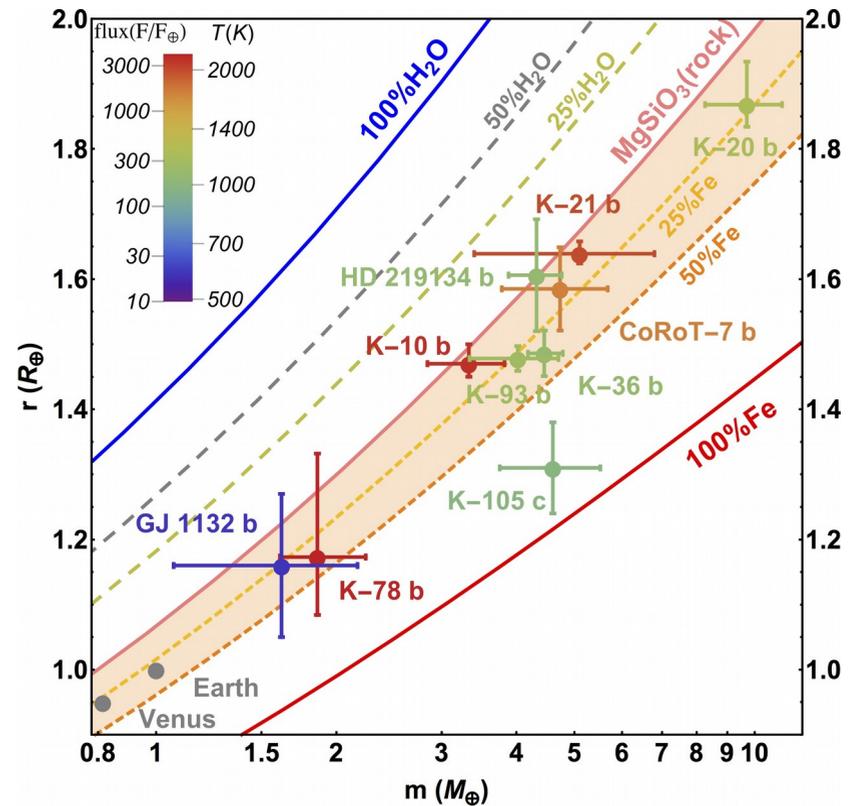
Cheops Calibrations

UGE Calibration team :

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Francois Wildi, Thibault Kuntzer

Cheops : Characterizing ExOPlanet Satellite

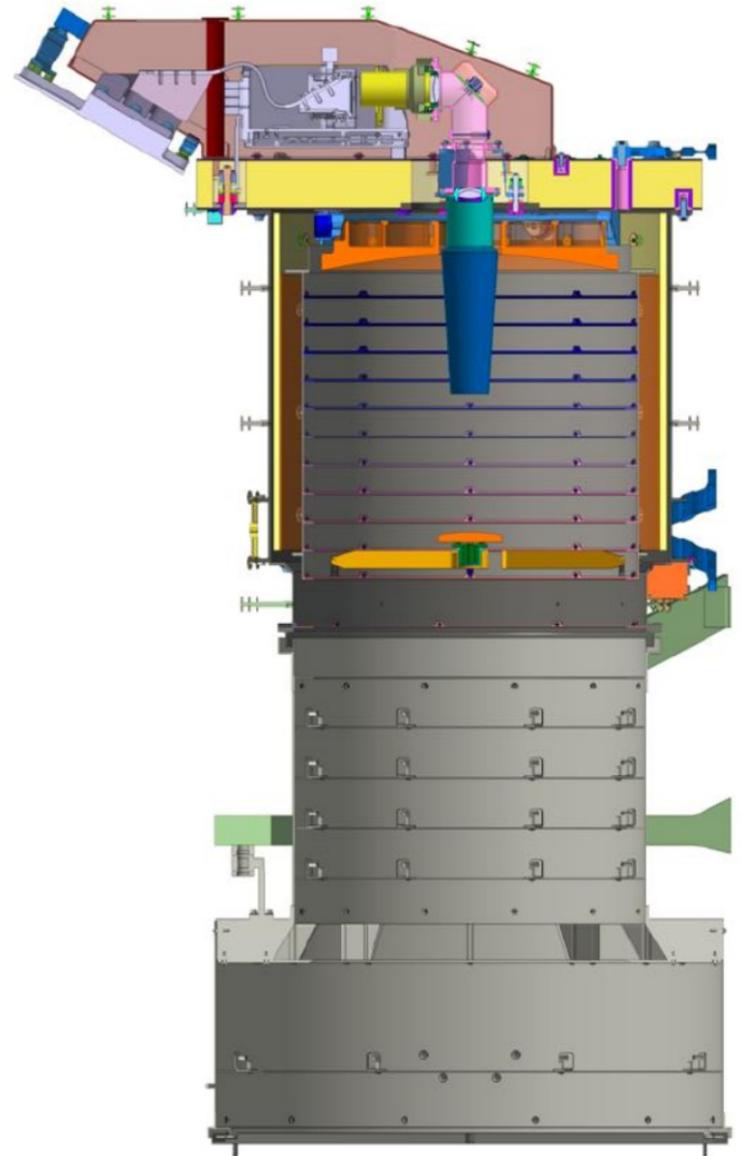
- ESA-S , mission
- Precision photometer :
20 ppm photometric precision
- Can be pointed to a large portion of the sky
- Science goal :
 - Mass / Radius relation for dense exoplanets



(Li Zeng et al, 2017)

Cheops instrument

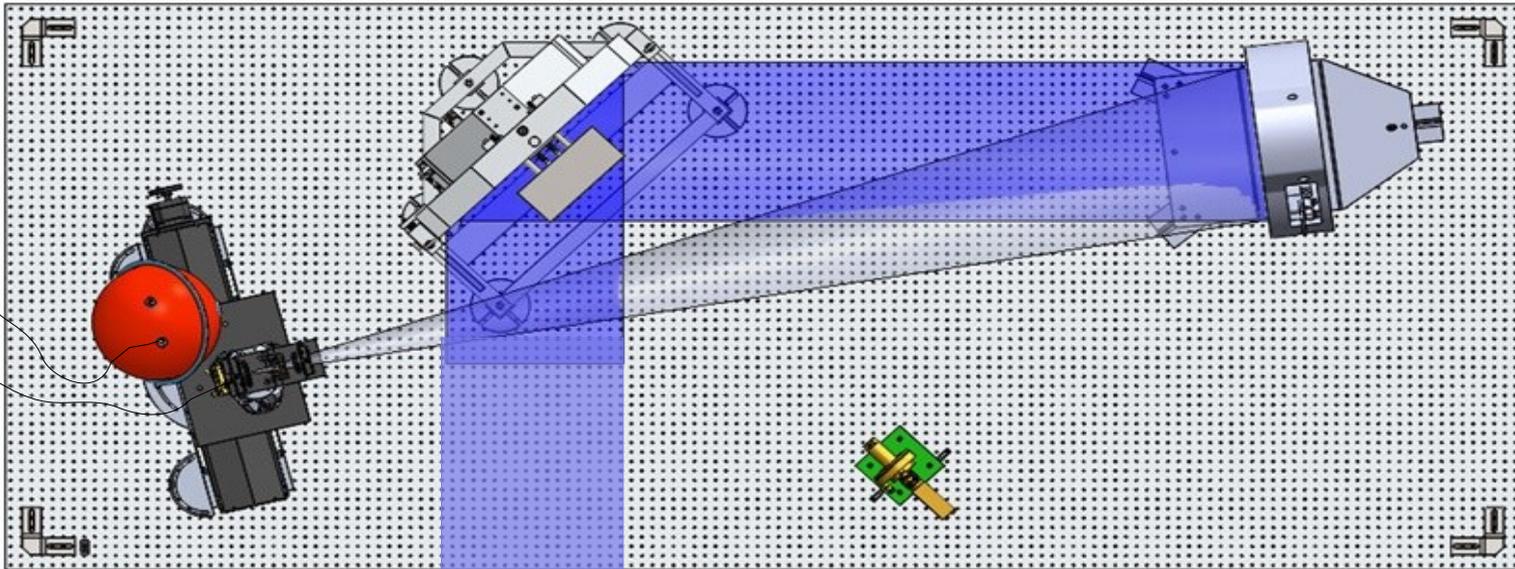
- Defocalized telescope
- Photometry of a single star
- CCD e2v 47-20 : 1024x1024 pix
- Sun-Synchronous
- Field is rotating
- Pointing $\sim 2-3$ arcsec
- Data : imagerie 200x200



Calibration Test bench

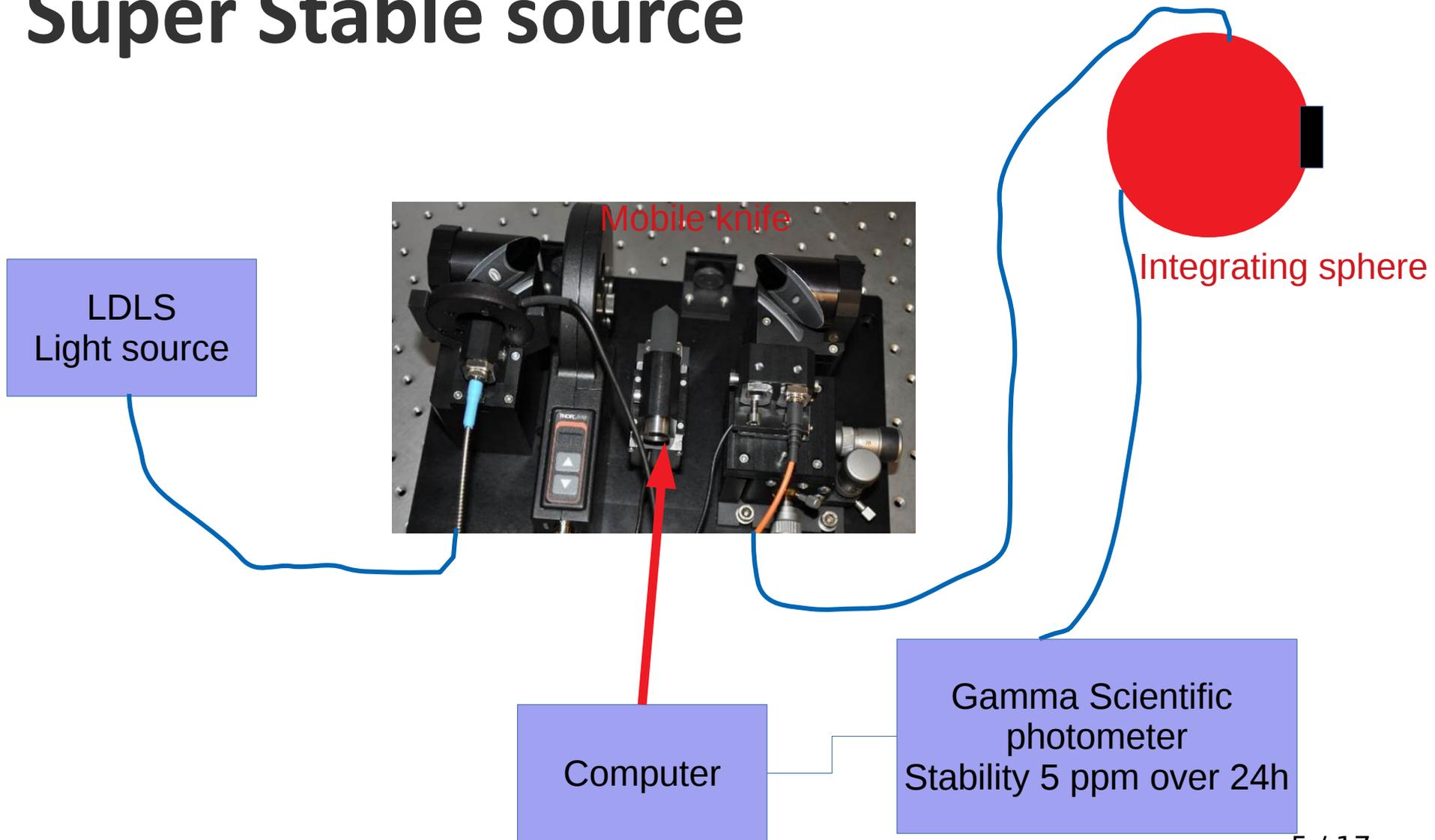
Calibration Source Module :

Super stable source
Neutral density
Filter wheel
Monochromator



CHEOPS TV chamber

Super Stable source

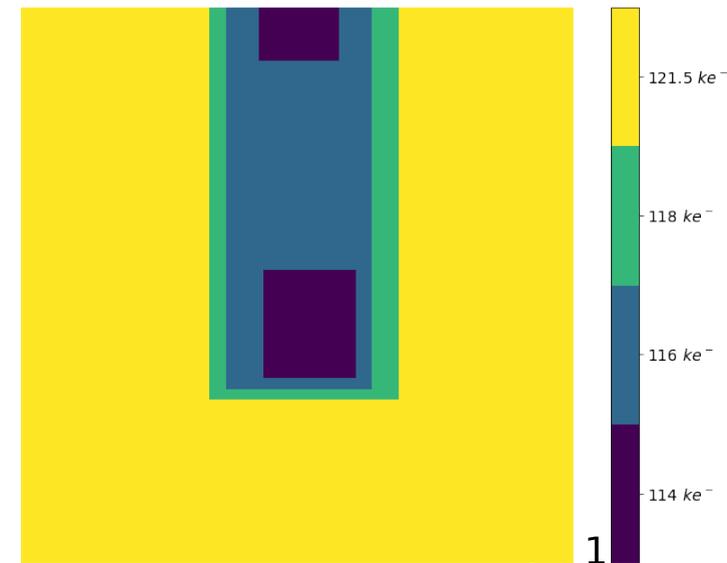
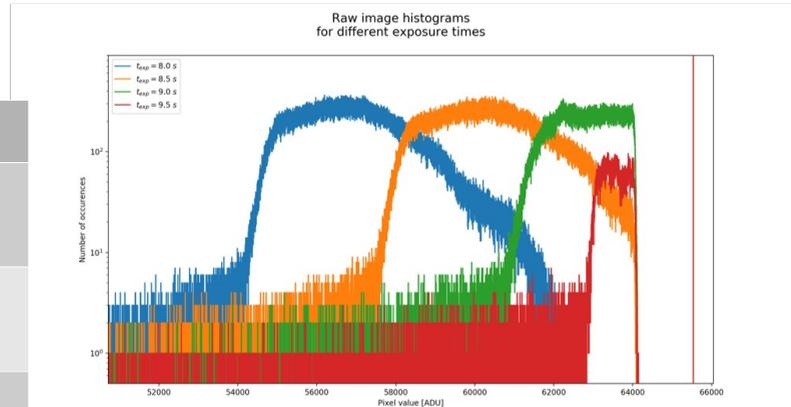


Calibration Test bench



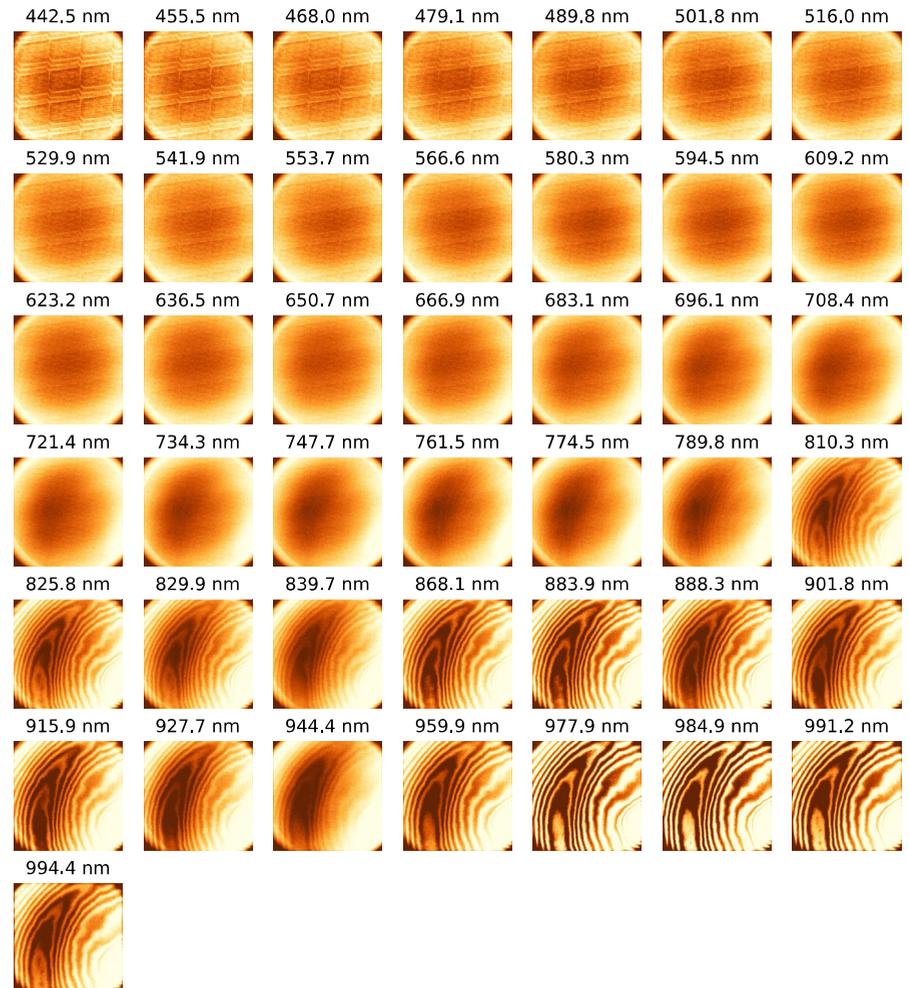
Detector chain Calibration

Characteristics	Value	Comment
RON Nominal 230 kHz	7.2 ADU (14.1 e-)	
RON Nominal 100 kHz	3.5 ADU (6.8 e-)	
Gain Nominal 230 kHz	0.511 +/- 0.003	
Dark	0.056 e-/s	
Warm pixels	7 pixels	With dark above 5 e-/s
Gain temperature sensitivity	-900 ppm/K	
Non linearity amplitude	1.2 %	
Full well	114-121 ke ⁻	



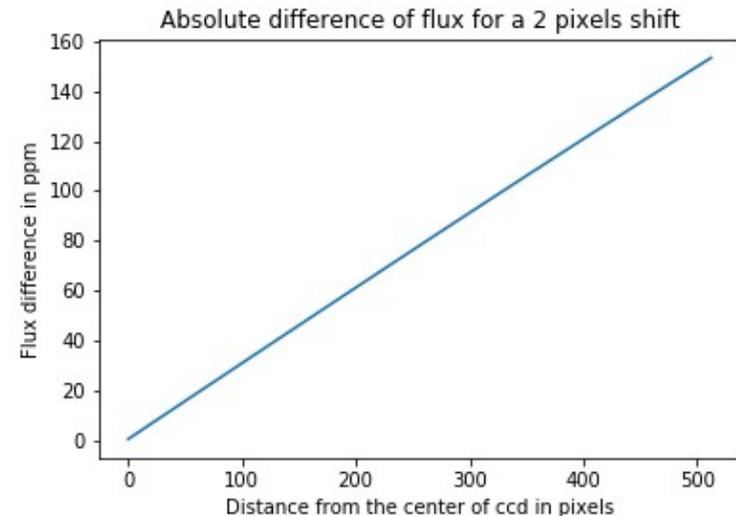
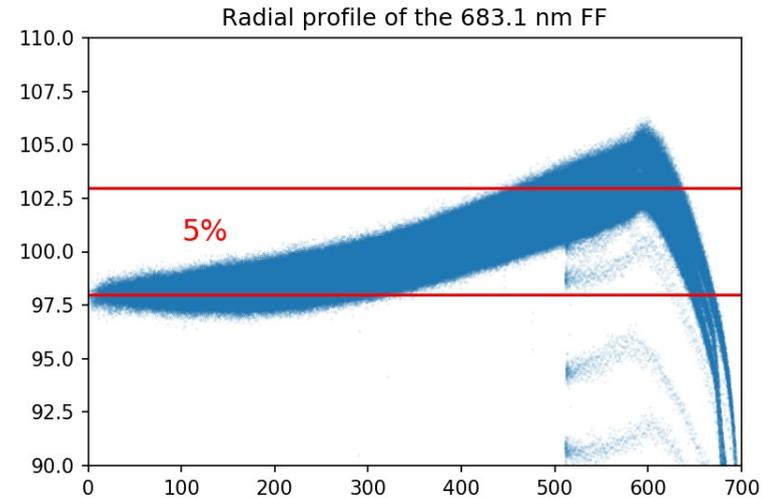
Flat-fields

- Overall target precision : 0.1 %
- Direct measurement with integrating sphere
 - Have to be corrected from sphere non uniformity
 - Have to be corrected from distortion
- Spectral reconstruction :
 - Monochromator + UVBRI Filter measurement

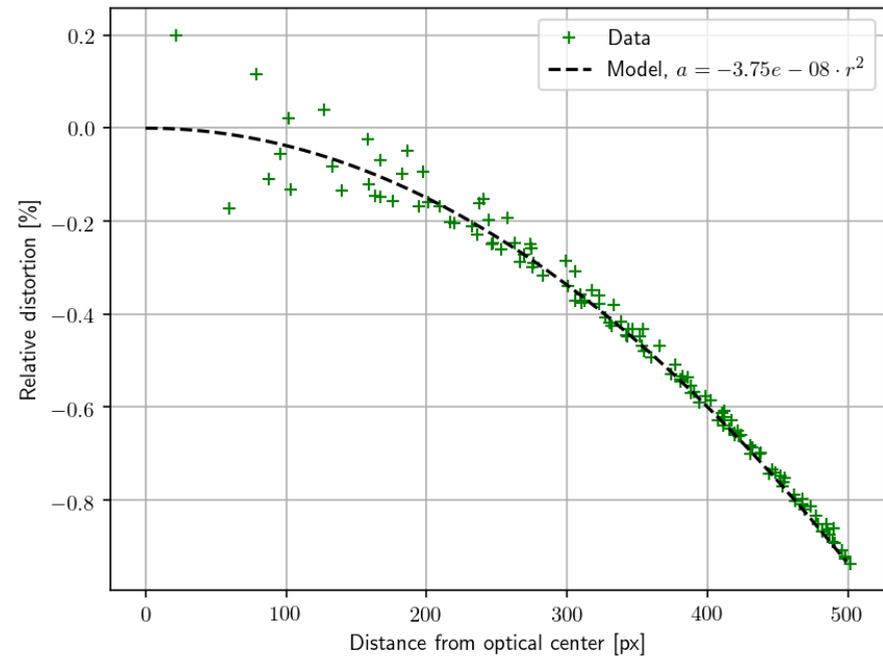
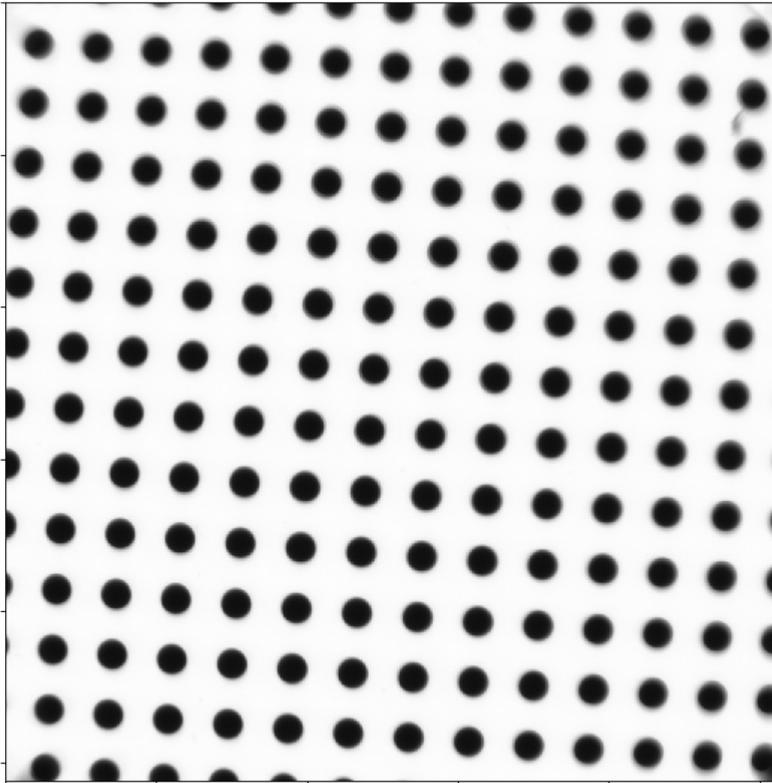


Flat-fields : Distortion

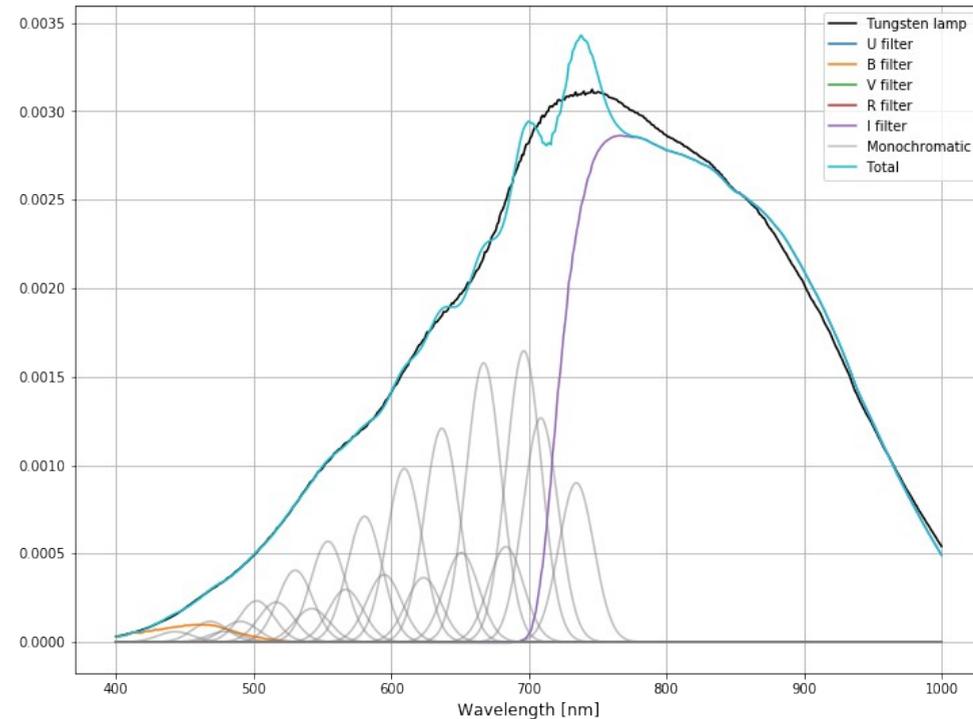
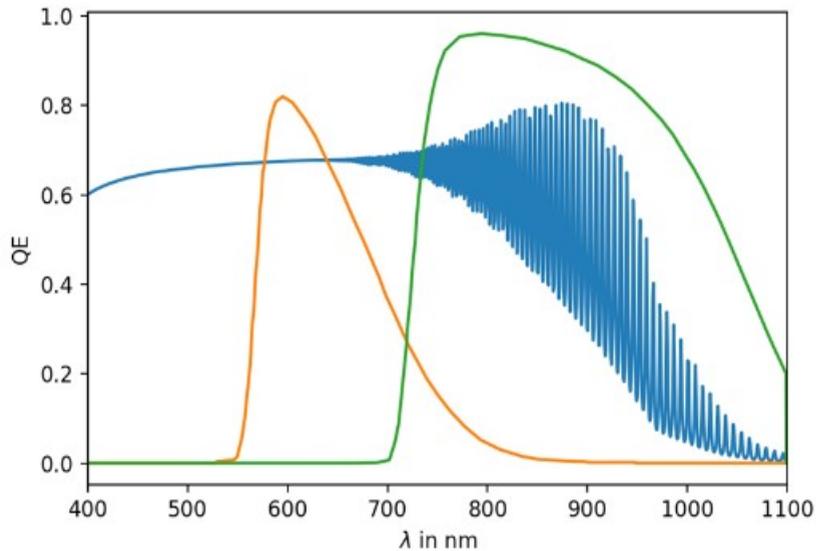
- There is more flux on the border of the measured FF
- It does not affect point sources
- If not corrected huge photometric errors
- Recommended to redo measurement in space



Flat-fields : Distortion measurement



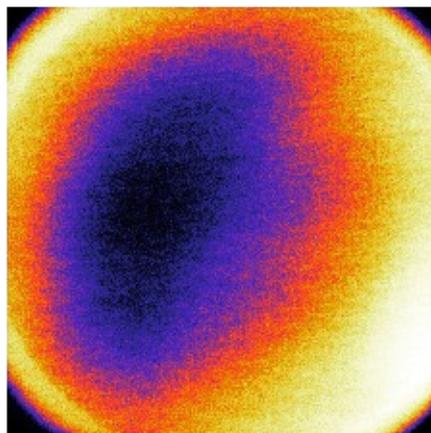
Flat-field : spectral synthesis



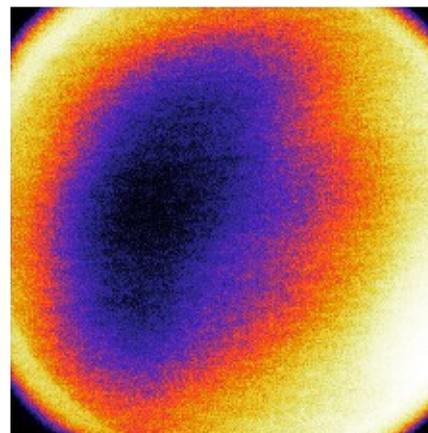
With the calibration measurement one can reproduce with high precision the “real” flat of a source with Smooth spectrum

Flat-field : spectral synthesis

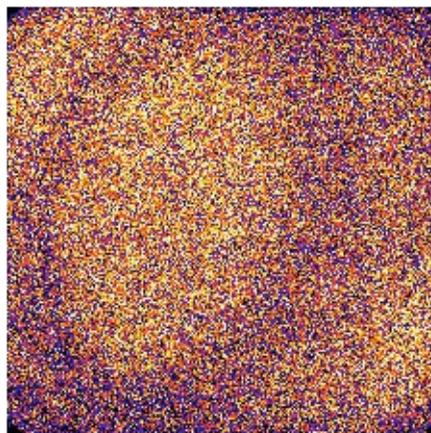
Measurement



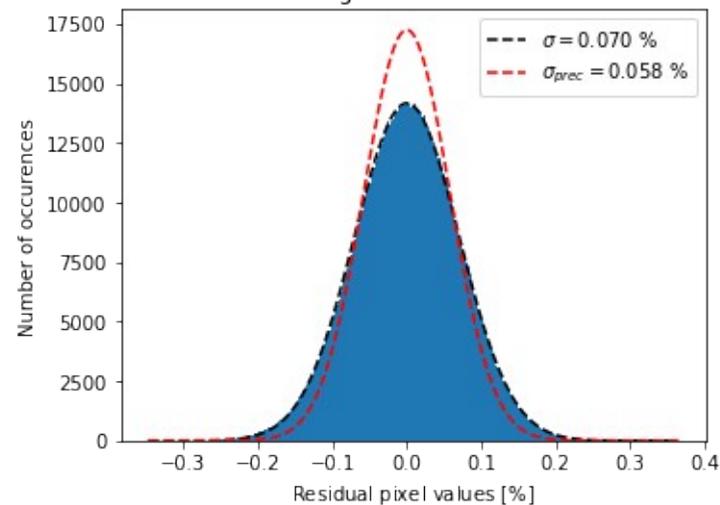
Simulation



Residuals = Meas. - Sim.



Histogram of Residuals

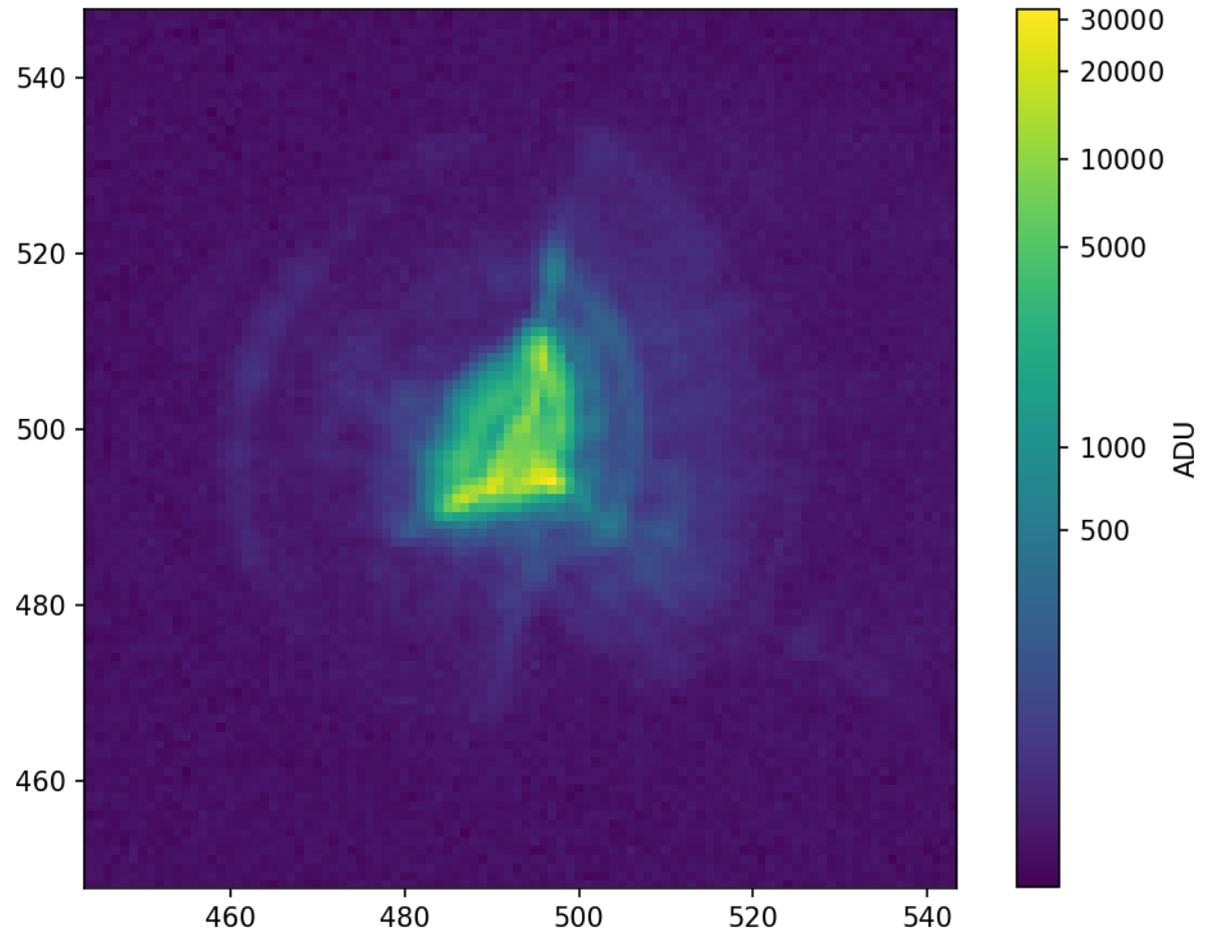


Flat-field : precision

- Photometric precision $\sim 0.06 \%$
- Error on the correction of the non uniformity of the integrating sphere $\sim 0.04 \%$
- Error due to the distortion correction $\sim 0.034 \%$
- **Total error** $\sim 0.08 \%$

PSF

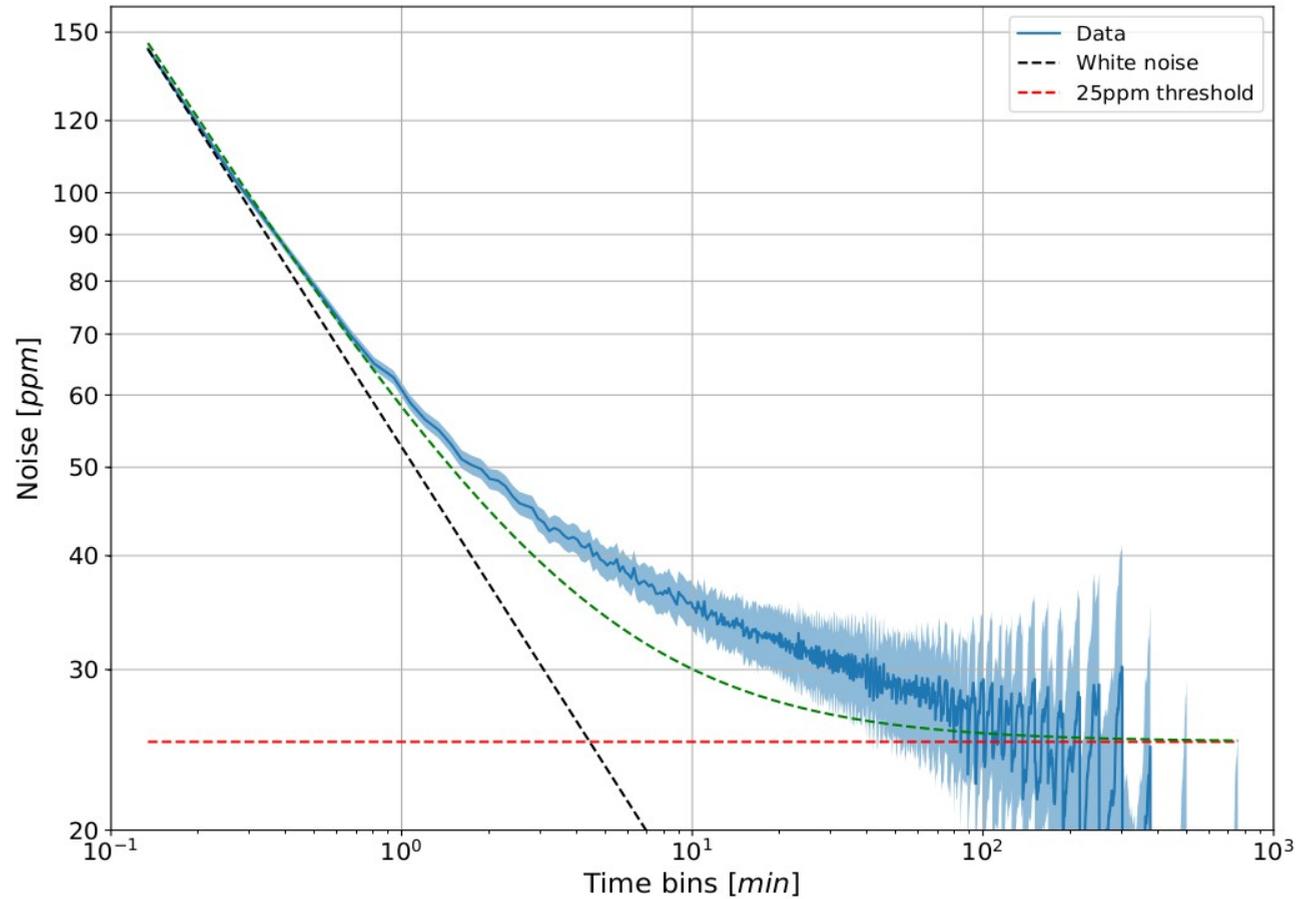
In the center of FoV
 $E90 = 12.8 \pm 0.3$ pixels



Performances

- No end-to-end test (lack of time)
- But test with integrating sphere
 - Temperature stability $< 1.5 \text{ mK} \Leftrightarrow < 2 \text{ ppm}$
 - Bias voltage stability $< 40 \text{ } \mu\text{V} \Leftrightarrow < 2 \text{ ppm}$
 - Test bench is the drifting element.
 - One can give minimum performance achieved (we are in the right range!)

Performances





Conclusion

- All needed calibrations available
- Instrument in good shape to make great science
- Launch next year