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40+ Years of Instrumentation for the La Silla Paranal Observatory

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As ESO Period 100 comes to a close, I look back at the development of ESO's instrumentation programme over more than 40 years. Instrumentation and detector activities were initially started by a small group of designers, engineers, technicians and astronomers while ESO was still at CERN in Geneva in the late 1970s. They have since led to the development of a successful suite of optical and infrared instruments for the La Silla Paranal Observatory, as testified by the continuous growth in the number of proposals for observing time and in the publications based on data from ESO telescopes. The instrumentation programme evolved significantly with the VLT and most instruments were developed by national institutes in close cooperation with ESO. This policy was a cornerstone of the VLT programme from the beginning and a key to its success.

Instrumentation: the interface between ESO and its users

Most astronomers in Europe are familiar with ESO as it is today, with its three observing sites in Chile, the Extremely Large Telescope under construction, the scientific and administrative centre in Santiago, headquarters in Garching, and as the European partner in the Atacama Large Millimeter/submillimeter Array (ALMA). However, they may not be aware of the modest goals (as compared to today's achievements) set by ESO's founders in the ESO Convention of 1962, which was signed by representatives from Belgium, France, the Federal Republic of Germany, the Netherlands and Sweden. An excerpt from the English version of the document states[1], "The purpose of the Organisation shall be to build, fit out and operate an astronomical observatory situated in the southern hemisphere. The initial programme of the Organisation shall comprise the construction, installation and operation of an observatory in the southern hemisphere, consisting of:

a. a telescope with an aperture of about 3 metres;
b. a Schmidt telescope with an aperture of about 1.20 metres;
c. not more than three telescopes with a maximum aperture of 1 metre;
d. a meridian circle;
e. the auxiliary equipment needed to carry out research programmes with the instruments listed in a., b., c. and d. above…".

When reading this text for the first time, I was amused to see that only the telescopes and the meridian circle only granted the title of "research instruments" while everything else was more modestly described as "auxiliary equipment". The first telescopes erected at the La Silla site (with diameters of 50 cm, 1 m and 1.52 m) were equipped with "auxiliary equipment" supplied by institutes in the member countries: photometers for the smaller telescopes and high-resolution spectrographs for the 1.52-metre telescope. These instruments mostly duplicated similar ones in operation at European sites and were conceived to carry out stellar work in the southern hemisphere, reflecting the focus of European astronomy at that time.

This was in the early 1970s, when the North American observatories were increasingly starting to focus their scientific research on extragalactic targets, spurred on by the discovery of the first quasars, which changed our view of the Universe. European astronomy needed larger telescopes and modern instrumentation to compete with these exciting scientific developments. ESO's founders had a vision that this was best achieved by joining forces, but progress was initially slow.

The 3.6-metre telescope, ESO's main project, saw first light in 1976. Lodewijk Woltjer, ESO Director General from 1975 to 1987, writes in his book (Woltjer, 2006), "When I came to ESO in 1975, it was evident that there was no real plan to effectively use the 3.6 m telescope for contemporary science. There also would be no suitable instrumentation to attach to the telescope." An instrumentation development programme was started while ESO was still at CERN in Geneva (between 1972 and 1980). This was further expanded when the Organisation moved to its new Headquarters in Garching, Germany. Two instrumentation groups, one optical and one infrared, were set up. They were led by astronomers who reported directly to the Director General. A dedicated group of engineers was put to work on the procurement and testing of optical and infrared detectors and their control systems within the Technical Division. A committee of astronomers from the member countries and from ESO, later called the Scientific Technical Committee, provided the guidelines and general specifications for these new developments. During those early years, when ESO began to build its reputation, the overall structure was agile and flexible and ensured that strategic choices in the development of instruments were driven by the science.

The importance of instrumentation and the associated detectors to observational astronomy cannot be underestimated. Instruments serve as a key interface between an observatory and its scientific users. Along with good atmospheric conditions and telescopes that operate smoothly, instrumentation can determine the scientific success of an observing run. If the instruments operate well and can compete with those available elsewhere, astronomers will obtain high-quality data that ultimately gives them a more effective long-term impact in their field of research. This, in short, is the primary goal of an observatory.

1978–1998: two decades of "fast and furious" growth

The instrumentation and detector programme started to show results at the telescopes in Chile at the end of the 1970s. First, the Coudé Échelle Spectrograph (CES) with a 1D digital detector become operational in the coudé room of the 3.6-metre telescope, fed by the newly erected 1.4-metre Coudé Auxiliary Telescope (CAT) and, a few years later, by an optical fibre from the 3.6-metre. An off-the-shelf instrument, the Boller and Chivens grating spectrograph, was acquired to offer the possibility to observe faint objects at the 3.6-metre. It initially used a 1D Image Dissector Scanner (IDS) detector.

Two instruments designed and built by ESO then become operational in 1984

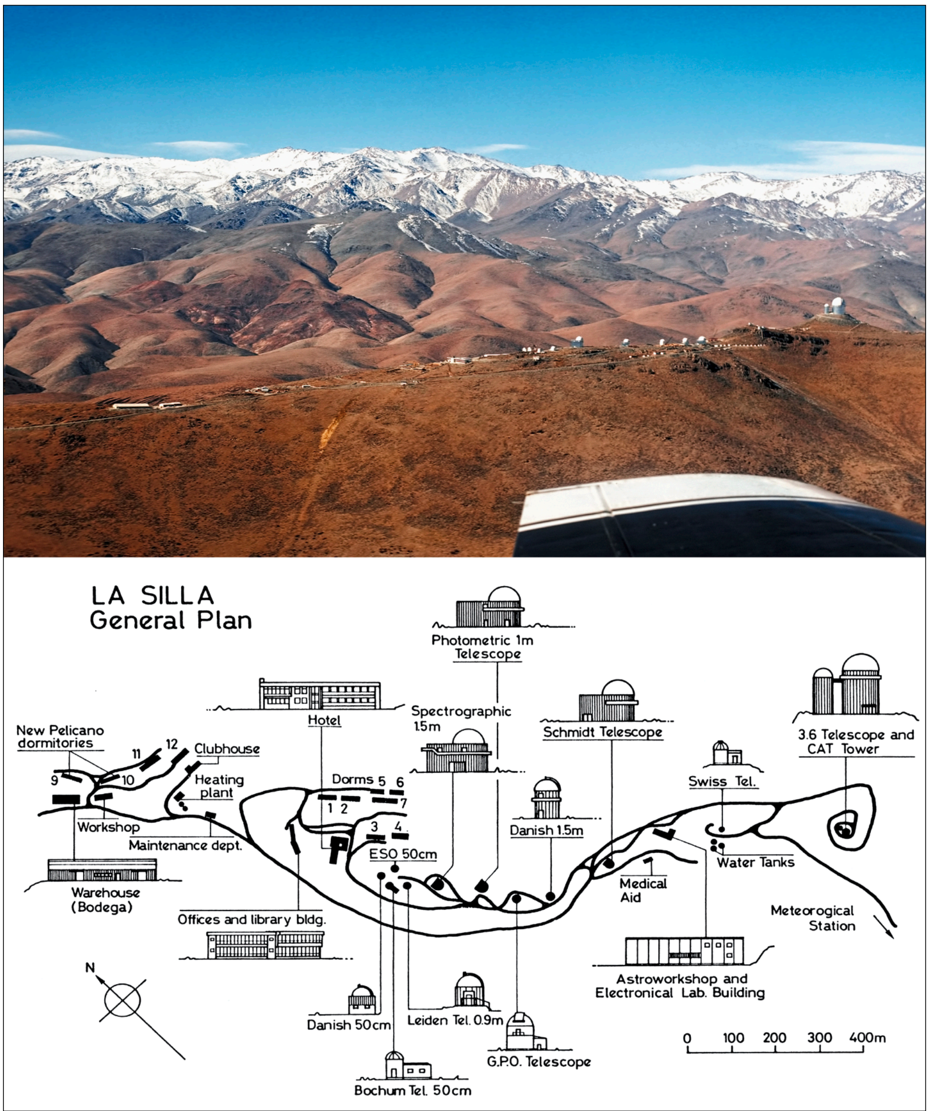

Figure 1. Below is the hand-drawn map of the La Silla Observatory from the beginning of the 1980s, before the installation of the 2.2-metre telescope and the NTT. A photo from the same epoch was taken from the plane that was used to commute staff from Santiago to the Pelicano airstrip close to La Silla. The small plane was in use until the early 1990s.

and 1985: CASPEC, an efficient cross-dispersed échelle spectrograph and the ESO Faint Object Spectrograph & Camera (EFOSC). Both used silicon charge-coupled device (CCD) detectors — the first to operate at the 3.6-metre telescope. The high efficiency of the optics, coupled with the high quantum sensitivity of the CCDs, boosted the performance of these instruments and, for the first time, gave European astronomers the possibility of competing on crucial observing modes with their colleagues at other 4-metre-class telescopes worldwide. In the mid-1980s these two instruments regularly used around 60 % of the telescope nights.

EFOSC deserves a special mention. This innovative transmission optics instrument was the first major work by the ESO designer Bernard Delabre, who recently retired. It was followed by an upgraded version, EFOSC2, which served as the prototype for the very successful FORS instruments at the Very Large Telescope (VLT). As noted by de Zeeuw et al. (2017), EFOSC clones or derivatives have been built for telescopes distributed across almost all continents. Delabre put forward many other original ideas over his 40 years at ESO, with the consistent aim of designing more efficient instruments using affordable optics. Most VLT instruments are based on his designs or incorporate his ideas. I worked with him on the definition of several instruments (EMMI, FORS, UVES, X-shooter), which was always a gratifying experience. On receiving a set of requirements, such as wavelength range, spectroscopic resolution, image scale and the likely properties of the detector, he would create a preliminary, often original, design in just a few days. A robust discussion with the project team would follow, about performance, feasibility and cost, and would eventually lead to a final configuration that formed part of an instrument proposal.

Table 1 lists the most-demanded instruments at the three most powerful La Silla telescopes, along with their period of operation and the number of publications that have used their data. The years from 1978 to 1998 saw a spectacular growth in ESO facilities, with the arrival of new instruments at the 3.6-metre telescope, the installation of the 2.2-metre Max-Planck-Gesellschaft (MPG)/ESO telescope and the completion of the New Technology Telescope (NTT) with three fixed instruments at its two Nasmyth foci. All of this was during the construction of the VLT. The growing interest and confidence of the community in the use of ESO's facilities was reflected in the number of observing proposals, which went from about 150 in 1978 to over 550 in 1995 (Patat et al., 2017).

The use of near-infrared (NIR) instruments was initially limited by the lack of suitable detectors. In the first part of this period, the first NIR spectrograph, IRSPEC, started operating at the 3.6-metre telescope with just a 32-diode linear detector, which was upgraded to a 58 × 62 pixel InSb array when the instrument was moved to the NTT in 1991. A few years later when the 1k × 1k pixel HgCdTe infrared arrays become available, ESO quickly put them into operation using two new instruments, SOFI at the NTT and ISAAC at the VLT. The two were immediately in high demand and delivered a rich harvest of scientific results.

Instrument name	Acronym	Telescope	Instrument type	Operating time	No. papers
Bollers & Chivens	B & C	3.6 m	Grating spectrograph	1978–1990	N/A
Cassegrain Échelle Spectrograph	CASPEC	3.6 m	Échelle spectrograph + spectropolarimetric mode	1984–1999	N/A
ESO Faint Object Spectrograph and Camera 1–2[a]	EFOSC1–2	3.6 m, NTT	Spectrograph, imager, polarimeter	1985 →	690
Infrared Spectrometer	IRSPEC	3.6 m, NTT	NIR 1D spectrograph	1987–1996	N/A
Thermal Infrared Multi-Mode Instrument[b]	TIMMI2	3.6 m	MIR spectrograph & imager	2000–2006	97
High Accuracy Radial velocity Planet Searcher[b]	HARPS	3.6 m	Échelle spectrograph	2003 →	689
ESO Multi-Mode Instrument	EMMI	NTT	Spectrograph & imager	1990–2008	689
Son of ISAAC	SOFI	NTT	NIR spectrograph & imager	1998 →	809
SUperb Seeing Instrument 2	SUSI2	NTT	Imager	1998–2008	130
Wide Field Imager[b]	WFI	2.2 m[d]	Wide field imager	1998–2013	515
Fibre-fed Extended Range Optical Spectrograph[b,c]	FEROS	2.2 m[d]	Échelle spectrograph	2003–2013	676

Table 1. The most popular instruments at the largest La Silla telescopes. The publication statistics are from 1 January 2000 to 31 January 2018, and are therefore unavailable for some of the earliest instruments. Some of the instruments were built by consortia; please see the Notes at the end of the article for further information on the Principal Investigators and teams.

While the ESO-built instruments took up the bulk of the observing time at the 3.6-metre telescope and at the NTT, the telescopes were also used by visitor instruments or part-time instruments supplied by national institutes. Most notably, the three adaptive optics (AO) systems (Come-On, Come-On+ and the ADaptive Optics Near Infrared System [ADONIS]) and a mid-infrared (MIR) version of EFOSC called TIMMI (superseded by TIMMI2), were developed in France and played a key role as scientific tools and as test benches for future VLT instruments.

Starting in 1993 at the NTT, a high-resolution NIR camera, SHARP (built in Germany), was used by a dedicated team for observations of the Galactic Centre, opening up a very successful line of research that has continued on to the present day with the VLT instruments SINFONI and GRAVITY, the latter only commissioned in 2017. A later addition to the list of instruments supplied by national institutes was the high-stability échelle spectrograph HARPS in 2003, which is installed in the coudé room of the 3.6-metre telescope and is now the only instrument offered at that telescope. As shown in Table 1, data taken with the instrument have been used for close to 700 publications since its installation, making it the most successful planet hunter in ground-based astronomy.

What I have outlined in this article is a somewhat selective version of two decades of the history of instrumentation at the La Silla Observatory. Other telescopes, the ESO 1-metre Schmidt, which was dedicated to the southern sky photographic survey, the spectroscopic ESO 1.52-metre and the Danish 1.54-metre with its CCD camera (the first to be installed on La Silla) and later host to the Danish version of EFOSC, also contributed significantly to the scientific growth of the user community. Additional instruments served a large number of users well; for example, the prime focus cameras and OCTOPUS (a multi fibre spectrograph at the 3.6-metre telescope), the two Boller & Chivens spectrographs at the 1.52-metre and the 2.2-metre telescopes, FEROS at the 1.52-metre telescope, and infrared cameras IRAC and IRAC2 at the 2.2-metre telescope. These were particularly useful in building the expertise that later bore fruit at the VLT. More details on various projects conducted over 50 years of ESO can be found in Madsen (2012).

The VLT era (1999–2018): collaborating with ESO Member State institutes

Construction of the VLT was approved by the ESO Council in December 1987. This was well before NTT first light in March 1989, so the exceptional image quality obtained in the first NTT observations, thanks to the newly implemented active optics, was as yet unknown. A number of other factors led to the approval of the VLT, including: the preparatory work that ESO carried out with technical studies in house; the organisation of meetings focussing on the science and design challenges of large telescopes; the favourable economic situation in ESO Member States; and the growing interest within the scientific community and amongst the public about new astronomical discoveries from the ground and from space. The good results obtained with the first ESO-built instruments, like CES, CASPEC and EFOSC, also helped to build confidence in ESO in the scientific community and in members of the ESO Council.

Discussions about VLT instrumentation started very early in the project, with VLT Working Groups, focused on different observing modes and composed of external and ESO scientists, set up in 1985. After these interactions, the first version of the VLT instrumentation plan was released in 1990 (D'Odorico et al., 1991), more than 8 years before first light. It already contained an outline of the first instruments to be built and the strategy for their procurement.

The cornerstones of the proposed approach, which was new for ground-based observatories, were:

- The majority of instruments had to be built by institutes, with ESO contributing standard items and selected subsystems.
- Instruments had to comply with a set of verifiable specifications and would be subject to regular review during construction.
- Hardware costs were to be paid by ESO, while the staffing provided by the institutes would be compensated by observing nights with the instrument (called Guaranteed Time Observations [GTO]).

Instrument name	Acronym	Type	Operation time	Team information
FOcal Reducer/low dispersion Spectrograph 1	FORS1	Vis. I,S,P	1999–2009	PI I. Appenzeller, Co-PIs R. Kudritzki & K. Fricke (Germany)
Infrared Spectrometer And Array Camera	ISAAC	NIR I,S	1999–2013	PI A. Moorwood (ESO), PM A. van Dijsseldonk, IS J. G. Cuby
FOcal Reducer/low dispersion Spectrograph 2	FORS2	Vis. I,S, P	2000 →	See FORS1
UltraViolet-Visual Échelle Spectrograph	UVES	Vis. Éch.	2000 →	PI S. D'Odorico (ESO), PM H. Dekker, IS A. Kaufer
Nasmyth Adaptive Optics System (NAOS)-CONICA	NACO	NIR AO I,S	2002 →	PIs R. Lenzen (Germany) & G. Rousset (France)
VIsible Multi-Object Spectrograph	VIMOS	Vis. MOS	2003 →	PI O. LeFèvre (France), Co-PI P. Vettolani (Italy)
Fibre Large Array Multi Element Spectrograph	FLAMES	Vis. MFS	2003 →	PI L. Pasquini (ESO), Co-PIs A. Blecha (Switzerland), C. Cacciari (Italy), M. Colless (Australia), F. Hammer (France)
Spectrograph for INtegral Field Observations in the Near Infrared	SINFONI	AO NIR IFS	2004 →	PIs N. Thatte & F. Eisenhauer (Germany), Co-PI T. de Zeeuw (Netherlands), H. Bonnet
VLT Imager and Spectrometer for mid-InfraRed	VISIR	MIR I-S	2005 →	PI P. O. Lagage (France), Co-PI W. Pel (Netherlands)
Cryogenic InfraRed Échelle Spectrometer	CRIRES	NIR Éch.	2007–2014[e] →	PI H.-U. Käufl (ESO), PM J. Pirard
High Acuity Wide field *K*-band Imager	HAWK-I	NIR I AO	2008 →	PI M. Casali (ESO), PM J. Pirard, IS M. Kissler-Patig
X-shooter	X-shooter	NIR Éch.	2009 →	PIs S. D'Odorico (ESO), F. Hammer (France), L. Kaper (Netherlands), P. Kiærgaard (Denmark), R. Pallavicini (Italy), PM H. Dekker, IS J. Vernet
K-band Multi-Object Spectrograph	KMOS	NIR MOS	2013 →	PIs R. Sharples (UK), R. Bender (Germany)
Multi Unit Spectroscopic Explorer	MUSE	Vis. IFS AO	2014 →	PI R. Bacon (France), Co-PIs T. de Zeeuw (Netherlands), S. Lilly (Switzerland), H. Nicklas (Germany), J. P. Picat (France), M. Roth (Germany)
Spectro-Polarimetric High-contrast Exoplanet REsearch instrument	SPHERE	NIR AO I,S,P	2015 →	PI J. L. Beuzit (France), Co-PI M. Feldt (Germany)
Échelle SPectrograph for Rocky Exoplanet- and Stable	ESPRESSO	Vis. Éch.	2018 →	PI F. Pepe (Switzerland), Co-PIs S. Cristiani (Italy), R. Rebolo-Costa (Spain), N. Santos (Portugal)
Enhanced Resolution Imager and Spectrograph	ERIS	NIR I,S AO	2020 (tbc)	PI R. Davies (Germany), Co-PIs S. Esposito (Italy), M. Kenworthy (Netherlands), M. Macintosh (UK), S. Quantz (Switzerland)
Multi Object Optical and Near-infrared Spectrograph	MOONS	Vis.–NIR MFS	2021 (tbc)	PIs J. Afonso (Portugal), M. Carollo (Switzerland), M. Cirasuolo (ESO), R. Maiolino (UK), H. Flores (France), T. Oliva (Italy), L. Vanzi (Chile),

Table 2. VLT Instruments from first light in 1999 to 2018. The second column lists the wavelength bands (Vis. visible, NIR near-infrared, MIR mid-infrared) and instrument capabilities, which are described as follows: AO adaptive optics, Éch échelle spectroscopy, I imager, IFS integral field spectroscopy, MFS multiple fibre spectroscopy, MOS multi-object spectroscopy, P polarimetry and S spectroscopy. The Team information lists the Principal Investigators (PIs) and Co-PIs. The latter were members of the consortium responsible for the project in their institute or for their country. In the case of ESO-led projects, project managers (PM) and instrument scientists (IS) are also given.

The resulting instrument collaborations included advantages for both parties. For ESO it enabled an ambitious instrumentation programme within budget and on schedule; it gave access to unique expertise that was nurtured in national institutes; and it fostered a sense of ownership of the VLT programme in a significant fraction of the astronomy community. For the institutes it led to the creation of competent, multidisciplinary instrument teams around an ambitious project, and made it easier to obtain funding from national agencies to develop the necessary infrastructure, including integration and testing facilities.

Finally, GTO provided the opportunity to carry out programmes that could have a significant scientific impact. This synergy between ESO and the different national groups has produced a unique set of high-quality instruments and greatly contributed to the growth of ground-based astronomy in Europe. Seven out of 11 first-generation instruments were built outside ESO and this percentage is even higher for the second generation. The contribution of ESO to the external instruments has been significant; all the detector systems (visible and NIR) were procured, integrated and optimised by ESO. Other significant examples of ESO deliverables are the AO systems for SINFONI, MUSE and HAWK-I and the large échelle grating unit for ESPRESSO.

Table 2 lists all of the instruments at the VLT today as well as the two that have been decommissioned and two that are in an advanced stage of construction. The operational lifetime of the first instruments has clearly exceeded the original estimates of a maximum of ten years of operation. This has been made possible by the homogeneous and high standards that were set for all instrument specifications and by effective maintenance procedures at the Observatory. Technical interventions and upgrades have been carried out when needed to keep instrument performance competitive. A detailed analysis of statistics of ESO observing proposals, and of the number of publications and the corresponding citations, has been carried out by Leibundgut et al. (2017) and concludes, "all VLT instruments are in constant demand, display a good scientific return and show significant scientific impact". The fact that citation counts continue to increase for all operational instruments is an indication of their ongoing competitiveness.

Interferometry was a key objective of the VLT from its conception. Table 3 lists the

Instrument name	Acronym	Instrument type	Operation time	Team information
VLTI Commissioning Instrument	VINCI	*K*, 2-beam	2001–2011	PI V. Coudé du Foresto (France), Co-PI P. Kervella (France, ESO)
Astronomical Multi-BEam combineR	AMBER	*H-K*, 3-beam, SC	2004 →	PI R. Petrov (France), Co-PIs F. Malbet (France), K.-H. Hofmann (Germany)
Mid-infrared Interferometric instrument	MIDI	*N*, 2-beam, SC	2003–2015	PI C. Leinert (Germany), Co-PIs G. Perrin (France), R. Waters (Netherlands)
Precision Integrated-Optics Near-infrared Imaging ExpeRiment	PIONIER	*H-K*, 4-beam, I	2011 →	PIs J. P. Berger, J. B. Le Bouquin (France)
GRAVITY	Gravity	*K*, 4-beam, I Astr., SC	2016 →	PI F. Eisenhauer (Germany), Co-PIs K. Perraut (France), G. Perrin (France), C. Straubmeier (Germany), W. Brandner (Germany), A. Amorim (P)
Multi-AperTure mid-Infrared SpectroScopic Experiment	MATISSE	*L-N*, 4-beam, I, SC	2019 →	PI B. Lopez (France), Co-PIs T. Henning (Germany), G. Weigelt (Germany), W. Jaffe (Netherlands), F. Vakili (France)

Table 3. VLTI instruments and key information about the instruments and the instrument building teams. PIs and Co-PIs are defined as in Table 2. The instrument type lists the wavelength band covered, the number of coherently combined telescope beams and the type of instrument using the following abbreviations: Astr. astrometry; I 2D imaging; and SC spectroscopic capability.

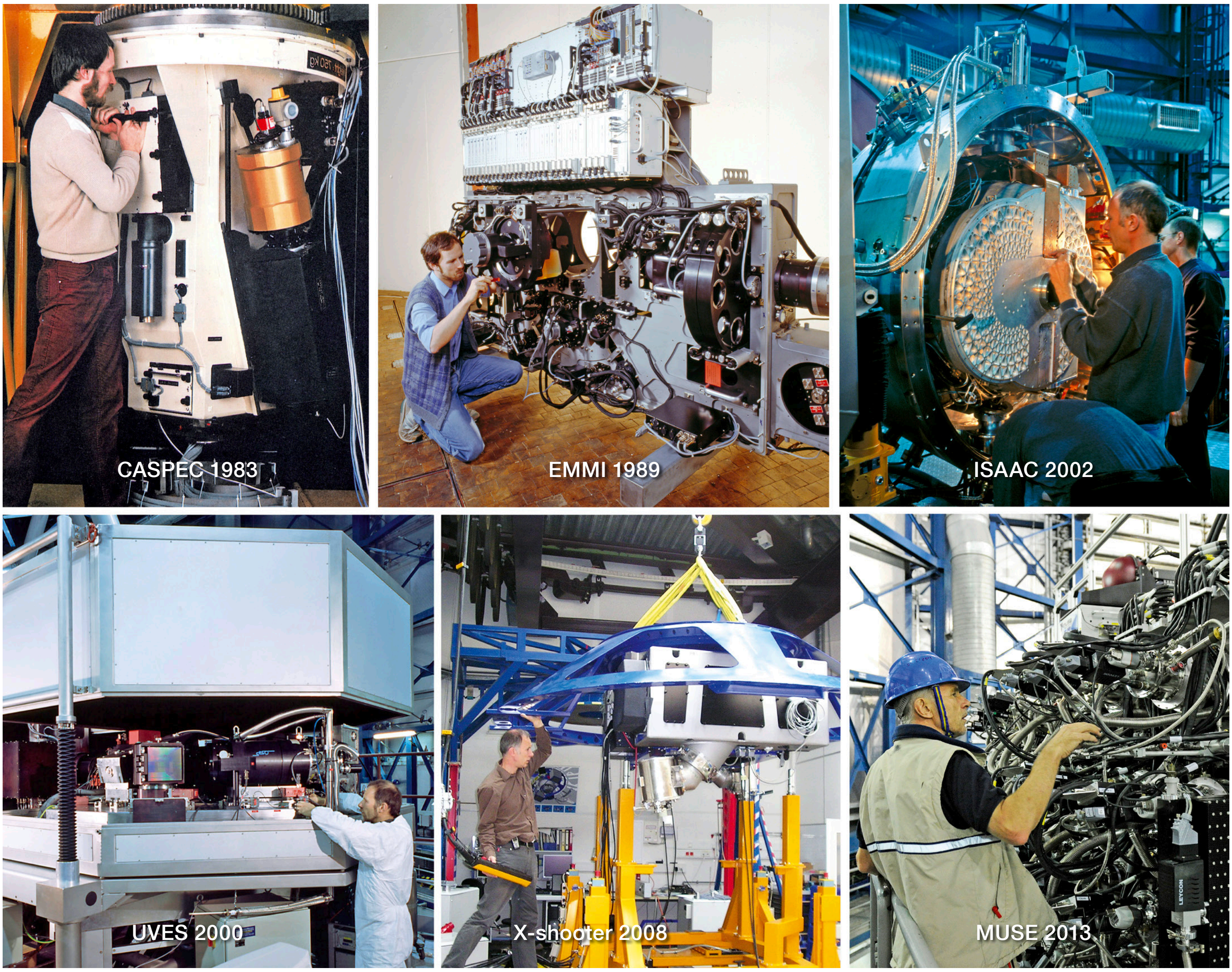

Figure 2. This mosaic of ESO instruments spanning 30 years of ESO history illustrates that the organisation is made up of individuals, not just of a sequence of projects. In this case the photos show Jean-Louis Lizon á l'Allemand, the long-time head of the Integration and Cryogenic Group, at work during the testing and integration of instruments for La Silla and Paranal. Equivalent pictures could be made up for many other members of the ESO personnel in Garching and in Chile. It is a useful reminder of the importance of in-house technical expertise and of the dedication of ESO staff to their unique jobs.

main VLTI instruments. These are located at the focus for coherent combination of the light beams from the four dedicated 1.8-metre Auxiliary Telescopes (ATs) or from the 8-metre telescopes. In practice, owing to the special requirements and exploratory nature of the interferometric observations, all of these instruments have been developed by national institutes in close collaboration with the VLTI group at ESO. Coherent combination of the light from the 8-metre Unit Telescopes has been carried out for more than a decade now, but ESPRESSO, a high stability échelle spectrograph that is being commissioned at the Paranal Observatory, is the first instrument which can be fed by the incoherent beam/(s) from either a single telescope or multiple telescopes. It will open up new parameter space in both limiting magnitude and wavelength accuracy, in high resolution spectroscopy at ESO.

In the last decade the cooperation between ESO and its community on Paranal has not been confined to the VLT but has led to the installation of two additional powerful telescopes. The VISTA 4-metre survey telescope with an infrared camera (VIRCAM), covering a field of 1.65 degrees in diameter, was delivered by the UK in 2007 as an in-kind payment when it joined ESO. The 2.5-metre VLT Survey Telescope (VST) was installed by the Italian National Institute for Astrophysics in 2011 and is equipped with a 1 × 1 degree field CCD camera (OmegaCAM), which was developed by a consortium from the Netherlands, Germany, Italy and ESO.

We are now approaching 20 years of VLT operation. The procedure set up more than 25 years ago for the definition and procurement of instruments has been consolidated and proven to be very successful. It has inspired similar approaches at all other major observatories worldwide. The 39-metre ELT telescope project that ESO is embarking on now opens up a new scenario. The unique properties of the AO-based telescope — the largest photon collecting area ever in one telescope — and the need to optimise the use of precious observing time require new thinking in the selection and design of instrumentation as well as in its operating mode(s). These are the exciting challenges that the ESO community faces over the next decade.

Acknowledgements

The instrumentation effort at ESO has involved the contributions of more than a hundred members of ESO staff over the last 40 years. This includes designers, managers, engineers, technicians, physicists and astronomers, both at ESO Headquarters and at the Observatory in Chile. Their role has often been decisive in determining the success of the projects. It is impossible to acknowledge their contribution individually here.

It is equally impossible to give the corresponding list of people from the institutes in the ESO member states who provided unique expertise and supplied fully working instruments. The names of external PIs and Co-PIs of the instruments in Tables 1, 2 and 3 are just a reminder of the massive external contribution to instrumentation. The full list of those involved with their responsibility in the different projects can be found in the publications quoted in the ESO instrument pages.

Finally, I would like to mention the key role of A. Moorwood, with whom I shared 30 years of ESO instrumentation activities, working under five Directors General, and to thank A. Glindemann, J. L. Lizon and L. Pasquini for supplying their unique knowledge for this article. The publication statistics are from the public ESO Telescope Bibliography, maintained by the ESO Library.

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Links

[1] Convention and Protocols, European Southern Observatory (January 1987): https://www.eso.org/public/archives/books/pdf/book_0017.pdf

Notes

[a] EFOSC2 was at the 2.2-metre telescope from 1991 to 1997, at the 3.6-metre telescope from 1998 to 2007 and at the NTT from 2008.

[b] The following La Silla instruments were built by consortia in collaboration with ESO. Some more information about their teams is listed below:
- TIMMI2: PI H. G. Reimann (Germany), Co-PIs H.-U. Käufl (ESO) and H. Hron (Austria).
- HARPS: PI M. Mayor (Switzerland), Co-PIs W. Benz (Switzerland), J. P. Sivan (France) and L. Pasquini (ESO).
- WFI: PI K. Meisenheimer (Germany), Co-PIs M. Capaccioli (Italy) and D. Baade (ESO).
- FEROS: PI B. Wolf (Germany), Co-PIs J. Andersen (Denmark), A. Kaufer (Germany) and L. Pasquini (ESO).

[c] FEROS was at the 1.52-metre telescope between 1999 and 2002.

[d] The 2.2-metre telescope was installed on long-term loan from the Max-Planck-Gesellschaft and has not been offered for time at ESO since 2014.

[e] CRIRES has not been offered to the community between 2014 and 2018 because of an upgrade project.


G. Hüdepohl (atacamaphoto.com)/ESO

The VLT/I at sunset.