EDGES MEMO #156

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To: EDGES Group

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Subject: EDGES2 error budget update

The budget table columns are as follows:

Error source	the origin of the error
Magnitude	full magnitude followed by the fraction remaining after subtraction of a model (no entry implies no model subtraction)
Structure	frequency structure F=file, M=medium, S=smooth
Low band	First column rms error 2nd column rms error after removal of 6 term polynomial 3rd column EoR bias 6 terms + EoR width 20 MHz 50-95 MHz
High band	3rd column EoR bias 6 terms + EoR width 40 MHz 100-190 MHz
Note	reference notes
Memo	relevant memos
N	Effect EoR bias reduced by more than 10 for Gal up/Down method blank cols indicate no significant effect on EoR
FP	Fourpoint
BL	Blade (see memo 154)

Notes:

1] The numbers in parentheses in the low band are for 10 dB attenuation between the antenna and 3-position switch.

2] For $8\lambda \times 8\lambda$ ground plane

3] Oxygen attenuation 2×10^{-4} dB/km at 100 MHz.

4] Occasional bursts from Jupiter at about 10^5J at 16 MHz. Expected to be very weak above 40 MHz. See Zarka 2004. Synchrotron continuum DIM from Jupiter is 5J.

5] Assumes a 1K temperature difference between the electronics during observation and during calibration. Assumes no linear correction based on temperature.

6] Assumes γ ~0.1 and variation of spectral index with Galactic latitude as per memo #7

7] Assumes -25 dBi horizon response

8] Assumes a polynomial fit of $f^{-2.5+i}$ where i=0 to 5 plus a Gaussian EoR signature of 40 MHz full width at half power for high band and 20 MHz for low band. The square root of the covariance is 25 for uniform weighting from 100 to 190 MHz and 50 to 95 MHz for high and low band respectively. The EoR signature is centered at 150 and 75 MHz.

9] In order to reduce the effects of noise in the S11 parameters a series is used to smooth the S11 data and the calibration results. See memo 129.

10] The fundamental limit to VNA accuracy is thought to be set by the ADC non linearity at the level of about 3×10^{-4} which sets the accuracy to about 5×10^{-5} linear unites which corresponds to 0.003 dB at a reflection coefficient of -15dB.

11] 5.35m×5.35m+2m×5m mesh on each side.

12] The high band blade dipole S11 has delay of about 6 ns compared with 10 ns for the Fourpoint. The smaller delay reduces the frequency dependence of the balun loss.

Error Source Magnitude	Structure	Low Band (mK)			High band (mK)			Note	UD	Memo
VNA S11 amp FP 0.01 dB	F	105	7	45	18	1.5	36	1,8	N	134
VNA S11 amp BL 0.01 dB	F	108	0.7	6	17	0.3	7	1,8	N	
VNA S11 phase FP 1.8ps	F	77	16	270	30	3	90	10	N	
VNA S11 phase BL 1.8ps	F	70	2	40	26	0.4	12	10	N	
Fpoint loss (emission) 0.002 dB	S	120			170					98
Blade loss (emission) 0.001 dB	S	50			70			12		
Balun loss FP 0.01 dB	F	700	5	81	1000	7	124			
Balun loss BL 0.01 dB	F	600	0.2	9	800	0.3	14			
ground noise 0.5%	M	1500	2	8	1500	2	20	11		88
groundplane loss 0.001 dB	S	60			60			2		
Calibration 1 K	M	3000	50 (10)		600	30		5,9	N	129
ionosphere absorption	S	22000			1000					79
ionosphere emission	S	12000			3000					101
atmosphere abs. 0.0016 dB	S	100			100			3		106
foreground	S	17000			3000			6		101
Jupiter 10^5J	F	1						4		2
Fourp beam var. (Gal Down)	M	2500	7	50	500	1.2	10			118
Blade beam var. (Gal Down)	M	3000	0.5	5	600	0.4	1			
Fourp beam var. (Gal Up)	M	150000	30	75	30000	5.9	15			118
Blade beam var. (Gal Up)	M	160000	15	75	32000	2.9	15			
Fourp beam var. (Gal Up/Down)	M	10000	10	20	2000	2.0	4			
Blade beam var. (Gal Up/Down)	M	7500	5	10	1500	1.0	2			154
horizon 7deg	M	2000	0.5	5	300	0.1	1	7		118

Table 1. EDGES-2 Error budget