ESO

European Organisation
for Astronomical
Research in the
Southern Hemisphere

Annual Report 2013

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

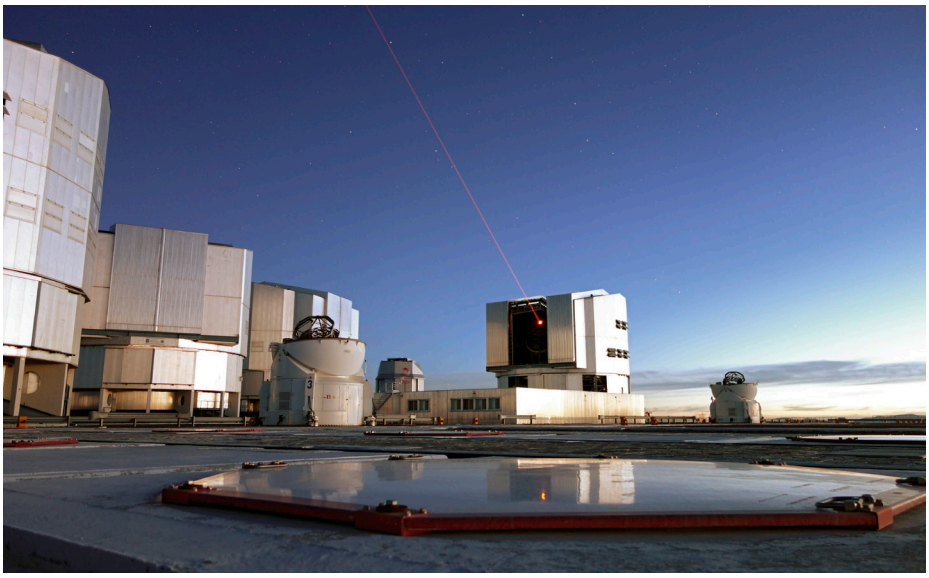
The European Southern Observatory

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 focussed 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 world-class observing sites in the Atacama Desert region of Chile: La Silla, Paranal and Chajnantor. ESO's first site is at La Silla, sited 2400 metres above sea level on a 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 3.58-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 fourth most scientifically productive in ground-based astronomy (after Paranal, NRAO and the Keck Observatory), the 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, and sited at 2600 metres above sea level, 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. Girard

The VLT uses a powerful laser to create a guide star in the night sky.

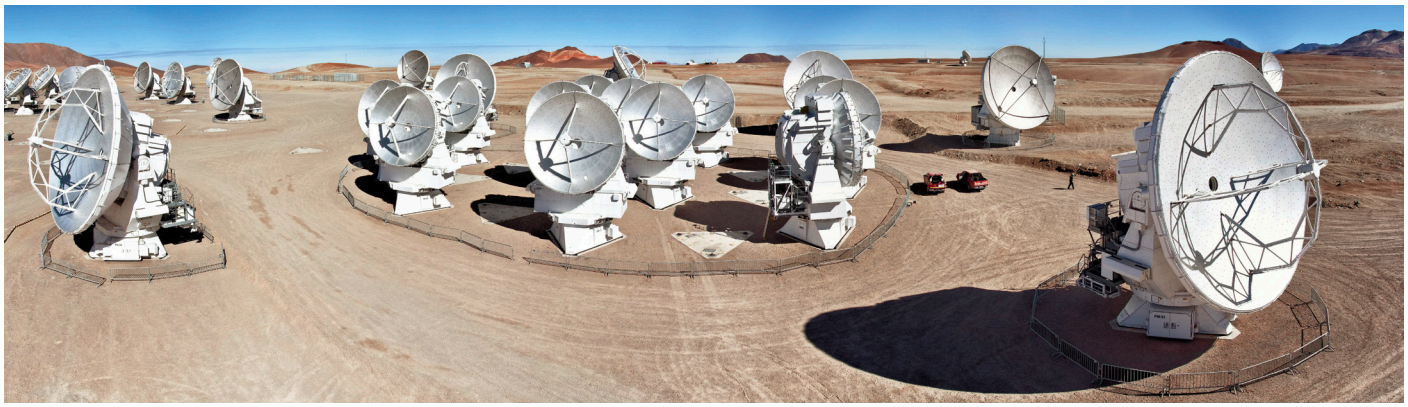
The VLT is a most unusual telescope, based on the latest technology. It is not just one, but an array of four telescopes, each with a main mirror of 8.2 metres in diameter. With one such telescope, images of celestial objects as faint as magnitude 30 have been obtained in a one-hour exposure. This corresponds 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 or from the four 1.8-metre movable Auxiliary Telescopes. In this interferometric mode, the telescope has vision as sharp as that of a telescope the

ESO/José Francisco Salgado (josefrancisco.org)

ESO's La Silla Observatory under a perfect sky.

[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.



This panorama shows 28 of the antennas that make up the Atacama Large Millimeter/submillimeter Array.

size of the separation between the most distant mirrors. For the VLTI, this is 200 metres.

Each year, about 1800 proposals are submitted for the use of ESO telescopes, requesting between three and five 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 2013 alone, 840 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 comprises an array of 66 12- and 7-metre diameter antennas observing at millimetre and submillimetre wavelengths. ALMA started scientific observations in 2011 and was inaugurated in 2013. It is located on the high altitude Llano de Chajnantor, at 5000 metres above sea level — 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.

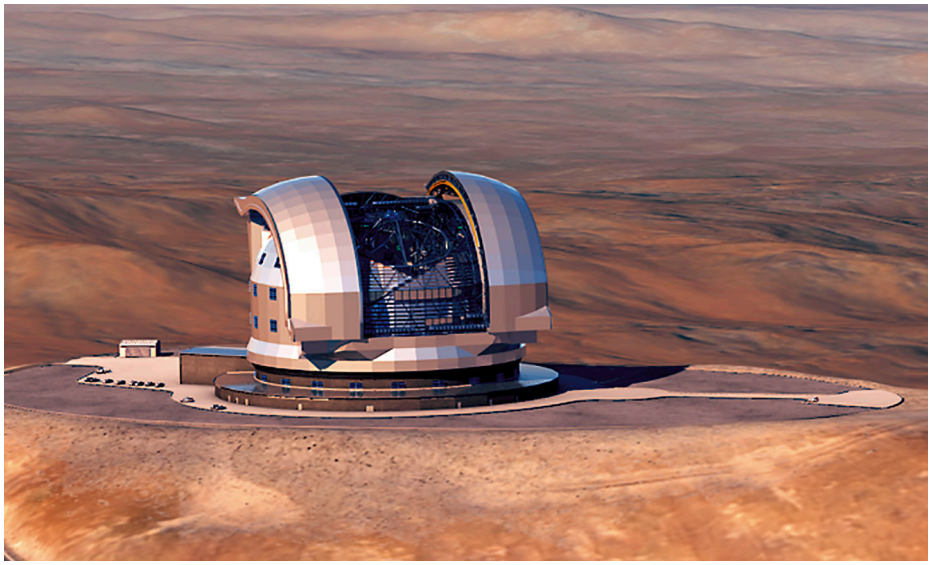
The Chajnantor site is also home to the Atacama Pathfinder Experiment (APEX) a 12-metre millimetre and submillimetre telescope, operated by ESO on behalf of the Max Planck Institute for Radio Astronomy, the Onsala Space Observatory and ESO itself.

The next step beyond the VLT is to build the European Extremely Large Telescope (E-ELT) with a primary mirror 39 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. 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 start of operations is expected at the beginning of next decade.

The ESO 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 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 2013 were approximately 130 million euros and ESO employs around 680 staff members.

Artist's impression of the European Extremely Large Telescope in its enclosure on Cerro Armazones.



ESO/L. Calçada

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Foreword

It is tempting to open this short foreword by highlighting a major positive development. There is possibly none as important as this one: ESO's operating telescopes at La Silla, Paranal and APEX on Chajnantor have continued to deliver outstanding world-class science. The very efficient model that ESO has adopted to operate its observatories, together with its highly skilled and dedicated staff, have been instrumental in reaching this primary goal of ESO's remit. Keeping a healthy instrumentation programme for ESO's facilities, in partnership with institutes from the Member States, is also a fundamental ingredient in maintaining the competitiveness of La Silla–Paranal into future decades.

In a modest but charming ceremony on 9 November, ESO and the Republic of Chile celebrated 50 years of working together to foster astronomy. This provided a unique opportunity to look back and realise how much both Chilean and European astronomy has evolved and benefited from this continuing and immensely fruitful partnership.

ALMA, the unique submillimetre observatory that ESO is building and operating in partnership with organisations in North America and East Asia, met several important milestones during the year. The President of the Republic of Chile, Sebastián Piñera Echenique, inaugurated the observatory on 13 March in a ceremony that gathered together dignitaries from the partner regions, including all ESO Council delegates and many ambassadors and astronomers from all over the world, authorities and colleagues from Chile and representatives from the local communities. Almost at the same time, ALMA welcomed its new director, Pierre Cox, replacing Thijs de Graauw, who had successfully led the project throughout most of its construction phase. ESO delivered the last of its 25 highest-quality antennas to ALMA, thus concluding the largest industrial contract ever placed in its history. Council commends all involved in reaching this major milestone.

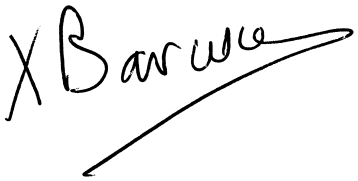
During its ramp-up from construction to operations, ALMA also faced significant difficulties, including a planned temporary hiatus in science observations to facilitate array commissioning, difficulties in getting the power production and distribution system into a normal operational state, and a temporary cessation of activities at the ALMA site during negotiations with the local staff. This fortunately ended with the signature of a new collective contract. ALMA will no doubt face other challenges on its way to becoming a fully operational astronomical observatory. But these potential problems appear insignificant when confronted with the absolutely astonishing science that ALMA delivers. With virtually every single ALMA observation becoming a breakthrough, submillimetre radio astronomy is truly entering a new era.

Council was glad to see significant progress towards the ratification of Brazil's Accession Agreement. The file entered the Brazilian Parliament early this year and passed with a unanimous positive vote the first two commissions of the Brazilian Congress. The ratification process continues and the entire ESO family looks forward to formalising its official welcome to Brazil as its 15th Member State.

The E-ELT programme also made very significant progress. Early in the year, Council received confirmation of the UK's participation in the programme, and soon added Denmark to the list of participating Member States. At the moment, only Spain is still to formalise its participation in the E-ELT. Fortunately the internal process taking place within Spain towards joining appears well advanced. Having all the Member States participating in all ESO programmes has proved to be a major strength of the organisation and Council looks forward to this phase for the E-ELT.

A key milestone towards E-ELT construction was achieved in November, when the Finance Committee — with the support of Council — awarded the contract to build the road and flatten the top of Cerro Armazones, where the E-ELT will be erected. Plans to start procuring major items for the telescope are on the table and Council will face important decisions on this critical phase during the coming years.

ESO has evolved into a very powerful organisation with an outstanding but very challenging programme of infrastructure to build and operate. In fact it can be argued that the span of ESO's activities is very much at the limit of the capabilities of the available budget and of its most valuable, but not excessively numerous staff complement. But there are other major future items of astronomical infrastructure in the portfolio of the governments of ESO Member States. These governments declare in the preamble of ESO's Convention that they are "*Desirous of […] promoting and organising cooperation in astronomical research*", which is interpreted as ESO being mandated to foster cooperation in astronomy. Council has started to reflect on whether ESO should take a more proactive role in enabling these facilities, beyond building and operating its own telescope suite. Our sister European international organisations in space science (ESA) and particle physics (CERN) have already adopted a strategic role extending beyond their own facilities. Is there a similar role to be played by ESO in the realm of large ground-based astronomical infrastructure? The thinking has just started.



Introduction

The past year has been as exciting and challenging as 2012 and saw major progress on many fronts. As already summarised in the foreword by the President of Council, the science output of the La Silla Paranal Observatory continues to increase and powerful new instrumentation is being added. ALMA was inaugurated, the 25 antennas from the AEM consortium have been delivered and the Early Science results are simply stunning. The sustained activities aimed at getting the Brazilian Accession Agreement ratified by the Brazilian Parliament started to bear fruit and 13 of the Member States have now joined the E-ELT programme, with Spain expected to join in the course of 2014.

In late January, the Government of Chile hosted the first summit of the Community of Latin American and Caribbean States and the European Union, which brought many heads of state to Santiago. ESO's activities were showcased during the summit and a number of the high-level participants visited Paranal, including the leadership of the European Union (Lady Ashton, President Barroso and President Van Rompuy). ALMA's inauguration in March also attracted high-level representatives of the Member States, including Minister Crato of Portugal and Minister Töchterle of Austria, as well as the EU Science Advisor Glover.

On 27 October President Piñera of Chile, accompanied by the Minister of Foreign Affairs Moreno, visited Paranal to hand over in person the deed to the tract of land containing Cerro Armazones. This generous donation had been agreed between Chile and ESO in late 2011. The ceremony signified that all the internal Chilean procedures required for the actual handover had been completed. This is a key step towards the realisation of the E-ELT, and it allows work to start on the construction of a new road to, and a platform on, Armazones.

A few days later, a number of activities took place to celebrate the 50th anniversary of the signing of the agreement between ESO and the Government of Chile for the establishment of the (first) ESO telescopes in Chile. This led to the creation of the La Silla Observatory and, subsequently, the further expansion of the programme with the Very Large Telescope on Cerro Paranal, partnership in ALMA and APEX on Llano de Chajnantor and the construction of the E-ELT on Cerro Armazones. In this same period Chile has become the world centre for ground-based astronomy. This owes much to the determination of the Government of Chile to protect the extraordinary but fragile treasure of its clear and dark skies, but also to its equally determined support of science and technology in the country, to the active promotion of international cooperation, and to the public appreciation of the night sky as a part of its cultural heritage.

Chile provides far more than a privileged platform for astronomical observation; Chilean universities and research institutions nowadays host internationally recognised scientists and research teams working at some of the leading frontiers of astronomy and cosmology. In those institutions, engineering programmes are being developed to produce state-of-the-art astro-technology products, developing capabilities and knowhow that also benefit many other aspects of Chilean society. ESO is proud to be associated with such an impressive growth in capabilities and looks forward to further close collaboration in the future. This is an example of international cooperation at its best.

Careful planning has led to an improvement in ESO's financial situation. As a follow-up to the 2011 engagement survey, full and transparent matrix management of engineering services, improved internal communication — including the launch of the "Intranews" and regular "DG coffees" — and the introduction of an improved performance appraisal procedure were introduced. Human Resources and Administration were (re-) combined into a single Directorate of Administration, IT services were harmonised across ESO, and the Office of the Director General was restructured.

The long-awaited Headquarters extension, consisting of a modern office and conference building and a separate technical building, both designed by Auer Weber and built by BAM Deutschland AG, was inaugurated on 4 December, just 18 months after the first stone was laid.

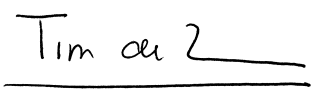
The office moves started before the end of the year and will be completed in the first quarter of 2014, bringing all Headquarters staff into a single set of interconnected buildings. This removes the need to rent space in the Max Planck Institute for Plasma Physics building elsewhere on campus and, finally, allows the removal of the venerable portacabins and the more recent temporary office building in the course of 2014.

The day before the inauguration, Dr Klaus Tschira formalised the donation of an impressive Visitor Centre by the Foundation bearing his name. It has been known since antiquity that a new star sometimes appears in the heavens. In the scientific language of the day, Latin, it was called *stella nova* or simply *nova*. Much later it was realised that some of these are, in fact, very distant and hence very bright explosions of entire stars and they were given the name *supernova*. The unique design of the new building resembles that of a close double star transferring mass from one component to the other — a process that will ultimately lead to the heavier component exploding as a supernova, briefly becoming as bright as the light from all the stars in the Milky Way together and easily visible from Earth. The expectation is that the new centre will similarly shine like a supernova, generating an enthusiasm and passion for

astronomy over a very wide catchment area. Construction will start in early 2015 and will take two years.

ESO's programme continues to grow, with E-ELT construction about to start. The new Council room is scoped for a further increase in Member States. The technical building has an appropriately sized integration hall for instruments prior to their shipment to the observatories. The recently improved organisational structure, implementing full matrix management of the engineering services that will allow ESO to efficiently carry out multiple programmes in parallel, is materially helped by having all the staff in buildings connected by the threeway bridge and containing multiple interaction areas. This will help to further improve internal communication and staff engagement.

The engagement of the ESO astronomical community in making use of our facilities remains as high and productive as ever, as symbolised by the fact that the year 2013 saw the 10 000th scientific paper from ESO data. The results obtained with ALMA are already living up to its high expectations, the VLT and APEX are now mature observatories and impressive machines of astronomical discovery and La Silla continues to hold two of the most efficient 4-metre-class telescopes in the world — an excellent starting point for the exciting years ahead when the E-ELT will begin making its contributions.



Part of the interior of ESO's new office and conference building in Garching.

Roland Halbe

Science

ESO | Acknowledgement: Martin Pugh

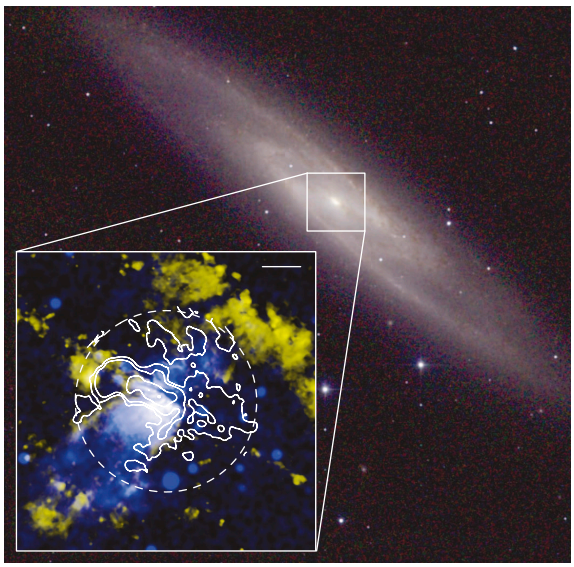
Research Highlights

Understanding galaxy formation and evolution

This year saw some significant changes in the Directorate. The Office for External Relations was closed and its functions moved to the Director General. The team of programme scientists was completed with the hiring of Jean-Philippe Berger for the VLTI and now covers all ESO programmes. As part of the matrix structure, the instrument scientists have been transferred from the Instrumentation Division and now form a new department of the Directorate of Science. The Directorate now has a consolidated structure, developed as part of the restructuring of the organisation. The ALMA inauguration was a good moment to advertise ESO and its activities to a larger community. Several scientific workshops explored future capabilities, such as one on E-ELT instrumentation and a workshop on ultraviolet astronomy. The new electronic Science Newsletter was launched to improve the flow of information to the community.

The standard model for the formation of structure in the Universe (known as Lambda Cold Dark Matter, ΛCDM) uses semi-analytic approximations to model the physical processes that lead to the conversion of gas into stars and thus into galaxies. The baryonic physics involved is complex and not well understood, but it can be replaced by "gastrophysical" recipes that, using information extracted basically from observations, capture the information about the various processes involved. Thus, significant progress in the understanding of the physical processes involved in the formation and evolution of galaxies necessarily involves statistics that, in turn, require a colossal amount of data. A great leap forward resulted from the exploitation of the Sloan Digital Sky Survey (SDSS), which provided high quality and uniform spectroscopic and photometric information for millions of galaxies. However, the SDSS is limited to local galaxies, thus providing an accurate picture of only the present structure of galaxies. The next step is to conduct similar surveys in terms of quality and uniformity, but reaching galaxies at higher redshifts and hence longer lookback times in the history of the Universe.

The VIMOS spectrograph has undertaken three such large surveys: VVDS, covering several existing imaging surveys; zCOSMOS, targeting the Hubble Space Telescope (HST) COSMOS field, and VIPERS, which is observing galaxies in the Canada-France-Hawaii Telescope Legacy Survey-Wide field. In combination, these surveys will return data for close to 200 000 galaxies, which is small compared to the SDSS, but does reach out to redshifts of $z \sim 1$ when the Universe was about half of its present age. The first analysis of these surveys, some of which were reported in previous Annual Reports, reveal two interesting results. The first is that the luminosity function of galaxies seems to be the same everywhere and every-when we look — and represented by the Schechter function. The second is that star formation in galaxies seems to cease abruptly for some unknown reason. The zCOSMOS team has shown that this happens through a mechanism termed quenching. This seems to exist in two distinct flavours: environmental quenching and mass quenching. In particular, the most massive galaxies in their dark matter haloes — called centrals by the zCOSMOS team — only experience mass quenching, while satellites (any other galaxy in the same halo) stop forming stars by either or both mechanisms. In the case of mass quenching, star formation ends rapidly when galaxies reach a certain mass. There is, as yet, no good theory to explain how this mechanism works, but one hypothesis is that when the star formation rates reach a certain threshold, the gas is violently and efficiently expelled from the galaxies, driven either by supernovae, stellar winds, or some other mechanism. This results in there being no, or very little, gas remaining

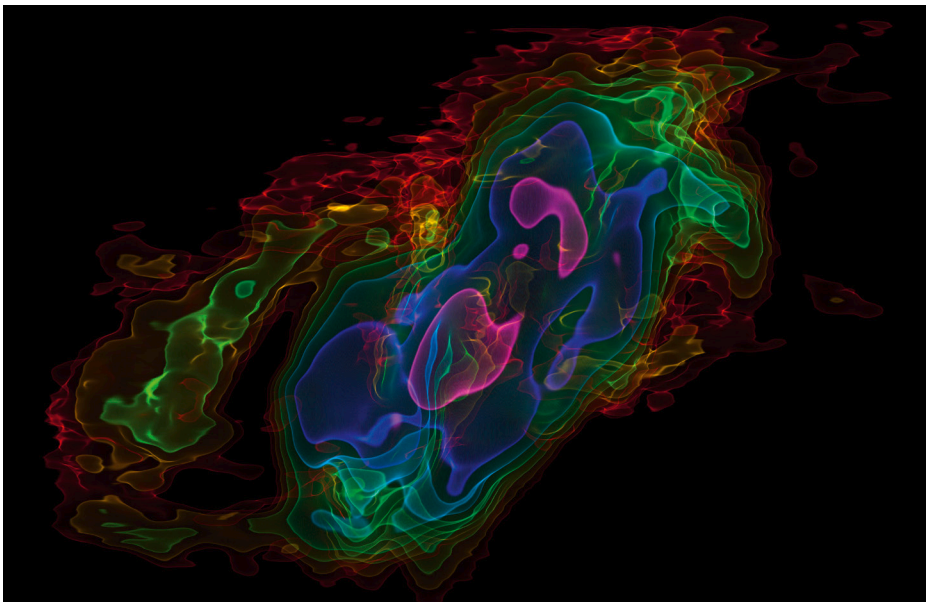


The main panel shows the stellar disc of NGC 253 in the Two Micron All Sky Survey *JHK* composite. The inset shows the central 2 kpc in false colour (soft X-ray emission, blue; Hα emission, yellow). The white contours represent CO emission distribution observed by ALMA. (Bolatto et al., 2013)

This glowing jumble of gas clouds make up a huge stellar nursery nicknamed the Prawn Nebula. Taken using the VLT Survey Telescope at ESO's Paranal Observatory in Chile, this picture shows clumps of hot newborn stars nestled in among the clouds that make up the nebula.

to fuel subsequent periods of active star formation.

ALMA has made a number of observations both in the local Universe and at high redshifts that appear to support this scenario. Locally, ALMA observed the nearby starburst galaxy NGC 253 in the Sculptor Group, located a mere 3.4 Mpc from our own galaxy. This galaxy is experiencing a powerful burst of star formation in its nuclear region, as shown in the figure to the right, and which has been known for some time to be driving a powerful wind of ionised gas.



ALMA (ESO/NAOJ/NRAO)/Erik Rosolowsky

This picture shows a view of a three-dimensional visualisation of ALMA observations of cold carbon monoxide gas in the nearby starburst galaxy NGC 253 (The Sculptor Galaxy). The colours represent the intensity of the emission detected by ALMA, with pink being the strongest and red the weakest. These data have been used to show that huge amounts of cool gas are being ejected from the central parts of this galaxy. This will make it more difficult for the next generation of stars to form.

Several of the extra-planar carbon monoxide (CO) features can be traced back in position and velocity to expanding molecular shell structures in the starburst region of NGC 253, providing clues to the launching mechanisms of the molecular wind. Two of these structures were found by previous CO observations and dubbed superbubbles. Four expanding shells with radii of 60–90 pc and expansion velocities of 23–42 km/s are found. The large momentum associated with each shell suggests that they are driven by the combined effects of multiple stellar winds and — at later stages — by supernovae originating in young stellar clusters that are not directly observed and for which, from the expanding shell dynamics, masses of about 6–40 × 10^4 $M_\odot$ for ages $t_{cluster}$ < 3 Myr are inferred.

The total molecular mass outflow rate driven by these winds is uncertain, mostly because the ratio of CO mass to total molecular hydrogen (H_2) mass is in general poorly constrained for molecular clouds outside the Milky Way and the Large Magellanic Clouds, but can be inferred to be between 3 and 30 $M_\odot$/yr, with a value of about 9 $M_\odot$/yr using the Milky Way CO to H_2 conversion ratio.

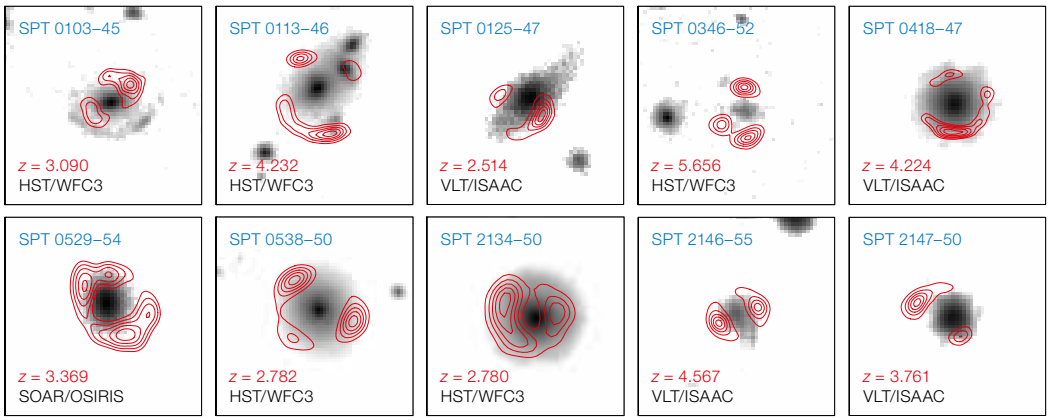
Thus, even in the most conservative case, the molecular mass-loss rate is comparable to the observed star formation rate (~ 2.8 $M_\odot$/yr) in the starburst of NGC 253 and probably a few times higher. Consequently, the central regions of NGC 253 will run out of gas in a few tens of millions of years.

In general, it is not clear what fraction of the outflowing gas actually escapes galaxies, particularly for low-velocity starburst-driven winds like that in NGC 253. Most of the baryons ejected by winds may just linger in the enriched haloes of star-forming galaxies to later rain back onto their discs, providing fuel for new episodes of star formation. The ALMA observations of NGC 253 show that the mass-loading of the starburst-driven wind is substantial and underlies the importance of recycling the enriched material in the star formation history of galaxies.

High-redshift galaxies

ALMA is also providing fundamental information about star formation and molecular outflows in the furthest reaches of the Universe. In particular, ALMA has finally removed the barrier that had severely hampered the identification of the most massive star-forming galaxies in the Universe. These galaxies, known as submillimetre galaxies, are so dusty that they are rendered extremely faint at optical and infrared wavelengths, making it difficult to identify and obtain their redshifts in earlier submillimetre surveys carried out with much lower spatial resolution. One of the promises of ALMA was to allow the direct determination of the redshifts of submillimetre galaxies from their submillimetre spectrum.

ALMA observations of 26 submillimetre galaxies from a sample found in a survey with the South Pole Telescope (SPT) confirmed that 23 of these 26 galaxies lie at redshifts z > 4, substantially increasing



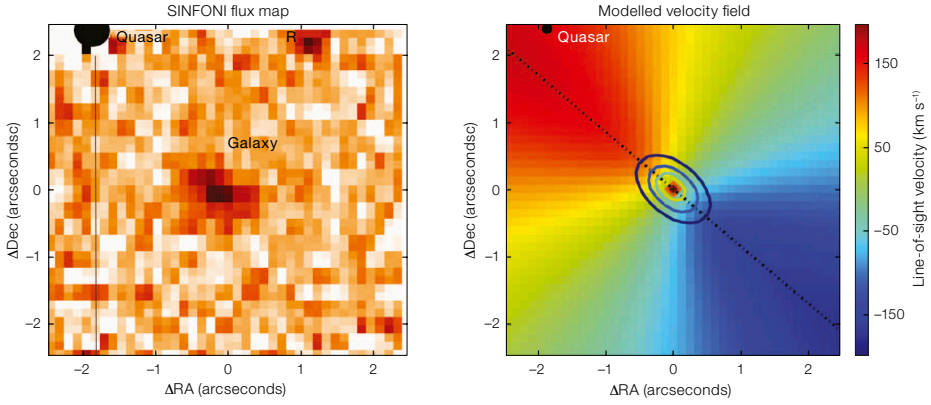
ALMA maps of extreme star-forming galaxies at $z > 4$ (red contours). The greyscale images are either space or ground-based near-infrared images of the lensing galaxies, mostly from HST or the VLT spectrometer ISAAC. (Vieira et al., 2013)

the fraction of massive star-forming galaxies at high redshifts. Interestingly, all the galaxies in this sample are strongly lensed by foreground galaxies (see top figure); otherwise, they would have been far too faint to be detected by the SPT, which, although at an excellent site, is still a rather small telescope.

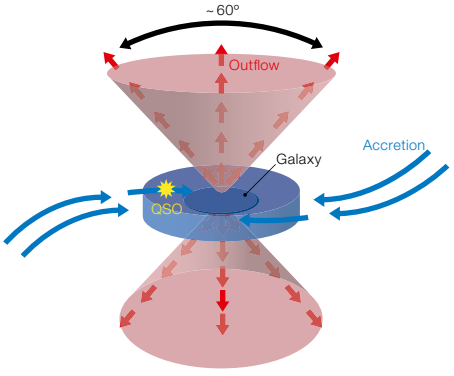
Continuing observations of submillimetre galaxies in the early Universe with ALMA and with other interferometers seem to indicate that starburst galaxies with a wide range of star formation rates drive molecular gas outflows at rates comparable to or larger than the rates at which they form stars. This indicates that mass-quenching occurs even before the onset of supernovae or the growth of supermassive black holes in their nuclei.

Recent observations on the VLT with the spectrographs SINFONI and UVES, however, find that this simple interpretation may actually be an over-simplification. The observations target a star-forming galaxy at $z = 2.3$ that is close to a QSO (quasar). The beauty of this combination is that, by observing the QSO at high resolution with UVES it is possible to obtain information about the neutral interstellar medium of the star-forming galaxy. Coupled with a study of the properties of the ionised interstellar medium with the adaptive optics (AO)-assisted mode of SINFONI, this enables a detailed picture do be drawn of the kinematics of gas around the central regions of the galaxy (see bottom centre figure).

The special configuration of this object, with the QSO just a few arcseconds away, allows both the cold material, which is seen in absorption against the light of the QSO, and the hot gas which is seen in emission, to be probed. This allowed the authors to build a reasonably realistic simple model of the outflows and inflows of gas in this galaxy, shown in the bottom right figure. Notably, both the rates of infalling and outflowing gas are similar, within the uncertainties, to the rate at which the galaxy is converting gas into stars — a few tens of solar masses per year. This would suggest that some sort of well-regulated feedback process is operating in this galaxy, although the authors offer no detailed indications of how this might actually work.



Left: Narrowband (rest-frame Hα) SINFONI AO image of a star-forming galaxy. The quasar HE2243–60 and the $z \sim 2.3$ galaxy are marked. Right: The fitted velocity field along with the flux contours. The dotted line shows the kinematic major axis. (Bouché et al., 2013)



Toy model showing the supernova-driven outflow (red) and the inflow of cold gas with low angular momentum from the intergalactic medium (blue). As the accreting cold gas dissipates its angular momentum it migrates toward the galaxy, forming an extended gaseous disc-like structure. The quasar line of sight (shown in yellow) intercepts only accreting gas, leading to the distinctive kinematic features seen in the UVES spectra. (Bouché et al., 2013)

Active galactic nuclei

In recent decades astronomers have gathered compelling observational evidence that almost every galaxy hosts a massive black hole at its centre. In a number of cases, the black hole is so massive that its accreting and emitting power can dominate the radiation spectrum of the entire galaxy.

The cores of these active galaxies are called active galactic nuclei (AGN) and are among the most energetic objects in the Universe. They are the focus of intense observational and theoretical study since they provide unique laboratories for probing the accretion and ejection processes around a central supermassive black hole.

Several classes of active galaxy have been defined based on their observational properties. Some of the most popular unified models propose to explain these differences as a consequence of the orientation of the galaxy with respect to the observer's line of sight. In these models, the presence of a geometrically thick dusty torus, surrounding a massive accretion disc that powers a strong wind and feeds the central black hole, is invoked to account for the different apparent classes. Within this paradigm, the torus emission dominates the entire mid-infrared spectrum. However, there is accumulating evidence that the picture might be more complex and require additional physical processes to be taken into account.

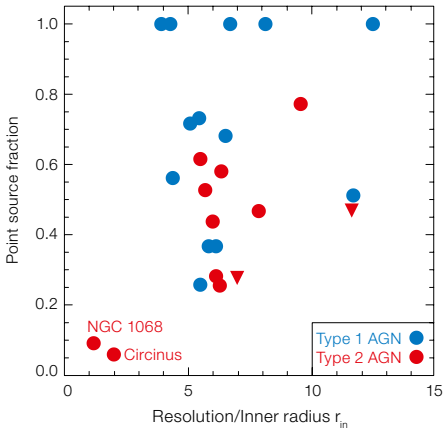
Challenging these models requires observations at spatial scales where the different components can be resolved. These direct observations are mandatory to bridge the gap between large-scale and inner-scale structures. Only infrared interferometry can provide the required 10-milliarcsecond resolution.

The Very Large Telescope Interferometer and its MIDI instrument have been extensively used in recent years to develop a new understanding of AGN. In particular they have provided direct evidence that the dust emission can only be accounted for if it is distributed in the form of clumps. The most recent observations are providing both a detailed and a statistical new view of AGN.

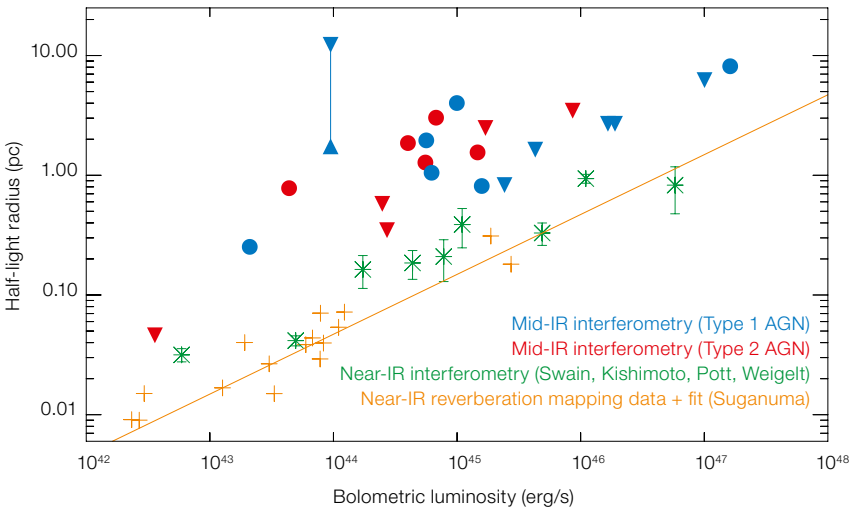
By accumulating numerous interferometric observations using pairwise combinations of all Unit Telescopes (UTs), the mid-infrared emission of the AGN NGC 3783 has been exquisitely mapped. These observations reveal that the warm dust, as observed in the mid-infrared, is aligned with the polar axis of the accretion disc, which is approximately perpendicular to the hot dust previously observed with the AMBER instrument. Both separate regions correspond to two distinct bumps in the infrared spectral energy distributions. This result is surprising since it is difficult to reconcile with a single equatorial dust torus, the standard picture for the dusty region in AGN. Thus, these results are a strong incentive to revise current models to account for this observation by including the contribution of dusty winds.

MIDI has also been used to carry out the first VLTI Large Programme observation of sample of 23 AGN. This remarkable achievement was made possible by pushing the limits of the technique beyond the existing sensitivity frontier to reveal the diversity of dusty AGN tori. The first conclusion of the programme is that a significant fraction of the sources show unexpectedly high levels of unresolved flux, even at the milliarcsecond resolution of the VLTI. This means that a significant part of the mid-infrared flux originates on scales included within the 0.1–10 parsec region around the central black hole. Secondly, the large variety of measured emission radii, even for AGN with similar luminosity, challenges the view that a single mechanism is responsible for the emission. Apart from the amount of unresolved flux, no significant difference was found between sources seen from the polar direction (type 1) and those seen from close to the disc plane (type 2).

Although the dust tori are thought to be very similar in all sources, radiative transfer simulations predict, contrary to the new observations, significant differences



The level of unresolved flux as a function of resolution. It is evident that resolution plays only a minor role in how the torus appears at mid-infrared wavelengths, proving the diversity of morphologies. (Burtscher et al., 2013)



The size–luminosity relation of AGN tori from the sublimation radius (green and orange points) to the "body" of the torus (MIDI, blue and red points — type 1 and type 2 sources). (Burtscher et al., 2013)

in the observed size when viewed from different directions. This is a problem for the orientation-based unified models upon which these simulations are based. Finally, for the best-resolved sources where evidence of extended polar elongation was revealed, the compact emission could be accounted for by a thindisc model attributed to the innermost part of the dusty torus. Such models do not, however, provide the covering factor needed for this type of unification.

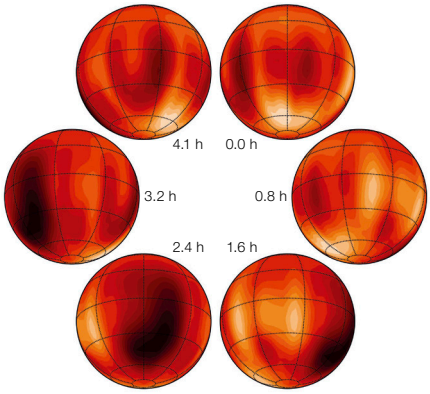
Overall these studies have revealed the necessity to revise significantly the dust distribution models at parsec scales around supermassive black holes and are a strong incentive to pursue the accumulation of spatially resolved observations. The possibility to resolve and distinguish the exact morphologies of the mid-infrared emission of a number of AGN will be greatly facilitated by the successor to the MIDI instrument, MATISSE. This instrument will be operational at the VLTI around 2017. By allowing the four UTs to be combined, MATISSE will provide ten times more information in a single observation than MIDI. The near-infrared second generation VLTI instrument GRAVITY will provide complementary information by measuring the size and geometry of the broad-line regions that are located closer to the supermassive black hole. This will open the way to detailed statistical studies and improve dramatically our understanding of the physical processes occurring at parsec scales in AGN.

Weather on brown dwarfs: between stars and planets

Brown dwarfs are more massive than planets, but not massive enough to initiate the sustained hydrogen fusion in their cores that powers self-luminous stars. They are born hot as a result of gravitational energy being transformed into heat during their contraction phases. They then slowly cool as they age. As they fall below ~ 2300 K, liquid or crystalline particles composed of calcium aluminates, silicates, and/or iron condense into atmospheric “dust” that, in turn, disappears at around 1300 K. Models to explain this dust dispersal incorporate an abrupt sinking of the entire cloud deck into the deep, unobservable part of the atmosphere, or a breakup of the cloud into scattered patches as seen, for example, on Jupiter and Saturn. Up until now, however, observations of brown dwarfs have been limited to globally integrated measurements and such measurements, although they can reveal surface inhomogeneities, cannot unambiguously resolve surface features.

New high-resolution observations with the VLT spectrometer CRIRES of the binary brown dwarf Luhman 16AB, located a mere 2 pc from the Sun, have allowed, for the first time, a map of the two-dimensional dust distribution on one of the stars, Luhman 16B, to be constructed.

The fact that the system is a binary made it possible to constrain the inclination angle of the rotation axes of the star and therefore to use Doppler imaging techniques to construct the cloud map. This is shown in the figure above over a full rotation period of the star. The map shows a large, dark, mid-latitude region; a brighter area on the opposite hemisphere located close to the pole; and mottling at equatorial latitudes.



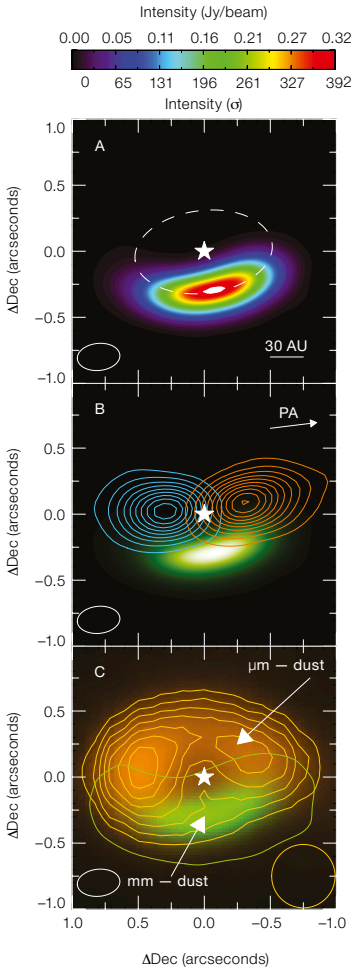
Surface map of Luhman 16B showing a bright near-polar region (seen in the upper-right panels) and a darker mid-latitude area (lower-left panels) consistent with large-scale cloud inhomogeneities. The lightest and darkest regions shown correspond to brightness variations of roughly ±10%. The rotation period of this star is 4.1 hours. (Crossfield et al., 2014)

These features are naturally explained as the patchy global clouds that are inferred to exist from observations of multi-wavelength variability. The dark areas would represent thicker clouds that obscure deeper and hotter parts of the atmosphere, whereas bright regions correspond to holes in the upper cloud layers that provide a view of the hotter, deeper interior. The high-latitude bright spot could be similar to the polar vortices seen on Jupiter and Saturn, and predicted to exist on highly irradiated gas giants in short-period orbits around other stars. Jupiter and Saturn also exhibit prominent atmospheric bands, but the data from the CRIRES spectrograph are not sufficiently sensitive to enable the detection of banding on the star.

Long-term monitoring of Luhman 16B suggests that its weather conditions change rapidly, but remain at least partly coherent from one night to the next, indicating that the characteristic timescale for the evolution of global weather patterns is of order one day. In this case, successive full nights of Doppler imaging could observe the formation, evolution and breakup of global weather patterns — the first time such a study would be possible outside the Solar System. Measurements of this kind would provide a revolutionary new benchmark against which to compare global circulation models of dusty atmospheres and could, perhaps, even measure differential rotation in Luhman 16B’s atmosphere.

Planet formation

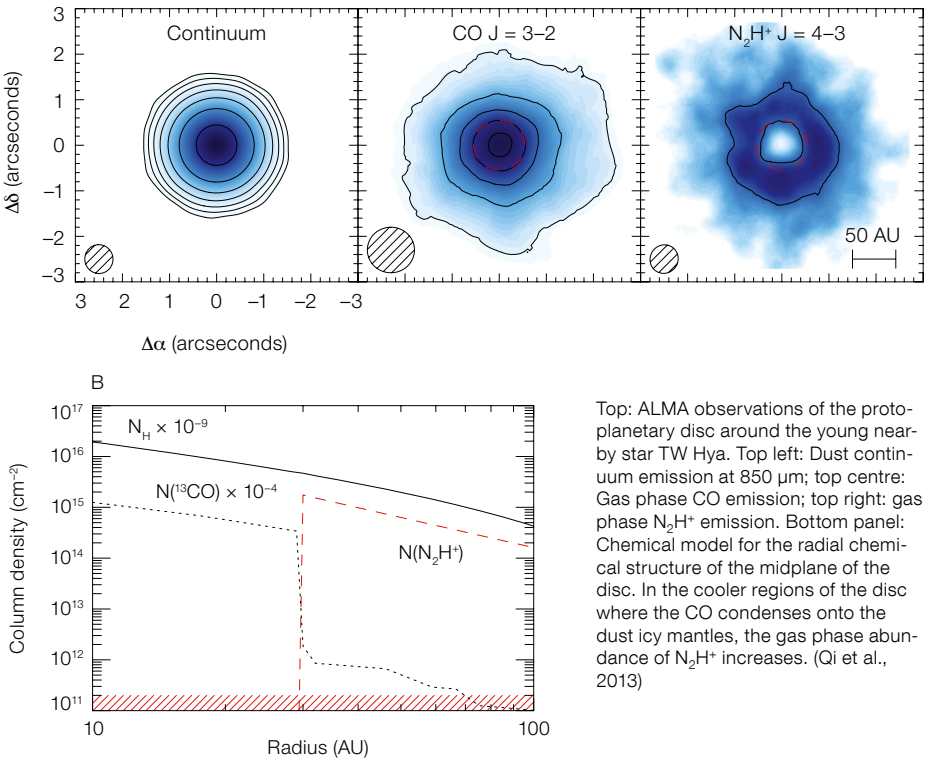
Planetary systems are expected to form in protoplanetary discs around young pre-main-sequence stars. The diversity of rocky and giant planets and the characteristics of their atmospheres are thought to result from a combination of the formation mechanism and the subsequent dynamical evolution. ALMA's current capabilities allow us to trace the initial steps of the planet formation process in two ways: by observing the growth of solids from micrometre-size particles to millimetre- and centimetre-size pebbles — the first step towards the formation of the rocky cores of planets — and by studying the transition of molecules from ices into the gas phase in the warmer regions of the discs.



Top (A): ALMA Band 9 (450 μm) continuum emission image of the protoplanetary disc around IRS 48 in Ophiuchus, showing the uneven distribution of dust grains in the outer disc (the white star shows the position of the central star and the dashed ellipse marks the inner edge of the outer disc cavity). Middle (B): Red and blue wings of warm carbon monoxide emission from the disc are depicted as contours overlaid on the continuum emission, showing the disc rotation around the central star. Bottom (C): The emission from small μm-sized particles throughout the disc is shown in the orange contours (VLT/VISIR image) overlaid on the submillimetre emission from millimetre-size grains. (van der Marel et al., 2013)

(Sub-)millimetre continuum observations are sensitive to the thermal emission from millimetre-size particles in the midplane of the disc. ALMA observations of the young protoplanetary disc surrounding the source IRS 48 in Ophiuchus have shown that these dust grains are concentrated in a very specific region of the disc with respect to that containing the micrometre-size grains observed in the infrared with the VISIR instrument on the VLT (see figure to the left). This spatial concentration of large grains can be explained by a radial and azimuthal gas pressure "dust trap" that is anticipated from numerical simulations of disc–planet interactions. The emerging picture is that it is planet formation feedback that perturbs the gas distribution in the disc, creating pressure traps that efficiently confine dust. This overcomes the growth/migration barriers to the formation of cometary-sized bodies in the outer disc. Similar, less extreme, structures have been detected by ALMA in many of the "transition" discs, suggesting that this feedback process from planets on the outer disc is a common feature and may be the dominant mechanism for the formation of large bodies at large distances from the central star.

The high sensitivity of ALMA, even under the limited conditions of Cycle 0, has allowed relatively high angular resolution and good sensitivity maps of different molecular species in protoplanetary discs to be made. Importantly, it is now possible to observe the indirect chemical effects of the drop of CO abundance in the gas phase as it condenses on the dust ice mantles in the cooler regions of the disc (T < 20 K). The snowlines of CO (the most abundant molecule after H_2) and water are very important in understanding the planetary formation process and, in particular, the accretion of CO and/or H_2O onto planetary atmospheres. The H_2O snowline is still too close to the central star to be observed directly by ALMA in Cycle 0, but the detection of the CO snowline with ALMA Science Verification and Cycle 0 data is a major milestone towards our understanding of how planetary atmospheres are assembled (see figure below).



Top: ALMA observations of the protoplanetary disc around the young nearby star TW Hya. Top left: Dust continuum emission at 850 μm; top centre: Gas phase CO emission; top right: gas phase N_2H^+ emission. Bottom panel: Chemical model for the radial chemical structure of the midplane of the disc. In the cooler regions of the disc where the CO condenses onto the dust icy mantles, the gas phase abundance of N_2H^+ increases. (Qi et al., 2013)

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The Milky Way glitters brightly over ALMA's antennas on the Chajnantor Plateau.

This image shows the cloud of cosmic gas and dust known as Gum 15. It is the birthplace and home of massive young stars.

Offices for Science

Paranal renaissance

On 25 May 1998 the first light of the first VLT Unit Telescope (Antu) opened a new era for European astronomy. This year, we celebrated the 15th anniversary of this historic event (see ESOcast 57: http://www.eso.org/public/videos/eso1322a/). The VLT is today the most productive ground-based observatory, with about 12 papers published per week based on data obtained at the Paranal Observatory.

Science is much more than dry numbers: it is about expanding our knowledge and comprehension of the Universe, triggering breathtaking discoveries such as observing the stars orbiting the supermassive black hole at the centre of the Milky Way; the first direct image of an exoplanet; and providing the definitive proof that some gamma-ray bursts are spawned by supernova explosions.

The questions we ask and the answers we find are tightly linked to our ability to design, build and operate cutting-edge telescopes and instruments. The VLT instrument portfolio deployed over the last 15 years is impressive: from the very first generation to the latest ambitious instruments such as the spectrograph KMOS (first light in 2013), the 3D-spectrograph MUSE (first light in January 2014) or the exoplanet imager SPHERE, which should be followed in a few years from now by the commissioning of GRAVITY, ESPRESSO and MATISSE.

Science highlights

We should never forget that in order to deploy and maintain this new generation of instruments and further exploit the full potential of the observatory, we need highly skilled people. Among these, ESO staff astronomers show a high degree of commitment to a programme that sees the service delivered to the community as an important part of ESO's core mission. ESO also understands that only by being active scientists themselves can the staff astronomers interact with the astronomical community to push the instruments to deliver the science for which they were conceived and beyond.

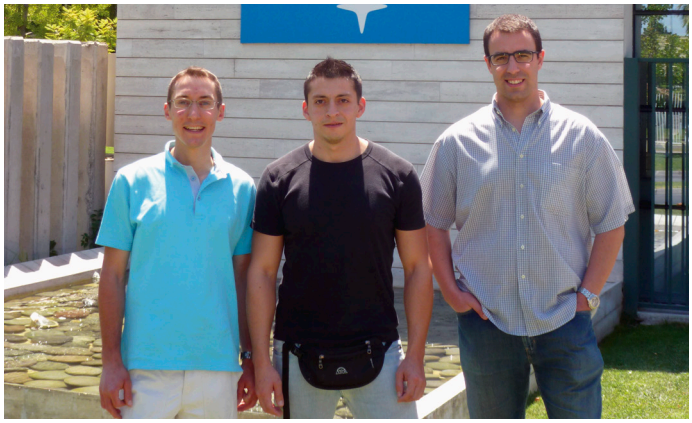
It is one of the tasks of the Offices for Science to help the astronomers to excel in this challenging task of performing well on both fronts.

This year, the ESO Offices for Science in Chile and Germany would like to highlight the performance of six distinguished staff members, two Faculty members, two Fellows and two Students, namely Dimitri Mawet, Oscar González and Julien Milli in Chile and Carlos de Breuck, Claudia Lagos and Dominika Wylezalek in Germany, for their outstanding scientific performance, their contributions to the scientific life in Vitacura and Garching and the synergies with their functional work.

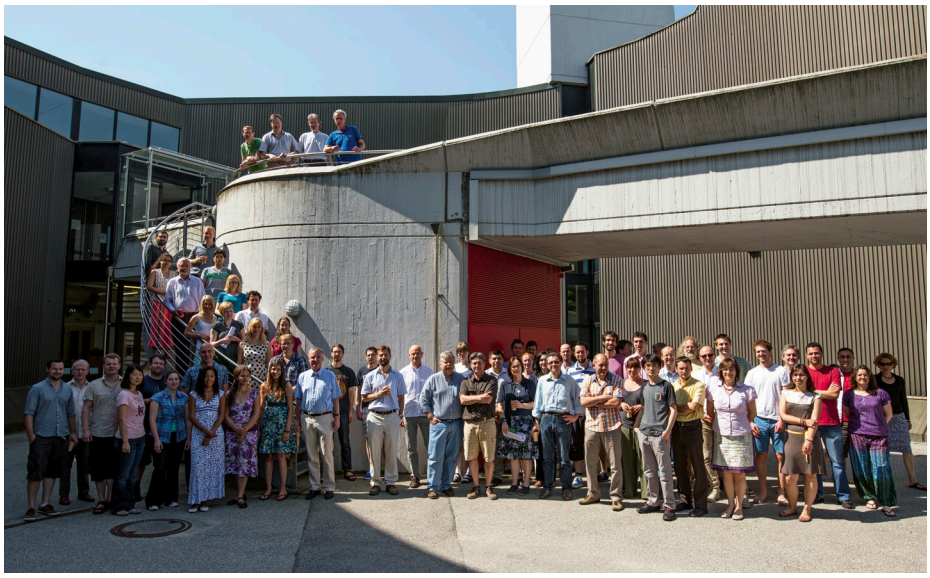
Dimitri Mawet arrived at ESO from JPL/NASA as a well-established expert in the field of high-angular resolution and high-contrast imaging. He had the well-defined goal of strengthening the AO expertise on Paranal in preparation for the arrival of SPHERE. Dimitri is particularly known as the inventor of the Vortex coronagraph. In 2012/2013, Dimitri experienced a burst in the number of requests for his coronagraph (installed recently on the NACO spectrograph at the VLT, and at the Large Binocular Telescope) thanks to its high scientific potential in the field of direct imaging of exoplanets and discs. He co-authored other scientific papers (one of those led by his PhD student, J. Milli), and participated in the breathtaking result published in *Nature* (Casassus et al., 2013) where ALMA observations suggest that a protoplanet sitting in the gap of a protoplanetary disc is accreting gas from the outer disc: this would be the first "image" of the process of planetary building (Press Release eso1301: http://www.eso.org/public/news/eso1301/).

Dimitri's expertise is acknowledged by his participation in several expert committees. Last year he helped to develop a roadmap to guide ESO's research and development plan for the Planetary Camera and Spectrograph of the E-ELT and participated in the definition of a coronagraphic NASA mission piggybacking on the Wide-Field Infrared Survey Telescope, using the AFTA/Nobeyama Radio Observatory telescopes. Dimitri participates intensively in our science life. Together with Julien Girard and Zahed Wahhaj, he promotes the Deep Imaging Group (DIG) group and supervises students both in-house and abroad. He is also a member of the Fellowship and

Julien Milli, Oscar González and Dimitri Mawet in Santiago.



Claudia Lagos, Carlos de Breuck and Dominika Wylezalek in Garching.



Group photograph taken during Science Day 2013 at ESO Headquarters.

Studentship Selection Committee in Chile. All this was achieved while maintaining a friendly, open-minded and ethical attitude towards his colleagues.

Oscar González joined ESO Chile as a Fellow at the end of 2012. His science centres on projects related to the scientific exploitation of the ESO VISTA Public Survey VISTA Variables in the *Vía Láctea* (VVV) survey data. In particular Oscar made an important contribution to our understanding of the Galactic Bulge, which has recently been shown to have an X-shape, probably due the presence of a bar (Vasquez et al., 2013; http://www.eso.org/public/news/eso1339/).

Oscar injects a lot of positive energy into our science environment in Vitacura and he actively contributes as colloquium organiser and co-supervisor of the PhD student Sergio Vázquez. This year, Oscar also mentored another PhD student, Bruno Dias. He is a regular contributor at our science-related gatherings, leading and instigating discussions and giving talks. On the mountain, Oscar has demonstrated a strong team spirit and commitment to the programme. He almost immediately became the VIRCAM instrument fellow where, thanks to his expertise gained through his science and as a team member of the VVV, he is playing a key role in the VIRCAM Instrument Operations Team, helping to keep VIRCAM delivering top-quality data.

After a first PhD year spent at the Institut de Planetologie et d'Astrophysique de Grenoble (IPAG) under the supervision of David Mouillet, Julien Milli joined ESO Chile to carry out the last two years of his degree working with Dimitri Mawet and Julien Girard.

This year Julien delivered an impressive amount of high quality work related to the technical aspects of high-contrast imaging and its respective science applications such as the direct detection of planetary mass companions and the study of debris discs, which comprise his main thesis topics. He was first author of a paper in 2012 and two more in 2013, with a total of nine papers in his short but promising career. He has been very active in advertising his results at international conferences and within the star formation community in Santiago that comprises astronomers from ESO Chile, ALMA and faculty members from some Chilean institutions.

Julien has energetically integrated himself into our science environment. With a generous and committed attitude, he has been a strong contributor to events led by the PhD students. He is one of the organisers of the AO/DIG group in Vitacura, holding frequent discussions with the key scientists. Moreover, whenever he can, he doesn't hesitate to volunteer to take part in outreach activities.

We are delighted that Julien has accepted an offer to become an ESO Chile Fellow. His duties are sure to include playing a key role in making SPHERE a revolutionary machine in the field of extrasolar planets and debris discs.

After holding a Marie Curie Fellowship at the Institut d'Astrophysique de Paris and an ESO Fellowship in Garching, Carlos de Breuck obtained an ESO staff position in 2006 as the APEX project scientist and APEX support astronomer. Carlos has a passion for high-redshift objects, with an emphasis on radio galaxies, which he studies both to probe their intrinsic properties and to use them as tracers of the global galaxy population. Carlos is a very experienced observer and has led projects at many ESO facilities (NTT, ESO 3.6-metre telescope, VLT) and elsewhere (Keck, Subaru, William Herschel Telescope, etc.). Carlos then built up very strong expertise as a submillimetre astronomer, supporting all aspects and phases of the APEX observations, representing ESO within the APEX collaboration and being the APEX contact point for several committees. Carlos thus became a key figure in important collaborations making use of APEX, ALMA or the Australia Telescope Compact Array, but also with programmes involving the European Space Agency's (ESA) Herschel and SINFONI at the VLT. This year, Carlos published an impressive set of 16 papers, playing a critical role in many of them. His scientific achievements for 2013 include colloquia, lunch talks or invited talks at international conferences. Carlos is a dedicated and passionate supervisor to students, advising or co-advising two PhDs at ESO (Bitten Gulberg and Dominika Wylezalek); Carlos co-chairs the local organising committee for the ESO 3D2014 workshop, taking place in March 2014 in Garching, and was a reviewer for French Agence Nationale de la Recherche and European Research Council proposals.

Claudia Lagos joined ESO in October 2012 after she received her PhD at the Institute for Computational Cosmology in Durham, for which she won the Springer Thesis prize, and more recently the

MERAC prize for the best thesis from the European Astronomical Society. Claudia's background is mainly theoretical with an emphasis on active galactic nuclei, star formation and feedback, via the development and use of semi-analytic models, but she came to ESO to expand her horizons and develop her taste for observations.

During her first year at ESO, Claudia showed a remarkable development in terms of her network of collaborators (within and beyond ESO) and the projects in which she is involved. She is applying her skills to take on new challenges, working on proto-clusters — joining the Spitzer Extragalactic Representative Volume Survey collaboration — and getting involved in the use of the Galaxy and Mass Assembly survey dataset. Claudia is steadily publishing in refereed journals, and is also now reviewing papers herself. She has been invited to talk at four conferences, including a review talk at a Ringberg workshop, something quite remarkable for someone so young. Claudia also won an Australian Research Council Centre of Excellence for All-Sky Astrophysics visitor grant to visit Perth and Melbourne for a month in November. She is an enthusiastic Fellow and her passion for science is contagious. She has been co-organising the Garching journal clubs, and is always willing to contribute to the science activities at ESO Headquarters. In order to learn about observations and doing submillimetre astronomy, she joined the ESO Garching ALMA Regional Centre (ARC) for her duty work and started attending their weekly meetings. Claudia was in charge of the ALMA Helpdesk along with Suzanna Randall. She performed as contact scientist for one of the Cycle 1 top priority projects and also helped in the organisation of the ALMA community days that took place in November. Claudia also worked on testing the ALMA Observing Tool and will go to the ALMA Operations Support Facility in Chile to lead several day and night shifts.

Dominika Wylezalek spent her second year at ESO as a PhD student supervised by Carlos de Breuck and Joel Vernet. Dominika visited Carlos's collaborator Daniel Stern at JPL/Caltech for a few months. This year, Dominika wrote two first author papers, and contributed to two other refereed papers. She presented a talk at the Sexten Conference on high-redshift clusters around radio-loud AGN and their luminosity functions: Dominika showed results on the evolution of mid-infrared luminosity functions of a large sample of high-z clusters ($1.3 < z < 3.2$) that hint at a star formation epoch as early as $z \sim 4$: this unexpected result certainly caught the attention of the audience and was even mentioned in the summary talk. Dominika has been very active in preparing the spectroscopic follow-up from Spitzer's CARLA project, played a major role in two successful Keck/MOSFIRE proposals, and is the Principal Investigator (PI) of a KMOS Science Verification proposal. She naturally volunteered to participate in the run that was her first direct experience with the VLT. Dominika is a pro-active student, being one of the representatives for the International Max-Planck Research School programme, co-organising the wine and cheese seminars, assisting ESO's Observing Programmes Committee (OPC) and organising and guiding a one-day workshop, Journey through Time and Space, at the second Bayerischer Mädchen-Technik Kongress. Dominika will defend her thesis in 2014 and then cross the Atlantic to join Johns Hopkins University as a postdoc.

Synergy with ALMA

Since November 2010, the ALMA Santiago Central Office and ESO Chile have both occupied the same Vitacura campus. Together, there are about 100 astronomers, from PhD students to Fellows and staff astronomers. This generates a great opportunity for collaboration and cross-pollination of ideas, especially in areas related to star and planetary formation, disc structure, etc. To harness this, the Vitacura Science Coordination team was created. On the ESO side, the team comprises Claudio Melo and Dimitri Gadotti (both staff members) and the ESO Fellows Rebeca Aladro, Lizette Guzman, Javier A. Rodón. On the Joint ALMA Observatory (JAO) side, Masao Saito (staff) and the Fellows Violette Impellizzeri and Tracey Hill are involved, while Aya Higuchi, a former member of the team, has just left Chile. Themed groups were merged by having a coordinator on each side and joint colloquia and morning coffees are regularly organised. This helps to spread expertise and allow participants to acquire a common language. Cross-training sessions were held during the year and all science committees have JAO representatives. The pay-off will come when the common science projects mature.

Fostering collaborations

This was also an important year in Garching, with the inauguration of the new extension to the ESO Headquarters in December. This will finally gather together all ESO staff within two connected buildings and provide more space for hosting science visitors. There is a new auditorium with increased capacity for organising larger-scale conferences. The year saw a number of ESO-organised workshops on both sites and externally, including:

- Astrochemistry in the ALMA Era, Copenhagen, Denmark, 28–31 January
- Shaping E-ELT Science and Instrumentation, ESO, Garching, 25 February–1 March
- ESO Workshop on The Deaths of Stars and the Lives of Galaxies, Santiago, Chile, 8–12 April
- Science with ALMA Band 2 (65–90 GHz), Bologna, Italy, 27–28 May
- MPA/MPE/ESO/EC Joint Conference on The Physical Link between Galaxies and their Halos, Garching, 24–28 June
- First La Serena School of Data Science, La Serena, Chile, 12–16 August
- ESA/ESO Science Operations 2013 Conference, Working Together in Support of Science, ESAC-Madrid, Spain, 10–13 September
- ESO/NUVA/IAG Workshop on Challenges in Ultraviolet Astronomy, ESO, Garching, 7–11 October
- ESO/Observatoire de Paris Joint Workshop on Metal Production and Distribution in a Hierarchical Universe, CNRS Observatoire de Paris Meudon, France, 21–25 October
- ALMA Community Days 2013: Preparing for Cycle 2, ESO, Garching, 19–20 November
- ESO Workshop on Deconstructing Galaxies: Structure and Morphology in the Era of Large Surveys, Santiago, Chile, 18–22 November

– Workshop on 400 Years of Stellar Rotation, Natal, Brazil, 21–26 November

In Garching, a very full and exciting Science Day was held on June 18, including more than 70 short talks given by ESO junior and senior astronomers (read more in Walsh et al. in the September 2013 issue of *The Messenger*, 153). We should also emphasise the contribution and engagement of ESO science staff in the new C2PAP Computing Centre, which emerged in the context of the new contractual period for the Excellence Cluster Universe, following the partnership between the Munich universities (TUM, LMU), the Munich Observatory, several Max Planck Institutes and ESO. This will provide unique expertise and numerical resources for researchers to conduct state-of-the-art simulations and modelling campaigns.

We would finally like to mention an initiative at ESO to implement a development programme for Fellows. All ESO Fellows will now go through a set of training modules during their first two years including programme management, interview skills, and effective networking, all tuned to the needs of scientists. This development programme aims to assist Fellows in developing interpersonal and employability-related skills and competencies, thus improving their career prospects after completion of their ESO Fellowship. The programme was launched this year and, during the next couple of years, we should be able to further optimise the modules and sessions to provide a unique training package for young astronomers.

This image from the Wide Field Imager on the MPG/ESO 2.2-metre telescope at ESO's La Silla Observatory in Chile, shows the bright star cluster Messier 7, also known as NGC 6475.

Allocation of Telescope Time

The tables show the requested and scheduled resources for ESO Periods 92 and 93 (P92, P93). These are specified as lengths of time in nights, as is usual for the La Silla Paranal Observatory and APEX.

The call for ALMA Cycle 2 proposals was issued at the end of the year, resulting in almost 1400 submitted proposals. The ALMA Proposal Review Committee will meet early in 2014 and the full statistics will be reported in the 2014 Annual Report.

The APEX and La Silla Paranal Observatory 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 the allocated time. The last two columns present the total telescope time allocations and the fractions per instrument.

ESO/F. Kamphues

The Atacama Pathfinder Experiment is located 5100 metres above sea level, at Llano de Chajnantor in the Atacama Desert.

Telescope	Instrument	Requested runs	Scheduled runs	Requested time	%	Scheduled time	%	Pressure	Total allocation	%
UT1	CRIRES	128	36	139	16.0 %	31	19.6 %	4.56	31	12.0 %
	FORS2	485	101	531	60.9 %	87	55.7 %	6.11	111	43.4 %
	KMOS	162	39	202	23.1 %	39	24.7 %	5.23	114	44.6 %
Total		775	176	872		156		5.59	255	
UT2	FLAMES	121	51	147	35.8 %	82	38.8 %	1.80	141	51.8 %
	UVES	250	100	264	64.2 %	129	61.2 %	2.04	132	48.2 %
Total		371	151	412		211		1.95	273	
UT3	ISAAC	30	4	53	7.3 %	5	2.5 %	11.87	5	2.2 %
	VIMOS	184	38	262	35.7 %	53	29.1 %	4.93	63	30.8 %
	X-shooter	325	112	417	57.0 %	125	68.5 %	3.33	137	67.0 %
Total		539	154	732		183		4.01	204	
UT4	HAWK-I	59	31	65	14.2 %	27	14.7 %	2.43	33	16.6 %
	NACO*	246	9	193	42.0 %	3	1.6 %		3	1.5 %
	SINFONI	173	135	202	43.8 %	152	83.7 %	1.32	162	81.9 %
Total		478	175	460		182		2.53	197	
VLTI	AMBER	128	28	100	31.5 %	29	23.3 %	3.51	37	22.4 %
	MIDI	176	50	84	26.4 %	26	21.5 %	3.18	38	23.0 %
	PIONIER	105	71	134	42.1 %	68	55.2 %	1.98	90	54.6 %
Total		409	149	319		123		2.60	165	
3.6-metre	HARPS	64	39	342	100.0 %	112	100.0 %	3.05	331	100.0 %
Total		64	39	342		112		3.05	331	
NTT	EFOSC2	89	35	365	63.8 %	129	60.1 %	2.83	185	56.0 %
	SOFI	49	25	208	36.2 %	86	39.9 %	2.43	146	44.0 %
Total		138	60	573		215		2.67	331	
APEX	CHAMP+	3	1	6	3.3 %	1	1.9 %	4.88	1	1.4 %
	LABOCA	15	7	22	12.0 %	13	20.7 %	1.66	25	29.7 %
	SABOCA	7	1	10	5.7 %	2	2.8 %	5.89	2	2.1 %
	SHFI	45	15	143	79.1 %	47	74.6 %	3.04	57	66.8 %
Total		70	24	181		63		2.87	85	

* NACO was initially offered in P92, but was removed from UT4 before the start of that period. The instrument was then offered for the last two weeks of P93 at UT1. This explains the very small amount of allocated time during the reporting period. For convenience, the instrument is listed under UT4.

Dawn at Cerro Armazones, site of the future European Extremely Large Telescope.

ESO/S. Brunier

Publication Digest

In September 2013, the 10 000th paper was entered into the Telescope Bibliography (*telbib*), the database of refereed publications that uses ESO data (http://telbib.eso.org). This milestone was marked by an ESO announcement, highlighting the paper based on VIMOS data that crossed the 10k line (see Announcement ann13073: http://www.eso.org/public/announcements/ann13073/). Throughout the year, 840 papers by members of the ESO user community were added to *telbib*. The number of papers based on data from the various observing sites as well as the total number per year can be found in the table. An overview of publication statistics is also available from a dedicated webpage that links to the corresponding records in the *telbib* database (http://www.eso.org/sci/libraries/telbib_pubstats_overview.html).

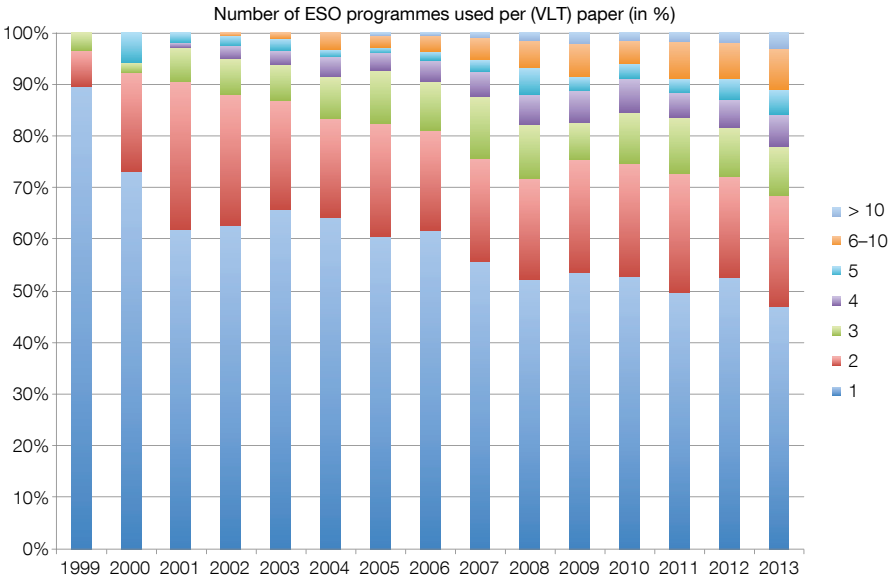
Scientific results using data from the Very Large Telescope (VLT/VLTI) led to more than 560 papers this year. With 117 refereed publications, UVES continues to be one of the most productive VLT instruments. The X-shooter spectrograph shows a steep increase in the number of publications and has produced a total of 168 papers from 2010 to 2013. For more detailed statistics of individual instruments, please consult the report, *Basic ESO Publication Statistics* (http://www.eso.org/sci/libraries/edocs/ESO/ESOstats.pdf).

Over time, an increasing number of programmes per paper have been used by authors. In 1999, the first year of VLT/VLTI publications, 90% of the papers were based on a single ESO programme, while in 2013 more than half used data from at least two programmes; 3% were even based on data provided by more than ten different programmes (see figure on the right).

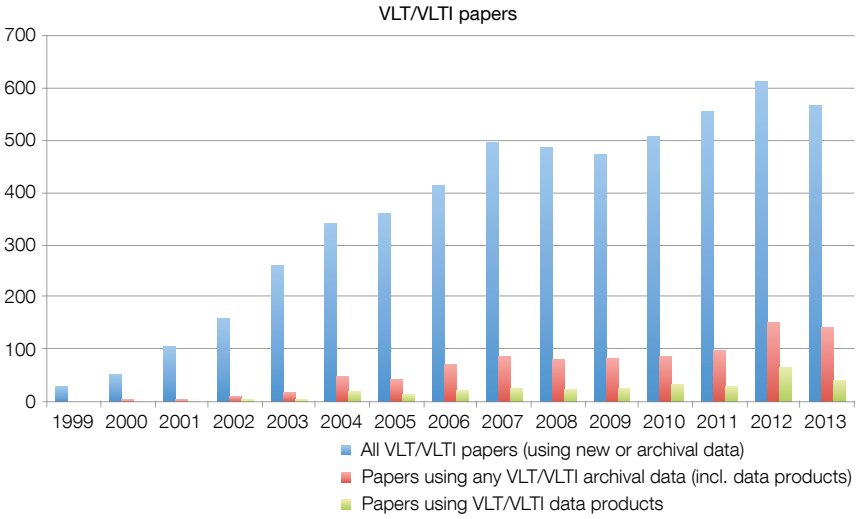
The ESO Science Archive continues to be an important resource for astronomers. By the end of the year, the *telbib* database contained more than 1300 papers that were exclusively or partly (i.e., along with proprietary data from ESO facilities) based on archival data: this corresponds to 13% of all *telbib* papers (1996–2013). For the VLT/VLTI, the percentage is even higher. In 2013, approximately a quarter of the papers made use of archival data

	VLT/VLTI	La Silla	Survey telescopes	APEX	ALMA	Total
1996		349				349
1997		389				389
1998		405				405
1999	29	324				348
2000	52	300				342
2001	105	316				399
2002	158	289				409
2003	260	305				512
2004	341	319				590
2005	359	296				606
2006	413	279		12		640
2007	494	313		1		718
2008	486	287		7		687
2009	471	260		15		658
2010	507	273	2	27		734
2011	553	283	13	26		782
2012	612	271	30	40	17	864
2013	565	273	38	43	40	840

Refereed papers using ESO data, 1996–2013. Papers can use data from more than one facility. VLT/VLTI: Papers using data generated by the VLT and VLTI instruments, including visitor instruments for which observing time is recommended by the ESO Observing Programmes Committee, e.g., VLT ULTRACAM, VLTI PIONIER. La Silla: Papers using data generated by facilities on La Silla, including visitor instruments for which observing time is recommended by the ESO OPC, e.g., NTT ULTRACAM. Papers based on data from non-ESO telescopes or observations obtained during "private" periods are not included. Survey telescopes: Papers using data generated by ESO's survey telescope VISTA. APEX: Papers using data generated by APEX, including visitor instruments for which observing time is recommended by the ESO OPC, e.g., Z-Spec. Other visitor instruments (e.g., APEX/CONDOR) are excluded. Only papers based (entirely or partly) on ESO APEX time are included. ALMA: Papers using data generated by ALMA. Only papers based (entirely or partly) on European ALMA time are included.



Number of ESO programmes that provided data for VLT/VLTI papers 1999–2013.



Number of ESO programmes used per VLT/VLTI paper.

(142 out of 565). In addition to raw data, the ESO Archive also contains various data products. Data products retrieved by researchers were used in 7% of all VLT/VLTI publications in 2013 (40 out of 565; see figure above), and in 28% of the VLT/VLTI papers that deploy archival data (40 out of 142).

Facilities located on La Silla provided data for 273 papers. The HARPS planet finder, mounted at the ESO 3.6-metre telescope, played a major role as 73 papers used its observational data. Also older facilities such as FEROS, SOFI, and EFOSC2 continue to provide data for numerous scientific papers. Non-ESO telescopes (for instance the Swiss 1.2-metre Leonhard Euler Telescope) and other facilities for which observing time is not evaluated by the ESO OPC (Observing Programmes Committee) are not included in the statistics.

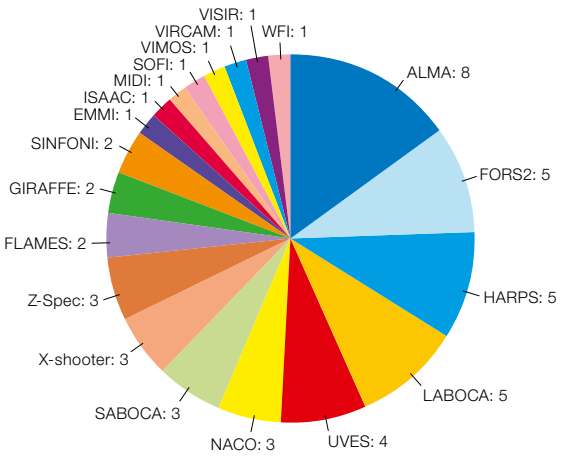
VISTA, located in close proximity to the VLT/VLTI, is ESO's first telescope dedicated to surveys. In the past year, 38 papers were published. Almost half of them (15) deployed data from the VVV survey, followed by papers using data from the UltraVISTA (7), VIPERS (5), VIDEO (5) VMC and VHS (3 each) and VIKING (2) surveys.

The number of APEX publications had climbed above 170 by the end of the year. This includes only scientific results from observations that were obtained during ESO/APEX time and constitutes 55% of all APEX publications that have appeared since 2006 (171 out of 308).

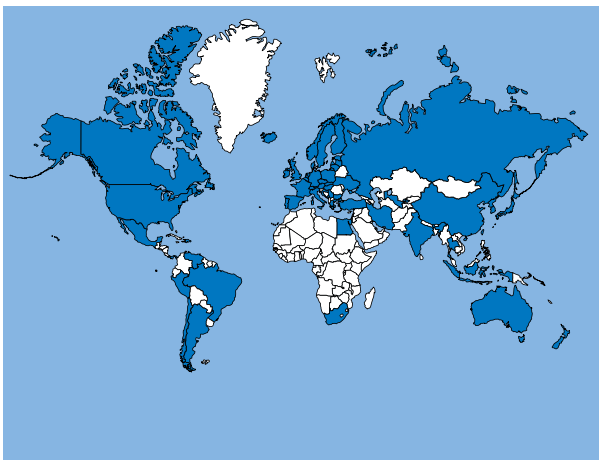
The *telbib* database also includes information about ALMA science papers. With 17 science papers published in 2012 and 40 this year, European ALMA time provided data for 67% of all ALMA papers published until the end of 2013 (57 out of 85). The ALMA bibliography is maintained jointly by the librarians at ESO and National Radio Astronomy Observatory (NRAO) as well as by the National Astronomical Observatory of Japan (NAOJ). While publications based on data from all ALMA partners are recorded in *telbib*, only those based on European observing time are counted in the ESO statistics.

This year, 27 scientific papers were featured in ESO press releases. The *telbib* database provides direct links to the respective press releases; likewise, science press releases link back to *telbib* and further into the ESO Archive from where the relevant observing data can be retrieved. The science press releases issued this year highlighted research from a variety of facilities. ALMA provided results for eight papers, followed by the FORS2 spectrograph, HARPS, and the LABOCA camera, which led to five press releases each. An overview of all instruments is shown in the figure, bottom left.

The ESO user community is truly worldwide. At present, *telbib* contains papers by first authors from 60 countries on all continents. Compared to 73 national members in the International Astronomi-



Left: Number of papers per instrument featured in ESO press releases in 2013.



Right: World map of first authors of ESO science data papers (dark blue).

cal Union, this leaves only a few white spots on the map of astronomically active countries. This wide geographic distribution shows ESO's importance in astronomical research and its international connectedness as illustrated in the map at the bottom of the previous page.

The statistics presented here are derived from the ESO Telescope Bibliography (*telbib*), a database of refereed papers published by the ESO user community that links publications with the data in the ESO Science Archive. *telbib* is developed and maintained by the ESO Library. It is compiled by scanning articles published in the major astronomical journals (the journals routinely screened for ESO-related keywords are: A&A, A&ARv, AJ, ApJ, ApJS, AN, ARA&A, EM&P, ExA, Icar, MNRAS, *Nature*, NewA, NewAR, PASJ, PASP, P&SS and *Science*) for relevant keywords (e.g., telescope and instrument names). All papers included in the database have been inspected visually to ensure that they use ESO observational data directly. Further information about *telbib* and various statistics and reports can be found at http://www.eso.org/sci/libraries/telbib_info.html.

The complete list of all 2013 papers is available at http://www.eso.org/libraries/telbib_info/AR/ESO_AnnualReport_publications2013.pdf. The file includes papers written by the ESO user community based on data generated by ESO facilities, followed by a separate listing of refereed publications by ESO scientists with or without use of ESO data.

Located about 1200 light-years from Earth in the constellation of Carina, the Toby Jug Nebula, more formally known as IC 2220, is an example of a reflection nebula. It is a cloud of gas and dust illuminated from within by a central star.

Operations

ESO/Y. Beletsky

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 (LPO) 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 Science Archive Facility holds all the data obtained with ESO telescopes as well as highly processed, advanced products derived from them. The directorate also provides ESO's contribution to ALMA operations through the European ALMA Support Centre (EASC).

Spectacular view from ESO's La Silla Observatory in northern Chile. Above the round domes of the telescopes, three of the planets in the Solar System — Jupiter (top), Venus (lower left), and Mercury (lower right) — are revealed after sunset.

Operations

The ESO Very Large Telescope at Paranal operates with four 8.2-metre Unit Telescopes, a suite of ten first generation instruments and two second generation instruments. The Laser Guide Star Facility (LGSF) provides an artificial reference star for two of the three adaptive-optics-supported instruments on the VLT. The VLT Interferometer combines the light of either the UTs or the ATs 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, and the VST, the VLT Survey Telescope, are in regular survey operation.

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

The observatory provides the operations support for the Atacama Pathfinder Experiment with its 12-metre submillimetre radio antenna located on the high plateau of Chajnantor at 5100 metres above sea level and its suite of heterodyne and bolometer facility instruments, together with a number of visitor instruments.

For observing periods 91 and 92, the scientific community submitted respectively 890 and 892 Phase 1 observing proposals for the LPO including APEX. These were the lowest numbers of observing proposals received in recent years, but still demonstrate the continued high demand for the ESO observing facilities. Some 80% of the proposals are for the Paranal site with VLT, VLTI and VISTA.

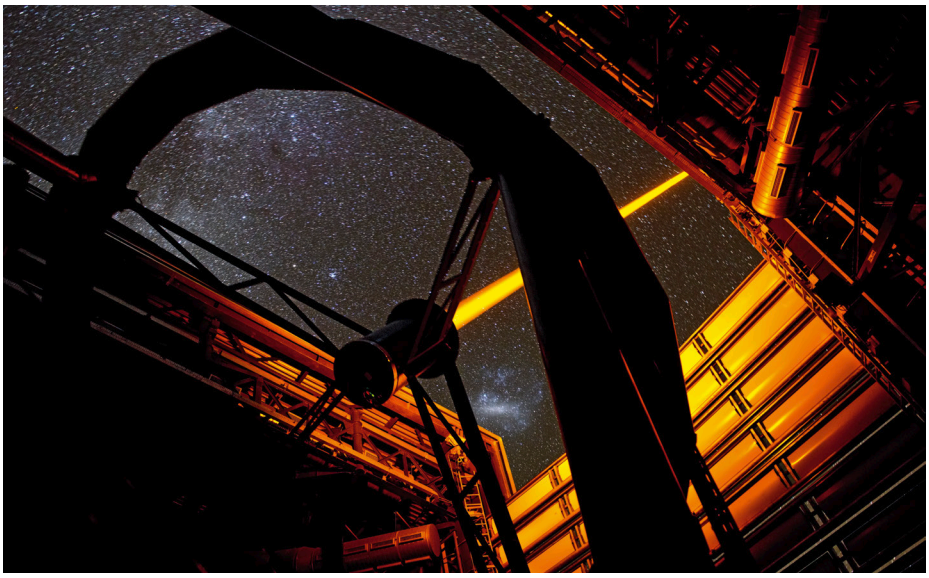
The observatory continued its efficient operation through high availability and low technical downtime of its telescopes and instruments, which are the key elements for productive scientific observations. In 2013 a total of 2281 nights were scheduled for scientific observations with the four UTs at the VLT and with the three major telescopes at La Silla. This is equivalent to about 92% of the total number of nights theoretically available over the whole year. The remaining 8% 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, 3% was lost due to technical problems and about 12% due to adverse weather conditions. On La Silla, bad weather accounted for losses of about 13% and technical problems for less than 1%. After unusually high loss times in 2012 due to single but significant failures at UT4 and the NTT, the technical loss times in 2013 returned to the expected levels.

VISTA delivered 295 nights of survey observations out of 364 scheduled nights. The VST delivered 257 nights of survey observations out of 347 scheduled.

Complementary to regular VLT operations, the VLT Interferometer was scheduled for an additional 227 nights to execute scientific observations using baselines with either the UTs or the Auxiliary Telescopes (ATs). The remaining nights of the year have been used for technical activities and for further development and commissioning of the interferometer and its infrastructure. In addition to 96 engineering nights some 38 nights were invested in the continued recovery and commissioning of the PRIMA astrometry facility. Four percent of the scheduled VLTI science time was lost due to technical problems and 15% due 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 high scientific productivity. We have counted 565 peer-reviewed papers that have been published in 2013 in different scientific journals that are at least partially based on data collected with VLT and VLTI instruments at Paranal. In addition 38 refereed papers were published referring to observations with VISTA and the VST at Paranal and 273 referring to ESO-operated telescopes at La Silla. Seventy-four

papers were based on APEX observations, out of which 43 used observations during the 24% share of ESO time. Since the start of operations in 1999 the VLT and VLTI have produced a total of 5405 publications, a number that is increasing by about a dozen every week. Interestingly, the veteran workhorse instruments UVES and FORS2 — both commissioned at the start of the VLT operation — still lead the publication statistics of all ESO instruments in 2013 with 117 and 101 publications, respectively. They are followed by VIMOS with 75 publications and the second generation instrument X-shooter with 70 publications in its fourth year of operation.



G.Hüdepohl (atacamaphoto.com)/ESO

The new PARLA laser in operation at ESO's Paranal Observatory.

Paranal Observatory

Instrumentation

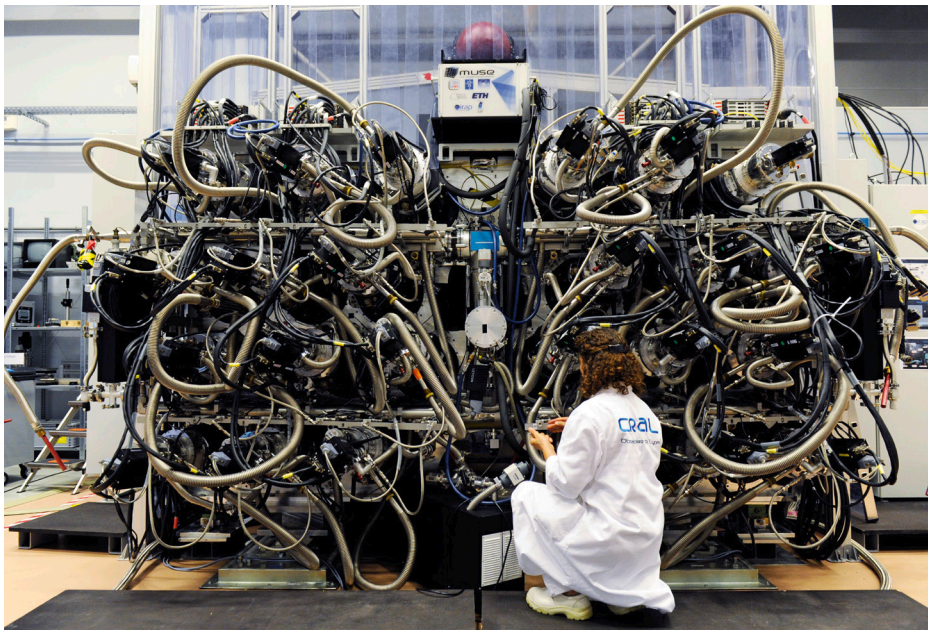
The observatory has been eagerly awaiting the arrival of the second generation VLT instruments KMOS, MUSE, and SPHERE after a gap of several years since the arrival of X-shooter.

The *K*-band Multi Object Spectrograph (KMOS) was the first of the trio to arrive at the telescope in late 2012 and was successfully commissioned early this year. After its full characterisation and integration into the VLT end-to-end operation scheme, the new instrument entered regular science operation on 1 October. The key capability of KMOS is to perform integral field spectroscopy in the near-infrared wavelength bands for 24 scientific targets simultaneously. For this the instrument design employs 24 configurable arms that position pick-off mirrors at user-specified locations in the Nasmyth focal plane of the Antu (UT1) telescope of the VLT. The sub-fields thus selected are then fed to 24 image slicer integral field units that partition each sub-field into 14 identical slices, with 14 spatial pixels along each slice. Light from the integral field units is then dispersed by three cryogenic grating spectrometers that generate 14 × 14 spectra with some 1000 Nyquist-sampled spectral resolution elements for each of the 24 independent sub-fields. The patrol field of the pickoffs is 7.2 arcminutes in diameter, which is the diameter of the unvignetted field at the VLT Nasmyth focus, thus minimising the thermal background in the *K*-band. Each integral field unit has a square field of view of 2.8 × 2.8 arcseconds; anamorphic magnification in the integral field units fore-optics ensures uniform spatial sampling of 0.2 × 0.2 arcseconds whilst maintaining Nyquist sampling (~ 2 pixel) of the spectral resolution element at the detector. The use of focal-plane pick-off arms allows considerable flexibility in selecting targets and, in particular, dealing with the strongly clustered or close-paired sources often found in clusters of stars or galaxies.

Shortly after KMOS had left the new integration hall it was immediately reoccupied by the next project: PARLA, the new laser source for the LGSF at Yepun (UT4). It replaces the original PARSEC laser after its six years of operation and PARLA has already demonstrated a greatly improved reliability and flexibility in operating the LGSF with the NACO and SINFONI adaptive optics instruments. It takes advantage of the new solid-state Raman fibre laser technology that will also be employed in the Four-Laser Guide Star Facility (4LGSF) of the Adaptive Optics Facility (AOF). The new laser source delivers up to 20 watts of continuous output power and is very stable. PARLA was successfully installed and commissioned at UT4 in January and February and since then has reliably delivered — in a reduced power mode — 7 watts of laser power into Paranal's sky, generating an artificial star about 90 kilometres up in the atmosphere. By creating and observing such a bright point of light, astronomers can probe the turbulence in the layers of the atmosphere above the telescope. This information is then used to adjust deformable mirrors in real time in order to correct most of the disturbance caused by the constant movement of the atmosphere and so create diffraction-limited images.

In the same month that KMOS commenced science operation, the preparations for the arrival of the Multi-Unit Spectroscopic Explorer (MUSE) to the Yepun (UT4) telescope started with the removal of the NACO instrument from the designated UT4 Nasmyth focus. Despite its advanced age, and in a departure from the original plan to decommission NACO at the time of arrival of MUSE, NACO was stored after its removal from the telescope and will be re-installed at UT1 in mid-2014 in place of CRIRES. CRIRES itself will undergo a major upgrade to be converted into a cross-dispersed high-resolution infrared spectrograph. Once NACO was dismounted, the modifications of the adaptor/rotator to increase the back focal length of the Nasmyth focal station could be initiated. MUSE and its future adaptive optics

module GALACSI require an increased spacing between the telescope-instrument rotator and the focal plane of the telescope to accommodate the necessary additional optics. While it is easy to shift the focal plane of the telescope by slightly moving its secondary mirror, the telescope's guiding system required a major opto-mechanical modification to absorb the additional optical path length inside the guide probe arm of the telescope. Commissioning the modified Nasmyth focus meant, in practice, re-commissioning the telescope according to the procedures established some 15 years ago during the initial VLT commissioning. The back focal length commissioning confirmed that the modification was successful and that the MUSE Nasmyth adaptor with its increased back focal length performs as well as any other focal station.



Eric Le Roux/Service Communication/UCBL/MUSE

MUSE is a new and uniquely powerful instrument to be installed at ESO's Very Large Telescope UT4 (Yepun).

The assembly, integration and verification activities of the MUSE instrument itself started in Chile with the arrival of the first 48 boxes bringing the disassembled instrument to Paranal. Shortly afterwards, the MUSE team started to re-assemble this complex instrument, with its 24 integral field units and spectrographs, in the new instrument integration hall at Paranal. By the end of the year the MUSE team had successfully completed this task and prepared the instrument for its transfer to the UT4 telescope in early January 2014 for subsequent first light and commissioning.

While MUSE was being prepared for its move to the telescope in December, the Spectro-Polarimetric High-contrast Exoplanet REsearch (SPHERE) passed its provisional acceptance in Europe and is expected to arrive in boxes at Paranal early in 2014, just as MUSE has been cleared from the new integration hall.

The UT3 focal station designated for SPHERE was still occupied by ISAAC. On 12 December, ISAAC was switched off and became, after FORS1, the second first generation VLT instrument to be decommissioned. ISAAC has been one of the most productive of the VLT instruments and has contributed to some 846 refereed scientific publications over its operational lifetime from 1999 to 2013 — and these will not be the last. In particular, the delta-call for proposals for ISAAC in observing period 91 attracted the attention of the ISAAC community with 153 proposals submitted, requesting a total of 2500 hours of observing time. From these, 800 hours of UT3 telescope time, which had become available due to the delays with the upgrade of the VISIR instrument, were easily filled and made many PIs and the observatory happy. It was possibly this unplanned consolation that helped the ISAAC community to accept the decommissioning of their instrument so valiantly and quietly.

Knowing that ISAAC would have to be decommissioned in December to make room for SPHERE, and having realised that VISIR would not be ready to come back to the UT3 telescope in period 92, an opportunity to provide the heavily oversubscribed X-shooter instrument with more observing time was recognised. In October, X-shooter was transferred from the Cassegrain focus of UT2 to the Cassegrain focus of UT3 where it currently only competes with VIMOS. X-shooter is expected to return to UT2 once SPHERE goes into regular operation, VIMOS starts the envisioned large public spectroscopic surveys, and the upgraded VISIR is ready to go on-sky again.

Telescope systems

The VLT Unit Telescopes continue to be extremely reliable systems, despite the fact that some of them are already approaching 15 years of continuous operation. A dedicated obsolescence programme has been initiated this year to ensure the continued high availability and maintainability of the telescopes and their subsystems for the years to come. This year, the biggest losses in observing time related to the telescope systems were caused by major failures of the rotation mechanisms of the UT4 and UT1 enclosures, which led in total to a loss of more than ten nights of observing time. While the damaged bogie in UT4 could be repaired *in situ*, the failing bogie in UT1 had to be dismounted for a full overhaul in the Paranal workshop.

The 8-metre coating unit remained a major source of concern for the observatory. Despite intensive internal efforts to track down the root causes of the degraded quality of the aluminium coatings produced on the VLT mirrors, no stable and reproducible coating process could be re-established this year. Consequently, the observatory has been seeking external help through a consultancy

with a consortium of Danish companies specialising in large vacuum and coating machines. This collaboration has now shown the first positive results and, despite some initial setbacks, we are confident that a full recovery plan can be established and implemented in the coming year, followed by a new and tailored preventive maintenance plan for the future.

Infrastructure

Paranal Observatory critically relies on the production of its own electrical energy in so-called *island mode*, i.e., without connection to any national electrical distribution grid. For several years the core of this energy production system has been a multi-fuel power generator backed up by a set of diesel generators. This year the generator provided the observatory with 10 GWh of energy using some 6.5 million litres of liquefied petroleum gas (LPG), more specifically, catalytic butane gas. To ensure that the generator continued to operate reliably a scheduled overhaul was carried out this year after five years of quasi-continuous operation. Part of this major maintenance activity was the replacement of the heart of the generator, the turbine itself. The turbine was successfully replaced by a spare and sent for refurbishment to the provider. The overhaul provided, in addition, the opportunity to test the generator with LPG based on propane as the primary fuel. This test was successful and gives the observatory some additional flexibility to react to the quickly changing availability of butane and propane gas on the Chilean market.

The successful maintenance of the generator was rewarded by a run of 1000 days and nights without an unplanned power blackout: a record that was quietly celebrated by the observatory. But only two weeks later, on 7 August and after 1016 days, the unavoidable blackout occurred due to the failure of a critical programmable logic controller (PLC) in the control system of the power station. Analysis of the root cause of the failure allowed additional improvements for the reliability and robustness of the power system to be identified and implemented. The days-without-blackout counter is now running again.

La Silla Observatory

La Silla Observatory continued to operate successfully according to the 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 MPG/ESO 2.2-metre telescope operated according to an agreement with the Max Planck Institute for Astronomy (MPIA, Heidelberg, Germany). This agreement ensured the continued operation of the MPG/ESO 2.2-metre telescope until the end of September 2013 with an ESO share of 25% of the available observing time in response to the continued requests by the community for the FEROS and WFI instruments. As of October, ESO's operation of the MPG/ESO 2.2-metre telescope ceased, but the telescope continues to be operated by the MPIA as an ESO-supported national telescope. All scientific data produced by the MPG/ESO 2.2-metre telescope with the WFI, FEROS, and GROND instruments continue to be ingested into the ESO Science Archive and become available to the community after programme-specific proprietary periods.

In addition the La Silla Observatory continues to support scientific projects at other national telescopes, i.e., the Danish 1.54-metre, the Swiss 1.2-metre Leonhard Euler Telescope, the Rapid Eye Mount, TAROT-S, the 1-metre ESO Schmidt, TRAPPIST and the ESO 1-metre telescopes.

APEX project

The Atacama Pathfinder Experiment continued to operate its 12-metre antenna and its suite of heterodyne and bolometer facility instruments and visitor instruments. This is done in a quasi-continuous 24-hour operation mode that maximises the exploitation of the exceptional conditions available at the site of Chajnantor at 5100 metres above sea level. This year a total of 237 days and nights were scheduled for science observations with APEX, out of which 194 could actually be used, with close to 4000 hours of on-sky science time.

This number is close to what was achieved in the year before, despite the fact that the 2013 APEX science operation was severely affected by five snowstorms that led to a total loss of about 22 days of observing time. In particular, the second half of June was lost for science observations due to several severe snowstorms. The high site infrastructure and the power generation in particular withstood the first snowstorm over a period of three days without breakdowns. Unfortunately the second storm caused a failure at the powerhouse. The high site could not be reached for several days. Therefore, the power could only be reinstated after the antenna, the instruments and the control buildings had already reached the local environmental temperatures, causing additional delays to the start of the science operation. With a huge effort by the APEX staff, as well as the visiting ArTeMiS team, it was possible to thaw the powerhouse and recover the power within two days. The first observations with the technical optical telescope could be performed after just one day and after only one further day, science operations started again with the recovered facility instruments.

The personnel strike at ALMA restricted access to the APEX site at Chajnantor and resulted in an additional loss of 94 hours of science time.

The APEX project is a partnership between the Max Planck Institute for Radio Astronomy (MPIfR, Bonn, Germany, 50% share), ESO (27% share) and the Onsala Space Observatory (OSO, Sweden, 23% share). Considering the continued success of the project, the APEX partners had recently extended their agreement to 31 December 2015 with a provision for a further extension until the end of 2017 "*if the performance of APEX is positively reviewed two years before the expiration of this Agreement*". The APEX project held a corresponding external review at APEX Sequitor in February and the review board "*[…] strongly recommends to extend the current APEX agreement through 2017, and to keep open the option to extend its operation until at least the end of this*

decade". Considering this positive recommendation, the APEX partners confirmed during the year their shared desire to maximise the scientific returns on their investments in APEX and to seek an extension to the APEX Agreement until 31 December 2017. It is expected that the corresponding agreement will be signed in early 2014.

The competitiveness of APEX in the era of a fully operational ALMA depends strongly on its survey capabilities and therefore on the results of the ongoing receiver developments at the APEX partners, in particular in the area of large-sized continuum cameras with several thousand detector elements. The first commissioning of one of these new instruments, called ArTeMiS (Architectures de bolomètres pour des Télescopes à grand champ de vue dans le domaine sub-Millimétrique au Sol — Bolometer arrays for wide-field submillimetre ground-based telescopes) has been an important step in this direction. ArTeMiS is a bolometric camera built by the Commissariat à L'Energie Atomique (CEA in Saclay, France) and designed for operations in the Cassegrain cabin of APEX. It operates at three wavelengths (450, 350 and 200 µm) simultaneously. Its 4608 pixels provide fully sampled images covering 4 × 2 arcminutes at 350 and 450 µm, with an additional 1152 pixels covering 2 × 1 arcminutes at 200 µm. The camera uses the technology of the Photodetector Array Camera & Spectrometer onboard the Herschel spacecraft, a technology developed at the CEA. During the first commissioning the focal plane was only partially populated with a subset of detectors, but the instrument was already outperforming the 32-pixel SABOCA facility instrument at APEX. To make this exciting new instrument available to its community, ESO has started negotiations with the CEA about the terms of such an agreement. It is expected that proposals for the fully commissioned ArTeMiS instrument will be accepted for the second half of 2014.

ArTeMiS team/ESO

ArTeMiS instrument installed in the Cassegrain cabin of the APEX telescope.

ArTeMiS team/Ph. André, M. Hennemann, V. Revéret et al./ESO/J. Emerson/VISTA Acknowledgment: Cambridge Astronomical Survey Unit

First ArTeMiS science observations of NGC 6334 (The Cat's Paw Nebula). The picture shows the glow detected at a wavelength of 350 µm coming from dense clouds of interstellar dust grains. The new observations from ArTeMiS show up in orange and have been superimposed on a view of the same region taken in near-infrared light by ESO's VISTA telescope at Paranal.

ESO/B. Tafreshi (twanight.org)

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

Data Management and Operations Division

The Data Management and Operations Division is responsible for off-site operations and user support for the La Silla Paranal Observatory and the European segment of ALMA. The DMO ensures that existing and future ESO facilities can be exploited efficiently, based on an integrated end-to-end operations approach.

European ALMA Regional Centre

Now well into Early Science operations, which began in September 2011, the European ALMA Regional Centre continued to support all European Principal Investigator ALMA projects in 2013, from the technical preparation of their projects — split into Scheduling Blocks, their execution and quality assurance, through to data delivery and post-delivery quality control. The ARC also continued to run the ALMA Helpdesk, through which all communications with ALMA users take place. In February, and with an ever-increasing data acquisition rate, the ALMA project passed yet another milestone, as the ALMA Archive opened to users from all over the world.

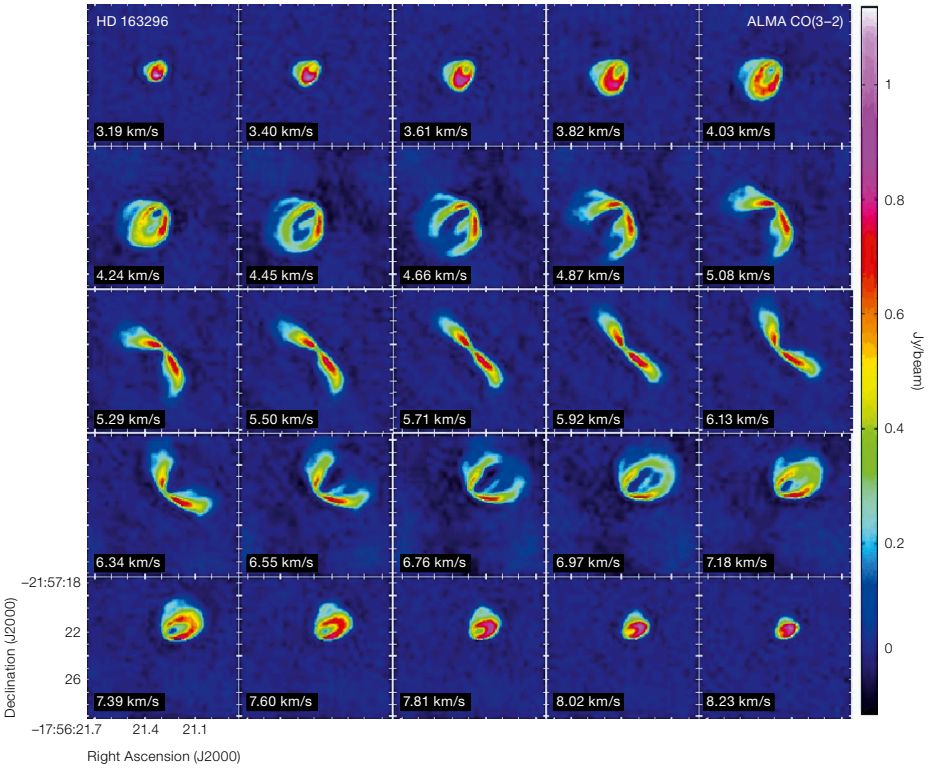
The data produced during ALMA observations, along with their calibrations, are stored in the ALMA Archive, where this year alone, 26.7 terabytes of data were ingested. In the same period, a total of 24 Cycle 0 and 22 Cycle 1 deliveries of Scheduling Blocks to European PIs were carried out, corresponding to 17 Cycle 0 and 15 Cycle 1 unique European projects, respectively. The quality assurance for more than 80% of these deliveries was carried out by the European ARC and ARC node staff.

A notable feature of the archive is data delegation, which allows PIs to give access to their proprietary datasets to one or more registered ALMA users without having to give them their credentials. All ALMA scientific datasets are subject to a proprietary period of twelve months from the date that they are delivered to the PI, at the end of which period they become publicly available. Since the opening of the archive it has been possible to query both public and proprietary data through the archive interface, according to a variety of search criteria, such as object name or position, frequency or spectral resolution, project ID or PI name and many more. An archive query returns a results table that allows users to identify and sort observations matching their search criteria and to select one or more datasets for download.

The number of peer-reviewed publications presenting results obtained with ALMA data is rapidly increasing. Out of the 65 peer-reviewed ALMA articles published this year, 20 came from ALMA projects led by European PIs, while another 20 were made possible thanks to Science Verification data, released in 2012. To date, about half of all ALMA peer-reviewed publications report discoveries on topics within the Star Formation and Interstellar Medium category. This category also received the largest number of requests for ALMA observing time in Cycle 0. An example of these results is shown in the figure below, which reports the spectral channels of the CO(3–2) line emission from a circumstellar disc around HD 163296, a five-Myr-old Herbig Ae star at a distance of 122 pc.

These channel velocity maps unveil, for the first time at submillimetre wavelengths, details of vertical structure, revealing both the back and the front side of a flared disc in Keplerian rotation (de Gregorio-Monsalvo et al. 2013, A&A, 557, 133).

A parallel activity of the ARC department is user support to ESO astronomers requesting observations with the APEX facility. During the year, the APEX support group in Garching provided extensive input to the APEX external review in February, which recommended the APEX agreement be extended up to the end of 2017. This extension was approved by Council in December. In particular, the collected statistics show that the ESO APEX user community is very broad, consisting of 1400 individual scientists. Another development this year was the installation of the ArTeMiS camera at APEX (see p. 35), which will now be offered to the ESO community as a replacement for SABOCA.



ALMA Science Verification data showing a CO(3–2) emission line towards the circumstellar disc around HD 163296.

The User Support Department

The User Support Department provides support to users of ESO facilities and to the operations teams of the LPO. In its day-to-day operations the department's astronomers support, review and optimise the preparation of observing material (also known as Phase 2 material) submitted by authors of accepted Service Mode programmes. This is to ensure compliance with Service Mode policies and to check the efficiency and adequacy of the proposed strategy for achieving the scientific goals. For Visitor Mode users, the department provides travel and logistic (organisational) support via its visiting astronomer travel office.

This year, the ISAAC delta call, issued during Period 90 in order to exploit the cancellation of some commissioning slots, represented a deviation from the standard *modus operandi*. On a very short timescale, it required the support of 83 new Service Mode runs (~ 20% increase), totalling more than 700 hours of telescope time. The smooth entry into operation of the new KMOS spectrograph was also achieved thanks to the dedication of support astronomers within the department, who played a major role in the implementation and execution of the Science Verification observations proposed by the community.

The department continuously hones the optimisation of its services to its main customers. In this respect we have improved the retrieval of observing information (e.g., night logs) for our users. The Garching version of the Night Log Tool (gNLT) now allows both Service and Visitor Mode PIs, as well as data/Phase 2 delegates, to request on-the-fly generation of a PDF night report for a specific observing night or a range of nights. This PDF night report has the same content as the night reports that users receive if they are subscribed to the e-mail service. The new gNLT release included some improvements for the access to the raw data in the ESO Archive, directly from the run progress pages. The web interface to request Programme Change Requests (related to either a target or an instrument set-up) was also modified so that Phase 2 delegates can now submit change requests on behalf of the PI.

The department is also involved developing projects, and so interacts with the user community at large on broad operational topics. During the past year, the department has continued working, for both ESO and its community, towards standardising of the operational metrics that have been identified as the most reliable, and offering informative health and efficiency checks. Furthermore, the online travel form for visiting astronomers was completely revamped as part of the upgrade of the visiting astronomer travel tools and released to the community in August. The new form takes advantage of the information stored in our operational databases such as the User Portal and the observation schedule. It relies on a three-step process, validating the incoming data, and delivering the travel request directly to the visiting astronomer travel office.

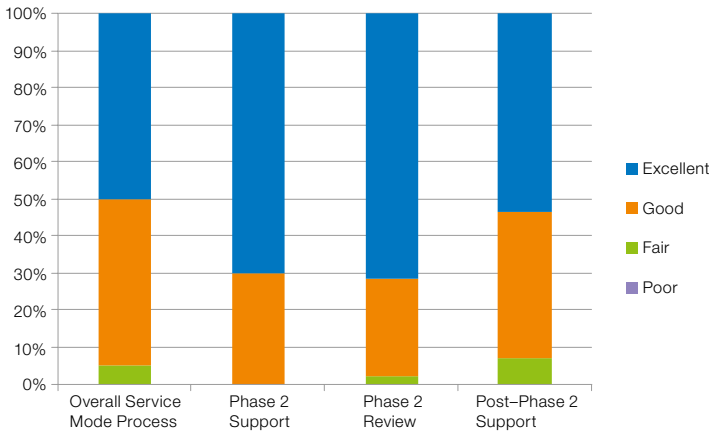
Regarding meetings, the highlight of the year was the co-organisation of the ESA/ESO Science Operations 2013 conference, held at the European Space Astronomy Centre (ESAC, Madrid) in September. The meeting brought together ground- and space-based communities working in science operations and was very well attended (150 participants). The programme covered all operational aspects, from project initiation, instrument design/review to Phase 1/2/3, observing strategy, community support, calibration, archive and data legacy. A detailed report of the content of the meeting was published in the December issue of *The Messenger* (No. 154 http://www.eso.org/public/products/messengers/Messenger_0154/).

Last but not least, the User Support Department is responsible for the organisation of the annual Users Committee meeting (see the Committees section of this report). During this forum — usually occurring in April — ESO representatives from various operational units meet with representatives of the users in all ESO Member States and Chile to openly and constructively discuss their respective communities' feedback. Users are generally satisfied with the services that ESO offers (see the figure below) and ESO is eager to receive suggestions for further improvements.

Back-end Operations Department

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 the expected and published ranges. Taking advantage of a fast data transfer link and dedicated data-processing and analysis tools, the quality control loop between Paranal and Garching is routinely closed on a timescale of about one hour. During this year the group processed about 8.5 TB of VLT/VLTI raw data in almost 150 000 processing jobs. In addition, 23 TB of data from the survey telescopes VISTA and the VST were processed to monitor the instrument performance and data quality. This is almost three times as much as the entire suite of all VLT/I instruments.



The main outcome of the Service Mode feedback campaign of 2013. Represented here are the results in the areas for which the User Support Department is principally responsible.

Complying with ESO policy, 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 Archive Science group has developed, in close collaboration with the Directorate of Engineering, 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). In addition to images, spectra, etc., the Phase 3 infrastructure also seamlessly handles source catalogues that are, arguably, the ultimate data product from the Public Surveys. This year marked two major milestones for ESO's Science Archive Facility with respect to data products. The first was that all of the eleven Public Surveys currently running have provided high quality advanced data products for publication to our community. This event was marked by a dedicated section in the December 2013 issue of *The Messenger*, with contributions from ESO and the survey teams, as well as archive users using the data products for their own science. Secondly, we started the massive publication process for data products generated in-house through the Science Archive Facility by running the corresponding data reduction pipelines on both the incoming raw data stream and historical data (reprocessing). These are accessible through the same interfaces as the Public Survey and Large Programme data products, providing a seamless user experience directed towards answering a user's scientific questions. We started by publishing about 100 000 UVES spectra with more instruments to follow during the course of 2014.

ESO's continuing efforts to improve the scientific quality of the data products are coordinated by the Science Data Products group. Support for user data reduction was enhanced by releasing Reflex workflows for SINFONI, a VLT first generation instrument that is much in demand, and the newly operational KMOS. Support for KMOS was also seamlessly introduced in the quality control loop and Science Archive Facility. In addition to the capability to run the data reduction modules, Reflex provides the capability to organise and associate the input data, as well as to interact with the data and to incorporate custom tools written in the popular *python* language.

Science Archive Facility

The Science Archive Facility is the single distribution point for all ESO data. This includes access to proprietary data for both Visitor and Service Mode runs, a process that is limited to the corresponding PIs and their authorised delegates for the duration of the proprietary period (typically one year). The time delay between the execution of an observation at the telescope and the moment at which the corresponding files become available for download through the Science Archive Facility was further reduced to a fraction of an hour. Several time-critical programmes benefitted from this, enabling them to fulfil their science goals.

Following the addition of more than 80 TB (in 4.5 million files) of new data this year, the total archive holdings now approach the 400 TB mark. Close to 33 000 archive data requests were made in the year (four million files), either accessing the web interfaces or programmatically. These correspond to the activities of more than 2100 unique archive users.

This year, the Science Archive Facility remained a strong contributor to ESO's scientific output as measured by the number of refereed publications. In fact, a quarter of the refereed papers published in the year from the VLT/I used exclusively or partly (i.e., in combination with new ESO observations) data retrieved from the ESO Archive (more details are given in the Publication Digest on p. 27).

Computer room at the Paranal control building.

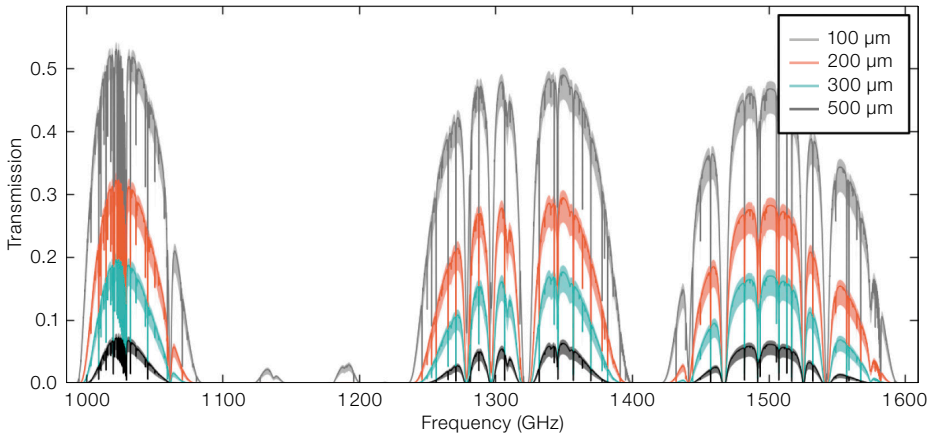

WGSOFF3
WU3DHS
WVMOS
WVISIR

European ALMA Support Centre

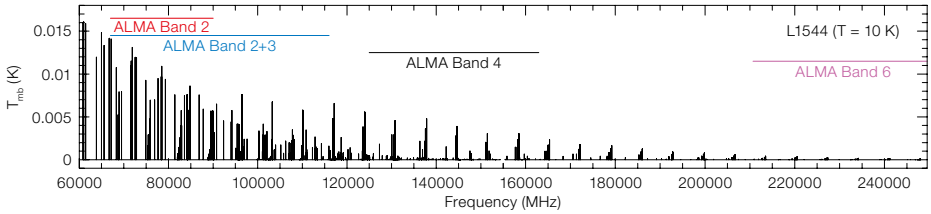
The European ALMA Support Centre is ESO's operations unit for ALMA and comprises the ALMA Regional Centre, ALMA offsite technical maintenance and development support, and ALMA science and outreach. The high-level scientific representation and scientific guidance of the European ALMA project will continue 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. EASC is the face of ALMA for the European scientific community and the international ALMA partners for ALMA operations. It 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. During 2013, EASC played an increasingly significant role in ALMA operations.

For the scientific user community, the central ARC at ESO Garching and the ARC nodes in Europe are the primary interfaces for individual ALMA users. 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, the European ALMA Regional Centre has been of important for the success of Early Science Cycle 0 and 1 observations and high quality data delivery. In addition, intensive preparations for Early Science Cycle 2, scheduled to start in June 2014, were carried out. More details regarding the ARC are given in the DMO section starting on p. 38.

At the beginning of the year, ALMA Computing became part of operations with the implementation of a partnership-wide integrated team for the operations phase. The ALMA Integrated Computing Team is responsible for developing, maintaining and supporting all the software for the ALMA Observatory and its regional centres. The team is composed of four similarly-sized teams in Europe, North America, East Asia and the Joint ALMA Observatory in Chile. Each partner supports, maintains and extends the parts of the ALMA software they developed and delivered during the construction period. The European Integrated Computing Team's main responsibilities



Computed atmospheric transparency in the 1–1.6 THz range at Chajnantor under excellent weather conditions. The different curves are computed for different values of precipitable water vapour as labelled (Rigopoulou et al. 2013, *The Messenger,* 153, 35).



Predicted spectrum for glycine, the simplest amino acid, emission in the low-mass core L1544, and the frequency coverage of some of the ALMA bands are shown (Jimenez-Serra et al., 2014).

are the archive, common software infrastructure, applications for the full lifecycle of observing projects, and telescope calibration, as well as major contributions to pipeline heuristics and Common Astronomy Software Applications (CASA) development. The European ALMA Support Centre leads the European Integrated Computing Team with support from the ESO Directorate of Engineering, the UK Astronomy Technology Centre (UK ATC) in Edinburgh, Institut de radioastronomie millimétrique in Grenoble, the Max Planck Institute for Radio Astronomy in Bonn and the Observatoire de Paris.

The EASC technical team is responsible for off-site technical support and hardware development projects. This year the first ALMA development project started: building Band 5 receivers for all 66 ALMA antennas. This was carried out by a European consortium with a hardware contribution from NRAO. The technical team also provided specific knowledge and assistance to the ALMA Observatory and negotiated the first maintenance contracts with specialised institutes in Europe to ensure hardware maintenance requiring specific, special skills.

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. In June the second call for ALMA upgrade studies in the ESO Member States was issued. Following an enthusiastic response, the proposals were reviewed and the overall scientific strategy discussed with the European ALMA Science Advisory Committee (ESAC) and the Scientific Technical Committee (STC) to set up the study programme for the years 2014–2016. The final studies, from the previous 2011–2013 cycle, are approaching their conclusions: the studies on the scientific opportunities and observing conditions for supra-THz interferometry with ALMA and the development of the science case and critical components design for the ALMA Band 2/3. A workshop to discuss the science possibilities with ALMA equipped with Band 11 was held in Oxford in March (see Rigopoulou et al. 2013, *The Messenger,* 153, 35). While observing beyond 1 THz

with ALMA will be challenging (see the figure at the top of the previous page), unique science possibilities were identified. The exciting scientific opportunities that will be available with ALMA Band 2/3 were discussed at a workshop in Bologna in May. High-redshift extragalactic spectral surveys and the study of complex deuterated and pre-biotic molecules in star-forming regions were identified as the most prominent cases (see the lower figure on the previous page). The ALMA upgrade studies, including those carried out in the other ALMA regions, will inform the overall ALMA Development Plan upgrade strategy that is being developed by a dedicated working group set up by the ALMA Development Plan Steering Committee with members coming from the ALMA Science Advisory Committee and the three regional ALMA Programme Scientists.

The ongoing ALMA upgrade projects made significant progress during the year. The Band 5 project, carried out by a European consortium of The Netherlands Research School for Astronomy (NOVA) and the Group for Advanced Receiver Development, has made significant progress towards setting up the full production line for the 67 receivers. The optical fibre project, led by JAO with strong contributions from NRAO and ESO, will provide a fast network connection between the ALMA Observatory and Santiago and will soon allow reliable high-speed data transfer to the Santiago office. The ALMA Phasing Project, led by the Massachusetts Institute of Technology and involving contributions from all ALMA partner regions, made a lot of progress and the first hardware and software deliverables are on track for installation and commissioning in 2014. This project aims to enable ALMA to become a station of a worldwide millimetre very long baseline interferometry network and, more generally, operate as a phased array. The Band 1 receiver project, led by ASIAA, the East Asia Front End Integration Centre with contributions from North America and Chile, passed initial reviews in which ESO was involved and will go through a final assessment in the course of 2014.

ESO/ALMA/Borquez (NRAO), Alhemar Duro

European antenna at the ALMA Operations Support Facility.

Programmes

ESO/B. Tafreshi (twanight.org)

Instrumentation for the La Silla Paranal Observatory

This year, all the ESO programmes are being executed within the new matrix-based organisational structure. ALMA construction is now substantially complete with the delivery of the last European antenna in September. The remaining construction deliverable is the ALMA Residence, for which the tendering process is underway. In December, the Director General signed the contract with ICAFAL Ingeniería y Construcción S.A. for the E-ELT road to Cerro Armazones and the levelling of the top of the mountain in readiness for the construction activities. Roberto Tamai has been appointed by Council as the new E-ELT Programme Manager and will take over in early 2014. The second generation VLT/I instrumentation continues to progress well with the delivery and successful reintegration of MUSE on Paranal being the highlight of the year.

One of the VLT Auxiliary Telescopes set against the splendour of the southern Milky Way.

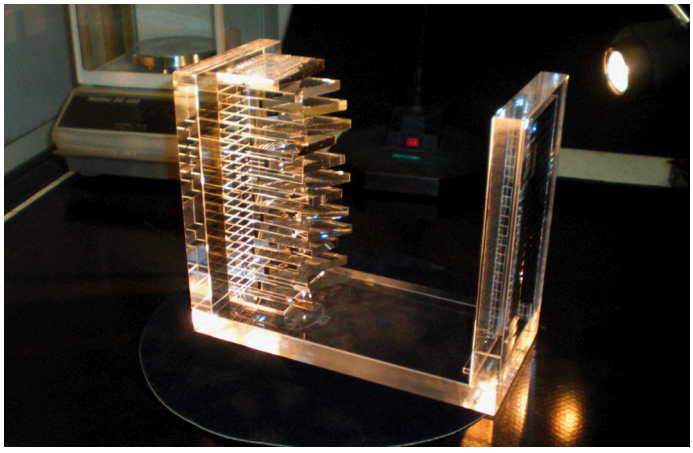
KMOS commissioning and operations

The on-sky commissioning of KMOS continued this year. After commissioning was successfully concluded in March, proposals were solicited for two public Science Verification runs that were held in June and September. In parallel with the preparations for Science Verification, the instrument was offered to the community, starting on 1 October. The response to the first full call for KMOS proposals was extremely strong, immediately making it one of the most oversubscribed instruments at the VLT. Formal preliminary acceptance in Chile has been postponed to 2014 because one long-term action item, related to the reduction of induced vibrations for VLTI operations, will only be completed at the beginning of next year. Before the start of the open-time proposals in October, problems with one of the pick-off arms were addressed, and it was replaced by a spare. The reason for the failure of the mechanism is under careful study by the KMOS team. Science Verification resulted in the appearance of the first refereed paper from KMOS data in the scientific literature (Sobral et al. 2013, ApJ, 779,139). The paper addresses one of the core science cases that drove the unique KMOS design, namely the characterisation of the dynamics of clusters at moderate redshift.

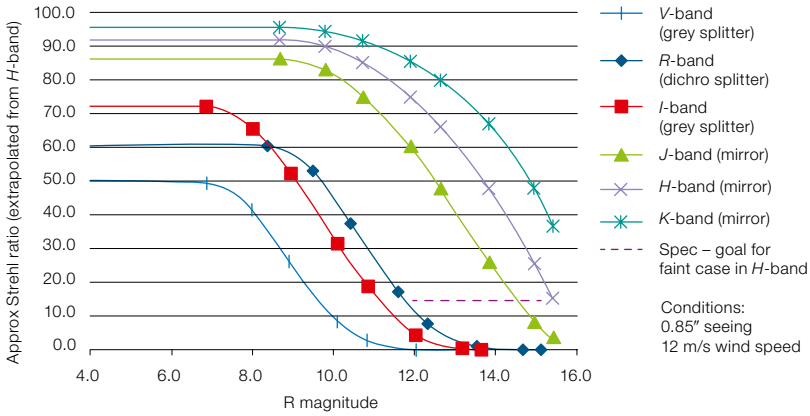
Instruments approved or under construction

The integral field units spectrograph MUSE (PI: Bacon, Lyon) has finished its integration phase and passed through the Provisional Acceptance Europe (PAE) process, culminating with its acceptance in September. When commissioned, the instrument will provide a massive 1 × 1 arcminute field of view, with each 0.2 arcsecond pixel giving a complete spectrum, and hence 90 000 spectra obtained in a single shot. MUSE was packed and shipped to Chile (in three consignments: 58 crates, 28 tonnes of material), where it was successfully reassembled in the new, refurbished integration hall at Paranal. In order to host MUSE and its AO module GALACSI, UT4 has been modified to include a new guiding arm that provides the additional 25 centimetres of back focal distance needed. MUSE will be transported from the integration hall to UT4 in January and its commissioning is expected to start in February 2014.

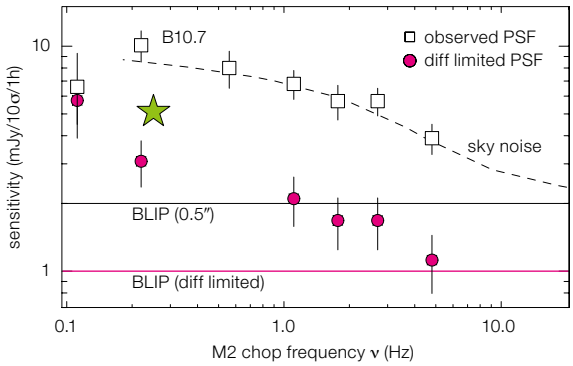
This year SPHERE (PI: Beuzit, IPAG-Grenoble) also went through a thorough and successful PAE process in Grenoble. PAE was granted at the end of the year, with a delay of a few months with respect to the schedule planned a year ago. The instrument delivers very good image quality, with Strehl ratios reaching 90% in the *H*-band in good (0.65-arcsecond) simulated seeing, despite the loss of functionality of some actuators in the high-order deformable mirror during summer testing. Another problem is that the deformable mirror changes its shape at rest with temperature, requiring retrofitting of an actively controlled mirror in the optical path. The contract for the production of a second deformable mirror had to



Field splitting optics for MUSE. Shown following successful manufacture at the premises of Winlight Optics (France). These optics re-format the field before it enters the spectrographs.



Laboratory test results for the SPHERE instrument show the Strehl ratio (optical performance compared to the diffraction limit) as a function of the *R*-magnitude of the guide star. The *H*-band performance was actually measured, while other wavelengths have been calculated using normal atmospheric scaling terms.



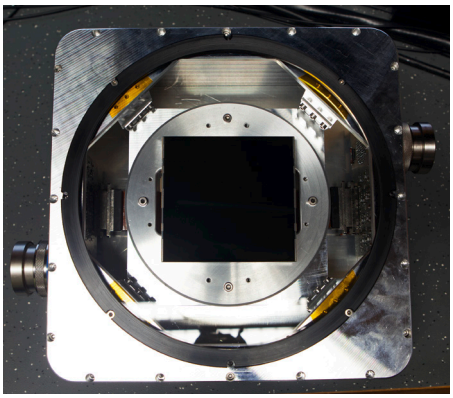
This figure shows the performance of the new AQUARIUS mid-infrared detector. The observed sensitivity (squares) improves with chop frequency as predicted (dashed line). At sufficient chop frequencies the noise becomes background photon noise limited (BLIP).

be cancelled because of failure in some manufacturing steps. A new inquiry for a potential spare deformable mirror has been issued.

Progress on the two second generation instruments for the VLTI has continued. GRAVITY (PI: Eisenhauer, Max-Planck Institute for Extraterrestrial Physics [MPE]) is in its integration phase: the beam combiner is now integrated at MPE and the infrared wavefront sensors at MPIA. Among the major steps forward, the instrument has now seen the first fringes from four beams in the lab, and most detectors have been delivered by ESO to the consortium, including the newly developed SAPHIRA wavefront sensor detector. The polarisation characteristics with respect to the UTs have been measured in a test campaign and critical issues are: how to deal with non-common path errors in the metrology injection and how to eliminate parasitic light on the science detector injected by the metrology laser. The MATISSE (PI: Lopez, OCA-NICE) project is also in its integration phase. MATISSE is proceeding on a slower schedule than GRAVITY with the PAE date now set for November 2015. The *N*-band detector has been delivered by ESO and a test multiplexer has been installed and used with the *N*-band cold optics. Manufacture of the remaining subsystems is progressing steadily, with some delays on the warm opto-mechanics, but without major concerns. The consortium presented a report on the analysis of the impact of excess detector noise, a problem with the new AQUARIUS detector. This is expected to be lower than the fundamental noise, and there is no sign of any spatio-temporal correlated noise, so the impact should be minimal. Tests will be performed to confirm these expectations.

The ESPRESSO ultra-stable high-resolution optical spectrograph (PI: Pepe, Geneva) progressed to its final design review this year. The Final Design Review was successful, but a delta-Final Design Review was deemed necessary and subsequently planned to deal with some aspects of the projects not addressed and to close the major interfaces with the VLT, in particular the detailed design and implementation of the four coudé trains. The interfaces with the structure required a fairly substantial effort and several trips by the consortium members to Paranal. The instrument detectors benefitted from early procurement and the first engineering device was received and tested at ESO. The Final Design Review allowed the procurement of the spectrograph optics to begin. Other contracts for major components, including the large cameras and the laser frequency comb, have been placed.

The Adaptive Optics Facility entered the system test phase, with important deliveries taking place, and the focus of activity switching from subsystem to system aspects. The test readiness review took place earlier in the year to validate the readiness to proceed with this phase. In December 2012 the deformable secondary mirror (DSM) was delivered to Garching and the AOF team initiated the optical tests of the unit on the ASSIST test bench. These were completed in July and validated the main optical specifications for the DSM. The final milestone (PAE) for the DSM acceptance took place in December. SAFRAN-REOSC also delivered the spare thin shell in November to ADS International (Italy), which will now proceed with gluing the voice coil magnets and coating. This second shell produced by SAFRAN-REOSC has shown a two- to three-fold improvement across all specifications. A second major intervention took place on UT4 in September to finalise the modifications of the telescope. The telescope was re-commissioned and after the intervention revealed behaviour similar to the one before. In particular, vibration tests showed no visible impact on the VLTI, and the new guider arm extension for



An engineering sample of one of the CCD detectors to be used in the cameras of the ESPRESSO instrument. This large CCD has more than 80 million pixels over an area of 92 × 92 millimetres.

MUSE-GALACSI has been successfully commissioned. The intervention was successful and UT4 is now ready to accommodate the AOF. The first laser unit for the 4LGSF was delivered to Garching and has been interfaced with the 4LGSF system. The first launch telescope has also been integrated and tested in conditions with a varying gravity vector and varying temperature, showing stable behaviour that is compliant with the specifications. Eighteen wavefront sensor cameras using e2v CCD220 and NGC controllers have been produced and are awaiting lenslet installation before being integrated into the adaptive optics modules GRAAL and GALACSI. The latter was also integrated and several subsystems validated, including the low-order infrared wavefront sensors. The GRAAL AO module has completed integration and the system tests have started in the lab using a natural guide star on-axis mode. The GRAAL SPARTA real-time computer is fully functional and was used to carry out these tests and now commands the DSM.

ERIS will be a new facility at the UT4 Cassegrain focus that will feed both an infrared imager and an upgraded SINFONI integral-field spectrograph with AO-corrected wavefronts. ERIS will use the deformable mirror of the AOF as well as one of its lasers to improve both the spatial resolution and sky coverage compared to the current NACO and SINFONI instruments. Two institutes were selected to collaborate with ESO on the construction of the instrument, after a competitive call for proposals this year. A consortium including MPE (Garching) and ETH (Zurich) will participate in the camera construction and the SPIFFI spectrometer upgrade, while INAF/OAA (Italy) will collaborate on the AO module. Instrument requirements have been finalised, and the design is converging towards a Preliminary Design Review in 2014.

Work on the VISIR upgrade continued, with excess noise on the new AQUARIUS detector delaying a return to the telescope. During the year, extensive work in the lab, as well as discussions and visits by the manufacturer, have now fully characterised the problem. The solution lies in using faster chopping and so various techniques for doing this have been investigated.

Following a recommendation by the STC in October 2012, the CUBES spectrograph project is waiting for the ratification of Brazil's membership of ESO before formal commencement. Following the STC recommendations, an ultraviolet conference was organised in the autumn, gathering together a large section of the community who are interested in the instrument. Valuable input was obtained to improve the instrument requirements.

The Laser Frequency Comb (LFC), a revolutionary way of achieving a very precise series of equally spaced and stable lines for spectrograph calibration, was approved for construction for the HARPS spectrograph in 2011. In 2012 a consortium of ESO, the Instituto de Astrofisica de Canarias (Spain) and the Universidade Federal do Rio Grande de Norte (Brazil) closed a contract with MENLO Systems to provide the turnkey system. The HARPS+LFC system was planned to be commissioned by the end of 2013, but instead the project has suffered several months of delay due to reliability problems with the photonic crystal fibre.

In April the Paranal instrumentation roadmap was presented to the STC. The roadmap traces the path for the development of new instruments for the LPO up to the year 2020. Within the plan, the start of a new instrument/project was envisaged for each year and, consistent with this, in April the STC recommended that the study and construction phases of the CRIRES upgrade (CRIRES+), and of the MOONS and 4MOST spectrographs, should proceed, delayed by one year.

CRIRES+ is an upgrade project with the aim of adding a cross-disperser to the instrument, so that the whole 1–5 micrometre range can be covered with only a few changes to the setup. A polarimetric mode is foreseen as well as the insertion of new gas cells. The project will be developed by ESO in collaboration with a consortium led by A. Hatzes (Tautenburg). After the Phase A review, the refurbishment of the CRIRES AO module was deemed desirable and was added to the scope of the project. Part of the project is the use of three large (2k × 2k) and new infrared detectors. Procurement by one of the consortium partners has already started. The associated guaranteed observing time was approved by Council at its December meeting.

After competitive Phase A studies for multi-object spectrographs, two facilities were evaluated:
– MOONS is an instrument for the infrared and is proposed for the VLT;
– 4MOST works in the visible domain and is proposed for the 4-metre VISTA telescope to achieve a very large field of view.

The science cases for both instruments and their telescopes were judged compelling and complementary. Both instruments were therefore recommended for construction. MOONS, proposed by a consortium led by M. Cirasuolo at UK ATC, has been considered with higher priority and the negotiations for its study and construction, as well as its definition, started this year. For 4MOST, proposed by a consortium led by R. de Jong at AIP Potsdam, similar activities will start in 2014.

VLTI infrastructure development

Following the re-structuring of the VLTI infrastructure developments, five separate projects were established. Many activities during the year concentrated on the astrometric performance of PRIMA, and the evaluation of efforts to achieve the science requirements.

VLTI-PR1: Auxiliary Telescope maintenance station. The construction of a new AT maintenance station on the VLT platform has proceeded. The requirements and statement of work were finalised and a first call for proposals issued which, unfortunately, did not produce a bidder. A second call, addressing smaller companies, was successful, but the submitted bids were much more expensive than foreseen. Action has been taken to evaluate possible trade-offs in the specifications, as well as in the organisation of the work to contain the costs below an acceptable ceiling.

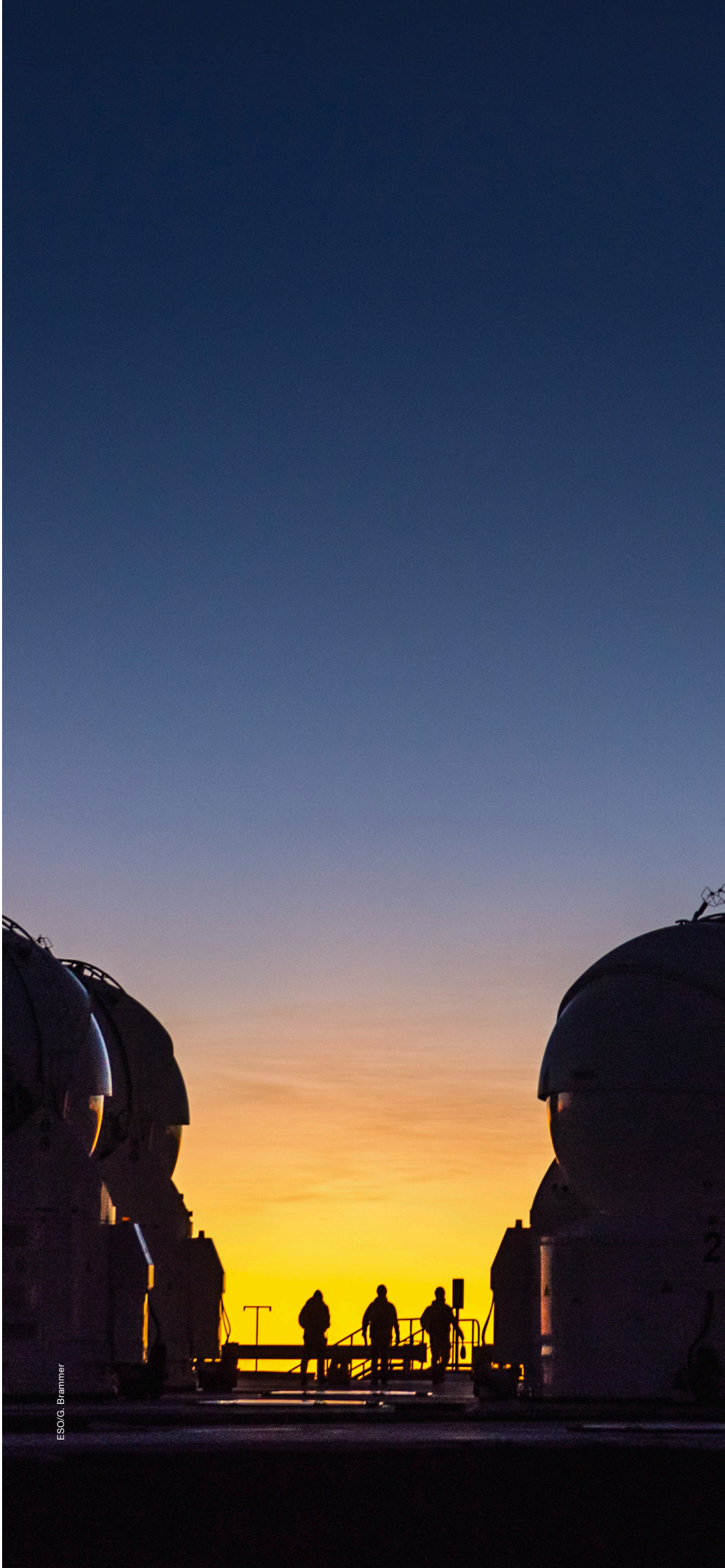
VLTI-PR2: PRIMA astrometry. The polarisation problem encountered in extending the metrology to M2 has been fully analysed and understood. PRIMA operations were carried out smoothly during the

second half of the year to characterise PRIMA's astrometric performance. The short-time astrometric performance (~ 160 microarcseconds) is still several times worse than the specifications, although it has improved by more than a factor of ten since 2011. A full analysis report and a recovery plan for PRIMA astrometry was prepared for a critical PRIMA gate review that will be held at the beginning of 2014.

VLTI-PR3: Adaptive optics for ATs: NAOMI. Design activities that should bring NAOMI to Preliminary Design Review in 2014 are proceeding, especially in the areas of wavefront sensor design and communications between the SPARTA light real-time computer and the wavefront sensor camera. The corrective optics documentation has been finalised and a call for tender issued to identify one institute for collaboration on the construction budget. Detailed clarification questions have been sent to the relevant institute.

VLTI-PR4: Preparation for the second generation instruments GRAVITY and MATISSE. Some structural changes were needed to the project due to personnel departures during the year. Activities concentrated on the consolidation of interfaces in the various affected VLTI areas (laboratory, coudé rooms and basements). In parallel, progress occurred in the integration of UT dual feed equipment, with the first installation completed on UT1. In addition, a new version of the interferometer supervisor software was installed and used in operational conditions.

VLTI-PR5: Second generation fringe tracker. The project made slow progress in 2013. The project also includes the acquisition of the last two differential delay lines, which have completed their Final Design Review this year.



ESO/G. Brammer

A perfect moment on the Paranal platform, where the number three seems to be the *leitmotif*. Three ESO staff members walk on the platform among three Auxiliary Telescopes of the Very Large Telescope, while three planets can be seen in a conjunction above them in the twilight sky. Jupiter (top), Venus (lower left), and Mercury (lower right).

ESO/Y.Beletsky

Night view of one of the ALMA transporters, Otto, at the ALMA high site on the Chajnantor Plateau.

ALMA

ALMA, the Atacama Large Millimeter/Submillimeter Array, is a large interferometer for radio wavelengths ranging from 0.3 to 9.6 millimetres. After more than ten years of construction activities, all subsystems were completed and put into operation this year. The only remaining items are the construction of the ALMA Residence and the commissioning of long baselines and some observing modes. ALMA has been built by an international collaboration between Europe, North America, and East Asia in collaboration with the Republic of Chile. This new observatory comprises 66 high-precision antennas with state-of-the-art receivers located on the Chajnantor Plateau of the Chilean Andes at 5000 metres above sea level in the district of San Pedro de Atacama. The 12-metre antennas can be placed in configurations with reconfigurable baselines ranging from 15 metres to, ultimately, 16 kilometres. Resolutions as fine as 0.005 arcseconds will be achieved at the highest frequencies, a factor of ten better than the HST at optical wavelengths.

By the end of the year, ALMA construction had basically been completed, with all subsystems delivered and in operation. Scientific observations, ALMA Early Science, which started in September 2011, continued as much as possible this year, in conjunction with Cycle 1 observations. The major highlights at the end of 2013 included:

- All European deliverables had been delivered (with the exception of the Residence). The last front end assembly was delivered in March, and the last European antenna, #25, in September.
- At the end of December the last equipped ALMA antenna was handed over from assembly, integration and verification (AIV) to operations. This milestone marked the end of many years of AIV work and provides ALMA with all 66 antennas.
- The permanent power system has been powering the whole observatory without interruption since mid-October, after gradually switching from the temporary system over the course of the year and weathering a few start-up issues.
- A call for tender for the construction of the ALMA Residence was issued.
- By the end of the year, about 36% of the ALMA Early Science Cycle 0 projects with a European PI had produced a printed refereed publication and additional projects have papers accepted or submitted, demonstrating the community's widespread excitement about the ALMA data.
- ALMA Early Science results from Cycle 1 were coming out and provided to the PIs via the ARCs. The efficiency of Early Science observations has been affected by construction activities and unusually bad weather during two periods of the year.
- The call for proposals for ALMA Cycle 2 (planned to start in June 2014) resulted in 1382 proposals — believed to be the highest number of proposals ever received by an observatory.
- The first ALMA development project, equipping all antennas with a Band 5 receiver, started in February. Prototypes have been developed and fabricated in Europe and are already installed at ALMA. Full production by a European consortium will continue until 2017.

Site construction work

The ALMA Observatory comprises three sites:

- the ALMA Operations Support Facilities (OSF) at 2900 metres above sea level;
- the Array Operations Site (AOS), located at 5000 metres above sea level on the Chajnantor Plateau; and
- the Santiago Central Office 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 was carried out. The assembly, integration and verification of antennas and other advanced equipment were completed there before transport to the AOS.

Olem & Adri Bacri-Normier (wingsforscience.com)/ESO

Aerial view of the Chajnantor Plateau, located at 5000 metres above sea level, where the array of ALMA antennas is located. The large antennas have a diameter of 12 metres, while 12 smaller antennas with a diameter of 7 metres make up the ALMA Compact Array.

ESO/Kouvo & Partanen

Artist's impression of the ALMA Residence showing the main hall in the main building, which will provide a communal area for the staff working at the observatory.

Manned 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). These roads have been in use since 2010 and were handed over to JAO for maintenance in 2011. The construction of the last element of the road work, the fully featured intersection with the public highway to replace the temporary one, started this year and is being carried out by the Ministerio de Obras Publicas as part of an agreement with ESO. It is expected to be completed in early 2014.

At the OSF, ESO's infrastructure contributions are:
- the OSF technical facilities building;
- the permanent power supply generation system for the entire ALMA Observatory and the power distribution at the OSF and up to the AOS; and
- the ALMA Residence.

The OSF technical facility buildings were completed and have been in use since 2008, although there were substantial modifications/upgrades, completed in 2010, to ensure the best fit to the modified needs of the users.

At the end of 2012, the multi-fuel power generation system entered into operation as the responsibility of JAO, initially feeding the OSF. The transition to full loads, including the AOS, was accomplished in May this year. There were some start-up issues that affected the system: a limit switch turned out not to be suitable for the environment, the pneumatic damping system on the fuel pumps lost its calibration, leading to excess vibration, a protection device was improperly configured, some workmanship issues had been identified, and two medium voltage cable connections (out of 180) needed reworking.

These various issues were resolved during the year under contractual warranty and, since October, the system has been running without interruption, thanks partly to the increased expertise of the operators and some refinements to the procedures. The acceptance meeting took place in December, with JAO's recommendation to formally accept the system.

This year, extreme levels of precipitation affected the installation of the medium voltage cables connecting the OSF to the AOS. However, thanks to some basic preventive measures, the damage was limited and the situation could be recovered quickly. A survey by safety representatives of the partnership concluded that the system could be used, provided suitable precautions were followed. They recommended to JAO, however, that long-term measures should be incorporated into the maintenance plans to avoid exposing the installation to further damage.

The design of the ALMA Residence, encompassing 120 rooms and all the required facilities such as a kitchen, dining room, general services, leisure facilities, etc. — contracted to the Architectural Office Kouvo & Partanen (Finland) — was completed early this year. In May a call for tender for the construction of the Residence was released. Offers have been received and evaluated and clarifications and negotiations with the potential bidders are continuing.

The acceptance by the JAO of the 192 antenna foundations at the AOS, completed in 2010 and outfitted with precision antenna interfaces in 2011–2012 slowed down due to a lack of resources within the JAO.

ALMA antennas

ESO has contributed 25 high-precision antennas, each 12 metres in diameter, to the ALMA antenna park. The delivery of these antennas was completed in the course of the year. The antennas were manufactured by the AEM consortium, composed of Thales Alenia Space (France and Italy), MT-Mechatronics (Germany) and European Industrial Engineering (Italy). Fabrication of the components was distributed between various subcontractors across Europe. The antenna steel structure (mount) was fabricated in Aviles, in northern Spain, where it was also pre-aligned prior to its shipping to Chile. The main dish structure and the receiver cabin, both made out of carbon fibre reinforced plastics, were fabricated, pre-assembled and measured in France. The motors, the panels, the local control electronics, and the metrology system were fabricated in Italy and shipped either directly to Chile or to the various integration sites. Germany contributed various subsystems, including the hexapod mechanism for the subreflector, legs made from carbon fibre reinforced plastics, thermal insulation, electronics and other parts.

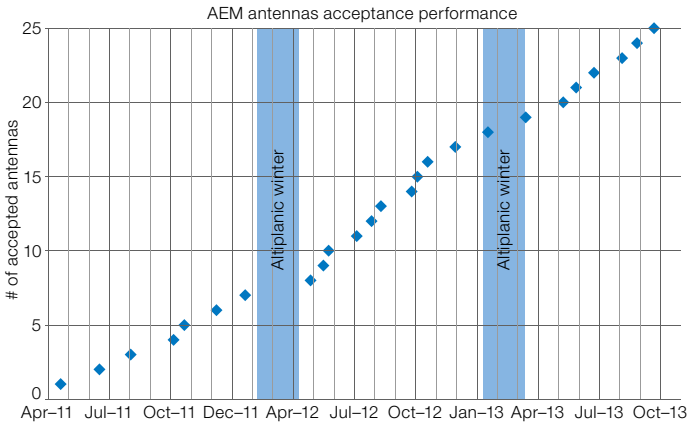
In 2013, the average delivery rate of the European antennas kept to the tight schedule achieved in 2012, and around one antenna a month was delivered. So, by September, the last eight remaining antennas had been accepted by ESO from the AEM consortium and were handed over to ALMA.

Initial hopes of finishing before September vanished due to some unexpected circumstances, including a period of severe Altiplanic winter weather disrupting some of the assembly and testing activities at the OSF. Also, two antennas needed more work before they could achieve their specified performance. These antennas were taken out of sequence in the processing so as not to affect the overall schedule. In the end, with a little more debugging effort by ESO and the AEM team, it was possible to track down the issue and bring the antennas fully within specification, in line with all the other European antennas. Since deliveries began in April 2011, a total of 25 antennas have been delivered over a period of 29 months (see the figure on the right).

By the beginning of 2013, ESO and AEM had already gained considerable experience in operating the antennas at the OSF and AOS. ESO has been tracking any technical problems affecting the antennas systematically in order to verify the reliability requirements and to identify any specific hardware items requiring attention as early as possible. On the basis of the results obtained, only a very few minor retrofits were performed on any of the antennas, eliminating any outstanding issues and contributing to the good overall availability of the antennas. This process was also supported by interventions on site by AEM with some key suppliers.

ESO had decided to use a computerised system to track all antenna malfunctions occurring during the warranty period. This substantially simplified the interface with AEM on these matters and, in general, the treatment of warranty issues was expedited. The departure of the contractor from the site in the last quarter of the year, after the last antenna was accepted, has resulted in a longer response time, and ESO is looking into this issue for the antennas still under warranty.

Final antenna delivered to ALMA.



Delivery dates of the 25 accepted AEM antennas over a period of 29 months.

This year ESO also started the final inspection of those antennas whose guarantee period was expiring. As of end of the year, four antennas were out of warranty, with more accumulating at a rate of approximately one a month. In general it has been confirmed that the antennas have completed their warranty periods without degradation or visible need for intervention. An important piece of information regarding the performance of the antennas was the confirmation in April that the primary reflector of antenna DA41, the first antenna delivered, which had been exposed to the environmental conditions at the 5000-metre site for almost two years, had remained stable to within the specifications (25 micrometres over the full 12-metre diameter) and no reflector adjustment was required. This was confirmed by a metrology campaign performed at the OSF and triggered by the final inspection at the end of the warranty period. For this very first antenna, ESO decided to transport it down to the OSF, while the remaining antennas will have their final inspection at the AOS. The stability of DA41's dish had already been investigated with astro-holography, but it was comforting to see that the higher resolution holography at the OSF did show good long-term stability in the reflector system.

With the expiring warranties in mind, ESO has procured a considerable number of spares to support the first years of operation and beyond. Most of the spares have been delivered, but some critical items relating to heating, ventilation and air-conditioning were not yet available on site, causing some downtime in December.

ESO/M. Marchesi

The final ALMA antenna is handed over to the observatory.

EFE/Ariel Marinkovic

This view of ALMA was taken from a small remote-controlled hexacopter.

The work of supporting ALMA AIV and the operation teams continued during the year, providing help in debugging problems, training and specific support at the OSF and AOS. Further, the transition between the construction and the operation phase of ALMA has been completed for the Antenna Group by transferring two antenna staff to the European ALMA Support Centre.

The front end system

The European Front End Integrated Project Team completed the delivery of all production items early in the year. The table to the right summarises the delivery of major European front end products.

In March, the 70th and last front end assembly (the 26th from Europe) was successfully delivered by the EU Front End Integration Centre (FEIC), located at the Rutherford Appleton Laboratory (UK), to the OSF.

Directly after delivering this last front end assembly, the dismantling of the EU FEIC started and was completed according to schedule in early April. The equipment that became available from the EU FEIC was sent to the OSF, after consultation with the JAO, while other items were sent to ESO Garching.

The remaining activities throughout the year focussed on supporting the JAO for maintenance. Several training sessions for JAO staff, e.g., for water vapour radiometers and amplitude calibration devices, were organised to make staff familiar with, and self-supporting for, the maintenance of front end products delivered from Europe. In addition, spare parts were delivered, as well as dedicated test equipment — e.g., a complete Band 7 cartridge test set — and tools.

STFC/ESO

EU FEIC staff at the Rutherford Appleton Laboratory celebrating shipment of the last front end assembly to the OSF.

Product	Delivered by 31 Dec 2013	Total	Percentage complete
Band 7 cartridges	73	73	100 %
Band 9 cartridges	73	73	100 %
Cryostats	70	70	100 %
Water vapour radiometers	58	58	100 %
Front end DC power supplies	83	83	100 %
Amplitude calibration devices	70	70	100 %
European front end assemblies	26	26	100 %

The back end system and the correlator

The final delivery of ESO's contribution to the back end subsystem took place this year: the final batch of spare photomixers, with the relevant documentation, was delivered to the Observatory. With this, the supply of the back end by ESO is completed in terms of components, equipment, documentation and training.

The ALMA correlator is a highly specialised super-computer, processing data from up to 64 antennas at a maximum rate of about 2×10^{15} operations per second. The system performance and the main design technical challenges are described in *The Messenger*, 135, 6, 2009 and the *ALMA Newsletter,* 7, 18, 2011.

In 2012 the ALMA correlator was completed, with the installation of the fourth quadrant at the AOS and its provisional acceptance at the end of the year. During this year the correlator went through an extended campaign of commissioning and integration tests carried out by the North American ALMA partner.

The disruptive events caused to the programmable components inside the correlator by cosmic rays at the 5000-metre AOS site turned out not to be a major issue: there are roughly ten events per day, and the mitigation measures that were implemented have demonstrated their ability to limit the impact of these events to within acceptable limits.

Non–recoverable hardware failures that were suspected to be caused by cosmic rays remained at a reasonably low level.

ALMA Computing

ALMA Computing construction activities were completed by end of 2012. Further computing activities moved to operations as of 1 January as part of the European ALMA Support Centre and are described in the EASC section.

System Engineering and Integration

The European ALMA System Engineering and Integration team completed its ALMA construction tasks by the end of 2012.

ALMA Science

By the end of this year, about 36% of the ALMA Early Science Cycle 0 projects with a European PI have resulted in a published, refereed publication and additional projects have papers accepted for publication or submitted. The very fast publication timescales demonstrate the widespread excitement in the community about the ALMA data and their excellent scientific quality. A large fraction of the overall ALMA publications so far have appeared in high impact journals (such as *Nature* and *Science*), demonstrating the transformational nature of the ALMA Observatory.

Significant effort was invested during the year in commissioning and Science Verification activities in order to deploy new observing modes for Cycles 1 and 2. Some of the highlights were:

1. The expansion of the correlator modes, allowing increased flexibility for spectral line and continuum observations, greatly enhancing the scientific potential of each individual observation;
2. The commissioning of the first continuum, on-axis, polarisation modes, and of the Band 4 and 8 receivers, which will all be offered in the upcoming Cycle 2;
3. The steady expansion towards longer baselines, enhancing the angular resolution provided by the array.

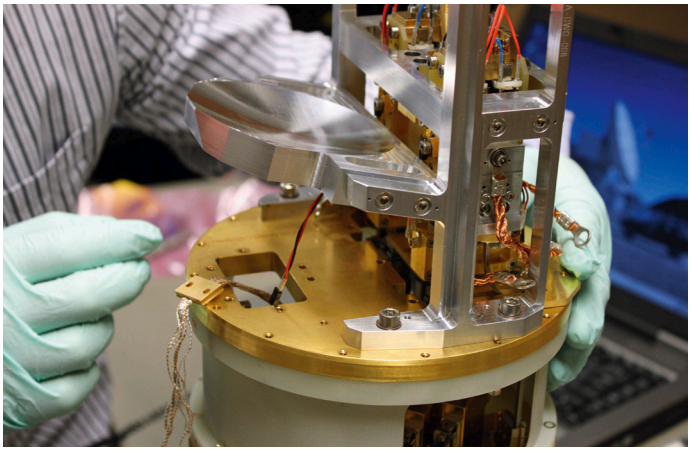
Progress was also made in numerous other areas, improving the overall efficiency of the observations and testing advanced observing modes for future cycles, including a few campaigns dedicated to the testing of solar observing.

Several scientific results were published, based on Science Verification datasets that had been released in the second half of 2012 (see p. 38, for an example). This demonstrates the complexity and scientific value of each individual ALMA dataset and the enormous potential for archival research. Most of the ALMA Cycle 0 data will become available for download in early 2014.

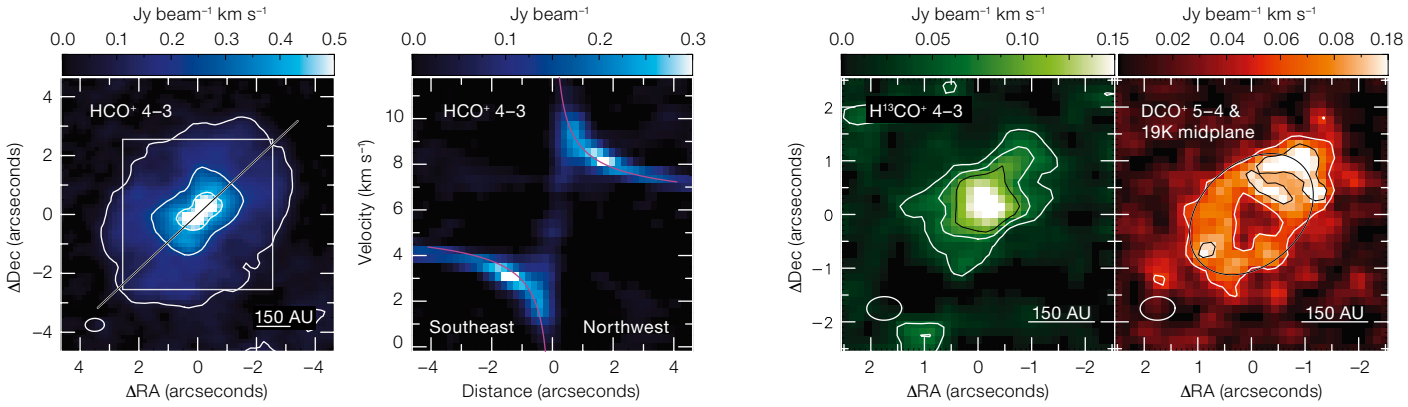
Technician Juan Carlos Gatica checks electronics on the ALMA correlator. He is using supplemental oxygen at the high altitude site.

Carlos Padilla, NRAO/AUI/NSF

One of the first six Band 5 receiver cartridges built for ALMA.



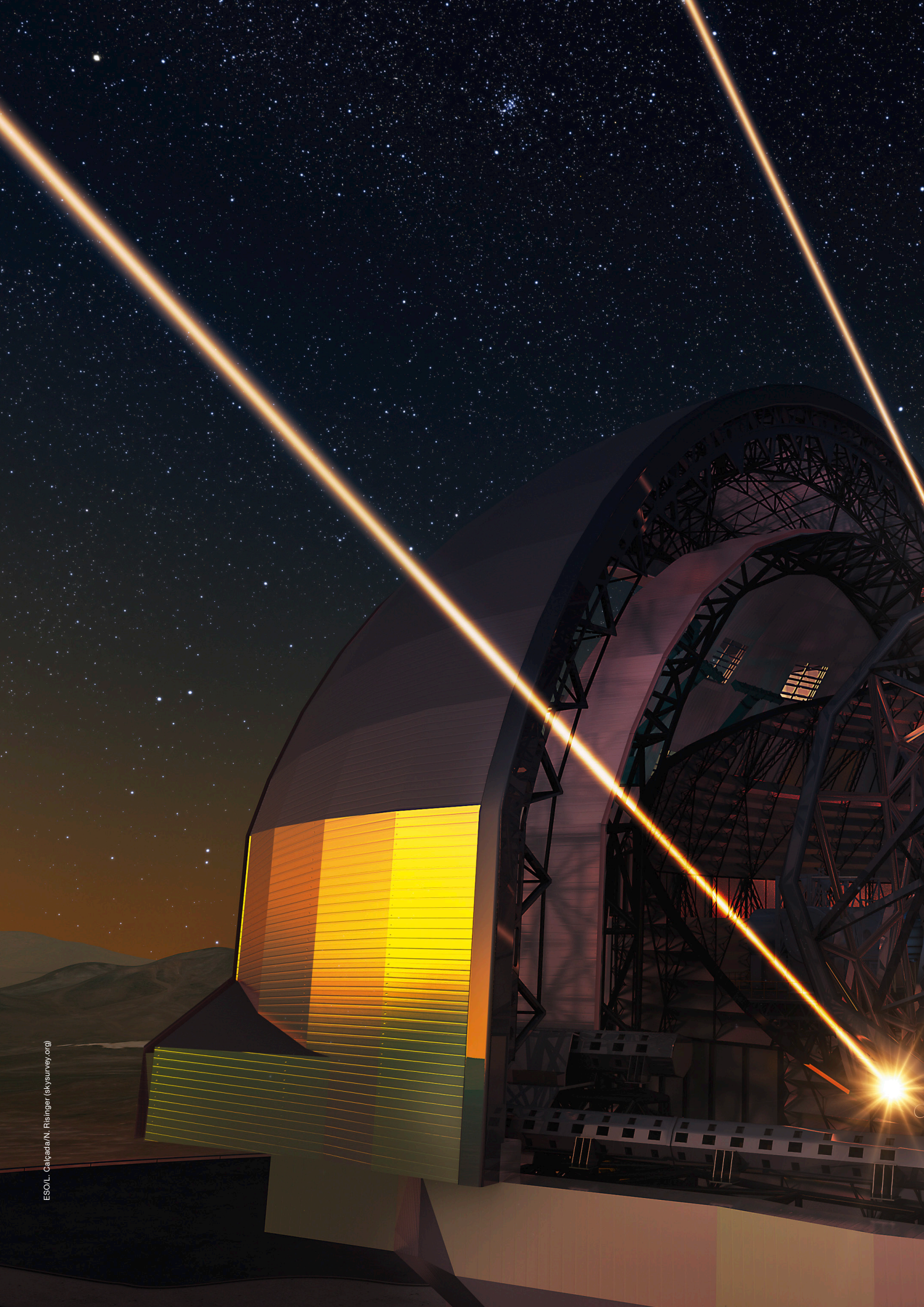
Onsala Space Observatory/Alexey Pavolotsky



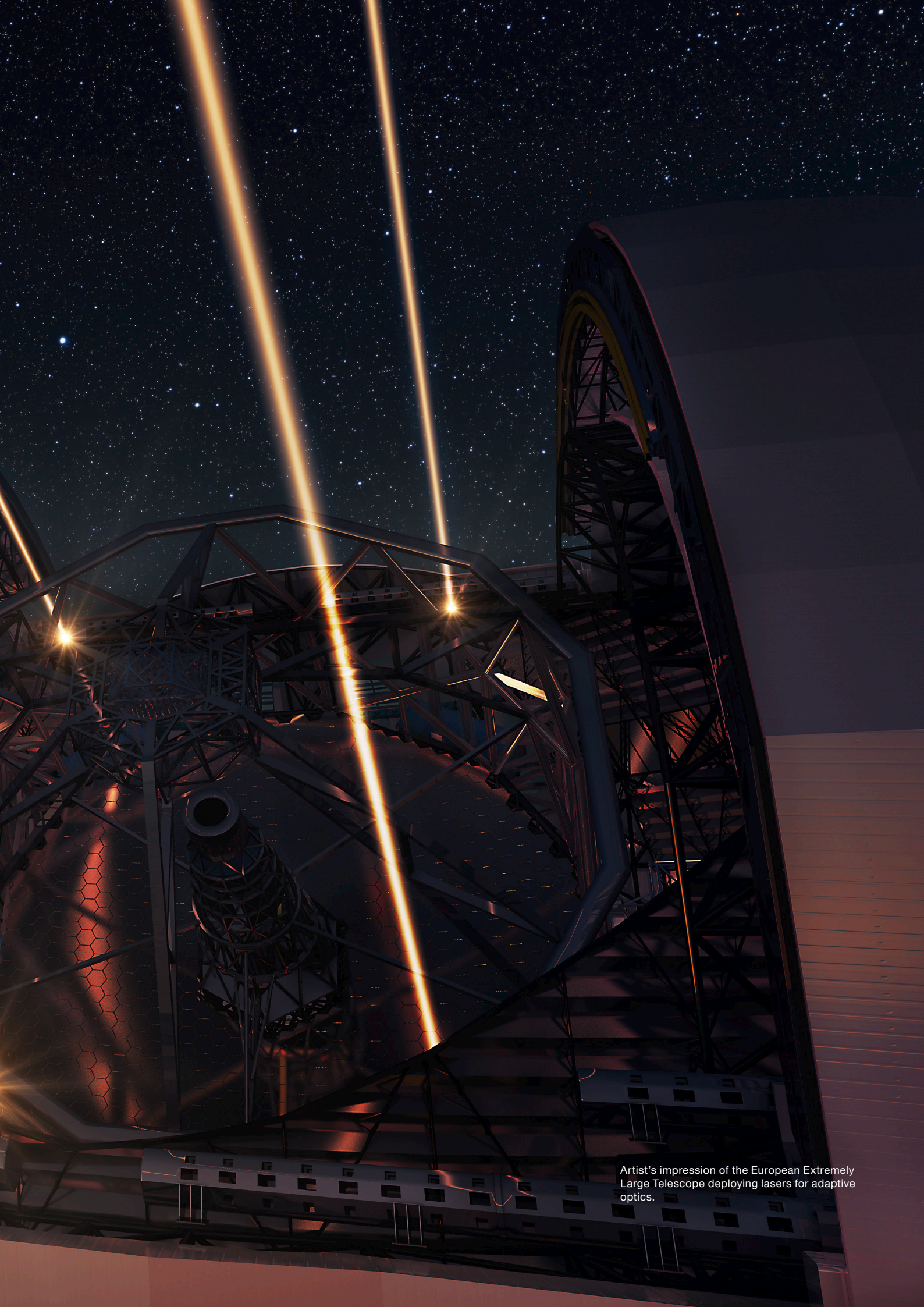
Direct measurement of the carbon monoxide snow-line in the protoplanetary disc surrounding the young star HD 163296. (Mathews et al., 2013)

ESO/C. Malin

A bright meteor over the ALMA array.



ESO/L. Calçada/N. Risinger (skysurvey.org)



Artist's impression of the European Extremely Large Telescope deploying lasers for adaptive optics.

European Extremely Large Telescope

During this year the E-ELT project has continued its preparations to move towards full construction while the full funding is being secured. With the approval of the ESO Council and Finance Committee, a critical milestone for the project was passed in late 2013: the contract with ICAFAL Ingeniería y Construcción S.A. for the approach road and platform on Cerro Armazones has been placed.

The 26-kilometre road will connect the Armazones summit with the B-710 public highway that connects the Paranal Observatory with the Chilean road network. The Armazones platform will require the removal of approximately 15 metres in height from the summit of the mountain. The total area of the platform will exceed 30 000 square metres. The work is expected to last 18 months and be ready for the start of on-site activities by the dome constructor in 2016.

At Armazones, the plans have been developing with respect to the lay-down areas, the construction base camp and the necessary facilities (access, power, water, sewage etc) to support both ESO's and the contractor's activities at the site. The preparations require the removal of existing installations from the site, including the facilities belonging to the Universidad Catolica del Norte and ESO's site-monitoring equipment.

The testing of the Armazones site has been the most extensive that any prospective ESO site has undergone. In addition to normal atmospheric parameters (seeing, wind speed, temperature etc) and parameters critical to the performance of adaptive optics systems, we have also measured the topographic amplification factor on Armazones for earthquakes. The shape of the mountain may act to focus seismic waves, thereby changing the ground acceleration relative to that which would be expected for a given earthquake strength. ESO installed seismometers at the Armazones site and established an empirical measure of the amplification factor.

All of these efforts are in anticipation of the tendering, in 2014, for the construction of the dome and main structure of the telescope. Both these elements are in the final stages of preparation of the detailed specifications, following vigorous and extensive interaction with industry.

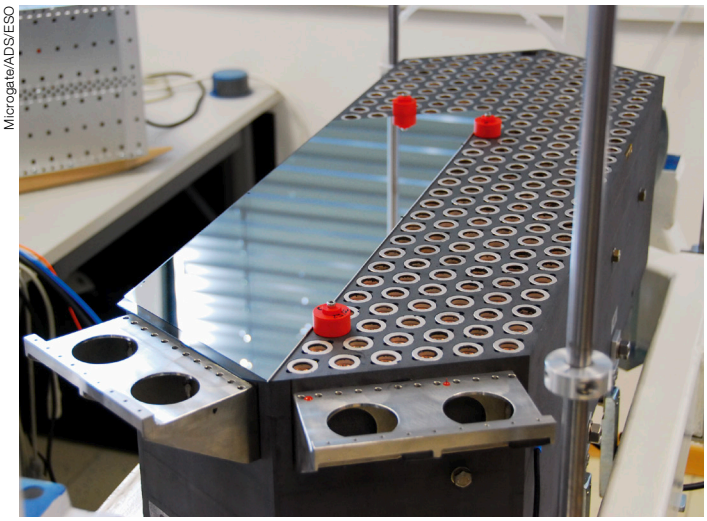
The seismic isolation test bed at ESO's Garching test facility. Both the lateral and the vertical components of the earthquake acceleration are significantly diminished through this isolation device, offering protection to both dome and telescope of the E-ELT.

The telescope optical systems have also been advancing. The contract with Adoptica for the deformable quaternary mirror (M4) is progressing well, and has passed a series of milestones. The design effort is focussed on mitigating various technical and programmatic risks identified in the prototyping phase. The deformable mirror relies on a stable backplane to provide the reference body for the actuators. The E-ELT M4 reference body will be made of silicon carbide.

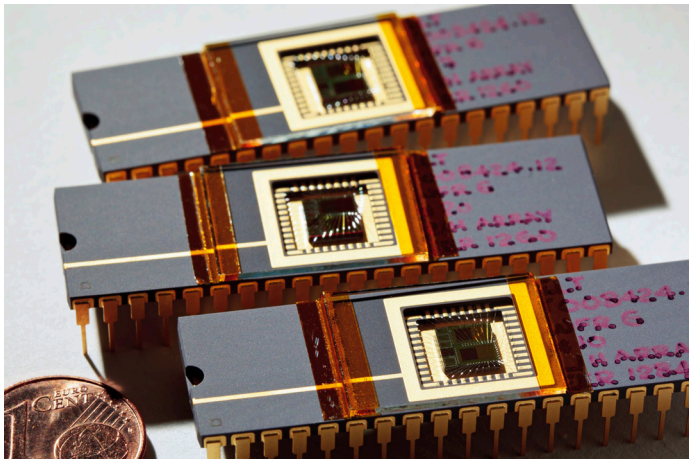
During the year there was substantial progress in setting up the manufacturing and testing process for the primary mirror segments. The successful delivery some years ago by Sagem of prototype segments has now been reproduced, with different technologies, at Optic Glyndwr with a first segment being successfully polished. The Laboratoire d'Astrophysique de Marseille has completed the design, manufacturing, and integration of a new concept of a warping harness. Such devices help to produce segments using the stressed mirror polishing technique. Warping tests were successful and the first polishing trials have started. All this bodes well for the production of the 931 segments necessary for the telescope.

The prototype systems developed during the design phase have been extensively used over the past few years to gain expertise in the control of segments, including the interplay between different segments, cross-coupling between actuators in a single segment and vibration control. The lessons learnt are propagating through our specifications for second generation systems that will form the basis for the construction system of segment support and actuation. Significant advances are also being made in the area of edge sensors and phasing sensors. These are both critical in reducing the

Microgate/ADS/ESO



Prototype of part of the adaptive support system for the M4 mirror of the E-ELT. The prototype has 350 actuators and co-located sensors. A small section of the thin mirror shell is mounted on the left part of the prototype in the picture. On the right the reference surface is visible as well as the sensors. The actuators are positioned inside the holes of the reference surface.



E-ELT technical demonstration wavefront sensors.

overall calibration needs of the telescope, hopefully reducing the amount of sky time needed to calibrate the primary mirror. In this area, the project is also making major advances in testing algorithms and phasing techniques at the GTC telescope in the Canaries, using observing time that was allocated as part of the ESO–Spain Accession Agreement. These measurements are providing the project with direct hands-on experience of realistic performance and the challenges of observing with a segmented primary mirror.

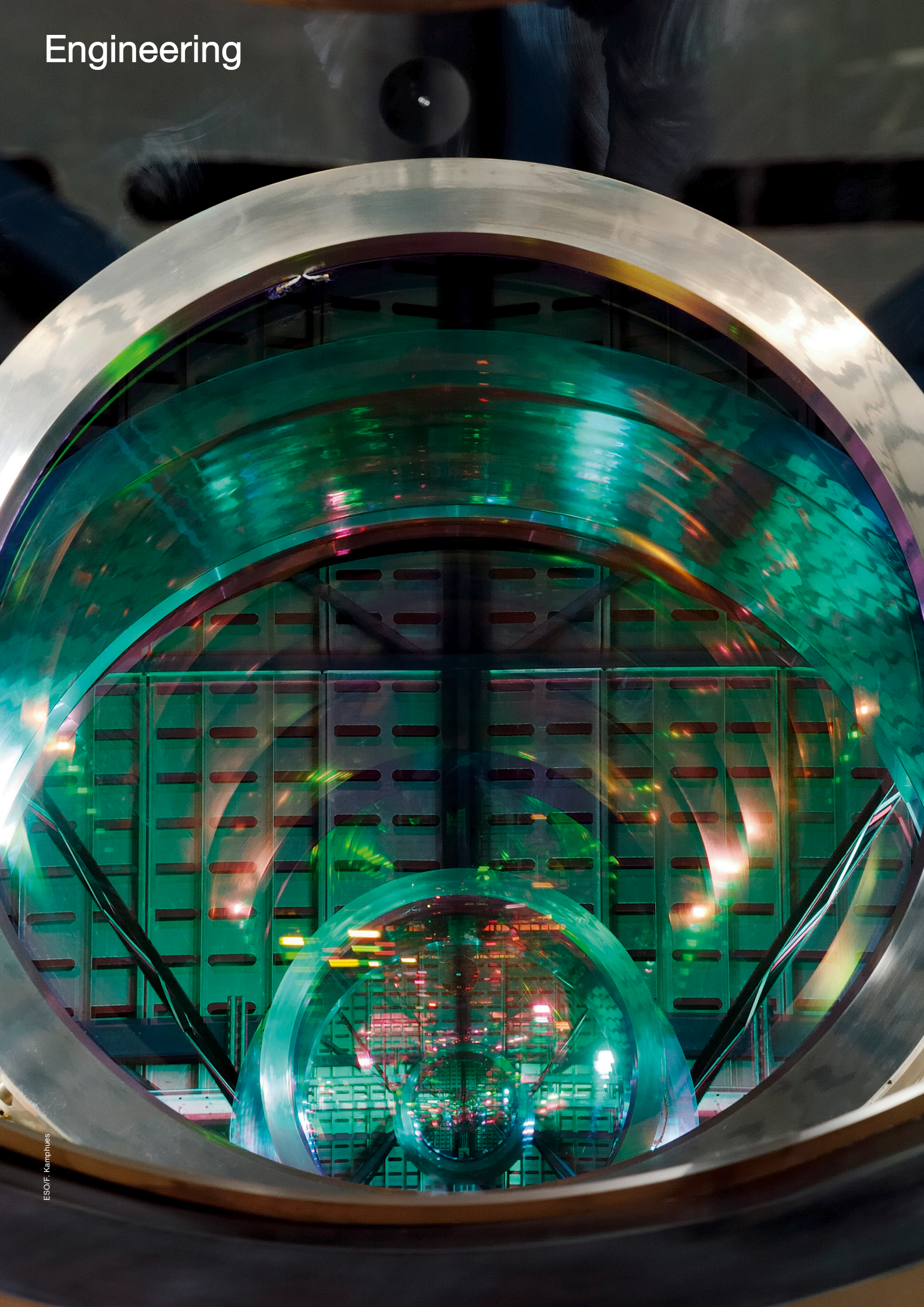
The control system for the E-ELT also saw much work during the year. Much, if not all, of the prototype testing was undertaken within the framework that we are establishing for telescope control. The testing therefore provides direct feedback to the control system as well as the hardware and algorithms. Work has been ongoing on a segment concentrator that would reduce the cabling and network complexity within the extensive M1 control system. Scaling of the real-time computing needs of the telescope has long been the focus of the project. Two major milestones were passed: the acceptance of a scale-one full ground layer adaptive optics performance real time controller for the M4 unit of the E-ELT, made from off-the-shelf PC hardware systems, and the production and testing in the field of a “mini-real-time-controller” for the NAOS adaptive optics system at the VLT, based on E-ELT adopted standards.

Activities in the area of E-ELT instrumentation increased in intensity during the year, in preparation for the anticipated launch of the contracts for first-light instruments, MICADO and HARMONI, in 2014. Planning and preparation of the specifications and statements of work are underway. In parallel with this, work on the instrument interfaces is progressing on two fronts. The architecture of the instruments on the Nasmyth platform has been studied in some depth, seeking to find an optimal solution for accommodating the instruments and their adaptive optics modules via a possible revision of the baseline design for the pre-focal station. Studies of the standard components that will be applicable to the E-ELT instruments are also underway. Standards for cryogenic components and instrument control are being considered, as well as for subsystems such as readout electronics for wavefront sensors, technical and scientific detectors. The start of design work on the three instruments in the Instrument Roadmap to follow on from the first-light instruments is the next major milestone for the instrumentation programme. The workshop, Shaping E-ELT Science and Instrumentation, in February, drew input from the ESO community on the scientific cases for the next instruments. A call for proposals for instruments to deliver these cases will be made in 2014. The next three instruments will be a mid-infrared imager and spectrograph, a high-resolution spectrograph and a multi-object spectrograph.

The E-ELT Science Office has had a busy year releasing the top-level requirements for the first-light instruments discussed above and working extensively with the community and their representatives on the project science team in the development of top-level requirements for the next three instruments. The E-ELT programme has now matured sufficiently to warrant its own subcommittee at the STC and the first meeting was held this year.

The E-ELT project, like the rest of ESO, was restructured this year to match the new full matrix work plan of the organisation. While almost all of the work is undertaken within the Engineering Directorate, the cohesion in, and direction of, the project is provided by the programme manager and the programme engineer, supported by the programme controller. The past year has been one of transition for the project as the E-ELT moves closer to construction.

Engineering



ESO/F. Kamphues

The Directorate of Engineering provides engineering resources and services to ESO programmes as well as to the operations teams at the Observatory and at Headquarters.

The Directorate went through a reorganisation this year that was part of the Matrix 2013 project. This project was initiated by the ESO Management to strengthen the matrix organisation and associated processes needed to conduct the ESO programme in the E-ELT era.

Close-up of the VISTA camera.

Information Technology Division

An IT Division was created within the Directorate with the goal of streamlining and consolidating IT services at ESO. The IT Division is structured around four main departments. The two local sites in Garching and in Chile are responsible for day-to-day IT operations and the delivery of the agreed-upon services to the sites' customers. The central IT Strategy and Governance Department is responsible for developing technical and operational strategies, technical standards, processes and procedures that are applicable across the whole of ESO. The main responsibilities of the Central Service Desk and Procurement Department are the operation of the Helpdesk, the coordination of all IT-related procurements with Contracts and Procurement as well as the management of the IT hardware and the software inventory.

Meanwhile, the IT Division continued to provide day-to-day services to all ESO users and has completed a number of projects, such as the deployment of a new telephone system in Garching.

Adaptive Optics Department

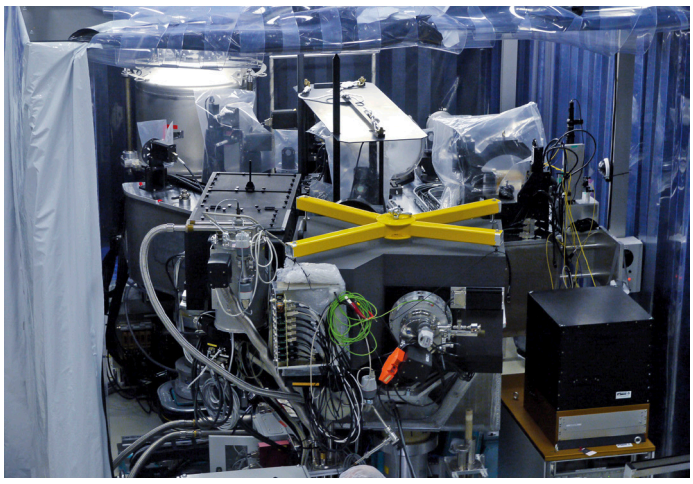
The instrument SPHERE successfully went through PAE and will receive the go-ahead for shipment to the Paranal Observatory early in February 2014. The figure below shows the instrument fully integrated in the laboratory at IPAG in Grenoble, France.

The SAXO extreme adaptive optics system designed for SPHERE has shown a performance with Strehl ratios above 90% at *H*-band up to an *R*-magnitude of 10, and still remaining higher than 50% at $R \sim 14$ in 0.85-arcsecond seeing and 12 m/s windspeed. Strehl ratios in the optical exceed 50% on bright stars. In 1.1-arcsecond seeing, the *H*-band Strehl ratio is still 85%. The raw point spread function (PSF) contrast, which does not make use of any differential quasi-static speckle calibration techniques, is already good enough to detect all of the exoplanets directly imaged so far in a few minutes of observation time.

After the arrival of SPHERE at the observatory, the assembly and integration phase will start in early March 2014. The first commissioning run with first light at the VLT is scheduled for May 2014. After commissioning all observing modes and the completion of Science Verification, it is foreseen that SPHERE will be offered for open-time observations in April 2015.

Sodium laser unit test

Laser unit 1 of the four-laser system currently being manufactured for the AOF was delivered to ESO in November. This delivery followed a test period and a factory readiness review. This 20-watt class laser, which has an output wavelength at 589 nanometres resonant with atomic sodium in the mesosphere, started further tests and integration into the ESO facility prior to acceptance of the laser unit.



SPHERE in the assembly laboratory at IPAG with all instruments integrated.

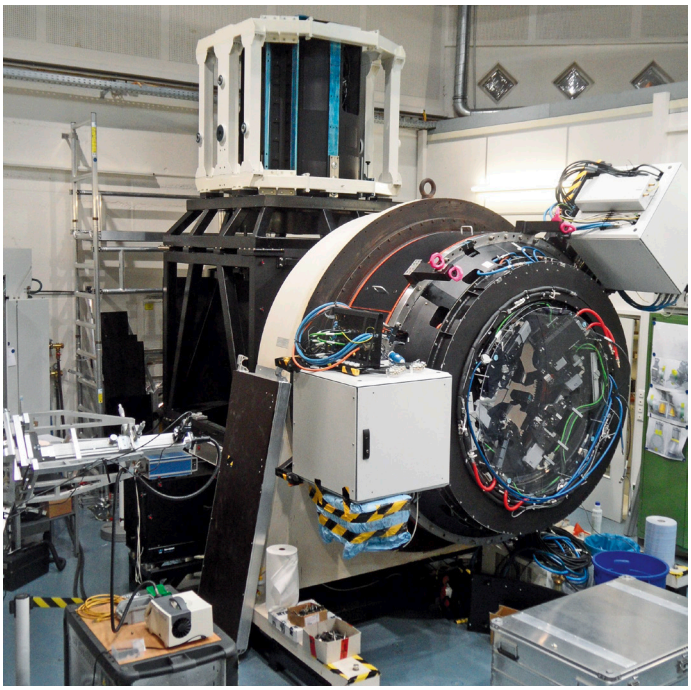
1.1-metre deformable secondary mirror

In December 2012, the new deformable secondary mirror was delivered to ESO by the Italian companies Microgate and ADS.

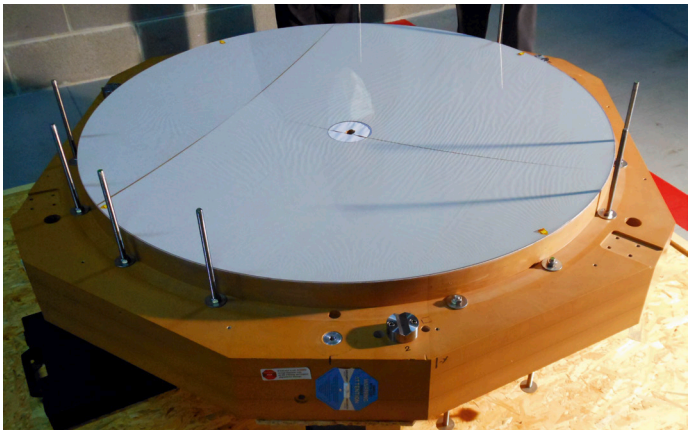
The DSM will replace the current secondary in one of the VLT's four UTs. The entire secondary structure includes a set of 1170 actuators that apply a force on 1170 magnets glued to the back face of the thin shell. Sophisticated, special-purpose electronics control the behaviour of the thin-shell mirror. The reflecting surface can be deformed up to a thousand times per second by the action of the actuators.

Following the functional acceptance tests, the DSM was mounted on the ASSIST test tower in the Assembly Hall. The mirror was optically characterised at ESO during the year with the support of Microgate-ADS and INAF/OAA at Arcetri.

The mirror optical quality reaches 38 nanometres root mean square (rms) after optical calibration. Post-processing shows that, removing the contribution of the ASSIST test bench, the mirror would reach 18 nanometres rms wavefront error.



Deformable secondary mirror installed on the ASSIST tower. At the bottom right the GRAAL adaptive optics module can be seen ready for system testing with the DSM.



The 1.1-metre diameter, 2-millimetre thick Zerodur thin shell mirror in its transport box.

Second 1.1-metre, 2-millimetre-thick shell delivery

The second 2-millimetre Zerodur thin shell, 1.12 metres in diameter, with excellent quality, was accepted from SAGEM (France) at the end of the year. The shell surface accuracy is a factor of five times better than the first shell delivered and the thickness uniformity is three times better, with excellent surface finishing. This new shell is considered to be the science grade unit for the VLT DSM while the first one will become the spare.

The suppliers of the complete DSM system supporting the thin shell, Microgate and ADS International (Italy), have developed dozens of new procedures, handling tools, crates and transport boxes to ensure that every step of the way for this fragile mirror shell is safe. Paradoxically, the safest place for the shell is when it is mounted on the telescope and securely held in place by the magnetic fields provided by the 1170 voice coils.

High performance real-time computer for the SPARTA AO system

On 18 December SPHERE passed its PAE and received the go-ahead to leave for Paranal. SPHERE brings with it the first SPARTA system. SPARTA is a complete system to perform adaptive optics control. It consists of a real-time unit in which the real-time pipeline from sensors to actuators is implemented, and a supervisor cluster that controls and optimises the real-time pipeline. The real-time unit can either be a multi-technology system with central processing units, digital signal processors and field-programmable gate arrays, featuring a remarkably low latency of 80 microseconds for SPHERE and very low jitter, or a normal central processing unit for smaller systems. The cluster is an array of computing-centre-class server systems where distributed computing is performed.

SPARTA is designed to be scalable, from small systems like NAOMI (the VLTI AO system for the ATs) and GRAVITY, with about 100 actuators, to larger systems

like GRAAL and GALACSI with more than 1000 actuators, multiple sensors and laser guide star systems. It supports a variety of sensors and AO architectures. The concept of a common platform shared across the various AO-assisted instruments has already produced significant savings in the labour cost necessary to build multiple AO systems and the saving will become increasingly important as more systems are built around the SPARTA platform, the next scheduled system being ERIS.

Advanced smart AO algorithms from Austria

On 22 October 2013, the final review of a four-year project, Mathematical Algorithms and Software for ELT Adaptive Optics, came to its conclusion. This project, part of the Austria's in-kind contributions to its accession to ESO, was approved by the ESO Council in June 2008.

This project aimed to develop algorithms and software for the correction of degraded images due to atmospheric turbulence for adaptive optics (AO) on a faster timescale than the traditional approach. The challenge was to invent a radically new approach to this problem whilst simultaneously reducing the required computing load.

The Austrian team comprised three institutes based in Linz: The Industrial Mathematics Institute of the University, the Johan Radon Institute for Computational and Applied Mathematics of the Austrian Academy of Science and the Industrial Mathematics Competence Center. It considered six AO-system types and analysed extensively four to eight mathematical reconstruction algorithms. The resulting algorithms (see table) are very fast, provide excellent quality and can provide enormous savings in the computing power required to perform the wavefront reconstruction on future AO systems for the E-ELT. However, probably the most significant achievement of this study was to make the control of those AO systems manageable with computers of reasonable size and cost and, in the extreme case of XAO, to bring such a complex system into the domain of feasible implementations.

Algorithm	System	Speed-up Factor
Cumulative reconstructor with domain decomposition (CuReD, CuRe w/ preprocessing)	SCAO/XAO	100–1000
CLIF for Pyramid wavefront sensing	XAO	200
Multi-Cure for Ground Layer AO	GLAO	100–1000
Kaczmarz	MCAO/LTAO/MOAO	10–200
Conjugate gradient	MCAO/LTAO/MOAO	10–20
Wavelets with preconditioned conjugate gradient	MCAO/LTAO/MOAO	10–100

Six algorithm types considered by the Austrian team.

Control and Instrument Software and Software Engineering Departments

The Programmable Logic Controllers project is an internal Directorate of Engineering activity that has been running since its approval this year. The project was started to complete the modernisation of the VLT control system to support PLCs and Ethernet-based field buses as the new standard platform for developing control systems for future VLT instruments. The goal of the project is not only the evaluation of the technology, but also the implementation of the software devices, including a software engineering environment. In addition, ESO staff are being trained in the new technology to be ready for ESPRESSO and ERIS, the first instruments to use the new standard.

Control Engineering Department

After the successful installation of the ESO Standard Telescope Axis Controller on the four Auxiliary Telescopes, deployment now continues on the Unit Telescopes. UT1 was the first to have the new controller permanently installed in November, with the remaining UTs to follow in 2014. The VST is the next candidate for an upgrade to the new controller in 2014. In cooperation with the Control and Instrument Software Department, the new controller algorithm will also be ported to new platforms (e.g., Beckhoff PLCs). In the LPO obsolescence management programme the VLT M1/M3 upgrade has been developed and tested in Garching. The final deployment and tests will be carried out in 2014. The department provides control engineering support to ALMA, the VLT and all E-ELT systems, and has a leading role in the E-ELT M1 test facilities, M1 control system, position actuator prototypes and the instrument control system framework. Substantial work has been done on damping and rejection technologies for the E-ELT segmented mirror system and the development of rejection algorithms for the AO systems of the VLT.

Data Flow Infrastructure Department

The department's work this year was dominated by enhancing existing services for the end-to-end VLT data flow, such as support for the Phase 1 monitoring programmes, moving target support in the Service Mode Observing Tool, ingestion of internal data products, media-based delivery of huge datasets and pre-imaging support in the archive request handler. New Reflex workflows are provided for various instruments and miscellaneous improvements were carried out to Phase 2 Proposal Preparation, to the archive's calibration selector and the Paranal and Garching Night Log Tools. Work on the new unified guide cam tool covering AOF instruments was started and new operational concepts to support dynamic prioritisation of long-running observation programmes were explored. Additionally, studies, prototyping and knowledge ramp-up were carried out on the evolution of the ESO Archive Facility and on a new web-based Phase 1 and 2 proposal submission system.

Detector Systems Department

Monolithic charged coupled device (CCD) production has reached the six-inch wafer scale limit, with the production of the new CCD types for ESPRESSO. As a

result of a competitive tendering process and careful detector selection for ESPRESSO's precision and stability requirements in the nanometre range, 9k × 9k, 10-micrometre pixel CCDs with 16 outputs were procured from e2v. After achieving warm first light in mock-up mechanics, the first ESPRESSO detector recently achieved first laboratory light in the ESO prototype cryostat, connected to an ESO NGC controller.

The application of the noise-free electron avalanche gain of HgCdTe material to near-infrared wavefront sensing and fringe tracking has resulted in a new technological breakthrough. By changing the growth technology to metal organic chemical vapour phase epitaxy, devices can now be operated at temperatures of 85 K with 99.97% of pixel operability at maximum avalanche gain. For the GRAVITY wavefront sensors the readout noise can be reduced to the negligible value of 0.2 electrons rms. This is a new enabling technology for adaptive optics and interferometry and has been developed in collaboration with SELEX SE in the UK.

Careful analysis and laboratory evaluation of the AQUARIUS detector has resulted in a detailed understanding of its reduced instrument sensitivity. The problem is associated with the thickness of the blocking layer in the detector that is a source of excess low frequency noise. This problem can be mitigated by the use of higher chopping frequencies of the secondary mirror of the VLT. It is planned to re-commission the detector and the VISIR instrument in the summer of 2014.

The NGC detector controller system is now in routine operation at the VLT and has reached a very high level of maturity. It has been used to operate many different detector types, such as the large slow-scan ESPRESSO CCD and the very high-speed mid-infrared AQUARIUS detector. It is very adaptable and continues to meet all instrumentation needs. With further development it will meet the requirements of detectors for the E-ELT.

Zero read-noise, high frame rate of 1500 frames per second operation, CCD220 L3Vision sensors will be deployed in the AO version of the NGC for wavefront sensor cameras for the first time at Paranal with the commissioning of the SPHERE instrument in the coming months. Fourteen more wavefront sensor cameras are destined for delivery to the AOF in the coming months.

The quarter-sized 880 × 840 pixel prototype of the ambitious, 1680 × 1680 pixel large format, high-speed E-ELT large natural/laser guide star wavefront sensor detector (code named NGSD) has been manufactured and is currently under evaluation by e2v Technologies (www.e2v.com).

Electronic Engineering Department

The department is heavily involved in LPO-related obsolescence management projects.

Our department is providing support to the LPO, not only at system development level, but also with respect to small project management. At the project level, in November, the department successfully managed to deliver the UT2 Safety chain project in time to the LPO team. At the system level, thanks to the proof of concept for virtualisation carried out last year on the MACCON motion controller board using field-programmable gate array technology, we were able to extend this work to the high voltage for Multiple Application Curvature Adaptive Optics and avalanche photodiode counter boards upgrade. Support to instrument projects is the second biggest activity of the department. This year we have contributed to the successful deployment of the PARLA laser, and supported MUSE, SPHERE, GRAVITY and GALACSI instruments. On the E-ELT project, we have concentrated our activities on evaluating the M1 cell on the Garching Hochbrück test stand, and finalising its related requirements documents.

Instrument Systems Department

The department has supported a total of nine instrumentation projects — on average one per staff member — providing project management and/or system engineering. Two major instruments, KMOS and MUSE, saw first light in the last 12 months and two others are in the final design phase. System engineering has also been provided for two E-ELT instruments.

One of the department's staff members (Juan Carlos González) was appointed E-ELT System Engineer, strengthening the link between telescope and the instrumentation.

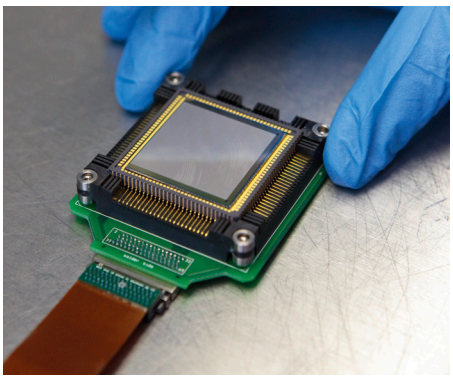
A new tool for system engineering (model-based system engineering) has been adopted and tested on an instrument project (CUBES). This activity was supported by the Control and Instrument Software Department.

A number of outreach activities (e.g., a presentation at the EIROforum School on Instrumentation, co-chair of the Science Organising Committee for Scientific Detector Workshop in Florence) have also been conducted.

Mechanical and Cryogenic Engineering Department

The work related to reducing vibrations in cryogenic instruments was completed when a comprehensive vibration specification for VLT UT instruments was generated and released.

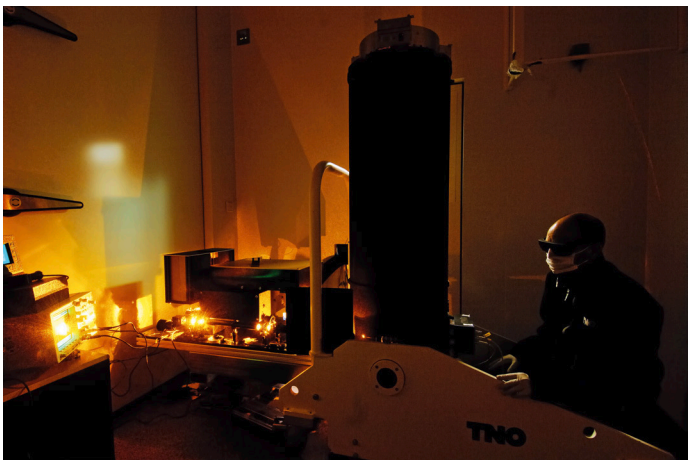
The department provided the detector mounts for MATISSE. An AQUARIUS detector was integrated with the *N*-band, and a HAWAII2RG detector with the *L*-band, cryostats. Specific cryogenic



AQUARIUS is a high flux 1K × 1K Si:As array for ground-based observations in the mid-infrared. It will be used by the VLT mid-infrared instrument VISIR and also in the VLTI instrument MATISSE.

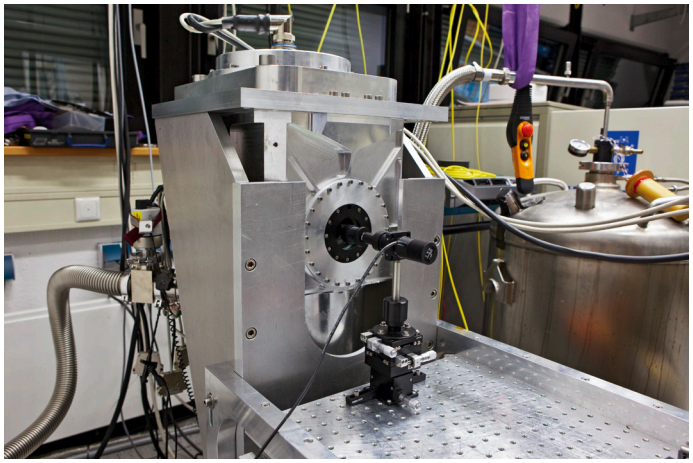
ESO/G. Hüdepohl (atacamaphoto.com)

The MUSE instrument during installation at the Paranal Observatory.



F. Kamphues/TNO/ESO

High-power laser test of the VLT's 4LGSF laser launch telescope in the ESO climatic chamber in Garching.



GRAVITY wavefront sensor.

Members of the GRAAL instrument team, inspecting GRAAL's mechanical assembly in the integration hall at ESO Headquarters in Garching.

preamplifiers were customised. Four-Kelvin thermal testing and optimisation were supported.

MUSE's vacuum cryogenic system was dismounted from the instrument and reintegrated at the Paranal Observatory. The instrument is operational and the 24 cryostats are running smoothly, fed by two liquid nitrogen tanks. Follow-up to integration and assembly for MUSE continued up to PAE, which was granted. After transfer to Paranal, support was provided for re-integration in the new integration hall.

A new sensor arm for MUSE, which is situated within the telescope rotator, has been designed, integrated and now commissioned. This will allow the necessary telescope focus shift to be accommodated for MUSE to operate.

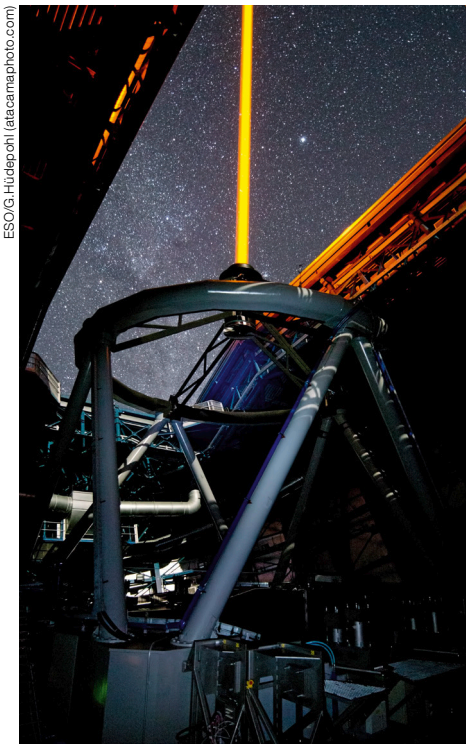
After extensive work to improve the cryogenic and detector performance, the first GRAVITY wavefront sensor cryostat equipped with the SAPHIRA infrared detector has been delivered to the GRAVITY consortium.

The first 4LGSF launch telescope system unit has been fully integrated and aligned. The second unit is expected to be aligned very soon. The final two units will be aligned and tested in 2014. These units will be installed on UT4 and will provide that facility with multiple (four) laser guide stars.

Additional department work included attaching GRAAL to the ASSIST test bench ready for the start of system testing and the continuation of GALACSI integration.

ESPRESSO camera support was provided to the detector team and integration and lenslet alignment provided to some of the wavefront sensor cameras prepared for SPHERE, GRAAL and GALACSI.

The ESO Technical Archive has been moved over to a document management



ESO/G.Hüdepohl (atacamaphoto.com)

The LGSF during PARLA commissioning.

system. This has been configured to allow very easy access to all of ESO's technical documents. An area within this system is set aside for collaborative working. This has been configured and will be used by projects to share documents more efficiently and to release them to the archive within the same system.

Optics and Photonics Department

The department is active in optical design for telescopes and instruments, active optics and wavefront control, metrology applied to E-ELT edge sensors and telescope alignment, laser guide stars, and optical fibres for instruments including ESPRESSO. We maintain the optics laboratory and support the integration and test of optical systems.

Investigation of stray light on the VST during bright periods led to the design and successful demonstration of an improved baffling scheme that is now being implemented as a permanent installation on the telescope.

Work for the adaptive optics facility included support for testing a new guider arm for the back focal length extension to enable MUSE and GALACSI to work together. We are also responsible for the 4LGSF, which continued assembly, integration and testing.

The PARLA laser project, delivering a new prototype laser source as an upgrade of the existing laser guide star facility at Unit Telescope 4 on Paranal, was completed. The new laser system, based on fibre laser technology developed by ESO, replaced the original PARSEC dye laser system, which was reaching the end of its life after making many important discoveries. The upgraded laser guide star facility delivers up to 7 watts of optical power onto the sky at the sodium-resonant wavelength of 589 nanometres. Availability of the facility for science operations has very significantly increased to around 200 hours per month after the upgrade.

Pipeline Systems Department

The department is responsible for the design, implementation and maintenance of the data processing and numerical software components, which are critical for the end-to-end operations of the ESO data flow systems for the VLT, VLTI, survey and La Silla telescopes, as well as ALMA. This includes the Common Pipeline Library, the VLT instrument pipelines, the ALMA/CASA data reduction software and the exposure time calculators.

The KMOS and MUSE pipelines have provided major additions to the suite of VLT pipelines during the year. The KMOS pipeline, including a Reflex workflow, has been delivered for commissioning, Science Verification and operations. The MUSE pipeline has been deployed on a multi-threaded 64-core architecture. High-performance computing remained a major area of development, in particular to support the parallelisation of the image processing in the ALMA/CASA package.

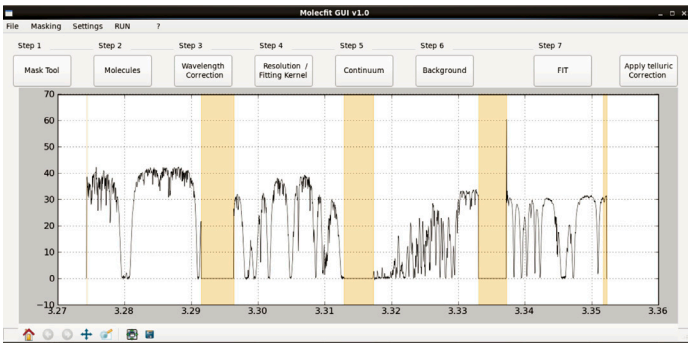
The development of science grade data products and Reflex workflows has continued, with the definition of a FORS-VIMOS pipeline upgrade project. The Austrian in-kind contribution for sky-modelling projects was successfully completed this year. A one-day Garching-Vitacura workshop on telluric correction was organised in June. The completion of the sky spectrum model project is a major contribution to the exposure time calculator system, as it provides a vast improvement in the accuracy of the results.

Structure and System Analysis Department

The main activities of the department were dedicated to writing, consolidating and justifying requirements for the various E-ELT supply specifications.

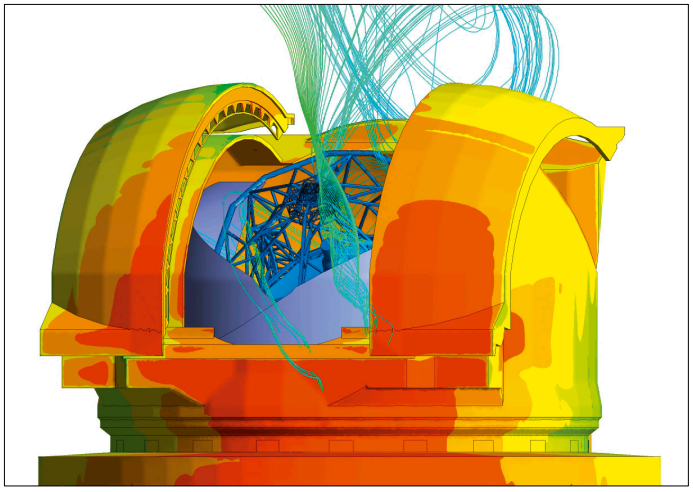
Based on detailed structural, control and optical ray-tracing models, system analysis support was provided to evaluate performance budgets (e.g., wavefront error, stroke, deformation) of the complete telescope, including its subsystems and to derive requirements at various specification levels.

A passive mirror support for the E-ELT M2 unit has been designed at a conceptual level and its feasibility analytically



The molecfit graphical user interface, the front end interface to the telluric absorption correction program developed in the framework of the Austrian in-kind contribution. The window shows a CRIRES spectrum, with fitting exclusion zones defined between the bands.

Installation of seismic station at Cerro Armazones.



Streamlines and pressure distribution from E-ELT dome and main structure computational fluid dynamics analysis.

validated. The proposed new design is expected to be less complex, stiffer and cheaper than the original active support configuration.

Transient earthquake analyses of the E-ELT main structure, including pier and seismic isolation systems were performed to evaluate the accelerations in the subsystems.

A measurement campaign of the seismic topographical amplification factor at Cerro Armazones was conducted to determine the amplification effect of the mountain shape. The results were evaluated and used to update the earthquake load specification for the E-ELT.

Computational fluid dynamics analysis studies of the E-ELT dome and main structure have been performed to support the requirements definitions for the windscreen and tracking performance.

VLTI Department

The VLTI Department provides project engineering, system engineering and software coordination support for projects related to the development of the VLTI infrastructure and of VLTI instruments.

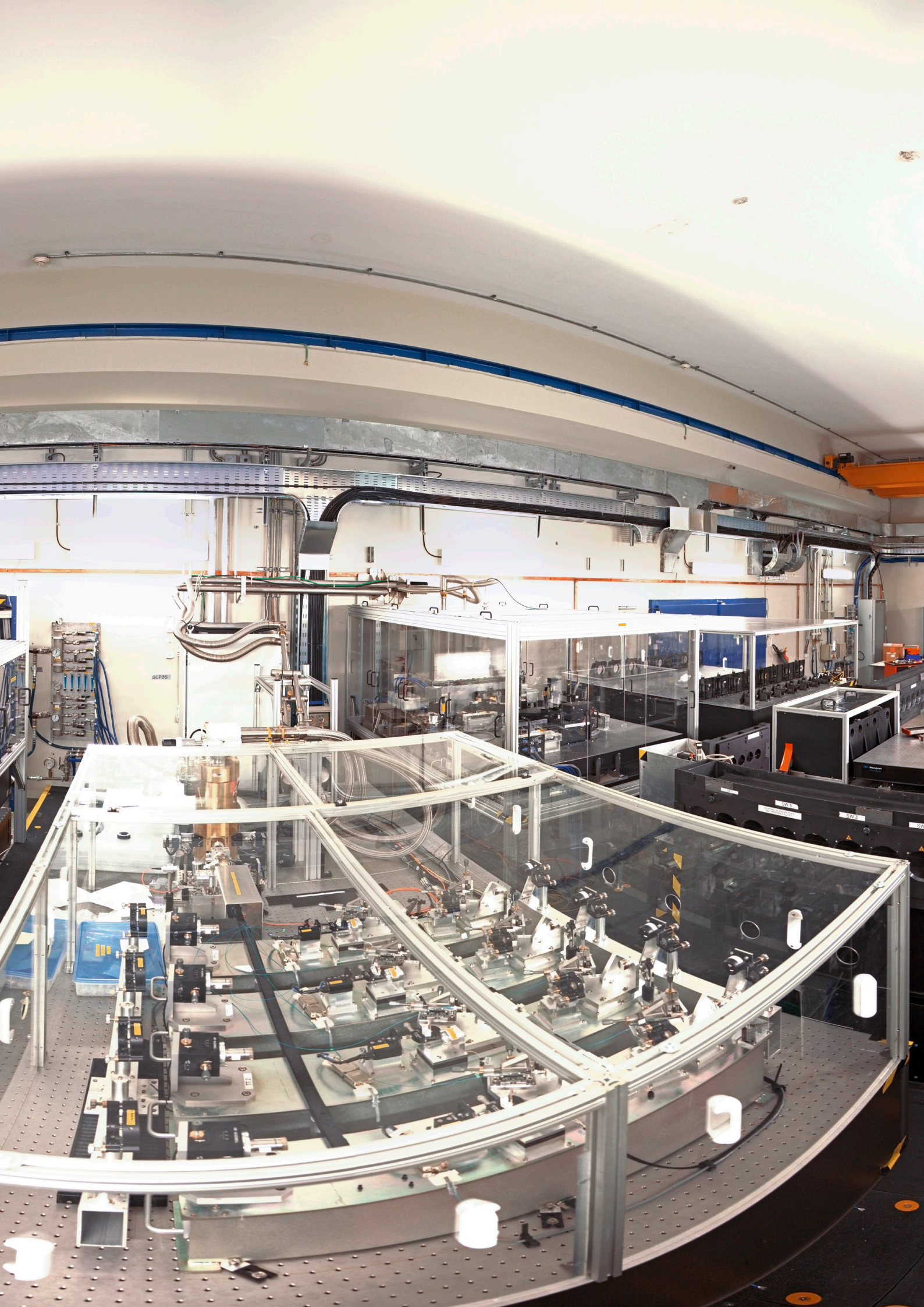
The main activity of this year was the investigation of PRIMA's (Phase-Referenced Imaging and Micro-arcsecond Astrometry facility) difficulties in reaching the astrometric accuracy goals fixed at the start of the project. The VLTI's polarisation behaviour with the ATs was simulated by the Structure and System Analysis Department while an opto-mechanical test set-up was developed by the VLTI and Control Software Departments. The measurements and simulation helped to pinpoint the culprit for PRIMA's polarisation misbehaviour and correct for it by fixing a quarter-wave compensation plate to the field de-rotator at the coudé focus of the telescopes. This led to successful and reliable astrometric test observations in September. The astrometric performance of PRIMA could then be evaluated at ~ 160 micro-arcseconds peak-to-peak accuracy (with non-gaussian dispersion) compared to the required performance of 20–50 micro-arcseconds rms. The accuracy is limited by the position of the retro-reflector of PRIMA (on mirror M2) and its uncontrolled movement with respect to the stellar entrance pupil (i.e., narrow-angle baseline stability). A recovery plan to reach the desired accuracy was prepared by the project team and is to be presented to an independent review board (PRIMA Gate Review) in January 2014.

The department also leads the continuous development of the VLTI supervisor software in charge of coordinating this complex infrastructure. We developed and tested new features needed by the PRIMA investigation, by the second generation instruments GRAVITY and MATISSE and by the regular software upgrades and improvements for operations.

The department provided system engineering and project engineering support for the follow-up of the second generation instruments GRAVITY and MATISSE and for the design of the VLTI second generation fringe tracker. In particular, we collaborated with the GRAVITY consortium to perform polarisation measurements on the VLTI infrastructure and Unit Telescopes, complementing the measurements mentioned above.

Finally the installation and test of the star separators on the Auxiliary and Unit Telescopes continued. First light of the star separator on UT1 on sky, a major milestone in preparation of the infrastructure for the GRAVITY instrument, was obtained in November. It showed an excellent pointing and control of the beam tip-tilt and pupil position.

The VLTI laboratory.



Administration

The ESO Headquarters extension in Garching.

The ribbon-cutting ceremony at the inauguration of the ESO Headquarters extension on 4 December 2013. From left to right in the picture: Patrick Geeraert, ESO Director of Administration, Tim de Zeeuw, ESO Director General, Hannelore Gabor, Mayor of Garching, Xavier Barcons, President of the ESO Council and Christoph Haupt, ESO Headquarters extension project manager.

ESO/S. Lowery

The ESO Headquarters extension buildings were accepted in December after 24 months of construction work. The official inauguration took place on the occasion of the 129th ESO Council meeting, which was held in the new council room. Just before Christmas, the buildings were opened for the staff with a housewarming party. Furnishing and moving offices started at the end of December and will be completed during the first quarter of 2014. With the completion of the Headquarters extension, the ESO staff are now finally co-located in one place. The new technical building will be used for the development, integration and testing of E-ELT instruments and enabling technologies.

Following some fundraising efforts, the Klaus Tschira Stiftung has decided to donate a planetarium and visitor centre to ESO. The new facility will be called ESO Supernova – Planetarium & Visitor Centre. A project team comprising the Outreach Department, Legal Services and the Facility Management Department provided input for the equipment and facilities and have drafted possible operational scenarios. The building permits will be requested in the first half of 2014.

Further changes in the Procurement Department were implemented to further professionalise the service to the internal customer and prepare for the forthcoming complex procurements relating to the E-ELT. The supplier database was improved, general conditions and standard documents were updated. Many industry events, workshops and training sessions were conducted during the year.

The preliminary inquiry phase for the dome and main structure for the E-ELT was completed and the full procurement for the construction of the road to Armazones and the topping of the mountain were carried out. This contract was signed on 9 December in Santiago de Chile with the company ICAFAL Ingeniería y Construcción S.A.

The Enterprise Resource Planning (ERP) team implemented a new resource planning tool allowing project managers to enter their human resource requests, which are subsequently allocated by the functional managers. This is an ongoing procedure, improving both the budget and resource planning processes. The implementation of a new fully integrated recruitment portal was realised and the switch to the Single Euro Payments Area (SEPA) payment-integration initiative was completed.

Safety was much involved in giving advice for the ESO Headquarters extension buildings and will also provide recommendations for new construction projects (ESO Supernova and the ALMA Residence). Regular safety inspections also led to continuous improvements in the existing building.

An increasing number of scientific and engineering projects solicited input from Safety throughout the year (e.g., E-ELT, ALMA, MUSE, SPHERE, AOF-DSM), including appropriate safety and conformity-related responsibilities in the programme and project management documentation.

The Chile office was successful in selling a plot of land in Antofagasta and has already made contacts to sell the property in La Serena. Both properties are unused and the sales are contributing to a better cash flow.

On the occasion of 50 years of ESO in Chile, the General Services in Vitacura organised a celebration for staff and their families on 30 October.

Celebrating 50 years of ESO in Chile.

The Finance Committee visiting ALMA during its 137th meeting, held in Chile in November.

Finance and Budget

Financial Statements 2013

Accounting Statements 2013
(in € 1000)

Statement of Financial Position	31.12.2013	31.12.2012
Assets		
Cash and cash equivalents	4208	6342
Inventories, receivables, advances and other current assets	25279	34313
Non-current assets	1058053	1047302
Total Assets	**1087540**	**1087957**
Liabilities		
Short-term borrowing	20000	13002
Payables, advances received and other current liabilities	54057	62257
Non-current liabilities	306374	394756
Total Liabilities	**380431**	**470015**
Accumulated surpluses/deficits	660310	681035
Pension fund loss/gain	65571	–2998
Other changes in net assets	–	–39058
Net surplus/ deficit for the year	–18772	–21037
Total Net Assets	**707109**	**617942**
Total Liabilities and Net Assets	**1087540**	**1087957**

Statement of Financial Performance	01.01.–31.12.2013	01.01.–31.12.2012
Operating Revenue		
Contributions from Member States	143668	132690
Contributions to special projects	6226	17299
In kind contributions	1313	1313
Sales and service charges	3432	3808
Other revenue	611	530
Total Operating Revenue	**155250**	**155640**
Operating Expenses		
Installations and equipment	3858	5594
Supplies and services	44246	54805
Personnel expenses	74492	78527
Depreciation of fixed assets	53955	43087
Other operating expenses	844	459
Total Operating Expenses	**177395**	**182472**
Net surplus/deficit from operating activities	**–22145**	**–26832**
Financial revenue	2490	1506
Financial expenses	1270	1297
Net surplus/deficit from financial activities	**1220**	**209**
Non periodic and extraordinary revenue	3192	5586
Non periodic and extraordinary expenses	1039	–
Net surplus (deficit) from non periodic and extraordinary activties	**2153**	**5586**
Net Surplus/Deficit for the Period	**–18772**	**–21037**

Cash Flow Statement	2013	2012
Cash Flow		
Net receipts	162805	166154
Net payments	–171937	–190964
Net cash flow from operating activities	**–9132**	**–24810**
Net cash flow from financing activities	**7000**	**13000**
Net Cash Flow = Net Decrease in Cash and Cash Equivalents	**–2132**	**–11810**

Budgetary Reports 2013
(in € 1000)

Income Budget	Budget	Actual
Contributions from Member States	136902	147878
Income from third parties and advances received	13091	7699
Other income	2964	4194
Consolidated entities	827	717
Total Income Budget	**153784**	**160488**
Payment Budget		
Programme	84177	63978
Technical infrastructure and production	7806	7347
Operations	73567	67250
Science support	9017	8070
General activities	27284	24422
Predicted payment delays	–5000	–
Financing cost	179	164
Consolidated entities	649	599
Total Payment Budget	**197679**	**171830**

Budget for 2014
(in € 1000)

Income Budget	2014
Contributions from Member States	165672
Income from third parties	10437
Other income	1325
Consolidated entities	620
Total Income Budget (approved)	**178054**
Conditional Income E-ELT (from Brazil and Spain)	67380
Total Income Budget incl. Conditional Income	**245434**
Payment Budget	**2014**
Programme	59913
Technical infrastructure and production	7828
Operations	71652
Science support	8454
General activities	26288
Financing cost	124
Consolidated entities	697
Total Payment Budget	**174956**

The External Auditors, Tribunal de Contas de Portugal*, have expressed their opinion that the financial statements for 2013 give a true and fair view of the affairs of the Organisation.

The accounting statements for 2013 show a negative result of –18.8 million euro. It is composed of a negative result from operating activities of –22.2 million euro, principally arising from 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 December 2013. It was partly compensated for by a surplus from financial activities of +1.2 million euro as well as a positive impact from non-periodic activities of +2.2 million euro. However, the budgetary outturn shows a positive development. More income than planned was received, mainly due to contributions for the E-ELT. Expenditure was below budgeted level resulting in substantial savings.

The net assets of the Organisation at 31 December 2013 amount to 707.1 million euro.

The negative cash flow from operating activities of –9.1 million euro in 2013 reflects the planned excess of payments over received income during the financial year. The main payments were for ALMA construction and for the Headquarters extension building. To cover financing needs, short-term borrowing of 20 million euro *vs.* 13 million euro at 31 December 2012 was taken up, resulting in an overall cash flow of –2.1 million euro. The cash position at 31 December 2013 was 4.2 million euro. All borrowing will be paid back by the end of April 2014.

The budget for 2014 was approved by the ESO Council in December 2013. The approved 2014 payment budget amounts to 175.0 million euros. It covers commitments for the current VLT/VLTI instrumentation programme and ALMA construction as well as a budget provision of 25.0 million euros for E-ELT construction activities.

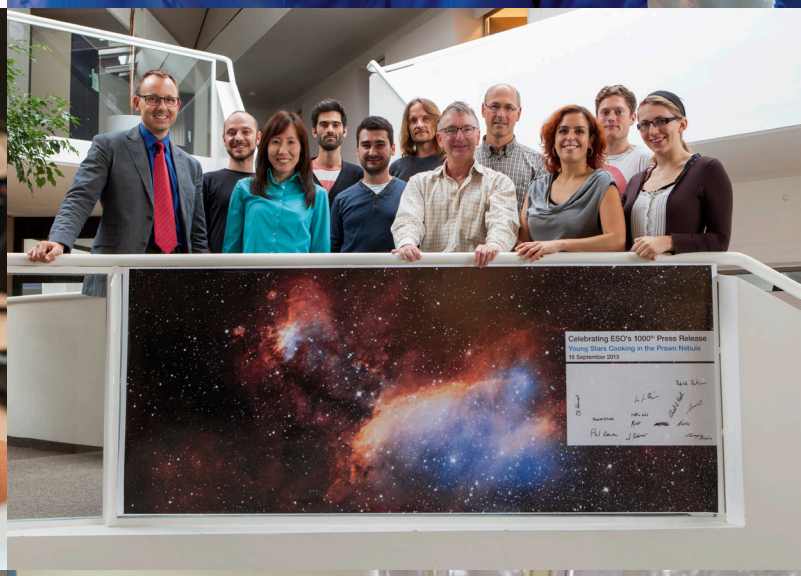
The 2014 approved income budget amounts to 178.1 million euro. It includes the regular contributions from the ESO European Member States, income from third parties and partners and other income including additional income for the E-ELT from all Member States having agreed to participate in the project. Conditional income for the E-ELT from Spain and Brazil adds up to 67.4 million euro resulting in a total expected income budget of 245.4 million euro subject to the participation of Spain and the full ratification of the Accession Agreement by Brazil during the course of the year.

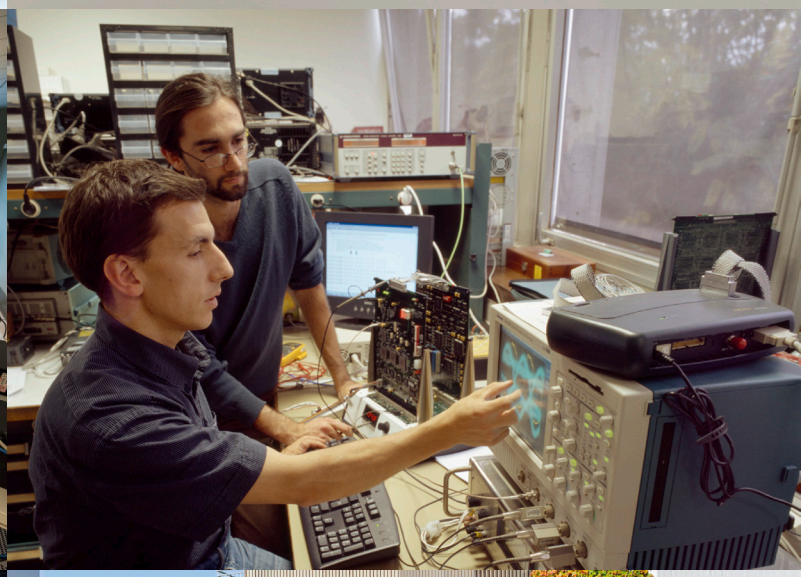
* Antonio José Avérous Mira Crespo (Member of the Portuguese Court of Auditors), Maria da Luz Carmezim (Head of Audit Department), Antonio A.F.B. Pombeiro (Senior Auditor), Mr. Nuno Martins Lopes (Auditor) and Ms. Filomena Maria de Oliveira Rolo (Auditor).

Reaching out to the stars at Paranal.

ESO/B. Tafreshi (twanight.org)

Human Resources





The Human Resources department (HR) deals with all services provided to employees in connection with their employment at ESO, starting from the definition of applicable policies to the conclusion and execution of employment contracts. Within this scope, HR deals with the following tasks:

- planning and definition of personnel resources policy and strategy;
- recruitment and selection procedures;
- support to employees regarding the implementation of applicable rules and regulations;
- occupational health and welfare;
- social security;
- training and professional development; and
- family matters for staff, including day-care and the European School.

HR strategy policy and planning

Performance management

A new performance management and professional development model and process have been developed. The management team approved the draft concept and oversaw a validation that took place through the Staff Association and unions, as well as through various working groups in Garching and Chile. The new process was finalised by the end of July and was applied on a trial basis to the Performance Review this year. At the beginning of 2014, its results will be reviewed and the finalised circular and guide will be presented to the governing bodies. During its meeting in September, the Standing Advisory Committee welcomed the significant effort made by ESO Management to improve this process. HR advisors ran training sessions in September and October to train staff and managers on the following in particular:

- process alignment with the ESO Way and the matrix reorganisation;
- improved and clearer links to the learning and development process, the ESO competency framework, career paths and the advancement process;
- revision of general performance criteria and overall performance assessment and ratings;
- written input to their appraisal by the corresponding feedback provider for matrixed staff members, including objectives and training requirements; and
- clarification of the underperformance management process.

Competency framework

ESO's existing competency framework was reworked by an external consultant, a group of nine staff members and HR advisors. The revised competency framework was reviewed by two further working groups in Garching and Chile, facilitated by members of HR. It has been developed in line with ESO's mission and values and serves as a reference document that aims to provide direction and consistency across all functions at ESO. The amended framework is focussed on behaviours and is designed to be used in the areas of recruitment, performance management, change management, 360° feedback as well as learning and development.

Flexible working time

As a result of the staff engagement survey, ESO Management has decided to introduce flexible working hours for staff with duty stations in Garching or Vitacura. The goals are both to improve the work–life balance of staff and to harmonise the existing individual, departmental, or divisional working time requirements around the core hours. The guidelines were applied on a trial basis for twelve months and a first review will take place in February 2014.

Code of Conduct

HR introduced the ESO Code of Conduct document, which will help to ensure a shared appreciation of ESO's values and their influence on the way we work with mutual respect. HR advisors presented it within the framework of the ESO Way to all departments.

Regular review — conditions of employment

The start of the five-yearly review of the conditions of employment was delayed, but finally started in July. ESO Management presented a first overview on the current status and results to the Tripartite Group in October. During the previous Finance Committee meeting, ESO Management suggested setting up a Working Group for the ESO Regular Review. It will comprise members from the Tripartite Group, the International Staff Committee and HR. A first report is expected in 2014.

Contract policy

ESO Management reviewed the current contract policy for International Staff Members in order to cope with the mid- and long-term requirements of the organisation. It took into account the new matrix structure, demographic impact, and the ratio of fixed and indefinite contracts and also compared it with other intergovernmental organisations. Council approved the amended contract policy at its meeting in December to become effective as of 1 January 2014.

Recruitment portal

An improved ESO recruitment portal was implemented in June. It is more user-friendly and provides a better service for internal and external applicants, such as a direct upload of recommendation letters.

Internal vacancies

In order to facilitate internal job rotations, the ESO Management introduced internal vacancy notices. If a position is still vacant after two weeks, it will be published on the HR webpage for external applicants. The possibility for direct reassignment is not affected by this measure.

Project-oriented matrix management

Following the staffing review in 2011, a project-oriented matrix management scheme was implemented in June 2013 to deploy staff efficiently and to meet the evolving demands of ESO. This restructuring, including the definition of roles and responsibilities of functional and project

managers, was developed in workshops with an external consultant and involved around 80 staff members from all departments across the organisation. HR designed a communication plan for reassignments and updated all relevant documents and policies.

Recruitment, selection and reassignment

During the year, 17 vacancy notices were published, prompting a total of 825 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	13	433
Local Staff Members	3	166
Fellows	1	226

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.

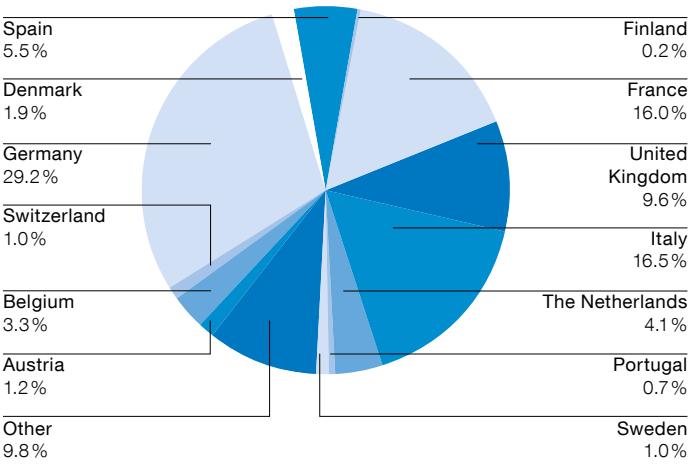
Within the ESO Fellowship Programme, six applicants were selected with duty station in Chile and six for Garching. Furthermore, nine candidates were awarded a Studentship in Europe and five candidates in Chile.

In addition, 19 members of personnel were reassigned internally.

Learning and professional development

360° feedback reviews

The main objective of implementing a 360° feedback review is to help managers reflect in a structured way on their leadership style, to identify strengths and weaknesses, and to define development plans where there are deficits, including a consistent follow-up. Based on a questionnaire, 451 members of personnel gave feedback to 39 middle managers. External coaches helped these managers to understand their feedback reports and commence a reflection process, which should lead to individual development plans that are followed up in close interaction with HR and the line managers.



Distribution of International Staff Members by nationality — 31 December 2013.

Employee relations and communications

HR continued to have regular discussions with the International Staff Committee and the unions in Chile in the areas of organisational development, policy amendments, regulations, health working group and training actions.

In the course of the year, one Rehabilitation Board examined a case concerning incapacity, illness and procedural actions and two Advisory Appeal Boards were appointed and their substantiated recommendations were followed by the Director General.

Collaboration and representation of HR

In monthly meetings of the ALMA Human Resources Advisory Group, HR gave advice on union matters and staff transitions from construction to operation. It also advised on the appointments of managers and in the development of policies and procedures.

In three meetings, the Tripartite Group dealt mainly with the developments of the CERN Pension Fund and the Staff Regulations, the annual review of remuneration and allowances, salary adjustments, the results of the engagement survey and staff policies.

Health and welfare and social security

Amended definition of the ESO Reference Salary within the CERN Pension Fund

This new pension scheme applies to Staff Members and Fellows starting on 1 January 2014 or later and is in particular based on the following parameters:

- contributions and benefits continue to be paid in Swiss francs (CHF);
- contributions are based on actual ESO salaries converted into CHF at market rate;
- retirement pensions are based on the final reference salary using the average exchange rate over the career.

In close collaboration with the representatives of the CERN management, CERN Legal Services and the CERN Pension Fund Governing Board as well as with the representatives of staff, ESO Management has amended correspondingly its Staff Regulations and the Agreement between CERN and ESO. At its meeting on 4 and 5 December, Council approved the amended Staff Regulations and the "Agreement between CERN and ESO concerning the admission of ESO staff to the CERN Pension Fund".

Health insurance

The health insurance scheme was adjusted according to the requirements of medical coverage and the developments in health care in the Member States.

Staff departure

Staff departures this year fall into the following categories:

Reasons	Staff Member	Local Staff Member
Resignation	11	4
Expiry of contract	4	0
Retirement	2	2
Mutual agreement	2	1
Death	0	1
Total	19	8

Astronomers coming back from a long observing night at the Paranal Observatory. This picture captured them at the entrance to the Residencia.

List of Staff

As of 31 December 2013

Director General

Tim de Zeeuw

Director General Support

Laura Comendador Frutos
Fernando Comerón
Gabriela Gajardo
Nikolaj Gube
Priya Nirmala Hein
Isolde Kreutle
Elena Llopis Liske
Claus Madsen
Enikő Patkós
Douglas Pierce-Price
Jasna Razmilic
Diego Rioseco
Jane Wallace

Robert Fosbury (Emeritus Astronomer)

Directorate of Administration

Patrick Geeraert

Patricia Adriazola
Andrés Oldemar Arias
Angela Arndt
Katalin Baltayne Korompay
Nikolaus Barnes
Roland Block
Jean-Michel Bonneau
Renate Brunner
Marcela Campos
Karina Celedon
Claudia Silvina Cerda
Mercedes Chacoff
Amal Daire
Alain Delorme
Evelina Dietmann
Andrea Dinkel
Sabine Eisenbraun
Willem Eng
Alain Gilliotte
Rebonto Guha
Leonardo Guzman
Robert Hamilton
Christoph Haupt
Charlotte Hermant
Georg Junker
Nathalie Kastelyn
Katarina Kiupel
Katjuscha Lockhart
Ignacio Lopez Gil
Rodrigo Lorca
Qiao Yun Ma
Maria Madrazo
Alessandro Martis
Anna Michaleli
María Angélica Moya
Christian Muckle
Hélène Neuville
Claudia Ober
Ester Oliveras
Ernesto Orrego
Betül Özener
Thomas Penker
Florence Perrault
Leonel Pizarro
Mauricio Quintana
Fabian Reckmann
Mario Riedel
Jürgen Riesel
Rosa Ivonne Riveros
Francky Rombout
Elke Rose
Marcia Saavedra
Nadja Sababa
Johannes Schimpelsberger
Heidi Schmidt
Maria Soledad Silva
Erich Siml
Roswitha Slater
Alexandra Specht
Albert Triat
Arnoldus Gregorius Tromp
Lone Vedsø Marschollek
Maritza Vicencio
Michael Weigand

Directorate of Engineering

Michèle Péron

José Antonio Abad
Roberto Abuter
Matteo Accardo
Eric Allaert
Emmanuel Aller Carpentier
Domingo Álvarez Mendez
Paola Amico
Luigi Andolfato
Javier Argomedo
Gerardo Ávila
Andrea Balestra
Pascal Ballester
David Bargna
Pablo José Barriga Campino
Thomas Bierwirth
Domenico Bonaccini Calia
Henri Bonnet
Reynald Bourtembourg
Roland Brast
Martin Brinkmann
Paul Bristow
Iris Bronnert
Enzo Brunetto
Bernard Buzzoni
Blanca Camucet
Alessandro Caproni
Sandra María Castro
Cecilia Cerón
Alberto Maurizio Chavan
Gianluca Chiozzi
Emanuela Ciattaglia
Mauro Comin
Livio Condorelli
Ralf Dieter Conzelmann
Paula Cristina Correia dos Santos
Claudio Cumani
Sebastian Deiries
Klaas Johannes Dekker
Bernard-Alexis Delabre
Françoise Delplancke-Ströbele
Nicola Di Lieto
Canio Dichirico
Philippe Dierickx
Martin Dimmler
Robert Donaldson
Dario Dorigo
Reinhold Dorn
Mark Desmond Downing
Michel Duchateau
Philippe Duhoux
Christophe Dupuy
Toomas Erm
Michael Esselborn
Enrico Fedrigo
Sylvie Feyrin
Gert Finger
Gerhard Fischer
Vincenzo Forchi
Robert Frahm
Christoph Frank
Armin Gabasch
Fernando Gago
César Enrique García Dabó
Aurea Garcia Rissmann
Daniel Gaytan
Christoph Geimer
Rodrigo Gesswein
Paolo Ghiretti
Bruno Gilli
Percy Glaves
Andreas Glindemann
Domingo Gojak
Juan Carlos González Herrera
Justo Antonio González Villalba
Thomas Grudzien
Ivan Maria Guidolin
Carlos Guirao Sanchez
Ronald Guzman Collazos
Wolfgang Hackenberg
Andreas Haimerl
Peter Hammersley
Jochen Haucke
Florian Heissenhuber
Guy Hess
Renate Hinterschuster
Ronald Holzlöhner
Georgette Hubert
Norbert Hubin
Evi Hummel
Derek James Ives
Olaf Iwert
Gerd Jakob
Bogdan Jeram
Paul Jolley
Andreas Jost
Yves Jung
Dimitrios Kalaitzoglou
Robert Karban
Markus Kasper
Lothar Kern
Mario Kiekebusch
Jean Paul Kirchbauer
Barbara Klein
Maurice klein Gebbinck
Jens Knudstrup
Franz Koch
Johann Kolb
Maximilian Kraus
Basilio Kublik
Hervé Kurlandczyk
Paolo La Penna
Uwe Lange
Miska Le Louarn
Samuel Lévêque
Steffan Lewis
Paul Lilley
Jean-Louis Lizon à L'Allemand
John Lockhart
Simon Lowery
Christian Lucuix
Lars Kristian Lundin
Pierre-Yves Madec
Antonio Ramón Manescau Hernández
Alisdair Manning
Massimiliano Marchesi
Enrico Marchetti
Juan Antonio Marrero Hernández
Stewart McLay
Leander H. Mehrgan
Serge Menardi
Samantha Milligan
Andrea Modigliani
Christophe Moins
Michael Müller
John Murray
Michael Naumann
Lothar Noethe
Ralf Palsa
Moreno Pasquato
Jérôme Paufique
Marcus Pavez
Martine Peltzer
Lorenzo Pettazzi
Thomas Pfrommer
Duc Thanh Phan
Werther Pirani
Cristian Pontoni
Dan Popovic
Eszter Pozna
Marco Quattri
Jutta Quentin
Andrew Rakich
Roland Reiss
Javier Reyes
Robert Ridings
Jesús Rodríguez Ulloa
Silvio Rossi
Stefan Sandrock
Marc Sarazin
Marcus Schilling
Christian Schmid
Dominik Schneller
Babak Sedghi
Paola Sivera
Fabio Sogni
Heiko Andreas Sommer
Christian Sönke
Jörg Stegmeier
Stefan Ströbele
Marcos Suárez Valles
Dieter Suchar
Roberto Tamai
Helmut Tischer
Rodrigo Javier Tobar Carrizo
Mirko Todorović
Sebastien Tordo
Stefano Turolla
Gerhard Ullmann
Arno Van Kesteren
Elise Vernet
Jakob Vinther
Rein Warmels
Andrew Wright
Michèle Zamparelli
Stefano Zampieri

Joint ALMA Observatory

Pierre Cox

Andreas Andersson Lundgren
Denis Barkats
Paulina Bocaz
Itziar De Gregorio Monsalvo
William Dent
Giorgio Filippi
Diego Alex García
Tracey Hill
Jorge Ibsen
Henderikus Jager
Rüdiger Kneissl
Stéphane Leon Tanne
Gianni Marconi
Gautier Mathys
Maurizio Miccolis
Theodoros Nakos
Lars-Åke Nyman
José Parra
Evert Pauwels
Neil Matthew Phillips
David Rabanus
Armin Silber
Giorgio Siringo
Russell Smeback
Stanislav Stefl
Baltasar Vila Vilaro
Eric Villard
Catherine Vlahakis
Nicholas Whyborn
Gert Tommy Wiklind

Directorate of Operations

Andreas Kaufer

Sergio Abadie
Margarita Acuña
Claudio Agurto
Bernardo Ahumada
Yazan Al Momany
Javier Alarcón
Jaime Alonso
José Luis Álvarez
Nicolás Álvarez
Paola Andreani
Iván Aranda
Juan Pablo Araneda
Pablo Arias
Oriel Alberto Arriagada
Karla Aubel
Francisco Azagra
José Baez
Pedro Baksai
Rogelio Bascunan
Giacomo Beccari
Angelika Beller
Juan Beltran
Andrew Biggs
Guillaume Blanchard
Israel Blanchard
Henri Boffin
Carlos Bolados
Pierre Bourget
Stéphane Brillant
Erich Bugueno
Francisco Caceres
Luis Alejandro Caniguante
Michael Cantzler
Rubén Cárcamo
César Cárdenas
Mauricio Cárdenas
Arnaud Carlier
Giovanni Carraro
Duncan Castex
Mónica Castillo
Roberto Castillo
Susana Cerda
Stella-Maria Chasiotis-Klingner
Claudia Cid
Alex Correa
Alejandra Cortés
Carlos De Breuck
Willem-Jan de Wit
Diego Del Valle
Nausicaa Delmotte
Álvaro Díaz
María Díaz Trigo
Danuta Dobrzycka
Adam Dobrzycki
Reinaldo Donoso
Javier Duk
Christophe Dumas
Michael Dumke
Carlos Duran
Cristian Elao
Cristian Esparza
Lorena Faundez
José Figueroa
Erito Flores
Juan Carlos Fluxa
Nathalie Fourniol
Wolfram Freudling
Eloy Fuenteseca
Dimitri Gadotti
Sergio Gaete
Julien H. V. Girard
Philippe Gitton
Frederic Yves Joseph Gonte
Andrés González
Edouard González
Jaime González
Javier Andrés González
Leonardo González
Sergio González
Patricia Guajardo
Carlos Guerra
Stéphane Guisard
Jonas Haase
Juan Pablo Haddad
Nicolas Haddad
Pierre Haguenauer
Reinhard Hanuschik
Evanthia Hatziminaoglou
George Hau
Pieter Hekman
Juan Pablo Henriquez
Cristian Herrera
Michael Hilker
Gerhard Hüdepohl
Rodrigo Huerta
Christian Hummel
Wolfgang Hummel
Elizabeth Humphreys
Valentin Ivanov
Nestor Jiménez
Petr Kabath
Ismo Kastinen
Thomas Klein
Carlos La Fuente
Francisco Labraña
Robert Alexander Laing
Octavio Lavin
Cédric Ledoux
Alfredo Leiva
Marcelo Lopez
Fernando Luco
Felipe Mac-Auliffe
Vincenzo Mainieri
Pedro Mardones
Kiriako Markar
Christophe Martayan
Stéphane Marteau
Mauricio Martínez
Eduardo Matamoros
Dimitri Mawet
Angel Mellado
Alejandra Mena
Antoine Mérand
Alberto Micol
Steffen Mieske
Sabine Möhler
Palle Møller
Lorenzo Monaco
Francisco Miguel Montenegro-Montes
Alex Morales
Sebastien Morel
Iván Muñoz
Sangeeta Mysore
Julio Navarrete
Mark Neeser
Nadine Neumayer
Hernan Nievas
Francisco Olivares
Rodrigo Olivares
Jared O'Neal
Juan Osorio
Juan Carlos Palacio
Laurent Pallanca
Ricardo Nelson Parra
Rodrigo Javier Parra
Andrés Parraguez
Diego Parraguez
Ferdinand Patt
Eduardo Peña
Isabelle Percheron
Monika Petr-Gotzens
Dirk Petry
Jorge Pilquinao
Juan Pineda
Andres Pino
Aldo Pizarro
Emanuela Pompei
Sébastien Poupar
Matteo Pozzobon
Francesca Primas
John Pritchard
Andrés Ramírez
Christian Ramírez
Suzanna Randall
Claudio Reinero
Marina Rejkuba
Sridharan Rengaswamy
Jörg Retzlaff
Claudia Reyes
Miguel Riquelme
Leonel Rivas
Thomas Rivinius
Chester Rojas
Pascual Rojas
Martino Romaniello
Cristian Romero
Rodrigo Romero
Felix Alberto Rozas
Francisco G. Ruseler
Fernando Salgado
Ariel Sanchez
Pierre Sansgasset
Jorge Santana
Ivo Saviane
Erich Schmid
Linda Schmidtobreick
Ricardo Schmutzer
Nicolas Schuhler
Frédéric Schuller
Alex Segovia
Fernando Selman
Waldo Siclari
Peter Sinclaire
Nicolas Slusarenko
Alain Smette
Gerardo Smith
Jonathan Smoker
Christian Spille
Thomas Stanke
Michael Fritz Sterzik
Felix Stoehr
Sandra Strunk
Thomas Szeifert
Lowell Tacconi-Garman
Richard Tamblay
Gie Han Tan
Mario Tapia
Manuel Torres
Eugenio Ureta
Josefina Urrutia
Guillermo Valdes
Elena Valenti
Jose Javier Valenzuela
Karen Vallejo
Mario Van Den Ancker
Eelco van Kampen
Pierre Vanderheyden
Paulina Venegas
Enrique Vera
Sergio Vera
Ignacio Vera Sequeiros
Jorge Vilaza
Zahed Wahhaj
Jeremy Walsh
Ueli Weilenmann
Luis Wendegass
Markus Wittkowski
Burkhard Wolff
Pavel Yagoubov
Véronique Ziegler
Elena Zuffanelli
Martin A. Zwaan

Directorate of Programmes

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Robin Arsenault
Fabio Biancat Marchet
Claudio Cabrera
Mark Casali
Marc Cayrel
Frédéric Derie
Roberto Gilmozzi
Peter Murray Gray
Serge Guniat
Volker Heinz
Lieselotte Jochum
Florian Kerber
Bertrand Koehler
Nicholas Charles Kornweibel
Pascal Martínez
Alistair McPherson
Katia Montironi
Luca Pasquini
Jean-François Pirard
Gero Rupprecht
Valérie Saint-Hilaire
Stefano Stanghellini
Josef Strasser
Donald Tait
Gianluca Verzichelli
Wolfgang Wild

Directorate for Science

Bruno Leibundgut

Rebeca Aladro
Susana Almagro Garcia
Julian David Alvarado Gomez
Joseph Anderson
Mathias André
Manuel Aravena
Armando Arellano Ferro
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Carlos Eduardo Barbosa
Juan Carlos Beamin
Jean-Philippe Berger
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Marco De Pascale
Romain Deschamps
Suhail Dhawan
Catrina Diener
Paul Elliott
Eric Emsellem
Steve Ertel
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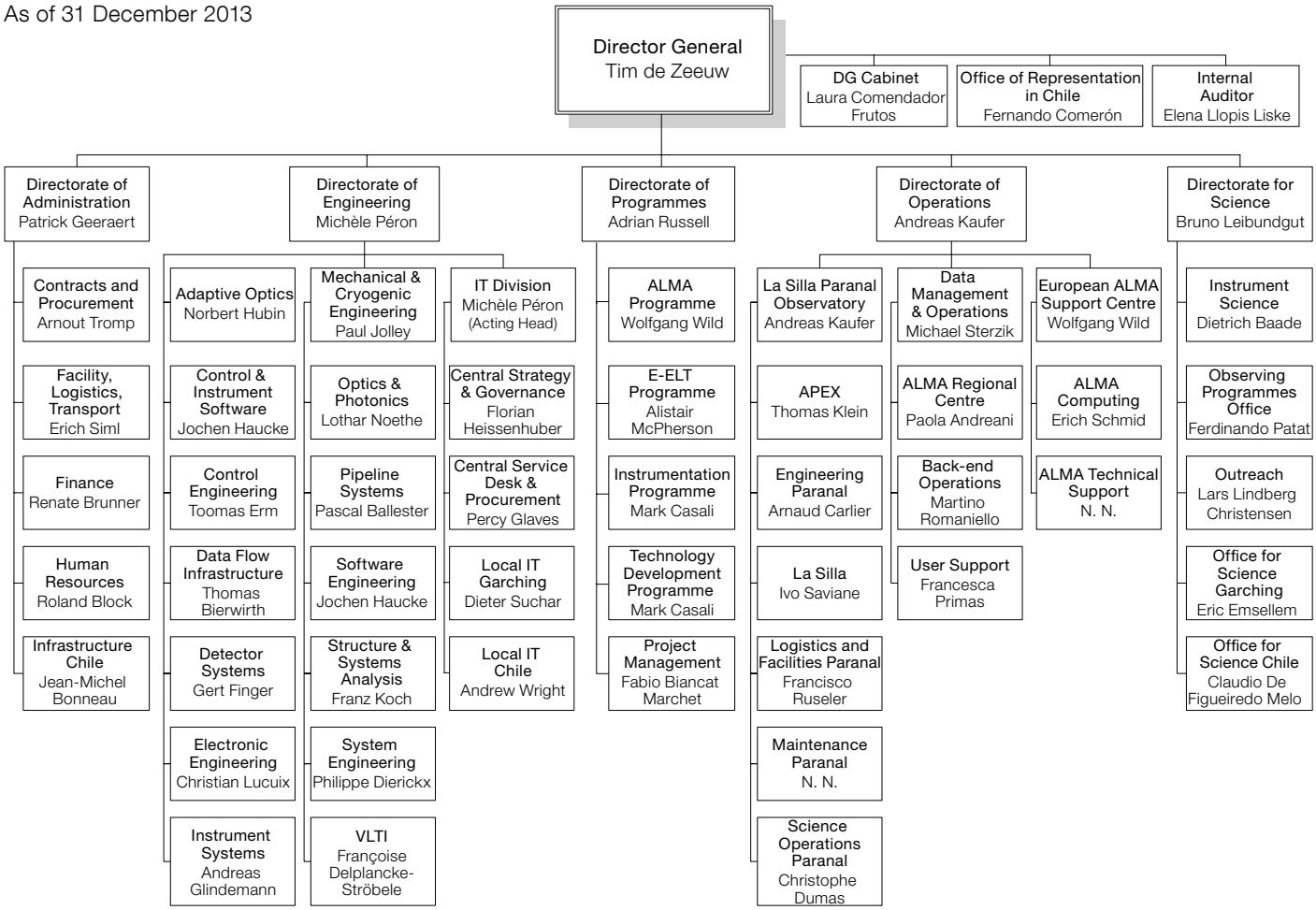
Maud Muriel Galametz
Elisabeth Gall
Roberto Galván-Madrid
Hernan Garrido
Stephan Geier
Neale Gibson
Adam Ginsburg
María Eugenia Gómez
Luis Goncalves Calçada
Oscar A. González
Rebekka Grellmann
Uta Grothkopf
Jason Harley Grunhut
Adrien Guerou
Sylvain Guieu
Bitten Gullberg
Lizette Guzman
Olivier Hainaut
Richard Hook
Renate Elisabeth Hoppe
Bernd Husemann
Gaitee Hussain
Laura Inno
Edmund Janssen
Izaskun Maite Jiménez Serra
Paulina Jirón
David Jones
Hans-Ulrich Käufl
Markus Kissler-Patig
Martin Kornmesser
Jens-Kristian Krogager
Thomas Krühler
Mirko Krumpe
Harald Kuntschner
Claudia del Pilar Lagos Urbina
Jochen Liske
Gaspare Lo Curto
Gianluca Lombardi
MD Golam Mafuz
Kate Louise Maguire
Carlo Felice Maria Manara
Michaël Marsset
Anna Faye Mc Leod
Silvia Meakins
Andrea Mehner
Jorge Melnick
Julien Milli
André Müller
Juan Carlos Muñoz-Mateos
Koraljka Muzic
Florian Niederhofer
Paolo Padovani
Ferdinando Patat
Joel Leslie Pfeffer
Farid Rahoui
Suzanne Ramsay
Javier Adrián Rodón
Myriam Rodrigues
Francisco Rodríguez
Paula Valentina Rodríguez
Joel Sánchez
Francesco Gabriele Saturni
Tullia Sbarrato
Markus Schöller
Raquel Yumi Shida
Matthew Shultz
Ralf Siebenmorgen
Anna Sippel
Rowena Sirey
Jason Spyromilio
Christina Stoffer
Marco Tazzari
Leonardo Testi
Svea Teupke
Grant Tremblay
Sergio Vasquez
Laura Ventura
Joël Daniel Roger Vernet
Karina Theresia Voggel
Maja Vuckovic
Ke Wang
Yue Wang
Roger Wesson
Julien Woillez
Dominika Wylezalek
Fei Yan
Bin Yang
Tayyaba Zafar
Herbert Zodet

Thijs de Graauw (Emeritus Astronomer)
Sandro D'Odorico (Emeritus Astronomer)
Massimo Tarenghi (Emeritus Astronomer)

This VLT image reveals two glowing clouds of gas. NGC 2014 (right) is irregularly shaped and red, while its neighbour, NGC 2020, is round and blue. These odd and very different forms were both sculpted by powerful stellar winds from extremely hot newborn stars that also radiate into the gas, causing it to glow brightly.

Organigram

As of 31 December 2013



At the edge of the hot, dry Atacama Desert, a hardy South American grey fox has just awoken. In the background, the white dome houses the Swiss 1.2-metre Leonhard Euler Telescope.

ESO/M. Tevez

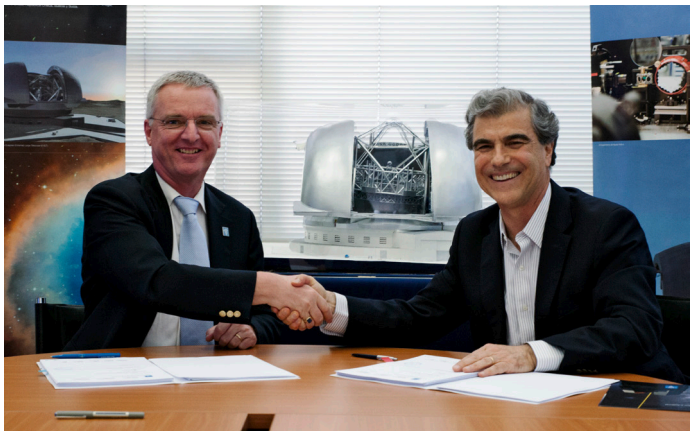
Director General Support

ALMA was inaugurated at an official ceremony, marking the completion of all the major systems of the giant telescope and the formal transition from a construction project to a fully fledged observatory. In the picture, some of the guests attending the inauguration ceremony are shown on one of the huge ALMA transporters. From left to right: Tim de Zeeuw, ESO Director General, the President of Chile, Sebastián Piñera, the director of the USA's National Science Foundation Subra Suresh, the director of ALMA Thijs de Graauw, and the Senior Vice Minister of Japan's Ministry of Education, Culture, Sports, Science and Technology, Teru Fukui.

In mid-March the Office of the Director General was reorganised into three departments: the Cabinet of the Director General, the Office for the ESO Representation in Chile and the Internal Audit Office. Furthermore, the Director General is supported by a personal assistant.

The purpose of creating the Cabinet as a distinct unit was to bring together a number of expert areas that are necessary to ensure ESO's function as an intergovernmental organisation, but — because of their horizontal and "non-technical" character — were not covered within the structure of the Directorates. These include the areas of Legal and International Affairs, Corporate Risks and Intellectual Property Management, Internal Communication, Council Secretariat and Cabinet Office and Protocol. Within these areas of expertise, the Cabinet supports the ESO Council and Finance Committee as well as the Director General and the ESO Management Team, as appropriate, in the development and implementation of ESO's overall strategy.

The Chilean President, Sebastián Piñera, visits Paranal to hand over the deeds for the transfer of the land for the E-ELT.



The signing of the contract to build the road and flatten the summit for the E-ELT.

Legal affairs

Beyond the recurring tasks of assisting in the preparation of Council and Finance Committee documents and participation in meetings of the Council, Finance Committee and other ESO Committees or Working Groups, considerable efforts were put into supporting the development of new pension provisions for future employees and a re-determination of the reference salary to calculate pension contributions and benefits. This coincided with a re-negotiation of the CERN–ESO Agreement on the admission of ESO Staff to the CERN Pension Fund.

Another major topic this year was the negotiation and drafting of a new Trilateral Agreement concerning ALMA with the partners in North America and East Asia, a task led by ESO. The draft was presented to the Committee of Council in October for comments. Following some further iterations, a close-to-final version was produced with the aim of having it approved and signed during 2014. Members of the Cabinet also assisted in the follow-up of issues concerning the ALMA Board and the ALMA Directors Council and in day-to-day legal issues that arose in Chile. In particular, legal advice was given during the collective bargaining process with the ALMA Local Staff Union.

As the E-ELT project steadily moved forward, the Cabinet closely monitored the remaining steps of the administrative process by the Chilean authorities to finalise the donation/concession of the land for the E-ELT. With construction activities set to commence in 2014, the Cabinet supported the Project Office and the Contracts and Procurement Department in the preparation of the call for tenders for major E-ELT contracts and the construction site regulations, including environmental and safety matters.

An important area of work is the provision of assistance to the ESO Representation in Chile in all legal matters, and in particular those concerning immunity issues and the legal status of ESO in Chile. Matters addressed ranged from cases of illegal mining activity, environmental aspects, the power supply to La Silla and the E-ELT to questions concerning the special relationship of Chile with ESO.

The construction work for the extension to the ESO Headquarters extension was

completed and the building was handed over to ESO by the construction company in December. The Cabinet worked in close collaboration with the Project Office and Administration to settle any remaining legal and administrative issues in preparation for closing the contracts with the construction company and the architects.

The Cabinet supported the Directorate of Administration, and the Human Resources and Contracts and Procurement Departments in particular, in various matters and, *inter alia*, helped with internal appeals and complaints before the Administrative Tribunal of the International Labour Organisation, the update and review of the Staff Rules and Regulations, internal memoranda and administrative circulars as well as with the update of the General Conditions of ESO Contracts and Purchase Orders.

ESO is in the process of setting up a new software asset management structure under the leadership of the Information Technology Division. Since its inception, the Cabinet has been supporting this effort using its expertise in the legal aspects of software licenses and license management.

Members of the Cabinet assisted in the negotiations and drafting of various agreements, regarding, for example, the transfer of the ALMA prototype antenna to a national institute for future use, the hosting and operations of a telescope ensemble on Paranal and the extension of the use of telescopes at La Silla by national institutes.

Internal Communication

The Internal Communication Office was set up as part of the Cabinet to strengthen and coordinate internal communication across ESO. This is the first time that ESO has had such a unit, with the specific mandate and responsibility for internal communication.

In addition to advising management and others on internal communication in general, the Internal Communication Office launched a range of specific activities during the year, aimed at improving internal communication at ESO.

A unified system for ESO-wide news was created, in the form of a channel for internal announcements on the ESO intranet. The Internal Communication Office coordinates the system, advises on announcement topics and contents, and helps edit texts. These appear on the intranet in a searchable archive, and are collected in a weekly e-mail newsletter that is distributed to all staff. This consolidation has reduced the overall use of mass e-mails to staff. The system was launched at the end of June, and a total of 177 internal announcements (somewhat more than one per working day) had been published by the end of the year.

The internal news channel is used for general news, announcements from Human Resources, or notices of meetings and events. In addition, there is a concerted effort to include information that might not have been previously communicated widely, such as news about projects passing significant milestones, staff arrivals, departures, and reassignments, congratulations to PhD students on passing their vivas, and more rapid updates on topics such as the ratification process of Brazil's ESO membership and the strike by Joint ALMA Observatory local staff.

A series of Coffee with the Director General events was started. These were designed to complement the all-hands meetings by offering staff an additional opportunity to ask questions and give feedback, in a smaller and less formal setting, on any topics they wished. These have taken place at the Garching Headquarters as well as at Paranal and in the Vitacura office.

To improve the flow of information between people across ESO, a new programme of informal and non-technical talks was set up. These talks, under the series title "What ESO really does", aim to give ESO staff an insight into what they and their colleagues across the organisation do and why they do it. In 2013, five talks took place in Garching, and one in Vitacura, on a wide range of topics such as the observing proposal process, the components that make up astronomical instruments, and how the ALMA antennas were procured.

Risk and intellectual property management, EU contracts

ESO reached several important milestones in corporate risk management activities during the year. The Cabinet leads and coordinates the regular update of the ESO Corporate Risk Register in order to provide support to the senior management for strategic decisions. It also provides strategic risk assessment for specific projects and programmes on request. ESO's first formal ESO Data Classification Policy was published in July. It defines the general classification scheme for all data in the possession of ESO in order to provide consistency regarding access, handling and disclosure of data. This provides the necessary security required by the respective data. Since the publication of the policy, considerable effort has been devoted to the implementation of the policy by providing training and support for ESO departments.

To support the ESO Management in case of a corporate crisis, the first operational continuity plan for the Garching and Santiago premises was published in September. As part of ESO's now integrated risk management practices, the Organisation signed a contract for insurance brokerage services for all non-life insurances with one of the leading broker companies. By the end of the year, ESO had revised its insurance programme and concluded a new structure and portfolio of insurance policies, allowing the ESO Management to set up a new balance between risk transfer and self-insurance. The Cabinet is responsible for the management of the new portfolio, in close collaboration with the Directorate of Administration.

Similarly, the Cabinet is responsible for ensuring that ESO complies with US International Traffic in Arms Regulations (ITAR) regulations and with the restrictions arising from UN embargoes. Within that task the Cabinet supported three projects with the negotiation of ITAR-related agreements and provided advice for the implementation of the rules.

Regarding intellectual property management, the ESO Raman Fibre Amplifier Patent (application issued in 2008, European Patent 2081264 granted in 2010) was also granted in Canada as 2711939 and Japan

Tim de Zeeuw, ESO's Director General, speaks at an ESO Industry Day on 22 January 2013 in the Nicolaus Copernicus Astronomical Center in Warsaw, Poland.

Information day for Israeli industry at the Asher Space Research Institute in Haifa, Israel.

as 5337819. The ESO ALMA Black Body Calibration patent application was published in Europe, Canada, USA and Japan. Knowhow in both areas is exploited via licenses to industry. Besides the management of ESO's patent portfolio, considerable effort was put into providing advice to ESO projects with regard to confidentiality issues and intellectual property ownership. This resulted in the conclusion of several non-disclosure agreements.

The Cabinet, in close collaboration with the relevant directorates and departments, is responsible for the management of EU projects. The ESO COFUND Fellowship Programme came to an end this year having supported ESO and the scientific community with nine fellowships hosted by the ALMA ARC nodes. Concerning new projects, ESO welcomed two excellent Marie Curie Fellows in Garching, each for a two-year period. In addition to the consultations with EIROforum and between the partnership and the European Commission, ESO has also undertaken a dedicated study of the next EU Framework Programme, Horizon 2020, by identifying possibilities and assessing the legal and financial aspects with a view to enabling informed decisions by the ESO Management about possible future ESO participation.

International affairs

In December 2010 the Federal Government of Brazil signed an accession agreement to join ESO as its 15th Member State. During 2013, a major effort was undertaken to support the ongoing ratification process in the Brazilian Congress. For this purpose, an *ad hoc* group was created with members of the Cabinet and others, working closely with the Brazilian authorities, the astronomical community and other relevant stakeholders. The ratification process gained momentum early this year when, at the request of President Dilma Rousseff, Congress opened the proceedings as a priority action. By the end of the year, the agreement had been approved by the Commission on External Relations and National Defence and the Commission on Science, Technology, Communication and Informatics, both of the House of Representatives. The Commission on Justice and Citizenship had begun its deliberations, based on a favourable recommendation by the Rapporteur, while the Commission on Finances and Taxation had yet to deal with the question. ESO's support actions also included making invitations to a number of relevant stakeholders to enable them to obtain a first-hand impression of ESO and its activities in Chile. This included media visits, tutorials on proposal writing for Brazilian astronomers offered by the Head of the Office for Science in Chile and an ESO presence at key events in Brazil in the course of the year.

Following an exchange of letters between the Director General and the Polish Minister for Science in late 2012, informal discussions at Ministry level took place in the course of 2013 with the aim of facilitating Polish membership of ESO. With Poland as a member, all the large European countries with a strong involvement in astronomical research would have become members.

The interest in establishing links with ESO remains strong in a number of countries. Informal discussions took place with parties at different levels in various countries. In July, the Director General visited South Africa and met with Mr Derek Hanekom, the South African Minister for Science and Technology, who had previously paid a visit to ESO in Garching. The visit was followed up by a high-level South African delegation visit to the ESO Paranal Observatory in December.

In late November, ESO organised a dedicated information day for Israeli industry at the Asher Space Research Institute in Haifa. The well-visited event was organised in cooperation with the Technion — Israel Institute of Technology, and leading Israeli astronomers. In addition to company representatives, participants included the Israeli Space Agency and the Israel-Europe R&D Directorate (ISERD, the Israeli inter-ministerial agency for Reasearch and Development cooperation with Europe).

The year 2013 marked five years since ESO became a permanent observer at the United Nations Committee for the Peaceful Uses of Outer Space (UNCOPUOS). On this occasion, ESO addressed the Committee and summarised its contributions over that period. A key element has

Chilean Minister of Economy, Development and Tourism, Mr. Félix de Vicente, during his visit to ESO Garching.

ESA astronaut Pedro Duque addresses the audience at ESO Headquarters.

been ESO's support for the UNCOPUOS Action Team 14, which deals with the potential threat from Near-Earth Objects. The team has elaborated recommendations for an international response to the impact threat for Near-Earth Objects, including the formation of an international asteroid warning network. The recommendations were submitted to the UN General Assembly and approved in October. The discussions within the Action Team also led to new collaboration between ESO and ESA in the context of ESA's Space Situational Awareness programme. ESO is the only major ground-based observatory directly involved in this Action Team that also has the powerful resources which might be called upon to locate and characterise faint or otherwise difficult to access potentially hazardous asteroids. In consequence ESO has set up a small expert group to facilitate the timely and appropriate submission of observing proposals to make astrometric and physical observations of potentially hazardous objects that require the use of large telescopes. As a test case, the team selected a small number of objects for astrometric measurements with the VLT under the DG's Discretionary Time. The first observations were carried out in December.

ESO maintained its participation in EIROforum, the partnership of eight European organisations that operate large research infrastructures. Thematic working groups in International Affairs, IT, Instrumentation, Knowledge and Technology Transfer facilitate joint activities such as the EIROforum School of Instrumentation, the third of which was held at CERN in May. A further topic has been the provision of input to the preparations for Horizon 2020, the 71 billion euro European Union support programme for science, technology and innovation. The science policy interactions by EIROforum included a detailed position paper on the role, prospects and opportunities of scientific instrumentation, in particular in large European research infrastructures.

Activities in host states

As part of the efforts to strengthen relations with the host state of Germany, a formal point of contact was appointed for the Federal authorities as well as for the Bavarian State Government. Support for Chile in Europe was manifested in ESO's participation in a major promotion activity in Germany, organised by the Chilean Ministry of Foreign Affairs and ProChile, the Chilean Export Promotion Bureau, in cooperation with the Bavarian Chamber of Industry and Trade. On this occasion, the Chilean Minister of Economy, Development and Tourism, Félix de Vicente, visited ESO Headquarters, accompanied by Jorge O'Ryan Schütz, Chile's Ambassador to Berlin.

The year 2013 marked the 50th anniversary of the signature of the agreement between ESO and Chile that initiated their long-term relationship. Commemorative activities culminated in an official celebration in Santiago on 8 November, with the participation of Chilean government officials, ESO Management, representatives of the ESO governing bodies, ambassadors, academic authorities, and prominent personalities from the Chilean astronomical community. The President of Chile received the Director General of ESO at the presidential palace on 14 November. Several embassies promoted activities reflecting on the importance of astronomy in culture and society, including the visits of European astronauts Pedro Duque and Claude Nicollier to Paranal.

The transfer of the land at Cerro Armazones to ESO was an important highlight in ESO's relations with Chile. Following official publication of the transfer decree, the documents were handed over by the President of Chile, Sebastián Piñera, to the ESO Director General during a ceremony at the Paranal Residencia in the presence of the Chilean Minister of Foreign Affairs, Alfredo Moreno, on 27 October.

The joint summit of the Economic Commission for Latin America and the Caribbean and the European Union took place in Chile at the end of January, with the participation of numerous heads of state. Taking advantage of their presence in Chile, the highest authorities of the European Union, the President of the European Council, Herman van Rompuy, the President of the European Commis-

The Prime Minister of France, Jean-Marc Ayrault, and Massimo Tarenghi at the Summit of the Community of Latin American and Caribbean States — European Union (CELAC-EU) in Santiago.

President of the European Council, Herman Van Rompuy, during a visit to the Paranal Observatory.

The President of the European Commission, José Manuel Barroso, during a visit to ESO's Paranal Observatory.

Austrian and Portuguese Ministers for Science visit Paranal.

Inauguration speech by the President of Chile at ALMA.

sion, José Durão Barroso, and the High Representative for Foreign Affairs and Security Policy, Catherine Ashton, visited Paranal.

The inauguration of ALMA on 13 March in the presence of President Piñera, which ESO organised together with the Joint ALMA Observatory and the other two ALMA Executives, also enabled interactions in Chile with senior representatives of Member States.

Other governmental delegations that visited Paranal included those headed by the Austrian Minister for Science and Research, Karlheinz Töchterle; the Portuguese Minister for Education and

Science, Nuno Crato; the Bavarian State Minister for Science, Research and the Arts, Wolfgang Heubisch; the Vice President of the German Federal Parliament, Eduard Oswald; the Chief Scientific Adviser to the President of the European Commission, Anne Glover; and a delegation of senior Swedish officials, who visited the ALMA Observatory as well. The Danish Crown Prince and Princess also visited Paranal, accompanied by the Danish Minister of Foreign Affairs, Villy Søvndal. The Chilean Minister of Mining, Hernán de Solminihac, and the Minister Secretary General of the Presidency, Cristián Larroulet, paid visits to Paranal as well. The Observatory also hosted the ambassadors of Finland, Greece, Norway and Poland.

Minister Heubisch's delegation at Paranal.

ESO maintains institutional contacts with Chilean academic authorities. The Rector of the University Andrés Bello visited Paranal on 27 June, and members of the Conference of Rectors of Universities in Chile travelled to the Observatory on 26 July. The Director of the Vatican Observatory, Dr José G. Funes, visited the Observatory in August. ESO was represented at the International Conference on Scientific Culture organised by Universidad Andrés Bello.

Chief Scientific Adviser to the President of the European Commission, Anne Glover, visits the Paranal Observatory.

Continuing its determined efforts to preserve the dark skies in the north of the country, the Government of Chile is leading a proposal to obtain the declaration by UNESCO for the sites where the major observatories are located as World Heritage Sites. ESO attended the launch meeting at UNESCO in Paris and has joined the other international observatories and other institutions in Chile in supporting this initiative. ESO also collaborates with other institutions on similar sky protection initiatives, such as the effort led by the EuroChile Foundation to obtain the Starlight label for the privileged areas in the II Region.

The Danish Crown Prince and Princess on the platform of the Very Large Telescope.

Internal Audit

Internal Audit provided support to the external auditors in the performance of their duties. Other regular activities during the year were the audit certificate for Associated Universities, Inc. as well as various audit certificates for EU-financed projects and the certification of the annual accounts of the Staff Associations in Chile and Europe.

The internal auditor also performed several audits, including audits of the risk management system at ESO, the accounting of fixed assets and one on procurement issues.

ESO images and model of the E-ELT in the centre of the Presidential Retreat room at the CELAC-EU Summit, before the start of the Presidents' private meeting. The summit, which is the biggest such event ever organised by Chile, took place in Santiago during the week of 22–28 January 2013.

Committees

Roland Halbe

Council

As its governing 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. Council and the DG are assisted by the following Committees:

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

The Scientific Technical Committee 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 is made up of representatives of ESO users from each Member State and advises the DG on matters concerning the use of ESO facilities.

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

The ALMA Proposal Review Committee is made up of the committee chair and the chairs of the ALMA Review Panels, of which there is at least one for each of the main scientific categories. The committee reviews the single ranked proposal list resulting from the merging of the individual ALMA Review Panel rankings and advises the ALMA Directors' Council on the scientific programme of ALMA.

View of one of the two circular cut-outs of the Headquarters extension with a diameter of 8.20 metres — exactly the same dimensions as the large VLT mirrors at the Paranal Observatory.

Both the Council and the Committee of Council (the informal body of Council) normally meet twice during the year: however, in 2013 there was a requirement for an additional Extraordinary Council meeting which took place at the same time as the March Committee of Council. The two ordinary Council meetings were held in Garching, on 5–6 June and 4–5 December. The first Committee of Council meeting was held in Chile on 11–12 March in conjunction with the ALMA Inauguration Event on 13 March, while the second was kindly hosted by the UK delegation in Edinburgh on 9–10 October. All the meetings were chaired by the Council President, Professor Xavier Barcons.

During the March meeting, Council approved, by simple majority, the interpretation of the Rules of Procedure for Council for non-participating Member States of a supplementary programme. Delegates also agreed that, for those Member States who had as yet not voted positively for the E-ELT, the timing for this was to be extended in order to ensure that (hopefully) all Member States would be able to participate in the programme.

At the June meeting, an update was provided by the Council President and the ESO Director General on a number of ongoing events/actions and the respective Directors/Division Heads presented feedback on all aspects of ESO's programme, including the status of La Silla, Paranal and ALMA. Dr Pierre Cox, the incoming ALMA Director, was welcomed to the meeting and gave his insight into the status of the project. During discussions, Council was pleased to note that two of the remaining three Member States had been able to change their vote to positive with regard to participation in the E-ELT programme. In order to follow the progress of the E-ELT, it was agreed that an E-ELT subcommittee of the STC should be established to advise the STC on technical and scientific matters related to construction and operations models as well as scientific priorities concerning its instrumentation. Council approved the External Audit Report 2012 and discharge was granted to the Director General for the same year. Financial aspects were discussed, culminating in the approval of a number of matters

Council and Committee of Council 2013

President	Xavier Barcons (Spain)
Austria	Sabine Schindler Daniel Weselka
Belgium	Christoffel Waelkens Sophie Pireaux
Czech Republic	Jan Palouš Jan Buriánek
Denmark	Uffe Gråe Jørgensen Cecilie Tornøe
Finland	Jari Kotilainen Pentti Pulkkinen
France	Jean-Marie Hameury Christophe Troyaux
Germany	Thomas Henning Thomas Roth
Italy	Bruno Marano/Giovanni Bignami Matteo Pardo
The Netherlands	Konrad Kuijken Jan van de Donk
Portugal	Teresa Lago Fernando Bello
Spain	Rafael Bachiller Luis E. Ruiz
Sweden	Claes Fransson Catarina Sahlberg
Switzerland	Georges Meylan Martin Steinacher (Vice President)
United Kingdom	Patrick Roche John Womersley

including future arrangements for the calculation of Member State contributions. The appointments of the chair and members of the Visiting Committee 2013 were approved, as was the Annual Report for 2012 and the document outlining the ESO Long Term Perspectives was noted.

The final Council meeting of the year took place in Garching in the splendid setting of the new Council room in the ESO Headquarters extension building. Following the regular updates of the ESO programme, approval was given by Council for a number of Guaranteed Observing Time awards including CRIRES+ and ERIS. Council also authorised the Director General to sign, on behalf of ESO, an amendment concerning the extension of APEX until 31 December 2017. It was agreed that an E-ELT Management Advisory Committee should be established which would act as an advisory body to Council and the Director General. A new working group, the Strategy Working Group to look at ESO's future role in ground-based astronomy, was approved with a first meeting planned for early 2014. As part of the discussions related to finance, approval was given for the ESO Budget and the scale of contributions, both for 2014. Elections took place for the appointment of personnel to the various ESO Committees including the ALMA Board, Finance Committee, OPC, STC and the Tripartite Group, as well as the unanimous re-election of the Council President and Vice President and the STC Chair. As the current Finance Committee Chair had completed his three-year term, Council unanimously appointed Dr Colin Vincent to take up this position. Two internal posts were also approved — the appointment of Professor Rob Ivison as Director for Science and Dr Roberto Tamai as the E-ELT Programme Manager. To celebrate the opening of the new building, an inauguration event was held at the end of the first day of the meeting which included a ceremony with speeches delivered by the Mayor of Garching, the Council President, the Director General, Mr Philippe Auer, the building architect and Mr Andreas Böhme from the construction company BAM. This was followed by guided tours of the new rooms and facilities.

View of the new Council Room in the new ESO Headquarters extension building in Garching.

Finance Committee

Finance Committee 2013

Chair	Johan Holmberg (Sweden)
Austria	Sabine Hertgen
Belgium	Alain Heynen
Czech Republic	Věra Zázvorková/Pavla Katzová
Denmark	Cecilie Tornøe (Vice-chair)
Finland	Sirpa Nummila
France	Patricia Laplaud
Germany	Gisela Schmitz-DuMont
Italy	Giampaolo Bologna
The Netherlands	Mirjam Lieshout-Vijverberg
Portugal	Maria José Almeida
Spain	Inmaculada Figueroa
Sweden	Tobias Hellblom
Switzerland	Astrid Vassella
United Kingdom	Colin Vincent

Mr Johan Holmberg chaired two ordinary Finance Committee meetings as well as one extraordinary meeting. The latter was held in October to discuss the importance of indexation on the ESO budget. The Finance Committee recommended the indexed budget to Council at its 137th meeting in November. As happens every three years, this meeting took place in Chile in combination with site visits to Paranal and ALMA.

At its 135th meeting in May, Finance Committee decided to recommend to Council the adoption of a new method for the calculation of the scale of Member States' contributions and its application from 2017 onwards. This will help to reduce the sometimes sharp variations in the yearly contributions.

Other subjects in the meetings included financial issues such as annual accounts, the external audit report and financial statements. The delegates also gave recommendations to Council regarding the ESO reference salary within the CERN Pension Fund and an amended contract policy as well as a new formula for the adjustment of remuneration and allowances for international staff.

The Committee approved the award of twelve contracts exceeding € 500 000, two amendments to existing contracts and two single-source procurements exceeding € 250 000, one of these by written procedure.

Auer Weber/ESO

The new ESO technical building. The building, which will also host one of the largest computer archives of astronomical data in the world, will nurture the technological and scientific innovations that ESO's European Extremely Large Telescope will require.

Scientific Technical Committee

The Scientific Technical Committee 2013

Austria	Josef Hron
Belgium	Hans Van Winckel (LSP)
Czech Republic	Stephane Vennes
Denmark	Johan Fynbo (LSP)
Finland	Alexis Finoguenov
France	Anne-Marie Lagrange (ESC Chair)
Germany	Matthias Steinmetz (ESC)
Italy	Alessandro Marconi (STC Chair)
Portugal	André Moitinho (LSP)
Spain	Almudena Alonso-Herrero (ESC)
Sweden	Sofia Feltzing (ESC)
Switzerland	Didier Queloz (LSP)
The Netherlands	Cornelis Maarten de Vos (LSP Chair)
United Kingdom	Robert Ivison (ESAC Chair)
Chile	Leonardo Bronfman

Members at Large
Elaine Sadler (ESAC)
Gillian Wright
John Monnier (LSP)
Rachel Akeson (ESAC)

Observer

Brazil	Marcos Diaz

The STC met twice for its regular semi-annual sessions. The subcommittees met the day before the STC to discuss several topics in greater depth. Following a decision by Council in June, a new subcommittee specifically focussing on E-ELT development met for the first time in October. The Committee met again, by teleconference, on 3 December to discuss VLT instrument planning for 2015 and 2016.

80th STC meeting

The STC held its 80th meeting from 22–23 April in Garching. The La Silla Paranal Subcommittee (LSP) and the European ALMA Science Advisory Committee met on 21 April and reported the outcome of their deliberations to the STC.

The terms of office for the representatives from the Czech Republic, Finland and Spain had come to an end and they were replaced.

The STC discussed the document presenting the long-term perspectives of the organisation. It was concerned by the pressure on the programme created by the non-indexation of the 2013 ESO budget and the corresponding savings, which had to be found within the ongoing programme. The STC appreciated the first discussions on plans beyond the current programmes: VLT/I, ALMA and E-ELT.

The Committee was concerned that, at this early stage in the E-ELT programme, the budgetary pressures had already started to blur the line between construction and operations as ESO moved instruments from the construction costs into the early years' operations budgets. The current planning for the instrumentation was supported by the STC. In particular, the increased flexibility for the start dates for the instruments was welcomed. The STC asked for an E-ELT subcommittee to be implemented by October, to provide better oversight.

The STC was very interested in the discussion of the planning of the future of the La Silla Paranal Observatory and welcomed the draft paper outlining ideas. It stressed that the approach with community input is the correct one and a planned retreat plus community workshop would be the right format for this process.

The presentation on the planning roadmap for VLT/I instrumentation was discussed and the formation of a core group of members from the STC, ESO and the community was encouraged. This core group should prepare a community workshop to discuss future scientific directions and the required instrumentation. The Committee then discussed the results of two Phase A studies concerning massively multiplexed spectrographs. It welcomed both studies and recommended that the instrument development be started after the recommendations from the Phase A reports are implemented. Given the budgetary situation, MOONS should proceed before 4MOST. For the latter, the operational model and the community input should be discussed further before implementing the project. A strict budgetary control should be exercised for all new instrument developments. The upgrade of the CRIRES instrument to an echelle mode and an upgrade of HARPS were recommended by the STC. Progress on the VLTI implementation has been apparent in the past year and the STC recommended optimising resources and the scientific return of this facility. The PRIMA situation was discussed along with the preparations of the infrastructure for the GRAVITY and MATISSE instruments. The STC was informed about the problems encountered during the VISIR upgrade and discussed possible solutions. It encouraged ESO to inform the community about the impact on current and future mid-infrared instruments using similar detector technology. A new instrument for the NTT should be solicited to upgrade this telescope. ESO is encouraged to find new ways to involve the community for such an instrument.

The STC noted the considerable progress with ALMA. It provided input concerning the Cycle 2 call and the planned development studies. It supported the proposed extension of APEX operations by two years noting that a further review in due time should take place to assess the impact of new instrumentation. The observing time ESO receives from the

The Scientific Technical Committee at its meeting in Garching in April.

Arizona Radio Observatory, in exchange for the ALMA prototype antenna, should be allocated to a few large projects.

81st STC meeting

The 81st meeting of the STC took place in Garching on 22–23 October. The LSP, ESAC and the newly formed ESC (E-ELT Subcommittee) met the previous day, 21 October, also in Garching, and all duly reported to the STC. The main topics of discussion were the ESO Budget and Forward Look 2014–2017 and updates on all major ESO programmes. The Committee was also presented new Terms of Reference and Rules of Procedure.

The ESO Budget and Forward Look 2013–2016 was presented to the STC, which expressed its appreciation of the efforts made by ESO to maintain its ambitious programmes despite the difficult financial situation. The STC stressed the continuing need for strategic decisions to be taken in the context of short-, medium- and long-term plans. The STC would like to work with the ESO Management to review the priorities of the scientific programmes and to evaluate the impact of the limited available resources on science programmes.

The ESC provided its first input to the STC and established its working *modus operandi*. The STC was encouraged by the progress with the financing of the E-ELT and recommended maintaining the momentum of the project, given that the competition is working on a very similar timescale.

The current planning for AO capabilities in the coming years at the VLT were discussed. The delay in the ERIS project will severely restrict ESO's AO-imaging capabilities for several years. The STC requested a trade-off study between the current VLT instruments in order to establish the planning for the coming years. All instruments should be assessed for their scientific impact to provide a basis for the future planning. This assessment was discussed by the STC at a special teleconference on 3 December. The Committee reiterated its encouragement to ESO for a call to the community for new instruments on the NTT.

The STC endorsed the VLTI development plan, but was concerned by the slow progress with the highest priority VLTI infrastructure projects: adaptive optics with the auxiliary telescopes and active vibration control. PRIMA should be assessed in a special review to report back to the STC.

The STC noted that the limit of 10% guaranteed observing time on the VLT given to instrument consortia for their contributions to the instrument will most likely be exceeded in the coming years. This will lead to a scientific impact on the broader community through a reduction of the observing time available to the general users. The Committee also believed that guaranteed observing time should be evaluated from all viewpoints to assess its impact. The STC would like to be informed regularly of the situation. The Committee was ready to discuss possible changes to the guaranteed observing time policy in the future.

The STC noted with pleasure the delivery of all 25 European antennas to ALMA. It was also impressed by the significant number of publications with ALMA data. It was concerned by ALMA's vulnerability due to the apparently unstable permanent power supply. It was further concerned that Cycle 1 and Cycle 2 observations may not reach the scientific goals. The STC endorsed the creation of a Portuguese ALMA Expertise Centre and asked ESO to formulate criteria for an Expertise Centre and conversion to a full ARC node. The STC also asked ESO to develop a long-term strategy for the ARC nodes. The ALMA development plans were presented to the STC and it recommended proceeding with the selected studies. The Committee did suggest investigating possible collaborations with other ALMA partners on overlapping development projects. The Committee regretted the long duration of Cycle 2, which could translate into missed scientific opportunities, hinder attempts to widen the community and create a disadvantage for researches with shorter contractual time scales. The STC recommended that ArTeMiS on APEX should be offered to the community and that the guaranteed observing time given to the consortium is commensurate with their efforts, but will not disadvantage the community.

The scientific potential for the Cerenkov Telescope Array was discussed by the STC. The scientific impact and potential for the ESO community should be discussed at the next meeting.

The STC recommendations from the 2013 meetings can be found in full at: http://www.eso.org/public/about-eso/committees.html.

Observing Programmes Committee

The Observing Programmes Committee 2013

Conny Aerts (Chair)
Norbert Langer (Vice-Chair)

Yann Alibert
Giuseppe Bono (P92)
Wolfgang Brandner
Fabio Bresolin
Andrea Comastri (P93)
Ric Davies
Jesus Falcon-Barroso
François Hammer
Martin Krause (P92)
Simona Mei
Ronald Mennickent (P93)
Dante Minniti (P92)
Don Pollacco (P93)
Tom Ray
Daniel Schaerer (P92)
Rainer Schoedel
Ben Stappers (P93)
Nial Tanvir
Massimo Turatto (P92)
Roland Walter (P93)

Marc Audard (P92 member at large)
Denis Burgarella (P92 member at large)
Davide Fedele (P93 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 92 (1 October 2013 to 31 March 2014) and 93 (1 April 2014 to 30 September 2014). The number of proposals for observations with the ESO telescopes in these two periods were 892 and 898 respectively.

The balance between extragalactic science (categories A and B) and stellar science (categories C and D) has shifted towards the stellar panels with two thirds of the proposals and the requested time now in C and D. This means that the demand for extragalactic observations has decreased slightly. The demand for requested time in category C (Interstellar Medium, Star Formation and Planetary Systems) is close to 40% — more than the extragalactic categories A and B combined.

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, remained the VLT instrument for which the largest amount of observing time was requested (531 nights); ahead of X-shooter (417) on Yepun (UT3). Because of the combined presence of FORS2 and the newly deployed KMOS, Antu is the most popular UT, with a ratio between the requested and the available time, or pressure, of 5.6, followed by Yepun at 4.0. The move of X-shooter (from UT2 to UT3) and the temporary unavailability of NACO has turned into a pressure decrease for Kueyen (2.0) and Melipal (2.6), respectively. The possibility of installing a visitor instrument at the VLT Interferometer continued to generate considerable interest in the community.

For P92 and P93 combined, proposals requesting a total of 134 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 68 nights.

The OPC reviewed 19 open-time proposals for the VISTA survey telescope, of which six 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; the tenth time this has happened. ESO received nine applications in P92 and P93, of which six qualified for the 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 programmes since P86, the number of Target of Opportunity proposals submitted this year remained similar to previous years. For P92 and P93 the OPC evaluated 40 proposals each, of which 15 and 23 were scheduled respectively, for a total of about 355 hours. FORS2 is the most demanded instrument for Target of Opportunity observations (about 210 requested hours), followed by X-shooter and UVES. These three instruments were allocated 65% of the Target of Opportunity time.

Calibration Programmes

Calibration Programmes are designed to allow users to complement the existing coverage of the calibration of ESO instruments. Their 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. A total of four Calibration Programmes were submitted this year, from which three were recommended for implementation by the OPC.

Large Programmes

Large Programmes 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. Large Programme 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 33 Large Programme proposals were received this year: 20 in P92 and 13 in P93. Following the OPC recommendations, six new Large Programmes were implemented in P92, and three in P93. The trend towards using a large fraction of the science time on the La Silla telescopes for the execution of Large Programmes, encouraged by ESO and already embraced by the community in recent years, continued. The total allocation to new and ongoing Large Programmes in P92–93 at the 3.6-metre telescope and at the NTT was 205 and 146 nights respectively. This corresponds to 62% and 44% of the available science time at these two telescopes (this includes the PESSTO Public Spectroscopic Survey, to which 90 nights per year are allocated).

Director's Discretionary Time

Proposals asking for 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 2013 the ESO user community submitted 93 DDT proposals. After taking advice from an internal committee comprising ESO staff astronomers, the Director General approved 47 DDT proposals for implementation. The total amount of requested DDT time was about 480 hours.

The 3.58-metre New Technology Telescope against a backdrop of stars. The distinctive octagonal enclosure that houses the NTT stands tall in this image. This telescope housing was considered a technological breakthrough when completed in 1989.

Users Committee

The Users Committee 2013

The Netherlands	Scott Trager (Chairperson)
Austria	Stefan Kimeswenger
Belgium	Emmanuel Jehin
Czech Republic	Adéla Kawka
Denmark	Hans Kjeldsen
Finland	Elja Laurikainen
France	Claire Moutou
Germany	Thomas Preibisch
Italy	Stefano Benetti
Portugal	Nanda Kumar
Spain	Lourdes Verdes Montenegro
Sweden	Kirsten Kraiberg Knudsen
Switzerland	Hans Martin Schmid
United Kingdom	Gary Fuller (Vice-chair)
Chile	Manuela Zoccali

The ESO Users Committee, an advisory body to the ESO Director General on matters related to the performance, operation and user interfaces of the La Silla Paranal Observatory and ALMA, held its annual meeting at ESO Headquarters on 25 and 26 April.

After the opening talk by the Director General on the ESO Programme and its latest updates, the now customary series of presentations (http://www.eso.org/public/about-eso/committees/uc/uc-37th.html) by ESO representatives of all key operational areas highlighted ESO's most recent operational achievements (presenters included the Observing Programme Office, the User Support Department, Paranal Science Operations, the Back-end Operations Department, the Data Flow Infrastructure Department, the Pipeline Systems Department and the ALMA Regional Centre). In support and ahead of the meeting, ESO delivered factsheets and reports to the Users Committee members. The reports included summaries of all End of Mission reports received on Paranal and La Silla and of Service Mode user feedback, prepared by Paranal and La Silla Science Operations and the User Support Department, respectively.

In turn, the Users Committee presented the main results of their user poll. Their feedback, together with the highlights presented by ESO, triggered the follow-up discussion, which focussed on the observing preparation tools (SkyCat), the data reduction environment (Reflex) and on the broader topic of observing proposals and OPC process.

The special topic — reserved for the second day of the meeting — was chosen to be VLTI Operations. This specific operational area had not, in recent years, been reviewed with the Users Committee. It was thus deemed useful to carry out a thorough evaluation, especially in view of the forthcoming new interferometry instruments (GRAVITY and MATISSE). The presence at this session of two VLTI expert users clearly helped the Users Committee and ESO to identify the strengths and weaknesses of the current system. Both presentations from the experts provided a very detailed analysis of all aspects of VLTI operations, from the submission of VLTI observing proposals and Phase 2 packages to their execution in Visitor and Service mode, to the availability of data reduction pipelines and data products in the ESO Archive. Their feedback was very important and the ESO team behind VLTI operations found it very valuable.

Based on the outcome of the user poll(s), on the content of the presentations and of the subsequent discussions, the Users Committee formulates its feedback to ESO in the form of recommendations, the implementation of which is then reviewed at the following meeting.

The Users Committee at its meeting in Garching in April.

The ESO Very Large Telescope begins a night of observations. Three of the four 8.2-metre Unit Telescopes are visible in this picture, taken looking toward the west, the closest one being Yepun (UT4).

ESO/G. Lombardi (glphoto.it)

ESO/Digitized Sky Survey 2

This image of cosmic clouds in the constellation of Orion reveals what seems to be a fiery ribbon in the sky. The orange glow represents faint light coming from grains of cold interstellar dust, at wavelengths too long for human eyes to see. It was observed by the ESO-operated Atacama Pathfinder Experiment in Chile.

Outreach

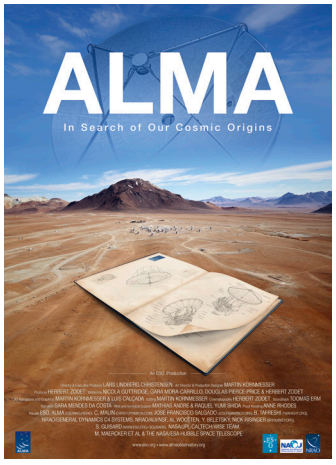
ESO's outreach activities focussed on major events this year. Soon after ESO's 50th anniversary in 2012, ESO, together with the Joint ALMA Observatory and its international partners, inaugurated ALMA, heralding a new era of discovery. The ALMA inauguration was streamed live and it was accompanied by a 16-minute movie called ALMA — *In Search of Our Cosmic Origins*, a photo book, a booklet about ethno-astronomy in the region and two brochures about the project and the contributions of the executives.

In 2013, ESO also celebrated 50 years of collaboration with Chile, a fruitful and forward-looking relationship that has allowed European and Chilean astronomy to work together to push back the boundaries of science, technology and culture. The celebrations were organised by the Representative in Chile and included a series of cultural events, some organised in collaboration with embassies of the ESO Member States in Chile, as well as a special reception (read more on p. 92).

The year continued with other remarkable highlights shared with the public: celebrating 15 years of the Very Large Telescope, the visit of several high-level European delegations to ESO's Paranal Observatory, following the Summit of the Community of Latin American and Caribbean States–European Union, two major visits to Paranal Observatory and ALMA for Brazilian media and releasing *Hidden Universe*, the first IMAX® 3D film with ESO as partner. The film is a ticket to the stars, taking viewers to ESO's Very Large Telescope and to ALMA, showing state-of-the-art telescopes in high-resolution time-lapse, mesmerising 3D versions of celestial structures, and a 3D simulation of the evolution of the Universe.

Major developments also took place at ESO Headquarters in Germany, which provided an opportunity to communicate with an audience interested in architecture. The opening of the Headquarters extension marked an important day in ESO's history, as it not only brought all of ESO's Garching staff together on one site, facilitating valuable collaborative work, but also provided a technical building for ESO's most advanced instruments to be assembled, tested and upgraded. We also announced the donation by the Klaus Tschira Stiftung to ESO for building a planetarium and visitor centre. The ESO Supernova will, from 2017, offer a memorable experience thanks to a fulldome planetarium that uses the latest technology, and almost 2100 square metres of permanent and temporary exhibitions.

Overall, 2013 offered the education and Public Outreach Department (ePOD) new



The poster for the 16-minute movie ALMA — *In Search of Our Cosmic Origins*.

The top priority for the media attending the ALMA inauguration was to get the best footage of the amazing "big science machines" at Chajnantor.

ESO/M. Kornmesser

This collage shows ESO's facilities in Chile, merged into a single imaginary landscape.

Malcolm Ludgate, Director of Photography for the IMAX® 3D film *Hidden Universe*, filming ALMA in Chile's arid Atacama Desert.

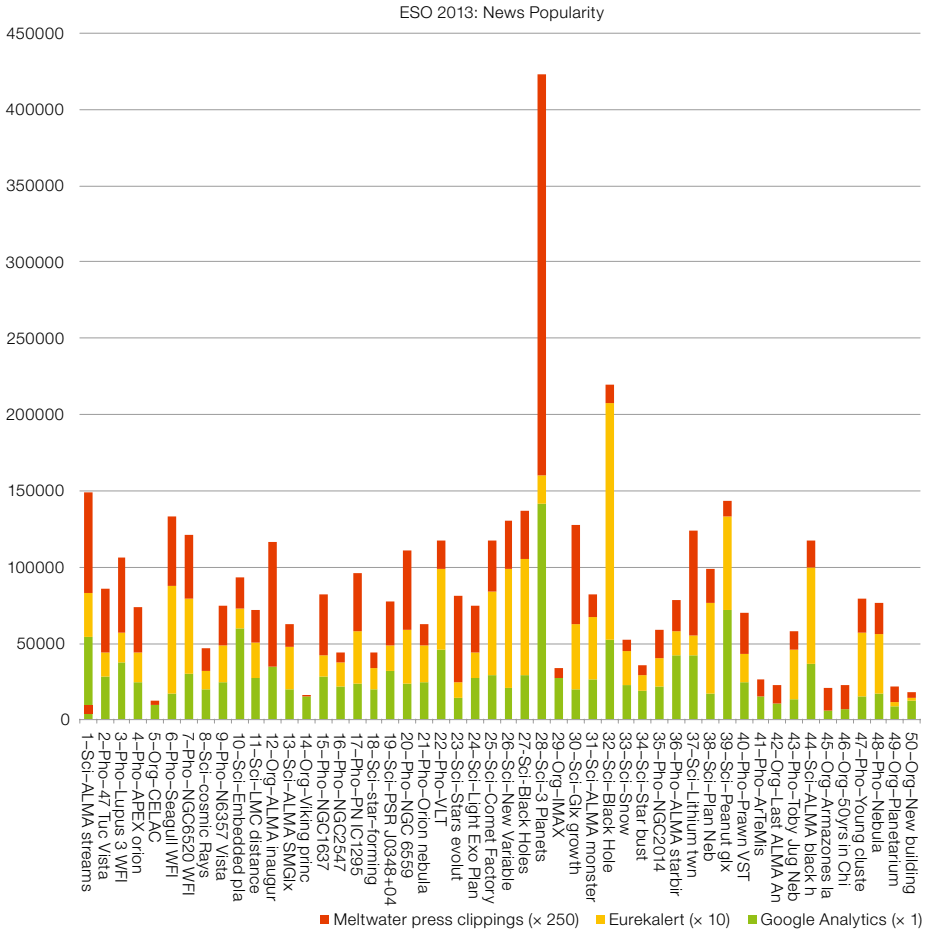
Bernhardt + Partner

Architectural rendering showing the ESO Supernova, scheduled to open in 2017. The new building, which is already becoming an exciting challenge for ESO's outreach department, was conceived and donated by Klaus Tschira, with the help of Darmstadt-based architects Bernhardt + Partner. When viewed from above the building symbolises a binary star system about to go supernova.

opportunities and challenges to bring ESO and astronomy closer to people. We stepped into new outreach territories, acquired new skills and continued our endeavours to make ESO a household science brand.

Press activities

A total of 50 press releases and 102 announcements were published during the year. Compared to earlier years there was a larger fraction of science releases, reflecting Early Science results from ALMA and the two survey telescopes, in addition to the continuing stream of results from both the VLT and La Silla facilities.



The relative popularity of the 50 press releases. Google Analytics measures the number of visitors to the news release web page on www.eso.org. 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 a particular 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 the year was eso1328, reporting the discovery of three planets in the habitable zone of Gliese 667C.

The most popular result of the year in terms of news coverage was a release about three planets in the habitable zone around the nearby star Gliese 667C. This result was based partly on a re-analysis of data from HARPS and confirms the popularity of exoplanet news and the pre-eminence of HARPS in this field.

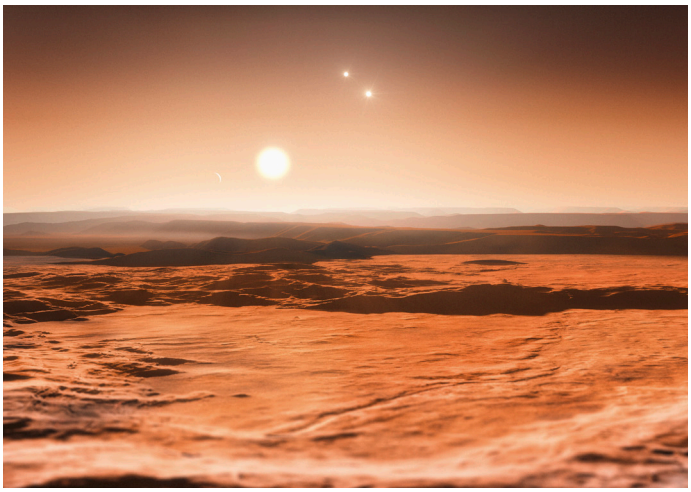
In second place was a report on VLT observations of the gas cloud currently making a close approach to the super-massive black hole at the centre of the galaxy, based on VLT observations. The leading edge of this stretched cloud was detected to have passed its closest approach. This fascinating and unique set of observations will continue in 2014.

The major news event of the year was the inauguration of ALMA on 13 March. Several news products were produced to mark the inauguration: two press releases, one on an ALMA science result in *Nature*, and another for the inauguration event itself (which required careful *in situ* coordination), an ESOcast and a Video News Release of the inauguration event itself. All these efforts led to impressive media coverage for ALMA and ESO, including several major pieces (front pages of national newspapers, evening TV news etc.). The streaming of the inauguration ceremony itself was viewed by 52 608 viewers.

News items to mark the 50th anniversary of ESO's presence in Chile, which was celebrated in late 2013, were produced.

An ESO Picture of the Week was issued for each week of the year, continuing both a series of beautiful and striking photographs and astronomical images, and a channel to report on news items that did not necessarily require a full press release or announcement.

During 2013 ESO received 126 formal interview requests from the media in addition to interviews given during media visits to the sites. Additionally, during the ALMA inauguration more than 80 interviews were given by ESO officials, experts and staff present at the ceremony held at the OSF. This led to a substantial number of news pieces on TV, radio, print and electronic media.



This artist's impression shows the view from the exoplanet Gliese 667Cd looking towards the planet's parent star (Gliese 667C).

ALMA technicians demonstrate one of the ALMA antenna front end receivers to journalists covering the ALMA inauguration at the OSF labs.

Publications

The number of products produced increased from 79 in 2012 to 105 in 2013, and the number of pages produced decreased by 63% to 1075 pages.

Audiovisuals

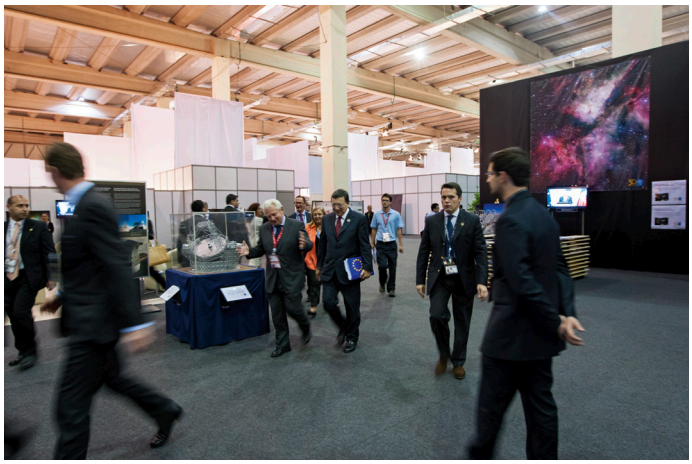
Ten episodes of the ESOcast video podcast and four video news releases were issued during the year. In addition several video clips related to ALMA and the VLT have been released.

The number of images in the online image archive grew from 6427 to 8363 (up 30%). The number of videos in the online video archive grew from 2002 to 2224 (up 11%, including 794 subtitle translations).

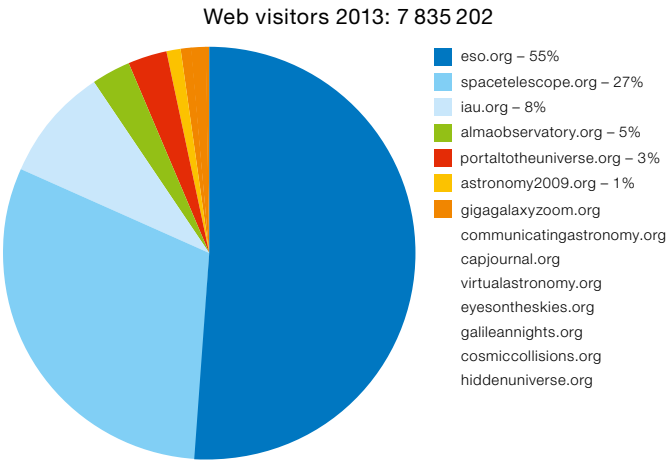
Exhibitions and events

In Europe, exhibition activities were reduced. Small exhibitions were set up at the European Week of Astronomy and Space Science (EWASS) in July 2013, for a ProChile event at the Internationale Handelskammer München and during the Open House Days at CERN in Geneva in September 2013.

In support of the Representation Office in Chile, a special temporary ESO exhibition was displayed at the CELAC–EU Summit, Chile's largest international summit ever held in Santiago. Over six days, 45 heads of state, 3000 delegates from more than 60 countries, and 1500 accredited journalists from around the globe were in contact with ESO through the *50 Years Awesome Universe* exhibition, informative panels, a giant ESO observatories floor



President of the European Commision, Jose Manuel Durao Barroso at the ESO exhibition area during the Summit of the Community of Latin American and Caribbean States and the European Union.



Distribution of the 7.8 million web visits among the ESO websites. The number of visitors on eso.org increased by 13%. While almaobservatory.org is still a small site, the number of visits almost doubled.

jigsaw, and telescope models. ESO's visibility was most prominent inside the Presidential retreat room, where an E-ELT model was placed at the very centre and images of the VLT were projected in large-format wall screens.

In total, 18 outreach events and exhibitions were supported in Chile, including seven ESO–Chile 50th Anniversary special events organised by embassies from Member States.

Web and software development

The core software for ESO's public web infrastructure was upgraded to the latest version, which provides bug and security fixes along with new features. Many new features were implemented, such as science announcements and newsletters, internal announcements (also visible on the information kiosks at ESO Headquarters), and local events exhibitions for each of the ESO Science Outreach Network (ESON) countries, and which are automatically included in the localised newsletters.

Translations in a given language family (e.g., German, Austrian German, Swiss German) are automatically created when one of the translations is uploaded. This avoids the need for manual copy/paste of the texts, and ensures that small fixes (typos, etc.) are fixed in a coherent manner.

All the web pages were consolidated into one web system. This migration resulted in many benefits: we now have an entry point for all ePOD web updates regardless of static or dynamic content, and this also made it possible, for instance, for ESON to update their own translated ESO mini websites. In addition, the number of elements on the pages has been reduced by between a third and a quarter, and the pages load three to four times faster.

The products archive was cleaned and updated with new product types created, and the IDs of all products were updated according to a new unique coherent scheme. These IDs are also used in the online shop and in the physical products archive.

Media, VIP and weekend visits in Chile

In collaboration with Representation and Operations in Chile, a total of 72 media and VIP visits to ESO sites were handled (3% fewer than in 2012).

The most exciting media visits of the year by far were the ones hosted within the framework of the ALMA Observatory inauguration, celebrated on 13 March. ePOD played a major role throughout the whole of the inauguration, providing extensive support to the Joint ALMA Observatory and other colleagues. In addition to the 70 science journalists from Europe, Brazil and Chile invited by ESO, ePOD took the lead in coordinating the visit to the site for a total of about 120 journalists covering the event. ePOD also ran the joint press conference at the ALMA OSF, including a simultaneous virtual conference for remote participants and took the lead in arranging interviews on site for interested media. Among the European and Brazilian journalists, 20 were selected by ESON to visit Paranal as part of a larger programme.

In the days after the inauguration, several VIP and media delegations were hosted at Paranal, together with Representation and Operations: the Danish Crown Prince and Princess, the Austrian Federal Minister for Science and Research, Karlheinz Töchterle, and the Portuguese Minister of Education and Science, Nuno Crato, as well as the Chief Scientific Adviser to the President of the European Commission, Professor Anne Glover.

Other large media delegations during the year included a special delegation of science journalists from Brazil, and a delegation of science journalists from France and Italy was invited (together with Thales Alenia Space).

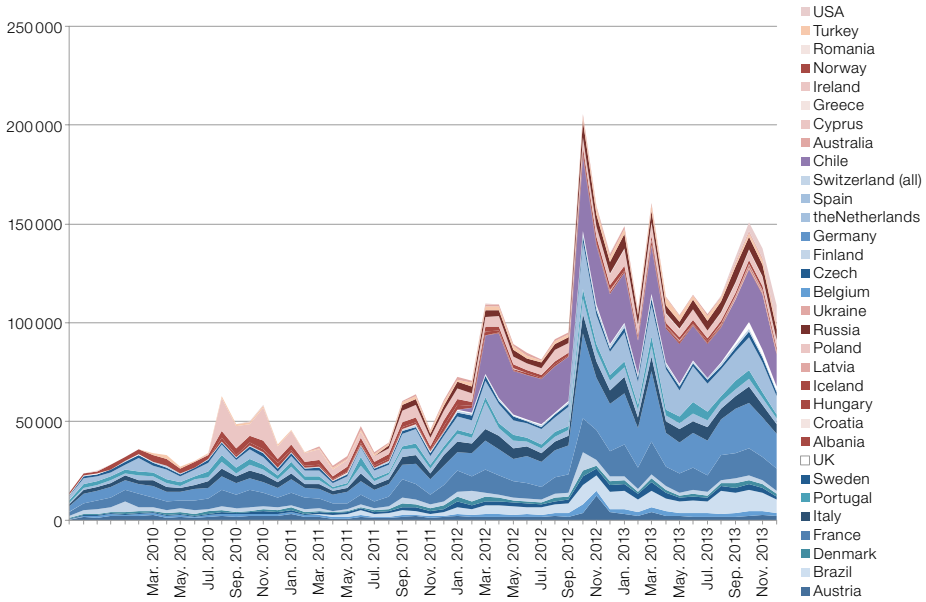
Other VIP and media delegations on Paranal through the year were the President of the Council of Europe, Mr Herman Van Rompuy, together with other dignitaries who participated at the CELAC–EU Summit, and the President of Chile,

Sebastián Piñera, for the ceremony of the donation of the Armazones land.

Public visits to the observatories went down by 17% compared to 2012, with a total of 6539 weekend visitors at La Silla and Paranal.

ESO Science Outreach Network

In order to increase the visibility of ESO in the Member States, ePOD operates the ESO Science Outreach Network, consisting of outreach specialists, press officers, educators who act as direct, local contacts with the media and who organise the translation of ESO-related information into their local language. ESON also includes volunteers in other countries, who disseminate astronomical news and information about ESO. In total, ESON operates in 30 countries, with information in 21 different languages. The press releases, as well as most pictures of the week, and announcements, are translated into 18 different languages. Furthermore, an ongoing fruitful collaboration with the EU Universe Awareness programme results in additional versions for children, issued as *Space Scoops*, which are also available in multiple languages. In 2013, 17% of the web pages viewed on eso.org were translated by ESON.



Translated web pages delivered by the ESO Science Outreach Network shown per country per month. The bluish colours identify the Member States, and reddish colours are used for the additional ESON members; Chile is identified in purple. In 2013, 17% of ESO's outreach pages were delivered in languages other than English.

Community coordination and distribution

ESO's community coordination efforts this year continued to support ePOD's main activities by optimising the impact of the products.

A major inventory update took place, which resulted in a new inventory system and the consolidation of the ESOshop catalogue to help the general public get a better overview of the products we have on offer.

Our newsletter subscriptions grew to over 27 000 subscribers. To expand our reach towards communities in the Member States and beyond, we also implemented a translation service for our newsletters that now brings ESO news to the general public and media in over 30 official languages/countries.

J. Durnwalder

The first ESO Astronomy Camp at the Astronomical Observatory of the Aosta Valley.

ESO was visible at big events such as the Garching Campus Open House Day and at the Cosmic Origins 2013 event organised by CERN on the occasion of the European event Researchers Night.

In terms of partnerships, we expanded our networks of Photo Ambassadors, Outreach Partner Organisations and volunteer translators.

With the help of one of our partners, Sterrenlab, ESO organised the first ESO Astronomy Camp for 56 secondary school students (29 girls and 27 boys), which took place from 26–31 December in Saint-Barthelemy, Nus, Italy.

In the social media, we started organising competitions with partners, as well as on our own channels to engage more with our audiences. We officially added an ESO LinkedIn page to constantly promote career opportunities. Our online communities reached over 50 000 friends on Facebook (up 73%) and over 20 000 followers on Twitter (up 56%). The Your ESO Pictures Flickr group passed the mark of 1000 photos shared by our community.

The planetary nebula Abell 33 captured using ESO's Very Large Telescope.

Calendar of Events

January

ESO Industry Day held in Warsaw, Poland on 22 January.

On 26–27 January, the Government of Chile hosted the first summit of the Community of Latin American and Caribbean States (CELAC) and the European Union (EU), which brought many heads of state to Santiago. ESO's activities were showcased with several important visits to Paranal. The visitors included European Commission President José Manuel Barroso, EU High Representative Lady Catherine Ashton and EU Council President Herman van Rompuy.

ESO meeting on Astrochemistry in the ALMA Era, Copenhagen, Denmark, 28–31 January.

February

ESO meeting on Shaping E-ELT Science and Instrumentation, ESO, Garching, 25 February – 1 March.

March

82nd Committee of Council meeting held in Santiago, Chile.

ALMA inauguration, 13 March. Following the ALMA inauguration the Science Ministers of Austria, Karlheinz Töchterle, and Portugal, Nuno Crato, paid visits to Paranal, as did Anne Glover, Chief Scientific Adviser to EC President Barroso.

Paranal was visited by the Crown Prince and Princess of Denmark on 14–15 March.

ALMA Board meeting.

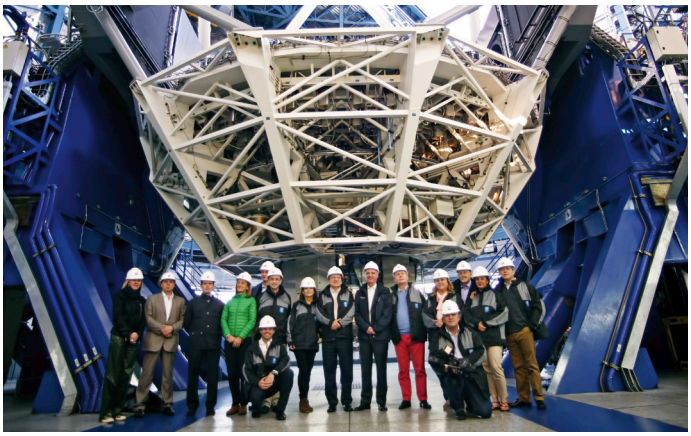
ESO Overview (internal review).

April

APEX Board meeting.

80th Scientific & Technical Committee meeting.

37th Users Committee meeting.



José Manuel Barroso and delegation at the VLT.

ESO Workshop on The Deaths of Stars and the Lives of Galaxies, Santiago, Chile, 8–12 April.

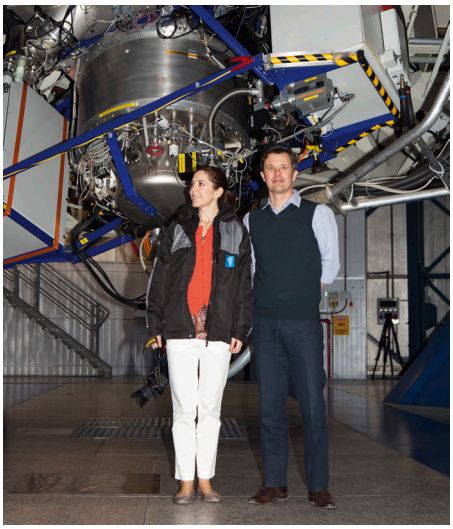
May

135th Finance Committee meeting.

92nd Observing Programmes Committee meeting.

A Bavarian university group, led by Wolfgang Heubisch, Bavarian Minister for Science, Research and the Arts, visited Paranal on 23–24 May.

The VLT celebrated its 15th anniversary since First Light on 25 May.



The Crown Prince and Princess of Denmark during their visit to ESO's Paranal Observatory.

ESO meeting on Science with ALMA Band 2 (65–90 GHz) Bologna, Italy, 27–28 May.

June

128th Council meeting.

Eduard Oswald, Vice President of the German Federal Parliament visited Paranal on 16–17 June.

Visit to the ESO Headquarters by Félix de Vicente, Chilean Minister for Economy, Development and Tourism, on 24 June. ESO participated in a major Chilean trade promotion event in Munich on the following day.

MPA/MPE/ESO/EC Joint Conference on The Physical Link between Galaxies and their Halos, Garching, 24–28 June.

July

On 26 July a visit to Paranal of the Conference of Rectors of Chilean Universities took place.

August

First La Serena School of Data Science, La Serena, Chile, 12–16 August.

September

The 10 000th scientific paper was entered into the ESO Telescope Bibliography.

ESA/ESO Science Operations 2013 Conference, on Working Together in Support of Science, ESAC-Madrid, Spain, 10–13 September.

Acceptance of the 25th and final European ALMA antenna on 23 September.

October

The science operation of KMOS commenced on 1st October.

83rd Committee of Council meeting.

136th Finance Committee meeting.

81st Scientific & Technical Committee meeting.

ESO/NUVA/IAG Workshop on Challenges in Ultraviolet Astronomy, ESO, Garching, 7–11 October.

ESO provides extensive support for the International Astronomical Union Conference Communicating Astronomy with the Public 2013, held in Warsaw, Poland between 14 and 18 October.

ESO/Observatoire de Paris Joint Workshop on Metal Production and Distribution in a Hierarchical Universe, CNRS Observatoire de Paris Meudon, France, 21–25 October.

On 27 October President Piñera of Chile, accompanied by the Minister of Foreign Affairs Moreno, visited Paranal to hand over in person the deed to the tract of land containing Cerro Armazones.

Several activities took place to celebrate the 50th anniversary of the signing of the agreement between ESO and the Government of Chile for the establishment of the (first) ESO telescopes in Chile.

November

137th Finance Committee meeting in Santiago, Chile.

ALMA Board meeting.

93rd Observing Programmes Committee meeting.

Group picture of the ESO/NUVA/IAG Workshop on Challenges in Ultraviolet Astronomy, ESO Garching.

ESO and the Republic of Chile celebrated 50 years of working together to foster astronomy at a ceremony on 9 November.

A Swedish Research Council Delegation visited Paranal and Chajnantor from 9–13 November.

ESO Workshop on Deconstructing Galaxies: Structure and Morphology in the Era of Large Surveys, Santiago, Chile, 18–22 November.

ALMA Community Days 2013: Preparing for Cycle 2, ESO, Garching, 19–20 November.

Workshop on 400 Years of Stellar Rotation, Natal, Brazil, 21–26 November.

ESO Industry Day at the Asher Space Centre in Haifa, Israel.

December

129th Council meeting held in the new ESO Headquarters extension buildings which were accepted during December.

On 10–12 December, a South African Government delegation, lead by Thomas Auf der Heyde, Deputy Director-General of the South African National Department of Science and Technology visited Paranal and Chajnantor.

The ESO Visiting Committee visited the ESO sites in Chile from 9 to 15 December.

First ESO Astronomy Camp held 26–31 December.

At a ceremony held on 14 November 2013 at the La Moneda Palace, Sebastián Piñera, the President of Chile, received the first atomic clock used by ESO in Chile from Tim de Zeeuw, ESO Director General.

The Milky Way looms over the Residencia at the Paranal Observatory in Chile's Atacama Desert.

John Colosimo (colosimophotography.com)/ESO

Glossary of Acronyms

4LGSF	Four-Laser Guide Star Facility
4MOST	4-metre Multi-Object Spectroscopic Telescope (Proposed new spectroscopic instrument for VISTA)
A&A	Journal, *Astronomy & Astrophysics*
A&ARv	Journal, *Annual Review of Astronomy and Astrophysics*
ADS International	Italian optics company working on the DSM for the VLT
AEM	ALMA construction consortium
AFTA	Astrophysics Focused Telescope Assets
AG	Aktiengesellschaft
AGN	Active Galactic Nucleus
AIP	Leibniz Institute for Astrophysics Potsdam
AIV	Assembly, Integration and Verification
AJ	The Astronomical Journal
ALMA	Atacama Large Millimeter/submillimeter Array
AMBER	Astronomical Multi-BEam combineR (VLTI Instrument)
AN	Journal, *Astronomische Nachrichten*
Antu	VLT Unit Telescope 1
AO	Adaptive Optics
AOF	Adaptive Optics Facility
AOS	Array Operations Site (ALMA)
APEX	Atacama Pathfinder Experiment
ApJ	*Astrophysical Journal*
ApJS	Journal, *Astrophysical Journal Supplement Series*
AQUARIUS	Mid-infrared detector array (VISIR)
ARA&A	Journal, *Annual Review of Astronomy and Astrophysics*
ARC	ALMA Regional Centre
ArTeMiS	Bolometric camera for APEX
ASIAA	East Asia FEIC (ALMA)
ASSIST	Adaptive Secondary Setup and Instrument Simulator (AOF test bench)
AT	Auxiliary Telescope for the VLTI
AU	Astronomical Unit
BAM	Construction company for the Headquarters extension
BLIP	Background photon noise limited
C2PAP	Computational Center for Particle and Astrophysics, Universe Cluster, Garching
CARLA	Clusters Around Radio-Loud AGN (Spitzer)
CASA	Common Astronomy Software Applications (ALMA)
CCD	Charge Coupled Device
CEA	Commissariat à L'Energie Atomique, France
CELAC_EU	Summit of the Community of Latin American and Caribbean States–European Union
CERN	European Organization for Nuclear Research
CHAMP+	Dual channel heterodyne receiver array (APEX)
CHF	Swiss francs
CLIF	Convolution with Linearized Inverse Filter algorithm for wavefront sensing
CNRS	Centre national de la recherche scientifique
CO	Carbon monoxide
COFUND	EU fellowship funding programme
CONDOR	1.5 THz heterodyne receiver (APEX)
COSMOS	HST survey programme
CRIRES	Cryogenic InfraRed Echelle Spectrometer (VLT)
CRIRES+	Planned upgrade to CRIRES
CUBES	Cassegrain *U*-band Brazilian ESO Spectrograph
CuRe	Fast wavefront reconstruction algorithms for XAO with pyramid WFS
CuReD	Fast wavefront reconstruction algorithms for XAO with pyramid WFS with pre-processing
DC	Direct Current
DDT	Director's Discretionary Time
DG	Director General
DIG	Deep Imaging Group (Vitacura)
DMO	Data Management and Operations Division
DRS	DRS, formerly Boeing, detector manufacturer
DSM	Deformable Secondary Mirror
EASC	European ALMA Support Centre
EC	European Commission
E-ELT	European Extremely Large Telescope
EFOSC2	ESO Faint Object Spectrograph and Camera (v.2)
EM&P	Journal, *Earth, Moon, and Planets*
EMMI	ESO Multi-Mode Instrument
ePOD	education and Public Outreach Department
ERIS	Enhanced Resolution Imaging Spectrograph
ERP	Enterprise Resource Planning (Administration software)
ESA	European Space Agency
ESAC	European Space Astronomy Centre (ESA, Spain)
ESAC	European Science Advisory Committee (for ALMA)
ESC	E-ELT Subcommittee
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
ETH	Swiss Federal Institute of Technology
EU	European Union
EWASS	European Week of Astronomy and Space Science
ExA	Journal, *Experimental Astronomy*
FEIC	Front End Integration Centre (ALMA)
FEROS	Fibre-fed, Extended Range, Échelle Spectrograph (MPG/ESO 2.2-metre)
FLAMES	Fibre Large Array Multi Element Spectrograph (VLT)
FORS2	FOcal Reducer/low dispersion Spectrograph (VLT)-2
GALACSI	Ground Atmospheric Layer Adaptive Optics for Spectroscopic Imaging (AOF)
GIRAFFE	Fibre-fed multi-object spectrograph and part of the VLT FLAMES facility
gNLT	Garching Night Log Tool
GLAO	Ground Layer Adaptive Optics
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 (MPG/ESO 2.2-metre)
GTC	Gran Telescopio Canarias
GWh	Gigawatt hours
HARMONI	Proposed first light integral field spectrograph for the E-ELT
HARPS	High Accuracy Radial Velocity Planetary Searcher (3.6-metre)
HAWK-I	High Acuity Wide field *K*-band Imager
HR	Human Resources
HST	Hubble Space Telescope
IAG	Institute of Astronomy, Geophysics and Atmospheric Sciences (Brazil)
Icar	*Icarus*, Planetary science journal, Planetary science journal
INAF	Italian National Institute for Astrophysics
IPAG	Institut de Planetologie et d'Astrophysique de Grenoble
IR	Infrared
ISAAC	Infrared Spectrometer And Array Camera (VLT)
ISERD	Israeli inter-ministerial agency for R&D cooperation with Europe
IT	Information Technology
ITAR	International Traffic in Arms Regulations
JAO	Joint ALMA Observatory
JPL	Jet Propulsion Laboratory
KMOS	*K*-band Multi-Object Spectrograph (VLT)
Kueyen	VLT Unit Telescope 2
LABOCA	Large APEX Bolometer CAmera
LFC	Laser Frequency Comb

LGSF	Laser Guide Star Facility
LMU	Ludwig-Maximilians-Universität München
LPG	Liquefied Petroleum Gas
LPO	La Silla Paranal Observatory
LSP	La Silla Paranal Subcommittee
LTAO	Laser Tomography Adaptive Optics
M#	Mirror #
MACAO	Multiple Application Curvature Adaptive Optic
MACCON	Motion controller manufacturer
MATISSE	Multi AperTure mid-Infrared SpectroScopic Experiment (VLTI)
MCAO	Multi-Conjugate Adaptive Optics
Melipal	VLT Unit Telescope 3
MENLO systems	Optical equipment manufacturer
MERAC	Mobilising European Research in Astrophysics and Cosmology
MICADO	Adaptive optics imaging camera (E-ELT)
MIDI	Mid-infrared Interferometric Instrument (VLTI)
MNRAS	Journal, *Monthly Notices of the Royal Astronomical Society*
MOAO	Multiple-Object Adaptive Optics
MOONS	Multi Object Optical and Near-infrared Spectrograph (VLT third generation)
MOSFIRE	Near-infrared multi-object spectrograph (Keck)
MPA	Max Planck Institute for Astrophysics
MPE	Max Planck Institute for Extraterrestrial Physics
MPfIR	Max Planck Institute for Radio Astronomy
MPG	Max-Planck-Gesellschaft
MPIA	Max Planck Institute for Astronomy
MUSE	Multi Unit Spectroscopic Explorer (VLT)
NACO	NAOS-CONICA (VLT)
NAOJ	National Astronomical Observatory of Japan
NAOMI	Adaptive optics system for the ATs (VLTI)
NAOS	Nasmyth Adaptive Optics System (VLT)
NASA	National Aeronautics and Space Administration
NEO	Near-Earth Object
NewA	Journal, *New Astronomy*
NewAR	Journal, *New Astronomy Reviews*
NGC	New General Catalogue
NGC	New General Detector Controller
NGSD	Proposed large natural/laser guide star WFS detector (E-ELT)
NOVA	The Netherlands Research School for Astronomy (Nederlandse Onderzoekschool voor Astronomie)
NRAO	National Radio Astronomy Observatory
NTT	New Technology Telescope
NUVA	Network for UltraViolet Astrophysics
OAA	Arcetri Astrophysical Observatory
OCA-NICE	Cote d'Azur Observatory (Observatoire de la Cote d'Azur)
OPC	Observing Programmes Committee
OSF	ALMA Operations Support Facilities
P&SS	Journal, *Planetary and Space Science*
PAE	Provisional Acceptance Europe
PARLA	PAranal Raman Laser, replacement for PARSEC (VLTI)
PARSEC	Sodium line laser for VLT AO
PASJ	Journal, *Publications of the Astronomical Society of Japan*
PASP	Journal, *Publications of the Astronomical Society of the Pacific*
PC	Personal Computer
PDF	Portable Document Format
PDR	Preliminary Design Review
PESSTO	Public ESO Spectroscopic Survey of Transient Objects
PI	Principal Investigator
PIONIER	VLTI visitor instrument
PLC	Programmable Logic Controllers (E-ELT)
PRIMA	Phase-Referenced Imaging and Micro-arcsecond Astrometry facility (VLTI)
PSF	Point Spread Function
QSO	Quasi Stellar Object, quasar
R&D	Reasearch and Development
rms	Root Mean Square
SABOCA	Shortwave Apex BOlometer Camera
SAFRAN-REOSC	High performance optics company
SAPHIRA	Detector for the GRAVITY wavefront sensor
SAXO	SPHERE'S AO system (VLT)
SCAO	Single-conjugate adaptive optics
SDSS	Sloan Digital Sky Survey
SEPA	Single Euro Payments Area
SHFI	Swedish Heterodyne Facility Instrument
SINFONI	Spectrograph for INtegral Field Observations in the Near Infrared (VLT)
SOFI	SOn oF Isaac (NTT)
SPARTA	Real-time computer for the AOF
SPHERE	Spectro-Polarimetric High-contrast Exoplanet Research instrument (VLT)
SPIFFI	SPectrometer for Infrared Faint Field Imaging
SPT	South Pole Telescope
STC	Scientific Technical Committee
TAROT-S	Télescopes à Action Rapide pour les Objets Transitoires South
telbib	ESO library telescope bibliography database
TRAPPIST	TRAnsiting Planets and PlanetesImals Small Telescope
TUM	Technische Universität München
UK	United Kingdom
UK ATC	UK Astronomy Technology Centre
Ultracam	High-speed camera (VLT)
UltraVISTA	Ultra-deep near-infrared survey in the COSMOS field
UN	United Nations
UNCOPUOS	United Nations Committee for the Peaceful Uses of Outer Space
UNESCO	United Nations Educational Scientific and Cultural Organization
UT 1–4	VLT Unit Telescopes 1–4: Antu, Kueyen, Melipal and Yepun
UVES	UV-Visual Echelle Spectrograph (VLT)
VHS	VISTA Hemisphere Survey
VIDEO	VISTA Deep Extragalactic Observations Survey
VIKING	VISTA Kilo-degree Infrared Galaxy survey
VIMOS	VIsible MultiObject Spectrograph (VLT)
VIP	Very Important Person
VIPERS	VIMOS Public Extragalactic Redshift Survey
VIRCAM	VISTA Infrared Camera
VISIR	VLT Mid-Infrared Imager Spectrometer
VISTA	Visible and Infrared Survey Telescope for Astronomy
VLT	Very Large Telescope
VLTI	Very Large Telescope Interferometer
VLTI-PR#	VLTI projects
VMC	VISTA survey of the Magellanic Cloud system
VST	VLT Survey Telescope
VVDS	VIMOS VLT Deep Survey
VVV	ESO public survey VISTA Variables in the *Vía Láctea*
WFI	Wide Field Imager (MPG/ESO 2.2-metre)
XAO	Extreme adaptive optics
XMM-Newton	X-ray Multi-Mirror satellite (ESA)
X-shooter	Wideband ultraviolet-infrared single target spectrograph (VLT)
Yepun	VLT Unit Telescope 4
zCOSMOS	Large Programme to measure 30 000 galaxies in the HST Cosmic Origins field
Z-Spec	Millimetre-wave spectrograph (APEX visitor instrument)
ΛCDM	Lambda Cold Dark Matter
µm	Micrometre

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Cover: The Milky Way arching over ALMA. The year 2013 marked the inauguration of the Atacama Large Millimeter/submillimeter Array on the Chajnantor Plateau in northern Chile. Credit: ESO/B. Tafreshi

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