ESO

European
Southern
Observatory

Reaching New Heights in Astronomy

ESO and Astronomy

Astronomy is the oldest of the natural sciences. The majestic Milky Way, stretching across the sky on a clear dark night, has been an awe-inspiring sight for generations of people from all historical eras and cultures past and present.

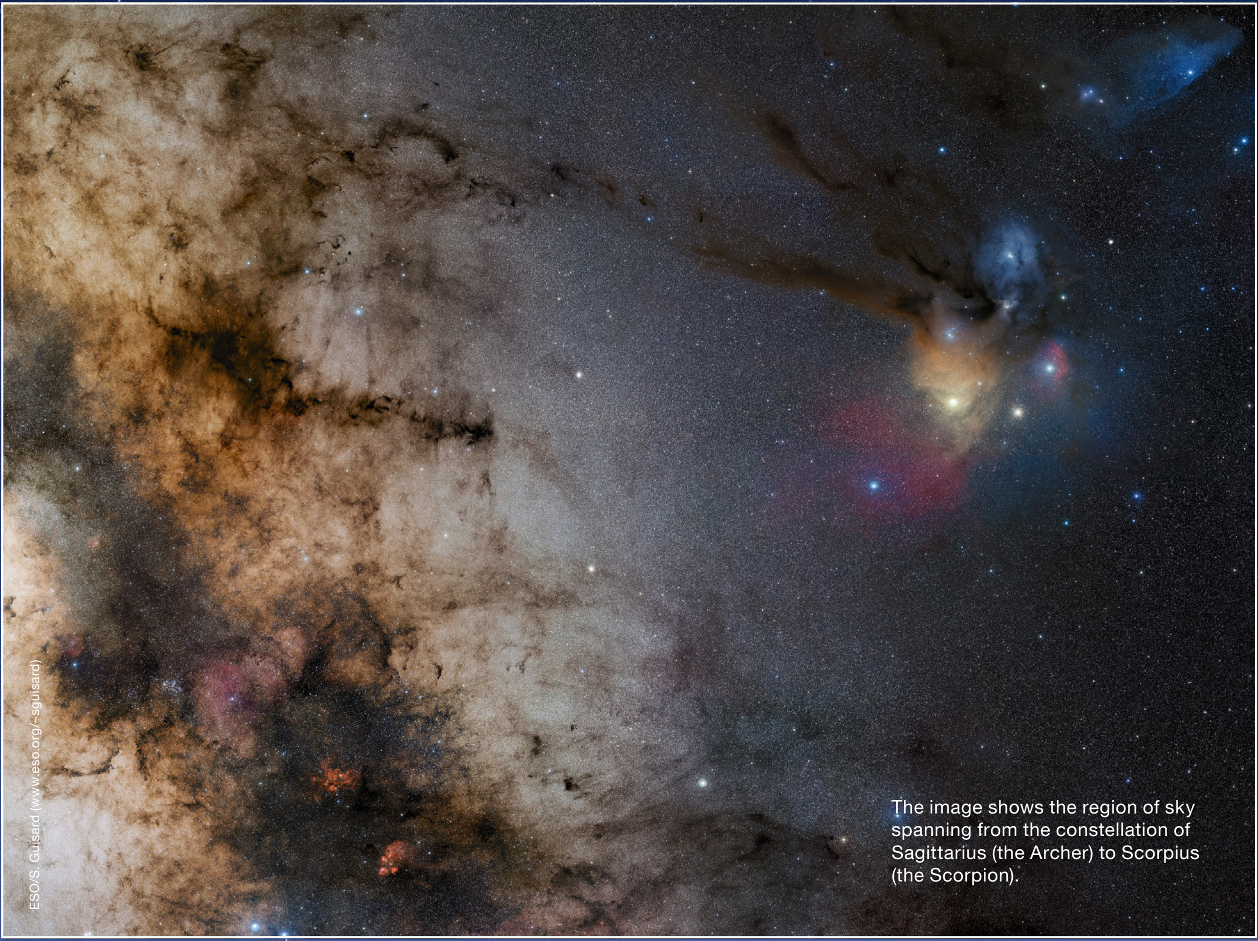
Today, astronomy stands out as one of the most dynamic sciences, using advanced technologies and sophisticated techniques to study objects at the edge of the observable Universe, to detect planets around other stars and to explore many other celestial bodies in unprecedented detail. We can begin to answer some of humanity's most fundamental questions, such as: Where did we come from? Is there life elsewhere in the Universe? How do stars and planets form? How do galaxies evolve? What is the Universe made of?

The European Southern Observatory (ESO) is the world's foremost intergovernmental astronomical organisation. It carries out an ambitious programme of designing, constructing and operating the world's most powerful and productive ground-based observing facilities. For this purpose, ESO is built on very constructive partnerships with the scientific community and industry, and in some cases with other parties around the world.

Observing proposals to use ESO's telescopes outnumber the amount of available nights by a factor of between three and five, or even more. This demand is part of the reason why ESO is the most productive ground-based observatory in the world, with almost three peer-reviewed papers based on ESO data being published every day on average. These scientific papers report some of the most remarkable discoveries in astronomy, and ESO is committed to continue enabling them by pursuing the most ambitious observational astronomy project in history, the construction of the Extremely Large Telescope.

Xavier Barcons
ESO Director General

ESO's Paranal Observatory, home to the Very Large Telescope.



ESO/S. Guisard (www.eso.org/~sguisard)

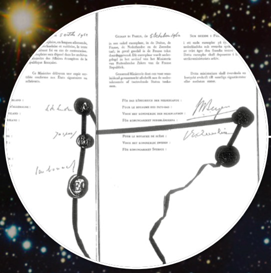
The image shows the region of sky spanning from the constellation of Sagittarius (the Archer) to Scorpius (the Scorpion).

ESO/B. Tafreshi (twanight.org)

Reaching out to the stars at Paranal.

ESO/J. Girard

Highlights from ESO’s History



5 October 1962

Founding members Belgium, France, Germany, the Netherlands and Sweden sign the ESO Convention.

6 November 1963

Chile is chosen as the site for the ESO observatory and the *Convenio* (also known as the *Acuerdo*), the agreement between Chile and ESO, is signed.

30 November 1966

First light for the ESO 1-metre telescope at La Silla, the first telescope to be used by ESO in Chile.

23 March 1989

First light for the New Technology Telescope.

25 May 1998

First light for the VLT’s first Unit Telescope (UT1), Antu.

17 March 2001

First light for the Very Large Telescope Interferometer.

8 June 2011

First images from the VLT Survey Telescope.

30 September 2011

ALMA starts Early Science observations and the first image is published.

5 October 2012

ESO celebrates its 50th Anniversary.

Infrared image of the Carina Nebula from the HAWK-I camera on the VLT.

7 November 1976

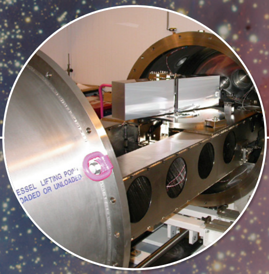
First light for the ESO 3.6-metre telescope.

5 May 1981

Inauguration of the ESO Headquarters in Garching, Germany.

22 June 1983

First light for the MPG/ESO 2.2-metre telescope.



11 February 2003

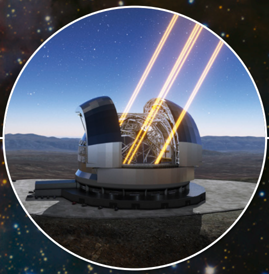
First light for the High Accuracy Radial velocity Planet Searcher (HARPS) at ESO's 3.6-metre telescope at the La Silla Observatory.

14 July 2005

First light for the submillimetre Atacama Pathfinder Experiment (APEX).

11 December 2009

VISTA, the pioneering infrared survey telescope, starts work.



19 June 2014

Groundbreaking ceremony for the Extremely Large Telescope (ELT) takes place.

26 May 2017

First Stone ceremony for the ELT is attended by the President of Chile, Michelle Bachelet Jeria.

The future

As terabytes of astronomical data flow to the astronomers in ESO's Member States, new discoveries await…

ESO/T. Preibisch

The ESO Sites

Northern Chile, which includes the Atacama Desert, has exceptionally clear and dark skies that, for 300 nights a year, offer stunning views of the southern skies, including the important central region of the Milky Way and the two Magellanic Clouds.

Chajnantor Plateau

At 5000 metres above sea level, the Chajnantor plateau is one of the highest astronomical sites in the world. It is home to the Atacama Large Millimeter/submillimeter Array (ALMA) — a partnership of ESO, North America and East Asia in cooperation with the Republic of Chile — and the Atacama Pathfinder Experiment (APEX), a 12-metre telescope operating at millimetre and submillimetre wavelengths.

Cerro Paranal

At 2600 metres above sea level, 130 kilometres south of Antofagasta and 12 kilometres inland from the Pacific coast of northern Chile, Paranal is one of the driest areas on Earth. It is home to the Very Large Telescope — an array of four Unit Telescopes and four movable 1.8-metre Auxiliary Telescopes, which form part of the VLT Interferometer — and two powerful survey telescopes: the VST and VISTA.

Cerro Armazones

The 39-metre Extremely Large Telescope is under construction here, just 23 kilometres from the Paranal Observatory, and will be integrated into the Paranal operational system.

Vitacura, Santiago de Chile, Chile

ESO's office in Santiago is an active centre for the education of new generations of researchers, and promotes exchanges between European and Chilean scientists through collaborations.

The Gum 15 star formation region imaged with the MPG/ESO 2.2-metre telescope.

Headquarters, Garching, Germany

ESO's Headquarters are located in Garching bei München in Bavaria, Germany. This is the scientific, technical and administrative centre of ESO. The site is home to a technical building, where ESO's most advanced instruments are developed, built, assembled, tested and upgraded. It is also home to one of the largest computer archives of astronomical data in the world and to the ESO Supernova Planetarium & Visitor Centre.

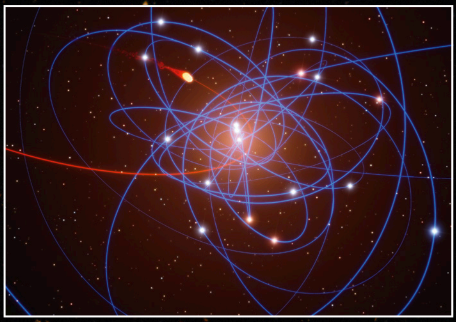
La Silla

ESO's first observatory was built at 2400 metres above sea level and 600 kilometres north of Santiago in Chile. It is equipped with several optical telescopes with mirror diameters of up to 3.6 metres. The ESO 3.6-metre telescope is now home to the world's foremost exoplanet hunter, HARPS (the High Accuracy Radial velocity Planet Searcher).

ESO's Top 10 Astronomical Discoveries

1 | Stars orbiting the Milky Way's supermassive black hole

Several of ESO's flagship telescopes were used in a continuous long-term study to obtain the most detailed view ever of the surroundings of the monster lurking at the heart of our galaxy — a supermassive black hole.



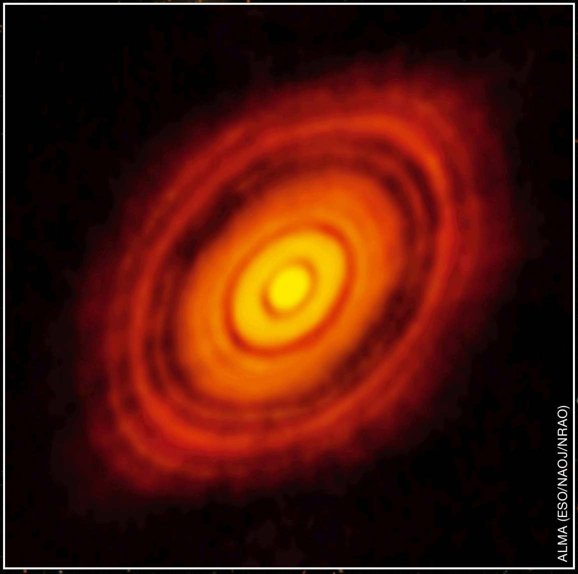
2 | The accelerating Universe

Two independent research teams, using observations of supernovae which included data from ESO's telescopes at La Silla and Paranal, showed that the expansion of the Universe is accelerating. The 2011 Nobel Prize in Physics was awarded for this result.

3 | Planet found in the habitable zone around the nearest star, Proxima Centauri

The long-sought world, designated Proxima b, orbits its cool red parent star every 11 days and has a temperature suitable for liquid water to exist on its surface. This rocky world is a little more massive than the Earth and is the closest exoplanet to us — and it may also be the closest possible abode for life outside the Solar System.

ESO/M. Kornmesser



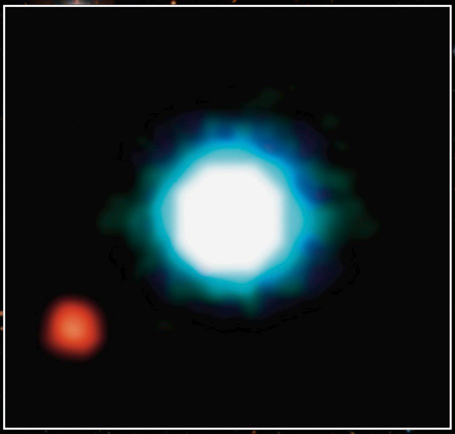
ALMA (ESO/NAOJ/NRAO)

4 | Revolutionary ALMA image reveals planetary genesis

In 2014, the Atacama Large Millimeter/submillimeter Array (ALMA) revealed remarkable details of a forming planetary system. The images of HL Tauri were the sharpest ever made at submillimetre wavelengths. They show how forming planets gather up dust and gas in a protoplanetary disc.

5 | First image of an exoplanet

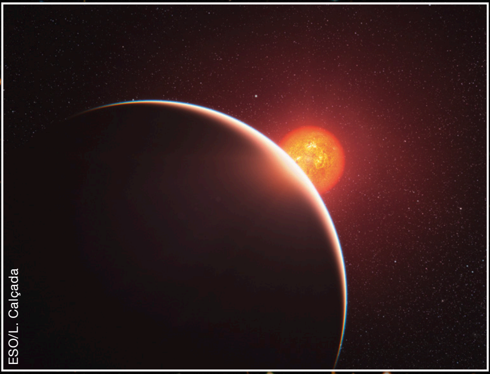
The VLT obtained the first ever image of a planet outside our Solar System. The five-Jupiter-mass planet orbits a star that failed to ignite nuclear reactions — a brown dwarf — at a distance of 55 times the mean Earth-Sun distance.



SDSS

6 | Oldest star known in the Milky Way

Using the VLT, astronomers measured the age of the oldest star known in our galaxy. At 13.2 billion years old, the star was born in the earliest period of star formation in the Universe. Uranium was detected in a star born when the Milky Way was still forming, and used as an independent estimate of the age of the galaxy.

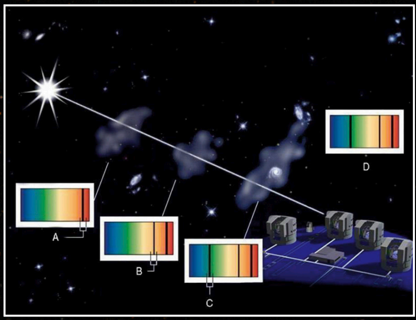


ESO/L. Calçada

7 | Direct measurements of the spectra of exoplanets and their atmospheres

The atmosphere around a super-Earth exoplanet was analysed for the first time using the VLT. GJ 1214b was studied as it transited its parent star and some of the starlight passed through the planet's atmosphere. The atmosphere is either mostly water in the form of steam or dominated by thick clouds or hazes.

ESO/N. Bartmann/spaceengine.org

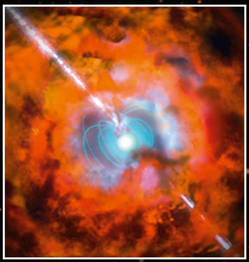


8 | Cosmic temperature independently measured

For the first time, the VLT detected carbon monoxide molecules in a galaxy seen as it was almost 11 billion years ago, a feat that had remained elusive for 25 years. This allowed astronomers to obtain the most precise measurement of the cosmic temperature in such a remote epoch.

9 | Record-breaking planetary system

Using ground and space telescopes, including ESO's VLT, astronomers found a system of seven Earth-sized planets just 40 light-years away orbiting the ultracool dwarf star known as TRAPPIST-1. Three of the planets lie in the habitable zone, increasing the possibility that the star system could play host to life. This system has both the largest number of Earth-sized planets yet found and the largest number of worlds that could support liquid water on their surfaces.



10 | Gamma-ray bursts — the connections with supernovae and merging neutron stars

ESO telescopes provided definitive proof that long gamma-ray bursts are linked with the ultimate explosion of massive stars, solving a long-time puzzle. In addition, a telescope at La Silla observed for the first time the visible light from a short gamma-ray burst, showing that this family of objects most likely originate from the violent collision of two merging neutron stars.

Deep-field image taken with the Wide Field Imager (WFI) on the MPG/ESO 2.2-metre telescope located at the La Silla Observatory.

The Very Large Telescope

The Very Large Telescope array is the optical flagship facility for European astronomy at the beginning of the third millennium. It is the world's most advanced optical and infrared observatory, consisting of four Unit Telescopes with main mirrors 8.2 metres in diameter. They can be used individually or together, like the four movable 1.8-metre Auxiliary Telescopes, to form an interferometer. These telescopes are so powerful that they can obtain images of celestial objects that are four billion times fainter than can be seen with the unaided eye.

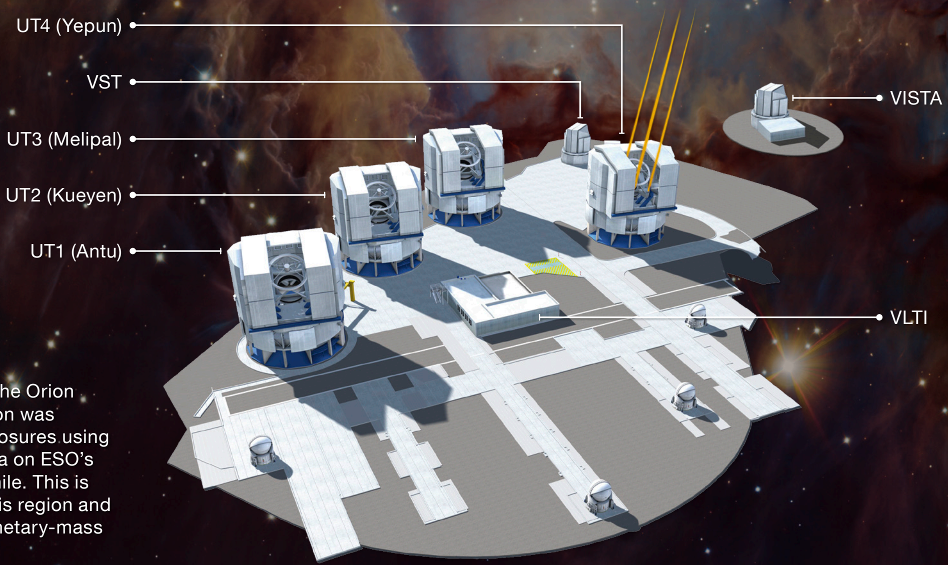
The VLT instrumentation programme is the most ambitious ever conceived for a single observatory. It includes cameras and spectrographs that cover a broad spectral region, spanning ultraviolet (0.3 µm) to mid-infrared (20 µm) wavelengths.

The 8.2-metre Unit Telescopes are housed in compact, thermally-controlled buildings, which rotate synchronously with the telescopes. This significantly minimises local effects on the observing conditions, such as air turbulence in the telescope tube, which might result from variations in temperature and wind flow.

The first of the Unit Telescopes began routine scientific operations on 1 April 1999 and since then the VLT has made an immense impact on observational astronomy. It is the most productive individual ground-based facility in the world, and VLT results lead to, on average, the publication of more than one and a half peer-reviewed scientific papers every day.

ESO's Paranal Observatory also hosts the NGTS (Next-Generation Transit Survey) and SPECULOOS (Search for habitable Planets EClipsing ULtra-cOOl Stars) national telescopes.

Name	VLT
Site	Cerro Paranal
Altitude	2635 metres
Wavelengths	Ultraviolet/optical/infrared
Components/techniques	Interferometry with 4 telescopes (maximum baseline 130 metres); 3 of which have adaptive optics
Optical design	Ritchey-Chrétien reflector
Primary mirror diameter	8.2 metres
Mount	Alt-Azimuth
First light	May 1998–September 2000



This spectacular image of the Orion Nebula star-formation region was obtained from multiple exposures using the HAWK-I infrared camera on ESO's Very Large Telescope in Chile. This is the deepest view ever of this region and reveals more very faint planetary-mass objects than expected.

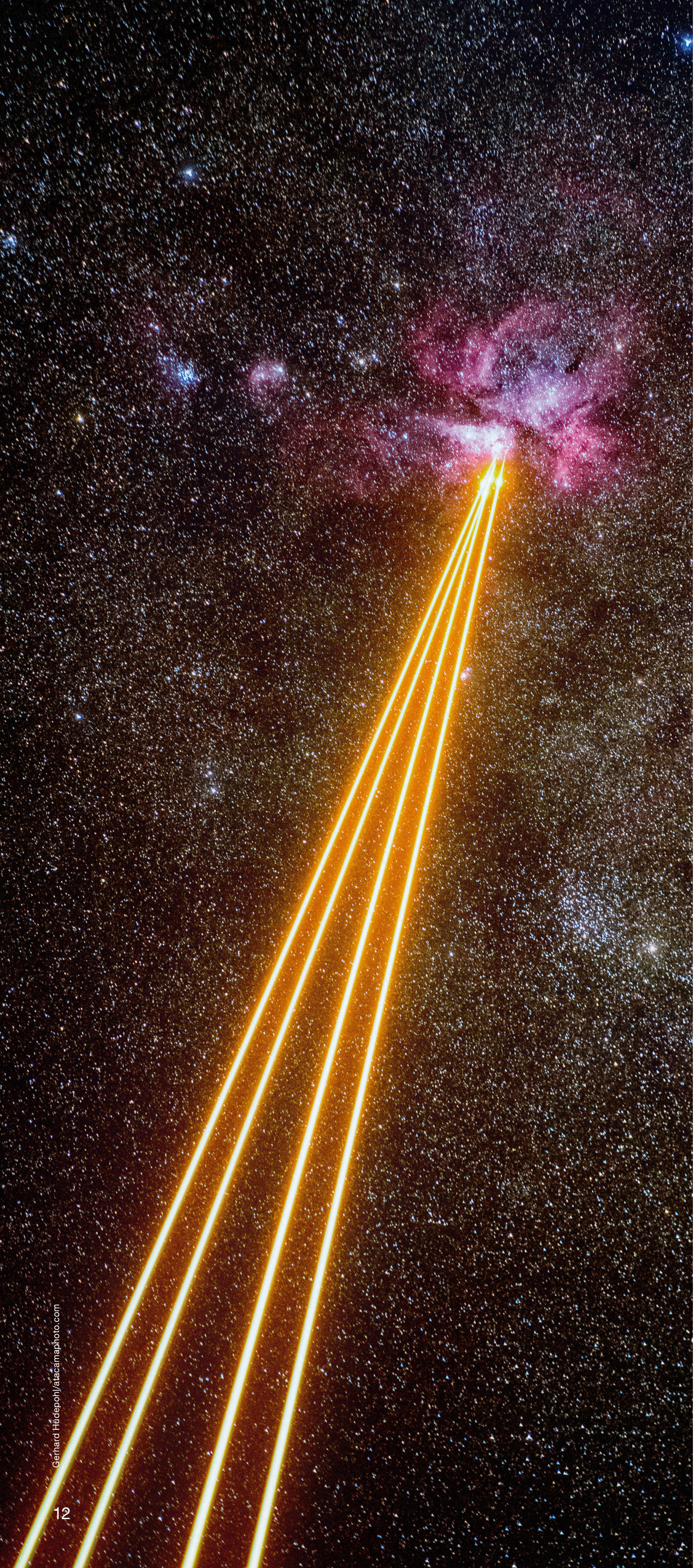
ESO/H. Drass et al.

Y. Beletsky (LCO)/ESO

Taken from inside the dome of the fourth Unit Telescope of ESO's Very Large Telescope (VLT), this spectacular shot captures the VLT's Laser Guide Star (LGS) trained on the centre of the Milky Way.

ESO/G. Hüdepohl (atacamaphoto.com)

The setting Sun dips below the horizon of the Pacific Ocean, bathing the Paranal platform in light in this amazing aerial image from the Atacama Desert in northern Chile.



Adaptive Optics

Turbulence in the Earth's atmosphere distorts images obtained from the ground and causes stars to twinkle. But astronomers at ESO use a method called adaptive optics to compensate for the effect of the atmosphere.

Sophisticated deformable mirrors controlled by computers can correct in real time for the distortion caused by the turbulence of the Earth's atmosphere, making the images obtained almost as sharp as those taken from space.

A reference star located very close in the sky to the object under study is needed to measure the distortions caused by the atmosphere so that the adaptive mirror can correct for them.

Since suitable stars are not always available, astronomers create artificial reference stars by shining a powerful laser beam 90 kilometres up into the Earth's upper atmosphere.

ESO is a leader in the development of adaptive optics and laser guide star technologies and collaborates with European institutes and industries. ESO's adaptive optics facilities have obtained many remarkable scientific results. These include the first direct observations of an exoplanet (see p. 8), as well as the detailed study of the environment around the black hole at the centre of the Milky Way (see p. 8).

The next generation of adaptive optics has been installed on the VLT. This technology employs multiple laser guide stars and also includes advanced extreme adaptive optics instruments such as planet finders. Even more advanced systems, tailored to meet the challenges of the ELT, are under active development. The use of multiple guide stars paves the way for obtaining a wider corrected field of view, a result that will be vital for future VLT and ELT science.

Paranal 4 laser guide star system pointing at the Carina Nebula.

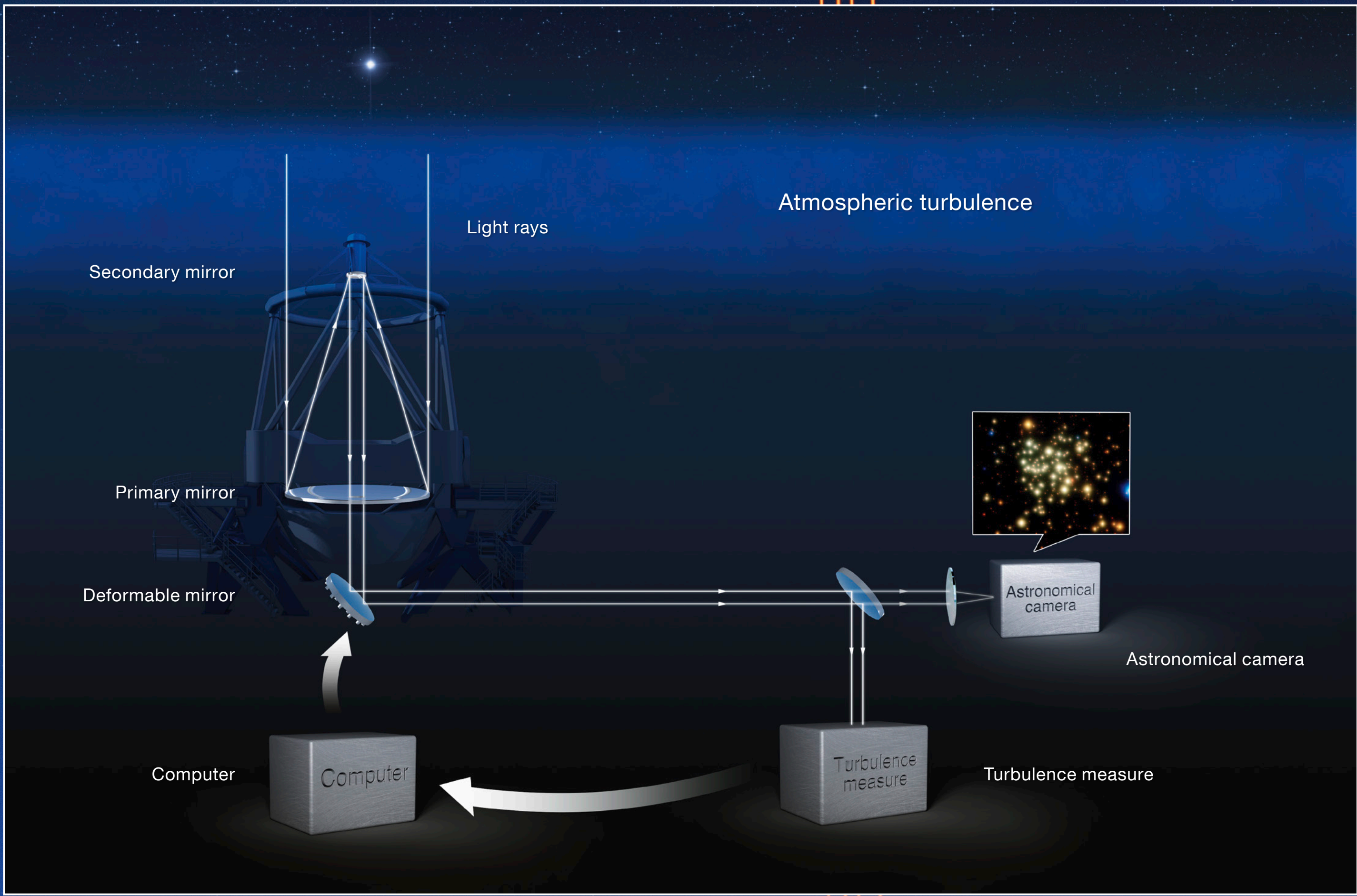


Illustration showing how adaptive optics works.

ESO/G. Hüdepohl

The 4 laser guide star system on Unit Telescope 4 of the VLT.

The VLT Interferometer

The telescopes of the VLT can be combined to form the Very Large Telescope Interferometer (VLTI), allowing astronomers to see details up to 16 times finer than with the individual telescopes alone. With the VLTI, it is possible to see details on the surfaces of stars and even to study the environment close to a black hole at the centre of another galaxy.

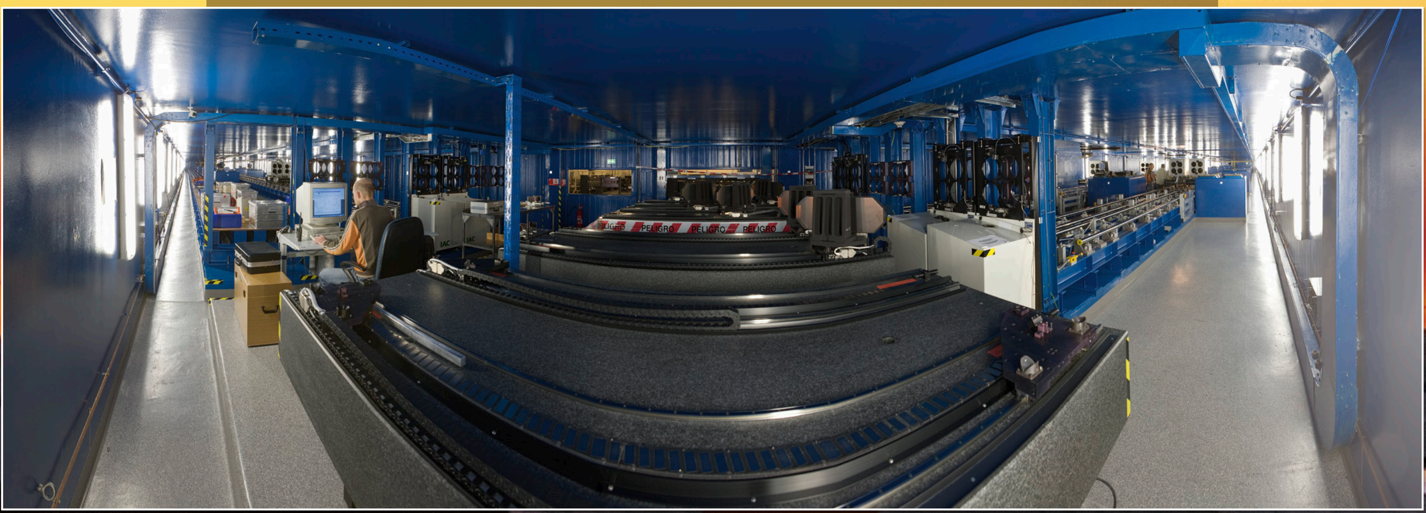
Light beams from the telescopes are combined in the VLTI using a complex system of mirrors in underground tunnels, where the light path lengths must be kept equal to within one thousandth of a millimetre over more than 100 metres. With this 130-metre large “virtual telescope”, the VLTI can perform measurements equivalent to picking out the head of a screw on the International Space Station, 400 kilometres above us in orbit, from the ground.

Although light from the four 8.2-metre Unit Telescopes can be combined in the VLTI, most of the time these large telescopes are used individually 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 every night, four smaller 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 include their own transporters which lift the telescopes and move them from one position to another.

Name	Auxiliary Telescopes
Site	Cerro Paranal
Altitude	2635 metres
Wavelengths	Optical/infrared
Components/techniques	Interferometry with 4 smaller telescopes (maximum baseline 200 metres)
Optical design	Ritchey-Chrétien with coudé optical train
Primary mirror diameter	1.82 metres
Mount	Alt-Azimuth
First light	January 2004–December 2006



Panoramic view of the Very Large Telescope Interferometer tunnel.

P. Horálek/ESO

Sunset at Paranal with one of the Auxiliary Telescopes open and ready for observations.

Survey Telescopes

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

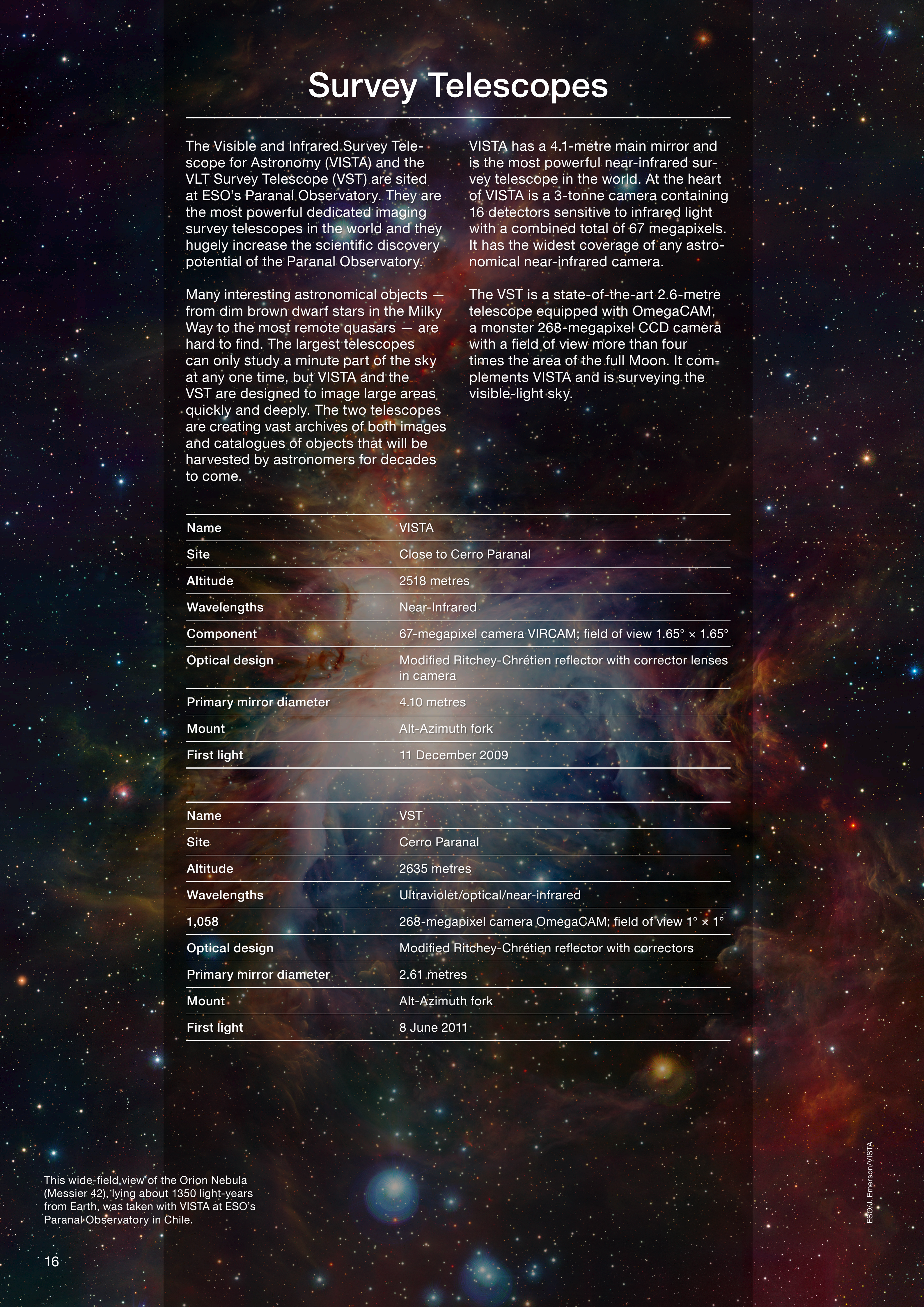
Many interesting astronomical objects — from dim brown dwarf stars in the Milky Way to the most remote quasars — are hard to find. The largest telescopes can only study a minute part of the sky at any one time, but VISTA and the VST are designed to image large areas quickly and deeply. The two telescopes are creating vast archives of both images and catalogues of objects that will be harvested by astronomers for decades to come.

VISTA has a 4.1-metre main mirror and is the most powerful near-infrared survey telescope in the world. At the heart of VISTA is a 3-tonne camera containing 16 detectors sensitive to infrared light with a combined total of 67 megapixels. It has the widest coverage of any astronomical near-infrared camera.

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 more than four times the area of the full Moon. It complements VISTA and is surveying the visible-light sky.

Name	VISTA
Site	Close to Cerro Paranal
Altitude	2518 metres
Wavelengths	Near-Infrared
Component	67-megapixel camera VIRCAM; field of view 1.65° × 1.65°
Optical design	Modified Ritchey-Chrétien reflector with corrector lenses in camera
Primary mirror diameter	4.10 metres
Mount	Alt-Azimuth fork
First light	11 December 2009

Name	VST
Site	Cerro Paranal
Altitude	2635 metres
Wavelengths	Ultraviolet/optical/near-infrared
1,058	268-megapixel camera OmegaCAM; field of view 1° × 1°
Optical design	Modified Ritchey-Chrétien reflector with correctors
Primary mirror diameter	2.61 metres
Mount	Alt-Azimuth fork
First light	8 June 2011



This wide-field view of the Orion Nebula (Messier 42), lying about 1350 light-years from Earth, was taken with VISTA at ESO's Paranal Observatory in Chile.

ESO/J. Emerson/VISTA

Inside the VST dome with the Milky Way shining above.

ESO/B. Tafreshi (twanight.org)

The VISTA telescope enclosure at sunset.

ESO/B. Tafreshi (twanight.org)

ELT

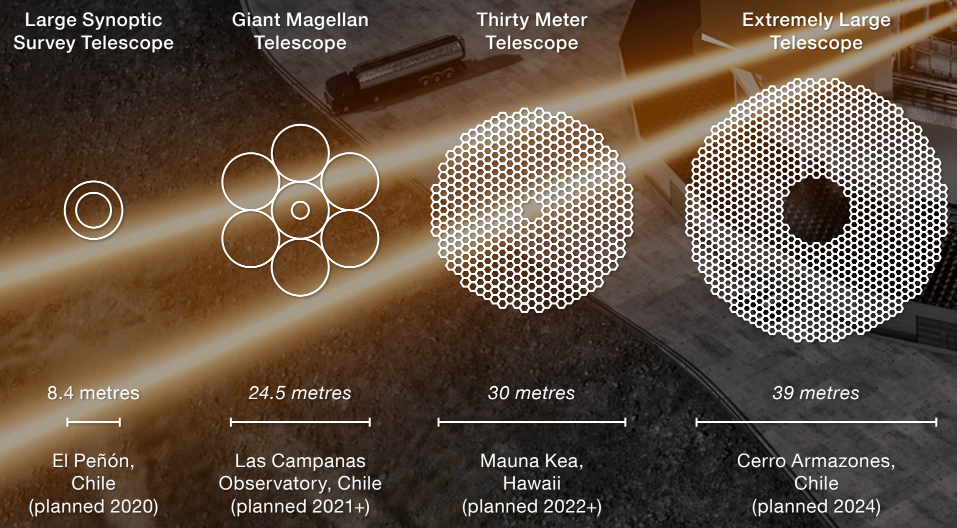
Extremely large telescopes are one of the highest priorities in ground-based astronomy. They will vastly advance astrophysical knowledge, allowing detailed studies of planets around other stars, the first objects in the Universe, supermassive black holes, and the nature and distribution of the dark matter and dark energy that dominate the Universe.

ESO's revolutionary Extremely Large Telescope (ELT) will have a 39-metre main mirror with a collecting area of almost 1000 square metres, making it the world's biggest eye on the sky. The ELT will be bigger than all currently existing large optical research telescopes combined and will gather about 15 times more light than the largest single optical telescopes today. Its adaptive optics technology will provide images 15 times sharper than those from the NASA/ESA Hubble Space Telescope. The ELT has a novel five-mirror design and the primary mirror is composed of 798 hexagonal segments, each about 1.4 metres across but only 5 centimetres thick.

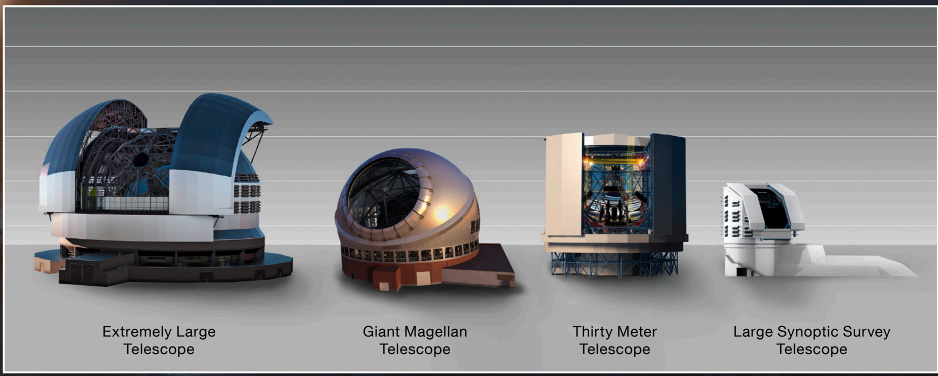
The ELT is expected to see first light in 2024, and it will tackle the biggest scientific challenges of our time. It will aim to study Earth-like planets orbiting in the habitable zones around other stars, where life could exist — one of the Holy Grails of modern observational astronomy. It will also perform stellar archaeology by studying old stars and stellar populations in nearby galaxies, as well as making fundamental contributions to cosmology by studying the first stars and galaxies, and probing the nature of dark matter and dark energy. Astronomers are also expecting new and unforeseeable questions to arise from the discoveries made with the ELT.

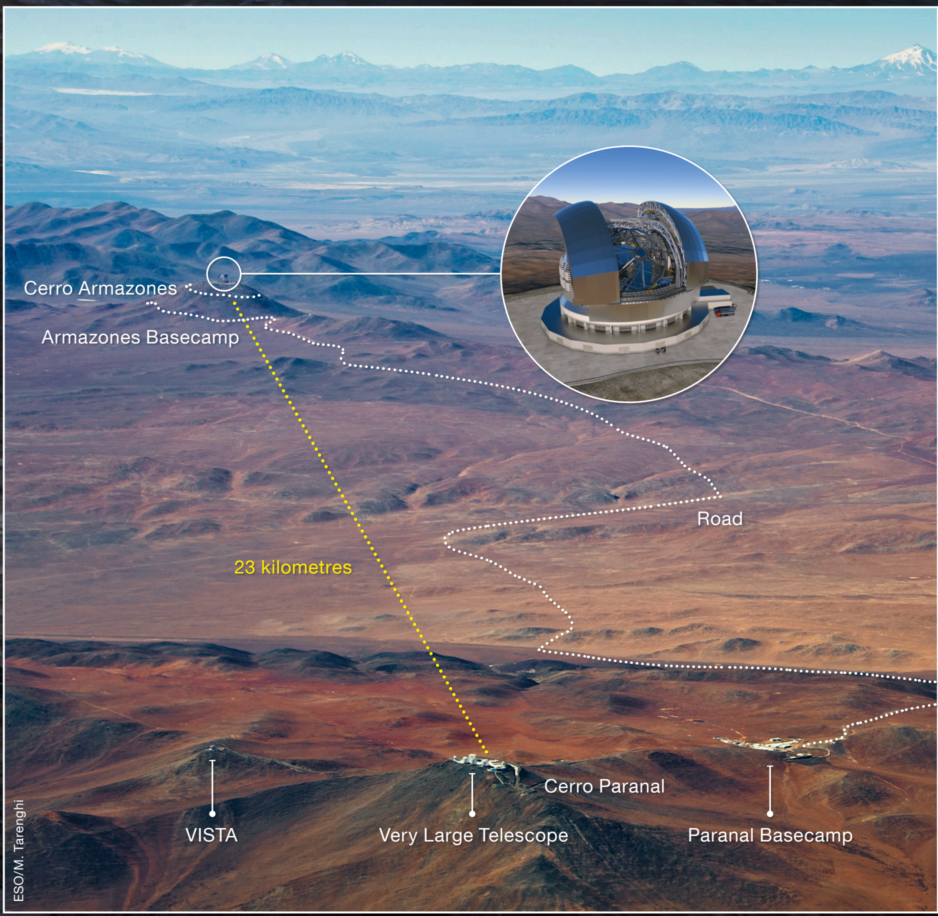
Name	ELT
Site	Cerro Armazones
Altitude	3046 metres
Wavelengths	Optical/near-infrared
Technique	Built-in adaptive optics using 2.6-metre deformable mirror and up to 8 laser guide stars
Optical design	Five-mirror design
Primary mirror diameter	39 metres
Mount	Alt-Azimuth
First light	2024

Size comparison of the primary mirrors of giant optical telescopes under construction.



ESO/L. Calçada





Upper: This graphic compares the dome of the Extremely Large Telescope with those of other major ground-based telescope facilities that are currently under construction.

Lower: This map of the region of northern Chile shows ESO's Paranal and Cerro Armazones sites and the road between them.

This artist's rendering shows a night view of the Extremely Large Telescope in operation on Cerro Armazones in northern Chile.

ALMA

High on the Chajnantor Plateau in the Chilean Andes, ESO and its global partners operate the Atacama Large Millimeter/submillimeter Array (ALMA), the largest astronomical project in existence. ALMA is a state-of-the-art radio observatory that studies light from some of the coldest objects in the Universe.

ALMA is composed of 66 high-precision antennas: the main array of fifty 12-metre antennas, which act together as a single telescope, and an additional compact array of four 12-metre and twelve 7-metre antennas.

ALMA probes the Universe at millimetre and submillimetre wavelengths with unprecedented sensitivity and resolution — its vision is up to ten times as sharp as that of the NASA/ESA Hubble Space Telescope. The light it observes lies between infrared light and radio waves in the electromagnetic spectrum, and comes from vast cold clouds in interstellar space and from some of the earliest and most distant galaxies in the Universe. Such regions are often dark and obscured in visible light, but shine brightly in the millimetre and submillimetre parts of the spectrum.

ALMA studies the building blocks of stars, planetary systems, galaxies and life itself, allowing astronomers to address some of the deepest questions about our cosmic origins.

Because millimetre and submillimetre radiation is heavily absorbed by water vapour in the Earth's atmosphere, ALMA was built 5000 metres above sea level on the Chajnantor plateau in northern Chile. The site has one of the driest atmospheres on Earth and the conditions are unsurpassed for observing.

ALMA is a partnership of ESO, the U.S. National Science Foundation (NSF) and the National Institutes of Natural Sciences (NINS) of Japan in cooperation with the Republic of Chile. ALMA is funded by ESO on behalf of its Member States, by NSF in cooperation with the National Research Council of Canada (NRC) and the National Science Council of Taiwan (NSC) and by NINS in cooperation with the Academia Sinica (AS) in Taiwan and the Korea Astronomy and Space Science Institute (KASI).

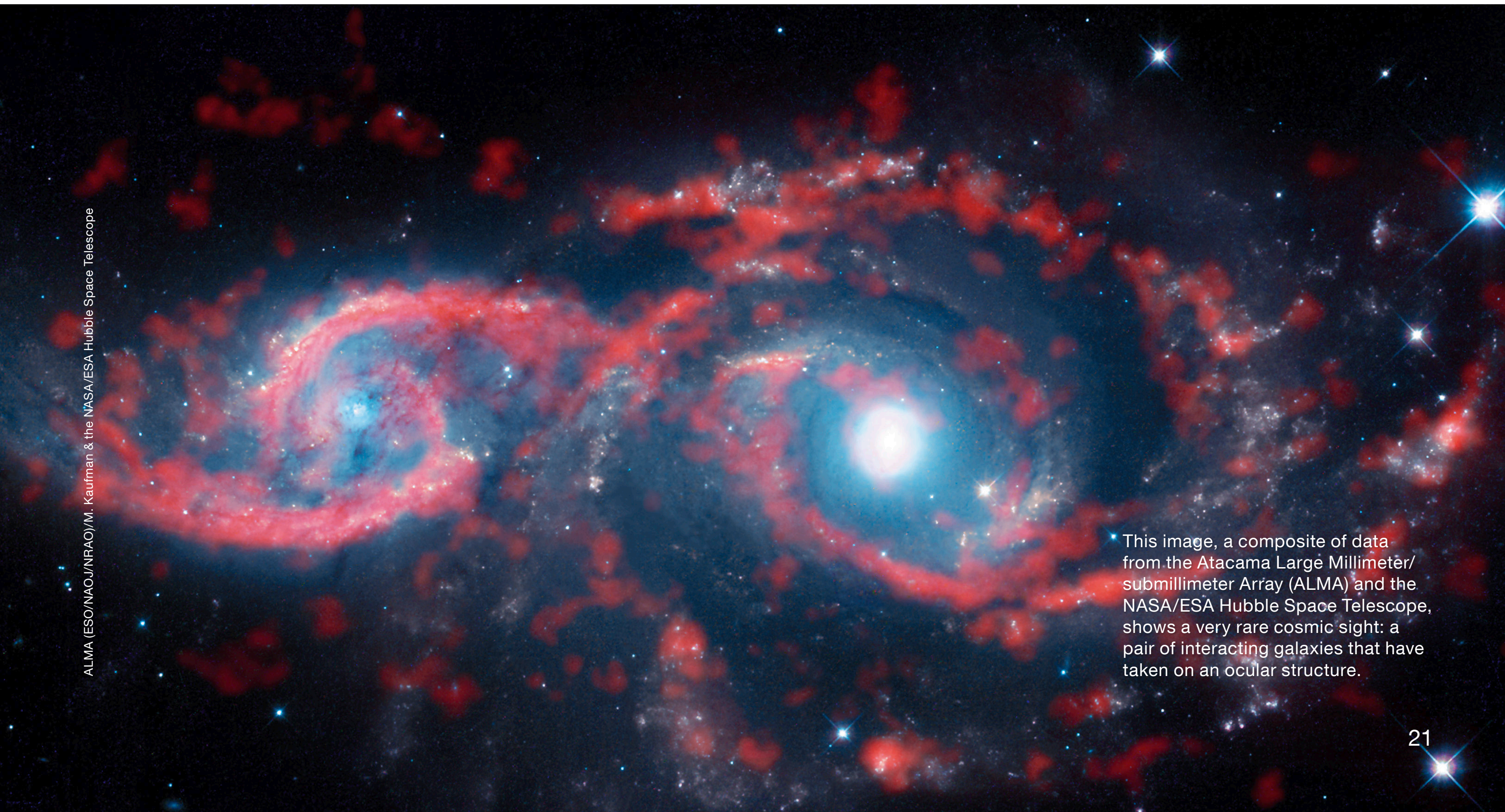
Name	ALMA
Site	Chajnantor
Altitude	4576–5044 metres
Wavelengths	Submillimetre
Technique	Interferometry with 150-metre to 16-kilometre baselines
Optical design	Cassegrain
Antenna diameter	54 × 12 metres; 12 × 7 metres
Mount	Alt-Azimuth
First light	30 September 2011

This view shows several of the ALMA antennas and the central regions of the Milky Way above.

ESO/B. Tafreshi (twanight.org)

ALMA (ESO/NAOJ/NRAO), J. Bally/H. Drass et al.

Stellar explosions are most often associated with supernovae, the spectacular deaths of stars. But new ALMA observations of the Orion Nebula complex provide insights into explosions at the other end of the stellar life cycle, star birth.



ALMA (ESO/NAOJ/NRAO)/M. Kaufman & the NASA/ESA Hubble Space Telescope

This image, a composite of data from the Atacama Large Millimeter/submillimeter Array (ALMA) and the NASA/ESA Hubble Space Telescope, shows a very rare cosmic sight: a pair of interacting galaxies that have taken on an ocular structure.

APEX

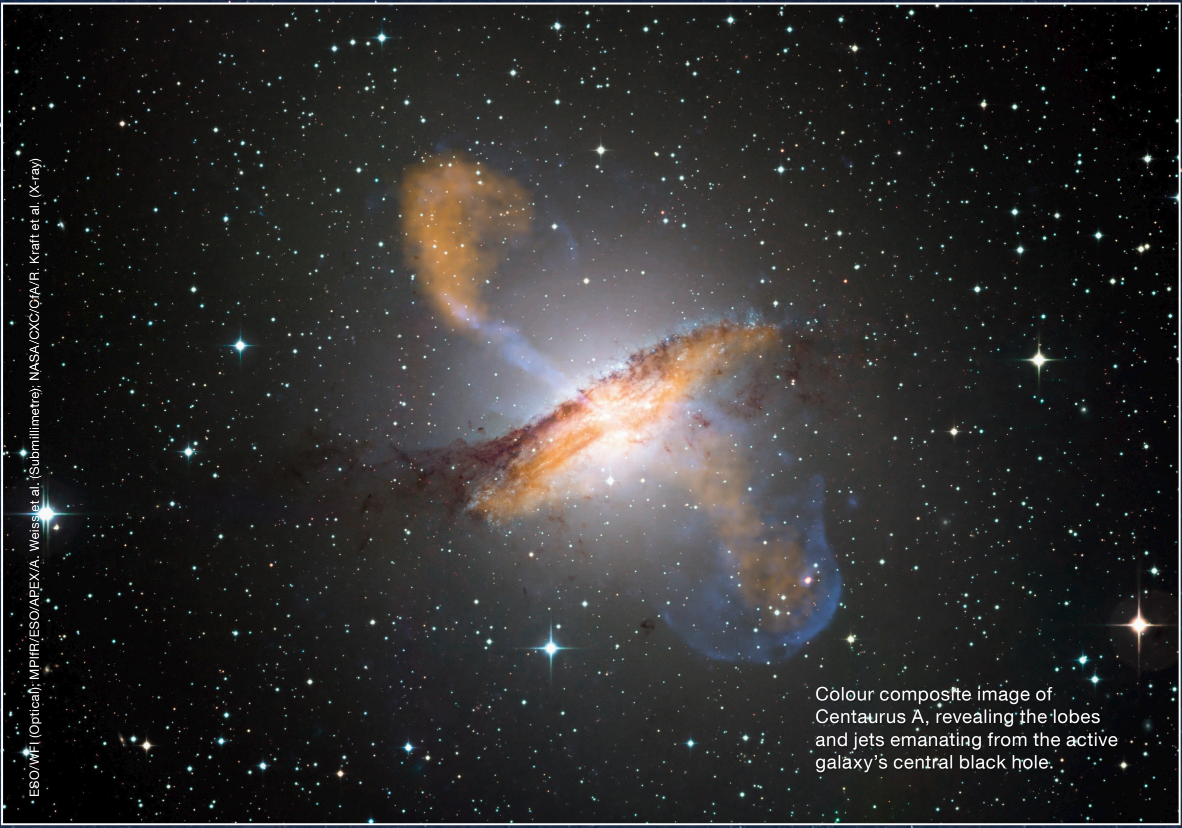
A complementary facility for millimetre and submillimetre astronomy is also located on the Chajnantor Plateau: the Atacama Pathfinder Experiment (APEX). This 12-metre telescope is based on an ALMA prototype antenna and operates at the ALMA site. APEX was operational for many years before ALMA and is taking on an important survey role now that ALMA is complete.

Like ALMA, APEX is designed to work at submillimetre wavelengths, which are key to revealing some of the coldest, dustiest and most distant objects in the Universe. Over the years, it has probed the wild early lives of today's most massive galaxies, studied matter torn apart by a supermassive black hole, and detected molecules of hydrogen peroxide in interstellar space for the first time. APEX is also used study the conditions inside molecular clouds, such as those in the Orion Nebula or the Pillars of Creation in the Eagle Nebula, advancing our understanding of the cradles of gas and dust where new stars are born.

APEX is a collaboration between the Max-Planck-Institut für Radioastronomie, the Onsala Space Observatory and ESO. The telescope is operated by ESO.

Name	APEX
Site	Chajnantor
Altitude	5050 metres
Wavelengths	Submillimetre
Optical design	Cassegrain
Primary antenna diameter	12 metres
Mount	Alt-Azimuth
First light	14 July 2005

The Atacama Pathfinder Experiment (APEX) telescope looks skyward during a bright, moonlit night on Chajnantor, one of the highest and driest observatory sites in the world.



ESO/WFI (Optical); MPIfR/ESO/APEX/A. Weiss et al. (Submillimetre); NASA/CXC/CfA/R. Kraft et al. (X-ray)

Colour composite image of Centaurus A, revealing the lobes and jets emanating from the active galaxy's central black hole.

ESO/Digitized Sky Survey 2

This dramatic new image of cosmic clouds in the constellation of Orion reveals what seems to be a fiery ribbon in the sky.

ESO/B. Tafreshi (twanight.org)

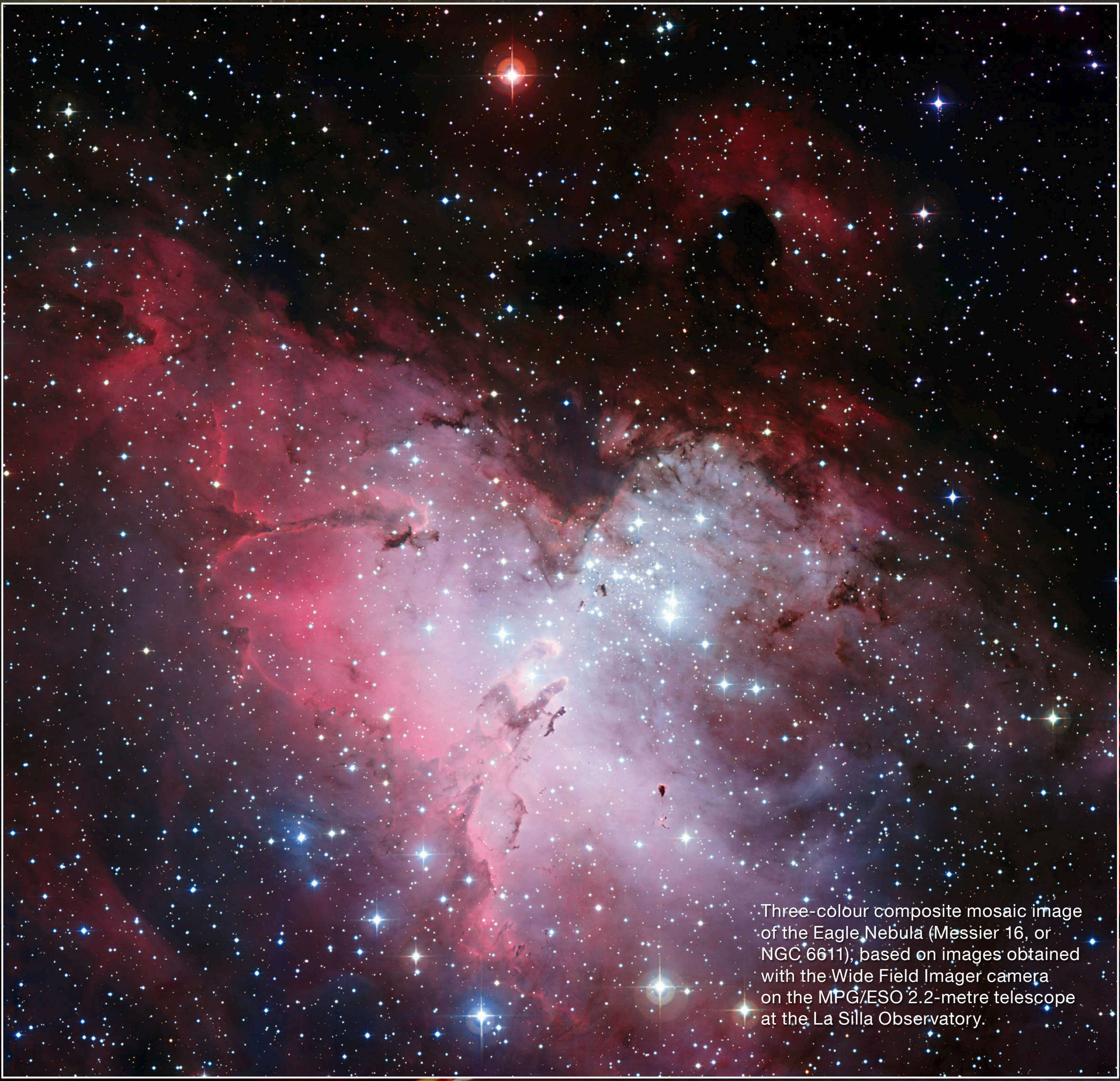
La Silla

The La Silla Observatory has been an ESO stronghold since the 1960s. Here, ESO still operates two of the best 4-metre-class telescopes, enabling La Silla to maintain its position as one of the most scientifically productive observatories in the world.

The 3.58-metre New Technology Telescope (NTT) broke new ground in telescope engineering and design. It was the first telescope 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.

The ESO 3.6-metre telescope has been in operation since 1977. Following major upgrades, it remains at the front line of 4-metre-class telescopes in the southern hemisphere. It is home to the world's foremost exoplanet hunter: HARPS, a spectrograph with unrivalled precision.

The infrastructure of La Silla is also used by many of the ESO Member States for targeted national projects such as the Swiss 1.2-metre Leonhard Euler telescope, the MPG/ESO 2.2-metre and the Danish 1.54-metre telescopes. The Rapid Eye Mount (REM) and TAROT (Télescope à Action Rapide pour les Objets Transitoires — Rapid Action Telescope for Transient Objects) are gamma-ray burst chasers. The TRAPPIST (TRAnsiting Planets and PlanetesImals Small Telescope), ExTrA (Exoplanets in Transits and their Atmospheres) and MASCARA (The Multi-site All-Sky CAmeRA) telescopes hunt for exoplanets. In addition, BlackGEM looks for optical counterparts to gravitational wave detections, and the Test-Bed Telescope — a project in collaboration with ESA — surveys artificial and natural near-Earth objects.


Three-colour composite mosaic image of the Eagle Nebula (Messier 16, or NGC 6611), based on images obtained with the Wide Field Imager camera on the MPG/ESO 2.2-metre telescope at the La Silla Observatory.

ESO/B. Tafreshi (twanight.org)

The ESO 3.6-metre telescope dome is silhouetted against the sky in a nighttime view of the La Silla Observatory.

CTA

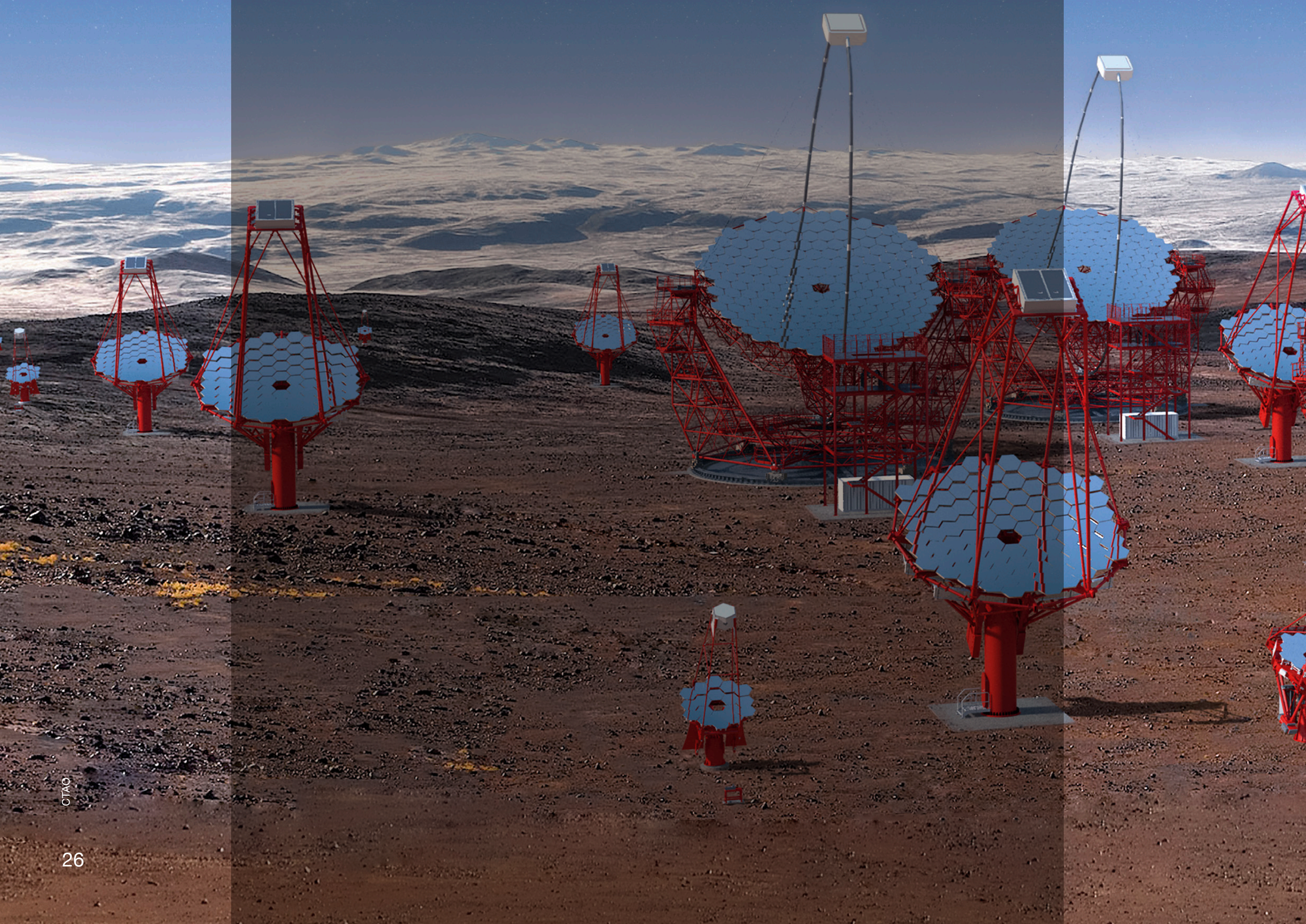
The Cherenkov Telescope Array (CTA) is a next-generation ground-based observatory being built for very high energy gamma-ray astronomy. It is foreseen that ESO's Paranal Observatory will host the southern array of the telescope, which would be supported by the existing advanced ESO infrastructure.

The CTA plan is to have around 118 telescopes worldwide, with 99 telescopes at the larger southern site, around ten kilometres south-east of the VLT. ESO would operate the southern array and in return, 10 % of the observing time on both the southern and the northern array — on La Palma — would be made available to scientists in the ESO Member States. In addition, 10 % of the observing time on the southern array will be reserved for Chilean science institutes.

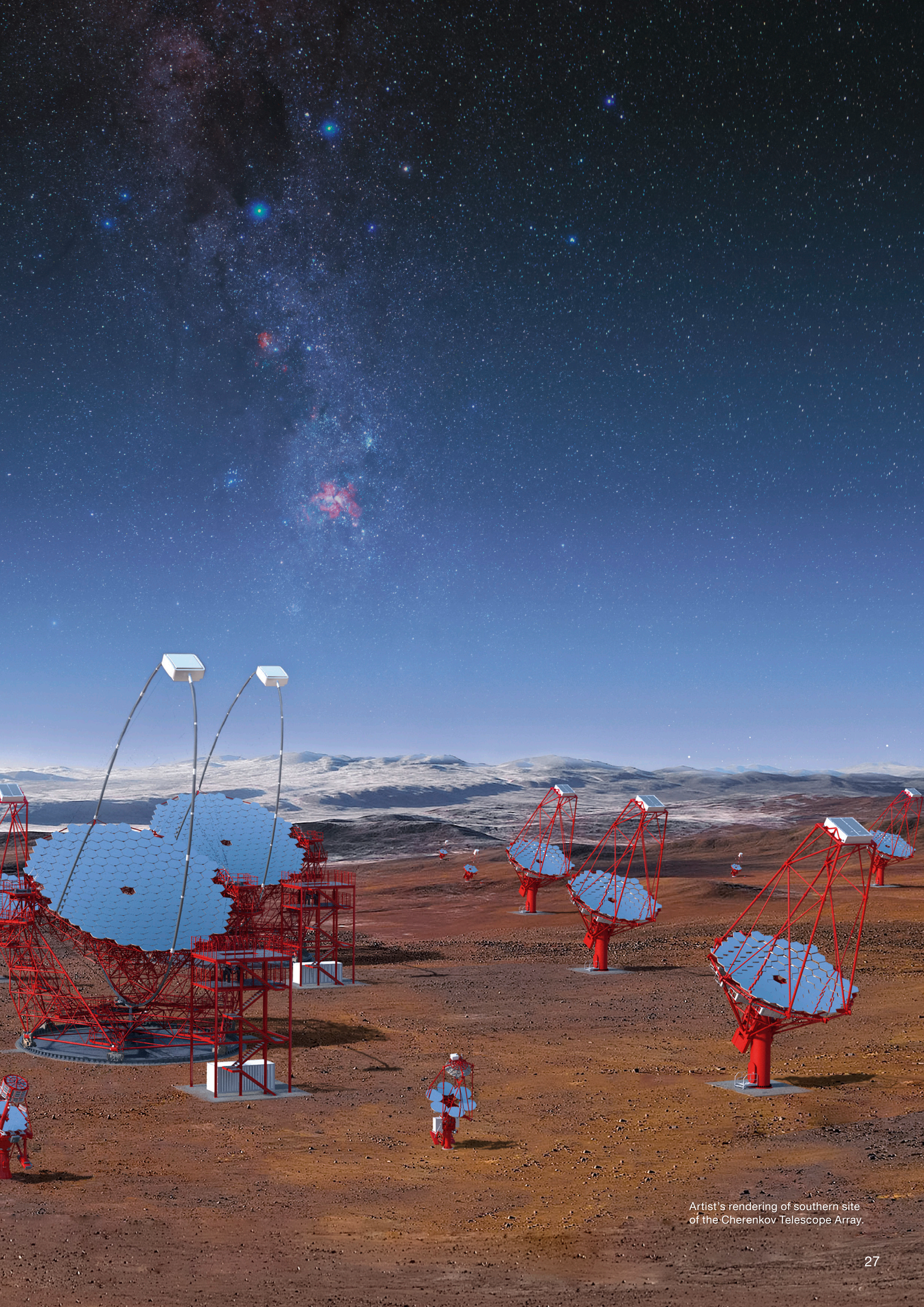
CTA serves as an open facility to a wide astrophysics community. Over 1350 scientists and engineers from five continents, 32 countries and over 210 research institutes are currently participating in the CTA project.

CTA — with its large collecting area and wide sky coverage — will be the largest and most sensitive high-energy gamma-ray observatory in the world. It will detect gamma-rays with unprecedented accuracy and will be 10 times more sensitive than existing instruments.

Gamma-rays are emitted by some of the hottest and most powerful objects in the Universe, such as supermassive black holes and supernovae. Although the Earth's atmosphere prevents gamma-rays from reaching the surface, CTA's mirrors and high-speed cameras will capture short-lived flashes of the characteristic eerie blue Cherenkov radiation that is produced when gamma-rays interact with the atmosphere. Pinpointing the source of this radiation will allow each gamma-ray to be traced back to its cosmic source, helping astronomers to study some of the most extreme and violent events in the high-energy Universe.



CTAO



Artist's rendering of southern site of the Cherenkov Telescope Array.

ESO & Chile

On 6 November 1963 the initial agreement between the Government of Chile and ESO was signed. This was the beginning of a more than 50-year international success story and the forging of an important cultural link between Chile and Europe. ESO is engaged in a close and very fruitful collaboration with Chile at many levels, including government, universities, science institutes and industry.

During this collaboration Chilean scientific, technological and engineering prowess has developed in step with the advances in astronomy and its associated technologies in ESO's Member States. This advancement has made Chilean scientists and engineers very valuable partners for ESO.

ESO contributes to the development of astronomy in Chile through the funds managed by the ESO–Government of Chile Joint Committee and the ALMA CONICYT Joint Committee, financing a wide range of activities in science, astrotechnology, and education. The Chilean astronomical community also has preferential access to a percentage of observing time on ESO telescopes.

In addition, ESO carries out several regional and local cooperation programmes in the regions of Coquimbo and Antofagasta, where the observatory sites are located. ESO also promotes natural conservation programmes and an awareness of the local heritage, including the dark skies, in those regions.

The cooperation between Chile and ESO has proved to be not only solid and long-lasting, but also flexible. Most importantly, this association opens an exciting pathway into the future — for the benefit of Chile, the ESO Member States, and the progress of science and technology.

Laguna Miñiques is situated high in the Andean Altiplano, close to the border to Argentina. Located about 80 kilometres south of ALMA, visitors pass by this beautiful lake when driving on Route 23 to Argentina.

A. Duro/ESO

From Idea to Published Paper: The Data Flow

The operation of ESO telescopes forms a seamless process that starts when astronomers submit a proposal for an observing project that addresses specific scientific objectives. Proposals are peer-reviewed by experts from the community and the approved projects are translated into a detailed description of the observations to be made.

The observations are then performed at ESO's telescopes, and the data collected are immediately made available to the corresponding research teams via the ESO archive. The scientific observations and their associated calibration data are also used by ESO scientists to monitor the quality of the data and the behaviour of the instruments in detail, to ensure that their performance is always within specification. This entire process relies on the continuous transfer of huge amounts of data between the observatories in Chile and ESO's Headquarters in Garching, Germany.

All the scientific and calibration data gathered are stored in the ESO Science Archive Facility. This contains a complete record of all observations obtained since the start of operations on Paranal by the Very Large Telescope, its interferometer and the survey telescopes VISTA and the VST. It also contains observations obtained with the La Silla telescopes and with the APEX submillimetre radio telescope on Chajnantor. Observations stored in the archive typically become publicly available one year after they were obtained, allowing them to be used by other researchers.

The traditional way of observing is to allow astronomers to travel to the telescope to carry out the observations themselves, assisted by expert locally-based personnel. Known as visitor mode, this allows astronomers to adapt their observing strategies to the atmospheric conditions and the results as they are obtained. But the necessary observing conditions cannot be guaranteed on any given night.

ESO has also developed an alternative scheme, called service observing. Each predefined observation specifies the acceptable conditions which should be obtained in order to fulfil its scientific goals. Based on these specifications, observations are flexibly scheduled at the telescope and carried out. The many advantages of flexible scheduling have made service observing the mode of choice for about 60–70 % of VLT users.

The data centre at ESO's Headquarters in Garching bei München, Germany, which archives and distributes data from ESO's telescopes.

Partnerships

Fostering cooperation in astronomy is at the core of ESO's mission. The organisation 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 ESO observatories. Astronomers often form international research teams with members in several countries.

ESO has an extensive programme for students and fellows, and senior scientists from the Member States and other countries work as visiting scientists at the ESO sites, contributing to the mobility of European scientists. In addition, ESO maintains a programme of international conferences with themes in frontline astronomical science and technology, and provides support for the international journal *Astronomy & Astrophysics*.

European industry plays a vital role in ESO projects. Close collaboration with a large number of European high-tech industries provides users with progressively better astronomical telescopes and instruments, made possible by the active and enthusiastic participation of commercial partners from all the Member States and Chile.

In the field of technology development, ESO maintains close connections with many research groups at scientific institutes in the Member States and beyond. Astronomers in the Member States are therefore involved in the planning and realisation of scientific instruments for current ESO telescopes, and for other existing or planned telescopes. Instrument development offers opportunities for national research centres of excellence, attracting young scientists and engineers.

Working at ESO

Are you interested in working in a stimulating international environment at the forefront of technology? At ESO you will experience an inclusive, international, and multicultural working environment, where respect and collaboration are paramount and where individual and team contributions are encouraged. Whether you join our technical, science or support teams, you will be part of a diverse and talented team, contributing directly to some of the most challenging astronomical projects. See jobs.eso.org and www.linkedin.com/company/european-southern-observatory.

Staff and conference visitors at ESO.

Flags of the ESO Member States on the Very Large Telescope platform.

ESO/Max Alexander

Education and Public Outreach

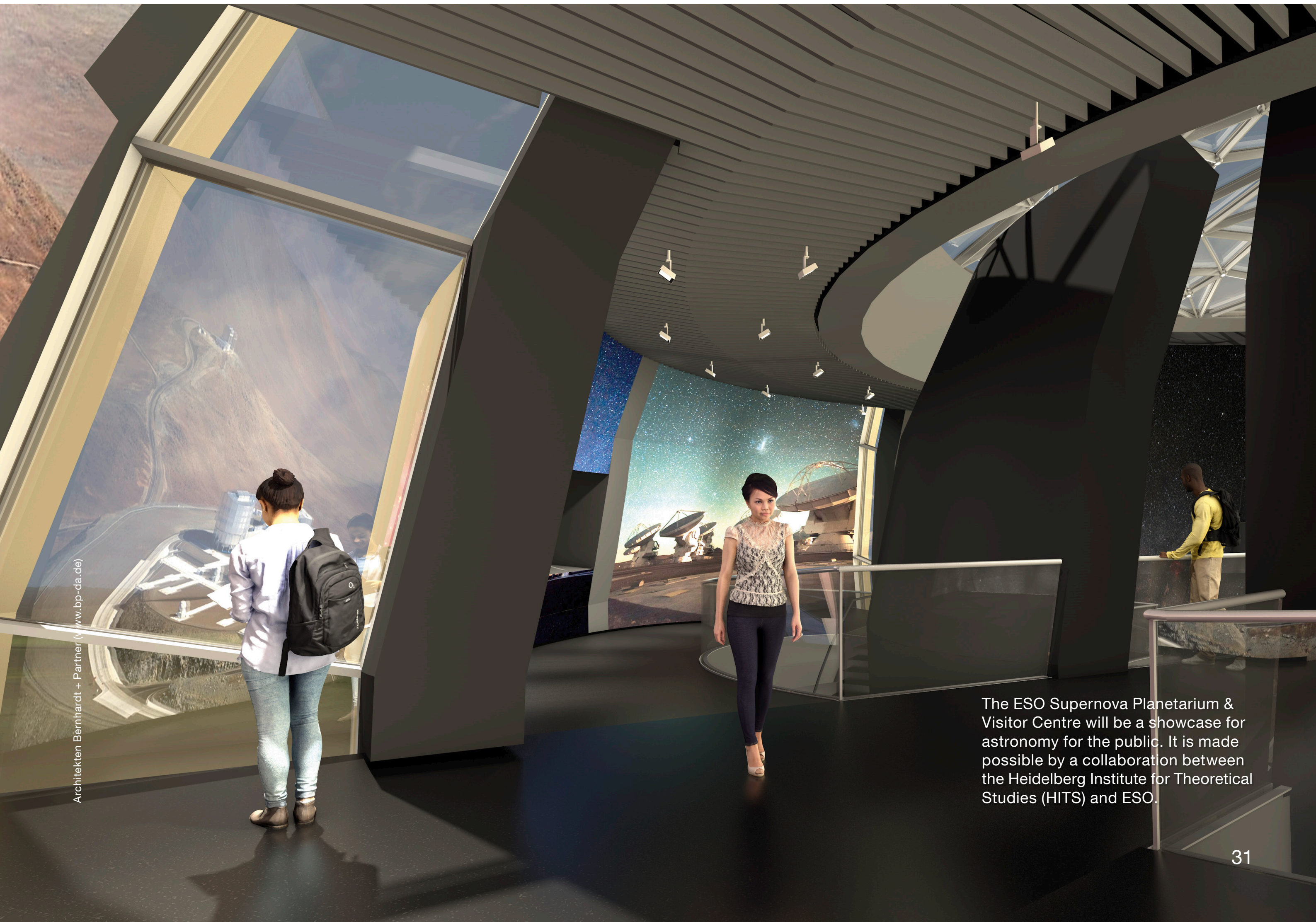
Targeted investments in education and outreach enable ESO to share both the science of astronomy in general and the results from the most important ground-based observatory in the world with the public and the media. ESO produces a wide range of free high-quality outreach products such as images, videos and print products.

The ESO Supernova Planetarium & Visitor Centre at its Headquarters in Germany is the first open-source planetarium in the world and a cutting-edge free astronomy centre for the public. The Centre provides an immersive experience, including interactive astronomical exhibitions that share the fascinating world of astronomy and ESO, leaving visitors in awe of the Universe we live in. It also delivers curriculum-based educational workshops for students and teachers, providing unforgettable learning experiences for schools.

In conjunction with the ESO Supernova, ESO produces free planetarium shows for other planetariums, innovative and authentic open-source science visualisations, and the first real-time, data distribution system for planetariums around the world.

Stay in touch

ESO has a diverse and active presence on social media across a variety of platforms, reaching hundreds of millions of people per year across Facebook, Twitter, Instagram, Pinterest, Flickr, YouTube, and LinkedIn. Connect with us to stay up-to-date with the latest discoveries, be the first to see breathtaking images taken by ESO telescopes, and get insight into the daily operations of our cutting-edge observatories. ESO also sends out weekly and monthly newsletters containing stunning images of the Universe, the latest science results from ESO's telescopes, and news about the organisation.



The ESO Supernova Planetarium & Visitor Centre will be a showcase for astronomy for the public. It is made possible by a collaboration between the Heidelberg Institute for Theoretical Studies (HITS) and ESO.

ESO/M. Kornmesser

www.eso.org

ESO Headquarters
Karl-Schwarzschild-Str. 2, 85748 Garching bei München, Germany
Phone: +49 89 320 06-0 | Fax: +49 89 320 23 62 | E-mail: information@eso.org

09.2017 — English