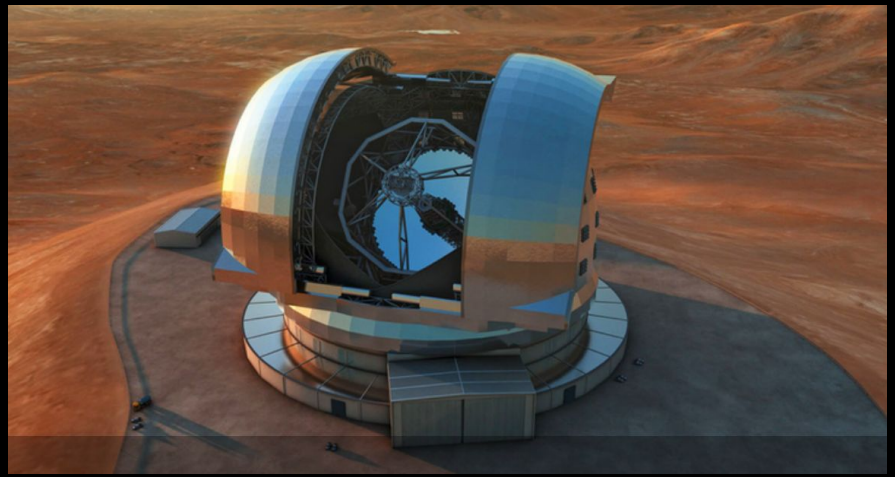
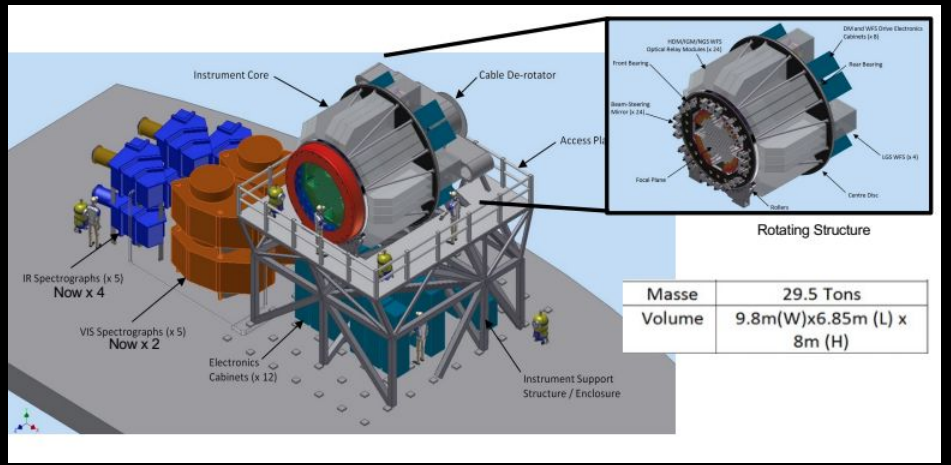
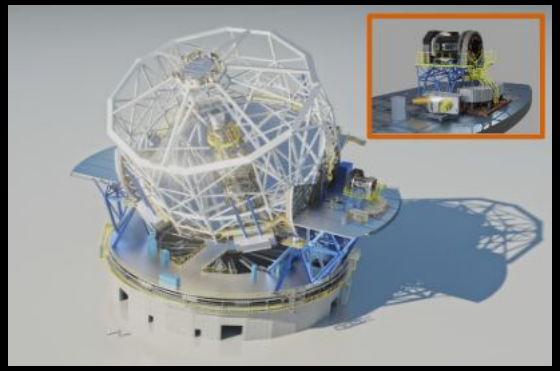
MOSAIC:
The MOS for the ELT
***

L.Pentericci on behalf of the italian MOSAIC team





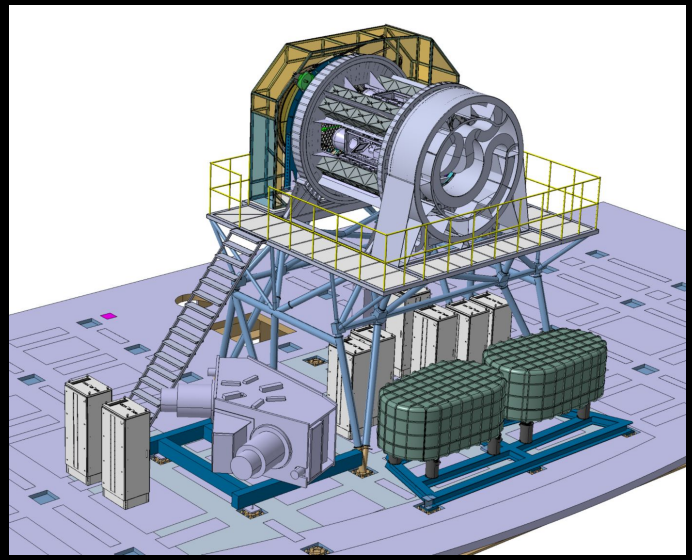
most material for the slides courtesy of R. Pello (PI) & M. Puech (co-PI)



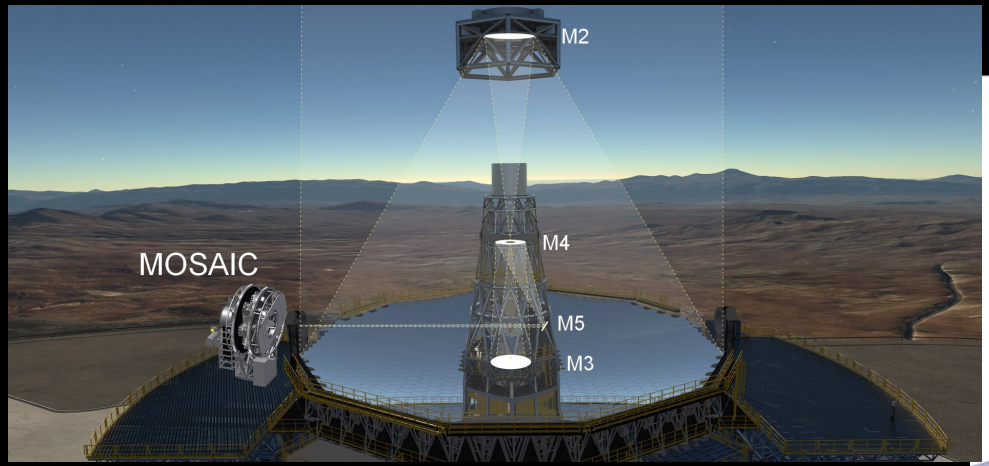
MOSAIC in a nutshell

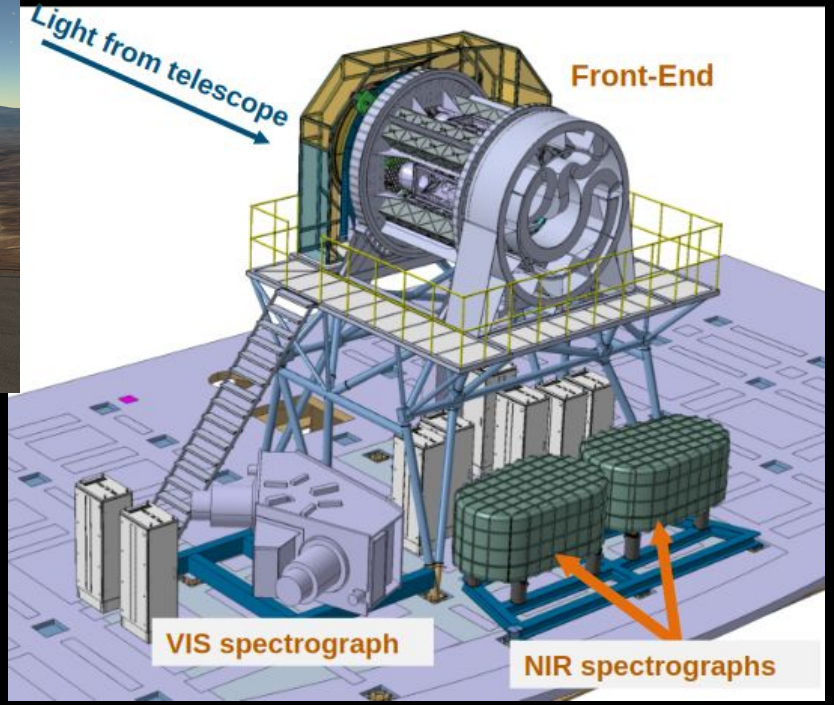
MOSAIC is a versatile Multi-Object Spectrograph, to be located at the Nasmyth A platform of the ELT

- MOSAIC is built on the legacy of three former ELT phase A instrument studies: EAGLE (Morris et al. 2012), OPTIMOS-EVE (Navarro et al. 2010), and OPTIMOS-DIORAMAS (Le Fèvre et al. 2010)
- Wavelength coverage: 0.39 to 1.8 microns
- MOSAIC is intended to use the widest possible FoV provided by the ELT : ~40 arcmin²
- Two observing modes: MOS & mIFU



MOSAIC on Nasmyth platform

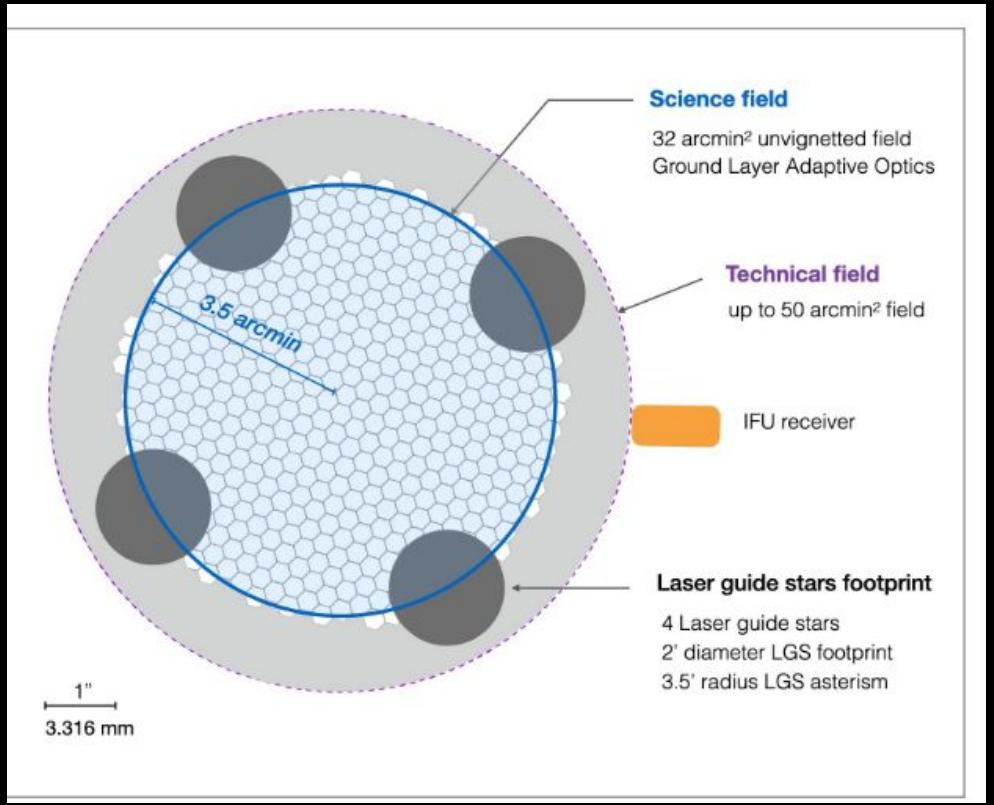




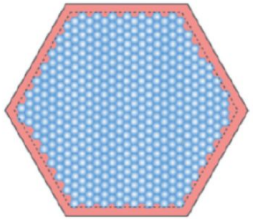
All MOSAIC modes will be assisted by Ground-Layer Adaptive Optics using both Natural and Laser Guide Stars

MOSAIC shared focal plane

MOSAIC focal plane is filled by hexagonal tiles.
On each tile there will be a locally controled positioner that allocates for some the MOS apertures and for the IFU pick-off mirror.



The HMM and IFU apertures

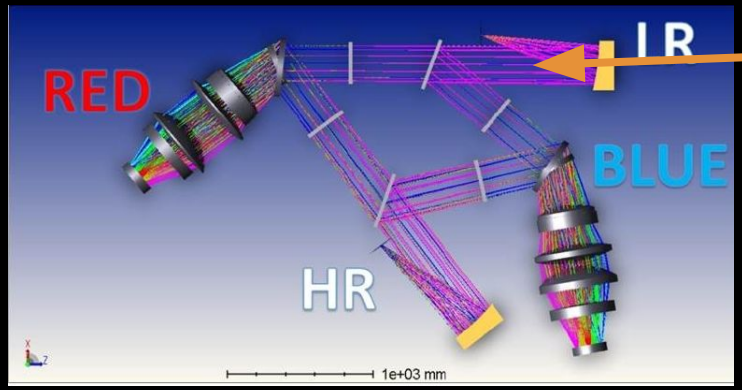
Mode	MOS-VIS-LR	MOS-VIS-HR	MOS-NIR	mIFU
Aperture				
Microlens sampling *(hexagon height)*	234 mas	180 mas	190 mas	150 mas
Actual spatial resolution	700 mas Circumscribed diameter	840 mas Circumscribed diameter	690 mas Circumscribed diameter	150 mas
Field of view				2.25 arcsec Circumscribed diameter

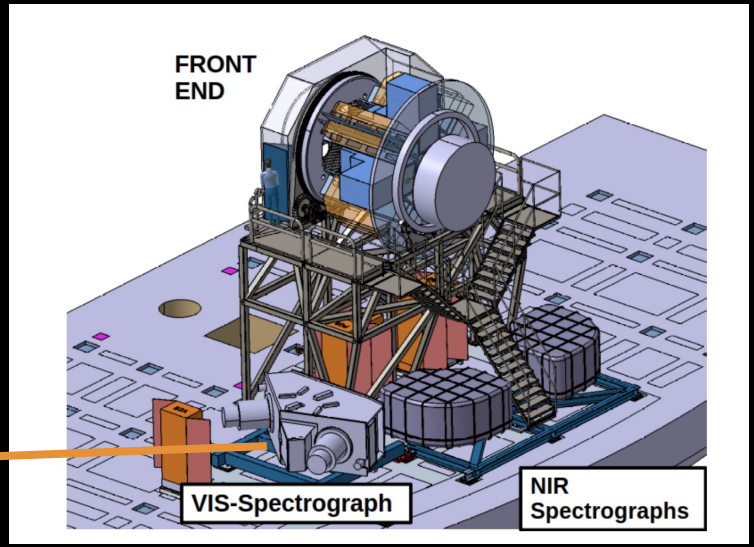
Density	6/arcmin^2	4/arcmin^2	6/arcmin^2	6/arcmin^2
Number	140	65	180	8

MOSAIC visible channel

The visible channel is optimized for galactic studies - high survey speed and Line Spread Function stability

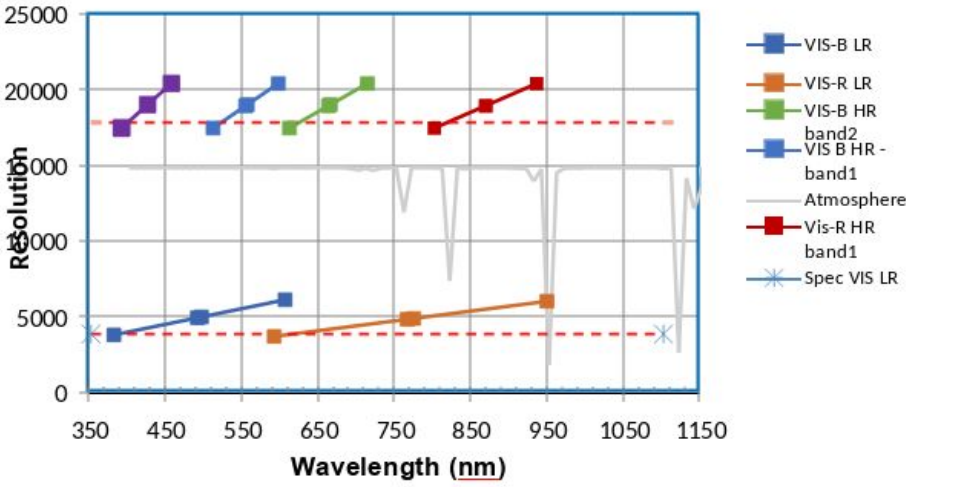
- Simultaneous coverage from 0.39-0.95μm at R~5000
- smaller ranges covered in R=19000
- Multiplex of 140 in LR, 65 in HR
- Observe the CaIITriplet region with high SNR
- Fiber core-undersize compared to the pupil to have stable illumination at the fiber input

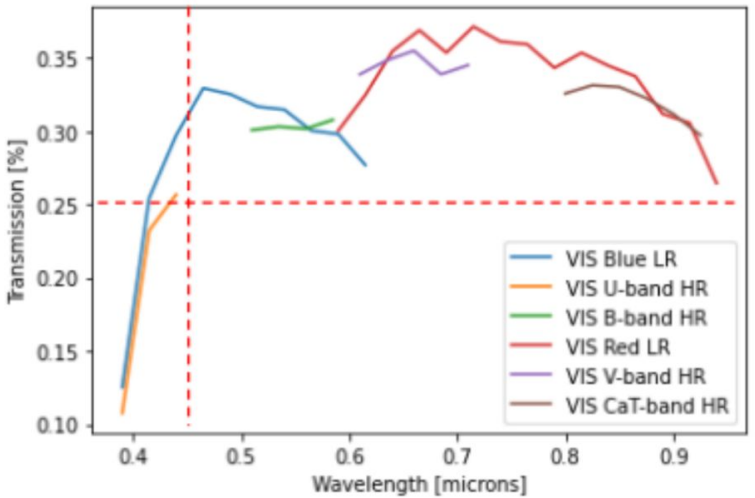




red and bue arm cameras

Resolution and transmission of MOSAIC visible channel

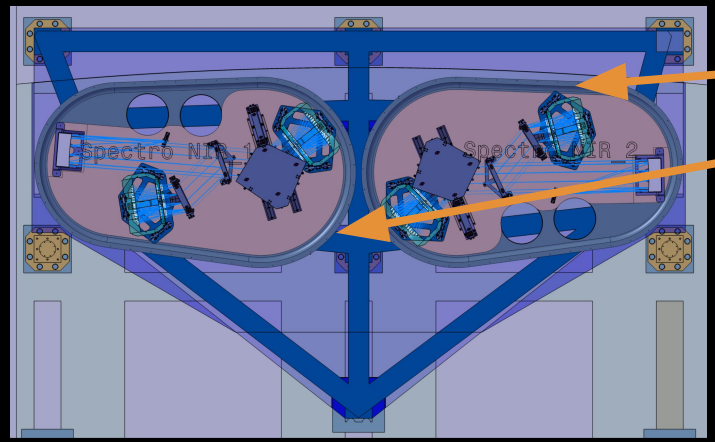


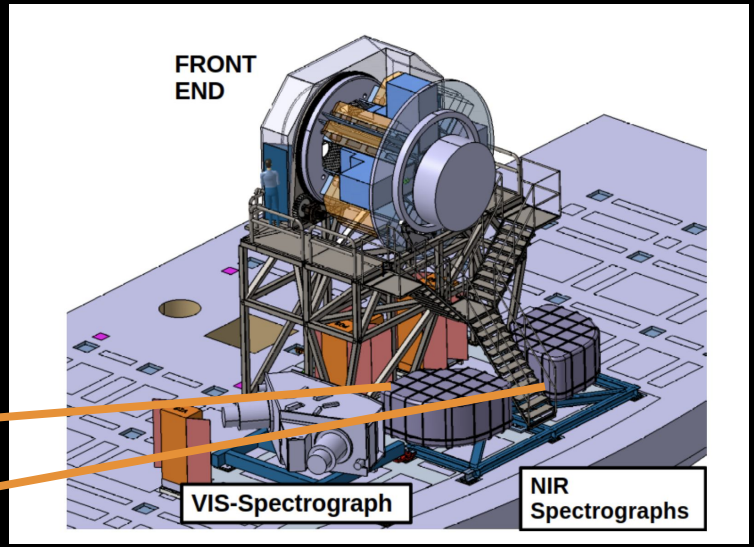


MOSAIC near-IR channel

The NIR channel is optimized for faint sources and optimal sky subtraction:

- NIR spectrograph derives from MOONS concept
- Two-cameras design is the current baseline
- Fibre oversized relative to pupil to maximize throughput

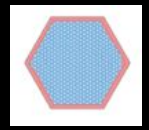




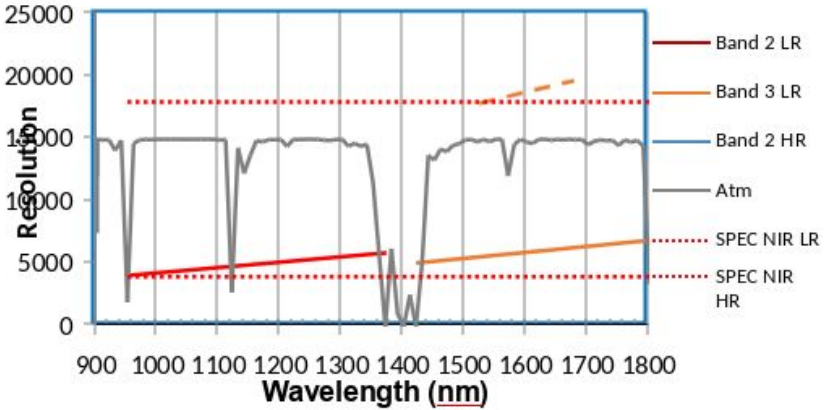
The NIR channel will have two observing modes

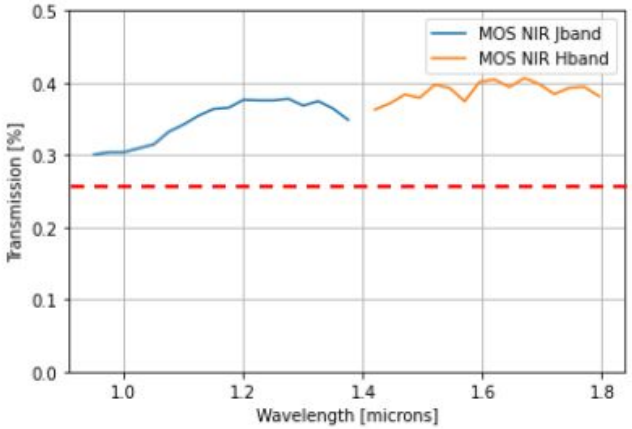
A MOS mode with multiplexing 180
With LR (4000) it will cover the range 0.95 to 1.8 μm in a single shot
With HR (>18000) it will cover a narrow range of specific interest

The mIFU mode will offer Integral Field Units for parallel observations of up to 8 extended objects
The individual FoV of each IFU will be ~2.2 arcsec in diameter, with hexagonal shape. Each spaxel (also hexagonal) will be 150mas on-sky, providing coarser spatial resolution compared to HARMONI, but optimised to reach higher surface brightness sensitivity for faint extended sources.



Resolution and transmission of MOSAIC near-IR channel





Summary of Observing modes and settings

- MOSAIC covers the full bandwidth from 0.39 to 1.8 microns
- VIS and NIR bandwidth are covered in a single exposure independently (not the same objects in VIS or NIR)
- 4 HR bands in VIS (can observe simultaneously two of them) and an HR in the H-band in NIR

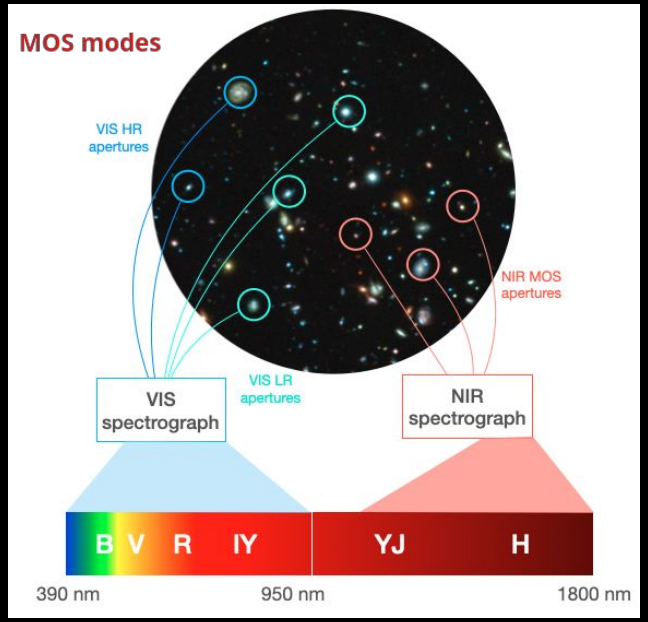
MODE	N	λ(min) nm	λ(max) nm	R(mid)	R(min)	Sampling pixels	m_{AB}
MOS VIS-LR	140	390	950	5000	4000	>3.57	26.0
MOS NIR-LR	180	950	1800	R>4000 (goal 5000)	>4000	>2.5	26.0-25.4
mIFU-LR	8	950	1800	R>4000 (goal 5000)	>4000	>2.5	25.0
MOS VIS-HR B1	65	390	455	19000	<18000 in few SRE	2.61	23.5
MOS VIS-HR B2		510	595				24.7
MOS VIS-HR R1		610	712				24.2
MOS VIS-HR R2		800	934				24.4
MOS NIR-HR	180	1523	1620	R>18000 (goal 23000)	18000	>2.5	23.8
mIFU-HR	8	1523	1620	R>18000 (goal 23000)	18000	>2.5	23.4

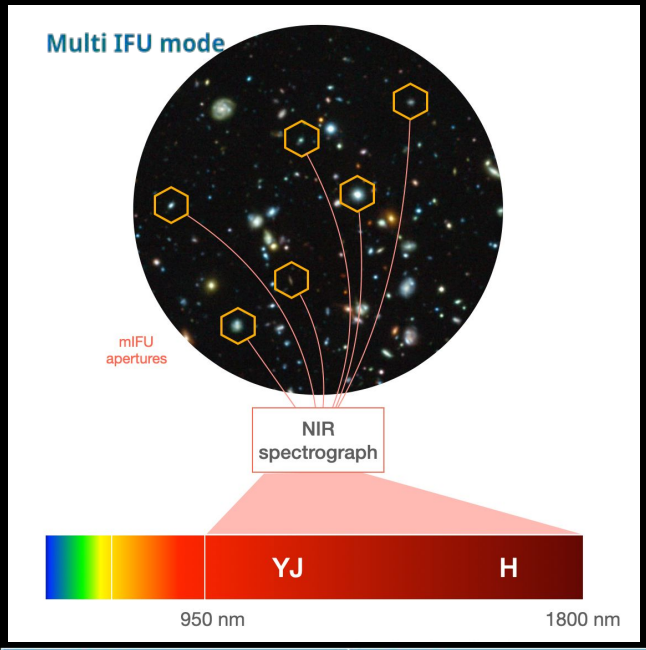
SNR=5 / 5h/ point source

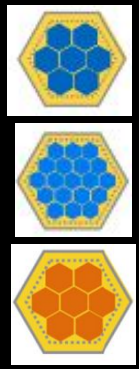
LR

HR

MOSAIC concept : a survey machine

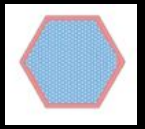




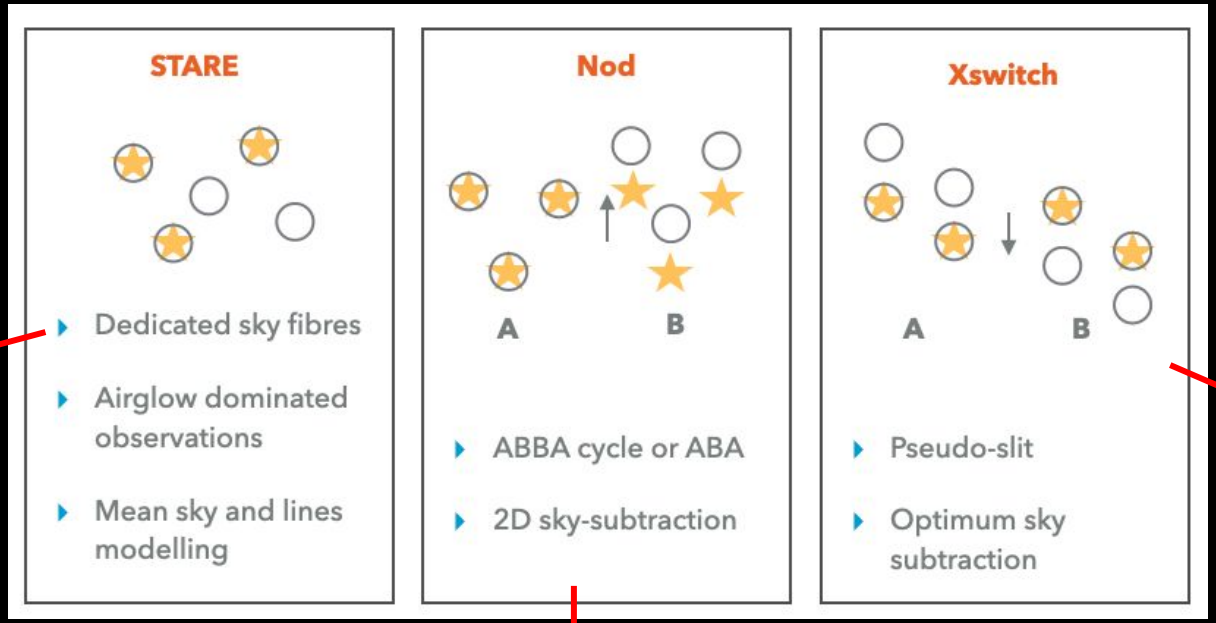


MOS mode	Multiplex
Visible Low resolution (R=4 000)	140
Visible High resolution (R=19 000)	65
NIR Low and High resolution	180

mIFU properties	Values
Multiplex	8
Field of view	2.2 arcsec (hexagonal)
Spaxel	150 mas



Sky subtraction modes



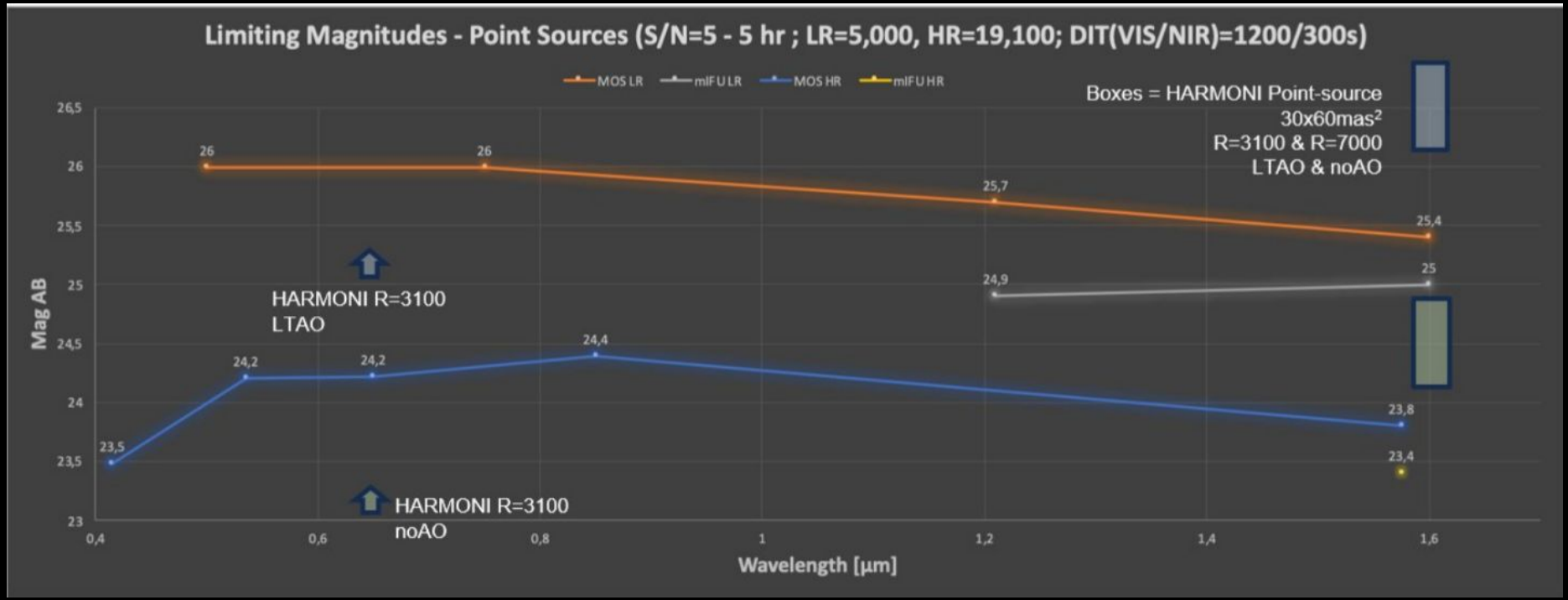
OH sky model from only a fraction of dedicated fibers

in NIR for faint sources similar to slit nodding 100% of time on target

in VIS, and in NIR for bright sources

Mode	Stare	Nod	Xswtich
MOS-VIS	x	x	
MOS-NIR	x	x	x
mIFU	x	x	

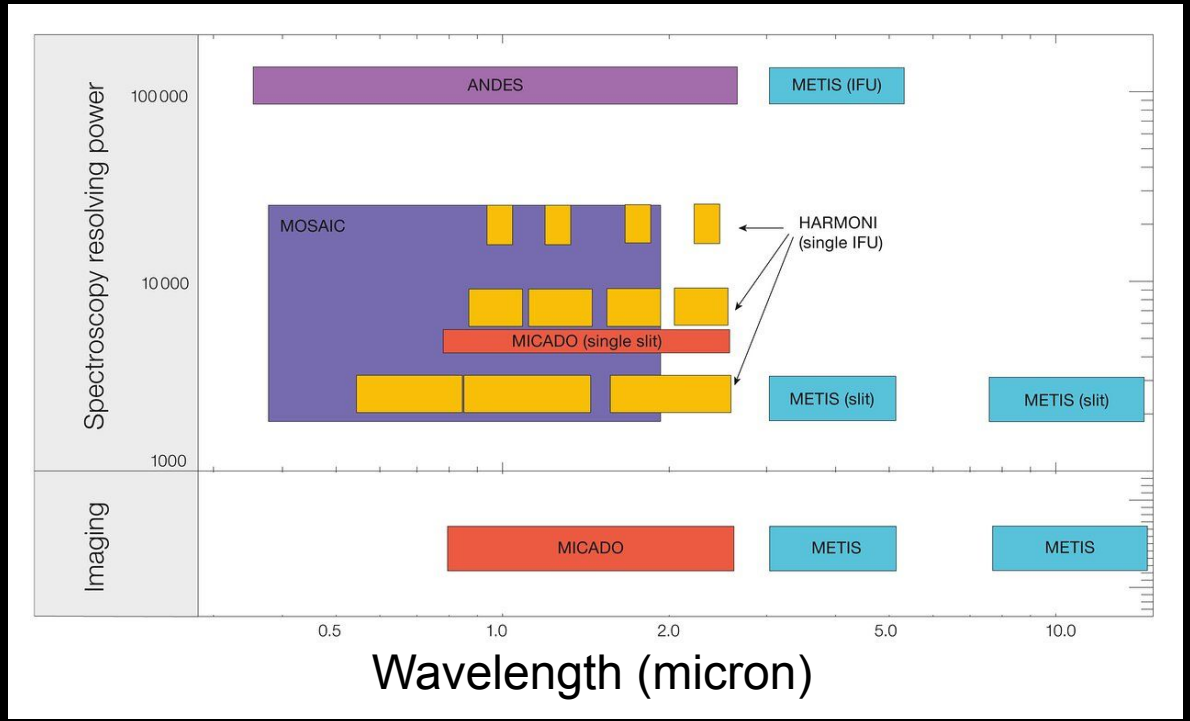
Sensitivity/limiting mag (AB)



MOSAIC in the landscape of ELT instrumentation

- Unique in providing multiplex at moderate spectral resolution in the VIS+NIR
- Unique in providing a large patrol field for MOS observations
- MOSAIC is optimized to provide:
  -High survey speed
  -High surface brightness sensitivity for faint sources

Unique spectral coverage & spectral resolution



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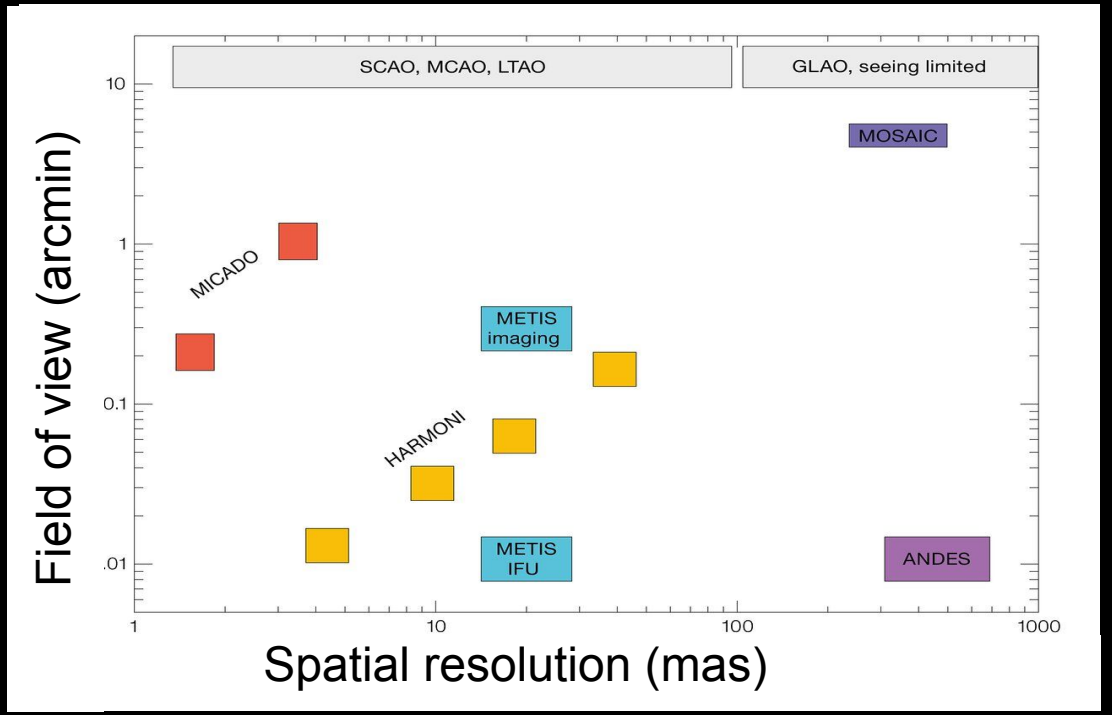
Unique field of view

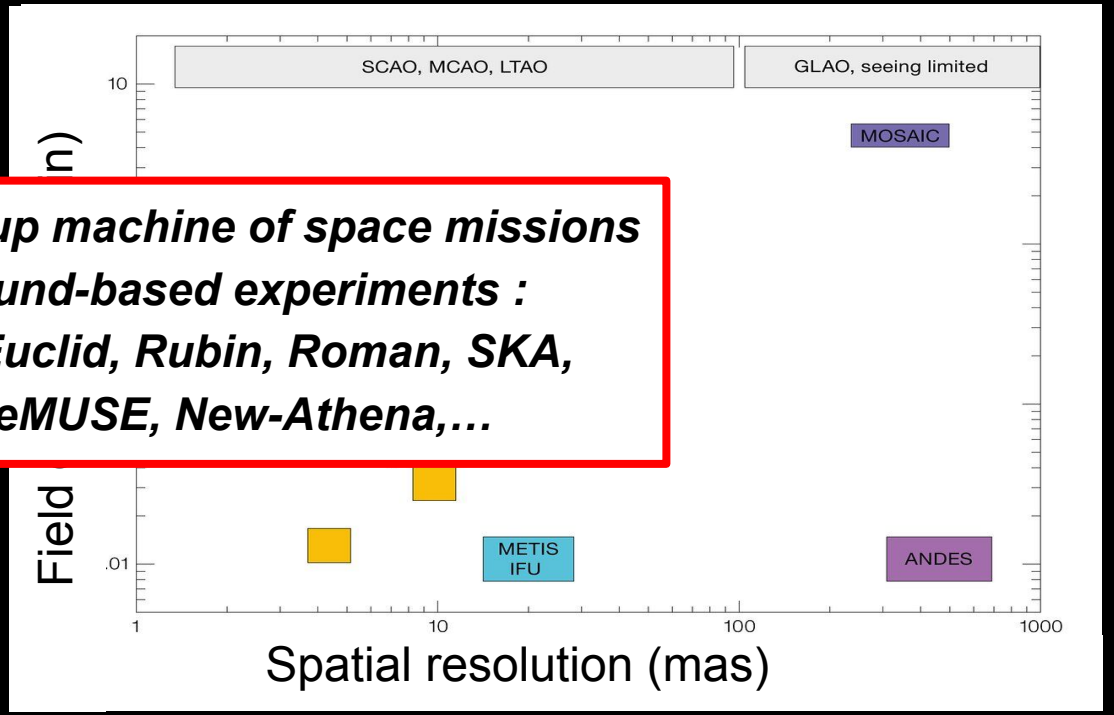


MOSAIC in the landscape of ELT instrumentation

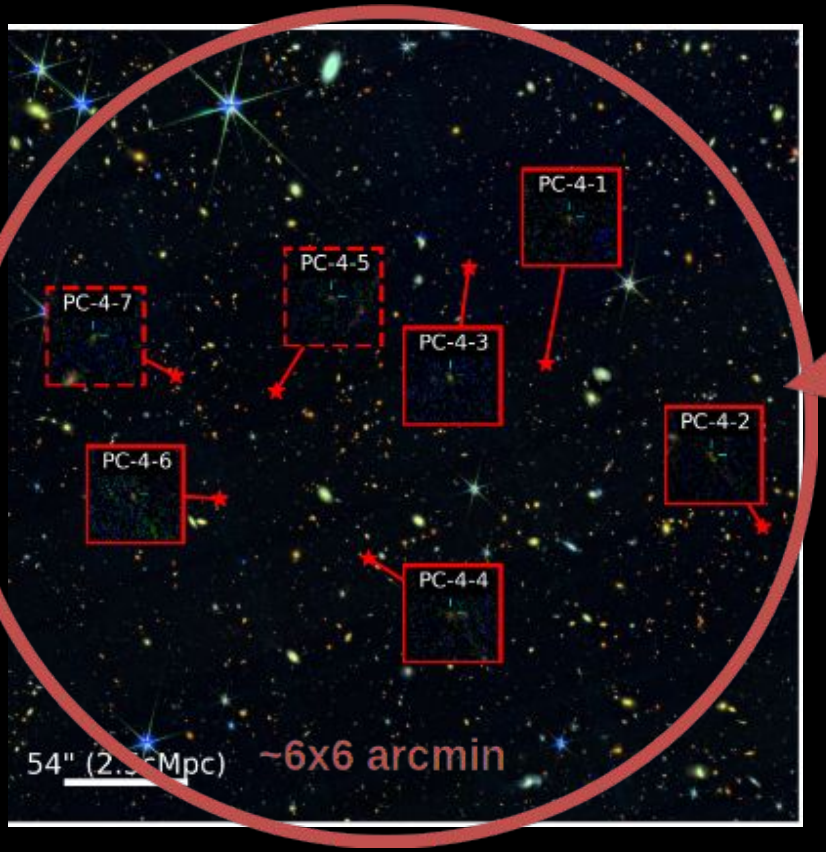
MOSAIC is the ELT Multi-Object Spectrograph

- Unique in providing multiplex at moderate spectral resolution in the VIS+NI
- Unique in providing a lar patrol field for MOS observations
- MOSAIC is optimized to provide:
  -High survey speed
  -High surface brightness sensitivity for faint sources

Follow-up machine of space missions and ground-based experiments : JWST, Euclid, Rubin, Roman, SKA, VLT/BlueMUSE, New-Athena,…



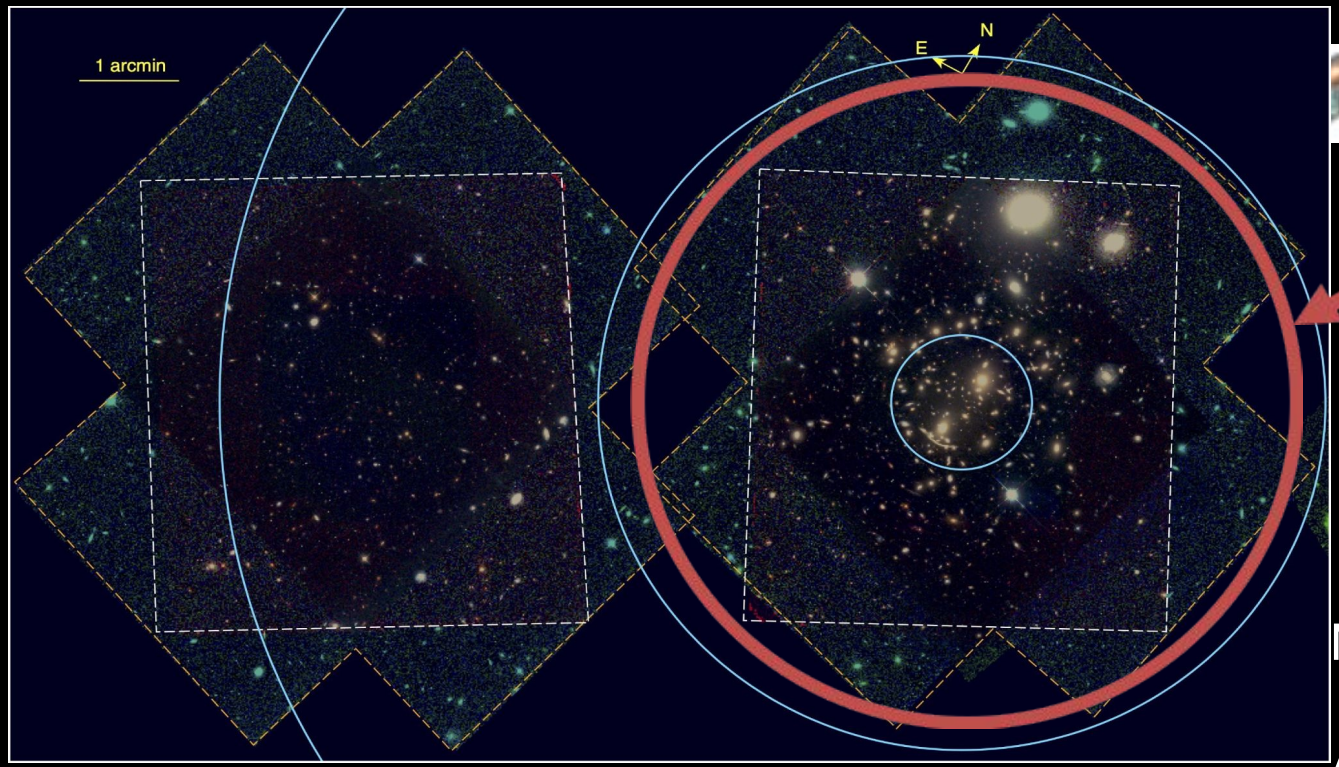
MOSAIC a unique field of view



MOSAIC

Wu+2025
Proto-cluster candidates at z~9
in the JWST COSMOS-Web field

MOSAIC a unique field of view



MOSAIC

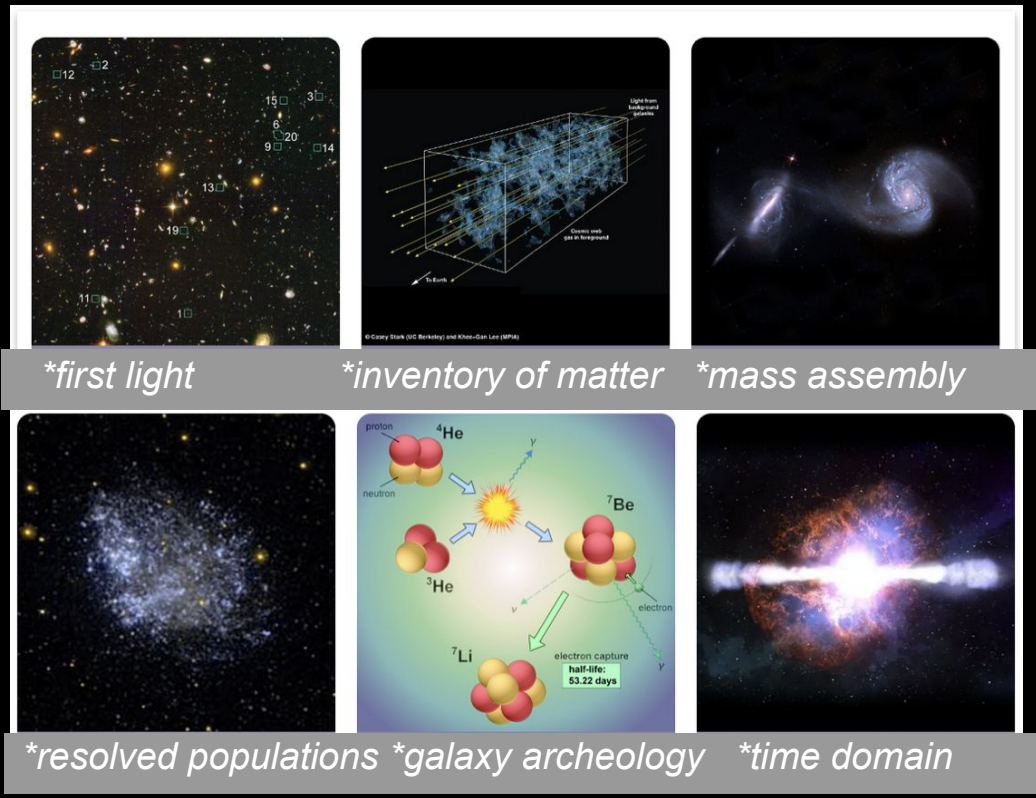
Niemiec+2023

A370 - BUFFALO

Science cases and working groups

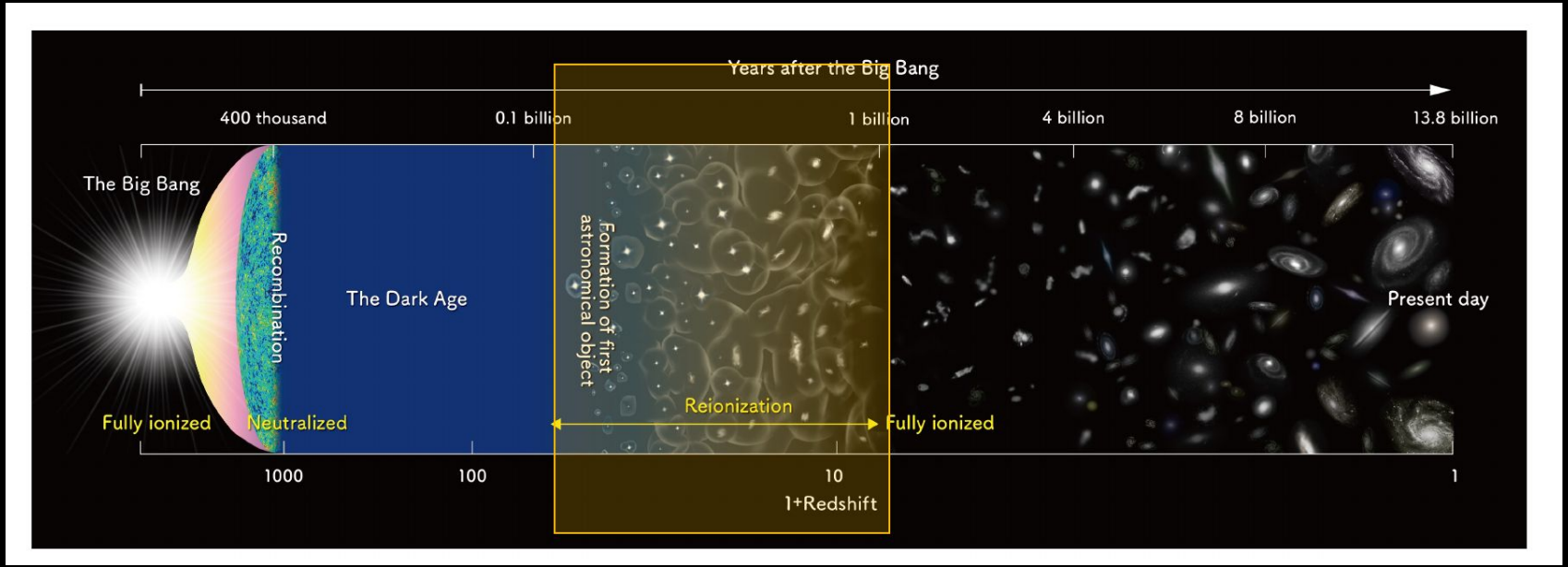
- **SWG1: First light galaxies and reionization – 105 members**
  - ***Coordinators**: Hayes, Kehrig, Laporte*
- **SWG2: Inventory of matter – *64 members***
  - ***Coordinators**: Johnson, Krajnovic, Pieri*
- **SWG3: Mass assembly of galaxies through cosmic time – *132 members***

  ***Coordinators**: Conselice, Dessauges-Zavadsky, Gonçalves*
- **SWG4/5: Stellar populations in and beyond the Milky Way – *106 members***
  - ***Coordinators**: Larsen, Pancino*
- **SWG6: Time Domain, Transients and multi-messengers – *25 members***
  - ***Coordinators**: Vergani, Porquet*



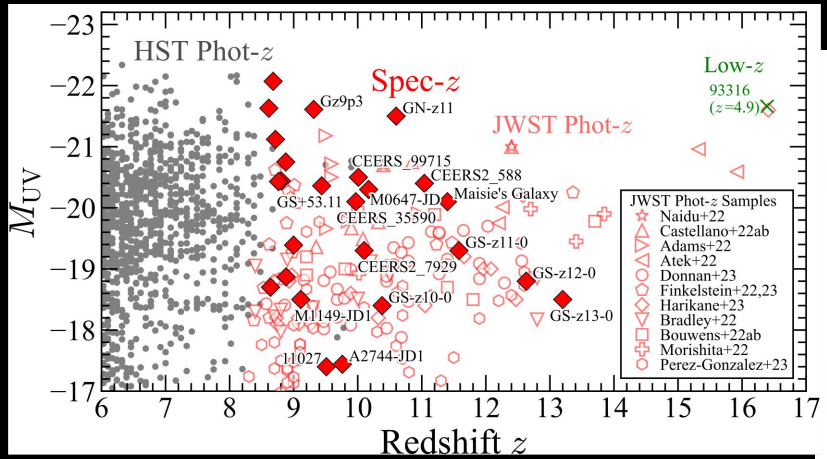
SWG4/5 see next talk by Elena Pancino

SWG1 - First-light galaxies at Epoch of Reionisation

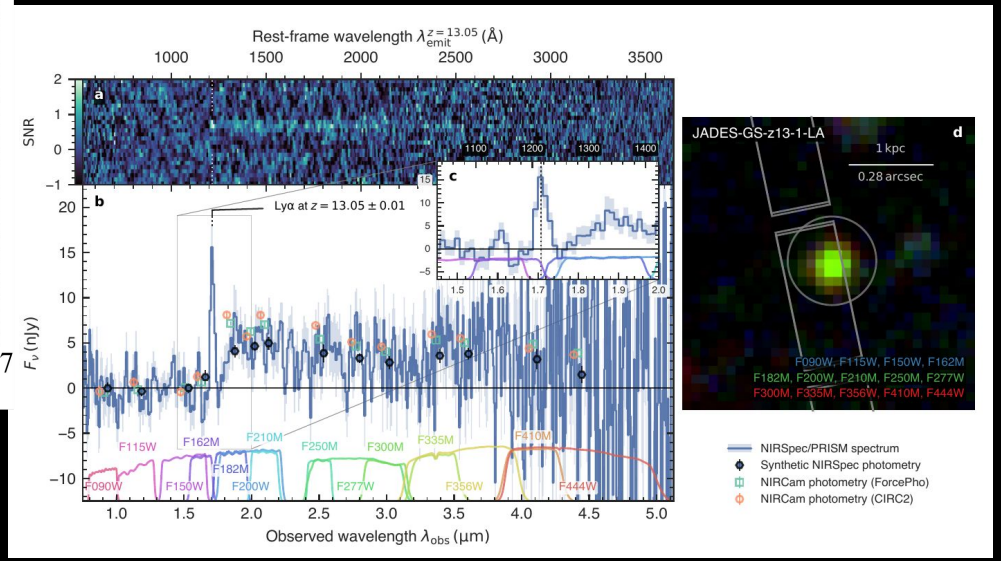


rf. talks by Samuel Gagnon-Hartman (galaxy -21cm cross correlation) and Lorenzo Napolitano (Lyα visibility) yesterday

What will be the role of MOSAIC after JWST has uncovered tens of high z galaxies, including Lyα emitters and AGN?

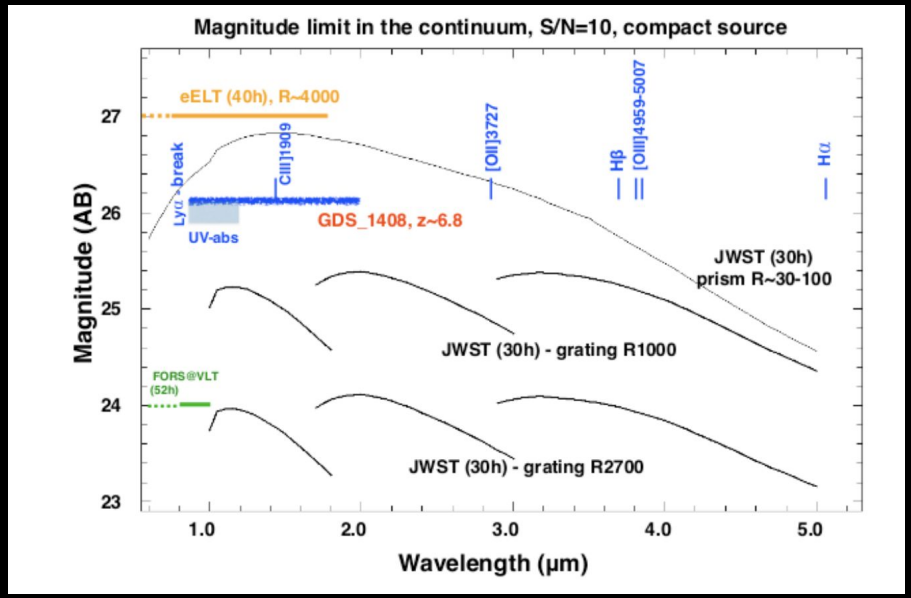


Roberts-Borsani+24, Adamo+24 etc

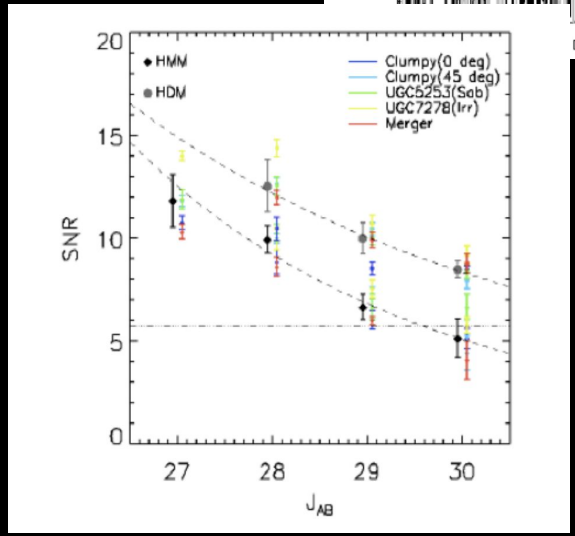


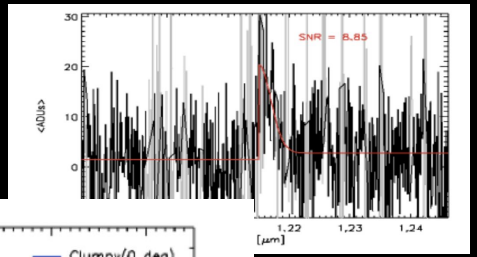
Witstok+25

FOV, sensitivity between skylines and spectral resolution!!



Expected magnitude limits in the continuum with 30 integrations for ELT-MOSAIC (orange) with R=4000 compared to JWST (black) for R=30, 1000,2700 (Puech+19)

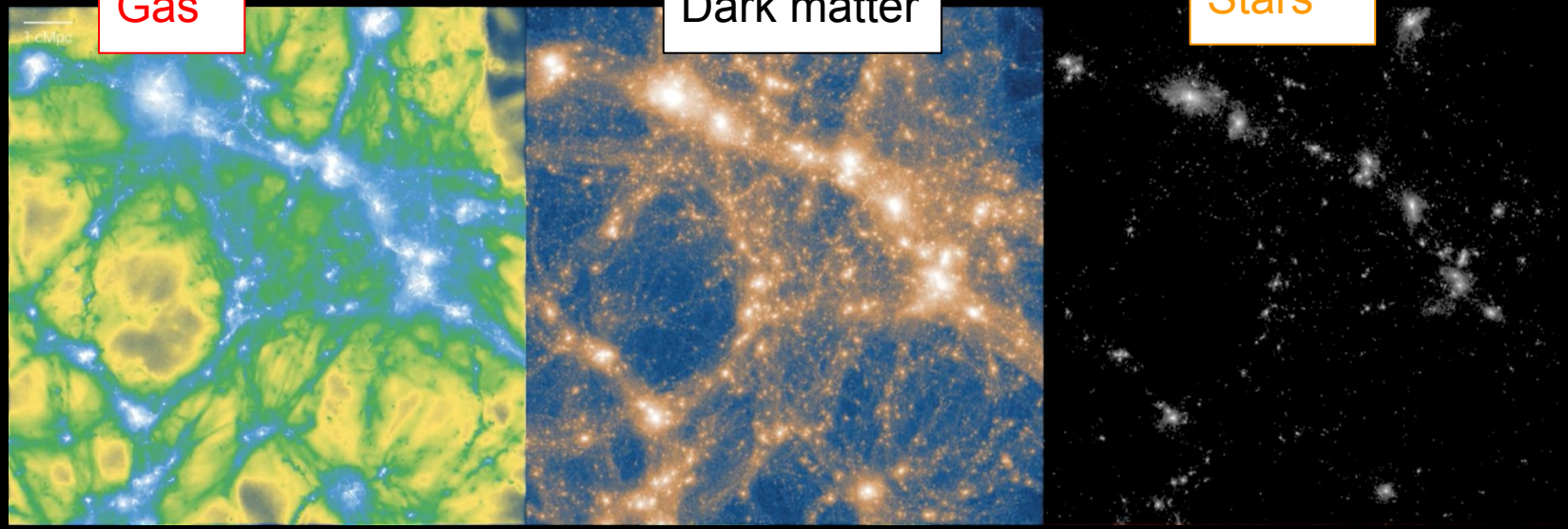




Disseau+

Expected S/N in the Lyα emission line at z=9 as a function of magnitude and morphology of the target

SWG2 - Inventory of Matter

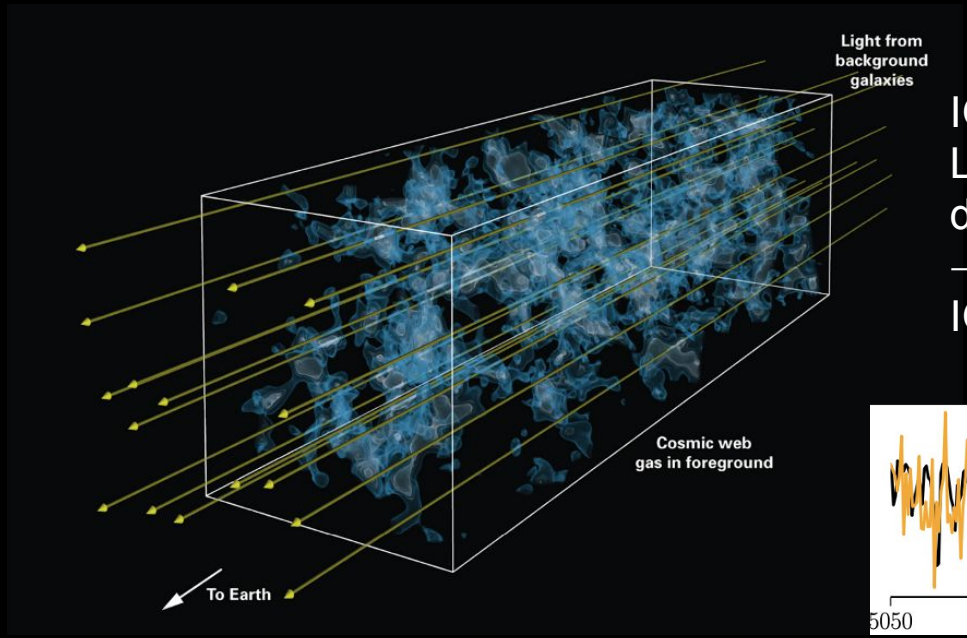


What is the baryon budget of the CGM over time ? How do galaxies accrete and expel their gas as a function of environment?

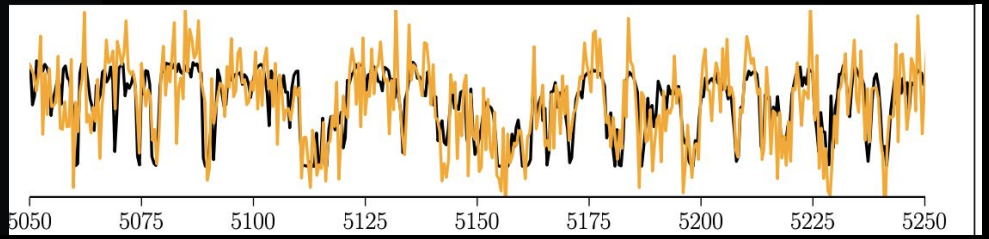
What is the Dark Matter content of high redshift galaxies ?
Fraction of DM, cores vs. cusp

What is the interplay between galaxies and the intergalactic medium: how do galaxies assemble their mass ? What is the extent and distribution of resulting feedback effects?

MOSAIC will enable mapping of the cold gas distribution in the IGM at z >3 on ~Mpc scales + Metals in the CGM

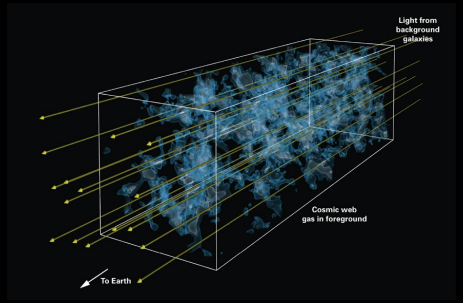


IGM tomography will be performed using LBGs a z>3 as background sources (as done now on the sparse QSO populations) → → an accurate 3D reconstruction of the IGM will be possible

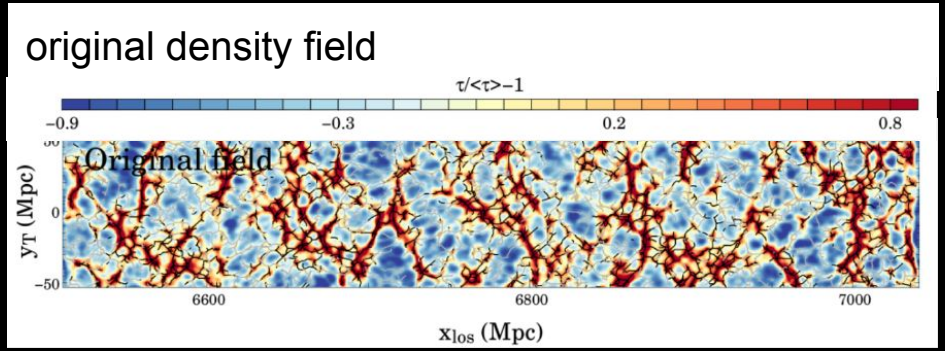


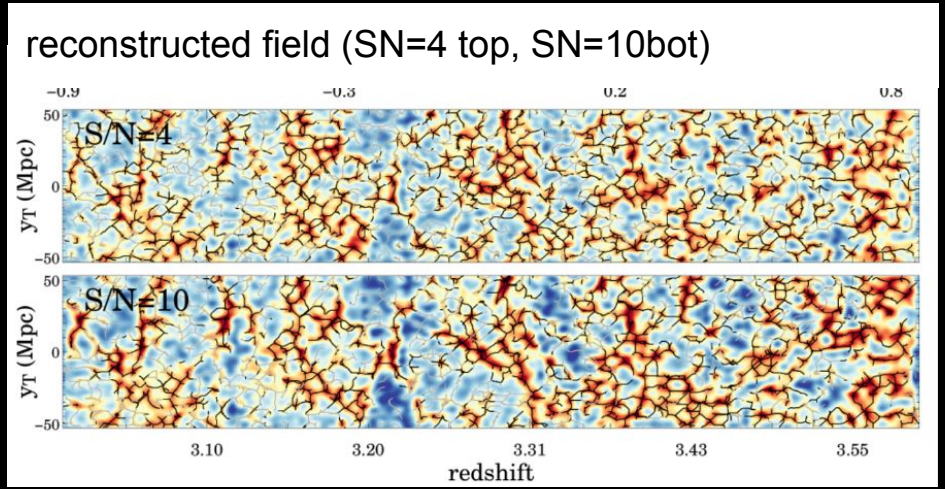
simulated portion of Lyα forest in a z=3.6 LBG with m=25 observed for 1.5 hours wth R=5000

MOSAIC will enable mapping of the cold gas distribution in the IGM at z >3 on ~Mpc scales + Metals in the CGM



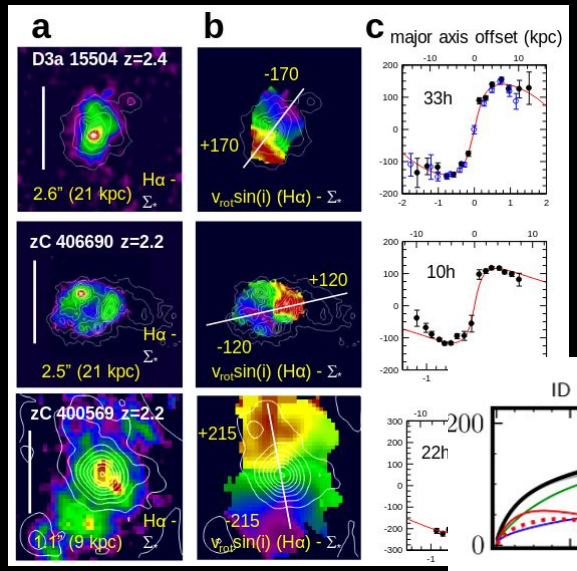
IGM tomographic reconstruction tested on simulated MOSAIC data using the Horizon-AGN simulation. The original (bottom) and reconstructed fields (top and middle).
(Japelj+19)



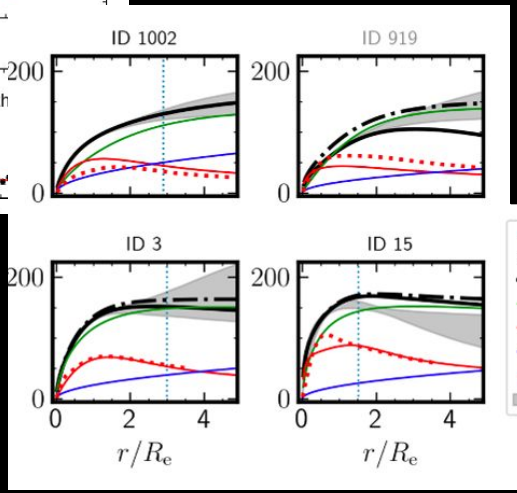


Rotation curves of distant galaxies and properties of dark matter

KMOS@SINFONI (Genzel+17)



MUSE (Bouche+22)



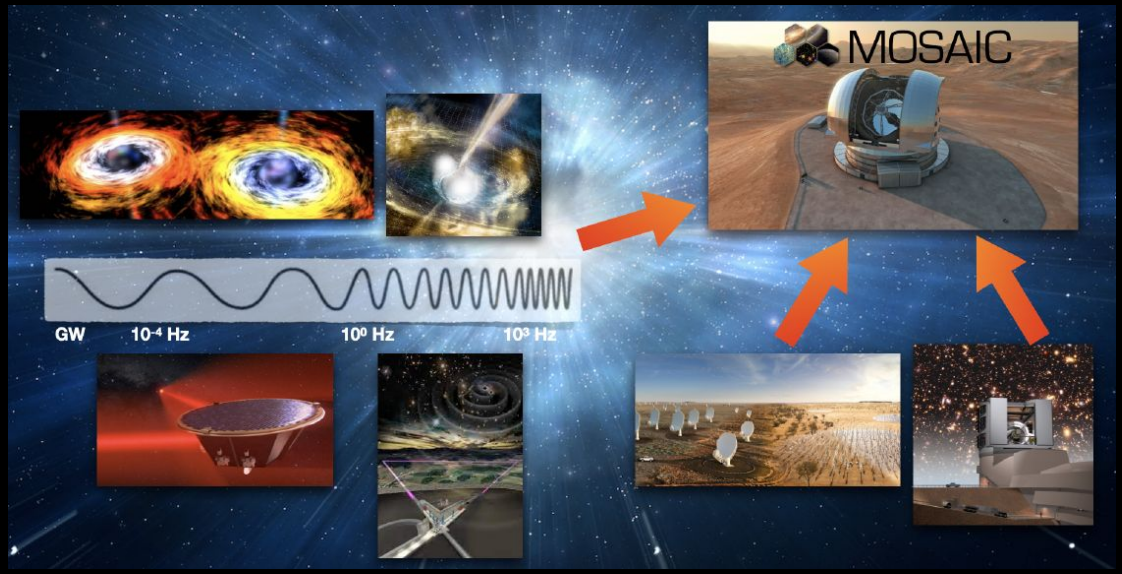
MOSAIC with mIFU can trace emission lines (OII, OIII) from ionized gas for galaxies out to very large radius

It will extended current studies to much earlier epoch (z=2-4)

Evolution of DM content as a function of redshift and mass

Evolution of stellar vs halo mass

SWG6 Time-domain, transients & multi-messenger



2030s will be a flourishing era for multimessenger astrophysics.

Gravitational wave interferometers will detect thousands of merging systems per year.

→ MOSAIC can provide EM counterpart detections beyond the local Universe

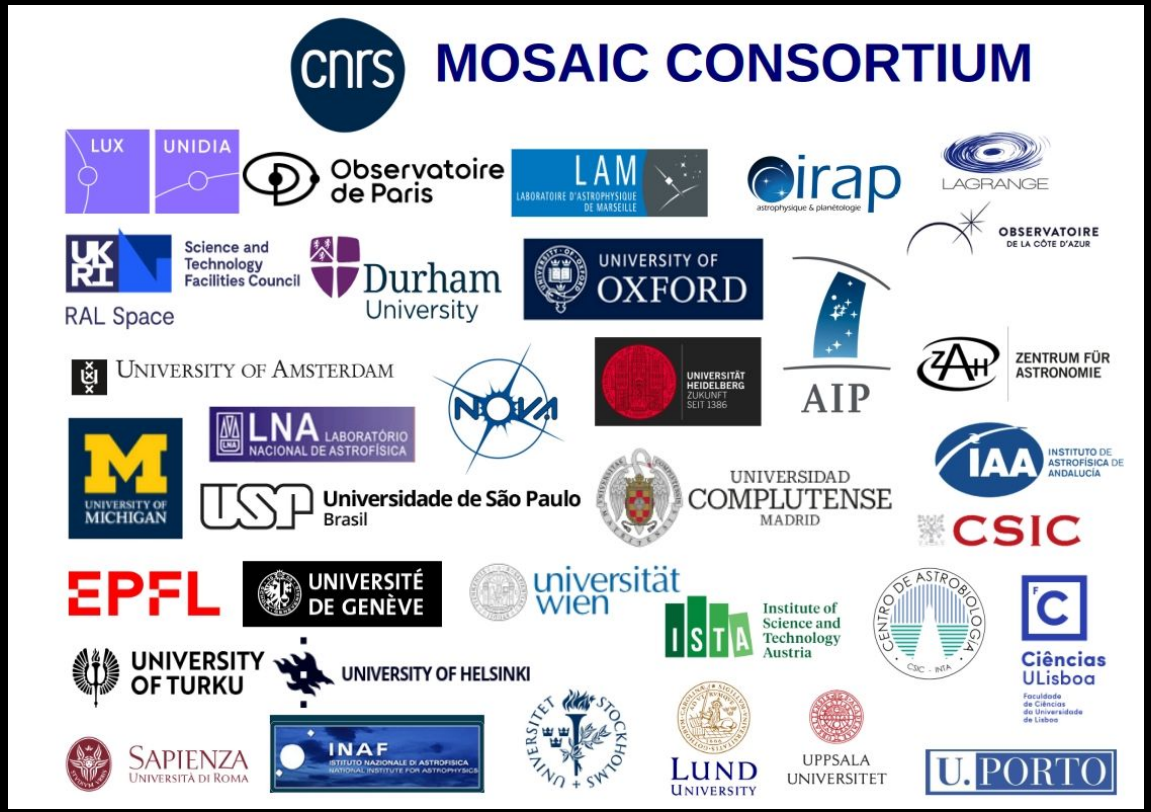
Large FoV, high multiplex & multi-IFU MOSAIC: Efficient follow-up of fields of faint transients detected in huge numbers by surveys (from optical to radio; e.g.: Vera Rubin Observatory and SKA). Spectroscopic characterizations (host galaxies & environment)

MOSAIC consortium

MOSAIC Consortium

- 25 Institutional Partners
- 33 Laboratories
- 14 countries
- ~350 members

The consortium is responsible for raising the funding needed for the complete construction and commissioning of the instrument



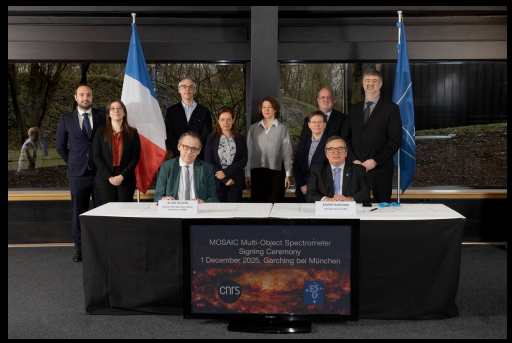
Project status

- **08/07/2025**: SAR (System Architecture Review). Official letter: SAR passed. MOSAIC has successfully completed the Phase B1

- **16-18/09/2025**: Phase B2 KOM & Progress Meeting #8 at LAM (Marseille). Starting the phase B2 (until the PDR)

- **27-29/10/2025**: Consortium Science Meeting in Amsterdam. ~60 people in person, ~20 people online. KOM for the Red Book

- **01/12/2025** ESO/MOSAIC signing ceremony ESO / CNRS (representing the MOSAIC Consortium) Official start of the Phase-B2



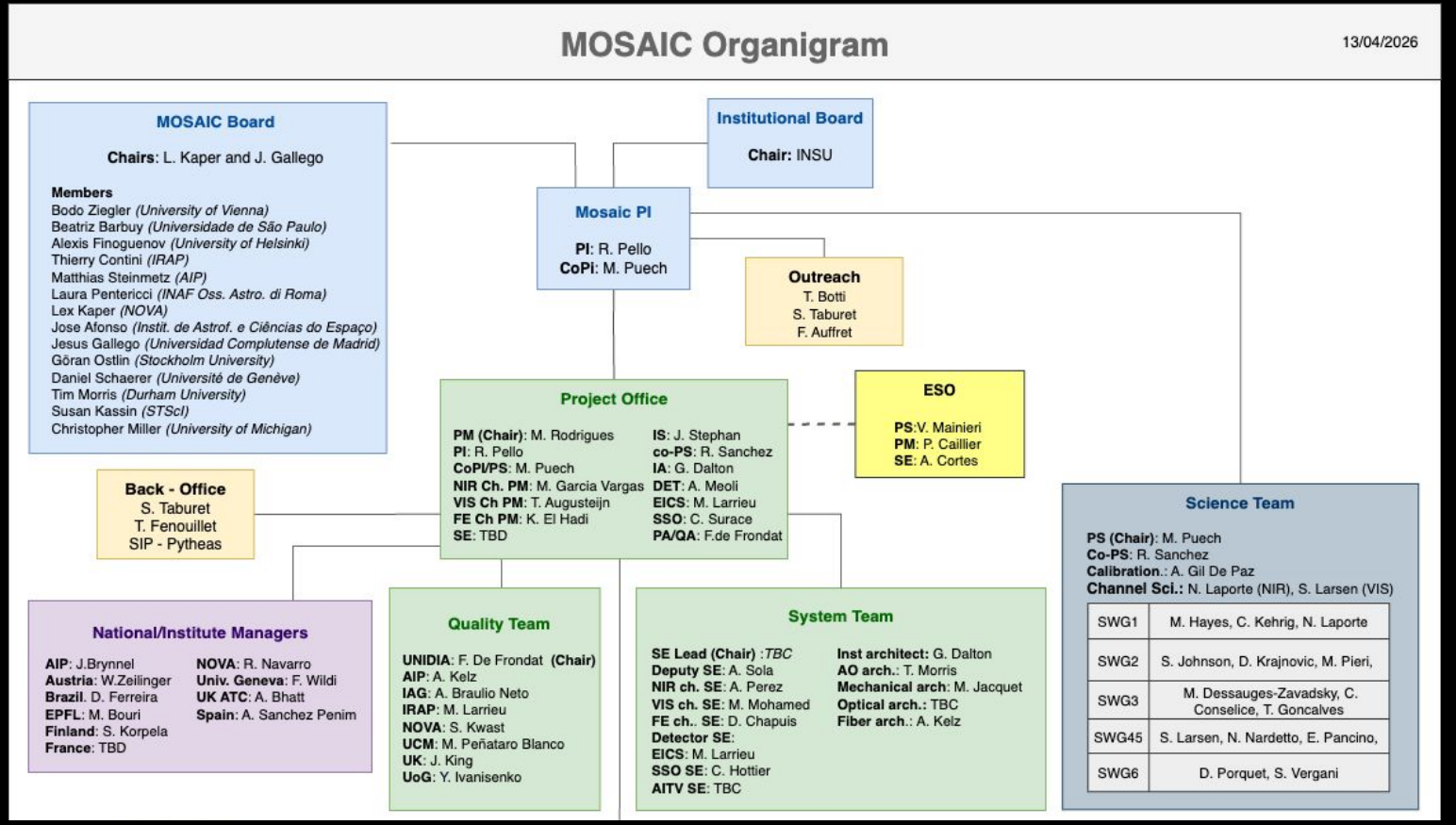
Contractual Key Milestones

Credit: Hermine Schnetler (Phase-B2 KOM)

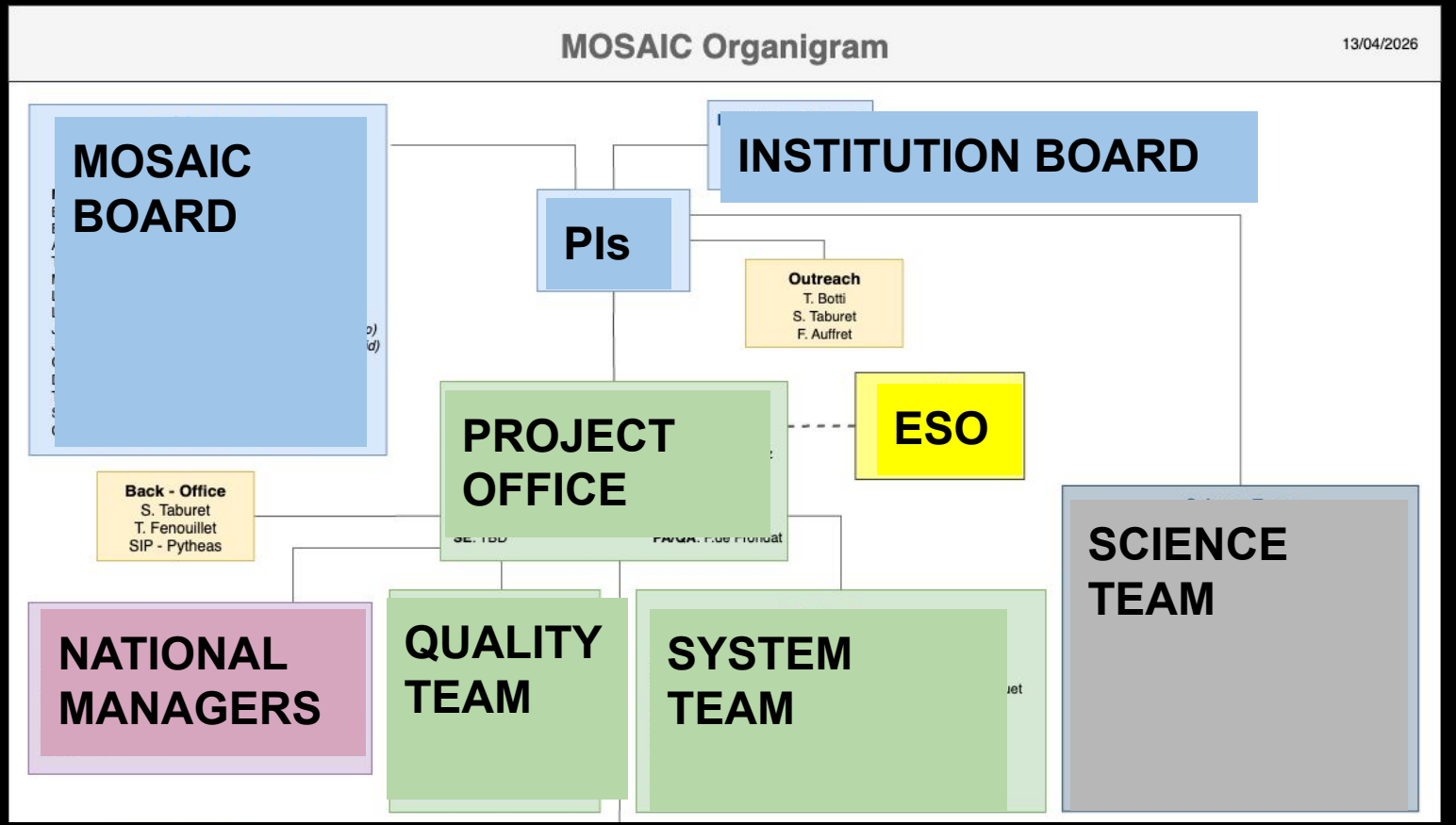
Dates reflects contractual dates as defined in ESO-349511MOSAIC SOW

** **Important note**:
If it is possible to conclude funding review (a) in time for the board meeting in December 2028, this date can accelerate the process

MOSAIC organization



MOSAIC organization



MOSAIC organization

italian contribution

Work Packages

Instrument Level

16	EICS
PM: M. Larrieu - IRAP SE: M. Dupieux - IRAP	
17	SSO
PM: C. Surace - LAM SE: C. Hottier - OP/UNIDIA	
19	Detectors
PM: D. Ives (TBC) SE: E. Georges	
18	AIT
PM: K. El Hadi - LAM SE: K. Dolhen - LAM	

Front End

21	Front End
PM: K. El Hadi - LAM SE: D. Chapuis - EPLF	
9	Focal Plane
PM: G. Dalton - UoO SE: I. Lewis - UoO	
10	ICOS
PM: D. Ferreira - LNA SE: B. Castilho - LNA	
11	Optical Relays
PM: N. Cvetojevic - Lagrange SE: J. Dejonghe - Lagrange	
20	Positioners
PM: M. Rombach - EPFL SE: M. Thurneysen - EPFL	
12	CALEMOS
PM: M. Garcia - UCM SE: A. Perez - UCM	
15	GLAO
PM: J. King - UoD SE: A. Bharmal/ R. Artan - AK ATC	

Vis Channel

22	VIS Channel
PM: T. Augusteijn - NOVA SE: M. Mohamed - NOVA	
4	Visible Spectrograph
PM: T. Augusteijn - NOVA SE: W. Seyfert - LWS	
6	Vis Fiber Link
PM: A. Kelz - AIP SE: A. Kelz - AIP	

NIR Channel

23	NIR Channel
PM: M. Garcia Vargas - UCM SE: A. Perez - UCM	
8	m-IFU Fiber Link
PM: P. Laporte - OP/UNIDIA SE: I. Guinouard - OP/UNIDIA	
7	NIR Fiber Link
PM: Y. Ivanisenko - UoG SE: A. Lanotte - UoG	
5	NIR Spectrograph
PM: M. Garcia - UCM SE: A. Perez - UCM	

MOSAIC italian role

Italy is entering the consortium with a 1M entry ticket +FTE

All members of the consortium will have access to the >200 nights of GTO time - the nights will be shared within the collaboration in the form of surveys

Surveys will be planned and managed by the science team lead by the SPB- Survey and Publication Board (Italy will have one member)

MOSAIC italian role

Current Italian involvement

Scientific involvement:

More than 50 people (mostly INAF)

43 are members of the MOSAIC science WGs (*all SWGs are covered except transients*)

- Elena Pancino leads the SWG4/5 **SEE NEXT TALK**

Technical involvement

** MOSAIC instrument control software OATo group lead by Sebastiano Ligori **SEE NEXT TALK**

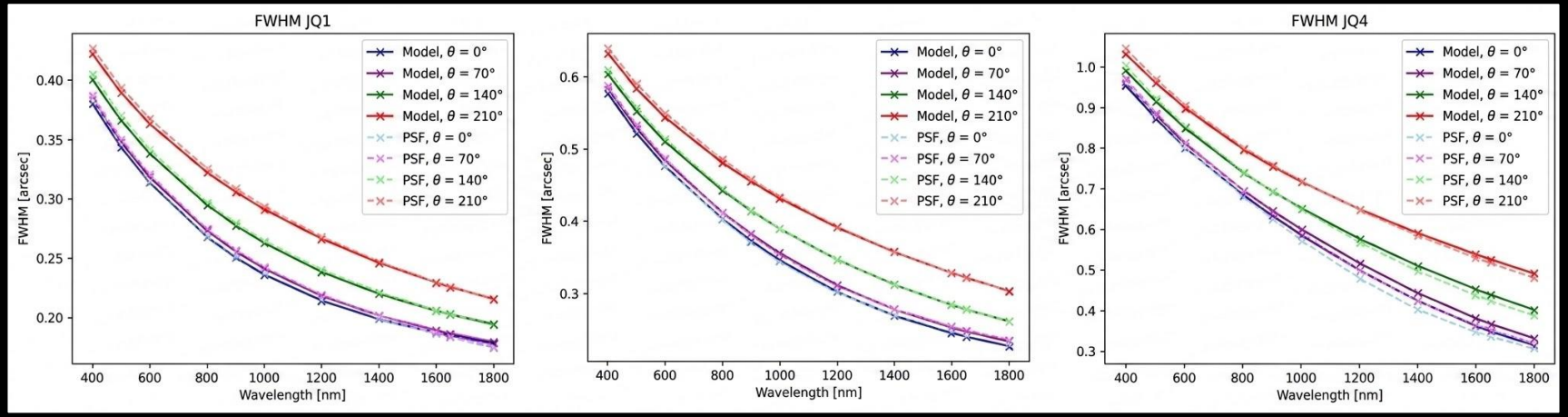
** end-to-end simulations Gianluca LiCausi (OAR)

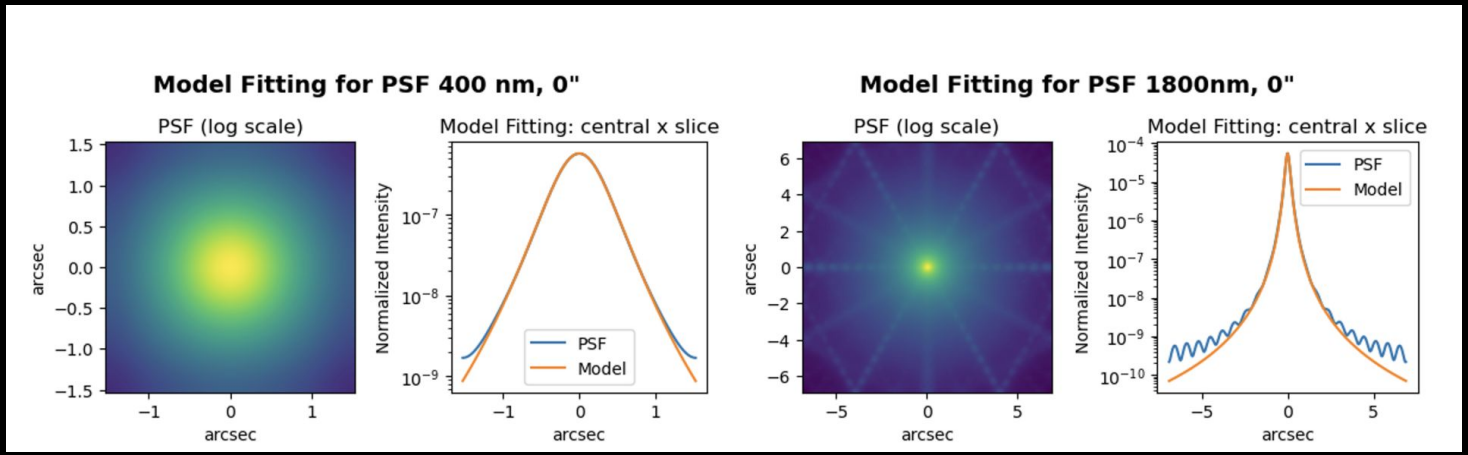
**two distinct subsystems within the Science Software (SSO) 1. Observation Preparation Software (ObsPrep) (Adriana Gargiulo-IASF) 2. GTO Scheduler (Paolo Franzetti IASF)

Summary and take home messages

- MOSAIC will be a highly versatile instrument, featuring high multiplexing capability, broad wavelength coverage, and multiple observing modes.
- It will be the only ELT instrument providing such a large field of view, enabling unique survey and follow-up opportunities.
- Although technically complex, MOSAIC is based on well-established and proven concepts, making it a relatively low-risk instrument
- MOSAIC will serve as a key follow-up facility for major space missions and ground-based observatories, including JWST, Euclid, LSST, Roman, SKA
- The Italian community has a long-standing tradition and strong expertise in multi-object spectroscopy, with major contributions to instruments such as VIMOS, FORS, MODS, and NIRSpec, and is therefore deeply involved in the MOSAIC project.

Observations - GLAO





Observations - GLAO

MOSAIC can observe practically all areas of key cosmological fields when GLAO uses NGS down to 19.5 Rmag.