CalVin 3 — A New Release of the ESO Calibrator Selection Tool for the VLT Interferometer

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Interferometric observations require frequent measurements of calibration stars of known diameter to estimate the instrumental transfer function. ESO offers the preparation tool CalVin to select suitable calibrators from an underlying list of calibrators. The latest version 3, first released in January 2011, offers major improvements in the number of available calibrators, the functionality of the search tool, as well as in terms of performance and ease of use. It has been developed in a collaboration between ESO and the French Jean-Marie Mariotti Center (JMMC).

The ESO VLT interferometer (VLTI) is an optical interferometer that is offered as a general user facility. It enables the community to conduct near-infrared (NIR) and mid-infrared (MIR) interferometric observations to obtain high spatial resolution measurements of celestial sources. The instruments of the VLTI that are offered to the community, currently including the NIR instrument AMBER and the MIR instrument MIDI, are supported by ESO in the same way as any of the VLT instruments of the Paranal observatory (c.f. Wittkowski et al. [2005] for further general information on observing with the VLTI).

In particular, ESO supports the preparation of interferometric observations using the AMBER and MIDI instruments with the preparation tools VisCalc and CalVin[1]. VisCalc estimates visibility values for the expected intensity distribution of the science target and the chosen VLTI configuration to assess the feasibility of an observation. CalVin may be used to select calibration stars for a given science target based on an underlying list of calibrators and a number of user-defined criteria. Both tools are also offered in an expert mode for the use of any arbitrary observatory location, baseline configuration and spectral wavelength band (for CalVin *B*-, *V*-, *R*-, *I*-, *J*-, *H*-, or *K*-bands).

Optical interferometers measure the amplitude and phase of the interference pattern. When normalised these quantities are the amplitude and phase of the complex visibility function, which is related to the intensity distribution by a Fourier transform. An unresolved point source theoretically has a visibility amplitude of unity. However, the measured visibility amplitude of an infinitely small target, also called the interferometric transfer function, will be less than unity owing to losses introduced by the Earth's atmosphere and the instrument. These losses are time variable and need to be frequently monitored. For this purpose, the observer needs to select suitable calibration stars of known diameter, which will be observed close in time to the science targets.

With the growing capabilities of the VLTI, the increasing number of instrument modes, and the improving limiting magnitudes, it has become clear that CalVin's capabilities need to be improved beyond those available when it was first offered in ESO Period 73. Starting with a workshop on interferometric calibrators held in Nice, France, in March 2008, ESO and the French Jean-Marie Mariotti Center (JMMC) have been collaborating on developing a new version of CalVin. The two latest versions of CalVin, version 3.0 released in January 2011 and version 3.1 released in July 2011, now offer major improvements in terms of the number of available calibrators, the functionality of the search tool, as well as in performance and ease of use.

Number of available calibrators

The underlying list of calibrators available with CalVin now incorporates the JMMC Stellar Diameter Catalog (JSDC[2]; Lafrasse et al., 2010). This catalogue is based on a search of catalogues available at the Centre de Données astronomiques de Strasbourg (CDS) using the bright mode of the JMMC calibrator search tool SearchCal[3] (Bonneau et al., 2006) with the faintest limiting magnitudes that are offered for the VLTI. The angular diameter estimates and their errors given in the resulting table are based on statistical estimates and provide information on whether a star is a suitable calibration source for a certain instrument and baseline configuration.

The observer may need to study selected calibrators in more detail to obtain a more precise estimate of their diameters (c.f., for example, Cruzalèbes et al., 2010). Each calibrator is assigned a quality grade depending on whether it is only included in the JSDC catalogue or is also in the catalogues by Bordé et al. (2002), Mérand et al. (2005) or Verhoelst (2005), which were used as the core underlying catalogues of CalVin 2, and whose properties are studied in more detail.

The capacity of, for example, the NIR AMBER table is now 27 814 calibrators, of the MIR MIDI table 27 989 calibrators, and of arbitrary locations (expert version of CalVin) 38 472 calibrators. Figure 1 shows the sky coverage of the underlying list of calibrators available for AMBER, highlighting two typical use cases, a bright calibrator case and a faint calibrator case. The bright calibrator case highlights calibrators of *K* magnitudes $K < 3$ as they are required for observations using the 1.8-metre auxiliary telescopes (ATs) and moderate conditions of 1.2-arcsecond seeing. The faint case highlights calibrators of *K* magnitudes $5 < K < 7$ as they are typically required for observations using the 8-metre unit telescopes (UTs).

New functionality of the selection tool

CalVin's selection tool includes a number of new functionalities corresponding to the increasing number of instrument modes available. CalVin can now be used to search for only those calibrators that are suited to a user-defined instrument mode in terms of the offered magnitude range of the respective mode. Observations are offered in service mode and visitor mode, where, in visitor mode the day of observation is known beforehand, but in service mode it is not. CalVin now accepts time ranges of either Universal Time, local sidereal time, or hour angle. CalVin outputs the observability of the science target and of the calibrators for the specified time interval taking into account the target altitude, shadowing constraints and the limited delay line stroke. In the case of Universal Time, the sun altitude is also taken into account. In order to assess the feasibility of a

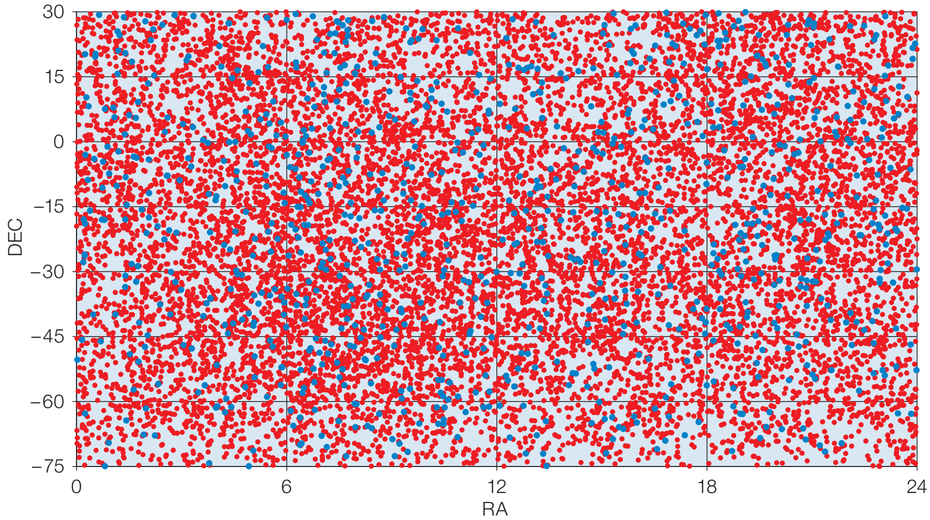

Figure 1. Sky coverage of the underlying list of calibrators available for the example of the NIR instrument AMBER. Blue circles highlight bright calibrators as typically used with the ATs and moderate (1.2 arcsecond) seeing conditions for which $K < 3$ mag. Red circles mark faint calibrators as typically used for observations with the UTs ($5 < K < 7$ mag).

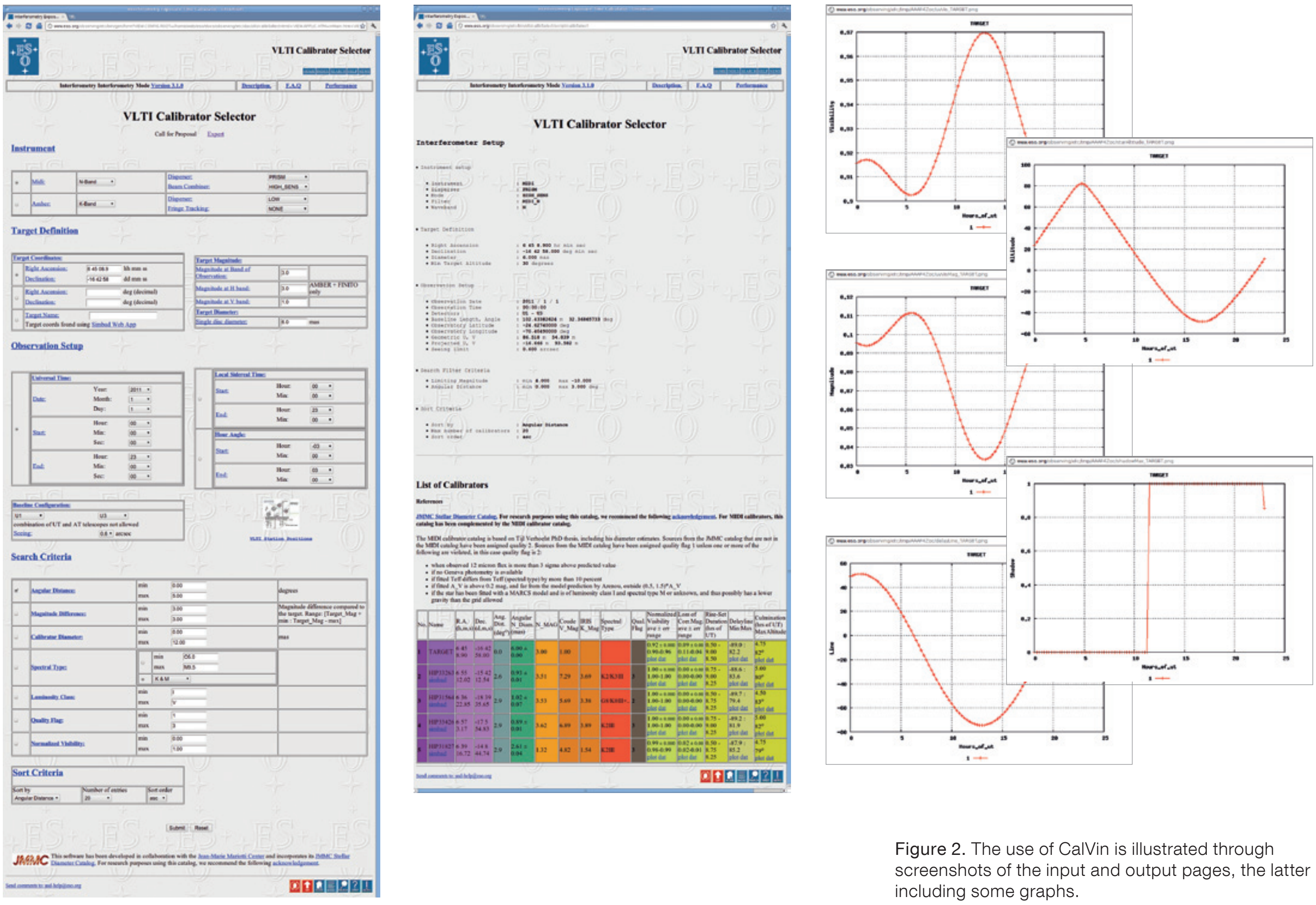

Figure 2. The use of CalVin is illustrated through screenshots of the input and output pages, the latter including some graphs.

calibrator observation, visibility amplitudes are computed for the same time intervals at the wavelengths of observation and of the VLTI fringe tracker FINITO, and magnitudes are given at the wavelengths of the guiding camera IRIS and the Coudé guiding camera. Figure 2 shows for illustration some screenshots of a query using CalVin.

Performance of CalVin

The performance of CalVin, in particular in terms of response time, has been optimised using a new database technology and JavaScript-based visualisation technology to display the plots. The ease of use has also been improved by optimising the layout of the query page, now including one single input page (Figure 2, left), compared to two pages in version 2.

Future directions

The current underlying list of calibrators lacks MIR magnitudes for many calibrators. We plan to add these using data from the AKARI/IRC mid-infrared all-sky survey (Ishiara et al., 2010). With upcoming fainter limiting magnitudes for the current VLTI instruments, and in particular for second generation VLTI instruments, the current underlying list may still not be sufficiently complete for the faintest magnitudes offered. The faint mode of SearchCal (Bonneau et al., 2011) may then be used to create a significantly larger underlying list of calibrators, which would also impose stronger requirements on the database technology. The additional use of the AKARI point source catalogue might then also allow a more robust selection of calibrator sources to be obtained. Astrometric observations using the upcoming VLTI facilities PRIMA and GRAVITY may require further selection criteria, such as a low proper motion of a phase reference calibrator, requiring additional information in the database as well as additional search criteria. An example of such a search for astrometric calibrators was recently described by Beust et al. (2011). Information on entries in the available bad calibrators' databases[4, 5] as well as information on previous observations may be added to the output result of CalVin in a future release.

References

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Links

[1] VisCalc and CalVin are available from: http://www.eso.org/observing/etc
[2] The JSDC catalogue: http://cdsarc.u-strasbg.fr/cgi-bin/VizieR?-source=II/300
[3] SearchCal is available at: http://www.jmmc.fr/searchcal
[4] The IAU Comm. 54 bad calibrators' registry (BCR) is available at: http://www.eso.org/sci/observing/tools/catalogues/bcr.html
[5] The bad calibrators' database at JMMC: http://apps.jmmc.fr/badcal

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One of the VLTI 1.8-metre Auxiliary Telescopes (ATs) being replaced on its tracks at Cerro Paranal after mirror re-aluminising. Each AT has its own transporter that lifts the telescope and moves it from one observing position to another on tracks. However the transfer by road to and from the coating plant at the base camp relies on a truck, as shown.