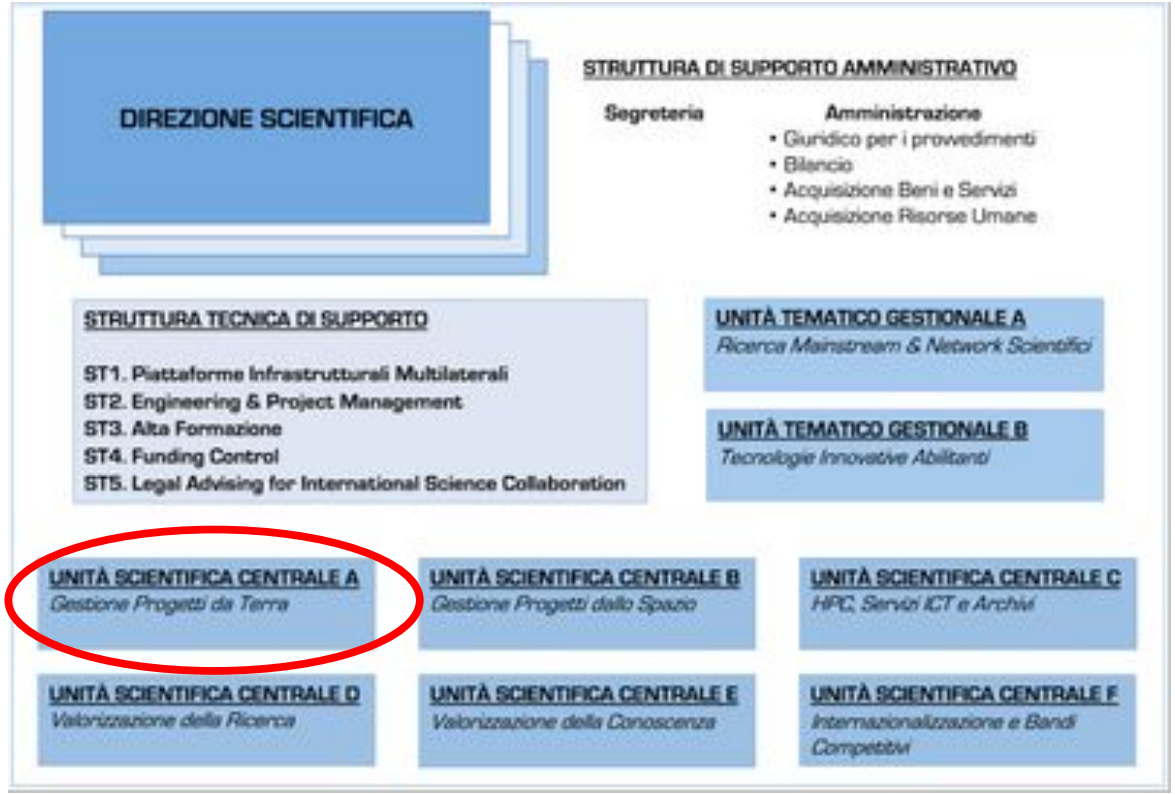
Progetti e strumenti del futuro da terra: prospettive per le tematiche scientifiche di RSN2

Marcella Marconi (INAF-OACn)
Coordinatore INAF USC-A
Membro 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.

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

-Nodo italiano dell’ALMA Regional Centre europeo.

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-Nodo italiano dell’ALMA Regional Centre europeo.

- Other ground-based projects (TBD)

2025: what has been done

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)

Planned events in 2026

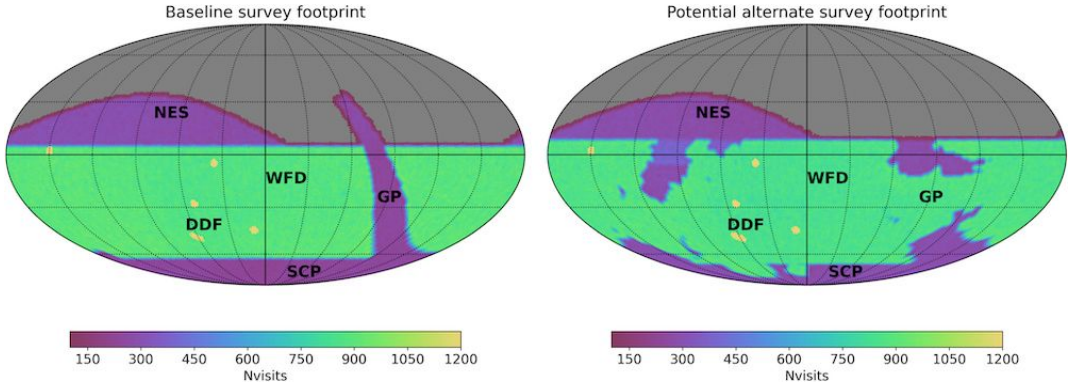
- **Rubin-LSST Italia Day, January 20** (*https://indico.ict.inaf.it/event/3418/*)
- **Meeting della strumentazione ELT a guida italiana, May 12-15** (*https://indico.ict.inaf.it/event/3450/overview*)

Both events will be held in Capodimonte (Auditorium Nazionale “Ernesto Capocci”)

The future of ground based instrumentation and facilities: perspectives for RSN2 studies

Next decade ground-based scientific landscape

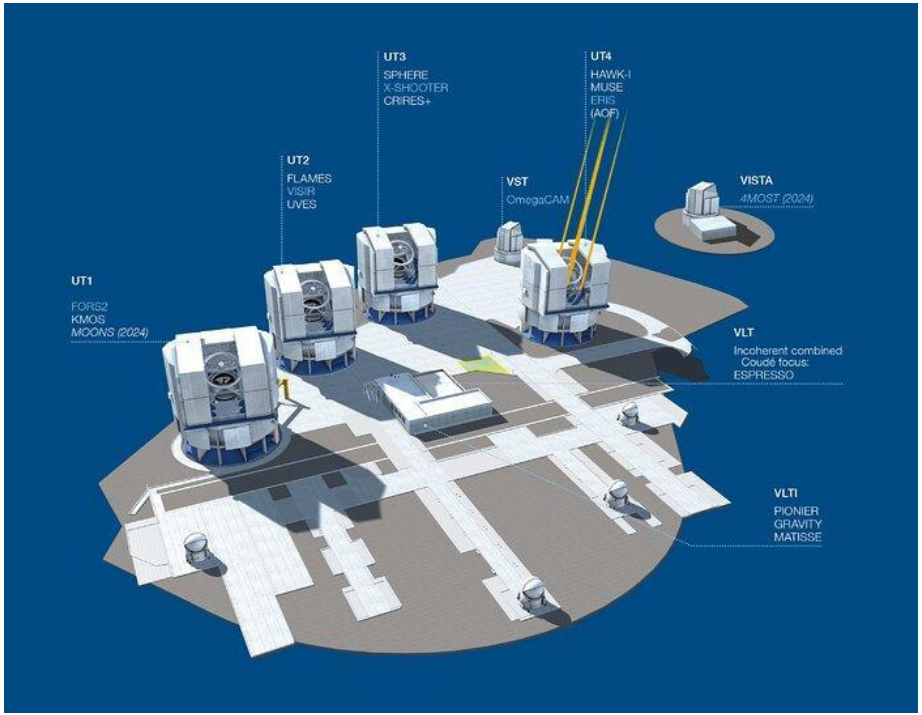
- **Southern optical sky sampled to 27 mag** and **millions of transients** with hourly to yearly variability observed by **Rubin/LSST**



The **Vera Rubin Observatory,** thanks to the telescope size and speed and to the camera sensitivity, was specifically designed to help **answer key questions** such as **Mapping the Milky Way** and **exploring variable and transient objects**

Next decade ground-based scientific landscape

The VLT system will enter in its fourth decade.



Next decade ground-based scientific landscape

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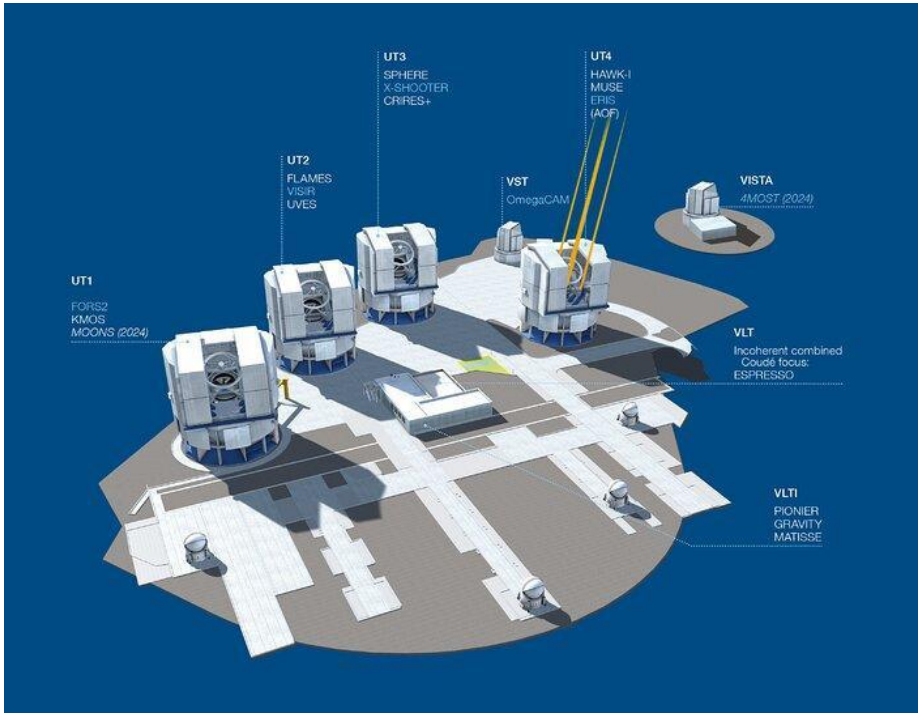
Ongoing Developments

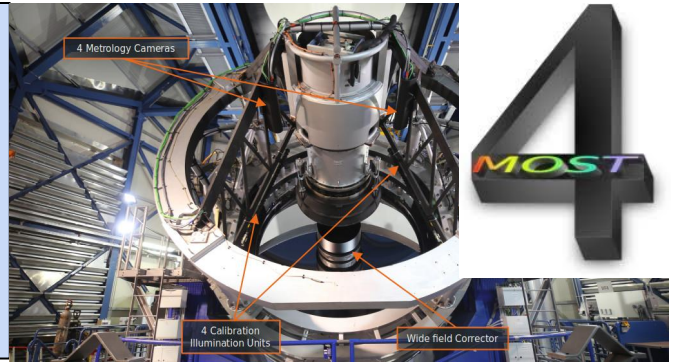
- 4MOST @ VISTA
- GRAVITY+ @ VLTI



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.
- **Galactic surveys** (both consortium and community) have been planned in the 4MOST Survey Program.



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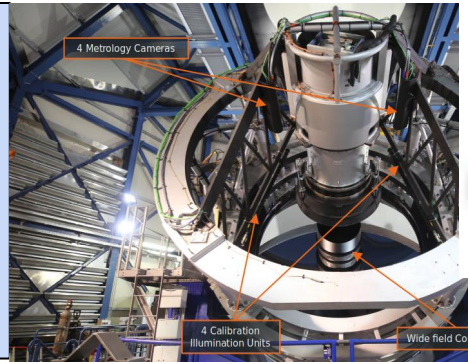


Among 4MOST science cases:

the **origin of the chemical elements** and the **formation of the first stars,** but also **the growth of the Milky Way** over cosmic time, but also the **Magellanic Clouds.**

Next decade ground-based scientific landscape

4MOST@VISTA

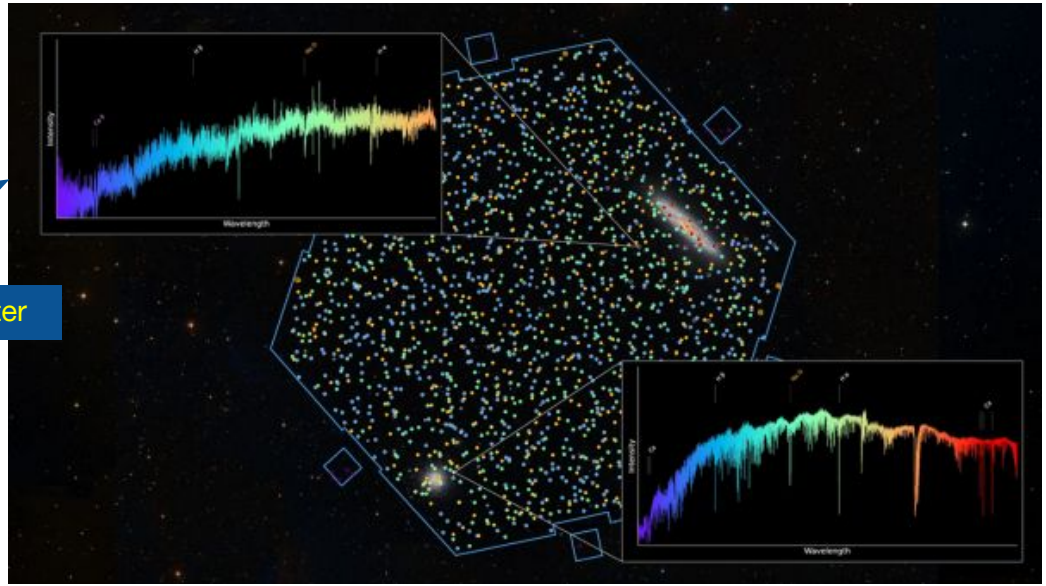
"First Light" achieved in October 2025.

Full science operations expected to start in the first half of 2026 after final commissioning.

The 4MOST first light field containing the Sculptor Galaxy and the globular cluster NGC288.
(Credit: AIP/Background: Harshwardhan Pathak/Telescope Live)

Next decade ground-based scientific landscape

4MOST@VISTA



Spectrum of a globular cluster

Spectrum of a star in NGC288

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

Among Gravity+ science cases:

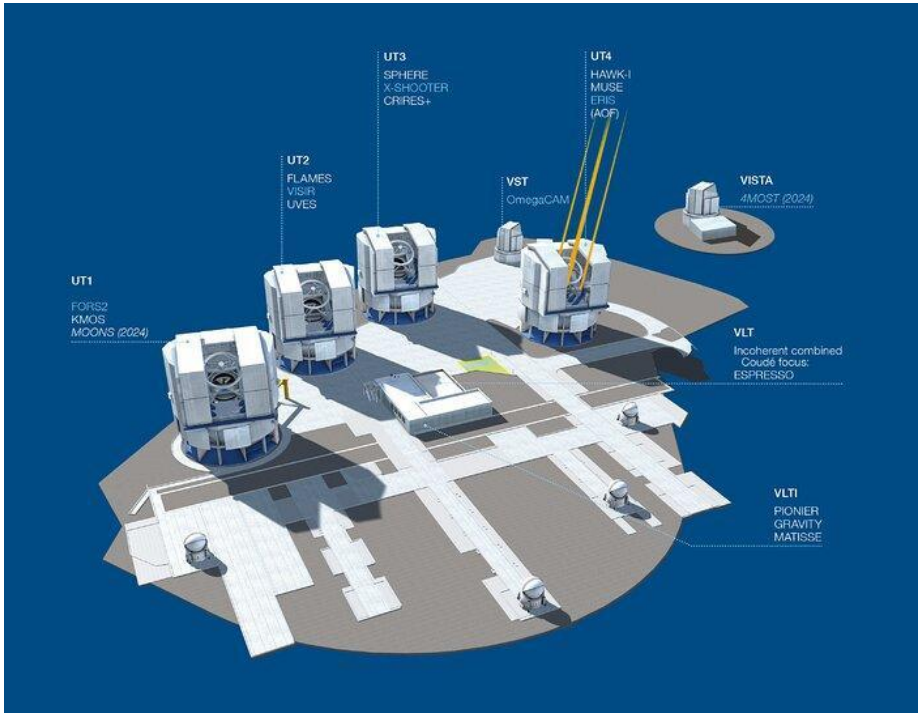
Characterization of exoplanets, and understanding **young stars and their planet-forming disks**

Next decade ground-based scientific landscape

The VLT system will enter in its fourth decade.

Next Development:

MOONS @ UT1



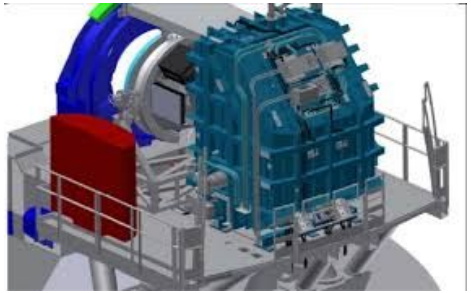
Next decade ground-based scientific landscape

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.



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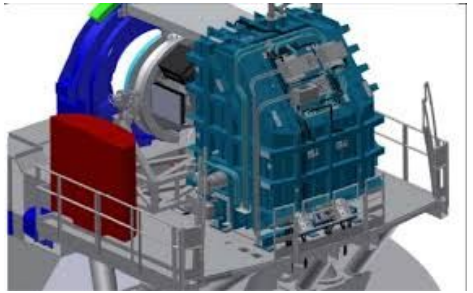


Among MOONS science cases:

- **Galactic archeology** → follow-up for the Gaia mission and VISTA Galactic surveys, delivering accurate radial velocities and chemical abundances for several million stars.

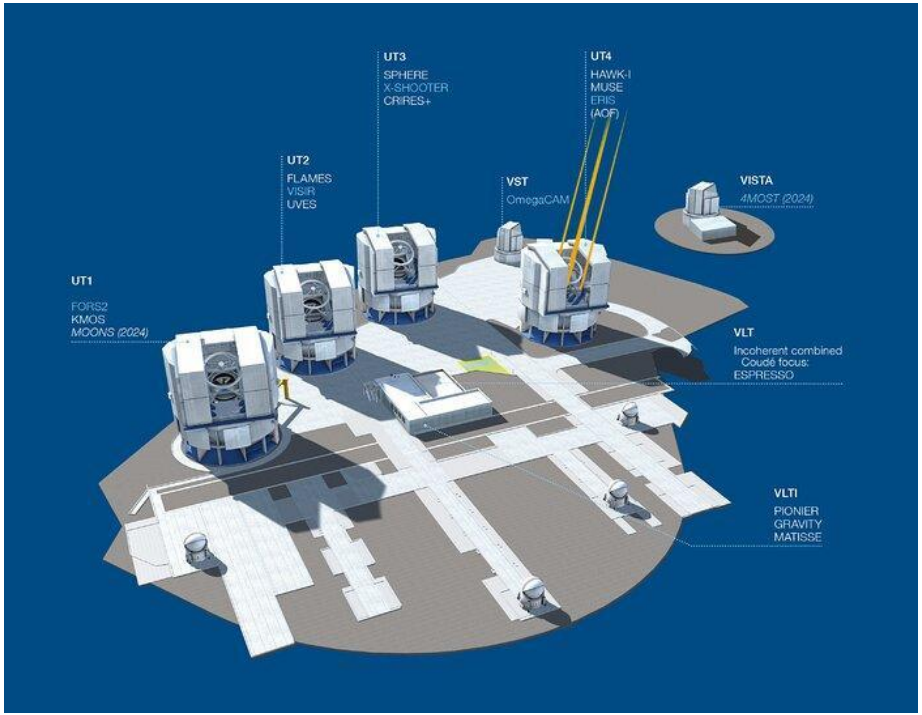
The near-IR coverage of MOONS will allow to investigate the Galactic bulge.

Next decade ground-based scientific landscape

The VLT system will enter in its fourth decade.

2029+:

- MAVIS @ UT4
- CUBES @ UT2

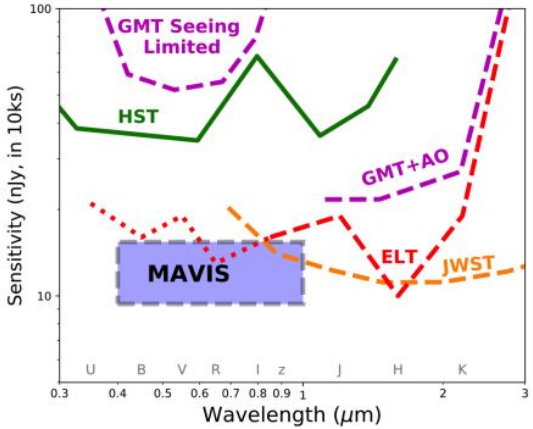


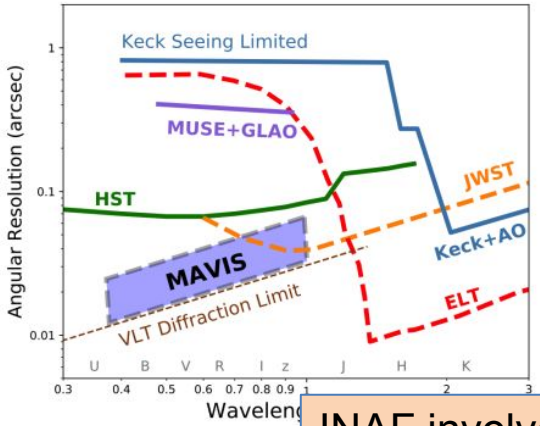
Next decade ground-based scientific landscape

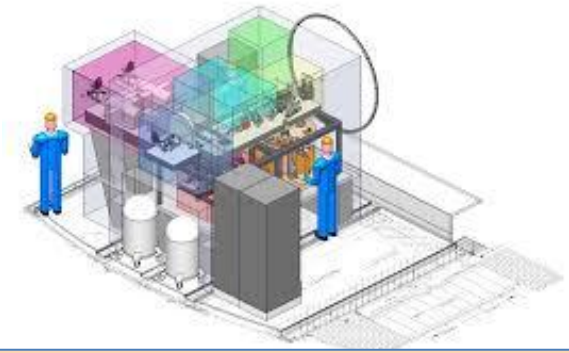
MAVIS

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

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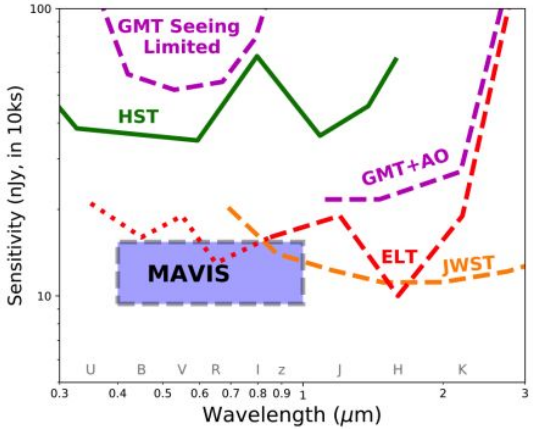
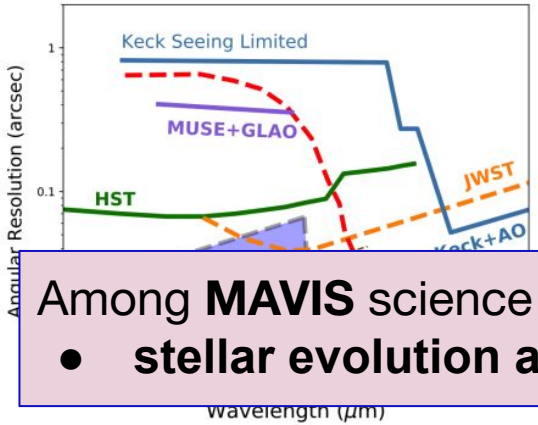
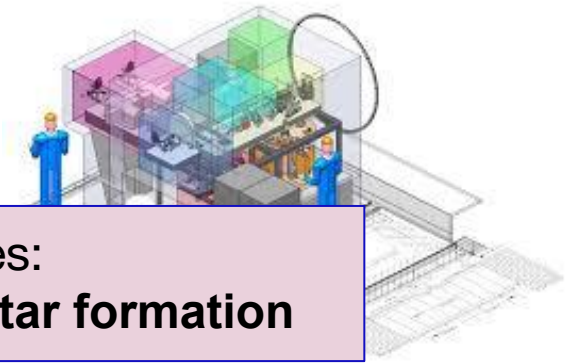






Among **MAVIS** science cases:

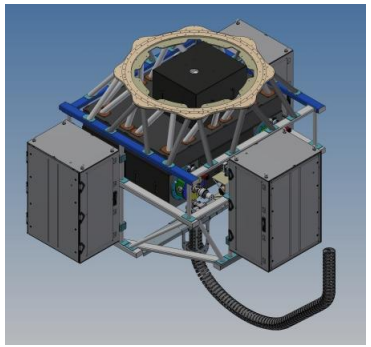
- **stellar evolution and star formation**

Next decade ground-based scientific landscape

CUBES

Cassegrain U-Band Efficient Spectrograph

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

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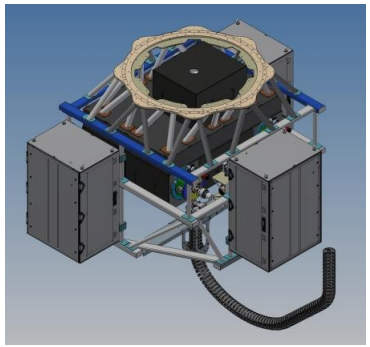
Among CUBES science cases:

- **metal-poor stars;**
- **CNO, Be, and primordial D**

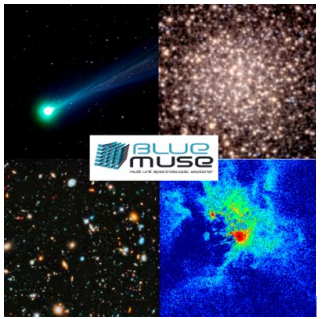
INAF PI-ship (S. Covino)



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

Next decade ground-based scientific landscape

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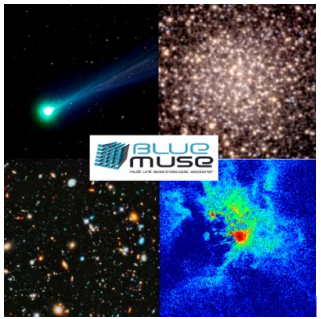


An optical seeing-limited, blue-optimised, medium spectral resolution, panoramic integral-field-spectrograph for VLT

BlueMUSE will offer new and unique science opportunities in many fields of astrophysics, including:
massive stars; **multiple populations globular clusters**; **ultra-faint dwarf galaxies**.

Next decade ground-based scientific landscape

ALMA Wideband Sensitivity Upgrade will be done

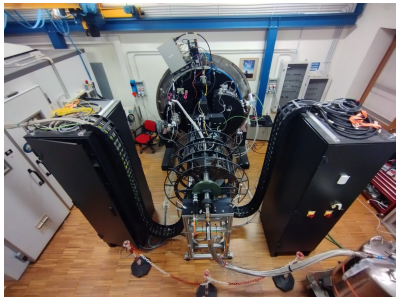
The upgrade will increase ALMA's bandwidth by a factor of 2 in a first stage and 4 when finalised.

It will open several science possibilities.
In **planet forming disks** possibility to detect fainter spectral lines much faster, gaining detailed insight into the properties of the disc, such as temperature and composition, in a single observation.

INAF involvement (Massardi et al.)

Next decade ground-based scientific landscape

At La Silla NIRPS and SOXS will be operated for more than 5 year



INAF PI-ship (S. Campana)

NIRPS (Near InfraRed Planet Searcher)

- **Earth-like rocky planets that could potentially be habitable.**

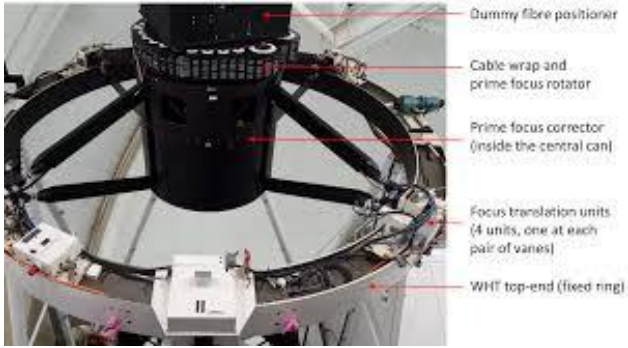
SOXS (Son Of X-Shooter)

- **Provide quick, high-efficiency UV-Vis/NIR spectroscopy;**
- **Follow up of transient and variable events observed by ongoing and upcoming surveys**

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



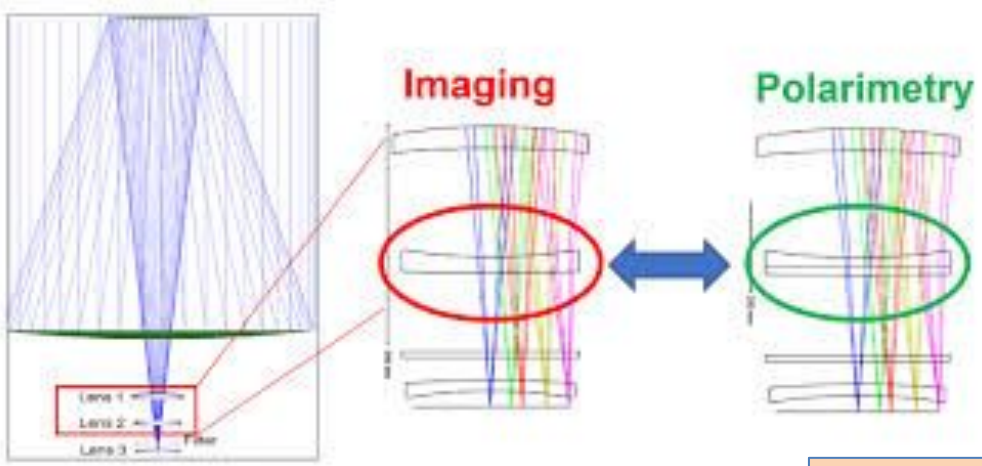
Among WEAVE science cases:

- **Galactic Archaeology**
- **Stellar, Circumstellar, and Interstellar Physics**

INAF involvement (A. Vallenari et al.)

VST will be equipped with VSTPOL

VSTPOL is a linear optical wide-field imaging polarimeter to be mounted on the VST.
→ an ideal complement of the next generation gamma-ray facilities such as CTA for the many TeV sources often displaying a significant degree of optical polarization.



INAF PI-ship (P. Schipani)

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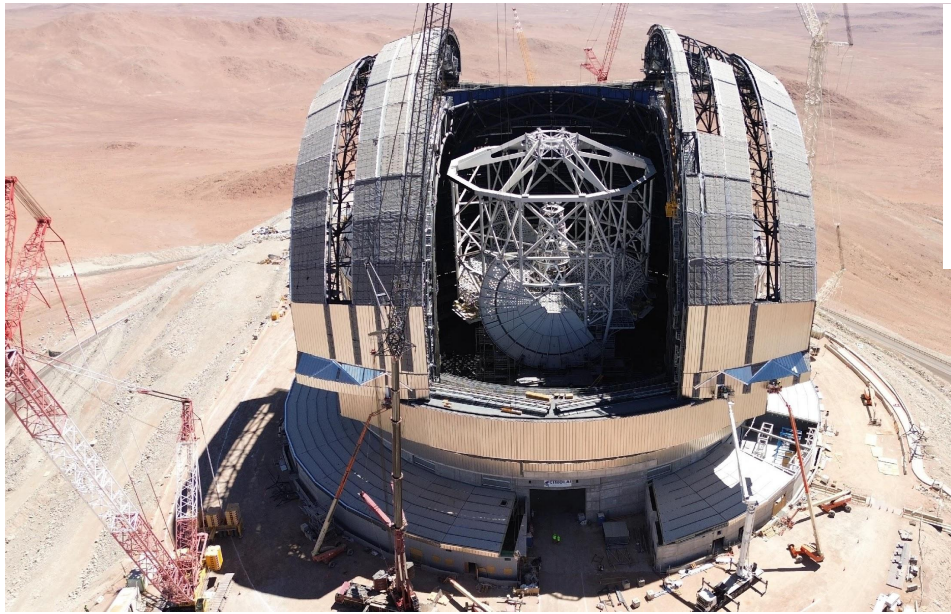
Among VSTPOL science cases:

- **Galactic transients and variable stars.**
- **Mapping magnetic fields in the Milky Way and in the Magellanic Clouds.**
- **Cepheids in the Magellanic Clouds.**

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

Next decade ground-based scientific landscape

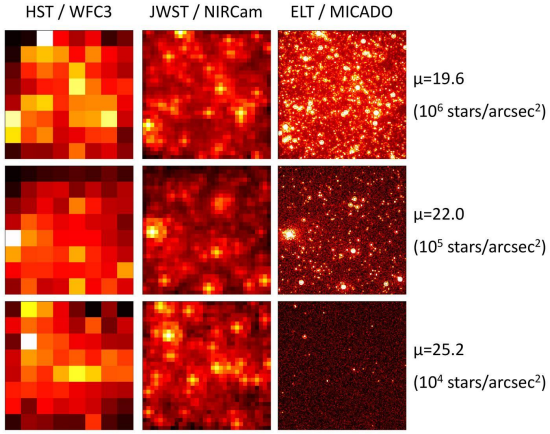
Multi-AO Imaging Camera for Deep Observations

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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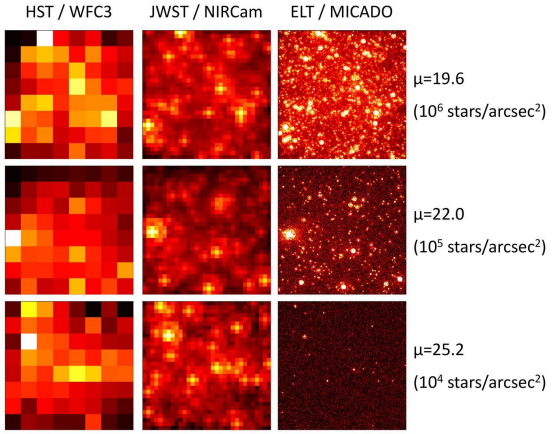


Credit: ESO/MICADO consortium

Among the scientific goals:

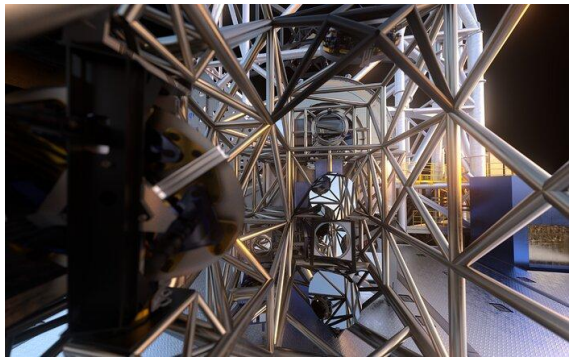
- **identifying exoplanets**;
- **resolving individual stars in other galaxies**.

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

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:
- **giant exoplanets**;
- **resolved stellar populations**.

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

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.

Among the key science goals:

Exoplanets and their atmospheres;

Stellar evolution.

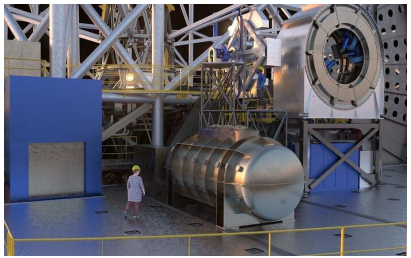
Next decade ground-based scientific landscape

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.**

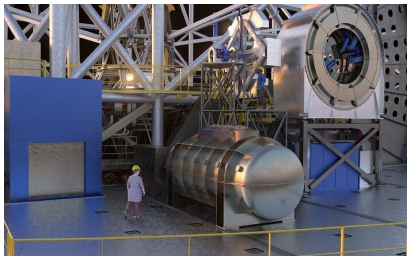
Next decade ground-based scientific landscape

Italian Piship (Marconi A.)

INAF involvement

ANDES

ArmazoNes high Dispersion Echelle Spectrograph



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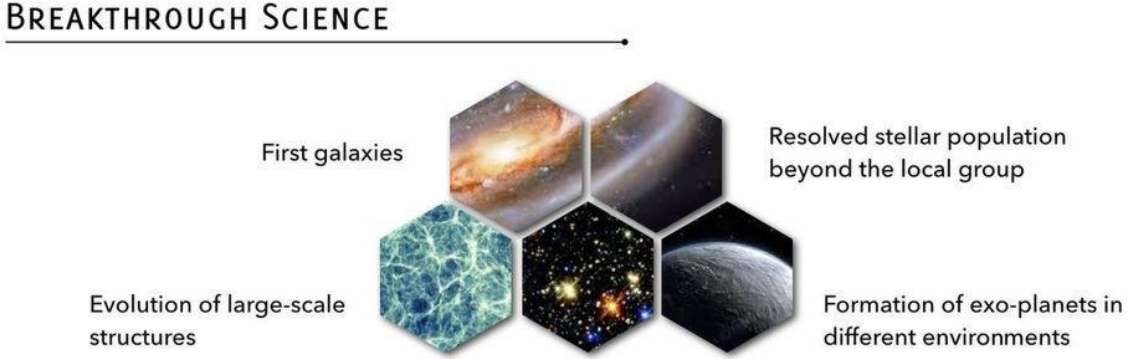
Among ANDES science cases:

- **characterising the atmosphere of Earth-like exoplanets;**
- **identifying the very first generation of stars**

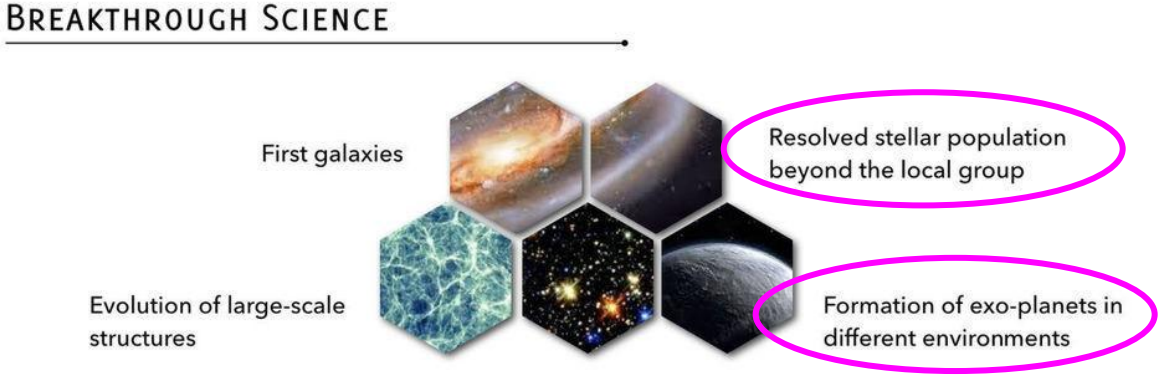
Next decade ground-based scientific landscape



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

PCS@ELT

The Planetary Camera and Spectrograph (PCS) for the ELT is a new instrument proposed for the **direct detection and characterization of exoplanets in the neighbourhood of the Sun** through eXtreme Adaptive Optics (XAO), coronagraphy and spectroscopy.

→ images and high-resolution spectra, allowing the atmospheric characterization of the detected planets,

Italian contribution is relevant both on scientific and technological aspects.

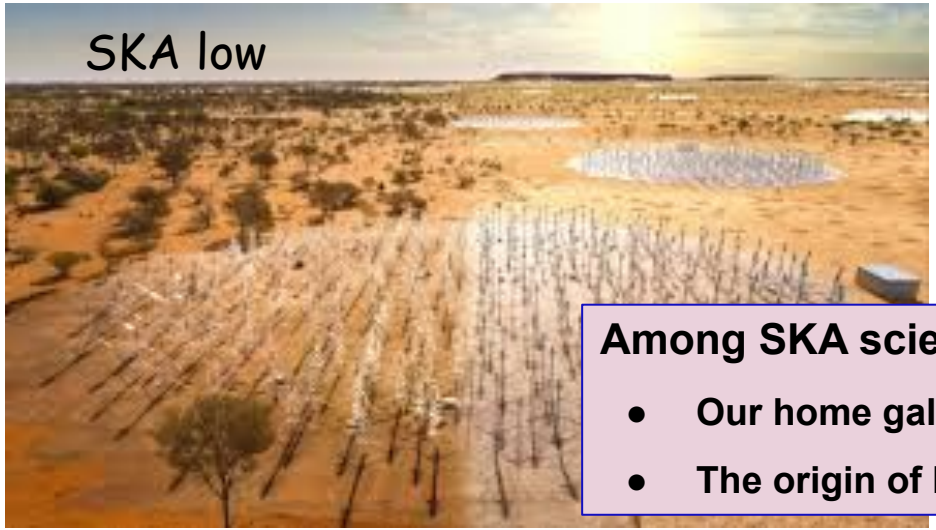
Next decade ground-based scientific landscape

SKAO

INAF involvement

Next decade ground-based scientific landscape

SKAO



Among SKA science cases:

- **Our home galaxy.**
- **The origin of life.**

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

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

Among ngVLA science cases:

- **Unveiling the Formation of Solar System Analogues;**
- **Probing the Initial Conditions for Planetary Systems**

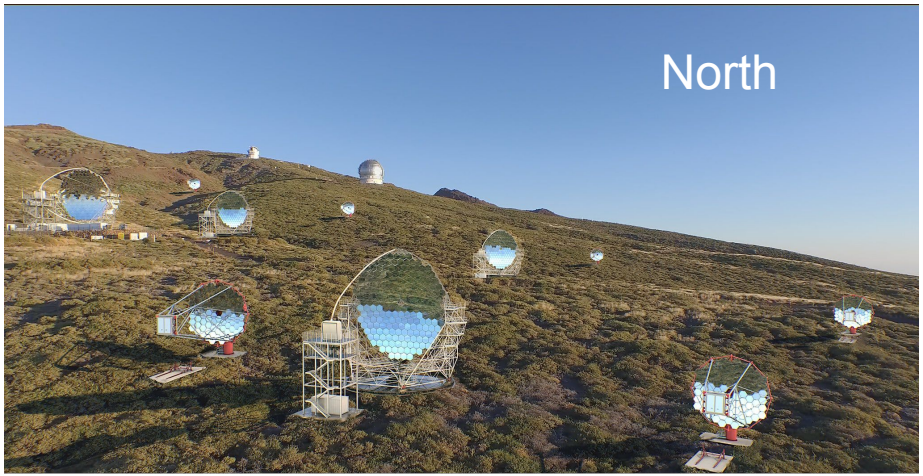
INAF involvement

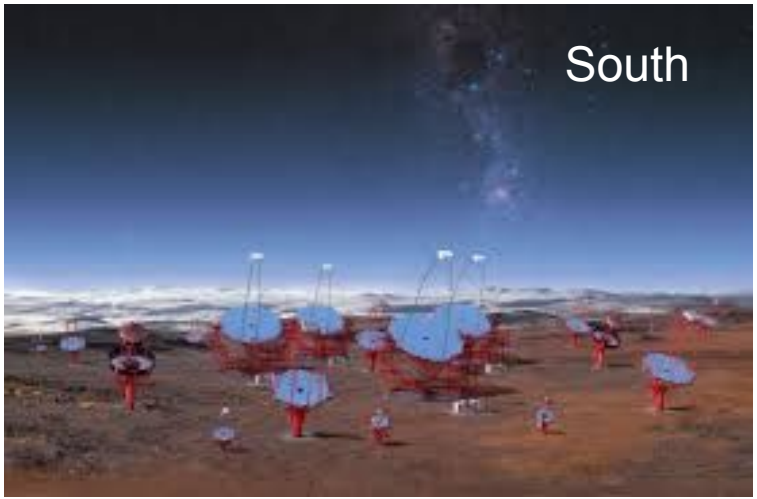
Cherenkov astronomy

INAF

CTAO

INAF involvement





CTAO will transform our understanding of the high-energy Universe, but will **also improve our knowledges of the star formation regions (e.g. in the Large Magellanic Cloud), the dark matter content of dwarf spheroidal galaxies**…etc…

What next (in the 2040s) from the ground, of interest for RSN2 ?

VLT beyond 2030

ESO aims to maintain the VLT and VLTI at the science forefront of astrophysical research in the ELT era and to guarantee the best synergies amongst the facilities.

ESO is organising the conference “VLT beyond 2030”, in Garching in January 2026 to review science topics, emerging technologies and expanding parameter spaces relevant for the VLT/I in the next decade and beyond.

ESO will issue a call for white papers for new projects/instruments for VLT/I during the conference with a deadline a year later, in January 2027, marking the start of the assessment phase.

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

The Senior Science Committee (SSC)

Preparatory phase

July 2024–Q3 2025

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

White papers

Jun-Dec 2025

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

Added upon the decision of the SSC

Call for ideas

Q3 2026–Q2 2027

Launch of call: Q3 2026

Letters of Intent due 1 Dec 2026

Proposals due: 1 Jun 2027

Assessment phase

Q3 2027–Q3 2028

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

Decision

Q3–Q4 2028

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

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More than 200 white papers → next SSC meeting at ESO at the beginning of February