LABORATORIO NAZIONALE ADONI OTTICA ADATTIVA

ISTITUTO NAZIONALE DI ASTROFISICA — INAF — NATIONAL INSTITUTE FOR ASTROPHYSICS

Osservatorio Astronomico di Padova

# SHARK-NIR overview and optomechanical design: an update


Davide Greggio

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# WHY SHARK

**Considering:**

- The excellent AO performance
- The current and next generation LBT instruments scenario
- The Northern Emisphere scenario
- The strong science case
- The wish to make a fast track project

**We proposed to build:**

- a simple camera (compact, light, close to the WFS) designed for high contrast imaging
- working in **VIS** and **NIR** bands
- capable to do:
  - **Coronagraphy**
  - **Direct Imaging**
  - **LR Spectroscopy**

# WHAT IS SHARK?

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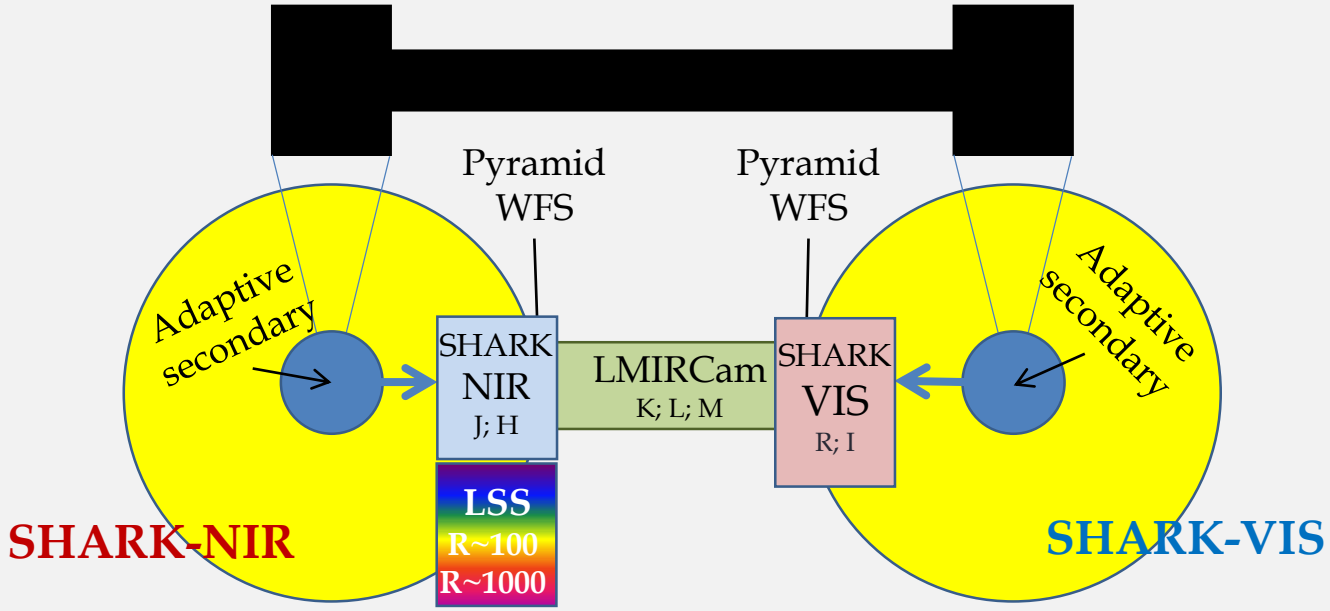
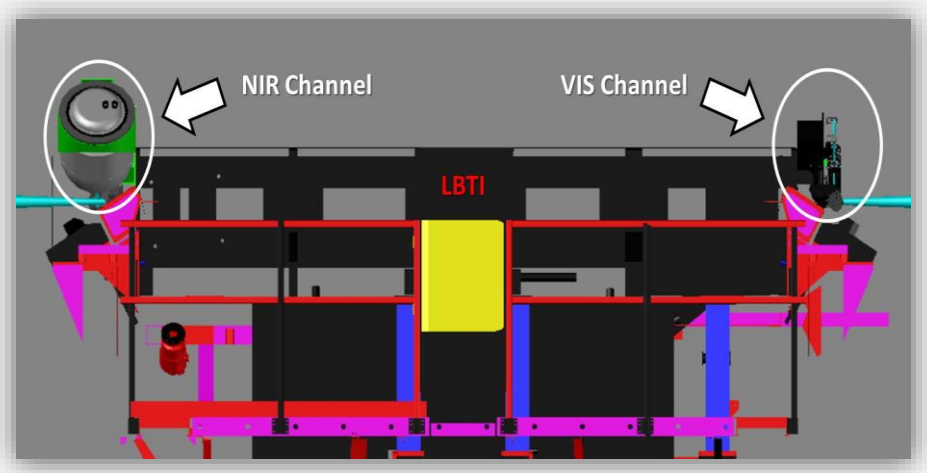
**SHARK-NIR**

- Coronagraphic camera with spectroscopic capabilities
- Extreme adaptive optics correction of FLAO
- Synergy with other LBT instruments: SHARK-VIS, LMIRCam



# SHARK POSITION AT LBT

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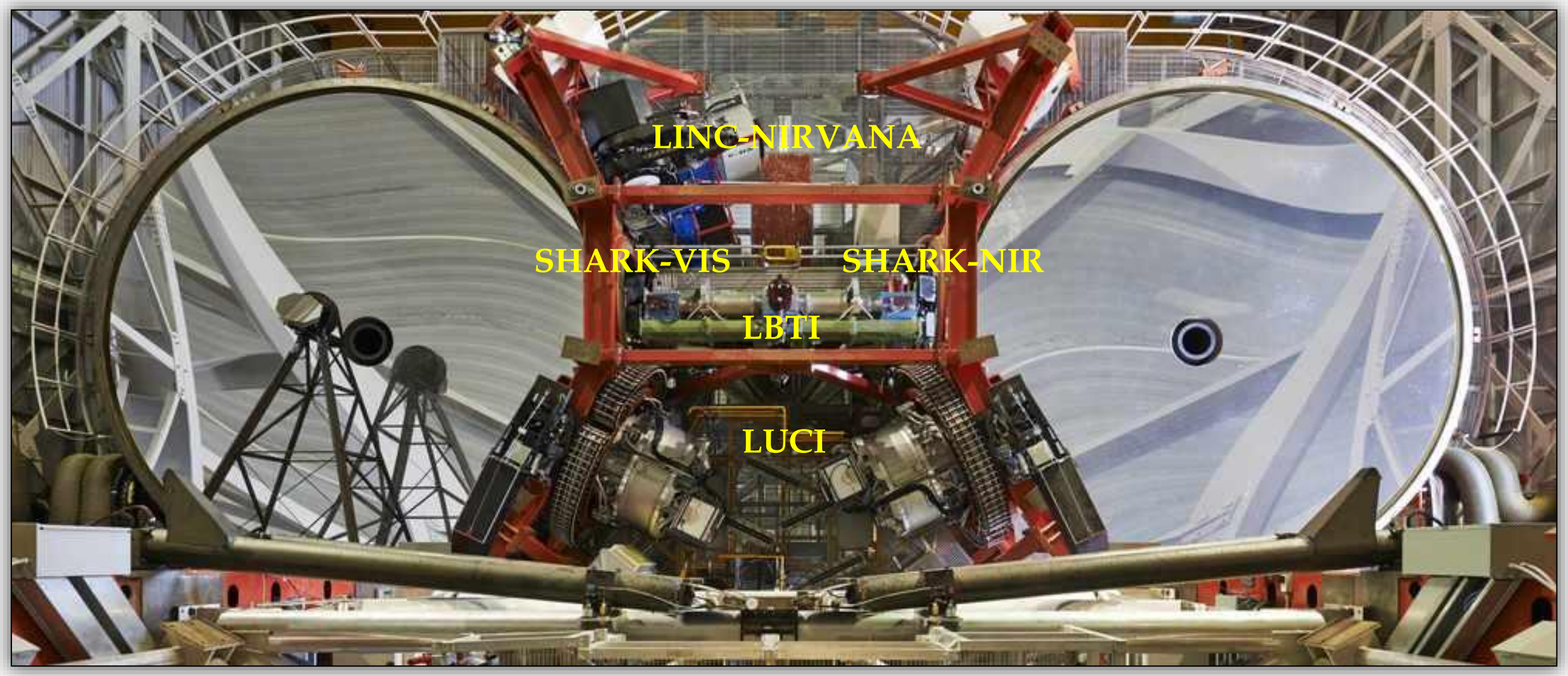
*Photo credit: LBTO - Enrico Sacchetti*



# SHARK – SCIENCE TARGETS

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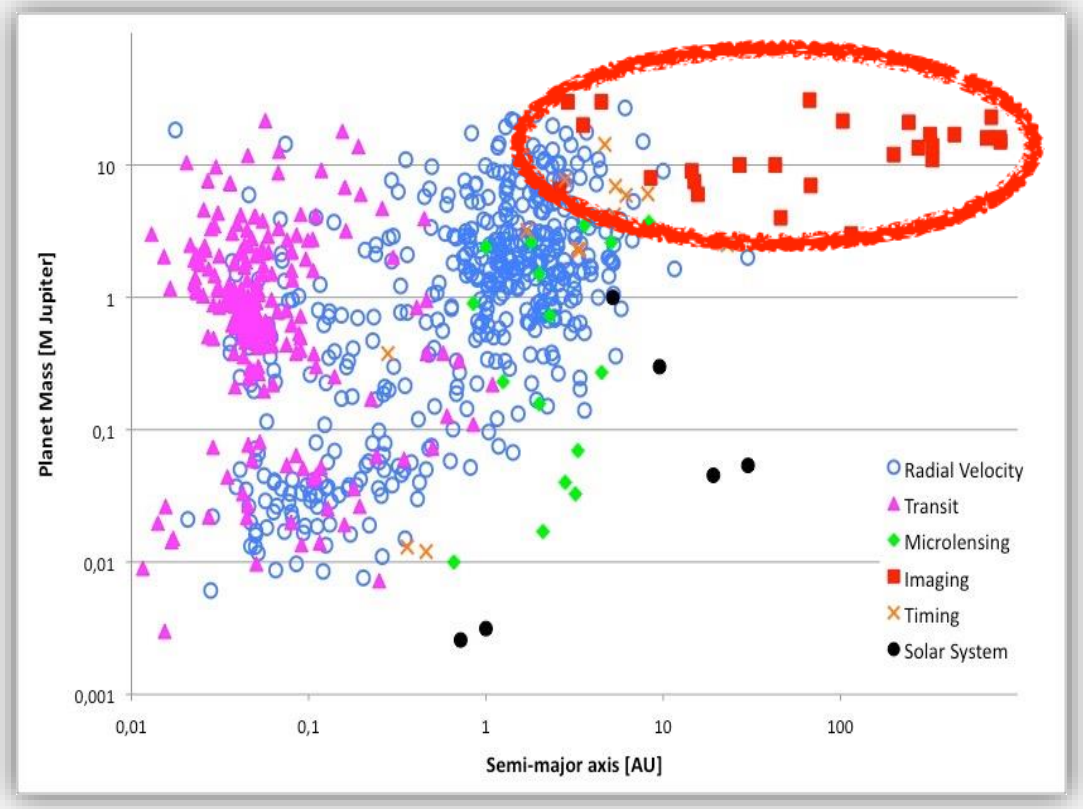
**Main science target:** direct imaging of exo-planets (detection and characterization)

**Other science:**

- Brown dwarfs
- Protoplanetary disks
- Stellar jets
- AGN




See talk by VALENTINA D'ORAZI

# INSTRUMENT SPECIFICATIONS

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| SHARK NIR main characteristics | |
|---|---|
| **Observing Modes** | Imaging/Coronagraphy/Spectroscopy/DBI |
| **Detector format [px]** | 2048x2048 (≈1220x1220 used area) |
| **Waveband [µm]** | 0.96 – 1.7 |
| **FoV x ["]** | 18 |
| **FoV y ["]** | 18 |
| **FoV along the diagonal ["]** | 25.5 |
| **Plate scale [mas/px]** | 14.5 |
| **Airy Radius @ 0.96 micron [px]** | 2 |
| **# of mirrors in the camera** | 8 (3 flat, 1DM and 4 OA parabolas) |
| **ADC** | Yes |
| **Nominal Strehl at <18″ FoV diameter (in all Bands)** | >98% |

# OPTO-MECHANICAL LAYOUT

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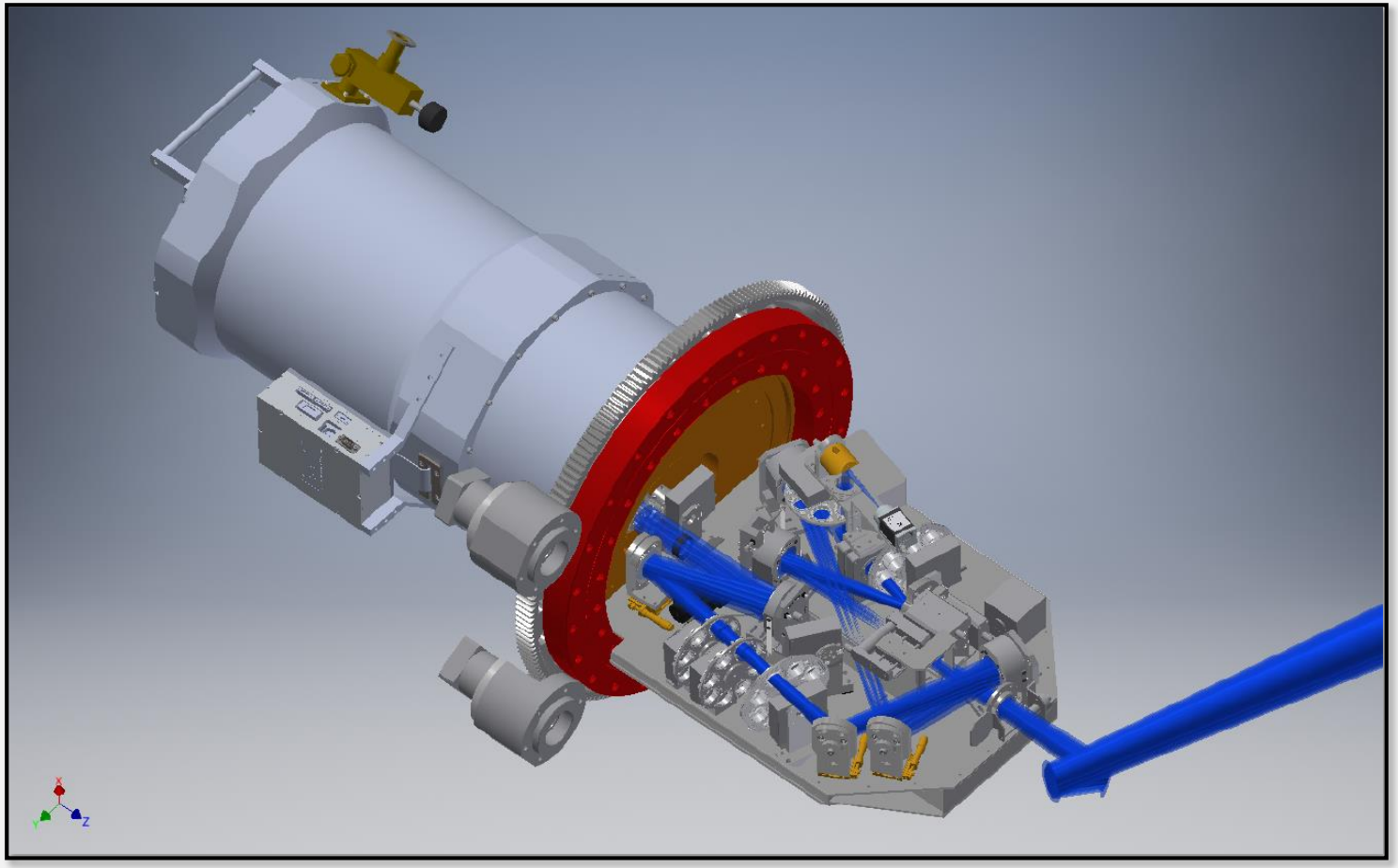
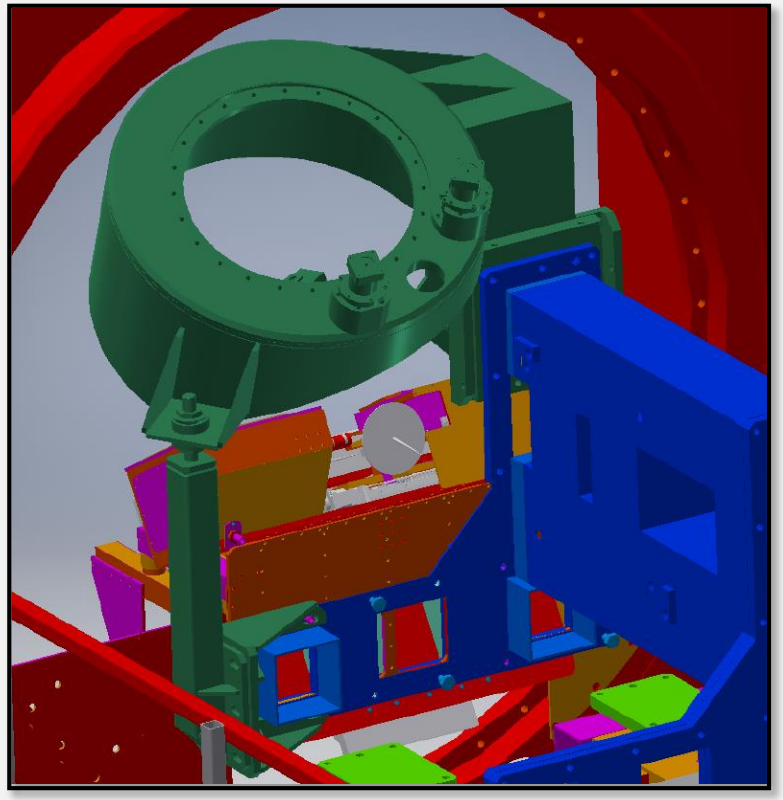
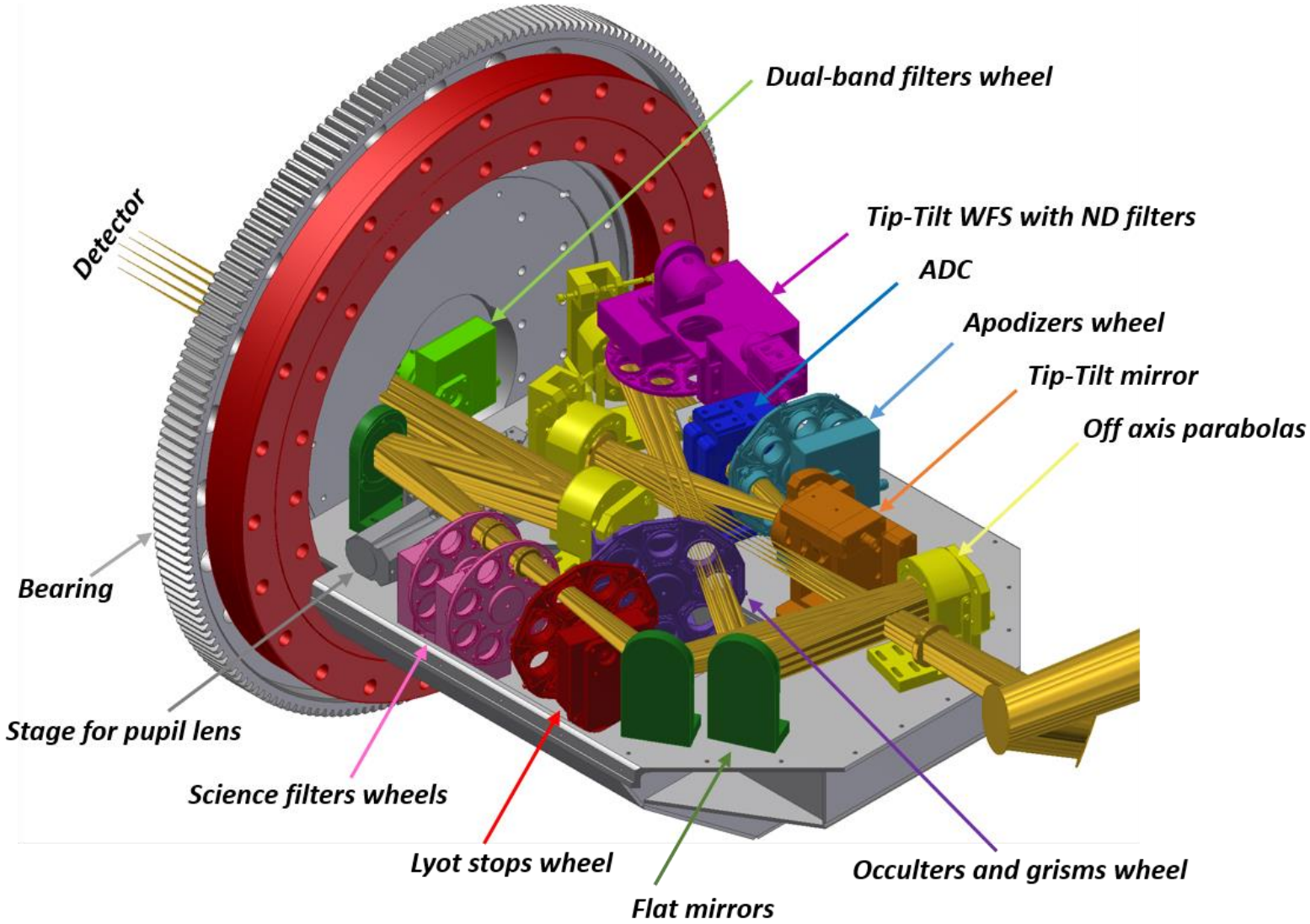
## Optical bench + Cryostat



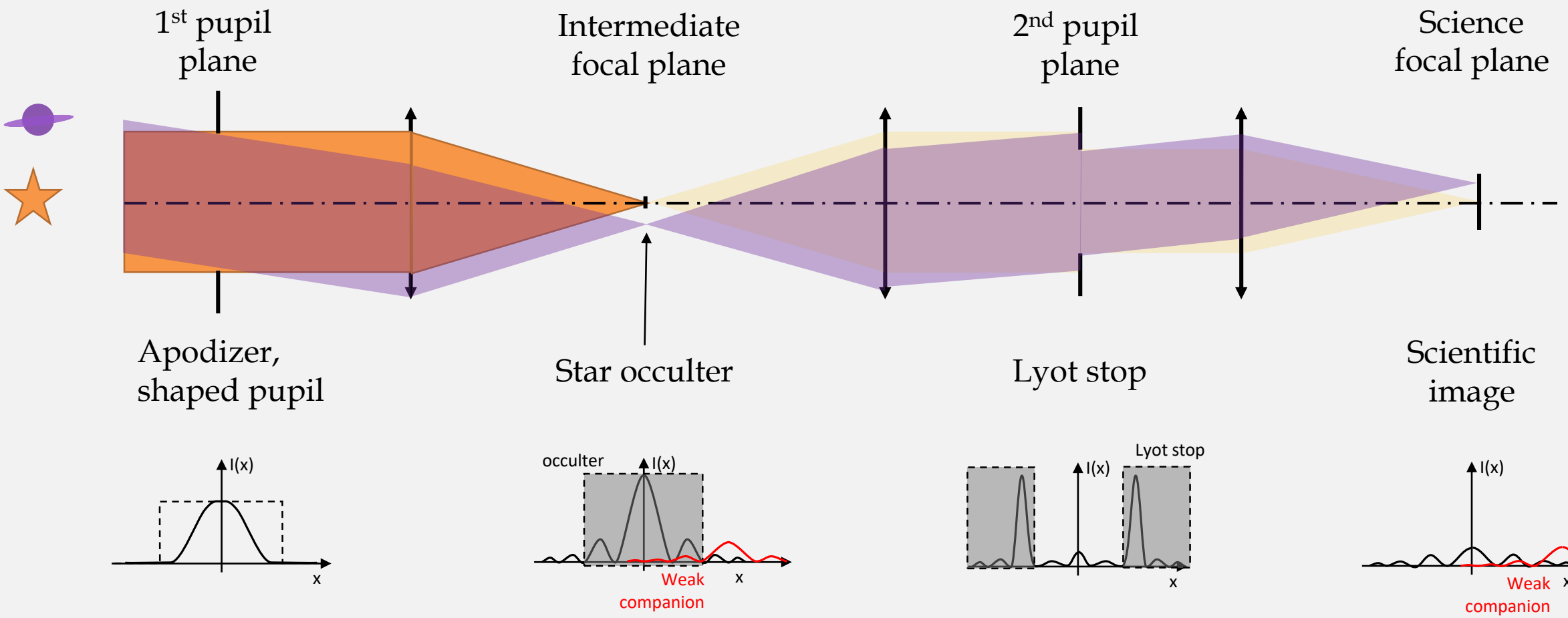
## SHARK Holding structure



# OPTO-MECHANICAL LAYOUT



# CORONAGRAPHY IN SHARK



# CORONAGRAPHIC TECHNIQUES

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- ✓ Gaussian Lyot
- ✓ Shaped pupil (both symmetric and asymmetric discovery space)
- ✓ APLC/4 Quadrant (?)

Field stabilized mode (de-rotator ON) requires circular symmetric masks (Classical Lyot and Gaussian Lyot).

Shaped Pupil and APLC are used in Pupil stabilized mode (de-rotator OFF)

# CORONAGRAPHIC PERFORMANCE

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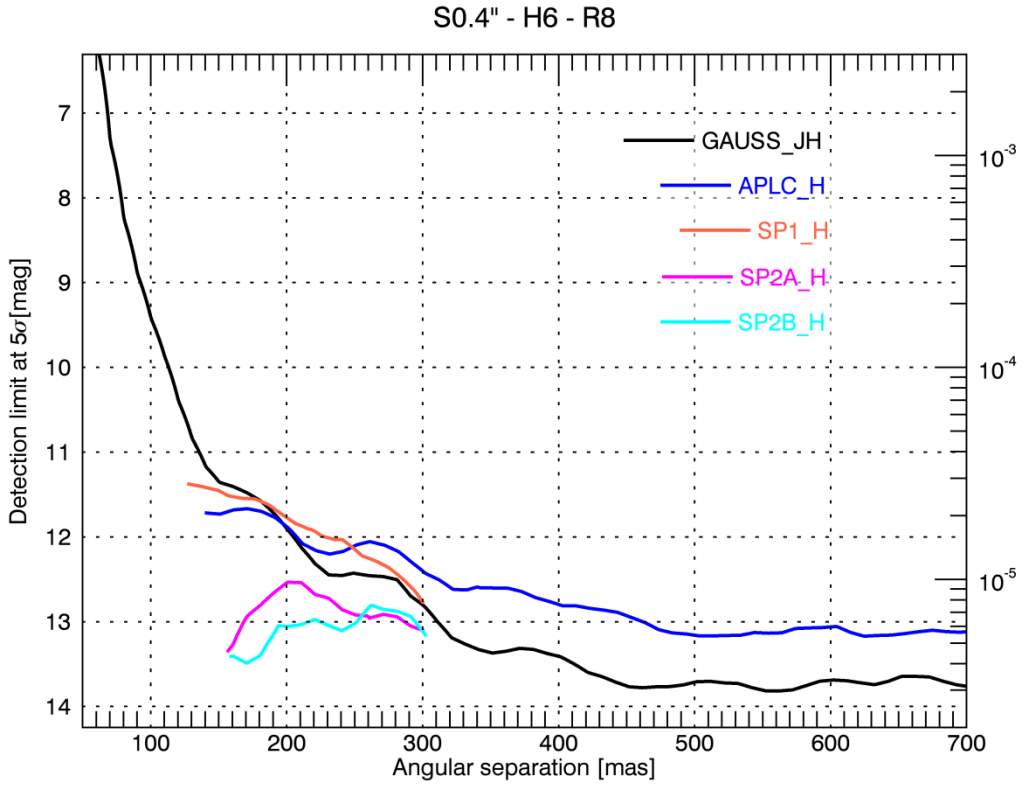
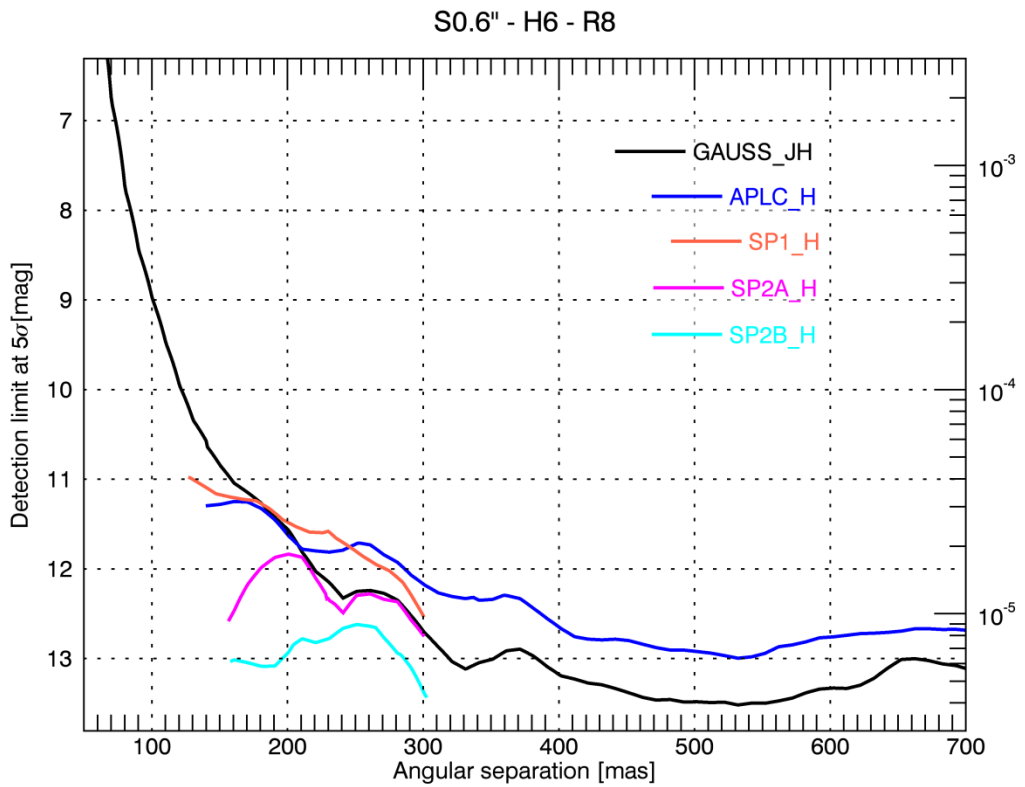
## 5-σ detection limit in H band for Rmag=8 with SOUL

See talk by ELENA CAROLO

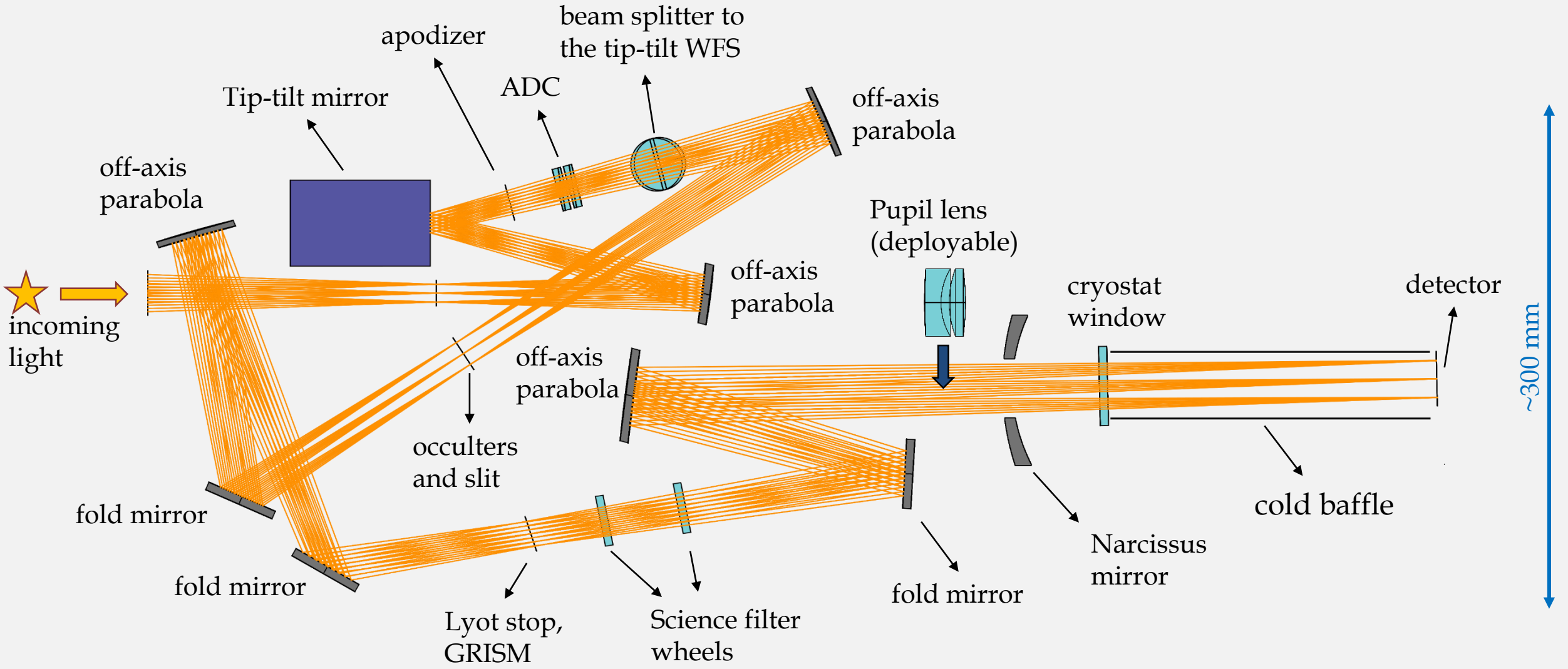
Seeing 0.4”




Seeing 0.6”



# SHARK – OPTICAL LAYOUT



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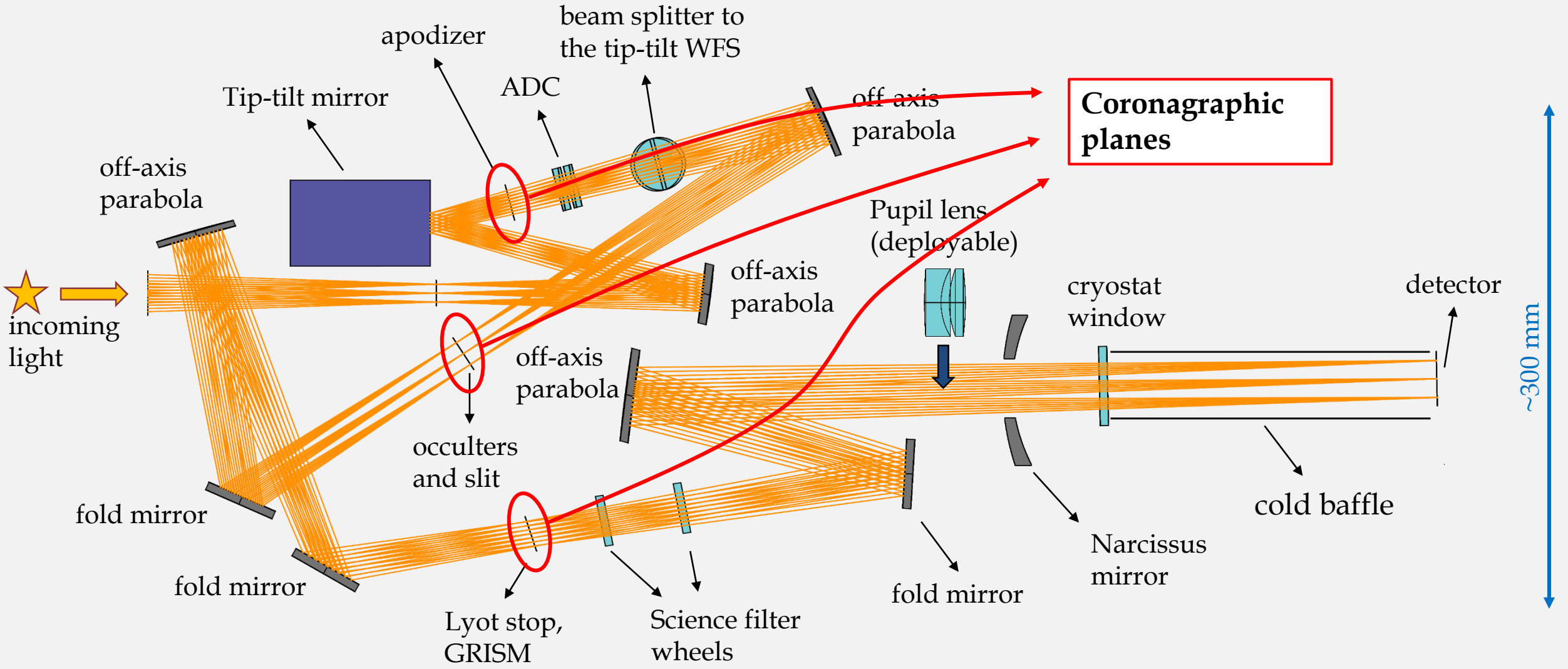

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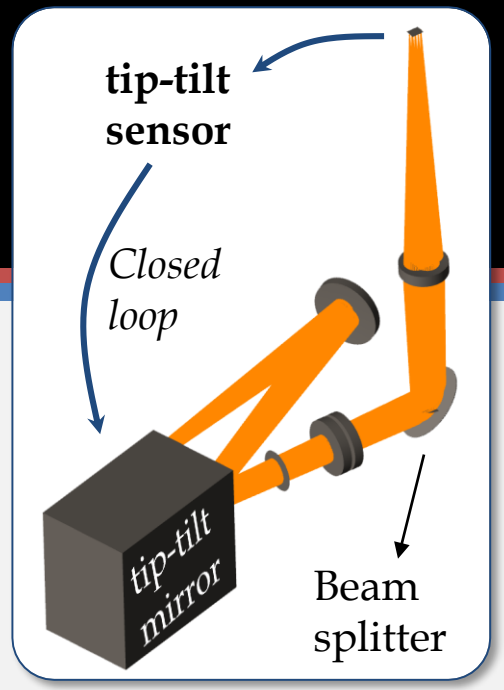
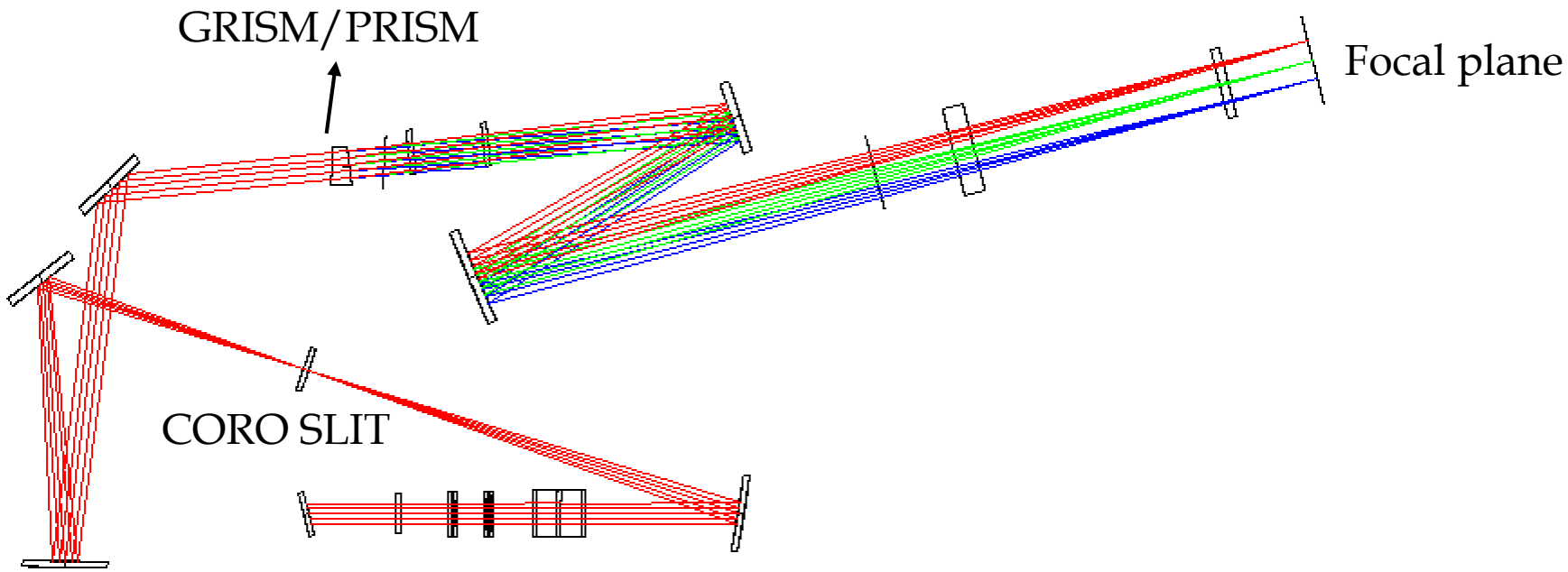



beam splitter to the tip-tilt WFS
apodizer
ADC
Tip-tilt mirror
off-axis parabola
off-axis parabola
off-axis parabola
Pupil lens (deployable)
cryostat window
detector
incoming light
off-axis parabola
occulters and slit
fold mirror
fold mirror
Lyot stop, GRISM
Science filter wheels
fold mirror
Narcissus mirror
cold baffle
~300 mm

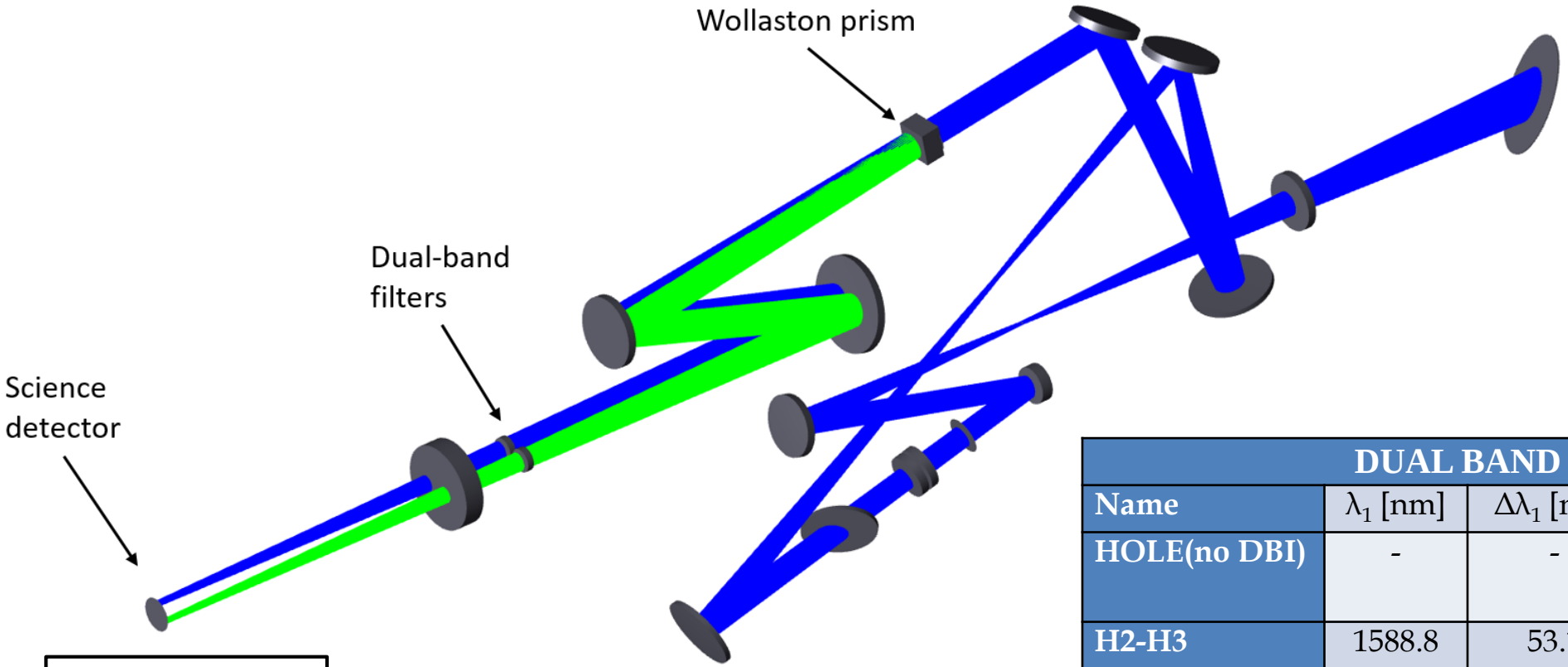
# SPECTROSCOPIC MODE

| 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




Radial FoV 1″

| 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** | | | | |

# RECENT UPDATES – FAST TT SENSOR

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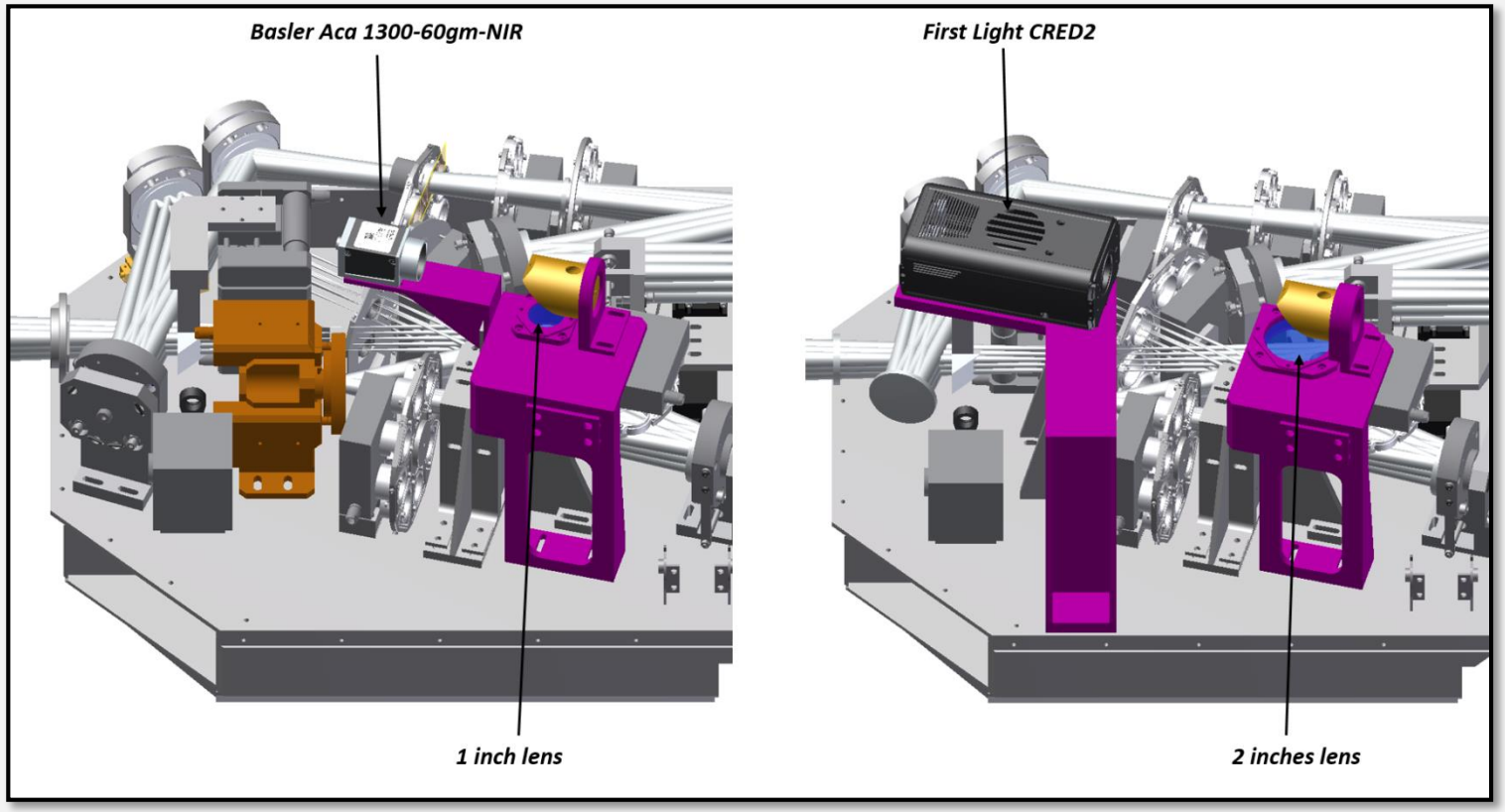
## Tip-tilt WFS upgrade

- New InGaAs camera (C-RED2)
- Sensitive in the full SHARK-NIR waveband (0.96-1.7 μm)
- Frame-rate up to 14KHz (with 32X32 px window)
- Same FoV as before (11”x13”)
- Low RON (<25$e^-$ )
- 3 mas precision up to mag=12 @ 1KHz

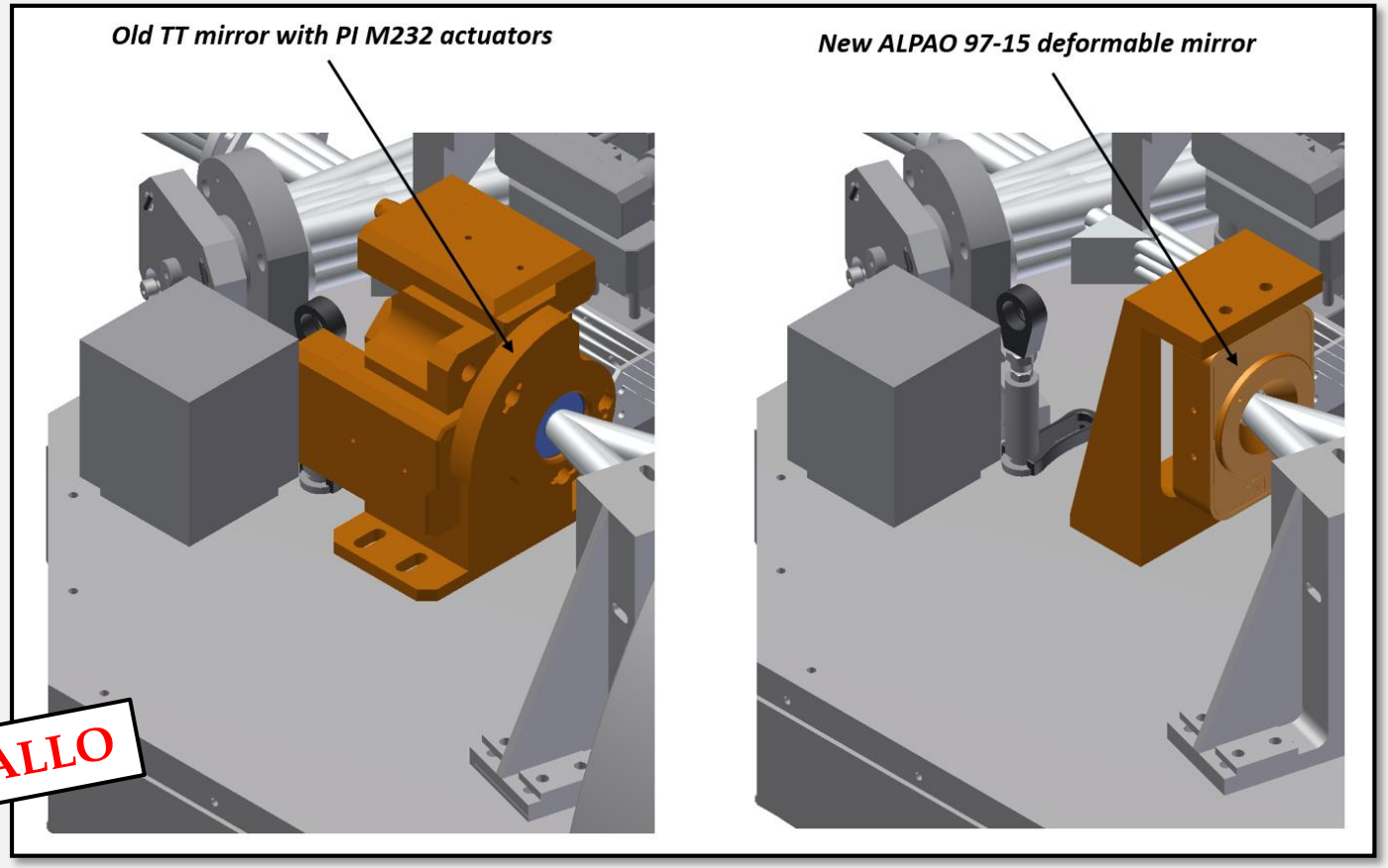
**BEFORE** **NOW**



# RECENT UPDATES – INTERNAL NCPA CORRECTION

## Tip-tilt mirror upgrade

- Tip-tilt mirror replaced by ALPAO DM 97-15
- 97 actuators, 13.5 mm pupil
- NCPA can be corrected internally without affecting pyramid's performance
- Smaller volume
- NCPA measured with phase diversity on science image




See talk by DANIELE VASSALLO

# THE SHARK-NIR TEAM

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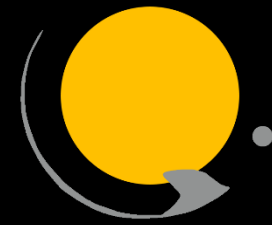

- ✓INAF-Padova (Project Responsible, Opto-Mechanics and INS Software)
- ✓INAF-Arcetri (AO Interaction and NIR camera testing support)
- ✓Steward Observatory (LBTI interfaces, NIR camera sub-system)
- ✓INAF-Brera (Dispersive elements design)
- ✓MPIA (for motors electronics and SW design support)
- ✓IPAG (CORO mask design)
- ✓INAF-Roma (Coordination with VIS Channel)
- ✓**INAF-Trieste** (Data archiving)
- ✓**Science team** (astronomers from 12 institutes)

# CURRENT STATUS

- **LBT board approval:** end of April 2017
- **Procurement phase:** June 2017 – September 2018
- **AIV phase**: September 2017 – January 2019
- **Preliminary Acceptance Europe:** January 2019
- **Commissioning start:** June 2019
- **SHARK-NIR operation:** October 2019