MEMO

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PAON2/04.02.13

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Subject: Some outcome of the first 4 months of PAON2 operation.

1 Introduction

The two 3m diameter dishes nicknamed PAON2 are in operation since 20/09/12. After 4 months, the dishes are still in operation even after mitigate weather with wind, showers, snow… The mechanics is solid enough and I focus on analysis output of the few data stored on Irods at CCIN2P3. Many results have been already described in MEMOs, I remind some of them and describe in more details new ones subject of mail exchanges.

2 Spectra oscillations

Thanks to a 2h noise run taken 21st Nov. 12 at 1kHz, the auto-correlations of the 4 polarizations have been averaged to get the 4 spectra shown on Figure 1. It manifests the presence of large oscillations with a peak-to-peak distance (p-t-p) of about 15MHz but also smaller oscillations with a p-t-p much lower. A zoom of the same spectra but in dB is presented on Figure 2.

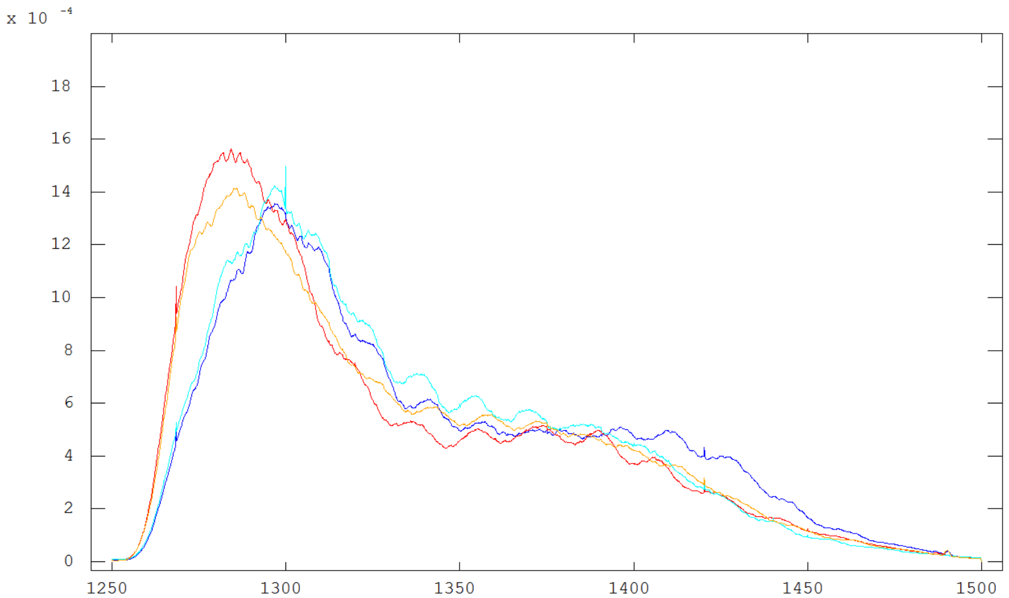

Figure 1 The auto-correlations [1250,1500]MHz averaged over ~7000sec (122kHz) during the noise run of the 21st Nov. 12. The color code stands for blue (Ch0), red (Ch1), cyan (Ch2), orange (Ch3). The histograms are normalized as the sum over the 2048 bins is set to unity. No filtering has been used.

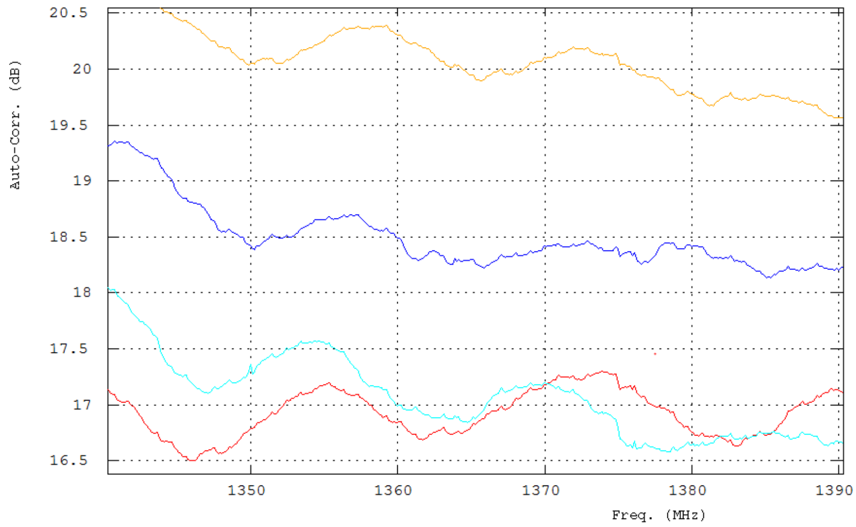

Figure 2 A zoom of same spectra of Figure 1 without normalization but in dB.

The origin of all these oscillations affecting the spectra since the Meudon prototype mounting is under investigation on a table top test bench: cable lengths, "I" connections… But new ideas on electronic are rising: ex. design of small boards with digitization & FFT done close to the dishes and sending the bits through optical link to a master board (Uniboard of the like) performing the visibility computations…

3 Visibilities fitting output

Using both the Sun transit (cf. PAON2/Sun/30.11.12) and CygA transit (not referenced) it has been performed successfully a visibility model fitting. It turns out that the effective radius of the dishes is a chromatic parameter and depends on the polarization as shown on Figure 3.

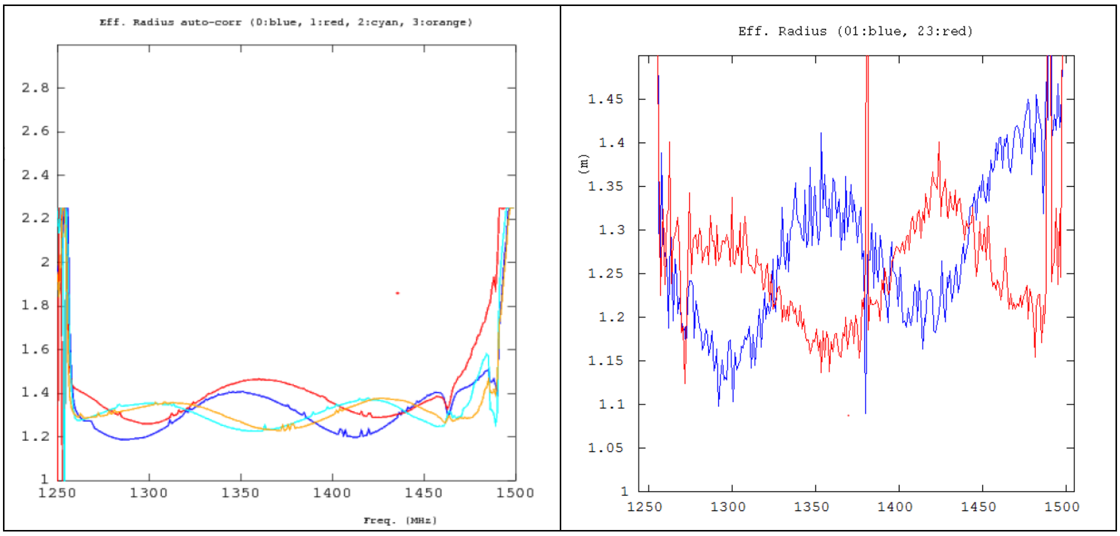

Figure 3 Fit results of the effective radius of the dishes. Left panel: the auto-correlations of the 4 channels during a Sun transit. Right panel: the cross-correlations of channels with aligned polarizations during a CygA transit.

If we take an average value of 1.25m, the geometrical efficiency defined as a surface ratio is of the order of η_{geom} ~ 70%. The baseline between the 2 dishes is well determined to about 12.1m with small chromaticity well in agreement between the two sets of data. In passing, the effect of the fringes dilution of about 50% due to finite Sun radio emission radius has been identified.

4 Noise and T_{sys}

In reference PAON2/09.11.12r2, I have investigated the determination of the T_{sys} thanks to the Sun transit of 9th Oct. 12 for the normalization and a "noise" run taken the same day later on for the fluctuation analysis. From the auto-correlations of the "noise" run which was quite stable, both the baseline levels and the fluctuation standard deviations have given coherent results. The T_{sys} is not independent of the global efficiency η of the dish & feed (surface illumination, surface regularity, feed efficiency). This can be summarized by the channel dependant value:

$$\frac{T_{sys}}{\eta} = (290 \div 380)K \qquad \text{(run 9/10/12)}$$

The 23rd Nov. 12 an observation of CygA transit has been performed followed by a rather long data acquisition. In total 4h at 1kHz (16µs/paquet) has been registered and averaged over 1MHz frequency bins and 5000 paquets. Both cross-correlations between the aligned polarizations are shown on Figure 4.

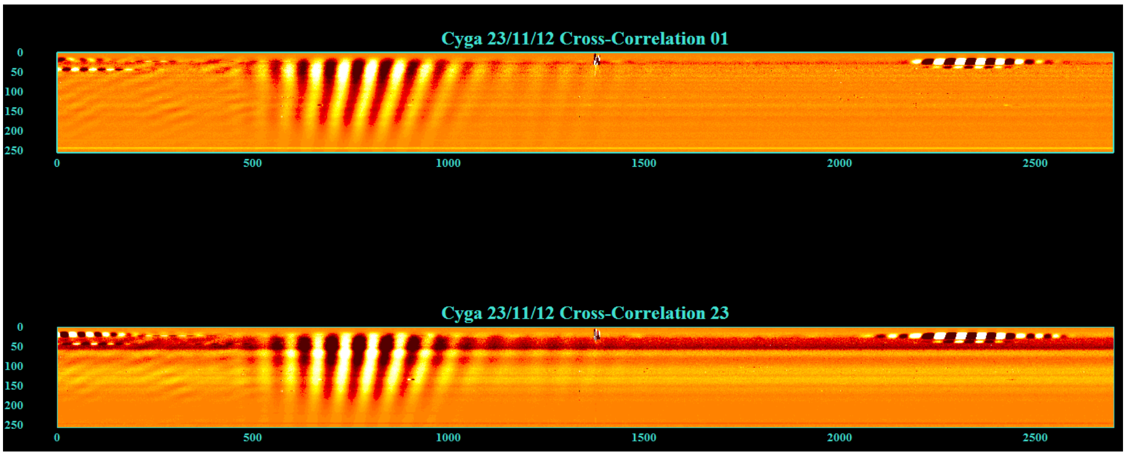

Figure 4: Cross-correlations between aligned polarizations during the observation of Cyga transit. The run in total represents 4h (x-axis). The 250MHz total band is along the y-axis of each image starting on top-left corner at 1250MHz. The main CygA fringes are localized roughly in the bin range [500, 1000] of the image while we see also human induced signals before and after the transit concentrated around 1275 ± 10 MHz (ie. the franges spacing do correspond to Sky rotation).

At 1400MHz, the cross-correlations time evolutions are shown on Figure 5. The baseline after the CygA transit is rather clean and allows one to estimate the T_{sys}/η ratio.

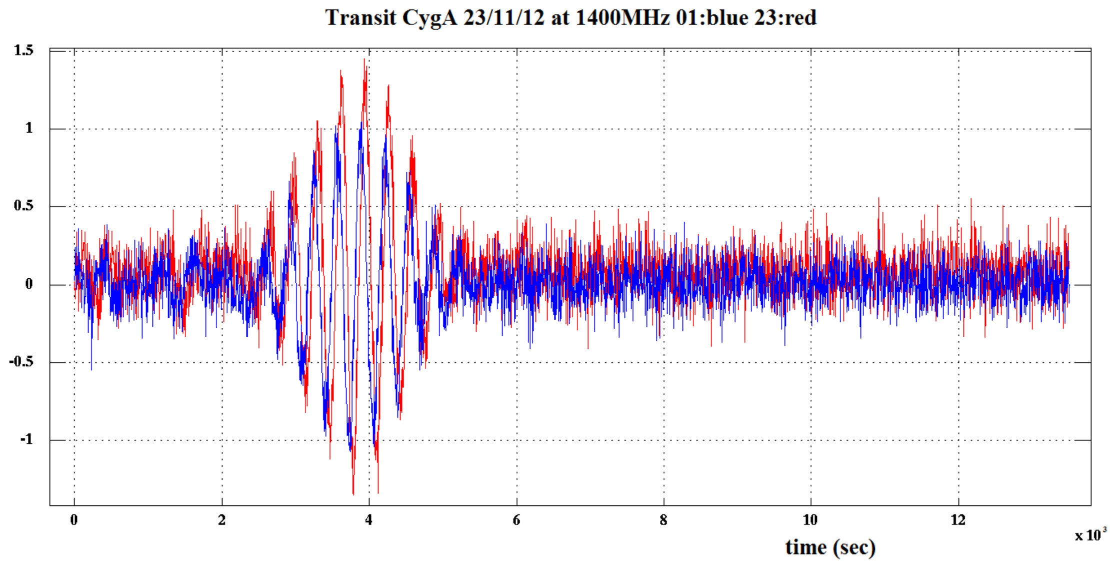

Figure 5 Evolution of cross-correlations (Figure 4) at 1400MHz.

The CygA strength of 1600Jy at 1400MHz which correspond at 4.1K (100% efficiency) for our 3m dish (see reference PAON2/09.11.12r2) fixes the cross-correlation signal scale using the 01-cross-correlation maximum (~1.05au).

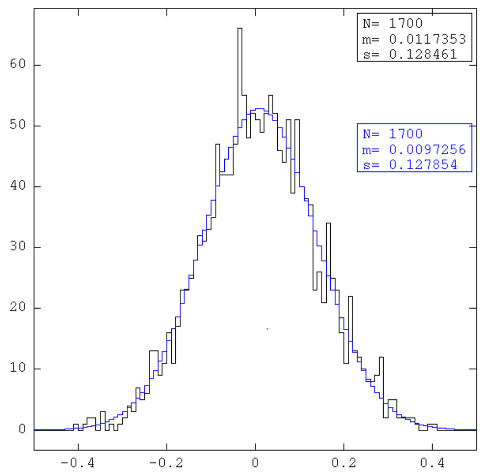

Figure 6 Histogram (and Gaussian fit) of the 01-cross-correlation after the CygA transit (see Figure 5).

Figure 6 presents the 01-cross-correlation fluctuations after the transit. Converted in temperature units it yields σ = 0.128 x 3.9 = 500mK. Then, to compute the T_{sys}/η ratio one takes into account the 1MHz frequency band width and the 5000x16μs = 80ms and a √2 factor as we use the cross-correlation signal. Putting all together, at 1400MHz one gets:

$$\frac{T_{sys}}{\eta} = \sigma[a.u] \times C[K/a.u] \times \sqrt{2\Delta t_{\text{int}} \Delta \nu} \approx 0.128 \times 3.9 \times \sqrt{2 \times 80\,10^{-3} \times 10^{6}} \approx 200K$$

Using the same method with the 23-cross-correlation at 1400MHz it yields T_{sys}/η ~ 175K.

One can repeat the exercise for the complete frequency band and both cross-correlations. The result is displayed on Figure 7. Besides the regions below 1300MHz and beyond 1450MHz, the T_{sys}/η determination is quite stable[1].

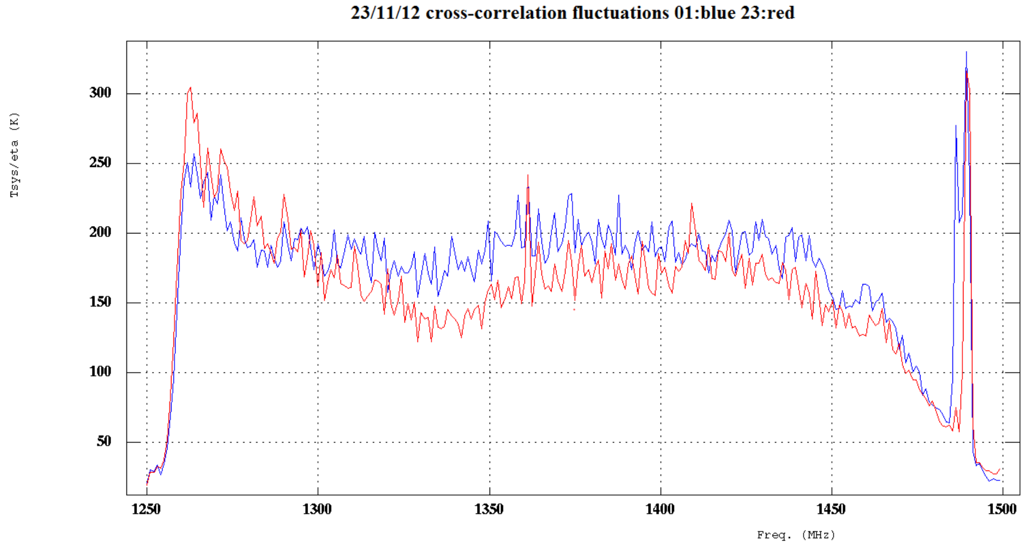

Figure 7 T_{sys}/η deduced from the 2 cross-correlations fluctuations and normalizations (see text).

It is noticeable that the T_{sys}/η values during the CygA 23rd Nov. 12 (14:36 UT) run are lower than the ones mentioned above for the run taken 9th Oct. 12 (14:36 UT). Between the two observations there was signaled on logbook some hardware modifications (cables, connections…) and software (FFT coefficients), so it is quite hard to connect the two results.

The T_{sys} of the feed and LNA has been measured by J. Pezzani (ref. PAON2JP0912A 7/09/12) with cold (the sky at 5K) and warm (absorber plate at 291K) loads. The result was 85K at 1400MHz. My estimate of the T_{sys}/η can indicate a global efficiency of $\eta \sim (40\div50)\%$ which includes the η_{geom} of 70% mentioned in Sec.3. In this interpretation the remaining efficiency factor is about $(57\div71)\%$.

The global efficiency of an antenna with the following characteristics, f/D=0.47 and D=3.5m, was estimated with the same feed design (see JP1210A/Rev2 14/01/11 and JP0611A 24/06/11). One would expect $\eta \sim 67\%$ at 1400MHz which is not so far to the above mentioned measurement. Especially, it is reminded that the PAON2 antenna have different geometrical factors: f/D=0.4 and D=3m. But at first glance, the feed is in principal still adapted, but ground temperature pollution may be a source of noise by geometrical mismatching between the feed and the dish which introduce side lobe leakages. On Sun transit run I have observed some tiny side lobes as shown on Figure 8.

[1] Special care has been taken to remove RFI spikes that affect sometimes the determination of the maximum during the CygA transit and/or the sigma of the fluctuations.

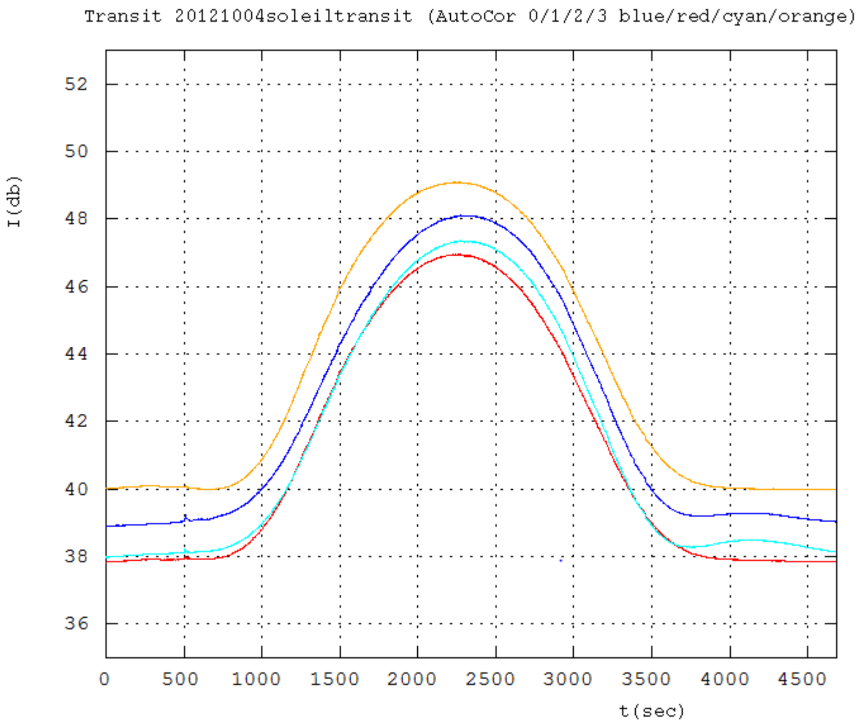

Figure 8 Auto-correlations measurements during a Sun transit 4th Oct. 12.

5 Summary & Outlook

After 4 months of operations, PAON2 has reached its main objectives presented at the LAL-CS. It was achieved a first measurement of T_{sys}/η level with a reasonable agreement with estimates. Also bright sources have allowed for lobe & fringes fitting.

We have identified spectra oscillations which are a source of future sensitivity limitations and I strongly encourage the clarification the exact origin of these noises as soon as possible. This potentially can justify a modification of the present electronic schema.

To perform an independent T_{sys} measurement, one needs to disentangle the global system efficiency. J. Peterson has suggested to put in front of the dish an uniform and cold surface as he does regularly. This is in fact in the same spirit as J. Pezzani has performed with the feed alone. High priority should be put to this measurement by a method or another.

Waiting for PAON4 or the like to be in operation, Ch. Magneville has proposed to take daily data during few hours on the same Sky region to start the map making process. To my concern, I agree on this and I think that the CygA run of 23/11/12 is a good example as there is a bright source for calibration of the visibility fluctuations during the map scanning.