EDGES MEMO #249

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To: EDGES Group

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Subject: Ranking of systematics in signature search

The initial signature search on the data from the second lowband system (lowband2) on an extended ground plane 100 m to the east of the electronics hut yielded the same signature obtained from lowband1 data but only when using the 2017 calibration. Finally, the same signature was found and reported in memo 247 using the Galaxy calibration method. However, the only evidence that the 2017 calibration is more correct than the 2016 calibration is from the data taken with a new type of antenna simulator reported in memos 243 and 219. While the Galaxy calibration results and the relative constancy of signature amplitude with GHA reported in memo 246 strengthen the case for the signature being real there is still a concern that the signature is the result of a systematic present in both lowband1 and lowband2. Memo 246 shows reasonable constancy of the signature amplitude with GHA. However when a signature search is performed the signature parameters show some dependence on GHA. Table 1 shows the search results for lowband1 on the extended ground plane.

GHA (hrs)	freq MHz	SNR	amp (K)	width (MHz)
0	78.9	11	0.88	22.4
4	78.1	14	0.59	21.3
8	78.1	18	0.48	18.1
12	78.5	22	0.53	18.5
16	77.7	19	0.65	18.4
20	78.1	14	0.83	20.1

Table 1. Search for signature using lowband1 data with 6 polynomial terms over frequency range 61 to 95 MHz. FEKO beam model was used for correction with dielectric constant 3.5 and conductivity 2e-2.

These results were obtained with the same number of polynomial terms and frequency range. Another signature search for Galaxy up data reported in memo 240 using 5 terms over a frequency range 67-95 MHz gave results with width 17.1 MHz and amplitude 0.65 K. The results of a search within 4 hours of Galactic center transit are very sensitive to the systematics and hence the choice of search window. In general however using 5 or 6 polynomial terms decreases the sensitivity but more data is needed to obtain a significant SNR. It is also noted that as in a VLBI fringe search the probability of false detection (PE) is given by $PE \approx ne^{-SNR^2/2}$ (Rogers, Doeleman, Moran AJ, 1995)

where n = number of points in the grid search

SNR=signal to noise ratio

so that for $n \approx 10^4$ and $PE < 10^{-2}$ a SNR>6 is needed and in practice an even higher SNR is needed for high significance if the rms after fit contains any systematics.

Figure 1 and 2 show the results of a signature search on loband2 data from 2017_082 to 2017_129 using 2017 and 2016 calibration respectively. A GHA range of 6 to 18 hrs was used with beam correction. In this case the use of 6 polynomial terms and a wide enough frequency range to obtain a significant SNR yields similar results while limiting the effects of systematics.

A ranking of the effects of various systematic effects is given in Table 1. These results were obtained by simulating data with 0.5 K signature with $\tau = 7$ at 78.5 MHz with FWHM 18.5 MHz using the characteristics of lowband2 with 2017 calibration and then processing the data with various changes. For example in the first entry the simulated data is searched for a signature with 3, 4, 5 and 6 polynomial terms and a frequency range 60 to 99 MHz. The blank entries for 3, 4 and 5 terms are because the detected signature was significantly different in frequency or width than the signature added to the simulated data. The best case was simulated data processed from a GHA range of 6 to 18 hours without beam correction. On the other hand the worst case was to process data at GHA=12 hours without beam correction and without a range of GHA which tends to average out the beam effects. The ranking between 1 and 6 were based on a combination of a minimal change in amplitude and a result at less than 6 terms. The levels of error in S11 were chosen to be more than the largest expected and at a level that result in effects are large at the difference between the 2016 and 2017 calibration of lowband2.

	Number of poly. terms				
Test	3	4	5	6	Rank
2016 vs 2017				0.49	5
No loss correction		0.47		0.51	2
No beam correction		0.30	0.42	0.48	1
No beam corr. GHA12				0.65	7
LNA S11 +1dB				0.51	5
LNA S1 + 100 ps			0.40	0.48	4
Ant. S11 + 0.2 dB			0.63	0.50	3
Ant. S11 + 100 ps				0.48	6

Table 1. Ranking of systematics. 1 is best (i.e. has the least effect on signature detection). Blanks indicate that the simulated signature of 0.5 K was not found. Entries are the amplitudes of the detected signature. The first entry of no beam correction is for an average from GHA=6 to 18 hrs. the second assumed data at GHA=12 hrs only.

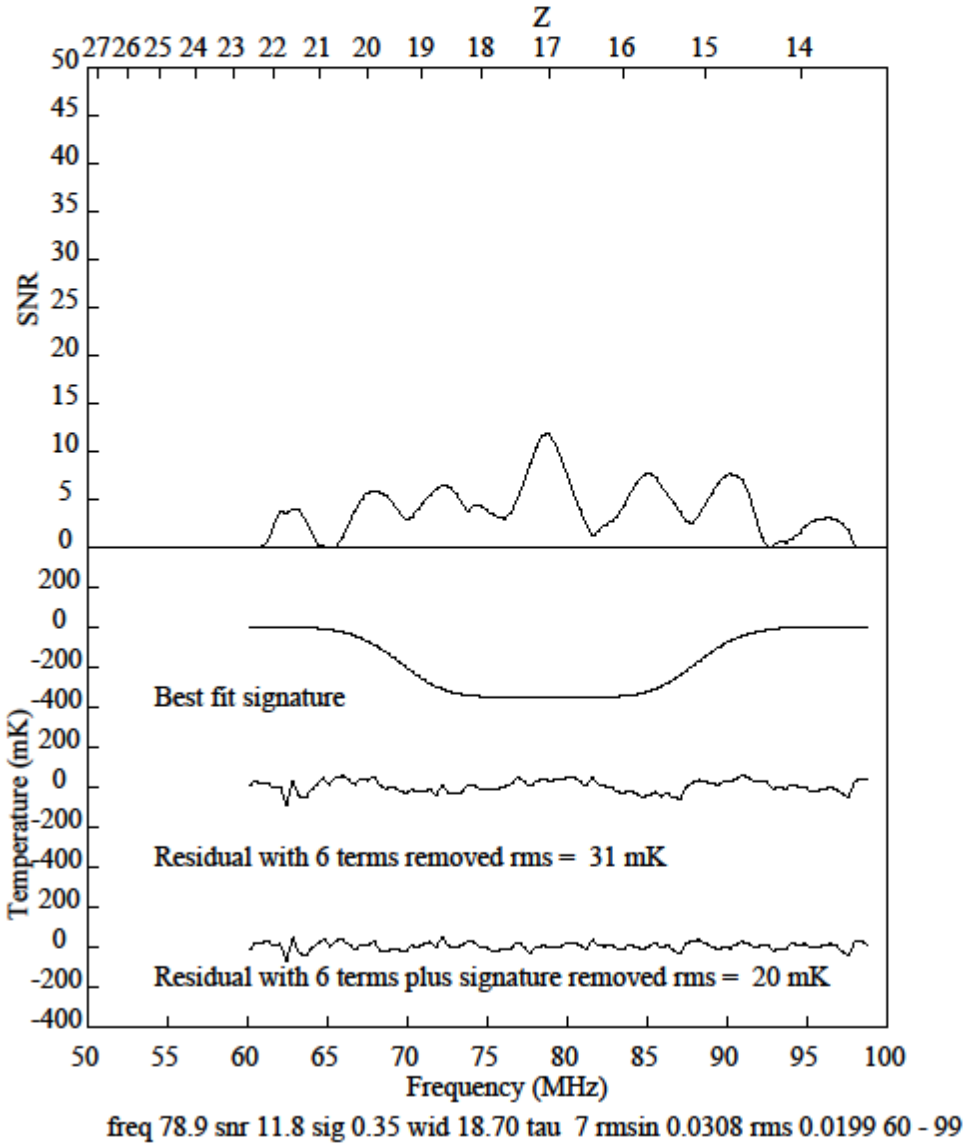

Figure 1. Signature search on lowband1 data with 6 polynomial terms using 2017 calibration.

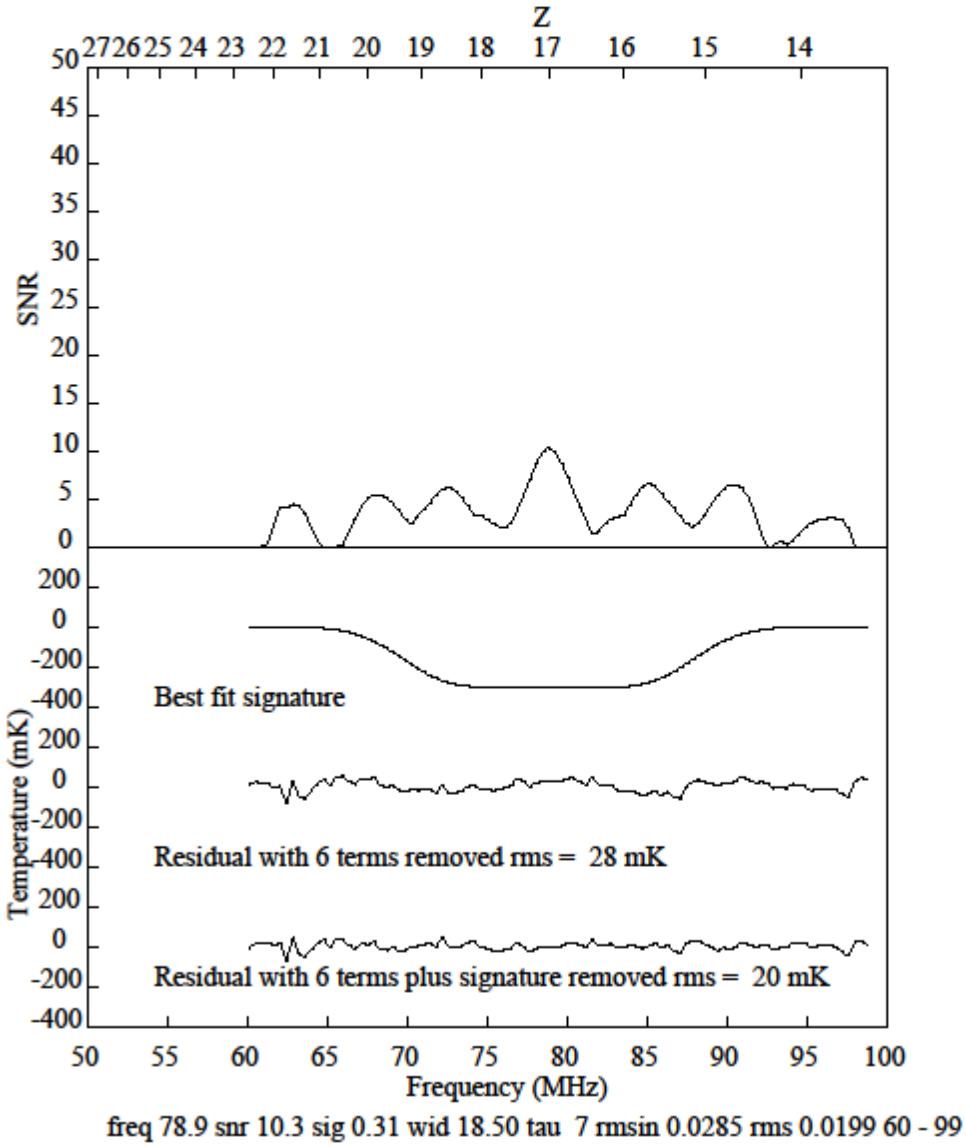

Figure 2. Signature search using 2016 calibration.