ESO

European
Southern
Observatory

A Universe of Discoveries

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About ESO

ESO, the European Southern Observatory, is the most scientifically productive observatory in the world. Established in 1962, ESO provides state-of-the-art research facilities to astronomers and astrophysicists and is supported by Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Italy, the Netherlands, Portugal, Spain, Sweden, Switzerland and the United Kingdom. Several other countries have expressed an interest in membership.

ESO Headquarters (comprising the scientific, technical and administrative centre of the organisation) is located in Garching, near Munich, Germany. In Chile, ESO operates, in addition to the main Vitacura office in Santiago, three world-class observational sites in the Chilean Atacama Desert. At La Silla, 600 kilometres north of Santiago and at an altitude of 2400 metres, ESO operates several medium-sized optical telescopes. The Very Large Telescope (VLT) is located on Paranal, a 2600-metre high mountain south of Antofagasta, which also hosts the VLT interferometer and two survey telescopes, the VST and VISTA. The third site is the 5000-metre high Llano de Chajnantor, near San Pedro de Atacama. Here a new submillimetre telescope (APEX) is in operation, and a giant array of 12-metre submillimetre antennas (ALMA) is being constructed in collaboration with East Asia, North America, and the Republic of Chile.

ESO is currently working on the plan for an Extremely Large optical/near-infrared Telescope, the E-ELT.

The annual member state contributions to ESO are approximately 135 million euros and ESO employs around 700 staff members.

"An almost unique level of international cooperation is achieved at ESO, and everything is done by those who can do it best, irrespective of their country or institution. This spirit of excellence is an example for all Europe."

Mrs Maria van der Hoeven,
Minister of Education, Culture and Science, the Netherlands

ESO and Astronomy

Astronomy is often described as the oldest science and there can be no doubt that a view out towards the majestic Milky Way as it stretches across the sky on a clear night must have been an awe-inspiring sight to people of all ages and cultures. Today, astronomy stands out as one of the most modern and dynamic of the sciences, using some of the most advanced technologies and sophisticated techniques available to scientists. These are exciting times for astronomy: technology now allows us to study objects at the far edge of the Universe and to detect evidence for planets around other stars. We can begin to answer a fundamental question that fascinates every one of us: are we alone in the Universe?

ESO is the pre-eminent intergovernmental science and technology organisation in astronomy. It carries out an ambitious programme focused on the design, construction and operation of powerful ground-based observing facilities for astronomy to enable important scientific discoveries.

ESO operates the La Silla Paranal Observatory at two sites in the Atacama Desert region of Chile. La Silla, a 2400-metre high mountain 600 kilometres north of Santiago de Chile, is home to several telescopes with mirror diameters of up to 3.6 metres. The flagship facility is the Very Large Telescope (VLT) on Paranal

mountain, whose design, instrument complement and operating principles set the standard for ground-based optical and infrared astronomy. The VLT interferometer (VLTI) enhances the capabilities of this unique facility even further, as do the VST (optical) and VISTA (near-infrared) survey telescopes.

Each year, about 2000 proposals are made for the use of ESO telescopes, requesting between four and six times more nights than are available. ESO is the most productive ground-based observatory in the world, which annually results in many peer-reviewed publications: in 2009 alone, about 700 refereed papers based on ESO data were published.

ESO is also the focal point for Europe's participation in the Atacama Large Millimeter/submillimeter Array (ALMA), an intercontinental collaboration with North America, East Asia and the Republic of Chile. The ALMA partners are constructing this unique facility at the high altitude site of Chajnantor in the Chilean Altiplano. ALMA will start scientific observations around 2011, and promises to be as transformational for science as the Hubble Space Telescope.

Beyond the VLT, the next step is to build an Extremely Large Telescope (E-ELT) with a primary mirror 42 metres in diameter. The E-ELT will be the world's biggest eye on the sky — the largest optical/near-infrared telescope. ESO has developed a pioneering new design, and is drawing up detailed construction plans together with the community. The E-ELT will provide our first ever images of Earth-like planets around other stars, which would be a truly remarkable milestone.

Tim de Zeeuw
ESO Director General

G. Hüdepohl/ESO

Understanding our World

Astronomers tackle key questions that challenge our minds and our imagination. How did the planets form? How did life develop on Earth, and is life ubiquitous in the Universe? How did galaxies form? What are dark matter and dark energy?

Astronomy is a modern, high-tech science that explores the space around us and attempts to explain the incredible processes that take place in this enormous volume. It studies our earliest beginnings and tries to predict the future of the Solar System, of the Milky Way galaxy and of the entire Universe.

Astronomy is a science of extreme conditions. It deals with the largest distances, the longest periods of time, the most massive objects, the highest temperatures, the strongest electric and magnetic fields, the highest and lowest densities and the most extreme energies known.

Astronomy is a physical science that is based on observations. With the exception of some of the celestial bodies in the Solar System, we cannot touch the objects that we investigate. We interpret the observed phenomena by applying our knowledge of the natural laws.

To enable these observations, astronomy employs some of the most sophisticated instruments and methods ever conceived by humans. High technology plays a very important role in astronomy.

Astronomy is an integral part of our culture and is a powerful representation of our inherent curiosity and desire to know our surroundings better. Now that we have explored most of the Earth's surface, astronomy deals with the vast "Terra Incognita" that surrounds us.

It contributes to a better understanding of our fragile environment and the extraordinary chance that life is possible on Earth. Through astronomy we have been led to appreciate how precarious our position in the Universe really is.

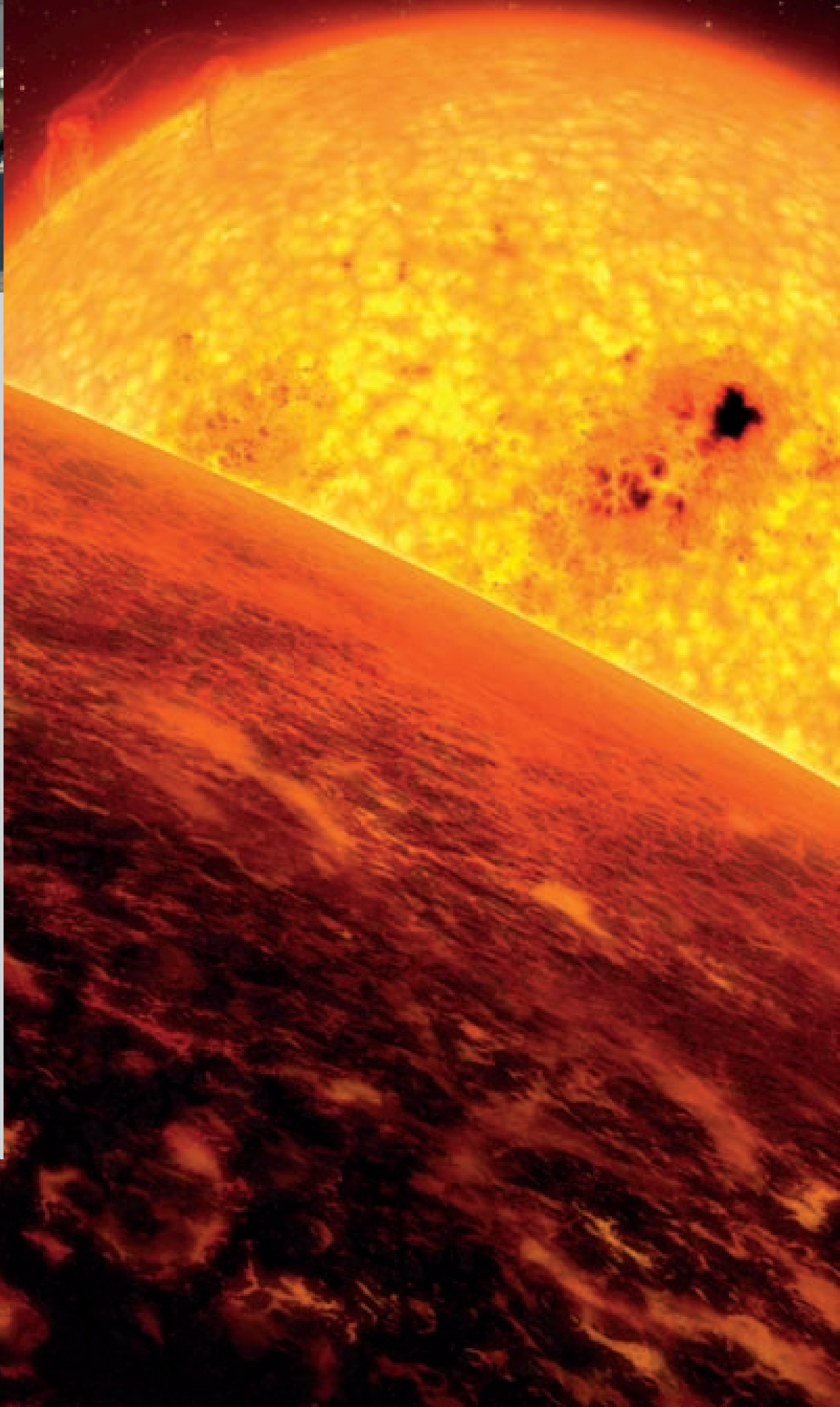
It also provides the necessary framework for future expeditions and possible subsequent expansion of the human race through space. By investigating the conditions out there, we set the tasks for future generations.

Observing distant galaxies means looking back in time — sometimes almost to the beginning of the Universe itself, when time began. It means studying how the Universe has evolved, how stars and planets formed, including the Earth. Astronomy is the study of origins. It is also the study of apocalyptic events. And great mysteries. Most of all, however, it is humanity's boldest attempt to understand the world in which we live.

Unravelling Cosmic Secrets

People at ESO: Christophe Dumas, Astronomer and Head of the Paranal Science Operations Department

"After graduating as electronics engineer from the French school Supelec, I decided to follow my main interest and become an astronomer. Before joining ESO I first worked in Hawaii to obtain my PhD in astrophysics and then at the NASA–JPL in California. My science interest lies in studying the small and primitive objects in the Solar System (asteroids, comets, and trans-Neptunians) to investigate the processes at stake in the formation of the terrestrial and giant planets, the origin of water on Earth, and what makes planets able to sustain life as we know it. For this I started to use adaptive optics, which allows us to make remote geological studies of these distant objects. This led me to work on searching for exoplanets and I am glad that I was member of the team that took the first image of an exoplanet with the VLT. In fact, I was the one taking the image at the telescope! I am also very proud as this image is now used as an illustration in many science magazines and textbooks. It really feels like we, at the VLT, are working at the ultimate frontier of science. With the laser guide star facility, adaptive optics has now become ever more powerful. SPHERE, the next generation exoplanet finder at the VLT will open the way to even further progress in this field, but for me the ultimate goal is to use the E-ELT to image an Earth-like planet around a star similar to the Sun."



Looking for Other Worlds

ESO telescopes provide the data for many results and breakthroughs in astronomy, and lead to a large number of scientific publications each year. Astronomers use these state-of-the-art observatories to study objects from within the Solar System to the furthest reaches of the Universe. Here, we join them on a journey through the cosmos, highlighting just some of the discoveries made at ESO.

The search for planets outside the Solar System constitutes a key element of what is possibly the most profound question for humanity: is there life elsewhere in the Universe? ESO's observatories are equipped with a unique arsenal of instruments for finding, studying and monitoring these exoplanets.

Using the Very Large Telescope, astronomers were able to spot the faint glow of a planet orbiting another star for the first time, taking the first-ever picture of an exoplanet. This new world is a giant one, some five times more massive than Jupiter. This observation marks a first major step towards one of the most important goals of modern astrophysics: to characterise the physical structure and chemical composition of giant and, eventually, Earth-like planets.

One of the telescopes at La Silla, using an innovative technique known as microlensing, worked as part of a network of telescopes scattered across the globe. This collaboration discovered a new exoplanet that is only about five times as massive as the Earth. Circling its parent star in about ten years, it most certainly has a rocky/icy surface.

With HARPS, the High Accuracy Radial velocity Planet Searcher, astronomers have discovered no fewer than four planets orbiting a nearby star with masses below that of Neptune, including a planet with twice the mass of the Earth — the smallest ever discovered — and a planet seven times the mass of the Earth that resides in its star's habitable zone. This planet orbits its host star in about 66 days and astronomers think that it is covered by oceans — a waterworld. This discovery marks a groundbreaking result in the search for planets that could support life.

"The tiny signals discovered by HARPS could not have been distinguished from 'simple noise' by most of today's available spectrographs."

Michel Mayor, Geneva Observatory, co-discoverer of the first exoplanet

"The spectra obtained of this comparatively faint star are absolutely superb — indeed of a quality which until recently was reserved for naked-eye stars only. Despite its faintness, the uranium line can therefore be measured with very good accuracy."

Roger Cayrel, Paris Observatory

Very Old Stars

Teams of astronomers have used the Very Large Telescope to perform unique measurements that pave the way for an independent determination of the age of the Universe. They measured the amount of the radioactive isotope uranium-238 in a star that was born when the Milky Way was still forming.

Like carbon-dating in archaeology, but over much longer timescales, this uranium clock measures the age of the star. It shows that the oldest star is 13.2 billion years old. Since the star cannot be older than the Universe itself, the Universe must be even older than this. This agrees with what we know from cosmology, which gives an age of the Universe of 13.7 billion years. The star, and our galaxy, must have formed very soon after the Big Bang.

Another result pushes astronomical technology to its limits, and throws new light on the earliest times in the Milky Way. Astronomers made the first ever measurement of the beryllium content in two stars in a globular cluster. With this, they studied the early phase between the formation of the very first stars in the Milky Way and those of this stellar cluster. They found that the first generation of stars in the Milky Way must have formed soon after the end of the Dark Ages that lasted for 200 million years after the Big Bang.

A Black Hole at the Centre of our Galaxy

People at ESO: Lucie Jílková, Student at ESO Vitacura

"I spent the first year of my PhD at Masaryk University in Brno in the Czech Republic, and I will go back there to finish my studies, after spending two years at ESO Chile. I have, until now, always preferred theory to observations, but I came to ESO to see if this holds true in a top-class environment. This is one of the reasons why I chose the ESO studentship in Santiago: to truly experience and learn more observational astronomy. In my thesis topic, I am analysing in detail the structure and motions of our little corner of the Milky Way galaxy, by studying the orbits of young open clusters. For this research I plan to use, among others, data from the FLAMES instrument at the VLT. Obtaining and processing this data will be a big challenge for me and I am looking forward to this new kind of work. Apart from the unique working experience and international collaboration I enjoy here at ESO, I am also glad to study in Chile, an amazing country, with breathtaking mountainous landscapes — so different from my home country in the heart of Europe."

The centre of the Milky Way galaxy.

What lies at the centre of the Milky Way? Astronomers have suspected that a black hole lurks at the heart of our galaxy for a long time, but could not be sure. After 16 years of regular monitoring of the Galactic Centre with ESO telescopes at the La Silla Paranal Observatory, scientists have finally obtained conclusive evidence.

Stars at the centre of the Milky Way are so densely packed that special imaging techniques such as adaptive optics (see page 25) were needed to boost the resolution of the VLT. Astronomers were able to watch individual stars with unprecedented accuracy as they moved around the Galactic Centre. Their paths conclusively showed that they must be orbiting in the immense gravitational grip of a supermassive black hole, almost three million times more massive than the Sun.

The VLT observations also revealed flashes of infrared light emerging from the region at regular intervals. Whilst the exact cause of this phenomenon remains unknown, observers have suggested that the black hole may be spinning rapidly. Whatever is happening, the black hole's life is not all peace and quiet.

Astronomers also use the VLT to peer into the centres of galaxies beyond our own, where they again find clear signs of supermassive black holes. In the active galaxy NGC 1097, they could see the intricate detail of a complex network of filaments spiralling down to the centre of the galaxy and possibly providing, for the first time, a detailed view of the process that channels matter from the main part of the galaxy down to its demise in the nucleus.

The central parts of the active galaxy NGC 1097.

"We needed even sharper images to settle the issue of whether any configuration other than a black hole is possible and we could count on the ESO VLT to provide those. Now the era of observational black hole physics has truly begun!"

Reinhard Genzel,
Director of the Max-Planck Institute for Extraterrestrial Physics

Gamma-ray Bursts

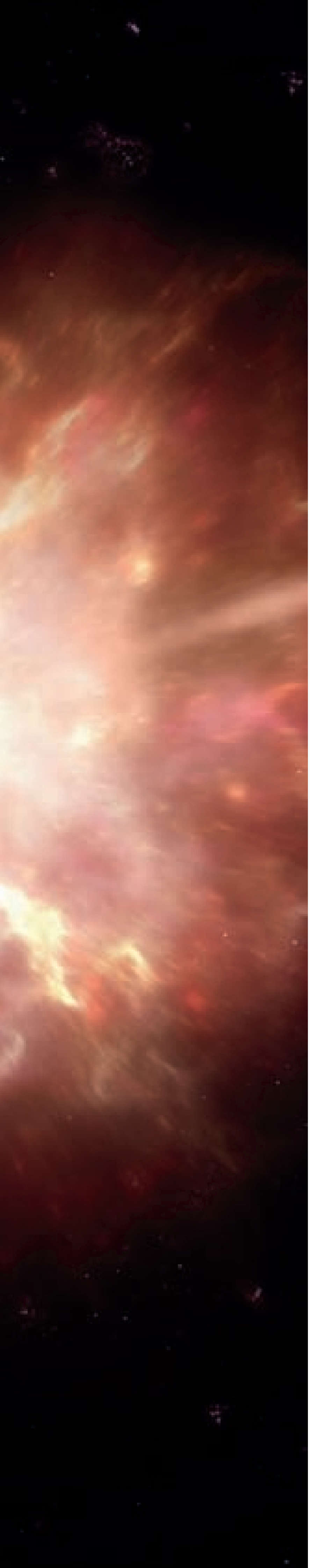
Gamma-ray bursts (GRBs) are bursts of highly energetic gamma rays lasting from less than a second to several minutes — the blink of an eye on cosmological timescales. They are known to occur at huge distances from Earth, towards the limits of the observable Universe.

The VLT has observed the afterglow of a gamma-ray burst that is the furthest known. With a measured redshift of 8.2, the light from this very remote astronomical source has taken more than 13 billion years to reach us. It is thus seen when the Universe was about 600 million years old, or less than five per cent of its present age. In just a few seconds it must have released 300 times as much energy as our Sun will in its entire lifetime of more than ten billion years. GRBs are the most powerful explosions in the Universe since the Big Bang.

Researchers have long tried to discover the nature of these explosions. Observations show that GRBs come in two types — short-duration (shorter than a few seconds), and long-duration — and it was suspected that two different kinds of cosmic event caused them.

In 2003, astronomers using ESO telescopes played a key role in linking long-duration GRBs with the ultimate explosions of massive stars, known as hypernovae. By following the aftermath of an explosion for a whole month, they showed that the light had similar properties to that from a supernova, caused when a massive star explodes at the end of its life.

In 2005, ESO telescopes detected, for the first time, the visible light following a short-duration burst. By tracking this light for three weeks, astronomers showed that the short-duration bursts — unlike the long-duration ones — could not be caused by a hypernova. Instead, it is thought that they are caused by the violent mergers of neutron stars or black holes.



ESO’s Top 10 Astronomical Discoveries

1 Accelerating Universe

Two independent research teams have shown that the expansion of the Universe is accelerating — based on observations of exploding stars with astronomical telescopes at La Silla.

2 First image of an exoplanet

The VLT has obtained the first-ever image of a planet outside the Solar System. The planet has five times the mass of Jupiter and orbits a failed star — a brown dwarf — at a distance of 55 times the mean Earth–Sun distance.

3 Stars orbiting the Milky Way black hole

Several of ESO’s flagship telescopes were used in a study lasting 16 years to obtain the most detailed view ever of the surroundings of the monster lurking at the heart of our galaxy — a supermassive black hole.

4 The gamma-ray burst–supernova connection

ESO telescopes have provided definitive proof that long gamma-ray bursts are linked with the ultimate explosion of massive stars, solving a long-time puzzle.

5 The motion of stars in the Milky Way

After more than 1000 nights of observations at La Silla, spread over 15 years, astronomers have determined the motions of more than 14 000 Sun-like stars residing in the neighbourhood of the Sun, showing that our home galaxy has led a much more turbulent and chaotic life than previously assumed.

6 Oldest star known in the Milky Way

Using ESO’s VLT, astronomers have measured the age of the oldest star known in our galaxy, the Milky Way. At 13.2 billion years old, the star was born in the earliest era of star formation in the Universe.

7 Merging neutron star—gamma-ray burst connection

A telescope at La Silla was able to observe the visible light from a short gamma-ray burst for the first time, showing that this family of objects most likely originated from the violent collision of two merging neutron stars.

8 Cosmic temperature independently measured

The VLT has detected carbon monoxide molecules in a galaxy located almost 11 billion light-years away for the first time, a feat that had remained elusive for 25 years. This has allowed astronomers to obtain the most precise measurement of the cosmic temperature at such a remote epoch.

9 Most distant object measured

The Very Large Telescope has obtained the spectral signature of the earliest, most distant known object in the Universe, seen only about 600 million years after the Big Bang.

10 Lightest exoplanet found

The HARPS spectrograph helped astronomers discover a system containing the lightest exoplanet — only about twice the mass of our Earth — as well as a planet located within the habitable zone, where liquid water oceans could exist.

Supporting Europe's Astronomers

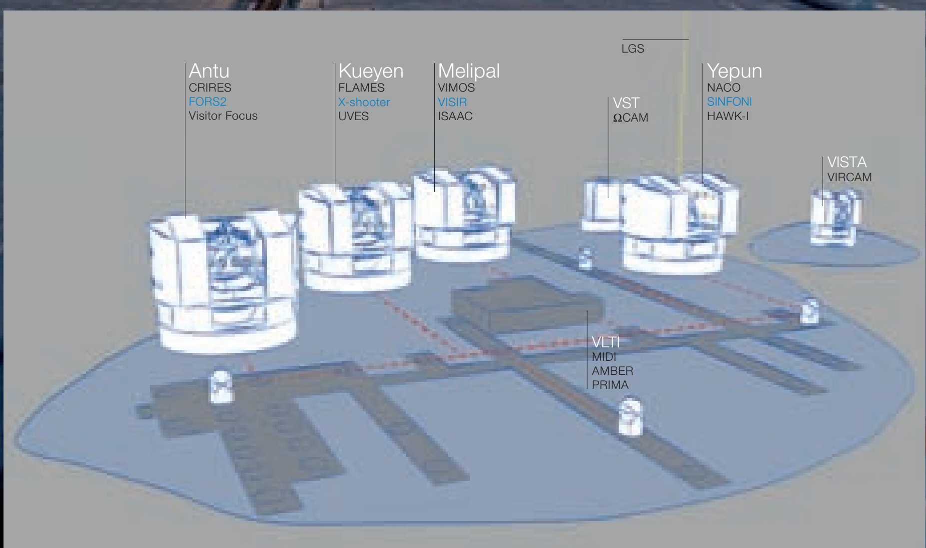
As set out in its convention, ESO provides state-of-the-art facilities for Europe's astronomers and promotes and organises cooperation in astronomical research. Today, ESO operates some of the world's largest and most advanced observational facilities at three sites in northern Chile: La Silla, Paranal 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.

"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)

Paranal

The Very Large Telescope array is the flagship facility for European astronomy at the beginning of the third millennium.



Instruments on the Very Large Telescope.

The VLT is the world's most advanced optical instrument, consisting of four Unit Telescopes with main mirrors 8.2 metres in diameter and four movable 1.8-metre Auxiliary Telescopes that can combine to form an interferometer.

The 8.2-metre 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 four billion times fainter than 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 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-metre 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 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. The VLT has already made an immense impact on observational astronomy. It is the most productive individual ground-based facility, and results from the VLT have led to the publication of an average of more than one peer-reviewed scientific paper per day.

People at ESO: Karla Aubel, Telescope and Instrument Operator at Paranal

"I came to ESO in 2001, while still doing my thesis to become a Physics Engineer. I first worked at La Silla, using my days off work to complete my thesis, and came to the VLT in 2005. From a young age, I have been curious about things, trying to find answers, and I thought physics was the way to go. Piloting the VLT, providing the best image quality, the finest tracking, and staying alert all night long, is my way of contributing to the astronomers' attempts to solve the mysteries of the Universe. And in the winter, with night shifts that are 14 hours long, this can be a tough job! But I like it. And when I see a report in the press about a discovery made by the VLT, I can't but think that I have been part of it. It really feels good and makes you realise that you are part of something important!"

Many Eyes, One Vision

Individual telescopes of the VLT observatory can be combined, in groups of two or three, to form a giant VLT interferometer (VLTI), allowing astronomers to see details up to 25 times finer than with the individual telescopes, and to study celestial objects in unprecedented detail. It is possible to see details on the surfaces of stars and even to study the environment close to a black hole.

The light beams are combined in the VLTI using a complex system of mirrors in underground tunnels, where the light paths must be kept equal to distances of less than 1/1000 millimetres over a 100 metres.

With this kind of precision the VLTI can reconstruct images with an angular resolution of milliarcseconds, including one of the sharpest images ever of a star, with a spatial resolution of only 4 milliarcseconds, equivalent to picking out the head of a screw on the International Space Station, 400 kilometres above us in orbit, from the ground.

Instruments for the Very Large Telescope Interferometer

VINCI:	VLT INterferometer Commissioning Instrument
AMBER:	Near-infrared instrument for photometric and spectroscopic studies
MIDI:	Mid-Infrared instrument for photometry and spectroscopy
PRIMA:	Instrument for Phase-Referenced Imaging and Microarcsecond Astrometry of particular interest for reaching fainter sources and searching for exoplanets

Moving Telescopes

Although the four 8.2-metre Unit Telescopes can be combined in the VLTI, most of the time these large telescopes are used for other purposes and so are only available for interferometric observations for a limited number of nights every year.

In order to exploit the power of 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, light beams are reflected from the AT mirrors and combined in the VLTI.

The ATs are very unusual telescopes — self-sufficient in their ultra-compact protective domes, they carry their own electronics, ventilation, hydraulics and cooling systems, and have their own transporter that lifts the telescope and moves it from one position to the other.

VISTA has a main mirror that is 4.1 metres across and is by far the largest telescope in the world dedicated to surveying the sky at near-infrared wavelengths. VISTA's operational synergy with the rest of the Paranal Observatory is beautifully illustrated in this photo.

G. Hüdepohl/ESO

Survey Telescopes

Two new and powerful telescopes — the Visible and Infrared Survey Telescope for Astronomy (VISTA) and the VLT Survey Telescope (VST) — are sited at ESO's Paranal Observatory in northern Chile. They are arguably the most powerful dedicated imaging survey telescopes in the world and will hugely increase the scientific discovery potential of the Paranal Observatory.

Many of the most interesting astronomical objects — from tiny, but potentially dangerous, near-Earth asteroids to the most remote quasars — are rare. Finding them is like looking for a needle in a haystack. The largest telescopes, such as ESO's Very Large Telescope and the NASA/ESA Hubble Space Telescope, can only study a minute part of the sky at any one time, but VISTA and the VST are designed to photograph large areas quickly and deeply. The two telescopes will spend most of their first five years performing a total of nine carefully designed surveys and will create vast archives of both images and catalogues of objects that will be harvested by astronomers for decades to come.

The surveys will produce science directly, and in addition, interesting objects discovered by the survey telescopes will form targets for detailed study both by the neighbouring VLT and by other telescopes on Earth and in space. Both survey telescopes are housed in domes close to the VLT and share the same exceptional observing conditions as well as the same highly efficient operational model.

VISTA has a main mirror 4.1 metres across and is the largest telescope in the world dedicated to surveying the sky. At the heart of VISTA is a 3-tonne camera containing 16 special detectors sensitive to infrared light with a combined total of 67 megapixels. It has the widest coverage of any astronomical near-infrared camera. VISTA became fully operational in 2009.

The VST is a state-of-the-art 2.6-metre telescope equipped with OmegaCAM, a monster 268-megapixel CCD camera with a field of view four times the area of the full Moon. It complements VISTA and will survey the visible-light sky.

The VST is the result of a joint venture between ESO and the Capodimonte Astronomical Observatory (OAC) of Naples, a research centre of the Italian National Institute for Astrophysics (INAF). The VST is expected to become operational at Paranal in 2011.

La Silla

The HARPS instrument.

The La Silla Observatory, 600 kilometres north of Santiago de Chile and at an altitude of 2400 metres, has been an ESO stronghold since the 1960s. Here, ESO operates some of the most productive 4-metre-class telescopes in the world.

The 3.5-metre New Technology Telescope (NTT) broke new ground for telescope engineering and design and was the first in the world to have a computer-controlled main mirror (active optics), a technology developed at ESO and now applied to the VLT and most of the world's current large telescopes.

Elsewhere at La Silla, the ESO 3.6-metre telescope has been in operation since 1977. Following major upgrades, it remains in the frontline among the 4-metre-class telescopes in the southern hemisphere.

It is home to the world's foremost exoplanet hunter: HARPS (High Accuracy Radial velocity Planet Searcher), a spectrograph with an unrivalled precision.

The infrastructure of La Silla is also used by many of the ESO member states for targeted projects such as the Swiss 1.2-metre Leonhard Euler telescope, the Rapid Eye Mount (REM) and TAROT gamma-ray burst chasers, as well as more standard user facilities such as the MPG/ESO 2.2-metre and the Danish 1.54-metre telescopes. The 67-million pixel Wide Field Imager on the MPG/ESO 2.2-metre telescope has taken many amazing images of celestial objects, some of which have now become icons in their own right.

ESO/Y. Beletsky

Spearheading New Technologies

People at ESO: Françoise Delplancke, VLTI Instrumentation Physicist

"My first impression of Cerro Paranal in the middle of the Atacama desert in Chile, after more than twenty hours of travel from Munich, was that I had landed on the planet Mars. The observatory that ESO has built in this hostile environment is a comfortable oasis equipped with the most advanced technologies in astronomy and operated by very professional and friendly people. The sky is so clear here that even with the naked eye you can distinguish the bluish and reddish colours of some stars in the Milky Way, a dream for an amateur astronomer living in a light-polluted European city. For the same reason, after staying an hour outside at night, you can see the surrounding landscape quite well in the starshine even without the light of the Moon. Once I had the rare chance to look through one of the UTs of Paranal at the Moon with my own eyes: I had the feeling of flying above its surface in a spacecraft."

From the start, the VLT was conceived as a formidable science machine — taking advantage of the latest technological developments.

Adaptive optics (AO) is a technique that allows the instruments on telescopes to overcome the blurring effect of the atmosphere, producing images that are as sharp as if taken from space. This allows fainter objects to be observed, and in finer detail. With AO, the telescope can, in principle, reach its diffraction limit — the best resolution theoretically possible. A VLT instrument would then be able to read a newspaper headline at a distance of more than 10 kilometres.

In order to work, AO needs a nearby reference star that is relatively bright, and this limits which parts of the sky can be observed. To overcome this limitation, a VLT Unit Telescope has recently been equipped with a powerful laser that can create an artificial star in the sky, where and when astronomers need it.

To make the VLT more efficient for interferometry, each Unit Telescope has been equipped with its own specially designed AO instrument, MACAO, which focuses light from distant objects into the narrowest beams possible.

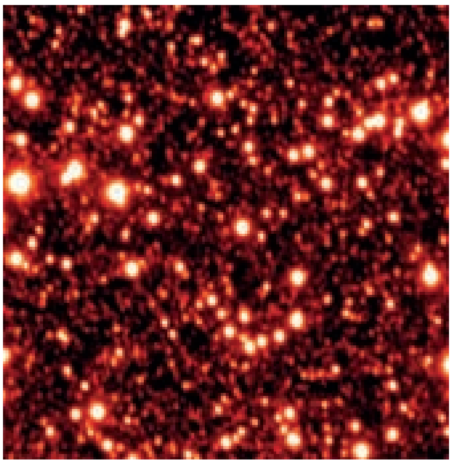
With seven AO systems installed so far, a laser guide star and the option to combine two or three telescopes for interferometry, the VLT is truly the world's most advanced ground-based observatory.

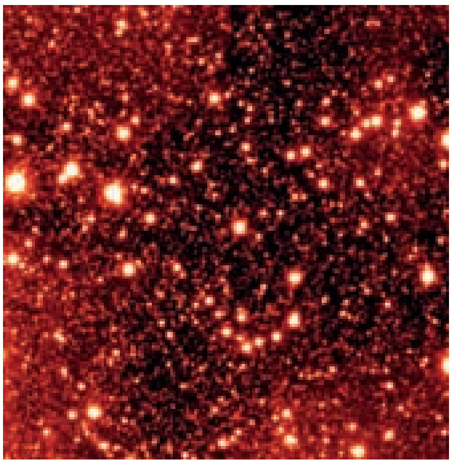
Together with several European institutes, ESO is now developing the next generation of adaptive optics facilities for the VLT, such as the SPHERE instrument. The SPHERE extreme adaptive optics facility will be dedicated to the direct imaging and characterisation of giant gas planets outside our Solar System with masses down to one Jupiter mass. This is an important step toward the detection and characterisation of potentially life-bearing Earth-like planets with the future European Extremely Large Telescope.

The VLT Laser Guide Star Facility

A laser guide star facility for use with the NACO and SINFONI AO instruments is currently in use at the VLT. With this system a powerful laser beam is projected onto the 90-kilometres high sodium layer in the Earth's atmosphere, creating an artificial "star". This star is used by the adaptive optics systems to measure and compensate for atmospheric turbulence effects almost anywhere in the sky.

The laser guide star facility is a collaborative project between ESO, the Max-Planck-Institut für extraterrestrische Physik in Garching, Germany (MPE) and the Max-Planck-Institut für Astronomie in Heidelberg, Germany (MPIA).





Comparison between an image obtained without (left) and with adaptive optics (right).

VLT Image Gallery

The VLT is a unique science machine at the forefront of astronomical research. It also produces astonishing and beautiful images of celestial objects, as shown in this gallery.

1 Majestic Spiral Galaxy NGC 7424

The beautiful multi-armed spiral galaxy NGC 7424 is about 40 million light-years away in the constellation of Grus (the Crane), and is seen almost directly face on. The galaxy is roughly 100 000 light-years across — quite similar in size to our own Milky Way.

2 The Horsehead Nebula

This image shows the famous Horsehead Nebula, which is situated about 1400 light-years away in the Orion molecular cloud complex. It is a dust protrusion in the southern region of the dense dust cloud Lynds 1630, on the edge of the H II region IC 434.

3 Stellar Nursery NGC 3603

NGC 3603 is a starburst region in our Milky Way: a cosmic factory where stars form frantically from the nebula's extended clouds of gas and dust.

4 The Pillars of Creation

This mosaic image of the Eagle Nebula (Messier 16) is based on 144 individual images. At the centre, is the star-forming region known as the Pillars of Creation.

5 Planet Jupiter

This sharpest whole-planet picture of Jupiter ever taken from the ground was obtained with the Multi-Conjugate Adaptive Optics Demonstrator (MAD) prototype instrument mounted on ESO's Very Large Telescope (VLT). The amazing image reveals changes in Jupiter's smog-like haze, probably in response to a planet-wide upheaval that took place more than a year ago.

6 The Irregular Galaxy NGC 1427A

NGC 1427A is an example of a dwarf irregular galaxy. In this particular case, the shape of the galaxy has been forged by its rapid, upwards motion through the cluster: with a speed of two million kilometres per hour relative to the cluster, NCG 1427A is being torn apart and will eventually be disrupted.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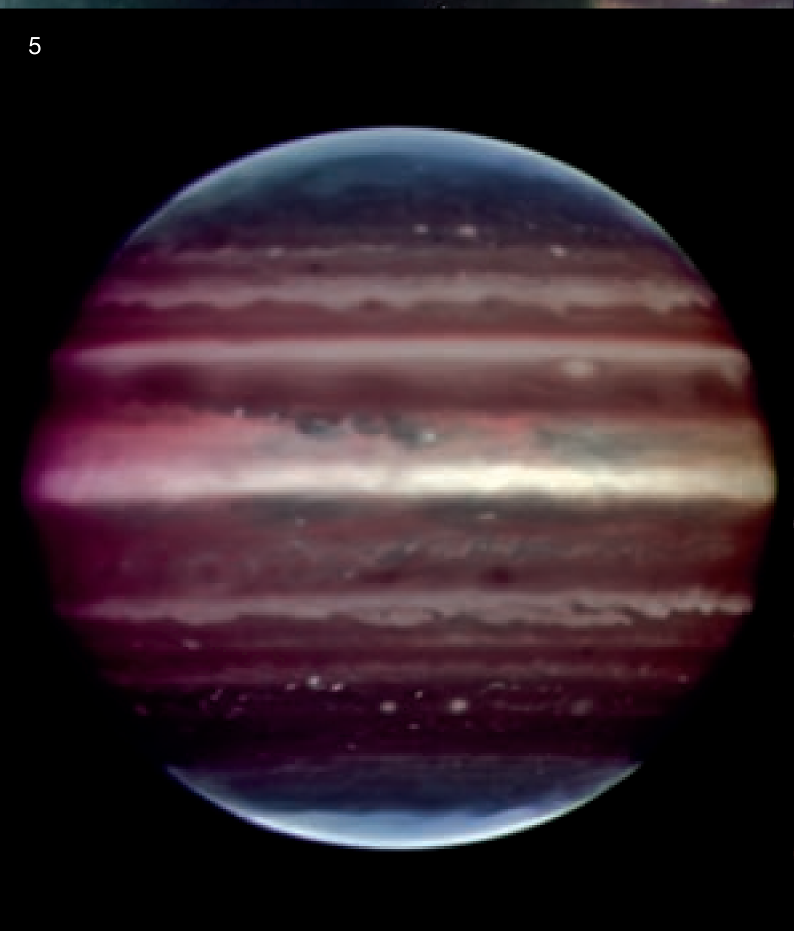
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6

Exploring the Cold Universe — ALMA

High on the Chajnantor plateau in the Chilean Andes, the European Southern Observatory, together with its international partners, is building the Atacama Large Millimeter/submillimeter Array, ALMA — a state-of-the-art telescope to study light from some of the coldest objects in the Universe. This light has a typical wavelength of around a millimetre, between infrared light and radio waves, and is therefore known as millimetre and submillimetre radiation.

Light at these wavelengths comes 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.

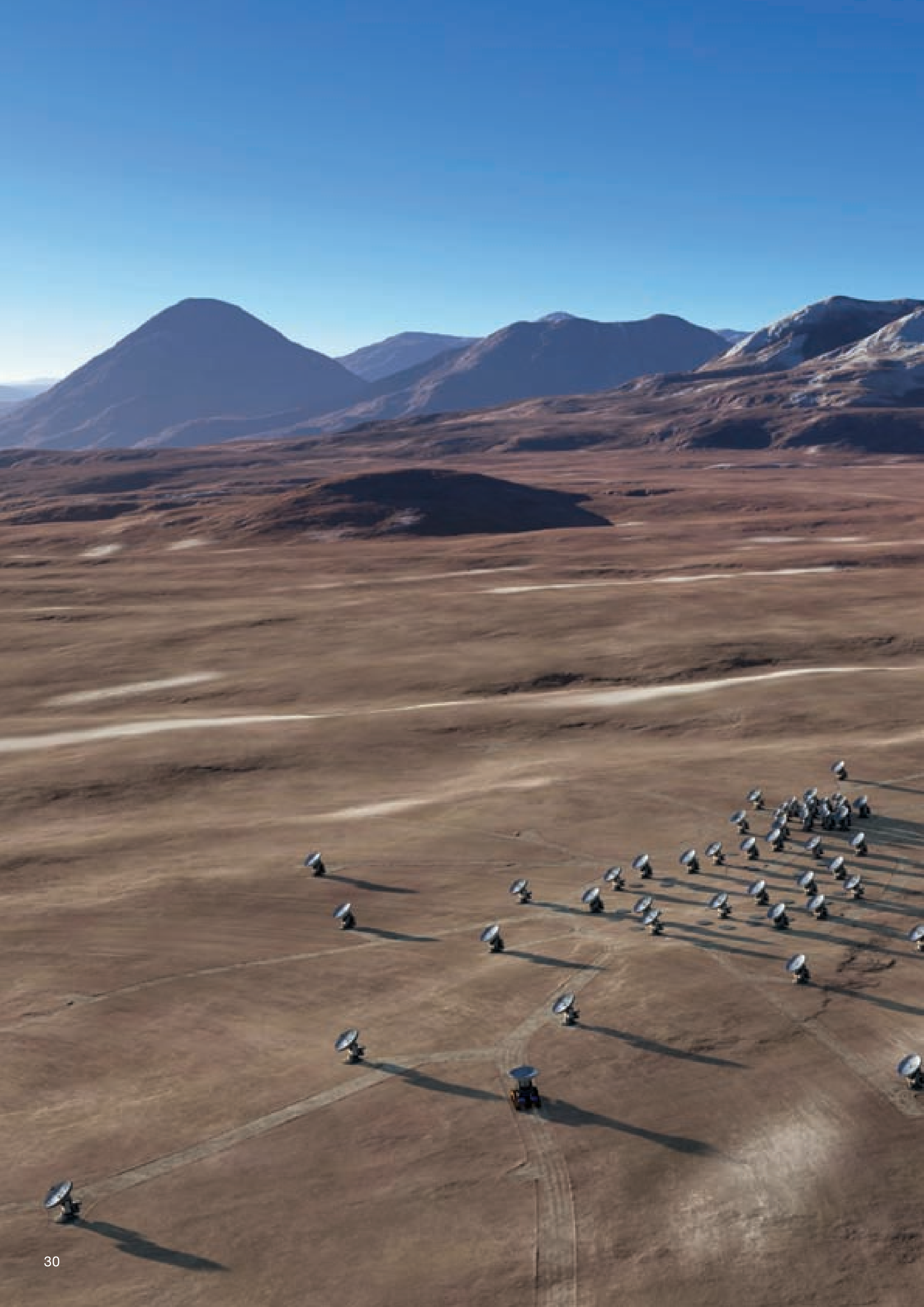
Millimetre and submillimetre radiation opens a window into the enigmatic cold Universe, but the signals from space are heavily absorbed by water vapour in the Earth's atmosphere. Telescopes for this kind of astronomy must be built on high, dry sites.

This is why ALMA, the largest astronomical project in existence, is being built on the 5000-metre high plateau of Chajnantor, one of the highest astronomical observatory sites on Earth. The ALMA site, some 50 kilometres east of San Pedro de Atacama in northern Chile, is in 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 metres higher than the observatories on Mauna Kea, and 2400 metres higher than the VLT on Cerro Paranal.

People at ESO: Stefano Stanghellini, ALMA Antenna Subsystem Manager

"I come from Tuscany, from a family in which going abroad in order to fulfil one's career dreams had always been a tradition. Prior to ESO I worked for Westinghouse Nuclear International in Brussels on nuclear power plants and later I moved to Germany to work on jet engines. As I was reading about the VLT, advertised to be a challenge for Europe and its engineers, I felt that my place was at ESO. In retrospect, I consider myself lucky to have worked for ESO in the incredibly exciting and successful years of the VLT! The team spirit was amazing with all at ESO having the same objective. How proud we were as in 1998 the VLT obtained First Light with excellent results: We had done it!

And now we are trying to reach the same success again, on an even larger, more global scale, with ALMA."



ALMA will be a single telescope of revolutionary design, composed initially of 66 high precision antennas, and operating at wavelengths of 0.3 to 9.6 millimetres. Its main 12-metre array will have fifty antennas, 12 metres in diameter, acting together as a single telescope — an interferometer. An additional compact array of four 12-metre and twelve 7-metre antennas will complement this. The antennas can be moved across the desert plateau over distances from 150 metres to 16 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 VLT interferometer.

ALMA is the most powerful telescope for observing the cool Universe — molecular gas and dust as well as the relic radiation of the Big Bang. ALMA will study the building blocks of stars, planetary systems, galaxies and life itself. By providing scientists with detailed images of stars and planets being born in gas clouds near our Solar System, and detecting distant galaxies forming at the edge of the observable Universe, which we see as they were roughly ten billion years ago, it will let astronomers address some of the deepest questions of our cosmic origins.

ALMA's construction will be completed around 2012, but early scientific observations with a partial array will begin around 2011.

A dark cloud seen in the visible (top), near-infrared (middle) and submillimetre (bottom).

A Global Endeavour

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

"The ALMA project is a very daunting technical challenge, since the antenna surface accuracy must be within 25 microns, the pointing accuracy within 0.6 arcseconds, and the antennas must be able to be moved over a distance of 10 kilometres, and offer Sun-sighting capability. We would like to thank ESO for trusting us to take on this new challenge."

Pascale Sourisse, President and CEO of Alcatel Alenia Space

APEX

While ALMA is currently under construction, astronomers are already doing millimetre and submillimetre astronomy at Chajnantor, with the Atacama Pathfinder Experiment (APEX). This is a new-technology 12-metre telescope — the largest submillimetre-wavelength telescope operating in the southern hemisphere, based on an ALMA prototype antenna, and operating at the ALMA site. It has modified optics and an improved antenna surface accuracy, and is designed to work with wavelengths in the 0.2- to 1.5-millimetre range.

Astronomers are using APEX to study the conditions inside molecular clouds, such as those around the Orion Nebula, or the Pillars of Creation in the Eagle Nebula. They have found carbon monoxide gas and complex organic molecules, as well as charged molecules containing fluorine, which had never been detected before. These discoveries advance our understanding of the cradles of gas where new stars are born.

APEX is a collaboration between the Max-Planck-Institut für Radioastronomie (in collaboration with Astronomisches Institut Ruhr-Universität Bochum), Onsala Space Observatory and ESO. The telescope is operated by ESO. It follows in the footsteps of the Swedish–ESO Submillimetre Telescope (SEST) which operated at La Silla from 1987 until 2003 in a collaboration between ESO and the Onsala Space Observatory. SEST worked in the wavelength range from 0.8 to 3 millimetres.

APEX observations of RCW 120, a stellar nursery.

High Efficiency — The Data Flow System

People at ESO: Petra Nass, User Support Department

"As Operations Support Scientist, working in Garching, I am the link between the astronomers who request observing time in service mode and the team of ESO astronomers actually doing the observations in Chile, so that the latter can provide the best data as possible, under optimal conditions. As such, I really think we are providing a 'service'. During the observation runs that I conducted to collect data for my own PhD, I was sitting alone in the control room of a telescope on a mountain, having several monitors in front of me which I had to scan and understand immediately, in addition to the stress of hoping for the best observing conditions. With service mode, this is no longer the case. Now, I make use of my experience as an observer to continually improve the way service mode is implemented and, thereby, even allow scientific studies to be accomplished which wouldn't have been possible with the conventional 'visitor' observing mode. This is a process that is continuously evolving: ALMA will operate in service mode, and we are thinking about how to adapt to the future E-ELT."

"ESO has revolutionized the operations of ground-based astronomical observatories with a new end-to-end data flow system, designed to improve the transmission and management of astronomical observations and data over transcontinental distances."

ComputerWorld Honors 21st Century Achievement Award Citation

The operational efficiency of ESO surpasses that of any other ground-based telescope on Earth. This is achieved by a unique combination of novel operational concepts, an elaborate maintenance scheme and an intricate, carefully planned system for storing, accessing and evaluating scientific and engineering data.

With traditional ground-based astronomical observatories, scientists apply for observing time, travel to the telescopes, carry out their observations themselves and take their data back to their home institutes to do the final scientific analysis. Data, once analysed, are often not available for re-use by others. The observing time is scheduled far in advance and, even at the best sites, variable weather conditions can have an adverse effect on the quality of the scientific data. As modern observatories become more complex, and are built in more remote places, this method of operating becomes less and less effective.

The ESO Data Flow System (DFS) is designed to solve these problems. It allows both traditional on-site observing as well as service mode observing, where data are collected by observatory staff at the request of the ESO user community. All the data are saved in the ESO science archive. After a one-year proprietary period during which the original investigators have exclusive access to their data, other researchers can access the data for their own use.

ESO was the first ground-based observatory to implement these concepts and tools within a complete system. It was also the first ground-based observatory to build and maintain such an extensive science archive, containing not only observations, but also auxiliary information describing those observations.
In both areas, ESO remains the world leader.

The benefits are clear. Observations can be planned and submitted from a user's home institution, without the need to travel to the observatory. This reduces the risk of mistakes and provides for much higher efficiency. Projects are executed under the most appropriate weather conditions, making the best use of every night. Demanding science programmes can also make use of large amounts of relatively rare and excellent atmospheric conditions. Large financial savings are made. Users receive processed data that have met well-defined quality assurance criteria and are ready for scientific analysis. Finally, users are supported by a team of ESO astronomers who are experts in all aspects of DFS operations.

The DFS strategy has produced a significant increase in the scientific productivity of the ESO user community. As measured by the number of papers in peer-reviewed journals, ESO is now the leading astronomical observatory in the world.

ESO has been recognised for excellence in this area by winning the ComputerWorld Honors 21st Century Achievement Award, a well-known prize in the international IT community.

Science Archive

All the data from the ESO telescopes and the Hubble Space Telescope are stored in the science archive, whose current total holding is about 65 000 gigabytes (GB) — the equivalent of about 15 000 DVDs.

More than 12 terabytes (TB) of data are distributed per year, following about 10 000 web requests. As this is bound to drastically increase once the VISTA and VST survey telescopes are fully in operation, as, together, they will produce about 150 TB of data per year, ESO has put in place a petabyte-class (1000 TB or 1 million GB!) archive.

ESO's enterprise-class database servers are coordinated between Germany and Chile, and their technology and complexity rivals that of major commercial enterprises such as the international banking community.

The Digital Universe

It is the existence of these archives that has allowed the development of an astrophysical virtual observatory. The virtual observatory (VO) is a concept born from the need of modern-day astronomy to exploit the wealth of present and future multi-instrument multi-wavelength datasets, in a quest to answer primordial questions such as the origin of the Universe, the evolution of galaxies, and the formation of stars and planets. This need generates the problem of accessing increasingly large amounts of data in combination with the huge volumes accumulated over the years, and its subsequent exploitation.

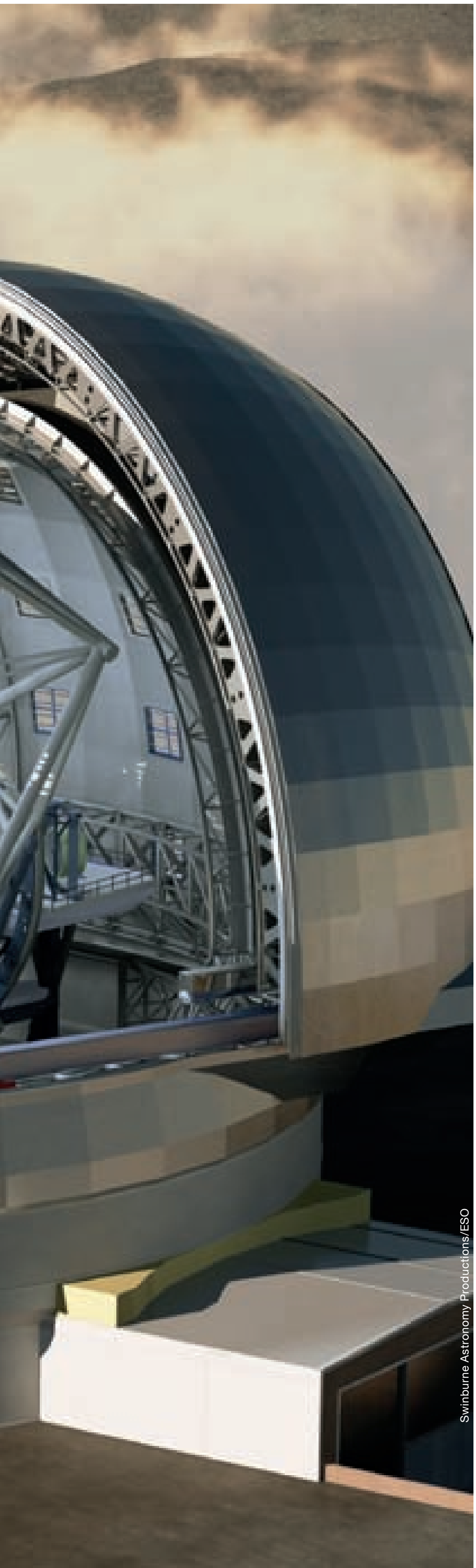
Set in this framework, the virtual observatory is an organised effort to provide astronomers with centralised and uniform access to data. This global, community-based initiative is being developed under the auspices of the International Virtual Observatory Alliance (IVOA).

The virtual observatory is proving its effectiveness with an increasing number of VO-enabled scientific discoveries covering all aspects on modern astronomy, from solar and stellar physics to extragalactic astronomy and cosmology.

Future Projects — The E-ELT

People at ESO: Marc Sarazin, E-ELT Site Surveyor

"I came to ESO, as an engineer/physicist, more than 20 years ago, to help identify the best site for the then future Very Large Telescope. Something revolutionary was happening in astronomy. In the past, we could not always fully exploit the potential of a good observing site, but thanks to the improvements in telescopes, this was changing. By understanding the atmosphere, we could choose the best site, and get the best possible science from the telescope.
It took us about ten years to properly characterise and choose the ideal site for the VLT, at Paranal. We are now involved in trying to find the best site for the E-ELT. For this, at ESO, we are looking at four different sites. But we also share the information with our American colleagues who are looking at the same number of other sites for their project. And as remote sensing has made tremendous progress, time in the field is shortened and complemented by remote analysis of an immense amount of available data. At the end, we are confident we will identify the most suitable location for this extraordinary facility."



Swinburne Astronomy Productions/ESO

The present generation of 8–10-metre-class telescopes, including ESO's VLT, allows astronomers to study the Universe in unprecedented ways, and leads to new and challenging research questions. To address these questions, a new generation of Extremely Large Telescopes (ELTs) with diameters of 30 metres 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 the E-ELT. With the basic reference design 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 metres and its adaptive optics concept, the E-ELT will be the world's biggest "eye" on the sky — the largest optical/near-infrared telescope conceived. The telescope's "eye" will be almost half the length of a soccer pitch in diameter and will gather 15 times more light than the largest optical telescopes operating today. The telescope has an innovative five-mirror design that includes advanced adaptive optics to correct for the turbulent atmosphere, providing images 15 times sharper than those from the Hubble Space Telescope.

"Extremely Large Telescopes are seen world wide as one of the highest priorities in ground-based astronomy. They will vastly advance astrophysical knowledge allowing detailed studies of inter alia *planets around other stars, the first objects in the Universe, supermassive black holes, and the nature and distribution of the dark matter and dark energy which dominate the Universe. The European Extremely Large Telescope project will maintain and reinforce Europe's position at the forefront of astrophysical research."*

The European Roadmap for Research Infrastructures, ESFRI Report 2006

Distant galaxies will appear as if they were in our backyard, offering an unbiased view of the history of stellar formation over most of the age of the Universe.

In December 2004, the ESO Council defined as ESO's highest priority strategic goal "the retention of European astronomical leadership and excellence in the era of Extremely Large Telescopes (ELT)", asking that "the construction of an ELT on a competitive timescale be addressed by radical strategic planning".

Following an extensive international review in October 2005 of a first concept study — the OWL project — the ESO project offices conducted a new study in 2006, 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 950 million euros, including the first generation of instruments.

The challenge of designing, constructing and operating a 30- to 60-metre telescope is substantial. Extrapolating technical solutions for light collectors from a 10-metre diameter to 30 metres 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 the 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 instrumentation is concerned, the goal is to create a flexible suite of instruments to deal with the wide variety of science questions that astronomers would like to see resolved in the coming decades. The ability to observe over a large range of wavelengths from the optical to mid-infrared, 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 coordinate the development of around five first generation instruments. 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 into 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-metre diameter mirror telescope, and is revolutionary. The primary mirror is composed of almost 1000 segments, each 1.45 metres wide, while the secondary mirror is as large as 6 metres 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 metres in diameter, relays the light to the adaptive optics system, composed of two mirrors: a 2.5-metre 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 metres in diameter that allows for the final image corrections. This five-mirror approach results in exceptional image quality, with no significant aberrations in the field of view.

Building Partnerships

EIROforum

Fostering cooperation in astronomy is at the core of ESO's mission. ESO has played a decisive role in creating a European Research Area for astronomy and astrophysics.

Every year, thousands of astronomers from the member states and beyond carry out research using data collected at the ESO observatory sites. Astronomers often form international research teams, with members in several countries. Their results are published in many hundreds of scientific articles each year.

ESO has an extensive programme for fellows (young astronomers with a PhD degree) and students, thus contributing to the mobility of European scientists. Senior scientists from the member states and other countries work for periods as visiting scientists at the ESO sites. In addition, ESO maintains a vigorous programme of international conferences with themes in front-line astronomical science and technology and provides logistical support for the international journal *Astronomy & Astrophysics*.

In order to provide users with progressively better astronomical telescopes and instruments, ESO cooperates closely with a large number of European high-tech industries. In fact, European industry plays a vital role in the realisation of ESO projects. Without the active and enthusiastic participation of commercial partners from all of the member countries and Chile, such projects would not be possible.

Also in the field of technology development, ESO maintains close connections with many research groups at university institutes in the member countries and beyond. Thus astronomers in the member countries are deeply involved in the planning and realisation of the scientific instruments for the VLT/VLTI and for ALMA, as well as for other existing or planned telescopes. Instrument development offers important opportunities for national research centres of excellence, attracting many young scientists and engineers.

ESO is a member of the EIROforum, the partnership of the seven European intergovernmental research organisations that operate major research infrastructures. Both directly and through the EIROforum partnership, ESO maintains close and fruitful relations with the European Commission. This has led to jointly funded projects in the field of technology development, training of young scientists, science education in Europe's primary and secondary schools and various coordination activities.

"Europe needs to join forces to muster the necessary critical mass of resources, expertise and scientific excellence. I welcome EIROforum's commitment to our common goals."

Janez Potočnik, European Commissioner for Science and Research

Janez Potočnik, European Commissioner for Science and Research, at the launch of the EIROforum paper on science policy.

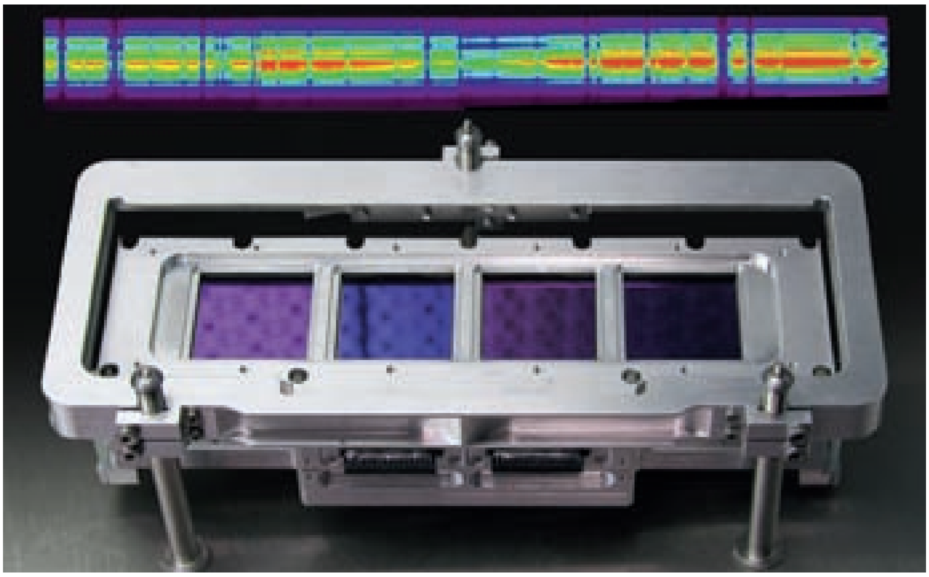
Meeting Society

Technology Transfer

Astronomy has a strong tradition of driving new technologies, many of which find more general applications at a later stage.

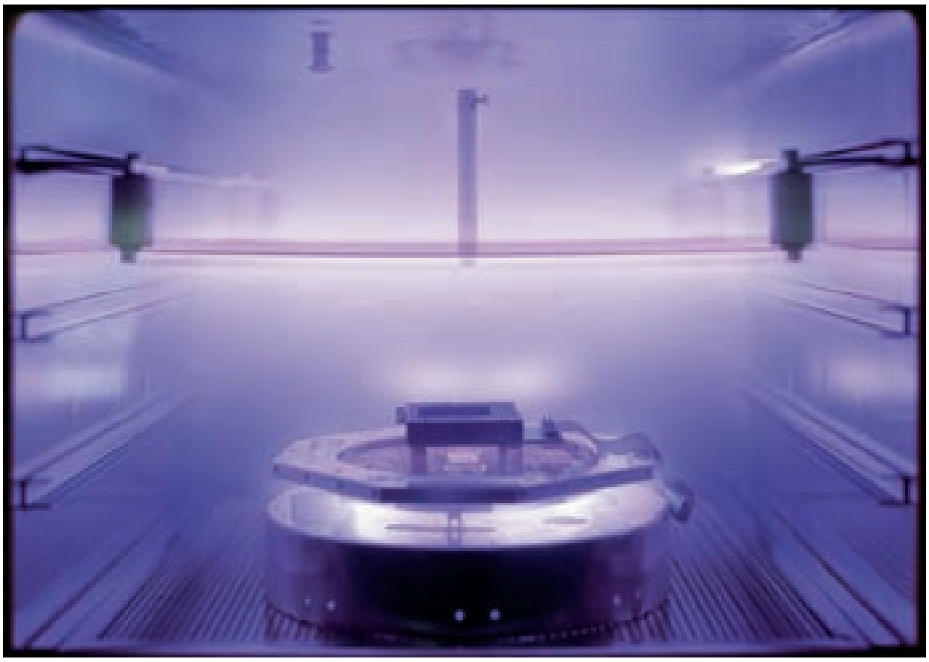
ESO's scientists and engineers work actively with their colleagues from European industry and other European research institutions to develop key technologies of the future. Technology transfer increases the value of ESO's research and development (R&D) activities to society as a whole, and particularly in the ESO member states.

Some of these R&D activities involve new optomechanical and optoelectronic systems, and extremely high-precision control and steering of heavy equipment. Others involve hardware and software for complex telescopes and instruments, mathematically advanced image analysis, and optimal handling, archiving and retrieval of extremely large amounts of data. ESO developed the revolutionary active optics system and played an important role in developing adaptive optics for civilian applications. Adaptive optics systems are not simply of crucial importance to next-generation telescopes, but are now entering mainstream optical engineering. For example, today, the wavefront-sensing technique is also exploited in modern medicine in connection with refractive laser surgery to correct for higher-order aberrations in the eye.



At the Forefront of Technology

Among the many innovative technologies that have been developed by ESO, pushed beyond customary limits or combined in novel ways, one can single out:
- Active optics
- Large metal blanks
- Shack-Hartmann wavefront sensors
- Real-time processors
- Fibre lasers
- Time reference system
- Data archive systems
- Virtual observatories
- Cryogenic bearings
- Thermally controlled cabinets



Over the last 20 years, ESO has accumulated considerable practical experience in the design and use of liquid nitrogen cryostats for CCD detectors. In the course of this time, ESO has developed a standard cryostat design that is widely used within the organisation. Because of the wider applicability of this technology, in 1999 ESO concluded an agreement with the French firm SNLS to manufacture and sell the ESO dewar under license.

ESO's Educational and Outreach Programmes

Astronomy has an innate appeal for people of all ages, partly because it concerns the fascinating, great questions "of life, the Universe and everything" and partly because much of the data obtained with telescopes can be presented as objects of stunning beauty. For many years ESO has been engaged in a very active programme of science communication, sharing the many scientific results obtained thanks to ESO telescopes with the public. This is done, whenever possible, in all the main languages of the ESO member states and by embracing a multimedia approach.

As part of this mission, ESO participates in major exhibitions, produces high quality press releases, brochures and books, images from raw science data, audiovisual material, and provides web services.

With its strong multidisciplinary character and powerful public appeal, astronomy can play an important role in modern science education. The stunning scientific results from ESO telescopes provide invaluable treasures for science teachers.

ESO has been the leading force behind several high-profile educational pilot programmes, often carried out in collaboration with partners including the European Commission. These efforts are continued and strengthened through joint EIROforum activities, with programmes targeting school children, such as *Life in the Universe* and *Scitech — couldn't be without it!*, and the *Physics on Stage* and *Science on Stage* programmes, which are directed towards European science teachers. With its partners in the EIROforum, ESO also publishes Europe's first international, multidisciplinary journal for science teaching, *Science in School*, and has set up a new yearly science teachers school.

ESO has played a major role in the organisation of the International Year of Astronomy (IYA2009). The final count of countries that were involved stands at 148, confirming that the IYA2009 network is the largest ever in science. More than 70 international organisations participated in the IYA2009 activities, along with 12 Cornerstone projects and 16 Special projects. ESO hosted the general secretariat of the IYA2009 and led several Cornerstone projects.

Working at ESO

Working at ESO means challenging, stimulating work in an inclusive and truly international and multi-cultural environment; working with the cutting-edge technology and the front-line scientific research that makes ESO a truly inspiring place.

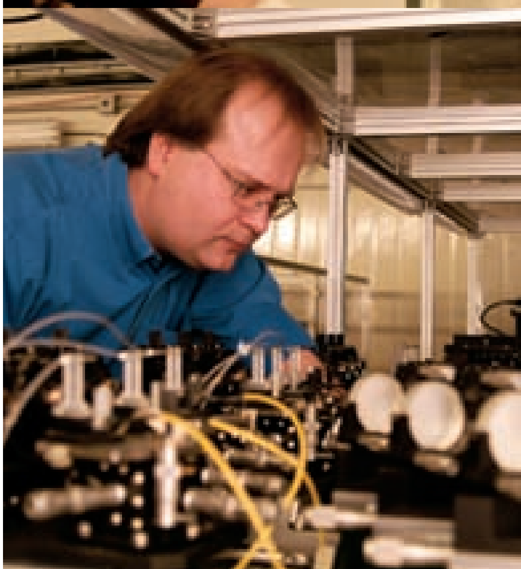
People at ESO are employed as international staff, local staff, fellows, students and associates.

International staff members represent a wide spectrum of professions ranging from scientists to skilled engineers, technicians and administrative employees. Associate members of the personnel work under short-term contracts with ESO to perform certain tasks in the field of scientific research, or for technical or administrative support.

Fellows are postdoctoral scientists, recruited in order to foster their scientific careers. ESO provides state-of-the-art facilities for astronomical observing and the opportunity to obtain practical experience during the active pursuit of a research programme. Studentship opportunities are available to students who are enrolled in a PhD programme in astronomy or related fields. The duration of the programme is one to two years and aims to enhance the postgraduate programmes of member state universities. Fellowships and Studentships are available either at ESO Headquarters in Garching or in Chile.

People at ESO: Jean-Michel Bonneau, Head of the ESO Finance Department

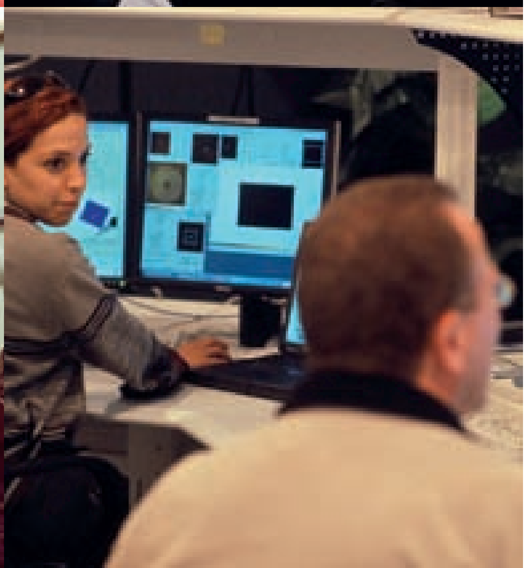
"Before joining ESO in 1996 I worked in several different areas as a Finance Controller — from the 1992 Winter Olympic Games in Albertville to a music label in Provence, France. I am glad I moved to ESO, with the opportunity to work for an organisation with unique, astronomical projects with budgets of several hundreds of millions of euros that obviously require staff specialised in accounting and financial matters. In the Finance Department, we make sure that financial resources are used according to the directions and regulations defined by the ESO governing bodies. We always keep in mind that consistent financing from ESO member states has permitted the realisation of the extraordinary infrastructures that are now available to the community."









ESO is …

- the most productive astronomical observatory in the world;
- a meeting point for scientists from the member states and a catalyst for innovative ideas;
- a vibrant organisation with major future projects for the coming generation of scientists;
- an active partner of industry;
- an active partner in science outreach and education;
- providing a cultural and scientific bridge between Europe and Chile;
- a fine example of a successful European collaboration.

How to obtain additional information

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