

## Science with the VLT in the ELT Era

held in Garching, Germany, 8–12 October 2007

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The workshop ‘Science with the VLT in the ELT Era’ was organised by ESO to provide a forum for its community to debate the likely evolution in the scientific use of the VLT over the next 10–20 years and to propose concepts for new instrumentation. Sessions were devoted to VLT and VLTI science highlights; future science priorities; VLT and VLTI synergy with ELTs, ALMA and JWST; second-generation VLT and VLTI instrumentation; new instrument concepts and VLT/I operating modes. Ample time was also made available for some very lively discussion sessions. This retrospective aims to summarise very briefly what was presented and to convey some feeling of the expectations and wishes of the community raised in the discussion sessions.

This was the latest in a series of Workshops organised primarily to provide the ESO community with a further opportunity to propose ideas and discuss the future of instrumentation at the VLT and VLTI. It was organised by ESO with help and input from its Scientific and Technical Committee (STC). A new slant this time was given by the fact that the timescale for the instrumentation concerned is expected to overlap with the availability of ALMA, JWST and, hopefully, a European Extremely Large Telescope. It was therefore considered important to devote time to discussing to what extent synergy or complementarity between these facilities might influence both the choice of instruments and/or operating modes of the VLT and its interferometric mode, the VLTI. This Workshop also provided the first opportunity to specifically assess the role of VLT and VLTI in the implementation of the recently published ASTRONET Science Vision. In practice, interest in these topics proved to be so high that it proved necessary to relocate the Workshop from ESO to the neighbouring Max-Planck-Institut für Extraterrestrische Physik whose help and hospitality in providing a large enough auditorium is most gratefully acknowledged. About 180 finally participated in the Workshop, some of whom appear in

Figure 1 and most of whom enjoyed the Bavarian style Workshop Reception and Dinner hosted by ESO at the Gasthof Neuwirt in Garching.

The opening welcoming address was given by the Director General, Tim de Zeeuw, who reminded us of ESO’s priorities as established by Council, which include continuing to fully exploit the VLT and VLTI and its associated survey telescopes, VST and VISTA, as well as completing ALMA on time and budget and designing and securing funding for construction and operation of an E-ELT. I then made a short introduction to the Workshop, recalling its most recent predecessors in 2001 and 2005, devoted to VLT and VLTI second-generation instruments respectively, and explaining the intention of including ‘ELT era’ in the title as proxy for the wider context in which VLT/I is expected to be operating around a decade from now.

### VLT and VLTI Science

The programme started with sessions on VLT and VLTI Science Highlights with invited (Alvio Renzini, Andrea Cimatti and Guy Perrin) and contributed (Martin Hähnelt, Piercarlo Bonifacio, Valentina D’Odorico, Mattieu Puech, Roberto Maiolino, Natascha Forster-Schreiber, Makato Kishimoto, Norbert Przybilla, Yiannis Tsamis, Giuseppe Bono, Walter Jaffe, Olivier Chesnau, Thorsten Ratzka, Gerd Weigelt, Stefan Kraus and Thomas Driebe) talks presenting scientific results which emphasise the unique science capabilities of the VLT and VLTI. This revealed that perhaps the most striking capability of the VLT so far has been its wide instrumental capability, distributed over 12 focal stations on 4 telescopes, thus allowing large amounts of observing time for each of a wide range of science programmes. This is somewhat in contrast to the original utilisation planned, which foresaw more simultaneous use of multiple instrument copies and the use of both coherent and incoherent combination of all four telescopes. During the discussion there appeared to be some consensus that maybe more consideration should, in fact, be given to exploiting these unique capabilities in the longer-term future.

The next session on Future VLT Science Priorities was the first such discussion on the future of the VLT/I since the appearance of the ASTRONET Science Vision document which was presented at the beginning (by Guy Monnet on behalf of Catherine Turon, chair of the ASTRONET Science Vision working group, who was unfortunately unable to attend). A short report on the Science Vision document can be found on page 2 of this issue. Although this Vision is to some extent directed more to future facilities, it is clear that VLT and VLTI will remain outstanding tools for addressing many of its high-priority science questions. These include a wide variety of capabilities for detecting and characterising exoplanets and the use of interferometry to study the effects of strong gravity e.g. produced by the black hole at the centre of our Milky Way. Jacqueline Bergeron elaborated beyond the Science Vision itself in outlining the many galaxy evolution studies needed. Many other areas were covered by contributions from Bob Nichol, Stephane Udry, Olivier Le Fèvre, Will Sutherland, Luigi Guzzo, Eelco van Kampen, Bram Venemans, Mike Irwin, Steffen Mieske, Grazina Tautvaisene and Klaus Reinsch.

The most lively discussion centred around the use of the VLT for extragalactic studies and, particularly, its suitability to address cosmological/physics questions concerning the origin and nature of dark matter and dark energy. Progressing beyond our current understanding of these mysteries appears to require investigations of massive samples, provided by imaging and redshift surveys, beyond those for which the VLT was designed and instrumented. Nevertheless, the VLT can bring powerful imaging and multi-object spectroscopic survey capabilities to bear on many questions concerning the origin and evolution of galaxies. The main issue to many for the future is field – e.g. could the field at the VLT be increased from its current maximum of 30’ at Nasmyth, to say around 1.5 degrees, by adding a prime focus on at least one of the 8-m Unit Telescopes? This facility could then be devoted to massive imaging and spectroscopic surveys. Although nothing is impossible, later contributed talks indicated that it would at least be technically challenging (weight and space restrictions, new active



**Figure 1:** Some of the participants at ESO's Science with the VLT in the ELT Era Workshop.

optics system) and would probably require an expensive rebuilding of the telescope, requiring financial and human resources well beyond those foreseen for the 2nd-generation instrumentation plan which triggered this workshop. As stressed later by Mark Casali, it should also not be forgotten that the 4-m VISTA telescope, expected to start operation on Paranal in the near future, will also be the most powerful infrared survey facility world-wide for years to come.

### Synergies between Facilities

Possible VLT and VLTI synergy with ELTs was the specific topic of the next session which was kicked off by a series of invited talks by Roberto Gilmozzi, Isobel Hook and Sandro D'Odorico who provided an excellent overview of the European ELT project including its science goals and growing instrumentation plan. Marijn Franx also gave an invited talk on VLT/ELT synergy but ended up concluding that there might not be as much as commonly assumed. At least the VLT will probably not be needed to generate targets for the ELT which would more likely come from smaller survey telescopes. Contributed talks on various scientific and instrumental aspects were given by Jochen Liske (ESPRESSO to CODEX), Cesare Barbieri (quantum astronomy), Klaus Strassmeier (magnetic fields), Ralf Siebenmorgen (mid-IR imaging and spectroscopy), Matthias Tecza (near-IR IFU spectrometer for the ELT),

Luca Labadie (synergy between LBT and ELT) and David Crampton (TMT science and instruments). In the following discussion there was indeed a feeling that, while the VLT may be useful for preparatory work in the pre-ELT era, the VLT and, particularly VLTI, will be most in demand for its complementary and unique scientific capabilities; these are therefore probably the ones to enhance through its future instrumentation programme. David Crampton's talk also suggested some possible complementarity between ELT and TMT, since neither project appears likely to have the resources to do everything alone.

This session was actually split into two by a dedicated Poster break to allow those interested to discuss with the presenters of a wide range of interesting posters covering: further scientific and technical aspects of ESPRESSO; science demonstrations of VLT/I; possible upgrades e.g. of FORS and FLAMES; science cases for high-resolution infrared spectroscopy and interferometry; etc.

The synergy theme was continued in the following session devoted to ALMA and JWST whose status were reviewed for us by Leonardi Testi and Mark McCaughrean respectively, and supplemented by contributions by Massimo Stiavelli and Luis Colina on extragalactic observations with JWST. Again, in the following discussion, the complementarity of these facilities rather than their synergy was stressed, although this may be largely a question of

semantics – obviously many astronomers want to use all of these facilities to tackle their particular science objectives.

### Second-Generation Instrumentation

Then came one and a half days devoted specifically to Second-Generation VLT and VLTI Instrumentation. By way of introduction I summarised the current status which includes several second-generation instruments already under development for the VLT, plus three VLTI instruments, selected for Phase A studies following the VLTI dedicated workshop in 2005. The studies have just been completed and are awaiting recommendation by the STC in October 2007. I also summarised the ESO resources available to implement one or more of these and also those resources for new VLT instruments, for which a similar amount of money and FTE resources have been earmarked in ESO's Long-Term Perspectives as for the already approved complement of second-generation instruments. Most of this money is foreseen to become available, starting in 2010, for the development of instruments intended to fill the gaps left by the retirement of first-generation instruments due to technical or obsolescence reasons, starting around 2015!

Presentations of the recently commissioned HAWK-I and the already approved second-generation instruments X-shooter, KMOS, MUSE and SPHERE by Mark Casali, Lex Kaper, Ray Sharples, Roland Bacon (Figure 2) and David Mouillet respectively demonstrated what a powerful enhancement of the VLT scientific capability they will bring in the period from now to around 2012. HAWK-I and MUSE will also profit from the ground layer and narrow angle adaptive optics corrections provided by the Adaptive Optics Facility (deformable secondary mirror, four laser guide stars and associated wavefront sensors to be installed on UT4 in 2012). Anticipating another topic featuring in this Workshop, that of VLT and VLTI



Photo: H. H. Heyer, ESO

Figure 2: Roland Bacon presenting the approved second-generation VLT instrument MUSE.

operational modes in the future, it is clear that HAWK-I, KMOS, MUSE and SPHERE have to a large extent been built to conduct specific surveys. With the last three instruments built with large external participation, these surveys will partly be performed by the Consortia themselves in their Guaranteed Observing Time. The community may also, however, increase the demand on survey-mode science, which means probably longer but fewer programmes and perhaps revisiting the large-programme restrictions currently applied by the ESO OPC.

Presentations of the three VLTI instruments VSI, MATISSE and GRAVITY were given by their PI's Fabien Malbet, Bruno Lopez and Frank Eisenhauer respectively. These are all genuine second-generation instruments that will permit combination of 4–6 telescopes, compared with the current 2–3, to enhance the 'imaging' capability, and also employ various fringe tracking and AO techniques to go deeper, thus enlarging the astrophysical areas open to interferometric research.

### New Instrument Concepts and Operating Modes

The final session on New Instrument Concepts and VLT/I Operating Modes was kicked off by Colin Cunningham who reviewed some exciting developments in smart focal plane and photonic technologies which may enable radically new types of instrumentation on the longer

term. Some of these and related aspects were returned to by Anthony Horton and Simon Ellis (photonics, IFUs, OH suppression). Wide-field options were presented separately by Stephen Todd and Ian Parry who illustrated the limited weight and space available for installing a prime focus at the VLT and by Roberto Ragazzoni who presented an alternative field-splitting approach being studied in connection with the ELT. Matt Lehnert proposed, alternatively, exploiting the Nasmyth field of nearly 30' with a super-GIRAFFE equipped with deployable IFUs.

The other extreme of combining all four 8-m telescopes was advocated by Paolo Molaro to tackle extreme science questions such as the possible variability of the fundamental constants. This was actually one of several talks and posters on scientific and technical design aspects of ESPRESSO, a high-resolution visible echelle spectrograph for the incoherent combined focus which was presented by Luca Pasquini on behalf of a large consortium. This instrument developed out of the studies of CODEX for the ELT but, in addition to being a pathfinder for this instrument and some of its new technologies (e.g. the use of a laser comb for wavelength calibration), would be a super HARPS and UVES with a wide science case and could operationally complement 4 UT VLTI by being usable during medium to poor seeing conditions. In the infrared Alistair Glasse and Tino Oliva proposed considering N band spectropolarimetry and near-IR echelle spectroscopy respec-

tively. Thomas Ott argued for the retention of high spatial resolution capability to continue Galactic Centre studies in the post-NACO era and Markus Kissler-Patig presented CASIS, a concept study of one possibility, a wide-field ( $1 \times 1'$ ) MCAO imager to be fed by the AOF at the Cassegrain focus of UT4. This proposal was in partial response both to a request by the STC, at the time of their recommendation of the Adaptive Optics Facility on UT4, to consider an optimised instrumentation of this focus plus the extremely promising results achieved with MAD, the MCAO demonstrator and shown earlier in this meeting by Giuseppe Bono. An interesting feature of the proposed design is that it provides simultaneous imaging in 5 bands between 0.6 and 5  $\mu\text{m}$ .

In the category of operational modes, Craig Mackay urged us to think more about 'lucky imaging' and showed results of sub-0.1" images obtained combining this technique with AO in the visible; Andrea Richichi demonstrated the even higher resolution achieved by recording lunar occultations with burst-mode IR photometry; Andreas Seifahrt argued the possibility of squeezing micro-arcsecond astrometry even from existing instruments; Valentin Ivanov promoted more high-time-resolution observations; and Florian Kerber showed how more science could be achieved through the use of physical instrument models and improved calibration.

The last presented word was given to VLTI with a closing session of contributed talks on the VLTI in the ELT era by Markus Schöller, extrasolar science with the VLT/I by Didier Queloz and the next step in AGN research with interferometers by Klaus Meisenheimer.

### Closing Discussion

The Workshop was finally closed with a lively discussion centred initially on the instrument proposals but recapitulating also other aspects already discussed earlier. These included the complementarity of VLT/I with other facilities including, but not exclusively, ALMA, JWST and ELT and the potential virtue of playing to unique features of the VLT/I, e.g. the ability to combine up to four 8-m telescopes

at the coherent and incoherent combined foci which have not been exploited so far. On the other hand it was repeated that some vital science goals, particularly related to DM and DE, require wide-field surveys and large amounts of observing time. For imaging at least there seemed to be a consensus that this might be better done by dedicated survey telescopes (including VISTA) on the ground or in space and that priority for supporting these science objectives should be given to more multi-object spectroscopy. Some proponents of this argued that the ideal would be a  $> 1$  deg field, but if this proved too difficult or costly then at least an attempt should be made to exploit better one or more of the 0.5 deg Nasmyth fields, e.g. by adding a near-infrared spectrograph to the FLAMES facility.

Support was also forthcoming for extending the AO imaging capabilities of the VLT using the AO Facility + MCAO, but not necessarily at the expense of other powerful applications including spectroscopy. Questions were also raised as to the availability within the ESO community of the resources needed to realise all these new powerful instruments on the VLT, VLTI and ELT. As yet, there is no definitive answer but an optimistic prognosis based on the increase in the number of ESO member states and instrument groups since the start of the VLT development. Many groups may also be particularly and specifically interested in exploiting VLT/I for its unique scientific capabilities and/or as a testbed for ELT pathfinder instruments or technology.

The talks and posters will be published as both paper and ebooks in the Springer Astronomy and Space Science Proceedings series.

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Report on

## ALMA Community Days

held at ESO Headquarters, Garching, Germany, 3–4 September 2007

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(ESO)

The third of the ALMA Community Days was held at ESO Garching in September 2007. Prospective ALMA users were updated on the progress of the ALMA project, the plans for operations and for the ALMA Regional Centres (ARCs). The meeting was a lively forum for the discussion of the detailed organisation of the network structure for the European ARC.

The third European ALMA Community Days took place in Garching on September 3 and 4, 2007. The previous ALMA Community Day took place in September 2004 (see Messenger, 118, 67). More than 120 people from the astronomical

community came to learn about the progress of the ALMA construction and the plans for operations, as well as to discuss the organisation of the ALMA Regional Centre in Europe. The meeting was sponsored by Radionet, which provided funding for many of the participants to travel to Garching.

The workshop was opened with a welcome from the new ESO Director General, Prof. Tim de Zeeuw, who reassured the audience of astronomers that one of the top priorities of ESO is to deliver the ALMA observatory on time and on budget, in order to allow timely exploitation of its full scientific potential. Prof. Massimo Tarengi, ALMA Director, reported on the enormous progress in the construction activities in the last few years. Three years ago, at the time of the last European ALMA Community Day

meeting, ALMA was still mostly a project 'on paper' with only a few of the pieces of prototype equipment being designed and built. In September 2007, most of the site infrastructure at both the Array Operations Site (AOS, Chajnantor Plateau 5000m) and the Operations Support Facility (OSF, at a more comfortable altitude of 2900m) is either completed or on track to be completed by the beginning of 2008. Five production antennas are being assembled and tested at the OSF, with more being manufactured in Europe, North America and Japan. The first front- and back-end sets are being integrated and a full quadrant of the correlator has been completely assembled, tested and is being packed for shipment to Chile and installation at the AOS Technical Building.

Alison Peck, ALMA Deputy Project Scientist, illustrated the plans for commissioning and for the initial opening of the