ESO

European Organisation
for Astronomical
Research in the
Southern Hemisphere

Annual Report 2014

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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 16 countries: Austria, Belgium, Brazil[1], the Czech Republic, Denmark, France, Finland, Germany, Italy, the Netherlands, Poland[1], Portugal, Spain, Sweden, Switzerland and the United Kingdom. Several other countries have expressed an interest in membership.

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

ESO operates three world-class observing sites in the Atacama Desert region of Chile: La Silla, Paranal and Chajnantor. ESO's first site is at La Silla, 2400 metres above sea level, and 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 the second-most scientifically productive observatory in ground-based astronomy (after Paranal), the Paranal site, 2600 metres above sea level, is the flagship facility of European astronomy. The Paranal Observatory includes 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 survey the skies exclusively in visible light. Paranal is situated about 130 kilometres south of Antofagasta in Chile, and 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/B. Tafreshi (twanight.org)

Paranal Observatory is one of the best places on Earth to take in the night sky. A mix of colours sweeps across the sky in this image.

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

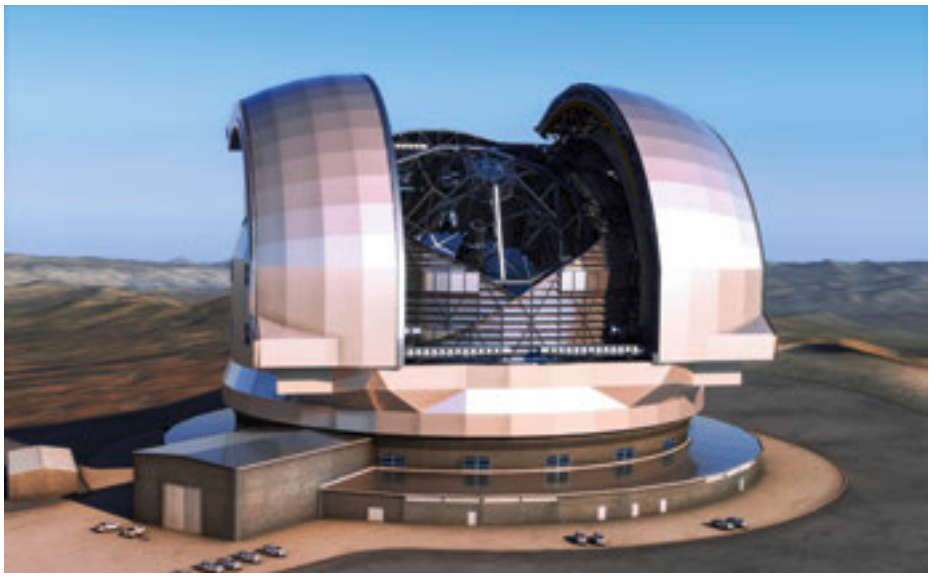
One of the most exciting features of the VLT is the option to use it as a giant optical interferometer (VLT Interferometer or VLTI). This is done by combining the light from two or more of the 8.2-metre telescopes and including one or more of four 1.8-metre movable Auxiliary Telescopes

Dave Jones Photography

The Sun sets over La Silla creating a fiery orange glow along the horizon.

[1] Brazil and Poland have already signed accession agreements, and will officially become the next ESO Member States on completion of the requisite ratification processes.

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



ESO/L. Calçada

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

Each year, almost 2000 proposals are submitted for the use of ESO telescopes, requesting between three and six times more nights than are available. ESO is the most productive ground-based observatory in the world whose operation yields many peer-reviewed publications: in 2014 alone, 865 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. ALMA is located on the high-altitude Chajnantor Plateau, at 5000 metres above sea level — one of the highest astronomical observatories in the world. The ALMA project is a partnership between ESO, East Asia and North America, in cooperation with the Republic of Chile.

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 the construction of the European Extremely Large Telescope (E-ELT) with a primary mirror 39 metres in diameter. The E-ELT will be the "world's biggest eye on the sky" — the largest optical/near-infrared telescope in the world. When complete, 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 around 2024.

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 is an active site for training new generations of researchers, acting as a bridge between scientists in Europe and Chile.

The regular Member State contributions to ESO in 2014 were approximately 151 million euros and ESO employs around 630 staff.

The antennas of the ALMA Observatory peer skywards, scanning the Universe for clues to our cosmic origins. Visible amongst the thousands of stars on the right side of this image are the Small and Large Magellanic Clouds.

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

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Foreword

There is no doubt that 2014 was another highly successful year for ESO, cementing its position as the world's leading astronomical observatory. We witnessed major progress in ESO's activities with vital steps taken in approving the main construction activities of the E-ELT, the completion of construction of the ALMA Observatory, and substantial enhancements to the VLT instrument complement. We welcomed the application by Poland to join ESO as the 15th European Member State, celebrated the 10th anniversary of Finnish accession and saw progress in the ratification of Brazilian accession through the parliamentary processes. Throughout all of these activities, the truly impressive scientific and technical output from ESO staff and the community of users was maintained, with the first image released from the ALMA Long Baseline Campaign demonstrating the enormous levels of excitement that astronomy can generate.

For many people, the La Silla Paranal Observatory, with the four Unit Telescopes (UTs) of the VLT, together with the VISTA and VST infrared and optical survey telescopes, the VLTI and the 4-metre-class telescopes on La Silla comprises the core scientific capability of ESO. They continue to be outstandingly productive, with the number of publications being maintained close to record levels. The VLT has been kept at the forefront of astronomical productivity through a programme of new instrumentation and upgrades. Over the last year, two new and innovative instruments, MUSE and SPHERE, were commissioned and the initial results give a foretaste of the rich harvest of discoveries from these second generation VLT instruments. The efficient commissioning of two complex instruments on Paranal within a short period reflects a key ingredient of ESO's success: the careful planning and close cooperation between the instrument teams and ESO staff.

The whole ESO programme is under review to ensure that it continues to be scientifically motivated and that it can be delivered within the resources available. This process has led to a slowdown in some instrument developments, but is designed to ensure that ESO continues to deliver world-class capabilities. Overall the breadth of the programme continues to be both impressive and challenging. The internal structure of ESO has been undergoing significant changes to prepare the organisation not only for maintaining, operating and exploiting the current facilities, but ensuring that the next major challenge, the construction of the 39-metre European Extremely Large Telescope, proceeds effectively. This has inevitably meant some changes in roles or operational modes for some personnel, but with Council's approval of major spending on the construction of the E-ELT in December 2014, we are now embarking on the first phase of this world-leading project.

By mid-2014, all of the ESO Member States had committed to the E-ELT programme. Intensive discussions and analyses were conducted throughout the year to identify a way to proceed with E-ELT construction within the current financial constraints of secured funding. Whilst we all hope that the funding levels to complete the full E-ELT project will be realised soon, some cost savings that can be implemented, if necessary, to complete a capable but somewhat descoped E-ELT have been identified. This plan allows construction of the time-critical main components of the telescope to get underway now and contracts for substantial elements of the telescope and instruments to be awarded in 2015. Seeing the installation of components of the world's leading optical/infrared telescope at the summit of Armazones in Chile over the next decade will be truly exciting and inspiring.

Formal construction of the ALMA Observatory at 5000 metres altitude on the Chajnantor Plateau was completed in 2014, with only the construction of the Residencia continuing beyond 2015. This marks the end of the first phase of a remarkably successful global astronomy project, where ESO, representing its Member States, has collaborated with North American and East Asian institutes and organisations to build a transformational millimetre and submillimetre wave facility. While there is much work still to be done to optimise the use of the array and fully implement all of the wavebands and modes, ALMA is moving towards routine operations and producing stunning scientific results. Improvements to hardware and software over the last year by observatory staff, working with colleagues in the partner regions, have greatly improved reliability of operation. The sensitivity and resolution are improving as the number of antennas and the antenna separations used for observations increases.

In October Council met in Turku, marking a decade of Finnish membership of ESO, and welcomed the proposal that Poland should accede to ESO. This was swiftly followed by a ceremony in Warsaw where Minister Lena Kolarska-Bobínska signed Poland's accession agreement; we look forward to the ratification of Poland's membership of ESO during 2015. We hope that ratification of Brazilian accession to ESO will be achieved on a similar timescale. The delegates to Council have discussed the role of ESO in the context of other major astronomy projects around the world and have looked at how ESO should develop in the future. There was broad recognition that the model ESO has used to date has been very successful and that it should be continued as far as possible. ESO has a strong and unified programme with all Member States contributing to, and involved in, all activities. Council sees this united programme as a real strength and one that should be maintained in the future.

Finally, I would like to express Council's gratitude to Xavier Barcons for his deep commitment and exemplary contributions as Council President over the last three years. Thank you Xavier!

Introduction

The past year may well prove to be one of the most memorable in ESO's history.

Poland signed the accession agreement with ESO on 28 October, and is proceeding forthwith with ratification. The ratification of the Brazilian accession to ESO also made further progress. At the time of writing the Brazilian Chamber of Deputies and the Senate have both approved the accession, and it now awaits the signature of President Rousseff. The Polish accession agreement has been approved by the Sejm and by the Senate, and has been signed into law by President Komorowski. Conversations with other countries interested in joining ESO have made progress too, which leads to realistic expectations of further enlargement of ESO membership in the coming years.

The 2013–2014 Visiting Committee, chaired by Jean-René Roy, assessed ESO's overall programme, and provided a very positive report to Council and myself for which I am grateful. The Committee was impressed with our world-leading programme and also provided constructive advice on how to move forward in the era of E-ELT construction. The committee had interacted with ESO staff at all the sites in Chile in late 2013, and at Headquarters in early 2014. The highlights of the conclusions and recommendations were presented to the staff in an All Hands meeting in June. Both the chair of the Visiting Committee and the Council President attended this meeting in person, and their participation was much appreciated by the staff.

The La Silla Paranal Observatory has continued to increase its scientific output. User support by ESO is much appreciated in the community, as shown by a recent poll. A study was undertaken to analyse the whole observing process, from proposal submission to scientific paper, based on 15 years of VLT operations, in order to find ways to further improve the model. Two powerful new instruments, MUSE and SPHERE, arrived on Paranal and quickly produced impressive results that anticipate the exciting discoveries that they will enable. The required effort needed to stay on track with the challenging arrivals planned for 2015–17, including the Adaptive Optics Facility, ESPRESSO, GRAVITY and MATISSE, led to the decision to discontinue PRIMA astrometry at the VLTI. An evaluation clearly showed that the effort required to bring the facility within specifications was not commensurate with its rapidly shrinking targeted application area after the successful launch of the European Space Agency's (ESA) Gaia satellite. The La Silla Observatory continues to make a strong impact and the call for new ideas for science with the NTT received much interest. APEX had a record year with 4400 hours of science time, despite being offline as usual during the altiplanic winter.

ALMA formally ended its construction phase after more than a decade of work by the partners. The highlight of the year was the Long Baseline Campaign, which demonstrated that submillimetre interferometry is possible over distances up to at least 15 kilometres. This was theoretically known, and was of course the reason for building antenna foundations at so many locations on Chajnantor, but needed to be proved. The Long Baseline Campaign involved staff members from all the ALMA partners and was a major success: the high-resolution image of the young stellar object HL Tauri attracted worldwide attention. Much further work remains to be done to move ALMA to full operations, but it is now abundantly clear that this is the most powerful radio telescope in the world and will indeed provide the transformational step forward in the study of the Universe for which it was built. The long process leading to an affordable high-quality ALMA Residencia came to a conclusion, with the construction contract signed late in the year and work starting early in 2015.

By early June all 14 Member States had committed to the E-ELT programme, and on 19 June the groundbreaking ceremony took place for the construction of the platform on Cerro Armazones, which will host the E-ELT. Vice Minister Maldonado of the Chilean Ministry of National Assets gave the formal command, from Paranal, for the first of many explosions that will reshape the mountaintop into a platform similar in size to that of Paranal. The ceremony was attended by many dignitaries and was broadcast widely. On the same day a contract was signed to connect Paranal

and Armazones to the Chilean grid via a transmission line to Paposo. When finished in 2017, this connection will significantly reduce the cost of power and allow the use of green energy.

Much work was done inside ESO and in the Member States to move forward on the construction of the E-ELT. This culminated in the Council decision in December to split the E-ELT construction into two phases, and to authorise spending up to 1012 million euros on the first phase. This decision decouples the timeline for the construction of the E-ELT from the timeline of the Brazilian ratification process. Phase 1 will deliver a fully functional E-ELT with a 39-metre diameter main mirror and most of the foreseen instrumentation and adaptive optics capabilities in 2024, or soon thereafter. Spending on the second phase of about 100 million euros to complete the capabilities of the E-ELT would not begin before 2017, even in the baseline plan. This two-phased approach provides time for Brazil (and other countries) to accede, in which case construction is back on the baseline plan, which is of course the preferred way forward. This decision by Council demonstrates the trust of the Member States in ESO's ability to deliver world-class observing capabilities for the scientific community. At the same time it ensures a bright future for many years to come. The green light for E-ELT construction will

no doubt also attract other candidate Member States.

The year also saw significant developments at ESO Headquarters in Garching. It was finally possible to give up the rented office space in the Max Planck Institute for Plasma Physics and to vacate, and subsequently retire, the venerable portacabins and the temporary office building. All staff are now on the ESO premises, in three interconnected buildings, with more space, a new auditorium, more meeting rooms, including a large new Council Room, and many opportunities for daily interaction. The new technical building is now appropriate for the scope of the overall programme. Once the new visitor centre (the ESO Supernova, whose construction is funded by the Klaus Tschira Stiftung) is ready in 2017, ESO premises will have undergone a nearly complete transformation.

Various changes in the organisational structure have been made, and include a new structure in the Directorate of Engineering as the final step in the consistent matrixing of all engineering services. Internal communication improved further. The collective bargaining with local staff unions in Chile towards the end of the year took place in a collegial setting and had a very positive outcome.

All these achievements have been possible because of the dedication and skills of ESO's staff, across all sites and disciplines. With ESO's future development now much better defined than a year ago, there is much to look forward to. It will be difficult to top the achievements of 2014, but it is certainly a goal!

Finally, 2014 also was the third term of Council President Xavier Barcons, who was succeeded by Patrick Roche. It is a distinct pleasure to thank Xavier for his very constructive and hands-on presidency and to welcome Pat as his successor.

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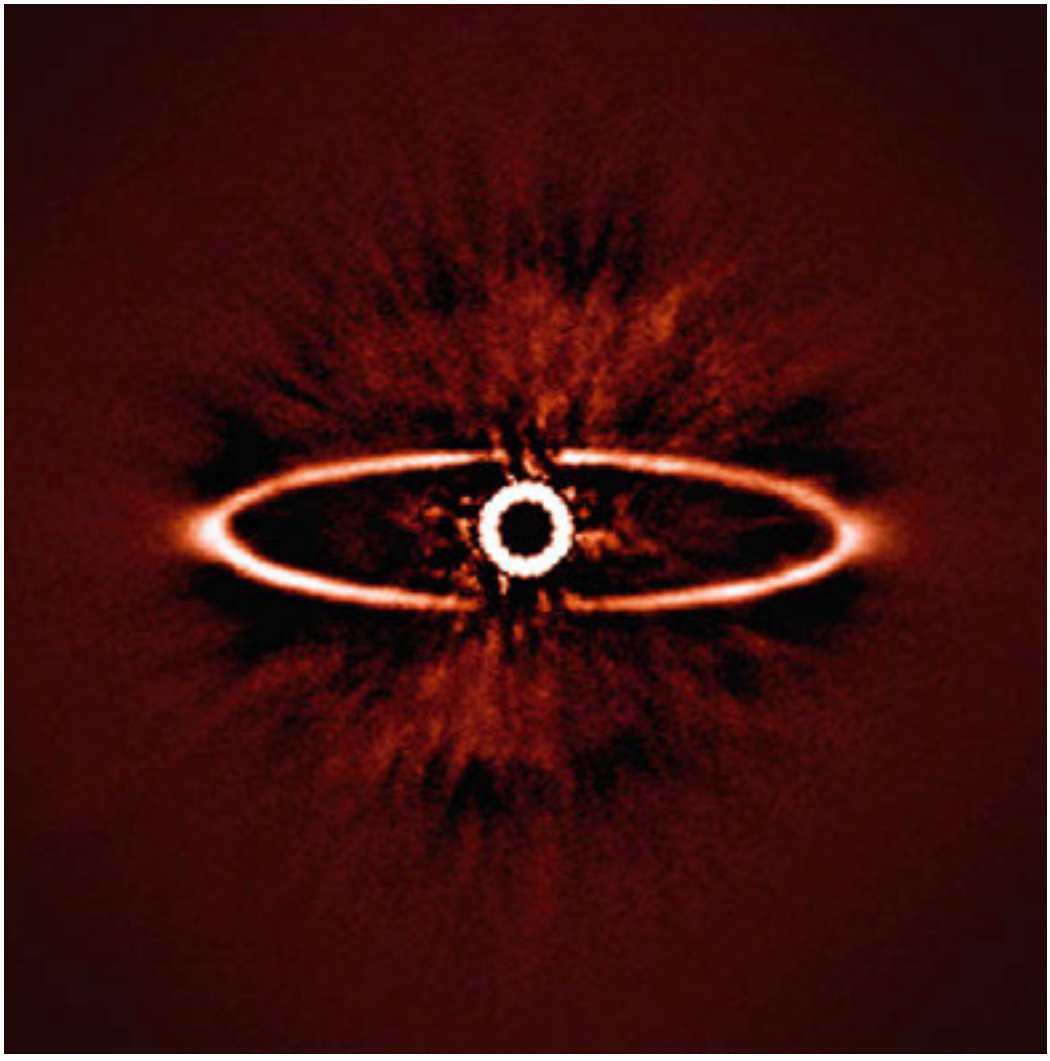


ESO/J.-L. Beuzit et al./SPHERE Consortium

This infrared image shows the dust ring around the nearby star HR 4796A in the southern constellation of Centaurus. It was one of the first produced by the SPHERE instrument soon after it was installed on the Very Large Telescope in May 2014.

This image was taken with a long exposure time from inside one of the large courtyards of the new office building at ESO Headquarters in Garching, Germany.

Aldo Amoretti, San Remo

Research Highlights

This year saw the Directorate for Science continue to evolve. On his retirement, just after the Science Verification phase of MUSE on the VLT, Jorge Melnick handed over as VLT Programme Scientist to Bruno Leibundgut. Rob Ivison took over from Bruno as Director for Science. Rob arrived from the University of Edinburgh and on appointment resigned his membership of ESO Committees (Scientific Technical Committee [STC]) and as chair of the European Science Advisory Committee (ESAC) and the ALMA Scientific Advisory Committee (ASAC). Dietrich Baade became Deputy Director for Science and his former position as Head of the Instrument Scientist Department — now the Project Science Department — went to Jason Spyromilio. Jason's work as E-ELT Programme Scientist was continued by his former deputy, Joe Liske, who helped secure approval for a two-phase approach to construction; ESO is now recruiting a long-term replacement.

A major exercise began, led by the Director for Science, to prioritise ESO's programme in terms of its scientific merit, with the involvement of the Programme Scientists, members of the ESO advisory bodies and the ESO Faculty.

The year concluded with a major conference in Tokyo to celebrate the "Revolution in Astronomy with ALMA", at which images from the Long Baseline Campaign were shown for the first time, heralding the many discoveries that will be made with this game-changing astronomical facility.

Very Large Telescope image of the Medusa Nebula.

ESO telescopes are used to observe celestial objects of nearly all types. The capability to use the same instrumentation to measure Solar System bodies and the most distant galaxies is a virtue of astronomy and offers our community the opportunity for a range of discoveries that cannot be achieved at other observatories. The research highlights display this diversity in the scientific topics studied at the available facilities.

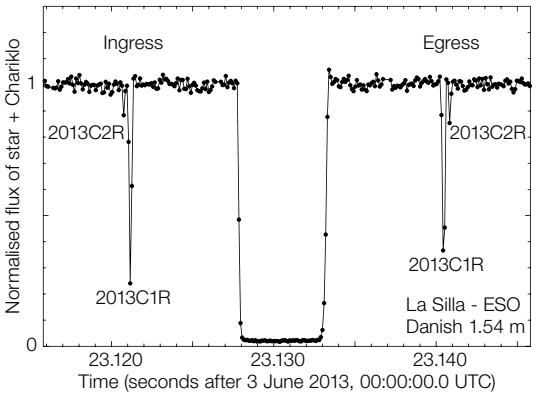
Discovery of a new ring system around the Centaur (10199) Chariklo

The major planets in the Solar System have rings surrounding them: the beautiful rings around Saturn are observable with small telescopes and the many moons around Jupiter also shepherd several small rings. Neptune and Uranus are also encircled by very faint rings, which have been discovered through stellar occultations. Stereoscopic observations of stellar occultations allow astronomers to obtain spatial information about the foreground object.

On 3 June 2013 the Centaur (10199) Chariklo temporarily covered a 12th magnitude star and eight telescopes scattered across South America observed the occultation. Chariklo is a small body orbiting the Sun at a distance of 15.8 au and is located between the orbits of Saturn and Uranus. The occultation of the main body, observed by three observatories (including La Silla, where the Danish 1.5-metre telescope and TRAPPIST participated, and Cerro Tololo, with two telescopes) was accompanied by "satellite" occultations symmetrically before and after the main occultation. Such separate, short occultations were observed at four additional observatories located further away from the occultation line of Chariklo itself. The Danish 1.5-metre observations show two rapid occultations of less than one second duration about 10 seconds before and after the main occultation.

The emerging picture is of a ring system surrounding the Centaur (radius ≈ 120 kilometres) with radii of about 391 and 405 kilometres and widths of only 7 and 3 kilometres, respectively. The rings appear to be circular, while the Centaur itself has an oblate shape. The geometry could explain a hitherto mysterious dimming of Chariklo in 2008. With the rings in the orientation observed during the 2013 occultation, the dimming in 2008 would be consistent with the rings covering part of Chariklo as seen edge on from Earth.

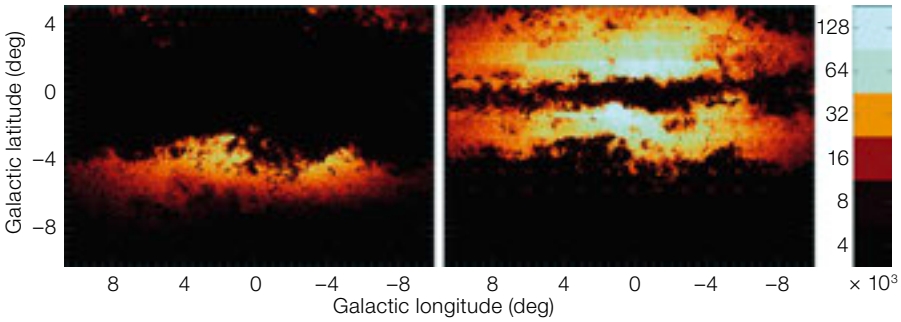
Small bodies of about one kilometre in size are required to stabilise the ring over thousands of years. So either the Chariklo ring system is very young and derives from a recent low-velocity impact, or there could be small bodies (perhaps moons) shepherding the rings.



Light curve of the occultation by the Chariklo system taken on 3 June 2013 with the Danish 1.5-metre telescope. The central drop is caused by the occultation by Chariklo of the star, whilst the two secondary events 2013C1R and 2013C2R are attributed to the ring system. From Braga-Ribas et al. (2014).

Surveys

ESO has engaged in a number of public surveys, first with the survey telescopes VISTA and the VST, and later with Public Spectroscopic Surveys at the VLT and the NTT. These massive investments in observing time are starting to pay dividends: 65 refereed papers from the VISTA surveys were published in 2014, six from VST surveys and 25 resulted from the Public Spectroscopic Surveys. These publication statistics demonstrate that the surveys contributed 11% of all ESO publications in 2014. There follows a brief selection of prominent results from some of these surveys.



Distribution of red clump stars with bluer colours (left) and with redder colours (right). The red stars are less affected by the obscuration of the dust lane, which is clearly visible in the left panel. From Minniti et al. (2014).

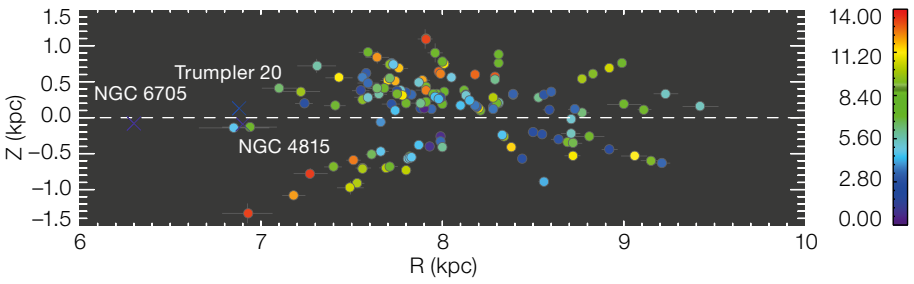
Stars in the Galactic Bulge

The spatial distribution of dust clouds towards the Milky Way Bulge has been established by observing the position of many stars. Near-infrared photometry of 157 million stars in the Bulge observed by the VISTA Variables in the *Via Láctea* (VVV) survey has been used for distance measurements, employing the red clump method for core helium-burning stars. The colour distribution indicates that there is a population of red clump stars whose light is two magnitudes fainter, on account of extinction by a foreground dust cloud stretching several degrees above and below the Galactic Plane. The dust lane is located in front of the Bulge and its presence has implications for the study of the Galactic Bar in the inner parts of the Milky Way.

Decomposing the different components in the Bulge region of the Milky Way requires kinematic information, and hence spectroscopy of many stars. The Gaia–ESO survey has measured 1200 stars in five fields towards the Bulge and combined this information with infrared photometry provided by the VVV survey. The rich and complex information resulting from this combination shows two main components of stars. One belongs to the metal-rich boxy or peanut-shaped Bulge component and displays kinematics like a bar, while the metal-poor stars constituting the other component are distributed in an extended and rotating structure with a higher velocity dispersion whose numbers dominate far from the Galactic plane.

Stars in the Solar Neighbourhood

The ultraviolet and visible spectrograph UVES has been used to investigate the age, metallicity and enrichment in alpha-elements (C, O, Ne, Mg, Si, S, Ar, Ca) of Sun-like stars (spectral types FGK) in the Solar Neighbourhood, as part of the Gaia–ESO Public Survey. One hundred and forty four stars with ages from 0.5 to 13.5 billion years were investigated at galactocentric distances from 6 to 9.5 kpc and vertical distances above and below the Plane of 1.5 kpc. The metallicity distribution is independent of age for stars younger than about eight billion years. Stars older than this show a decrease in iron abundance relative to hydrogen [Fe/H] and an absence of metal-rich stars. Remarkably there is a preponderance of older stars inside the Solar orbit and these stars are also more enriched in magnesium compared to iron [Mg/Fe]. These investigations were based on the early data and full statistics are expected when the survey is completed.

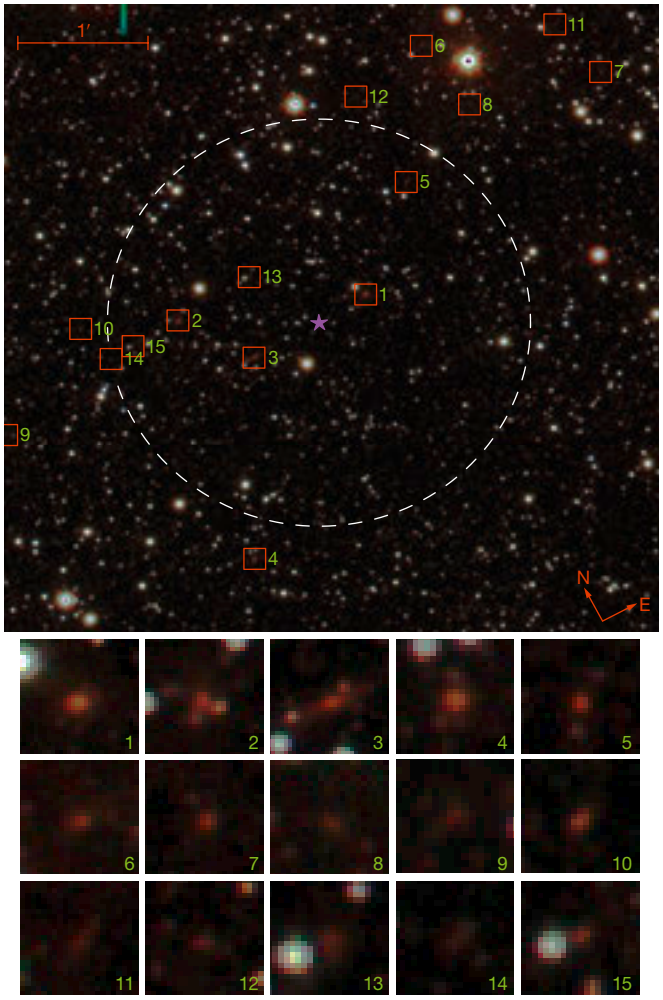


Distribution of FGK stars in the Galactic Disc observed in the Gaia-ESO survey with distance above the Galactic Plane (Z) *vs.* line-of-sight distance (R); the stars are colour coded by age in Gyr. The positions of three young clusters are shown by crosses. From Bergemann et al. (2014).

Stars in the thick and thin Discs

The stars in the Galactic Plane are distributed in at least two components: a thin Disc, and a thick Disc surrounding the inner Disc. The chemical composition and the dynamics of these different discs have been explored with a first set of 1000 stars with well-measured parameters (temperature, surface gravity, chemical abundance and radial velocities) from the Gaia–ESO survey. A chemical separation can be observed in the relative abundances of alpha-elements and metals. The abundance of metals increases with height above the Galactic Plane, while the alpha-element content decreases. The thin Disc chemistry, however, appears essentially constant. This is an indication that the evolution of the two components was rather different, with the thick Disc experiencing a settling process when its rotation increased.

The inner Galactic Disc with high extinction is also called the zone of avoidance, as dust absorption prevents observations of extragalactic objects on the other side of the Milky Way. High energy radiation, e.g., X-rays, is not affected by absorption and penetrates this region. X-ray emission



VISTA image of a cluster of galaxies behind the Galactic Plane. The circle indicates the X-ray position of the cluster. Individual cluster galaxies are shown in the postage stamps. From Coldwell et al. (2014).

of hot gas in a cluster of galaxies within the zone of avoidance was reported in 2014. The VVV Galactic Plane survey is ideally suited to confirm such clusters and characterise individual galaxies, which otherwise are unobservable. The galaxies were identified through their colours and morphologies. The spatial distribution of the galaxies is rather asymmetric indicating that the cluster may still be forming. This pilot study shows the potential of the infrared survey data to discover structures behind the Milky Way.

The Magellanic Clouds

The dense sampling of the Magellanic Clouds has enabled astronomers in the VISTA Magellanic Clouds (VMC) Survey team to establish a very large sample of Cepheid and RR Lyrae stars to sharpen their application as distance indicators. The different calibrators yield an extremely small scatter, showing that the distance scales based on young and old stars can be made consistent to a very high degree. The time baseline between the Two Micron All Sky Survey (2MASS) and the ongoing VISTA observations is long enough that the proper motion of the Large Magellanic Cloud can be established. This is important for an understanding of the dynamics of the Magellanic Clouds and the Milky Way. The proper motion of about 40 000 stars in a small part of the Large Magellanic Cloud has been established using about 8000 background galaxies and is found to be larger than determined by previous measurements. It is as yet unclear whether the derived motion is dominated by the angular momentum of the Large Magellanic Cloud or its motion relative to the Milky Way. This will be answered once all stars in the Large Magellanic Cloud have been measured astrometrically by the end of the VMC survey.

Very distant galaxies

The very deep infrared imaging of the Hubble Space Telescope COSMOS field by the UltraVISTA public survey has yielded 34 new luminous galaxies in the redshift range from 6.5 to 7.5. The most massive galaxy in this sample is about $10^{10}\,M_{\odot}$ and is the most massive known galaxy in the young Universe. The bright end of the luminosity function at a redshift of 7 does not appear to decline as steeply as the luminosity functions at lower redshifts, indicating that the galaxies still follow the dark matter mass distribution. The process whereby star formation decreases (quenching), leading to the features of the galaxy luminosity function at lower redshifts, has not yet started in these galaxies.

Supernovae

The regular monitoring of supernovae has allowed the Public ESO Spectroscopic Survey for Transient Objects (PESSTO) to observe some unique events. A new class of superluminous supernovae was identified a few years ago and PESSTO has contributed four well-observed objects to this class of very rare stellar explosions. The main question concerns the energy source driving their extreme luminosity. While radioactive decay appears to be less likely, because an unreasonably large amount of radioactive material would have to be synthesised in the explosion, the energy input from a very highly magnetised neutron star, or the conversion of the kinetic energy of the supernova shock to radiation through interaction with circumstellar material, are still possible. For one superluminous supernova, no hydrogen is observed in its spectrum, which hints at a progenitor star that has lost its hydrogen envelope, while in other, even rarer, cases some hydrogen is still observed. In one case a re-brightening of the supernova after 100 days has been observed, which could be explained by multiple circumstellar shells or the ionisation front of the neutron star breaking out of the ejecta.

Dust production in planetary systems

Exozodiacal dust is thought to be produced by collisions between asteroids and the evaporation of comets in the inner zone around main sequence stars. Its presence in the habitable zone of the Solar System, as the zodiacal light, can be appreciated even with the naked eye. Extending this study to other planetary systems provides information on dust production, the dynamical processes at play and the interaction between planets and minor bodies of extrasolar systems. Exozodiacal emission is important for another reason — it can compete with that of exoplanets and, as such, might hinder future exo-Earth direct detection missions.

ESO/L. Calçada

Artist's impression of bright exozodiacal light. This light is starlight reflected from hot dust created as the result of collisions between asteroids and the evaporation of comets.

While debris discs correspond to cold dust emission from the outskirts of planetary systems, the equivalent of the Kuiper Belt, exozodiacal dust is warmer and can be emitted from the habitable zones of such systems. Debris discs have a sufficiently large extent that they have been directly imaged, but the inner zones present greater observational challenges and can only be revealed by carefully monitoring the near- to mid-infrared photometric excess. The latter techniques are limited in their dynamic range.

The VLTI and its PIONIER instrument have been used to overcome this dynamic range limitation by spatially disentangling the stellar emission from the dust emission using high spatial resolution, high-contrast observations. An unbiased sample of main sequence stars has been surveyed. Since PIONIER allows precisely calibrated observations at milliarcsecond resolution to be carried out, it can resolve and separate the puzzling hot dust emission from the stellar photosphere. Excess fluxes (i.e., excess of extended emission over the star emission) as small as 1% were detected in about 10% of a sample of 92 stars, the first such extensive survey with the VLTI and the largest stellar sample ever searched for exozodiacal dust. Additionally the survey revealed the presence of five previously unknown stellar companions.

The existence of this exozodiacal dust does not however seem to correlate with the existence of outer debris discs. Also theoretical models of exozodiacal dust production, involving steady-state collisional cascades, do not seem to be able to explain the brightness of these excesses. The high frequency of detections seems to rule out violent transient events involving more massive collisions, so other dust-production or dust-trapping mechanisms have to be explored.

The amount of emission detected is, however, about 100 to 1000 times higher than for zodiacal dust. The implication is that more systems could possess emission strong enough to outshine that of any Earth-like planets and thus the planets would have escaped detection. This poses a serious challenge for future attempts to directly image exo-Earths and calls for more investigations and elaborate observing strategies. Expanding similar observations from the near- to the mid-infrared with the second generation VLTI instruments GRAVITY and MATISSE will considerably advance our understanding of the nature, localisation and origin of this exozodiacal dust.

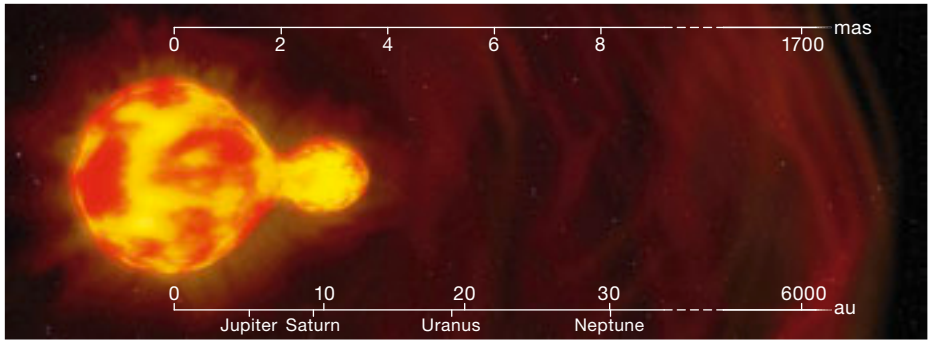
The fate of binary stars: Witnessing the rare common envelope phase

Opportunities to capture a star undergoing evolutionary changes on human timescales are not frequent. Yellow hypergiant stars are an extremely rare type of massive star whose origin is not yet well understood. Yellow hypergiants reach extreme luminosities of the order $10^{5-6}\,L_{\odot}$, but only a dozen such stars have been identified in the Galaxy. They are extremely unstable and variable, and their distance determination is affected by significant uncertainties. Yellow hypergiants may represent the next evolutionary phase of the most massive red supergiants as they cross the yellow evolutionary void towards the blue supergiant phase, or be the missing luminous blue variables enshrouded by an extended photosphere that reddens their colours. The yellow hypergiant phase lasts for only a few hundred to a few thousand years and is characterised by powerful mass-loss events. They are strong candidates to validate high stellar mass evolutionary models and as such have implications for extragalactic studies.

The AMBER multi-beam combiner at the VLTI has been used in conjunction with long-term photometric monitoring in order to shed new light on one such system, HR 5171A. The measurements have shown that the star has a very

extended photosphere (1315 ± 260 $R_\odot$), much larger than predicted for yellow supergiants. This makes HR 5171A one of the ten largest stars known in the Galaxy (50% larger than Betelgeuse) and might indeed indicate that it is a massive star just leaving its red supergiant phase, or that some external mechanism is causing the envelope to expand.

The second surprise from the VLTI observations of HR 5171A was the detection of a stellar companion in direct contact with the yellow hypergiant surface. Moreover the photometry revealed that the contact might have happened only a few decades ago as the photosphere was expanding. This represents the first direct observation of a system caught in the act of mass transfer and most probably stripping of its envelope. The yellow hypergiant primary star must be experiencing wind-driven Roche lobe overflow and feeding the companion star.



Roche lobe model of the yellow hypergiant HR 5171A at phase 0.25. Scales in milliarcseconds and au are shown, together with the radii of the orbits of the giant planets in the Solar System. From Chesneau et al. (2014).

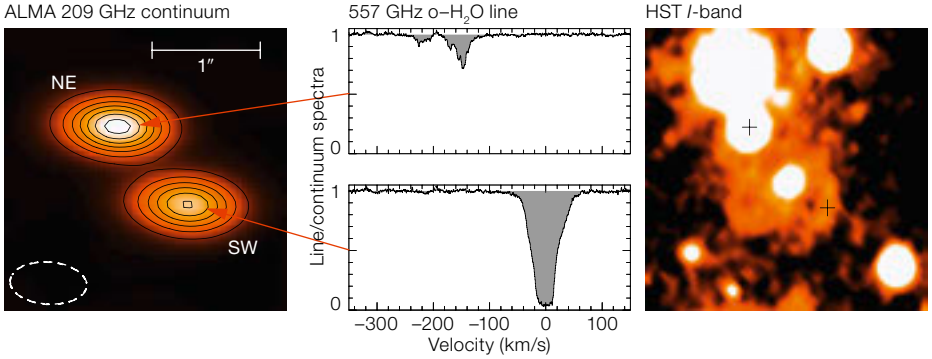
Another possible interpretation of considerable importance is that we might be observing a close binary star at an extremely rare late stage: the common envelope phase. The existence of such a mechanism has been proposed to explain the existence of peculiar very close binary systems. The VLTI observation now offers the possibility of witnessing directly such a system as it rapidly evolves. The prediction is that mass transfer will lead to the production of an envelope enshrouding both the primary core and the secondary star. Friction will cause orbital shrinking and heat up the envelope, which will expand: one of the possible outcomes could then be a merger of the two stars.

The interstellar medium of high-redshift galaxies

Some of the most spectacular results from ALMA Early Science observations are related to the study of the physics and chemistry of the interstellar medium (ISM) of high-redshift galaxies.

The blazar PKS1830-211 at redshift z = 2.5 is lensed into two separate images by a spiral galaxy located at redshift 0.89. This unique combination of a bright background continuum source and a gas-rich lens allows for a detailed absorption line study of the ISM of the spiral galaxy at redshift z = 0.89. The chemical abundances in the ISM at this redshift are found to be consistent with estimates in the Galaxy. The ground-state ortho line of water shows the deepest absorption, suggesting that this line will be an excellent probe for the interstellar medium of galaxies.

Water is also detected as the most prominent emitter after carbon monoxide (CO) in the stacked spectrum of 22 high-redshift (z ~ 2–5.7) lensed submillimetre galaxies which have been followed up with ALMA from the South Pole surveys. In addition to CO and H_2O, the stacked spectrum reveals clear detections of [C I], ^{13}CO, HCN, HNC, HCO^+ and CN and these are used to constrain the physical properties of the emitting gas. The ISM of these high-redshift star-forming galaxies is found to be consistent with being warm and dense, as is the case with strong star-forming complexes in the local Universe and in the Milky Way Galactic Centre.

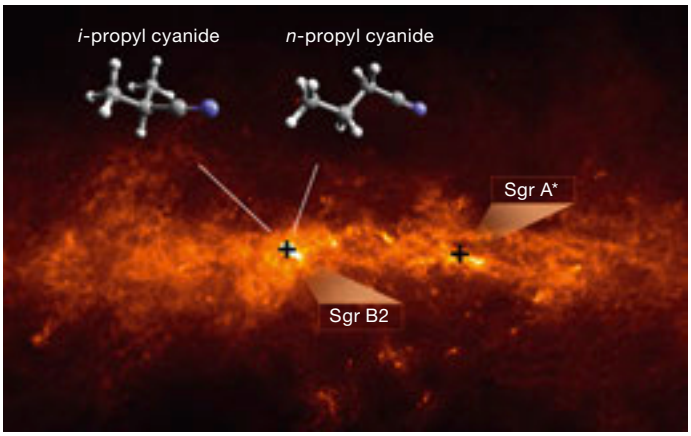


ALMA observations of the gravitationally-lensed blazar PKS1830-211. From left to right: the ALMA continuum image of the lensed blazar; water absorption spectra from the interstellar medium of the lensing galaxy against the blazar continuum; Hubble Space Telescope (HST) *I*-band image of the lens — a spiral galaxy at z = 0.89 — with the position of the two blazar images shown by crosses. Note that the SW image of the blazar is located beyond one of the spiral arms of the lens. From Muller et al. (2014a,b).

Astrochemistry

Simple molecules are abundant in the interstellar medium of galaxies. Molecular clouds and cores are studied as the birth sites of stars and clusters. Investigating the lifecycle of star formation and death and their relationship with the ISM throughout cosmic history is indeed one of the key ALMA science goals. Dense molecular cores also contain a wide variety of less abundant complex organic molecules. These are large C-bearing molecules, containing at least six atoms. Understanding the diversity of the chemical products of the ISM and the pathways for the formation and preservation of these molecules is important for our understanding of the development of pre-biotic molecules in space. The identification of simple amino acids in Solar System meteoritic and cometary material suggests that a large part of pre-biotic chemistry can occur outside planetary atmospheres. Several ALMA programmes aim to advance our understanding of how common these pathways are in molecular clouds and protostars, and whether abundant complex organic material is delivered to forming planetary systems from their parental cloud cores. The detection with ALMA in a young Solar analogue star system of a simple sugar (glycolaldehyde), an important molecule for the chemistry of ribonucleic acid, has already been reported in the 2012 Annual Report.

A major breakthrough in this area was achieved with the observation of the branched isomer of the complex organic molecule propyl cyanide (C_3H_7CN). The commonly found isomer of propyl cyanide (called *normal* or n-C_3H_7CN), already detected in interstellar space, is the straight chain form: each of the four carbons and the nitrogen is linked to at most two of the heavy atoms (i.e., they are arranged in a chain), with two or three hydrogen atoms linked to three of the four carbons. The prime regions in which to search for complex molecules in the ISM are hot molecular cores, compact and dense regions around massive protostars where the icy mantles of dust grains are evaporated and complex organic molecules can be observed in the gaseous phase.



The dense ISM in the central region of the Galaxy, as observed by the Herschel-Hi-GAL survey; the location of the Galactic Centre (Sgr A*) and the hot molecular core in Sgr B2 are marked. Graphical models of the chain (*normal*-propyl cyanide) and branched (*iso*-propyl cyanide) isomers of C_3H_7CN are shown; hydrogen atoms are shown in white, carbon in grey and nitrogen in purple. From Belloche et al. (2014).

The best-studied hot core is located in the Central Molecular Zone, close to the centre of the Galaxy: Sgr B2. Using the powerful combination of ALMA's angular resolution and sensitivity, it is possible to overcome one of the main limitations to searching for new complex molecules in Sgr B2: line confusion. About 50 transitions of *iso*-C_3H_7CN and over 100 transitions of n-C_3H_7CN were detected by ALMA, allowing for a secure identification of the molecules and accurate modelling. A graphical model of the detected molecules, against a Herschel image of the Galactic Centre, is shown. The branched isomer is found to have an abundance as high as 40% of the normal isomer and detailed chemical models show a variety of chemical pathways to produce these molecules on interstellar ices.

The detection of abundant branched isomers of complex organic molecules in the ISM is a breakthrough in understanding the chemical processing pathways towards pre-biotic molecules, as complex biologically relevant molecules, and especially amino acids, are branched.

Protoplanetary discs and young planetary systems

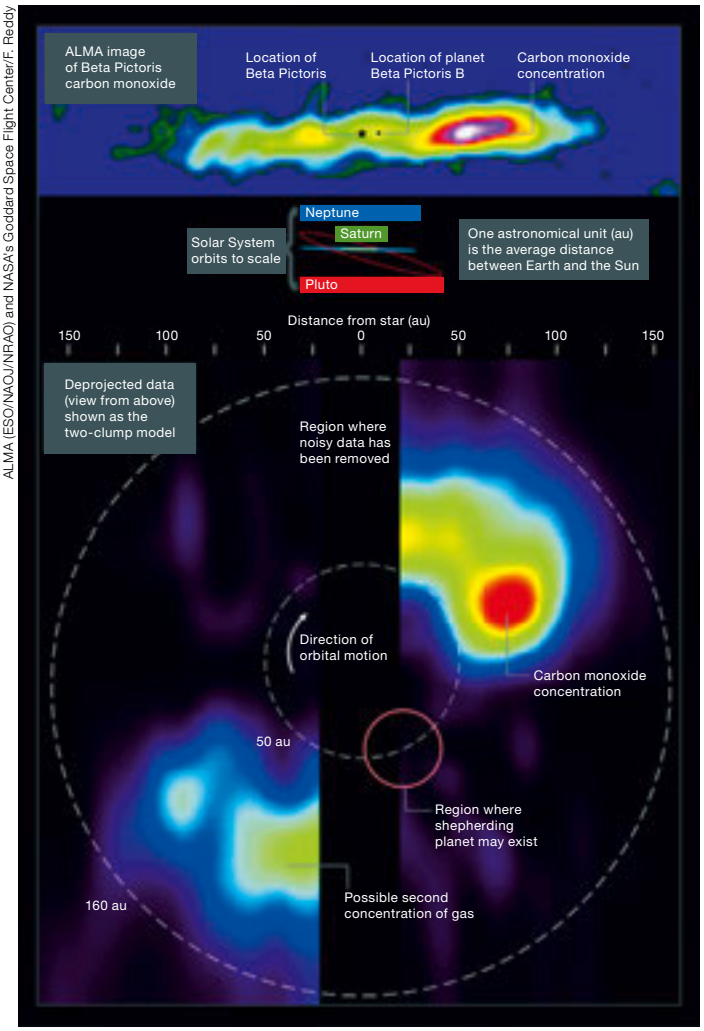
A number of high-profile results on protoplanetary discs and young planetary systems were obtained by ALMA in 2014. As the array expanded its angular resolution and sensitivity, resolved chemical studies of young and evolved discs become possible, revealing the characteristics of discs as they form during the protostellar accretion phase and as they evolve towards the formation of planetary systems. Two specific highlights for young single-star discs have been the detection of the chemical signature of the shock at the transition between the infalling envelope and disc of the young protostar IRAS 04368+2557, and the detection of formaldehyde (H_2CO) in the disc around IRS48 in Ophiuchus. These results show the chemical processing of the material in discs leading to the production of the molecular material that will be delivered to the planetary atmospheres as part of the planet formation process.

Another important highlight in this area was the study of the properties of discs and molecular gas in multiple systems of young stars. Most stars are found as part of multiple systems in nearby star-forming regions, so understanding the evolution

of discs and the possible formation of planetary systems in these environments is critical. Evidence for the continuous supply of fresh material from the outer circumbinary ring to the inner disc of one of the young stars of the GG Tauri multiple system provides evidence that these inner small discs may be long-lived and support planet formation. ALMA observations of the young system HK Tauri have also shown the presence of misaligned circumstellar discs. These findings suggest that planetary systems may indeed form in multiple-star systems and that the conditions for creating non-coplanar planetary systems may be rooted in multiple star formation mechanisms.

ALMA's sensitivity and angular resolution also allow detailed studies of young planetary systems and their tenuous discs, dubbed debris discs as they are thought to be replenished by dust from collisions of larger bodies in the system. Detailed ALMA observations of the Beta Pictoris debris disc dramatically confirmed the presence of large collisions within the planetary system by showing the presence of unevenly distributed carbon monoxide gas. In contrast to the dust, observed simultaneously with the molecular gas, the CO is concentrated in one or two clumps within the disc. This observed amount of gas could have been produced by the collisional destruction of a Mars-mass planetary body.

ALMA (ESO/NAOJ/NRAO) and NASA's Goddard Space Flight Center/F. Reddy



Top: ALMA CO(3-2) observations of the Beta Pictoris debris disc. Bottom: De-projected image, using spatial and kinematical constraints, showing the location of the molecular gas concentrations in the disc. In the middle a sketch of the Solar System to scale is also shown. From Dent et al. (2014).

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Like the gaping mouth of a gigantic celestial creature, the cometary globule CG4 glows menacingly in this image from the Very Large Telescope.

Offices for Science

Forecasts of any type are never easy to make and are usually prone to big surprises. Fortunately for us, at the Offices for Science, the scientific thrills expected for 2014 did materialise, thanks to the arrival of the two second generation VLT instruments MUSE and SPHERE.

In coordination with other departments, the Offices worked hard to prepare the ground for these instruments. A number of informal discussions were organised to raise awareness of the scientific possibilities brought by these unique instruments. We had the opportunity to hear about the instruments in talks given by instrument consortium members passing through the ESO premises. The Offices for Science also encouraged ESO astronomers to team up with the community to submit proposals for Science Verification. Last but not least, some information technology (IT) infrastructure in the form of multi-core machines with plenty of memory was put in place to allow for prompt reduction and analysis of the data obtained with MUSE and SPHERE.

First year of the Fellow Development Programme

The Fellow Development Programme was created by the Offices for Science together with the Human Resources Department to allow our fellows to develop skills in areas that complement and build upon the academic and professional development that they acquire through their fellowships. The programme focuses on training in project management, scientific writing and presentation skills, effective networking and people skills, including sessions on career coaching, preparing job applications and preparing for interviews. These courses are spread over three years and are facilitated by external consultants. In Chile, the choice of qualified consultants is much reduced with respect to Europe so the development programme was implemented with a mix of in-house and external trainers. In coordination with Human Resources in Chile, some of the training sessions were hosted together with other departments, thus allowing a larger number of staff to benefit.

Science highlights

The Offices would like to highlight the performance of six distinguished staff members, two faculty members, two fellows and two students, for their outstanding scientific performance and contributions to the scientific life in Vitacura and Garching. For 2014, the Office for Science in Chile would like to feature Steffen Mieske, Thomas Krühler and Catrina Deiner, and the Office for Science in Germany will focus on the achievements of Gaitee Hussain, Stephan Geier and Bitten Gullberg.

As a preface, we would like to congratulate Dominika Wylezalek for her talk given on behalf of ESO PhD students during the Annual Overview in March. Dominika gave a vibrant and inspiring talk conveying a message to be remembered: how exciting it is to be part of ESO and how the ESO students contribute to the organisation's scientific ecosystem, and beyond, by becoming ESO ambassadors throughout the world. That message went straight to the hearts of the audience. Brava Dominika!

This year Steffen Mieske was involved at the forefront of an international collaboration that addressed an unresolved question in galaxy research about ultra-compact dwarf galaxies, some of the densest stellar systems in the Universe. These systems have masses of up to $2 \times 10^8\ M_\odot$, but half-light radii of just 3–50 parsecs. For about a decade it had puzzled astronomers that the dynamical masses of these dwarfs are higher than expected for their stellar luminosity. Steffen and colleagues had proposed that this additional mass comes from supermassive black holes at the centres of these puzzling objects. This prediction could be tested by a collaboration in which Steffen was directly involved, using kinematic data of the ultra-compact dwarf galaxy M60-UCD1. Dynamical modelling of these data revealed the presence of a supermassive black hole with a mass of $2.1 \times 10^7\ M_\odot$, matching the predictions made by Steffen in 2013.

Steffen is a strong presence and contributor to our science environment. In spite of his new duties as Deputy Head of the Science Operations Department at the Paranal Observatory, he continues to participate in science activities and to animate the Star Cluster group. Steffen is also a dedicated member of the Fellowships and Studentships Selection Committee whose contribution is very much appreciated by the Office. He is also the co-chair of the ESO Workshop on

Left: Thomas Krühler.

Right: Steffen Mieske and Catrina Deiner.

Satellites and Streams due to take place in Santiago in March 2015.

After holding a Marie Curie Fellowship at the Dark Cosmology Centre in Copenhagen, Thomas Krühler joined ESO/Chile in September 2013 as a fellow with duties on Paranal. His scientific interests centre on gamma-ray bursts (GRBs), the most brilliant explosions in the Universe. Thomas uses GRBs primarily as tools to study the evolution of star-forming galaxies and interstellar matter at very high redshift. Using over 200 hours of data from X-shooter, Thomas led, and has just recently completed, the largest and most comprehensive survey of gamma-ray burst host galaxies ever performed, shedding new light on gamma-ray burst progenitors and their relation to the formation of very massive stars.

As MUSE instrument fellow, Thomas actively contributed to its commissioning, the Science Verification programme and Early Science operation on Paranal. In Vitacura, together with Fernando Selman (La Silla Paranal Observatory Staff), they set up the new machine to be used for the reduction of MUSE data. The MUSE data reduction server was also welcomed by La Silla Paranal Observatory (LPO) instrument scientists in order to tackle potential problems with their instruments. Thomas is very active in public outreach, and organised an astronomy day at the Colegio Aleman de Santiago. For him, the challenge of managing and interacting with 150 eight-year-old school children is extremely rewarding. Thomas was in particular very honoured to be invited to present his recent scientific work in a plenary talk at the 2014 meeting of the German Astronomical Society.

Catrina Deiner is a PhD student from the Eidgenössische Technische Hochschule Zürich, working under the supervision of Simon Lilly. She spent one year in Chile working with Cedric Ledoux (LPO staff). Her main focus is on the understanding of galaxy evolution in the context of the environment at $z \sim 2$, when the cosmic star formation rate peaked and galaxies rapidly built up their stellar mass. Catrina recently reported the discovery of a high-redshift proto-cluster ($z = 2.5$) with the FORS2 VLT spectrograph. After a careful analysis, Catrina and collaborators concluded that this overdensity, whilst being highly significant and evolving into a Coma-like cluster by $z = 0$, does not contain galaxies that are different from the coeval field. Furthermore, high-redshift proto-clusters are much larger structures than are generally observationally recognised, often spanning several megaparsecs.

Bitten Gullberg, Stephan Geier and Gaitee Hussain.

Always eager to engage in discussions, attend seminars and participate in the extragalactic group, Catrina contributed a lot to our science environment. Together with Joe Andersen (ESO Fellow) and Stéphane Brillant (ESO Staff), Catrina put in place a proposal-writing mini-workshop where attendees received training in how to write a good proposal. She also got all students and interns together to give a series of talks where their technical skills could be exhibited and shared.

Gaitee Hussain joined ESO Garching in 2007 in the Observing Programmes Office, which is responsible for allocating time on all of ESO's telescopes. The input and recommendations made by a peer review process, currently involving 79 astronomers worldwide, is crucial to ensure the strong scientific programme at ESO. In 2014, Gaitee was invited to serve as a reviewer for a NASA panel, enabling her to see the process from a different perspective and help improve the input we provide to ESO reviewers.

Gaitee's research is focused on understanding the role of magnetic fields in the formation and evolution of Solar-type stars. As more and more exotic planetary systems are discovered, it is increasingly important to characterise the environment in which these systems formed and evolved. Gaitee uses indirect-imaging techniques, inspired by medical imaging, that enable the detection and mapping of magnetic fields on the surfaces of stars hundreds of parsecs away, probing microarcsecond spatial scales. Gaitee is now heavily involved in a Large Programme, Magnetic Topologies of Young Stars & the Survival of close-in massive Exoplanets (MaTYSSE), using data from the Canada France Hawaii Telescope and the ESO 3.6-metre telescope to extend such studies and look for planets around young stars.

In 2014, Gaitee was awarded a visiting Chair position and a five-year grant at the Institut de Researche en Astrophysique et Planétologie in Toulouse to work with postdocs and students there. Gaitee is also supervising two students, Julian David Alvarado Gomez and Céline Dupont, presented three reviews during 2014 and chaired the Local Organising Committee for the ESO workshop, held in November 2014, on high angular resolution astronomy. This brought together communities that use differing high-resolution astronomical techniques, including interferometry, astro-tomography, lucky imaging and adaptive optics.

Stephan Geier and his collaborators designed a large observing programme to search for hot subdwarf (sdO/B) stars in close binary systems, which are the stripped cores of red giants and are likely formed via close binary interactions. They

aim to find both low-mass substellar companions, such as planets and brown dwarfs, and massive compact companions, such as white dwarfs, neutron stars or black holes. The spectroscopic results were written up in 2014 by Stephan and collaborators in two papers. They discovered three hot subdwarfs with brown dwarf companions, providing more evidence that substellar objects can significantly affect late stellar evolution. Another highlight was the discovery and analysis of the fastest unbound star in the Galaxy: it is very likely to be the surviving companion of a white dwarf, which exploded as a supernova type Ia. This result appeared in *Science*. Stephan is also involved in the Phase 3 validation of the first large area catalogues from the VISTA and VST public surveys, supporting these projects from the ESO side.

Stephan continued to progress on his *Habilitation*, which is a major piece of original research work for a higher degree at a German university. Stephan also went observing in La Silla, mentoring an ESO Student there, a trip that has already led to two accepted papers. Stephan also coordinated two one-day workshops and co-organised the Directorate for Science social day. Stephan's outstanding achievements were acknowledged with the 2014 Ludwig Biermann Award of the Astronomische Gesellschaft, and he was awarded a Marie Curie Individual Fellowship, which should take him to the UK for the next step of his bright career.

Bitten Gullberg is part of the SPT SMG (South Pole Telescope Submillimetre Galaxy) collaboration and has mainly been working with [C II] emission in high-redshift lensed dusty star-forming galaxies, publishing her first first-author paper on that topic. Using APEX and Herschel, Bitten and her collaborators detected [C II] emission towards 17 out of 20 galaxies in the redshift range 2.1 to 5.7. Combining these observations with data from the Australia Telescope Compact Array, they measured [C II]/CO(1-0) line luminosity ratios which are consistent with the geometric structure of photon-dominated regions, familiar from the study of local H II regions. That work was presented at three different conferences, most recently at the "Revolution in Astronomy with ALMA — the 3rd Year" in Tokyo.

Group photo of the participants in the conference "3D2014 — Gas and Stars in Galaxies: A Multi-wavelength 3D Perspective", held in Garching.

Bitten has now joined the HeRGÉ collaboration and for the past few months has been working on a pilot project with Carlos De Breuck and Joel Vernet (ESO Staff), studying a high-redshift radio galaxy at a redshift of 2.9 by combining ALMA and MUSE observations. These have provided a fresh view of the complex morphology of these distant systems, illustrating the importance of combining multi-wavelength 3D data.

Bitten was one of two student representatives at ESO, has been part of the Student Selection Committee, was twice a scientific assistant at the Observing Programmes Committee (OPC) and co-organised the ESO Journal Club. She has given talks about ESO and even arranged a tour in the infrared laboratories for two groups of Danish high school students who had won the Danish Science Cup. Bitten is now an accomplished observer, who has been Principal Investigator of several APEX proposals, as well as Herschel Director's Discretionary Time and Jansky Very Large Array projects, and has spent almost two weeks at APEX as an astronomer on duty.

Meetings at ESO

The organisation of scientific conferences and workshops occupies an important place in ESO's scientific life and is at the heart of our constant efforts to foster collaborations in astronomy. In 2014, both sites welcomed a number of scientific meetings, including:

- Exoplanet Observations with the E-ELT, Garching, 3–6 February;
- 3D2014 — Gas and Stars in Galaxies: A Multi-wavelength 3D Perspective, Garching, 10–14 March;
- Herbig Ae/Be Stars: The Missing Link in Star Formation, Santiago, 7–11 April;
- Formation and Evolution of Star Clusters in Chile, Santiago, 14–16 May;
- Clustering Measurements of Active Galactic Nuclei, Garching, 14–18 July;
- RASPUTIN: Resolved And unresolved Stellar PopUlaTIoNs, Garching, 13–17 October;
- HIRES 2014: Astronomy at High Angular Resolution — A Cross-disciplinary Approach, Garching, 24–28 November;
- ALMA Cycle 2 PI CASA Tutorial, Garching, 26–28 November;
- International Symposium: Life as a Planetary Phenomenon, organised by the University of Heidelberg and hosted by ESO, Santiago, 27–28 November.

As usual, we welcomed many visitors, specific groups and school visits to ESO. In 2014, we also organised specific sessions for Masters students enrolled within the Astromundus programme: 16 students visited ESO Headquarters in January to learn more about ESO, and, thanks to the efforts of Gaitee Hussain, Elizabeth Humphreys and many others, attended a hands-on tutorial on writing an ALMA proposal in real time.

This VISTA image shows a dense cloud of dust and gas associated with the molecular cloud IRAS 16562-3959, clearly visible as an orange smudge among the rich pool of stars at the centre of the image.

ESO/VVV Team/A. Guzmán

Allocation of Telescope Time

The table shows the requested and scheduled observational resources allocated for Period 94 (P94: October 2014–March 2015) and Period 95 (P95: April 2015–September 2015), for the La Silla Paranal Observatory and APEX. These are specified in nights, the usual allocation unit for the La Silla Paranal Observatory and APEX.

The La Silla Paranal Observatory and APEX statistics include only proposals submitted during the two periods (P94 and P95). Current Large Programme runs approved in previous periods, Guaranteed Observing 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.

The ALMA Proposal Review Committee for the allocation of time in Early Science Cycle 2 (covering June 2014 to October 2015) met in London, Ontario, Canada 10–14 March 2014. The table shows the requested and scheduled resources for the ALMA Observatory in Cycle 2, but only high priority (A+B) scheduled proposals and hours are listed. The request and allocation statistics, listed by ALMA frequency band, for Europe and all partners (including North America, East Asia, Europe and the host country of Chile) are both included. The scheduling unit for ALMA is hours of array time.

ESO/G. Lambert

This image of the future home of the E-ELT was taken in November 2014 from Paranal. The levelling of the summit of Cerro Armazones is well advanced (lower left) and the new wider road that is being built up the mountain can also be well seen.

Telescope	Instrument	Requested runs	Scheduled runs	Requested time	%	Scheduled time	%	Pressure	Total allocation	%
UT1	NACO	206	61	144	18.6%	42	26.6%	3.42	44	17.8%
	FORS2	385	107	431	55.7%	83	52.2%	5.21	105	42.3%
	KMOS	158	31	198	25.6%	34	21.3%	5.88	99	39.9%
Total		749	199	773		158		4.88	249	
UT2	FLAMES	78	22	155	18.5%	34	16.5%	4.49	102	36.1%
	UVES	179	54	254	30.4%	46	21.9%	5.57	47	16.6%
	X-shooter	368	110	429	51.2%	128	61.6%	3.34	134	47.4%
Total		625	186	838		208		4.02	283	
UT3	SPHERE	106	47	105	27.1%	39	26.8%	2.70	39	21.8%
	VIMOS	167	51	255	66.1%	84	57.9%	3.05	117	65.8%
	VISIR	41	34	27	6.9%	22	15.3%	1.20	22	12.4%
Total		314	132	386		144		2.67	178	
UT4	SINFONI	162	62	220	37.0%	74	42.8%	2.96	80	33.8%
	MUSE	254	65	260	43.7%	65	37.6%	3.97	123	51.8%
	HAWK-I	119	38	114	19.3%	34	19.6%	3.35	34	14.4%
Total		535	165	594		174		3.42	237	
VLTI	AMBER	39	13	37	28.2%	22	30.8%	1.65	22	24.8%
	MIDI	34	10	16	12.3%	5	7.5%	2.94	13	14.6%
	SpecialVLTI	50	48	78	59.6%	45	61.6%	1.75	55	60.6%
Total		123	71	131		73		1.81	90	
3.6-metre	HARPS	83	52	484	100.0%	133	100.0%	3.64	316	100.0%
Total		83	52	484		133		3.64	316	
NTT	EFOSC2	97	32	381	64.6%	107	56.3%	3.56	178	54.3%
	SOFI	55	26	209	35.4%	83	43.7%	2.52	150	45.7%
Total		151	58	590		190		3.11	328	
APEX	CHAMP+	4	2	4	2.4%	2	2.5%	2.50	2	1.5%
	LABOCA	14	7	39	25.0%	13	21.3%	2.96	19	18.3%
	SABOCA	0	0	0	0.0%	0	0.0%	N/A	0	0.0%
	SHFI	32	15	112	72.5%	47	76.2%	2.40	83	80.3%
Total		50	24	154		61		2.52	103	

ALMA	Band	Requested proposals All/EU	Requested hours All/EU	Scheduled proposals (A+B) All/EU	Scheduled hours (A+B) All/EU	Pressure (by hours)) All/EU
	3	444/184	1808/739	89/29	528/175	5.71/6.00
	4	112/46	326/118	19/8	44/21	7.38/9.29
	6	560/210	2132/748	159/40	594/255	3.59/4.85
	7	595/241	2362/922	153/51	593/302	3.99/4.21
	8	93/39	308/111	36/14	112/62	2.74/2.47
	9	109/51	381/185	30/13	70/39	5.41/6.91
Total		1383/562	7317/3041	353/115	2568/690	4.23/4.86

The Atacama Pathfinder Experiment telescope (APEX).

C. Durán/ESO

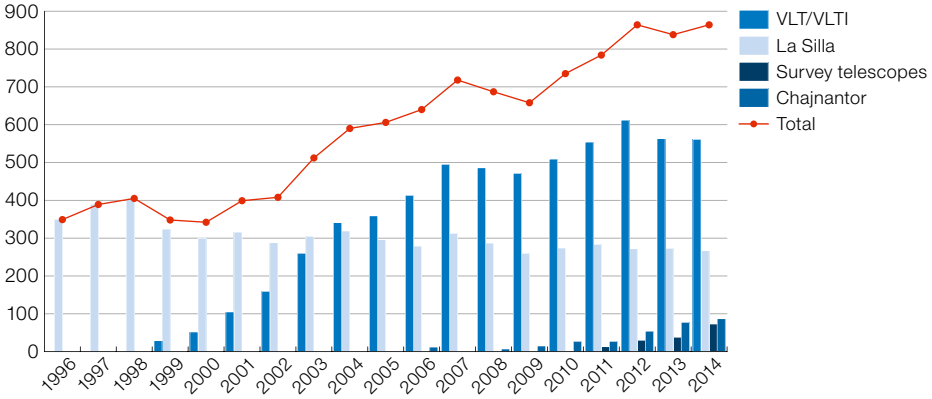
Publication Digest

In 2014, the ESO user community published 865 refereed papers, reaching once again the all-time high of 2012. During the year, more than 10 000 refereed astronomy papers were reviewed by the ESO librarians and approximately 7.5% fulfilled the criteria for inclusion in the ESO Telescope Bibliography (telbib: http://telbib.eso.org). The numbers of papers based on data from the individual observing sites, as well as the total numbers per year, are shown. An overview of publication statistics is also available with links to the corresponding records in the telbib database (http://www.eso.org/sci/libraries/telbib_pubstats_overview.html).

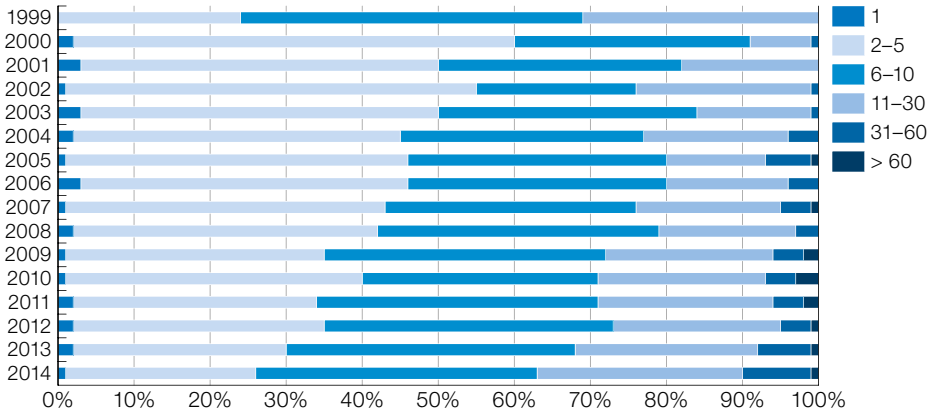
The VLT and VLTI provided data for 562 refereed papers in 2014. The workhorse instruments UVES and FORS2 led with 137 and 105 articles, respectively, while the spectrographs VIMOS and FLAMES/GIRAFFE achieved the remarkable numbers of 78 and 59 papers. With 68 scientific publications, X-shooter continues to be a very productive instrument. Further statistics of individual instruments can be found in the *Basic ESO Publication Statistics* report.

Clear trends can be seen regarding the number of authors per paper. In the early years of VLT operations, more than half of the articles were written by rather small groups of one to five authors. Over time, the fraction of teams with larger numbers of authors has continually increased, leading to more than a quarter (27%) of all VLT/VLTI papers in 2014 with 11–30 authors. In addition, 9% of the publications were written by groups with more than 30 members. During the past ten years, a steady percentage (1–3%) of articles have been authored by even larger collaborations, consisting of more than 60 authors per paper, while the number of single-author papers has diminished. An overview of the number of authors per paper for all VLT/VLTI papers per year is shown.

As was the case in previous years, the facilities located at La Silla continued to provide data for many papers (more than 260 in 2014). A total of 71 papers were based on observations made with the HARPS exoplanet hunter. Data from the FEROS and EFOSC2 spectrographs and SOFI led to almost 50 papers each.



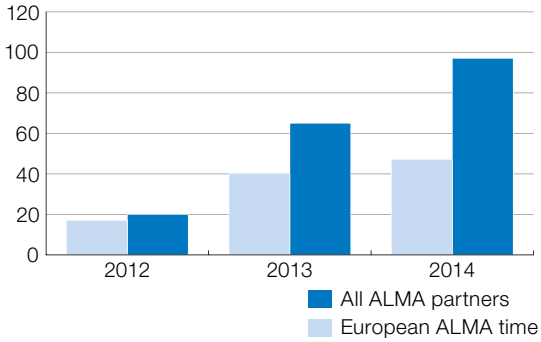
Refereed papers using ESO data, 1996–2014 — note that papers can use data from more than one facility.
VLT/VLTI: Papers using data generated by the VLT and VLTI instruments, including visitor instruments for which observing time is recommended by the OPC, e.g., VLT ULTRACAM, VLTI PIONIER.
La Silla: Papers using data generated by facilities on La Silla, including visitor instruments for which observing time is recommended by the OPC, e.g., NTT ULTRACAM. Papers based on data from non-ESO telescopes or observations obtained during reserved periods (e.g., national allocations of time) are not included.
Survey telescopes: Papers using data generated by the survey telescopes VISTA and VST.
APEX: Papers using data generated by APEX, including visitor instruments for which observing time is recommended by the OPC, e.g., Z-Spec; other visitor instruments (e.g., 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.



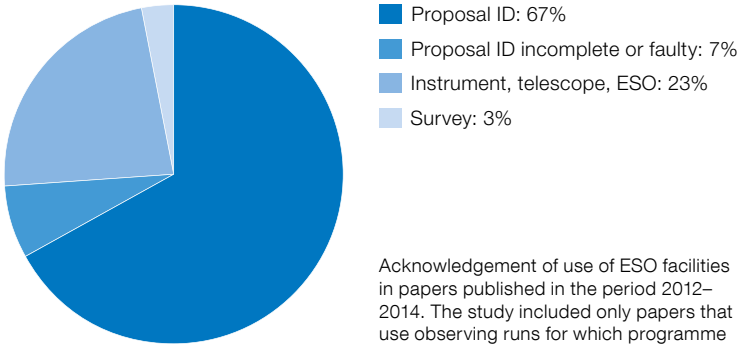
Number of authors per paper for VLT/VLTI publications over the period 1999–2014.

Interestingly, even observations from decommissioned instruments and telescopes are still being used in publications: in 2014, 33 articles were published based on these data. Note that non-ESO telescopes (for instance the Swiss 1.2-metre Leonhard Euler Telescope) and other facilities located on La Silla, for which observing time is not evaluated by the OPC, are not included in the statistics.

In 2014, the first papers based on data from the VLT Survey Telescope were published, mostly using data from the VST/OmegaCAM Photometric Hα Survey of the Southern Galactic Plane (VPHAS+) and ATLAS surveys. Observations at ESO's other survey telescope, VISTA, led to the impressive number of 65 papers in 2014, almost doubling the result of the previous year. Among these papers, outstanding output was achieved by the VISTA Variables in the *Via Láctea* (VVV) survey, which allowed scientists to publish 24 papers in the past year, followed by papers using data from the UltraVISTA survey (14 papers), the VISTA Hemisphere Survey (VHS, 8 papers) and the VISTA Magellanic Clouds survey (VMC with 8).



Numbers of papers during 2012–2014 using time allocated to Europe and to all ALMA partners.



Acknowledgement of use of ESO facilities in papers published in the period 2012–2014. The study included only papers that use observing runs for which programme IDs are assigned (i.e., excluding, for instance, observations at the Swedish–ESO Submillimetre Telescope [SEST]).

The APEX telescope generated data that led to 46 articles based on ESO/APEX time, constituting almost two thirds of all papers published by APEX users in 2014 (46 out of 74, or 63%). By the end of the year, the total number of papers using APEX data had passed 380.

In its third year of publications, the ALMA Observatory produced 97 refereed papers, far outnumbering the result of the previous year. About half of the articles (47 papers, or 48%) used European ALMA observing time. The total number of papers published between 2012 and 2014, using observations provided by all ALMA partners is 182. The ALMA bibliography is maintained jointly by the librarians at ESO and the National Radio Astronomy Observatory (NRAO) in the USA as well as by the National Astronomical Observatory of Japan (NAOJ). Publications based on data from all ALMA partners are recorded in telbib, but only those based on European observing time are counted in the ESO statistics.

In 2014, a quarter of all refereed articles (212 out of 865, or 24.5%) used exclusively or partly (i.e., in addition to proprietary ESO observations) data obtained from the ESO Science Archive. This fraction increased from around 18% to above 25% in 2012 and has been rather stable since. Likewise, a steady use of pre-reduced data, known as Science Data Products, provided by the Science Archive Facility can be noticed during this period: since 2012, almost 12% of scientific papers employed Science Data Products each year (see table).

	All ESO papers (using new or archival data)	Papers using archival data (incl. Science Data Products)	Papers using Science Data Products	Archive (incl. Science Data Products) in %	Science Data Products in %
1999	348	1	1	0.3	0.3
2000	342	3	0	0.9	0.0
2001	399	6	2	1.5	0.5
2002	408	19	3	4.7	0.7
2003	512	20	3	3.9	0.6
2004	590	54	23	9.2	3.9
2005	606	55	15	9.1	2.5
2006	640	98	24	15.3	3.8
2007	718	115	28	16.0	3.9
2008	687	107	25	15.6	3.6
2009	658	113	31	17.2	4.7
2010	735	134	42	18.2	5.7
2011	784	141	38	18.0	4.8
2012	864	224	101	25.9	11.7
2013	838	224	96	26.7	11.5
2014	865	212	100	24.5	11.6

Total numbers and percentages of ESO telbib papers 1999–2014 using exclusively or partly archival data and Science Data Products.

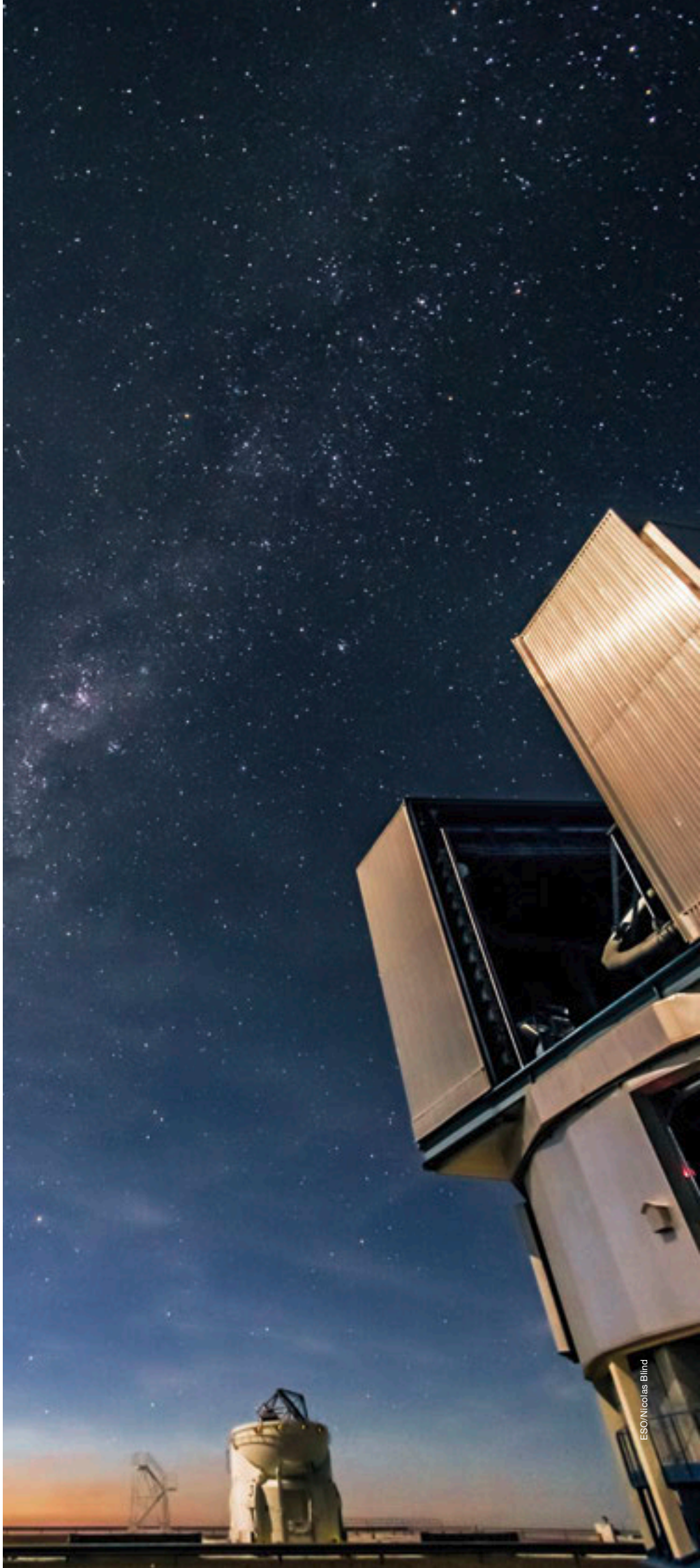
Correct indication of all ESO programmes that were used in research papers is of the utmost importance so that the publications can be linked to the corresponding data in the ESO archive. In order to achieve a uniform way of indicating the use of observations, a policy regarding publications based on ESO data is communicated to researchers on several occasions during the observing process: for instance, when Principal Investigators (PIs) are informed about awarded observing time based on the proposals submitted to the OPC, at the time when their data become publicly available (typically after a proprietary time of one year), or when researchers request data from the ESO archive. The publication policy is also available on the web.

Over the past few years, the librarians have monitored the way in which authors give credit to the ESO facilities that provided the data. It has turned out that large inconsistencies exist between the acknowledgement request by ESO and the actual information provided by authors. Of 2515 papers published between 2012 and 2014, only two thirds (67%) of the authors indicated correct and complete programme IDs of all observations used in their papers. This

fraction includes a few cases in which users downloaded data from the ESO archive and (correctly) mentioned the archive request ID (9 papers). Another 7% of the authors listed programme IDs in their papers, but the identifiers were incorrect or incomplete. Almost a quarter of the publications (23%) merely acknowledged the instrument, telescope or ESO as an organisation, as credit for data use. The increasing numbers of papers based on surveys constitute many particularly difficult cases, where often the only trace of data use is the survey name, with no indication of either the programme IDs nor even the facilities that generated the data (3% of all ESO papers over 2012–2014).

These findings emphasise the importance of human curation of the ESO Telescope Bibliography in order to properly link papers and observations, enabling astronomers to easily access the data used in papers (by linking from the telbib database to the archive) and to find out which papers have already been published based on specific observations (through links from the archive to telbib).

The statistics presented here are derived from 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 for ESO-related keywords (e.g., telescope and instrument names). 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*. All papers included in the database have been inspected visually by the curators to ensure that they directly use ESO observational data. Further information about telbib and various statistics and reports can be found on the web.



This image shows the beginning of sunrise over the Very Large Telescope.

Operations

ESO/B. Tafreshi

La Silla Paranal Observatory

The Directorate of Operations is responsible for all activities related to science operations, including the preparation and execution of observing programmes, the operation of the La Silla Paranal Observatory with its La Silla, Paranal and Chajnantor sites, and the delivery of raw and calibrated data. These activities involve user support, dataflow 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 data obtained with ESO telescopes as well as highly processed, advanced products derived from them. Operations also includes ESO's contribution to ALMA operations through the ESO ALMA Support Centre (EASC).

The magnificent Milky Way galaxy is radiant over the La Silla Observatory. The ESO 3.6-metre telescope is shown in the middle.

Operations

The ESO Very Large Telescope at Paranal operates with four 8.2-metre Unit Telescopes and a suite of ten first generation instruments and three of the four second generation instruments. The Laser Guide Star Facility provides one of the three adaptive-optics-supported instruments of the VLT with an artificial reference star. 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 visitor instrument at the VLTI focus. VISTA and the VST are in regular survey operation.

On La Silla the New Technology Telescope and the ESO 3.6-metre telescope operate with an instrumentation suite of three instruments. The La Silla site further supports eight national telescope projects.

The observatory also provides the operations support for the Atacama Pathfinder Experiment with its 12-metre submillimetre radio antenna located on the high Chajnantor Plateau at an altitude of 5000 metres. APEX has a suite of heterodyne and bolometer facility instruments and hosts a number of visitor instruments.

For observing periods 93 and 94, the scientific community submitted respectively 898 and 901 Phase 1 observing proposals for the La Silla Paranal Observatory, including APEX. These numbers are slightly lower than have been received in recent years, but still document the continuing high demand for ESO observing facilities. Some 80% of the proposals are for the Paranal site with VLT, VLTI and VISTA.

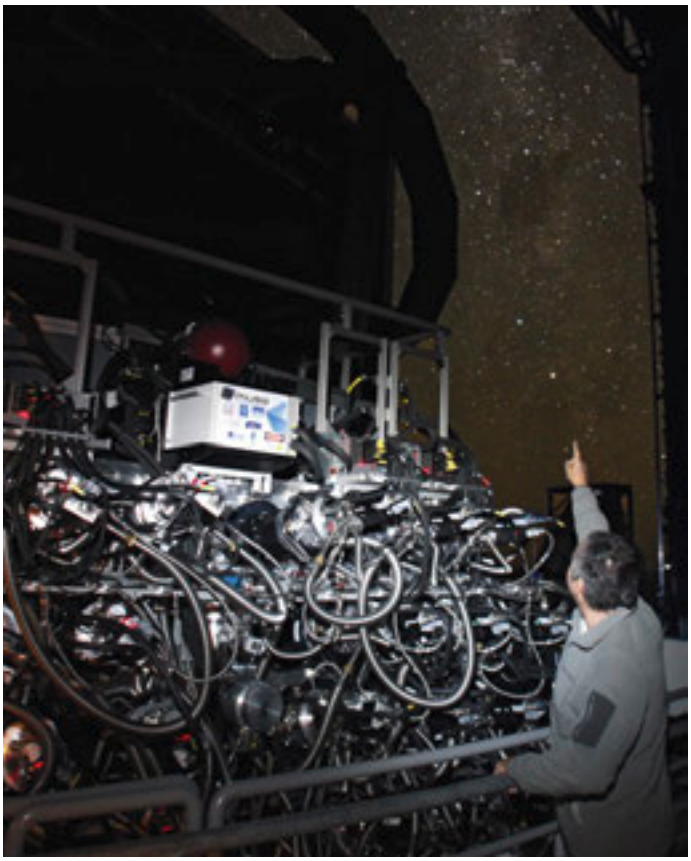
The observatory continued its efficient operation through high availability and low technical downtime of its telescopes and instruments — key elements for productive scientific observations. In 2014 a total of 1897 nights were scheduled for scientific observations with the four UTs at the VLT and with the two major telescopes at La Silla. This is equivalent to about 87% of the total number of nights theoretically available over the whole year. The remaining 13% of the nights 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. There were 128 nights of commissioning time on the UTs in 2014, primarily for the second generation instruments MUSE and SPHERE. Out of the available science time for the VLT, 2.5% was lost due to technical problems and about 13.5% due to adverse weather conditions. On La Silla bad weather accounted for losses of about 13.5%, and technical problems for less than 1%.

VISTA delivered 278 nights of survey observations out of 347 scheduled; the VST delivered 248 observing nights out of 336. Both survey telescopes were affected by about 15% weather losses. The technical losses of VISTA were, at 4%, comparable to the UTs. For the VST, however, the technical losses amounted to 12%, primarily attributable to three severe problems encountered during the year.

In addition to the regular VLT operations, the VLT Interferometer was scheduled for 235 nights to execute scientific observations using baselines with either the UTs or the ATs. The remaining nights were employed for technical activities and for further development and commissioning of the interferometer and its infrastructure. In addition to 121 engineering nights, some eight nights were invested in commissioning activities, primarily for the upgrades of the PIONIER instrument. Some 2.7% of the scheduled VLTI science time was lost due to technical problems, 15% due to bad weather.

The combination of high operational efficiency, system reliability and availability of the La Silla and Paranal telescopes and instruments for scientific observations, has again resulted in a high scientific productivity. In 2014, 562 papers that are at least partially based on data collected with VLT and VLTI instruments at Paranal were published in different refereed scientific journals (compared to 563 in 2013). In addition 73 (38 in 2013) refereed papers were published in 2014 referring to observations with VISTA and the VST and 267 (273) to ESO-operated telescopes at La Silla. APEX observations accounted for 74 (74) papers, out of

which 46 (43) were based on observations during the 27% share of ESO time. Since its start of operation in 1999, the VLT and VLTI have produced a total of 5970 publications and add a dozen every week. Interestingly the veteran workhorse instruments UVES and FORS2 — both commissioned at the beginning of the VLT's operations — still lead the publication statistics from all ESO instruments in 2014 with 137 (117 in 2013) and 105 (101) publications, respectively. The first second-generation instrument X-shooter follows with 68 (70 in 2013) publications in its fifth (fourth) year of operation.



ESO/Ghaouti Hansali/Fernando Selman

MUSE at the Nasmyth focus of the Yepun (UT4) telescope.

Paranal Observatory

Instrumentation

Over the last three years, the observatory has seen the seamless arrival of the second generation VLT instruments KMOS, MUSE and SPHERE. The *K*-band Multi Object Spectrograph (KMOS) was the first of the trio, and was successfully commissioned during early 2013 and entered regular science operation on 1 October 2013.

In the same month that KMOS started science operation, the re-assembly of the Multi-Unit Spectroscopic Explorer (MUSE) started in the new instrument integration hall at Paranal. By the end of 2013 the MUSE team had successfully completed this task and the instrument was transferred to UT4 in mid-January. Only 12 nights later, on 31 January 2014 shortly after sunset, first light was achieved on Kapteyn's star — an M1 red dwarf star at a distance of 13 light-years from Earth. MUSE took 13 years to be designed, built and brought to the VLT, so that the photons observed by MUSE during first light had just left Kapteyn's star when the MUSE project started. Having achieved this important milestone, the commissioning of the instrument could start in earnest.

The key capability of MUSE is to perform integral field spectroscopy over almost the full optical domain with a mean resolving power of 3000. With its modular design composed of 24 identical integral field unit modules, it spatially samples the sky over a near-contiguous field of view of one by one arcminutes with spatial pixels of 0.2 by 0.2 arcseconds, well adapted to the best natural seeing conditions at Paranal. For each of the 86 400 spatial pixels, the corresponding spectra are recorded on the 24 detectors with a total of 384 megapixels per exposure. In future, MUSE will utilise the VLT Adaptive Optics Facility (AOF) via the GALACSI adaptive optics system. It will then offer, in addition, an adaptive-optics-corrected field of view of 7.5 by 7.5 arcseconds, sampled with 0.025 by 0.025 arcsecond spatial pixels.

MUSE is an extremely powerful tool for all astronomers who need to record simultaneously the three-dimensional (spatial and spectral) information from the sky over a large field of view to study extended objects, such as Solar System bodies, crowded areas of the sky and galaxies or, for example, to study many distant galaxies or individual stars in other galaxies. MUSE will further dedicate a large fraction of its observing time to surveys of the unknown sky, stitching together numerous deep observations of contiguous patches of one square arcminute.

Commissioning and Science Verification of MUSE proceeded rapidly over the year and therefore the instrument could be offered to the community for regular science operation as of 1 October, i.e., only nine months after its arrival at the telescope — a record in the 15-year history of VLT instrumentation.

When MUSE had just completed its first commissioning run and cleared the integration hall in February, the last of the trio of second generation instruments, the Spectro-Polarimetric High-contrast Exoplanet REsearch (SPHERE) instrument arrived in boxes at Paranal. After re-assembly and extensive testing in the integration hall the instrument was transferred to UT3 and achieved first light in early May.

The primary scientific aim of SPHERE is to image and characterise giant exoplanets orbiting nearby stars. For this

ESO/J. Girard

The SPHERE instrument reintegrated at the Nasmyth focus of the Melipal (UT3) telescope.

purpose SPHERE employs three novel techniques to reach the highest possible contrast necessary to reveal the planets adjacent to a star that is shining millions of times more brightly than the planets themselves. The first technique is to use extreme adaptive optics to correct for the effects of the Earth's atmosphere so that images are sharper; the second employs a coronagraph that blocks out the light from the star; the third is differential imaging that exploits differences between planetary and stellar light in terms of its colour or polarisation. All three techniques together contribute to increase the imaging contrast and allow otherwise invisible exoplanets to be revealed. Obviously these high-contrast imaging techniques available with SPHERE are not limited to detecting exoplanets, but also allow the study of any close environment around stars with the highest spatial resolution.

As for MUSE, the commissioning and characterisation of SPHERE progressed well over the year. Both teams alternated on a monthly basis with their respective runs on the telescope. SPHERE Science Verification produced a spectacular set of data for the scientific community to explore the potential of the new instrument and to prepare the first proposals for its scientific use. Considering the rapid progress of the commissioning and integration into observatory operation, SPHERE will be offered to the community for regular science operations as of 1 April 2015.

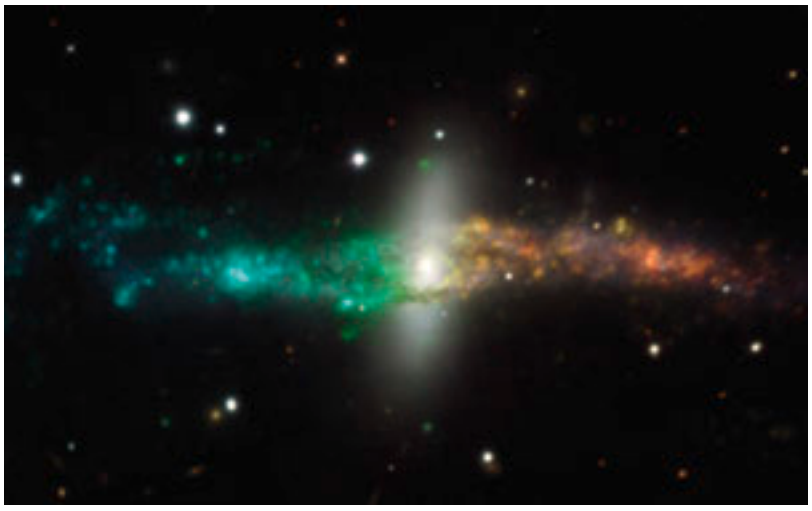
In preparation for the arrival of MUSE at UT4, the NAOS-CONICA (NACO) instrument was removed from the Nasmyth focus. Despite its advanced age and contrary to the original plan to decommission NACO at the time of the arrival of MUSE, NACO was stored after its removal from the telescope to be re-installed on UT1 in mid-2014 in place of the CRIRES spectrograph.

Following this plan, CRIRES itself was dismounted in July and shipped to Europe to undergo a major upgrade to be converted into the cross-dispersed high-resolution infrared spectrograph CRIRES+. Unfortunately, during the removal of the separate adaptive optics module of CRIRES, the module was severely damaged close to its final parking position in one of the storage halls in the Paranal basecamp. This accident was the first major incident in the history of Paranal that had led to a severely damaged instrument. Fortunately no one was injured during the incident. An in-depth investigation was carried out to prevent future incidents of this kind and to guarantee the safety of equipment and personnel. The damaged adaptive optics module was eventually shipped to Garching to be repaired in time for the arrival of the upgraded CRIRES+.

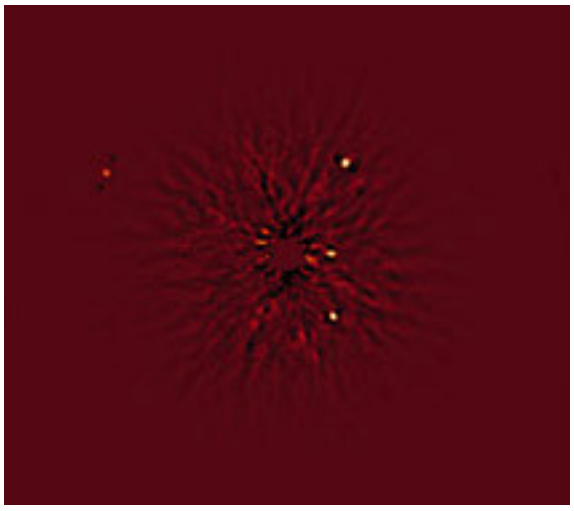
Alarmed by this incident, the re-installation of the fragile NACO instrument at the freed focus of UT1 was carried out

Colour composite of the unusual polar ring galaxy NGC 4650A created from data from the MUSE instrument.

ESO/MUSE consortium/R. Bacon



Four planets around HR 8799 imaged with SPHERE in the *H*-band.



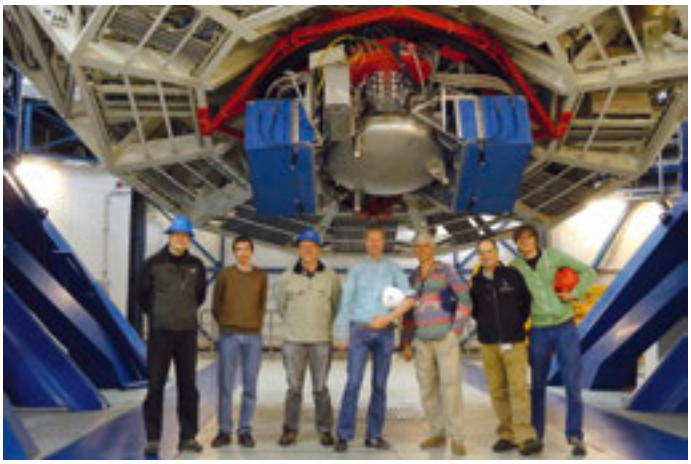
with special care and taking particular precautions. Nevertheless, despite the installation itself being successful, the science detector of the CONICA instrument was found to be non-operational during the first re-commissioning run in September. Subsequent trouble-shooting activities led to the conclusion that the Aladdin3 detector itself was damaged beyond repair. Since no spare Aladdin3 detector was available, the former ISAAC spectrometer long-wavelength Aladdin2 detector was recovered from this decommissioned instrument and installed in NACO. This new (old) Aladdin2 detector installed in CONICA has slightly different noise properties from the original Aladdin3 detector, but enabled NACO to be brought back into science operation in January 2015, but only after almost three months of scheduled science time had been lost due to this failure.

To complete this year's planned instrument rotations, the X-shooter instrument was installed back on the Cassegrain focus of UT2 for the beginning of the new observing period in October. It had spent one year on UT3, taking advantage of the available free Cassegrain focus due to the ongoing upgrade of the spectrometer VISIR. In retrospect X-shooter only gained a few additional observing nights as a result of this move. In light of the risks and difficulties experienced with instrument removals this year, the concept will have to be scrutinised in more detail in the future before being proposed again.

After completion of its upgrade and extensive testing in the integration hall, VISIR resumed commissioning on UT3 towards the end of the year. The proposed strategy to overcome the sensitivity problems of the new AQUARIUS detectors by increasing the chopping frequency of the telescope secondary mirror was confirmed to be successful. VISIR, the only mid-infrared instrument of the VLT, will resume operation on 1 April 2015 and will offer new large detectors and a number of new observing modes.

Infrastructure

The 8-metre mirror-coating unit remained a major source of concern for the observatory. Despite intensive internal efforts



VISIR re-commissioned at the Cassegrain focus of UT3.

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. Consequently, the observatory has been seeking external help through a consultancy with a consortium of Danish companies specialised in large vacuum and coating machines. This collaboration led, after one year of intensive analysis and testing, to a costly recovery plan that will be implemented in the coming year followed by a new and tailored preventive maintenance plan for the future.

Reorganisation of technical activities

After 15 years of successful technical operation of the Paranal Observatory, the technical activities were reorganised to ensure future operational continuity and cost efficiency of the operations. A new Maintenance, Support and Engineering Department was created and integrates the former Maintenance and Engineering Departments. The new department comprises some 70 staff members and builds on the Maintien en Condition Opérationnelle concept and the French normalisation standard AFNOR NF X 60-010 to classify five levels of maintenance, from system parameter setting (Level 1) to reconstruction of systems (Level 5). This concept covers all activities which ensure proper functioning, i.e., availability of a system during its lifetime. It has been widely implemented since the 1990s in modern operational sites such as space centres, harbours and even armies. It distinguishes between technical and support activities: technical activities include preventive and corrective maintenance, configuration management, analysis of technical facts and implementation of lessons learned. It further identifies obsolescence and related projects. Support activities include coordination and planning, quality assurance, spare part supply and the management of technical documentation and facts.

The transition to the new organisational structure occurred smoothly over the year after a formal kick-off on 1 April. The engineers and technicians of the Maintenance, Support and Engineering Department took up their new responsibilities with great enthusiasm and are dedicated to ensuring the availability of the systems under their care. A new support and quality assurance group is taking care of most of the support activities. The mapping of all operational systems at Paranal according to their criticality for operation, i.e., the availability of the observatory, their maintainability according to industrial standards and the required staff competencies, is still ongoing. Activities that are not considered core competencies of ESO (e.g., maintenance of commercial of-the-shelf components, Level 1 and 2 maintenance and warehouse services) are outsourced as service contracts to specialised companies. In addition, the Directorate of Engineering provides manpower and support for regular and specialist maintenance and repair of instruments and facilities, both remotely and by staff visits as

ArTeMiS team/ESO

The ArTeMiS cryostat in position at APEX.

required. This effort is now fully accounted for in the Paranal operations budget.

In view of the future integration of the E-ELT into the operation of the Paranal-Armazones Observatory, this reorganisation of the technical activities at Paranal is an important step towards ensuring the future scalability of the technical support towards the requirements posed by the E-ELT.

La Silla Observatory

The La Silla Observatory continued to operate successfully according to the streamlined operations model. The La Silla 2010+ model supports the continued operations of the two major telescopes and their instrumentation, i.e., the ESO 3.6-metre telescope with HARPS and the NTT with SOFI, EFOSC2 and visitor instruments.

The NTT remains one of the best 4-metre-class telescopes in the southern hemisphere, providing excellent image quality and high efficiency at negligible technical down time, but remains equipped with two aging facility instruments, EFOSC2 and SOFI, that were commissioned in 1990 and 1998, respectively. Recognising the continued demand for the NTT by the scientific community, and the need to seek new instrumentation or other scientifically competitive uses of the telescope, while reducing the operational costs to ESO, a call for ideas was issued, opening up new opportunities for large scientific projects at the NTT. In order to enable telescope access for innovative ideas, upgraded or new scientific instruments, up to 50% of the NTT telescope time from 2016 to 2020 will be made available to selected projects in return for contributions to the NTT operation. Contributions can be in cash or in-kind, through the provision of new scientific instruments of wider interest to the ESO community, upgrades to existing instrumentation or operation support, a combination thereof, or equivalent.

An impressive number of 19 letters of interest with high-quality proposals were received in response to the call by the end of March. After a down-select process, seven out of the 19 proposers were invited to present detailed scientific-technical proposals by mid-February 2015; two proposers were invited to proceed with their proposals directly to the OPC for scientific evaluation and scheduling of their proposals with the existing EFOSC2 and SOFI instruments. At the time of writing five detailed proposals for the construction of new instruments for the NTT have been received.

La Silla Observatory further continued to support scientific projects at other national telescopes, i.e., the MPG/ESO 2.2-metre telescope, the Danish 1.54-metre telescope, the Swiss 1.2-metre Leonhard Euler Telescope, the Rapid Eye Mount telescope (REM), TAROT, the ESO 1-metre Schmidt telescope, the TRAPPIST telescope and the ESO 1-metre telescope.

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 in a quasi-continuous 24-hour operation mode, which maximises the exploitation of the exceptional conditions available at the Chajnantor site. In 2014, a total of 266 days and nights were scheduled for science observations with APEX out of which 240 could actually be used, with more than 4400 hours of on-sky science time.

The APEX project is a partnership between the Max Planck Institute for Radio Astronomy, Bonn, Germany (50% share), ESO (27% share) and the Onsala Space Observatory, Sweden (23% share). Considering the continued success of the project, the APEX partners in 2013 extended their agreement to 31 December 2015, and agreed to seek an extension of the APEX Agreement until 31 December 2017. The corresponding agreement was duly signed at Ringberg Castle (Bavaria, Germany) in January 2014. Discussions about a potential further extension of the agreement have commenced. The competitiveness of APEX in the era of a fully operational ALMA strongly depends on its instrumentation capabilities and therefore on the results of the ongoing receiver developments at the APEX partners.

The 4608-pixel bolometric camera ArTeMiS was built by the Commissariat à L'Energie Atomique (CEA) in Saclay, France, and commissioned at the Cassegrain focus of APEX. ArTeMiS is the first ESO Principal Investigator instrument that became available exclusively to the ESO community through a collaborative agreement between ESO and the CEA signed during the year.

The Onsala Space Observatory and ESO further developed a memorandum of understanding concerning the construction, integration and operation of an ALMA Band 5 receiver for APEX, where ESO will deliver the pre-full-production ALMA Band 5 cartridge and the local oscillator as part of the warm cartridge assembly. OSO have designed and built the optics, the cryostat, and the complete integrated system. The delivery and commissioning of the Swedish-ESO PI receiver for APEX (SEPIA) is expected in early 2015, in time to harvest the first scientific results with Band 5 before it becomes available at ALMA.

A. Tudorica/ESO

The VLT on Cerro Paranal. Three of the VLT Unit Telescopes can be seen, as well as one of the four Auxiliary Telescopes and the VST in the background.

Data Management and Operations

The Data Management and Operations Division is responsible for offsite operations and user support of the La Silla Paranal Observatory and the European segment of ALMA. The Division ensures efficient exploitation of existing and future ESO facilities based on an integrated end-to-end operations approach. The Division drives the evolution of the VLT dataflow system and ensures a coherent development programme to accommodate new requirements.

User Support

The primary role of the User Support Department (USD) is to support Service Mode users of the La Silla Paranal Observatory facilities. Through an efficient help desk (usd-help@eso.org) and the public release of up-to-date observing tools, the USD acts as an important interface between the community and the observatory, handling a range of different types of requests and providing support during the implementation and follow-up of Service Mode observations. The careful verification of all Service Mode observing material ensures compliance with Service Mode policies as well as efficient observing strategies aligned with the scientific goals set by the investigators. Furthermore, the USD is also responsible for the travel of visiting astronomers to the observatory sites in Chile and for all matters related to the Users Committee.

On top of day-to-day operations and routine support tasks, the past year saw the latest second generation VLT instrument, MUSE, enter into operations; after a series of effective commissioning runs and a successful Science Verification, MUSE scored as the second most requested Service Mode instrument on the VLT in Period 94, after X-shooter. At the same time, significant progress was also made with the commissioning of SPHERE (on UT3), which will be offered to the user community from 1 April 2015. Despite Service Mode remaining the most requested and allocated mode at Paranal (at ~70% during 2014), the visiting astronomer travel office supported 572 astronomers in their travel arrangements to Chile: 282 to La Silla, 251 to Paranal and 39 to APEX.

As part of the preparatory activities for the annual meeting of the Users Committee (see p. 105), a new feedback campaign was launched in February 2014 targeting Service Mode users who were awarded time in Periods 92 and 93. This was the first time that users interacted with our updated and user-friendly questionnaire. All the results, based on a 30% response rate (a new record), are available from the USD Phase 2 web pages. The overall outcome shows a very high level of satisfaction with the services that the USD provides to the community, as shown in the two charts: one for general support and the other for Phase 2 specific support.

A major highlight for the USD during 2014 was the consolidation of the Dashboard for Operational Metrics at ESO project that aims to derive and monitor robust operational metrics, in order to provide a systematic measure of the effectiveness of Service Mode operations. The main results of this effort were published in the December issue of *The Messenger* in an article entitled “Fifteen years of Service Mode observing at ESO”. The report presents different flavours of observing efficiencies, including detailed breakdowns of run completion rates and also accounts for how the available science time is used.

Back-end operations

Providing the best science data is at the core of ESO’s mission of enabling major science discoveries by the community. Although several of the steps to fulfil this goal apply to all three sites of the La Silla Paranal Observatory, the focus here is on Paranal, where all of them are fully in place.

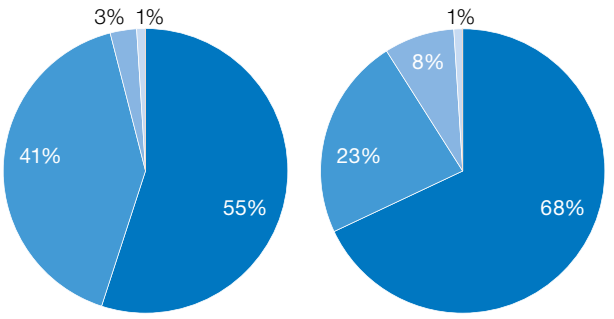
Raw data is transferred in real time from the observatory to ESO Headquarters and processed into products. For this purpose, during 2014 about 44 TB of raw data from the Paranal Observatory were processed, including 14 TB from the new instrument MUSE alone, in about 150 000 processing jobs. The current performance of the instruments is constantly measured in a quality control process. Relevant health-check parameters are then measured, trends identified and the results are fed back to the observatory for immediate follow-up, as needed. Calibration completeness and quality are also checked.

The aim is to ensure that all aspects are in place so that science can be extracted from the data, from their arrival in the archive and throughout their lifecycle. This process includes ensuring that the appropriate observing procedures are in place, the appropriate calibrations are taken and that suitable data reduction tools (also known as pipelines) are available. In 2014 Science Data Products from multi-object spectroscopy with FORS and VIMOS, two of the most highly demanded instrument modes offered on Paranal, and the second generation VLT instruments MUSE and KMOS were extensively enhanced.

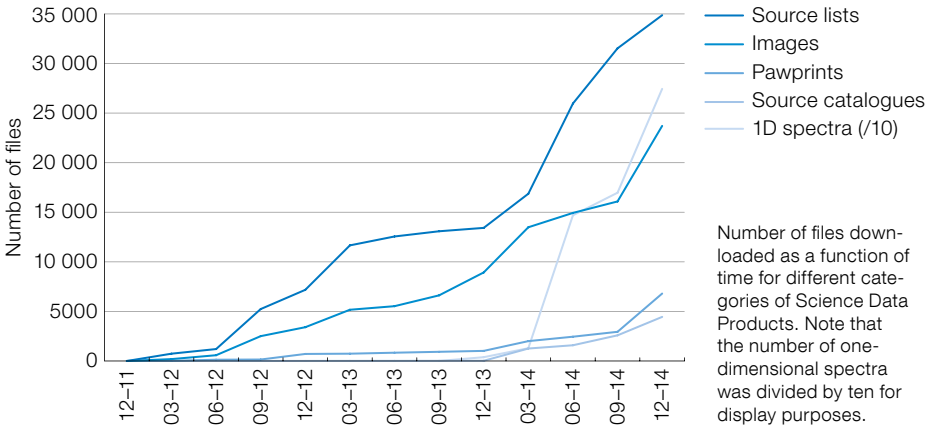
Ultimately, the raw data and the tools to process them were delivered to the community, as well as reduced data that are ready for direct scientific use. These latter products are generated both in-house, by running mature data reduction pipelines, and returned by the community. While the providers are responsible for generating these “external data products” and for their quality, extensive content validation and homogenisation, in collaboration with the providers themselves, are carried out to ensure valuable and coherent archive content; this is the Phase 3 process. The available data product releases are listed on the Phase 3 web pages.

The ESO Science Archive Facility (http://archive.eso.org) is the one access point to the data from the La Silla Paranal Observatory. In 2014 the benchmark of half a petabyte of raw and product data holdings was exceeded, and with an annual output to the community of 170 TB, it fulfils the double role of being both a technical/operational data archive and also a science resource in itself. By making data available to the community at large, the Science Archive Facility fosters the use of the data by scientists not involved with the original proposal for their own novel and independent science goals. Papers based only on archive data make up roughly 10–15% of ESO’s yearly output in terms of refereed publications, with papers using both archive and new data contributing an additional 10%. An archive paper is defined as a paper that makes use of data for which

none of the authors were part of the original observing proposal (this definition is common to all the major observatories). Such papers can be queried from the ESO Telescope Bibliography telbib. Roughly one quarter of the archive papers use data that were not published at all by the respective PIs. Moreover, the Science Archive Facility plays a fundamental role in fulfilling the goals of Public Surveys, for which the legacy value of the Science Data Products is a key science driver: about as many people not involved with the survey teams have accessed these data as there are Co-Investigators on the original proposals. The popularity of the different data products provided is very high, with one-dimensional spectra and source lists being the most requested, as shown by the trends in the figure to the right.



User satisfaction with the overall support provided by the USD (left) and with specific support/advice provided at Phase 2 (right).

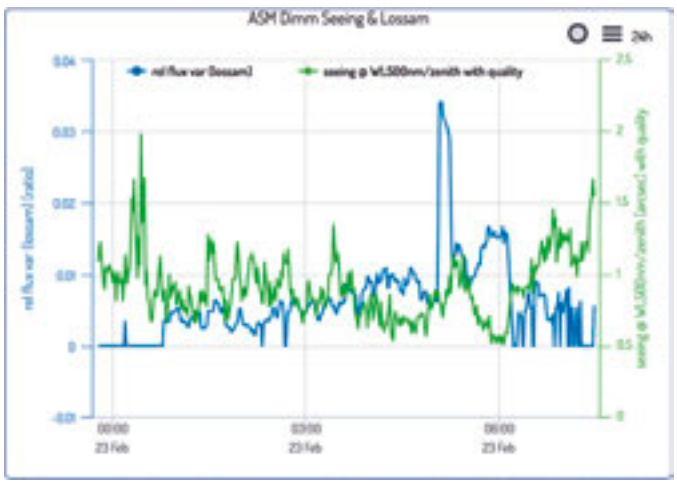


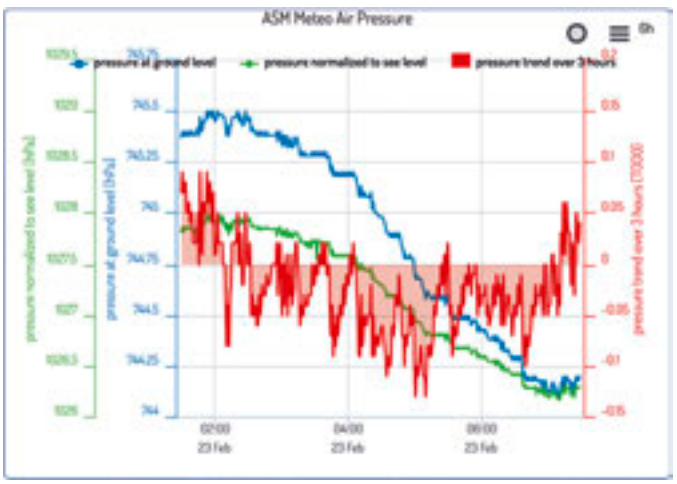
Number of files downloaded as a function of time for different categories of Science Data Products. Note that the number of one-dimensional spectra was divided by ten for display purposes.

Dataflow projects

Dataflow applications and services supporting the end-to-end VLT dataflow cover the proposal submission system (Phase 1), observation specification and execution in Visitor and Service Mode (Phase 2), archiving and retrieval of raw frames, data reduction, quality control, the validation and ingestion of data products including catalogues (Phase 3), and their subsequent archive publication and exploration. These systems ensure the continuation of astronomical value delivered to the user community and a high operational efficiency and effectiveness both in Garching and at the observatory. In 2014 many enhancements to existing tools were implemented. These included support for the Service and Visitor Mode observing tools for detecting laser collisions of telescopes by the new Paranal Adaptive Optics Facility; Mac OS support for the data reduction workflow application Reflex; and the association of master calibrations to raw science frames during archive retrieval. New projects were also started, including the development of a unified GuideCamTool for the selection of guide stars, tip/tilt stars and the production of finding charts, which will eventually support all required instruments and integrate with the Phase 2 Proposal Preparation Tool. Since the ambient site-monitoring infrastructure in Paranal is currently undergoing a major upgrade, a modern web-based application is being developed that will soon serve both Paranal and the ESO community, as shown by the screenshot in the figures below.

Details of the web-based interface to the Paranal astronomical site monitor.





In terms of technical strategy, a study was started to ensure the mid-term, cost-effective scalability of ESO's bulk data storage infrastructure. Moreover, a strategic technical focus area for the ESO dataflow was consolidated: wherever possible, future dataflow solutions will be based on modern, dynamic web applications and infrastructure. This approach simplifies dramatically the rapid publication of new features, as well as bug fixes, without redistributing desktop tools, while at the same time providing a cleaner, more productive and more maintainable development paradigm. The necessary steps were taken in conjunction with the Directorate of Engineering to develop the required technical skillsets. In the mid-term, this approach will have multiple benefits. These include a new Phase 1 proposal submission system with dramatically improved usability, a more flexible observation specification in Phase 2 as required by some new instruments, and modern archive services providing new approaches to explore the Science Archive Facility.

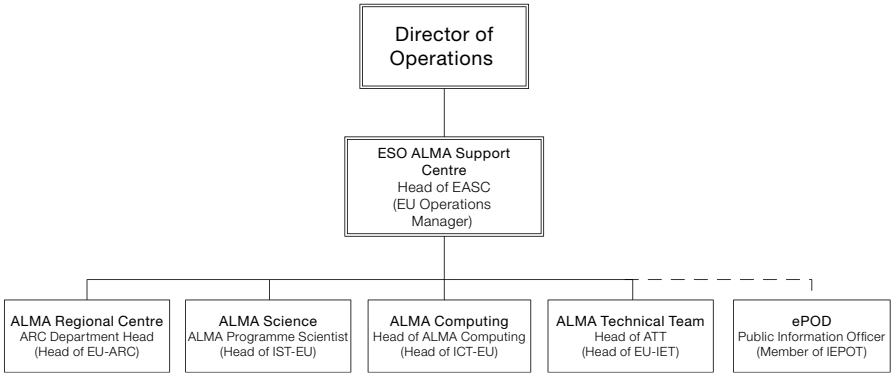
The control building at the Paranal Observatory can be seen below a rising Milky Way, like the proverbial pot of gold at the end of a celestial rainbow.

Y. Beletsky/ESO

ESO ALMA Support Centre

The ESO ALMA Support Centre (EASC) is ESO's offsite operations unit for ALMA. It is one of the three ALMA Support Centres, which are based at the three ALMA Executives in Europe, North America and East Asia to support the Joint ALMA Observatory (JAO) and the ALMA onsite operation. EASC 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 is provided by the ESO ALMA Programme Scientist, who acts as the head of the Integrated Science Team (IST) and works 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. EASC is an important component in the success of ALMA, both for its performance as a scientific instrument and for ESO as a partner in the ALMA project. In 2014, EASC was fully operational and played an important role in ALMA operations.

For the scientific user community, the central ALMA Regional Centre (ARC) based at ESO Garching and the ARC nodes in Europe are the primary interfaces with individual ALMA users. As in previous years, the European ARC has been of prime importance for the success of Science Verification and Early Science observations and for high-quality data delivery. More details about the ARC are given in the following section.



Top-level structure of EASC. The EASC Division is structured in four departments, with a link to the education and Public Outreach Department (ePOD) through the Integrated Education and Public Outreach Team (IEPOT).

ALMA Computing

The ALMA Computing Department within EASC is part of the quadrilateral ALMA Integrated Computing Team (ICT) consisting of contributions from North America, East Asia, the JAO and ESO. The ICT is responsible for the ongoing development, maintenance and operations support of the entire suite of ALMA software, a code base of about six million lines distributed over 25 subsystems. ESO, in collaboration with several European science institutes is responsible for the ALMA archive, the ALMA common software infrastructure, telescope calibration and a wide range of operations applications, and makes important contributions to the data processing software, such as CASA (Common Astronomy Software Applications) and the science pipeline.

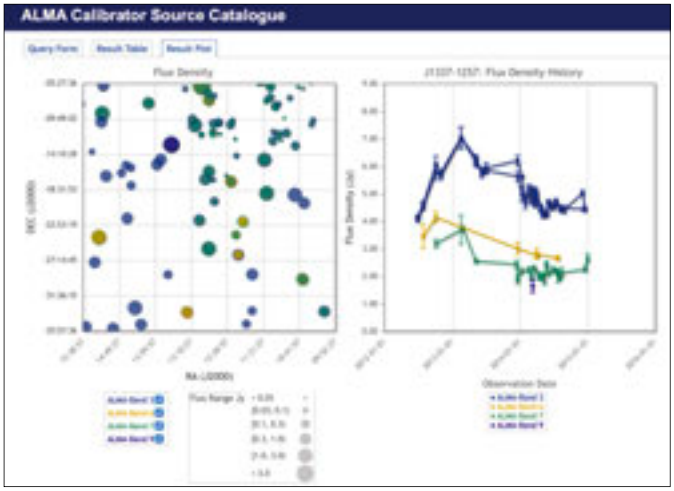
The focus for 2014 was on improving the stability and performance of the ALMA software, which has led to much improved observing efficiencies in the latter part of the year. The usability of many operational tools has been improved significantly. Many new features are still being added to the tools as the observatory gains more experience with the full lifecycle of ALMA observing projects and additional observing modes are being commissioned. New applications, such as the ALMA dashboard, which displays the live array status and the ALMA Calibrator Source Catalogue (see top left figure on the next page, and described in Fomalont et al. 2014, The Messenger, 155, 19), have been added to the deliverables of the ALMA computing group at ESO.

ALMA Technical Team

The ALMA Technical Team (ATT) at EASC is responsible for offsite technical support and hardware development projects. In 2014, the ATT provided support, specific knowledge and assistance to the ALMA Observatory in the areas of antennas, antenna transporters, front ends, calibration devices, the back end, the correlator and site infrastructure (in particular the power system). The first contracts for hardware maintenance, which require specific and specialist skills or equipment (such as a cleanroom), were finalised with specialised institutes in Europe.

The full range of ALMA-wide maintenance plans is still being developed. The definition and implementation of the JAO-led Integrated Engineering Team (IET), the combination of the engineering teams of the three ALMA Executives and the JAO, analogous to the ICT, was drafted in 2014. The IET's task is to provide technical support to the whole ALMA Observatory throughout the partnership, following agreed procedures and division of tasks among the ALMA partners. The ATT at ESO is the European part of the IET. It has provided remote (offsite) maintenance of the ESO deliverables throughout 2014, including:

- European ALMA antennas. Warranty actions for the antennas were followed up with the ALMA construction consortium, AEM, to ensure that the high antenna availability continued. A number of highly specialised tasks were also carried out on the antennas. The tilt meters have shown an unexpected failure rate affecting the antenna reliability. The root cause seems to have been identified by the manufacturer and has been removed in the repaired units.
- Provision of spares for the AEM antennas. ESO staff supported AEM in warranty activities and trained JAO personnel in troubleshooting AEM antennas with some onsite missions.
- Further training on the job in the front-end area was given to JAO technical staff.



An example query from the ALMA Calibrator Source Catalogue. A number of calibrator sources have been selected from the sky map (left panel) and show flux density variations that need to be monitored at regular intervals (right panel).

An amplitude calibration device being serviced at the OSF. Each ALMA antenna has one of these devices to calibrate of the radio signals.

– Technical issue with the amplitude calibration devices, which developed in 2014. Each ALMA antenna houses one of these devices to enable radio calibration of the received signals. Each device includes a movable robotic arm with radiometric loads for calibration (the design of one type received a patent) and provides space for filters. These devices were designed, built and delivered by ESO and ESO contractors. Based on increased operations experience onsite, it was found that some devices needed to be reworked to make the movable parts fully oil-tight. This servicing was done in time for the Early Science observation block in December through a joint, fast and well-coordinated effort between EASC, the JAO and contractors with specific knowledge.
– Support for the JAO antenna transporter group in the review of maintenance activities for the antenna transporter.
– Contract oversight. Several contracts in Europe, placed by the ATT with the EASC, are running for offsite maintenance of the digitisers, digitiser clocks, correlator tuneable filters and Band 7.

ALMA development

The ALMA partnership foresees continuous upgrades and the development of new software, front ends (e.g., additional receiver bands) and other hardware or system capabilities during the operations phase.

The Band 5 project, carried out by a European consortium of NOVA, the Netherlands Research School for Astronomy, and GARD (Sweden), has made significant progress. In May 2014, the project successfully passed the Manufacturing Readiness Review, which marked the project's formal readiness for the manufacturing phase. Following this important milestone, large-scale procurements were started and activities ramped up for the production of 73 Band 5 receiver cartridges. The plan for the integration of Band 5 into the existing ALMA front ends at the Operations Support Facility (OSF) was finalised and approved. The plan is optimised so as to minimise the effects on the working ALMA system and any disturbance to science operations. Front-end assemblies which need to be removed from an antenna for preventive maintenance (mainly the cryocooler) will also receive a Band 5 cartridge, minimising the overheads of this integration. Towards the end of 2014, the technical infrastructure and management structure were implemented at the OSF in time to start regular integration activities in April–May 2015 when the first production cartridge arrives.

The optical fibre project, led by the JAO with contributions and co-funding by NRAO and ESO, will provide a fast network connection between the ALMA Observatory and Santiago. In 2014 it reached an important milestone with the completion of the first high-speed link from the OSF to the Santiago office. The construction of the second, redundant, link is in progress. Use of this link, foreseen for early 2015, will enable ALMA to have a high-speed data link to the rest of the world.

ALMA development studies

In order to prepare for larger ALMA upgrades, ESO runs an ALMA development study programme. External proposals are collected in response to a call for ALMA upgrade studies, which are typically released every three years following a specific European ALMA Science Advisory Committee/Scientific Technical Committee (ESAC/STC) recommendation. The proposals are selected for negotiation and funding after a detailed review by an EASC committee and following an ESAC/STC recommendation.

In 2014 two studies reached successful conclusion: one investigating the scientific opportunities for supra-THz interferometry with ALMA and the other evaluating the scientific case and some possible technical options for an ALMA Band 2+3. A coordination meeting was

held in March 2014 in Florence, to discuss the possibility of building one or more prototype receivers for the supra-THz frequency range. Equipped with this frequency band ALMA could observe heavy and deuterated molecules in the local Universe and also low excitation molecular gas, as well as carry out efficient spectral scans for high-redshift galaxies.

A series of new ALMA upgrade studies was also launched in 2014, to study possible upgrades to the ALMA cryostats and digital electronics systems, to develop advanced data analysis software and to enable exciting new observing modes to study the Sun, supermassive black holes in our own and nearby galaxy centres, and more. The digital electronics upgrade will hopefully allow the existing digitiser cards to be replaced for better maintainability and to process a wider intermediate frequency range, enabling the full sensitivity and spectral efficiency of a new generation of receivers with broader bandwidths to be exploited. The advanced data analysis software aims to deliver optimisation and automatic line identification algorithms for ALMA; these algorithms will allow users to make use of the rich spectral datasets and may also allow ALMA to provide automatic line identifications for archive data.

High spatial resolution observation of the supermassive black holes in our own Galaxy and in nearby galaxies will be made possible when ALMA will be used as part of a millimetre very long baseline interferometer. ALMA, connected with other millimetre observatories in the world as a single millimetre very long baseline interferometer instrument, will allow the study of the gas close to the surface of the black hole and to test directly its most elusive properties. While the technical modifications needed to enable this observing mode with ALMA are being implemented and tested in Chile, the challenging aspects of organising the use of ALMA as part of a global network are being addressed.

ALMA science conference

ALMA Early Science results are being published while the observatory is making the transition to full science operations, so 2014 was the right moment for a conference dedicated to ALMA science. The conference “Revolution in Astronomy with ALMA — the 3rd Year” was held in Tokyo on 8–11 December 2014. It highlighted the science results from ALMA obtained during the first three years of science operations and was effective in motivating future collaborations among researchers around the world. In its first three years of science operations, ALMA has been producing a growing number of impressive and scientifically compelling results as the most powerful millimetre/submillimetre interferometer in the world. The science topics covered many fields of astronomy, including: cosmology and galaxies in the distant Universe; nearby galaxies and the Galactic Centre; the interstellar medium and star formation in our own Milky Way; astrochemistry; circumstellar discs; exoplanets; the Solar System; stellar evolution and the Sun. Almost 300 participants travelled to Japan to discuss the exciting ALMA results.

Participants at the conference “Revolution in Astronomy with ALMA — the 3rd Year”, held in Tokyo, Japan, 8–11 December 2014.

This is the sharpest image ever taken by ALMA — sharper than is routinely achieved in visible light with the NASA/ESA Hubble Space Telescope. It shows the protoplanetary disc surrounding the young star HL Tauri. These new ALMA observations reveal substructures within the disc that have never been seen before and may indicate the possible positions of planets forming in the dark patches within the system.

ALMA (ESO/NAOJ/NRAO)

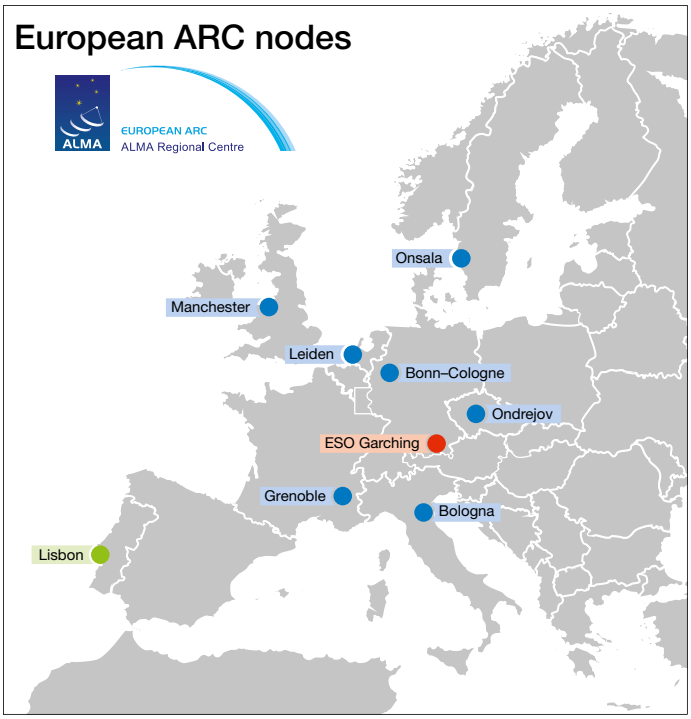
European ALMA Regional Centre

The role of the European ALMA Regional Centre is to provide a wide range of support tasks to the European community and to the ALMA project. Its specific roles are to strengthen the European ALMA community, broaden access to ALMA science to all European astronomers, optimise the scientific return, provide expert assistance for ALMA commissioning and optimisation of capabilities and provide tools to users and the observatory. In summary, the European ARC contributes to “making ALMA work”.

The European ARC is unique in having a distributed network of nodes, with the ESO node coordinating the activities and working in closer contact with the ALMA Observatory. The ARC nodes have close ties with the community (active research environments), host many of the millimetre/submillimetre experts in Europe and are actively involved in ALMA commissioning and optimisation of array capabilities.

In 2014, the ARC network expanded to acquire a new Centre of Expertise in Lisbon, Portugal. This Centre aims to build up the community, expand the user base, and further develop areas of technical and scientific expertise in Portugal, with the goal of assuming official status as an ARC node in due course.

Since the very beginning of Early Science operations in September 2011 (with 16 antennas), the European ARC has been very active and successful in supporting all European PI ALMA projects.

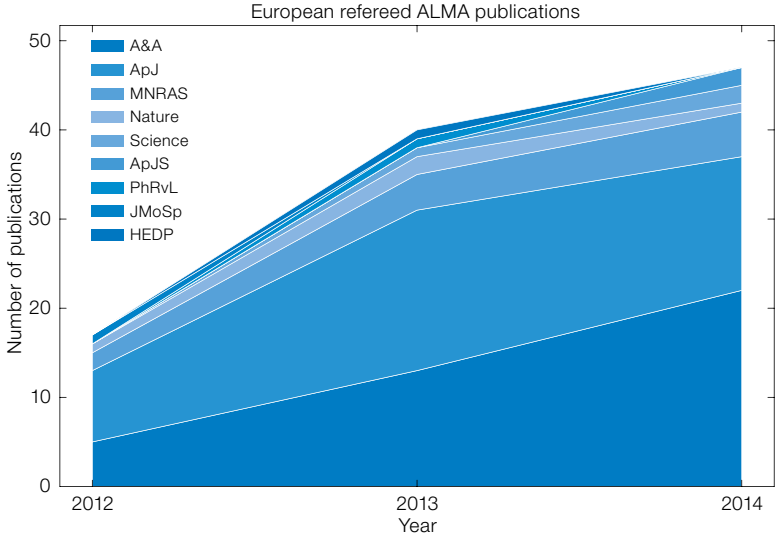


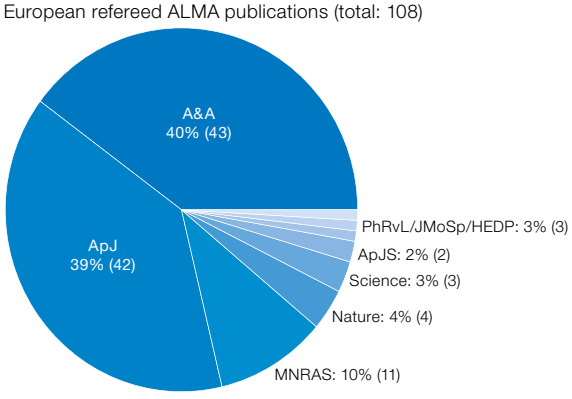
The European ARC is a network of institutes and consists of the central ARC node at ESO (red) and seven ARC nodes (blue) in Bologna (Italy), Bonn–Cologne (Germany), Grenoble (France), Leiden (the Netherlands), Manchester (UK), Ondrejov–Prague (Czech Republic) and Onsala (Sweden). There is also a new Centre of Expertise in Portugal (green).

This support stretches from the technical preparation of the projects, their execution and quality assurance through to data delivery and post-delivery quality control.

The success of the European ARC network is highlighted by some numbers; of a total of 1108 submitted Cycle 1 proposals, 481 were European (43%); in Cycle 2 of a total of 1383 proposals, 562 (41%) were European. The pressure factors for the highest priority projects were 9.1 (overall ALMA pressure factor is 5.7) in Cycle 1 and 4.9 (global ALMA: 3.9) in Cycle 2.

During 2014, the European ARC processed a total of 568 execution blocks and 318 scheduling blocks (each scheduling block is split into one or more execution blocks according to the science goal of the project). The average analysis time is seven working days and the average





The distribution of all publications based on ALMA data that can be attributed to the European Executive, by journal. The large fraction of Astrophysical Journal (ApJ) ALMA papers comes from the fact that all Science Verification data are attributed to all three ARCs and so American authors publishing in ApJ are counted.

delivery time to the PIs is 22 days (an excellent value compared to the average for the global ALMA community). Two hundred and thirty two scheduling blocks (413 execution blocks) were delivered to European PIs.

In February 2013, the ALMA science archive opened to users from all over the world, with the first Cycle 0 datasets becoming public, and since then, ALMA archival research studies have become a reality. The total of downloaded ALMA data in Europe amounts to 51 TB (out of 97 TB total); 57% of all refereed ALMA publications use data from the European ALMA Executive (ESO) and 40% of all refereed ALMA publications have a PI in one of the ESO Member States. These figures are illustrated in the bottom figures on the previous page where a statistical summary of the European refereed ALMA publications is plotted, split by the journal of publication.

The ARC also includes user support for the Atacama Pathfinder Experiment 12-metre ALMA antenna located at Chajnantor. This was the most productive year so far for APEX, both in terms of the number of hours on sky (4400) and by the number of papers published (74). The most popular instrument within the ESO community has shifted from the Large APEX Bolometer Camera (LABOCA) to the Swedish Heterodyne Facility Instrument (SHFI). In addition, two PI instruments were temporarily installed in 2014: from June to September, the ArTeMiS bolometer array covering a field of view of 4 by 2 arcminutes with full sampling; and from December, the Supercam 345 GHz heterodyne array from the University of Arizona was installed in the Cassegrain cabin. Supercam is the largest such array worldwide, and over 200 hours were devoted to mapping several square degrees of the Galactic Plane, Orion and the NGC 628 region, together with parts of the Large and Small Magellanic Clouds, in the CO(3-2) line.

After an intensive installation campaign by the instrument team and APEX staff, the Supercam visiting instrument was successfully installed in the Cassegrain cabin of APEX. Supercam is a 64-pixel 345 GHz heterodyne array built by the University of Arizona.

Programmes

ESO/G. Lambert

Instrumentation for the La Silla Paranal Observatory

The year 2014 has been a very productive one. ALMA construction is now substantially complete, with only the Residencia left to build. It was also a year in which two major second generation instruments were installed on the VLT and successfully commissioned, both immediately yielding spectacular results. This is an unprecedented achievement in the history of ESO. Excellent progress was also made on many other projects as well. However, the year was not without its difficulties: lack of ESO effort resulted in management implementing a six-month hiatus for the ESO work on the Enhanced Resolution Imager and Spectrograph (ERIS) and the upgrade to the CRyogenic high-resolution Infra-Red Echelle Spectrograph (CRIRES+). Following the successful launch of Gaia and the Phase-Referenced Imaging and Micro-arcsecond Astrometry (PRIMA) gate review in January 2014, the decision was made to cancel the PRIMA project and focus ESO's effort on ensuring the success of the two second generation VLTI instruments GRAVITY and the Multi AperTure mid-Infrared Spectro-Scopic Experiment (MATISSE). Work has progressed quickly with the levelling of Armazones in preparation for the E-ELT. Of course, the undoubted high point of the year was the culmination of many years of hard work to reach the point where ESO Council was able to approve the way forward for the construction of Phase 1 of the E-ELT.

The Next-Generation Transit Survey is located at ESO's Paranal Observatory. This project will search for transiting exoplanets.

Instrument commissioning and operations

The *K*-band multi-object spectrograph, KMOS, was granted Provisional Acceptance in Chile at the end of 2014. This major milestone follows a full year of operations and significant efforts to improve the reliability of the cryogenic pick-off arms. A major overhaul of the KMOS robotic pick-off arms was undertaken to eliminate problems with the premature aging of the linear bearings. This had resulted in several arms with unreliable positioning, requiring them to be disabled. All the bearings will be replaced early in 2015 with hybrid ceramic bearings, better adapted to the extreme conditions under which the arms are required to perform.

MUSE was installed on UT4 on 19 January 2014. After alignment, MUSE saw its first light on 31 January. During 15 nights in February 2014, the first functional tests and performance assessments were made. From the early minutes onwards, MUSE worked as expected and the whole run went very smoothly. The performance, as anticipated by the laboratory measurements, is excellent: the throughput of the instrument is very high, peaking at 55% at 700 nanometres. When including the telescope and atmospheric transmission, the end-to-end peak efficiency is an outstanding 35%, making MUSE the most efficient spectrograph on the VLT in the 500–850 nanometre wavelength range. Two further commissioning runs in May and July were necessary to fully integrate the instrument into the Paranal infrastructure, optimise operations and tune the data reduction procedures. All scientifically useful data collected during those runs are publicly available from the VLT MUSE commissioning webpage.

A call for Science Verification proposals was issued in mid-April and more than 85 proposals were received; 49 were scheduled for observation. Observations were carried out during two observing runs in June and August 2014, and all but two proposals could be completed. The science topics covered are extremely wide and include studies of a brown dwarf atmosphere; multiple stellar populations in globular clusters; the star formation history in circumnuclear rings of spiral galaxies; the interstellar medium in galaxies affected by ram-pressure stripping; dynamical constraints on intermediate-mass black holes; and studies of lensed quasars and high-redshift proto-clusters. Since 1 October 2014, the MUSE wide-field mode in natural seeing has also been offered to the community.

The year 2014 also saw the integration and commissioning of ESO's new exoplanet imager SPHERE at the VLT. After shipment in February, the installation and testing on Paranal started early in March and lasted until the end of April. First light and commissioning followed between early and mid-May. The instrument's performance was already very compelling at that time, and subsequent commissioning periods in July, August and October were used to tune operational procedures. The adaptive optics performance of SPHERE is excellent, with *H*-band Strehl ratios of about 90% routinely achieved on sky in good observing conditions. The efficient correction of aberrations also produces, for the first time, diffraction-limited images at optical wavelengths with an 8-metre-class telescope: angular resolution better than 20 milliarcseconds is achieved, several times sharper than Hubble Space Telescope images. The contrast performance exceeds expectations, and is better than 10^{-6} at 5σ confidence in good conditions. Angular differential imaging, a method which could not realistically be tested in the laboratory because of the missing telescope field rotation, turned out to be very effective in enhancing the image contrast on account of the very high instrument stability.

A comprehensive Science Verification campaign was launched at the end of 2014. Spectacular data with unprecedented angular resolution could be achieved, e.g., resolving the stellar surface of a star with a diameter of about 55 milliarcseconds or binary stars with separations on similar angular scales. A wide range of science topics was covered including imaging and spectroscopy of Solar System objects, exoplanetary systems, protoplanetary and debris discs around young stars, the mass loss and environment of evolved stars, the circumstellar ring of SN 1987A and the inner region of the active galactic nucleus (AGN)

of NGC 1068. The commissioning and Science Verification successes have created high expectations in the community, reflected in a large number of proposals submitted for the Period 95, starting in April 2015. Early guaranteed time observations had already started in P94, ushering in a new era of exoplanet and high-contrast imaging observations.

Instrument upgrades

In the VLT Imager and Spectrometer for mid-InfraRed (VISIR), the observed excess low frequency noise of the newly installed AQUARIUS detector array appears to be inherent to the design of the device. It could not therefore be remedied at the detector level, and faster chopping with the VLT secondary mirror (M2) has been selected as the most effective way forward. Following extensive analysis and testing, an improved M2 field stabilisation control loop has been implemented and commissioned at the Cassegrain focus of UT3, providing chopping frequencies up to 5 Hz. In addition, two potentially critical problems with the AQUARIUS detector mounts and electrical isolation have been diagnosed and successfully addressed. On-sky performance was demonstrated during two commissioning runs, showing better sensitivity than the old VISIR (see figure below); for spectroscopy at 10 µm a gain of a factor of more than six is realised in observing efficiency. VISIR will resume

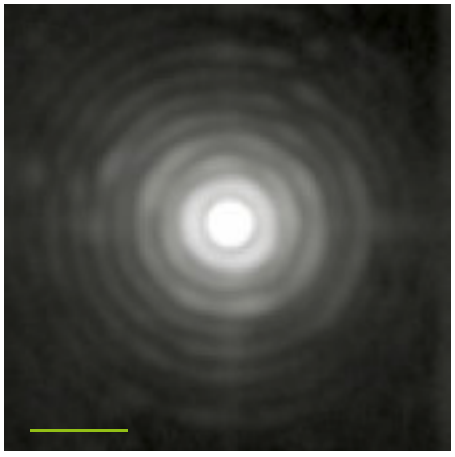


Image quality with VISIR in the PAH1 filter for the bright star HD 45348 (~150 Jy). The individual frames were combined with shift and add. The green bar denotes an angular extent of one arcsecond.

science operations with imaging, low- and high-resolution spectroscopy in Period 95. The availability of real-time monitoring of atmospheric water vapour will allow optimum use of good sky transparency, crucial for observations in the mid-infrared, to be made.

CRIRES+ is the upgrade that will transform CRIRES into a cross-dispersed spectrograph, increasing the simultaneously covered wavelength range by a factor of ten. For advanced wavelength calibration, custom-made absorption gas cells will be added and a spectro-polarimetric unit will allow circularly polarised spectra to be recorded. The main science drivers include the search for super-Earths in the habitable zone of low-mass stars, the atmospheric characterisation of transiting planets and the origin and evolution of stellar magnetic fields. Following Council approval of Guaranteed Observing Time, the agreement with the consortium led by Artie Hatzes (Thüringer Landessternwarte Tautenburg) was signed.

The reinstallation of NACO at the CRIRES focus of UT1 required the removal of CRIRES in mid-2014, one year earlier than the original CRIRES+ schedule, and so the instrument was shipped back to ESO Headquarters. CRIRES is operated in conjunction with a 60-element curvature adaptive optics system that requires intervention to prevent its obsolescence. The accident during the dismounting of this module, when the fore-optics and adaptive optics (AO) modules were damaged, necessitated its complete shipping to Garching for repair and upgrade. The Preliminary Design Review for the CRIRES+ project is scheduled for April 2015.

Instruments under construction and in design

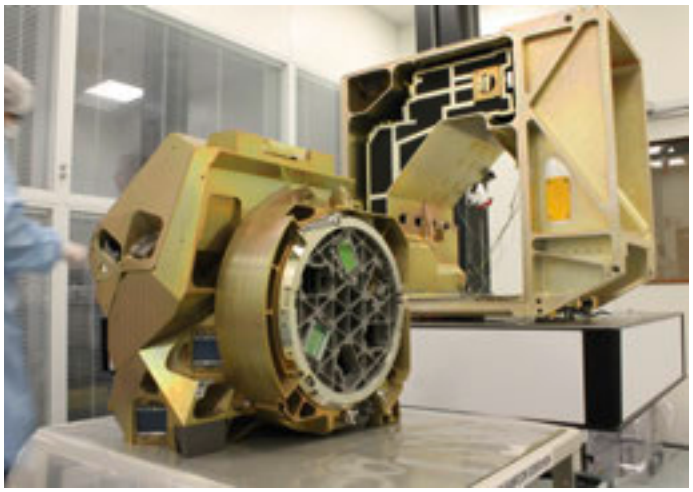
The Adaptive Optics Facility proceeded with reviews and system tests in 2014, with first shipments and commissioning activities planned to start in 2015. The adaptive optics module GRAAL, serving the infrared imager HAWK-I, was extensively tested on the ASSIST test bench for the whole of 2014. First, the maintenance mode using a natural guide star was validated under realistic simulated

The AOF test configuration in the Garching laboratory: the deformable secondary mirror sits on top of the ASSIST bench and the GRAAL module is mounted on the Nasmyth focus simulator, with the CAMCAO silver cryostat in the foreground.

conditions. With 0.8-arcsecond seeing, the delivered Strehl ratio was > 70% in *H*-band (limited by the test setup). This mode will serve as a maintenance tool for the deformable secondary mirror, exploiting its 1170 actuators and correction capability fully. In the second part of 2014 the ground layer correction mode of GRAAL was tested and the star image diameter was reduced by a factor of 1.75, which is very close to the optimal correction.

The subproject concerning multiple laser guide stars took delivery of the four 22-watt laser units manufactured by TOPTICA (Germany). Soon the lasers were integrated into the laser guide star subunits and the first system was thoroughly tested. A review concluded this series of tests and authorised their installation on UT4 for the start of commissioning tests. A review was conducted in Chile in November to validate the scientific operating concept for the AOF and concluded successfully.

GRAVITY, a second generation VLTI instrument (PI: Frank Eisenhauer, Max Planck Institute for Extraterrestrial Physics Garching), combines four telescopes in the *K*-band to measure astrometric



The MATISSE *N*-band cryostat and cold optics under installation in front of the warm optics bench at the OCA laboratory in Nice.

The ESPRESSO vacuum vessel.

separations of objects located within the 2-arcsecond field of view of the VLTI with a precision of 10 microarcseconds and enables spectroscopic imaging. At the end of 2014, the beam combiner instrument was ready for full system tests. The assembly and integration of the infrared wavefront sensors was also progressing. The main obstacle that GRAVITY has been facing is light from the metrology laser being scattered onto the science and fringe-tracking detectors. This light mostly originates from a holmium resonance in the fibre delay lines. Two potential mitigation paths for this increase of background have been identified: moving to a shorter laser wavelength or implementing three-way metrology. The five SAPHIRA detectors were upgraded to the next generation, leading to unprecedented performance with readout noise below one electron at liquid nitrogen temperatures. The Provisional Acceptance Europe process has been initiated and the shipment of the beam combiner to Chile is planned for mid 2015.

MATISSE, a four-way beam combiner for the *L*- to *N*-band (PI: Bruno Lopez, Observatoire de la Cote d'Azur [OCA], Nice), is the other second generation VLTI instrument. It will provide simple imaging at interferometric resolution of a wide range of targets, including asteroids, young stellar objects and AGN. The manufacturing of the subsystems has been completed after problems with some of the warm optics were solved. MATISSE is now in the integration and verification phase at OCA: both the *LM*- and *N*-band cryostat assemblies, including cold optics and engineering grade detectors, are installed in the laboratory and the warm optics are being integrated and aligned. Provisional Acceptance Europe is planned for early 2016.

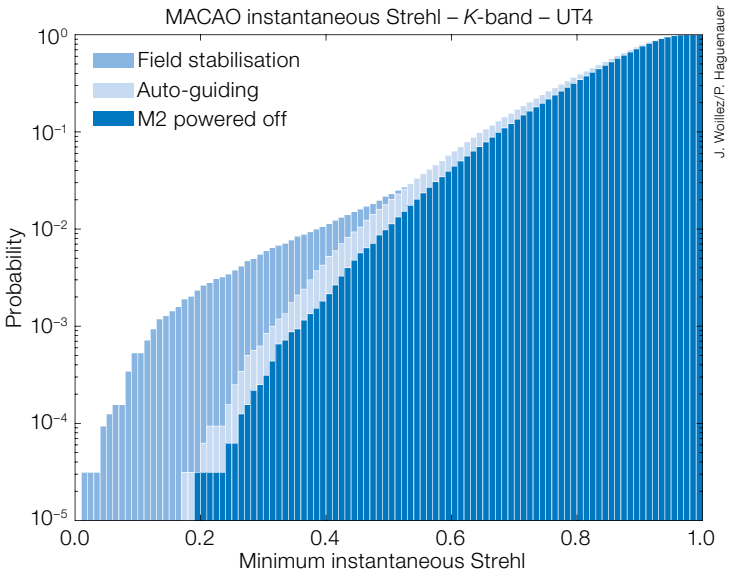
Procurement of components for the ESPRESSO ultra-stable high-resolution optical spectrograph project (PI: Francesco Pepe, Geneva) has progressed well. The vacuum vessel and the thermal enclosures have already been delivered and the calibration unit has been assembled. The echelle grating has arrived at ESO Headquarters, but the throughput is on the low side, and possibilities for its replacement are being evaluated. The first images were recorded with the cooled engineering grade detectors. The optical bench is in the manufacturing phase and the procurement of the spectrograph optics is ongoing. The cameras have suffered various delays, but they are expected by the beginning of 2016, without impact on the current schedule. All the change requests aimed to prepare the coudé paths and the combined coudé laboratory at Paranal for the installation of the coudé train and the instrument have been processed and approved. The two external layers of thermal enclosures were assembled in Paranal in the combined coudé laboratory in November, and the laboratory is now ready to host the instrument when it arrives.

In 2012 a consortium composed of ESO, the Instituto Astrofísica de Canarias (IAC, Spain) and Universidade Federale do Rio Grande do Norte (UFRN, Brazil) closed a contract with Menlo Systems GmbH to provide the turnkey laser frequency comb system for HARPS. The laser frequency comb allows a series of precisely equally spaced and stable lines to be produced for spectrograph calibration. After intense research and development activities, a durable photonic crystal fibre has been found. The coupling to this fibre has been improved, and the laser frequency comb has reached the required standard of reliability, with installation and commissioning scheduled for April 2015.

MOONS, the Multi-Object Optical and Near-infrared Spectrograph for the VLT will cover the range 0.8 to 1.8 µm with a fibre-fed multi-object spectrograph (PI: Michele Cirasuolo, UK-ATC, Edinburgh). MOONS will have 1000 fibres in the focal plane and will offer spectral resolutions of about 4000 and 20 000. Following a competitive Phase A process and STC recommendation, the agreement for the construction of MOONS was signed in September 2014. The preliminary design phase is currently underway for all aspects of the instrument and the proposed fibre positioning and metrology systems are being prototyped.

Following the STC's recommendation to pursue 4MOST (4-metre Multi-Object Spectroscopic Telescope) studies with a

Construction work on the new AT station at Paranal.



Instantaneous Strehl ratio performance improvements resulting from an optimised use of the UTs. Replacing field stabilisation by auto-guiding, and powering off the tip/tilt control of the secondary mirrors has improved the statistics of low Strehl events, directly translating into an improved fringe tracking limiting magnitude and performance.

view to starting construction in 2015, the consolidation of the 4MOST consortium (PI: Roelof de Jong, Institut für Astrophysik, Potsdam) and budget is taking place. Contractual documents are being finalised in parallel. 4MOST will be a world-class facility for fibre-fed multi-object spectroscopy and will be installed on VISTA. Its unique capabilities result from a large field of view, medium and high spectral resolutions in the visible range for both Galactic and extragalactic applications with very high multiplex capabilities.

ERIS will be a new infrared facility for the *J*- to *M*-band (1–5 µm) at the UT4 Cassegrain focus; it will feed both an infrared imager and the upgraded integral field spectrograph (SPIFFI) of SINFONI with AO-corrected wavefronts. ERIS will use the AOF's deformable mirror, as well as one of its lasers, to improve both the spatial resolution and sky coverage compared to the current NACO and SINFONI instruments. After a six-month hiatus, the project was re-established as a consortium-led project, and down-scoped in some technical areas (no infrared tip/tilt sensor or pyramid wavefront sensor) while minimising the impact on the scientific requirements, in order to maintain the schedule. The consortium will be led by the Max Planck Institute for Extraterrestrial Physics (MPE, Garching; PI: Richard Davies).

The Paranal Instrumentation Programme was presented to Council in December 2014. The document traces the path for the development of new instruments for the Paranal and La Silla Observatory until the year 2020.

VLT infrastructure projects

After the VLTI work was re-organised into separate projects, it became clear that a high level of coordination and a system view for the whole VLTI facility was required. This approach was necessary in order to implement the major infrastructure changes needed to host the second generation instruments GRAVITY and MATISSE and to guarantee their best performance. Following the AOF scheme, the VLTI projects will therefore be coordinated by a VLTI facility project starting in 2015. The VLTI interferometric instrument PIONIER was upgraded with a new detector in 2014 and will be relocated in the combined laboratory. The VLTI interferometric instrument MIDI will be decommissioned in 2015.

The VLTI infrastructure projects (VLTI-PR) are briefly overviewed; PR1–5 were introduced in the 2013 Annual Report and PR6 concerning investigations of vibrations has been added.

VLTI-PR1: Auxiliary Telescope service station. The construction of the service station is progressing well and is expected to be completed by April 2015.

VLTI-PR2: PRIMA astrometry. The PRIMA gate review was held in January 2014, after which ESO asked the STC to recommend that the PRIMA project be cancelled, but with no irreversible action being taken prior to the confirmation by ESA that Gaia is fully functional. Following the gate review recommendations, a PRIMA lessons learned exercise has been conducted with an external chair. After endorsement by the STC, the work on PRIMA astrometry was therefore stopped and the resources allocated to other VLTI projects.

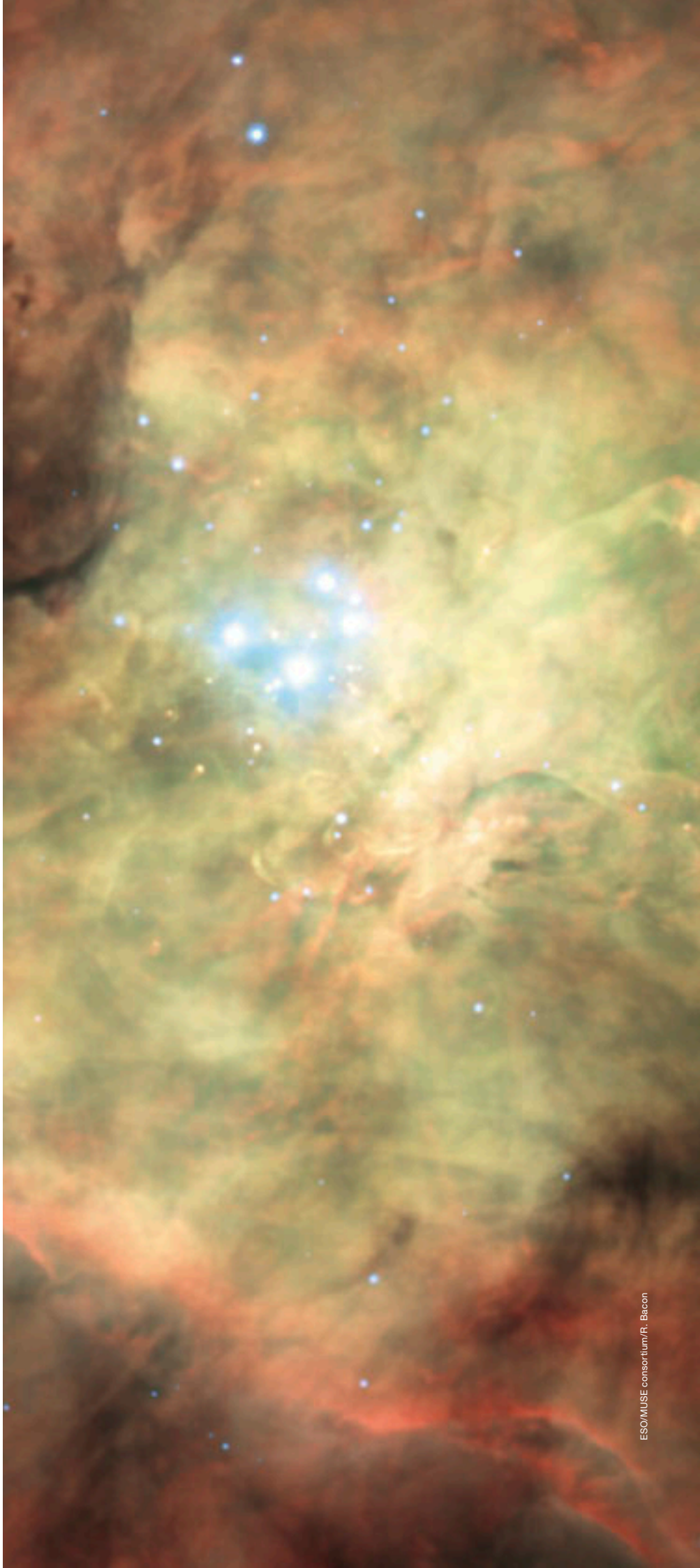
VLTI-PR3: Adaptive optics for the Auxiliary Telescopes. The design of the New Adaptive Optics Module for Interferometry (NAOMI) is progressing and the Preliminary Design Review is planned for May 2015.

VLTI-PR4: Preparation for GRAVITY and MATISSE. The changes to the VLTI infrastructure necessary for the implementation of GRAVITY and MATISSE have been

finalised. These changes impact the VLTI laboratory and the coudé rooms of the four UTs and work will start in April 2015 and last six months. The upgrade of the adaptive optics dedicated to the VLTI inside the UT coudé rooms (Multi Application Curvature Adaptive Optics, MACAO) started in November and will continue for the whole of 2015. The manufacture of the last pair of differential delay lines is nearly finished and they will be integrated on Paranal in August 2015.

VLTI-PR5: Second generation fringe tracker. The Phase A study is running, aimed at establishing the use of GRAVITY as a second generation fringe tracker for MATISSE and a Phase A review is planned for March 2015.

VLTI-PR6: Performance and vibrations. Early in 2014, the Paranal System Engineering group gathered some evidence that UT field stabilisation, a closed loop between the guide probe and the secondary mirror, was responsible for tip/tilt disturbances beyond the correction capability of MACAO at the VLTI (see top right figure on the previous page). These disturbances were identified as being responsible for systematic fringe-tracking failures on the UTs. In a joint VLTI-SPHERE investigation, the local tip/tilt control loop of the secondary mirror of the UTs was found to inject significant tip/tilt in the 20–200 Hz frequency range. The instantaneous Strehl performance of MACAO and the contrast of SPHERE were improved by temporarily disabling this control loop. Finally, as a side benefit to the MACAO obsolescence project, the control bandwidth of its controller was improved and a vibration-tracking algorithm was implemented, resulting in better performance. Step by step, throughout the year, the quality of the beam delivered by the UTs has improved, as witnessed by the tip/tilt and fringe sensors of the VLTI. Additional activities to improve the performance are planned for 2015.



Picture of the Orion Nebula based on a mosaic of many MUSE datasets that were obtained soon after the instrument achieved first light in early 2014.

ESO/Y. Beletsky

ALMA antennas observing the night sky.

ALMA

ALMA, the Atacama Large Millimeter/submillimeter Array, is a large interferometer for radio wavelengths ranging from 0.3 to 9.6 millimetres. ALMA was constructed through an international collaboration between Europe, North America and East Asia in cooperation with the Republic of Chile. The ALMA Observatory comprises 66 high-precision antennas with state-of-the-art receivers located on the Chajnantor Plateau at 5000 metres above sea level in the district of San Pedro de Atacama, in the Chilean Andes. The 12-metre diameter antennas can be placed in configurations with reconfigurable baselines ranging from 15 metres to ultimately 16 kilometres. Resolutions as fine as 0.005 arcseconds can be achieved at the highest frequencies, a factor of ten better than the NASA/ESA Hubble Space Telescope at optical wavelengths.

After more than ten years of construction and with all subsystems completed and in operation in 2013, the year 2014 was marked by the transition to full science operations and the stunning science results resulting from the Early Science observations. In particular, the commissioning of the long baselines, still a construction task, resulted in extraordinary results. The only remaining ESO-related construction item to be delivered to ALMA is the ALMA Residencia.

The major highlights in 2014 included:
– ALMA construction was completed and all subsystems were in operation.
– The use of long baselines, up to 15 kilometres, was commissioned in a dedicated campaign involving many people from the ALMA partnership. The results were stunning and, among others, produced the extraordinary image of the protoplanetary disc of HL Tauri, which featured strongly in the press worldwide.
– Early Science Cycle 1 was finished and Cycle 2 started.
– The construction contract for the ALMA Residencia was signed.

The ALMA Residencia

The procurement of the ALMA Residencia was completed in 2014. Following the design by the architectural office Kouvo & Partanen (Finland), finished in 2013, the tendering process in 2013/14 led to acceptable offers and the construction contract was signed at the end of 2014.

Given the harsh desert environment, remote location and necessity for shift work (both day and night) for the ALMA staff, the Residencia was designed to provide a pleasant onsite environment for staff and visitors, who come from as many as 20 countries worldwide. The initial design was undertaken by Kouvo & Partanen and was then adapted to the Chilean market by Rigotti & Simunovic Arquitectos, a Chilean firm of architects.

The Residencia has two main zones: common areas and dormitory areas. The design uses a modular concept so that more accommodation can be added if necessary. Initially there will be 120 rooms extending across six buildings.

The common areas include leisure facilities such as a library, cafeteria, lounge, spa with gym, swimming pool, sauna and barbecue area. A kitchen and dining room will also be provided, with enough space to accommodate half of the residents at any one time.

Close-out of construction activities

ESO's involvement in ALMA's other construction activities has come to an end, and in 2014 contracts were either closed after the warranty expired or warranty cases were followed up.

The last European ALMA antenna, manufactured by AEM, was delivered in 2013. During 2014, the last of the 25 AEM antennas was relocated to the Chajnantor Plateau and used for science observations depending on the available receiver bands.

In 2014, ESO staff continued to follow up warranty cases and assisted in coordinating the dismantling process of the AEM antenna construction site at the OSF. ESO staff gained considerable experience in systematically tracking technical warranty issues affecting the antennas or other subsystems, in order to verify the reliability requirements and to detect specific hardware items requiring attention as early as possible.

ALMA extension of capabilities

During 2014, there was a significant amount of effort invested by all ALMA partners to complete ALMA's capabilities. The commissioning and Science Verification activities were carried out by the Extension of Capabilities Group, headed by the Joint ALMA Observatory, with

View of the Array Operations Site, located at 5000 metres above sea level, on the Chajnantor Plateau. 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/B. Tafreshi (twanight.org)

Silvio Rossi/ESO

Silvio Rossi/ESO

Views of the cleared AEM antenna construction site at the OSF where the 25 European ALMA antennas were integrated and tested.

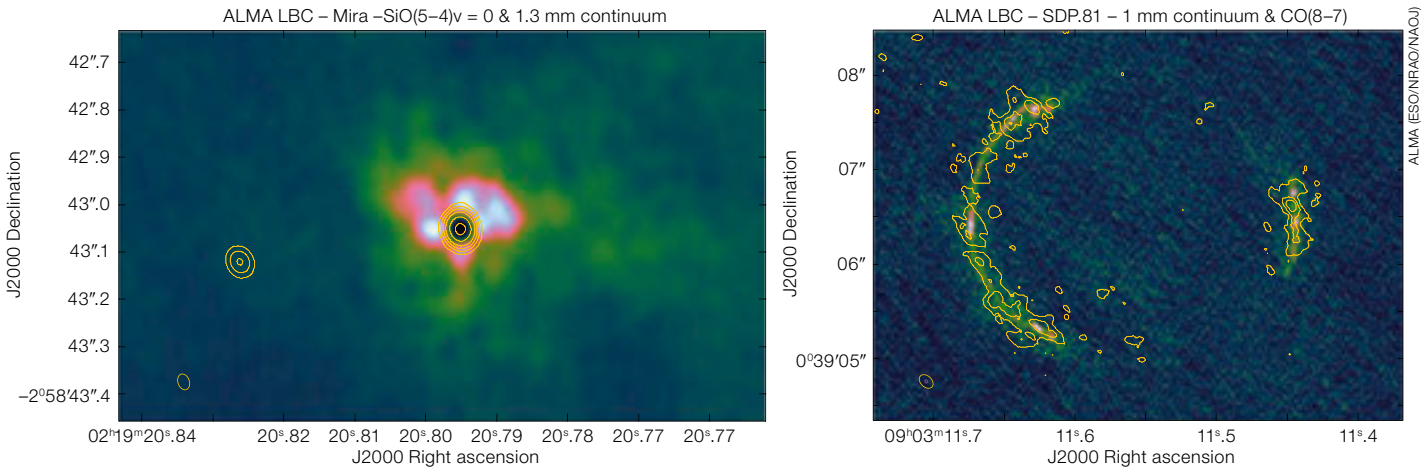
ESO/Rigotti + Simunovic Arquitectos

Architectural rendering of the future ALMA Residencia. This image shows the general view of the array of buildings. The larger V-shaped building contains the dining room, kitchen and leisure facilities; the others are the six dormitory buildings.

significant contributions from all the ALMA regions. Significant progress has been made in the procedures for high frequency calibration, polarisation observations and advances towards delivering the Solar observing modes. Experts from European institutes and universities were supported by ESO to take part in the activities in Chile and data analysis was carried out in Europe. The major achievement of the year was the successful testing of ALMA's long baselines.

The period from September to November 2014 was dedicated to the Long Baseline Campaign (LBC), with the goal of testing and verifying the longest baseline observing modes. ALMA baselines as long as 15 kilometres were tested, and Science Verification data were obtained at wavelengths of 0.87, 1.3 and 3.4 millimetres. The figure below shows two examples of long baseline Science Verification data

ALMA long baseline Science Verification data: The SiO (5–4) envelope around the evolved star Mira (left); image of the dust emission (colour scale) and CO (8–7) warm gas (contours) in the z = 3.04 lensed submillimetre galaxy SDP.81 (right). All the ALMA Science Verification data are available on the ALMA Science Portal.



(see also ESO press release eso1436). The images, with angular resolution up to 30 milliarcseconds (i.e., better than achieved routinely with the Hubble Space Telescope), reveal unexpected features with an unprecedented level of detail in all sources, demonstrating the transformational nature of ALMA. Long baseline Science Verification data on the asteroid Juno, the asymptotic giant branch star Mira, the protoplanetary disc of HL Tauri (shown on p. 45) and the gravitationally-lensed submillimetre galaxy SDP.81 are publicly available on the ALMA Science Portal. These results amply demonstrate that the ALMA design and technical implementation are sound and able to deliver the promised science, also on baselines of up to 15 kilometres.

This picture shows the ALMA transporter Otto. It is one of two transporters which are able to carry the huge antennas up to the Chajnantor Plateau and move them around there.

ESO/Y. Beletsky

European Extremely Large Telescope

This was a very important year for the E-ELT, marking the actual start of the construction both from a practical point of view, with the groundbreaking ceremony in June, and, formally, with the green light in December by ESO Council to start the telescope construction with a phased approach.

The planning for the E-ELT phased approach included a major effort from the E-ELT management team and project managers. This approach, which splits the programme into two phases, permits the 90% funding level required to start construction to be met, as defined by Council when approving the E-ELT programme back in 2012. Spending of around one billion euros has been authorised for the first phase, which will cover the construction costs of a fully working telescope with a suite of powerful instruments and first light targeted in ten years time. For the time being, 10% of the overall project costs have been shifted to a second phase.

The telescope components that are not yet funded in the first phase include parts of the AO system, some of the instrument work, the innermost five rings of segments of the telescope main mirror (a total of 210 mirror segments) and a spare set of primary mirror segments needed for more efficient telescope operation in the future. One of the two prefocal stations has also not been funded, but this will be needed only when procurement of instruments to be accommodated on the second Nasmyth platform begins. The power conditioning system has also been moved to Phase 2, but it is expected that the connection to the Chilean national electrical grid that is under construction (to bring electricity to the Paranal–Armazones area) will provide the required supply quality in order not to affect the operations. The postponement of the construction of these components does not reduce the extraordinary scientific achievements that the telescope will be able to accomplish at the end of Phase 1. These components will be approved as additional funding becomes available, including that expected from the accession of Brazil as a Member State.

The construction countdown to the first 40-metre-class telescope on sky has begun!

At the beginning of the year the handover of the programme leadership from Alistair McPherson to Roberto Tamai took place. On this occasion, the managerial structure and processes were consolidated and adjusted to match the needs of the construction phase. The high-level management plan was updated with details on the programme organisation and processes, leading to a transparent, integrated team structure with clear roles and responsibilities, and well-defined communication channels. The approach to project engineering and project control has evolved towards a close involvement of these two functions at the level of the main projects constituting the E-ELT programme.

At E-ELT system level, engineering budgets have been completed, system engineering processes have been fine-tuned and a first detailed Assembly Integration and Verification plan and schedule have been put together. Furthermore, the package of 51 technical nights on the Gran Telescopio Canarias telescope, allocated as part of the Spanish accession agreement to ESO, has now been completed. These nights enabled ESO to gather considerable experience in phasing a segmented primary mirror and have validated the baseline algorithms and technical budgets developed over the past few years.

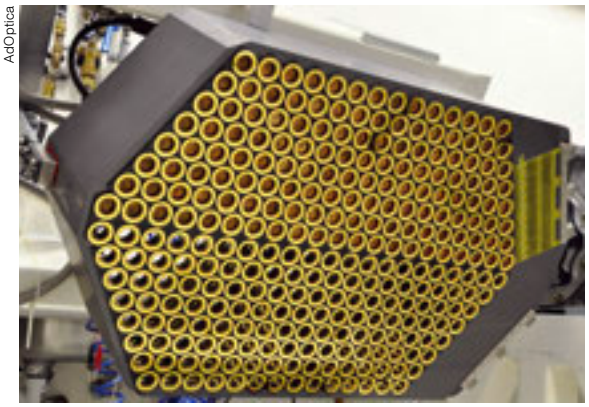
The most notable event of the year was undoubtedly the Armazones groundbreaking ceremony on 19 June in the presence of several distinguished guests and high-level officials from both Chile and the ESO Member States. During this ceremony the Chilean company ICAFAL Ingeniería y Construcción S.A. blasted part of the top of Cerro Armazones and loosened about 5000 cubic metres of rock. This is just the first part of an elaborate levelling process, which will help landscape the mountain, so that it can accommodate the 39-metre telescope and its huge dome. A grand total of 220 000 cubic metres will need to be

Rapid progress in flattening the peak of Cerro Armazones had been achieved by December 2014.

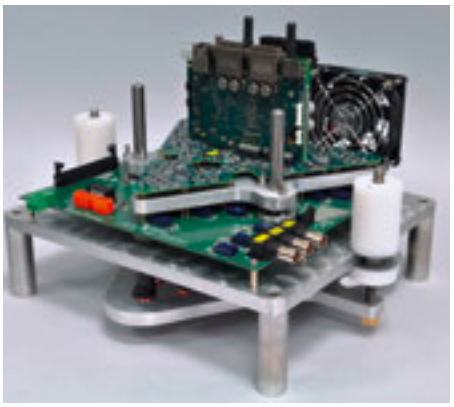
ESO/G.Hüdepohl (atacamaphoto.com)

Two test segments for the E-ELT 39-metre primary mirror. The prototype support system on the left was produced by CESA (Spain) and the one on the right by VDL/TNO (the Netherlands).

AdOptica



Left: M4 adaptive mirror demonstration prototype showing its two sectors equipped with capacitive sensor electrodes.



AdOptica

Right: An element of the M4 adaptive mirror of the E-ELT housing a set of voice-coil actuators, capacitive sensors and associated electronics and cooling circuitry.

removed to make room for the 150-metre by 300-metre E-ELT platform. Apart from this spectacular event, the road and platform construction contract with ICAFAL has progressed very well during the year. The massive earthworks for the road were completed over more than half of the road length (the rest being planned for completion in mid-2015) while the platform has been levelled to within less than 1.5 metres of its final level, which lies about 17 metres below the original summit.

The year also saw another important achievement for the infrastructure of the observatory on Paranal and Armazones: despite their location in the middle of the Atacama Desert, both sites will be served by the Chilean electrical grid. ESO succeeded in signing a contract with Grupo SAESA, a Chilean electrical company, to extend the national grid and supply electricity, as a regulated client, to the different consumers there.

Another important milestone was the launch, in the spring, of the call for tender for the procurement of the dome and telescope main structure, including final design and construction until commissioning onsite. This contract is expected to be placed by the end of 2015 and will be the largest industrial contract ever placed by ESO.

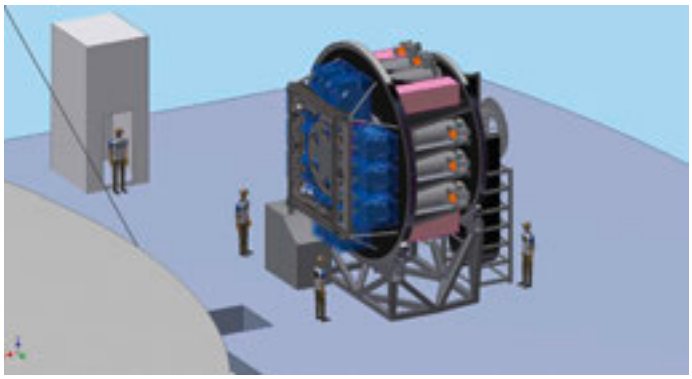
Another critical call for tender was launched for the primary mirror (M1) segment supports, capitalising on the lessons learned from the M1 test setup activities that have taken place over the past few years. The finalisation of this tender led, in the first days of 2015, to the signature of two parallel contracts with CESA (Compañía Española de Sistemas Aeronáuticos S.A.; Spain) and VDL (Van Der Leegte Groep, the Netherlands) to include the delivery of the manufacturing documentation package for the production of the series. The contracts also include the development of the procedures required to integrate the supports with the E-ELT glass segments, to handle and transport the segment assemblies and to operate and maintain them. The contracts consist of a design phase followed by the production of engineering models and testing.

The call for tender for the procurement of the 2-millimetre thin, 2.4-metre diameter glass shells for the quaternary adaptive mirror (M4) was launched in the autumn. This was an important milestone for this highly critical, fragile and long-lead item. It was the result of the intense activities performed under the ESO contract by Adoptica to develop the preliminary design of the M4 adaptive mirror unit. The contract includes a demonstration prototype representing a scale-one subset of the complete, 5316-actuator system including the representative optical shell, electro-mechanics, control electronics and cooling system. The tests performed on the prototype have shown that the very challenging requirements for this critical E-ELT subsystem can be met and that the design is mature enough to enter the procurement phase for the complete M4 unit.

Internal activities have continued on other mirror units (notably the secondary and tertiary mirror units) to optimise the procurement strategy and prepare the corresponding technical specifications and statements of work for the procurement contracts. Particular emphasis has been put on the architecture of the Nasmyth platform, which will host the suite of scientific instruments and the telescope wavefront control hardware (the prefocal station). A specific optical control project has been established to tackle this difficult task with a view to defining the interface between the telescope and its instruments in sufficient detail to enable the instrument design studies to start in 2015.

The control system activities passed an important milestone in December with the successful Preliminary Design Review of the M1 local control system. This internal ESO design activity focused on a trade-off between two designs of the local electronic cabinets (segment concentrators). These cabinets are critically close to the primary mirror and must therefore dissipate a minimum of energy to avoid thermal disturbance in the glass segments. At the same time, they must pre-process all the signals and commands exchanged with the many sensors and actuators attached to each segment, notably the edge sensors, the positioning actuators and the warping harnesses.

In the summer, the M1 test stand and the quinternary mirror (M5) prototype developed during the E-ELT Phase B studies were moved from the rented laboratory space in Garching Hochbrück to the brand-new technical building in the Headquarters extension building. In addition to the advantage of close proximity to Headquarters offices, this new location is much quieter in terms of ground microvibrations, a very important feature for



EAGLE instrument consortium

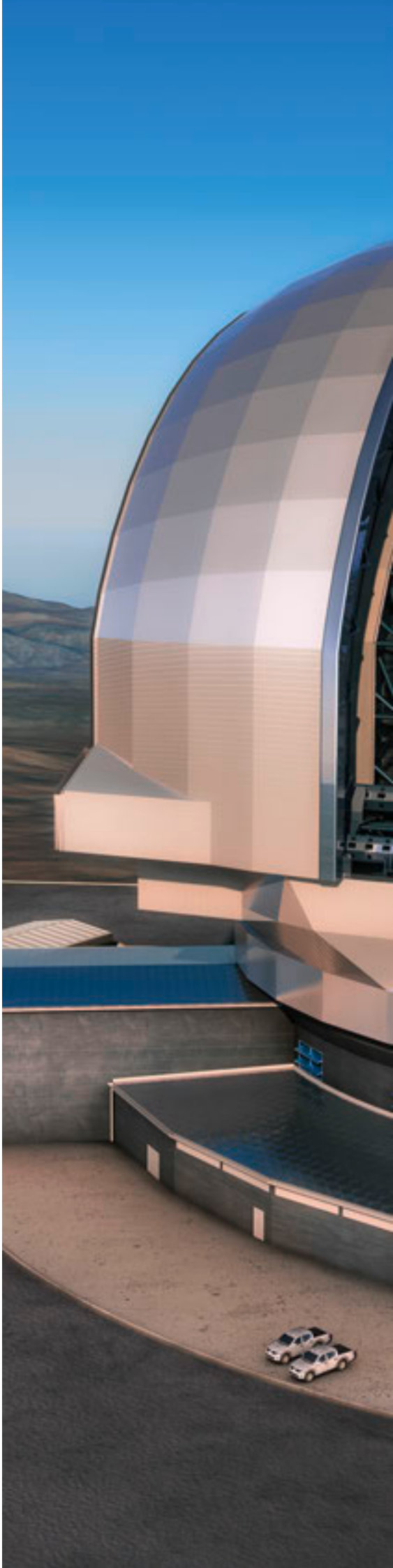
A computer-aided design visualisation of the proposed E-ELT multi-object adaptive-optics spectrograph EAGLE.

future testing of the control system for these optical components at the nanometre level. Finally, development activities continued to reduce the risk associated with critical components such as the edge sensors measuring the phasing of the M1 segments. A new climate-controlled test-bed was developed to further characterise the prototypes developed in the past few years.

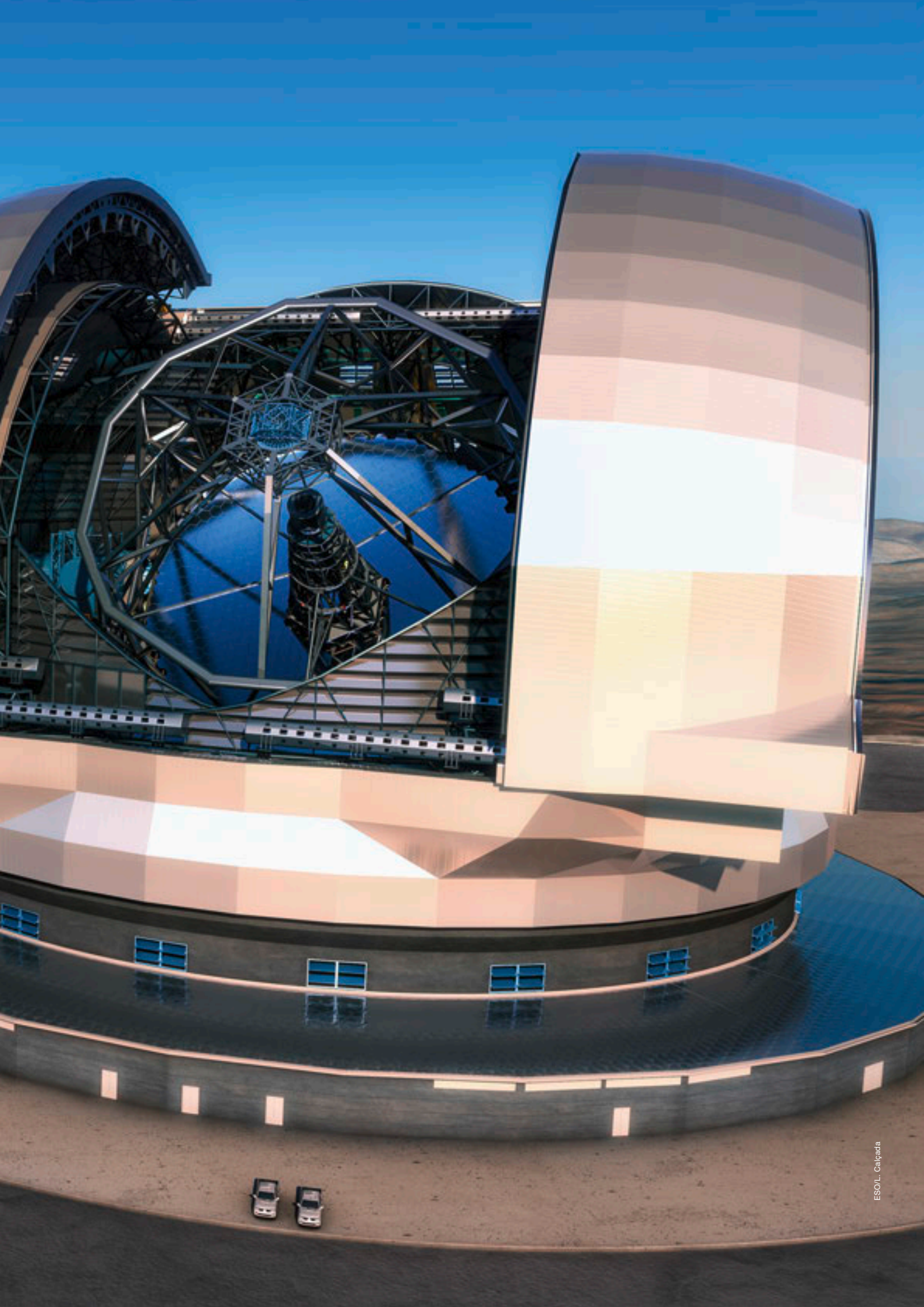
Work on the preparation for the first contracts for E-ELT instruments has continued during 2014. ESO is working with consortia of universities and institutes in the Member States to define three of the first generation instruments and their AO systems. The instruments are a near-infrared diffraction-limited camera (MICADO), an optical-infrared integral field spectrograph (HARMONI) and a mid-infrared imager and spectrograph (METIS). The requirements for these instruments have been revised and updated by the E-ELT Programme Scientist, in collaboration with the ESO community of astronomers. To reach the science goals, two standalone adaptive optics modules are foreseen: a multi-conjugate AO module and a laser tomographic AO module. Instrument and AO module concepts that meet the scientific goals and fit within the timescales and budget constraints of the E-ELT programme are being developed by consortia supported by ESO. After the presentations of these concepts to the ESO committees, the design and construction phases for the instruments will formally start with the signatures of the instrument agreements in 2015.

ESO will issue a call for proposals for a high-resolution spectrograph and a multi-object spectrograph. In anticipation of the future development of a multi-object spectrograph, a revision to the earlier Phase A study for an adaptive-optics-assisted, multi-integral-field instrument was undertaken by the EAGLE consortium. This new study was necessary as EAGLE was designed for the gravity-invariant platform on the E-ELT that is no longer included in the design. The study was successfully concluded in March 2014.

The E-ELT Programme Scientist continued to actively liaise with the scientific community by organising a conference and a workshop. The topic of the former was exoplanet science and the latter was devoted to fundamental physics. Advice was sought from the E-ELT Project Science Team on the top-level requirements for the mid-infrared imager and spectrograph, high resolution spectrograph and multi-object spectrograph, and the discussion of science operations plans was initiated. The E-ELT Programme Scientist reported to, and responded to several requests from, the E-ELT Subcommitttee of the STC (ESC).



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



ESO/L. Calçada

Engineering

Y. Beletsky (LCO)/ESO

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

The Directorate went through its final re-organisation in 2014, which resulted in a leaner structure with seven departments. Many of the activities carried out by the staff of this Directorate are under the governance of the Directorates of Programmes and Operations and are reported at the appropriate places in this Annual Report.

VLT's UT4 observing the centre of the Milky Way with adaptive optics assisted by the laser guide star.

Mechanical Engineering Department

Within the new matrix operation of the Directorate of Engineering, a new Mechanical Engineering Department was formed and deployed from mid-October. The department is responsible for the definition, design, analysis, procurement and initial assembly of mechanical, opto-mechanical, cryogenic and vacuum systems for advanced telescope and instrumentation systems for all ESO observatories.

One of the main activities of the Mechanical Engineering Department in the past year was dedicated to writing, consolidating and justifying requirements for the various E-ELT supply specifications in the areas of mechanical engineering and structural analysis. Based on structural models, systems 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 conceptual design and analysis verification of the interface structure between the secondary mirror and its cell was carried out to check its structural feasibility and required design volume. The quaternary mirror interface to the E-ELT main structure was updated to the new handling scheme and a new design developed and proposed to the M4 contractor.

Computational fluid dynamics analyses were carried out at short notice to study the possible impact of the planned disposal of backfill material at the northern side of the Armazones summit. According to the results, no significant impact on the performance of the E-ELT due to wind flow and turbulence above the platform is expected.

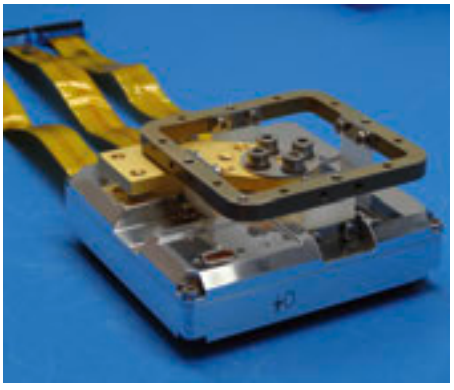
The transporter team at ALMA was supported in the analysis of a recent transporter failure and recommendations of how to adapt the maintenance scheme were made. Also the operational concept of the antenna transporters was reviewed and proposals for improvements in efficiency were presented to ALMA.

The project data management system went into its next phase and is now available as a collaboration tool. Project team members can now create new documents inside the system, document numbers are assigned automatically and approvals implemented in the system. The transfer of the project data management system to ESO premises has been accomplished with the definition and installation of the servers within the ESO IT environment.

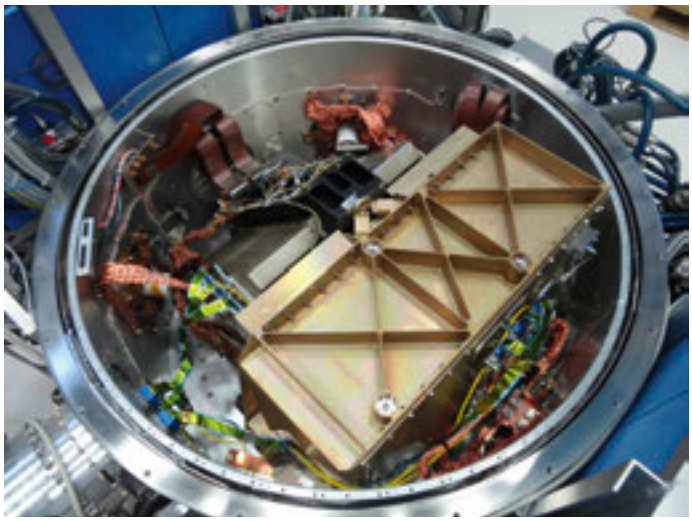
The laboratories in the new technical building were occupied and equipment and machinery were moved from the main building to the new facilities. The new mechanical workshop is in nominal operation, and all machines, including a new five-axis milling machine, were recommissioned and are fully operational. The metrology laboratory has been fully equipped and was ready for use in mid-September.

The department supported a large number of ongoing projects with opto-mechanical design, drafting and manufacturing, assembly integration and testing activities, specifically for the Four Laser Guide Star Facility and the upgrades to UT4, the VLTI infrastructure and CRIRES, ERIS, ESPRESSO, GRAAL and GALACSI. The design and manufacturing, assembly integration and testing for the laser guide star units involved considerable modifications, manufacturing and implementation of auxiliary parts; shipment of the first laser guide star unit in the first quarter of 2015 is planned.

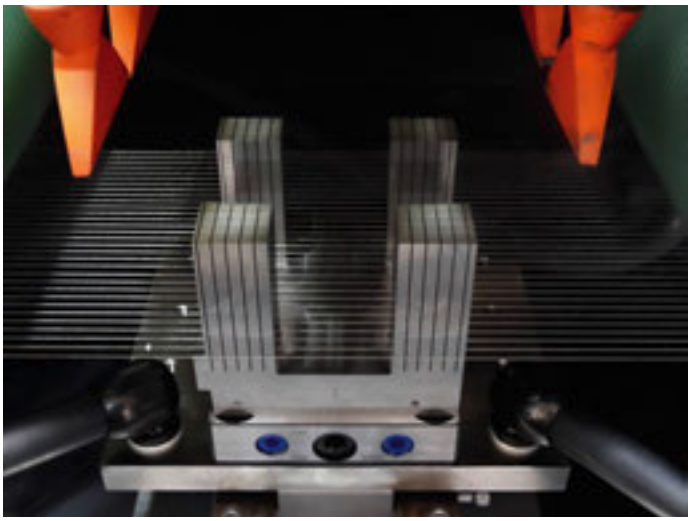
The AQUARIUS detector mount design was upgraded to mitigate potential mechanical stress problems. After reliability testing at 4 K, the new science



Upgraded AQUARIUS detector mount to be operated at 4 K.



Work on the upgrade to the VISIR mid-infrared instrument.



High-precision tool for fabrication of piezoceramic actuators.

grade detector devices were integrated with both VLT mid-infrared instruments. One unit was installed in the MATISSE *N*-band, and two in VISIR. The department supported the extensive VISIR upgrade activities up to the instrument's re-commissioning at the telescope.

The assembly, integration and testing of the GRAVITY wavefront sensor cryostats equipped with the SAPHIRA infrared detector has progressed. Two units were delivered to the GRAVITY consortium. The department provided design and manufacturing, assembly integration and testing of high precision tools for the fabrication of piezoceramic actuators for the GRAVITY deformable mirror development project.

Electronics Department

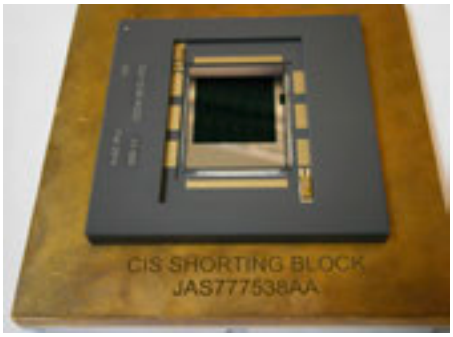
The department consists of four groups: the Telescope and Instrument Electronic Engineering Group; the Electrical Compliancy Engineering Group; the Electronic Developments, Lab Facilities & Workshop Group; and the Detector System Group.

Preparation of the E-ELT dome and main structure documents for the coming call for tender was a major focus. At subsystem level, the development of the primary mirror's local control system utilised prototypes already delivered to ESO in order to assess the readiness of the design. This work included the revision of requirements and overall design, mainly power distribution, electronics and electronic cabinet design, culminating in a successful internal Preliminary Design Review during the last quarter of 2014. For the M1 segment subunits, the tendering process was completed at the end of 2014 with the selection of two companies, which won separate contracts for the development of a set of engineering and qualification models.

A new control strategy was developed using the E-ELT M5 scale-one prototype as a test bench. The aim of upgrading the M5 local control system was twofold: 1) to develop a flexible system which permits testing and verifying different control and active damping techniques; and 2) designing the M5 local control systems according to E-ELT design conventions and development standards for future developments of E-ELT local control systems. Active damping based on a positive feedback loop was successfully tested and the results presented at the SPIE 2014 conference in Montreal.

As well as regular support to the new instruments MUSE and SPHERE, those in upgrade (CRIRES+) and those under construction (GRAVITY and GALACSI), replacement boards for NACO (high voltage amplifier and avalanche photodiode) were designed and tested. These boards, based on field-programmable gate array technologies, are part of the department's efforts to address, together with the LPO team, the obsolescence of the VLT's major instrument electronics subsystems. Based on the principle of

Replacement avalanche photodiode board for NACO, based on field-programmable gate array technologies.



The prototype of the natural guide star detector delivered by e2v in its mounting.

developing pin-to-pin hardware/software compatible boards, significant progress has been made in finding a solution to replace the MACCON motion control driver boards. All of these boards should enter full production in the middle of 2015, in order to replace aging stock at Paranal and ensure proper operation for the next 10 to 15 years.

Work has substantially progressed in finding alternative power sources and/or cheaper solutions to the provision of electric power to all the observatory sites. Although permissions have not yet been granted, it is expected that the Chilean national grid will start to supply electricity to the Paranal and Armazones sites before the end of 2018. On La Silla a photovoltaic park and electricity supply system are being planned. Preliminary activities have already started onsite and construction work is expected to start in 2016. General support for electric power engineering, electromagnetic compatibility and safety-related compliance, lightning protection and electrical design has continued in the form of support to many ESO projects, among them instruments and sites, including the new Headquarters building. ESO technical specifications and international norms and standards have been applied, and will continue to do so, for ongoing and future projects. Operational support, e.g., in the electric power stability of the ALMA Observatory, has been one of the key activities in 2014.

One of the major events for the Detectors Group was the arrival of the first ESPRESSO detector, which belongs to the family of the largest monolithic charge-coupled devices (CCDs) in the world (9k by 9k, 10 µm pixel size, 16 outputs). The detector achieved less than 3 electrons read-out noise with the New Generation Controller (NGC), and shows excellent cosmetic quality. A new detector mount for extremely stable detector performance at the nanometre level to measure radial velocity down to 10 cm s^{-1} precision with the ESPRESSO spectrograph was designed and constructed in-house.

In the area of visible wavefront sensing, zero read noise, high frame rate (1000 frames per second), CCD220 L3Vision sensors have been deployed in the adaptive optics wavefront sensor cameras of the SPHERE instrument and in GALACSI and GRAAL. A new revision of the prototype quarter-sized 880 × 840 pixels natural guide star detector, with a view to the more ambitious 1760 × 1680 pixels laser guide star detector for the E-ELT, has been delivered from e2v. The first images taken with these devices at frame rates of 700 frames s^{-1} have shown a readout noise below 3 electrons root mean square.

In the domain of infrared wavefront sensing, the noise-free HgCdTe electron avalanche photodiode arrays developed in collaboration with SELEX (UK) have matured and are now being deployed in the four wavefront sensors and in the GRAVITY fringe tracker. Due to a technological breakthrough, made possible by changing the growth process, all five liquid phase epitaxy science arrays of GRAVITY have been exchanged for metal organic vapour phase epitaxy science arrays that do not need deep cooling and can operate in vibration-free nitrogen bath cryostats. The arrays have excellent cosmetic quality at avalanche photodiode gains of up to 150. This technology is only available in Europe and will revolutionise infrared wavefront sensing and fringe tracking.

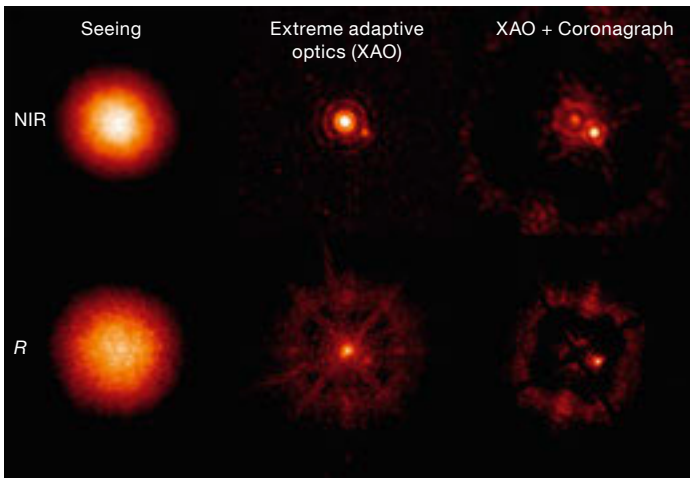
Systems Engineering Department

The department comprises four groups (Adaptive Optics, Instrument Systems, Systems Analysis and Systems Engineering Processes and Standards) covering all essential engineering functions, including requirement engineering, verification, disciplinary integration and technical coordination, system architectural design and system analysis. Its services are employed in adaptive optics, instruments, telescopes and infrastructure projects. The work of the Instrument Systems Group features prominently in many of the projects described in the Programmes section (see p. 48).

Adaptive Optics

The mission of the Adaptive Optics Group is to provide the ESO community with globally competitive ground-based adaptive optics observing capabilities, overcoming the limitation of atmospheric turbulence.

The heart of the SPHERE instrument, successfully commissioned during 2014, is its extreme adaptive optics system, SAXO, developed by the French aerospace research agency, ONERA, in collaboration with ESO, who supplied the novel low light level CCD wavefront sensor cameras, the deformable mirror and the SPARTA real-time computer. SAXO virtually removes the optical degradations introduced by the atmosphere and restores space-observatory-like image quality. The corrected image of a star is largely dominated by the Airy ring structure, which is then removed by a coronagraph. SAXO is capable of delivering unprecedented image quality from optical to near-infrared wavelengths for stars brighter than approximately magnitude 10 at the VLT and still has significant image improvement for stars as faint as 14.



Achernar (α Eridani) observed with SPHERE; the companion, 70 times dimmer than the main star, is clearly observed when the coronagraph is used. The separation of the two stars is 0.15 arcseconds and the seeing was 0.7 arcseconds. Near-infrared (NIR): *H*-band (1600 nm); visible: *R*-band (650 nm).

SLODAR during commissioning on Paranal.

GRAAL was extensively tested on ASSIST, together with the deformable secondary mirror. ASSIST allows realistic observing conditions to be simulated, thus to assess and optimise the performance of GRAAL. Using Octopus, the powerful numerical simulation facility developed within the AO group during the past decade, it has been possible to validate the experimental results obtained with ASSIST. The agreement between simulation and laboratory results for both single conjugate AO and for ground layer AO is good, and gives confidence in the reliability of the AO simulations and in the performance that can be achieved by GRAAL.

After two years of work to bring it to Paranal standards, the SLODAR (SLOpe Detection and Ranging) instrument, designed and built at the University of Durham, was commissioned at Paranal as part of the upgrade of the VLT astronomical site monitor to support AOF operation. SLODAR allows the fraction of the turbulence in the ground layer, which could be removed by the AOF in wide-field mode, to be estimated. The new VLT astronomical site monitor will improve science observation support through its ability to distinguish turbulence travelling at high and low altitudes.

Systems Analysis

The Systems Analysis Group is composed of AO experts and systems analysts involved in the E-ELT effort since Phase B. The group provides support primarily for the E-ELT project in the areas of performance budgets, control strategy and interfaces to instruments. It also develops expertise within ESO in the control of segmented mirrors.

In the framework of ESO's access to technical time at the Gran Telescopio Canarias, the group demonstrated an innovative bicolour phasing procedure, which consolidates the E-ELT baseline, inherited from the experience with the segmented mirror of the Keck Telescope and mitigates some of the risk with the phasing of the E-ELT primary mirror.

Processes and Standards

The Processes and Standards Group provided systems engineering support to the E-ELT programme during 2014. The work focused on the definition of systems engineering processes for the development of the E-ELT system and support for E-ELT programme engineering in the coordination of technical activities.

A number of procedures defining the processes for requirements and interface management, configuration and documentation management, as well as system verification were produced and became active. These procedures define a number of E-ELT systems engineering activities, e.g., change request management, organisation and conduct of engineering reviews.

In the coordination of E-ELT technical activities, the aim is to ensure a consistent system-wide approach. The work during the year concentrated mainly on supporting the preparation of technical specifications and interface control documents for the procurement of several subsystems. Also, critical system-level activities like the preparation of the technical budgets were supported.

The approach to the above activities has been developed with a view to the main challenge for 2015, that of defining a broad systems engineering framework for ESO, starting from that adopted for the E-ELT.

Optics and Photonics Department

The department supports ESO's projects in the area of optical design for telescopes and instruments, active optics and wavefront control, metrology for telescope alignment, laser guide stars, optical fibre technology, integration and testing of instruments. The department also manages the optics laboratories and the integration facilities.

Some investigations and tests were conducted to assess the performance of modern high accuracy laser metrology systems. This was in the context of monitoring the E-ELT inter-mirror positions and mitigating the risk of blind acquisition failure, and helping to detect misalignments that cannot be unambiguously captured by the wavefront sensors.

Work continued on improvements to the VST. First-order stray light baffling was completed and led to significant reductions in stray light in the VST images. The existing image analysis algorithm used by the VST active optics was upgraded with a new library of aberration modes

Aitor Bereciartua (IAC)

The laser launch telescope for the ESO Wendelstein laser guide star unit under demonstration at the Teide Observatory.

and a new calibrated measurement of linear astigmatism. On-sky validation tests showed that the rotation of the VST M2 about its coma-neutral point can be controlled to an accuracy of ~ 3 arcseconds. Based on these results, a new operational version of the image analysis software is planned in the first half of 2015. Promising alternative means of measuring telescope perturbations were developed and tested on sky, by direct analysis of science images using patterns of spot sizes and ellipticities across the field. This method, which does not require additional hardware, could prove to be a robust and reliable alignment tool, also useful for other projects.

In the area of laser guide stars, a team of astronomers and engineers from ESO, the Instituto de Astrofísica de Canarias, the Gran Telescopio CANARIAS and INAF Osservatorio Astronomico di Roma achieved first light and successful commissioning of the ESO Wendelstein laser guide star system at the IAC's Observatorio del Teide on Tenerife in Spain. Following an agreement in April 2014 between ESO and the IAC, the infrastructure required for the experiment was built at the observatory. The team carried out the installation and commissioning of the ESO Wendelstein laser guide star unit, the receiver system and the automated observing software. These joint activities are research and development studies to optimise the laser guide star return brightness from the upper atmosphere, with special attention being paid to the influence of the geomagnetic field on the performance.

Participants at the Instrument Control Systems seminar in Garching, October 2014.

Control Software and Engineering Department

The work on the PLC project (programmable logic controller) was concluded, resulting, on the formal side, in a definition of ESO PLC standards to be released in 2015 and on the technical side, in a set of standard application cases for PLCs. These applications are now available for internal users as well as outside partners for VLT and E-ELT instruments.

The applications were presented in the Instrument Control Systems 2014 seminar that took place 20–24 October in Garching. The aim of the seminar was to present the new hardware and software standards being adopted to the VLT instrument developers from ESO partner institutes, as well as to give a status update on consolidated systems, like NGC and SPARTA. The seminar consisted of presentations and two days of hands-on exercises where participants had the opportunity to gain practical experience controlling instrument functions.

The ALMA Common Software (ACS) is the software infrastructure used to develop the ALMA distributed software. The ACS is mainly maintained through an industry contract. The 11th ACS workshop was held in Garching from 4–6 November 2014. The ACS, released under the GNU Lesser Public License, has been adopted by a number of other telescopes as the framework within which to develop their control software. Most of the attendees of this part of the workshop came from external projects adopting ACS to develop their distributed control software, including ARIES21 for the 40-metre Radio Telescope, the Cherenkov Telescope Array, the Long Latin American Array, the Sardinia Radio Telescope and Universitätssternwarte Bochum.

The open source tool Jenkins was selected as the basis for future automated test

Participants at the 11th ALMA Common Software Workshop in Garching, November 2014.

environments within ESO. A prototype activity with Jenkins was started in the VLT software environment on the NRI (night run infrastructure), an internally developed system, which has been in use for VLT and ALMA software for many years. With low effort the NRI could be replaced by Jenkins to run the VLT software. Jenkins is not only a one-to-one replacement, but also brings additional benefits. For example the runtime of a complete test cycle in Jenkins could be reduced due to parallelism to about eight hours (compared to ~ 16 hours in NRI). Besides VLT software, Jenkins is already used for the E-ELT as a test environment for the LabView code and in instrument control software for PLC testing.

A showcase for the excellent co-operation between the Directorates of Operations and Engineering was the upgrade of the VLT primary mirror cell/tertiary mirror tower. Obsolete hardware needed replacement and also the related control software had to be adapted. After intensive discussions on the best solution and proper preparation, the upgrade was performed on UT1 in November 2014. Tests have shown that UT1 performance was not impacted by the upgrade, and so upgrades to the other three UTs can follow during 2015.

Science Operation Software Department

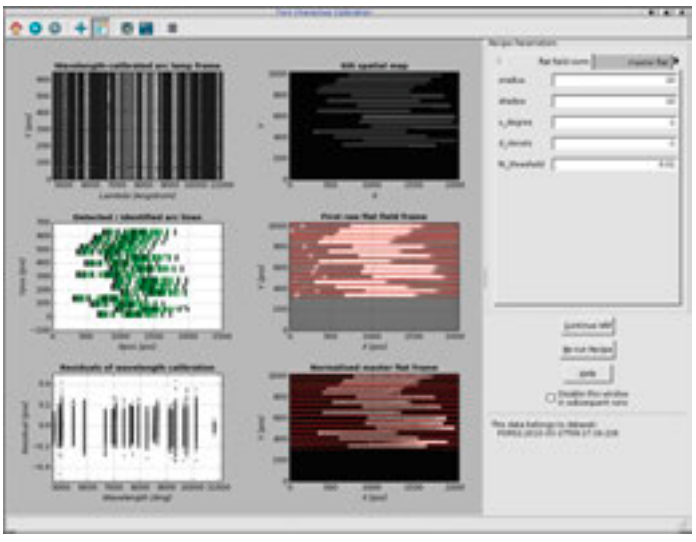
The Science Operation Software Department is responsible for the software for the end-to-end operations of the observatory. Science operations software includes all components required for proposal submission, scheduling, execution, archiving, processing, visualisation, and quality control of the observations. This software is used by operational teams for planning and running scientific operations, as well as by scientific users in the community for the handling of observing proposals, the preparation of observations, and the access and processing of observation data.

An important task of the department is to provide support to operational applications and several process improvements were defined in order to streamline the process and provide a better service to operation teams. In particular a single interface for problem reporting, based on Jira, will be used in the context of application support.

The Data Flow Infrastructure Group provided development resources to the VLT and ALMA dataflow projects, such as the ALMA source catalogue tool, the association of master calibrations to raw files to assist in locating calibration data in the Science Archive Facility and laser collision detection for Paranal. One of the highlights of 2014 was the deployment of ALMA integrated reports, which collate information about science operations from a variety of sources, providing the Director and the Board with up-to-date information about the observatory's efficiency.

After successful commissioning and Science Verification in 2014, the SPHERE pipeline is currently undergoing validation with respect to quality control parameters, robustness and reduction speed. The SPHERE pipeline comprises three separate reduction cascades, one for each of the instrument arms, in effect three different pipelines.

In the context of the multi-object spectra project as part of the Science Data Products, a major effort has been carried out to improve the science quality of the reduced FORS2 spectroscopic multi-object spectra data (multi-slit, multi-object and long slit). All the main algorithms of the pipeline were reviewed and a comparison with other state-of-the-art multi-object spectra pipelines was carried out,



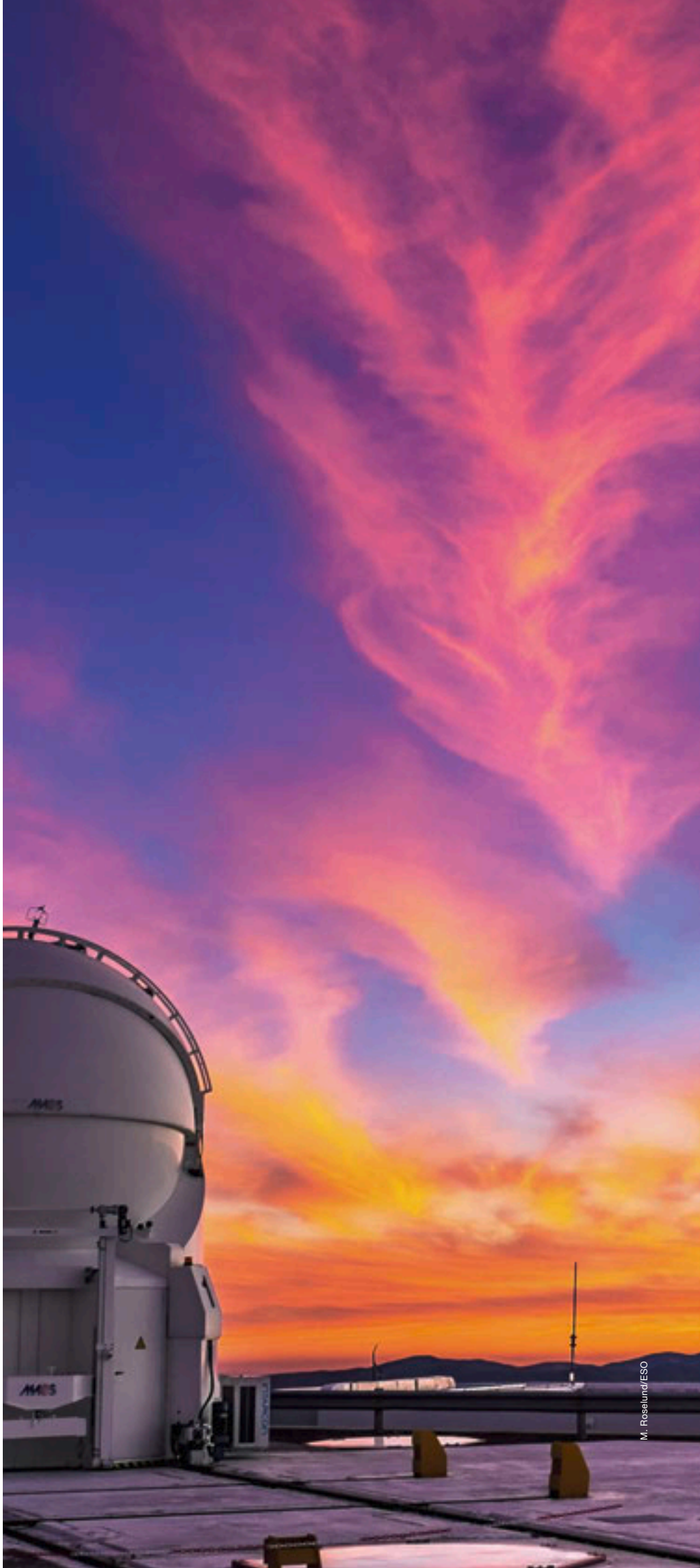
Screenshot of one of the interactive windows of the FORS2 spectroscopy Reflex workflow. The windows provide information about the quality of the wavelength calibration, slit tracing and flat-field normalisation, while the tabs on the right allow the user to change parameters and rerun the recipe.

demonstrating the currently adopted autocalibration approach. The spectroscopic pipeline can now be executed within the Reflex environment using a provided workflow, which greatly simplifies the organisation of the data, quick inspection of pipeline products and fine-tuning of recipe parameters with interactive displays. The pipeline implements full error propagation using the statistical uncertainties associated to most of the processing steps.

The commissioning of the VLT dataflow software comprised the upgrade of 15 dataflow system workstations to 64-bit scientific Linux 6.3, as well as the installation of patch releases on three data transfer workstations. The entire upgrade went very smoothly and completed a major milestone for the homogenisation of the dataflow system. Technological solutions were also studied with IT to streamline the deployment of applications using standard Unix installation tools, in order to simplify support to the operational groups.

Information Technology Department

The IT Department consists of four groups: IT Group Chile and IT Group Garching, supported by IT Strategy and Governance and the IT Central Service Desk. The IT groups in Chile and Garching are responsible for day-to-day IT support of ESO users and the science archive in Garching and observatories in Chile. The department completed numerous IT projects, such as the implementation of Eduroam, the telephone upgrade at the ESO Guesthouse, the refurbishment of the data centre at Vitacura, and a global network design. IT Strategy and Governance has provided support to the department in completing calls for tender for laptops and desktops, the backup system in Garching and IT out-tasking in Chile and Garching. The IT Central Service Desk and Procurement manage day-to-day helpdesk queries and are responsible for IT procurement.



The Sun setting over the Pacific Ocean paints the wavering ribbons of cloud overhead and the VLT platform below in surreal hues.

This image, taken by OmegaCAM on the VLT Survey Telescope at Paranal, shows a section of the Ara OB1 stellar association. In the centre of the image is the young open cluster NGC 6193, and to the right is the emission nebula NGC 6188, illuminated by the ionising radiation emitted by the brightest nearby stars.

Administration

ESO/E. Grafl

ESO Headquarters in Garching, Germany, seen from above. The original Headquarters building, the extension offices and the new technical building are all visible.

Industry showed a strong interest in the start-up activities for E-ELT procurements. An industry day was organised in Austria and two events were held in Garching, one for Czech industry and one dedicated to the M1 segment support for the E-ELT. The contract for the road and the platform on Armazones is progressing well and the call for tender for the dome and main structure was released.

In December, ESO and the Consortium L y D–Axis, consisting of the Chilean companies Constructora L y D S.A. and Axis Desarrollos Constructivos S.A., signed the contract for the construction of the ALMA Residencia. Two contracts were also signed to connect La Silla, Paranal and Armazones to the Chilean electrical grid.

The Contracts and Procurement Department released some new processes and procedures. Among them was a procedure on the collaboration with institutes that regulates the process for the selection of institutes for consortia to build instruments.

After the successful move of staff from the Max Planck premises to the Headquarters building, the old offices were renovated and returned. The temporary buildings were sold and removed in preparation for the construction of the ESO Supernova Planetarium & Visitor Centre for which the German authorities granted the building permit.

ESO/Luis Calçada

Removal of the temporary office buildings at ESO Headquarters. This image shows them being dismantled, and captures both the beginning, and end, of an era.

The Administration team in Chile was successful in selling an ESO property in La Serena, which was no longer in use. Together with some logistical streamlining, this has helped to improve the financial situation.

Safety aspects were involved in the preparation and move into the Headquarters extension building, which took place during the first quarter of 2014. The E-ELT dome and main structure tender required significant input with regard to safety-related engineering disciplines. The experience gained in this process has allowed further refinement of the conformity assessment policy, with consequent wide application throughout the E-ELT programme and elsewhere in the organisation and its projects.

Ten years ago, on 2 June 2004, the Enterprise Resource Planning system commenced operations and since then has been expanded with a series of improvements and additional functionalities. In the course of 2014, among other developments, the supplier database for the procurement team was updated, and access via web pages and an e-learning platform was implemented.

Architectural rendering of the future ALMA Residencia. View of the interior yard, between the dormitory buildings.

ESO/Rigotti + Simunovic Arquitectos

Architekten Bernhardt + Partner (www.bp-da.de)

Artist's impression of the ESO Supernova Planetarium & Visitor Centre. Construction is funded by the Klaus Tschira Stiftung and it will be run by ESO.

Finance and Budget

Financial Statements 2014

Accounting Statements 2014
(in €1000)

Statement of Financial Position	31.12.2014	31.12.2013
Assets		
Cash and cash equivalents	22 045	4 208
Inventories, receivables, advances and other current assets	23 066	25 279
Non-current assets	1 069 676	1 058 053
Total Assets	**1 114 787**	**1 087 540**
Liabilities		
Short-term borrowing	0	20 000
Payables, advances received and other current liabilities	65 261	54 057
Non-current liabilities	504 281	306 374
Total Liabilities	**569 542**	**380 431**
Accumulated surpluses/deficits	641 538	660 310
Pension fund loss/gain	–98 157	65 571
Other changes in net assets	–	–
Net surplus/ deficit for the year	1 864	–18 772
Total Net Assets	**545 245**	**707 109**
Total Liabilities and Net Assets	**1 114 787**	**1 087 540**

Statement of Financial Performance	2014	2013
Operating Revenue		
Contributions from Member States	151 086	143 668
Contributions to special projects	9 213	6 226
In-kind contributions	7 506	1 313
Sales and service charges	2 333	3 432
Other revenue	662	611
Total Operating Revenue	**170 800**	**155 250**
Operating Expenses		
Installations and equipment	1 705	3 858
Supplies and services	47 670	44 246
Personnel expenses	68 081	74 492
Depreciation of fixed assets	60 446	53 955
Other operating expenses	839	844
Total Operating Expenses	**178 741**	**177 395**
Net Surplus/Deficit from Operating Activities	**–7 941**	**–22 145**
Financial revenue	2 495	2 490
Financial expenses	1 000	1 270
Net Surplus/Deficit from Financial Activities	**1 495**	**1 220**
Non-periodic and extraordinary revenue	8 310	3 192
Non-periodic and extraordinary expenses	–	1 039
Net Surplus/Deficit from Non-periodic and Extraordinary Activities	**8 310**	**2 153**
Net Surplus/Deficit for the Period	**1 864**	**–18 772**

Cash Flow Statement	2014	2013
Cash Flow		
Net receipts	173 615	162 805
Net payments	–135 778	–171 937
Net Cash Flow from Operating Activities	**37 837**	**–9 132**
Net Cash Flow from Financing Activities	**–20 000**	**7 000**
Net Cash Flow = Net Increase/Decrease in Cash and Cash Equivalents	**17 837**	**–2 132**

Budgetary Reports 2014
(in €1000)

Income Budget	Budget	Actual
Contributions from Member States	166 884	169 843
Income from third parties and advances received	11 644	15 809
Other income	1 726	8 426
Consolidated entities	620	681
Total Income Budget	**180 874**	**194 759**

Expenditure Budget		
Programme	69 311	47 985
Technical infrastructure and production	8 254	7 908
Operations	73 643	72 208
Science support	8 460	7 776
General activities	26 562	25 600
Financing cost	124	99
Consolidated entities	697	642
Total Expenditure Budget	**187 051**	**162 218**

Budget for 2015
(in €1000)

Income Budget	2015
Contributions from Member States	173 487
Income from third parties	23 543
Other income	1 293
Consolidated entities	747
Total Income Budget (approved)	**199 070**

Expenditure Budget	2015
Programme	73 063
Technical infrastructure and production	8 389
Operations	70 235
Science support	7 969
General activities	25 401
Financing cost	52
Consolidated entities	867
Total Expenditure Budget (approved)	**185 977**

The External Auditors, Tribunal de Contas de Portugal*, have expressed their opinion that the financial statements for 2014 give a true and fair view of the affairs of the organisation.

The accounting statements for 2014 show a positive result of 1.9 million euros against a deficit of 18.8 million euros in 2013. It is composed of a result from operating activities of –7.9 million euros, a surplus from financial activities of 1.5 million euros and a positive impact from non-periodic activities of 8.3 million euros.

The net assets of the organisation at 31 December 2014 amount to 545.2 million euros.

The cash flow from operating activities in 2014 was positive by 37.8 million euros. The main payments were for the Headquarters extension building and first expenditures on the E-ELT, in particular for the road and platform. Receipts increased due to additional advance funding from Member States for the E-ELT and funds received from the Klaus Tschira Stiftung for the new visitor centre. Short-term loans taken up in 2013 were paid back and no borrowing was needed at the end of 2014. The cash position at 31 December 2014 was 22.0 million euros.

ESO Council approved the budget for 2015 in December 2014. The approved 2015 expenditure budget amounts to 186.0 million euros. The increase with respect to 2014 mainly reflects the start of the E-ELT Phase 1 as well as the construction of the visitor centre. It also covers commitments for the current Paranal instrumentation programme and for the ALMA Residencia.

The 2015 approved income budget amounts to 199.1 million euros. It includes the regular contributions from the ESO European Member States, income from third parties and partners, and other income as well as additional income for the E-ELT from all Member States and funding from the Klaus Tschira Stiftung for the visitor centre. Conditional income from Brazil and Poland will be added as soon as these countries have completed their respective ratification procedures.

* Antonio José Avérous Mira Crespo (Judge of the Portuguese Court of Auditors), Maria da Luz Carmezim (Head of Audit Department), Filomena Maria de Oliveira Rolo (Auditor), Nuno Martins Lopes (Auditor).

Coated in a layer of ashen dust and littered with heavy equipment vehicles, the peak of Cerro Armazones appears conspicuously flattened as work continues to craft a platform for the European Extremely Large Telescope.

ESO/G. Hüdepohl (atacamaphoto.com)

Human Resources

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

- Planning and definition of overall personnel resources policy and strategy;
- Coordination of the recruitment and selection procedure;
- Employment contracts;
- Support to employees with regard to implementation of the applicable rules, regulations and contractual terms;
- Maintenance and storage of personnel records;
- Occupational health and welfare;
- Social security matters;
- Training and professional development;
- Family matters connected with employment contracts, including day-care and education provision at the European School Munich.

Collective bargaining

Preparation for the collective negotiations for Local Staff Members took place during much of 2014, and included a salary study and review of working conditions in Chile. On 30 September 2014, the union proposal for the collective contract was received, marking the starting date of the negotiation process. The latter part of October was devoted to the preparation of statistical information, formal presentations to the union and an initial answer to the collective contract proposal. Several bargaining meetings with union directives (Paranal/La Silla) then took place during the first three weeks in November. The collective bargaining process was successfully concluded within the established schedule and the contract was signed for a two-year period (2014–2016).

Performance management and professional development

The performance management and professional development (PMPD) programme was further strengthened in 2014 in the following areas:

- The roles and responsibilities concerning performance management within a matrix structure were specified in more detail;
- For staff members who work in a matrix structure, the feedback provider participates in parts of the annual review meeting as needed;
- The process of managing partial performance has been clarified;
- In encouraging a wider use of the self-reflection form, emphasis is now laid on focusing on the plan for professional development during the performance review meeting.

Human Resources delivered several training sessions to managers and staff to reinforce the performance management and professional development process. The quality of these reviews has clearly improved and advances have been made in managing underperformance. There is now also a clearer link between PMPD and the learning and development process and the ESO Competency Framework.

Fair treatment, courtesy and respect policy

The ESO policy regarding fair treatment, courtesy and respect has been revised together with ESO Management to take into account the experiences of working with it over the last few years.

The role of the mediator and HR harassment advisor has been defined in more detail and an external contact person is now available for members of personnel (one for Garching and one for Chile). The external contact person, just like the internal harassment contact person, is impartial and her/his role is to provide information and guidance to members of personnel who feel they are not being fairly treated, members of personnel accused of harassment, members of personnel who indicate they have witnessed harassment, or others seeking support related to harassment issues.

Regular review — conditions of employment

As foreseen in the ESO Staff Regulations, a regular review can be initiated by Council, or by the Tripartite Group established by Council, to consider the nature of the employment conditions, and to benchmark, collate and analyse relevant data from other organisations or private industry. A working group comprising members from the Tripartite Group, the International Staff Committee and HR was set up and met throughout 2014. A data collection enquiry was distributed to twelve reference organisations covering the following aspects:

- Real movement in net remuneration for the period 2006–2013;
- Basic salary levels as per 2013;
- Remuneration, social security and social conditions for ESO Fellows and PhD Students;
- Comparison of allowances, indemnities, reimbursements and other payments;
- Working time and social conditions;
- Annual indexation of salaries.

The deadline for replies to this data collection was set at July 2014 and a preliminary report was presented to the Tripartite Group in September 2014. Further follow-up is foreseen at the beginning of 2015.

Munich Dual Career Office

Human Resources are in regular contact with the Munich Dual Career Office to support spouses of international employees during their job search in the Munich area.

Gender in ESO

A presentation on Gender in ESO took place in March given by HR and a representative from the Directorate for Science. The main topics covered were: the example to be set by managers at all times in meetings and through their actions; freezing of posts for fellows in Chile during unpaid maternity leave; fellowship scheme for engineers; and improvements in work/life balance issues in general.

Girls' Day at ESO Headquarters

On 27 March 2014, ESO opened its doors to 50 female school students, aged between 10 and 17, to give them an insight into science and technology professions

within the organisation, and thereby to encourage them to choose such careers in the future.

The 50 students were split into eight groups, with each group focusing on two engineering / technical topics (one of them in the laboratory) and one astronomical topic. With one hour for each topic, the girls could participate in experiments and engage in discussions. The girls actively participated and informal positive feedback was received.

Recognition for 25 and 35 years of service

In 2014, seven staff members celebrated 25 years of service and three celebrated 35 years of service.

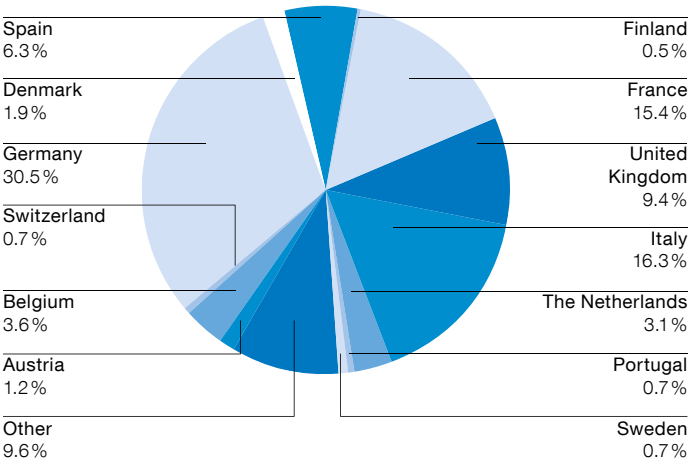
Recruitment, selection and reassignment

During the year, 42 vacancy notices were published prompting a total of 1470 applications. The number of recruitment campaigns completed according to contract type were as follows:

Contract type	No. of campaigns	No. of applications
International Staff Members	31	1035
Local Staff Members	9	230
Fellows	2	205

All positions were advertised on the ESO Recruitment Portal. For International Staff 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. All ESO advertisements contain a statement regarding the commitment to equal opportunities.

Within the ESO Fellowship Programme, six applicants were selected with duty station in Chile and four for Garching. Furthermore, six candidates were awarded ESO Studentships in Europe and four in Chile.



Distribution of International Staff Members by nationality at 31 December 2014.

In addition, seventeen members of personnel in Garching and four in Chile were reassigned internally due to operational re-configuration, or upon request.

Employee relations and communications

Human Resources continues to have regular consultations and discussions with the International Staff Committee and the unions in Chile.

In the course of the year, the Rehabilitation Boards examined one case concerning incapacity, illness and procedural actions and an Advisory Appeals Board was appointed.

Collaboration and representation of HR

ESO HR has participated in monthly meetings of the ALMA Human Resources Advisory Group giving advice on union and appointment matters.

During two meetings in 2014, the Tripartite Group dealt mainly with the developments of the CERN Pension Fund, matters related to the Staff Rules and Regulations and the annual review on salary adjustments.

Learning and professional development

Follow-up after 360° Feedback

Human Resources focused in 2014 on the development of the organisation's middle management (Department and Group heads) through the delivery of tailored development activities that addressed key areas of the 360° Feedback:
- Managing difficult conversations;
- Managing upwards;
- Delegation skills;
- Conflict management;
- Time management.

Coaching is considered as a further development of the 360° Feedback, and HR is investigating the establishment of a structured approach towards coaching, through use of external coaches.

Fellow Development Programme

The year 2014 also marked the roll-out of the Fellow Development Programme, designed by Human Resources in collaboration with fellows and the heads of the Offices for Science. The aim of the programme is to offer learning opportunities for ESO's postdocs to develop their interpersonal and employability-related skills and competencies, providing the scientific community with well-trained fellows.

Health and welfare and social security

CERN Pension Fund

A new pension scheme with the CERN (European Organization for Nuclear Research) Pension Fund for staff members and fellows was introduced to new recruits as of January 2014. The conditions are:
- Contributions and benefits continue to be paid in Swiss francs;

– Contributions are based on actual ESO salaries converted into Swiss francs at market rate;
– Retirement pensions are based on the final reference salary using the average exchange rate over the career.

The Annual Information Meeting of the CERN Pension Fund took place at ESO Headquarters in September.

Health insurance

Several amendments to the health insurance scheme were made in order to adjust and update the medical coverage to the needs and/or the developments of health care in the Member States.

HR advice and administration

HR also handles a wide spectrum of personnel-related activities. As an integral part of this service, a variety of pertinent documents and circulars have been produced and issued.

Staff departures

The departures of staff in 2014 fall into the following categories:

Reasons	Staff Member	Local Staff Member
Resignation	8	3
Expiry of contract	12	0
Retirement	2	3
Mutual agreement	3	0
Death	1	0
Total	26	6

Within RCW 34 — located in the southern constellation of Carina — a group of massive young stars hide in the brightest region of the cloud.

List of Staff

As of 31 December 2014

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

Emeritus Astronomers

Thijs de Graauw
Robert Fosbury
Sandro D'Odorico
Massimo Tarenghi

Directorate of Administration

Patrick Geeraert

Patricia Adriazola
Andres Oldemar Arias
Angela Arndt
Katalin Baltayne Korompay
Roland Block
Anita Bode
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
Robert Hamilton
Charlotte Hermant
Georg Junker
Nathalie Kastelyn
Katarina Kiupel
Katjuscha Lockhart
Ignacio Lopez Gil
Rodrigo Lorca
Qiao Yun Ma
Maria Madrazo
Alessandro Martis
María Angélica Moya
Christian Muckle
Hélène Neuville
Claudia Ober
Ester Oliveras
Ernesto Orrego
Betül Özener
Thomas Penker
María Francisca Pérez
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
Steffi Steins
Orsolya Szécsényi
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 Méndez
Paola Amico
Luigi Andolfato
Javier Eduardo Argomedo Zazzali
Gerardo Ávila
Andrea Balestra
Pascal Ballester
David Bargna
Pablo José Barriga Campino
Domenico Bonaccini Calia
Henri Bonnet
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
Bernard-Alexis Delabre
Françoise Delplancke-Ströbele
Nicola Di Lieto
Canio Dichirico
Martin Dimmler
Robert Donaldson
Dario Dorigo
Reinhold Dorn
Mark Desmond Downing
Michel Duchateau
Philippe Duhoux
Christophe Dupuy
Toomas Erm
Siegfried Eschbaumer
Michael Esselborn
Sylvie Feyrin
Gert Finger
Gerhard Fischer
Vincenzo Forchi
Robert Frahm
Christoph Frank
Armin Gabasch
Fernando Gago
César Enrique García Dabó
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
Gerald Hechenblaikner
Florian Heissenhuber
Guy Hess
Renate Hinterschuster
Ronald Holzlöhner
Stefan Huber
Georgette Hubert
Evi Hummel
Derek James Ives
Olaf Iwert
Gerd Jakob
Bogdan Jeram
Paul Jolley
Andreas Jost
Yves Jung
Dimitrios Kalaitzoglou
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
Mervi Johanna Lampinen
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
Antonio Ignacio Molina Conde
Michael Müller
John Murray
Michael Naumann
Lothar Noethe
Ralf Palsa
Moreno Pasquato
Jérôme Paufique
Marcus Pavez
Federico Pellegrin
Martine Peltzer
Lorenzo Pettazzi
Thomas Pfrommer
Duc Thanh Phan
Werther Pirani
Dejan Popovic
Eszter Pozna
Marco Quattri
Jutta Quentin
Andrew Rakich
Roland Reiss
Javier Reyes
Robert Ridings
Jesús Rodríguez Ulloa
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
Helmut Tischer
Rodrigo Javier Tobar Carrizo
Mirko Todorović
Sebastien Tordo
Stefano Turolla
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
Itziar De Gregorio Monsalvo
William Dent
Giorgio Filippi
Diego Alex García
Serge Guniat
Tracey Hill
Jorge Ibsen
Rüdiger Kneissl
Stéphane Leon Tanne
Gianni Marconi
Gautier Mathys
Lars-Åke Nyman
José Parra
Neil Matthew Phillips
David Rabanus
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Russell Smeback
Baltasar Vila Vilaro
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Catherine Vlahakis
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Erich Bugueno
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Michael Cantzler
Robin Capocci
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César Cárdenas
Giovanni Carraro
Duncan Castex
Mónica Castillo
Roberto Castillo
Susana Cerda
Claudia Cid
Lodovico Coccato
Franco Colleoni
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
Nathalie Fourniol
Michel Frantz
Wolfram Freudling
Eloy Fuenteseca
Dimitri Gadotti
Sergio Gaete
Julien H. V. Girard
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Edouard González
Jaime González
Javier Andrés González
Leonardo González
Sergio González
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Carlos Guerra
Stéphane Guisard
Jonas Haase
Nicolas Haddad
Juan Pablo Haddad
Pierre Haguenauer
Reinhard Hanuschik
Evanthia Hatziminaoglou
George Hau
Juan Pablo Henriquez
Cristian Herrera
Michael Hilker
Gerhard Hüdepohl
Rodrigo Huerta
Wolfgang Hummel
Christian Hummel
Elizabeth Humphreys
Valentin Ivanov
Nestor Jiménez
Petr Kabath
Ismo Kastinen
Thomas Klein
Carlos La Fuente
Francisco Labraña
Robert Alexander Laing
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
Ivan Muñoz
Sangeeta Mysore
Julio Navarrete
Mark Neeser
Hernan Nievas
Rodrigo Olivares
Francisco Olivares
Jared O'Neal
Juan Osorio
Juan Carlos Palacio
Laurent Pallanca
Rodrigo Javier Parra
Ricardo Nelson 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
Silvio Rossi
Felix Alberto Rozas
Laura Ruiz Zorrilla
Francisco G. Ruseler
Fernando Salgado
Ariel Sanchez
Sebastian Sanhueza
Pierre Sansgasset
Jorge Santana
Ivo Saviane
Erich Schmid
Linda Schmidtobreick
Ricardo Schmutzer
Nicolas Schuhler
Frédéric Schuller
Fernando Selman
Waldo Siclari
Peter Sinclaire
Nicolas Slusarenko
Alain Smette
Gerardo Smith
Jonathan Smoker
Christian Spille
Thomas Stanke
Christian Stephan
Michael Fritz Sterzik
Felix Stoehr
Sandra Strunk
Thomas Szeifert
Lowell Tacconi-Garman
Richard Tamblay
Gie Han Tan
Mario Tapia
Konrad Tristram
Josefina Urrutia
Guillermo Valdes
Elena Valenti
Jose Javier Valenzuela
Karen Vallejo
Mario Van Den Ancker
Eelco van Kampen
Pierre Vanderheyden
Paulina Venegas
Sergio Vera
Ignacio Vera Sequeiros
Jorge Vilaza
Zahed Wahhaj
Jeremy Walsh
Ueli Weilenmann
Luis Wendegass
Wolfgang Wild
Markus Wittkowski
Burkhard Wolff
Pavel Yagoubov
Véronique Ziegler
Gerard Zins
Elena Zuffanelli
Martin A. Zwaan

Directorate of Programmes

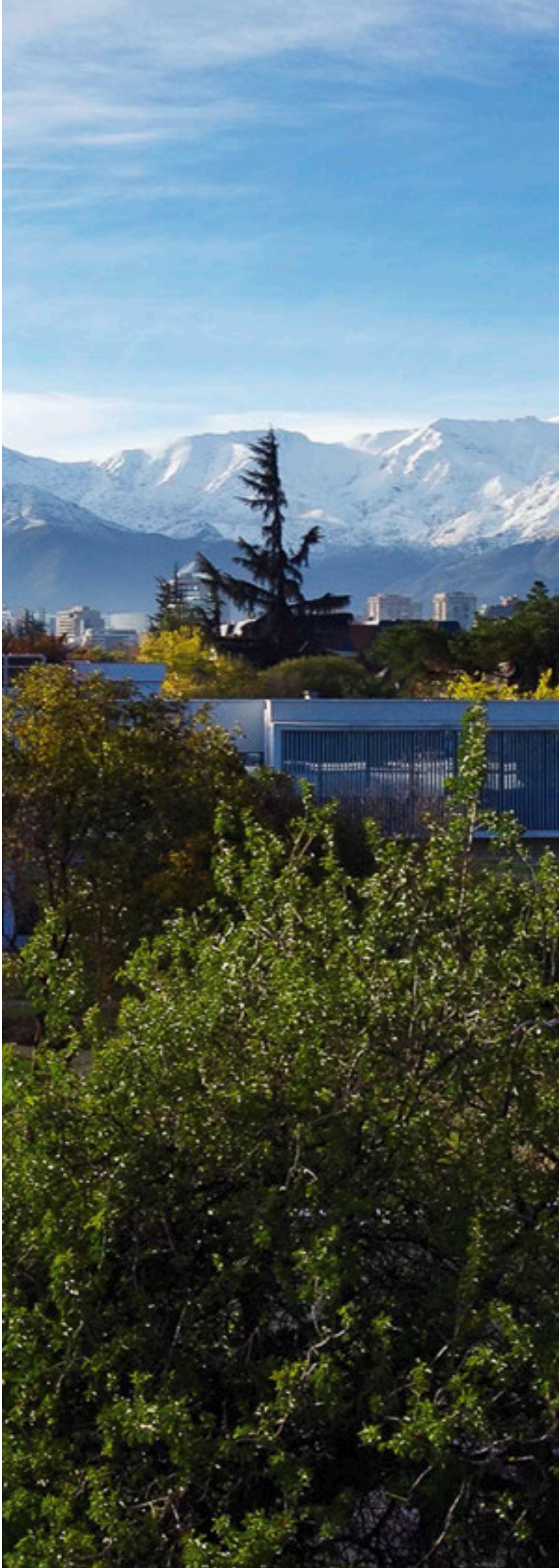
Adrian Russell

Robin Arsenault
Fabio Biancat Marchet
Claudio Cabrera
Mark Casali
Marc Cayrel
Frédéric Derie
Philippe Dierickx
Roberto Gilmozzi
Frederic Yves Joseph Gonte
Peter Murray Gray
Christoph Haupt
Volker Heinz
Norbert Hubin
Lieselotte Jochum
Florian Kerber
Bertrand Koehler
Nicholas Charles Kornweibel
Pascal Martínez
Katia Montironi
Luca Pasquini
Jean-François Pirard
Gero Rupprecht
Valérie Saint-Hilaire
Stefano Stanghellini
Josef Strasser
Donald Tait
Roberto Tamai
Gianluca Verzichelli

Directorate for Science

Robert Julian Ivison

Rebeca Aladro
Susana Almagro García
Julian David Alvarado Gomez
Joseph Anderson
Mathias André
Suryashree Aniyan
Maryam Arab Salmani
Vinodiran Arumugam
Daniel Asmus
Dietrich Baade
Juan Carlos Beamin
Jean-Philippe Berger
Matthieu Bethermin
Jutta Boxheimer
Pamela Bristow
Stella-Maria Chasiotis-Klingner
Roxana-Adela Chira
Lars Lindberg Christensen
Silvia Cristiani
Gergely László Csépány
Joana Mafalda da Cruz Carmo Martins
Jozua de Boer
Claudio De Figueiredo Melo
Marco De Pascale
Suhail Dhawan
Eric Emsellem
Steve Ertel
Anja Feldmeier
Maud Muriel Galametz
Stephan Geier
Neale Gibson
Adam Ginsburg
María Eugenia Gómez
Luis Goncalves Calçada
Oscar A González
Uta Grothkopf
Jason Harley Grunhut
Adrien Guerou
Nicolas Guillard
Bitten Gullberg
Claudia Patricia Gutiérrez Avendaño
Lizette Guzman
Olivier Hainaut
Xavier Haubois
Richard Hook
Renate Elisabeth Hoppe
Bernd Husemann
Gaitee Hussain
Soh Ikarashi
Katharina Immer
Laura Inno
Edmund Janssen
Izaskun Maite Jiménez Serra
Paulina Jirón
Evelyn Johnston
Darshan Kakkad
Tomasz Kaminski
Muhammet Emin Karabal
Hans-Ulrich Käufl
Wolfgang Kerzendorf
Martin Kornmesser
Thomas Krühler
Harald Kuntschner
Claudia del Pilar Lagos Urbina
Bruno Leibundgut
Jochen Liske
Gaspare Lo Curto
Kate Louise Maguire
Michaël Marsset
Luca Matrà
Anna Faye Mc Leod
Melissa McClure
Silvia Meakins
Andrea Mehner
Julien Milli
André Müller
Juan Carlos Muñoz-Mateos
Koraljka Muzic
Gaël Noirot
Paolo Padovani
Ferdinando Patat
Lura Katherine Pitchford
Gergely Popping
Farid Rahoui
Suzanne Ramsay
Javier Adrián Rodón
Francisco Rodríguez
Paula Valentina Rodríguez
Markus Schöller
Christine Schulz
Elyar Sedaghati
Raquel Yumi Shida
Matthew Shultz
Ralf Siebenmorgen
Jason Spyromilio
Matthew Taylor
Marco Tazzari
Leonardo Testi
Svea Teupke
Laura Ventura
Joël Daniel Roger Vernet
Ruud Visser
Karina Theresia Voggel
Ke Wang
Yue Wang
Linda Watson
Roger Wesson
Julien Woillez
Siyi Xu
Bin Yang
Tayyaba Zafar
Sarolta Zahorecz
Herbert Zodet

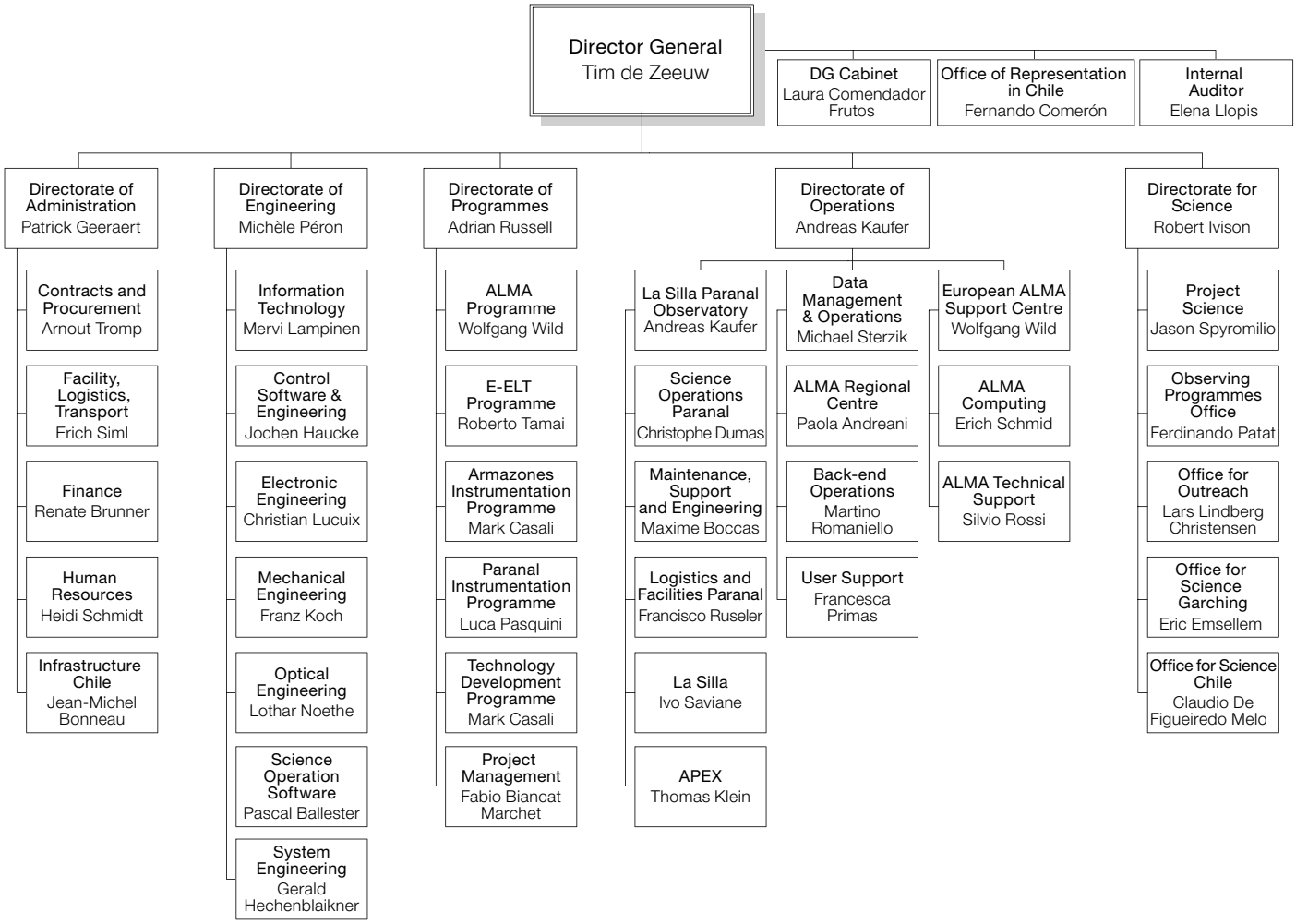


The ALMA Santiago Central Office, located in Vitacura, plays host to astronomers, technicians and administrative staff. Some 15 kilometres off, in the background of this image, the beautiful snow-capped peaks of the Chilean Andes are visible.

ESO/J. Girard

Organigram

Organisational Structure December 2014



This colourful view of the ALMA array shows the Milky Way shining high above the antennas. The array allows astronomers to address some of the deepest questions of our cosmic origins.

Y. Beletsky (LCO)/ESO

Director General Support

ESO's Director General, Tim de Zeeuw at the 223rd AAS Meeting which was held in Washington DC, 5–9 January 2014.

The Cabinet of the Director General, the Office for the ESO Representation in Chile and the Internal Audit Office work together to support the Director General. The Cabinet brings 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 — are not covered within the structure of the Directorates. These include the areas of legal affairs, internal communication, corporate risks and intellectual property management, international affairs, the Council Secretariat and Cabinet Office and protocol. Within these areas of expertise, the Cabinet additionally supports the ESO Council and Finance Committee and the ESO Management Team, as appropriate, in the development and implementation of ESO's overall strategy.

Signature of the agreement between ESO and the company Grupo SAESA to connect the sites at Cerro Paranal and Cerro Armazones to the Chilean electric power grid.

Legal affairs

One of the main tasks of the Office of Legal and International Affairs this year was to assist in the development of the E-ELT Way Forward, independent of progress of the ratification of the Brazilian accession agreement to ESO. In the process, several meetings, both within ESO Management and with the E-ELT Working Group set up by Council, took place as well as several iterations with the Finance Committee (FC) and the STC. All the input and comments were considered in the corresponding document, which Council used, in December 2014, as the basis for its approval of the construction of the E-ELT in two phases. As one of the major construction activities for the E-ELT, the Office of Legal and International Affairs further supported the Project Office and the Contracts and Procurement Department in the preparation and release of the calls for tender for the E-ELT dome and main structure.

After several years of negotiations and following more meetings and iterations in 2014, the Trilateral Agreement concerning operations of ALMA with the partners at the National Science Foundation (US) and the National Institutes of Natural Sciences (Japan) could be finalised. ESO Council approved the agreement in December and the corresponding approval processes of the partners have started. With the top-level objectives, structure and principles of ALMA operations in place, the review of all related agreements, policies and procedures has begun — a task within ESO led by the Cabinet. In particular, the negotiations on the management agreement between the three ALMA Executives, AUI, ESO and NAOJ have commenced, with first meetings at the end of 2014.

For the Office of Legal and International Affairs in Chile, beyond the regular task of providing assistance in all legal matters to the ESO Representation in Chile, one of the main areas of work in 2014 was to assist the Directorate of Engineering in the negotiation and signature of contracts regarding the supply of electricity to La Silla and Paranal. In the same context, Legal Affairs in Chile provided support in the environmental study of the gas pipeline project to the ALMA site.

As in previous years, the Cabinet closely collaborated with the Directorate of Administration, in particular the Human Resources and the Contracts and Procurement Departments and, *inter alia*, provided support with internal appeals and complaints before the Administrative Tribunal of the International Labour Organisation, and with an update of the Staff Rules and Regulations and specific contractual issues.

Internal communication

The Internal Communication Office continued working to strengthen and coordinate internal communication across ESO. In addition to advising ESO Management and others on internal communication in general, the Internal Communication Office continued to run the internal announcements and internal newsletter. These were set up in 2013 and are the official internal channel for ESO-wide news, and for other ESO news of interest to a substantial group of staff members. Almost 500 internal announcements were published during the year. During 2014, the coverage expanded to include, among other things, introductions of newly arrived high-level staff, information about VIP and media visits to the sites, and additional news from the observatories.

More "Coffee with the Director General" events took place in Garching, Vitacura, Paranal, La Silla and at APEX, offering staff an opportunity to ask questions and give feedback in an informal setting.

The Internal Communication Office organised the 2014 ESO Overview, at which highlights of ESO's entire programme were presented by speakers from across the organisation. The talks covered a broad range of scientific, technical, operational and administrative topics for an ESO-wide audience. Particular effort was put into adding variety to the schedule by including different speakers and topics from those in previous years. After the overview, a survey was taken to gather feedback about the event from staff.

The "What ESO Really Does" programme of informal and non-technical talks remained popular. These talks aim to give ESO staff an insight into what they and

Group photo of the workshop ASTRONET 2014 — Tools, Best Practices and Methodologies for Technology Transfer.

The ESO accession agreement with Poland was signed by the Polish Minister of Science and Higher Education, Lena Kolarska-Bobińska, and ESO's Director General Tim de Zeeuw, in the presence of other senior officials from Poland and ESO.

their colleagues across the organisation do and why they do it. In 2014, nine talks took place in Garching, and five in Vitacura, on topics ranging from the applications of lasers and optical fibres at ESO, through the importance of safety, to the role played by the ESO libraries.

Risk and intellectual property management, EU contracts

In 2014, one of the major tasks of Risk and Intellectual Property Management was to ensure the proper implementation of ESO's data classification policy, which was published in 2013. The aim of this policy is to ensure the necessary and efficient safeguarding of ESO's, and of its collaborators, and contractors, proprietary and confidential data, information and knowledge. Many areas were affected by the policy, and, among others, the document classification practices of ESO, as well as the data storage and archiving rules were adjusted in order to comply with ESO's data classification policy. Closely connected to data classification, ESO also looked into the question of data security, in particular in the area of cloud storage and its legal implications for intergovernmental organisations.

With regard to non-life insurance policies, ESO, via its broker, implemented some fundamental changes within its policy portfolio. In order to reduce costs and harmonise coverage, one single umbrella policy has covered all ESO property since August 2014. The activities of the year were closed with a site survey visit by the insurance broker and underwriter for the Garching facilities.

In 2014, ESO's corporate risks were revised every three months at the management team meetings. Both the respective methodology and procedure is now part of ESO's management practices on many different levels and in all programmes.

In the area of intellectual property management and knowledge transfer, ESO continued its modest but successful activities. The ESO Raman fibre amplifier patent has been finally granted in all the designated countries: Germany, United Kingdom, France, Canada, Japan and the USA. The know-how is available for licensing.

ESO, within the ASTRONET EU project, organised a one-day technology transfer workshop at ESO Headquarters on 24 November 2014, attended by technology transfer experts from ESA, CERN, the European Synchrotron Radiation Facility, the European X-ray Laser Project, Innovative faseroptische Spekroskopie und Sensorik (innoFSPEC) Potsdam and other ASTRONET organisations (http://www.eso.org/public/events/special-evt/astronet2014/).

International affairs

During 2014, efforts continued in support of the ratification process in Brazil, directed towards enabling the country to formally join ESO. Significant progress had been achieved towards the end of 2013, but in 2014 the process was slowed down, partly due to high-level changes within the Brazilian administration and partly due to the presidential and congressional elections in October and the ensuing effects on the law-making process. Thus the ESO case could not be closed and remains on the table of the Congress for approval during the first half of 2015.

Negotiations with Poland moved from informal discussions in 2013 to a formal stage, resulting in the signing of the accession agreement in Warsaw on 28 October 2014. The task of formal negotiations of the terms and conditions of the Polish accession to ESO as well as the drafting of the accession agreement was led by the Cabinet. By the end of the year the parliamentary ratification process had been initiated. It is expected to be finished within the first half of 2015, after which ESO will formally welcome Poland as a new Member State.

The year 2014 saw renewed interest for ESO membership from Norway and Ireland, prompted by the continued operational success of the current ESO

E-ELT groundbreaking event official photo.

facilities and ALMA, and the progress made towards the realisation of the E-ELT. This has also sparked a strong interest in the Australian astronomical community. Discussions with Australian scientists and authorities took place throughout the year and resulted in the establishment of an informal ESO–Australia working group. Early-stage informal discussions took place with other countries, as well.

ESO took part in the International Conference on Research Infrastructures in April and the conference "Evolving landscape of Research Infrastructures in Europe" in September, which were organised by the Greek and Italian EU Presidencies, respectively. In addition, ESO participated in the EuroScience Open Forum in 2014 in July in Copenhagen, which offered a forum for exchange with science policymakers from several countries.

ESO continued its active participation in EIROforum. This included the preparation of a position paper on the sustainability of research infrastructures, at the invitation of the European Commission. Contributions were made to the formulation of a Charter for Research Infrastructures and discussions about a possible major technology initiative within the Horizon 2020 Framework Programme regarding the development of new scientific detectors. The Cabinet also represented ESO as an observer in the Square Kilometre Array board meetings.

Finally, ESO participated in the regular meetings of the United Nations Committee for the Peaceful Uses of Outer Space, with a particular focus on the preparation of a possible global response to the potential threat from near-Earth objects.

Host state activities

Major events took place in Chile in connection with the beginning of the construction of the E-ELT. Work by the Chilean company ICAFAL on the construction of the access road and the platform started in early March. An official ceremony took place on 19 June on Paranal, and the first major blasting of the summit of Cerro Armazones was watched from Cerro Paranal by representatives of the ESO Council and upper management, observatory staff, national, regional and local authorities, ambassadors of Member States, and representatives of companies involved in the works.

The agreement for the connection of the observatory to the power grid was signed at Paranal on the same day. The groundbreaking ceremony received extensive coverage by both national and international media.

The new Chilean government took office in March. ESO was honoured by the presence of President-elect Michelle Bachelet at one of the bilateral meetings of diplomatic and international organisation delegations that occurred the day prior to the Presidential inauguration. The President of the Council, the Director General, the Director of Operations and the Representative in Chile could thus update President-elect Bachelet on the developments that had taken place since the end of her previous administration. A number of meetings with the new authorities, many of them coordinated by the Chilean Ministry of Foreign Affairs and

The Director General Tim de Zeeuw met Michelle Bachelet, the incoming President of Chile, on 10 March 2014, the day before her inauguration.

On Thursday 21 August 2014, former Chilean President Ricardo Lagos visited the ESO Guesthouse in Santiago, where he met the Director General and other ESO staff.

ESO/F. Comerón

An ambassadors' visit to Paranal on 2 May 2014. From left to right, Mr Luis Lorvão, Ambassador of Portugal; Ms Brigitta Al-Ojeil, Head of Mission of Lebanon; and Mr Timothy Kane, Ambassador of Australia.

with the participation of representatives of the other international observatories based in Chile, have taken place during the year.

ESO was honoured by the private visit of former President Ricardo Lagos to the ESO Guesthouse in August. The Director General, the Director of Administration and the Representative in Chile gave Mr Lagos an overview of the most important developments in the relationship between ESO and Chile since the end of his Presidency, and Mr Lagos offered some valuable views on matters of current interest in this area.

Visits by Brazilian academic authorities to ESO facilities have continued during 2014, hosted by the Head of the Office for Science in Chile and by the Representative, to raise awareness of the advantages of ESO membership in view of the impending ratification by Brazil. The status and perspectives of the accession process were discussed during the visit of the Brazilian Minister of Science and Technology, Mr Clélio Campolina, to Santiago in June.

The long-term collaboration between ESO and a variety of institutions in Chile has continued in many ways. One of these continues to be the allocation of funding through the ESO–Chile Joint Committee, to which a record 38 proposals from 16 institutions where submitted in 2014.

ESO and its observatories continue to be of special interest to the diplomatic representations of the Member States and other countries. Besides the diplomatic representatives who attended the Armazones groundbreaking ceremony on 19 June, Paranal was visited this year by the following ambassadors: Ms Marion Kappeyne van de Copello, of the Netherlands; Mr Luis Lorvão, of Portugal; Mr Carlos Robles Fraga, of Spain; Mr Timothy Kane, of Australia; Mr Yang Wanming, of China; Ms Naciye Gökçen Kaya, of Turkey; Ms Reem Al-Khaled, of Kuwait; and the Head of Mission of Lebanon, Ms Brigitta Al Ojeil. The former ambassador of Chile to Germany, Mr Jorge O'Ryan Schütz, also visited Paranal. Both ESO and ALMA were visited by a delegation of Dutch universities forming part of NOVA. Other Chilean visitors to Paranal include Senator Guido Girardi and former minister Carlos Ominami. Last but not least, the Polish vice-minister of Foreign Affairs Ms Katarzyna Kacperczyk visited the Vitacura premises in October, shortly before the signature of the Poland's accession agreement to ESO.

In Europe, ESO accepted invitations to participate in events organised by the German Federal Government, including the annual meeting of the German diplomatic representations worldwide, and by the Bavarian State Government. Contacts increased between the State Government Cabinet Office and the Ministry of Economic Affairs, in particular.

Internal audit

The internal audit provided support to the external auditors in the performance of their duties and delivery of reports to the Director General. The internal audit is an independent, objective assurance and consulting activity designed to add value and improve the organisation's operations. Other regular activities during the year were the audit certificate for ESO partners 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 other audits, including of the in-kind elements in the financial statements for 2013.

ESO/B. Tafreshi (twanight.org)

In this scene a bright, crimson sunset complements the colourful centre of the Milky Way and the zodiacal light above the platform of the Very Large Telescope on Cerro Paranal.

The little-known nebula Gum 15 is located in the constellation of Vela (The Sails). It has some similarity to the more famous H II region, the Trifid Nebula (Messier 20).

Committees

Top: At their meeting on 3 December 2014 ESO's main governing body, the Council, gave the green light for the construction of the European Extremely Large Telescope in two phases.

Below: Three generations of Council presidents. From left to right: Patrick Roche (current Council president), Xavier Barcons (Patrick Roche's predecessor) and Laurent Vigroux (Xavier Barcon's predecessor).

Council

As its main governing body, ESO Council determines the policy of the organisation with regard to scientific, technical and administrative matters. Both the Council and the Committee of Council (the informal body of Council) normally meet twice during the year: however, in 2014 there was a requirement for two additional extraordinary Council meetings, which took place in conjunction with the March and October Committees of Council. The two ordinary Council meetings were held in Garching, on 3–4 June and 3–4 December. The two Committee of Council meetings were kindly hosted by the Italian and Finnish delegations respectively in Rome on 4–5 March and in Turku on 7–8 October. All meetings were chaired by the Council President, Xavier Barcons.

During the March meeting, Council approved the establishment of the E-ELT Management Advisory Committee (EMAC), which was put in place as an advisory body to both Council and the ESO Director General. The prime function of this committee is to provide appropriate and timely management oversight and advice to assist in the delivery of the E-ELT programme.

At the June meeting, an update was provided by the Council President and the ESO Director General on a number of ongoing events and actions and the respective directors and heads of department presented feedback on all aspects of ESO's programme, including the status of La Silla, Paranal and ALMA. Spain confirmed its participation in the E-ELT, which was approved by the delegates and Council expressed its great satisfaction that all the ESO Member States were now part of the programme. After much discussion, it was agreed that further reconsideration would be postponed until the December Council meeting with regard to the way forward for the E-ELT, which would be preceded by a revised version of the related document being reviewed during the forthcoming FC, STC and Committee of Council meetings. Council was provided with the report of the findings of the Visiting Committee, the recommendations from which were being taken forward by the Executive. The Annual Report was approved, as were the External Audit Report and the 2013 financial statements. Discharge was granted to the ESO Director General for the same year and much appreciation was expressed to the external auditors for their hard work and efforts over the past twelve months. Finally, concerns were expressed about the status of the funding for the CERN Pension Fund, which were to be raised with the CERN Council President.

In October, a short extraordinary Council meeting took place. During this meeting, Council approved the accession of Poland to ESO and looked forward to welcoming them into the organisation once the ratification process had been completed, which was envisaged to be around mid-2015.

The final Council meeting of the year took place in Garching. Following the regular updates of the ESO programme, approval was given by Council for the establishment and membership of an ALMA Construction Lessons Learned Committee. This was not a formal review of the project, but a fact-finding exercise to establish what ESO had learned from ALMA, which could in turn be applied to future projects, in particular the E-ELT. The ALMA Trilateral Agreement was also approved. For the E-ELT Way Forward, the revised document and resolution were discussed and, following the recommendation from the FC and STC, the resolution was approved by Council. Council expressed their great pleasure at having reached this very important milestone and looked forward to the success of the E-ELT programme in the future. The E-ELT policy on Guaranteed Observing Time was agreed. As part of the discussions related to finance, approval was given for the ESO Budget and the scale of contributions, both for 2015. Elections took place for the appointment of personnel to the various ESO Committees including the ALMA Board, FC, OPC, STC and the Tripartite Group. As Xavier Barcons and Martin Steinacher were completing their three-year terms as Council President and Vice President respectively, elections took place for their successors and Patrick Roche and Jan Palouš were duly appointed. As he was retiring from Council, Georges Meylan was warmly thanked for his many contributions during his time as a member of the Swiss delegation from 2008 onwards. Appreciation was also expressed to Xavier Barcons for his dedicated and most effective leadership of Council and all present wished him every success for his future endeavours.

Council and Committee of Council 2014

President	Xavier Barcons (Spain)
Austria	Sabine Schindler/ João Alves Daniel Weselka
Belgium	Christoffel Waelkens Sophie Pireaux
Czech Republic	Jan Palouš Jan Buriánek
Denmark	Uffe Jørgensen Cecilie Tornøe
Finland	Jari Kotilainen Antti Väihkönen
France	Denis Mourard Laurent Vigroux
Germany	Thomas Henning Thomas Roth
Italy	Giovanni Bignami Matteo Pardo
The Netherlands	Konrad Kuijken Jan van de Donk
Portugal	Paulo Garcia Fernando Bello/Pedro Carneiro
Spain	Rafael Bachiller Fernando Ballestero
Sweden	Hans Olofsson Catarina Sahlberg
Switzerland	Georges Meylan Martin Steinacher (Vice President)
United Kingdom	Patrick Roche John Womersley/Colin Vincent

Finance Committee

Finance Committee 2014

Chair	Colin Vincent (United Kingdom)
Austria	Sabine Hertgen (Vice-chair as of June 2014)
Belgium	Alain Heynen
Czech Republic	Pavla Katzová
Denmark	Cecilie Tornøe (Vice-chair until May 2014)
Finland	Sirpa Nummila
France	Patricia Laplaud
Germany	Gisela Schmitz-DuMont
Italy	Giampaolo Bologna
The Netherlands	Mirjam Lieshout-Vijverberg
Portugal	Filipa Baptista Coelho
Spain	Inmaculada Figueroa
Sweden	Johan Holmberg
Switzerland	Astrid Vassella
United Kingdom	Maggie Collick

The Finance Committee had two ordinary meetings, as well as one extraordinary meeting in 2014, all of them chaired by Colin Vincent.

In these meetings, the Finance Committee delegates discussed the financial aspects of the various options for the way forward for the E-ELT and prepared a recommendation for Council. The FC also recommended that Council approve several amendments to the Staff Rules and Regulations. In total, they also approved eight contracts exceeding €500 000, two amendments to existing contracts and six single-source procurements exceeding €250 000. The contracts regarding the supply of electric power to the La Silla Observatory and the extension of the Chilean grid system to supply power to the Paranal and Armazones areas will significantly reduce costs for energy supply.

In addition, at the 138th meeting in May, the FC recommended that Council approve the ESO financial statements and the external audit report for 2013.

Approval for securing the Chilean peso exchange rates, limited until December 2014, secured a substantial saving in the execution of the budget. The delegates also discussed the new procedure for the selection of collaborating institutes. Such collaborations could be for the development and construction of instruments, development of technology and other subjects. The Finance Committee also received an update on the status of ESO's insurance policies, where savings could be achieved after a call for tender and a restructuring of policies.

The 139th meeting in September focused on the way forward for the E-ELT, the budget for 2015 and the forward look for 2016–2018. These subjects were recommended to Council in the 140th FC meeting together with the scale of contributions and a small increase in the cost to completion for the construction of the ALMA Residencia.

Moreover, the Finance Committee approved seven proposals for the award of contracts by written procedure.

Roger Wesson/ESO

ESO signed an agreement with the Chilean company Astronomy and Energy (a subsidiary of the Spanish LKS Group) to install a Solar farm at the La Silla Observatory. ESO has been working on green solutions for supplying energy to its sites for several years, and these are now coming to fruition.

Scientific Technical Committee

The Scientific Technical Committee 2014

Chair	Alessandro Marconi (Italy)
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)
Portugal	André Moitinho (LSP)
Spain	Almudena Alonso-Herrero (ESC)
Sweden	Sofia Feltzing (ESC)
Switzerland	Michael Meyer (ESAC)
The Netherlands	Marco de Vos (LSP Chair)
United Kingdom	Ian Smail (ESAC)
Chile	Leonardo Bronfman

Members at Large

Elaine Sadler (ESAC Chair)
Gillian Wright
John Monnier (LSP)
Rachel Akeson (ESAC)

Observer

Brazil	Marcos Diaz

The Scientific Technical Committee met twice in ordinary session during 2014, on 8–9 April and 21–22 October, and for an extraordinary meeting on 19 September. There was also an STC teleconference on 11 June to discuss a scientific prioritisation exercise being led by the Director for Science, which covers the majority of the activities at ESO, excluding the Cabinet and the Administration, and which is due to report to the STC in April 2015.

82nd STC meeting

At its regular spring meeting, the STC heard the outcomes of meetings of the E-ELT Subcommittee (ESC), the La Silla Paranal Subcommittee (LSP) and the European ALMA Science Advisory Committee (ESAC).

The STC noted that recent events had resulted in an “overheating” of the ESO programme. The STC welcomed the fact that the instrumentation programme is being reviewed in a coherent way, arguing that particular attention must be given to the trio of projects, NACO, CRIRES+ and ERIS, which had been put on hold.

The results of the PRIMA gate review were presented to the STC along with a proposed course of action. The STC concurred with the recommendation of the board that the PRIMA project should be cancelled, but with no irreversible action being taken prior to the confirmation by ESA that Gaia is fully functional. The STC endorsed the plan to utilise all the personnel and resources thus freed toward VLTI infrastructure projects. The STC supported the view that a lessons-learnt review be held, considering stewardship and management as well as technical points.

The STC recognised the high scientific merit of two exoplanet transit projects proposed for the LPO. The proposers were urged to provide more information on the extent of the proposed public archive and a clearer picture of the possible scientific return to the ESO community. With regard to the call for ideas for the NTT, the number of proposals received impressed the STC and it asked to be represented in the proposal evaluation.

The high scientific priority of moving forward with the E-ELT was re-emphasised by the STC and the importance was stressed of being on sky with as much as overlap with the James Webb Space Telescope as possible. The STC therefore supported staying on the current schedule with first light for E-ELT planned for 2024 and was glad to note the call for Phase A proposals for two E-ELT instruments, namely a multi-object spectrograph (MOS) and a high-resolution spectrograph (HIRES). In view of ESO’s desire to have competitive proposals, the STC recommended announcing a deadline distant enough to allow the community to properly organise itself and wished to see the number of available Guaranteed Observing Time nights announced together with the call for proposals. The STC endorsed the top-level requirements of the E-ELT instruments MOS and HIRES and the mid-infrared instrument (METIS).

Regarding ALMA, the STC was pleased to hear of progress in addressing several of the areas of concern from its last meeting. The power supply at the ALMA site was reported to be much more stable. The return to a 12-month observing cycle from Cycle 3 onwards was welcomed. Good progress was reported in delivering Cycle 1 data, and the STC commended the excellent support being provided by all ARC nodes. The STC was concerned that several key positions at the Joint ALMA Observatory were still either unfilled, or filled on an interim basis, and requested that the position of ALMA Chief Scientist be reinstated, since this person could provide several important linkages, for example as a JAO scientific representative to the ALMA Development Plan and a point of contact for very long baseline interferometry issues and planning.

The STC was concerned that the technical assessment of almost 1000 ALMA Cycle 2 proposals was placing a very heavy workload on the ARC and JAO staff, and probably represents the maximum number of proposals that this group can assess effectively. The STC recommended that the technical assessment process for ALMA proposals be revised. The STC endorsed the definition, responsibilities and evaluations proposed by ESO for the ALMA centres of expertise.

The STC noted the recent review of the ALMA Band 2+3 development study, and recommended the continuation of coordinated efforts to develop a combined Band 2+3 receiver system for ALMA. The strength of the science case for millimetre very long baseline interferometry was acknowledged, and the high level of interest shown by European groups; it was recommended that millimetre very long baseline interferometry, including phased ALMA, should be offered as an open-access facility subject to peer review. The STC supported the idea that ALMA development should proceed within the framework of an overarching long-term strategy for ALMA, and was pleased to hear that a working group has been set up by the ALMA Development Steering Committee to develop a scientific vision for ALMA in the 2030s.

ESO and the APEX team were congratulated on another year of high observing efficiency and continued scientific productivity. The connections between APEX and ALMA observations were acknowledged to be strong. The initial results from ArTeMiS appear encouraging and cover a wide range of astrophysical topics. The STC recommended that Supercam, a 345 GHz receiver built by the Arizona Radio Observatory, should be offered again to the ESO community in Period 95. The STC also recommended that the ALMA Band 5 receiver at APEX should be offered to the ESO community.

The STC thanked the CTA representatives, Werner Hofmann and Stephan Wagner, for attending the STC meeting and providing an interesting and illuminating presentation of the CTA science case. The STC concurs that the science for CTA is of interest to the ESO community, as outlined in the ASTRONET roadmap.

83rd and 84th STC meetings

The STC supported the adoption of a two-phase approach to construction of the E-ELT as a backup plan, allowing major contracts to be placed in 2015. The STC stated that ESO had presented a convincing example of a two-phase construction plan with a fixed cost for Phase 1, allowing for the construction of a scientifically competitive telescope with full instrument capabilities at the end of Phase 2. The STC felt that Phase 1 will provide world-leading facilities at first light; in order to maintain that leadership, and for a complete and competitive exploitation of the E-ELT, Phase 2 is essential. The STC endorsed the decision to design the two-phase plan so that it does not diverge from the original baseline until 2017, so that first-light science remains competitive. The STC recommended that after Council approval of the two-phase plan, ESO should explore avenues to identify additional funding in order to either remove the need for the back-up plan or, if necessary, to ensure that a minimum of activity has to be postponed to Phase 2. In the event that the back-up plan is needed, the STC recommended that bringing laser tomographic AO back to the baseline schedule is the highest scientific priority. The STC also recommended that the Guaranteed Observing Time policy for the E-ELT proposed by ESO be implemented.

The teams from ESO and from the instrument consortia were congratulated on the smooth commissioning of MUSE and SPHERE, an unprecedented achievement for simultaneously dealing with two complex instruments.

The STC was happy to note that in general the Public Surveys are progressing well, but was concerned with the public availability of data products for some of the surveys. The committee recommended that ESO be firm with PIs and data centres, as agreed in the survey management plans.

The STC was presented with a document on hosting telescope projects (STC-545) and recommended the proposed guidelines for implementation.

The STC noted that the ALMA construction phase was formally completed on 30 September 2014. Although a few items (including the ALMA Residencia) remain to be completed, this represented a major achievement for the project. STC was also pleased to hear of the good progress on the ALMA Long Baseline Campaign, with phase closure achieved on baselines out to 15 kilometres. A spectacular long baseline Science Verification image at 230 GHz (of HL Tauri) gave a first taste of the transformational science enabled by the commissioning of the long baselines.

Concern was voiced by the STC that the scientific execution efficiency for the first three months of ALMA Cycle 2 (June–September 2014) was low — significantly below the target efficiency for Cycle 2. The STC recommended that urgent action be taken to identify the main reasons for this low efficiency, and that a timely plan be developed (and advertised to the community) to deal with incomplete proposals ahead of the Cycle 3 call for proposals. The STC noted that ALMA's scientific productivity is maximised by getting data into the hands of PIs as rapidly as possible, and endorsed the recommendations of an ALMA Scientific Advisory Committee report on data delivery policies. The STC recommended that the opportunity to propose large programmes on ALMA should only be offered (in Cycle 4 and beyond) when certain important conditions are fulfilled.

A large number of STC members retired at the end of 2014, including its most recent chair, Alessandro Marconi.

Observing Programmes Committee

The Observing Programmes Committee 2014

Maria Teresa Ruiz (Chair)
Nial Tanvir (Vice-Chair)

Yann Alibert (P94)
Micol Bolzonella (P95)
Wolfgang Brandner (P94)
Fabio Bresolin (P95)
Alessandro Bressan (P95)
Marcio Catelan (P95)
Andrea Comastri (P94)
Emanuele Daddi (P94)
Massimo Della Valle (P94)
Pierre-Alain Duc (P95)
Jesus Falcon-Barroso (P95)
Alan Fitzsimmons (P95)
Malcolm Fridlund
Henk Hoekstra (P95)
Suzanne Madden
Simona Mei (P94)
Dante Minniti (P94)
Tim Naylor (P95)
Anna Pasquali (P94)
Reynier Peletier
Don Pollacco (P94)
Rainer Schoedel (P94)
Ignas Snellen (P95)
Ben Stappers
Roland Walter

Thorsten Ratzka (member-at-large P94)
Alan Fitzsimmons (member-at-large P94)
Greg Herczeg (member-at-large P94)
Peter Jonker (member-at-large P94)
Walter Maciel (member-at-large P94)
Francesco La Barbera (member-at-large P95)
Marcella Longhetti (member-at-large P95)

During its meetings in May and November, the Observing Programmes Committee evaluated the proposals submitted for observations to be executed in Periods 94 (1 October 2014 to 31 March 2015) and 95 (1 April 2015 to 30 September 2015). The numbers of proposals for observations with the ESO telescopes in these two periods were 901 and 931 respectively.

The fraction of submitted proposals (excluding Large Programmes) is 22.2%, 19.7%, 27.4% and 30.7% for A, B, C and D categories, respectively. In terms of requested time the fractions are 30.3%, 17.5%, 25.9% and 26.4%. This is a slight shift towards stellar science (categories C and D) with respect to extragalactic science (categories A and B). The advent of KMOS (P94) and MUSE (P95) has largely re-established the balance between the two branches, which in previous periods was clearly dominated by stellar and planetary science.

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 (UT1), remained the VLT instrument receiving the largest amount of observing time requested (431 nights), slightly ahead of X-shooter (429) on Kueyen (UT2). Because of the combined presence of FORS2, NACO and KMOS, Antu is the most popular UT, with a ratio between the requested and the available time, or pressure, of 4.9, followed by Kueyen (4.0). The temporary unavailability of VISIR and the move of X-shooter to UT2 have decreased the pressure for UT3 (2.7). The possibility of installing a visitor instrument at the VLTI continued to generate considerable interest in the community.

In P94, proposals requesting a total of 78 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 45 nights. The VLTI was not offered in P95 because of the planned activities for the preparation of the new generation of VLTI instrumentation.

The OPC reviewed 19 open-time proposals for the VISTA survey telescope, of which ten 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 in 2014. ESO received one application in P94 and P95, which did not qualify 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 as of Period 86, the number of Target of Opportunity proposals submitted in 2014 remained similar to previous years. For P94 and P95 the OPC evaluated 44 and 50 proposals each, of which 14 and 26 were scheduled, for a total of about 375 hours. FORS2 is the most requested instrument for Target of Opportunity observations (about 260 requested hours), followed by X-shooter and UVES. These three instruments were allocated 56% of the ToO time.

Calibration Programmes

Calibration Programmes are meant 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.

In 2014 (P95 only) two Calibration Programmes were submitted. Both proposals were recommended for implementation by the OPC, and one of them was recommended for implementation during technical time.

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. The execution of Large Programmes 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 37 Large Programme proposals were received in 2014: 20 in P94 and 17 in P95.

Following the OPC's recommendations, four new Large Programmes were implemented in P94, and two in P95. 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 LPs in P94–95 at the 3.6-metre telescope and at the NTT was 153 and 166 nights respectively. This corresponds to 48% and 50% of the available science time at these two telescopes (this includes the PESSTO Public Spectroscopic Survey to which 90 nights per year are allocated at the NTT).

Public Spectroscopic Surveys

In P94 the OPC recommended two new Public Spectroscopic Surveys, both at UT3 with VIMOS, for implementation for a total allocation 181 and 103 nights, to be distributed across seven and four semesters, respectively. The two programmes were approved by the Director General and scheduled as of P94. These two Public Spectroscopic Surveys are in addition to those approved in P88, PESSTO (NTT+EFOSC2/SOFI) and ESO–Gaia (UT2+FLAMES).

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 2014 the ESO user community submitted 74 DDT proposals. After taking advice from an internal committee composed of ESO staff astronomers, the Director General approved for implementation 49 DDT proposals. The total amount of requested DDT was about 383 hours.

A. Tudorica/ESO

The road leading to the VLT at Paranal.

Users Committee

The Users Committee 2014

Chair	Gary Fuller (United Kingdom)
Austria	Bodo Ziegler
Belgium	Emmanuel Jehin
Czech Republic	Adéla Kawka
Denmark	Hans Kjeldsen (Vice-chair)
Finland	Elja Laurikainen
France	Philippe Delorme
Germany	Thomas Preibisch
Italy	Stefano Benetti
The Netherlands	Matthew Kenworthy
Spain	María Rosa Zapatero Osorio
Sweden	Kirsten Kraiberg Knudsen
Switzerland	Hans Martin Schmid
Chile	Wolfgang Gieren

The Users Committee represents ESO's astronomical community at large and acts as an advisory body to the ESO Director General on matters related to the performance, operation and user interfaces to the La Silla Paranal Observatory, APEX and ALMA. The annual meeting of the Users Committee took place at ESO Headquarters on 10–11 April 2014.

The Users Committee meeting is an important forum, where updates from ESO and feedback from the user community are exchanged and openly discussed. The meeting is organised by the User Support Department, within the Directorate of Operations, one of the main interfaces between ESO and the user community. After the opening talk by the ESO Director General, who provided an update on the ESO programme, representatives of the main operational units reviewed ESO's major operational achievements. This introductory session closed with a special presentation — Fifteen Years of End-to-end Operations at the VLT — showing the productivity of ESO facilities in terms of publications and how this compares with the completion rates of approved programmes.

As is now the norm at the Users Committee meetings, the second day started with a special topic session, which this year was dedicated to observing tools. The choice of topic was driven by the latest release of a significantly upgraded version of ESO's main observing tools (the Phase 2 Proposal Preparation release 3 [P2PP3], the Observing Tool release 3 [OT3] and the Visitor Mode Observing Tool), but also included a number of ancillary tools, such as the observing preparation software tools FIMS (the FORS Instrument Mask Simulator), FPOSS (the FLAMES Fibre Positioner Observation Support Software), VMMPS (the VIMOS Mask Preparation Software), SADT (Survey Areas Definition Tool), etc. At the special topic sessions, expert users are invited to attend and share their experience. Their feedback, together with that collected by the Users Committee members directly from their own communities, drives the subsequent discussion. Overall, the user community is very satisfied with the upgrades to the tools and endorses further improvements, some of which are already being planned.

Finally, on both days of the meeting some time is reserved to discuss old and new recommendations, always with the final goal of improving ESO services and communications. Based on detailed input provided by ESO representatives, the Users Committee evaluates ESO's accomplishments with respect to the recommendations they had set the year before and formally closes them once these have been achieved. The meeting closes with the reading of a new set of recommendations, usually drawn from the feedback the Users Committee has received, as well as from the discussions that took place during the two-day meeting. These represent the official Users Committee feedback to ESO and guide further developments in different operational areas.

ESO/B. Tafreshi

Sunset at the La Silla Observatory.

Visiting Committee

Visiting Committee 2013–2014	
Chair	Jean-René Roy (Canada)
Switzerland	Willy Benz
United Kingdom	Paola Caselli
France	Fabienne Casoli
Australia	Matthew Colless
Switzerland	Lyndon Evans
Germany	Hartmut Grote
USA	Buell T. Jannuzi
Germany	Hans-Walter Rix
Italy	Monica Tosi (Vice-chair)

Every three to four years, the international scientific profile of ESO is assessed by a Visiting Committee of eminent scientists. The Visiting Committee reports to the Council and the Director General; a presentation of results is made to Council and also to staff at an All Hands meeting. The last Visiting Committee reported in 2010 and a new committee was selected in 2013.

The role of the Visiting Committee is to present an international perspective, from a distinguished group of active scientists with a broad range of backgrounds, on how well ESO complies with its overall mission. The Committee examines the international competitiveness of the research carried out by the users of ESO facilities. It comments on the range and future perspectives for the scientific activities at the ESO sites and how they foster competitive international research in comparison with other facilities worldwide.

In order to guide science planning, the 2013–2014 Visiting Committee were tasked with commenting on several specific aspects, in addition to weighing the implementation of the recommendations of the previous Visiting Committee. Their views were sought on the role of ESO in the ALMA global partnership, the integration of ALMA into the ESO programme, and how ESO efforts have affected the construction phase and the transition to operations. One particular aspect, on which the Visiting Committee were asked to comment, was the progress, current performance and future prospects of VLTI and its broad impact on astronomy. Finally, feedback on the internal readiness of the organisation to carry out major programmes, such as the E-ELT, in parallel with current operations of La Silla Paranal, APEX and ALMA, was sought.

During the period 8–13 December 2013, the Visiting Committee visited the sites in Chile (Vitacura, the La Silla and Paranal Observatory, and APEX and ALMA at Chajnantor) followed by a visit to ESO Headquarters from 10–14 February 2014. Their report was presented to the Director General in May and the Chair reported its content at the Council meeting in June.

The Visiting Committee opened their report by highlighting ESO as a flagship of European science. The organisation continues to deliver and operate world-leading opportunities for its Member States and their astronomers. Both the scientific discoveries and the technical developments in collaboration with institutes and industry have made ESO a world leader in astronomical technologies.

The Committee noted that the size of the portfolio is growing and, even with continuing stable funding from the Member States, expressed some concern whether the match of funding to the programme ESO is asked to deliver will continue to be adequate. They advocated “clear prioritisation among programmes, continued skilful management, and full utilisation of the talents and skills of the community” as being essential in order for ESO to successfully continue operation at the planned level.

Specific comments on the evolution of operations for Paranal, a clear roadmap for La Silla, support for dealing with multiple Large Programmes (LPO and ALMA) at the same time as developing the E-ELT, staff empowerment and engagement, the retention of a high value given to scientific research within ESO, the matrix project and outreach, were presented.

As directed, the role of ESO within ALMA was commented on by the Committee and some concern expressed that the transition from construction to operation required careful management. ESO’s long experience in operating observatories can provide strong support in this area. The Committee’s review of the VLTI confirmed that it delivers unique science and that steady progress has been made, and is continuing; the Committee report concluded that VLTI is the future in optical–near-infrared milli-arcsecond astronomy.

A number of the concerns expressed in the Visiting Committee report had already been addressed by the end of 2014, such as the green light for two-phased E-ELT construction, the review of the VLTI instrumentation and the cancellation of the PRIMA project, and the improving efficiency of ALMA operations throughout 2014 culminating in the successful completion of the ALMA Long Baseline Campaign.

This night scene, taken at ESO's La Silla Observatory, is humming with activity. The major players are Comet Lovejoy, glowing green in the centre of the image; the Pleiades above and to the right; and the California Nebula, providing some contrast in the form of a red arc of gas directly to the right of Lovejoy.

P. Horálek/ESO

Outreach

The year marked the beginning of a new era for ESO's outreach efforts with the preparation for the ESO Supernova Planetarium & Visitor Centre, donated by the Klaus Tschira Stiftung. This project will have an impact on both the local and global community. In the ramp up to the first activities for the ESO Supernova, education and planetarium productions have started to play a much larger role. At the same time, the core outreach focal areas are being maintained, with special attention being paid to innovative ways of communicating astronomy.

There were several major outreach milestones in 2014. The most prominent was the groundbreaking ceremony for the E-ELT, which revolved around a controlled blasting on the summit of Cerro Armazones. Later in the year, the green light given by ESO Council for the construction of the E-ELT in two phases, proved a substantial highlight.

The new Headquarters extension building, opened at the end of 2013, attracted considerable media attention in 2014, and was one of the main points of interest during the Open House Day on 11 October. The architects of the Headquarters extension Auer Weber won the prize for Best in Interior and Architecture for the building project at the Architecture – Interior – Technical Solutions Awards 2014.

E-ELT groundbreaking event. Left: Part of the 3000-metre high peak of Cerro Armazones was blasted away as a step towards levelling the summit in preparation for the construction of the largest optical/infrared telescope in the world. Right (from left to right): ESO Director General Tim de Zeeuw, Chilean Vice Minister of National Assets Jorge Maldonado, Intendente de Antofagasta Valentin Volta and president of ESO Council Xavier Barcons. Jorge Maldonado is holding the radio as he is giving the command for the blast.

As part of the preparations for the ESO Supernova, the education and Public Outreach Department started producing high-quality material for use in digital fulldome planetarium shows in the facility from 2017. As part of the mandate to communicate astronomy with the Member

Photos from the Open House Day 2014. In conjunction with the other facilities based at the science campus in Garching, ESO invited visitors to experience at first hand the work at ESO Headquarters.

ESO/B. Tafreshi (twanight.org)

Left: Christoph Malin and Herbert Zodet loading equipment into one of the trucks early in the morning, for the trip to ALMA Observatory. Taken during the ESO Ultra HD Expedition.

Right: Poster for the *Journey to the Centre of the Milky Way*, the first fulldome planetarium mini-show produced in-house by ESO for the ESO Supernova Planetarium & Visitor Centre.

States and beyond, this material is made available free of charge to other planetariums. The multimedia production was also upgraded to ultra-high definition as part of these preparations.

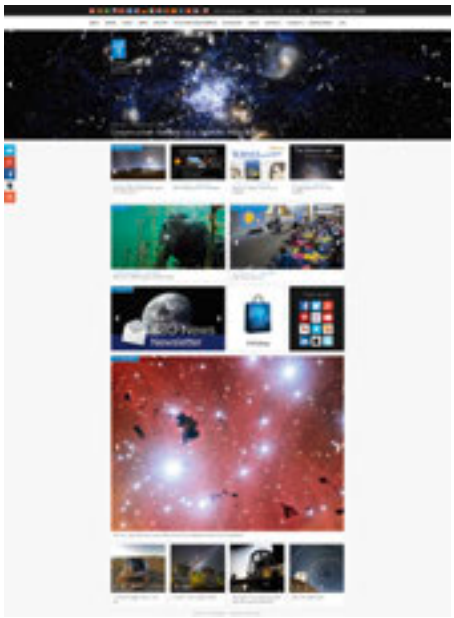
An expedition with four world-renowned astrophotographers travelled to Chile to capture material in ultra-high definition and fulldome format. Hundreds of video clips and photographs from the Ultra HD Expedition have been released online. The year 2014 also saw the first short fulldome planetarium show — *Journey to the Centre of the Milky Way*, which is available for free download on the ESO website.

To fulfil the educational goals of the ESO Supernova, ePOD has joined in partnership with the Heidelberg House of Astronomy (also built by the Klaus Tschira Stiftung) for the development of an educational strategy. Plans for several important educational activities have been made, such as: educational planetarium shows at different levels; educational workshops; supporting material for teachers; and material to improve astronomy literacy. All the programmes are linked to school curricula.

Another important project was a redesign of the ESO public web pages. The main motivation for the changes was to give the site a more user friendly interface and to make it more mobile friendly. The new responsive design adapts itself automatically to the resolution of the display that the visitor uses, and integrates the many different languages available with seamless navigation.

Press activities

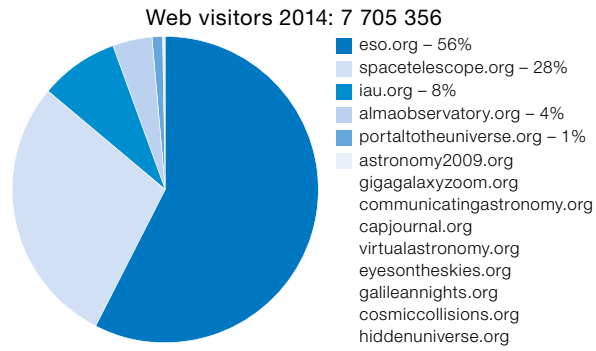
Compared to earlier years, the total number of press releases was a little lower, but the number of science releases was almost unchanged. There were many releases based on data from ALMA and the two survey telescopes VISTA and the VST, in addition to the continuing stream of results from both the VLT and La Silla facilities. Overall the number of incoming results that are evaluated for press releases is on the increase.



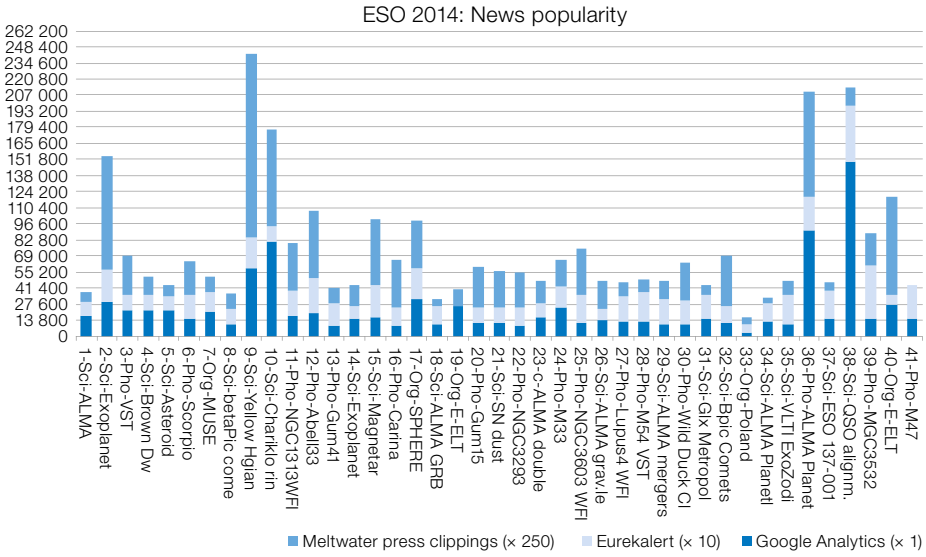
Screenshot of the new eso.org front page.

There was no obviously most popular release of the year, but the most viewed ones covered a wide range of topics and facilities. They included a release about the biggest known yellow hypergiant star (HR 5171A), the discovery of rings around the Centaur (10199) Chariklo, ALMA long baseline observations of the disc around the young star HL Tauri and a mysterious result about the alignment of quasar spin axes across large-scale structure in the Universe. The installation of two important new science instruments on the VLT, MUSE and SPHERE, were marked by press releases for both first light and subsequent science results.

The major news event of the year was the groundbreaking ceremony for the E-ELT in Chile on 19 June. The event took place at the Paranal Observatory, 20 kilometres away from the blasting, and was attended by distinguished guests from both Chile and the Member States, as well as representatives of the local communities, senior officials from the project and ESO staff. A comprehensive outreach campaign was designed around the event including live streaming, live tweets, dedicated video and photo materials. These efforts led to impressive media coverage, with many major pieces in national newspapers and on radio and television news.



The distribution of the 7.7 million web visits in 2014 among the websites hosted at ESO.



The relative popularity of the 41 press releases in 2014. 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 aggregation 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 releases were eso1409 (discovery of the largest yellow hypergiant), eso1410 (rings around Chariklo), eso1436 (ALMA long baseline observations of the disc around HL Tauri) and eso1438 (mysterious quasar alignments).

An ESO Picture of the Week was issued for each week of the year, continuing this series of beautiful and striking (terrestrial) photographs and astronomical images, and remains a very valuable channel to report on news items that do not necessarily require a full press release or announcement.

During 2014 ESO received more than a hundred formal interview requests from the media in addition to interviews given during media visits to the sites. This number does not include many dozens of interviews given by ESO officials, experts and staff at the E-ELT groundbreaking.

Publications

The number of products remained very high (at just below 100), and the volume of pages produced showed an increase. Examples of ePOD products are brochures, the calendar, stickers, apparel, electronic posters and periodicals.

Audiovisuals

The ESOcast video podcast series remains alive and well, and continues to nudge its way up the iTunes rankings. Four ultra-high definition video compilations were issued during the year.

The online image and video archive remains one of the biggest outreach assets and continues to grow at a constant rate. The crowdsourcing of subtitle translations is functioning well and has recently received a boost with more than 400 volunteer translators contributing.

Exhibitions and events

In terms of exhibitions and events, the year was less active than the recent past but a handful of exhibitions were set up in Chile and Europe. One of them was a renovation of the exhibition *Una ventana al Universo*, one of five permanent exhibitions installed at the Museum Ruinas de Huanchaca, in the city of Antofagasta, Chile. After several months of renovation work, the exhibition was reopened on 7 October 2014 by Fernando Comerón, ESO Representative in Chile, and Paula Baltra, General Manager of Fundación Ruinas de Huanchaca.

Web and software development

The design code for the ESO public web pages was rewritten from scratch, to make the site more visually appealing while retaining a low response time. This new design was implemented using responsive technologies to ensure that the site is user friendly regardless of the type of devices used (desktop computer, tablet, phone, etc.). The layout and content of the pages were adjusted accordingly, in all the languages in which ESO provides information.

The different sites maintained by ePOD were migrated to new servers and use a new back-end architecture that allows for faster and more consistent deployment. New kiosks were installed in the Headquarters extension building.

The supernova website (supernova.eso.org) re-uses the new methodology from eso.org, while keeping a distinct identity.

Media, VIP and weekend visits in Chile

Many prestigious media outlets visited the sites in Chile, including the BBC (United Kingdom), *New Scientist* magazine (Italy),

Above: Some key figures from ESO's outreach in 2014.

Below: Annual meeting of the ESO Science Outreach Network in March 2014.

France 5 TV (France), TV2 (Denmark), as well as the award-winning Chilean film director Patricio Guzmán (Best Director, Berlinale 2015). The visit to Paranal and Armazones by the Swiss 3D movie company NVP3D was especially exciting and challenging. The project, co-led by the Swiss delegate to the ESO Council, Georges Meylan, captured the complex placing of the explosive charges and subsequent spectacular blast on the top of Cerro Armazones in high-resolution 3D. The media visits remain an extremely visible activity for ESO with an audience counted in the hundreds of millions.

The public weekend visits to La Silla and Paranal enjoyed a small increase compared with 2013.

ESO Science Outreach Network

In order to increase the visibility of ESO in the Member States, ePOD operates the ESO Science Outreach Network (ESON), consisting of outreach specialists, press officers and 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. 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 2014, 25% of the web pages viewed on eso.org were translated by ESON.

Community coordination and distribution

Efforts were made to reduce distribution costs by doing more coordinated checks of returned shipments and by requesting all subscribers to *The Messenger* to reconfirm their subscriptions. The address database continued to undergo updates and improvements as a central communication tool. The newsletter subscriber base has continued to grow.

A revamp of the promotion workflow was implemented to enable full use to be

made of the many promotional channels for each product, activity or partnership.

ESO has continued to develop its presence in all of the most popular social media networks. Over 10 000 messages were posted solely on Facebook and Twitter, attracting millions of visitors. Facebook competitions were organised, and social media were used to reach out to local schools and public observatories.

A new streamlined workflow for social media was implemented, allowing more content to be posted on more channels with less effort and translation of the posts into many languages (with the help of the ESON network and volunteer translators). The activity on social media has moved from a couple of posts per week to a couple of posts per day, which has had a strong impact on the statistics. A steady reach of about 30 000 visitors/day has been achieved, which is a significant improvement. The ALMA, International Astronomical Union and ESA/Hubble social media channels were also integrated into the new workflow.

New channels could be opened as a consequence of the new workflow: ESO is now on Google+ and Pinterest, and later in the year social media accounts for the ESO Supernova were added in both English and German.

Artist's impression of the ESO Supernova Planetarium & Visitor Centre. The ESO Supernova is made possible by a collaboration between the Heidelberg Institute for Theoretical Studies and ESO. The Klaus Tschira Stiftung, a German foundation that supports the natural sciences, mathematics and computer science, offered to fully fund the construction and ESO will run the facility.

Architekten Bernhardt + Partner (www.bp-da.de)

Calendar of Events

January

APEX board meeting, ESO Garching.

First light of MUSE on 31 January, with observation of Kapteyn's Star (VZ Pic).

February

ESO Visiting Committee present in Garching, 10–14 February.

Industrial Liaison Officers' meeting.

Second thin meniscus Zerodur mirror (1.2-metre diameter and 2-millimetre thick) for the AOF adaptive secondary delivered to ESO by Safran-Reosc.

ESO Workshop on Exoplanet Observations with the VLT, ESO Garching, 3–6 February.

March

84th Committee of Council meeting, ESO Garching, immediately followed by 130th Council meeting.

ALMA board meeting, ESO Garching.

Tim de Zeeuw and Council President Xavier Barcons meet Michelle Bachelet, the incoming President of Chile.

ESO Overview (internal review).

Initial work begins on the construction of the road from Paranal to Cerro Armzones by the Chilean company ICAFAL Ingeniería Construcción S. A.

Annual meeting of the ESO Science Outreach Network.

The new 22-watt laser for use in the AOF was accepted from the supplier TOPTICA and its partner MPB.

Girls' Day, part of the German nationwide event, was held at ESO Garching.

ESO Workshop 3D2014: Gas and stars in galaxies: A multi-wavelength 3D perspective, ESO Garching, 10–14 March.

IAC/ESO

ESO and the Instituto de Astrofísica de Canarias, represented by the ESO Director General and Rafael Rebolo, the IAC Director, sign an agreement on adaptive optics collaboration.

April

Magnitude 8.2 earthquake in northwest Chile occurs on 2 April. There were no casualties and no damage was incurred at the ESO observing sites.

82nd Scientific Technical Committee meeting.

38th Users Committee meeting.

The Paranal–Armazones area is announced as one of the two possible sites for the Cherenkov Telescope Array by the international consortium. The other site is at Aar in Namibia.

ESO Workshop on Herbig Ae/Be stars: The missing link in star formation, ESO Vitacura, 7–11 April.

May

First light of SPHERE on 4 May.

ALMA Centre of Expertise opens at the Centre for Astronomy and Astrophysics, Faculty of Science of the University of Lisbon, Portugal.

138th Finance Committee meeting.

94th Observing Programmes Committee meeting.

Signing of agreement to use the Teide Observatory on Tenerife of the Instituto de Astrofísica de Canarias (IAC) for laser guide star adaptive optics experiments.

ESO Workshop on Formation and Evolution of Star Clusters in Chile, ESO Vitacura, 14–16 May.

June

131st Council meeting, ESO Garching, in which Spain confirmed its full participation in the E-ELT.

SPIE 2014 meeting on Astronomical Telescopes and Instrumentation, Montreal, Canada, with many ESO presenters participating.

Groundbreaking ceremony for the E-ELT held on Cerro Paranal on 19 June with controlled blasting of the peak of Cerro Armazones.

Signing of agreement with Grupo SAESA to connect Paranal and Armazones to the Chilean national electrical power grid.

Final ALMA antenna arrives on the Chajnantor high site. This was the last of the 25 European ALMA antennas (12-metre aperture), manufactured by the AEM consortium, to be integrated into the array.

July

European Week of Astronomy and Space Science meeting, in Geneva, featuring many ESO presentations.

Signing of an agreement between ESO and the Chilean company, Astronomy and Energy (a subsidiary of the Spanish LKS Group) to install a Solar electricity farm at La Silla.

Group photo of the workshop HIRES 2014: Astronomy at high angular resolution — a cross-disciplinary approach.

ESO/Davide Cenadelli

A group photo of the participants at the Astronomy Camp in 2014.

ESO Workshop on Clustering Measurements of Active Galactic Nuclei, ESO Garching, 14–18 July.

August

The Korea Astronomy Space Sciences Institute and the Japanese National Institutes of Natural Sciences sign an agreement, marking the entry of Korea into the East Asia ALMA Consortium.

September

139th extraordinary Finance Committee meeting.

Austrian Industry Day held at the Austrian Federal Economic Chamber in Vienna.

Czech Industry day held at ESO Garching.

ESO mini-workshop on Fundamental Physics with ESO Facilities and the E-ELT, ESO Garching, 18–19 September.

Signing of agreement between ESO and the UK Science and Technology Facilities Council Edinburgh-based Astronomy Technology Centre (UK ATC) to build the VLT Multi-Object Optical and Near-infrared Spectrograph (MOONS).

Beginning of the ALMA Long Baseline Campaign.

October

1 October — MUSE enters regular Service and Visitor Mode observing.

85th Committee of Council meeting.

83rd Scientific Technical Committee meeting.

Open House Day at ESO Garching attended by some 3300 members of the public.

ESO exhibition, *A Window to the Universe*, re-opens in Antofagasta at the Museum de Ruinas Huanchaca.

ESO Workshop RASPUTIN: Resolved And unresolved Stellar PopUlaTIoNs, ESO Garching, 13–17 October.

Instrument Control Systems seminar, ESO Garching, 20–24 October.

Signing of the agreement for entry of Poland into ESO between the Polish Minister of Science, Lena Kolarska-Bobińska and ESO Director General in Warsaw on 28 October.

November

140th Finance Committee meeting.

ALMA board meeting.

11th ALMA Common Software workshop, ESO Garching, 4–6 November.

95th Observing Programmes Committee meeting.

Announcement of winners of 2nd ESO Astronomy Camp bursaries.

Breakthrough Prize in Fundamental Physics awarded for discovery of dark energy to a team including two present and two former ESO staff.

Tim de Zeeuw received an honorary degree in astronomy from the University of Padova in Italy.

European ARC CASA Tutorial for ALMA Cycle 2 PIs, ESO Garching, 26–28 November.

ASTRONET 2014 — Tools, Best Practices and Methodologies for Technology Transfer workshop, ESO Garching, 24 November.

ESO Workshop HIRES 2014: Astronomy at high angular resolution — a cross-disciplinary approach, ESO Garching, 24–28 November.

International Symposium “Life as a Planetary Phenomenon”, part of the Santander International Summer School organised by the University of Heidelberg and held at ESO Vitacura, 27–28 November.

December

132nd Council meeting, ESO Garching. Adoption of the way forward for the E-ELT construction with a two-phased approach and approval for spending of 1012 million euros on the first phase.

Second ESO Astronomy Camp for school students held at the Astronomical Observatory of the Aosta valley in Nus, Italy.

A. Duro/ESO

Laguna Miñiques is situated high in the Chilean Atacama Desert, close to the border with Argentina.

Glossary of Acronyms

4MOST	4-metre Multi-Object Spectroscopic Telescope (Proposed new spectroscopic instrument for VISTA)
A&A	Journal, *Astronomy & Astrophysics*
A&ARv	Journal, *Astronomy and Astrophysics Review*
ACS	ALMA Common Software
AEM	ALMA construction consortium
AFNOR	Association Française de Normalisation
AGN	Active Galactic Nucleus
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
APEX	Atacama Pathfinder Experiment
ApJ	*Astrophysical Journal*
ApJS	*Astrophysical Journal Supplement Series*
AQUARIUS	Mid-infrared detector array (VISIR)
ARA&A	Journal, *Annual Review of Astronomy and Astrophysics*
ARC	ALMA Regional Centre
ARIES21	Control system for 40-metre Radio Telescope (Yebes, Spain)
ArTeMiS	Bolometric camera for APEX
ASAC	ALMA Scientific Advisory Committee
ASSIST	Adaptive Secondary Setup and Instrument Simulator (AOF test bench)
ASTRONET	EU scheme for astronomy to increase cooperation and coordination of research activities carried out at national or regional level in the Member States and Associated States
AT	Auxiliary Telescope of the VLTI
ATLAS	VST survey of southern sky at high Galactic latitudes
ATT	ALMA Technical Team
au	Astronomical unit
AUI	Associated Universities Inc., the North American executive for ALMA
CAMCAO	Camera for Multiconjugated Adaptive Optics, near-infrared camera (AOF)
CASA	Common Astronomy Software Applications (ALMA)
CCD	Charge Coupled Device
CEA	Commissariat à L'Energie Atomique, France
CERN	European Organization for Nuclear Research
CESA	Compañía Española de Sistemas Aeronáuticos S.A. (Spain)
CHAMP+	Dual channel heterodyne receiver array (APEX)
CO	Carbon monoxide
CONDOR	1.5 THz heterodyne receiver (APEX)
CONICA	High-resolution near-infrared camera (VLT, NACO)
COSMOS	HST survey programme
CRIRES	Cryogenic InfraRed Echelle Spectrometer (VLT)
CRIRES+	Planned upgrade to CRIRES
CTA	Cherenkov Telescope Array
DDT	Director's Discretionary Time
DG	Director General
EAGLE	Proposed E-ELT multi-object adaptive-optics spectrograph
EASC	ESO ALMA Support Centre
E-ELT	European Extremely Large Telescope
EFOSC2	ESO Faint Object Spectrograph and Camera (v.2)
EIROforum	Organisation consisting of eight scientific European international organisation, devoted to fostering mutual activities
EM&P	Journal*, Earth, Moon, and Planets*
ePOD	education and Public Outreach Department
ERIS	Enhanced Resolution Imager and Spectrograph
ESA	European Space Agency
ESAC	European Science Advisory Committee (for ALMA)
ESC	E-ELT Subcommittee (of STC)
ESO	European Organisation for Astronomical Research in the Southern Hemisphere
ESON	ESO Science Outreach Network
ESPRESSO	Echelle SPectrograph for Rocky Exoplanet- and Stable Spectroscopic Observations
EU	European Union
ExA	Journal, *Experimental Astronomy*
FC	Finance Committee
FEROS	Fibre-fed, Extended Range, Échelle Spectrograph (2.2-metre)
FIMS	FORS Instrument Mask Simulator
FLAMES	Fibre Large Array Multi Element Spectrograph (VLT)
FORS2	FOcal Reducer/low dispersion Spectrograph (VLT)-2
FPOSS	FLAMES Fibre Positioner Observation Support Software
Gaia	Astrometric satellite (ESA)
GALACSI	Ground Atmospheric Layer Adaptive Optics for Spectroscopic Imaging (AOF)
GIRAFFE	Fibre-fed multi-object spectrograph and part of the VLT FLAMES facility
GmbH	Gesellschaft mit beschränkter Haftung, German limited liability company
GNU	Free Unix-style operating system
GRAAL	GRound-layer Adaptive optics Assisted by Lasers (AOF)
GRAVITY	AO assisted, two-object, multiple-beam-combiner (VLTI)
GRBs	Gamma-ray bursts
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
HD	High Definition
HEDP	Journal, *High Energy Density Physics*
HeRGÉ	HErschel Radio Galaxies Evolution
Hi-GAL	Herschel infrared Galactic Plane Survey
HIRES	Proposed E-ELT high-resolution spectrograph
HR	Human Resources
HST	Hubble Space Telescope
IAC	Instituto de Astrofísica de Canarias
ICAFAL	Ingeniería y Construcción S.A., Chilean construction company
Icar	*Icarus*, Planetary science journal
ICT	Integrated Computing Team (ALMA)
IEPOT	Integrated Education and Public Outreach Team (ALMA)
IET	Integrated Engineering Team (ALMA)
INAF	Italian National Institute for Astrophysics
ISAAC	Infrared Spectrometer And Array Camera (VLT)
ISM	Interstellar medium
IST	Integrated Science Team (ALMA)
IT	Information Technology
JAO	Joint ALMA Observatory
JMoSp	*Journal of Molecular Spectroscopy*
KMOS	*K*-band Multi-Object Spectrograph (VLT)
Kueyen	VLT Unit Telescope 2
LABOCA	Large APEX Bolometer CAmera
LBC	Long Baseline Campaign (ALMA)
LKS	Spanish energy company

LPO	La Silla Paranal Observatory
LSP	La Silla Paranal Subcommittee
M#	Mirror #
MACAO	Multiple Application Curvature Adaptive Optics instrument
MACCON	Motion controller manufacturer
MATISSE	Multi AperTure mid-Infrared Spectro-Scopic Experiment (VLTI)
MaTYSSE	Magnetic Topologies of Young Stars & the Survival of close-in massive Exoplanets
Melipal	VLT Unit Telescope 3
METIS	Proposed mid-infrared imager and spectrograph (E-ELT)
MICADO	Proposed adaptive optics imaging camera (E-ELT)
MIDI	Mid-infrared Interferometric Instrument (VLTI)
MNRAS	Journal, *Monthly Notices of the Royal Astronomical Society*
MOONS	Multi Object Optical and Near-infrared Spectrograph (VLT third generation)
MOS	Proposed multi-object spectrograph (E-ELT)
MPG	Max-Planck-Gesellschaft
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
NewA	Journal, *New Astronomy*
NewAR	Journal, *New Astronomy Reviews*
NGC	New General Catalogue
NIR	Near-infrared
NGC	New Generation Controller
NOVA	The Netherlands Research School for Astronomy (Nederlandse Onderzoekschool voor Astronomie)
NRAO	National Radio Astronomy Observatory
NRI	Night Run Infrastructure
NTT	New Technology Telescope (La Silla)
NVP3D	Swiss 3D film company
OCA	Observatoire de la Cote d'Azur
OmegaCAM	Wide-field camera (VST)
ONERA	Office national d'études et de recherches aérospatiales
OPC	Observing Programmes Committee
OS	Operating system
OSF	ALMA Operations Support Facility
OT3	Observing Tool release 3
P#	Observing Period
P&SS	Journal, *Planetary and Space Science*
P2PP3	Phase 2 Preparation Tool release 3
PASJ	Journal, *Publications of the Astronomical Society of Japan*
PASP	Journal, *Publications of the Astronomical Society of the Pacific*
PESSTO	Public ESO Spectroscopic Survey of Transient Objects
PhRvL	Journal, *Physics Review Letters*
PI	Principal Investigator
PIONIER	VLTI visitor instrument
PLC	Programmable Logic Controllers
PMPD	Performance management and professional development
PRIMA	Phase-Referenced Imaging and Micro-arcsecond Astrometry facility (VLTI)
REM	Rapid Eye Mount telescope (La Silla)
SABOCA	Shortwave Apex BOlometer Camera
SADT	Survey Areas Definition Tool
SAESA	Sociedad Austral de Electricidad, Chilean electrical company
SAPHIRA	Detector for the GRAVITY wavefront sensor
SAXO	SPHERE'S AO system (VLT)
SEPIA	Swedish-ESO PI receiver for APEX
SHFI	Swedish Heterodyne Facility Instrument
SINFONI	Spectrograph for INtegral Field Observations in the Near Infrared (VLT)
SLODAR	SLOpe Detection and Ranging (Paranal)
SMG	Submillimetre galaxies
SOFI	SOn oF Isaac (NTT)
SPARTA	Real-time computer for the AOF
SpecialVLTI	Designation for VLTI visitor instrument(s)
SPHERE	Spectro-Polarimetric High-contrast Exoplanet Research instrument (VLT)
SPIE	International society for optics and photonics
SPIFFI	SPectrometer for Infrared Faint Field Imaging (SINFONI, VLT)
SPT	South Pole Telescope
STC	Scientific Technical Committee
Supercam	64-pixel heterodyne imaging spectrometer (APEX visitor instrument)
TAROT	Télescopes à Action Rapide pour les Objets Transitoires
TB	Terabyte
telbib	ESO Telescope Bibliography (ESO Library database)
TNO	Netherlands Organisation for Applied Scientific Research
TRAPPIST	TRAnsiting Planets and PlanetesImals Small Telescope (La Silla)
UFRN	Universidade Federal do Rio Grande do Norte, Brazil
UK	United Kingdom
UK-ATC	UK Astronomy Technology Centre
Ultra HD	Ultra-high definition
ULTRACAM	High-speed camera (VLT UT3:P74–79; NTT: P85–87)
UltraVISTA	Ultra-deep near-infrared survey in the COSMOS field
USD	User Support Department
UT	VLT Unit Telescopes 1–4: Antu, Kueyen, Melipal and Yepun
UVES	UV-Visual Echelle Spectrograph (VLT)
VDL	Van Der Leegte Groep, the Netherlands
VHS	VISTA Hemisphere Survey
VIMOS	VIsible MultiObject Spectrograph (VLT)
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
VMMPS	VIMOS Mask Preparation Software
VPHAS+	ESO Public Survey VST/OmegaCAM Photometric Hα Survey
VST	VLT Survey Telescope
VVV	ESO Public Survey VISTA Variables in the *Vía Láctea*
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
Z-spec	Millimetre-wave spectrograph (APEX visitor instrument)
µm	Micrometre

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ALMA Array Operations Site
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Cover: Construction of the asphalt road from Paranal to Armazones, where the E-ELT will be sited, is underway. Work began in March and is due to take around 16 months to complete.
Credit: ESO/Gerd Hüdepohl (atacamaphoto.com)

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