The EAGLE instrument for the E-ELT, developments since delivery of Phase A

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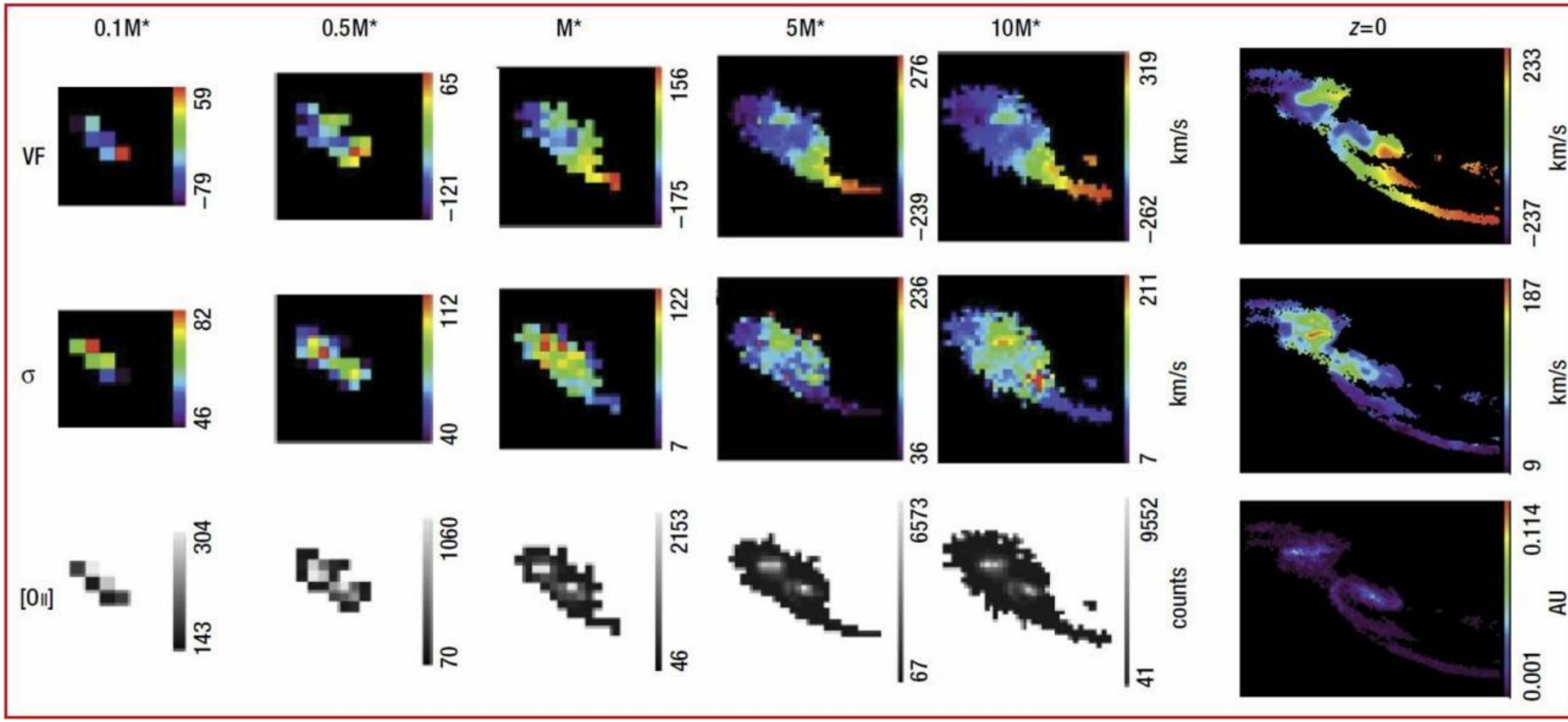
Outline

- (A quick reminder of) The Case for EAGLE
- What is multi-object adaptive optics?
- EAGLE Updates since Phase A
- CANARY results

Logic for EAGLE

- E-ELT designed and costed to deliver a potentially diffraction limited performance across 10 arcmin diameter focal plane (5 mirrors).
- Not affordable to pave whole focal plane with pixels at the diffraction limit (100k x 100k NIR pixels) even for just imaging.
- Surface density of plausible targets about 1 per square arcmin, each about 1 arcsec across.
- Just correct and observe around each individual target. Collect targets across whole field of view.

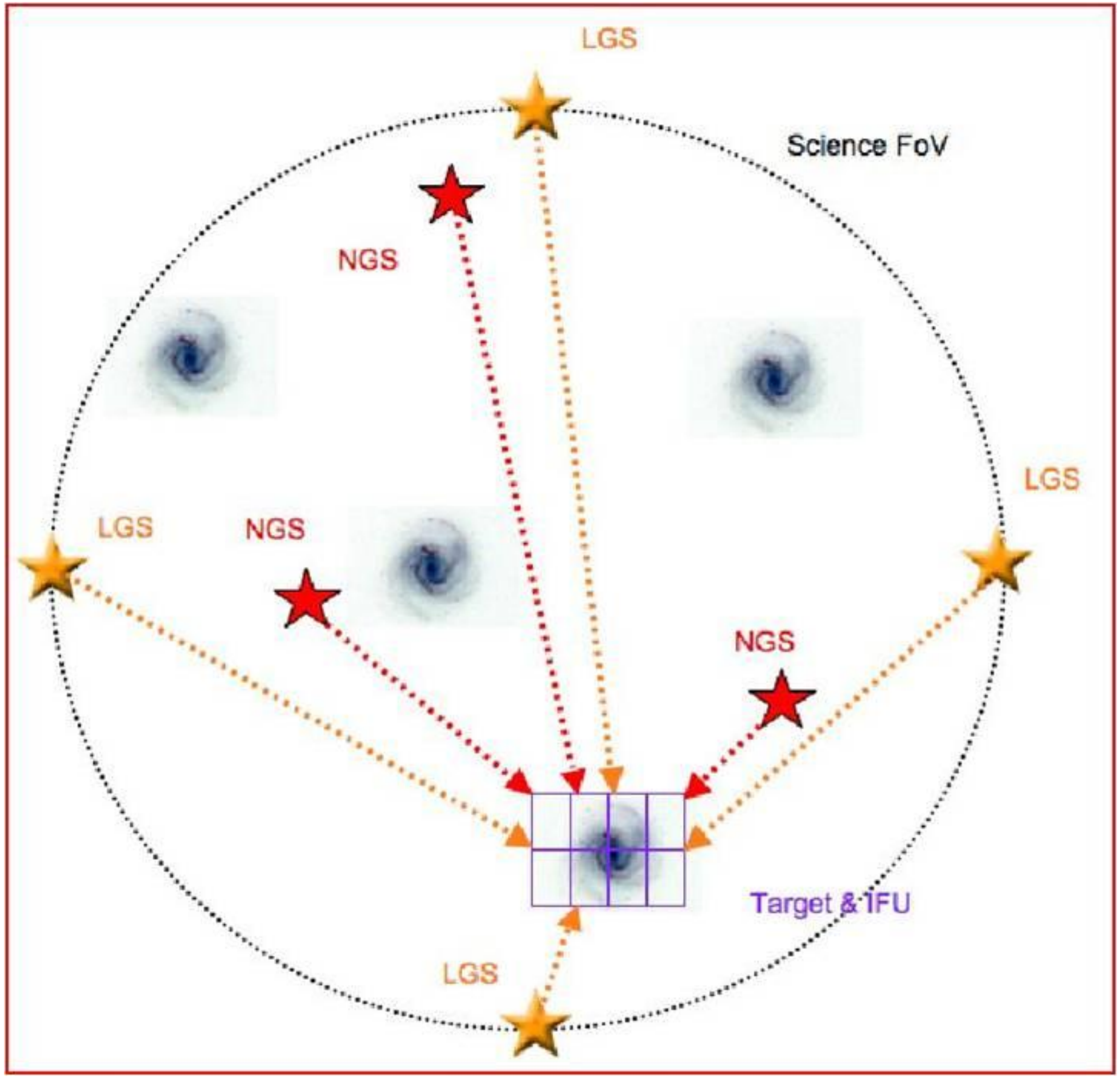


Simulated EAGLE observations of a major merger at z = 4 (Puech et al. 2010), with the input template (z = 0) shown on the right-hand side. The simulations are shown as a function of the characteristic galaxy mass (M*), with the upper panels showing the recovered velocity field; central panels: velocity dispersion; lower panels: emission-line map. We are currently limited to study of a handful of lensed high-redshift systems (e.g. Swinbank et al. 2009) but such observations will be routine for EAGLE, with its multiplex enabling efficient surveys.

What is MOAO?

- **M**ultiple **O**bject **A**daptive **O**ptics
- A technique for extending Adaptive Optics correction to multiple objects distributed within a very wide field of regard
- Planned operating mode for several facility class instruments:
  - RAVEN on Subaru
  - Keck NGAO
  - EAGLE on the E-ELT
- Involves Open Loop Correction AND tomography
  - New!

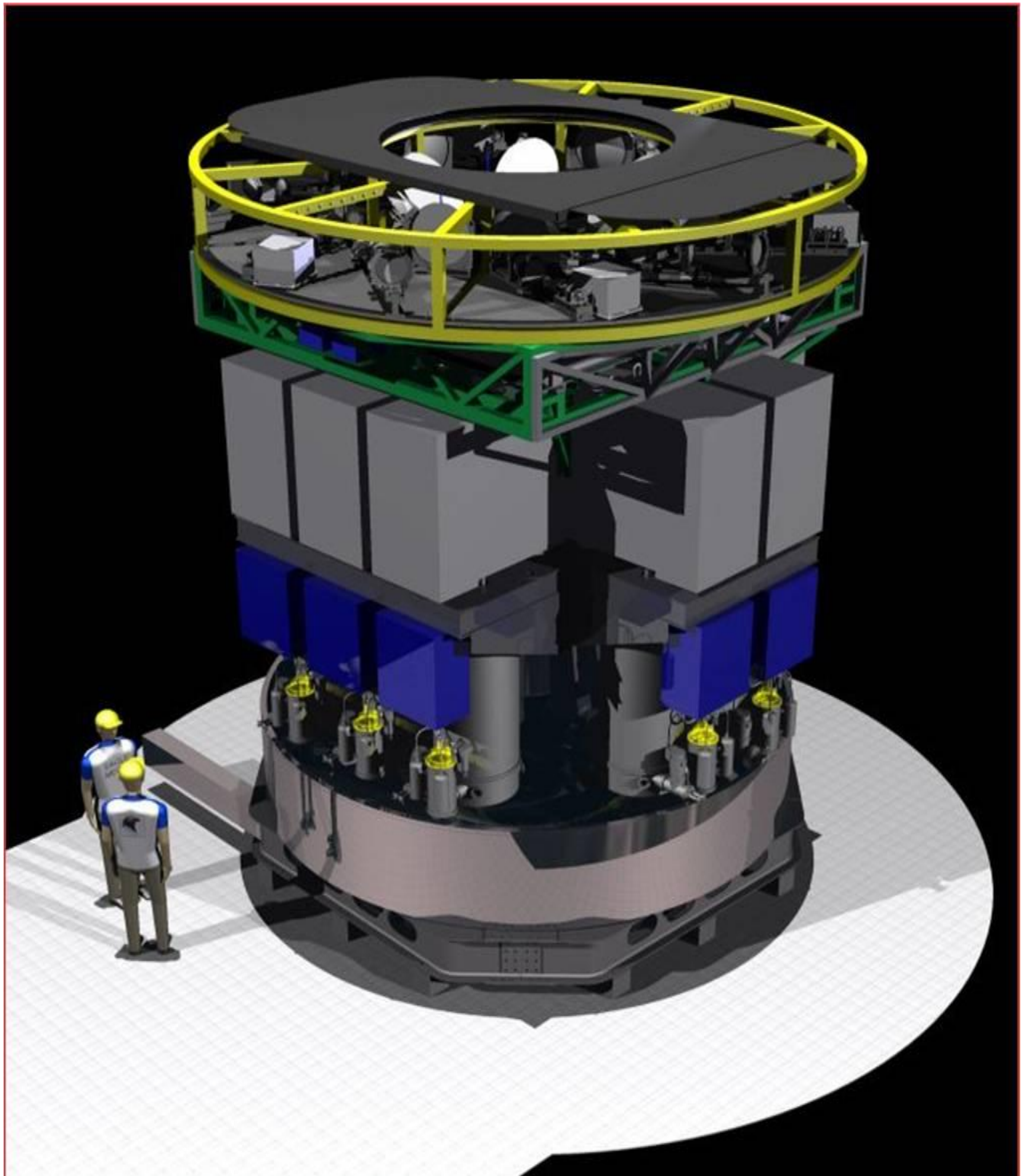
How does MOAO work?



Tomographic
Wavefront
Sensing

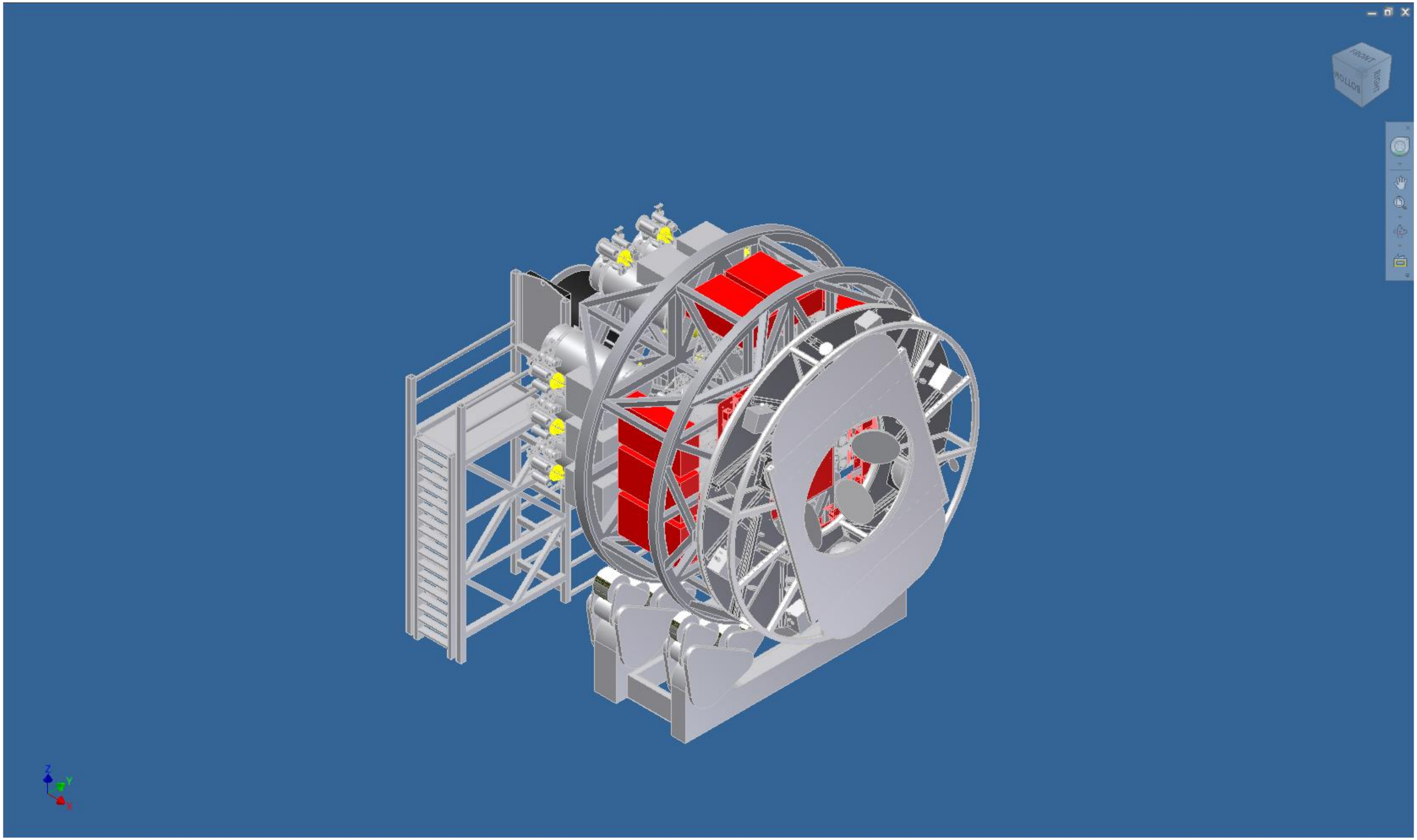
EAGLE Work Ongoing

- Design to fit Nasmyth (ESO delta Phase-A bid)
- Simplifying Spectrometer (Single mode instrument, R=8000)
- System Modelling:
  - AO end-to-end modelling, MOAO+GLAO, Canary results.
  - Sensitivity to plate scale variations
- Discussions with Optimos/EVE Team

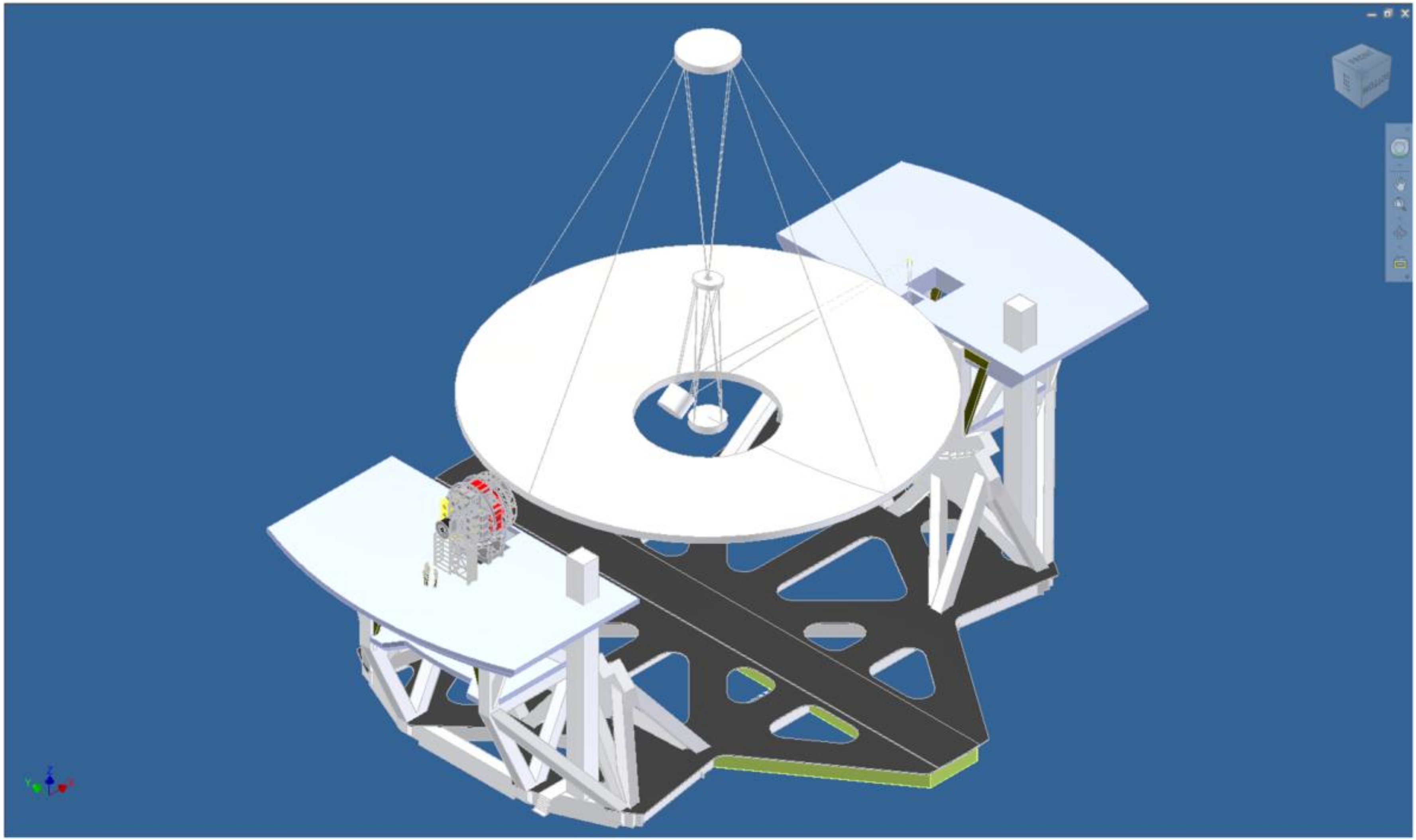


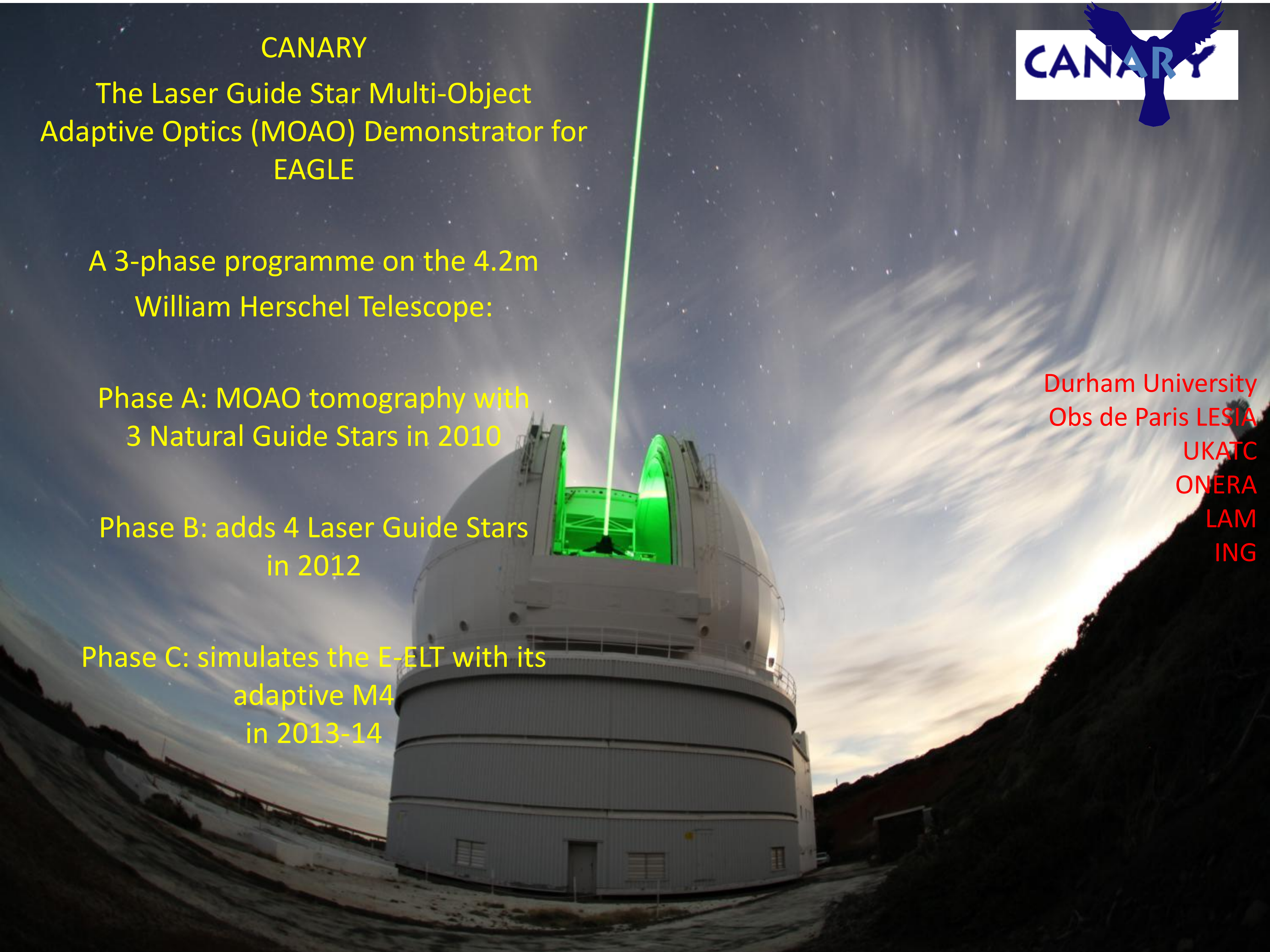
Original Phase A EAGLE design

First pass EAGLE mechanical support after rotation

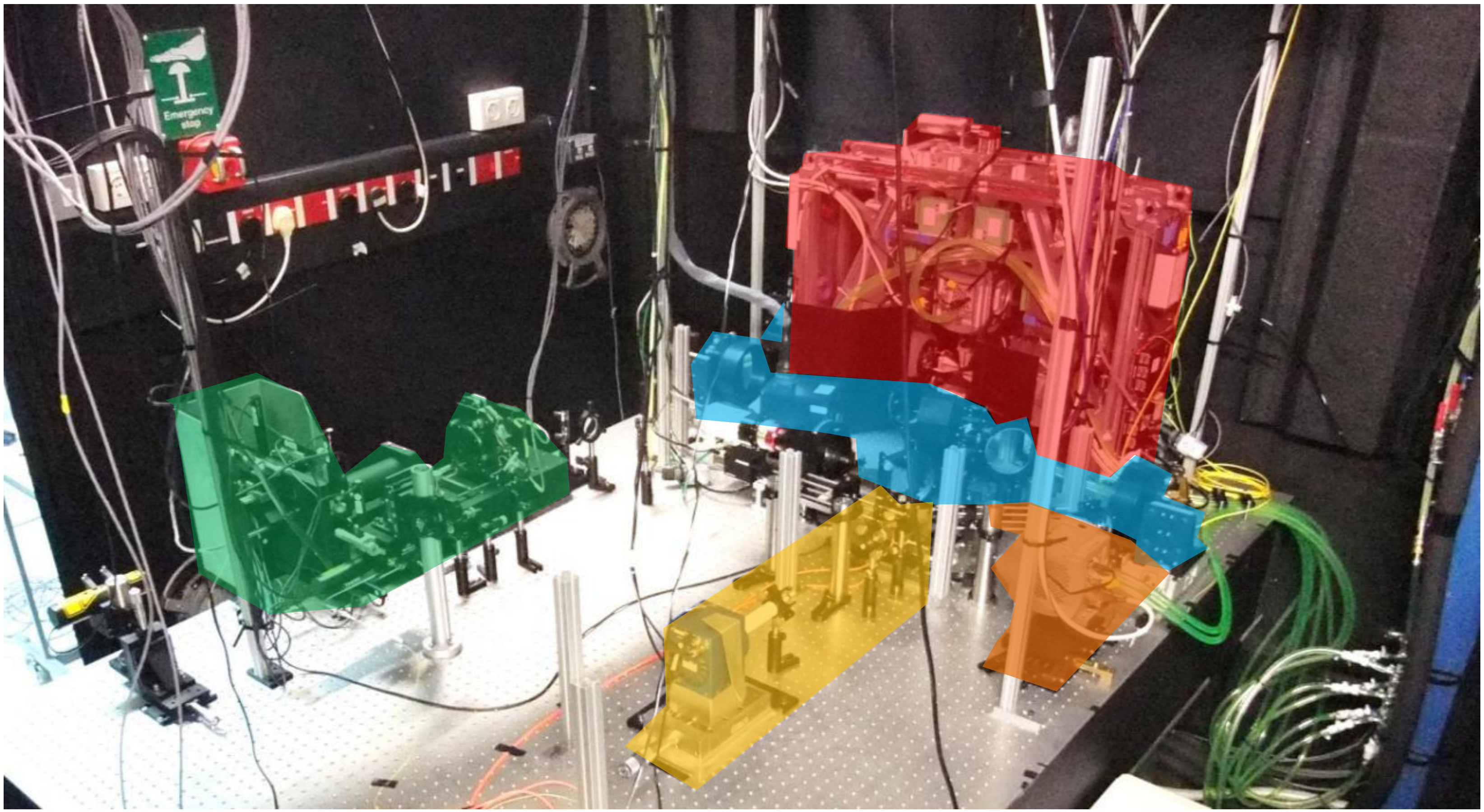


EAGLE on the E-ELT Nasmyth Platform

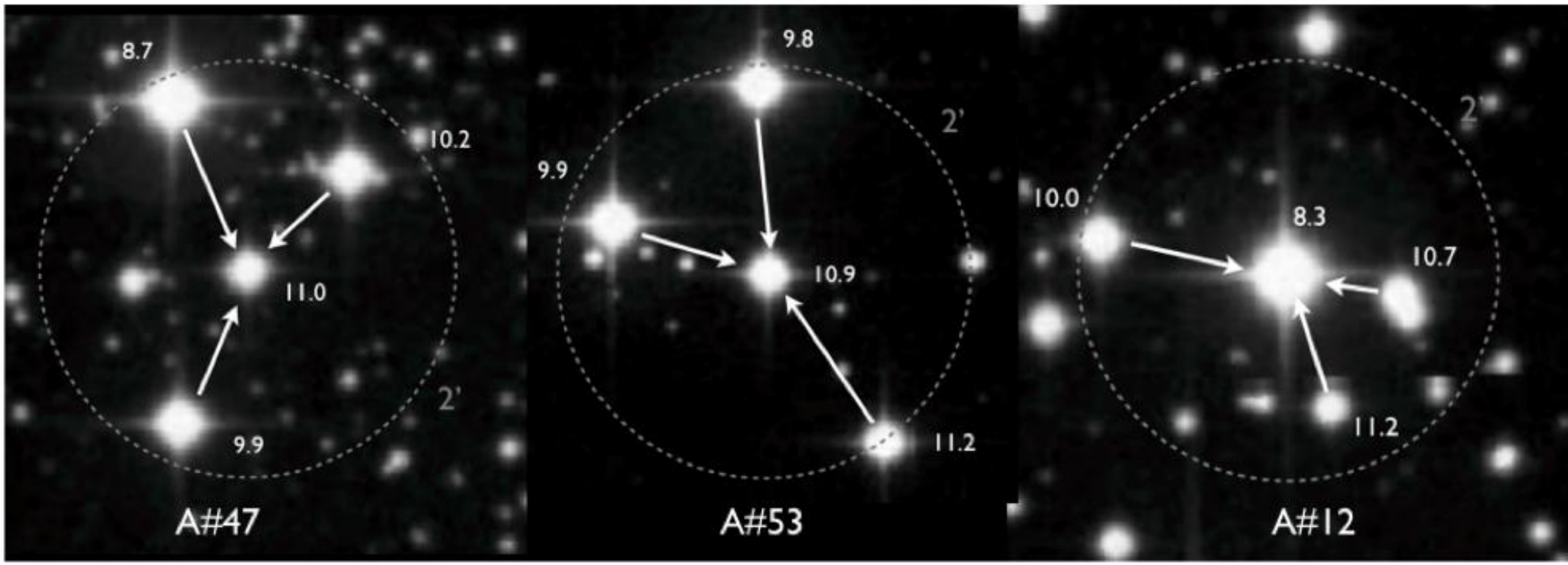



CANARY
The Laser Guide Star Multi-Object Adaptive Optics (MOAO) Demonstrator for EAGLE
A 3-phase programme on the 4.2m William Herschel Telescope:
Phase A: MOAO tomography with 3 Natural Guide Stars in 2010
Phase B: adds 4 Laser Guide Stars in 2012
Phase C: simulates the E-ELT with its adaptive M4 in 2013-14
Durham University
Obs de Paris LESIA
UKATC
ONERA
LAM
ING

CANARY at the WHT



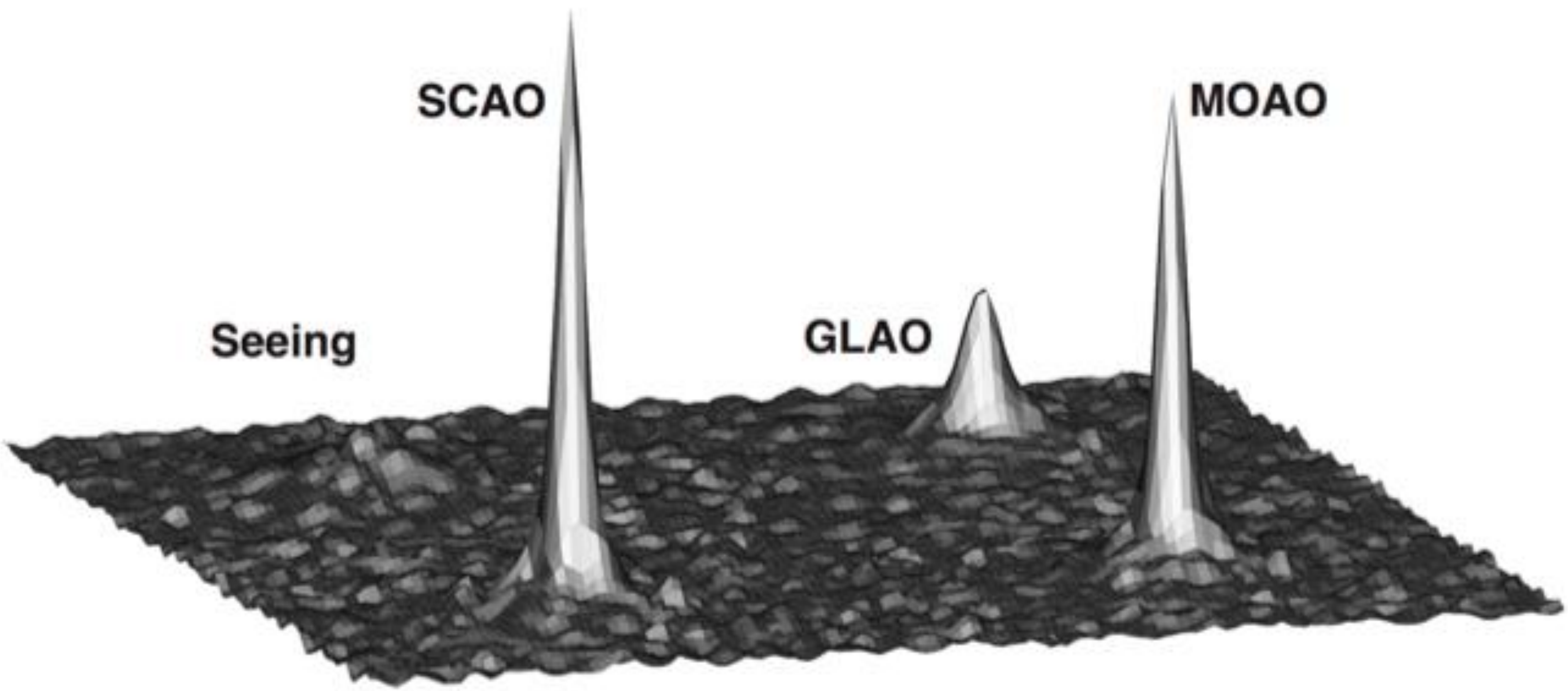
The 3 observed asterisms in Sept 2010 (2’ fov circle)



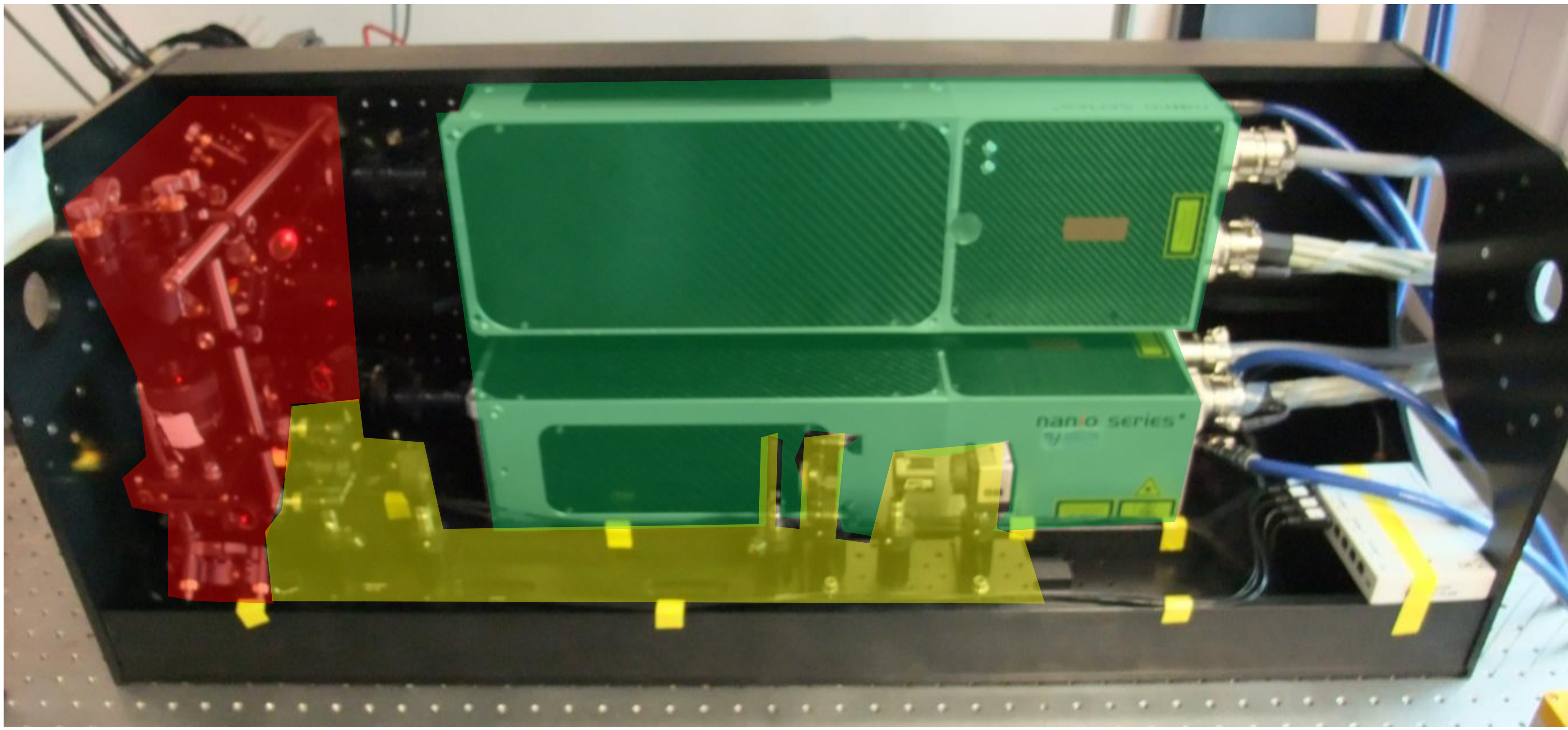
Strehl ratio comparison image

seeing-limited (SR =1% at 00h59mn)
GLAO (SR=9% at 00h42mn)
MOAO (SR=19.4% at 00h29mn)
SCAO (SR=23.8% at 00h32mn)

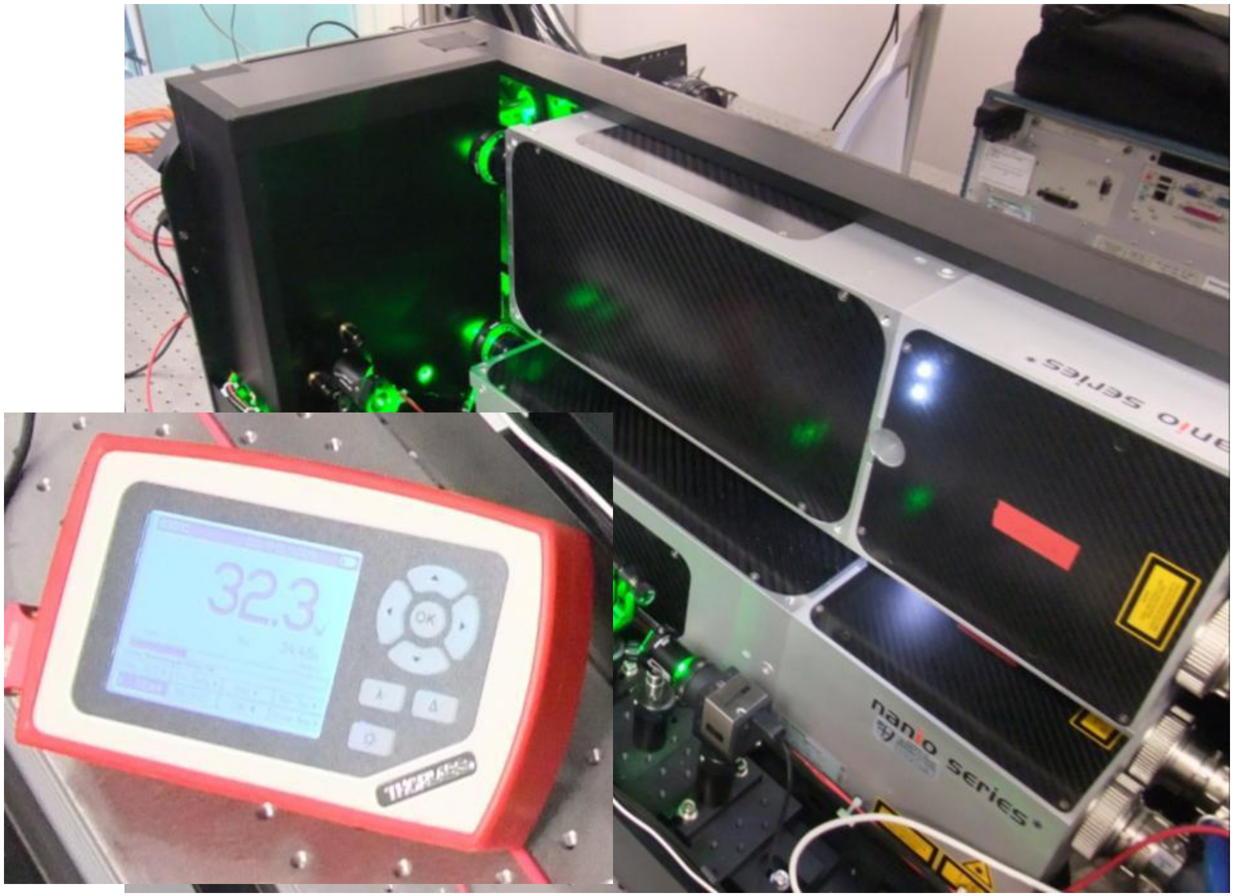
Wavelength is 1.53microns



Laser Launch system

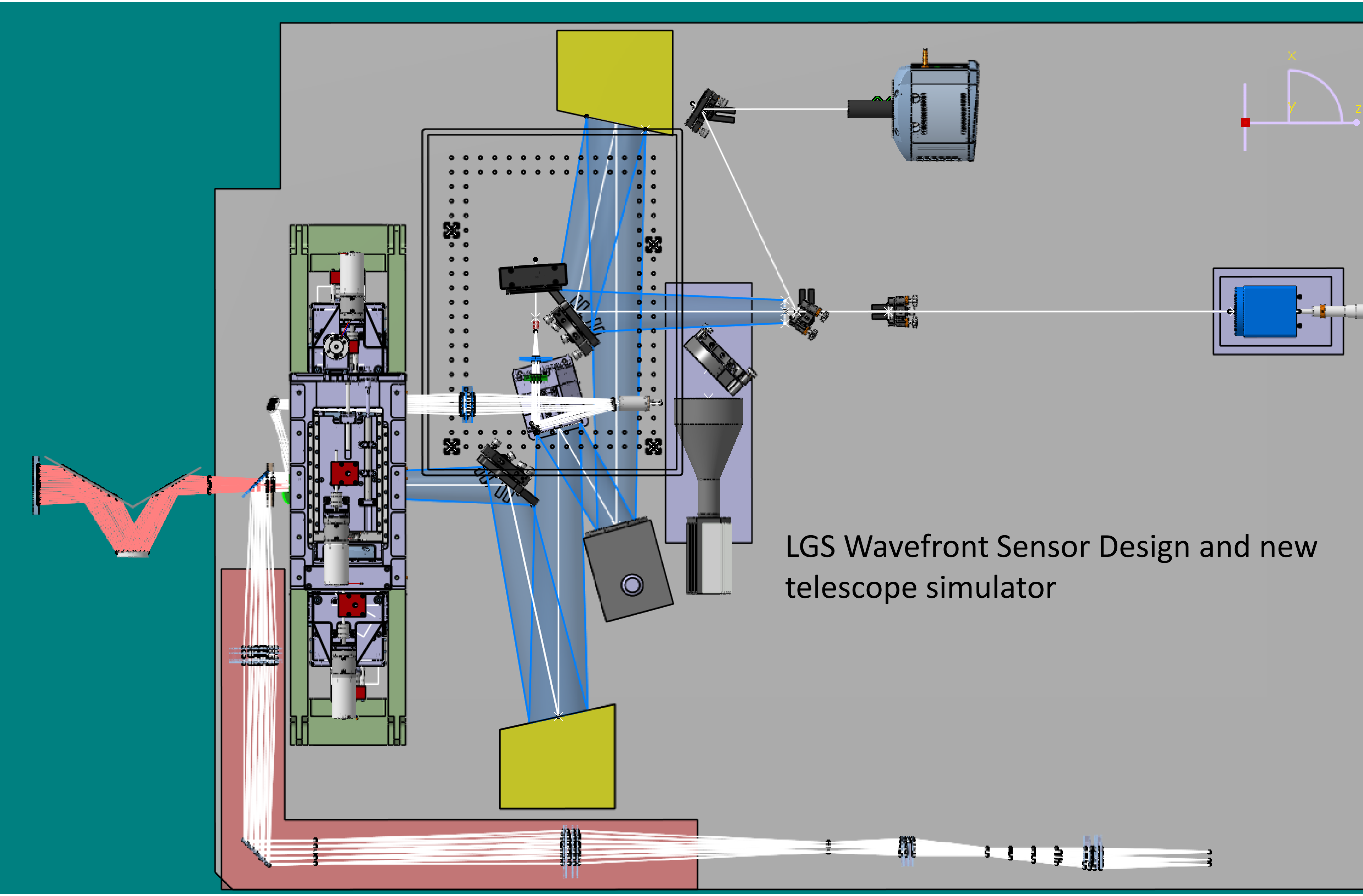


Laser Launch SYSTEM



Output power exceeds 30W requirement

7-11 March 2012 LGS Commissioning Run



On:sky: July 2012

CANARY Phase B Bench with Laser Guide Star Wavefront Sensors

The End

Phase A Requirements comparison (with thanks to JRAS)

	Eagle	Optimos-EVE
Wavelength (μm)	0.8-2.5	0.3-1.7
Simultaneous range	One band	> λ/10
Resolving Power	8k	5-10k 15-20k 30-60k
Radial velocity (km/s)	-	3 (raw)
Patrol field (arcmin)	>5	>7
Contiguous subfield (arcsec^2) ; [multiplex; gap]	2-5 [> 20-40; <3 x IFU gap]	0.5 [> 200; <10" gap] 10 [> 20] 100 [>1]
Spatial sampling (mas)	50-100	<300
PSF	30%EE/spaxel	GLAO
Sky coverage	80% at poles	GLAO

Phase A Technology comparison (with thanks to JRAS)

	Eagle	Optimos-EVE
Cooling	80-120k (multi-cryostat)	170k (chiller)
Gravity invariance	Co-rotating	Stable + fibre link from rotating plate
Pickoff optic technology	Positioned mirrors	Positioned fibres
Relay optics	Deformable mirror	
IFU technology	Machined metal	Fibres+lenslets
Multiplicity	10 identical units with 2 IFUs + spectrograph	2 spectrographs with 2 arms (Optical, NIR)
Dispersion	VPH	VPH
Detector	"ESO" (4k x 4k) [x 10]	CCD (2 x 2) x (6k x 6k) [x 2] Hawaii (1 x 3) x (4k x 4k) [x 2]
AO	Integrated MOAO	GLAO