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Report on the

2017 ESO Calibration Workshop: The Second-Generation VLT Instruments and Friends

held at ESO Vitacura, Santiago, Chile, 16–19 January 2017

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The participants at the 2017 ESO Calibration Workshop shared their experiences and the challenges encountered in calibrating VLT second-generation instruments and the upgraded first-generation instruments, and discussed improvements in the characterisation of the atmosphere and data reduction. A small group of ESO participants held a follow-up retreat and identified possible game changers in the future operations of the La Silla Paranal Observatory: feedback on the proposals is encouraged.

Introduction

Calibration is a critical component in the conversion of raw data to material ready for scientific analysis. Consequently, a complete, consistent calibration plan for each dataset fulfilling quality control criteria was recognised as a cornerstone of the operation of the Very Large Telescope (VLT). In 2007, ESO organised its first Calibration Workshop (Kaufer & Kerber, 2007) in order to: (a) foster the sharing of information, experience and techniques between observers, instrument developers and the instrument operation teams; (b) review the actual precision and limitations of the applied instrument calibration plans; and (c) collect the current and future requirements of the ESO users. The first Calibration Workshop focused on calibration issues affecting the first generation of VLT instruments.

Ten years later, ESO instrumentation has changed considerably following the arrival of second-generation instruments — the *K*-band Multi-Object Spectrograph (KMOS), the Multi Unit Spectroscopic Explorer (MUSE), the Spectro-Polarimetric High-contrast Exoplanet REsearch instrument (SPHERE) and the X-shooter spectrograph — and the completion of major upgrades of first-generation ones, such as the High Accuracy Radial velocity Planet Searcher (HARPS) and the VLT Imager and Spectrometer for mid-InfraRed (VISIR). In the near future, it will evolve further with the completion of the upgrade of the CRyogenic InfraRed Echelle Spectrometer (CRIRES) to CRIRES+, the arrival of the Echelle SPectrograph for Rocky Exoplanet and Stable Spectroscopic Observations (ESPRESSO) and the adaptive-optics-assisted instrument modes of MUSE and the High Acuity Wide-field *K*-band Imager (HAWK-I). In addition, other instruments are in plan: SOn of X-Shooter (SOXS) and the Near InfraRed Planet Searcher (NIRPS) at La Silla; the Enhanced Resolution Imaging Spectrograph (ERIS) and the Multi Object Optical and Near-infrared Spectrograph (MOONS) at the VLT; and the 4-metre Multi-Object Spectroscopic Telescope (4MOST) at the Visible and Infrared Survey Telescope for Astronomy (VISTA). For many of these instruments, the increase in complexity requires challenging calibration to achieve optimum performance.

Figure 1. The attendees at the 2017 Calibration Workshop photographed in the garden of ESO Vitacura.

The 2017 ESO Calibration Workshop brought together astronomers and instrument scientists from various fields of expertise to share their experience, engage in open discussions, challenge current limitations and try to develop creative concepts for better calibration in the future. The workshop covered:

– all aspects of calibration that are relevant to the user community or to science operations at ESO's Paranal (VLT) and La Silla sites;
– the progress made in characterising the properties of the atmosphere that allow science operations to make the best use of current conditions;
– progress made in data reduction and pipeline tools.

The ESO office in Vitacura was chosen as the venue for the workshop to foster collaboration between the major ground-based observatories in Chile. The sunny weather also allowed the participants to enjoy lunches and the conference dinner in the pleasant gardens; see Figure 1.

The workshop

The participants — from ESO Headquarters in Garching and from the Chile sites, from various institutes in Europe, from Gemini Observatory, Las Campanas Observatory, the Large Synoptic Survey Telescope (LSST) project, US National Institute of Standards and Technology (NIST), the Pontificia Universidad Catolica de Chile (PUC), the Center for Astronomy in Harvard, USA, and the Space Telescope Science Institute (STScI) in Baltimore, USA — listened to presentations grouped in sessions organised around a central theme. Most of the sessions included: (i) a talk describing an ESO instrument, its calibration plan and issues affecting the

quality of the data; (ii) an invited talk, or several, on the specific theme of the session; and (iii) contributed talks on various calibration or data reduction aspects. Ample time was left after each presentation, and at the end of each session, for lively discussion.

The themes of the various sessions were focused: on calibration of adaptive-optics-fed instruments (SPHERE); infrared spectroscopy and metrology; high-accuracy wavelength calibration (such as for HARPS, ESPRESSO, and the Giant Magellan Telescope [GMT] Consortium Large Earth Finder [G-CLEF]); reference data (molecular line parameters and atomic lines used for wavelength calibration); lessons learned from past instruments regarding polarimetry; calibrations for integral field units and sky background reduction strategies in multi-fibre spectrographs; photometry; astrometry; the Earth's atmosphere; wide-field surveys, as obtained by VISTA's infrared camera VIRCAM or the future LSST; and data reduction.

The concluding remarks by Susanne Ramsay (ESO) crystallised various themes which often appeared in the various presentations. For example, is calibration a tool to fix hardware issues: can that step be avoided by improving instrument design? Can we rely on physical instrument models instead? However, since everything changes, one must be always attentive and constantly assess the quality of calibrations and their validity period (*semper vigilo*): calibration plans are living things. But this task should not keep us from being more ambitious, for example in attempting to reduce the time spent on sky-subtraction in the near infrared. Interaction with users is also a key input: data that cannot be reduced do not return any science! Finally, ESO should prepare now and respond to the challenges to be presented by LSST and the European Space Agency (ESA) Gaia satellite, and for the new instrumentation on the 40-metre-class Extremely Large Telescope.

An innovative feature of the meeting was that technical time on the VLT (and on the ESO 3.6-metre) was pre-allocated in preparation for the calibration workshop. This observing time will be used to execute novel and innovative self-contained calibration methods and concepts. A specific session was organised to present their content and merit to all participants at the workshop. These calibration proposals will then be executed during pre-allocated time in due course.

All the presentations, recordings and question-and-answer sessions will soon be available on Zenodo[1] or through the workshop webpage[2].

The retreat

After the workshop, a small group of ESO participants met at Paranal for a retreat. They identified the following potentially game-changing topics or actions for the operation of the La Silla Paranal Observatory, which were then ordered on a 2D graph of "scale of impact" *vs* "likelihood of execution":

1. The integration of the high-accuracy astrometric and photometric data, obtained by Gaia, LSST and surveys like the VISTA Hemisphere Survey (VHS), into ESO operations was recognised by all as the most likely to happen with the largest impact. Aspects that will be impacted range from the calibration of the telescope adaptors, the internal astrometric calibration of instruments like KMOS, to data reduction, on the basis that most fields will have a sufficiently high density of stars for accurate astrometric and photometric calibrations.
2. Another potentially high-impact topic is how to better characterise the state of the atmosphere and, based on that, how to forecast relevant atmospheric parameters, along with which data should be used for optimal processing of adaptive optics data reduction and analysis? An accurate atmospheric profile is also required for optimal correction of telluric absorption lines by tools such as Molecfit (Smette et al., 2015; Kausch et al., 2015). What will be the impact of high-accuracy forecasts (in particular, of the turbulence including the seeing) on observations within a time frame of hours to days?
3. Physical modelling of the instrument behaviour was best illustrated by the talk by Robert Lupton on LSST. Ideas that were identified included an exposure time calculator (ETC) callable by a user script, which can also be used to systematically compare observations with expectations and to analyse hardware problems. Furthermore, how could an ETC be used for calibration — potentially reducing the number and frequency of on-sky calibrations — and how best to follow up on this approach when comparing the model with reality?
4. Presentations by Miwa Goto on infrared spectroscopy and Florian Kerber on the Low Humidity ATmospheric PROfiling radiometer (LHATPRO: Kerber et al., 2012) indicated that the VLT could "fly" when certain conditions occur: the amount of precipitable water vapour above Paranal can occasionally be the same as on a site at 5000 metres (Kerber et al., 2014)! On the other hand, the number of programmes requesting the best seeing conditions is small. If the opportunities are rare, how could the Observatory best make use of them? ESO should promote programmes whose science can only be carried out under excellent conditions. The Call for Proposals for Period 100 will already mention this concept, which could be reinforced in future calls once the implications are better evaluated.
5. Should the calibration strategy be better matched to the requested science? At one extreme, we could imagine that users provide not only their science Observing Blocks, but also all their Calibration Blocks. The content of such Calibration Blocks would also be based on an ETC to ensure that the quality of the science data is not degraded, for example due to insufficient signal-to-noise ratio in the flat fields.
6. Instrument Operations Teams ensure that instruments provide the best science and calibration data. They should, however, be encouraged to contact expert users in the community to promote collaboration with ESO and disseminate the knowledge to the wider community, or to identify specific problems with an instrument.
7. Does the ELT have specific calibration requirements which can only be addressed by specific VLT observations? The next few years should be used to first identify these needs and

then define and conduct the relevant observations.
8. New calibration sources such as Laser Frequency Combs or stable Fabry-Pérot calibration units will soon become operational at ESO: what is their potential for other VLT instruments? Problems with high-purity Thorium-Argon hollow-cathode lamps following recent stricter environmental regulations could be dealt with by a bulk order in collaboration with other observatories.
9. ESO should take a more active role in defining the needs for laboratory data. Archival data may play a crucial role to improve molecular line parameters which are required for accurate, synthetic telluric line correction in tools such as Molecfit.

The participants in the retreat compiled and agreed on a list of action items to further explore these different topics and transform them into specific improvements for their integration into ESO operations. These action items and the corresponding deadlines will be pursued in order to ensure progress towards a timely implementation.

Conclusions

According to the feedback received, the 2017 ESO Calibration Workshop succeeded in its aim of encouraging discussion of calibration issues, not only for ESO instruments but also at other ground-based observatories. Seeds of potential game changers in improving ESO future operations were identified and need to be brought to fruition. We encourage everyone interested in the subject to further explore these topics with us through the email account calibration2017@eso.org.

References

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Links

[1] Zenodo: http://www.zenodo.org
[2] Conference web page: http://www.eso.org/sci/meetings/2017/calibration2017.html

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Highlights from the CERN/ESO/NordForsk

Gender in Physics Day

held at CERN, Geneva, Switzerland, 27 January 2017

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In their role as observers on the EU Gender Equality Network in the European Research Area (GENERA) project, funded under the Horizon 2020 framework, CERN, ESO and NordForsk joined forces and organised a Gender in Physics Day at the CERN Globe of Science and Innovation. The one-day conference aimed to examine innovative activities promoting gender equality, and to discuss gender-oriented policies and best practice in the European Research Area (with special emphasis on intergovernmental organisations), as well as the importance of building solid networks. The event was very well attended and was declared a success. The main highlights of the meeting are reported.

GENERA and its objectives

The Gender Equality Network in the European Research Area (GENERA) is a Horizon 2020 project that focuses on evaluating, monitoring and improving existing or new gender equality plans of research organisations in the field of physics. The GENERA Consortium includes 13 beneficiary partners, either Research Performing Organisations (RPOs) or Research Funding Organisations (RFOs) scattered across Europe, and a number of associate partners and observers. Among the latter, CERN (the European Organization for Nuclear Research), NordForsk (an organisation that facilitates and provides funding for Nordic research cooperation and research infrastructure) and ESO, follow the GENERA activities very closely. The first meeting of the project was held at ESO's Headquarters in June 2015. The final goal of GENERA is very ambitious, i.e., to propose and create organisational structures allowing physics research in Europe to benefit from a more gender-balanced research community.

Within the GENERA network, one special initiative that looks in more detail at national gender equality plans and at the existence of innovative activities that help with the gender balance, is the organisation of national Gender in Physics Day (GiPD) events. Each of the 13 beneficiary partners is expected to organise one such event in their own country. Each event follows common organisational guidelines that consist of collecting a general overview on the national situation (both in terms of gender statistics and initiatives) and offering topical workshops in the areas most relevant to that country.