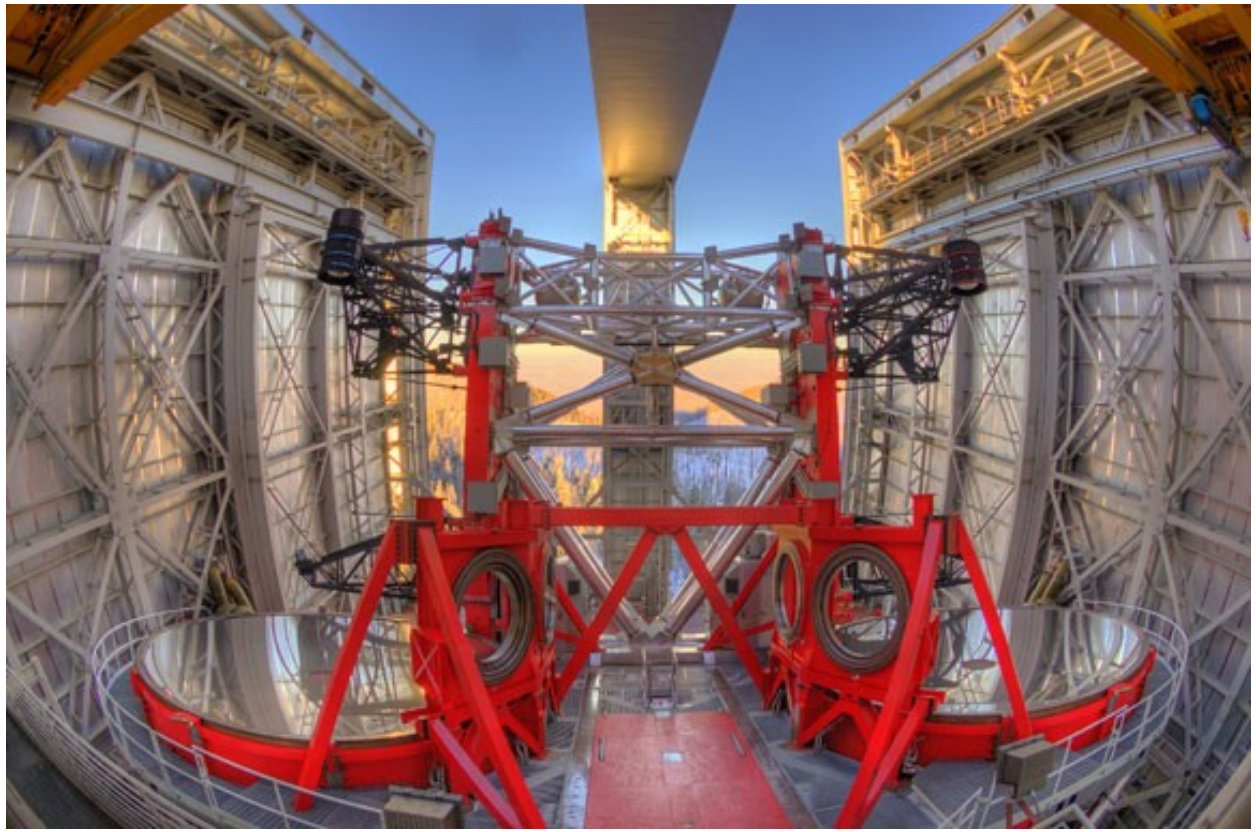
# SHARK-NIR, a status update

**Luca Marafatto** on behalf of SHARK-NIR team

**Wavefront sensing in the VLT/ELT era, 4th edition, June 18 2019**

# WHAT IS SHARK-NIR?

- Camera for high-contrast imaging and spectroscopy in the NIR, mainly dedicated to detection and characterization of exoplanets
- Observing modes:
  - Classical Imaging
  - Coronagraphic imaging
  - Long Slit spectroscopy
  - Dual Band Imaging



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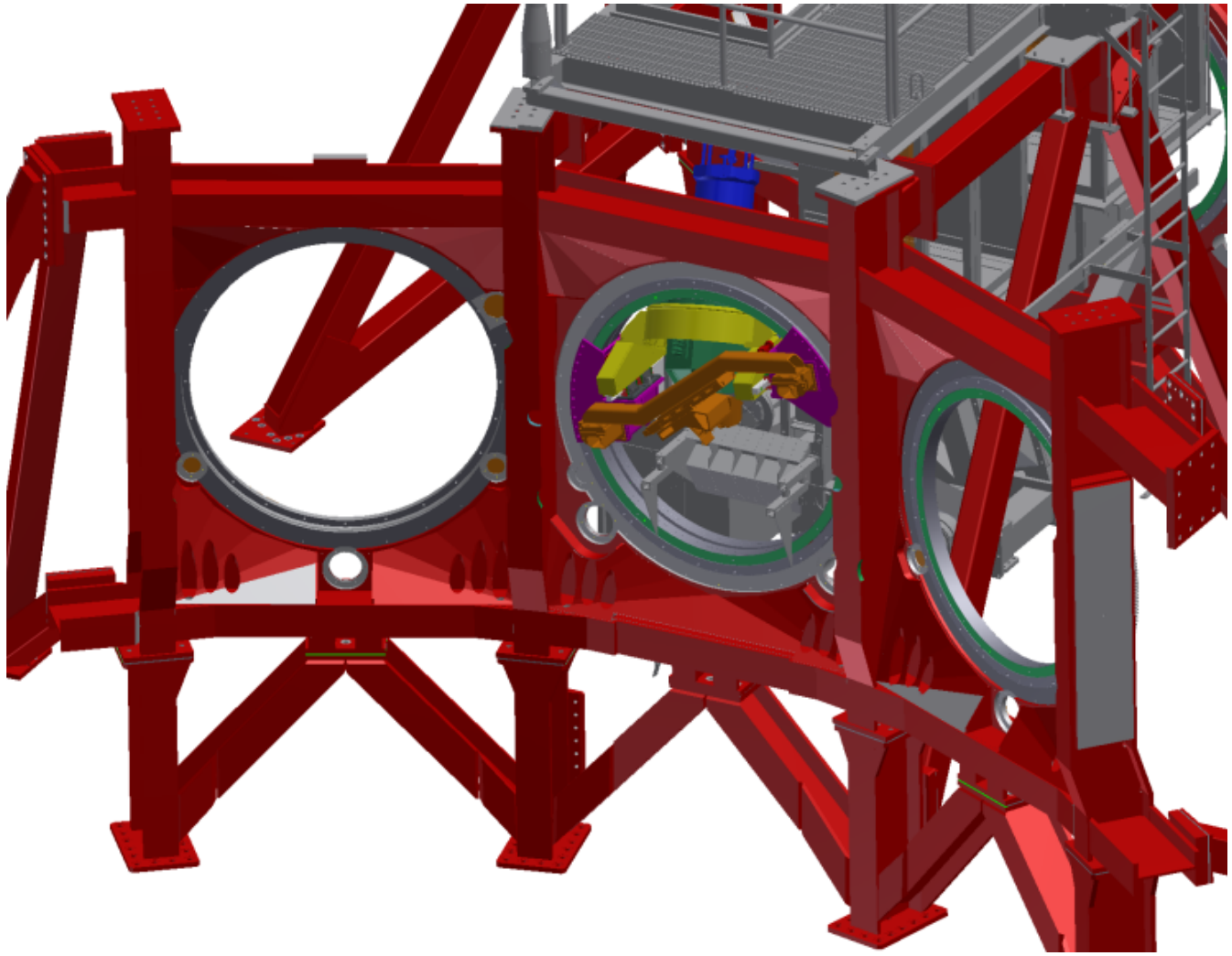

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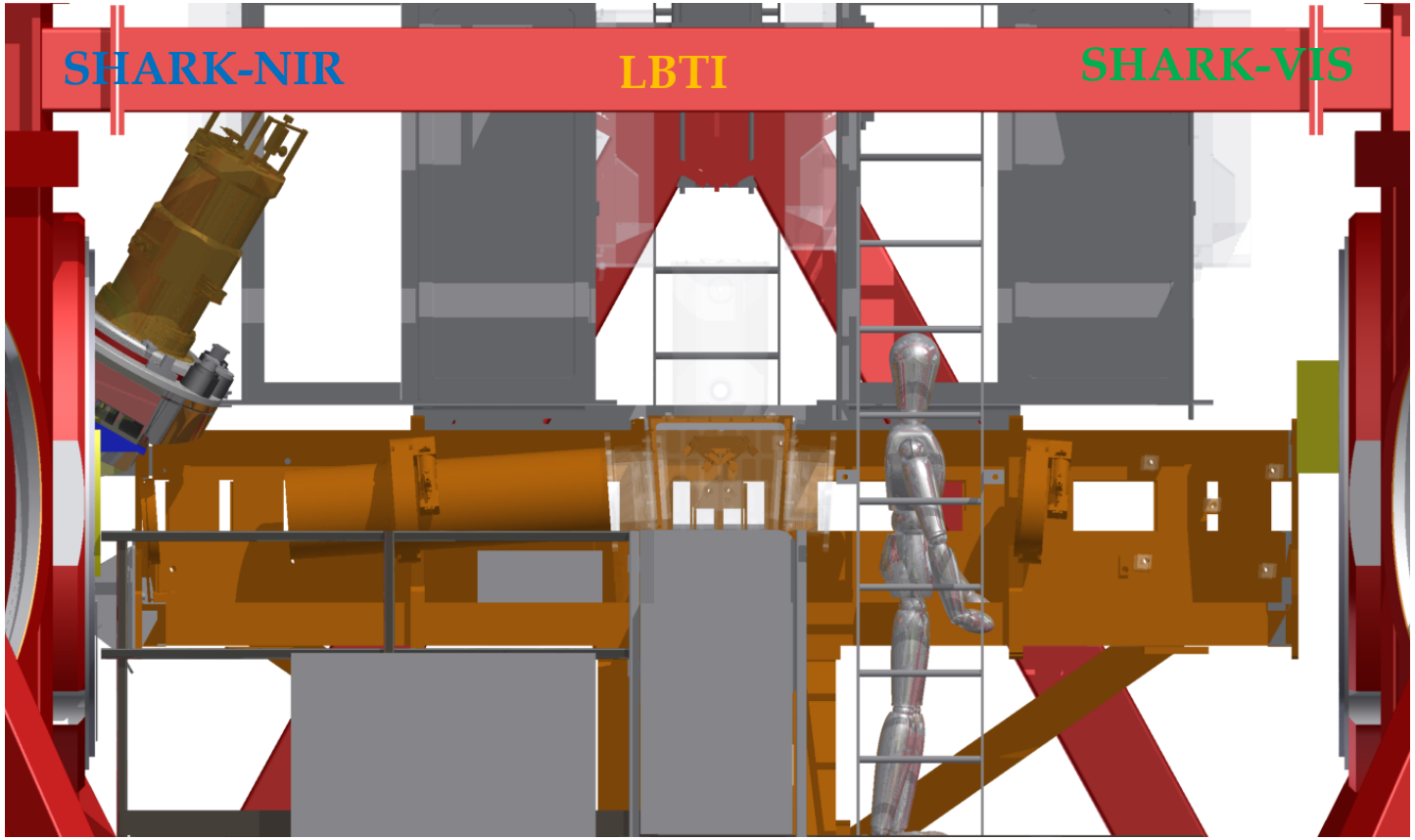
- Camera for high-contrast imaging and spectroscopy in the NIR, mainly dedicated to detection and characterization of exoplanets
- Observing modes:
  - Classical Imaging
  - Coronagraphic imaging
  - Long Slit spectroscopy
  - Dual Band Imaging
- Synergy with other LBT instruments

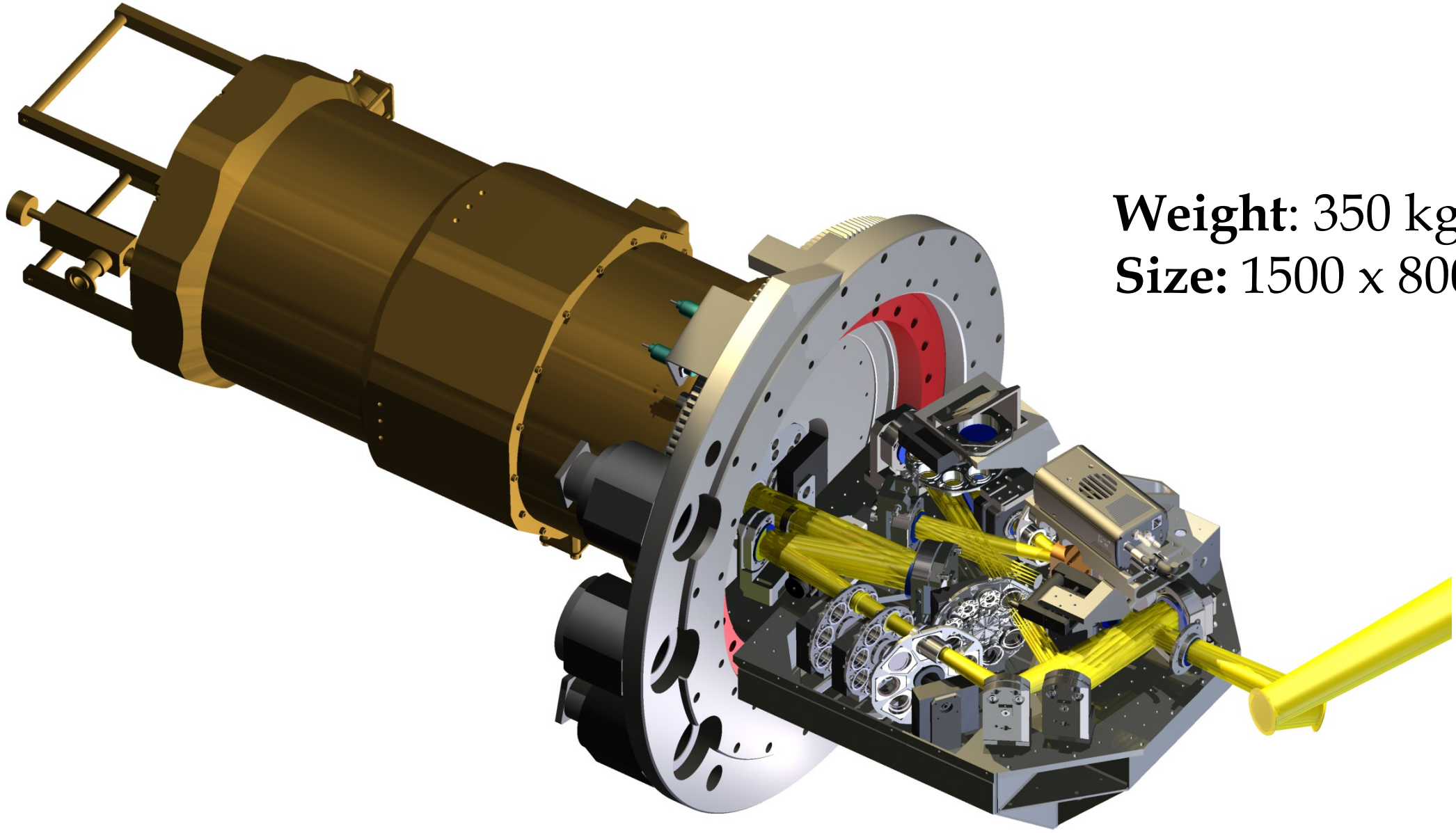
  (SHARK-VIS, LMIRCAM)



# INSTRUMENT SPECIFICATIONS

| SHARK-NIR main characteristics | |
|---|---|
| **Observing Modes** | Imaging/Coronagraphy/Spectroscopy/DBI |
| **Detector format [px]** | 2048x2048 (≈1220x1220 used area) |
| **Waveband [µm]** | 0.96 – 1.7 |
| **FoV ["]** | 18 x 18 |
| **FoV along the diagonal ["]** | 25.5 |
| **Plate scale [mas/px]** | 14.5 |
| **Airy Radius @ 0.96 micron [px]** | 2 |
| **Nominal Strehl at <18'' FoV diameter (in all Bands)** | >98% |

# OPTO-MECHANICAL LAYOUT



**Weight**: 350 kg
**Size:** 1500 x 800 x 800 mm

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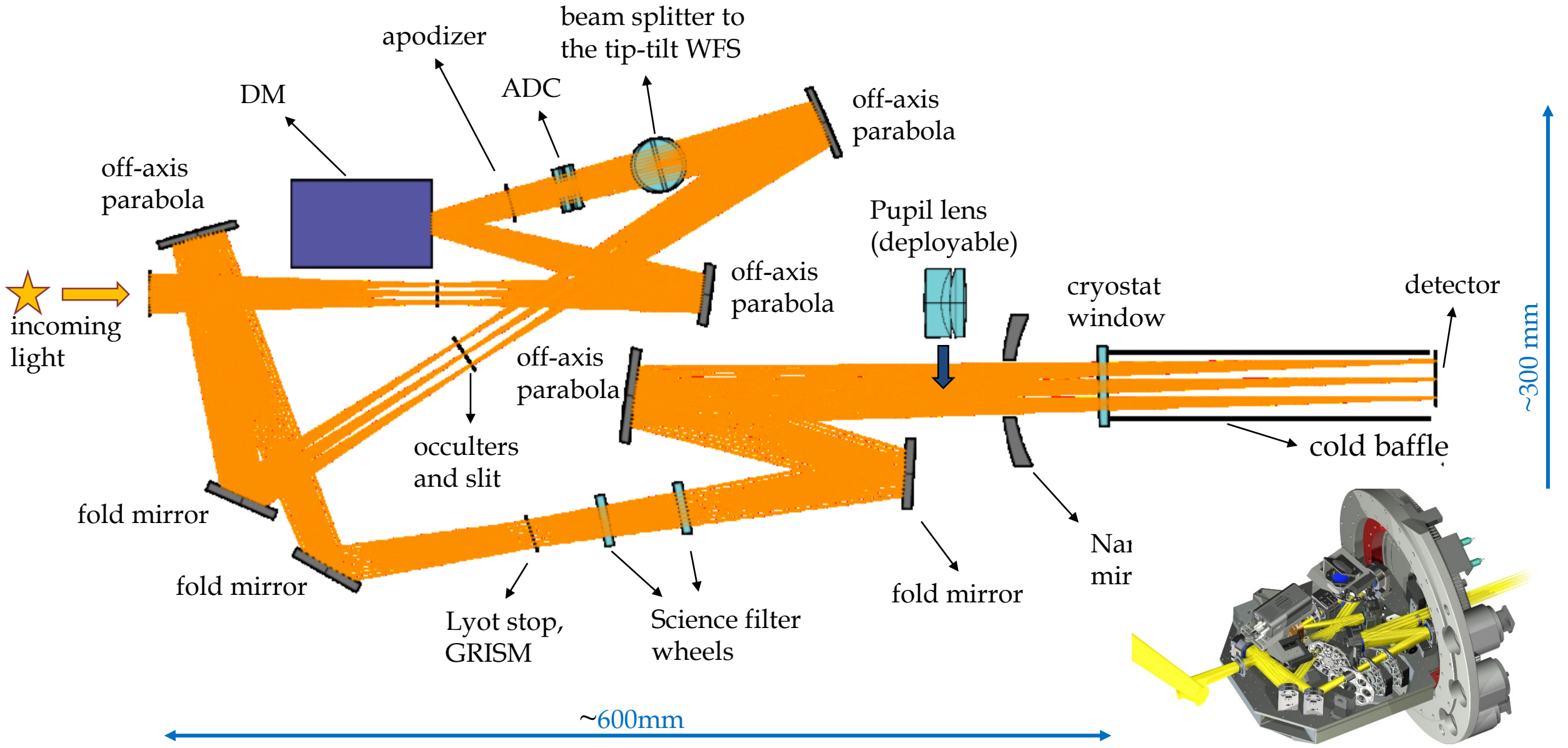

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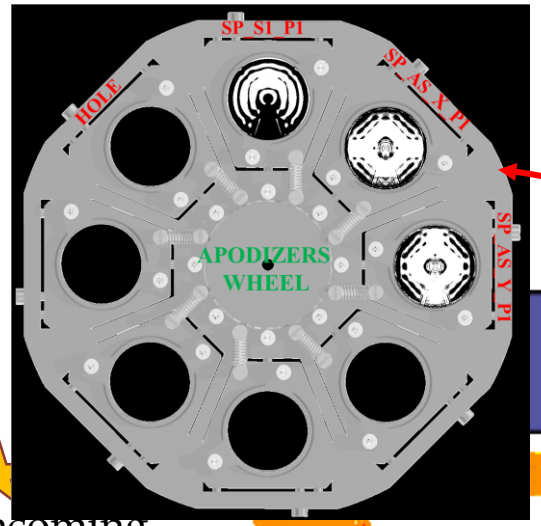



apodizer

beam splitter to the tip-tilt WFS

ADC

off-axis parabola

**Coronagraphic planes**

Pupil lens (deployable)

off-axis parabola

cryostat window

detector

incoming light

off-axis parabola

occulters and slit

cold baffle

fold mirror

fold mirror

Lyot stop, GRISM

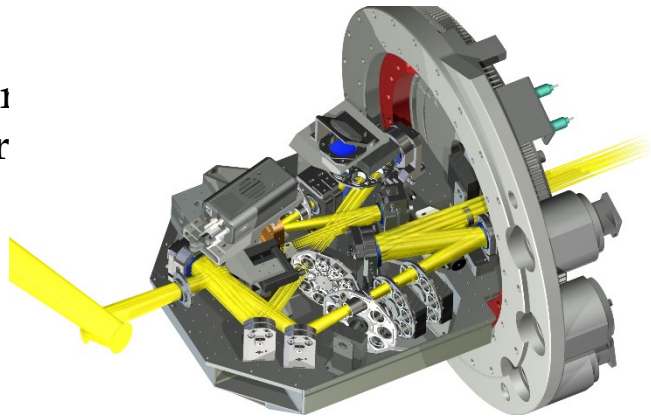
Science filter wheels

fold mirror

Nai mir

~300 mm

~600mm



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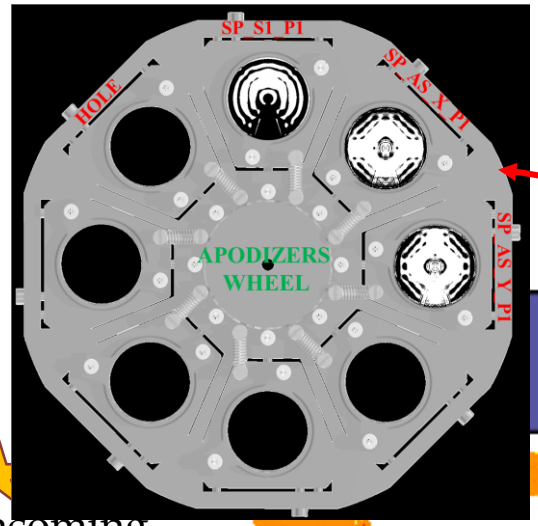


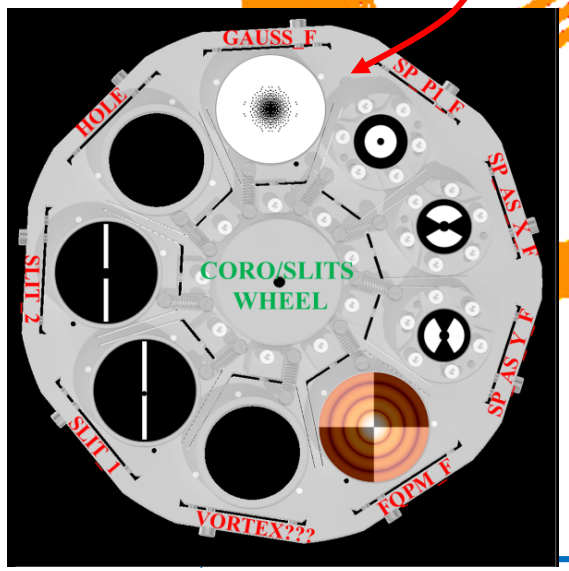


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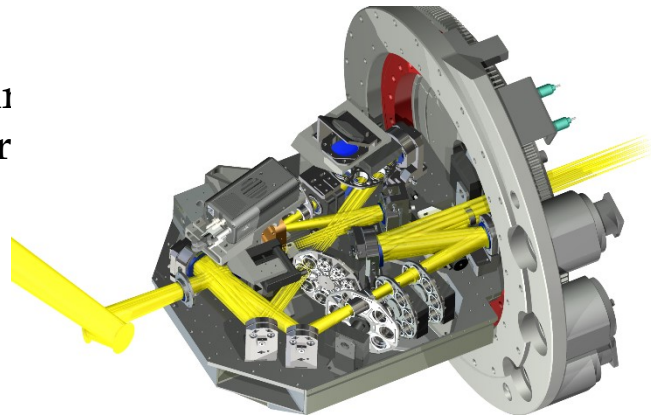

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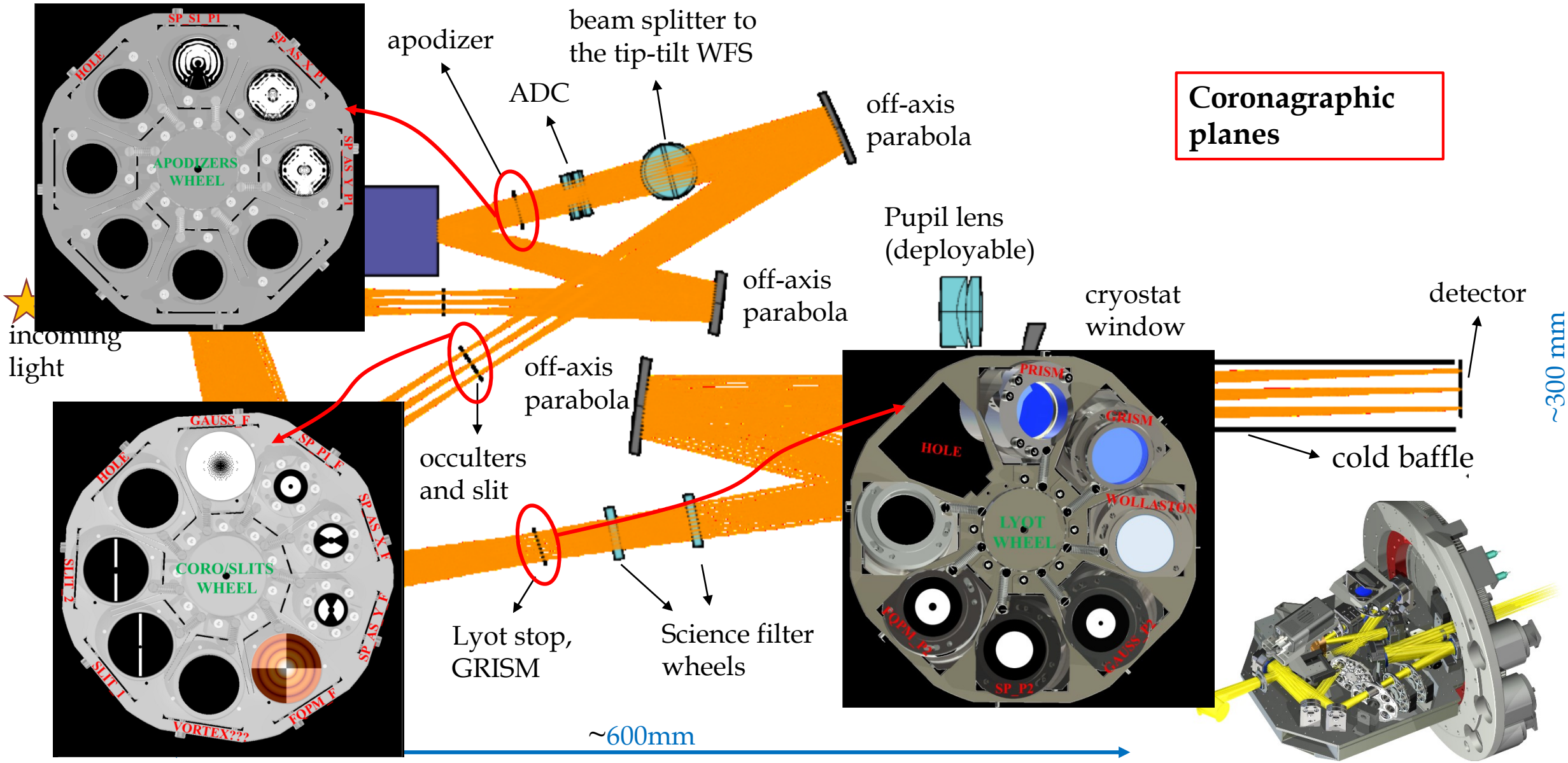
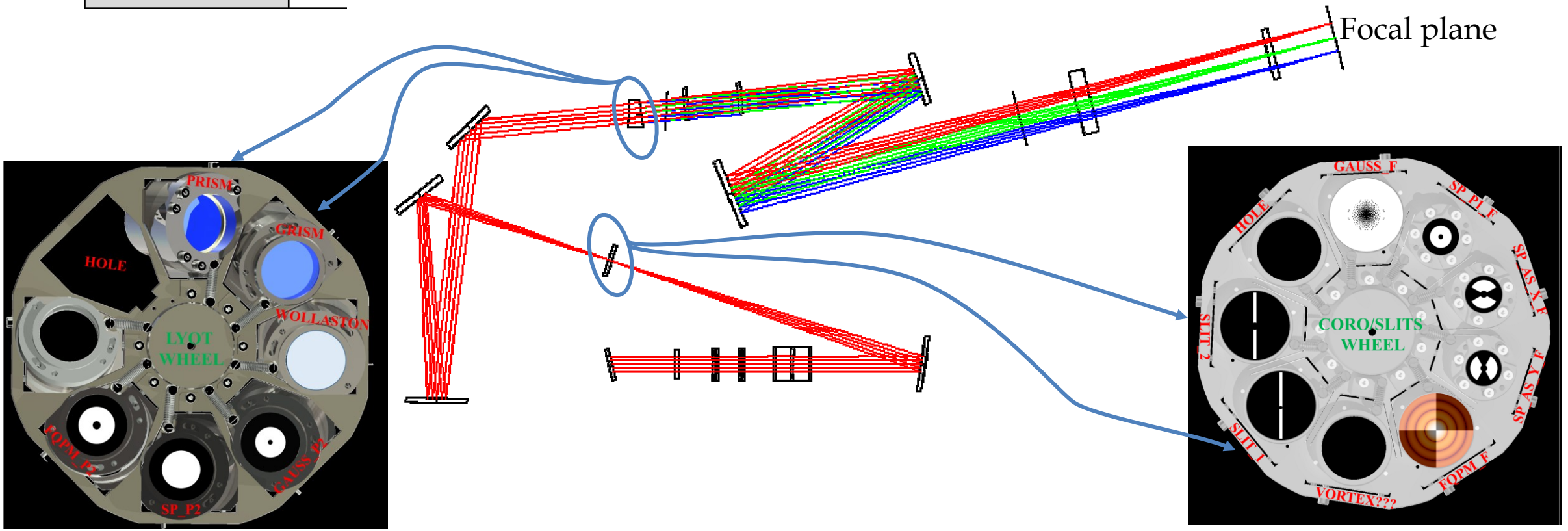


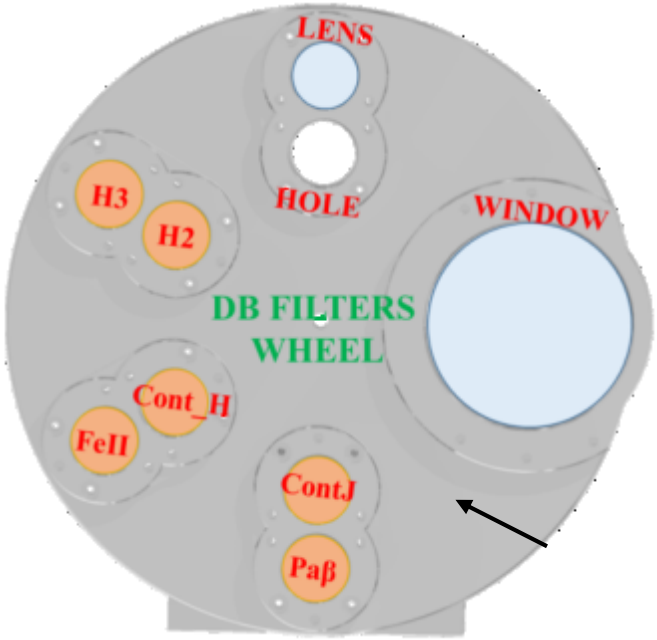
# SPECTROSCOPIC MODE

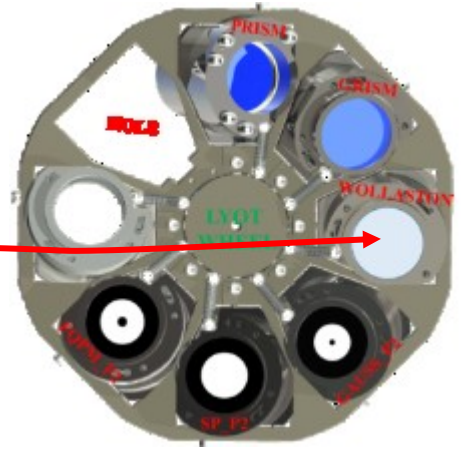
| DISPERSIVE ELEMENTS | | |
|---|---|---|
| | Low Res | Medium Res |
| **Dispersing element** | Prism | Grism |
| **R** | 100 | 700 |

| CORO SLITS WITH OCCULTER | | |
|---|---|---|
| | Slit width | Occulter size |
| **Coro slit 1** | 100 mas | 100 mas |
| **Coro slit 2** | 100 mas | 200 mas |



# DUAL BAND IMAGING MODE







| DUAL BAND FILTERS | | | | |
|---|---|---|---|---|
| **Name** | $\lambda_1$ [nm] | $\Delta\lambda_1$ [nm] | $\lambda_2$ [nm] | $\Delta\lambda_2$ [nm] |
| **HOLE (no DBI)** | - | - | - | - |
| **H2-H3** | 1588.8 | 53.1 | 1667.1 | 55.6 |
| **ContJ-Pa β** | 1215.7 | 18.3 | 1281.3 | 20.9 |
| **ContH-Fe II** | 1557.8 | 24.1 | 1645.5 | 26.1 |
| **Phase diversity** | Window | | Defocusing lens | |

# THE HIGH-CONTRAST IMAGING FORMULA

**How do we obtain high contrast in the vicinity of such bright stars?**

| | | | |
|---|---|---|---|
| XAO correction | + | → | *External: SOUL (talk by Agapito)* |
| Optimized wavefront control strategy | + | → | *Internal (talk by Biondi)* |
| Coronagraph(s) | + | → | *Internal: Shaped Pupils, Gaussian, 4QPM* |
| Post-processing pipeline | = | | |
| High contrast | | | |

# WAVEFRONT CONTROL

A deformable mirror to correct for instrumental aberrations and to stabilize the PSF

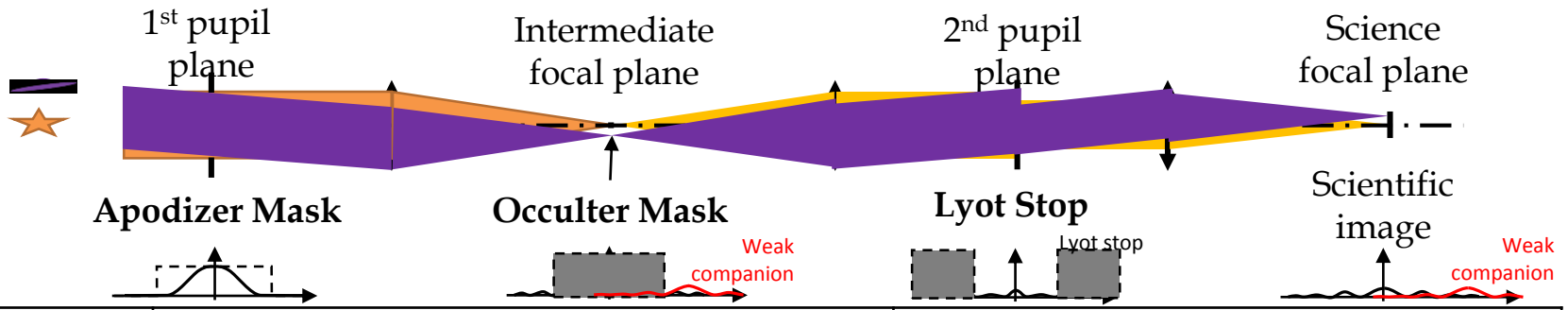
## WFS Camera

- InGaAs camera (C-RED2)
- Sensitive in the full SHARK-NIR waveband (**0.96-1.7 µm**)
- Frame-rate up to **14 kHz** (with 32X32 px window)
- Low RON (<30 $e^-$ )
- **3-5 mas** precision up **@ 1KHz**

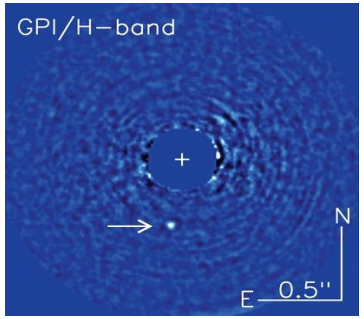

## Deformable Mirror

- ALPAO DM 97-15
- **97 actuators**, 13.5 mm pupil, up to **2 kHz** speed
- NCPA can be corrected internally without affecting pyramid's performance
- NCPA measured with phase versity on science image

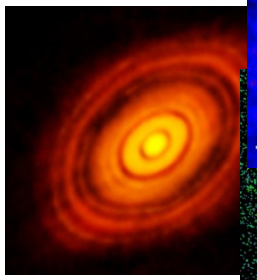

# CORONAGRAPHS

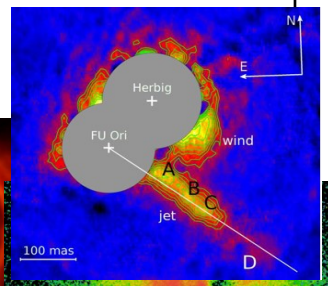


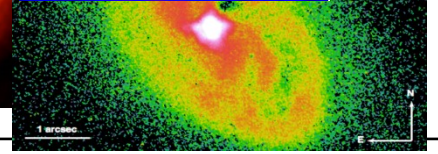

Exoplanets




Disks/Jets/ AGN

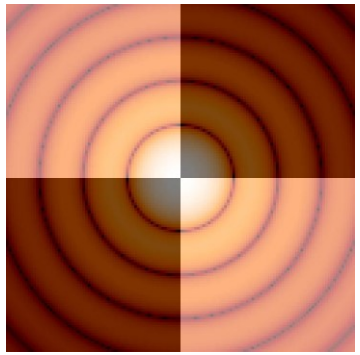




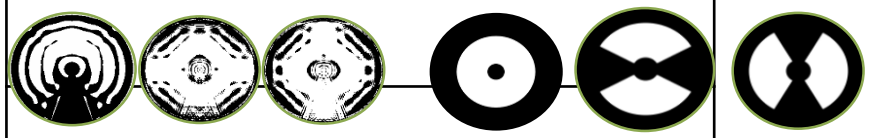

## FQPM

- Working in H-band
- Access to the whole 18 x 18'' FoV
- Very small IWA (~50 mas)
- High throughput
- Very sensitive to low-order aberrations



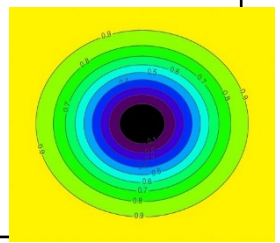
## SHAPED PUPIL

- Working in H-band
- Small field (100-300 mas)
- High contrast near to the star
- Robust to low-order aberrations



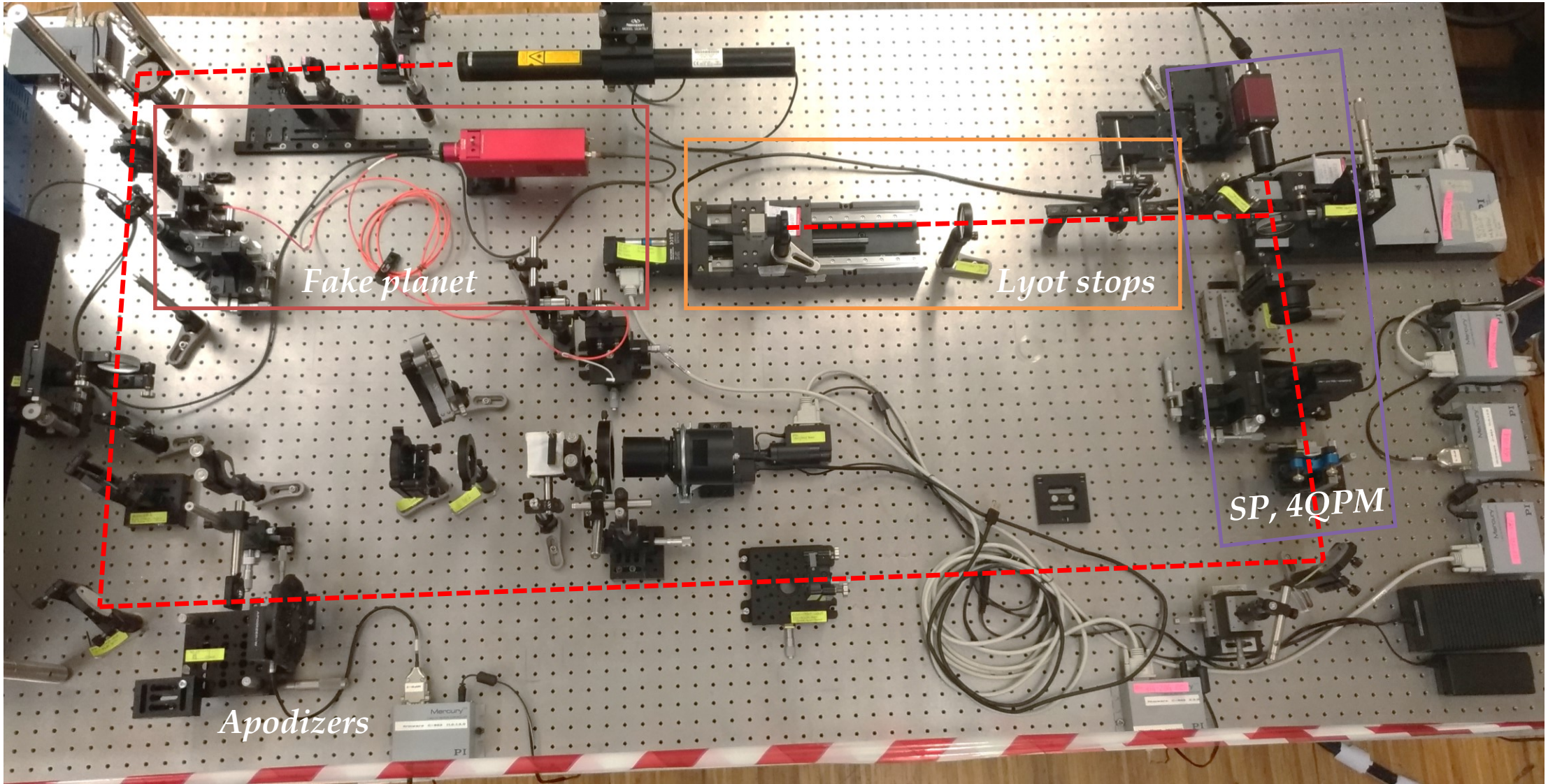
## GAUSSIAN LYOT

- Optimized for both J and H band observations
- Moderate contrast
- Access to the whole FoV



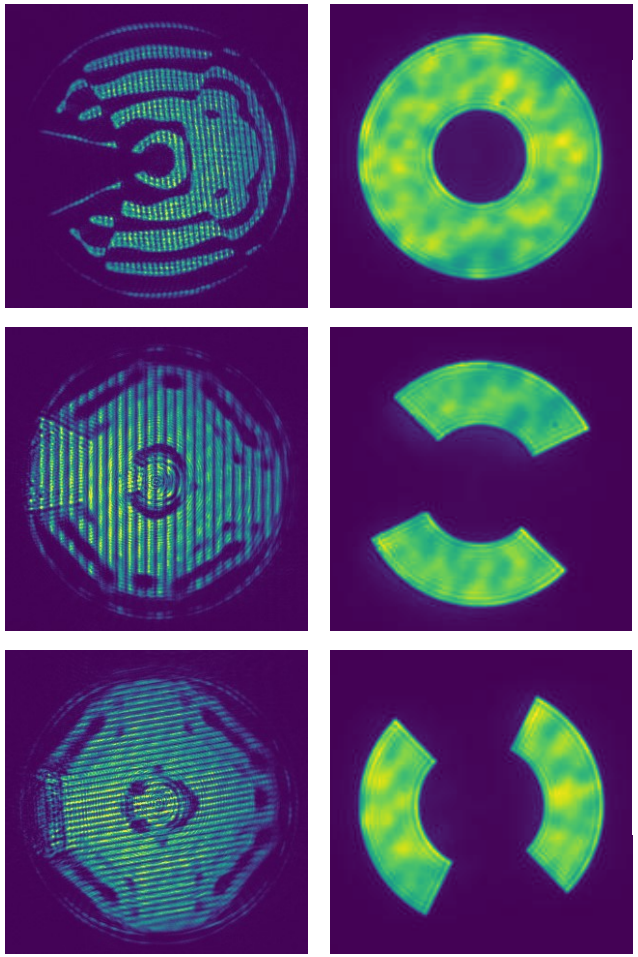
# CORONAGRAPHS - ON-GOING ACTIVITIES

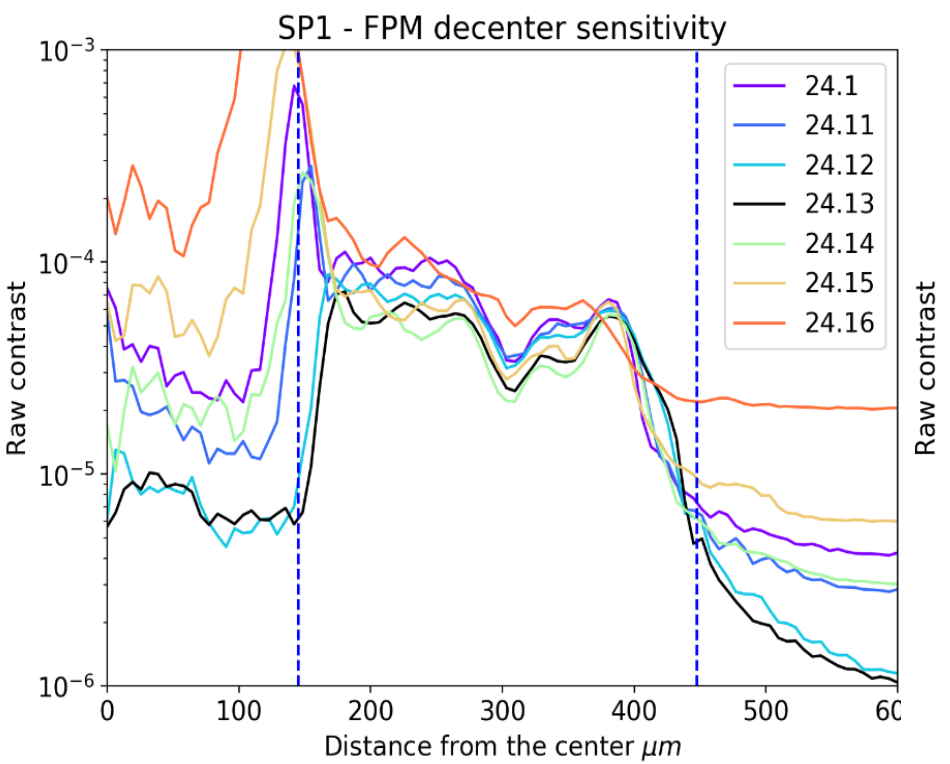
Coronagraphic masks characterization, performance analisys, alignment procedure

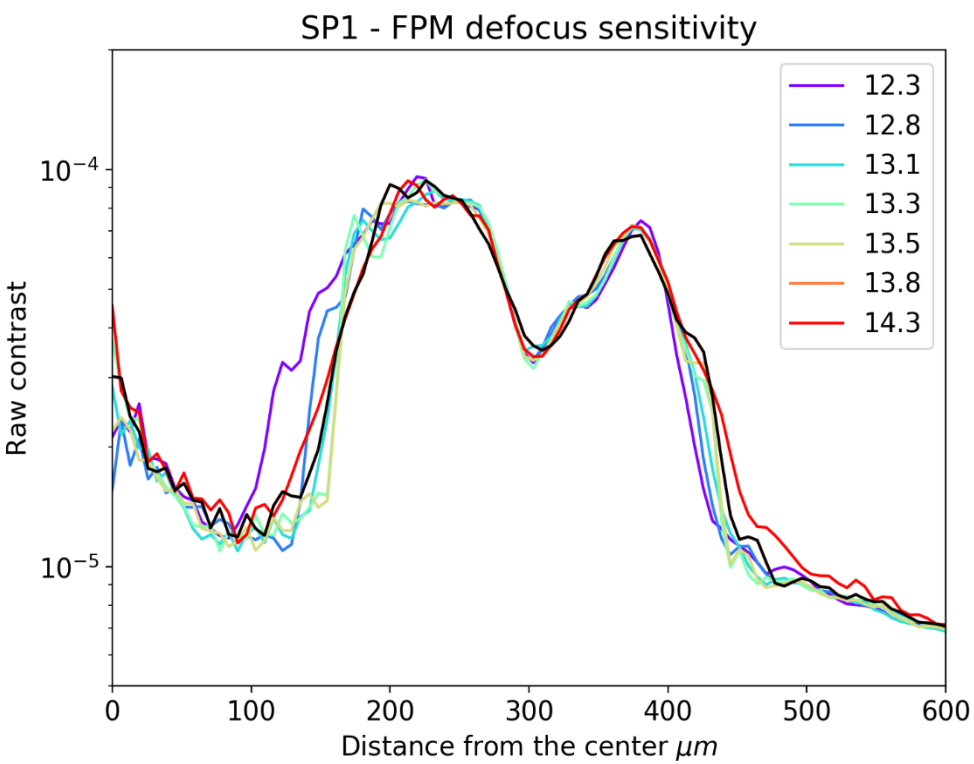


# CORONAGRAPHS - ON-GOING ACTIVITIES

*Apodizer image* *Occulter image*





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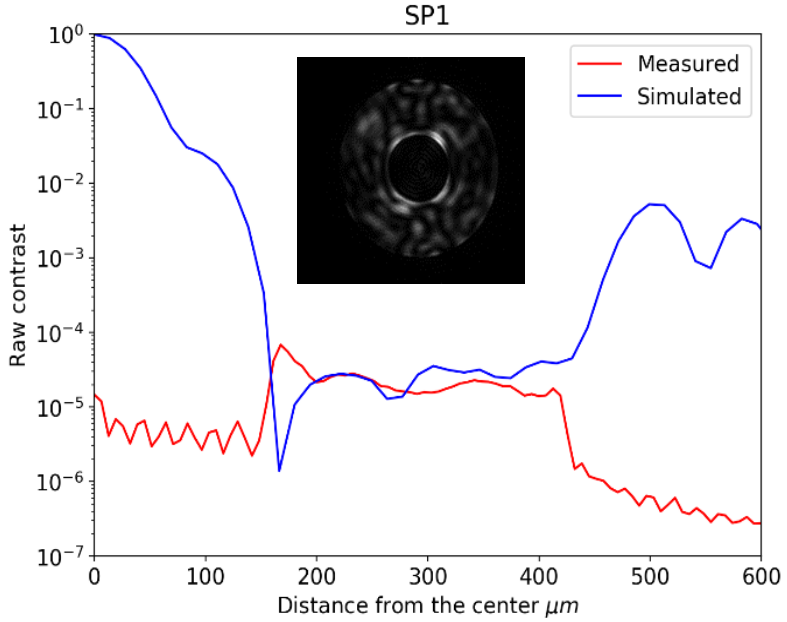
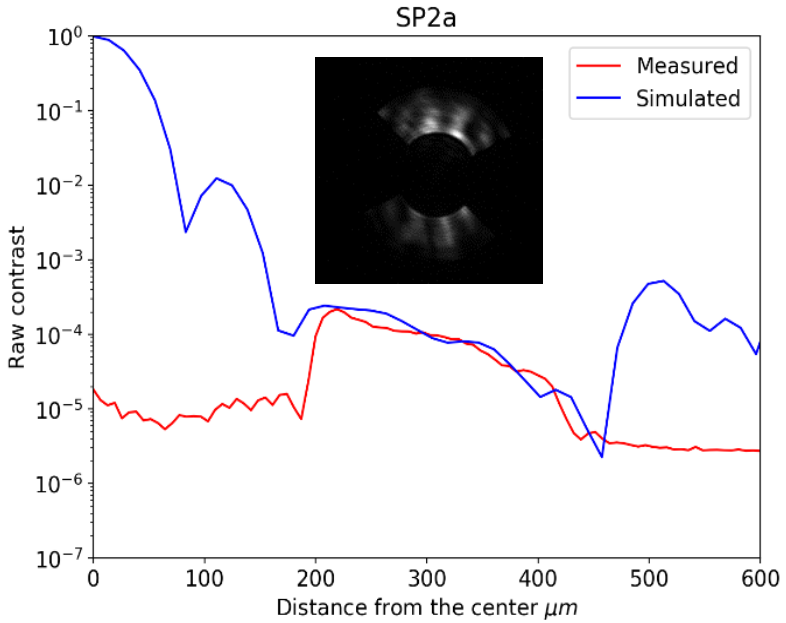
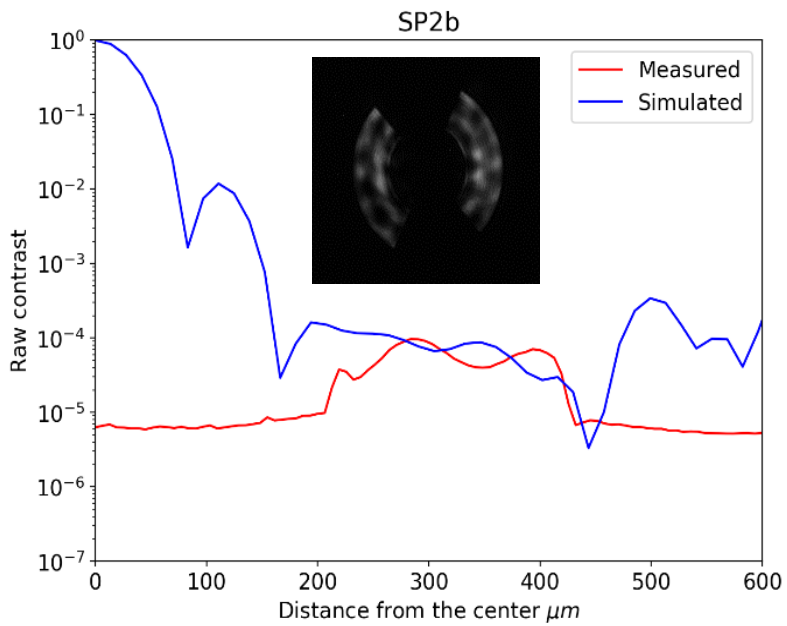


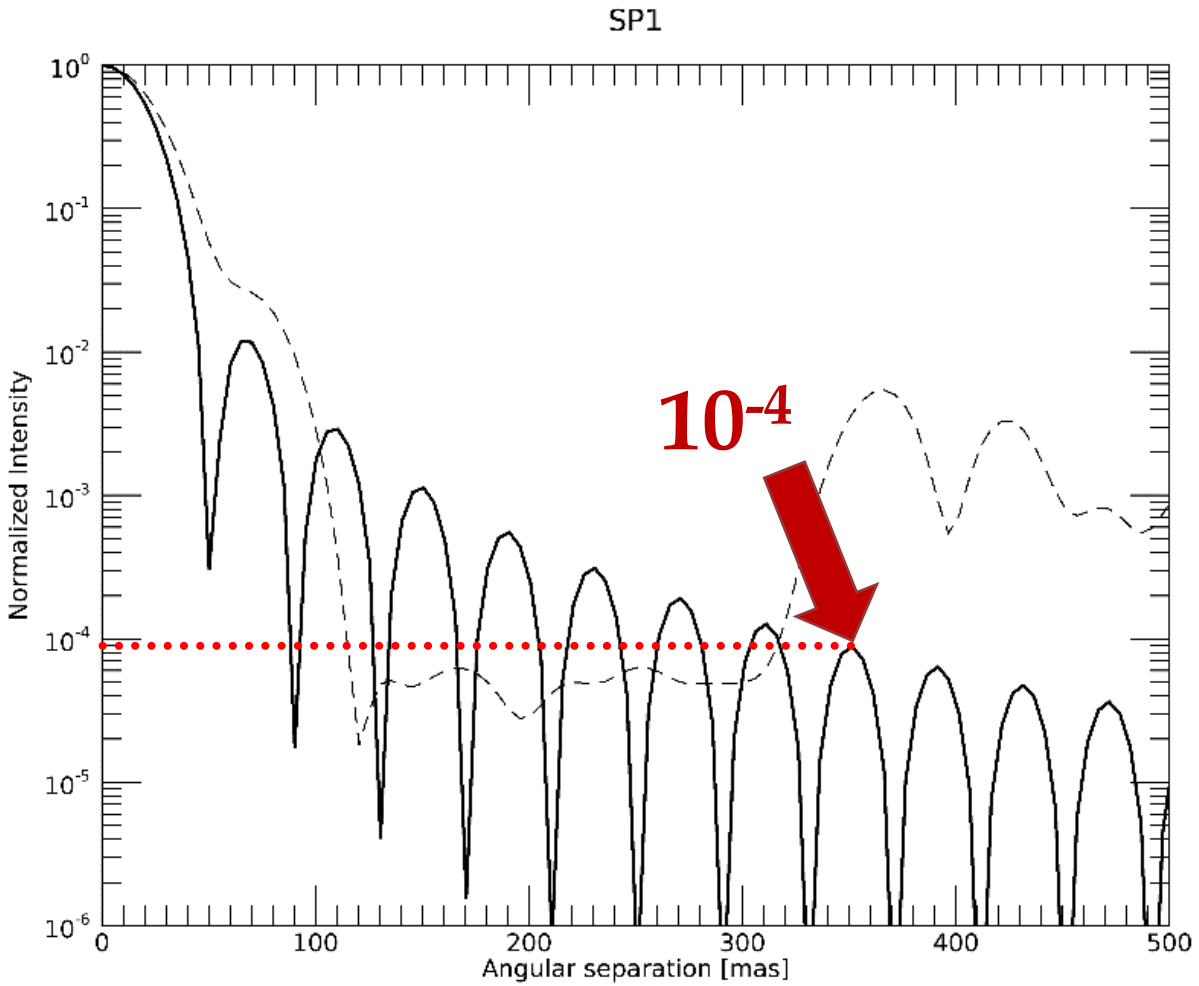



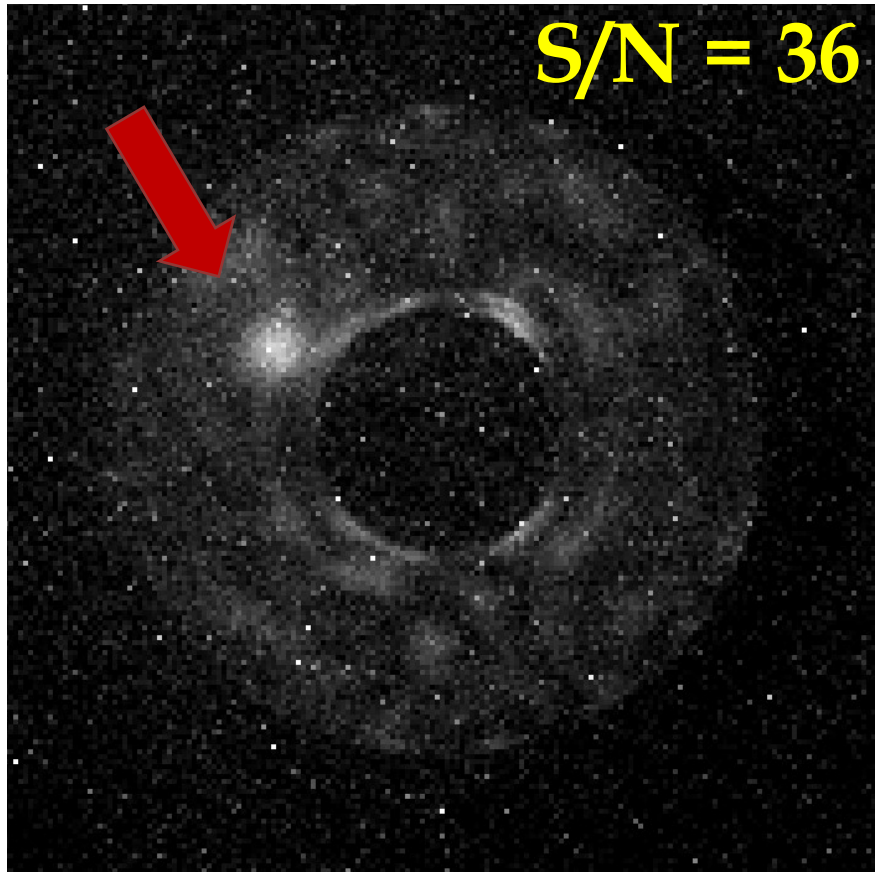




| Coronagraphic mask technique | IWA [μm] | | OWA [μm] | |
|---|---|---|---|---|
| | theoretical | measured | theoretical | measured |
| SP1_FPM_H | 196 | 198 | 528 | 521 |
| SP2a_FPM_H | 262 | 266 | 528 | 521 |
| SP2b_FPM_H | 247 | 250 | 528 | 521 |

# CORONAGRAPHS - ON-GOING ACTIVITIES

*Fake planet*



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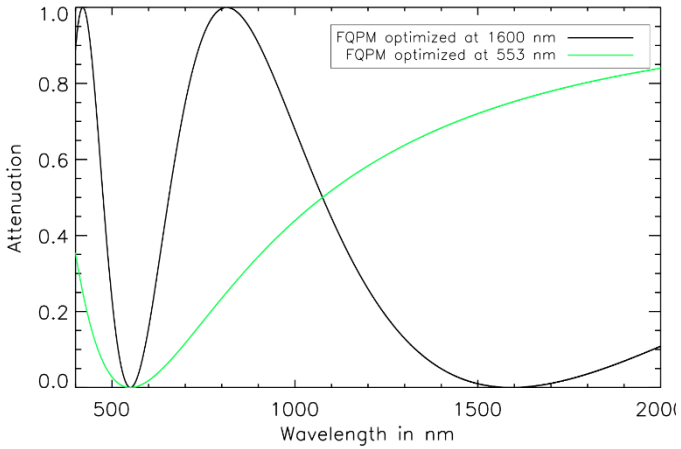
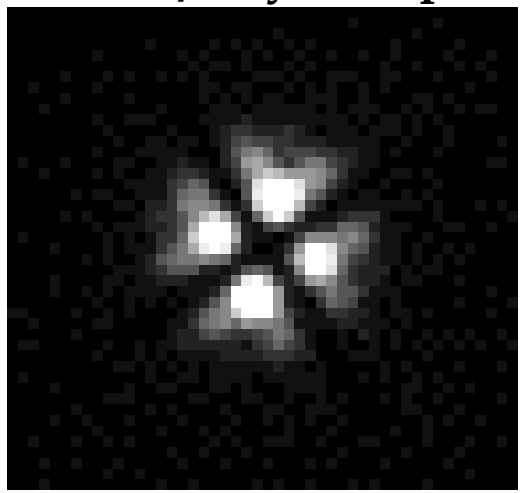
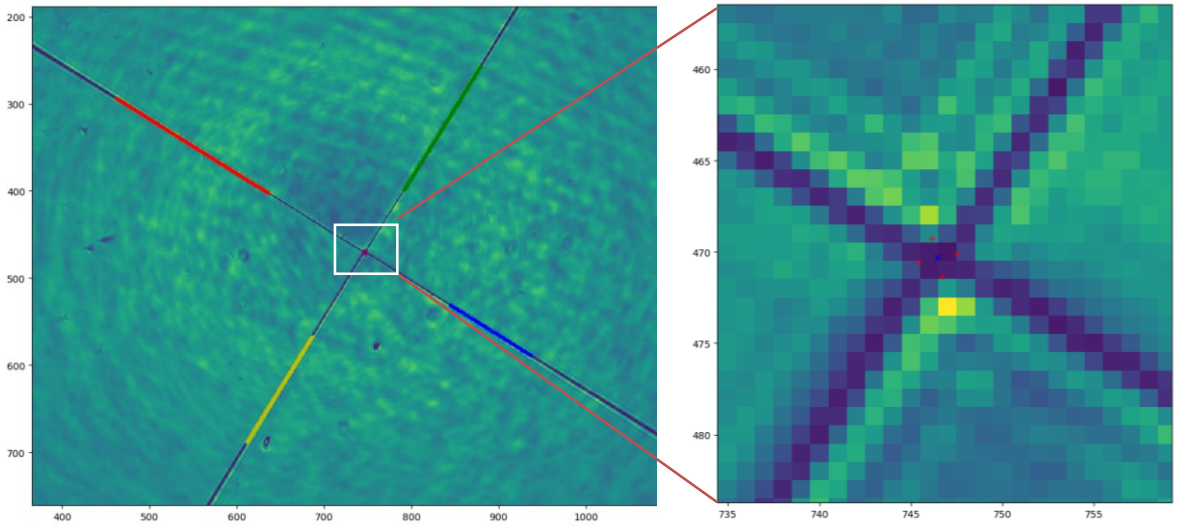


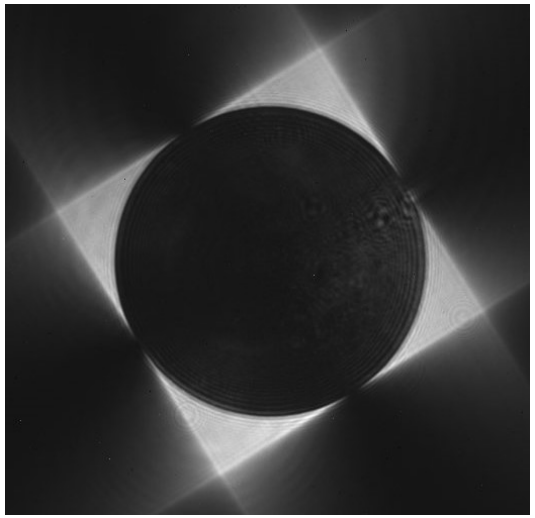

**FP w/o Lyot Stop**



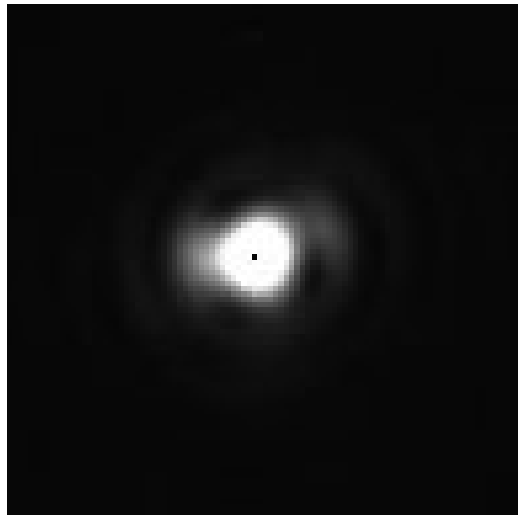
**4QPM centering procedure**

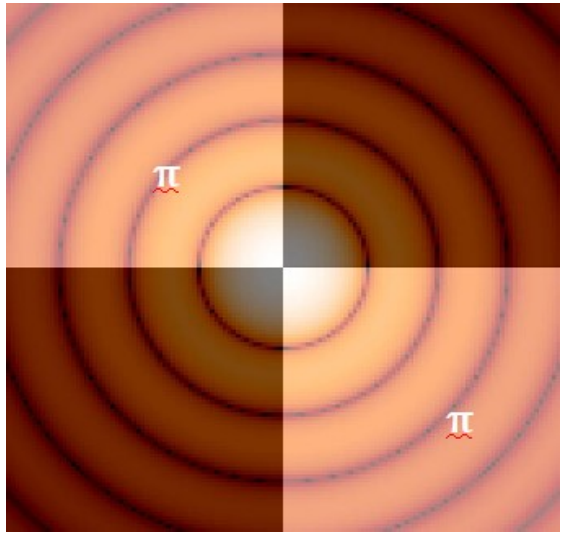


**Pupil plane**



**FP w/ Lyot Stop**





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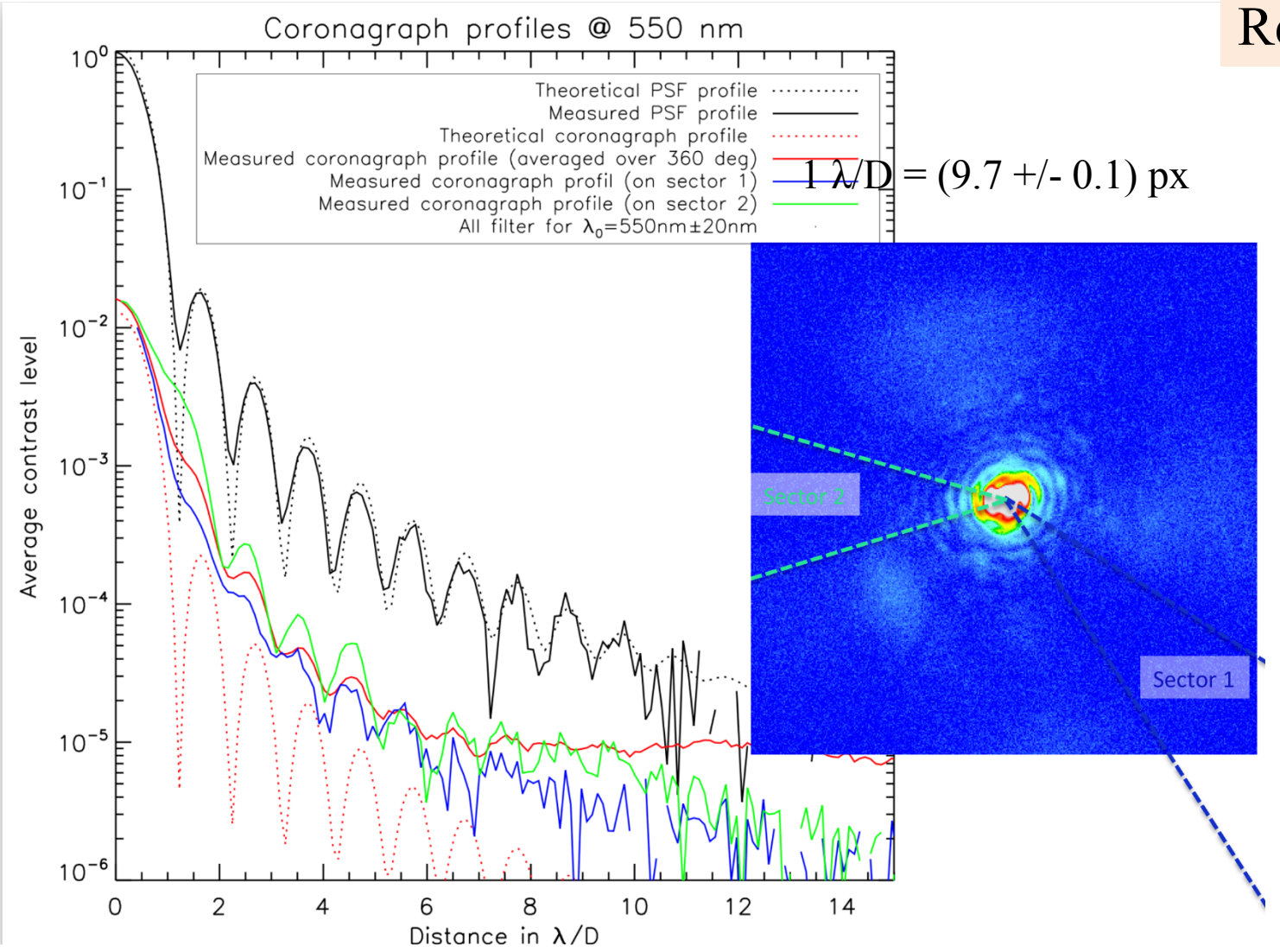



1 λ/D = (9.7 +/- 0.1) px

Rejection on 25λ/D Square box → R $^2$

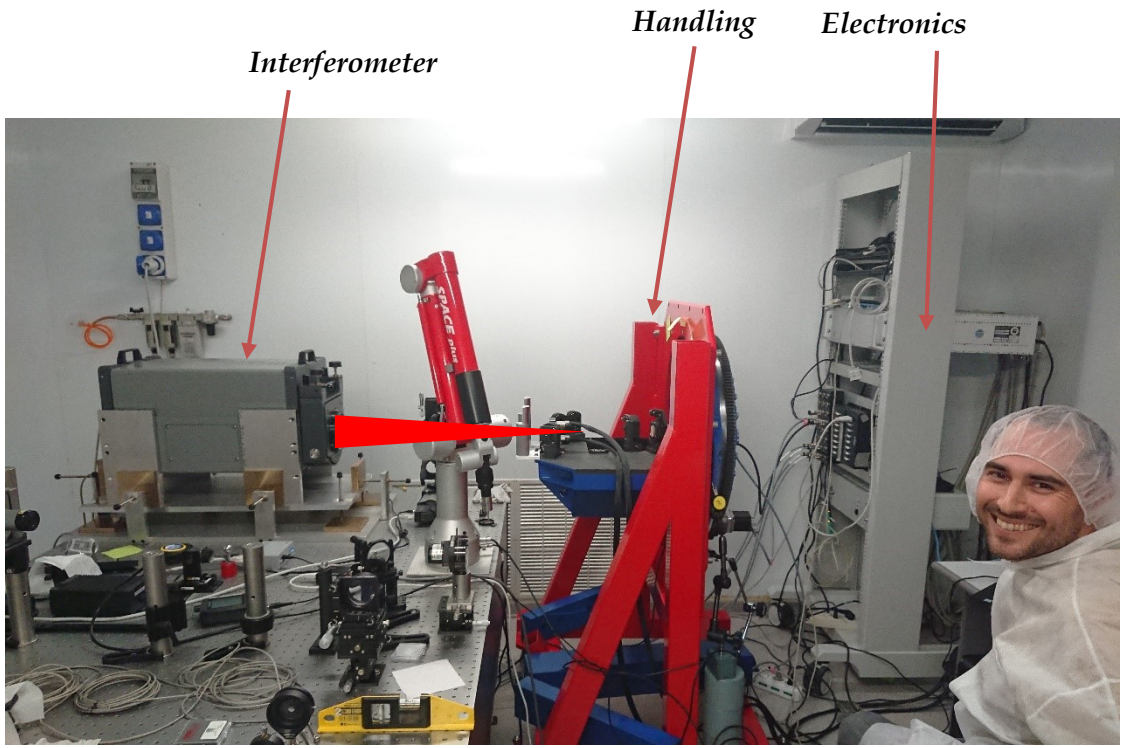
| Padova | LESIA |
|---|---|
| R=λ/Δλ ~14 | R~100 |
| 550 nm | 1650 nm |
| Rej. = 40 | Rej. = 400 |

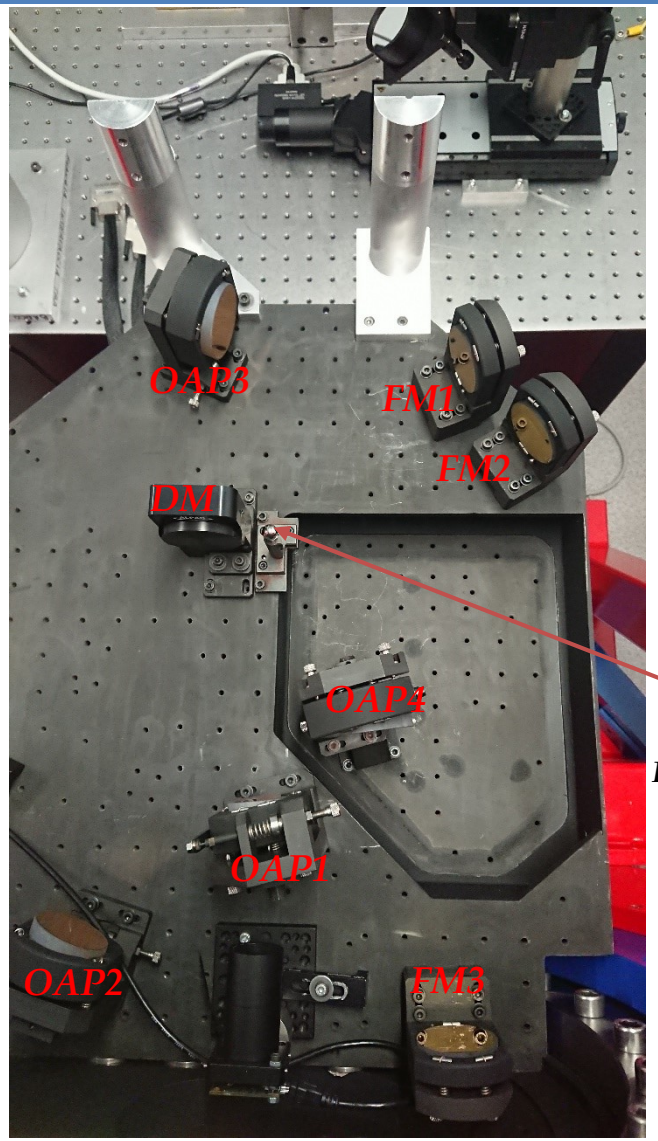
**Rej. (Padova)**
**Expected 8 (from R ratio)**
**Measured 40!**

# CLEAN ROOM - ON-GOING ACTIVITIES

Alignment beams (collimated laser beam for refractive optics alignment, converging beam for OAPs alignment) available.

Rough mechanical mirrors pre-alignment completed.



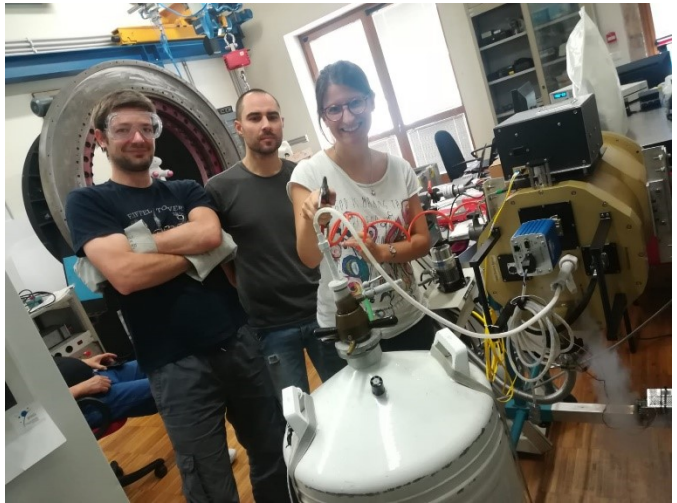



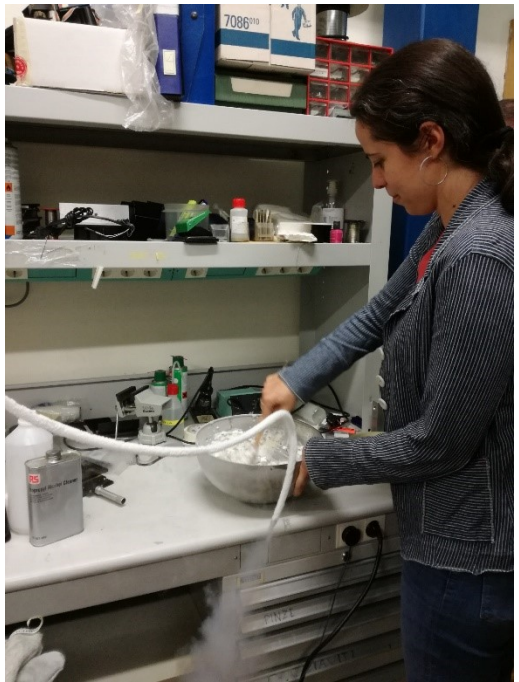
# SCIENTIFIC CAMERA

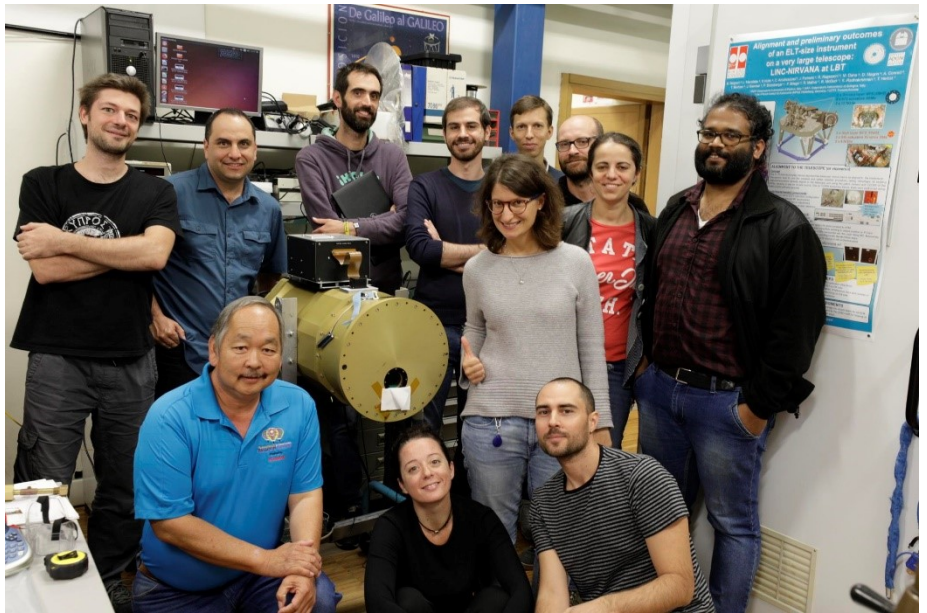
Infinite shipping issues


2.5 Days of camera at 81 K (Padova is at sea level):

- Functional tests performed
- Cooling down, warming up procedure tested
- Cryostat can hold 52 hours in worst configuration
- VPN setup in order to allow remote connection from Steward to debug SW issues







# NEXT STEPS

| | | |
|---|---|---|
| 2019 | Nov.? | Delivery of the NIR camera sub-assembly from SO to INAF |
| 2019 | Dec. | Delivery of dispersive element |
| 2020 | May | End of AIV phase |
| 2020 | Jun. | PAE review |
| 2020 | Mid | Start of commissioning at LBT |
| 2020 | Fall | SHARK-NIR in operation |

Thank you for your attention!