VLTI instruments: from J to N band instrumental calibrations, from short to long baseline astronomical calibrations

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1 VLTI Layout, instruments and sub-systems

The VLT Interferometer (VLTI) has been operating on Paranal since 2001 with first fringes obtained at 2 micron with VINCI, the VLTI commissioning instrument. Since October 2005, two VLTI instruments are offered for Service

Fig. 1. The Paranal Observatory and the location of the DIMM

Mode (SM) observations, MIDI (offered since April 2004) is operating in the N Band between 8 to 12 microns and AMBER (near-infrared/red focal instrument for the VLTI) operates in the J, H and K bands. MIDI observations are performed using two UT (Unit Telescopes 8.2m) or two ATs (Auxiliary Telescopes: 1.8m), while AMBER has been operating until now with three UTs and will be offered from the next period (April 2007) also with three ATs.
The different stations of the telescopes are shown in figure 2, the baselines range from 8m to 200m.
Several sub-systems such as the telescopes (UTs or ATs), the AO systems (MACAO), the fringe tracker (FINITO and in the future PRIMA) , the delay

lines, are also part of the VLTI. The status of all these sub-systems has to be understood. They are monitored either regularly with the daily calibrations or at the time of the science observation with the attached calibrations. We are also monitoring the correlation between data taken by external instruments (such as the DIMM, see figure 1).

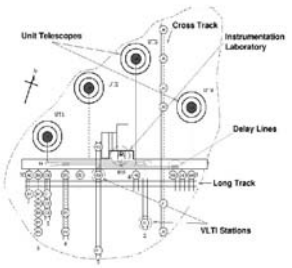

Fig. 2. The VLTI stations layout

2 VLTI daily calibrations and reference frames

VLTI like the other VLT instruments follows a calibration plan which includes daily calibrations. The detector as well as some of the most important elements of the instrument are monitored. In the case of MIDI, the detector Read Out Noise and its linearity is measured daily and trended. The position of the reference beams (see fig 3), the transmission of the dispersive elements and data for wavelength calibration are also taken daily.

For AMBER, the calibration plan includes daily calibration of the internal status of the instrument (see fig 3) as well as a monitoring of the alignment of the instrument. Other calibrations such as the Pixel to Visibility Map are taken together with the observations. During the alignment and the calibrations of the instruments, reference frames are available to the observer for comparison.

3 Monitoring of the VLTI sub-systems

The VLTI is a complicated system with two main instruments MIDI and AMBER and several sub-systems (Telescopes, AO systems, fringe tracker, Delay lines). Data from these different sub-systems are recorded during the daily calibrations and during the observations.

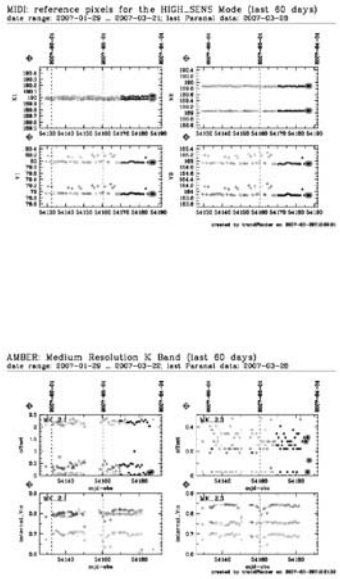

Fig. 3. Instrument trending for MIDI (top) and AMBER (bottom). MIDI: position of the two beams in one of the MIDI instrument setting, there is sometimes a jump of both beams in the Y position, this problem is under investigation. AMBER: top: offset between the different channels, bottom the internal visibility of the instrument

3.1 monitoring of the different MACAO sub-systems

To get diffraction limited images with MIDI and AMBER on the UTs, MACAO is used during the observations. The MACAO systems are installed on the UT Coud focii and are feeding the VLTI delay lines with a corrected IR beam from 1000-13000nm with up to 50% Strehl at 2.2microns. The operational conditions for good quality operations with MACAO are a seeing less than 1.5 arcsec, a coherence time larger than 1.5ms, an air mass smaller than 2 and the distance between the science target and the AO target less than 57.5 arcsec. The plots (figure 4) show the comparison between the different MACAO units during AMBER observations with 3 telescopes.

3.2 Comparison between MACAO and the DIMM measurements

The VLTI is part of the Paranal Science Operations Team (PSO) and the performances of the instruments and of the different sub-systems are also compared to other Paranal instruments. When VISIR (operating also in the

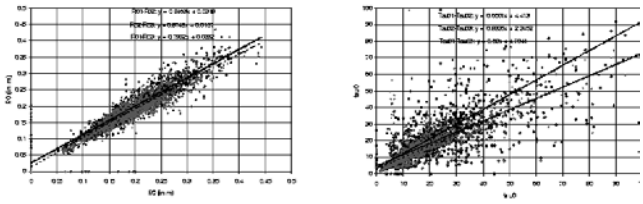

Fig. 4. The left plot shows the Fried parameter (R0) in m, and the right plot the coherence time Tau0 in ms, both are calculated for 500nm. The data for each telescope is represented by a different shape. These data were taken both under SM operations and under test where the atmosphere did not allow a good correction. The differences seen between the MACAO systems on the 3 telescopes are under analysis.

N band) is operating at the same time than MIDI, some data (such as the sky background) taken on both instruments could be compared. The differential image motion monitor (DIMM) records seeing parameters such as the Fried parameter R0 or the coherence time (Tau0). We are for example studying the correlation between the data measured by the DIMM, the different MACAO units and the atmospheric conditions.
Future studies involve the comparison between the Strehl Ratio recorded by the MACAO sub-systems, the distance from the source and other atmospheric parameters such as the isoplanatic angle with the quality of the MIDI acquisition image.

3.3 Photometric and instrumental visibility trending

We implemented a calibration plan for the MIDI and the AMBER instruments, to observe regularly some calibrator and photometric standard stars. For MIDI photometric observations are taken on spectro-photometric objects (not known as variable), some of them are also observed regularly with the VISIR instrument. A list of potential bright standard calibrators is also available. They are extracted from the VLTI list of potential calibrators CALVIN. Regular observations of these objects are done on the different baselines for instrument monitoring.

Astronomical calibrators

In addition to the data taken to monitor the instrument, astronomical calibrators are measured during the night to calibrate the science data. Depending of the night (Service Mode (SM), Visitor Mode (VM) or technical nights), the astronomical calibrators are either defined by the SM or the VM PI or taken from CalVin (for technical nights). The instrumental Transfer function is trended using these data.

Observations of standard stars

Each night, some photometric standard stars are observed, the flux of these objects ranges from a few Jansky to more than 100 Jy. We study the variation of the flux on the detector as a function of different parameters (station, telescope, delay line, airmass, atmospheric parameters). This is still under study.

4 Conclusions

It is essential to monitor and trend all the important sub-systems to insure a good quality of the science data. Knowing which part of system to calibrate, monitor and trend is important and is in constant evolution and discussed between members of the VLTI team. This knowledge is also transfered to the community with the instruments Health Check pages maintained by the Quality Control team at ESO.

5 bibliography

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