VLTI Memo

Memo Number: ???

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Subject : **Open Loop piston measurements**

Presents :

Scope of this memo

The goal is to provide realistic sequence and PSD of the piston over the Paranal observatory. Ideally, sequences for several baseline lengths, different telescopes (UTs/ATs) and different weather conditions should be delivered.

Data reduction and analysis

Open loop piston sequences can be obtained with the FINITO (H-band, down to a DIT of 0.5ms) and the AMBER instruments (J, H or K-band, down to 13ms). To do so, one should carrefully select an unresolved ($V > 0.5$), very bright star ($H < 3$ on the ATs), so that a proper phase measurement can be done even several tens of microns from the white fringe. Selecting such a star could be problematic on long baselines.

Both instrument provide phase and group-delay estimation. However the group-delay is more noisy, is estimated at lower rate, and suffers from more complicated bias and artefacts. In this memo we measured the piston by unwrapping the instantaneous phases measurements. FINITO data have been recorded with the RMNrec. Processing consists into:

- Extract the FINITO raw phases from the RMNrec tables.
- Unwrap the phase (add π each time the phase difference is larger than π).
- Convert the phases into OPD (I used fringe-spacing of 1.7μm).
- Compute the RMS and the PTP.
- Compute the PSD, and re-sample it at specified frequencies.

The FINITO phase data are clearly affected by a frequency oscillation at 25Hz, which corresponds to 2×5fringes$\times$4readouts$\times$DIT for a DIT of 1ms. We see two possible reasons: *1)* an effect of the FMU return point (badly executed or taken into account) or *2)* an effect of the finite coherence envelope that could bias the ABCD estimation. First effect is expected to be constant for all scans, while second effect is expected to be seen only of the fringe packed is not properly centered in the OPD-window. Figure. 1 demonstrates that the 25Hz comes from an effect of the envelope (effect 2).

AMBER data are not expected to be strongly biased at any frequencies. AMBER data have been recorded with classical observation templates in LowResolution mode. The window range has to be dramatically shrunk to few channels to allow DIT as small as 13ms. Data processing is:

- Reduce each file with `amdlib-2.2` using default parameter. Be careful that a P2VM is therefore necessary and should have been taken during the observations.
- Extract the phase of the VISDATA product (complex amplitude, stored in the OIVIS table of the `amdlib` OIFITS product).
- Unwrap and convert the phases into OPD (I used fringe-spacing of 2.2μm).
- Compute the RMS and the PTP.
- Compute the PSD, and re-sample it at specified frequencies.

Data set

- 2009-05-16T06:20 and latter: Simultaneous FINITO (H-band, 1ms) and AMBER data (K-band, 13ms) in open loop data in good conditions with D0-H0-G1. Target SAO-184014 is a known binary but this should not be a problem. H= 2.4mag. 20 files have been obtained with FINITO and 10 with AMBER. All showing similar PSD slopes (see Fig. 2 and 3) but with large difference in RMS (see Fig. 4 and 5).
- **TO BE EXPANDED WITH DATA ON UTs ON FOR DIFFERENT AMBIENT CONDITIONS**

Table 1*: Observation summary*

date	telescope	instrument	seeing	tau0	RMS	PTP	slope
2009-05-16	D0-H0-G1	FINITO-H, 1ms	0.75	5ms	10μm	50μm	-2.1
2009-05-16	D0-H0-G1	AMBER-K, 13ms	0.75	5ms	8μm	35μm	-2.2
...							

Discussion

These results represent a first characterization of the piston strength and PSD over Paranal with the existing instruments used in operation. AMBER and FINITO present compatible results. **The power at 25Hz in the FINITO data should not be considered as real.**

The power extend over very short frequencies (at least 200Hz) and down to very slow frequencies (at least 0.1Hz) with a constant power law. Comparison with expected power-law for Kolmogorov turbulence should be attempted.

Figures

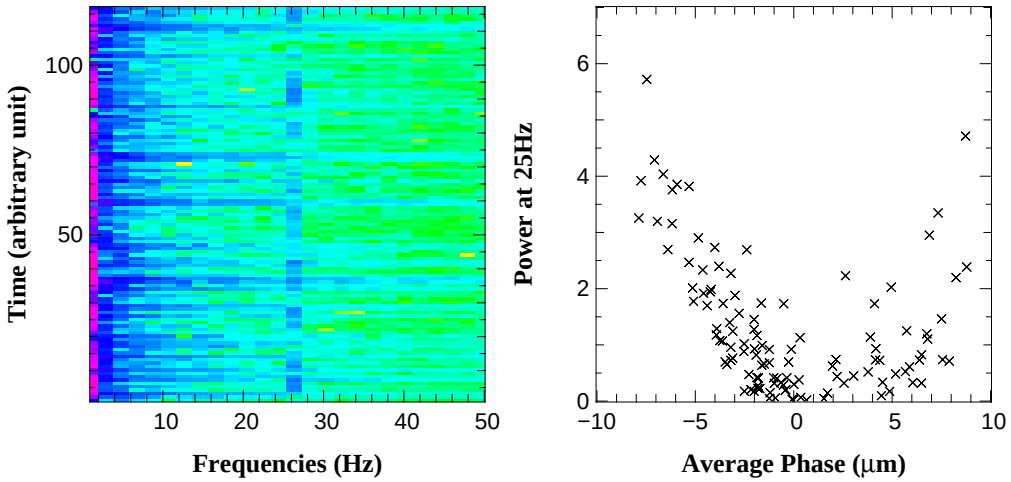

Figure 1*: Left: time-frequency decomposition of the unwrapped phase signal from FINITO channel 1. The total time range (about 60s) has been cut into consecutive sequences of 1s. The power at 25Hz is clearly visible and is changing with time. Right: Power at 25Hz plotted versus the actual average phase over 1s. The further the fringes from the central position, the larger the power at 25Hz.*

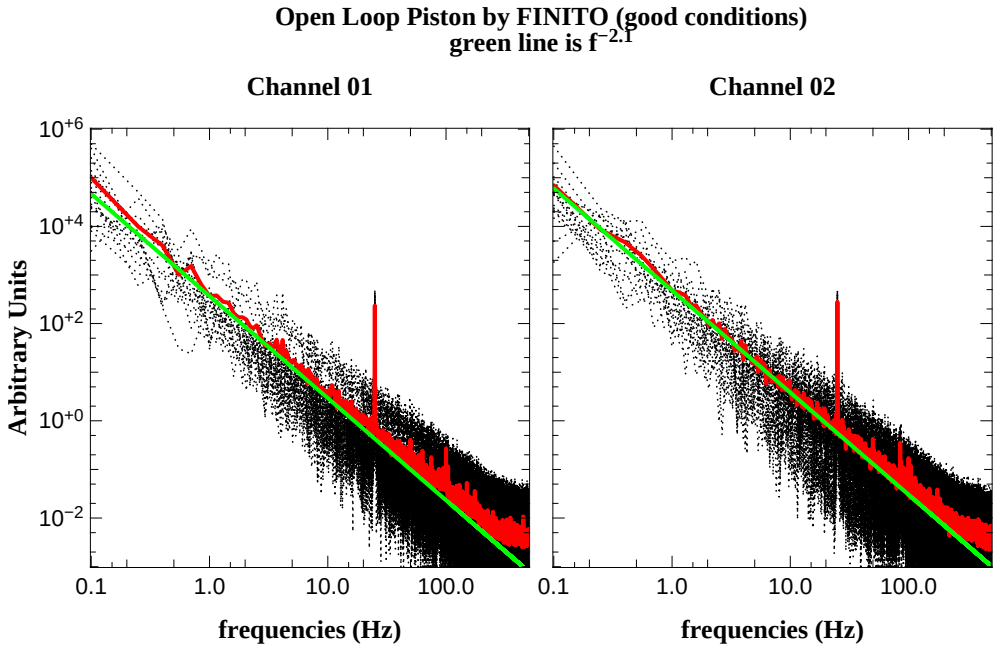

Figure 2*: Individual PSD (dotted lines), averaged PSD (red) and characteristic slope (green) for open loop piston as measured with FINITO in good conditions. The 25Hz is contaminated by the envelope effect of FINITO scanning concept.*

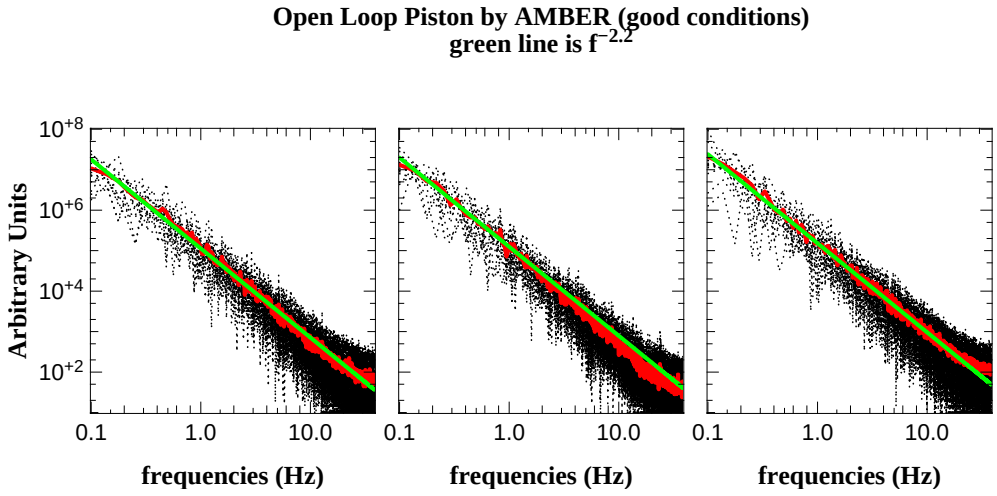

Figure 3*: Individual PSD (dotted lines), averaged PSD (red) and characteristic slope (green) for open loop piston as measured with AMBER in good conditions.*

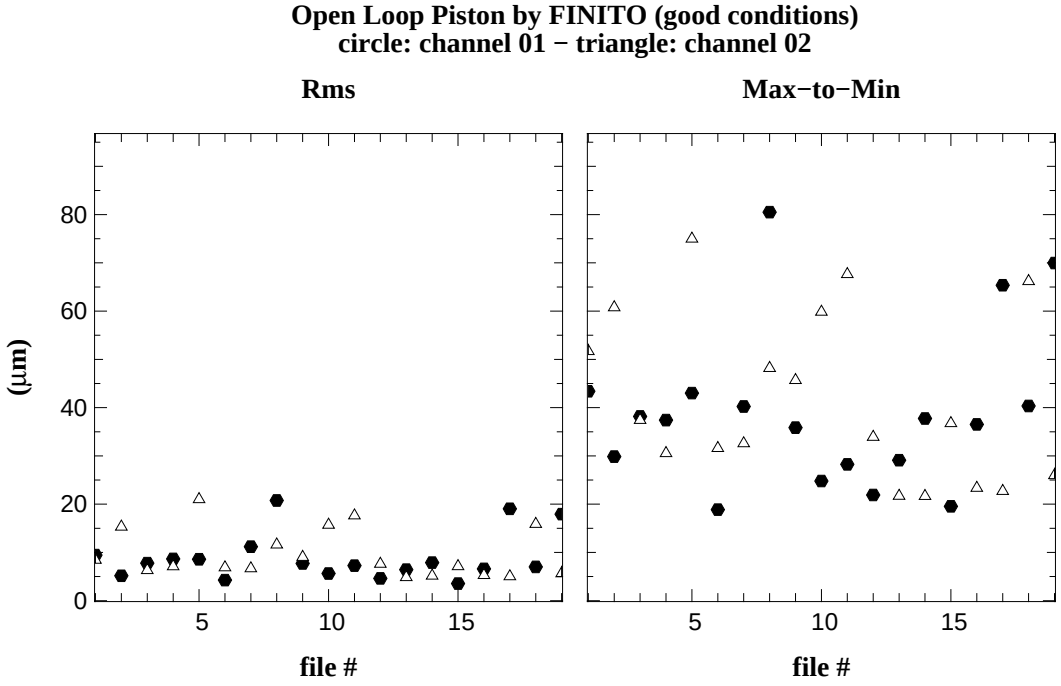

Figure 4*: RMS (left) and PTP (right) over* $\sim 30s$ *of the piston sequences corresponding to Figure 2, plotted in* μm*. Symbols are for the 2 FINITO baselines.*

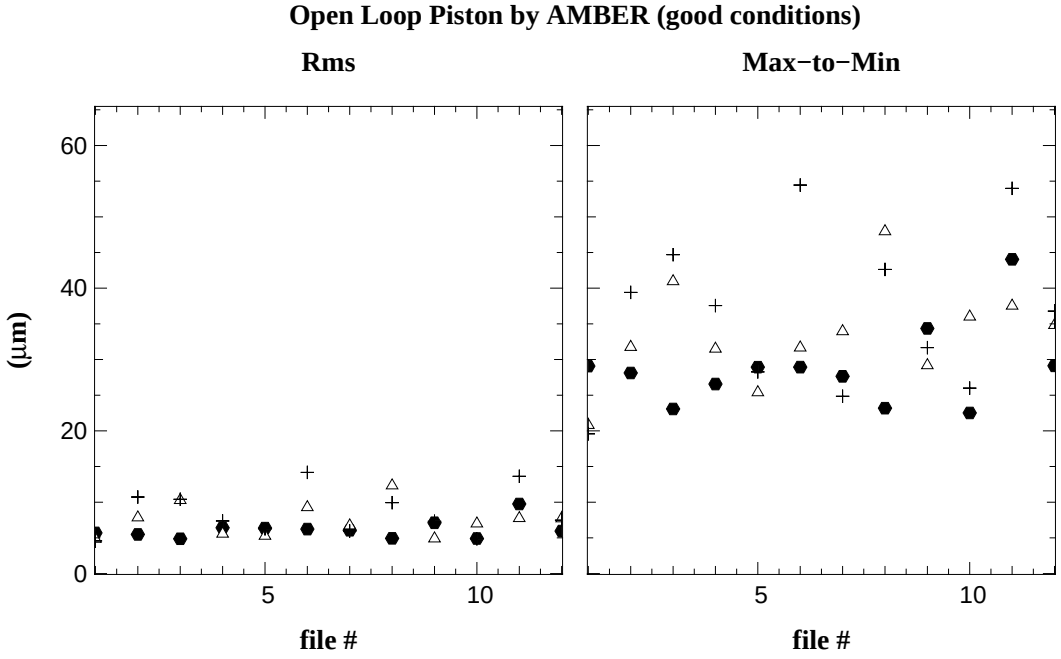

Figure 5*: RMS (left) and PTP (right) over* $\sim 30s$ *of the piston sequences corresponding to Figure 3, plotted in* μm*. Symbols are for the 3 AMBER baselines.*