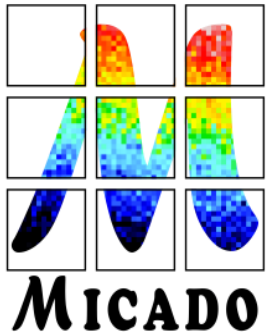
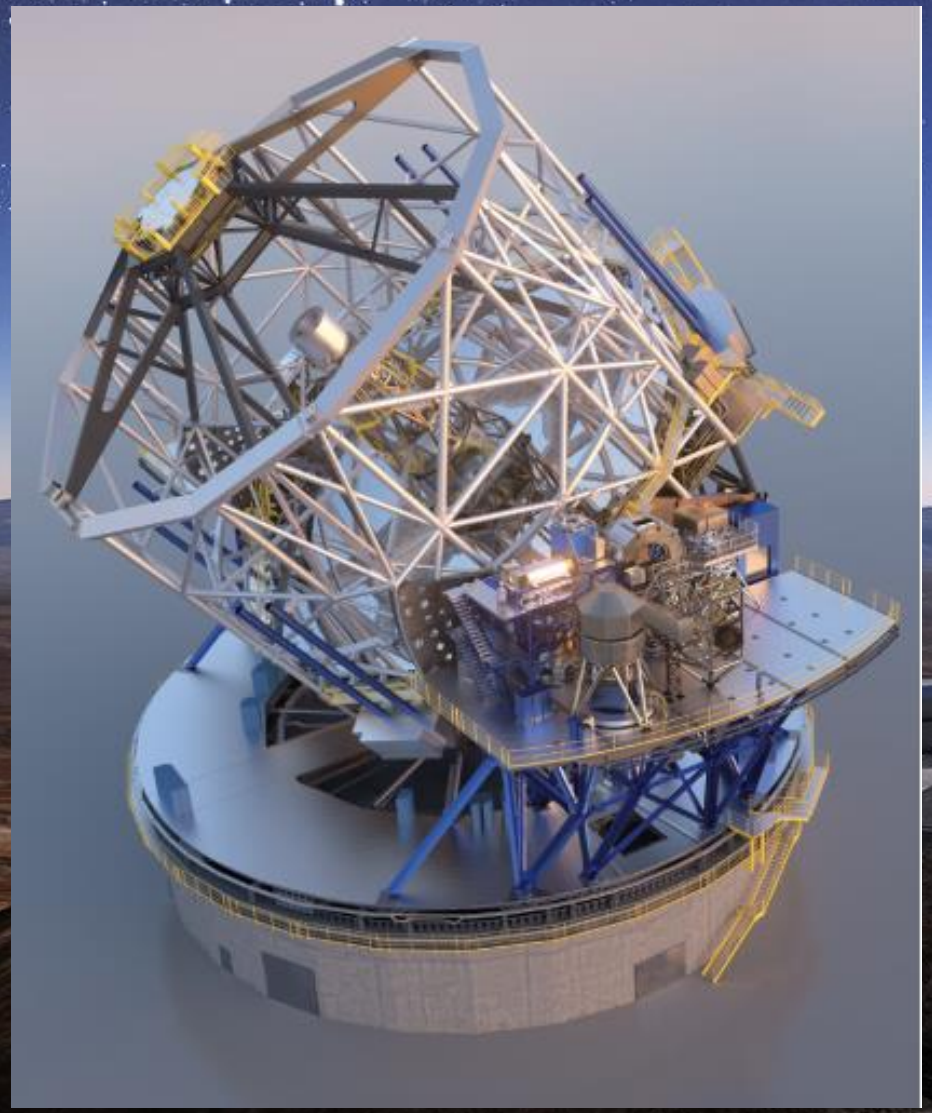


Sebastian Rabien

for the MICADO consortium

ELT Instruments Day, Geneva 7.4.2022

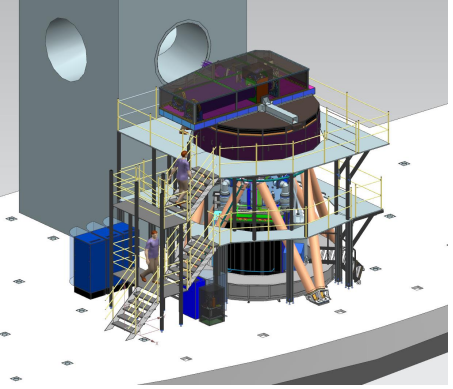
ELT / MICADO



MICADO is:

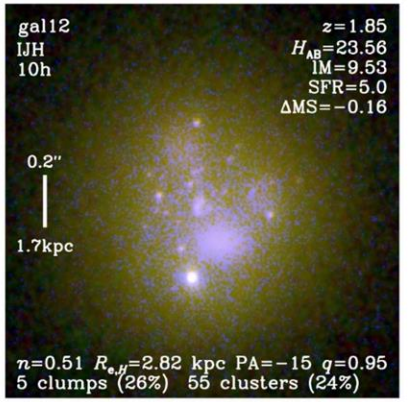
- The first light instrument for the ELT
- A near infrared imaging camera
- An astrometric imager
- A high contrast imaging system
- A single object high resolution spectrograph

At diffraction limited performance of the 39m ELT!



ELT / MICADO

- Current Phase: Final Design (Review in 2021..2022)
- First Light: ~2027



Capabilities

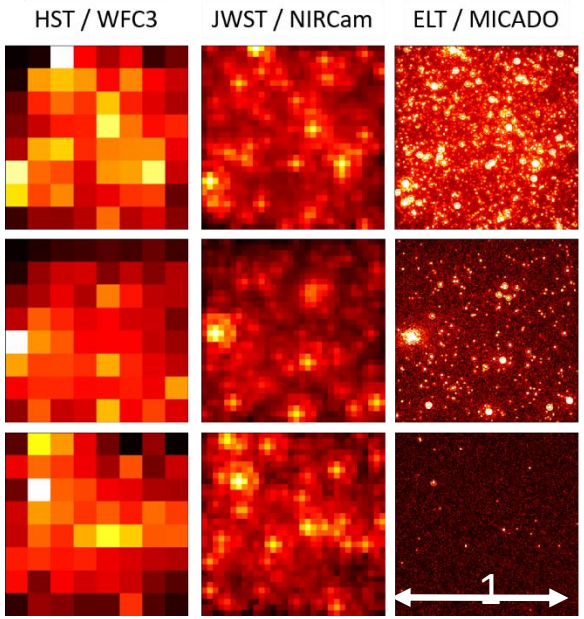
- Imaging
  - 0.8-2.4µm with 30 broad/narrow filters
  - 1.5 & 4mas pixels for 19 & 51” FoV
  - Similar sensitivity to JWST, and 6× better resolution
- Astrometric imaging
  - 50µas precision anywhere in the field
  - 10µas/yr = 5km/s at 100 kpc after only a few years
- High Contrast imaging
  - focal & pupil plane coronagraphs
  - angular differential imaging
  - small inner working angle
- Spectroscopy
  - for compact sources
  - fixed configuration for 0.84-1.48µm & 1.45-2.46µm
  - R ~ 20,000 for point sources (R ~ 10,000 across slit)

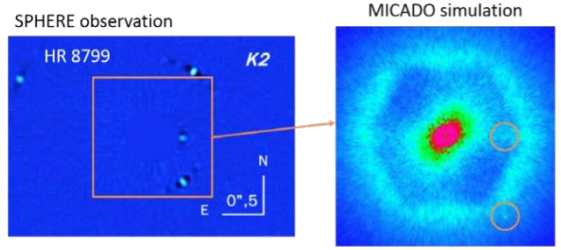
Science Drivers

Galaxy Formation and Evolution
- Resolved stellar populations, SFHs
- Internal structure
- QSO host galaxies

Massive Black Holes
- Galactic Center
- IMBHs
- BH – galaxy co-evolution
- Seed BHs

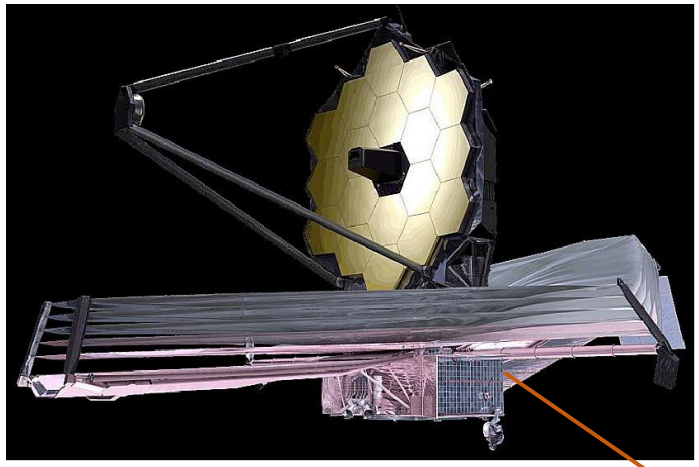
Exoplanets (atmospheres)
- at small orbital separations (~ 1 AU) around nearby stars (< 20 pc)
- at larger separations (> 10 AU) around more distant stars (> 100 pc)
- circumstellar disks.



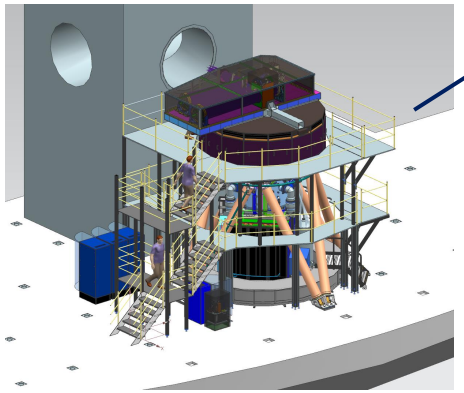


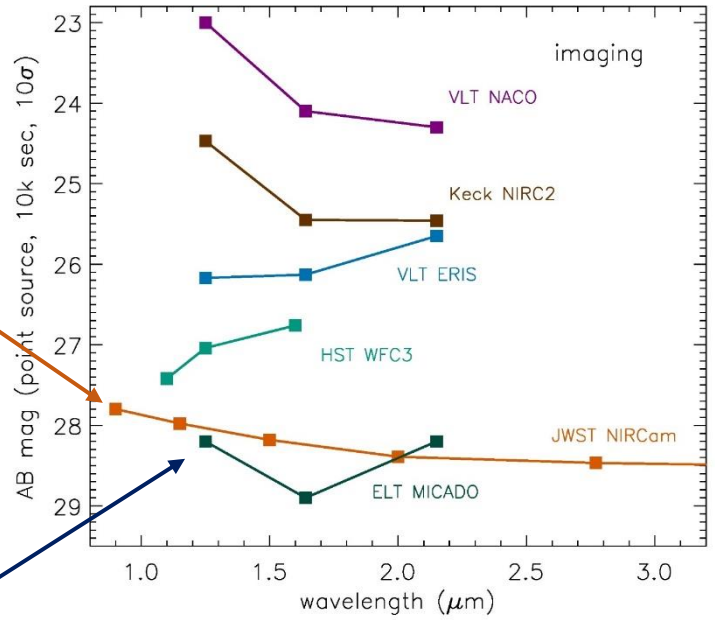
ELT / MICADO: Sensitivity

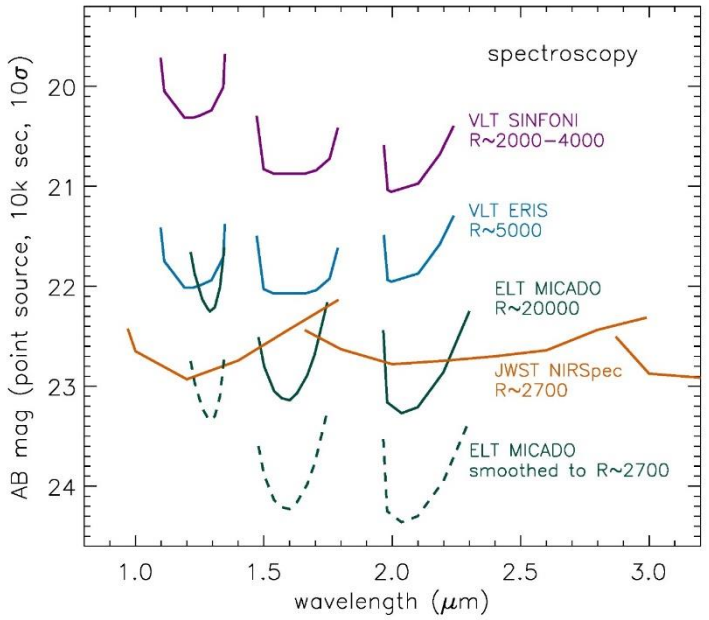
JWST



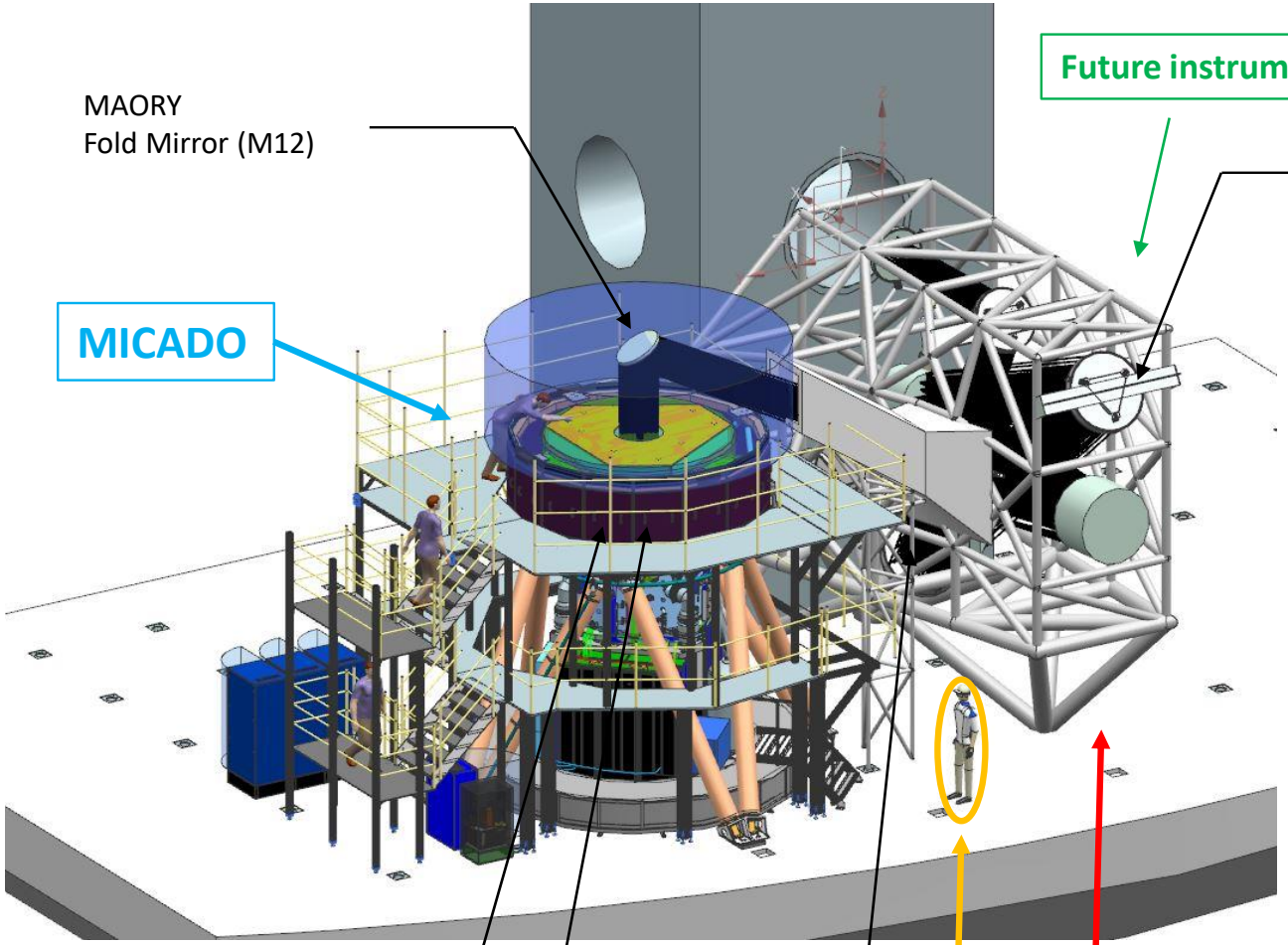
MICADO





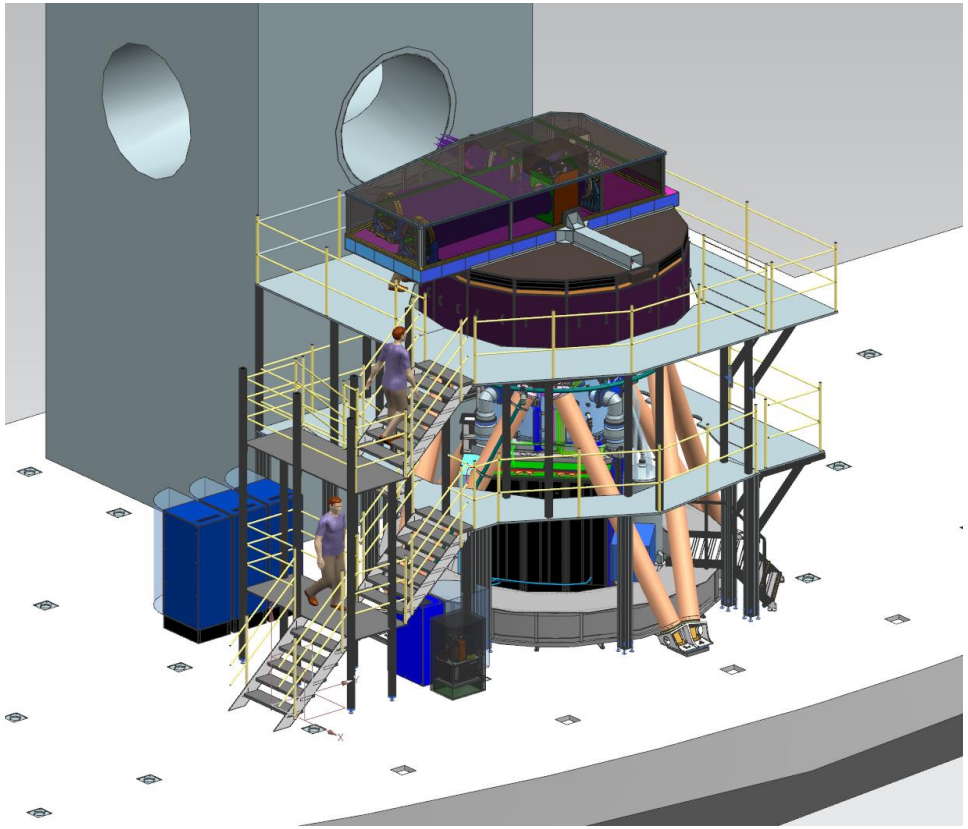


Two instrument phases

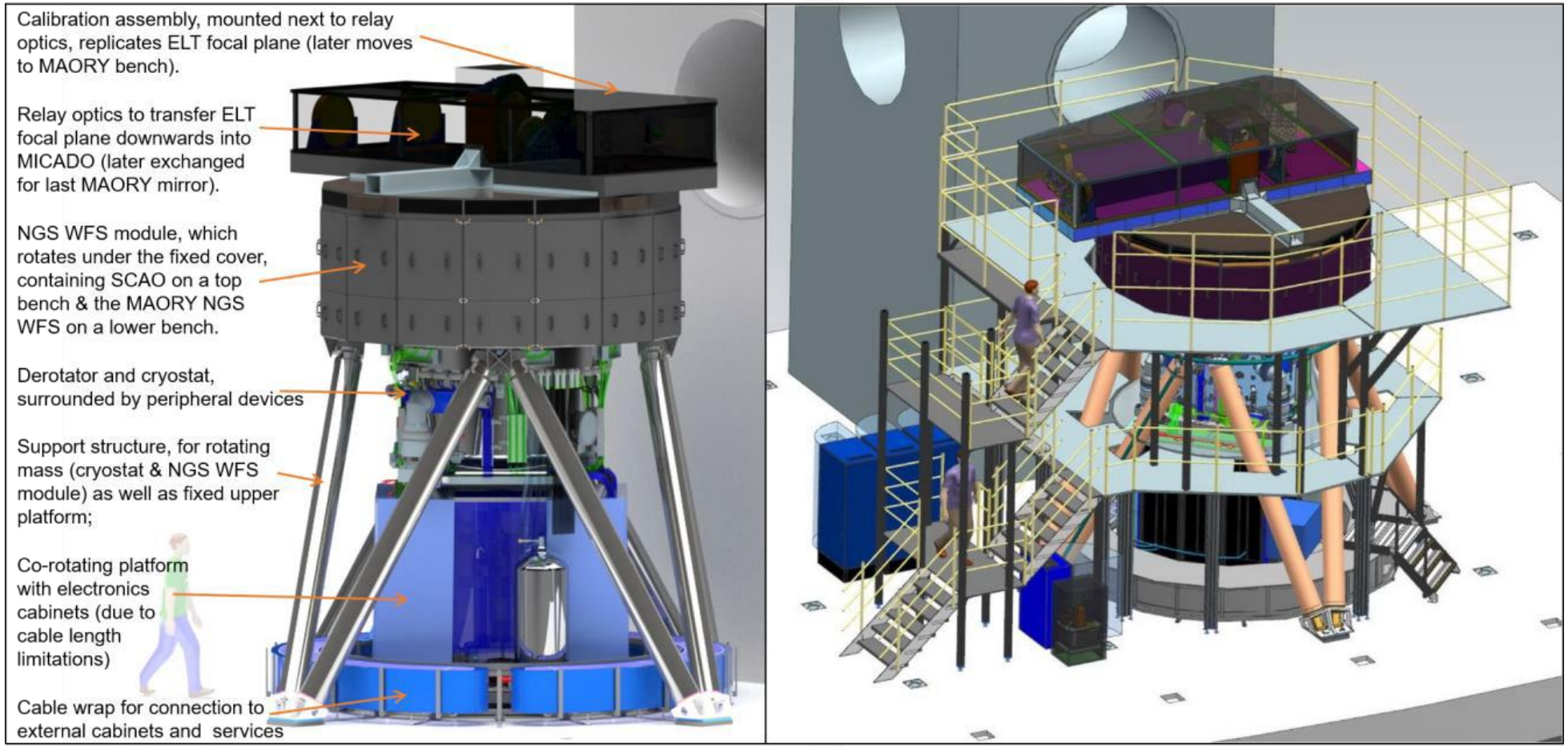


MICADO in MAORY mode

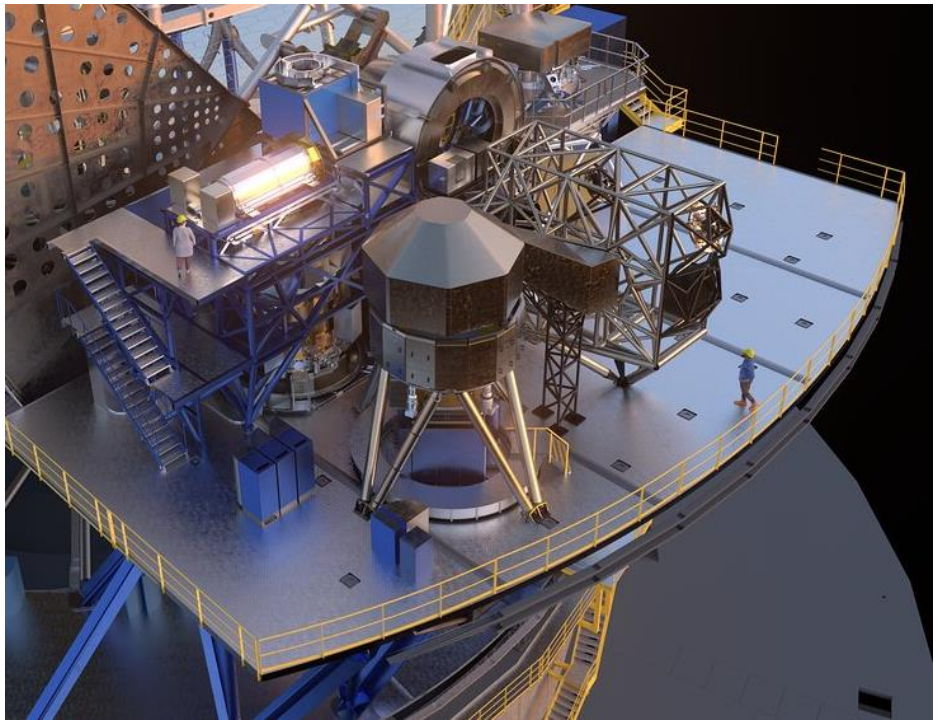
MICADO in stand alone mode

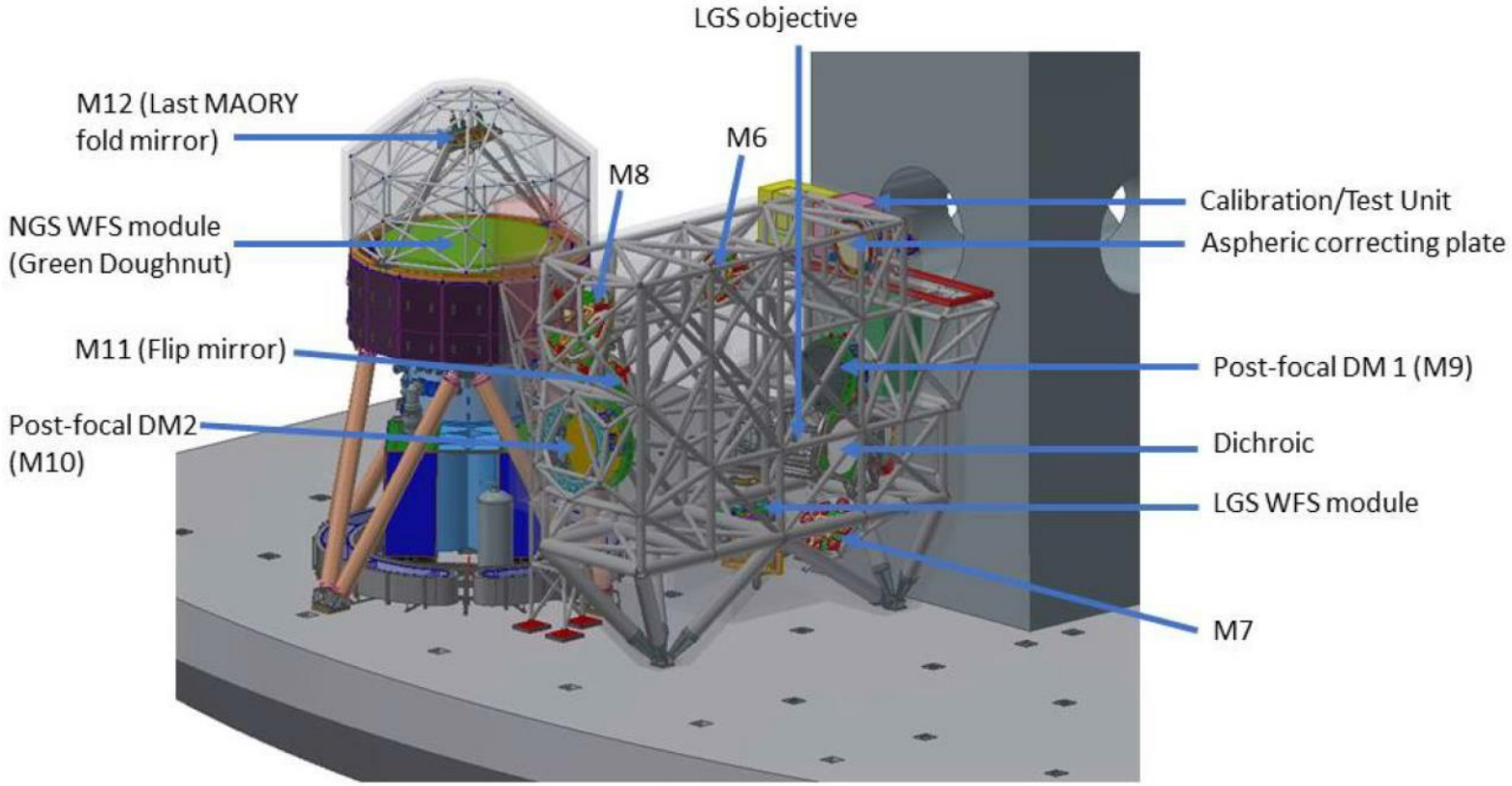


MICADO: Stand Alone

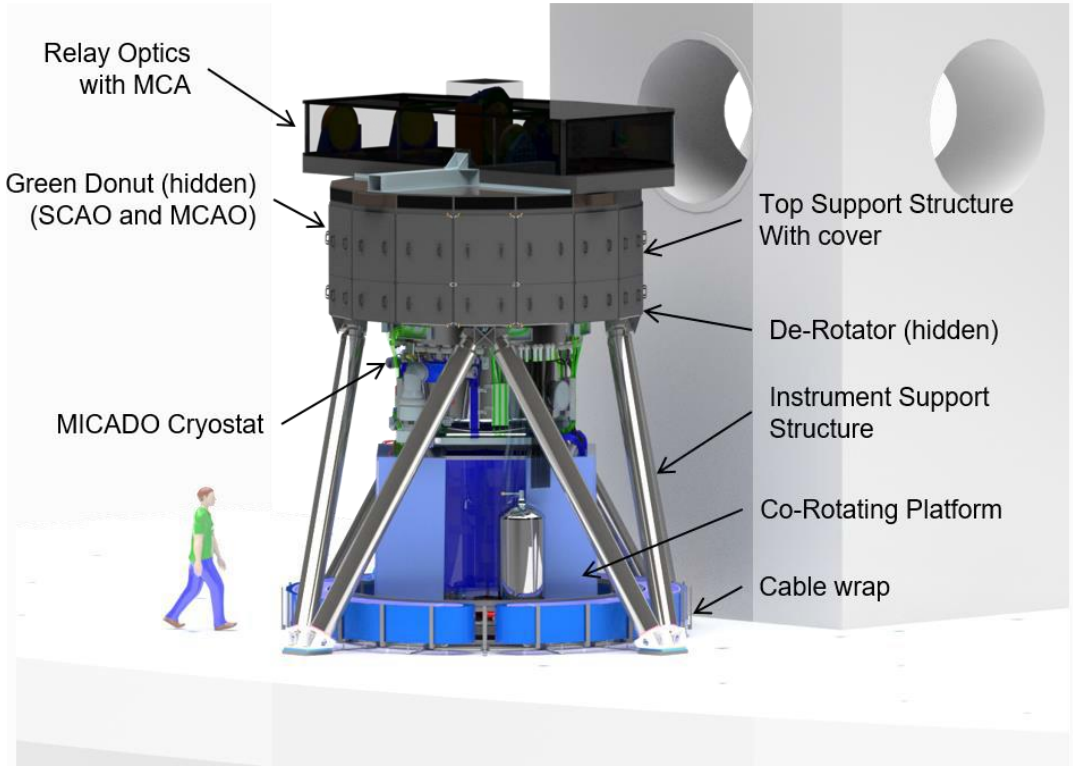


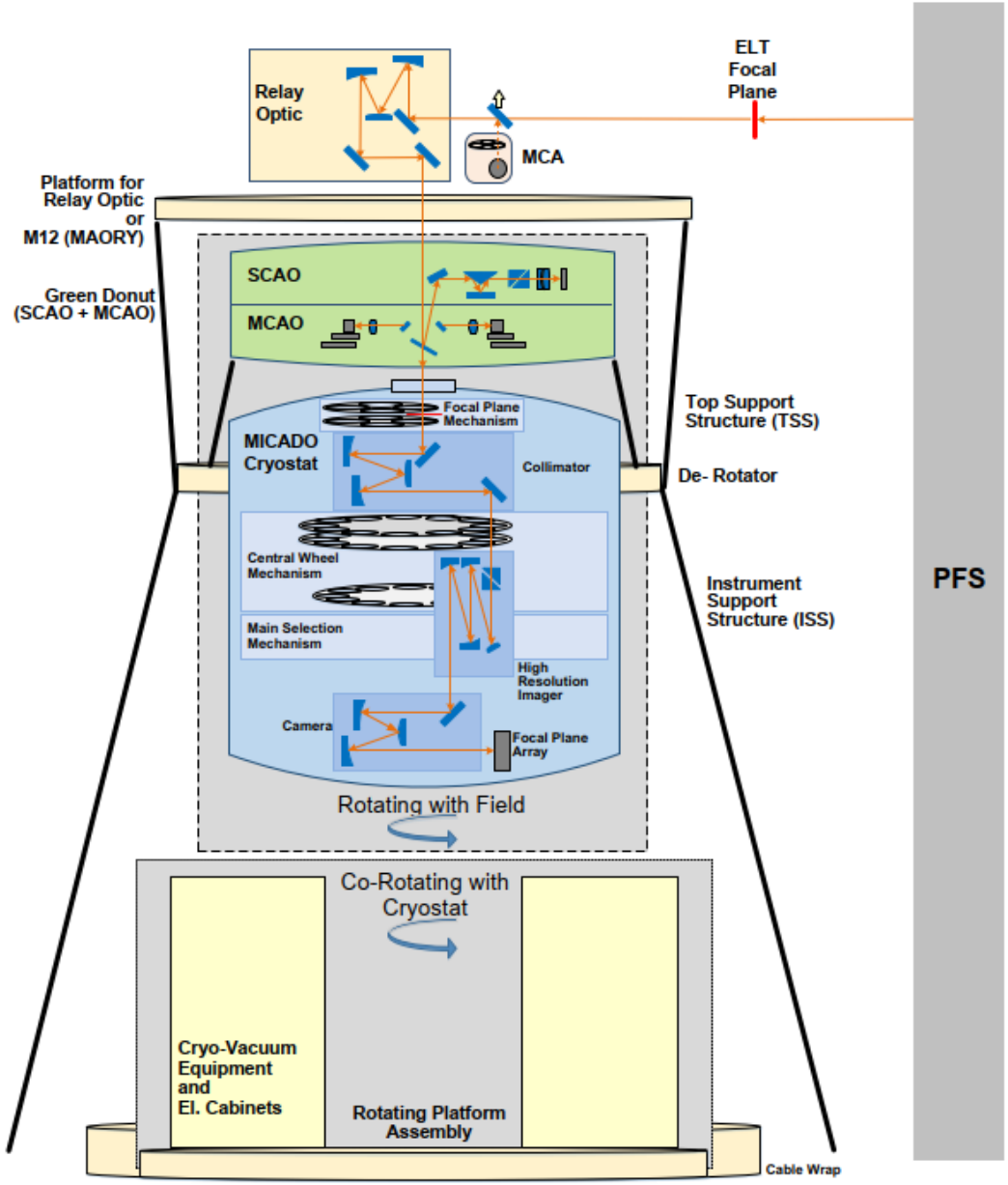
MICADO in MAORY Mode





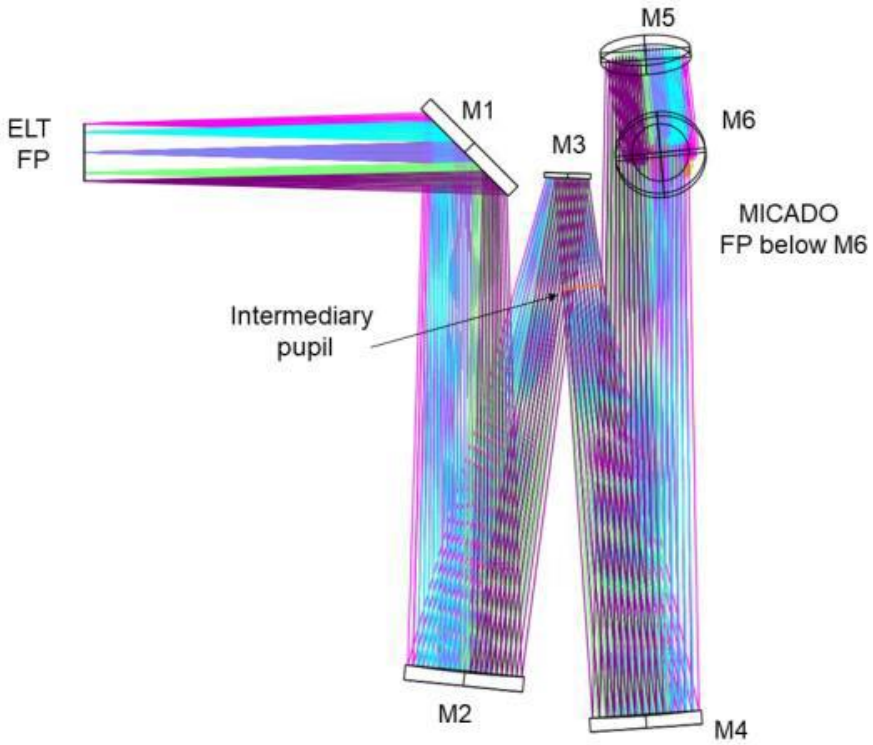
Architecture

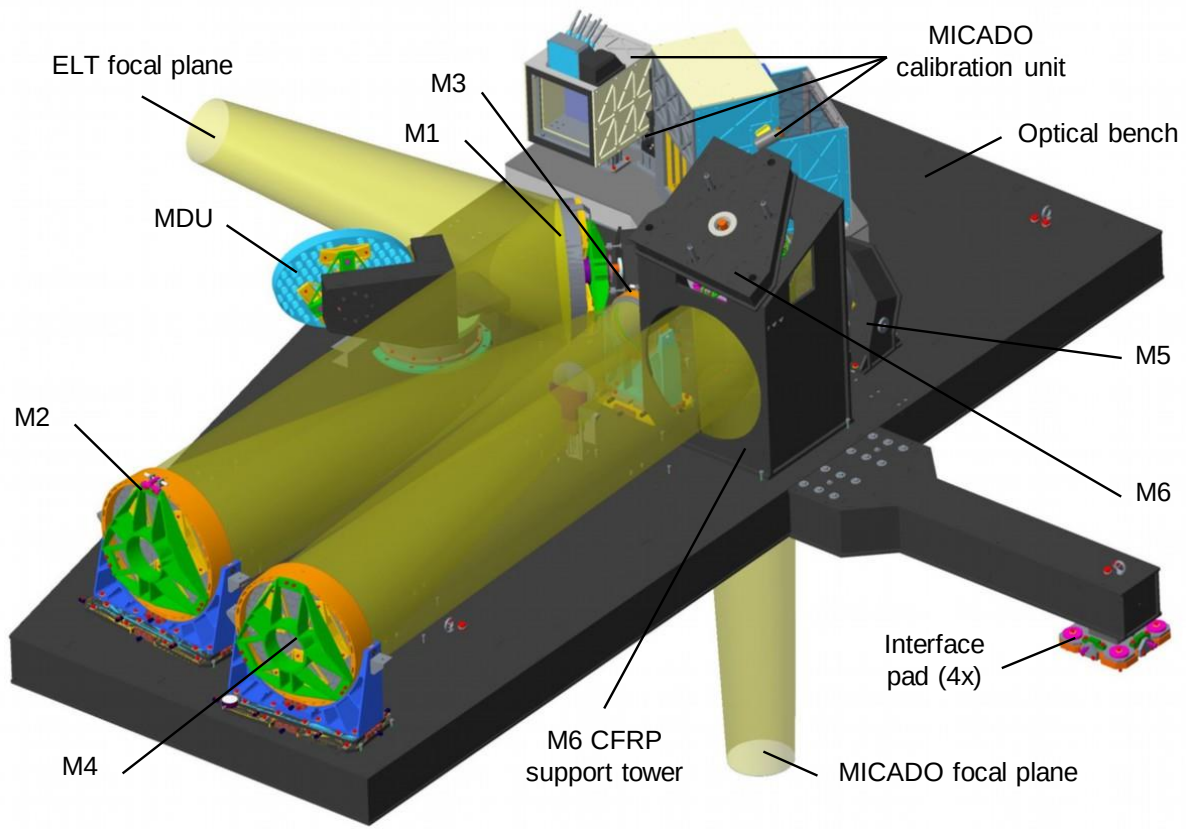




Relay optics

- Three mirror an-astigmat
- Diffraction limited performance
- CFRP breadboard design
- Motorized fold mirrors for field and pupil aligmnent to MICADO





Calibration Assembly

Flat fielding & Spectroscopic calibration:

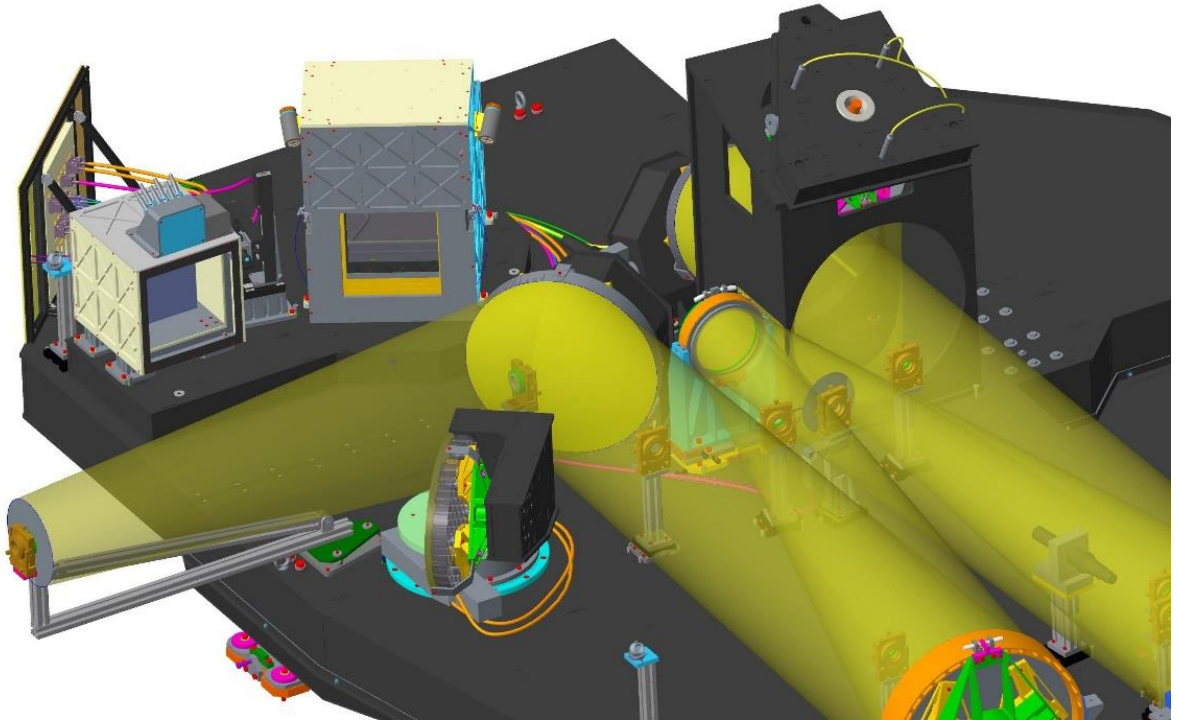
- A spectralon, illuminated by a tungsten lamp for flat fielding, or fibre fed spectral gas lamp sources and a Fabry Perot for spectral calibration

Movable source:

- A diffraction limited source at 0.75 and 1.5 µm patroling within the SCAO field of view

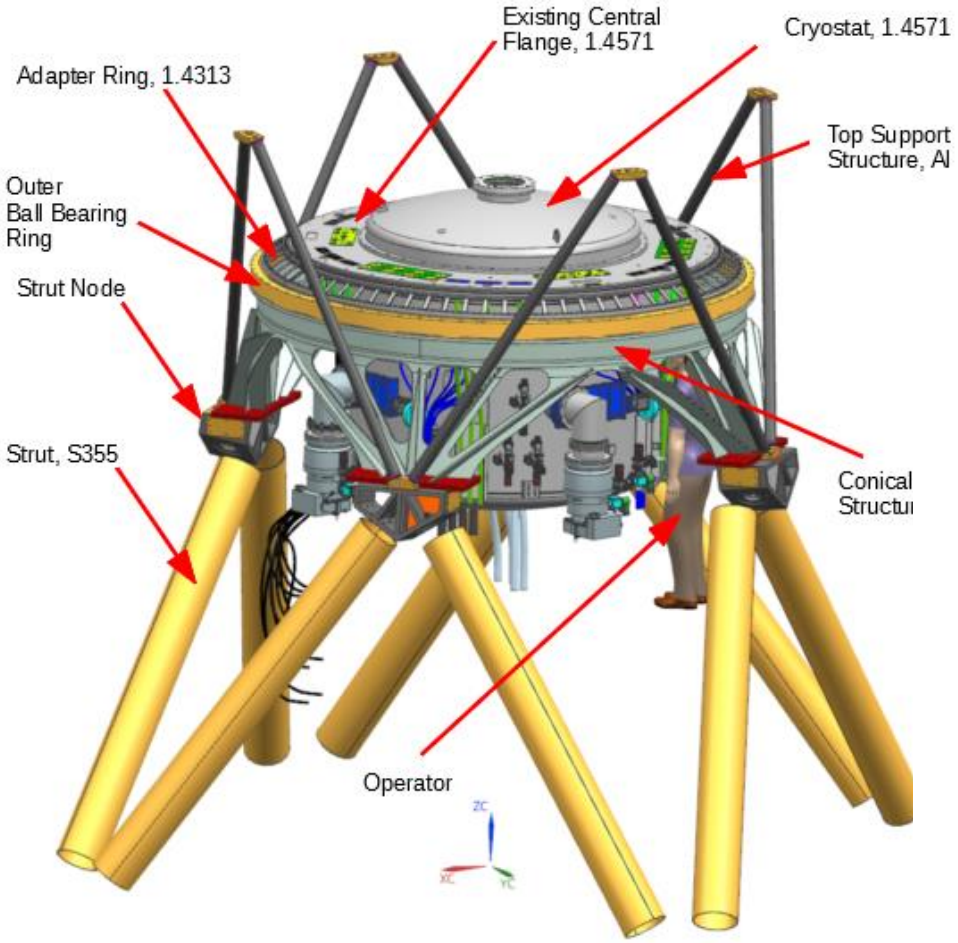
Astrometric calibration:

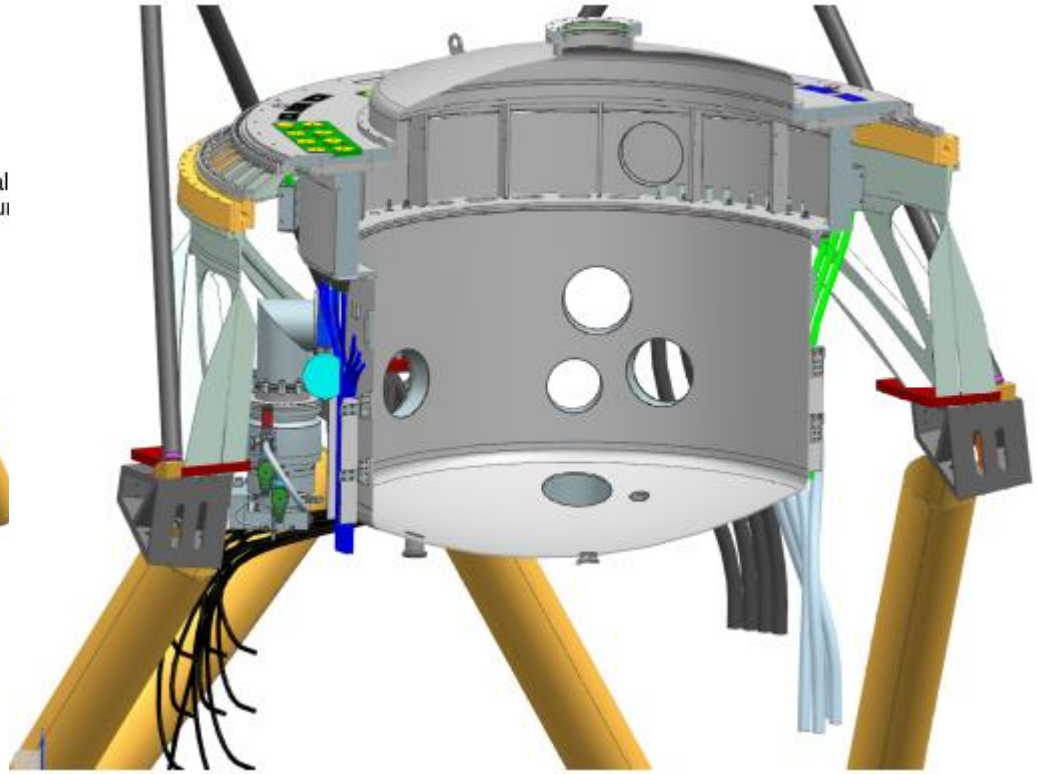
- A pinhole mask attached to a hexapod for astrometric distortion calibration



De-Rotator

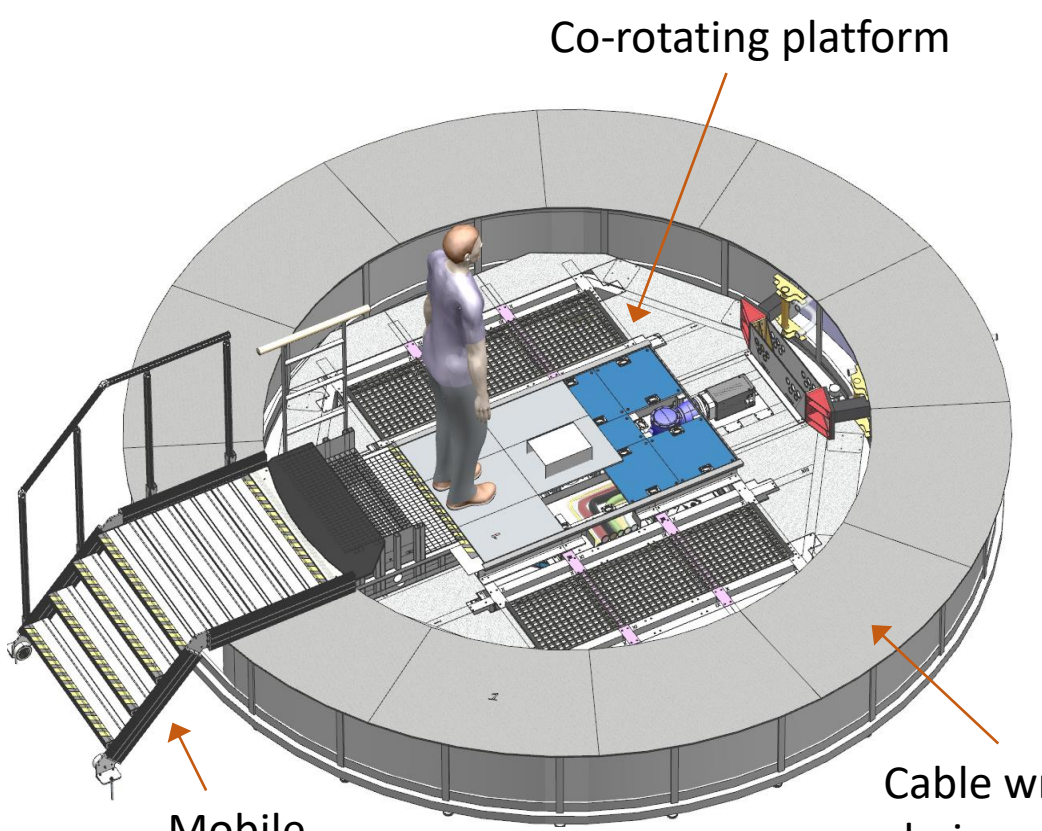
- A large bearing that carries the cryostat and the adaptive optics sensors
- A drive system with a high precision encoder band ensures that MICADO follows the field rotation with ~2 arcsec accuracy

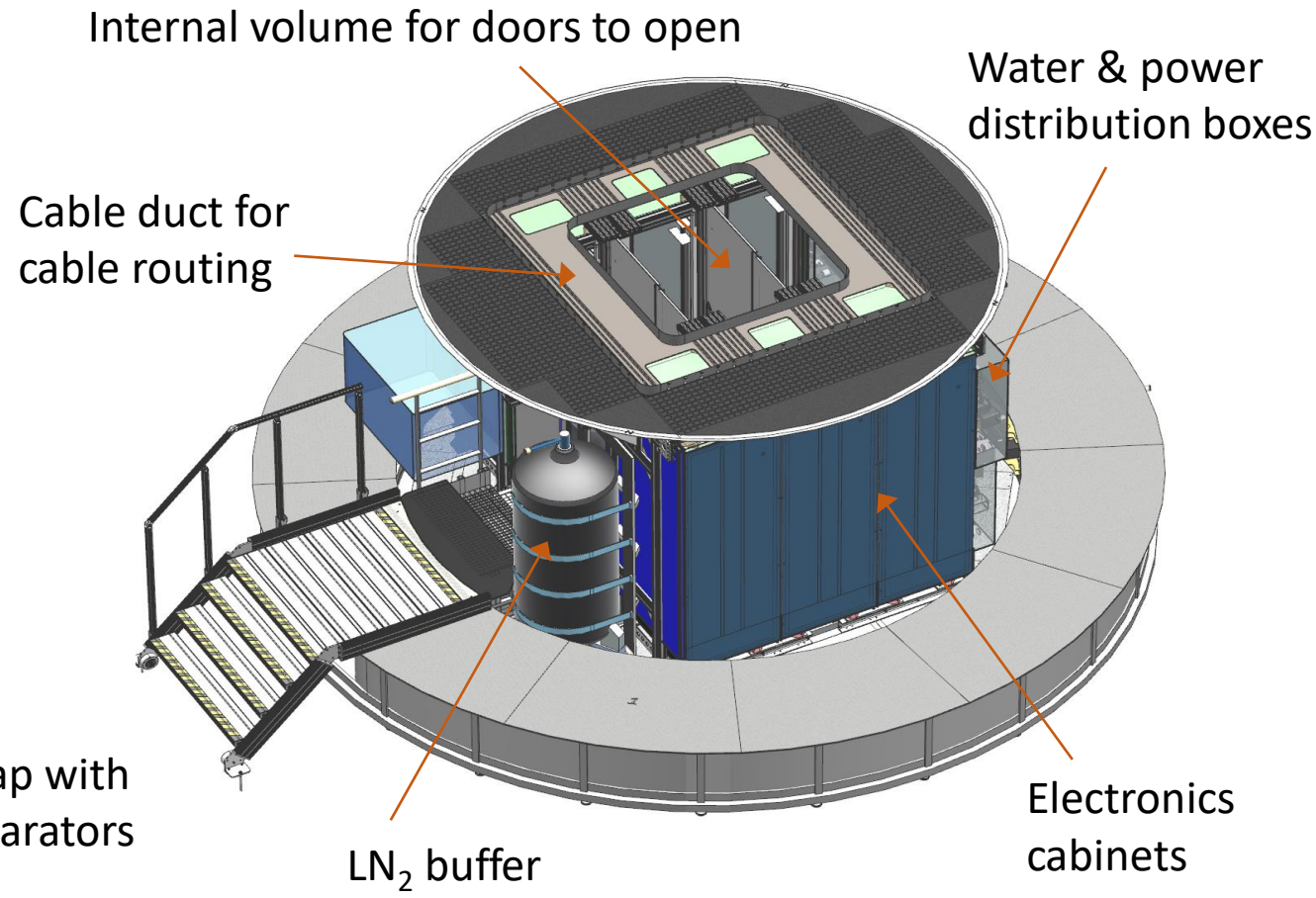




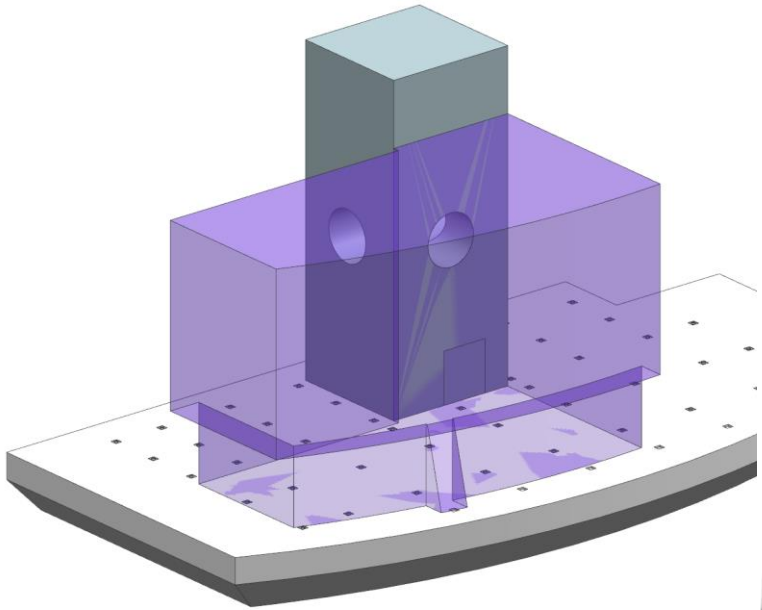
Co-Rotator

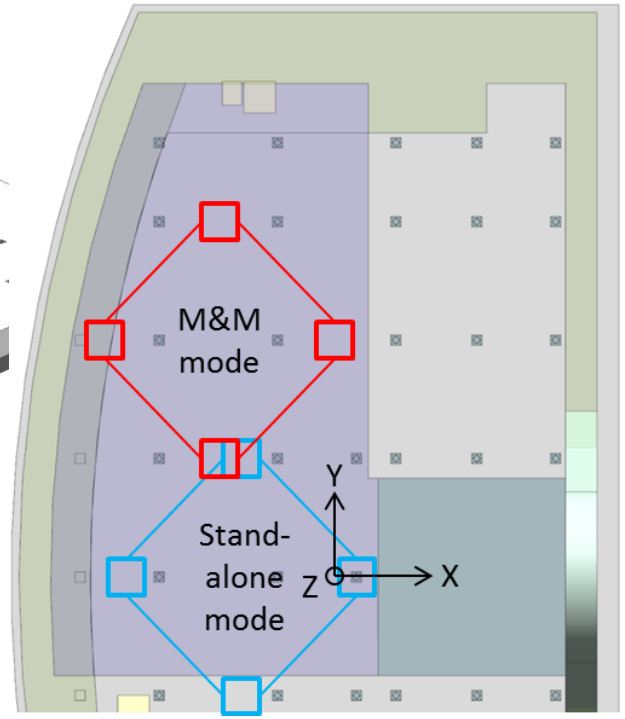
Institut für Astrophysik Göttingen

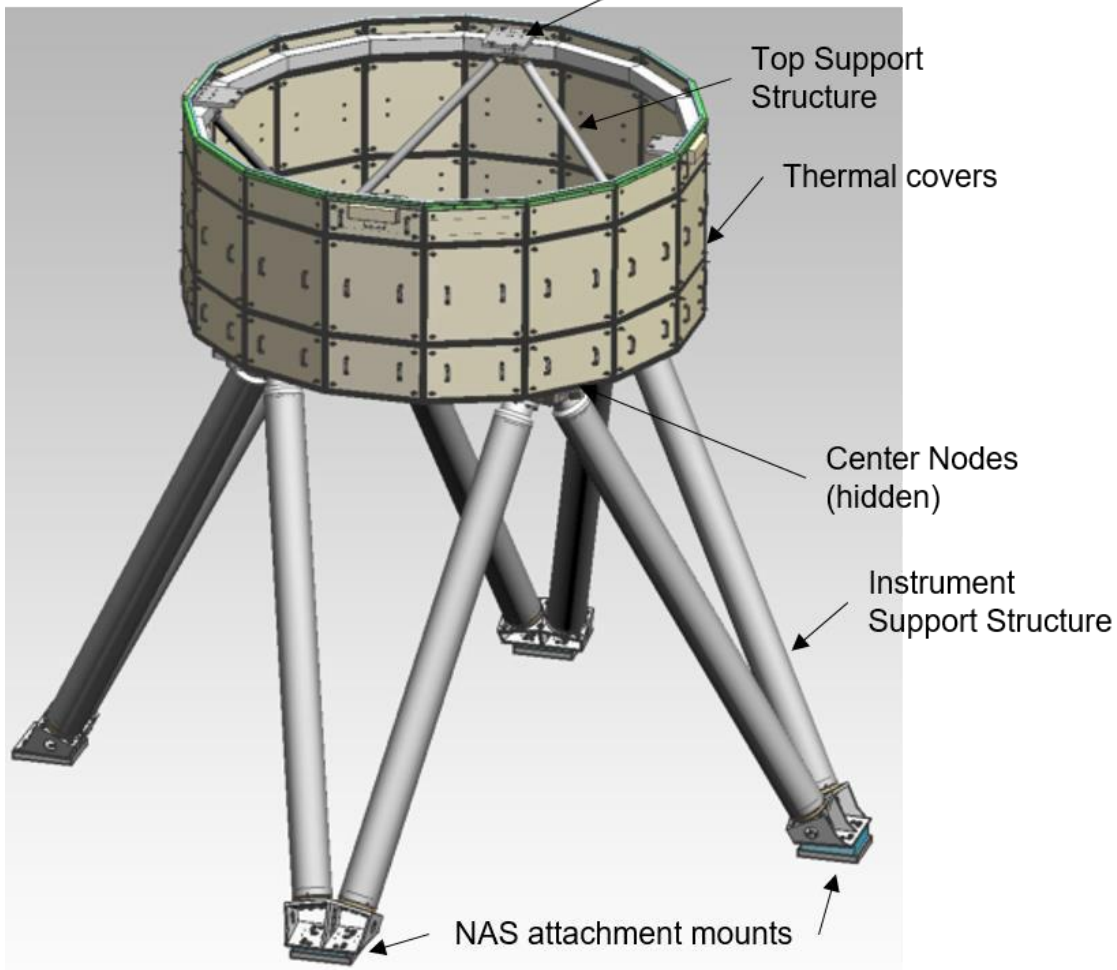




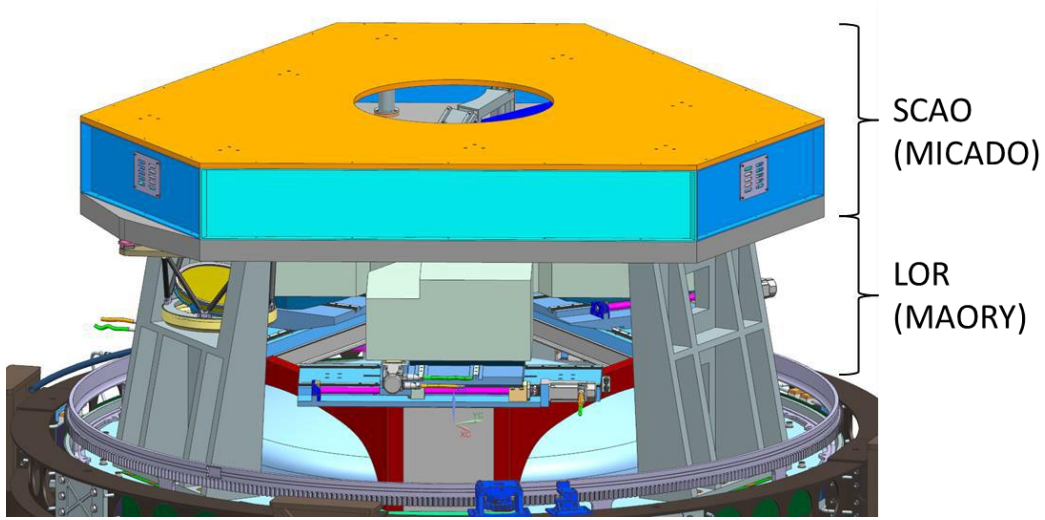
Nasmyth interface & support structure





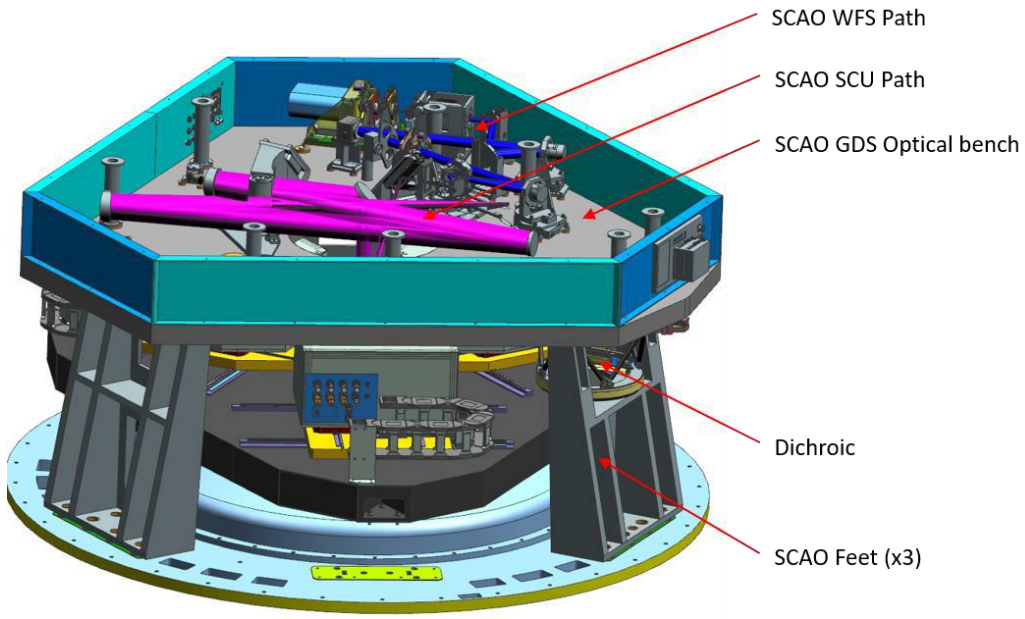


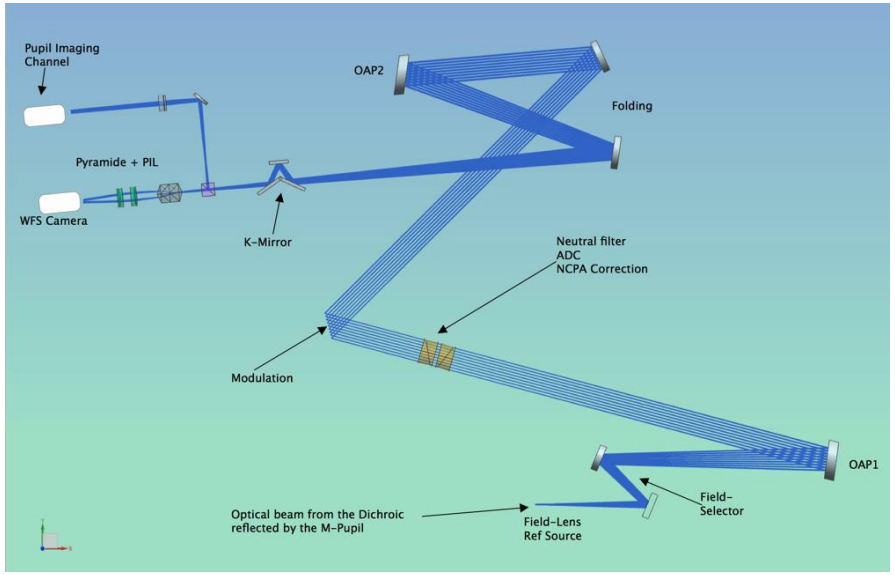
SCAO System



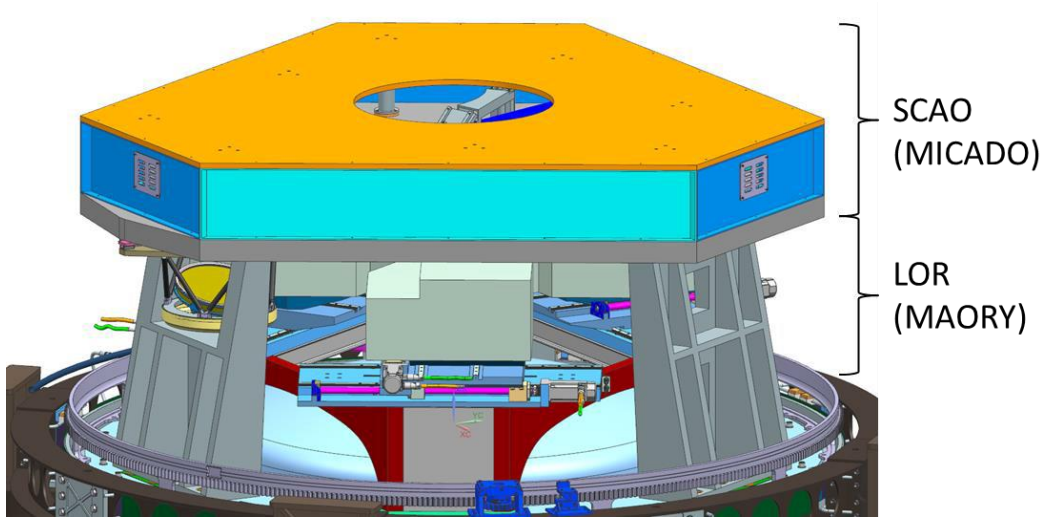
A pyramid based adaptive optics system controlling the ELT built-in adaptive mirror.

- 6x20 arcsec field of view
- atmospheric disperson correction
- K-mirror compensating the pupil rotation
- WFS camera based on EMCCD

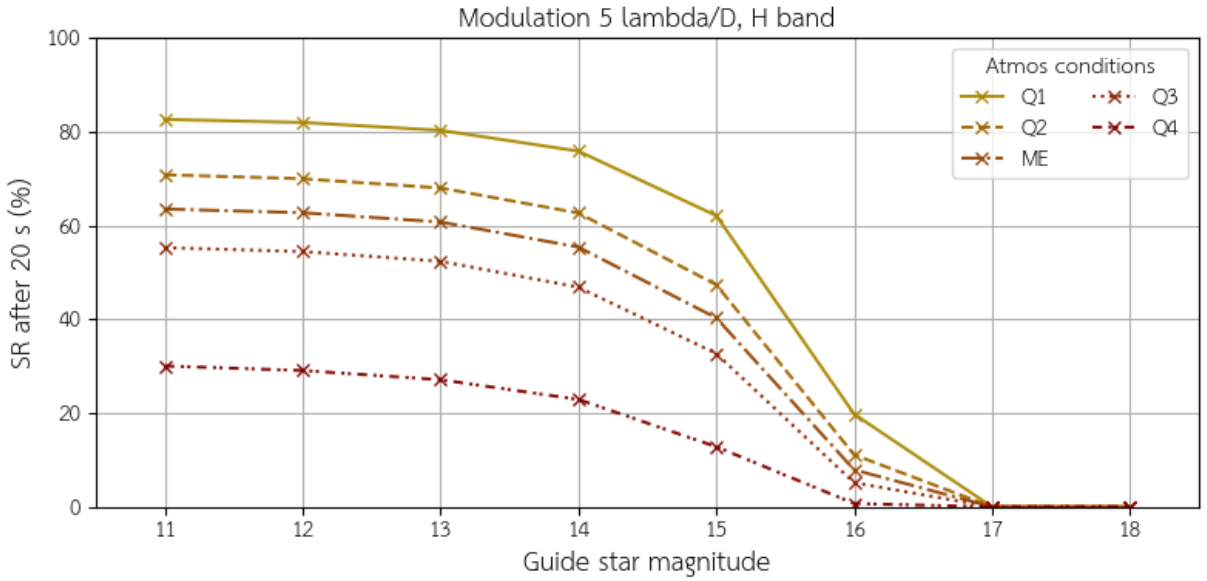


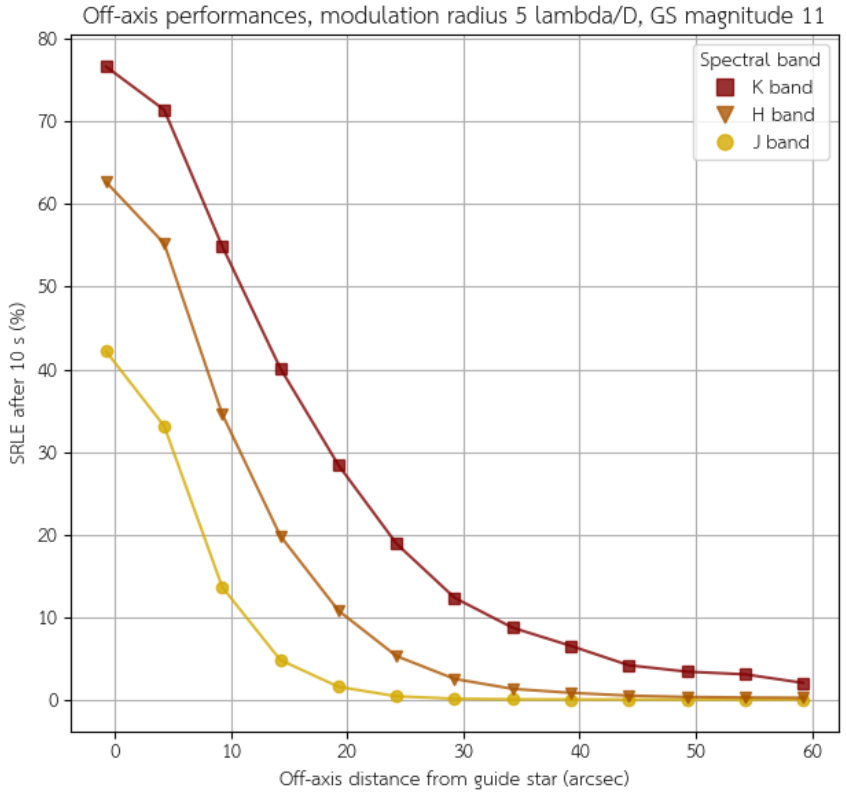


SCAO System



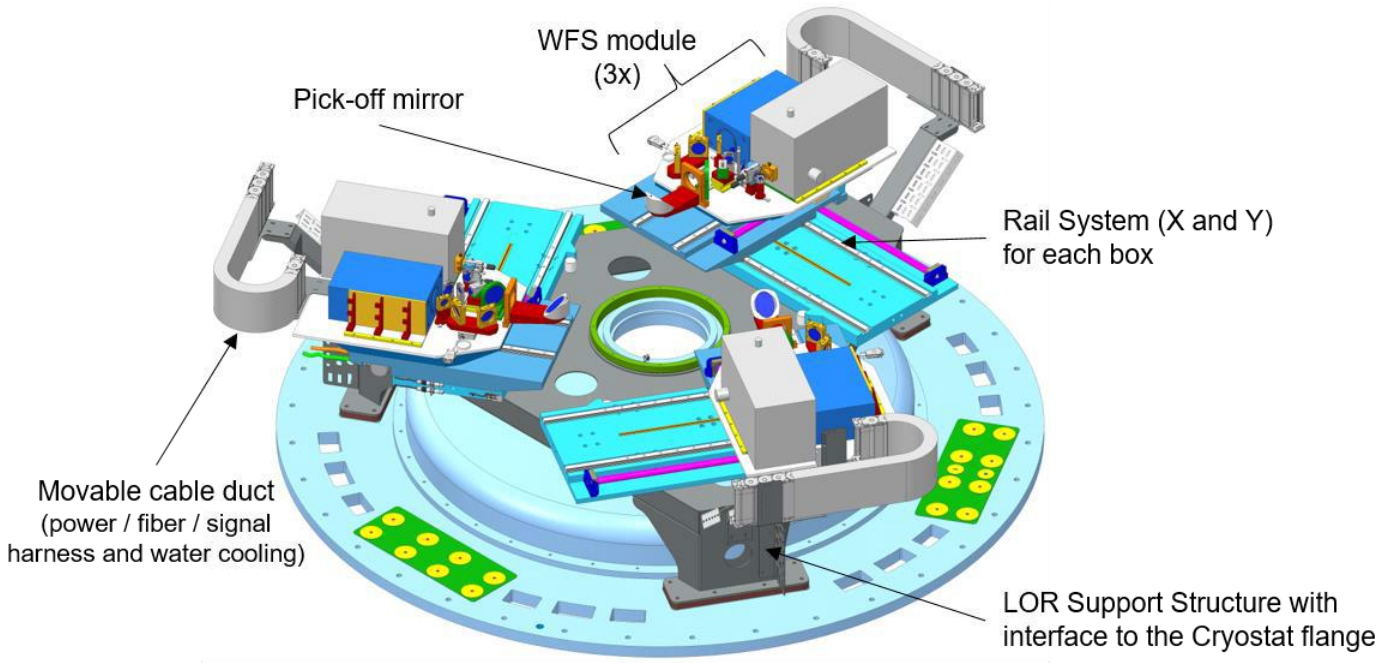
Expected Performance

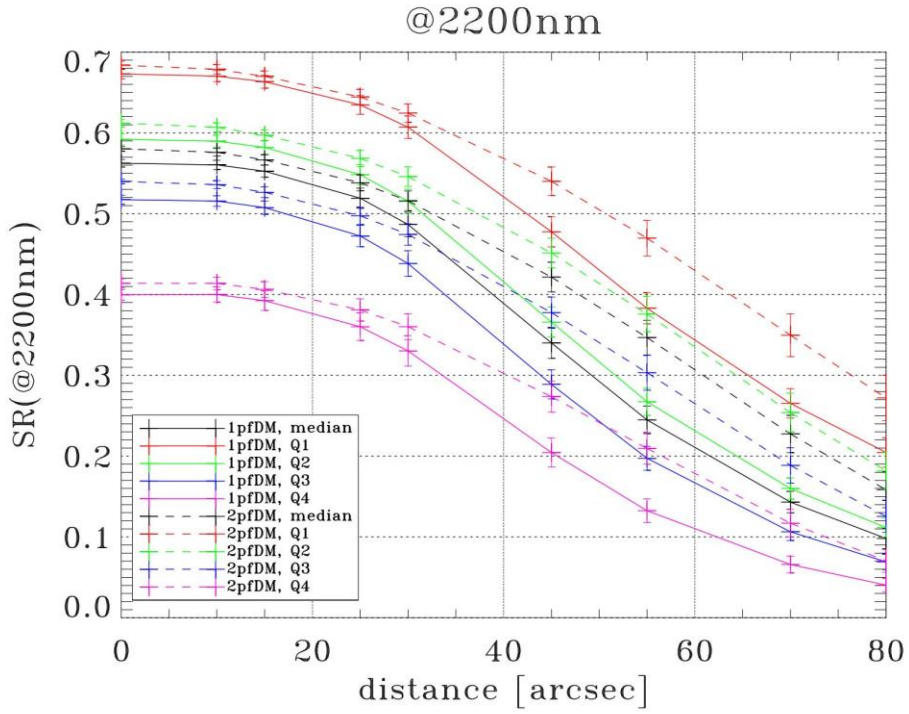




MCAO LOR module

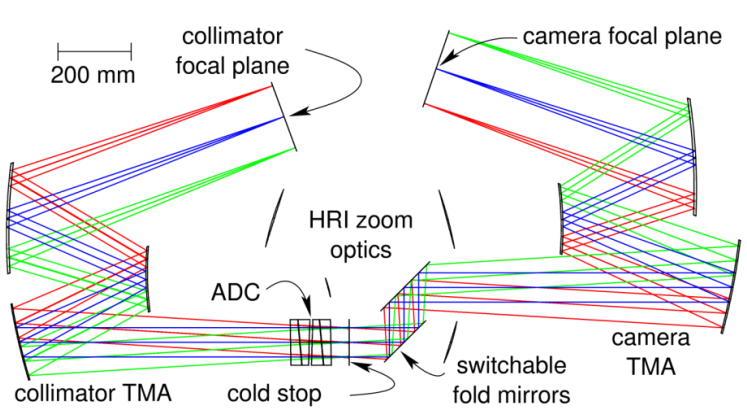
- Picks 3 stars in a large patrol field for low order referencing
- NIR and VIS cameras



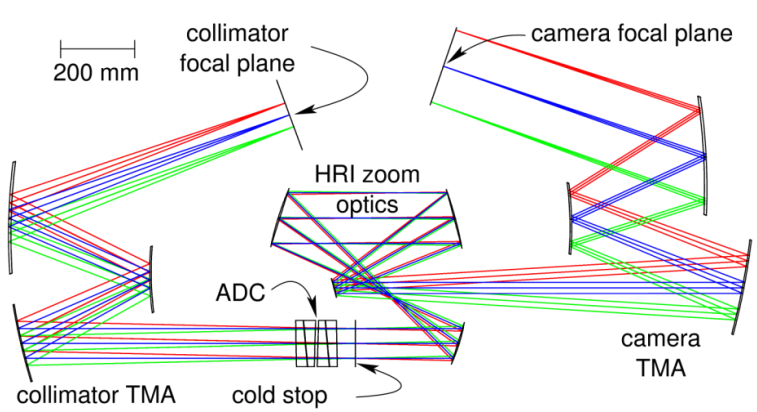


Expected MAORY performance

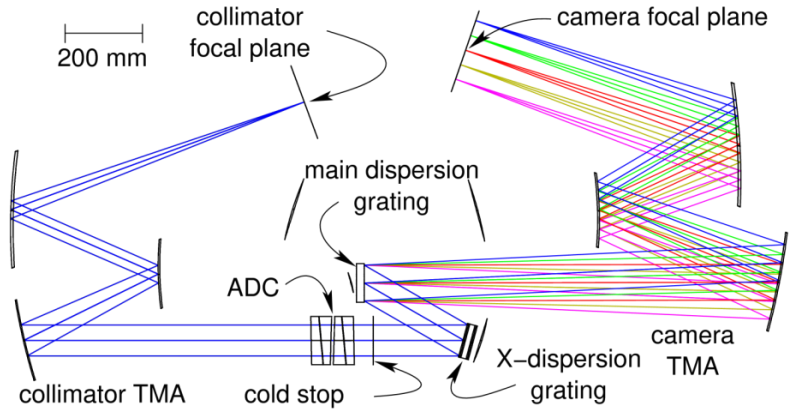
Cold optics



Low resolution mode



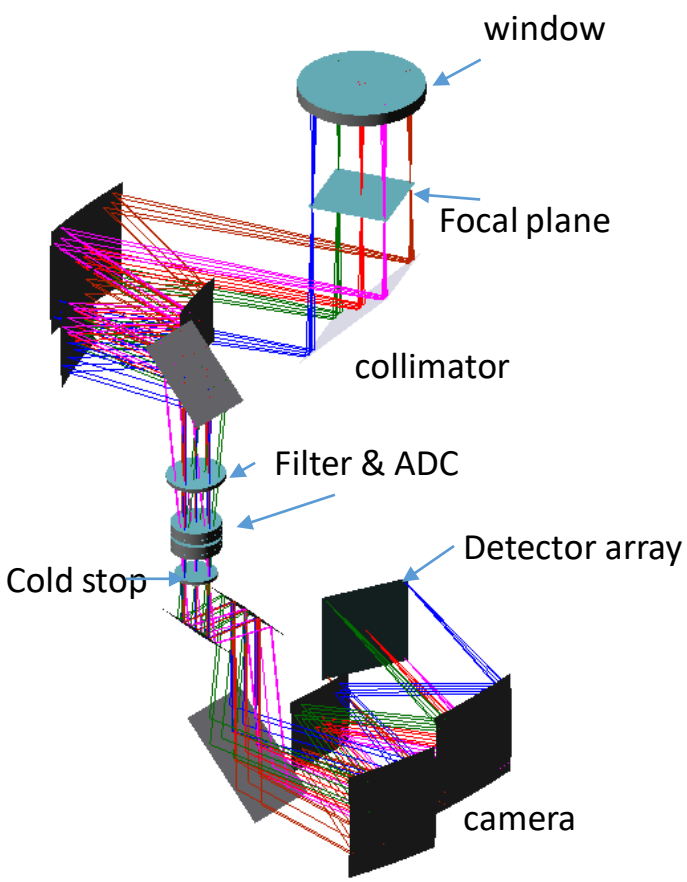
High resolution mode

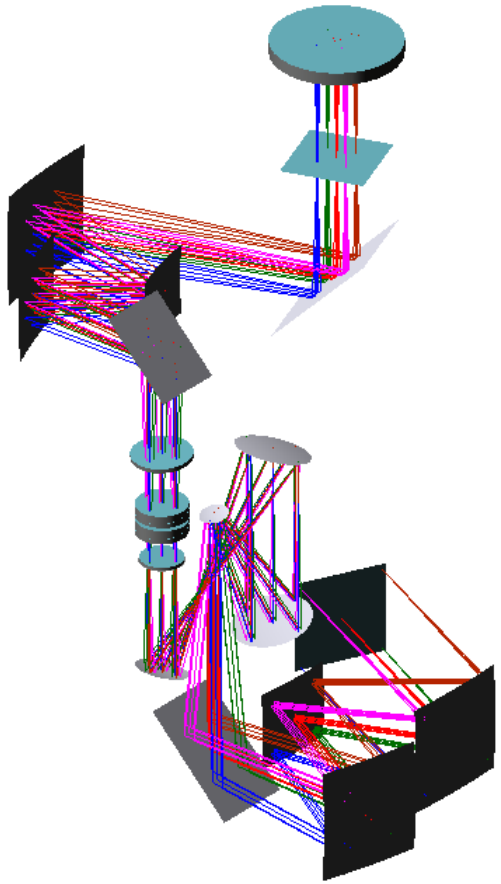


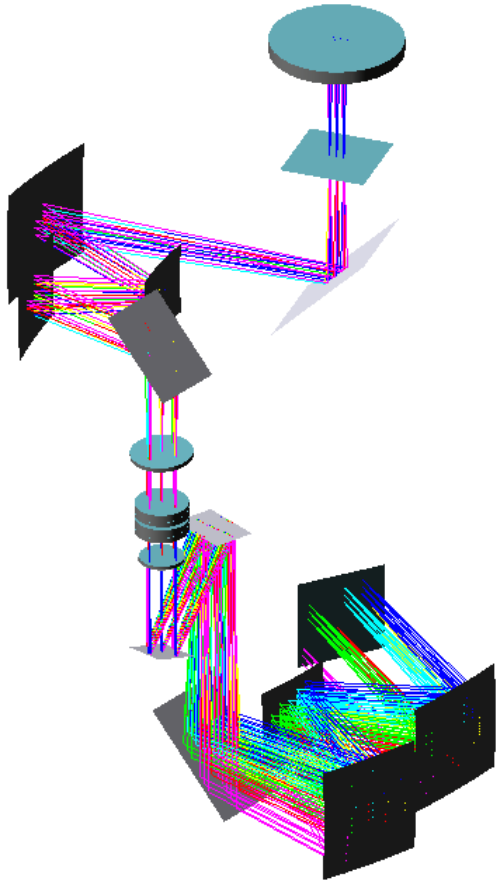
Spectroscopic mode

Cold optics

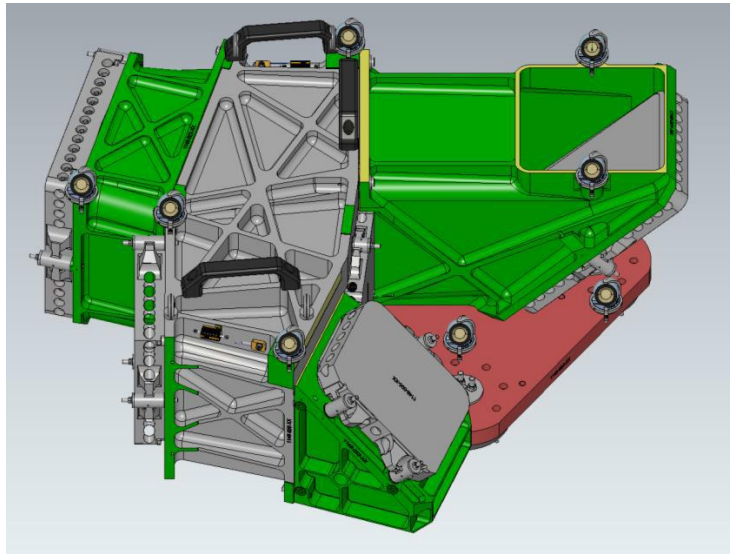
3-d arrangement





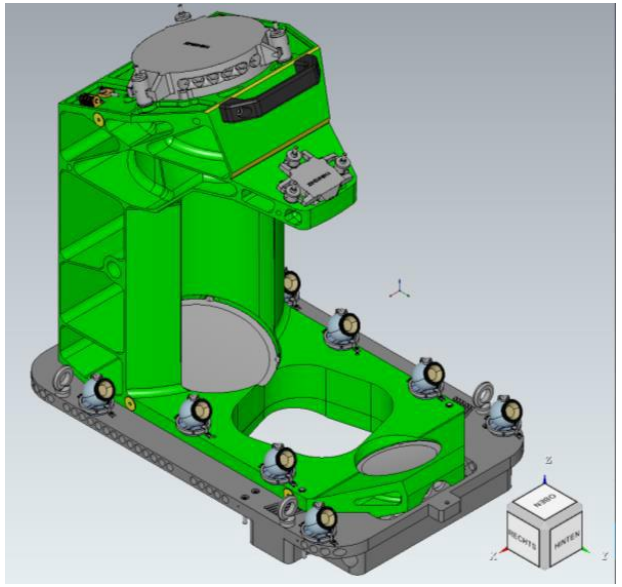


Cold optics assemblies

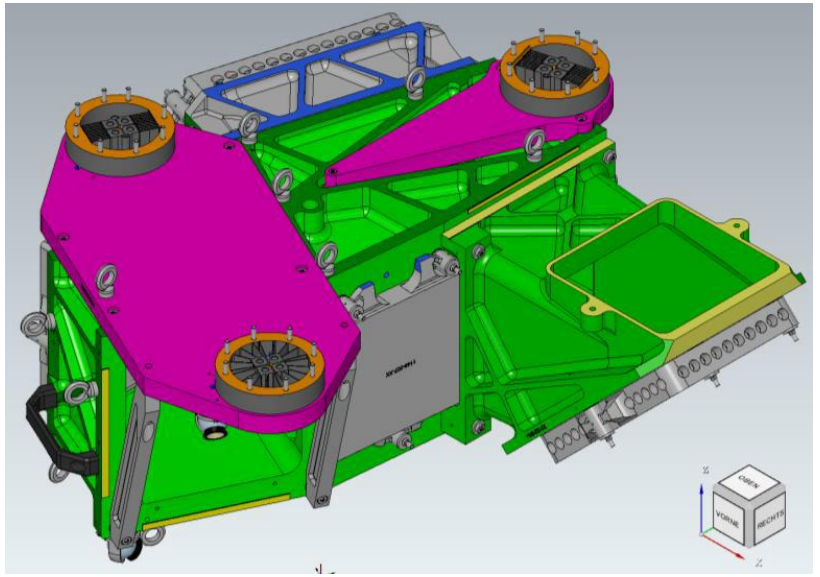


Collimator

- Free form metal mirror assemblies
- Diffraction limited performance
- Integrated units



High resolution imager

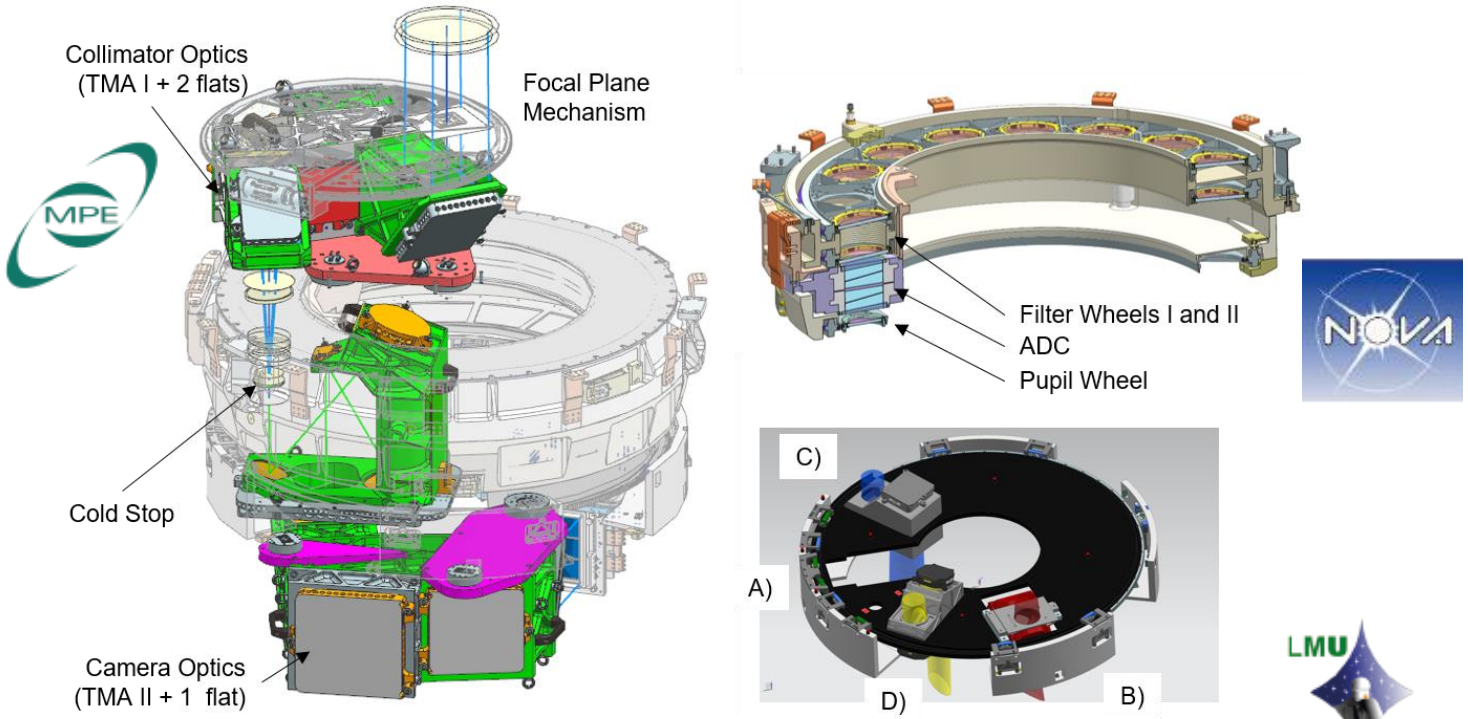


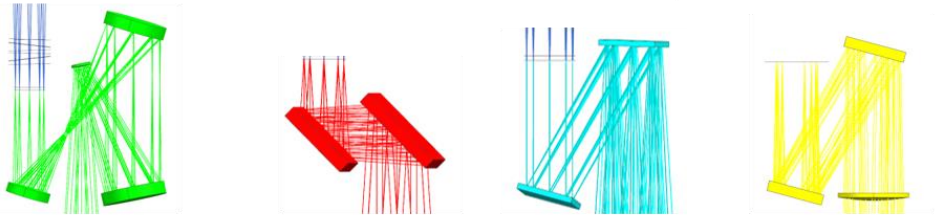
Camera

Fraunhofer IOF

Fraunhofer-Institut für Angewandte Optik und Feinmechanik IOF

Cryo mechanisms





A) HRI
1.5 mas imager
(4 fixed mirrors)

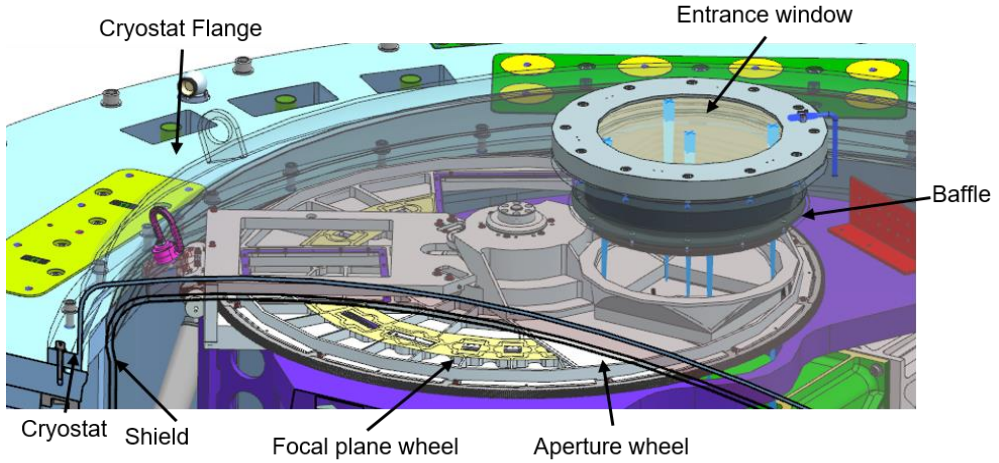
B) LRI
4 mas imager
(2 flat fold mirrors)

C) SPE
Spectroscopy
(2 gratings)

D) PIM
Pupil Imager
(2 mirrors)

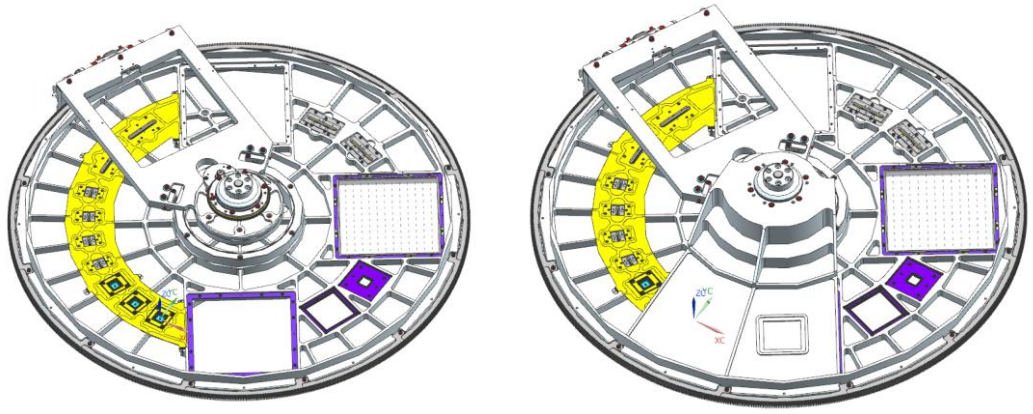
- Focal plane mechanism
- Filter wheels
- ADC
- Pupil wheel
- Main switching mechanism
- Detector positioning system

Focal Plane Mechanism



Focal plane wheel:

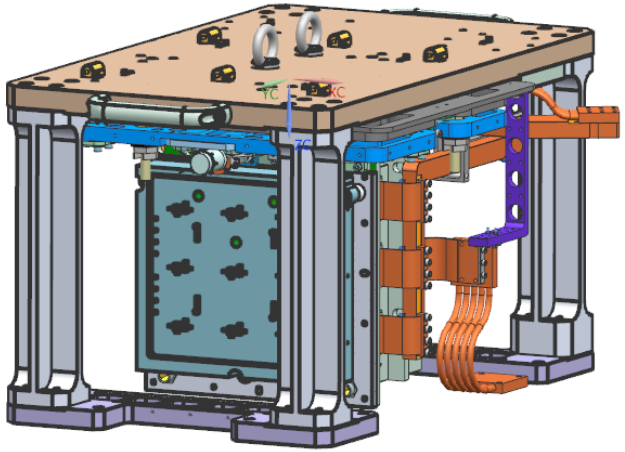
- Holds all field masks, slits, coronographs and an astrometric calibration mask
- Precise re-positioning required
- Driven by a magnetically coupled gear system for high precision and wear free movement
- Capacitive encoder included



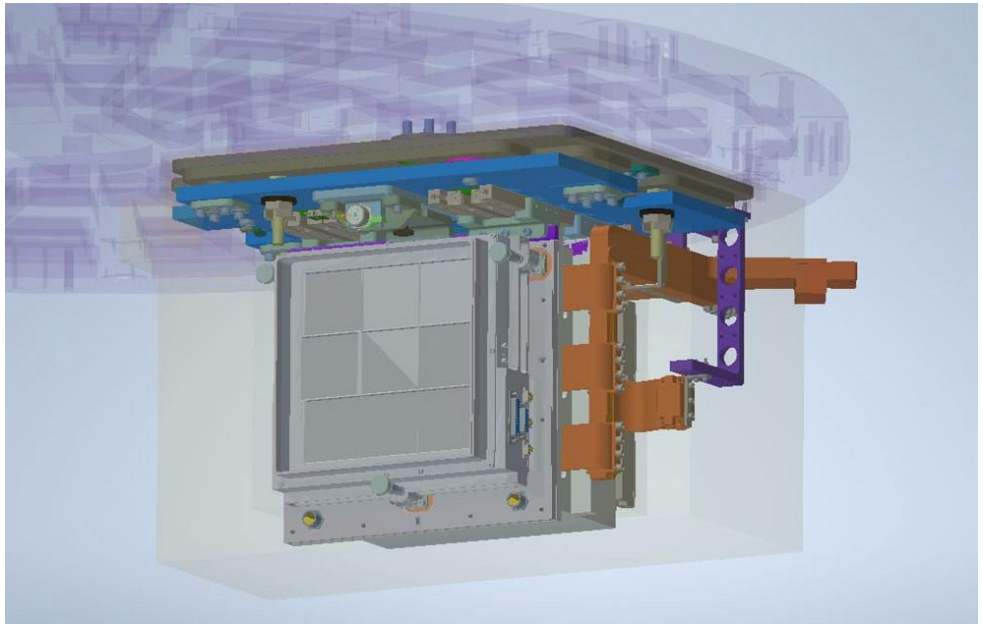
Shutter wheel

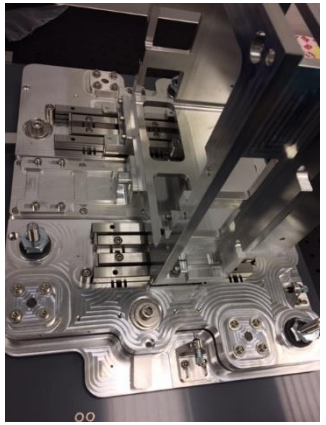
- Opens/ closes the light path
- Positions a small field mask
- Driven by a magnetically coupled gear system for wear free movement

Detector Array and Positioning System

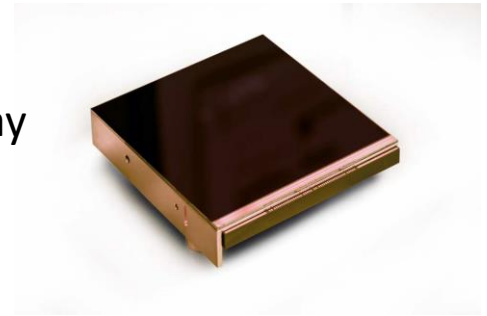


- Prototype design finished
- Nearly all parts are manufactured and assembled in the warm
- cleaning and integration into the EUCLID Cryostat
- Functional test in the cold in progress

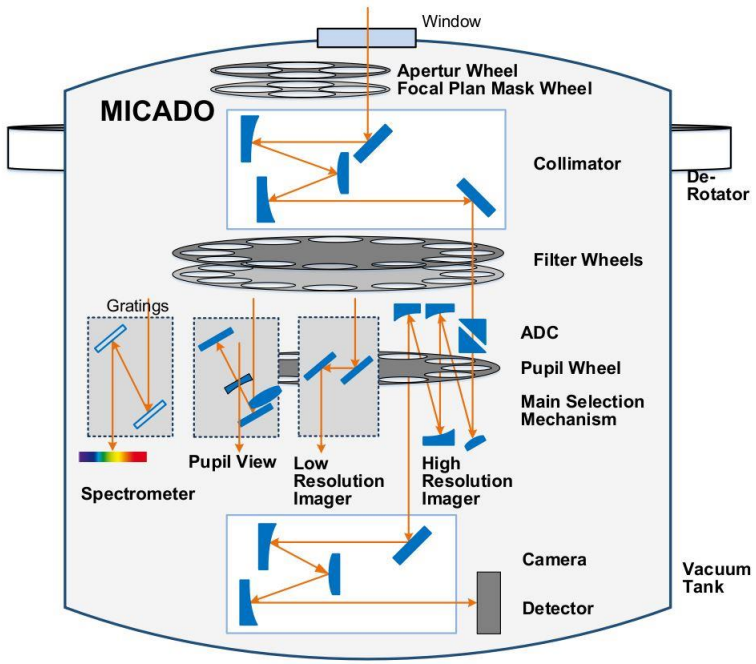


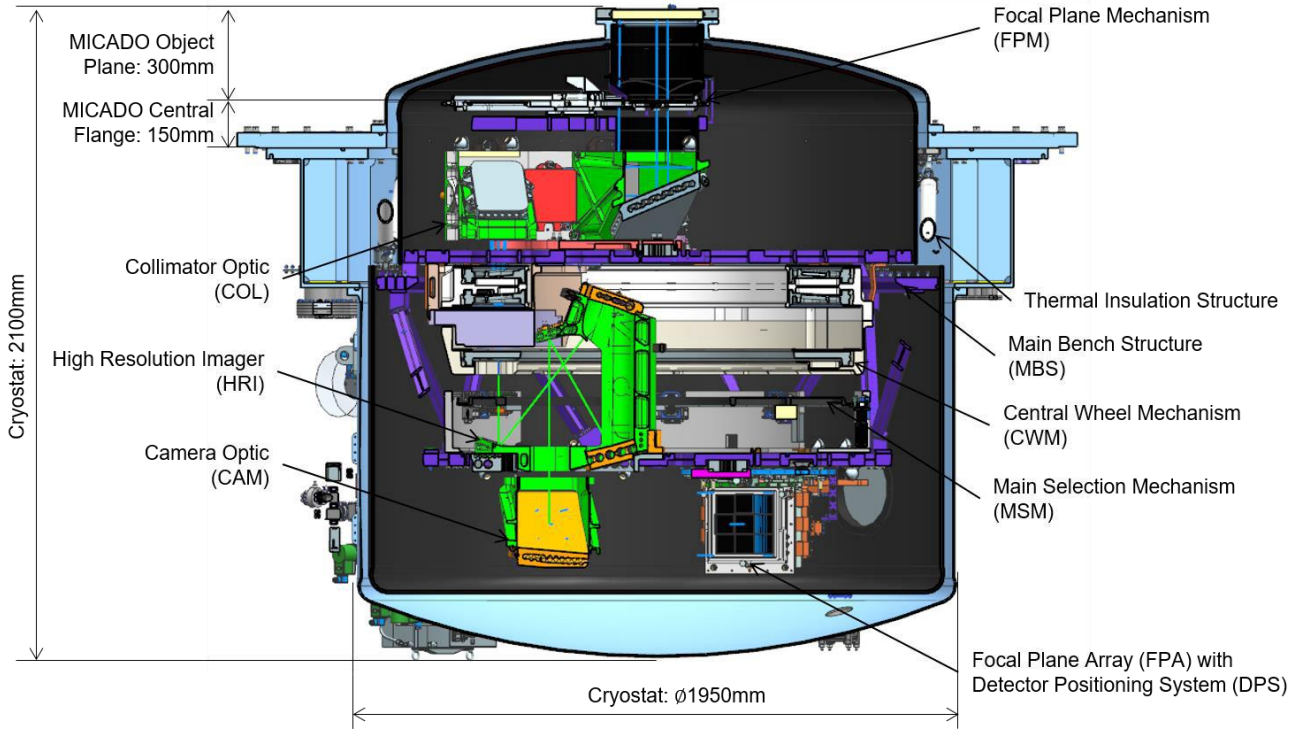


- 9 H4RG Detector array
- Mounted to an alignment and focussing stage

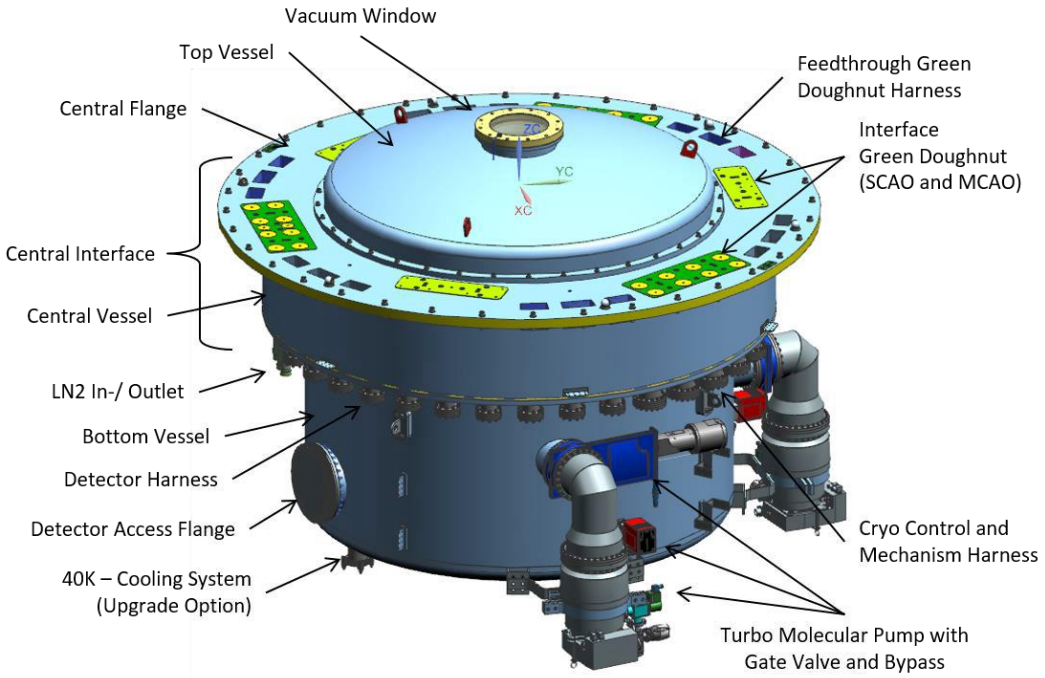


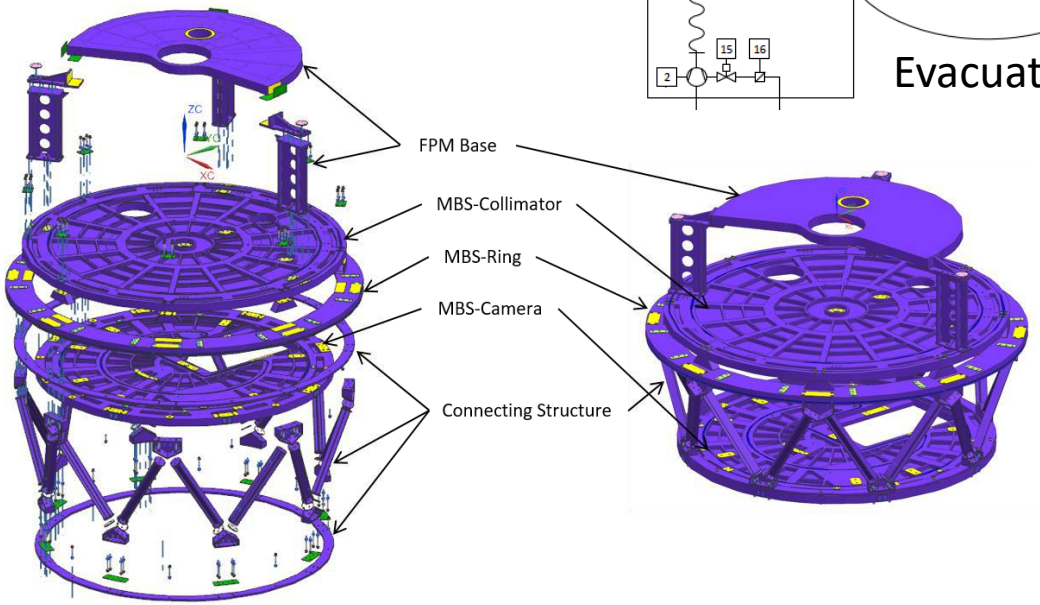
Cryostat assembly

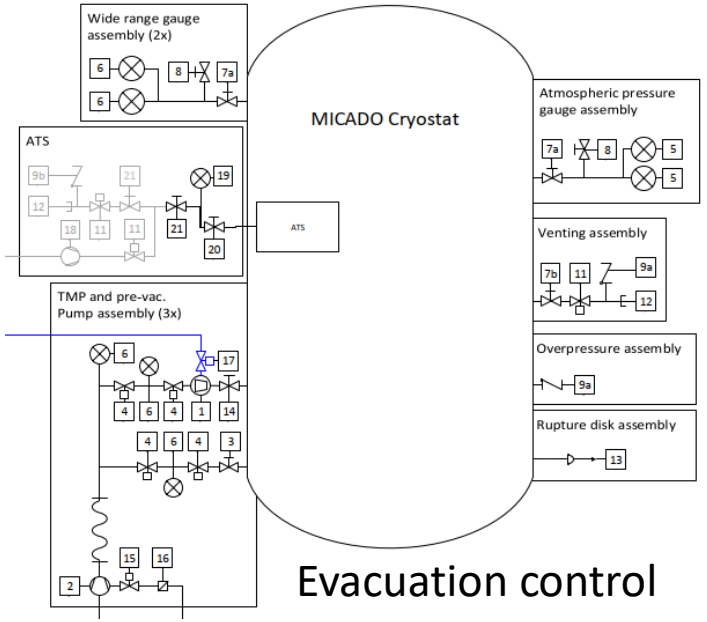




Cryo structure & vessel







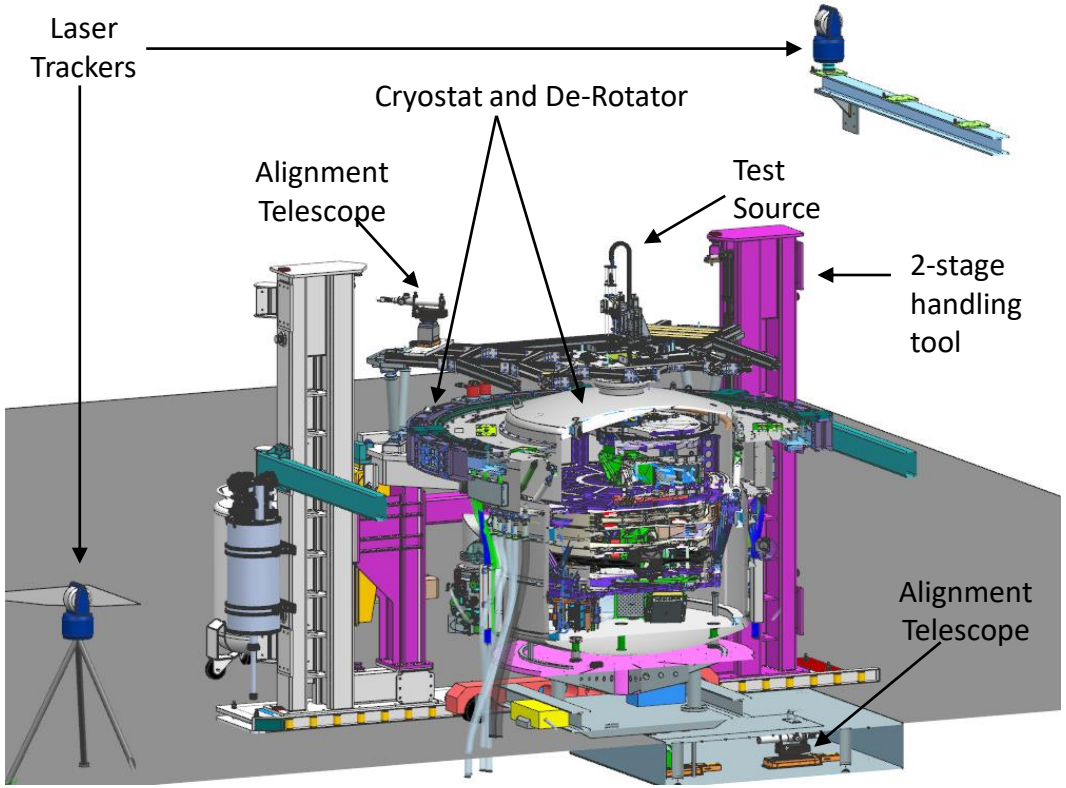
Evacuation control

AIT/V

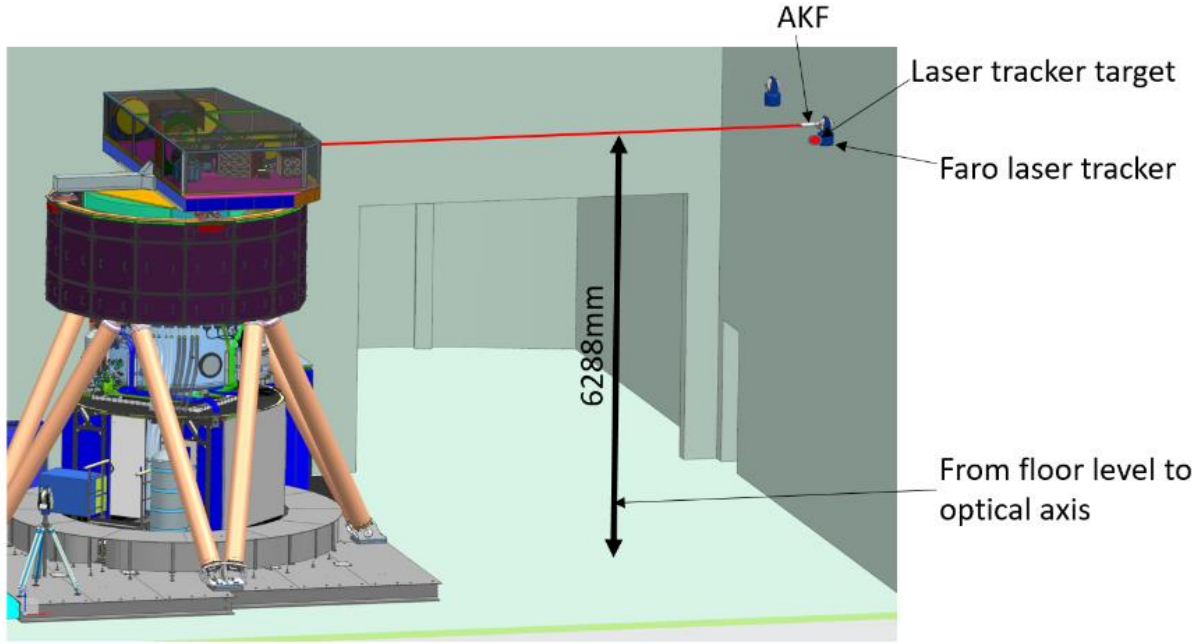
- Following modular approach → integration, test and verification campaigns already at sub-system level

- At higher level: 2 phases (+ the integration at the telescope)

→ Cold system (Cryostat + De-rotator + SCAO)

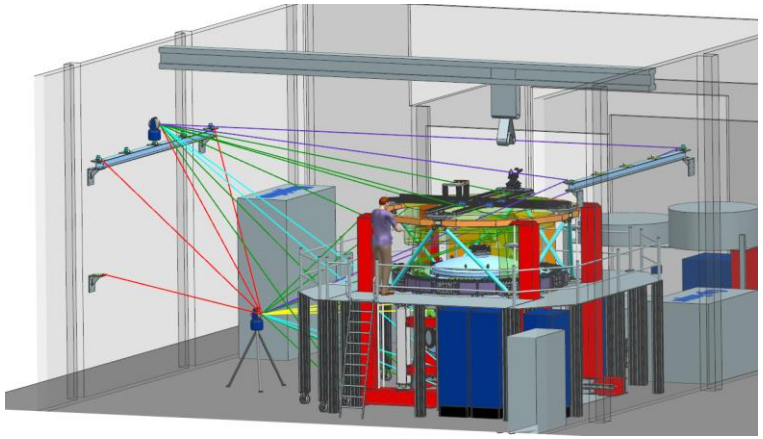


→ Warm system (Cold system + Relay Optics + Calibration Unit + Support structure + Co-rotator)

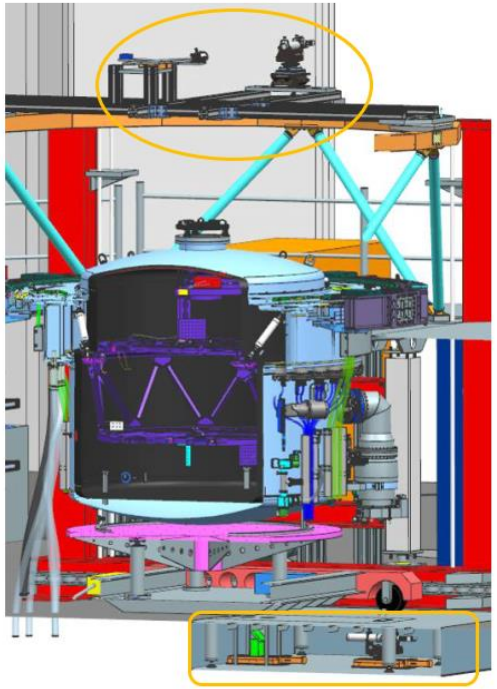


Integration and Aligment strategy

- Define a reference system linked to De-rotator rotation axis, using a laser tracker system and retro-reflectors on all sub-systems (for Cold and Warm system)



- Define a reference system linked to De-rotator rotation axis and to the pupil position, using alignment telescopes (for the Cold system)



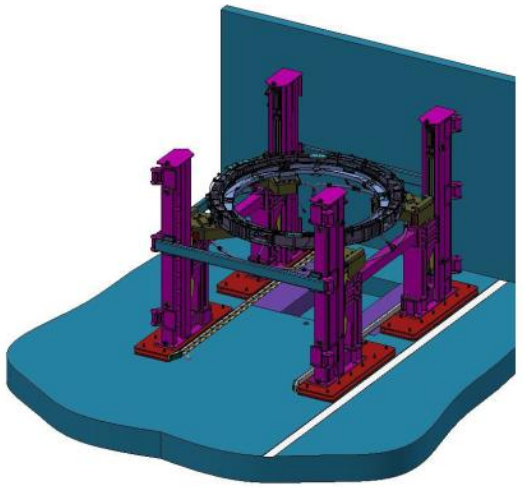


Figure 4: X4SS in 0 position X4 hall

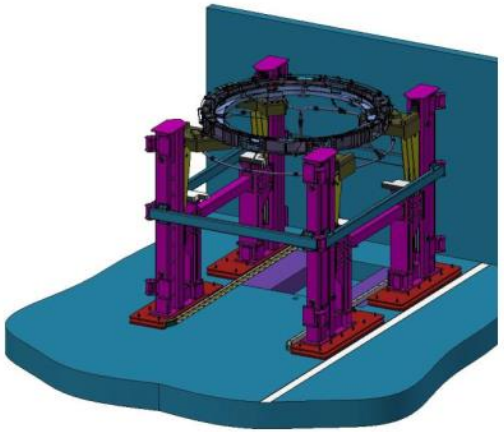
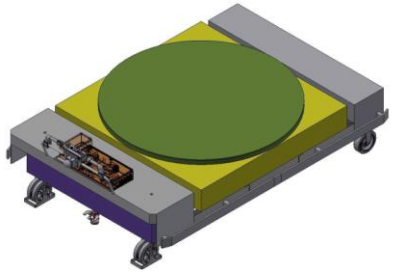


Figure 5: X4SS in top position X4 hall



- For the Cold system a custom support structure and assembly trolley have been designed to deal with limited space in integration hall

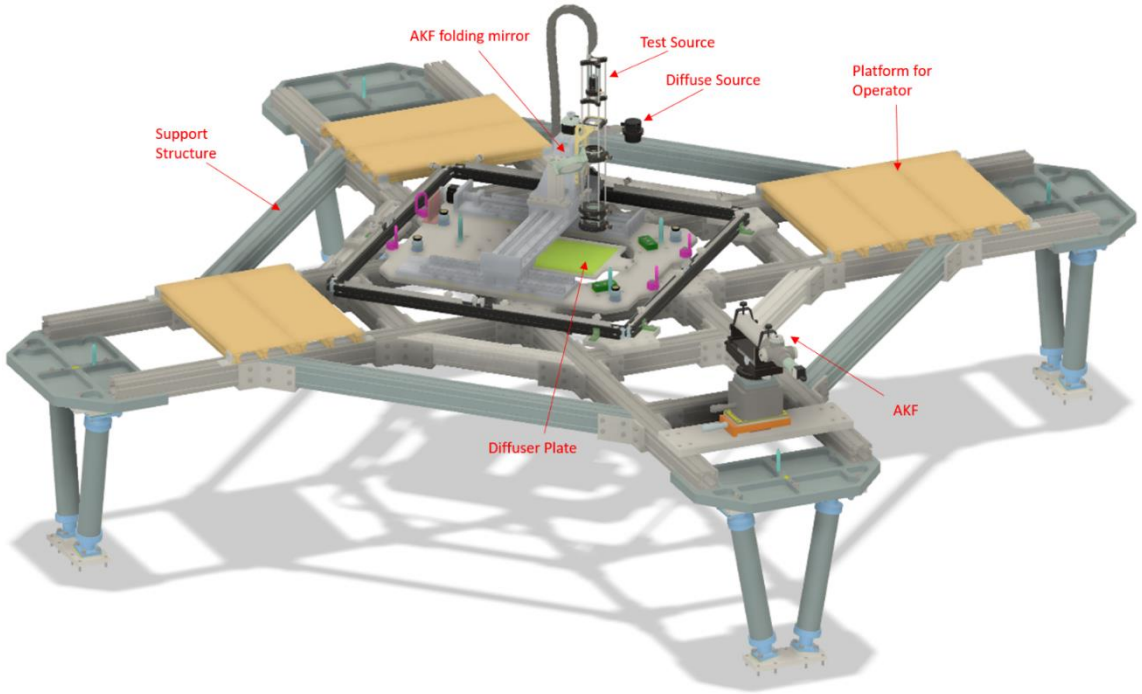
- Every sub-system has adjustment (shims) and re-positioning (pins) capabilities.

- Most constraining accuracies:
  50 µm lateral
  4 arcsec tilt

Tests

- Cold system

Optical tests are perfomed using a custom test source mounted on top of the cryostat

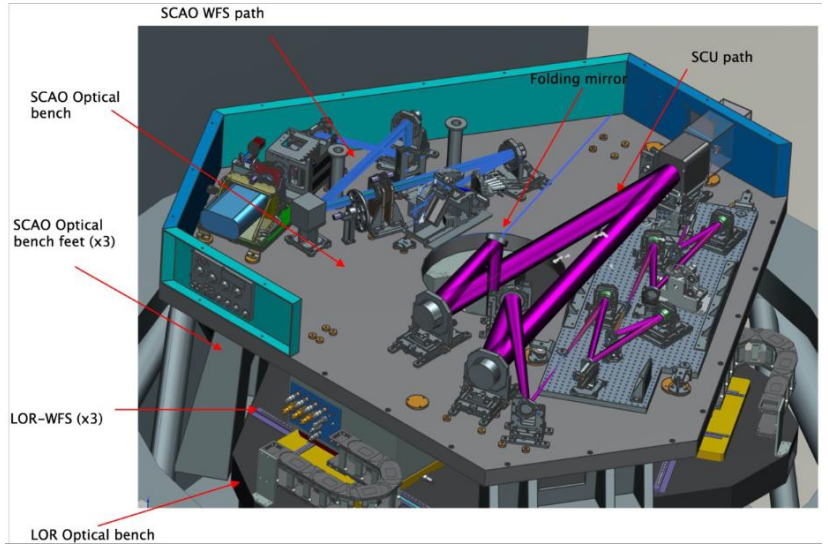


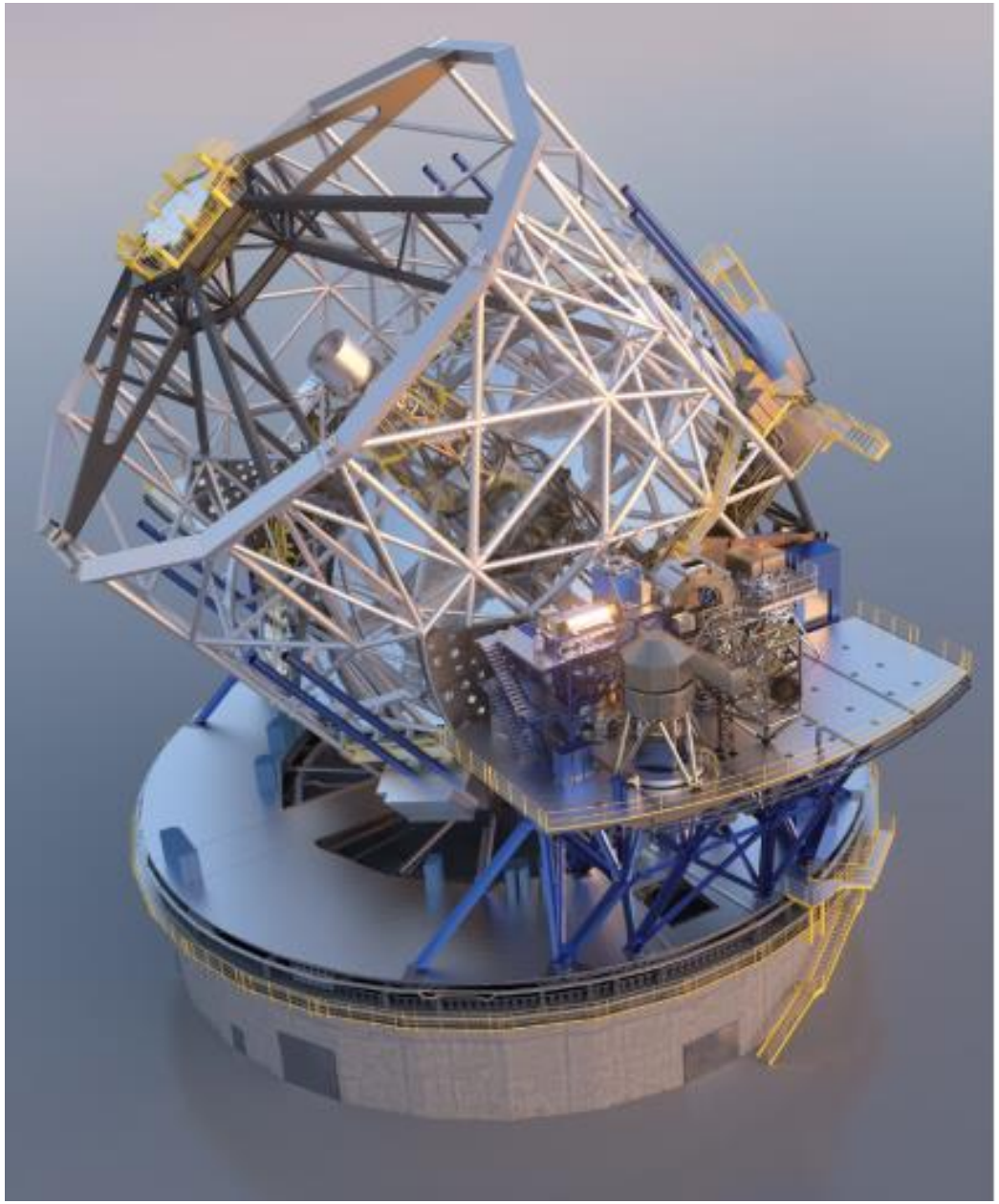
Others, like cryo-vacuum tests, power tests, timing tests etc are performed using the system diagnostic

- Warm system

The calibration unit allow the optical test and calibration of the whole instrument

- SCAO bench includes its own Calibration Unit for test and calibrations during the AIT phases





And there are of course many more items to MICADO…

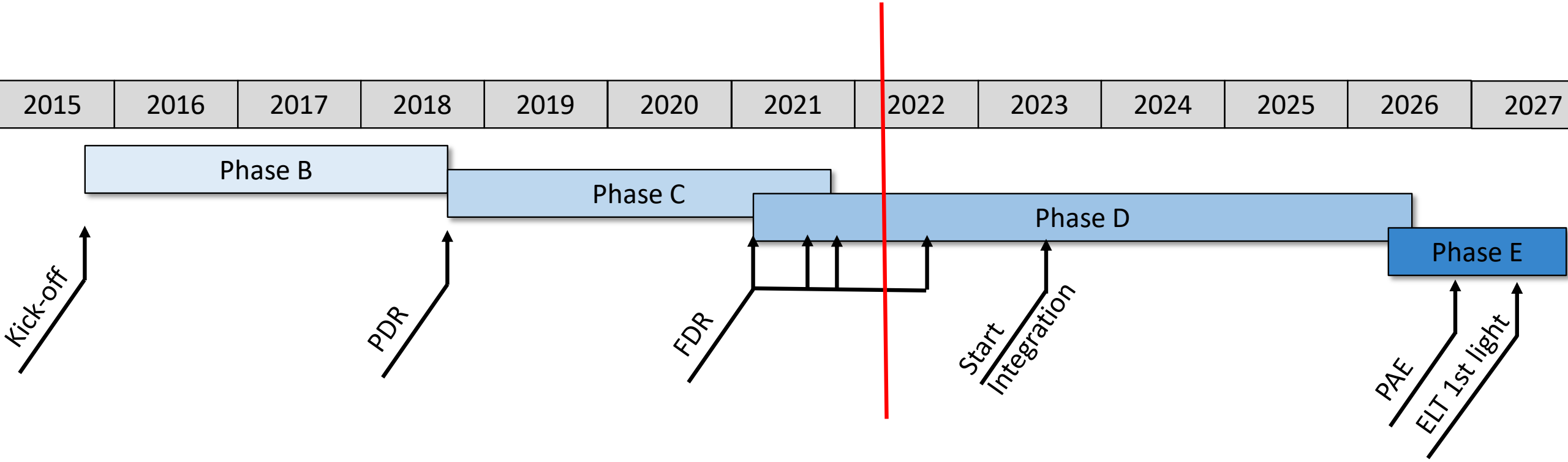
- Real time AO control
- Instrument control
- Cryo control
- Electronics and cabling
- Supplies and cooling
- Data handling
- Pipeline processing
- Assembly, Integration and Test
- Packing and shipment
- Re-assembly and commissioning
- …

MICADO Milestones:

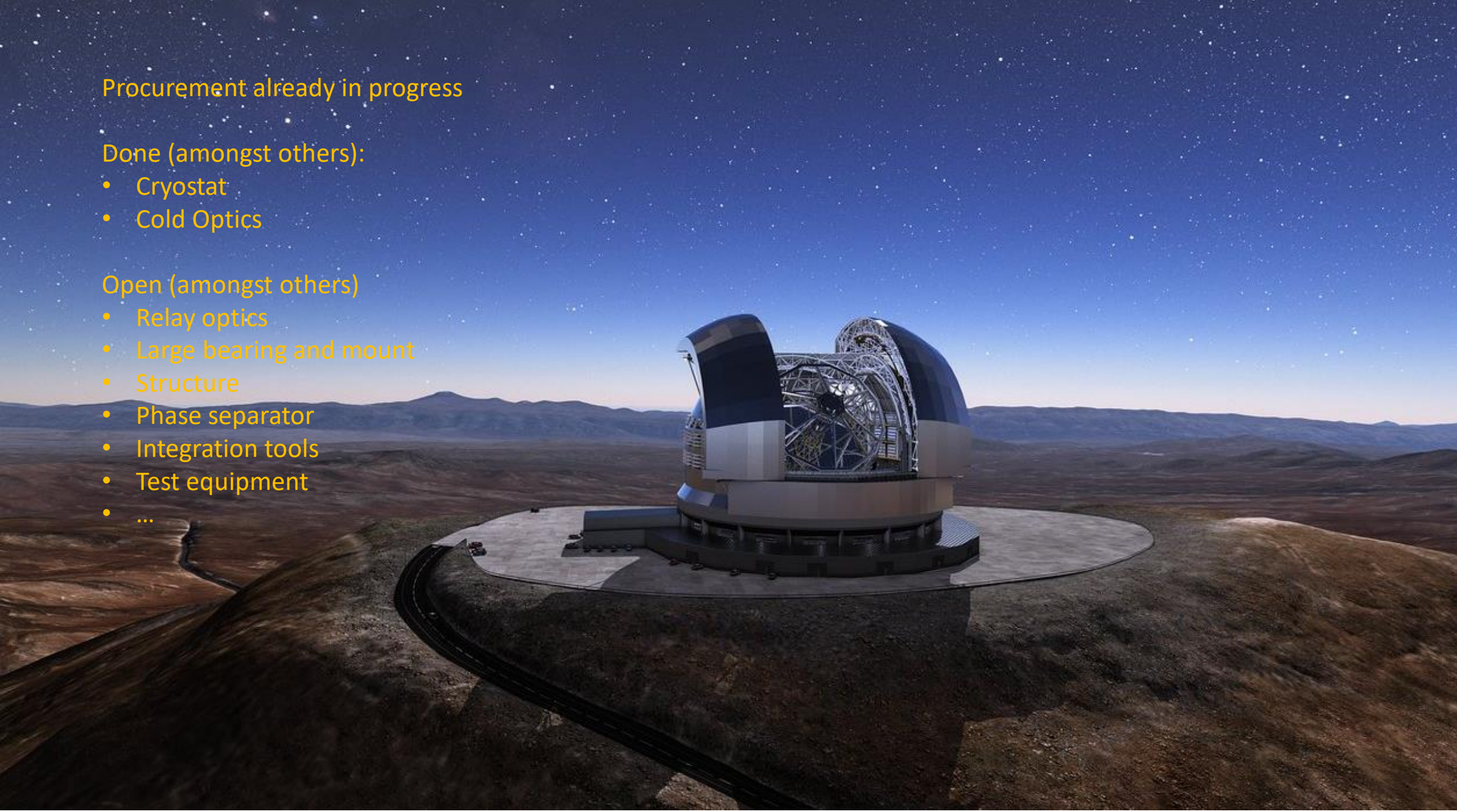
- FDR: Start (Part I): February 2021 (in three parts, till End 2022)
- Assembly and Integration: Start: May 2023 (in MPE X4 Integation Hall)
- Move to ESO (Garching) Integration Hall: August 2025
- System and PAE acceptance tests: March-July 2026
- PAE: November 2026

ELT Milestones:

- Technical First Light: 2027 (planned)



After an initial phase of operations at ELT first light during which MICADO will be available only with the SCAO system, it will move to its final configuration where it interfaces to MAORY and will benefit from both a SCAO and a MCAO correction.



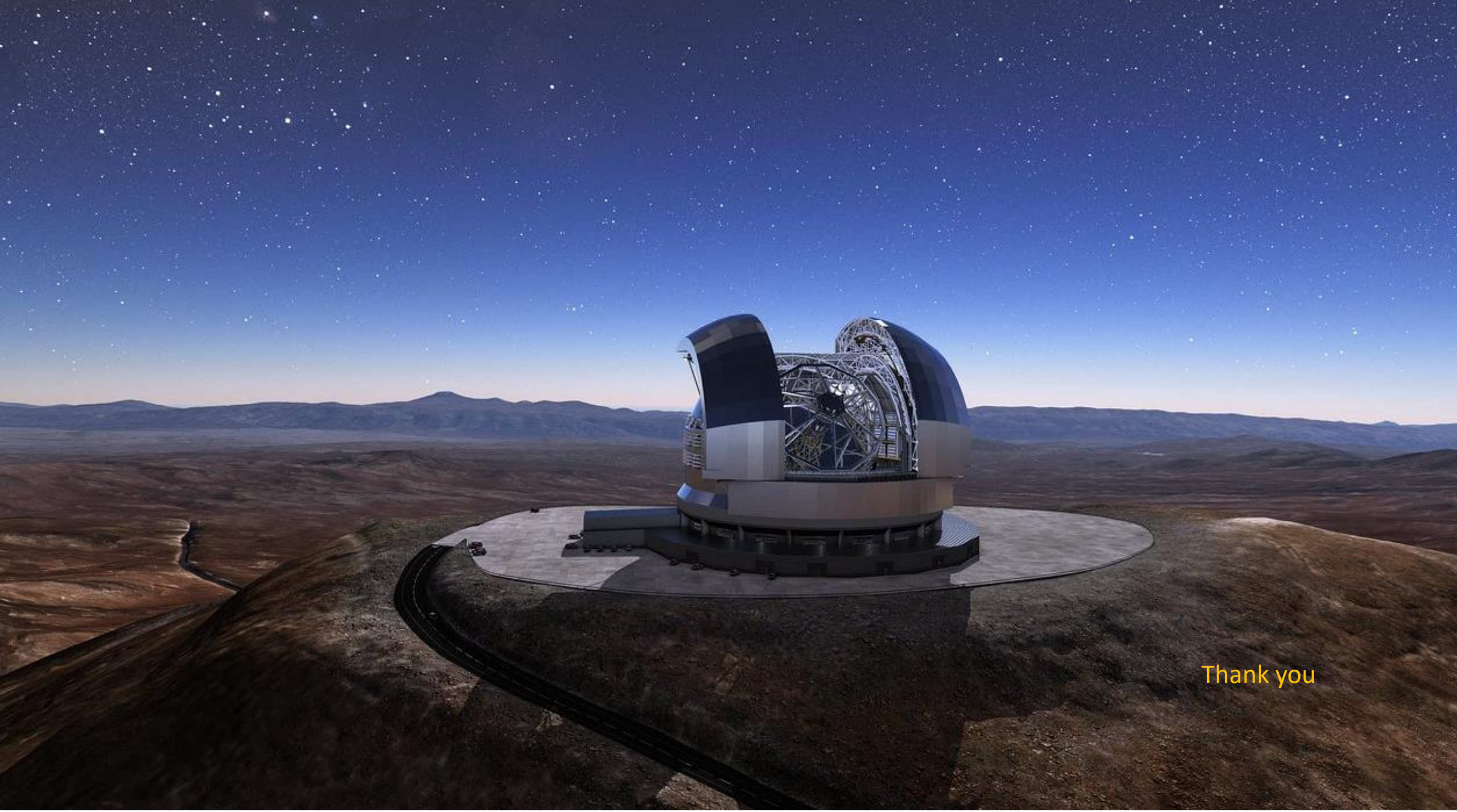
Procurement already in progress

Done (amongst others):

- Cryostat
- Cold Optics

Open (amongst others)

- Relay optics
- Large bearing and mount
- Structure
- Phase separator
- Integration tools
- Test equipment
- …


Thank you