ESO Information Sheet

About ESO

ESO

European Organisation for Astronomical Research in the Southern Hemisphere

ESO. Astronomy made in Europe

About ESO

ESO is the foremost intergovernmental European Science and Technology organisation in the field of ground-based astrophysics. It is supported by 12 countries: Belgium, Denmark, France, Finland, Germany, Italy, the Netherlands, Portugal, Spain, Sweden, Switzerland and the United Kingdom. The Czech Republic is currently in the process of joining ESO. Further countries have expressed interest in membership.

Created in 1962, ESO provides state-of-the-art research facilities to European astronomers and astrophysicists. In pursuit of this task, ESO's activities cover a wide spectrum including the design and construction of world-class ground-based observational facilities for the member-state scientists, large telescope projects, design of innovative scientific instruments, developing new and advanced technologies, furthering Euro¬pean co-operation and carrying out European educational programmes.

ESO operates the La Silla Paranal Observatory at several sites in the Atacama desert region of Chile. The first site is at La Silla, a 2400 m high mountain 600 km north of Santiago de Chile. It is equipped with several optical telescopes with mirror diameters of up to 3.6 metres. The 3.5-m New Technology Telescope (NTT) was the first in the world to have a computer-controlled main mirror. Whilst La Silla remains one of the scientifically most productive observing sites in the world, the 2600 m high Paranal site with the Very Large Telescope array (VLT) is the flagship facility of European astronomy. Paranal is situated about 130 kmsouth of Antofagasta in Chile, 12km inland from the Pacific Coast in what is probably the driest area in the world. Scientific operations began in 1999 and have resulted in a high number of extremely successful research programmes. The VLT is a most unusual telescope, based on the latest technology. It is not just one, but an array of four telescopes, each with a main mirror of 8.2-m diameter. With one such telescope, images of celestial objects as faint as magnitude 30 have been obtained in a one-hour exposure. This corresponds to seeing objects that are four billion times fainter than what can be seen with the naked eye.
One of the most exciting features of the VLT is the possibility to use it as a giant optical interferometer (VLT Interferometer or VLTI). This is done by combining the light from several of the telescopes, including one or more of four 1.8-m moveable Auxiliary Telescopes, three of which are now in operation. In the interferomet¬ric mode, one can reach the resolution on the sky that would be obtained with a telescope of the size of the separation between the most distant of the combined mirrors.

In 2006, over 1700 proposals were made for the use of ESO telescopes. They have resulted in a large number of peer-reviewed publications. In 2006, 630 refereed papers were pub¬lished based on data from ESO telescopes.
The Atacama Large Millimetre Array (ALMA), one of the largest ground-based astronomy projects of the next decade, is a major new facility for world astronomy. ALMA will be comprised of a giant array of 54 12-m submillimetre quality antennas, with baselines of several kilometres. An additional array of twelve 7-m antennas is also foreseen. Con¬struction of ALMA started in 2003 and will be completed in 2012; it will become incrementally operational from 2010 on. ALMA is located on the high-altitude Llano de Chajnantor (5000 m elevation), east of the village of San Pedro de Atacama in Chile. The ALMA project is a partnership between Europe, Japan and North America in cooperation with the Republic of Chile. ALMA is funded in Europe by ESO, in Japan by the National Institutes of Natural Sciences in coopera¬tion with the Academia Sinica in Taiwan and in North America by the U.S. National Science Foundation in cooperation with the National Research Council of Canada. ALMA construction and operations are led on behalf of Europe by ESO, on behalf of Japan by the National Astronomical Observatory of Japan and on behalf of North America by the National Radio Astronomy Observatory, which is managed by Associated Universities, Inc.

The Chajnantor site is also home for the 12-m APEX submm/mm telescope, operated by ESO on behalf of the Onsala Space Observatory, the Max Planck Institute for Radio Astronomy and ESO itself.

ESO has built up considerable expertise in developing, integrating and operating large astronomical telescopes at remote sites. Together with the ideas developed in the framework of the OWL Conceptual Study and the EC co-funded Extremely Large Telescope Design Study, this expertise forms the backbone of the effort to develop a next generation extremely large ground-based optical/infrared telescope for Europe's astronomers. Currently known as the E-ELT, ESO has developed a basic reference design for a 42-m telescope with a novel 5-mirror optical concept. The current detailed design phase is scheduled to be completed by the end of 2009.

The ESO headquarters are located in Garching, near Munich, Germany. This is the scientific, technical and administrative centre of ESO where technical develop¬ment programmes are carried out to pro-vide the observatories with the most advanced instruments. It is also home for the Space Telescope – European Coordinating Facility (ST-ECF), operated jointly by ESO and the European Space Agency (ESA).

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The Very Large Telescope

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The Very Large Telescope

The Very Large Telescope array (VLT) is the flagship facility for European astronomy at the beginning of the 3rd Millennium.

It is the world's most advanced optical instrument, consisting of four Unit Telescopes with main mirrors of 8.2-m diameter and four movable 1.8-m Auxiliary Telescopes. The telescopes can work together, in groups of two or three, to form a giant 'interferometer', allowing astronomers to see details corresponding to a much larger telescope.
The 8.2-m Unit Telescopes can also be used individually. With one such telescope, images of celestial objects as faint as magnitude 30 can be obtained in a one-hour exposure. This corresponds to seeing objects that are 4 billion times fainter than what can be seen with the unaided eye.

The VLT instrumentation programme is the most ambitious programme ever conceived for a single observatory. It includes large-field multi-channel imagers, adaptive optics corrected cameras and spectrographs, as well as high-resolution and multi-object spectrographs and covers a broad spectral region, from deep ultraviolet (300 nm) to mid-infrared (20 μm) wavelengths. The 8.2-m Unit Telescopes are housed in compact, thermally controlled buildings, which rotate synchronously with the telescopes. This design minimises adverse effects on the observing conditions, for instance from air turbulence in the telescope tube, which might otherwise occur due to variations in the temperature and wind flow. The first of the Unit Telescopes, 'Antu', went into routine scientific operations on 1 April 1999. Today, all four Unit Telescopes and all four Auxiliary Telescopes are operational. Already, the VLT has made an unquestionable impact on observational astronomy.

Many Eyes, One Vision

Individual telescopes of the VLT observatory can be combined, by two or three, as the 'VLT Interferometer' (VLTI), so that they act as a single, giant telescope, as large as the entire group. Up to 25 times finer detail can be observed than with the individual telescopes.
In the VLT Interferometer, the light beams are combined using a complex system of mirrors in underground tunnels. To do this, the light paths must be kept equal to less than 1/1000 mm.
The VLTI can reconstruct images with an angular resolution of milliarcseconds, which means that in principle it could distinguish the two headlights of a car on the Moon.

Moving Telescopes

Although the four 8.2-m Unit Telescopes can be combined in the VLTI, most of the time these large telescopes are used for other purposes. They are therefore only available for interferometric observations for a limited number of nights every year. In order to exploit the VLTI each night, four smaller, dedicated 'Auxiliary Telescopes' (ATs) are available. The ATs are mounted on tracks and can be moved between precisely defined observing positions. From these positions, their light beams are combined in the VLTI. The ATs are very unusual telescopes. In their ultra-compact protective domes, they carry their own electronics, ventilation, hydraulics and cooling systems. Each AT has a transporter that lifts the telescope and moves it from one position to the other. Almost like a snail, it moves around with its own housing.

http://www.eso.org/projects/vlt/

"This is a tribute to the human genius. It is an extraordinary contribution to the development of knowledge, and as Commissioner for Research, I am proud that this is a European achievement."

Philippe Busquin,
European Commissioner for Research (2000-2005)

The Unit Telescope's Names

Following a contest among schoolchildren in the II Region of Chile, the main VLT telescopes (also known as the Unit Telescopes) were given names from the indigenous Mapuche language. Thus, the telescopes are called:
ANTU (UT1; The Sun)
KUEYEN (UT2; The Moon)
MELIPAL (UT3; The Southern Cross)
YEPUN (UT4; Venus – or 'evening star')

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About ESO

As set out in its convention, ESO provides state of the art facilities for Europe's astronomers and promotes and organises cooperation in astronomical research. Today, ESO operates some of the world's largest and most advanced observational facilities at three sites in Northern Chile: La Silla, Paranal and Chajnantor. These are the best locations known in the southern hemisphere for astronomical observations. With other activities such as technology development, conferences and educational projects, ESO also plays a decisive role in forming a European Research Area for astronomy and astrophysics.

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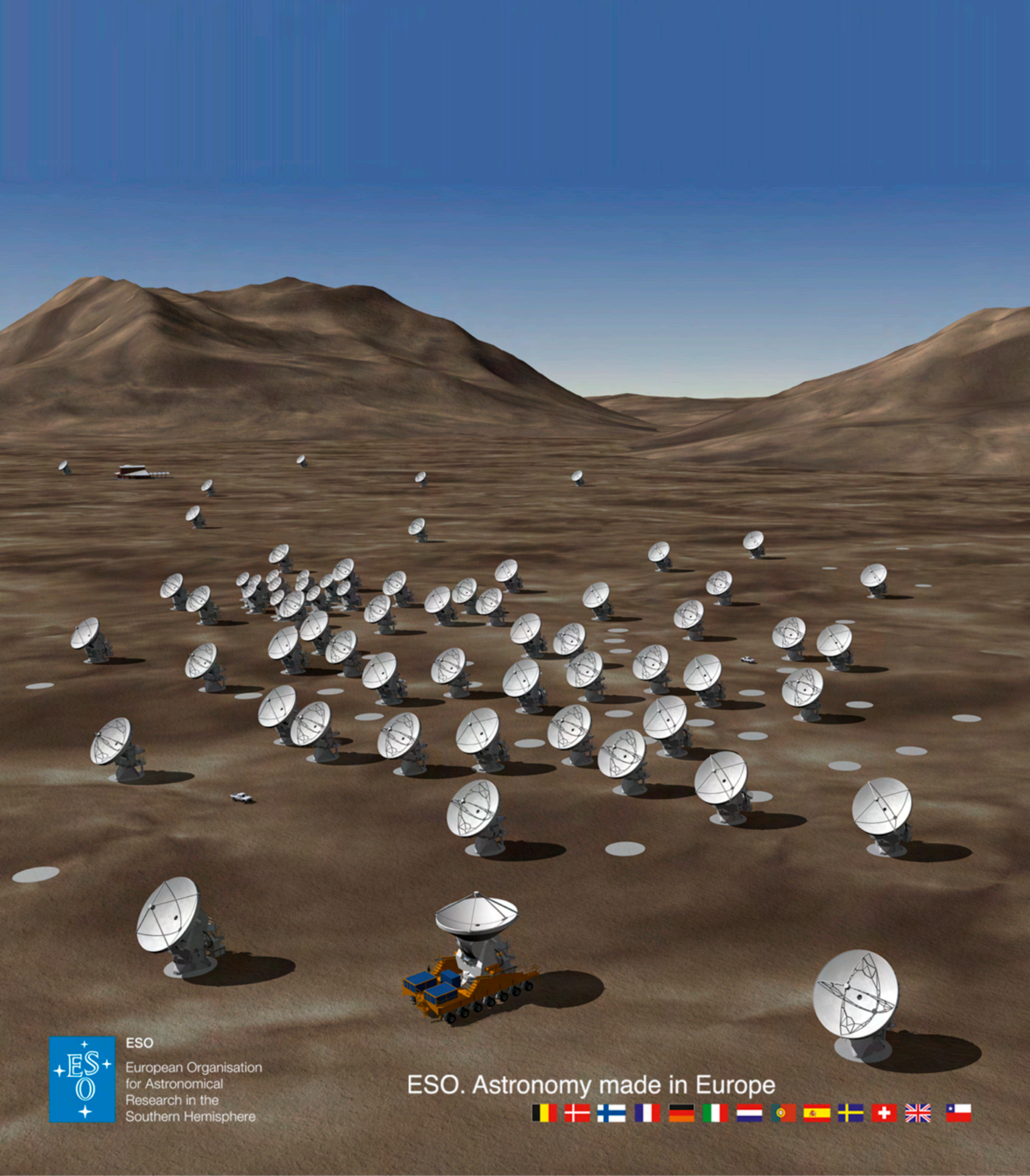
ALMA - The Atacama Large Millimeter Array



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ALMA - Exploring the cold Universe

High on the Chajnantor plateau in Chile's Atacama desert, ESO is building state-of-the-art telescopes to study light from some of the coldest objects in the Universe.

This light has wavelengths of around a millimetre, between infrared light and radio waves, and is therefore known as millimetre and submillimetre radiation.
Light at these wavelengths shines from vast cold clouds in interstellar space, at temperatures only a few tens of degrees above absolute zero, and from some of the earliest and most distant galaxies in the Universe. Astronomers can use it to study the chemical and physical conditions in molecular clouds – the dense regions of gas and dust where new stars are being born. Often, these regions of the Universe are dark and obscured in visible light, but they shine brightly in the millimetre and submillimetre part of the spectrum. Millimetre and submillimetre radiation opens a window into the enigmatic cold Universe, but the signals from space are heavily absorbed by water vapour in the Earth's atmosphere. This is why telescopes for this kind of astronomy must be built on high, dry sites, and why ESO has chosen the 5100 m high plateau at Chajnantor.

Here, together with its international partners, ESO is building ALMA, the Atacama Large Millimeter/submillimeter Array. The ALMA site is some 50 km east of San Pedro de Atacama in northern Chile, in the Atacama desert – one of the driest places on Earth. Astronomers find unsurpassed conditions for observing, but they must operate a frontier observatory under very difficult conditions. Chajnantor is more than 750 m higher than the observatories on Mauna Kea, and 2 300 m higher than the VLT on Cerro Paranal.

ALMA will be a single instrument, composed initially of 66 high-precision antennas, and operating at wavelengths of 0.3 to 10 mm. The main array will have fifty 12-m diameter antennas, acting together as a single telescope – an interferometer. The antennas can be moved across the desert plateau over distances from 150 metres to 15 kilometres, which will give ALMA a powerful variable 'zoom'. It will be able to probe the Universe at millimetre and submillimetre wavelengths with unprecedented sensitivity and resolution, with a vision up to ten times sharper than the Hubble Space Telescope, and complementing images made with the VLTI. ALMA will provide scientists with detailed images of stars and planets being born in gas clouds near our Solar System. It will also detect distant galaxies forming at the edge of the observable Universe, which we see as they were roughly ten billion years ago. ALMA will provide a window on celestial origins that encompasses both space and time, providing astronomers with a wealth of new scientific opportunities.

A Global Endeavour

The ALMA project is a partnership between Europe, Japan and North America in cooperation with the Republic of Chile. ALMA is funded in Europe by ESO, in Japan by the National Institutes of Natural Sciences in cooperation with the Academia Sinica in Taiwan and in North America by the U.S. National Science Foundation in cooperation with the National Research Council of Canada. ALMA construction and operations are led on behalf of Europe by ESO, on behalf of Japan by the National Astronomical Observatory of Japan and on behalf of North America by the National Radio Astronomy Observatory, which is managed by Associated Universities, Inc.

http://www.eso.org/projects/alma/

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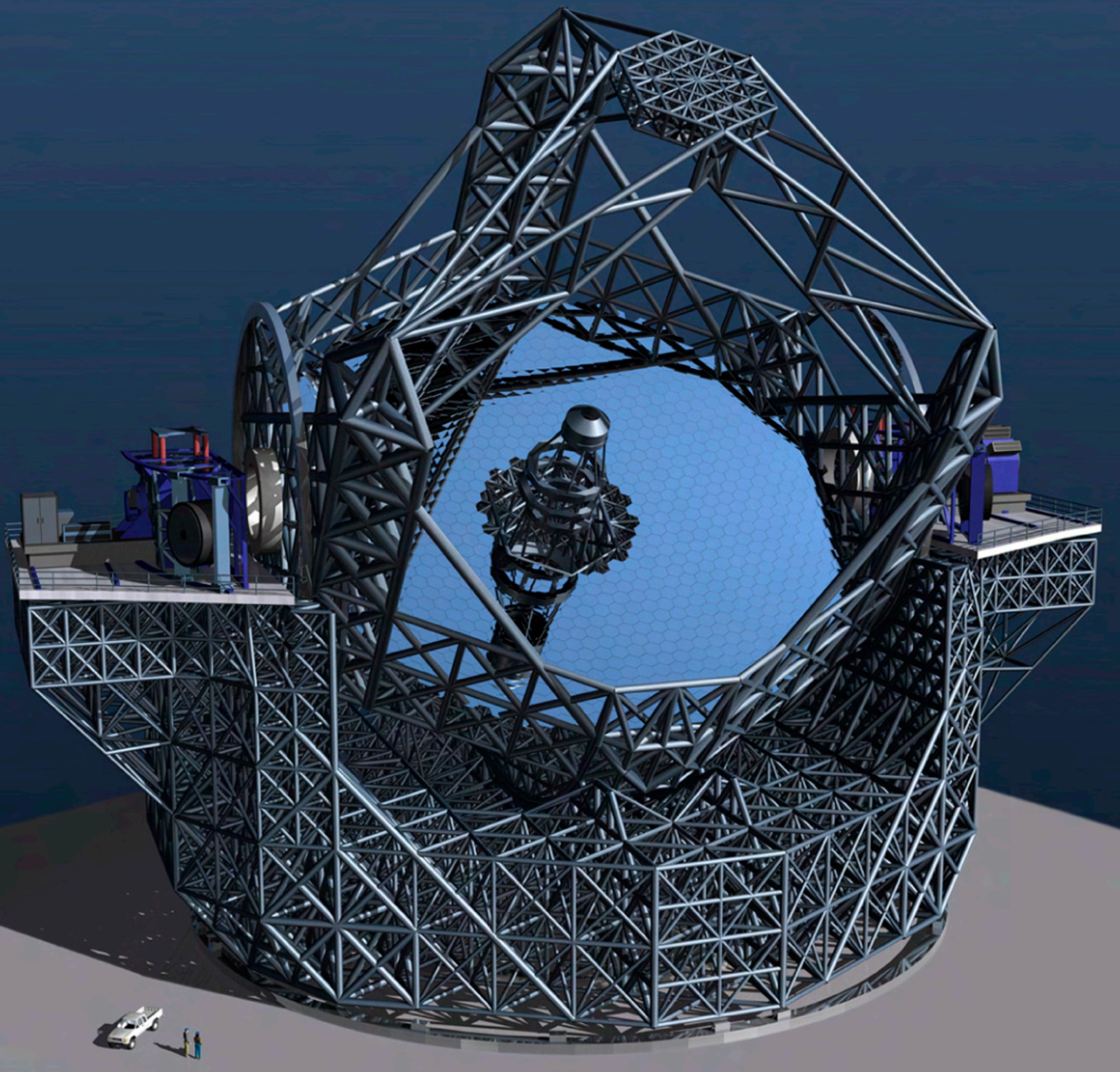
The European Extremely Large Telescope



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The European Extremely Large Telescope

The present generation of 8-10 m class telescopes, like the ESO VLT, allows astronomers to study the Universe in unprecedented ways, and leads to new, challenging research questions.
To address these questions, a new generation of Extremely Large Telescopes (ELT) with diameters of 30 m or more is currently being planned. Such telescopes may, eventually, revolutionise our perception of the Universe as much as Galileo's telescope did.
These future giants are expected to come into operation in the 2015-2020 timeframe. They will tackle the scientific challenges of their time, including peering at the 'Dark Ages' of our Universe – its first hundreds of millions of years – and tracking down Earth-like planets in the habitable zones around other stars.
ESO has built up considerable expertise in developing, integrating and operating large astronomical telescopes at remote sites. Furthermore, for several years ESO has been engaged in conceptual studies for an extremely large optical and infrared adaptive telescope.
This expertise forms the backbone of efforts to develop an Extremely Large Telescope for Europe's astronomers, known as E-ELT. With the basic reference design – a telescope with a 42-m segmented primary mirror - completed by the end of 2006, the final design of this facility has now begun with the aim of having the E-ELT observatory in operation around 2018. In parallel, crucial enabling technologies are being developed by a large consortium of European institutes and high-tech industrial firms within the ELT Design Study, with ESO and the European Commission as the main funders. With a diameter of 42 m and its adaptive optics concept, the E-ELT will be more than one hundred times more sensitive than the present-day largest optical telescopes, such as the 10-m Keck telescopes or the 8.2-m VLT telescopes.
Following an extensive international review in October 2005 of a first concept study –the OWL project – the ESO Project Offices conducted in 2006 a new study, produced with the help of more than 100 astronomers, to carefully evaluate performance, cost, schedule and risk. In November 2006, the results were subject to detailed discussions by more than 250 European astronomers at a conference in Marseille. Their enthusiastic welcome paved the way for the decision by the ESO Council to move to the crucial next phase of detailed design of the full facility. This final study is scheduled to last for three years, after which construction could start. The present estimated cost for the E-ELT is around 800 million euro.
The challenge of designing, constructing and operating a 30 to 60-m telescope is substantial. Extrapolating technical solutions for light collectors from a 10-m diameter to 30 m or more, while achieving an excellent image quality in a sizable field, poses numerous issues. ESO is working with more than thirty European scientific institutes and high-tech companies towards establishing key enabling technologies needed to make the ELT feasible at an affordable cost within the next 5-10 years. Two highly important aspects of the E-ELT's development are the control of high-precision optics over the huge scale of the telescope, and the design of an efficient suite of instruments that allow astronomers to achieve the E-ELT's ambitious science goals.
As far as instrumention is concerned, the goal is to create a flexible suite of instruments to deal with the wide variety of science questions astronomers would like to see resolved in the coming decades. The ability to observe over a large range of wavelengths from the optical to midinfrared, with multi-user instruments, will allow scientists to exploit the telescope's size to the full. Streamlined integration of the instruments with the active and adaptive control systems could be challenging. ESO will co-ordinate the development of around 5 first-generation instruments, at an estimated hardware cost of €86 million. This also requires a considerable investment in skilled human resources, and management of these projects over a host of collaborating institutions will be a challenge in itself. Only by tapping the intellectual resources all over Europe could this development be successful, as it has been for the VLT instrument suite.

A revolutionary concept

The present concept features as a baseline a 42-m diameter mirror telescope, and is revolutionary. The primary mirror is composed of 906 segments, each 1.45-m wide, while the secondary mirror is as large as 6-m in diameter. In order to overcome the fuzziness of stellar images due to atmospheric turbulence the telescope needs to incorporate adaptive mirrors into its optics, and a tertiary mirror, 4.2-m in diameter, relays the light to the adaptive optics system, composed of two mirrors: a 2.5-m mirror supported by 5000 or more actuators so as to be able to distort its own shape a thousand times per second, and one 2.7-m in diameter that allows for the final image corrections. This five mirror approach results in an exceptional image quality, with no significant aberrations in the field of view.

http://www.eso.org/projects/e-elt/

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