Pipeline reductions of AMBER calibrator data

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ABSTRACT

Service (and visitor) mode operations by ESO involving the three-beam NIR combiner AMBER on the VLTI are now in their third year, and a large number of observations of calibrators have been accumulated. We present results on the stability of the transfer function, with and without the FINITO fringe tracker, as well as trends and correlations. The reductions were made using publicly available software for AMBER and therefore can be used as a reference for the data quality independent observers may expect from AMBER.

Keywords: AMBER,VLTI

1. INTRODUCTION

In a previous paper[1] we presented some results from the processing of MIDI calibrator data taken from ESO's service mode archive, using a tool (MyMidiGui) based on science-grade data reduction software written by MIDI consortium members. Data taken on calibrators is publicly available right after it arrives in the archive, and is being accumulated rapidly in regular service mode operations. Even after commissioning of a new instrument and publication of a corresponding report there is a need to learn about the routinely achieved quality of the data and their limitations, using the very same software that is applied to produce the scientific results. Similarly to MIDI, we developed a tool based on amdlib distributed by the Jean-Marie Mariotti Center, which allows quasi-pipeline reductions for speed and convenience. The main GUI of this tool, MyAmber Gui, is shown in Fig. 1. Independently from these efforts, the quality control group under ESO's Data Management and Operations division monitors instrument health and science data quality using dedicated stand-alone pipelines (see paper by Percheron, this volume).

2. PISTON BIAS

In the low resolution mode of AMBER ($R < 35$), even small tilts of the fringes due to OPD (optical path difference) offsets (piston) lead to significant fringe amplitude loss because of bandwidth smearing. The detrimental effect on on the average fringe amplitudes (Fig. 2) can be avoided in amdlib by specifying a piston threshold (e.g. 8 microns) above which to discard frames. Alternatively, the effect could be calibrated on a frame-by-frame basis, but this change to amdlib is still pending (see Fig. 3).

3. TRANSFER FUNCTION

This function (TF), also called interferometer efficiency or system visibility, is the visibility measured by the interferometer on unresolved calibrators and is unity for an ideal interferometer and no air turbulence. Its value and stability are amongst the most important quality indicators of an interferometer. We show in Fig. 4 a typical TF for observations in MR mode.

4. TRANSFER FUNCTION WITH AND WITHOUT FINITO

The FINITO fringe tracker enables the real-time co-adding of interferograms on the AMBER detector for up to 12 s. This mode, now coming into routine operation at VLTI, was the originally envisaged way of operating AMBER. We compare TFs obtained without and with FINITO which show increased level and stability when using the fringe tracker. We show in Figs. 5,6 calibrator data obtained in the same night with (first four observations) and without finito.

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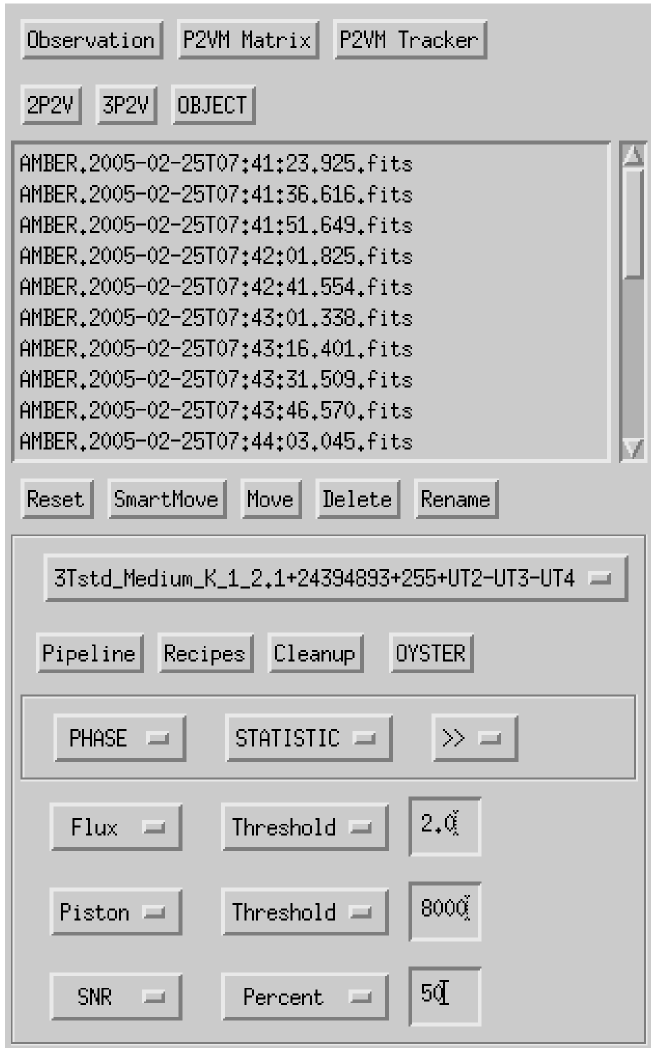

Figure 1. The layout of the main GUI of myambergui, an IDL based front-end to amdlib. Files that have been selected using the Observation button in the first row for a reduction are shown in the file window. Above this window, in the second row, three buttons correspond to the steps in the reduction to be performed. These bring up GUIs for a more detailed analysis of the intermediate results, such as frame-by-frame results of visibility statistics or group delays. The third row of buttons contains those to manage raw data files in the directory, while the bottom section is used to run the pipeline.

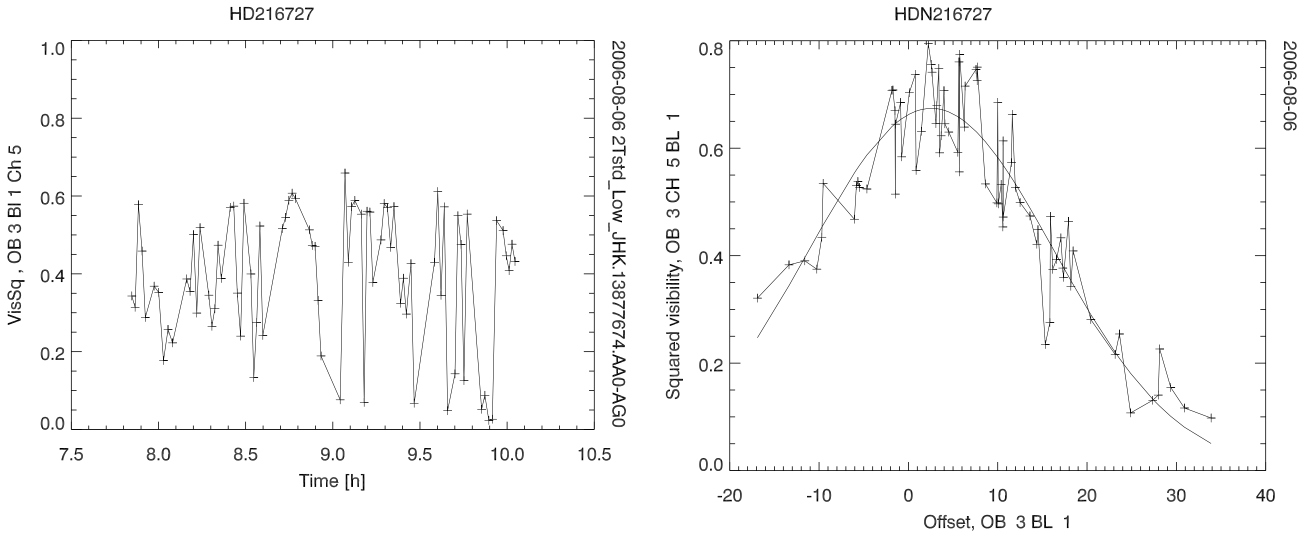

Figure 2. The plots show the bias of the visibility amplitude in LR mode due to the significant fractional bandwidth. The bias, if left uncorrected, corrupts amplitudes on a calibrator as shown on the left. As shown on the right, the amplitude drops to half its peak value at about 15 microns offset (piston) from the center. The width (FWHM) of this Gaussian is about half of what would have been expected for $R = 35$, which is estimated as λR, but this is due to a lower effective R because of a larger slit width in the spectrograph.

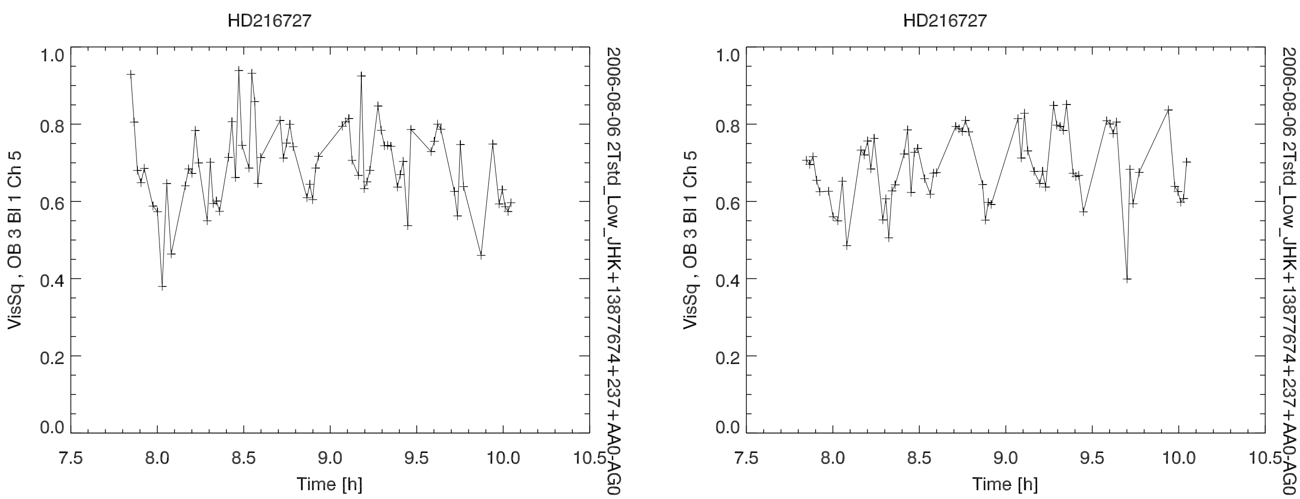

Figure 3. The bias can be either corrected (left figure), or avoided by only averaging frames with a piston smaller than a threshold (right figure, threshold = 8 microns) . Baseline is A0-G0. The latter method gives slightly better results, but discards more frames. The first method is currently limited by the fact that it is based on single OBJECT file-averaged piston values.

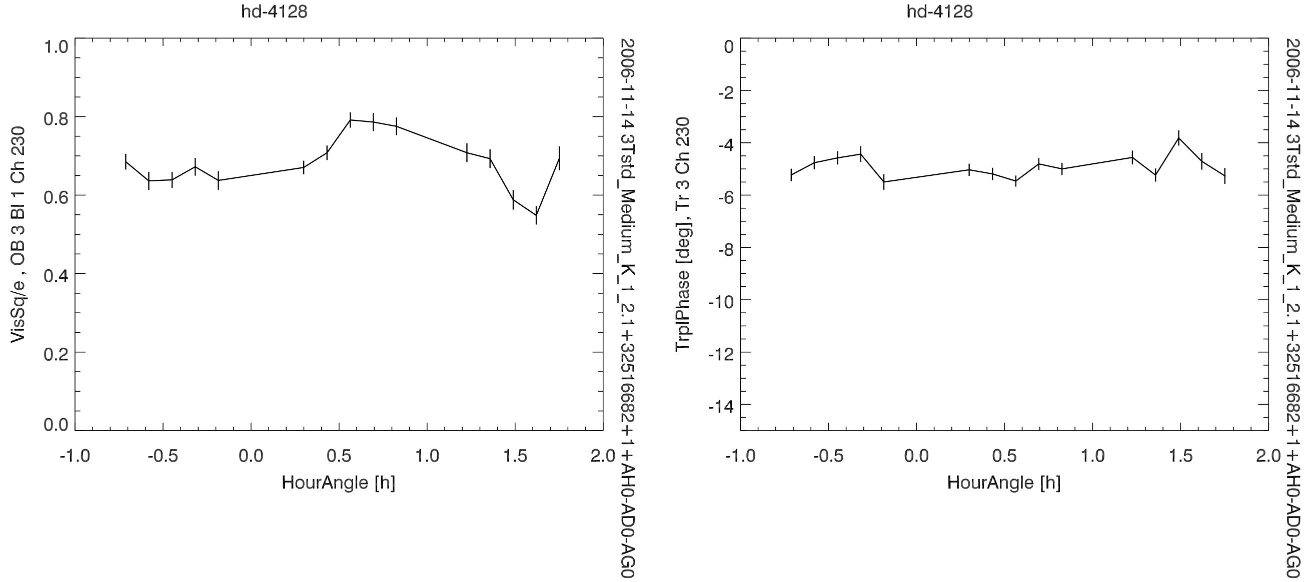

Figure 4. The K-band TF of medium resolution (MR) observations is shown. The MR TF tends to be higher than the LR TF, and the closure phases are much more stable. The measured closure phase offset is relative to the PVM defined zero point, and is used to correct the closure phases of the science targets to which the same P2VM applies.

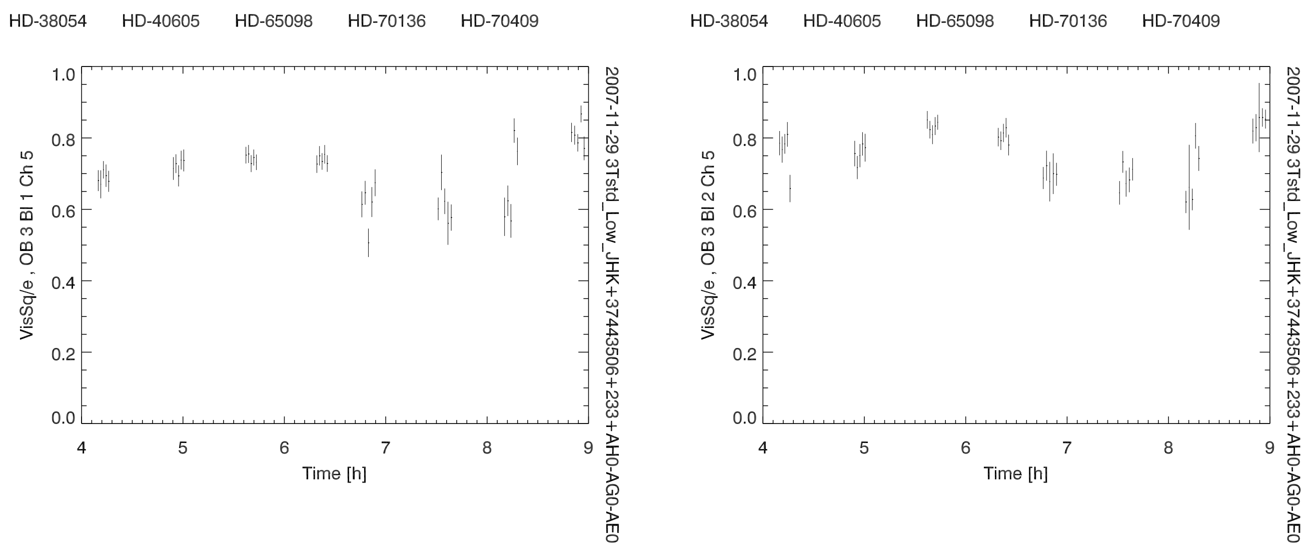

Figure 5. Here, fringe tracking was employed for the first four observations (until about 6:30 UT), when a second group of calibrators too faint for FINITO were observed. Seeing was around 1" in this (second) half of the night. Two baselines are shown, the third one is shown in Fig. 6.

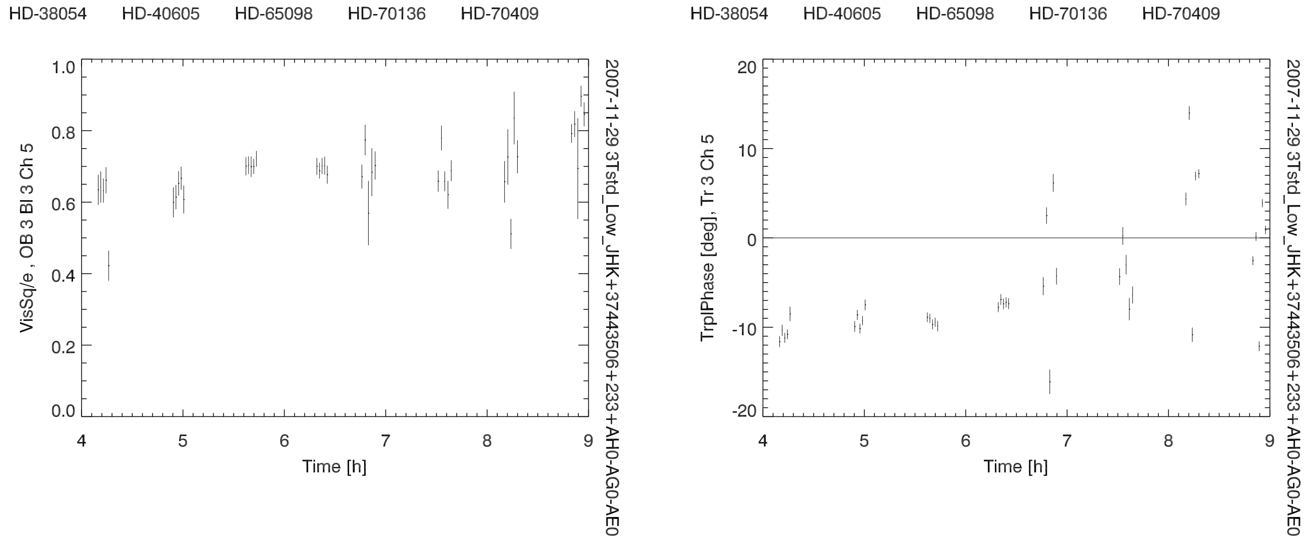

Figure 6. The third baseline for the observations described in Fig. 5 (left). Also shown (right) is the closure phase which improved significantly when fringe tracking was used for the first set of four observations.

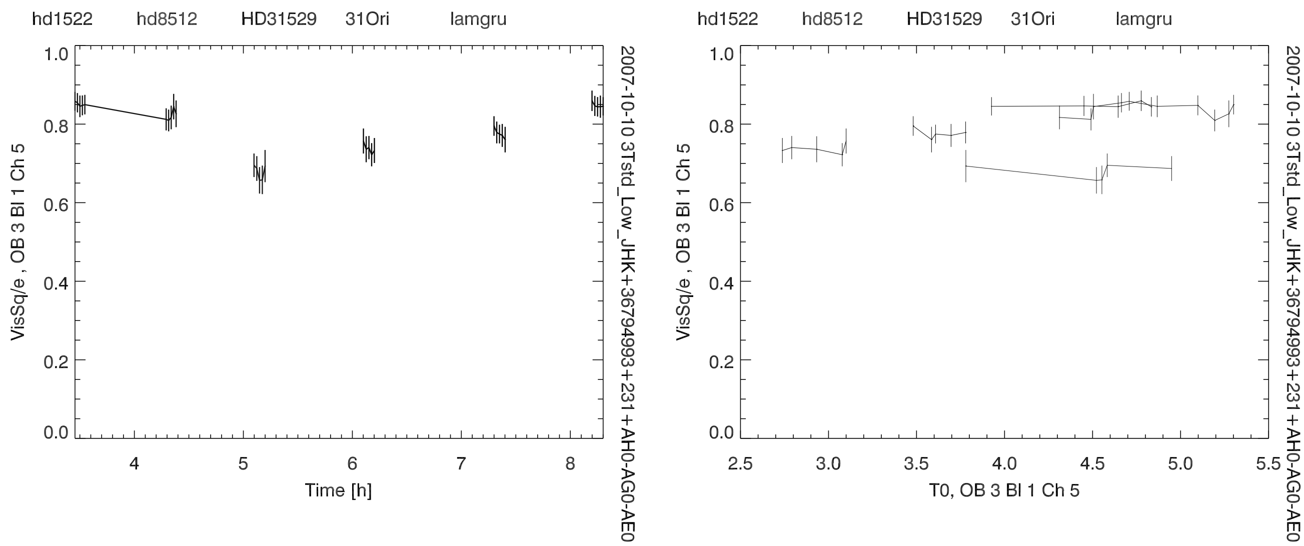

Figure 7. While on the left the TF is plotted as a function of time, we can see on the right that with one exception (HD 8512), the visibility amplitude shows a slight correlation with the coherence time t_0. r_0 was between 0.5" and 0.6", except for a peak at 0.9" around 6 UT. (As to HD 8512, it needs to be investigated whether the estimated angular diameter of this calibrator is correct; baseline was H0-G0.) The coherence time on Paranal is derived from the DIMM seeing monitor using wind measurements, and is not derived from the interferometric data here.

5. CORRELATIONS WITH SEEING INDICES

It is important to look for correlations of the fringe amplitude with various interferometric and atmospheric performance indicators (such as residual phase RMS or seeing r_0). These could, if they exist, be used to calibrate fringe parameters and thus lead to a more stable global (i.e. nightly) calibration. In Fig. 7, a weak correlation of TF with t_0 can be seen in data taken with FINITO. That this is mostly due to the residual phase RMS is shown in Fig. 8. Finally, how FINITO performance depends on coherence time is shown in Fig. 9.

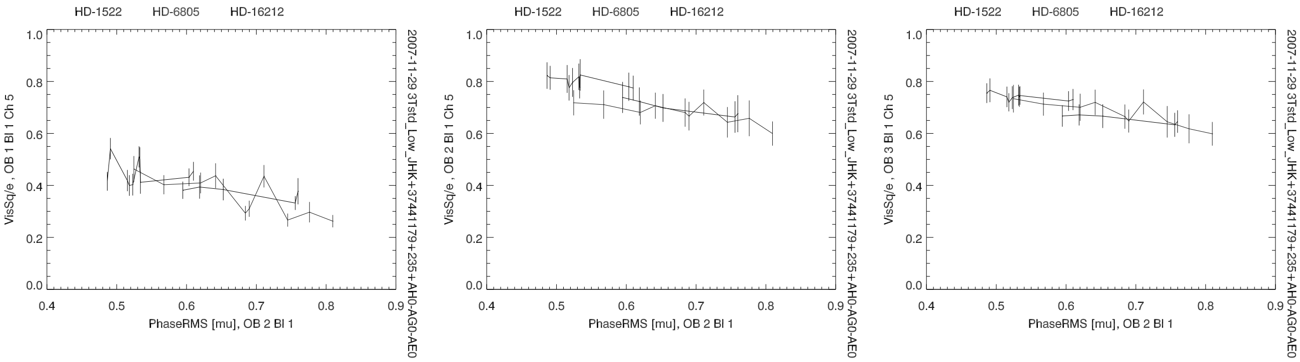

Figure 8. The fringe tracker provides two diagnostic parameters to determine its actual performance during tracking. One of them is the RMS of the (residual) FINITO fringe phase. We show here weak but expected correlations of a decreasing visibility amplitude with increasing phase RMS. Good results were obtained in all three J, H, and K bands, even though the TF in the J band is much lower than in the other bands. These observations were performed during rather poor seeing (2" on average), but with a coherence time of about 2 ms. In addition, the observed stars are all of 1st magnitude in the H band, used by FINITO.

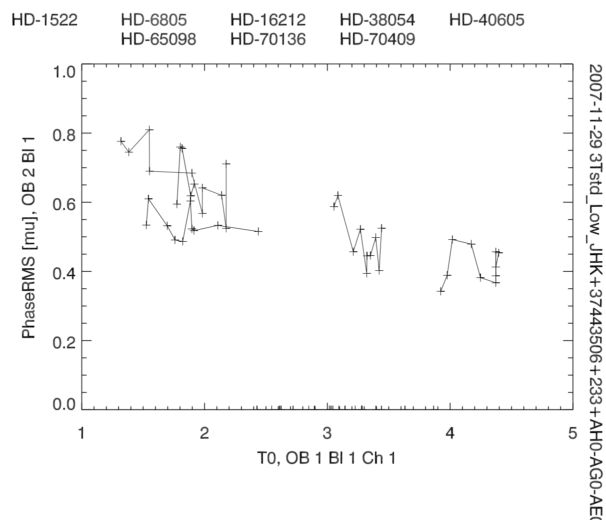

Figure 9. The seeing conditions of the night of 2007, Nov 29, varied sufficiently enough to reveal a correlation between the FINITO performance (as expressed by the phase RMS), and the coherence time t0 (in this case just Fried's parameter r0 divided by the wind speed, measured by the ambient seeing monitor on Paranal). The data corresponding to the two P2VM calibrations of this night have been combined for this plot.

REFERENCES

[1] Hummel, C. A. and Percheron, I., "Pipeline reductions of VLTI/MIDI data and quality control," in [*Advances in Stellar Interferometry. Edited by Monnier, John D.; Schöller, Markus; Danchi, William C.. Proceedings of the SPIE, Volume 6268, pp. 62683X (2006).*], *Presented at the Society of Photo-Optical Instrumentation Engineers (SPIE) Conference* **6268** (July 2006).