



Instrumentation Programmes at ESO

Mark Casali



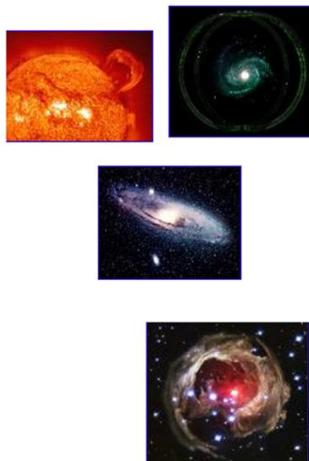
Content

- Instrumentation at ESO
 - Introduction
 - Instruments in Construction
 - Technologies
- Future Instrument Programmes
 - La Silla Paranal Programme
 - E-ELT programme



Introduction

What is an instrument?



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Introduction

Instrumentation at the VLT



13 operational instruments
on the VLT

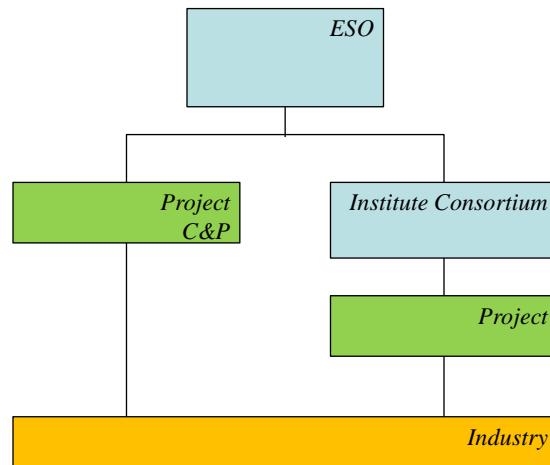
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Introduction

Structure of Projects

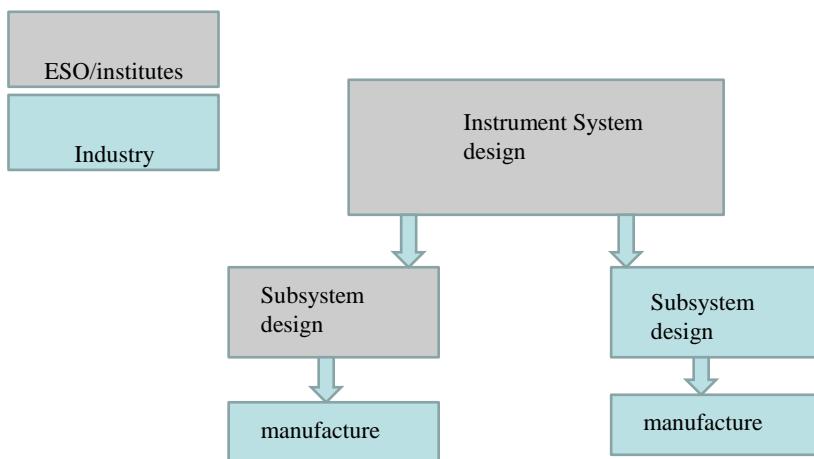


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Introduction

level of procurement



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Introduction

15 years of change

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

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Instruments in Construction

List of Instruments

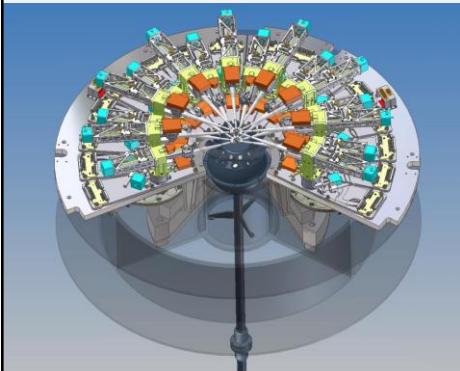
- KMOS [IR 24-IFU IR spectrograph](#)
- MUSE [1 arcmin square optical IFU](#)
- SPHERE [high-order AO imager/spectrometer](#)
- AOF [4-laser, deformable M2, AO facility](#)
- MATISSE [LMN band 4-UT VLTI instrument](#)
- GRAVITY [K-band precision microarcsec VLTI](#)
- ESPRESSO [10 cm/sec precision optical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

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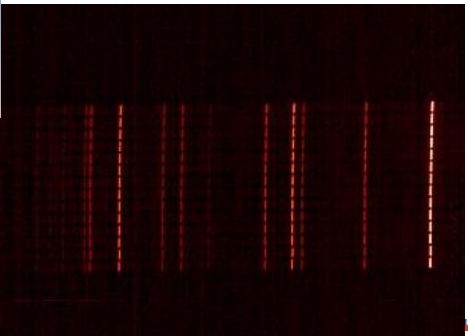




Instruments in Construction KMOS



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



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Instruments in Construction KMOS



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Instruments in Construction

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

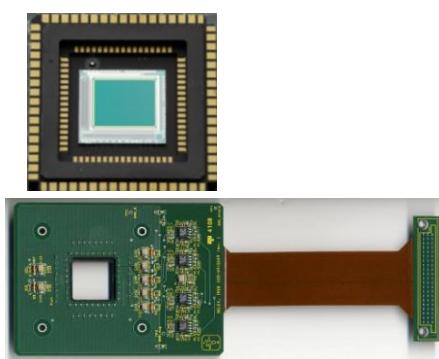
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Technologies

$\lambda_c = 2.5 \mu\text{m}$ 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



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Technologies

CCD Mosaic for OmegaCAM

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

Technologies

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 spectrograph

comb

Thorium-argon

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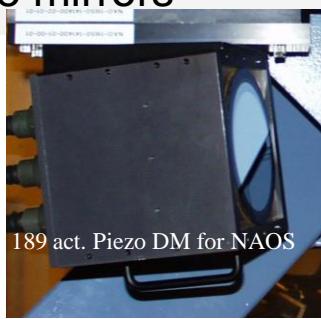
Technologies

Piezo Deformable mirrors

52 actuator piezo DM
COME-ON-PLUS



60 actuator bimorphs
piezo DM:
MACAO



1377 act. Piezo DM for SPHERE
with its drive electronics

Inc.

50x50 actuator matrix
of 1mm pitch



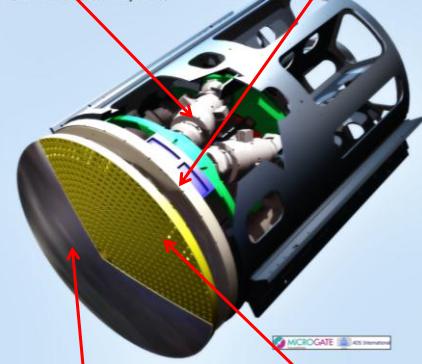
Technologies

Electromagnetic deformable mirrors

Hexapod for
centring & fine
focusing

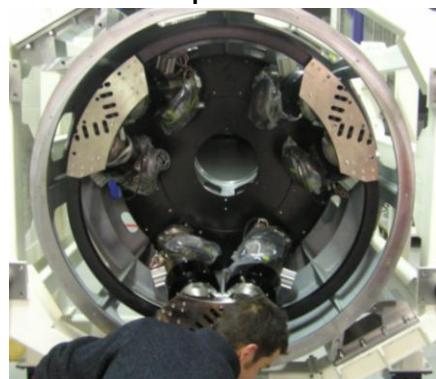
Cold Plate; heat
evacuation & act.
attachment

VLT Deformable secondary mirror



ADS/Micogate

- Ø 1.1m convex
- 1170 actuators
- 29 mm actuator pitch
- 1 ms response



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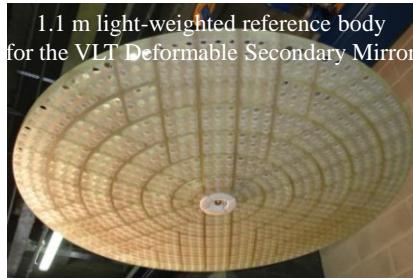




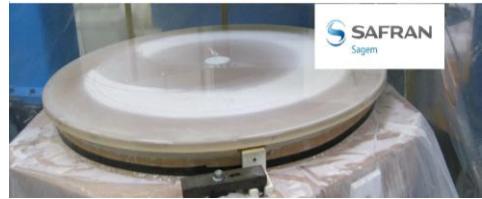
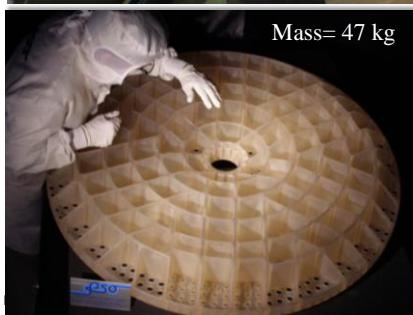
Technologies

Special optics for AO

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

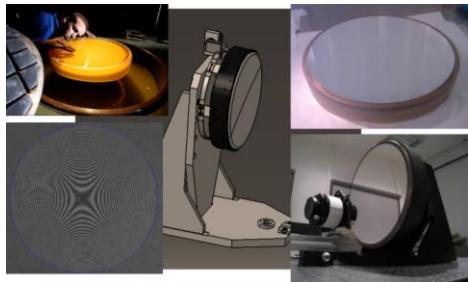


Mass = 47 kg



1.1m Zerodur shell, in manufacturing

400 mm stress polished toric mirror
(<1nm rms wavefront error)



Future Instrument Programmes

La Silla - Paranal



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La Silla Paranal Programme

1. ERIS

- 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

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La Silla Paranal Programme

2. multi-object spectrograph

- 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
- Decision in first quarter 2013
 - 0, 1 or 2 instruments. €6M from ESO. Matching funds from outside.

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La Silla Paranal Programme

Future instruments

year	Phase A/ Prel. Study	Design/ Construction	Delivery
2011	ERIS MOS		
2012	CUBES CRIRES Up.	ERIS	KMOS VIMOS Up. VISIR Up.
2013		MOSI CRIRES Up. CUBES	MUSE SPHERE PRIMA
2014	New I(MOSII?)		GRAVITY
2015	New II	New I	MATISSE CRIRES Up.
2016	New III	New II	ESPRESSO ERIS
2017	New IV	New III	MOSI CUBES
2018	New V	New IV	
2019	New VI	New V	New I(MOSII?)
2020		New VI	

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La Silla Paranal Programme

Future instruments

year	Phase A/ Prel. Study	Design/ Construction	Delivery
2011	ERIS MOS		
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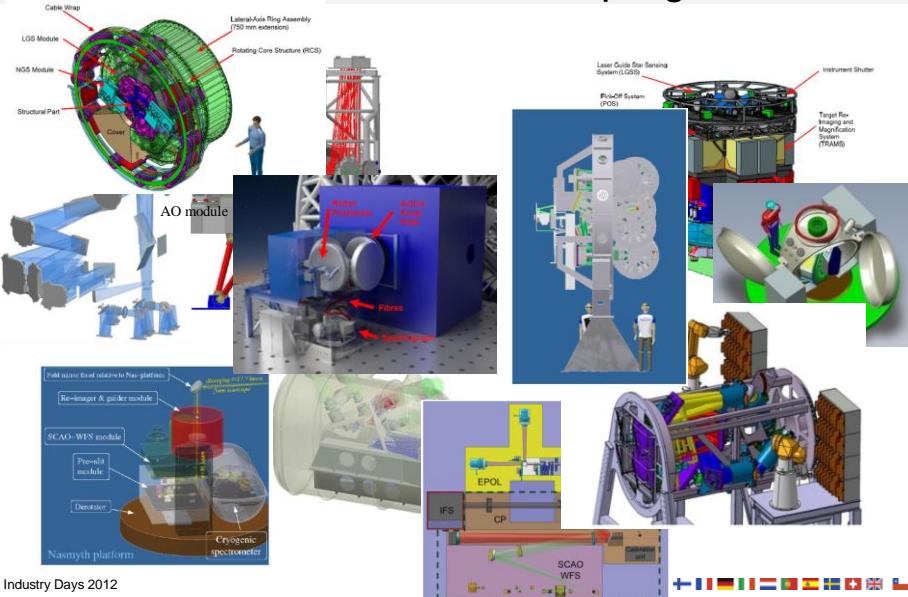
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Future Instrument Programmes

ELT Instrument programme



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E-ELT Instrument Programme

Approved Roadmap

year	ELT-IFU	ELT-CAM	ELT-3	ELT-4	ELT-5	ELT-6	ELT-PCS
2012	Decide science reqmts, AO architecture.		VISIR start on-sky	Develop science requirements for MOS/HIRES			Call for proposals for ETD
2013			Selection: ELT-MIR/MOS/HIRES Call for proposals for MOS/HIRES				
2014							
2015				Selection: ELT-MOS/HIRES	Call for proposals		
2016							
2017						TRL check	
2018						TRL check	
2019					Selection	TRL check	
2020						TRL check	
2021						TRL check	
2022 Tel technical 1 st light							
	Pre-studies taking the form of Phase-A or Δ-Phase-A work and/or ESO-funded enabling technology development (ETD)						
	Decision point						
	Development of Technical Specifications, Statement of Work, Agreement, Instrument Start.						

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E-ELT Instrument Programme

Approved Roadmap

year	ELT-IFU	ELT-CAM	ELT-3	ELT-4	ELT-5	ELT-6	ELT-PCS
2012	Decide science reqmts, AD architecture.		VISIR start on-sky	Develop science requirements for MOS/HIRES			Call for proposals for ETD
2013			Selection ELT-MIR/MOS/HIRES Call for proposals for MOS/HIRES				
2014							
2015				Selection ELT-MOS/HIRES		Call for proposals	
2016							
2017							TRL check
2018							TRL check
2019						Selection	TRL check
2020							TRL check
2021							TRL check
2022 Tel technical 1 st light							
	Pre-studies taking the form of Phase-A or Δ-Phase-A work and/or ESO-funded enabling technology development (ETD)						
	Decision point						
	Development of Technical Specifications , Statement of Work, Agreement, Instrument Start.						

- First four instruments funded from construction budget. €100M.
- Later instruments funded from operations budgets

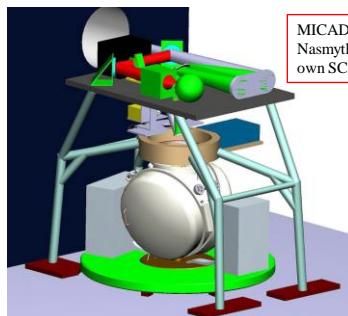
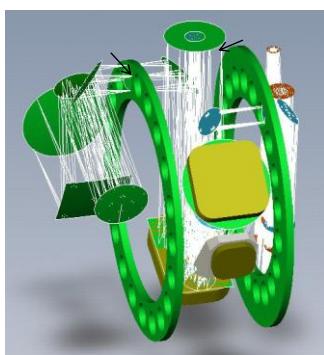
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E-ELT Instrument Programme

instrument 1: ELT-CAM

- MPE, MPIA Heidelberg, USM Germany
- INAF Italy
- NOVA Netherlands
- OPM LESIA France



MICADO at the direct Nasmyth focus with its own SCAO sensor

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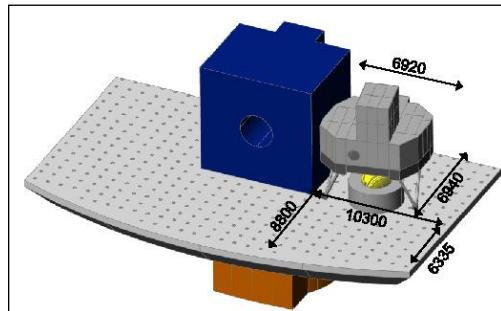




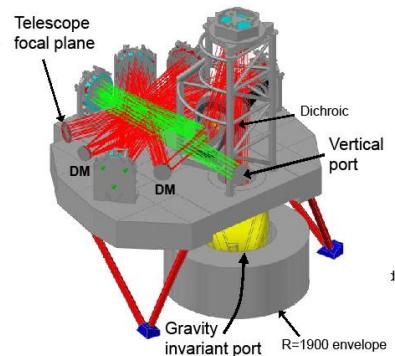
E-ELT Instrument Programme

Instrument 1: ELT-MCAO

- INAF Italy
- ONERA France
- TBD



‘Facility’ adaptive optics system supporting two instruments.



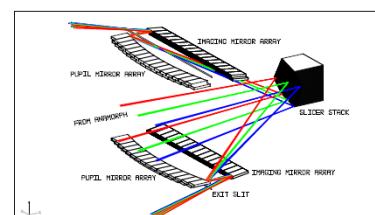
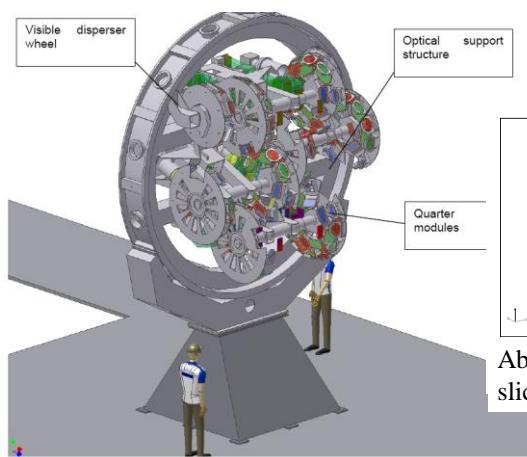
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E-ELT Instrument Programme

instrument 2 : ELT-IFU

- Oxford, UKATC UK
- CRAL, CSIC France
- IAC Spain



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

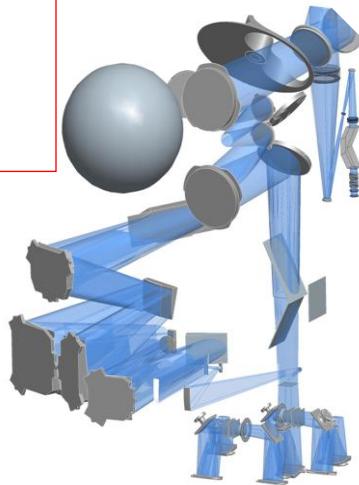
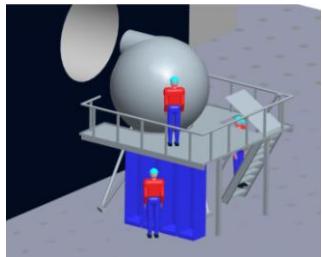
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E-ELT Instrument Programme instrument 3: ELT-MIR

- NOVA (Leiden and Dwingeloo) *Netherlands*
 - MPIfA Heidelberg *Germany*
 - CEA Saclay, DSM/IRFU *France*
 - KU Leuven *Belgium*
 - ATC *UK*

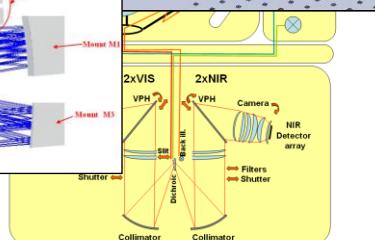
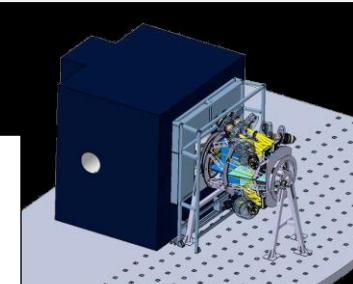
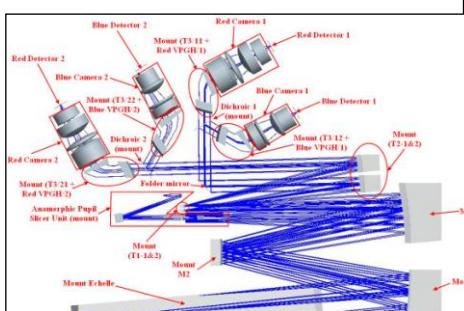


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E-ELT Instrument Programme instrument 4: MOS or HIRES

Instrument and consortium to be decided by 2015



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Scale of instrumentation programme

Spend on procurement M€

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020
LSP	4.0	3.1	3.2	6.6	3.0	3.3	5.0	3.0	3.0
ELT	0.1	2.5	3.9	2.3	8.0	14	9.4	10.7	7.6
total	4.1	5.6	7.1	8.9	11.0	17.3	14.4	13.7	10.6

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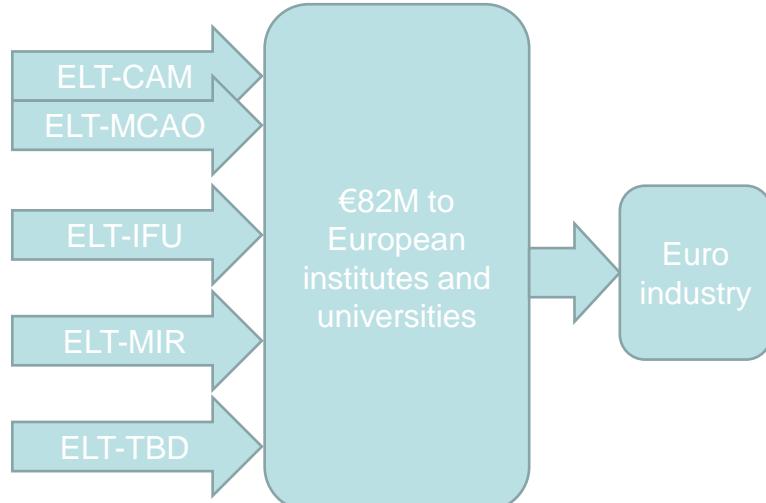
**END
&
Questions**

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E-ELT Instrument Programme Funded by ELT construction budget



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