ESO's Extremely Large Telescope (ELT)

The world's **biggest eye** on the sky

“With the ELT we’re going to see things that were impossible to see before. We’re going to see things and we’re going to be surprised!”

Didier Queloz, Nobel Prize Laureate,
Professor at the Universities of Cambridge, UK, and Geneva, Switzerland

How the ELT will look atop Cerro Armazones, Chile.

Credit: ESO/L. Calçada

A **revolutionary** telescope

The past decade has brought astronomical revelations that have excited people from all walks of life, from finding planets around Proxima Centauri, the nearest star to the Sun, to the first image of a black hole. On a mountain in the Atacama Desert in Chile, ESO, the European Southern Observatory, is building a telescope that will revolutionise astronomy for decades to come. ESO's Extremely Large Telescope (ELT) will dramatically change what we know about our Universe and make us rethink our place in the cosmos.

The Orion Nebula as seen by ESO's Very Large Telescope. The ELT will allow us to capture images of cosmic objects like this with a resolution five times greater.

Credit: ESO/H. Drass et al.

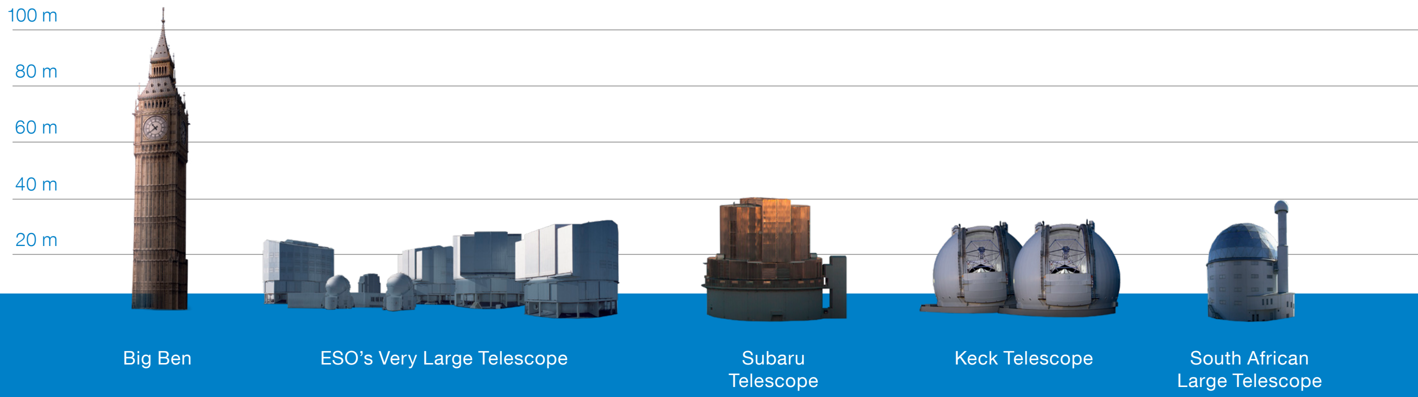
When it starts operating later this decade, the ELT will track down Earth-like planets around other stars, and could become the first telescope to find evidence of life outside of our Solar System. It will also probe the furthest reaches of the cosmos, revealing the properties of ancient galaxies and the nature of the dark Universe. On top of this, astronomers are hoping for the unexpected with the ELT — yet unimaginable discoveries that will push the boundaries of our knowledge of the cosmos.

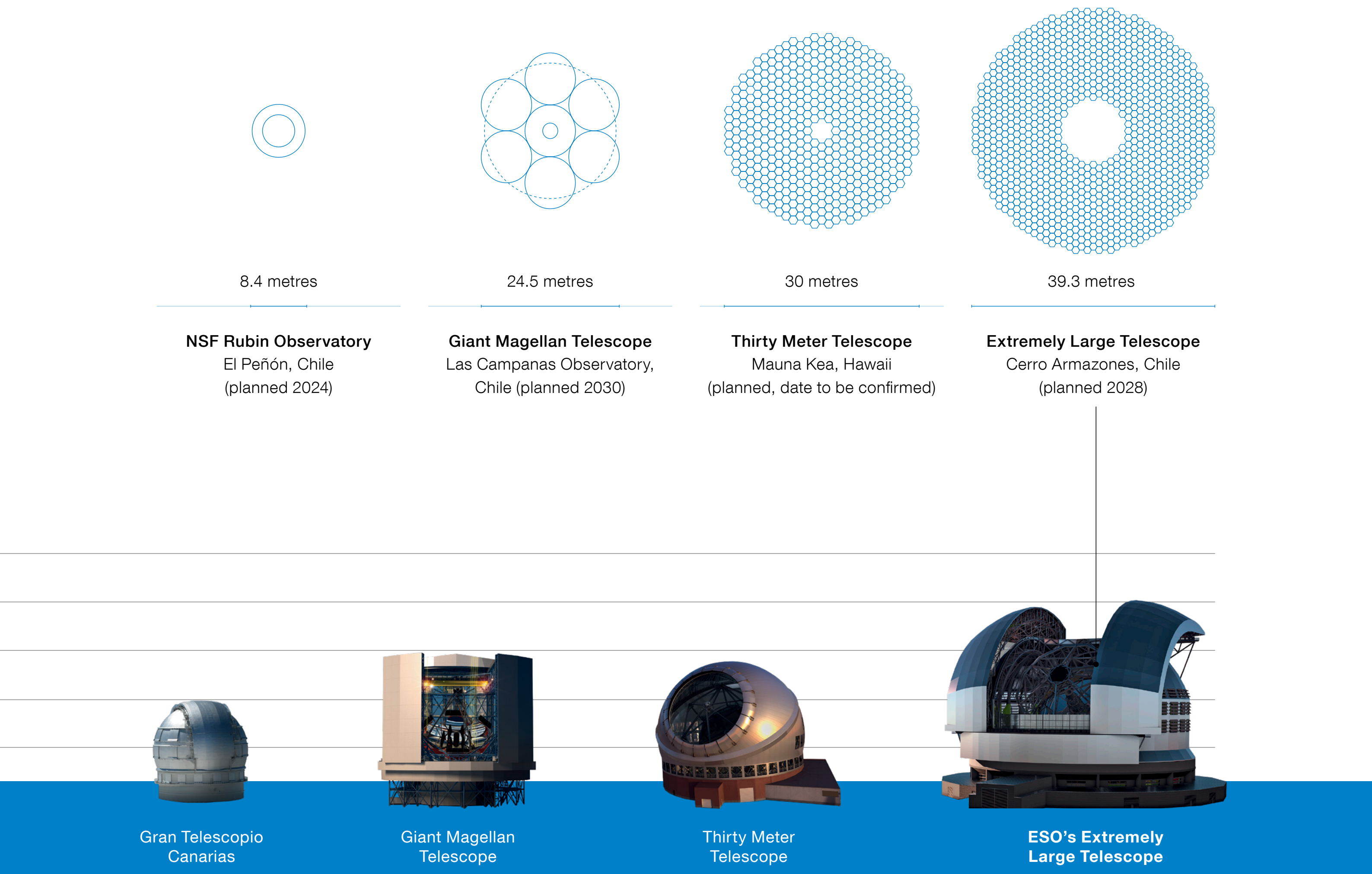
Building a **giant**

Pushing the boundaries of science requires thinking big. The ELT will be the largest optical/infrared telescope in the world.

The telescope will have a main mirror nearly 40 metres in diameter, too large to be made from a single piece of glass. The mirror will consist of nearly 800 hexagonal segments that, working together, will gather more light than all the existing large research telescopes on the planet combined, and 100 million times more light than the human eye. Thanks to this giant mirror, and other sophisticated systems, ESO's ELT will provide images 15 times sharper than those from the NASA/ESA Hubble Space Telescope.

The telescope will be housed in a huge dome that will shelter it from the extreme environment of Chile's Atacama Desert. With a diameter of 88 metres, the dome will have a footprint roughly equivalent to that of a football (soccer) pitch. It will be 80 metres high, about the height of Big Ben without the spire. The dome consists of an enclosure that opens and closes to allow observations of the night sky, as well as a pier that rotates with high accuracy to track celestial objects.





8.4 metres
24.5 metres
30 metres
39.3 metres
NSF Rubin Observatory
El Peñón, Chile
(planned 2024)
Giant Magellan Telescope
Las Campanas Observatory,
Chile (planned 2030)
Thirty Meter Telescope
Mauna Kea, Hawaii
(planned, date to be confirmed)
Extremely Large Telescope
Cerro Armazones, Chile
(planned 2028)
Gran Telescopio
Canarias
Giant Magellan
Telescope
Thirty Meter
Telescope
ESO’s Extremely
Large Telescope

ELT facts

Name	Extremely Large Telescope (ELT)
Site	Cerro Armazones, Atacama Desert, Chile
Altitude	3046 metres
Main mirror diameter	39 metres
Light collecting area	978 square metres
Number of main mirror segments	798
Main mirror segments alignment precision	Tens of nanometres (1/10 000 the thickness of a human hair) across its entire 39-metre diameter
Type	Optical/near-infrared extremely large telescope
Optical design	Five-mirror design
Telescope field of view	10 arcminutes
Enclosure	Hemispherical dome
Weight of the main structure	3700 tonnes
Number of bolts used in the dome	~30 million
First light date	2028

The Extremely Large Telescope is being built on Cerro Armazones in the Chilean Atacama Desert, at 3046 metres altitude and just 23 kilometres from the site of ESO's Very Large Telescope (VLT) at Paranal.

Credit: ESO/M. Tarenghi

Pushing the boundaries of technology

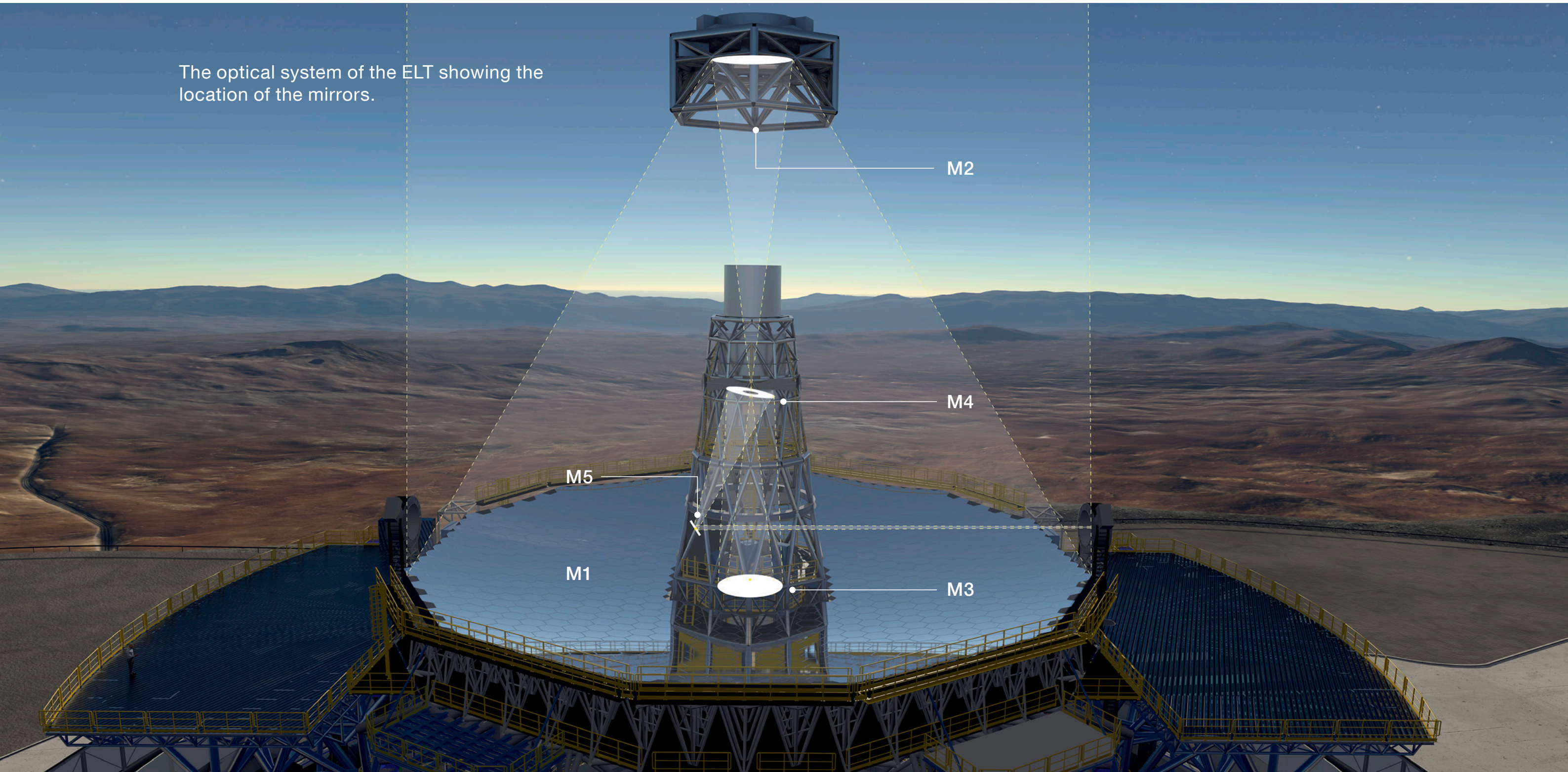
ESO's ELT has an unusual optical design based on a novel five-mirror scheme that will yield exceptional image quality coupled with a wide field of view (one third of the width of the full Moon).

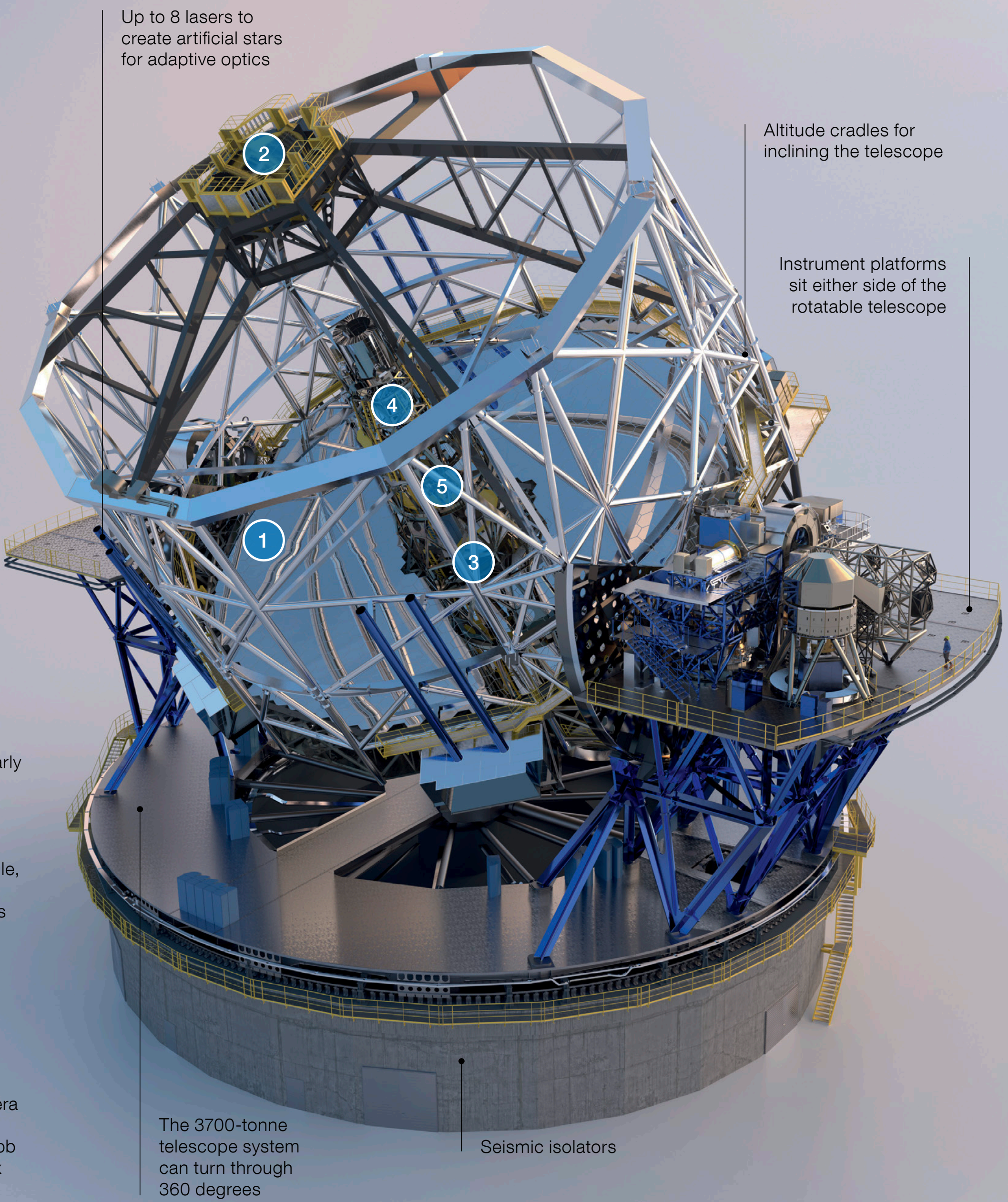
Adaptive mirrors, as components of both the telescope and its instruments, will compensate for the fuzziness in images introduced by atmospheric turbulence. One of these, the telescope's fourth mirror, or M4, will be very thin and supported by more than 5000 actuators that adjust its shape up to a thousand times a second.

The telescope will be equipped with giant instruments to analyse the light that it captures. They are currently under development at institutes around Europe and will be mounted on a platform so big it could support one of the Unit Telescopes of ESO's Very Large Telescope.

The contract for the ELT telescope main structure and dome is the largest ever placed for a ground-based telescope.

The optical system of the ELT showing the location of the mirrors.





Five-mirror design

1 Main mirror 39.3 metres diameter
2 Secondary mirror. Largest secondary (and largest convex) mirror ever produced
3 Tertiary mirror
4 Adaptive fourth mirror
5 Rapid tip-tilt fifth mirror

First-generation instruments

HARMONI, a 3D spectrograph, will be used to explore galaxies in the early Universe, study the constituents of the local Universe and characterise exoplanets in great detail.

MORFEO, an adaptive-optics module, will help to compensate for distortions caused by turbulence in Earth's atmosphere.

METIS, a mid-infrared imager and spectrograph, will focus on exoplanets, protoplanetary discs, Solar System bodies, active galactic nuclei, and high-redshift galaxies.

MICADO, a dedicated imaging camera for the ELT, will have a sensitivity comparable to that of the James Webb Space Telescope and a resolution six times greater.

Preparing for **a revolution**

June 2014

Part of the 3000-metre peak of Cerro Armazones was blasted away during a ground-breaking ceremony, the first step towards levelling the summit in preparation for construction.

December 2014

ESO Council gives the green light for the ELT construction.

July 2015

ESO Council authorises the ESO Director General to sign the contracts for the first set of instruments for the ELT.

January 2018

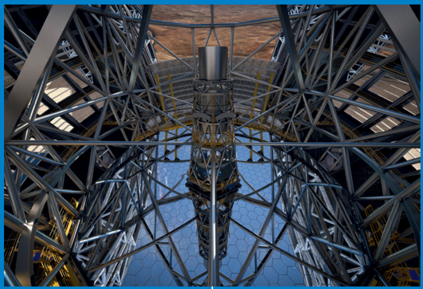
The first hexagonal segments for the ELT's 39-metre main mirror are successfully cast by the German company SCHOTT.

May 2018

Foundation work begins atop Cerro Armazones, paving the way for construction of the dome and telescope structure.

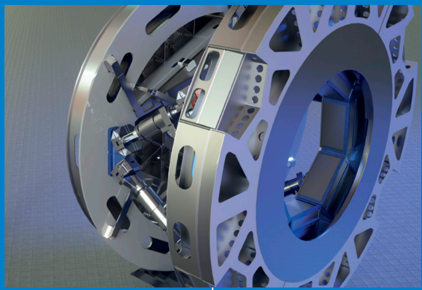
August 2019

The first 18 ELT primary mirror blanks are delivered to the French company Safran Reosc for polishing before they are cut into hexagons and receive a final precise polishing.



2023

First mirror segments polished.



2027 (planned)

M4 adaptive unit completed.

July 2022

Inauguration of the Paranal–Armazones solar power plant, which will supply renewable energy to the ELT.

2026 (planned)

Erection of the ELT dome completed.

2028 (planned)

Technical first light and first scientific observations conducted, aimed at demonstrating the ELT's capabilities.

2025 (planned)

Secondary mirror completed.

Tackling the **biggest cosmic challenges**

With the start of scientific operations targeted for 2028, ESO's Extremely Large Telescope will address many of the most pressing unsolved questions in astronomy. Thanks to its size and suite of front-line instruments, it may eventually revolutionise our perception of the Universe, much as Galileo's telescope did 400 years ago.

Artist's impression showing a view of the surface of the planet Proxima b orbiting the red dwarf star Proxima Centauri, the closest star to the Solar System.

Credit: ESO/M. Kornmesser

ESO's ELT may be the first telescope to enable us to identify life beyond the Solar System, at long last answering one of humanity's most fundamental questions.

The ELT will discover and study planets with masses as low as the Earth's in the habitable zone, by making precise measurements of the wobbling motion of stars perturbed by the planets in orbit around them. The ELT will also be able to obtain direct images of larger planets and via high-resolution spectroscopy characterise the atmospheres of transiting planets — and possibly find the telltale biomarkers indicating that there may be life present on those planets. ELT's suite of instruments will allow astronomers to probe the earliest stages in the formation of planetary systems and to study protoplanetary discs around stars in the making.

Exploring the history of the Universe

By probing the most distant objects, ESO's ELT will provide vital clues to help us understand the formation of the first objects in the Universe — primordial stars, primordial galaxies and black holes — and learn how they are related.

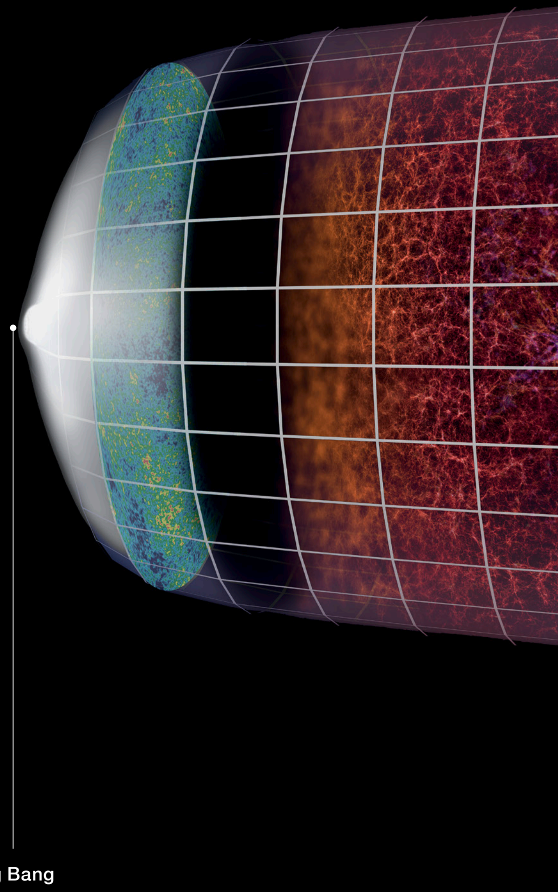
Studies of extreme objects like black holes will benefit from the power of the ELT to provide greater insight into time-dependent phenomena.

The ELT is designed to carry out detailed studies of the first galaxies and to follow their evolution through cosmic time.

ESO's ELT will be a unique tool for making an inventory of the changing abundances of the elements in the Universe with time, and for understanding the history of star formation in galaxies.

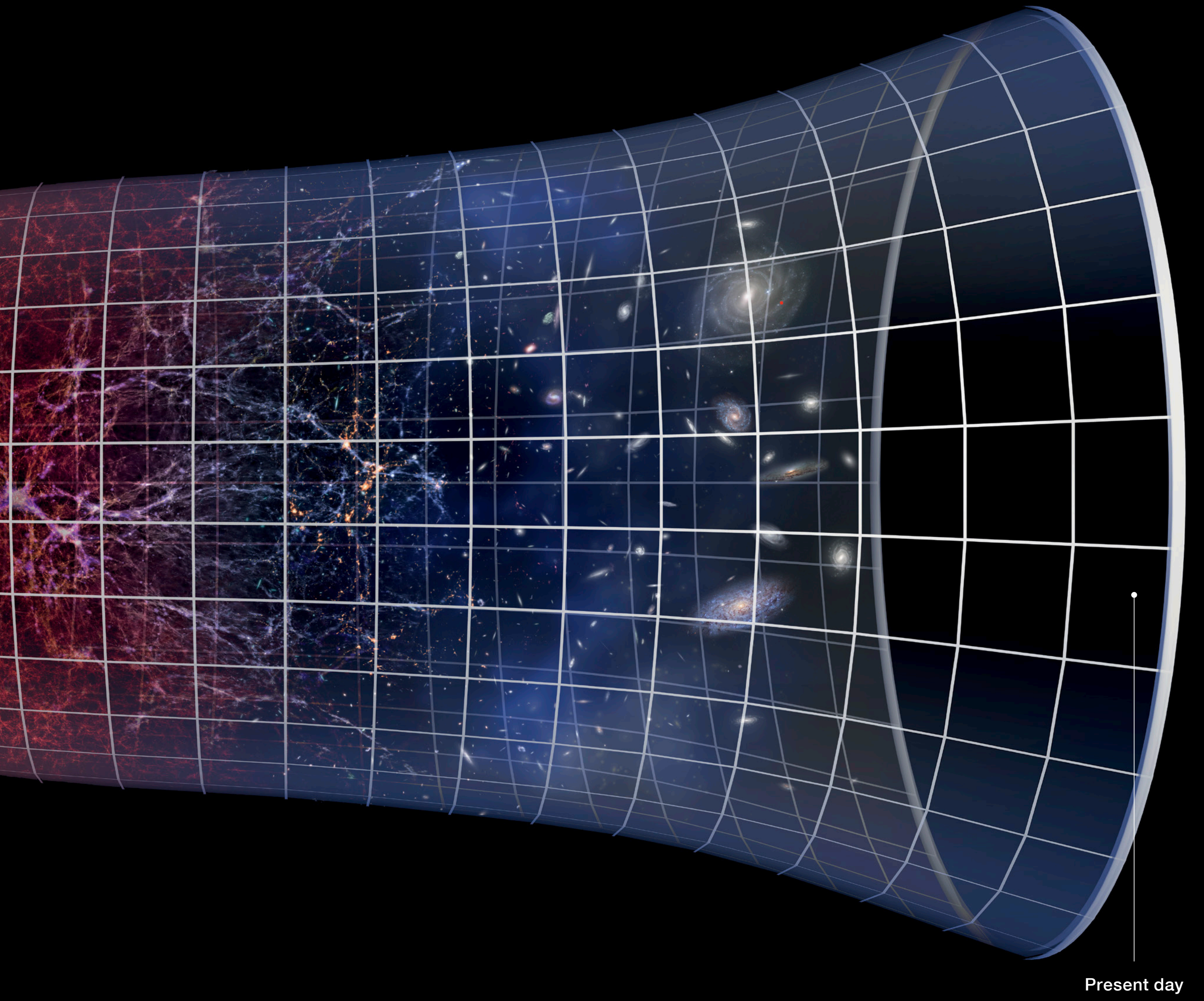
The ELT has the potential to make a direct measurement of the acceleration of the Universe's expansion, a measurement that would have a major impact on our understanding of the Universe.

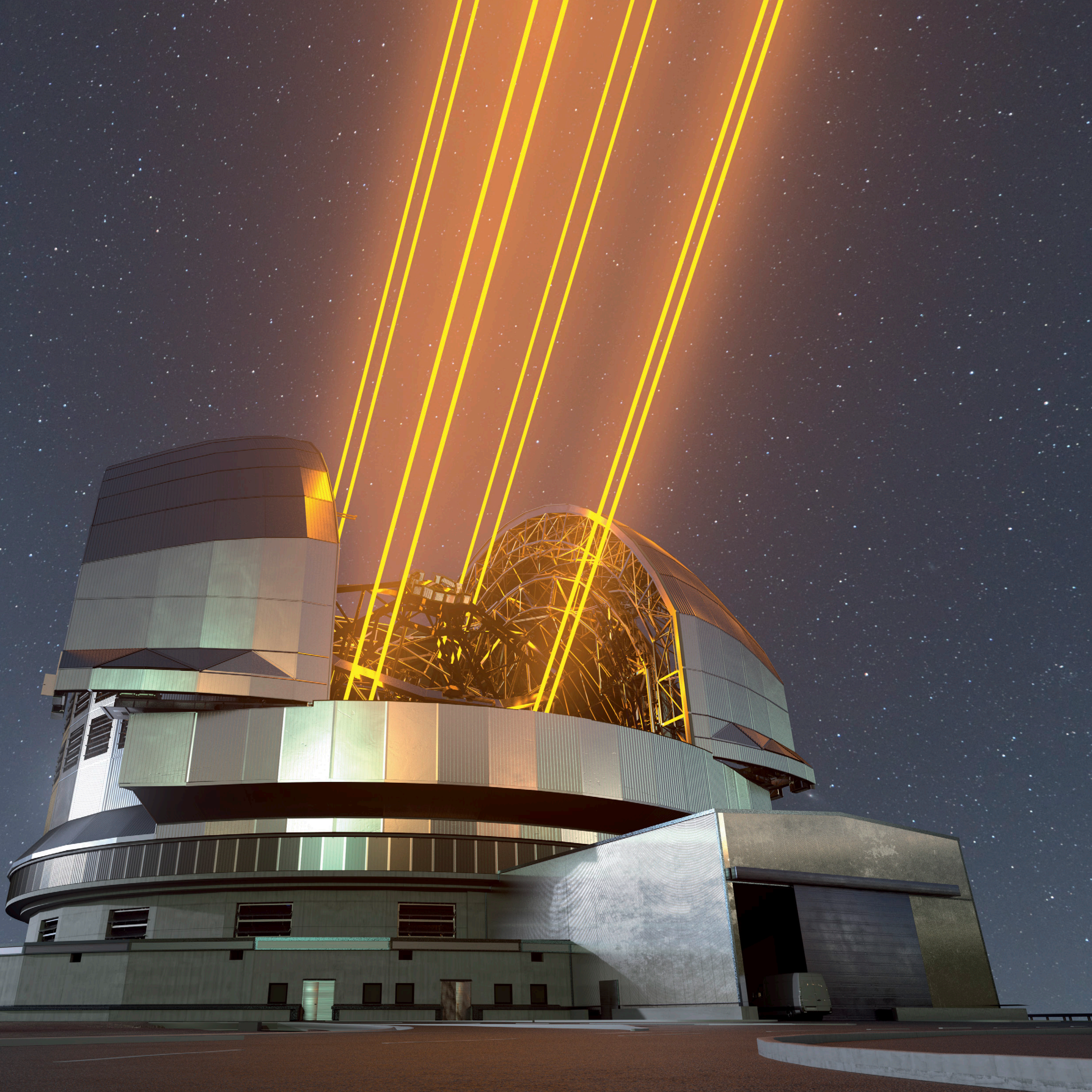
ESO's ELT will also search for possible variations with time of the fundamental physical constants. An unambiguous detection of such variations would have far-reaching consequences for the basic laws of physics.



Graphical representation of the Universe's evolution and expansion, from the Big Bang to the present day, spanning nearly 14 billion years.

Credit: ESO/M. Kornmesser


Present day



“I’m hoping that with the ELT we will be able to understand what our place in the Universe is in concrete terms – maybe finding the answer to whether we’re alone in the Universe.”

Amina Helmi, ESO Council Member,
Full Professor at Kapteyn Astronomical Institute, the Netherlands

European
Southern
Observatory

The European Southern Observatory (ESO) enables scientists worldwide to discover the secrets of the Universe for the benefit of all. We design, build and operate world-class observatories on the ground — which astronomers use to tackle exciting questions and spread the fascination of astronomy — and promote international collaboration in astronomy. An intergovernmental organisation supported by 16 Member States and two partner countries, ESO has headquarters in Germany and operates three observing sites in Chile.

European Southern Observatory

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