The 2007 ESO Instrument Calibration Workshop

A Personal Summary

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More than 20 of the top 50 Google hits for "Calibration Workshop" concern astronomy

Astronomical calibrations enable the

- **transformation of qualitative observations to quantitative measurements**
- **projection of non-tangible objects onto the human (and also microphysics) world**

<u>No calibration - no astronomy</u>

Calibrating Astronomical Observations (I)

- Only have 8 observables:
  - 2 coordinates (RA, DEC)
  - time
  - wavelength
  - flux
  - degree of polarization
  - angle of polarization
  - phase (differences)

Calibrating Astronomical Observations (II)

- **Only need to consider 3 basic types of scientific calibrations:**

  - **radiometry** – always tough

    extinction, sky background, instrumental background, sky concentration, slit losses, slit illumination, PSF, detector linearity, standards, variability, and many more atrocities

  - **geometry** – mostly easy

    but: flexure (e.g., VIMOS, FORS) requires differential parametric correction (or much time: hysteresis)

    but: sensitivity to vibrations (VLTI)

    but: do HARPS (Lovis), NACO (Seifahrt), VLTI et al. show that we have been settling for too little? (Lo Curto)

  - **chronometry** – trivial (since introduction of GPS)

    amazing – can this be true?

Calibrations at ESO

- Calibrations form the core of the very broad QC process

www.eso.org/QC

- Calibration plans – calibrate instruments rather than data sets.
  In 1995, philosophy received with much skepticism.
  Seemingly working quite well, but users see complexity.

Marconi

- Have calibration plans been optimized for minimum effort?
  Does ESO over/under-calibrate data? Or is it just about right?

Marconi, Scodeggio / Hanuschik, Rosati; Osip, Kaufer, Käufl

- Have calibration plans been adjusted to meet (changing) scientific requirements (expectations)?

Kaufer, Rosati

- Physical models: becoming more common; predictive rather than clean-up calibration; add more physics as you learn to understand the instrument

Rosa, Bristow, Jung, Walsh; Kaufer

Challenges – from VLT to ELT (I)

Pipelines

- make them modular — Péron (recipes, CPL)
- make them configurable — Hook & Sampo (ESO Reflex)
- develop standard modules for standard tasks — Izzo
- minimal assumptions — Grado, Horrobin, Roth
- error propagation and estimates — Nissen, Møller Larsen
- publication-ready results — Emsellem, Izzo
- robustness (must scale with data volume)

- **Archive**
  - support *in situ* operations on images and parameters
  - project log files onto exposures
  - pro-active filters for selection of candidate calibration data
  - offer also processed data — Nissen; Romaniello; Rosati (Advanced Data Products), Hildebrandt

Merksätze (I)

- ***Calibration is a life-long learning process.***
  (Marconi)

- ***Equivalence of experience and calibration: They are what we did not have when we needed them the most.***
  (Unidentified)

- ***Calibration cannot make up for poorly prepared observations.***
  (Bonifacio)

- ***A well calibrated instrument (ETC) is a prerequisite for the successful planning of any observing project.***
  (Anonymous)

Challenges (II)

- **Trend analyses** — Part of ESO-standard QC but not used for calibration
- **Atmospheric extinction and background**
  - a larger challenge than any decent instrument — All
  - fast and long-term variations — Patat, Riello, Rosa
  - a 42-cm telescope will do — Bonifacio, Burke
  - feed ASM/LOSSAM data into calibration procedures — Patat, Freudling
  - consider autoguider and image analyzer data
  - repeatedly observed (standard) fields — Mason
  - IR transparency from precipitable water vapor — Smette, Thomas-Osip
  - good IR calibrators from ISO and Spitzer — Dobrzycka, Pantin
  - interferometry depends on seeing — Hummel
- **Radiometric calibration of adaptive-optics data** — (Davies, Clenet)

Merksätze (II)

- ***Calibration cannot subtract noise. But it often adds noise.*** **(Bonifacio)**
- ***Calibration maps are a strong alternative to re-sampling.*** **(Davies, Izzo)**
- ***Artifacts are removed most effectively by multiple re-sampling.*** **(Emsellem)**
- ***Cannot follow two, probably not more than one, slides/minute.*** **(Self-cross-calibration with mental model)**

Challenges (III)

- Sky subtraction from (MOS, IFU, etc.) spectra — Bonifacio, Monelli
- Large-scale structure in flat fields — Eemerson, Freudling, Rosati, Selman
- Continuum retification — Nissen
- Monitoring did not detect WFI contamination — Selman
- Detector fringing
  - built-in calibration tools not possible
  - rapid non-homologous variability of night-sky lines — Patat
  - physical model — Walsh
  - thick deeply or fully depleted CCDs (and CMOS) can eliminate the problem (and increase near-IR sensitivity) — Nissen, Baade

Merksätze (III)

- ***Software is a pipeline if it can reduce data from several instruments of the same kind.***
  (Izzo, Möhler)

- ***Pre-natal modelling is better than post-mortem calibration.***
  (Rosa)

- ***We must optimize cost.***
  (Nobody)

- ***Involve the end users. Need agency/forum for coordination, and management for prioritization in the case of limited resources.***
  (Lindler, Emsellem)

Challenges (IV)

- Instrument design
  - stiff mechanics
  - very good telescope
  - pre-construction simulation
  - provisions for quality monitoring
  - active compensatory control loops
  - calibration plan derived from scientific requirements
  - filters with standard passbands

Many

Richichi

Lorente (IFU's), Ramsay Howat (KMOS)

Clenet (NaCo)

Käufl (CRIRES)

Selman

- Surveys: homogeneity in sky and time
  - weaving calibration nets
  - special quality control (also using source catalogs)

Burke, Emerson, Hildebrandt, Irwin, Keller, Lewis, Mellier, Rosati, Riello, Selman

- Laboratory and telluric calibration tools and data

Araujo-Hauck, Burke, Kerber, Lovis, Papadaki, Saitta, Schmidt

- Standard stars

Barrena, Bauwens, Burke, Dobrzycka, Keller, Morel (CalVin), Rodriguez Espinosa, Vernet

Merksätze (IV)

- ***False matches can confirm expectations most beautifully.***
  (Izzo)

- ***If it's wrong, a polynomial will fit it.***
  (Rosa)

- ***'Calibration Manifesto': A combination of meritocracy (physical models) and democracy (plain data) is the optimal constitution.***
  (Izzo and Rosa)

- ***NIR polarimetry at ESO is a last-minute add-on for enthusiasts.***
  (Ageorges, Schmid)

- ***Polarimetry would be more popular with better support.***
  (Ageorges, Schmid / Patat)

Challenges (V)

- Performance monitoring and optimization of the tools
  - public test data and standard results
  - low-level interactivity
- Closing the feedback loops quickly and effectively
  (Multidisciplinary Instrument Operations Teams)
- Gathering and disseminating the community-wide experience
  Open-source tools
  Calibration workshops
- Pipeline feedback to engineering calibrations, health checks ('preventive calibration'), etc
  Ageorges, Marconi, Möhler, Selman
- EMC
  Millour, Pantin, Selman

Merksätze (V)

- ***If you know how to improve your calibrations and tools, do it.***
  (Tycho – quoted by Rosa)
- ***Thou shalt not have parallel pipelines.***
  (Emsellem / Möhler, Hummel / Hanuschik)
- ***The sky is the limit.***
  (Many – meaning the Earth's atmosphere)
- ***ESO should accept and support calibration proposals.***
  (Emsellem and the Calibrated Majority)
- ***The best quality check is a logarithmically scaled 3-color image.***
  (Irwin)

Everyone's Uncalibratable Pet

Eierlegende Wollmilchsau (aka egg-laying woolly milk pig)

Physical modell courtesy M. Rosa

The Calibration Workshop Experience

- We have covered a lot of ground, have exchanged encouragements, re-confirmations, and new inspirations.
- ESO has received a lot of valuable (calibrated!) feedback from its users community.
- In the area of public surveys, ESO is entering an era of qualitatively new cooperations (similar to the very successful joint Community/ESO development of instruments).
  This "Public Private Partnership" (PPP) could be a promising *ansatz* for other calibration tasks.
- ESO thanks you for your contributions,
- and we thank the organizers!

We look forward to the continuation: Auf Wiedersehen!