Effect of the reduced AT/VLTI field of view on long baselines on MIDI data quality

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1 Summary

We investigate the reduction of the field of view (FOV) on long baselines and its effect on MIDI data quality. We find that data quality suffers signifcantly on the long baselines (longer than 60 m) and recommend a more detailed investigation into solutions to the problem. Among these are a better alignment of MIDI with respect to the VLTI, and the removal of the 2.5 bar software pressure limit of the Variable Curvature Mirrors (VCM).

2 History

This report follows one prepared in 2006 on the AT/VLTI field of view effect on MIDI data quality (C. Hummel, et al.) at a time when observations were performed without the VCMs. (These optical devices transfer the pupil to the entrance window of MIDI for maximum FOV and minimum contamination by tunnel background.

Using a dedicated science-grade data reduction pipeline (MyMidiGui), we have been processing SM calibrator data from selected nights which are posted at *http://www.eso.org/∼chummel/midi/vsop/db.html*. More recently, observations were also preformed on a list of "suspicious" calibrators during times when no SM OBs were available in the queues. (Even though these calibrators are not in the CalVin database of recommended calibrators, they are not necessarily bad, which is the reason for them being observed during IDLE time.)

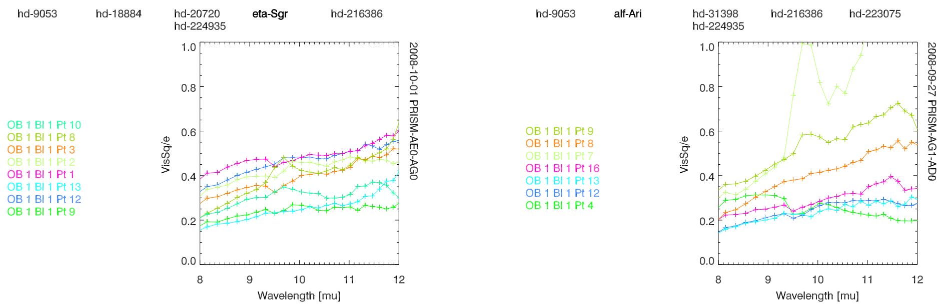

Figure 1: Observations on 2008-09-30 (E0-G0, left) and 2008-09-26 (G1-D0, right). The (squared) visiblity amplitudes have been normalized using estimated stellar diameters. We only plot stars with more than 40 Jy flux, and for the long baseline we also exclude stars with estimated diameters of more than 8 mas (30% correction for resolution).

3 SM calibrator results

Recent results obtained on a short baseline (E0-G0, 16 m on the ground) and a long baseline (G1-D0, 72 m) are shown in Fig. 1. We notice that the scatter of the visibilities on the long baseline is significantly larger than on the short baseline. That this however is not always the case is shown in Fig. 2 for E0-G0 compared to H0-D0 (64 m). In general, the likelyhood that the PSF is too near the field edge is much higher with AT observations than UT observations.

4 Acquisition

The chopped acquisition frames shown in Fig. 3 show the reduced FOV of the G1 station relative to the D0 station.

5 FOV as a function of delay

Note that the plate-scale on the MIDI detector for the ATs is 0.38 arcsec/pix, while the PSF is 3 pix = 1.14 arcsec in diameter. We have measured the FOV using chopped acquisition frames (if available, otherwise the photometry may

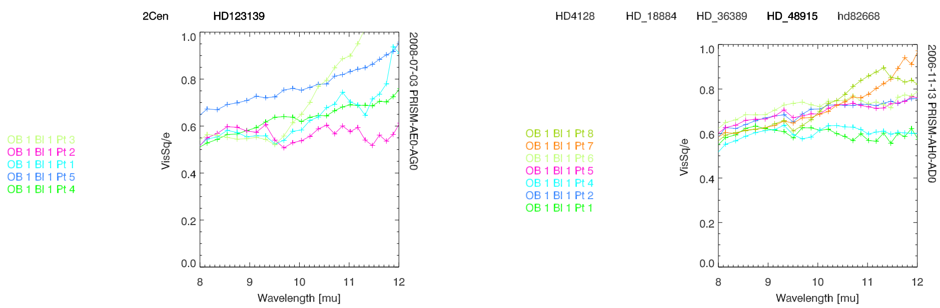

Figure 2: Left: E0-G0 (2008-07-02); right: H0-D0 (64 m on the ground, 2006-11-13). On the longer baseline, only stars with more than 40 Jy flux have been plotted, estimated diameters are up to 14 mas (correction 20%)

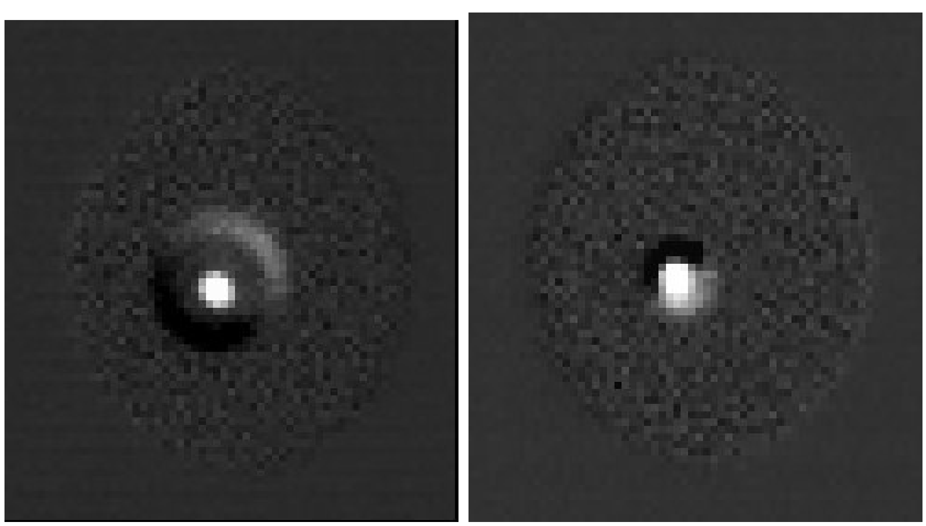

Figure 3: Left: G0 FOV; right: G1

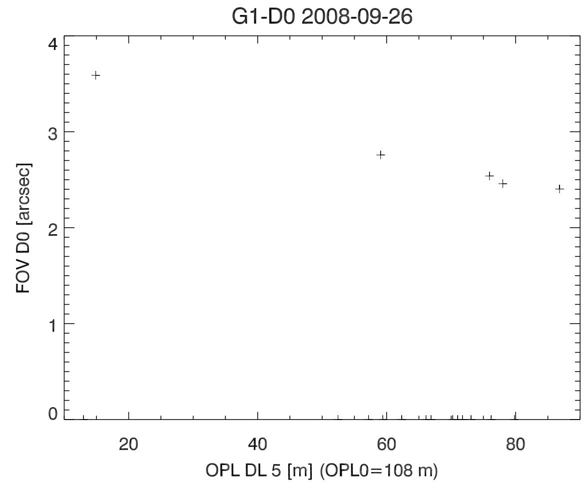

Figure 4: FOV of D0 on 2008-09-26 (G1-D0, 72 m): D0 at 15 m has FOV=3.6", consistent with 2006-11-12, but decreases to 2.5" at 80 m. (G1 varies between 1.8" and 2.2" at moderate OPL=10 - 25 m, but with OPL0=140 m.)

be used too) and determined that there is a dependency on the delay (OPL). Figs. 4 and 5 shows the results. The longer the delay, the smaller is the FOV. At best, we measured a FOV=5.4 arcsec for E0 (OPL0=92 m), and FOV=4.5 arcsec for G0 (OPL0=76 m), both with OPL less than 30 m.

The most likely cause of restricted FOV (varying with the position of the delay-line carriage) is the entrance aperture of the delay-line carriage. The diameter of this aperture is ≈0.2 m. Setting the limit for vignetting when the center of the beam reaches the edge of the aperture, we can write the FWHM FOV as FOV= 0.01 * 0.2 / (OPL0 + OPL), where OPL0 is the fixed distance from the AT station to the delay-line when the carriage is at zero, and OPL is the mechanical position of the carriage. The factor 0.01 comes from the AT optics (beam compression from 1.8 m to 18 mm causing angles in the lab to be multiplied by 100). From the data we have, considering DL5 is used, we have OPL0 = 99.9 m for the A0 station and OPL0 = 91.7 m for the G1 station. The prediction is shown in Fig. 6.

The VCM can only help to reach this vignetted FOV: when it is inflated

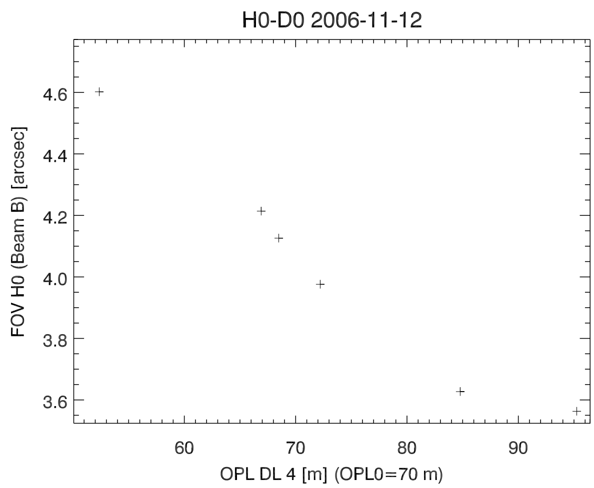

Figure 5: FOV of H0 on 2006-11-12 (H0-D0, 64 m): The plot shows that the FOV of H0 decreases from 4.6” at 50m OPL to 3.6” at 85m. OPL0 for H0 is 70m, OPL0 for D0 is 108m. D0 was constant at OPL=5m, with FOV=3.8”.

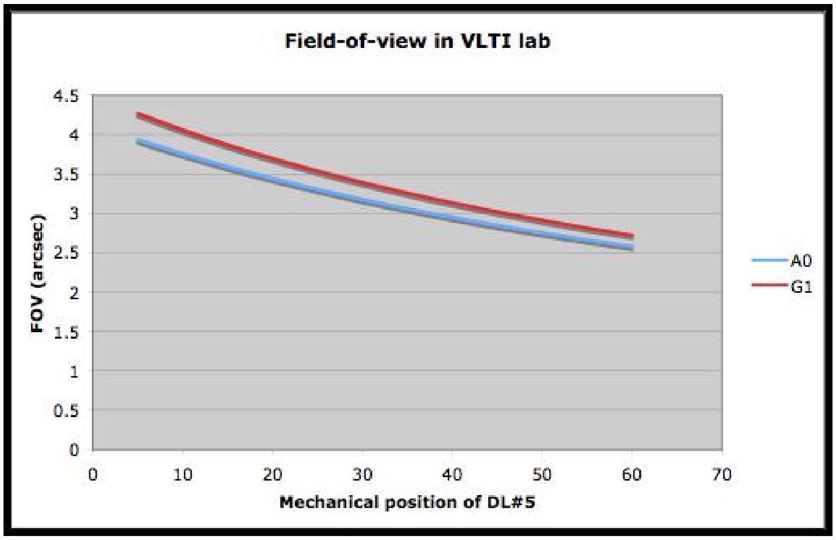

Figure 6: The VLTI theoretical FOV for stations A0 and G1, depending on the mechanical position of the carriage.

to reimage the pupil at the entrance of MIDI, the FOV is limited by the carriage position. Otherwise, it will be smaller.

It is clear on the acquisition images that the edge artefacts are 3 pixels wide. Therefore, the minimum acceptable FOV can be estimated to be 9 pixels (= 3.42 arcsec). If we consider a tolerance of 1 pixel on the MIDI FOV alignment (which is already not easy to achieve), we can say that the minimum FOV for MIDI should be 3.8 arcsec. This would require a limitation in the DL range which would need to be enforced in the delay-line control software.

6 Conclusions

The MIDI data quality on the long VLTI baselines is uncertain, at best. Even a small mislignment causes the image to be too close to the edge of the FOV, which results in systematic photometric errors of the kind seen 2 years ago when the VCMs were not operational. Furthermore, if the limit currently implemented for the maxmimum VCM pressure (2.5 bar) is kept, the available sky on the longest baselines will be restricted as shown in Fig. 7, unless a further reduction in FOV is accepted when going beyond these limits.

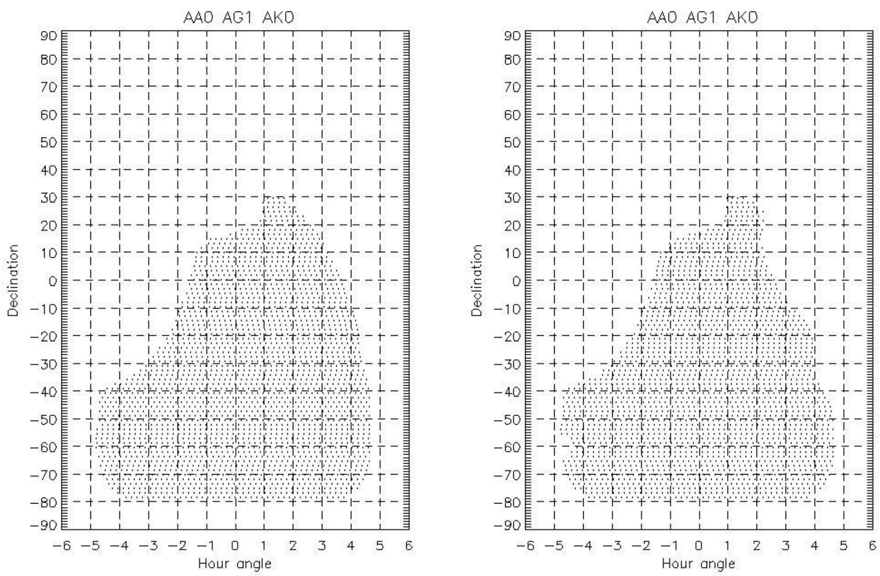

Figure 7: The available sky (shaded) for operations on A0-G1-K0 (left), and with a software limit of 2.5 bars on the VCM pressure (right)