EDGES MEMO #175

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To: EDGES Group

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Subject: Simulations of error sources for EDGES-2 blade antenna

Simulations of the effects of errors have been made using a method similar to that of memo 156 in a way more closely related to the actual hardware and software used to analyze the data reported in memo 171. The method involves running a calibration and generating simulated 3 position switched data spectrum from this calibration which is then processed using another calibration in which some parameters are changed and offsets applied to some of the S11 data. If none of the parameters are changed and no offsets are applied the final result is an rms of zero. Table 1 shows the results of the changes in fitting and application of offsets. The effects of offsets are linear so that applying an offset of only 12.5 ps instead of 25 ps to the antenna S11 will reduce the rms residuals by a factor of 2.

	Frequency Range		
	Galaxy cal	Galaxy down	Galaxy down
Parameter change	112-195	112-195	120-175
Antenna S11 25 ps change	22	67	12
Antenna S11 0.05 dB change	3	7	1
Antenna S11 fit 7 to 8 poly terms	7	25	8
Antenna S11 data day 203 to 262	4	9	5
LNA S11 25 ps change	29	24	7
LNA S11 0.05 dB change	2	9	2
Noise parameter fit 4 to 5 poly terms	5	5	1
Turn off antenna loss correction	13	11	1
Turn of hot load loss correction	2	2	0
Open shorted cable S11 25ps change	50	50	6
Open and shorted cable S11 0.05 dB change	4	4	1
Antenna S11 data day 212 to 262	2	5	2

Table 1. Effects of parameter changes on rms residuals to 5 term fit using physical functions (see memo 172). The number in are mK rounded to the nearest mK. Many other changes have been tested like changing

the assumed temperature of the hot load. All other reasonable parameter changes have an effect below 1 mK.

The first results column is for the Galaxy calibration "difference" method described in memo 172. The second and third columns are for a 300 K signal at 150 MHz with spectral index of -2.5. In most cases the Galaxy calibration method is less sensitive to instrumental error especially in S11 amplitude. The third column shows "Galaxy down" sensitivity to errors with a reduced frequency coverage which is a little less sensitive to the effects of instrumental error than for the Galaxy calibration method. Preliminary analysis of actual data from 2015_204 through 2015_266 have rms residuals of about 10 mK for Galaxy down covering 12-175 MHz and Galaxy calibrated rms residuals of about 20 mK covering 112-195 MHz. For the Galaxy down results are quite dependent on which day's antenna S11 data is used and so far it is not clear if this is due to calibration errors, changes in an antenna S11 or changes in the S11 measurement errors. The Galaxy results are much less sensitive.

Similar simulations for the low band gave the following results:

Parameter change	Galaxy cal.	Galaxy down
Antenna S11 25ps change	3	6
Antenna S11 0.05dB change	3	14
Antenna S11 fit 7 to 8 poly terms	0	5
LNA S11 25 ps change	0	4
LNA S11 0.05 dB change	0	2
Noise parameter fit 4 to 5 poly terms	4	4
Turn off antenna loss correction	8	5

Table 2. Effects of parameters changes to rms residuals given in mK to 5 term fit for low band antenna and receiver. A frequency range of 55 – 95 MHz was assumed.

The low band system is far less sensitive despite the sky noise increase by a factor of 5.6. The main reason is the much lower S11 of the LNA. In a simulation in which the LNA S11 is raised by 20 dB from about -38 to -18 dB the change of 25 ps in the antenna S11 produces rms residuals of 6 and 25 mK as compared with 3 and 6 in Table 2. Figure 1 illustrates the relative insensitivity using a simulation of the EoR limit that could be set in the presence of a 25 ps error in antenna S11. Galaxy calibration was used.

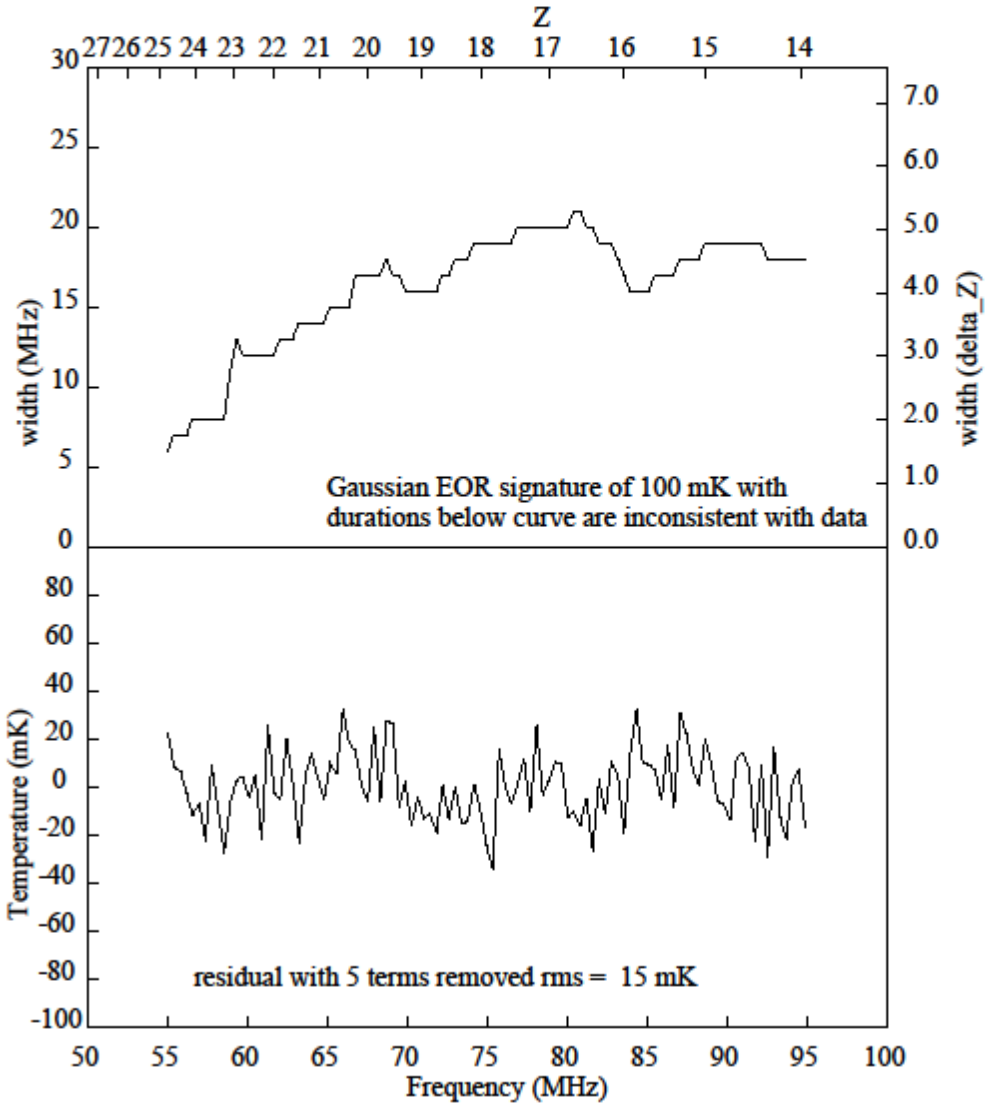

Figure 1. Simulation of EoR detection limit with systematic 25ps error in antenna S11 plus 10mK noise.