European Extremely Large Telescope

Science Case and Instruments

Markus Kissler-Patig
E-ELT Project Scientist

Science Case

Science case

- Today's great ideas

  Design Reference Mission, Design Reference Science Plan, Science Cases of the Instrument Teams, ...

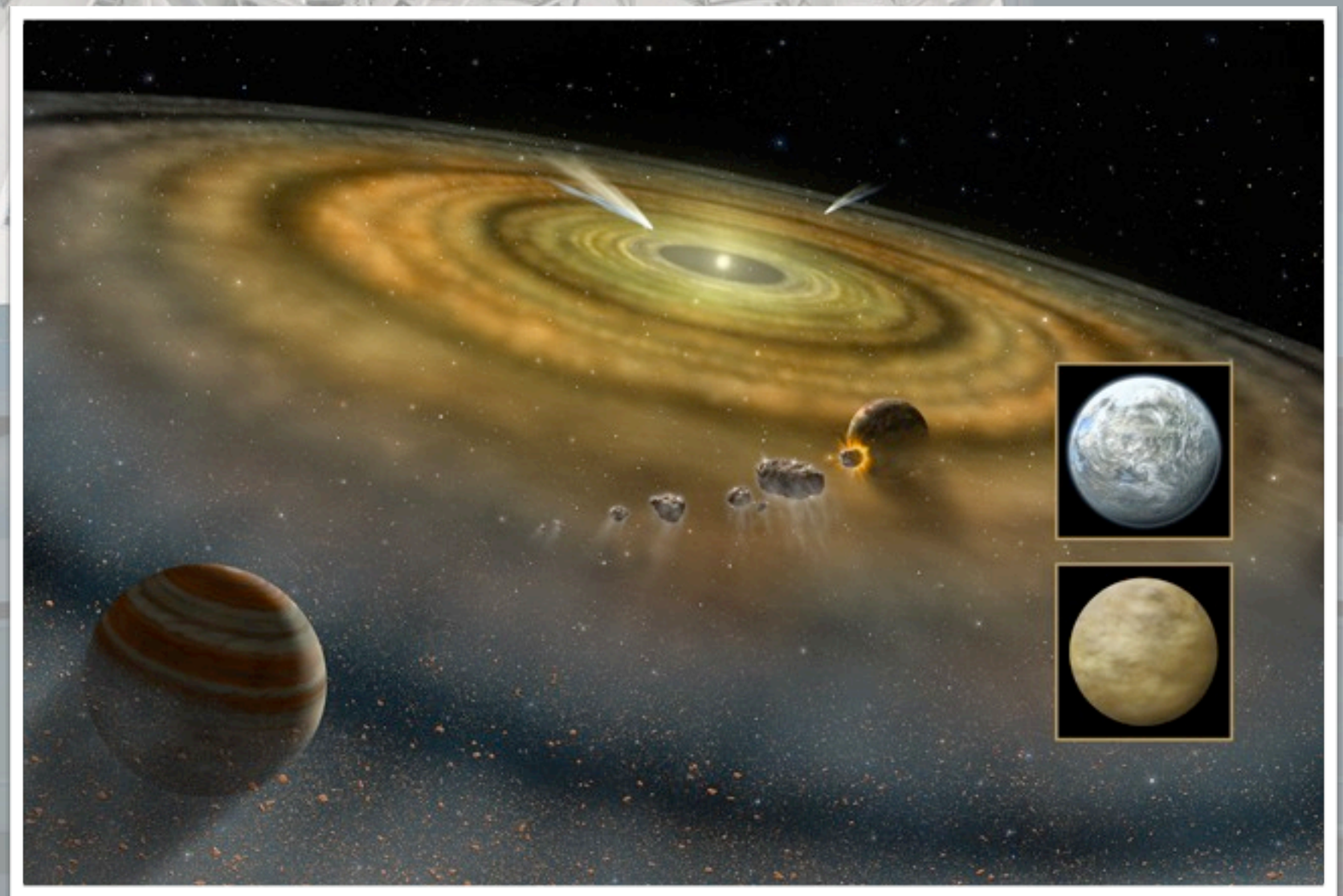
- Synergies with other major ground- and space-based facilities

  (8m class telescopes, ALMA, JWST, surveys, SKA, ...)

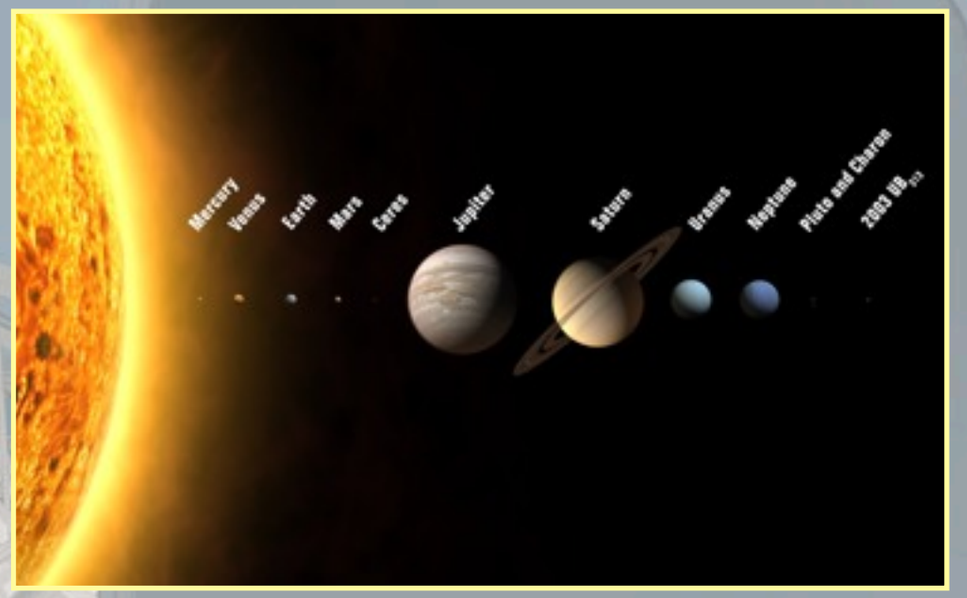
- Enable Discoveries - expect the unexpected

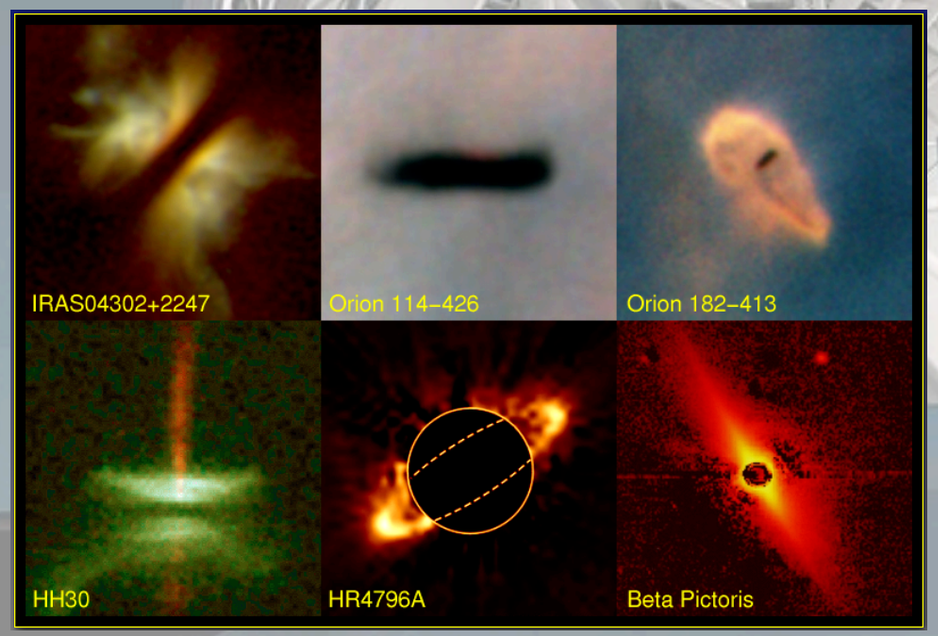
Today's Science

Planets & Stars



- From giant to terrestrial exo-planets: detection, characterisation and evolution



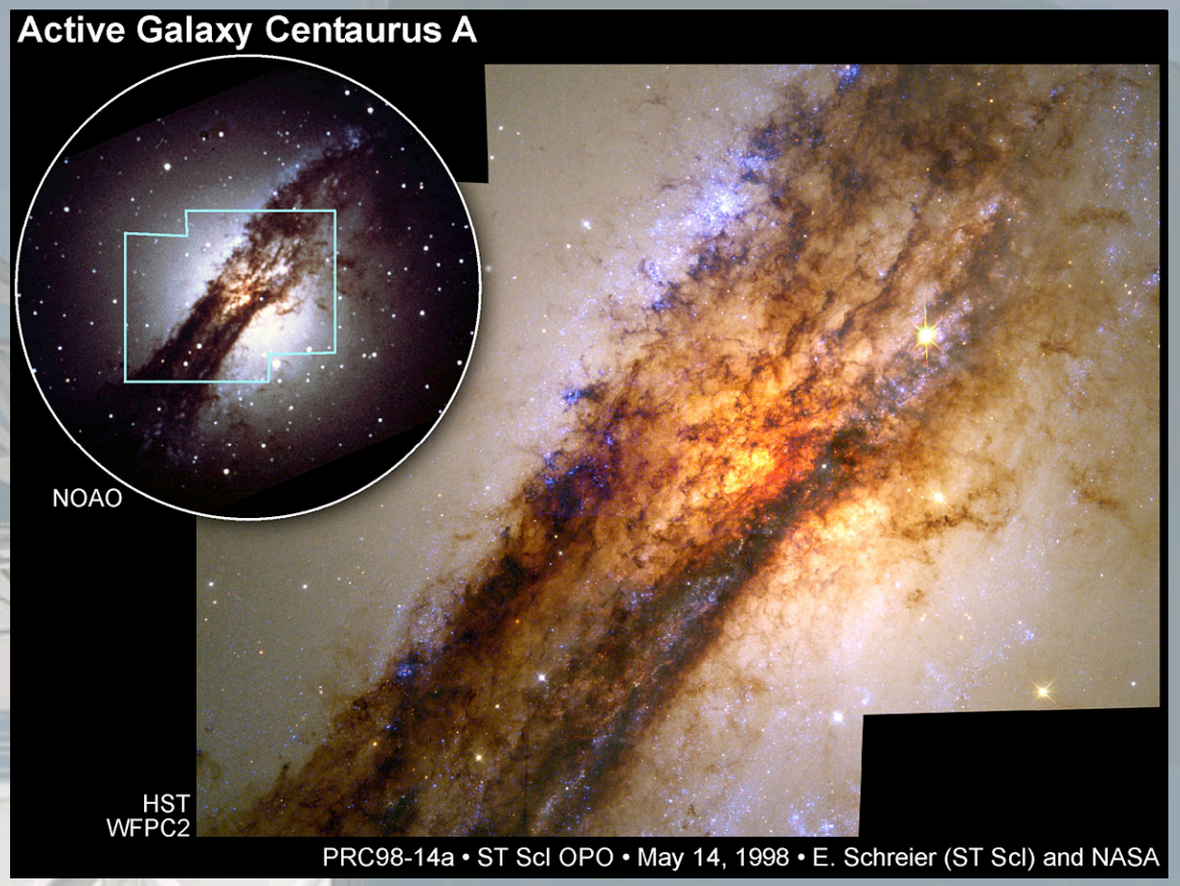


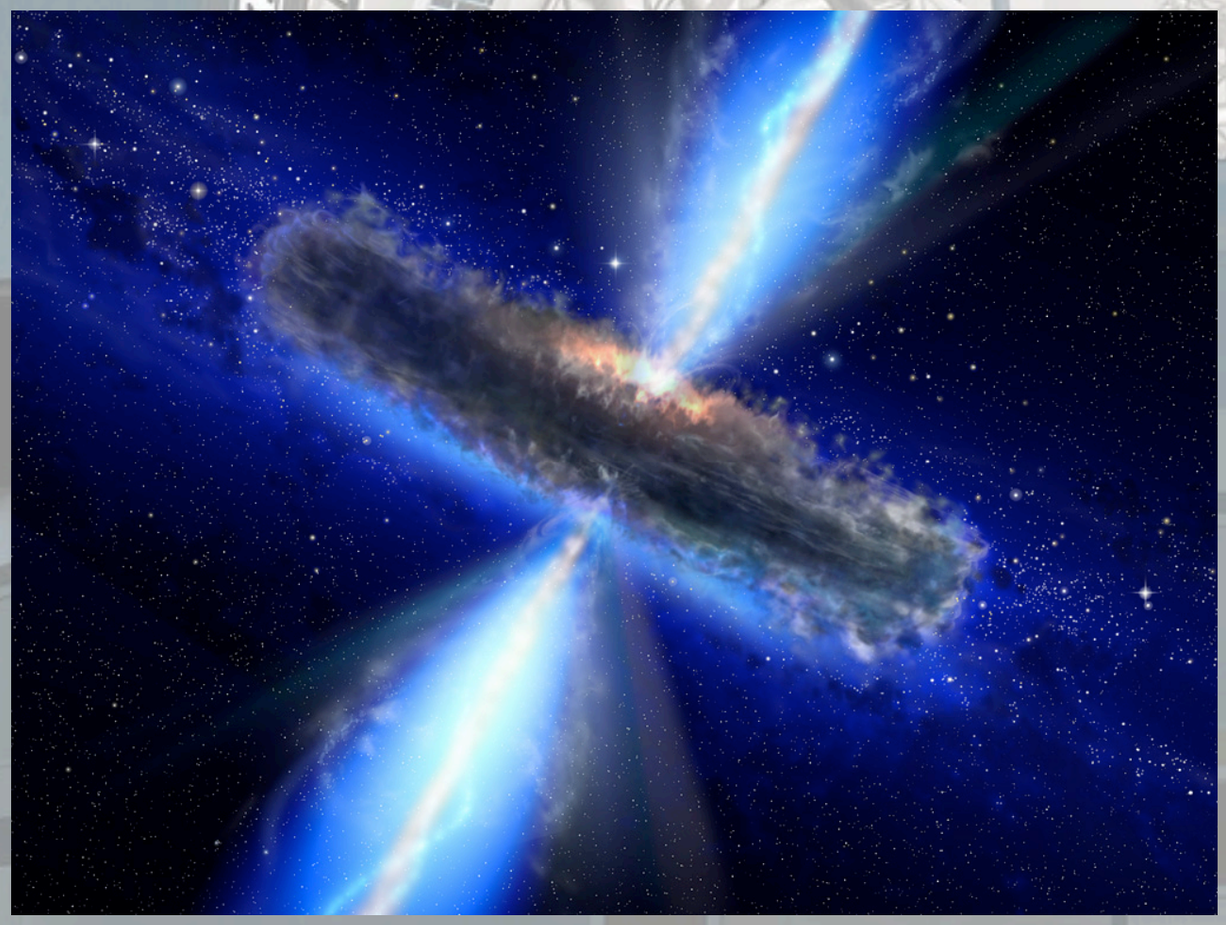
- Circumstellar disks

- Young clusters and the Initial Mass Function

Stars & Galaxies

- Imaging and spectroscopy of resolved stellar populations in nearby giant galaxies

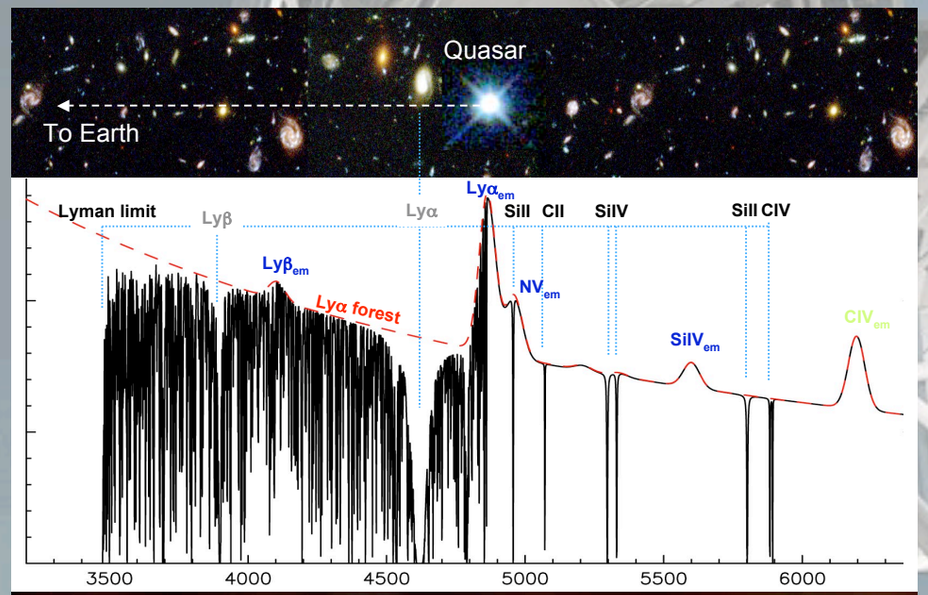


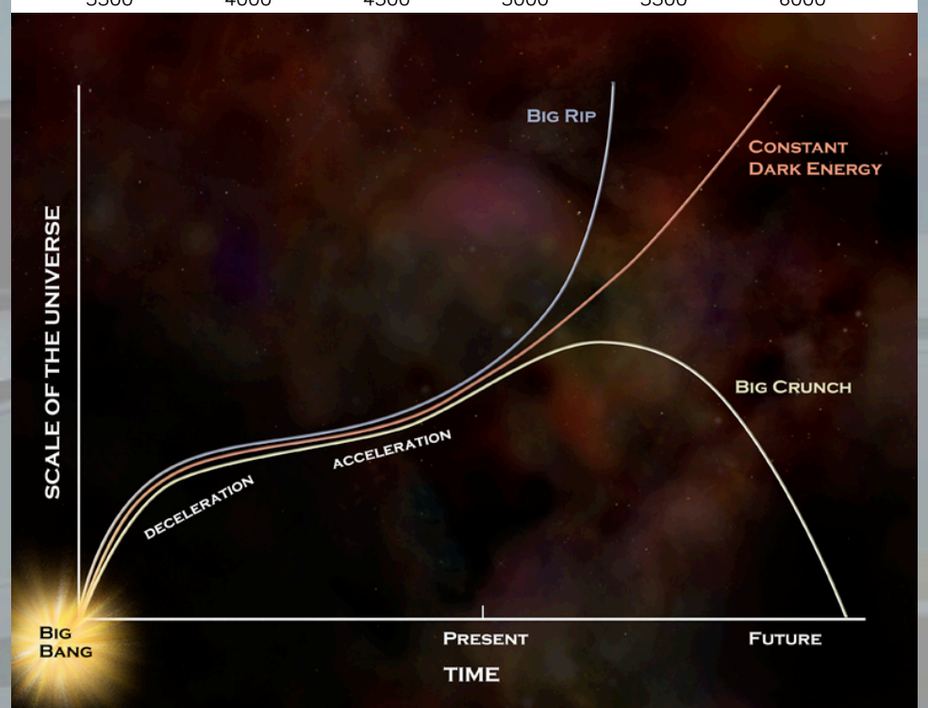


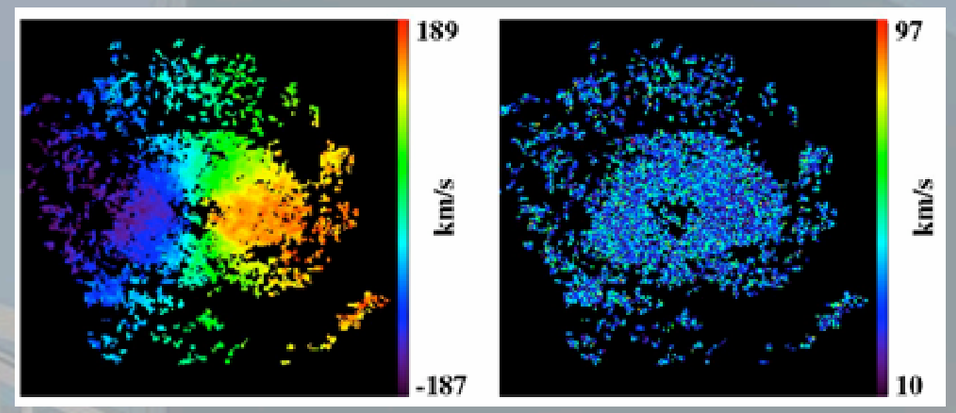
- Black holes and AGN

Galaxies & Cosmology

First light: the physics of highest-redshift galaxies





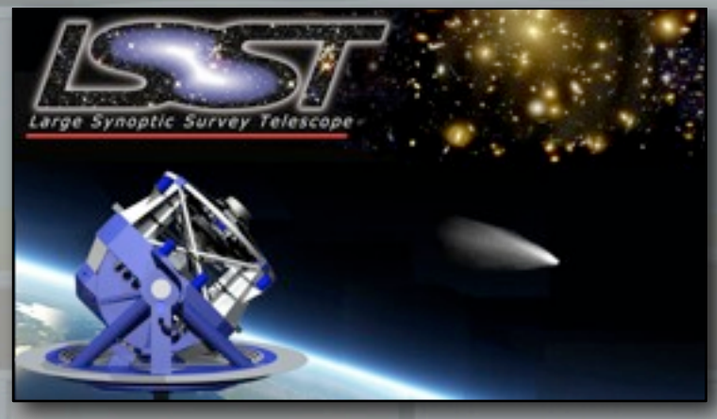


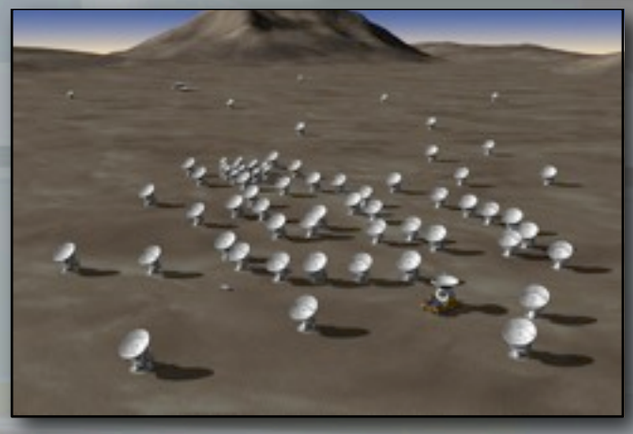
- IGM, metal enrichment
- A dynamical measurement of the expansion history of the universe

Synergies

Synergies

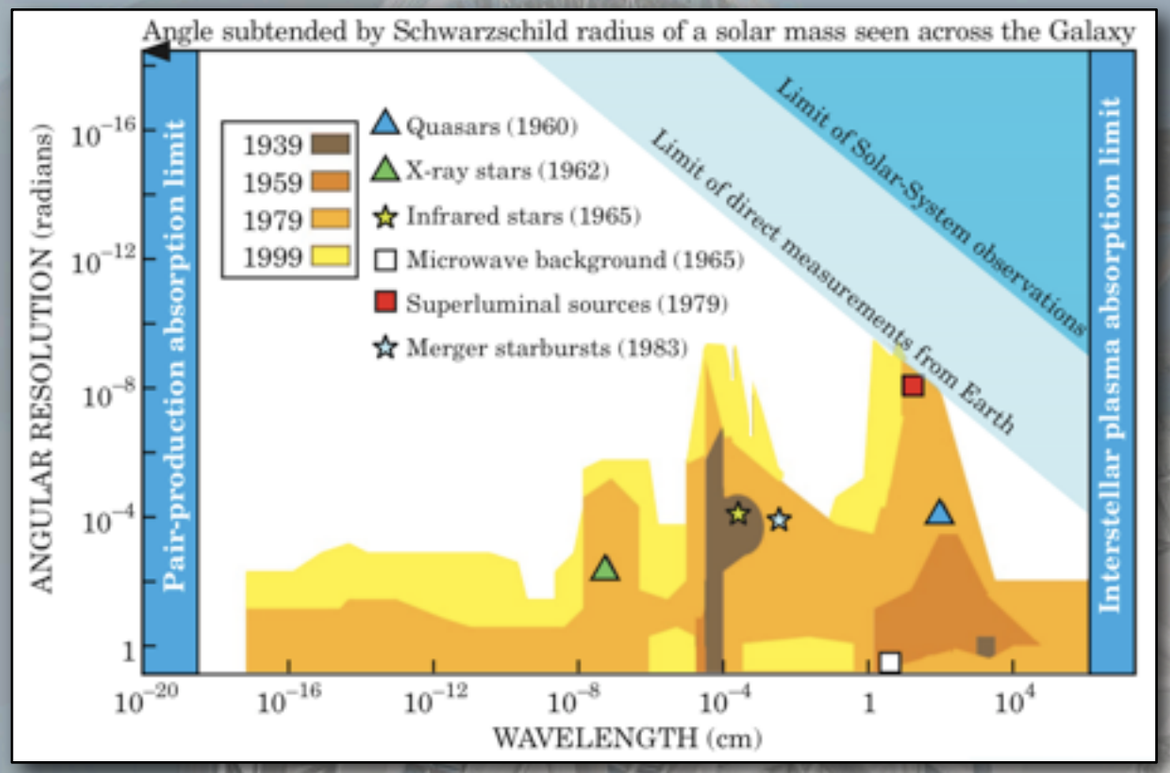
- **Today's 8-10m class telescopes**
- **The Atacama Large Millimeter Array (2012)**
- **The James Webb Space Telescope (2014)**
- **Large survey telescopes (next decade)**
- **The Square Kilometre Array (2020+)**
- **other space missions**





Discoveries

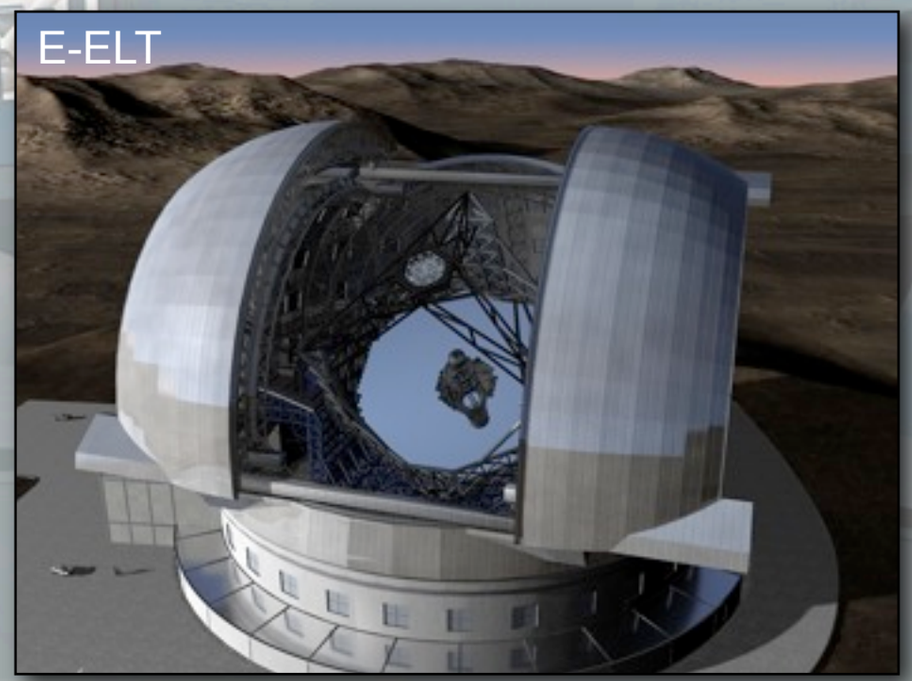
Discovery potential



M.Harwit, Physics Today, Nov. 2003

Discoveries by opening new parameter space

- Spatial resolution
- Photon sensitivity



~50 m²	~400 m²	~600 m²	~1200m²	(JWST: 25 m²)
1µm: 25 mas	9 mas	7 mas	5 mas	(JWST: 34 mas)

Instruments

E-ELT Instrumentation

ESO relies also for the E-ELT on its strong instrumentation tradition.

Despite having only one telescope, up to 6 permanently installed instruments are foreseen.

The current budget foreseen in the construction proposal will be of the order of 90 million Euros.

This will allow to build 2-3 instruments for first light, followed by another 3-4 instruments in the first decade.

Instruments phase A/concept studies

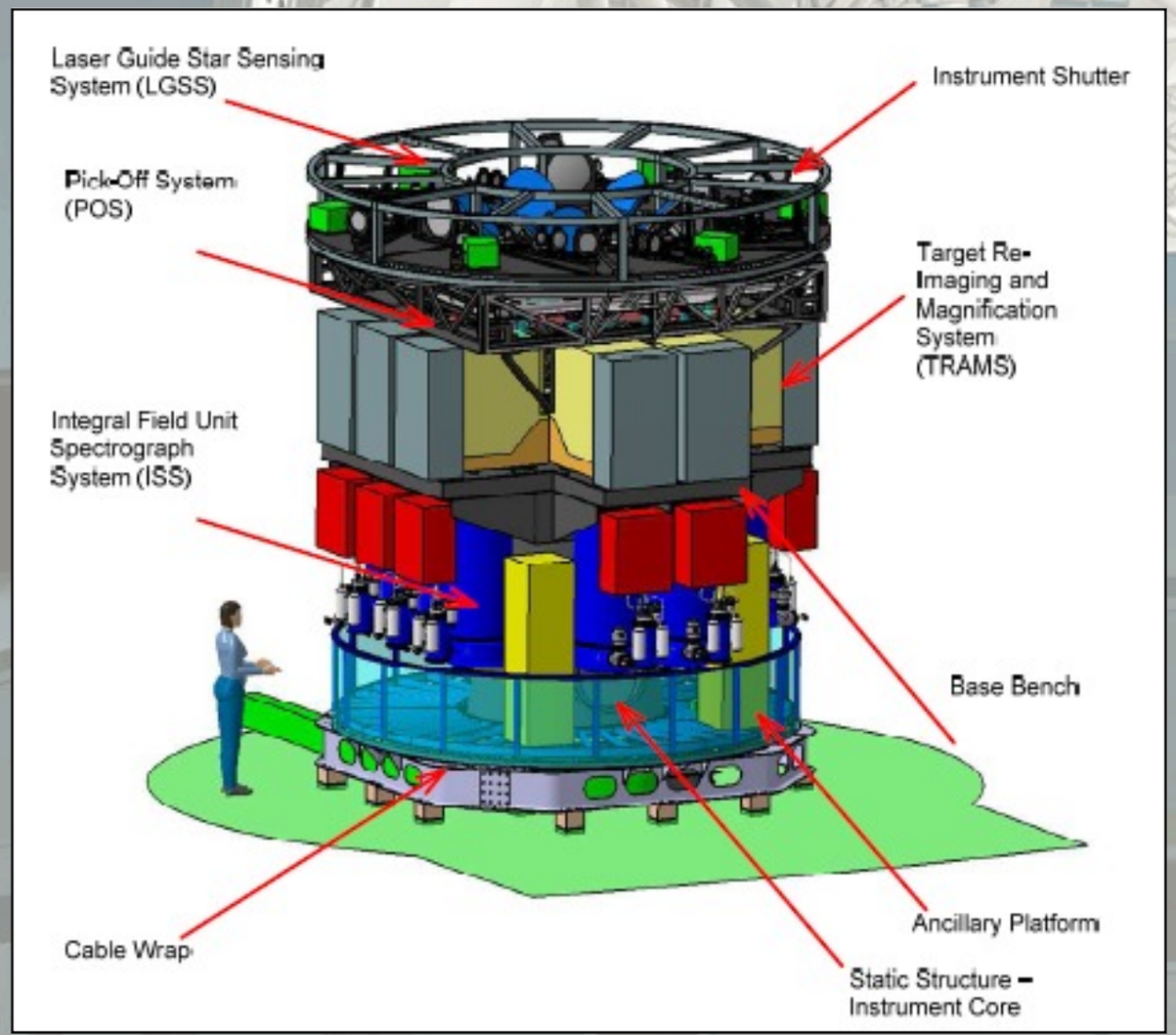
The following instruments have all been studied over 15-24 months and concluded recently with a final design review.

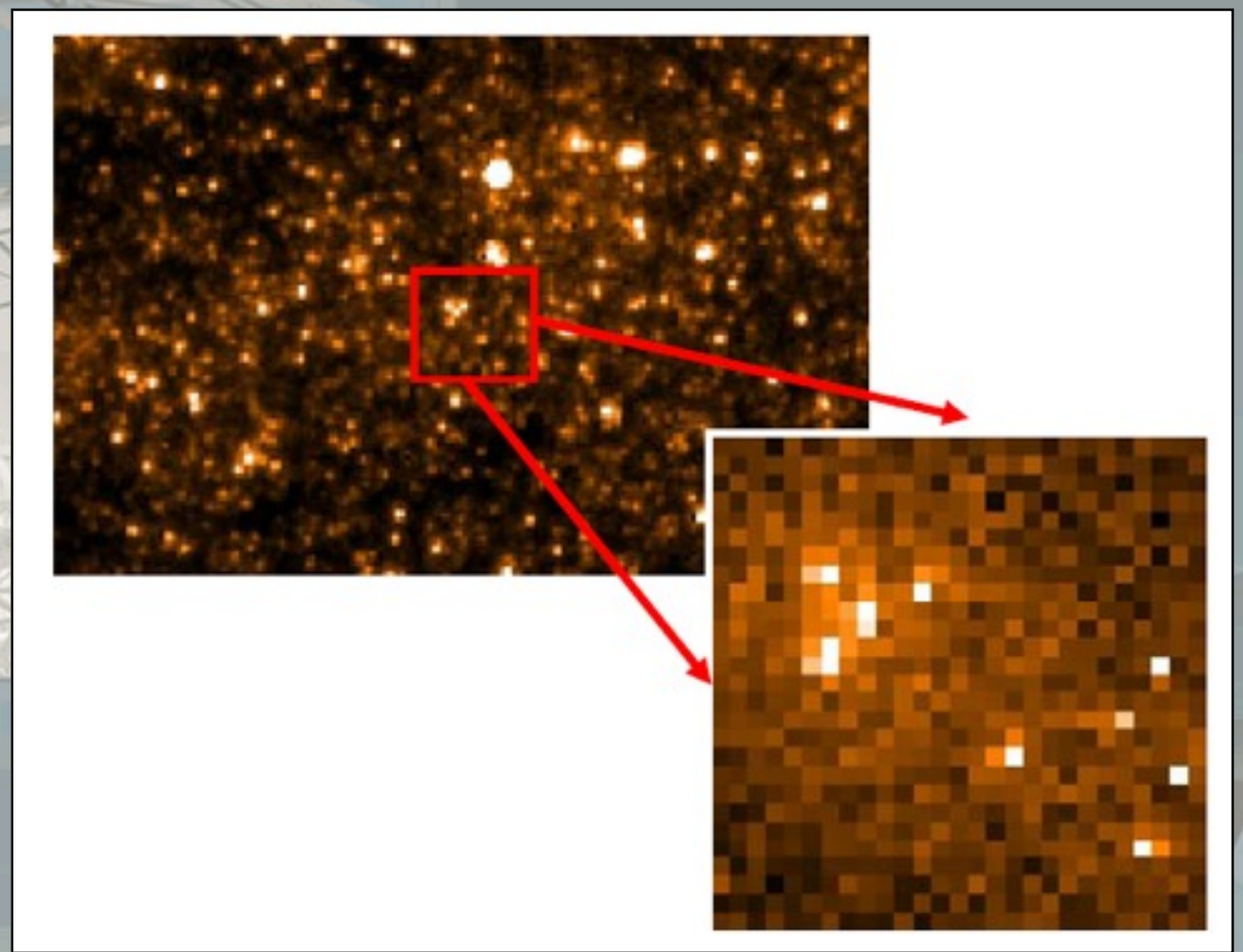
EAGLE: Wide-field, multi-IFU, AO-assisted NIR spectrograph

PI: Jean-Gabriel Cuby

Co-PI: Simon Morris

LAM, Uni. Durham, UK ATC, GEPI, ONERA, LESIA





- Near-infrared: 0.8-2.45µm
- Patrol field: 38 arcmin^2

- 20-IFU fields: 1.65”x1.65”
- R~4000,10000
- Multi-Object AO

MICADO: Diffraction limited NIR, Imaging Camera

PI: Reinhard Genzel
MPE, MPIA, USM, INAF-OAPD, NOVA , LESIA

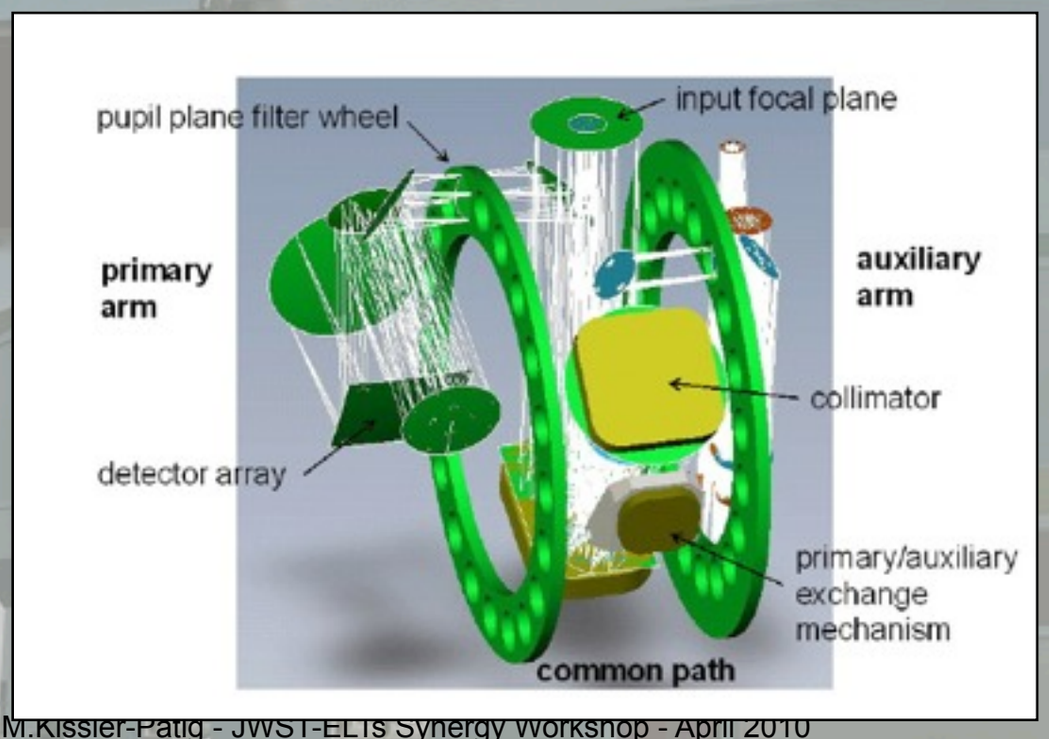
Primary Imaging Field

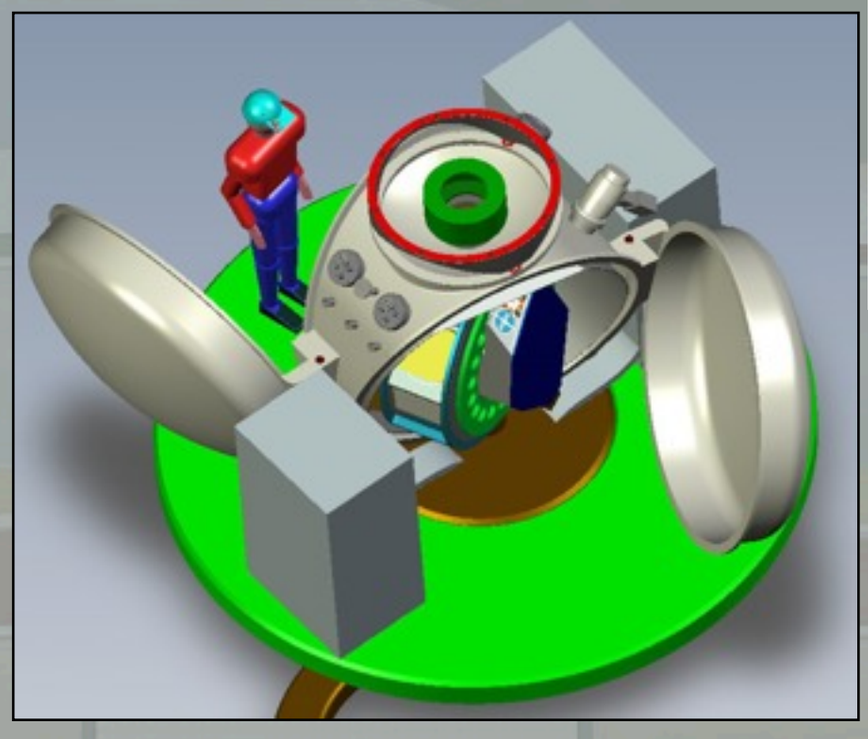
- 53” across, 3mas pix
- high throughput
- 4x4 HAWAII 4RG detectors
- ~20 filter slots

Auxiliary Arm

- 1.5mas & 4mas pixels
- imaging & spectra R=3000
- 1 HAWAII 4RG detector

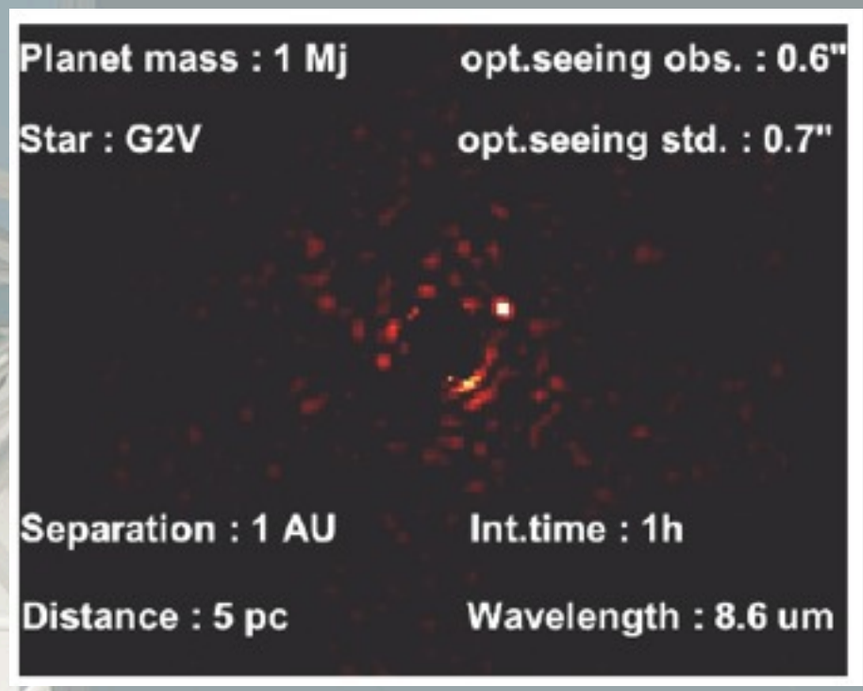
AO System – MCAO/MAORY

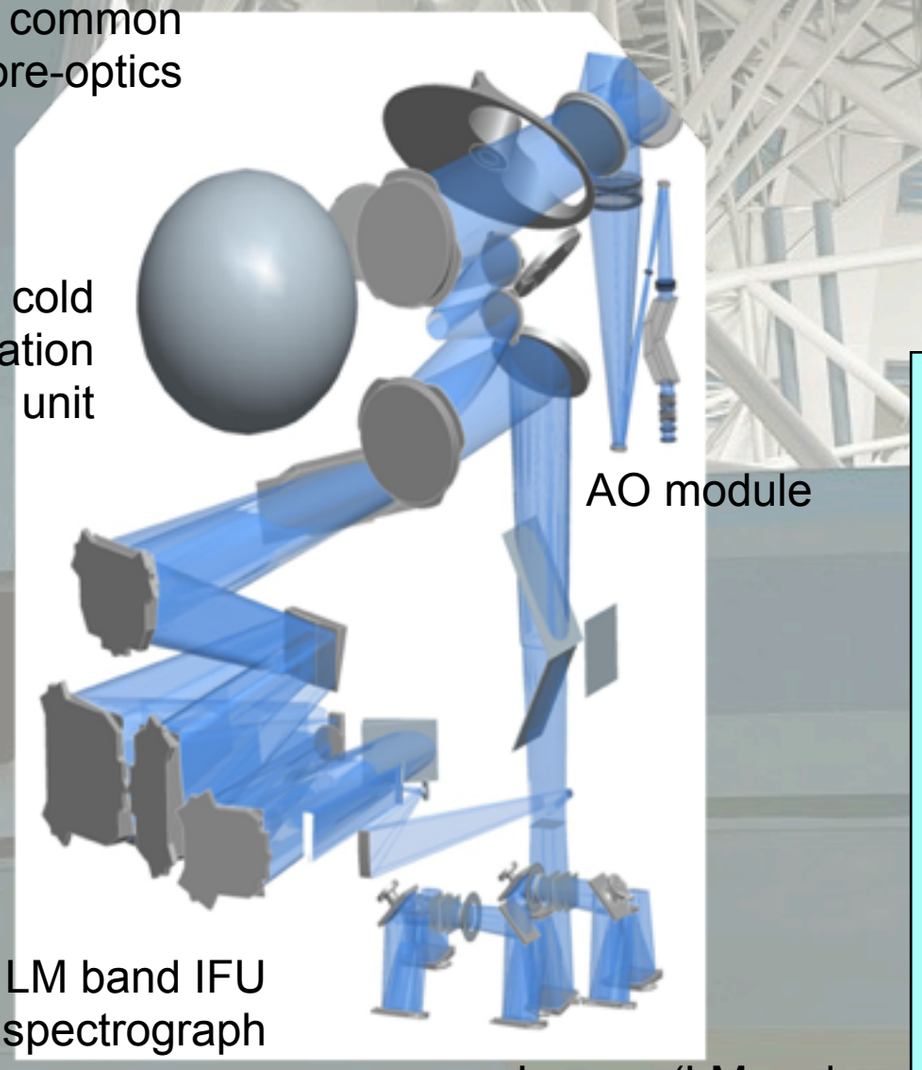




METIS: mid-IR imager and spectrograph

PI: Bernhard Brandl,
Nova, MPIA, CEA Saclay, KU Leuven, UKATC





- Diffraction limited imager [18″×18″]
- L/M band and N band
  - includes coronagraphy
  - R ≤ 5000 long-slit spectrometer
  - includes polarimetry
- High resolution IFU [≥ 0.4″×1.5″]

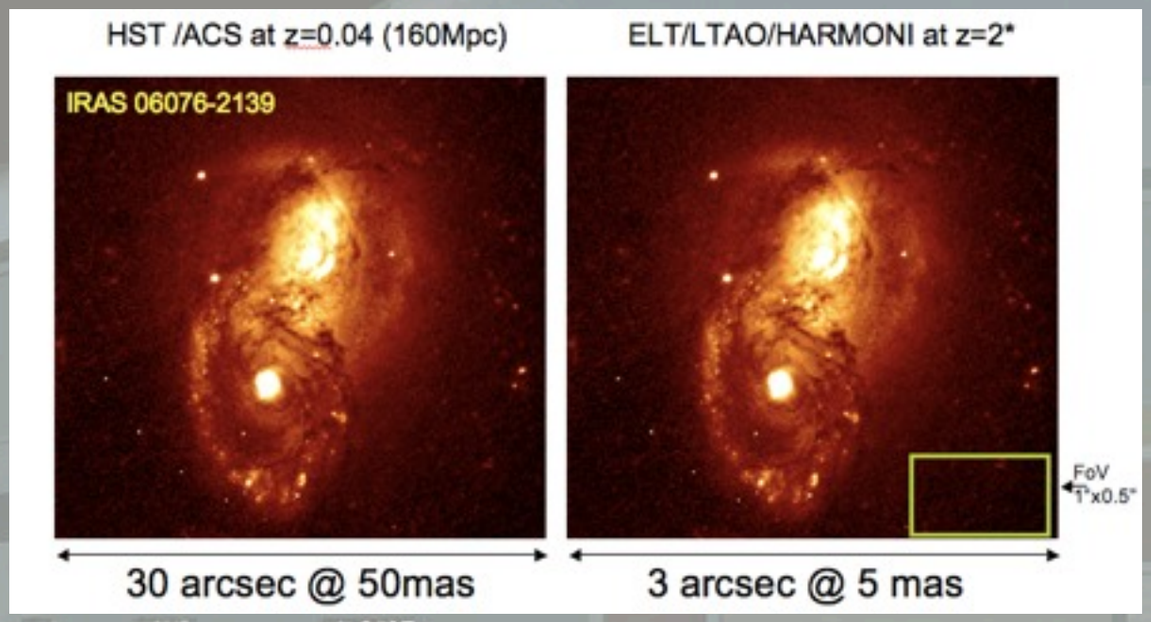
spectrograph for L/M, (R ~ 100,000)

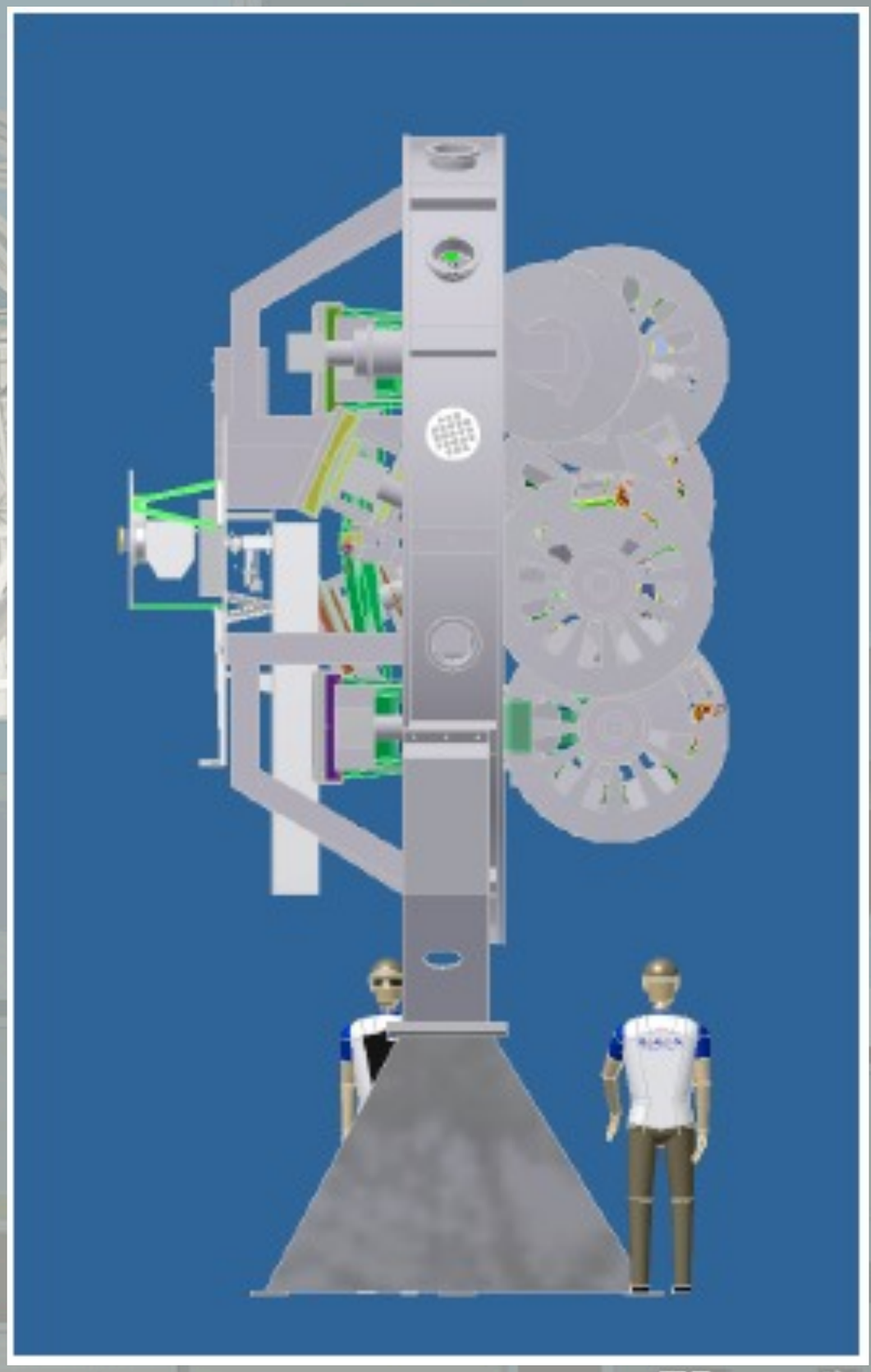
- LTAO/ATLAS plus on-board SCAO

HARMONI Single field, wide band IFU, NIR spectrometer

PI: Niranjan Thatte,
Oxford, CRAL, CSIC, IAC,UK ATC, ONERA

- Wavelength range 0.47-2.45μm
- Spectral resolving power
  - R ≈ 4000, 10000, 20000
- 4 spatial scales
  - 4mas, 10mas, 20mas, 40mas
- 4 fields of view
  - 0.5" x 1.0" , 1.25" x 2.5"
    2.5" x 5“, 5" x 10“
- LTAO/ATLAS

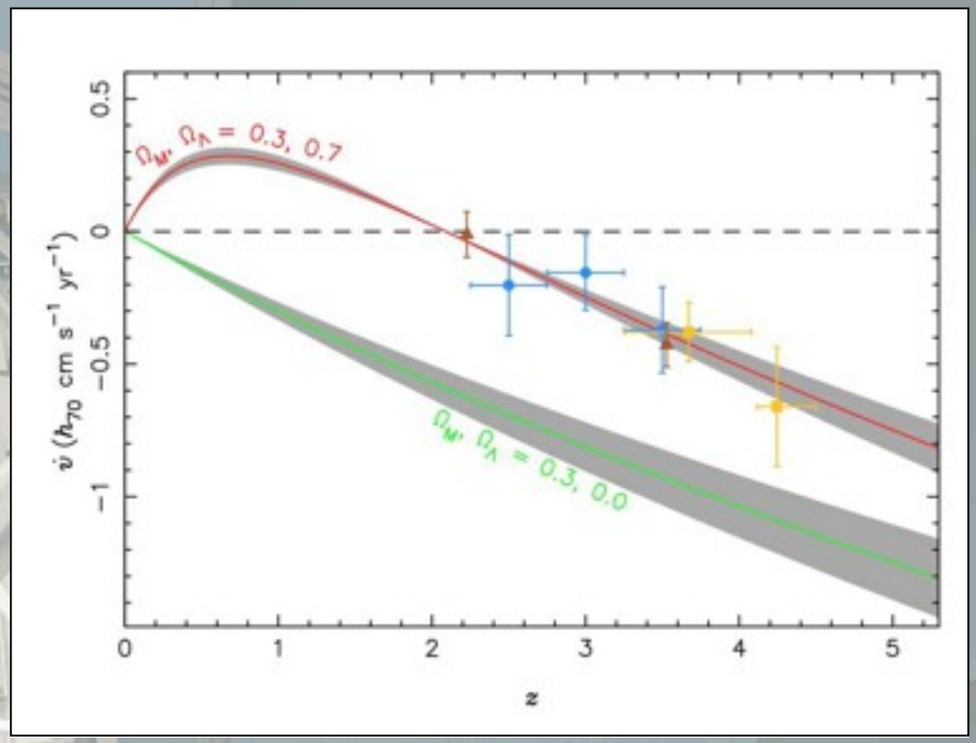




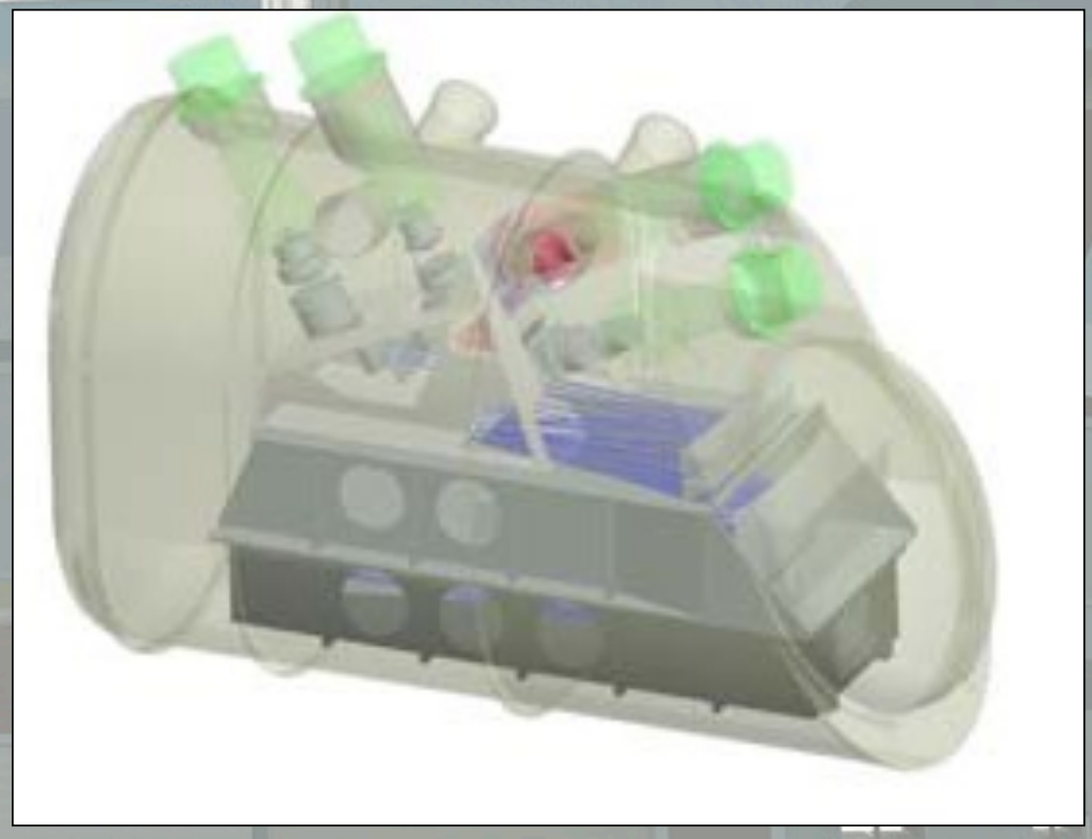
CODEX:
high stability, high resolution visible spectrograph

PI: Luca Pasquini, ESO

Geneve Observatory, IAC, INAF-Trieste and Brera, IoA Cambridge



- field of view (0.82” = point sources)
- 0.37-0.71μm
- R~130,000
- ~2cms^{-1} Doppler precision over 30yrs
- no adaptive optics
- located in the coudé room



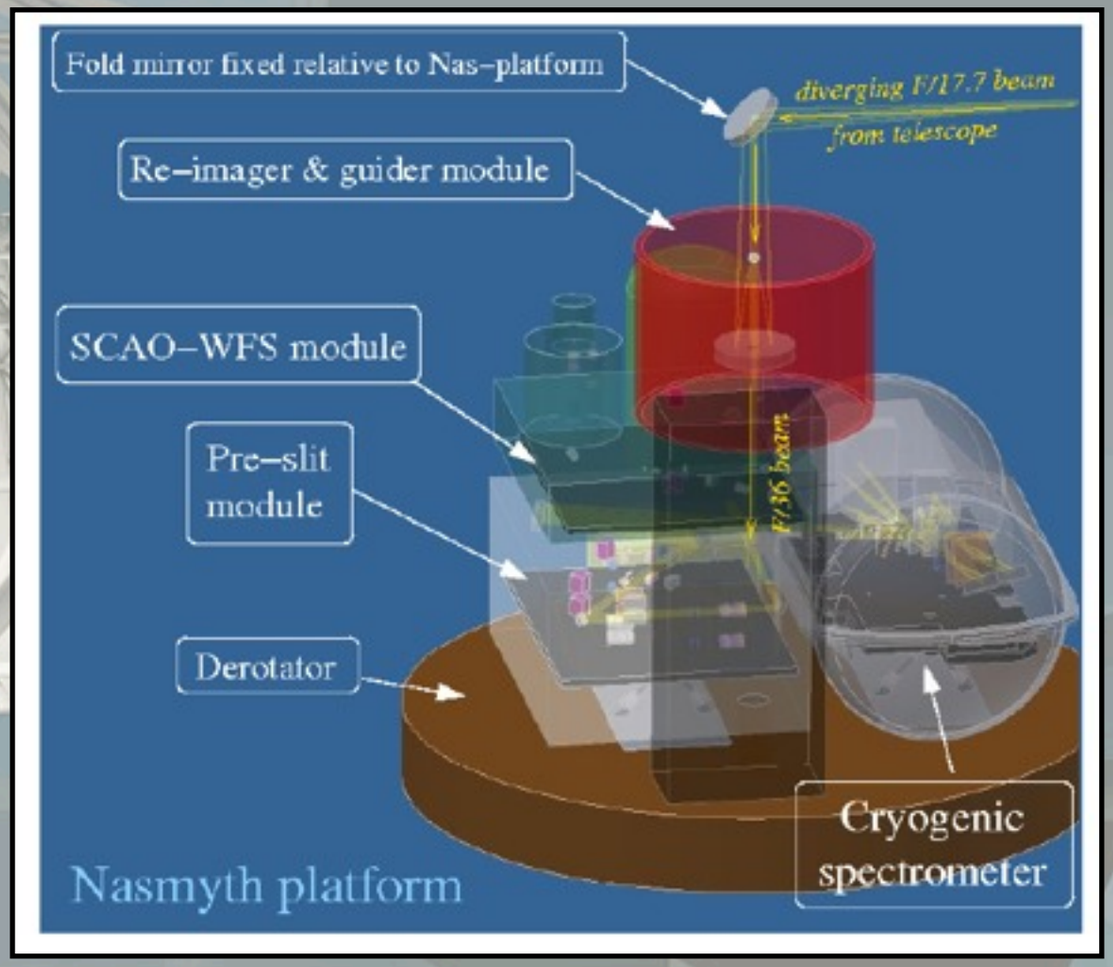
simple — a high resolution near-IR spectrograph for the E-ELT

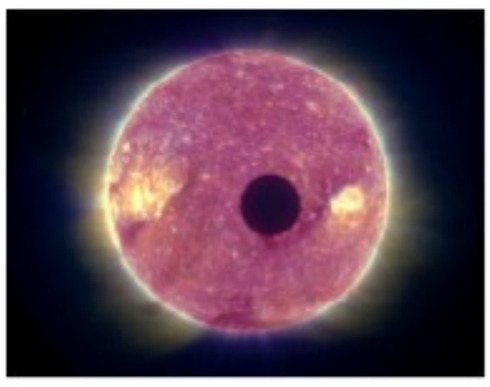
PI: Livia Origlia, Bologna

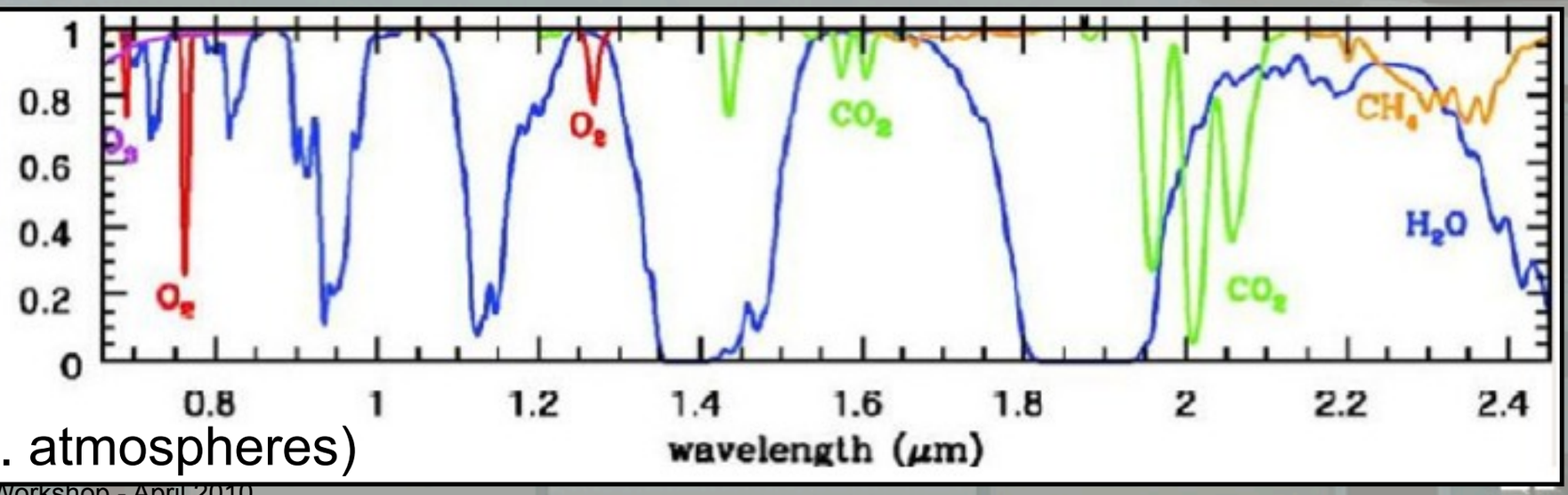
INAF, UAO, TLS, PUC

- 0.84-2.5μm
- Complete spectrum
- R~130,000
- Slit: 27x450mas

- SCAO on-board
- MCAO/MAORY or LTAO/ATLAS







Exoplanets (incl. atmospheres)

EPICS: exo-planet imaging camera and spectrograph

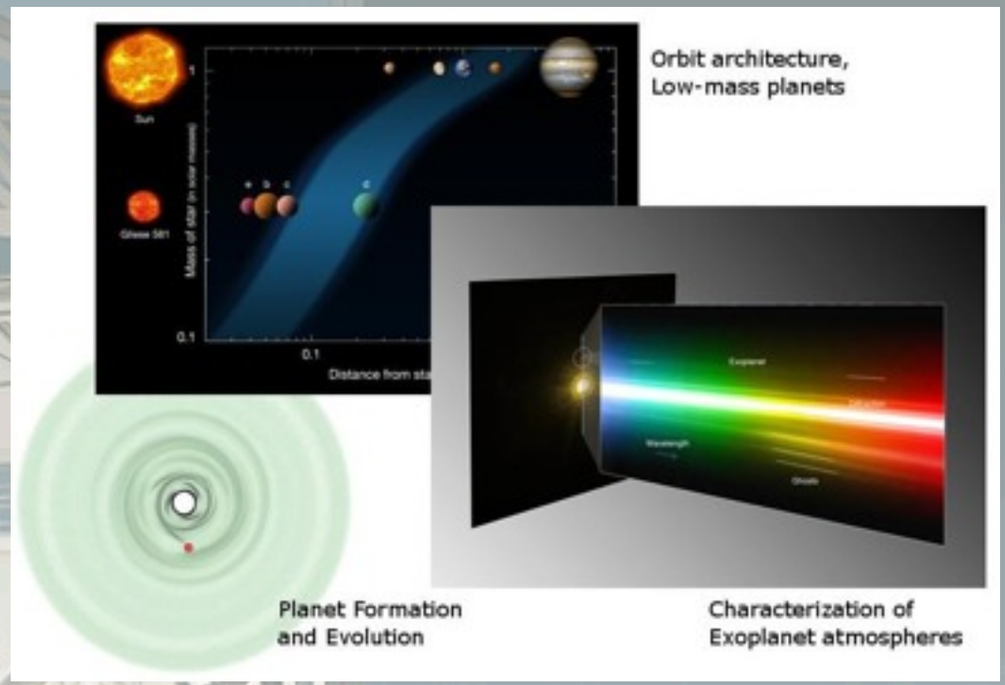
PI: Markus Kasper, ESO

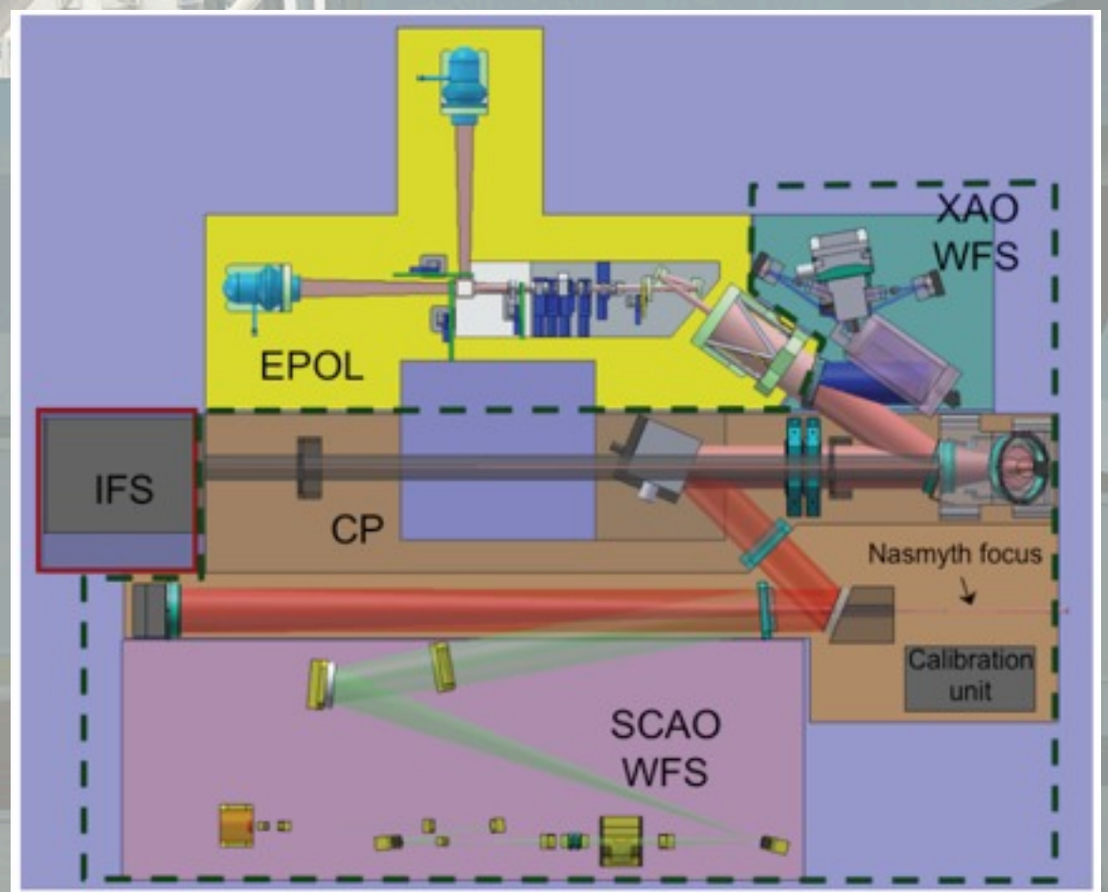
LAOG,LESIA, Uni. Nice, LAM,ONERA, Uni.Oxford, INAF, ETH Zurich, NOVA

- IFS 0.95-1.65µm
- FOV: 0.8" x 0.8"/2.33mas
- 0.8" x 0.014" long slit
- R = 125, 1400 and 20000

- EPOL 0.6-0.9µm
- Coronagraphic polarimeter
- FOV: 2" x 2"/1.5mas

Contrast ratios – 10^{-8} – 10^{-9}
XAO – very high (90%) Strehl





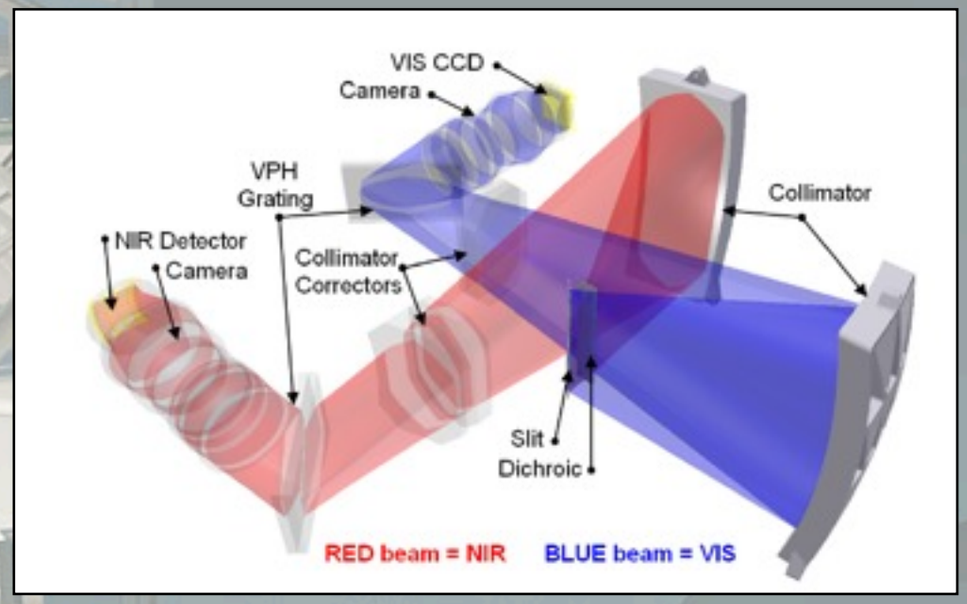
OPTIMOS-EVE - Extreme Visual Explorer

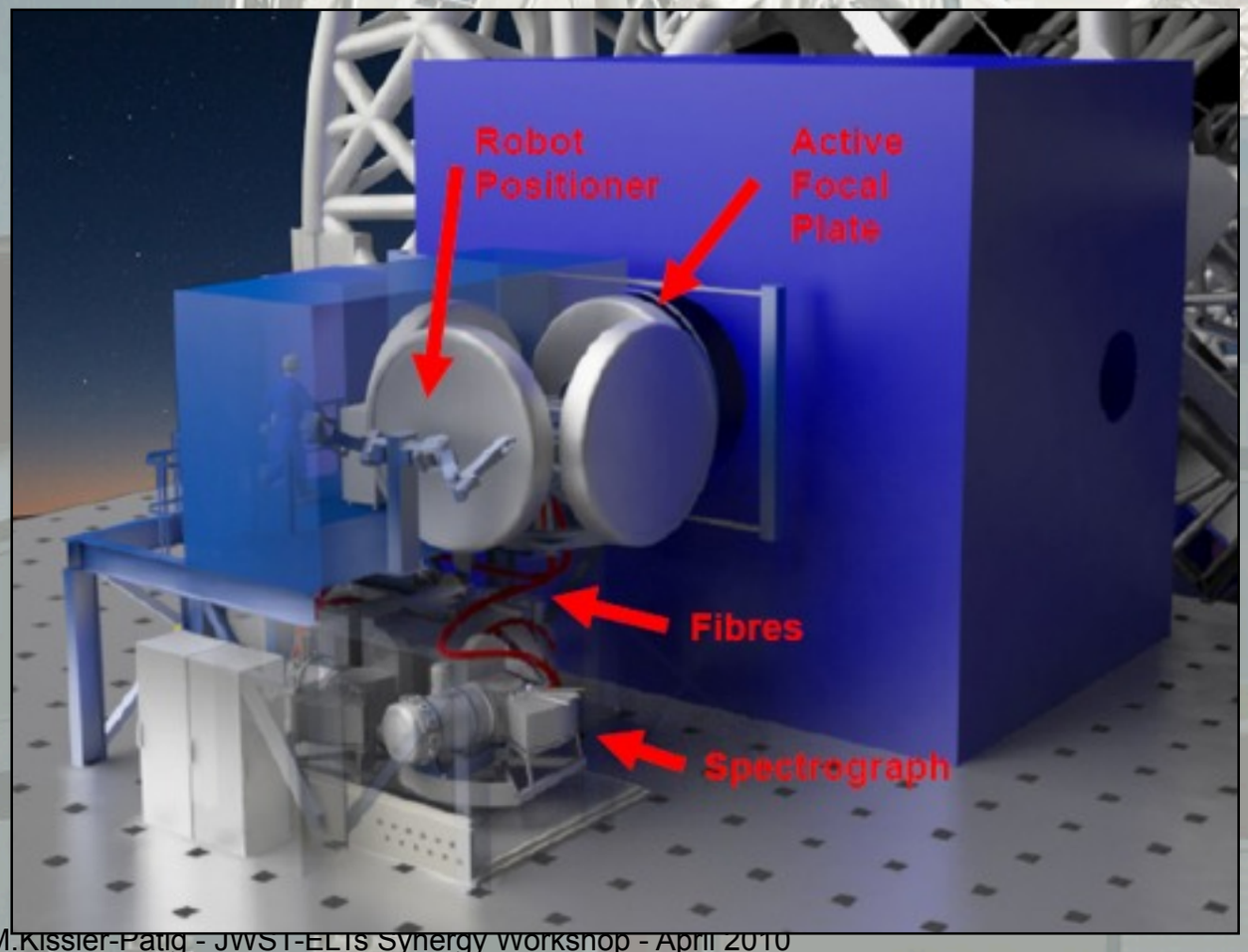
PI: Francois Hammer

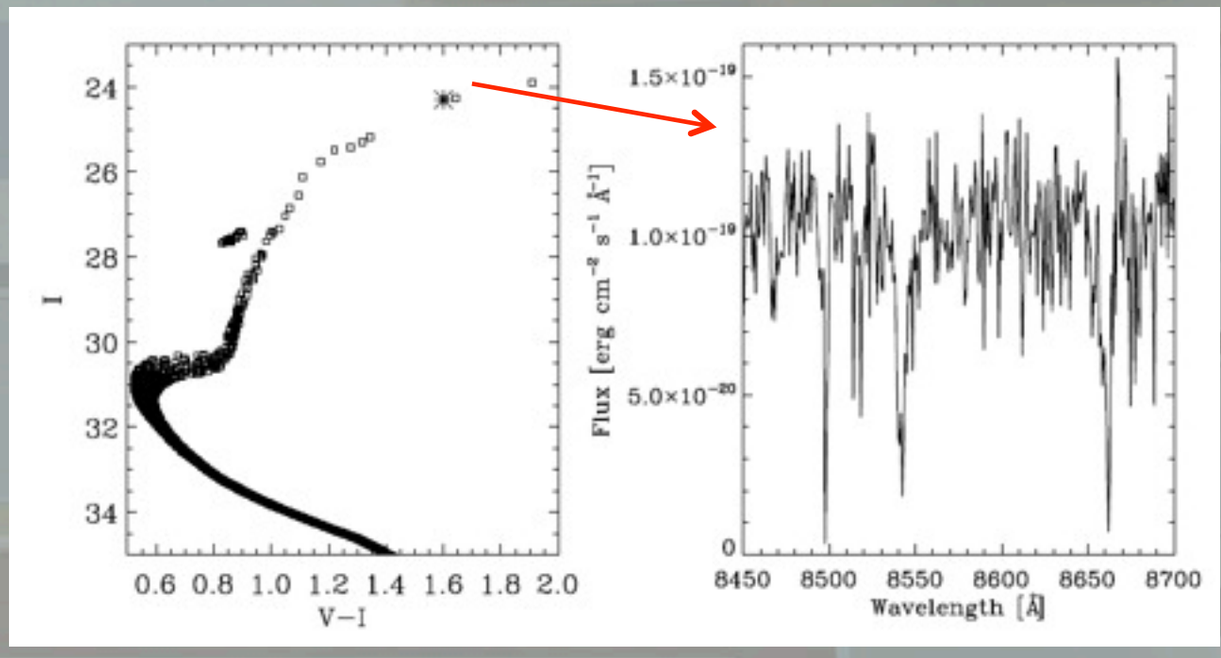
GEPI,NOVA, INAF, RAL, Nils Bohr Institute

- 0.37μm-1.7μm
- Patrol field - ~7'
- 240 fibres /R~5000
- 70 fibres / R~15000

- 40 fibres / R~30000
- 30 IFUs 1.8" x 3"
- 1 IFU 7.8"x13.5"
- Both IFUs / R~5000





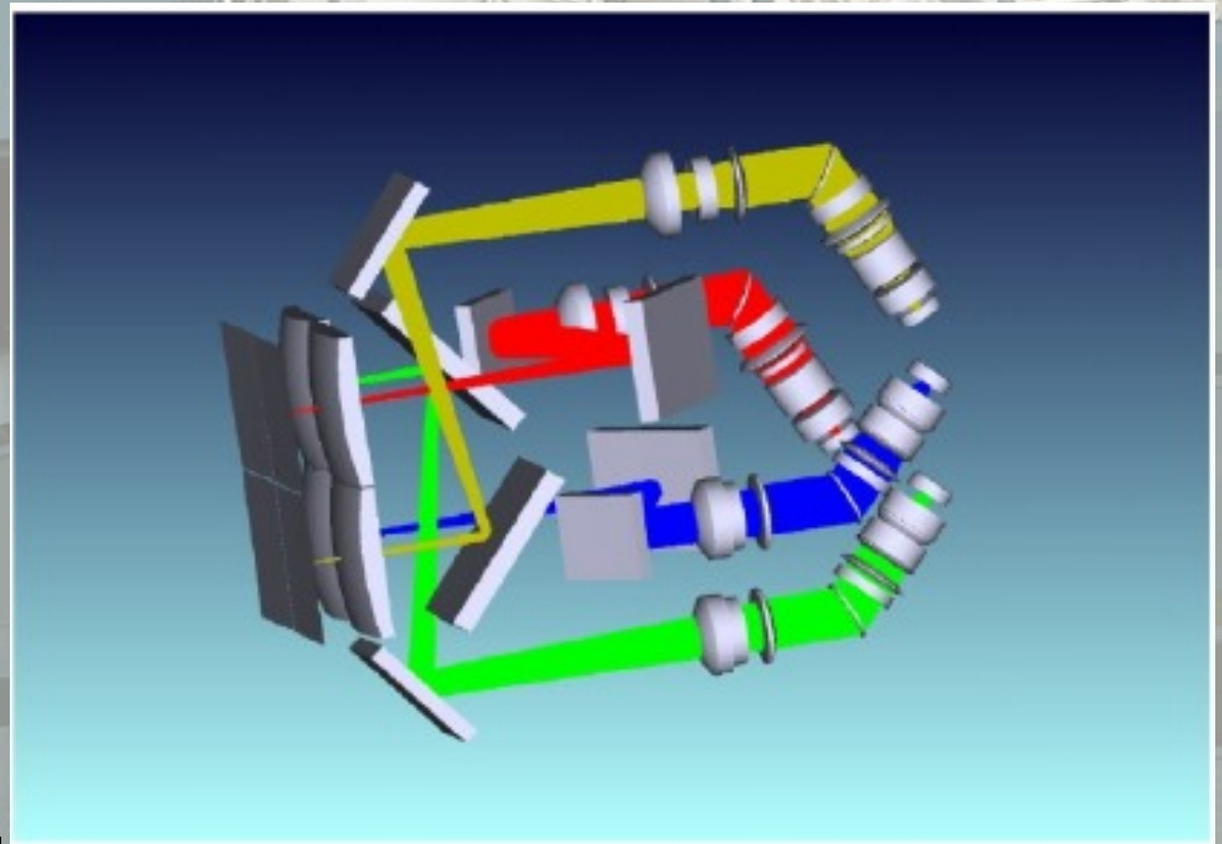


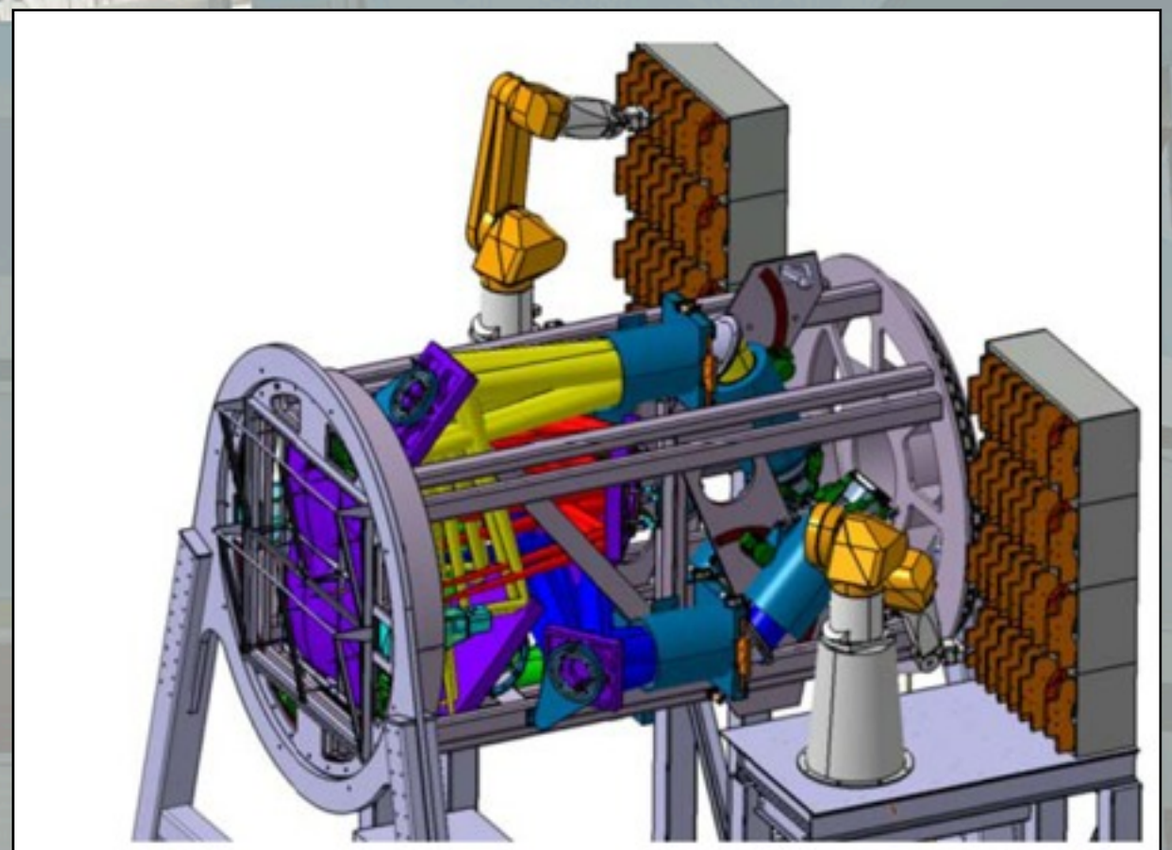
OPTIMOS-DIORAMAS:
wide field imaging multi-slit spectrograph

PI: Olivier Le Fèvre

LAM, IASF-Milano, Obs. Haute Provence, HP, Obs. Genève, IAC

- MOS and Imager over 6.8'x6.8' FOV
- Standard visible and NIR filters for imaging
- 480 slits in the visible range, 120 for NIR
- R~300, 1000, 2500 visible; 400,800,3000 for NIR





ATLAS: laser tomography AO module

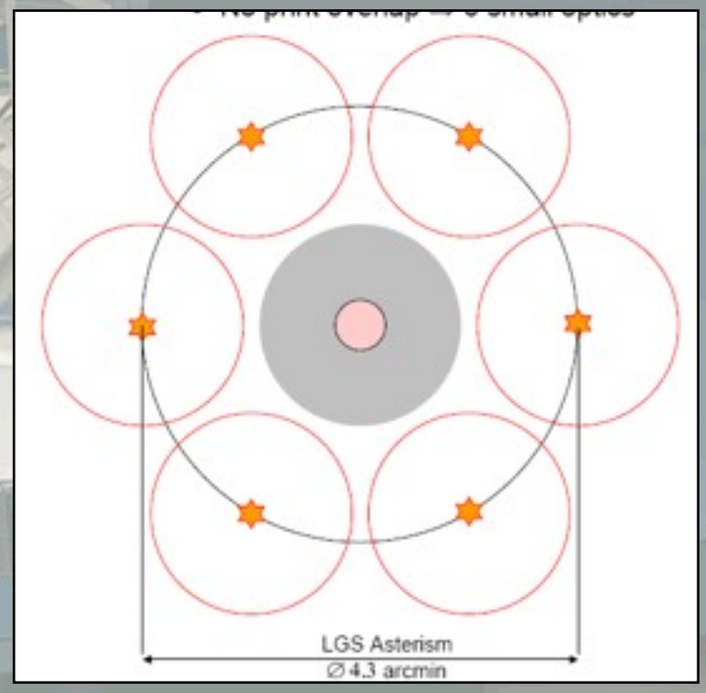
Advanced Tomography with Laser for AO systems

PI: Thierry Fusco

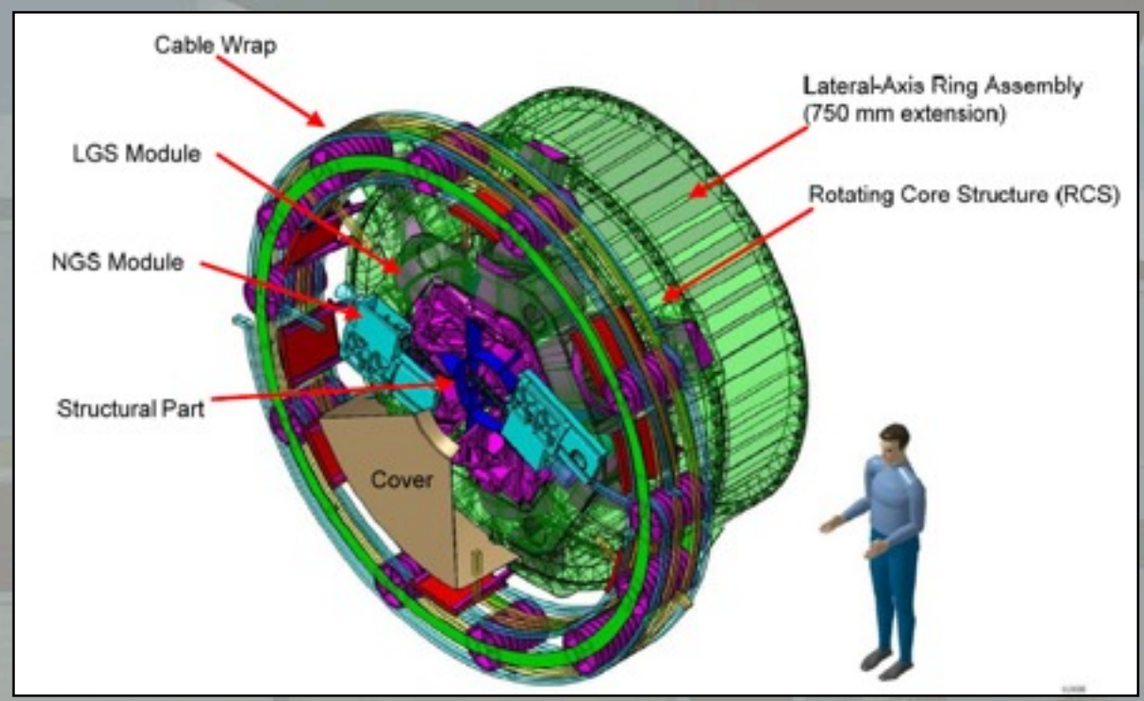
ONERA,GEPI, LESIA, UK ATC, LAM

Adaptive optics using laser guide stars

- Very high quality images (S.R. >50% in K) over ~30'' field
- Excellent sky coverage
- Uses the telescope adaptive mirrors, simple design, >90% transmission
- No additional mirrors in the instrument optical path



- Instrument 'clients'
  - SIMPLE, HARMONI, METIS



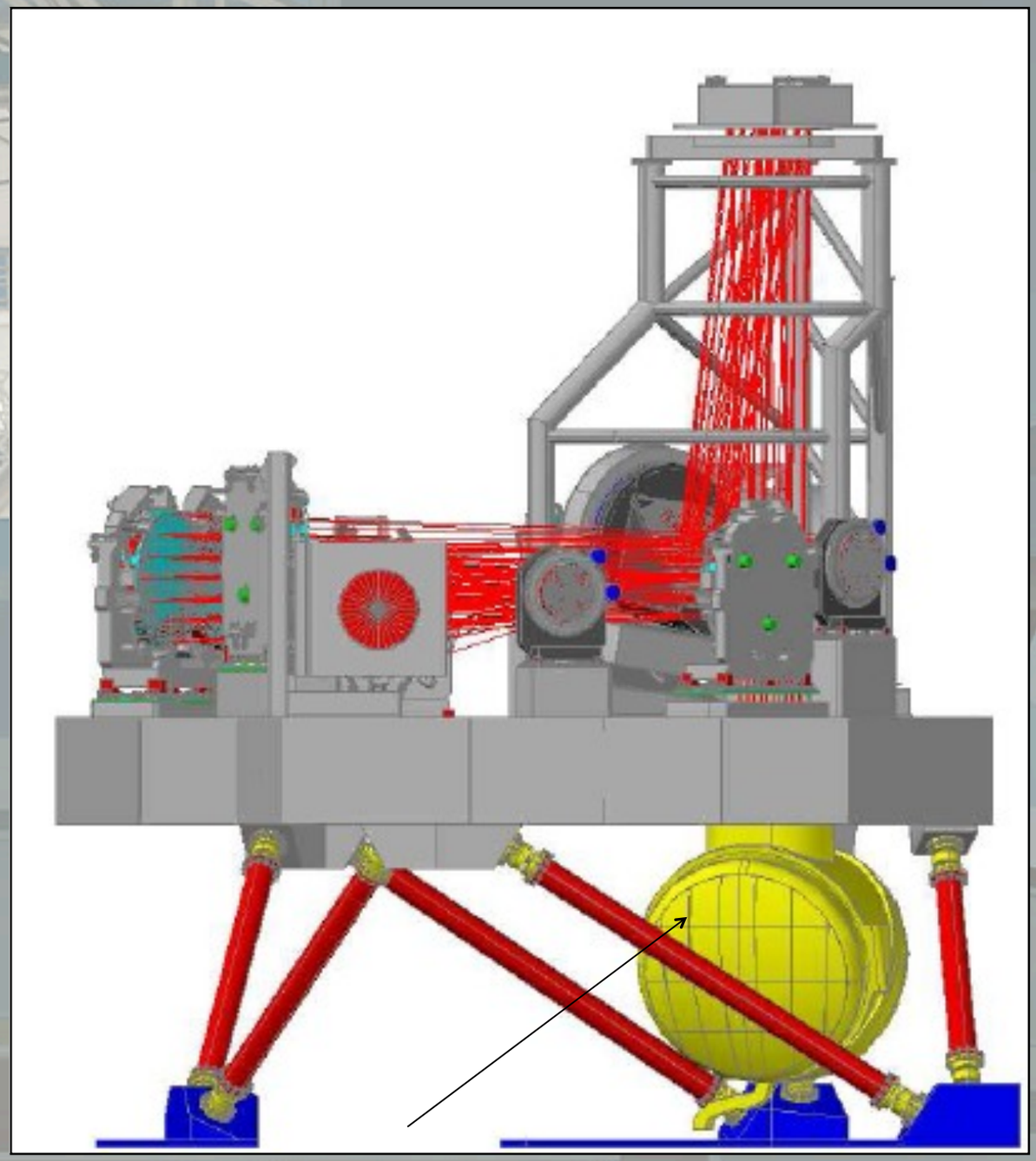
MAORY: multi-conjugate AO relay

PI: Emiliano Diolaiti

INAF (Bologna, Padova, Arcetri), ONERA

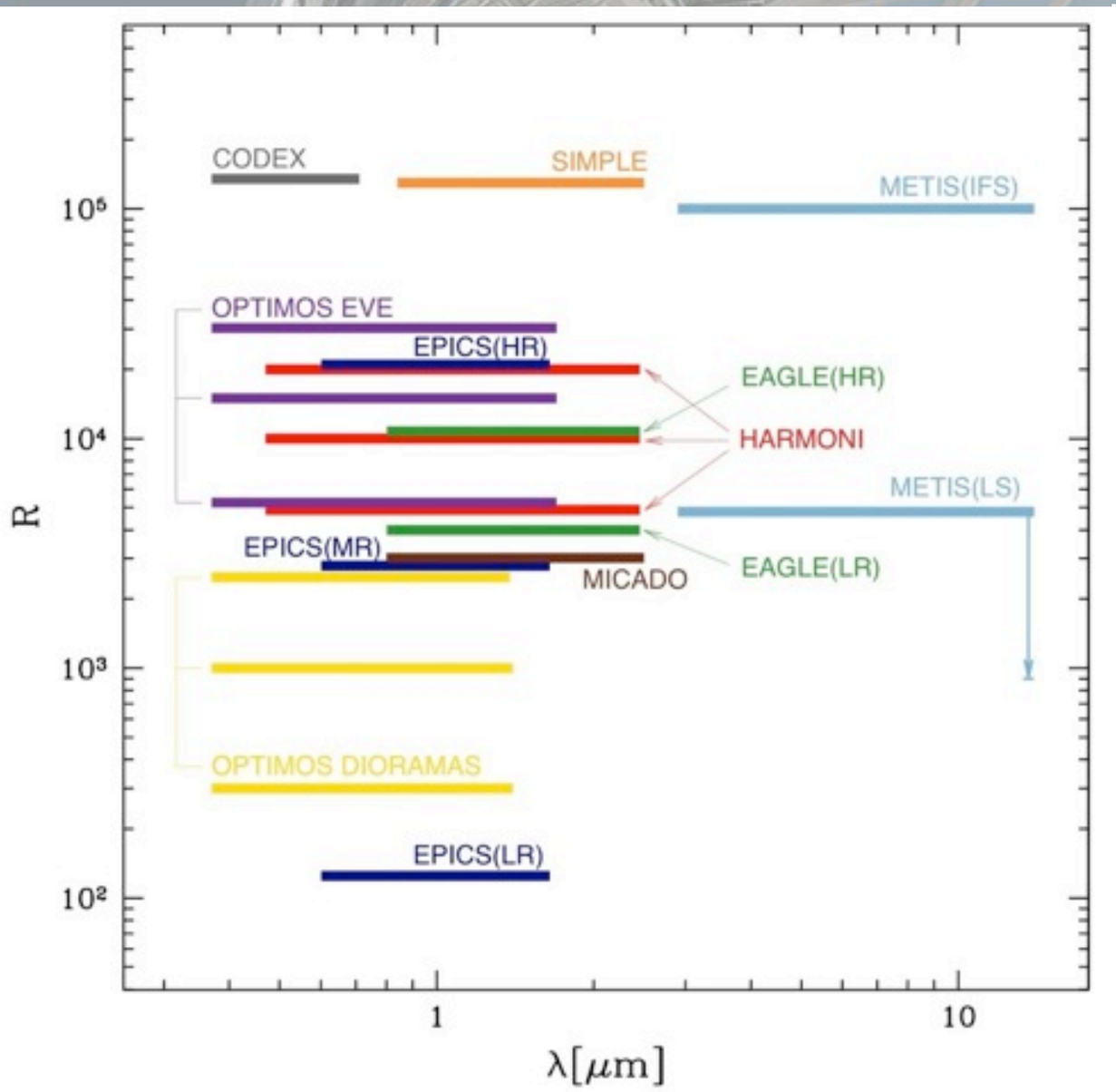
Multi-conjugate AO with 6 laser and 3 natural guide stars

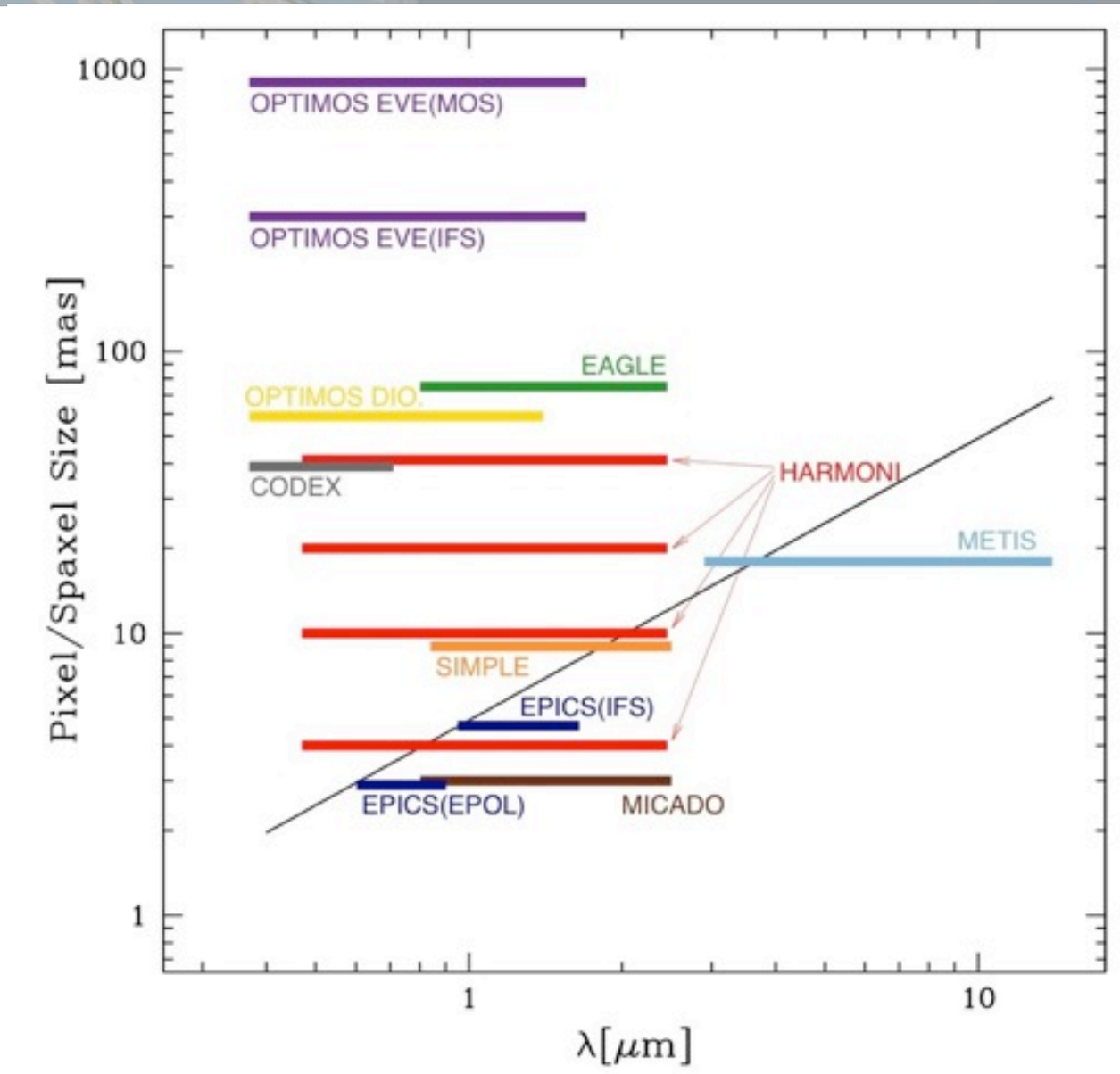
- 0.6 μm < λ < 2.4 μm
- Very high quality images (S.R. >50% in K) over a wide field - 2', Central 1' clear
- MAORY deformable mirrors conjugated to atmospheric layers at 4km, 12.7km
- Two output ports



- Instrument 'clients'
  - SIMPLE, MICADO

Instrument phase A/concepts Summary





Instrumentation Summary

In the construction proposal, the project will propose 2-3 first light instruments, as well as 3-4 capabilities for the first generation.

The Science Working Group is currently preparing a scientific recommendation to the project.
ESO's Science Technical Committee will review the proposed Instrumentation Plan.

The instruments will address the key science cases and exploit the two unique factors of the E-ELT:

- **high spatial resolution**
- **huge photon collecting power**

Thank You