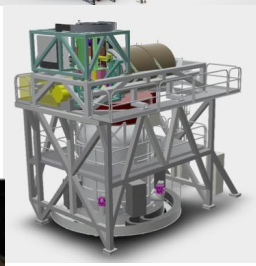
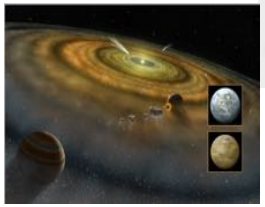
The ELT and its instruments

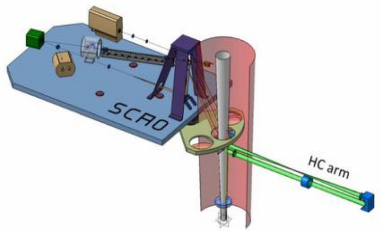
Presented by B. Neichel on behalf of the HARMONI consortium

Summary

1. General introduction
2. The Extremely Large Telescope
3. Instruments & HARMONI
4. Conclusions







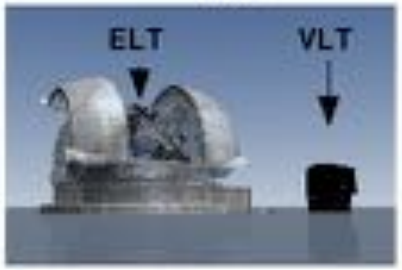
General Introduction

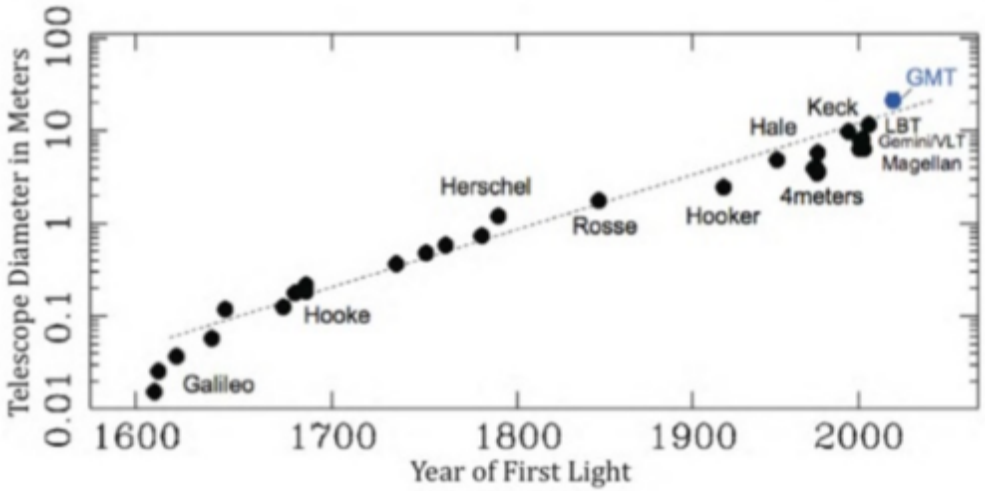
VLT - D=8m

E-ELT
D=39m

400 Years of Ground Based Astronomical Instrumentation

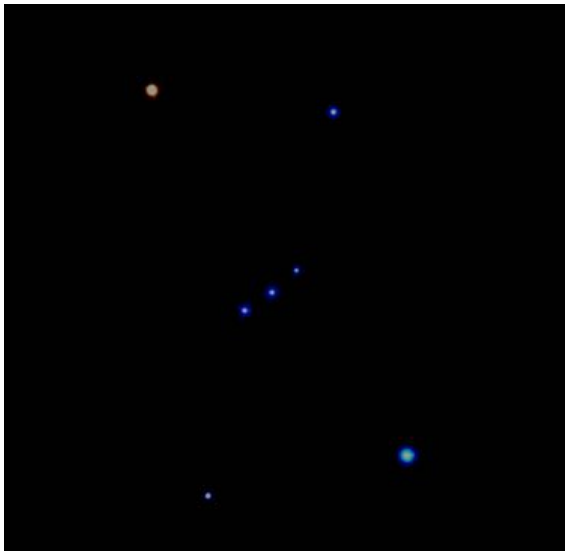
From a few centimeter in 1609…**…to 40 meters… in 6 years from now!**



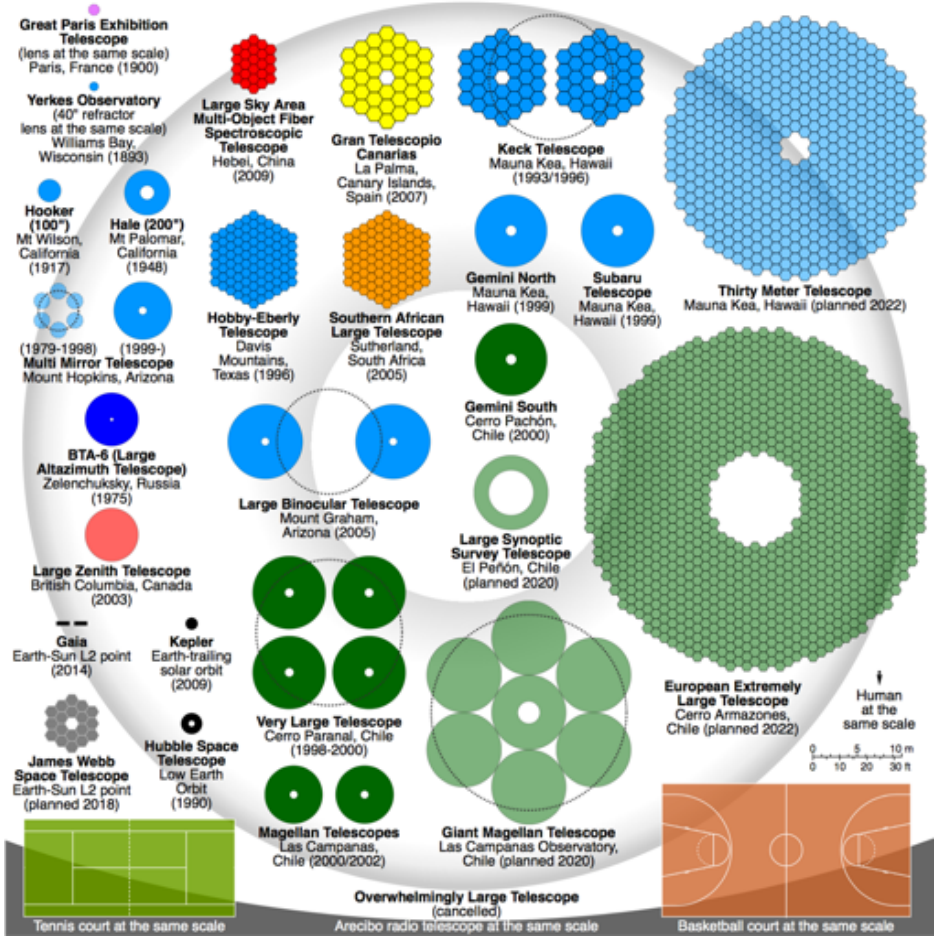


Exponential growth… For collecting power

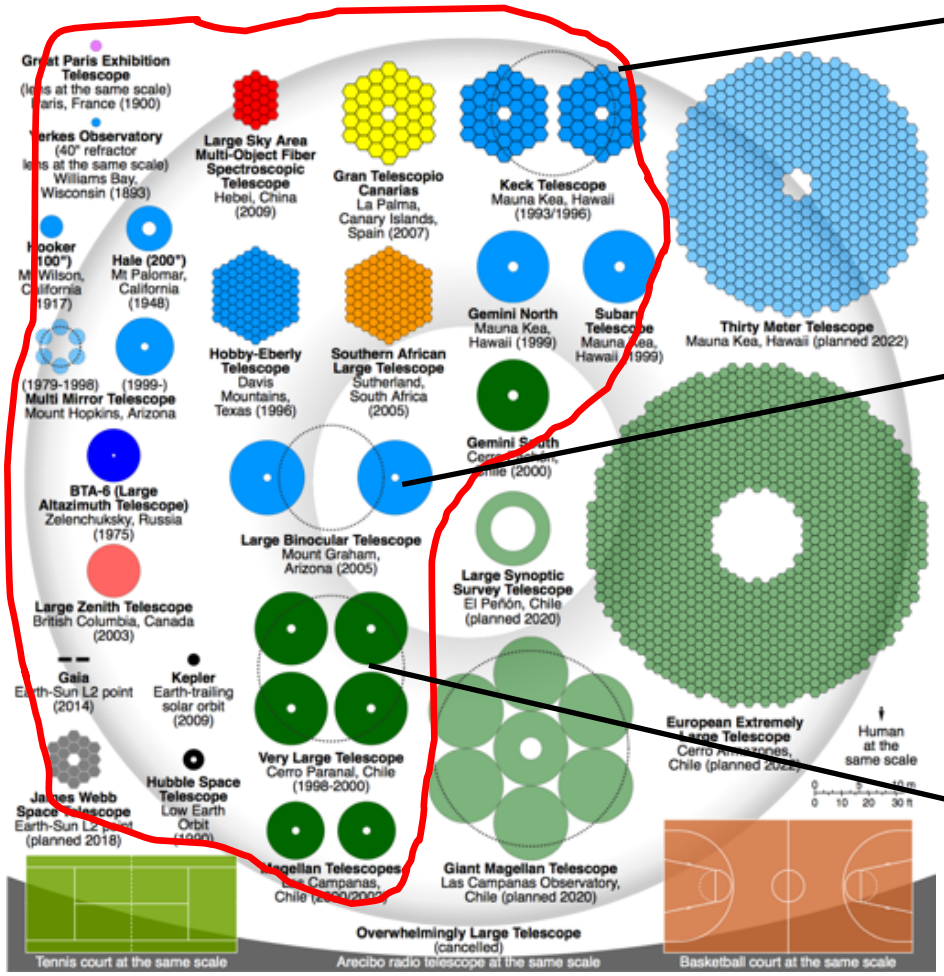
Exponential growth… For collecting power



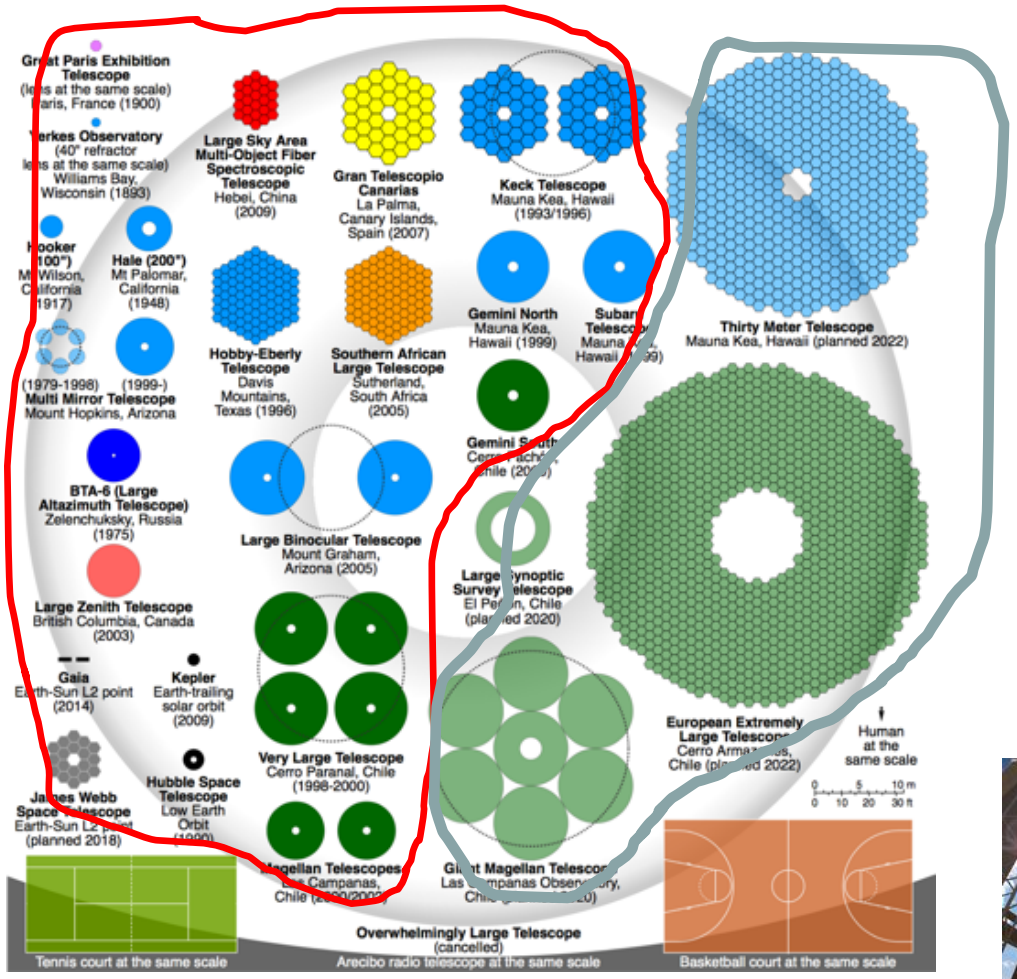
Exponential growth… For collecting power

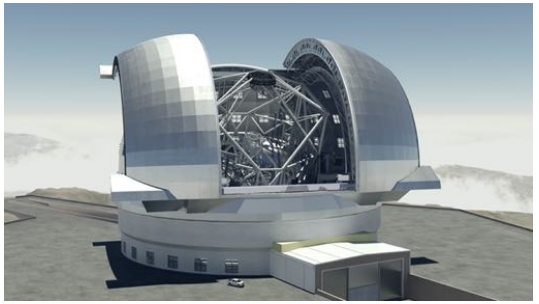


Exponential growth… For collecting power

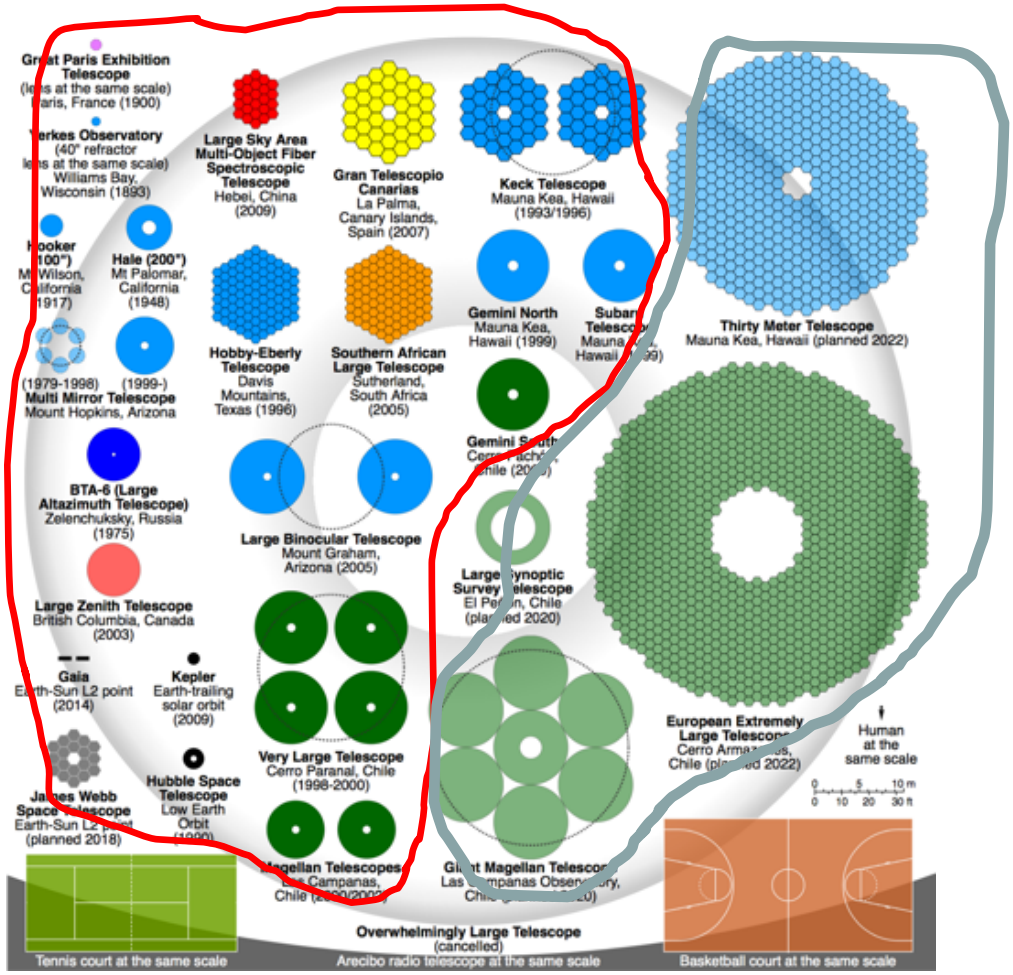


Exponential growth… For collecting power

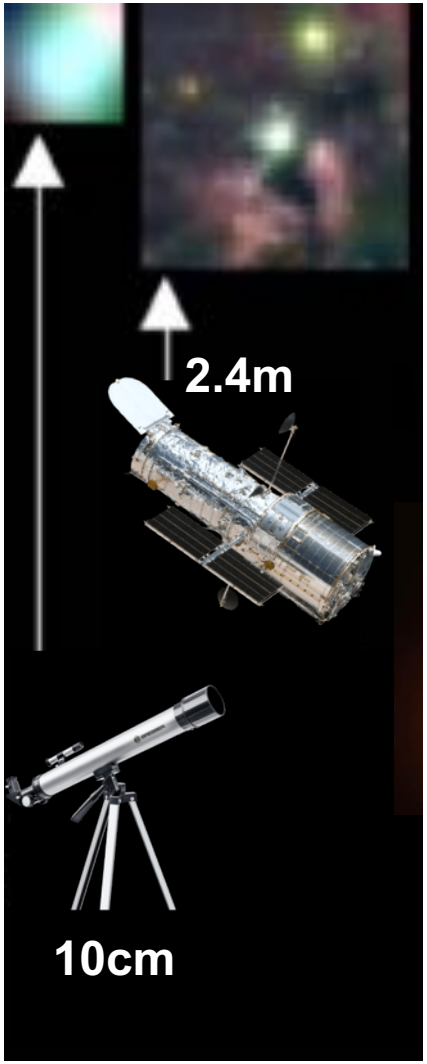




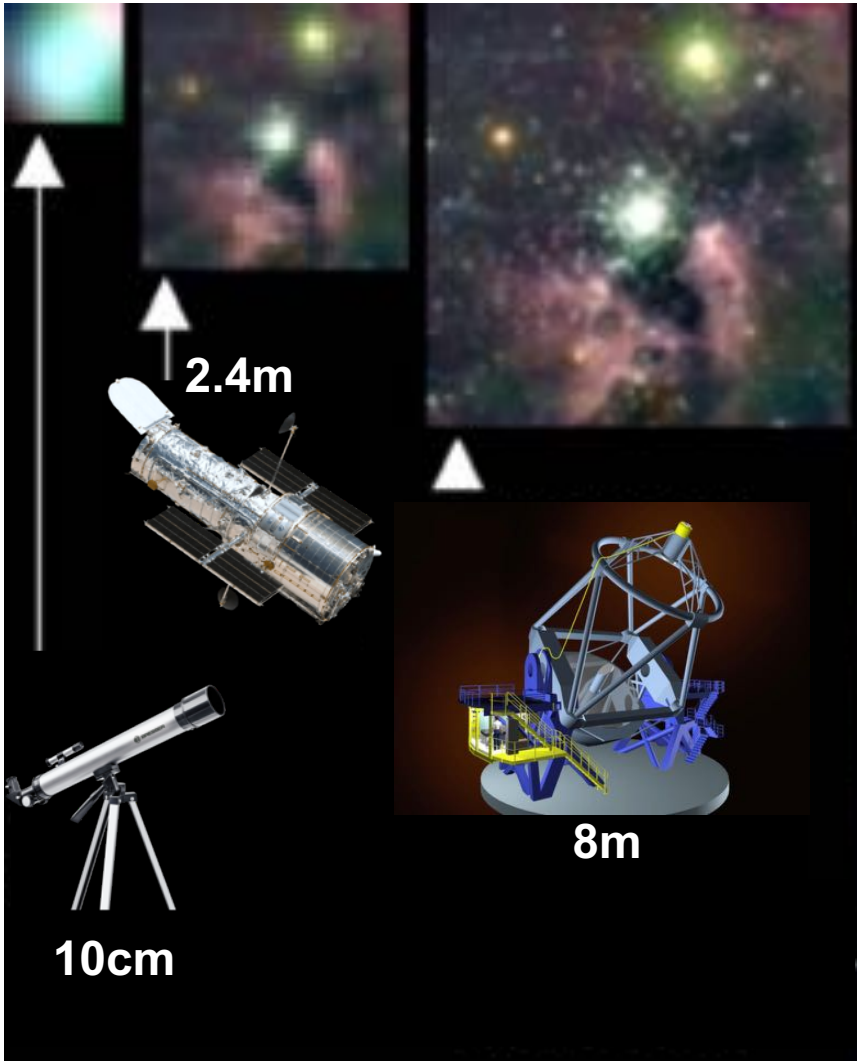
Exponential growth… For collecting power



Exponential growth… For resolution



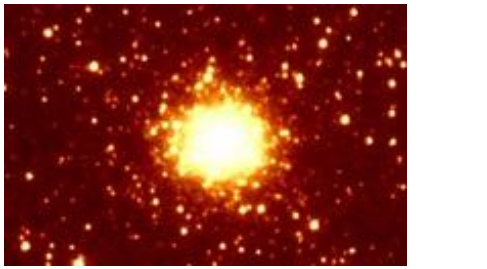
Exponential growth… For resolution



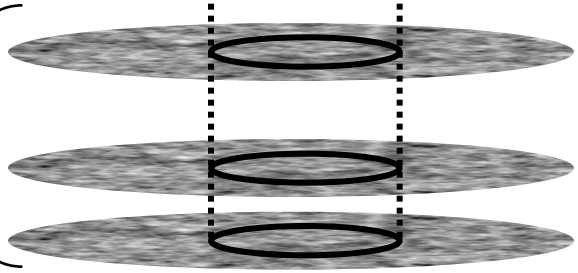
Exponential growth… For resolution

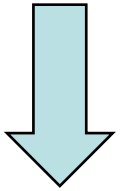
https://www.eso.org/public/france/images/eso9946a/?lang

Adaptive Optics



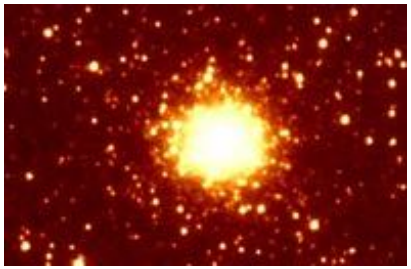
Earth's atmosphere



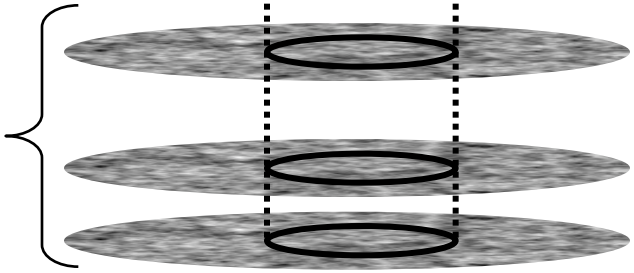


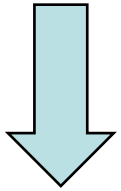
Spatial resolution is lost…

Adaptive Optics



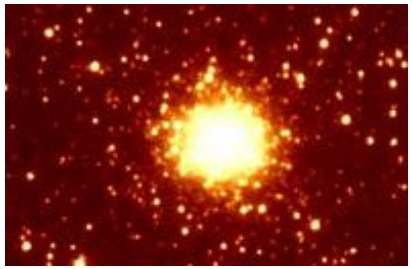
Earth's atmosphere



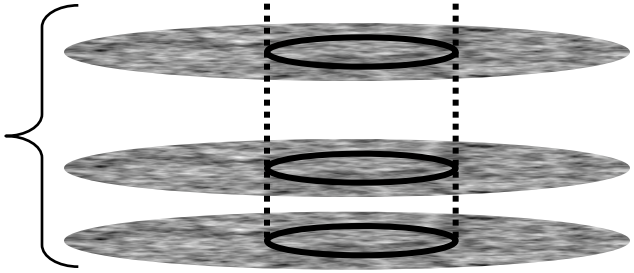


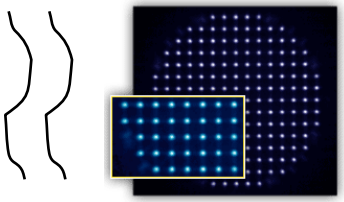
Spatial resolution is lost…

Adaptive Optics

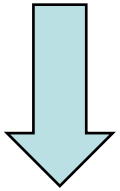


Earth's atmosphere



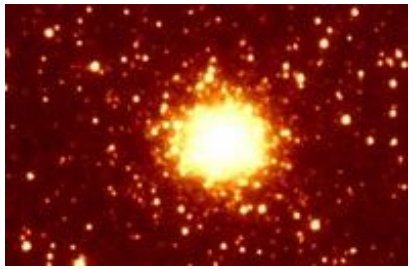


Wave-Front Sensor

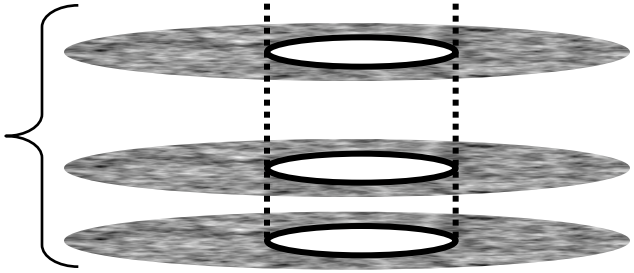


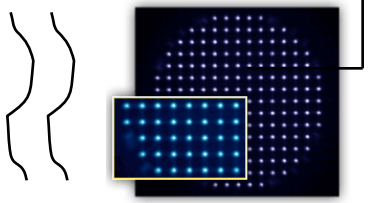
Spatial resolution is lost…

Adaptive Optics

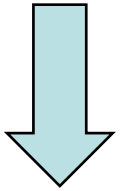


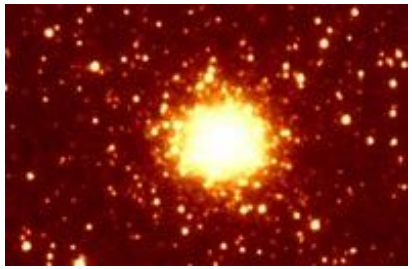
Earth's atmosphere



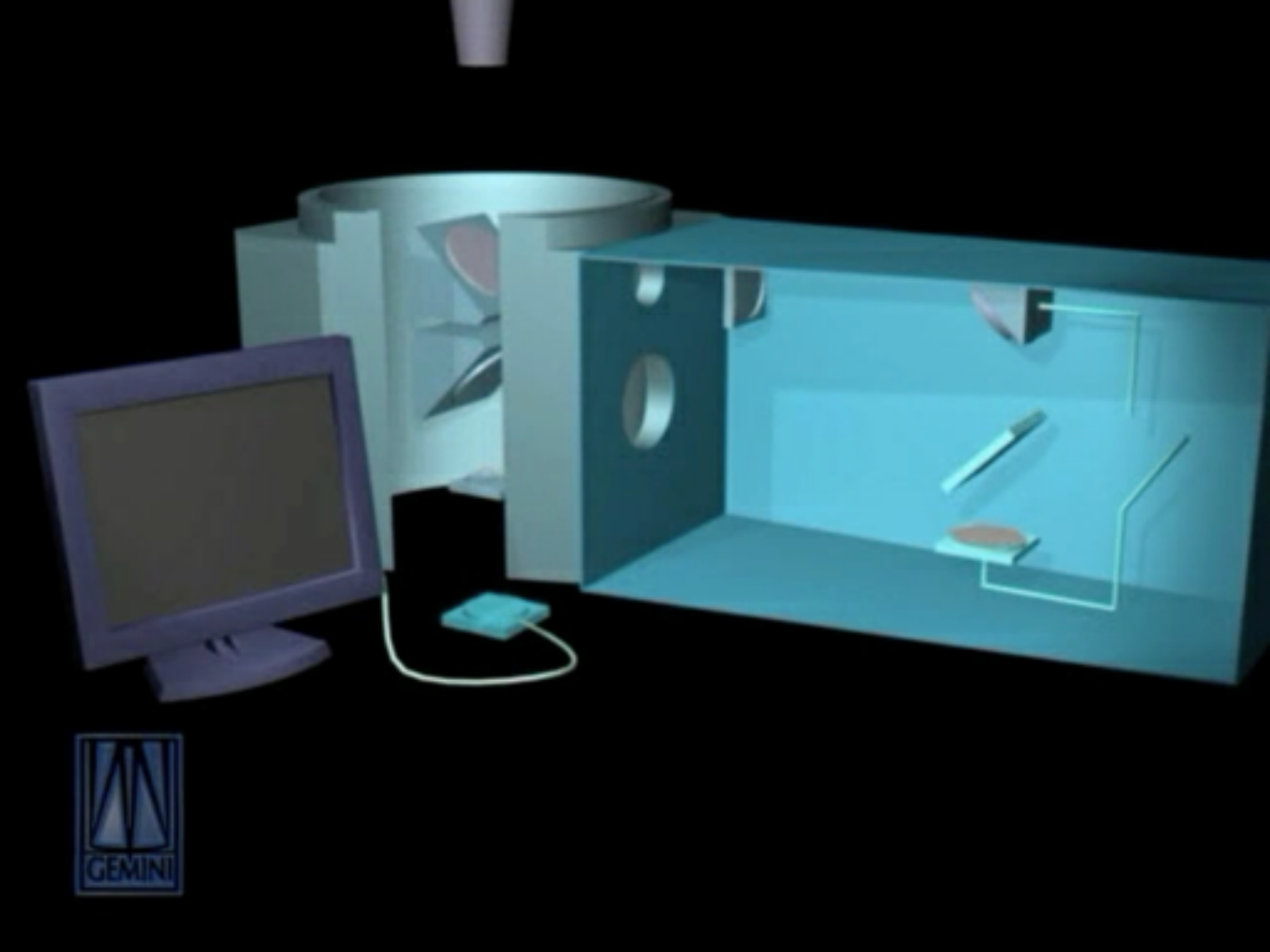


Wave-Front Sensor

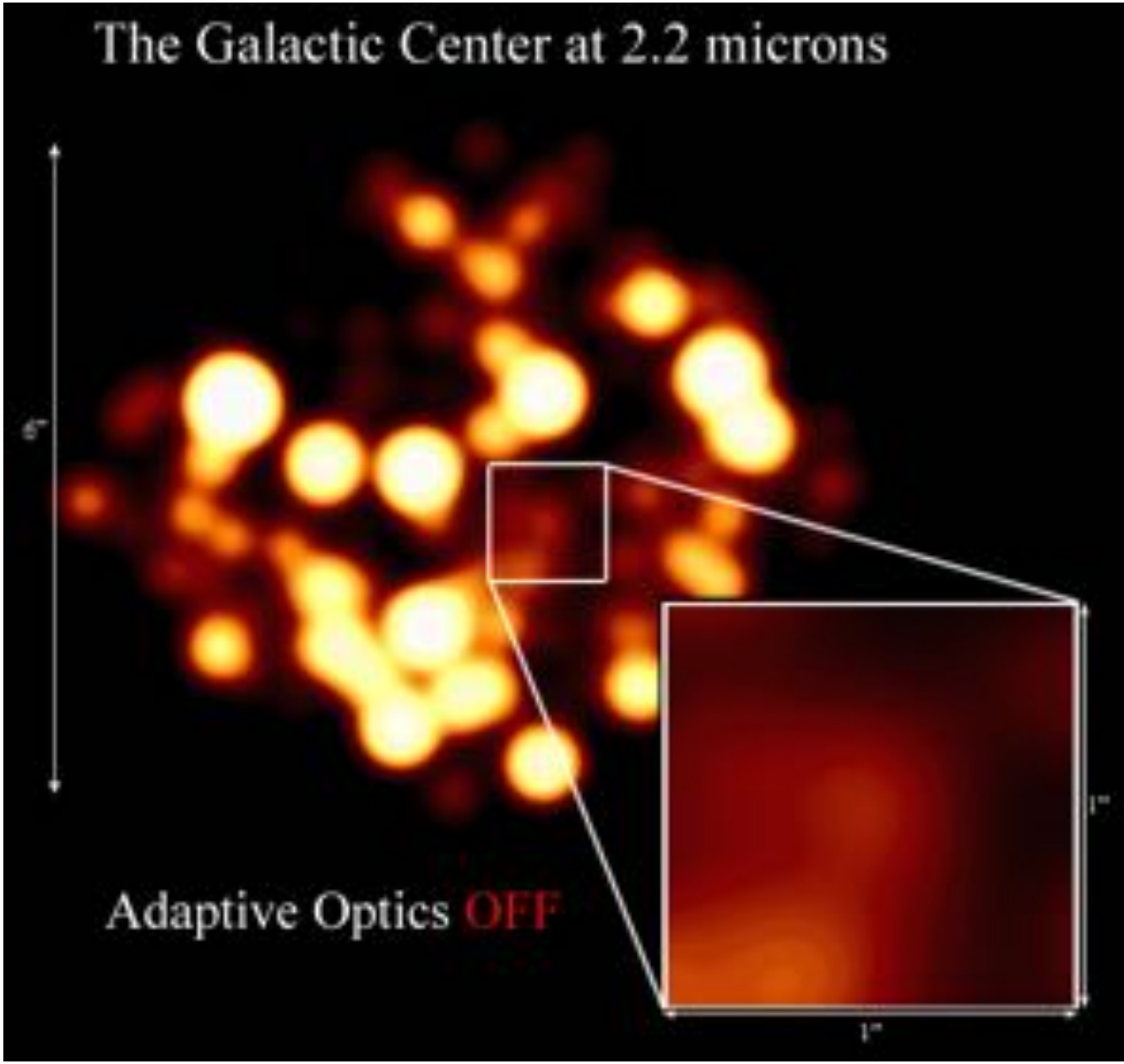




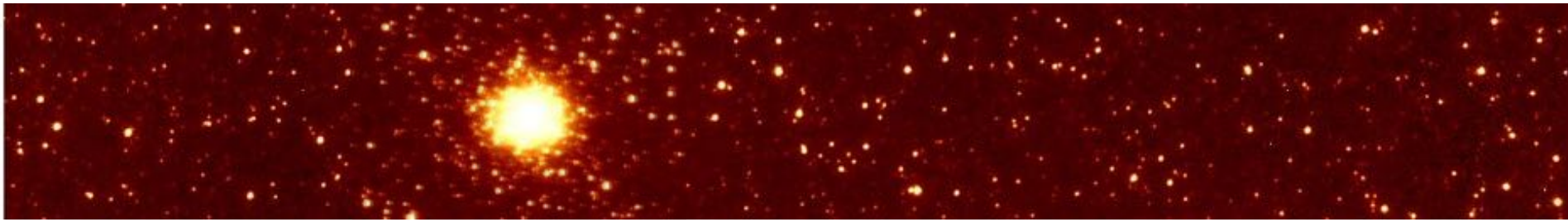
Spatial resolution is restored

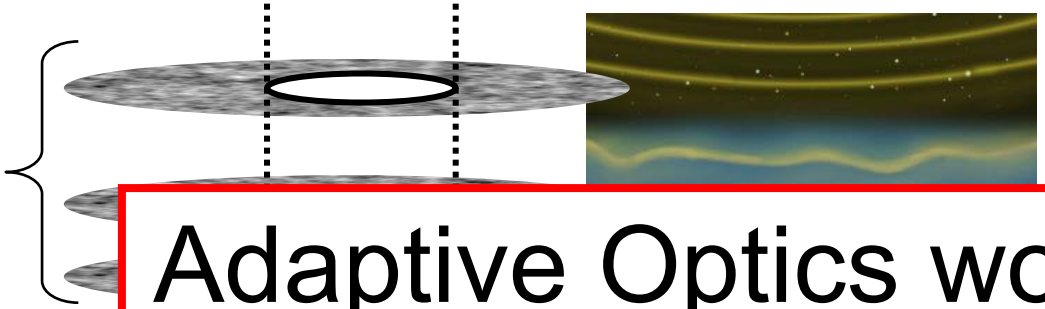

GEMINI

Adaptive Optics



Adaptive Optics

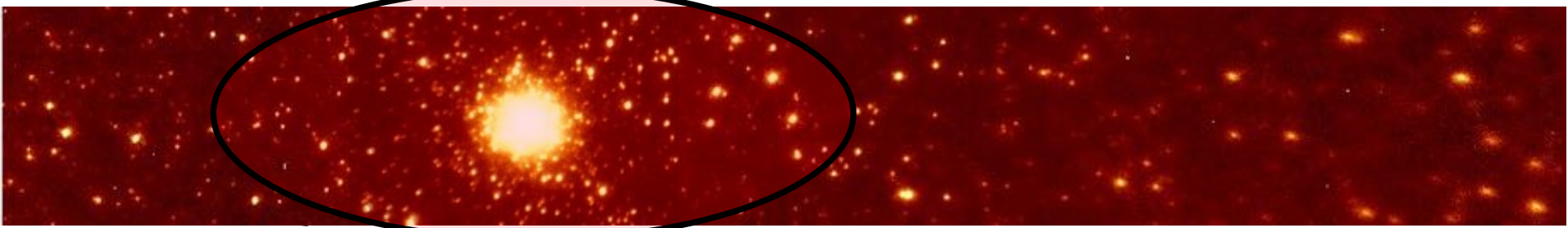




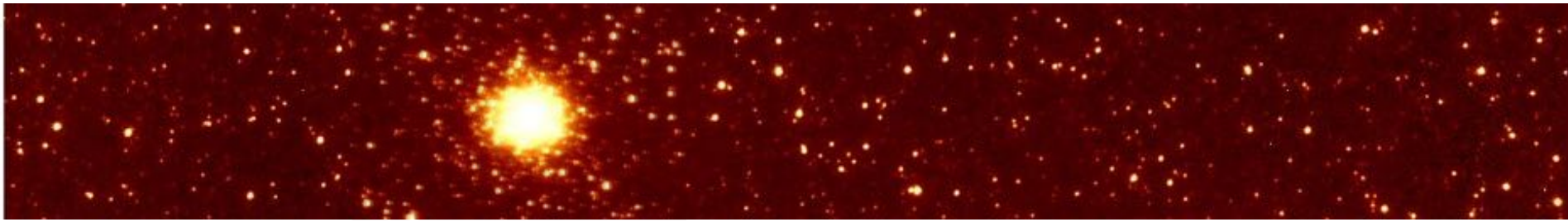
Earth's atmosphere

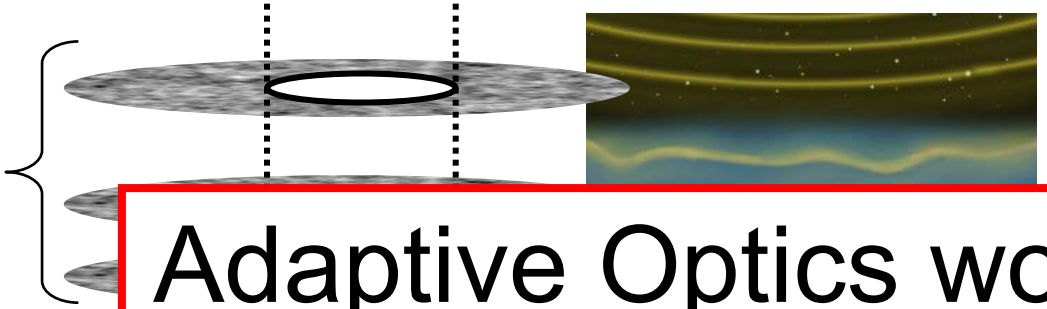
Adaptive Optics works **close** to a **bright** guide star

Wave-Front Sensor



Adaptive Optics

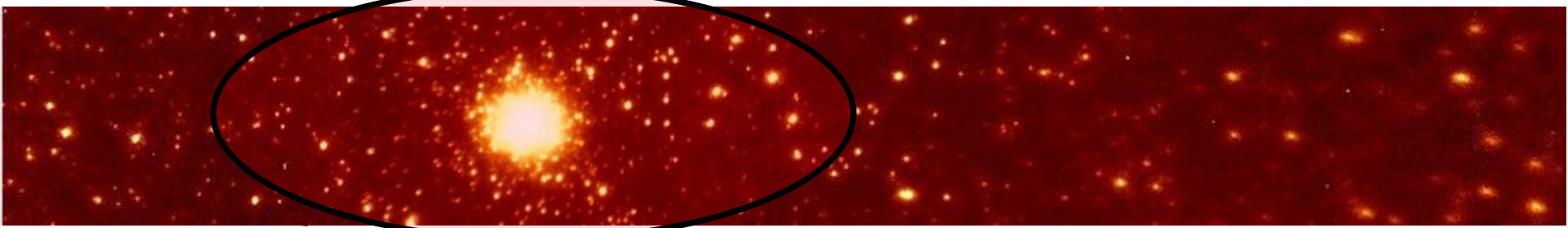




Earth's atmosphere

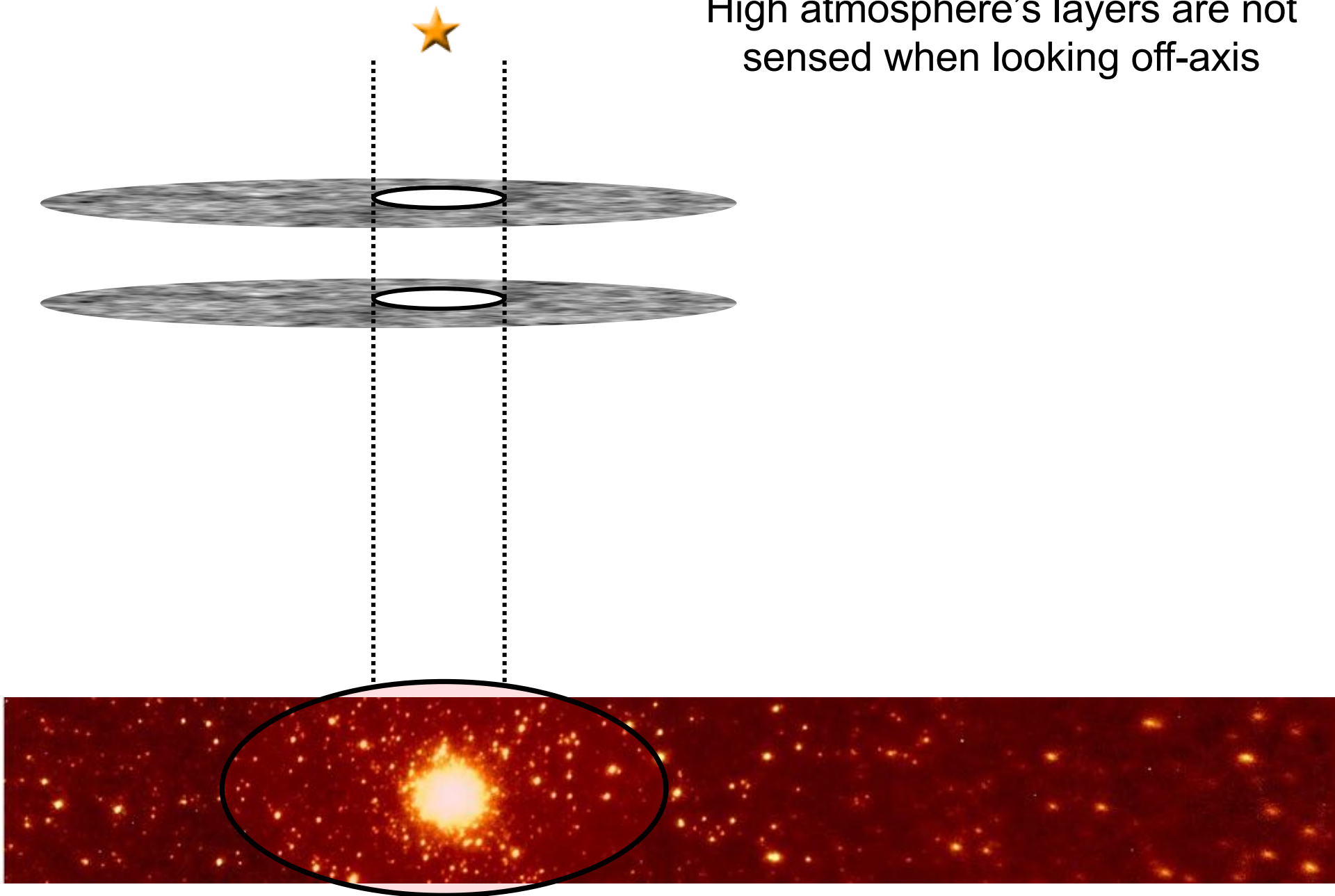
Adaptive Optics works **close** to a **bright** guide star

Wave-Front Sensor



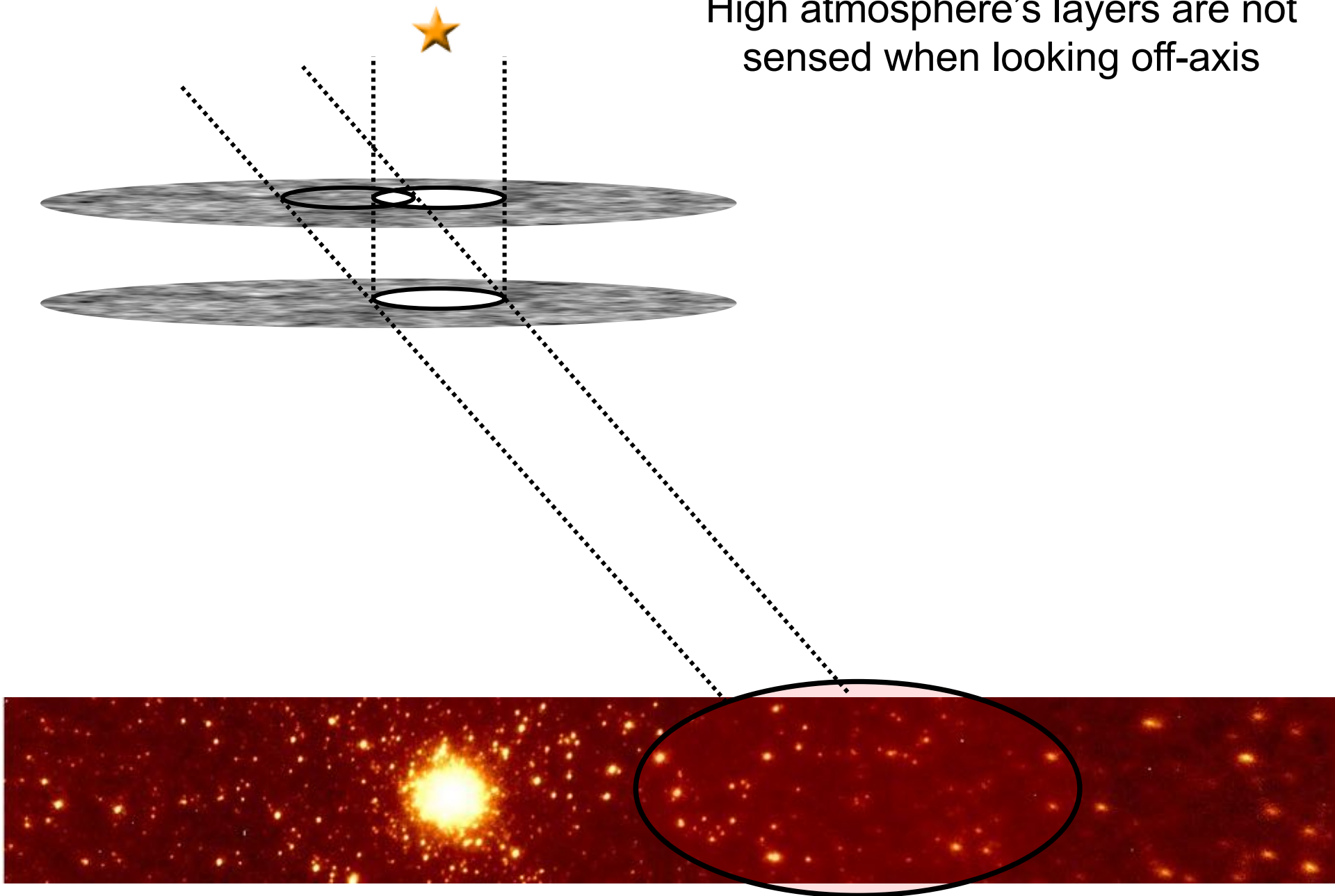
Anisoplanatism

High atmosphere's layers are not sensed when looking off-axis



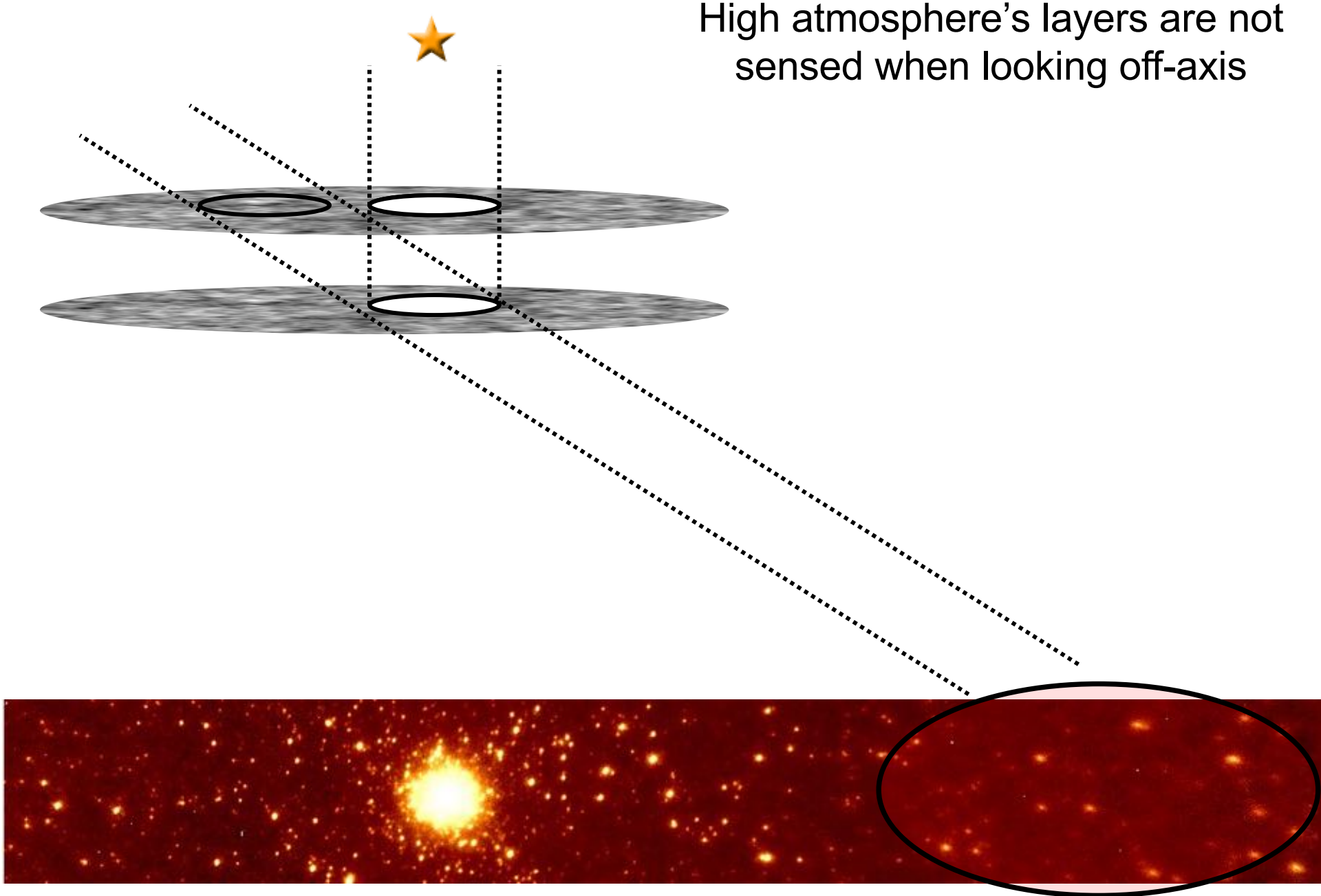
Anisoplanatism

High atmosphere's layers are not sensed when looking off-axis

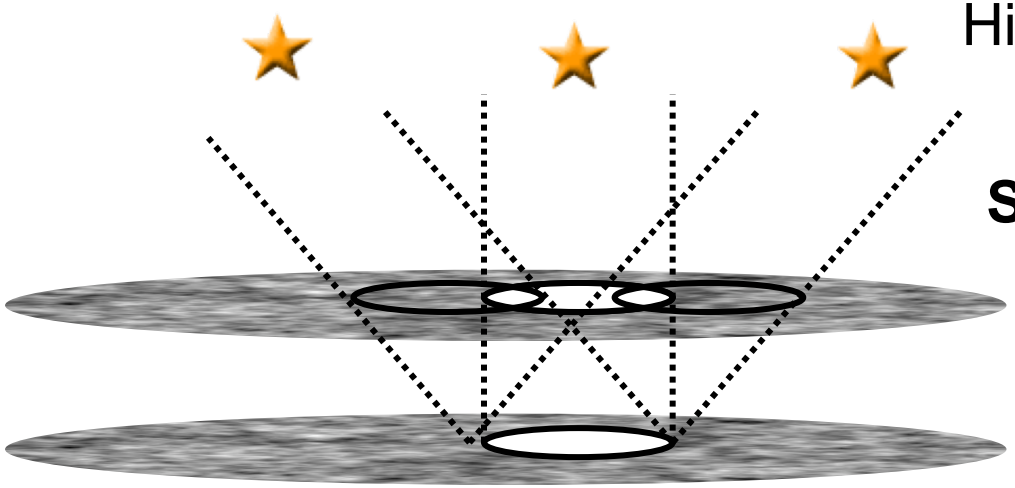


Anisoplanatism

High atmosphere's layers are not sensed when looking off-axis

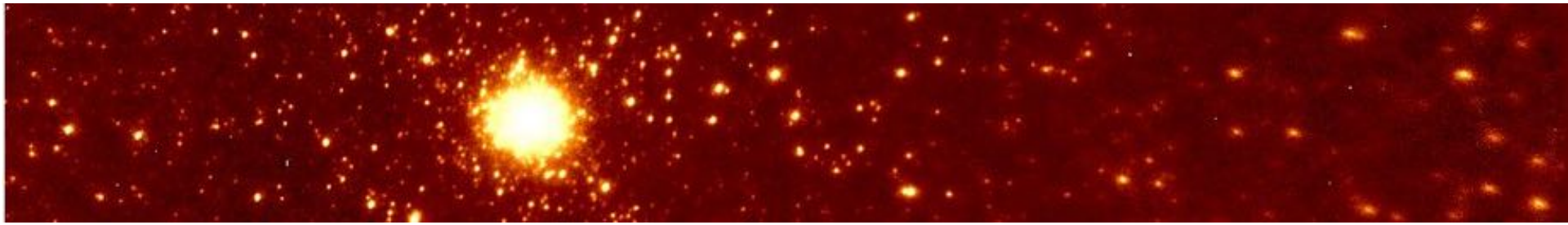


Tomography

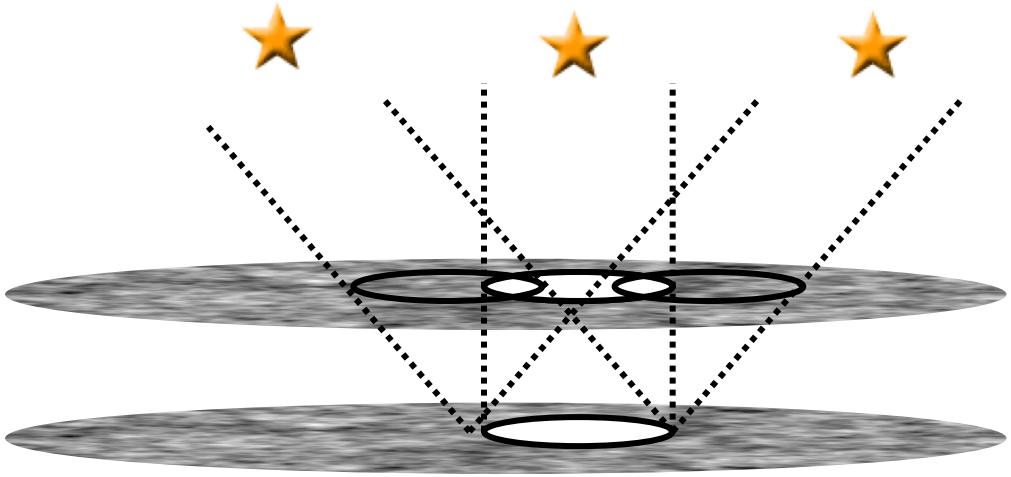


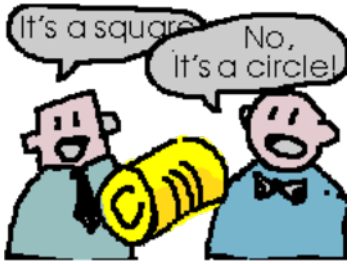
High atmosphere's layers are not sensed when looking off-axis

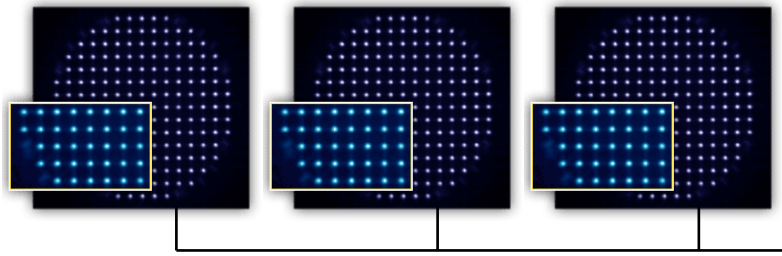
Solution => Combine off-axis measurements

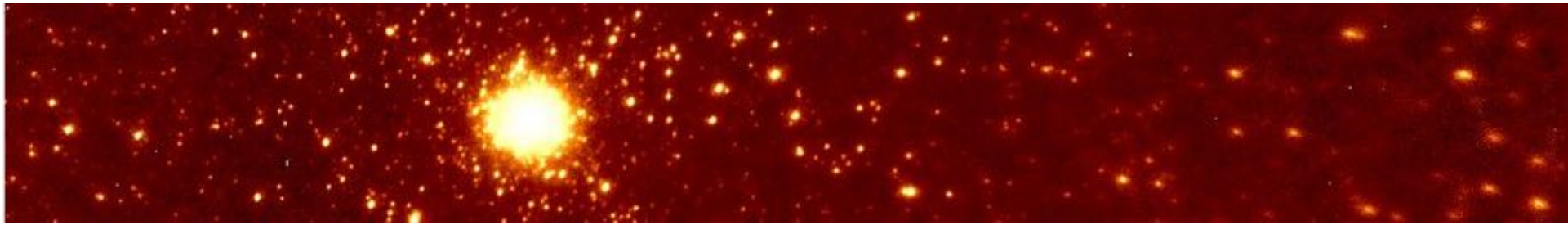


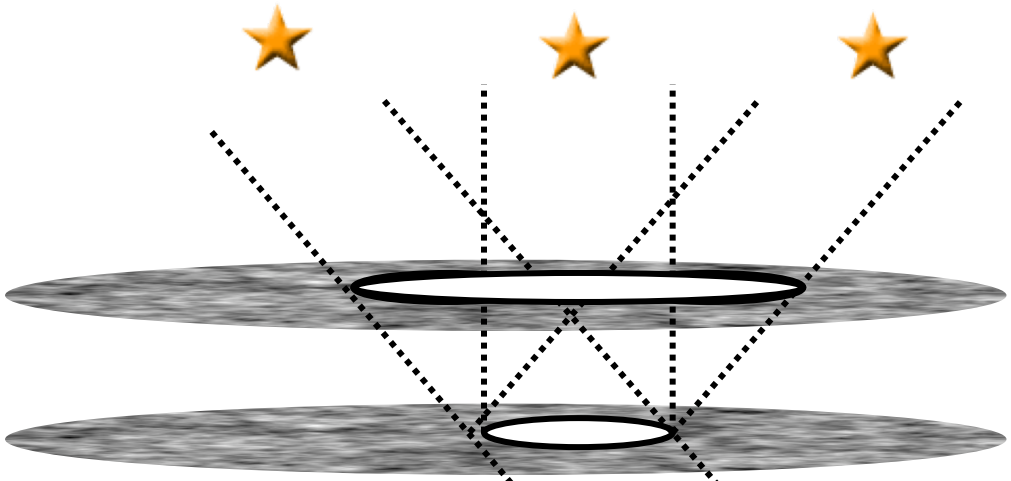
Tomography





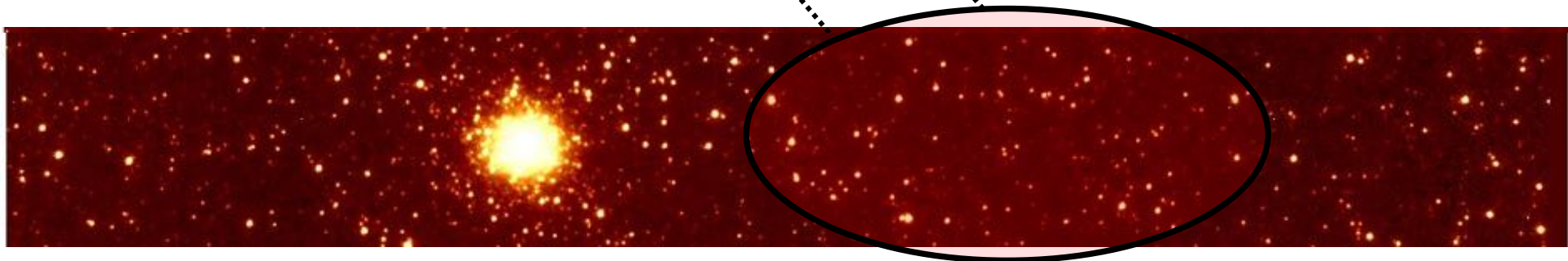






=> Combine off-axis measurements

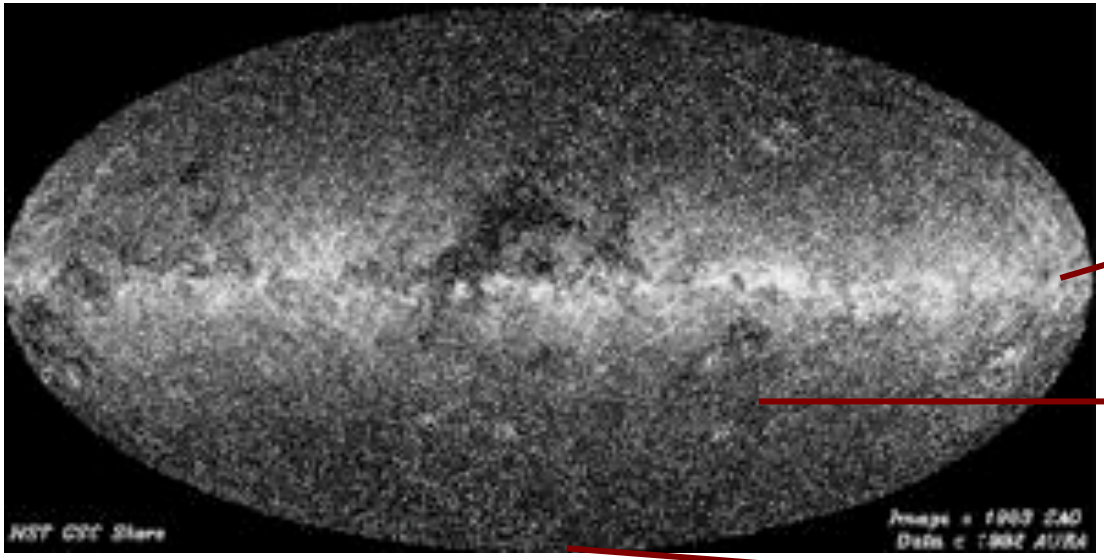
Good correction in a larger FoV !

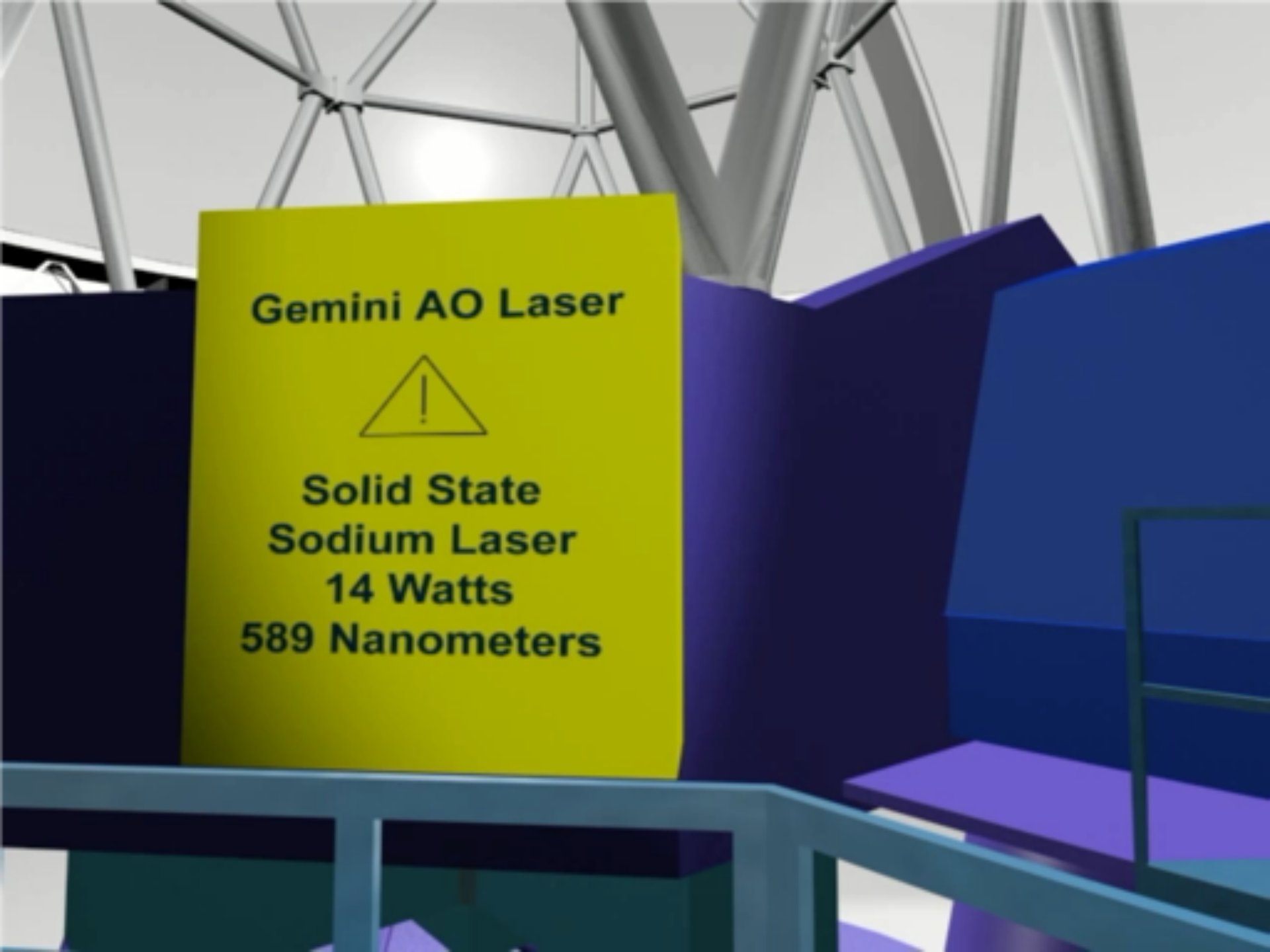


Adaptive Optics works **close** to a **bright** guide star

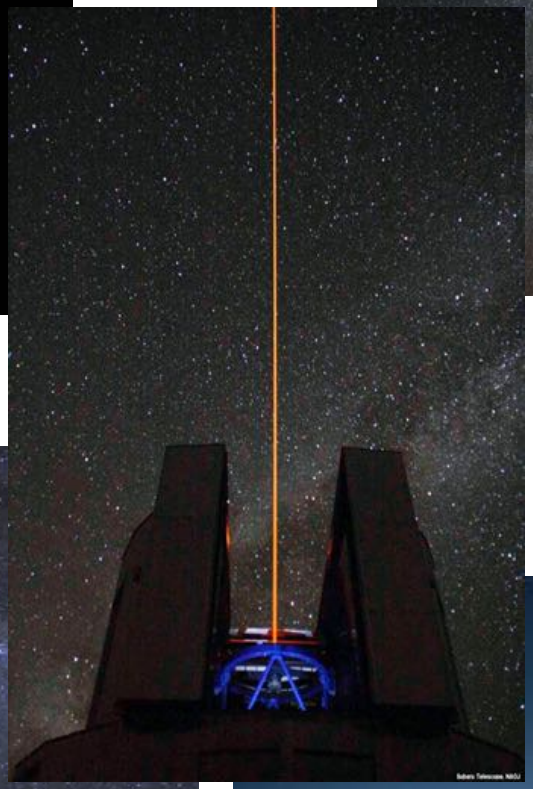
How many Guide Stars are available ?

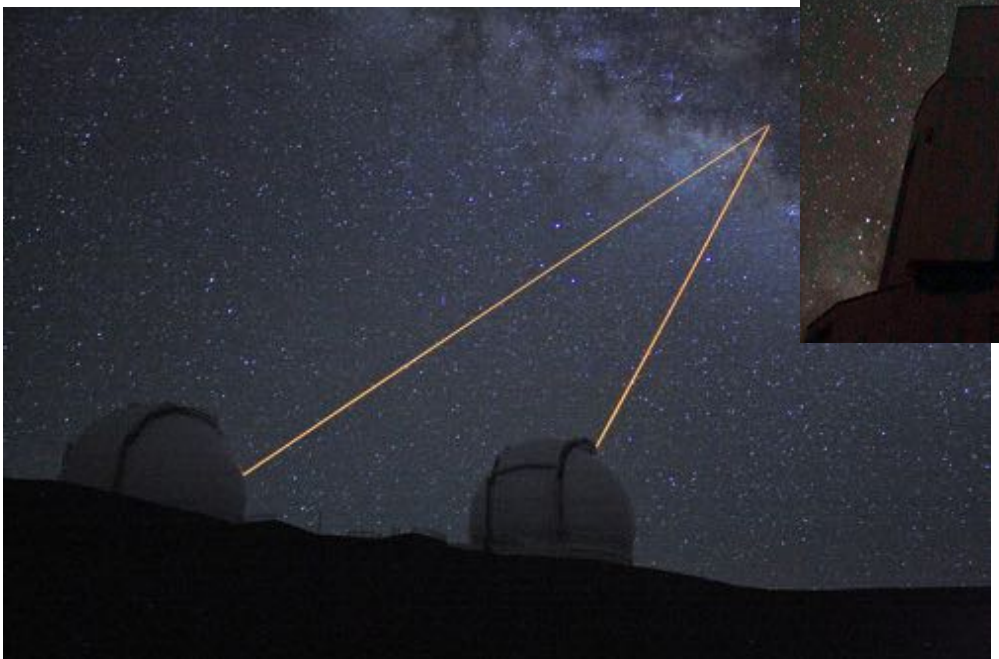
3 stars with R < 16 in a 2 arcmin FoV



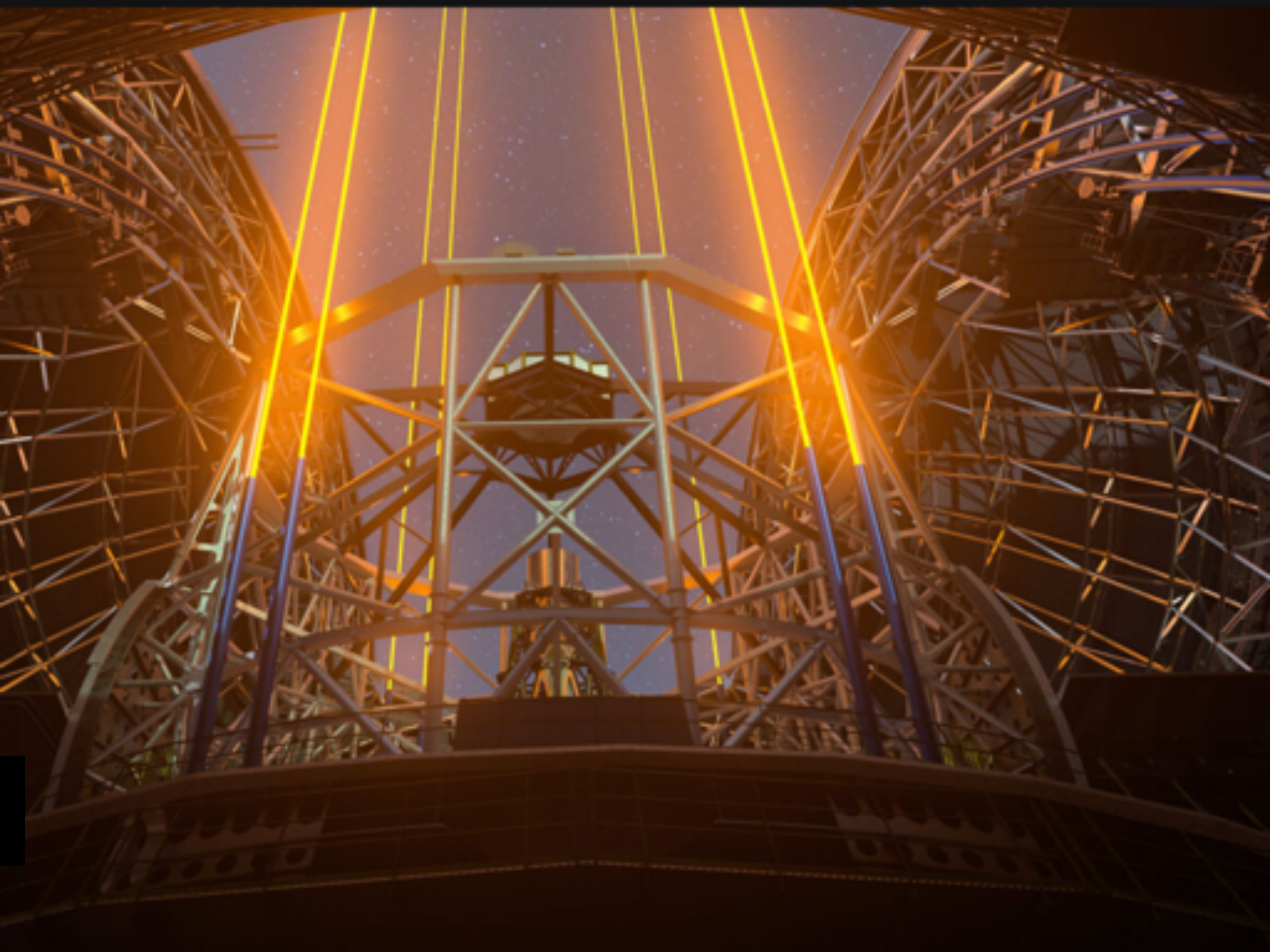

Gemini AO Laser
Solid State
Sodium Laser
14 Watts
589 Nanometers

Laser Guide Star





Laser Guide Star

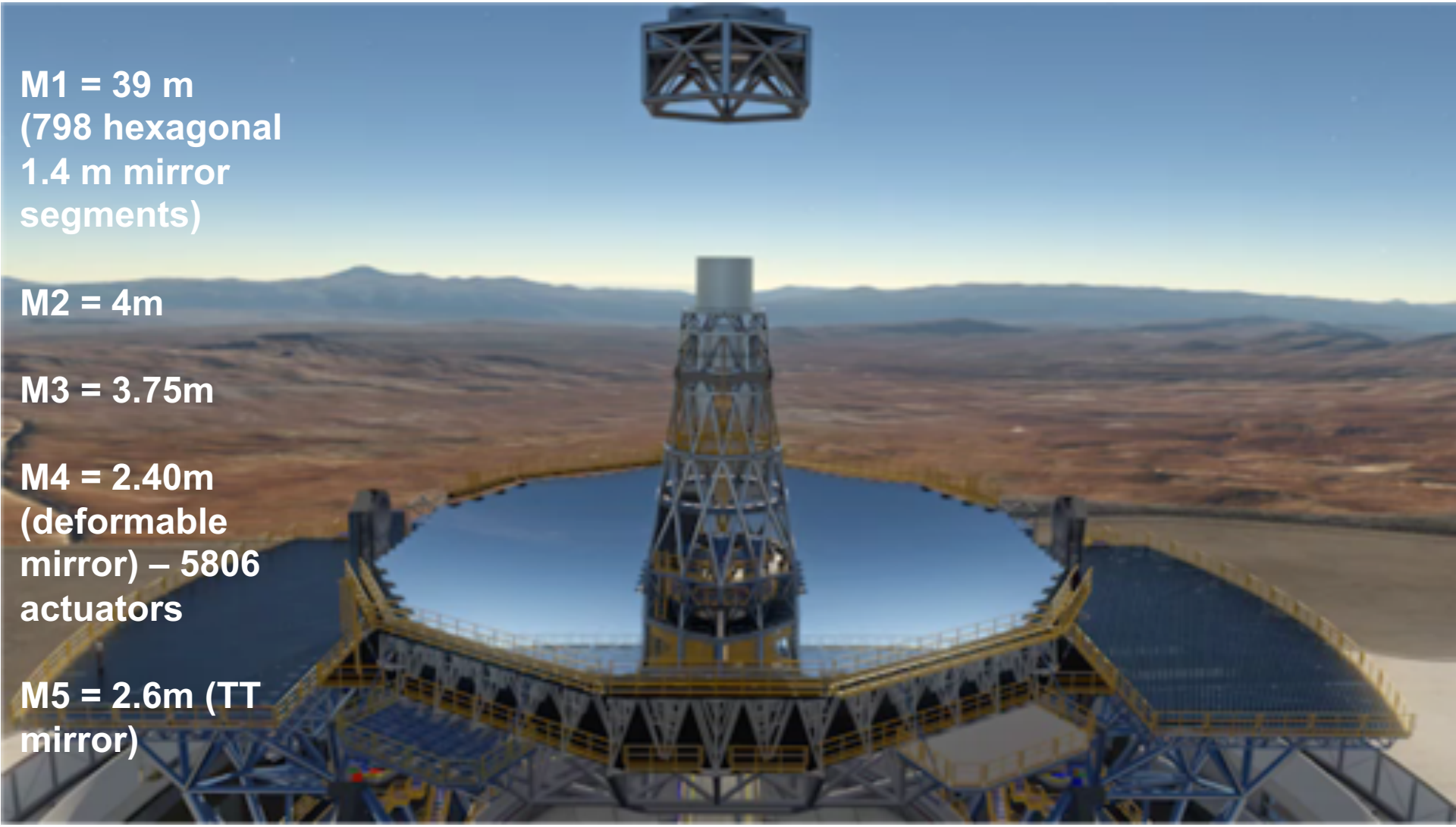


Summary

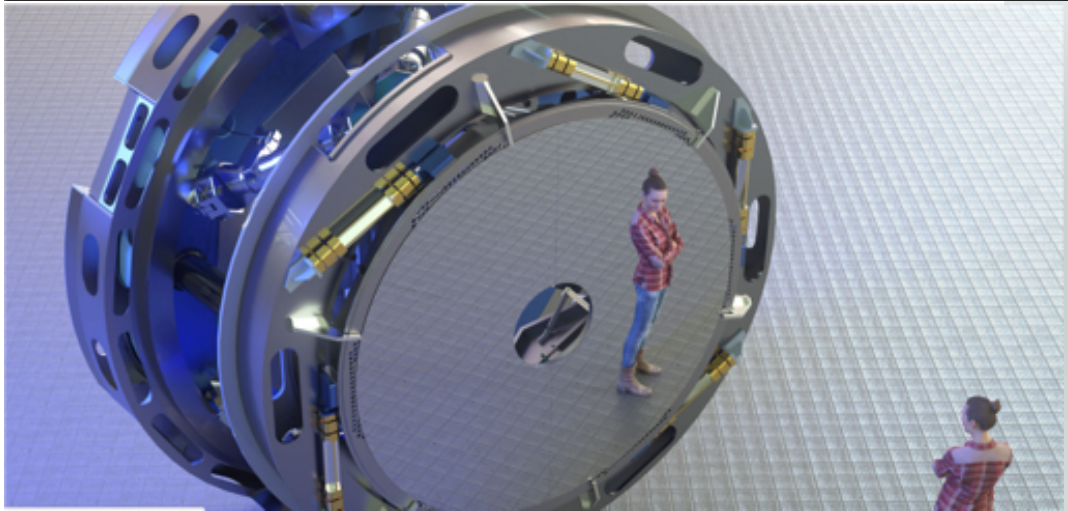
1. General introduction

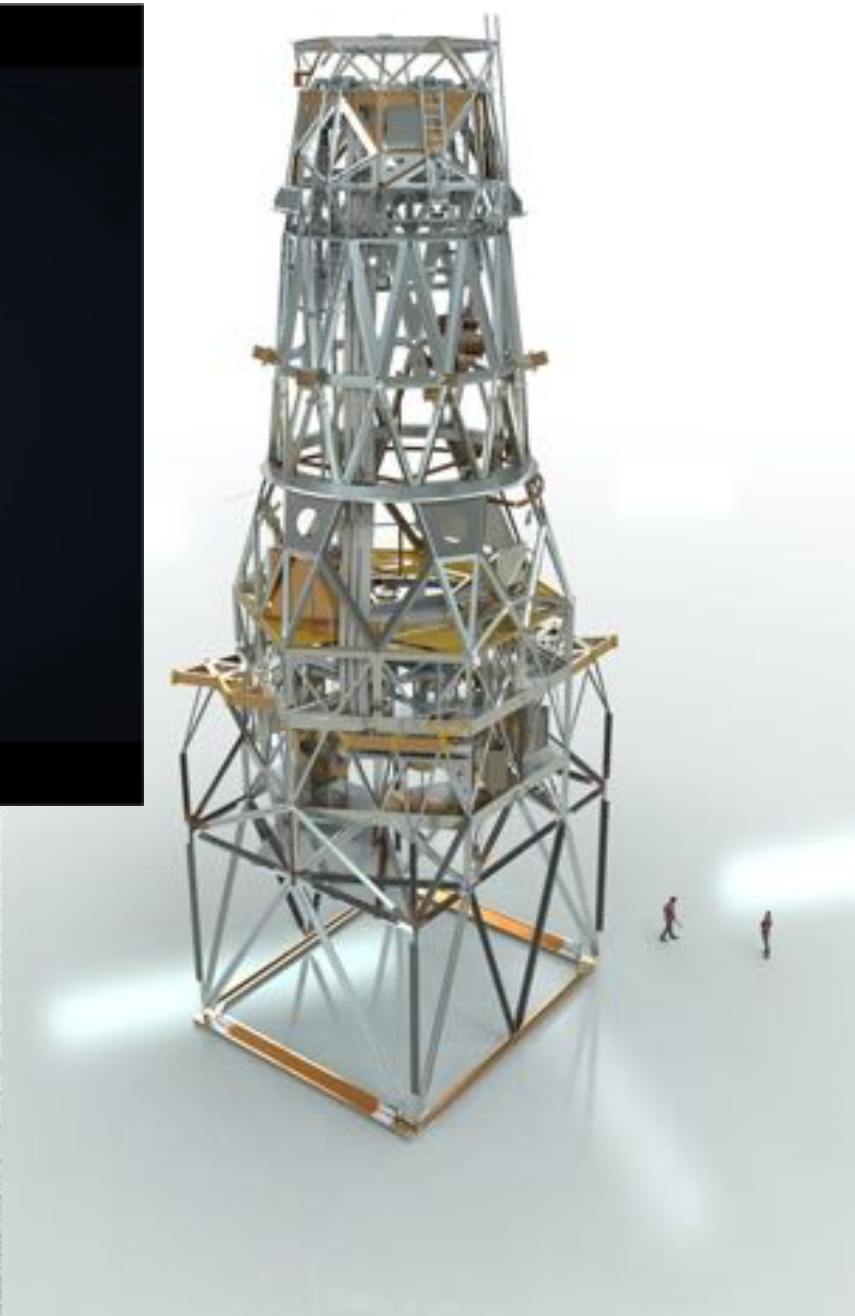
2. The Extremely Large Telescope

The telescope

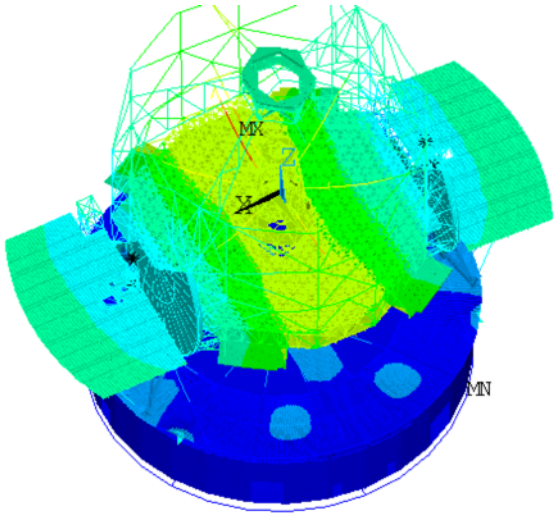


The telescope

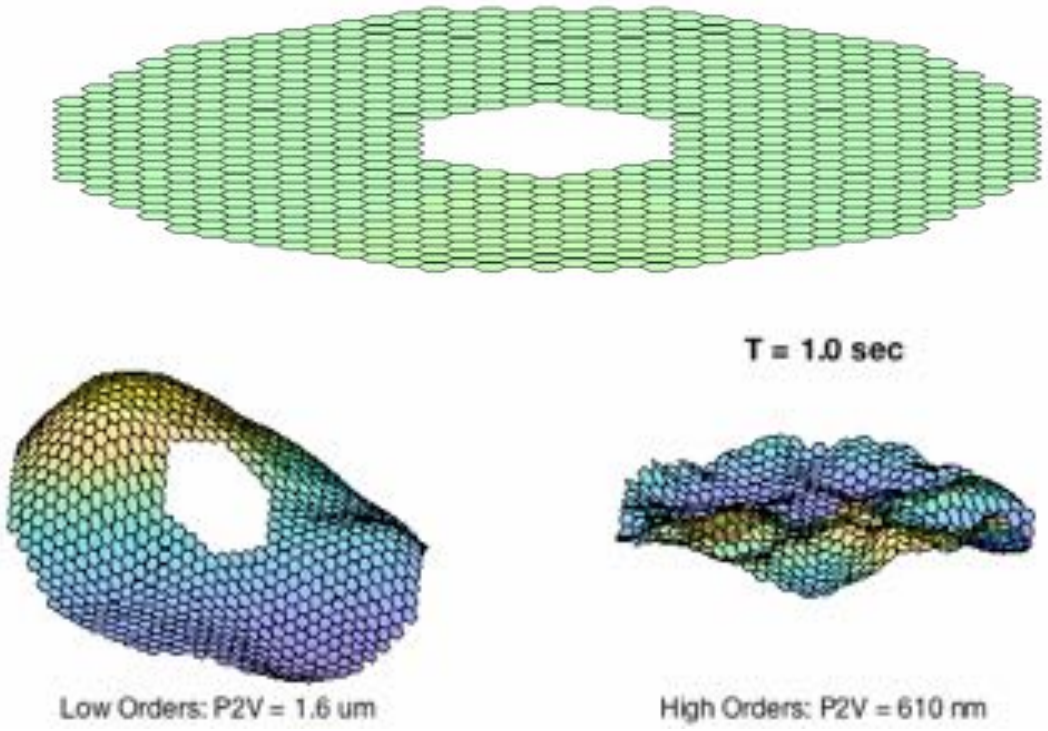


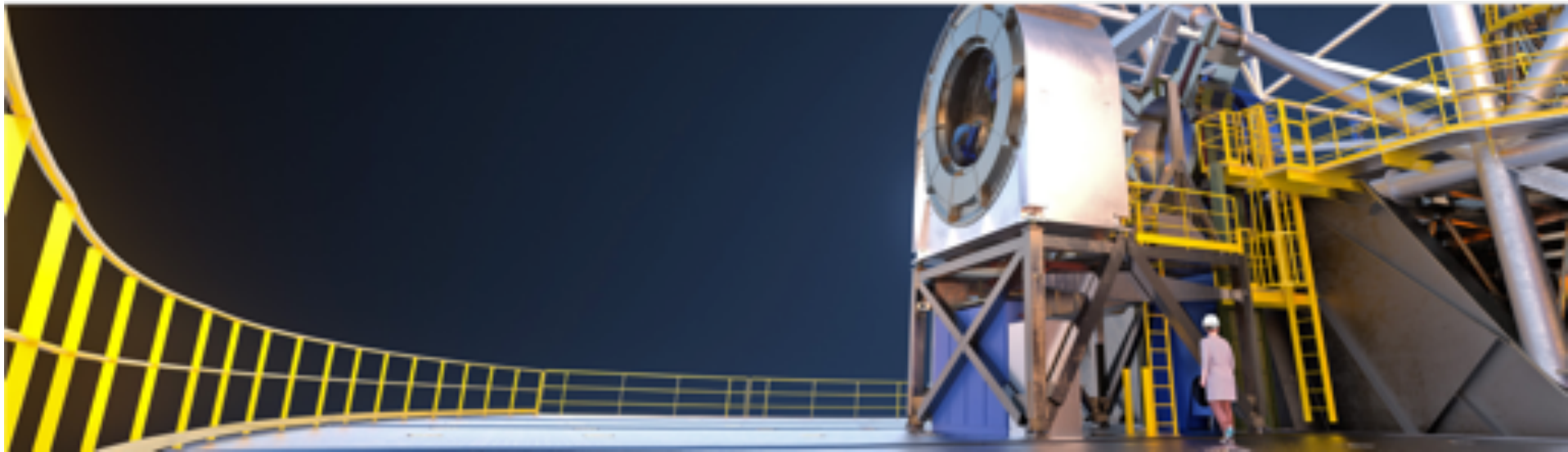


The telescope

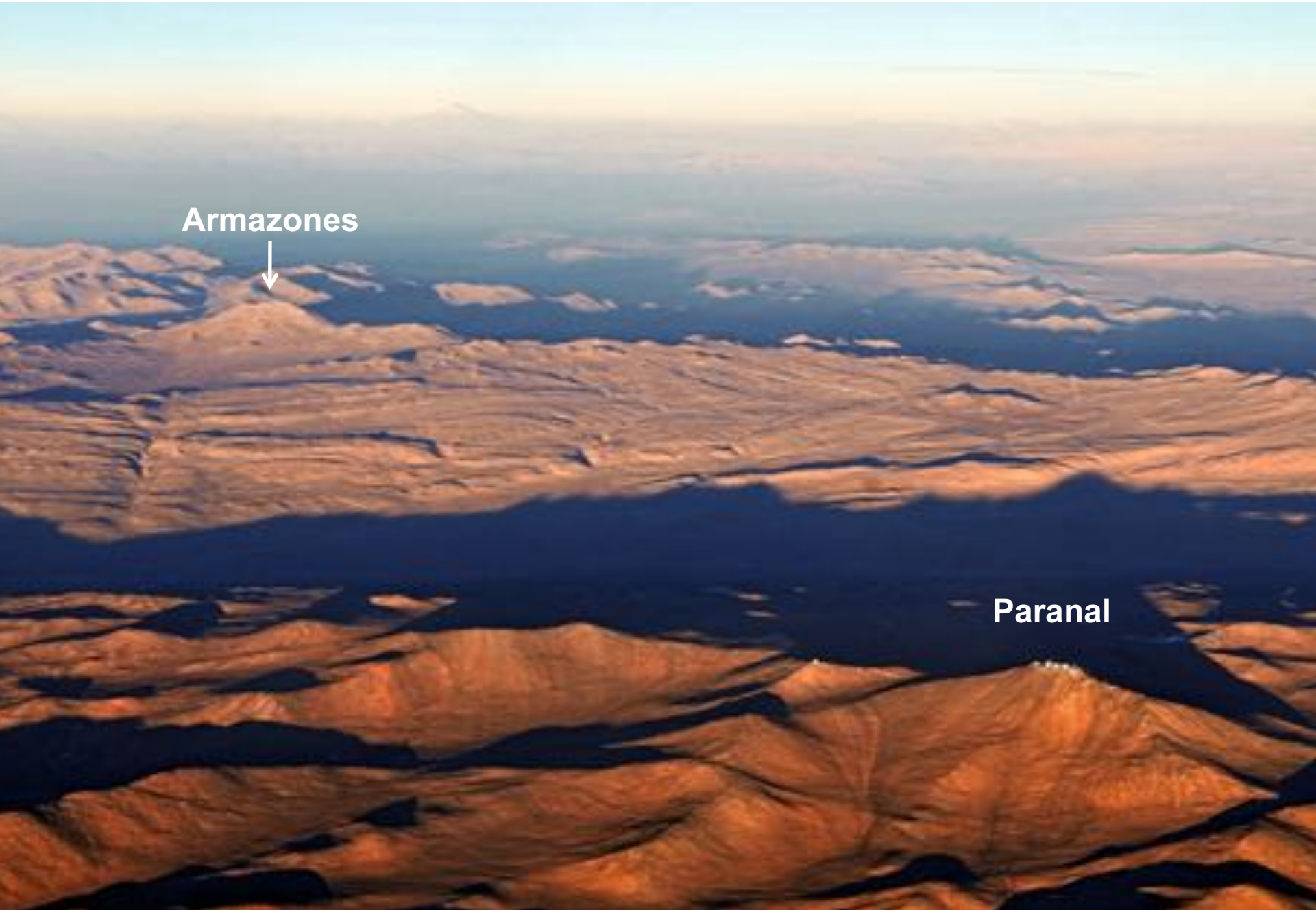


Credits: ESO

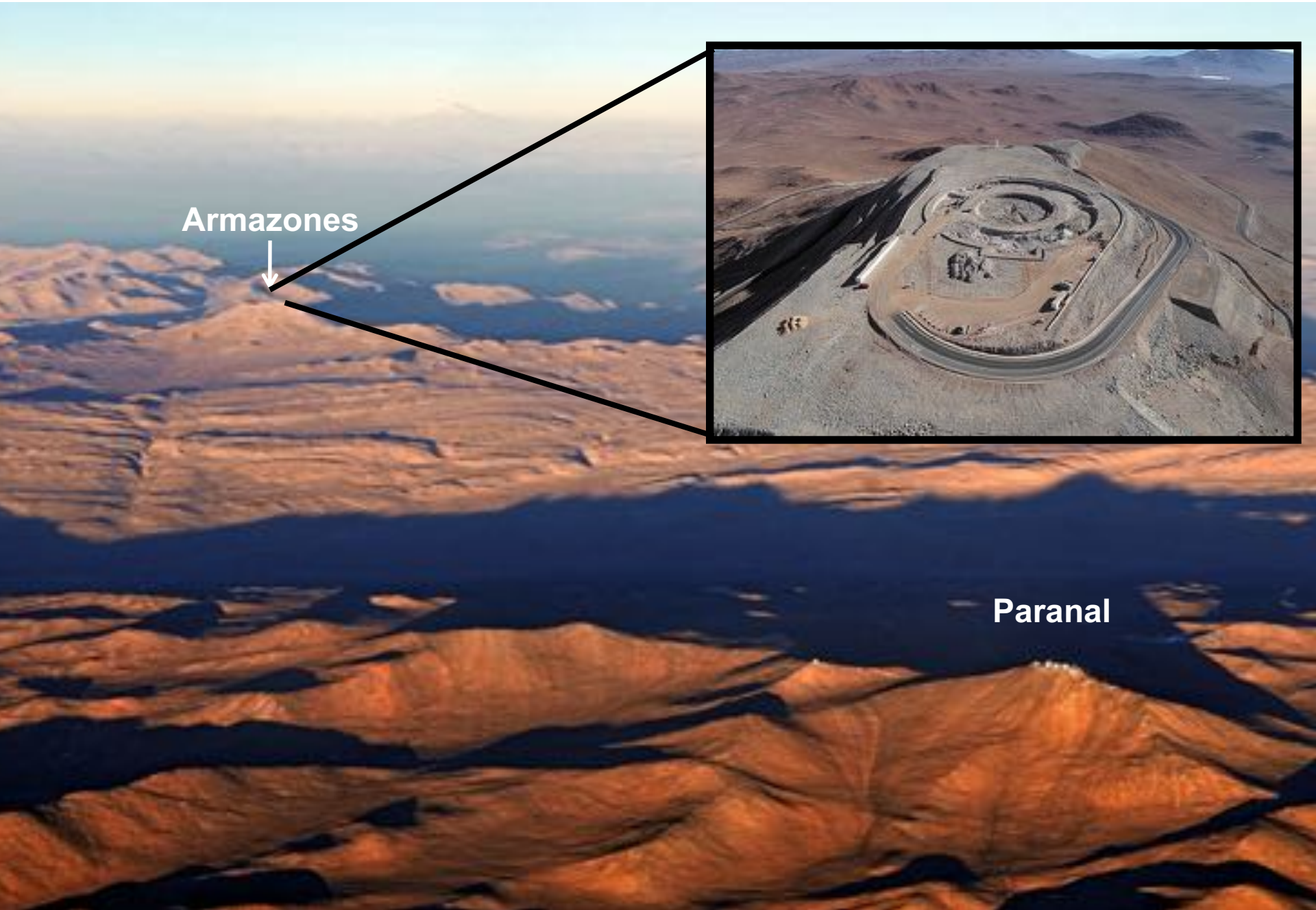




The telescope



The telescope



The telescope

Pictures Courtesy ESO

The telescope

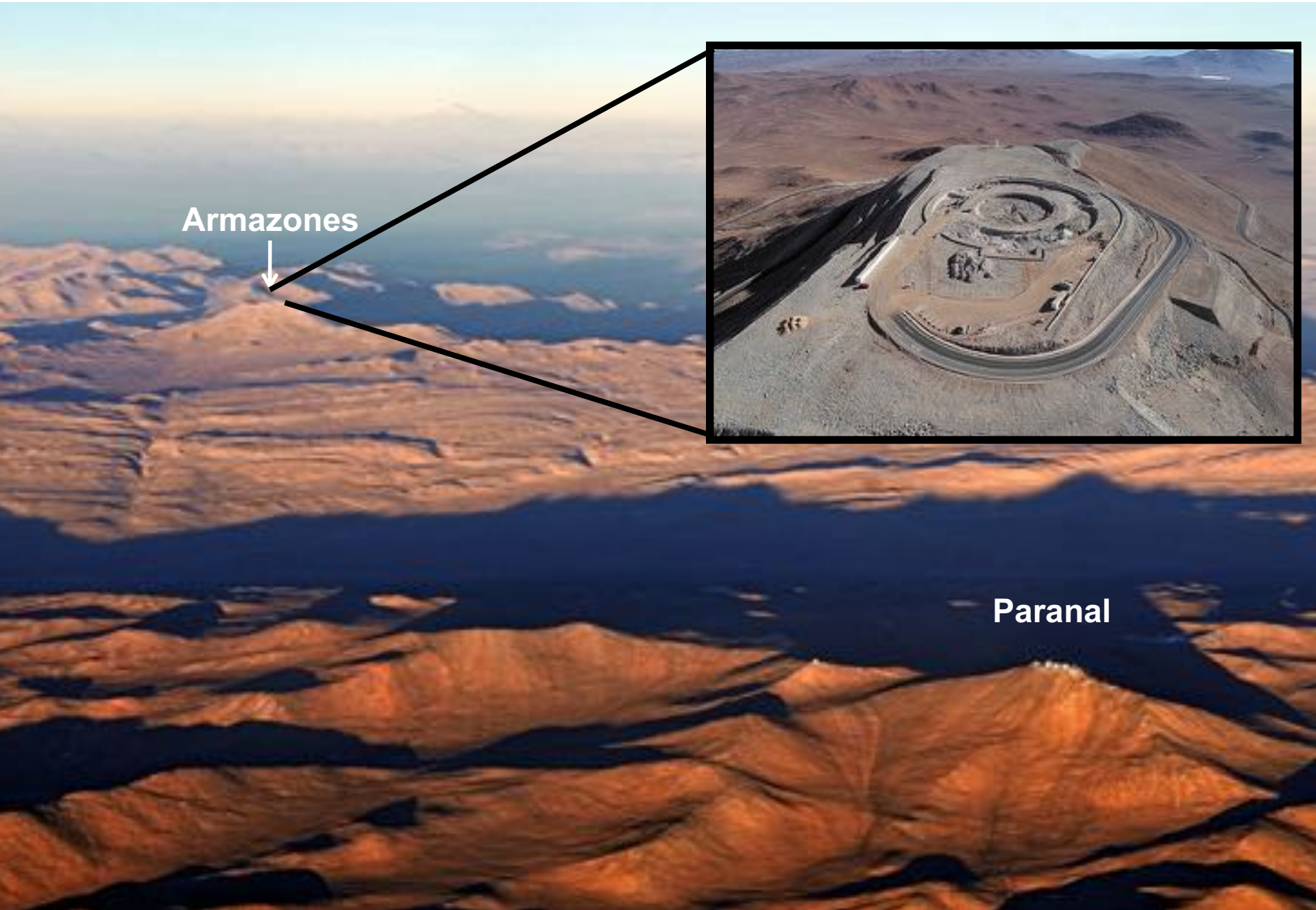
The telescope

Pictures Courtesy A. Vigan/F. Cantalloube

The telescope

Pictures Courtesy A. Vigan/F. Cantalloube

The telescope

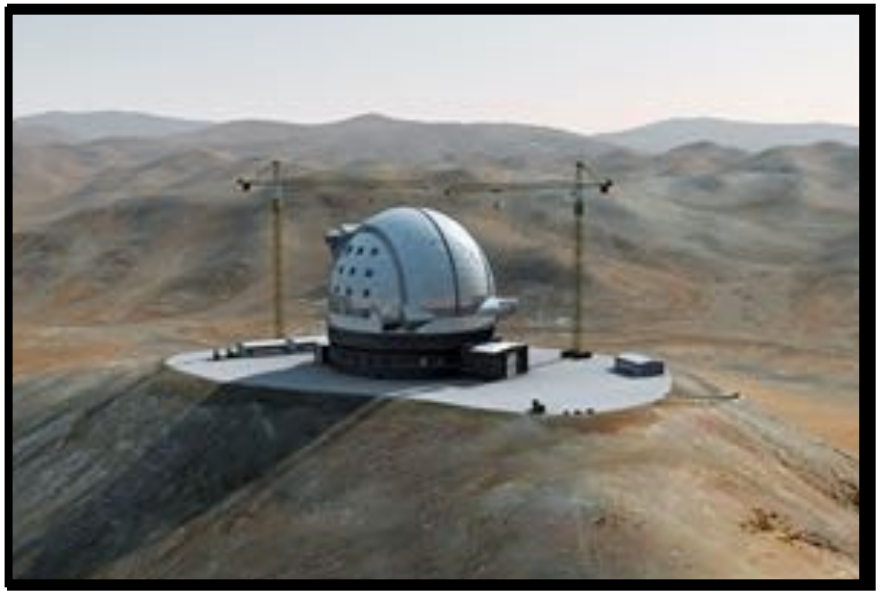


The telescope

2018 **2026**

(not covid corrected)

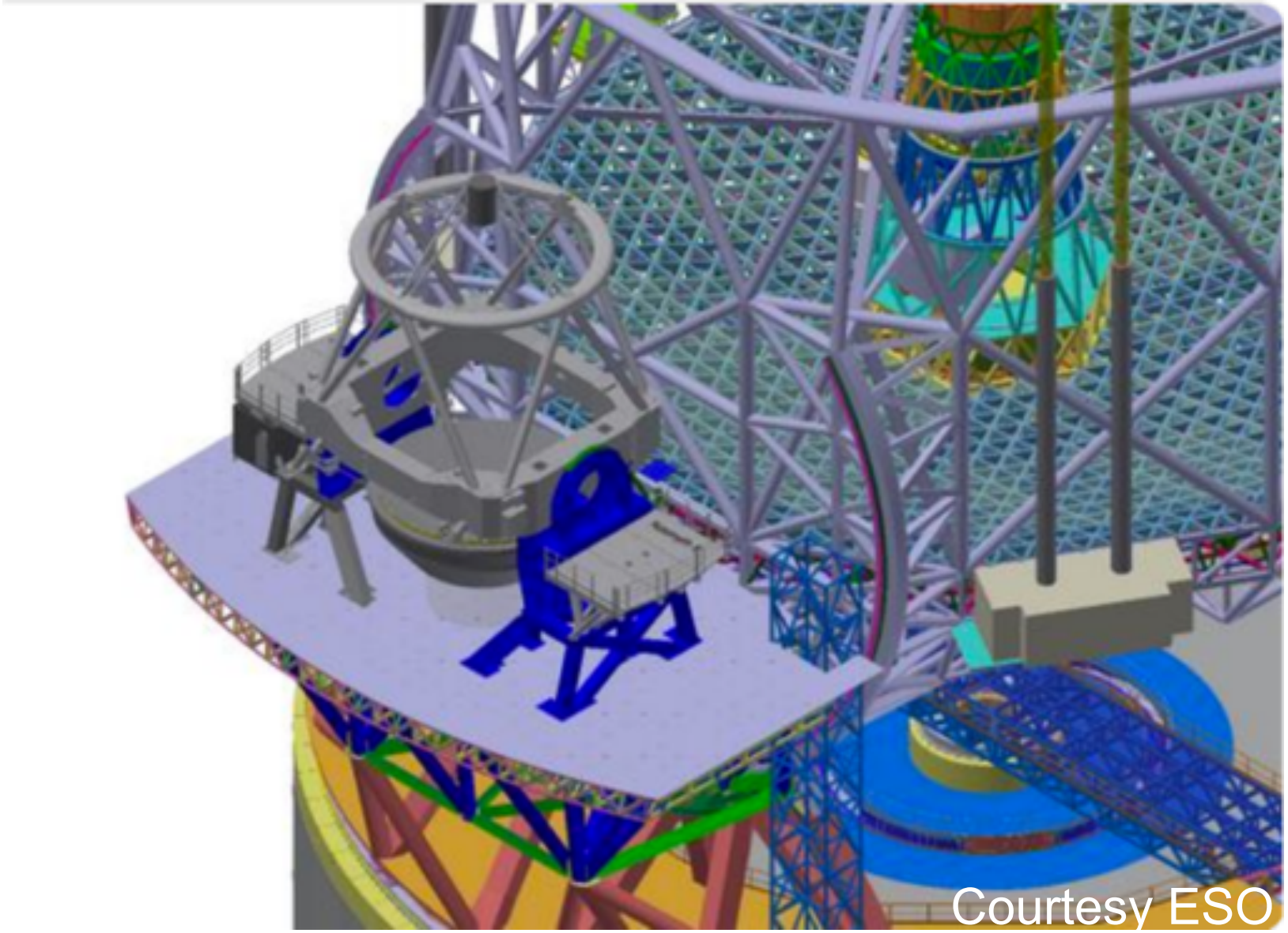
The telescope



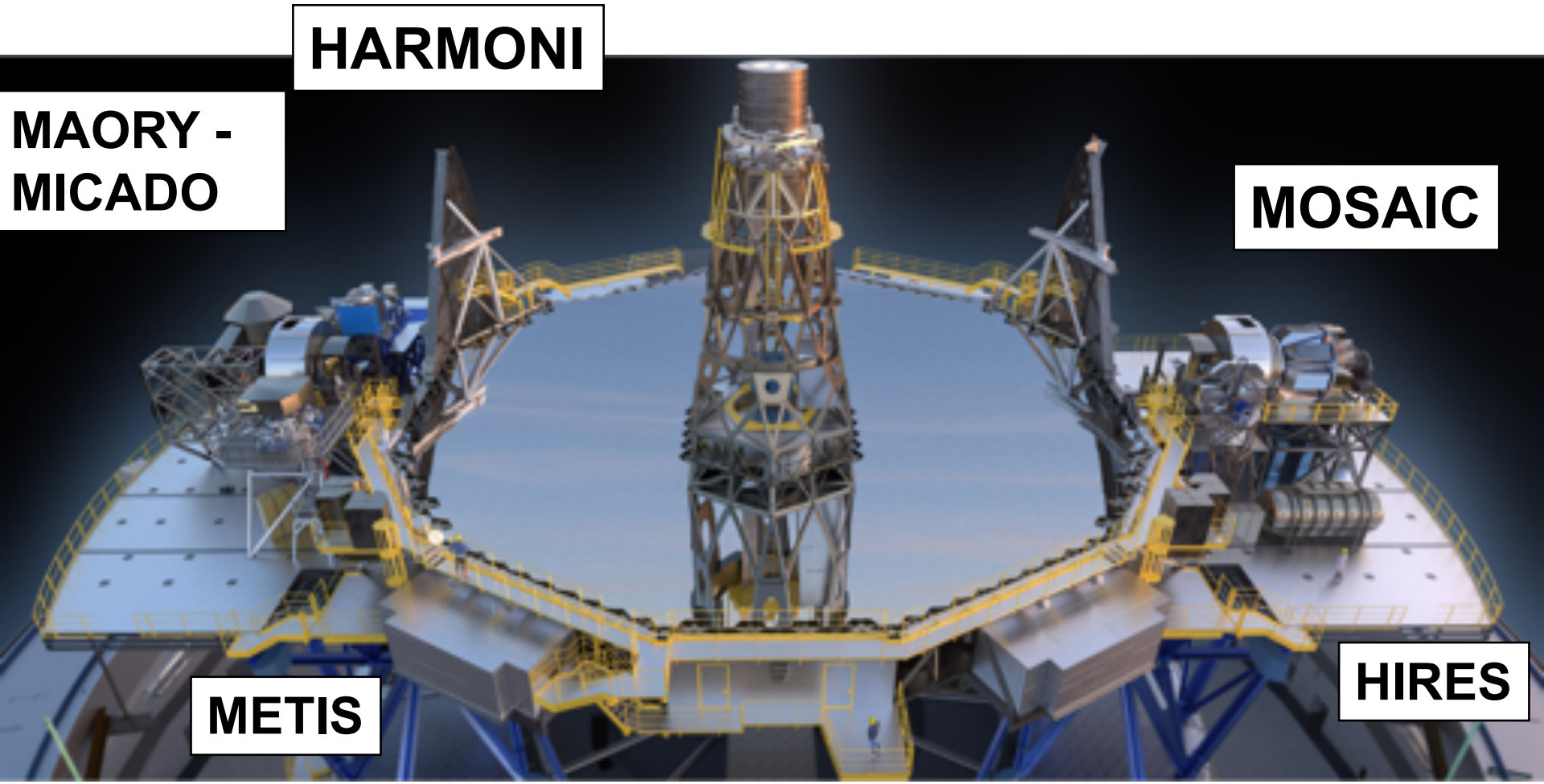
2018 **2026**

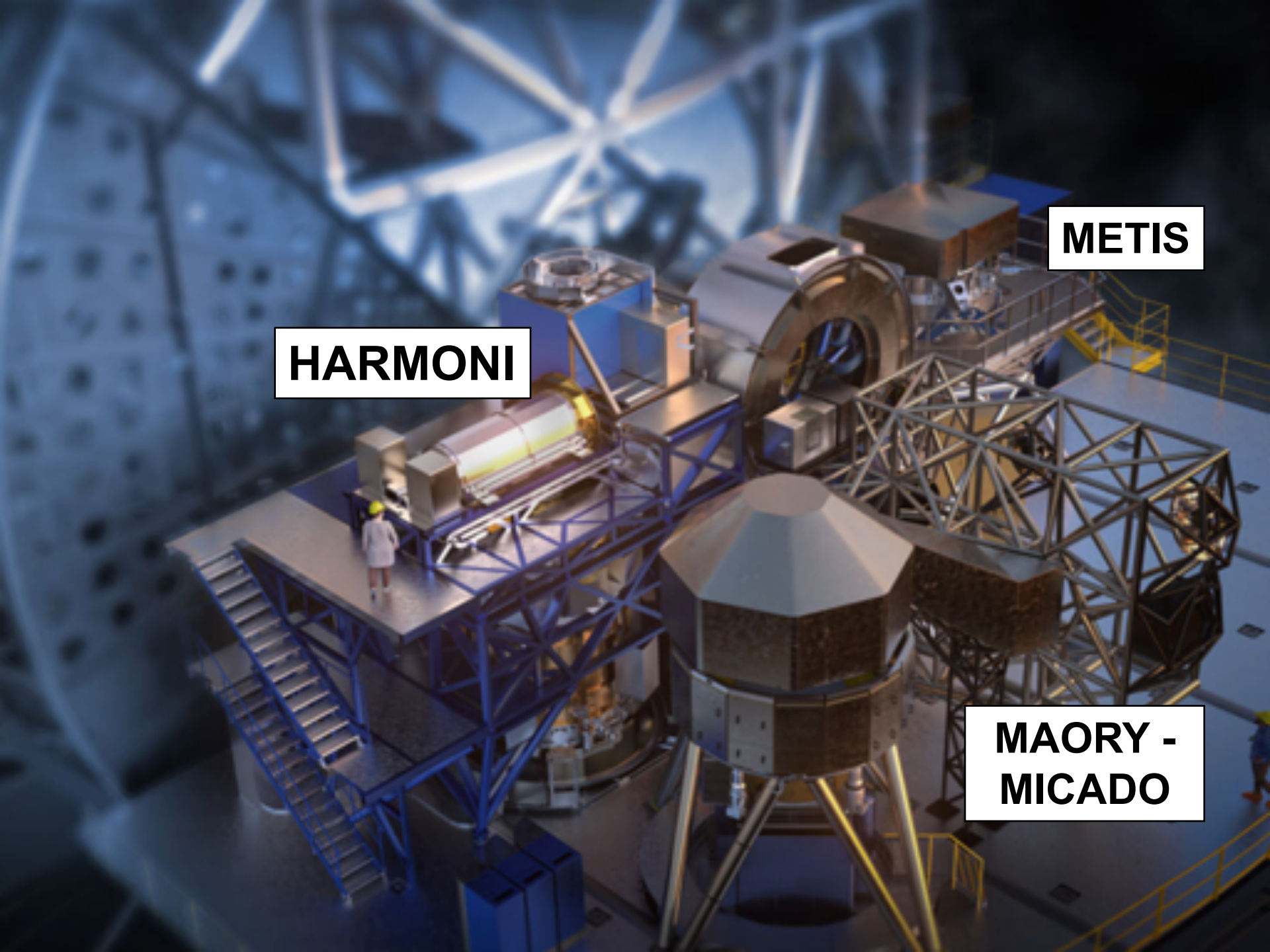
(not covid corrected)

The ELT instruments



The ELT instruments




METIS
HARMONI
MAORY - MICADO

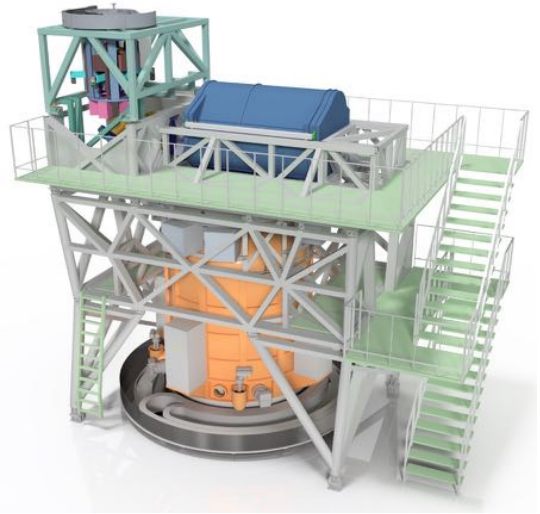
Summary

1. General introduction

2. The Extremely Large Telescope

3. HARMONI Overview

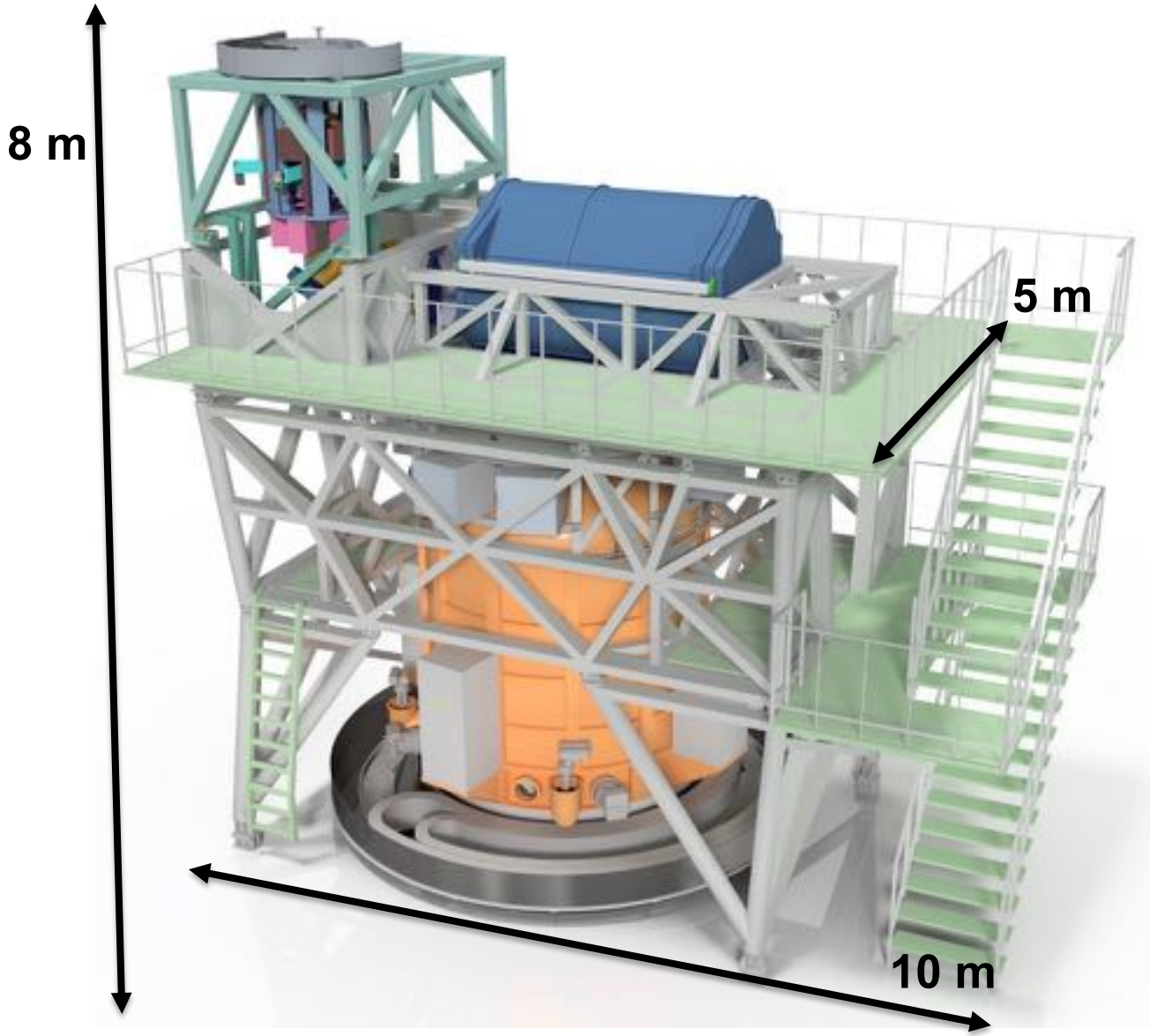
4. Conclusions



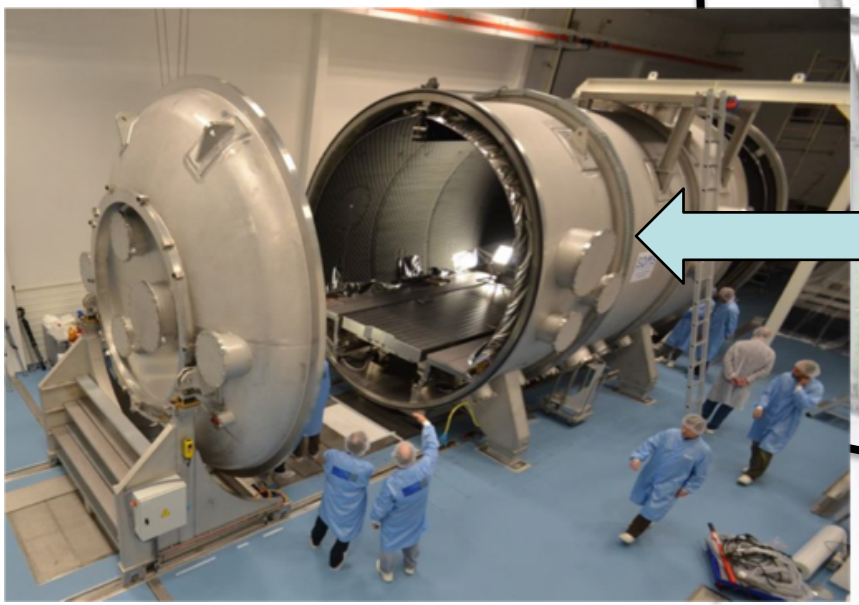
HARMONI Consortium

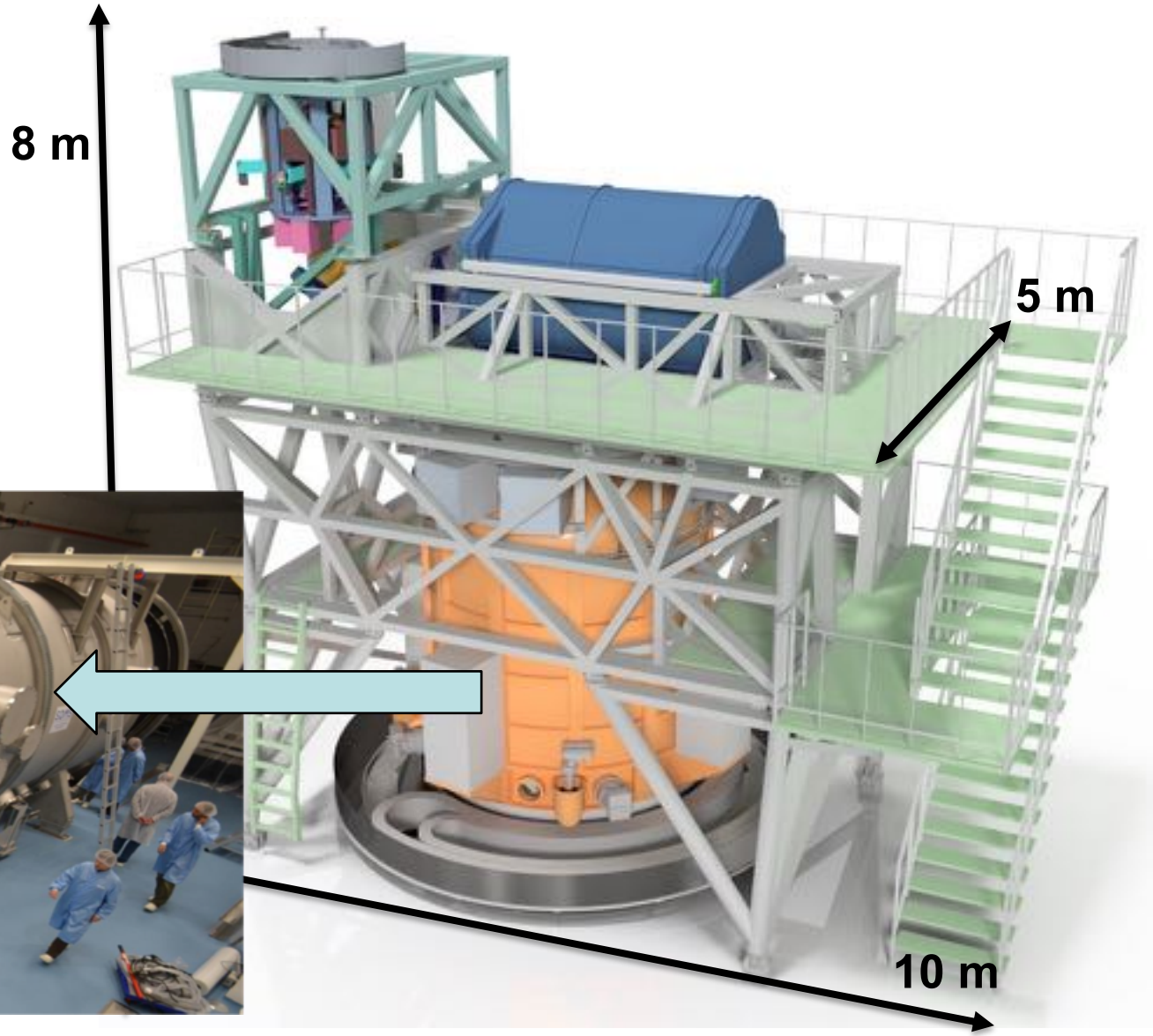
Partner	Associate Partner	Responsibilities
University of Oxford (PI)	STFC – RAL Space	Spectrographs & Obs. Prep
UK ATC Edinburgh		Cryostat, AIV, Rotator, LTAO
Durham University		RTC, NGSWFS
IAC, Tenerife		Pre-optics & Electronics
CSIC – CAB (INTA), Madrid		Calibration & Sec. guiding
CRAL, Lyon	IRAP, Toulouse EFISOFT, INSU	IFU, Software & Control Com.
LAM, Marseille (Deputy PI)	ONERA, Paris IPAG, Grenoble	SCAO, LTAO, AIT, High Contrast
Michigan University		

HARMONI Overview

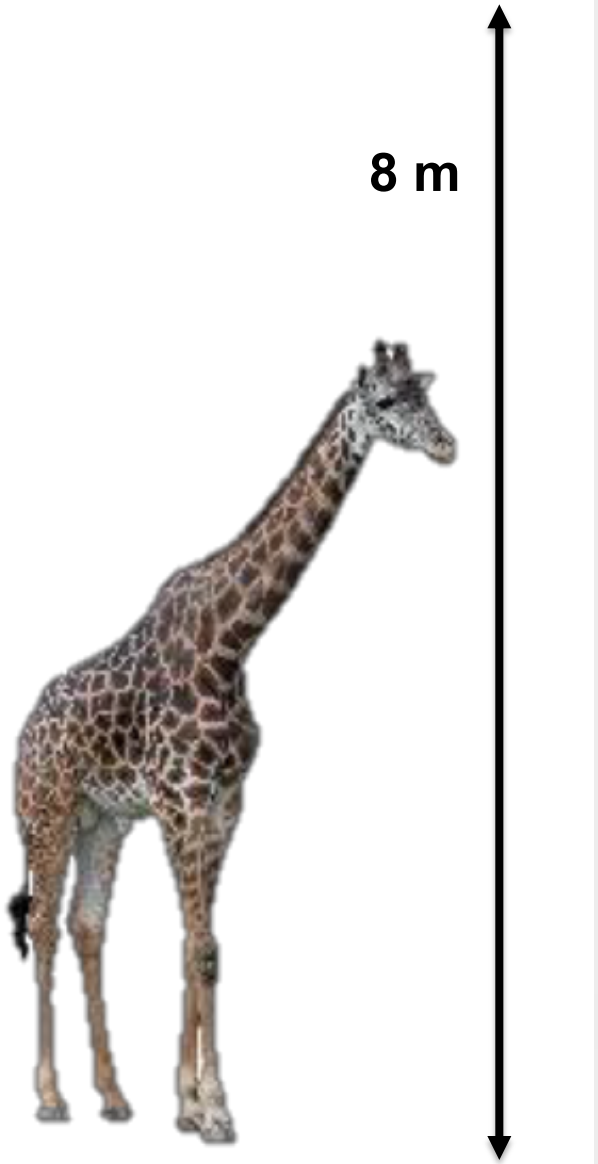


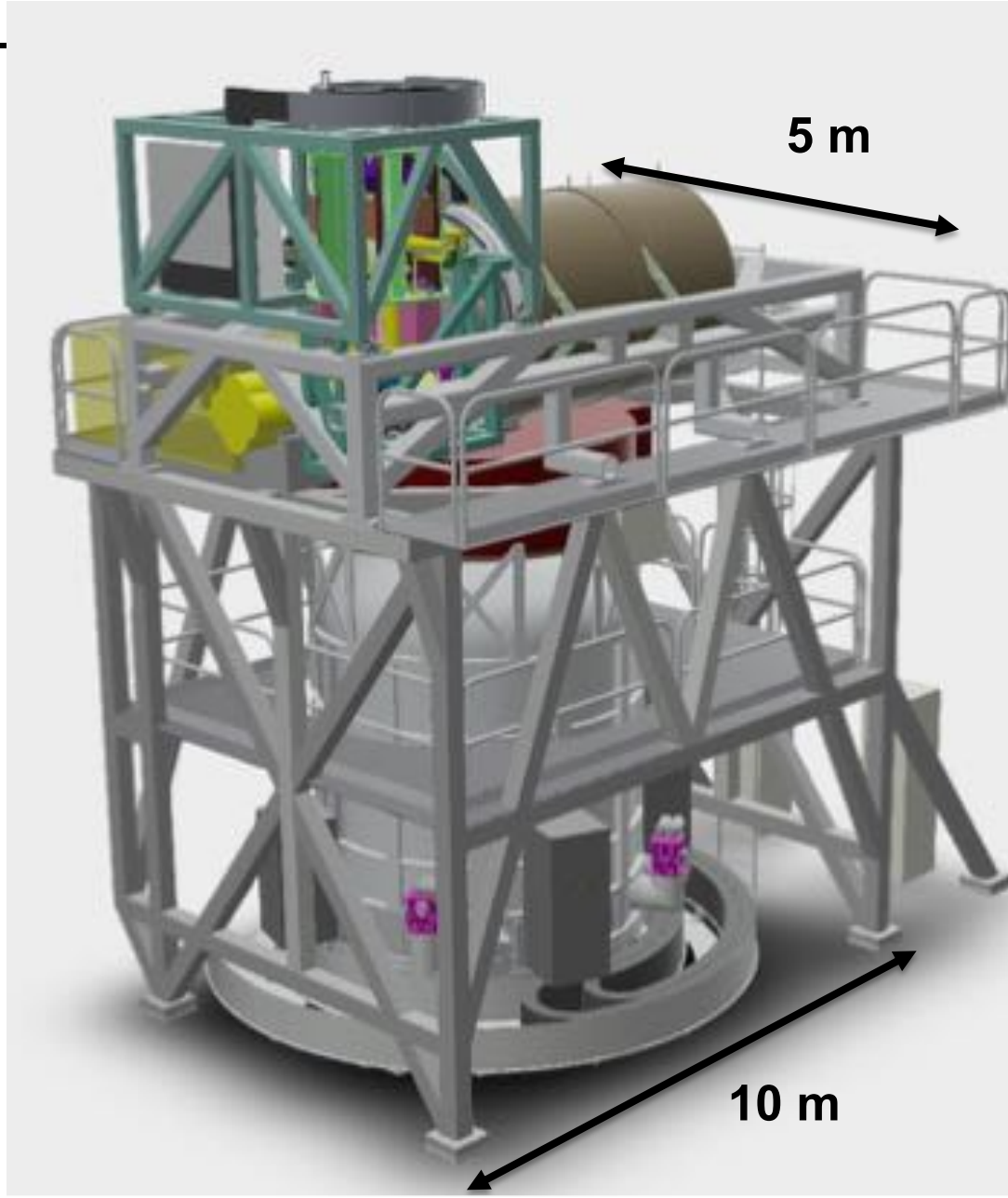
HARMONI Overview



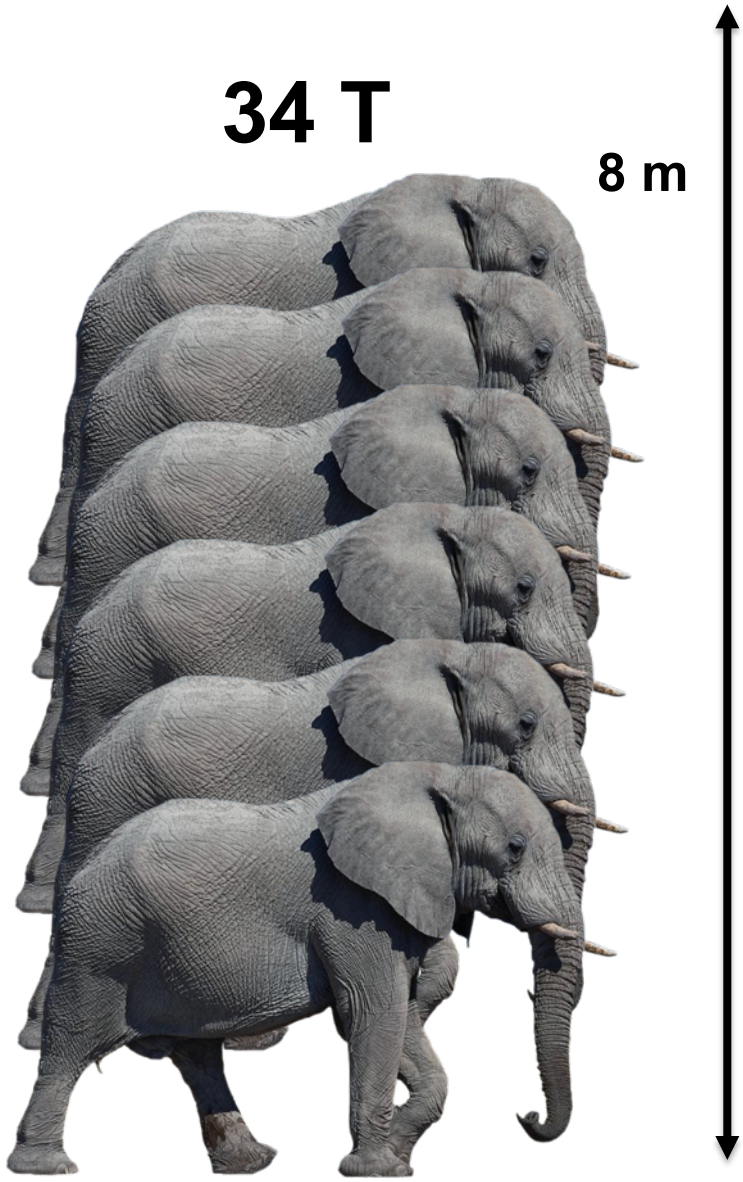


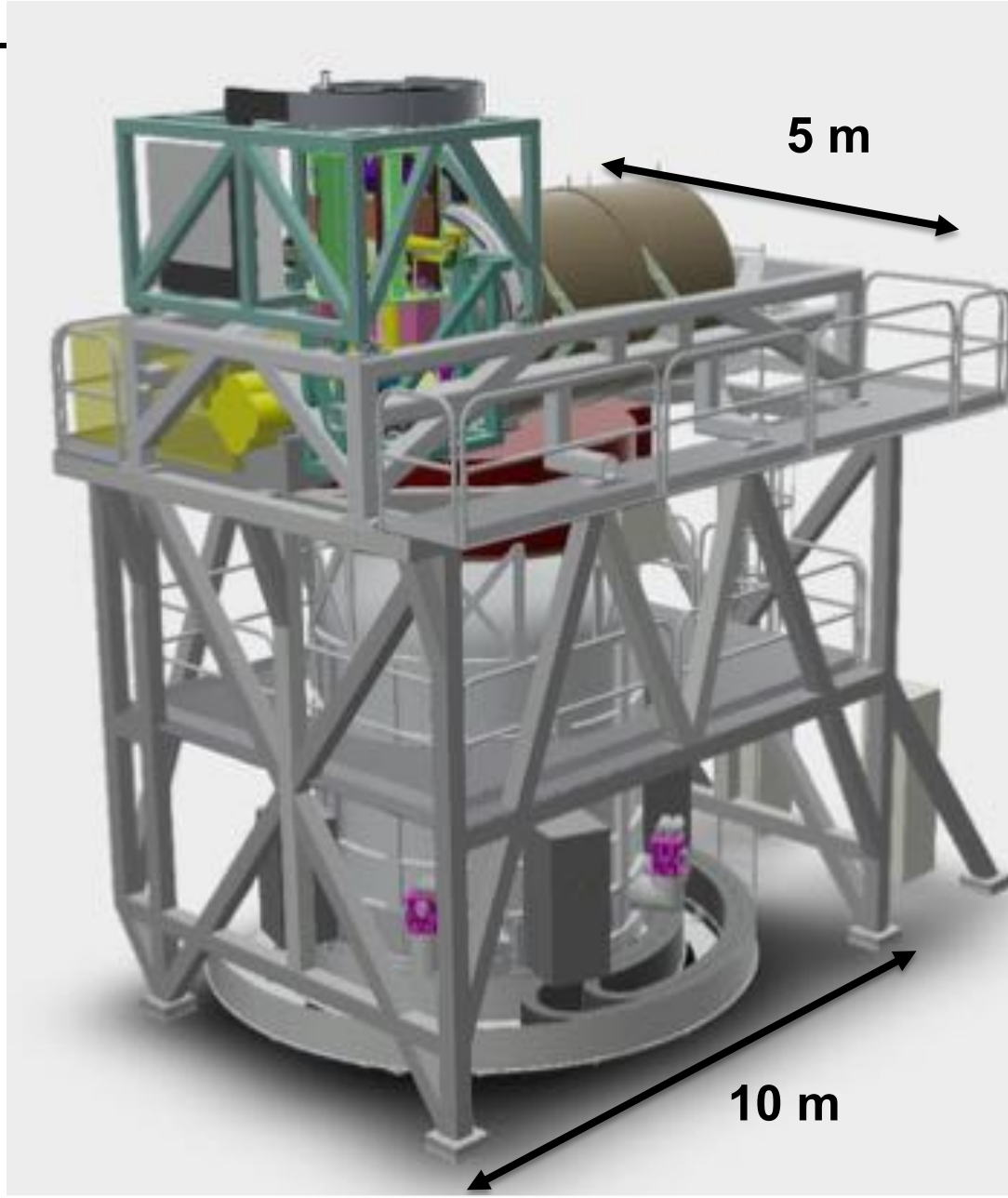
HARMONI Overview



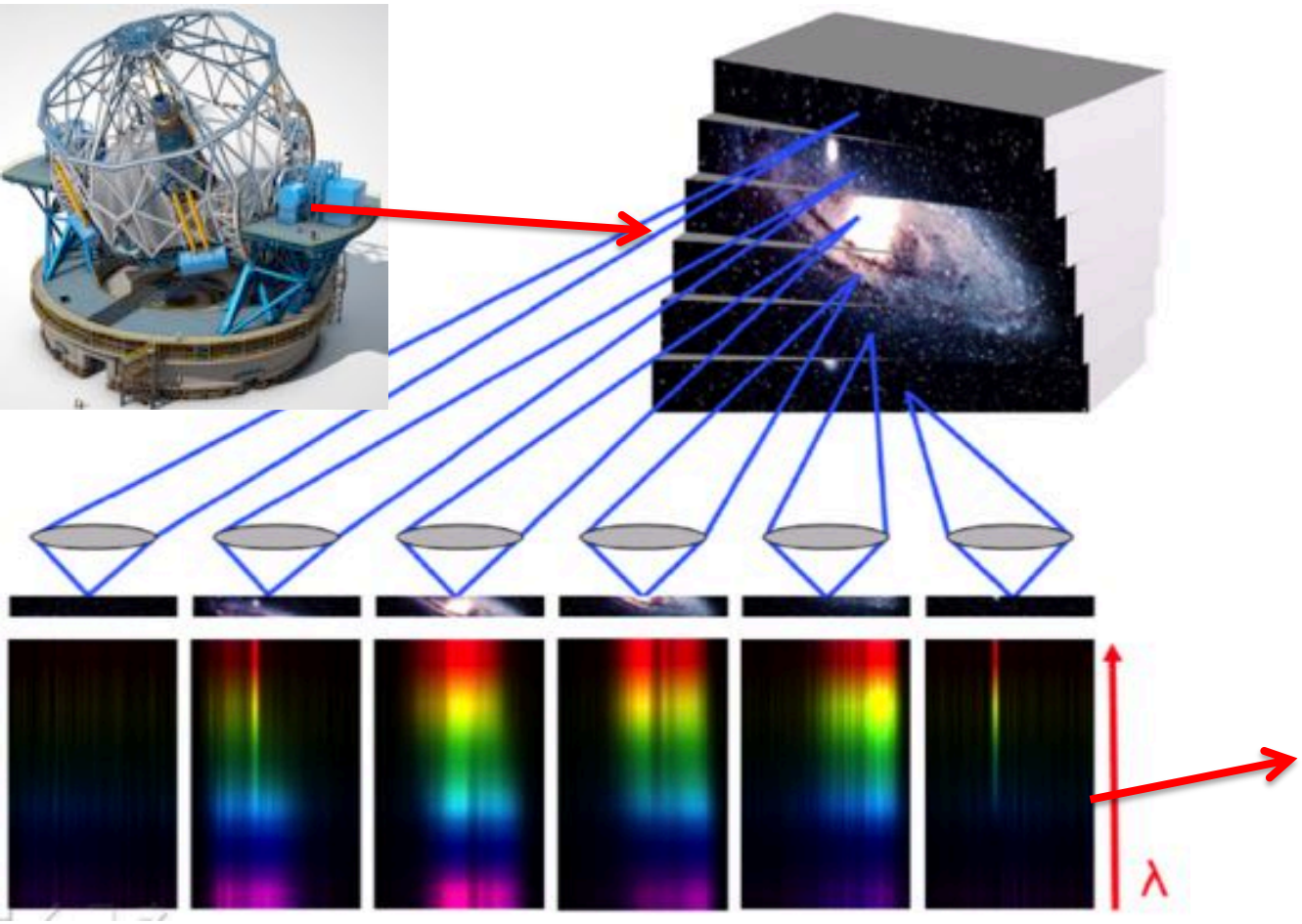


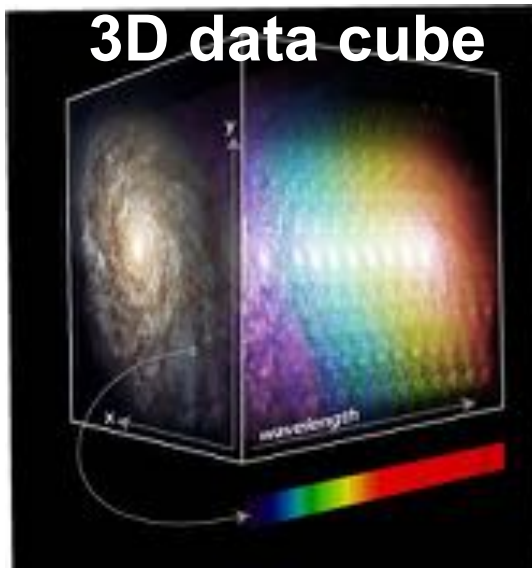
HARMONI Overview





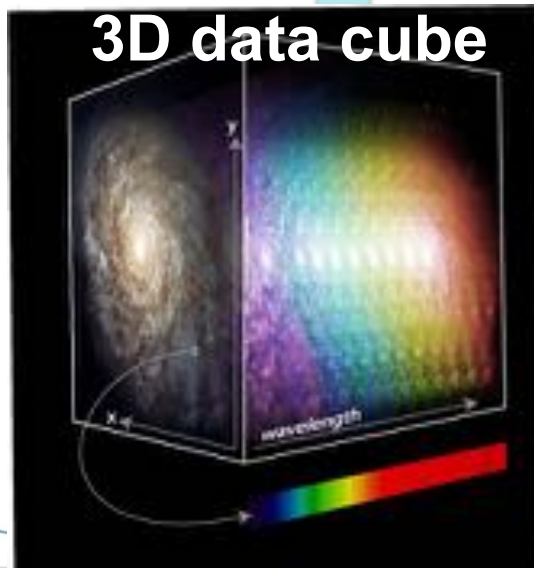
Integral Field Spectrograph – providing ~ 30 000 spectra per exposure.
visible and near-infrared spectroscopy (0.5–2.4 μm)



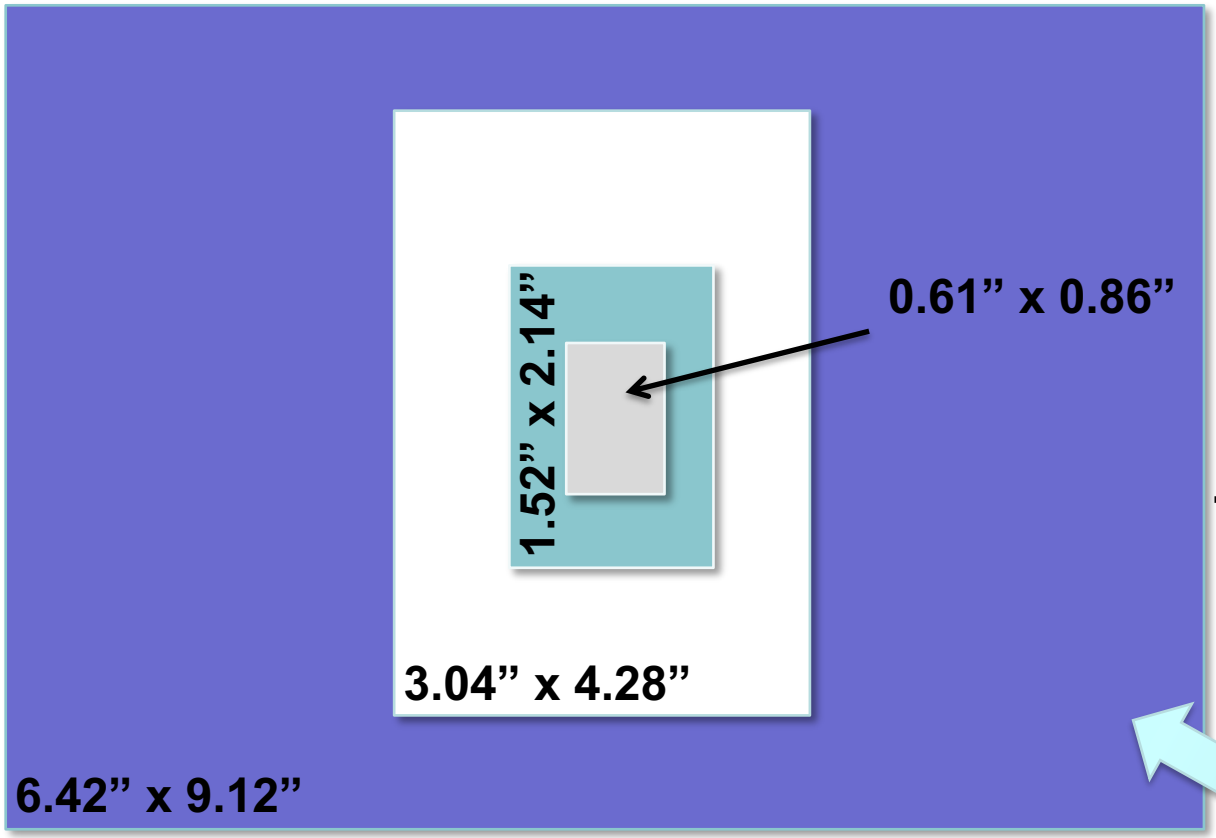


HARMONI = 3 resolving powers

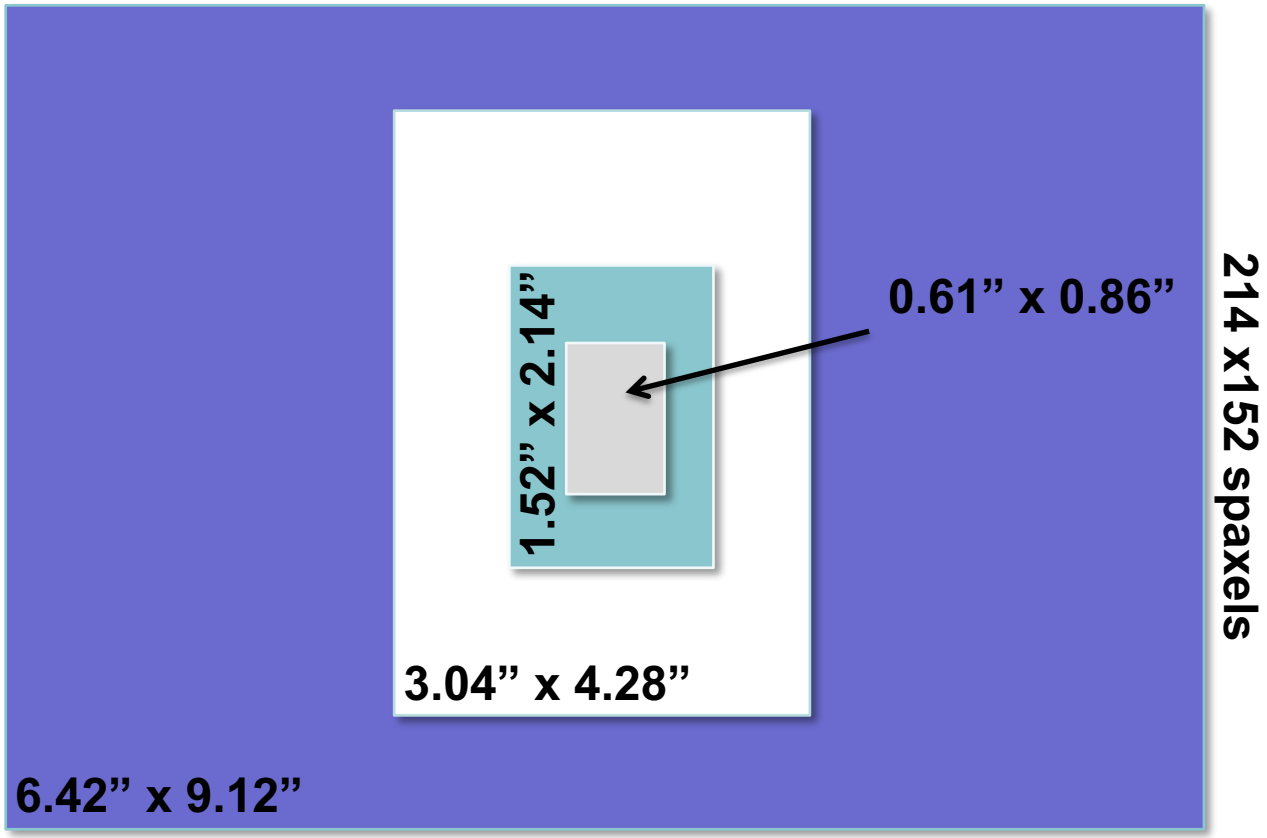
Bands	Wavelengths (µm)	R
"V+R" or "I+z+J" or "H+K"	0.45-0.8, 0.8-1.35, 1.45-2.45	**~3000**
"I+z" or "J" or "H" or "K"	0.8-1.0, 1.1-1.35, 1.45-1.85, 1.95-2.45	**~7500**
"Z" or "J_high" or "H_high" or "K_high"	0.9, 1.2, 1.65, 2.2 (TBD)	**~20000**



HARMONI = 4 spatial scales



HARMONI = 4 spatial scales



60 x 30 mas

20 mas

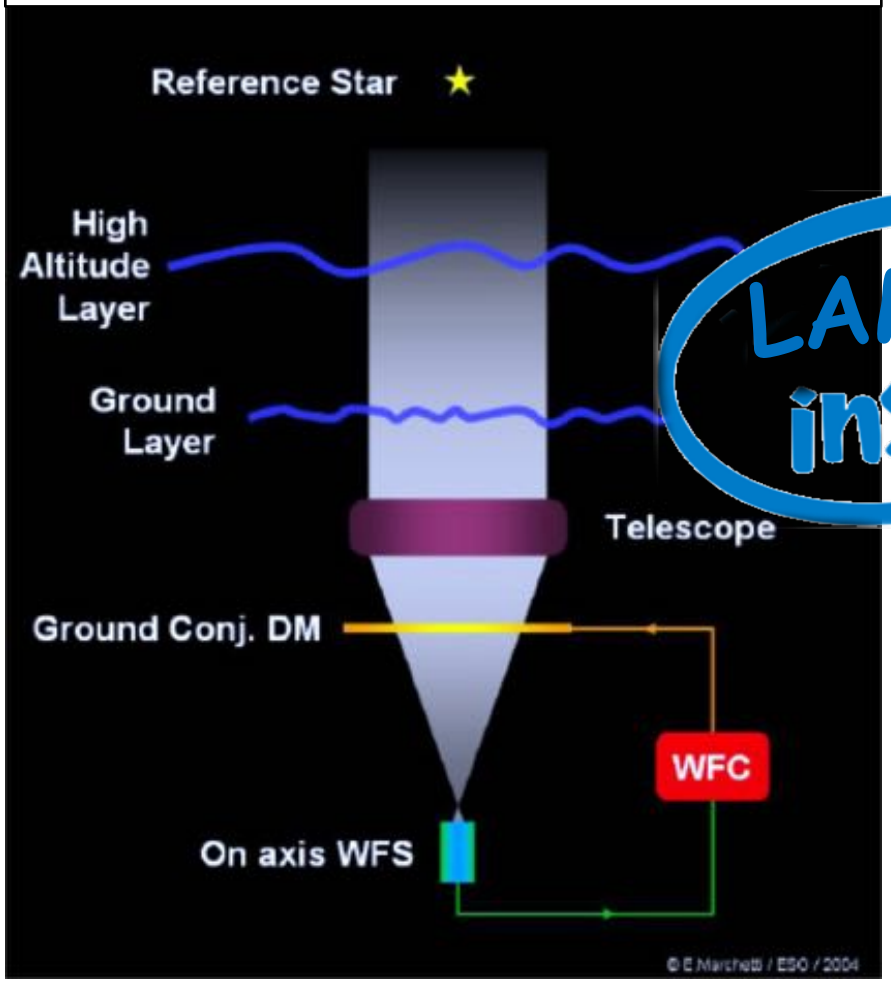
10 mas

4 mas

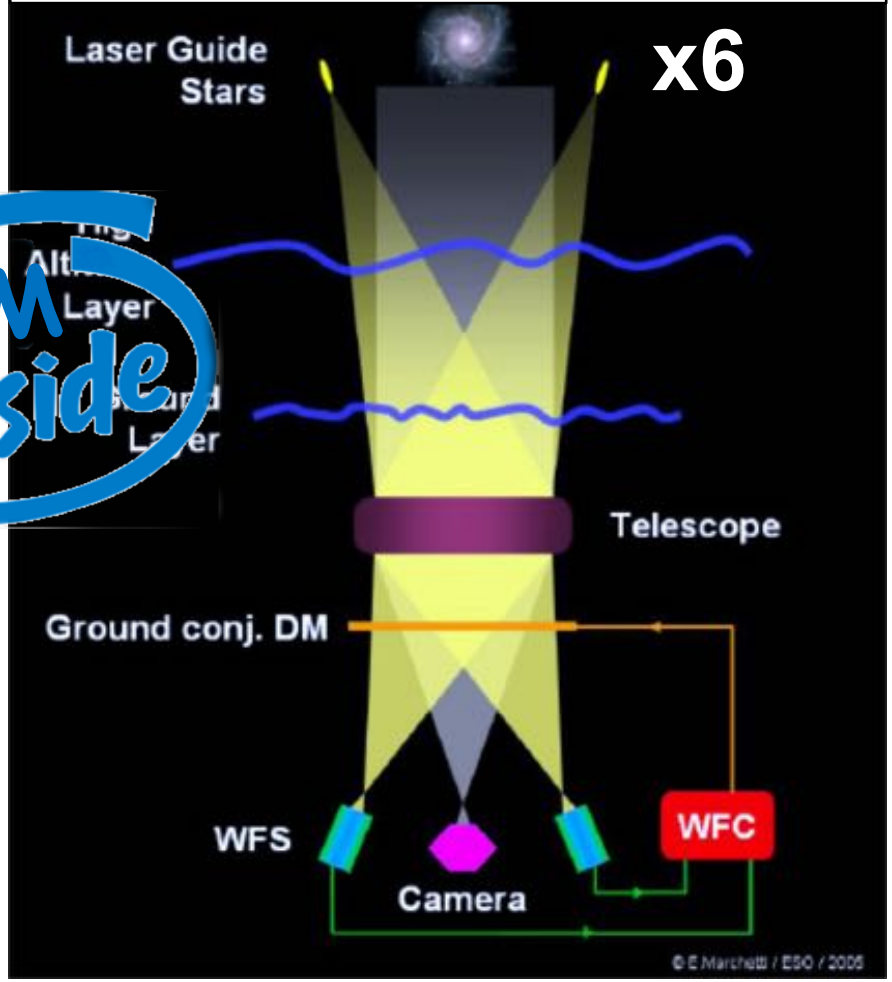
Assisted with Adaptive Optics

HARMONI Overview

Single Conjugated AO



Laser Tomography AO



LAM inside

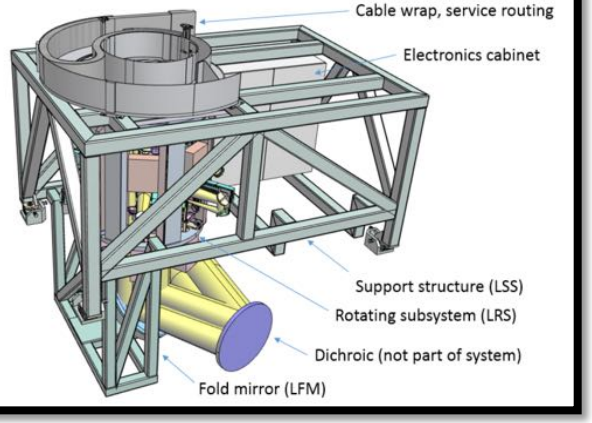
High-Performance – Low sky coverage

High-Performance & sky coverage

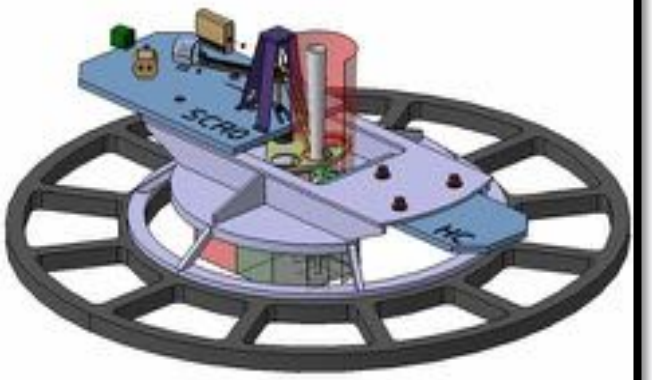
CSIC · Durham University · University of Oxford · RAL Space · Science & Technology Facilities Council UK Astronomy Technology Centre · irap · ONERA · LAM · CRAL · IPAG · ESO

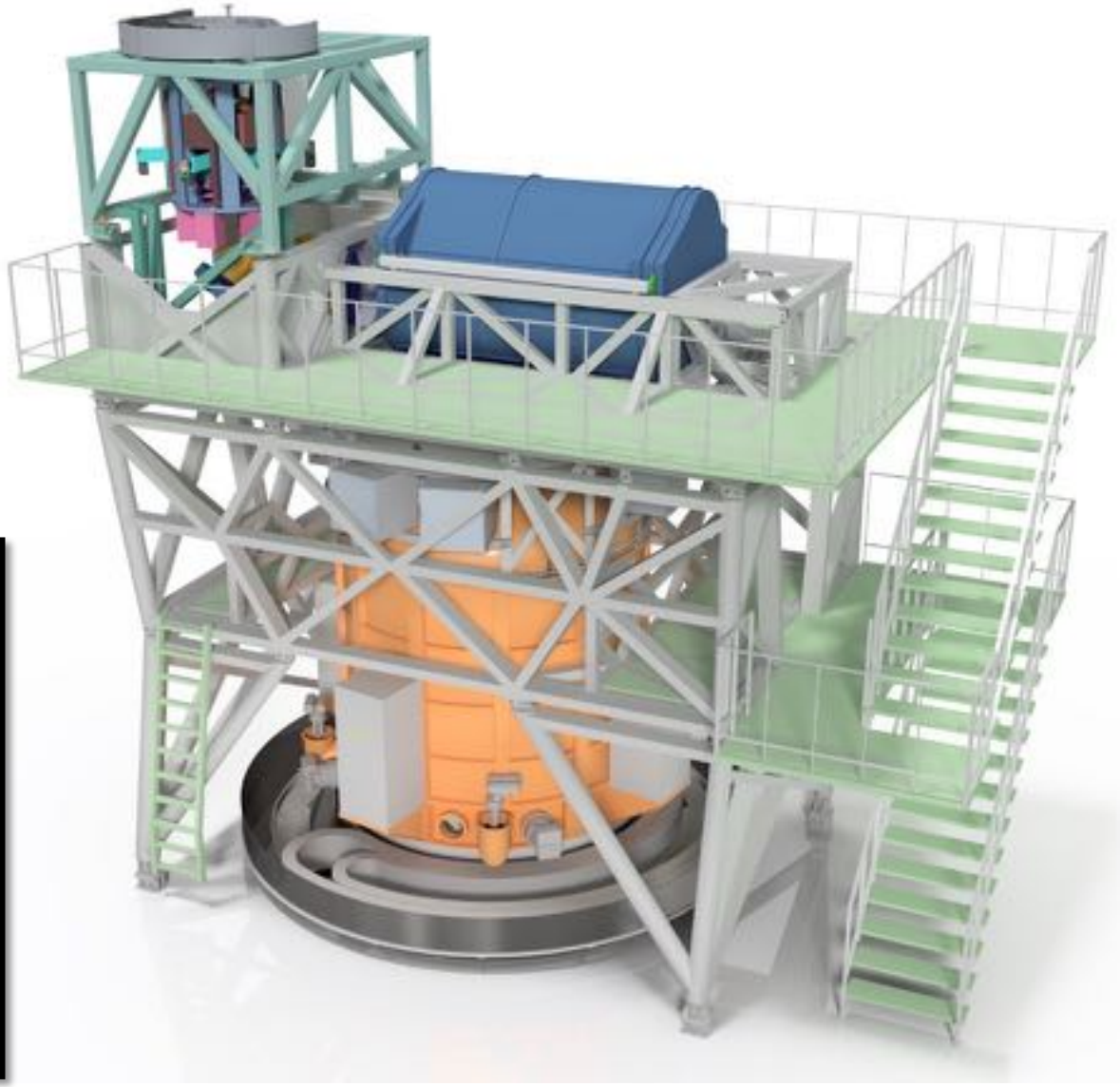
HARMONI Overview

Laser Guide Star WFS



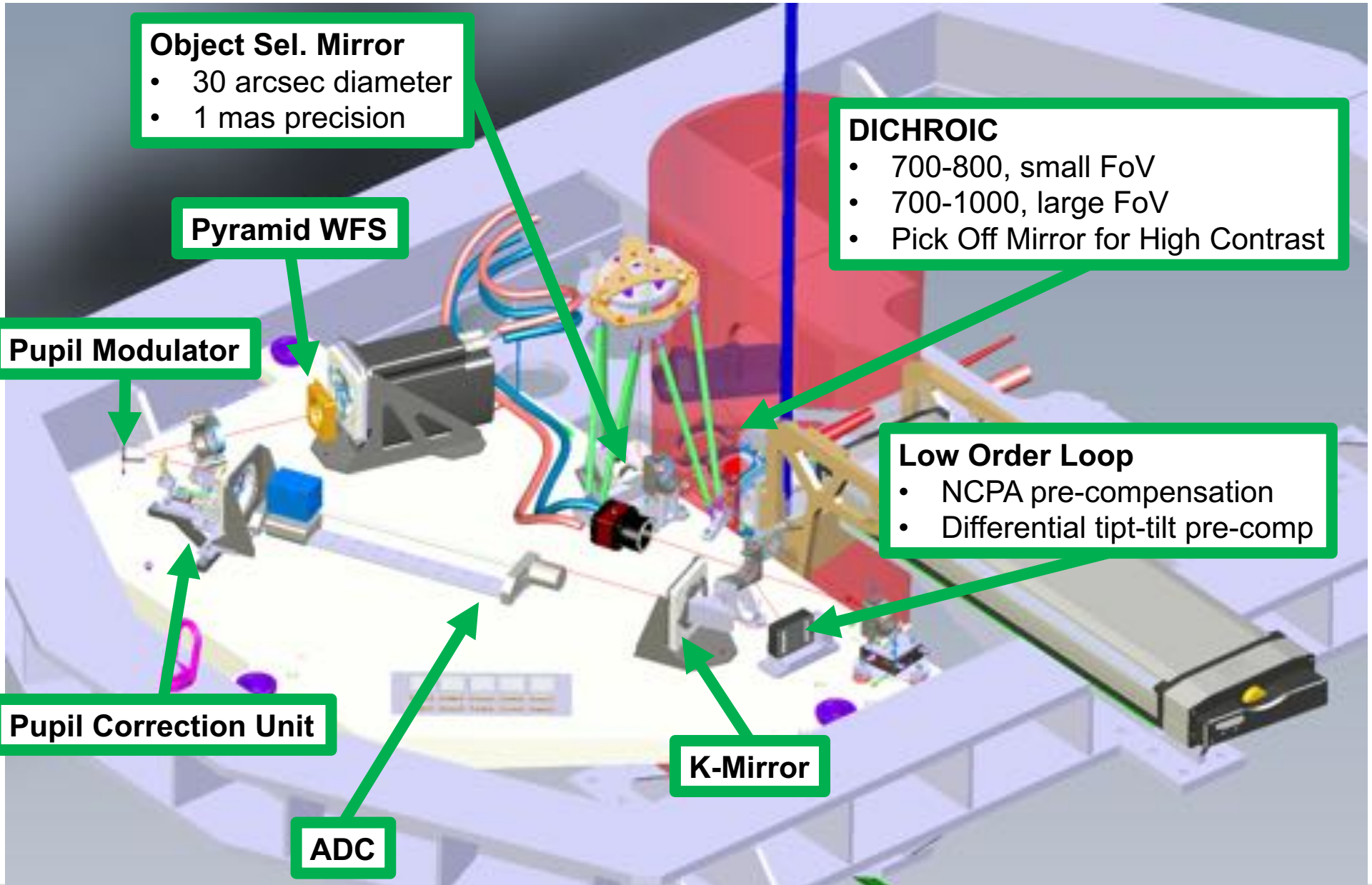
SCAO, High-Contrast & Natural Guide Star WFS



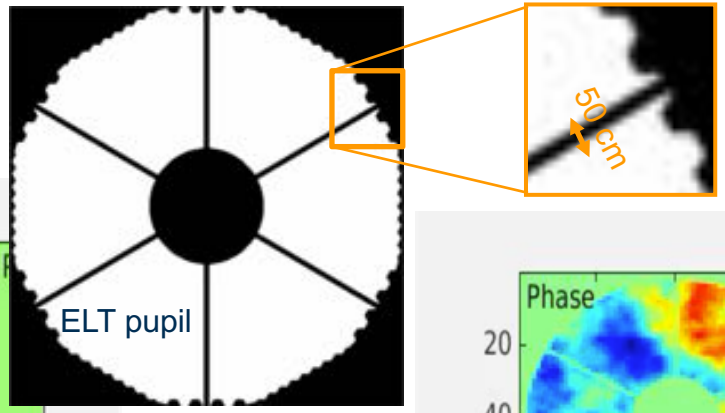


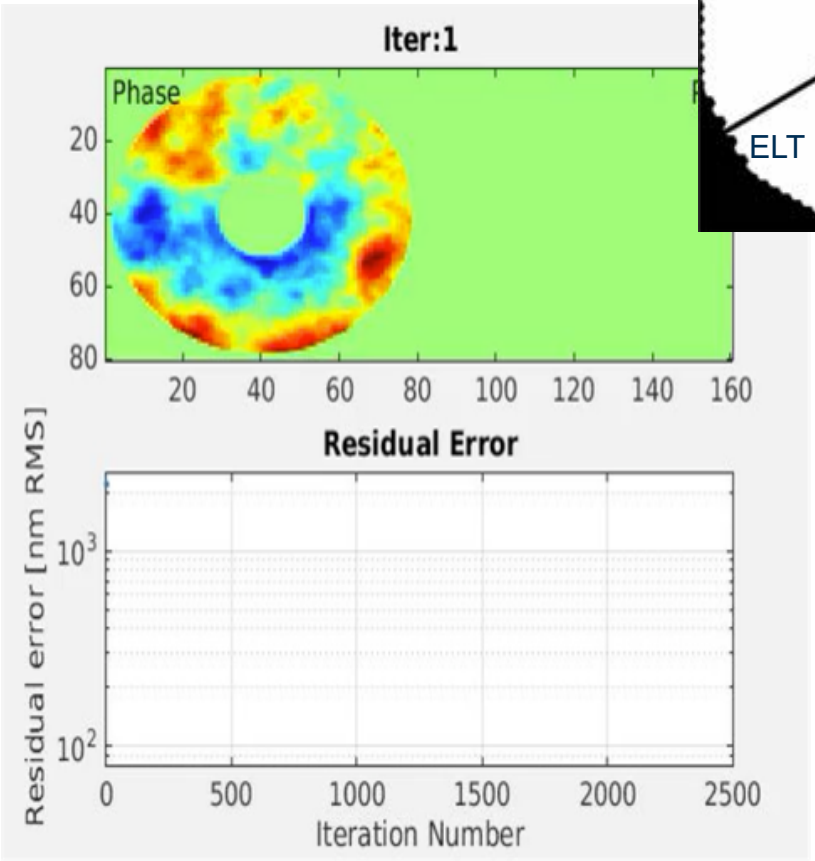
CSIC · Durham University · University of Oxford · RAL Space · Science & Technology Facilities Council UK Astronomy Technology Centre · irap · ONERA · LAM · CRAL · IPAG · ESO

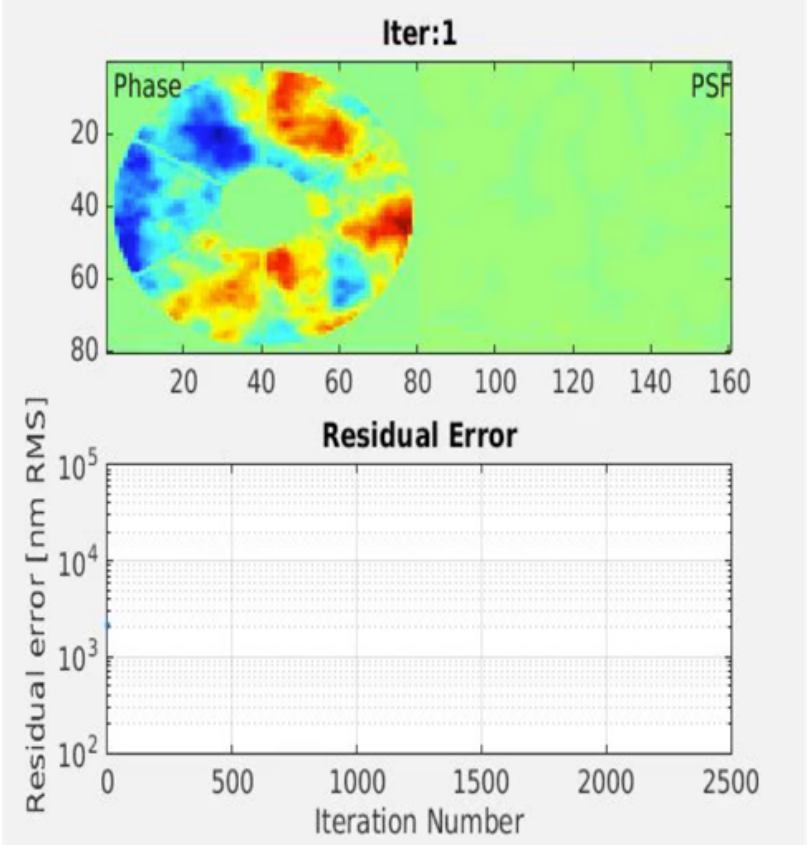
SCAO = Pyramid WFS



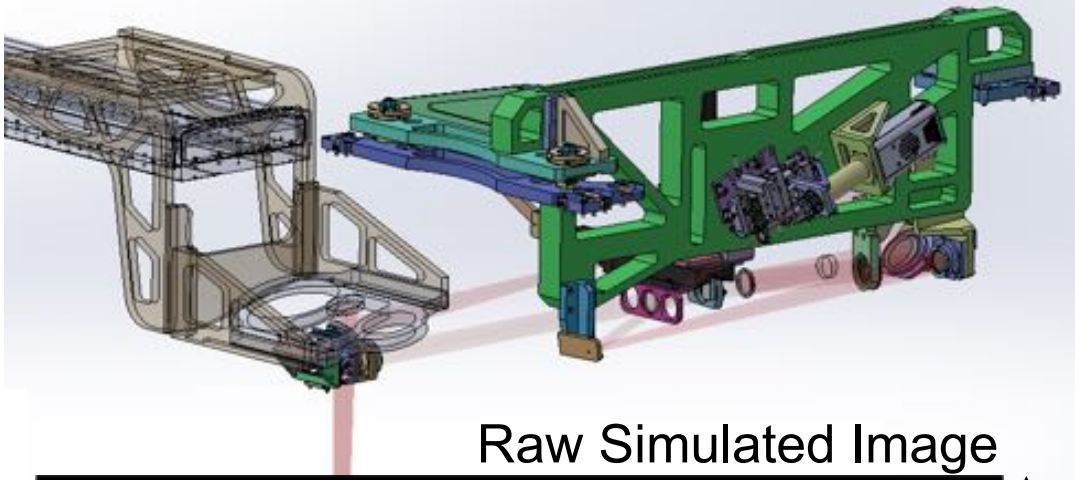
SCAO = Pyramid WFS … Pupil Fragmentation ☹



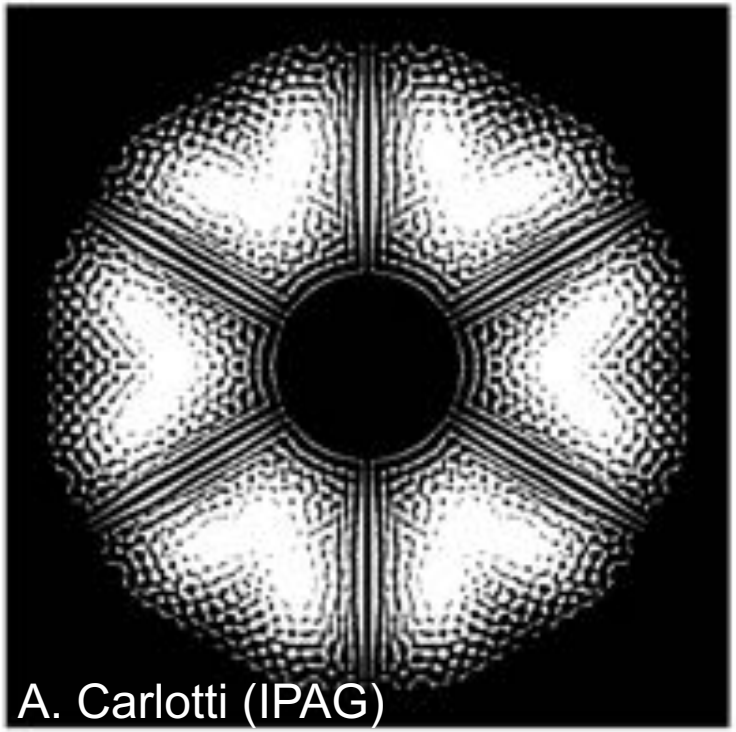




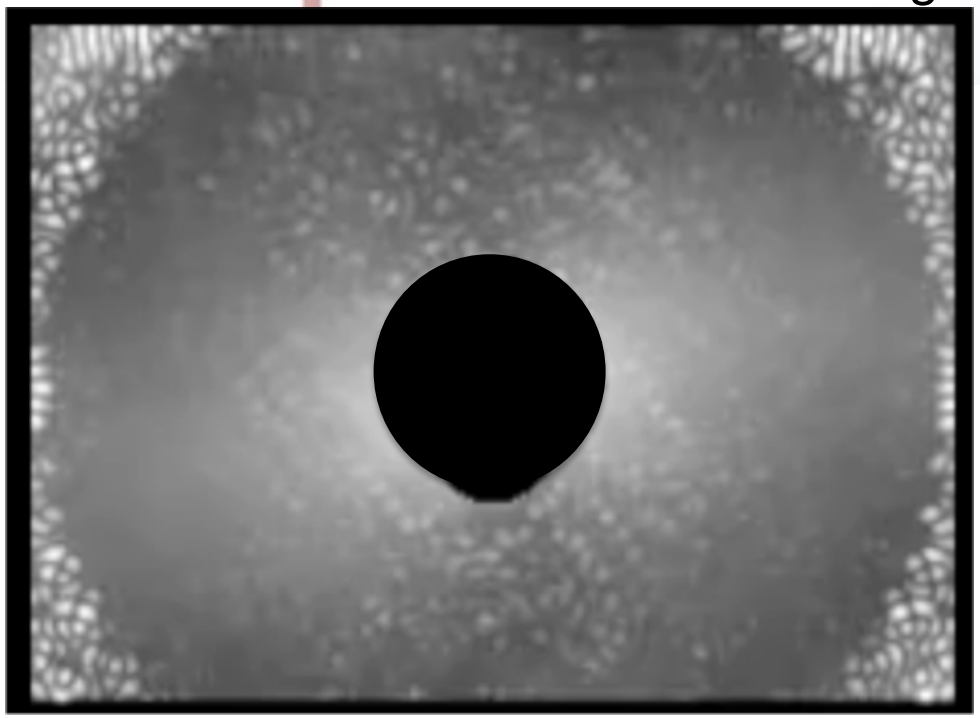
High Contrast



Shaped pupil transmission

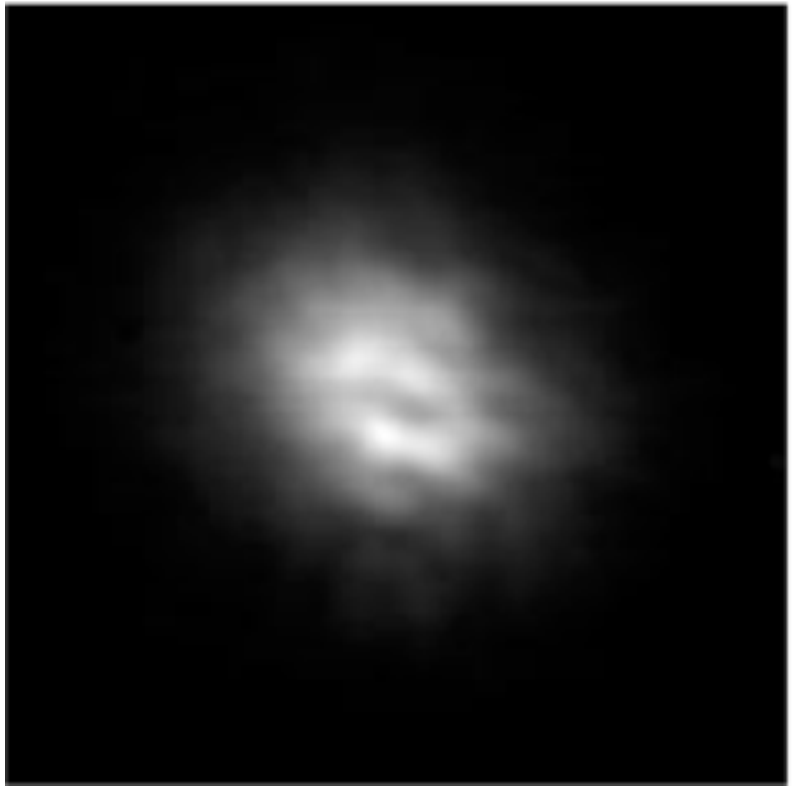


Raw Simulated Image



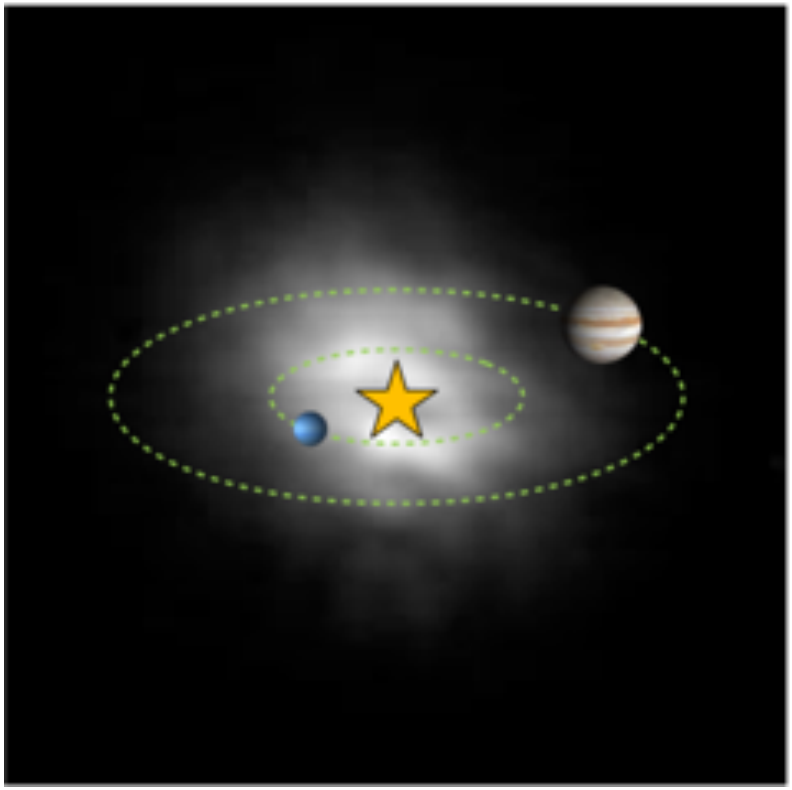
10-6 contrast at 100mas.

Sans optique adaptative

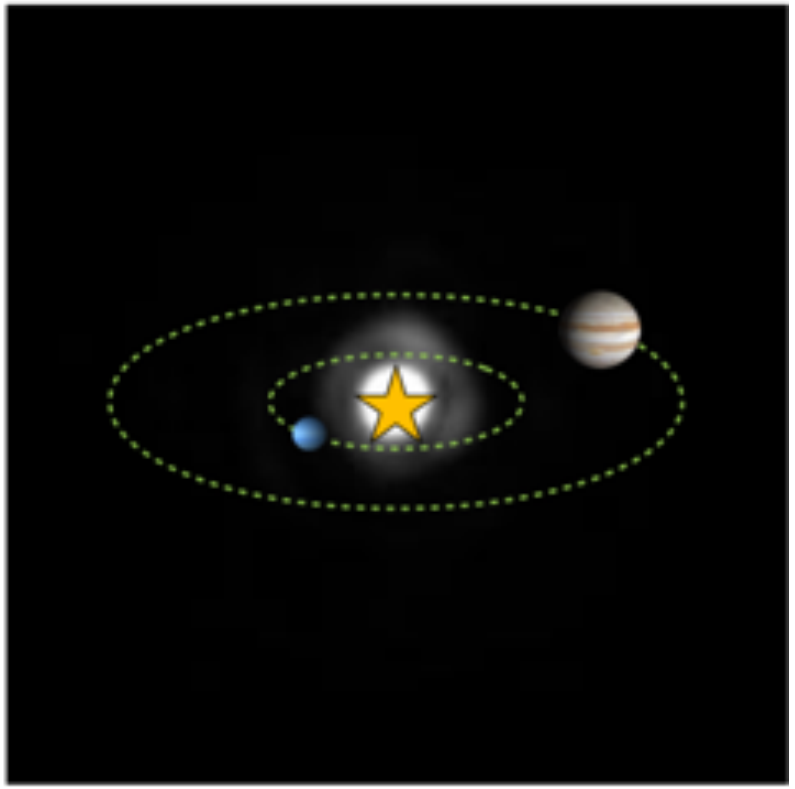


Avec optique adaptative

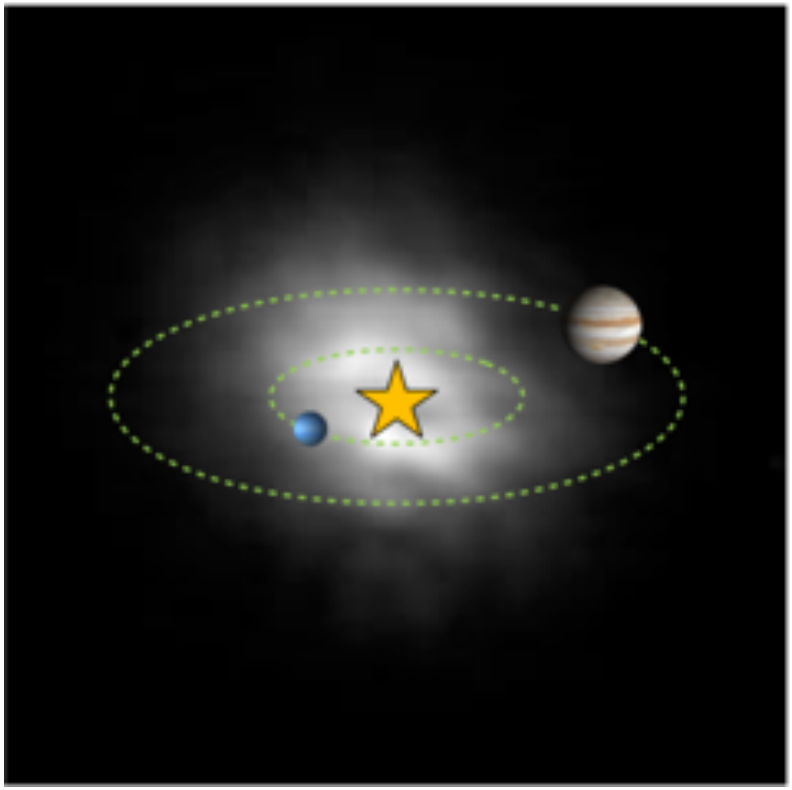
Sans optique adaptative



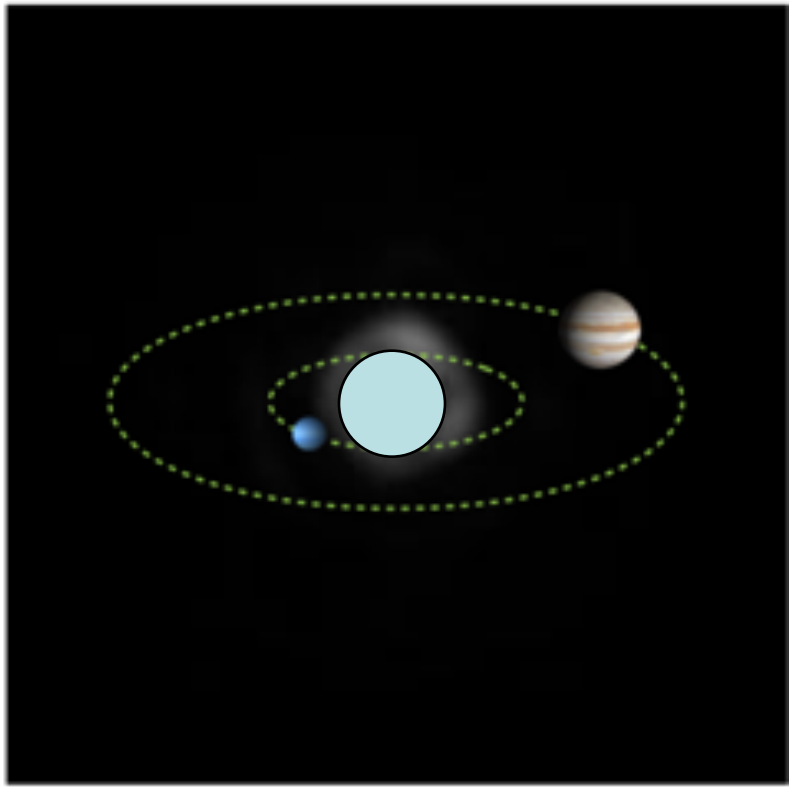
Avec optique adaptative

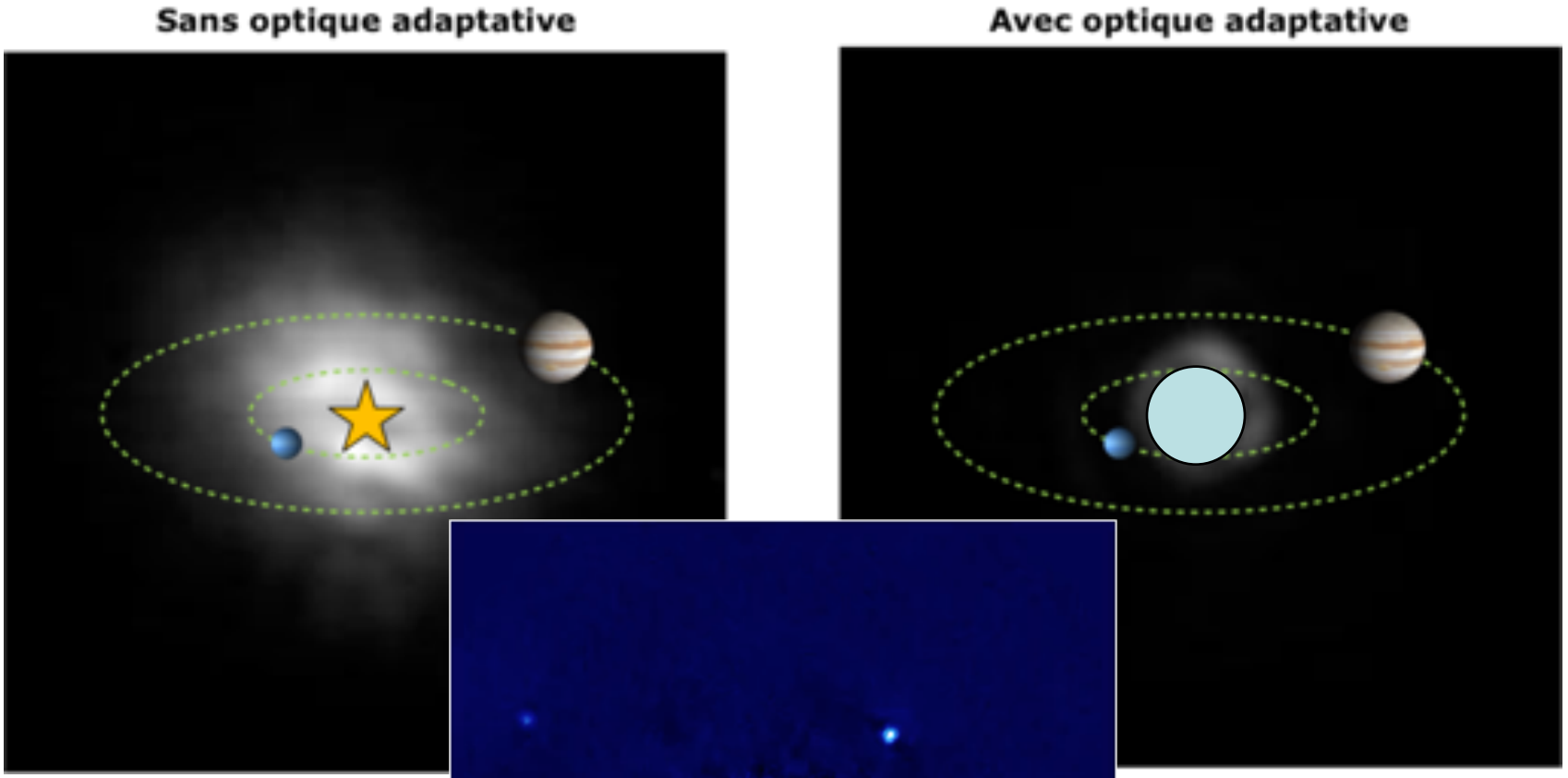


Sans optique adaptative



Avec optique adaptative

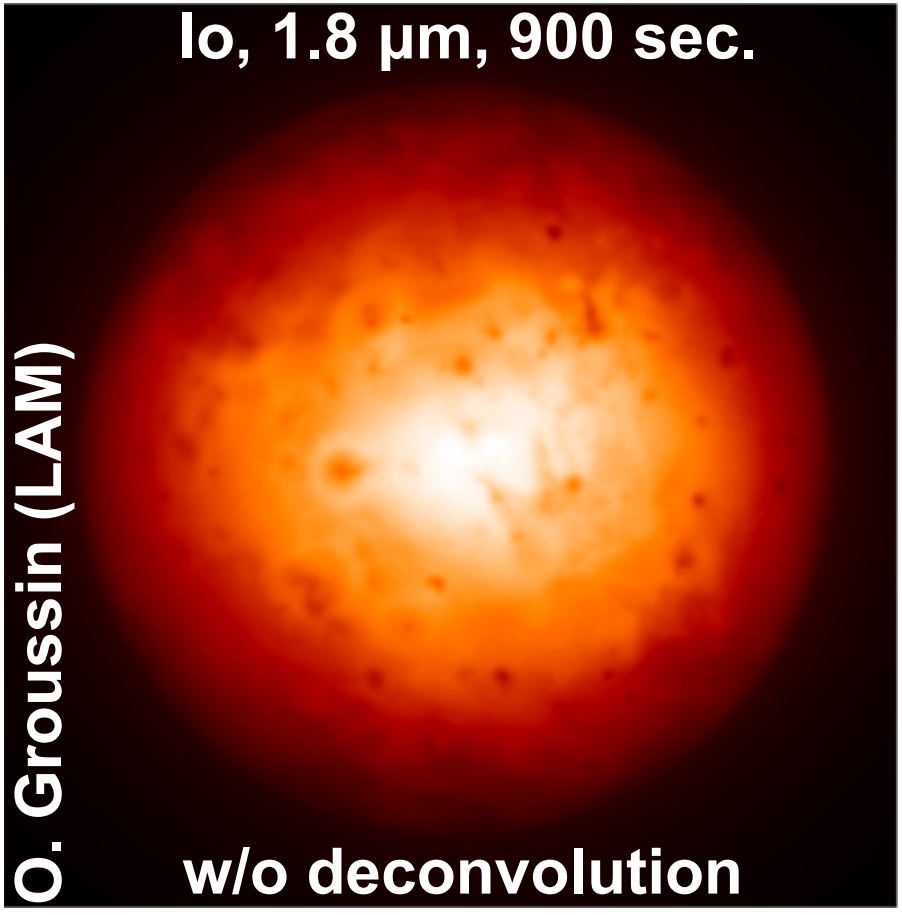


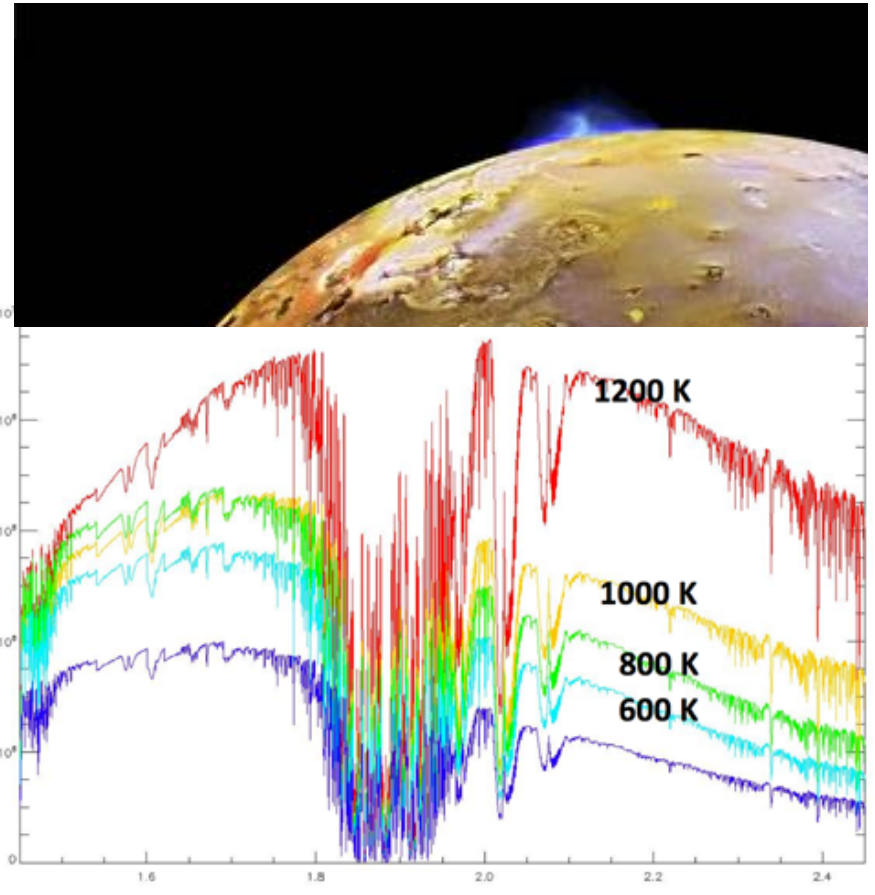

Sans optique adaptative
Avec optique adaptative
2009-07-31
20 au
Jason Wang /
Christian Marois

HARMONI – Science Case

Origin and evolution of small bodies (asteroids, comets, TNOs) and satellites of giant planets

O. Groussin, O. Mousis, P. Vernazza





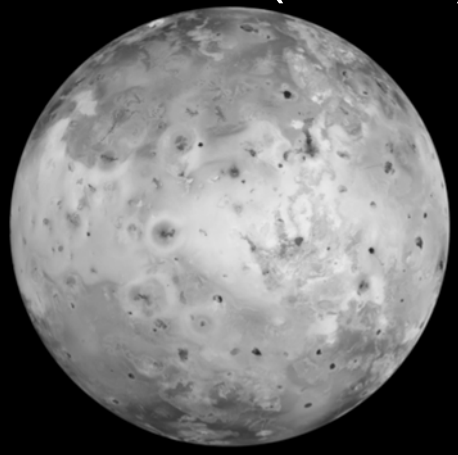
HARMONI – Science Case

Origin and evolution of small bodies (asteroids, comets, TNOs) and satellites of giant planets

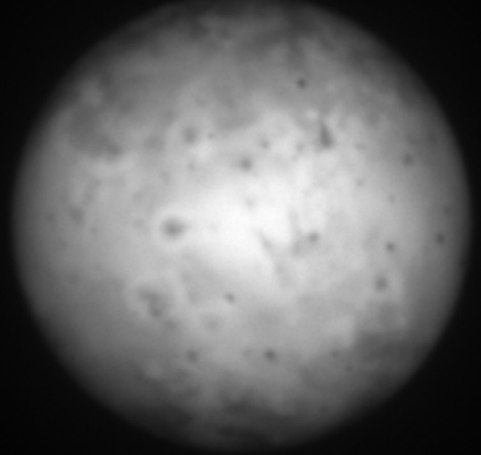
France Solar system science group:
O. Groussin, O. Mousis, S. Douté, J. Carter, N. Ligier

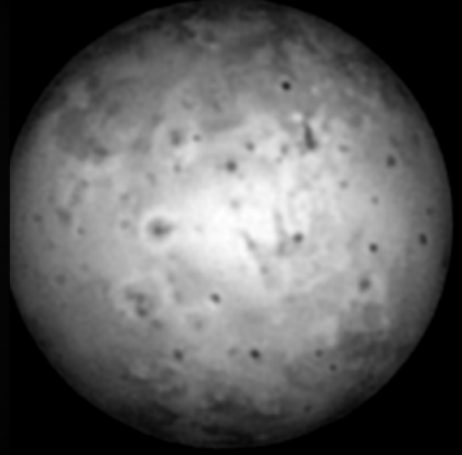
Io, 1.8 µm, 900 sec.

Galileo (in situ)



HSIM LTAO 4 mas

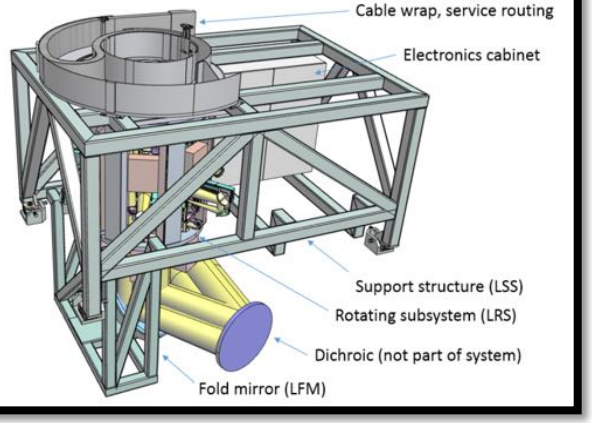




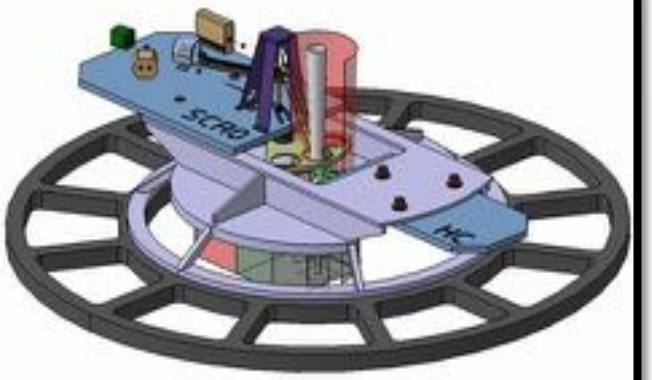
Deconvolution by R. Fetick

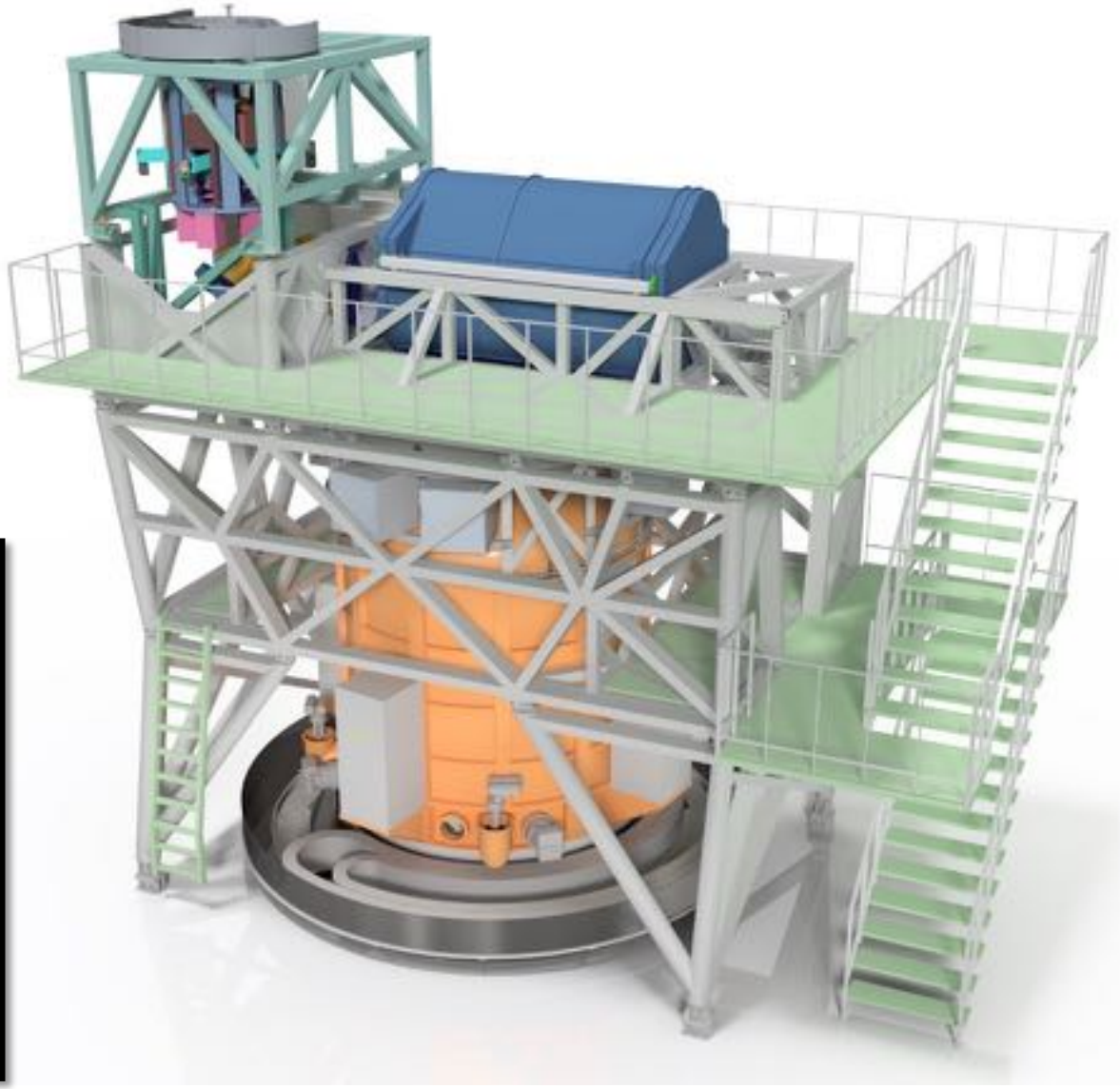
HARMONI Overview

Laser Guide Star WFS



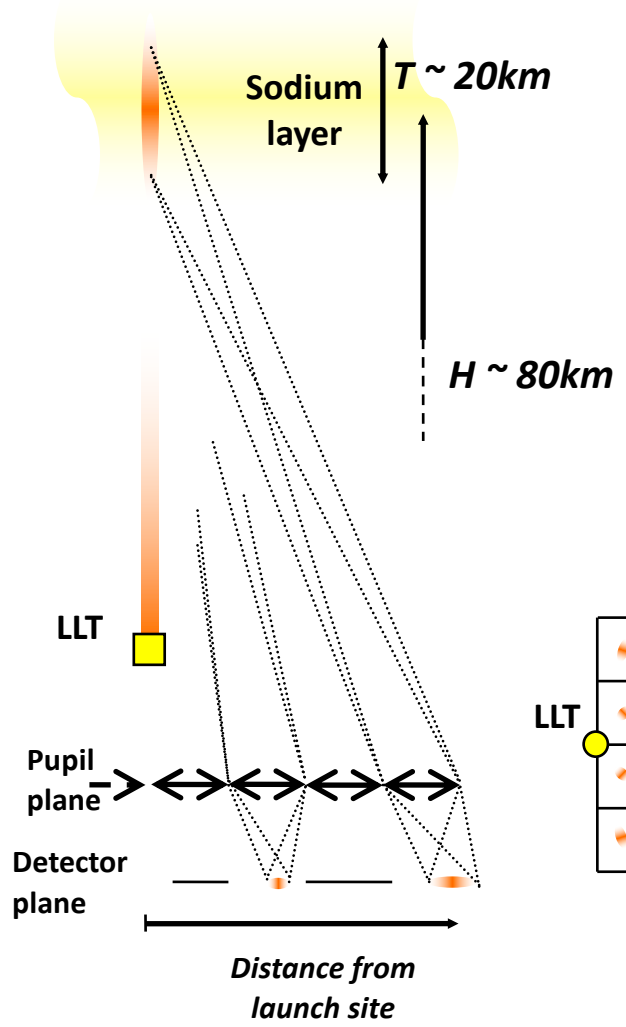
SCAO, High-Contrast & Natural Guide Star WFS

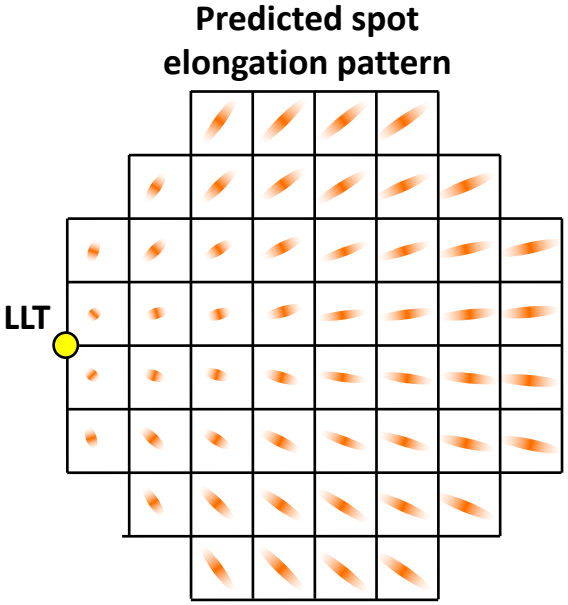


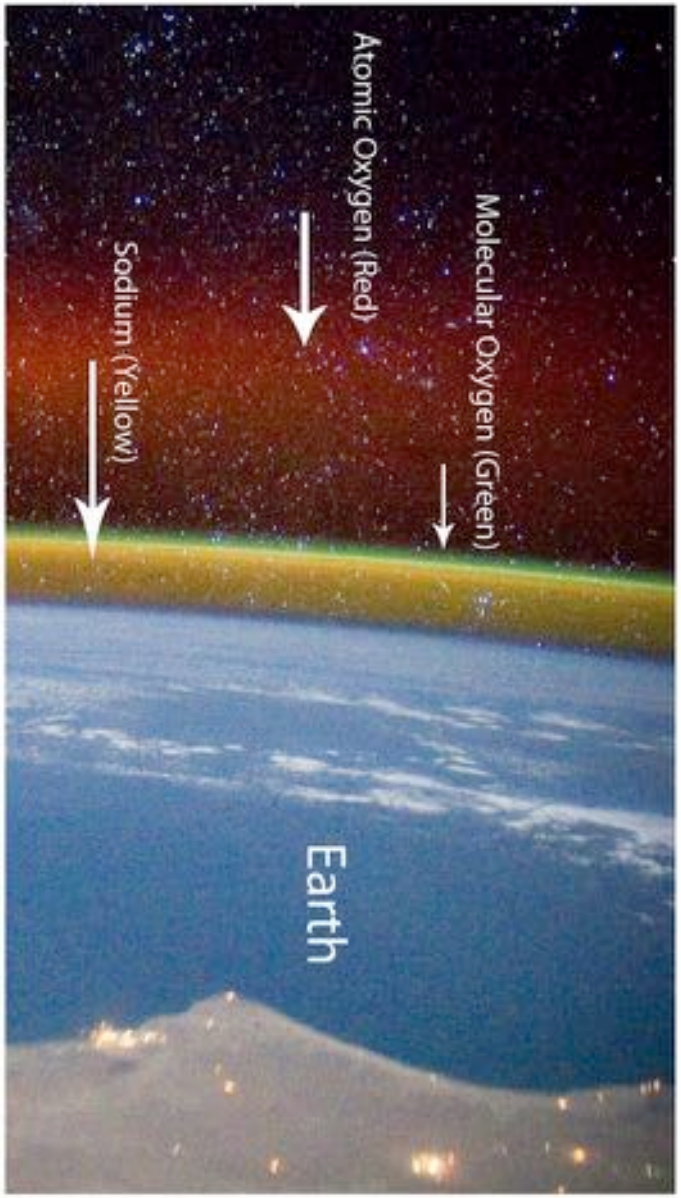


CSIC · Durham University · University of Oxford · RAL Space · Science & Technology Facilities Council UK Astronomy Technology Centre · irap · ONERA · LAM · CRAL · IPAG · ESO

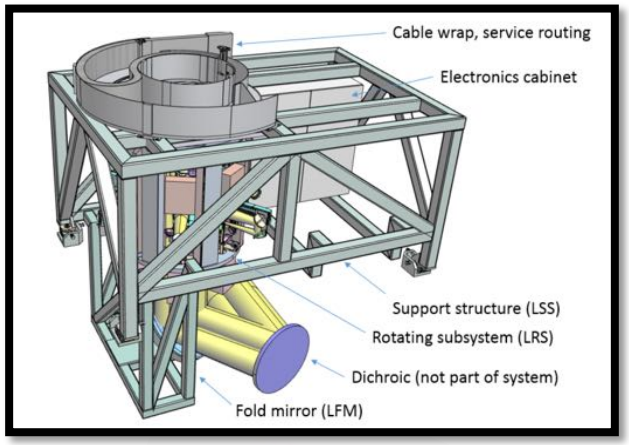
Sensing on LGS

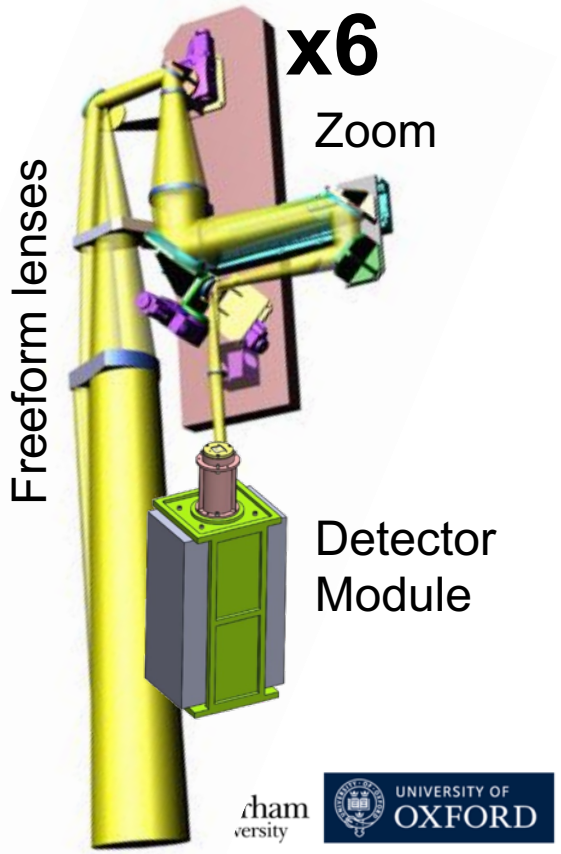


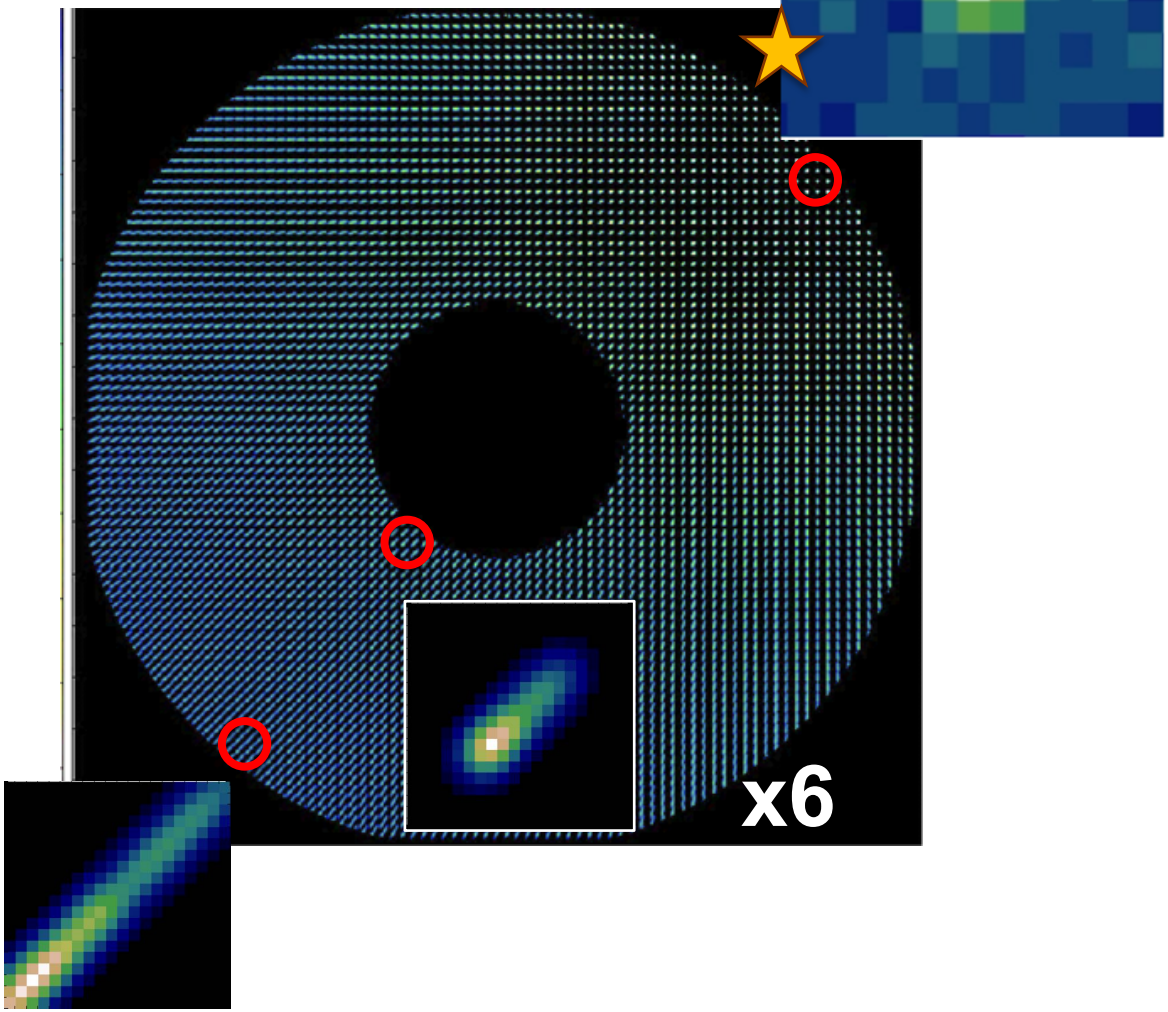




Laser Guide Star WFS = 80x80 Shack-Hartman

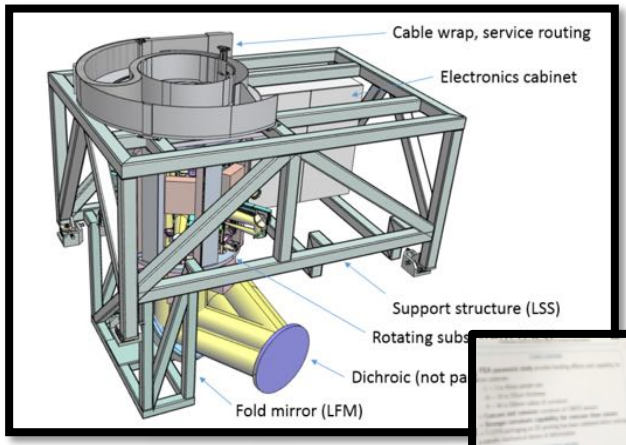


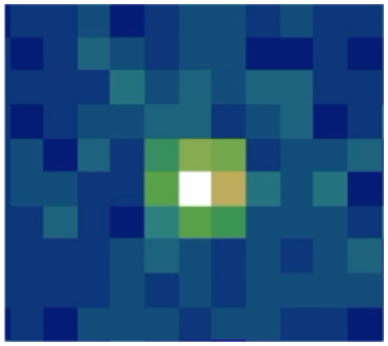


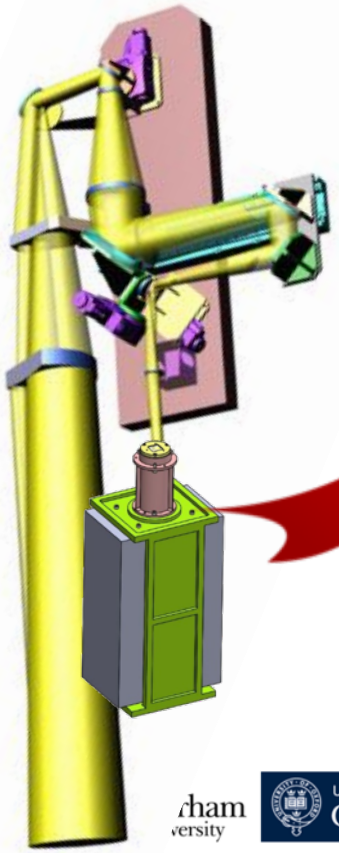


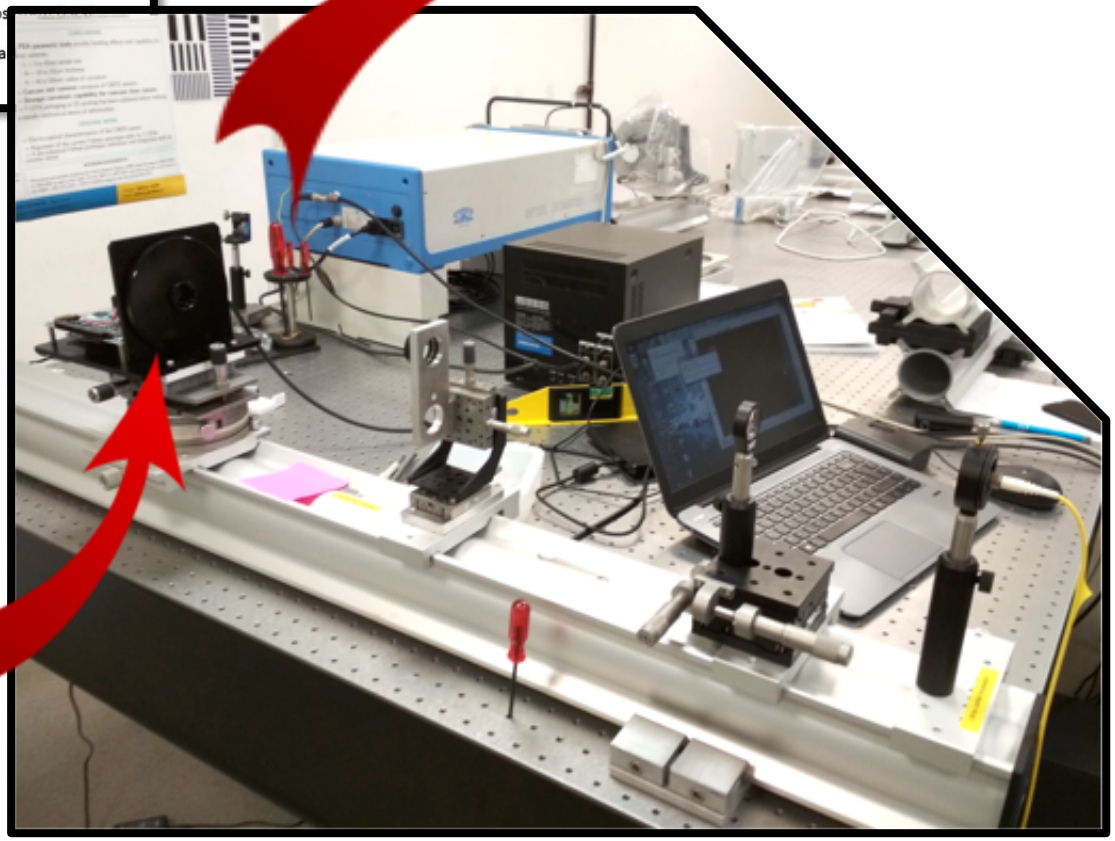
HARMONI Overview

Laser Guide Star WFS = 80x80 Shack-Hartman



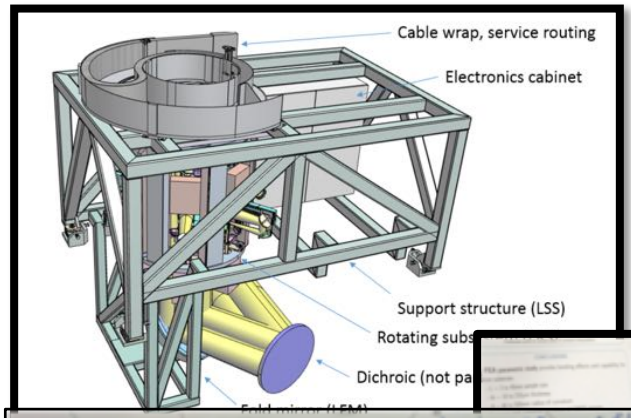


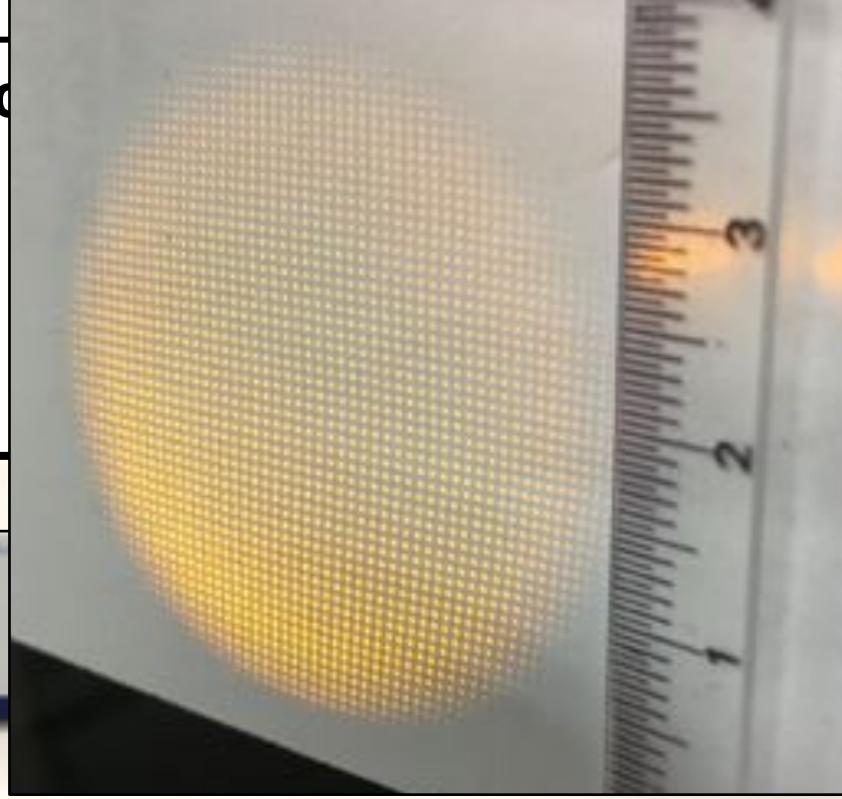


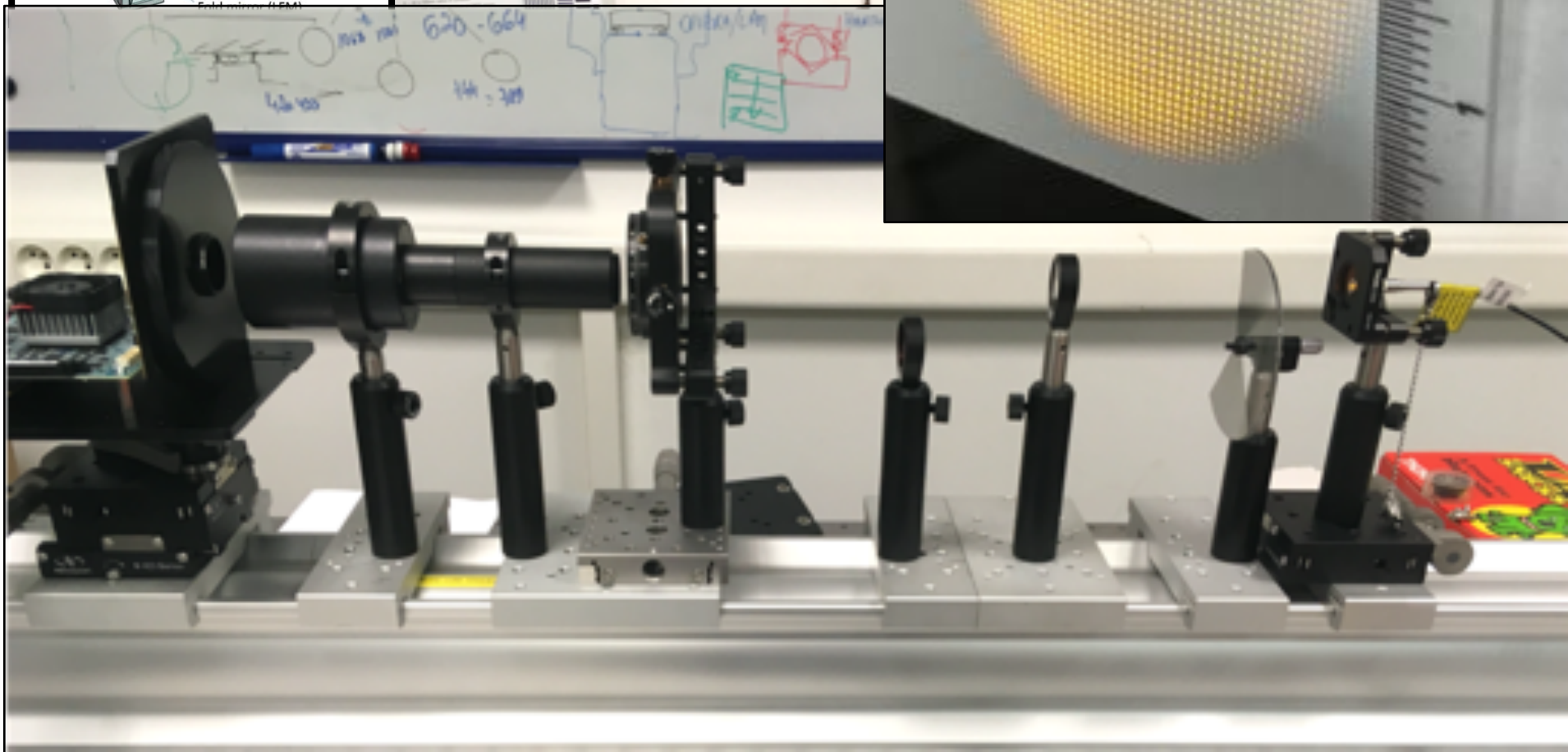


HARMONI Overview

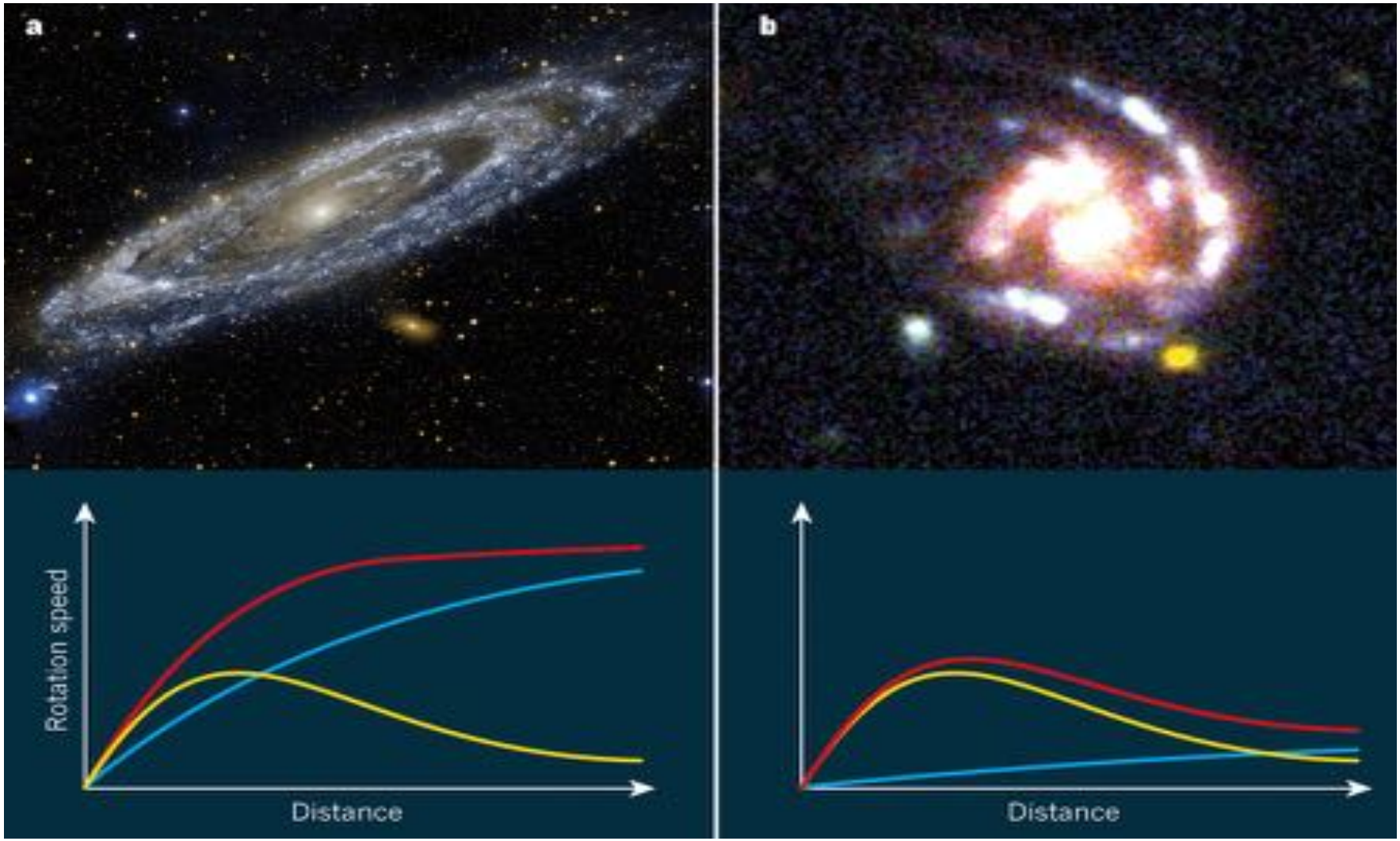
Laser Guide Star WFS = 80x80 Shac



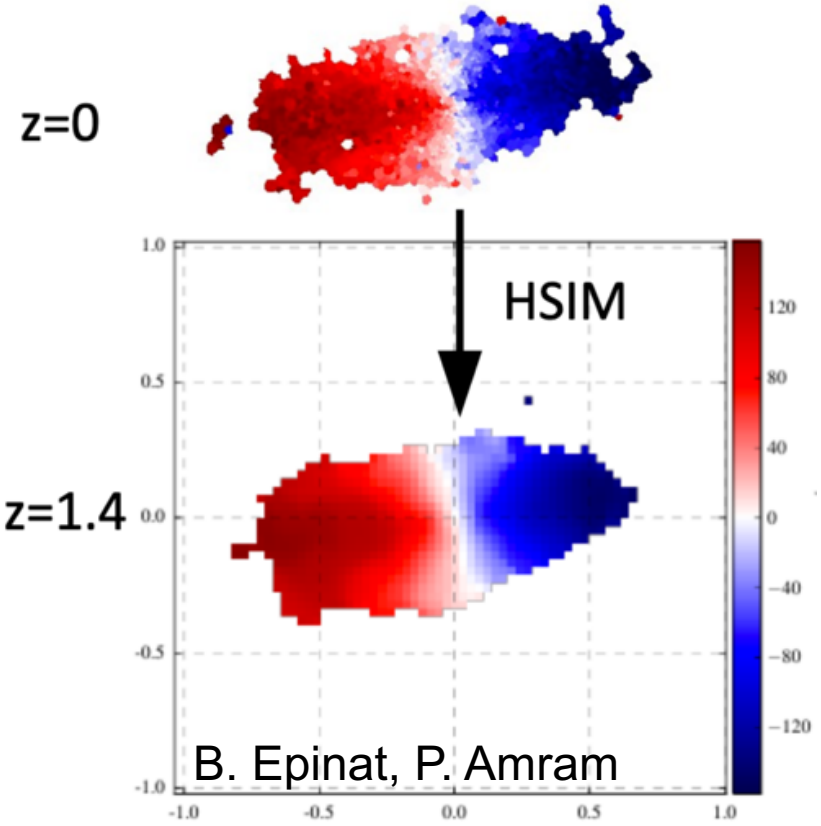


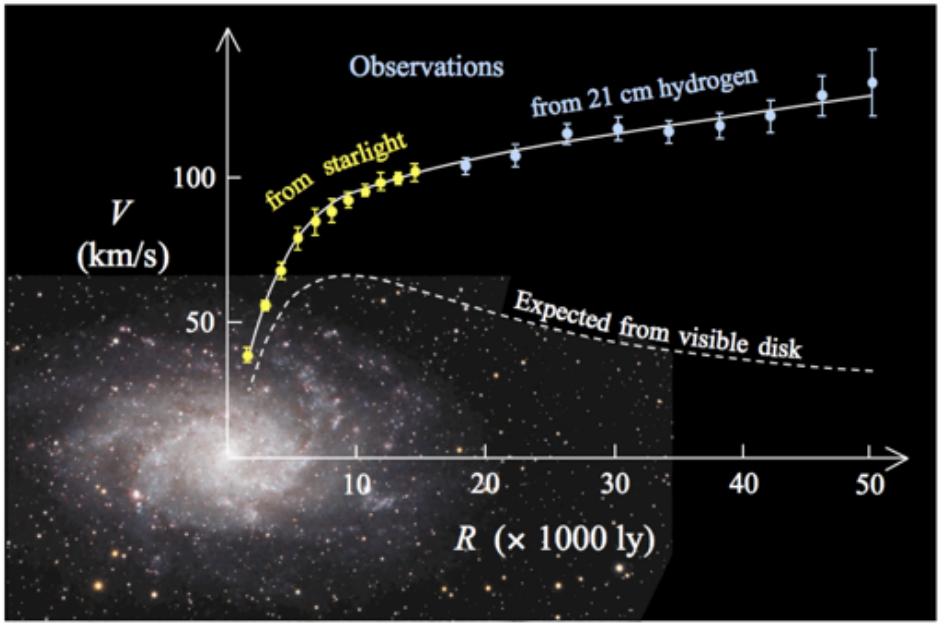


HARMONI – Science Case



kinematics and line properties of galaxies at z=2 – Dark Matter distribution



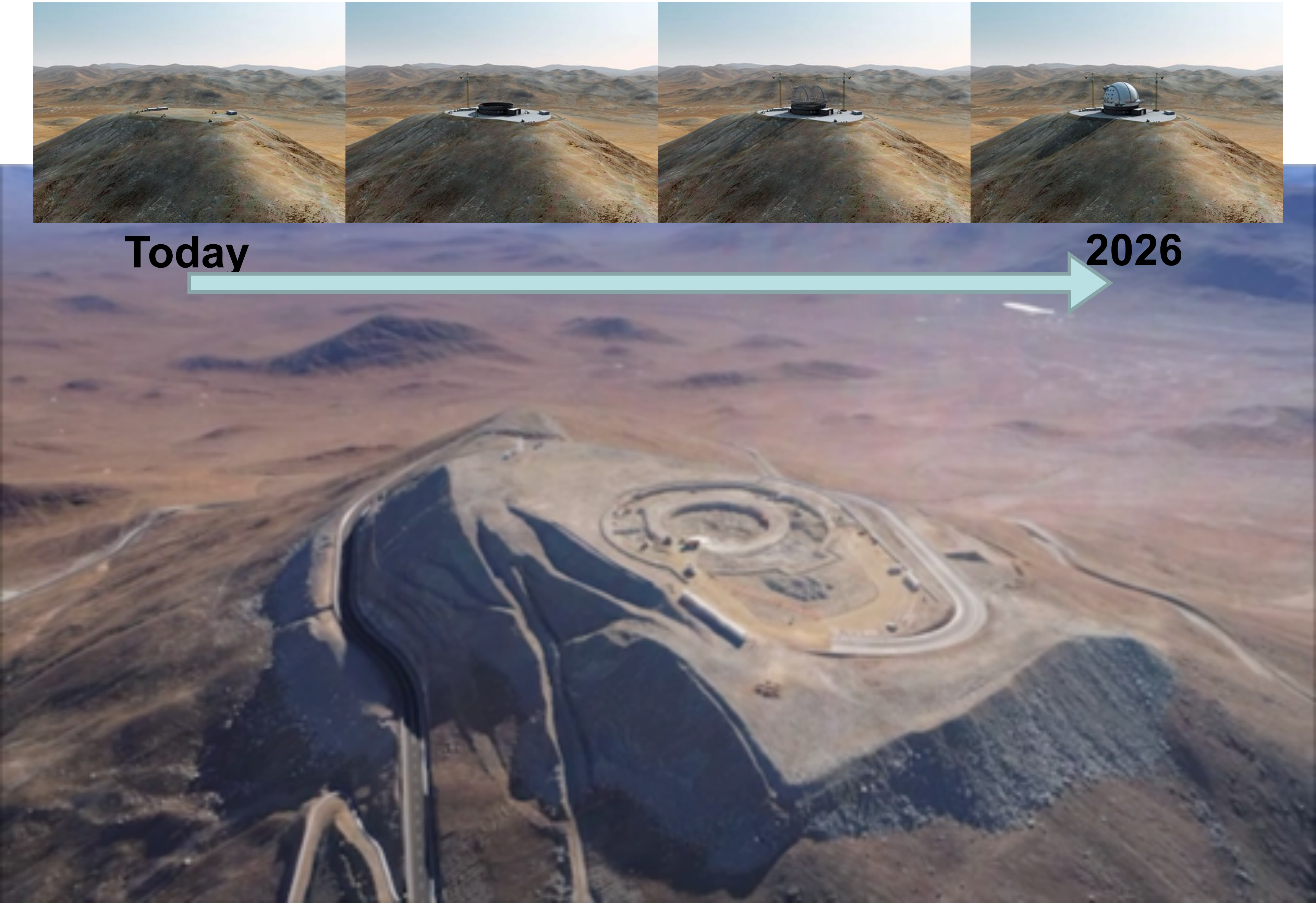


DM fraction at z>1 - Cusp vs. core DM profiles

HARMONI Schedule

Today

HARMONI Schedule



HARMONI Schedule

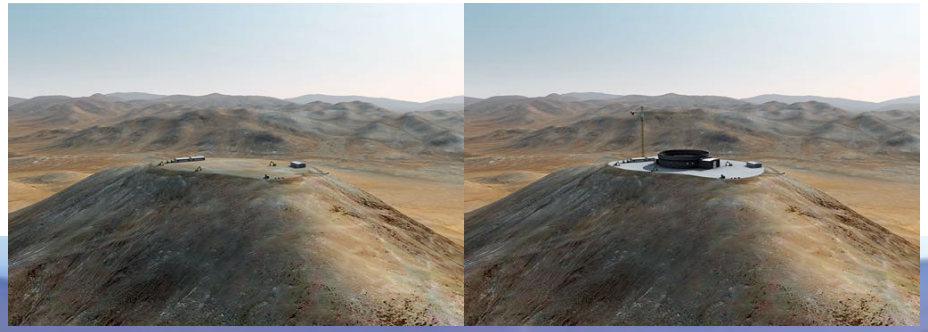
Today

2026

Dec 2017

PDR

HARMONI Schedule



Today

2026

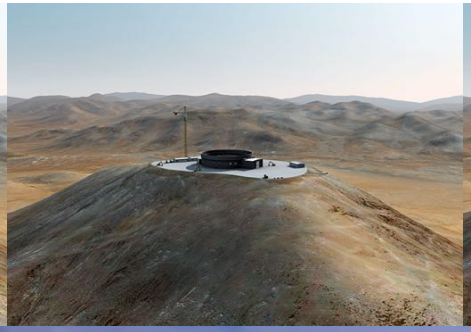
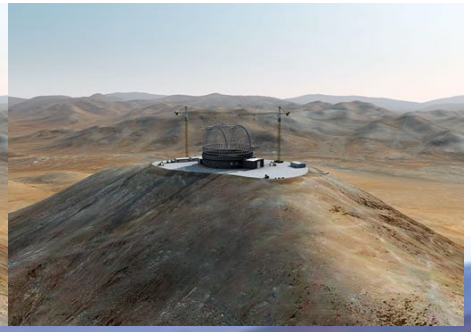
Dec 2017

end 2022

PDR

FDR

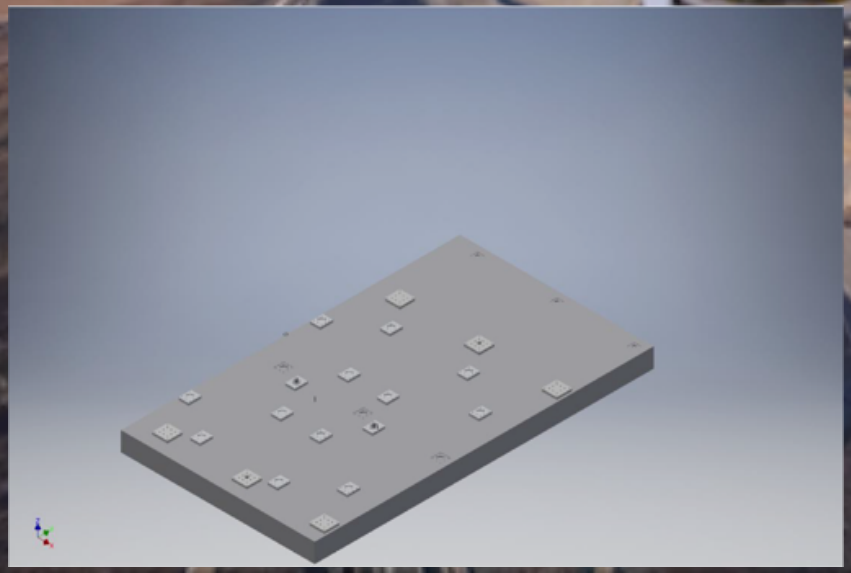
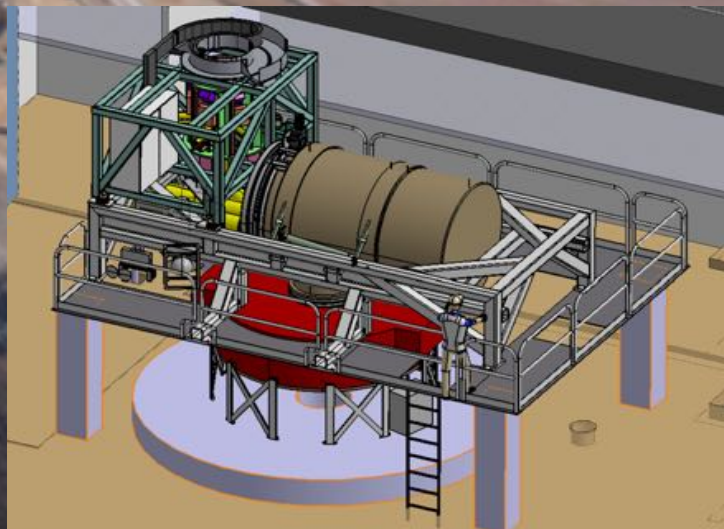
HARMONI Schedule

Today → 2026

Dec 2017 — end 2022 — 2026

PDR	FDR	MAIT

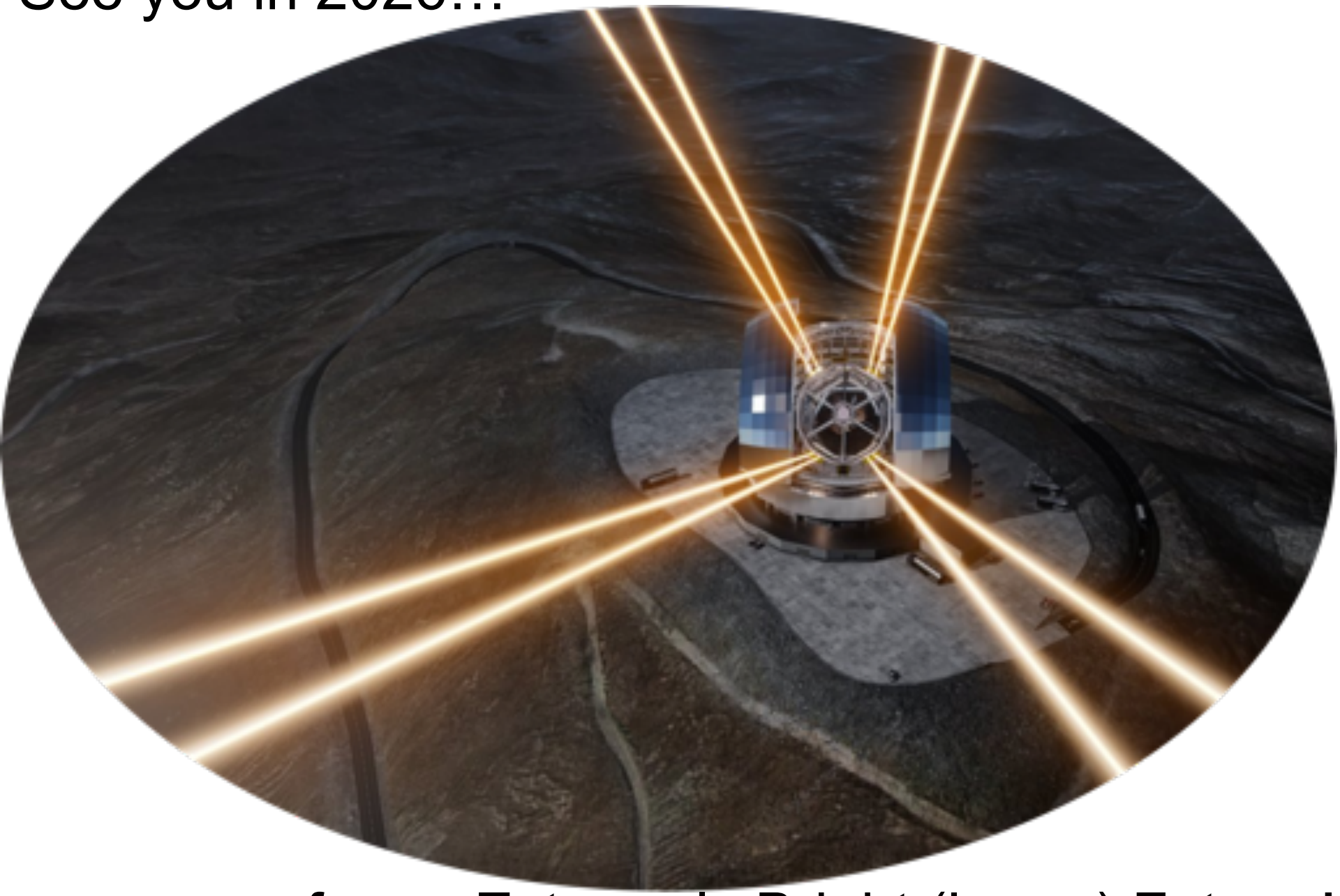
HARMONI Schedule

Today → 2026

Dec 2017 — end 2022 — 2026

PDR	FDR	MAIT	Install/Comm.

See you in 2026…



… for an Extremely Bright (Laser) Future !

Thank you