- The AO modes for HARMONI -
From Classical to Laser-assisted tomographic AO systems

Benoît Neichel, Thierry Fusco, Carlos M. Correia, Kjetil Dohlen, Leonardo Blanco, Kacem El Hadi, Jean-François Sauvage, Noah Schwartz, Yoshito Ono, Fraser Clarke, Emmanuel Hugot, Miska Le Louarn, Niranjan A. Thatte, Matthias Tecza, Hermine Schnetler, Ian Bryson, Angus M. Gallie, David M. Henry, Tim J. Morris, Richard M. Myers, Joël Vernet, Jérôme Paufique, Peter Hammersley, Jean-Luc Gach, Alexis Carlotti, Ariadna Calcines, Pascal Vola, Sandrine Pascal, Marc Llored, Dave Melotte, Olivier Martin, Arlette Pecontal, Andrew Reeves, James Osbron, Matthew Townson

HARMONI Consortium

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

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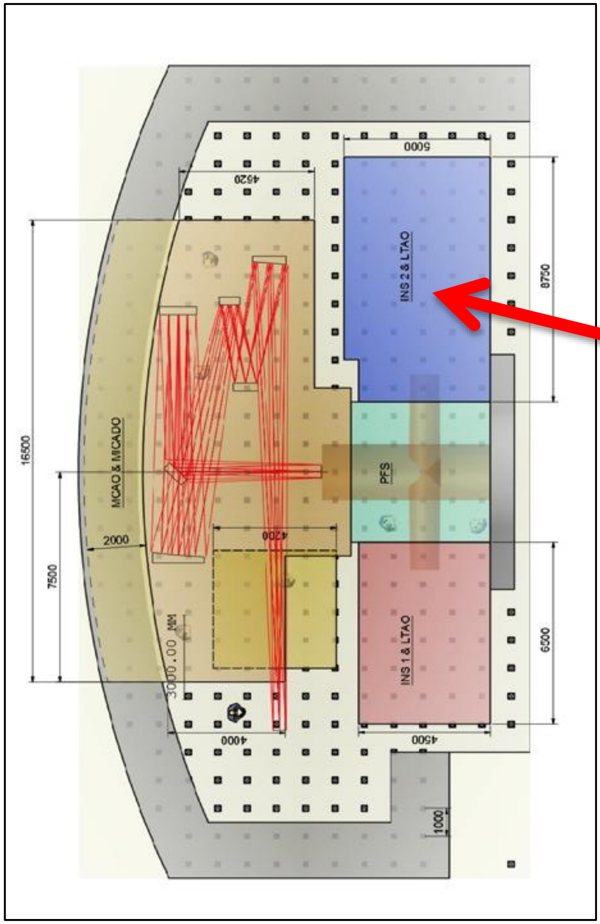
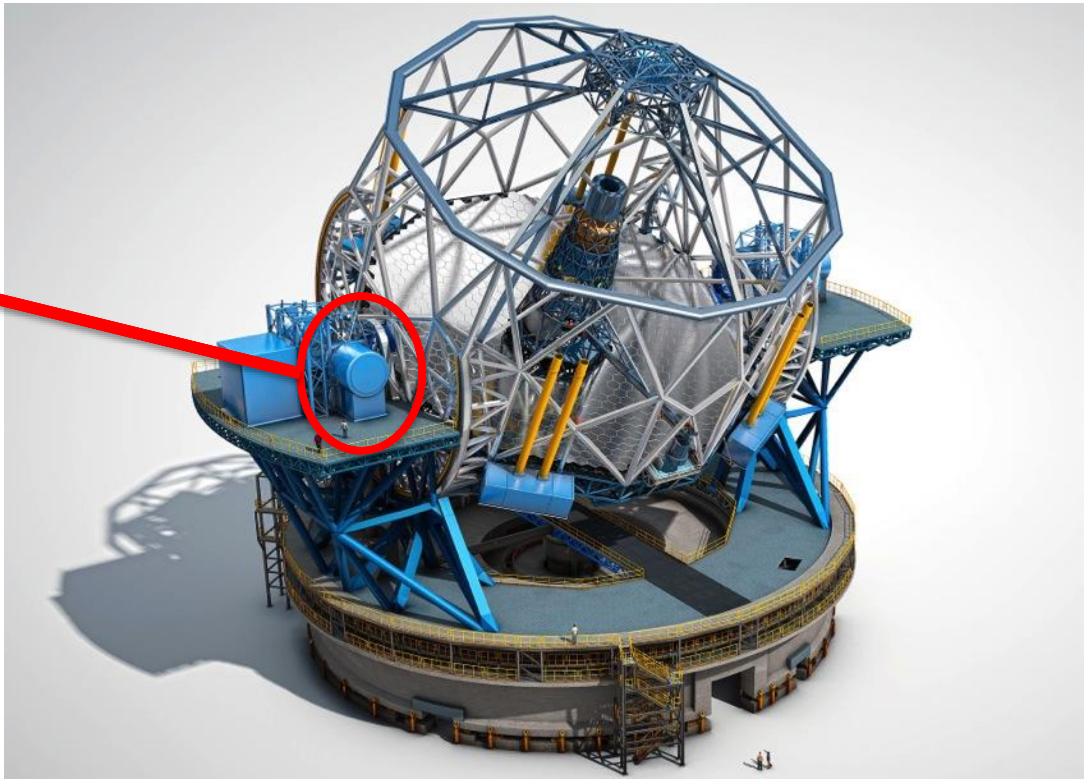
Thanks for hosting us this week !!

HARMONI Overview

HARMONI = High Angular Resolution - Monolithic - Optical and Near-infrared - Integral field spectrograph

First light ELT instrument





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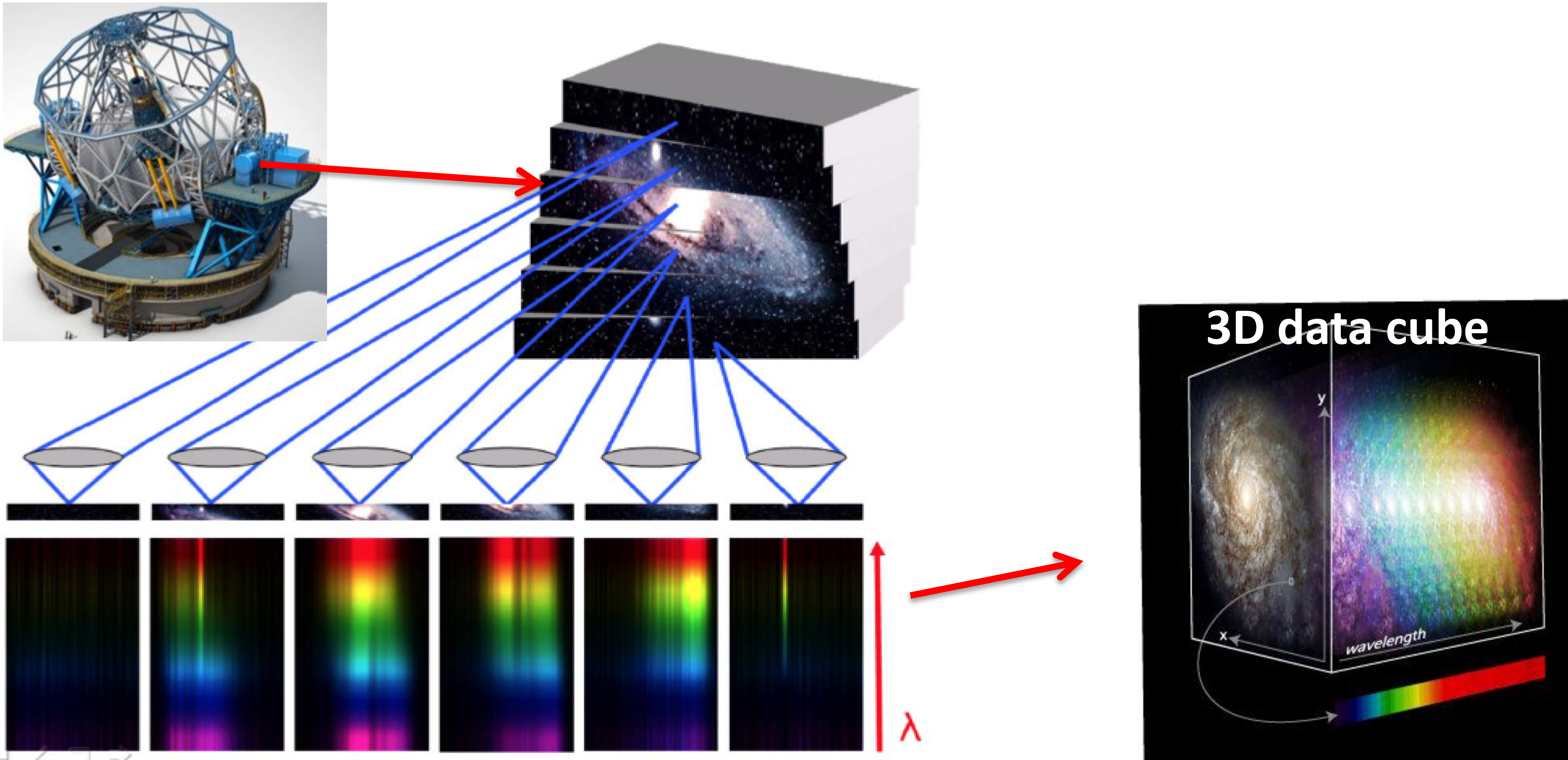
ESO
LAM

HARMONI = High Angular Resolution - Monolithic - Optical and Near-infrared - Integral field spectrograph

First light ELT instrument

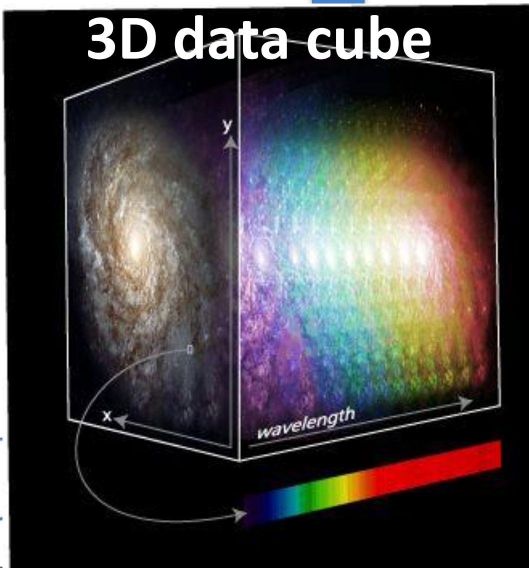
Workhorse instrument - visible and near-infrared spectroscopy (0.5–2.4 µm)

Integral Field Spectrograph – providing ~ 30 000 spectra per exposure



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**



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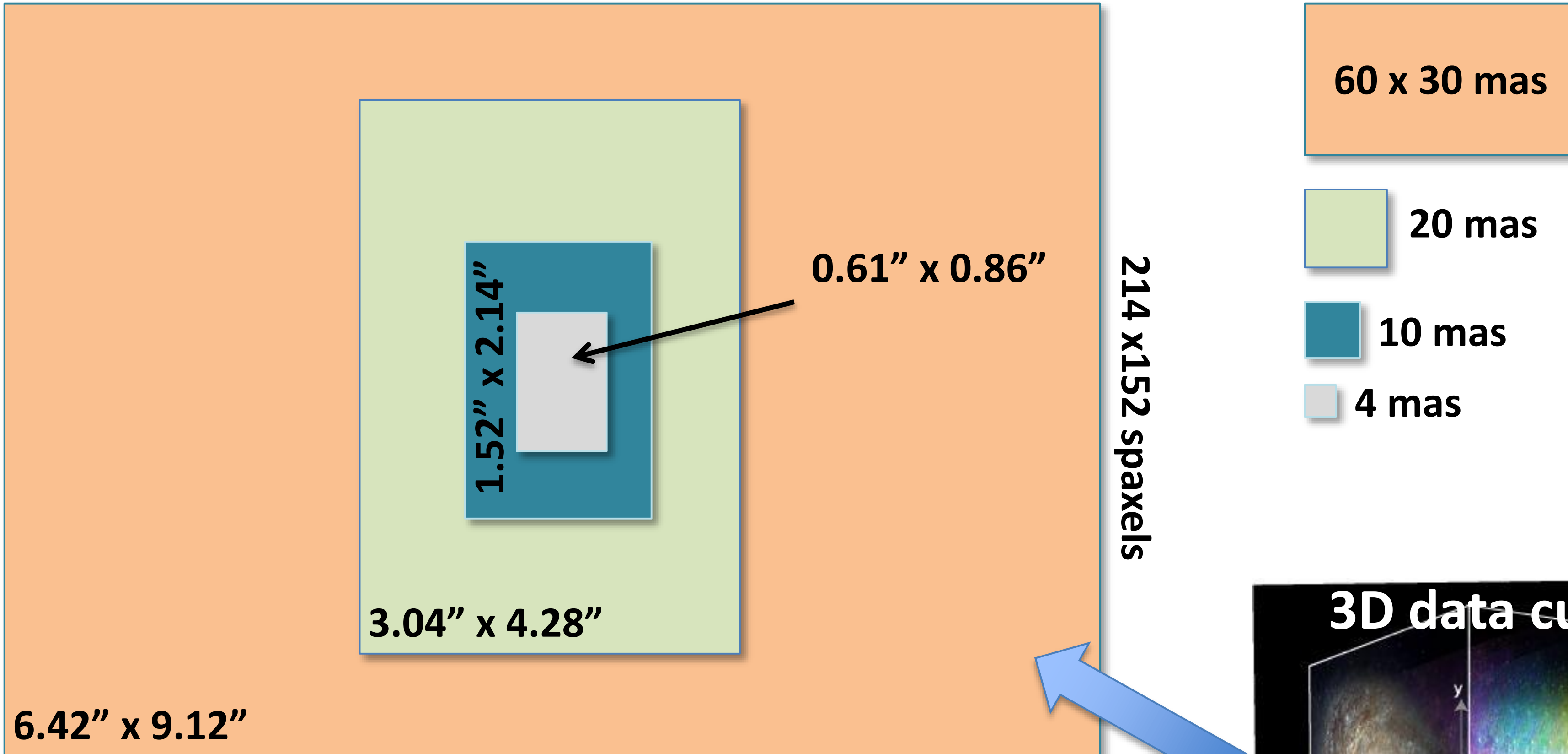
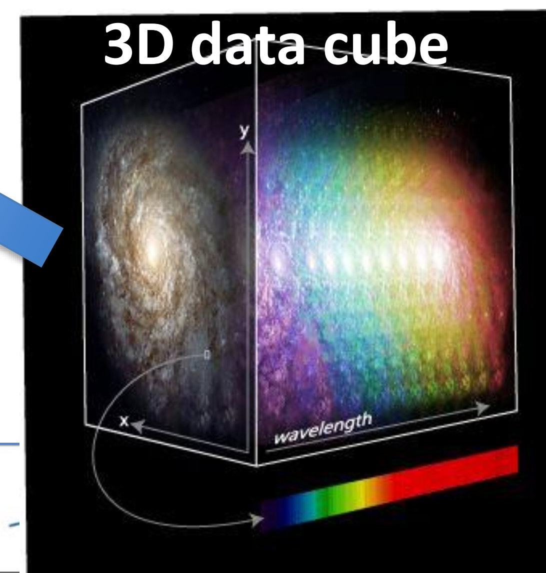
HARMONI = 4 spatial scales





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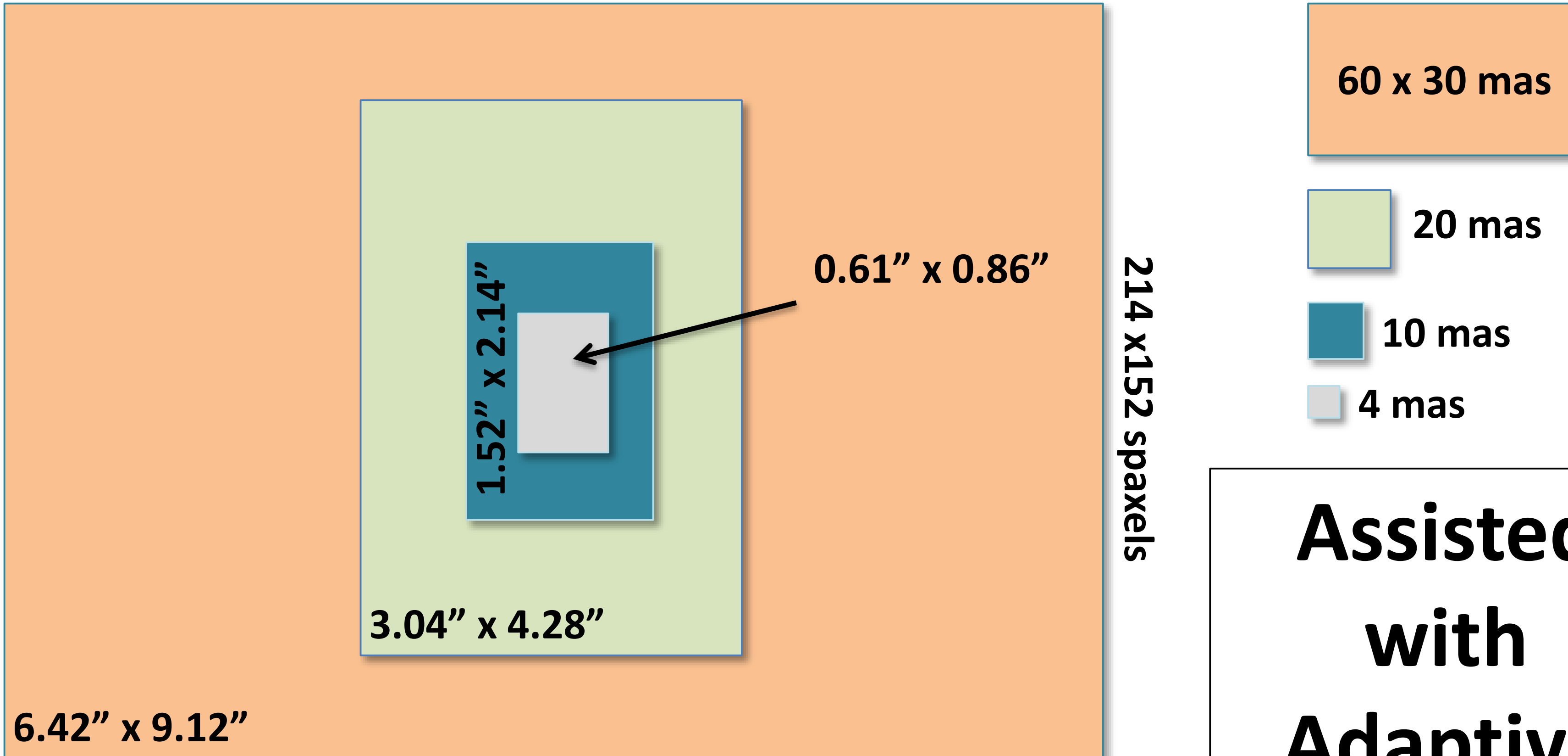
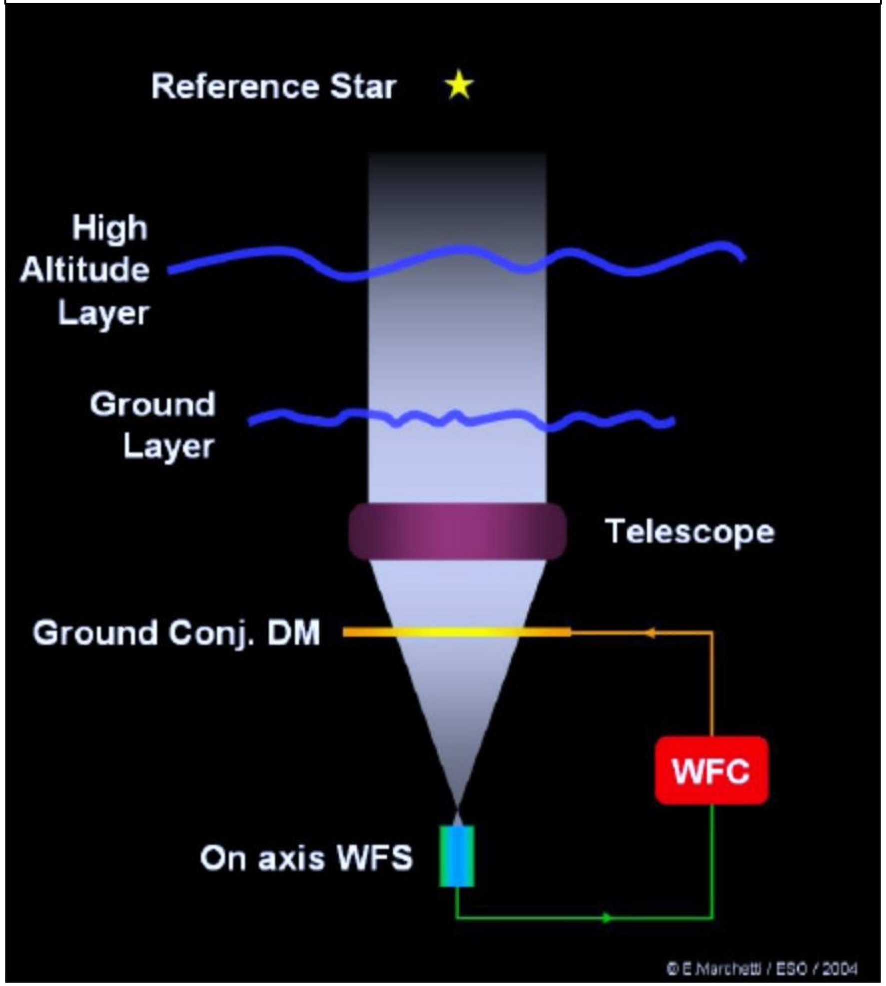


Assisted with Adaptive Optics

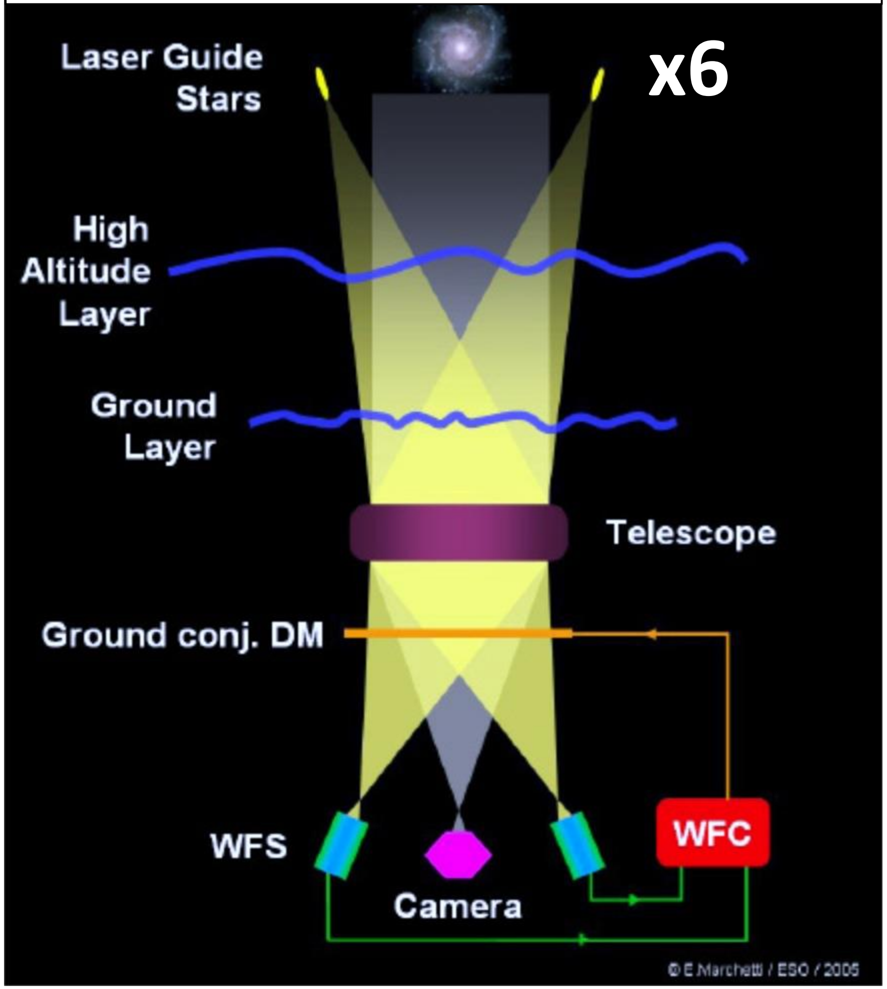
HARMONI: Two AO modes

Single Conjugated AO



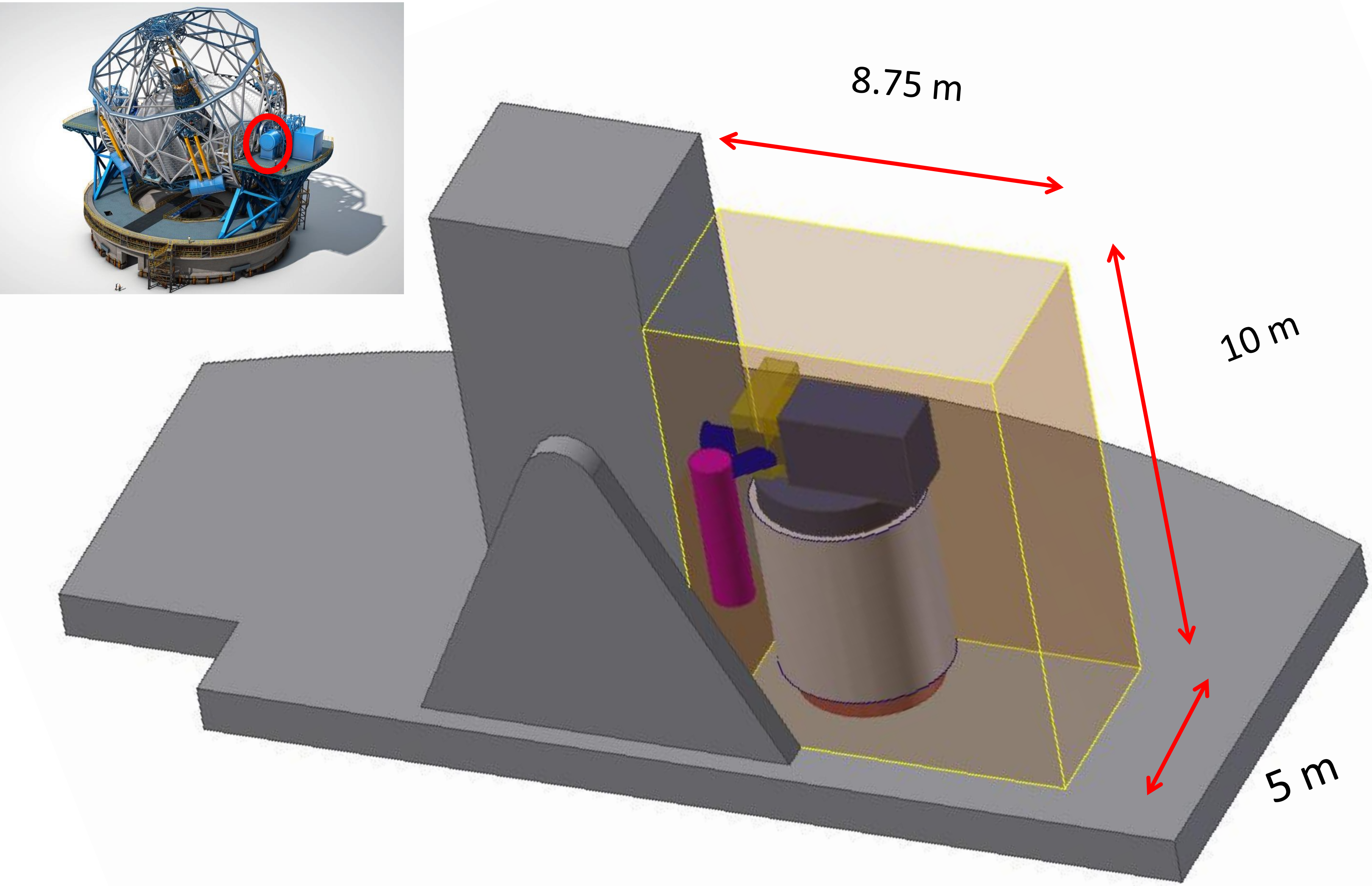
High-Performance – Low sky coverage

Laser Tomography AO

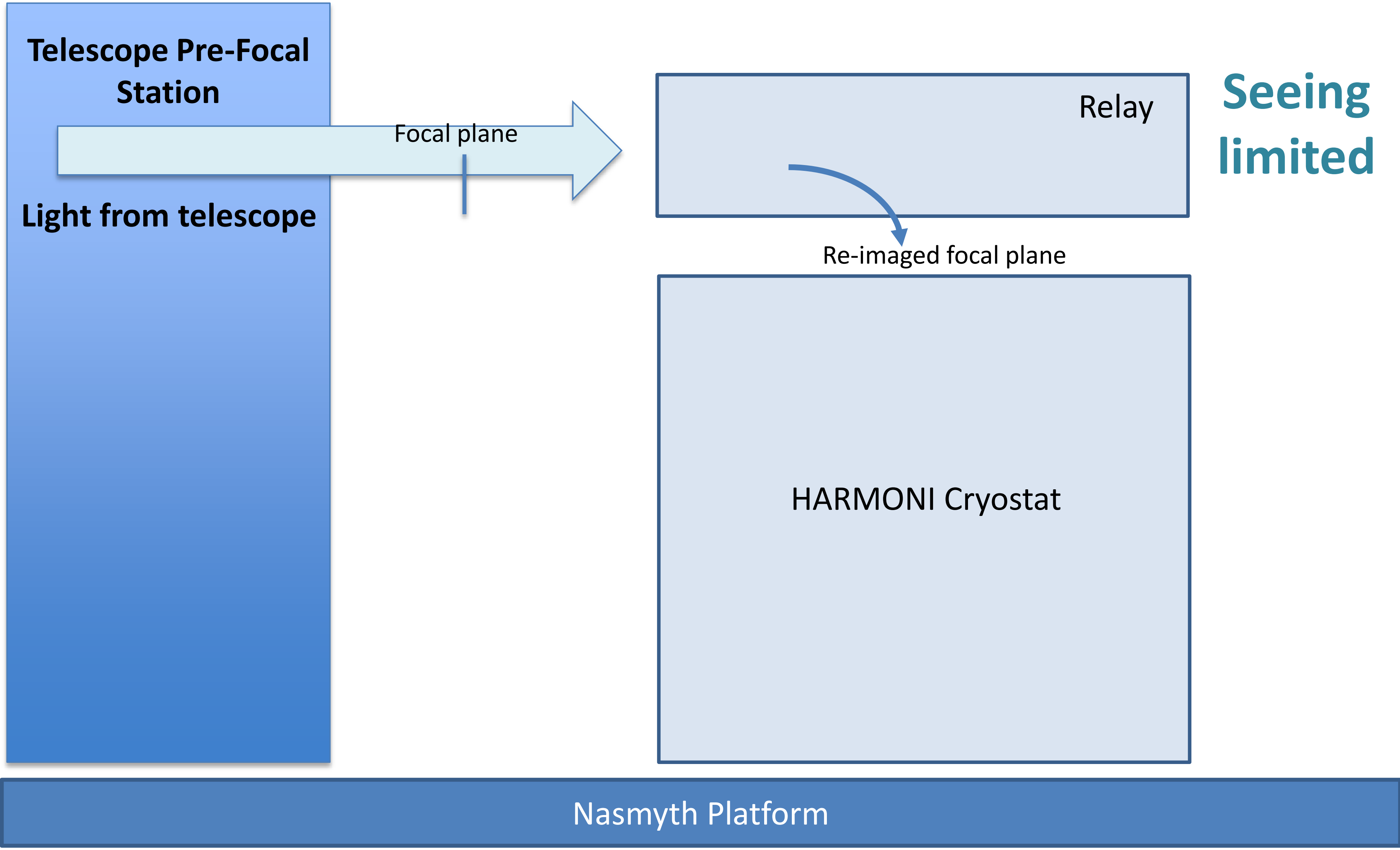


High-Performance & sky coverage

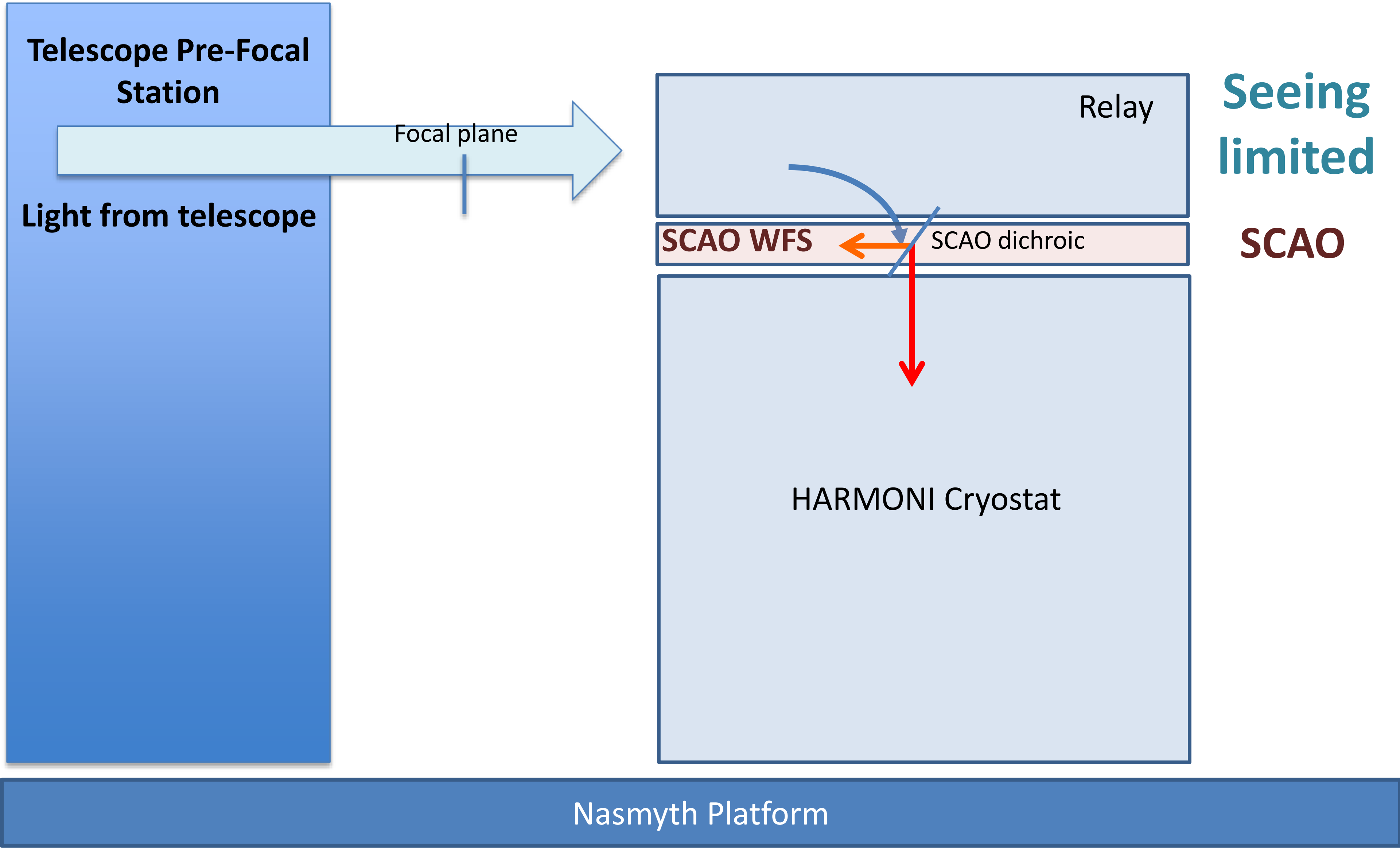
HARMONI, SCAO & LTAO implementation



HARMONI, SCAO & LTAO implementation



HARMONI, SCAO & LTAO implementation



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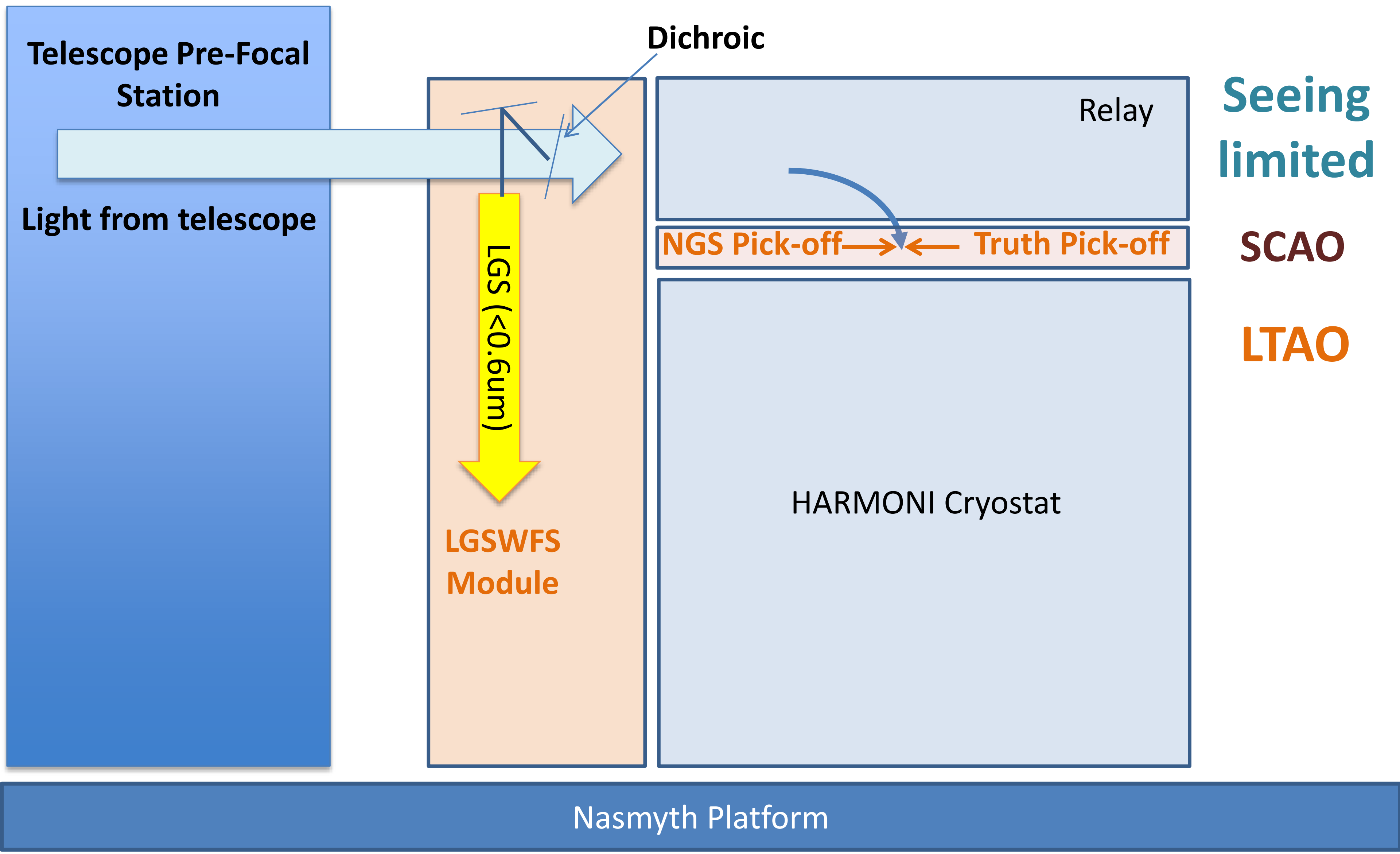

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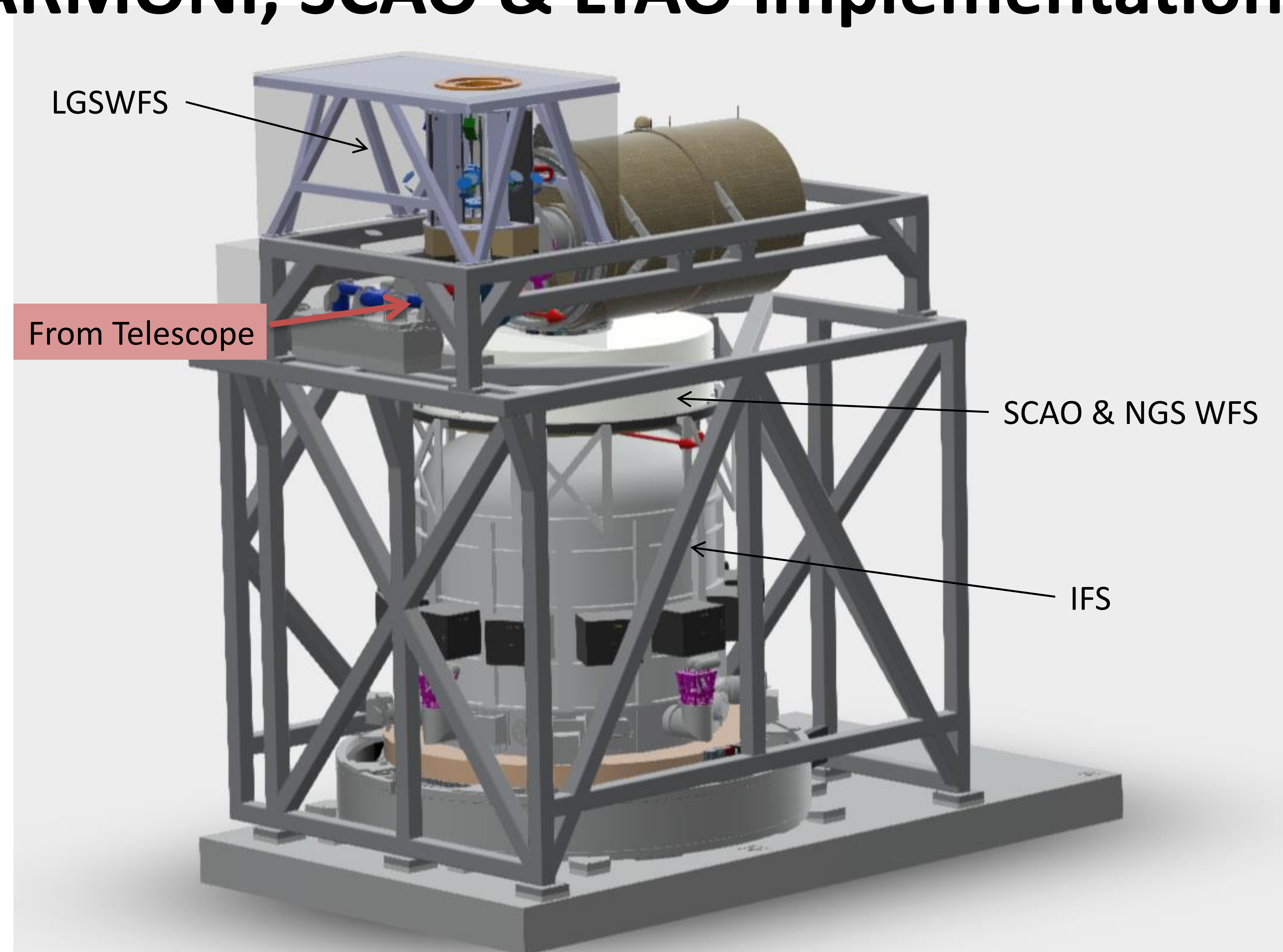

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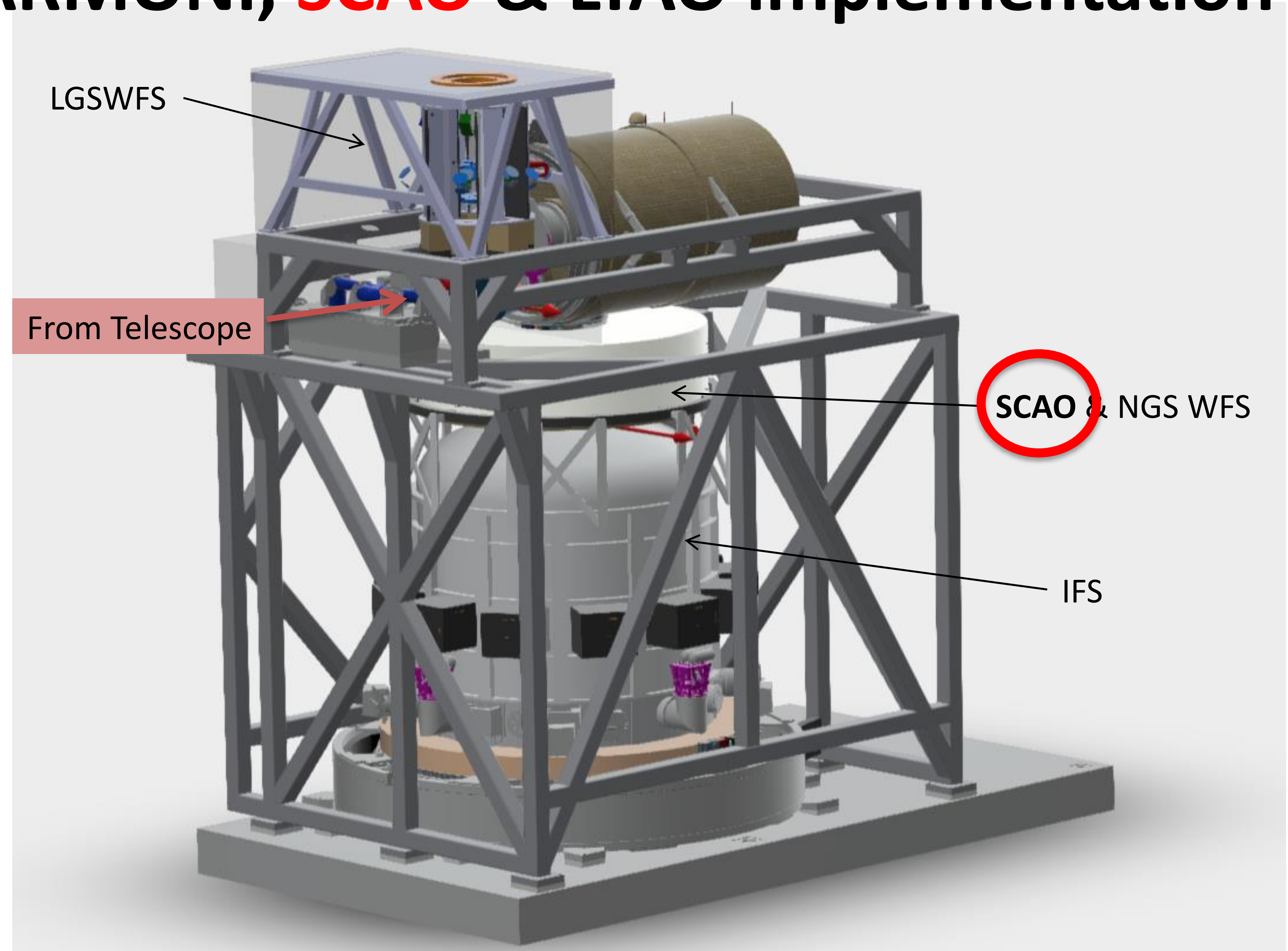
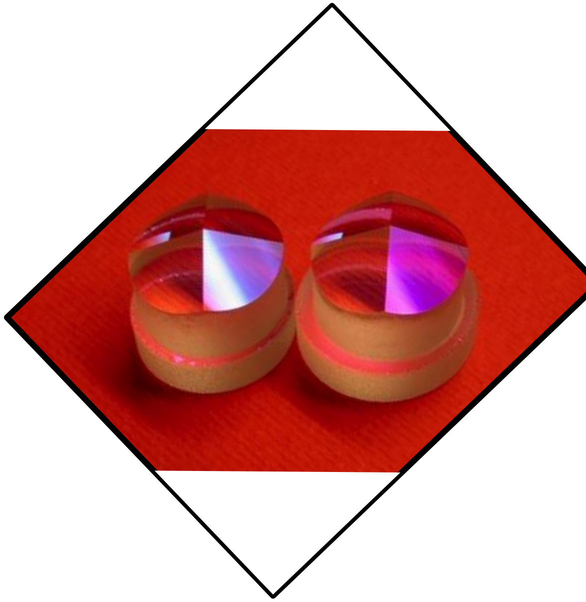
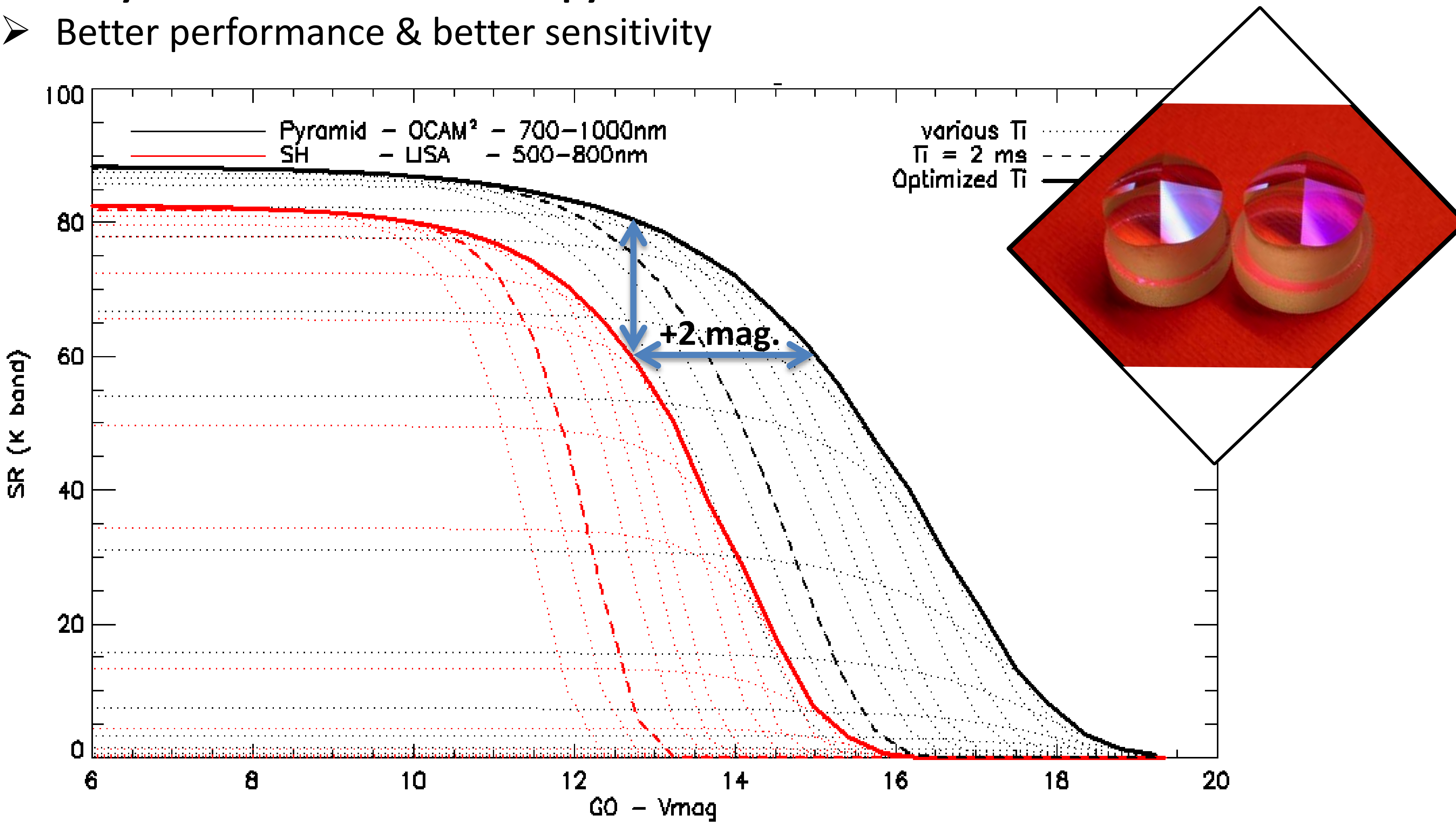


SCAO system baseline is to use a pyramid WFS:



SCAO system baseline is to use a pyramid WFS

- Better performance & better sensitivity



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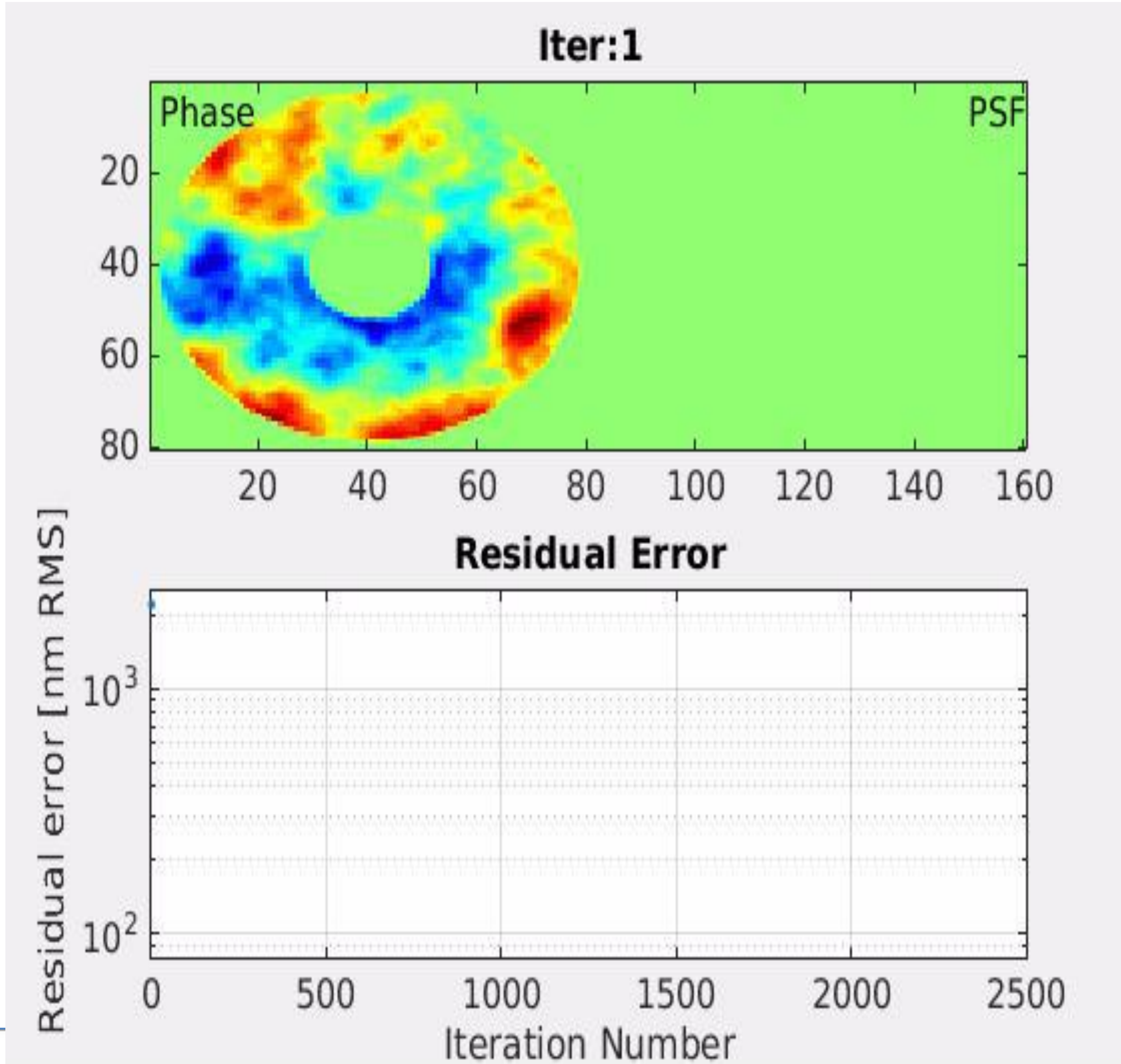
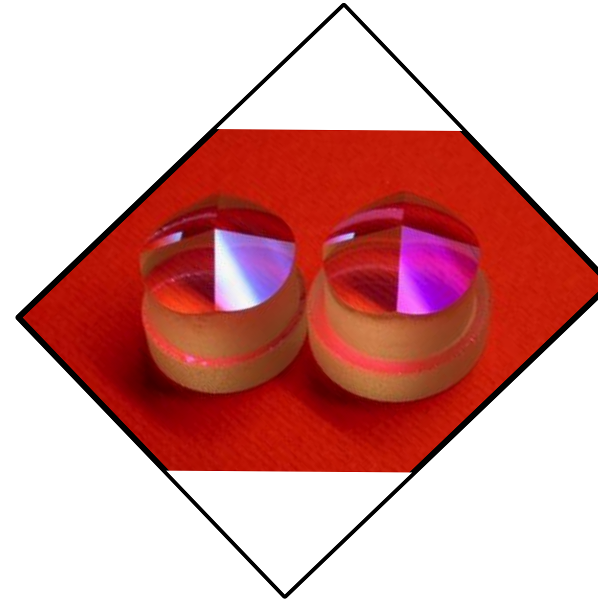
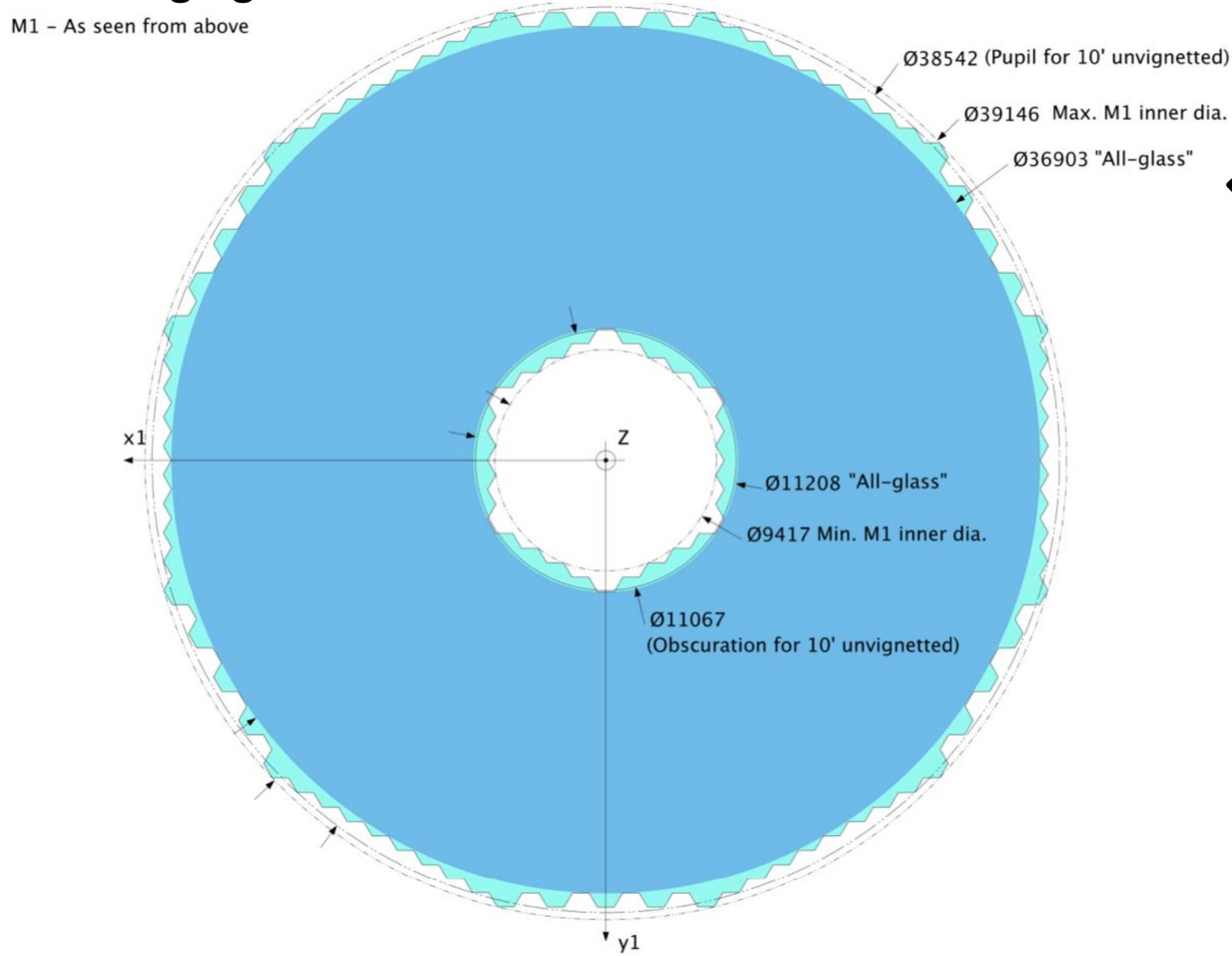
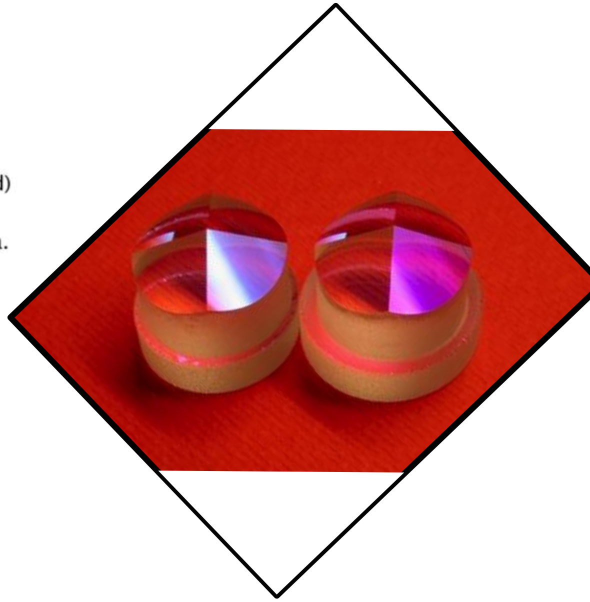




SCAO system baseline is to use a pyramid WFS

- Better performance & better sensitivity
- Managing the "Island" effect





See Noah Schwartz talk on Friday

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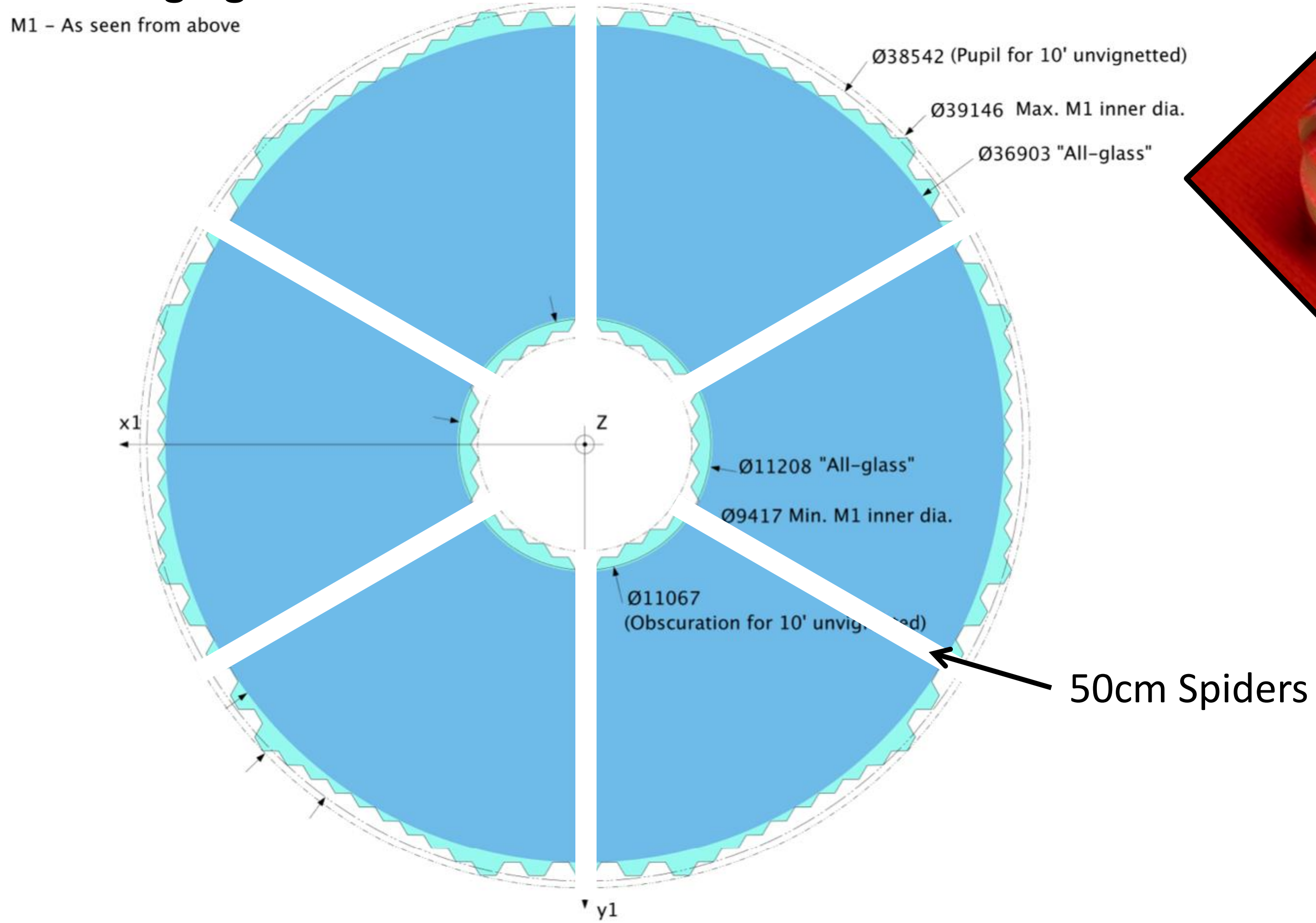

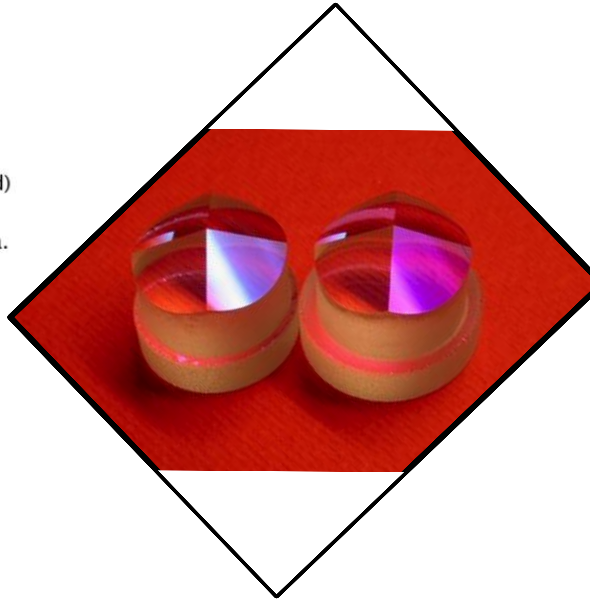

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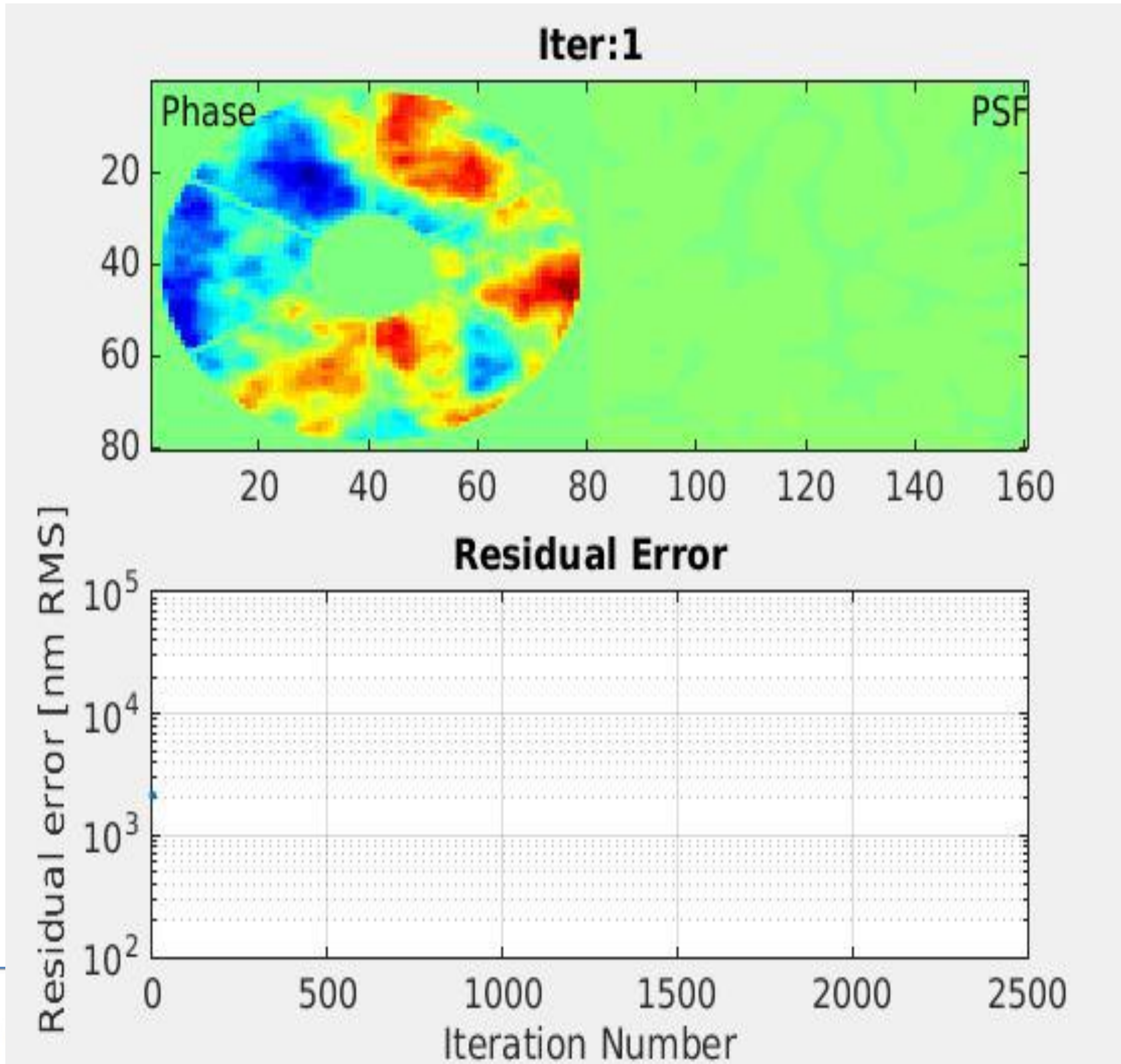

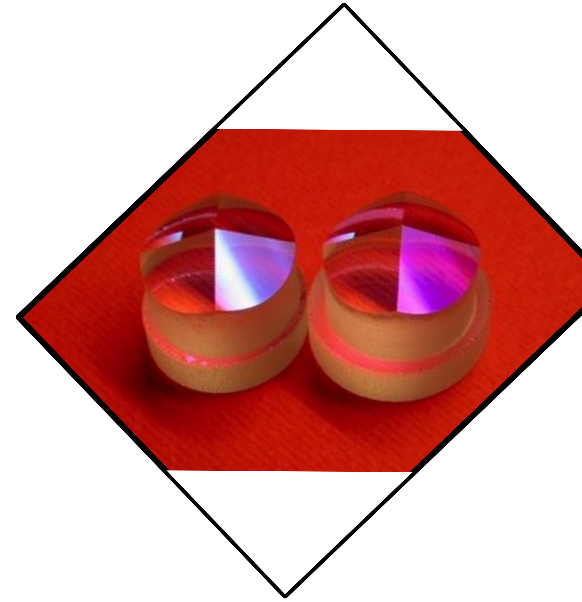

SCAO system baseline is to use a pyramid WFS

- Better performance & better sensitivity
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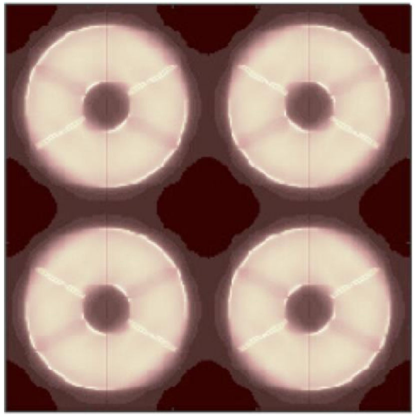
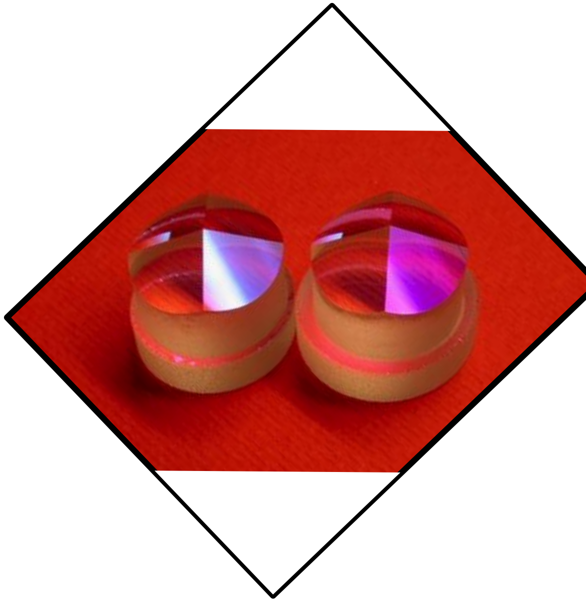
Small modulation provides information on what's behind the spider



+ Secret ingredient
See Noah Schwartz talk on Friday



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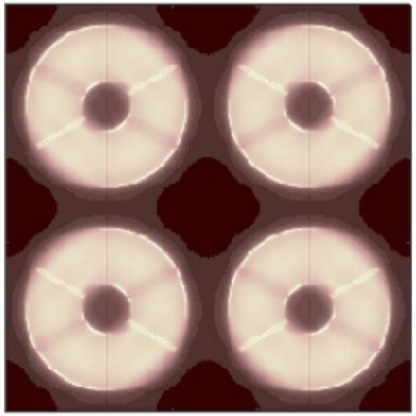

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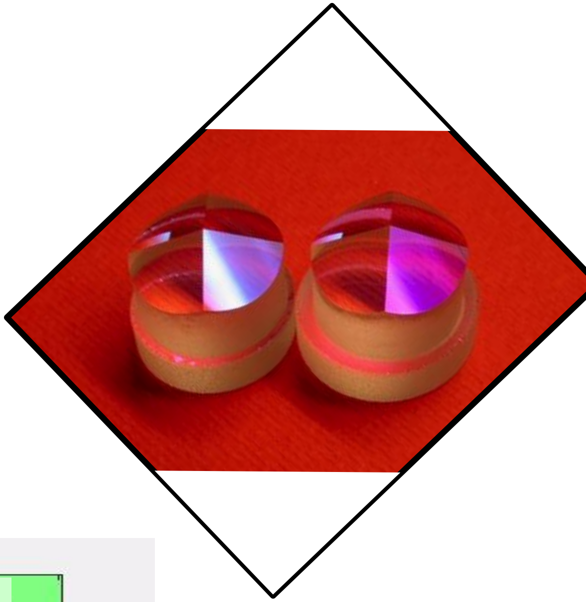
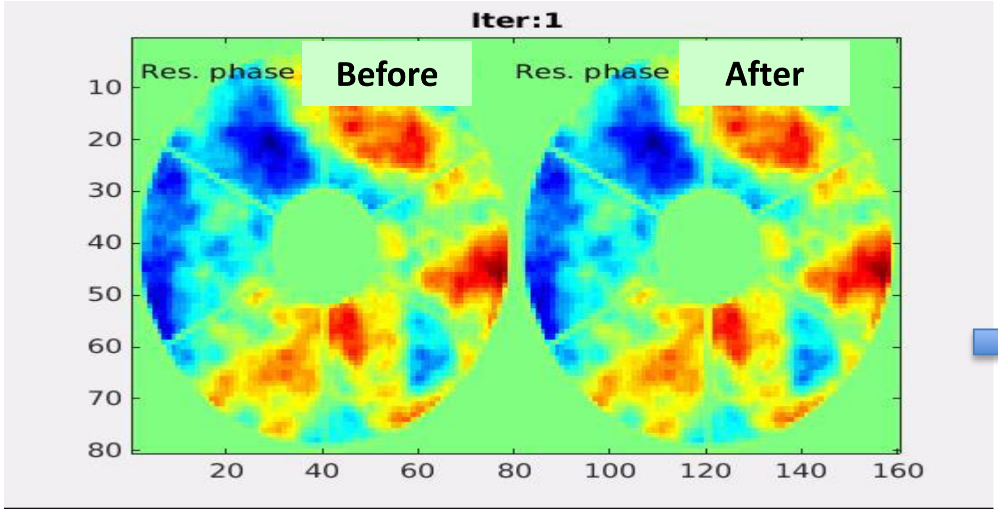




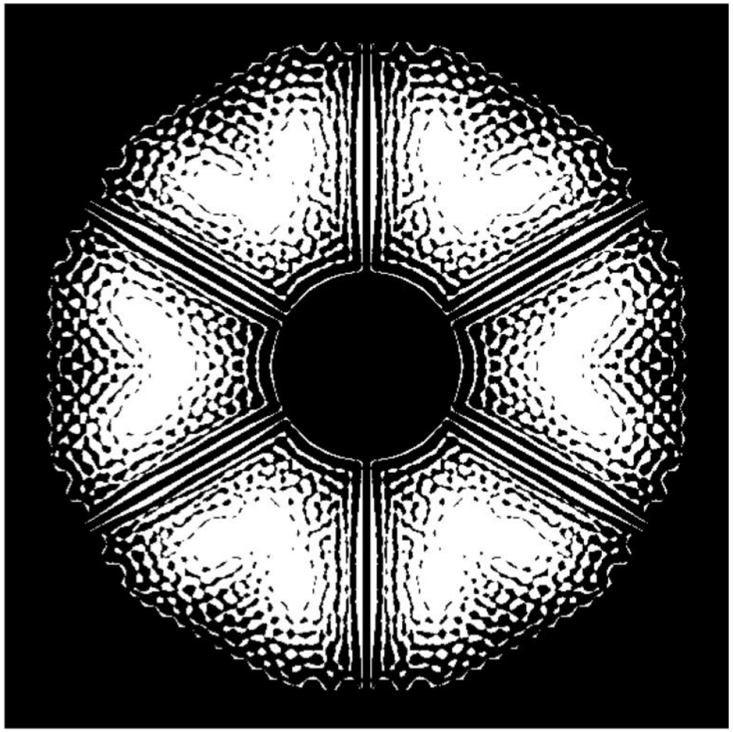
Residuals less than 50nm

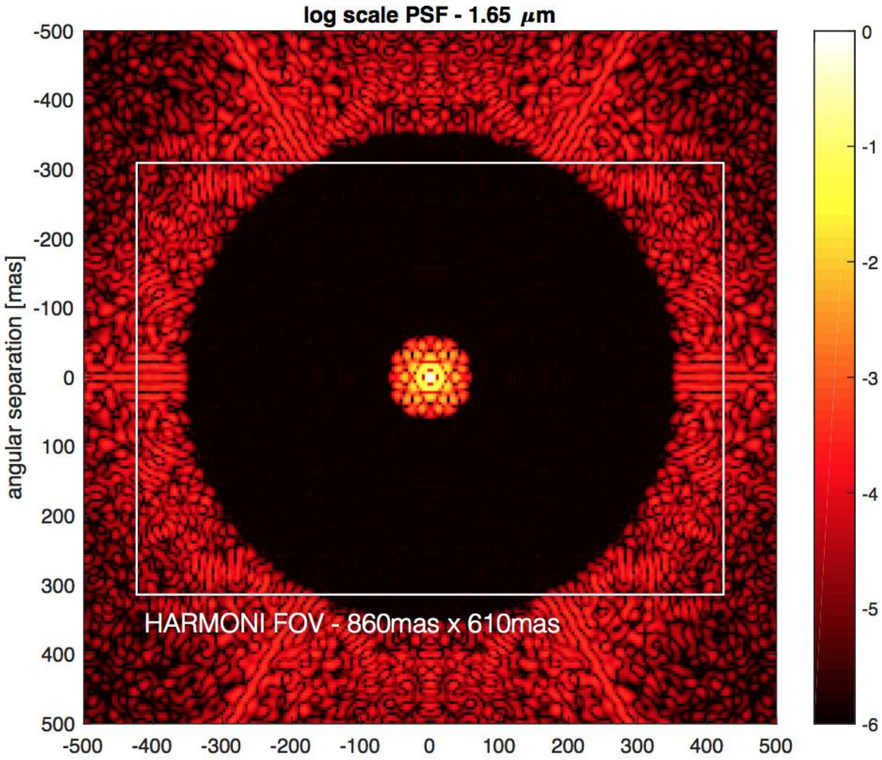
SCAO will provide a SR of >70% in K-band

High Contrast :

Spectral characterization of young Jupiters around nearby stars in H & K bands at R=3000-20000, with **a 10-6 contrast at 200mas**.

Shaped pupil transmission



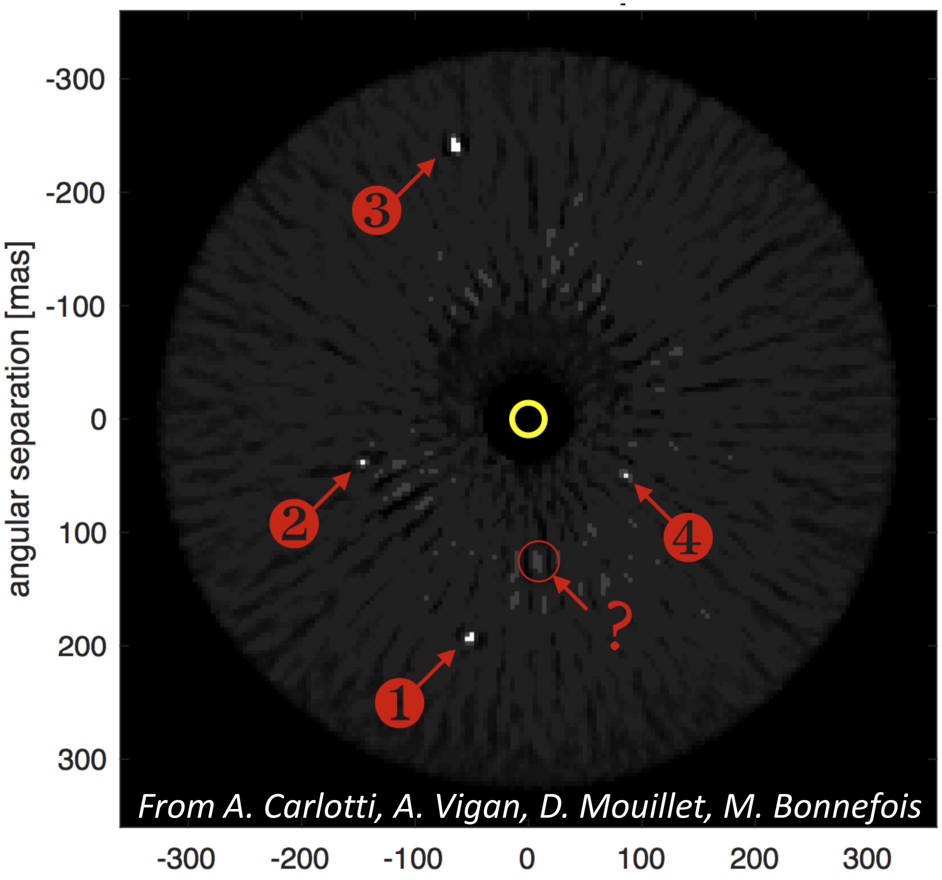


From A. Carlotti, A. Vigan, D. Mouillet, M. Bonnefois

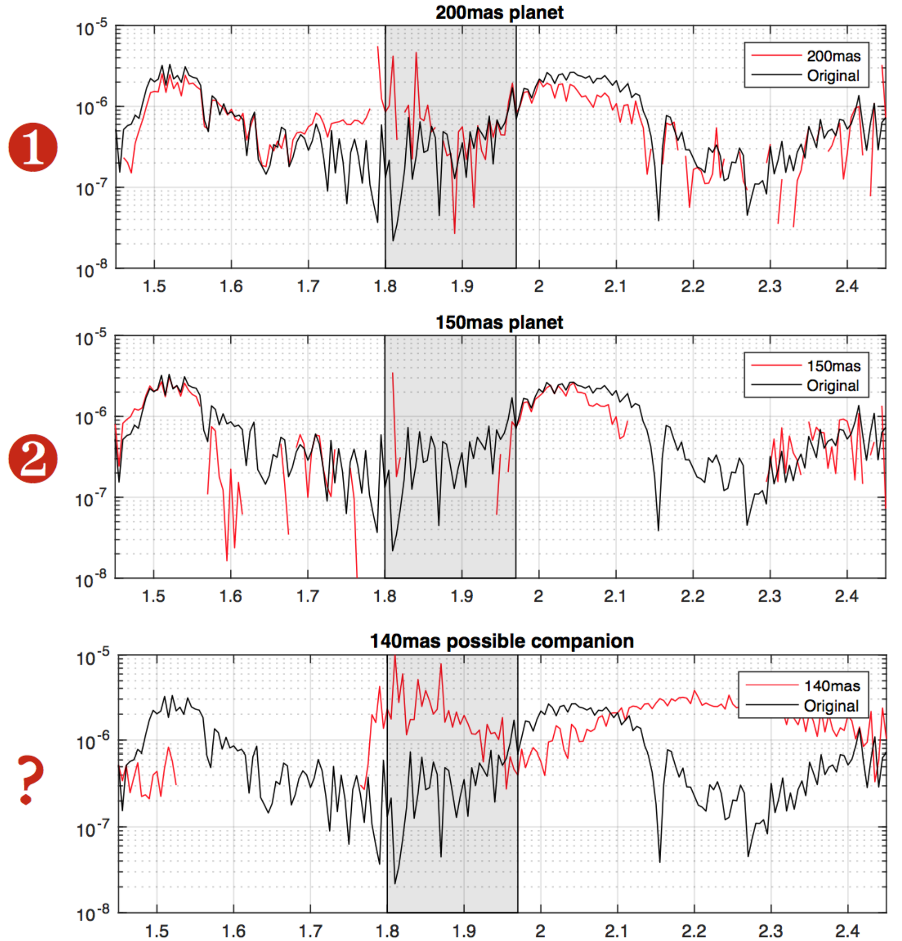
High Contrast :

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

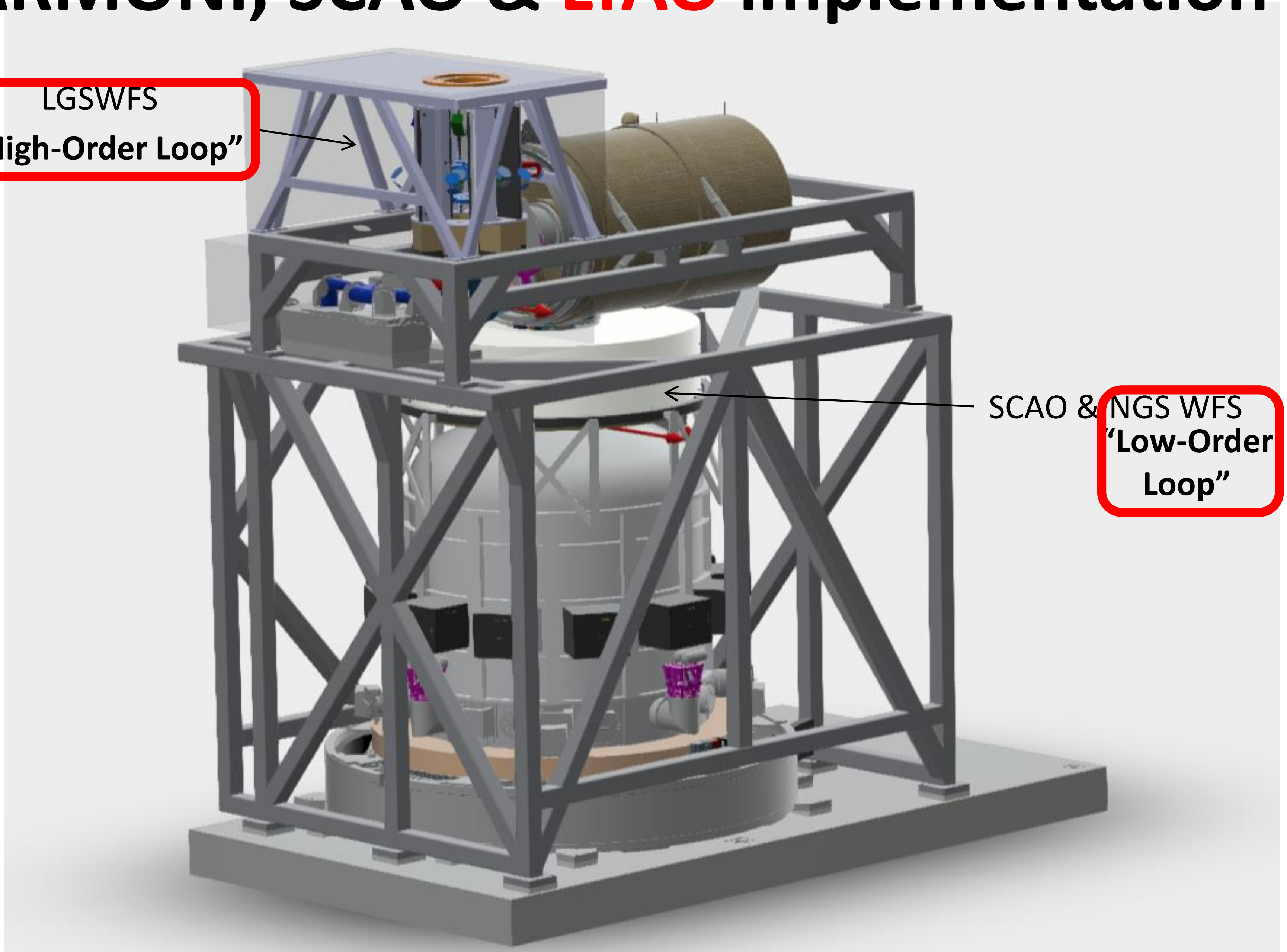
The 4 planets appear in the detection map



Extracted spectra



HARMONI, SCAO & LTAO implementation



LTAO Top-Level Specifications:

4 mas

Strehl K > 60%

Jitter < 2mas

Sky Coverage >10% at the Pole

10 mas 20 mas

EE (20mas) > 40%

Jitter < 5mas

Sky Coverage of >50% at the Pole

60 x 30 mas

EE (40mas) > 50%

Jitter < 10mas

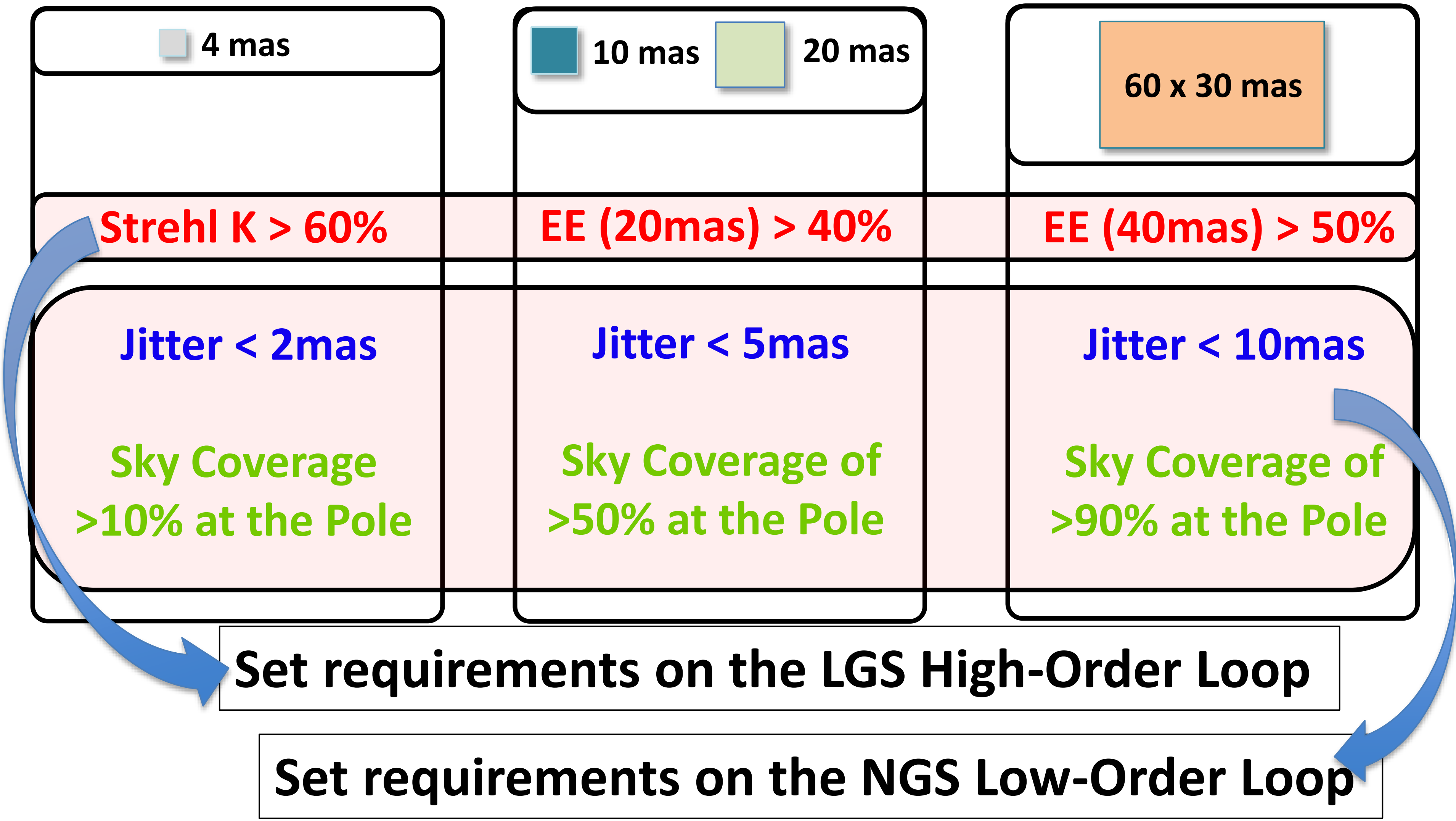
Sky Coverage of >90% at the Pole

LTAO Top-Level Specifications:

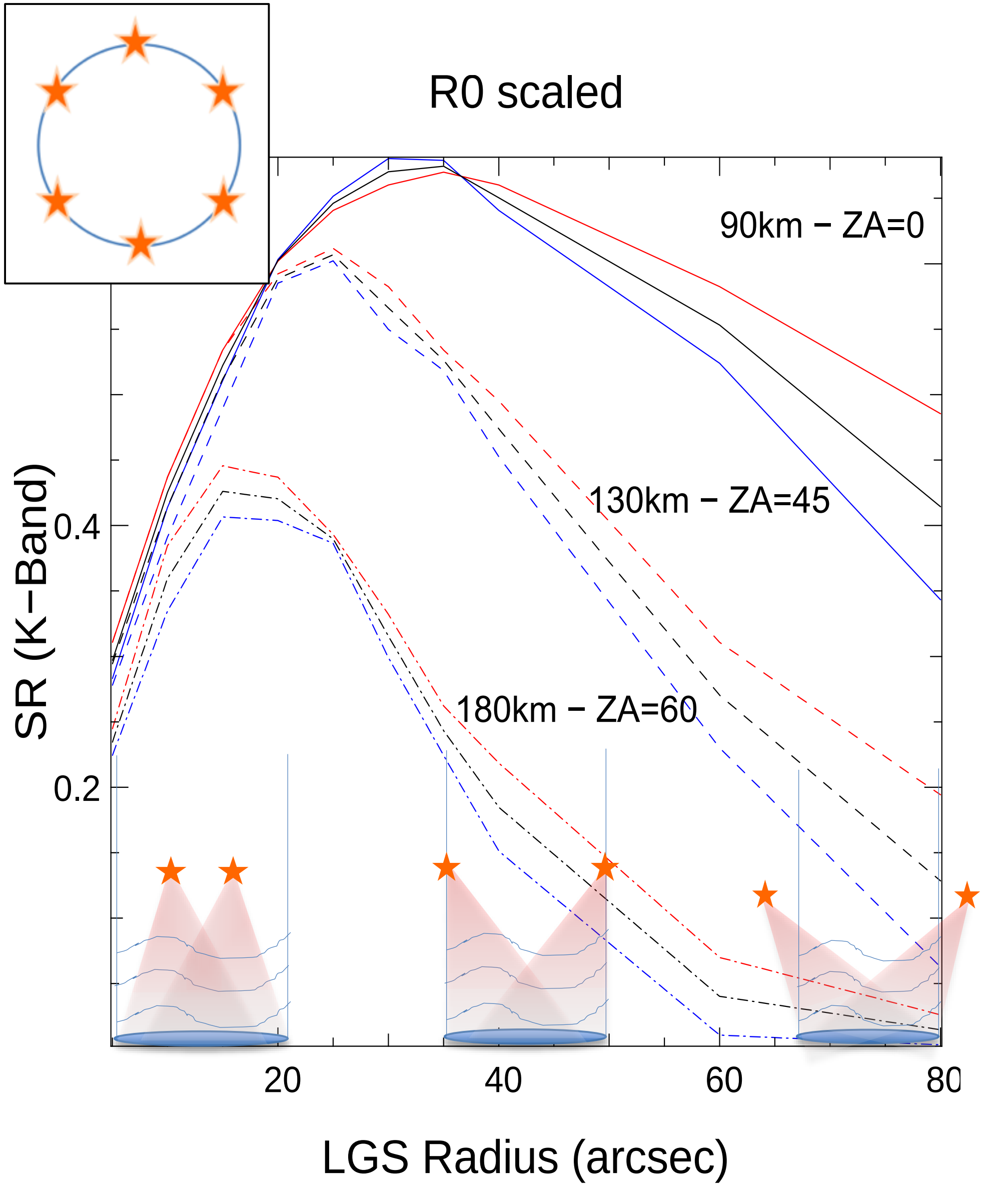
4 mas	10 mas / 20 mas	60 x 30 mas
Strehl K > 60%	EE (20mas) > 40%	EE (40mas) > 50%
Jitter < 2mas	Jitter < 5mas	Jitter < 10mas
Sky Coverage >10% at the Pole	Sky Coverage of >50% at the Pole	Sky Coverage of >90% at the Pole

Set requirements on the LGS High-Order Loop

LTAO Top-Level Specifications:



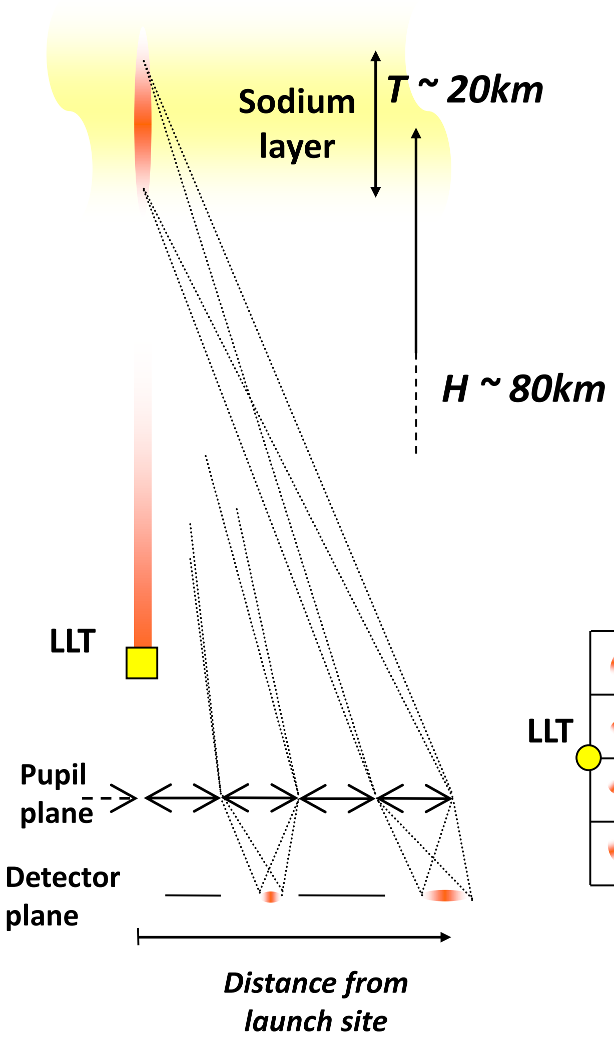
Laser constellation

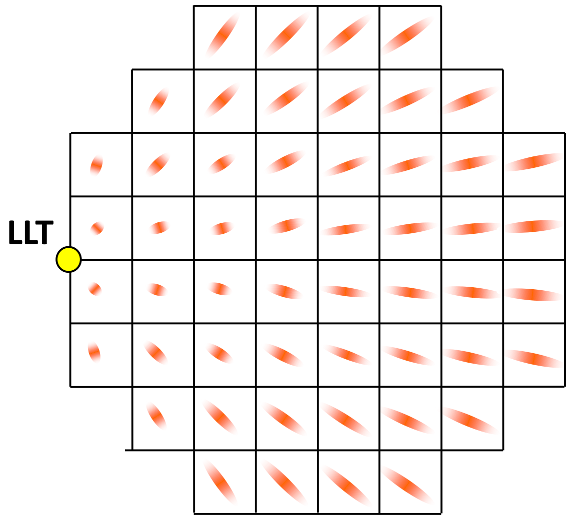


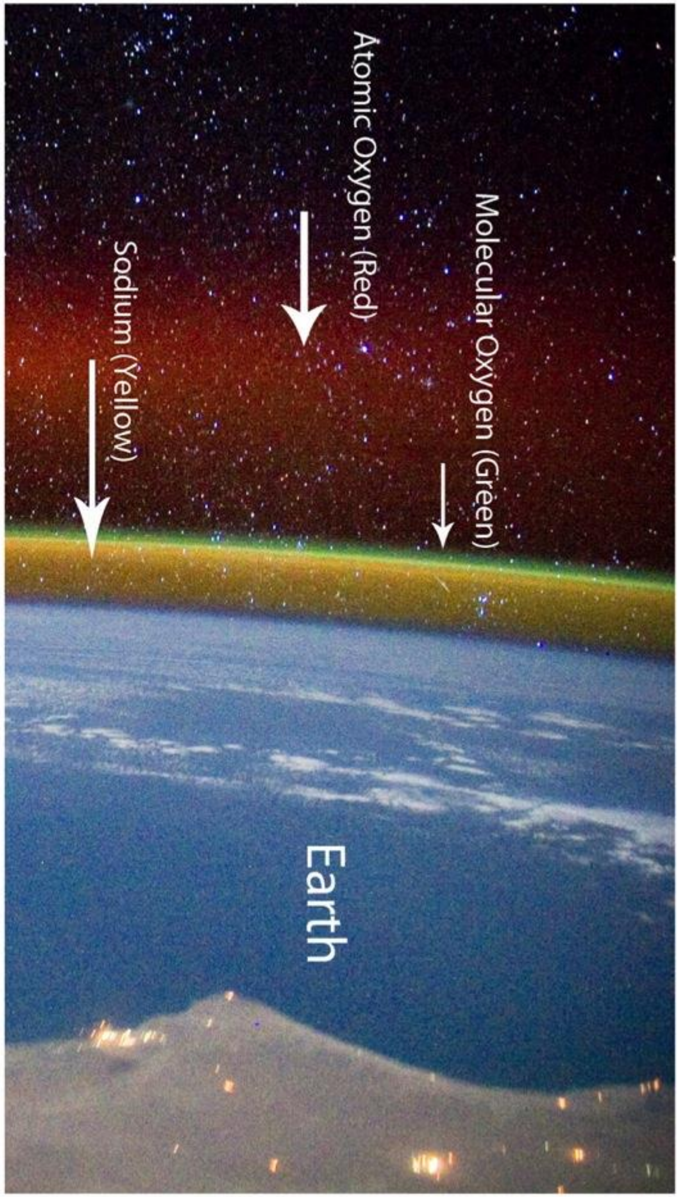
- **Optimal LGS constellation between R=[15-40]"**
- **"Small" constellation greatly helps for tomographic error**

See Thierry Fusco talk on Thursday

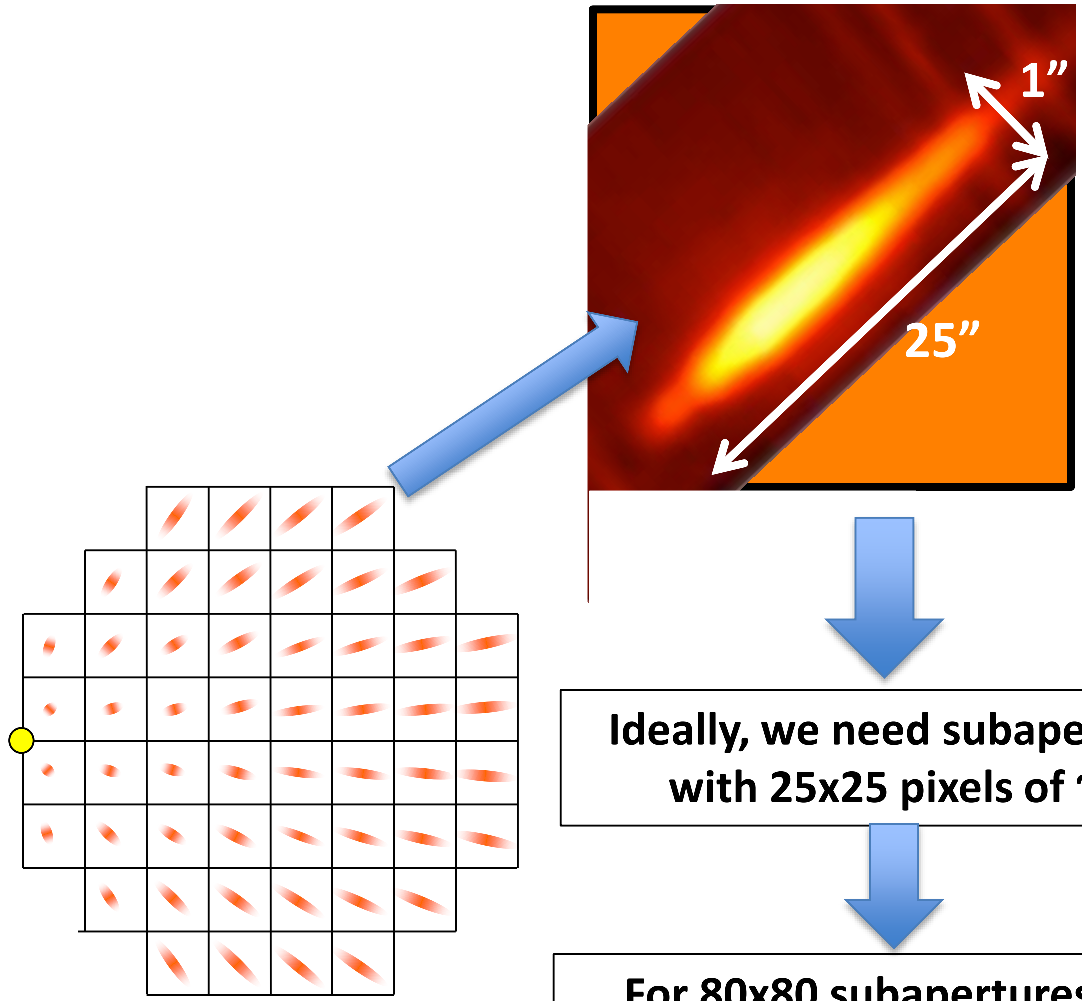
Sensing on LGS







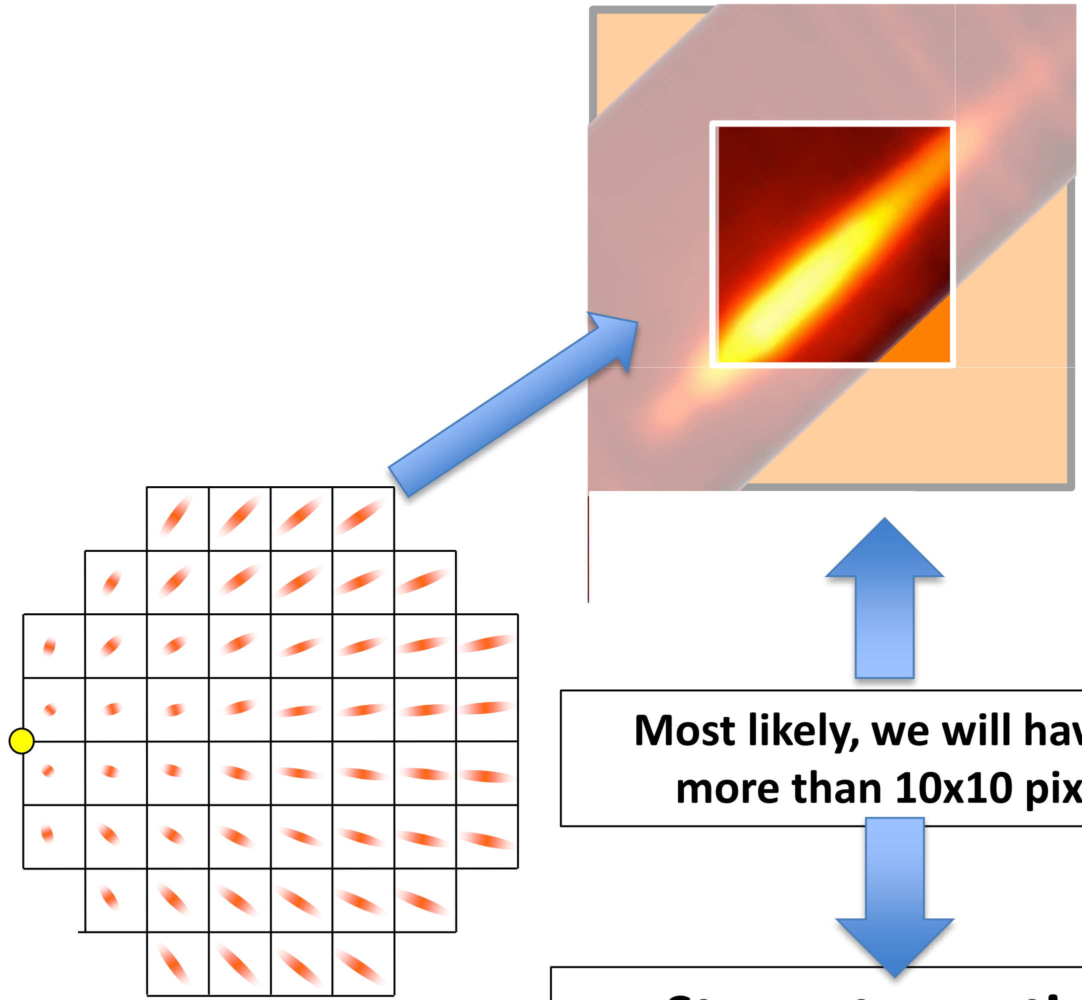
Dealing with spot elongation



Ideally, we need subapertures with 25x25 pixels of ~1”

For 80x80 subapertures, we need 2000 x 2000 pixels

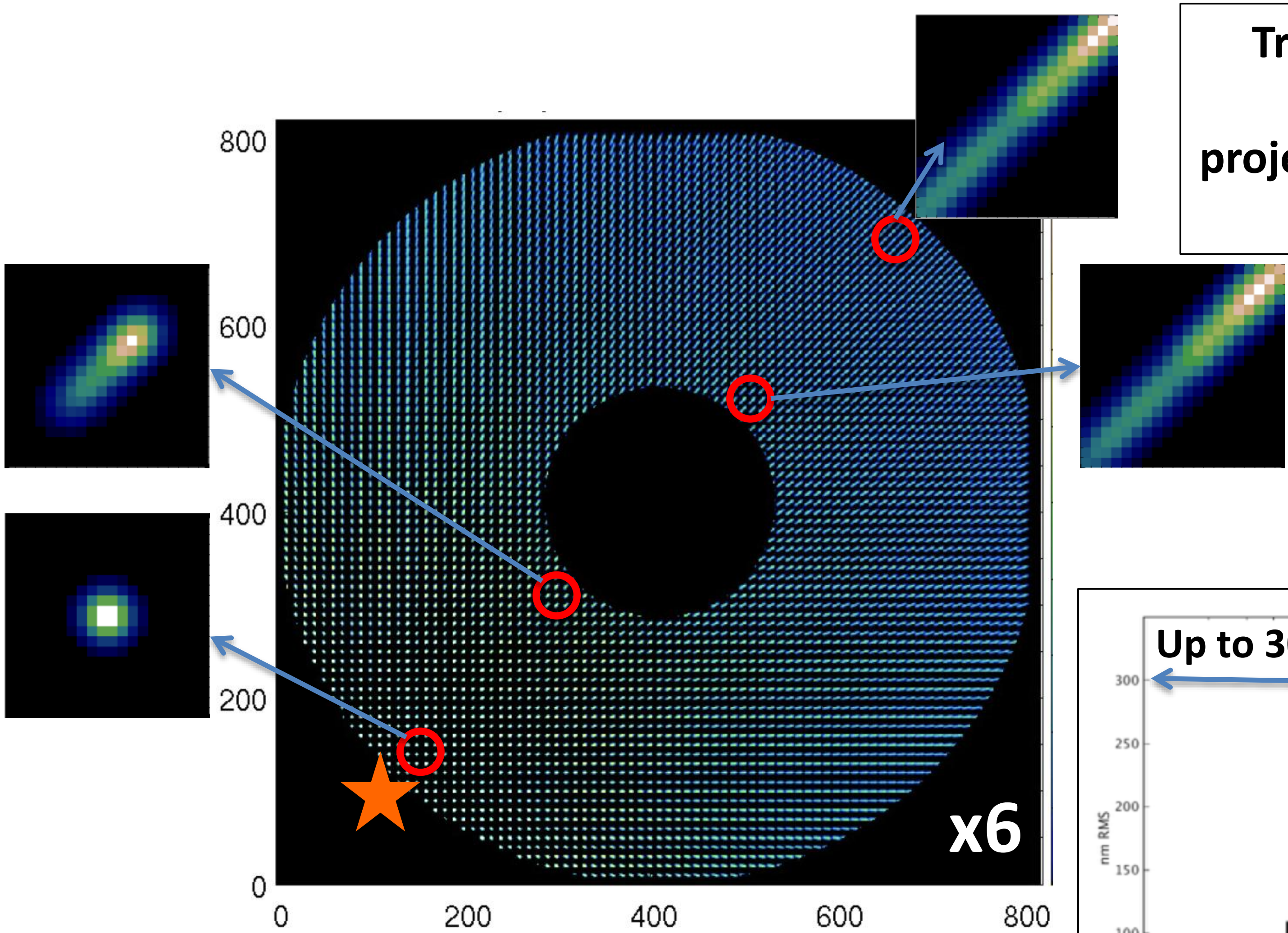
Dealing with spot truncation



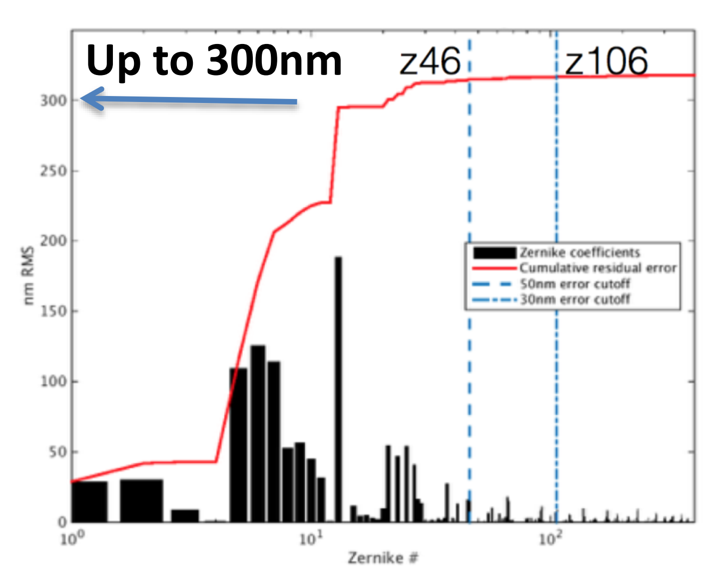
Most likely, we will have no more than 10x10 pixels

Strong truncation

Dealing with spot truncation



Truncation induces biases that are projected on-axis by the Tomography



See Leo Blanco talk on Thursday

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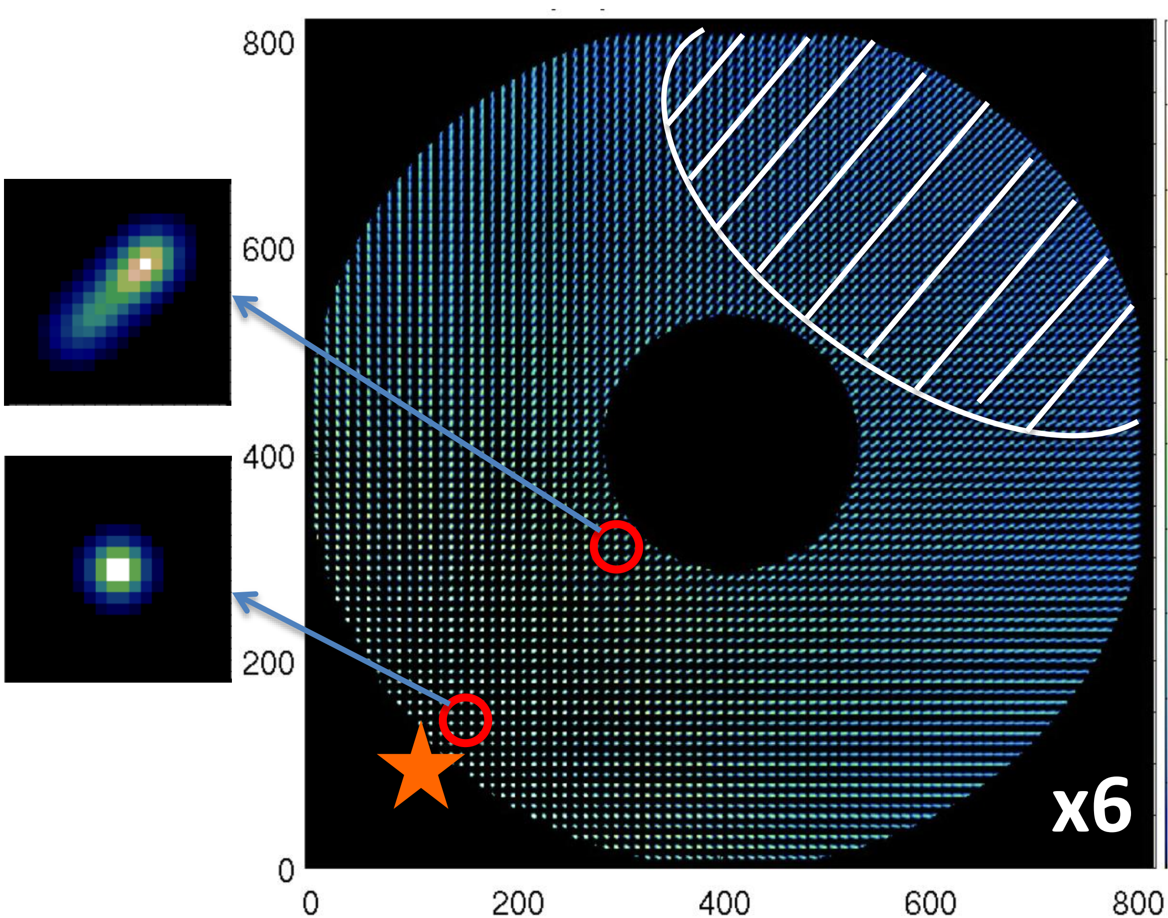
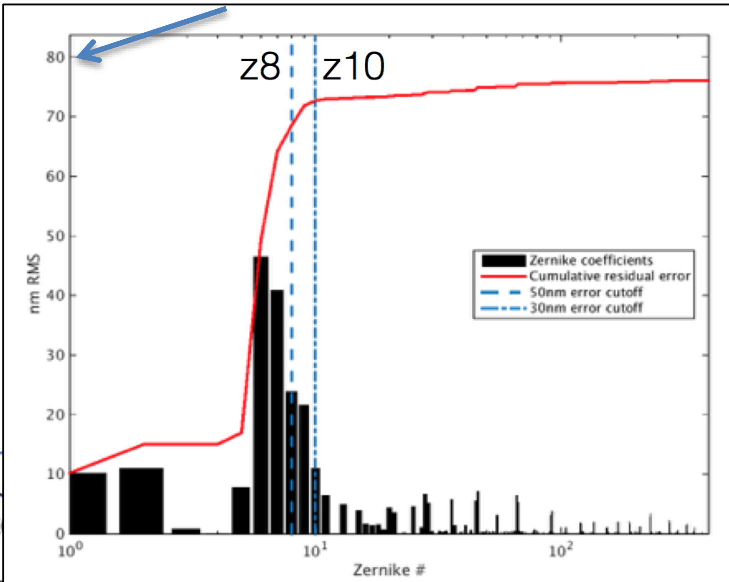
Dealing with spot truncation



One way to reduce this impact is to reject the truncated measurements

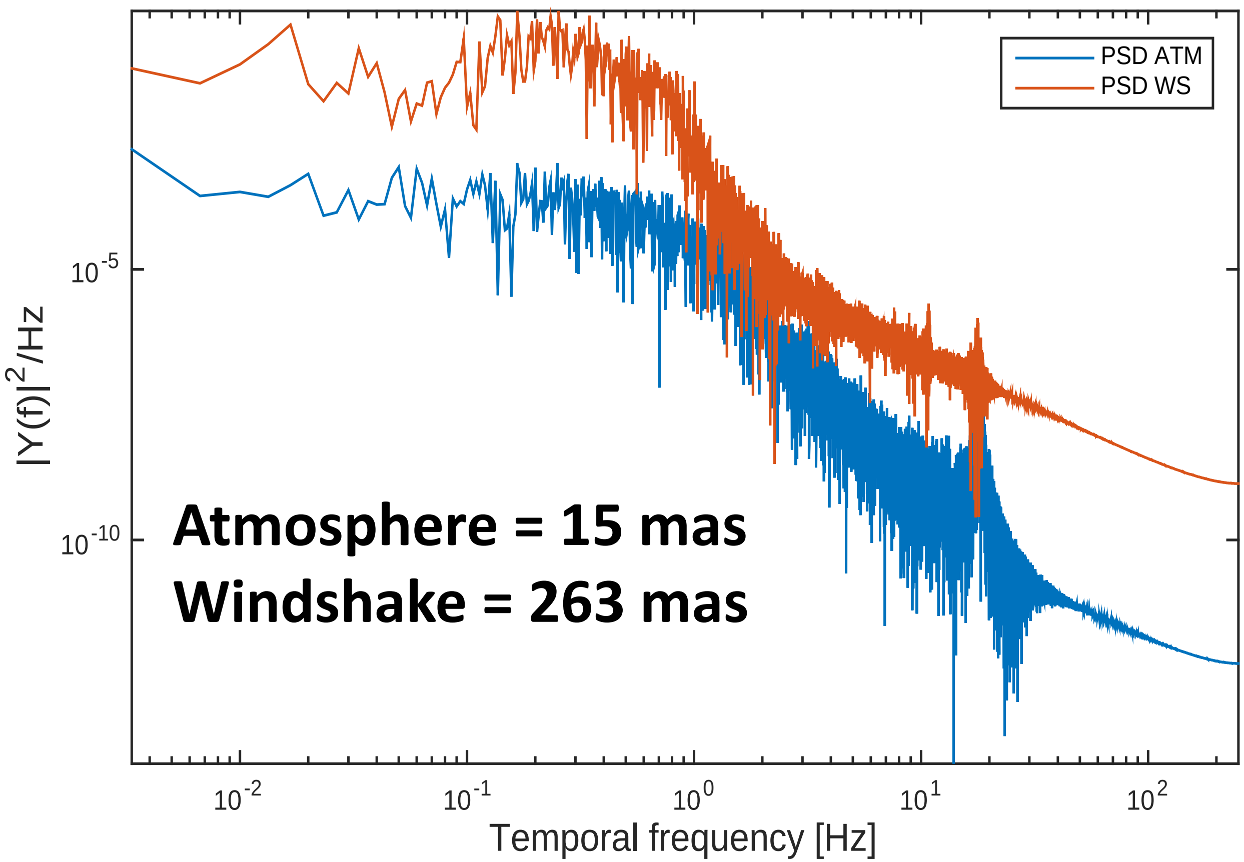
Down to 80nm



See Leo Blanco talk on Thursday

Sensing on NGS

Main offender is the telescope Windshake



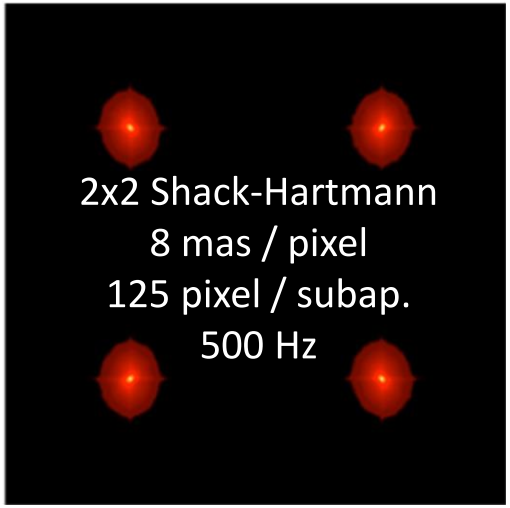
But windshake is isoplanatic: we can use the telescope WFS to reduce it

Sensing on NGS

Jitter control strategy:

- Use “bright but far” stars to compensate windshake with telescope WFS
- Use “faint but close” star to compensate atmospheric jitter

1.2 to 2.2 microns



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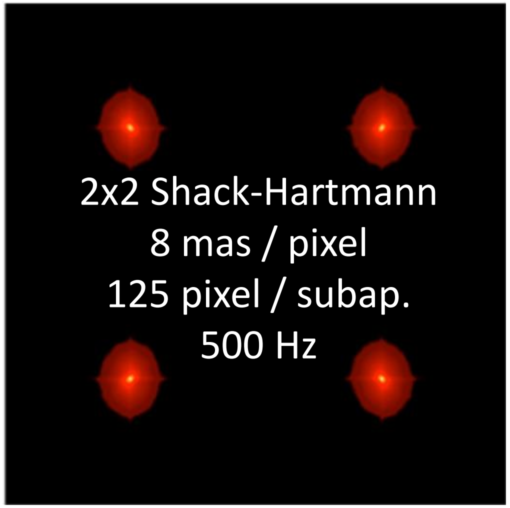
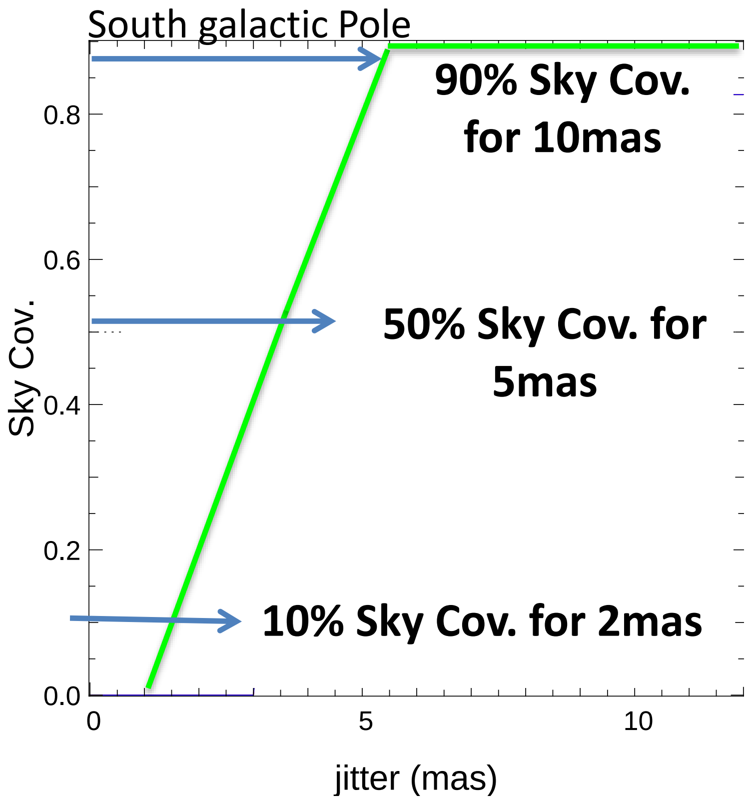
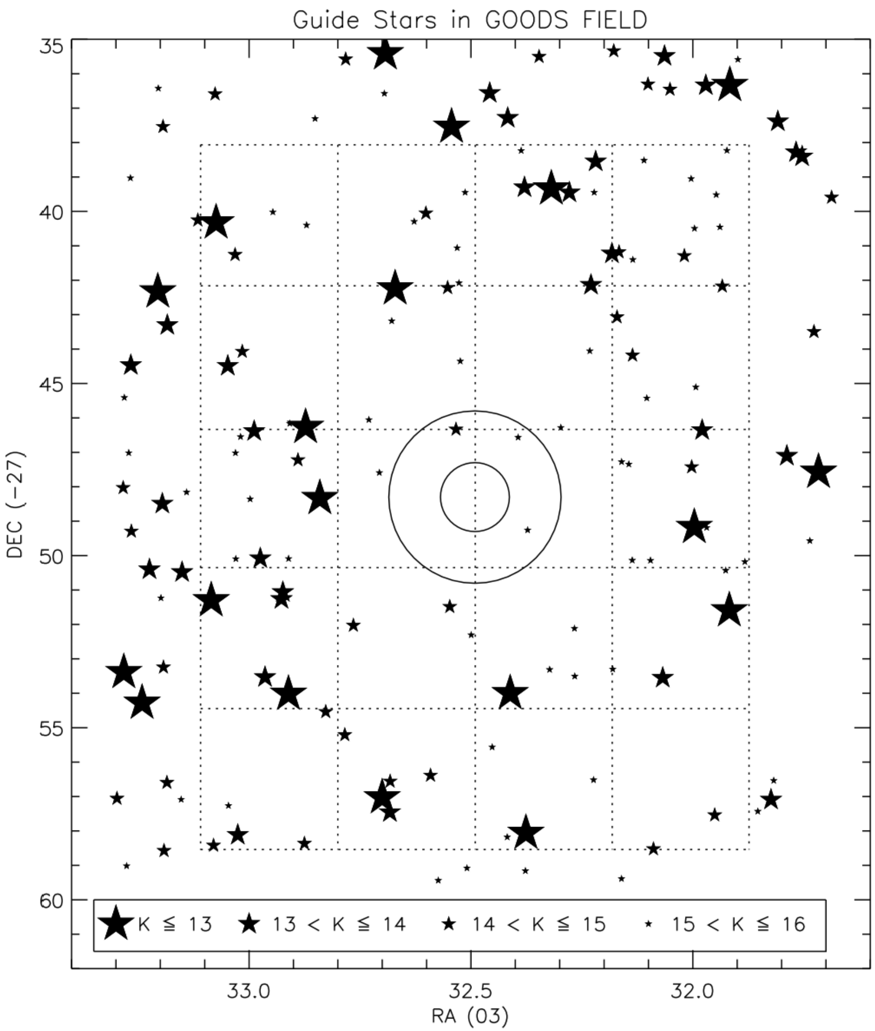
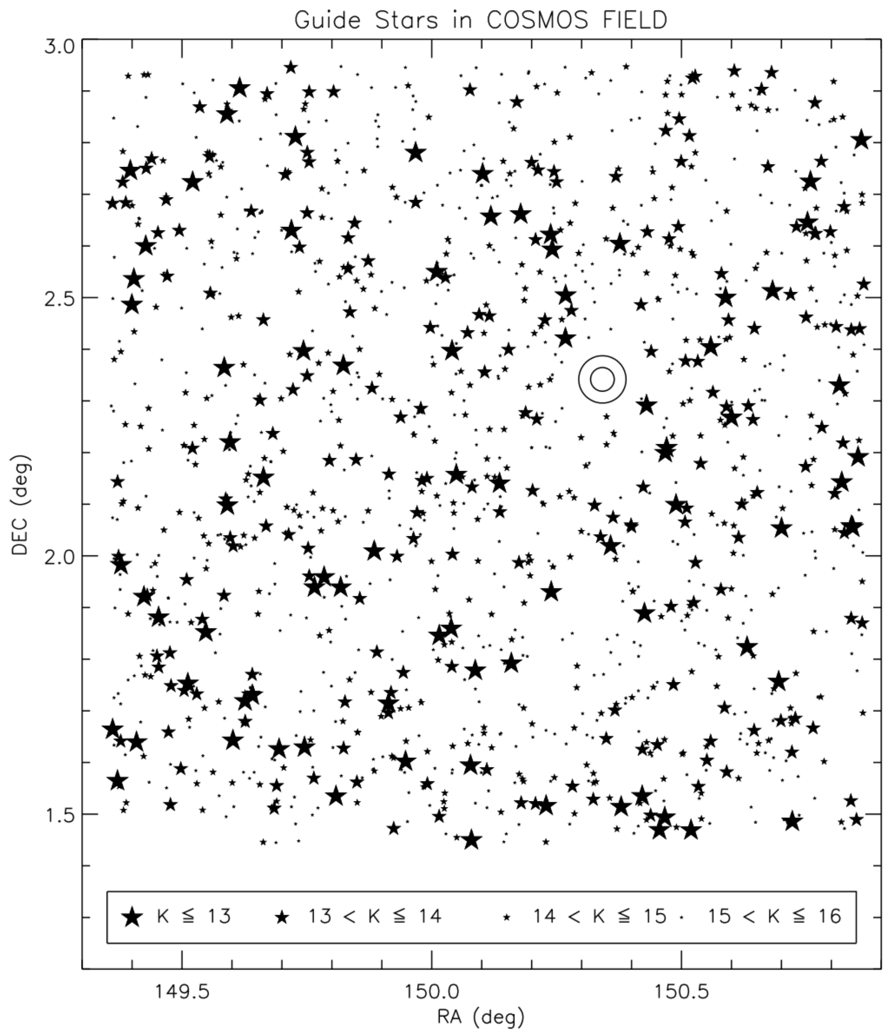




See Carlos Correia poster on Thursday

Sensing on NGS





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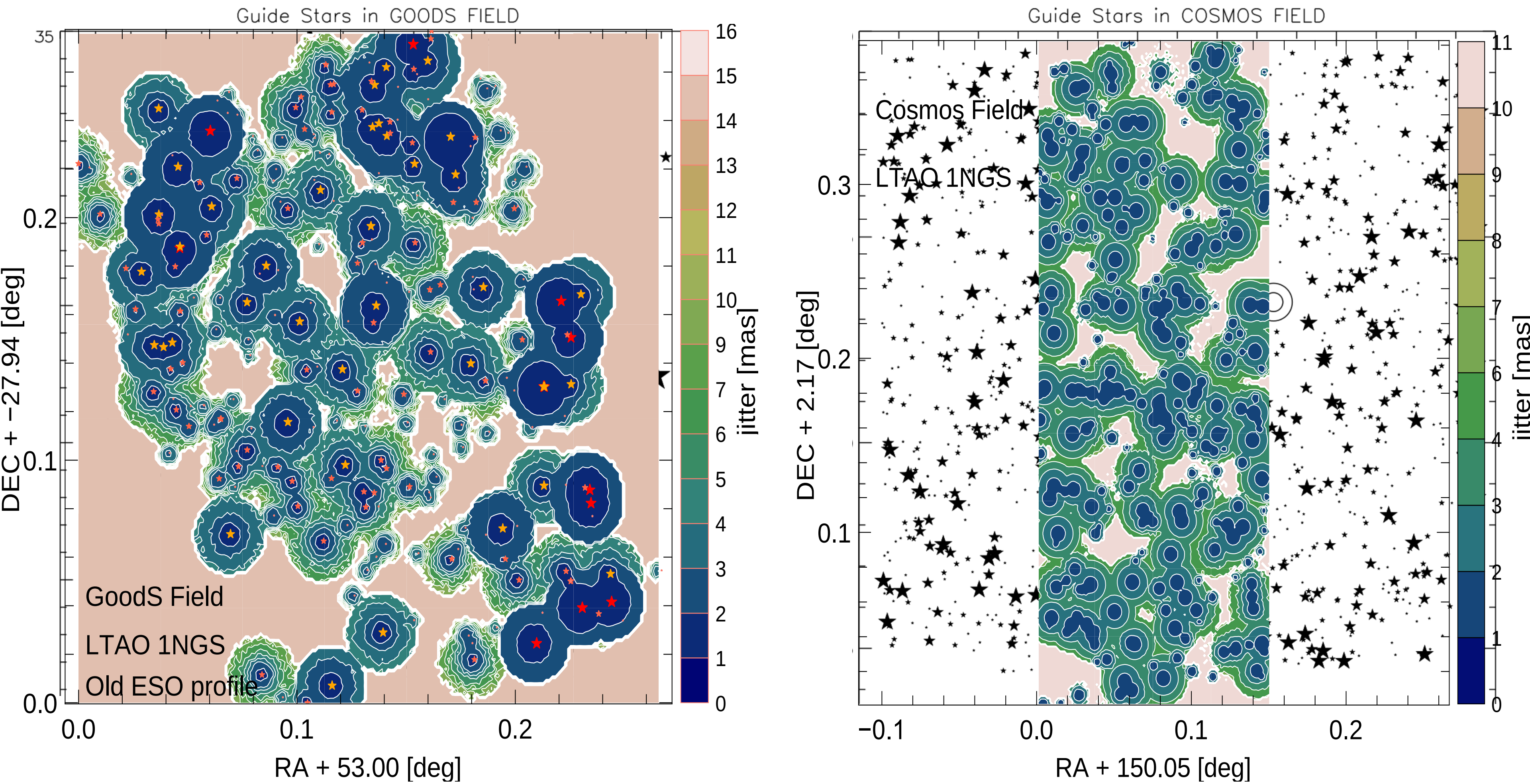
Sensing on NGS

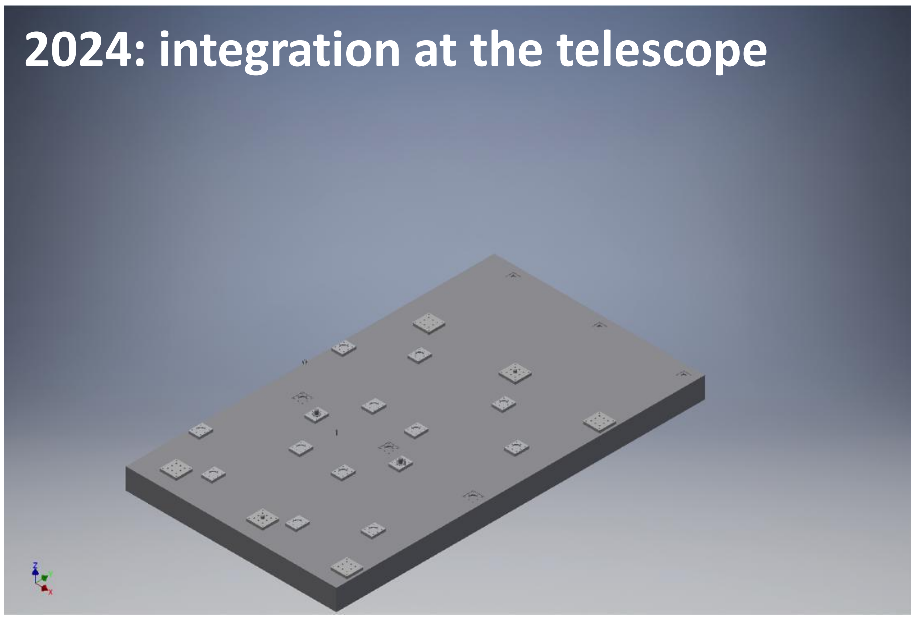


The NGS strategy fulfills the science requirements for all observations

Conclusion: HARMONI schedule

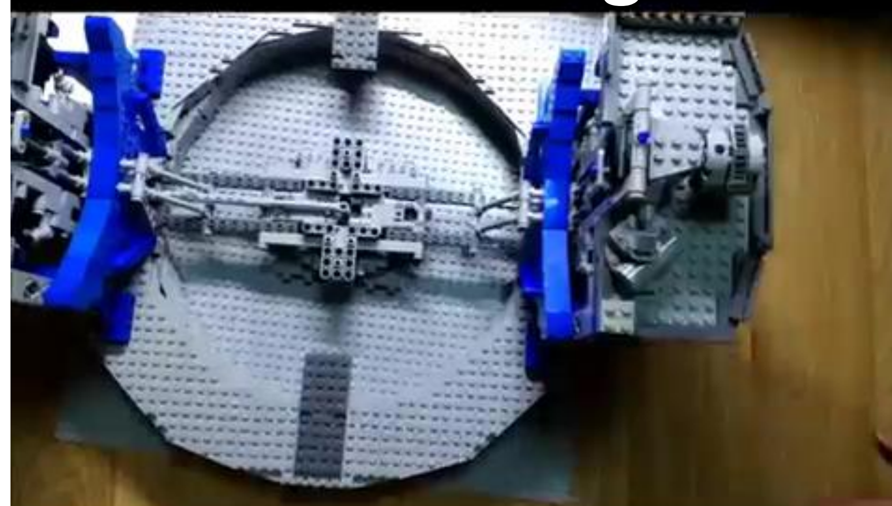
Conclusion: HARMONI schedule

12/2017	2019		2023
PDR	FDR	MAIT	



HARMONI

2024: 1st light !



Dr. Frans Snik

- The AO modes for HARMONI -

1 more slide before Coffee Break !

LABORATORIO NAZIONALE ADONI OTTICA ADATTIVA

WaveFront Sensing in the VLT/ELT era II

2-4 October 2017
Padova, Italy
Europe/Rome timezone

https://www.ict.inaf.it/indico/event/521/

- Overview
- Loc & Soc
- Registration
  - Registration Form
- Participant List
- Venue
- Accomodation
- How to reach Padova
- Photos
- Gender Equity

After the first WorkShop in Marseille we announce the second edition of the WaveFront Sensing in the VLT/ELT era. The Workshop will take place in Padova, Italy, at the local Botanical Garden, from 2 to 4 October 2017.

WaveFront Sensing is at the heart, and a key component, of an Adaptive Optics system and often it dictates the ultimate capabilities of the latter, especially in the astronomical domain. The new challenges dictated by the development of some science field, like the exoplanets detection and characterization, pushed the development of these devices, along with new opportunities coming from new generation of instrumentations for 8m class telescopes and the construction of a next generation of Extremely Large Telescopes.
In this scenarios new technologies, new developments, new concepts, and new ideas, circulated in the framework of WaveFront Sensing.
The parameter's space where such devices are requested to push their limits beyond the current one – and sometimes beyond what is believed to be their ultimate limits- become increasingly large and to some extent complex. Wide field, use of artificial references from large apertures, new level of accuracy in the compensated wavefront –just to mention a few examples- are just among the new kind of challenges where detector's technology, ideas and devices are requested to compete in a race for the ultimate performance in terms of contrast, field of view, sky coverage, to name a few examples.

Register now, for the 2 to 4 October 2017 in Padova, Italy

LABORATORIO NAZIONALE ADONI OTTICA ADATTIVA

WaveFront Sensing in the VLT/ELT era II

2-4 October 2017
Padova, Italy
Europe/Rome timezone

https://www.ict.inaf.it/indico/event/521/

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Marseille 2016

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SCAO system baseline is to use a pyramid WFS

- ➢ Better performance & better sensitivity