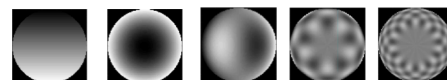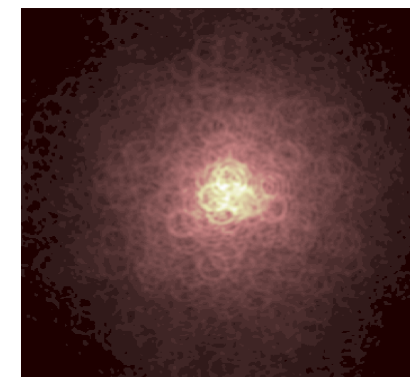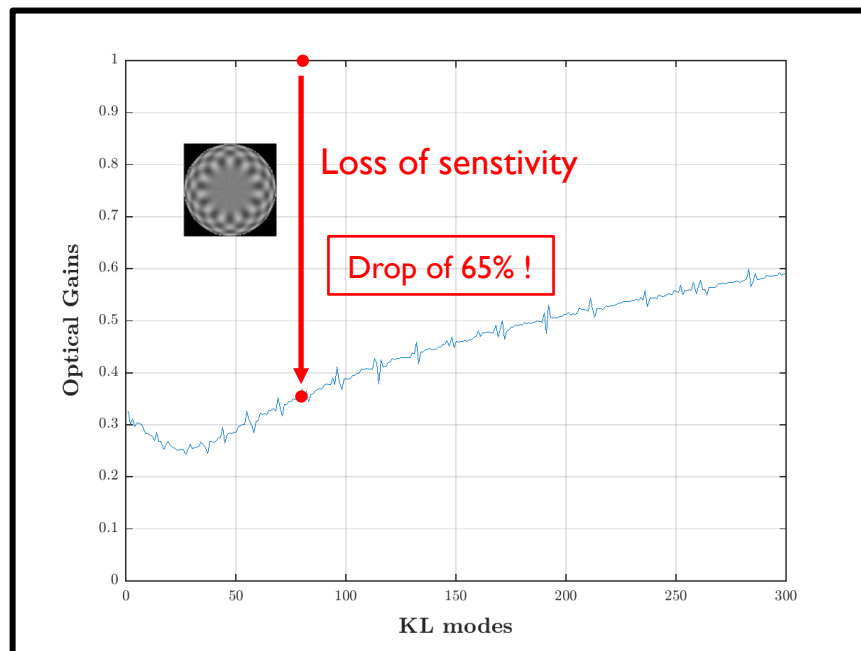# Dealing with Pyramid wavefront sensor non-linearities: a focal plane assisted method

Vincent Chambouleyron, Olivier Fauvarque, Nicolas Levraud, Charlotte Bond, Jean-François Sauvage, Benoît Neichel & Thierry Fusco

Wavefront-sensing Workshop 2020 - OCA

OPTICAL GAINS

Loss of senstivity

Drop of 65% !

Handling Pyramid WFS non-linearities ⟶ Keeping track of the Optical Gains

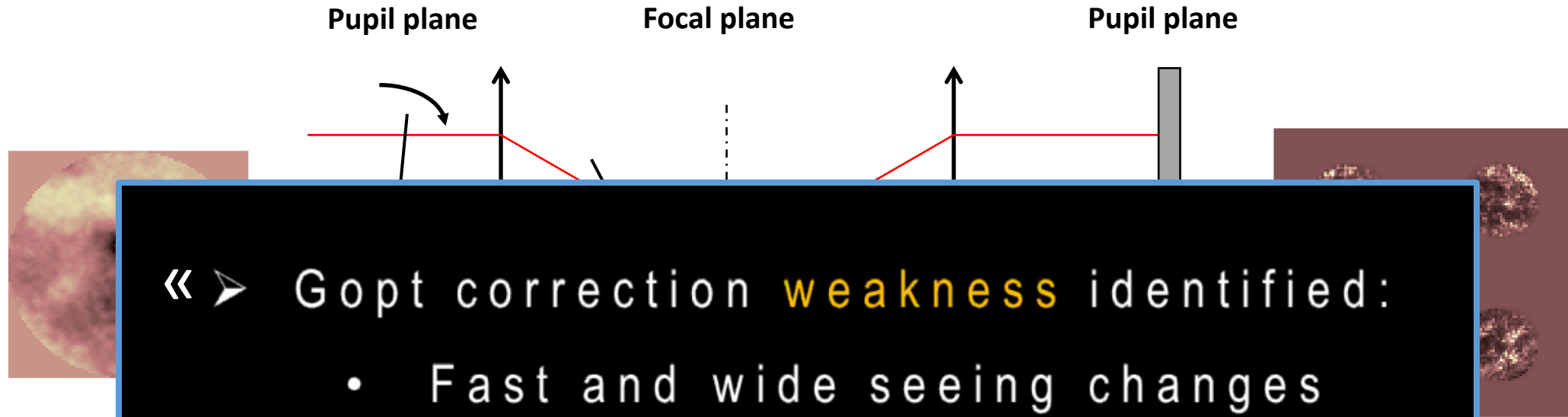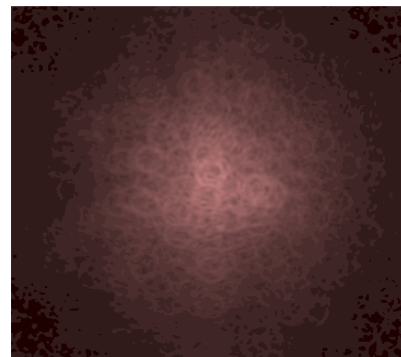BOOTSRAP

Predictive Control

PSF Reconstruction

NCPA

How to track the Optical Gains ? A focal plane assisted method

Pupil plane   **Focal plane**   **Pupil plane**

« ➤ Gopt correction **weakness** identified:
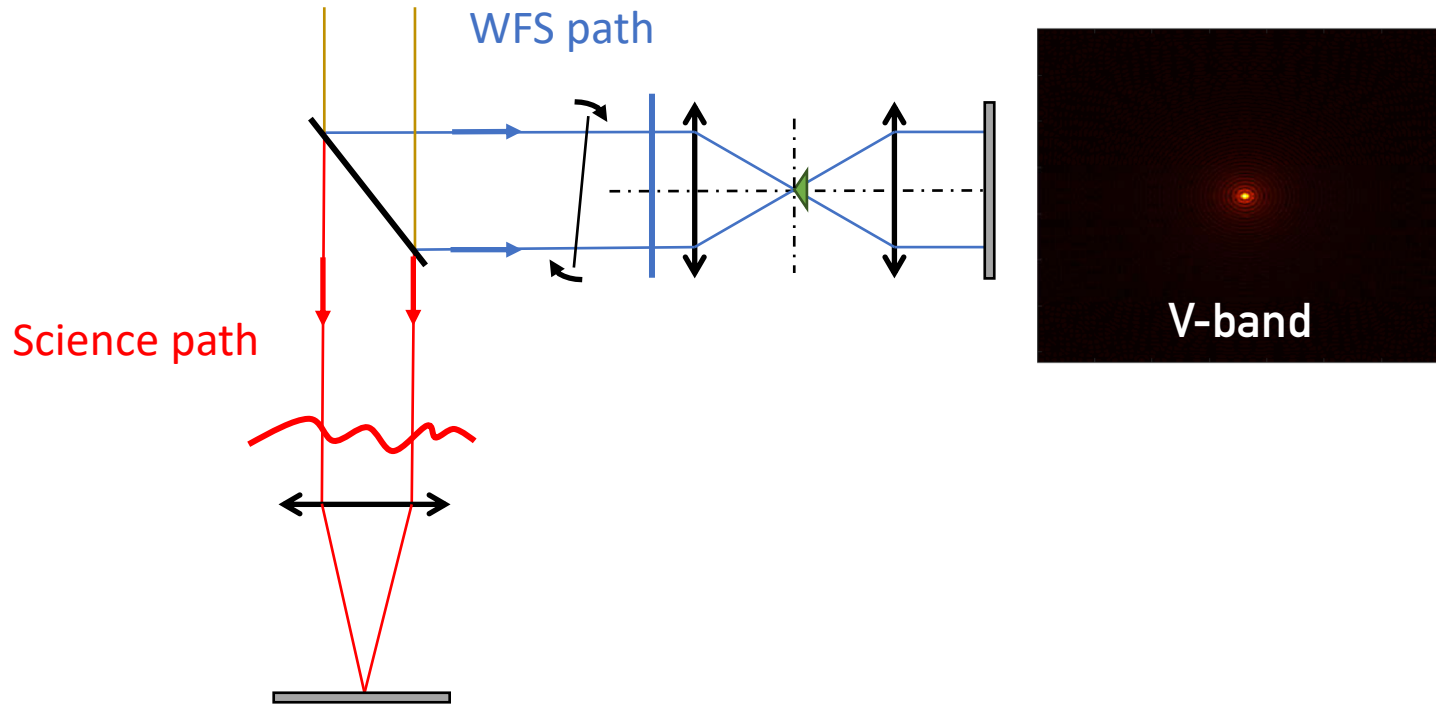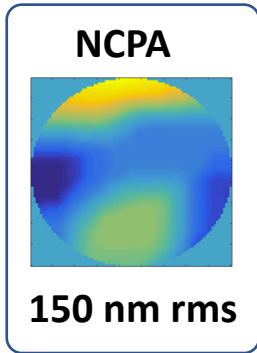 - Fast and wide seeing changes
  - Multiple stars with similar flux »

*Enrico Pinna - October 14th 2020, 3.22pm CET*

Convolutive model

$$\mathbf{IR} = 2\mathbf{Im}\left[\bar{\hat{m}}(\hat{m} \star \widehat{\mathsf{PSF}})\right]$$

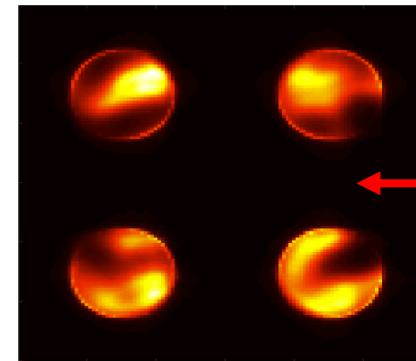# Non-Common Path Aberrations with the Gain Scheduling Camera

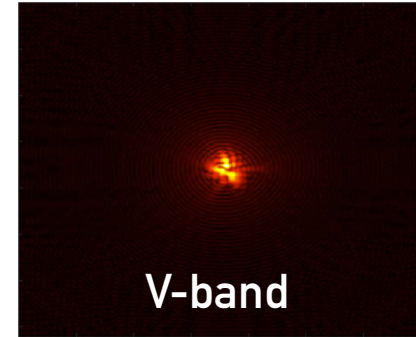**NCPA**

150 nm rms
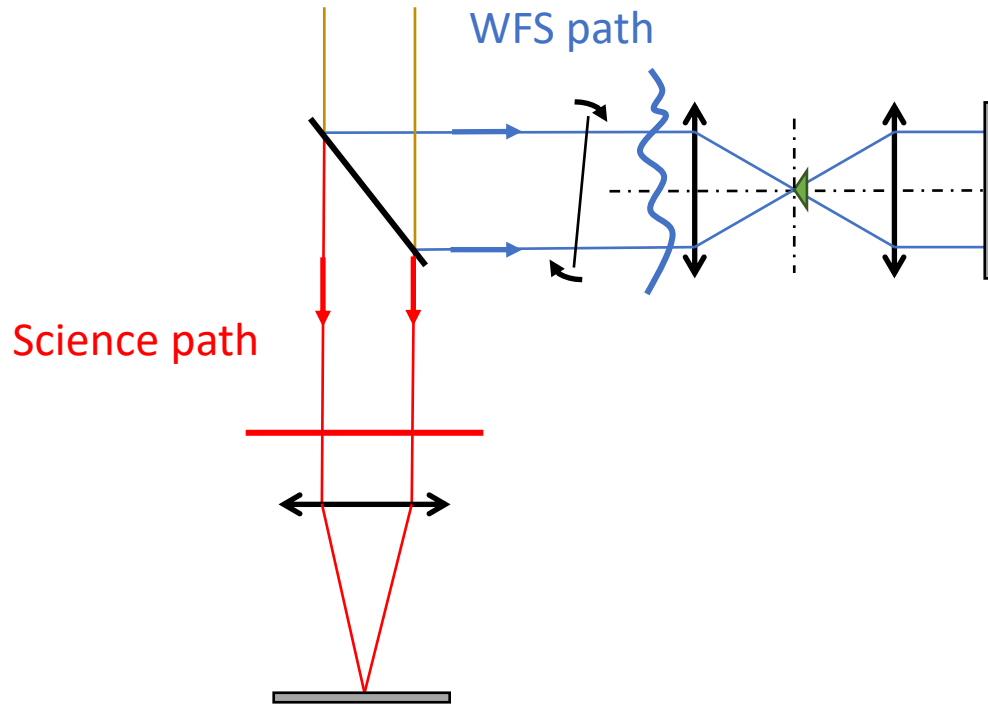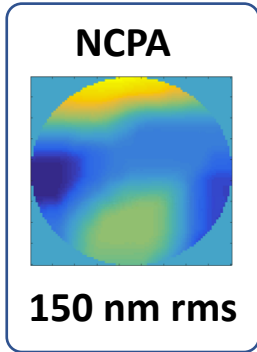
WFS path

Science path
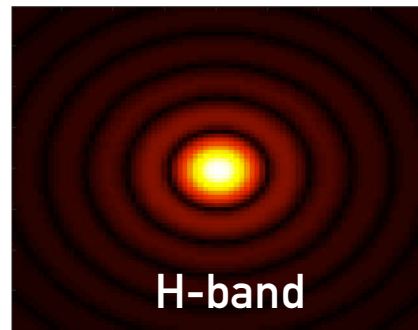
V-band

H-band

Oomao

Resolution = 90 px
D = 8m
Frame rate = 500 Hz
r0 = 15 cm @ 550 nm
Science: H-band
WFS: visible
400 modes (KL)

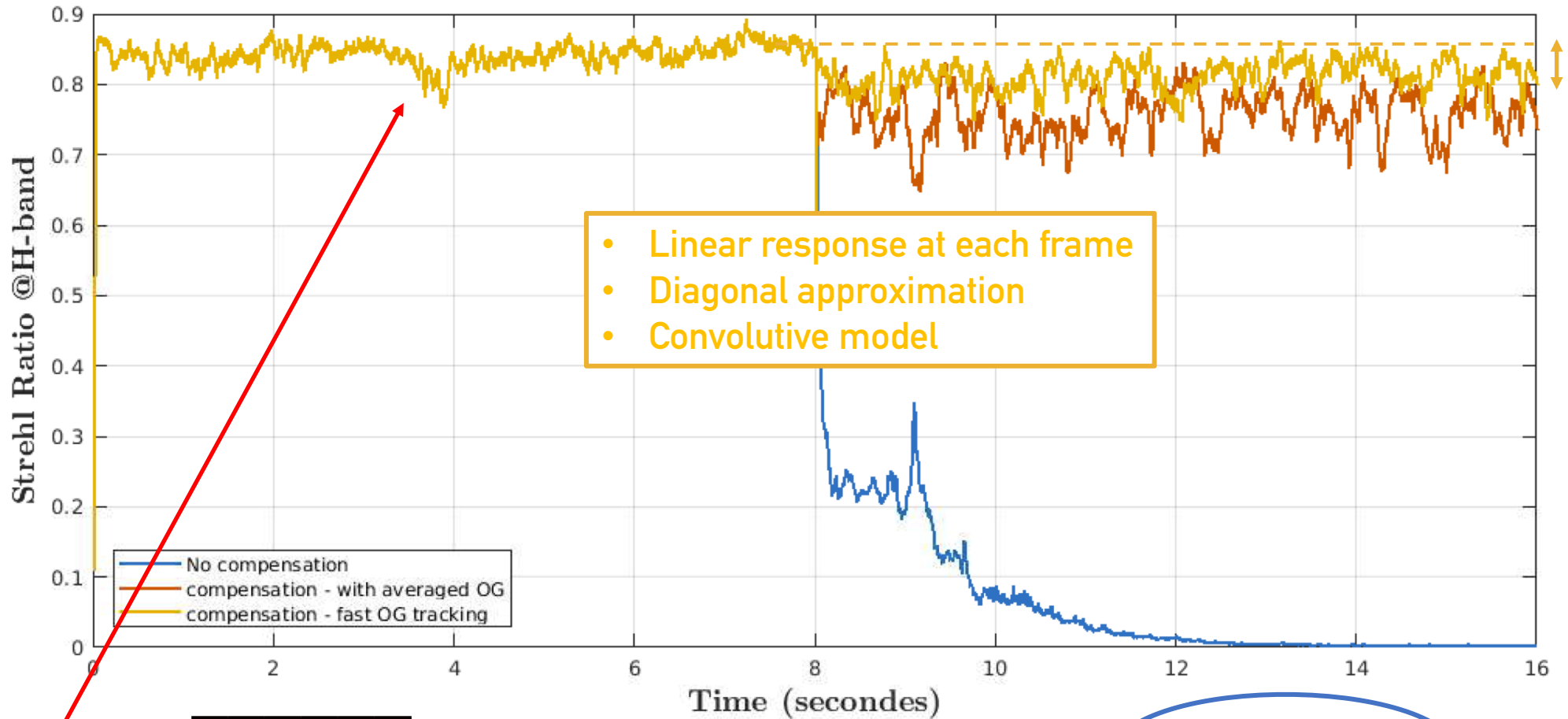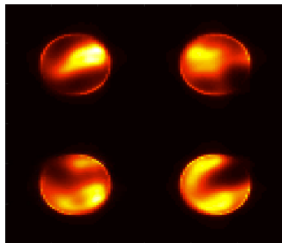# Non-Common Path Aberrations with the Gain Scheduling Camera

NCPA

150 nm rms

WFS path

Science path

V-band
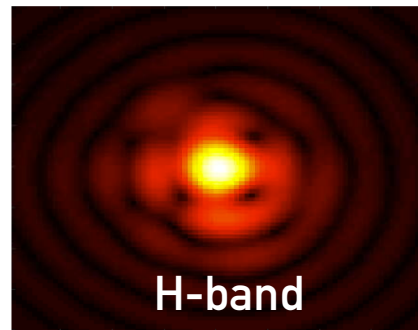
To be scaled by the Optical Gains !

Offsets on Pyramid

H-band

Oomao

Resolution = 90 px
D = 8m
Frame rate = 500 Hz
r0 = 15 cm @ 550 nm
Science: H-band
WFS: visible
400 modes (KL)

- Linear response at each frame
- Diagonal approximation
- Convolutive model

Strehl Ratio @H-band

No compensation
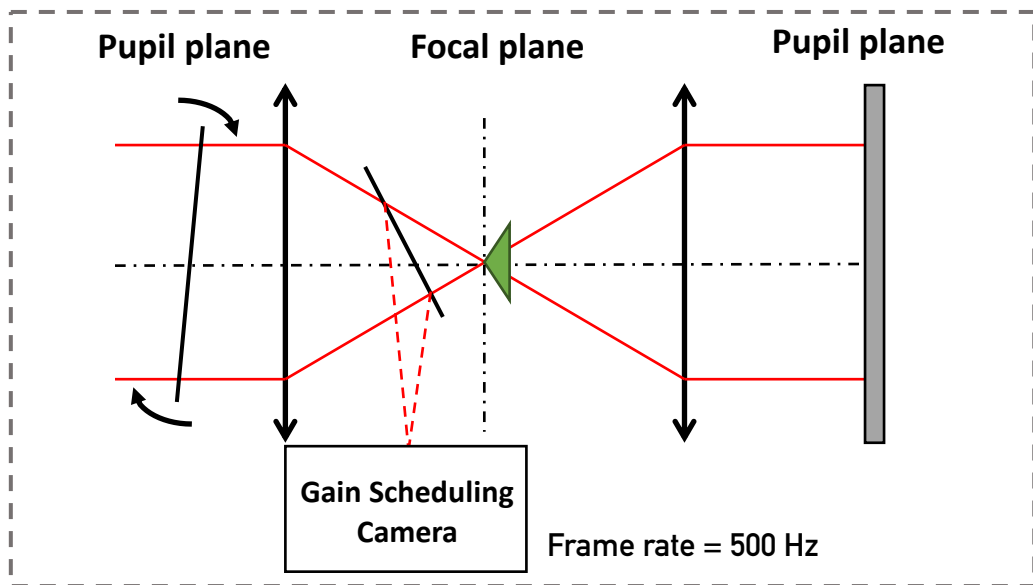compensation - with averaged OG
compensation - fast OG tracking

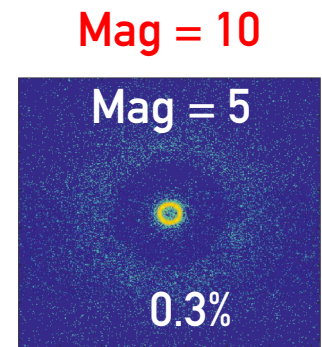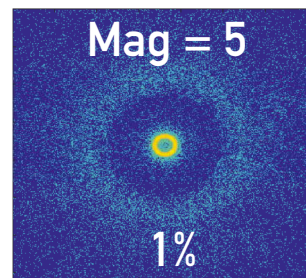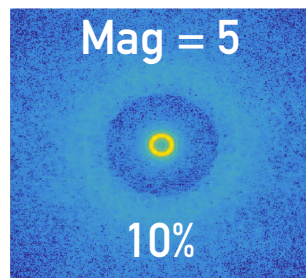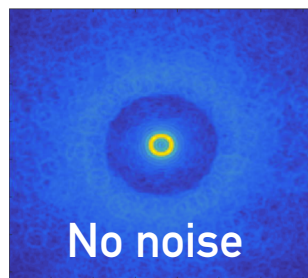Time (secondes)

$G_{opt} \times$

Optical Gains

Pushing too much

+

Impact of photon noise on the Gain Scheduling Camera

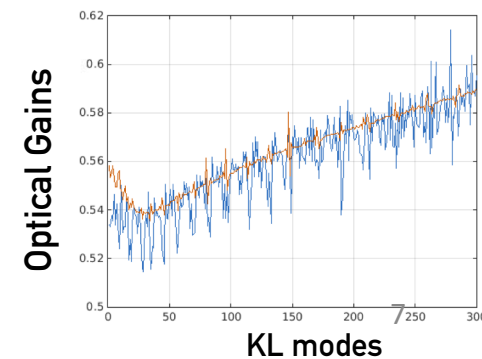Pupil plane   Focal plane   Pupil plane
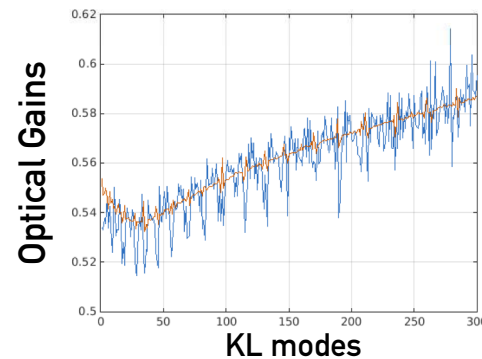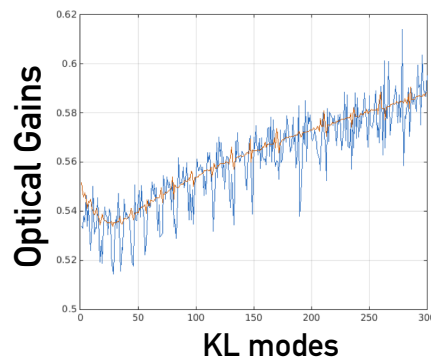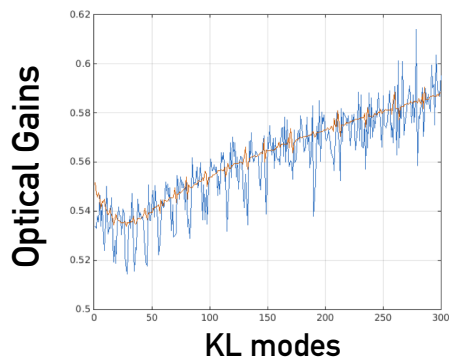
Gain Scheduling Camera

Frame rate = 500 Hz

DRAWBACK: Steal photons on the way !

METHOD REALLY ROBUST TO PHOTON NOISE !

Mag = 10

No noise

Mag = 5
10%

Mag = 5
1%

Mag = 5
0.3%   10%

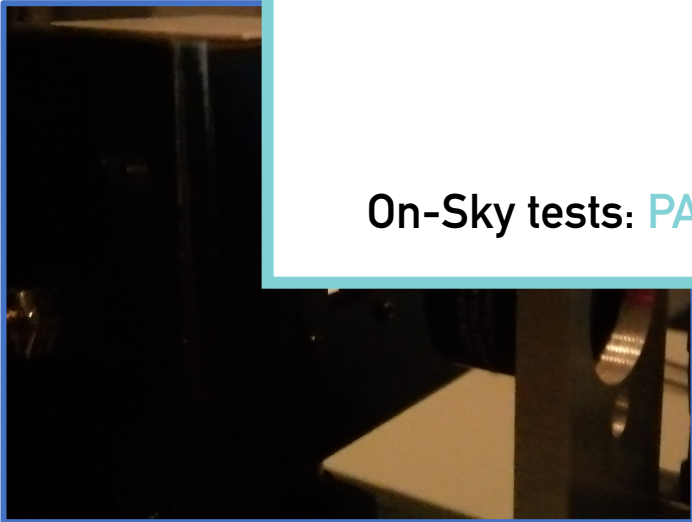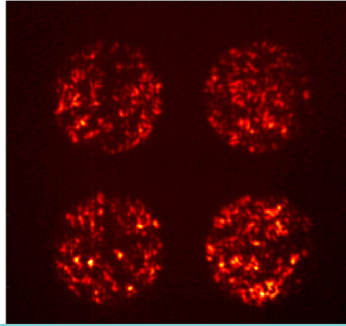Optical Gains vs KL modes

Tests on LOOPS bench

LOOPS Bench at LAM

Spatial Light Modulator in a pupil plane

High order aberrations

Pupil Masking

- Central obturation
- Spiders

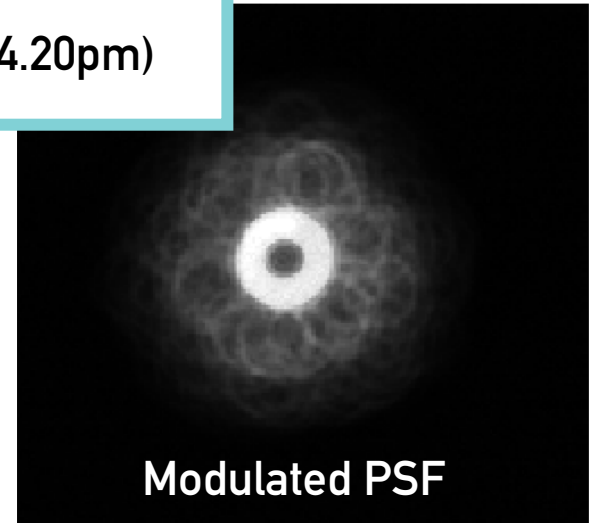Gain Scheduling Camera
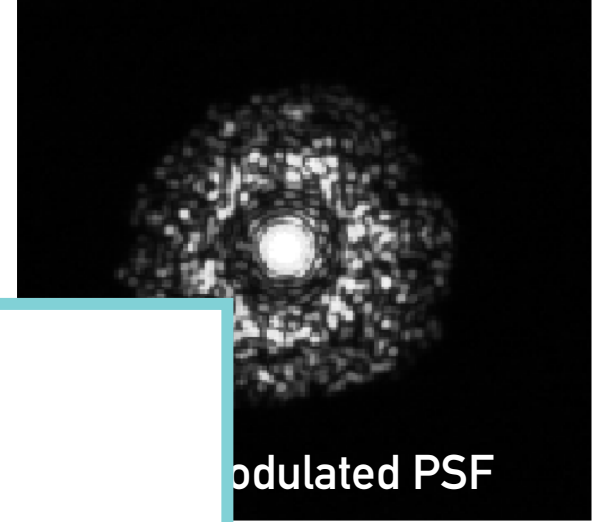
Modulated PSF

Modulated PSF

On-Sky tests: PAPYRUS Project at OHP – Gilles OTTEN talk (tomorrow 4.20pm)