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 May 8, 2017

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To: EDGES Group

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Subject: Sensitivity of the variation of the signature amplitude with GHA to systematics.

The effect of most systematics change substantially with GHA. For example, beam chromaticity increases by a large factor close to the transit while most other instrumental systematics, like an error in the estimate of the antenna or ground plane loss, have an effect that increases in proportion to the foreground strength. Observing the variation of signature amplitude with GHA provides a good test of the level of systematics present in the data.

Table 1 from memo 245 shows the signature amplitude for blocks of 4 hours of GHA

GHA	T at 75 MHz	Amp (K)	SNR
0	4532	0.45	5
4	3069	0.46	9
8	1640	0.44	13
12	1658	0.57	21
16	1995	0.59	11
20	3369	0.66	9

Table 1. using lowband1 data on the extended ground plane from 2016_251 to 2017_095. The parameters of the weighted least squares were

6 polynomial terms

Signature	center	78.5 MHz
	width	18.5 MHz
	$\tau =$	7
Frequency	start	65 MHz
	stop	95 MHz
Antenna beam	FEKO	$\epsilon=3.5, \sigma=2e-2$ S/m
Daily limit	on rms	300 mK

9 polynomial terms to smooth antenna S11

The number of polynomial terms was chosen to be large enough to obtain noise like residuals yet small enough to obtain significant SNR.

Following some sensitivity simulations reported later, it was discovered that smoothing the antenna S11 with 9 terms may not be optimum and 10 terms may be needed to avoid over smoothing the antenna S11. Table 2 shows

GHA	T at 78 MHz	Amp (K)	SNR
0	4533	0.49	6
4	3072	0.48	9
8	1640	0.47	13
12	1658	0.58	21
16	1995	0.61	12
20	3369	0.67	10

Table 2. 10 term smooth of antenna S11.

GHA	T at 78 MHz	Amp (K)	SNR
0	4532	0.42	5
4	3072	0.43	9
8	1640	0.39	11
12	1658	0.60	22
16	1995	0.54	12
20	3368	0.65	9

Table 3. Without beam correction.

GHA	T at 78 MHz	Amp (K)	SNR
0	4507	0.50	6
4	3052	0.49	9
8	1632	0.46	14
12	1650	0.59	22
16	1985	0.61	12
20	3350	0.69	10

Table 4. Without loss correction.

GHA	T at 78 MHz	Amp (K)	SNR
0	4535	0.42	5
4	3071	0.43	8
8	1641	0.43	12
12	1659	0.56	20
16	1997	0.58	11
20	3371	0.63	9

Table 5. + 1 dB to LNA S11

GHA	T at 78 MHz	Amp (K)	SNR
0	4532	0.44	5
4	3069	0.46	8
8	1640	0.44	13
12	1658	0.57	21
16	1995	0.58	12
20	3369	0.65	9

Table 6. + 100 ps to LNA S11

The result of increasing the number of polynomial terms from 9 to 10. The results are close to those in Table 1 but have slightly higher SNR and slightly less variation of signature amplitude with GHA. Tables 3, 4, 5, 6 and 7 show the results of no beam correction, no loss correction, a - 1 dB change to the LNA S11 and +100 ps to the LNA S11. These results show that the major systematics don't have a large influence on the signature amplitude when 6 polynomial terms are used to absorb these systematics.

Simulations of the effects of systematics on the signature amplitude for least squares solutions for the signature plus 4, 5 and 6 polynomial terms at GHA=0 and GHA=12 hours are given for lowband1 and lowband2 in Tables 7 and 8. It is noted that the effects of 1 dB and 100 ps changes in LNA S11 are larger for the lowband2 because it has a larger input reflection coefficient. The simulated effects with 6 terms are in reasonable agreement with the measured changes listed in Table 1 to 6.

6-terms		5-terms		4-terms		
0	12	0	12	0	12	Reference vs test
-0.04	0.02	0.13	-0.01	0.54	-0.07	Beam corr vs none
-0.03	-0.01	0.06	0.03	-0.04	-0.01	ref. vs + 1 dB to LNA S11
-0.01	-0.01	-0.01	-0.01	0.15	0.05	ref. vs +100 ps to LNA S11
-0.03	-0.01	0.02	0.01	0.01	0.02	ref. vs +0.1 dB to ant S11
0.04	0.01	-0.03	-0.01	-0.02	-0.01	Nfit 4= 9 vs nfit4=10
0.05	0.02	-0.12	-0.04	-0.12	-0.07	Loss corr vs none

Table 7. Simulated effects of systematics on the signature amplitude using the lowband2 receiver and antenna characteristics. The amplitude change 4 hour blocks at GHA=0 and GHA=12 hours are shown for 4, 5 and 6 polynomial terms.

6-terms		5-terms		4-terms		
0	12	0	12	0	12	Reference vs test
-0.03	-0.01	0.23	0.08	0.02	0.02	2017 cal vs 2016 cal
-0.04	0.02	0.20	-0.02	0.53	-0.06	Beam corr vs none
-0.16	-0.06	0.36	0.13	1.45	0.53	ref. vs + 1 dB to LNA S11
-0.07	-0.03	-0.18	-0.07	0.57	0.20	ref. vs + 100 ps to LNA S11
0.04	0.02	-0.03	-0.01	-0.27	-0.14	ref. vs 0.1 dB to ant S11
0.07	0.01	0.21	0.06	0.14	0.04	Nfti4=9 vs nfit 4=10
0.06	0.02	-0.20	-0.06	-0.20	-0.09	Loss corr vs none

Table 8. Simulations using lowband2 characteristics.