GRAVITY acquisition camera

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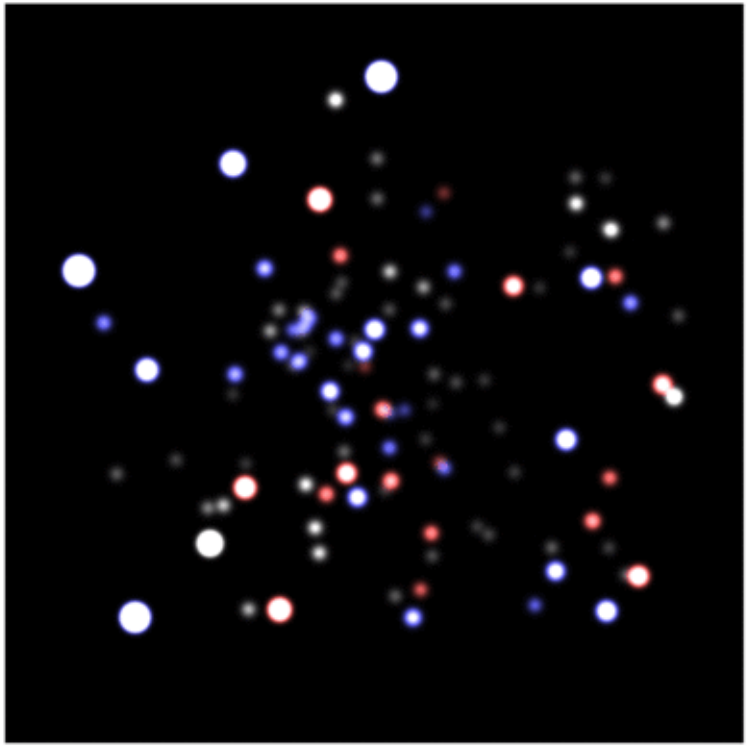
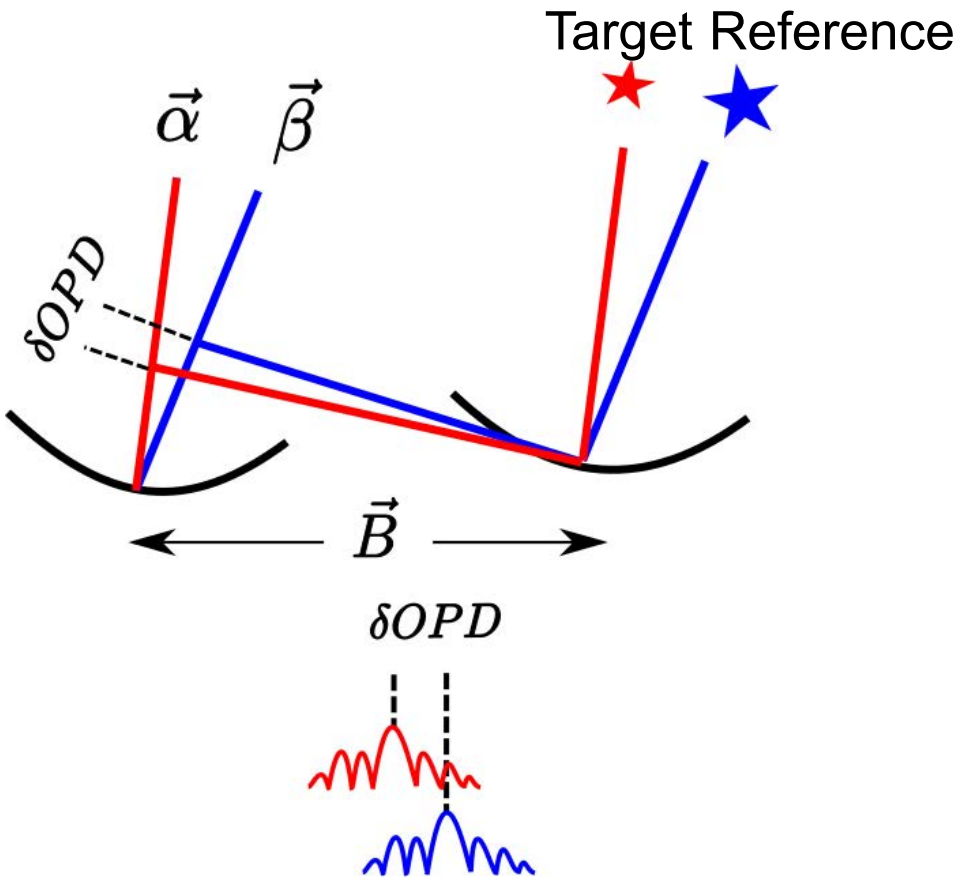
14th January, NICE

GRAVITY: phase-reference interferometer





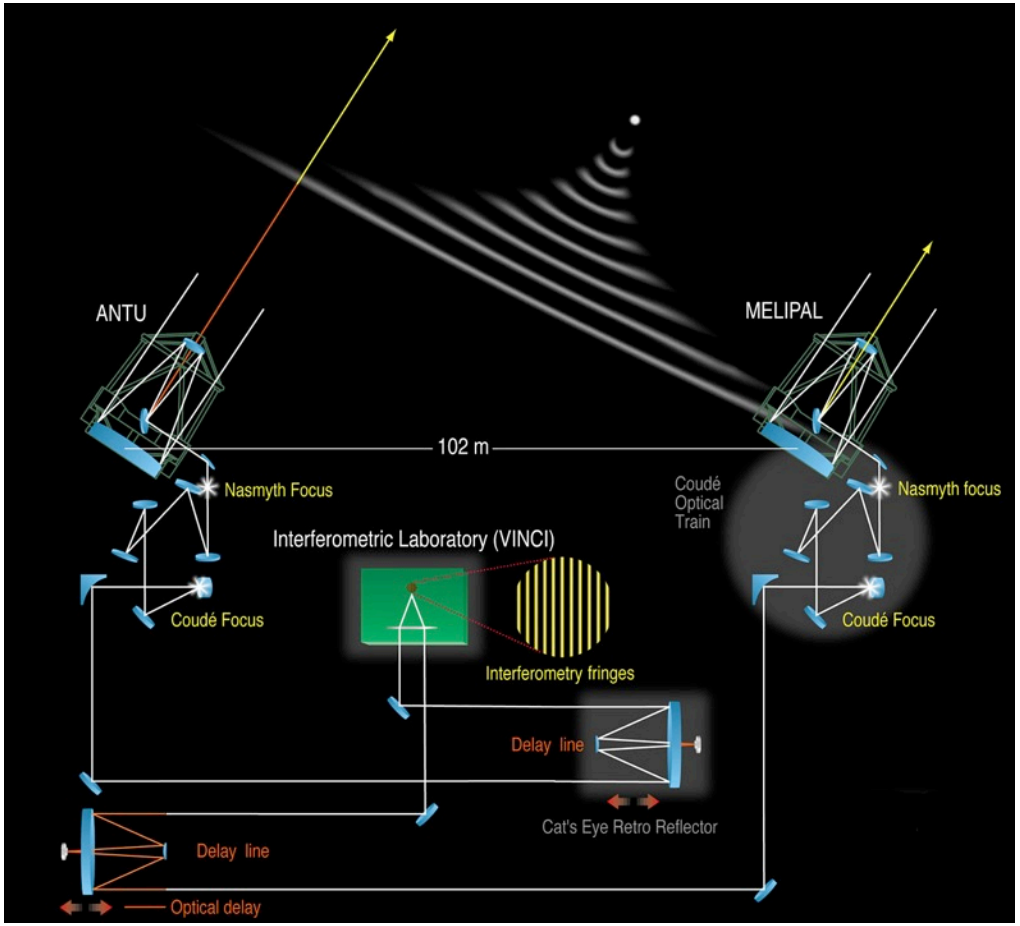
$$\delta OPD = \vec{B}.(\vec{\alpha} - \vec{\beta})$$

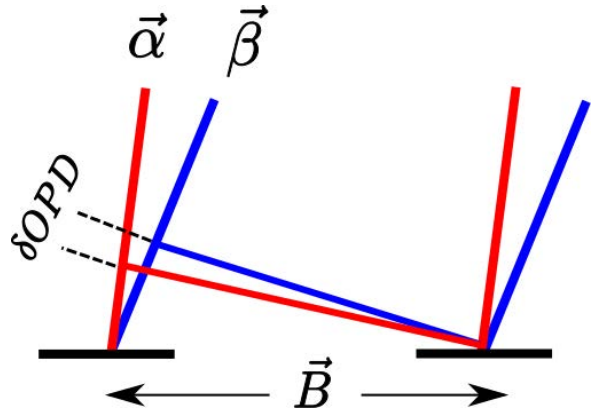
5 nm 500 µm 10 µ arcsec

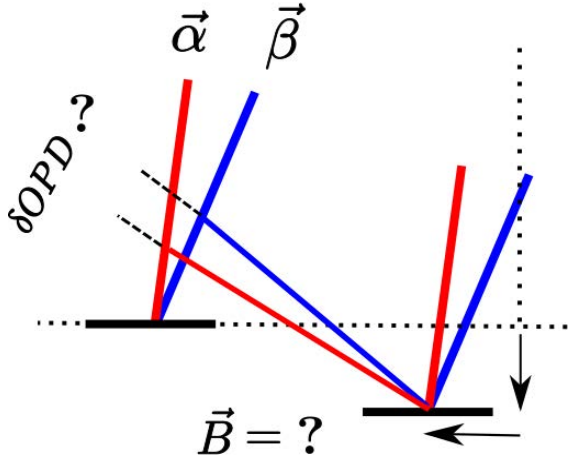
GRAVITY subsystems

- Adaptive optics
- Metrology system
- Integrated optics
- Fringe tracker
- Fiber coupler and laser guiding system
- Acquisition camera

Why acquisition camera: To stabilize pupil motions

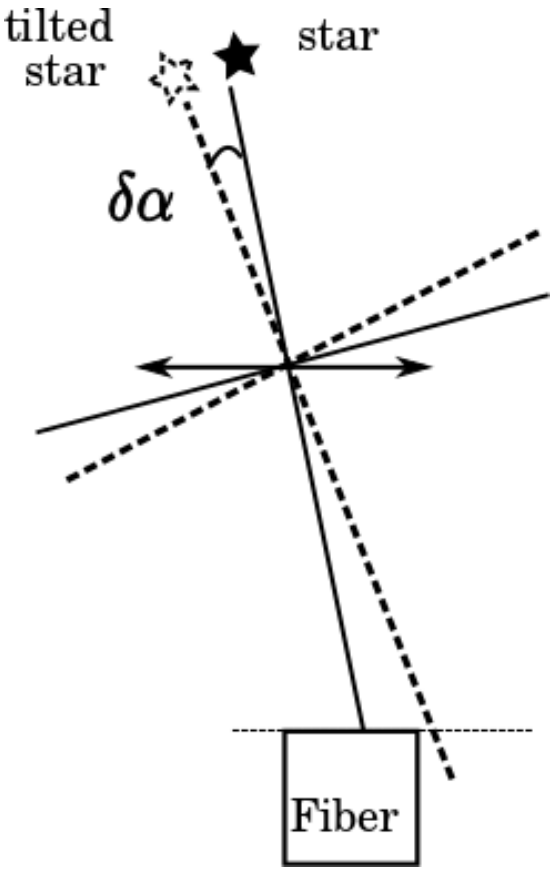






Why acquisition camera (2): atmospheric tip-tilts

In GRAVITY the coherent beam combination implemented with fiber fed integrated optics



Problems:

1. Flux injection
2. Astrometric error

Technical requirements to achieve GRAVITY aims

To achieve 10 micro arcsec astrometry, GRAVITY requires

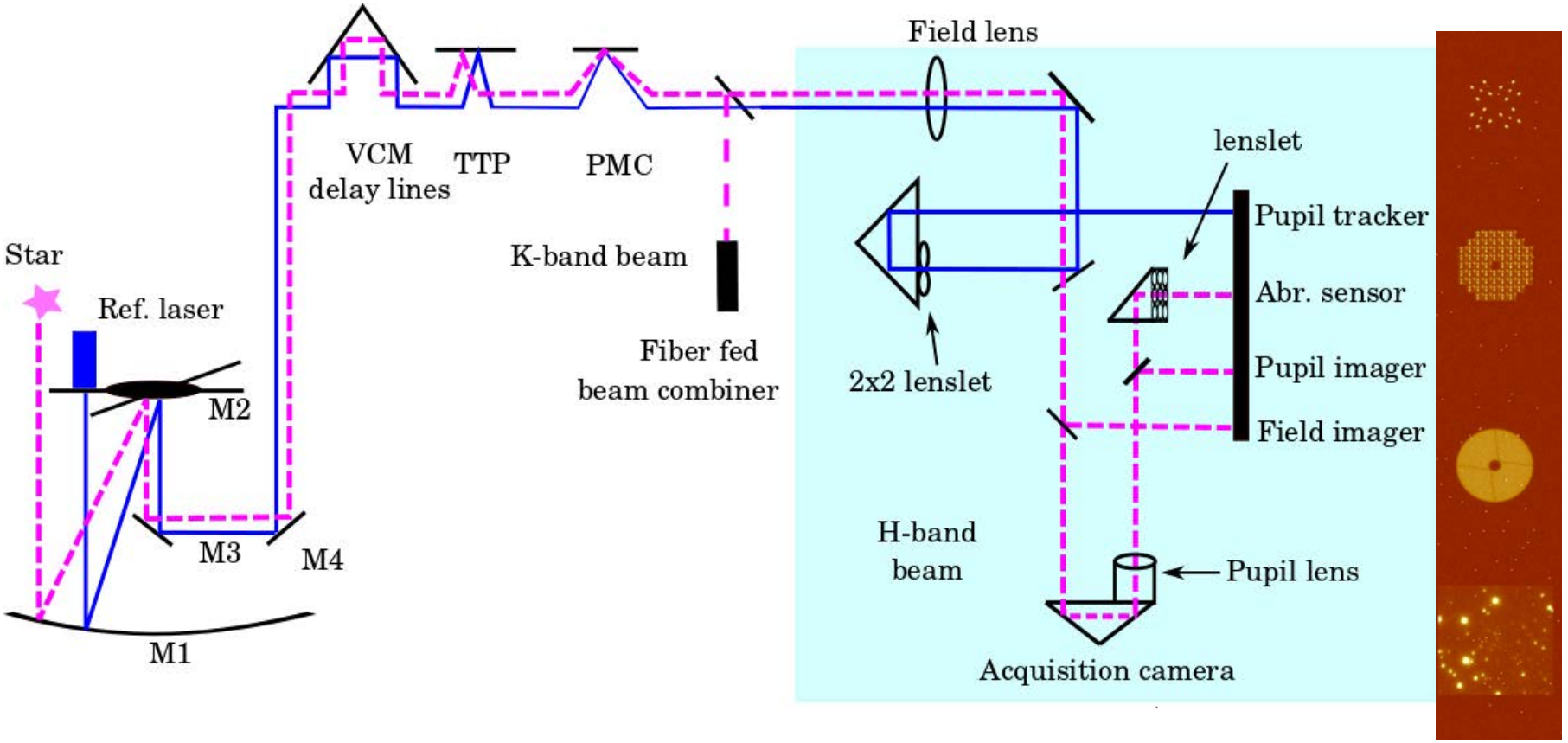
1. Field stability (error ≤ 2 mas)

2. Pupil stability:
   - lateral position error ≤ 4 cm, i.e., 0.5% 8m telescope;
   - longitudinal pupil position error ≤ 1 m.

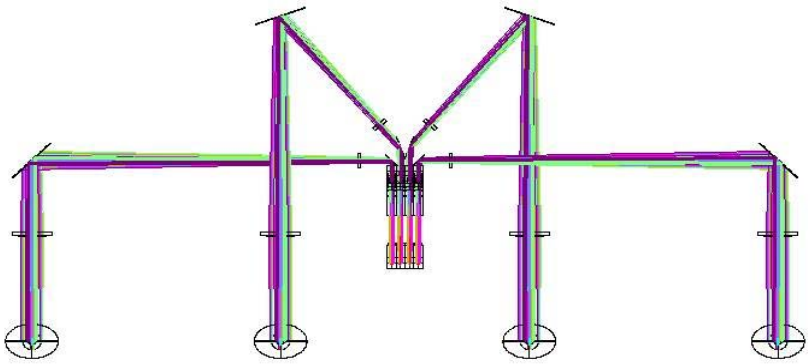
3. Wavefront sensing (error ≤ 80 nm)

So we need a beam analyzing system and correction system !!

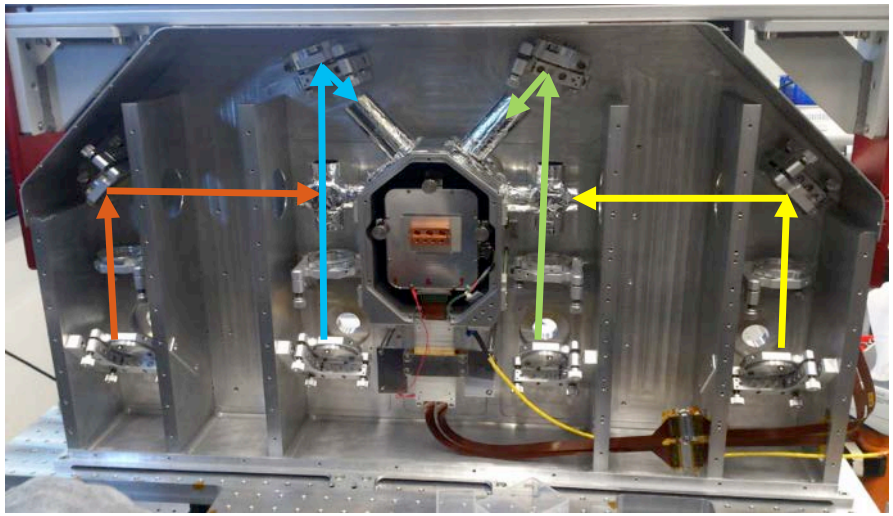
Acquisition camera optical layout



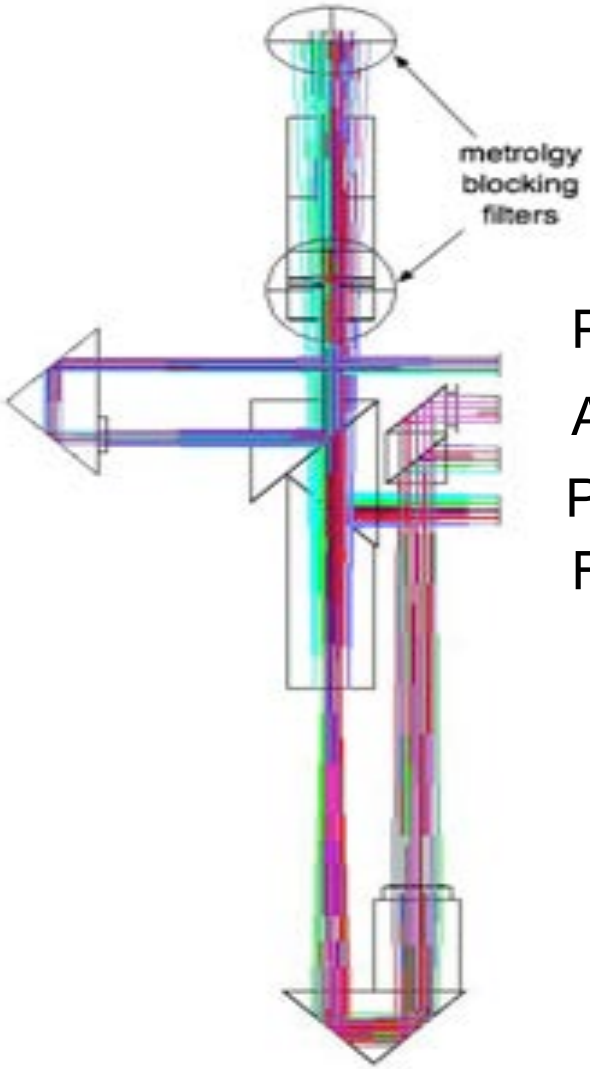
Acquisition camera: folding optics



UT4 UT3 UT2 UT1



Acquisition camera: core beam analyzer



Pupil tracker

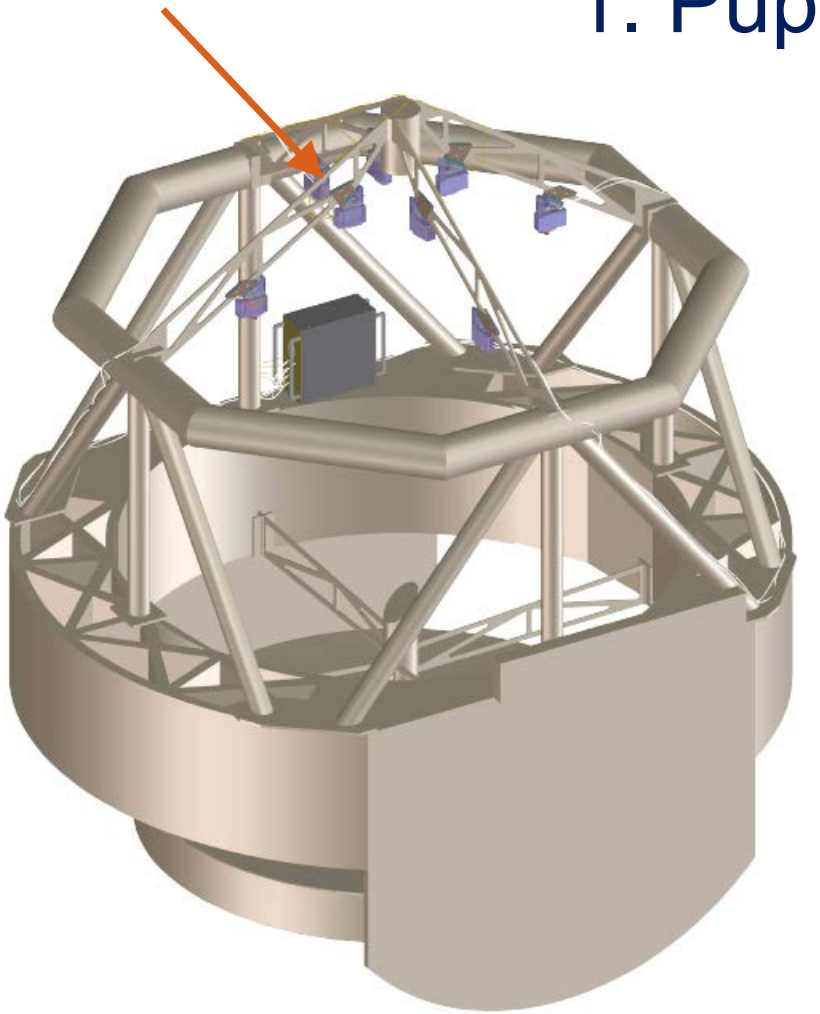
Aberration sensor

Pupil imager

Field tracker

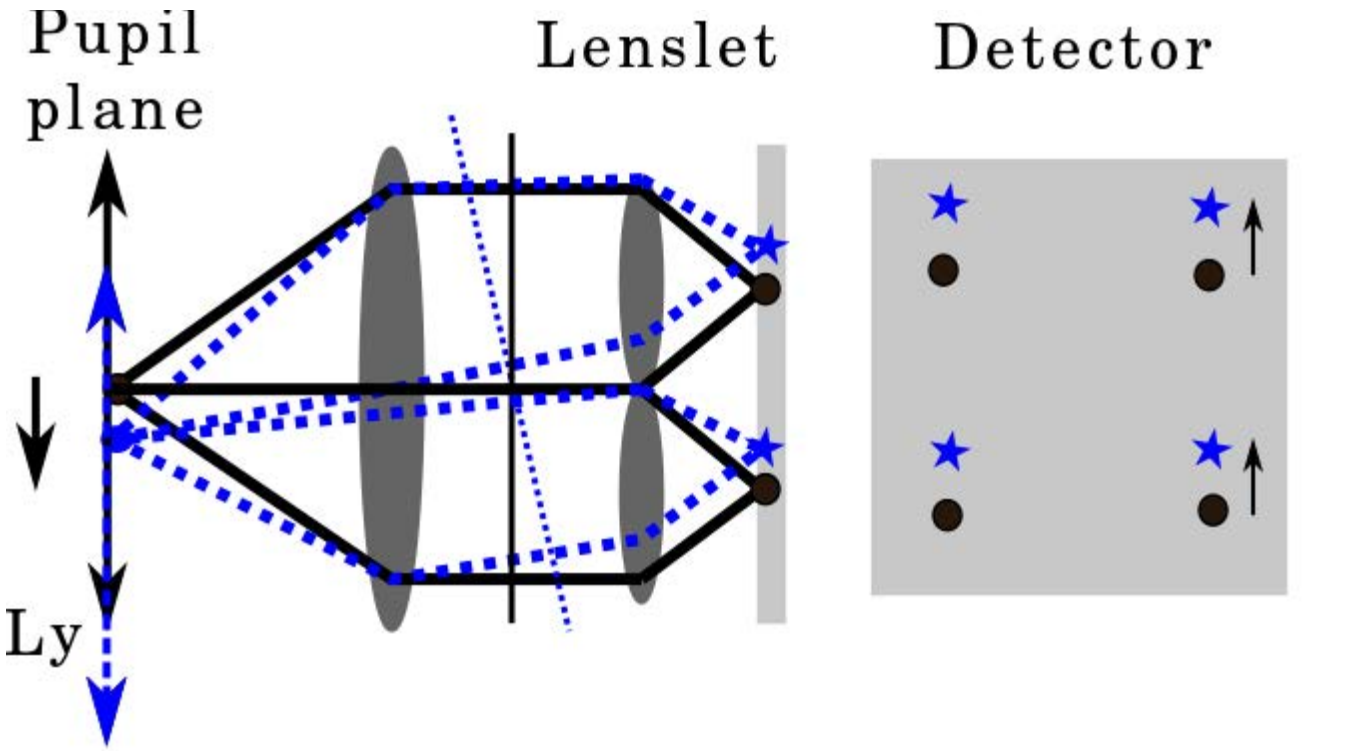
Optics embedded in it

1. Pupil tracking



- ✓ To track telescope pupil motions, 4 lasers are mounted on M2 spiders.
- ✓ Lasers are imaged with 2x2 lenslet.

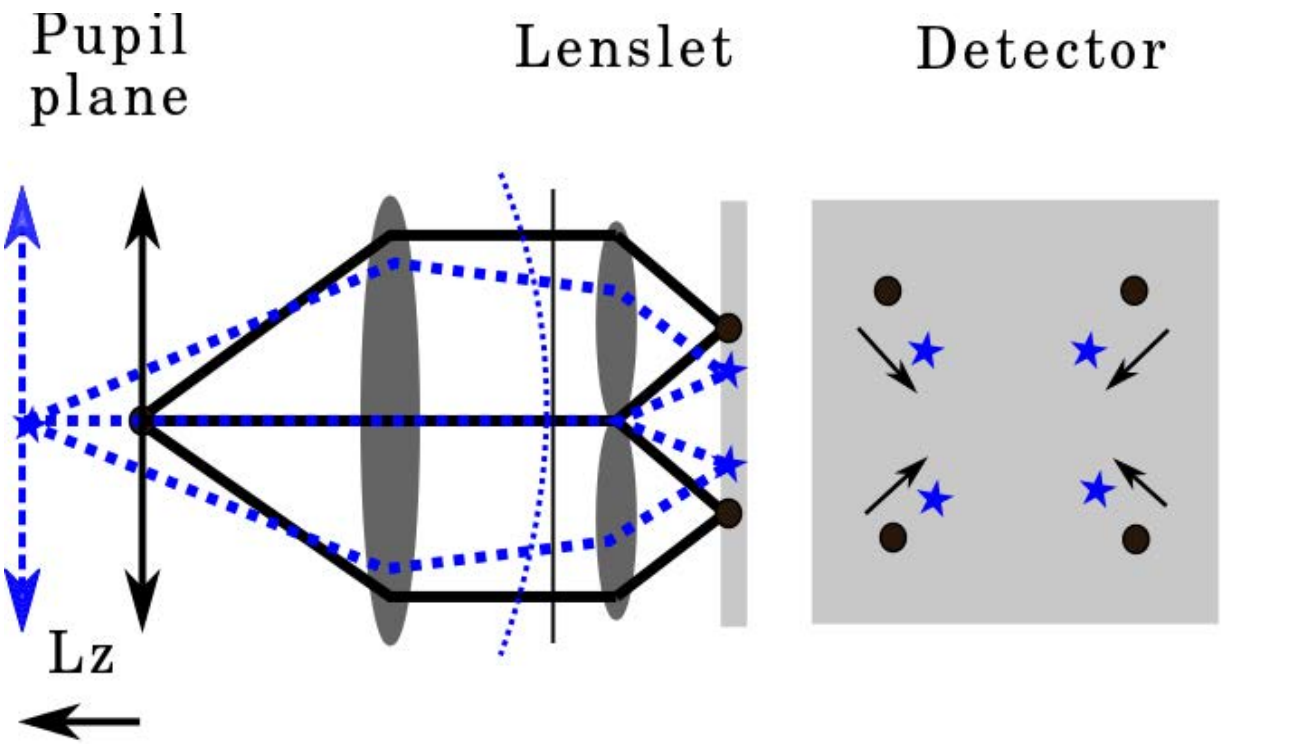
a) Lateral pupil tracking



(a) Optical layout of lat. pupil shift

(b) Lat. pupil shifted spots

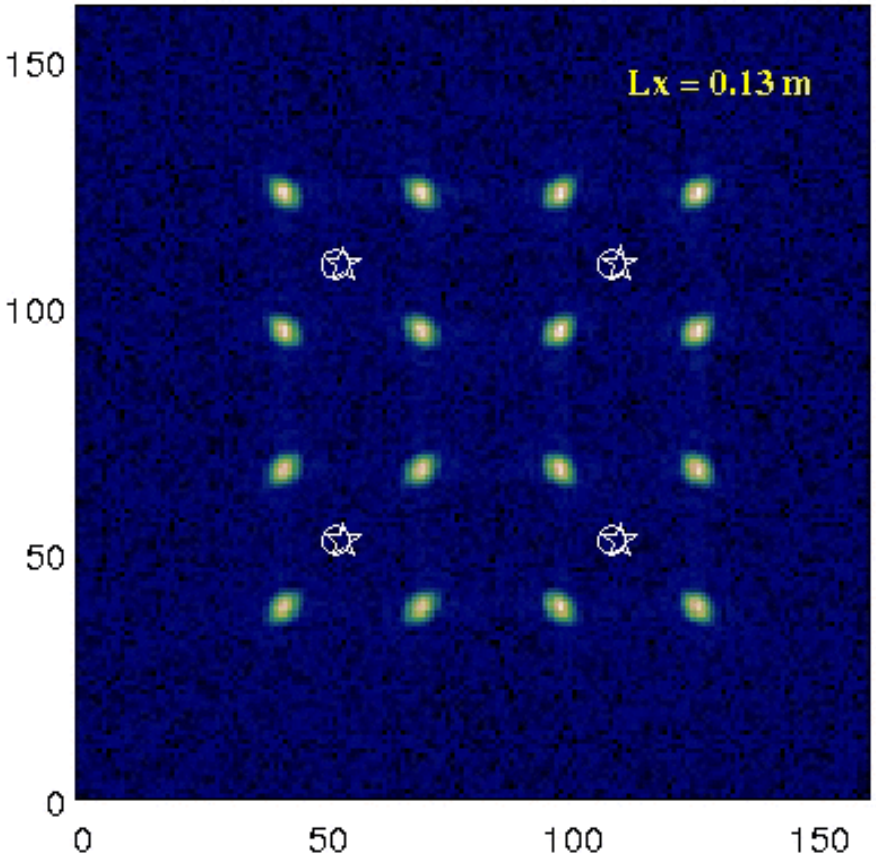
b) Longitudinal pupil tracking



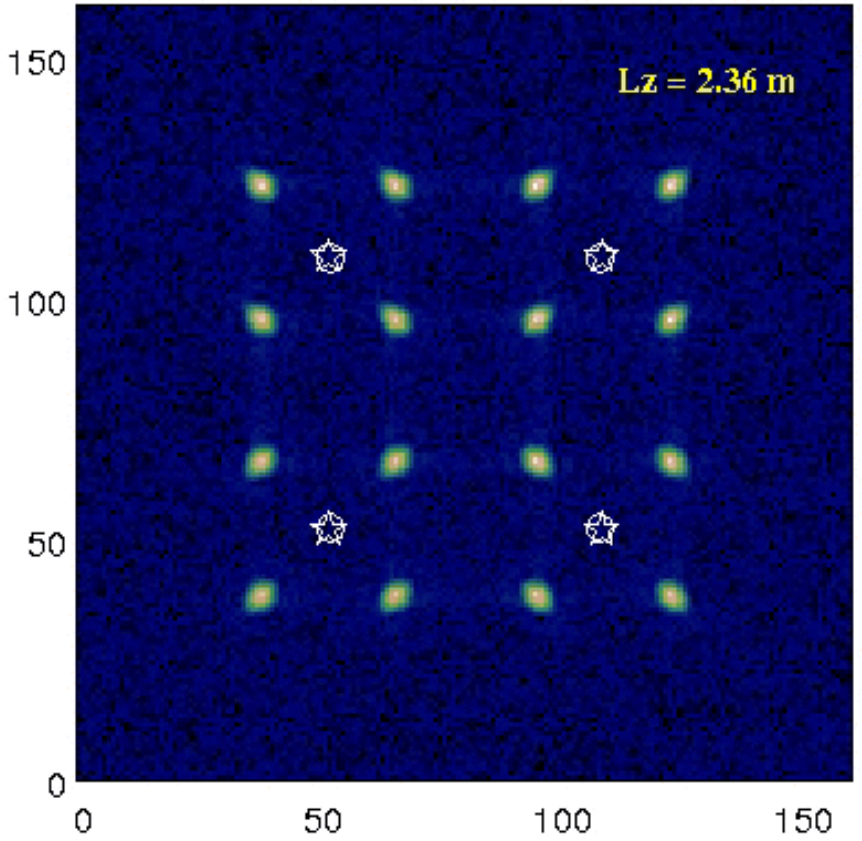
(c) Optical layout of long. shifted case

(d) Long. pupil shifted spots

Pupil shifts measurement

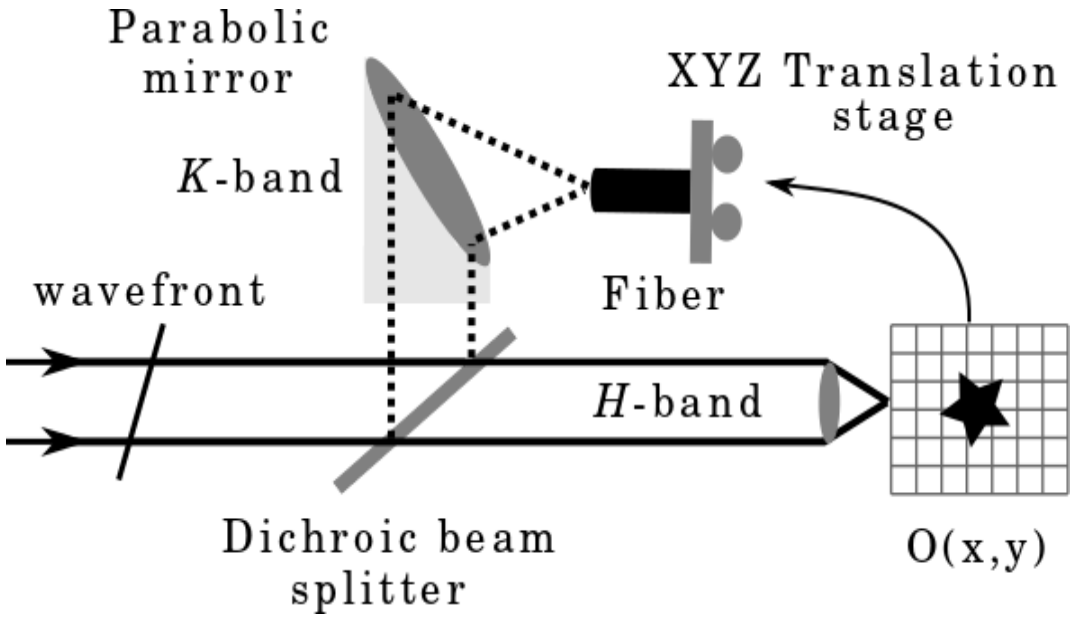


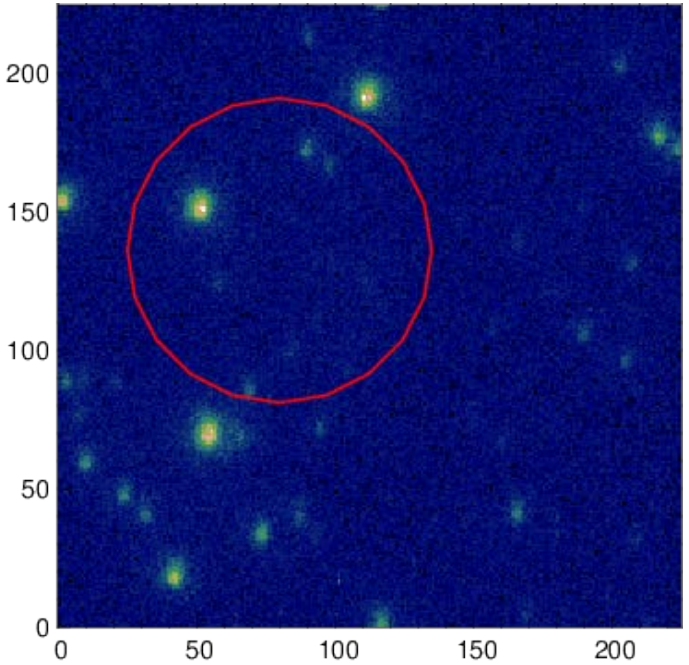
Lateral pupil shifts



Longitudinal pupil shifts

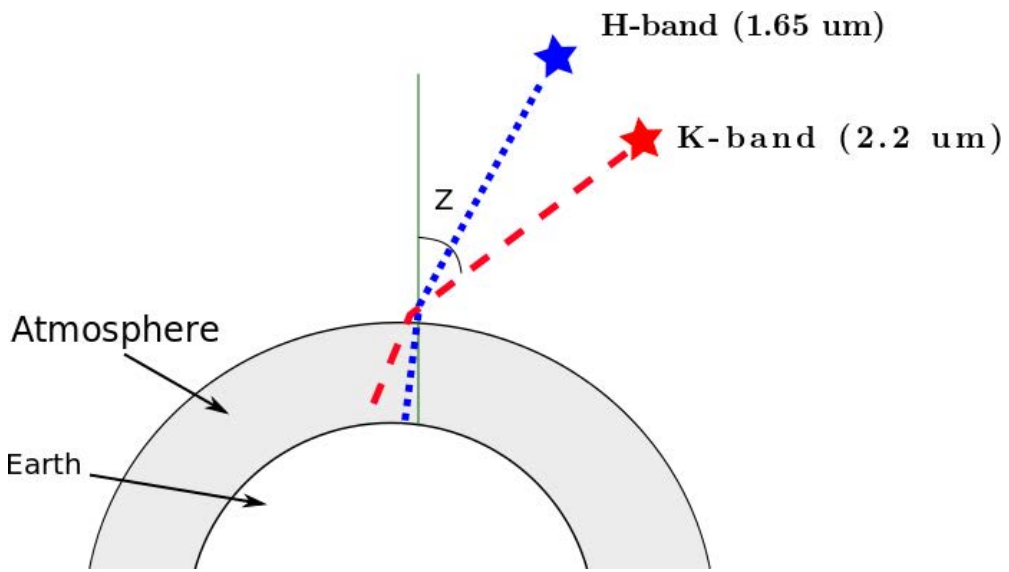
2. Field imaging and tracking

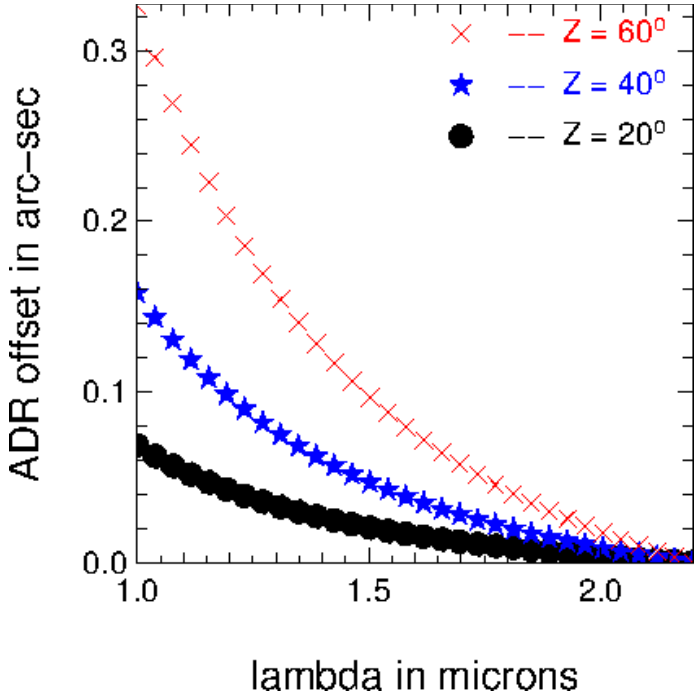




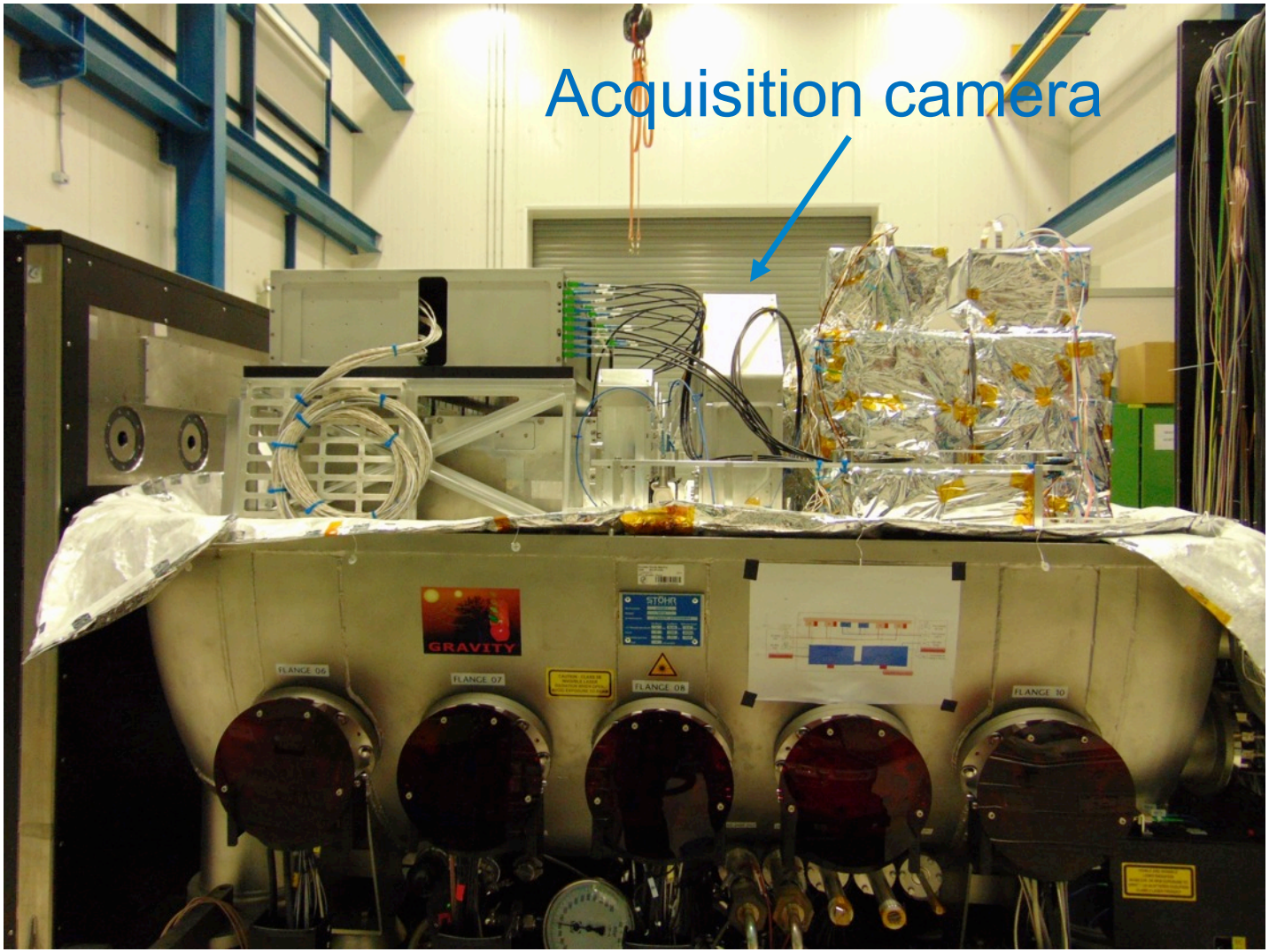
AO residual and tunnel seeing tip-tilts are measured with a precision of 2 milliarcsecond.

Atmospheric dispersion shifts between acquisition camera and K-band fiber

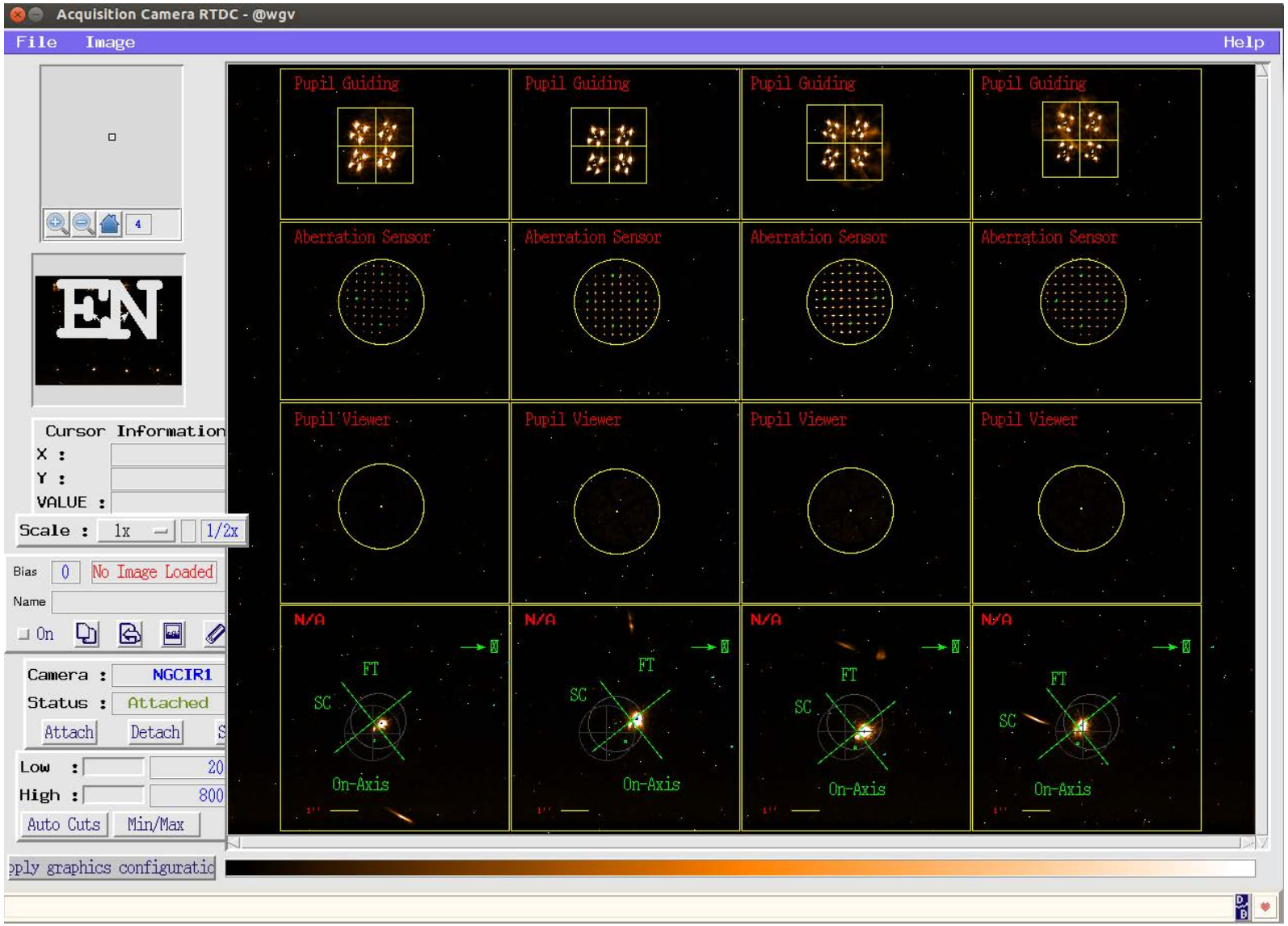




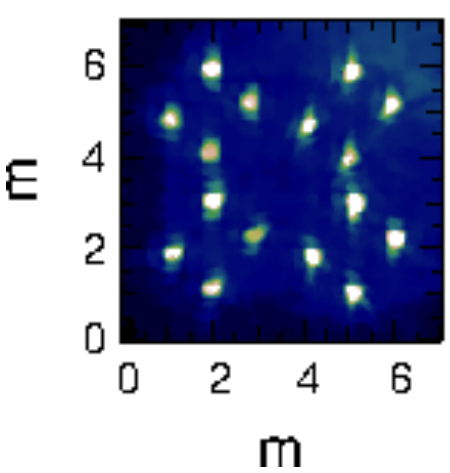
GRAVITY


Acquisition camera
GRAVITY
FLANGE 06
FLANGE 07
FLANGE 08
FLANGE 10

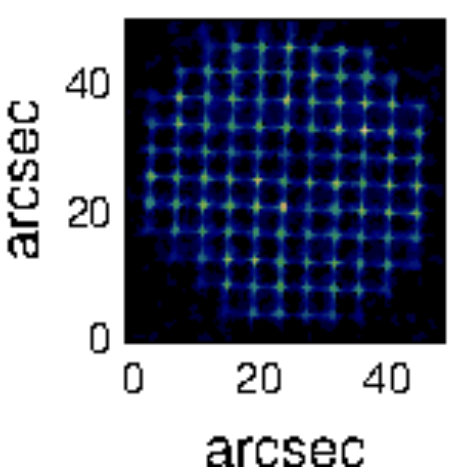
Acquisition camera Real Time Display



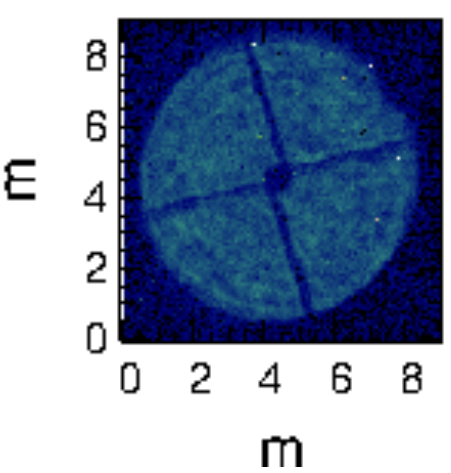
For one telescope



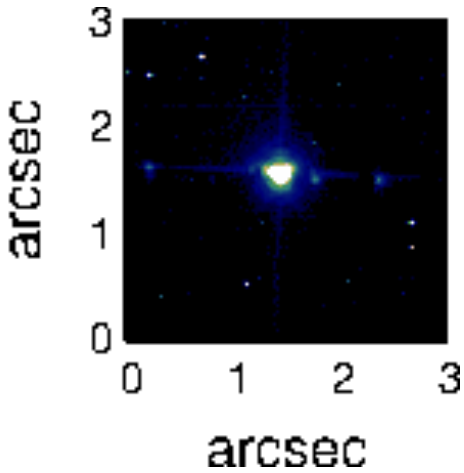
Pupil tracker



Aberration sensor



Pupil imager



Field imager

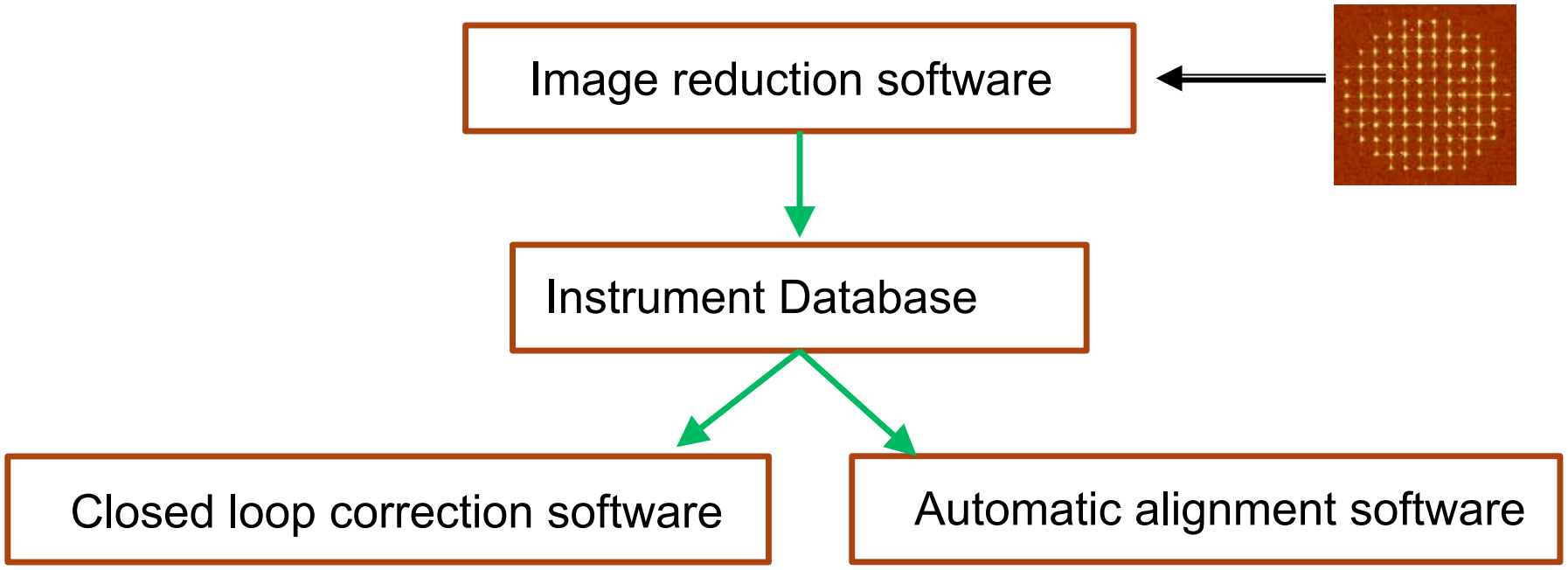
Software developed

Main tasks:

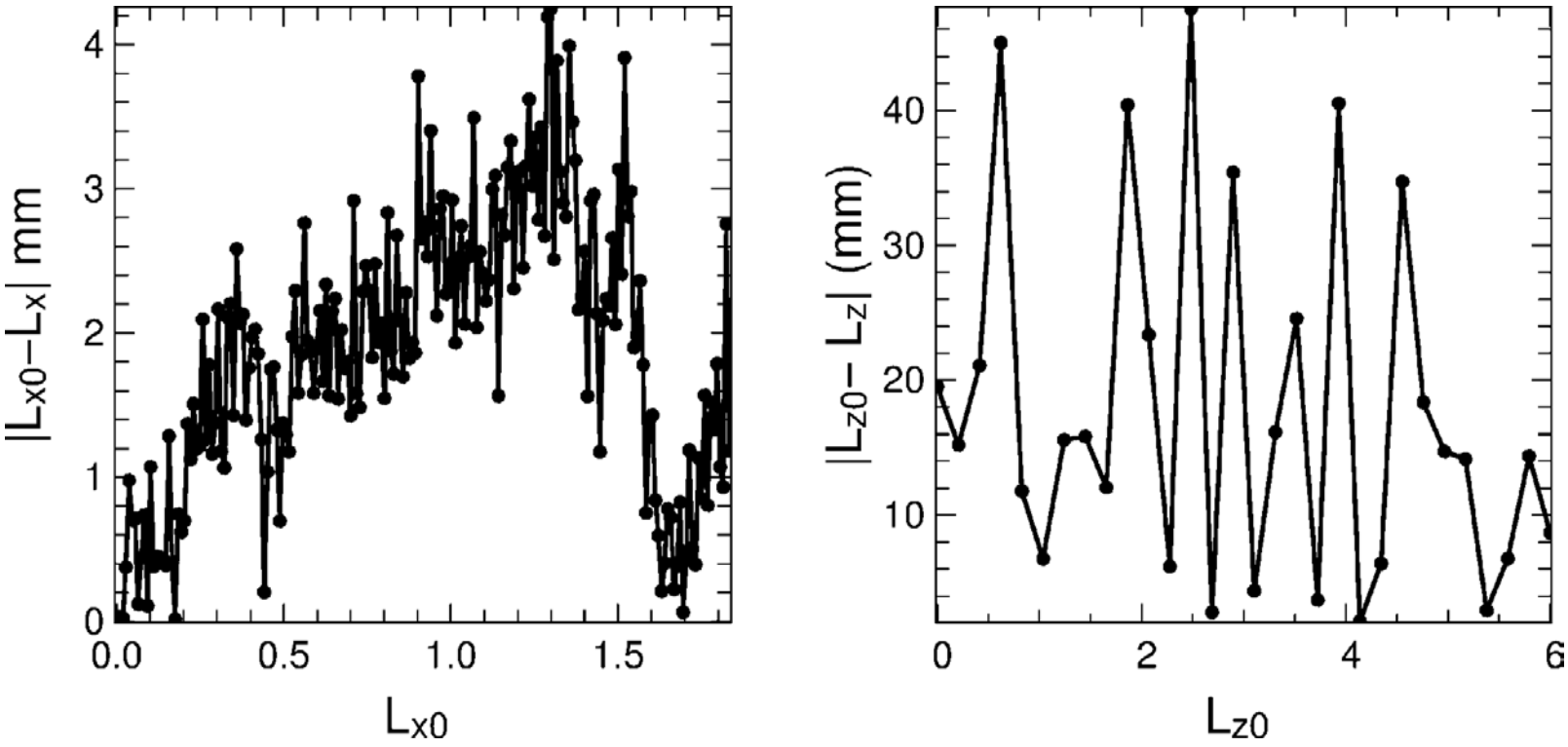
1. Image reduction software

2. Closed loop correction software.

3. Automatic alignment of GRAVITY with the VLTI optics.

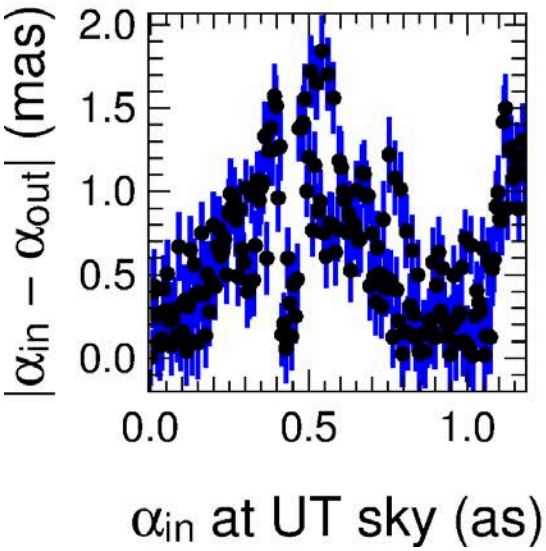


Pupil tracking characterization with calibration unit

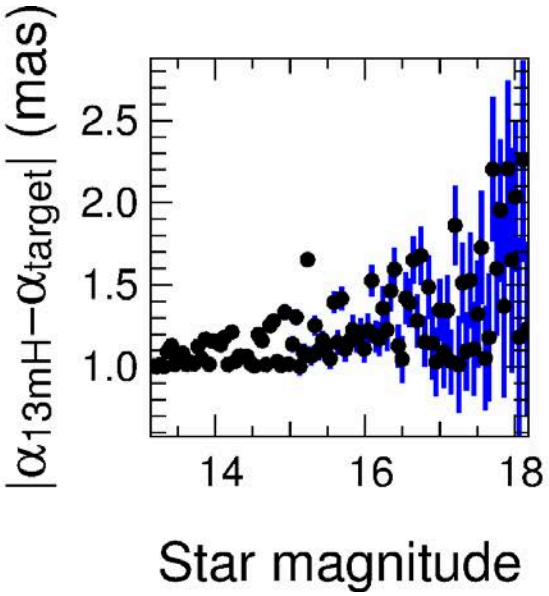


By applying known pupil shifts the pupil tracker is characterized.

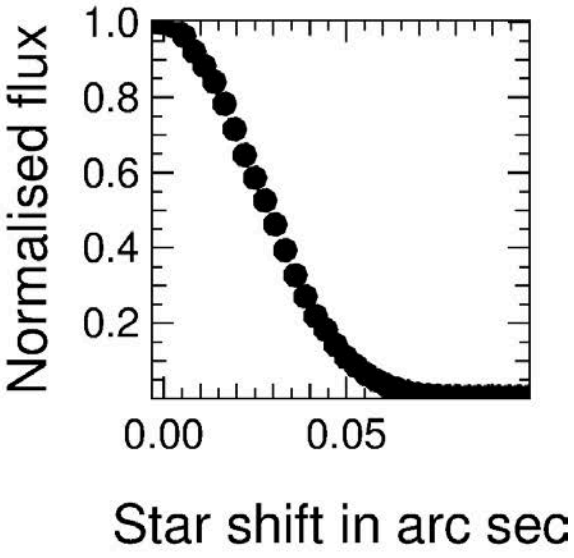
Field tracking characterization



Tip-tilts

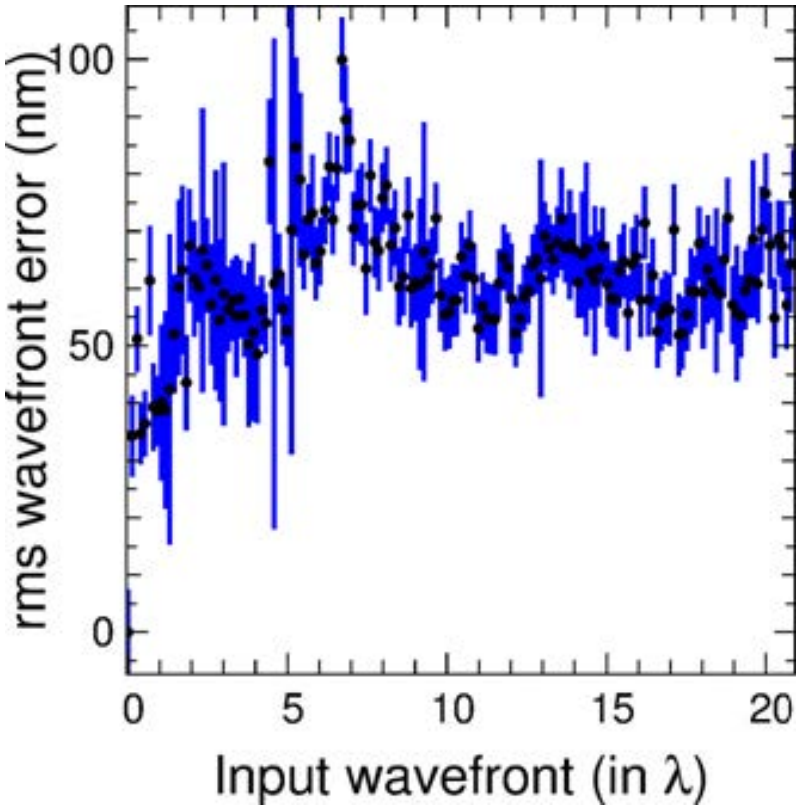


Star magnitude



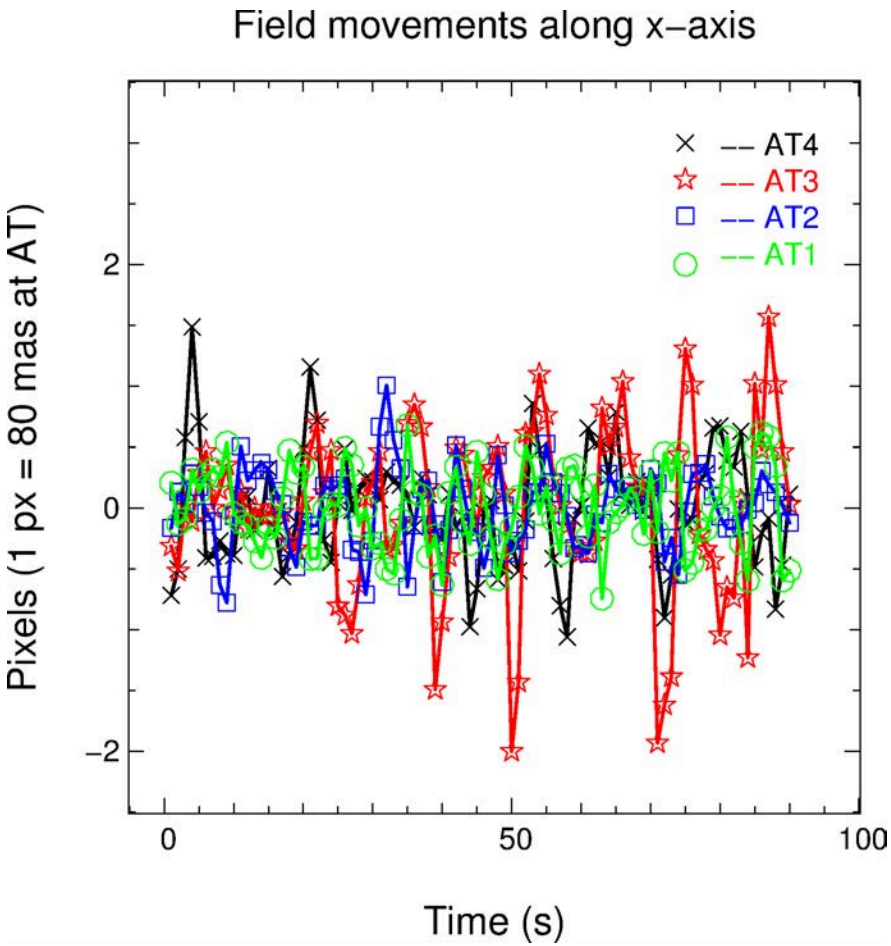
Fiber flux

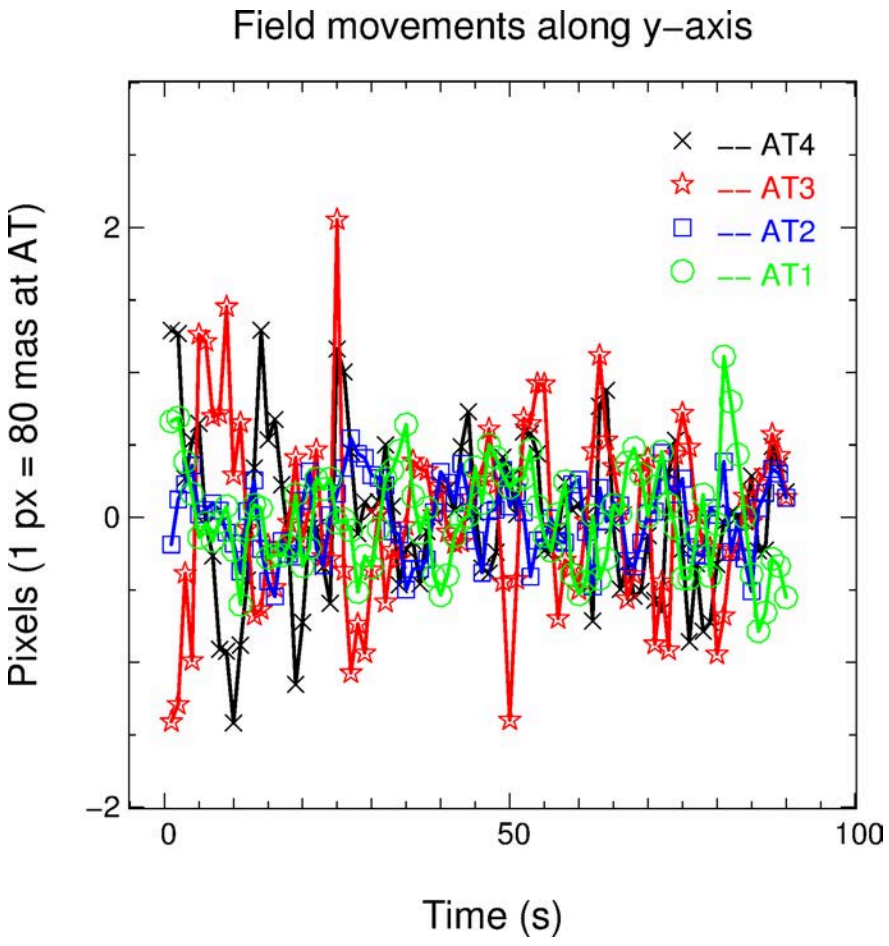
Aberration sensor characterization



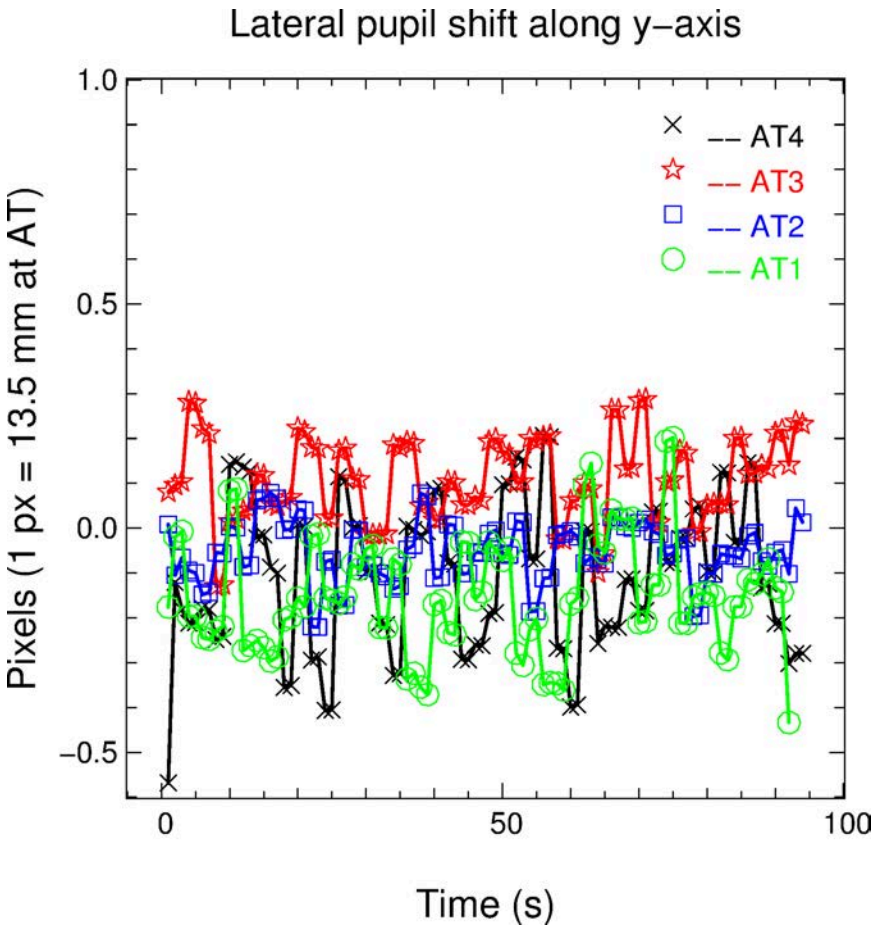
By applying known wavefront error the aberration sensor characterized.

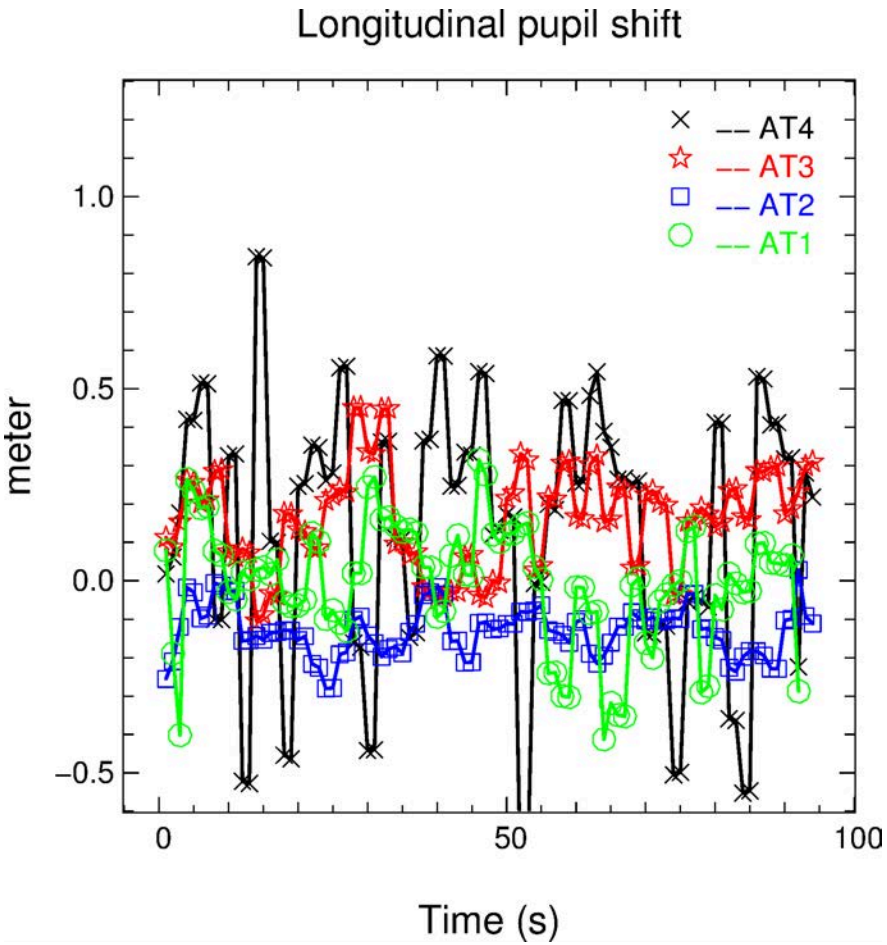
On-sky field residuals





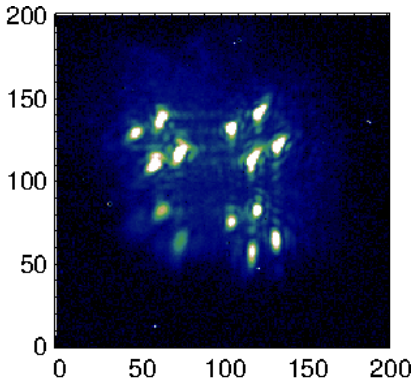
On-sky pupil residuals

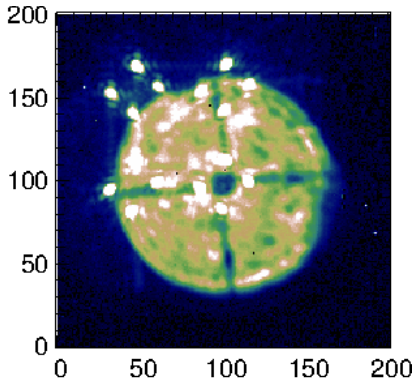




Further improvements progressing

1. Robust pupil sensor in the presence of background and vignetting.





2. Wavefront sensing in the presence of low SNR and in vignetting cases.

Conclusions

Field Tracker: Active in closed loop field stabilization.

Pupil Tracker: Active in pupil stabilization.

Aberration tracker: Quasi-static higher order wavefront aberrations measurement. Currently they are used for defocus correction.

- ✓ Used in automated alignment of GRAVITY with the telescopes.
- ✓ The beams guiding satisfies GRAVITY specifications.

Many thanks