

# Enabling Groundbreaking Science: Current and Future Instrumentation at ESO



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MPIA

# Outline

- Instrumentation at La Silla:
  - Current
  - Near future
- Instrumentation at Paranal:
  - Current
  - Near future
- Instrumentation for ELT
  - First light instruments

*Disclaimer:* this talk is about optical and infrared instrumentation, for ALMA and CTAO see talks by De Breuck and Doro



Image credit: ESO

# ESO sites in Chile

ALMA

Armazones

Paranal

La Silla

Chilean headquarters



Image: ESO



Image: ESO

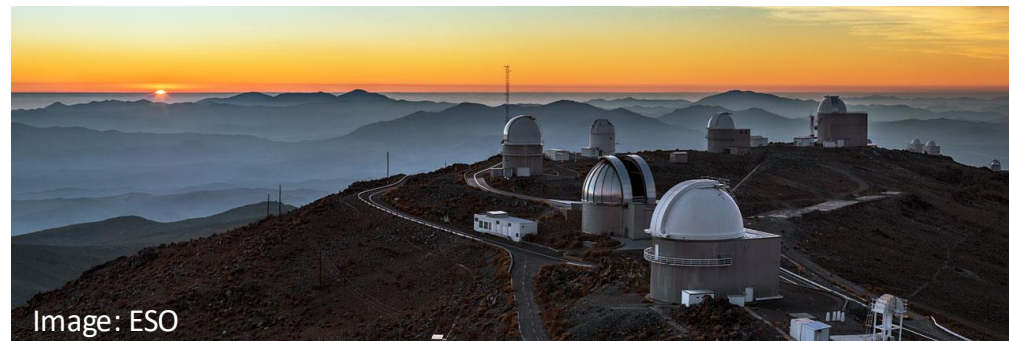


Image: ESO

# La Silla, ESO's first observatory



Image: ESO

# Current La Silla instrumentation

Instrument	Spectral Coverage	Observing Mode	Spectral Resolution	Multiplex	Note	Telescope
HARPS	optical 378-691nm	echelle, polarimetry	120,000	no	2 fibres, high accuracy; 2 fibers, high efficiency	3.6m
NIRPS	near-IR 971-1854nm	echelle	84,000	no	fibre-fed. HARPS and NIRPS can be operated simultaneously.	3.6m
EFOSC-2	optical 350 - 1100nm	imaging, spectroscopy, polarimetry, coronagraphy	~1000	no	imaging and spectroscopic polarimetry	NTT
ULTRACAM	optical: u',g',r' or u',g',i' or u',g',z'	3-channel, high-speed CCD camera	-	no	frame rate up to 300Hz; field-of-view of 6 arcmin	NTT



# Future: SOXS @ NTT

- Son Of X-Shooter
- Wavelength 350 – 2000 nm in a single exposure
- $R = 3500 - 6500$  (using a 1-arcsecond slit)
- Will permit probing transients as faint as 20th magnitude or more
- Being commissioned at NTT

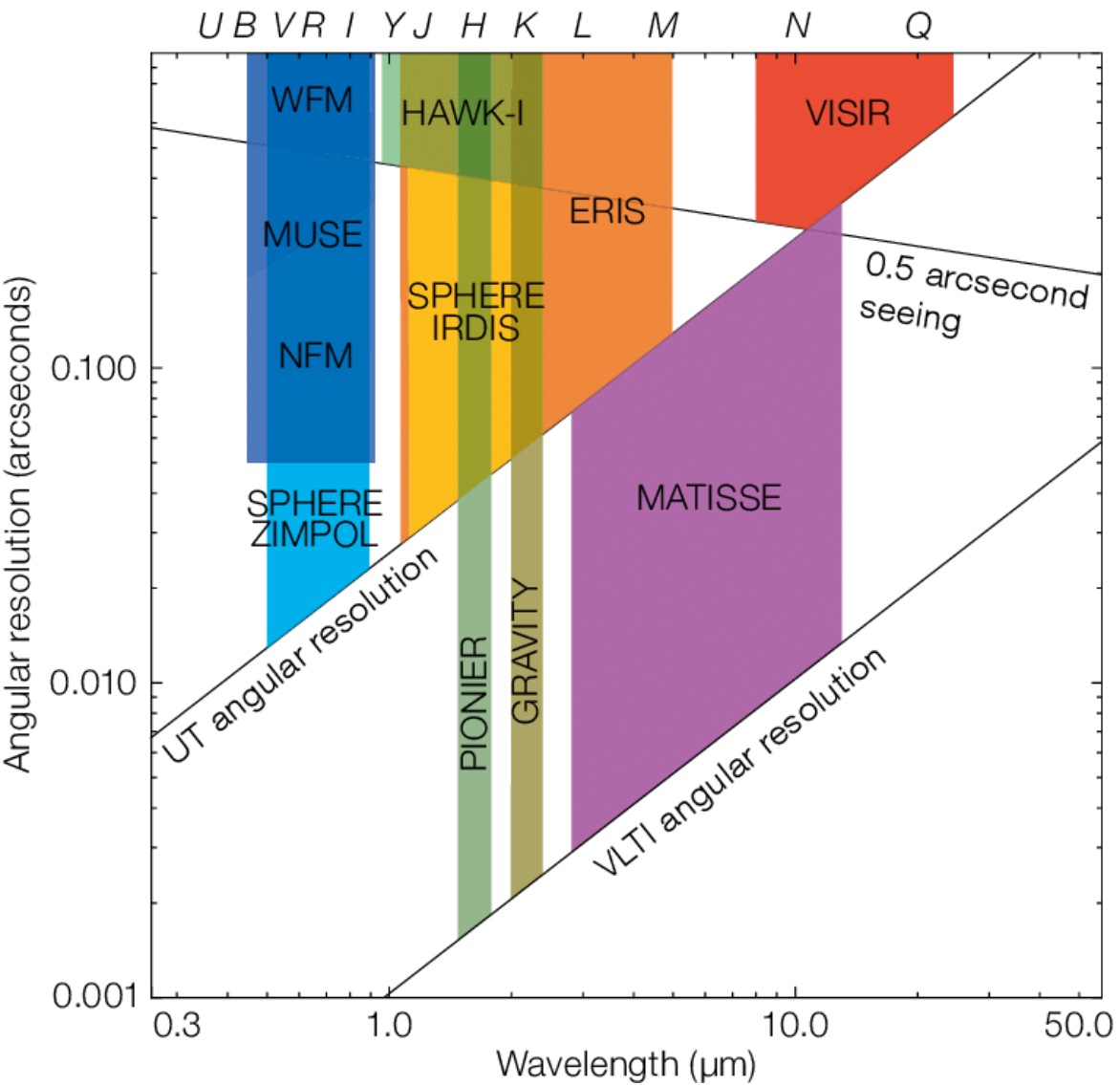


# VLT— ESO's current flagship facility



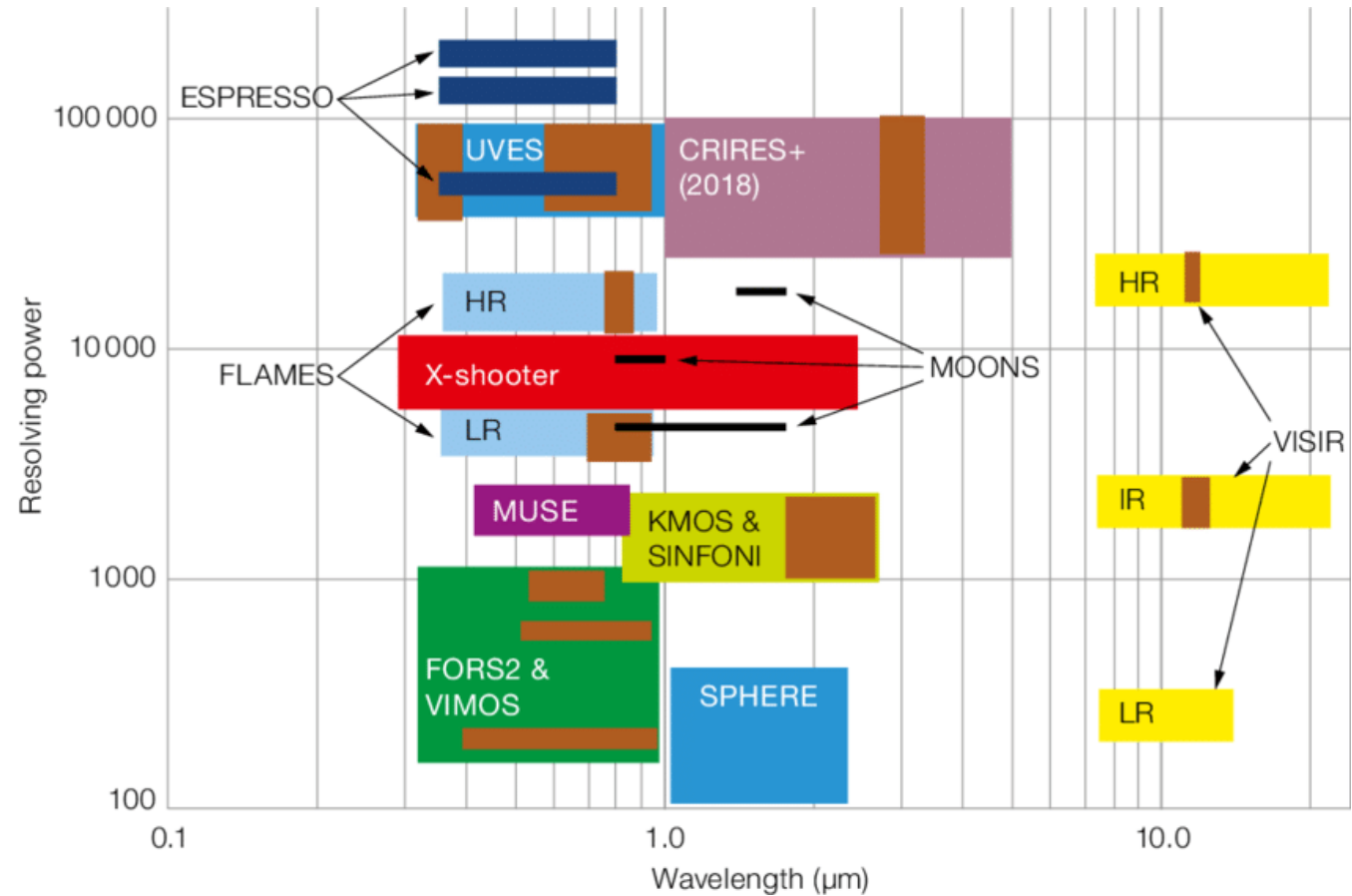
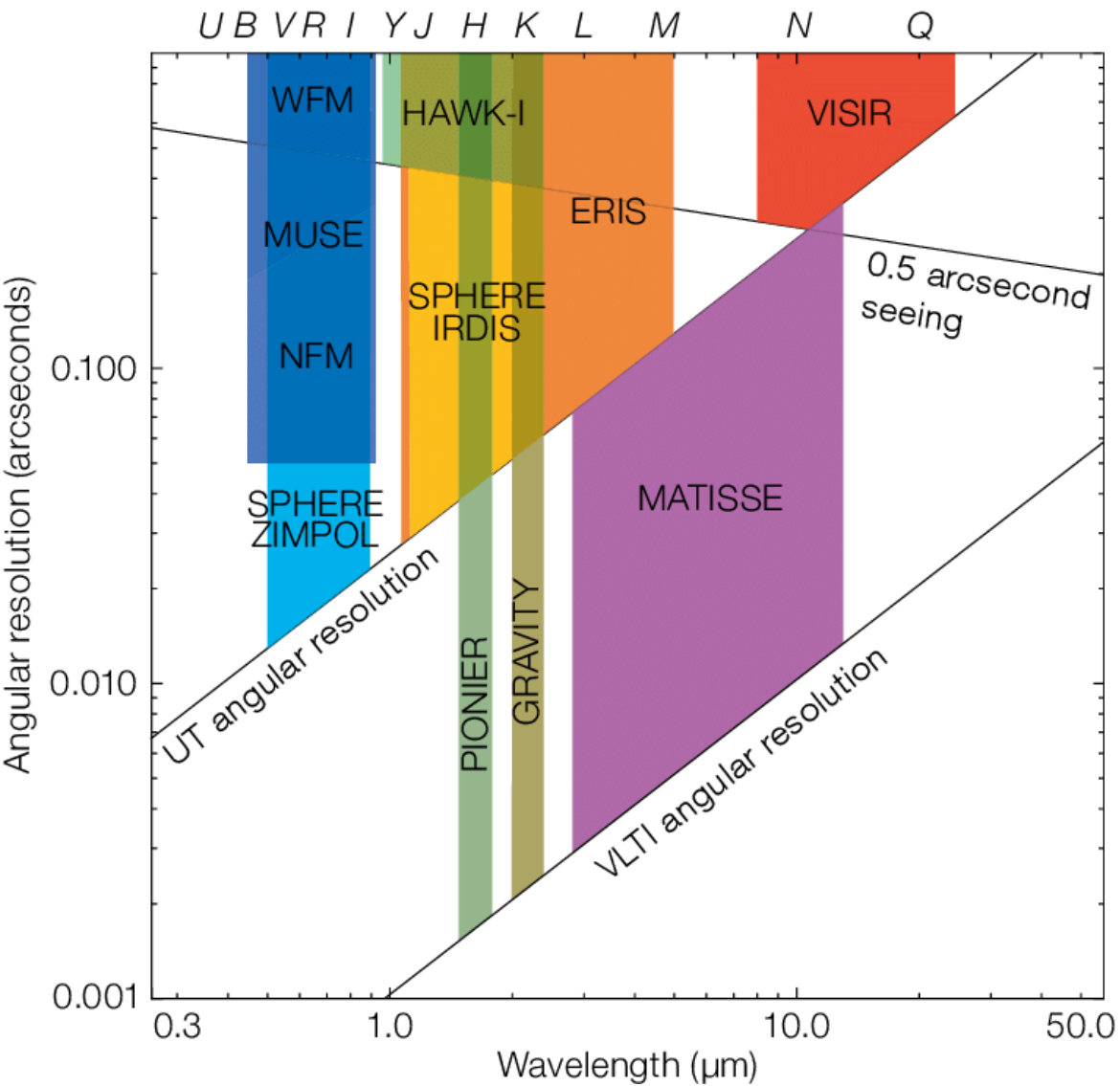


# ESO Instrument capabilities



de Zeeuw, The Messenger 2016

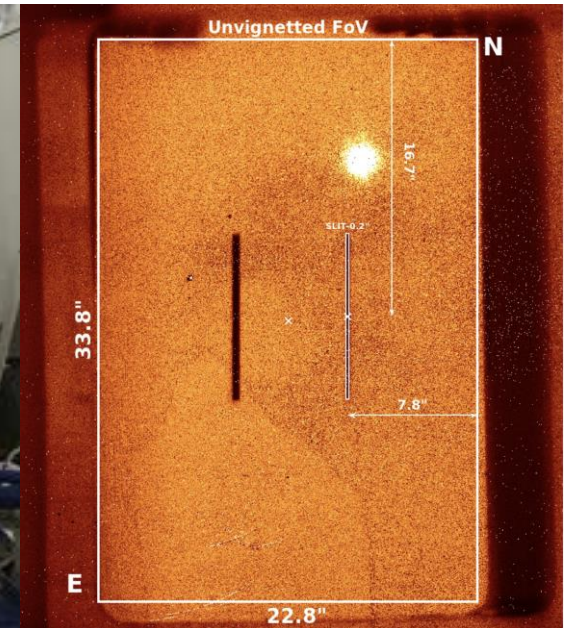
# ESO Instrument capabilities



de Zeeuw, The Messenger 2016

# CRIRES+ @ UT3

- Cryogenic high-resolution InfraRed Echelle Spectrograph
- Refurbished instrument offered since 2022
- Upgraded to cross-dispersed echelle
- Added spectropolarimetry, linear and circular polarimetry below 2500nm
- AO assisted, 29 wavelength settings, gas cells and Fabry-Perot etalons for precision RV
- $wl = 0.95\text{-}5.3 \mu\text{m}$ ,  $R = 40,000\text{-}80,000$



# MUSE @ UT4

- Multi-Unit Spectroscopic Explorer
- Integral field spectroscopy
- AO assisted, WFM offered also without AO
- Two modes:
  - WFM: on sky 60"x60" with spaxel size 0.2"
  - NFM: 7.5"x7.5" with spaxel size 0.025"
- $wl = 465 - 930 \text{ nm}$ ,  $R = 1770@480\text{nm}$ ,  $3590@930\text{nm}$

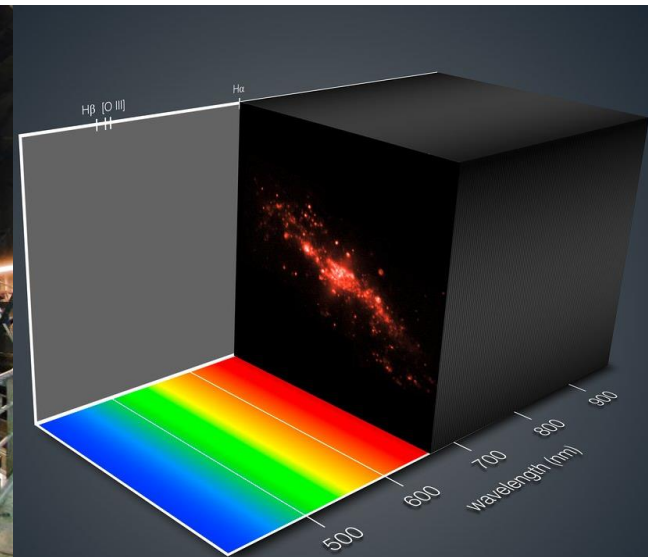
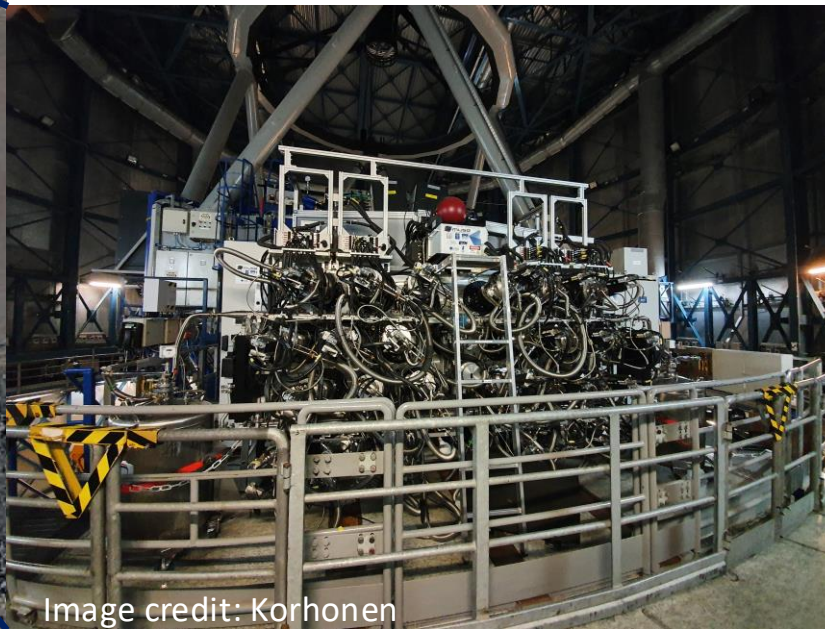


Image credit: ESO

Image credit: Korhonen

Image credit: ESO

# ERIS @ UT4

- Enhanced Resolution Imager and Spectrograph
- Offered since 2023, replacing NaCO and SINFONI
- Adaptive optics with natural and laser guide stars
- Imaging, coronagraph, sparse aperture mask interferometry, integral field spectroscopy
- $wl = 1-5 \mu m$ ,  $R = 5000-11200$

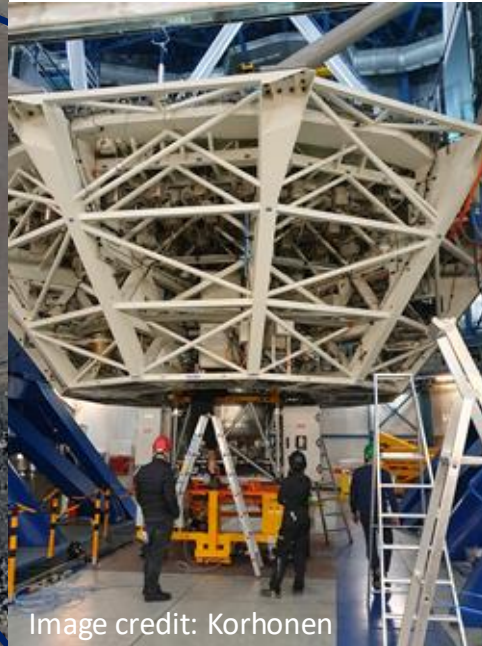


Image credit: ESO

Image credit: Korhonen

Image credit: ERIS IOT

# MOONS @ UT1

- Multi-Object Optical and Near-infrared Spectrograph
- ~1000 fibers deployable over ~500 square arcmin FOV
- WI = 0.6 - 1.8 micron, R = ~4,000-6,000
- High resolution mode in two selected spectral regions: Call triplet (R~9,000) and H-band (R~20,000)
- Commissioning at UT1 later in 2026



# 4MOST @ VISTA

- A fibre-fed spectroscopic survey facility
- 2.5-degree diameter field-of-view
- 2436 science fibres
- All-sky 5-year public surveys, >50 million targets
- 10 main consortium surveys and 8 community programs → 120+ sub-surveys
- First-light in Oct 2025, now in Science Verification phase

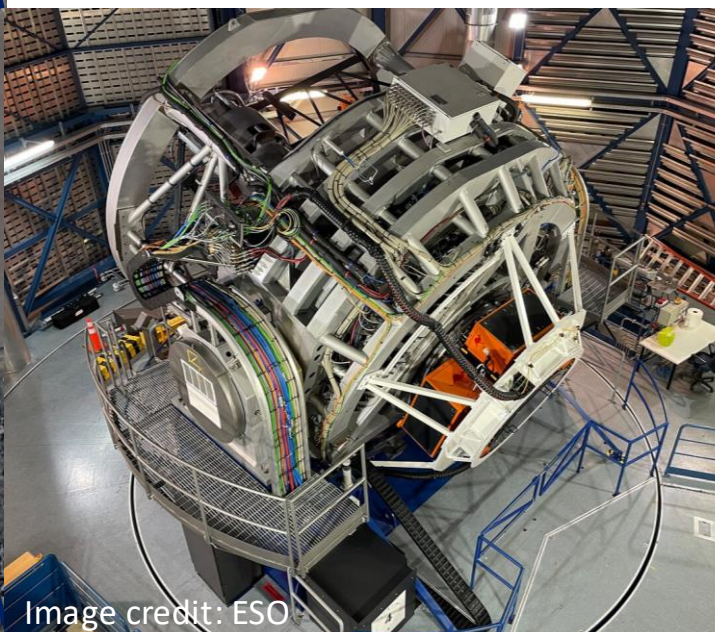


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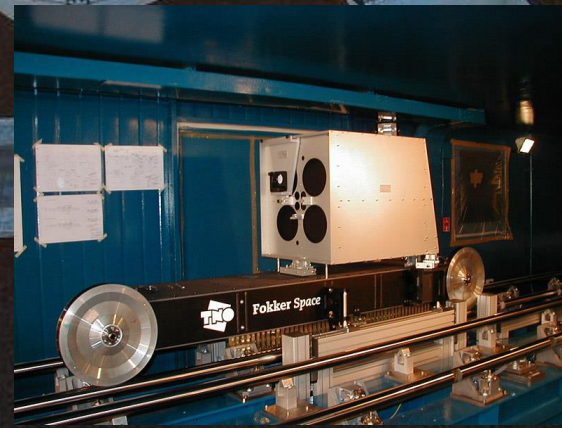
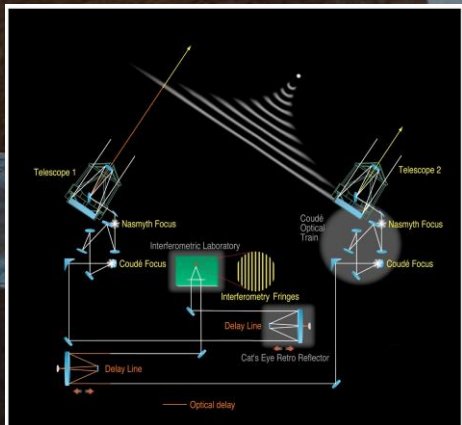
Image credit: ESO

Image credit: MPIA

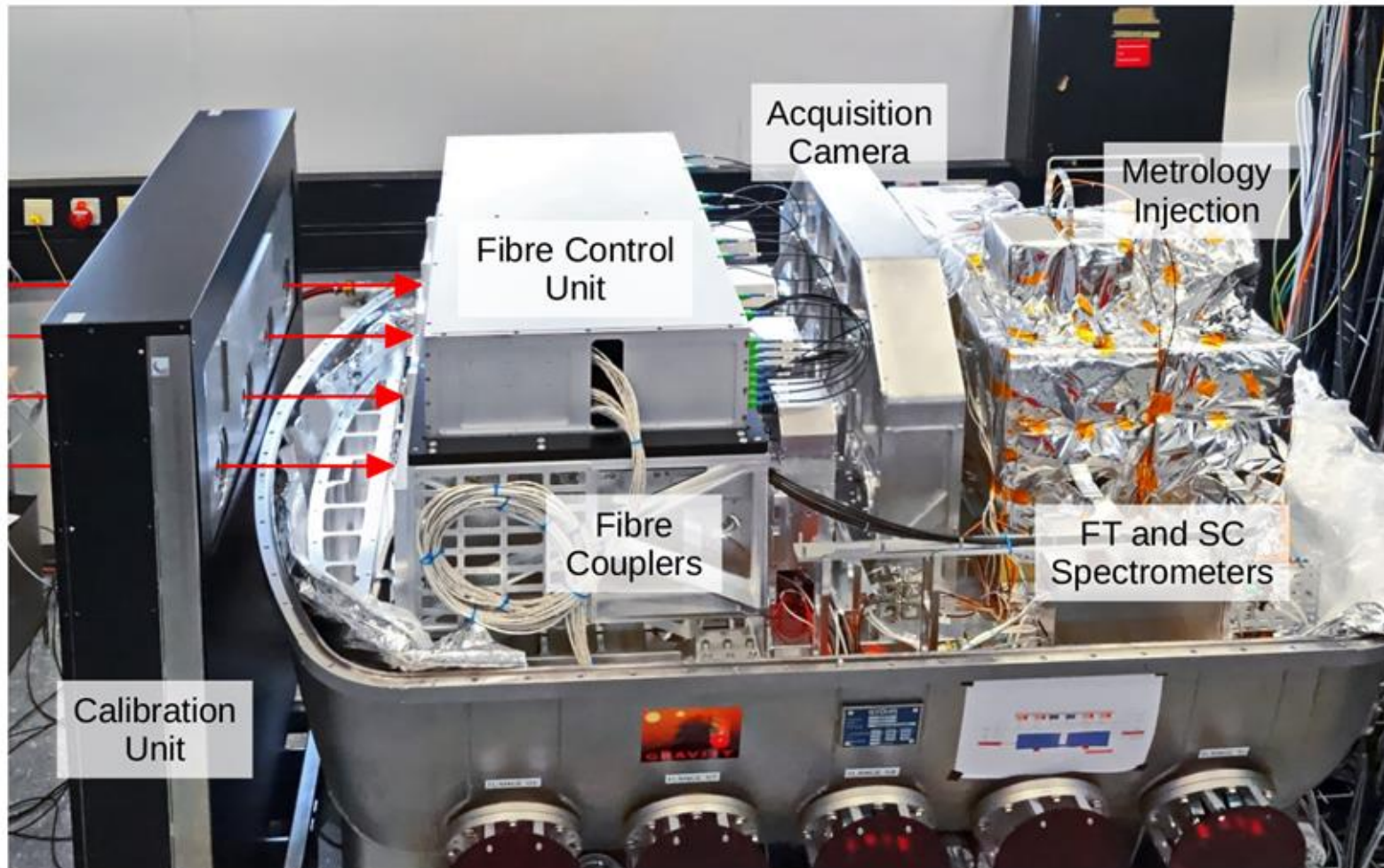
# Very Large Telescope Interferometer - VLTI

Three 4-beam combiners:

- PIONIER: H-band
- GRAVITY: K-band
- MATISSE: L, M, and N bands



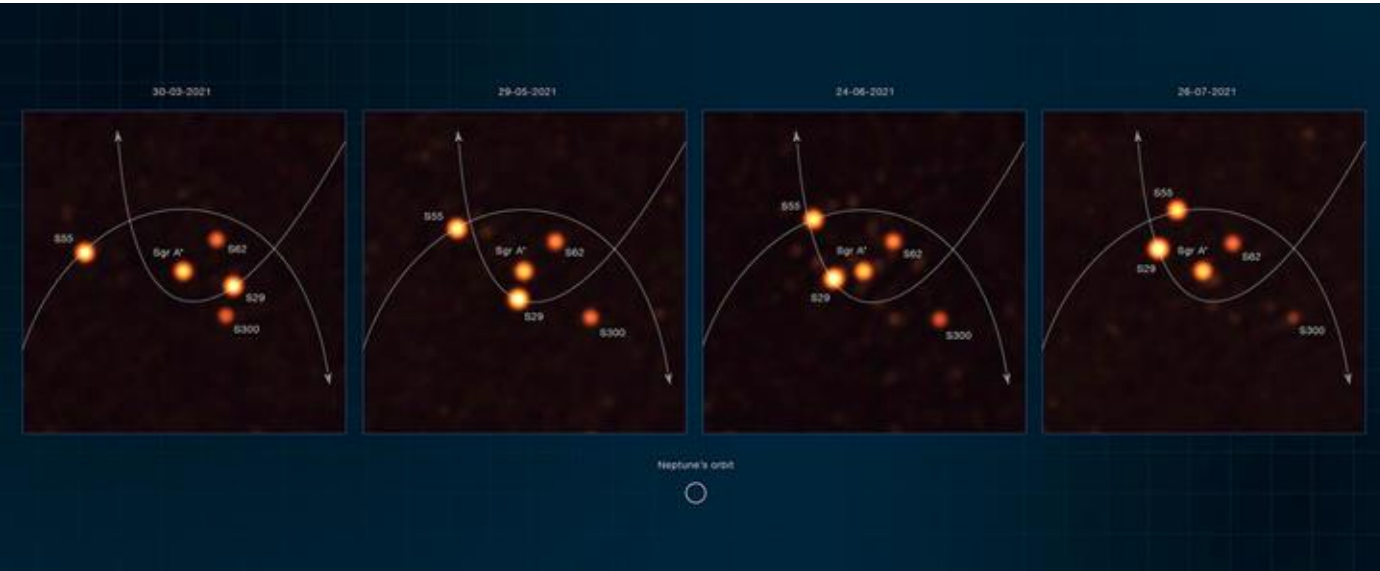
# What is GRAVITY



- 4 beam combiner - delivers spectrally dispersed visibilities, differential and closure phases
- K band,  $\lambda_l = 2.05 - 2.45 \mu\text{m}$
- $R = 20, 500, 4000$



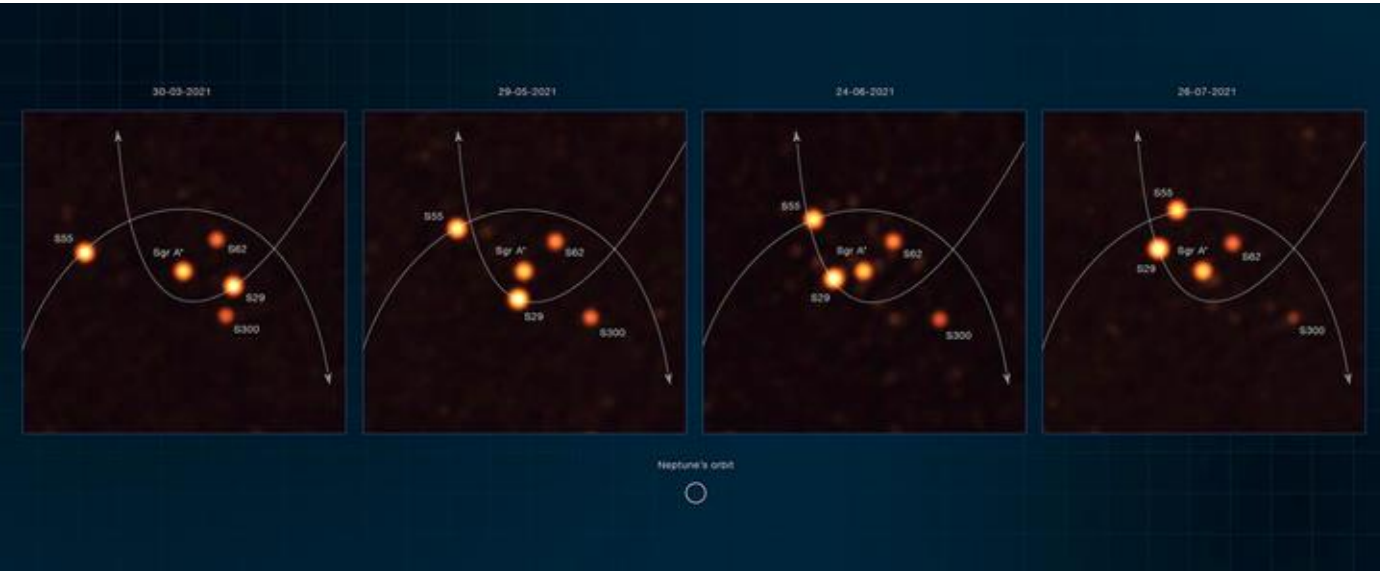
# Science with GRAVITY



GRAVITY was built to study the Galactic Centre

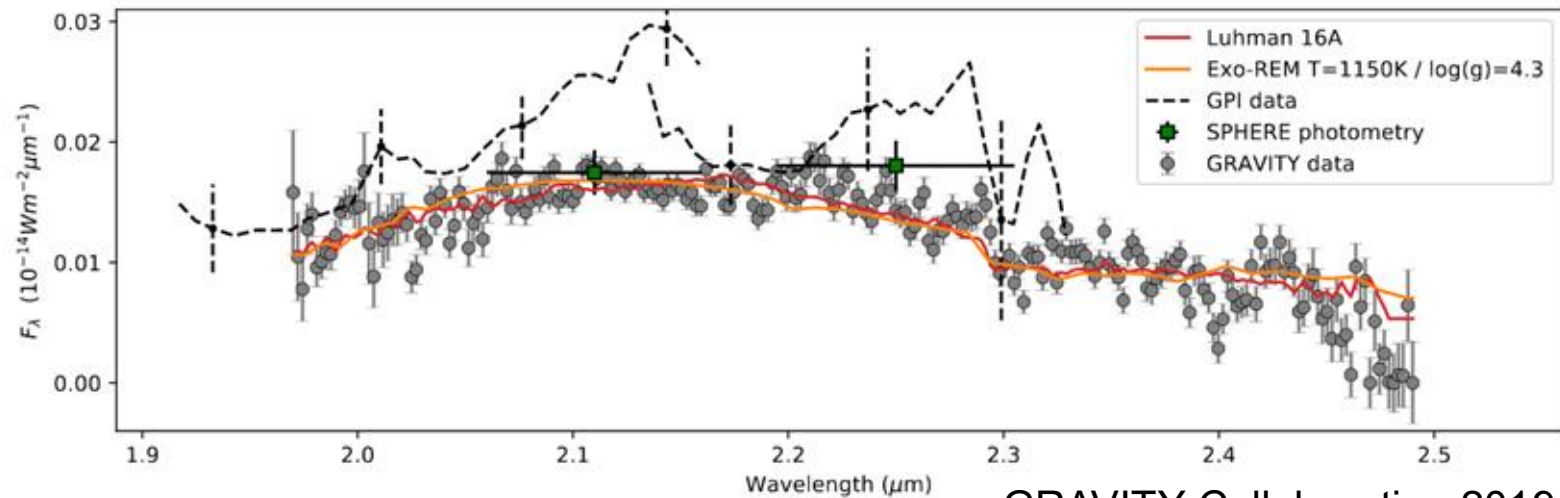
GRAVITY Collaboration 2022

# Science with GRAVITY



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## HR8799e

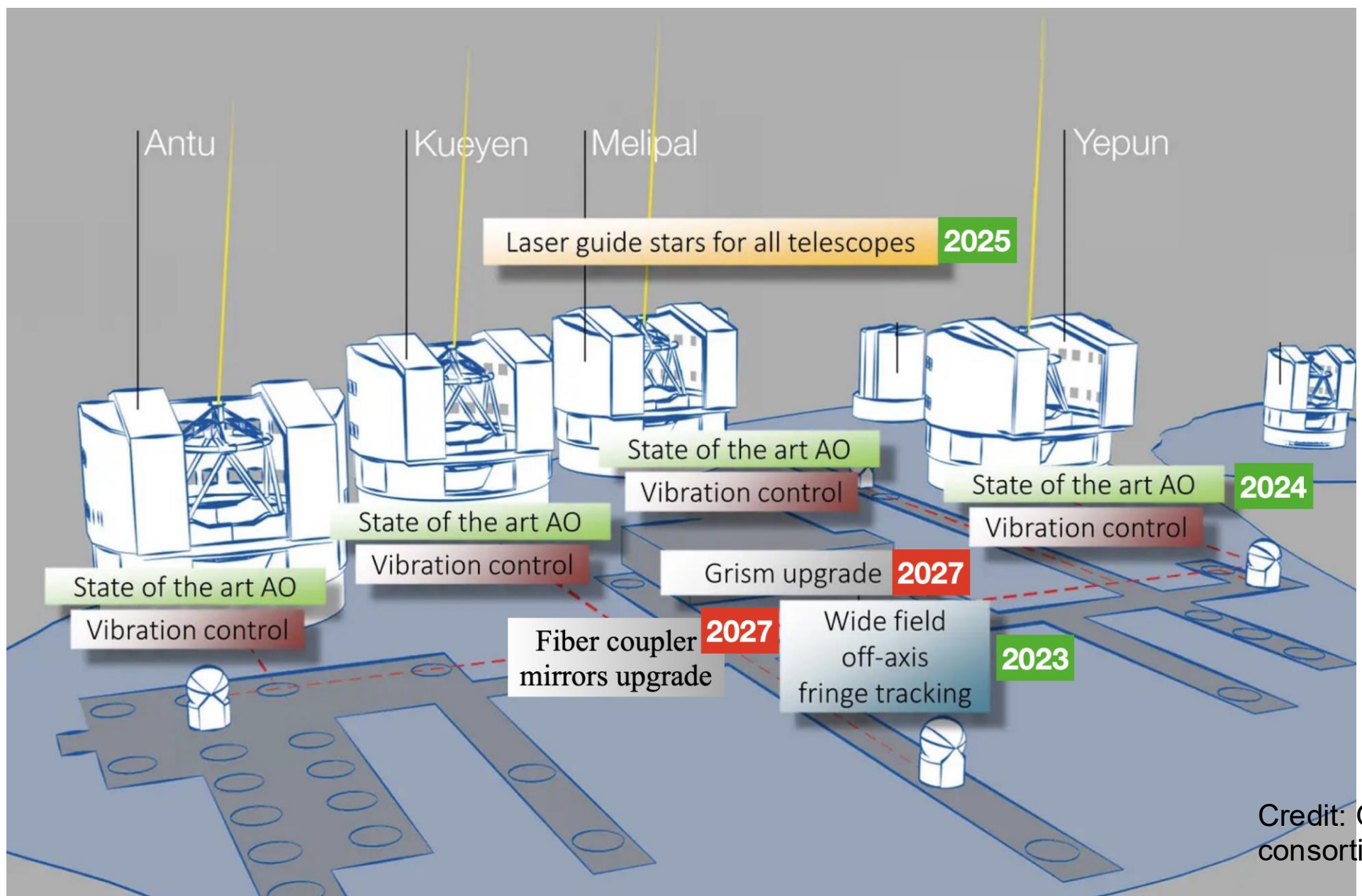


...but it is also excellent in taking spectra of exoplanets

GRAVITY Collaboration 2019

GRAVITY Collaboration 2022

# What is GRAVITY+



Credit: GRAVITY+ consortium





# ELT Instrumentation

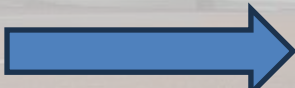


ELT construction site in April 2026, credit: ESO

# ELT is an Adaptive Optics telescope

Image: ESO

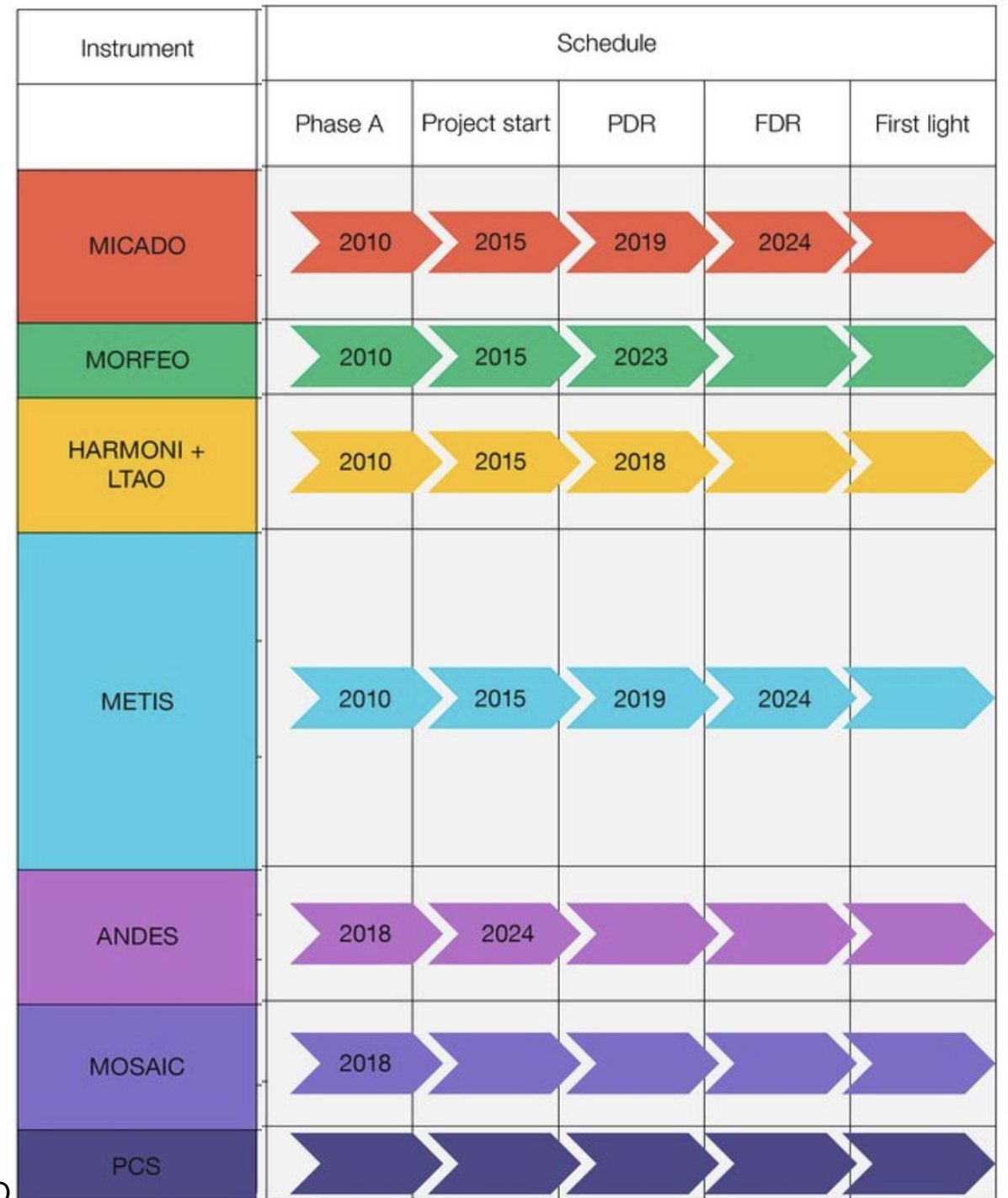
The 39 metre main mirror has a diffraction limit of  $\sim 0.03''$  at 500nm. Median seeing on Paranal is  $0.8''$

To fully utilise the size of ELT, one needs to correct the disturbance caused by the Earth's atmosphere  Adaptive Optics



# Currently Planned ELT instruments

- **MICADO**: Multi-AO Imaging Camera for Deep Observations
- **MORFEO**: Multiconjugate adaptive Optics Relay For ELT Observations
- **HARMONI**: High Angular Resolution Monolithic Optical and Near-infrared Integral field spectrograph
- **METIS**: Mid-infrared ELT Imager and Spectrograph
- **ANDES**: ArmazoNes high Dispersion Echelle Spectrograph
- **MOSAIC**: Multi-Object Spectrograph
- **PCS**: Planetary Camera and Spectrograph



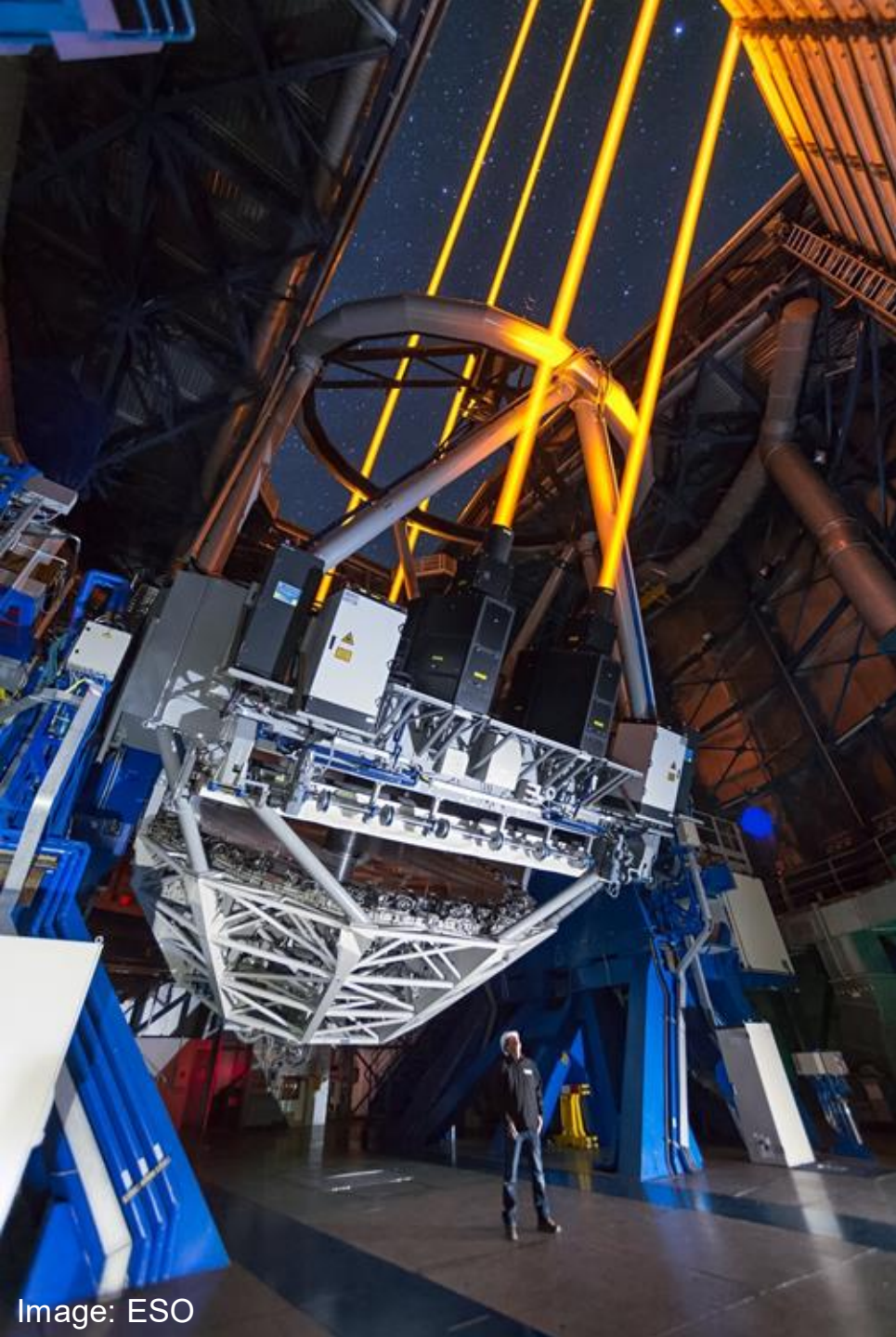
Credit: ESO

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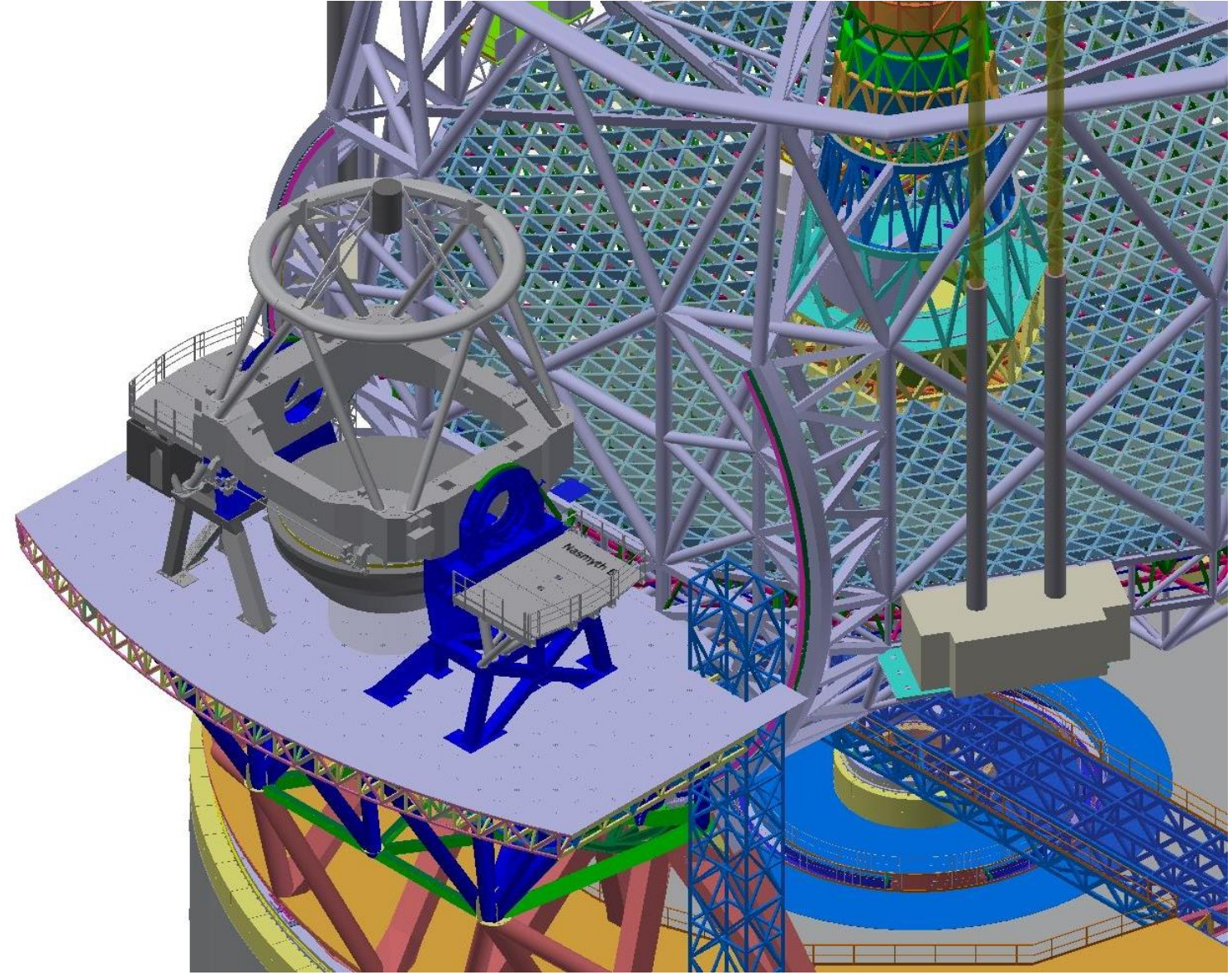
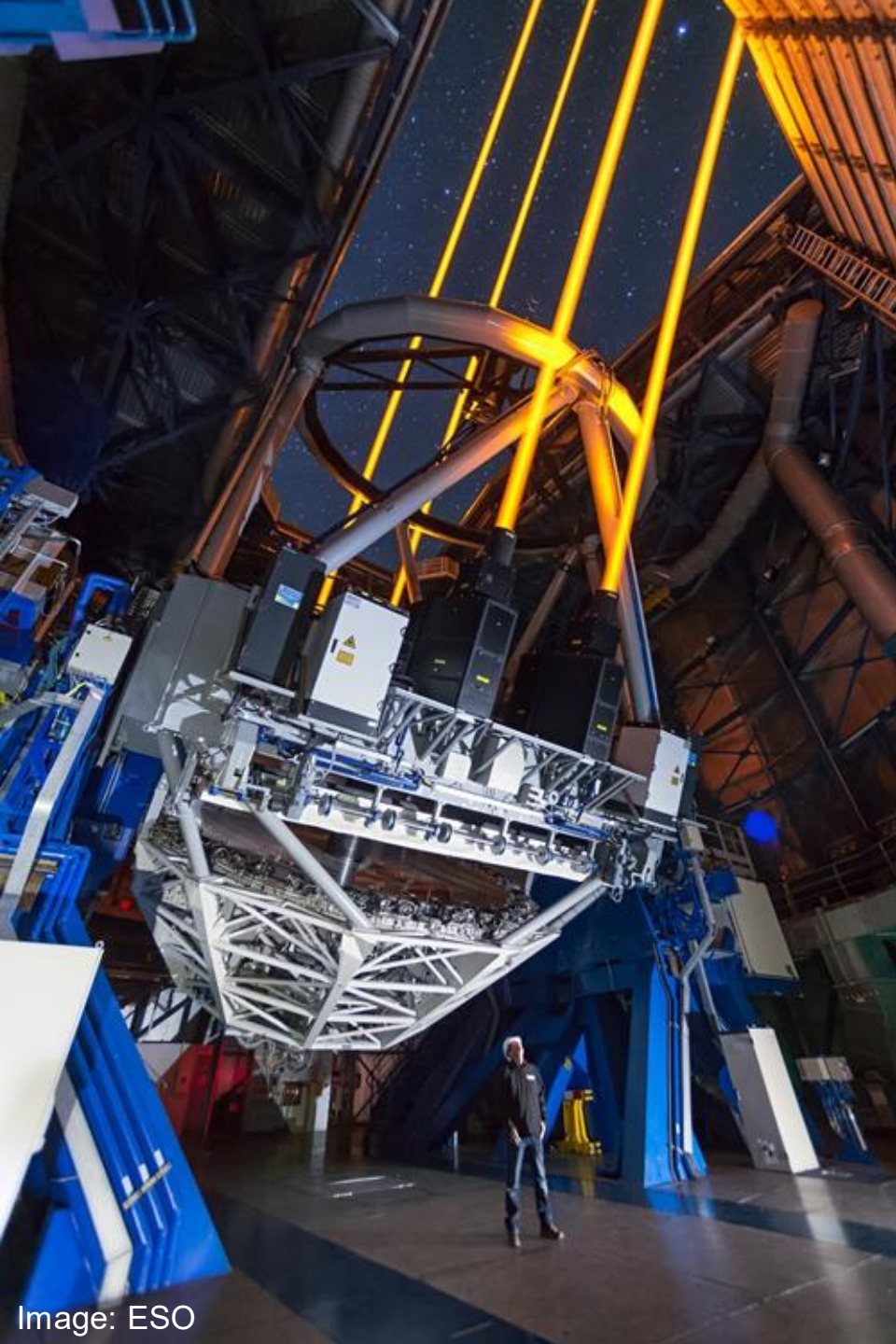
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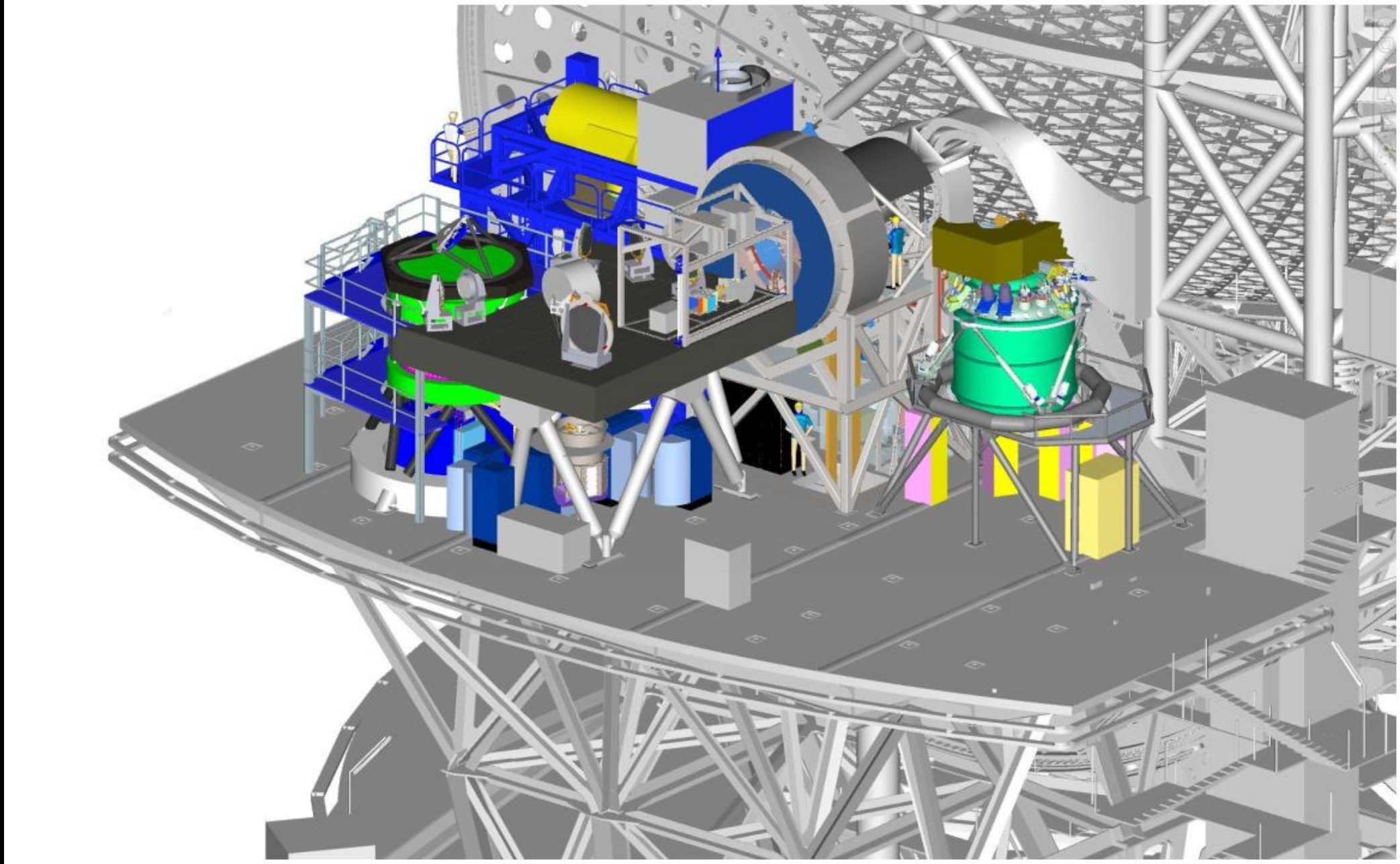
Instrument	Schedule				
	Phase A	Project start	PDR	FDR	First light
MICADO	2010	2015	2019	2024	
MORFEO	2010	2015	2023		
HARMONI + LTAO	2010	2015	2018		
METIS	2010	2015	2019	2024	
ANDES	2018	2024			
MOSAIC	2018				
PCS					

Really “extremely large”

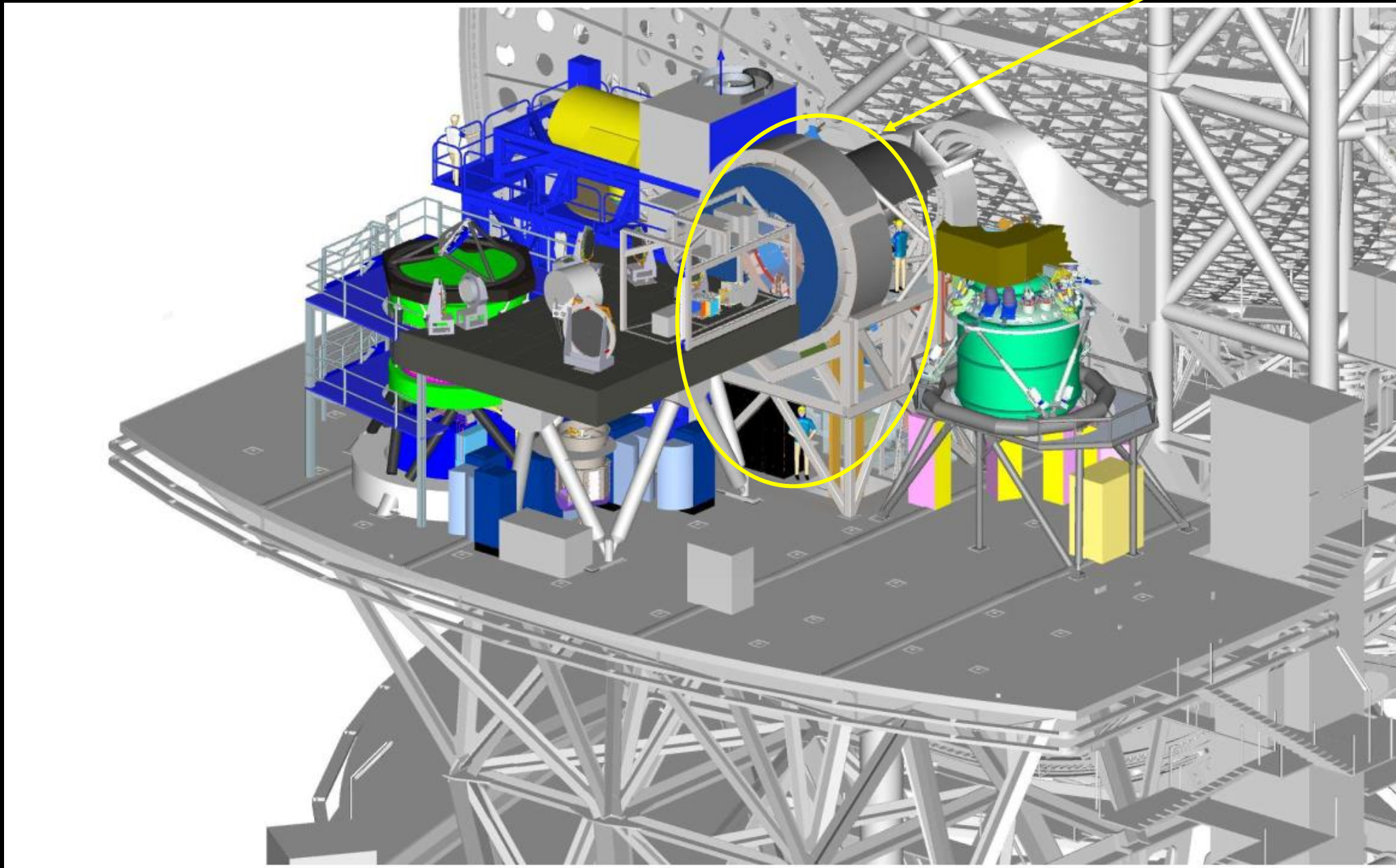


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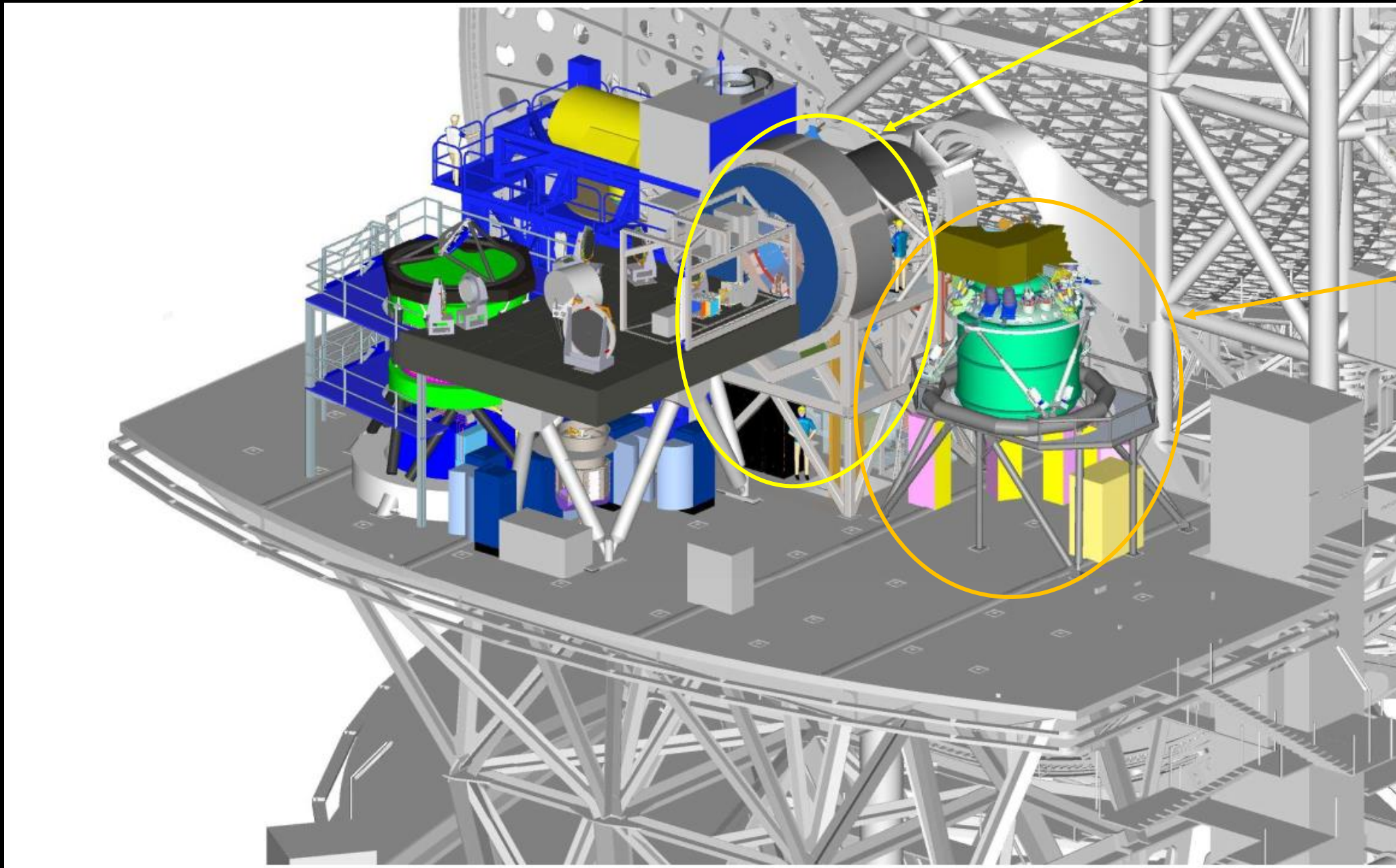


**Prefocal station (PFS)**



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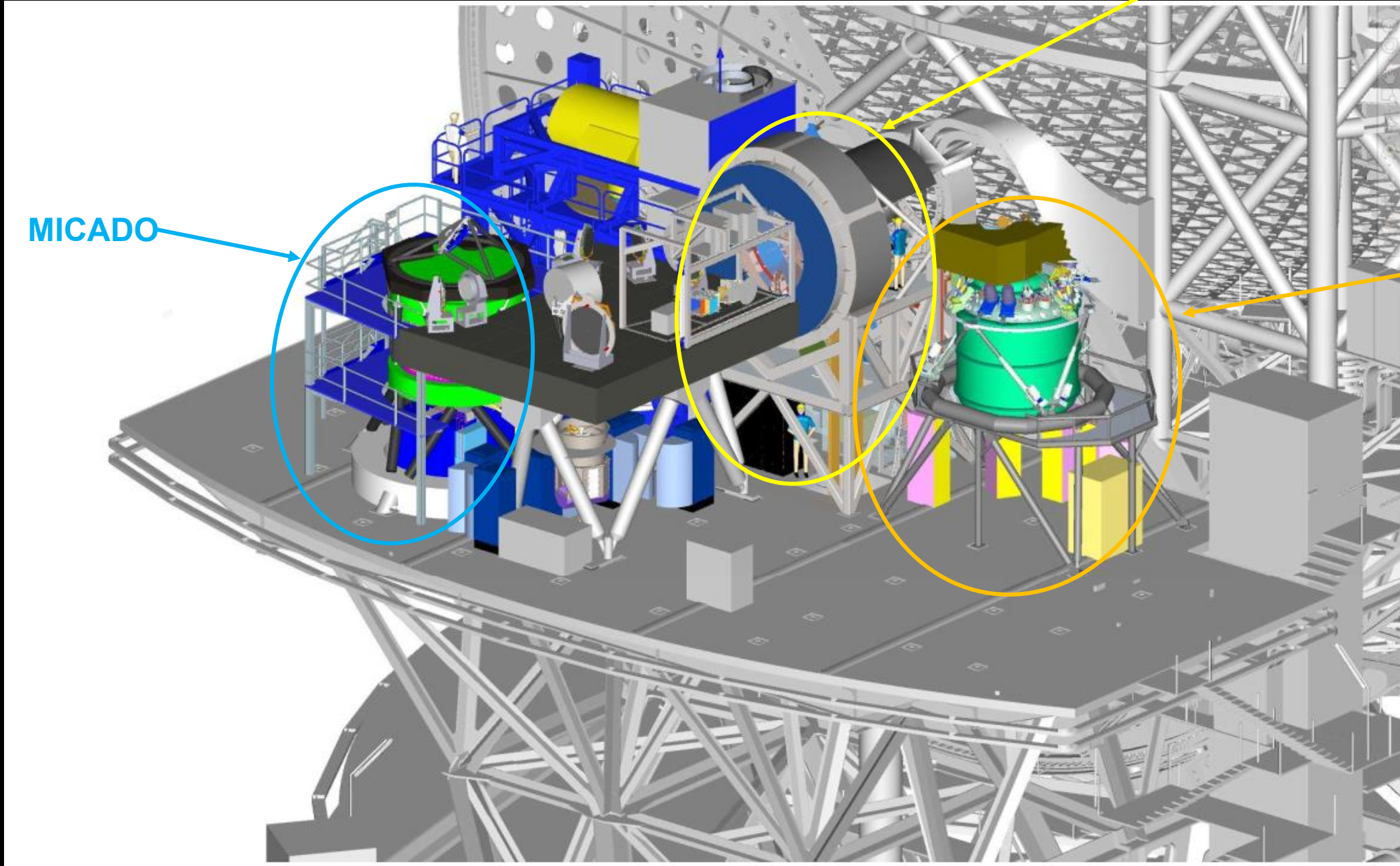
**METIS**



MICADO

Prefocal station (PFS)

METIS

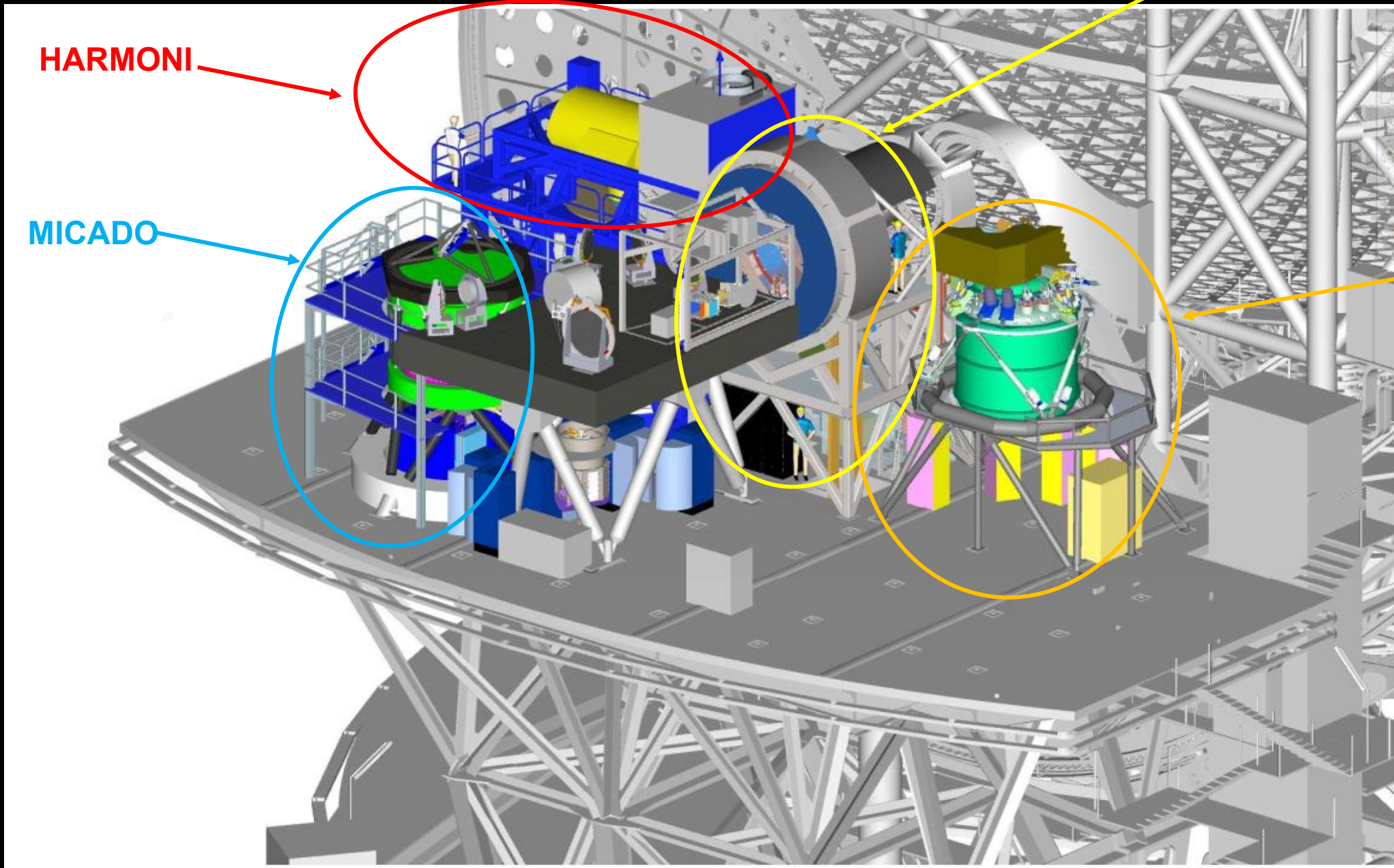


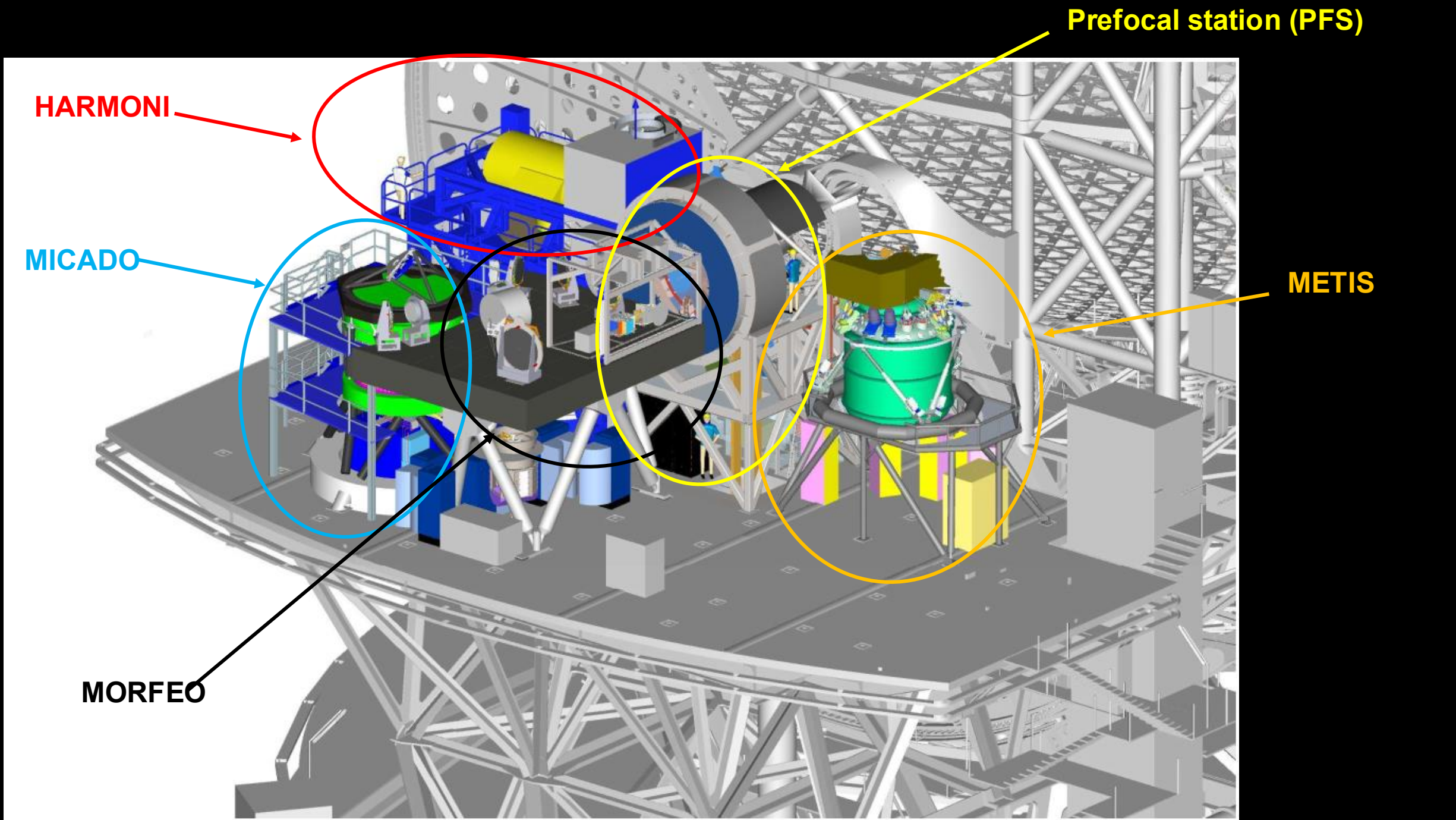
**HARMONI**

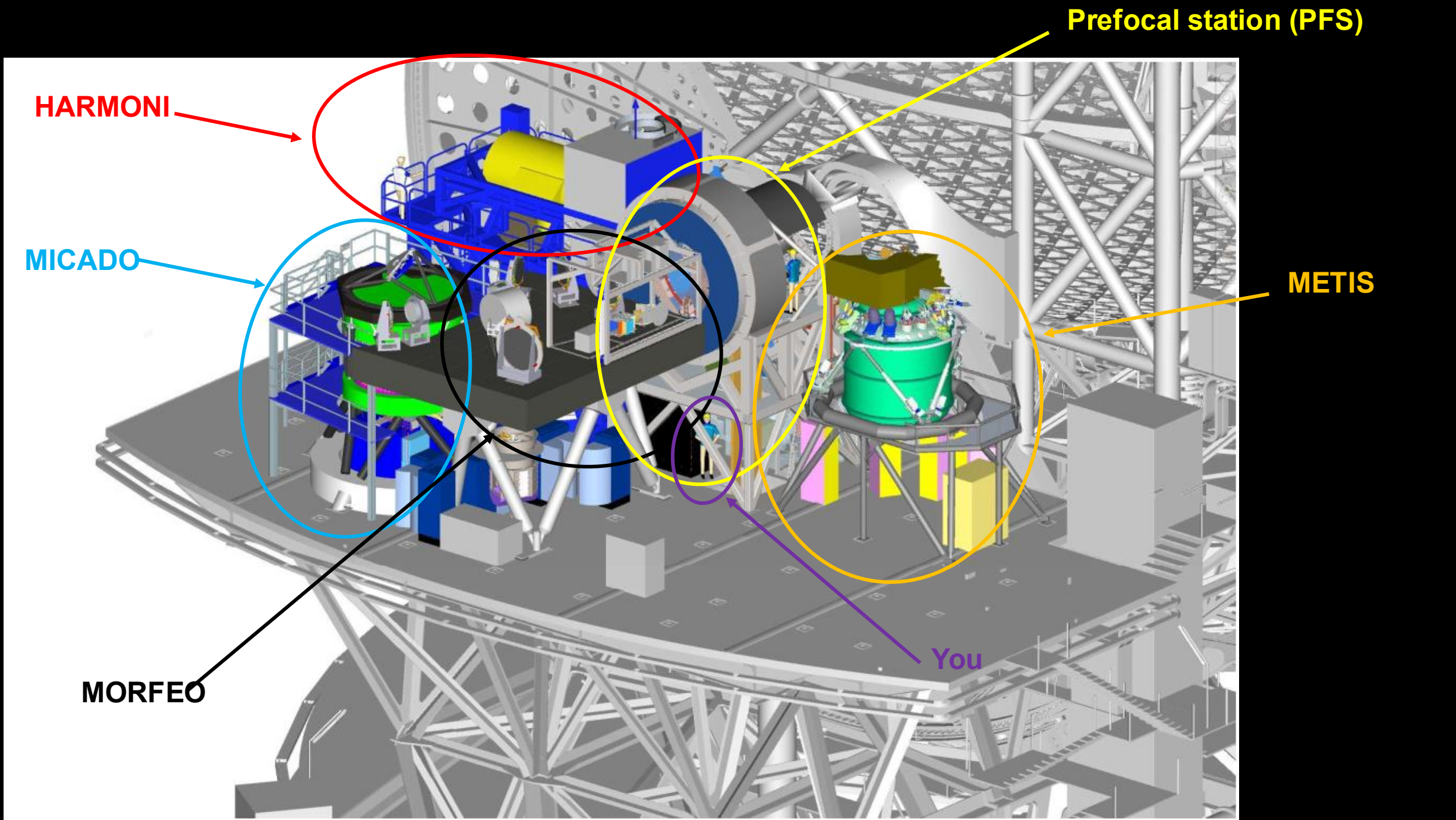
**MICADO**

**Prefocal station (PFS)**

**METIS**

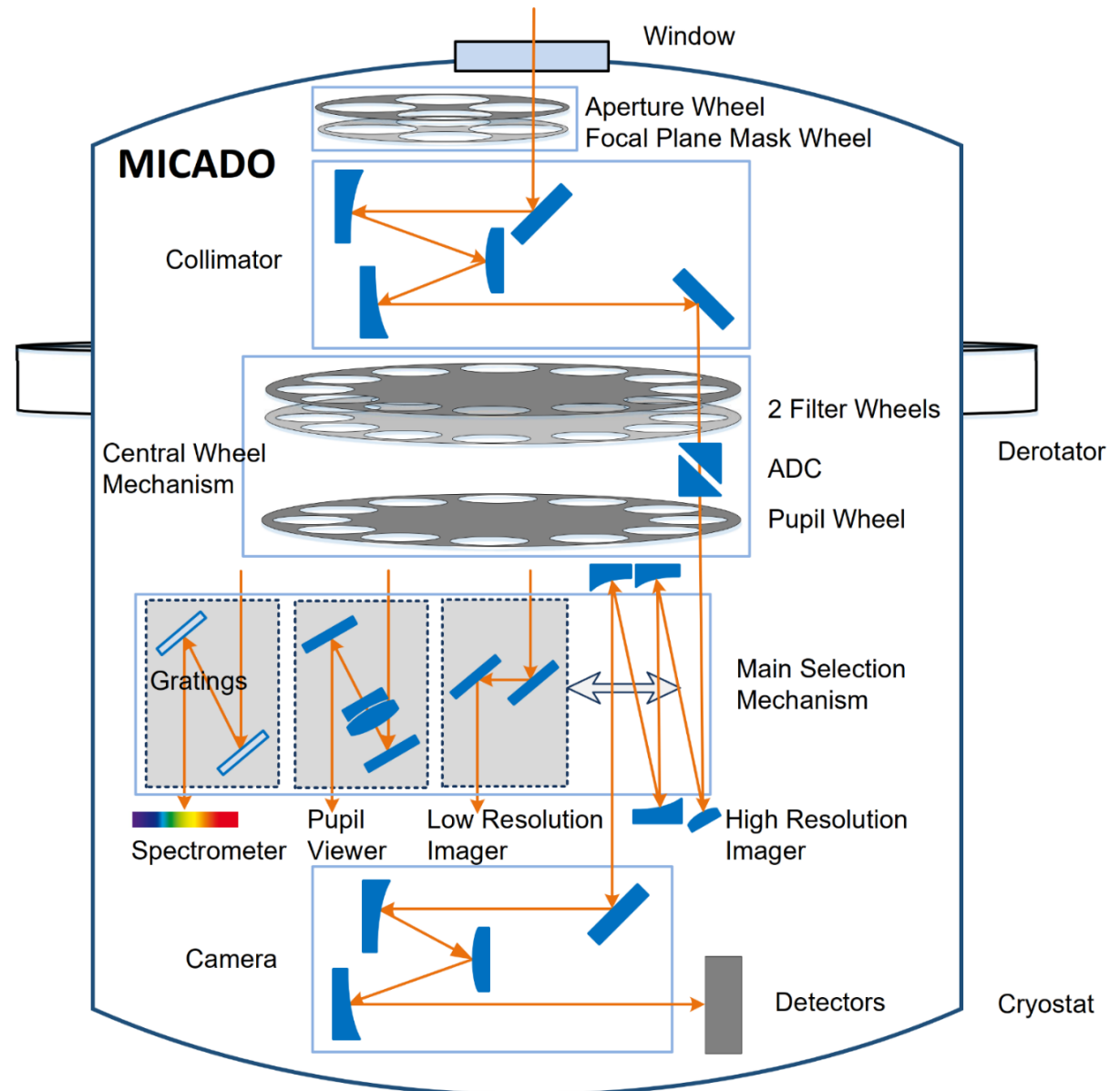
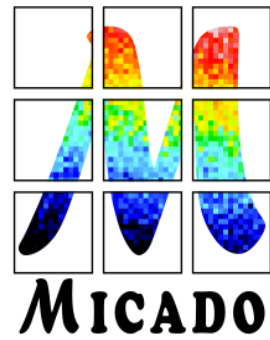
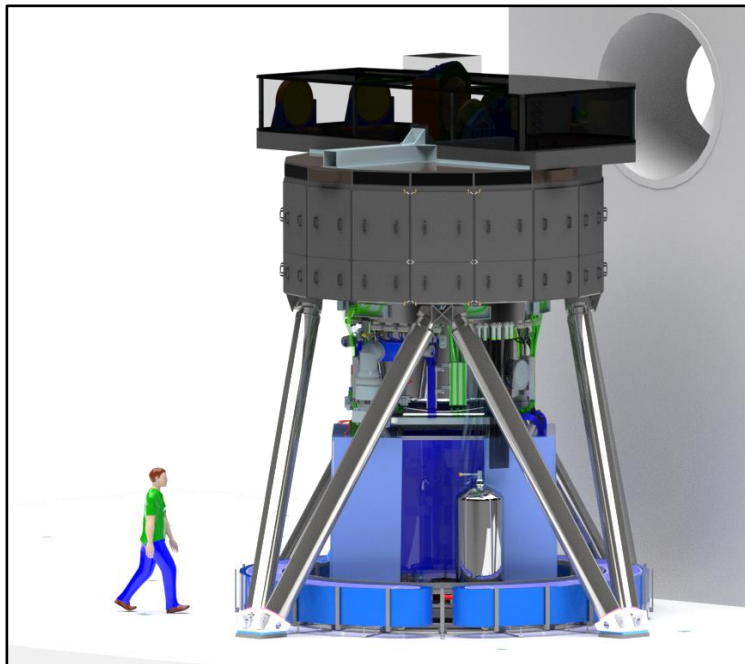






# MICADO: Multi-AO Imaging Camera for Deep Observations

- Imaging 0.8-2.4 $\mu\text{m}$  with 30 filters
- Astrometry: 50 $\mu\text{s}$  precision anywhere in the field
- Focal and pupil plane coronagraph
- Spectroscopy:  $R=20,000$  for 0.84-1.48 $\mu\text{m}$  & 1.45-2.46 $\mu\text{m}$



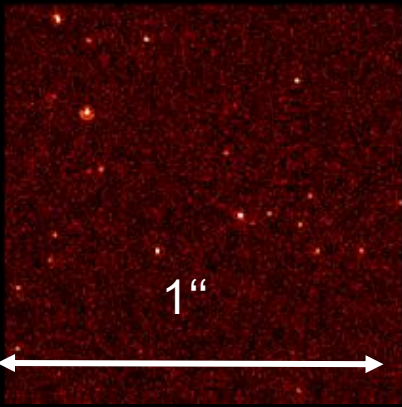
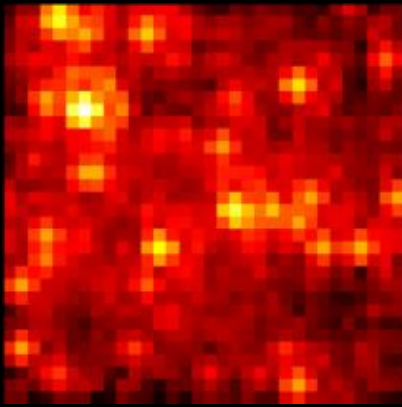
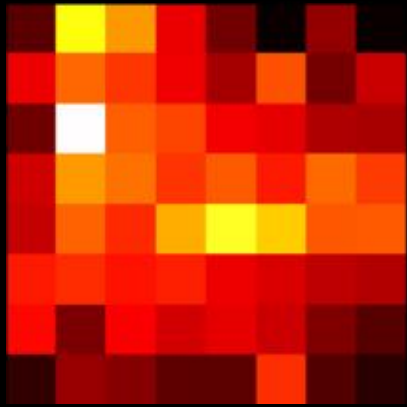
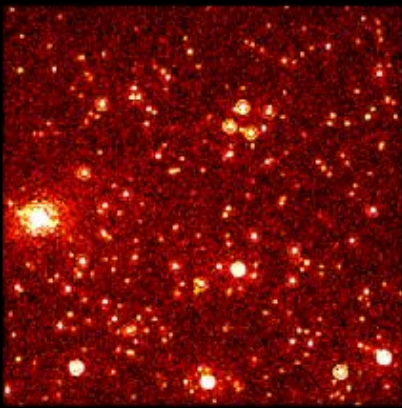
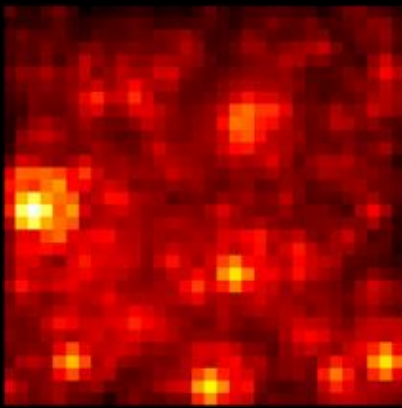
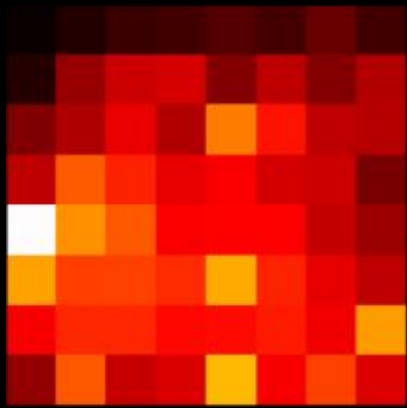
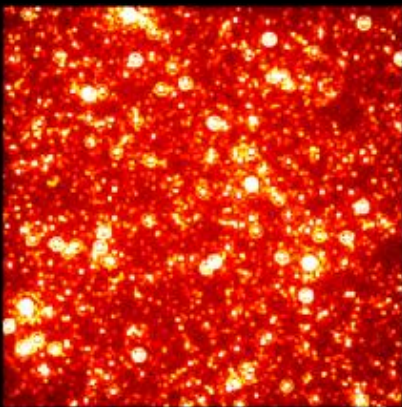
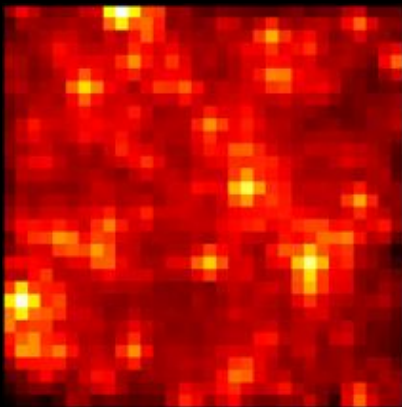
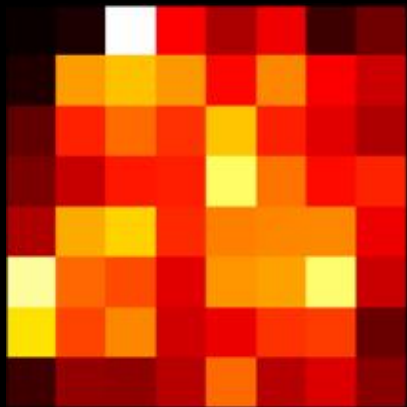
Credit: MICADO consortium



HST / WFC3

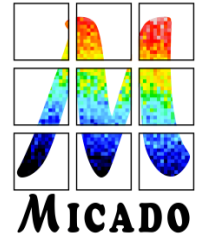
JWST / NIRCам

ELT / MICADO

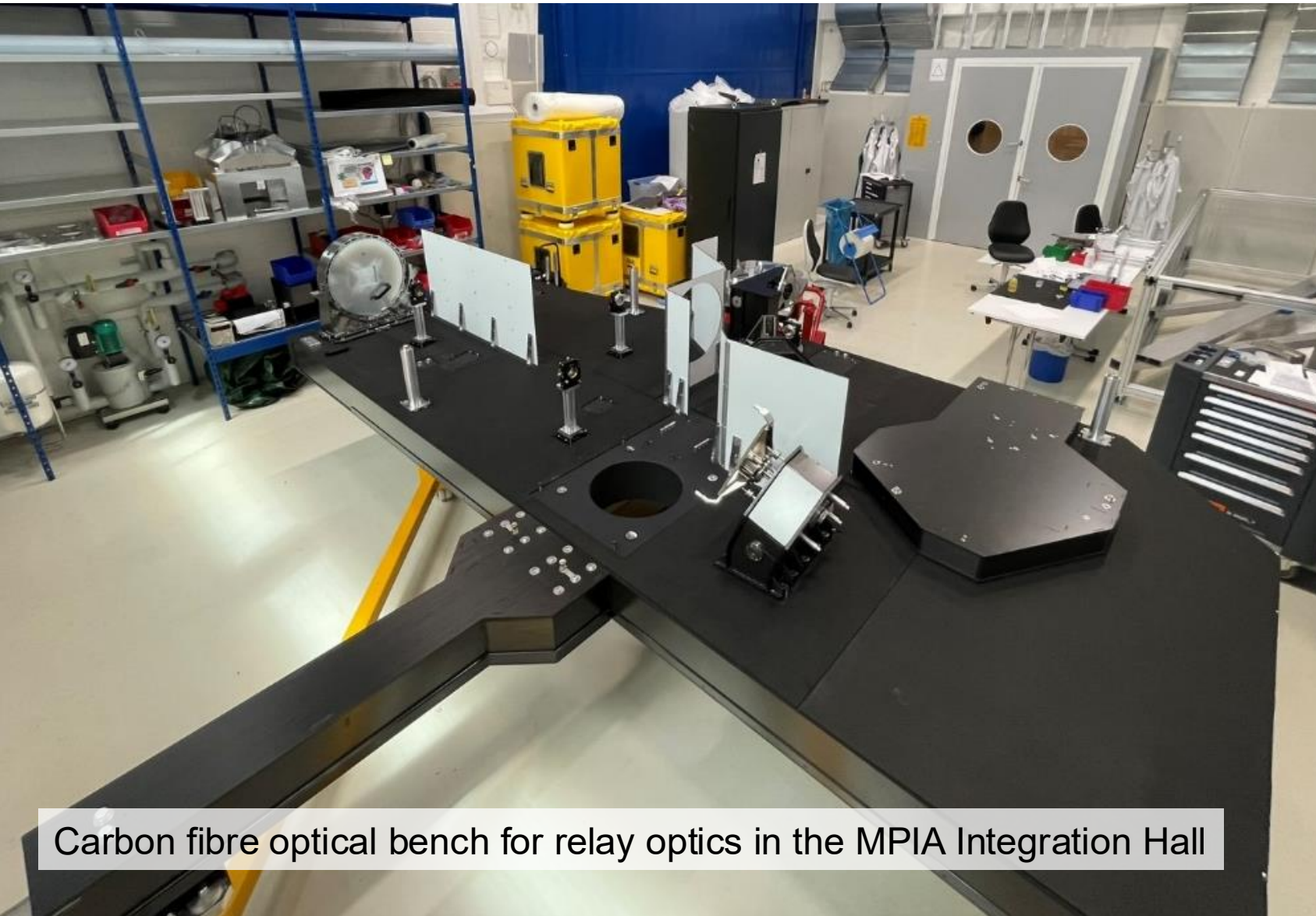


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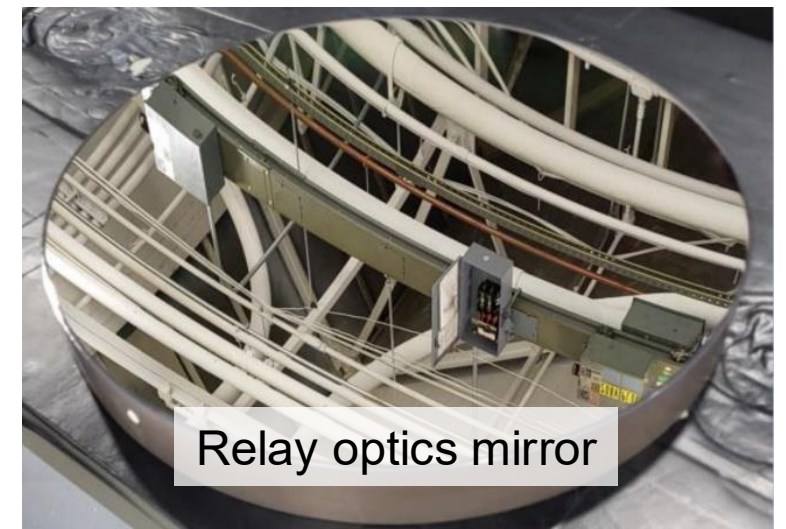
# MICADO at MPIA



Carbon fibre optical bench for relay optics in the MPIA Integration Hall



One of the relay optics mirror holders



Relay optics mirror

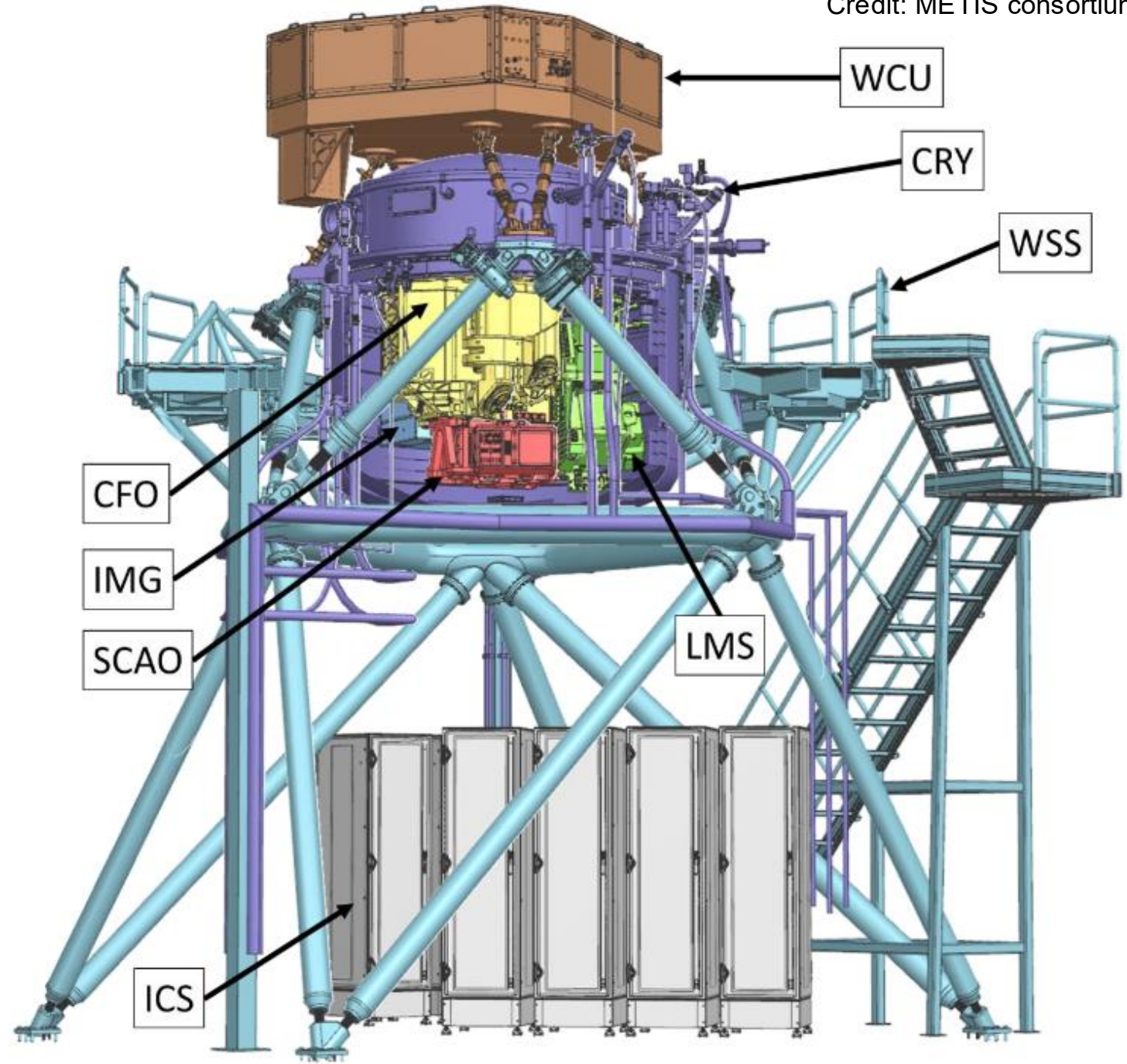
# METIS

Mid-infrared  
ELT Imager and  
Spectrograph

- L, M and N bands
- imaging
- coronagraphy
- medium-resolution spectroscopy (3-13  $\mu\text{m}$ ),
- high-resolution integral field spectroscopy (3-5  $\mu\text{m}$ )



Credit: METIS consortium





# METIS at MPIA





Technical “first light” in March  
2029

Scientific “first light” in December  
2030

QUESTIONS?

