HARMONI at ELT: Full scale prototype of the LGS WFS

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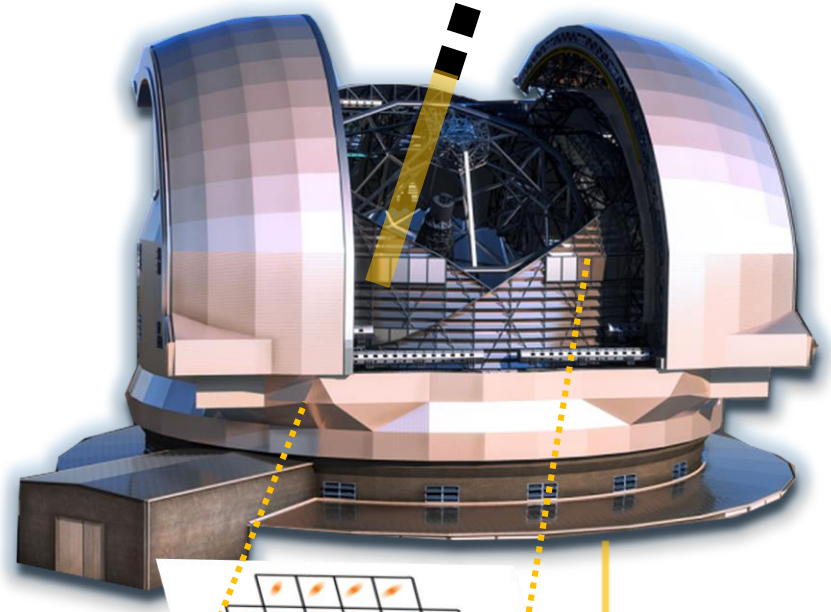
sodium layer

The LGS

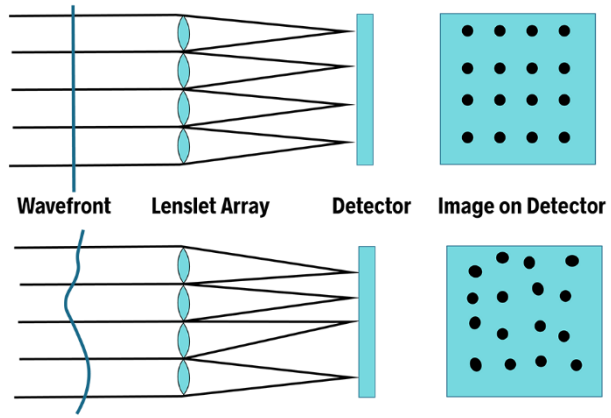
~20km

turbulences

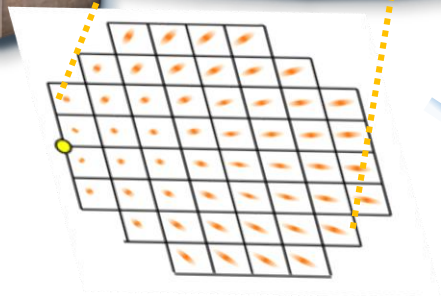


~80km

Shack-Hartmann



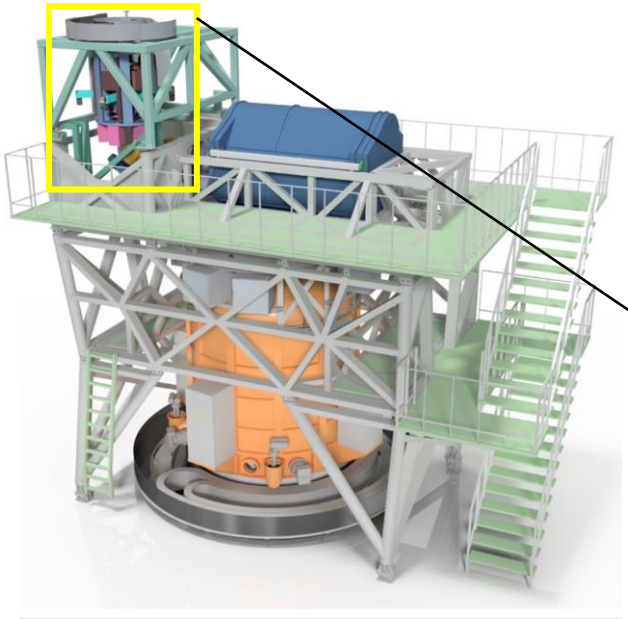
SH subapertures



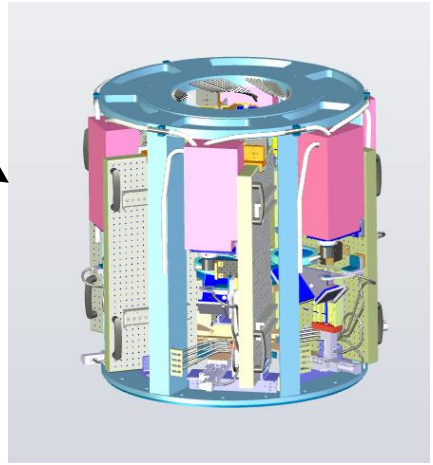
The sodium layer is around 90km high and its thickness is about 20km. The lasers are situated on the side of the telescope, therefore the wavefront sensor will see an elongated spot.

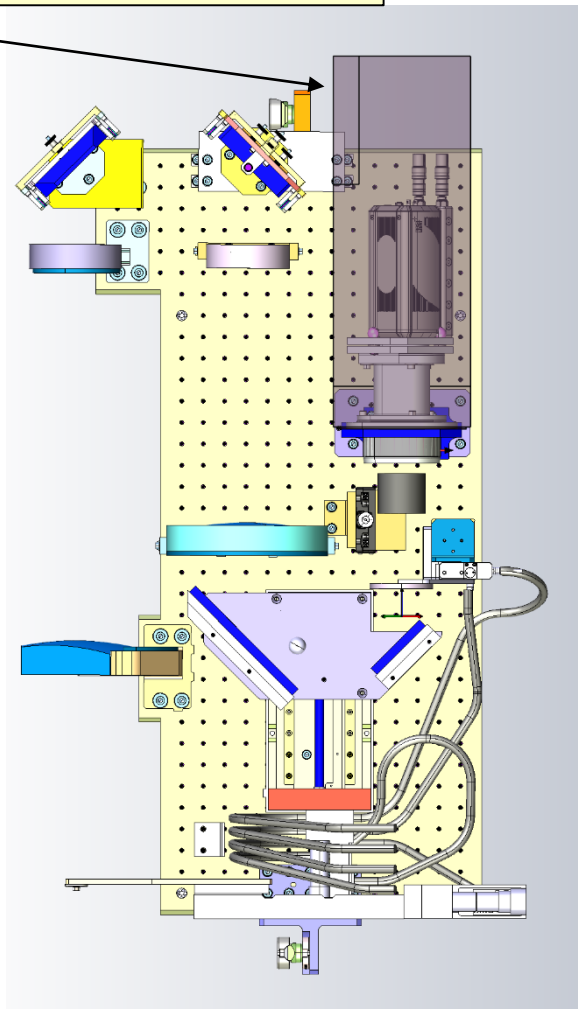
HARMONI (High Angular Resolution - Monolithic - Optical and Near-infrared - Integral field spectrograph)

LGSS (**L**aser **G**uide **S**tar **S**ensor)



LDM (**L**aser guide star **D**etector **M**odule)



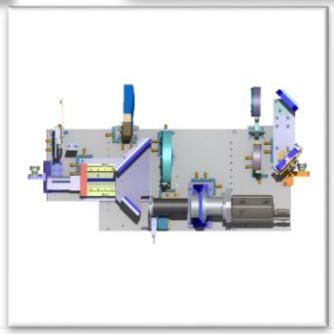


Goals for Harmoni:

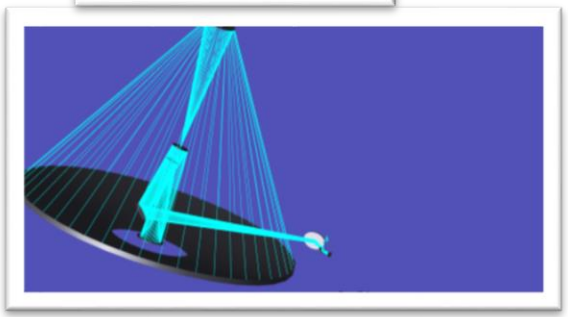
-Physics of distant galaxies
-Stars in other galaxies
-Characterization of giant exoplanets
-Relationship between black holes and their galaxy
-…

Overview

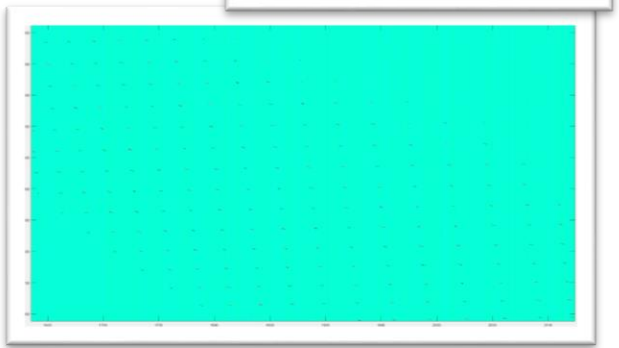
-Characterization of the WFS, camera, relay, microlenses array, SLM.



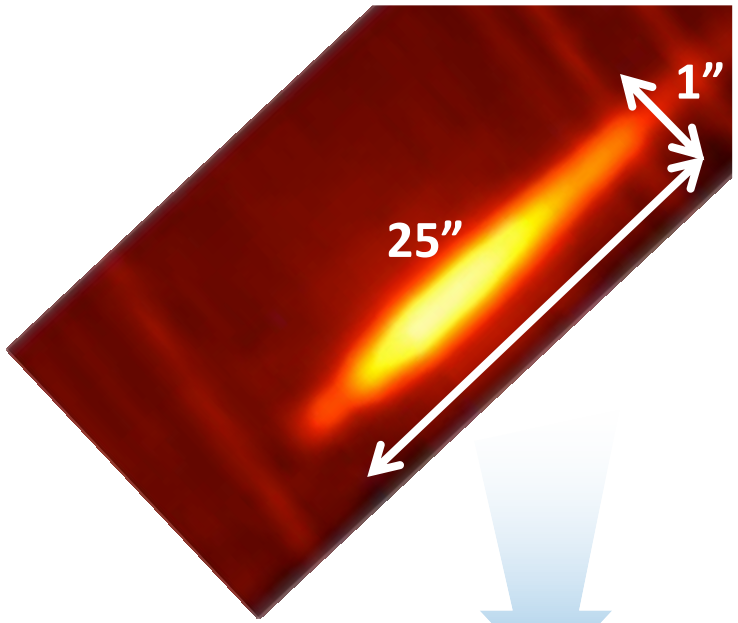
-Optical design to emulate the ELT and turbulences. Innovative solution for elongated source



-AO perfomances, closed loops, COGs vs WCoGs, interaction matrix analysis, IM simulations.



C-Blue Camera



QE 0,72 @589nm

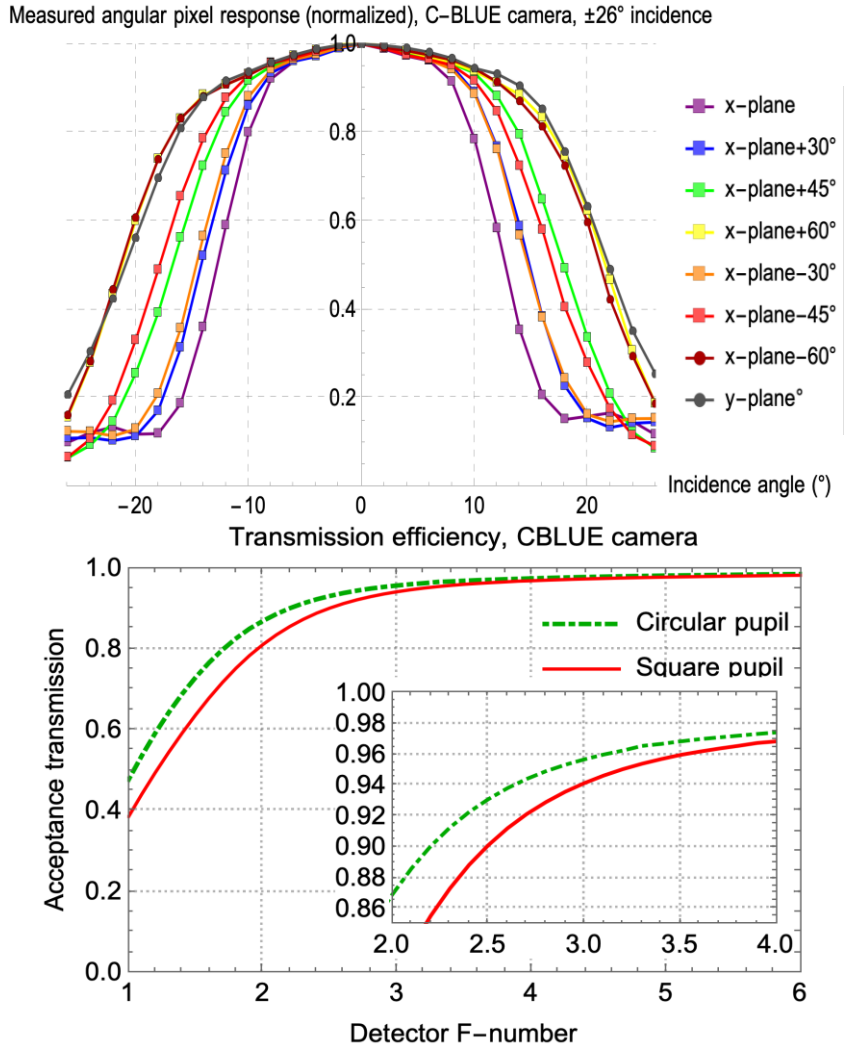
Ideally, we need subapertures with 25x25 pixels of ~1”/pixel

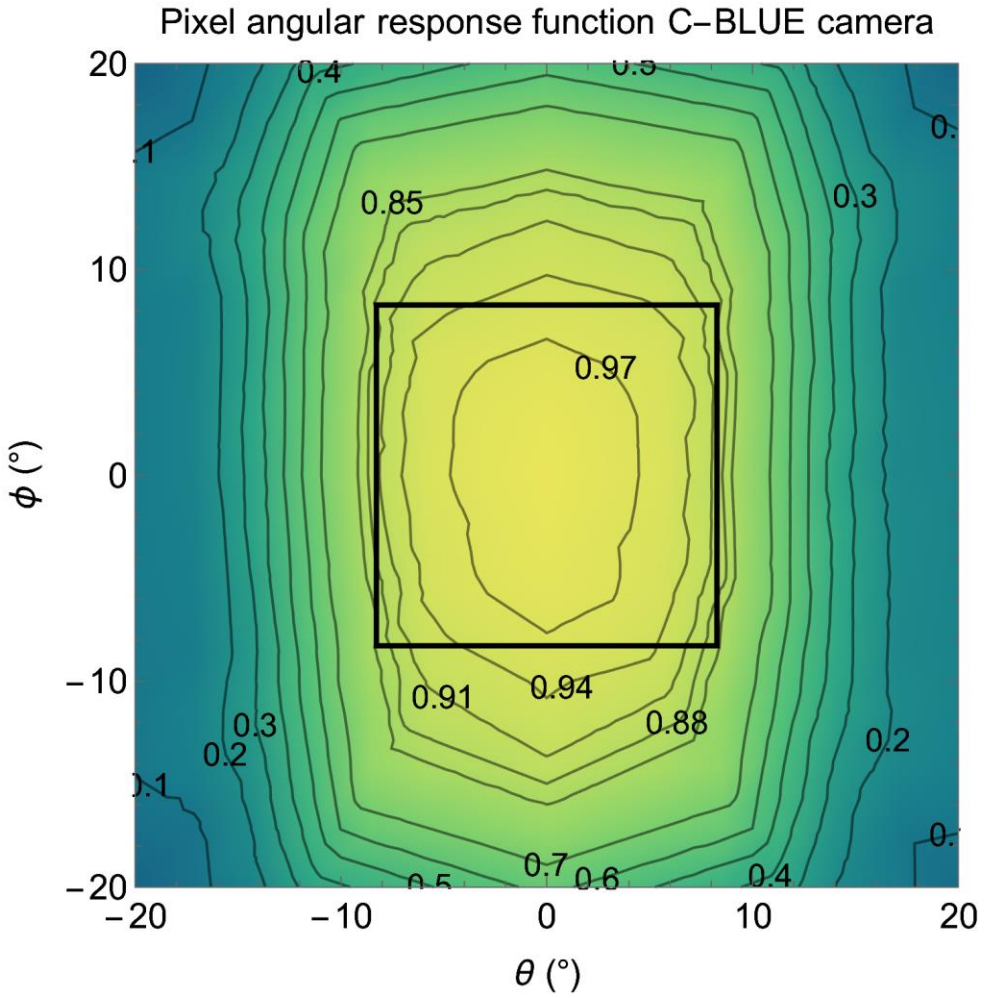
For 80x80 subapertures, we need 2000 x 2000 pixels

2000x2000 pixels detector, running at 500Hz, with RON<3e- does not exist…

Instead, we are using a C-Blue camera with:
1608×1104 pixels
RON<3e-
500Hz
Global shutter

C-BLUE acceptance angle





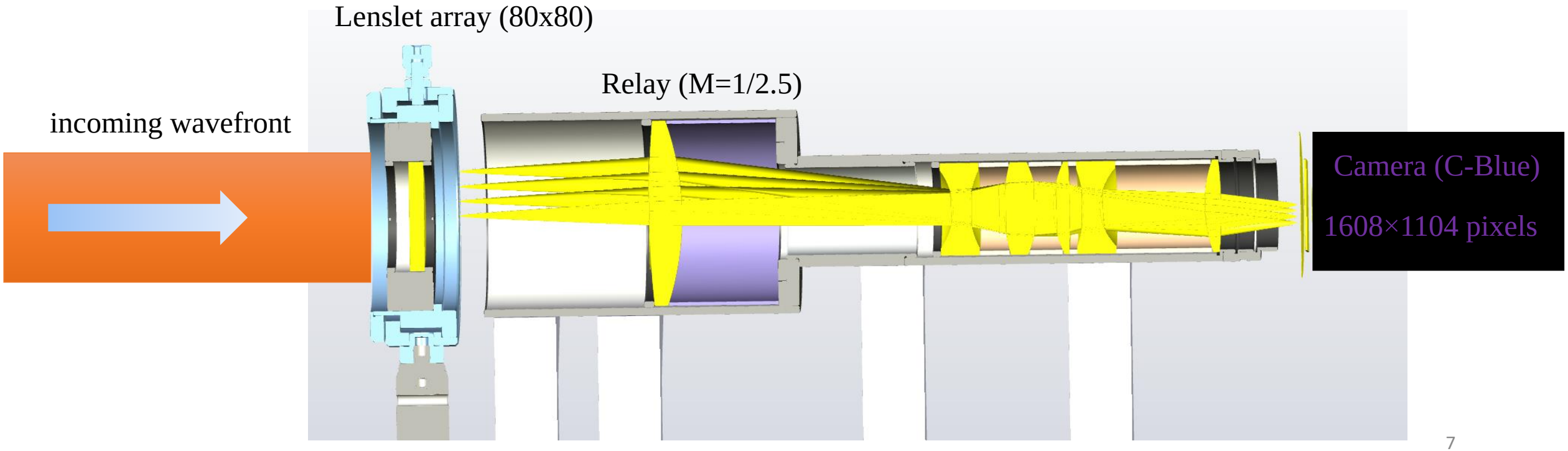
1. Z. Ke, F. Pedreros and al. "CMOS sensor performance for laser guide star wavefront sensing," *submitted to JATIS*.

The LDM (Laser guide star detector module)

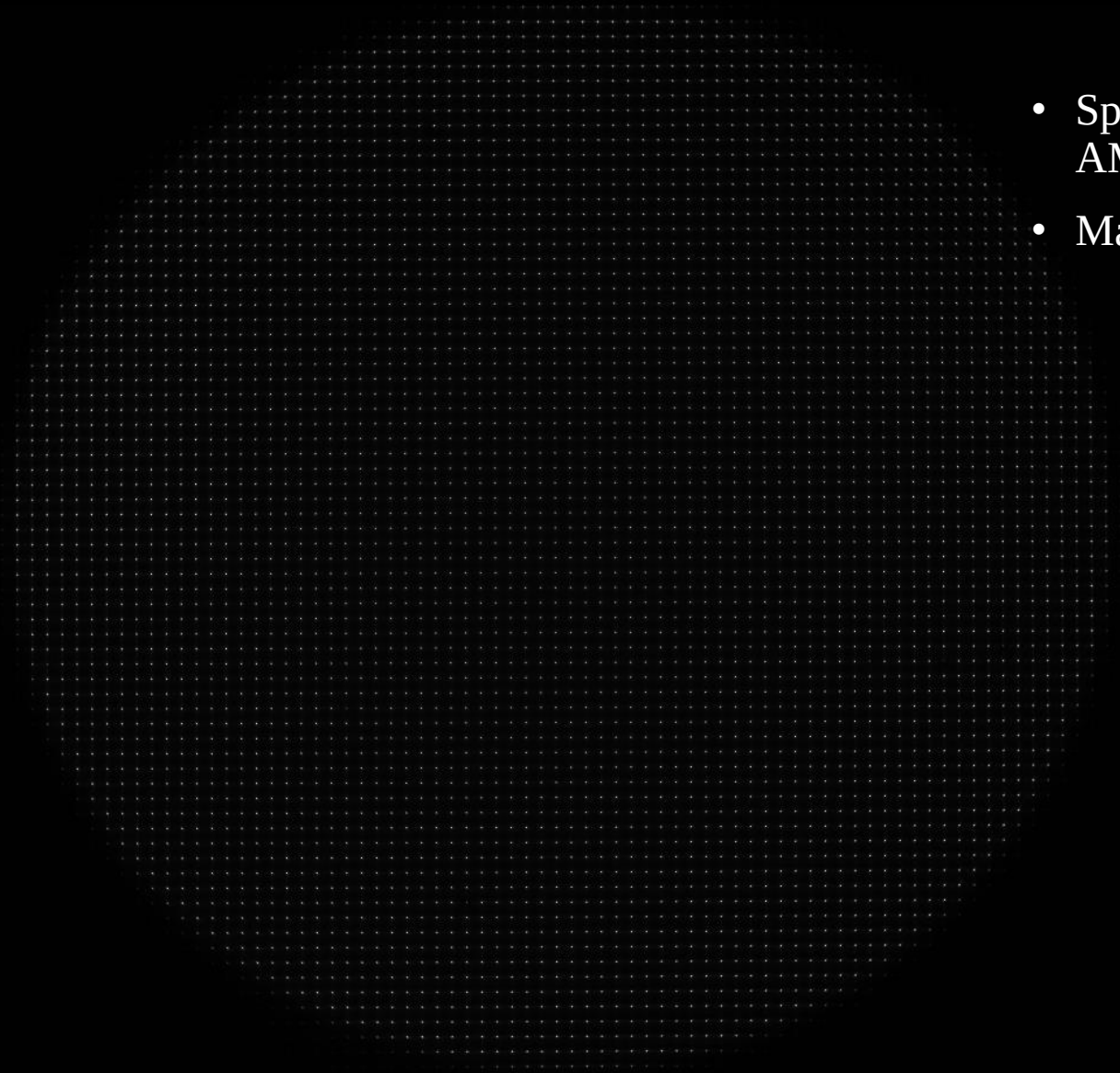
-The wavefront sensing is done with a **Shack-Hartmann**.

-The focal of the microlenses is small (large field 15'', 80x80 subapertures to sample the 39m M1), therefore we use a relay to re-image the pupil on the camera.

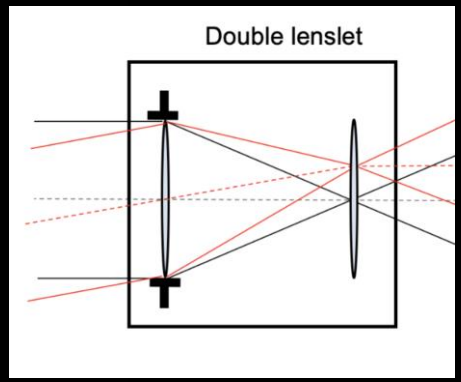
-Due to the number of subpertures and the size of the elongated spots, we need an important number of pixels, therefore we are using a CMOS sony sensor 1608x1104 pixels. (C-Blue).



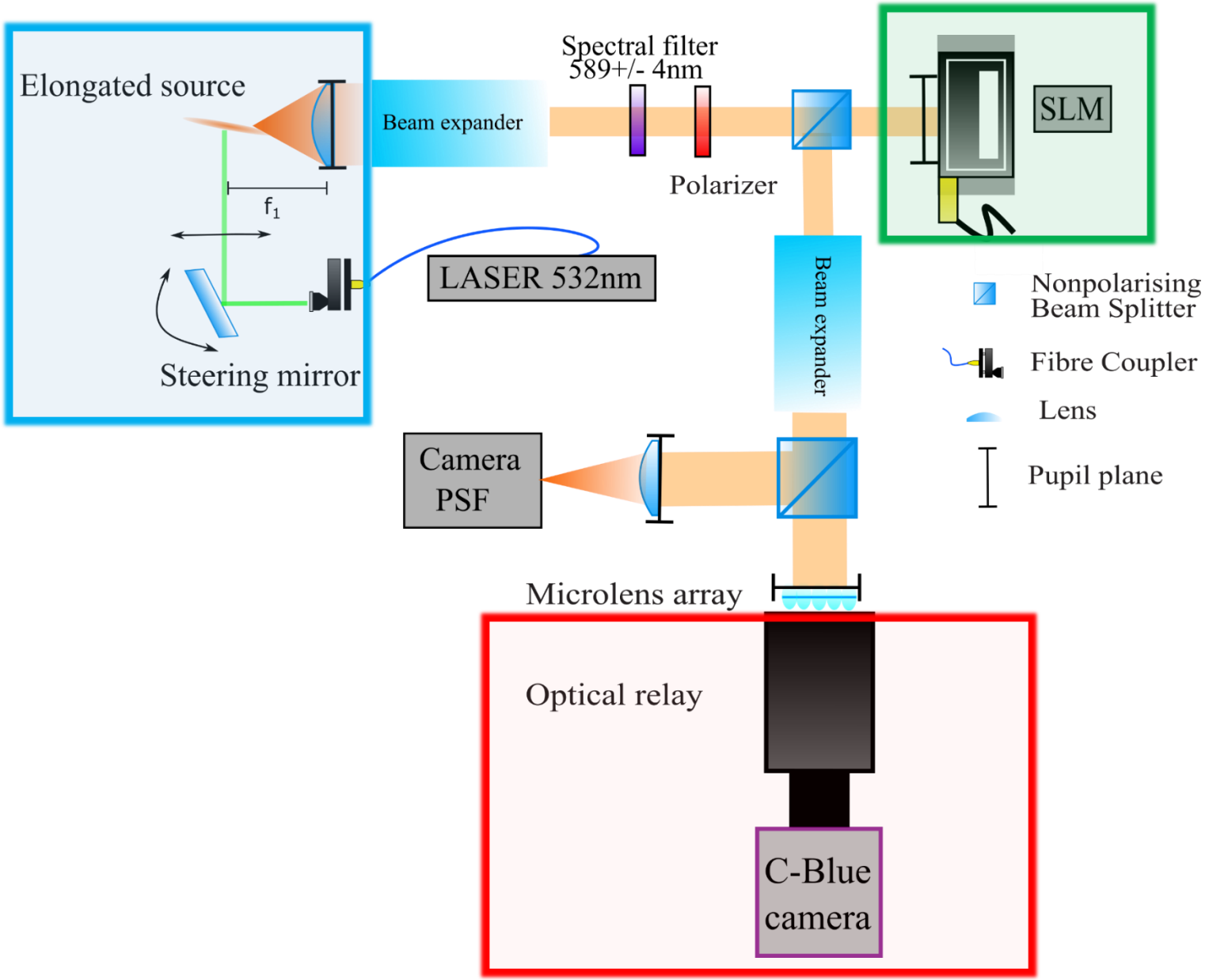
The microlenses array



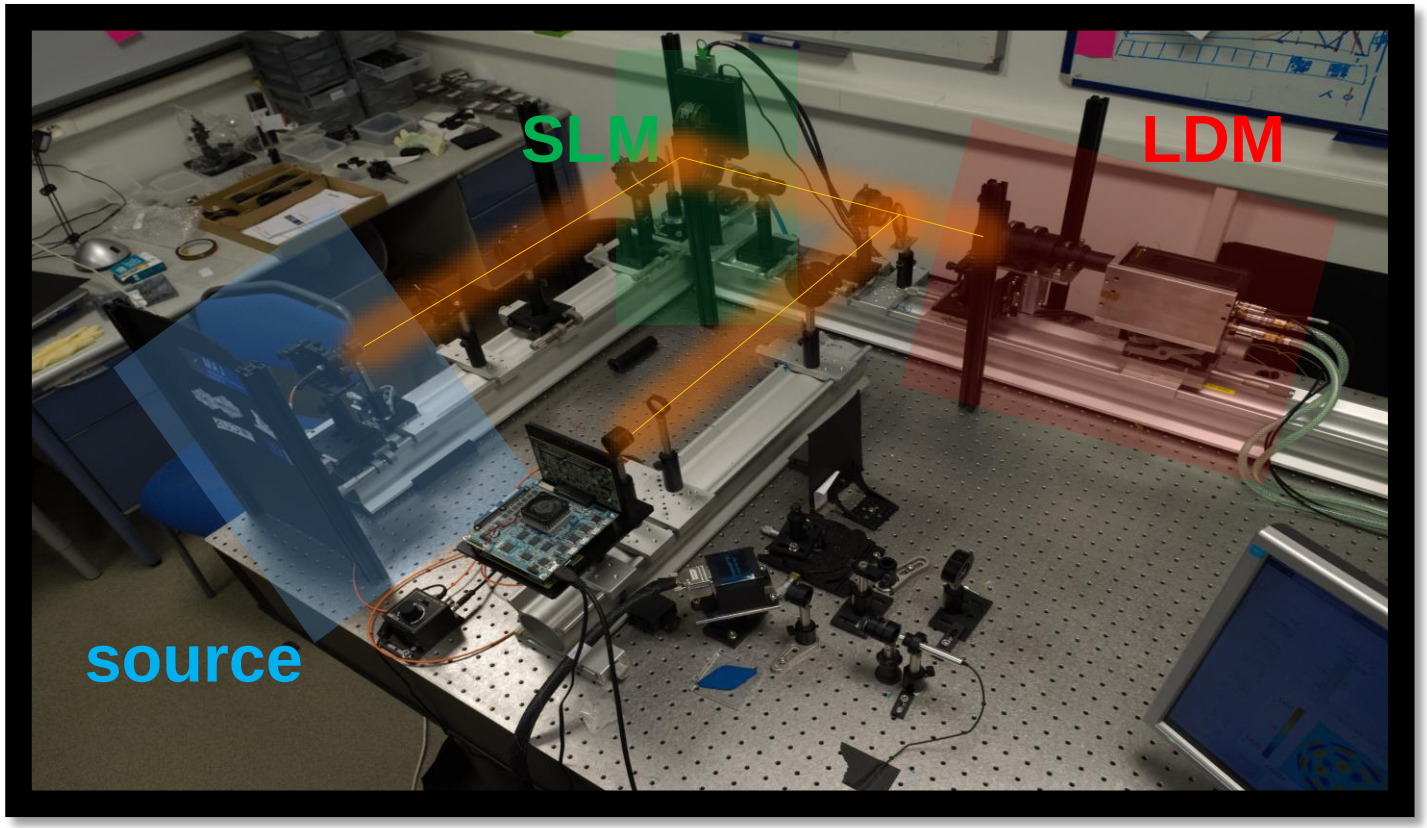
- Specification of the microlens array manufactured by AMUS :
- Main characteristics:
  - Lenslet pitch : 290µm
  - Lenslet focal distance : 2.5mm
  - Lenslet number: 80 (on circular aperture of 24.00mm diameter)
  - Number of « useful » lenslet : 80
  - Optimal pupil size on the lenslet array : 24.0mm
  - Lenslet F number : 8.645



Optical Bench

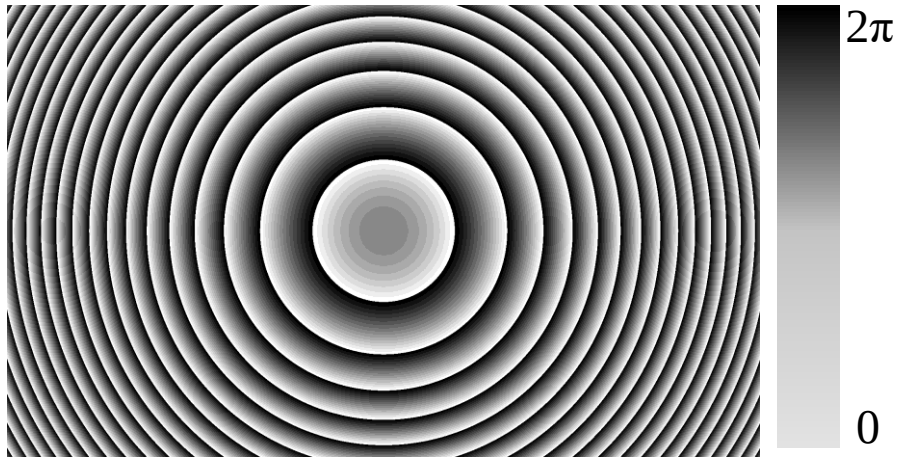


2nd step: we add phase aberation with a SLM



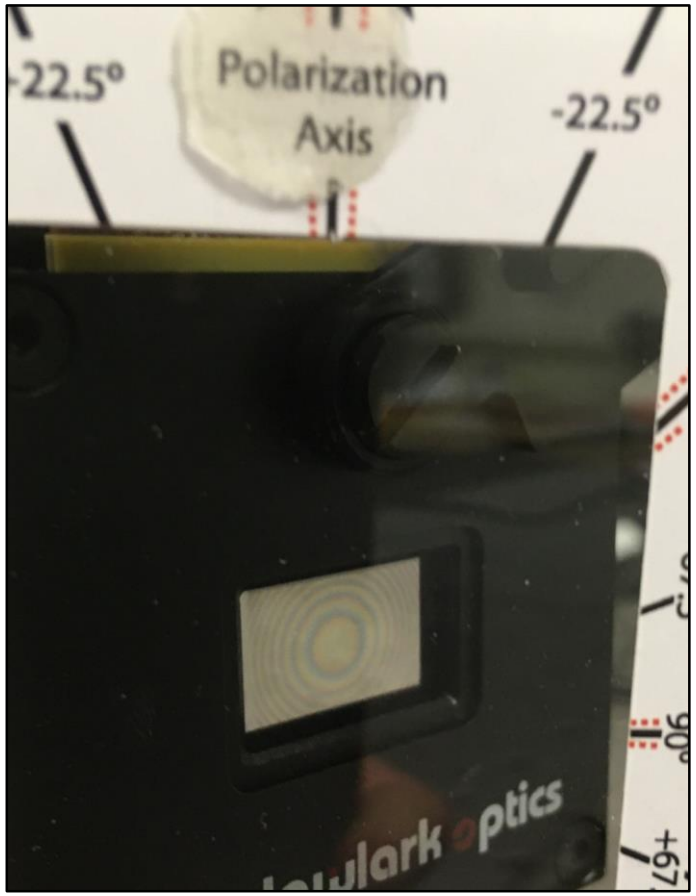
The SLM: Loading a Zernike phase map

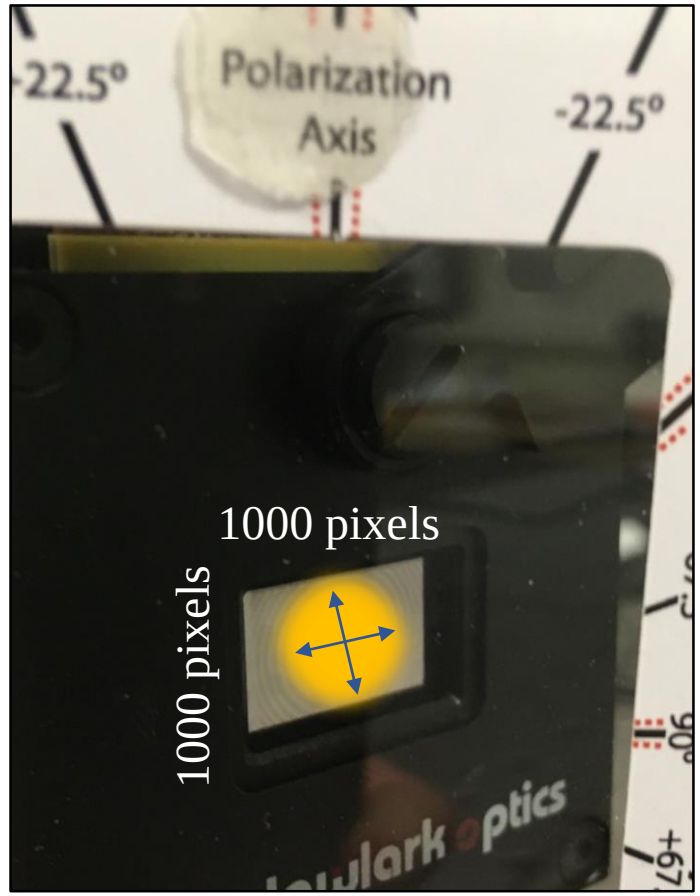
Phase map loaded into SLM Focus



Polarization axis of liquid crystals (aka *slow axis, extraordinary axis*) in this SLM is vertical

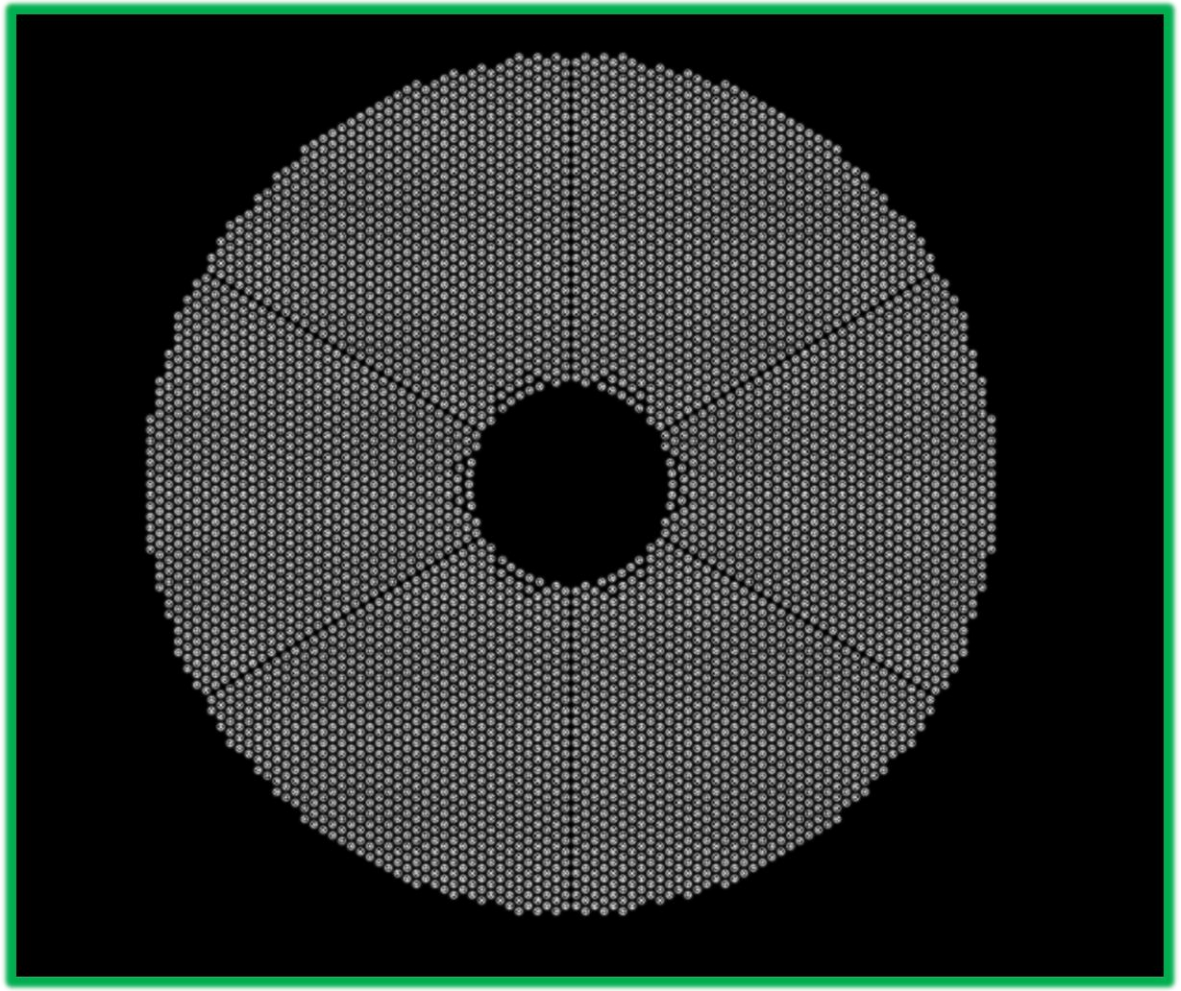
SLM seen through polarizer film





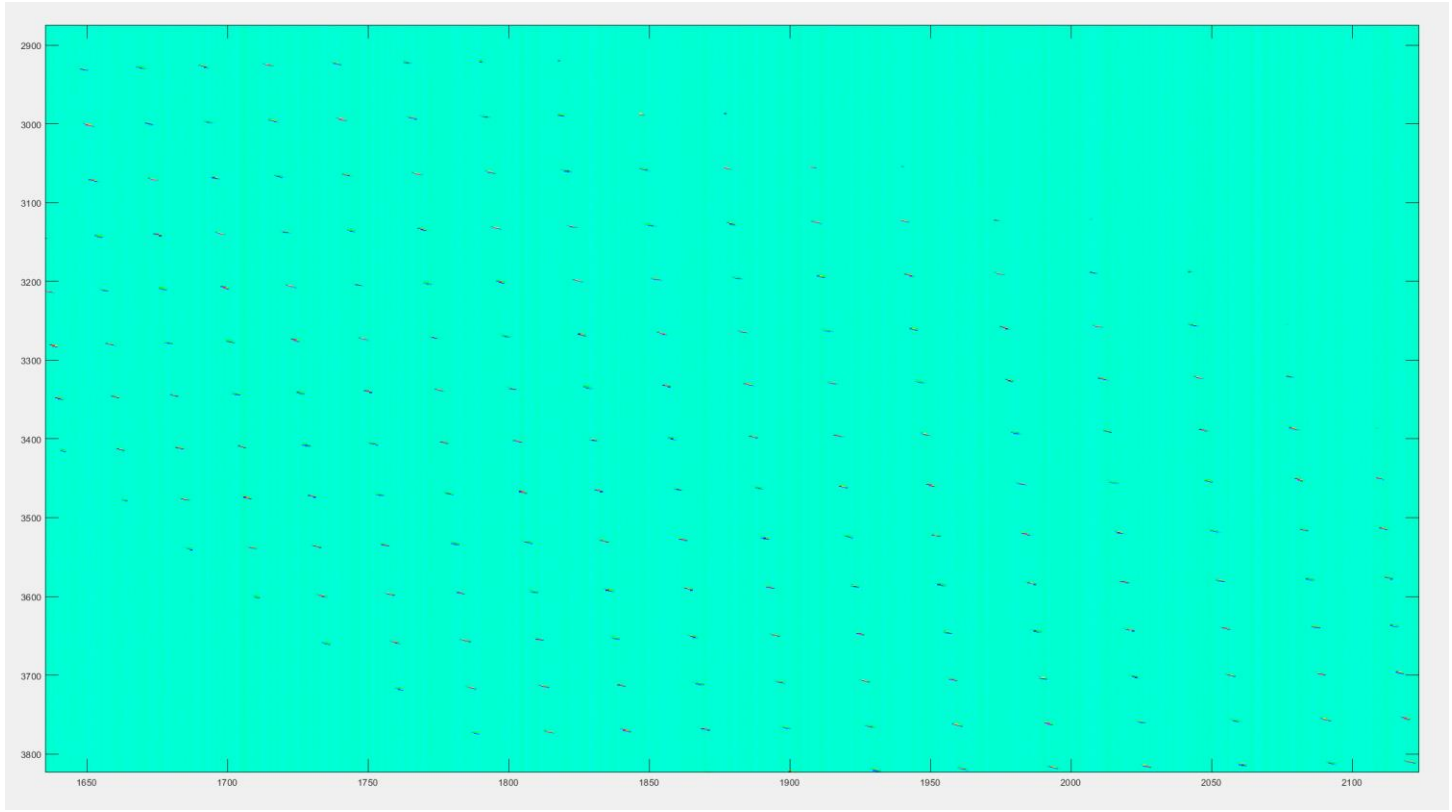
Vertical polarization

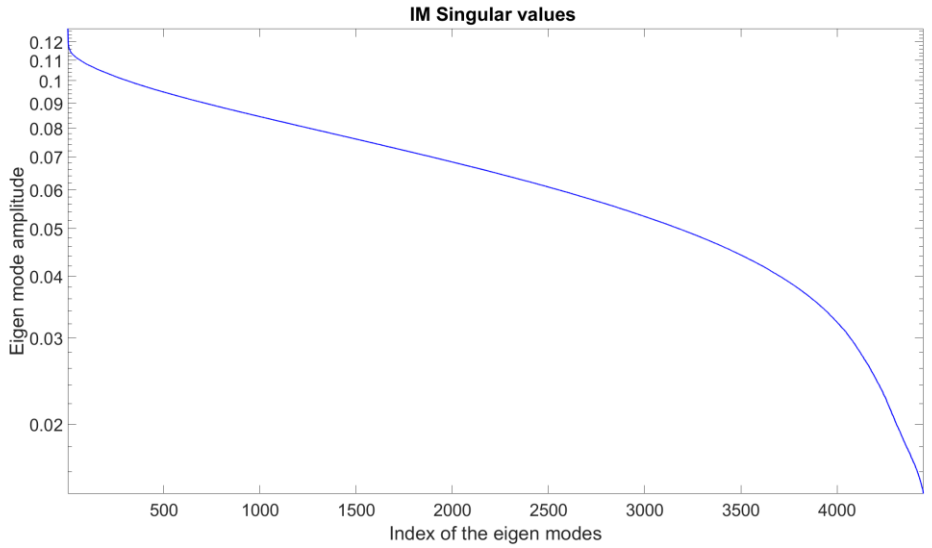
Interaction matrix and reconstruction



M4 influence fonctions projected on M1. We use that geometry to create interaction matrices. We also acquired IM in the Fried configuration, with gaussian as influence functions, with ESO influence functions. The SLM allows us to change the geometry or the influence function easily.

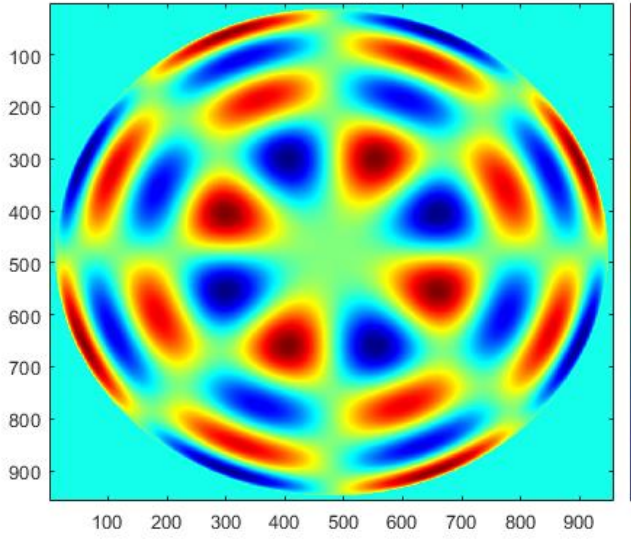
Experimental interaction matrix



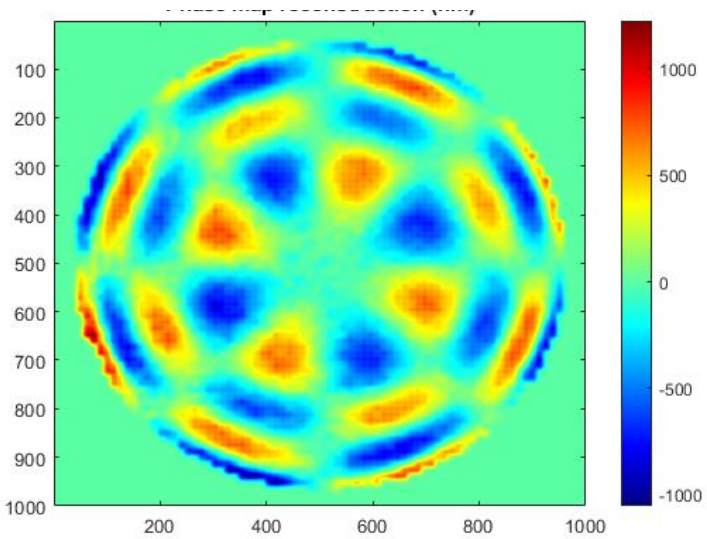


Experimental interaction matrix

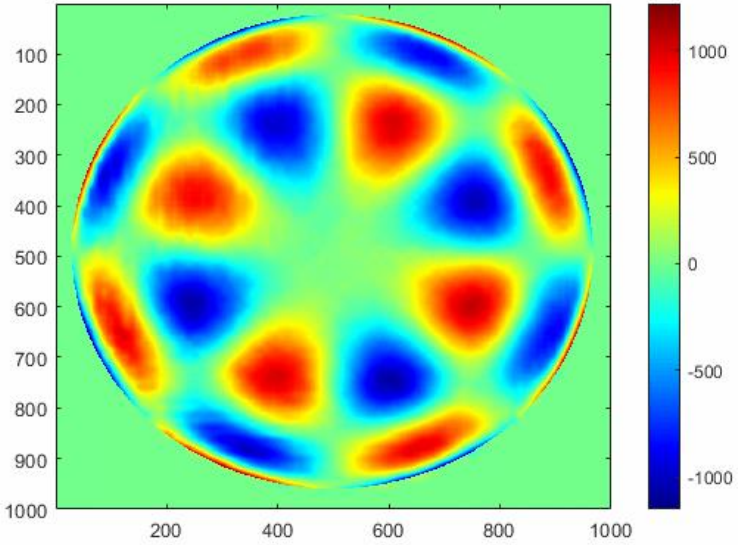
Phasemap printed on the SLM



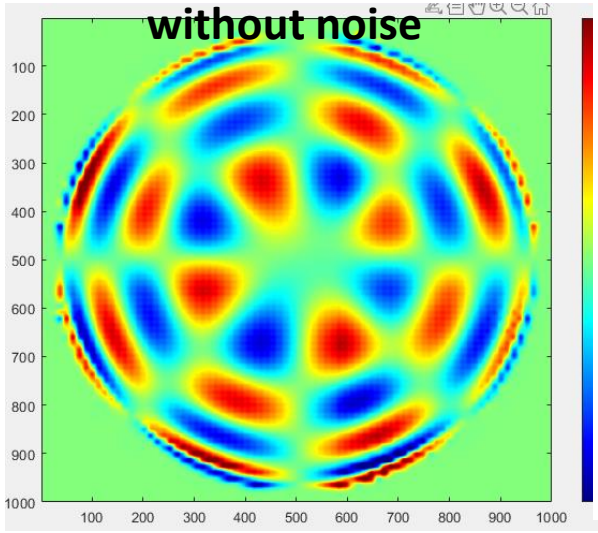
Experimental reconstruction



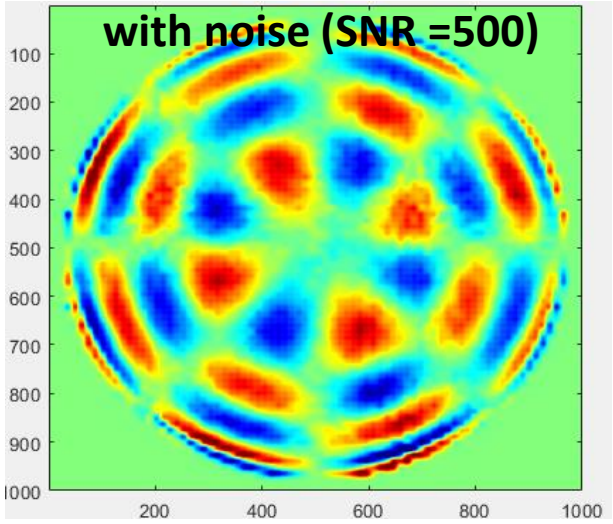
Closing loops experimentally

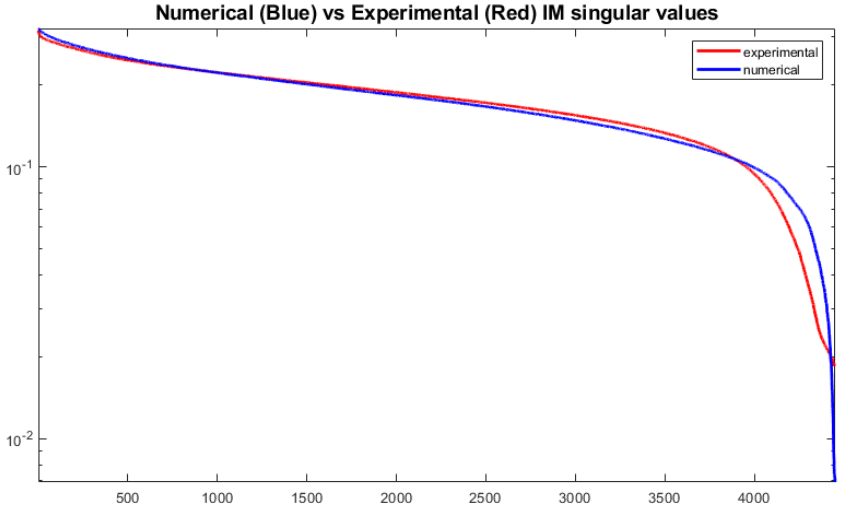


reconstruction simulation without noise



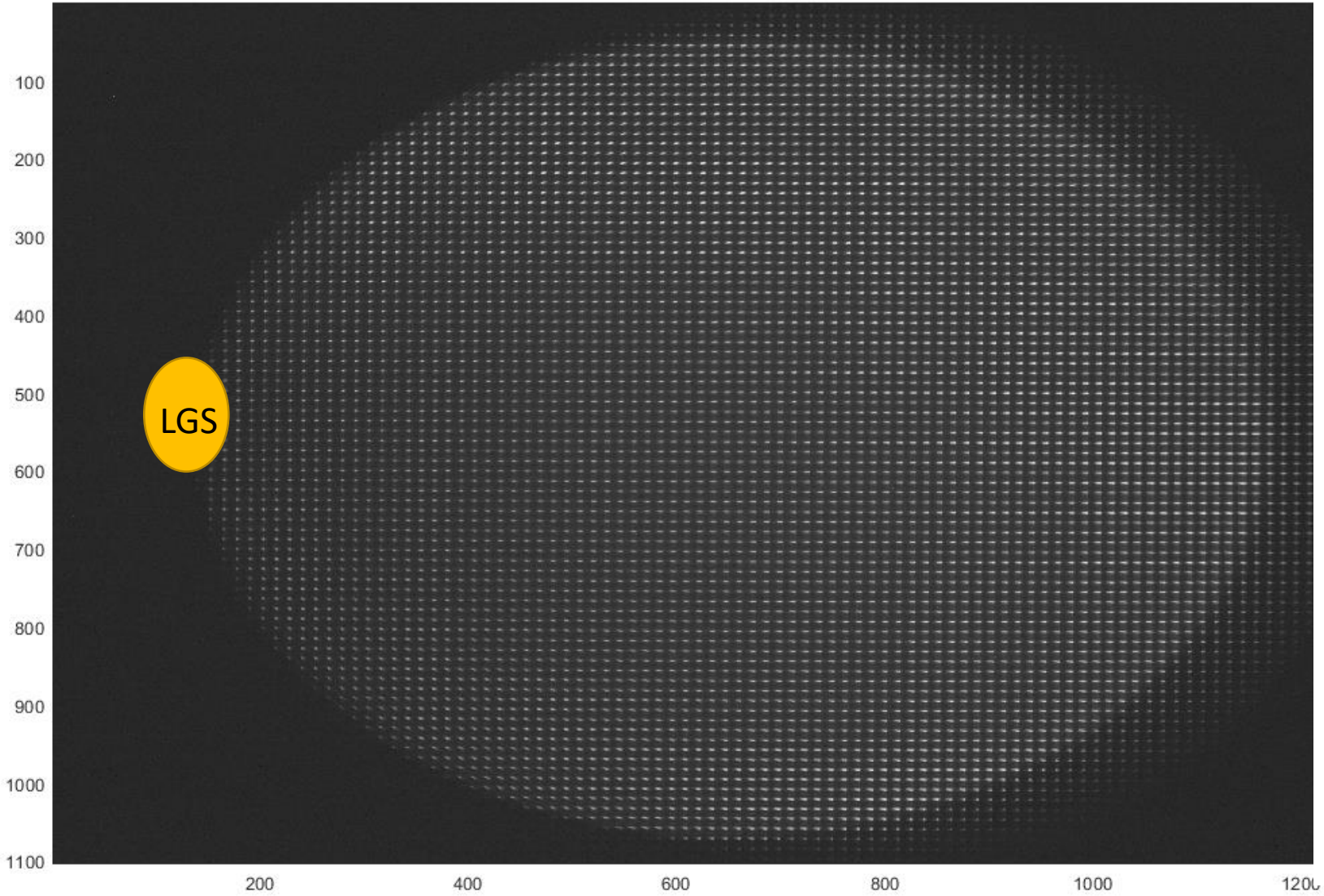
reconstruction simulation with noise (SNR =500)

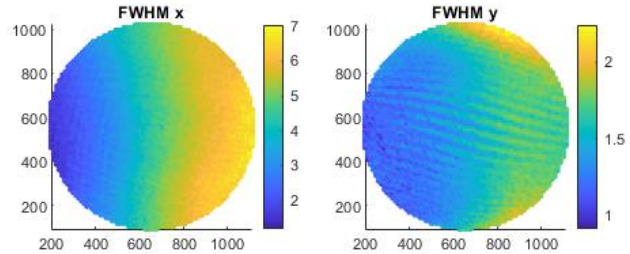


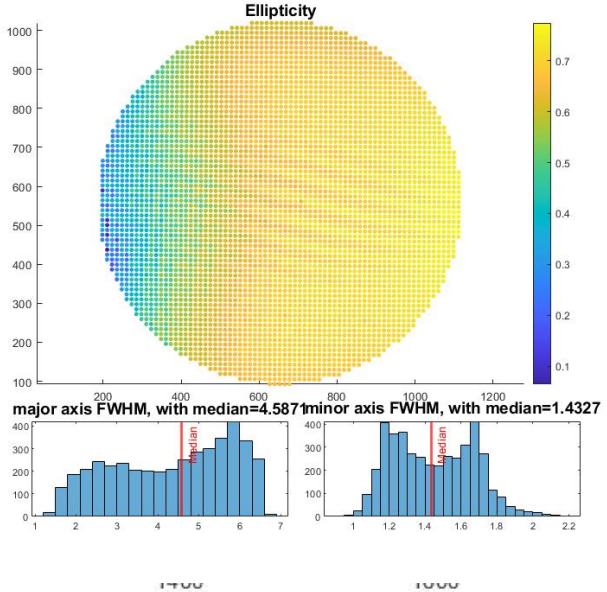


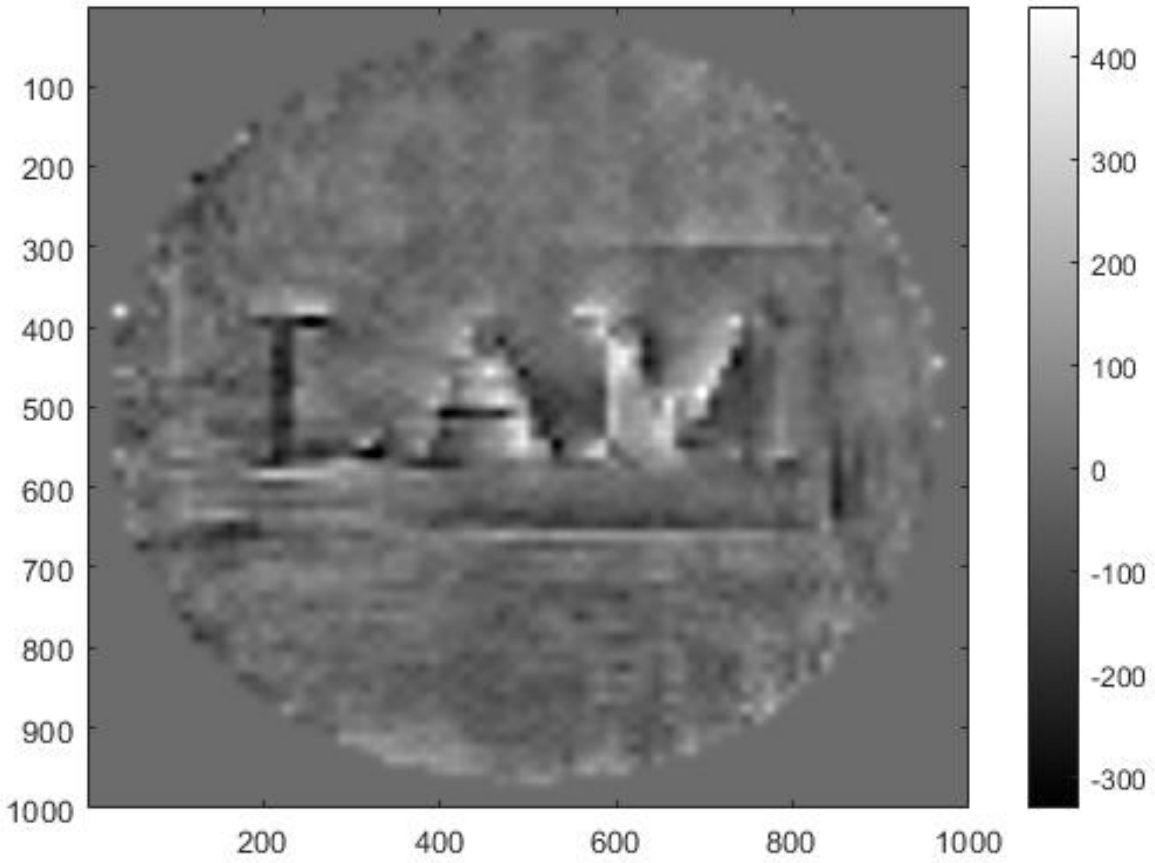
Next step: with elongated spot

Next step: with elongated spot








100
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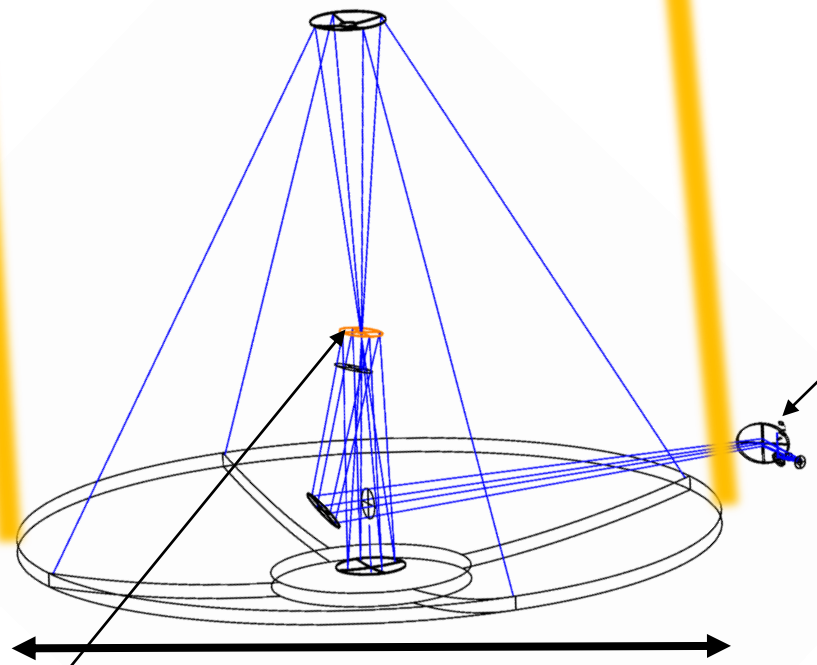
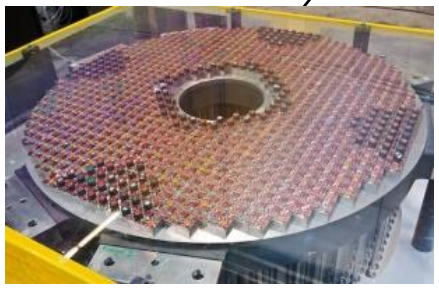
Merci

Overview

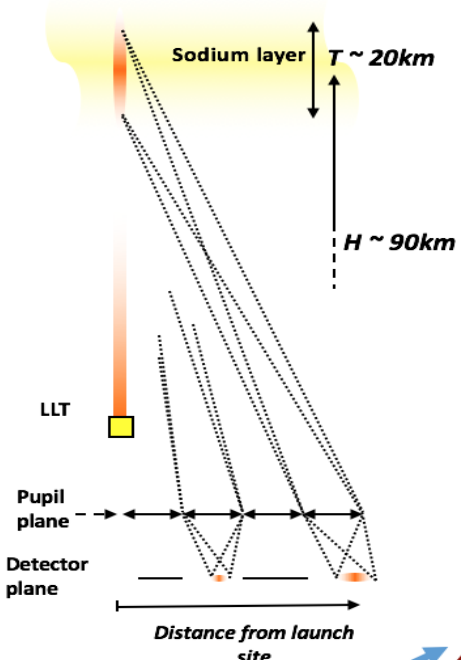


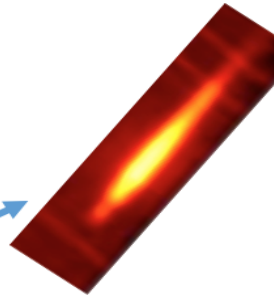
39m

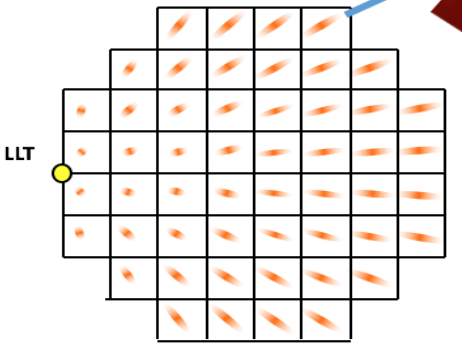
science instruments Harmoni



M4 deformable mirror (2,4m)







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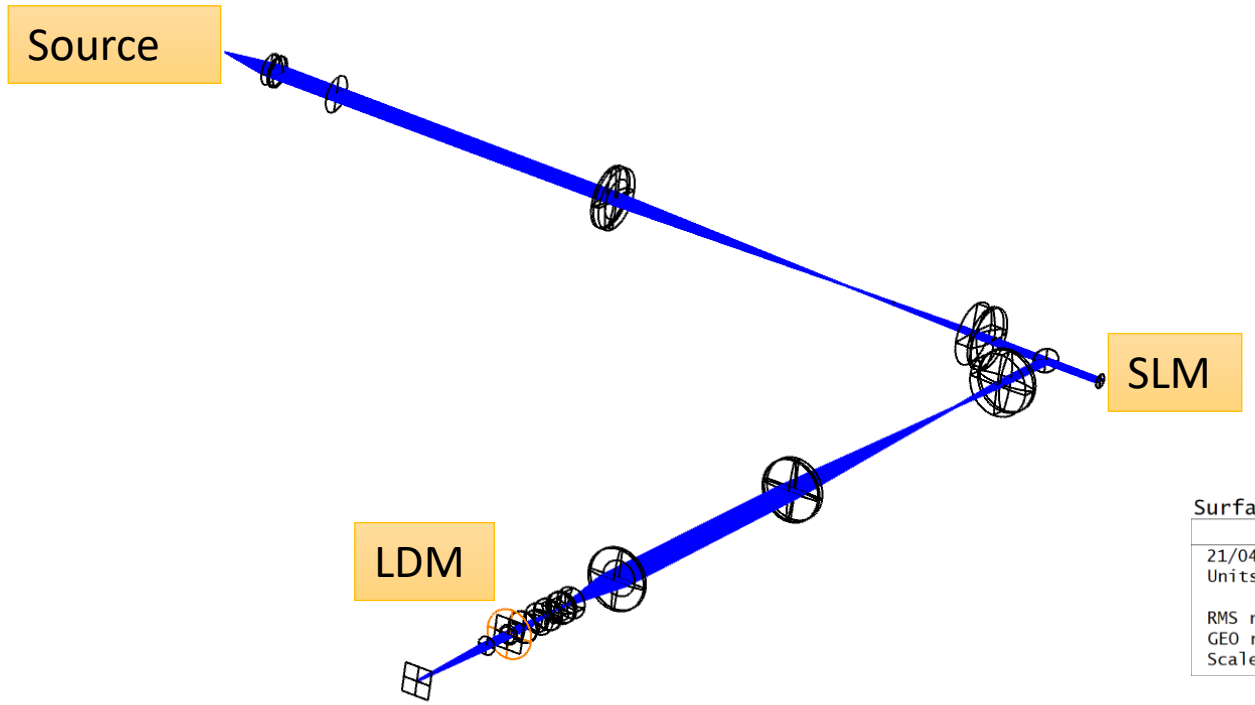
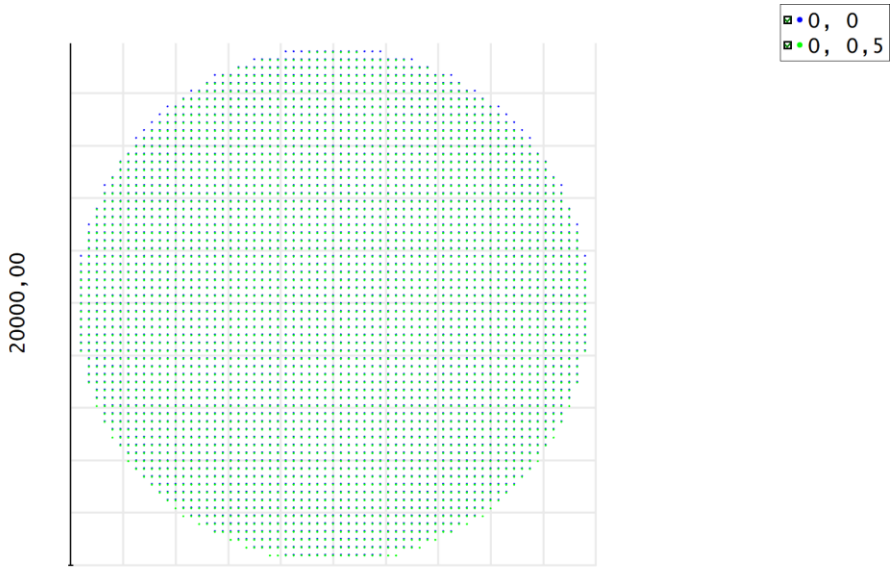
Optical Bench





Surface: IMA

Full Field Spot Diagram

21/04/2021 Units are µm. Legend items refer to Field positions RMS radius : 6904,90 GEO radius : 9936,25 Scale bar : 2e+04 Reference : Chief Ray	Zemax Zemax OpticStudio 21.1 LGS_Bench_design_2inches_real_lenses_and_relay.zmx Configuration 1 of 1

500 mm

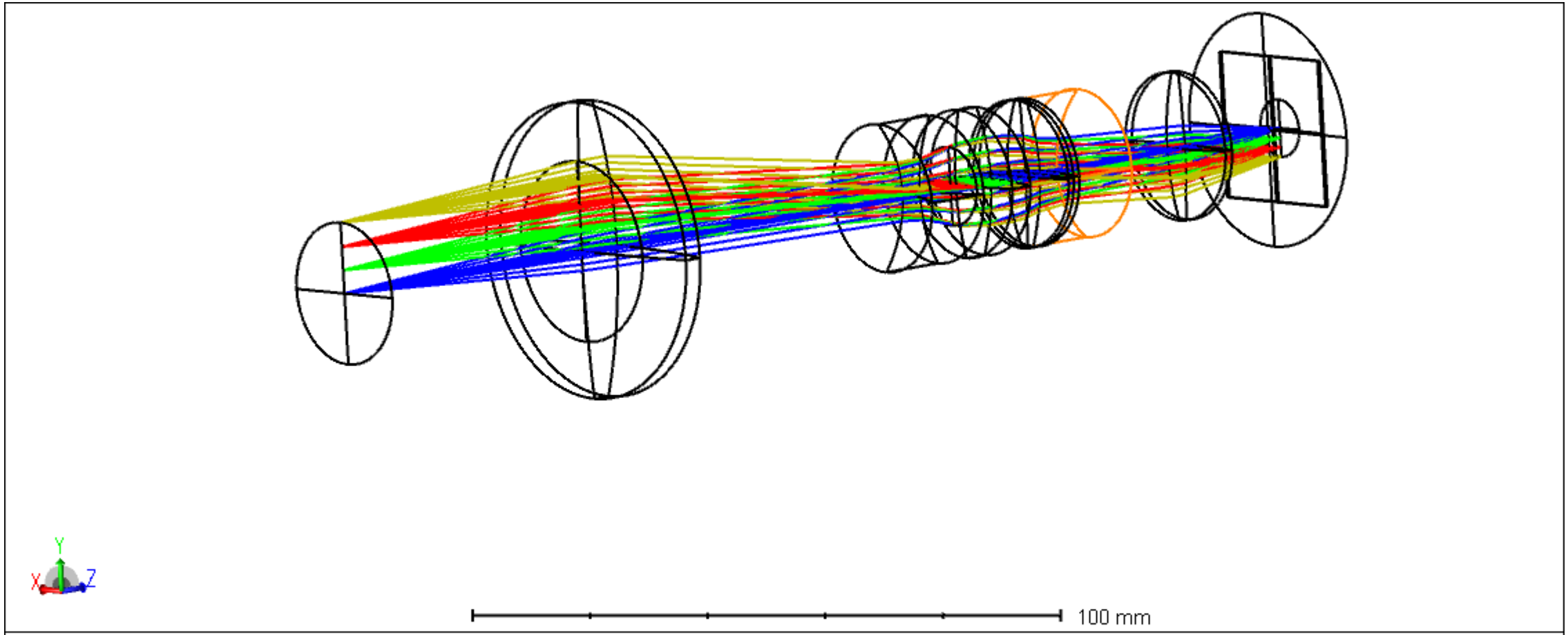
3D Layout

15/06/2022

Zemax
Zemax OpticStudio 21.1

LGS_Bench_design_2inches_real_lenses_and_relay.zmx
Configuration: All 1

The LDM (Laser guide star detector module)



3D Layout

07/06/2021

Zemax
Zemax OpticStudio 21.1

HARMONI LDM RELAY PROTO SONY 2,48+6T.zmx
Configuration 1 of 1