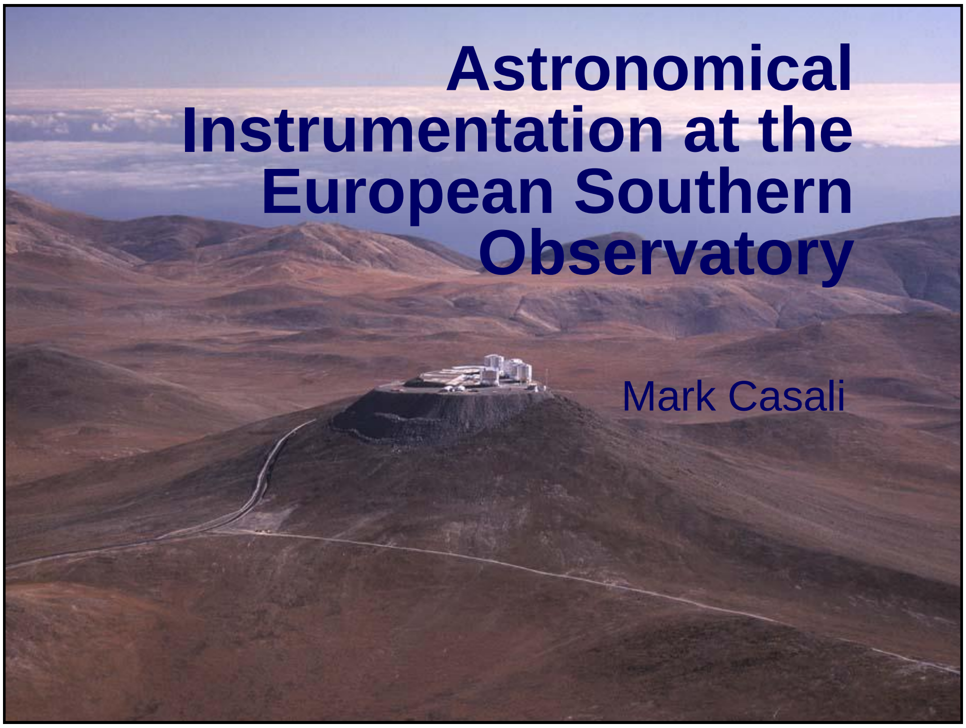
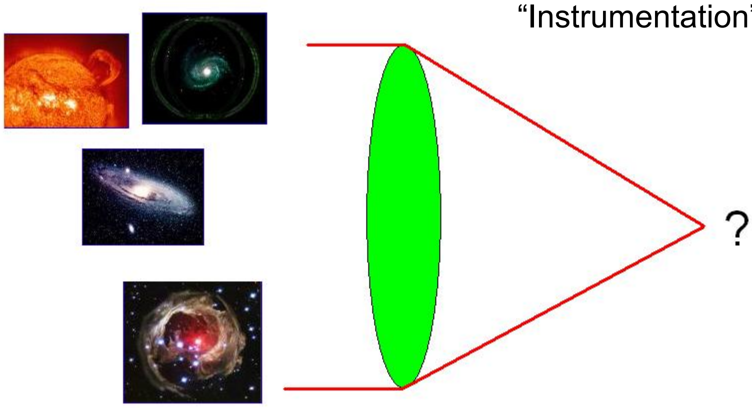


- General introduction to instrumentation
- New instruments and opportunities
  - La Silla – Paranal Observatory (VLT)
  - E-ELT
  - Instrumentation R & D

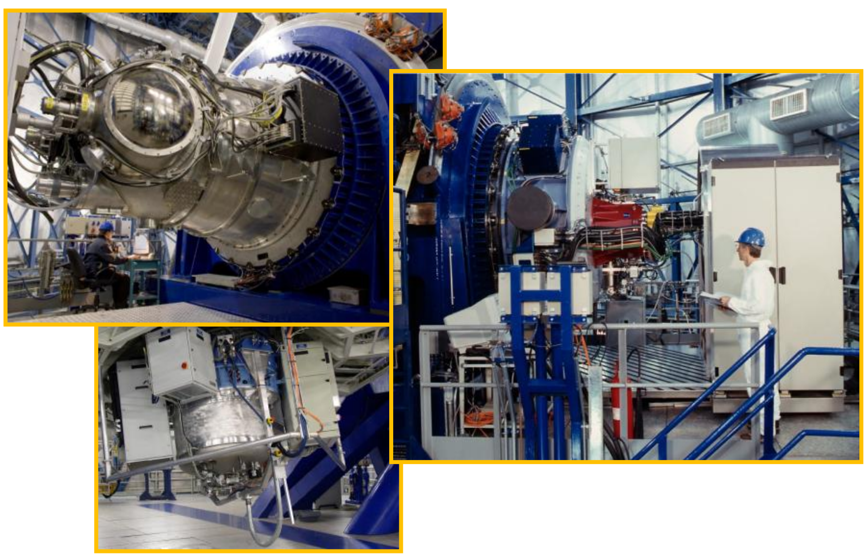
1. Introduction

What do we mean by “Instrumentation” ?



3

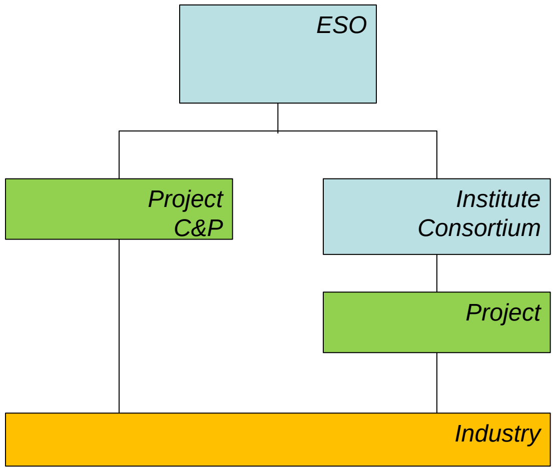
Instrumentation



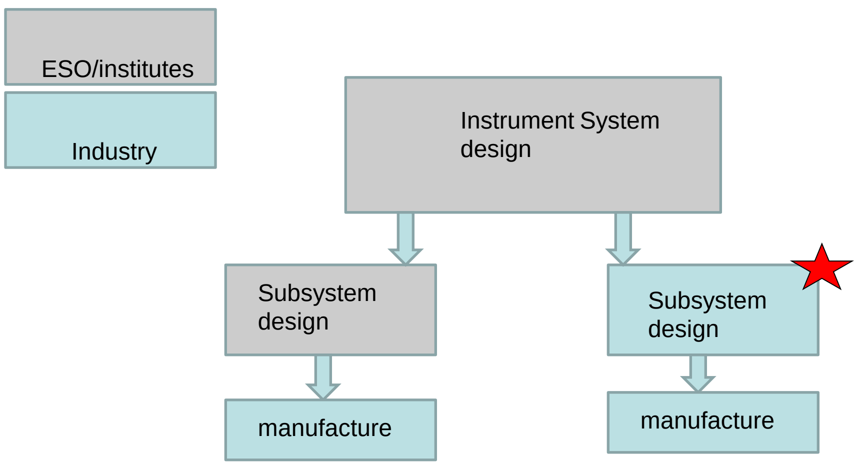
ESO Industry Days 2011

4

Instrumentation construction



Level of industrial procurements



10 years of change

- Non-astronomical technology developments
  - Adapted for astronomy
  - Computing, optics
- Targeted R&D in institutes and industry
  - Detector developments, deformable mirrors
- Large increase in funds for instruments, matching telescope investments

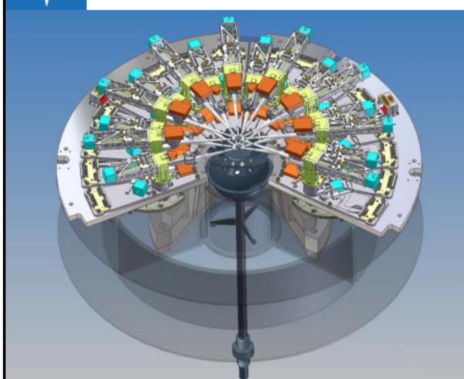
Instruments under development

- KMOS IR 24-IFU IR spectrograph
- MUSE 1 arcmin square optical IFU
- SPHERE high-order AO imager/spectrometer
- AOF 4-laser, deformable M2, AO facility
- MATISSE LMN band 4-UT VLTI instrument
- GRAVITY K-band precision microarcsec VLTI
- ESPRESSO 10 cm/sec precision optical spectrometer

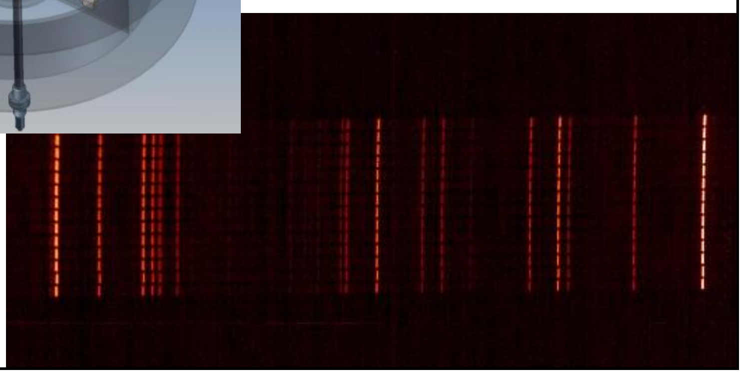
Key technologies

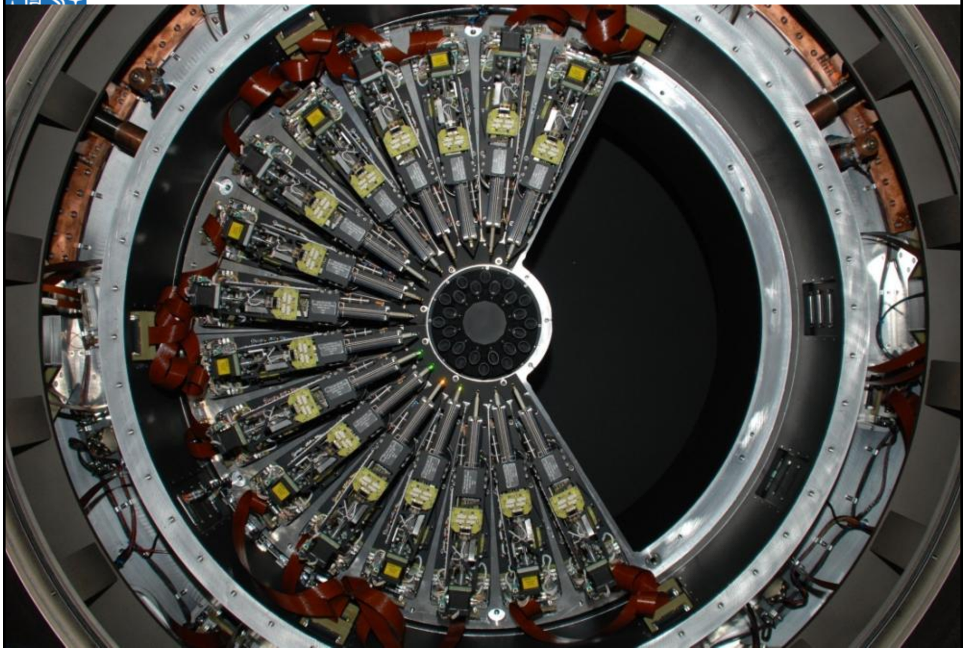
- Cryogenics
- Optics
- Vacuum
- Precision mechanics (also cryogenics)
- Deformable mirrors
- Stiff, light structures
- Imaging detectors
- Low-noise electronics
- Real-time computing
- Control systems and software

KMOS (2012)



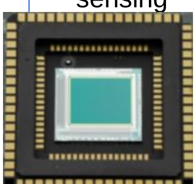
PI – R.Sharples, Durham
24 2.8x2.8” IFUs. 0.2” sampling.
3 spectrographs (H2RG)
24 cryogenic pick-off arms,
operating on 7.2’ field
1 to 2.5 micron operation



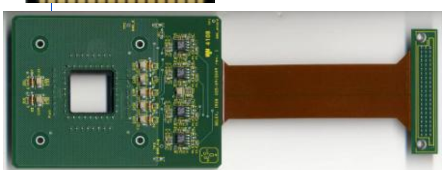


λ_c=2.5 μm HgCdTe eAPD

- unlike silicon HgCdTe offers noiseless avalanche gain of up to 33
  - 3 successful predevelopment studies with 4-channel 320x256 prototype
  - new 32-channel multiplexer in development at SELEX tailored to needs of GRAVITY fringe tracker and AO wavefront sensing



320x256 eAPD array



cryogenic preamplifier

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CCD Mosaic for OmegaCAM

- 8 x 4 science mosaic of 2K x 4K e2v CCD44-82 devices
- 268 10^6 15µ x 15µ pixels (0.21 arcsec x 0.21 arcsec)
- + two 2K x 4K CCDs for autoguiding
- + two 2K x 4K CCDs for image analysis (AO and focus)
- To be commissioned in 2011 on 2.6-m VST

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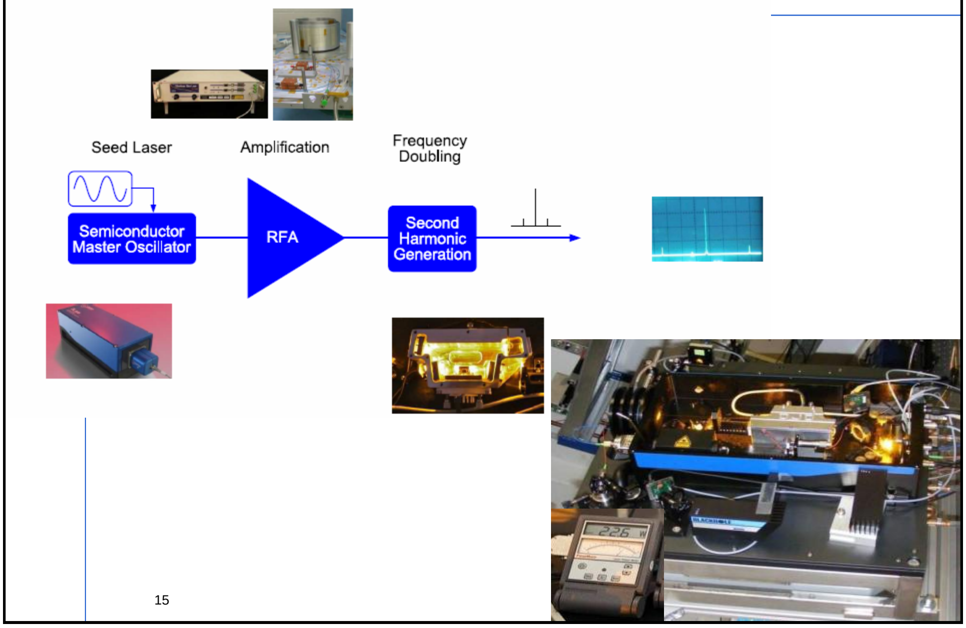
Lasers

Development of industrial fiber Raman sodium laser for VLT AOF



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Laser Frequency Comb

- Laser Frequency Combs as calibrators
  - Provides a series of perfectly equidistant lines
  - Covers a large wavelength domain
  - Stabilized at the 10^{-11} to 10^{-15} level
  - The absolute reference linked to an atomic clock
- ESO in collaboration with the MPQ have been developing a LFC calibration system for use in astronomical spectrographs since 2008
- Tested on HARPS

comb

Thorium-argon

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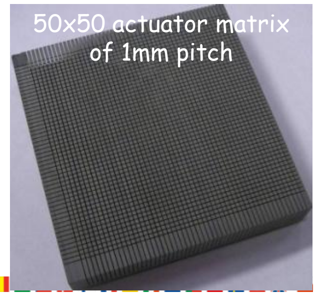
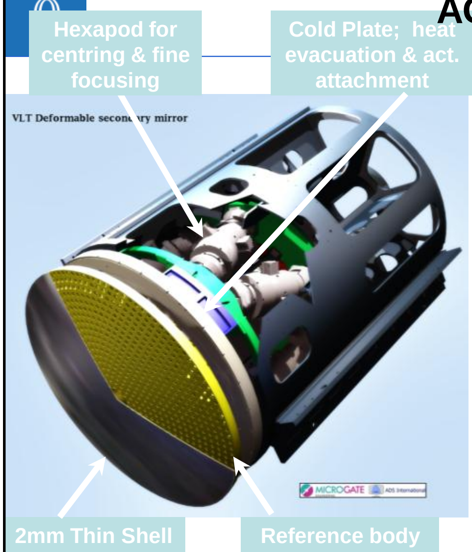
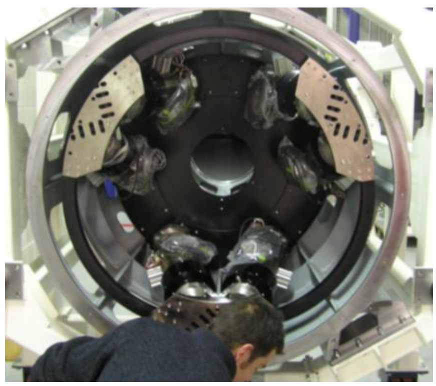
Development of Piezo DM technology



Large Deformable mirrors development for AOF

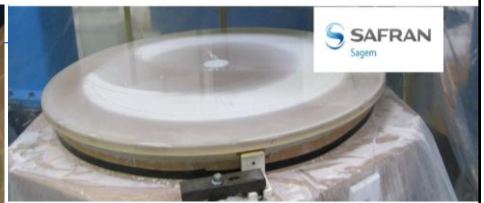


- Ø 1.1m convex
- 1170 actuators
- 29 mm actuator pitch
- 1 ms response
- Stroke 50 / 1.5 µm

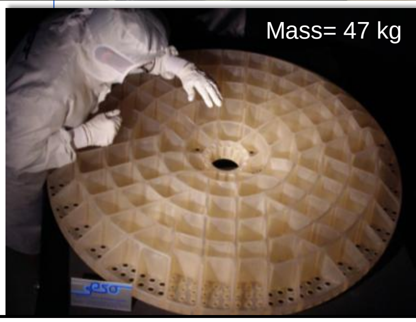


Special optics for AO

1.1 m light-weighted reference body for the VLT Deformable Secondary Mirror

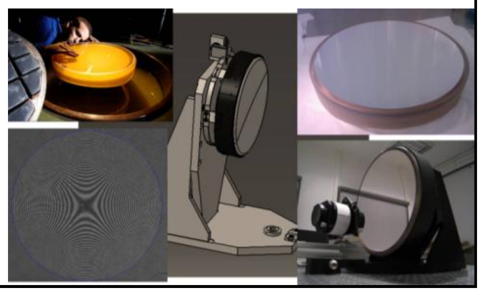


1.1m Zerodur shell, in manufacturing



Mass= 47 kg

400 mm toric mirror for SPHERE using stress polishing; <1nm rms WFE



2. New Instruments and opportunities

- VLT
- E-ELT
- R&D

If you are interested in specific opportunities please contact: **eso_ins@eso.org**

Scale of instrumentation programme

Spend in industry M€

Year	2011	2012	2013	2014	2015	2016	2017	2018
VLT	5.1	4.0	3.1	3.2	6.6	3.0	3.3	5.0
ELT		0.2	3.2	3.1	6.9	12.2	12.6	15.4
total	**5.1**	**4.2**	**6.3**	**6.3**	**13.5**	**15.2**	**15.9**	**20.4**

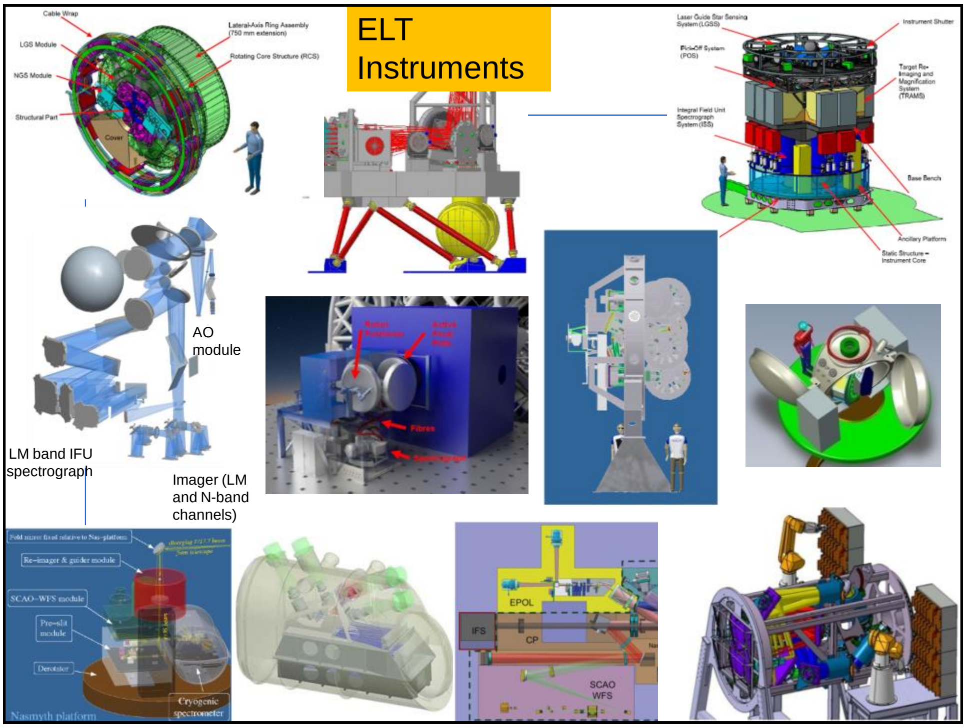
VLT

VLT

- ERIS : AO high-resolution imager/spectrometer
  - Precision mechanical assemblies
  - Stiff mechanical structures
  - Cryogenic Infrared imager
    - Low vibration 40K cooling system
- ESO project
  - Outsourcing to industry and institutes

VLT

- Multi-Object Spectrograph conceptual design studies
  - Two studies for optical and IR instruments
    - Optical and IR fibres
    - Fibre robotic positioners
    - Optics
    - IR and Optical detectors



Phase A studies identified the key technologies

Name	Instrument type	Wavelength range	FoV and sampling	Spectral resolution	AO support envisaged	Notes
MICADO	Diffraction limited NIR Imager (slit spectroscopy?)	0.8-2.4 µm	30" 3-5 mas/pix		SCAO/MCAO	
HARMONI	Single-field NIR spectrograph	0.8-2.4 µm	~1"-10" 4-40 mas/pix	~4000 (~20.000)	SCAO/LTAO	
EAGLE	Wide-field multi-object NIR spectrograph	0.8-2.4 µm	patrol field ≥5' 10-50 mas/pix	~5000 (>10.000?)	MOAO	multiplex >20
CODEX	High-resolution visual spectrograph	0.35-0.72 µm	point source	>120.000	Tip-Tilt?	stability < 2 cm/s over 30 years
METIS	Mid-IR imager and spectrograph	3.5-20 µm	30" 15-30 mas/pix	5-200 ~100.000	SCAO/LTAO	Polarimetry
EPICS	Planet finder	0.6-1.8 µm	~2"-4"	>50	XAO	Polarimetry
OPTIMOS	Optical MOS (+ imaging?)	0.3-1.8 µm	5'-10' FoV	1000 or 10.000	GLAO	multiplex >100
SIMPLE	NIR high-resolution spectrograph	0.8-2.4 µm	slit	>100.000	SCAO/LTAO	
MAORY	Multi-conjugated AO module	0.6-2.4 µm	2' FoV			2 DMs + M4, 6 LGS
ATLAS	Laser tomography AO module	0.6-2.4 µm	1' FoV			M4, 6 LGS

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Industrial opportunities: detectors

- Visible light science detectors
  - approx. 10-15 4k x 4k low noise CCD detectors
  - 4-6 9k x 9k format sought by optical spectrograph
- Infrared light science detectors
  - approx 40 4k x 4k low noise NIR (HgCdTe) detectors
  - 2 1024 x 1024 MIR (5-14um) detectors
- Near infrared and visible wavefront sensor detectors: fast read-out, low noise
  - 20 CCD detectors, format 1000-2000k-squared
  - ~5 HgCdTe detectors, format 1000k-squared

Industrial opportunities: optics

- The instrument programme will require significant procurement of large optics
  - (up to ~400mm, lenses and mirrors)
- Other areas of possible interest
  - Deformable mirrors of ~80x80 sub-apertures
  - Lenslet arrays for wavefront sensors
  - Micro-optics (mm scale) for integral field units (glass and Al)
  - Optical fibres – high transmission, broadband
  - Large dichroic mirrors
- Estimated spend on optics ~30MEuros over 2012-2020

Instrumentation ELT R&D

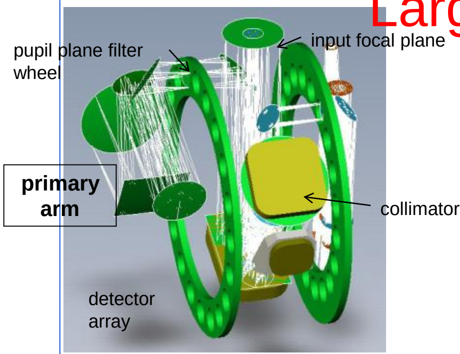
- Short time, low risk development & prototyping will be made within the instrument projects
  - Under the responsibility of the project consortium
  - Funded within the cost of the instrument
  - Related milestones will be defined with Consortium
- Longer time, key enabling technologies with higher risk for the project will start before the instrument selection (upon ELT approval)
  - ESO is preparing a long term development plan for instrumentation which will be updated on a two-year basis

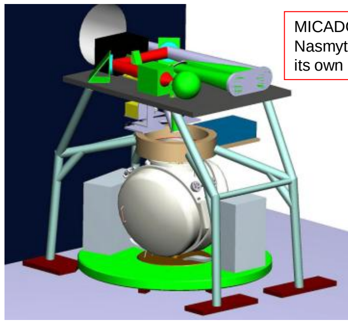
Two First light ELT instruments

MICADO: NIR, large field, diffraction limited camera

- PI: Reinhard Genzel, Garching
- MPE, MPIA Heidelberg, USM, INAF, NOVA, OPM LESIA

Large Precision Optics





MICADO at the direct Nasmyth focus with its own SCAO sensor

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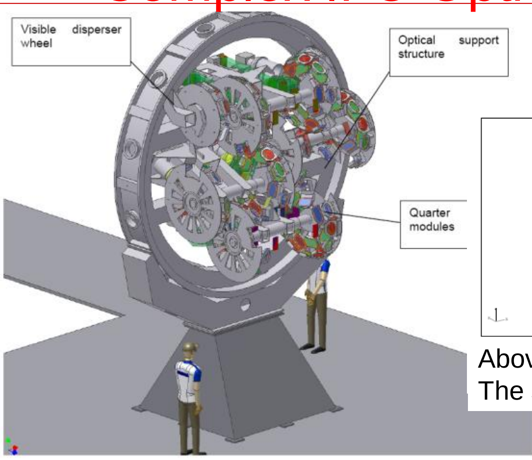
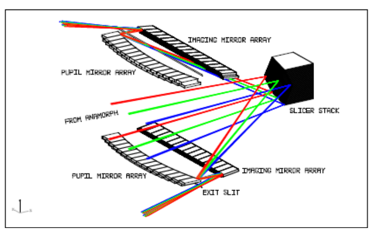
HARMONI : Single IFU, vis-NIR Spectrograph

- PI: Niranjan Thatte, Oxford
- Univ. Oxford, CRAL, CSIC, IAC,UK ATC

Complex IFU Optics



Left, the opto-,mechanical structure inside the 4-m diam. cryostat.



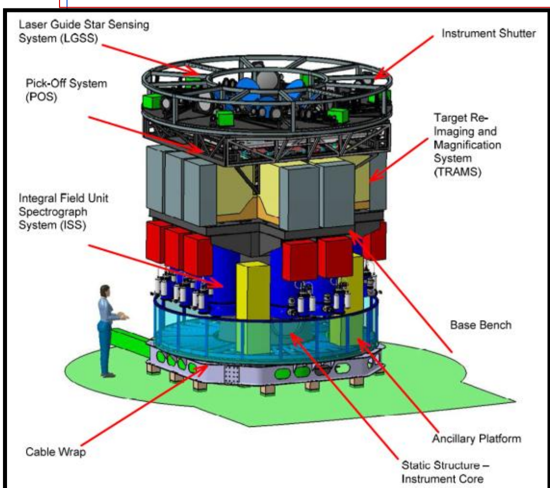
Above, the integral field unit. The slicer stack is 64x64mm

Possible future ELT instruments

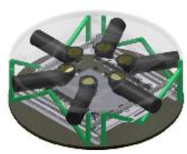
EAGLE: near-infrared multi integral-field spectrometer

Precision cryo-mechanics

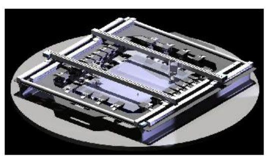
- PI: Jean-Gabriel Cuby, LAM
- ONERA, OPM GEPI & LESIA, UK ATC, Durham Uni.

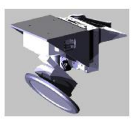


Laser guide star pick-offs



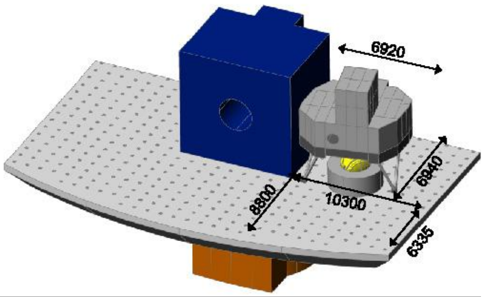
Selection of science sources

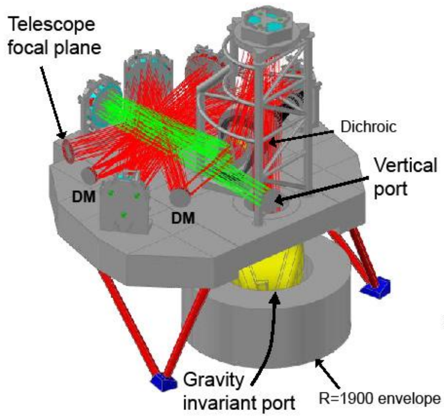




MAORY: Multi-Conjugate Adaptive Optics module

- PI: Emiliano Diolaiti, Bologna
- INAF (OABo, OaPd, PA Arcetri) ONERA





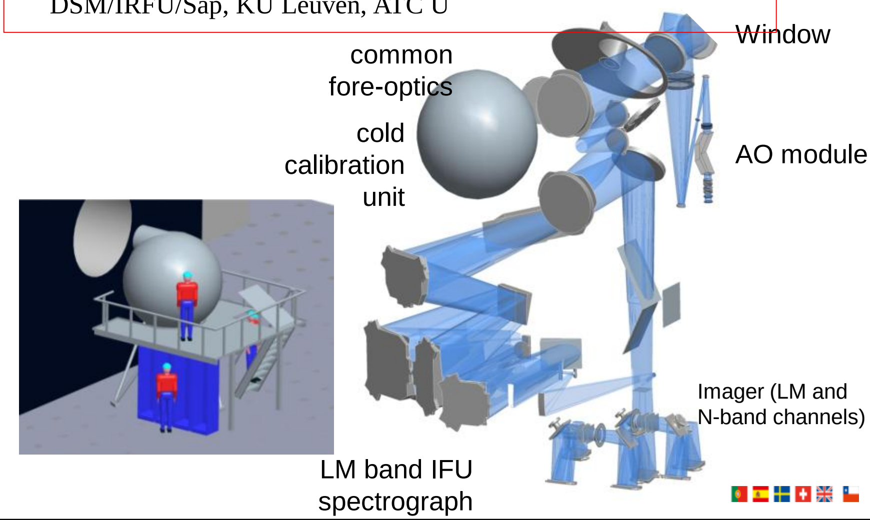
'Facility' adaptive optics system supporting two instruments.

Adaptive optics systems

METIS: Mid IR Imager - Spectrograph

cryo-optics & mechanics

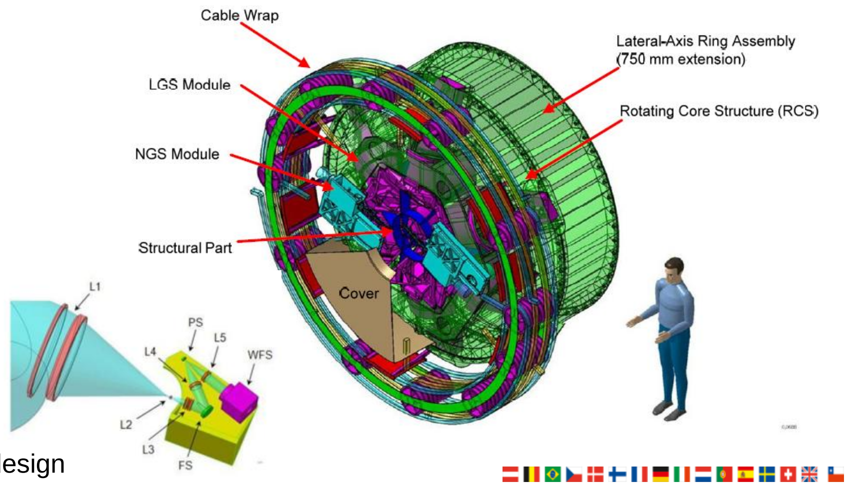
- **PI:** Bernhard Brandl, Amsterdam
- NOVA (Leiden and Dwingeloo), MPIfA Heidelberg, CE Saclay DSM/IRFU/Sap, KU Leuven, ATC U



ATLAS: laser-tomography adaptive optics

- PI: Thierry Fusco, Paris
- ONERA, OPM GEPI & LESIA

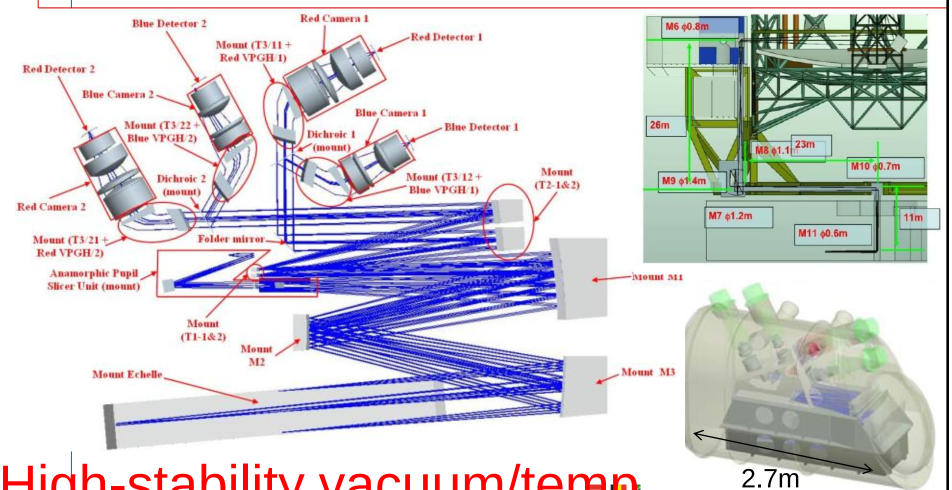
Compact mechanics/optics



LGS design

CODEX: high stability optical spectrograph

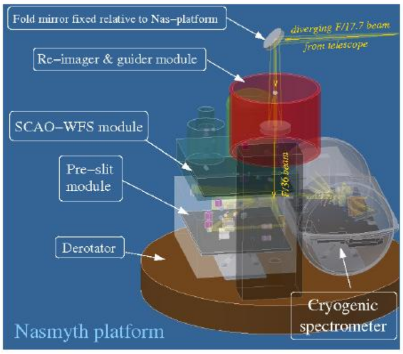
- PI: Luca Pasquini, ESO
- Geneve Observatory, IAC, INAF, IoA Cambridge

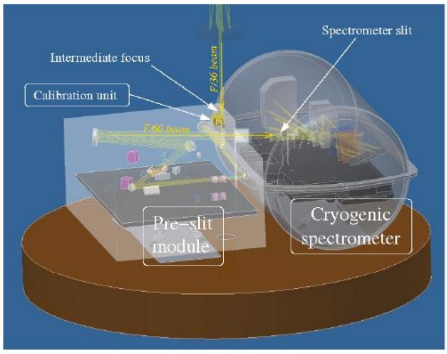


High-stability vacuum/temp

SIMPLE: high resolution NIR echelle spectrograph

- PI: Livia Origlia
- INAF (Bologna, Arcetri, Roma), UAO, TLS, PUC

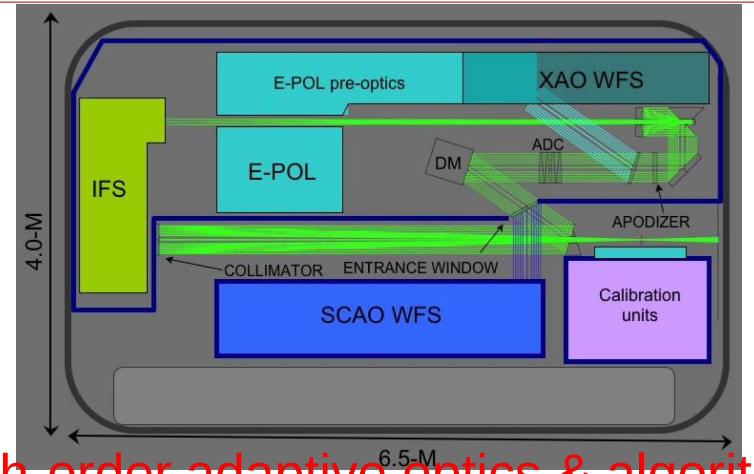




Stable cryo-optics/mechanics

EPICS Exoplanets Imaging Camera Spectrograph

- PI: Markus Kasper, ESO
- LAOG,LESIA, Uni. Nice, LAM,ONERA, Uni.Oxford, INAF (Padova), ETH Zurich, NOVA (Amsterdam, Utrecht)

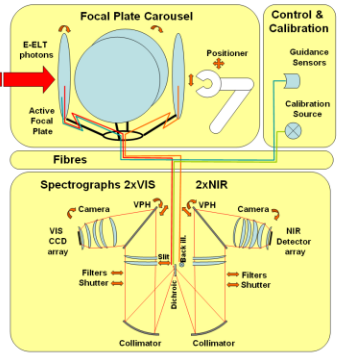


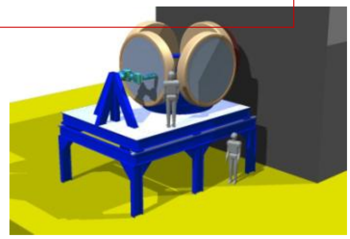
High-order adaptive optics & algorithms

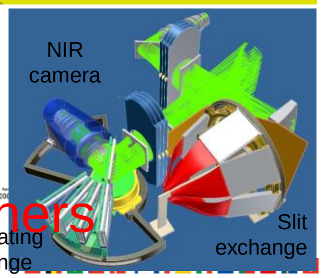
OPTIMOS – EVE: Optical-NIR MOS Fibre-based

PI: Francois Hammer, GEPI
NOVA, INAF, RAL, AIP, ZfA Heidelberg, NBI Copenhagen

Functional Overview





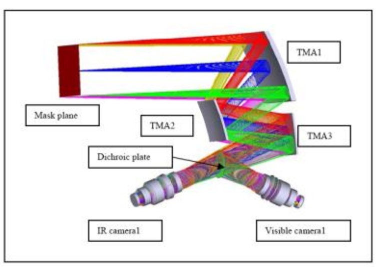


Mechanical fibre positioners

OPTIMOS-DIORAMAS: Optical slit-MOS + imaging

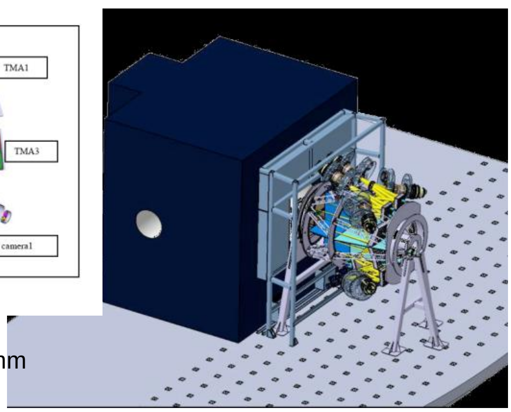
- PI: Olivier LeFevre, Marseille
- LAM, IAC, IASF-Milano

Precision mechanical systems



Optical system layout (1 quadrant)

Camera entrance pupil ~250mm



OPTIMOS-DIORAMAS at the E-ELT Nasmyth focus

END
&
Questions