EDGES MEMO #212

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August 30, 2016

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To: EDGES Group

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Subject: EDGES-2 low band error budget

This is an update of the earlier EDGES-2 budgets in memos 136, 156 and 182. It considers the major error sources for the low band. Table 1 lists the estimates made using simulations and Table 2 gives the results of some tests on low band data shown in memo 202.

Error sources	Galaxy Up (mK)	Galaxy Dn (mK)	Notes
Antenna S11 phase 10^{-4}	25	1	1
|S11| magnitude 10^{-4}	24	1	
LNA S11 phase 10^{-4}	13	4	
|S11| magnitude 10^{-4}	6	2	
Balun loss	84	40	2
Ground loss	46	13	3
S11 change 1	13	4	4
S11 change 2	84	26	5
Calibration change	5	5	6
S11 smooth change	17	6	7
Antenna delay 30 ps	27	12	
Beam correction	1400	116	8

Table 1. Simulation of major sources of error. Rms values for 5-term physical functions 52-97 MHz.

Notes:

1] S11 changes in voltage units in a direction which changes the phase and magnitude of 10^{-4}.

2] Change in rms for ignoring balun loss

3] Effect of ground loss

4] Effect of changing antenna S11 from measurements obtained on 2015_342 to those of 2015_289.

5] Effect of change from 2015_342 to 2016_175.

6] Since only one calibration has been done the effect was simulated by changing the smoothing or calibration from a 7-term to a 5-term polynomial.

7] Effect of changing the smoothing of the antenna S11 from 10 to 9-term polynomial.

8] The effect of beam correction for current 10×10m ground plane. See memos 184, 185, 186, 188, 189, 192, 198, 201, 202, 203, 204 and 206.

Tests on low band data

Test	Galaxy up (mK)	Galaxy Dn (mK)	Diff (mK)	Notes
Reference processing	260	110	72	1
Without beam correction	1200	170	480	2
Change to conductivity 1e-2	300	120	110	3
Change to S11 from 2015_342	240	110	73	
Change to cal using wfit=7	260	100	74	
Without balun or ground loss	270	87	71	
Change antenna 591 by 100 ps	320	140	75	
Change antenna S11 by 0.1 dB	250	110	69	
Change LNA S11 by 100ps	300	130	76	
Change LNA S11 by 0.1 dB	270	120	74	

Table 2. Effects of changes to processing of low band data.

Notes:

1] Data is from 2015_286 to 2016_200 with Sun below horizon. “Galaxy Up” is 3 hours centered at GHA=0 and “Galaxy Dn” is 7 hours centered at GHA=10. Rms values are for the residuals to a fit of 5 physical terms from 52 to 97 MHz. Beam correction with dielectric 3.5 and conductivity 2e-2 S/m. Blade S11 from 2016_175. Calibration with wfit=5. The reference spectra are shown in Figure 3 of memo #202.

2] The effect of the beam chromaticity is the dominate source of systematic error. While the average over 7 hours centered at GHA=10 hr is effected the average over 3 hours centered at Galactic transit is effected to such a large degree that the difference is also strongly affected.

3] Most of the beam chromaticity, which comes from the finite ground plane, is strongly dependent on the soil conductivity. These effects are clearly observed in a change of the spectra following rain. See spectra in memo #202.

General Comments.

In the low band, most instrumental effects, except those from beam effects are cancelled in the difference spectra which is approximately equal to the “Galaxy Dn” spectrum minus one third of the “Galaxy Up” spectrum. While the difference spectra are not shown the effect of the listed changes except beam correction, make only small changes to the “reference” spectra shown in Figure 3 of memo 202.