First Electric Field Conjugation wavefront control on the THD2 bench

Wavefront sensing and control in the VLT/ELT era, 3rd edition

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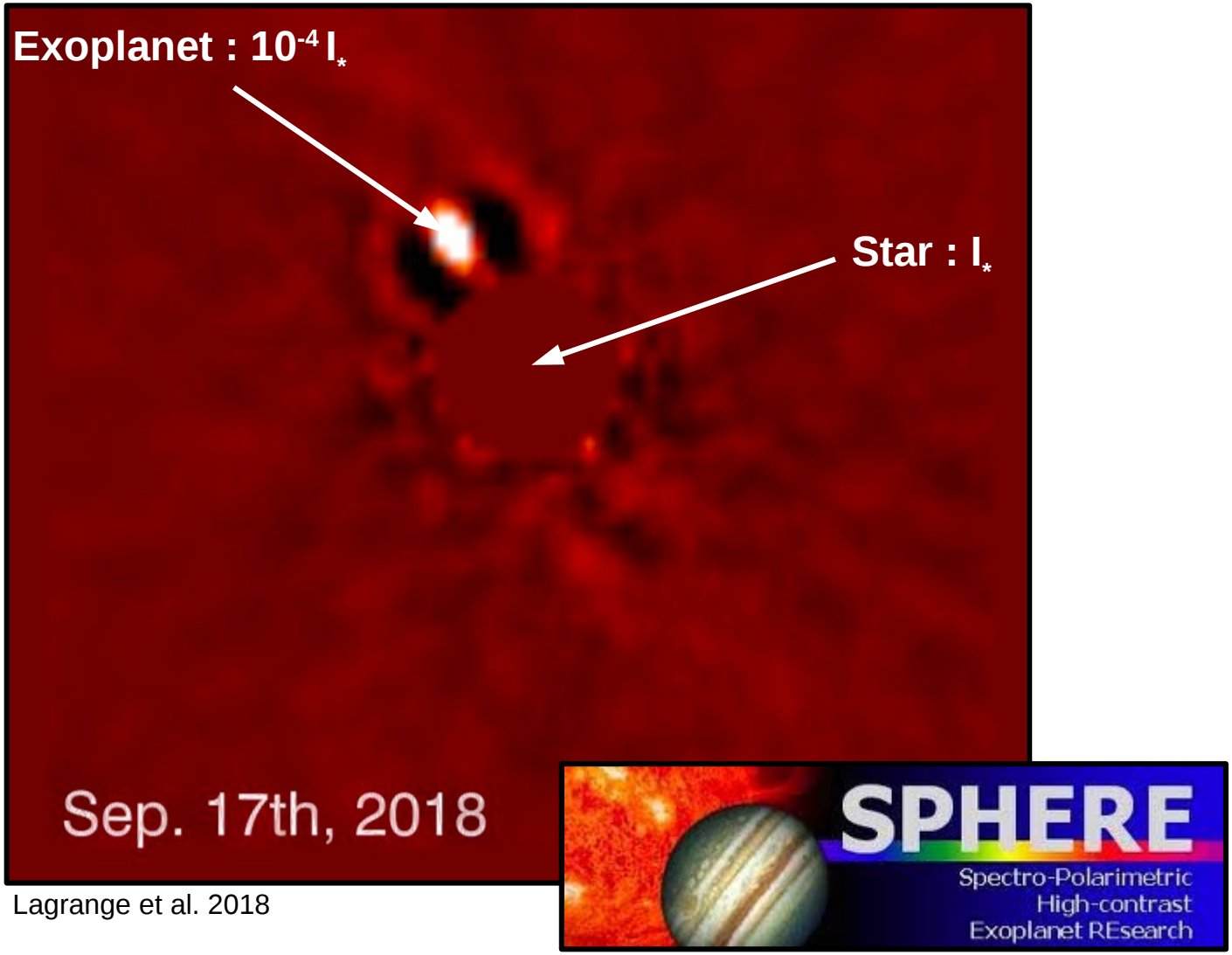
Laboratoire d'Études Spatiales et d'Instrumentation en Astrophysique

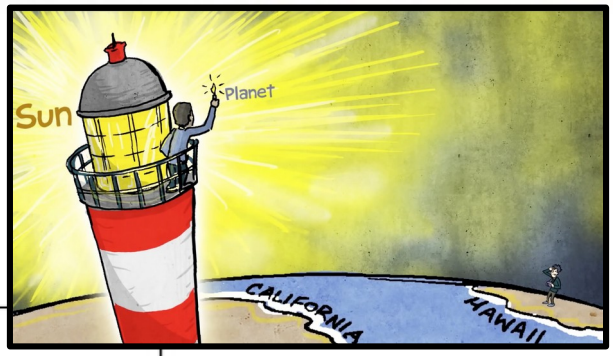
Beta-pictoris b



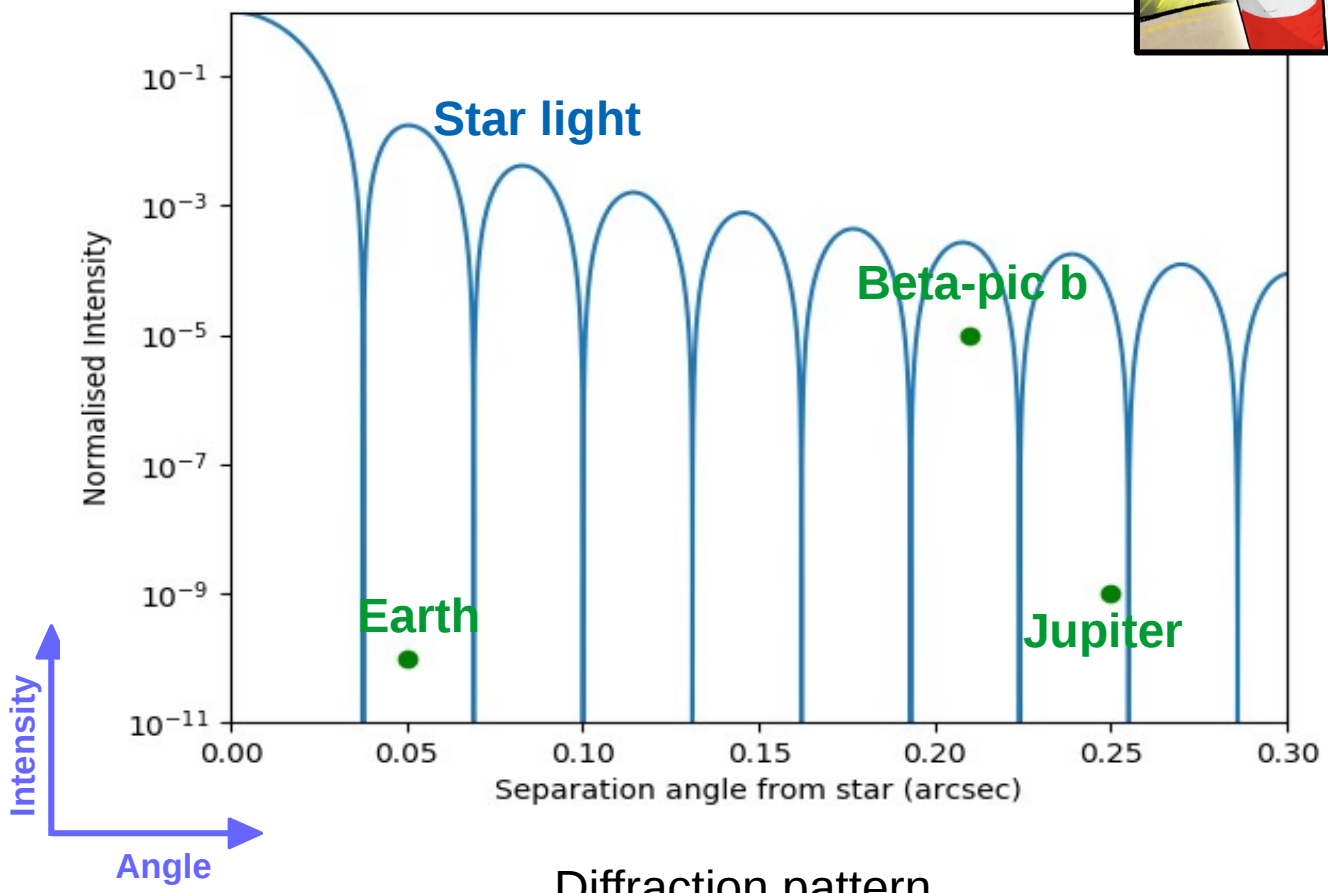
Lagrange et al. 2018

High contrast imaging issues

Wavelength=1.5µm
Telescope Diameter=10m
Target settled at 20 pc



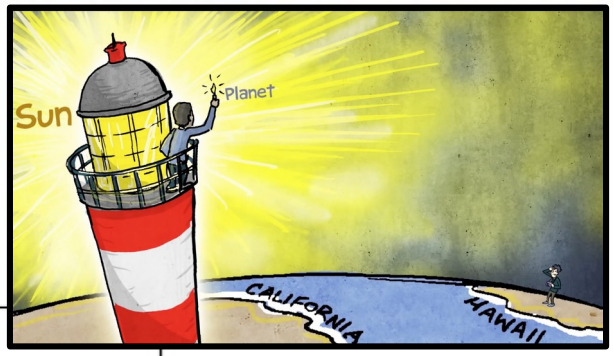
Without coronagraph

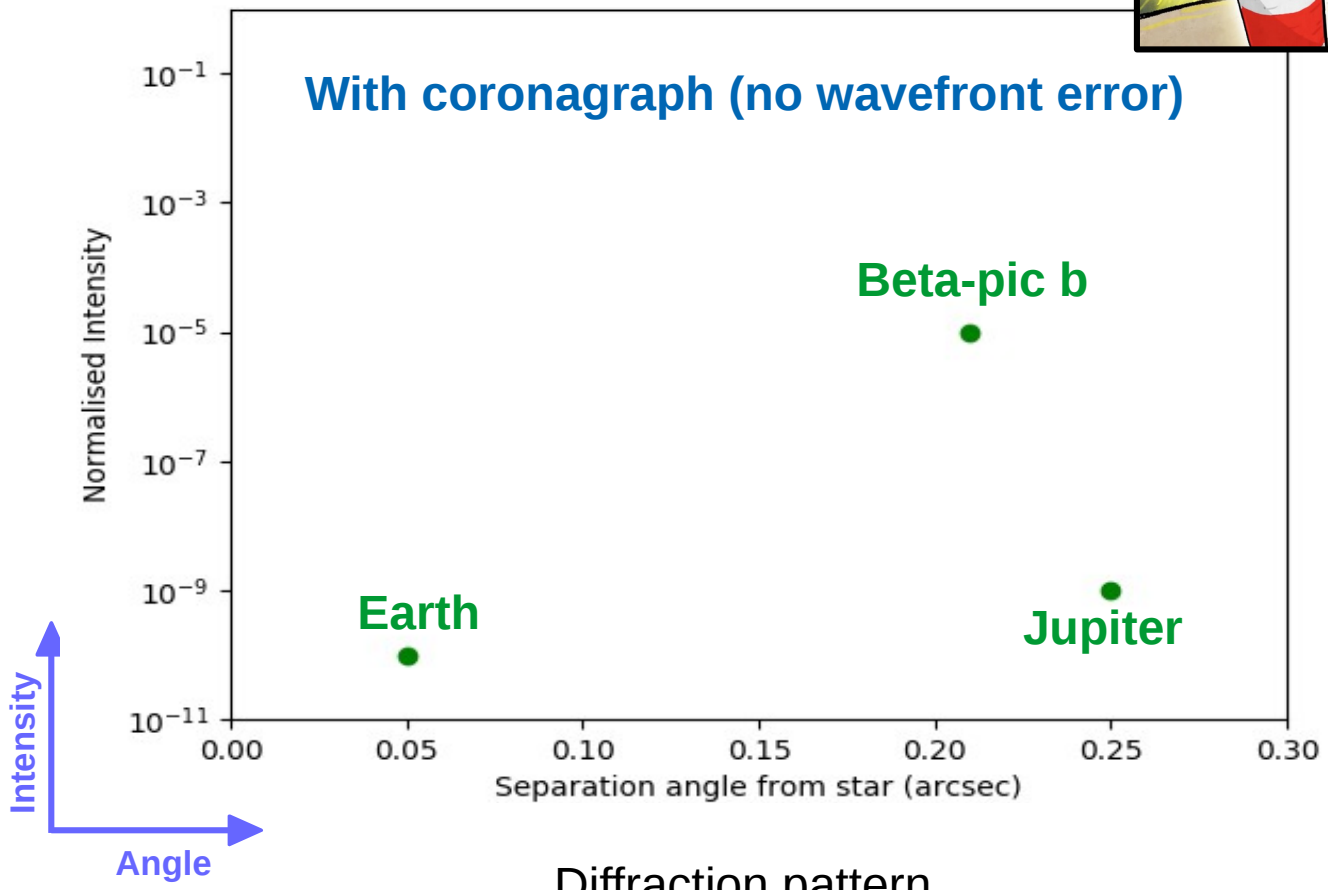


Diffraction pattern

Solution : a perfect coronagraph

Wavelength=1.5µm
Telescope Diameter=10m
Target settled at 20 pc

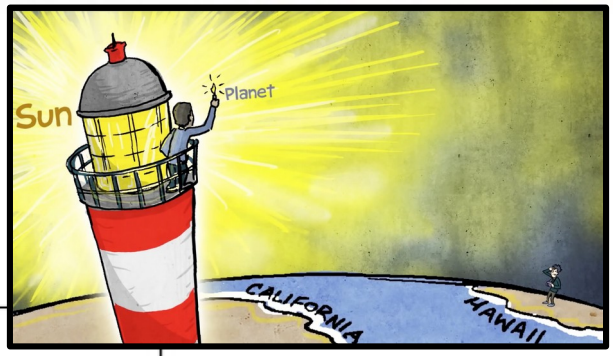


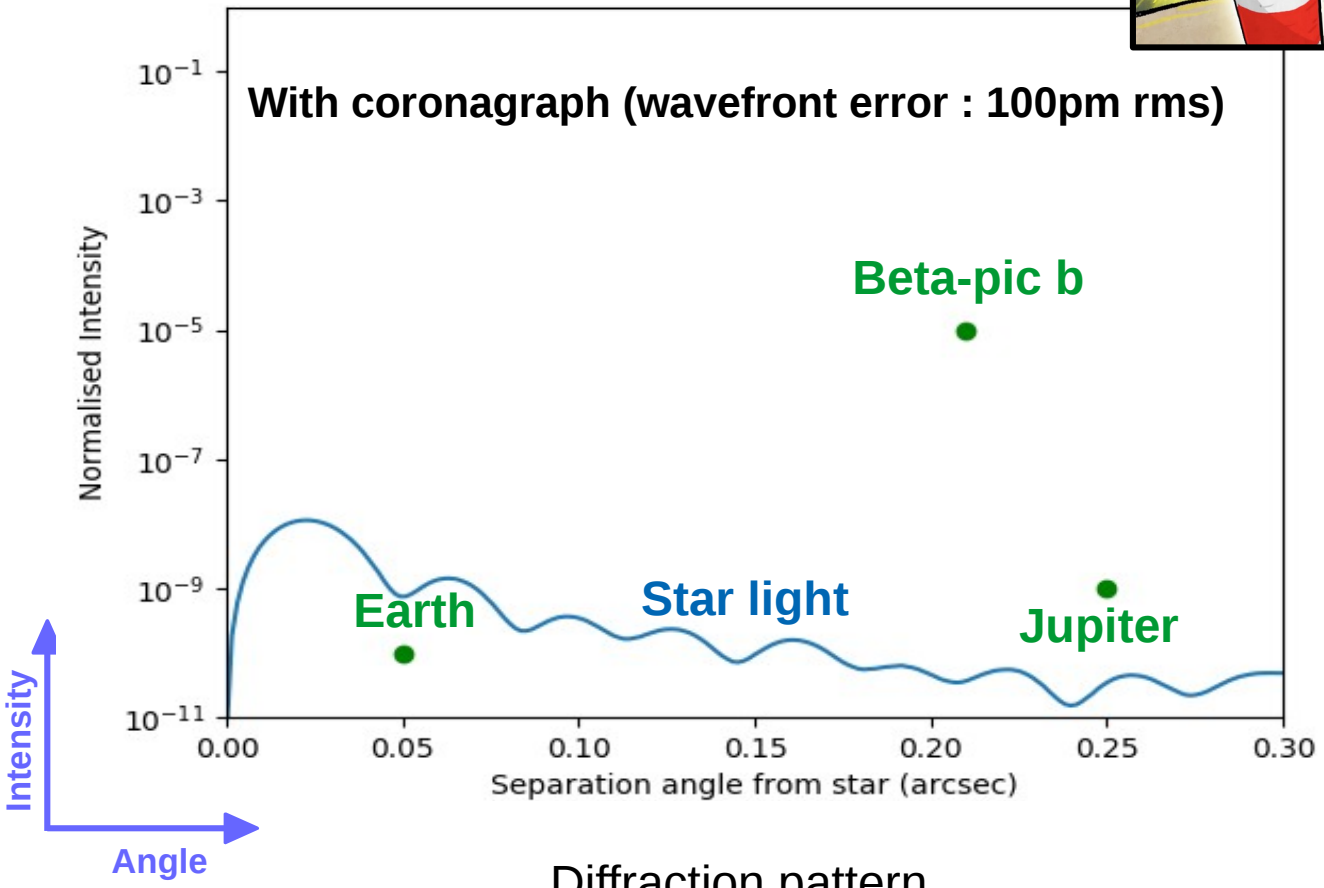


Diffraction pattern

Limitation : wavefront error

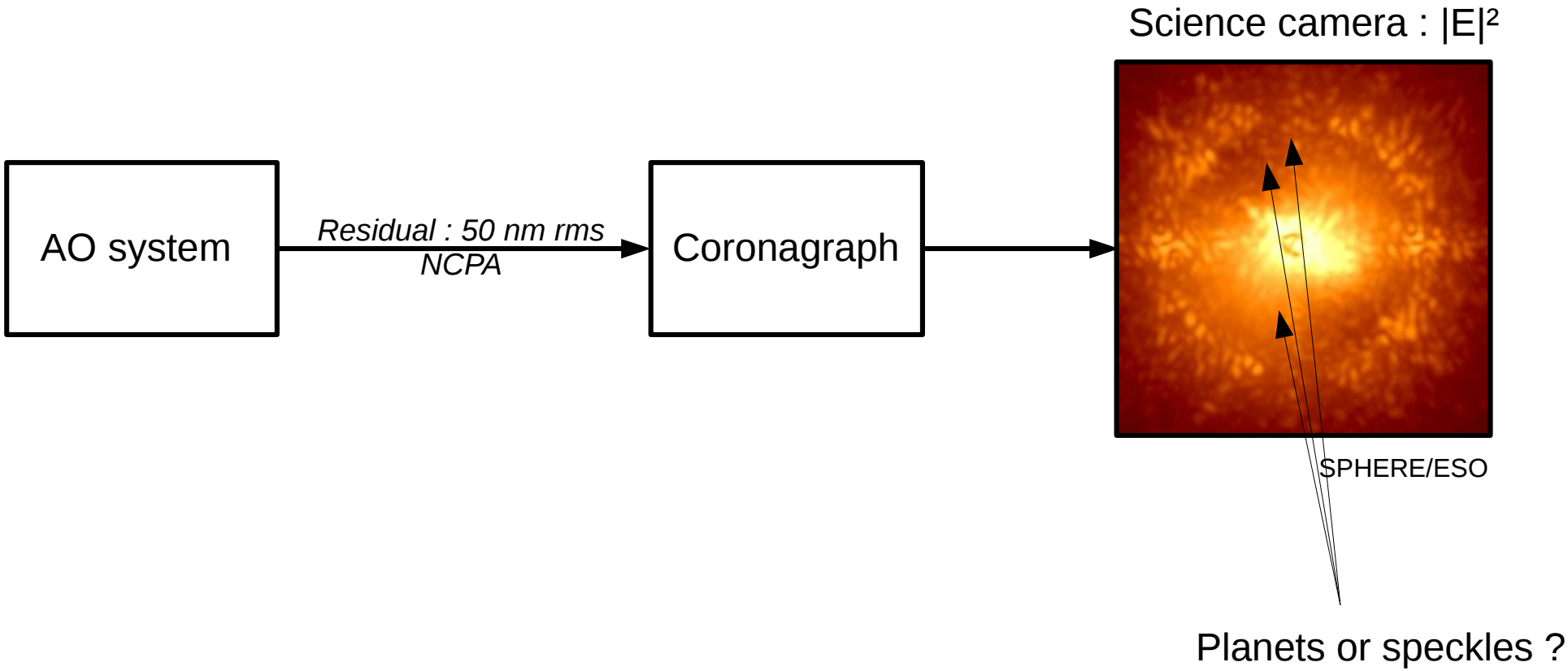
Wavelength=1.5µm
Telescope Diameter=10m
Target settled at 20 pc



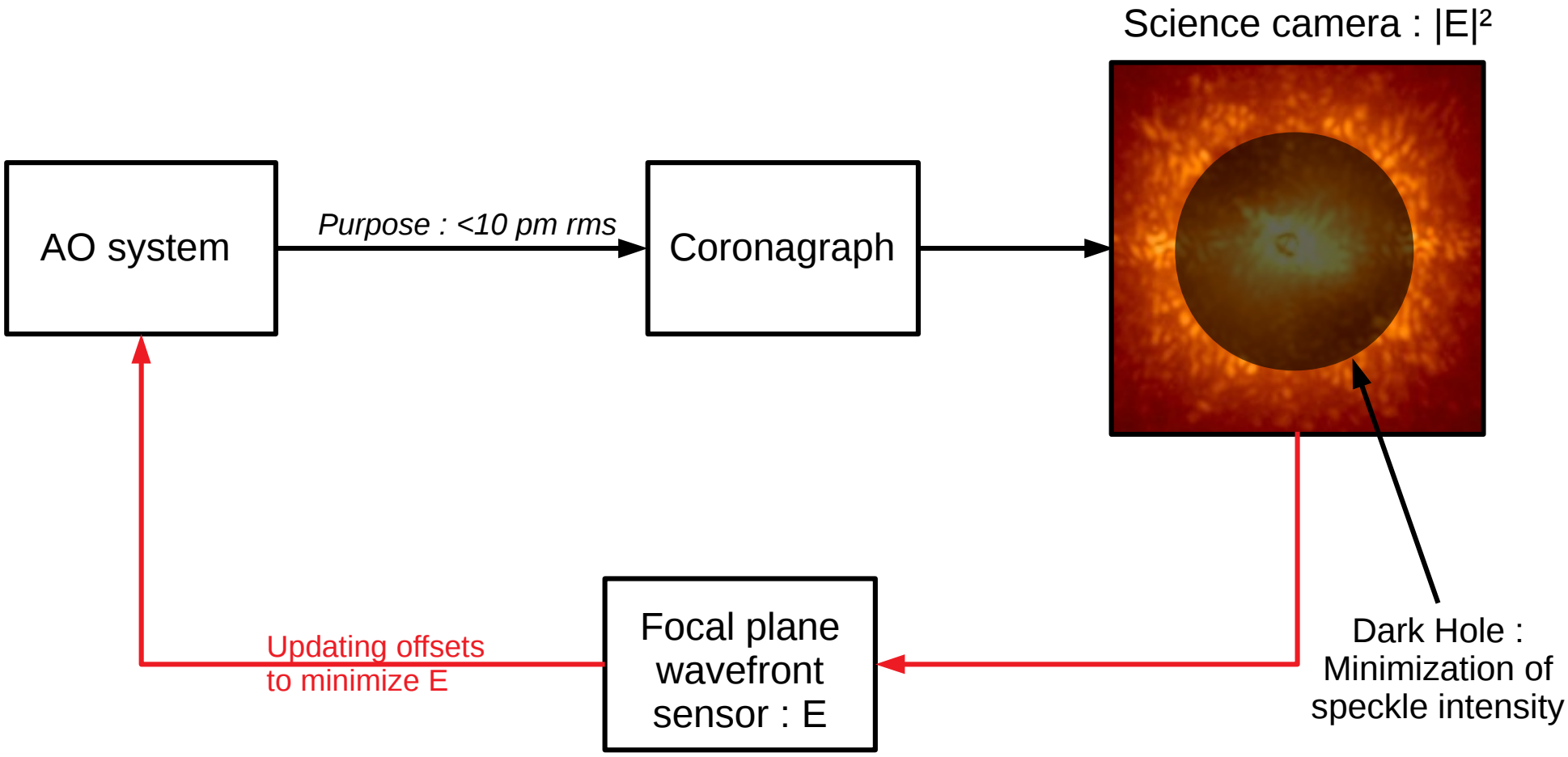


Diffraction pattern

Non-common path aberrations issue



Solution : Focal plane wavefront sensor



Electric Field Conjugation

Bordé (2006), Give'on (2007)

Wavefront sensor : Temporal modulation of a speckle pattern

Electric Field Conjugation

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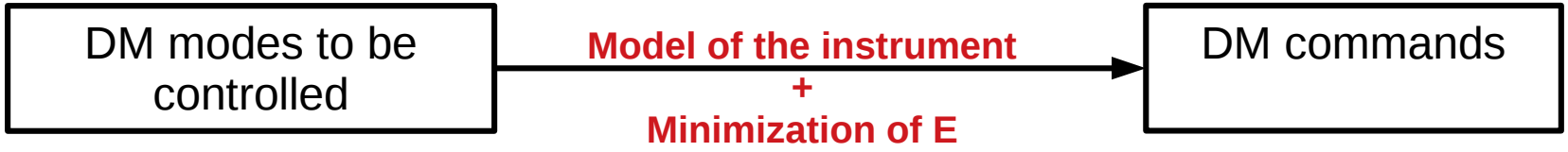
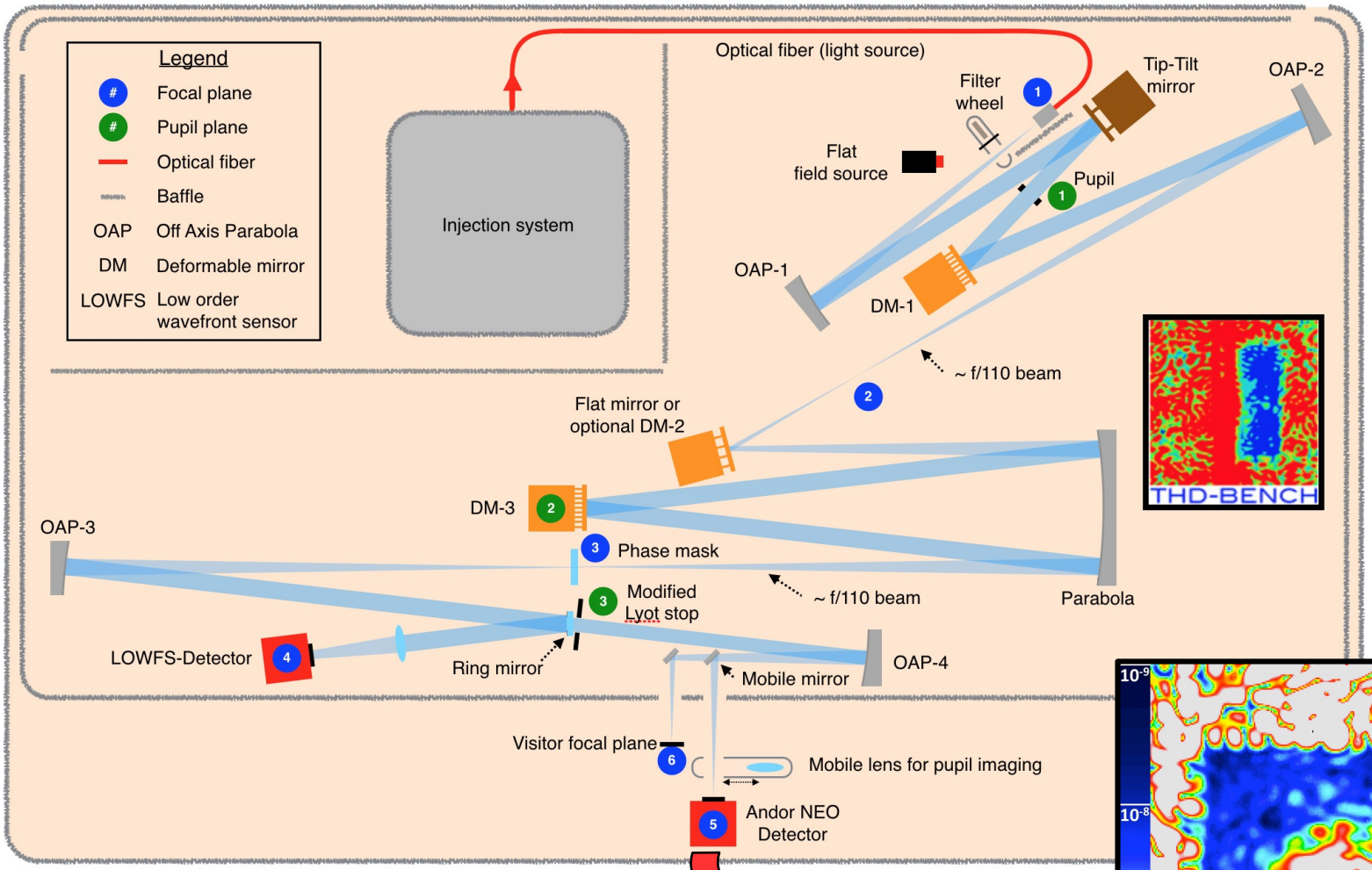
Wavefront control :



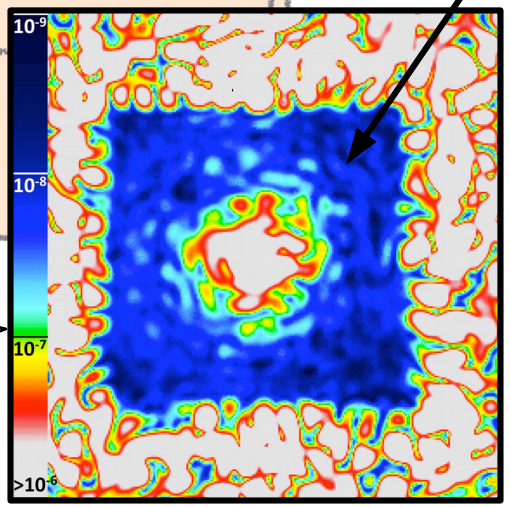
THD2 bench

Crédit: http://thd-bench.lesia.obspm.fr/

λ=783 nm
Coro=FQPM



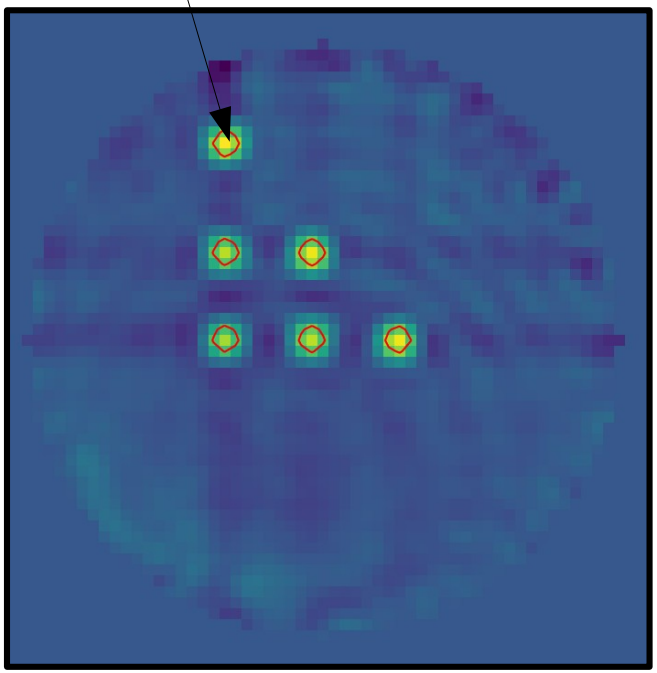
Dark Hole



Baudoz et al. (In prep) : **Contrast <10^{-8} at 5λ/D with Self Coherent Camera**

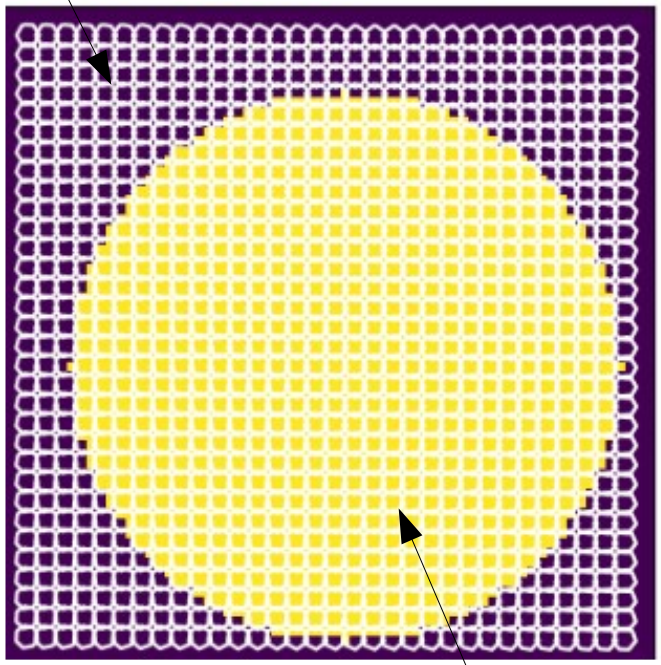
Calibration of the instrument

Position of the pushed actuators according to the model



Aberration estimation

Actuators grid

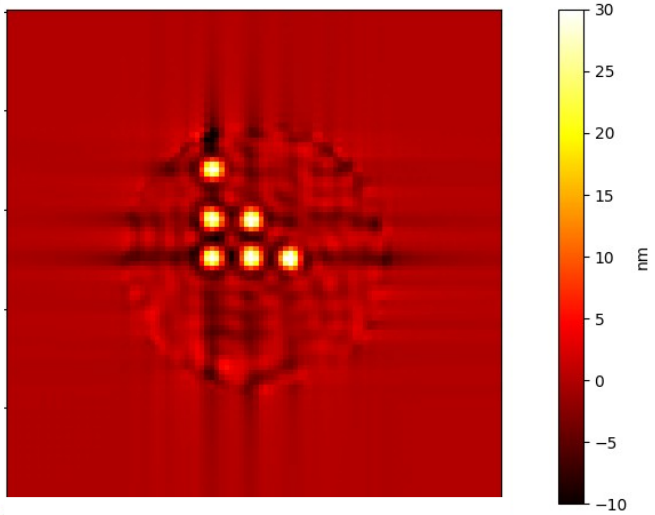


Entrance pupil

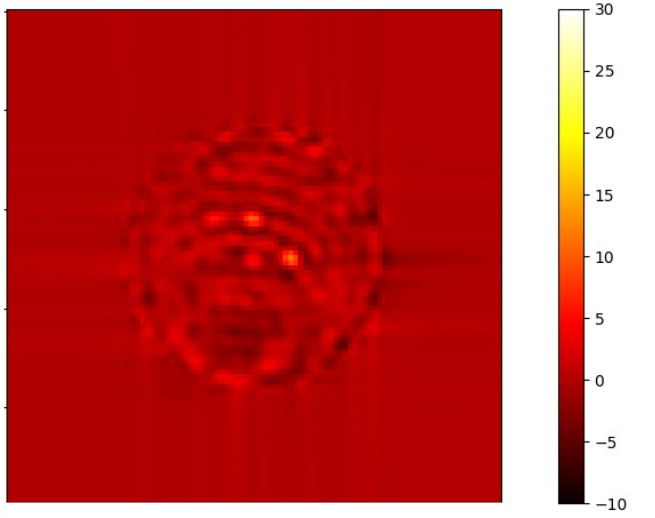
Lab EFC wavefront sensor on THD2

Probes : 3 x single actuator

Phase



Amplitude



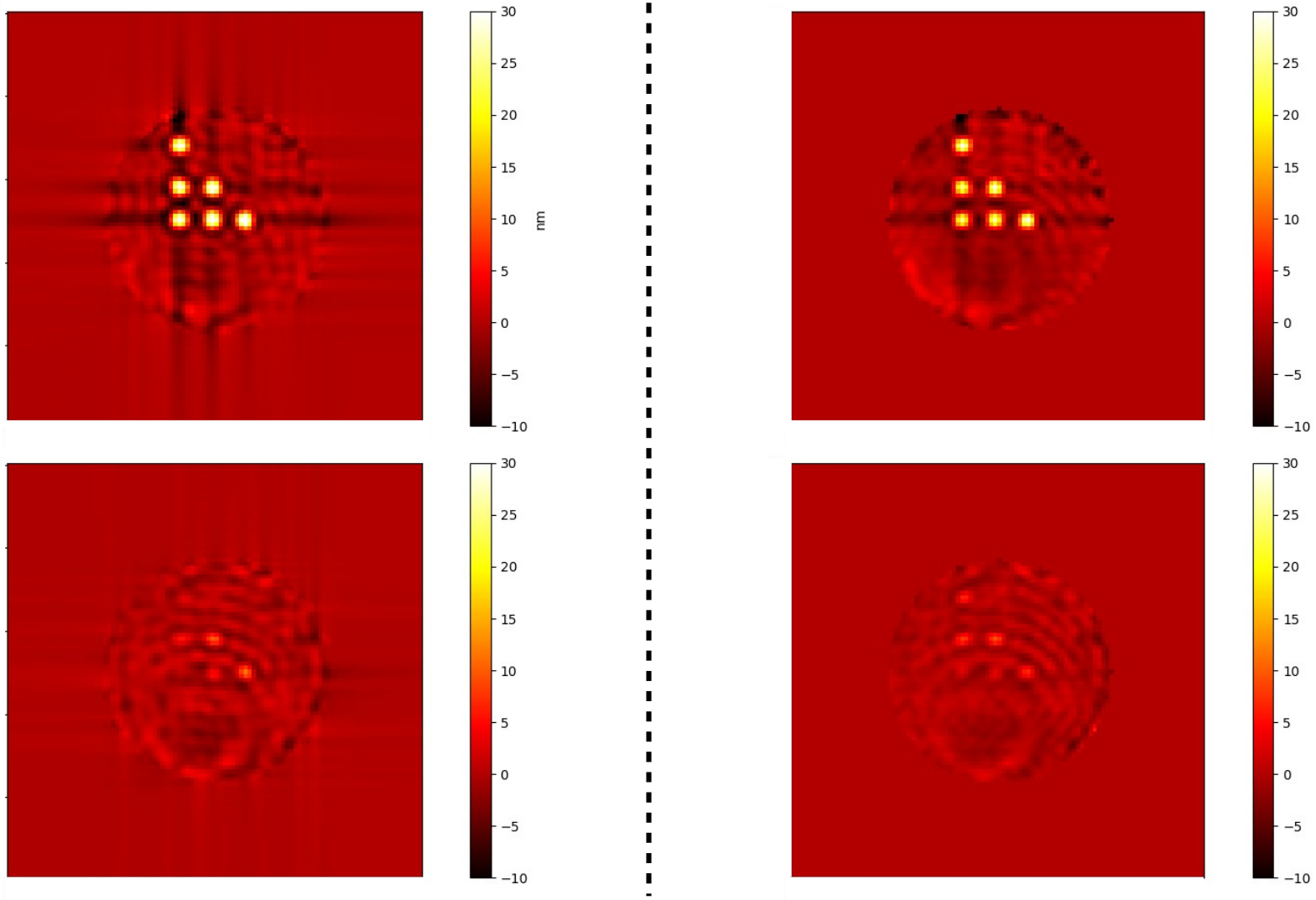
EFC

Lab EFC wavefront sensor on THD2

Probes : 3 x single actuator

Phase

Amplitude



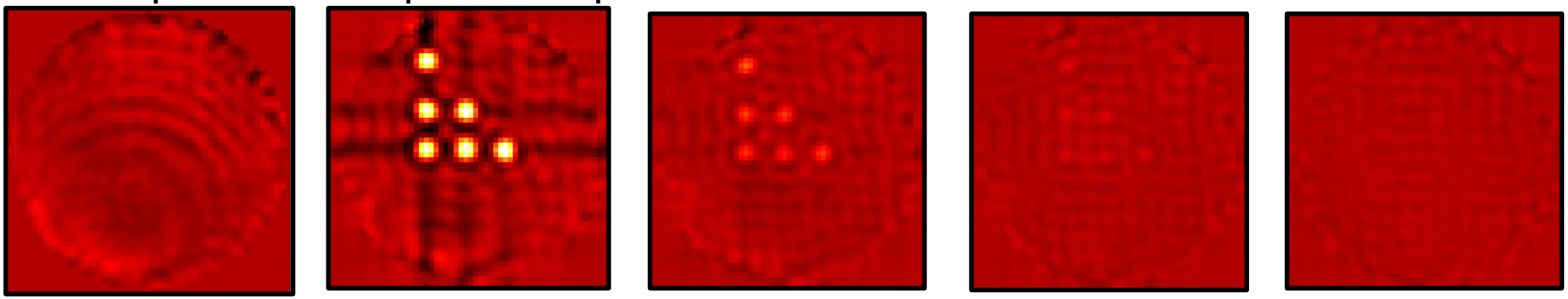
EFC **SCC**

Lab EFC wavefront control on THD2 : Full FOV

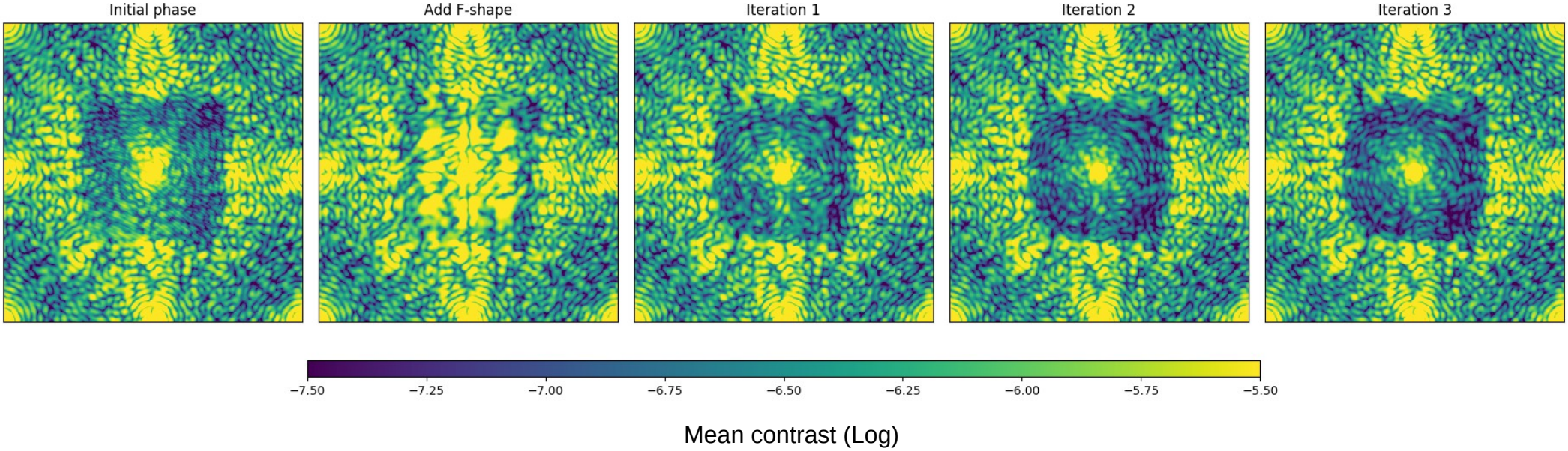
EFC correction

Modes : 692 x single actuator

Pupil plane :

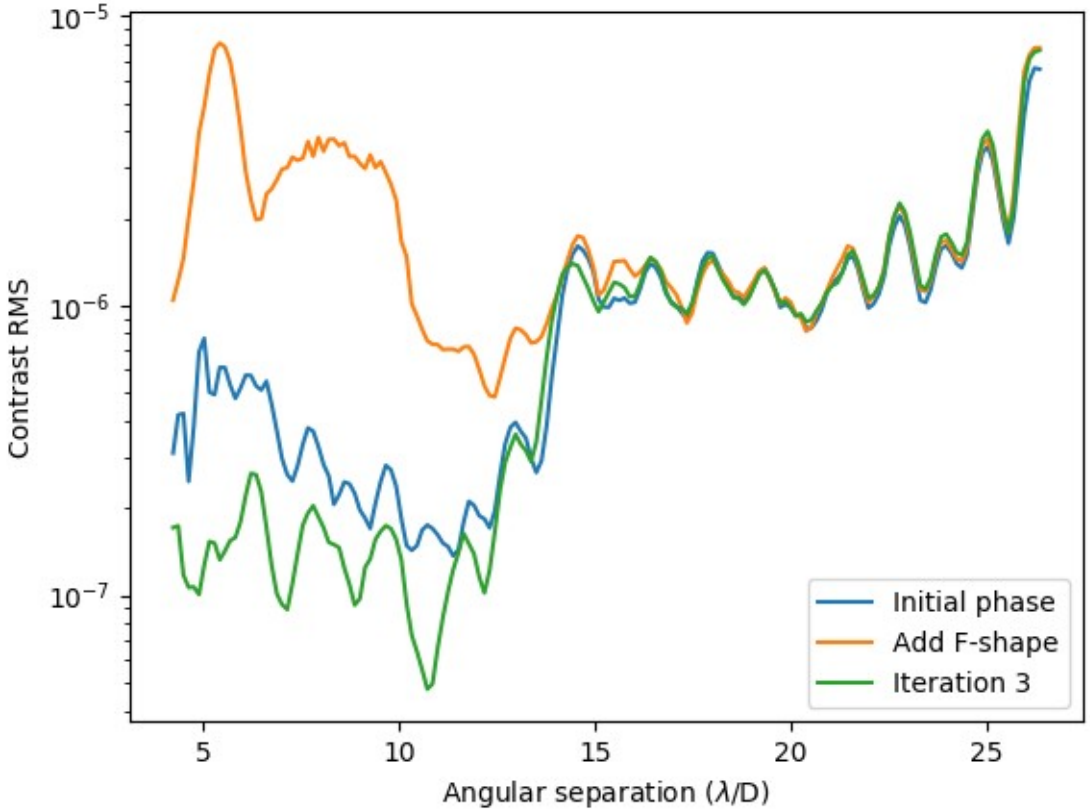


Focal plane :



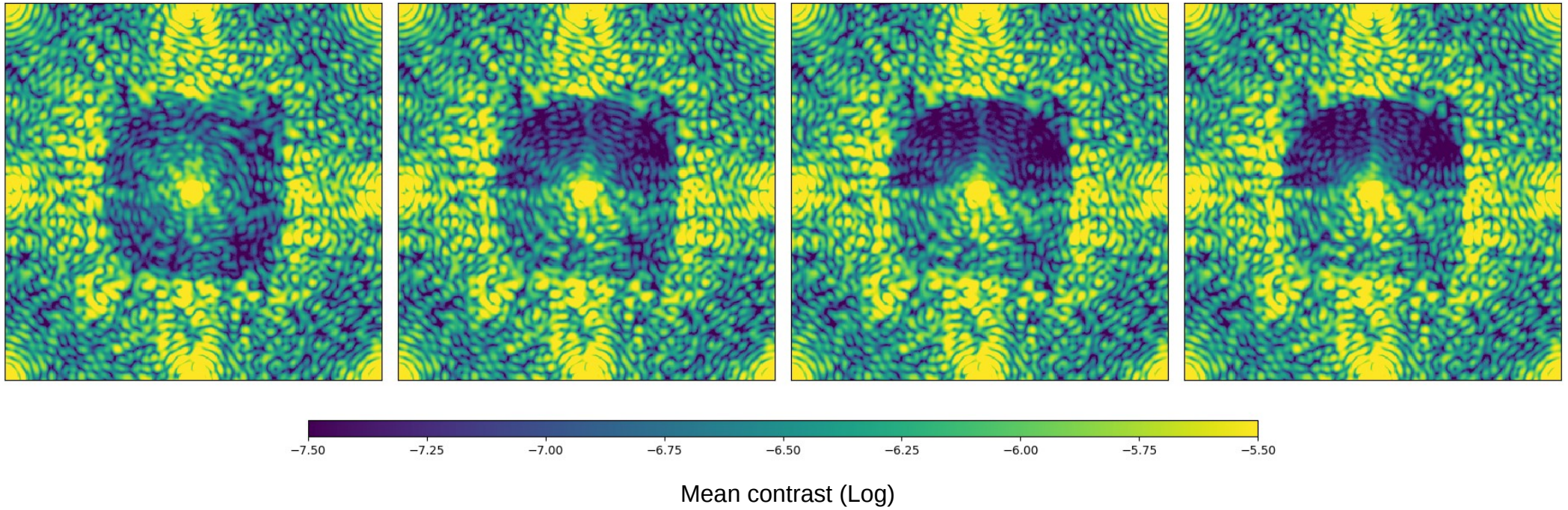
Result for correction full FOV

10^{-7} between 5 and 12 λ/D



Lab EFC wavefront control on THD2 : Half Dark Hole

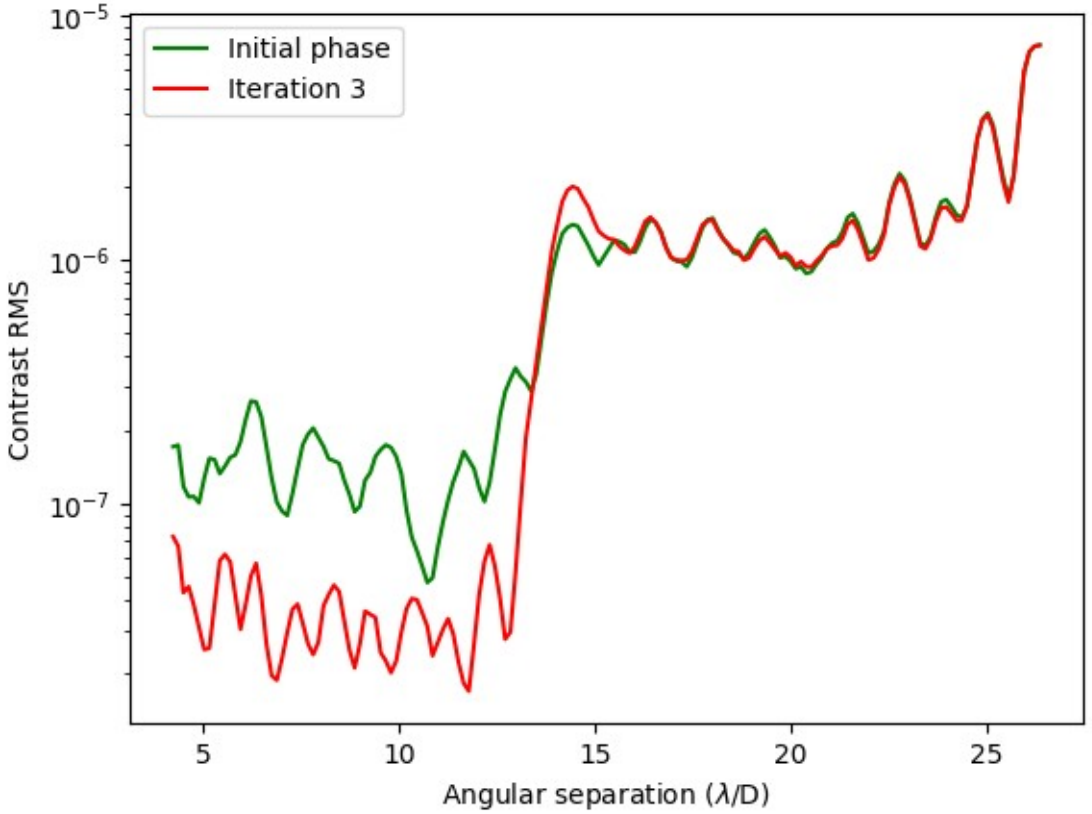
EFC correction
Modes : 578 x single actuator



Potier et al, in Prep.

Result for correction Half Dark Hole

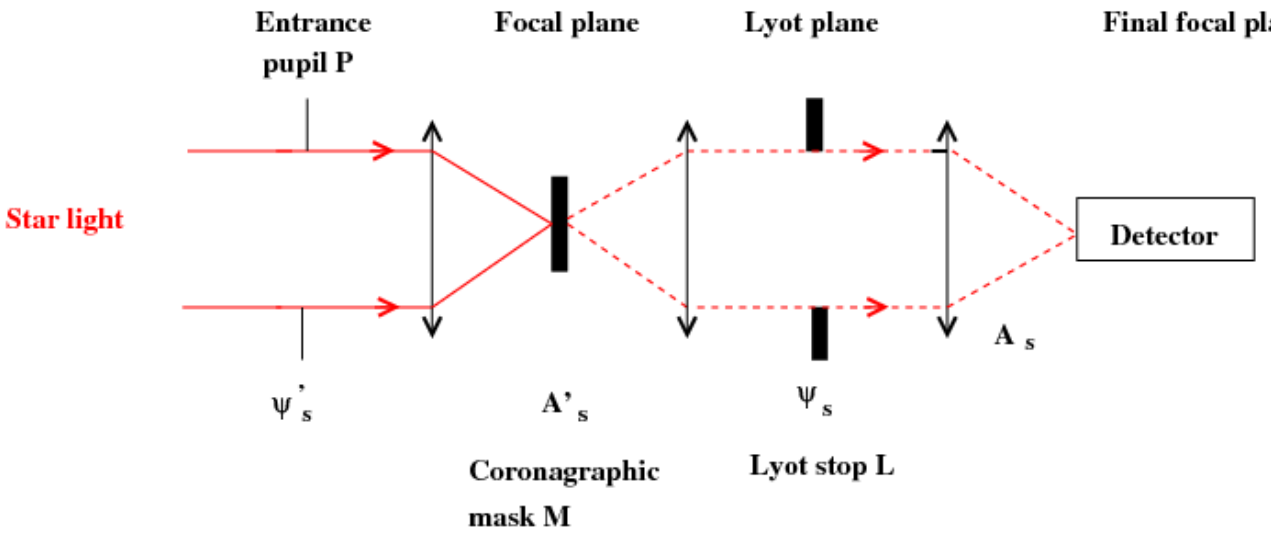
2×10^{-8} between 5 and 12 λ/D

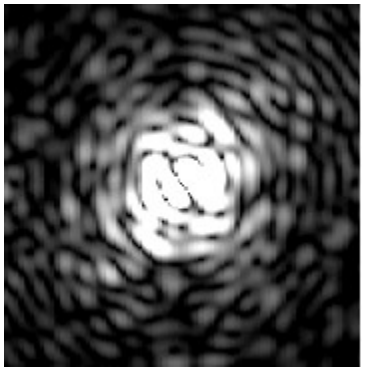


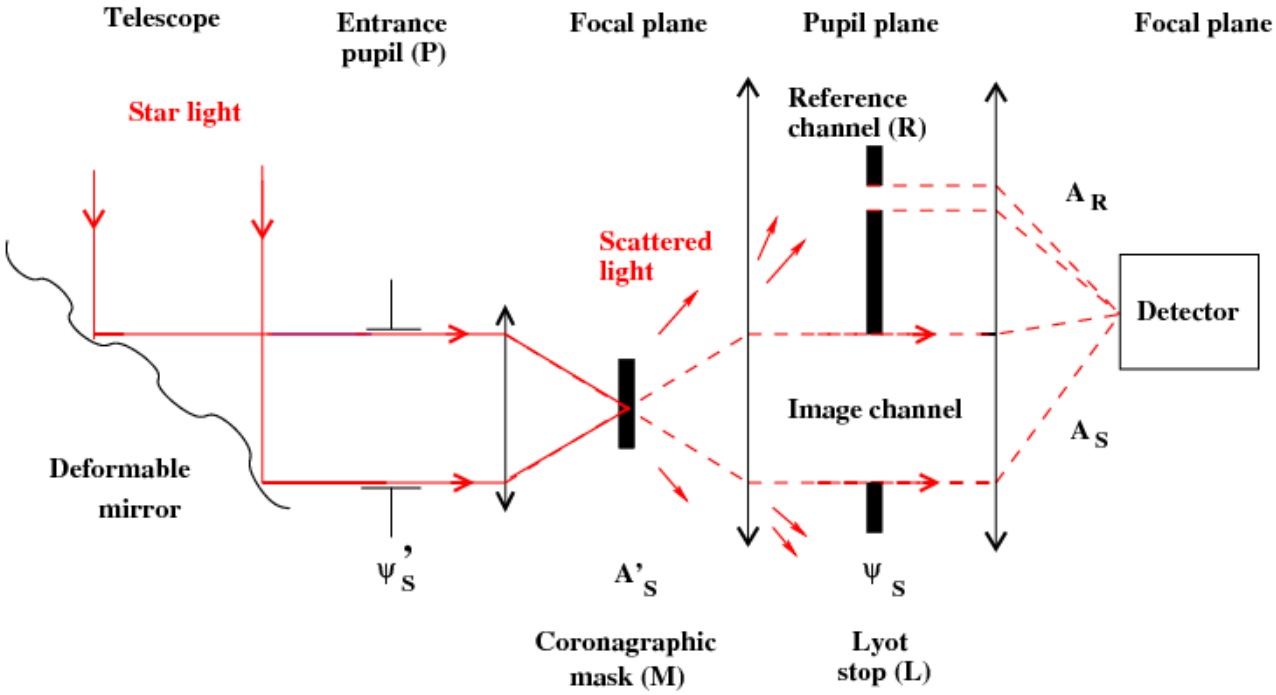
Prospectives

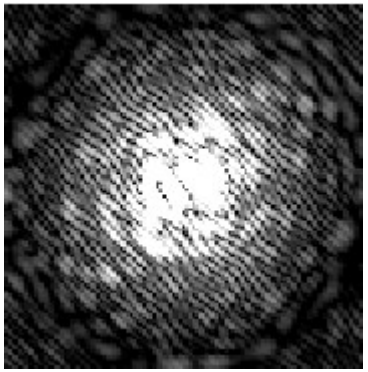
- Parametric study of EFC
    - Best probes ?
    - Best correcting modes ?
    - Impact of error on instrument model ?
- Amplitude correction with the second DM.
- Trying EFC on SPHERE to prepare ELT instrument.

Self Coherent Camera principle





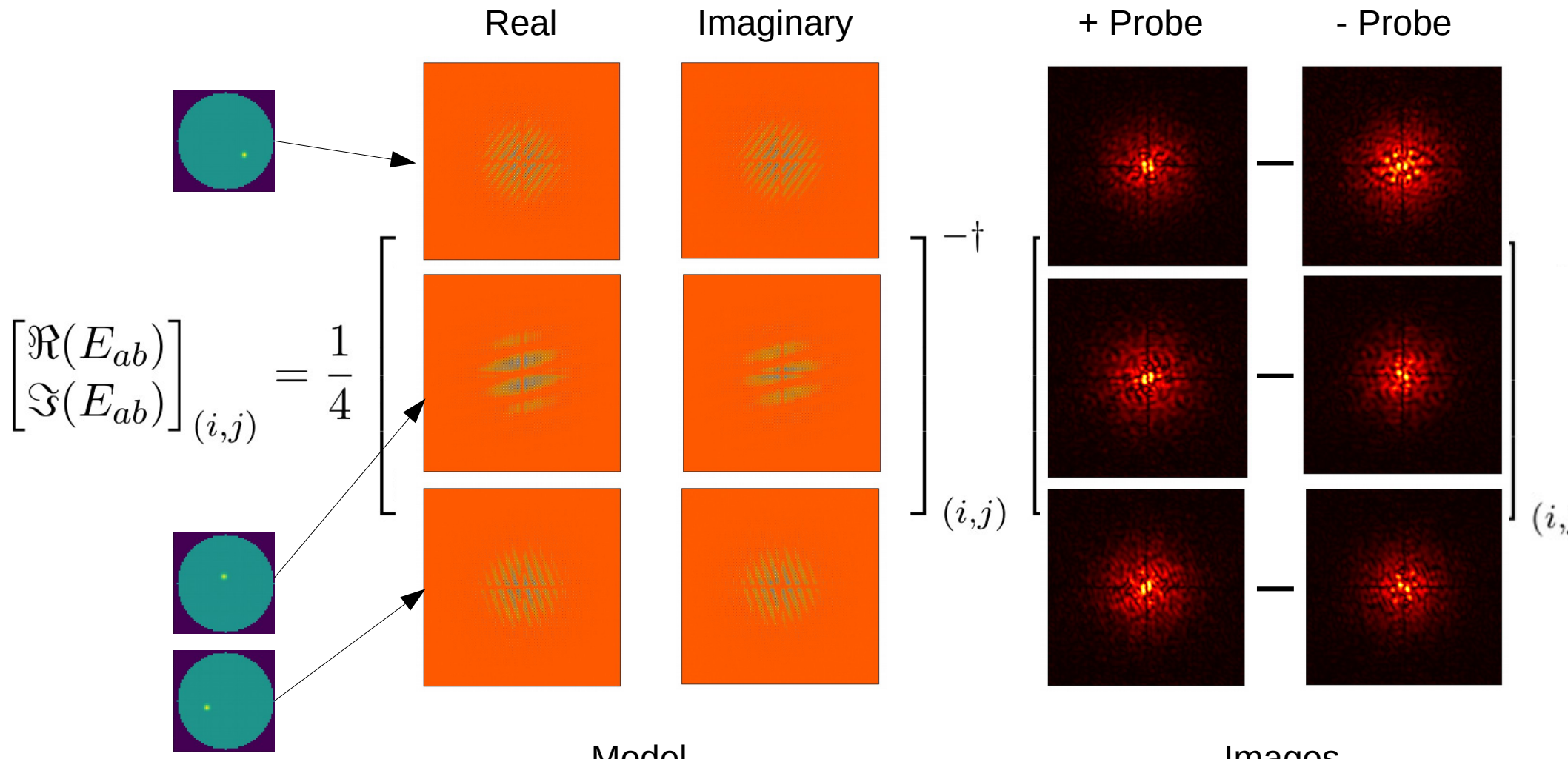




Mazoyer et al. 2014

Electric Field Conjugation principle

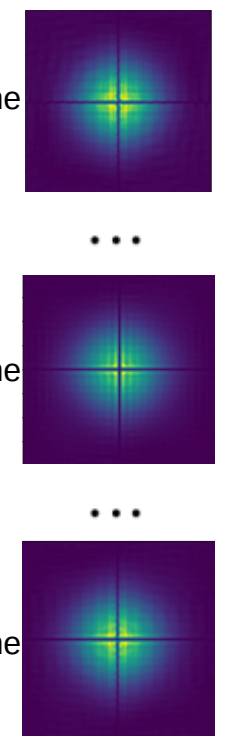
Estimation stage :



Electric Field Conjugation principle

Correction stage : E_{ab} minimization

$$G = \begin{bmatrix} \cdots \\ \text{Focal plane} \\ \cdots \\ \text{Focal plane} \\ \cdots \\ \text{Focal plane} \\ \cdots \end{bmatrix}$$

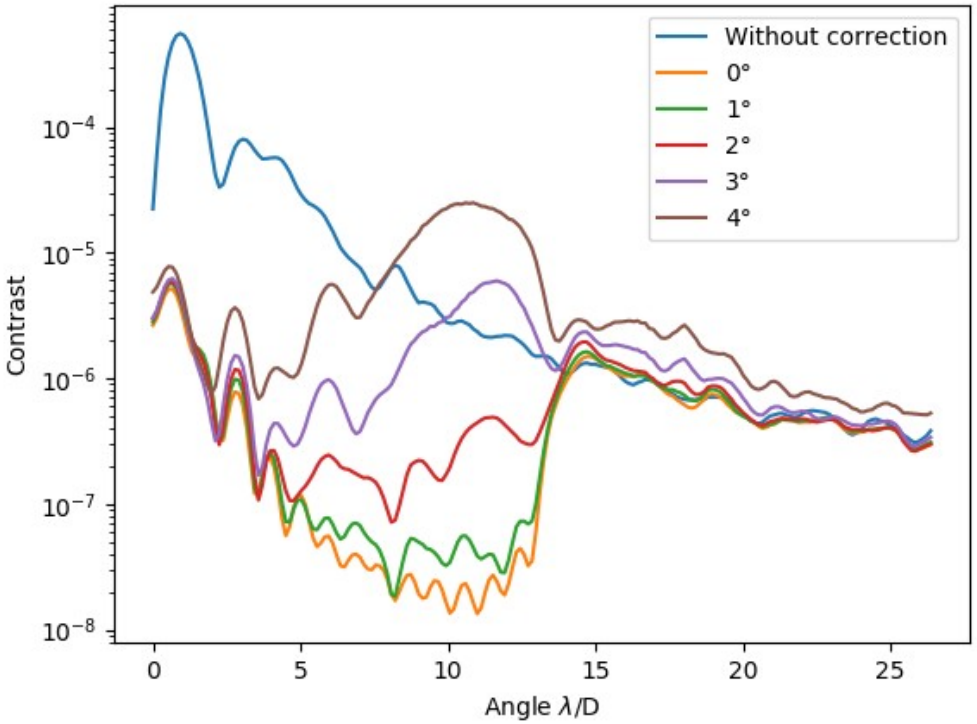


1024 modes

$$\bar{a} = -g \begin{bmatrix} \Re(G) \\ \dots \\ \Im(G) \end{bmatrix}^{-1} \begin{bmatrix} \Re(E_{ab}) \\ \dots \\ \Im(E_{ab}) \end{bmatrix}$$

Error on model

Rotation



Translation