



Toward a next-generation mm/submm observatory

*Gary Fuller
UK ARC Node
The University of Manchester*



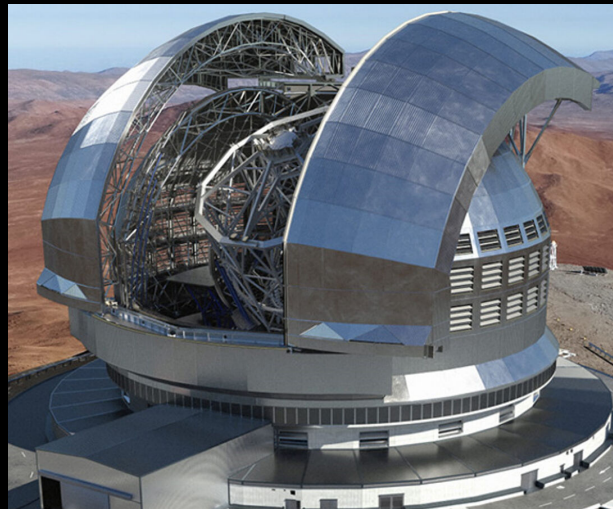
And the next 15 years will widen the gap

Euclid



Optical-NIR telescope

ELT



Optical-MIR telescope

Roman



Optical-NIR telescope

Rubin



Optical-NIR telescope

GMT



Optical-MIR telescope

Fundamental questions will remain

For example:

- How did the *first galaxies* form their stars?
- How do the physical conditions of star formation *change* over cosmic time & spatial scales?
- How do *super-massive black holes* form and grow?
- How do protoplanetary disks form the observed wide range of planetary systems?

Answering these questions requires a high-resolution view of the cold universe

European effort towards an ALMA2040 vision

European ALMA2040

[Home](#)

[Workshops](#) ▾

[Contributing](#)

[Documentation](#)

[Timeline](#)

[Working Groups](#)

[Contact](#)



ALMA
2040

**Transformational science with a (sub-)mm interferometer in
the 2040s**

Towards a next-generation ALMA-like observatory

www.euroalma2040.com

ALMA2040 science working groups

~ 450 members, so far mostly from Europe

▶ High-redshift Universe

Leads: Tom Bakx (Chalmers) & Francesca Rizzo (U. Groningen)

▶ Active Galactic Nuclei

Leads: Roberto Decarli (INAF Bologna) & Miguel Pereira Santella (IFF-CSIC)

▶ Cosmology & Fundamental Physics

Leads: Violette Impellizeri (ASTRON) & Hannah Stacey (ESO)

▶ Local Universe

Leads: Jan Forbrich (U. Hertfordshire) & Miguel Querejeta (OAN)

▶ Interstellar Medium & Star Formation

Leads: Maite Beltran (INAF-Firenze) & Jes Jørgensen (Copenhagen)

▶ Planet Formation

Leads: Luca Matrà (Trinity College) & Catherine Walsh (U. Leeds)

▶ Sun & Stars

Leads: Wouter Vlemmings/Theo Khouri (Chalmers) & Sven Wedemeyer (U. Oslo)

▶ Transients & Time-Domain Astronomy


Leads: Kuo Liu (MPIfR) & Karri Koljonen (NTNU)

▶ Solar System Bodies & Exoplanets

Leads: Arianna Piccialli (BIRA-IASB) & Miriam Rengel (MPS)

Coordinators:

Stefano Facchini, Jacqueline Hodge, Eva Schinnerer

A graphic illustration of the ALMA 2040 project. It features several large radio telescope dishes on a mountain ridge under a starry night sky. The text 'ALMA 2040' is prominently displayed in the upper center in a light blue, sans-serif font. The dishes are rendered in various colors like green, purple, and blue, and are illuminated with beams of light.

ALMA
2040

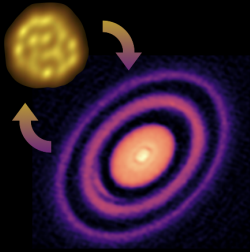
A photograph of a modern, curved building with large windows, likely an observatory or research facility. The building is dark, and the sky is a deep twilight blue. The text 'ALMA2040: Science Opportunities in the 2040s' is overlaid in a large, white, sans-serif font across the middle of the image.

ALMA2040: Science
Opportunities in the 2040s

2025 May 19 - 22

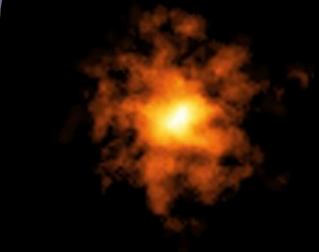


ALMA2040 Key Science Drivers



The life cycle of planetary systems & stars

Including the formation of rocky planets down to ~AU scales



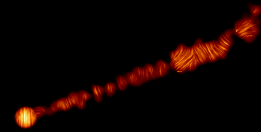
The formation and evolution of structure

Including primordial galaxies and black holes out to $z \sim 20$



Evolution of the cosmic baryon cycle

Including dust & the development of chemical complexity that leads to life



Physics of the extreme universe

Including resolving (BH) jet engines in space, time, and polarization

FORESEEN CAPABILITIES:

- > 5-10× line sensitivity
- > 3-5× angular resolution
- Simultaneous multi-band observing
- On-the-fly calibration

ALMA 2040

THE NEXT-GENERATION
(SUB-)MILLIMETER
INTERFEROMETER



Learn more / join the effort:
euroalma2040.com



Towards an ALMA2040 vision

[arXiv:2512.15652](https://arxiv.org/abs/2512.15652)

Towards ALMA2040

An update from the European community and invitation to contribute

Stefano Facchini (U. Milan), **Jacqueline Hodge** (Leiden U.), **Jes Jørgensen** (U. Copenhagen), **Eva Schinnerer** (MPIA), **Gie Han Tan** (TU Eindhoven), **Tom Bakx** (Chalmers), **Andrey Baryshev** (U. Groningen), **Maite Beltran** (INAF Firenze), **Leindert Boogaard** (Leiden U.), **Roberto Decarli** (INAF Bologna), **María Díaz Trigo** (ESO), **Jan Forbrich** (U. Hertfordshire), **Peter Huggard** (RAL), **Elizabeth Humphreys** (ESO), **Violette Impellizeri** (ASTRON), **Karri Koljonen** (NTNU), **Kuo Liu** (MPIfR), **Luca Matrà** (Trinity College), **Miguel Pereira Santella** (IFF-CSIC), **Arianna Piccialli** (BIRA-IASB), **Gergö Popping** (ESO), **Miguel Querejeta** (OAN), **Miriam Rengel** (MPS), **Francesca Rizzo** (U. Groningen), **Lucie Rowland** (Leiden U.), **Hannah Stacey** (ESO), **Wouter Vlemmings** (Chalmers), **Catherine Walsh** (U. Leeds), **Sven Wedemeyer** (U. Oslo), **Martina Wiedner** (Obs De Paris)

Abstract

Over the last 15 years, the Atacama Large Millimeter/submillimeter Array (ALMA) has revolutionized astrophysics by providing unprecedented resolution and sensitivity in observing the cold universe, including the formation of stars, planets, and galaxies. With groundbreaking discoveries ranging from the first detailed images of protoplanetary disks to the kinematics of galaxies in the Epoch of Reionization, ALMA has showcased the vast discovery potential of the (sub-)mm wavelength regime. However, in another 15 years from now—in the 2040s—the science landscape will have changed dramatically as new major observational facilities will have started their operations or have come towards advanced maturity in their scientific outcome (e.g., JWST, Rubin Observatory, ELT, Euclid, Gaia, Plato, Ariel, Roman Space Telescope, SPHEREx, LiteBIRD, LISA, SKA and others). At the same time, ALMA's current Wideband Sensitivity Upgrade will have been in place for ~10 years, and ALMA itself will have been operational for 30 years. To fully exploit this era, the community needs a next-generation facility operating at (sub-)mm wavelengths with capabilities far beyond those possible within ALMA's current infrastructure.

Towards an ALMA2040 vision

- *Define science & systems requirements by Q1 2026*
- *Define array configuration (homogeneous, hybrid), sensitivity, frequency needs*
- *Explore technical options (antennas, receivers, front/backend, correlator, data, operations, ...) by spring 2026 (invited to join RADIONET as guest instrument)*
- *Lorentz center workshop 18-19 March 2026 to draft first base concept*
- *Global call for scientific and technical 'ALMA2040 White Papers'* ←
 - *Call expected ~beginning of Q2 2026; Due ~summer 2026*
- *Full design concept by Fall 2026*
- *Submit letter of intent to ESO's Expanding Horizon call (2026 Dec 1)*

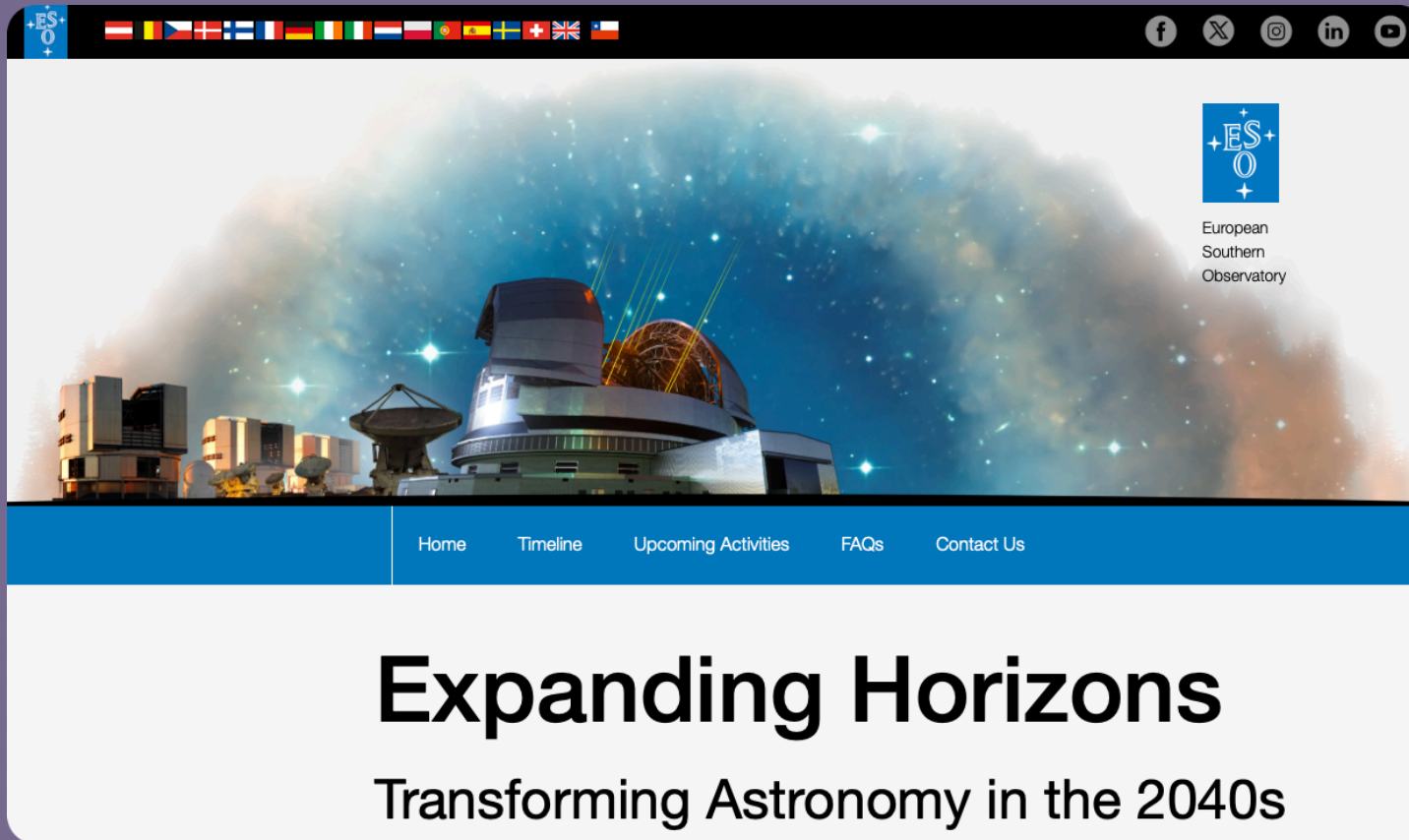
in 2026



Towards an ALMA2040 vision

- *Prepare required document for proposal idea (January to May 2027)*
- *Submit idea proposal to ESO's Expanding Horizon call (2027 June 1)*

in 2027



The image shows a screenshot of the ESO website's 'Expanding Horizons' page. The header features the ESO logo and a row of member state flags. The main content area has a large, vibrant image of an astronomical observatory at night, with a blue and white color scheme. The ESO logo and name are visible in the top right corner. Below the image is a navigation bar with links for Home, Timeline, Upcoming Activities, FAQs, and Contact Us. The main heading reads 'Expanding Horizons' in a large, bold font, followed by the subtitle 'Transforming Astronomy in the 2040s'. The URL 'next.eso.org' is displayed in the bottom right corner.

next.eso.org



Science Users Information

- [Observing Facilities](#)
- [Future Facilities and Development](#)
- [Observing with ESO Telescopes](#)
- [Science Software](#)
- [Science Archive Facility](#)
- [Science Activities](#)
- [Science Publications](#)
- [Science and Technical Meetings](#)
- [Seminars at ESO Garching](#)
- [Seminars at ESO Santiago](#)
- [Conferences and Workshops](#)
- [Conferences 2026](#)
- [AGN - FAAST](#)
- [Expanding Horizons](#)
- [ESO Observing School at La Silla](#)
- [VLTI Community Days 2026](#)
- [CMF2IMF](#)
- [NUCLEI 2026](#)
- [SNII-RSG](#)
- [Writing and Communicating your Science](#)
- [SummerResearch2026](#)
- [CHASES 2026](#)
- [ScientificWritingVitacura26](#)
- [Bridging Horizons](#)
- [IR2026](#)
- [TipTop Meeting at ESO](#)
- [MAVIS 2026](#)
- [VLT beyond 2030](#)
- [Conferences 2025](#)
- [Conferences 2024](#)



EXPANDING HORIZONS: WHAT ARE THE ASTRONOMICAL CHALLENGES OF THE 2040S

13 - 17 JULY 2026

Garching near Munich, Germany

Quick links

- [Home](#)
- [Important dates](#)
- [SOC/LOC](#)
- [Invited speakers](#)
- [Registration](#)
- [Fee payment](#)
- [Programme \[Zenodo\]](#)
- [Code of conduct & Chair Guidelines](#)
- [Accommodation](#)
- [Travel](#)

ESO's Expanding Horizons process aims to identify the main scientific challenges that will face European astronomers in the 2040s, and the type of transformational ground-based facility that will be required to address these fundamental questions.

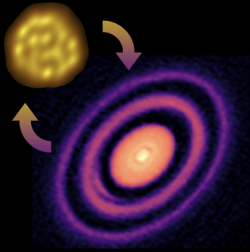
Following the call for Scientific White Papers in late 2025 - an initiative designed to galvanise the European astronomical community to engage in the Expanding Horizons process - we are delighted to announce this community-wide workshop.

This meeting will bring together astronomers from a wide range of research backgrounds to present their vision of what the key scientific questions will be 2040s. The workshop will also be a platform to investigate the potential synergies between the different scientific themes, the required facilities and the key enabling technologies needed for the 2040s and beyond.

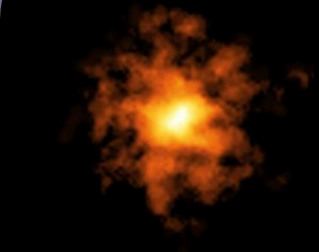
This five-day workshop will consist of mixture of plenary and breakout sessions, with participants recommended to attend over the entire five-day programme.

E-mail: ExpH_workshop@eso.org

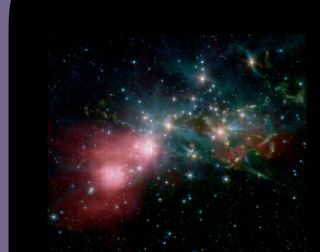
ALMA2040 Key Science Drivers



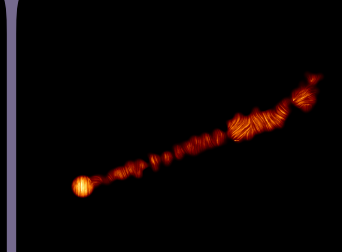
The life cycle of planetary systems



The formation and evolution of stars



Evolution of the cosmic web



Physics of the extreme environment

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THE NEXT-GENERATION
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If you want an ALMA-like facility in 2040+, please get involved, submit/contribute to White Papers, & engage your communities!

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