The MAORY Multi-Conjugate Adaptive Optics module

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On behalf of the MAORY module Consortium

Requirements (from Phase A)

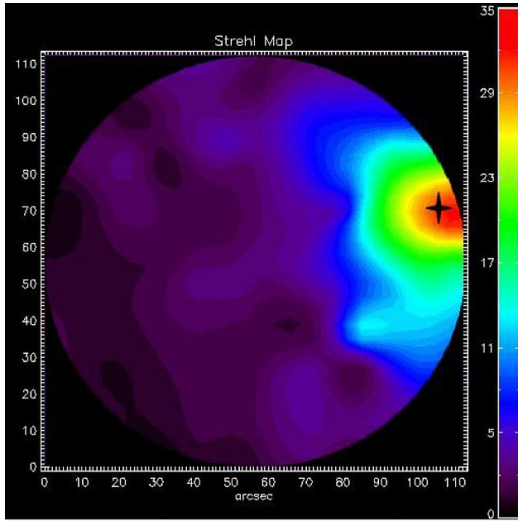
- **Multi conjugate Adaptive Optics RelaY**
  - Compensate atmospheric turbulence
  - Relay telescope focal plane to science instrument

- **Main requirements related to client instrument MICADO**
  - Wavelength range 0.8-2.4 µm
  - Field of view 53"×53"
  - Uniform adaptive optics correction with high sky coverage
  - Gravity invariant exit port with field derotation

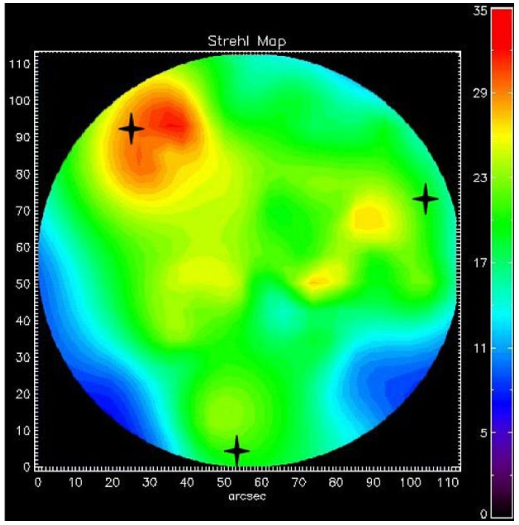
- **Other requirements**
  - MCAO module to be placed on E-ELT Nasmyth platform
  - Lateral exit port for another possible instrument TBC

Multi-Conjugate Adaptive Optics

Strehl Ratio maps @K (2.2 μm)

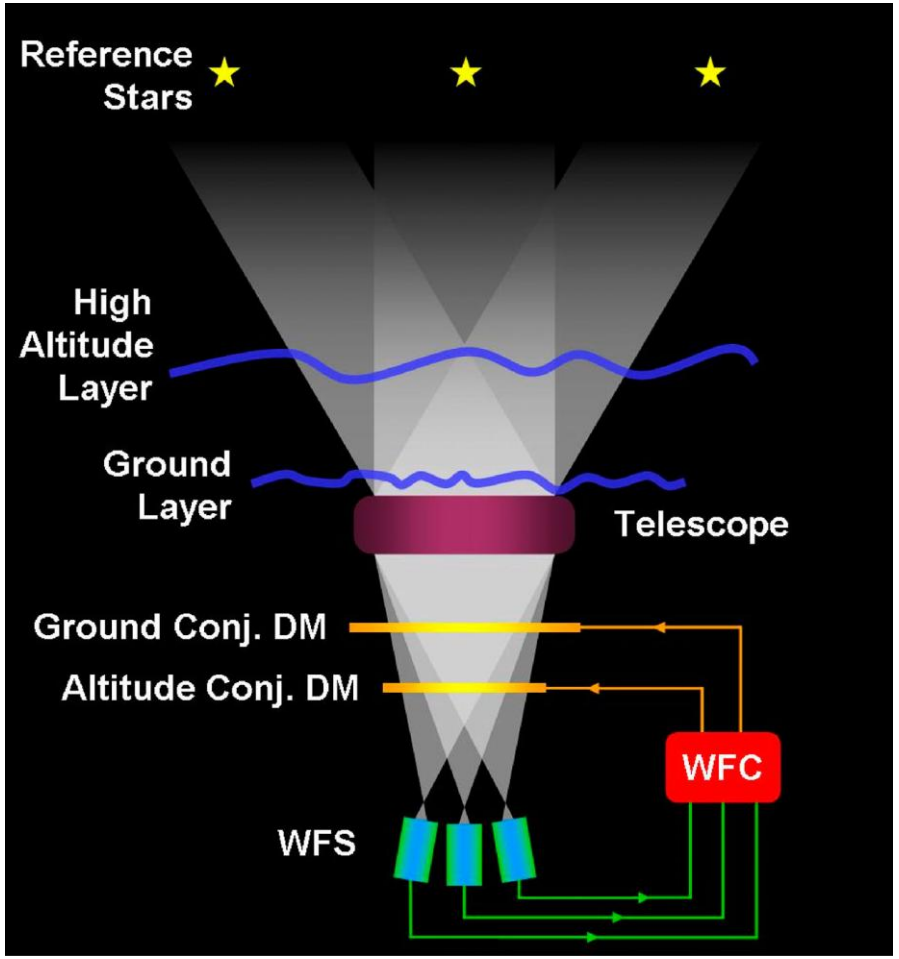


SCAO

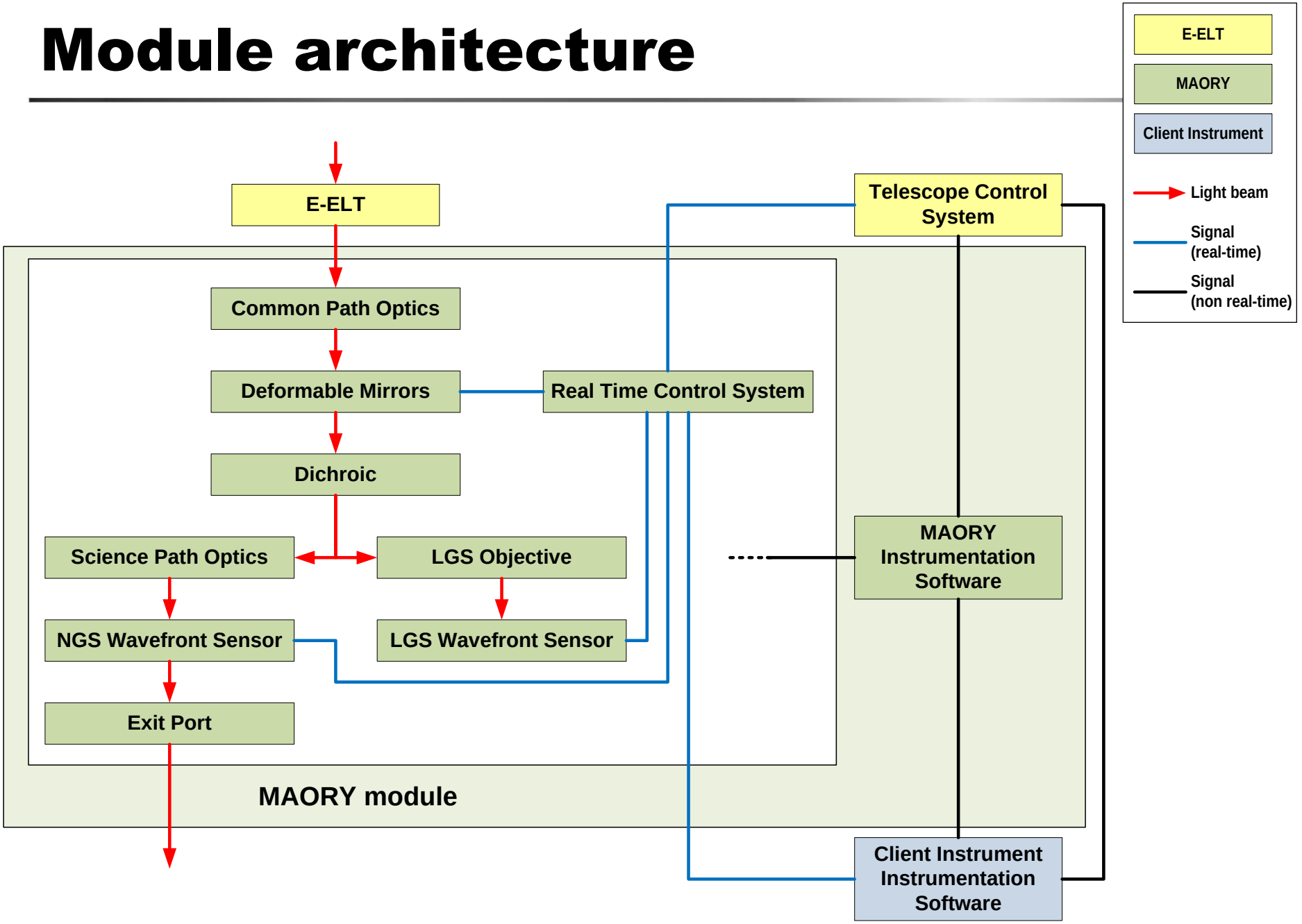


MCAO

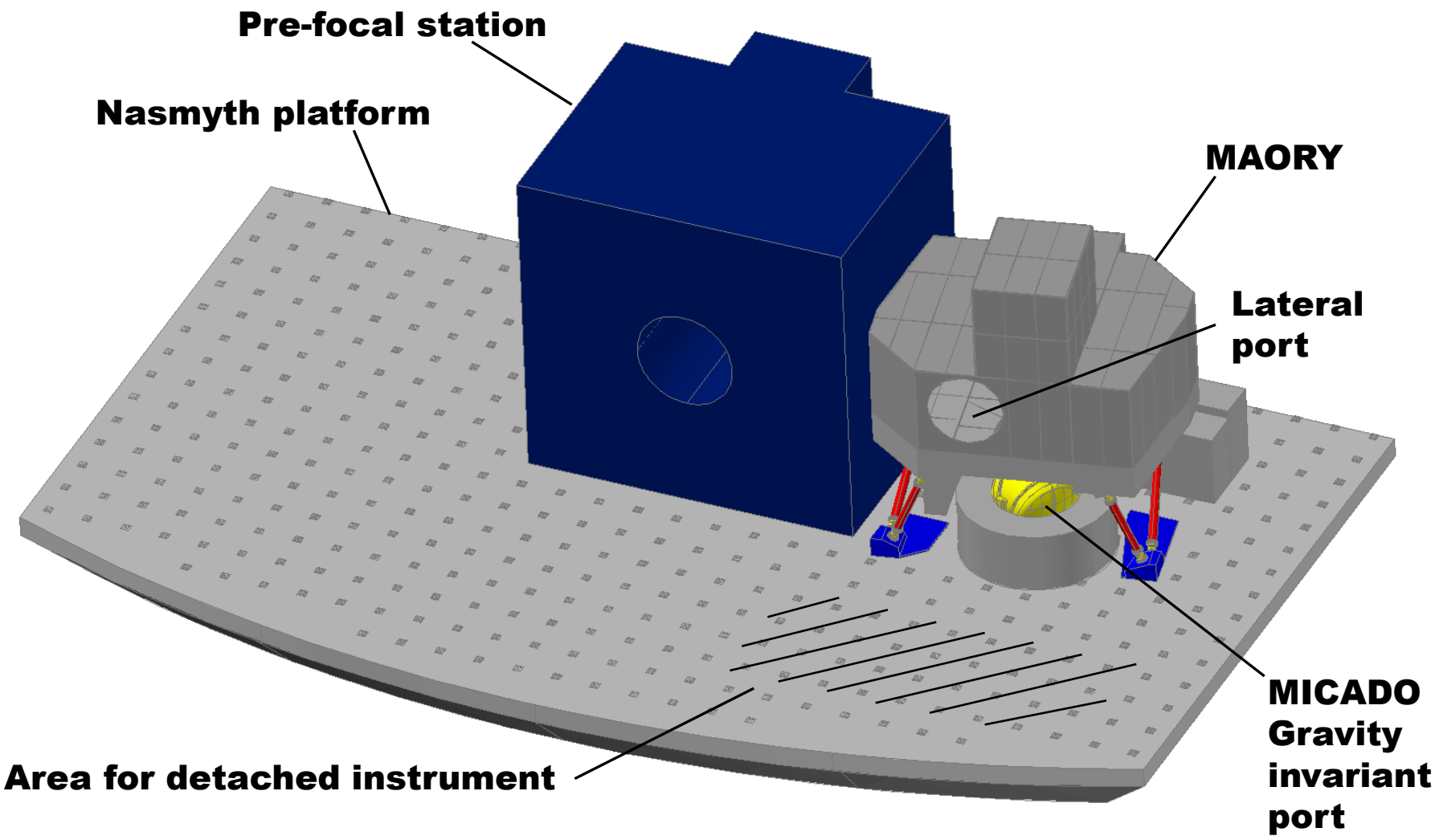
MCAO demonstrated by MAD on VLT



Module architecture



Module layout

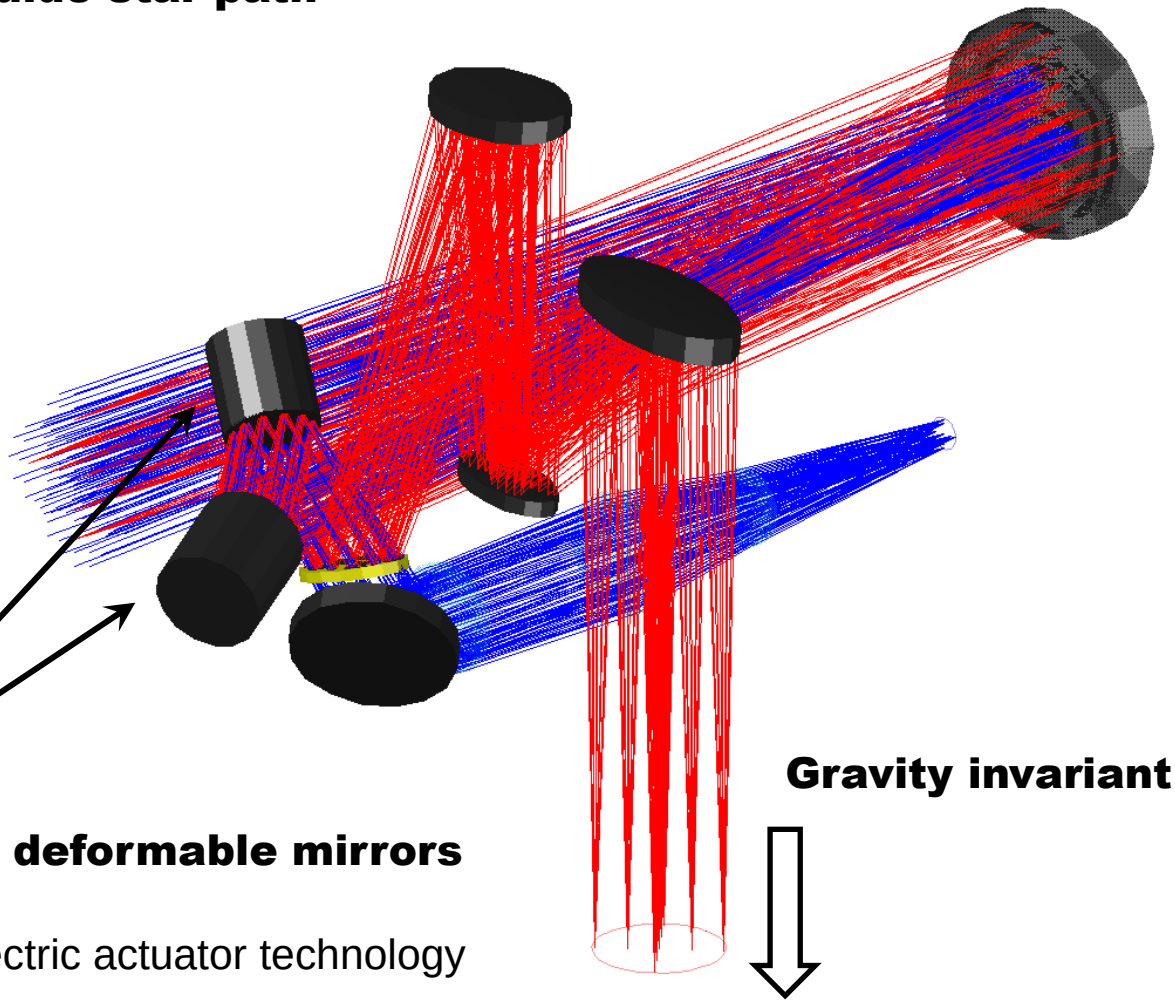


Post-focal relay optics

Science path

Laser guide star path

Alternative optical design under discussion



Light beam from E-ELT

Two post-focal deformable mirrors

Gravity invariant exit port

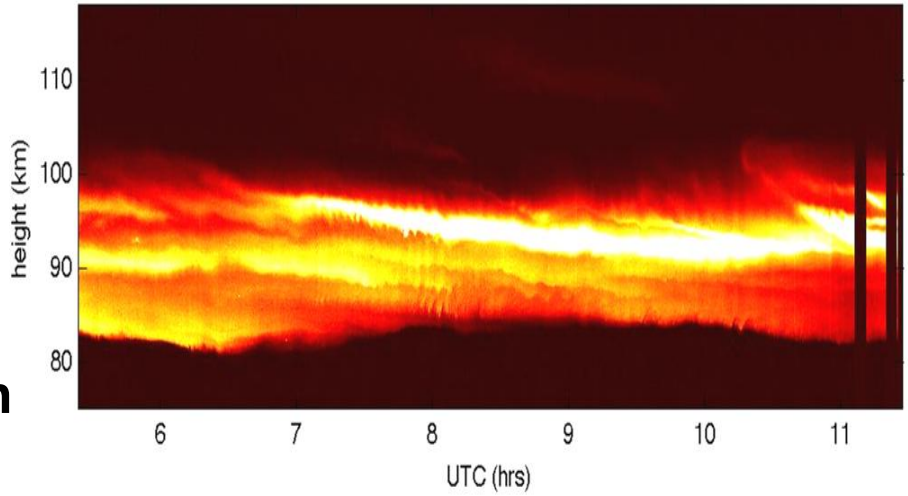
Baseline piezo-electric actuator technology under review

LGS Wavefront Sensor

Why Laser Guide Stars?

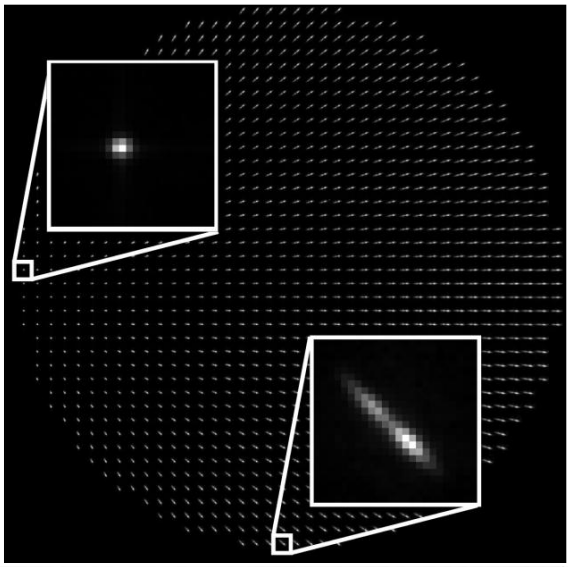
- Sky coverage and performance uniformity
- Demonstrated by GeMS on Gemini Telescope in MCAO mode

Sodium layer data kindly provided by
Paul Hickson, University of British Columbia



LGS Wavefront Sensor description

- 6 Sodium Laser Guide Stars
- Wavefront Sensor type: Shack-Hartmann (~80×80 subapertures, 500 fps)



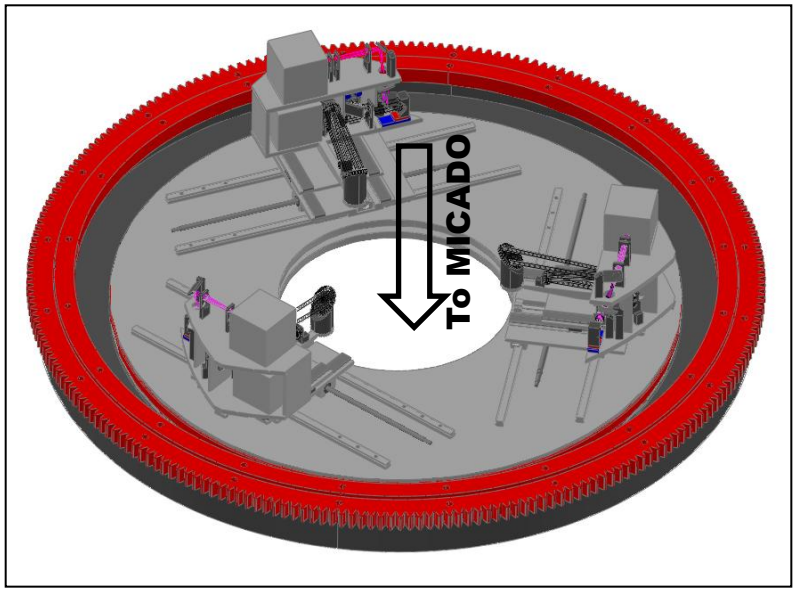
Sodium layer and LGS issues

- Finite distance → multiple LGS
- Tilt indetermination → Natural stars required
- Sodium density profile is structured and variable in time → Natural stars required

NGS Wavefront Sensor

Required stars

- 3 Stars over 2.6 arcmin field of view
- Limiting magnitude H ≈ 21-22
- Each probe split into two channels



Tip-Tilt & Focus channel

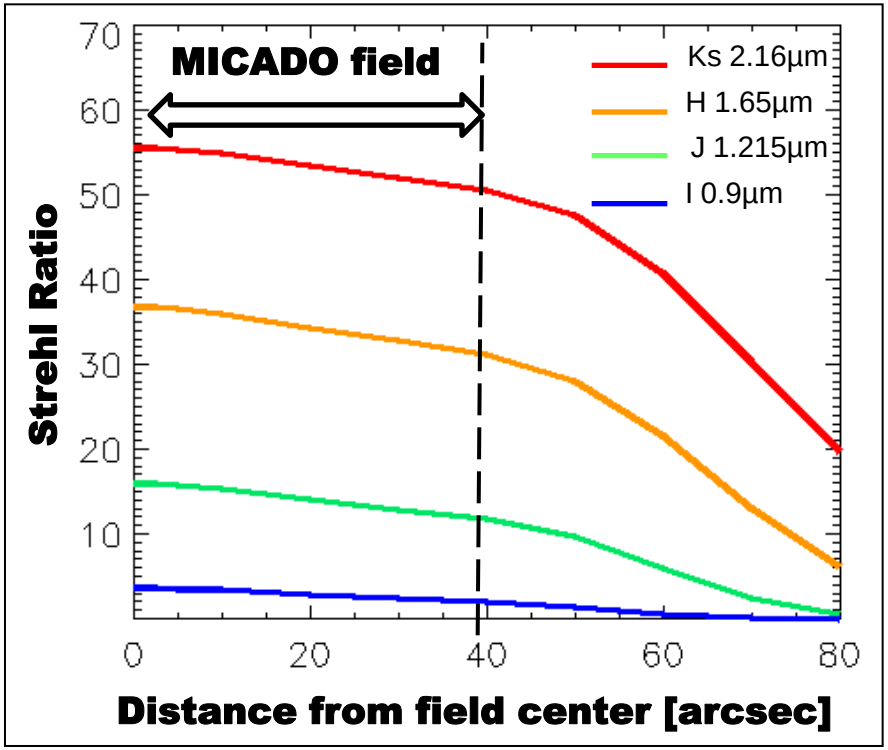
- Wavelength range 1.5-1.8 µm
- 100-500 Hz frame rate

Reference channel

- Wavelength range 0.6-0.9 µm
- Prevent propagation of spurious signals seen by LGS wavefront sensor
- Measure low-medium order modes at slow frame rate (~0.1 Hz)
- Engineering mode:
  Full Natural Guide Star wavefront sensing at fast rate

Adaptive optics performance

Strehl Ratio
Median atmospheric conditions (seeing 0.8")

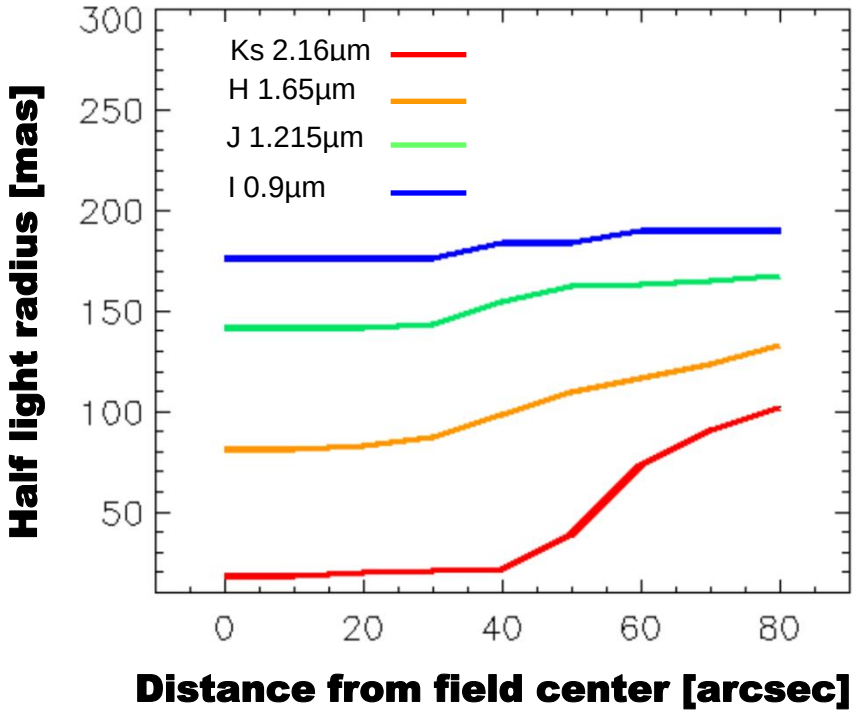


Sky coverage
Galactic Pole

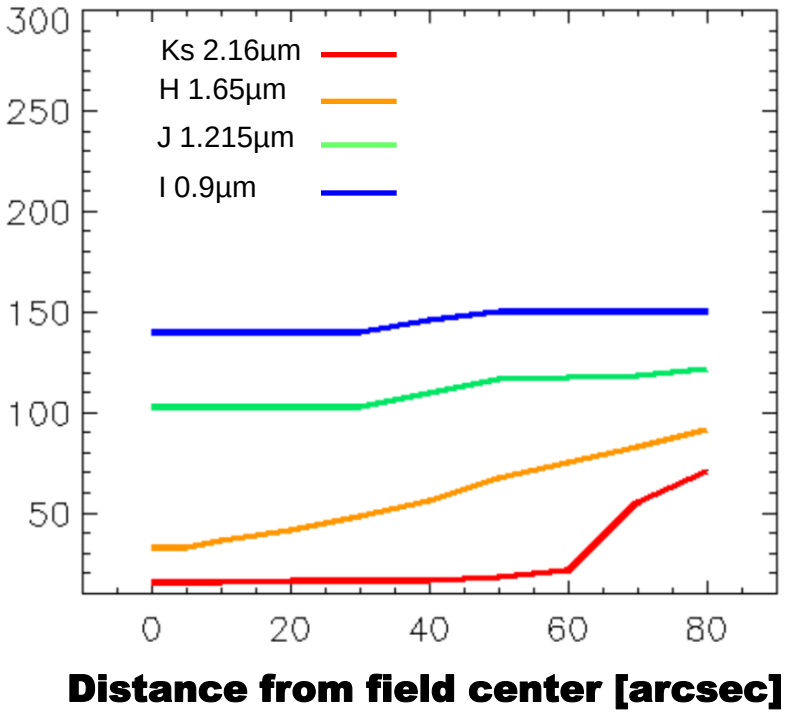
Minimum field-averaged Strehl Ratio (53"×53")				% Sky
2.16 µm Ks band	1.65 µm H band	1.215 µm J band	0.9 µm I band	
0.53	0.34	0.14	0.03	**39%**
0.51	0.32	0.13	0.03	**50%**
0.41	0.22	0.06	<0.01	**80%**

Half-light radius

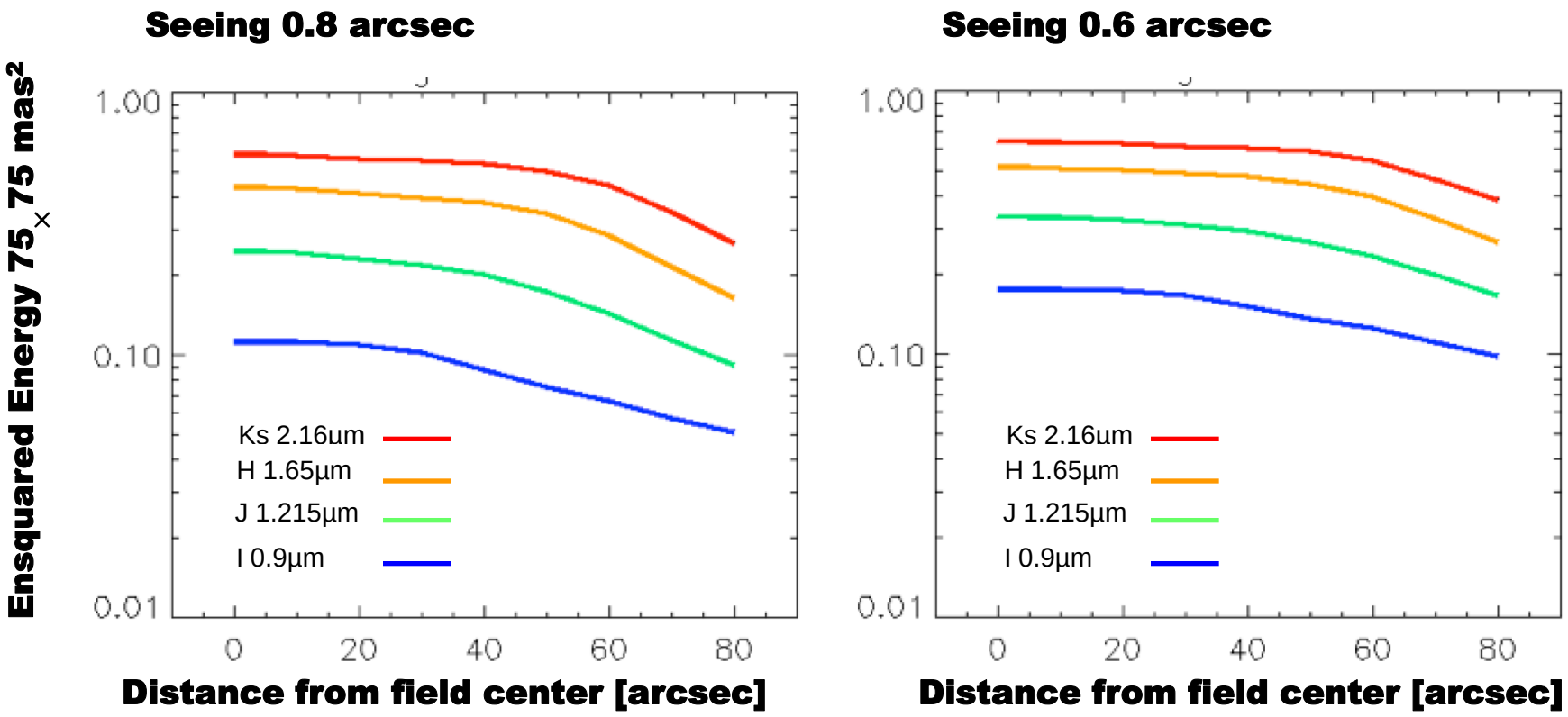
Seeing 0.8 arcsec



Seeing 0.6 arcsec



Ensquared Energy



Project overview

- Phase A study Nov 2007 – Dec 2009
- MCAO module approved by ESO as part of first-light instrumentation to serve E-ELT diffraction-limited camera MICADO
- Project plan for next phases under consolidation
  - Negotiations between ESO and INAF (lead institute) are well advanced
  - INAF is supporting the project through its Directorate of Science

Project overview

- Current Consortium organisation
  - **INAF** (Lead Institute, System responsibility, sub-systems: platform, NGS WFS, deformable mirrors procurement, auxiliary equipments, science support tools)
  - **Durham University** (Real Time Control System)
  - **Observatoire de Paris LESIA** (LGS wavefront sensor)
  - **ESO** (wavefront sensor cameras, deformable mirrors development TBC)

- Preliminary project schedule

	Y01		Y02		Y03		Y04		Y05		Y06		Y07		Y08		Y09		Y10	
Phase B																				
Phase C																				
Phase D																				
Phase E																				

- On-going preparatory activities with dedicated funds awarded to INAF by Italian Ministry for Research

Integration room preparation