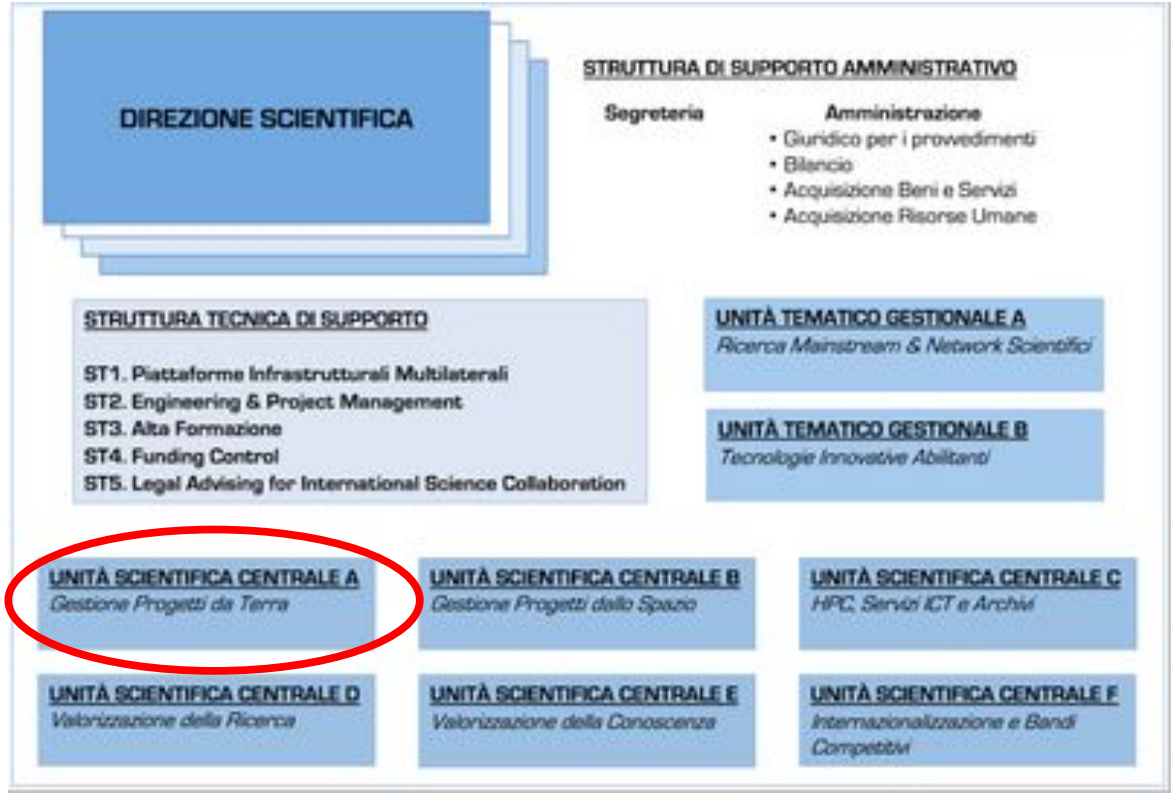
Progetti da terra: prospettive per le tematiche scientifiche di RSN1

Marcella Marconi (INAF-OACn)
INAF USC-A, ESO SSC

USC A


DIREZIONE SCIENTIFICA
STRUTTURA DI SUPPORTO AMMINISTRATIVO
Segreteria
Amministrazione
• Giuridico per i provvedimenti
• Bilancio
• Acquisizione Beni e Servizi
• Acquisizione Risorse Umane
STRUTTURA TECNICA DI SUPPORTO
ST1. Piattaforme Infrastrutturali Multilaterali
ST2. Engineering & Project Management
ST3. Alta Formazione
ST4. Funding Control
ST5. Legal Advising for International Science Collaboration
UNITÀ TEMATICO GESTIONALE A
Ricerca Mainstream & Network Scientifici
UNITÀ TEMATICO GESTIONALE B
Tecnologie Innovative Abilitanti
UNITÀ SCIENTIFICA CENTRALE A
Gestione Progetti da Terra
UNITÀ SCIENTIFICA CENTRALE B
Gestione Progetti dallo Spazio
UNITÀ SCIENTIFICA CENTRALE C
HPC, Servizi ICT e Archivi
UNITÀ SCIENTIFICA CENTRALE D
Valorizzazione della Ricerca
UNITÀ SCIENTIFICA CENTRALE E
Valorizzazione della Conoscenza
UNITÀ SCIENTIFICA CENTRALE F
Internazionalizzazione e Bandi Competitivi

USC A projects

- “Opt-NIR”

ADONI, ANDES, CUBES, ERIS, ESPRESSO, LBTITA, LOCNES, LSST, MASTER, MAVIS, MICADO, MOONS, MORFEO, MOSAIC, NIRVANA, PCS R&D Roadmap, SAXO+, SHARK-NIR, SHARK-VIS, SOXS, TETIS, TNG, VST, WEAVE.

- Radio
  (SRT, LOFAR, MEERKAT, SKA, VLBI)

-Nodo italiano dell’ALMA Regional Centre europeo.

- Other ground-based projects (TBD)

Activities

Monitoring and collection inputs/requests from PIs and new appointments.

Steering Committee (e.g. ANDES e MAVIS) and Institutional Board (e.g. MOSAIC) meetings; MoU (e.g. SAXO+, PCS R&D Roadmap) and Consortium Agreements (e.g. ANDES) revision activities.

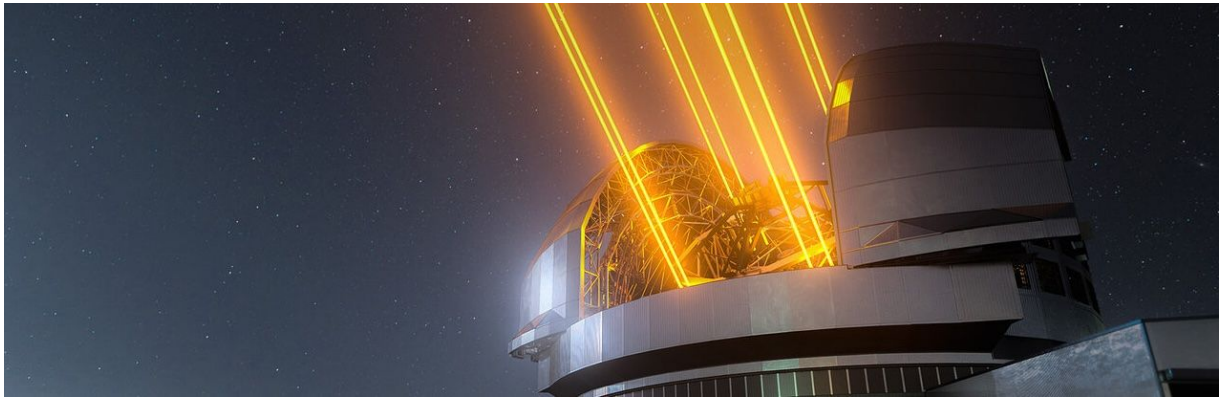
In-person attendance at meetings/events (e.g. MAVIS MATI workshop in Padova, May 24-28 2025, Rubin-LSST day in Palermo - June 23, meeting with the Australian Ambassador in Montemario for MAVIS - December 11)

Operational meetings and visits (e.g. ANDES PO on July 3 2025, the meeting on italian ground-based facilities on September 9 2025, tour of INAF structures with ground-based instrumentation with the UTG B, from December 2025)

Events in 2026

- **Rubin-LSST Italia Day, January 20** (*https://indico.ict.inaf.it/event/3418/*)

- **Meeting della strumentazione ELT a guida italiana, May 12-15** (*https://indico.ict.inaf.it/event/3450/overview*) to be held in Capodimonte (Auditorium Nazionale “Ernesto Capocci”)



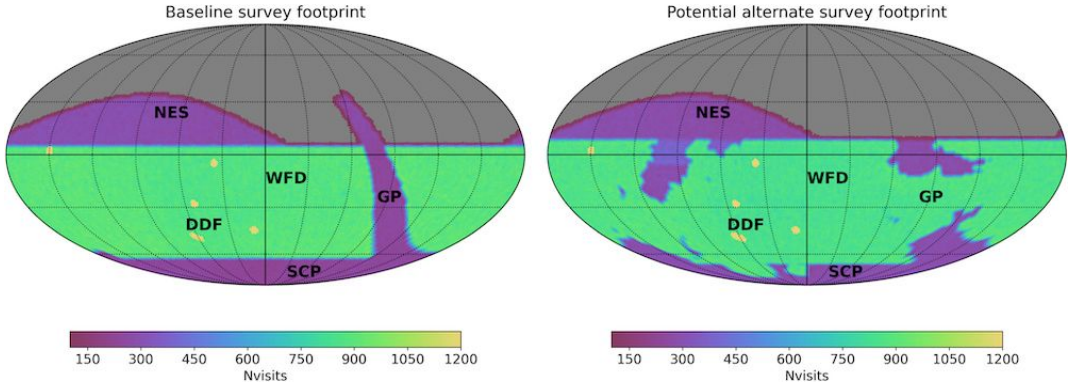
Abstract submission: March 31

Registration: April 24

The future of ground based instrumentation and facilities: perspectives for RSN1 studies

Next decade ground-based scientific landscape

- **Southern optical sky sampled to 27 mag and millions of transients with hourly to yearly variability observed by Rubin/LSST**



The **Vera Rubin Observatory,** thanks to the telescope size and speed and to the camera sensitivity, was specifically designed to help **answer key questions** concerning **time-domain**, **Solar System**, **MW**, **cosmology**

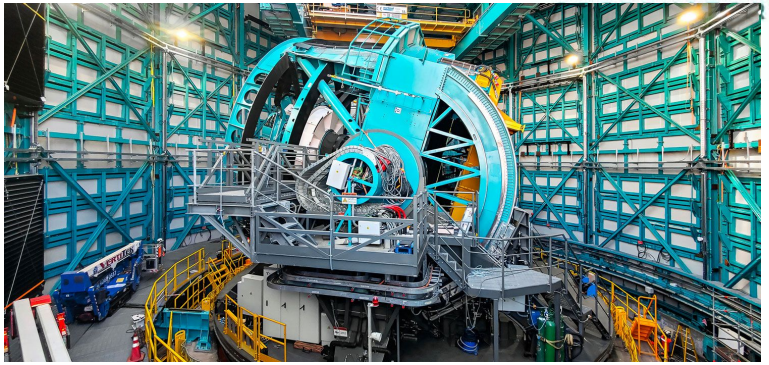
Vera Rubin Telescope

Primary mirror diameter : 8.4 m
Field of View : 9.6 square degrees
Focal plane : 189 4kx4k science CCD chips, 0.2 arcsec/pixel
Survey duration : 10 years
Number of visits: ~2.1 million

Nightly data size: 20 TB/night
Final database size (DR11) : 15 PB
Number of objects (full survey, DR11): 20B galaxies 17B resolved stars 6M orbits of solar system bodies

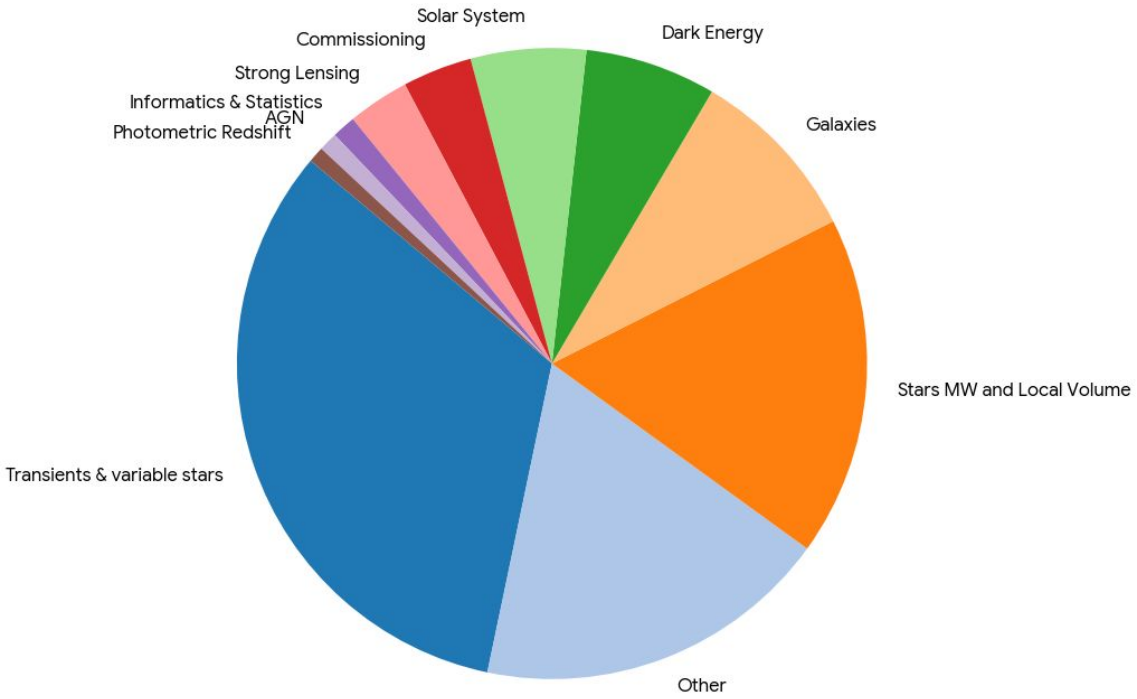
six filters: u g r i z y

Southern optical sky sampled to 27 mag

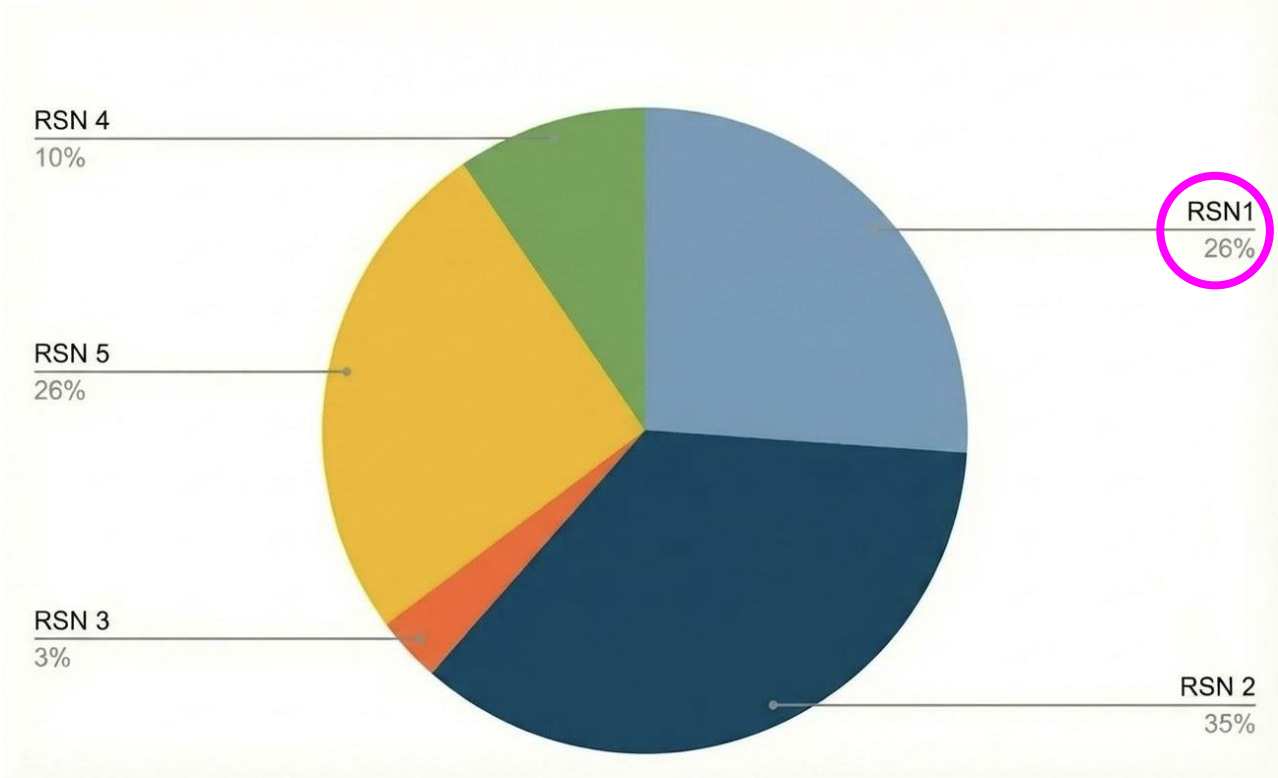


The italian participation

Almost 200 Italian scientists interested. In-kind contribution program led and funded by INAF



The RSN1 contribution



Credits. Claudia Raiteri (LSSTItaly day 2026)

Title: ***AGILE: and end-to-end Rubin-LSST simulation of AGN, galaxies and stars***
PI: Angela Bongiorno

Title: ***Directable SW contribution for the Galaxies SC: Tools for the measurement of surface brightness fluctuations on LSST data***
PI: Michele Cantiello

Title: ***Structural parameters with machine learning***
PI: Crescenzo Tortora, Nicola R. Napolitano

Title: ***Tools for the simulations, detection, and characterization of galaxy clusters***
PI: Alex Saro

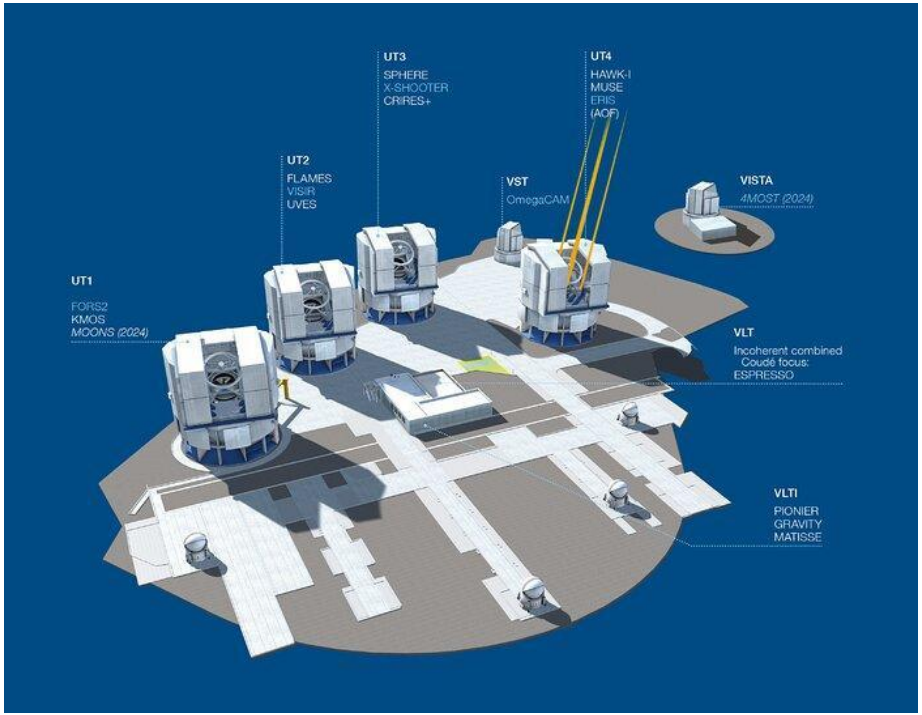
Title: ***A Cluster Spectroscopy Hub for galaxy cluster science with Rubin/LSST***
PI: Piero Rosati

Title: ***Exploiting the synergy between LSST and VST to investigate the cosmos: the expansion rate and the geometry o the Universe measured through the time delays of strongly lensed variable sources***
PI: Claudio Grillo

Title: TIMEDOMES - ***Toward next generation time-domain surveys***
PI: Maurizio Paolillo

Next decade ground-based scientific landscape

The VLT system will enter in its fourth decade.

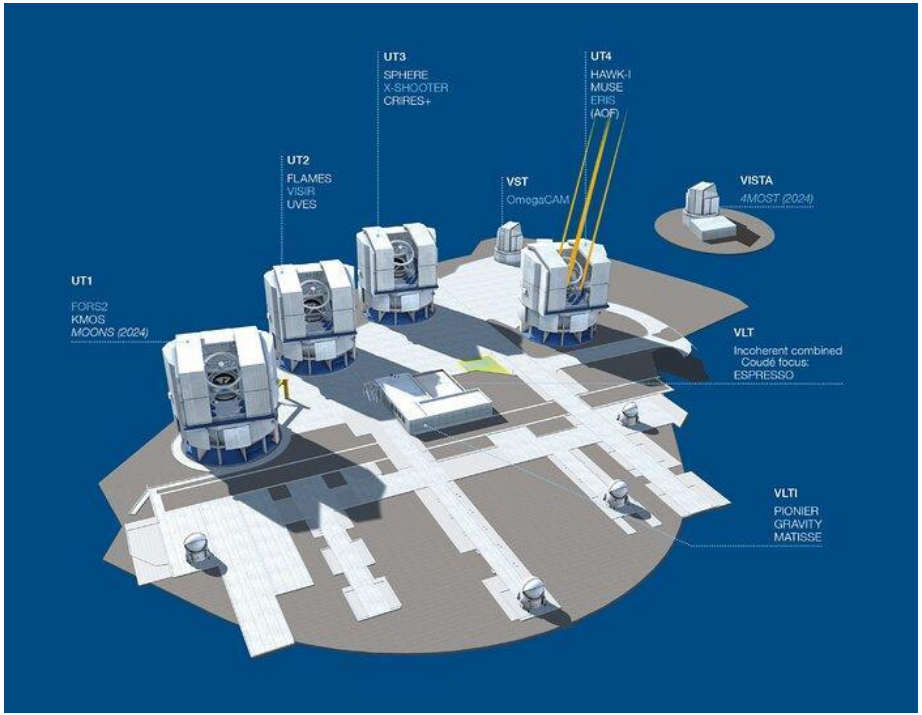


Next decade ground-based scientific landscape

The VLT system will enter in its fourth decade.

Ongoing Developments

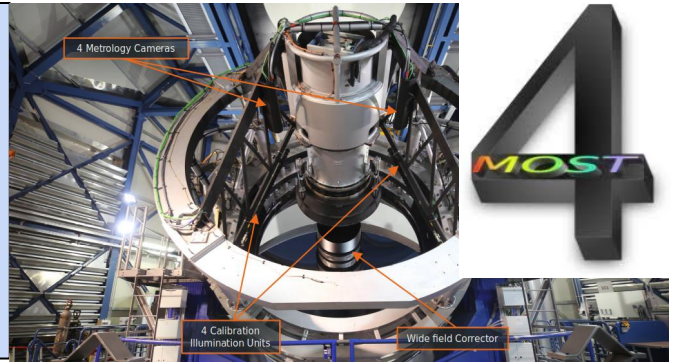
- 4MOST @ VISTA



Next decade ground-based scientific landscape

4-metre Multi-Object Spectroscopic Telescope (4MOST@VISTA)

- **2400-object fibre-fed multi-object** spectrograph.
- foreseen to cover in a **5-year survey** most of the Southern sky 2-3 times → more than 20 million spectra.
- **Extragalactic surveys** (both consortium and community) have been planned in the 4MOST Survey Program.



Next decade ground-based scientific landscape

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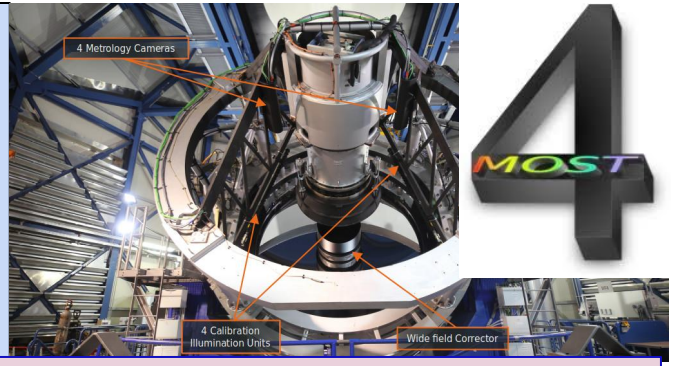


Among 4MOST scientific cases:

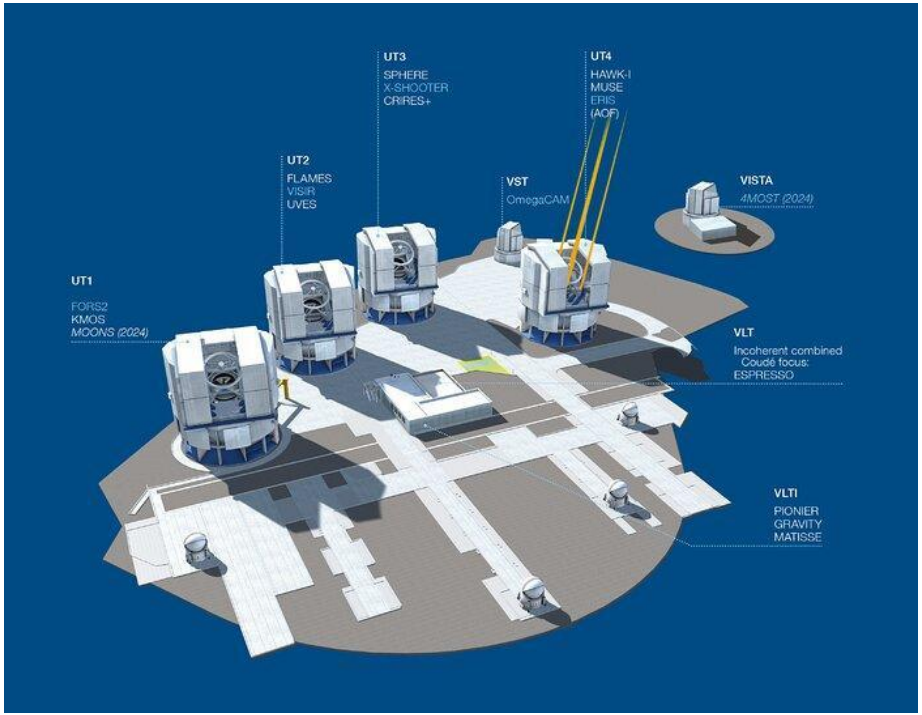
- Test the nature of **Dark Energy** and gravity on the largest scales.
- Create the largest census of **supermassive black hole growth** in the universe.
- Weigh **dark matter halos** by observing how galaxies cluster together.
- Determine **how environment (clusters vs. voids) shuts down star formation**.
- Observe transients to perform **time-domain cosmology**

Next decade ground-based scientific landscape

The VLT system will enter in its fourth decade.

Ongoing Developments

- 4MOST @ VISTA
- GRAVITY+ @ VLTI



Next decade ground-based scientific landscape

Gravity+

GRAVITY+, first suggested to the ESO community at the VLT2030 conference in 2019 and recommended by ESO's Scientific Technical Committee in 2020, is an **upgrade to VLTI and its GRAVITY instrument.**

→ **imaging of fainter and more remote astronomical objects**

→ **improving the high contrast precision on bright objects.**

Next decade ground-based scientific landscape

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→ **imaging of fainter and more remote astronomical objects**

→ **improving the high contrast precision on bright objects.**

Among Gravity+ scientific goals:

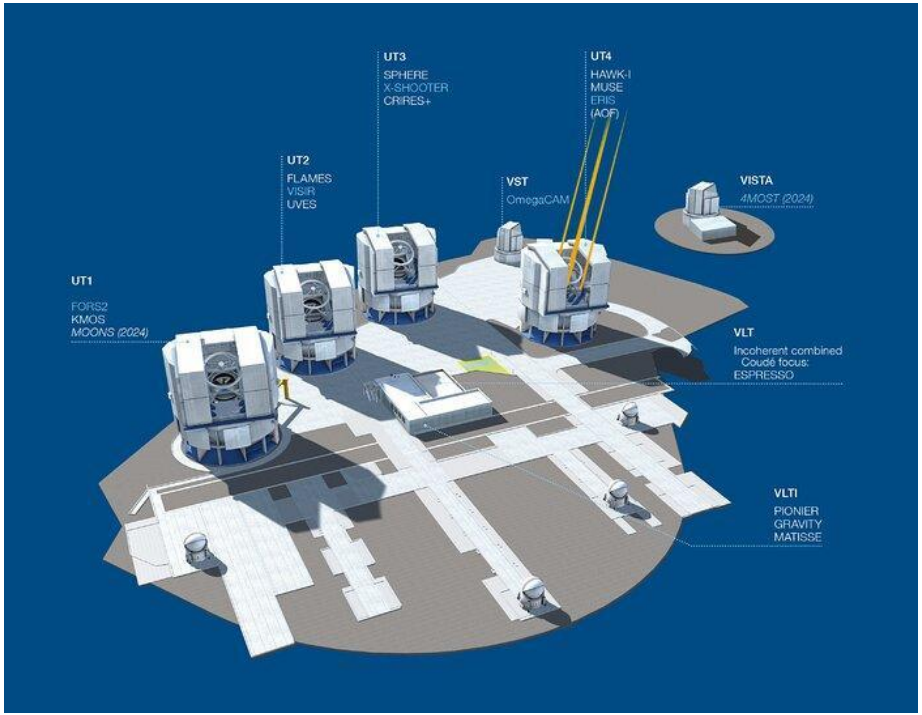
1. Direct Measurement of **SMBH Masses Across Cosmic Time**
2. Probing the **Unified Model of AGNs**
3. Exploring the **Early Universe and Faint Objects**
4. Search for **Intermediate-Mass Black Holes**

Next decade ground-based scientific landscape

The VLT system will enter in its fourth decade.

Next Development:

MOONS @ UT1



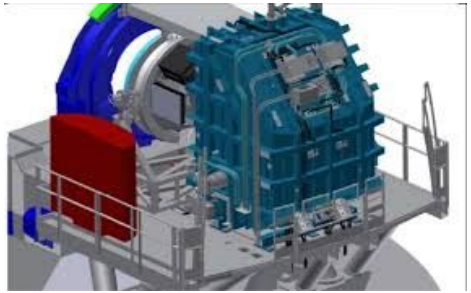
Next decade ground-based scientific landscape

MOONS

INAF involvement (E. Oliva et al.)

Multi Object Optical and Near-infrared Spectrograph for the VLT

It will have ~1000 fibers deployable over a field of view of ~500 square arcmin. The total wavelength coverage is from 0.6 micron to 1.8 micron, accessed in medium and high resolution modes.



Next decade ground-based scientific landscape

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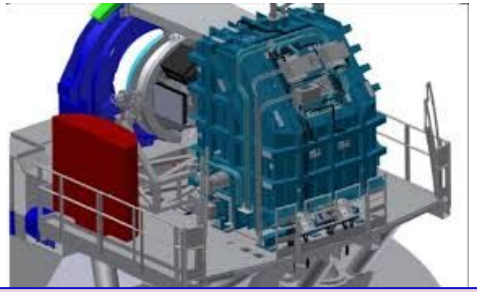


One of MOONS scientific goals is **to study galaxy formation and evolution over the last 12 billion years.**

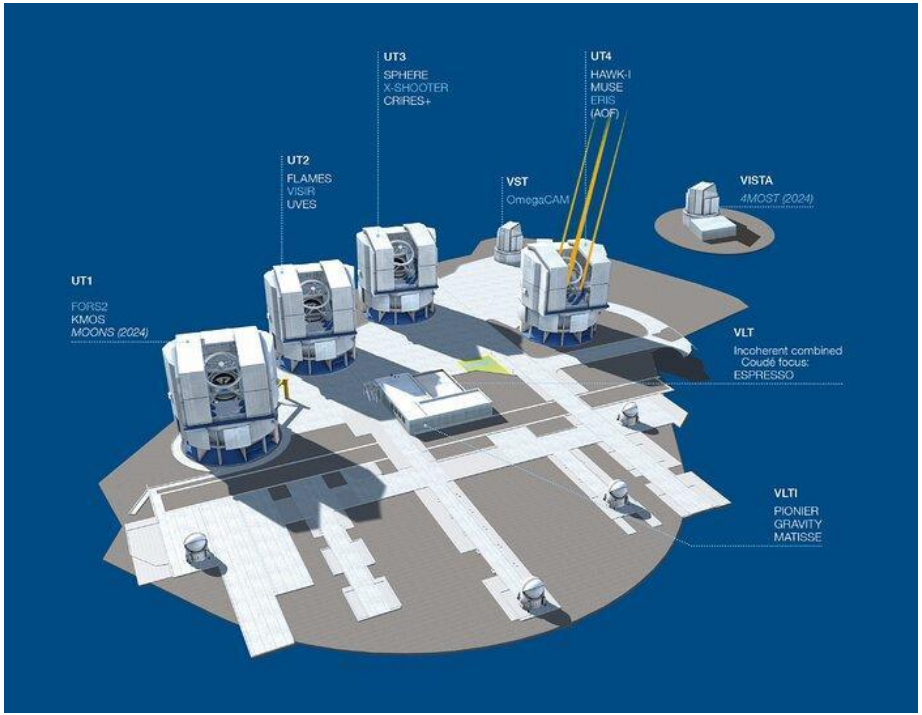
The primary extragalactic survey, **MOONRISE** (MOONS Redshift-Intensive Survey Experiment), is allocated 190 nights of Guaranteed Time Observation (GTO) to observe approximately half a million galaxies.

Next decade ground-based scientific landscape

The VLT system will enter in its fourth decade.

2029+:

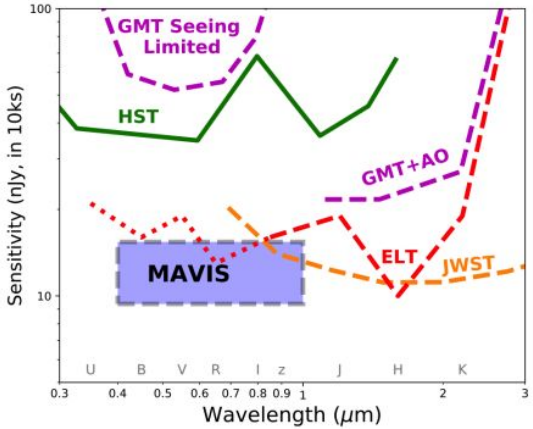
- MAVIS @ UT4
- CUBES @ UT2

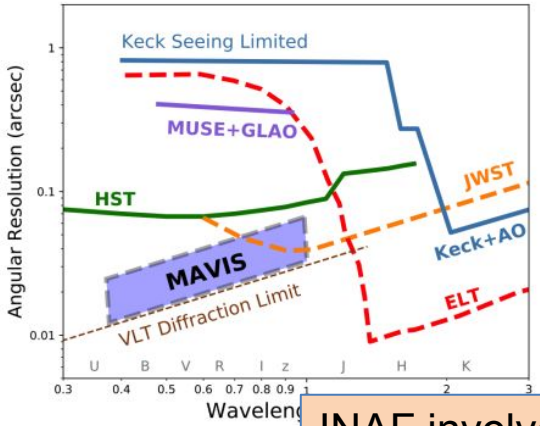


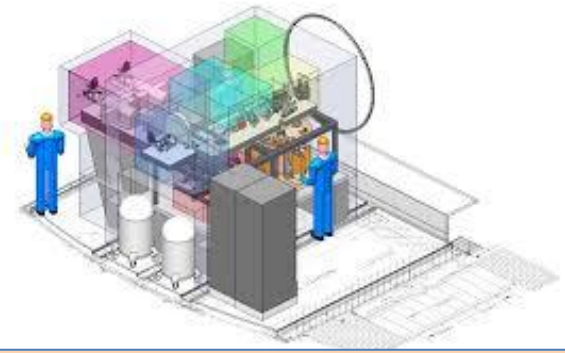
Next decade ground-based scientific landscape

MAVIS
Deeper than HST, sharper than JWST

MCAO-Assisted Visible Imager and Spectrograph

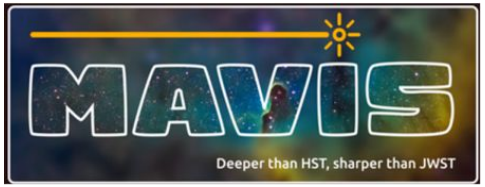






INAF involvement (M. Bergomi, V. Viotto et al.)

Next decade ground-based scientific landscape



MCAO-Assisted Visible Imager and Spectrograph

MAVIS main extragalactic scientific goals are:

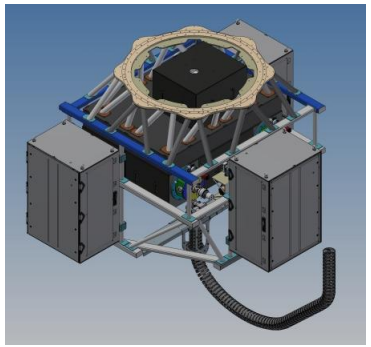
- to observe the "middle ages" of the universe (z in the range 1-5) to see **how chaotic, clumpy young galaxies evolved into spirals and ellipticals**.
- to extend "precision archaeology" to galaxies up to 50–100 Mpc away, **revealing how environmental factors drive galaxy evolution**.
- to resolve the dense cores of extragalactic star clusters and **search for Intermediate-Mass Black Holes**.

Next decade ground-based scientific landscape

CUBES

Cassegrain U-Band Efficient Spectrograph

While MAVIS focuses on high-resolution imaging and spectroscopy, **CUBES** is optimized for a different frontier: **sensitivity in the near-ultraviolet**.



→ will provide a high efficiency UV spectrograph at UT2 with a spectral range of 300-400nm and two resolutions of 20K and 7K.

INAF PI-ship (S. Covino)

Next decade ground-based scientific landscape

CUBES

Cassegrain U-Band Efficient Spectrograph

While MAVIS focuses on high-resolution imaging and spectroscopy, **CUBES** is optimized for a different frontier: **sensitivity in the near-ultraviolet**.

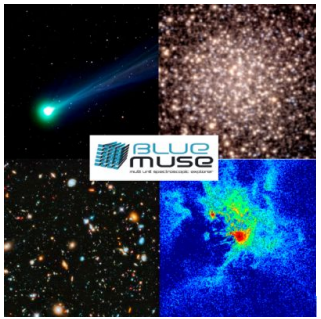
Among CUBES science cases:

1. Probing the **"Missing" Baryons** by observing the **Circumgalactic Medium** at z 1.5-2.8.
2. Measuring the **Cosmic UV Background**
3. Looking at very distant, chemically "pristine" gas clouds illuminated by background quasars and measuring **primordial D** as critical "fossil" from the Big Bang.
4. Studying the intense **UV emission from the accretion disks of supermassive black holes** to understand how their energy output shapes the evolution host galaxies.

Next decade ground-based scientific landscape

BlueMUSE

First suggested to the ESO community at the VLT2030 conference in 2019 and recommended by ESO's Scientific Technical Committee in 2020, but then started after Gravity+.



An optical seeing-limited, blue-optimised, medium spectral resolution, panoramic integral-field-spectrograph for VLT

BlueMUSE will map the "Cosmic Web" by detecting **faint emission from the intergalactic medium** and the gas reservoirs surrounding galaxies. It will study the **chemical enrichment of galaxies across cosmic time**.

Next decade ground-based scientific landscape

ALMA Wideband Sensitivity Upgrade will be done

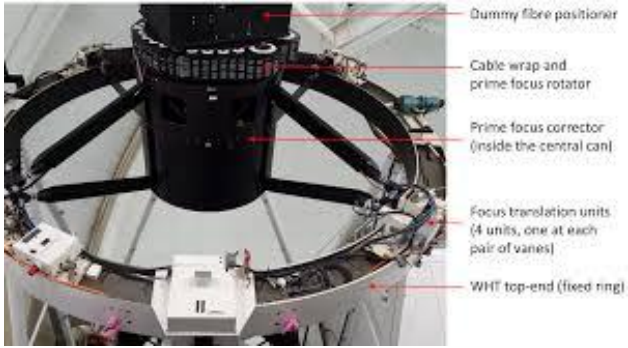
The upgrade will increase ALMA's bandwidth by a factor of 2 in a first stage and 4 when finalised. It will open several high-priority extragalactic frontiers such as **probing the early universe**; performing **extragalactic astrochemistry**, high-resolution imaging of **gas kinematics**, investigating **massive black holes**.

INAF involvement (ARC- Massardi et al.)

Next decade ground-based scientific landscape

The survey WEAVE will be completed

WHT Enhanced Area Velocity Explorer
a new multi-object survey spectrograph for the William Herschel Telescope

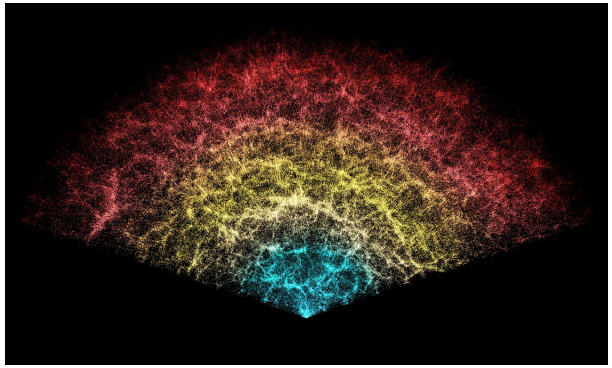


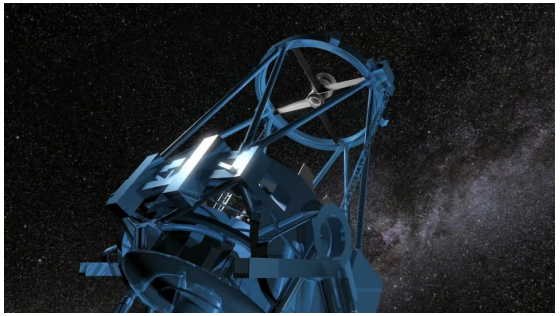
Among WEAVE science cases:

- **Galaxy Evolution and Kinematics** analyzing stellar and gaseous properties of galaxies at various redshift (0.3-0.7)
- **Cosmological Structure** using quasar absorption lines to map the large scale structure of the Universe.

INAF involvement (A. Vallenari et al.)

Next decade ground-based scientific landscape



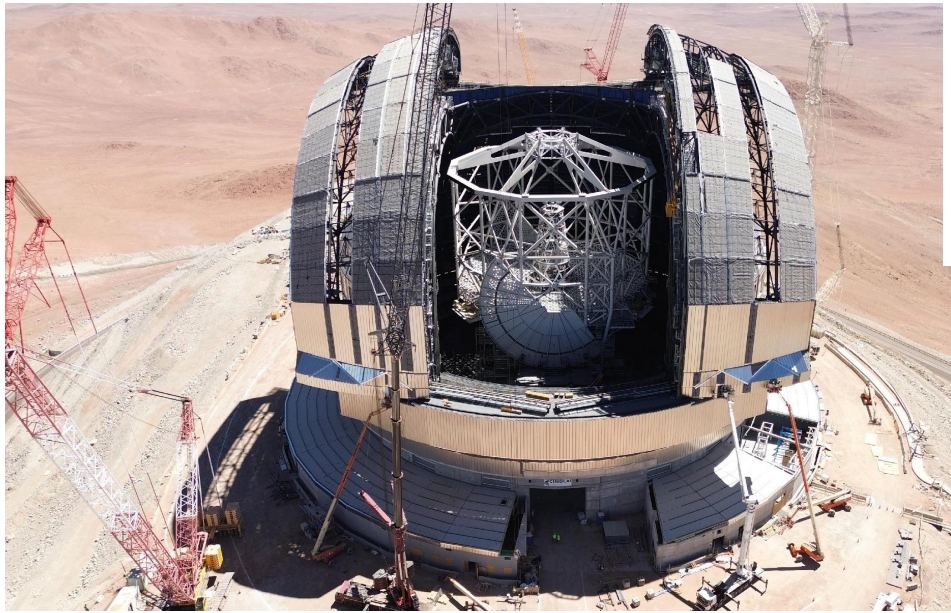


Dark Energy Spectroscopic Instrument
→ five-year survey to create the largest 3D map of the Universe ever
→ an unprecedented look at the nature of dark energy and its effect on the large-scale structure.

Subaru Primary Focus Survey
→ wide range of wavelengths ranging *from the NUV to NIR*
→ dark matter and dark energy. history of galaxies

Next decade ground-based scientific landscape

ELT will be operational



MORFEO
Multiconjugate adaptive Optics Relay For ELT Observations

HARMONI

MICADO

ANDES

MOSAIC

METIS
Mid-infrared ELT Imager and Spectrograph

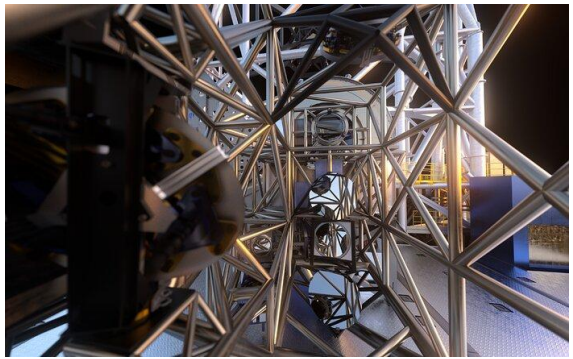
INAF

INAF Pisip (P. Ciliegi)

MORFEO

Multiconjugate adaptive Optics Relay For ELT Observations

A first-generation ELT instrument that will help compensate for the distortion of light caused by turbulence in the Earth's atmosphere which makes astronomical images blurry. **MORFEO will enable other instruments, such as MICADO in the first instance, to take exceptional images.**



MORFEO will use nine guide stars (three real stars and six artificial laser stars), state-of-the-art wavefront sensors, and up to three deformable mirrors to measure and correct for turbulence at three different heights in the atmosphere.

Next decade ground-based scientific landscape

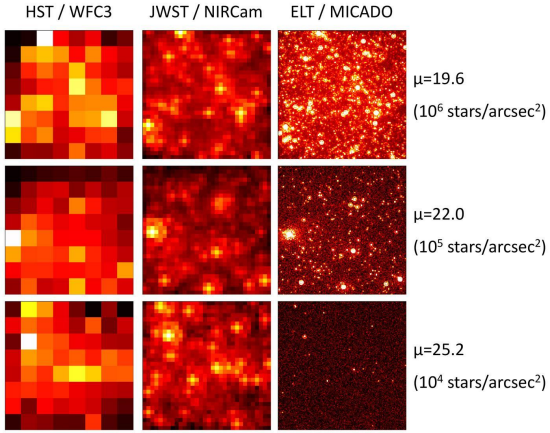
Multi-AO Imaging Camera for Deep Observations

MICADO

A first-generation ELT instrument

→ **high spatial resolution**
→ **sensitivity to infrared wavelengths**

INAF involvement (B. Vulcani et al.)



Credit: ESO/MICADO consortium

Next decade ground-based scientific landscape

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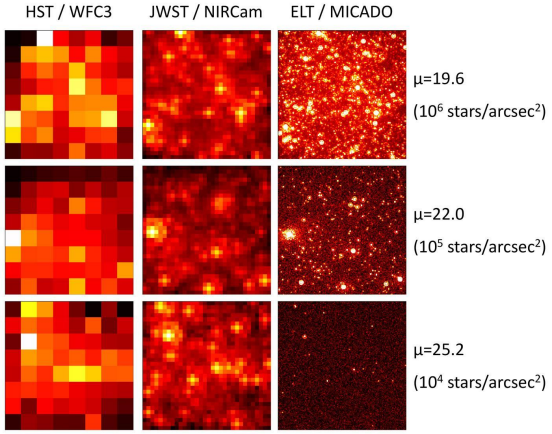

: ESO/MICADO consortium

Among the scientific cases:

- Galaxy Evolution at High Redshift (z > 1)
- Supermassive Black Holes
- Dark Matter and Dynamics
- Galactic archeology beyond the Local Group

Next decade ground-based scientific landscape

High Angular Resolution Monolithic Optical and Near-infrared Integral field spectrograph

3D spectroscopic capabilities and a variety of spatial and spectral settings
→ It will provide visible and near-infrared spectroscopy

Next decade ground-based scientific landscape

High Angular Resolution Monolithic Optical and Near-infrared Integral field spectrograph

3D spectroscopic capabilities and a variety of spatial and spectral settings
→ It will provide visible and near-infrared spectroscopy

Among the scientific goals:

- Probing the Physics of Distant Galaxies;
- Active Galactic Nuclei (AGN) & Supermassive Black Holes;
- Intermediate Mass Black Holes;
- Quasar host galaxies

Next decade ground-based scientific landscape

METIS

Mid-infrared ELT Imager and Spectrograph

It is one of the first-generation ELT instruments.
It will cover the infrared wavelength range and allow the study of a wide range of science topics.

Next decade ground-based scientific landscape

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Mid-infrared ELT Imager and Spectrograph

It is one of the first-generation ELT instruments.
It will cover the infrared wavelength range and allow the study of a wide range of science topics.

Among METIS scientific goals:

- **Dust-Obscured Nuclei**
- **Black Hole Dynamics**
- **Star-Formation Feedback**
- **High-Redshift galactic morphologies**

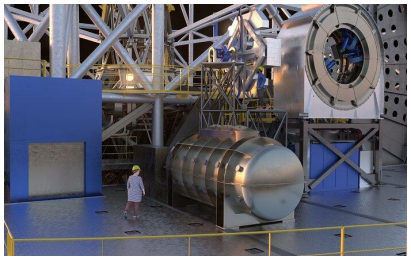
Next decade ground-based scientific landscape

Italian Piship (Marconi A.)

INAF involvement

ANDES

ArmazoNes high Dispersion Echelle Spectrograph



A second-phase ELT instrument that will combine high resolution and wide spectral range **to study astronomical objects that require highly sensitive observations.**

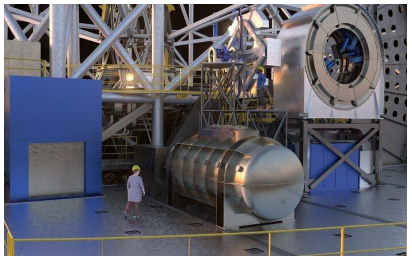
Next decade ground-based scientific landscape

Italian Piship (Marconi A.)

INAF involvement

ANDES

ArmazoNes high Dispersion Echelle Spectrograph



A second-phase ELT instrument that will combine high resolution and wide spectral range **to study astronomical objects that require highly sensitive observations.**

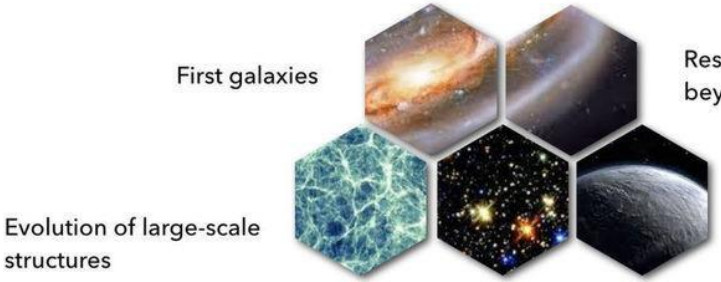
Among ANDES science cases:

- **Cosmic Acceleration:**
- **Intergalactic Medium**
- **Fundamental Constants**
- **Big Bang Nucleosynthesis**

Next decade ground-based scientific landscape

MOSAIC

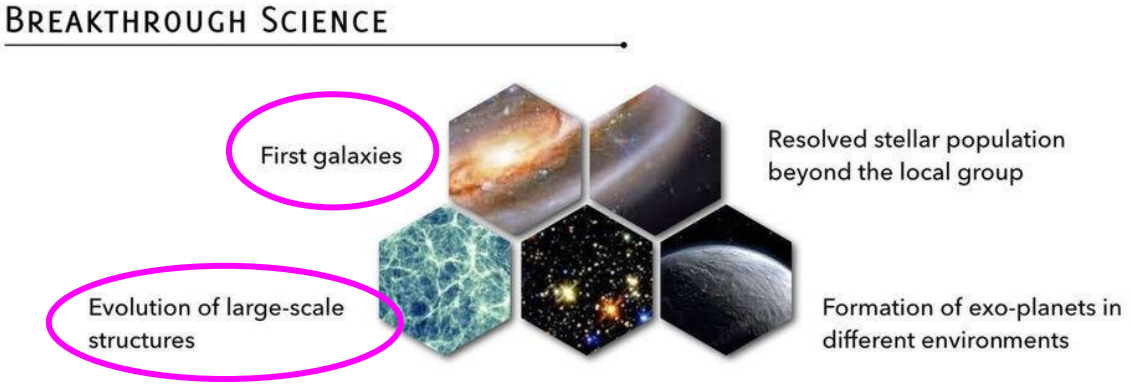
BREAKTHROUGH SCIENCE



A **multi-purpose MOS for the ELT**, covering the Visible and Near Infrared bandwidth with two modes: multi-object spectroscopy (MOS) and spatially resolved spectroscopy (mIFU).

INAF involvement (L. Pentericci et al.)

Next decade ground-based scientific landscape



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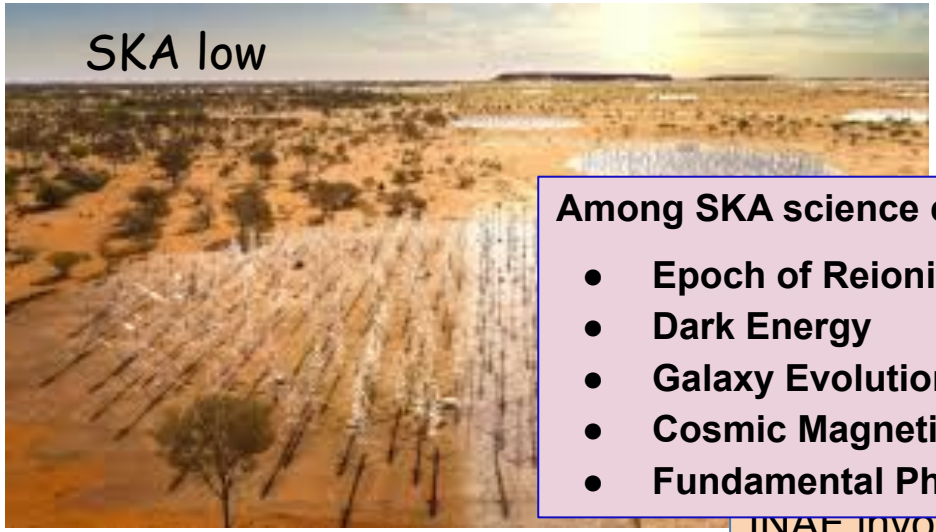
Next decade ground-based scientific landscape

SKAO

INAF involvement

Next decade ground-based scientific landscape

SKAO



Among SKA science cases:

- **Epoch of Reionization**
- **Dark Energy**
- **Galaxy Evolution**
- **Cosmic Magnetism**
- **Fundamental Physics**

INAF involvement

Next decade ground-based scientific landscape

The next-generation VLA (ngVLA) is an interferometric array that improves by more than an order of magnitude the sensitivity and spatial resolution of the Jansky VLA and ALMA at the same wavelengths.

Early Science start date in 2028, with full array operations beginning in 2034.

INAF involvement

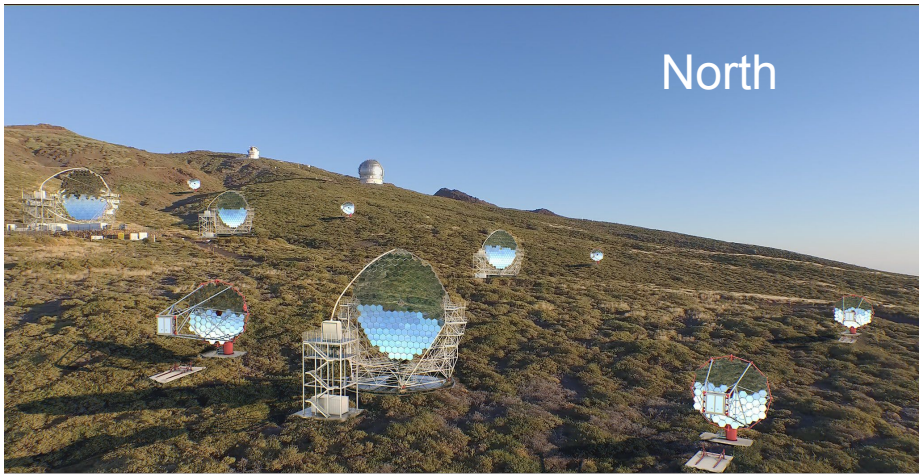
Next decade ground-based scientific landscape

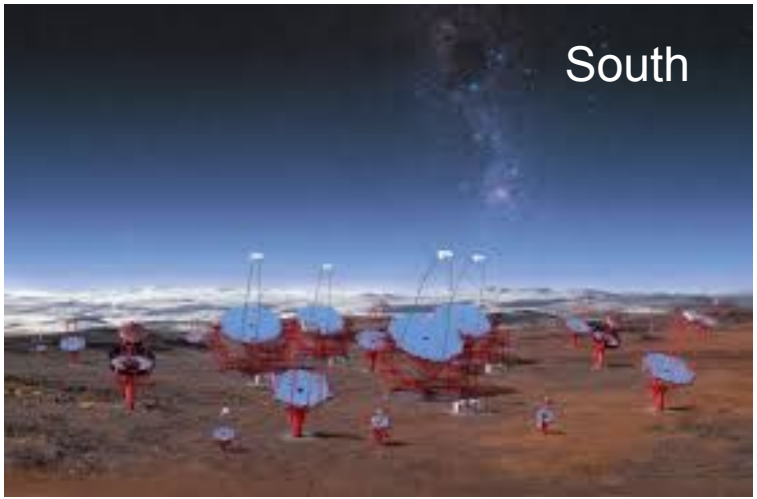
The next-generation VLA (ngVLA) is an interferometric array that improves by more than an order of magnitude the sensitivity and spatial resolution of the Jansky VLA and ALMA at the same wavelengths.

Among ngVLA science cases:

- **Assembly, Structure, and Evolution of Galaxies from the First Billion**
- **Formation and Evolution of Supermassive Black Holes**

INAF involvement





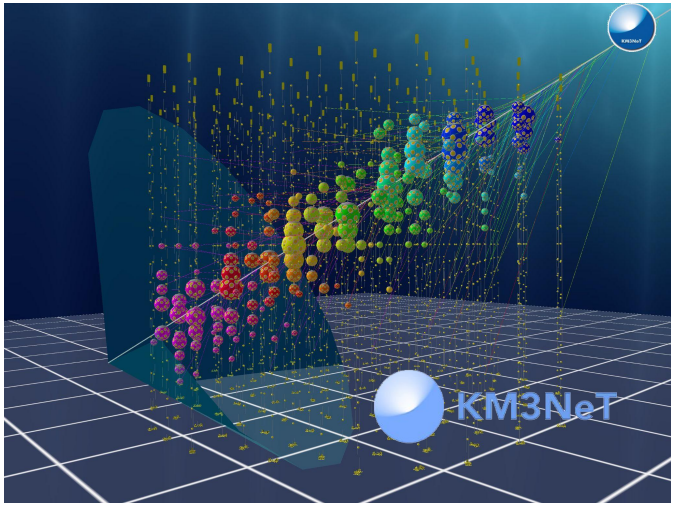
CTAO will transform our understanding of the high-energy Universe, but will **also** probe the nature of **Dark Matter**, and test **fundamental physics**.

Multi-messenger facilities

INAF involvement

EINSTEIN TELESCOPE

The ET will study the universe with gravitational waves, tracing it back to the time when light appeared.
→ **to understand its origin, how it formed and evolved and what its future will be.**



see also TRIDENT and **IceCube-Gen2**

High-Redshift Universe and Galaxy Assembly

Early Universe and Fundamental Physics

Cosmography and Dark Energy

Probing the Early Universe and Dark Matter

Extragalactic neutrino sources

What next (in the 2040s) from the ground?

Call for white papers for new projects/instruments for VLT/I with a deadline in January 2027

What is the next (after ELT) big ESO challenge?

What ESO's next programme could be…

The next ESO Programme should be identified **in line with ESO's vision and strategy**. It should be a **transformational facility in the 2040s landscape** that enables scientific benefits in several areas and serves a **large part** of the astronomical community. It could be:

- A new telescope facility at an existing or new observatory site;
- A significant upgrade of an existing facility that is (co-)owned by ESO (e.g. instrumentation);
- Other ideas or combinations.

Important: ESO does not operate as a funding agency. The new facility will be **led and owned** by ESO or in **partnership** with other organisations.

The ESO Senior Science Committee

- **Angela Adamo**, University of Stockholm (ESO STC, Galaxies)
- **Joss Bland-Hawthorn**, University of Sydney (Astrophotonics)
- **Marica Branchesi**, Gran Sasso Science Institute (Multi-messenger)
- **Paul Callanan**, University College Cork (ESO Council, Compact objects, chair)
- **Heather Cegla**, University of Warwick (Life & Habitability)
- **Stéphane Charlot**, Institute d'Astrophysique de Paris (Cosmology)
- **Vik Dhillon**, University of Sheffield (ESO Council, Transients & stars)
- **Marcella Marconi**, INAF- Osservatorio Astronomico di Capodimonte (Stellar pop.)
- **Nanda Rea**, Institut de Ciències de l'Espai – CSIC (Transients & high-energy)
- **Hans-Walter Rix**, MPIA (Galaxies)
- **Karin Öberg**, Harvard (star/planet formation) [Paola Caselli had to withdraw]
- **Norbert Hubin** – after November

Timeline

July 2024–Q3 2025

- Present and explain the process to the community
- Trigger dialogue about astronomy challenges & disruptive technologies in 2040s

Jun-Dec 2025

- Launch of call: Ju 25
- White papers due Dec 15, 2025
- 3 pages max
- Science focus.

Q3 2026–Q2 2027

- Launch of call: Q3 2026
- Letters of Intent due 1 Dec 2026
- Proposals due: 1 Jun 2027

Q3 2027–Q3 2028

- Performed by SSC and ESO Executive
- Transparently share what ideas are being proposed at a dedicated community workshop

Q3–Q4 2028

- Presented at STC and Finance Committee
- Council decision
- Decision is **not** the start of the new Programme

More than 200 white papers

Several scientific ideas for a similar facility

Similar scientific ideas proposed for different facilities

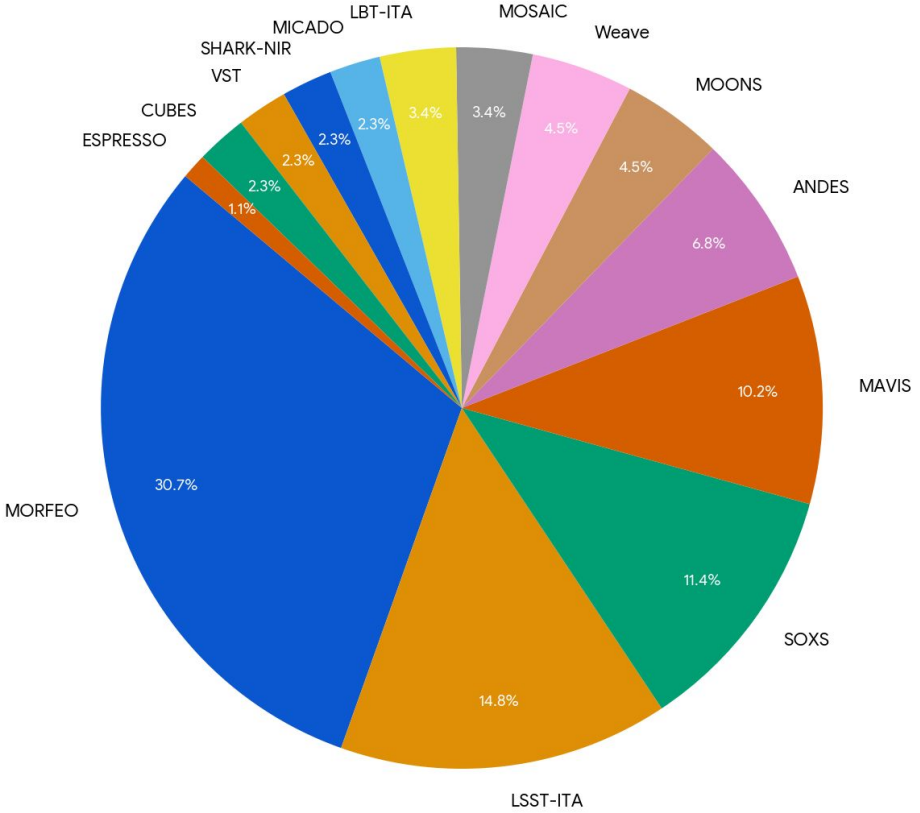
Need for the community to create connections

International meeting at ESO in the Summer (?)

The future of ground-based astronomy (also in INAF) is bright.

We need the young generations to be able to build and scientifically exploit what is coming and will come.

Looking only at Opt-NIR ground based projects: 88 TD/AdR



Data based on fund requests for 2026