



MAORY

Multiconjugate Adaptive Optics RelaY for E-ELT

PAOLO CILIEGI

on behalf of the MAORY team



MAORY

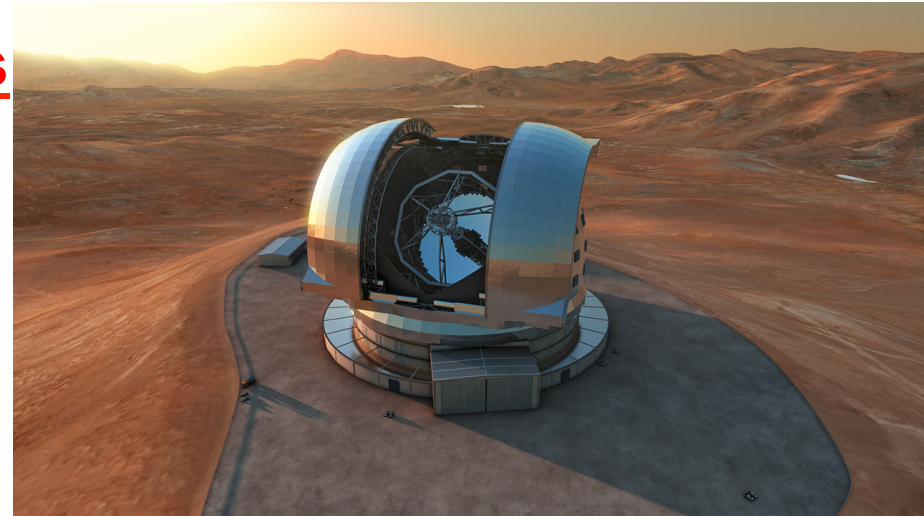
- **WHAT IS IT ?**
- **TO DO WHAT ?**
- **HOW IT IS DONE ?**
- **WHO DOES IT ?**
- **HOW THESE PEOPLE ARE ORGANIZED ?**



WHAT IS IT ?

E-ELT first light instruments

- **HARMONI**
High Angular Resolution Monolithic Optical and Near-infrared Integral field spectrograph
- **METIS**
Mid-infrared E-ELT Imager and Spectrograph
- **MAORY**
Multi-conjugate Adaptive Optics Relay
- **MICADO**
Multi-AO Imaging Camera for Deep Observations



Artist's impression of the E-ELT
Credit: ESO / L. Calçada



Past phases and milestones

Phase A

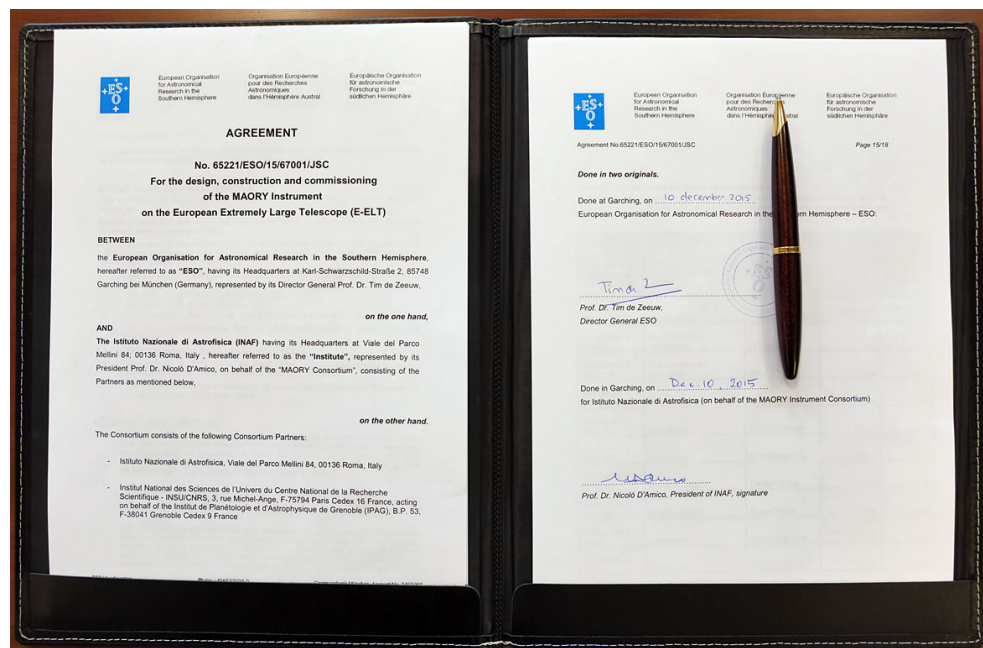
- Nov 2007 - Dec 2009
- Review held on 10-11 Dec 2009

Phase B preparation

- Instrument re-baselining
- Requirements definition
- Contractual documents preparation
- Consolidation of facilities at INAF

Agreement signature

- 10 Dec 2015



Credit: ESO / M. Zamani

MAORY SIGNATURE 10/12/15



KICK – OFF MEETING 02/02/16





MAORY supporters in Italy

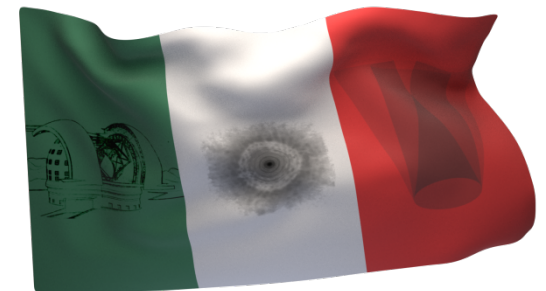
T-REX project: Italian technology for E-ELT, the world's biggest telescope (PI M. Tosi)

- Project funded by MIUR
- Crucial support to INAF participation in E-ELT instrumentation
- Development of facilities
 - Re-modelling of integration lab for MAORY (IASF Bologna)
 - Re-modelling of integration lab for MAORY NGS WFS Module (OA Arcetri)
 - Acquisition of general purpose instrumentation for MAORY AIV (OA Bologna)
 - Development of optics prototyping facilities (OA Brera)



New “progetto premiale” on adaptive optics (PI R. Ragazzoni)

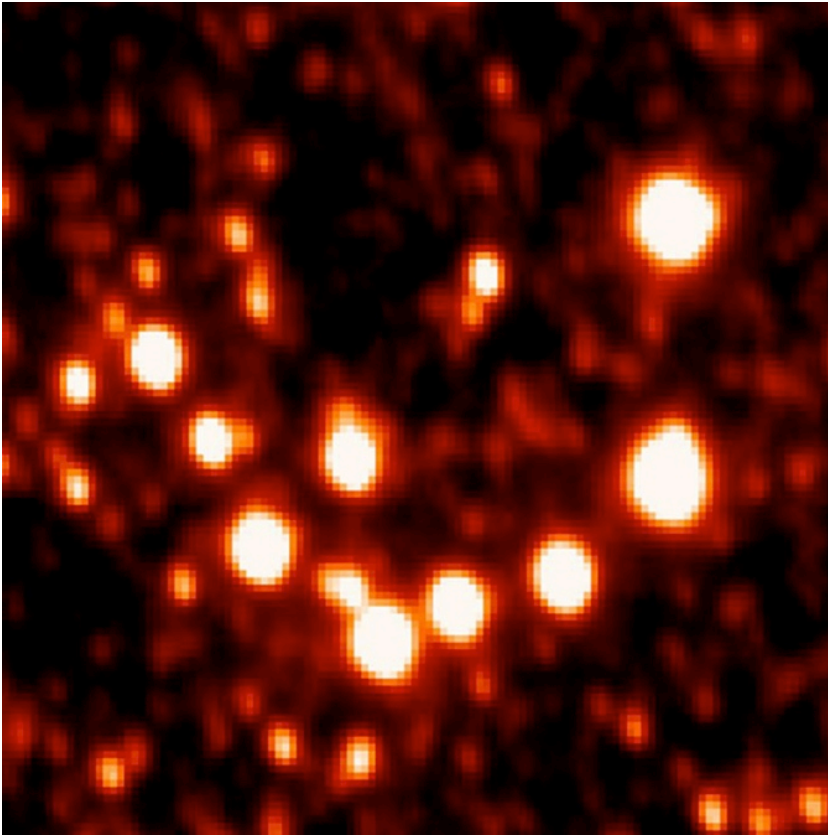
- Submitted to MIUR, Sep 2015



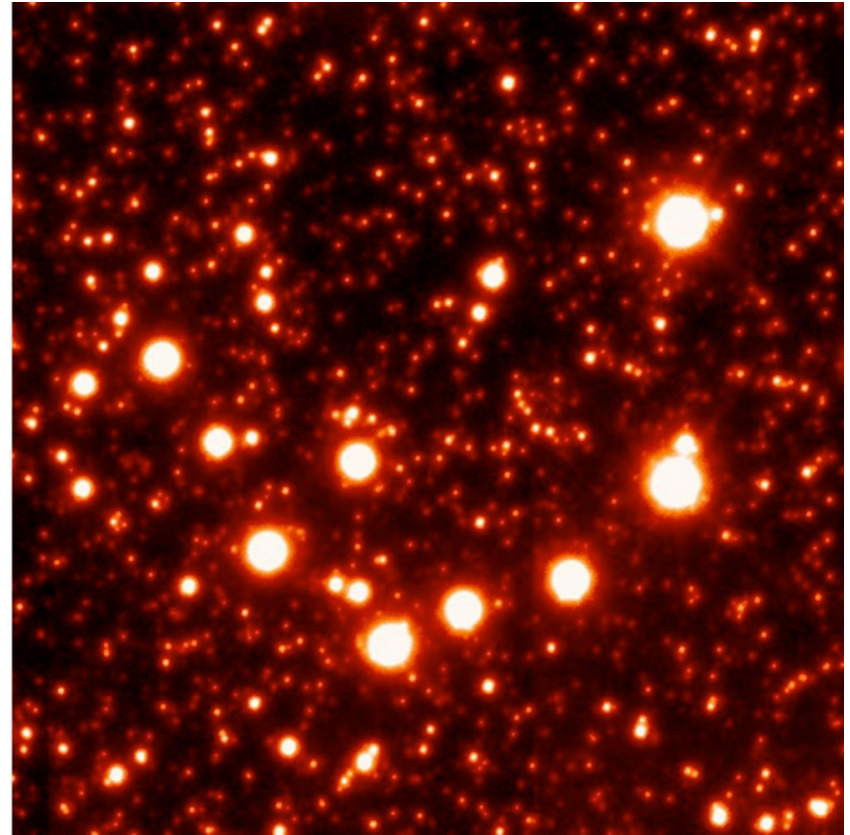


TO DO WHAT?

20 x 20 arcsec region near the center of globular cluster Omega Centauri



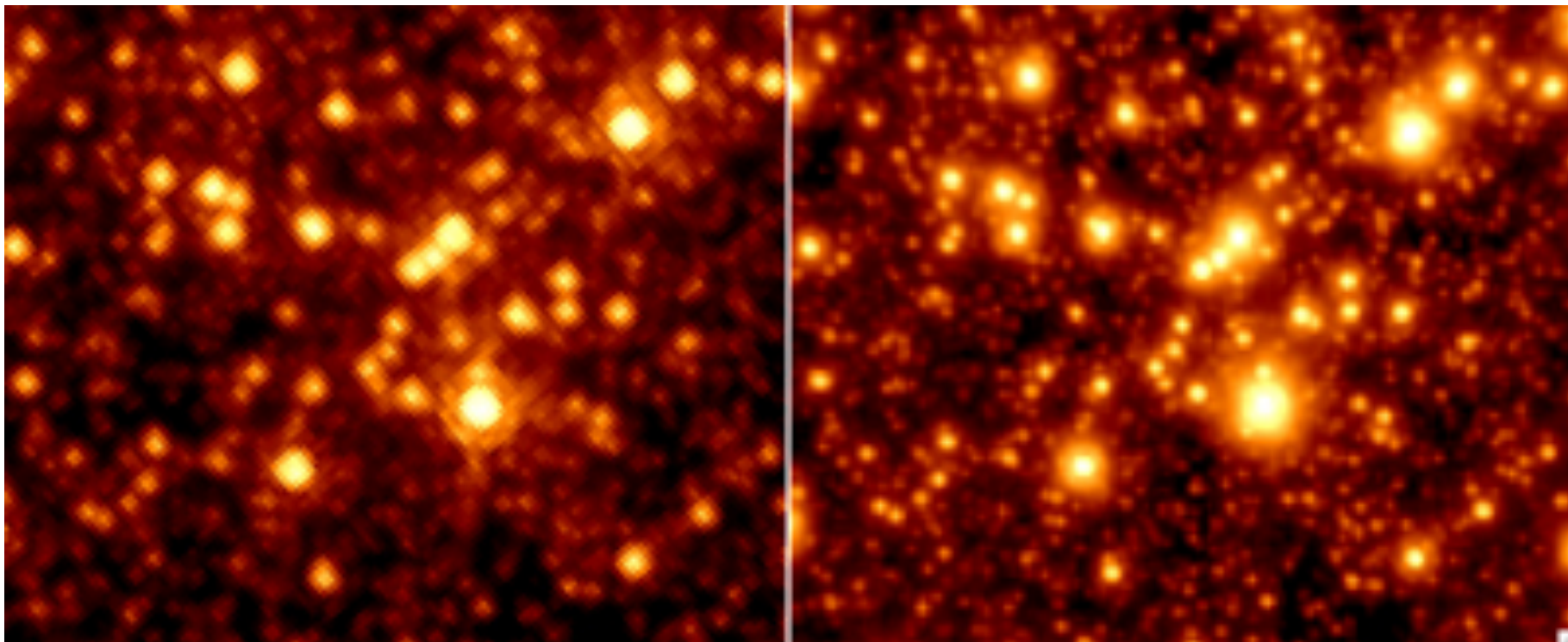
K-band seeing limited
FWHM = 0.6 "



MAD with MCAO correction
FWHM < 0.1 "



TO DO WHAT ?



HST

FLAO LBT

H band image of Globular Cluster M92



MAORY requirements

Primary client instrument: MICADO

Astrometric accuracy

- MAORY shall permit observations such that the relative position on the sky of an unresolved, unconfused source of optimal brightness with respect to an optimal set of reference sources must be reproducible to within 50 μas (goal: 10 μas) over a central, circular field of 20 arcsec diameter (goal: across the entire field of view) and over all timescales in the range of 1 hour to 5 years

Photometric accuracy

- MAORY shall permit observations with MICADO such that the relative flux of an unresolved, unconfused source of optimal brightness with respect to an optimal set of reference sources must be reproducible to within 0.02 mag (goal: 0.01 mag) across the entire field of view and over all timescales in the range of 1 hour to 5 years

Other requirements

- Second port for instrument to be defined



Expected AO performance

Expected MCAO performance (telescope included)

Assumptions: wavelength 2.2 μm , one deformable mirror in MAORY, 6 LGS, full M1

Strehl ratio	Sky coverage	Conditions
SR \approx 0.3 (TBC)	50% (TBC)	Median seeing As close to zenith as possible Field of view 1 arcmin
SR \approx 0.15 (TBC)	50% (TBC)	Sub-optimal seeing Zenith distance 30° Field of view 2 arcmin
SR \approx 0.4-0.5 (TBC)	Not applicable	Best seeing Zenith distance 30° Field of view 20 arcsec

With 2 deformable mirrors in MAORY, performance under median conditions is comparable to performance under best conditions with 1 deformable mirror

Expected SCAO performance: SR > 0.6 (goal > 0.7)

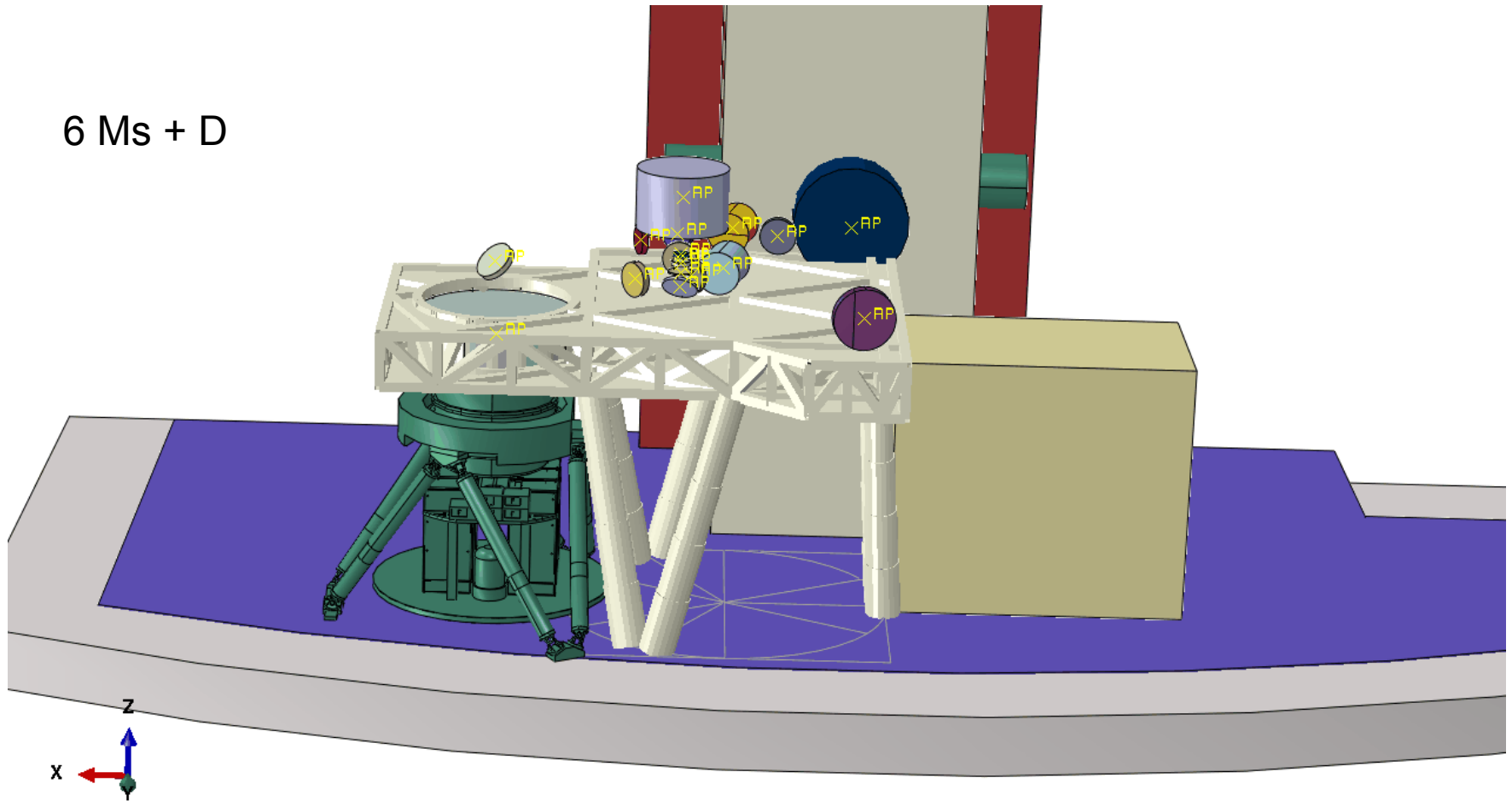
Conditions: on-axis, zenith angle < 30°, guide star magnitude $V < 12$, median seeing



HOW IT IS DONE?

Optical and mechanical design

6 Ms + D

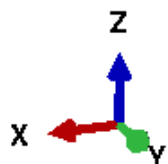
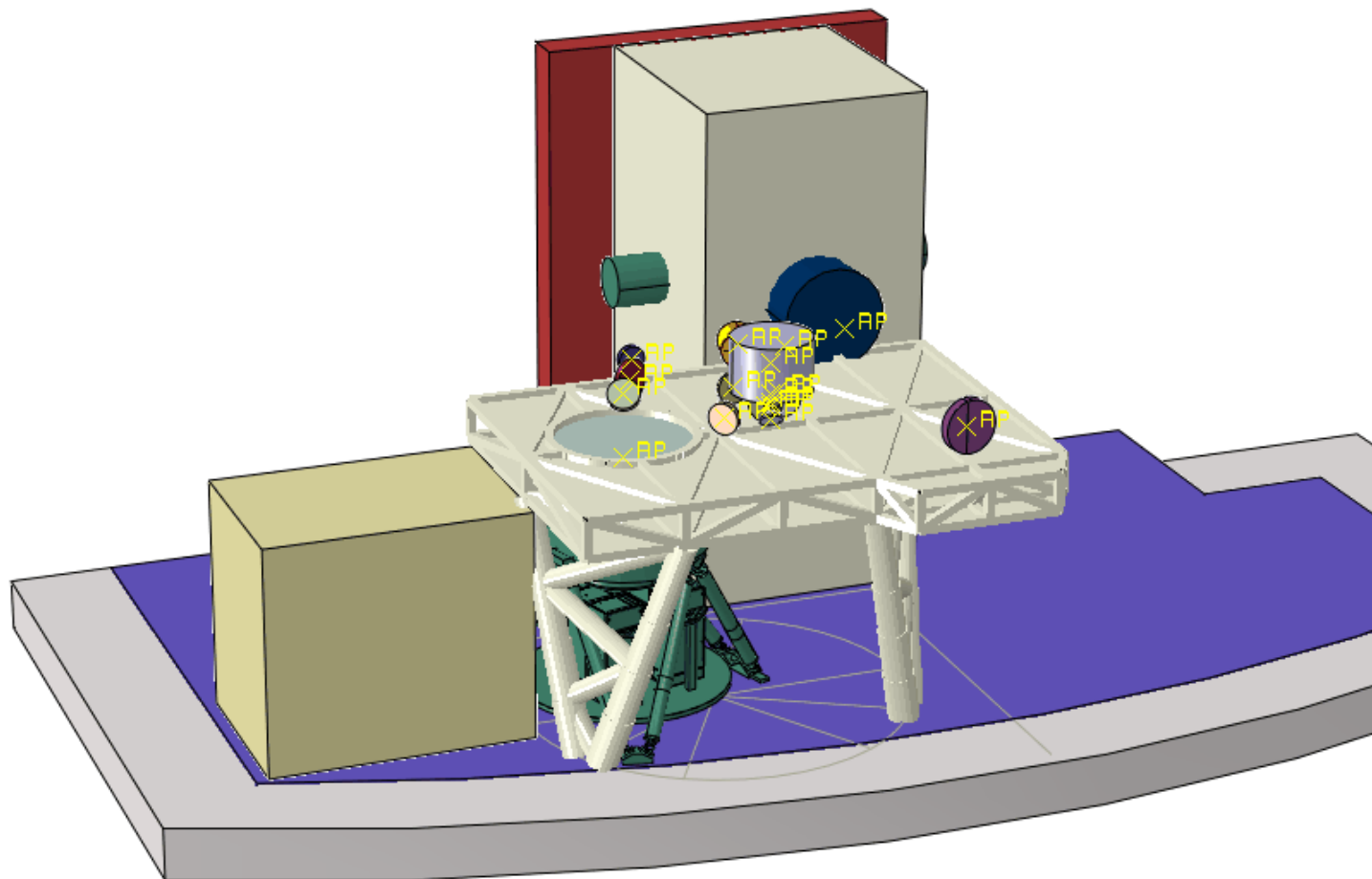




HOW IT IS DONE?

Optical and mechanical design

6 Ms + D

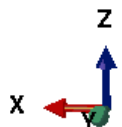
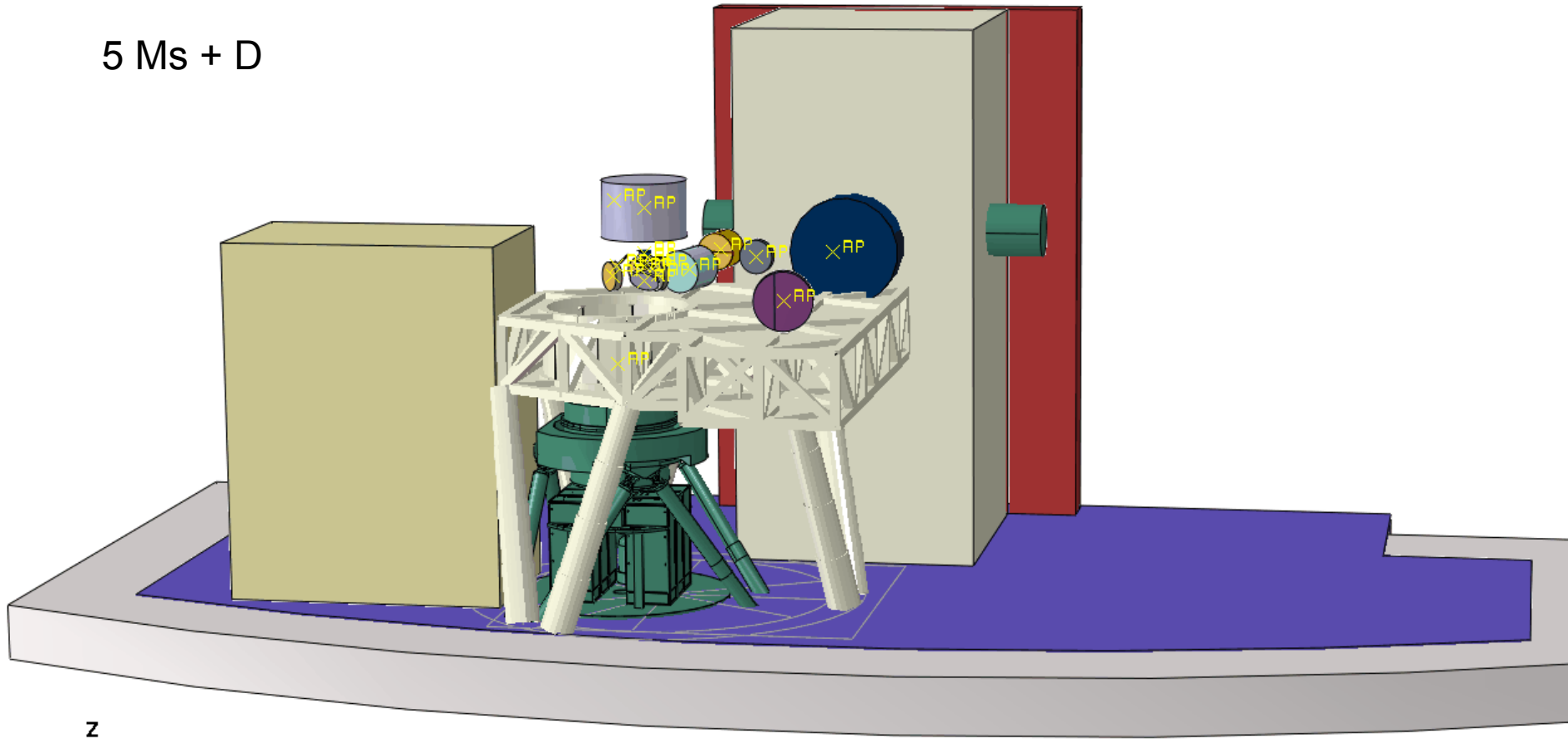




HOW IT IS DONE?

Optical and mechanical design

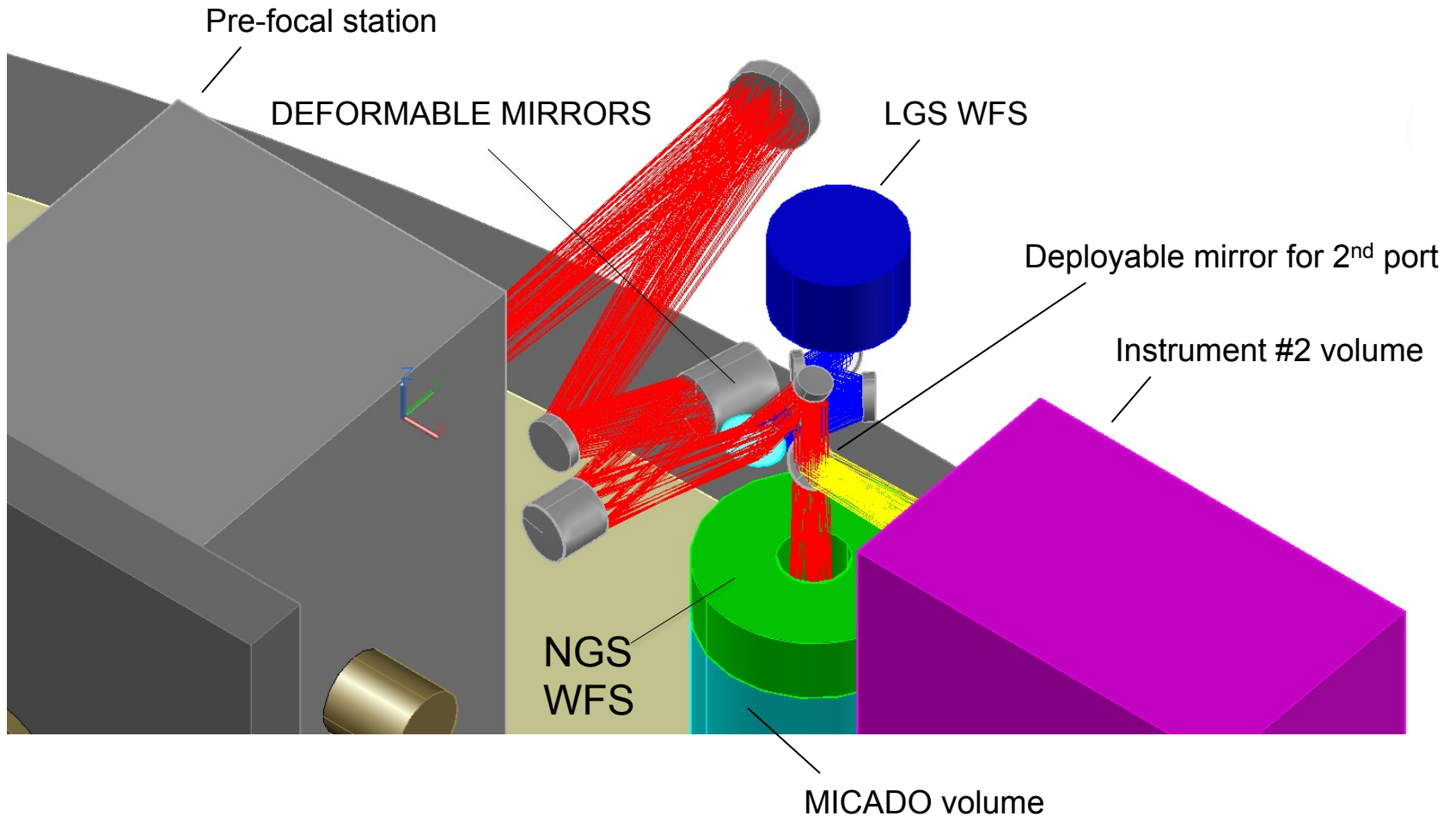
5 Ms + D





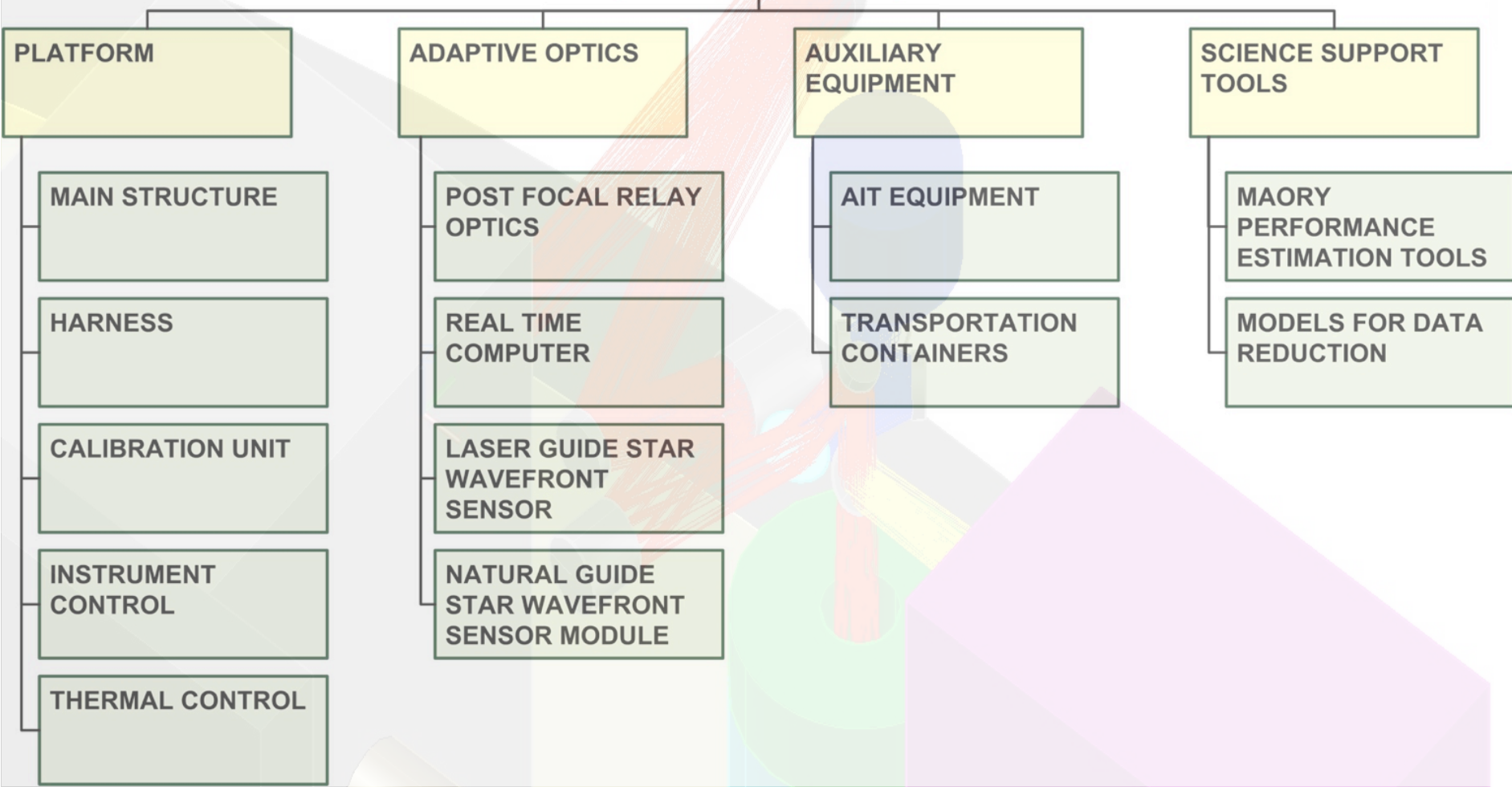
HOW IT IS DONE?

Optical and mechanical design





MAORY



WHO DOES IT ?

THE MAORY CONSORTIUM



Country	Institute	Co-I/PI	Principal supplies
Italy	Istituto Nazionale di Astrofisica (INAF)	Emiliano Diolaiti	System level: MAORY Project Office and System Team, MAORY instrument Sub-system level: Platform, Post-Focal Relay Optics, RTC, NGS WFS Module, Auxiliary Equipment, Science Support Tools
France	Institut de Planétologie et d'Astrophysique de Grenoble (IPAG)	Philippe Feautrier	Sub-system level: provide LGS WFS Contribution to System Level AO engineering



WHO DOES IT ?

INAF INSTITUTES

INAF – OSSERVATORIO ASTRONOMICO DI BOLOGNA

INAF – IASF BOLOGNA

INAF – OSSERVATORIO ASTROFISICO DI ARCETRI

INAF – OSSERVATORIO ASTRONOMICO DI BRERA

INAF – OSSERVATORIO ASTRONOMICO DI CAPODIMONTE

INAF – OSSERVATORIO ASTRONOMICO DI PADOVA



Consortium MoU / GTO

Guaranteed Time Observations

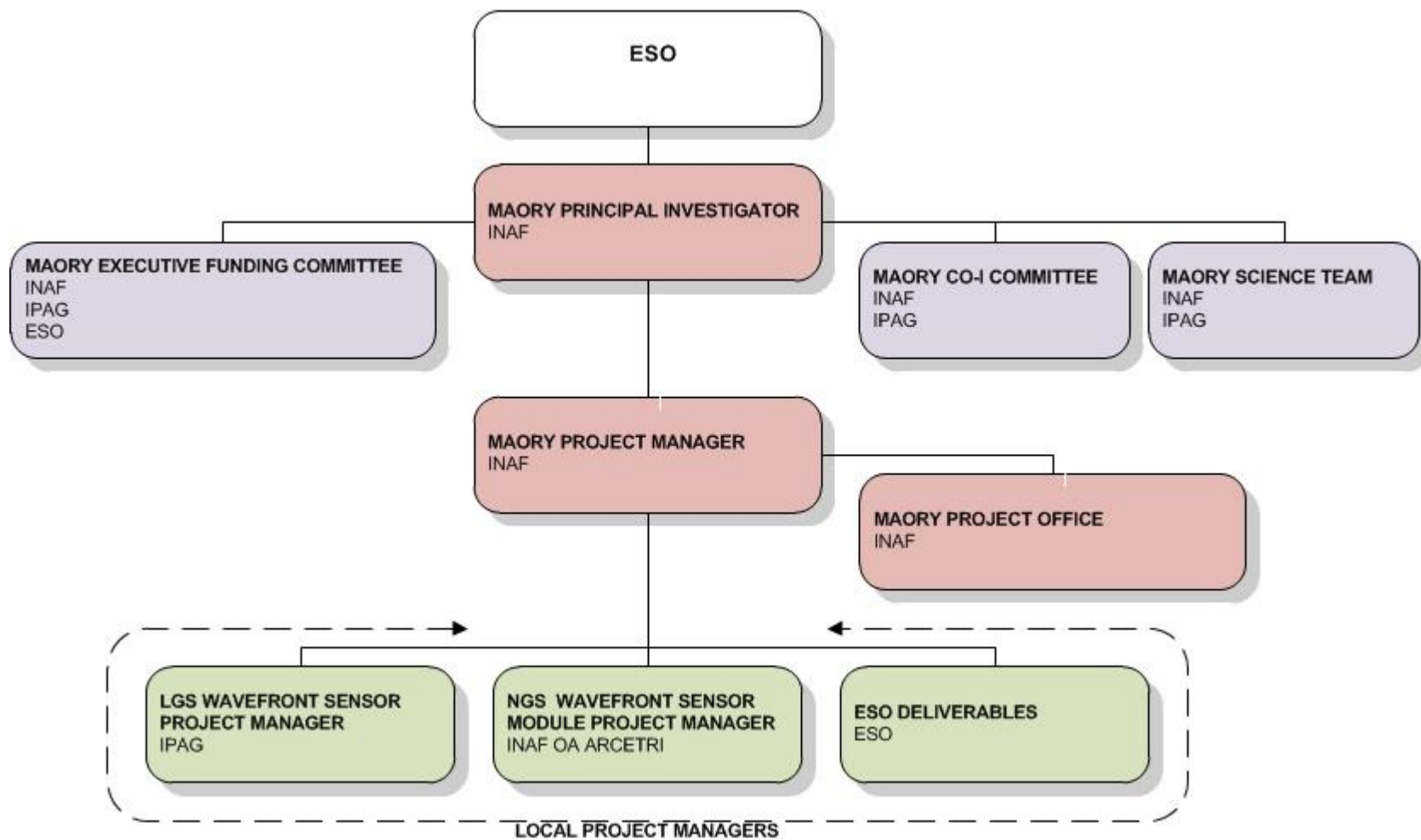
- 65 nights GTO in return for design, construction and commissioning of MAORY

Institute	Number of GTO nights
INAF	54
INSU IPAG	11

- Announcement of opportunity for GTO managed by MAORY Science Team
- Joint science proposals between the Consortium partners are encouraged

HOW WE ARE ORGANIZED







MAORY TIME LINE

The MAORY project will contain three phases with their associated system level reviews

Phase B

Split in to Phase B1 and Phase B2

With the MAORY System Requirements Review (SRR) at the end of Phase B1

With the **MAORY Preliminary Design Review (PDR)** at the end of Phase B2

Phase C/D

With the **MAORY Final Design Review (FDR)** at the end of the phase C

With the MAORY System Qualification Review (SQR) during the Phase D

The MAORY **Preliminary Acceptance in Europe (PAE)** review will be held at the end of the Phase D

Phase E

Maory Readiness Review, review of readiness to be mounted on the Nasmyth Platform

The Phase E terminates with the **MAORY Provisional Acceptance Review in Chile (PAC)**



MAORY WWW

<http://www.maory.oabo.inaf.it>



MAORY

Multi-conjugate Adaptive Optics Relay for E-ELT



MAORY (Multi-conjugate Adaptive Optics Relay) is one of the key instruments for the European Extremely Large Telescope (E-ELT), the 39 m diameter optical-infrared telescope that the European Southern Observatory (ESO) will build in the next decade in collaboration with its community of member States.

MAORY is a post-focal adaptive optics module. It supports the **MICADO** near-infrared camera by offering two adaptive optics modes: Multi-Conjugate Adaptive Optics (MCAO) and Single-Conjugate Adaptive Optics (SCAO).

Development of the SCAO mode is a joint endeavour between the MAORY and MICADO instrument teams. The MCAO mode is required to achieve uniform adaptive optics compensation over the full MICADO field of view; the SCAO mode is required for peak performance, rather than uniformity over the field, when a suitable Natural Guide Star is available.

In the MCAO mode, wavefront sensing is performed by a system based on up to six Laser Guide Stars for high-order wavefront sensing and three Natural Guide Stars for low-order wavefront sensing; wavefront compensation is achieved by up to two deformable mirrors in MAORY, which work together with the telescope adaptive and tip-tilt mirrors M4 and M5 respectively. In the SCAO mode, wavefront distortions are measured by a single Natural Guide Star wavefront sensor and compensated by the telescope M4 and M5 mirrors, while the deformable mirrors inside MAORY are kept flat.



KICK OFF MEETING
ESO – MAORY SIGNATURE

MAORY CONSORTIUM INSTITUTES

