EDGES MEMO #382

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To: EDGES Group

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Subject: Simulations of EDGES-3 noise and comparison with data using antenna simulator

The simulation used in memo 380 is augmented with the addition of Gaussian noise added to each position of the 3-position switch to compare with EDGES-3 data taken with the antenna connected to the antenna simulator described in memo 199 with a 6 dB attenuator to generate a spectrum close to that from the sky. The primary objective is to determine how much integration time is needed for calibration and sky observations in a short deployment in Alaska or other test site.

For these tests the frequency range is limited to 52 – 120 MHz and 6 Linlog terms to model the sky. Test data was taken for a total of 16,000 3-position switch cycles on the antenna simulator using 5 days of 15 hours each. Calibration data was taken with 400 3-position switch cycles for each of 4 spectra needed for calibration which took 8 hours.

The first entry is the result for the extraction of the the Nature absorption profile which was added to the antenna simulator spectrum. The results on the other entries are from the simulations with different levels of added noise.

Sky int sec	Cal int sec	VNA noise	center	amp	width	rms1	rms2
1e5	2.5e3	1e-4	77.7	0.46	17.7	85	40
1e5	2.5e3	1e-4	77.9	0.38	18.3	70	39
1e5	2.5e3		77.6	0.44	18.8	73	32
0	0		78.0	0.50	19.0	74	1
0	2.5e3		77.9	0.55	19.1	80	5
0	2.5e4		77.9	0.52	19.1	76	2
1e5	2.5e3	1e-4	77.9	0.38	18.3	70	39
0	0	1e-4	77.6	0.47	19.9	67	18
0	0	1e-4	77.2	0.52	20.5	77	34 37-term
0	0	2e-4	77.2	0.44	20.8	68	36
1e5	2.5e3	2e-4	78.0	0.36	17.9	78	53
1e6	2.5e4	2e-4	78.2	0.43	18.2	78	40
1e6	2.5e4	-2e-4	78.3	0.51	18.1	83	23

Table 1. Effects of noise on absorption feature extraction. rms1 and rms2 are the rms of a 6 term LinLog fit to the sky with added Nature absorption before and after grid search for absorption best fit parameters. The VNA noise is in fractional values and the last entry is negative to indicate that the noise is only added to the LNA S11 values.

The VNA noise level assumed for the EDGES-3 data is taken as 1e-4 but may have some systematics as discussed in memo 363. Figures 1 and 2 show the results of the absorption grid search for the data taken on the antenna simulator and the simulation respectively. These results are the first 2 entries of the table.

Most of the sensitivity to VNA noise arises from the antenna S11 measurement and for a smooth antenna S11, which is normally the case, the antenna S11 should be smoothed with a 12-term polynomial to reduce the effects of VNA noise. All entries in Table 1 used a 12-term polynomial to smooth the antenna S11 except the case labeled “37-term” for which a 37-term Fourier series was used to interpolate the antenna S11 to the frequencies of the spectra.

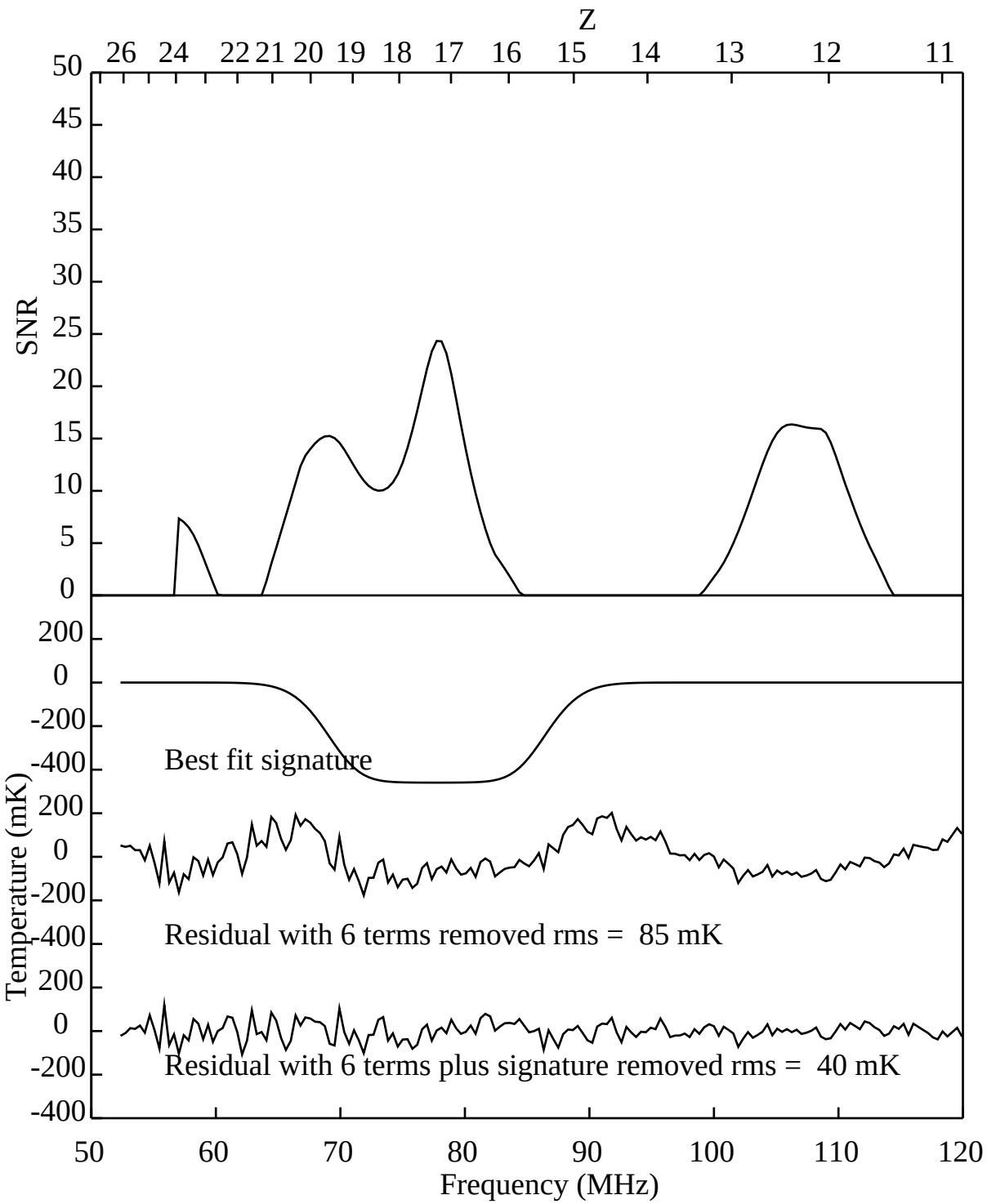

Figure 1. Grid search for the Nature (2018) absorption which has been added to the calibrated spectrum of the antenna simulator.

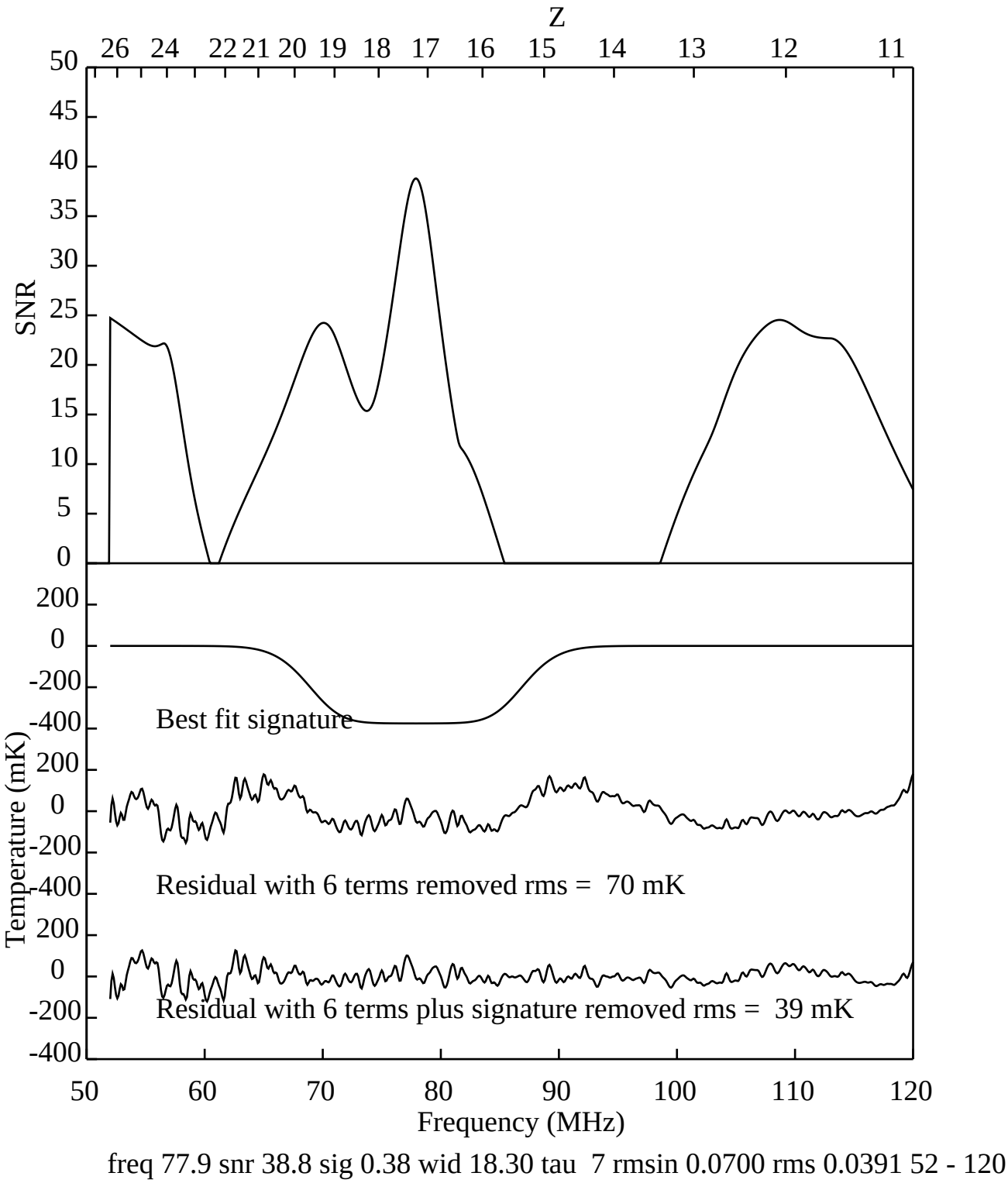

Figure 2. Grid search using simulated data with added noise due to the integration times used for the calibration and spectra taken for the antenna simulator. An estimate of the VNA S11 noise in the antenna simulator data of Figure 1 is also added to the simulated S11 data.