



Pre-LISA EM session

*Vincenzo Mainieri  
MOS project scientist  
WST project scientist*



# 2025 - 2030 – (2035)

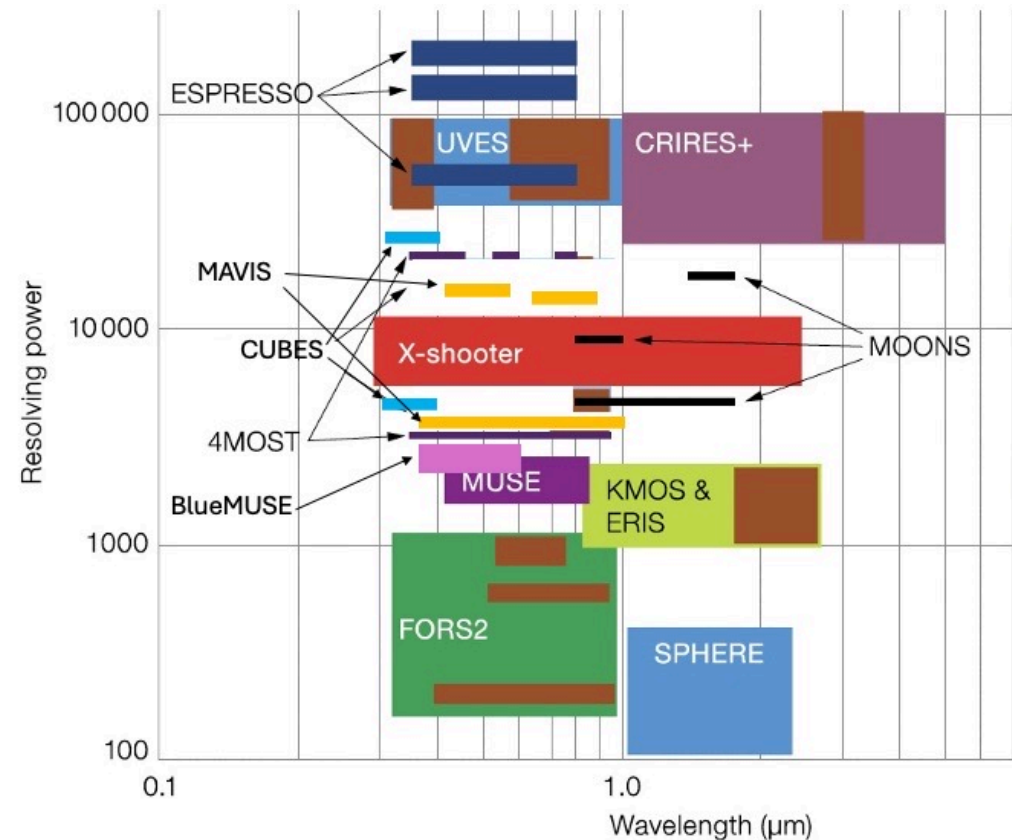
## Optical/Near-IR coverage from the ground/ESO



Unique parameter space coverage (e.g., wavelength, spectral and angular resolution, multiplexing) with specialized and general-purpose instruments.

New instruments ready for the beginning of 2030s will maximize the complementarity with the ELT:

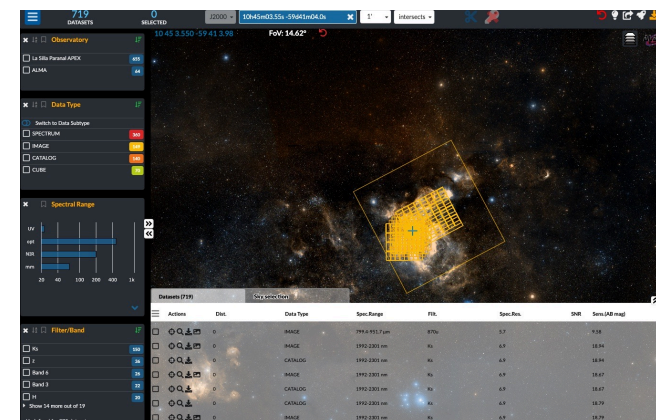
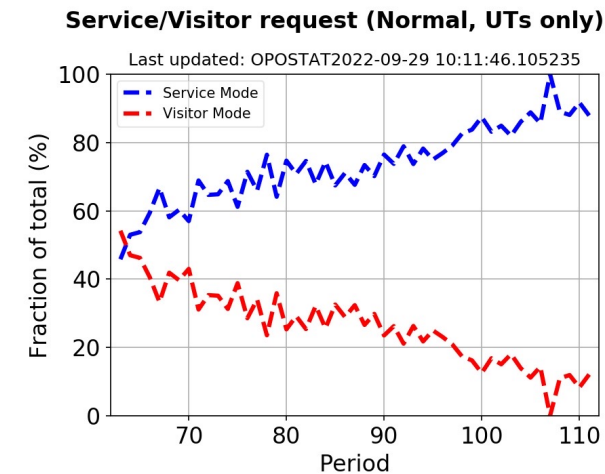
- The exploration of the UV and blue end (e.g., CUBES, BlueMUSE).
- Exploit AO at shorter wavelengths (MAVIS).
- And more as part of the "VLT 2030" process (e.g. second DSM).



# ESO operations: reliable and flexible



- Service Mode and Visitor Mode
- DDT channel
- The transient sky:
  - Flexible scheduling
  - Variables timescales
  - Large Target of Opportunity fraction
  - Rapid Response Mode
- Systematic archiving:
  - Time series
  - Advanced data products



# 2025 - 2030 – (2035)



## Massive spectroscopic surveys publicly available

- New KMOS public surveys (200 nights)
  - Massive Spectroscopic Surveys with millions of high-quality spectra:
    - MOONS - VLT multiplex=1000,  $0.65\mu\text{m} < \lambda < 1.8\mu\text{m}$  R= 5,000 – 20,000
    - 4MOST – VISTA multiplex=2300,  $0.37\mu\text{m} < \lambda < 0.9\mu\text{m}$  R= 5,000 – 20,000
    - PFS – Subaru multiplex=2300,  $0.37\mu\text{m} < \lambda < 1.2\mu\text{m}$  R= 5,000
    - FOBOS – Keck multiplex=1800,  $0.31\mu\text{m} < \lambda < 1\mu\text{m}$  R= 3,000
-

# 4MOST

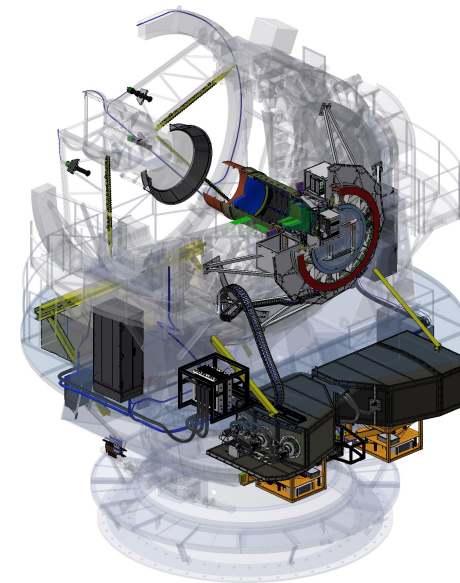


[www.4most.eu](http://www.4most.eu)

P.I. Roelof de Jong (AIP)

Start operations: Q4 2025

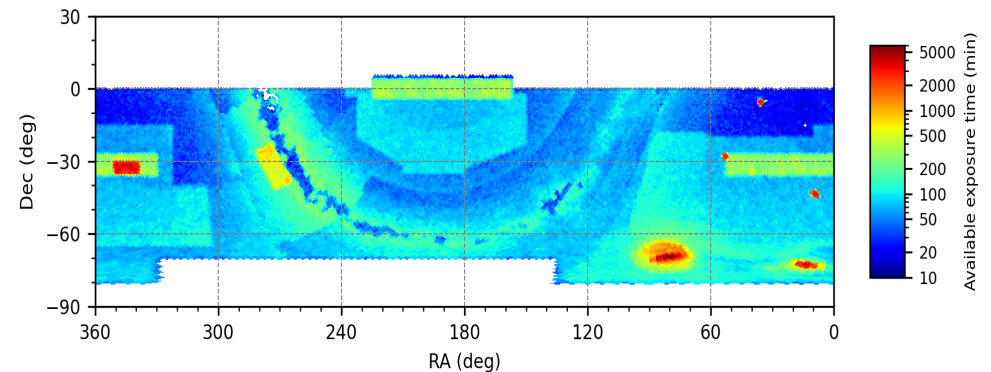
Specification	Design value
Field-of-View (hexagon)	$\sim 4.2 \text{ degree}^2 (\phi > 2.6^\circ)$
Multiplex fiber positioner	2436
Medium Resolution Spectrographs (2x)	R $\sim 4000\text{--}7500$
# Fibres	812 fibres (2x)
Passband	370–950 nm
Velocity accuracy	< 1 km/s
Spectral sampling (pixels/FWHM)	> 2.8 pixels
High Resolution Spectrograph (1x)	R $\sim 20,000$
# Fibres	812 fibres
Passband	392.6–435.5 nm, 516–573 nm, 610–679 nm
Velocity accuracy	< 1 km/s
Spectral sampling (pixels/FWHM)	> 2.56 pixels



# 4MOST surveys (2025-2030), but also -2035



- Unique operations model for MOS instruments at ESO to maximize the science return
- 4MOST program defined by *Public Surveys (raw data immediately public)* of 5 years
- All Surveys will run *in parallel*
  - Surveys share fibres per exposure for increased efficiency
- **Key Surveys** set observing strategy
  - Millions of targets all sky
- **Add-on Surveys** for smaller surveys
- Several passes of sky with exposures ~20 mins
- Wedding-cake distribution for total time 1h to 10h



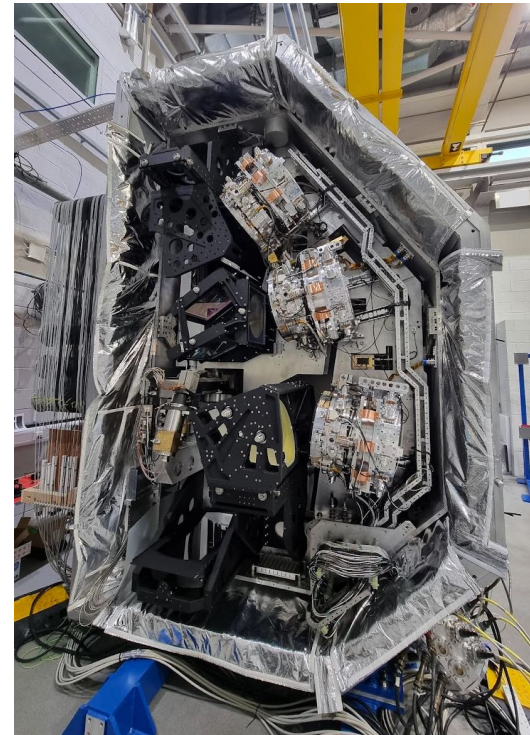
Approved surveys: 10 Consortium surveys + 15 Community surveys

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# MOONS

P.I. Michele Cirasuolo

Start of operations: Q4 2025



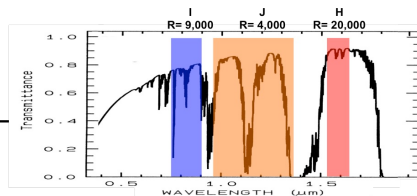
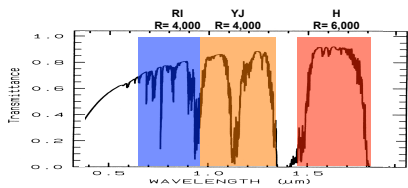
**Field of view:** 500 sq. arcmin at the 8.2m VLT

**Multiplex:** 1000 fibers

**Medium resolution:**  
 Simultaneously 0.64 $\mu$ m-1.8 $\mu$ m  
 • 0.64-0.95 $\mu$ m at R=4,000  
 • 0.95-1.35 $\mu$ m at R=4,000  
 • 1.42-1.81 $\mu$ m at R=6,600



**High resolution:**  
 Simultaneously 3 bands:  
 • 0.76-0.90 $\mu$ m at R = 9,000  
 • 0.95-1.35 $\mu$ m at R=4,000  
 • 1.52-1.63 $\mu$ m at R=20,000



[www.vltmoons.org](http://www.vltmoons.org)



2029 - 2039



**ELT**

39m diameter



**TMT**

30m diameter



**GMT**

25m diameter





# ELT Instruments



## HARMONI + LTAO

- IFU spectrograph 0.5-2.5um
- R from 3500 to 20,000
- Spaxels: 4mas to 60mas

## METIS

- Imager L,M,N band
- Single slit spectrograph
- IFU @R=100,000

## MORFEO

- MCAO module
- Clients: MICADO + second possible instr.
- 2 extra DMs

## MICADO

Imager 0.8-2.5um

FoV 53"x53" @4mas/pix and  
20"x20" @1.5mas/pix

Single slit spectrograph

## MOSAIC

- Multi-obj. spectrograph
- 300 fibers + 8 IFUs
- R=5000 – 20,000
- 0.4-1.8um

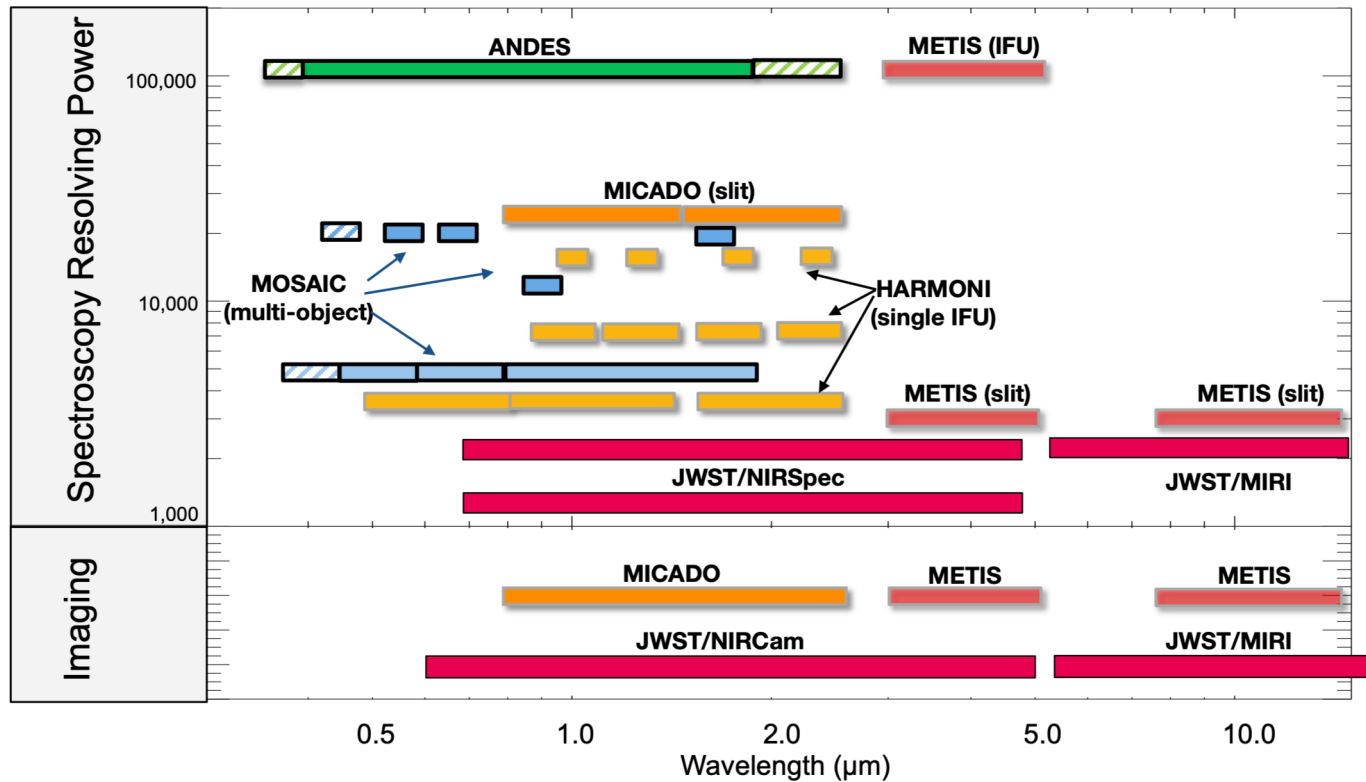
## ANDES

- High-res spectrograph
- R>100,000
- 0.4 – 1.8um

# ELT and JWST capabilities



Spectral resolving power and wavelength



# 2040+

## ESO's next programme – after ELT



- ESO about to launch the process to identify the next programme
  - Which fundamental problems in astronomy are expected to be addressed?
  - A new transformational facility
  - 2 years of scientific dialogue and debate around scientific challenges of the 2040s, and disruptive technologies.
  - Then a call for ideas
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# Wide-field Spectroscopic Telescope



EU HORIZON funded  
concept study  
2025-2028



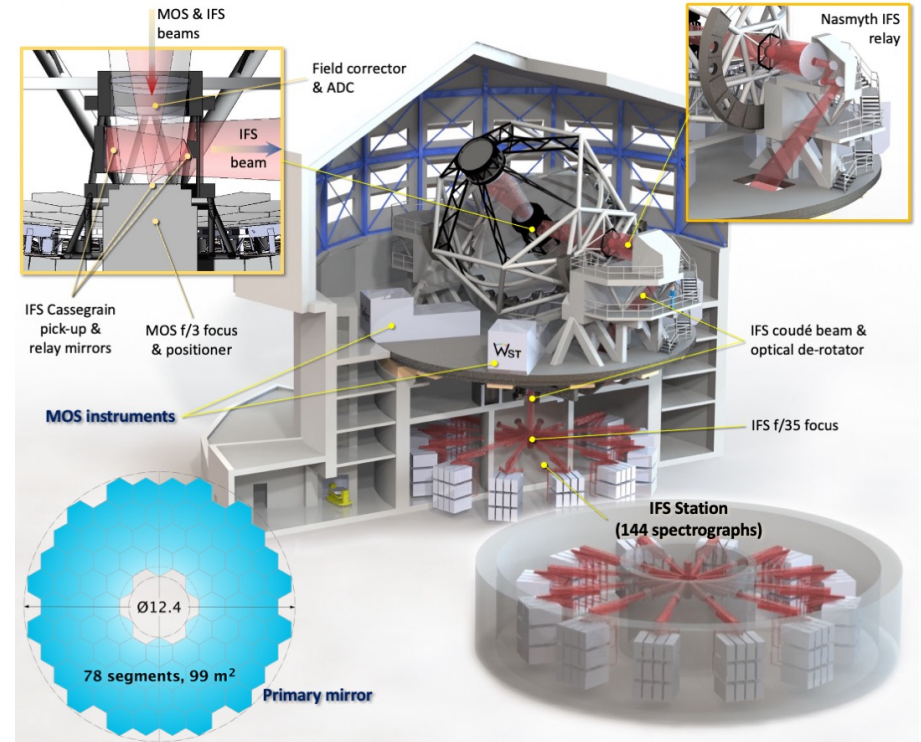
**ROLAND BACON**  
Coordinator



**VINCENZO MAINIERI**  
Project Scientist

Telescope aperture (M1)	12 m seeing limited		
Telescope FoV	3.1 deg <sup>2</sup>		
Telescope Spec. range	0.35-1.6 μm		
Operations	MOS and IFS simultaneous operations ToO implemented at telescope and fibre level		
Modes	MOS-LR	MOS-HR	IFS
FoV	3.1 deg <sup>2</sup>	3.1 deg <sup>2</sup>	3x3 arcmin <sup>2</sup> (mosaic on 9x9 arcmin <sup>2</sup> )
Spectral range (simultaneous)	0.37-0.97 μm	0.37-0.97 μm 3-4 windows	0.37-0.97 μm
Spectral resolution	4000	40000	3500
Multiplexing	20000	2000	

*Join the WST  
Science Team!*



A general purpose, wide-field, high-multiplex (MOS+IFU) spectroscopic facility on a 11m telescope

*p.s.: not an ESO project yet.*




<https://www.wstlescope.com/>



# Thank you!

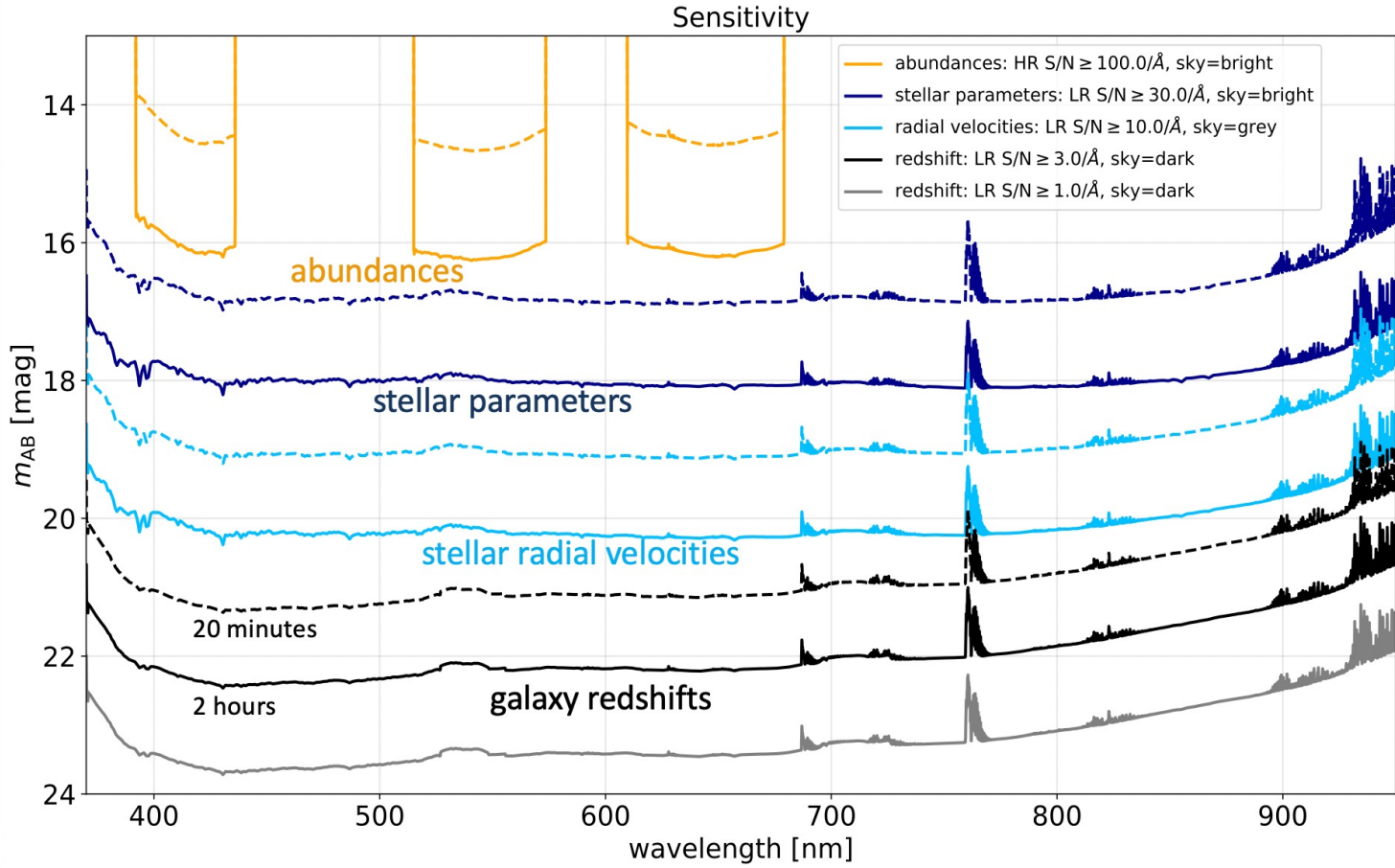
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**Vincenzo Mainieri**  
**vmainier@eso.org**

-  @ESO Astronomy
-  @esoastronomy
-  @ESO
-  european-southern-observatory
-  @ESOobservatory



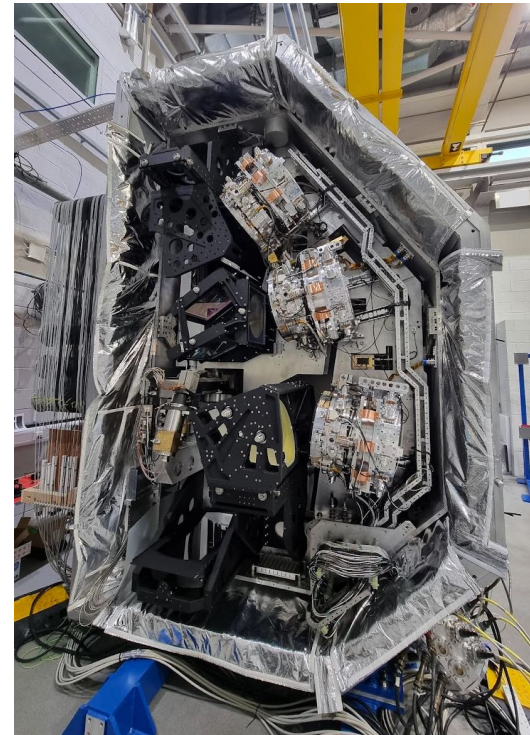
# 4MOST Sensitivity



# MOONS

P.I. Michele Cirasuolo

Start of operations: Q4 2025



**Field of view:** 500 sq. arcmin at the 8.2m VLT

**Multiplex:** 1000 fibers

## Medium resolution:

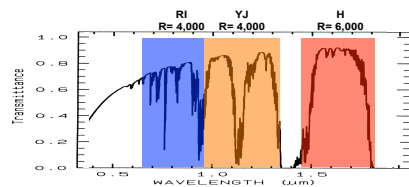
Simultaneously 0.64 $\mu$ m-1.8 $\mu$ m

- 0.64-0.95 $\mu$ m at R=4,000
- 0.95-1.35 $\mu$ m at R=4,000
- 1.42-1.81 $\mu$ m at R=6,600

Sensitivities in 1hr integration:

**Emission lines:**  
 $2 \times 10^{-17}$  erg/s/cm<sup>2</sup> ( $5\sigma$ )

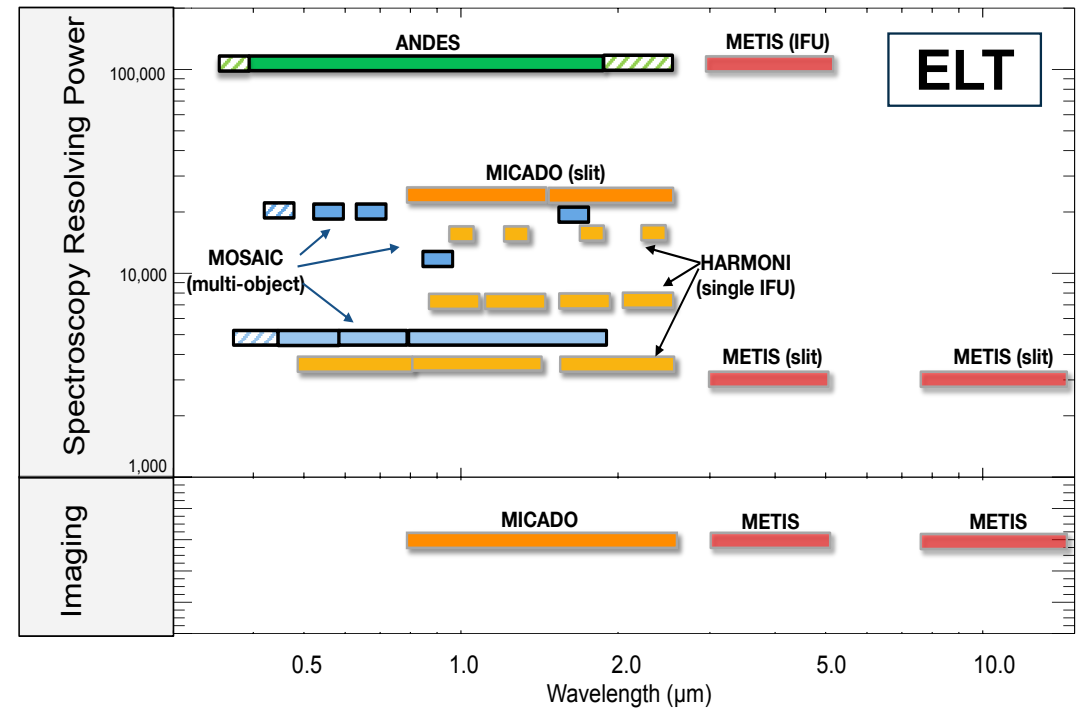
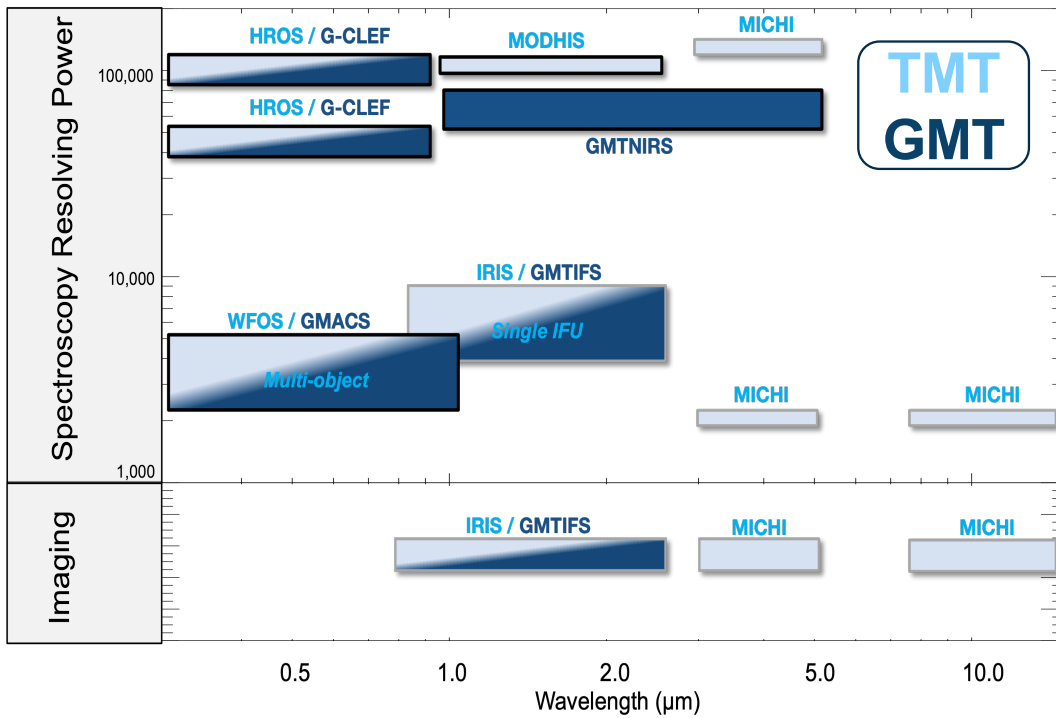
**Continuum:**  
AB = 22.7 ( $5\sigma$ ) with the spectrum rebinned, after sky subtraction, to an effective resolution of R=1,000



[www.vltmoons.org](http://www.vltmoons.org)



# Instrumentation at the ELTs





# ELT and JWST capabilities

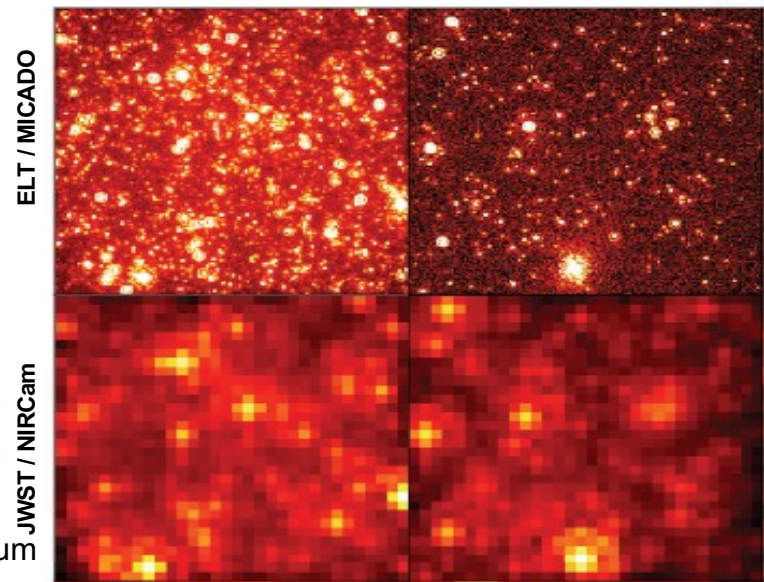
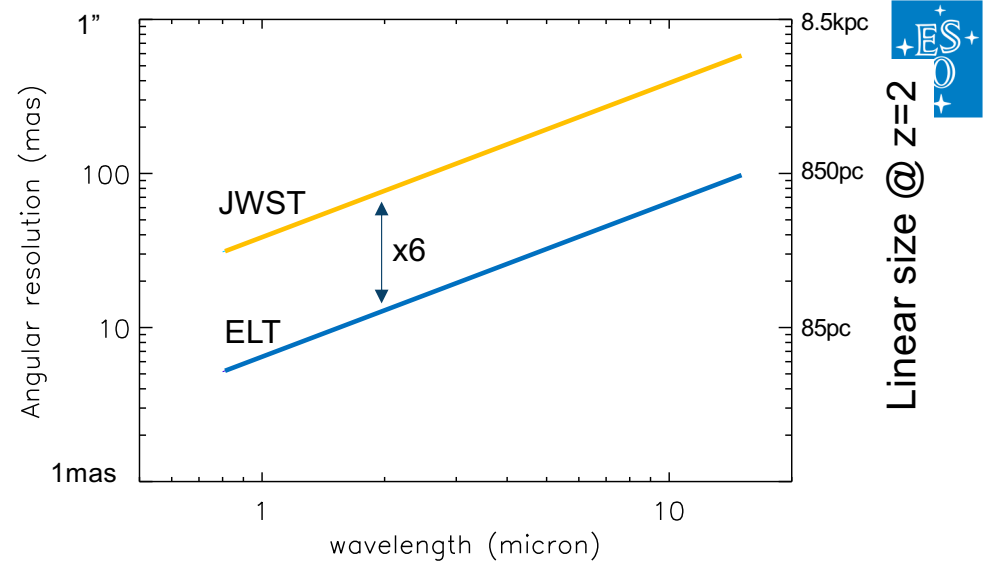
## Angular resolution and image quality

Angular resolution ( $\theta \sim \lambda/D$ )

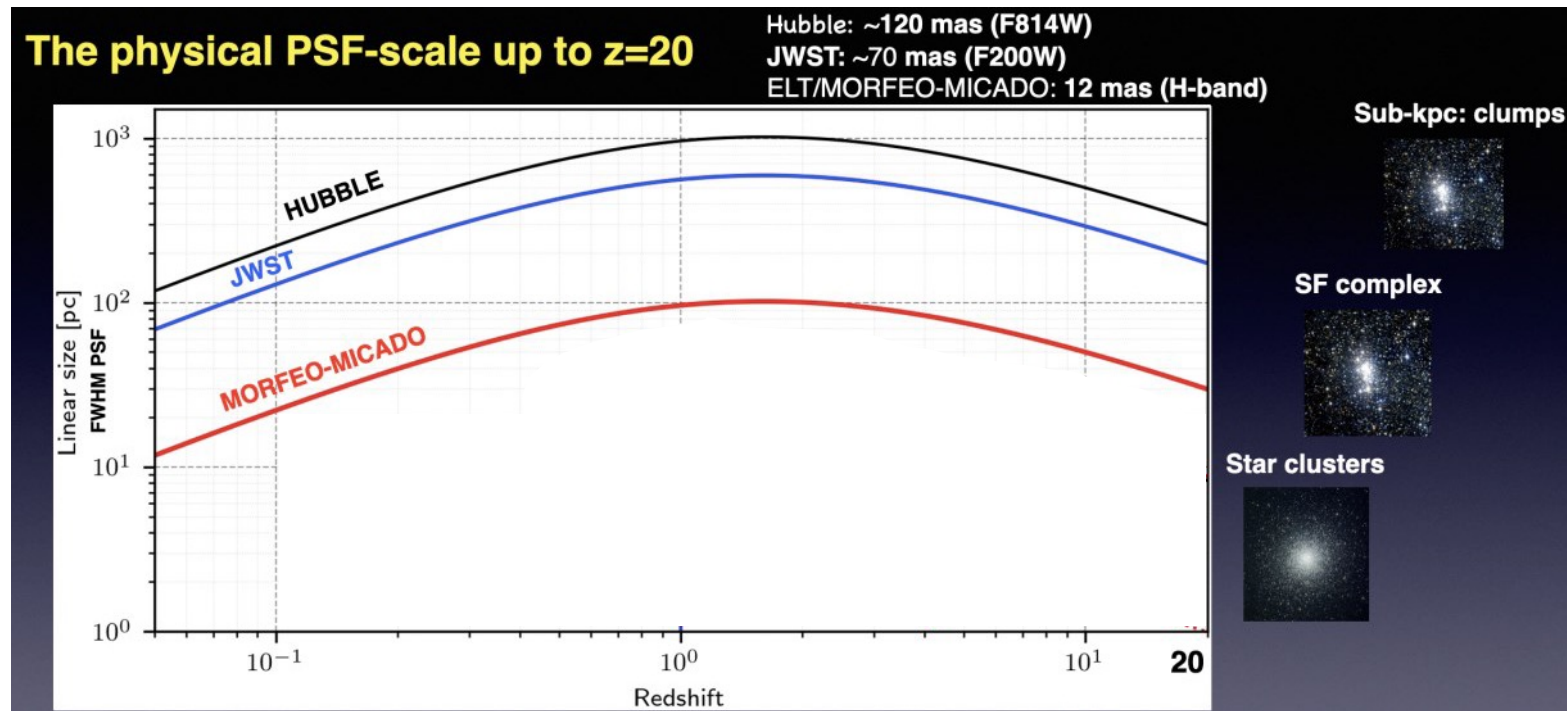
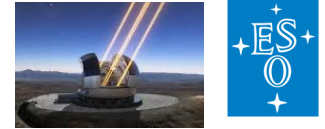
- ELT  $\theta_H \approx 10$  mas
- 6x better than JWST

Sensitivity ( $\sim D^2/\theta^2 \propto D^4$ )

- Sensitivity boost with flux concentration
- 500x better than 8m seeing-limited telescopes



# ELT and JWST capabilities



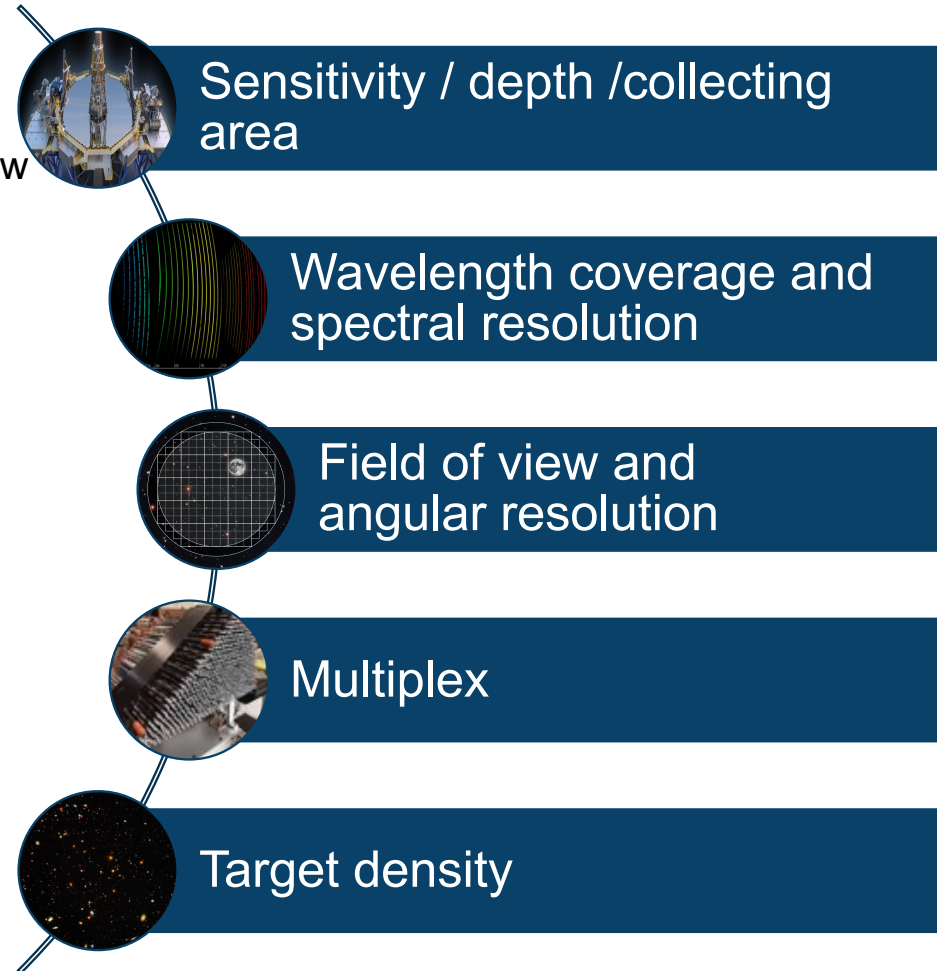
Credit: E. Vanzella, MORFEO Consortium

# 2029 - 2039

## Landscape and new projects

- ELT in operation
- 8-10m class ground-based telescope still going strong with new instruments:
  - e.g. for VLT: MAVIS (visible AO imager and spectrograph), BlueMUSE (opt/UV IFU)
- ALMA upgraded with new correlator

**Some projects still in development: what are the key capabilities that you need ?**



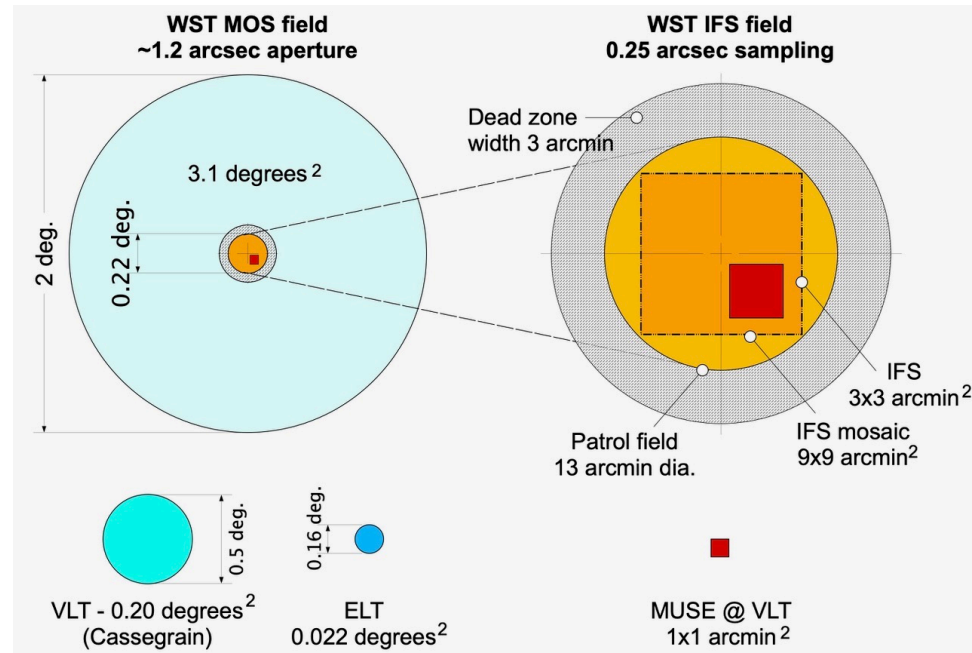


# Wide-field Spectroscopic Telescope



- A multi-purpose facility covering a wide range of science topics ([Mainieri+24](#))
- 3-years (2025-2028) **concept study** approved with HORIZON EU funding

Join the WST Science Team!

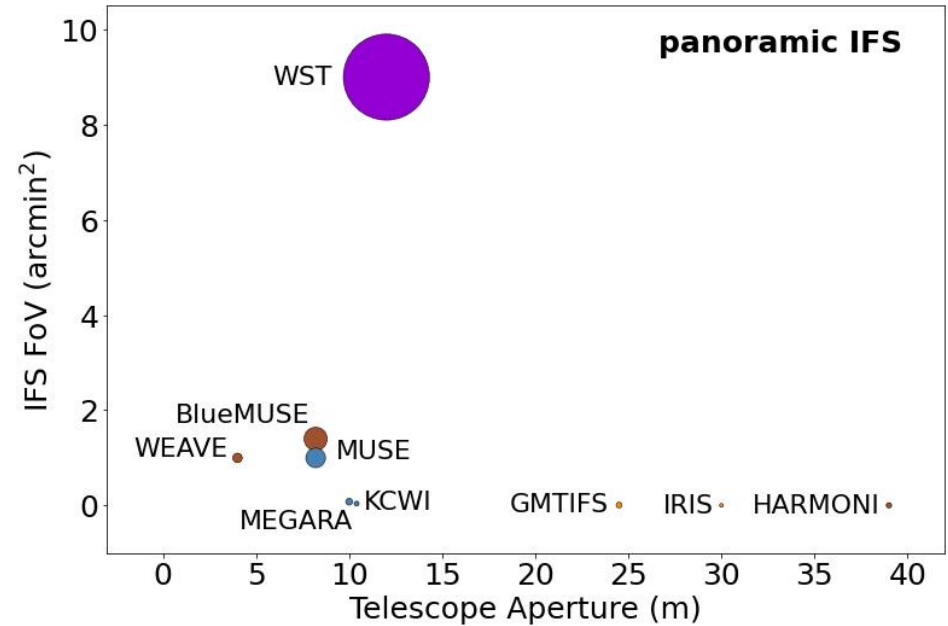
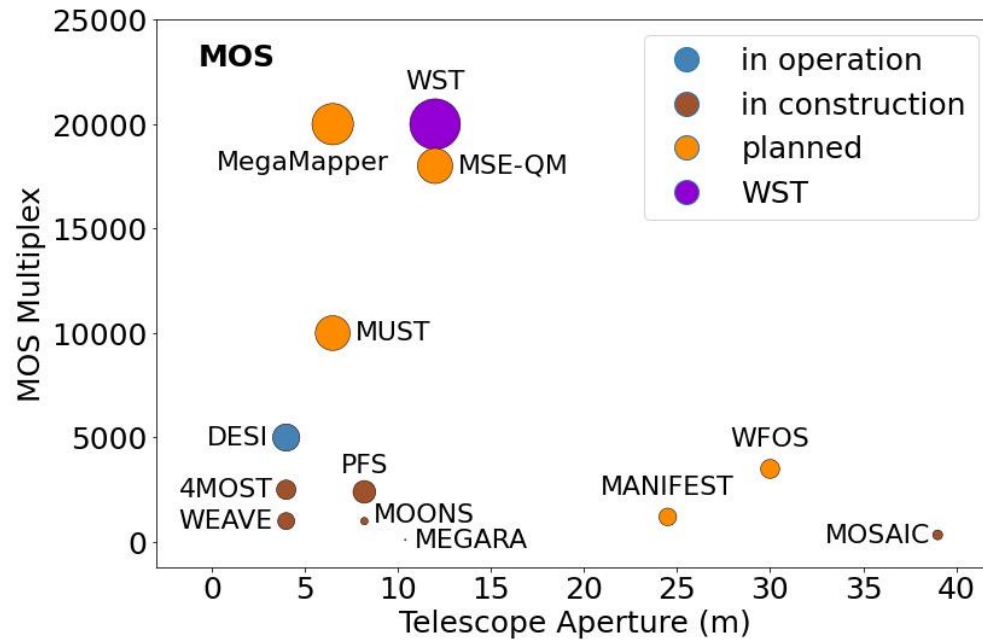


<https://www.wstlescope.com/>

*p.s.: not an ESO project yet.*



# Comparison with other facilities



Comparison of MOS (left panel) and IFS (right panel) capabilities with existing and proposed ground-based spectroscopic facilities. **Circle areas are proportional to the etendue (i.e., aperture times field of view area).**

*p.s.: not an ESO project yet.*