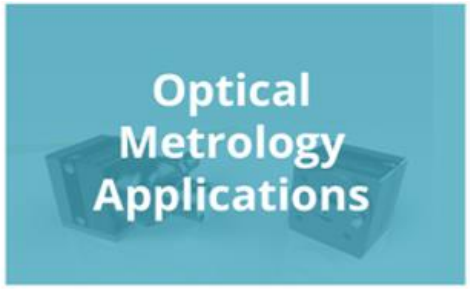
Wavefront sensors and adaptive optics for optical metrology, lasers and microscopy



CIAO can now work on extended sources

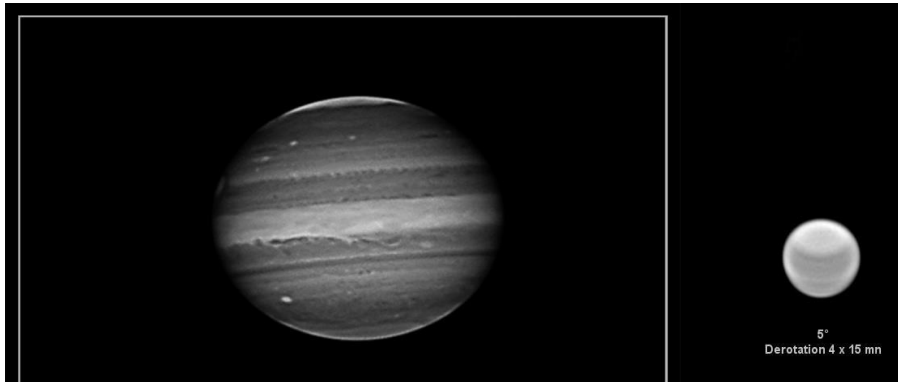
Station de Planétologie des Pyrénées

D MOD 010c

C ompact
I nnovative
A daptive
O ptics

- The first goal is to add an active optics feature on the telescope to remove its static aberration (alignement, gravity, thermal…) ***It is very often the main problem of 0.5 to 2m class telescopes***

- The second goal is to compensate the effect of the air turbulences and do adaptive optics . This technique allows increasing the exposure duration without lossing any spatial resolution. For example : CH4 measurements on Jupiter or Uranus

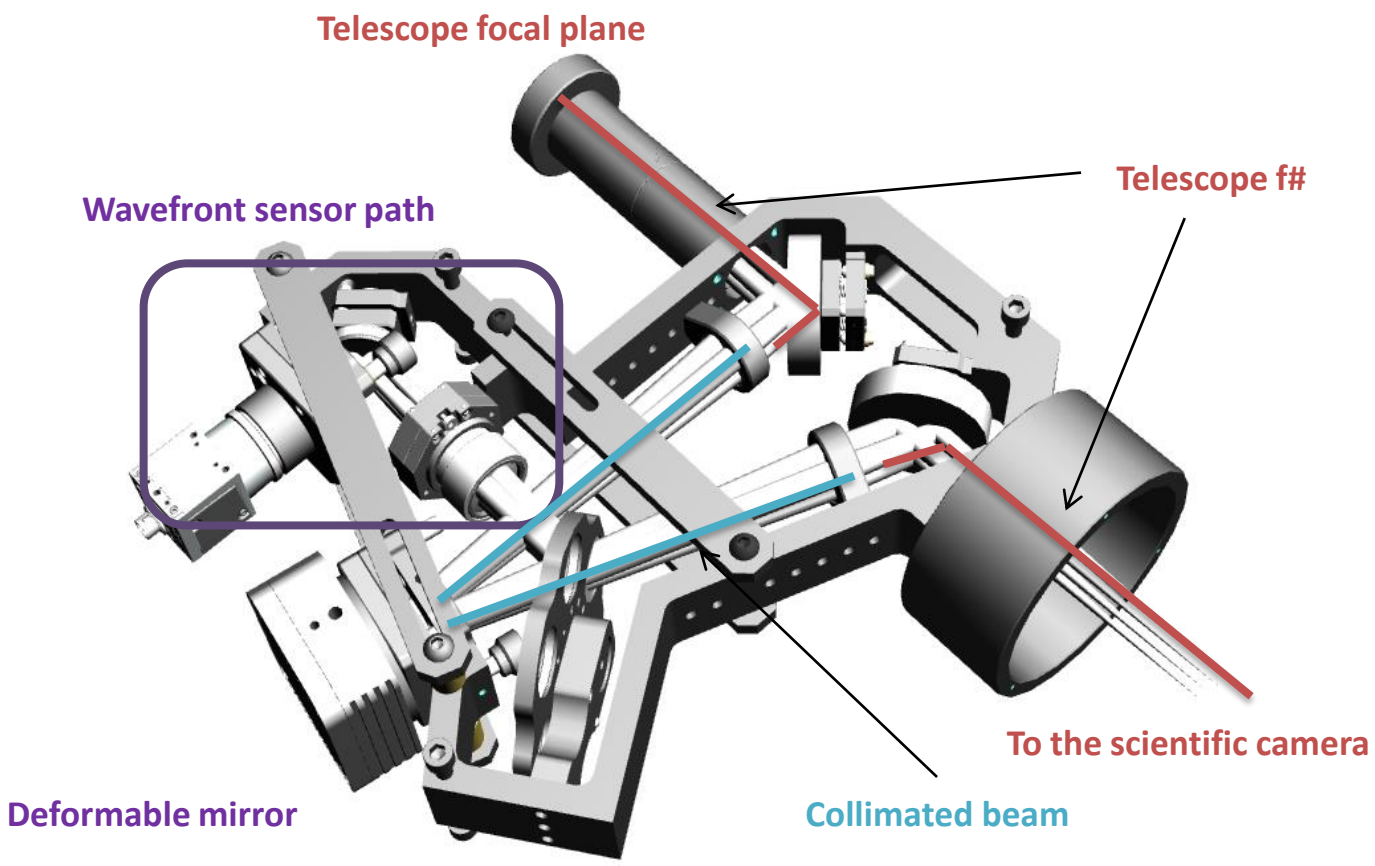


- The third goal is to increase the efficiency of the « lucky imaging technique » used by hobbyist astronomers

Specifications

Connected to the telescope through the eyepiece holders
Telescope from f/10 to f/17
field : 8x8 mm at f/17
Loop at 100 Hz for objects with magnitude 5
from 400nm à 800nm
Quick access to the deformable mirror and wavefront sensor
The user can choose between different kinds of beam-splitter
Allow the use of a filter wheel or ADC

No spec on the Strehl, let’s just see…



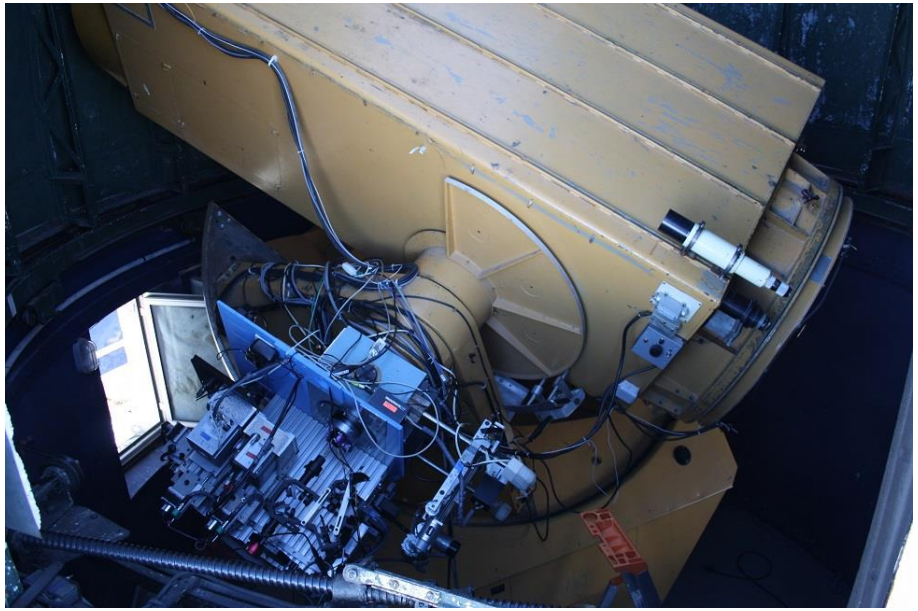
The deformable mirror

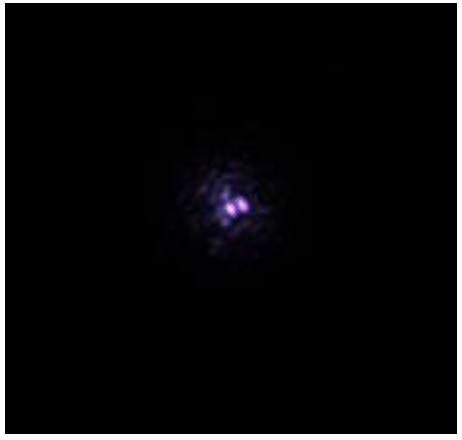
- Monomorph piezo-electric with > 20 actuators
- > 1kHz
- 10 mm diameter
- < 15 nm rms WFE accuracy for low orders
- > 5µm PtV of curvature and astigmatism

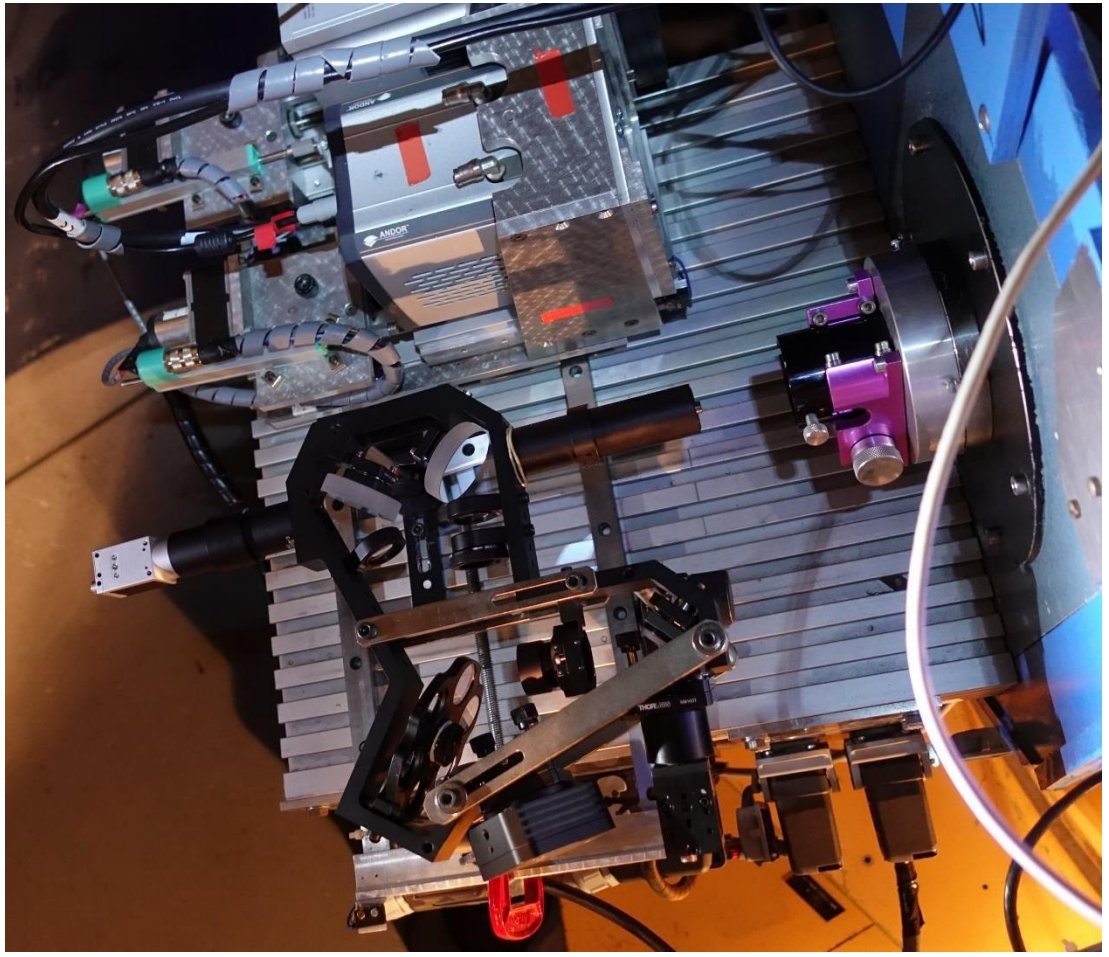
The wavefront sensor

- Shack-Hartmann 11x11 microlenses
- 1.2kHz
- 20 nm rms accuracy at 5000 photons per microlens

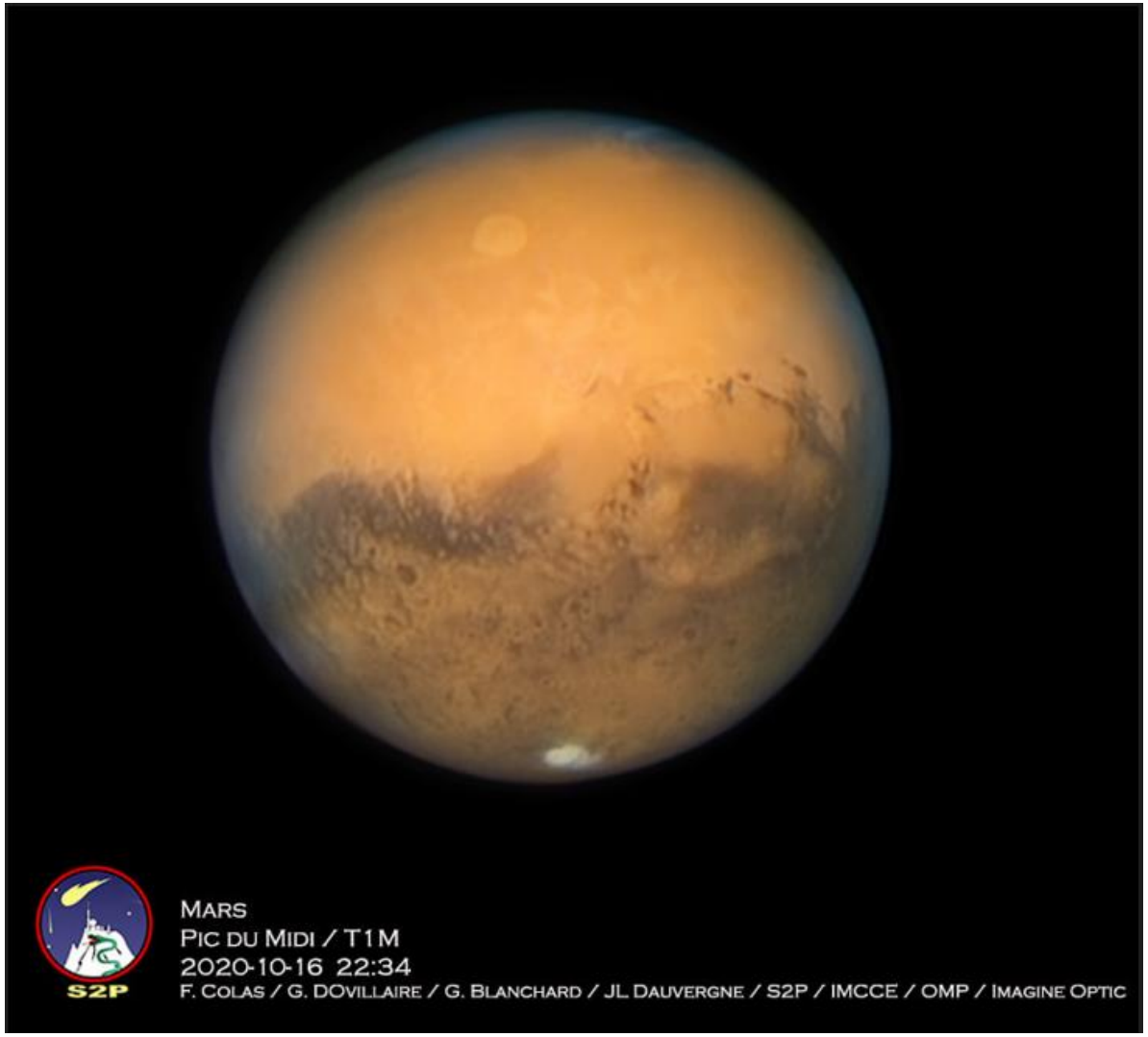
First light in 2017





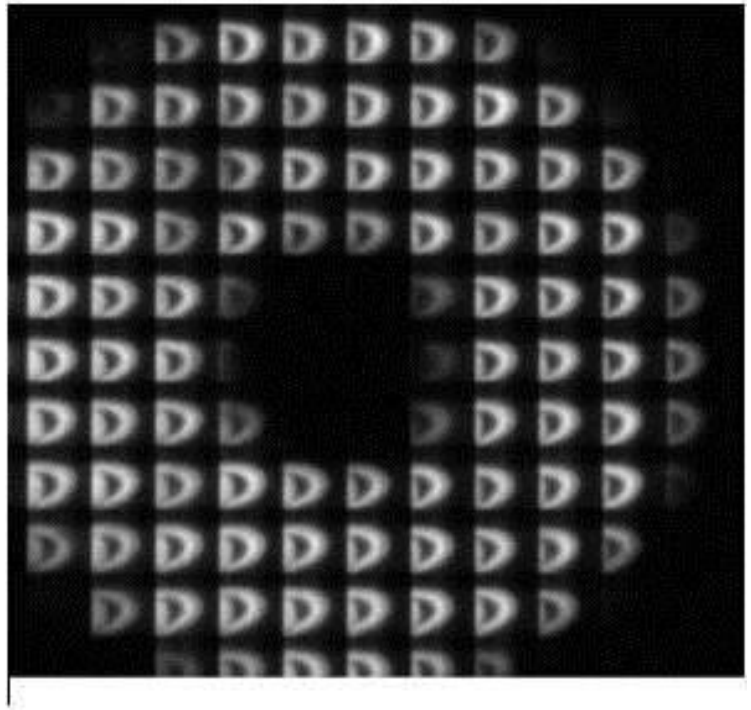


Active optics mode in 2020



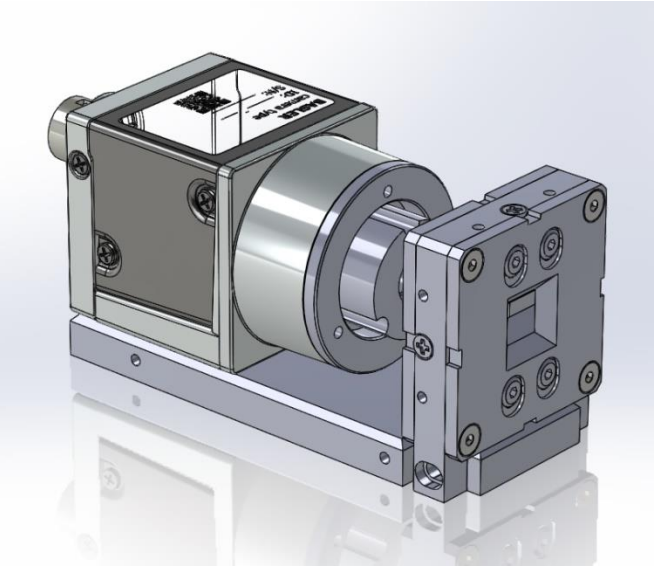
The most detailed image of mars acquired from ground ?

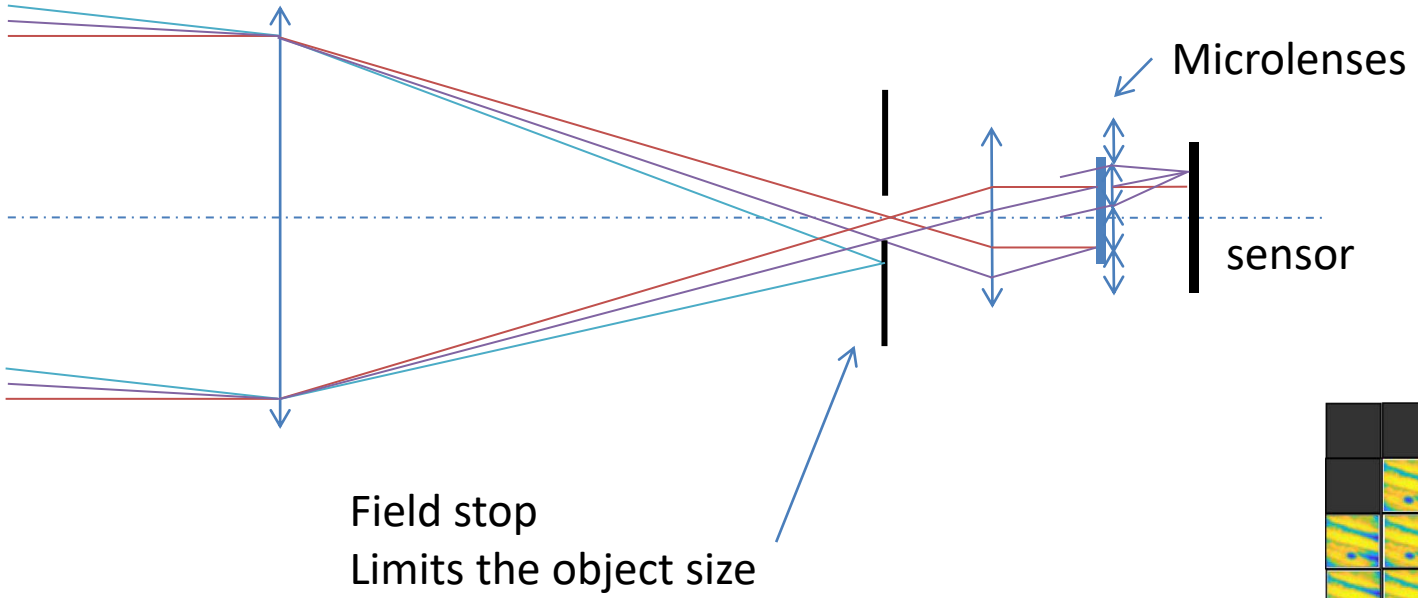
When you aim a bright object such as Saturn

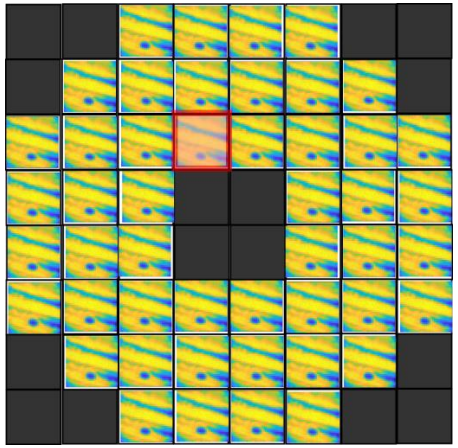


A standard Shack-Hartmann algorithm is not adapted

An extended source Shack-Hartman: HASO WIDE

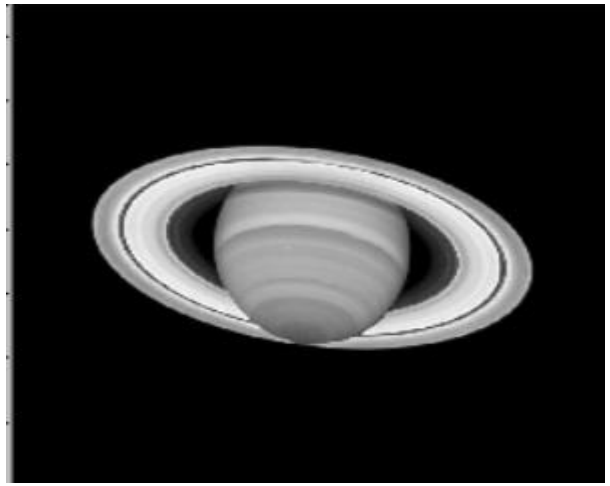




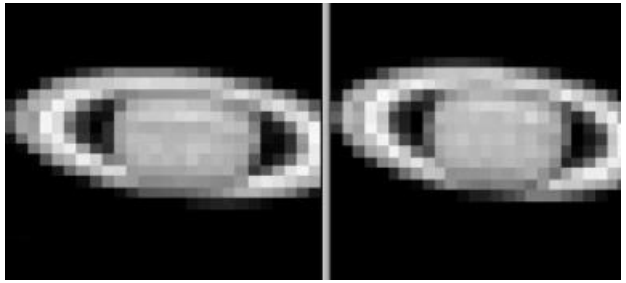


Sub-images are created on the detector
The relative position of all sub-images contains the information of the incoming wavefront
The filed stop avoid the overlap between images

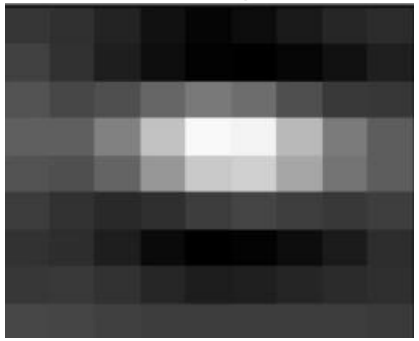
Some simulations

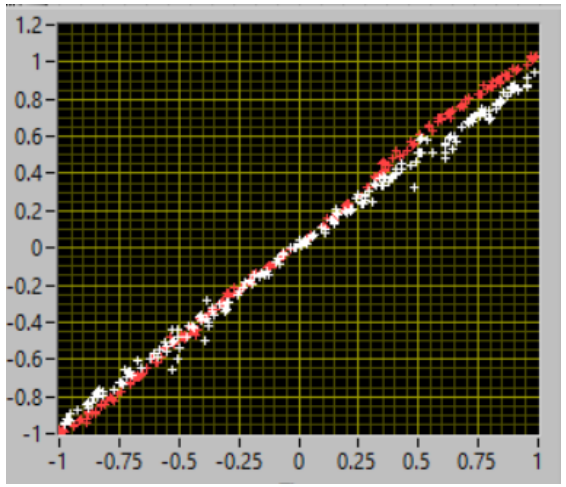


Sub-sampling, Known shifts are added



Intercorrelation maps





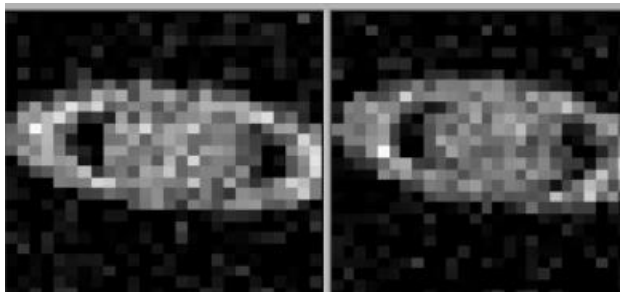
(in unit of pixel)
X in white
Y in red

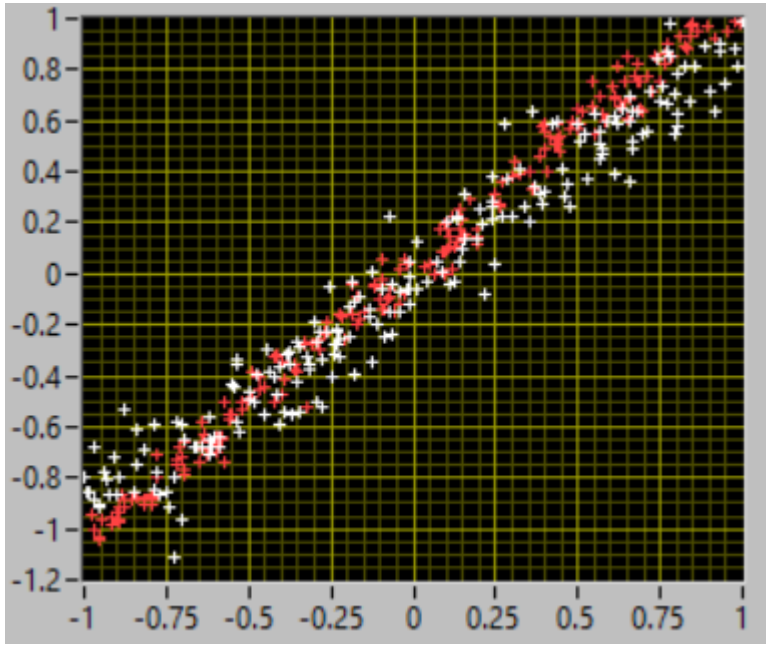
Standard deviation is 0.059 pixels RMS

400 000 ph/microlentilles

Some simulations

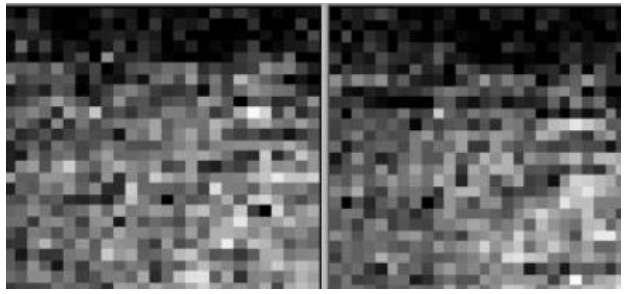
10000 ph/microlentilles

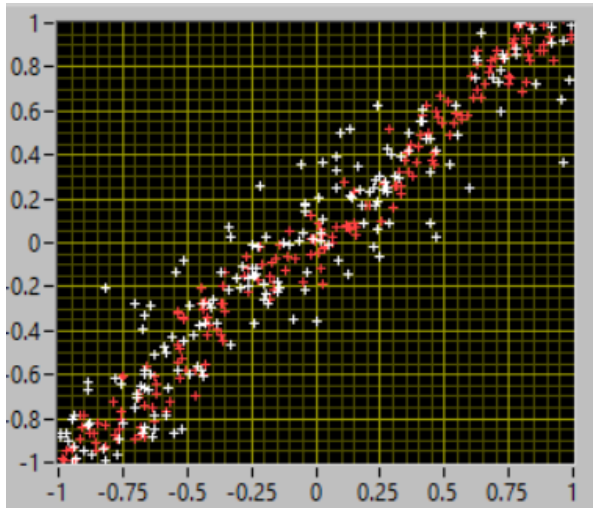


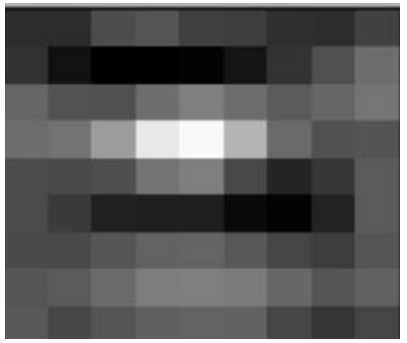


Standard deviation is 0.14 pixels RMS

Some simulations



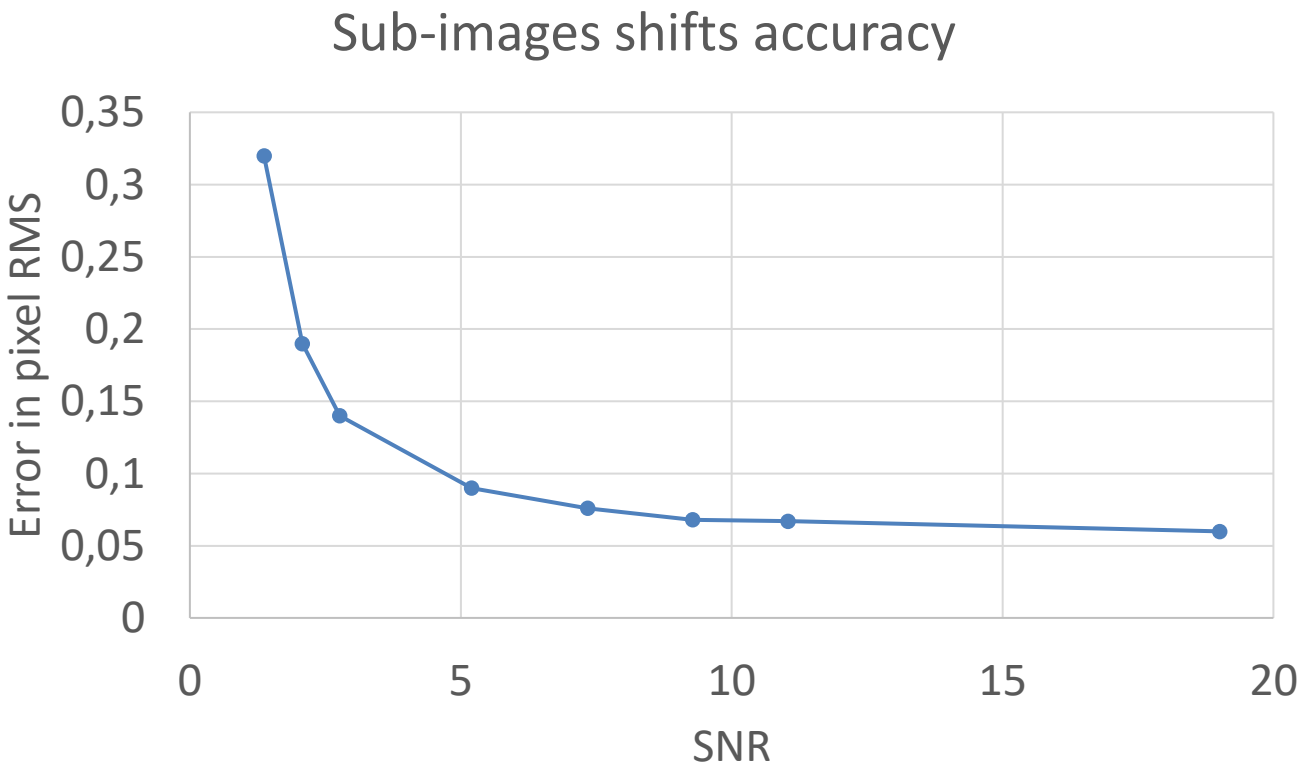




Standard deviation is
0.24 pixels RMS

(20000 ph/microlentilles)

Some simulations



SNR

Spatial RMS of temporal means

/

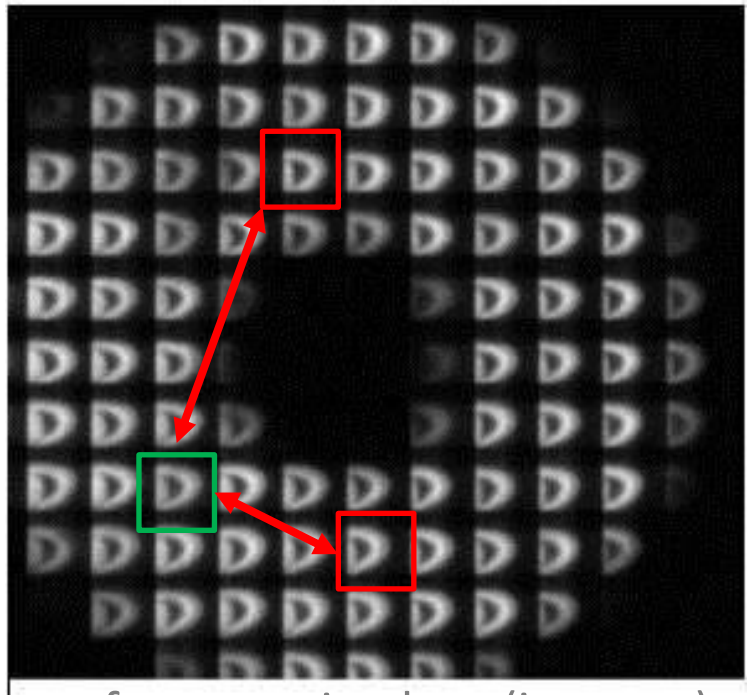
Spatial mean of temporal RMS

Contrast in the image

Noise in the image

The extended source Shack-Hartman: the tilt problem

Spatial intercorrelations

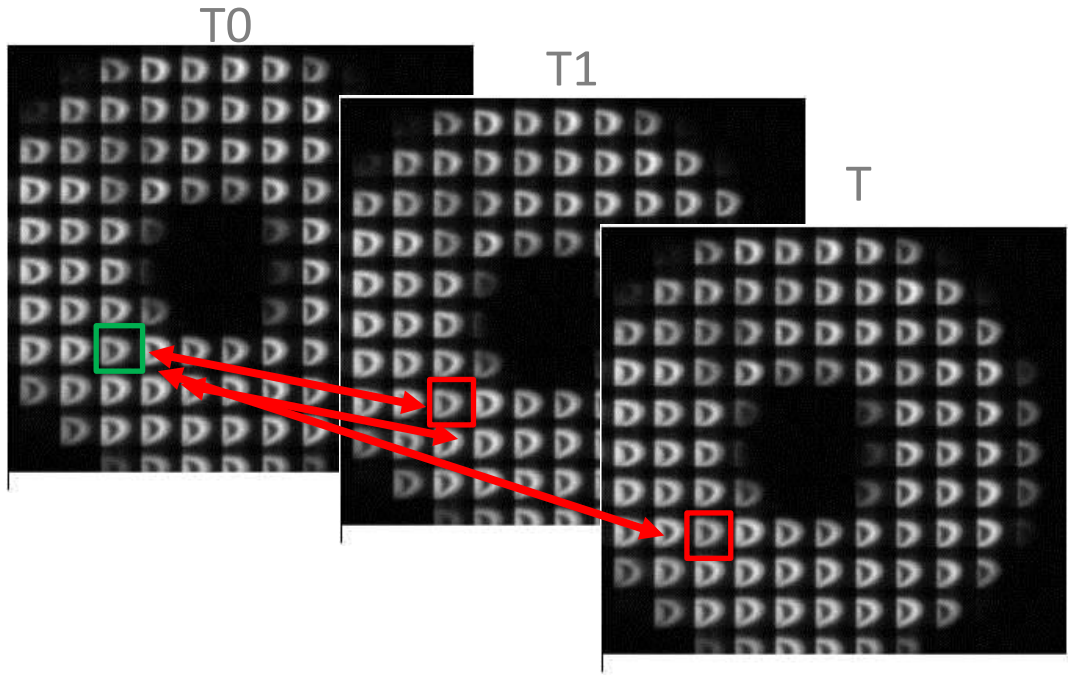


The reference microlens (in green) measures always tilt=0

→ The wavefront tilt is not measured

THEN

Temporal intercorrelations

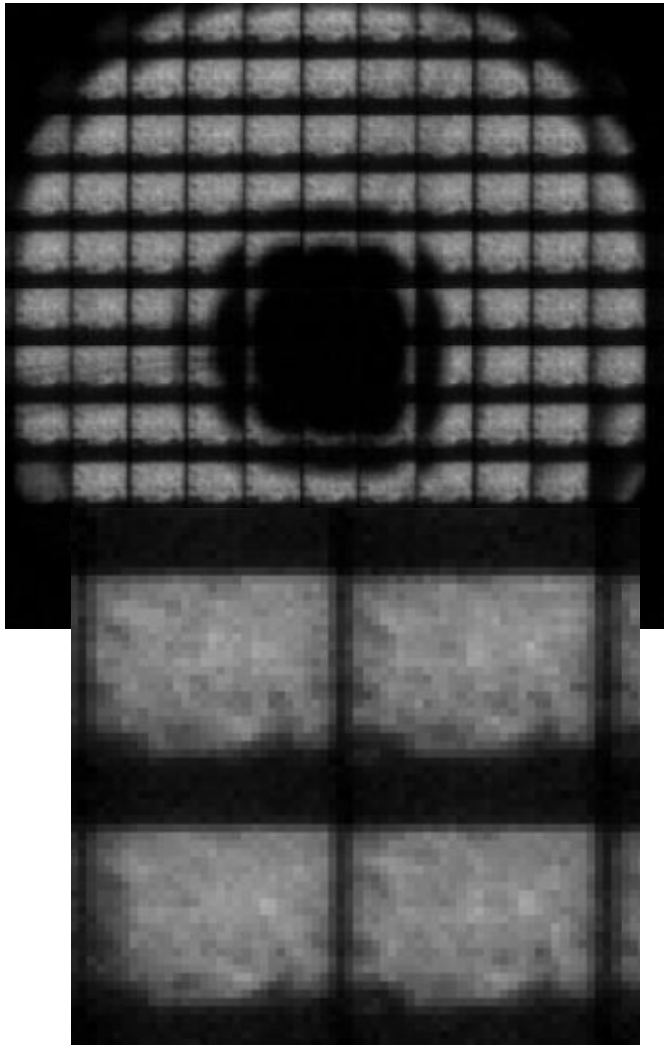


The first image is taken as a reference

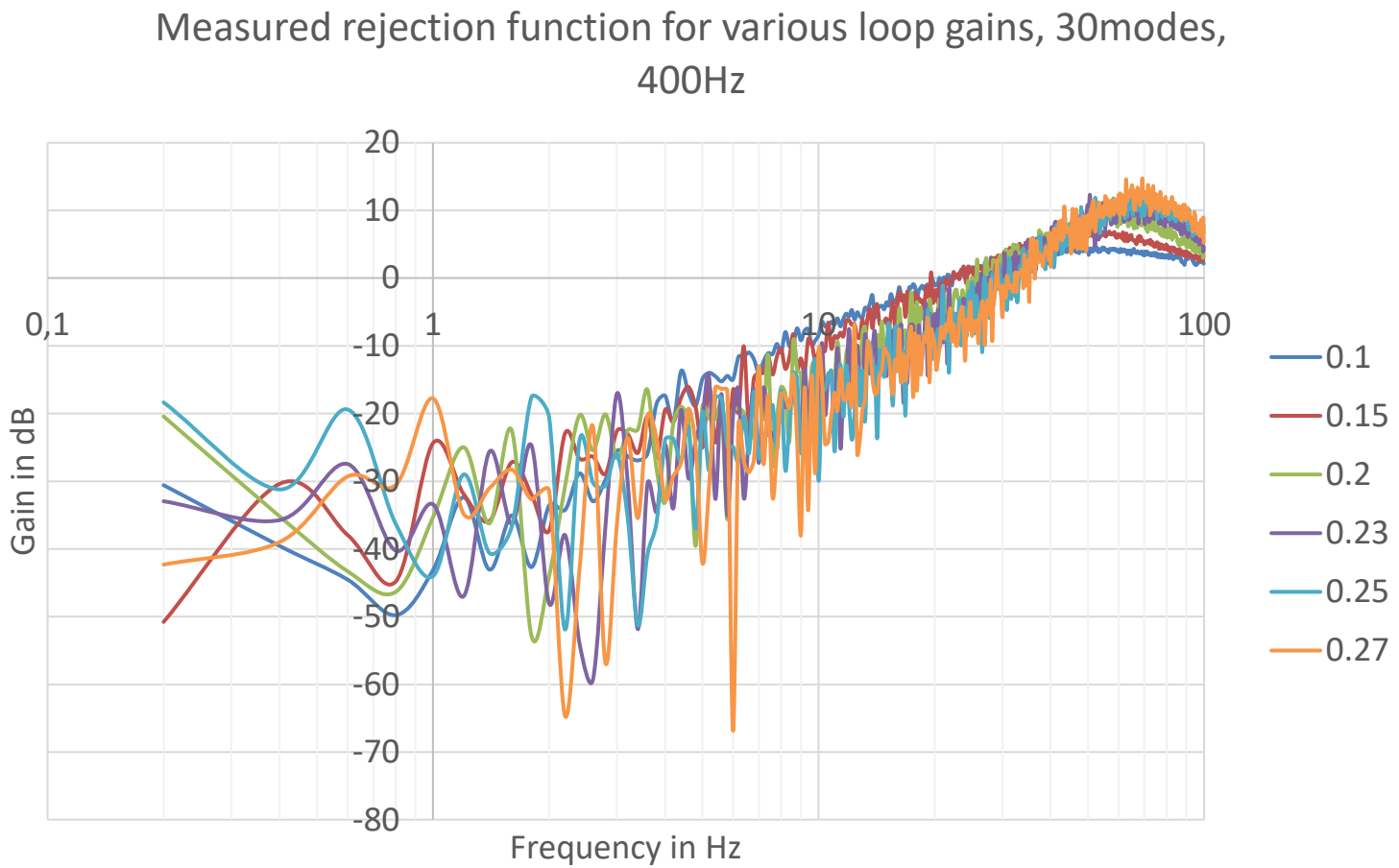
→ The static aberrations are not corrected

In real… on the moon

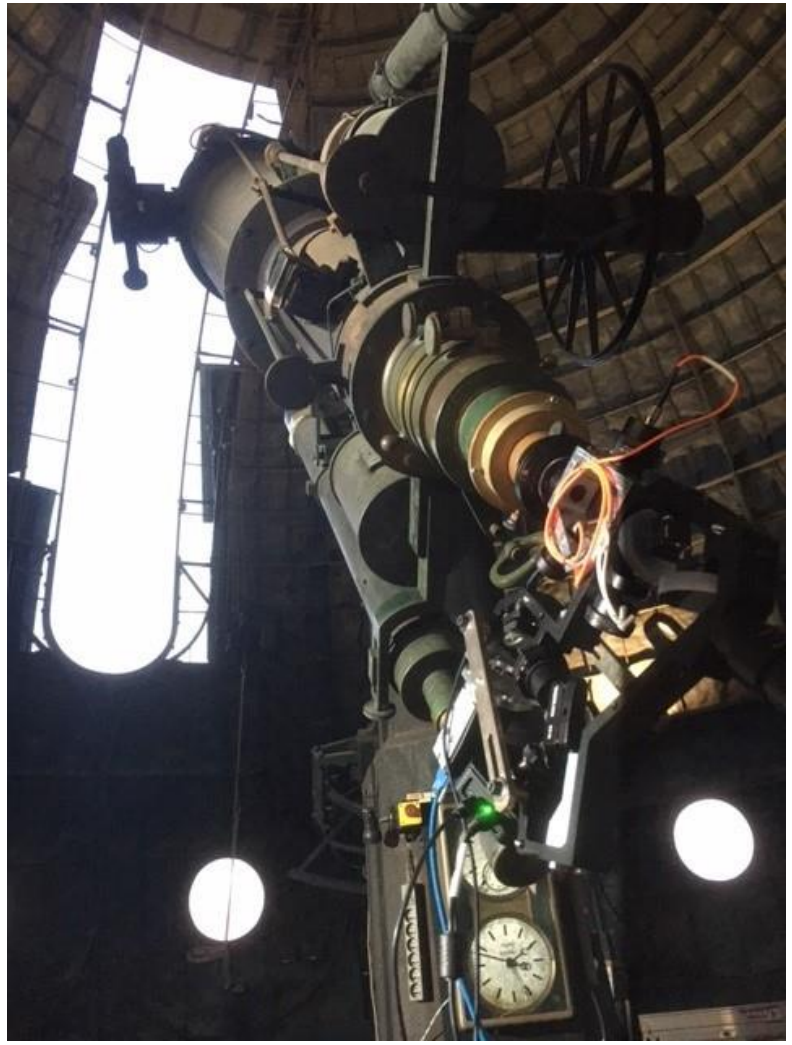
Mewlon 250 + CIAO,
2021-12-21, Paris

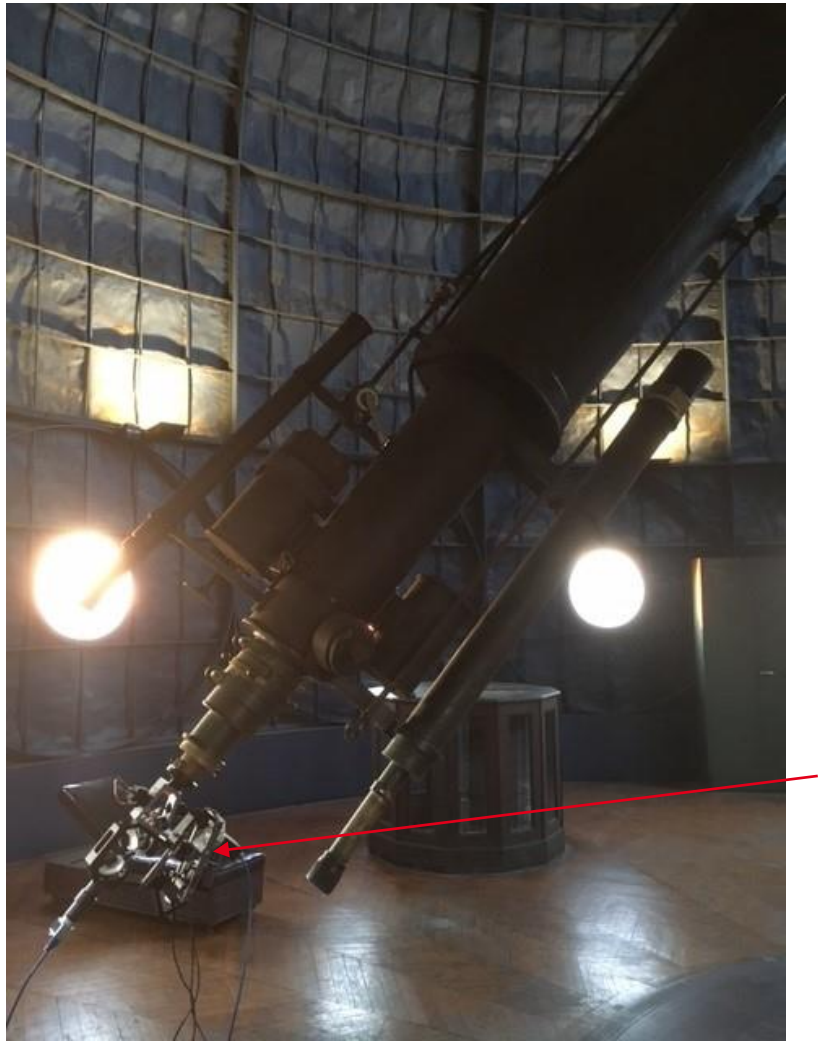


Temporal perfomances



Let’s have fun

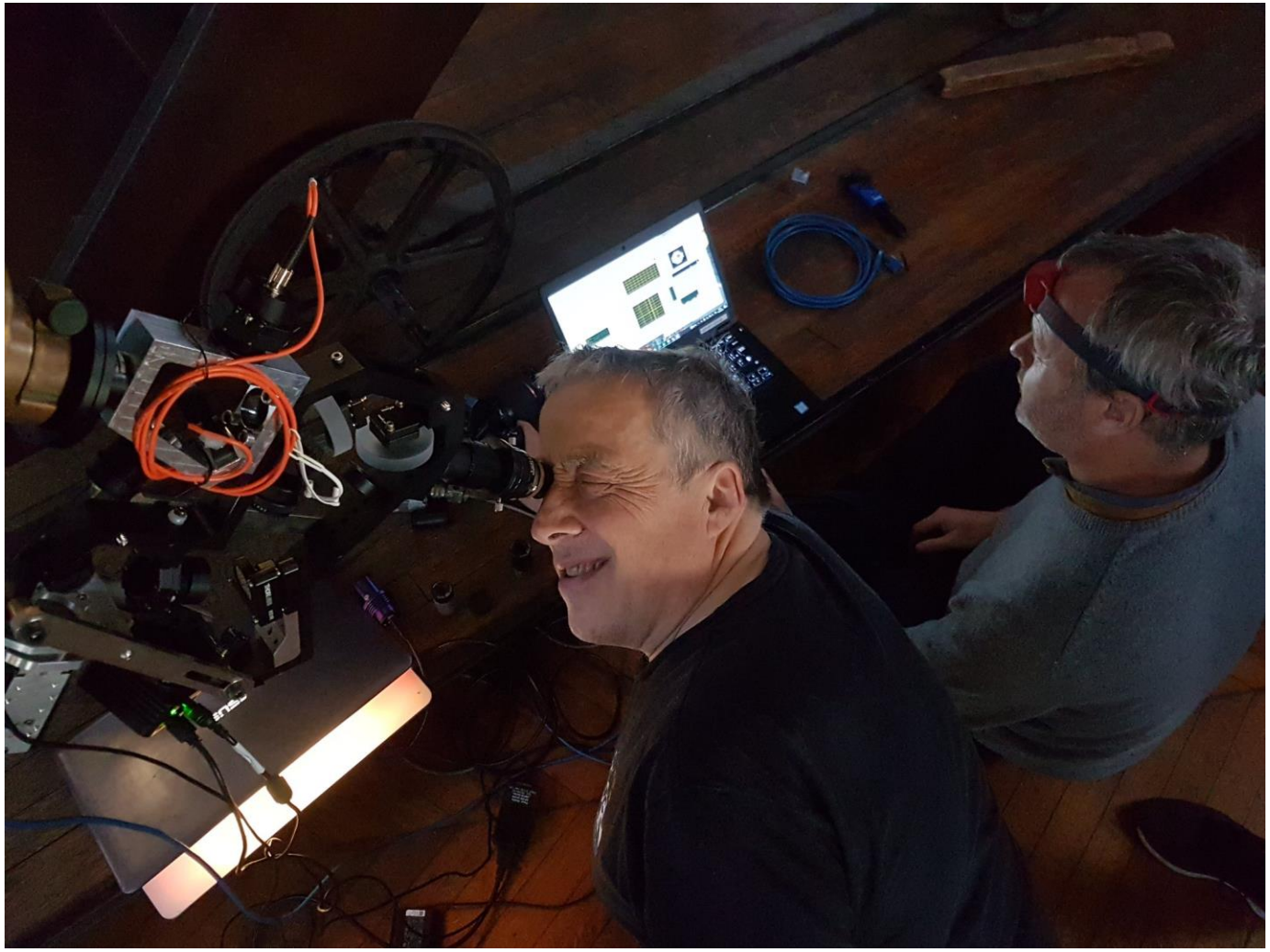




The Arago telescope at Observatoire de Paris

CIAO

Let’s have fun



Thanks

https://www.youtube.com/watch?v=Q9EEChj534s&t=85s

François Colas
Jean-Luc Dauvergne
Guillaume Blanchard
Guillaume Dovillaire