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March 17, 2025

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To: EDGES group

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Subject: Simulation of 3-position switch noise and bias in EDGES-3

Memos 18, 46, 147, 176, 230 and 268 discuss the 3-position noise bias which has a small but not completely negligible effect on the EDGES-3 data. Table 1 shows the results of simulation data in which each 3-position switch cycle is simulated for up to 100 hours of antenna data.

Freq (MHz)	SNR	Amp (K)	Width (MHz)	Freq range	Bias fraction	Time on each switch position	Cal. time hours per short,open,hot,amb	Antenna time hours
78.6	48.2	0.46	19.3	50 - 190	4e-5	8 sec	1	100
79.0	11.3	0.36	18.3	50 - 190	4e-4	0.8 sec	1	100
77.9	86.4	0.49	18.9	50 - 190	4e-5	8 sec	10	100
78.0	90.7	0.52	19.1	50 - 190	4e-5	8 sec	100	100
78.1	28.4	0.51	18.9	50 - 190	4e-4	0.8 sec	10	10
77.7	27.8	0.53	19.1	50 - 190	4e-5	8 sec	10	10
78.1	684	0.49	18.8	50 - 190	0	no noise	10	10
87.7	97.5	6.46	17.6	58 - 100	4e-5	8 sec	1	10
78.1	30.2	0.25	17.3	58 - 110	4e-5	8 sec	1	10
77.0	27.8	0.82	19.2	55 - 120	4e-5	8 sec	1	10
78.3	70.0	0.61	19.5	58 - 120	4e-5	8 sec	4	10

Table 1. Simulated effects of 3-position switching for different integration times

These simulations used a 4 term loglog polynomial to extract the 2018 21cm result of 0.5 K centered at 78 MHz with width of 19 MHz and $\tau=7$ flattening which was added to the sky noise of 150K at 150 MHz with spectral index of 2.5.

The 3-position cycle connects to LNA to the antenna, hot, ambient, open and shorted cables, in position 0, load in position 1 and load plus calibration noise in position 2. The temperatures of ambient load, hot load and calibration noise are 297, 367 and 1000K respectively.

These simulations, which simulate the gaussian noise in each switch position for up to 100 hours (i.e. 450,000 calls the c-code gauss() function for 0.8 sec) show that the 8 sec time on each switch position is adequate to keep the 3-position bias fraction to 4e-5. Overall the calibration of 1 hour is sufficient but 3 hours is more desirable. The use of a 0.8 sec switch time shows that the effects of 3-position switch bias would be much more significant for a system using fast switching with electronic switches.

The last 4 entries of table 1 show that with the 120 inch open and shorted cables of EDGES-3 the calibration should be done over the available bandwidth of 50 – 190 MHz unless a longer integration time can be spent on the calibration. In the case of 58 – 100 MHz the calibration fails and with 58 – 110 MHz only a marginal detection of the absorption owing to a marginal calibration. Another factor in the

3-position, which is discussed in memo 230 is to use compatible processing for the antenna and calibration processing.

The results for the first entry in Table 1 are shown in Figure 1.

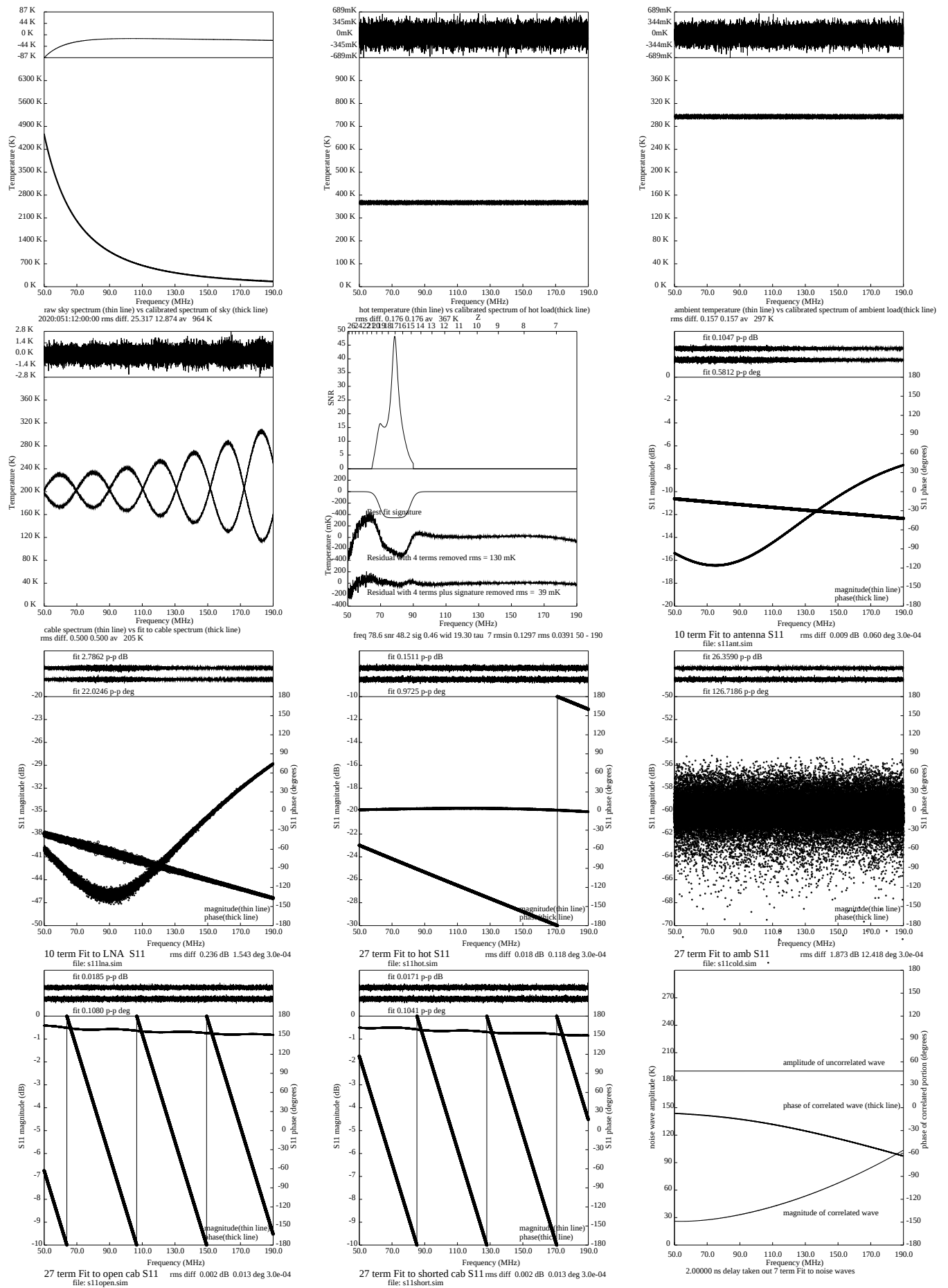


Figure 1. Spectra, s11, noise waves and 21-cm grid search for first entry in Table 1.