More results on the stability of the transfer function of AMBER

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1 Overview

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 amdlib (JMMC software, *http://www.jmmc.fr/*) and the MyAmberGUI tool (*http://www.eso.org/ chummel/amber/myambergui/myambergui.html*), and therefore can be used as a reference for the data quality independent observers may expect from AMBER. Please note that all visibilities in this report are squared visibilities. This report continues one which was published in the proceedings of the SPIE conference in Marseille, 2008, by the same author.

The transfer 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. In this report, the plots show the squared TF, unless otherwise noted.

For the reductions, we have used public calibrator data recorded both in SM and VM. The latter mode more often provided homogenuous data sets, however, since the OBs are not classified by the night astronomer accordining to certain quality control criteria, it is not always guaranteed that every observation was performed without any technical or weather problems.

2 MR/HR transfer functions without FINITO

While the LR TF without FINITO has been described previously, we investigate in a little more detail here the MR/HR TF as observed with the UTs. (There are no AT data in HR mode, since observing in MR/HR without FINITO is not possible.) Figs. 1 and 2 show MR data taken with the UTs, and one notices the much lower TF when comparing to observations with the ATs, shown in Fig. 3. The MR TF without FINITO is more stable than the LR TF, due to the latter suffering from piston dependent bandwidth smearing. We show in Fig. 3 an example of the HR TF.

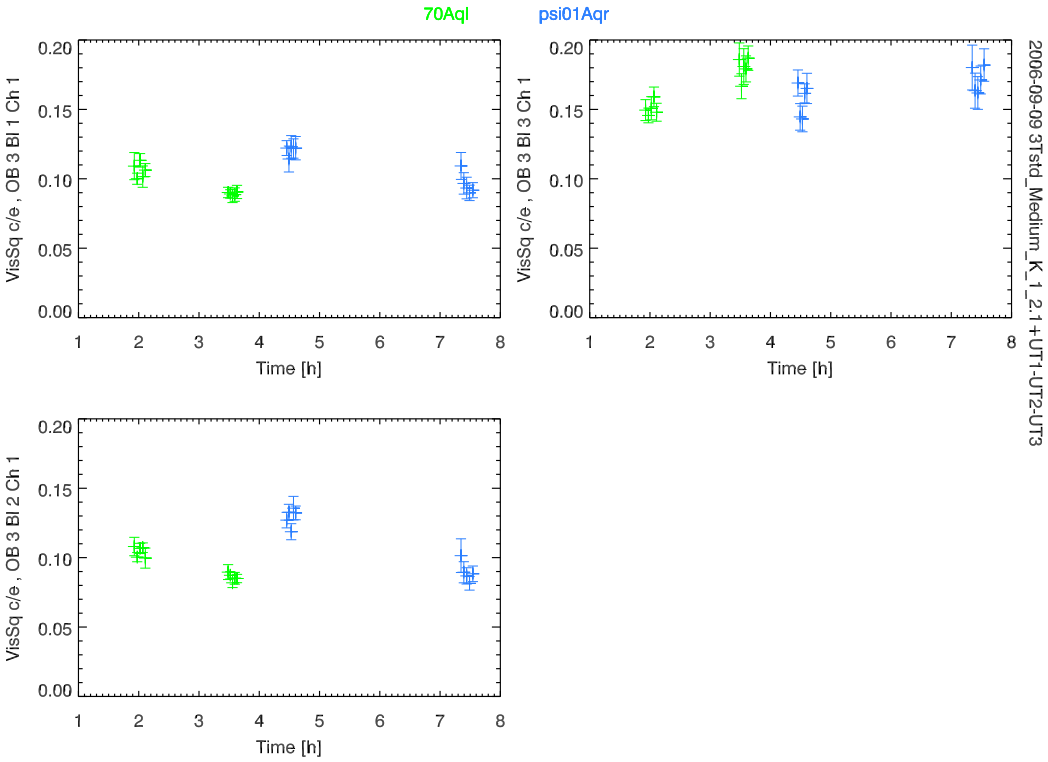

Figure 1: MR data (without FINITO) from 2006-09-08. 50% of the best frames selected. Baselines are (from left to right): UT1-UT2, UT2-UT3, and UT3-UT1. Median seeing was 1.2". When selecting all frames, the (squared) amplitudes would be about 75% of the values shown. The amplitudes were normalized using the expected diameters, and the median values (with median errors) across the spectra are shown. AMBER DIT was 50 ms.

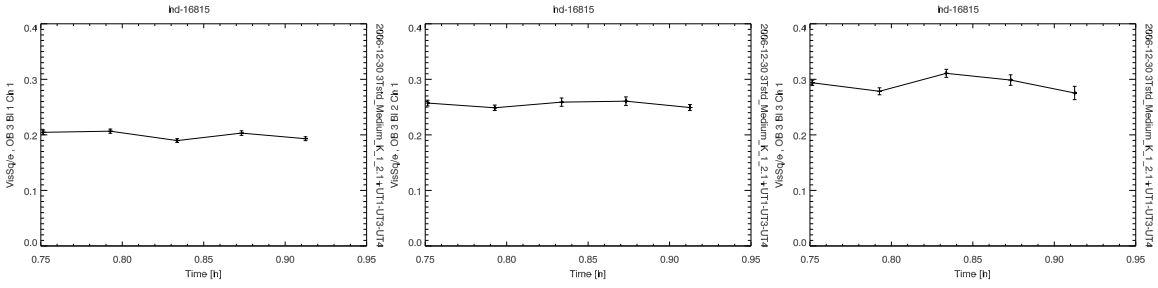

Figure 2: MR data from 2006-12-29. 50% of the best frames selected. Baselines are: UT1-UT3, UT3-UT4, and UT4-UT1. Median seeing 0.9". The amplitudes were normalized using the expected diameters, the median value across the spectrum is shown.

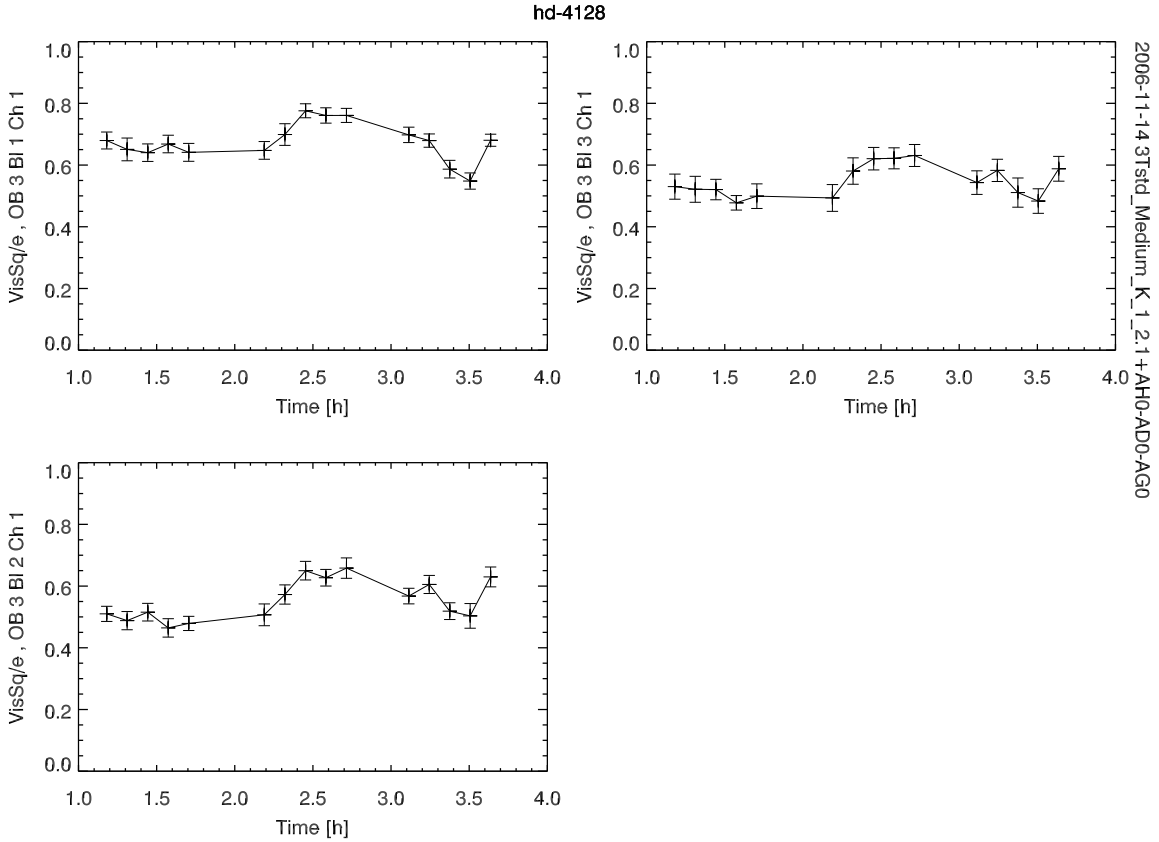

Figure 3: MR data from 2006-11-13. 50% of the best frames selected. Baselines are: AH0-AD0, AD0-AG0, and AG0-AH0. Median seeing 0.8". The amplitudes were normalized using the expected diameters, the median value across the spectrum is shown.

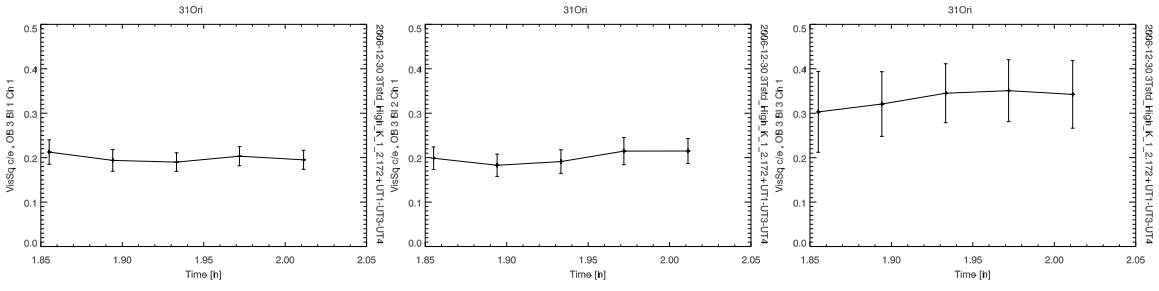

Figure 4: HR data from 2006-12-29. 50% of the best frames selected. Baselines are: UT1-UT3, UT3-UT4, and UT4-UT1. Median seeing 0.9". The amplitudes were normalized using the expected diameters, the median value across the spectrum is shown.

3 Transfer functions with 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 in routine operation at VLTI, was the originally envisaged way of operating AMBER.

3.1 LR transfer function

The LR TF is much improved with FINITO due to the absence of frames with large piston. We show in Figs. 5 to 7 JHK calibrator data from a VM program taken on 2009-10-31. The AMBER DIT was always 25 ms, except for the first observation, where it was 27 ms. FINITO DIT was always 0.5 ms (FAST mode). We can see in the plots the effects of bad seeing, which occurred in a brief period between 7 UT and 8 UT. Especially the closure phases benefit from the use of FINITO, as shown in Fig. 8. The varying offsets from zero are due to the fact that a new P2VM was taken for every observation of 10 Ori.

We also show results in this mode for a night where different calibrators were observed, in Figs 9 to 12. All observations were reduced with the same P2VM; however, the AMBER DIT was 25 ms for the first one (HD 13596), while it was 50 ms for the other ones. FINITO was group tracking with 4 ms DIT for 80 Tau, while it was used in phase tracking mode and 1 ms DIT for all other observations.

The effect of group tracking (if done with the recommended longer DIT) on the TF seems to be small, while the effect on the closure phases is noticable, as expected. The higher visibility of HD 13596 is due to the shorter AMBER DIT, but some elements of uncertainty remain since this star is also rather large (2.44 mas, according to the Borde et al. catalogue) and therefore the correction for extension is significant.

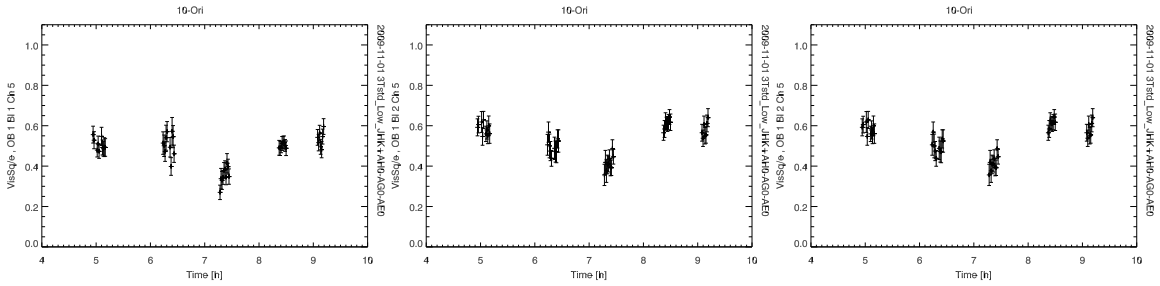

Figure 5: LR J-band TF with FINITO. Median seeing 1.3", with poor seeing of 1.7" between 7 UT and 8 UT. 20% of the best frames were selected. Baseline are H0-G0, G0-E0, and E0-H0.

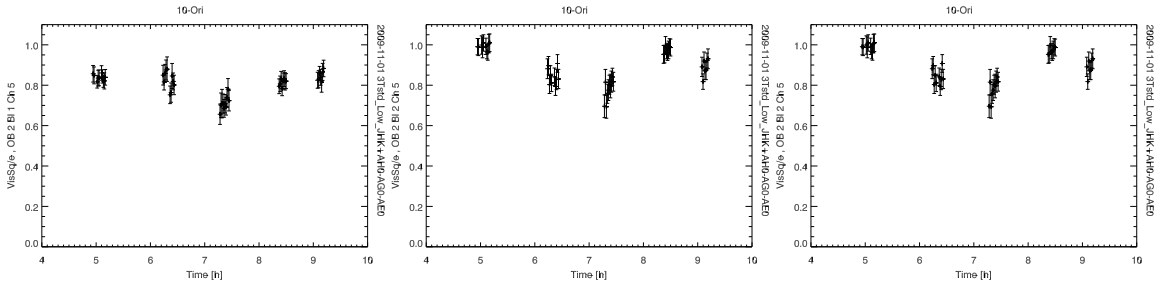

Figure 6: Same as Fig. 5, but for H-band.

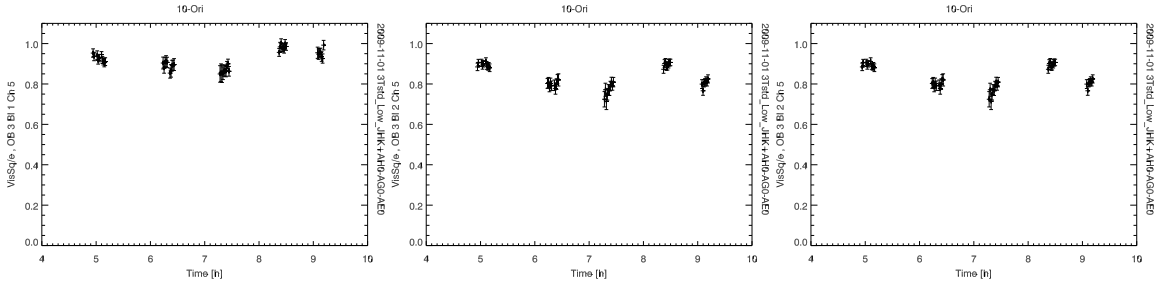

Figure 7: Same as Fig. 5, but for K-band.

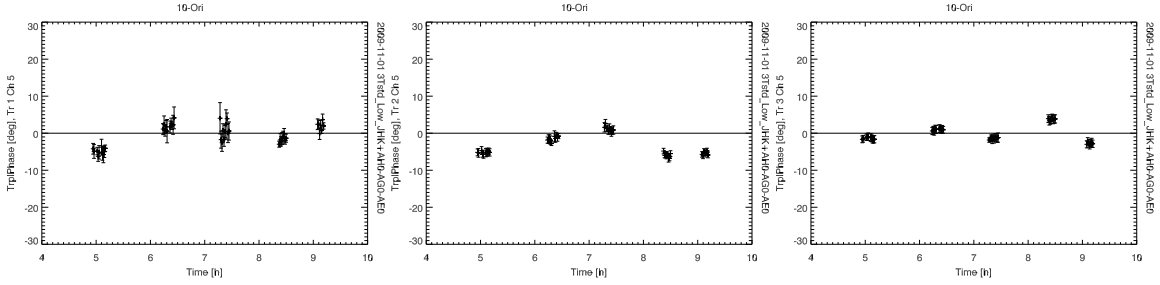

Figure 8: LR JHK-band closure phases with FINITO. All frames were selected.

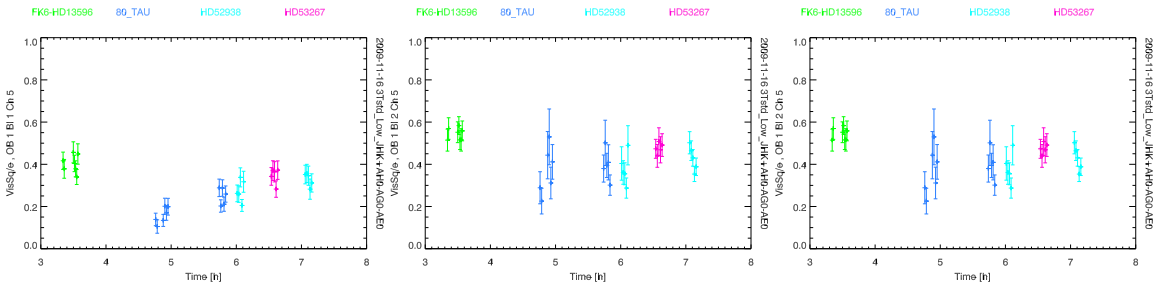

Figure 9: LR J-band TF with FINITO. Median seeing 1.2" before 5 UT, 0.9" after 5 UT. 20% of the best frames were selected. Baseline are H0-G0, G0-E0, and E0-H0.

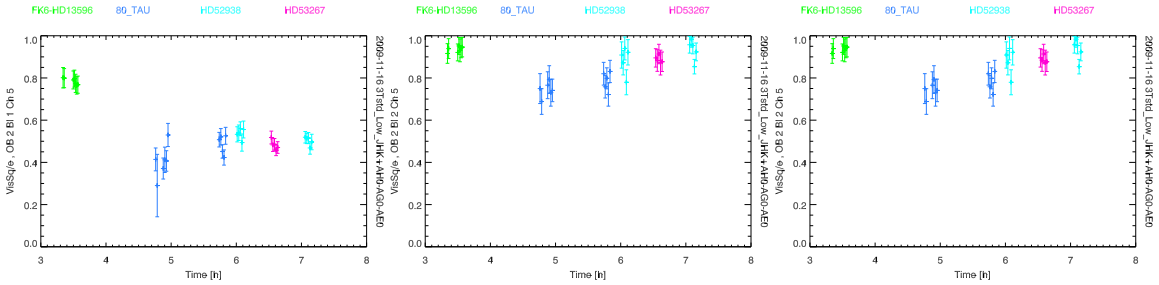

Figure 10: Same as Fig. 9, but for H-band.

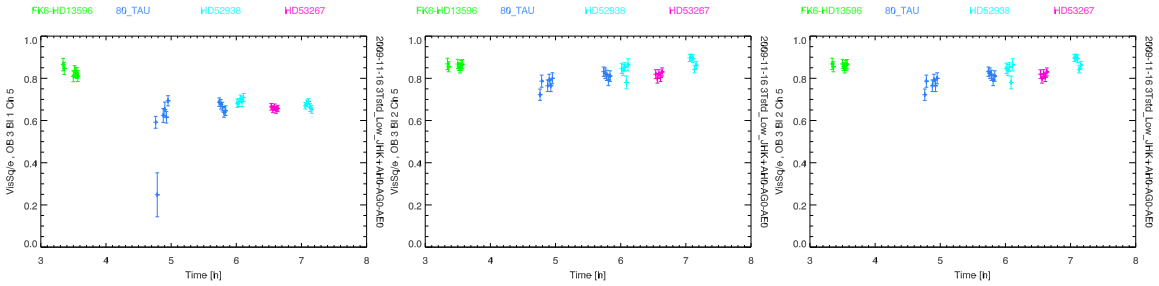

Figure 11: Same as Fig. 9, but for K-band.

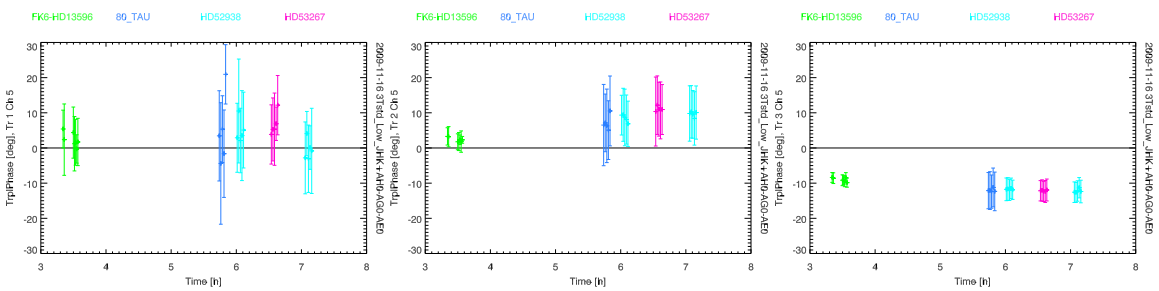

Figure 12: LR JHK-band closure phases with FINITO. All frames were selected.

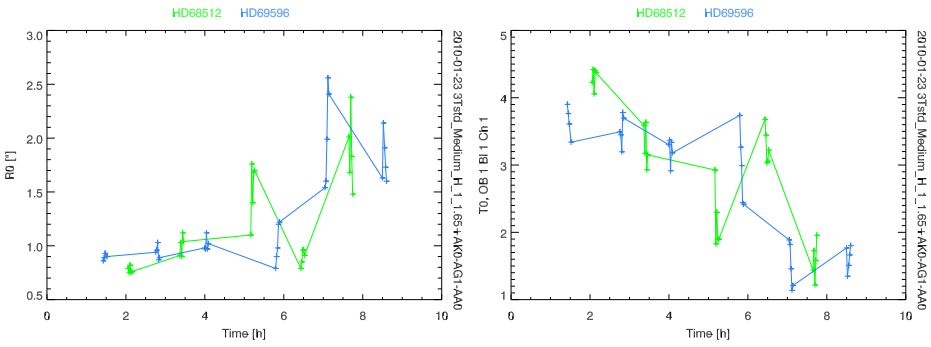

Figure 13: Seeing conditions for the night of 2010-01-22.

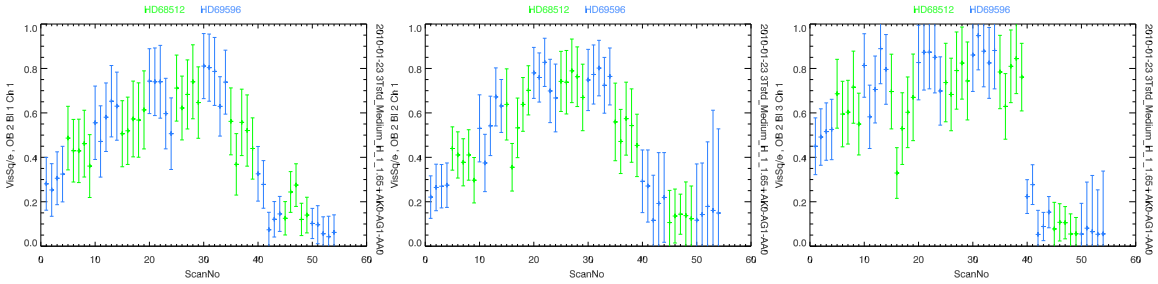

Figure 14: MRH (squared, normalized) visibilities with FINITO, plotted versus observation index. AMBER DIT was 1 s, FINITO DIT was 1 ms. 50% of the best frames were selected. The median seeing was 1". Baselines are K0-G1, G1-A0, A0-K0. Diameters of calibrators were adopted as follows; HD 068512: 1.4 mas; HD 069596: 1.6 mas.

3.2 MRH transfer function

The MRH mode was newly offered in P84, and we show an example of the TF recorded in VM on 2010-01-22. The seeing conditions in this night were not that good, and are shown in Fig. 13.

The plots (Fig. 14) show the median values of the normalized squared visibility amplitude across the spectra. The variation of the amplitudes with time is large, and, as we will see, seems typical for the long integration times (on the order of seconds) used for MR and HR observations. The varying performance of FINITO in tracking the fringes is reflected in the phase RMS value, and Fig. 15 shows the strong correlation of this parameter with the visibility amplitude.

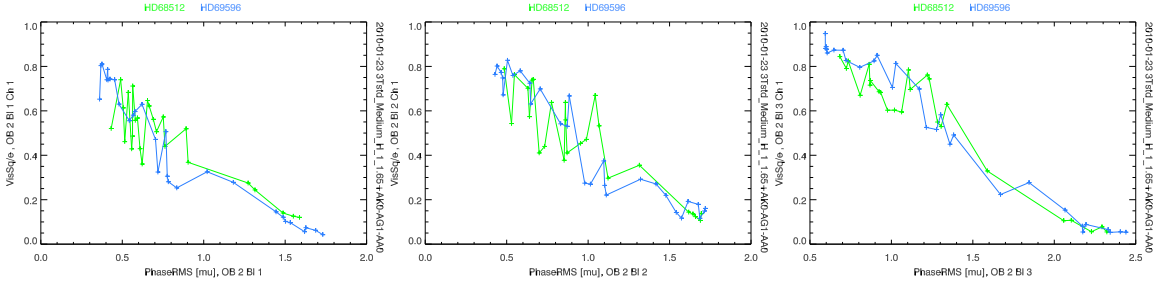

Figure 15: The correlation of the MRH visibilities with the FINITO phase RMS.

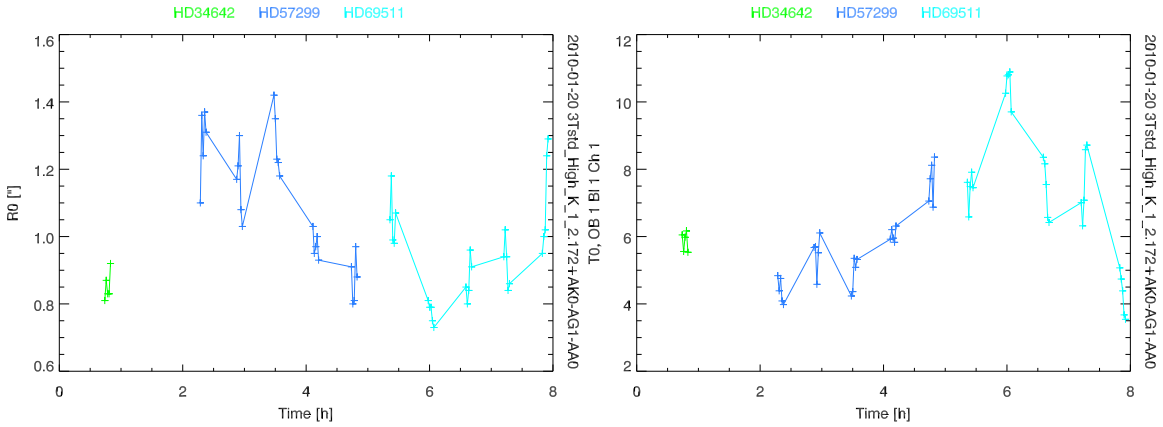

Figure 16: Seeing conditions for 2010-01-19.

3.3 HR transfer function

The HR mode is offered for the K-band only, and we show here results from 2010-01-19. Basically, we find the same correlations as present in the MR data due to the long coherent integration time.

3.4 Conclusions

The stability of the (linear) TF in LR mode with FINITO is quite good, about 4%-8%, 3%-4%, and 2% in J, H, and K, respectively. In MR and HR mode, the TF depends strongly on the FINITO phase RMS, and if the latter is not taken into account, even a CAL-SCI-CAL sequence of observations will not produce good repeatibility of the TF.

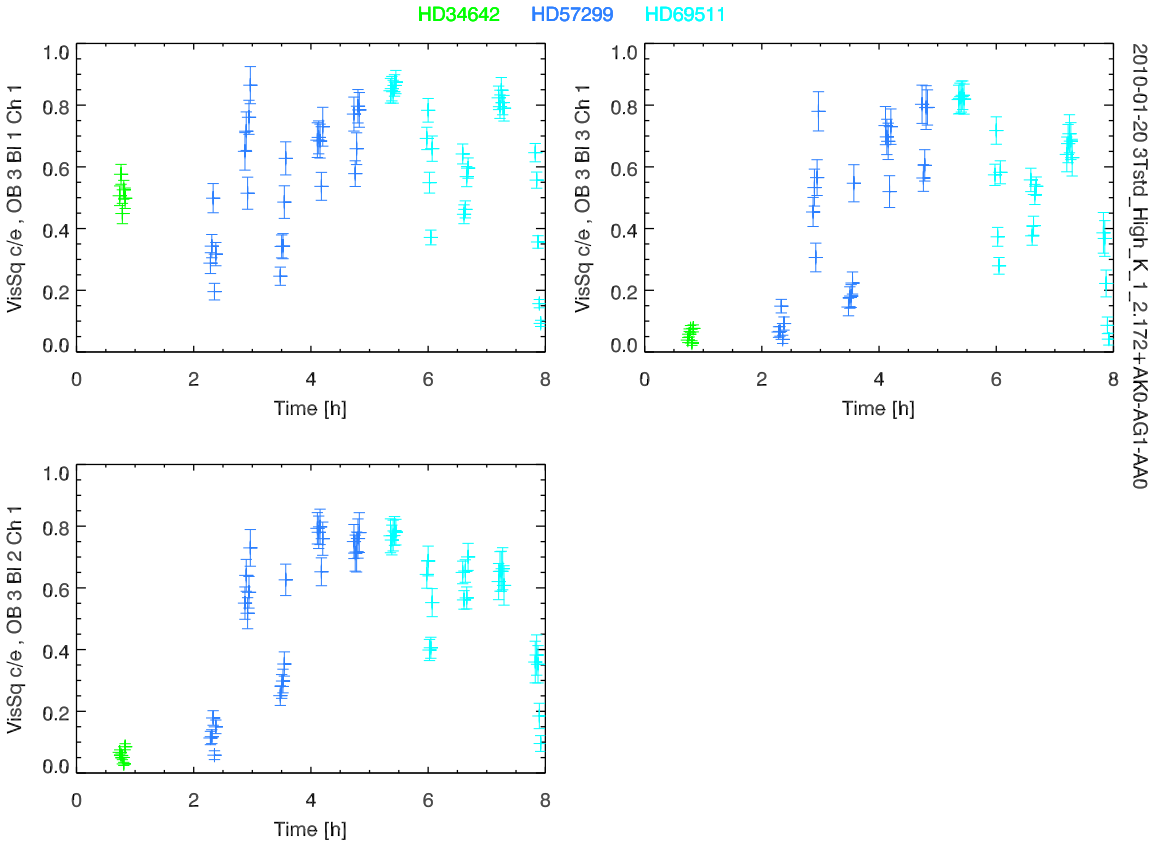

Figure 17: HRK (squared, normalized) visibilities with FINITO. The median (squared) visibility amplitude of the spectrometer is plotted. AMBER DIT is 5 s, FINITO DIT is 1 ms. 50% of the best frames were selected. The median seeing was 1". Baselines are K0-G1, G1-A0, A0-K0. Diameters of calibrators were adopted as follows; HD 34642: 1.4 mas; HD 057299: 1.3 mas; HD 69511: 1.5 mas. It is unclear why the visibilities of HD 34642 are so close to zero on two of the baselines.

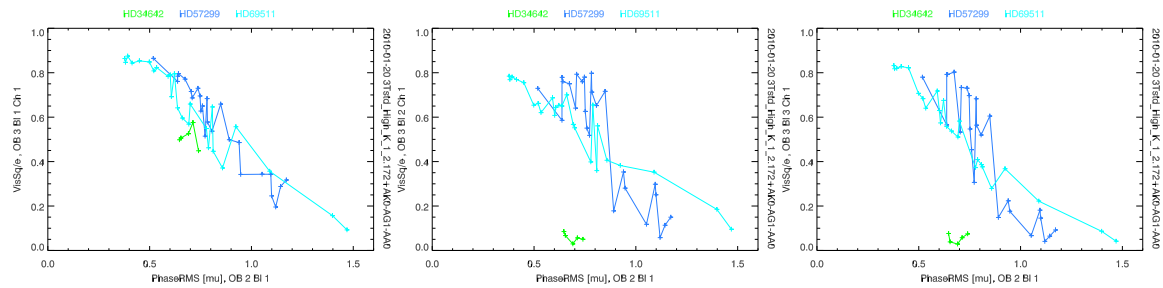

Figure 18: HRK (squared, normalized) visibilities with FINITO versus FINITO phase RMS.