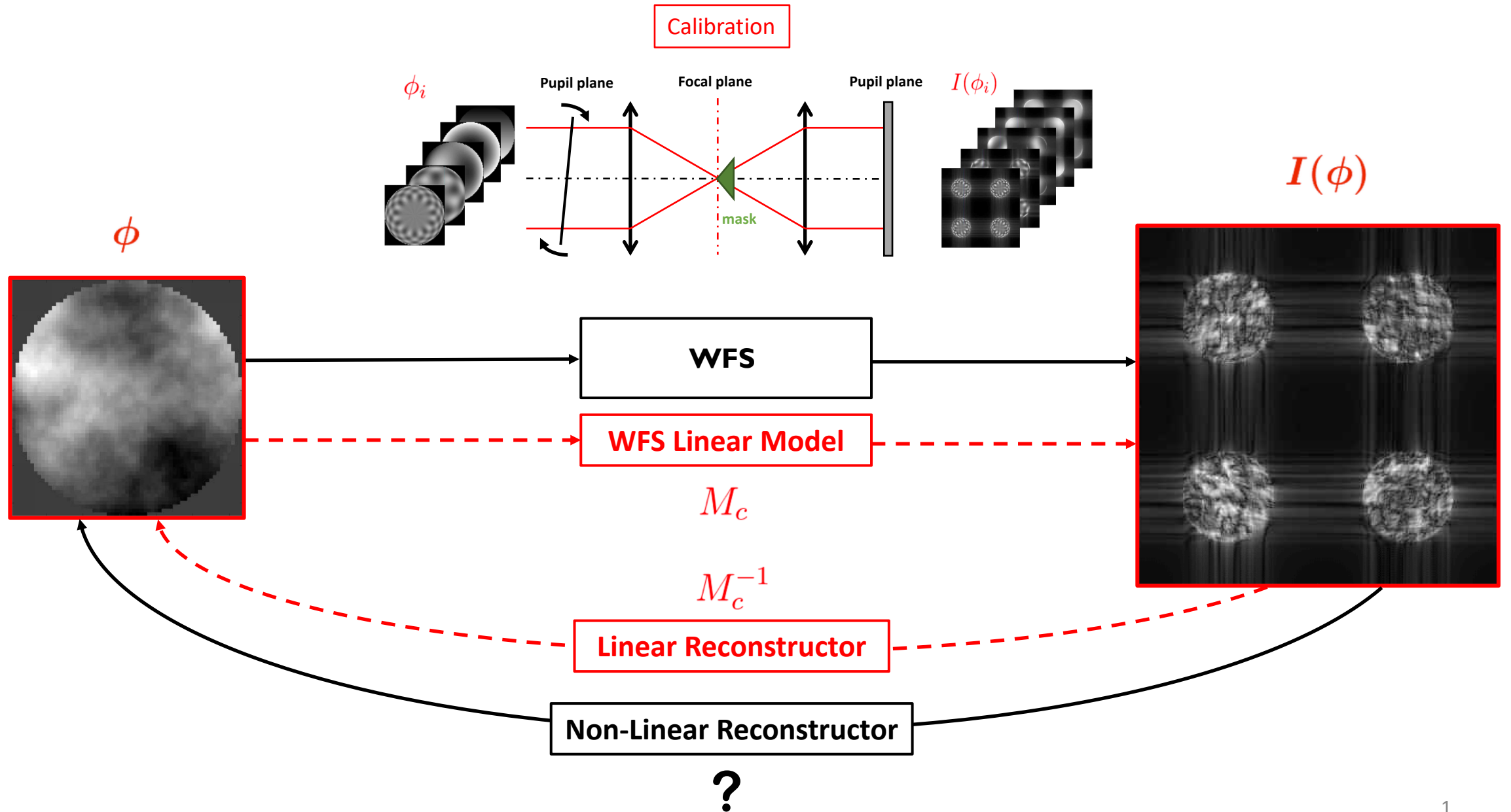


Using a modulation camera to control Pyramid Wavefront Sensor on the fly

Vincent Chambouleyron, Olivier Fauvarque, Pierre Janin-Potiron
Benoît Neichel & Thierry Fusco

Towards a non-linear reconstructor ?



Towards a non-linear reconstructor ?

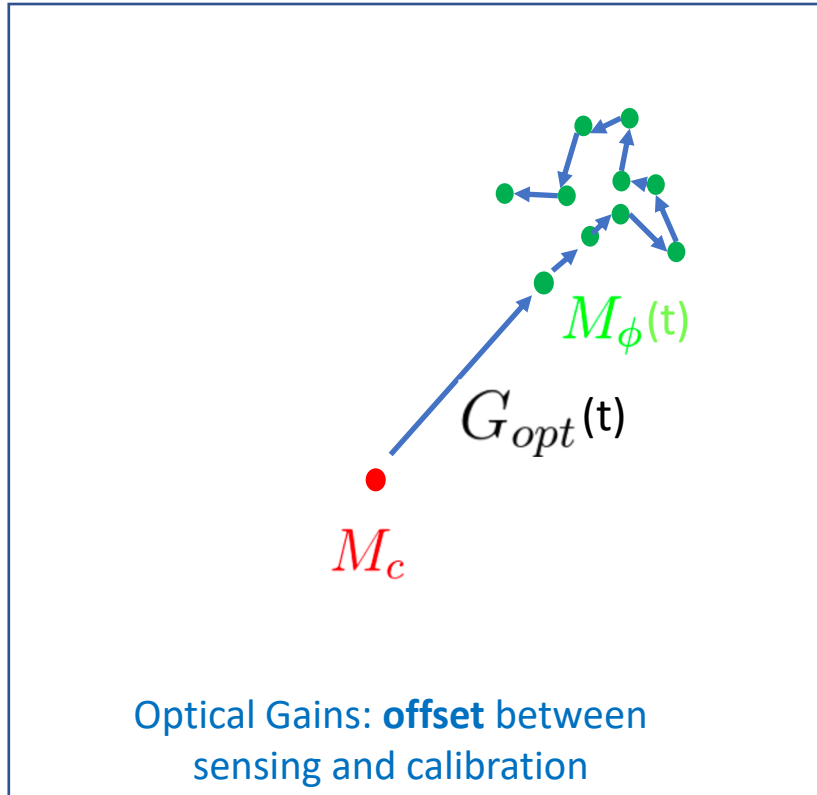
$$s(\phi) = M_c \phi$$

Pyramid WFS = Linear Parameter-Varying System (LPVS)

$$s(\phi) = M_\phi \phi$$

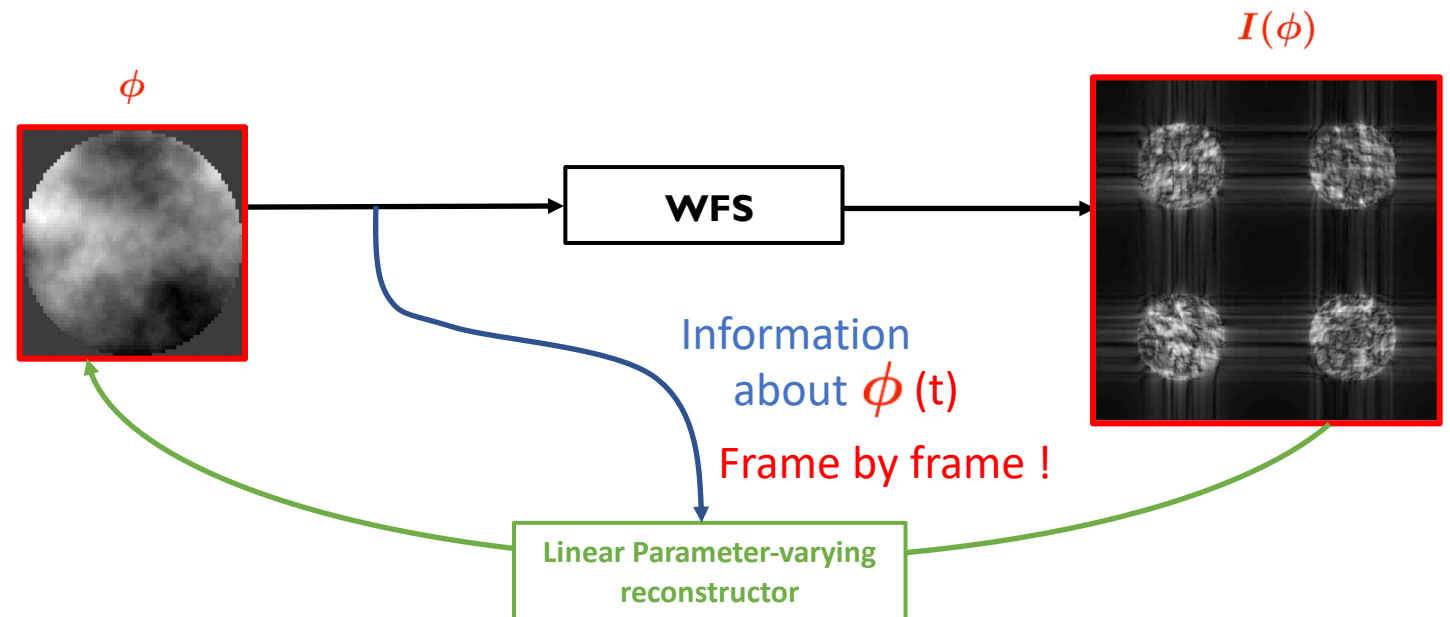
Matrix which depends on ϕ

Interaction Matrix Space

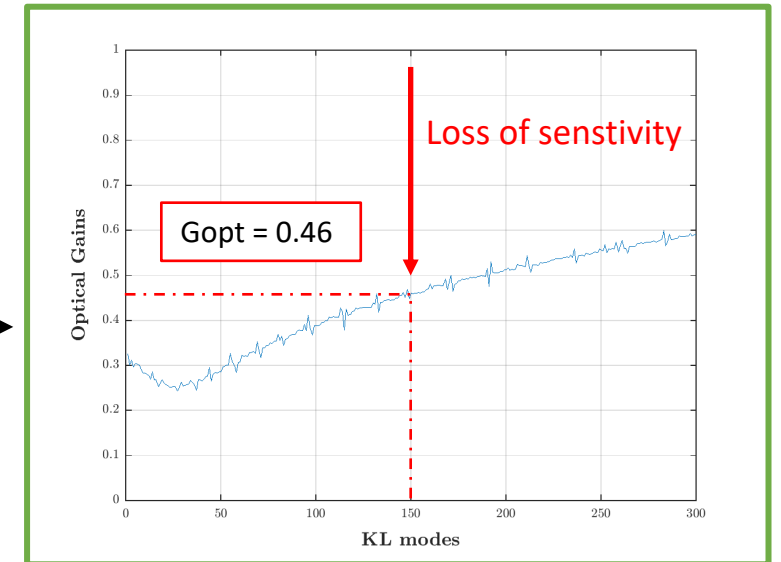
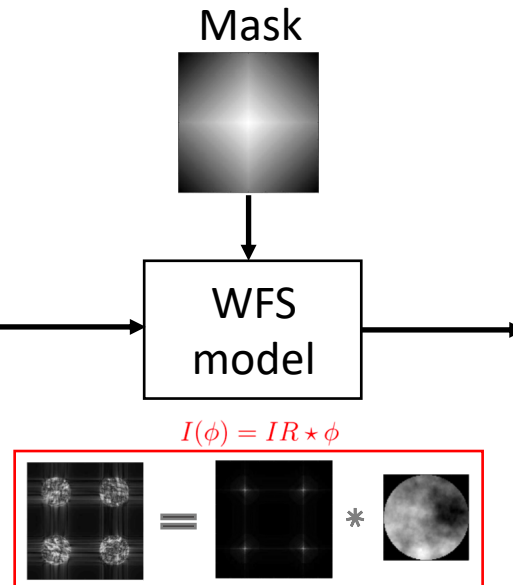
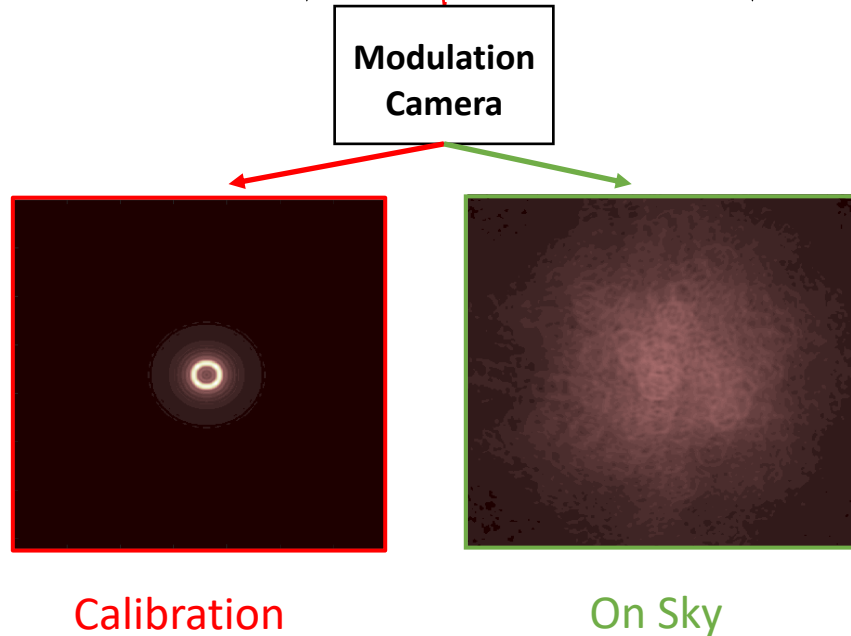
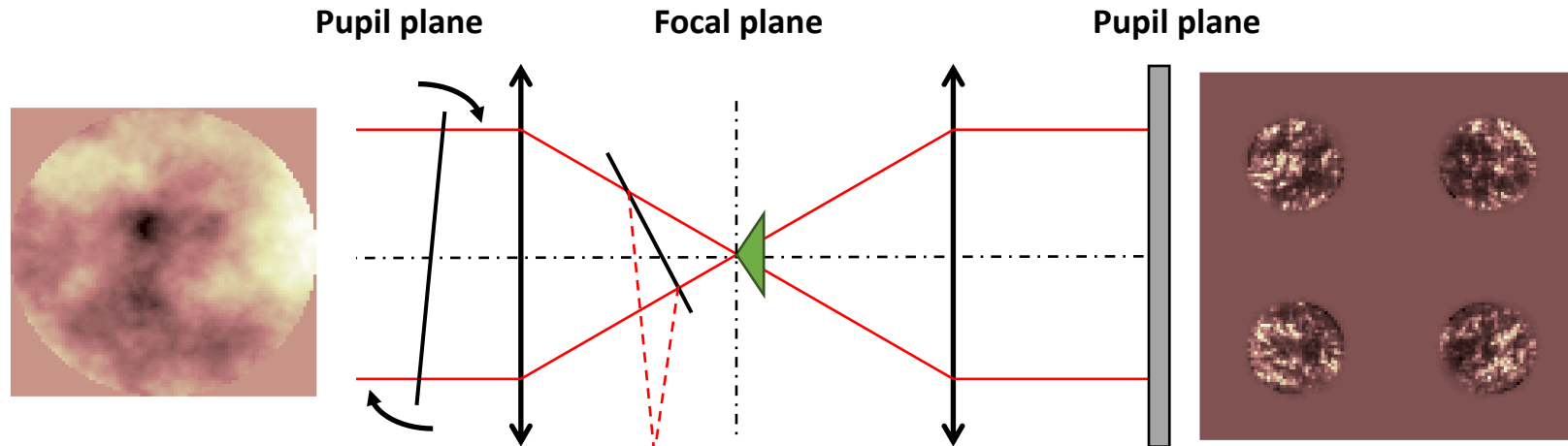


The **Reconstructor** need to be aware of the state of the system

We need to perform **gain scheduling**

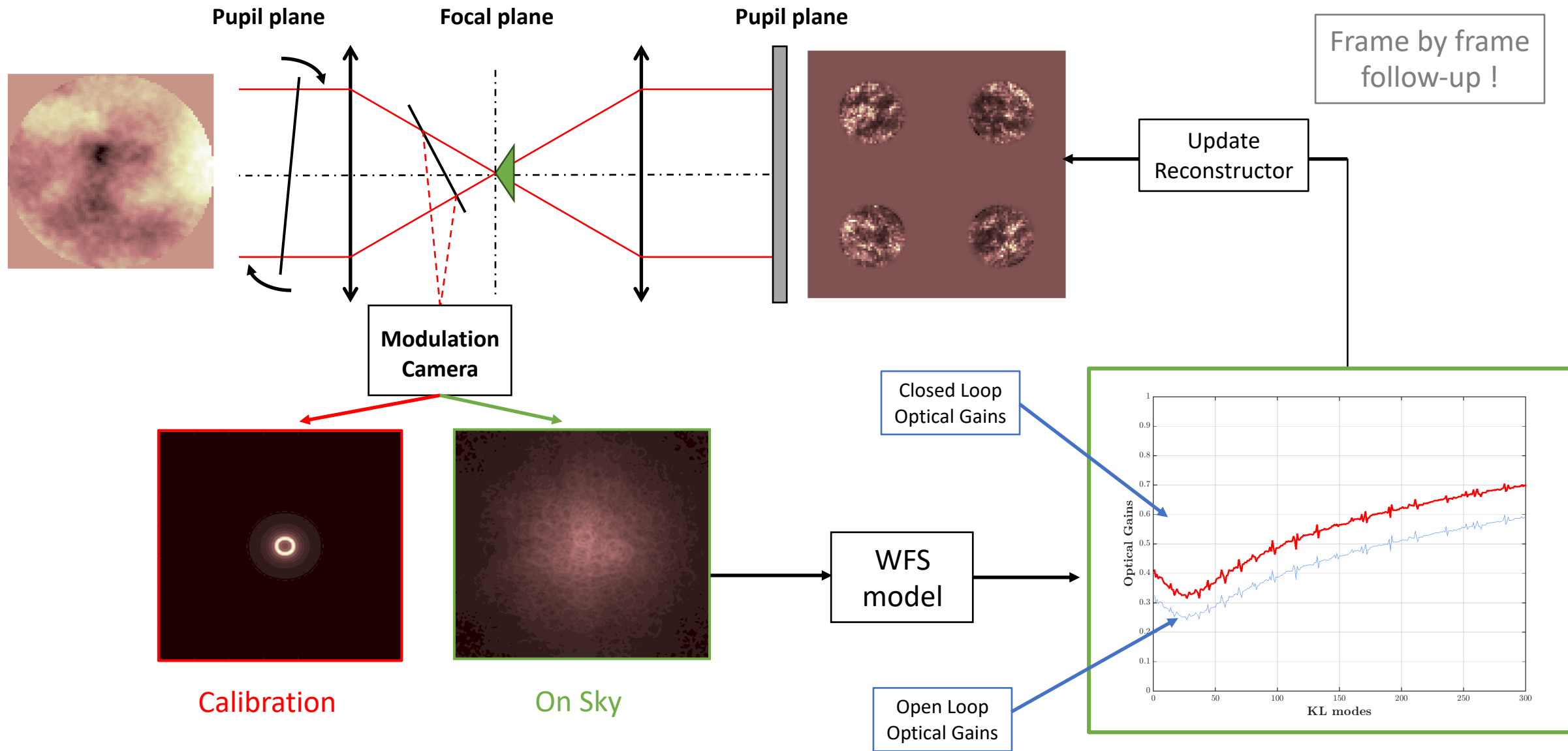


How to perform gain scheduling ? **One possible solution**

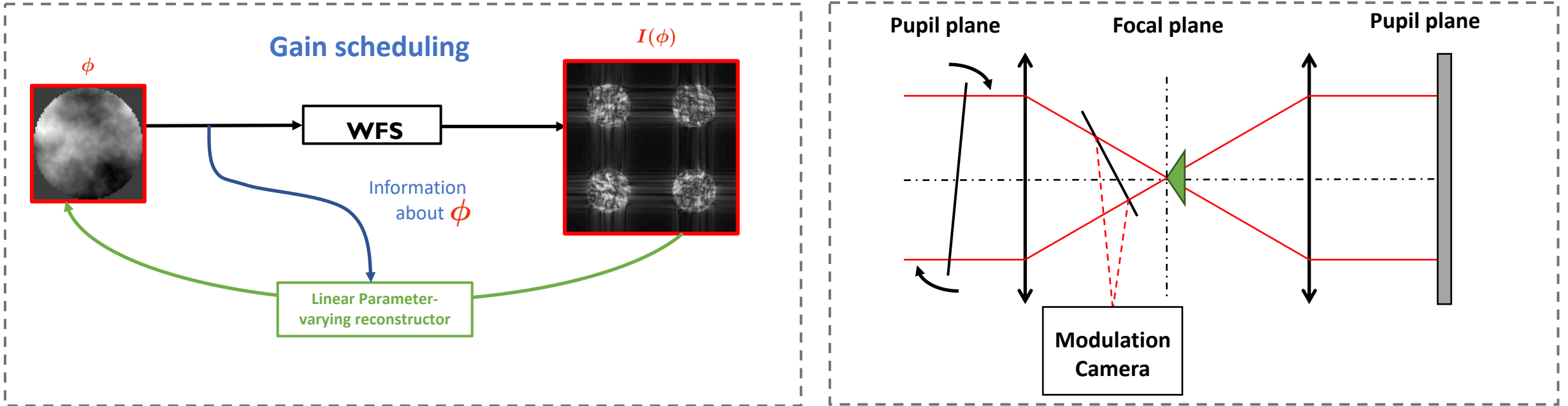


Fauvarque 2019

How to perform gain scheduling ? **One possible solution**



How to perform gain scheduling ? **One possible solution**



DRAWBACK: Steal photons on the way !

NO PAIN

ADVANTAGE: Absolute measurements
« Free from the loop »

NO GAIN

Applications

BOOTSTRAP

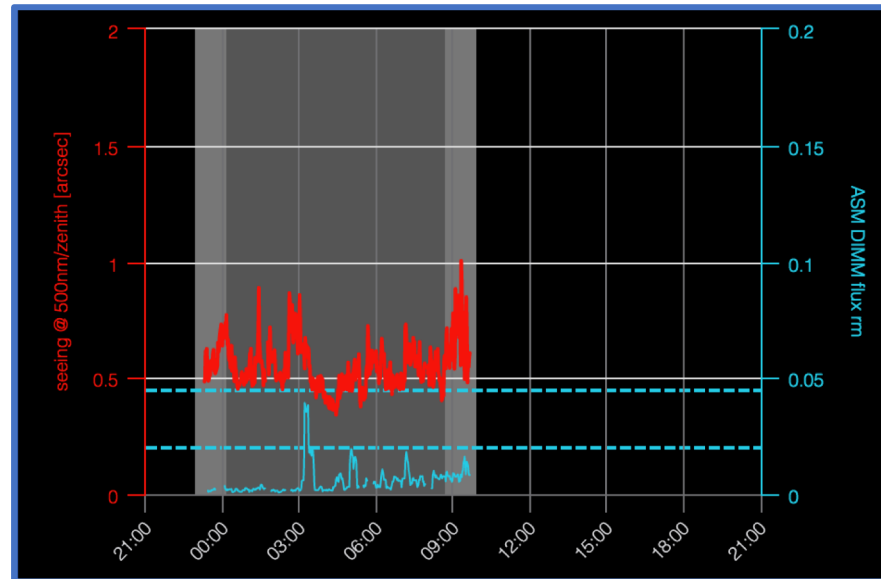
Open-Loop
Optical Gains

Fast Bootstrap
+
Easier Bootstrap on
strong turbulence

Towards a
non-modulated
Pyramid ?

ENHANCEMENT OF CLOSED-LOOP ROBUSTNESS AND PERFORMANCE

Strong variation of seeing during the night



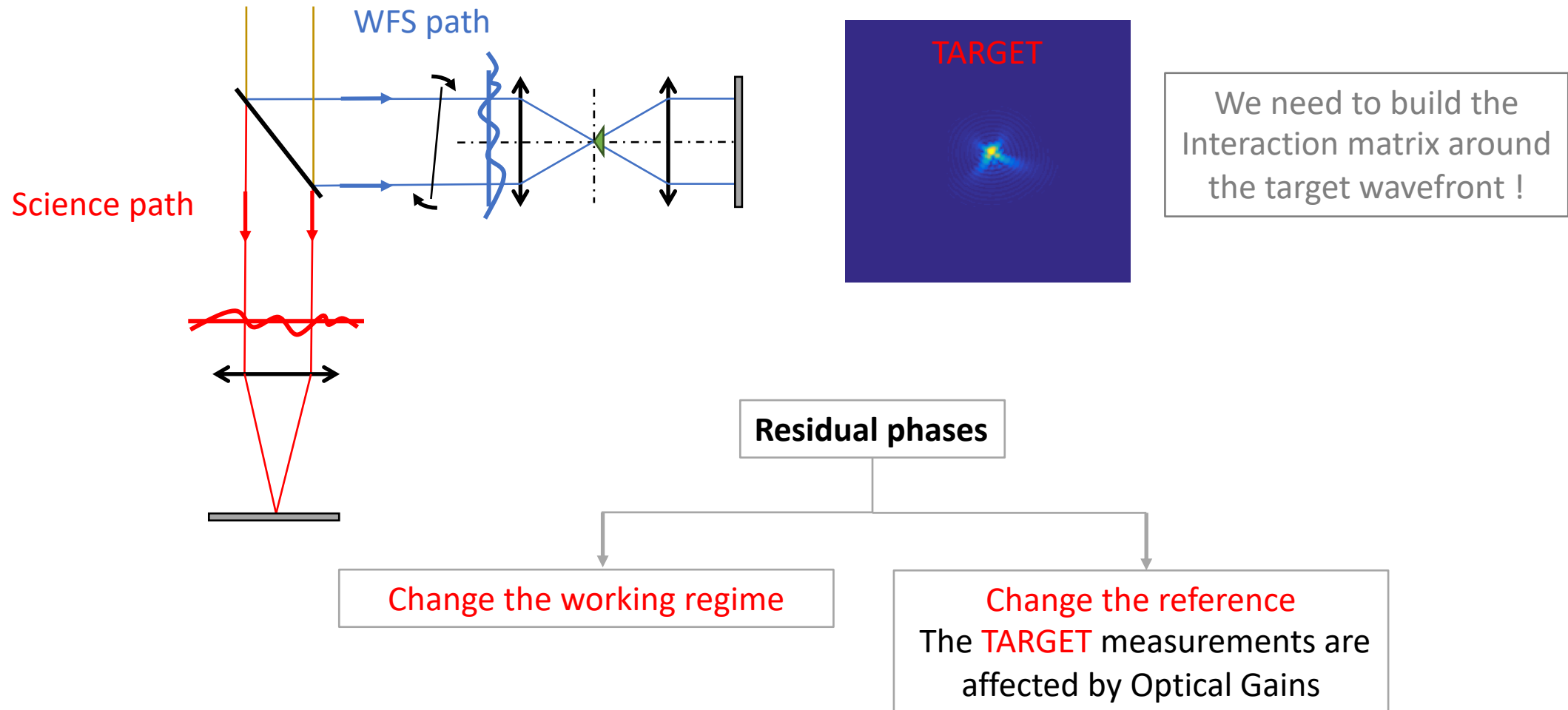
Seeing at Paranal October 21th 2019

HANDLING NCPA

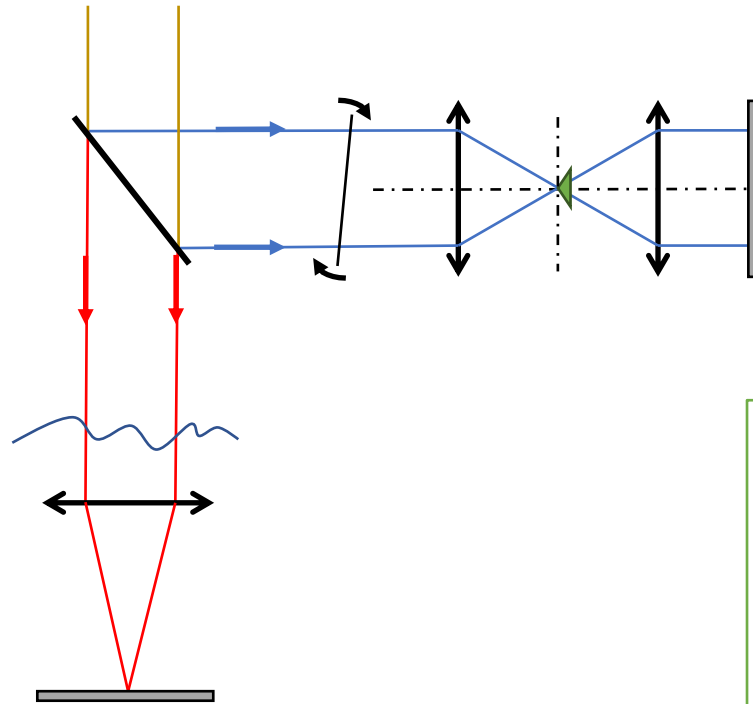
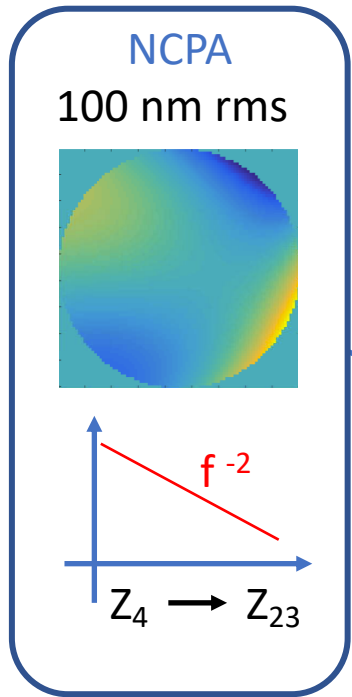
Non-Common Path
Aberrations

Issue with the PyWFS

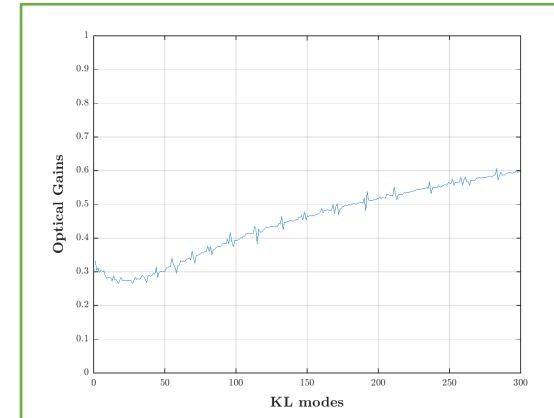
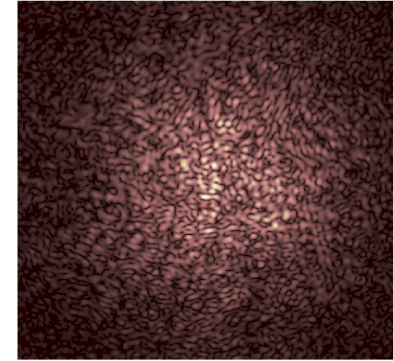
How to handle **NCPA** with the PyWFS ?



How to handle **NCPA** with the PyWFS ?

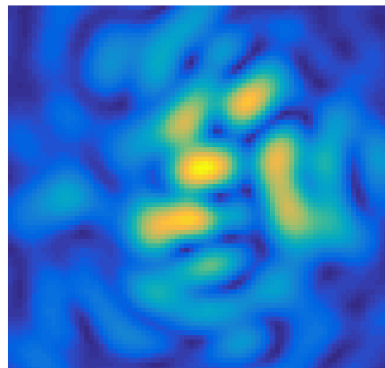


Visible



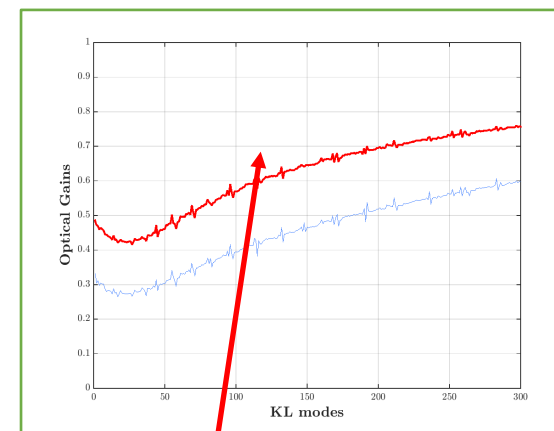
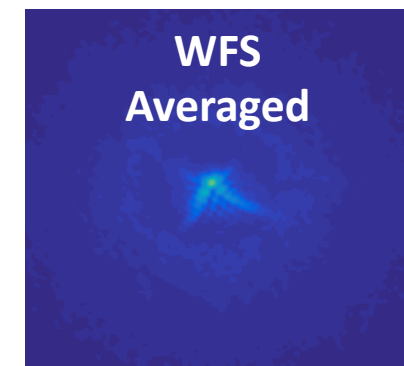
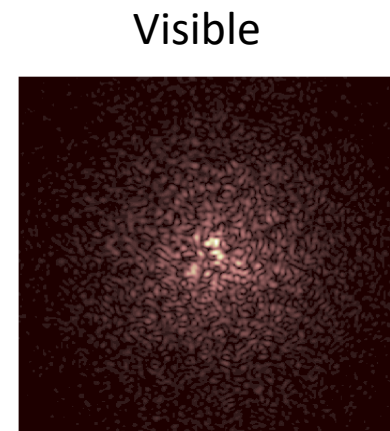
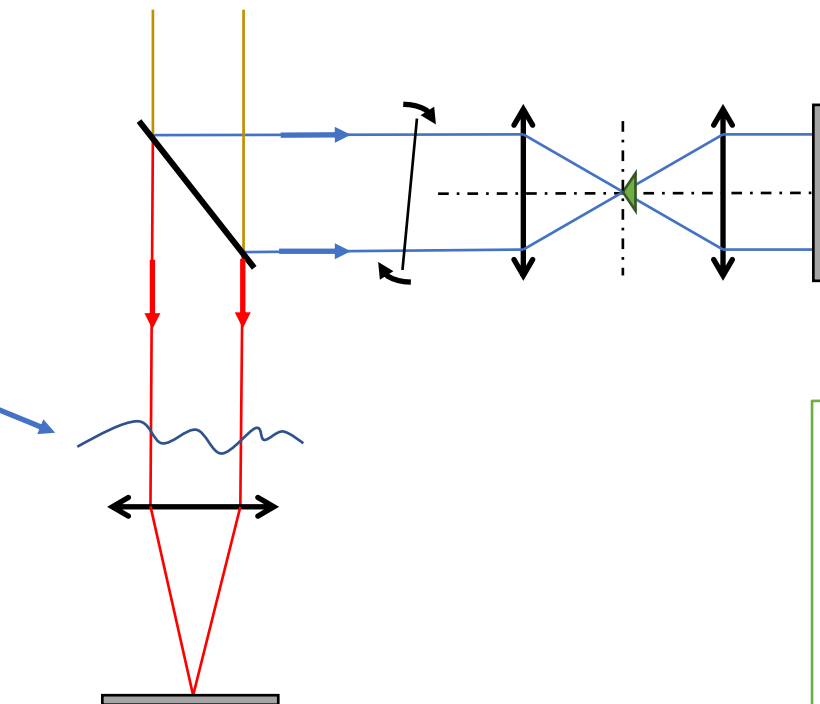
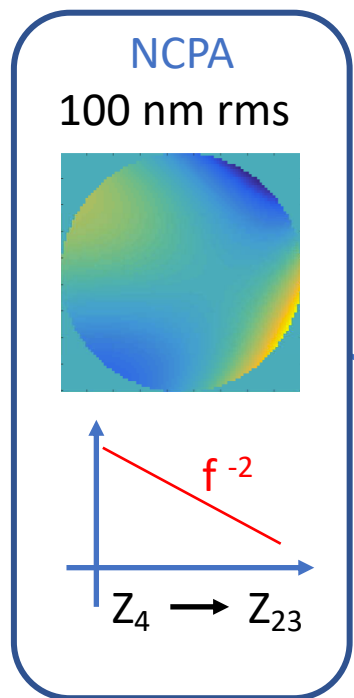
Oomao

Resolution = 90 px
D = 4m
r0 = 10 cm @ 550 nm
Science: K-band
WFS: visible
300 modes (KL)



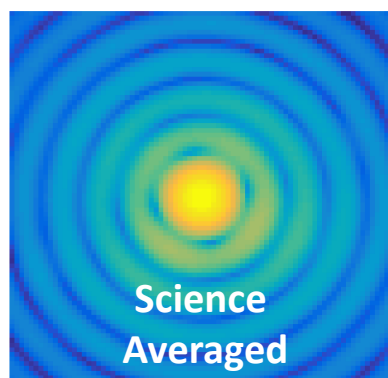
K-band

How to handle **NCPA** with the PyWFS ?



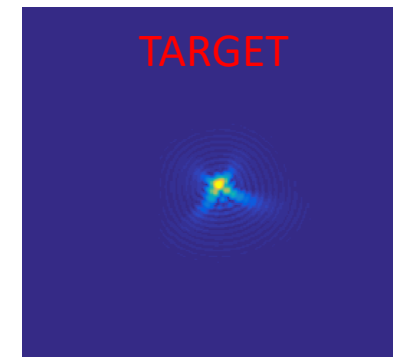
Oomao

Resolution = 90 px
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 r0 = 10 cm @ 550 nm
 Science: K-band
 WFS: visible
 300 modes (KL)

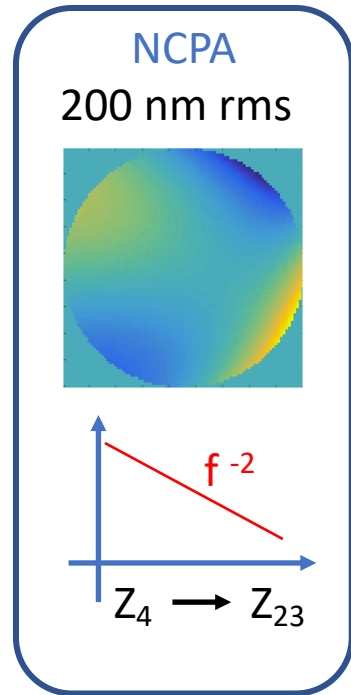


K-band

Because Optical Gains, the loop converge towards the wrong reference
Pushing too much !

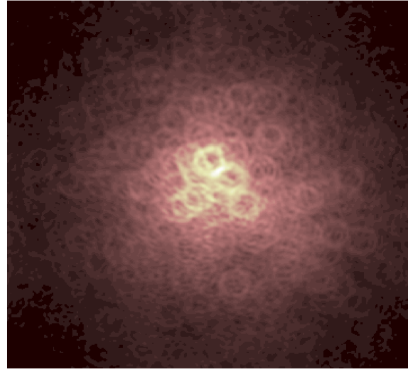


How to handle **NCPA** with the PyWFS ?

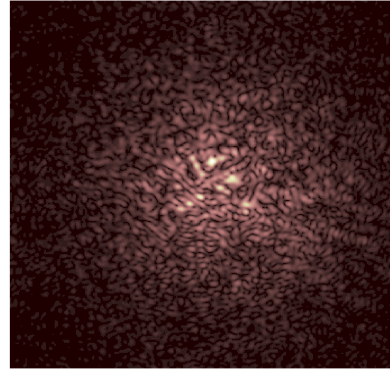


How to handle **NCPA** with the PyWFS ?

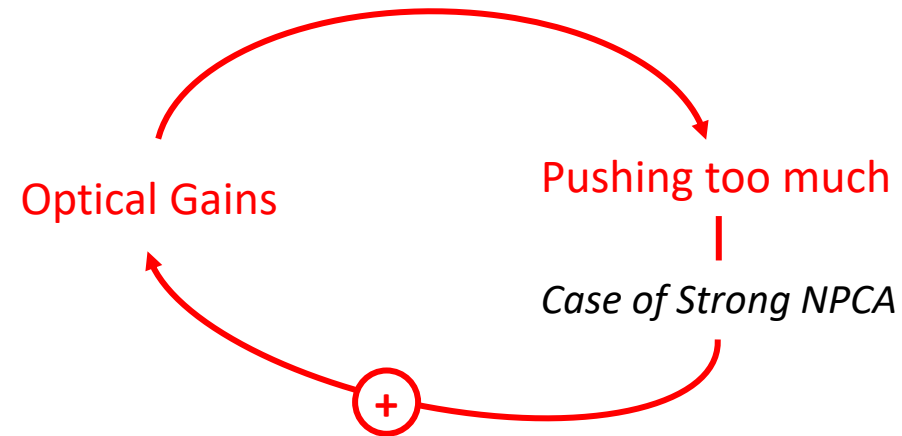
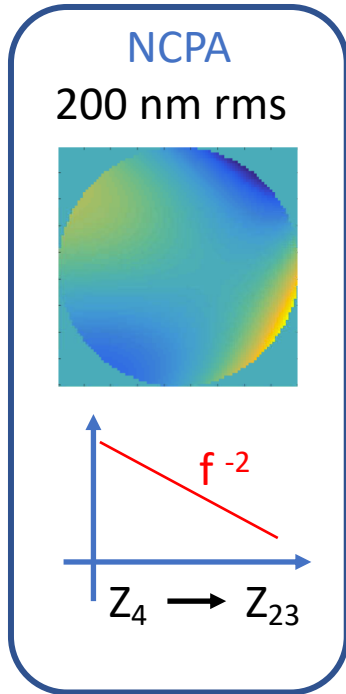
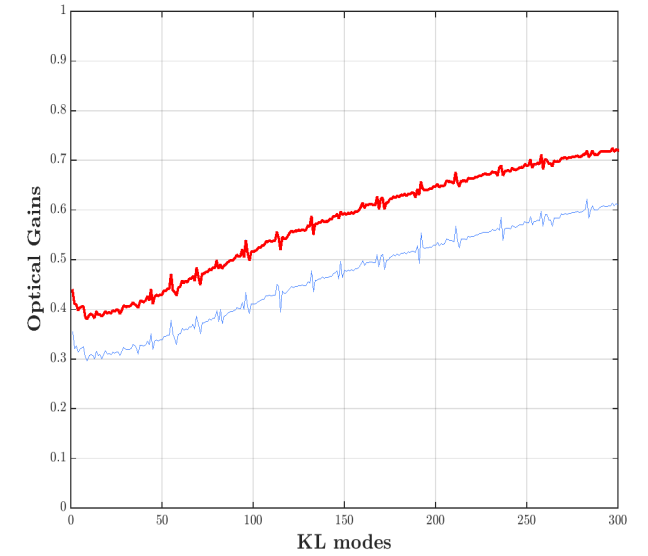
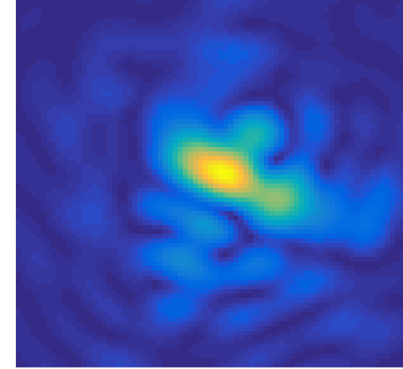
Modulation Camera



PyWFS



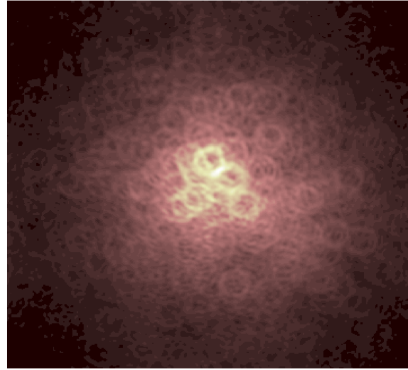
Science



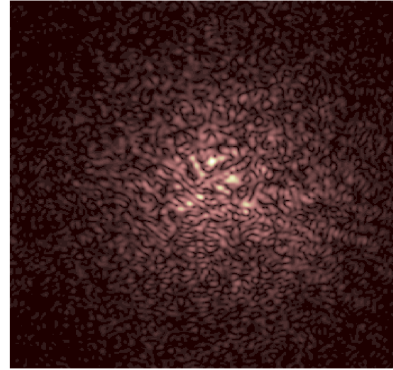
THE NCPA CATASTROPHE !

How to handle **NCPA** with the PyWFS ?

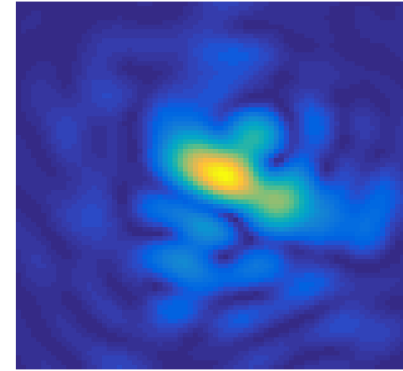
Modulation Camera



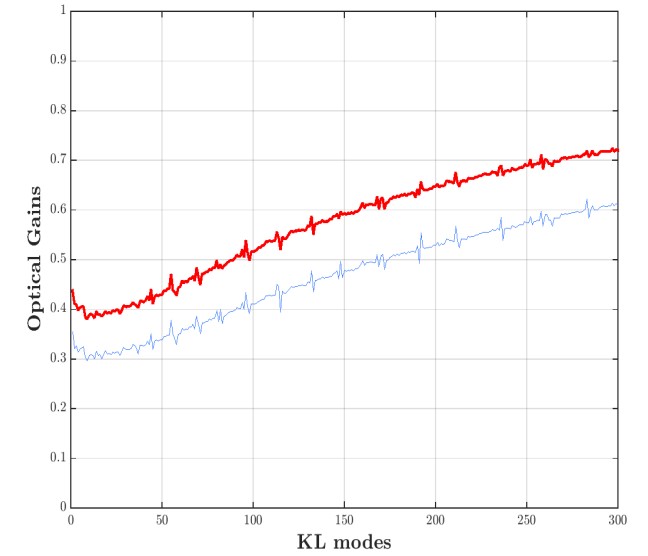
PyWFS



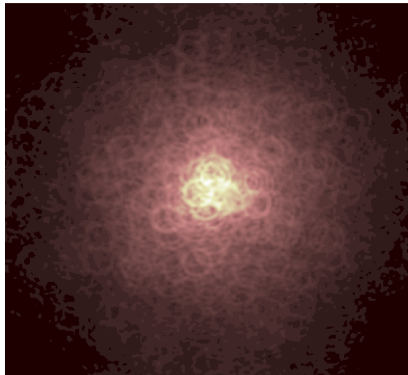
Science



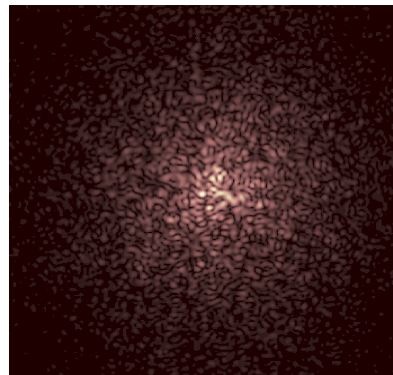
Uncompensated reference



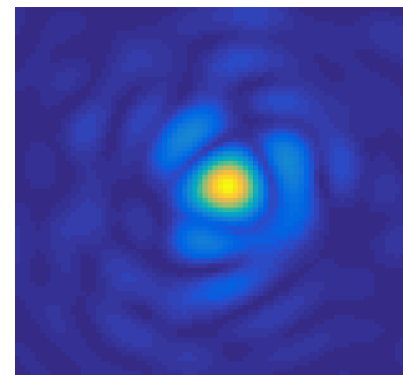
Modulation Camera



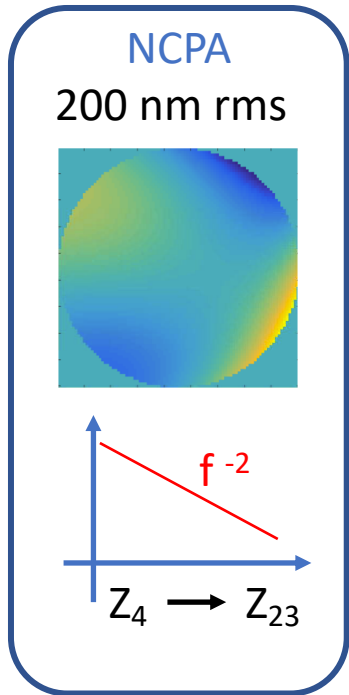
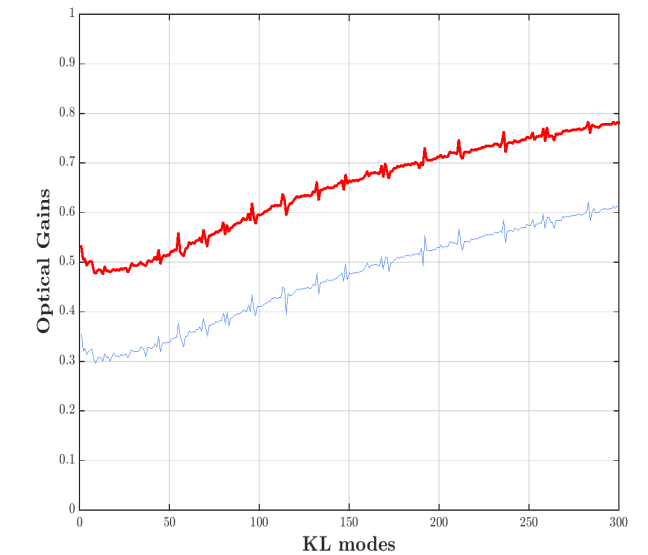
PyWFS



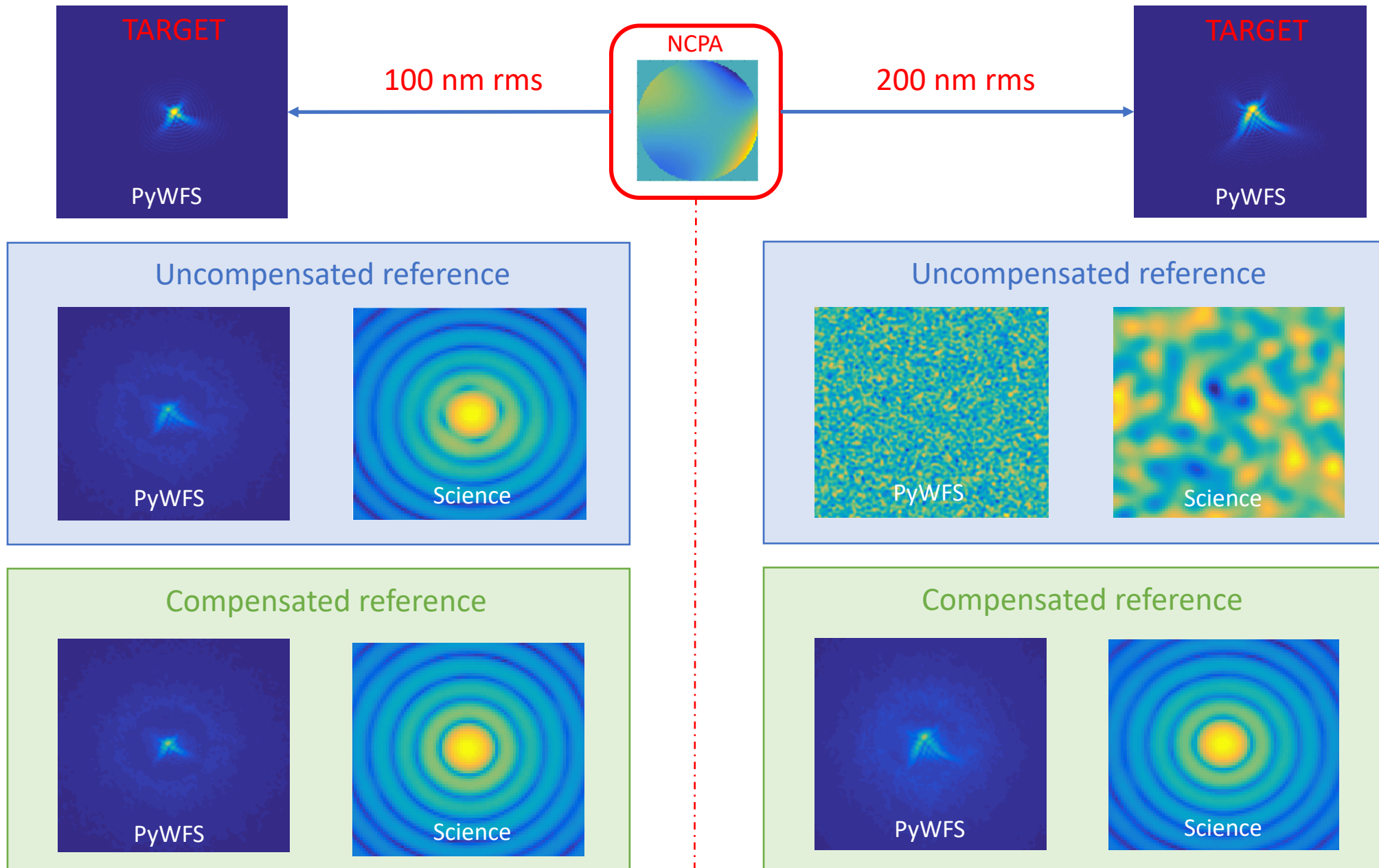
Science



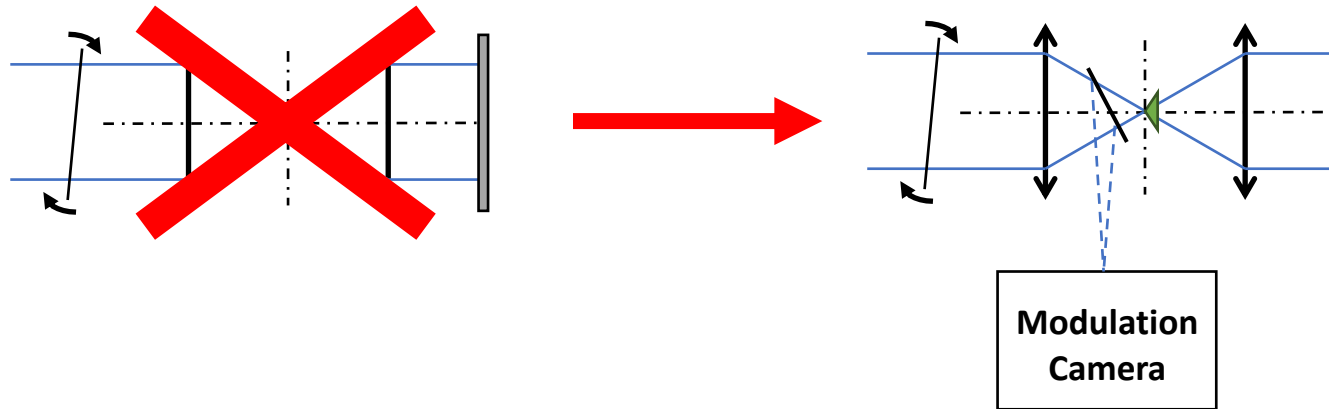
Compensated reference



How to handle **NCPA** with the PyWFS ?



Conclusion



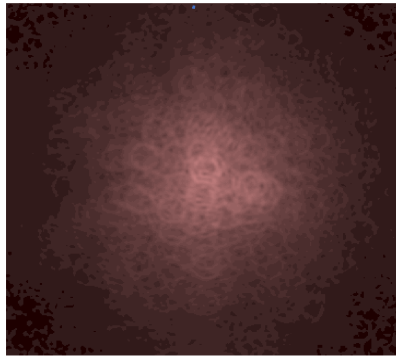
Some Questions

- Noise on modulation camera → Impact on Optical Gains computation ?
- Can we use the modulation camera at another wavelength ?

**To come : tests
on the LOOPS v2.0
bench !**



THANK YOU

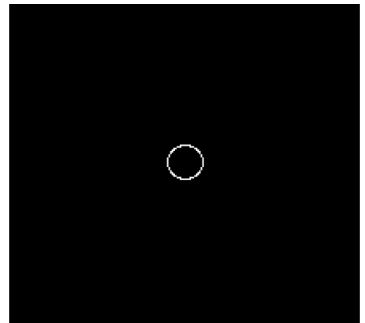


If you have it, use it !

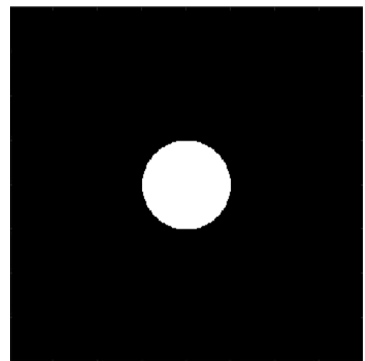
ANNEX: The Convolutional Model – FAUVARQUE 2019



m
Mask



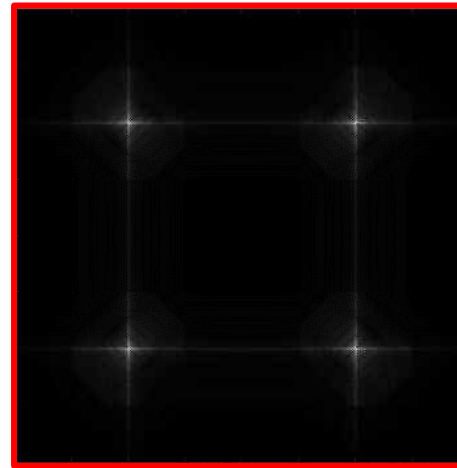
$\tau\omega$
Modulation



\mathbb{I}_P
Pupil



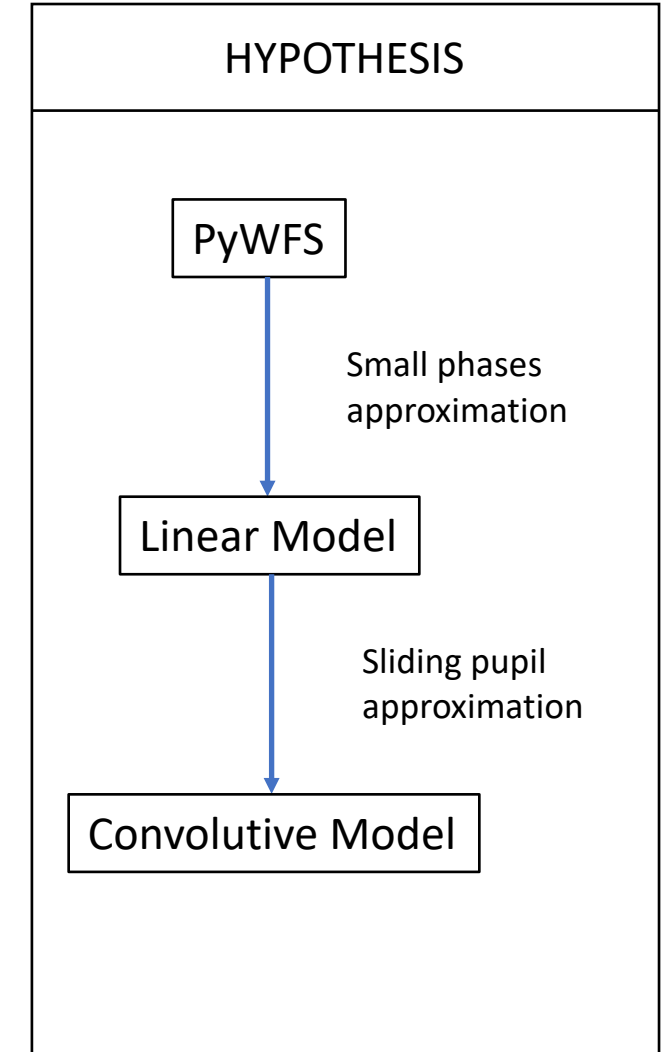
At Calibration



$$\mathbf{IR} = 2\text{Im}[\bar{\hat{m}}(\hat{m} \star (\tau\hat{\omega}\mathbb{I}_P))]$$

→
Camera

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



ANNEX: The Convolutional Model – FAUVARQUE 2019

