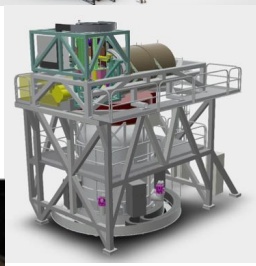
HARMONI
The ELT first light IFU

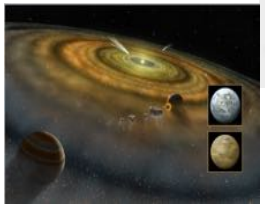
Presented by B. Neichel on behalf of the HARMONI consortium

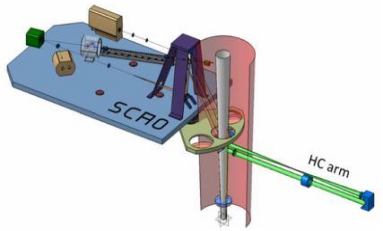
CSIC · Durham University · University of Oxford · RAL Space · Science & Technology Facilities Council UK Astronomy Technology Centre · irap · ONERA · LAM · CRAL · IPAG · ESO

Summary

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



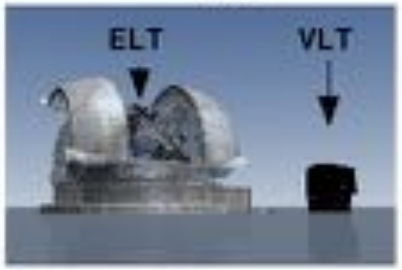


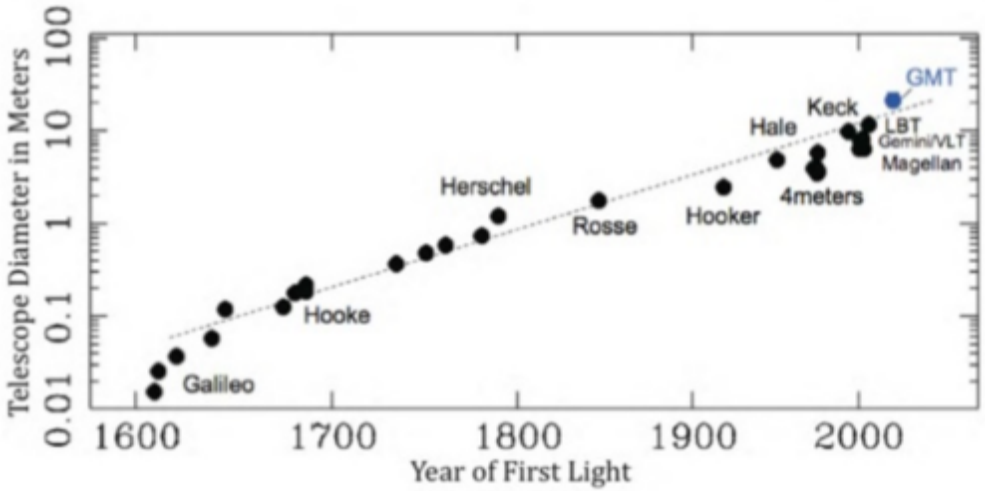


General Introduction

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

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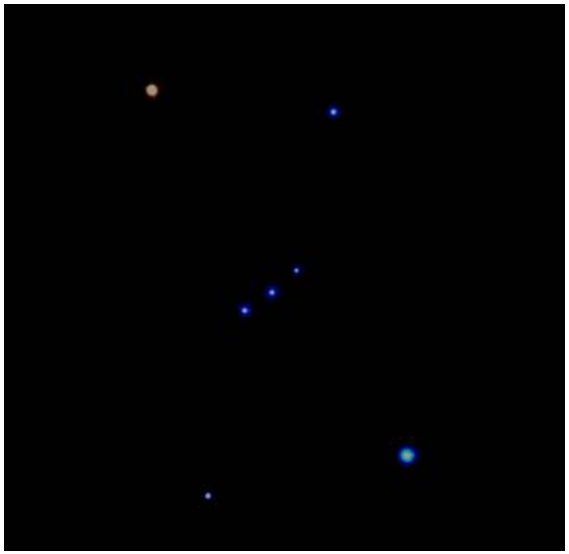

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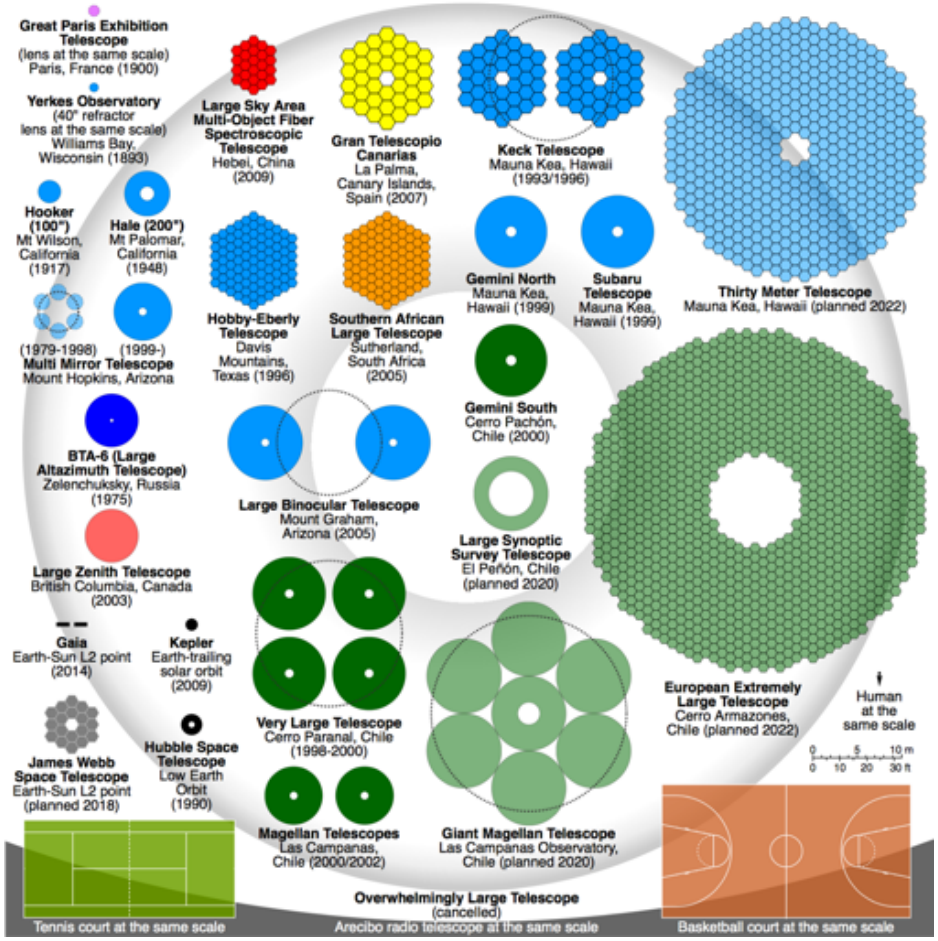

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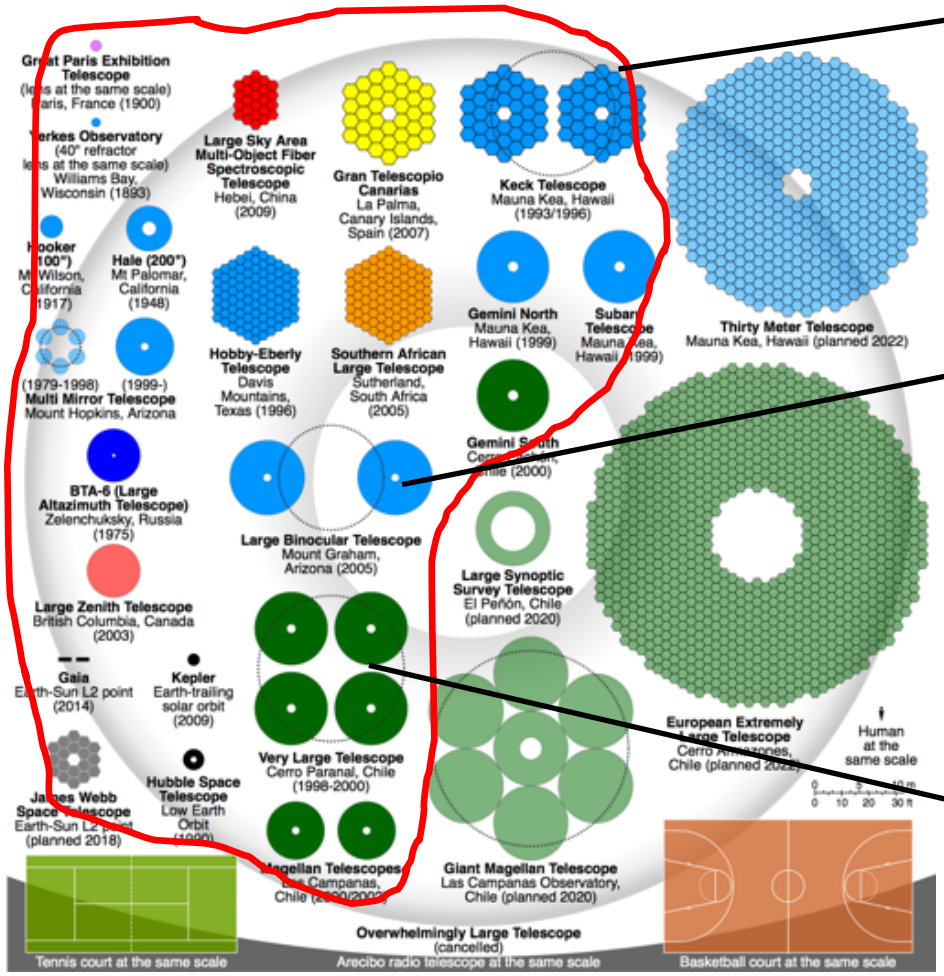

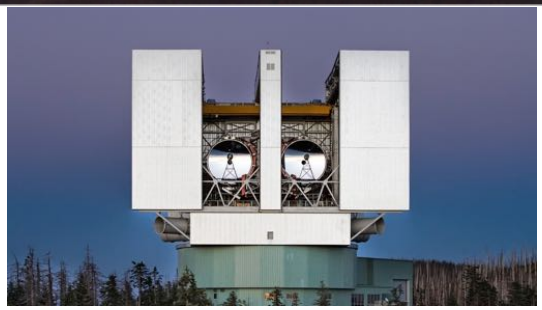

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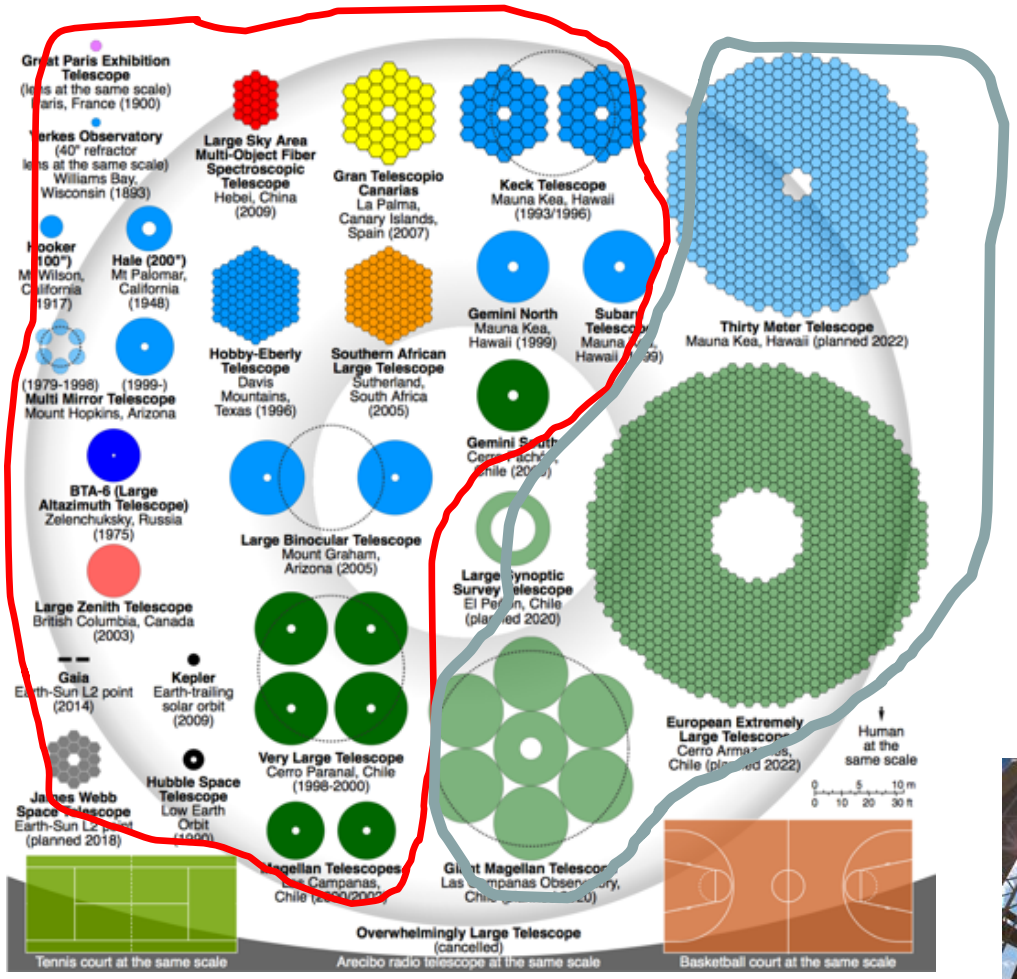

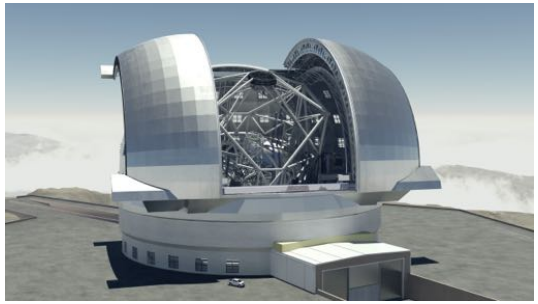

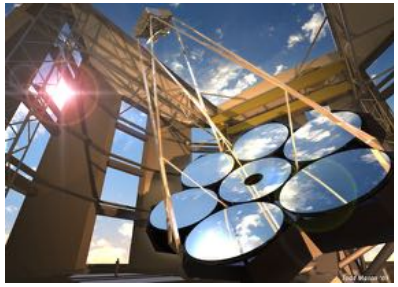

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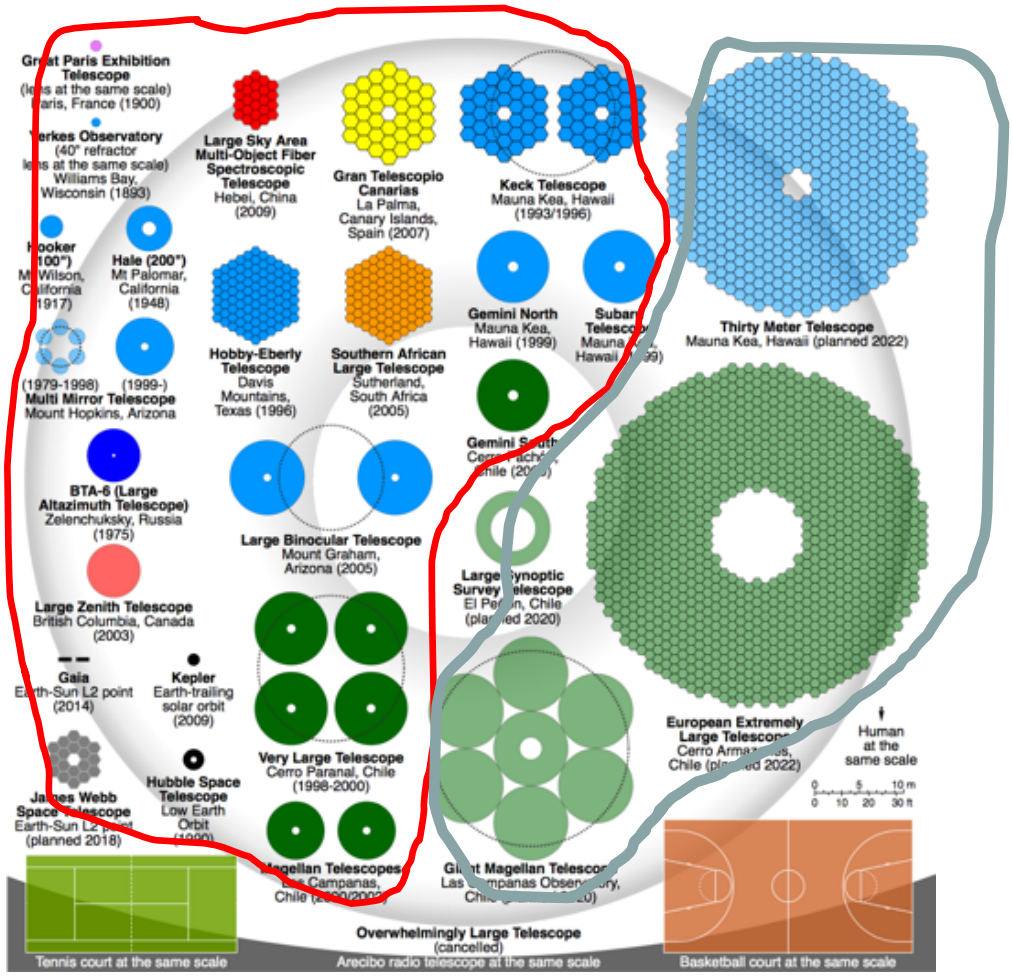
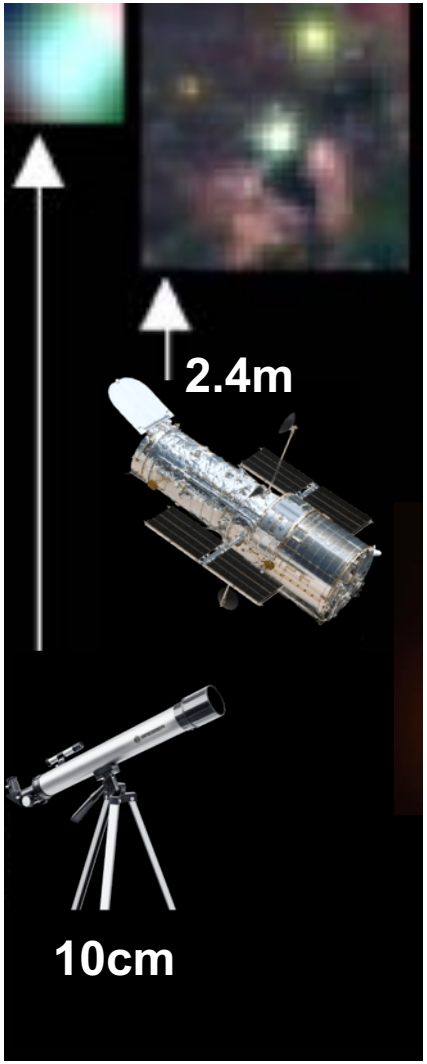


Exponential growth… For resolution



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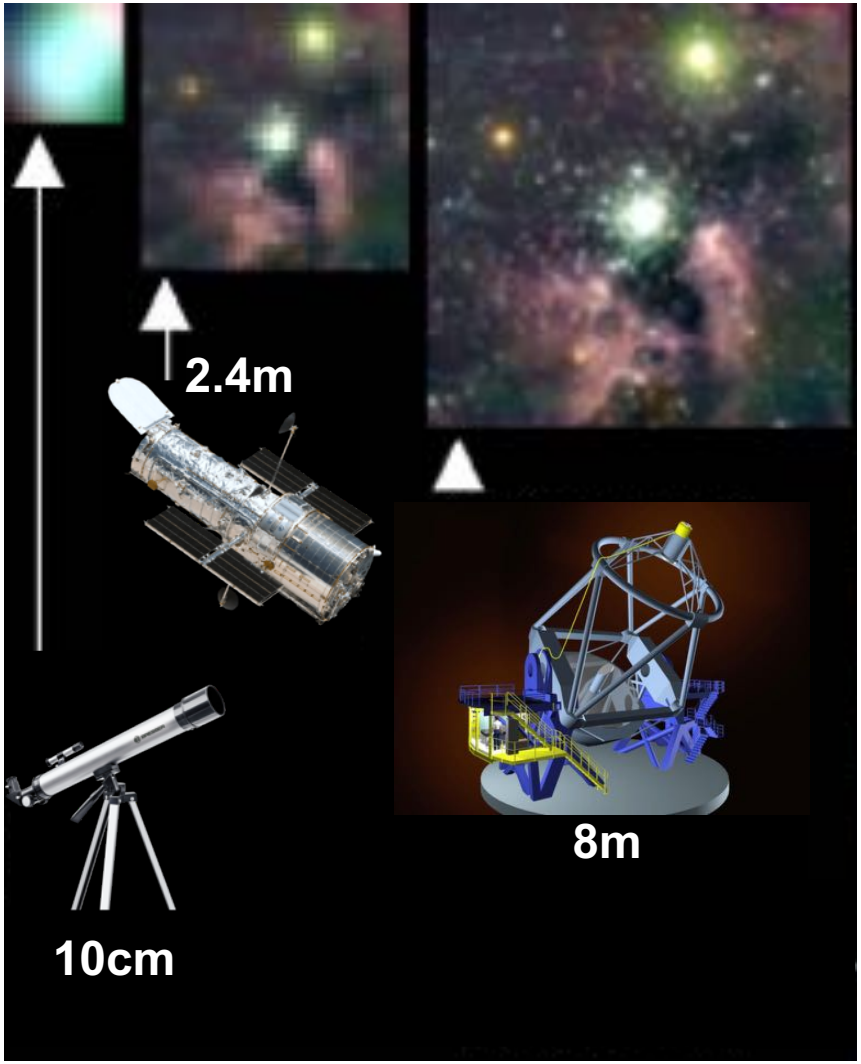

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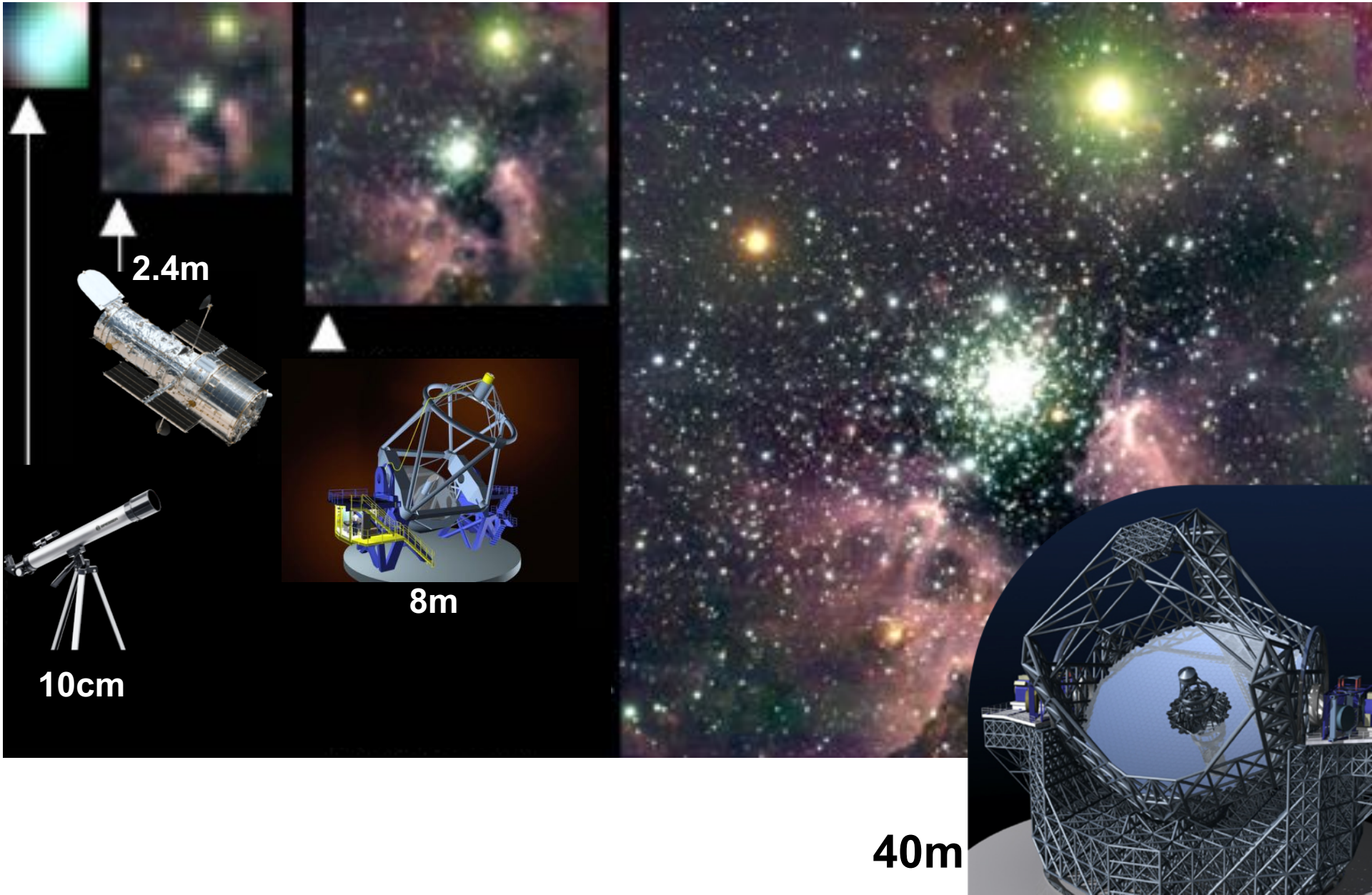
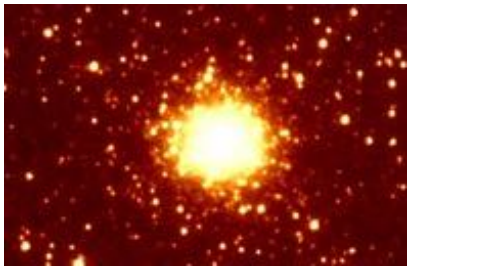
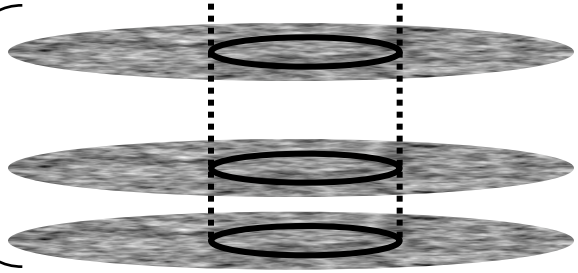
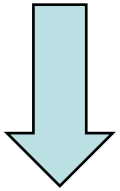


Adaptive Optics



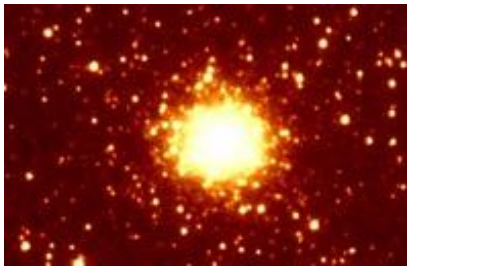
Earth's atmosphere





Spatial resolution is lost…

Adaptive Optics



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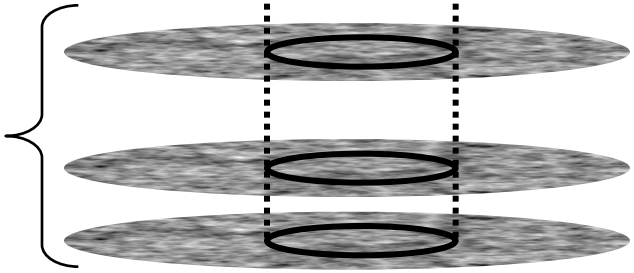

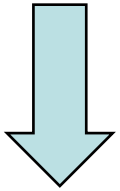

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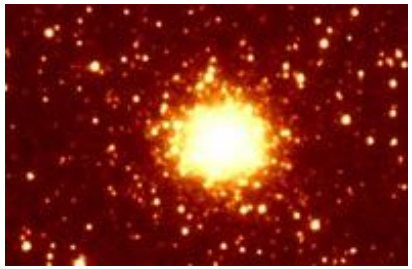

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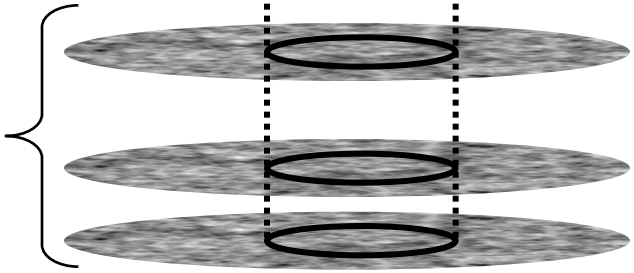
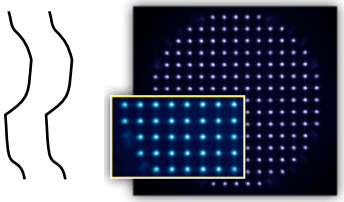
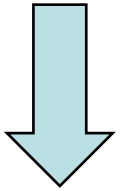




Wave-Front Sensor



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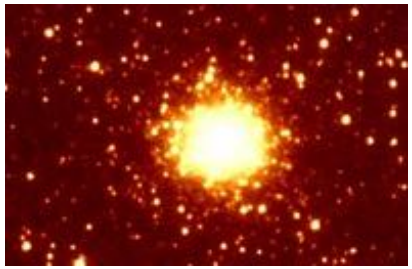

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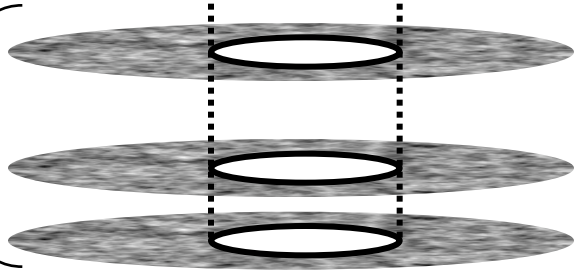

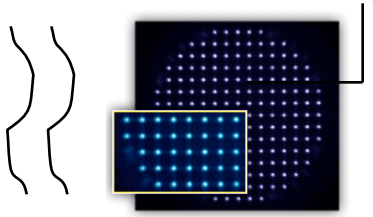

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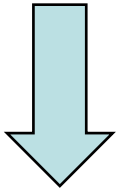
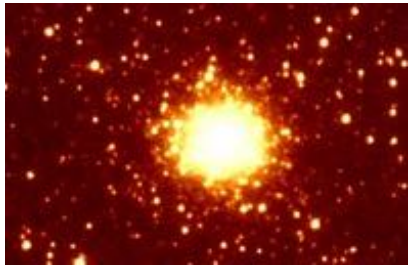
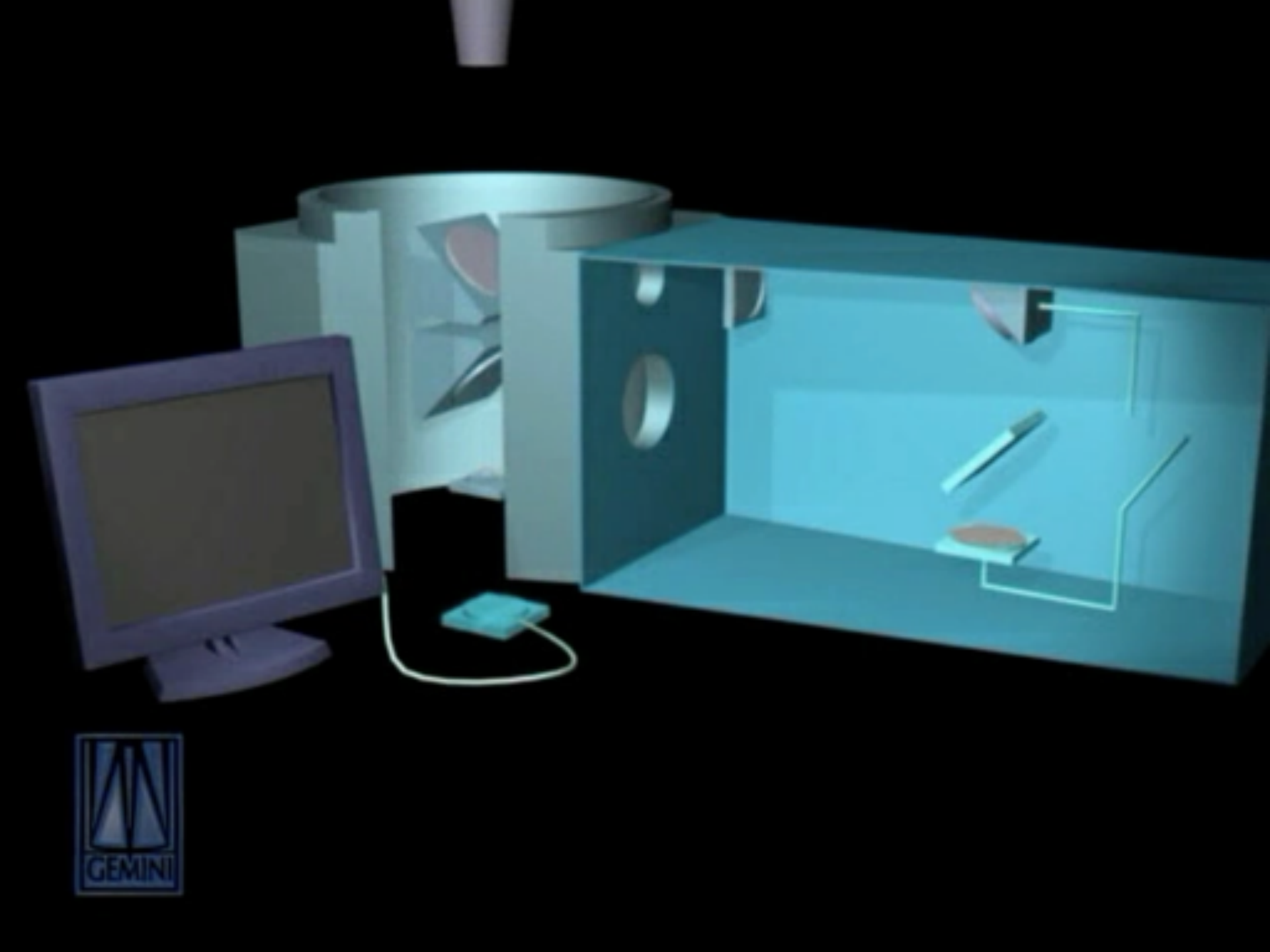
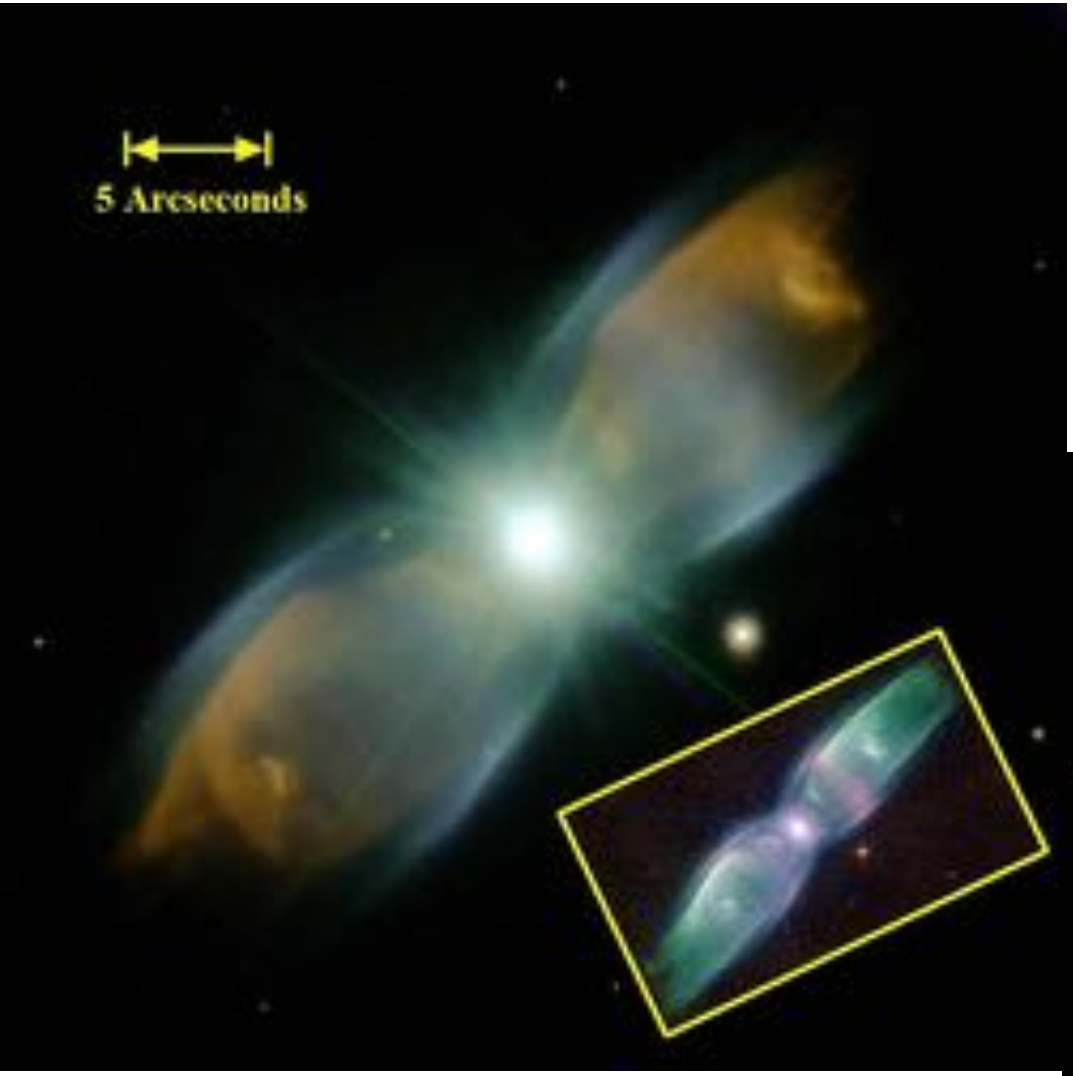


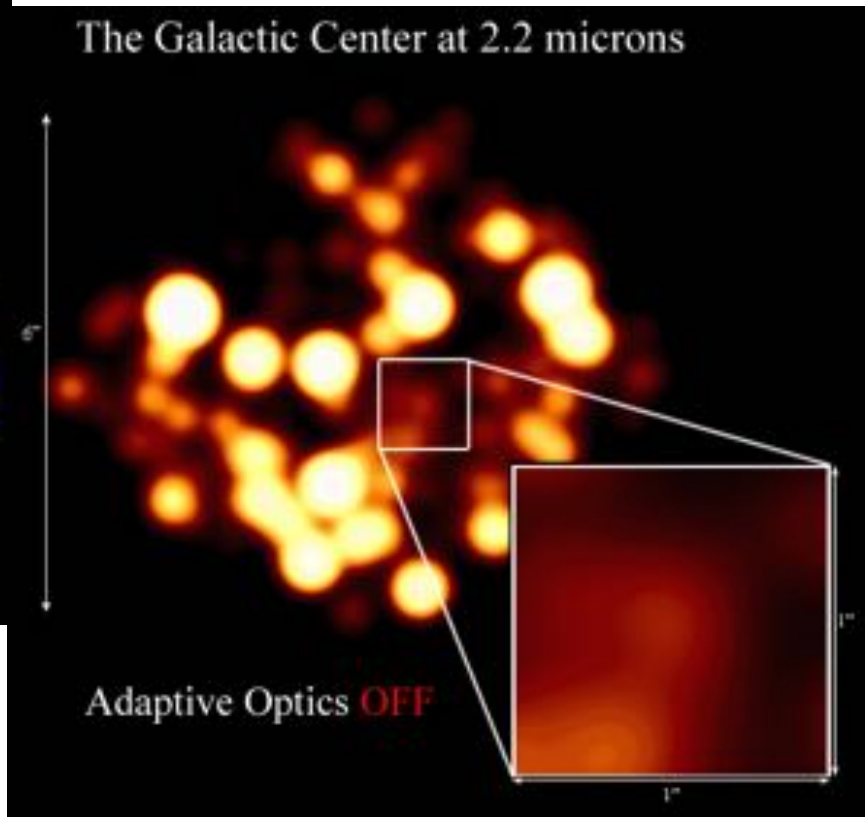
Spatial resolution is restored




GEMINI

Adaptive Optics





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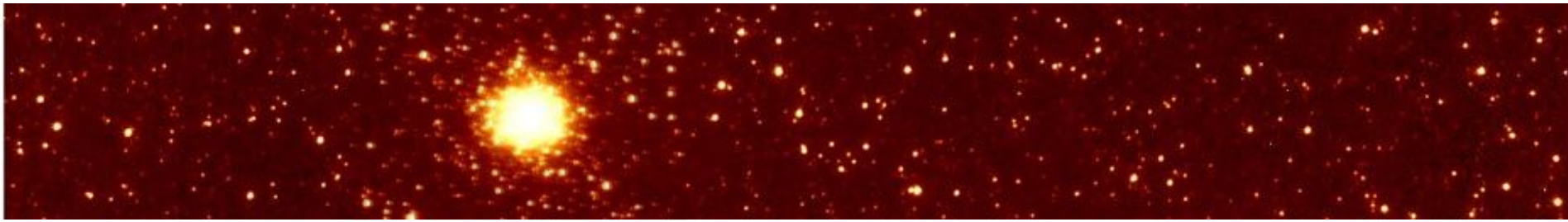
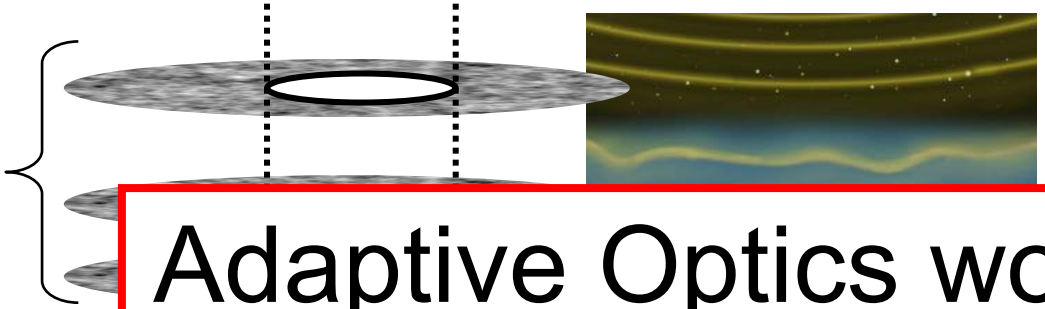
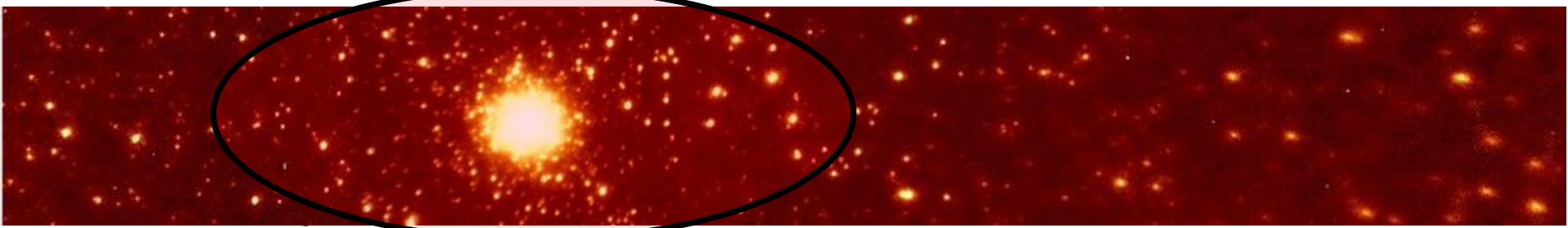




Earth's atmosphere

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

Wave-Front Sensor



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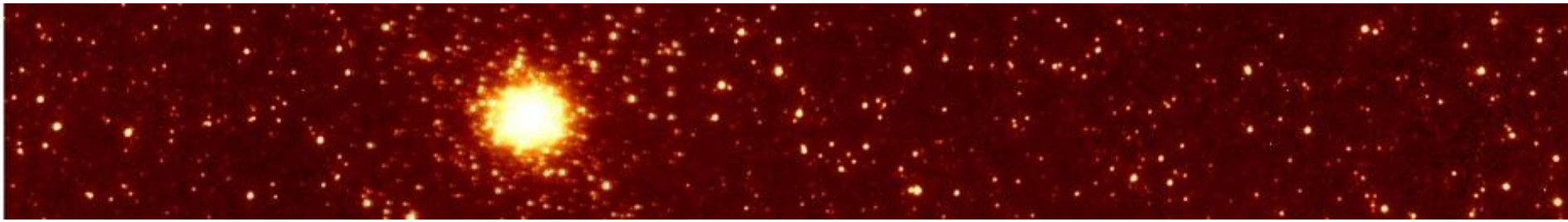

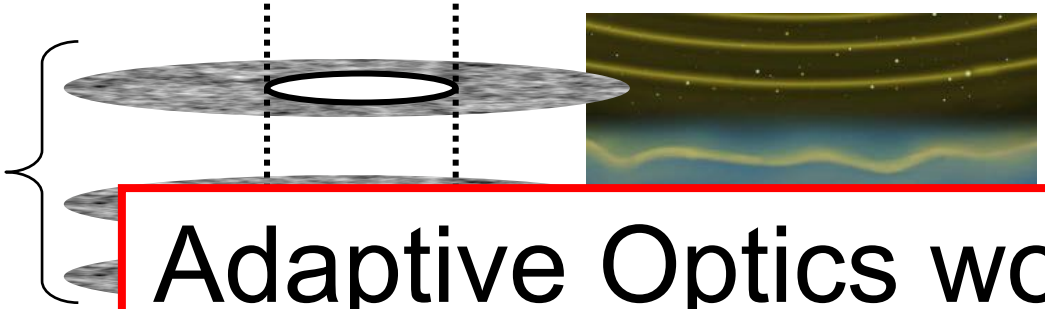

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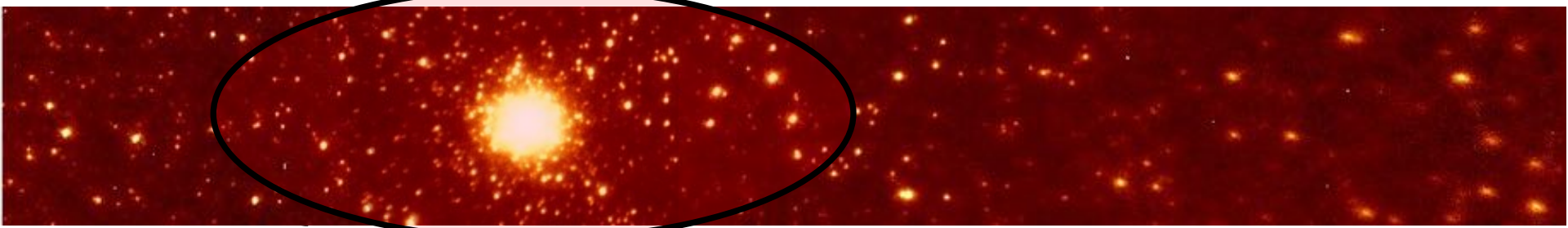
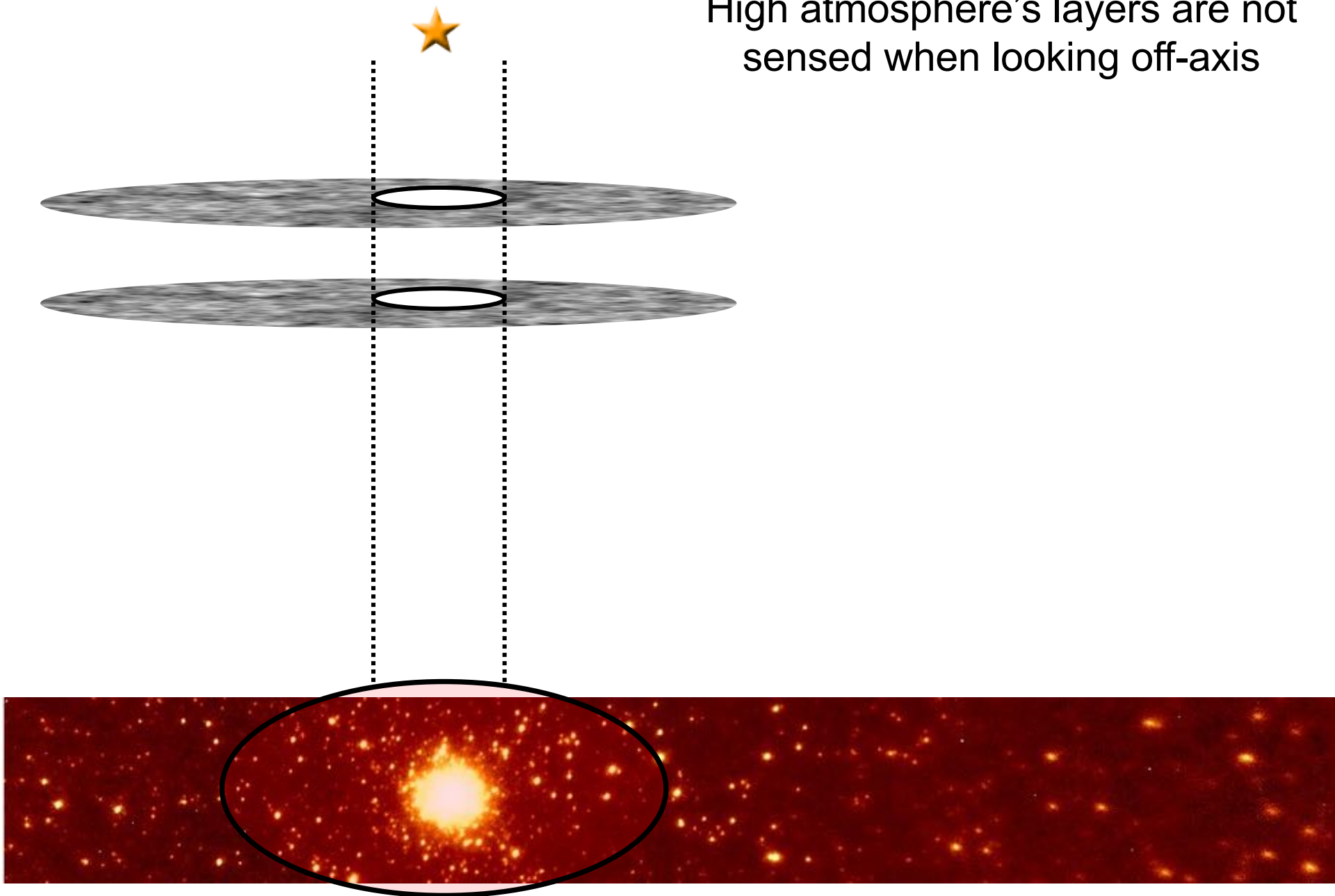


Anisoplanatism

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



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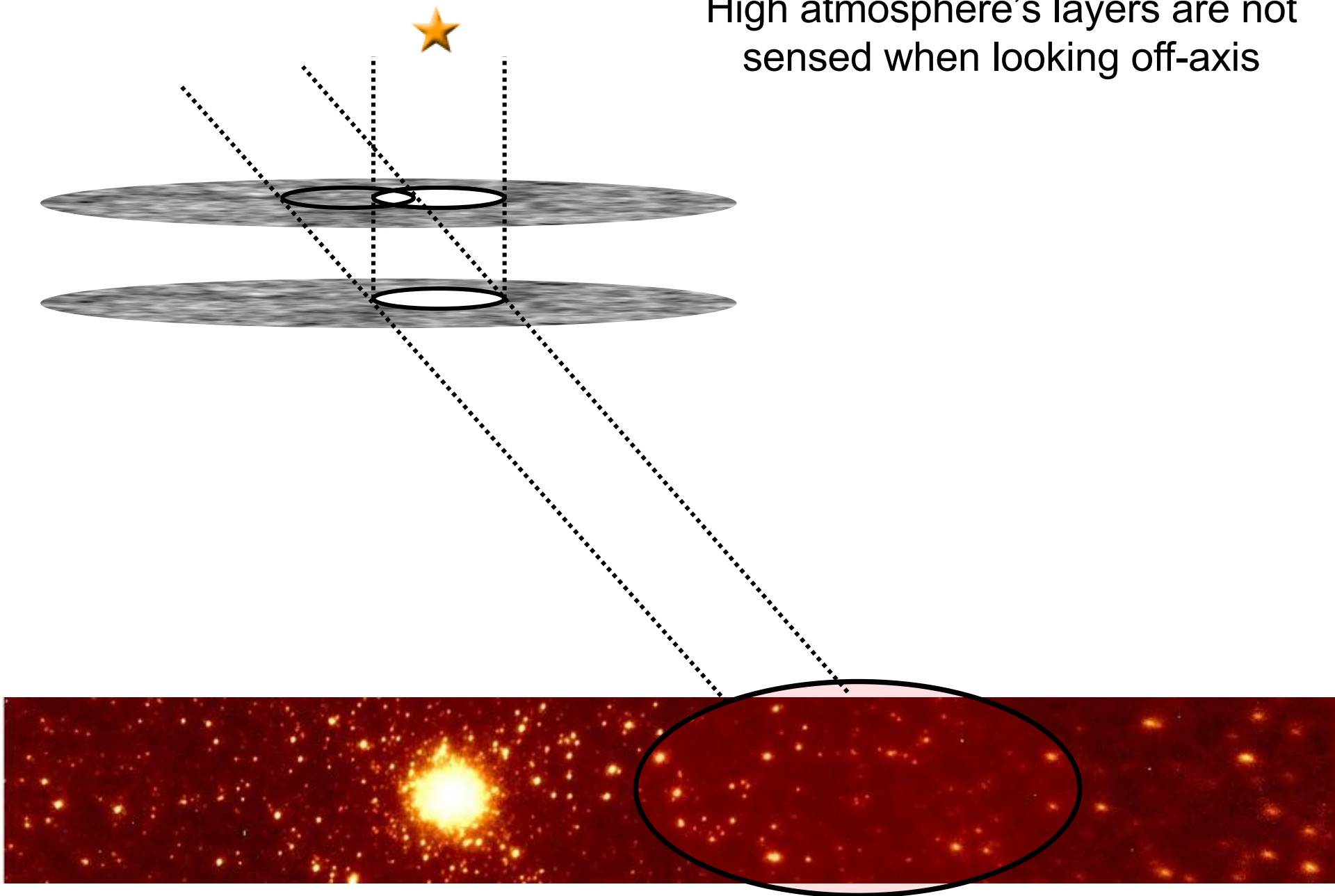

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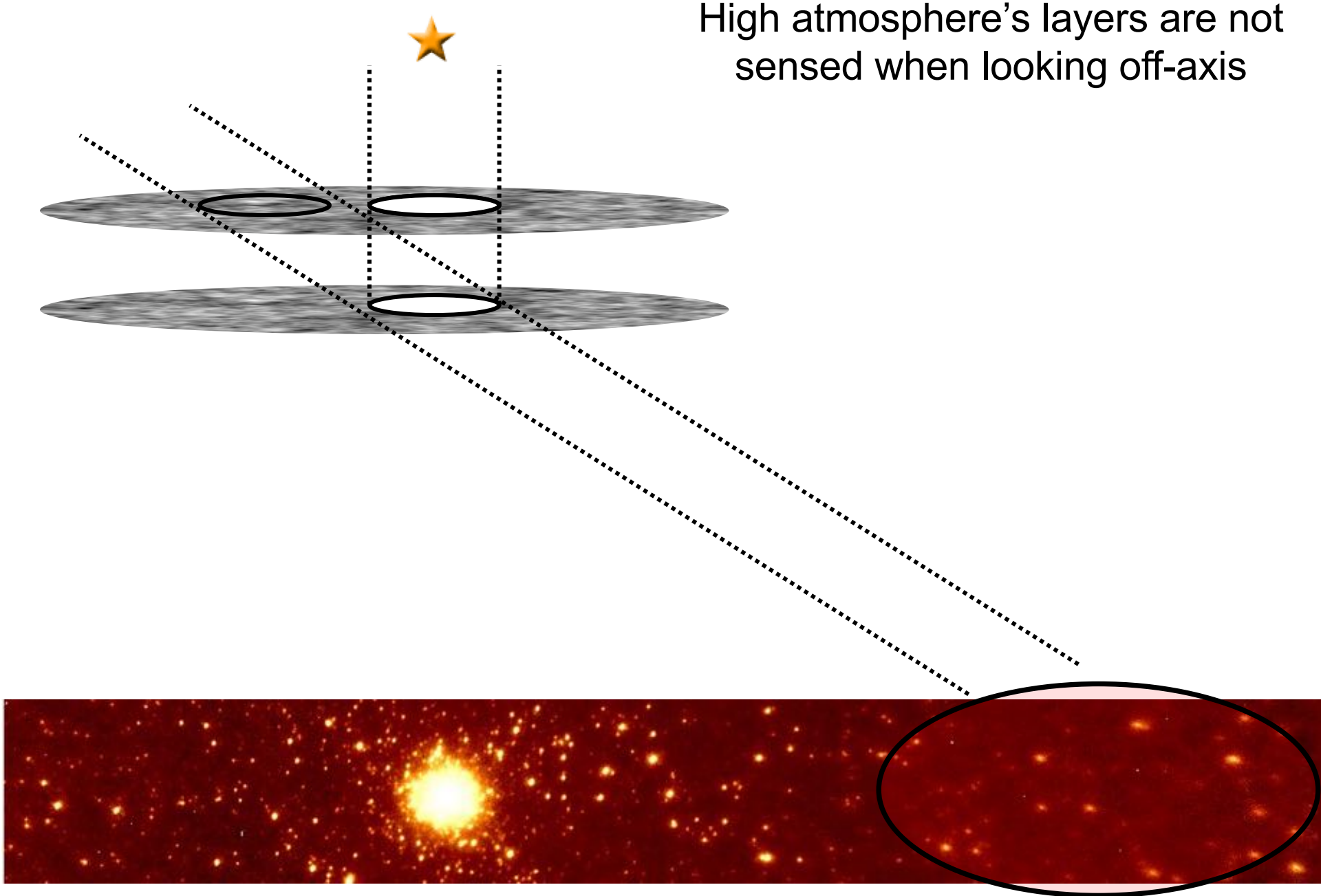
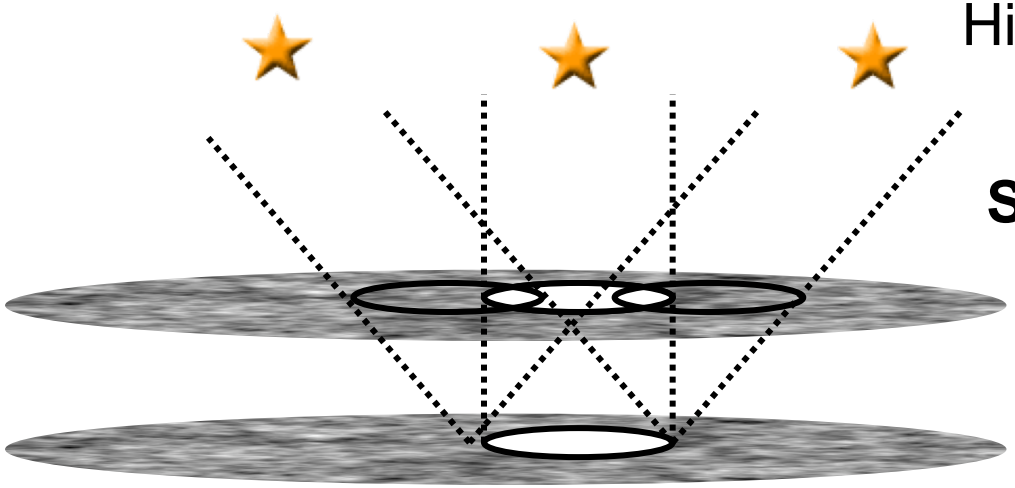
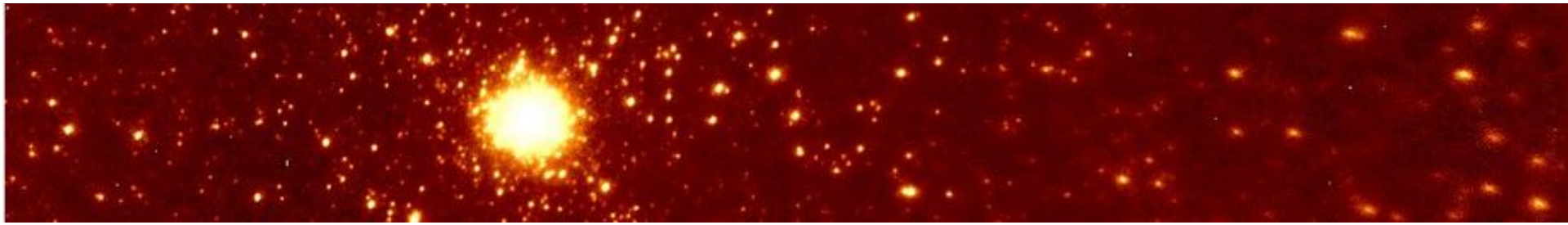


Tomography

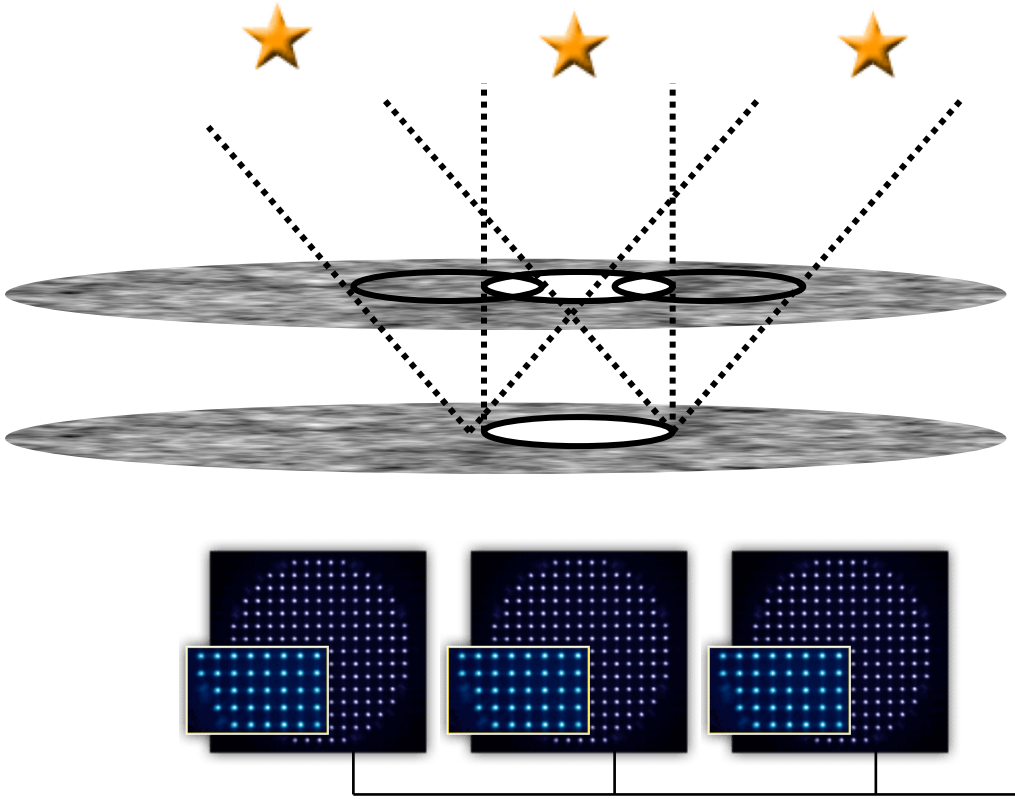


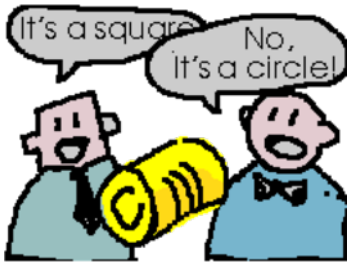
High atmosphere's layers are not sensed when looking off-axis

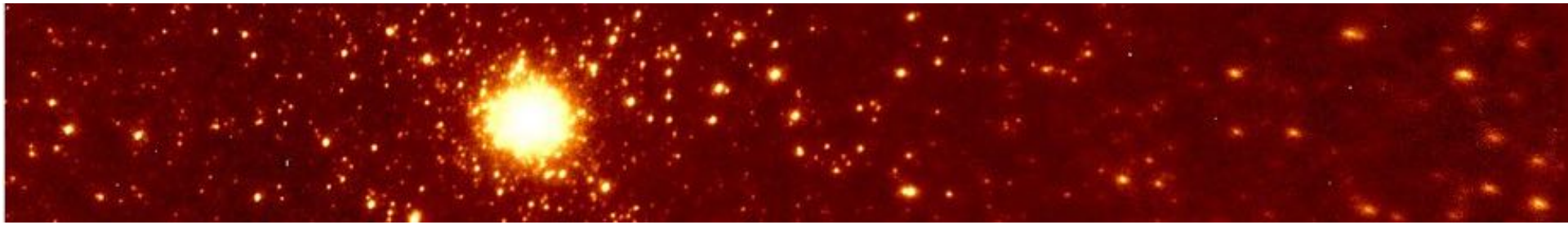
Solution => Combine off-axis measurements

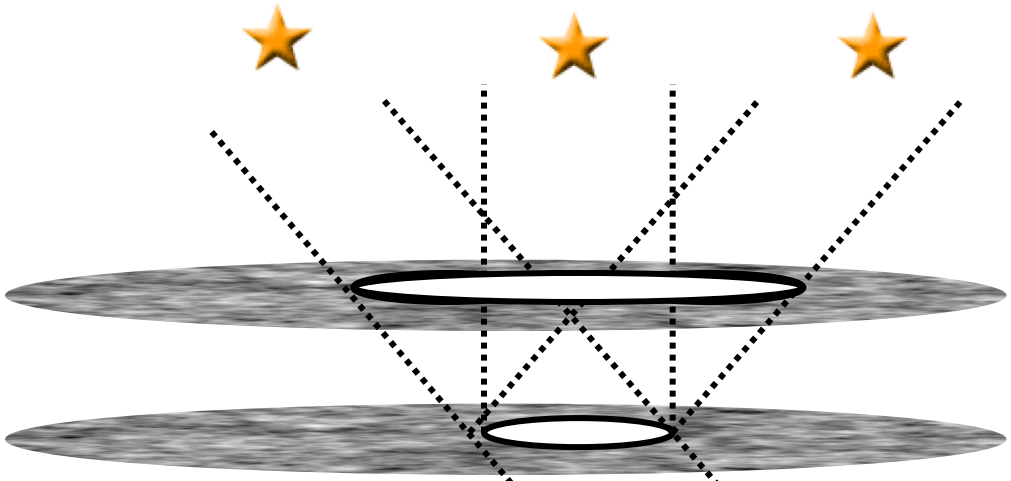


Tomography



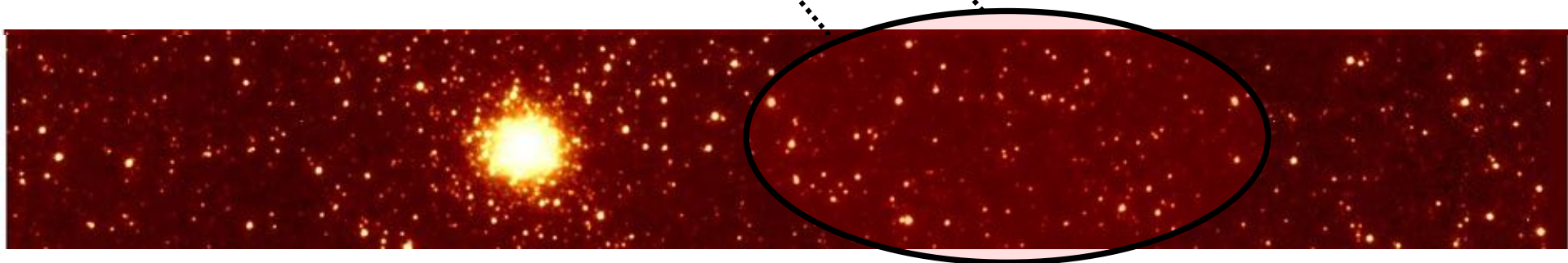






=> Combine off-axis measurements

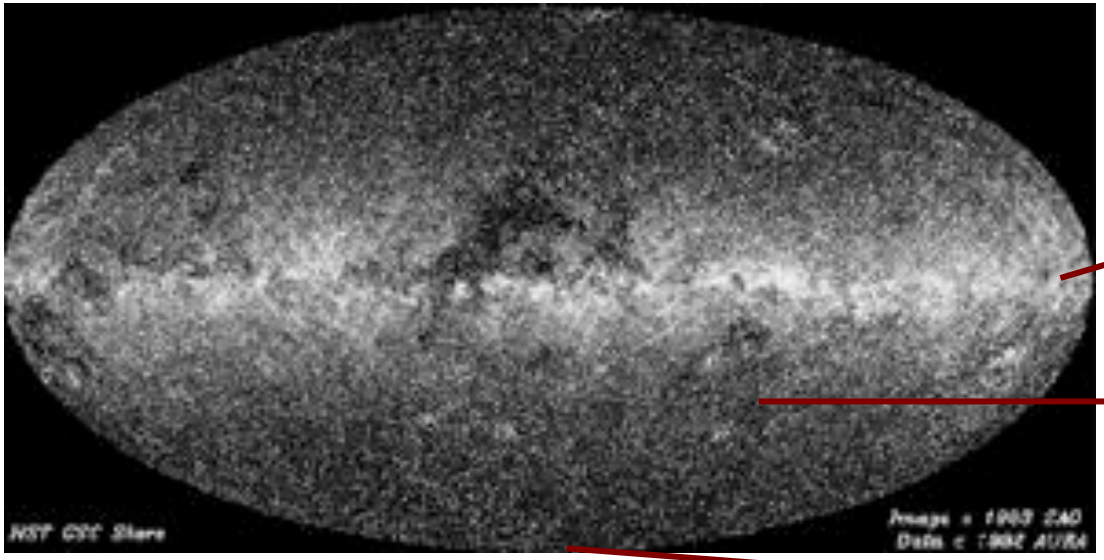
Good correction in a larger FoV !

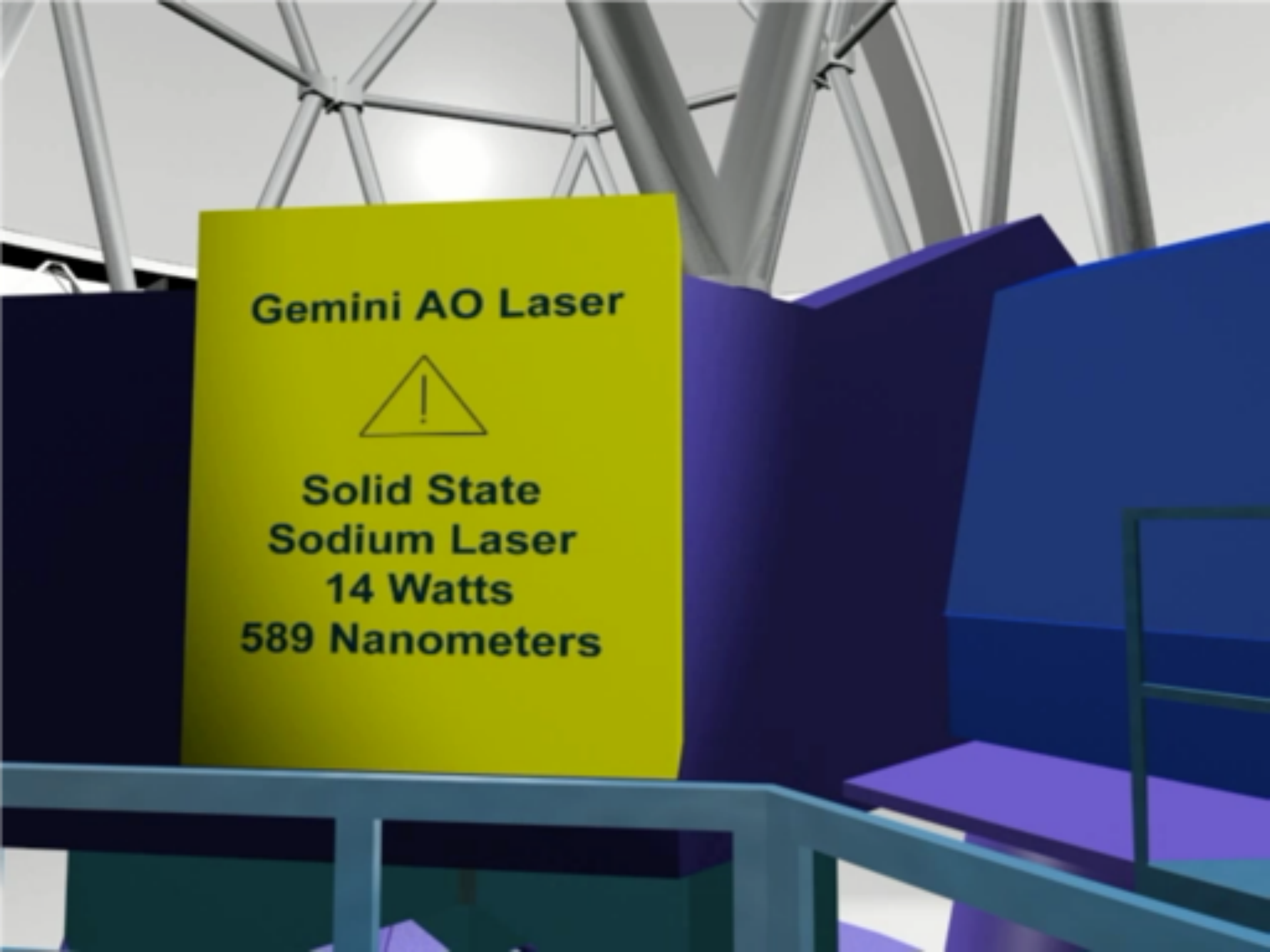


Adaptive Optics works **close** to a **bright** guide star

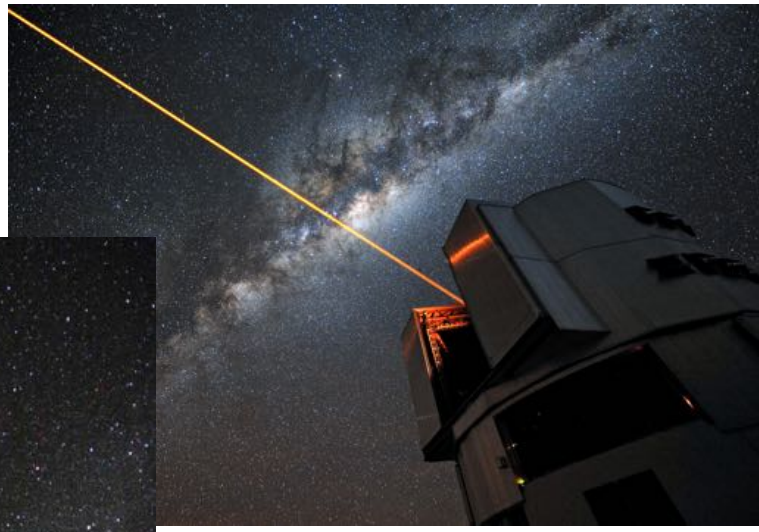
How many Guide Stars are available ?

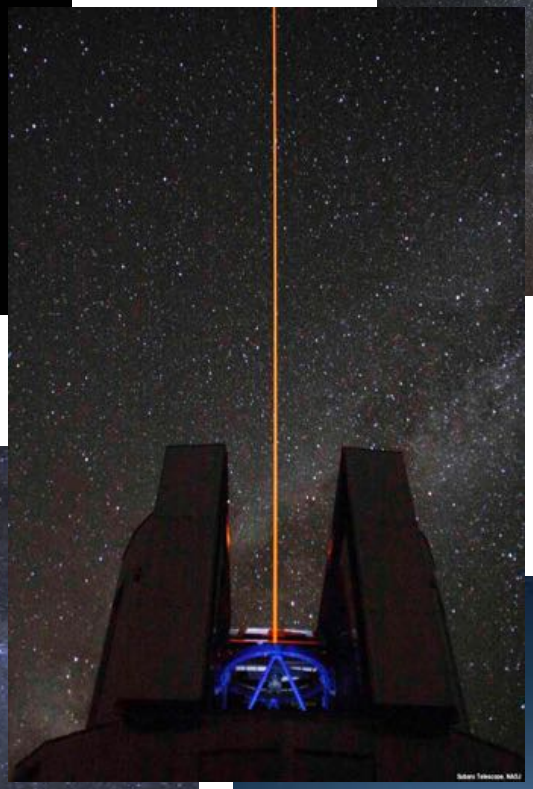
3 stars with R < 16 in a 2 arcmin FoV

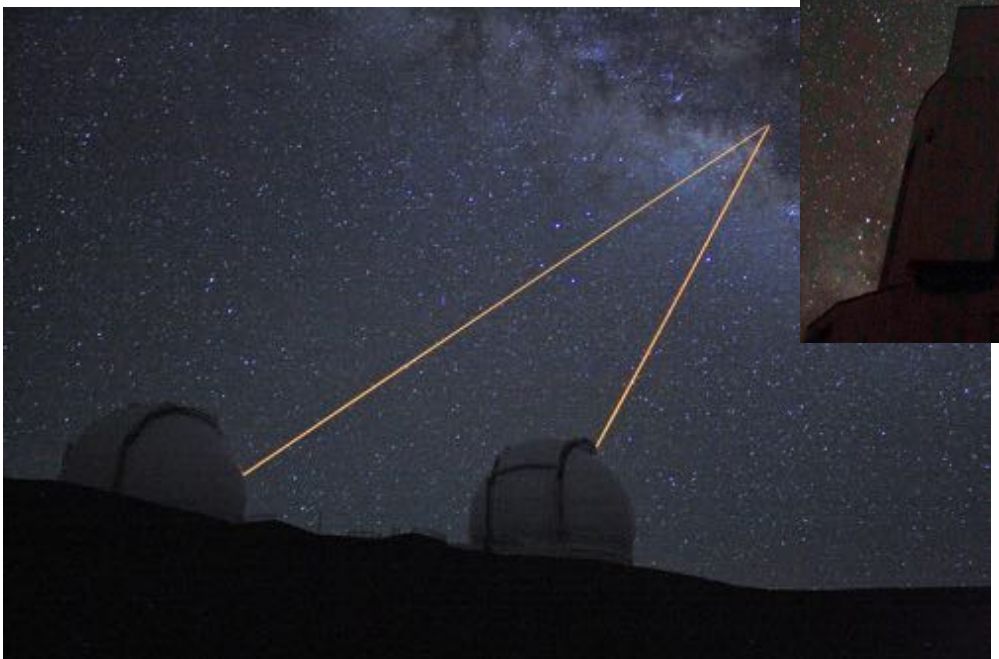



Gemini AO Laser
Solid State
Sodium Laser
14 Watts
589 Nanometers

Laser Guide Star







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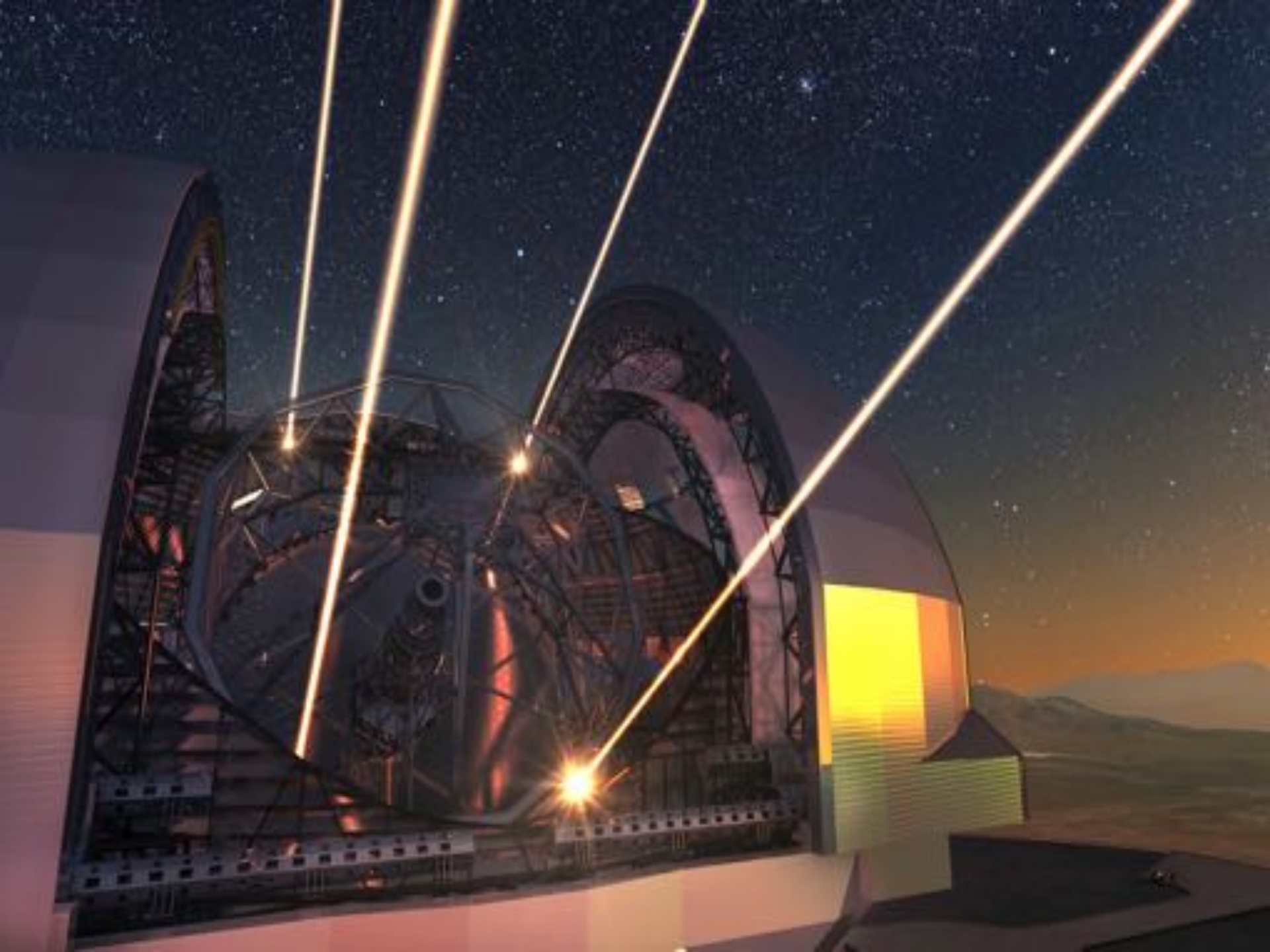


Summary

1. General introduction

2. The Extremely Large Telescope

The telescope

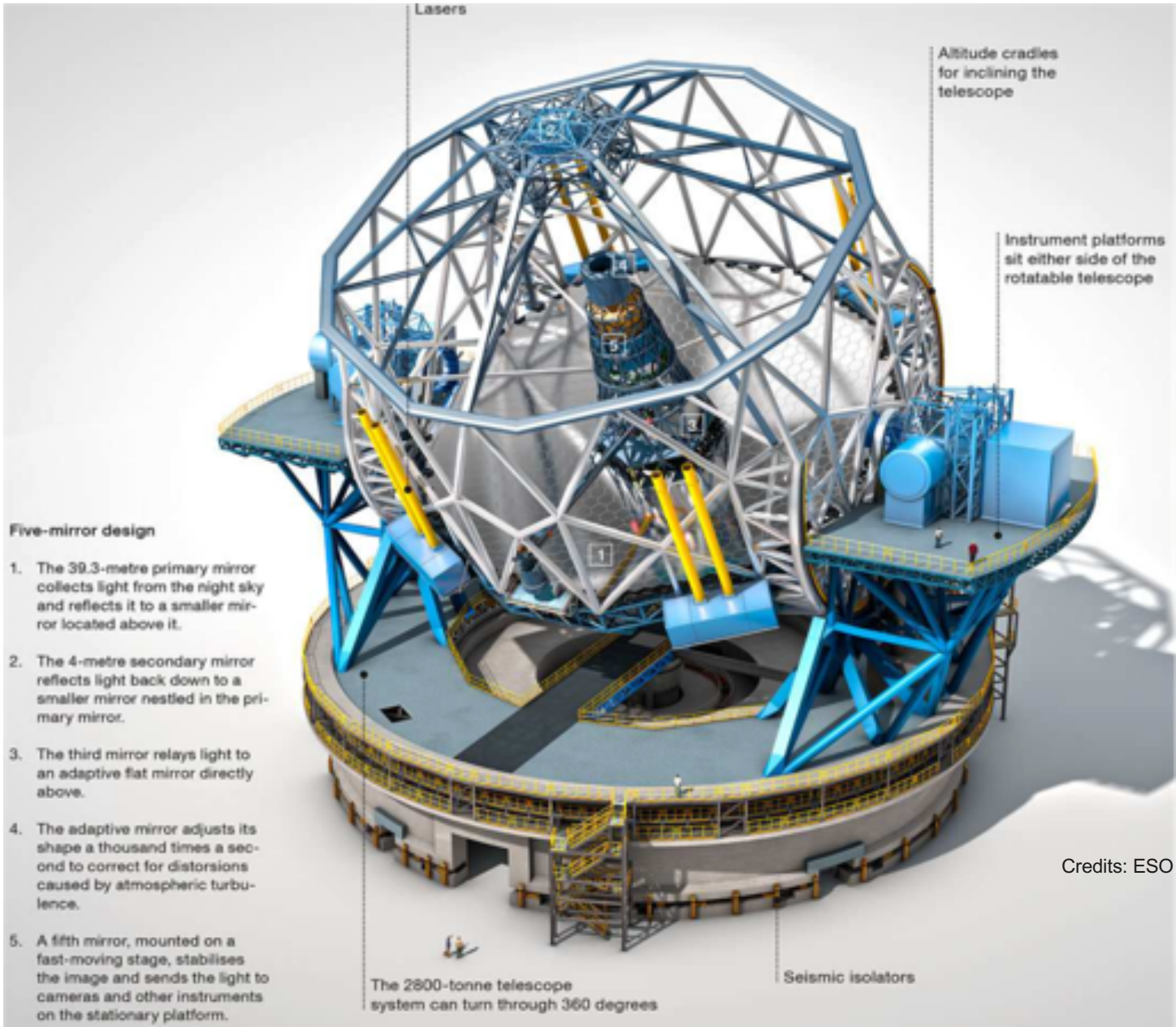
M1 = 39 m (798 hexagonal 1.4 m mirror segments)

M2 = 4m

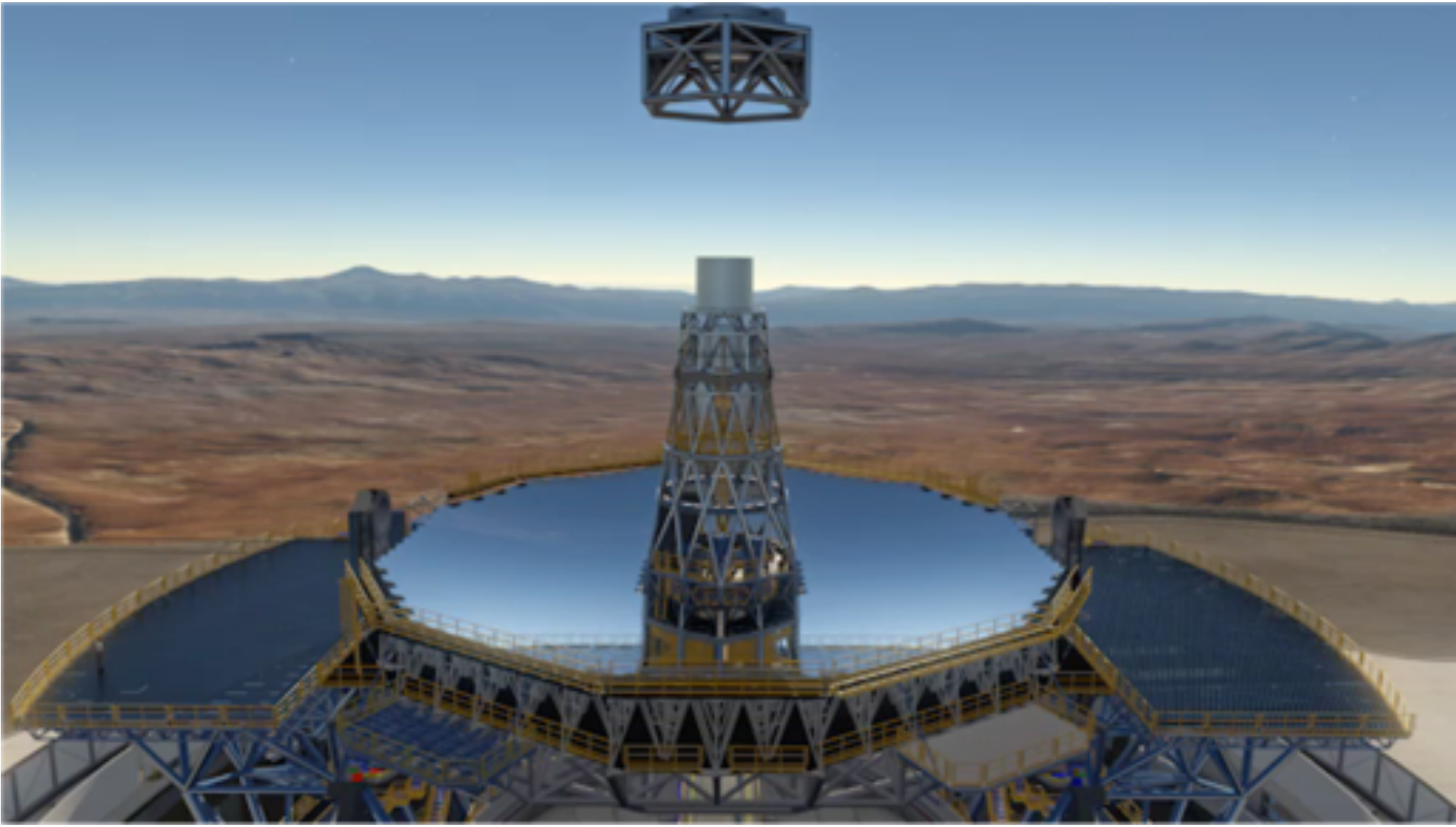
M3 = 3.75m

M4 = 2.40m (deformable mirror) – 5806 actuators

M5 = 2.6m (TT mirror)



The telescope



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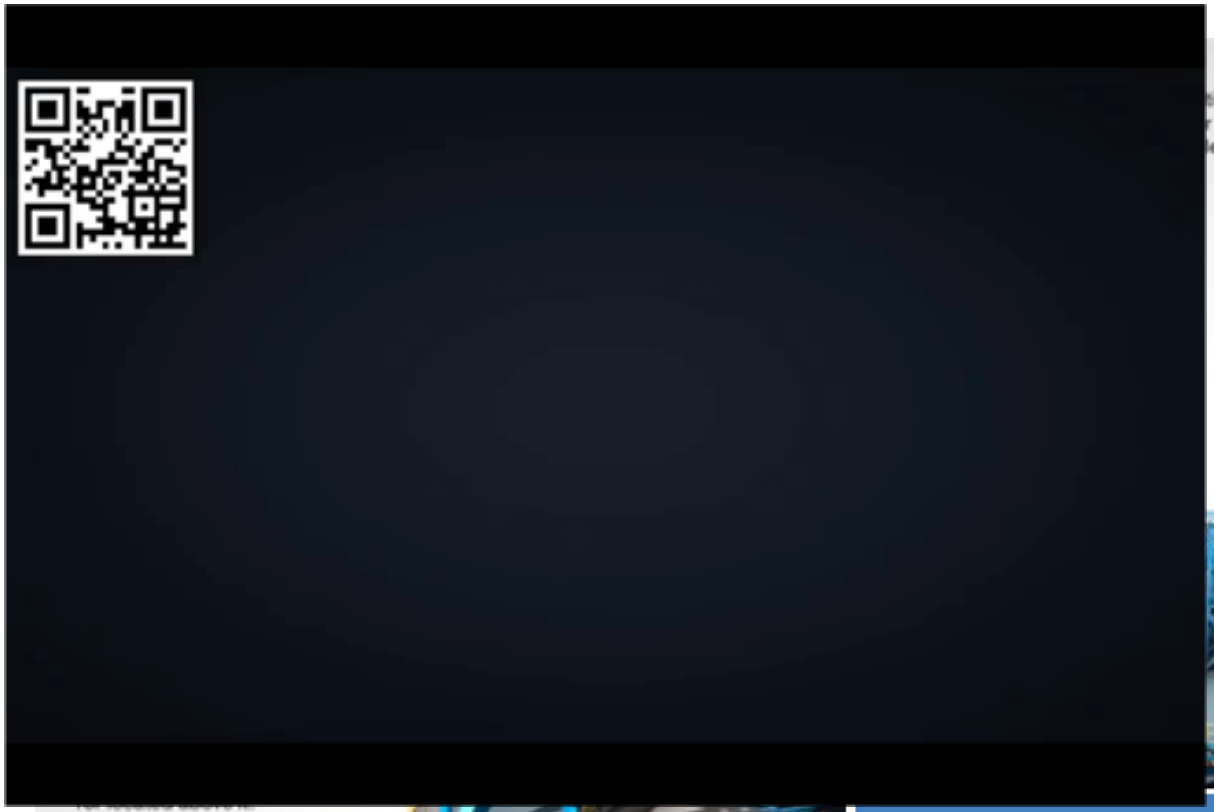
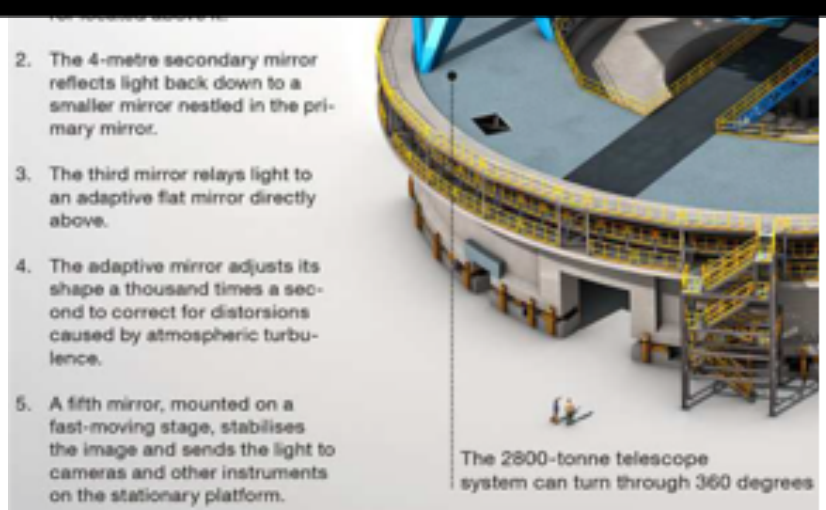
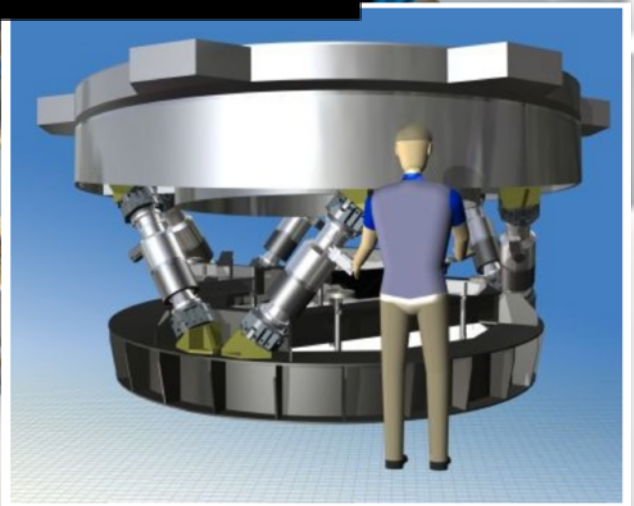
M5 = 2.6m (TT mirror)

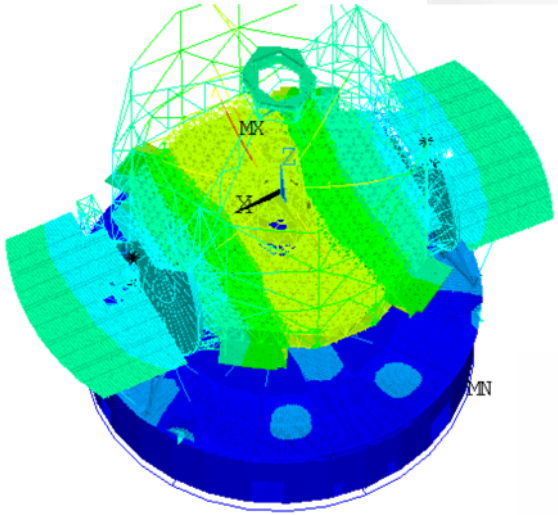


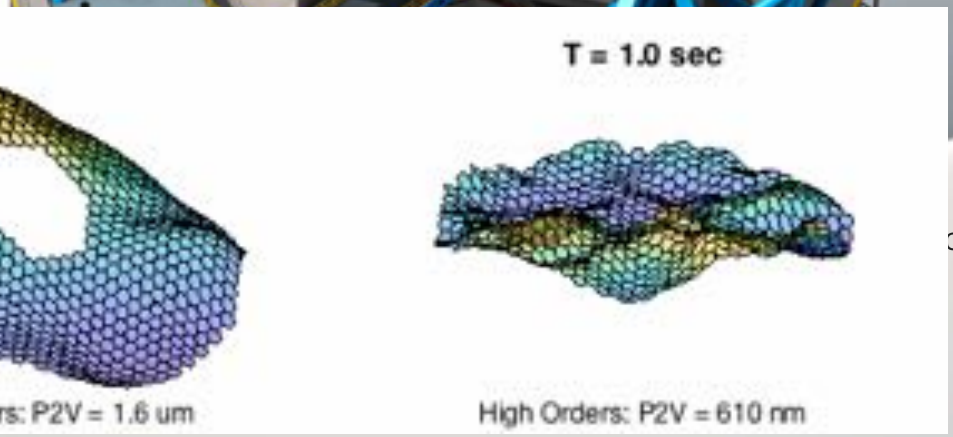




The telescope

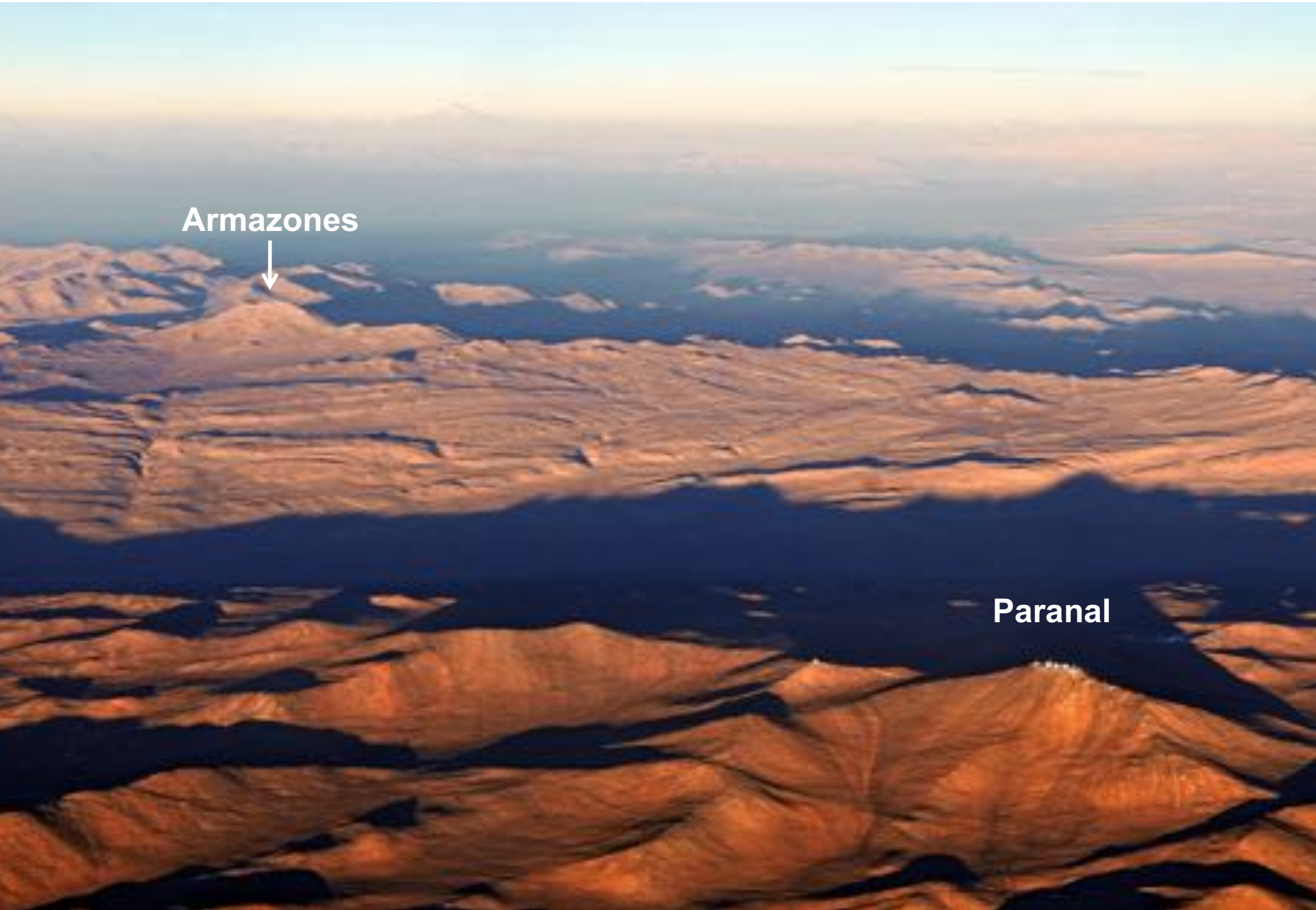
M1 = 39 m
(798 hexagonal 1.4 m mirror segments)



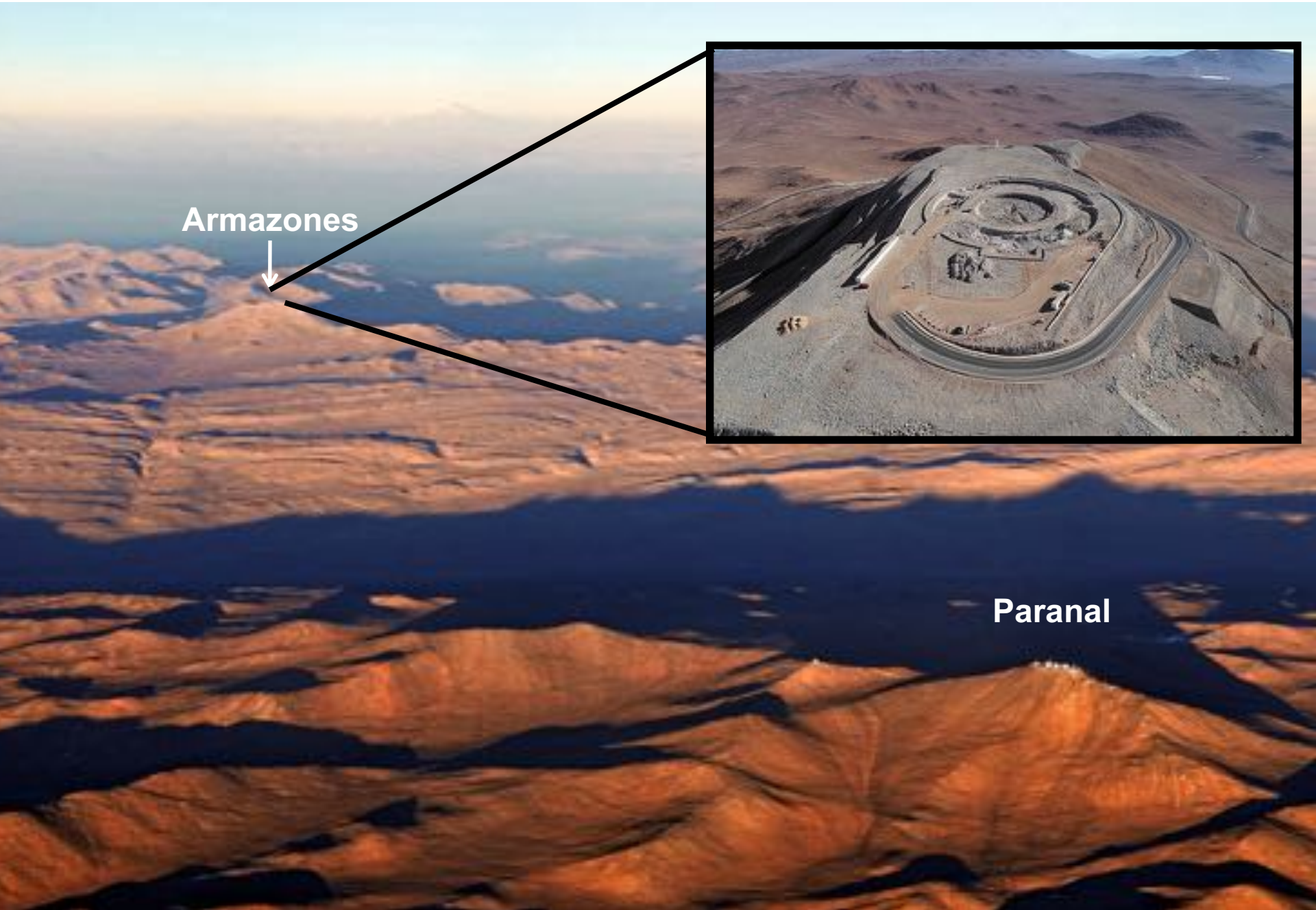


Credits: ESO

The telescope



The telescope

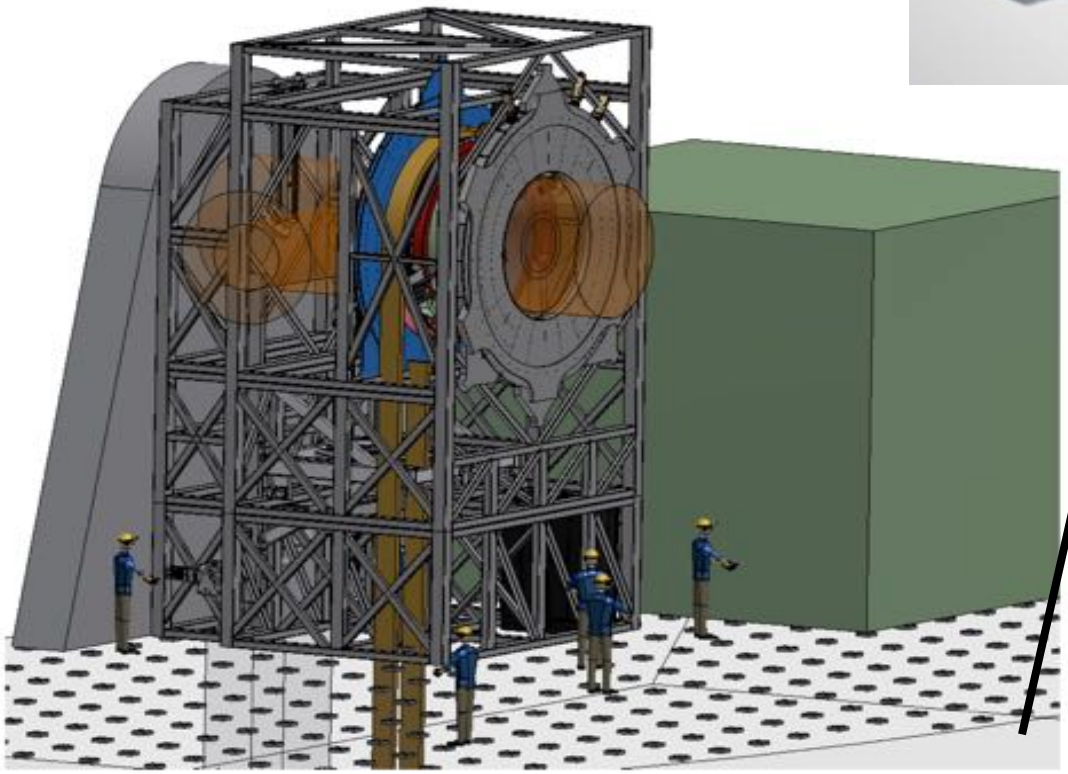


The telescope

2018

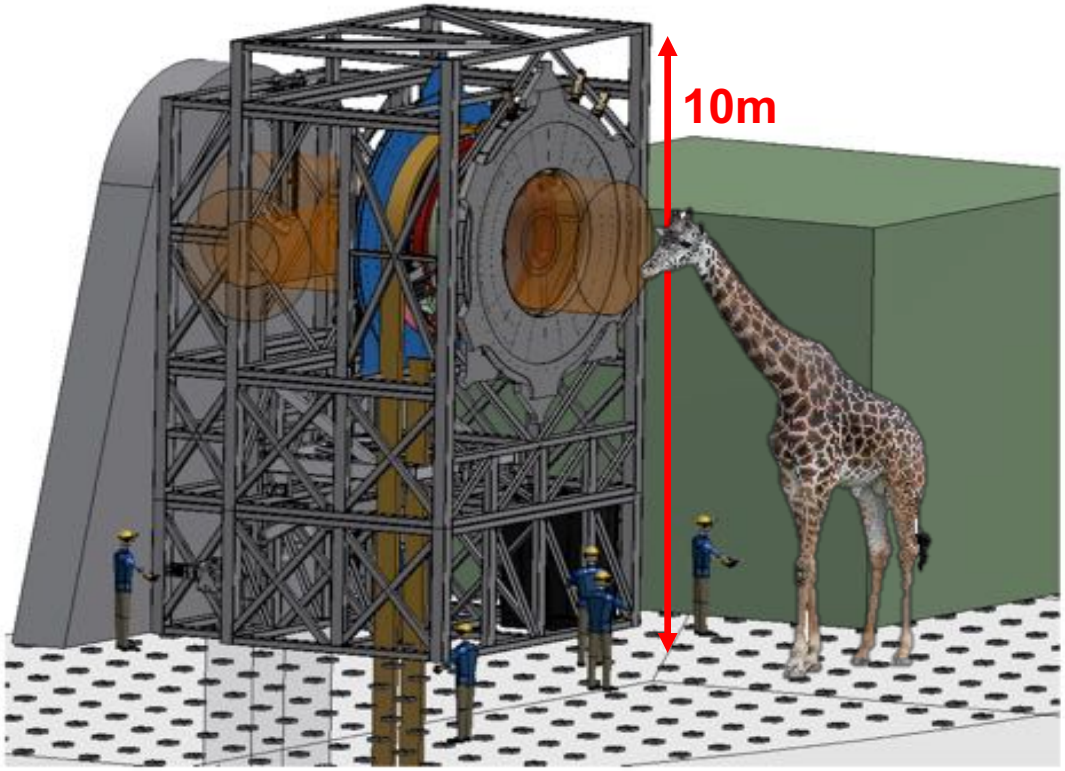
2025

The telescope

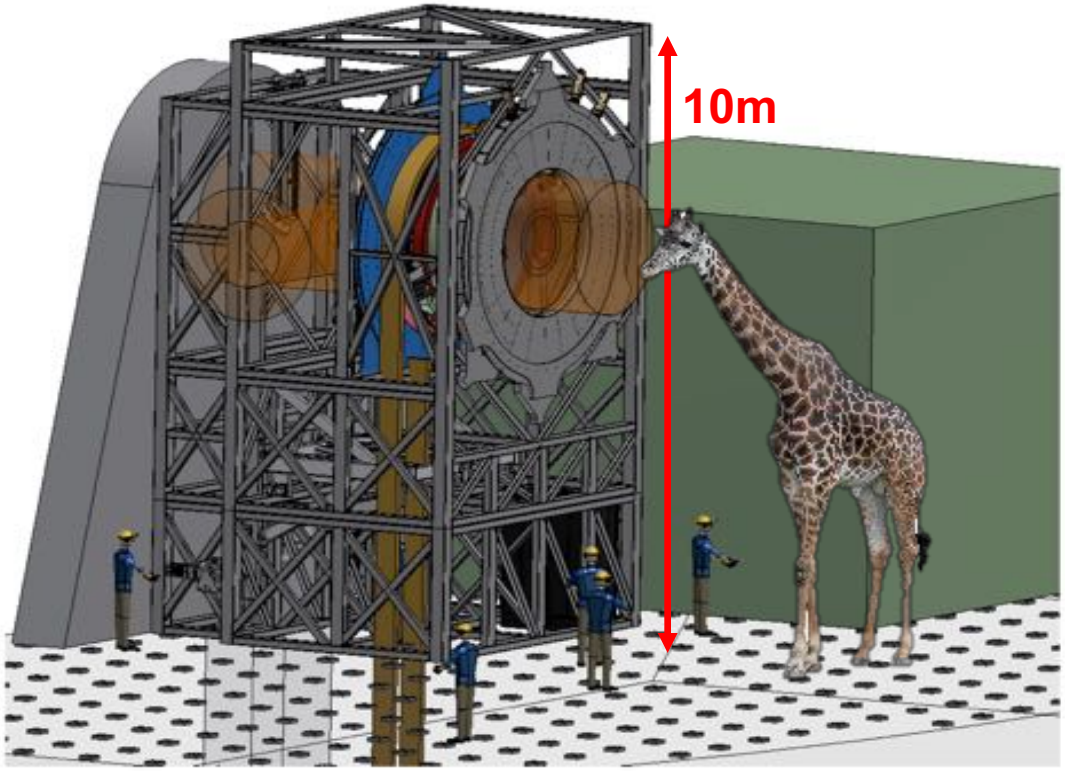


2025

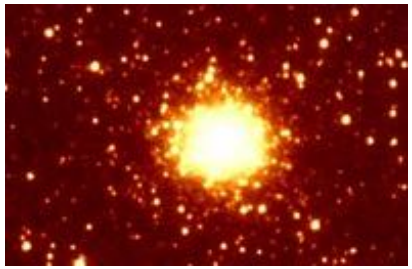
The telescope



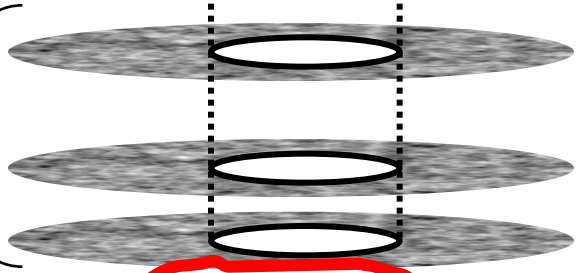
The telescope



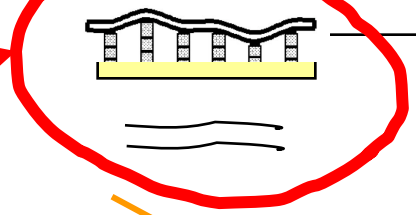
Adaptive Optics

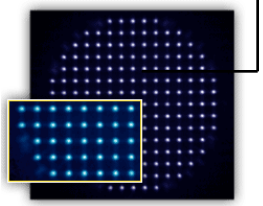


Earth's atmosphere

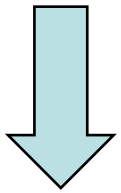


Telescope

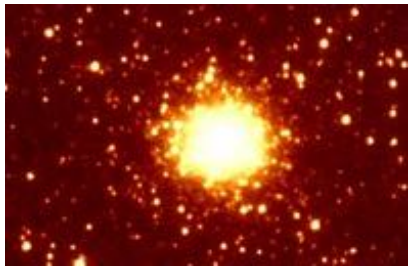




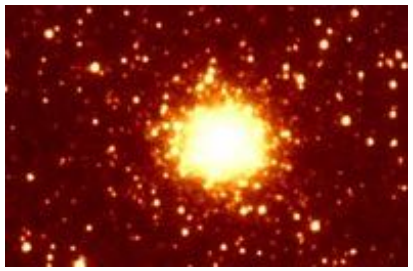
Wave-Front Sensor



Spatial resolution is restored

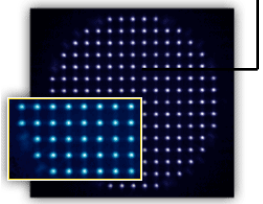


Adaptive Optics



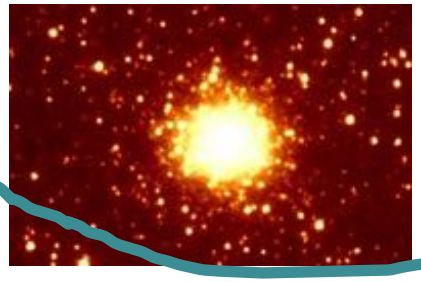
Earth's atmosphere

Telescope



Wave-Front Sensor

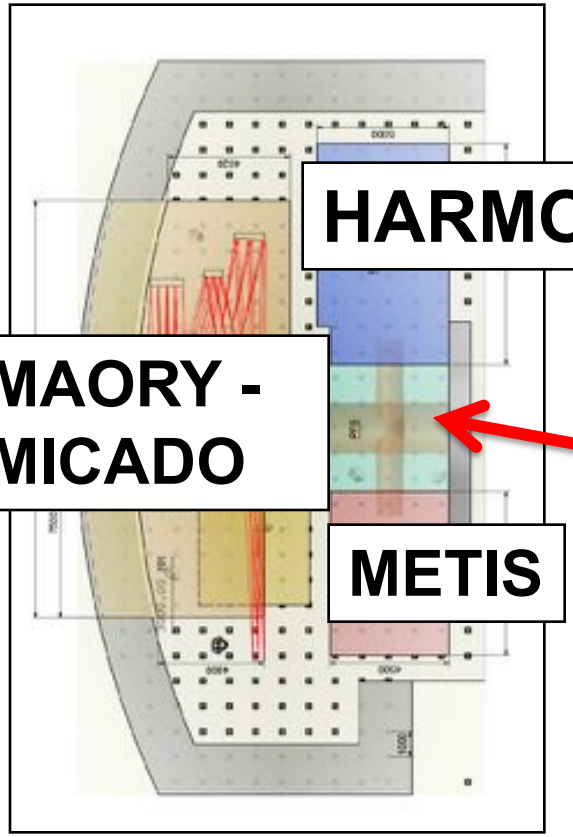
Instrument



Spatial resolution is restored

The ELT instruments

First light ELT instrument



HARMONI

MAORY - MICADO

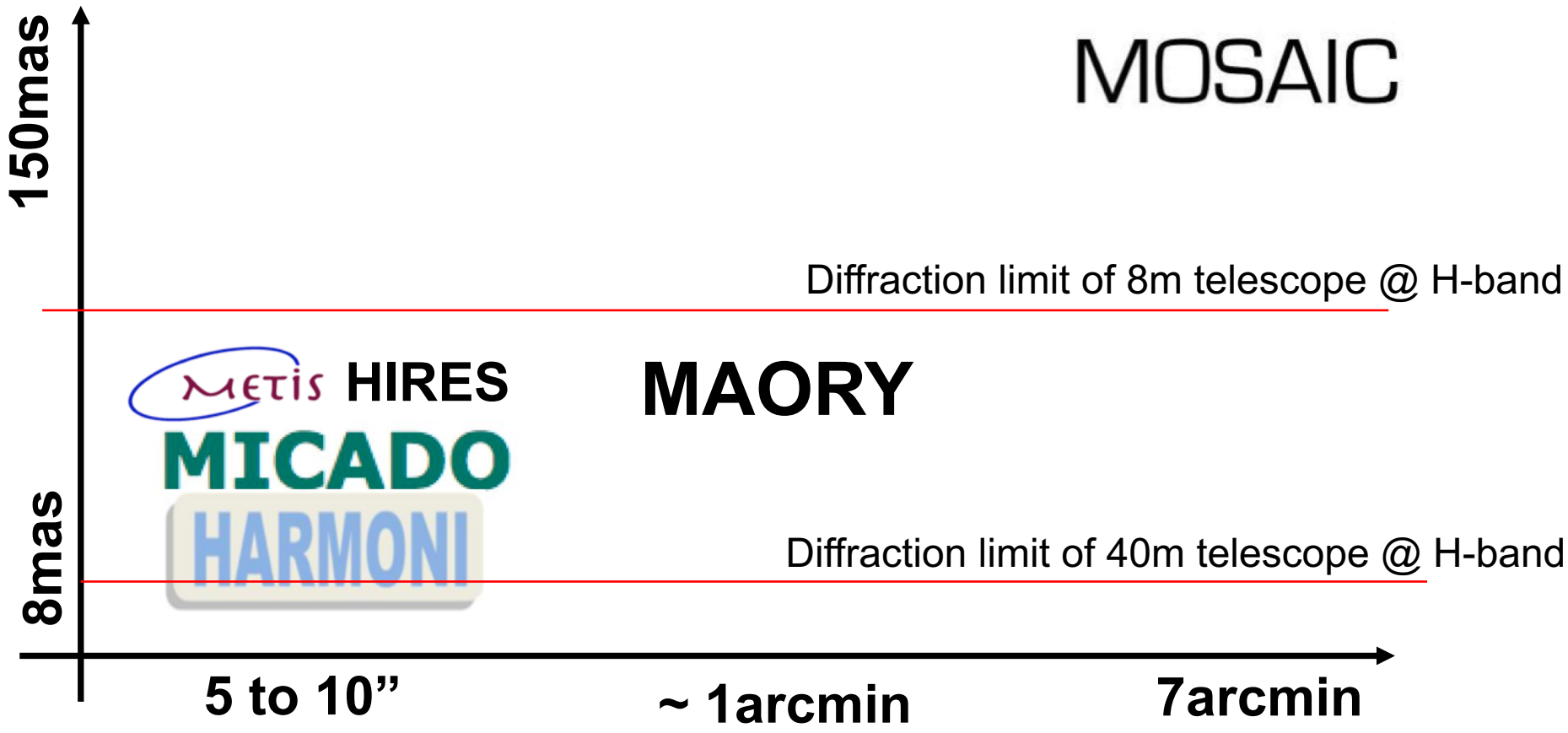
METIS

2nd generation

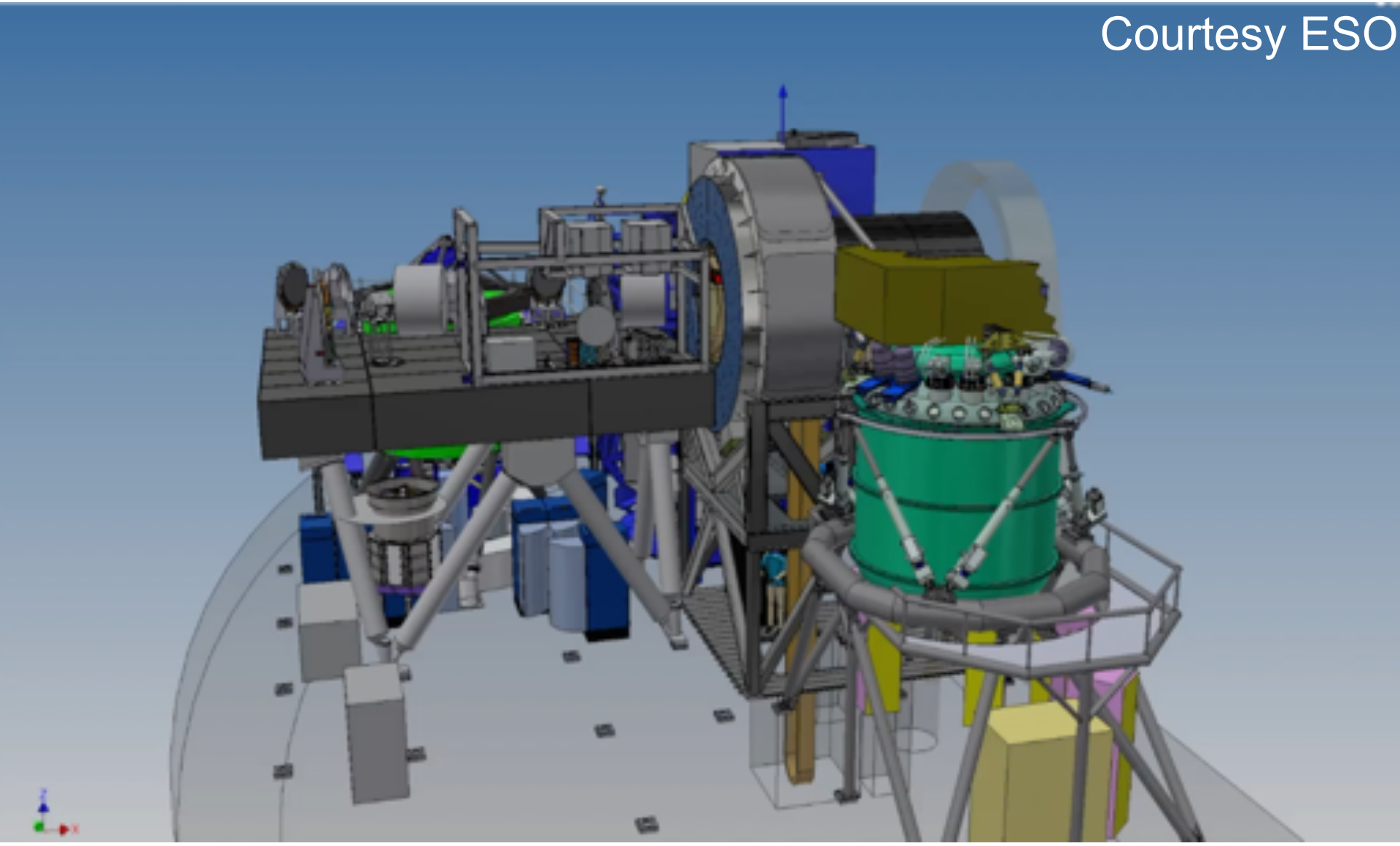
MOSAIC

HIRES

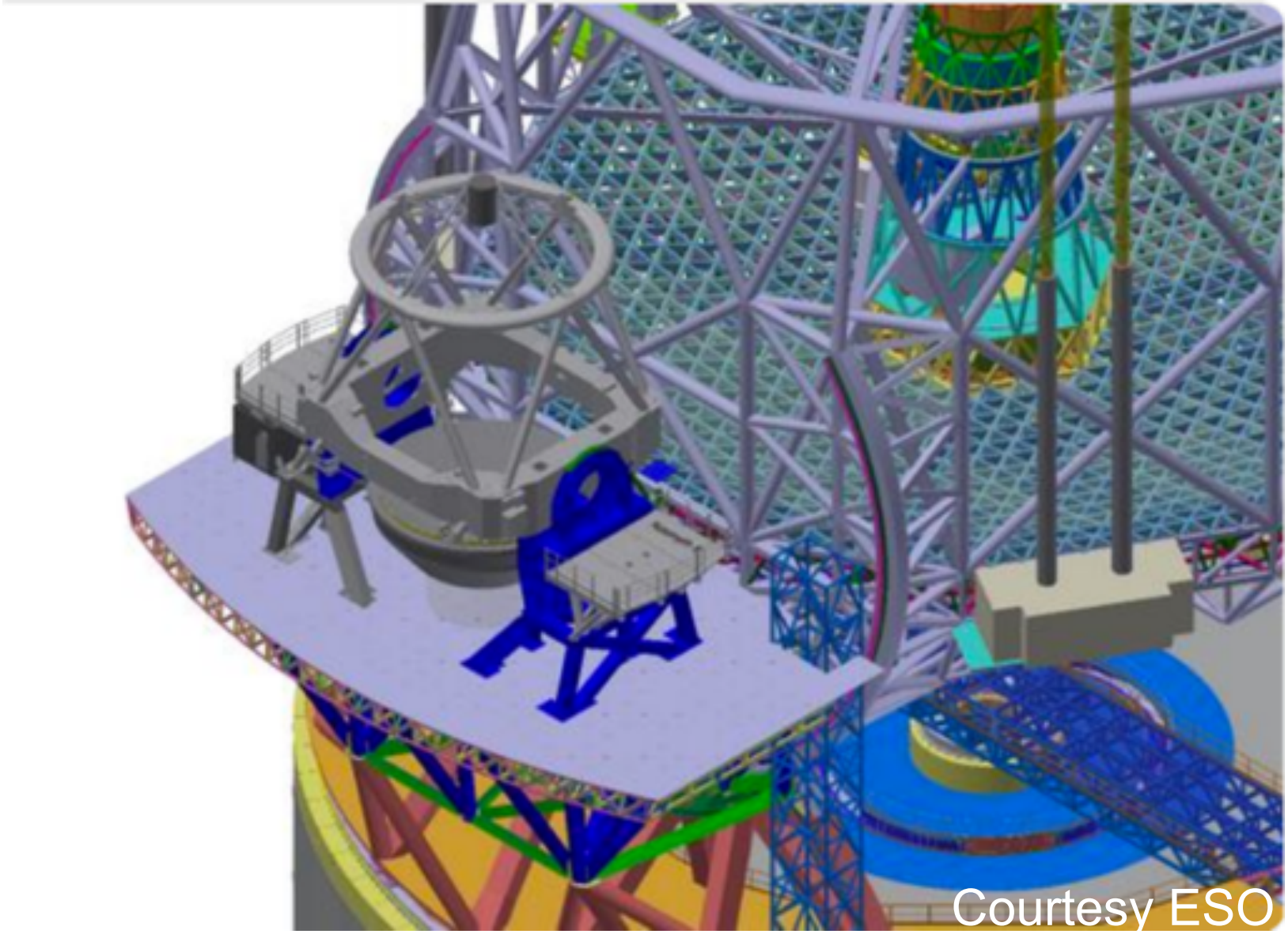
The ELT instruments



The ELT instruments



The ELT instruments



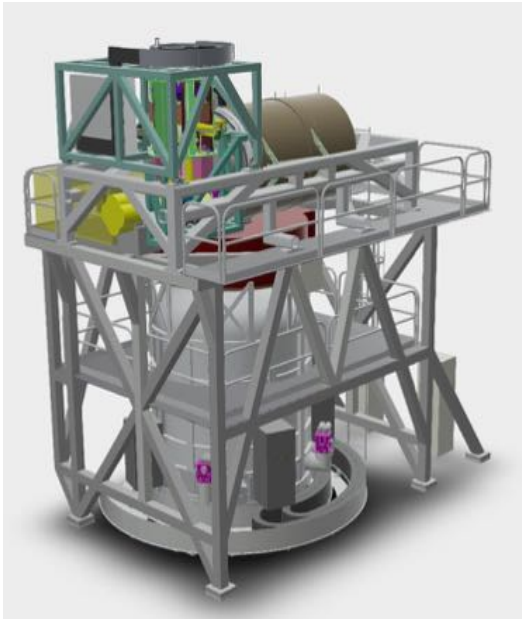
Summary

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		IFU, Software & Control Com.
LAM, Marseille (Deputy PI)	ONERA, Paris IPAG, Grenoble	SCAO, LTAO, AIT, High Contrast
Michigan University		

HARMONI Overview

The HARMONI team: Niranjan Thatte, Benoit Neichel, Ian Bryson, Thierry Fusco, Fraser Clarke, Hermine Schnetler, Mathias Tecza, Kjetil Dohlen, Dave Melotte, Tim Morris, Eddy Younger, Sofia Dimoudi, Anne Bonnefois, Anne Costille, Jean-Francois Sauvage, Kacem El-Hadi, Pascal Vola, William Ceria, Amandine Caillat, Carlos, Correia, Cyril Petit, Edgard Renault, Francois Henault,

Zoltan Hubert, Eric Stadler, Jean-Luc Gach, Laurent Jocou, Nicolas Vedrenne, Patrick Rabou, Philippe Balard, Thibaut Moulin, Serge Meimon, William Bon, Yves Magnard, Angel Alonso-Sanchez, Santiago Arribas, Lisa Bardou, Andy Born, Miguel Cagigas, Alexis Carlotti, Elodie Choquet, Madeline Close, Marc Dubbledman, Chris Evans, Vanessa Ferraro-Wood, Angus Gallie, Jose Gigante, Oscar Gonsalez, Stephen Goodsell, Sylvain Guieu, David Henri, Elvio Hernandez, Aurelien Jarno, Alexandre Jeanneau, David Jenkins, Marie Larrieu, Florence Laurent, Magali Loupias, Evencio Mediavilla, David Montgomery, Arlette Pecontal, Miguel Pereira-Santaella, Laure Piqueras, Alban Remilleux, Myriam Rodrigues, Luis Rodriguez, Noah Schwartz, Patrick Smith, Matt Townson, …

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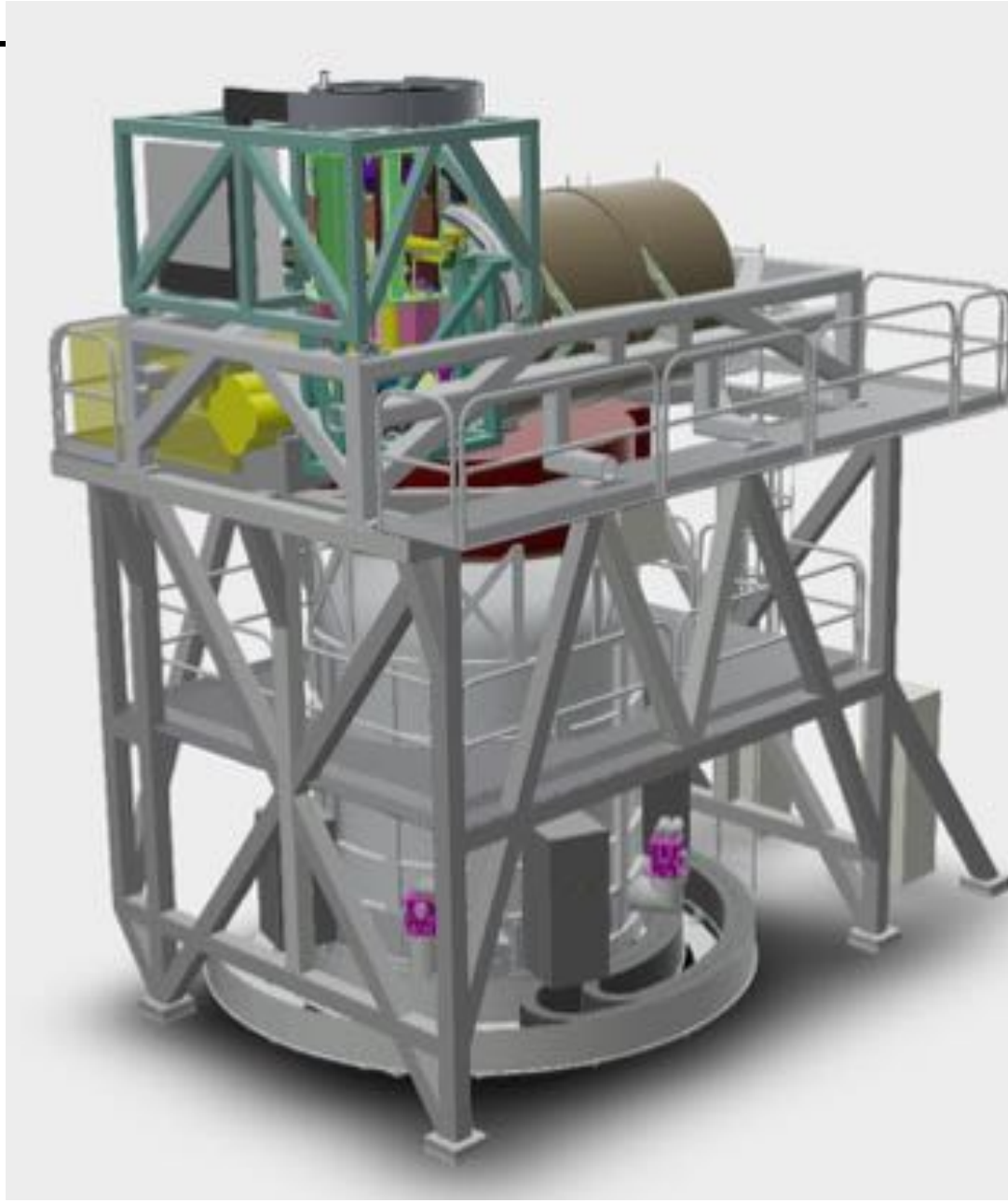
HARMONI Overview



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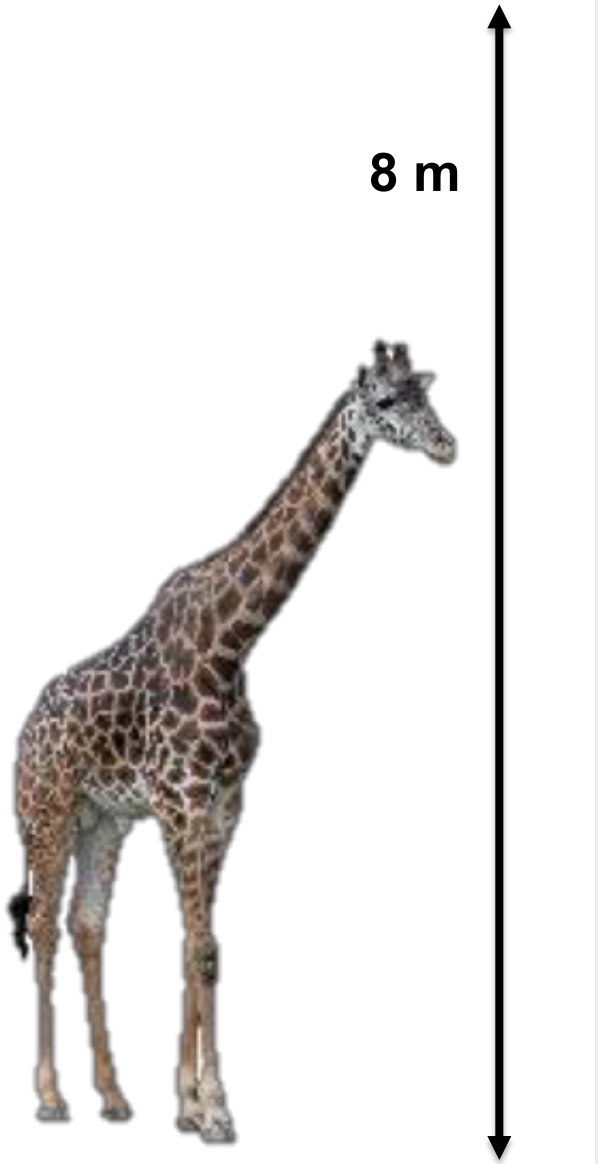
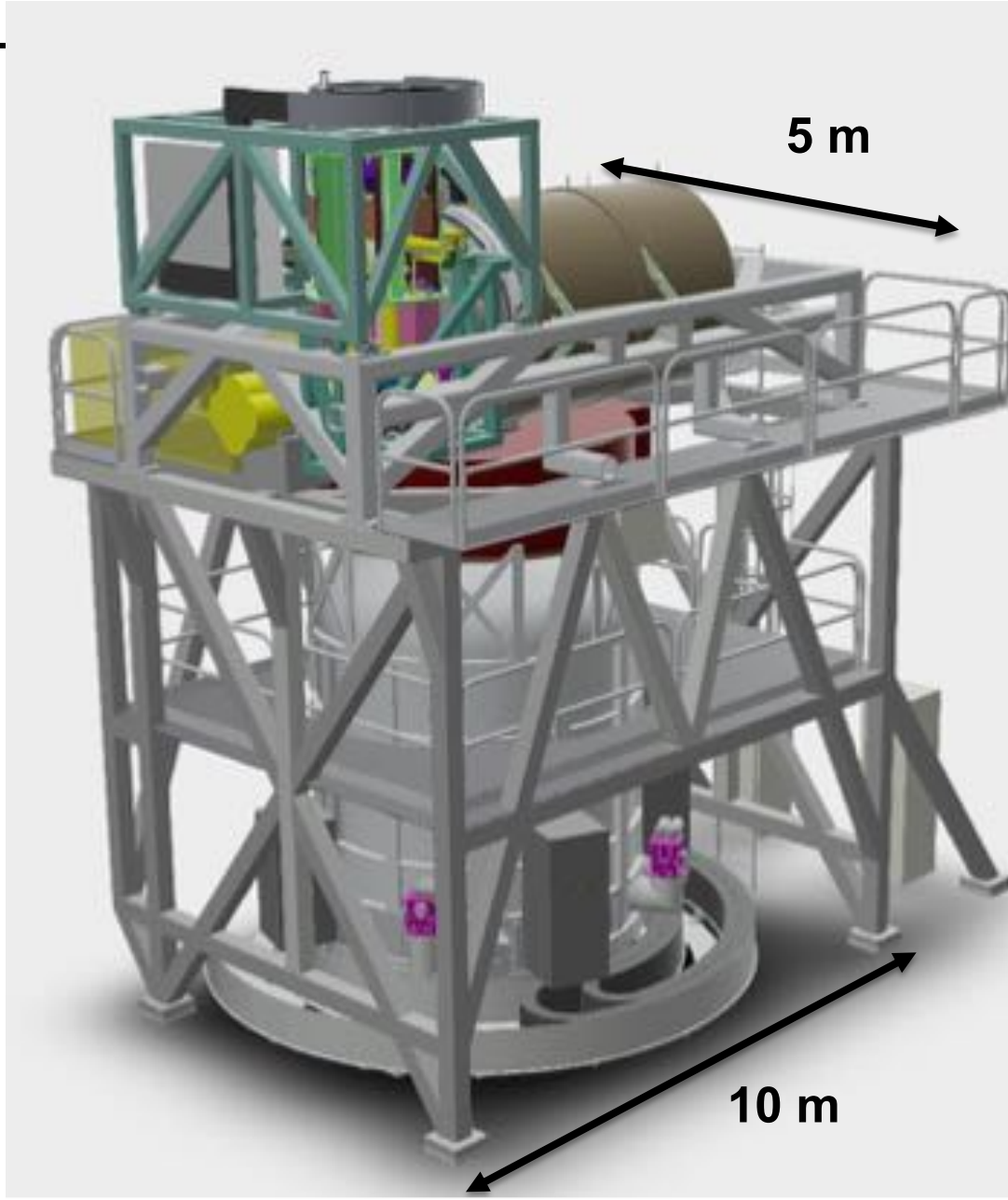
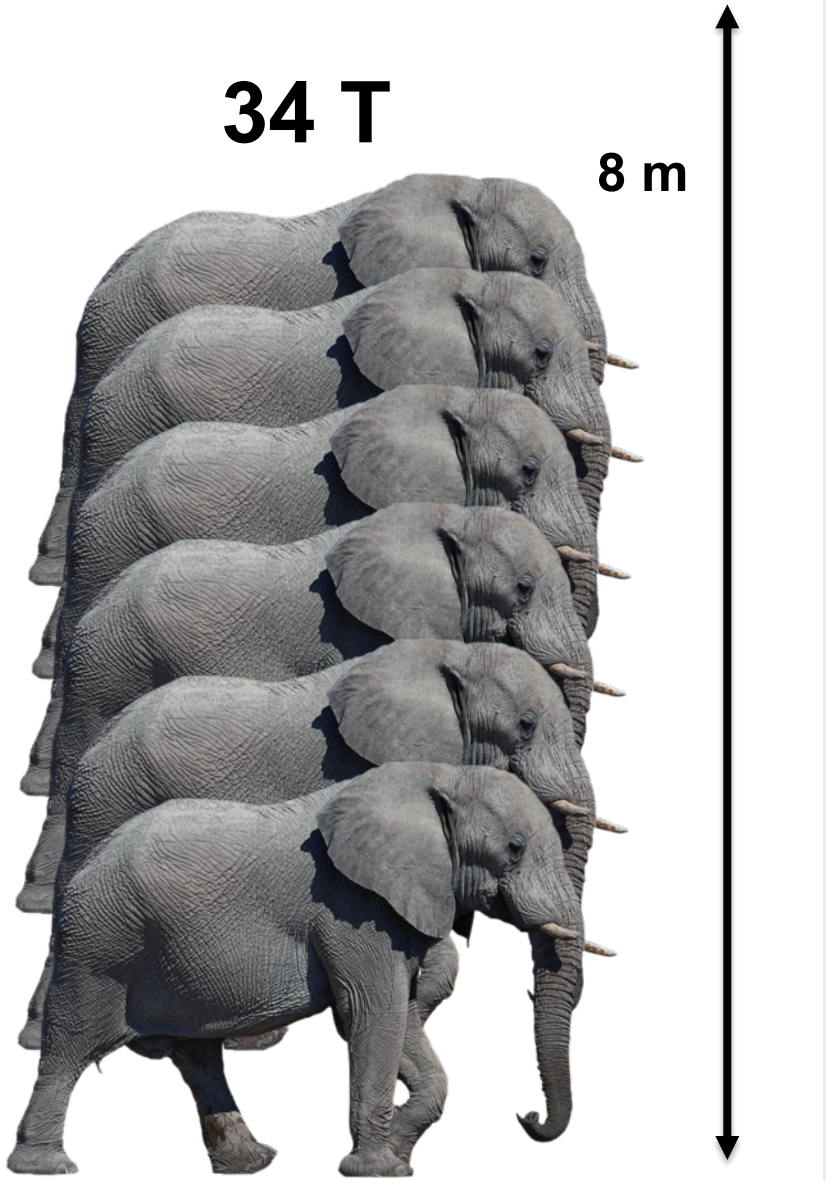
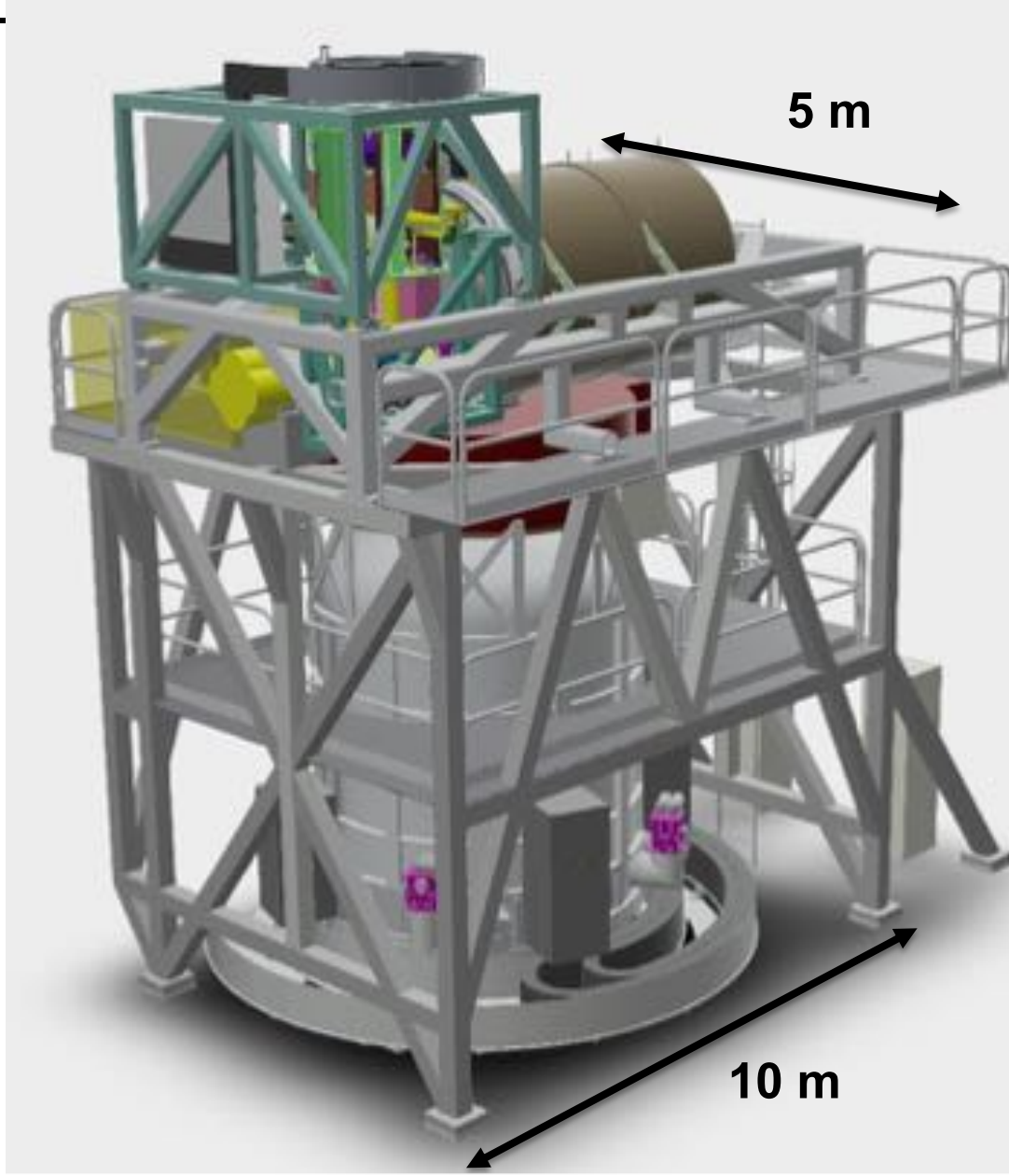
HARMONI Overview





HARMONI Overview





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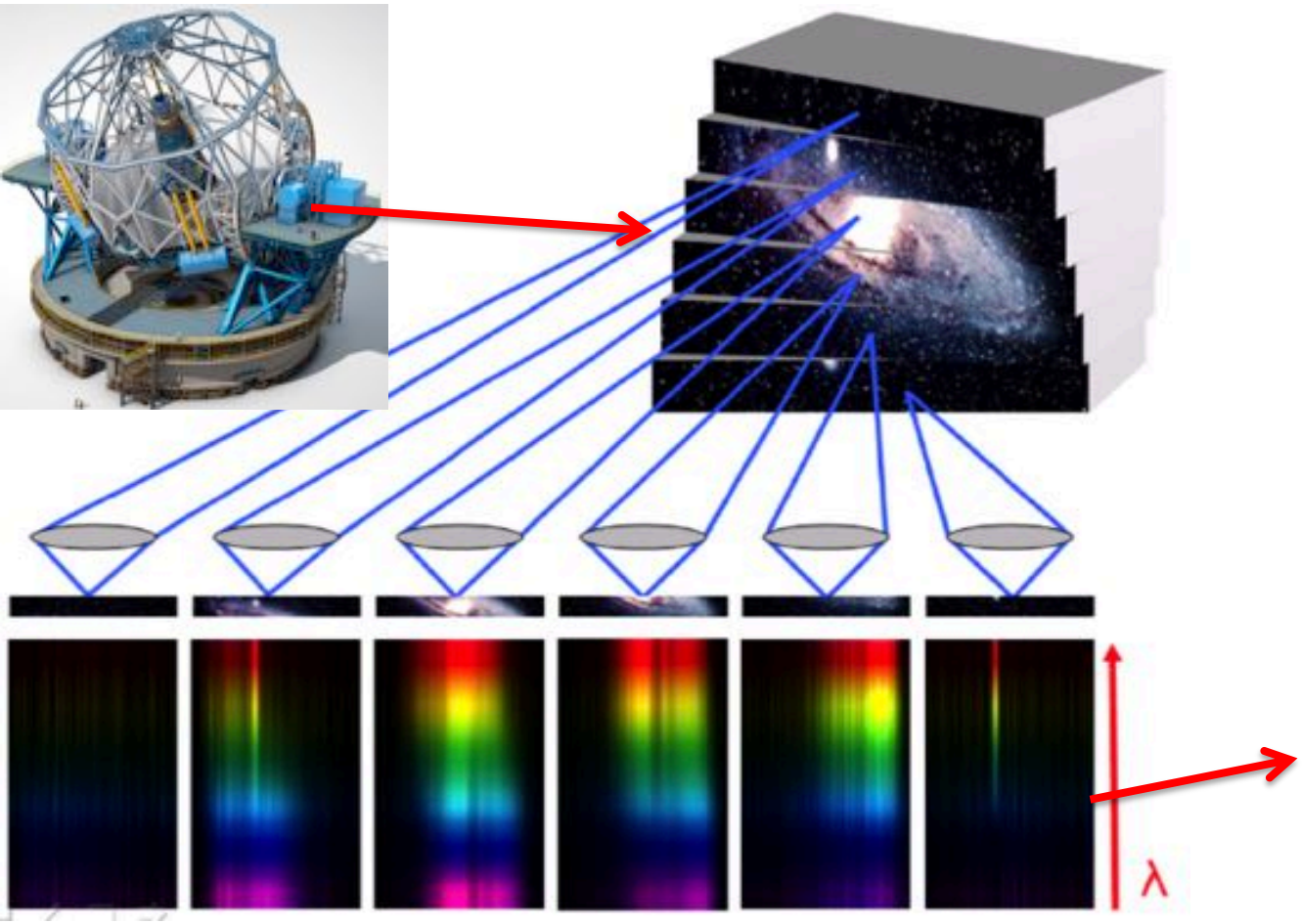
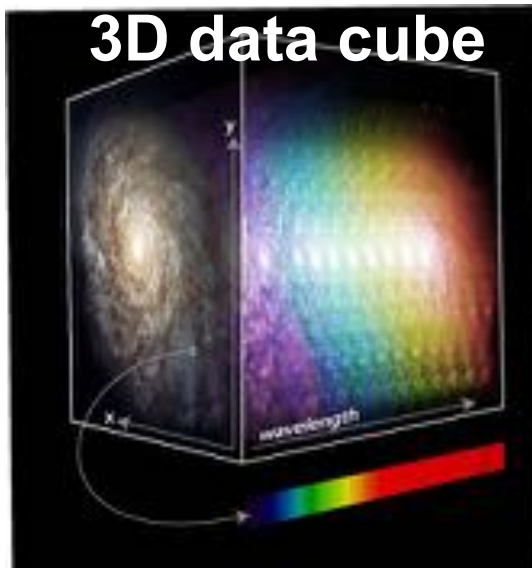
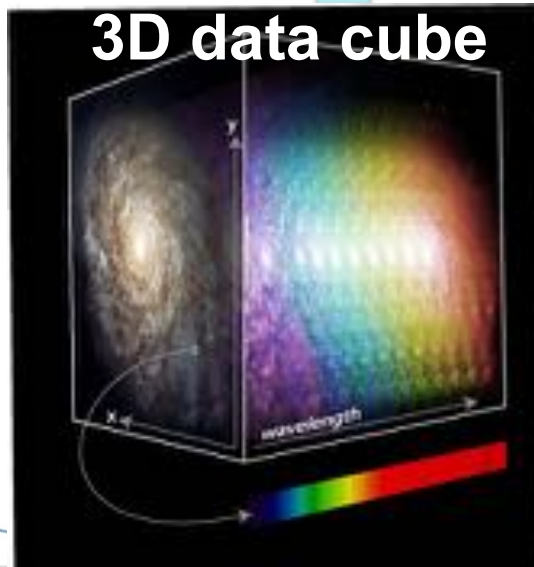
Integral Field Spectrograph – providing ~ 30 000 spectra per exposure.
visible and near-infrared spectroscopy (0.5–2.4 μm)



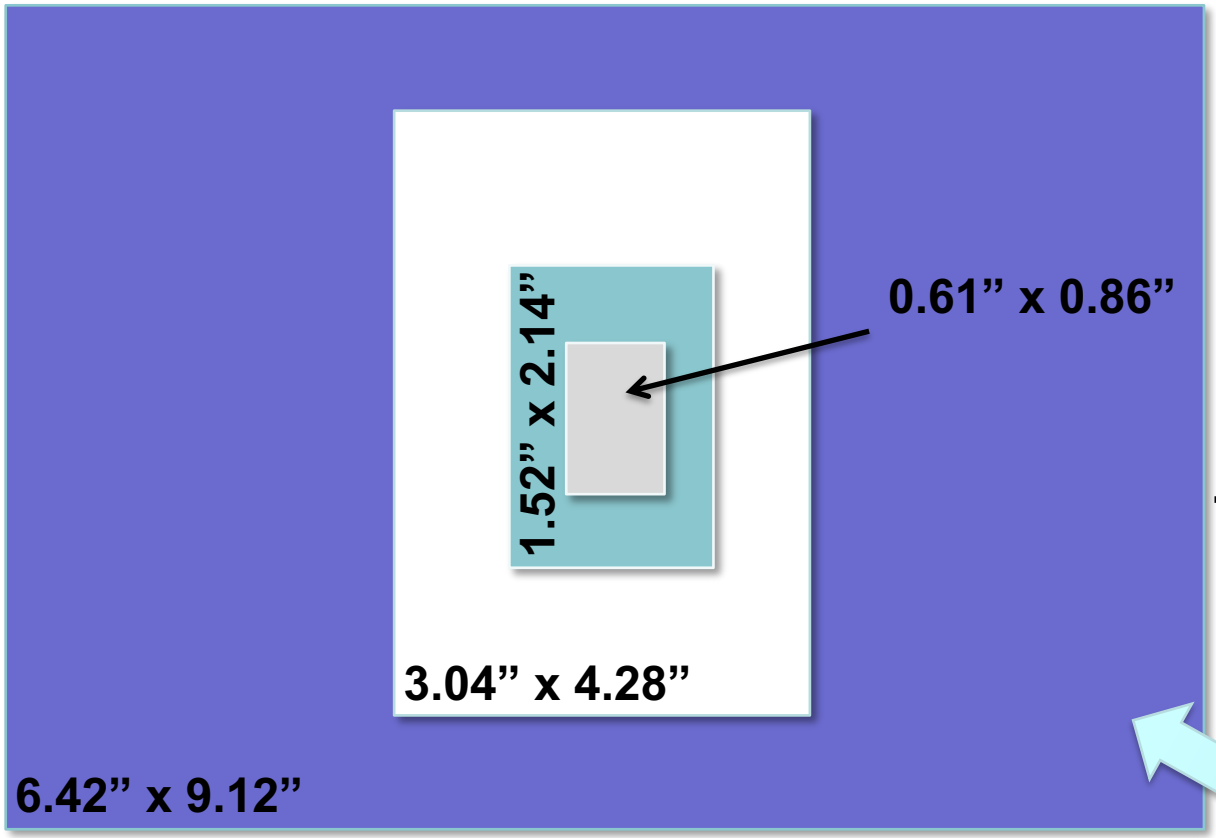


HARMONI = 3 resolving powers

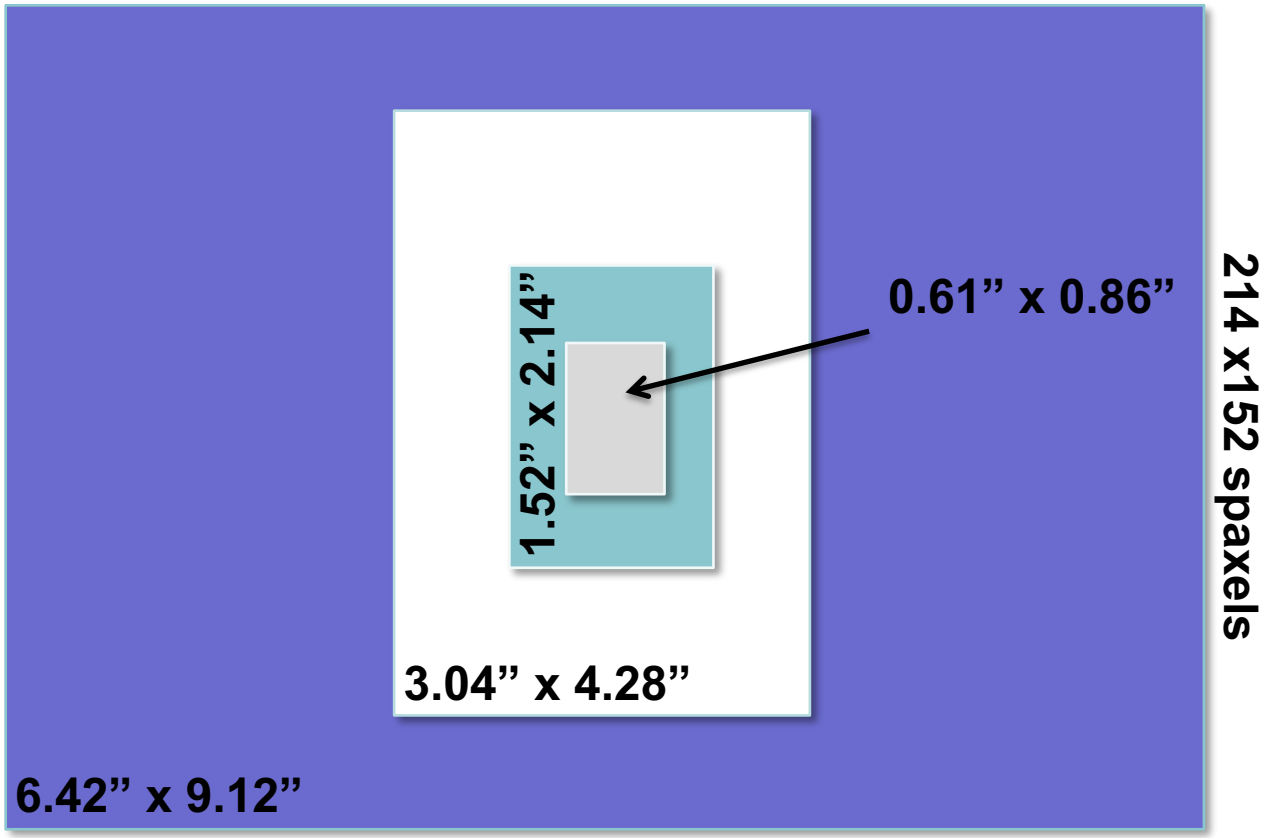
Bands	Wavelengths (µm)	R
"V+R" or "I+z+J" or "H+K"	0.45-0.8, 0.8-1.35, 1.45-2.45	**~3000**
"I+z" or "J" or "H" or "K"	0.8-1.0, 1.1-1.35, 1.45-1.85, 1.95-2.45	**~7500**
"Z" or "J_high" or "H_high" or "K_high"	0.9, 1.2, 1.65, 2.2 (TBD)	**~20000**



HARMONI = 4 spatial scales



HARMONI = 4 spatial scales



60 x 30 mas

20 mas

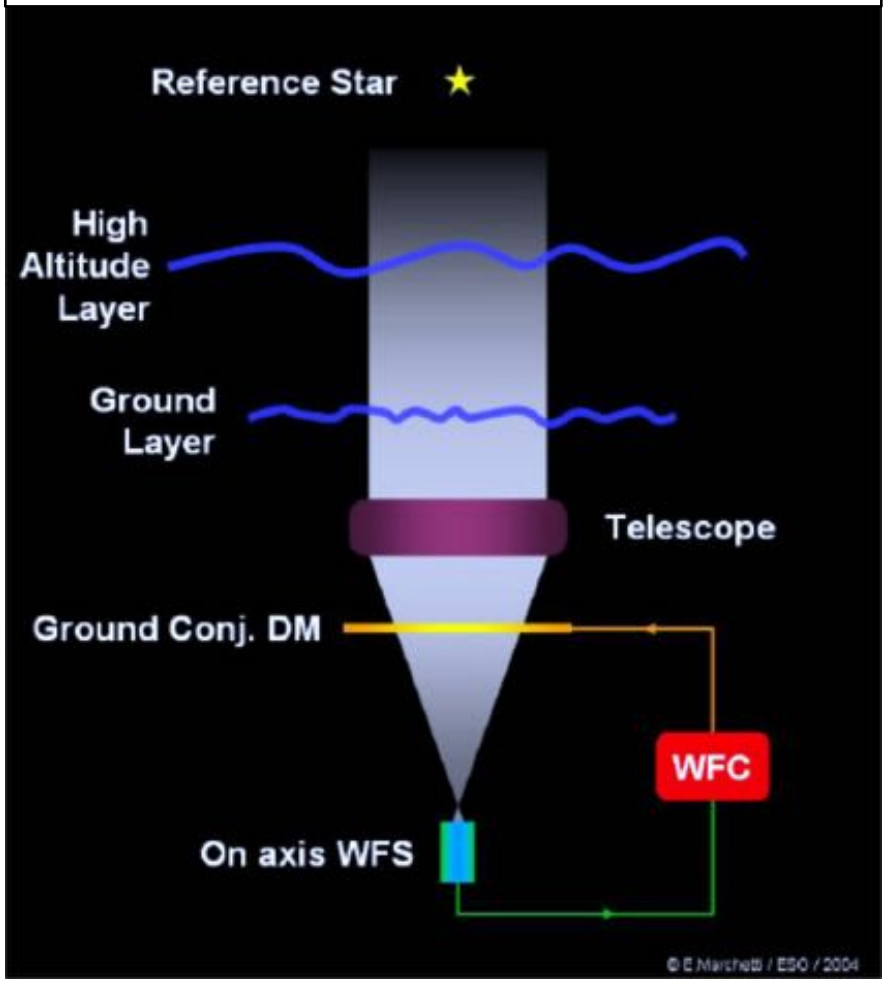
10 mas

4 mas

Assisted with Adaptive Optics

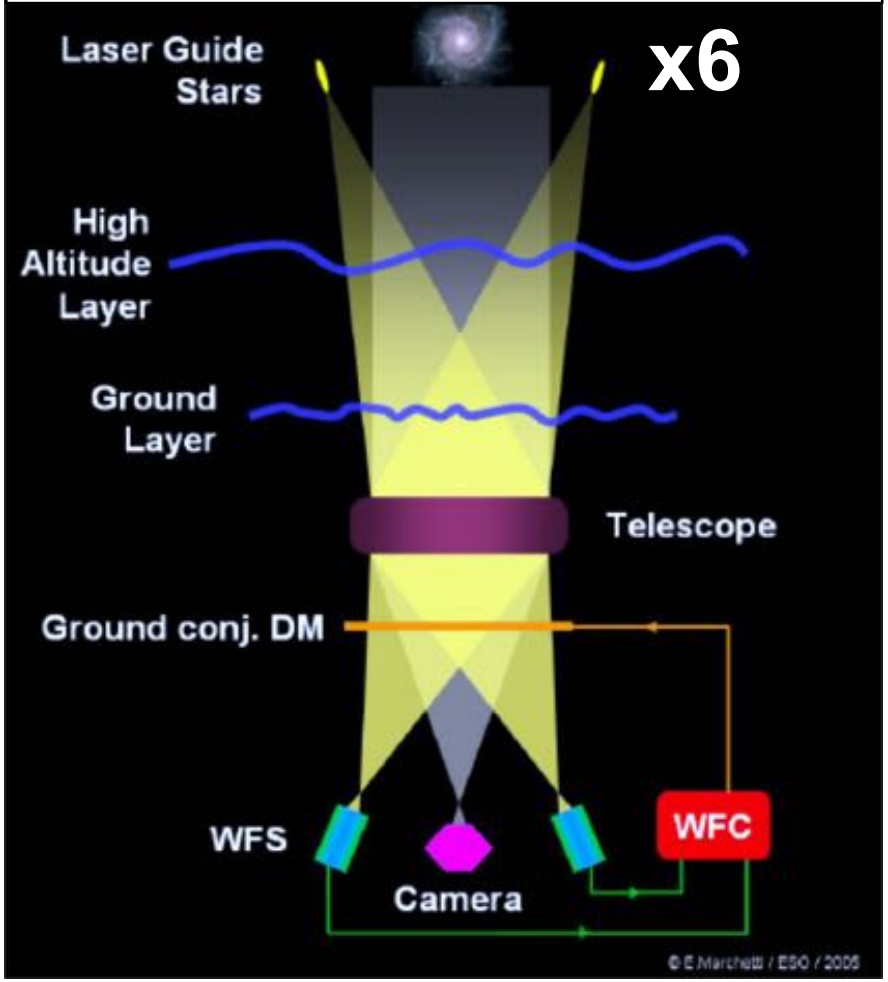
HARMONI Overview

Single Conjugated AO



High-Performance – Low sky coverage

Laser Tomography AO



High-Performance & sky coverage

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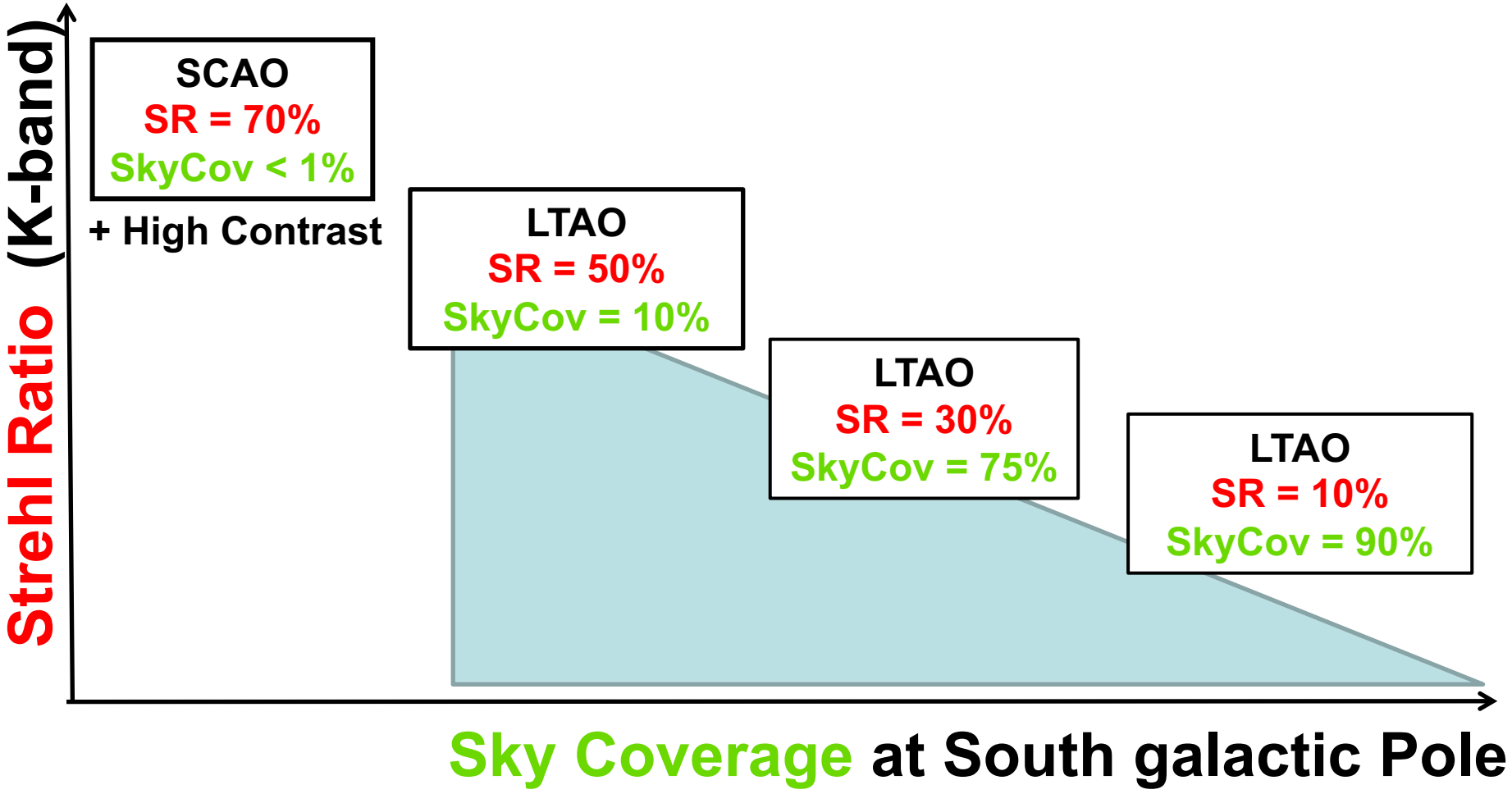
HARMONI Overview



HARMONI – Science Cases

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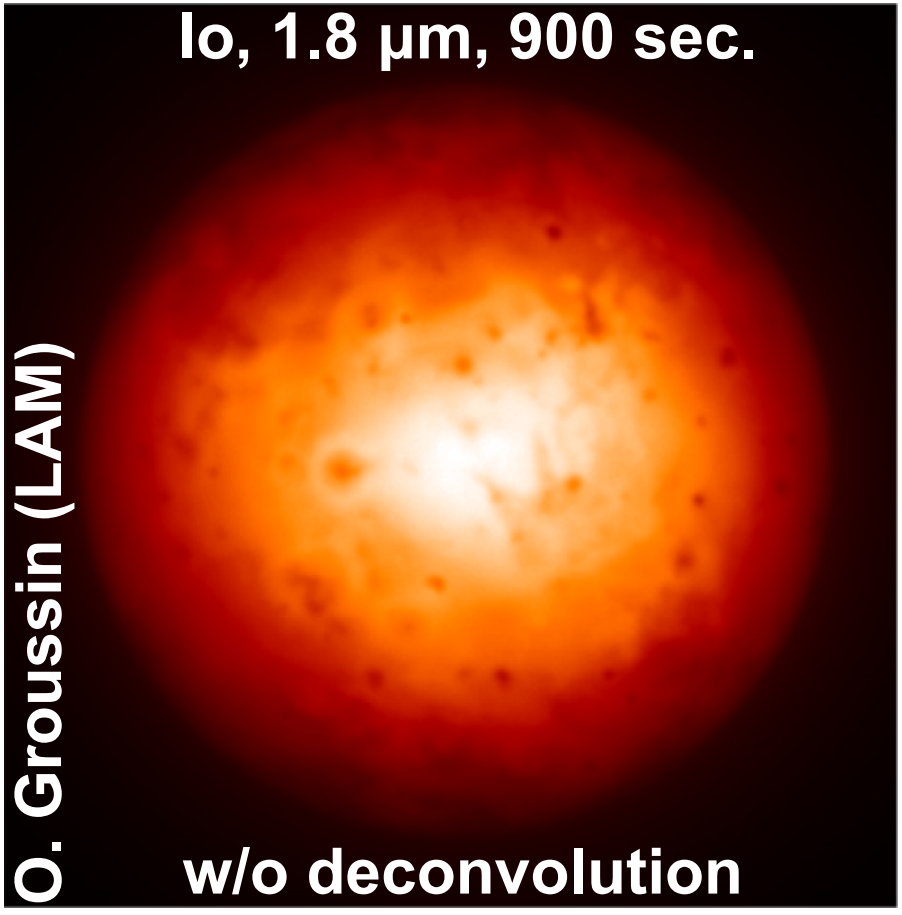
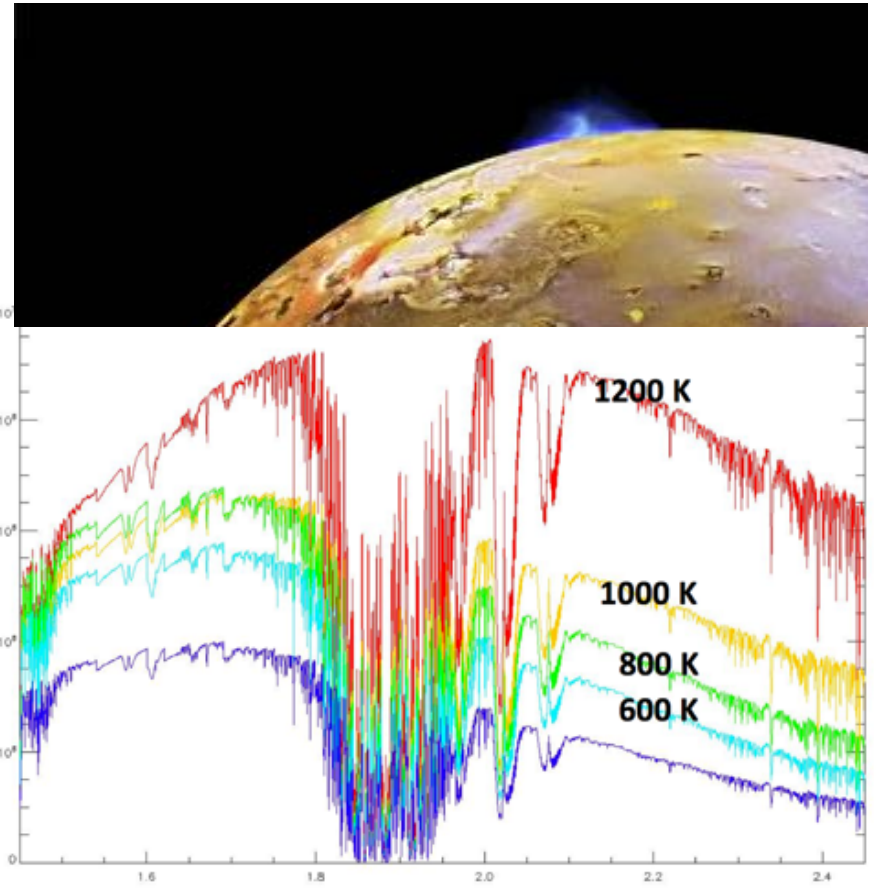
HARMONI – Science Case

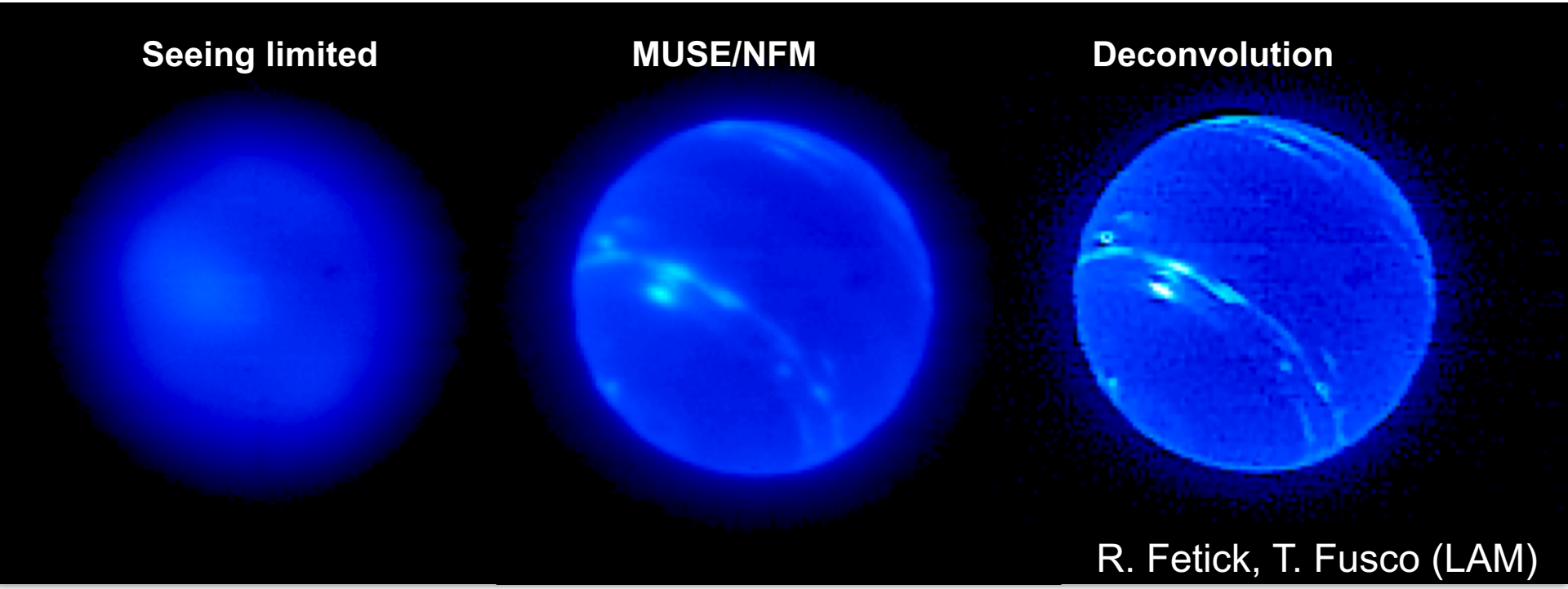
Origin and evolution of small bodies (asteroids, comets, TNOs) and satellites of giant planets





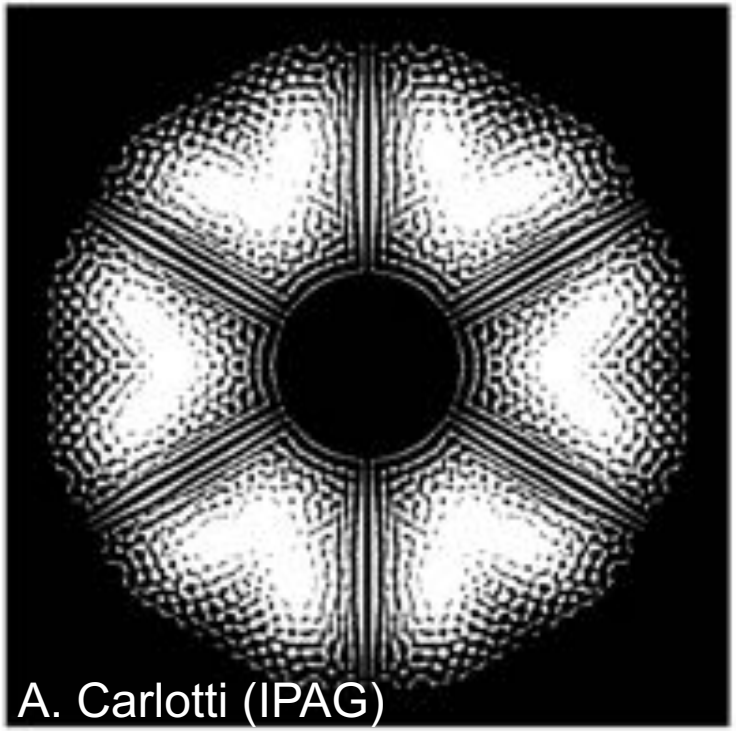
HARMONI – Science Case

Example with MUSE-NFM



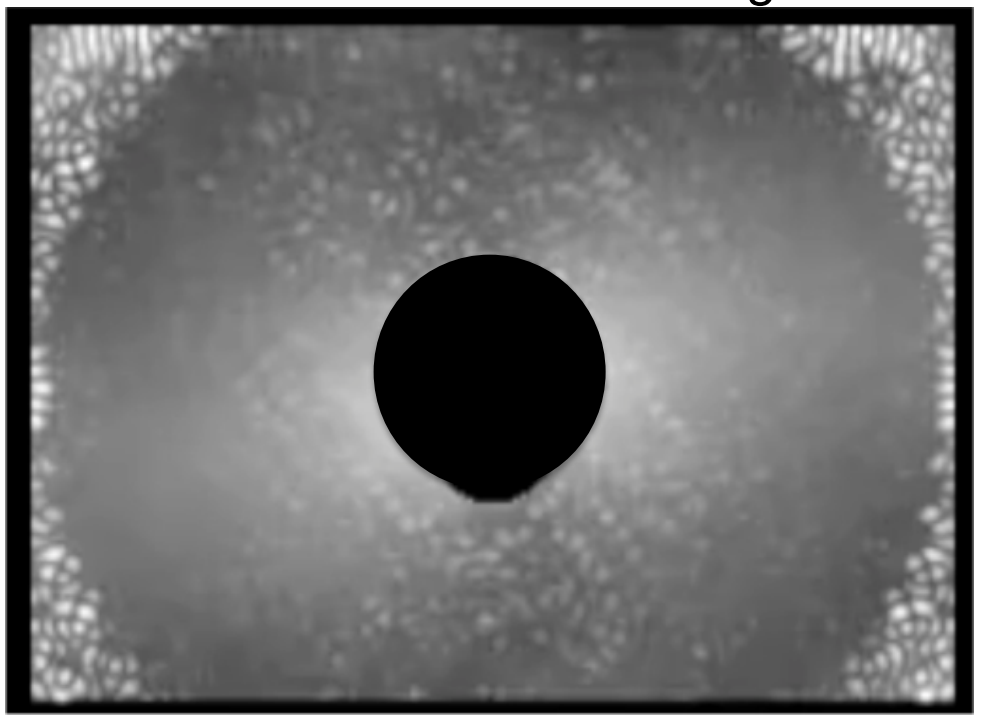
HARMONI will also benefit from High-Contrast

Shaped pupil transmission



A. Carlotti (IPAG)

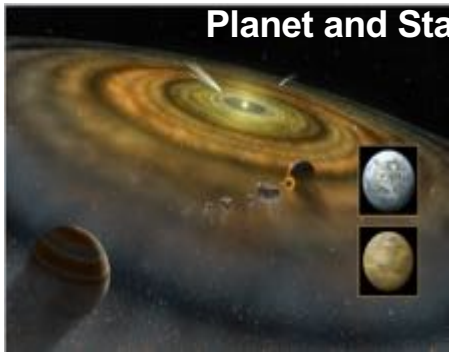
Raw Simulated Image

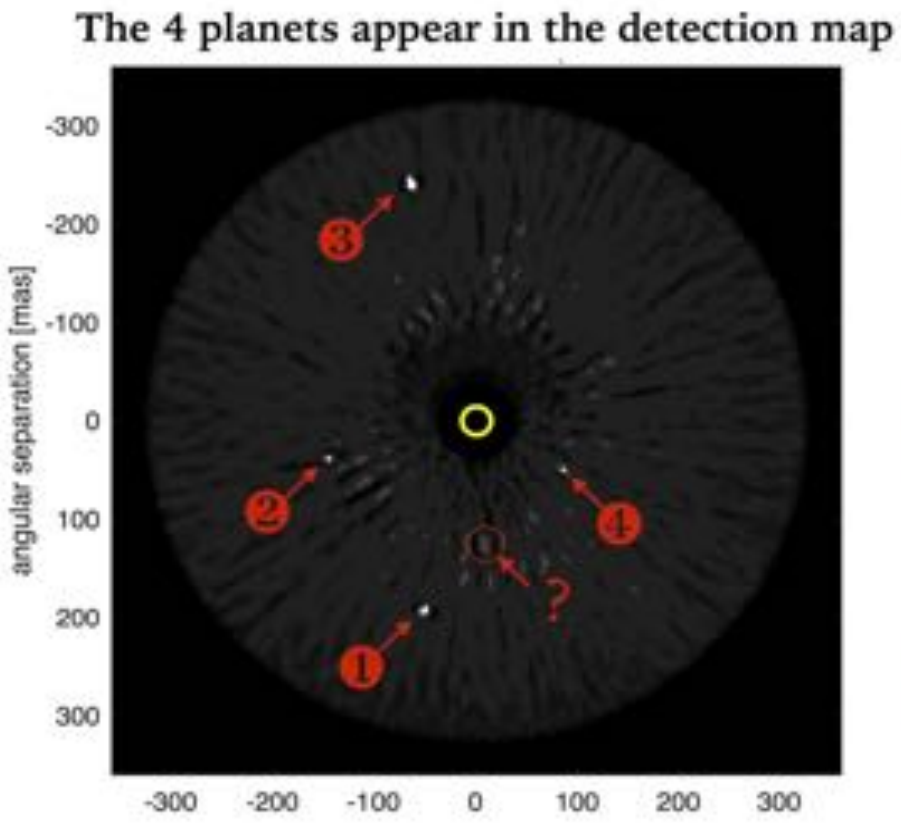


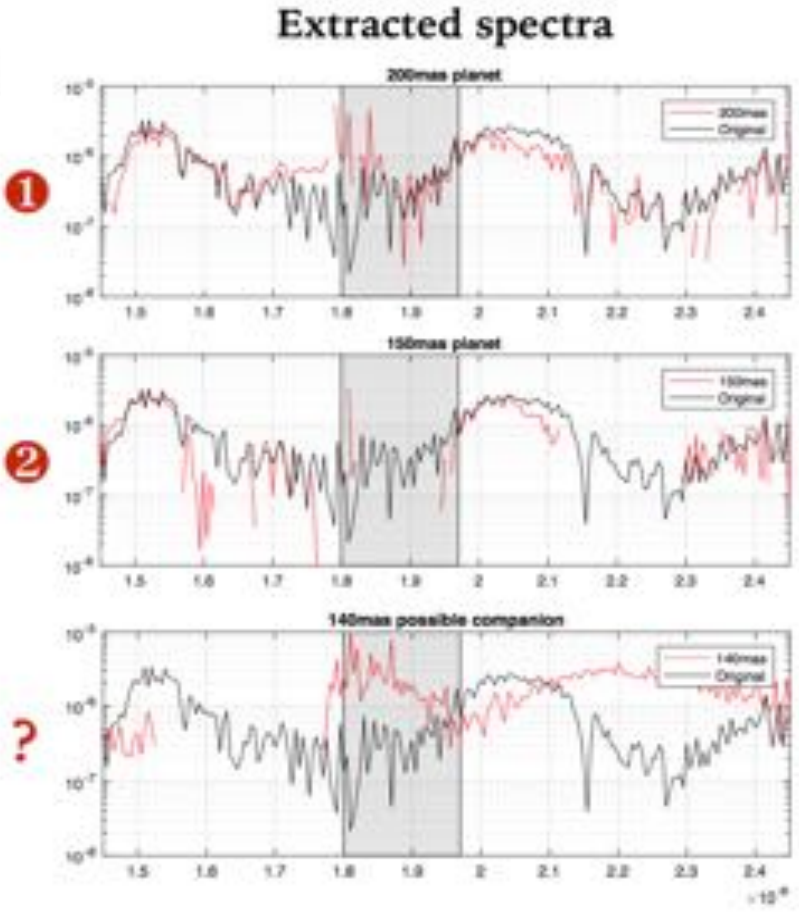
10-6 contrast at 200mas.

HARMONI – Science Case

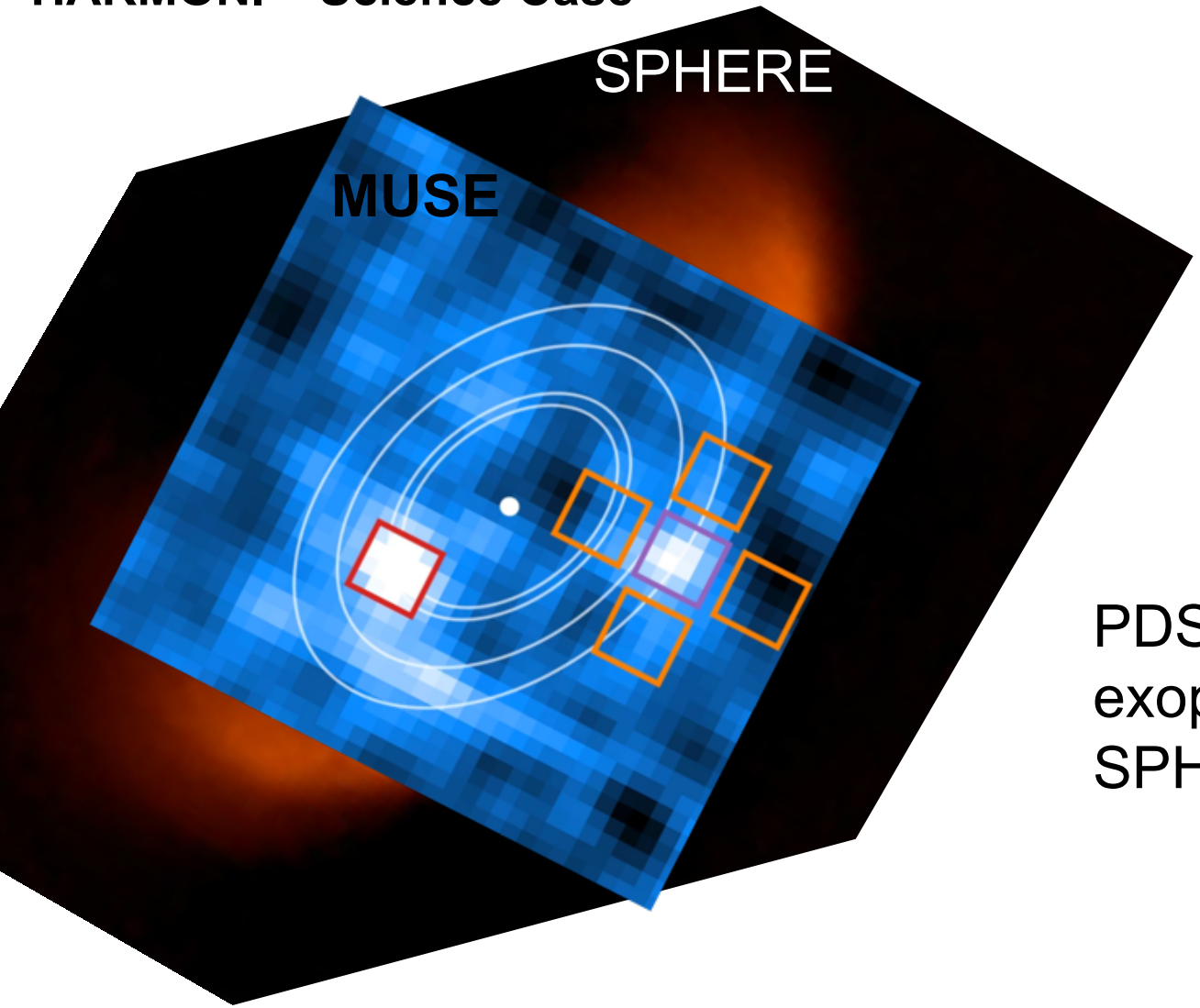
Spectral characterization of exo-planets:
Simulated data of 4 planets w/ 10^{-6} planets contrast & 51 Eri b-like synthetic spectrum (2h exp. with H=6 star).





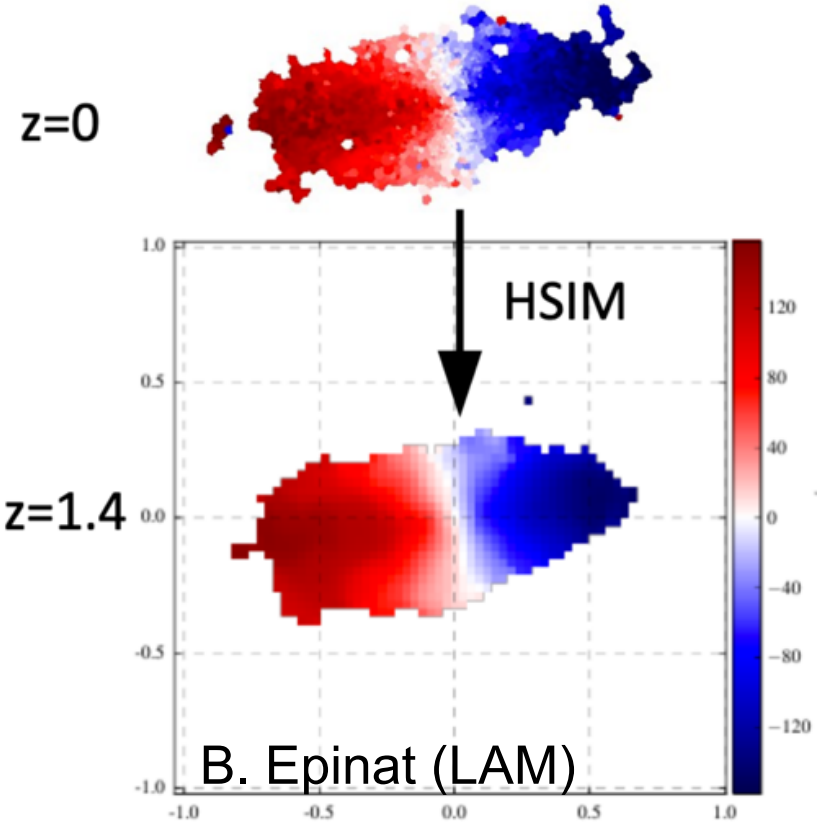


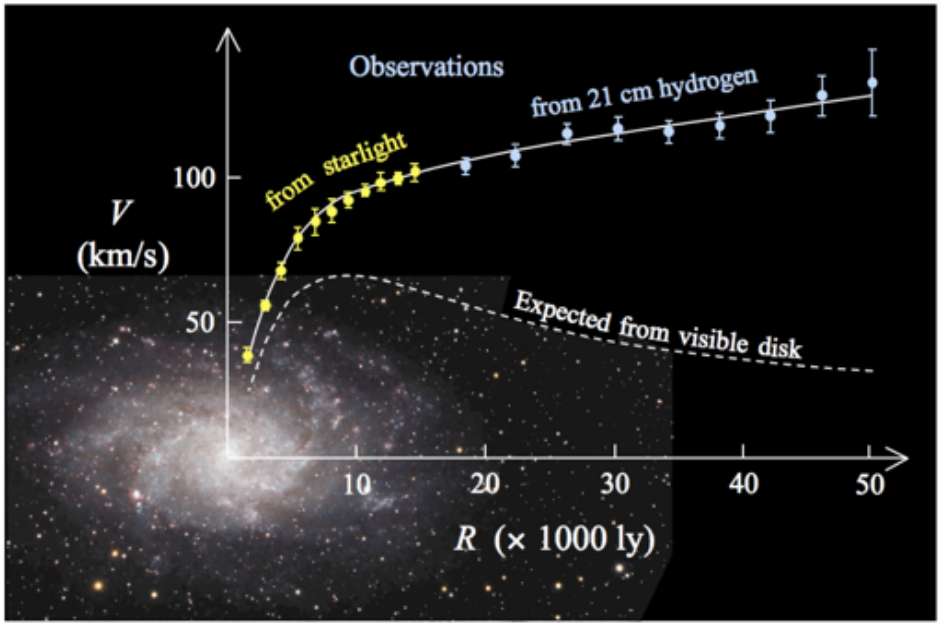
HARMONI – Science Case



PDS70b – one of the 2 exoplanet detected by SPHERE @ VLT

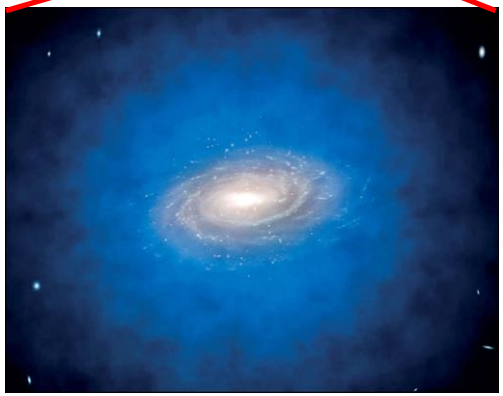
kinematics and line properties of galaxies at z=2 – Dark Matter distribution

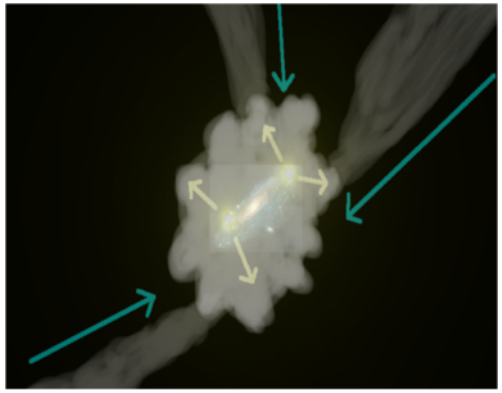




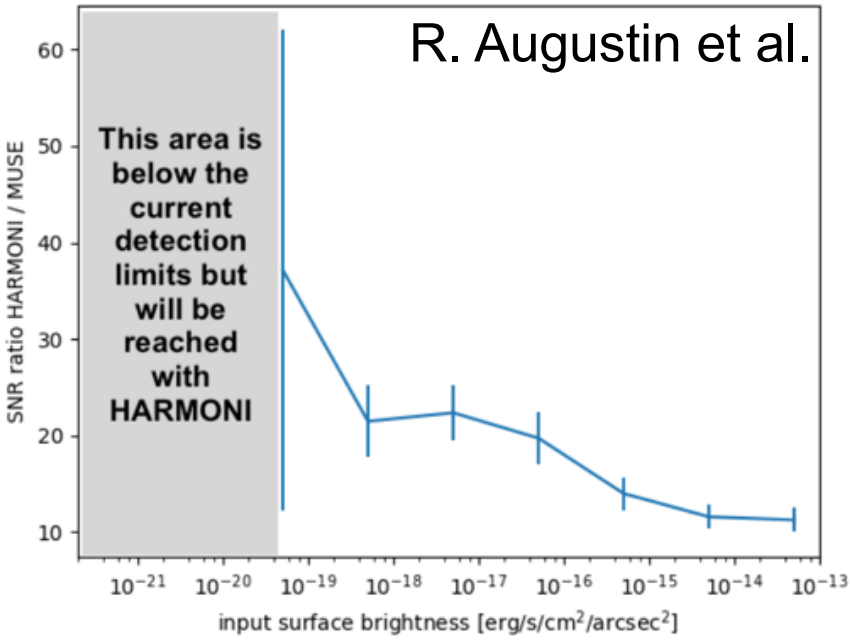
Galaxies and cosmology

Ly-Alpha emission around distant galaxies





40x better than MUSE
800x better than SINFONI



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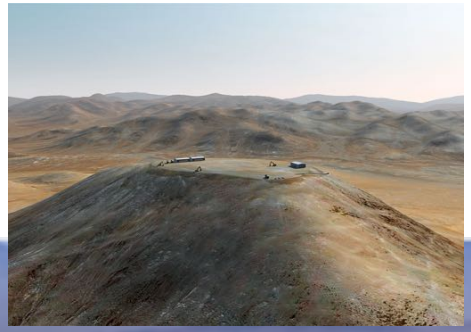
HARMONI Schedule



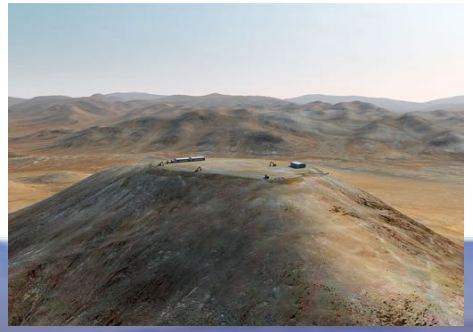
Today

HARMONI Schedule

Today

2025

HARMONI Schedule

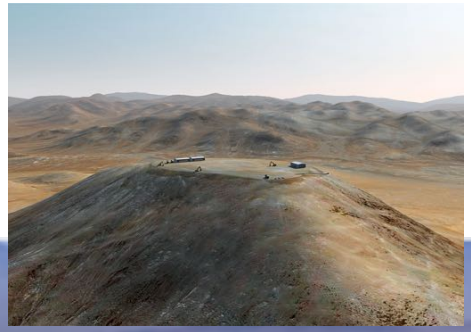


Today → 2025

Dec 2017

PDR

HARMONI Schedule



Today → 2025

Dec 201

PDR

European Southern Observatory

ann18092 — Announcement

ELT's HARMONI spectrograph passes Preliminary Design Review

Cutting-edge instrument passes critical tests and gains powerful adaptive optics system

20 December 2018

HARMONI Schedule

Today

2025

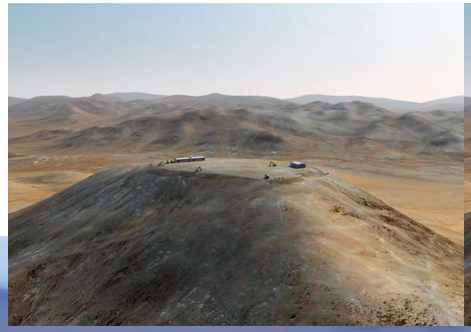
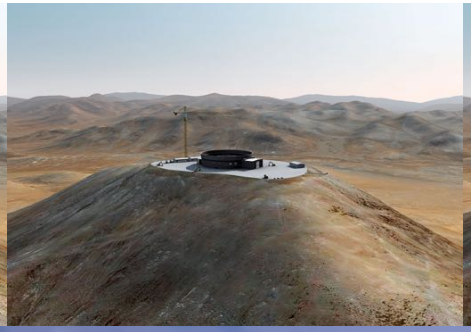
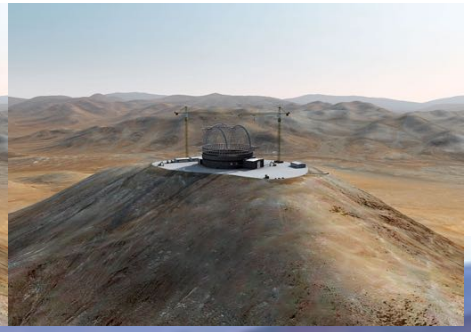
Dec 2017

end 2020

PDR

FDR

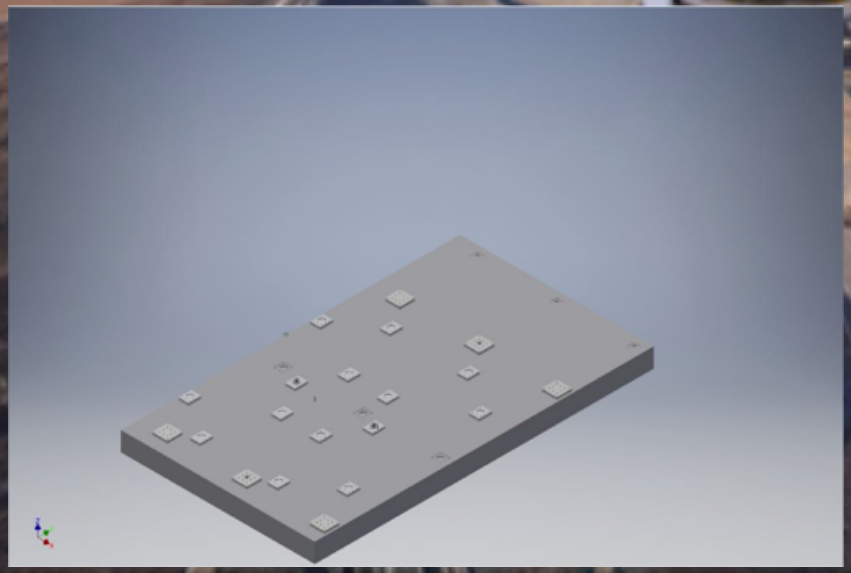
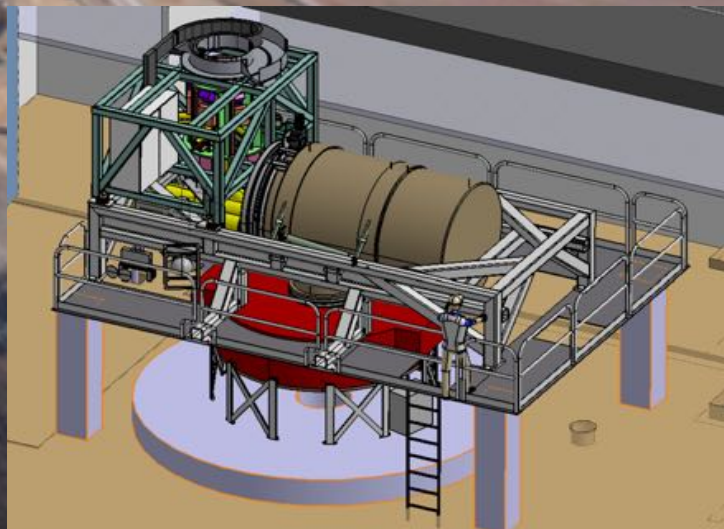
HARMONI Schedule

Today → 2025

Dec 2017 — end 2020

PDR	FDR	MAIT

HARMONI Schedule

Today → 2025

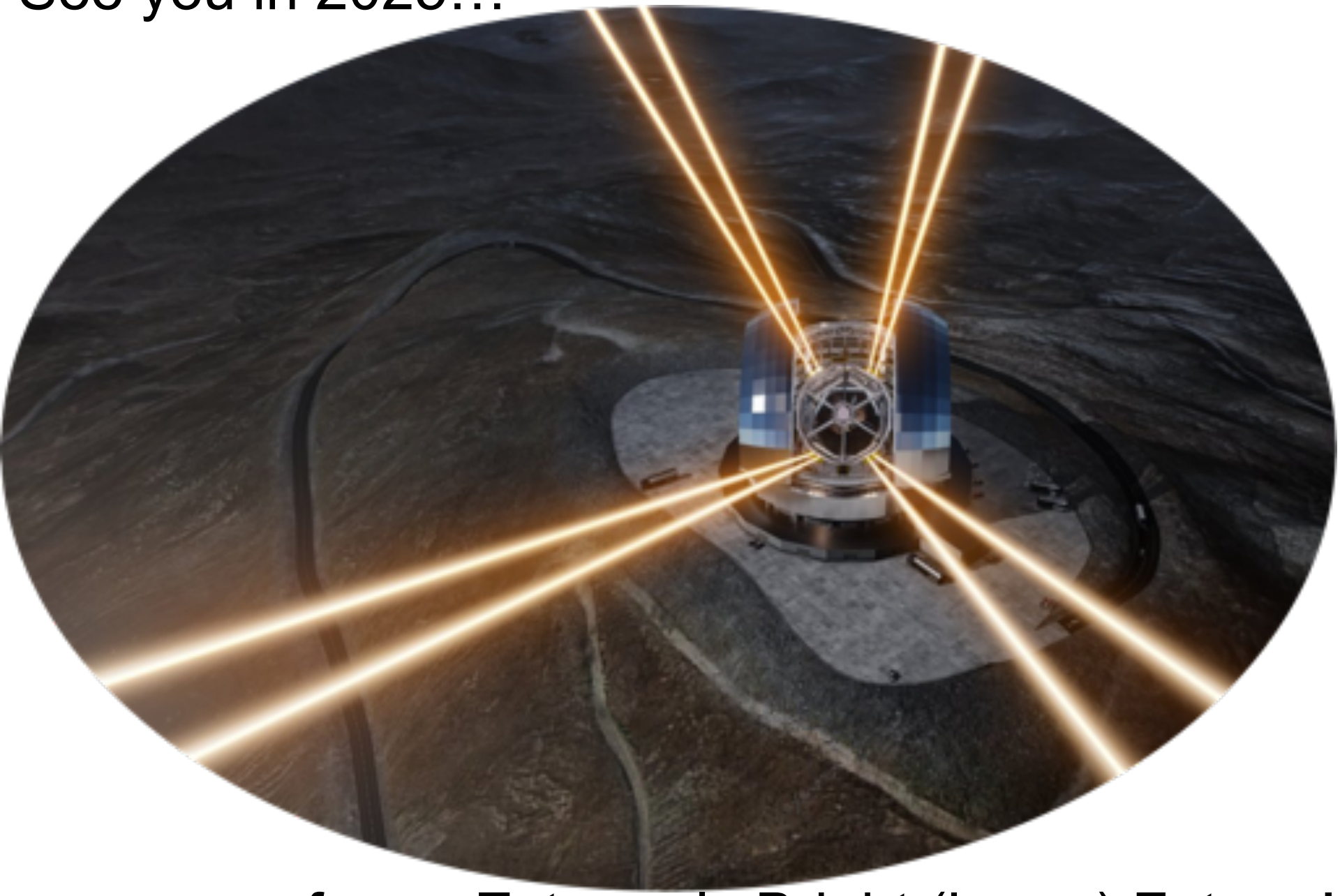
Dec 2017 — end 2020 — ELT 1st light

PDR	FDR	MAIT	Install/Commissioning

Summary

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

See you in 2025…



… for an Extremely Bright (Laser) Future !

Thank you