ESO

European Organisation
for Astronomical
Research in the
Southern Hemisphere

Annual Report 2011

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presented to the Council by the
Director General
Prof. Tim de Zeeuw

The European Southern Observatory

ESO, the European Southern Observatory, is the foremost intergovernmental astronomy organisation in Europe. It is supported by 15 countries: Austria, Belgium, Brazil[1], the Czech Republic, Denmark, France, Finland, Germany, Italy, the Netherlands, Portugal, Spain, Sweden, Switzerland and the United Kingdom. Several other countries have expressed an interest in membership.

Created in 1962, ESO carries out an ambitious programme focused on the design, construction and operation of powerful ground-based observing facilities enabling astronomers to make important scientific discoveries. ESO also plays a leading role in promoting and organising cooperation in astronomical research.

ESO operates three unique world-class observing sites in the Atacama Desert region of Chile: La Silla, Paranal and Chajnantor. ESO's first site is at La Silla, a 2400-metre-high mountain 600 kilometres north of Santiago de Chile. It is equipped with several optical telescopes with mirror diameters of up to 3.6 metres.

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, a technology developed at ESO and now applied to most of the world's current large telescopes. While La Silla remains at the forefront of astronomy, and is still the third most scientifically productive in ground-based astronomy (after Paranal and the Keck Observatory), the 2600-metre-high Paranal site, with the Very Large Telescope array (VLT), the Visible and Infrared Survey Telescope for Astronomy (VISTA), the world's largest survey telescope, and the VLT Survey Telescope (VST), the largest telescope designed to exclusively survey the skies in visible light, is the flagship facility of European astronomy. Paranal is situated about 130 kilometres south of Antofagasta in Chile, 12 kilometres inland from the Pacific coast in one of the driest areas in the world. Scientific operations began in 1999 and have resulted in many extremely successful research programmes.


ESO/J. Pérez

Star trails over ESO's La Silla Observatory.

The VLT is a most unusual telescope, based on the latest technology. It is not just one, but an array of four telescopes, each with a main mirror of 8.2 metres in diameter. With one such telescope, images of celestial objects as faint as magnitude 30 have been obtained in a one-hour exposure. This corresponds to seeing objects that are four billion times fainter than those seen with the naked eye.

One of the most exciting features of the VLT is the option to use it as a giant optical interferometer (VLT Interferometer or VLTI). This is done by combining the light from two or more of the 8.2-metre telescopes and including one or more of four 1.8-metre moveable Auxiliary Tele-

The ESO Very Large Telescope atop Cerro Paranal, some 120 kilometres south of Antofagasta, in the Chilean Atacama Desert.

[1] Brazil, having signed an Accession Agreement in December 2010, will officially become the 15th Member State of ESO on completion of the requisite ratification process.

ALMA (ESO/NAOJ/NRAO), W. Garnier (ALMA). ACKGT: General Dynamics C4 Systems

Five of the first ALMA antennas at the Array Operations Site.

scopes (AT). In this interferometric mode, the telescope has vision as sharp as that of a telescope the size of the separation between the most distant mirrors. For the VLTI, this is 200 metres.

Each year, about 2000 proposals are submitted for the use of ESO telescopes, requesting between three and six times more nights than are available. ESO is the most productive ground-based observatory in the world whose operation yields many peer-reviewed publications: in 2011 alone, more than 780 refereed papers based on ESO data were published.

The Atacama Large Millimeter/submillimeter Array (ALMA), the largest ground-based astronomy project in existence, is a revolutionary facility for world astronomy. ALMA will comprise an array of 66 12- and 7-metre diameter antennas observing at millimetre and submillimetre wavelengths. Construction of ALMA started in 2003 and it started scientific observations in 2011. ALMA is located on the high altitude Llano de Chajnantor, at 5000 metres elevation — one of the highest astronomical observatories in the world. The ALMA project is a partnership between Europe, East Asia and North America, in cooperation with the Republic of Chile. ESO is the European partner in ALMA.

The Chajnantor site is also home to the Atacama Pathfinder Experiment (APEX) a 12-metre millimetre and submillimetre telescope, operated by ESO on behalf of the Max Planck Institute for Radio Astronomy, the Onsala Space Observatory and ESO itself.

The next step beyond the VLT is to build a European Extremely Large optical/infrared Telescope (E-ELT) with a primary mirror 39.3 metres in diameter. The E-ELT will be the “world’s the biggest eye on the sky” — the largest optical/near-infrared telescope in the world and ESO is, together with the community, drawing up detailed construction plans. The E-ELT will address many of the most pressing unsolved questions in astronomy. It may, eventually, revolutionise our perception of the Universe, much as Galileo’s telescope did 400 years ago. The final go-ahead for construction is expected in 2012, with the start of operations at the beginning of next decade.

ESO’s Headquarters are located in Garching, near Munich, Germany. This is the scientific, technical and administrative centre of ESO where technical development programmes are carried out to provide the observatories with the most advanced instruments. ESO’s offices in Chile are located in Vitacura, Santiago. They host the local administration and support groups, and are home to ESO/Chile astronomers when they are not at the observatories. This site also contains the new ALMA Santiago Central Office. ESO Vitacura has become an active node for training new generations of researchers, acting as a bridge between scientists in Europe and Chile.

The regular Member State contributions to ESO in 2011 were approximately 131 million euros and ESO employs around 740 staff members.

ESO/L. Calçada

Artist’s impression of the European Extremely Large Telescope.

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Foreword

During this, the final year before the celebration of ESO's 50th anniversary, Council has been following and strongly supporting the wide range of activities reported here. This Annual Report clearly depicts a very lively organisation, which is enthusiastically completing its first half century with a very exciting and challenging programme ahead.

The accession of Brazil to ESO, signed at the end of 2010, has been progressing towards parliamentary ratification, and this is expected to be completed in 2012. Council was pleased to see that, following the fast-track signature of the accession agreement and, according to the provisions set out for this interim period, actions have been taken in 2011 to engage Brazil fully as ESO's 15th Member State. Brazilian astronomers are successfully accessing ESO telescopes, industrial awareness actions have taken place and involvement in new instrumentation from Brazilian research centres is commencing.

The telescopes at the La Silla Paranal Observatory that are already in successful operation were joined this year by the VST, and the regular survey operations of VISTA continued. ESO Council is very proud to have the most powerful and scientifically productive ground-based observatory in the world. It must be remembered that keeping the telescopes in La Silla, Paranal and APEX in Chajnantor in the best working condition requires effort and dedication from ESO staff, often in cooperation with researchers and institutions from the Member States.

ALMA made very swift progress this year, with more than 25 antennas already in place at the high site. The first six European antennas were accepted this year and two of them became part of the 16-antenna array that started Early Science observations. Other high technology items from Europe are largely or even fully delivered, with most of the action now being directed towards the integration of these components. The permanent power supply system, a very large deliverable from ESO to the ALMA project, was nearing the end of commissioning and will be accepted and handed over to the project early in 2012. Council is also keeping a careful watch on progress with the ALMA Residencia, which is now being designed. This is a very important ingredient for ALMA's successful operations over the coming decades. ALMA is set at a truly captivating site, but living conditions are often very harsh. Council is committed to securing a Residencia that provides similar living conditions to those on Paranal.

ALMA Early Science started on 30 September, thus reaching a very important milestone. The call for proposals was open to the worldwide astronomical research community for Early Science observations with ALMA and was a resounding success, particularly in ESO's Member States, where the oversubscription factor was more than tenfold. It is very rewarding to see that this collaboration, which ESO has developed with international partners in ALMA, is fulfilling the expectations from a wide research community that was eagerly awaiting this unique and transformational facility to start, even in a limited fashion, science operations.

With ALMA well on track towards completion, the next large ESO project — the E-ELT— also received full attention from Council. ESO conducted a delta-Phase B study of the project to make this telescope, the largest ever conceived, workable programmatically. In June, the 39-metre design was adopted. In addition to the invaluable input from ESO's standing advisory bodies, and in particular that of the Science and Technology Committee and its working groups, Council specifically requested external technical and cost external reviews of the project. The output from all reports received indicates that the E-ELT project rests on a solid foundation and that the cost estimates are very sound. Another critical milestone, the signature of the site agreement for the E-ELT with the Government of the Republic of Chile, fully in line with the offer made to host the telescope in 2010, was also successfully concluded.

The E-ELT construction proposal was prepared in October and released in December. With very constructive advice from the Finance Committee, Council was unanimously able to set up the principles for the financial scenario to fund the construction phase of the E-ELT. Delegations started to work feverishly to secure their share of these funds and it was very reassuring to see that by December a significant number of the Member States were already prepared to commit.

The E-ELT is a project for an ESO with 15 Member States, which means 15 different governments with an equal number of different approval procedures. It is clear that several months will be needed to conclude the process across the ESO membership. While this is taking place, Council authorised the ESO executive to continue with E-ELT preparatory activities, especially those related to risk reduction. The goal is now for Council to be able to approve E-ELT construction in 2012, when ESO will celebrate its 50th anniversary.

In closing, I would like to thank and recognise the dedication to ESO Council of my predecessor as President, Dr Laurent Vigroux.

President of the ESO Council
Xavier Barcons

Introduction

This year saw much progress across ESO's programme and a remarkable increase in ESO's visibility at the highest levels of the governments of the Member States and Chile. President Klaus of the Czech Republic, the Royal Heirs of Spain and the Crown Prince of Belgium all visited Paranal, as did Ministers Moreno and Parot from Chile and a delegation from Austria. Minister Garmendia of Spain, and a delegation from the Netherlands also visited both Paranal and Chajnantor.

Science

The Nobel Prize for Physics was awarded for the discovery of the accelerating expansion of the Universe by two teams, one led by Saul Perlmutter and the other by Brian Schmidt and Adam Riess, with ESO staff members Bruno Leibundgut and Jason Spyromilio amongst the team. The discovery was based in part on data taken with the NTT and the VLT. The scientific productivity of the ESO telescopes on La Silla, Paranal and Chajnantor continued to increase and the total number of refereed papers surpassed last year's record. The ESO telescopes remain highly oversubscribed. Two very large Public Spectroscopic Surveys were selected, one on the VLT and the other on the NTT, in both cases as ground-based preparation for and follow-up of the Gaia astrometric space mission to be launched by the European Space Agency (ESA) in 2013.

Operations

Commissioning of the VST and its optical camera OmegaCAM was carried out in the first nine months of the year and the VST went into regular survey operations on 15 October. The first advanced data products from the VISTA public surveys were made available to the community through the ESO archive and the observing efficiency of APEX was further increased.

Programmes

The implementation of the ambitious suite of second generation VLT instruments and the Adaptive Optics Facility stayed on track. A comprehensive implementation plan for the VLTI, covering the period through 2016, was developed and fully supported by the Scientific and Technical Committee. PRIMA at the VLTI measured its first astrometric vector, but at the end of the year it became clear that further improvement of the metrology was needed. This is being implemented.

ALMA

There was much progress on construction with many ESO deliverables completed, for example, the Netherlands Research School for Astronomy (NOVA)-led Band 9 receivers. The Finnish architectural firm Kouvo and Partanen won the competition for the design of the ALMA Residencia. By the end of the year four antennas of the European consortium (AEM) were incorporated into the array at ALMA's Array Operations Site (AOS) and another seven were in mechanical integration at the Operations Support Facilities (OSF). Early Science (Cycle 0) observations started in September after an overwhelming response from the community to the call for proposals. The response from the ESO "region" was higher than for the other partners, due in large part to the effective coordination of preparatory activities by the ESO ALMA Regional Centre, including its nodes in a number of the Member States.

European Extremely Large Telescope

The delta-Phase B study was concluded and the revised design with a segmented 39.3-metre main mirror was adopted as a baseline at the June Council meeting. A comprehensive instrumentation roadmap was developed in close collaboration with the community. The full construction proposal was submitted to Council in October and passed an external cost review as well as a separate cost and risk review carried out by an independent company. Funding principles for the construction of the E-ELT were developed with advice from the Finance Committee and unanimously approved by Council. This foresees the go-ahead of E-ELT construction when 90% of the cost to completion (or cost of construction of the telescope and instruments excluding contingency) is secure. While approval formally requires a two-thirds majority of the Member States, the firm intention is to have all Member States participate.

A new agreement with the Government of Chile regarding the E-ELT was signed on 13 October together with Minister of Foreign Affairs Moreno, during a festive occasion in Santiago attended by the ambassadors of most of the Member States. The Agreement includes the donation of a large tract of land contiguous to the Paranal property containing Cerro Armazones, a 50-year free concession of a further tract of land, and also regulates the Chilean observing time on the E-ELT.

ESO Long-term Perspectives were updated and demonstrate that ESO can carry out its programme with the current 14 Member States and Brazil in a way that will allow the E-ELT to be the first (and largest) of the next generation of giant telescopes to be operational, assuming construction approval comes in mid-2012. By the end of the year, five Member States were already in position to commit the required extra funding for the E-ELT, including ESO's largest Member State, Germany.

New Member States

ESO was pro-active in engaging the Brazilian astronomical and industrial community in its programme but the parliamentary ratification of the Brazilian accession agreement is turning out to take longer than expected. The governments of a number of Member States and also that of Chile actively encouraged the Brazilian government to move forward and honour its commitment to the 14 Member States of ESO. By the end of the year there were clear signals that progress towards ratification had resumed.

The astronomical communities in at least half a dozen additional countries are interested in an association with ESO, and informal discussions about potential membership are taking place at government level in some cases. The increased interest in ESO membership is driven by the clear signals that ESO is steadily moving ahead towards E-ELT construction.

Organisation

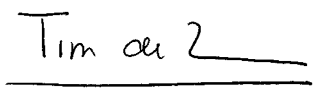
Early in the year, a comprehensive staffing review was carried out in order to make sure ESO has the right skill mix to carry out its programme. This led to further strengthening of matrix management between the Directorates of Programmes and Engineering, a clarification of the respective roles, and a readjustment of the management structure inside some divisions to improve efficiency. The new structure has been in place since 1 October and puts ESO in a position to carry out its ambitious programme of continuing to operate its observatories, shouldering its share of ALMA construction and operations and constructing the E-ELT on a competitive timescale.

A number of internal procedures were updated in the course of the year, including the General Conditions for Contracts and the Staff Rules and Regulations.

Headquarters building extension

The detailed design by Auer+Weber+Assoziierte was finalised and the contract for construction was awarded to BAM. Construction activities had started by the end of the year, including removal of the existing Storage Hall). Completion is expected in the second half of 2013.

The month of June saw the unexpected and very sudden passing of staff member Carlo Izzo from the Software Development Division and of Alan Moorwood, ESO's recently retired Director of Programmes.



Tim de Zeeuw
ESO Director General

G.Gillet/ESO

As the full Moon sets, the Sun is about to rise on the opposite horizon. The Very Large Telescope has already closed its eyes after a long night of observations, and telescope operators and astronomers sleep while technicians, engineers and day astronomers wake up for a new day of work.

ESO/H.H. Heyer

After nightfall on 15 June 2011 at the ESO Headquarters in Garching, near Munich, Germany, a blood-red Moon rose above the horizon. This striking phenomenon was due to a total lunar eclipse in progress at moonrise.

Science

ESO/VISTA/J. Emerson. Acknowledgment: Cambridge Astronomical Survey Unit

Research Highlights

Extrasolar planets

ESO's observing facilities continue to provide unique and exciting scientific results. The number of refereed publications based on data from ESO continues to rise and this year reached 783. Astronomical collaboration is fostered through the organisation of several workshops in Garching and in Vitacura. ESO continues to run active Studentship and Fellowship programmes and these are described in the new section on the Offices for Science included this year. Outreach activities continue at a high level and the inclusion of social media has proved to be a success, with an increasing number of people following ESO through these channels. The collection and selection of observing proposals for the ESO facilities remains a core function. The ESO community has maintained a very high number of submitted proposals, which implies intensive work by the Observing Programmes Committee. The selection of two Public Spectroscopic Surveys was certainly a highlight of the year. Commencing with this report, the usual publication list will no longer be printed, but will be provided electronically on the ESO website.

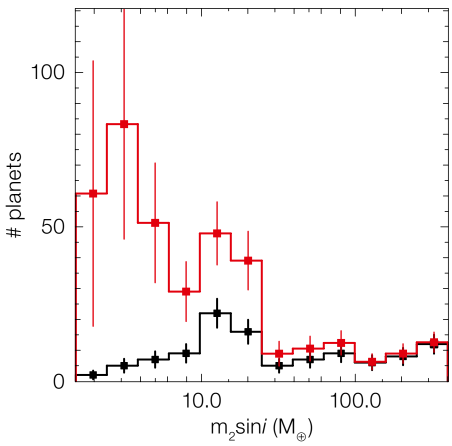
ESO's Visible and Infrared Survey Telescope for Astronomy has captured this unusual view of the Helix Nebula (NGC 7293), a planetary nebula located 700 light-years away.

Over the past 15 years, the study of extrasolar planets has witnessed a truly impressive development in which ESO telescopes have played a crucial and highly prominent role.

The 2009 and 2010 Annual Reports described some of the most exciting results on exoplanets that were coming from ESO telescopes in that period. This year has seen the discoveries continue: the planet-hunter HARPS on the 3.6-metre telescope has dominated the radial velocity detection of new planetary systems, adding tens of new planets to the exoplanet repertoire, among them some Earth-like planets within the habitable zones of their stars. These will become prime targets for future investigation with a new generation of telescopes to be pioneered with the E-ELT. The high radial velocity precision of HARPS coupled with the long observation campaign of eight years has allowed the population of super-Earths — planets with masses between one and ten times the mass of the Earth — to be characterised....

The known population of super-Earth and Neptune-type planets — collectively termed SEN — with masses less than about 30 to 40 Earth-masses is shown in the figure below.

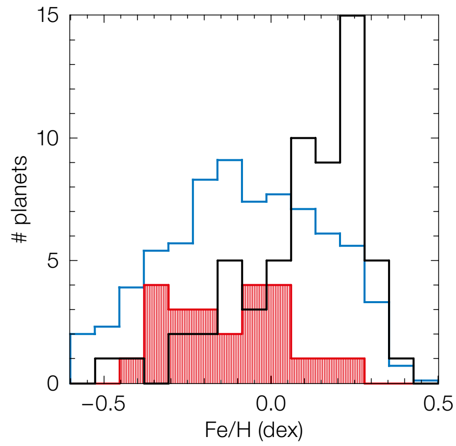
Histogram of known planetary masses. This shows the observed histogram (black line) and the numbers after correction for the detection bias (red line) — which represent the efficiency of the methods for detecting planets of different masses. The horizontal axis represents the fact that, from radial velocities alone, we cannot know the inclination of a planetary orbit around its star and so have a geometrical uncertainty inherent in the value. Super Earths (1–10 $M_\oplus$) dominate the sample.



About 50 % of solar-type stars host at least one SEN. The mass distribution decreases strongly from 15 to 30 Earth masses ($M_\oplus$) despite the fact that such planets are detected much more easily. Also, the SEN population seems to prefer intermediate orbital periods from 40 to 80 days. Unlike giant gaseous planets, the SEN population does not exhibit a preference for metal-rich host stars. The difference between both populations of planets is striking. Stars with gas-rich giant planets have predominantly super-solar metallicities, while the stars hosting SEN have mostly sub-solar abundances. It is interesting to note that the HARPS estimate for the occurrence rate of low-mass planets with periods shorter than 100 days is larger than 50 %, which is remarkably different from the estimate resulting from NASA's Kepler mission, which uses planetary transits as its (photometric) detection method. This discrepancy underlines the fundamental importance of employing *both* the radial velocity and transit search methods.

Other ESO instruments have been used to characterise the atmospheres of exoplanets and substantial observational constraints have been obtained to enhance our understanding of planet formation mechanisms. So this has also been a very active year for exoplanet research with ESO telescopes.

Histograms of host star metallicities ([Fe/H]) for giant gaseous planets (black line), for planets less massive than 30 $M_\oplus$ (red) — SEN, and for the global combined sample stars (blue line). The latter histogram has been divided by ten for ease of visual comparison. The host stars of SEN have predominantly sub-solar metallicities.



Understanding planet formation

The preferred paradigm for planet formation — core accretion — embraces the idea that the dust grains in the disc grow and coagulate to form planetesimals, which eventually form rocky cores. These subsequently continue to accrete and the planetesimals grow to become full-blown planets. Many of these discs can be resolved directly by the Hubble Space Telescope while large ground-based telescopes equipped with adaptive optics systems have the angular resolution and dynamic range to allow direct detection of young exoplanets in systems with evolved discs. The VLTI and ALMA provide a much better method of finding them. In recent years a large number of discs characterised by a lack of significant mid-infrared (IR) emission and a rise of emission into the far-IR have been detected. These transitional discs are believed to be in an intermediate evolutionary state between gas- and dust-rich primordial protoplanetary discs, and debris discs. The lack of mid-IR excess in cold discs has been interpreted as a sign of inner disc clearing, created by several mechanisms (see below), one of them being the formation of a planet that sweeps out its orbital region as it accretes gas and dust from the disc.

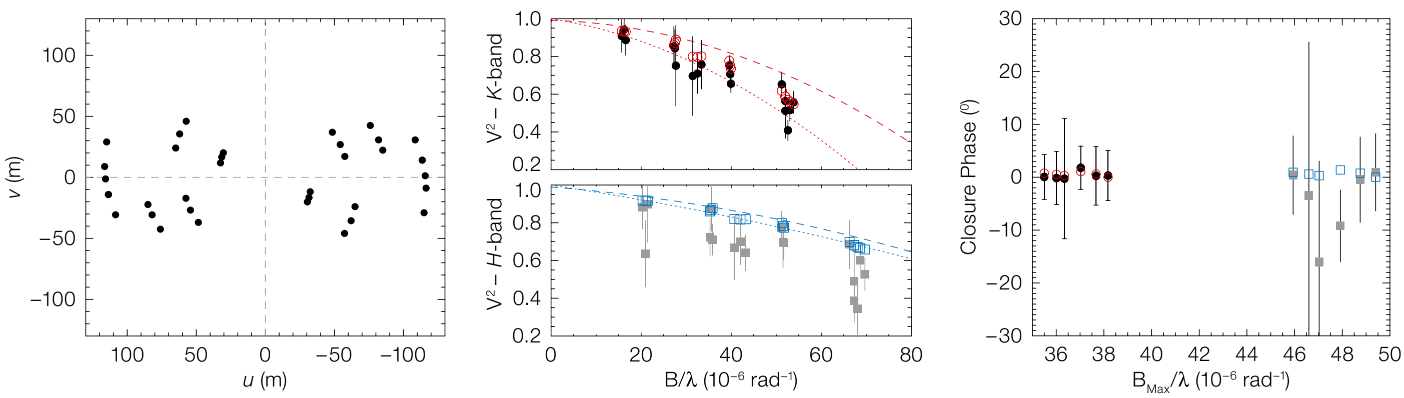
The angular sizes of some of these discs are ideally suited to interferometric observations. A prototypical transition disc is found around the star T Cha, a T Tauri star that has also been extensively studied with the Spitzer Space Telescope. To explain the spectrum of T Cha, two separated regions in the disc were required: an inner low-mass belt (from 0.08–0.2 Astronomical Units [AU]), and a massive outer disc extending from 15 to 300 AU. The large gap of almost 15 AU is consistent with the lack of emission around 10 µm and makes T Cha an ideal system to search for young planets. AMBER at the VLTI is ideally suited to map the inner structure of the disc in detail. By combining the AMBER observations with spectral fitting, the presence of an even narrower (0.13–0.17 AU) optically thick inner disc is implied. Near the inner edge of the inner disc (0.13 AU), the dust reaches a temperature close to the dust sublimation temperature. The outer disc is not detected by the AMBER observations, but new parameters for the inner disc force a change in the inner rim of the outer disc from 15 AU found from Spitzer observations to 7.5 AU: still broad enough to harbour a young planet. In the near future ALMA observations will allow a full characterisation of the hole in T Cha as well as holes in other transitional discs.

The AMBER observations rule out a close companion as the cause of the gap in the disc, so a search for a planetary companion was undertaken using the sparse aperture masking mode of NACO on the VLT. This led to the detection of an object in the *L′*-band (3.8 µm) located at 6.7 AU from the star, well within the gap in the disc. The object was not detected in the *K*-band and the extremely red *K–L′* colour allows the rejection of the idea that the object is a stellar companion. Thus, the object could be either a very low-mass star or a brown dwarf, either one being enshrouded in dust, or a recently formed planet within the disc. Additional observations will confirm whether the object is bound to the star, and characterise its physical parameters.

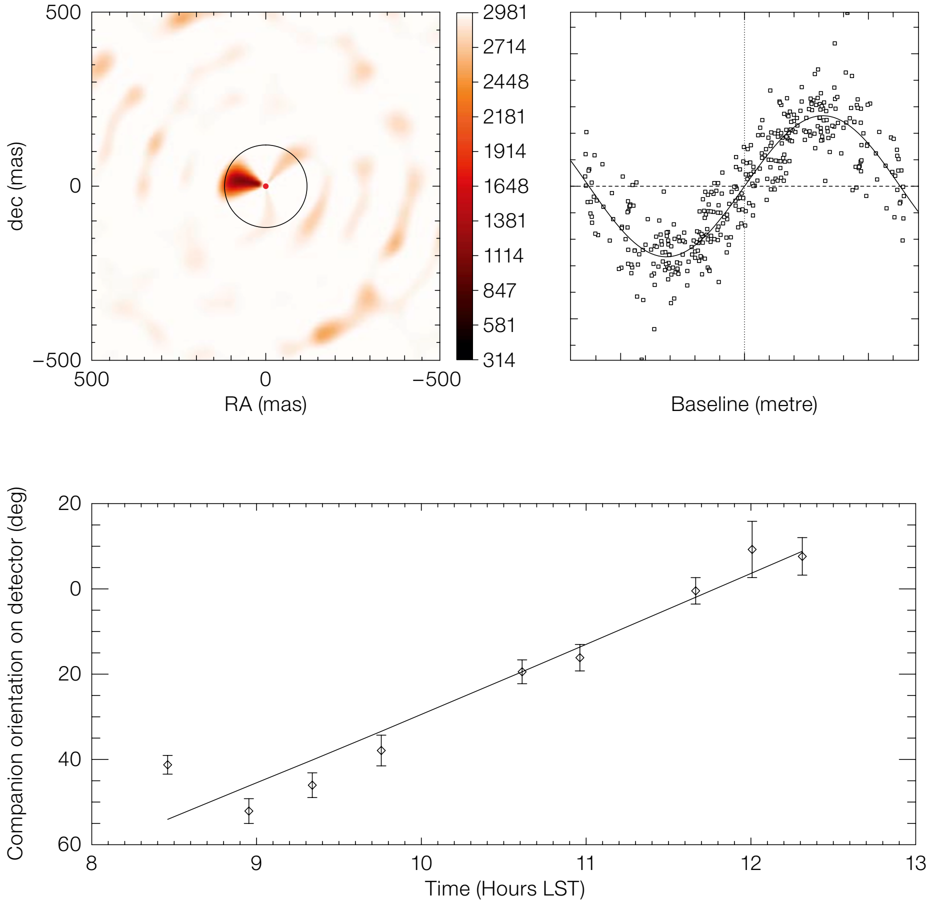
Planet formation is not the only mechanism able to clear gaps or create the central holes in transitional protoplanetary discs. Two other mechanisms have been proposed: grain growth and photoevaporation driven by the central star. Large dust particles are less efficient at absorbing starlight resulting in a decrease of the dust continuum emission. Photoevaporation is expected to be a ubiquitous and important mechanism to disperse the circumstellar dust and gas from which planets form. The third mechanism is giant planet formation. The possible presence of evolved dust in the inner region of transitional discs will be explored in the submillimetre at high angular resolution with ALMA.

The classical T Tauri star TW Hya with a nearly face-on transition disc exhibits a 4-AU inner hole in its dust distribution. TW Hya has been extensively investigated from X-ray to radio wavelengths, notably by the VLT with VISIR and CRIRES, and by the VLTI with MIDI. The large body of observations available for TW Hya indicates that grain growth does not explain the large hole in the centre of the disc.

High resolution spectroscopy and spectro-astrometry with VISIR have detected a photoevaporation-driven disc wind in the central 10 AU around the star. Combined with observations at other wavelengths and with interferometric observations from VLTI and Keck, the VISIR



Left panel: Fourier plane *(u, v)* coverage of the VLTI observations of T Cha. Observed squared visibilities (middle) and closure phase (right). *H*- and *K*-band (1.6 and 2.2 µm) data are represented by squares and circles respectively. Overplotted are the predictions from the best-fitting disc model (open symbols). Dashed and dotted lines in the middle panel are a second-order polynomial fit to the modelled visibilities for the extreme values of the inner disc radius.



Results from the *L′* sparse aperture masking observations: a companion candidate is detected at 61.8 ± 7.4 milliarcseconds (mas) from the central source with a flux ratio of 0.92 ± 0.20% in *L′*. Upper left panel: χ^2 as a function of the position of companion candidate. The black circle corresponds to the imaging resolution of the telescope (1.22λ/*D*). Upper right panel: best fit of the model of the companion (solid line) overplotted on the deconvolved phase. Lower panel: orientation of companion detections made using each of the nine individual data files plotted in raw detector coordinates. Spurious structures should appear fixed, while real features will rotate with the sky, as illustrated by the overplotted solid line that depicts the expected orientation for an object with a sky position angle of 78 degrees.

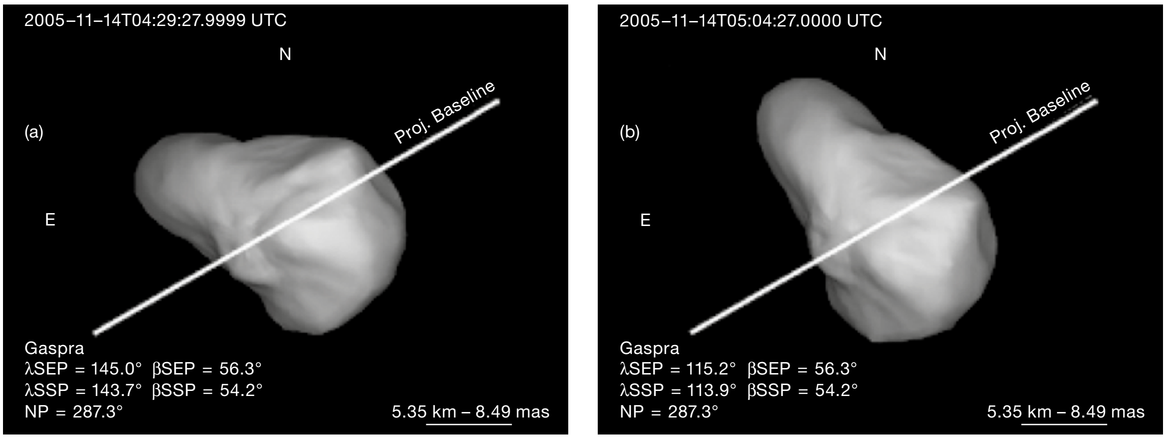
observations indicate that most of the blue-shifted [Ne II] line emission seen arises from the optically thick part of the disc and not from optically thin inner hole. This wind is not responsible for creating the inner hole in the transitional disc. The observations are consistent with the presence of a giant planet located between 2 and 3 AU from the star and with a mass between four and seven times that of Jupiter, although photo-evaporation cannot be excluded as an alternative explanation. Thus, TW Hya is a primary candidate to image a giant extrasolar planet directly.

Understanding the Solar System

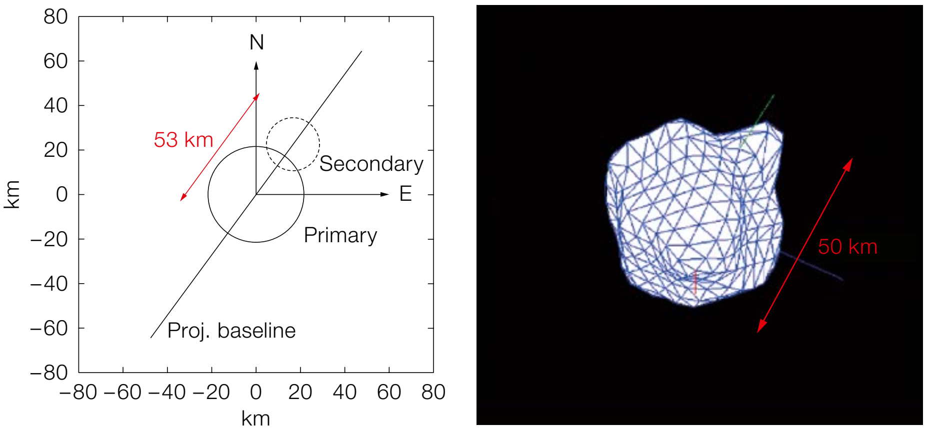
The study of the physics of asteroids is crucial to constrain models of formation, growth, and the physical properties of the plantesimals out of which the inner Solar System planets formed by accretion. The density and the internal structure are among the most important characteristics of asteroids and yet they are among the least constrained by measurement. The determination of the density requires knowledge of the volume of the object, which is a particularly difficult observational task because most asteroids are small. For example, in the main asteroid belt (between Mars and Jupiter) only 200 of the more than 600 000 asteroids known today have sizes larger than 50 kilometres. Therefore it is very important to develop techniques to measure the sizes of asteroids smaller than 50 kilometres. Until recently, the only available techniques have been infrared radiometry, which has been applied to about 140 000 objects thanks to the WISE satellite observations, and the measurement of stellar occultation timings. However, the first method is based on the assumption of spherical shapes — and small asteroids can have shapes that are very different from spheres. The second method is hard to apply because the time window for the observations is rather narrow and because stellar astrometric catalogues and asteroid orbits are often not known with sufficient precision.

Recently the VLTI has been used successfully to measure asteroid sizes; first using the Unit Telescopes (UTs), and lately using the Auxiliary Telescopes (ATs) and MIDI. The VLTI can measure the size of the asteroid in the direction of the projected baseline vector, as illustrated in the figure on the next page.

The VLTI observations in the thermal IR with MIDI also allow constraints to be placed on the physical properties of the objects, namely the albedo, the thermal inertia and the roughness of the surface. This was demonstrated by MIDI observations of (41) Daphne using the ATs and interpreted using a thermophysical model. Photometric observations provide



Model of the main belt asteroid (951) Gaspra projected onto the plane of the sky for two different VLTI observations. Comparisons with spacecraft images of the object allow the errors in the method to be estimated.



The shape of the asteroid (234) Barbara obtained using two independent techniques. Left: The VLTI-MIDI contact binary model that best fits visibility and flux measured by MIDI. Right: Preliminary (unpublished) shape model obtained from photometric light curve inversion and observations of stellar occultations, projected onto the plane of the sky at the epoch of the VLTI-MIDI observations. Note the good agreement between the overall dimension and the “nose” of the shape model on the right and the double-lobed shape obtained with the VLTI.

information about the shape and the spin state of an asteroid which, combined with interferometric visibilities, allows a detailed model of the asteroid including surface macroscopic roughness and the response of the material to temperature changes (thermal inertia) to be constructed.

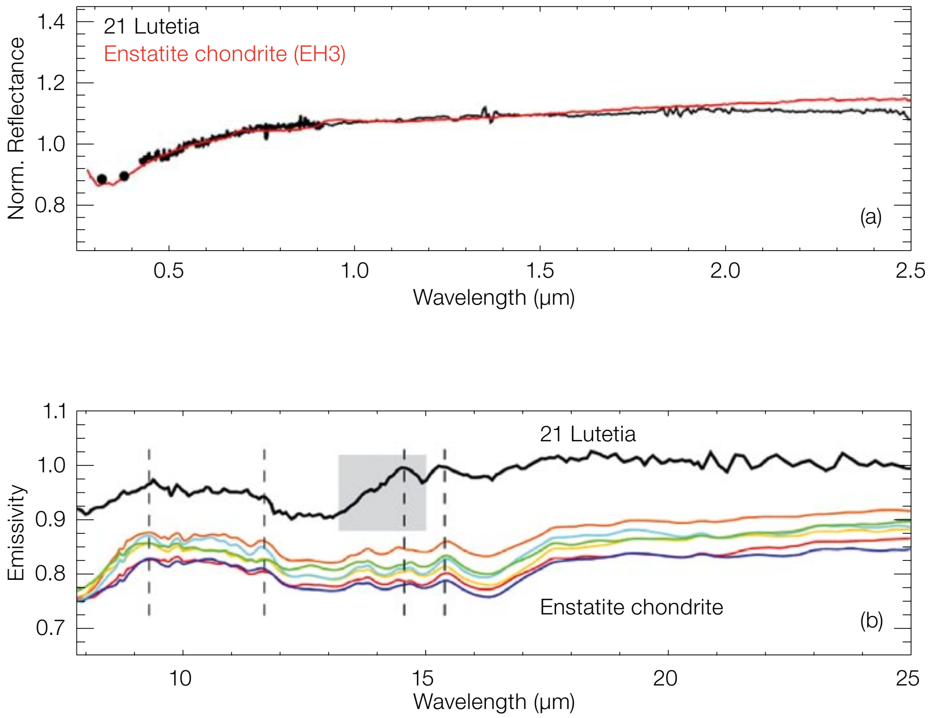
Because the thermal inertia of asteroids is finite, the temperature is not uniform, but varies across the object in a way that depends on the past illumination history. The VLTI allows the resolution of the temperature distribution across the asteroid surface and thus the calculation of the macroscopic roughness and the thermal inertia. The results for (41) Daphne indicate a moderate to low roughness and a very low thermal inertia. This is in agreement with previous observations that indicate that large (> 100 kilometres; Daphne measures 185 kilometres) asteroids have very low thermal inertia, but large asteroids also have high roughness — at odds with the findings for (41) Daphne.

Thermal inertia is a sensitive indicator for the presence of thermally insulating regolith (like dust) on the surface. In the case of kilometre-sized asteroids the thermal inertia is crucial for estimating the changing orbits of these bodies caused by the anisotropic thermal emission of the asteroids known as the Yarkovsky effect.

The chemical and isotopic compositions of meteorites, coupled with dynamical simulations, indicates that the main belt asteroids comprise both objects formed *in situ* as well as a population of interlopers. These interlopers are predicted to include the building blocks of the terrestrial planets as well as objects that formed beyond Neptune. The asteroid (21) Lutetia has orbital parameters that undoubtedly make it a *bona fide* main belt object, but its composition has long been a matter of debate. In fact, fewer than 1 % of the main belt asteroids have mineralogical compositions similar to (21) Lutetia.

A team of astronomers combined data from several ground-based and space telescopes, including the NTT on La Silla, to obtain a high quality spectrum of (21) Lutetia spanning the wavelength range from 0.3 to 25 μm. A detailed comparison of this spectrum with laboratory measurements of meteorites showed that the asteroid has spectral and physical (albedo, density) properties similar to the class of meteorites known as enstatite chondrites. The chemical and isotopic composition of these chondrites indicates that they were an important component in the formation of the Earth and other terrestrial planets. Thus the current location of Lutetia is incompatible with its formation location, so how did it get there? There are several possibilities: it could have been scattered by forming protoplanets or by the migration of Jupiter that happened at the time the Earth was forming. Incidentally, Lutetia was visited by the ESA’s Rosetta spacecraft, which also found very low thermal inertia and indicated a surface of very fine regolith.

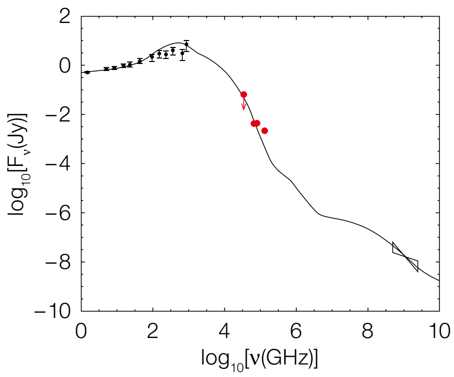
Spectral comparison of (21) Lutetia with enstatite chondrite meteorites. The top figure shows the comparison from the ultraviolet to the near-IR of Lutetia and the enstatite meteorite KLE 98300 (EH3). The bottom panel shows the comparison with several enstatite meteorites in mid-IR emissivity.



Thus Lutetia appears to be a rare survivor that escaped planetary accretion and therefore contains the precursor material from which the terrestrial planets formed. These results have very important implications for the crucial question of determining which known chondritic materials could possibly be the building blocks of Earth. Enstatite chondrites are certainly part of the story but they cannot by themselves account for all characteristics of Earth's bulk chemical and isotopic composition. Thus, by studying main belt interlopers via extensive spectroscopic surveys it may eventually be possible to infer the composition of the primordial Earth.

Our Galaxy, the Milky Way: The Galactic Centre

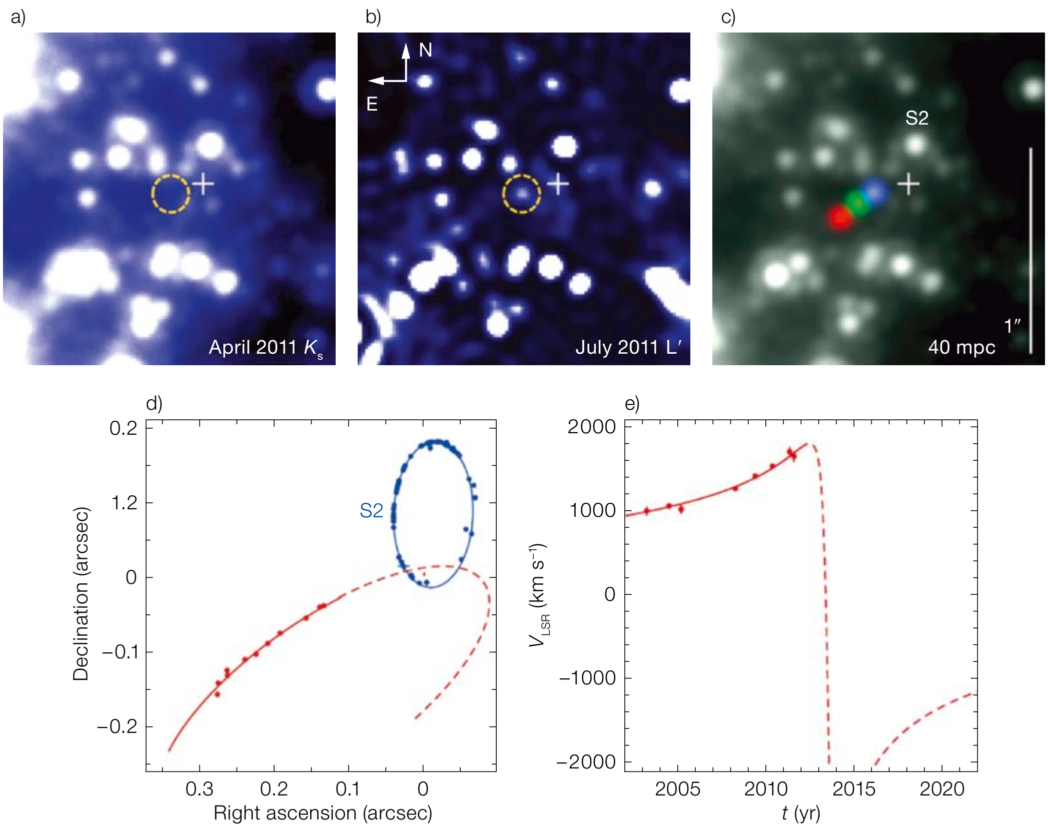
At the exact centre of our galaxy lies a mysterious radio source called Sagittarius A* (Sgr A*). Measurements of stellar orbits in the close vicinity of Sgr A*, made mostly with ESO telescopes since 1992, provide compelling evidence that Sgr A* is a black hole of about four million solar masses. With the exception of modest X-ray and infrared flares, Sgr A* is surprisingly faint, suggesting that the accretion rate and radiation efficiency near the event horizon are currently very low. However, the object is continuously visible in the IR up to a wavelength of 4.8 µm, but has never been detected at longer wavelengths. Extensive infrared observations with the VLT at 2.1–2.2, 3.8 and 4.8 µm have enabled the refinement of the spectral energy distribution of the object and so better constrain the models. The best fitting model shown in the figure to the right is an advection-dominated accretion flow model where the black hole is fed by Bondi–Hoyle accretion of hot plasma in the Galactic Centre region. A small



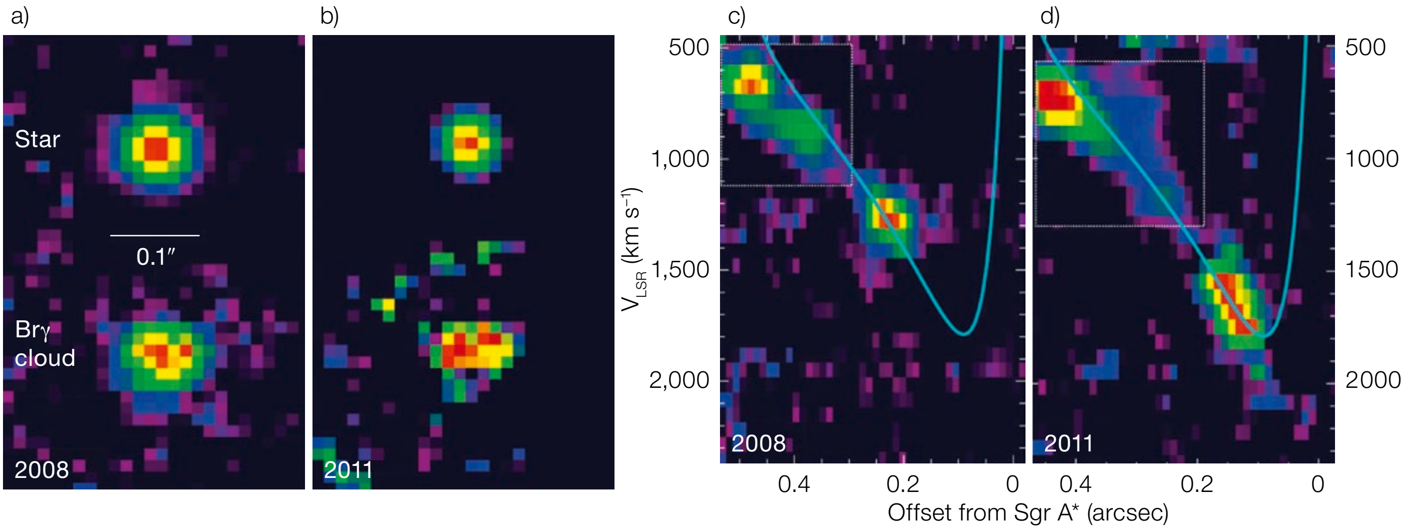
Mean spectral energy distribution (SED) of Sgr A* from the radio to the X-ray. The red dots are the points observed with the VLT. The solid line shows the best fit of an advection-dominated accretion flow with a jet. Since the radio part of the SED is fitted by synchrotron emission in all models, the VLT points provide crucial constraints.

fraction of the accretion flow is ejected near the black hole and, after passing through a shock, forms a jet.

Recently, adaptive optics observations with NACO and SINFONI at the VLT have detected an object (cloud) that is moving almost directly into the Sgr A* accretion zone at a speed of about 1700 km/s. The observations tightly constrain the orbit of the object to be highly eccentric with an innermost approach to the black hole of a mere 36 light-hours, which the cloud will reach in the summer of 2013. Panels a and b of the figure at the top of the next page show that the object, which is detected in the *L′*-band but not in the *K*-band, must have a remarkably low temperature. This temperature (about 550 K) and the luminosity of the object (about five solar luminosities) are unlike any star so far seen near Sgr A*. This and the spectrum of the object, which shows redshifted emission components, suggest that the object is a dusty ionised gas cloud and not a star. The three coloured blobs in panel c of this figure indicate the proper motion of the cloud to be about 42 milliarcseconds per year measured at



(Left) Infalling dust cloud in the Galactic Centre. The top panels (a and b) show that the object is detected in NACO adaptive optics images in the *L′*-band (3.8 µm), but not in the *Ks*-band (2.2 µm) indicating that the object is not a star but a dusty gas cloud. The cloud is also detected in the *M*-band at 4.7 µm but not in the *H*-band (1.7 µm). Panel c shows the proper motion of the cloud for three epochs 2004.5 (red), 2008.3 (green) and 2011.3 (blue). The bottom panels (d and e) show the orbit of the cloud calculated from the proper motions and the radial velocity evolution.



(Bottom) The velocity shear in the gas cloud. The left panels show the integrated Brγ emission line maps of the cloud compared with a star. The right panels show the stretching in position and velocity of the cloud as it approaches Sgr A*. The cyan lines show the calculated orbital path of the cloud described above.

three epochs from 2004 to 2011. The radial velocity of the cloud has increased from 1250 km/s in 2008 to 1650 km/s in 2011. The combination of the astrometric and the radial velocity information constrains the orbit of the cloud, which is shown in panels d and e of the figure at the top.

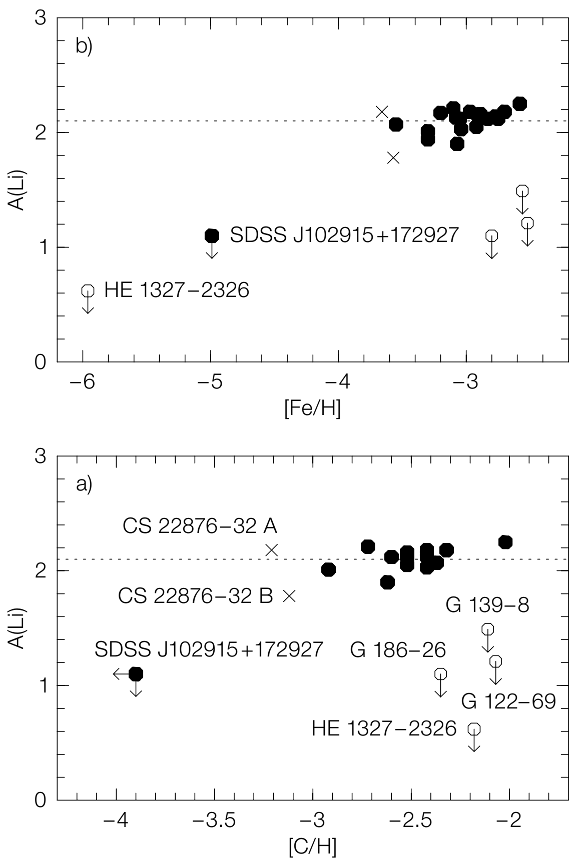
The figure above shows the velocity shear in the gas cloud obtained from the SINFONI data. The right panels show the stretching of the cloud in the direction of the orbit from 2008 to 2011 (Panel d).

Observations across the electromagnetic spectrum during the passage of the cloud nearest to the black hole will provide unique information about the physical conditions of the accretion zone, and will strongly constrain the physics of black hole accretion given the excellent knowledge of the mass available.

The first stars

The halo of the Milky Way should contain long-lived, low-mass stars of primordial chemical composition representing the first stars to form in the Universe. Yet, despite extensive searches, the lowest metallicity stars found in the halo of the Milky Way have metal abundances $Z \sim 1.5 \times 10^{-5}$. Moreover, these stars have low iron abundance, but are rich in carbon, nitrogen, and oxygen, indicating substantial enrichment by previous generations of stars. This knowledge has led to the suggestion that low-mass stars that survive to the present day ($M < 0.8$ solar masses) cannot form until the interstellar medium has been enriched above a critical value.

VLT observations with X-shooter and UVES have identified one star from the Sloan Digital Sky Survey (SDSS) with a very low metallicity $Z \leq 6.9 \times 10^{-7}$ and a chemical pattern typical of classical metal-poor stars, i.e. without enrichment of carbon, nitrogen and oxygen. This discovery shows that low-mass stars can indeed be formed out of very low metallicity gas.



Lithium abundance of SDSS J102915+172927 compared to that of other metal-poor stars. The Spite plateau (dotted line) is shown for iron [Fe/H] and carbon [C/H]. Li-depleted stars are found for different values of [Fe/H] and [C/H] indicating that lithium depletion is independent of either. Note that the square brackets represent the logarithmic abundance ratio relative to hydrogen compared to the ratio in the Sun and measured in dex.

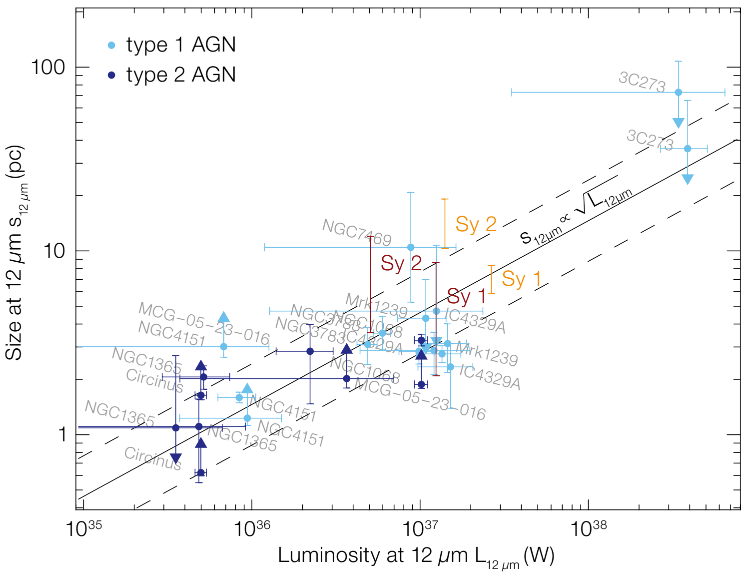
Remarkably, lithium is completely absent in the spectrum of this star, while normal metal-poor stars display a nearly constant lithium abundance known as the Spite plateau. The most straightforward interpretation of the Spite plateau is that the lithium observed in these stars is primordial, i.e. produced in the Big Bang. However, the theoretical primordial abundance of lithium is a factor of two to three larger than the value of the Spite plateau, a discrepancy that remains largely unexplained. The upper limit for the lithium abundance of the new extremely metal-poor SDSS star (SDSS J102915+172927) implies that the lithium abundance lies far below the Spite plateau, an observation that may shed some light into the origin of the Spite plateau value.

Stars similar to SDSS J102915+172927 are probably not so rare. Observations of a small sub-sample of SDSS candidates indicate that one should find between 5 and 50 within the area of sky accessible to the VLT and many more in the whole SDSS survey.

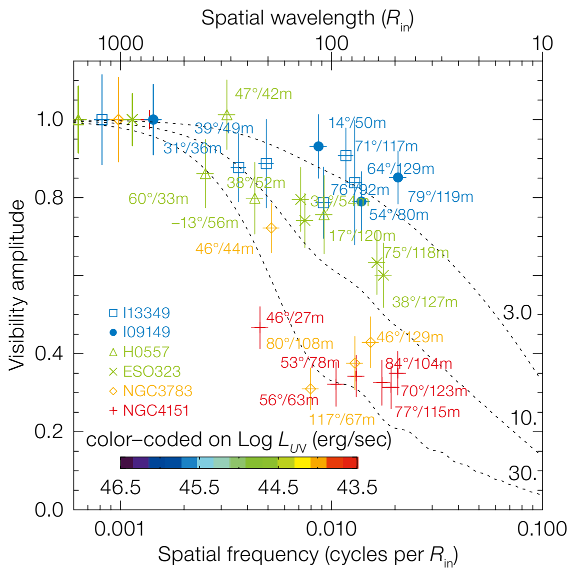
Testing the standard model for active galactic nuclei

The standard or unified model for active galactic nuclei (AGN) postulates that the active nucleus is surrounded by a dusty torus that produces a viewing-angle-dependent obscuration of the central engine. Thus Seyfert 1 galaxies are observed at low inclination angles such that one can see the central engine directly, while Seyfert 2s are highly inclined so the central engine is hidden by the dusty torus. The putative torus absorbs the hard ultraviolet continuum emission from the central engine and re-emits it in the infrared. This idea is apparent in the tight correlation between X-ray and mid-IR luminosities for both types of Seyfert galaxies.

A key step for understanding the accretion process in AGNs is to determine the role and structure of the putative obscuring torus that hides the ultraviolet (UV)/optical emission of the central engine and the broad line emission in the type 2 sources. The dust grains in the torus absorb the energy from the central source and, since the innermost dust sublimates at about 1500 K, this sets the inner radius of the torus (R_{in}). The dust sublimation region, therefore, radiates mostly in the



Correlation between the torus size and luminosity for type 1 and type 2 AGN. The solid line shows the fit to the data and the dashed lines indicate the scatter in the relation. The orange and red vertical bars indicate the range of values allowed by the models.



Observed mid-IR visibilities of all the targets averaged over a 10 to 12 µm bandpass as a function of spatial frequency in units of cycles per R_{in}. The data are colour-coded in terms of the UV luminosity of the central engine. Each data point is plotted with different symbols for different objects, and is labelled with the *position angle/length* of the baseline. It is quite clear that the radial structure in units of R_{in} changes from being compact in higher luminosity objects to extended in lower luminosity objects. Dotted curves are visibility functions for power-law brightness distribution with the normalised half-light radius $R_{1/2}/R_{in}$ = 3, 10 and 30, which roughly delineates the brightness distribution of the sample.

near-infrared at wavelengths of a few µm while the outer dust grains at lower temperatures emit in the mid-IR (~10 µm).

With limited spatial information, the torus structure has been inferred from the observed spectral energy distribution. With the advent of interferometers, however, we are beginning to gain far more direct information both in the near- and mid-IR by spatially resolving the inner structure of the AGN.

The sublimation radii of dusty tori have long been inferred through a technique called reverberation mapping, which obtains the light travel time from the central engine to the inner rim, measured by comparing the UV/optical light curves with the near-infrared light curves in the *K*-band. Reverberation mapping has established a correlation between the UV/optical luminosities of AGN (L_{UV}) and the near-IR reverberation radius R_K such that $R_K \sim L_{UV}^{1/2}$. Therefore one expects the interferometric ring radii measured in the near-IR also to scale roughly as $L_{UV}^{1/2}$. Given the compact near-IR angular sizes of the dust sublimation region, the existing interferometers allow only to partially, not fully, resolve the region, but nonetheless have confirmed the results from reverberation studies.

The situation is better in the mid-IR because these wavelengths sample the full radius of the torus and not only the dust sublimation region. Thus, snapshot observations with MIDI at the VLTI have been obtained for a significant sample of both type 1 and type 2 AGN. By fitting Gaussian profiles to the observed visibility curves it has been possible to infer that the mid-IR sizes of the tori, R_{MIR}, are consistent with being proportional to $L_{UV}^{1/2}$ (see figure top left) although, in this sample, the consistency is sensitive to the most distant AGN that are unresolved by MIDI.

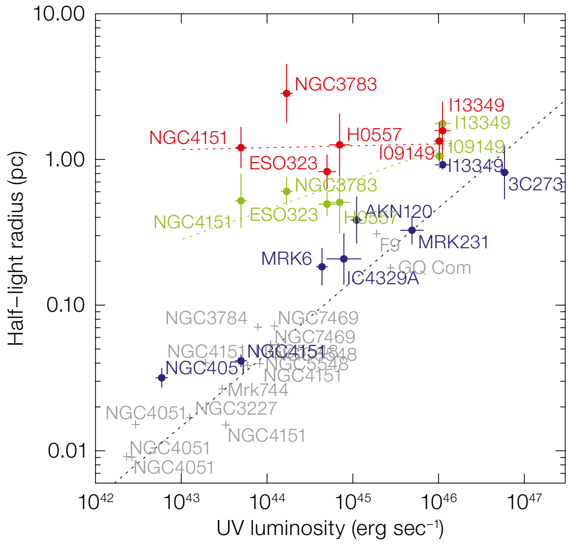
These observations enable estimates of the mid-IR sizes of the tori, but not of their structure. Consequently, another group of observers undertook a survey of six type 1 AGN with MIDI, spanning a range of baselines from 27 to 129 metres. These observations were complemented with near-IR and mid-IR observations taken with different telescopes and instruments including VISIR at the VLT and near-IR observations with the Keck interferometer. In order to eliminate instrumental or simple distance biases, the observed spatial frequencies were normalised by the inner-rim radius of the tori R_{in} calculated from the optical luminosities $L_{UV}^{1/2}$ using the correlation from the reverberation mapping. The top right figure shows the resulting observed visibilities for the six objects in the sample.

The radial structure is seen in the top right figure to clearly depend on luminosity; the structure in units of R_{in} looks more compact in higher luminosity objects. This implies that the increase in the mid-IR physical size with luminosity is more gradual than $L_{UV}^{1/2}$, in apparent contradiction with the snapshot observations discussed above. The reason for the discrepant results most likely lies in the assumption of Gaussian light distributions. Visibility curves of the best observed objects are much better reproduced by power-law distributions than by Gaussians, the latter not fitting the data very well.

The size–luminosity relation in the mid-IR was revisited using the half-light radius $R_{1/2}$ of the power-law fit to the observations as a measure of the size of the dusty tori in the mid-IR. This is shown in the figure to the right.

It seems a little risky to derive generic properties for the obscuring tori of type 1 AGN from observations of just six objects. However, the sample spans over 2.5 orders of magnitude in the UV luminosity of the central engine, so the results are probably quite robust. The radial structure of the dust distribution was found to change systematically with luminosity. The mid-IR radial brightness distribution can be described by a power law with an inner boundary set by the dust sublimation radius R_{in}. Thus, contrary to previous results, the mid-IR radii are not proportional to $L_{UV}^{1/2}$, but increase significantly more slowly with luminosity as shown in the figure.

Most importantly, these results show that the VLTI is beginning to fulfil one of its primary design goals: to resolve the central regions of AGN at near- and mid-IR wavelengths. We are not quite there yet in the near-IR, but ongoing improvements to the AMBER system should soon allow resolution of the dust sublimation regions.



Half-light radii $R_{1/2}$ in parsecs (pc, red and green for 13 and 8.5 μm, respectively), plotted against UV luminosity L. The red and green dotted lines are power-law fits to $R_{1/2}$ at 13 μm ($\propto L^{0.01\pm0.07}$) and 8.5 μm ($\propto L^{0.21\pm0.05}$), respectively. Thin-ring radii at 2.2 μm, also in pc, are plotted in purple from Keck Interferometer data. Plotted with gray plus signs are the near-IR reverberation radii with the black dotted line showing the $L^{1/2}$ fit. This fit is the definition of the inner radius R_{in}, as described in the text.

The epoch of reionisation

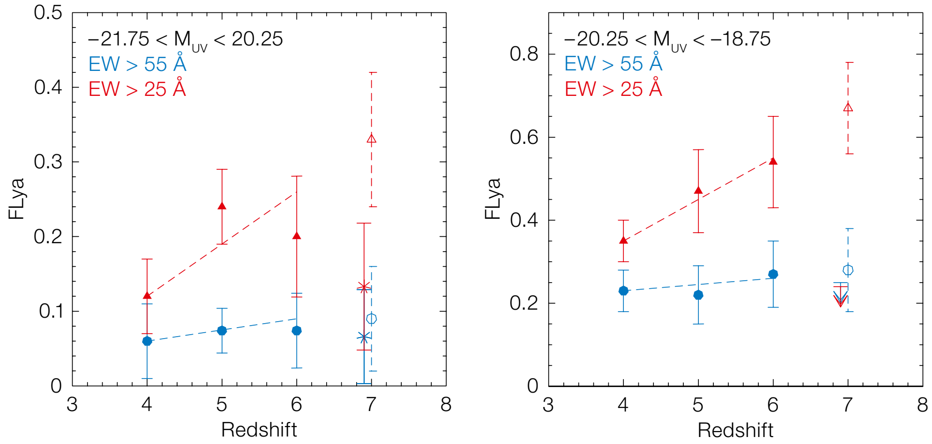
In Big Bang cosmology, the first phase change of hydrogen in the Universe was recombination, which occurred about 400 000 years after the Big Bang as the expansion cooled the Universe to the point where the rate of combination of an electron and proton to form hydrogen was higher than the ionisation rate of hydrogen. The Universe was opaque before recombination because photons scatter off free electrons (and, to a significantly lesser extent, free protons), but it became transparent as more and more electrons and protons combined to form hydrogen atoms. The Universe continued to be opaque at those wavelengths where the hydrogen atom absorbs radiation, in particular at the wavelength of Lyman-α (Ly-α), which is a resonance line. The Dark Ages commenced at the time of recombination and continued until the first stars formed.

A second phase change occurred once objects energetic enough to ionise hydrogen started to form in the early Universe. As these objects formed and radiated energy, the intergalactic medium of the Universe transformed from its neutral state back to being an ionised plasma. This occurred at redshifts of between about 20 and 6. The observational determination of the "epoch of reionisation" remains one of the frontiers of cosmology and is a very active field of research.

One of the ways of probing the ionisation of the intergalactic matter is through spectroscopy of very distant galaxies and AGN. The light to the blue of the Ly-α line will be completely absorbed by neutral hydrogen and the spectrum of objects within the neutral Universe will show a sharp cut-off at the wavelength of Ly-α. This effect provides a technique for finding distant galaxies and quasars (QSOs) through the deep trough in their spectra bluer than Ly-α. Galaxies found in that way are called Lyman break galaxies or LBGs. In order to find galaxies at the largest redshifts one needs to observe in the near-IR and a survey was undertaken using HAWK-I on the VLT to find galaxies at red shifts $z \sim 7$ that also showed moderately strong Ly-α emission lines. The survey yielded 20 candidates (called z-dropouts because they are not detected at wavelengths bluer than the z-band — around 0.9 μm) out of which five galaxies were confirmed spectroscopically using ultra-deep FORS2 observations. As shown in the figure at the top of next page, the fraction of galaxies showing Ly-α emission is dramatically below the extrapolation of the fractions found in surveys at lower redshifts. This sharp decrease can be explained through reionisation, but this explanation requires a dramatic increase of 60% in the neutral hydrogen fraction from $z = 6$ to $z = 7$.

Due to their high luminosities, QSOs should in principle provide ideal probes of the Universe at high redshift. In practice, however, quasars have historically been identified in optical surveys, which are insensitive to sources at redshifts exceeding $z \sim 6.5$. Deep surveys at infrared wavelengths are now providing the possibility to find quasars beyond the optical limit. One such survey with the UK Infrared Telescope (UKIRT) in Hawaii identified an object (ULAS J1120+0641) whose photometric properties in different bands from the optical to the near-IR were consistent with a quasar at redshift $z \geq 6.5$. Spectroscopic observations with FORS2 at the VLT and GNIRS on Gemini North placed the object at $z = 7.085$ making it the most distant QSO known.

Quasars are believed to be powered by accretion onto their central black holes. Thus, the mass of the black hole can be determined from the quasar's luminosity and the width of the Mg II emission line. For ULAS J1120+0641 the mass of the black hole is inferred to be 2×10^9 times the mass of the Sun. The existence of $\sim 10^9\ M_{sun}$ black holes at $z \sim 6$ already placed stringent limits on the possible models of black hole seed formation, accretion mechanisms, and merger histories and so the discovery

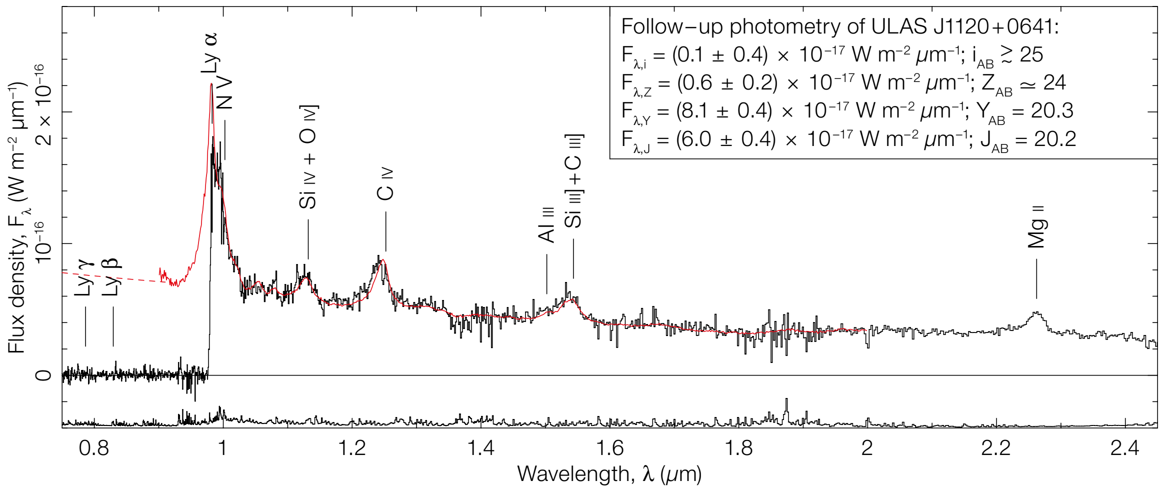


The fraction of galaxies with Ly-α emission as a function of redshift for two different Equivalent Width (EW) thresholds (25 Å in red and 55 Å in blue). The filled triangles and circles at $z \sim 4$, 5, and 6, respectively, are observations taken from the literature; the open triangle/circle is the extrapolation to $z \sim 7$ (dashed lines). The two asterisks and the upper limits in the lower panel are from the HAWK-I/FORS2 $z \sim 7$ sample.

that a $2 \times 10^9\ M_{sun}$ black hole existed just 0.77 Gyr after the Big Bang makes these restrictions even more severe.

The figure below shows the combined FORS2/GNIRS spectrum of the quasar together with the average spectrum of about 170 quasars at redshifts between 2.3 and 2.6 from the SDSS, showing that they are nearly identical.

The most striking feature of this spectrum is that the flux of ULAS J1120+0641 drops essentially to zero blueward of its Ly-α line. This sharp cut-off can be attributed to absorption by neutral hydrogen along the line of sight, indicating that the neutral hydrogen densities at redshifts of $z \sim 7$ were substantially higher than at $z \sim 6$, consistent with the observations of $z \sim 7$ LBG discussed above. Only about 100 bright quasars with $z > 7$ are expected over the whole sky, so ULAS J1120+0641 will remain a vital probe of the early Universe for some time.



Spectrum of ULAS J1120+0641 at $z = 7.08$ compared to a composite spectrum of quasars at lower redshifts. The high-z quasar shows no flux bluewards of its Ly-α line.

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This artist's impression shows how a distant quasar powered by a black hole with a mass billions of times that of the Sun may look.

The Milky Way above ESO's Very Large Telescope at Cerro Paranal in northern Chile's Atacama Desert.

Offices for Science

The Offices for Science, one in Garching and one in Santiago, are responsible for developing and maintaining a vibrant scientific environment at ESO. Our objectives are to facilitate forefront research by staff astronomers so that they can provide the best support to the ESO community and ESO projects, and to train the next generation of astronomers through the Studentship and Fellowship programmes.

The day-to-day activities of the Offices take many forms. Support is provided for research and research-related travel for about 110 staff astronomers, 25 scientists, 40 fellows and 50 students who ESO employs. The offices manage the Fellowship, Studentship and Visitor programmes, foster scientific exchanges with neighbouring institutions and organise conferences, colloquia, seminars and workshops at ESO. All of these activities are facilitated by the hard work of dedicated committees and coordinators made up of astronomers, fellow and student representatives. In addition, the Heads of the Offices for Science monitor and evaluate the scientific performance of all ESO science staff, providing support and advice to assist with their career development. The ESO library is an integral part of the Offices for Science. The librarians provide an information centre at ESO for all astronomers and engineers and develop and maintain productivity measures for staff, projects and facilities (see the section on Publications).

The past year was a busy but very successful one for the Offices. ESO astronomers, fellows and students authored or co-authored more than 500 research papers in leading astronomical journals, many of them in collaboration with astronomer colleagues in ESO Member States. Three ESO astronomers had proposals accepted for ALMA Cycle 0 observations. ESO Astronomers, whose role is to support ESO missions, contributed in many and diverse ways to ESO's scientific success this year. Four examples are highlighted.

Jean-Philippe Berger

Giovanni Carraro

Jean-Philippe Berger, a Paranal Operations Astronomer who serves as Instrument Scientist for AMBER, published 11 papers, two of them as lead author, including a review article. In addition, Jean-Philippe supervised three ESO students and also helped to organise public outreach efforts by ESO Chile staff for economically disadvantaged schools in Santiago.

Giovanni Carraro, Paranal Operations Astronomer and Instrument Scientist for HAWK-I, published 14 papers during 2011, including three as first author. Giovanni also serves as organiser for colloquia in Vitacura and supervised two ESO PhD students.

Nando Patat, who recently took a new post at ESO as Head of the Observing Programmes Office, published ten papers, five of them as first author. In addition, Nando chaired the Fellow and Student Selection Committee in Garching, supervised one ESO student and co-supervised another. He was also active in public outreach.

Marina Rejkuba, a User Support Astronomer in charge of providing assistance to users of the VLT data flow system, published 15 papers, four as first or second author. Marina also led two discussions at the Aspen Conference, served on the local organising committee of one ESO workshop, and supervised a PhD and an MSc student.

Nando Patat (left) and Marina Rejkuba

ESO hosted short- and long-term scientific visits (from a few days or weeks to a few months respectively) by more than 150 astronomers, the majority from ESO Member States. Such visits foster close ties and scientific interactions between ESO and the user community it serves. Scientific interactions and the diffusion of new ideas were also at the core of the ten ESO-sponsored workshops that were organised in Europe and South America in 2011. More than 1000 astronomers, postdocs and students from the ESO user community and beyond participated in the following events:
– ESO Workshop on Evolution of Compact Binaries, Viña del Mar, Chile, 6–11 March 2011;
– ESO Fellows Days 2011, Garching, Germany, 4–5 April 2011;
– ESO Workshop on Dynamics of Low-mass Stellar Systems: From Star Clusters to Dwarf Galaxies, Santiago, Chile, 4–8 April 2011;

Participants of the ESO Workshop on Fornax, Virgo, Coma et al.: Stellar systems in high density environments, organised at ESO Garching in June 2011.

- ALMA Community Days 2011: Towards Early Science, Garching, Germany, 6–7 April 2011;
- ALMA Early Science, Massive Star Formation workshop Garching, Germany, 8 April 2011;
- ESO Workshop on Multiwavelength Views of the ISM in High-redshift Galaxies, Santiago, Chile, 27–30 June 2011;
- ESO Workshop on Fornax, Virgo, Coma, et al.: Stellar systems in nearby high density environments, Garching, Germany, 27 June–1 July 2011;
- Feeding the Giants: ELTs in the Era of Surveys, Ischia (Napoli), Italy, 29 August–2 September 2011;
- ESO/MPE/MPA/ExcellenceCluster/USM Joint Astronomy Conference on Formation and Early Evolution of Very Low Mass Stars and Brown Dwarfs, Garching, Germany, 11–14 October 2011;
- Ten Years of VLTI: From First Fringes to Core Science, ESO, Garching, 24–27 October 2011;
- ADASS XXI, Paris, 6–10 November 2011;
- ESO Fellows Days 2011, Santiago, Chile, 21–25 November 2011.

The ESO library launched a new public interface to the *telbib* system to make it easier for anyone to find papers based on observations with ESO telescopes and instruments. The librarians also began compiling monthly lists of papers published by ESO astronomers, fellows and students, with links posted on ESO's web pages. To further enhance internal streaming of information, the Offices for Science launched a new bi-monthly internal newsletter, called *Science News*, with the goal of keeping all ESO science staff informed about interesting developments related to the scientific life at ESO and to their career development. Recognising the challenges that astronomers at all stages of their careers face in today's job market, the Offices for Science organised several career training workshops for ESO science staff in both Garching and Santiago, thus enhancing the marketability of ESO students, fellows and astronomers.

NEWS FROM THE OFFICES FOR SCIENCE MARCH/APRIL 2011

Science News

ESO's student internship programme

The Offices for Science inaugurated a new internship programme last year with the goal of providing more opportunities to host short-term students at ESO.

These internships, which last from 1 to 4 months, are intended primarily for MSc students who want to work on a research project under the supervision of an ESO staff Astronomer or Fellow. Currently two FTEs are allocated for intern positions - one in Garching and one in Vitacura - with preference given to students from ESO member States and Chile. Interns receive financial support to cover their living expenses in Garching or Santiago.

Because this is a trial programme with a limited number of FTEs, it is not advertised outside of ESO at present and students cannot apply directly. Instead, ESO Astronomers or Fellows who wish to supervise an intern should identify a candidate and then submit an application to the respective Head of the Office for Science. Applications can be submitted any time until all positions are filled.

To date, six students have participated in the internship programme in Santiago and four in Garching, where they worked on diverse research projects. Interns and their supervisors have been very positive about their experiences: one student credits his internship with cementing his decision to continue in astronomy and another applied for (and was accepted) into ESO's PhD studentship programme after completing his internship.

Several internship positions are **still** available for 2011 in Garching and Santiago. For more information, please consult the ESO Science Twiki or contact the Heads of the Offices for Science.

Upcoming deadlines

- **April 29th**: deadline for submission of Notice of Intent for ALMA Early Science
- **May 31st**: registration deadline for Feeding the Giants: ELTs in the Era of Surveys workshop
- **June 15th**: application deadline for ESO studentships in Garching and Santiago
- **June 30th**: deadline for ALMA Early Science proposals
- **June 30th**: registration deadline for the ESO/MPE/MPA/ExcellenceCluster/USM Joint Astronomy conference on Formation and Early Evolution of Very Low Mass Stars and Brown Dwarfs

Cover page of the internal newsletter *Science News* distributed by the ESO Offices for Science (March/April edition).

The ESO Studentship and Fellowship programmes continue to be in great demand, with roughly 30 times more applications than available positions. A total of six new fellows and eight new students were hired in Garching, and five and six in Chile, respectively. Two ESO Fellows Days took place this year, one in Garching and one in Santiago. These events bring together ESO fellows from both sides of the ocean to learn more about the exciting research being done by this impressive group of young scientists and to help stimulate new scientific collaborations. An added bonus this year was a visit to the ALMA site on the Chajnantor plateau. The new internship programme, which provides unique opportunities for MSc students to work closely with ESO astronomers, also continues to be popular. A new mentoring programme was also implemented this year for students and fellows and, in addition, a biannual reporting system for students was introduced to help ensure that they remain on track with their thesis work.

ESO Garching students, with the ESO Headquarters in the background.

With the generous support of the COFUND programme under the Marie Curie Actions of the European Commission (FP7-COFUND), ESO extended its Fellowship programme in 2009 with nine additional three-year-long positions dedicated to the ALMA project and hosted at any of the ALMA Regional Centre (ARC) nodes (including the ESO Headquarters in Garching). Building on their work and unique expertise, two of the ESO ALMA COFUND fellows successfully competed for permanent positions in Europe in 2011.

Participants of the ESO Fellows Days in Chile, visiting the ALMA high site on the Chajnantor plateau.

ALMA under construction at the Chajnantor plateau, Chile.

Allocation of Telescope Time

This year it is possible to add, for the first time, the statistics for ALMA to those for APEX and the La Silla Paranal (LSP) telescopes. The tables show the requested and scheduled resources for ESO Periods 88 and 89 and for ALMA Cycle 0. This is divided into the lengths of time (in nights for LSP and APEX, but in hours for ALMA) for each instrument/band and telescope.

The numbers for ALMA Early Science Cycle 0 include only ESO Principal Investigator (PI) proposals and the highest ranked projects amongst them. The requested and allocated numbers of runs and amount of time (in hours) per frequency band are reported.

The APEX and LSP numbers include only proposals submitted during the periods of interest. Current large programme runs approved in previous periods, guaranteed time runs and public survey runs are not included. The pressure is computed as the ratio between the requested and allocated time. The last two columns contain the total telescope time allocations and the fractions per instrument.

The Atacama Pathfinder Experiment at Chajnantor, in the Atacama Desert, Chile.

Telescope	Instrument	Requested runs	Scheduled runs	Requested time	%	Scheduled time	%	Pressure	Total allocation	%
UT1	CRIRES	135	78	144	17.4 %	72	23.8 %	2.00	72	23.7 %
	FORS2	515	222	683	82.6 %	230	76.2 %	2.97	231	76.3 %
Total		650	300	827		302		2.74	303	
UT2	FLAMES	142	35	235	28.0 %	46	24.5 %	5.07	73	27.8 %
	UVES	154	58	193	23.0 %	43	22.7 %	4.49	53	20.2 %
	X-shooter	321	88	410	48.9 %	100	52.8 %	4.10	136	51.9 %
Total		617	181	838		189		4.43	262	
UT3	ISAAC	129	57	153	30.7 %	64	38.3 %	2.38	64	29.3 %
	VIMOS	192	55	260	52.2 %	69	41.4 %	3.74	116	53.0 %
	VISIR	84	41	85	17.1 %	34	20.3 %	2.50	39	17.7 %
Total		405	153	498		168		2.97	219	
UT4	HAWK-I	139	46	139	19.3 %	31	14.2 %	4.41	44	17.4 %
	NACO	314	158	300	41.7 %	120	54.0 %	2.50	123	49.1 %
	SINFONI	202	55	281	39.0 %	71	31.8 %	3.97	84	33.5 %
Total		655	259	719		222		3.24	252	
VLTI	AMBER	170	65	132	50.9 %	50	52.5 %	2.63	68	44.4 %
	MIDI	114	36	42	16.3 %	13	13.9 %	3.18	26	17.3 %
	Special VLTI	73	18	85	32.7 %	32	33.5 %	2.65	59	38.3 %
Total		357	119	259		95		2.72	153	
2.2-metre	FEROS	51	24	202	58.8 %	77	56.9 %	2.63	77	56.9 %
	WFI	28	10	141	41.2 %	58	43.1 %	2.43	58	43.1 %
Total		79	34	343		135		2.55	135	
3.6-metre	HARPS	78	33	432	100.0 %	102	100.0 %	4.23	322	100.0 %
Total		78	33	432		102		4.23	322	
NTT	EFOSC2	115	35	481	69.3 %	141	66.7 %	3.41	181	58.5 %
	SOFI	54	21	213	30.7 %	70	33.3 %	3.03	128	41.5 %
Total		169	56	694		211		3.28	308	
APEX	LABOCA	44	21	109	43.9 %	41	47.6 %	2.64	48	51.4 %
	SABOCA	14	7	25	10.0 %	13	15.4 %	1.86	13	14.3 %
	SHFI	55	14	114	46.0 %	32	37.0 %	3.56	32	34.3 %
Total		113	42	247		87		2.86	93	
ALMA	Band 3	138	10	456	23.6 %	25	14.9 %	18.24	N/A	N/A
	Band 6	167	11	509	26.3 %	22	13.1 %	23.14	N/A	N/A
	Band 7	219	25	726	37.6 %	87	51.8 %	8.34	N/A	N/A
	Band 9	72	9	241	12.5 %	34	20.2 %	7.09	N/A	N/A
Total		596	55	1932		168		11.50		

Publication Digest

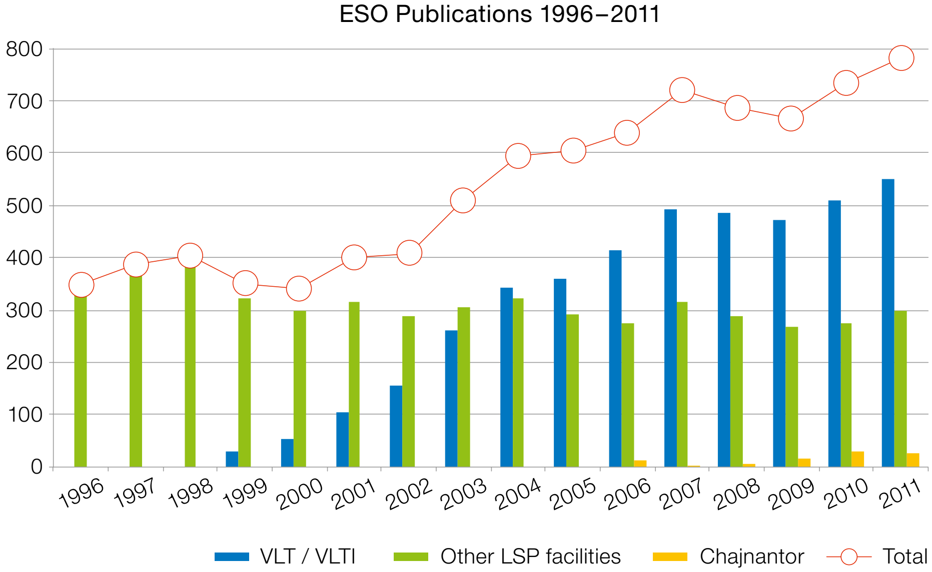
A total of 783 refereed papers using observational data from ESO's telescopes and instruments appeared in 2011; this is an all-time high in ESO's history. Since 1996, almost 12 000 individual authors from nearly 90 countries have published more than 8500 scientific papers based on ESO data.

The VLT/VLTI alone provided data for 551 papers in 2011, an increase of approximately 8% since last year. The total number of papers using VLT/VLTI data is now well above 4000. Papers that use archival data have accounted for a steady fraction of 16% during recent years. Approximately 5% of papers each year use special data releases, known as data products (http://archive.eso.org/cms/eso-data/eso-data-products/).

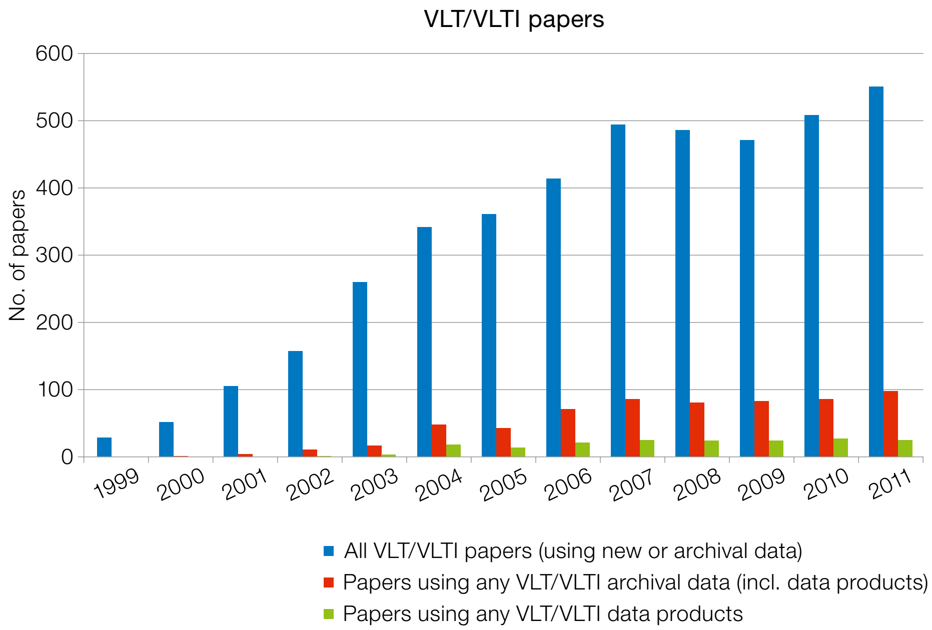
ESO's facilities at La Silla and those at Paranal that are not part of the VLT/VLTI led to 298 refereed publications. The year 2011 marked the first year of science papers based on regular VISTA/VIRCAM observations, using data from the VMC and VVV surveys. APEX resulted in 25 papers. This number incorporates only those with data obtained during ESO/APEX observing time.

Papers can use data from more than one facility, and therefore the total number of papers cannot be calculated by simply adding all publications from the individual sites. The exact numbers per year can be found in the Basic ESO Statistics document (http://www.eso.org/libraries/edocs/ESO/ESOstats.pdf).

Note also that the publications discussed here do not include data from non-ESO time, such as the Swiss 1.2-metre Leonhard Euler Telescope, GROND on La Silla, APEX observations during non-ESO time, or visitor instruments for which observing time is not evaluated by the ESO Observing Programmes Committee (OPC). This means that in reality ESO facilitates many more papers through its operations support and by providing the infrastructure for such instruments and telescopes.

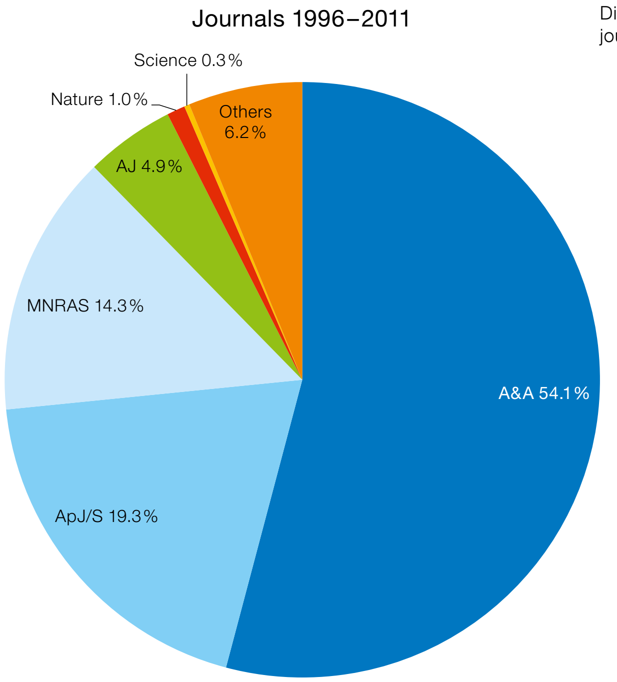


Refereed papers using ESO data, 1996–2011.
VLT/VLTI: Papers using data generated by VLT and VLTI instruments, including visitor instruments for which observing time is recommended by the ESO OPC, e.g., VLT ULTRACAM, VLTI PIONIER.
Other LSP facilities: Papers using data generated by other facilities of the La Silla Paranal Observatory, including VISTA at Paranal, as well as La Silla telescopes and instruments. Visitor instruments for which observing time is recommended by the ESO OPC, e.g., NTT ULTRACAM are also included.
Papers based on data from non-ESO telescopes or observations obtained during "private" periods are not included.
Chajnantor: Papers using data generated by APEX instruments, including visitor instruments for which observing time is recommended by the ESO OPC, e.g., P-Artemis, Z-Spec. Other visitor instruments (e.g., APEX/CONDOR) are excluded. Only papers based (entirely or partly) on ESO APEX time are included.



The graph shows the number of all VLT/VLTI papers (blue) as well as the number of those papers that use general archival data (red) and archive data products (green).

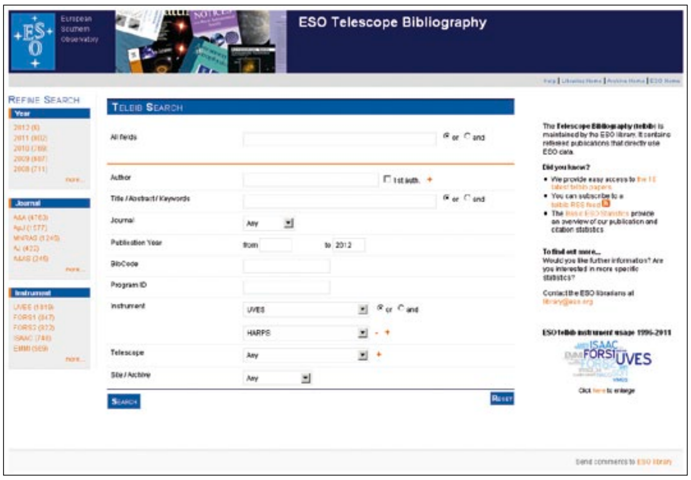
During the publication years from 1996 to the end of 2011, more than half of all ESO data papers were published in the European journal *A&A* (54.1 %), followed by approx. 19 % in the *ApJ* and its *Supplement*, and more than 14 % in *MNRAS*. Papers published in *AJ* account for almost 5 %.



Distribution of ESO data papers by journal, 1996–2011.

These numbers are extracted from the ESO Telescope Bibliography (telbib), a database of refereed publications that use ESO data. Telbib is a unique source that connects published articles with the observing programmes that generated the data. It is maintained by the ESO librarians. In December 2011 a completely redesigned public interface was released, providing new features and sophisticated search functionalities (http://telbib.eso.org). A detailed description of the telbib database can be found at http://telbib.eso.org/help.html.

In order to maintain telbib so that it is as complete and current as possible, more than 10 000 articles published in the main astronomy journals (Journals that are routinely screened for ESO-related keywords are: *A&A*, *A&ARv*, *AJ*, *ApJ*, *ApJS*, *AN*, *ARA&A*, *EM&P*, *Icarus*, *MNRAS*, *Nature*, *NewA*, *NewAR*, *PASJ*, *PASP*, *P&SS*, *Science*) were screened for ESO-related keywords during 2011. On average, 7–8 % of these papers used ESO observing data in order to achieve new scientific results and therefore qualified for inclusion in the telbib database. At ESO, the selection policies are defined by the Director for Science. The ESO librarians are also in regular contact with telescope bibliography curators at other large observatories, for instance the Hubble Space Telescope and Gemini, in order to exchange best practices for bibliometric issues.



The new public interface of the ESO Telescope Bibliography.

In addition to tracking the community's data papers, the ESO librarians also trace refereed papers published by ESO scientists. As these now occupy more than 35 pages of text they will not be published as part of the ESO Annual Report. Two lists can be found online at http://www.eso.org/libraries/telbib_info/AR/ESO_AnnualReport_publications2011.pdf

They contain all 2011 papers in refereed journals that use ESO data and all peer-reviewed publications by ESO scientists without ESO data use published in 2011.

Operations

ESO/José Francisco Salgado (josefrancisco.org)

La Silla Paranal Observatory

The Directorate of Operations is responsible for all science operations-related activities including the preparation and execution of observing programmes, the operation of the La Silla Paranal Observatory with its La Silla, Paranal and Chajnantor sites, and the delivery of raw and calibrated data. This involves user support, data flow management, operations technical support and the development and maintenance of a science archive as provided by the Data Management and Operations (DMO) Division. The archive holds all the data obtained with ESO telescopes as well as highly processed, advanced products derived from them. The Directorate includes ESO's contribution to ALMA operations through the European ALMA Support Centre (EASC).

Operations highlights this year were the successful integration the VLT Survey Telescope, as the second survey telescope after VISTA, into the Paranal Observatory with its end-to-end operations, and the successful support of the start of ALMA science operations in Cycle 0 through the European ALMA Regional Centre and its distributed nodes.

The Milky Way over La Silla.

Operations

The ESO Very Large Telescope at Paranal operates with four 8.2-metre Unit Telescopes and a suite of ten first generation instruments together with the first of the second generation instruments. The Laser Guide Star Facility (LGSF) provides two of the three adaptive optics supported instruments of the VLT with an artificial reference star. The VLT Interferometer combines the light of either the Unit Telescopes or the Auxiliary Telescopes to feed either one of the two interferometric first generation instruments with a coherent wavefront further stabilised by the VLTI fringe tracker or the VLTI visitor instrument focus. VISTA, the Visible and Infrared Survey Telescope for Astronomy, is in regular survey operation. VST, the VLT Survey Telescope, is the latest addition to Paranal and, in mid-October, commenced survey operation with its OmegaCAM optical wide-field 256 megapixel camera.

On La Silla the New Technology Telescope, the ESO 3.6-metre telescope, and the MPG/ESO 2.2-metre telescope operate with a suite of six instruments. The La Silla site further supports six national telescope projects.

In addition, the Observatory provides the operations support for the Atacama Pathfinder Experiment, located at the high plateau of Chajnantor at an altitude of 5100 metres, with its 12-metre submillimetre radio antenna and its suite of heterodyne and bolometer facility instruments and a number of visitor instruments.

For observing Periods 87 and 88, the scientific community submitted respectively 966 and 1011 Phase 1 observing proposals for the La Silla Paranal Observatory, including APEX. This indicates the continued high demand for the ESO observing facilities. Some 80% of the proposals are for the Paranal site with VLT, VLTI and VISTA.

The Observatory continued its efficient operation through high availability and low technical downtime of its telescopes and instruments — key elements for productive scientific observations. This year a total of 2431 nights were scheduled for scientific observations with the four UTs at the VLT and with the three major telescopes at La Silla. This is equivalent to about 95% of the total number of nights theoretically available over the whole year. The remaining 5% were scheduled for planned engineering and maintenance activities to guarantee the continuous performance of the telescopes and instruments and include time slots for the commissioning of new instruments and facilities. Out of the available science time for the VLT only 2.6% was lost due to technical problems and about 13% due to adverse weather conditions. On La Silla, bad weather accounted for losses of about 15% and technical problems for only 1%.

VISTA delivered 231 nights of survey observations out of 348 scheduled nights. An unplanned mirror coating activity and unforeseen technical problems encountered during the dismounting of the primary mirror accounted for 58 nights lost from the originally scheduled nights. The VST started science operation on 15 October and by the end of the year had already delivered 61 nights of survey observations.

In coordination with regular VLT operations, the VLT Interferometer was scheduled for an additional 191 nights to execute scientific observations using baselines with either the UTs or the ATs. The remaining nights of the year were used for technical activities and for further development and commissioning of the interferometer and its infrastructure. In addition to 116 engineering nights, some 54 nights were used for the continued installation and commissioning of the PRIMA facility. 7.7% of the scheduled VLTI science time was lost to technical problems and 21% to bad weather.

The combination of high operational efficiency, system reliability and up-time of the La Silla and Paranal telescopes and instruments for scientific observations has again resulted in a high scientific productivity. A number of 551 peer-reviewed papers have been published in 2011 in different scientific journals and are at least partially based on data collected with VLT and VLTI instruments at Paranal. In addition, 298 refereed papers were published referring to observations with VISTA at Paranal and ESO-operated telescopes at La Silla. Forty-eight papers were based on APEX observations, out of which 25 used observations obtained during ESO time. Since the start in 1999, the VLT and VLTI operation has resulted in a total of more than 4200 publications.

VISTA operations

The Visible and Infrared Survey Telescope for Astronomy with its VIRCAM instrument started public survey operation in observing Period 85 in April 2010. Since then it has rapidly achieved a stable operational mode, despite some pending technical and efficiency issues that the Observatory continues to address with the VISTA project team. The year 2011 was the first full year of VISTA operation, with 348 nights being scheduled for science operations with the continued execution of the six VISTA public surveys. The remaining few nights were reserved for planned engineering and commissioning activities. However, late in 2010 the scientists and engineers from the VISTA operation team noticed a decreasing sensitivity of VISTA which was traced back to a decreasing reflectivity of the two telescope mirrors. As a result, a previously unplanned renewal of the reflective mirror coatings was added to the VISTA schedule early this year to bring the telescope back to its full sensitivity. The analysis of the unexpectedly fast loss of reflectivity of the protected silver coatings of the mirrors remained inconclusive. The Observatory decided to replace the damaged protected silver coatings of the VISTA mirrors with unprotected aluminium coatings, i.e., the same type of coating used for the mirrors of the VLT Unit Telescopes, which is known to be stable and durable over several years. The consequence of this decision was that, since the reflectivity of aluminium is lower than that of silver, the overall reflectivity of VISTA would be reduced by 5–25% — depending on the wavelength — with respect to what could be achieved with a stable silver coating. The decision was, however, supported by measurements and simulations that showed the reflectivity of the unstable silver coating becoming lower than that of aluminium after only about three months. During the coming two years VISTA will operate with aluminium coatings, and a stable protected silver coating will be developed to restore VISTA to maximum efficiency in early 2013.

The VISTA re-coating was planned for a period of four weeks in March and April. Unfortunately, during the dismounting of the primary mirror of VISTA an axial mirror support was found to be detached and the mirror substrate slightly damaged. The analysis and repair of this damage added another month to the downtime resulting in a delayed return to operation with shiny aluminium-coated primary and secondary mirrors on 8 May. Subsequent on-sky verification of the overall efficiency of the telescope and instrument confirmed that the throughput of VISTA was restored to the expected value and it remains stable over time.

Despite the unplanned loss of 58 observing nights, the VISTA public surveys and open-time programmes made good progress during the rest of the year. This resulted in the first delivery of high-level data products — fully processed and calibrated images and source catalogues — from the public surveys to the scientific community through the ESO Science Archive by the end of the year. Known as Phase-3 data releases, these form an integral part of the public survey projects and are delivered by the principal investigators to enable and enhance the scientific use of the incredibly large datasets produced by the surveys.

VST and OmegaCAM operations

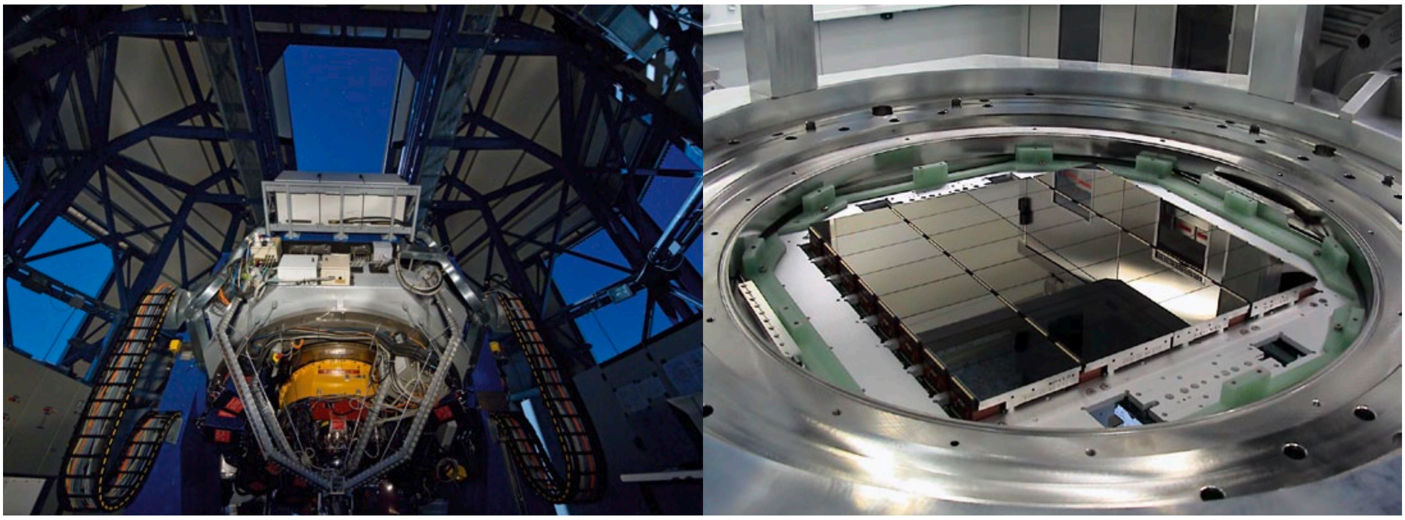
The VLT Survey Telescope is a 2.6-metre wide-field survey telescope and is the optical counterpart to VISTA. The VST is the latest addition to the operational telescope suite of the Paranal observatory site and is equipped with the focal plane instrument OmegaCAM. The telescope has an altitude-azimuth mount with an f/5.5 modified Ritchey-Chrétien optical layout with an actively controlled meniscus primary mirror, a hexapod-driven secondary mirror and an integrated image analysis system. It also contains two interchangeable correctors: a high-throughput two-lens corrector, which provides high throughput from the *u*- to the *z*-bands and an Atmospheric Dispersion Corrector (ADC) for observations at lower elevations.

The VST and the OmegaCAM instrument form a system that is designed to critically sample the best seeing at Paranal over a wide field: the VST provides a 1-degree unvignetted field of view which OmegaCAM samples with a 32-CCD (Charge Coupled Device), 16k × 16k (256 mega-)pixel detector mosaic at 0.21 arcseconds per pixel. The CCDs are thinned, blue sensitive, three-edge buttable CCD44-82 e2v devices of high cosmetic quality. The VST + OmegaCAM system achieves an image quality such that, in the absence of atmospheric seeing, 80% of the energy from a point source falls within a 2 × 2 pixel area over the full field. The field distortion is very low, resulting in an image scale that is virtually constant over the whole field and that allows accurate astrometric calibration to a precision of 0.1 arcseconds rms. Unlike VIRCAM, the gaps between the OmegaCAM CCDs are narrow and the overall geometric filling factor of the array is 91%. In addition to the 32 CCDs forming the science array, OmegaCAM also contains four auxiliary CCDs around the edges of the field. Two of these are used to autoguide the telescope to track both field position and rotation accurately. The other two auxiliary CCDs are mounted 2 millimetres outside the focal plane — one in front, one behind — and are used for recording defocused star images for curvature-wavefront sensing and the control of the active optics system of the telescope to ensure the best possible image quality across the large field of view. OmegaCAM further contains a 12-filter exchange mechanism. Currently the available filters include the Sloan *ugriz* set, Johnson *B* and *V* filters, several narrowband filter mosaics, a Stromgren *v* filter, and a special calibration filter.

The VST was built by the Italian Istituto Nazionale di Astrofisica (INAF) under the lead of Capodimonte Observatory in Naples. OmegaCAM was constructed by a consortium of institutes in the Netherlands (NOVA, in particular the Kapteyn Institute, OmegaCEN Groningen and Leiden Observatory), Germany (in particular the university observatories of

ESO/G. Lombardi

ESO/INAF-VST/OmegaCAM/O. Iwert



The VST (left) and the detector array of OmegaCAM (right) with its 32 science detectors and four auxiliary detectors.

Munich, Göttingen and Bonn) and Italy (INAF, in particular the Padua and Capodimonte Observatories). The detector system was provided by the ESO Optical Detector Team.

Commissioning of the VST started at Paranal in early January 2011. By the end of February an acceptable telescope performance had already been achieved, allowing the the OmegaCAM instrument to be mounted. On 27 March the joint VST–OmegaCAM–ESO commissioning team achieved first light with the VST+OmegaCAM system. During its commissioning, OmegaCAM was the first instrument on Paranal to take advantage of the availability of the high-speed data link from Paranal to Europe as provided by the EVALSO network infrastructure: all data taken with OmegaCAM were, despite the large volume, instantaneously transferred to ESO Headquarters in Garching and to the consortium members all over Europe for processing and analysis of the test data, allowing rapid feedback to the commissioning team on the mountain. Commissioning was formally concluded by mid-August and was followed by Science Verification and dry runs to fully integrate the new telescope and instrument into the operational environment of the Observatory. Science operations started on 15 October, only nine months after the start of commissioning for the telescope. Since then,

Optical (left) and near-infrared (right) view of NGC 253 as provided by the VST and VISTA survey telescopes.

the VST and OmegaCAM have been fully dedicated to the execution of the three approved public surveys and Guaranteed Time Observations, the latter in compensation for the efforts of INAF and the OmegaCAM consortium members.

The VST telescope remains the property of the INAF, but is on loan to ESO and operated by ESO for an initial period of ten years according to the INAF–ESO agreement signed in June this year. This agreement follows the principles of the Memorandum of Understanding on the VST project from 1998, but stipulates that INAF receives in return for its contributions to the VST 10% of the observing time in the first four years, 15% in the following two years, and 20% in the remaining four years. The reduced percentage in the first four years was agreed by INAF to help to accelerate the execution of the VST public surveys in their first critical years.

VST operation is fully integrated into the end-to-end operations model for ESO survey telescopes and has taken advantage of the new automatic scheduling tools deployed for the survey telescopes and also the experience already gained with VISTA. The VST operation team has now started collecting experience with the VST during real operational conditions and has determined that operational overheads that are larger than expected. These additional overheads result primarily from an increased time necessary to move the telescope from one position on the sky to the next and to adjust the active optical system at the new position. Despite the individual delays being small, the large number of telescope pointings required each night to survey the sky result in an accumulation of considerable amounts of time over an observing night with a consequent decrease in the operational efficiency. The operation team is working with the telescope and instrument consortia to further reduce the operational overheads and to increase the operational reliability of the system in order to maximise the survey efficiency of the VST+OmegaCAM.

The VLT Interferometer

The VLT Interferometer this year executed about 191 nights of scientific observations with the MIDI, AMBER, and PIONIER instruments using UT and AT baselines. The remaining time was used intensively for engineering and commissioning activities in order to complete and improve the interferometer infrastructure including the ATs. The installation and commissioning of the new PRIMA astrometric and phase-referencing facility continued over the course of the year and required an investment of some 54 commissioning nights.

The first scientific instrument taking full advantage of the capability of the VLTI to provide coherent beams from either the four Auxiliary Telescopes or the four Unit Telescopes is the VLTI Visitor Instrument PIONIER, which was developed by the Laboratoire d'Astrophysique de Grenoble in France. The acronym stands for Precision Integrated Optics Near-infrared Imaging ExpeRiment, which expresses the primary goal of this instrument, i.e., to take model-independent milliarcsecond resolution images of the surfaces and close environments of stars, including their planets, and to understand better the powerful engines associated with black holes at the centres of galaxies.

The heart of the instrument is an integrated optical circuit that brings the light waves from the four different telescopes together to create interference. The resulting resolving power of the telescope array has the sharpness not of the individual 1.8-metre AT or the 8.2-metre UT, but that of a much bigger virtual telescope some 100 to 200 metres across — limited only by how far apart the telescopes are positioned. After the successful commissioning of PIONIER with four ATs in 2010, on 17 March 2011 the instrument combined the light collected by all four UTs for the first time — coincidently exactly ten years after the very first fringes were obtained by the VLTI with the commissioning instrument VINCI and two 40-centimetre siderostats. Having all four UTs finally working together as a single telescope can be considered a major milestone in the history of the VLT project, which always anticipated that the four 8.2-metre telescopes would eventually be able to work together either coherently as part of the VLTI with an angular resolution equivalent to a 130-metre telescope or incoherently with the light-collecting power equivalent to a 16-metre telescope. The latter capability is planned to be used in a few years by the ESPRESSO instrument, an ultra-precise high-resolution spectrograph which can be fed by up to four UTs at the same time.

La Silla Observatory

La Silla Observatory continues to successfully employ its streamlined operations model. This La Silla 2010+ model supports the continued operations of the three major telescopes and their instrumentation, i.e., the 3.6-metre telescope with HARPS, the NTT with SOFI, EFOSC2 and visitor instruments, and the MPG/ESO 2.2-metre telescope with FEROS and WFI. The 2.2-metre telescope operates according to an agreement with the Max-Planck-Institut für Astronomie (Heidelberg, Germany). This agreement ensures the continued operation of the 2.2-metre telescope until 2013 with an ESO share of 25% of the available observing time in response to the continued high pressure by the community on the FEROS and WFI instruments.
La Silla Observatory further continues to support scientific projects at the Danish 1.54-metre telescope, the Swiss 1.2-metre Leonhard Euler Telescope, the REM (Rapid Eye Mount) telescope, the TRAPPIST (TRAnsiting Planets and PlanetesImals Small Telescope), the ESO 1-metre Schmidt telescope, and the TAROT (Télescope à Action Rapide pour les Objets Transitoires).

During the year the three parts of the HARPS upgrade project initiated in 2008 were delivered: the new polarimeter unit for the HARPS spectrograph was successfully completed by Uppsala University (Sweden) and has been available to the scientific community since Period 86. This new mode transforms HARPS into the most powerful high-resolution spectro-polarimeter in the southern hemisphere. The Observatoire de l'Université de Genève (Switzerland) delivered the new Fabry-Perot (FP) calibration system that provides a reference spectrum with

ESO/José Francisco Salgado (josefrancisco.org)

The light from all four 8.2-metre Unit Telescopes of ESO's Very Large Telescope in Cerro Paranal on 17 March 2011 was successfully combined for the first time using PIONIER, a new generation instrument in the VLT Interferometer. ESO Photo Ambassador Gerhard Hüdepohl was there to capture the moment.

numerous equidistant spectral lines of equal intensity and achieves a photon-noise-limited radial velocity accuracy of about 2 cm/s with long-term drifts that are of the order of only few centimetres per second per hour. The new calibration device is fully supported by the HARPS data reduction pipeline and has been available to the community since Period 88. Finally, this year ESO delivered the secondary (tip-tilt) guiding unit for the ESO 3.6-metre telescope to correct for high-frequency tracking errors of the telescope which further stabilises the light injected into the HARPS spectrograph at the fibre entrance. The combined effect of the last two upgrades results in superior radial velocity accuracy down to some 50 cm/s and contributes to maintaining HARPS's world leading position as the most successful planet hunter.

APEX

The Atacama Pathfinder Experiment continued to operate its 12-metre antenna and its suite of heterodyne and bolometer facility instruments and visitor instruments in a quasi-continuous 24-hour operation mode, which maximises the exploitation of the exceptional conditions available at the site of Chajnantor at an altitude of 5100 metres. This year a total of 262 days and nights were scheduled for science observations with APEX, out of which 210 could actually be used resulting in a total of 3700 hours of on-sky science time. This corresponds to a 70 % increase of the on-sky time compared to 2007, showing that APEX has reached operational maturity at a high level of observing efficiency.

The APEX project is a partnership between the Max-Planck-Institut für Radioastronomie (MPIfR, Bonn, Germany, 50 % share), ESO (27 % share) and the Onsala Space Observatory (OSO, Sweden, 23 % share) originally foreseen to terminate after six years of science operation, i.e., by the end of 2012. However, considering the success of the project, all APEX partners have expressed their wish to continue the project to extract the maximum scientific benefit from this unique facility. Therefore, the APEX operation agreement was extended until 31 December 2015 with unchanged shares of observing time. The partners signed the corresponding formal extension agreement on 11 April in Bonn.

As consequence of the extended lifetime, new investments in the antenna and the infrastructure are required to overcome the consequences of obsolete hardware and an aging infrastructure at the high site of Chajnantor and in the base camp in Sequitor near San Pedro de Atacama. Therefore, the APEX partners have agreed to a re-investment plan for the coming years. Accordingly, some initial investments have already been made this year, examples being the upgrade of the antenna control system and metrology and the refurbishment of the dormitories and kitchen in the base camp.

The agreement between the APEX partners makes provision for a further extension until 2017. conditional on the scientific competitiveness of APEX in the coming years. The competitiveness of APEX in the era of a fully operational ALMA will strongly depend on its survey capabilities and therefore on the results of the continuing receiver developments at the APEX partners, in particular in the area of large-sized cameras with several thousands of detector elements.

The Atacama Pathfinder Experiment telescope looks skyward during a bright, moonlit night on Chajnantor, one of the highest and driest observatory sites in the world. Astronomical treasures fill the sky above the telescope, a testament to the excellent conditions offered by this site in Chile's Atacama region.

ESO/B. Tafreshi/TWAN (twanight.org)

Data Management and Operations Division

The beginning of ALMA Early Science was the main highlight of Data Management and Operations this year, being the culmination of many years of preparation. The ALMA Regional Centre has continued to provide support in improving the quality of the observation handling tools, by preparing the European astronomical community to make full use of the new facility and helping the Joint ALMA Observatory on site in its commissioning and Science Verification activities. In addition, the support provided to actual operations and the role of ARC as the main reference point for European ALMA users has now come to the forefront. The support that ALMA users have enjoyed from ARC greatly benefits from the experience gathered by ESO in the operation of the VLT, as well as from the sharing of the technical support infrastructure.

DMO support is given to the entire complement of telescopes and instruments on Paranal including its latest addition, OmegaCAM at the VST. The maintenance of a high standard of support in view of the increased number of facilities is possible thanks to the experience and dedication of the operations staff and also to improvements in the tools, developed with the Software Development Division, that support operations. Such developments apply to all aspects of operations, including the back end, where important improvements have taken place this year in science archive services. The current ease of access to data just obtained, along with their associated calibrations has rendered the distribution of data to users on physical media obsolete. These improvements benefit both the teams that obtained observing time at the ESO facilities and the archive users who take advantage of the increasing data legacy of ESO telescopes. Some of these improvements have been enabled by the increased bandwidth between Paranal and Garching which, thanks to the EVALSO project, now makes it possible to have the whole data stream from Paranal transferred to Garching almost in real time.

The proven concepts of VLT end-to-end operations form the basis of the science operations model proposed for the E-ELT as part of its construction proposal. This defines directions for the further development of operations on Paranal over the coming years and of the infrastructures that support them.

User Support Department

The User Support Department (USD) represents the primary link between the ESO users' community and the Observatory. As such, it provides support to users of ESO facilities (VLT/I, VISTA, VST, and especially, but not exclusively Service Mode users) in the definition and implementation of the best observing strategies. It delivers up-to-date status information services, follows up on and offers solutions to issues and problems, and provides on-site support to the La Silla Paranal Observatory.

A part of the year was devoted to the optimisation of the USD staffing structure to streamline our operational procedures and services and prepare to take on new challenges. The user support group of the APEX facility was thus transferred to the ALMA Regional Centre Department to strengthen the synergies between APEX and ALMA. Within the USD, the definition and implementation of two groups has been completed: the User Support Group, responsible for day-to-day support, and the Operations Support Group (already in place for a few years) which is in charge of the definition and maintenance of the front-end infrastructure of the VLT data flow (e.g., operational tools and interfaces).

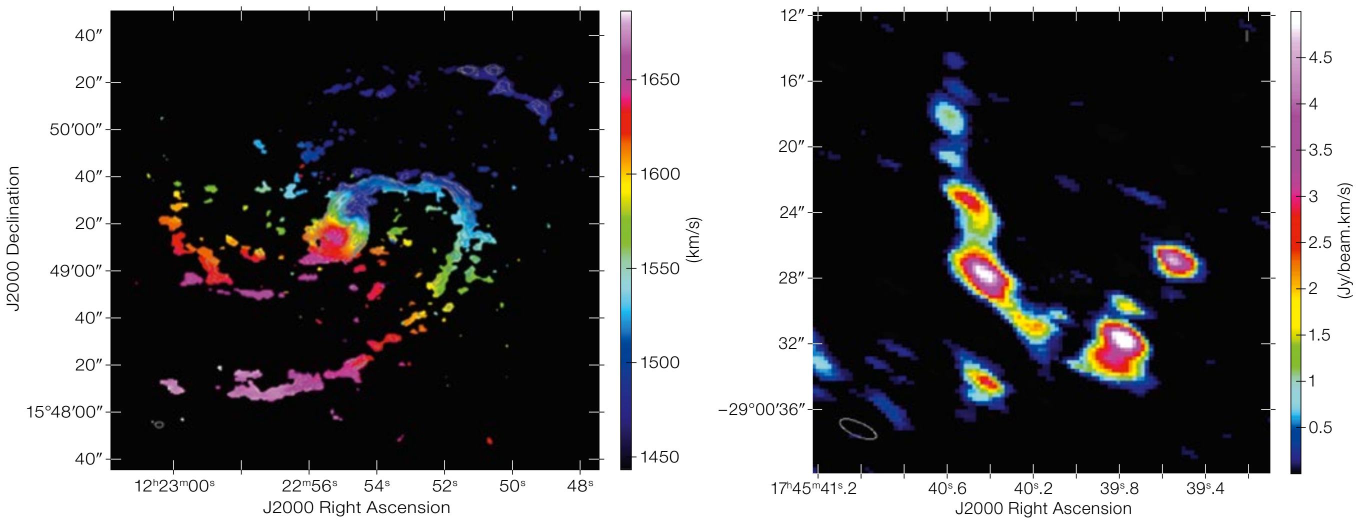
The entrance of the second ESO survey telescope, the VST, into operation represents one of the main USD achievements in 2011. The smoothness that characterised the start-up of VST/OmegaCAM operations reflects a very effective team comprising several dedicated staff both in Garching and in Chile. While the last commissioning run was still active in mid-August, two Phase 2 announcements had already gone out so that science observations could start at the beginning of October.

Other highlights include:
- The USD organised a VISTA Operations Review, mostly internal to the Directorate of Operations, held at the ESO Headquarters in June 2011, about 1.5 years after the start of VISTA/VIRCAM operations. This review focused on a deep analysis of the entire infrastructure behind ESO public surveys, with the aim of feeding back the lessons learned until then.
- USD astronomers have contributed significantly to various projects: instrument upgrades (VIMOS, VISIR), instrument reviews (ESPRESSO Preliminary Design Review, GRAVITY Final Design Review), definition and implementation of new tools (new Remedy schema, new Phase 2 preparation tool — version 3 — soon to be deployed to the VLT/I).

European ALMA Regional Centre

The European ALMA Regional Centre's mission is to provide the science and technical support services necessary for the European user community to exploit ALMA and APEX to their full scientific potential. ALMA support is coordinated through seven nodes distributed across Europe, and then coordinated by a central eighth node located at ESO Headquarters in Garching. In this distributed network, user support and operations experience at ESO can be combined with the millimetre-wavelength astronomy experience that exists in the community to create the best science support services.

During ALMA science operations, the core of the ESO ARC activities will include assisting the user community with the technical preparation of observing proposals and ensuring that the observing programmes make efficient use of ALMA. Furthermore, the ARC will run a helpdesk service and coordinate the face-to-face user support offered by the network of nodes across Europe. It will be responsible for the maintenance and refinement of the ALMA data archive and the delivery of data to principal investigators. ARC staff will provide feedback on the operations-related software systems and implement new software algorithms. Finally, the ARC is committed to assisting the Joint ALMA Observatory (JAO) in its daily observational operations.



The face-on grand design spiral galaxy M100 and the centre of the Milky Way galaxy SgrA* were observed with ALMA in Bands 3 and 6, respectively, as part of the Science Verification programme. The EU ARC and ARC nodes reduced the data. The images show the CO(1-0) velocity field of M100, with total intensity contours overlaid (left panel) and a map of the H30alpha line in SgrA*, where the intensity is integrated between -490 and 330 km/s (right panel).

ALMA operations highlights

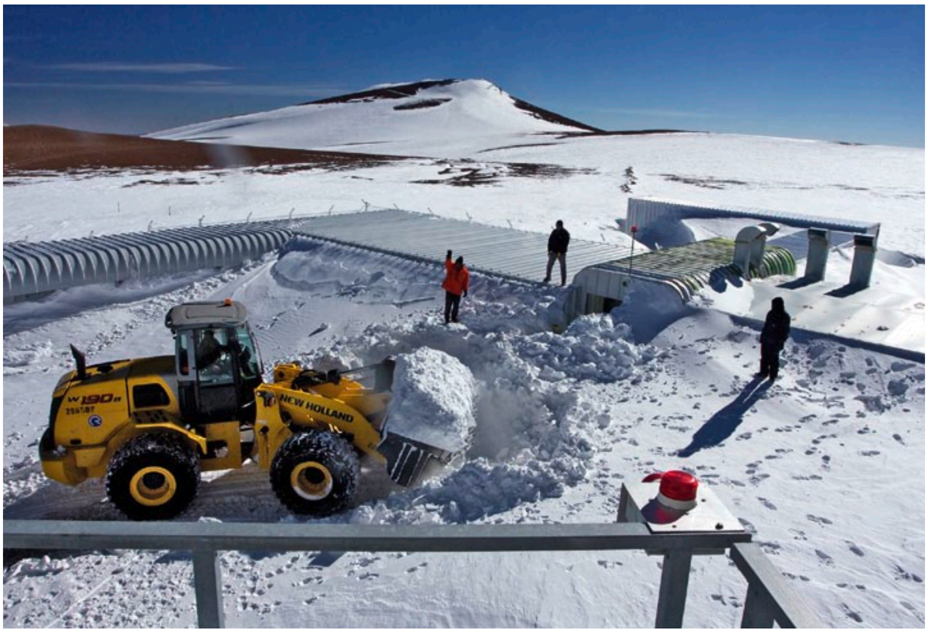
ALMA Early Science started on 30 September with the observations of the first project queue. The European ARC as a whole has contributed heavily to this success, participating in the activities at the JAO and spreading awareness in the European community through tutorials, workshops and a helpdesk. The European ARC has been particularly successful as reflected in the largest percentage of proposals submitted for Cycle 0, which exceeded the ESO share by far.

ARC experienced an exciting year with final preparations being made for the start of ALMA Early Science operations. As in previous years, ARC was fully involved with activities in Chile at JAO. An important part of the commissioning activity consisted of testing the end-to-end data flow by making use of Science Verification projects suggested by the community. The aim is to test ALMA's scientific capabilities. The ALMA staff at the EU ARC have been very active in assisting JAO, in taking data, reducing them and making them publicly available through the ALMA science portal (http://almascience.eso.org/alma-data/science-verification).

APEX highlights

The APEX non-stop 24-hour operation mode is now well established as an integral part of the APEX/ESO operational paradigm. Three teams take turns with debriefing and smoothly overlapping shifts at sunrise, noon and sunset. As expected, the formal agreement to extend APEX operation to 31 December 2015 was signed in April.

This year APEX offered, besides the normal complement of facility instrumenta-



Packed snow being cleared from the APEX support buildings.

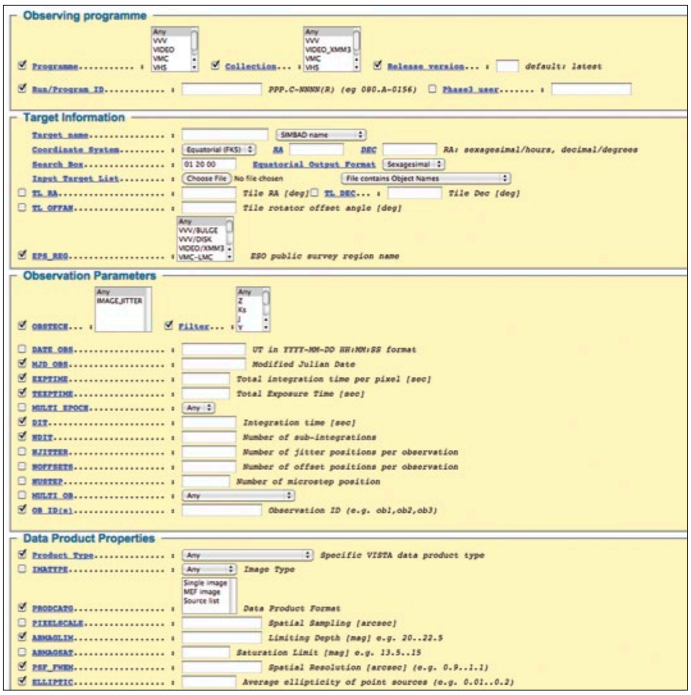
tion, a PI instrument Z-Spec. Z-Spec is a broadband (190 to 310 GHz) bolometer-based low resolution spectrograph. It was operated successfully for three runs during the year. The first results from the January run have been submitted for publication and have already led to two successful ALMA follow-up proposals.

In June and July, extreme weather conditions resulted in the APEX support buildings being covered in packed snow and also made the site unreachable for several days (see the picture). Damage to the sensitive electronics and generators by snow infiltration was avoided thanks to the swift and appropriate reaction of the APEX staff and with help from ALMA to clear the access road.

Data products

The Data Processing and Quality Control group works closely with the Paranal Science Operations department to ensure that all instruments always perform within expected and published ranges. Taking advantage of the fast data transfer link, the quality control loop between Paranal and Garching is routinely closed on a timescale of about one hour. During the year the group processed more than 11 TB of VLT/VLTI raw data. In addition, 50 TB of data from the survey telescopes VISTA and the VST were processed to monitor the instrument performance and data quality. This is five times as much as the entire suite of the other 14 VLT/I instruments on Paranal.

Advanced science data products from public surveys and large programmes are being returned to the Science Archive Facility by the respective PIs for the community at large to exploit. The External Data Products group has developed, with the Software Development Division, a set of standardised procedures and tools to streamline this process, dubbed Phase 3 by analogy with the submission of observing proposals (Phase 1) and the specification of the detailed observing strategies (Phase 2). The first Phase 3 for VISTA was carried out for five out of the six surveys on VISTA. Close to 10 TB of high quality data products are now available for browsing and download from the ESO Science Archive Facility. They



A screenshot of the query interface for highly processed data products from the public surveys with VISTA via the ESO Science Archive Facility.

are primarily astrometrically and photometrically calibrated, mosaicked and coded images each covering 1.5 deg^2 of sky, their weight maps and associated single band source lists in different bands. A screenshot of the dedicated query form is shown in the figure above.

ESO's efforts this year to improve the scientific quality of the data products, a task coordinated by the Science Data Products group, continued with a new public release of Reflex. This is again the outcome of a close collaboration with the Software Development Division. Reflex is a software platform to run ESO data reduction modules in a user-friendly way. In addition to the capability for running the data reduction modules themselves, Reflex provides, among other features, the capability to organise and associate the input data as well as the possibility to insert custom tools written in popular languages (currently python). This new release addresses the shortcomings that emerged in the first version and adds support for reduction of UVES red-arm data.

Science Archive Facility

Following the addition of 4.1 million files and 60 TB this year, including 14 TB of data from the first full year of VISTA operations, the total archive holdings comprise some 23.4 million files occupying 240 TB. A total of 28 581 archive data requests were made in the year and these correspond to the activities of about 2530 unique archive users. The total volume of data requested was 2.9 million files. New archive data releases included: commissioning data for the new mode of NACO, the coronagraphic apodising phase plate; and the first public release of data products from the VISTA public survey.

There were major initiatives during the year that greatly increased the access to archive products and the efficacy of calibration of downloaded products. Direct download was introduced to allow the user to almost instantly download the requested files to a local computer. The new download manager gives the user various options to control and monitor the download to ensure that all files arrive intact and in a timely fashion and with an option for very large requests to be delivered on USB hard disk. As another improvement, the PI is now enabled to delegate the access to proprietary data. This data delegation is of particular merit in more efficiently managing the workload within a research team.

The other initiative links an archive request for science files with the selection of the calibration data required to process the data for scientific exploitation. This new service groups together the raw science files that need to be calibrated and associates and builds a request for all the necessary calibration files. This service effectively makes the delivery of the package of raw data and calibration files to PIs redundant, although still gives the user the option to request delivery of all these data. This service was initially introduced for all Paranal data back to 2009 and is being extended to include older data.

Operations Technical Support

The Operations Technical Support Department operates the ESO Data Centre, maintains the operational central and task-specific computer systems, manages mission-critical database servers and provides operational web support as well as action remedy development in support of the ESO data flow.

The ESO Primary and European ALMA Regional Centre archives were extended with an additional 24 storage nodes consisting of 576 disks of 2 TB each. This archive is located within the Operations ESO Data Centre in Garching and is integrated into remotely controlled and monitored actively cooled racks providing stable ambient conditions to increase the lifetime of the entire archive.

Infrastructure improvements to the ESO analytic database server, hosted in a flexible and highly reliable storage array, have improved query performance by a factor of five.

The European ALMA Regional Centre in Garching was the first one to be connected to the ALMA data flow, when ALMA metadata was replicated from the ALMA operations database in Chile. The almascience.eso.org user support portal and website was incorporated into operations.

The ALMA correlator being scrutinised by Enrique Garcia, Correlator Technician in the instrument group. Enrique is working with oxygen at 5000 metres altitude.

European ALMA Support Centre

ESO formally instituted the European ALMA Support Centre on 1 October 2009. EASC is developing into the face of ALMA for the European scientific community and the international ALMA partners for ALMA operations. EASC is an important component for the success of ALMA, both for its performance as a scientific instrument and for ESO as a partner in the ALMA project.

EASC responsibility comprises the roles of ALMA Regional Centre operations, ALMA offsite technical maintenance and development support, ALMA science and outreach. The high-level scientific representation and scientific guidance of the European ALMA project will continue to be provided in the operations phase by the European Programme Scientist, who acts in close collaboration with the VLT and E-ELT Programme Scientists to exploit the scientific synergies with ESO's other major programmes.

For the scientific user community, the central ARC at ESO Garching and the ARC nodes in Europe are the primary interfaces to the individual ALMA users. In the case of the VLT this function is successfully performed by the User Support Department in the DMO, which has many commonalities with the function of the central ARC. Other functions foreseen for the ARC correspond to other departments in the support for VLT operations (e.g., archive, etc.). The share of core and additional functions between the central ARC and the ARC nodes is detailed in the ARC node implementation plan. This year ARC and the ARC nodes commenced with ALMA Early Science operations (ALMA proposal Cycle 0), for which a call for proposals was issued on 30 March, with observations starting on 30 September.

The ALMA partnership foresees continuous upgrades and the development of new software, front ends (e.g., additional receiver bands) and other hardware or system capabilities during the operations phase. The interface at ESO for the technical community in Europe will be the ALMA Technical Support group of EASC. The ALMA upgrade and development programme is funded through the ALMA operations budget via a competitive proposal process. The process is governed by the ALMA development plan principles, which were agreed between the ALMA partners this year. The basic principle is to establish one coherent ALMA development programme across the three ALMA partner regions with each partner managing the approved development projects according to their own rules and traditions. In this context, EASC will ensure and enable high quality proposals from the European instrumentation community, coordinate and manage the programme in Europe as well as represent Europe in the international ALMA collaboration. In 2010 the EASC initiated a first call for studies for ALMA upgrades and developments in Europe having as its primary aims to: give European groups the opportunity to propose ALMA upgrades that may later be implemented as part of the ALMA Development Plan; support the development of conceptual and detailed designs for ALMA upgrades; and encourage relevant long-term research and development. After evaluation of the received proposals and with the intense involvement of the ALMA European Science Advisory Committee (ESAC), several selected studies were commenced early in the year: preparations for ALMA Band 5 full production; phasing ALMA for (sub-)millimetre very long baseline interferometry (VLBI) observations; implications and cost for the back-end system of doubling the IF bandwidth; and ALMA Band 9 upgrade options. Further studies were negotiated and are expected to start early in 2012.

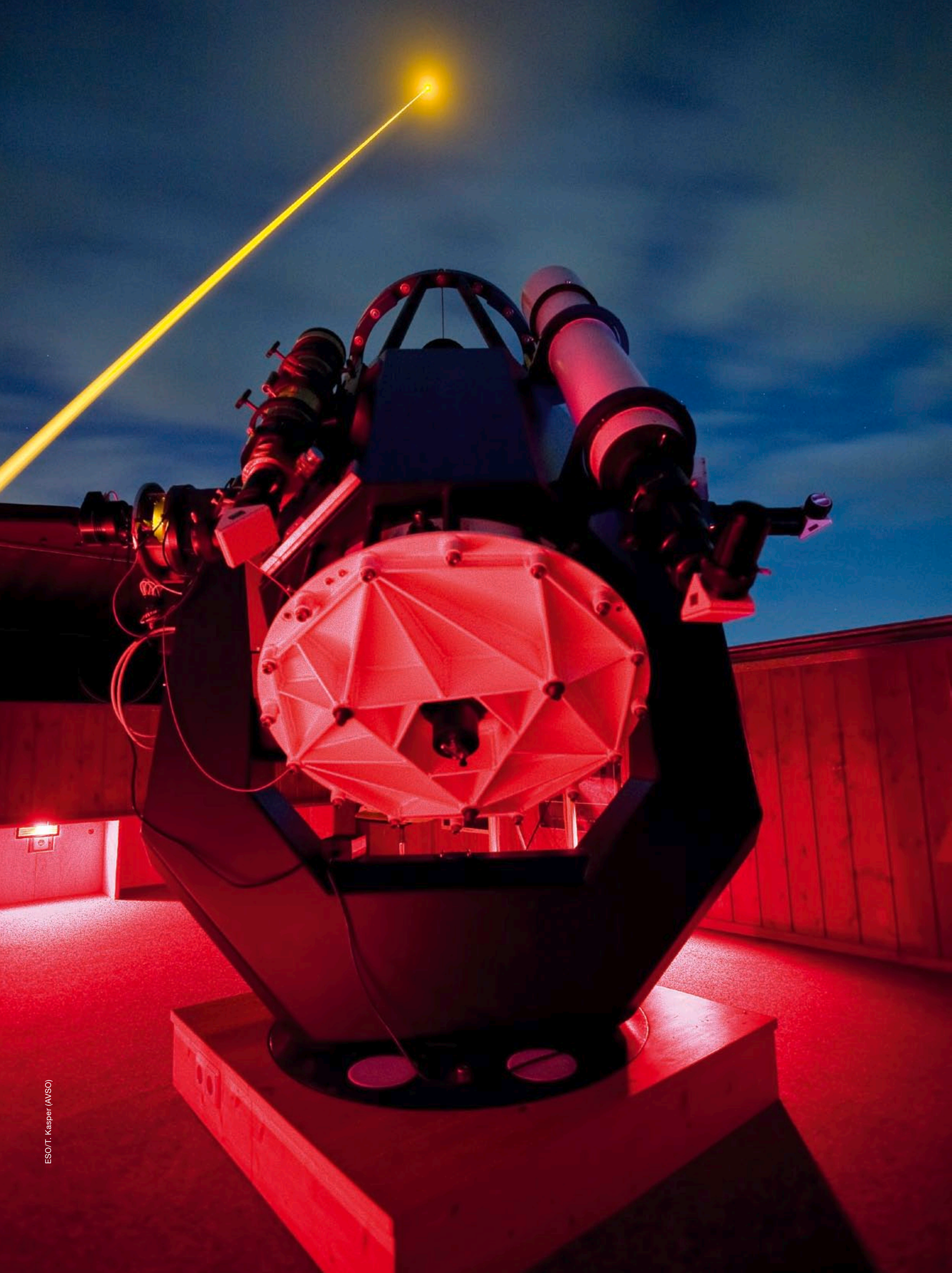
Outreach and media presentation of ALMA and its achievements are provided by the ESO education and Public Outreach Department (ePOD), in coordination with the outreach department of JAO and those of the other ALMA partners.

ESO/S. Stanghellini

The first European antenna for ALMA reaches new heights, seen here being transported to the observatory's Array Operations Site. The 12-metre diameter antenna arrived at the Chajnantor plateau, 5000 metres above sea level, to join antennas from the other international ALMA partners.

Otto
SCHEUERLE

Programmes



ESO/T. Kasper (AVSO)

Instrumentation for the La Silla Paranal Observatory

The year 2011 has been a pivotal one for many of the projects in the Directorate of Programmes. There has been continued good progress with the La Silla Paranal instrumentation programme, but arguably the most significant milestones achieved were in the areas of ALMA and the E-ELT. ALMA started Early Science operations and ESO delivered the first six AEM antennas to the JAO, both major milestones. On the E-ELT, the design modifications were completed and the ESO Council adopted the new 39-metre design. A full E-ELT construction proposal was produced, including an instrumentation roadmap. The revised E-ELT design was subjected to an in-depth external cost review by independent external experts and to a second independent external cost review by a commercial company. Both reviews found that the costs and the risks of the project were understood and under control and that the project is ready to enter the construction phase.

The Directorate of Programmes underwent a significant restructuring in 2011 with some staff from each division transferring to the Directorate of Engineering. The Instrumentation Division was reorganised into a fully matrixed division, including the VLTI staff, and the Telescope Division was reorganised to become the E-ELT Division. This marked the end of Roberto Gilmozzi's tenure as Division Head of the Telescope Division. Roberto remains Deputy Director of Programmes and Programme Scientist for the La Silla Paranal and Armazones Observatories.

ESO's Wendelstein laser guide star unit had its first light at the Allgäu Public Observatory in Ottobeuren, Germany. Laser guide stars are artificial stars created high up in the Earth's atmosphere using a laser beam with a power of several watts.

The ESO second generation instrument programme is one of the most ambitious in ground-based astronomy. In the next few years, the results of this collaboration between ESO and Member State institutes will lead to the delivery of many new, exciting and unique instruments. Although these new facilities will enhance the scientific capabilities of the La Silla Paranal Observatory in important areas, they will also be part of a continuing instrumentation plan that will continue for the rest of this decade and beyond.

The first generation of instruments delivered to Paranal was intended to provide general purpose capabilities in imaging and spectroscopy and to ensure coverage of the usable spectral range. The second generation programme is focused on more specialised scientific goals and aims to tackle more specific scientific questions. High spatial resolution has become a key technical requirement in many cases, using either adaptive optics or interferometric modes. In addition, special camera and spectrograph capabilities are also under development. Finally, the plan to upgrade instruments has continued where substantial performance increases can be achieved through limited technical modifications.

New instruments for high spatial resolution

The Adaptive Optics Facility (AOF) is a large project to convert UT4 into an adaptive optics (AO)-optimised telescope, comprising sodium lasers, wavefront sensors and a deformable secondary mirror (DSM) with 1170 actuators. During the year, most of the components for the DSM were received by the manufacturer and, by the end of the year, integration was completed and global system tests started with a dummy thin shell mirror. The real thin shell mirror itself is a highly critical component of the DSM and is being manufactured by SAGEM (France). Late in the year, the shell reached the specified optical quality and the delicate process of releasing it from its blocking body and handling it safely into its transport crate was completed. It will be delivered to the DSM contractor (Microgate, Italy) before the end of January 2012. Testing of the complete AOF system will be carried out in the laboratory before shipment to the observatory using a sophisticated test bench (ASSIST) provided by the University of Leiden. Testing the 1.1-metre convex DSM represents a major challenge, and the ASSIST optical design provides this capability. One challenge has been the optical polishing of its

SAGEM/ESO

Engineers at SAGEM (France) stand behind a remarkable thin-shell mirror that they have created for the Very Large Telescope Adaptive Optics Facility. The front convex face is the optical surface and the concave face will be equipped with 1170 small magnets glued on the surface allowing controlled deformation via forces applied by voice coil actuators. The shell is 1120 millimetres in diameter and 1.998 millimetres thick.

ESO/N. Hubin

GRAAL main assembly in the ESO integration hall with optics installed.

F. Kamphues/TNO/ESO

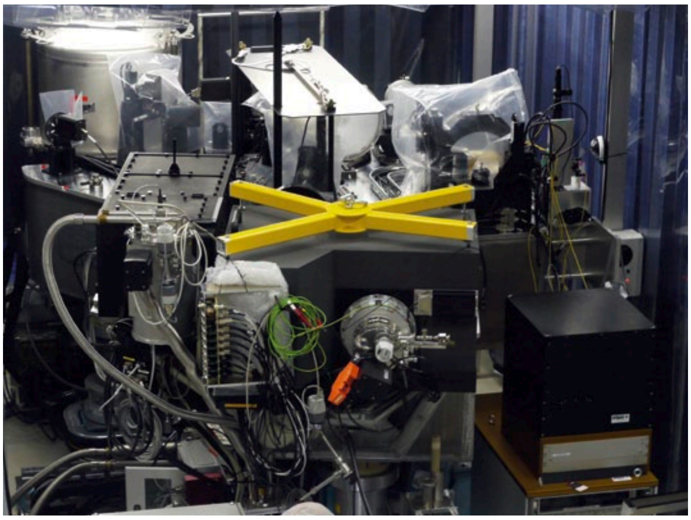
The first optical tube assembly unit completely assembled in TNO's cleanroom in the Netherlands.

main optical element, a high quality, large aspheric mirror (1.7 metres) manufactured by AMOS (Belgium). The large mechanical structure (Bossenkool, Netherlands) was delivered to Garching in the summer and fully erected in the ESO integration hall by the Leiden team in collaboration with ESO. The AOF includes a system to launch four laser beams into the sky, producing artificial guide stars in the sodium layer at an altitude of 90 kilometres. These will be used as reference sources by the adaptive optics modules GRAAL and GALACSI. There are two key laser subsystems: powerful sodium lasers and launch telescopes. In July, TNO (Netherlands Organisation for Applied Scientific Research) delivered the first of four launch telescopes to ESO. These constitute one important building block of the Four-Laser Guide Star Facility (4-LGSF) project.

SPHERE (PI: Beuzit, IPAG-Grenoble) is a specialised instrument designed for exoplanet imaging and spectroscopy with first light scheduled for late 2012. The instrument integration was well underway during the year with all subsystems passing their assembly readiness reviews. All the scientific cameras are working well and exceeding expectations in both image quality and stability. Bench tests show that SAXO, SPHERE's AO system for exoplanet detection, delivers a superb image quality in excess of 80% Strehl ratio in the *H*-band in median seeing conditions. Due to problems with the electrode impedance in the original high-order deformable mirror developed by CILAS (FRANCE), ESO has launched a contract for the manufacture of a replacement mirror. The original will be used during testing so as not to delay the project and will then be replaced by the new mirror for commissioning/science on the VLT.

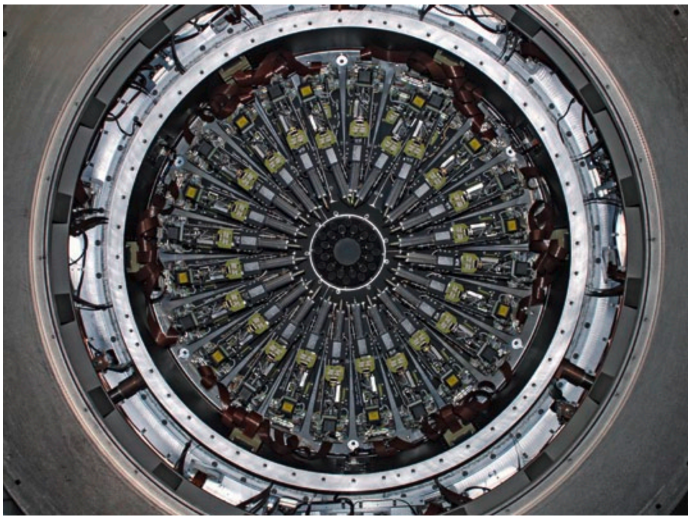
The two approved second generation instruments for the VLTI, GRAVITY and MATISSE, both continued in their design phases this year. GRAVITY (PI: Eisenhauer, Max Planck Institute for Extraterrestrial Physics (MPE) Garching) is an instrument for precision narrow-angle astrometry and interferometric imaging, combining four telescopes in the *K*-band. The Final Design Review for the main part of the instrument, the beam combiner, took place successfully in October. Interfaces in all the VLTI laboratories and coudé rooms have been defined and clarified between the instruments sharing the spaces — GRAVITY, MATISSE and ESPRESSO. Construction of testbeds for qualification of individual subsystems was started and new developments, such as the integrated optics beam combiner chips, are being fine-tuned. The target for the instrument team is a 2014 commissioning date on the telescope. MATISSE (PI: Lopez, OCA-NICE) will be a general purpose interferometric imager/spectrometer operating in the 3–5 μm and 10 μm atmospheric windows and able to combine the light from either four UT telescopes or four 1.8-metre auxiliary telescopes. The MATISSE Preliminary Design Review was closed in May and the science detectors were subsequently ordered. The optics and cryogenics Final Design Review was passed during the year.

A Phase A study is currently underway for a new AO instrument to be mounted at the Cassegrain focus of UT4 and used with the AOF. The design of ERIS, an enhanced resolution imaging spectrograph, foresees a new AO wavefront-sensing module that will use an AOF laser and the new AOF DSM to replace NACO imaging and give much improved performance. In addition, the corrected field also can be fed to the existing SPIFFI IFU (integral field unit) spectrograph to effectively provide a major upgrade to its performance. The aim is to deliver ERIS to Paranal soon after the commissioning of the AOF on UT4, at which point, in combination with SPHERE, NACO capabilities will have been replaced and enhanced. The Phase A review and possible approval of the project by the Scientific Technical Committee (STC) and ESO management will take place in 2012.



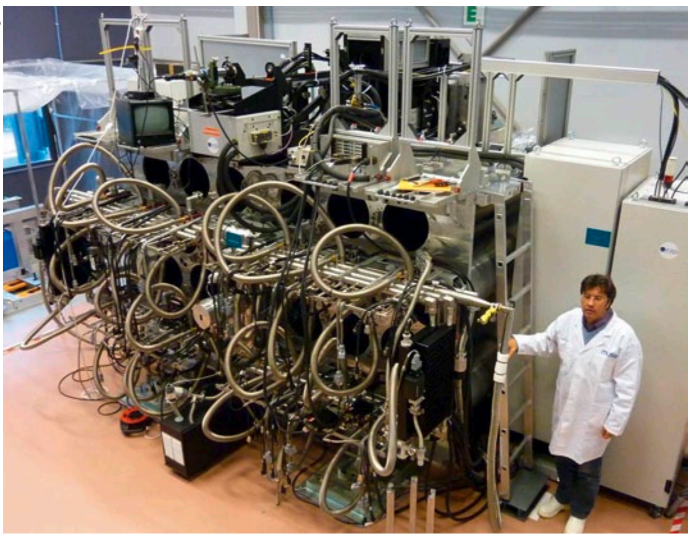
ESO/N. Hubin

The SPHERE common-path and instrument infrastructure including the science instruments IFS, ZIMPOL and IRDIS.



ESO/A. Glindemann

A view from above of the KMOS instrument showing all 24 robotic cryogenic arms integrated into the focal plane.



ESO/G. Finger

System integration of the MUSE instrument at the Observatoire de Lyon. Pumping and cooling lines can be seen.

Cameras and spectrographs

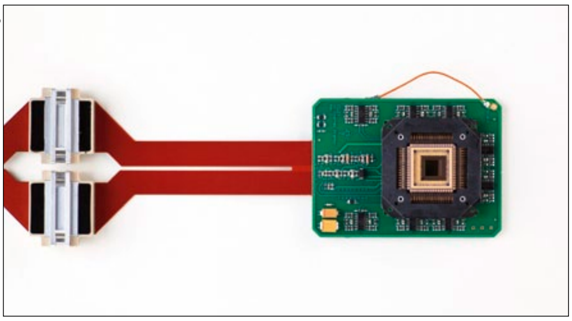
KMOS (PI: Sharples, Durham) is a second generation instrument to be delivered to the VLT in 2012. This near-infrared multi-field spectrometer can observe 24 2.8-arcsecond fields simultaneously and take spectra of 14 × 14 spatial elements within each. A test readiness review was passed in December, KMOS integration is now virtually complete and the team is preparing the instrument for final debugging and Preliminary Acceptance Europe. All the pickoff arms and IFUs have now been integrated into the instrument. A puzzling image quality problem in the spectrometer, which delayed progress earlier in the year, was finally traced to a misshapen final lens element that induced stresses due to the spectrograph collimator mount. Once this problem was corrected, the final image quality met all specifications. The first commissioning of the instrument should now be in September 2012.

MUSE (PI: Bacon, Lyon) is an integral field spectrograph with a field of view of 1 × 1 arcminutes, fine spatial sampling, intermediate spectral resolving power (R = 3000) and large spectral coverage. Subsystems and components continue to arrive in Lyon for final instrument integration. The derotator has been integrated into the fore-optics and both the calibration unit and field-splitting optics have been accepted from the manufacturers. Twelve IFUs have been assembled and successfully tested in Lyon and the instrument main structure was installed and aligned on the VLT simulator in the lab. A new version of the data reduction pipeline was successfully installed in Lyon. Delivery to Paranal for commissioning is expected in late 2012.

ESPRESSO (PI: Pepe, Geneva) is an ultra-stable optical high resolution spectrograph for the combined coudé focus of the VLT. Delivery to Paranal is expected in late 2015. It can be operated from either one of the UTs or by collecting the light from up to four UTs simultaneously. ESO has substantial participation in the instrument with deliveries of major subsystems and components. The Preliminary Design Review was held in October and was successful, with recommendations for improved analysis of interfaces with the infrastructure at Paranal and careful attention to observing procedures.

OmegaCAM (PI: Kuijken, Leiden) is the VLT Survey Telescope (VST) large-format CCD camera. It was successfully installed on the VST and made fully operational in four commissioning runs between March and August. The complex detector system, consisting of 32 2k × 4k CCDs from the company E2V, is working well. Dry runs for the approved VST public surveys were successfully conducted.

Following an ESO call for proposals to study new multi-object spectrograph options, two proposals were selected and funded for Phase A studies. 4MOST (PI: de Jong, AIP-Potsdam) is an optical instrument for installation on either the NTT or VISTA, and MOONS (PI: Cirasuolo, Astronomy Technology Centre [UK ATC]-Edinburgh) is an infrared spectrograph for the VLT. Both studies kicked off this year and reviews of both will take place in the first quarter of 2013.



ESO/G. Finger

The prototype e-APD detector from SELEX (UK), ready for testing at ESO on its flexiboard.

Upgrades to existing Instruments

The upgrade project for the existing VISIR instrument was approved in 2010 and consists of upgrades to the hardware (especially the mid-infrared detector), improved software support, and enhancements to the science operations of the instrument. The Final Design Review for the project was passed this year and work is continuing on a challenging schedule to install it on the VLT during the third quarter of 2012. A water vapour radiometer, important for predicting the instrument performance on the sky, was successfully commissioned on Paranal at the end of the year. The new 1k × 1k mid-infrared Aquarius detector from Raytheon is the most important part of the upgrade, and has been fully tested and characterised in the lab in Garching. Lessons learned from the testing will be applied to newly designed electronics for implementation in VISIR. A new software pipeline that provides new capabilities has also been successfully tested.

VIMOS is a multi-slit optical spectrograph on UT3. In 2010 a major upgrade to the instrument started within ESO with the goals of improving its performance and reliability. The project included installing new red-sensitive CCDs, active flexure compensation, new shutters, correction of focal plane tilts and off-axis image quality, and volume phase holographic gratings. A new camera focusing mechanism that uses a direct-drive motor and absolute encoder has also been tested successfully and will be installed. A new mode that uses existing catalogues to produce the slit mask and thereby removes the need for pre-imaging in most cases has been tested successfully and will be implemented. During the year, work proceeded on all these aspects and preparations are now in place for a final intervention in 2012 to conclude the project.

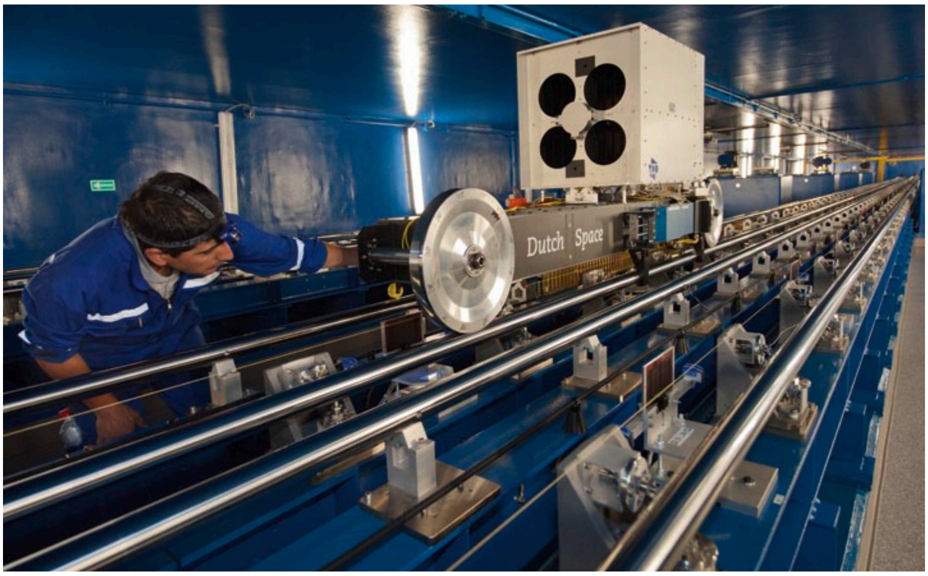
The accurate calibration of high resolution spectrographs to achieve the stability and precision required to detect the radial velocity perturbations caused by planets orbiting other stars is a challenging and difficult process. This year, following an STC recommendation, Council approval was given to build and install a laser frequency comb (LFC) on the HARPS instrument on the 3.6-metre telescope on La Silla. The project will be a collaboration between ESO, the Instituto de Astrofisica de Canarias in Spain and the Universidade Federal do Rio Grande de Norte in Brazil. With this calibration system, HARPS will reach a long-term radial velocity precision below 30 cm/s, consolidating ESO's leadership in this field and paving the way for future, more ambitious instruments. The contract with MENLO systems GmbH concerns the development of the LFC system to turnkey level in two years and offering it to the community from Period 92.

Technology development

The Aquarius mid-infrared detector is the major upgrade component for VISIR and will replace its current unstable detector. Aquarius saw first light in the ESO lab this year and was fully operational by the end of the year. The cooling of the detector itself in the test cryostat has been improved with the result that temperatures as low as 4.5 K can now be used. Tests conducted using a star simulator and chopper to mimic performance on the telescope confirmed that the performance of the detector is better than those already installed in the VISIR instrument. The temperature dependence of the dark current was also measured. Together with the improved signal-to-noise sensitivity, much better cosmetic quality, increased pixel count and improved detector stability, the new detector is expected to result in a major improvement to the performance of VISIR.

An important new development in infrared detectors for wavefront sensing and fringe-tracking is the infrared avalanche photodiode array, a project being led by ESO with the aim of providing devices with very low effective read noise due to avalanche amplification. Tests with prototype e-APD (electron Avalanche Photodiodes) arrays from SELEX (UK) are continuing and leading to a greater understanding of these devices. In order to improve array performance, SELEX is moving to Metal Organic chemical Vapour Phase Epitaxy (MOVPE) technology and a contract has been placed by ESO to assess the potential of e-APDs grown this way. The arrays will be hybridised and, after six months, the best MOVPE array will be delivered to ESO for evaluation in our laboratories.

A substantial effort has been underway for some time to reduce the vibrations coming from the closed-cycle helium refrigerators on VLT instruments. The vibrations are known to add noise to the optical path stability in the VLTI. Initial efforts focused on reducing vibrations from existing instruments with initiatives to find a new low-vibration cooler standard, changes to thermal couplings and investigation of active damping systems. These have all led to significant reductions in the level of vibration induced on the VLT. This year efforts also turned to better characterisation and specification of the vibrations so that the problem could be avoided in future instruments before commissioning. A specification was developed based on measurements of induced VLTI path errors and will be formalised in a test procedure for future instruments prior to shipping.



ESO/Max Alexander

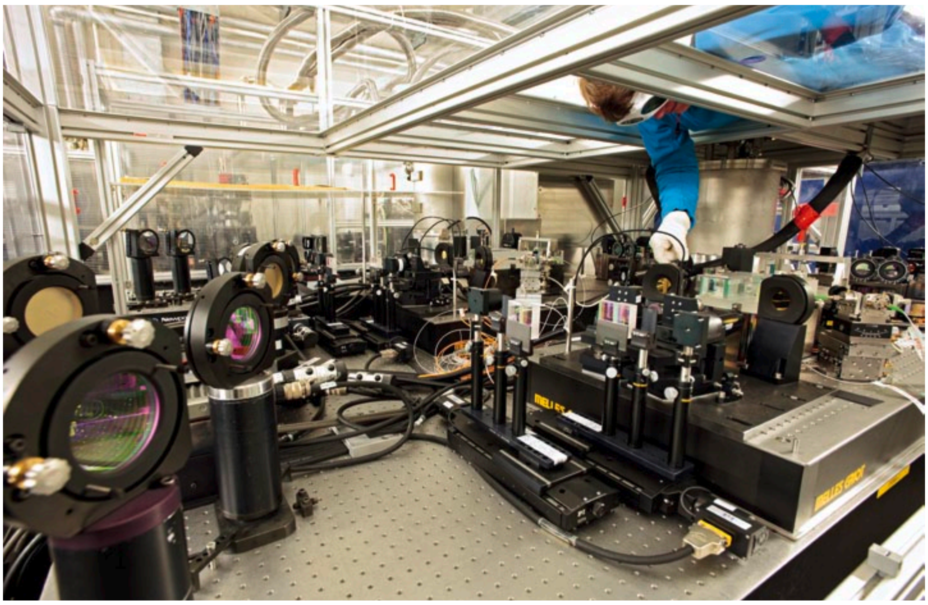
The delay lines in the Very Large Telescope Interferometer tunnel, where the light from a distant celestial object that has been collected by two or more telescopes is delivered to the interferometric laboratory and combined to produce a pattern of fringes.

VLTI-PRIMA

This year brought some challenges for the VLTI-PRIMA project with many ups and downs. The first astrometric measurements were achieved but showed large errors. These were identified as being due to a single sign error in the millions of lines of code of the PRIMA software. After correction, residuals of some tens of micro-arcseconds (corresponding to some tens of nanometres of optical path) were obtained on several pairs of stars over periods from one night to 40 days, which gave rise to great hopes for PRIMA performance. Unfortunately, subsequent measurements on other binaries at different positions in the sky showed that the measurements were not repeatable, with optical path errors of several tens of micrometres again. These errors are highly degenerate and do not allow a disentangling of the required astrometric vector from errors in the interferometric baseline.

The process of identifying and quantifying the source of these errors is now underway. Hardware solutions to eliminate or measure the errors are being studied by an enlarged team, including ESO staff members and external experts. All efforts of the VLTI team in Garching are now concentrated on solving the astrometric problems and providing the PRIMA astrometric mode to the community as soon as possible with an acceptable accuracy of 50 micro-arcseconds over several weeks.

In the meantime, work on the adaptive optics system for the Auxiliary Telescopes (NAOMI) has progressed. Tests of the PRIMA fringe tracker together with the MIDI instrument have been successful, providing good quality MIDI data on fainter objects than currently possible with MIDI alone.



ESO/H.H.Heyer

Françoise Delplancke adjusting the PRIMA instrument, which is partially accessible from the top only.


ESO/B. Tafreshi (twanight.org)

This panoramic view of the Chajnantor plateau shows the antennas of the Atacama Large Millimeter/submillimeter Array ranged across the unearthly landscape.

ALMA

ALMA, the Atacama Large Millimeter/Submillimeter Array, is a large interferometer for radio wavelengths ranging from 0.3 to 9.6 millimetres. It is currently being built by an international collaboration between Europe, North America and East Asia in collaboration with the Republic of Chile. This new observatory will comprise 66 high precision antennas with state-of-the-art receivers located on the Chajnantor plateau of the Chilean Andes at 5000 metres altitude in the district of San Pedro de Atacama. ALMA will provide astronomers with data with unprecedented sensitivity and resolution. The 12-metre antennas will have reconfigurable baselines ranging from 15 metres to 16 kilometres. Angular resolutions as fine as 0.005 arcseconds will be achieved at the highest frequencies, a factor of ten better than the Hubble Space Telescope at optical wavelengths.

During the year ALMA construction has progressed significantly, and ALMA Early Science operations have started. The major highlights at the year's end included:
- Twenty-four antennas of 12-metre aperture and four of 7-metre were located at the 5000-metre site.
- A total of sixteen European antennas have been shipped to Chile. Six have been accepted, three of these have been brought to the 5000-metre site, and many others are undergoing testing, commissioning or integration.
- Good to very good progress has been made on many European front-end component deliverables.
- By mid-year everything was ready to receive scientific proposals in response to the first ever ALMA call for proposals: Early Science. Almost 1000 proposals were submitted by the science communities from within the ALMA partner regions.
- After proposal evaluation and selection, Early Science observations started with 16 antennas on 30 September.
- Infrastructure work proceeded very well with the permanent power system in the final stages of commissioning, and the selection of the architects for the ALMA Residence.

ALMA (ESO/NAOJ/NRAO), W. Garnier (ALMA). Acknowledgment: General Dynamics C4 Systems

Aerial view of the OSF at 2900 metres altitude. In the foreground is the European antenna integration site with seven complete AEM antennas.

Site construction work

The ALMA observatory comprises three sites:
- the ALMA Operations Support Facilities at an altitude of 2900 metres;
- the Array Operations Site, located at 5000 metres altitude on the Llano de Chajnantor; and
- the Santiago Central Office (SCO) at ESO's Vitacura premises.

The OSF is the operations centre for the entire ALMA observatory and is also the place where the final assembly of the antennas is carried out. The Assembly, Integration and Verification (AIV) of antennas and other advanced equipment is being completed there before transport to the AOS.

Operations at the AOS are limited to an absolute minimum due to the harsh environment. The AOS technical building hosts the correlator, a specialised computer that processes the digitised signals from the antennas before they are transmitted via fibre-optic lines to the data storage facilities at the OSF.

ESO has, within the agreement concluded with its international partners, assumed responsibility for providing several major construction works on all three ALMA sites. In addition, ESO has managed the construction of roads leading from the public Chilean highway to the OSF (15 kilometres), and continuing to the AOS (28 kilometres). By the end of the year the final outfitting, with the installation of safety barriers and traffic signs, was nearing completion.

At the OSF, ESO is in charge of:
- the construction of the OSF technical facilities;
- the installation of the permanent power supply system for the entire ALMA observatory;
- the construction of the ALMA Residence.

The last modifications to the OSF technical facilities required the provision of additional office area and a suitable area for a future visitor centre.

The multi-fuel power generation system (see the figure at the top of the next page) at the OSF, consisting of three turbines each with a capacity of 3.8 MW, is currently being assembled and commissioned. The contract for the liquefied petroleum gas storage facility for the generation system was awarded and the manufacture of the three 200 m^3 tanks

ESO/Diego Fente Vazquez – TSK Electronica y Electricidad S.A.

The multi-fuel power generation system comprises three turbines each with a capacity of 3.8 MW.

ESO/C. Cabrera

The liquefied petroleum gas storage facility for the generation system consists of three 200 m^3 tanks.

was completed (see the figure in the middle). The medium voltage distribution system that distributes the power generated to the facilities at the OSF and to the AOS was also completed and entered the commissioning phase.

The whole system, which corresponds to a power system sufficient for a town of several thousand inhabitants, will begin operations in 2012.

A call for tender for the design of the permanent ALMA Residence was released early in the year and, following the selection process, the concept proposed by the architects Kouvo & Partanen (Finland) was chosen (see the figure at the bottom). The design should be finished in the second half of 2012 and the call for tender for the construction will swiftly follow. The Residence, with a total of 120 rooms, is expected to be available by 2014.

Besides providing the 192 antenna foundations at the AOS (completed in 2010), ESO is responsible for installing high accuracy interfaces on them. This is a delicate and challenging activity since the required precision in positioning the interfaces is a few micrometres over a range of several metres, to be achieved in a rather harsh environment. By the end of the year about 90 % of the foundations were equipped with the interfaces; the work will be completed early in 2012.

ESO/Kouvo & Partanen Oy

The concept for the ALMA Residence proposed by the Architectural Office Kouvo & Partanen (Finland).

The Santiago Central Office, in use since 2010, was outfitted early in the year with special rooms providing redundant cooling, an uninterruptable power supply and fire protection to host the observatory's important digital storage and computing equipment.

ALMA antennas

ESO is providing 25 high-precision antennas of 12 metres diameter to ALMA. The antennas are manufactured by the AEM Consortium, composed of Thales Alenia Space (France and Italy), MT-Mechatronics (Germany) and European Industrial Engineering (Italy). Antenna production is distributed throughout Europe at various subcontractors, some of whom are also involved in the development of special key components. Major antenna parts are shipped to Chile where they are assembled into complete antennas. This assembly is done at a dedicated work area at the OSF.

During the year the serial production of most antenna parts was completed, including the reflecting panels, the receiver cabins, the quadrupod legs and a number of other subassemblies. Only a few of the steel structures and carbon fibre reinforced plastic reflectors remain in production, the rest being either on site or in shipment.

In April, the first AEM antenna was formally accepted and handed over to ALMA. It was equipped with the receiver and back-end electronics ready for undergoing final testing and transport to the AOS. The acceptance testing of this antenna was accomplished in about six months, a relatively short period considering the complexity of the system. The ALMA aiv team confirmed the good results obtained with the antenna during acceptance testing by ESO. At the end of July the antenna was moved to the AOS where it was rapidly integrated into the antenna array to become ready for science.

At the beginning of June the second AEM antenna was accepted by ESO and delivered to ALMA. This acceptance included the successful testing of the onboard thermal and wind metrology system used to reach the required pointing performance of the antenna. This system is based on a distributed network of thermal sensors which allow deflections in the structure due to temperature to be reconstructed, and on inclinometers that are used to recover the deflection due to wind. While these corrections are not completely new, the design of the inclinometer is a novelty. Its fast dynamical performance allows it to be effectively used during all operating modes of the antenna including fast switching. The time to bring the overall metrology system to a mature operating state was remarkably short, allowing the process of acceptance and delivery of antennas to proceed on a regular basis.

The subsequent antennas were accepted at a rate of approximately one every six weeks. By the end of the year, six antennas had been delivered to ALMA. Three of these were operating at the AOS, while the others were being prepared for transport.

More antennas at the AEM work area were at various stages in their path to delivery:
- one antenna was in the final stages of acceptance testing;
- two antennas were undergoing commissioning; and
- five antennas were at different stages of assembly.

Eight integration pads, each allowing assembly and on-sky testing, are available to the AEM. During the initial phase of assembly, movable shelters are built around the antenna until the reflector has to be mounted, after which only finishing and commissioning work is performed. Pointing tests are done on the sky by using an optical pointing telescope mounted on the antenna reflector.

The reflectors themselves are assembled in a special building where two units can be processed in parallel. After an initial learning phase, the reflector assem-

ESO/Max Alexander

Night time gluing of two antenna reflector sections at the European antenna assembly site. The glue is prepared, weighed and samples are sent for lab tests.

ESO/S. Rossi

Handover of European antenna DA41.

ESO/S. Stanghellini

ESO/S. Stanghellini

On the left is one of the European antennas pointing at the horizon. Behind it is one of the antennas provided to the project by Japan, while on the right, on the transporter vehicle and pointing upwards, is another European antenna. This is the first European antenna starting its journey up to the Array Operations Site on the Chajnantor plateau, photographed in July.

Two European antennas at Chajnantor.

bly process is now routine and achieves consistent results both in terms of accuracy and duration. The process starts with the temperature controlled gluing of the half BUS (BackUp Structure) and proceeds to the mounting of adjusters and reflector panels under dimensional control by a laser tracker. Thirteen reflectors were completed by the end of the year, and work had started on the following two units. Steel structures, BUS and cabins up to the 16th antenna are on site and up to the 19th antenna are in shipment.

This year the antenna project saw a major leap forward, both in terms of delivering antennas and in assessing the excellent performance of the European antennas. The only aspect remaining to be fully verified, through operational experience, is their reliability.

The results obtained in the project have been possible thanks to the intense hands-on effort by all the ESO groups involved. Overall progress is carefully watched by the ESO management, which has held regular meetings with the AEM consortium to ensure that the contractor masters the remaining risks and that the project maintains the acquired momentum. Antenna delivery will be completed in 2013.

The front-end system

It was a successful year for the European Front End Integrated Project Team (FE IPT). The delivery of products progressed according to schedule (see table below).

Two major European FE milestones completed were the Band 9 cartridge production and the amplitude calibration device production.

In December NOVA (The Netherlands) shipped the last of 73 Band 9 cartridges to the European FE Integration Centre (FEIC). NOVA is the first of the four baseline cartridge suppliers within the ALMA construction to achieve this very important milestone. Also in December, the final consignment of amplitude calibration devices was shipped by ESO Garching to the ALMA Observatory.

As is evident from the table, in addition to the delivery of front-end assemblies by the European FEIC, only two major FE component productions remain to be completed. Both of these component productions, Band 7 cartridges and cryostats were ahead of schedule at the end of the year and will be completed by mid-2012.

Progress at the European FEIC located at the Rutherford Appleton Laboratory (RAL, UK) was unfortunately less than expected. The departure of all the test engineers in the first half of the year and their consequent replacement caused a major disruption of the EU FEIC activities and a serious delay in delivering FE assemblies to the project. ESO gave substantial support to RAL to replace and train new European FEIC staff and by the end of the year the staffing was again at a sufficiently high level. Aside from these staffing problems, technical problems were encountered with test equipment as well as with the FE assemblies to be integrated, causing additional delays. As a

Product	Delivered by 31 Dec 2011	Total	Fraction complete
Band 7 cartridges	60	73	80 %
Band 9 cartridges	73	73	100 %
Cryostats	61	70	87 %
Water vapour radiometers	58	58	100 %
FE DC power supplies	83	83	100 %
Amplitude calibration devices	70	70	100 %
European front-end assemblies	7	26	27 %

This table shows the delivery status of major European FE products by the end of the year.

result of these issues only four FE assemblies were delivered to the ALMA Observatory while nine had been scheduled at the beginning of the year.

One essential service provided this year by the European FE IPT to the ALMA Observatory was FE maintenance training of JAO staff for the following European deliverables:
– cryostats, including windows and infrared filters;
– Band 9 cartridges;
– amplitude calibration devices;
– FE dc power supplies; and
– water vapour radiometers.

After this training, JAO staff became increasingly self-supporting in the operation and maintenance of ESO's FE products.

The back-end system and the correlator

Most of the Back-End (BE) components to be supplied by ESO were provided to the ALMA Observatory on schedule and are being integrated into the overall ALMA system.

The back-end system is sketched in the figure below where ESO's deliverables are shaded in yellow. Each ALMA antenna is equipped with the elements shown in the left half of this schematic overview. Signals coming from the front end of an antenna are processed, digitised and converted to one single optical signal transmitting the scientific data through one single optical fibre at a rate of 96 Gbit/s to the AOS technical building. The optical demultiplexer/amplifier receives, amplifies and de-multiplexes the optical signal from the antennas and conveys it to the tunable filter installed in the correlator. Each correlator input can be connected to each antenna station by means of a fibre-optic patch panel and associated patch cables (see table above).

Component	Supplier	Total	Received
Photomixers	RAL	619	451
Digitisers	Univ. Bordeaux	281	281
Digitiser clocks	IRAM	68	68
Optical transmitter MUX	ESO	80	80
Optical fibre patch cables sets	Huber+Suhner	2	2
Fibre patch panels	Huber+Suhner	2	2
Optical de-MUX and amplifiers	ESO	80	80
Tunable filters	Univ. Bordeaux	554	554

This table summarises the supply of BE components by ESO.

The last production batches of the broadband, high-speed ALMA digitisers were successfully integrated in Chile during the year. To ease the maintainability and performance checking of the digitiser assemblies, robust new test equipment based on the original design was produced by the University of Bordeaux under an ESO contract.

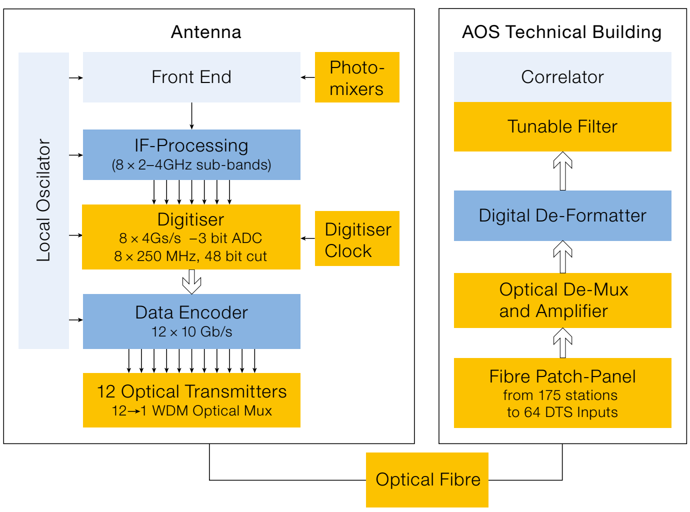
The ALMA correlator is a highly specialised supercomputer processing data from up to 64 antennas at a rate of up to about 2×10^{15} operations per second. The system performance and main design technical challenges are described in *The Messenger,* 135, 6, and the *ALMA Newsletter,* 7, 18.

Alain Baudry/ESO

Digitiser test equipment serves as a trouble-shooting tool for the ALMA digitiser.

Two quadrants of the correlator were in continuous use at the AOS for Commissioning and Science Verification (CSV) and Early Science tasks, while the third and fourth quadrants were used as a test bed to help develop new features such as multi-resolution modes. Upgrade at the AOS to two-quadrant operation was completed to allow up to 32 antennas to be processed.

Monitoring of event upsets due to cosmic rays at the AOS is possible thanks to a special circuit implemented in the field programmable gate array chips on the tunable filter bank cards, delivered by the University of Bordeaux. Events are observed and will be monitored further to explore any potential impact on the correlator system integrity.



The ALMA back-end system. Parts in yellow are provided by ESO.

ALMA computing

The ALMA Computing Integrated Product Team (CIPT) operates as an integrated development team with proportionate contributions from Europe, North America and East Asia. Collaboration with the ALMA Department of Computing (ADC) has become increasingly important as the observatory commences Early Science operations. The CIPT and the ADC have therefore started to merge into a quadrilateral integrated computing team, in which the Chilean side will focus on the operations and first-level support of the software and archives. Software maintenance and development in all areas will continue to be provided well into the ALMA operations phase by teams from the three Executives.

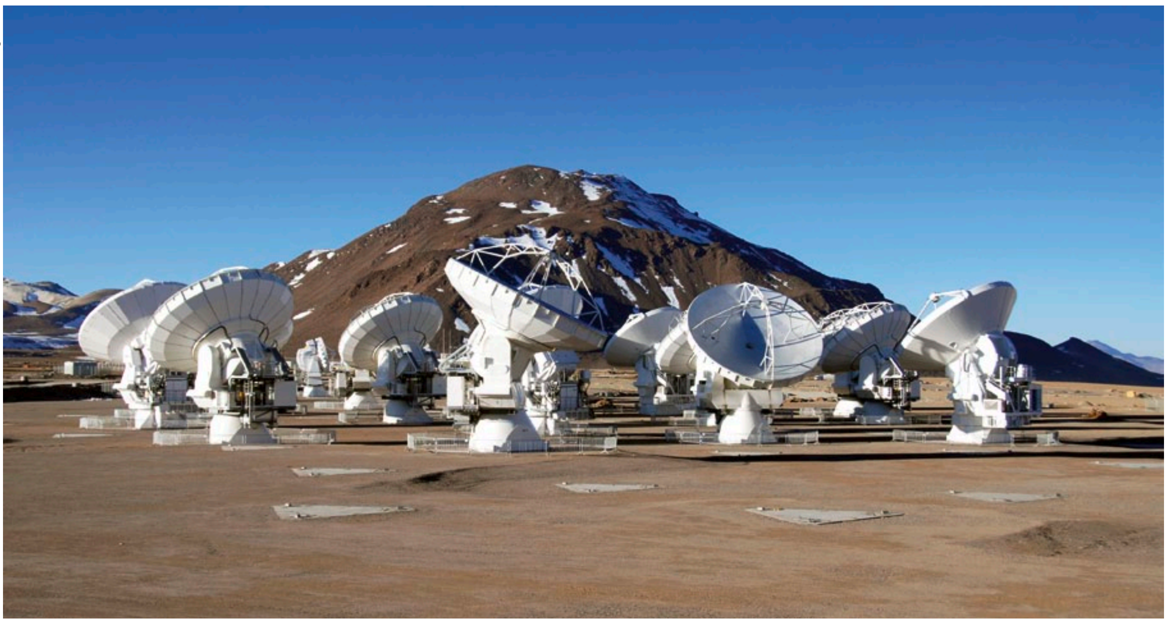
ESO leads the European computing team and receives strong support from the ESO Software Development Division. Other developers come from the ATC in Edinburgh, Institut de Radioastronomie Millimétrique (IRAM) in Grenoble, the Max-Planck-Institut für Radioastronomie in Bonn and the Observatoire de Paris. The contracts with all these institutes were renewed in 2011 for a further three years.

Significant progress has been made in all areas during the year, many of them in improving stability, usability and performance. The following list highlights some of the more publicly visible achievements in European-led areas:
- The ALMA observing tool and science portal has been used successfully by scientists around the world to prepare and submit nearly a thousand proposals for Early Science observations.
- A number of collaboration tools have been successfully used for the assessment, rating, scheduling and tracking of ALMA observing programmes.
- New and powerful database servers have been deployed for the ALMA Archive at the Santiago Central Office and the Operations Support Facility to handle not only the submission of hundreds of science proposals in the final hours before the submission deadline, but also the massive quantity of observing and monitoring data continuously ingested by the archive.
- Bi-directional replication of observing programmes and associated metadata has been established between the OSF, SCO and the three ALMA Regional Centres situated in Germany, the US and Japan, as well as mirroring of observing data from the OSF to the SCO and the ARCs. This allows users to access data directly from their own regional centre.
- Deployment of new operator interfaces at the OSF has been achieved following recommendations by human–computer interface experts. This also included a proposal for an improved layout of the main control room at the OSF that will be implemented in 2012.
- Significant contributions have been made to the development of the CASA data reduction, telescope calibration and science pipeline software used to produce the first ALMA data packages delivered to scientists.
- Continuing improvements were made to the software testing and delivery processes, including the introduction of an incremental software delivery to the observatory, establishing a software change control board, the appointment of a release manager and the formalisation of the delivery, testing and acceptance processes.

System engineering and integration

The European ALMA System Engineering (SE) team continues to work on all SE activities in close collaboration with the ALMA SE team. Specifically, system verification is now getting up to speed and the European team is involved in verifying requirements such as signal dynamic range, cross-talk between polarisation and spurious signals. ALMA is now in a phase within which work is shifting more and more to verification, analysis, trouble-

ESO/S. Stanghellini



A view of the antennas at the AOS in October.

shooting and acceptance. In parallel, project-level documentation is kept up to date. SE personnel participate in or chair all design reviews and acceptance events.

The compressor enclosures that serve as control for the cryogenic system are a European SE deliverable. By the end of the year, all sets were manufactured and delivered to the OSF.

The ALMA computerised maintenance management system was handed over to ALMA in 2010. It is now being populated with product information for the different subsystems.

A new European product assurance (PA) structure and reporting process has become operational with the objective of enabling the European ALMA project manager to identify, in a timely manner, critical PA issues and so be able to react appropriately. A PA audit was performed on the photomixer subcontractors in order to guarantee continuous quality that extends to the later phase of production. Additionally, an effort to assess the reliability, availability, maintainability and safety (RAMS) status of the European deliverables has been introduced. This allows the identification of missing critical RAMS elements, ensuring a smooth handover to operations.

ALMA science

One of the most important events for ALMA this year was the start of Early Science observations. In preparation for this, the first Science Verification observations were performed and released. The first cycle of ALMA Early Science programmes from external users was implemented. Even with the limited set of antennas and capabilities available for Science Verification and Early Science Cycle 0, ALMA is already the most powerful submillimetre astrophysical observatory. The Science Verification data on the NGC 4038/4039 galaxy merger (the Antennae Galaxies, see figure) has already been used together with infrared observations from the VLT for a scientific publication (Herrera, C. N. et al. 2012, A&A, 538, L9). A complete description of the ALMA Science Verification process and available data can be found at the ALMA science portal (http://almascience.eso.org/alma-data/science-verification, see also Testi and Zwaan, 2011, *The Messenger,* 145, 17). The ALMA Early Science Cycle 0 proposals and projects are summarised on p. 103.

The ALMA CSV activities continued throughout the year with the aim of commissioning and delivering observing modes to the Science Operations team. Since the start of Early Science operations, the fraction of time dedicated to CSV has been reduced significantly and work has shifted focus towards the delivery of the capabilities expected for Early Science Cycle 1. Initial tests on polarisation, solar observations, Atacama compact array interferometric and total power operations were carried out in the last part of the year. Initial tests of long baseline interferometry are planned for 2012. As in previous years, several visitors from European institutes have continued to support CSV efforts.

Several workshops, meetings and tutorials on ALMA science were organised in 2011, mainly in collaboration with the ARC network (see p. 44). In the first part of the year, most workshops focussed on the preparations for Early Science Cycle 0 (e.g., Randall & Testi, 2011, *The Messenger*, 144, 39 and Longmore et al. 2011, *The Messenger*, 144, 41), while in the second part, the focus shifted towards planning for Cycle 1 and ALMA data reduction. Workshops emphasising science synergies between ALMA and other facilities were also organised and supported.

The first ALMA development plan studies were also initiated this year. Groups headed by NOVA were contracted to study the possibility of upgrading the ALMA Band 9 cartridge to sideband separating (2SB) operations and to complete preliminary evaluations for the possible full production of the Band 5 receivers. The Max-Planck-Institut für Radioastronomie (Bonn) is heading the European contribution to a study aimed at providing VLBI capabilities with ALMA. More studies are being negotiated for a start in early 2012.

ALMA enhancement programme

ESO is leading a consortium of six scientific institutes that are providing additional software and hardware to enhance the performance of the ALMA observatory. These activities are entirely supported through the European Commission's Framework Programme 6 (FP6).

IRAM (France) has developed sophisticated techniques for on-the-fly observations. The University of Cambridge (United Kingdom) has successfully implemented software for radiometric phase corrections that are already being routinely used by ALMA.

Specialists from Chalmers University (Sweden), STFC/RAL (United Kingdom) and the University of Chile have designed, developed and assembled six ALMA Band 5 receivers. The first frontend unit with a Band 5 receiver was integrated with an antenna in October and subsequently transported to the AOS. The Band 5 receiver project was presented in Brussels at the Exhibition of the Innovation Convention 2011, held on 5 and 6 December and organised by the European Commission.

ALMA (ESO/NAOJ/NRAO). Visible light image: the NASA/ESA Hubble Space Telescope

The Antennae Galaxies (also known as NGC 4038 and 4039) are a pair of distorted colliding spiral galaxies about 70 million light-years away, in the constellation of Corvus (The Crow). This view combines ALMA observations, made in two different wavelength ranges during the observatory's early testing phase, with visible-light observations from the NASA/ESA Hubble Space Telescope.

European Extremely Large Telescope

During the year, the E-ELT project team consolidated the design of the project, guided by a risk mitigation approach. Programmatic as well as technical risks identified in the original design of the telescope were singled out and the project office worked together with its industrial partners to develop strategies and designs that mitigated or reduced these risks. The high cost of the 42-metre project dominated the programmatic risk, resulting in a cash-flow-based schedule rather than a technical schedule. The design of the 42-metre telescope had already been considered cost effective by the external technical review undertaken at the end of Phase B and therefore significant cost reduction could only be achieved through some reduction in the scope of the project. Modifications of the 42-metre design that kept the original diameter were analysed but yielded only minor cost savings. Therefore an option with a reduced diameter became the focus of the delta-Phase B in 2011.

The E-ELT Science Office thoroughly evaluated the impact of a reduced telescope diameter on science. The Design Reference Mission served as benchmark for the evaluation of a telescope with two rings of segments removed. For a large fraction of the science cases, this could be offset by increasing the exposure times by ~ 20–34 %. Where spatial resolution is the limiting factor, the limits were to be reduced by 9 %. The exoplanet case deserves a special mention: two of the three components of this case (detection of Earth twins by the radial velocity method, and characterisation of the atmospheres of transiting planets) are unaffected; for the third component (direct imaging of Earth-like planets) the same results as for the original baseline can be achieved, but at 20 % smaller distances (half the volume). Overall, all of the major science cases of the E-ELT can essentially be maintained.

In parallel with the science evaluation, the systems engineering team inside ESO reviewed and revised over 4000 items in our documentation archive to create a new baseline for the project. A complete revision of the interfaces between subsystems was undertaken, providing an opportunity to incorporate not only the new design, but also the input from industry and academia on the Phase B design.

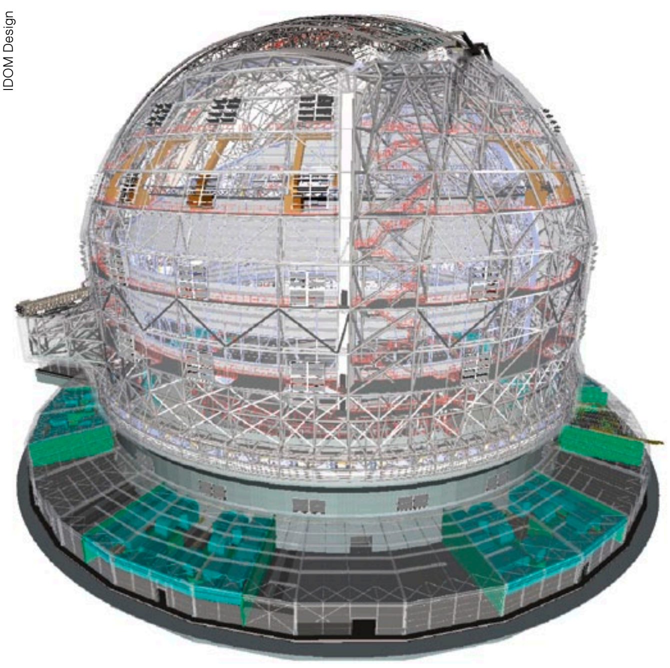
E-ELT segment assemblies being integrated at ESO.

The project considered the options that opened with the reduction in diameter of the primary mirror (M1) as the seed for other changes. By making the primary mirror faster as well as smaller, the size of the secondary mirror (M2) could be reduced to below 4.2 metres. This smaller diameter opened two risk mitigation paths for the project, one in polishing with a simplified process and the other in broadening the supplier base for the blanks. The exposure to the wind near the aperture of the dome was also significantly reduced, thereby improving the performance of the telescope. With the reduction of the telescope diameter came also a reduction in the dimensions of the Nasmyth platforms and a significant reduction in the volume and mass of the dome and the telescope mount. The removal of the gravity-invariant focus also simplified the telescope mount, making it lighter and cheaper. Programmatically the reduction of the number of segments in the telescope from over 1000 to just fewer than 800 relieved some technical schedule constraints.

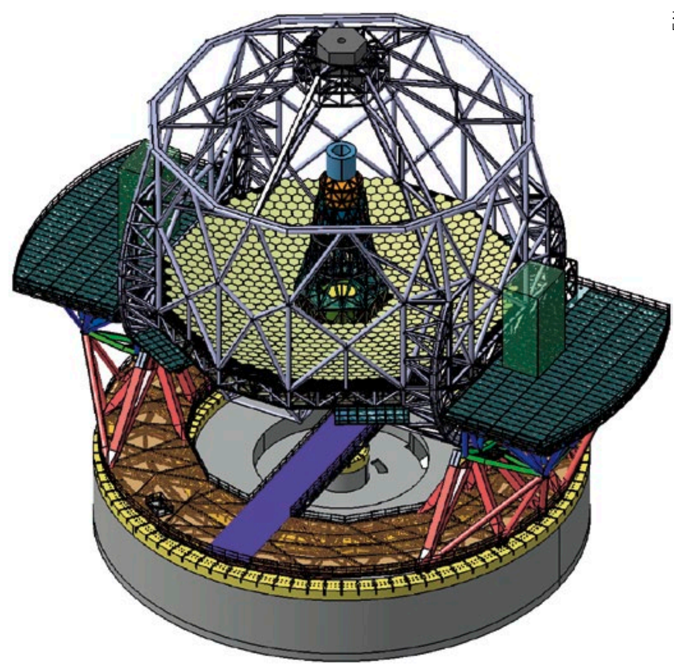
New contracts were started to assess the performance and reliability of alternative segment polishing techniques, i.e., stressed mirror polishing. Although the developments were not totally complete by the end of the year, the achieved results are very encouraging. The alternative techniques allow mitigating risks and offer flexibility in the segment procurement strategy.

Contracts were placed to revise and review the designs of the telescope mount and dome and update the schedule and cost offers that ESO held at the end of Phase B. The work undertaken by the various contractors has been delivered to ESO and the revised design consolidated into a new baseline. Significant reduction in the complexity of the dome was achieved by replacing the lifting platform that provided access to the secondary mirror and the Nasmyth foci with cranes. As mentioned above, further cost and complexity reduction were achieved by removing from the mount the gravity-invariant focus at the Nasmyth level. The telescope retains the coudé focus for instruments that require the ultimate stability. The redesign has enabled the use of steel for the secondary mirror spider instead of the previous baseline of carbon fibre.

This year some of the prototyping commenced during Phase B continued and a number of new activities designed to reduce technical risks started. For example, a carbon fibre reference body for the quaternary deformable mirror and a silicon carbide tip-tilt mirror are in the prototyping phase with hardware components manufactured and under test.



General view of the 40-metre-class dome.



General view of the 40-metre-class main structure.

The 2.4-metre quaternary adaptive mirror (M4) requires a stable reference structure relative to which the deformable mirror is positioned. Existing large deformable mirrors rely on zero expansion glass, as is used in the mirrors of telescopes, (e.g., Schott Zerodur) to provide this stable platform. The dimensions of the E-ELT quaternary provide a strong incentive to seek alternative solutions and while silicon carbide was prototyped during Phase B, the delta-Phase B provided the option to test carbon fibre as well. A large prototype (600 mm × 135 mm × 100 mm boxed beam) representing the reference body has been manufactured including the glued inserts that the actuators use.

The quaternary mirror unit cooling system received much attention this year with the prototype testing of alternative coolants. This activity is aimed at reducing the risk of leaks.

The baseline solution for the large (3 m × 2.5 m) tip-tilt mirror (M5) in the telescope is that it will be made of lightweighted glass. Brazed silicon carbide solutions have been explored with particular emphasis on the quality of the joints. Work is still continuing in this area, potentially with far-reaching consequences for the field of large lightweight optics.

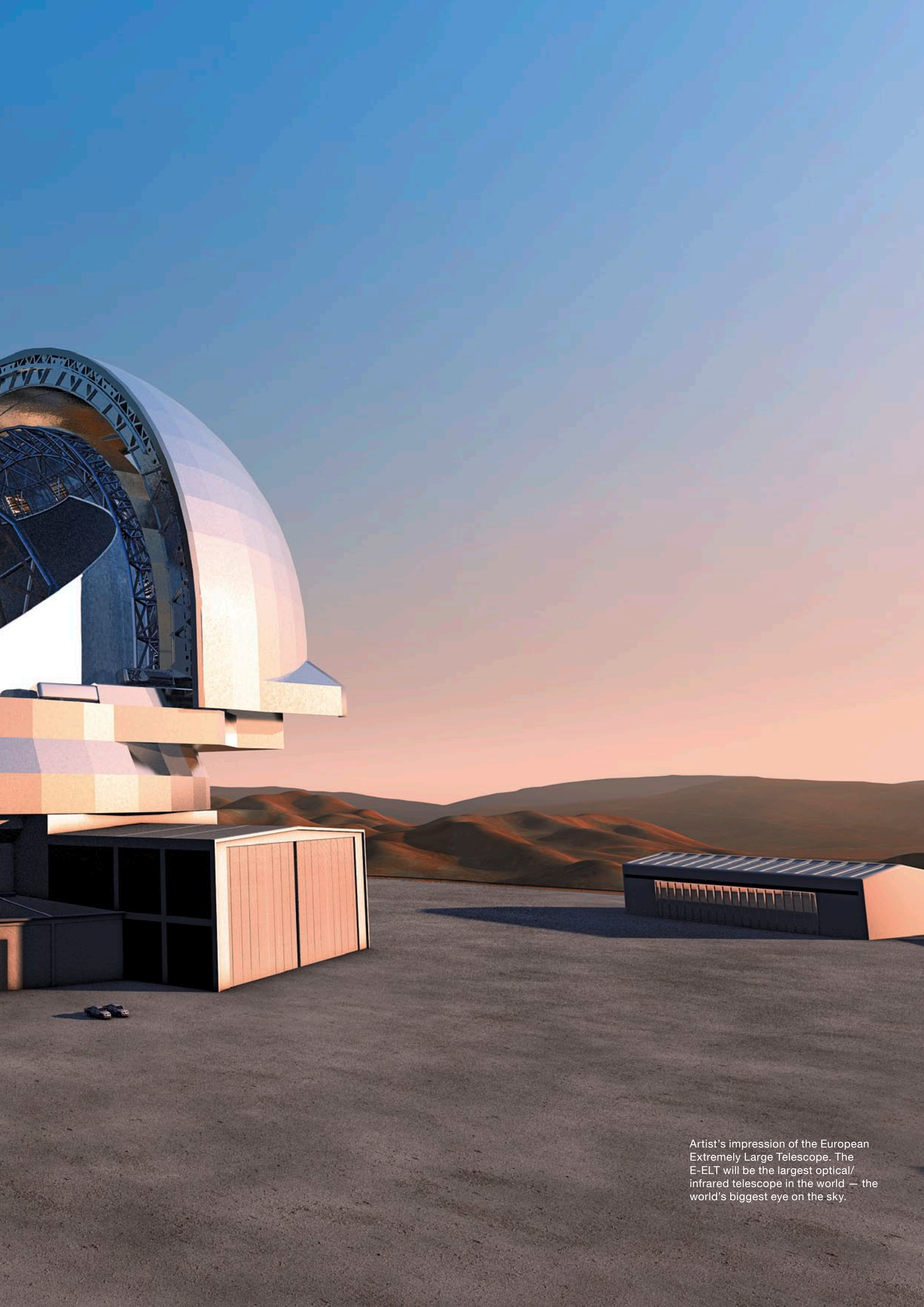
The E-ELT project has adopted seismic isolation as the baseline solution to mitigate the risk of large earthquakes. This year it was possible to prototype and test components and designs for the isolators. Tests were made on scaled versions of the lateral and vertical isolators and the couplings that ensure the telescope pier retains the stiffness necessary for observations.

The prototype segments, mirror supports, edge sensors and actuators made during Phase B have been integrated into a subsector of the final primary mirror at the M1 test facility at ESO. Glass segments polished to their final prescription (at the edge of the primary mirror) were integrated with their whiffletree supports, warping harnesses, position actuators and edge sensors and the installation on the M1 cell simulator started.

The 40-metre-class design is not a simple scale-down version of the 42-metre design — there is more here than meets the eye. For example, some positions of the error budget are affected in a manner that is different from that implied by linear scaling. The change has been scrutinised for risks associated with major contributors. This exercise required the project team to make reasonable design assumptions in order to enable the corresponding analyses. In a nutshell, the results obtained with this strategy clearly indicate that, while in certain areas technical risks may have increased slightly (the faster primary is more sensitive to misalignments), the top error sources of the former baseline (e.g., wind buffeting on the secondary mirror unit) are now controlled to a more manageable level. Towards the end of the year the analyses (in particular those in relation to wind) were extended in order to provide suitable metrics and input numbers for supply specification (e.g., quaternary mirror).

Two independent cost reviews of the project took place late in the year. The first was undertaken by external telescope experts who, over a period of one week, delved into all the cost and programmatic issues of the E-ELT. The second review was undertaken by a commercial firm specialising in reviewing large construction projects. This review focused on the procurement strategies and the costing methodology based on industrial benchmarks. Both reviews gave the project a clean bill of health.

The revised 40-metre-class project was adopted by the ESO Council this year as the new baseline for the project.



Artist's impression of the European Extremely Large Telescope. The E-ELT will be the largest optical/infrared telescope in the world — the world's biggest eye on the sky.

Engineering

ESO/G.Hüdepohl (atacamaphoto.com)

Technology Division

The Directorate of Engineering, created in July 2010, comprises the Software Development Division (SDD) and the Technology Division (TEC). The Directorate provides support in the following engineering areas: control engineering, electronic engineering, information technology, mechanical and opto-mechanical engineering, optical and photonics engineering, software engineering, structural and system analysis. Its mission is to deliver the requested services with high quality and in a cost-effective way. This is now achieved by optimising the allocation of resources, developing and maintaining engineering standards that meet the project requirements, and promoting synergies between projects where applicable.

The Directorate of Engineering plays an instrumental role in the clarification of roles and interfaces between projects and the matrix as well as the required optimisation of business processes.

The dynamism of ESO's Very Large Telescope in operation is wonderfully encapsulated in this unusual photograph, taken just after sunset at the moment Unit Telescope 1 starts work.

Following the establishment of the Directorate of Engineering in 2010, this year has seen the release of the document that defines the agreement regarding the interfaces and the roles of the Directorate of Engineering within the Organisation. This essentially defines the strategy the organisation has established for its matrix structure. An internal review was carried out to ensure that the required positions and skills of the staff are appropriate to meet long-term needs, in particular during the E-ELT construction phase. The Technology Division, as part of the Directorate of Engineering, was strongly involved in the implementation of the decisions taken as a result of this review that included a wider implementation of the matrix approach to the whole organisation. Eighteen staff were moved to TEC. Considerable work has been carried out to merge the Mechanical Systems Department with the Integration, Cryogenic and Vacuum Systems Department. TEC also took the opportunity to merge the Optics and Laser Departments into a single Optics & Photonics Engineering Department.

Control Engineering Department

The new ESO standard telescope axis controller was developed with modern design methods. It can be configured to deliver optimal performance for different telescope axis types. For the design, simulation and test, a model-based approach is being employed that allows for platform and target independence.

This Matlab/Simulink tool suite is being used, including its code generation tools. This is the method commonly employed in the automotive and aerospace industry, following the so-called V-model. Plant models, achieved through system identification of the target, were used in simulations to verify the controller. It was then tested in the laboratory with a hardware-in-the-loop simulator representing the actual telescope structure.

The first verification on a real target was carried out in August as part of the E-ELT prototyping on a VLT UT and, during November, extensive tests were successfully executed on all four VLTI ATs with the result of increased reliability and improved wind rejection.

Telescope Electronic Engineering Department

The Telescope Electronic Engineering (TEE) Department has finished developing a new version of motion controllers. This new version is based on the widely used CAN-BUS controller area network field bus and contains modern control algorithms for both velocity and positioning functions. This controller is fully integrated into the VLT software framework and is delivered with PC-based user-friendly configuration software.

TEE has also finalised the development of the latest generation of instrument cryogenic control systems. These innovative controllers are based on the PLC (Programmable Logic Controller) technology that is widely used in industry. The previous generation of cryostat controller, based on discrete logic systems, was efficient but complex to develop and maintain. The increasing complexity of the instruments could not continue to be handled with this technology. The newly proposed controller concept offers the advantage of associating safety and flexibility with the addition of a more user-friendly human interface. Thanks to the modern concept, the instrument developers have greater flexibility in the evolution of their design concepts within the instrument development phase.

In collaboration with the Control Instrument Software and the Control Engineering Departments, our electronic engineers have started the development of a modern and innovative instrument control system framework. This new concept benefits directly from the technology defined for the E-ELT, filling the gap between the VLT and the E-ELT developments. The obsolescence management of key telescope and instrument components, like the telescope safety chain and main axis control, will directly benefit from the new technology. This year, the obsolete Paranal precise time synchronisation system was the first to be upgraded according to a technology chosen for the E-ELT.

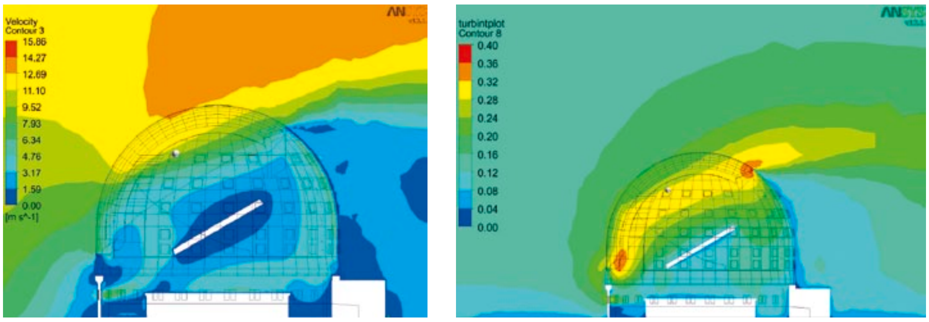
Structure and System Analysis Department

The Structures and System Analysis Department has made significant contributions to the follow-up of several E-ELT subsystem amendment contracts for the resized 39-metre telescope and to the requirements consolidation. System analysis support was provided for performance and error budget verification. Detailed structural, control and ray-tracing models, representing the telescope structure and its subsystems, were built to simulate the performance of the entire system and to derive requirements for subsystem specifications. In several cases the results of the analyses led to design modifications which resulted in simplifications and cost reductions, e.g., the removal of main structure friction devices and central radial bearings.

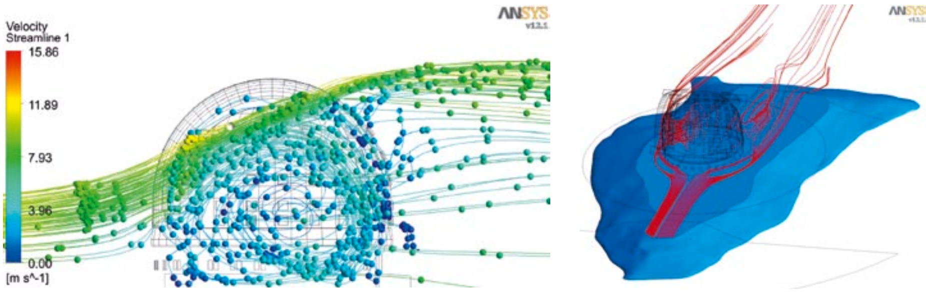
The wind load characterisation was further developed by evaluating wind tunnel measurements, Computational Fluid Dynamics (CFD) analyses and full-scale measurements. A CFD model of the 39-metre telescope and dome structure was built to investigate the impact of the telescope location on the mountain plateau in terms of turbulent intensity and velocity distribution.

A general purpose ray-tracing model was generated and successfully applied to E-ELT, GRAVITY, PRIMA and the Gran Telescopio Canarias (GTC).

Analysis verification under earthquake load was provided to various structures on Paranal such as the Nasmyth platform extension and the pit cover plate support for MATISSE.



Velocity distribution around the E-ELT dome (left) and turbulence intensity (right).



Velocity streamlines around the E-ELT dome.

Geotechnical investigations on the Armazones peak.

Mechanical and Cryogenic Engineering Department

The Mechanical and Cryogenic Engineering Department's (MCED) involvement in the ALMA foundation installations has now drawn to a close, resulting in 142 foundations equipped with antenna interfaces. The remaining foundations are being completed by MCED-trained contractors.

The manufacture of thermal enclosures, mounted to protect sensitive equipment on the antennas exposed to the elements, has now been completed. All units are either on site or in transit.

The MCED has designed and procured a dedicated test stand which replicates at full-size part of the mirror cell of the E-ELT. It is able to tilt to simulate one component of the motion of the telescope. This will enable the testing of up to four full-sized mirror segments for the primary mirror.

Vibrations induced by mechanical coolers cause problems with data quality. A counter-vibration device has been tested on the two operational instruments and shown to result in significant improvement.

Developments in the production of complex castings, with a view to decreasing cost, have been investigated. It is possible to use 3D CAD data to "print" a complex wax-impregnated mould. This is used in casting the aluminium alloy structure, which can have a wall thick-

IDOM/ESO

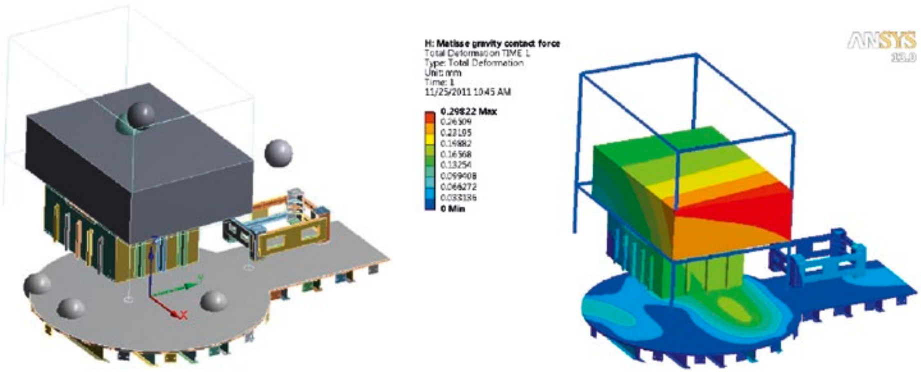
Seismic isolation prototype testing.

ness of only 2 millimetres. The cost savings can be up to a factor of ten compared to that of machining from solid.

A different method of mirror production has been investigated. This employs a 40 μm thick layer of silicon deposited on a silicon carbide substrate. The silicon layer is then polished to provide an optical-quality surface ready for mirror coating resulting in a very strong lightweight mirror.

A product document management system has been studied with a view to implementation at ESO. All of our CAD data will be controlled via this system. This enables us to search and re-use data, link products together with test/design documents and archive our documents more efficiently. This will be extended to all technical documents in the coming months.

ESO/ANSYS



Pit cover for MATISSE: Finite element model (left) and gravity deformation (right).

Optics and Photonics Engineering Department

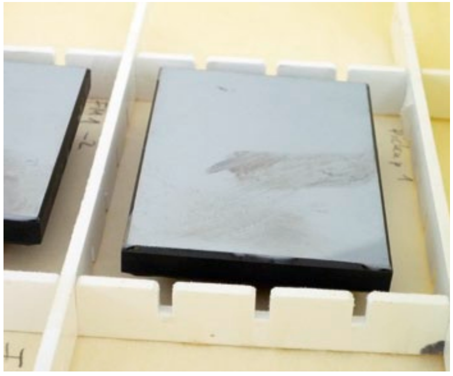
The test bench for the development of new techniques for the phasing of segments has been reinstalled in the optical laboratory and upgraded with an adaptive optics system. Together with a turbulence generator and its core device, the active segmented mirror, it can now

E-ELT primary mirror test stand fully loaded with four fixed frames and dummy masses.

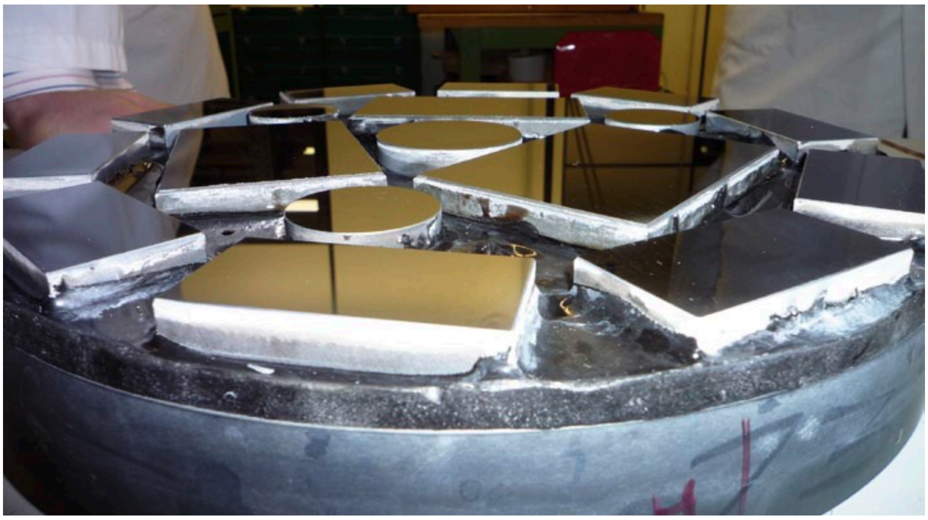
E-ELT primary mirror test stand equipped with dial test indicators in preparation for laser tracker tests.

3D “print” of a wax-impregnated mould.

Final aluminium cast component.



A silicon carbide mirror substrate with a silicon layer shown prior to polishing.



Silicon carbide mirrors during the polishing process.

simulate the phasing activities in the future E-ELT. Issues that will be studied include the capability of the adaptive optics system to correct for the effects generated by segment misalignments.

The four laser guide stars for the Adaptive Optics Facility passed their Final Design Review and started Assembly Integration and Test. A prototype laser guide star successfully completed commissioning and on-sky tests at the Allgäu Public Observatory in Ottobeuren, Germany during the summer. Following the success of this prototype, the department is preparing the replacement of the PARSEC laser on UT4 with a new fibre laser. This would reduce both cost and the resources needed to operate and maintain the laser. It will also allow the use of the laser when required instead of when available as it is today.

Other activities

In order to provide electricity to the future enlarged Paranal and Armazones Observatory, TEC has compared the various supply alternatives. This study concluded that the connection to the grid is the most advantageous solution. TEC is now working to find the best possible connection to either the Sistema Interconectado Central or to the Sistema Interconectado del Norte Grande in Chile.

This year a first optics course was organised at ESO in which several tens of ESO staff participated.

The Division also contributed to ensuring that the image quality of the VST telescope falls well within specifications. Following the delivery of all the batches during the year, the Division also contributed to the work packages for the ALMA amplitude calibration devices.

ESO/M. Kornmesser

On Thursday 18 August 2011, the sky above the Allgäu Public Observatory in southwestern Bavaria was an amazing sight, with the night lit up by two very different phenomena: one an example of advanced technology, and the other of nature's dramatic power.

Software Development

The challenge for the Software Development Division is to provide each project and operation team with the requested resources and products whilst monitoring the quality of the work being done, the standards in use and the commonalities between projects where appropriate.

General IT Department

Many of the general information technology (IT) services are outsourced but supervised by ESO staff. A new contract, which was awarded to DCS, brought in a new incident reporting system as well as more formal procedures for handling incidents and change requests. The goal of these changes is to consistently improve the quality of the IT services provided, boosting user satisfaction.

The team operates and manages a data centre that holds a server and storage infrastructure for all its services. The storage system underwent major changes (new version of NetApp) while a new virtual infrastructure was built. It allows for the instant provisioning of servers and storage whilst guaranteeing a high level of service availability.

The department put considerable efforts into preparing for the telephone systems upgrade in Vitacura. The current system, based on a PABX (Private Automatic Branch Exchange), is old, difficult to maintain and has failed several times in recent years. It will be replaced at the beginning of 2012 by voice over internet protocol (VoIP) telephony.

The migration of web pages to the new web content management system based on CQ5, including the pages of the Paranal science operation team, has progressed steadily during the year. This system enables information to be fresh, consistent and of high quality while allowing for decentralised content creation.

Software Engineering Department

The Software Engineering Department provides the development teams with software engineering services such as the environment and tools to support the software lifecycle, software quality assurance and control. The department is also in charge of integrating software modules, preparing and validating releases before they are delivered to the customer.

The department chairs the software engineering working group that is in charge of developing standards for software development including coding standards, document templates and processes. Currently these standards are only recommended, but it is anticipated that some of them will become mandatory as soon as the appropriate process is in place in the organisation.

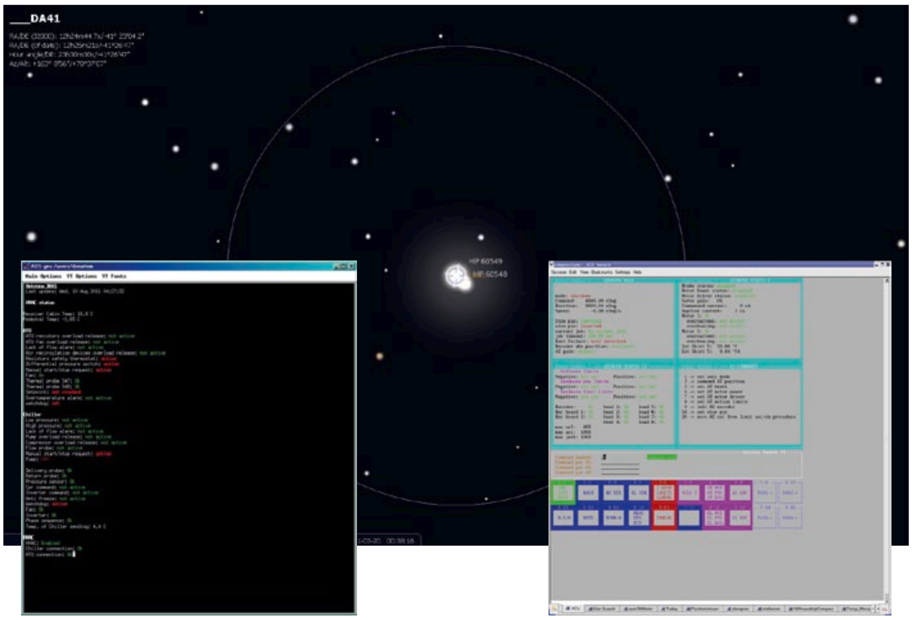
The migration of the version control system used at the VLT to the one that has been chosen as the baseline for the E-ELT was completed. This will allow code to be reused between the two facilities. Another example of synergy is the migration of the VLT *makefiles* to those used by ALMA. The team was heavily involved in the integration of the VLT and ALMA releases as well as in the verification and validation of ALMA and VLT dataflow software. Efforts have also been made to improve the quality of the work being done in this area by unifying procedures, templates for plans and reports.

Virtualisation is one of the important current IT technologies being evaluated and deployed by SDD. It is used to hide the physical characteristics of a computer, showing an abstract computing platform. The team continued to develop know how in this field in anticipation of the E-ELT construction.

Control & Instrument Software Department

The Control & Instrument Software Department has this year shared its time between developing software for the VLT/VLTI observing facilities, ALMA and the E-ELT.

The ALMA software, from the low-level ALMA common software to the high-level graphical user interface (GUI), the executive, which is the interface between the ALMA system and the operators,



(Back image): This screenshot shows the pointing position of antenna DA41 in the sky during the acceptance pointing tests. A piece of software was developed in order to be able to visualise the current position in the sky of the ALMA antennas from the Stellarium open source software. (Bottom left): This is a screenshot of the aemACUStatus.py python GUI developed to improve the diagnostics capabilities on the European antennas given to ALMA. This GUI is a text-based GUI to be able to see easily the status of the main subsystems of the European antennas. (Bottom right) Picture taken from the ALMA control room during the first night of DA41 pointing tests acceptance by ALMA. This was the first light of DA41 with the optical telescope, after having handed the antenna over to ALMA.

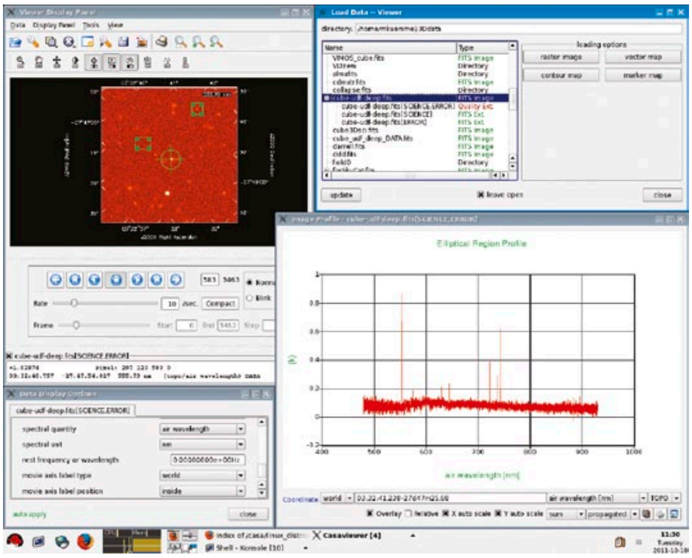
was successfully delivered for Early Science. The team worked hard to debug, understand and solve scalability and performance issues coming up during the commissioning of the antennas. The usability of the interfaces for ALMA operators and astronomers has improved over the past year thanks to the support of experts from INRIA (France).

While the preparation work, including evaluation of technologies and prototyping activities for the E-ELT, has progressed steadily during the reporting year, development work for La Silla is continuing and the VLT software was restructured to facilitate its maintenance. Major software developments kept the PRIMA team busy. The obsolescence of electronic devices requires an upgrade to newer technologies to avoid putting the availability of telescope systems at risk. Requirements analysis and evaluation of potential solutions were carried out. The E-ELT is introducing hard and soft PLCs as a replacement for the local control unit based on the VME bus. The instrument team has evaluated this technology and, in particular, has prototyped motor and cryogenic controllers with a customised PLC solution that can be integrated in second generation VLT instruments such as ESPRESSO. These prototyping activities also contribute to the development of the engineering know how within the team.

Data Flow Infrastructure Department

As part of the effort provided to the ALMA CIPT, the Data Flow Infrastructure Department participated in (and led) the development of high-level dataflow applications such as proposal handling and the science archive. The subsystems were ready for the beginning of Early Science, a major achievement for the team.

On the VLT/VLTI side, the department concentrated its efforts in the development of the Phase 2 tools that support scheduling containers. These applications will be deployed in 2012 and will allow the PIs of Observing Programmes to define sophisticated observing strategies for their Observation Blocks. A new application for logging all science operation-related activities, the night log tool,



CASA viewer for the VLT.

was designed, developed and deployed at the survey facility VISTA. This tool will replace the existing Remedy-based application and will provide a more streamlined, efficient workflow on the mountain.

One of the highlights of the VLT dataflow back-end developments has been the release of the CalSelector, an application that allows users who are retrieving science data from the ESO Archive to associate and download the appropriate calibration data. The development work on the Phase 3 infrastructure for the survey facilities continued at full speed. The Phase 3 infrastructure allows users from the Public Surveys to deliver advanced data products to the ESO Archive.

Pipeline Systems Department

Together with the Data Flow Infrastructure Department, the Pipeline Systems Department (PSD) prepared a new release of Reflex together with an X-shooter workflow. Reflex is a front-end GUI to pipelines based on a workflow engine, Kepler. This activity also included an improvement of the accuracy of the science data reduction.

Much effort was put into following up the work done by the external instrument consortia who are building the second generation VLT instruments: MUSE, KMOS and SPHERE. The deployment of the OmegaCAM pipeline took place before the commissioning of the instrument.

Part of the PSD mission is to improve the quality of the science products generated by existing pipelines on a one-to-one basis. This year the upgrade of the FORS pipeline for the FORS absolute photometry project was completed. A new version of a VISIR imaging data reduction, making use of sophisticated combination and mosaicking algorithms, was implemented.

The visualisation tool for VLT 3D IFU data, which is based on the ALMA data reduction system CASA and therefore a good example of the reuse of technologies, will be available on schedule for the commissioning of the corresponding instruments.

All ESO pipelines are based on the ESO Common Pipeline Library in order to facilitate maintenance and sharing of functionalities. This year the library underwent a major upgrade to fully support 64-bit architecture and to implement thread safety — two functionalities required by the second generation instrument MUSE.

Pipelines are released for public use via the website www.eso.org/pipelines when they have reached an acceptable level of quality and stability.

As every year, a number of new exposure time calculators (e.g., for OmegaCAM) have been released to the community.


ESO/T. Preibisch

This broad panorama of the Carina Nebula, a region of massive star formation in the southern skies, was taken in infrared light using the HAWK-I camera on ESO's Very Large Telescope. Many previously hidden features, scattered across a spectacular celestial landscape of gas, dust and young stars, have emerged.

Administration

Contract signature with BAM Deutschland AG.

Georg Fahrenschon (right), the Bavarian Minister of Finance, with ESO Director General, Tim de Zeeuw (left), during the Minister's visit to ESO Headquarters in Garching, on 5 May 2011.

The Finance Department prepared the first closing of the annual accounts under the IPSAS norms (International Public Sector Accounting Standards). The financial statements for 2010 received the audit certificate from the external auditors from the Portuguese Court of Auditors in April 2011. The statements were presented and approved at the following Finance Committee and Council meetings. This concluded an important and long-prepared task carried out by ESO's accounting group.

Besides the preparation of the annual budget for 2012, the ESO budget and planning group worked on a revised long-term financial plan for the E-ELT. In December Council adopted a resolution on the funding principles for the project.

Industry days were organised during the year to inform companies about the opportunities that will arise from the construction of the E-ELT.

During the year, the newly released procurement and sales procedures were rolled out and the Contracts and Procurement Department conducted workshops in Garching and in Chile. New tools and templates facilitated the consistent application of the rules. The contracts were signed for the architectural design of the ALMA Residencia and for the construction of the extension of the ESO Headquarters building in Garching.

In preparing the ground for the Headquarters extension, the facility logistics transport dismantled and sold the ESO warehouse. All the warehouse stock was transferred to the new rented storage hall in Hochbrück.

The design of the ESO Headquarters extension was completed, all building permits and prerequisites from the local authorities needed for the construction were obtained and the contract for the construction was placed.

This year ESO participated in seven EU 7th Framework Programme projects. The ASTRONET, RadioNet and OPTICON projects continue to provide the European astronomical community with essential networking opportunities in preparation for the future scientific and infrastructural developments in astronomy. The ALMA enhancement project delivered the most sensitive radio receiver for radio waves, known as Band 5, to the ALMA project. The ESO Fellowship programme, which receives financial support from the EU under a Marie Curie COFUND project, provides outstanding and unique training and research opportunities to postdoctoral fellows.

A new patent application regarding an in-house development on an ALMA calibration loads design was submitted to the European Patent Office in September. In parallel, a license agreement to exploit and commercialise the technology was concluded with a company from the UK.

Policies on technology transfer and International Traffic in Arms Regulations (ITAR) were elaborated, and a corporate risk register, which is reviewed by the ESO management on a regular basis, was compiled.

Safety performed various reviews and inspections of the installations in Garching and Vitacura. An update to the ESO safety policy and organisation was released in July. The EIROforum informal meeting of Safety Officers, an ESO initiative, met twice and exchanged experience and best practices in relation to safety, health and environmental protection.

The administrative information system was upgraded and migrated to an SQL database which allowed the implementation of several new applications such as automatic budget control and approval workflows.

People attending the EIROforum meeting of Safety Officers, held at ESO Headquarters, in Germany, in 2011. EIROforum is a collaboration between eight European intergovernmental scientific research organisations, including ESO.

Finance and Budget

Financial Statements 2011

Accounting Statements 2011
(in € 1000)

Statement of Financial Position	31.12.2011	31.12.2010
Assets		
Cash and cash equivalents	18150	50859
Inventories, receivables, advances and other current assets	61954	11837
Non-current assets	973832	992834
Total Assets	1053936	1055530
Liabilities		
Payables, advances received and other current liabilities	40709	42137
Non-current liabilities	332192	154871
Total Liabilities	372901	197008
Accumulated surpluses/deficits	858522	897734
Net assets of new consolidated entities	235	−39212
Net surplus/deficit for the year	−177722	–
Total Net Assets	681035	858522
Total Liabilities and Net Assets	1053936	1055530

Statement of Financial Performance	01.01.–31.12.2011	01.01.–31.12.2010
Operating Revenue		
Contributions from Member States	131487	131725
Contributions to special projects	13744	18474
In kind contributions	15651	7617
Sales and service charges	3818	3779
Other revenue	2025	292
Total Operating Revenue	166725	161887
Operating Expenses		
Installations and equipment	27406	7998
Supplies and services	40937	37540
Personnel expenses	223662	91000
Depreciation of fixed assets	49237	47912
Other operating expenses	907	602
Total Operating Expenses	342149	185052
Net surplus/deficit from operating activities	−175424	−23165
Financial revenue	2620	3885
Financial expenses	4918	19933
Net surplus/deficit from financial activities	−2298	−16047
Net surplus/deficit for the period	−177722	−39212

Cash Flow Statement	2011	2010
Cash Flow		
Net receipts	163760	165264
Net payments	−196469	−230366
Net cash flow = Net decrease in cash and cash equivalents	−32709	−65102

Budgetary Reports 2011
(in € 1000)

Income Budget	Budget	Actual
Contributions from Member States	144693	144469
Income from third parties and advances received	12291	12005
Other income	7483	4375
Consolidated entities	728	614
Total Income Budget	165195	161463
Payment Budget		
Programme	126487	101914
Operations	62382	60293
Science support	8729	7685
Cross-directorate functions	25409	23965
Consolidated entities	571	494
Total Payment Budget	223578	194351

Budget for 2012
(in € 1000)

Income Budget	2012
Contributions from Member States	151534
Income from third parties	20945
Other income	1565
Astronomy & Astrophysics (A&A) Journal	468
Total Income Budget	174512
Payment Budget	
Programme	93958
Operations	62526
Science support	8445
Cross-directorate functions	37888
Astronomy & Astrophysics (A&A) Journal	468
Total Payment Budget	203285

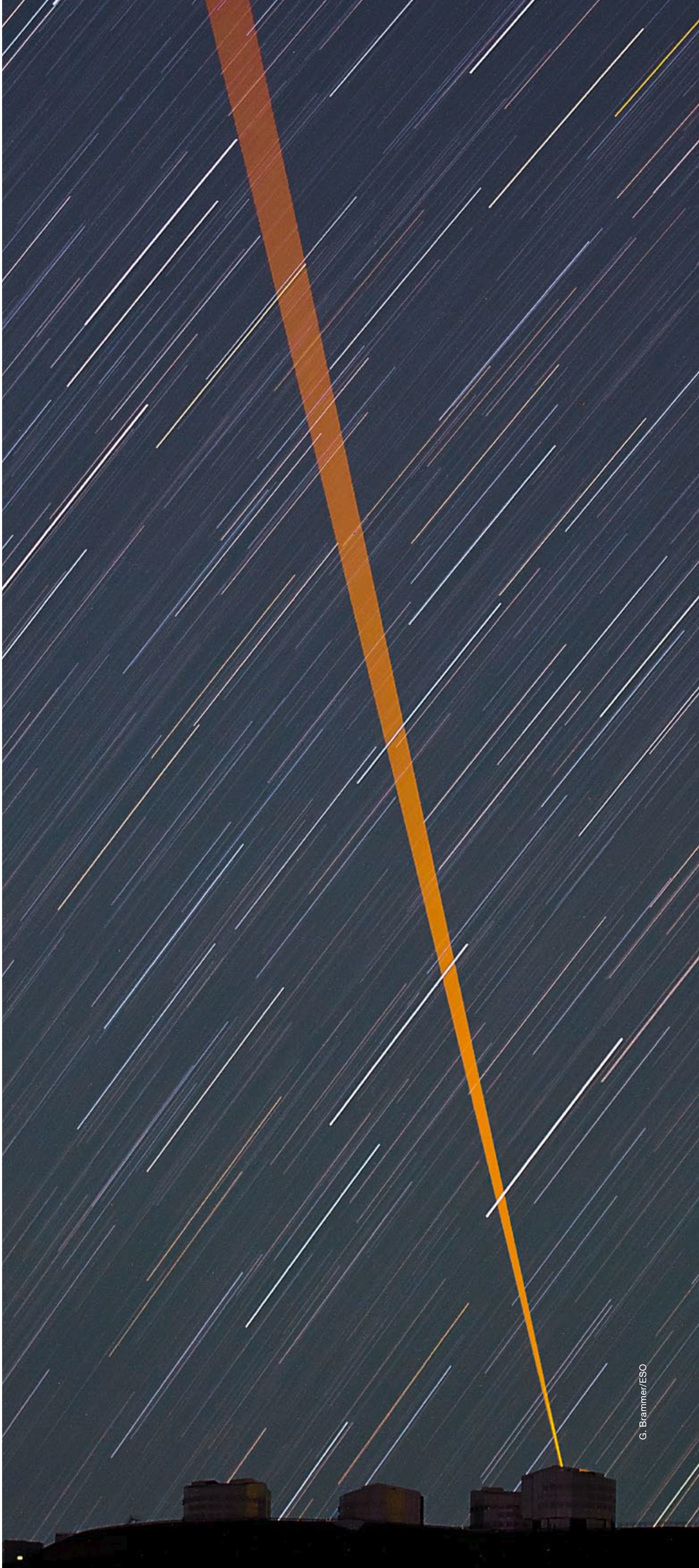
With the financial statements for the year, the Organisation has completed the implementation of the IPSAS norms, as prescribed by the Financial Rules and Regulations adopted by the ESO Council in December 2009.

The External Auditors, Tribunal de Contas de Portugal[1], have expressed their opinion that the financial statements for 2011 give a true and fair view of the affairs of the Organisation.

The accounting statements for 2011 show a negative result of –177.7 million euros. This result corresponds to the increase in the provision for retirement benefits at the closing date, following the outcome of the actuarial study of the shared CERN/ESO Pension Fund at 31.12.2011. The re-evaluation of the calculated provision is mostly due to changes in actuarial assumptions of both a financial and a demographic nature. The change in provision appears under personnel expenses. The net assets of the Organisation at 31.12.2011 amount to 681.0 million euros.

The negative cashflow of –32.7 million euros in 2011 reflects the planned excess of payments over received income during the financial year. Although lower than in 2010, the 2011 payments for ALMA construction still represented one third of the Organisation's total payments. The cash position has decreased correspondingly to 18.1 million euros at 31.12.2011.

The budget for 2012 was approved by the ESO Council in December 2011. The approved 2012 payment budget amounts to 203.3 million euros. It covers another significant annual tranche of the ALMA construction and includes a budget provision for the start of E-ELT construction activities, subject to the approval of the E-ELT construction phase by the ESO Council in the course of the year. The 2012 income budget amounts to 174.5 million euros. Besides the contributions from the ESO European Member States, it includes a contribution from Brazil as a new Member State, in line with the accession agreement signed with Brazil in December 2010.



An unusual time-lapse exposure of the sky over Paranal.

[1] Joao Pinto Ribeiro (Member of the Portuguese Court of Auditors), Maria da Luz Carmezim (Head of Audit Department) and Antonio Pombeiro (Senior Auditor).

Human Resources

(All images) ESO/M. Alexander

The responsibilities of the Human Resources Division (HR) lie within the following areas:
– HR strategy policy and planning
– Professional advice
– Recruitment and selection
– Pay and benefits
– Occupational health and welfare
– Employee relations and communications
– Employment contracts
– Social Security
– Training and professional development
– Family matters and education

Recruitment, selection and reassignment

During the year 30 vacancy notices were published, prompting a total of 1293 applications. The numbers for recruitment campaigns completed according to the contract type were as follows:

Contract Type	No. of Campaigns	No. of Applications
Staff members	23	573
Local staff members	7	507
Fellows	12	213

All positions were advertised on the ESO website. For international positions, notifications were sent to all members of Council, the Finance Committee and the delegates of other ESO Committees, as well as to national and international research centres and observatories. In addition, prominent advertisements for selected positions were placed in appropriate specialist publications and on recruitment web pages.

Within the ESO Fellowship Programme, seven applicants were selected with a duty station in Chile and six applicants were selected for Garching. Five candidates were awarded positions in the ESO Studentship Programme in Europe and seven engineering students were selected for participation in various projects in Chile.

Three staff members were temporarily transferred to Chile to support the commissioning activities for ALMA construction and the Joint ALMA Observatory.

All ESO advertisements contain a statement regarding the commitment to equal opportunities. In 2011, the number of female staff represented 22 % of the overall count. The breakdown by staff category is shown in the figure above.

In March a staffing review took place with the goal of establishing whether the positions and skills required to carry out the entire programme were available amongst the staff. The main conclusions of the review were that there is a strong commitment of ESO staff and the breadth and the quality of the activities are impressive. The action that followed the review was the design of an overall staffing plan to allow for a project-oriented matrix management scheme to deploy staff efficiently to meet the evolving demands of ESO programmes. The restructuring of the Directorate of Operations (DOP) and the Directorate of Engineering (DOE) called for the reassignment of 48 staff members.

HR strategy, policy and planning

Following the recommendation of the Indefinite Appointments Advisory Board, the Director General granted 19 staff members indefinite appointments with effect from 1 August 2011. Furthermore, ten local staff members in Chile were granted indefinite contracts.

HR developed policies for the protection of personnel against the financial consequences of illness, accident and disability (effective 1 July 2011) and amended the retirement age policy, effective from January 2012.

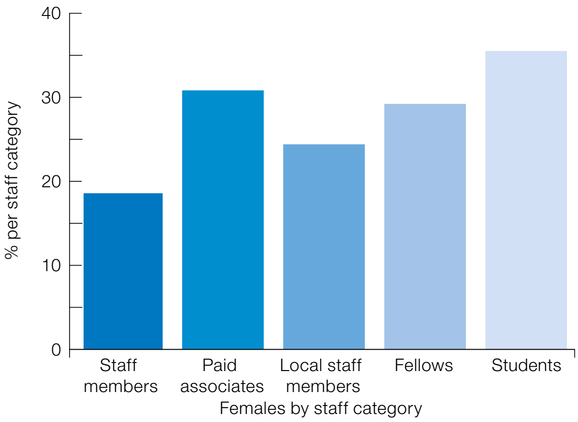
HR performed its essential roles in the preparation of budgetary documents and guidelines, providing the corresponding updates to the position plan and designing, in close interaction with the DOE and the DOP, the full-time equivalent allocation to the matrix division following the staffing review.

The Director General approved the application of the new law on parental leave for ESO's Local Staff Members in Chile.

Training and professional development

A comprehensive training programme was offered and organised in Garching. A total of 293 staff attended training during the year at the Headquarters.

The main areas of training included workshops addressing the fair treatment, courtesy and respect policy; a pilot course in managing contractors; conflict management training for staff in management and non-management positions; a comprehensive writing skills programme covering technical, scientific and general writing skills; a retirement preparation workshop; LabView core courses at levels I and II. In addition, an effective communication programme was designed. A 360° feedback activity was rolled out for a pilot group of department and group heads and different options for use and implementation will be explored in 2012. Early in the year, the proposed leadership programme was launched for directors and division heads and this will continue into 2012. A group of department and group heads attended all four modules of the ESO management development pro-



Breakdown of female fraction for each staff category at the end of 2011.

gramme, including an internal workshop on documents, processes and approach related to performance management. Staff attended training offered by organisations within the EIROforum, including workshops on recruitment, scientific presentation skills and project management.

Employee relations and communications

Regular consultation and interaction with the international staff committee and the unions in Chile have continued. A total of 26 meetings in Garching and Chile were held in order to inform, discuss and exchange opinions in the areas of organisational development, policy amendments, regulations, family working group and training actions.

In the course of the year, three Rehabilitation Boards examined cases concerning incapacity, illness and procedural actions. Two Advisory Appeal Boards were appointed and their substantiated recommendations were followed by the Director General.

HR initiated a staff engagement survey across the Organisation to which there was a response rate of 65 %. The survey is an important tool for the identification of the strengths and the areas of improvement needed in the working environment and in the development of the staff. The survey also provides an opportunity to compare ESO's working environment with that of leading companies in comparable high-performing industry sectors and with international organisations. In early 2012, the overall result of the survey was presented to all staff and were made available to everyone on the intranet.

Collaboration and representation of HR

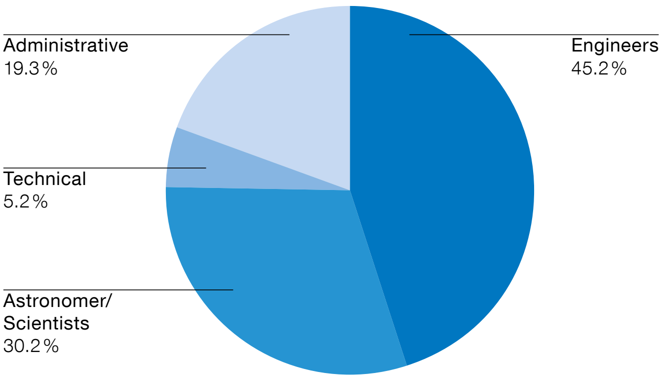
ESO HR has participated in monthly meetings of the ALMA Human Resources Advisory Group and contributed in particular to the release of a training guide, a recruitment and selection guide, an education policy, a policy against harassment and discrimination, in the clarification of budgetary issues and advising on union matters and staff transition from construction to operation.

HR also organised and participated in two meetings of the Tripartite Group that dealt mainly with the developments of the CERN Pension Fund and the changes affecting its regulation, salary adjustments, results of the staffing review and the steps to be taken in response to the engagement survey.

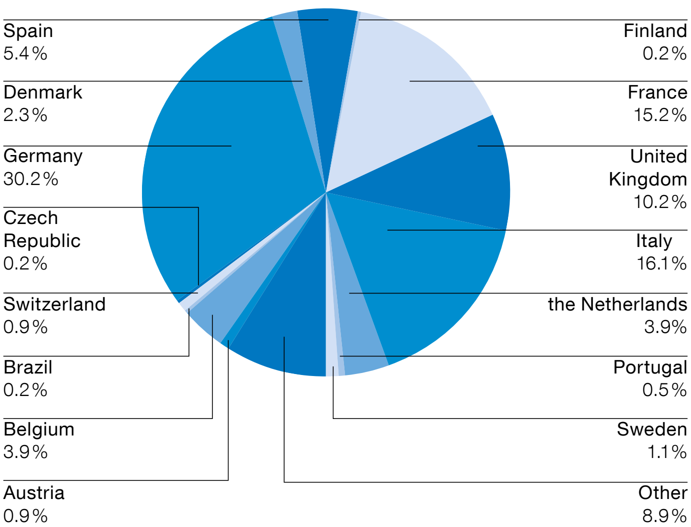
Two meetings of the EIROforum took place during the year and included the pertinent topics of the HR competence framework, the organisation of a symposium for young researchers, joint career fairs and training events for researchers in areas of project management and presentation skills.

Social security

A working group consisting of representatives of the CERN management, ESO management and the CERN Pension Fund was set up to find an optimal solution for the calculation and payment of contributions and pensions for ESO staff on the basis of effective ESO salaries. Meetings took place in January and April and positive developments and results were achieved. By means of a letter sent in June, ESO recommended the parameters of, and provided additional information on, the study of a euro-denominated pension plan to the Actuarial and Technical Committee (ATC) of the CERN Pension Fund. After discussions by the ATC, the study was sent to the chairman of the CERN Pension Fund Governing Board.



Distribution of staff by job category — 31 December 2011.



Staff members by nationality — 31 December 2011.

In November the chairman sent a report concerning the implications of the possible introduction of such a plan, indicating that these implications had not enabled the CERN Pension Fund Governing Board, at this stage, to prepare any recommendations to the CERN Council on this matter. A reply to this letter was submitted at the beginning of 2012.

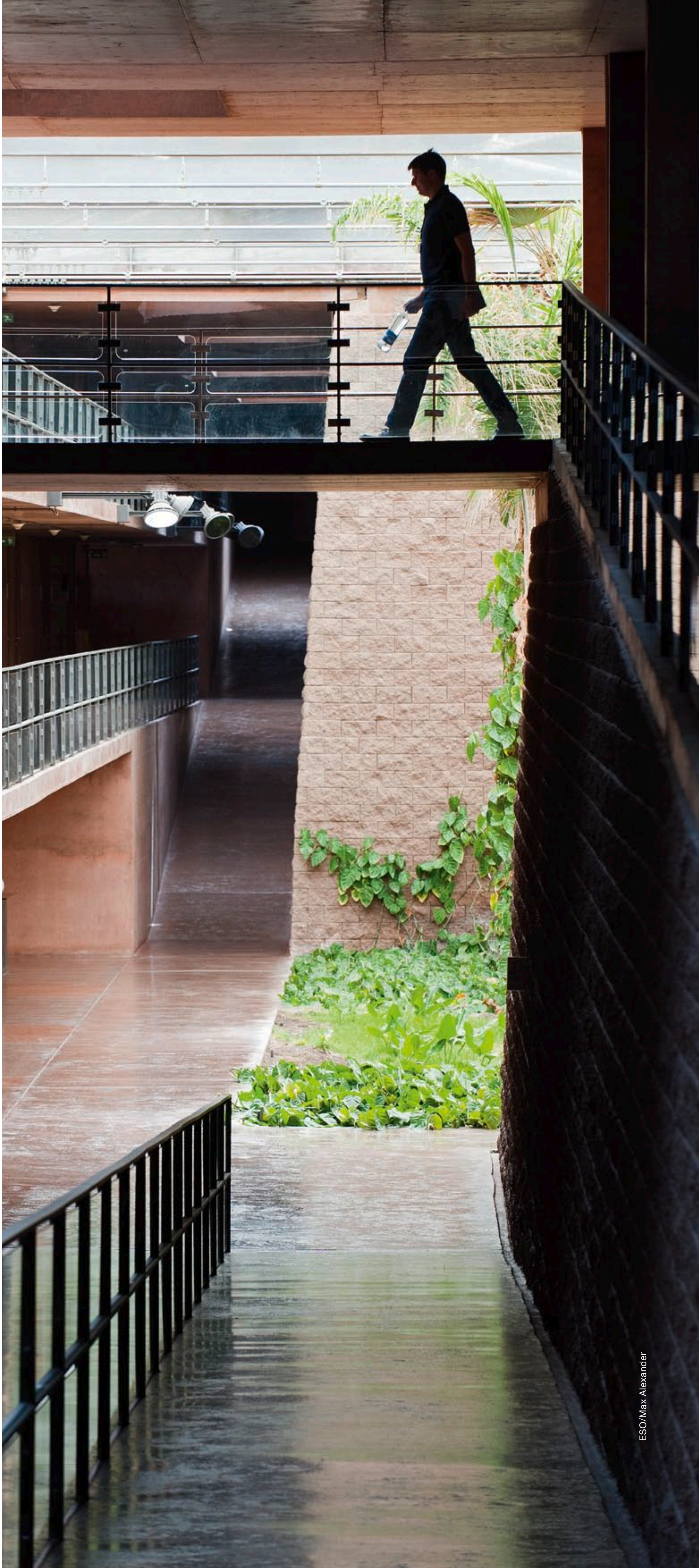
HR administration

As part of its comprehensive and service-oriented contract administration duties, HR also handles a wide spectrum of personnel-related activities, including operation of the payroll and adjustment of social security systems, presentations to staff, full-time equivalent allocation, budget preparation and control, statistics, the settlement of over 3000 travel claims, special services for international staff in Chile (accreditation, schooling, accommodation and relocation), review and update of the HR intranet web pages, organisation of formal induction days for new staff members in Chile and Garching and organisation of regular medical examinations. As an integral part of this service, a variety of pertinent documents have been produced and issued.

Staff departure

The departures of staff members this year fall into the following categories:

Reasons	Staff member	Local staff member
Resignation	8	2
Expiry of contract	5	0
Retirement	6	2
Mutual agreement	3	6
Dismissal	0	0
Death	1	0
Total	23	10



The Paranal Residencia.

ESO/Max Alexander

List of Staff

As of 31 December 2011

Office of the Director General

Tim de Zeeuw

Mary Bauerle
Laura Comendador Frutos
Gabriela Gajardo
Nikolaj Gube
Isolde Kreutle
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Elena Llopis
Diego Rioseco
Massimo Tarenghi
Jane Wallace

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Nadja Sababa
Heidi Schmidt
Maria Soledad Silva
Roswitha Slater
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Lone Vedsø Marschollek

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Javier Argomedo
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Pascal Ballester
Klaus Banse
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Thomas Bierwirth
Reynald Bourtembourg
Blanca Camucet
Alessandro Caproni
Sandra María Castro
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Vincenzo Forchi
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Armin Gabasch
Bruno Gilli
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Paul Lilley
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Juan Antonio Marrero Hernandez
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Michael Müller
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Fernando Alvarez
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Bruno Leibundgut

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Nathalie Fourniol
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Christian Hummel
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Jörg Retzlaff
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Felix Stoehr
Dieter Suchar
Lowell Tacconi-Garman
Elena Valenti
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Eelco van Kampen
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Jeremy Walsh
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Alvaro Alvarez Candal
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Daniela Barria
Amelia Maria Bayo
Giacomo Beccari
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Jutta Boxheimer
Gabriel Brammer
Eli Bressert
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Lodovico Coccato
Luca Cortese
Gráinne Costigan
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Sebastian Daemgen
Timothy Davis
Holger Drass
Guillaume Drouart
Eric Emsellem
Anja Feldmeier
Anna Feltre
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Caroline Foster-Guanzon
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Anaelle Maury
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Ferdinando Patat
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Magaretha Pretorius
Myriam Rodrigues
Paula Valentina Rodriguez
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Gert Tommy Wiklind

ESO/C. Malin (christophmalin.com)

The VLT early in the evening, undergoing a routine inspection after a light earthquake.

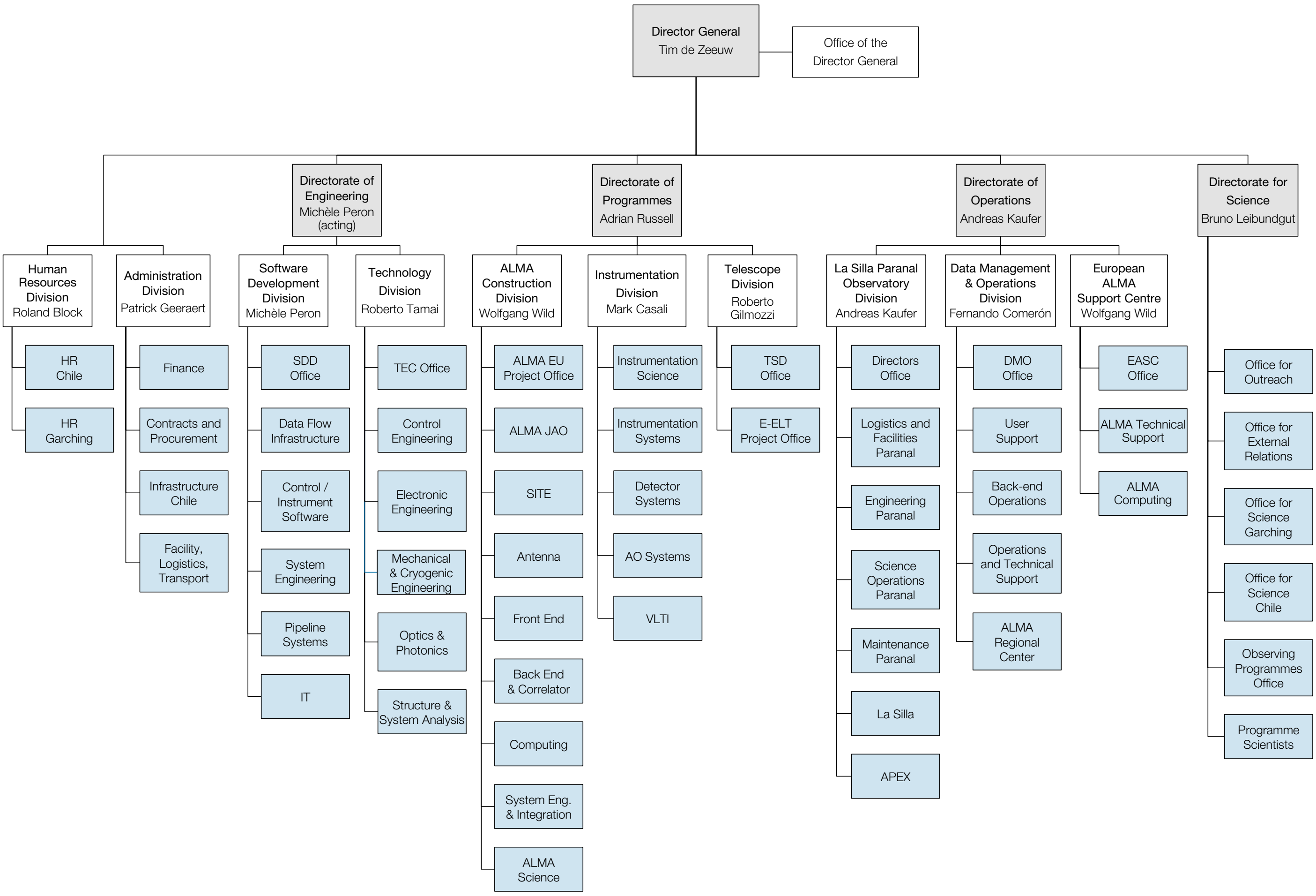
Dry and wet: views outside...
and inside the Paranal Residencia...

ESO/C. Malin (christophmalin.com)

ESO/Max Alexander

Organigram

As of 31 December 2011



Office of the Director General

The Chilean Minister of Foreign Affairs, Alfredo Moreno (right), and ESO Director General, Tim de Zeeuw (left), signing an agreement on 13 October 2011 regarding land for the European Extremely Large Telescope.

Legal Service

The mission of the Legal Service (LS) is to ensure, by providing legal counsel and participating in negotiations and proceedings, that ESO's administrative dealings are lawful.

The LS contributed to the preparation of Council and Finance Committee documents. It participated in meetings of the Council, Finance Committee, Tripartite Group, and the Working Groups on new Member States and on CERN Pension Fund matters. It assisted in the follow-up of issues concerning the ALMA Board, the ALMA Director's Council and the APEX Board (e.g., preparation of a *Nota Verbal* for the APEX extension and support in establishing principles for ALMA Operations concerning the ALMA Proposal Review Process and the ALMA Development Plan).

The LS had high-level interactions with Member States (e.g., agreement with Finland on early funding for the E-ELT) and with potential new Member States (e.g., preparation of draft accession agreements, participating in informal discussions and negotiations and providing all the information and documentation required). Moreover, the LS played a major role in the successful conclusion of an agreement with the United Kingdom concerning the delayed delivery of VISTA.

Much effort was devoted to the negotiation, drafting and successful conclusion of an agreement with Chile for the installation of the E-ELT on Cerro Armazones. In this context, agreements were drafted to be concluded with European and Chilean institutes operating telescopes nearby to assure that the area is fully available for the E-ELT. Furthermore, all legal aspects connected to the E-ELT, such as site protection issues, property right issues and aspects related to the interaction with the Chilean authorities were monitored by the LS.

The LS provided advice with regard to immunity issues and the legal status of all ESO sites in cases of illegal mining activities, water and geothermal matters. Environmental aspects, accidents and safety issues were also reviewed. Support was provided on agreements, *Nota Verbale* and interactions with Chilean national and local authorities.

On 3 June 2011 in Prague, the Director of the Department of International Cooperation in Research and Development of the Ministry of Education, Youth and Sports of the Czech Republic, Dr Jan Marek (seated, right) and the ESO Director General, Prof. Tim de Zeeuw (seated, left) signed an agreement committing the Czech Republic to provide its full share of the additional financial contribution required for construction of the European Extremely Large Telescope.

The LS assisted the ESO Administration in the update of provisions dealing with ESO's legal status in the General Conditions of Contracts and provided guidelines for negotiations with potential suppliers as well as assistance in the update of ESO safety documents. It contributed to the negotiation and conclusion of contracts as well as support in the settlement of contractual disputes. It also dealt with Chilean civil and labour lawsuits. It clarified the legal treatment of ESO's VAT exemption in Chile and the interpretation of Chilean legislation relevant to ESO activities. It provided legal assistance in the call for tenders for the construction of the Headquarters extension in Garching and the conclusion of a contract with the general contractor. It also contributed to the conclusion of an agreement with INAF concerning the loan and operation of the VST.

The LS also gave advice on human resource matters such as agreements for the secondment of personnel and the training of young graduates, and helped with the update of the Staff Rules and Regulations and the review of internal memoranda, administrative circulars, CERN Pension Fund matters, internal appeals and complaints in front of the Administrative Tribunal of the International Labour Organisation.

International Relations

Chile relations

ESO–Chile relations entered a new phase on 13 October with the signature by the Chilean Minister of Foreign Affairs, Alfredo Moreno and the ESO Director General of a new ESO–Chile Agreement concerning the E-ELT. This not only represents an important step towards the realisation of the E-ELT project, securing the location of Armazones for what will be the largest optical–infrared telescope in the world, but also establishes closer relations between Chile and ESO with respect to cooperation in science and technology. ESO received a large donation of land where the new telescope is to be built, together with a free of charge concession for the surrounding area in order to protect the observing conditions for astronomy around the Paranal Observatory.

The year has been marked by an impressive and serious demonstration of interest in the Observatories with visits at the highest levels. The many distinguished visitors included the President of the Czech Republic, HE Václav Klaus; their Royal Highnesses Prince Felipe and Princess Letizia of Asturias, accompanied by Ministers Alfredo Moreno and Catalina Parot from Chile; HRH Prince Philippe of Belgium; Guido Girardi and Juan Pablo Letelier, the President and Vice-President of the Chilean Senate; the Spanish Minister for Science, Dr Cristina Garmendia; a high level Austrian delegation led by Dr Barbara Weitgruber, the Director General for Research; Dr Babs van den Bergh of the Ministry of Education Culture and Research in The Netherlands; and the Vice President of the Chinese Academy of Sciences, Wenlong Zhan. Other visits included official delegations from Chile and ESO Member States, plus a considerable interest of the general public for the regular visits in weekends.

During the year, ESO was asked by the Government of Chile to be present at, or to contribute directly to the success of several important events. In particular, ESO played a significant role in an important conference in December organised by the President of the Senate and attended by the President of Chile. ESO prepared a display at the entrance of the conference building and, thanks to cooperation with amateur astronomers in Chile, offered the opportunity to observe the sky during the day and night. President Piñera eagerly took advantage of the occasion.

The Joint Committee continued its many years of support to astronomy in Chile. After an in-depth analysis of a large number of proposals, well exceeding the available resources, funding was allocated to meritorious projects in areas that develop research, new professors, extending scientific activities and public outreach. A similar exercise, managed by the Chilean commission CONICYT, resulted in the allocation of funds from the international ALMA partnership to promote astronomy in Chile.

ESO continued its annual cooperation with the town of Taltal through a scholarship programme for meritorious students and cooperations with the community of Séquitor and with Universidad Católica del Norte in Antofagasta.

In Santiago, ESO received recognition in the form of awards from the Vitacura Municipality as good and prominent neighbours and, most outstandingly, from the Chilean Association of Engineers for its engineering activities in Chile over the course of many years.

Further efforts were made in the area of outreach through the organisation of various meetings aimed at promoting the visibility of ESO and astronomy. These discussed the promotion of astronomical tourism in Region II in Chile, as well as in Santiago. To this end, funding is being sought for the installation of a visitor centre at Paranal.

External relations

In preparation for the construction phase of the E-ELT and in collaboration with the individual Industrial Liaison Officers of the Member States, a series of Industry Days was organised in order to introduce the E-ELT project to representatives of companies that might be interested in doing business with ESO. A team of experts made presentations covering a general introduction to ESO and more technical and specialised information on the E-ELT project, the ESO instrumentation programme, ESO technology development and needs, and ESO procurement. After the presentations, the industrial representatives had the opportunity for short face-to-face meetings with the ESO experts at which they could introduce themselves and their companies. By the end of the year, events had been held in ten of ESO's 14 Member States and Brazil (Austria, Belgium, Brazil, the Czech Republic, Denmark, Finland, the Netherlands, Portugal, Spain and the UK), with visits to the remaining countries expected in early 2012. In support of this initiative, a new ESO and Industry flyer was produced jointly with ePOD, as well as an information sheet on the industrial opportunities by sector that will arise from the E-ELT construction.

ESO has permanent observer status at the United Nations Committee on the Peaceful Uses of Outer Space, and is part of Action Team 14 which is responsible for preparing a comprehensive set of recommendations regarding detection, monitoring, and information and warning system as well as possible mitigation efforts, for dealing with the potential Near-Earth Object threat. ESO was able to offer expert advice to the technical discussions and make constructive suggestions regarding ground-based observations as part of the proposals.

ESO was represented at board level in various European network activities, including the Square Kilometer Array, OPTICON and ASPERA. As a member of EIROforum, ESO participated in the production of position papers on the development of the FP8 programme and the European Commission's consultation on the European Research Area by the EIROforum Coordination Group and Thematic Working Group on International Affairs.

On 24 November 2011 ESO's Paranal Observatory in Chile was honoured with a visit from Their Royal Highnesses the Prince and Princess of Asturias — the Spanish Crown Prince and Princess.

President Piñera observes the Moon with amateur telescopes provided by ESO. He is accompanied by the President of the Chilean Senate, Guido Girardi (left), the President of the Chilean House of Representatives, Patricio Melero (right), and the Vice-President of the Senate, Juan Pablo Letelier (centre).


ESO/José Francisco Salgado (josefrancisco.org)

The La Silla Observatory, prominently overlooking the landscape from the peak.

Committees

Council

As its ruling body, the ESO Council determines the policy of the organisation with regard to scientific, technical and administrative matters while delegating the day-to-day running to the Director General (DG). Council and the DG are assisted by the following Committees:

The Finance Committee (FC) is charged with the general responsibility of advising Council on all matters of administrative and financial management and of exercising, on behalf of Council, matters for which they have been delegated the requisite powers, including the award of major contracts.

The Scientific Technical Committee (STC) is established as an advisory committee on matters related to the planning and operation of ESO and advises Council and the DG on policy matters of scientific importance and priorities.

The Users Committee (UC) is made up of representatives of ESO users from each Member State and advises the DG on matters concerning the use of ESO facilities (telescopes, instruments, computers, etc.).

The Observing Programmes Committee (OPC) reviews and ranks all observing proposals and provides a recommendation for the distribution of observing time to the DG. The OPC is organised in topical panels by scientific categories.

Hoisting the ESO flag at ESO's Headquarters, next to the flags of the organisation's Member States.

As its ruling body, the ESO Council determines the policy of the organisation with regard to scientific, technical and administrative matters while delegating the day-to-day running of the Organisation to the Director General. Both the Council and the Committee of Council (the informal body of Council) normally meet twice during the year and each Council meeting includes an update on all aspects of ESO's programme. However, as had happened in 2010, there were a number of important issues for which Council's approval was sought and accordingly there were two additional extraordinary Council meetings held during the year. All meetings were located in Garching, with ordinary meetings taking place on 7–8 June and 7–8 December. Extraordinary meetings were held on 2 March and 6 October, in conjunction with the Committee of Council meetings (1–2 March and 5–6 October). All meetings were chaired by the President of Council, Dr Laurent Vigroux.

At the June meeting, Council approved an extension of the Director General's contract to 31 August 2017. A range of topics was reviewed, resulting in the delegates unanimously authorising the Director General to sign an agreement with the University of Geneva on behalf of the ESPRESSO consortium for the construction and delivery of the ESPRESSO instrument for the VLT, agreeing to establish a working group consisting of Council delegates and ESO representatives to discuss the policy of the accession of new Member States, and approving the External Audit Report 2010 while granting discharge to the Director General for the year 2010. Much discussion also took place with regard to the way ahead for the E-ELT and the envisaged ESO Long-term Perspectives. On a personal note, it was with sadness that delegates bid farewell to Mr Henrik Grage who was retiring after over 40 years in attendance at Council and FC meetings.

For the extraordinary meeting in October, much discussion again centred on the E-ELT proposal. Council delegates unanimously authorised the Director General to sign the Spanish text of the draft Agreement with the Government of Chile concerning the establishment of the

Council and Committee of Council 2011

President	Laurent Vigroux (France)
Austria	Sabine Schindler Daniel Weselka
Belgium	Christoffel Waelkens Sophie Pireaux
Czech Republic	Jan Palouš Jana Bystřická
Denmark	Uffe Jørgensen Henrik Grage/Peter Sloth
Finland	Jari Kotilainen Pentti Pulkkinen
France	Jean-Marie Hameury Grégoire Fauquier
Germany	Thomas Henning Andreas Drechsler/ Thomas Roth
Italy	Matteo Pardo Bruno Marano
The Netherlands	Konrad Kuijken Jan van de Donk
Portugal	Teresa Lago Fernando Bello
Spain	Xavier Barcons (Vice President) Jordi Torra/Rafael Bachiller
Sweden	Claes Fransson David Edvardsson
Switzerland	Georges Meylan Martin Steinacher
United Kingdom	John Womersley Patrick Roche

E-ELT and they also approved the document "ESO Council Resolution on Funding Principles for the E-ELT Construction Proposal" for the construction phase of the project.

During the final meeting of the year in December, Council unanimously agreed to authorise the Director General to sign a Memorandum of Understanding with the Instituto de Astrofisica de Canarias (IAC, Spain) and the Universidade Federal do Rio Grande de Norte (UFRN, Brazil) for the acquisition of a laser frequency comb for the HARPS instrument. Also approved, as proposed by the Finance Committee, were the recommendations concerning the financing of the E-ELT and the amended Staff Regulations. Elections took place for the appointment of personnel to the various ESO Committees including the ALMA Board, the ALMA Science Advisory Committee, FC, OPC, STC, the New Member State Working Group and the Tripartite Group. Not least was the unanimous appointment of Prof. Xavier Barcons as the new Council President and Dr Martin Steinacher as the Vice President. The outgoing President, Dr Laurent Vigroux, was warmly thanked by all Council delegates who expressed their gratitude for his dedicated and effective leadership of Council over the past three years.

Just before the June meeting, the Danish Council member Jens-Viggo Clausen passed away. His place on Council has been taken by Uffe Gråe Jørgensen.

Group photo on the occasion of the ESO Council's 122nd Meeting, held at ESO Headquarters in Garching on 7–8 June 2011. Sixth person from the right is Mr Henrik Grage who retired after over 40 years in attendance at Council and FC meetings.

Finance Committee

Finance Committee 2011	
Chair	Johan Holmberg (Sweden)
Austria	Daniel Weselka
Belgium	Robert Renier
Czech Republic	Věra Zázvorková
Denmark	Cecilie Tornøe (Vice-chair)
Finland	Jaana Aalto
France	Patricia Laplaud
Germany	Gisela Schmitz-DuMont
Italy	Germana Di Domenico
The Netherlands	Coen van Riel (May) Mirjam Lieshout-Vijverberg (November)
Portugal	Fernando Bello
Spain	Luis Ruiz López
Sweden	Tobias Hellblom
Switzerland	Astrid Vassella
United Kingdom	Colin Vincent

The Finance Committee held two ordinary meetings and one extraordinary meeting this year, all chaired by Mr Johan Holmberg. The extraordinary meeting in September focused on E-ELT matters. At the end of the year, the Finance Committee and Council adopted a resolution on the funding principles for the E-ELT construction. The Finance Committee recommended the budget for the year 2012 to Council for approval. It also dealt with further financial issues such as the annual accounts, the external audit report, the cashflow situation, financial statements and Member State contributions.

The Committee established a working group to reflect on future arrangements for the calculation of the scale of Member State contributions to decrease the sometimes sharp variations.

Attention was given to the confidential Procurement Audit Report. Its findings were taken into account in the updated ESO Procurement and Sales Procedures.

The Committee approved the award of eight contracts exceeding € 500 000, four single-source procurements exceeding € 250 000 and twelve amendments to existing contracts. One contract was approved by written procedure. Information concerning procurement statistics, forthcoming calls for tender and price enquiries exceeding € 150 000 was received. The Finance Committee appreciated the document on procurement statistics and industrial return coefficients in an extended form with tables and diagrams based on payments, in addition to the commitment-based data.

General personnel topics concerning international and local staff as well as CERN Pension Fund matters were discussed by the Committee.

As the Sun sets over Cerro Armazones, plans are well advanced for building the world's biggest eye on the sky: ESO's European Extremely Large Telescope. With a primary mirror 39.3 metres in diameter, the E-ELT will dwarf all existing visible-light telescopes.

ESO/S. Brunier

Scientific Technical Committee

The Scientific Technical Committee 2011

Austria	Josef Hron (ESE)
Belgium	Joris Blommaert (ESE)
Czech Republic	Michael Prouza (LSP)
Denmark	Johan Fynbo (LSP)
Finland	Lauri Haikala (ESAC)
France	Yannick Mellier (LSP Chair)
Germany	Tom Herbst (ESE Chair)
Italy	Alessandro Marconi (STC Vice-chair, LSP)
The Netherlands	Marco de Vos (LSP)
Portugal	José Afonso (ESAC)
Spain	Santiago Arribas Mocoroa
Sweden	Göran Olofsson (ESE)
Switzerland	Didier Queloz (ESE)
United Kingdom	Rob Ivison (ESAC)
Chile	Leonardo Bronfman

Members at Large

Willy Benz (STC Chair)
David Crampton (ESE)
Elaine Sadler (ESAC)
Linda Tacconi (ESAC Chair)

The STC had two regular meetings and an extraordinary meeting convened to provide a recommendation to Council about the redesigned E-ELT project. The STC subcommittees met regularly before the STC to discuss several of the topics in more detail, leading to recommendations by the STC itself.

75th STC meeting

The STC met for its 75th meeting from 12–14 April in Garching. An extra half day was added for an extended closed session. The E-ELT Science and Engineering (ESE) subcommittees had met on 22 and 23 March, while the La Silla Paranal (LSP) and the ALMA European Science Advisory Committee were convened during the days before the STC. The main topics of the meeting were discussions of the draft of the Long-term Perspectives of ESO document, the VLTI implementation plan, the near future of adaptive optics at the VLT, the selection of the Phase A studies of wide-field spectrographs for ESO telescopes, and the E-ELT design and instrument complement.

STC was presented with a draft Long-term Perspectives document outlining the planned evolution of ESO's programmes over the construction period of the E-ELT. The STC endorsed the overall balance of the plan and was pleased to see a continuing budget line for VLT upgrades and new instrumentation that was consistent with science capabilities remaining as the highest priority.

The STC discussed the VLTI implementation plan that maps a way forward for the infrastructure and defines the priorities. It was pleased that the plan allowed progress to be tracked and facilitated the early identification of potential problems. The STC recommended that the plan be implemented in full in order to maintain coherence within the VLTI programme.

STC stressed the scientific importance of keeping near-infrared diffraction-limited imaging capabilities at the VLT despite the planned decommissioning of NACO. The possible solutions were discussed at length and the STC was of the opinion that ESO was on the right track and commended the efforts being made to ensure a NACO-like capability in the mid-term and to keep ESO competitive in high angular resolution astronomy in the long term.

Removing another instrument to maintain NACO was considered and the STC stated that this required careful planning in order to minimise overall science

G. Blanchard(eso.org/~gblancha)/ESO

ESO optician Guillaume Blanchard captured this marvellous wide-angle photo of "Christmas Comet" Lovejoy on 22 December 2011. After passing a mere 140 000 kilometres from the Sun's surface Comet Lovejoy was the talk of the amateur astronomy community over Christmas 2011.

losses. In this respect, a number of possible options were addressed, but it was considered too early to take a decision.

STC requested ESO to look further into the question of an alternate focus for NACO and the consequences of taking any given instrument down while firming up its adaptive optics plan.

STC noted the developments in the down-selection process for a wide-field spectrograph. It appreciated the open process through which progress was achieved and looked forward to further discussion of the instruments under study.

Concerning the E-ELT, the STC was pleased by the progress made but was not able to comment on the changes in the design study as this was still too early. The STC emphasised that a clarification of the further selection of the instrument complement of the E-ELT beyond first light should be developed in due time.

The STC congratulated the ALMA team for the overall progress in construction and received a presentation on Early Science and the planning of the Cycle 0 call for proposals. It was concerned about the possible single-point failure of the ALMA archive and stressed that all necessary resources should be devoted to ensure a reliable and robust system for the call.

76th STC extraordinary meeting

An extraordinary STC meeting lasting one day was organised on 23 September preceded by an ESE meeting on 22 September. The topic was the discussion and assessment of the re-baselined E-ELT telescope design and instrumentation roadmap. The STC was convinced that the new design could achieve all major scientific goals envisaged for the E-ELT, albeit over a longer time scale and with reduced signal in some cases.

All science cases suffer from the reduction in telescope diameter. In many cases, longer integrations can make up for the loss in collecting area. The STC considered the new telescope baseline as leading only to an overall loss of efficiency. In the exoplanet case, the new baseline telescope leads to a significant decrease in the number of potential targets. The STC did point out that the E-ELT will be the only facility worldwide able to reach this science goal. Even a potentially small number of targets will allow for unique and ground-breaking science to be carried out with a cultural impact far beyond the scientific community. Any further reduction in the E-ELT diameter will definitively result in the loss of the remaining targets. The STC strongly recommended against any further reduction in the size of the telescope.

The STC reaffirmed the scientific interest of the two foreseen first light instruments and supported the selection, on an equal scientific footing, of the high-resolution spectrograph (HIRES), the thermal-infrared instrument (MIR), and a multi-object spectrograph (MOS) as the subsequent set of capabilities to be implemented. The STC was of the opinion that the activities described in the roadmap should start for all three instrument capabilities as soon as possible. For HIRES and MOS, these activities will provide an opportunity for the community to further define the desired instrument requirements.

77th STC meeting

On 18 and 19 October the STC met in Garching. The ESAC had met on 22 September, while the LSP Committee convened on 11 October. The ESE had already met in connection with the extraordinary STC the month before. Reports on those subcommittee meetings were presented at the STC. The STC discussed the draft budget of ESO and noted that the budget overall is tight, but still allows ESO to maintain its preeminent position in ground-based astronomy even during the construction period of the E-ELT.

The implementation of a laser frequency comb as calibration of the HARPS instrument was discussed extensively. The extension of the science case in advance of ESPRESSO was highly appreciated. The STC recommended that the HARPS LFC should not interfere with the development of ESPRESSO nor delay the schedule of ESPRESSO. The development of the HARPS LFC can be used to improve the readiness of ESPRESSO.

An extensive discussion on planning the adaptive optics instrumentation took place. The STC took note of ESO's plan to follow a two-pronged strategy by developing a new adaptive optics module together with a camera to complement SINFONI and a new adaptive optics instrument for the mid-term future. The STC re-iterated that ESO should seek a scientifically optimal solution with the aid of an appropriate panel of experts, in case NACO needs to be moved to a new focus.

The progress on the wide-field spectrographs was presented. The STC recommended that the decision process should be based primarily on the science cases and technical feasibility regardless of the telescope on which the instrument will be mounted.

The report from the OPC working group was presented to the STC. The STC supported ESO's effort to implement the best possible selection process ensuring a fair and efficient proposal submission and selection process.

The STC was very pleased by the progress of ALMA. For a sustainable operation and to retain the required expertise and knowledge, it recommended that ESO work with its partners to ensure the retention of key staff and to improve staff morale.

Observing Programmes Committee

The Observing Programmes Committee 2011

Michael Rowan-Robinson (Chair)

Narciso Benitez (P88 member at large)
Giuseppe Bono (P89)
Alain Chelli (P88 member at large)
Romano Corradi (P89 member at large)
Sofia Feltzing (P89)
Annette Ferguson
Laura Ferrarese (P89)
Eileen Friel (P88)
Asuncion Fuente (P88 member at large)
Petr Hadrava (P89 member at large)
Guillaume Hebrard
Wolfgang Hillebrandt
Leslie Hunt
Emmanuel Jehin
Hans Kjeldsen (P88)
Jean-Paul Kneib
Rolf Kudritzki
Gwendolin Meeus (P89 member at large)
Dante Minniti
Jean-Louis Monin (Vice-Chair)
Neil Nagar (P88)
Patrick Petitjean
Bianca Poggianti
Sandra Savaglio (P89)
Daniel Schaerer (P89 member at large)
Regina Schulte-Ladbeck (P88)
Ian Smail (P89 member at large)
Mathias Steinmetz (P88)
Massimo Turatto (P89 member at large)
Paul van der Werf (P89)
Glenn White (P88 member at large)

During its meetings in May and November, the Observing Programmes Committee evaluated the proposals submitted for observations to be executed in Periods 88 (P88; 1 October 2011 to 31 March 2012) and 89 (P89; 1 April 2012 to 30 September 2012). The numbers of proposals for observation with the ESO telescopes in these two periods were 1010 and 969. In the same period, ESO also received fifteen large programme proposals for time on the GTC within the framework of the accession agreement of Spain into ESO. In addition, a delta-call was issued in P88 for the VST–OmegaCAM guaranteed time allocation and fifteen proposals were received. During the P88 meeting, the OPC also reviewed two proposals invited by ESO for Public Spectroscopic Surveys (see below).

The distribution of proposals across the different scientific areas remained similar to recent periods. There were again about twice as many proposals for galactic scientific projects, pertaining to OPC categories C (interstellar medium, star formation and planetary systems) and D (stellar evolution), as for extragalactic topics, which comprise categories A (cosmology) and B (galaxies and galactic nuclei). The OPC categories are specified in full at www.eso.org/sci/observing/proposals/opc-categories.html.

As in previous periods, FORS2, which is mounted on Antu (Unit Telescope 1 of the VLT, or UT1), remained the VLT instrument on which the largest amount of observing time was requested (683 nights), ahead of X-shooter (410 nights) on Kueyen (UT2). Kueyen was again the most popular UT, with a ratio between the requested and the available time, or pressure, of almost 4.5, while the pressure on the other UTs was close to 3. The possibility of installing a visitor instrument at the VLT Interferometer has generated considerable interest in the community. Between P88 and P89, proposals requesting a total number of 85 VLTI nights were submitted for PIONIER, a near-infrared interferometric visitor instrument designed for imaging and fed by four telescope beams. These proposals were allocated 32 nights. The OPC reviewed 33 open-time proposals for the VISTA survey telescope, of which 12 were scheduled.

On La Silla, HARPS and EFOSC2 remained in high demand.

Within the framework of the continuing agreement between ESO and ESA for a joint telescope time allocation scheme for coordinated observations with the VLT and XMM-Newton, proposals for such observations were invited again, for the eighth time. ESO received one joint application in P89, which qualified for allocation of telescope time. Time at both facilities was granted to two joint proposals evaluated by the XMM–Newton Observing Time Allocation Committee.

Targets of Opportunity

Despite the stricter criteria applied to Target of Opportunity (ToO) programmes from Period 86, the number of ToO proposals submitted in 2011 remained similar to previous years. For P88 and P89 respectively, the OPC evaluated 46 and 43 proposals, of which 19 and 24 were scheduled, for a total of about 520 hours. FORS2 is the most demanded instrument for ToO observations (about 370 requested hours), followed by X-shooter and UVES. These three instruments were allocated 73 % of the ToO time.

Calibration Programmes

Calibration Programmes (CP) are meant to allow users to complement the existing coverage of the calibration of ESO instruments. The main evaluation criterion is the comparison of the potential enhancement of the outcome of future science that can be expected from their execution with the immediate return of current period science proposals directly competing for the same resources. Two CPs were accepted in P88 from two submitted and four in P89 from the six submissions.

Large Programmes

Large Programmes (LP) are projects requiring a minimum of 100 hours of observing time that have the potential to lead to a major advance or breakthrough in the relevant field of study. LP execution is spread over several observing periods with a maximum duration of four years for observations to be carried out with the La Silla telescopes and of two years on the VLT/I and on APEX. A total of 36 LP proposals were received this year: 17 in P88 and 19 in P89. Following the OPC recommendations, three new LPs were implemented in P88, and five in P89. The trend towards using a large fraction of the science time on the La Silla telescopes for the execution of LPs, encouraged by ESO and already embraced by the community in recent years, has continued. Eight current LPs were scheduled on the 3.6-metre telescope in P89, receiving a total allocation of 114 nights (66 % of the science time). At the NTT during the same period, seven LPs were underway, totaling 71 nights of observing time.

ESO/GTC programmes

The third and fourth calls for ESO/GTC proposals were issued along with the P88 and P89 calls for proposals for observations with ESO telescopes. They invited principal investigators from ESO Member States to submit LP proposals to take up the observing time offered on the GTC within the framework of the accession agreement of Spain into ESO. Two members-at-large appointed by Spain assisted the OPC in evaluating the proposals. Notwithstanding this difference, the OPC handled the ESO/GTC proposals in the same way as regular ESO LPs. In a second step, the ESO–Spain Liaison Committee reviewed the proposals deemed suitable for implementation by the OPC by considering the relevant technical and operational constraints. As an outcome of this process, ESO/GTC time was allocated to two programmes.

Public Spectroscopic Surveys

Following the recommendations of the OPC, the Director General has approved two Public Spectroscopic Surveys (PSS): one at the VLT (UT2/FLAMES), and one at the NTT (EFOSC2-SOFI). The two PSS have been allocated 60 and 90 nights per year, respectively. More details on the surveys can be found at http://www.eso.org/sci/observing/policies/PublicSurveys.

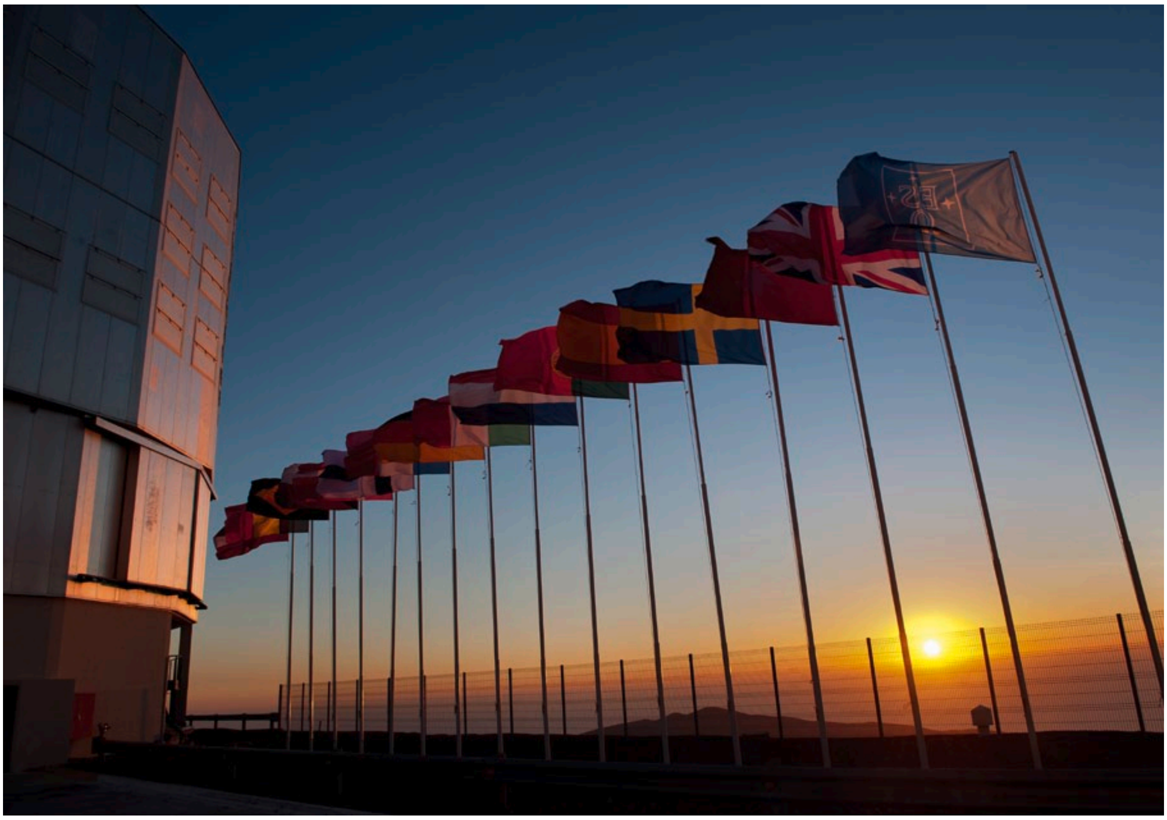
OPC procedures

The OPC Working Group, created by the Director General in 2009 with the mission to evaluate the current ESO proposal selection process and to study possible improvements, has delivered an extensive report to ESO. The Observatory is now studying the possible implementation of the various recommendations contained in the report.

Director's Discretionary Time

Proposals requesting Director's Discretionary Time (DDT) may be submitted throughout the year for programmes that present a level of urgency incompatible with the regular proposal cycles handled by the OPC. In 2011 the ESO user community submitted 113 DDT proposals. After taking advice from an internal committee comprising ESO staff astronomers, the Director General approved for implementation 58 DDT proposals. The total amount of requested DDT time was about 500 hours.

ESO/Max Alexander



Autumn sunset at Paranal in March.

ALMA Program Review Committee

The ALMA Program Review Committee (PRC) met in Chile in August 2011 to review the 919 proposals submitted in response to the ALMA Early Science Cycle 0 call for proposals. The PRC, chaired by Neal Evans, ranked all proposals based on the assessment of the scientific value alone. The ranked list of proposals was then split by regions and the highest priority projects were chosen from the lists to fill the share of ALMA time for each partner. The list of 112 highest ranked proposals included 35 proposals with PIs from the ESO Member States.

ALMA(ESO/NAOJ/NRAO), Ítalo Lemus(ALMA)

ALMA Cycle 0 science assessors in Vitacura, Chile, at the entrance to the ALMA Santiago Central Office building.

The ALMA Program Review Committee for Early Science Cycle 0

Neal Evans (Chair)	The University of Texas at Austin (US)
Yuri Aikawa	Kobe University (Japan)
Rachel Akeson	California Institute of Technology (US)
Andrew Baker	Rutgers, The State University of New Jersey (US)
John Bally	University of Colorado at Boulder (US)
Beatriz Barbuy	University of Sao Paulo (Brasil)
Maite Beltran	Arcetri Astrophysical Observatory (Italy)
Jacqueline Bergeron	Institut d'Astrophysique de Paris (France)
Andrew Blain	University of Leicester (UK)
Dominique Bockelée-Morvan	Paris Observatory (France)
Leonardo Bronfman	University of Chile (Chile)
John Carpenter	California Institute of Technology (US)
Cecilia Ceccarelli	Grenoble Observatory (France)
Jose Cernicharo	Centro de Astrobiología (Spain)
Tracy Clarke	Naval Research Laboratory (US)
Françoise Combes	Paris Observatory (France) – Vice-Chair
Leen Decin	Catholic University of Leuven (Belgium)
Jayanne English	University of Manitoba (Canada)
Asunción Fuente	National Astronomical Observatory (Spain)
Yasuo Fukui	Nagoya University (Japan)
Gaspar Galaz	Pontificia Universidad Católica de Chile (Chile)
Guido Garay	University of Chile (Chile)
Jorma Harju	Helsinki University (Finland)
Naomi Hirano	Academia Sinica Institute of Astronomy and Astrophysics (Taiwan)
Leslie Hunt	Arcetri Astrophysical Observatory (Italy)
Frank Israel	Leiden University (The Netherlands)
Rob Ivison	Royal Observatory, Edinburgh (UK)
Hiroshi Karoji	The University of Tokyo (Japan)
Ryohei Kawabe	National Astronomical Observatory of Japan
Paulina Lira	University of Chile (Chile)
Dariusz Lis	California Institute of Technology (US)
Dieter Lutz	Max-Planck-Institute for Extraterrestrial Physics (Germany)
Tom Millar	Queen's University Belfast (UK)
Akira Mizuno	Nagoya University (Japan)
Raffaella Morganti	Netherlands Institute for Radio Astronomy (The Netherlands)
Neil Nagar	University of Concepción (Chile)
Sadanori Okamura	The University of Tokyo (Japan)
Hans Olofsson	Chalmers University of Technology (Sweden)
Takashi Onaka	The University of Tokyo (Japan)
Ilaria Pascucci	University of Arizona (US)
Alexandra Pope	University of Massachusetts at Amherst (US)
Luis Felipe Rodriguez	National Autonomous University of Mexico
Dave Sanders	University of Hawaii at Manoa (US)
Nick Scoville	California Institute of Technology (US)
Debra Shepherd	National Radio Astronomy Observatory, Socorro, NM (US)
Lister Staveley-Smith	International Centre for Radio Astronomy Research (Australia)
Yoshiaki Taniguchi	Ehime University (Japan)
Masato Tsuboi	Institute of Space and Astronautical Science (Japan)
Dave Wilner	Harvard-Smithsonian Center for Astrophysics (US)
Christine Wilson	McMaster University (Canada)

Users Committee

The Users Committee 2011	
Austria	Werner Zeilinger (Chair)
Belgium	Martin Groenewegen
Czech Republic	Jiří Grygar
Denmark	Frank Grundahl
Finland	Seppo Katajainen
France	Mathieu Puech (Replacement for Vanessa Hill)
Germany	Thomas Preibisch
Italy	Stefano Benetti
The Netherlands	Scott Trager (Vice-chair)
Portugal	Nanda Kumar
Spain	Lourdes Verdes-Montenegro
Sweden	Nils Ryde
Switzerland	Hans Martin Schmid
United Kingdom	Gary Fuller
Chile	Manuela Zoccali (Excused)

The annual meeting of the Users Committee took place at ESO Headquarters in Garching on 14 and 15 April and was organised by the User Support Department within the Operations Directorate. This is an important forum where updates from ESO and feedback from the users' community are exchanged and openly discussed.

After a series of presentations given by representatives of different ESO operational groups, covering the main ESO achievements in operating its facilities, the UC Chair Prof. Zeilinger (Austria) reported on the main points discussed at the UC/OPC/OPO liaison meeting. The topics discussed were OPC feedback, the Phase 1 ESOform package and the difficulties in finding enough astronomers willing to serve on the OPC. The first two items are not really new issues and concern OPC feedback being too generic and the known limitations of the current Phase 1 submission process. The third topic addressed the difficulties faced by the OPC Chair in finding enough astronomers willing to serve on the OPC for Period 88. No unique solution could be found for this, other than proposing a common effort to sensitise the community to the importance of this commitment. In this respect, Werner Zeilinger reported that, as a follow-up action, the 2011 UC Users' Poll included a specific question about willingness to serve on the OPC. The response was encouraging, and he hoped that this would help alleviate the problem.

The second part of the morning was dedicated to the feedback received from each Member State and to an open discussion of some specific topics: NACO's forthcoming decommissioning and its consequences, ESO's Long-term Perspectives, over-pressure on the Kueyen telescope and the ESO Public Spectroscopic Surveys with special emphasis on those that had requested VIMOS.

As usual, the second day started with a Special Topic session that this year was dedicated to APEX operations. After an introduction from ESO, providing a detailed overview of how the APEX facility is being operated, two special guests (i.e., frequent users) were invited to present their views on APEX from an astronomer/user point of view (Prof. Maiolino and Dr Albrecht). The feedback they provided was positive overall and the discussion that followed touched upon all aspects relating to APEX observations.

Finally, on both days some time was reserved to discuss old and new recommendations, always with the final goal of improving ESO services and communications.

The ESO Users Committee meeting which took place at ESO Headquarters on 15 April 2011.

ESO/INAF-VST/OmegaCAM. Acknowledgement: OmegaCen/Astro-WISE/Kapteyn Institute

The first released VST image shows the spectacular star-forming region Messier 17, also known as the Omega Nebula or the Swan Nebula, as it has never been seen before. This vast region of gas, dust and hot young stars lies in the heart of the Milky Way in the constellation of Sagittarius (The Archer).

Outreach

Expanding the reach

In our fast-paced information society with its incredible quantity of available material, outreach has changed along with the way we experience information. A proliferation of communication channels such as those provided by phone and tablet Apps, video podcasts, blogs or social media platforms like Twitter, Facebook, Flickr, Google+, Pinterest etc., allow individuals to share information as never before. Under these challenging communication conditions, ePOD has managed to keep its number of website visitors constant, while expanding in other areas as a result of following the target groups into their own territory. To a significant degree, individuals have moved from traditional mass media channels, and even from traditional websites, towards creating their own communication channels, content and communities.

Almost half of the end-users are now being reached via other platforms than the ESO website: iPad App users, video podcast subscribers, Facebook fans, Twitter followers, Youtube and Vimeo viewers and Flickr friends among others. Only the frontline impact can be measured directly, but this is multiplied via third parties as information travels across online communities. As an example, thanks to an open licensing model the ESO podcasts are shared on many other YouTube channels, where they regularly receive dozens or even hundreds of thousands of views per video.

In addition to the online presence, ePOD has invested in improving its promotion of the organisation and distribution of its products by creating an online, multi-user database of contacts to increase its electronic and physical distribution lists. An array of new e-mail newsletters connected with a direct mailing system was set up to inform the media, educators, and the general public about ESO's activities and products. The number of subscribers went up to almost 15 000 during the year. All print products and merchandise are now proactively distributed, the moment they arrive, to the most relevant target groups. Print loss has been reduced as print volumes are carefully tuned to distribution plans. Also the number of media visits has gone up dramatically — almost three times as many as last year.

Faced with an empowering communication model where individuals no longer consume information passively, but actively contribute to creating it mainly via social media, ePOD has moved into the territory of the target groups, creating communities by giving them the raw material to experience, co-create and spread, thus expanding the reach.

Press activities

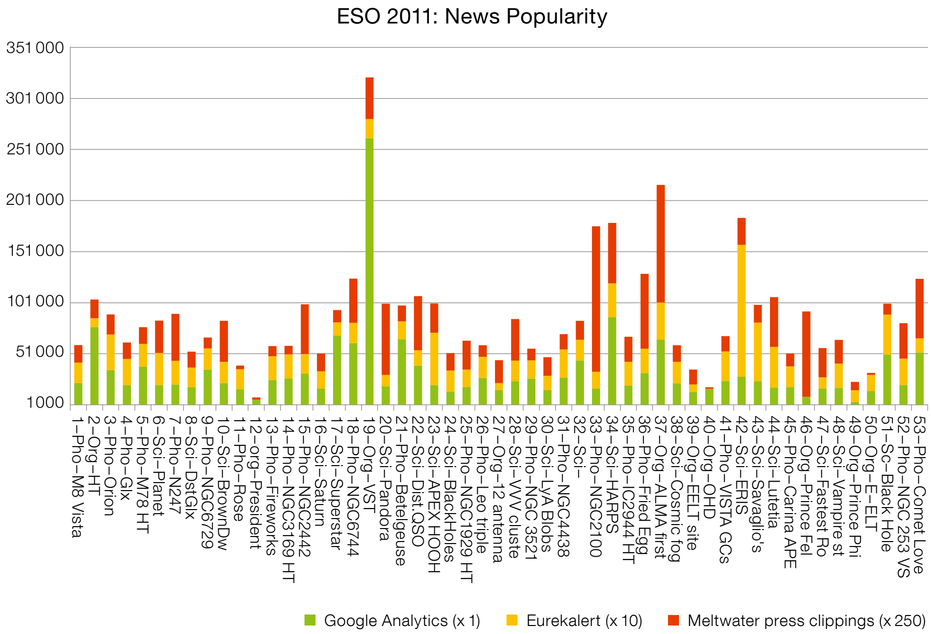
ePOD published 53 press releases for ESO (up 6 % from 2010), and 23 press releases for ESA/Hubble and the International Astronomical Union combined (ESO is running both press offices on a contractual basis). ESO issued 89 announcements (down 13 %).

An ESO Picture of the Week was issued for each week of the entire year, providing a continuous flow of pleasing images and a channel to report on news and developments that are not necessarily front-page news. ePOD also organised two press conferences, discussing major HARPS exoplanet findings and the start of the ALMA Cycle 0 operations.

A media poll to survey the opinion of media representatives and other public information officers on ESO'S media relations was carried out and the interesting results implemented in the workflows.

Astronomical images continue to be one of the most effective assets in astronomy education and public outreach; as an aesthetic connection between humankind and the Universe, they also provide a visual proxy for scientific progress (despite the progress itself often being made with spectroscopic observations).

In order to increase the visibility of ESO via the production of a steady stream of top quality of outreach images, the ESO Science Archive has been extensively searched for suitable data, which have been processed and assembled, amounting to about 100 released images



Popularity of 2011 press releases, for eso.org. The press releases are identified by their release number. Google Analytics measures the number of visitors to the news release web page. Eurekalert counts how many journalists followed the news release link on the Eurekalert website (a news concentration and distribution site for journalists). Meltwater is an electronic press clippings service; the metric being the number of online newspaper articles about the news release. These three metrics have widely different values and have been scaled to the range of Google Analytics values. The most popular release of 2011 was the "First Images from the VLT Survey Telescope".

This striking image, taken with the FORS2 instrument on the Very Large Telescope as part of the ESO Cosmic Gems programme, shows a beautiful yet peculiar pair of galaxies, NGC 4438 and NGC 4435, nicknamed The Eyes. The larger of these, NGC 4438, is thought to have once been a spiral galaxy that was strongly deformed by collisions in the relatively recent past. The two galaxies belong to the Virgo Cluster and are about 50 million light-years away.

The new La Silla Visitors Centre (artist's impression).

— many of which are now in ESO's Top 100 list. Despite applying various creative search mechanisms, and even crowdsourcing in the form of the ESO Hidden Treasures competition in 2010, this source has now been exhausted.

A new programme called ESO Cosmic Gems aims to provide spectacular ESO colour images for public release, outreach and education by acquiring new data in conditions where science observations would otherwise not be possible. This programme is inspired by the very successful Heritage programme on the Hubble Space Telescope.

Publications

The production of print products and merchandise this year again increased significantly with 35 % more products from 2010 to 2011. This included several different types of merchandise branded with the ESO 50th anniversary logo.

Audiovisuals

Fourteen episodes of the ESOcast video podcast and four video news releases were published during the year.

The number of images in the online image archive grew from 4264 to 5042 (up 18 %). The number of videos in the online video archive grew from 1260 to 1410 (up 12 %).

A system for crowdsourcing translated subtitles for ESOcast episodes and making them available on www.eso.org and through iTunes was set up. Volunteer translators provide translations in advance of the release of new episodes.

Photographs were taken for a variety of events and occasions such as conferences and meetings, and staff photos were taken for the kiosk display in the lobby area at ESO Headquarters, Garching.

The large effort of scanning images from the ESO historical picture archive has nearly been concluded and many of the images uploaded online.

Events and exhibitions

ESO was present at 47 exhibitions this year (down 24 %). In many cases the exhibitions were carried out in partnership with local organisers to reduce the load on ESO's resources.

Nine permanent exhibitions continued to draw crowds. The ninth permanent exhibition which opened in 2011 was at the La Silla Visitors Centre in the former Ritz building at La Silla.

A handful of unconventional visits to the sites helped sharing ESO with new audiences: the launch of a luxury IWC watch, and two car commercials — Land Rover and BMW.

Support for the ESO Open House Day 2011 was provided in the form of project coordination, printing tasks, panels and exhibitions, talks, videos and an event to promote the E-ELT — building a full-sized mirror out of cardboard hexagons.

Planning for ESO's 50th anniversary outreach activities continued in the run up to the year 2012.

ESO/Land Rover

Georg Fischer

Two car commercials using the scenery at Paranal: Land Rover's Range Rover and BMW's 6 Series Gran Coupé (including clouds and other components "imported" digitally from a photo taken in Los Angeles).

Web and software development

Significant progress was made with the ePOD web software and hardware infrastructure in order to sustain the pressure of the many users and large downloads. Several new archives such as stars@eso, New on eso.org, Special Events, Exhibitions, Press events and more were added.

The three iPad/iPhone Apps had more than a quarter of a million installs in total.

All ESO images were tagged with contextual metadata and a smaller portion of them now also have sky coordinates. The project to add coordinates to the images will continue in 2012.

Three information kiosks were set up in the reception of the ESO Headquarters together with a large cabinet offering print products to visitors and staff.
This project will be rolled out at the other ESO sites in 2012 and 2013.

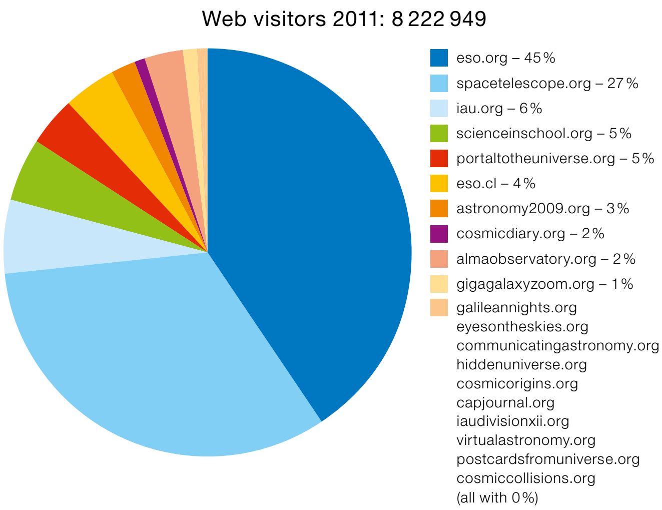
Additional activities in Chile

In collaboration with Representation and Operations in Chile, 951 media and VIP visits were handled at the sites (up 170 %) and 7528 weekend visitors to La Silla and Paranal (down 16 %). The former represents a substantial increase, due to a higher level of media interest in ESO and improved workflows allowing the higher activity level. The local Chilean media coverage of ESO's activities continues to be at a very high level.

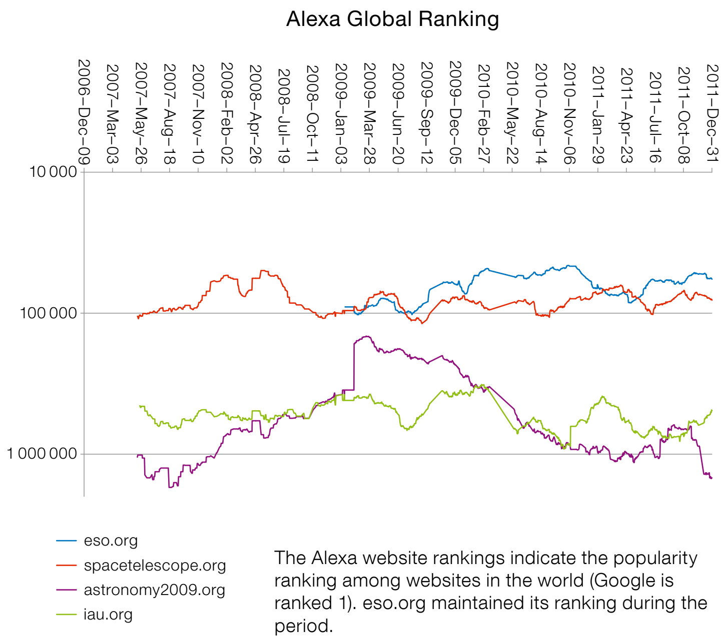
ESO Science Outreach Network

The ESO Science Outreach Network (ESON) added five new countries: Albania, Brazil, Cyprus, Russia and

On Saturday, 15 October, the European Southern Observatory opened the doors of its headquarters in Garching bei München, Bavaria, Germany, to the public. Throughout the day, thousands of visitors had the chance to help build a full-size mock-up mirror of the largest planned telescope in the world — the European Extremely Large Telescope — and to experience many other aspects of ESO's work.



The number of visits on eso.org has been maintained at 3.4 million this year, while expanding in other areas. Almost half of our end users are being reached on other platforms than our website: iPad App users, video podcast subscribers, Facebook fans, Twitter followers, Youtube and Vimeo viewers, Flickr friends etc.



The Alexa website rankings indicate the popularity ranking among websites in the world (Google is ranked 1). eso.org maintained its ranking during the period.

Ukraine. In total 17 different languages and 29 different mini-sites with information are offered. In addition a special "translation" for kids called Space Scoop was added in several languages in a fruitful collaboration with the European Universe Awareness programme.

Education

ESO continued to support *Science in School*, the European science education journal published by EIROforum. ESO also participated in the nationwide German Girls' Day activities designed to give female school students an insight into science and technology professions and to encourage more of them to choose such careers in the future.

EIROforum outreach and education

ESO participated in the EIROforum Outreach and Education Thematic Working Group, which was disbanded at the end of the year. ESO awarded its special EIROforum prize at the 2011 EU Contest for Young Scientists to student Pavel Fadeev, who visited the ESO sites at Paranal and Santiago in Chile.

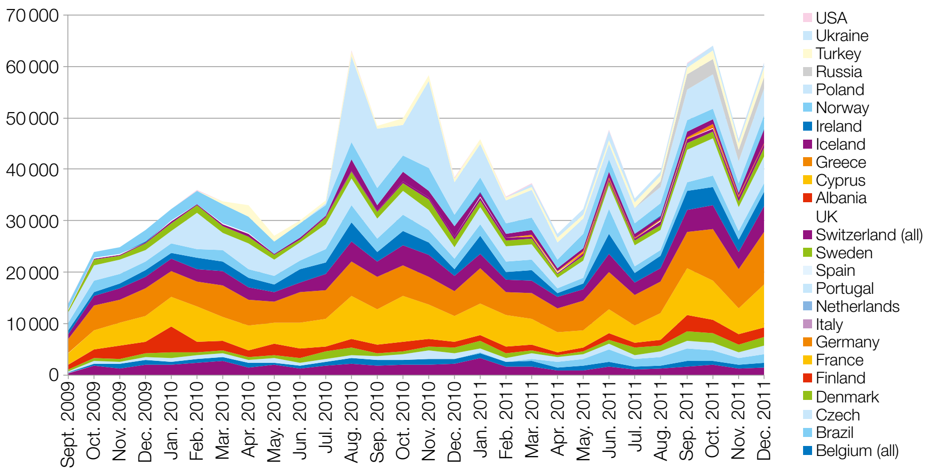
Community coordination

Many partnerships were either developed or expanded: photo ambassadors, outreach partner organisations and ESO ambassadors. These have become really important networks in the daily work.

An initiative to connect with the community and encourage them to share their view of ESO, a Flickr group called "Your ESO pictures" was set up.

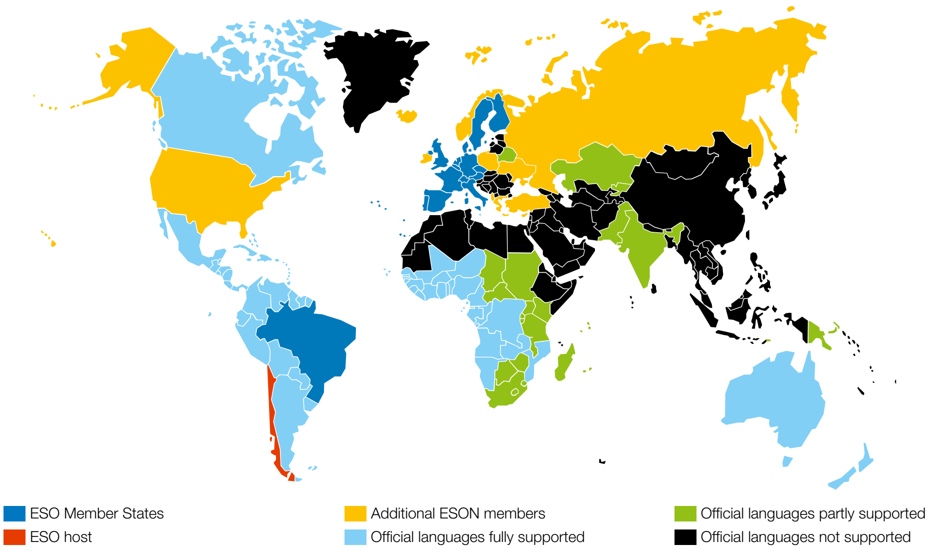
Both on Facebook and Twitter, the size of ESO's communities increased substantially — Twitter followers up 152 % and Facebook fans up 70 %.

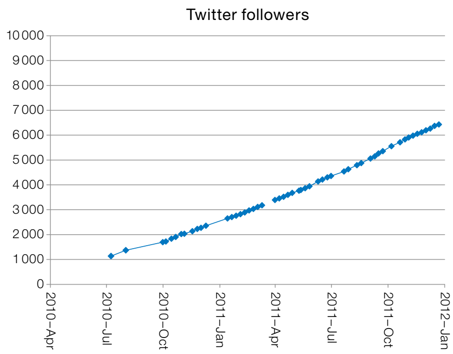
The system for the distribution of print products and merchandise survived its first full year of operation and was further improved with the inventory information becoming almost complete with 600 products in active distribution.



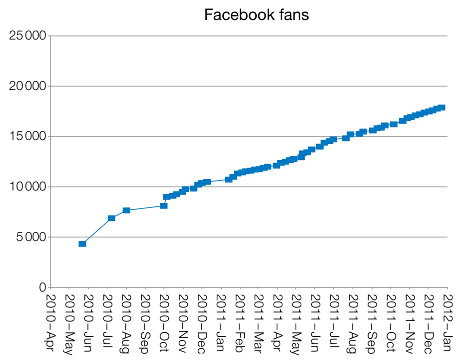
(Top) ESO Science Outreach Network visits per country per month. The strong colours vaguely relate to the flags of the Member States, and more subdued colours are used for the additional ESON members.

(Bottom) The language coverage of the ESO Science Outreach Network globally. Several "dark patches" still exist where none of the official languages are supported with either weekly press releases or as a minimum a basic website.





ESO Twitter followers from July 2010 to the end of 2011.



Facebook fans from June 2010 to the end of 2011.

These bizarre ice and snow formations are known as penitentes. They are here illuminated by the light of the Moon.

ESO/B. Tafreshi (twanight.org)

Calendar of Events

January

ALMA study on Band 9 upgrade options commenced.

ESO was present at the Job Fair in Berlin, Germany.

March

78th Committee of Council meeting.

121st (Extraordinary) Council meeting.

ESO was present at the International Career Day 2011 in Lausanne Switzerland.

ESO Workshop on Evolution of Compact Binaries, Viña del Mar, Chile, 6–11 March.

First fringes obtained with PIONIER using four UTs.

First light of OmegaCAM with the VST.

The acceptance tests of the first European ALMA antenna were completed.

The first ALMA call for proposals (Cycle 0, Early Science) was issued at the end of the month.

April

75th STC meeting.

ALMA Board meeting.

President Klaus of the Czech Republic visited Paranal on 6 April.

ESO exhibition in Zurich, Switzerland: *Keine grünen Männchen* (Search for extraterrestrial life).

Girls' Day event at ESO Headquarters, Germany.

ESO exhibition at the RAS National Astronomy Meeting, Llandudno, North Wales, UK.

ESO exhibition at Anniversary Revista Cuerpo Diplomatico, Santiago, Chile.

Austrian delegation visits Paranal.

First European antenna delivered to the ALMA Observatory.

An ALMA study on preparations for ALMA Band 5 full production was started.

ESO Workshop on Dynamics of Low-Mass Stellar Systems: From Star Clusters to Dwarf Galaxies, Santiago, Chile, 4–8 April.

ALMA Early Science, Massive Star Formation workshop, Garching, 8 April.

May

130th Finance Committee meeting.

A delegation from Austria, led by Dr Barbara Weitgruber, visited Paranal on 22 May.

The Nobel Prize in Physics 2011 was awarded "for the discovery of the accelerating expansion of the Universe through observations of distant supernovae" to two teams led by Saul Perlmutter and by Brian Schmidt and Adam Riess, the latter including ESO staff members Bruno Leibundgut and Jason Spyromilio. The discovery was based in part on data taken with the NTT and the VLT.

The exhibition *Giant Telescopes* as part of the Göteborg science festival, Sweden.

ESO exhibition at the science festival ars-technica 4, Linz, Austria.

ESO exhibition Beyond the Stars, University Museum, Groningen University, the Netherlands.

June

122nd Council meeting.

At the June Council meeting, a 39-metre segmented main mirror was adopted as the E-ELT baseline.

Delivery of the first set of ALMA Science Verification data.

ESO Workshop on Multiwavelength Views of the ISM in High-redshift Galaxies, Santiago, Chile, 27–30 June.

ESO Workshop on Fornax, Virgo, Coma, et al.: Stellar systems in nearby high-density environments, Garching, 27 June–1 July.

July

The TNO (Netherlands) delivered to ESO the first of four launch telescopes which constitute one important building block of the 4-LGSF project.

The first European ALMA antenna was transported to the AOS at 5000 metres altitude.

ESO exhibition at JENAM 2011, St. Petersburg, Russia.

ESO exhibition at 63. Reunião Anual da Sociedade Brasileira para o Progresso da Ciência, Goiania, Brazil.

August

Minister Cristina Garmendia of Spain visited Paranal and Chajnantor on 1 August.

The Chilean Minister of National Assets, Catalina Parot, visited Paranal on 24 August.

A delegation from the Netherlands, including Dr Babs van den Bergh of the Ministry of Education Culture and Research, visited Paranal and Chajnantor.

A successful ALMA proposal review process was carried out using online collaboration tools developed at ESO.

Conference, Feeding the Giants: ELTs in the era of surveys, Ischia (Napoli), Italy, 29 August–2 September.

September

76th STC meeting.

131st Finance Committee meeting.

Exhibition at 36th Brazilian Astronomical Society Meeting (Sociedade Astronômica Brasileira), Águas de Lindoia, Brazil.

ESO exhibition Finland–Chile in Tapiola Cultural centre, Espoo, Finland.

ALMA proposal Cycle 0 observations commenced at the end of the month.

Assembly of the ALMA power generation system completed.

October

79th Committee of Council meeting.

123rd (Extraordinary) Council meeting.

76th STC meeting.

Open House Day, ESO Headquarters, Germany.

Group photo of the conference "Ten years of VLTI: from first fringes to core science".

ESO/MPE/MPA/ExcellenceCluster/USM Joint Astronomy Conference on Formation and Early Evolution of Very Low Mass Stars and Brown Dwarfs, Garching, 11–14 October.

Conference, Ten years of VLTI: From first fringes to core science, ESO, Garching, 24–27 October.

Start of regular survey operations with OmegaCAM and the VST.

During a formal ceremony at the Ministry of Foreign Affairs in Santiago on 13 October, the Director General and the Chilean Minister of Foreign Affairs, Alfredo Moreno, signed the E-ELT Agreement with the Government of Chile: this event was attended by the ambassadors of most of the ESO Member States.

The first ALMA Band 5 receiver was delivered to the OSF, mounted on an antenna and moved to the AOS.

November

132nd Finance Committee meeting.

ALMA Board meeting.

The Royal Heirs of Spain, the Prince and Princess of Asturias, visited Paranal on 24 November where they were met by the Director General, Spanish Council Delegate Xavier Barcons, the ESO Representative in Chile and the Observatory Director. They were later joined by the Chilean Minister, Alfredo Moreno.

ESO exhibition at Astrofestivalen, Oslo, Norway.

ESO exhibition at Congreso del Futuro, Santiago, Chile.

The detailed design by Auer+Weber+Assoziierte for the Headquarters building extension was finalised and the contract for construction was awarded to Bam Deutschland AG.

December

124th Council meeting.

The Crown Prince of Belgium visited ESO-Vitacura on 5 December and Paranal on 7 December.

The production of ALMA Band 9 receiver cartridges (73 units) was completed by NOVA. This was the first complete delivery of baseline receivers to ALMA.

The production of ALMA amplitude calibration devices (70 units) was completed.

The sixth European ALMA antenna was accepted.

VISTA amidst the browns and reds of the desert.


ESO/B. Tafreshi (twanight.org)

Glossary of Acronyms

2SB	Sideband separating
4-LGSF	Four-Laser Guide Star Facility
4MOST	4-meter Multi-Object Spectroscopic Telescope (Proposed new spectroscopic instrument for VISTA or NTT)
A&A	Journal, *Astronomy & Astrophysics*
ADC	Atmospheric Dispersion Corrector (VISTA)
ADC	Department of Computing (ALMA)
AEM	ALMA construction consortium
AGN	Active Galactic Nucleus
AIV	Assembly, Integration and Verification
AJ	*The Astronomical Journal*
ALMA	Atacama Large Millimeter/submillimeter Array
AMBER	Astronomical Multi-BEam combineR (VLTI Instrument)
Antu	VLT Unit Telescope 1
AO	Adaptive Optics
AOF	Adaptive Optics Facility
AOS	Array Operations Site (ALMA)
APEX	Atacama Pathfinder Experiment
ApJ	*Astrophysical Journal*
Aquarius	Mid-infrared detector array (VISIR)
ARA&A	Journal, *Annual Review of Astronomy and Astrophysics*
ARC	ALMA Regional Centre
ASPERA	AStroparticle ERA-NET
ASSIST	Adaptive Secondary Setup and Instrument Simulator (AOF)
ASTRONET	Astronomy ERA-NET
AT	Auxiliary Telescope for the VLTI
ATC	Actuarial and Technology Committee (CERN)
ATC	Astronomy Technology Centre (United Kingdom)
AU	Astronomical Unit
BE	Back End (ALMA)
BUS	BackUp Structure
CASA	ALMA data reduction software
CCD	Charge Coupled Device
CERN	European Organization for Nuclear Research
CFD	Computational Fluid Dynamics
CIPT	Computing Integrated Product Team (ALMA)
CONDOR	1.5 THz heterodyne receiver (APEX)
CONICA	COudé Near-Infrared CAmera (VLT)
CONICYT	Comisión Nacional de Investigación Científica y Tecnológica
CP	Calibration Programme
CRIRES	Cryogenic InfraRed Echelle Spectrometer (VLT)
CSV	Commissioning and Science Verification
dc	Direct Current
DDT	Director's Discretionary Time
DG	Director General
DMO	Data Management and Operations Division
DOE	Directorate of Engineering
DOP	Directorate of Programming
DSM	Deformable Secondary Mirror
e-APD	electron Avalanche Photodiode
EASC	European ALMA Support Centre
EC	European Commission
E-ELT	European Extremely Large Telescope
EFOSC2	ESO Faint Object Spectrograph and Camera (v.2)
EIROforum	Organisation consisting of the seven largest scientific European international organisations devoted to fostering mutual activities
EM&P	Journal, *Earth, Moon, and Planets*
ePOD	education and Public Outreach Department
ERA-NET	EU scheme to step up the cooperation and coordination of research activities carried out at national or regional level in the Member States and Associated States
ERIS	Enhanced Resolution Imaging Spectrograph
ESA	European Space Agency
ESAC	European Science Advisory Committee (for ALMA)
ESE	ELT Science and Engineering
ESO	European Organisation for Astronomical Research in the Southern Hemisphere
ESON	ESO Science Outreach Network
ESPRESSO	Echelle SPectrograph for Rocky Exoplanet- and Stable Spectroscopic Observations
EU	European Union
EVALSO	Enabling Virtual Access to Latin-american Southern Observatories
EW	Equivalent Width
FC	Finance Committee
FE	Front End
FE IPT	Front-End Integrated Project Team (ALMA)
FEIC	Front-End Integration Centres (ALMA)
FEROS	Fibre-fed, Extended Range, Optical Spectrograph (2.2-metre)
FLAMES	Fibre Large Array Multi Element Spectrograph (VLT)
FORS1	FOcal Reducer/low dispersion Spectrograph (VLT)-1
FORS2	FOcal Reducer/low dispersion Spectrograph (VLT)-2
FP	Fabry-Perot
FPn	nth EC Framework Programme
GALACSI	Ground Atmospheric Layer Adaptive Optics for Spectroscopic Imaging (AOF)
GHz	GigaHertz
GNIRS	Gemini North Infrared Spectroscope
GRAAL	GRound-layer Adaptive optics Assisted by Lasers (AOF)
GRAVITY	AO-assisted, two-object, multiple-beam-combiner (VLTI)
GROND	Gamma-Ray Burst Optical/Near-Infrared Detector (2.2-metre)
GTC	Gran Telescopio Canarias
GUI	Graphical User Interface
HARPS	High Accuracy Radial Velocity Planetary Searcher (3.6-metre)
HAWK-I	High Acuity Wide field *K*-band Imager (VLT)
HIRES	High-resolution spectrograph (E-ELT)
HR	Human Resources
IAC	Instituto de Astrofísica de Canarias
IAU	International Astronomical Union
Icarus	Planetary science journal
IFS	Integral Field Spectrograph (SPHERE, E-ELT)
IFU	Integral Field Unit
INAF	Istituto Nazionale di Astrofisica (Italy)
INRIA	Institut National de Recherche en Informatique et en Automatique
IPSAS	International Public Sector Accounting Standards
IR	InfraRed
IRAM	Institut de Radioastronomie Millimétrique
IRDIS	Near-infrared polarimeter
ISAAC	Infrared Spectrometer And Array Camera (VLT)
ISM	Interstellar medium
IT	Information Technology
ITAR	International Traffic in Arms Regulations
IYA2009	International Year of Astronomy 2009
JAO	Joint ALMA Observatory
JENAM	Joint European and National Astronomy Meeting
Jy	Jansky
KMOS	*K*-band Multi-Object Spectrograph (VLT)
Kueyen	VLT Unit Telescope 2
LABOCA	Large APEX Bolometer CAmera
LBG	Lyman Break Galaxies
LFC	Laser Frequency Comb
LGSF	Laser Guide Star Facility
LP	Large Programme
LS	Legal Service
LSP	La Silla Paranal
LST	Local Sidereal Time
$M_{\oplus}$	Earth mass

mas	milliarcseconds
MATISSE	Multi AperTure mid-Infrared SpectroScopic Experiment (VLTI)
MCED	Mechanical and Cryogenic Engineering Department
Melipal	VLT Unit Telescope 3
MIDI	Mid-infrared Interferometric Instrument (VLTI)
MIR	Mid-infrared Instrument (E-ELT)
Mn	Mirror #n
MNRAS	Journal, *Monthly Notices of the Royal Astronomical Society*
MOONS	IR Multi-object spectrograph for VLT(Proposed new spectroscopic instrument for VISTA or NTT)
MOS	Multi-object Spectrograph (E-ELT)
MOVPE	Metal Organic chemical Vapour Phase Epitaxy
MPA	Max Planck Institute for Astrophysics
MPE	Max Planck Institute for Extra-terrestrial Physics
MPG	Max-Planck-Gesellschaft
MPIfR	Max Planck Institute for Radioastronomy
MUSE	Multi Unit Spectroscopic Explorer (VLT)
MUX	Multiplexers
NACO	NAOS-CONICA (VLT)
NAOMI	Adaptive optics system for the ATs (VLTI)
NAOS	Nasmyth Adaptive Optics System (VLT)
NASA	National Aeronautics and Space Administration
NewA	Journal, *New Astronomy*
NewAR	Journal, *New Astronomy Reviews*
NL	The Netherlands
NOVA	The Netherlands Research School for Astronomy (Nederlandse Onderzoekschool voor Astronomie)
NTT	New Technology Telescope
OmegaCAM	Optical Camera for the VST
OPC	Observing Programmes Committee
OPO	Observing Programmes Office
OPTICON	Optical Infrared Coordination Network for Astronomy
OSF	ALMA Operations Support Facilities
OSO	Onsala Space Observatory
P&SS	Journal, *Planetary and Space Science*
PA	Product Assurance
PABX	Private Automatic Branch Exchange
PARSEC	Sodium line laser for VLT AO
P-Artemis	Prototype large bolometer array (APEX)
PASJ	Journal, *Publications of the Astronomical Society of Japan*
PASP	Journal, *Publications of the Astronomical Society of the Pacific*
pc	parsec
PI	Principal Investigator
PIONIER	VLTI visitor instrument
PLC	Programmable Logic Controllers (E-ELT)
Pn	Period #n
PRC	Program Review Committee (ALMA)
PRIMA	Phase-Referenced Imaging and Micro-arcsecond Astrometry facility (VLTI)
PSD	Pipeline Systems Department
PSS	Public Spectroscopic Surveys
QSO	Quasi Stellar Object, quasar
RadioNet	Radio Astronomy Network in Europe
RAL	Rutherford Appleton Laboratory, Didcot (UK)
RAMS	Reliability, Availability, Maintainability and Safety
REM	Rapid Eye Movement Telescope (La Silla)
SABOCA	Shortwave APEX BOlometer Camera
SAXO	SPHERE'S AO system (VLT)
SCO	Santiago Central Office (ALMA/ESO Vitacura)
SDD	Software Development Division
SDSS	Sloan Digital Sky Survey
SE	System Engineering (ALMA)
SED	Spectral Energy Distribution
SEN	Super-Earth and Neptune-type planets
SHFI	Swedish Heterodyne Facility Instrument (APEX)
SINFONI	Spectrograph for INtegral Field Observations in the Near Infrared (VLT)
SOFI	SOn oF Isaac (NTT)
SPHERE	Spectro-Polarimetric High-contrast Exoplanet Research instrument (VLT)
SPIFFI	SPectrometer for Infrared Faint Field Imaging
STC	Scientific Technical Committee
STFC	Science and Technology Facilities Council (UK)
TAROT	Télescope à Action Rapide pour les Objets Transitoires
TB	Terabyte
TEC	Technology Division
TEE	Telescope Electronic Engineering
TNO	Netherlands Organisation for Applied Scientific Research
ToO	Target of Opportunity
TRAPPIST	TRAnsiting Planets and PlanetesImals Small Telescope
UC	Users Committee
UFRN	Universidade Federal do Rio Grande de Norte
UK	United Kingdom
UKIRT	UK Infrared Telescope
ULTRACAM	High-speed camera (VLT)
US	United States
USD	User Support Department
USM	University Observatory Munich
UT	Unit Telescope of the VLT
UT1–4	VLT Unit Telescopes 1–4: Antu, Kueyen, Melipal and Yepun
UV	UltraViolet
UVES	UV-Visual Echelle Spectrograph (VLT)
VIMOS	VIsible MultiObject Spectrograph (VLT)
VINCI	VLT INterferometer Commissioning Instrument (VLTI)
VIRCAM	VISTA IR Camera
VISIR	VLT Mid-Infrared Imager Spectrometer
VISTA	Visible and Infrared Survey Telescope for Astronomy
VLBI	Very Long Baseline Interferometry
VLT	Very Large Telescope
VLTI	Very Large Telescope Interferometer
VMC	VISTA survey of the Magellanic Cloud system
VST	VLT Survey Telescope
VVV	ESO public survey VISTA Variables in the Vía Láctea
WFI	Wide Field Imager (2.2-metre)
WISE	Wide-field Infrared Survey Explorer (NASA)
XMM-Newton	X-ray Multi-Mirror satellite (ESA)
X-shooter	Wideband ultraviolet-infrared single target spectrograph (VLT)
Yepun	VLT Unit Telescope 4
ZIMPOL	Zurich Imaging Polarimeter (SPHERE, E-ELT)
Z-Spec	Millimetre-wave spectrograph (APEX visitor instrument)

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Cover: Star trails over ALMA. ESO Photo Ambassador Babak Tafreshi snapped this remarkable image of the antennas of ALMA.
Credit: ESO/B. Tafreshi/TWAN (twanight.org)

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