The natural guide star module for MAORY (& a SCAO system for HIRES)

Adoni workshop

Firenze, 12th-14th April 2016

LABORATORIO NAZIONALE ADONI OTTICA ADATTIVA

Intoduction

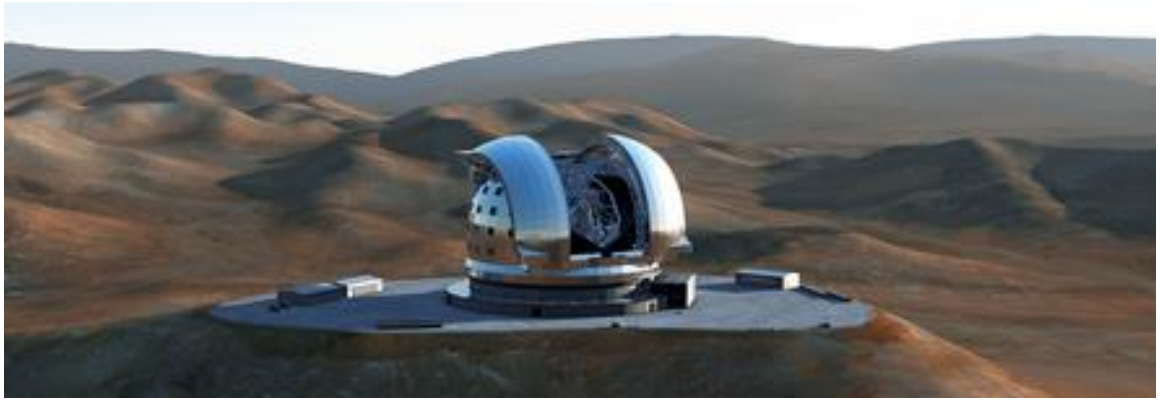
MAORY kick off meeting, Bologna Feb 2016 (talk by P. Ciliegi on 12/4)

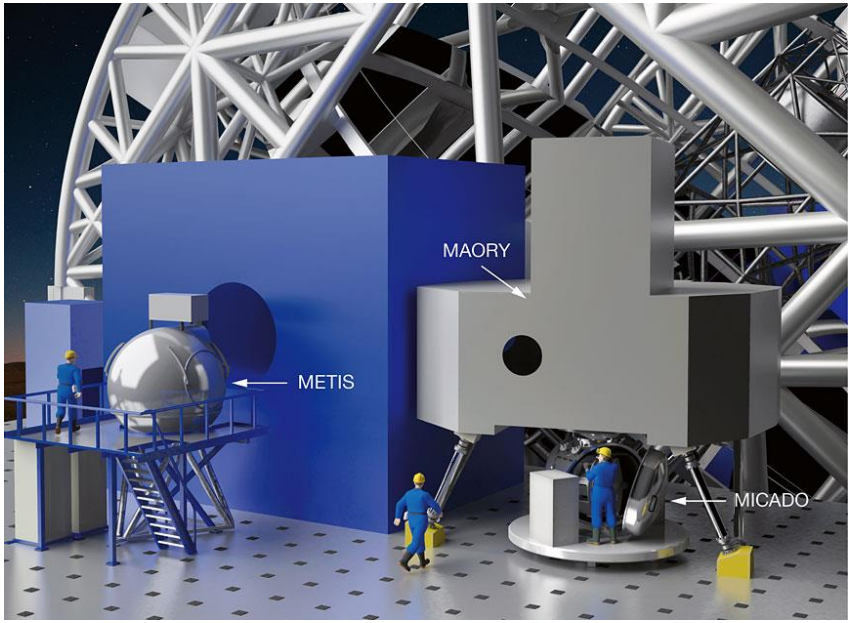
In the next slides:

1. **Summary of activities done so far on NGS module sub-systems (mainly during the «T-REX phase»)**
2. **Task and resources organization for Phase B**

- **A hit to a SCAO system for HIRES**

MAORY





- Post-focal AO facility of the EELT installed on Nasmyth platform
- Will serve MICADO imager and spectrograph + a 2° gen. instrument

MICADO main specs:

Wavelength coverage:	NIR (1.0–2.4 µm)
Field of view	53x53 arcsec
Spatial resolution:	6-12 mas
Spectral resolution:	R~8000

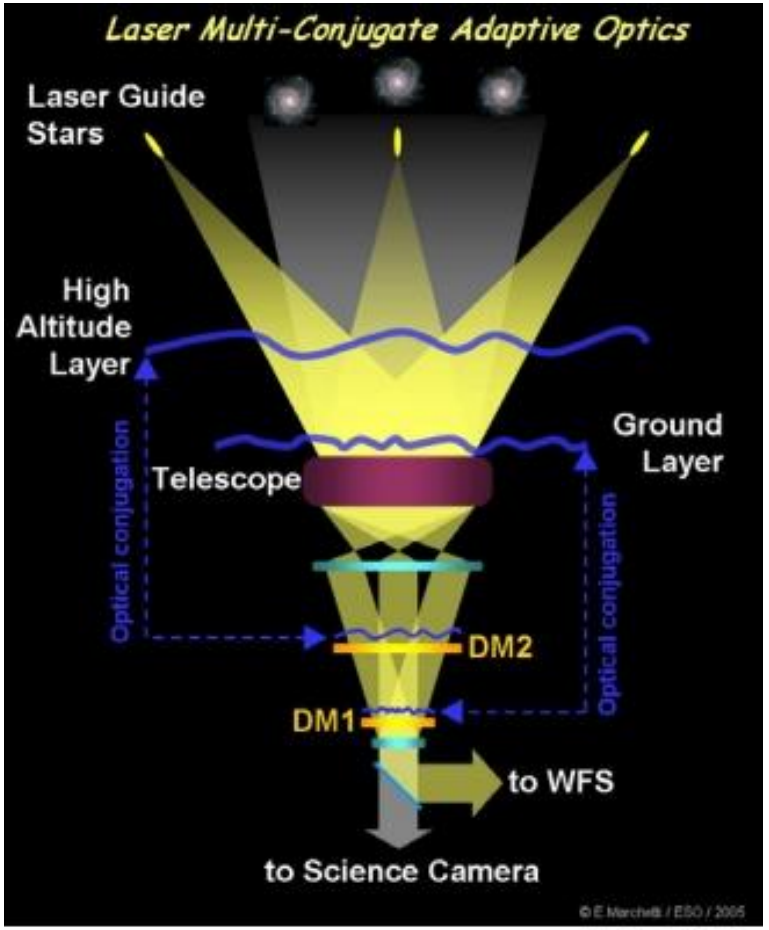
MAORY MCAO mode

From MAORY SoW:

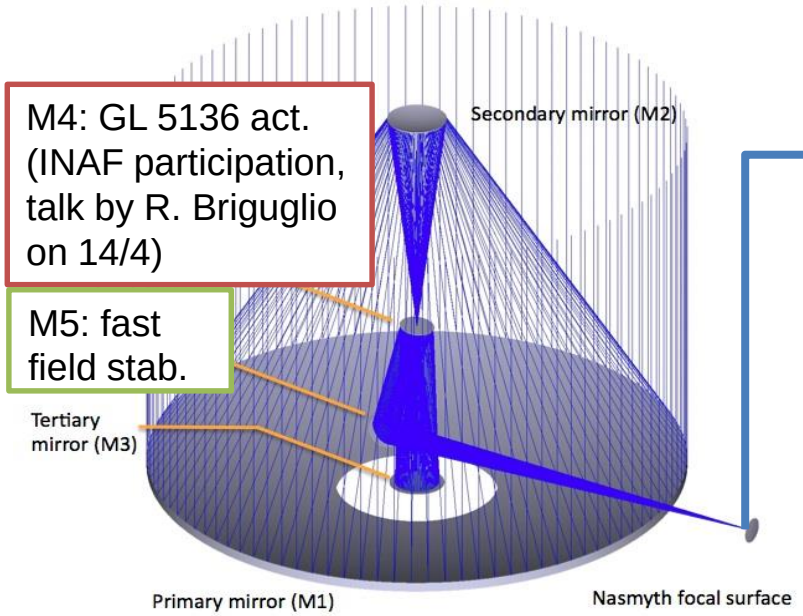
The baseline for E-ELT 1st light science is for MICADO to operate behind the MAORY MCAO system.

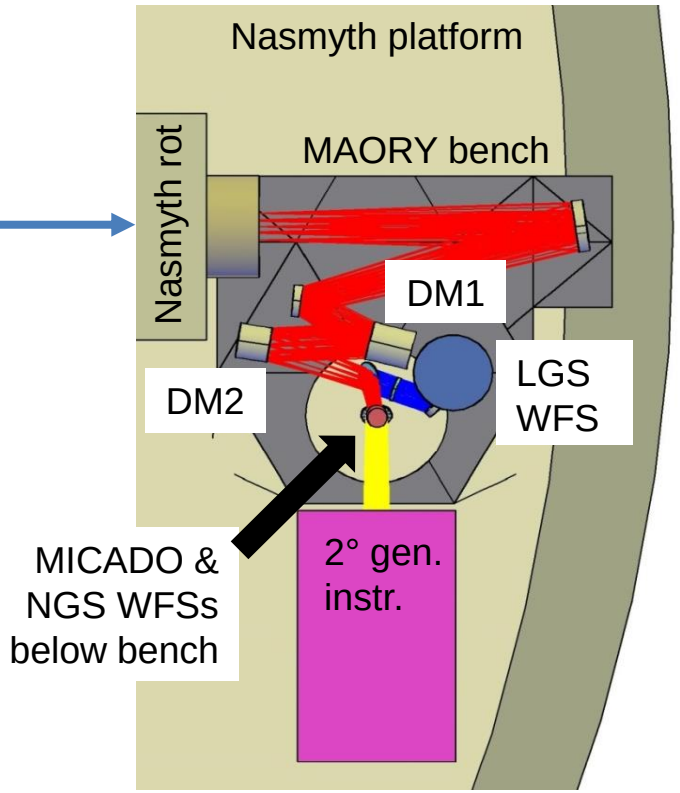
From technical specification MAORY MCAO should provide:

- 30% SR in K-band under median seeing conditions [R-MAO-82]
- 10% SR variation across MICADO field [R-MAO-85]
- 50% sky coverage at galactic pole [R-MAO-74]



MAORY layout





Actual design is based on:

3x DMs based on voice coil technology (M4 + 2 post-focal)

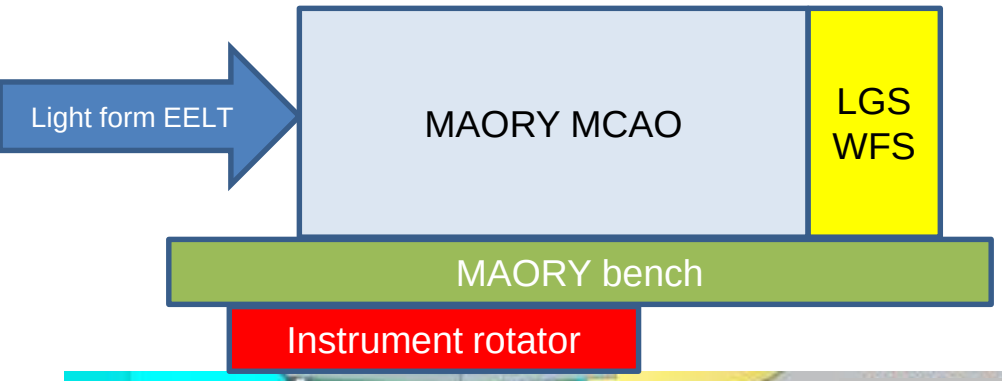
6x LGS WFS to perform tomographic measurement of atmosphere

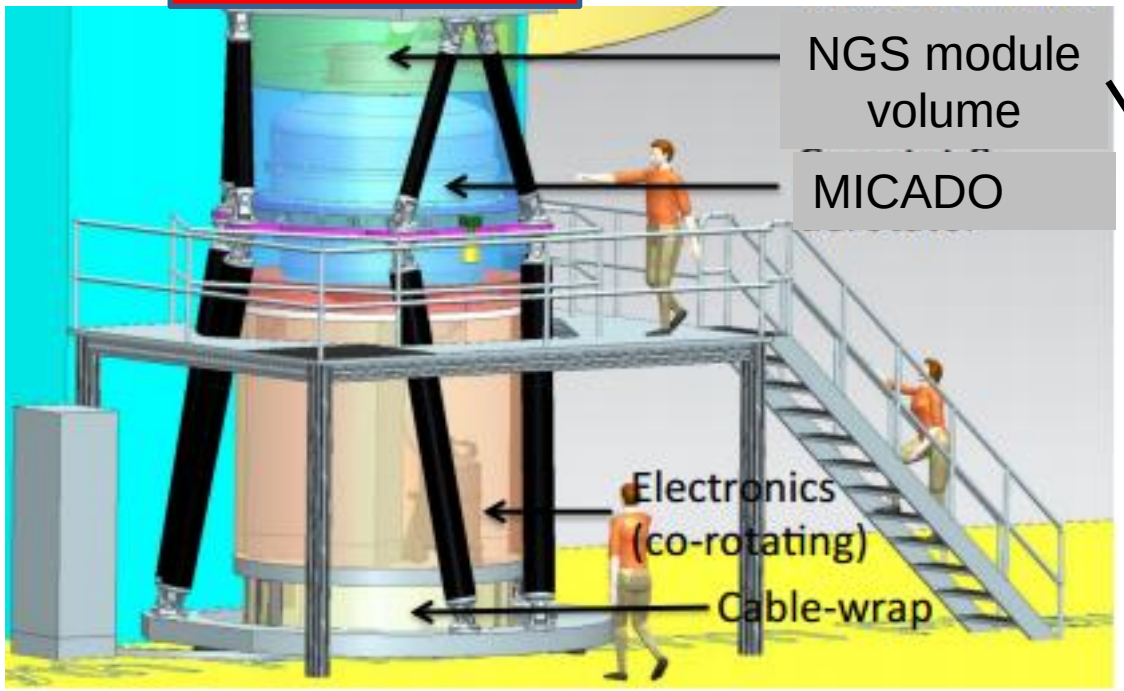
3x NGS sensors to measure the atmospheric tip-tilt component

3x NGS reference sensors to to compensate for LGSs drifts, plate scale variations

Low-order and reference (LOR) unit
INAF - Arcetri

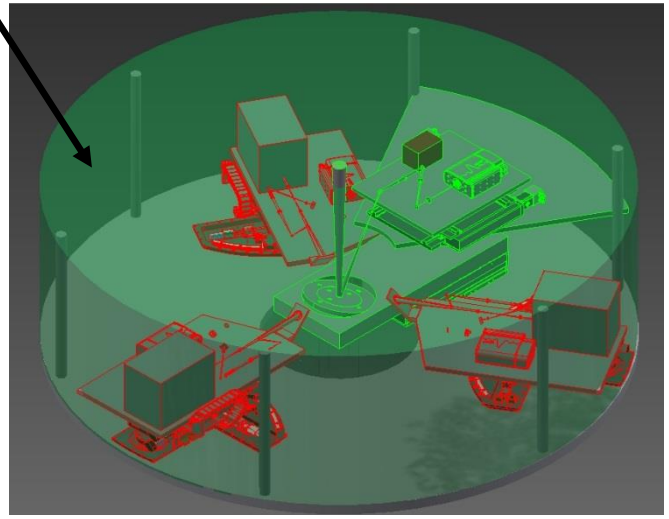
NGS module volume (Green Doughnut)





The NGS WFSs are placed in a dedicated module between MAORY and MICADO (NGS module):

- Co-rotating with MICADO
- Attached to MAORY bench or MICADO (depending on MAORY optical desing)



LOR unit functionality

The basic layout for MCAO NGS WFSs was already addressed in T-REX:

- NGS pickoff with mirror on a 160” doughnut around MICADO FoV

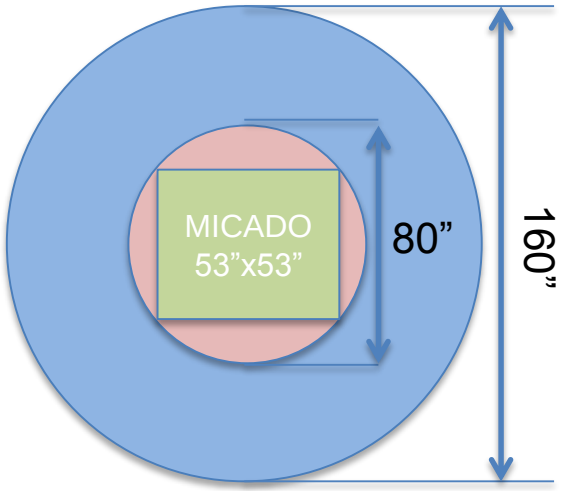
1. Tip-tilt (low order) sensor:

Trade-off study was performed simulating different geometries (2x2, 3x3, 5x5 Sas), VIS or IR (OCAM or Cred detectors), NGS color and mag.

⇒ Best solution identified was a SH 2x2 IR sensor

2. Reference sensor:

- Basic functionality is to work as slow reference sensor to de-trend LGSs wavefront estimate of low order modes
- Option to add NGS-MCAO functionality (useful in early commissioning and science phases to remove the complexity related to LGS on EELT)

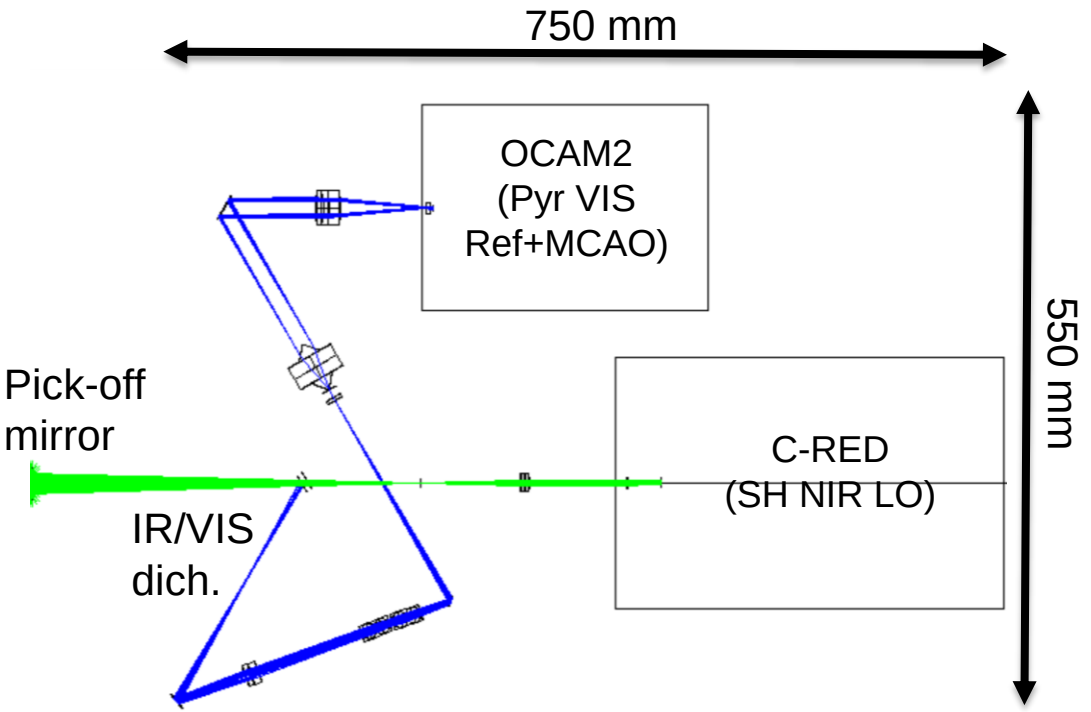


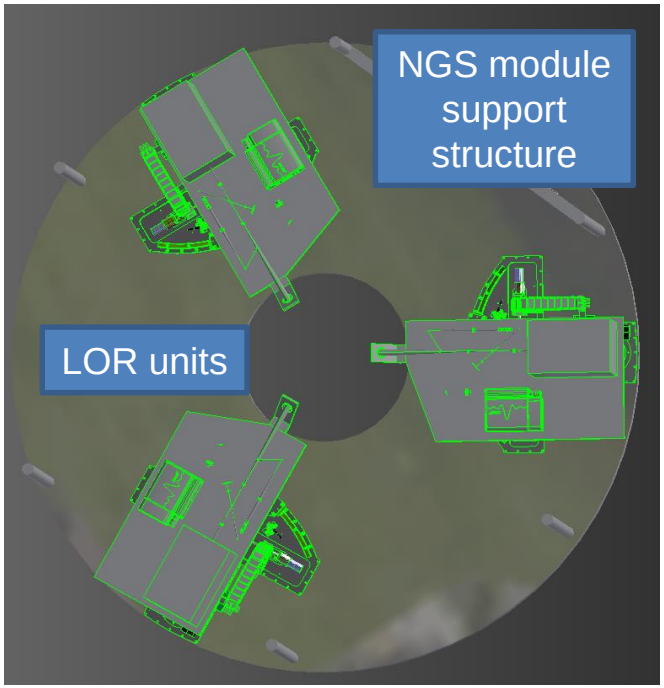
Ref. only	Ref. + NGS-MCAO
• SH WFS • 5x5 (10x10?) • Slow (1-10Hz)	• Pyr. WFS • 80x80 (binnable) • Fast (1kHz)

LOR unit concept

Outcome of T-REX:

- The low order and reference sensors will share a common support structure
- Using polar coordinate stages at 120° geometry will maximize SC
- Dichroic will split between IR (LO) and VIS (Ref)





LOR unit Phase B

MAORY Phase B started with KOM on 2 Feb 2016

Work packages for LOR preliminary design have been identified:

- LOR unit specifications
- Optics preliminary design (REF and LO branches)
- Preliminary mechanical design and finite element analysis
- Motorized functions, cabling and control electronics
- Preliminary assembly and Alignment procedures and tools
- Analysis of the REF NGS WFS camera and controller requirements
- Analysis of the LO NGS WFS camera and controller requirements
- Preparation of the specifications and interface documentation of the REF and LO WFS cameras and controllers

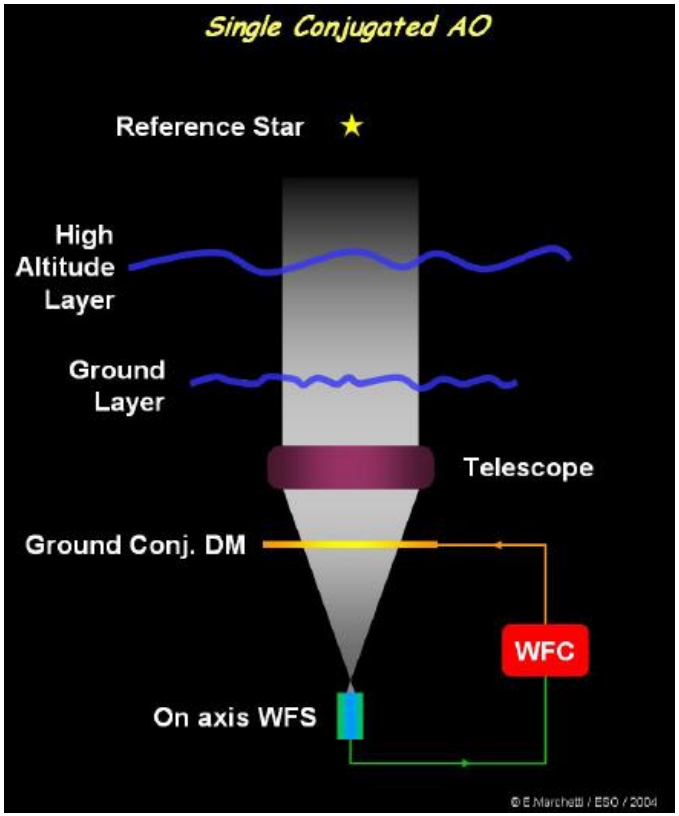
M&M SCAO mode

From MAORY SoW:

A SCAO mode within MAORY is needed for full scientific exploitation and for meeting the E-ELT TLRs.

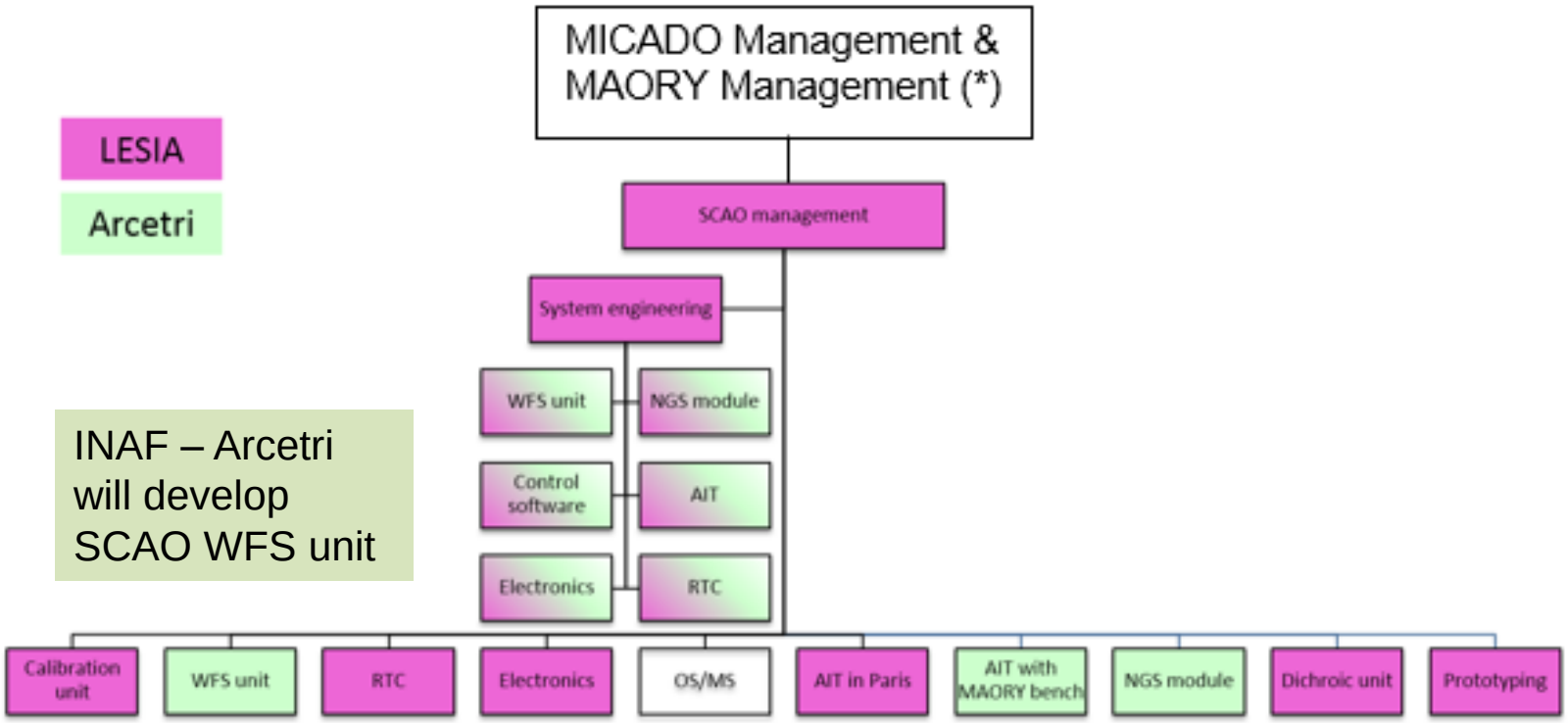
A SCAO mode will also be useful in a phased approach for optimizing AO performance of the MAORY/MICADO system once at the telescope.

This development should be a joint endeavour between the MAORY and MICADO consortia […]



M&M SCAO WBS

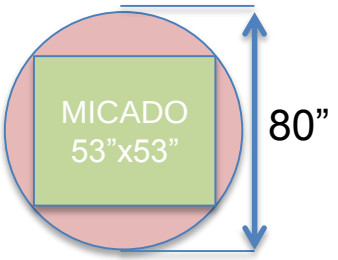
- WBS approached in Feb 2016 meetings
- Arcetri and LESIA will share the work under MAORY/MICADO management

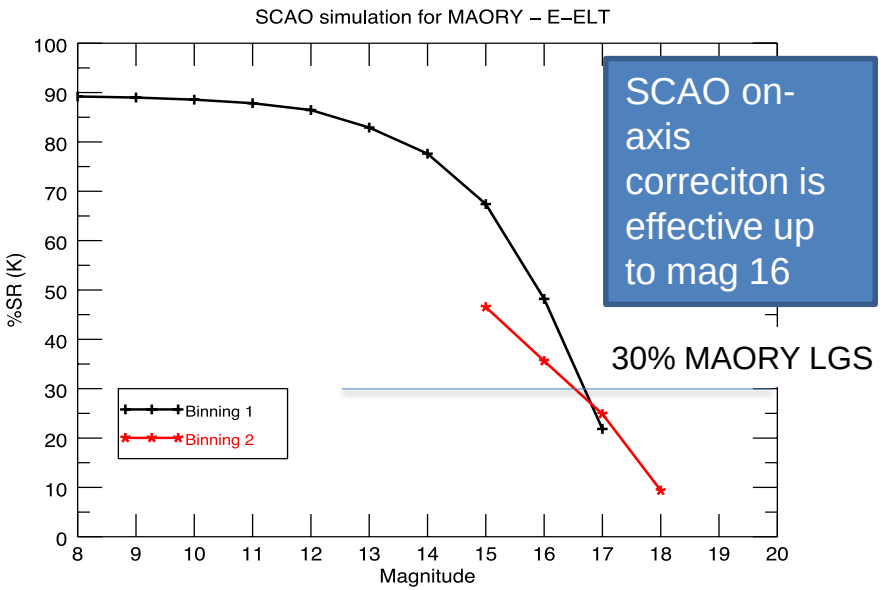


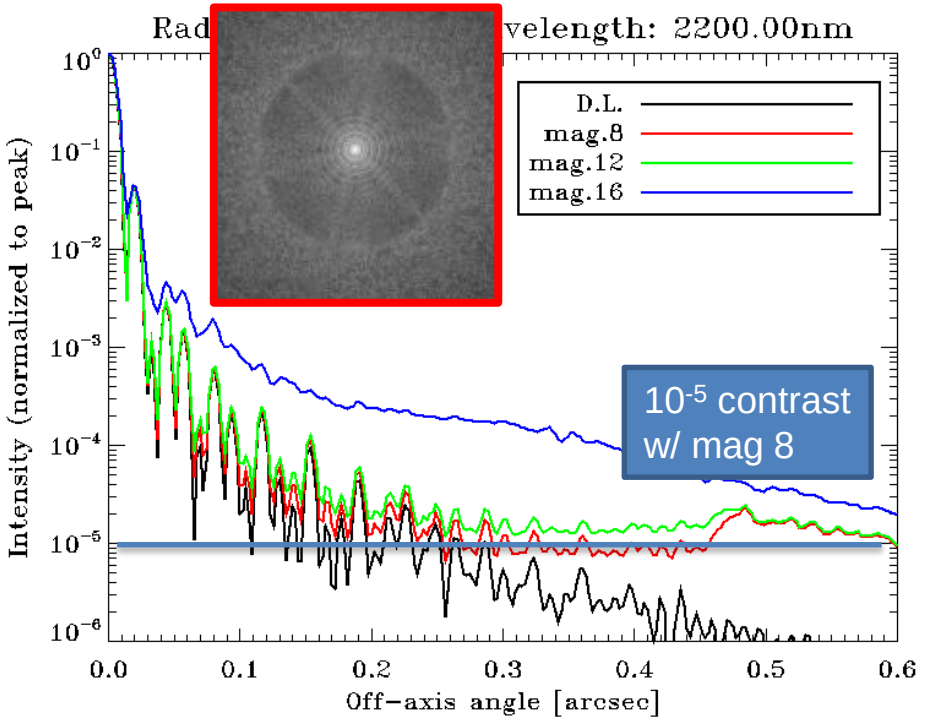
SCAO unit functionality

Several technical requirement for SCAO were already identified during T-REX:

- NGS pickoff w/in MICADO FoV => dichroic is required
- Full FoV patrolled w/ linear stages
- Trade-off study based on numerical simulations to identify performance of PWFS 80x80 Sas:

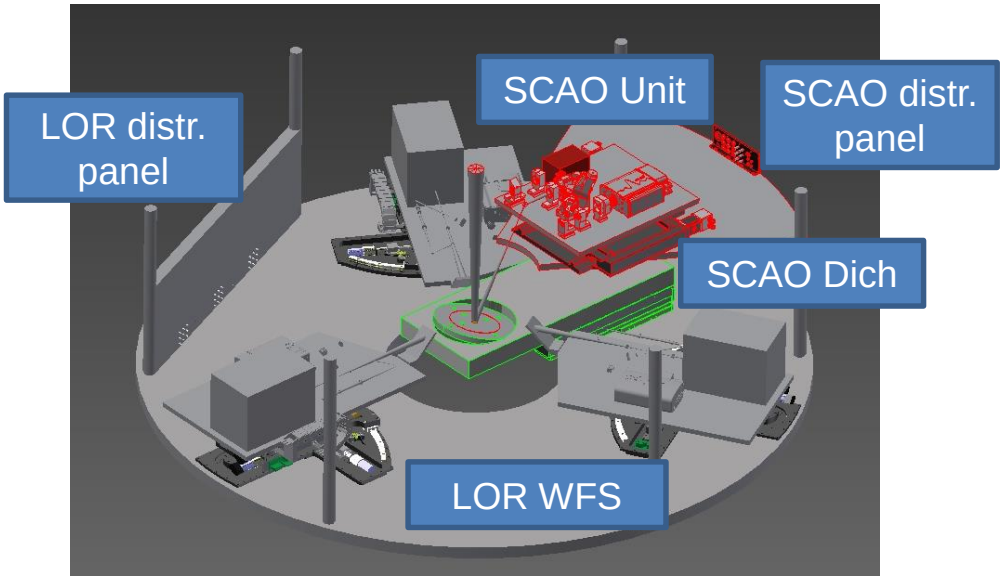


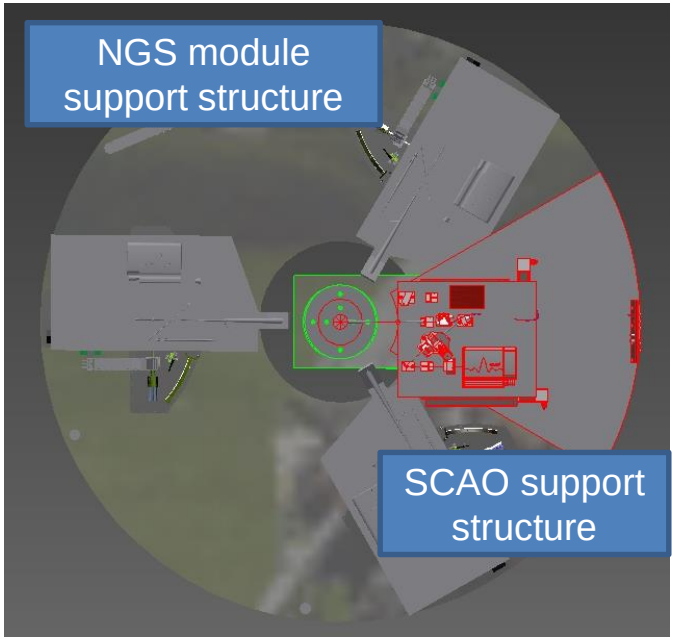




NGS module concept

- **3x LOR units** (for MCAO) at 120° to maximize SC (req. 50% at galactic poles) and fixed to baseplate to reduce differential flexures wrt MICADO
- **SCAO module** (WFS + dichroic) has a dedicated volume slice
- Independent service distribution (Eth., Pow., Cables, …) for the 2 sub-systems to minimize interface with MCAO sub-systems
- Control and RT electronics is ouside (part is co-rotating, part is outside rotator)





NGS module Phase B

- Work packages have been defined for all project phases
- Work load for each task have been evaluated

Example of Phase B:

WP ID	WP Title	Duration [caly]	Work [py]	Work [%]
E-MAO-ADM-1100	NGS WFS Module Management	2,00	1,61	80%
E-MAO-ADM-1200	NGS WFS Module Engineering	2,00	4,92	246%
E-MAO-ADA-1100	NGS WFS Module Support Structure Design	2,00	1,18	59%
E-MAO-ADB-1100	LOR WFS Units Design	2,00	2,36	118%
E-MAO-ADC-1100	SCAO WFS Unit & Dichroic Unit Design	2,00	2,60	130%
E-MAO-ADD-1100	NGS WFS Module Control & Calibration SW Design	2,00	1,61	80%
E-MAO-ADE-1100	NGS WFS Test & Calibration Tools Design	2,00	1,44	72%

Phase B: end date 02/08/18, duration 2.0 calendar years from KOM

total person years 15,72
~ 8 persons full time

1 person year = 211.5 working days
work [%] = work[py] / duration [y]

Involved personnel (INAF - Arcetri)

- Arcetri personnel identified for the NGS module development
- 2 positions opened (Software + AO engineer)

Name	Position	Task	
A. Riccardi	Senior Researcher	Prog.Manager/AO Eng.	P
S. Esposito	Senior Researcher	AO Expert/AO Eng.	P
M. Xompero	Researcher	Managing/AIT	C
M. Lauria	Administrative	Adminitrative Repres.	C
L. Fini	Senior Researcher	Software	P
L. Carbonaro	Technician	Mechanics	P
M. Bonaglia	Post-Doc	Optics/AIT	C
V. Biliotti	Technician	Electronics	P
A. Puglisi	Technician	Software/AIT	P
L. Busoni	Researcher	Sys Engineer/AIT	P
C. Giordano	Post-Doc	Num. Simulations	C
G. Agapito	Post-Doc	Num. Simulations	C
C. Del Vecchio	Senior Researcher	FEA	P
D. Ferruzzi	Technician	Optics	C
R. Briguglio	Post-Doc	AIT	C
G. Di Rico	Post-Doc	Software/Electronics	C
TBH-SE	Post-Doc	AO Engineer/AIT	C
TBH-SW	Post-Doc	Software/AIT	C

P = Permanent Staff
C = Contract Staff
TBH = To Be Hired

Conclusion

- **The conceptual studies of the NGS module (LOR & SCAO units) performed during T-REX phase have identified useful guide lines for preliminary design**
- **MAORY Phase B had official start with KOM of 2 Feb 2016**
- **Definition of specifications for LOR units (fast TT + reference sensors) are ongoing together with trade-off studies to define their functionalities**
- **The SCAO module WBS is available, task have been identified and shared between INAF – Arcetri and Lesia**
- **The task allocation for phase B to involved personnel have been addressed (2 positions opened: SW + Sys. engineering)**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In questa pagina vengono pubblicati avvisi relativi a borse di studio e posizioni a concorso presso l'Osservatorio di Arcetri.
Studio di dischi protoplanetari attraverso Osservazioni (sub)millimetriche ALMA
08-01-2016
Properties of surface materials of primitive carbon-rich asteroids to support OSIRIS-REX mission
19-02-2016
SKA-CSP software prototypes development
03-03-2016
ADAPTIVE OPTICS Software Engineer
08-04-2016
System Engineering for Adaptive Optics projects of Large and Extremely Large Astronomical Telescopes

The HIRES project

- HIRES: high resolution spectrograph for the E-ELT capable of providing a spectrum at R~100,000 over 0.4-2.5 μm
- HIRES consortium composed of institutes from 12 countries
- Italy (INAF lead technical institution, PI A. Marconi)
- Brazil, Chile, Denmark, France, Germany, Poland, Portugal, Spain, Sweden, Switzerland, United Kingdom
- HIRES consortium awarded Phase A study by ESO
- kick off 22/3/16
- end by 22/3/18

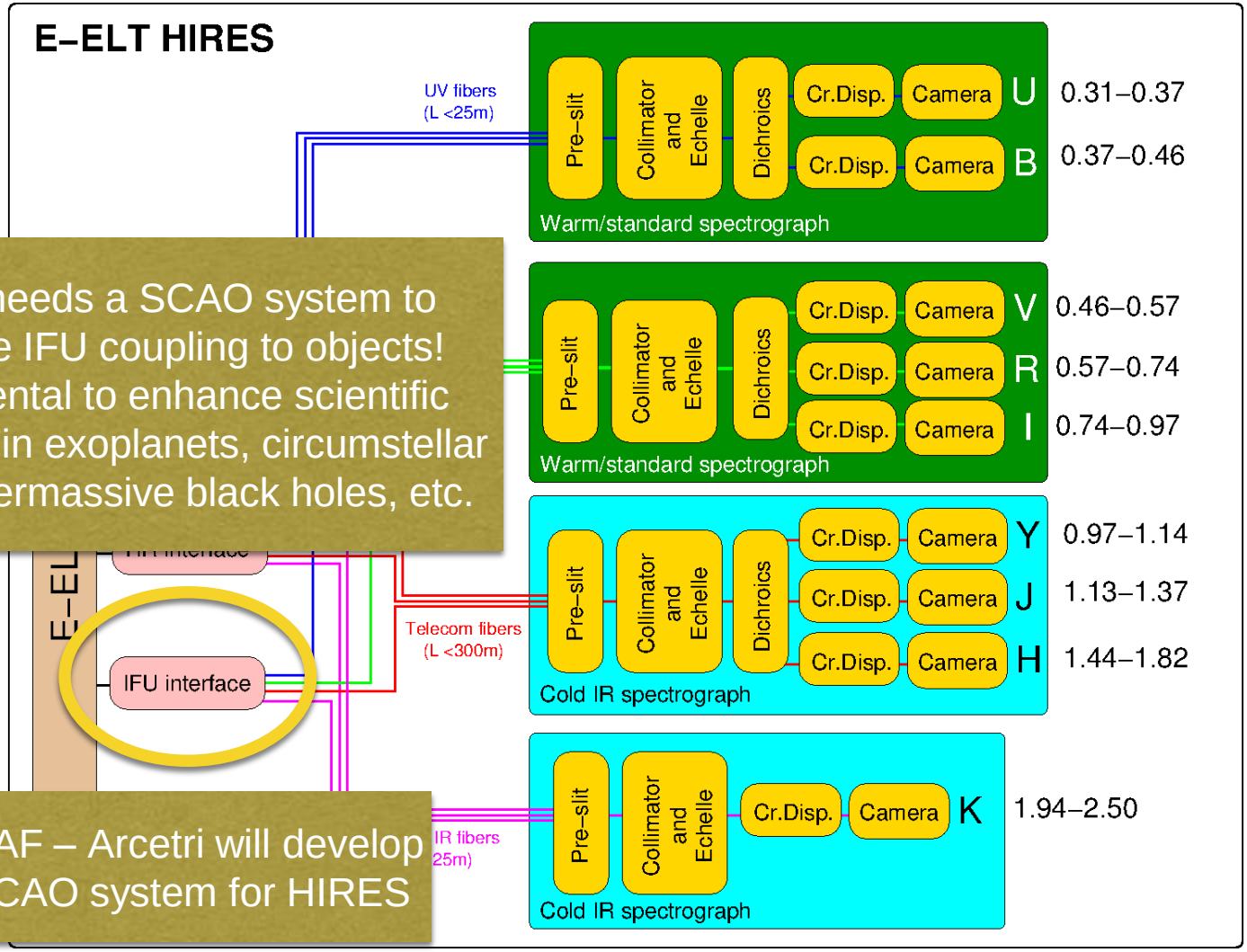
Science Cases to be addressed

- **Exoplanets** (characterisation of Exoplanets Atmospheres: detection of signatures of life)
- **Stellar Astrophysics** (abundances of solar type and cooler dwarfs in galactic disk bulge, halo and nearby dwarfs: tracing chemical enrichment of Pop III stars in nearby universe)
- **Intergalactic Medium** (Signatures of reionization and early enrichment of ISM & IGM observed in high-z quasar spectra)
- **Fundamental Physics** (variation of fundamental constants - α, m_p/m_e Sandage Test)
- **Protoplanetary Disks** (dynamics, chemistry and physical conditions of the inner regions)
- **Stellar Populations** (metal enrichment and dynamics of extragalactic star clusters and resolved stellar populations)
- **Galaxy Evolution** (massive early type galaxies during epochs of formation and assembly)
- **Supermassive Black Holes** (the low mass end)

Community White Paper: Maiolino et al. 2013, ArXiV:1310.3163

Instrument concept

- 4 independent fibre-fed spectrometers optimised over 4 spectral ranges (UB, VRI, YJH, K): simultaneous coverage 0.31-2.5 μm



HIRES needs a SCAO system to maximize IFU coupling to objects! Fundamental to enhance scientific throughput in exoplanets, circumstellar disks, supermassive black holes, etc.

INAF – Arcetri will develop SCAO system for HIRES

Backup slides

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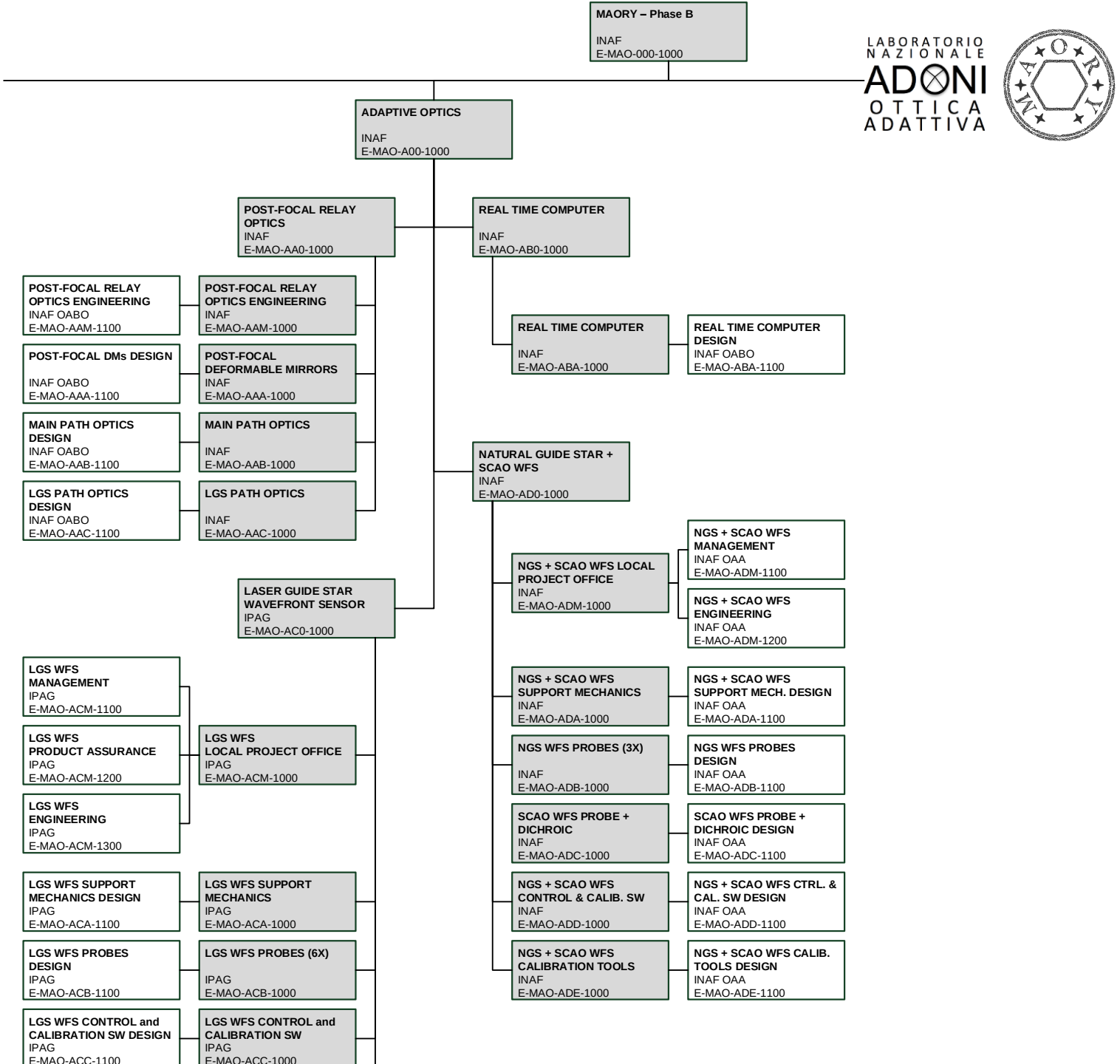
MAORY milestones

Milestone Number	Phases – Key milestones	Due Time
1	Kick Off Meeting	2016-02-02
2	Preliminary Design Review (PDR)	2018-02-02
3	Final Design Review (FDR)	2019-08-02
4	Preliminary Acceptance Europe (PAE)	2024-02-02
5	Provisional Acceptance Chile (PAC)	2025-08-02
6	Final Acceptance (end of Guarantee period)	2027-08-02


MAORY – Phase B
INAF
E-MAO-000-1000
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ADAPTIVE OPTICS
INAF
E-MAO-A00-1000
POST-FOCAL RELAY OPTICS
INAF
E-MAO-AA0-1000
REAL TIME COMPUTER
INAF
E-MAO-AB0-1000
POST-FOCAL RELAY OPTICS ENGINEERING
INAF OABO
E-MAO-AAM-1100
POST-FOCAL RELAY OPTICS ENGINEERING
INAF
E-MAO-AAM-1000
REAL TIME COMPUTER
INAF
E-MAO-ABA-1000
REAL TIME COMPUTER DESIGN
INAF OABO
E-MAO-ABA-1100
POST-FOCAL DMs DESIGN
INAF OABO
E-MAO-AAA-1100
POST-FOCAL DEFORMABLE MIRRORS
INAF
E-MAO-AAA-1000
MAIN PATH OPTICS DESIGN
INAF OABO
E-MAO-AAB-1100
MAIN PATH OPTICS
INAF
E-MAO-AAB-1000
LGS PATH OPTICS DESIGN
INAF OABO
E-MAO-AAC-1100
LGS PATH OPTICS
INAF
E-MAO-AAC-1000
NATURAL GUIDE STAR + SCAO WFS
INAF
E-MAO-AD0-1000
NGS + SCAO WFS LOCAL PROJECT OFFICE
INAF
E-MAO-ADM-1000
NGS + SCAO WFS MANAGEMENT
INAF OAA
E-MAO-ADM-1100
NGS + SCAO WFS ENGINEERING
INAF OAA
E-MAO-ADM-1200
LASER GUIDE STAR WAVEFRONT SENSOR
IPAG
E-MAO-AC0-1000
NGS + SCAO WFS SUPPORT MECHANICS
INAF
E-MAO-ADA-1000
NGS + SCAO WFS SUPPORT MECH. DESIGN
INAF OAA
E-MAO-ADA-1100
NGS WFS PROBES (3X)
INAF
E-MAO-ADB-1000
NGS WFS PROBES DESIGN
INAF OAA
E-MAO-ADB-1100
SCAO WFS PROBE + DICHROIC
INAF
E-MAO-ADC-1000
SCAO WFS PROBE + DICHROIC DESIGN
INAF OAA
E-MAO-ADC-1100
NGS + SCAO WFS CONTROL & CALIB. SW
INAF
E-MAO-ADD-1000
NGS + SCAO WFS CTRL. & CAL. SW DESIGN
INAF OAA
E-MAO-ADD-1100
NGS + SCAO WFS CALIBRATION TOOLS
INAF
E-MAO-ADE-1000
NGS + SCAO WFS CALIB. TOOLS DESIGN
INAF OAA
E-MAO-ADE-1100
LGS WFS MANAGEMENT
IPAG
E-MAO-ACM-1100
LGS WFS PRODUCT ASSURANCE
IPAG
E-MAO-ACM-1200
LGS WFS ENGINEERING
IPAG
E-MAO-ACM-1300
LGS WFS LOCAL PROJECT OFFICE
IPAG
E-MAO-ACM-1000
LGS WFS SUPPORT MECHANICS DESIGN
IPAG
E-MAO-ACA-1100
LGS WFS SUPPORT MECHANICS
IPAG
E-MAO-ACA-1000
LGS WFS PROBES DESIGN
IPAG
E-MAO-ACB-1100
LGS WFS PROBES (6X)
IPAG
E-MAO-ACB-1000
LGS WFS CONTROL and CALIBRATION SW DESIGN
IPAG
E-MAO-ACC-1100
LGS WFS CONTROL and CALIBRATION SW
IPAG
E-MAO-ACC-1000

Phase B: Preliminary design (24months)

- NGS module management
- NGS module engineering
- NGS module support structure
- LOR WFS unit
- SCAO WFS unit & dichroic
- NGS module control & calibration SW
- NGS module test & calibration tools
- SCAO WFS unit and dichroic design shared with MICADO

Phase C/D: final design and MAIT

- NGS module management
- NGS module engineering
- NGS module support structure
- LOR WFS units
- SCAO WFS & dichroic
- NGS module Control & Calibration SW
- NGS module test & calibration tools
- NGS module AIT

Phase E: Commissioning

- NGS module reintegration on site

Phase B: PDR

Phase C/D: FDR and M

LOR unit Phase B

MAORY **WORKPACKAGE DEFINITION** **0.1**
Feb 2015

WORKPACKAGE	**LOR WFS Units Design**	**E-MAO-ADB-1100**
WP manager Deputy WP mgr.	L. Busoni M. Bonaglia	INAF OAA
WP description	Specification and preliminary design of the MAORY Low Order and Reference (LOR) WFS units including the WFS camera specification	
WP required input	1. Preliminary optical interface between MAORY and MICADO 2. Preliminary mechanical interface between MICADO and NGS WFS module 3. REF and LO WFS camera requirements from the provider 4. Preliminary interface documentation covering the electrical, thermal and mechanical interfaces to the camera and controller 5. Preliminary communication interfaces to the MAORY RTC	
Tasks included	1. NGS WFS units specifications 2. Optics preliminary design (REF and LO branches) 3. Preliminary mechanical design and finite element analysis 4. Motorized functions, cabling and control electronics 5. Preliminary assembly and Alignment procedures and tools 6. Analysis of the REF NGS WFS camera and controller requirements 7. Analysis of the LO NGS WFS camera and controller requirements 8. Preparation of the specifications and interface documentation of the REF and LO WFS cameras and controllers	

LO numerical simulation

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Simulation studies the median condition case where a baseline of 30% SR in K band is required. Goal is 40%. E-ELT site median values for seeing conditions are assumed. tech. Specs includes 145nm of telescope aberration as additional disturbance

seeing median value of 0.67 arcsec

effective wind speed 10 m/s

Input wavefront pre-corrected to 40% K band SR (335nm rms)

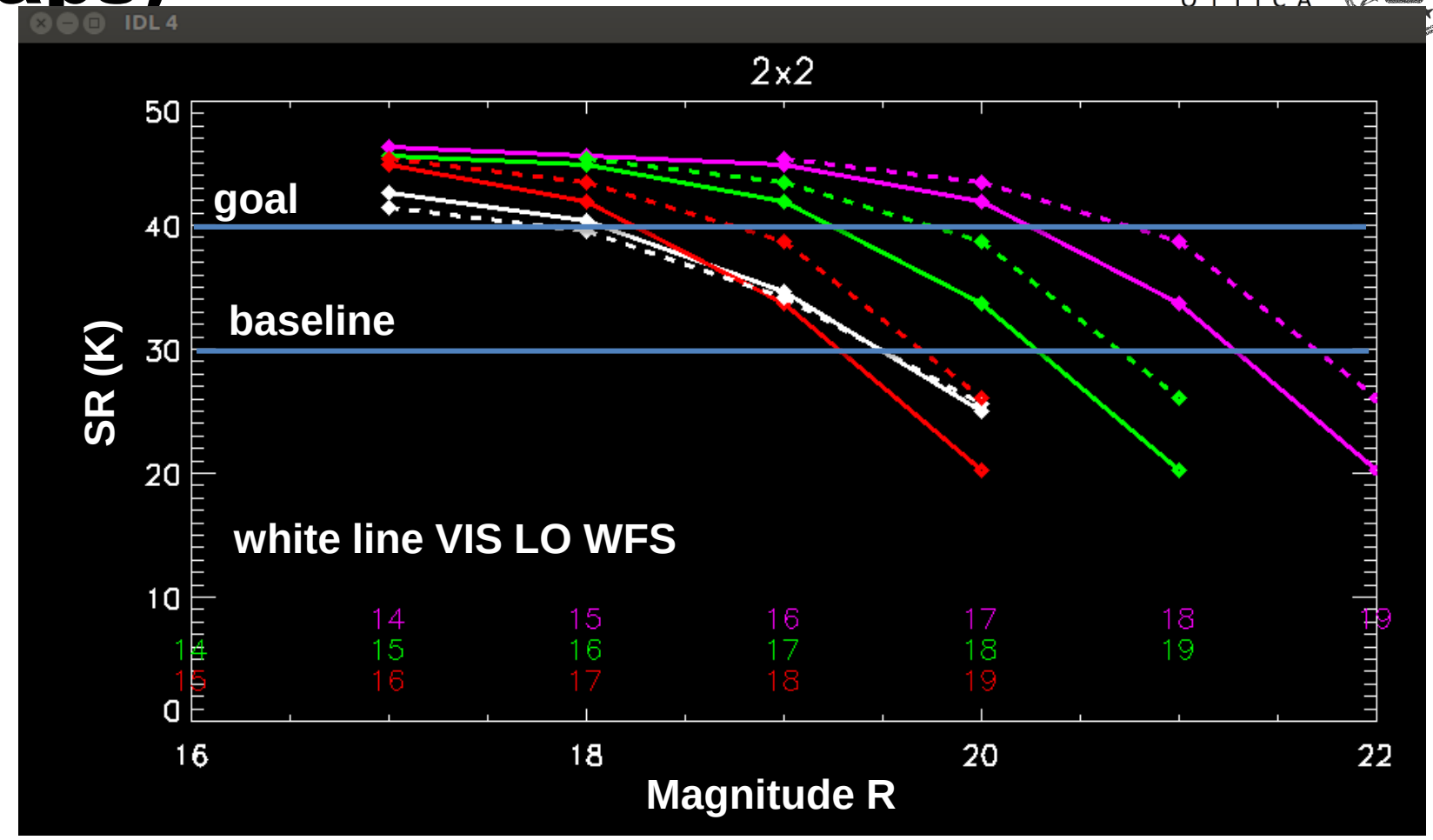
VIS case (CCD220)
2step CoG
FoV 1.2”
# of pixel 12
2nd step FoV 6x6pixel
bw 300nm
wl 700
sky 34
ron 0.37e-
fps 200

IR case (CRed detector)
2step CoG
FoV 1.0”
# of pixel 50
2nd step FoV 4x4pixel
bw 300nm
wl 1650
sky 921
ron 1.0e-
fps 200

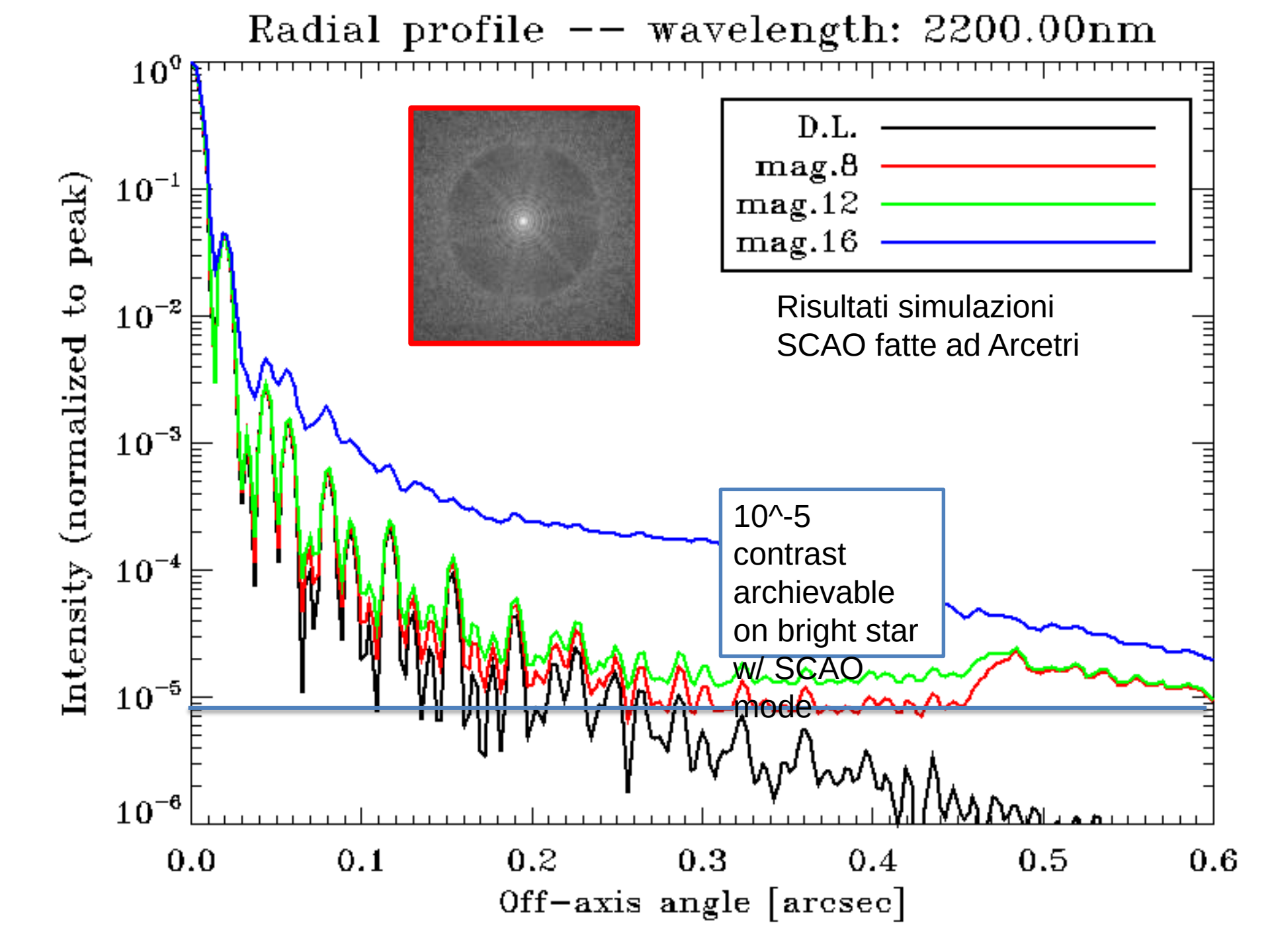
# of subaps explored with simulations:

2x2
3x3
5x5

LO simulation of performances (2x2 subaps)

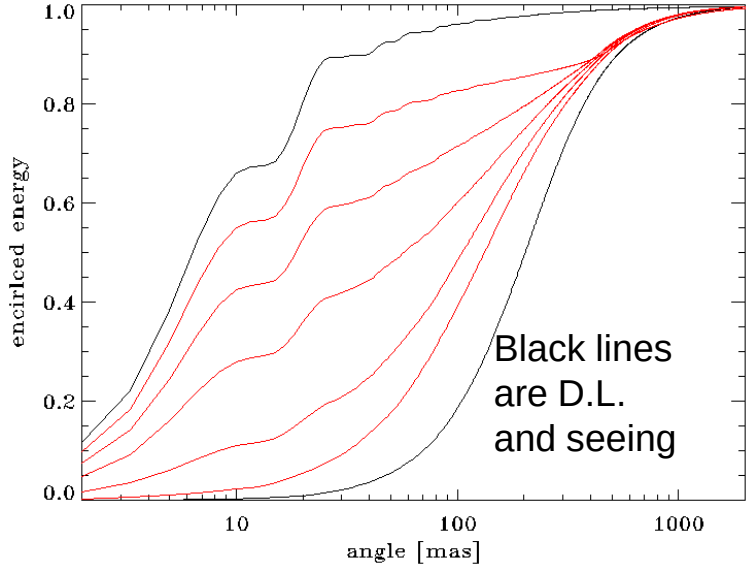


Rmag ref. star	VIS	IR (col=1)	IR col=2	IR col = 3
baseline	19.5	19.7	20.7	21.7
goal	18	18.7	19.7	20.7

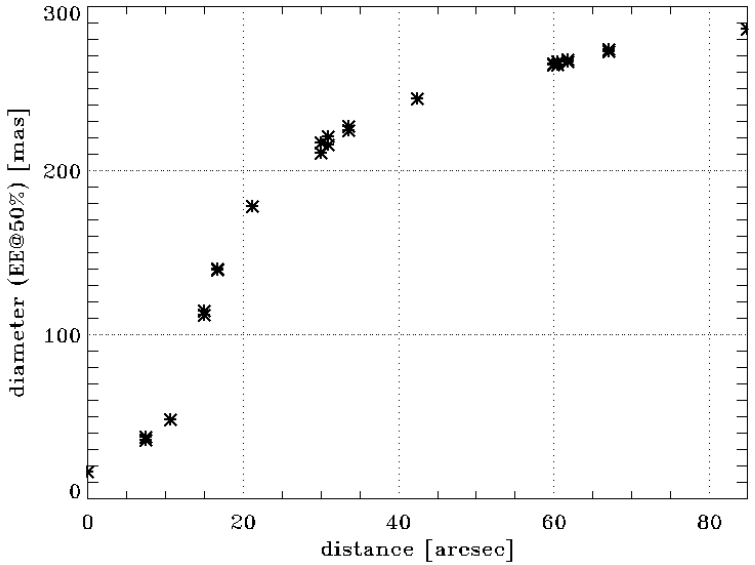

Radial profile -- wavelength: 2200.00nm
Intensity (normalized to peak)
Off-axis angle [arcsec]
D.L.
mag.8
mag.12
mag.16
Risultati simulazioni
SCAO fatte ad Arcetri
10^-5
contrast
archievable
on bright star
w/ SCAO
mode

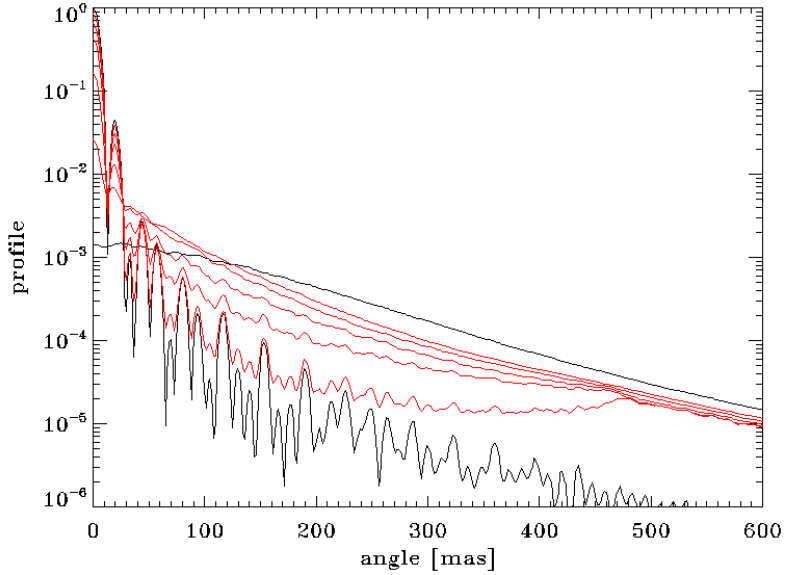
EELT R=12

EE and profiles shown are the ones on the first raw of the grid

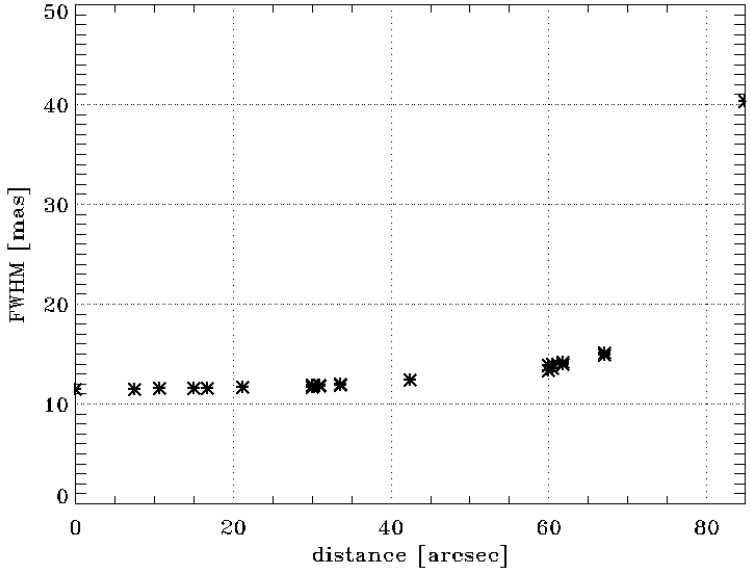


EE@50%



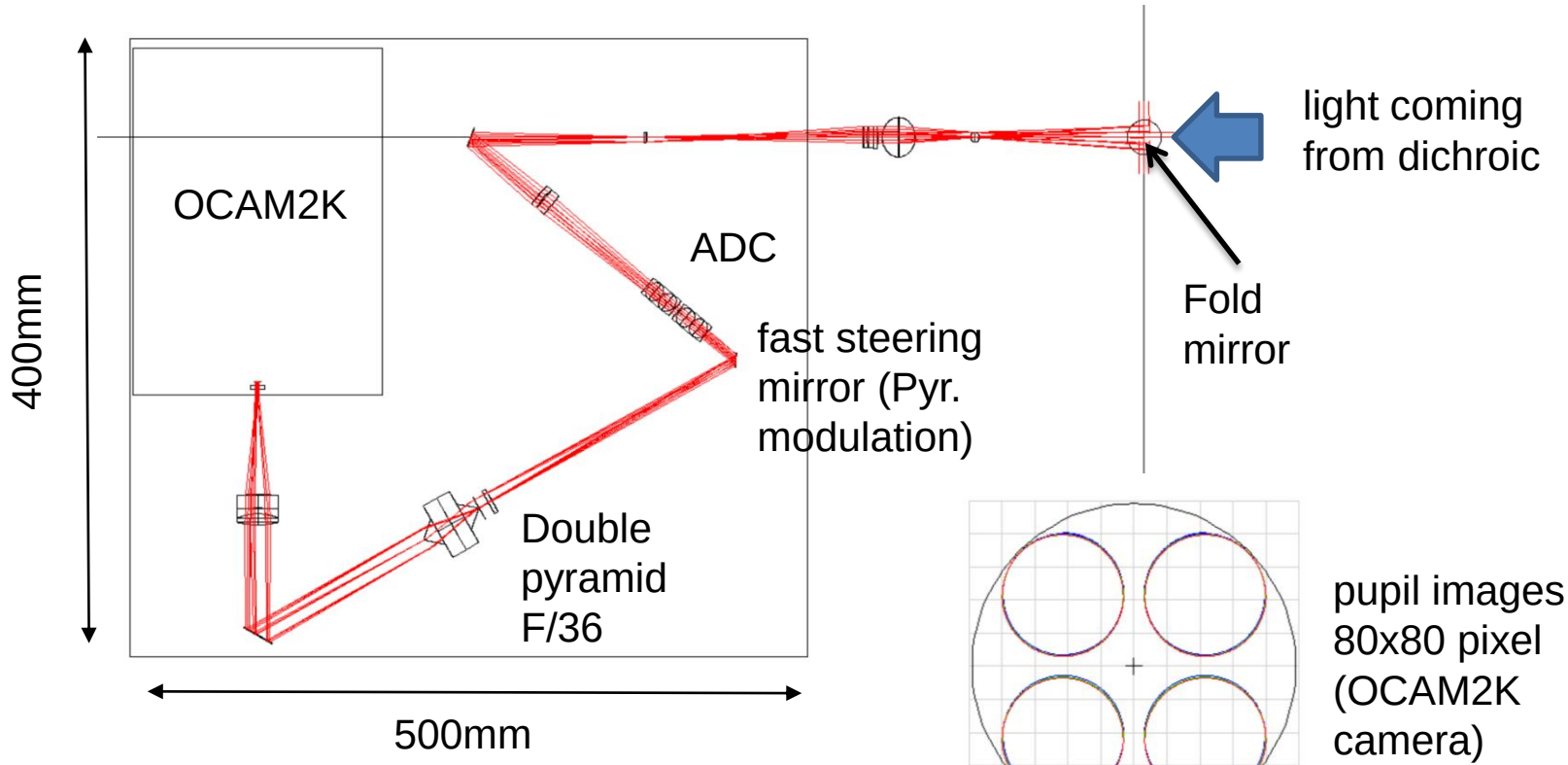


FWHM



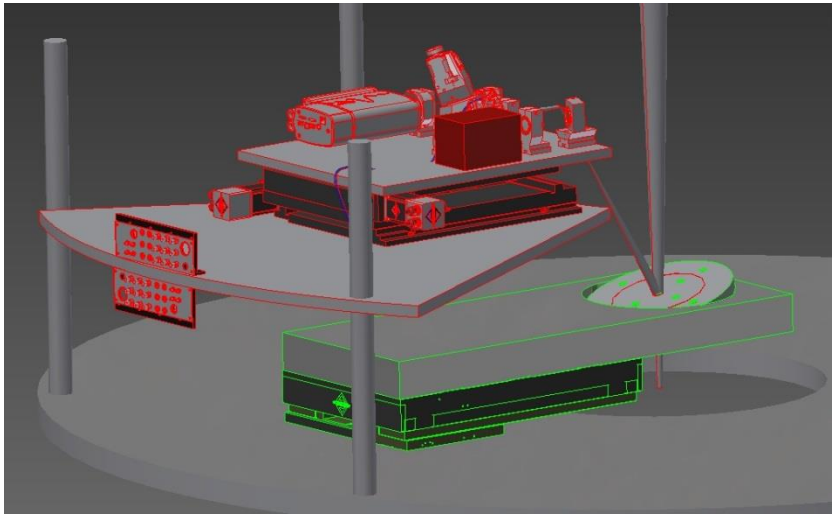
SCAO unit concept

- An optical sketch with Pyramid WFS (80x80SAs) using OCAM detector
- NGS pickoff from science field with dichroic + fold mirror
- Linear stages are needed to patrol full FoV



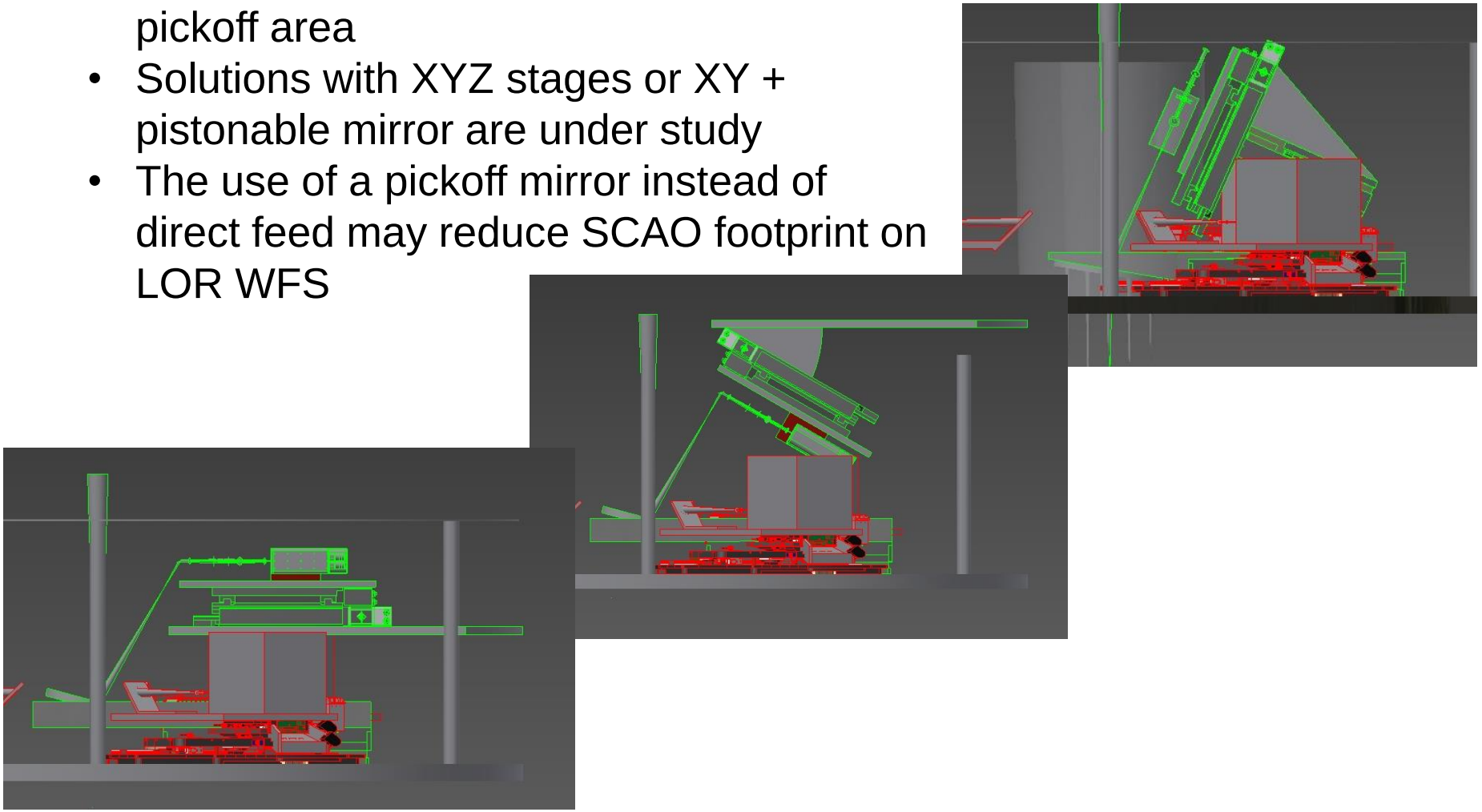
SCAO & Dichroic Units concept

- SCAO + Dichroic occupy an ‘’independent’’ slice of GD volume
- SCAO + Dichroic are on a common support structure -> single interface, less diff. flex.
- Independent supplies lines directly from SCAO cabinets
- Slidable dichroic on bottom, SCAO on top
- Parked SCAO leaves LOR FoV unobstructed



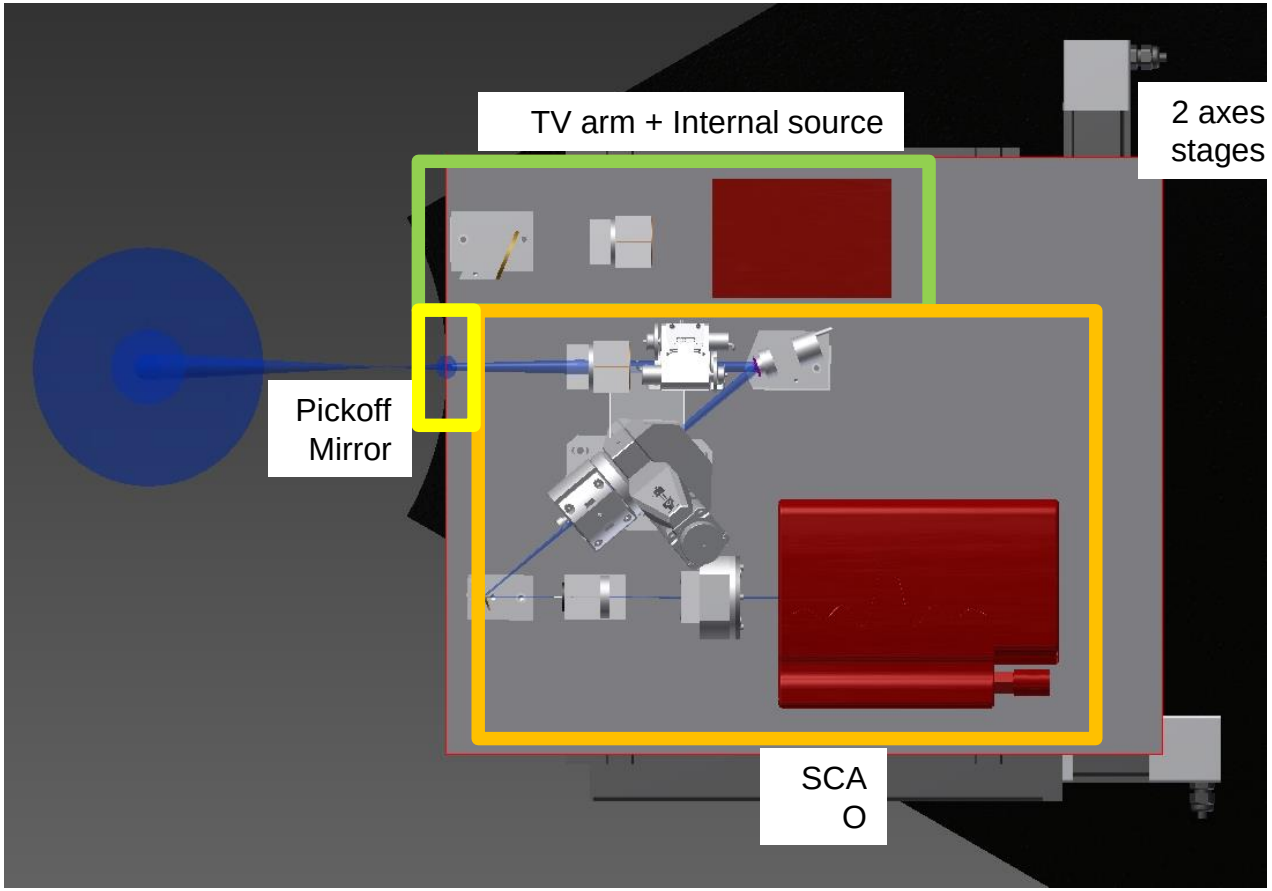
SCAO FoV

- SCAO needs to patrol a FoV of 53x53” and to leave unobstructed the LOR WFS pickoff area
- Solutions with XYZ stages or XY + pistonable mirror are under study
- The use of a pickoff mirror instead of direct feed may reduce SCAO footprint on LOR WFS



SCAO Unit

- Tip-tilt stage allows to compensate for chief-ray tilt due to finite pupil distance (TBQ)
- Large FoV camera (TBC)
- Internal light source for fast functionality checks



Components

- SCAO is based on modualted Pyramid concept
- 2’’ FoV, F35 => 6mm/’’ on pyramid
- ADC sketched (ABA-ABA layout)
- Pupil derotator (K-mirorr or Dove prism)
- Doble glass pyramid