EDGES MEMO #185

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
HAYSTACK OBSERVATORY

WESTFORD, MASSACHUSETTS 01886

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Telephone: 781-981-5400
Fax: 781-981-0590

To: EDGES Group
From: Alan E.E. Rogers
Subject: More tests of the effects of a finite ground plane

The difficulty of understanding the low end of the low band discussed in memo #183 prompted a more careful examination of the effect of the 10 m × 10 m low band ground plane discussed in memo #184. Tests of the effect of the loss of the high band 5 m × 5 m with 2 × 5 m extensions on each side show that inclusion of the loss estimated using FEKO with the GF method are significant and are summarized as follows:

1] At GHA = 10 hrs 5 term fit rms is reduced from 25 m to 19 mK for 100 to 190 MHz.

2] At GHA = 0 hrs 5 term fit rms is reduced from 190 to 140 mK for 100 to 190 MHz.

3] The added beam effects due to the finite ground plane appear to have little if any effect at high band while the effects of loss are significant and need to be corrected.

Simulations of beam effects using 5 term fit from 100 to 190 MHz.

Up	Dn	Ground plane size	Note
3	1.0	Infinite	1
28	1.5	5 m × 5 m + 4 × 2 m × 5 m	2
91	17	5 m × 5 m	3
211	80	2.5 m × 2.5 m + 4 × 1 m × 2.5 m	4
217	75	2.5 m × 2.5 m	4

Table 1. Beam effects in mK for 5 term fits Galaxy Up and Down.

Notes: 1] Current model for high band

2] Simulated beam effects for improved high band model

3] Simulated beam effects for low band if multiplied by 5.6

4] Small ground plane showing factor of about 4 increase in beam effects for the factor of 2 decrease in size.

These simulations explain why additional beam effect due to the finite ground plane size are not significant for high band but are significant for the current 10 m × 10 m low band ground plane when the Galaxy up. For example low band data from 51 to 95 MHz for days 2015-286 to 2015-349 has 5-term rms reduced to 120 mK and 140 mK for GHA = 10 and GHA = 0 respectively. With infinite ground plane beam correction these 5-term rms residuals are increased to 190 and 1400 mK respectively.

Figure 1 shows the “Galaxy up” spectra for low band with 5 physical terms removed using the beam correction for the low band blade on an infinite ground plane. With 5-terms removed the beam correction has little effect on the residuals. The level of residuals expected for low band from Mozdzen et al. 2015 with 5-terms removed after multiplying the numbers in table 2 by 6 is about 40 mK. The residual of the average in Figure 1 is 1400 mK. This is reduced to 140 mK by using the beam correction from the FEKO GF simulation assuming a dielectric constant of 3.5. While 140 mK is still higher than expected the factor of 10 reduction suggests than the additional beam chromaticity is the primary reason for the high residuals at the low band. The reduction of the residuals with the “Galaxy down” at GHA = 10 hours while only a factor of about 1.6 suggests that a fraction of the systematic shown in Figure 3 is the result of beam effects. A tentative conclusion is that beam effects will have to be accurately estimated in order to use “Galaxy up” data to further explore and correct the sources systematic trends evident in the average spectrum shown in Figure 3. The large reduction in the rms residual shown in Figure 2 is dependent on the number polynomial terms used to smooth frequency dependence of the beam. 8 terms gave the best result but this could be fortuitous as errors in the modeling could be cancelling other systematic effects. Tests of the effects of mesh size and comparison with other EM modeling software are needed.

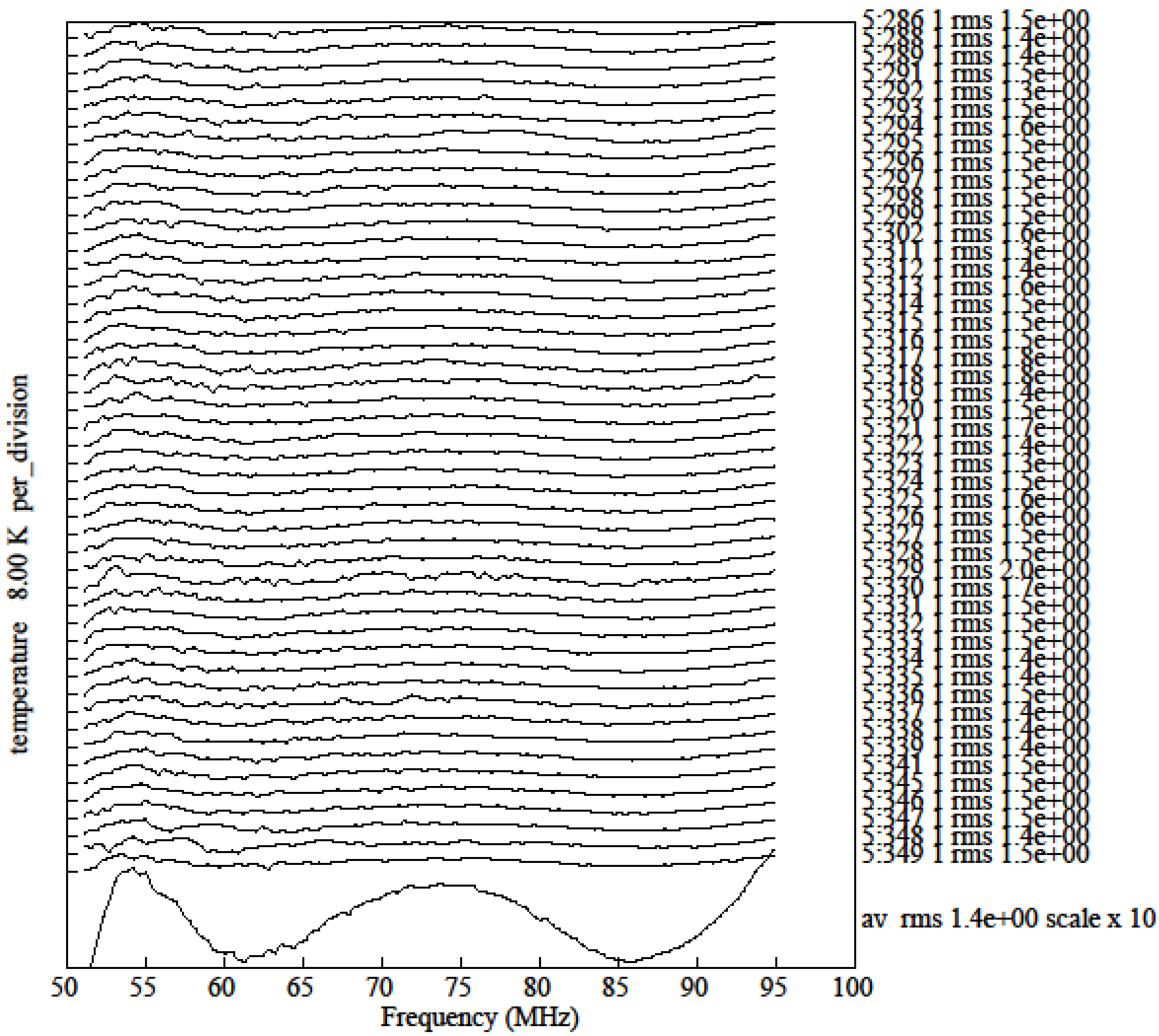

Figure 1. Low band spectra residuals at GHA = 0 with 5 terms removed and corrected with beam derived from blade antenna on infinite ground plane.

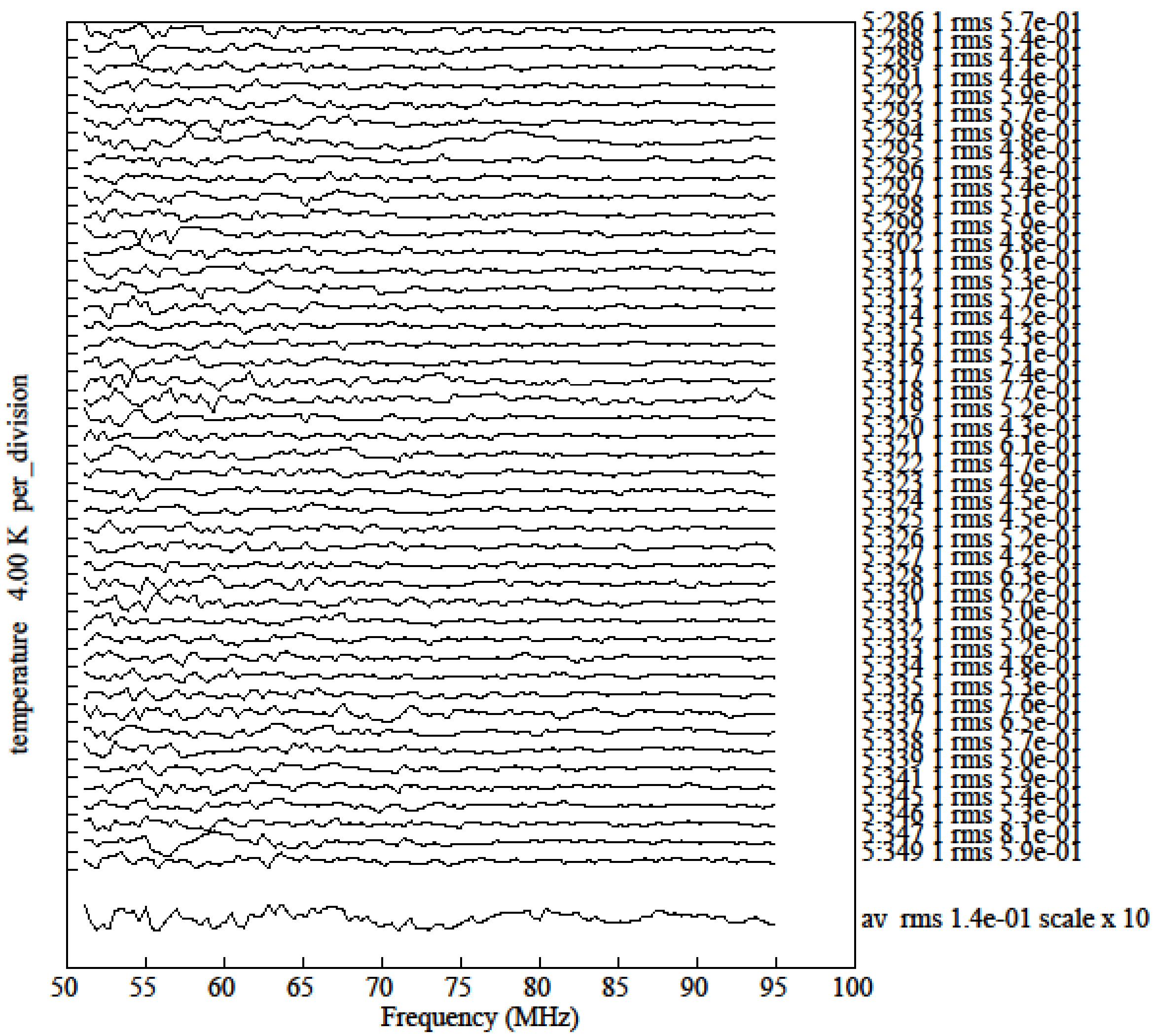

Figure 2. Low band spectra residuals at GHA = 0 with 5-terms removed and corrected with GF beam.

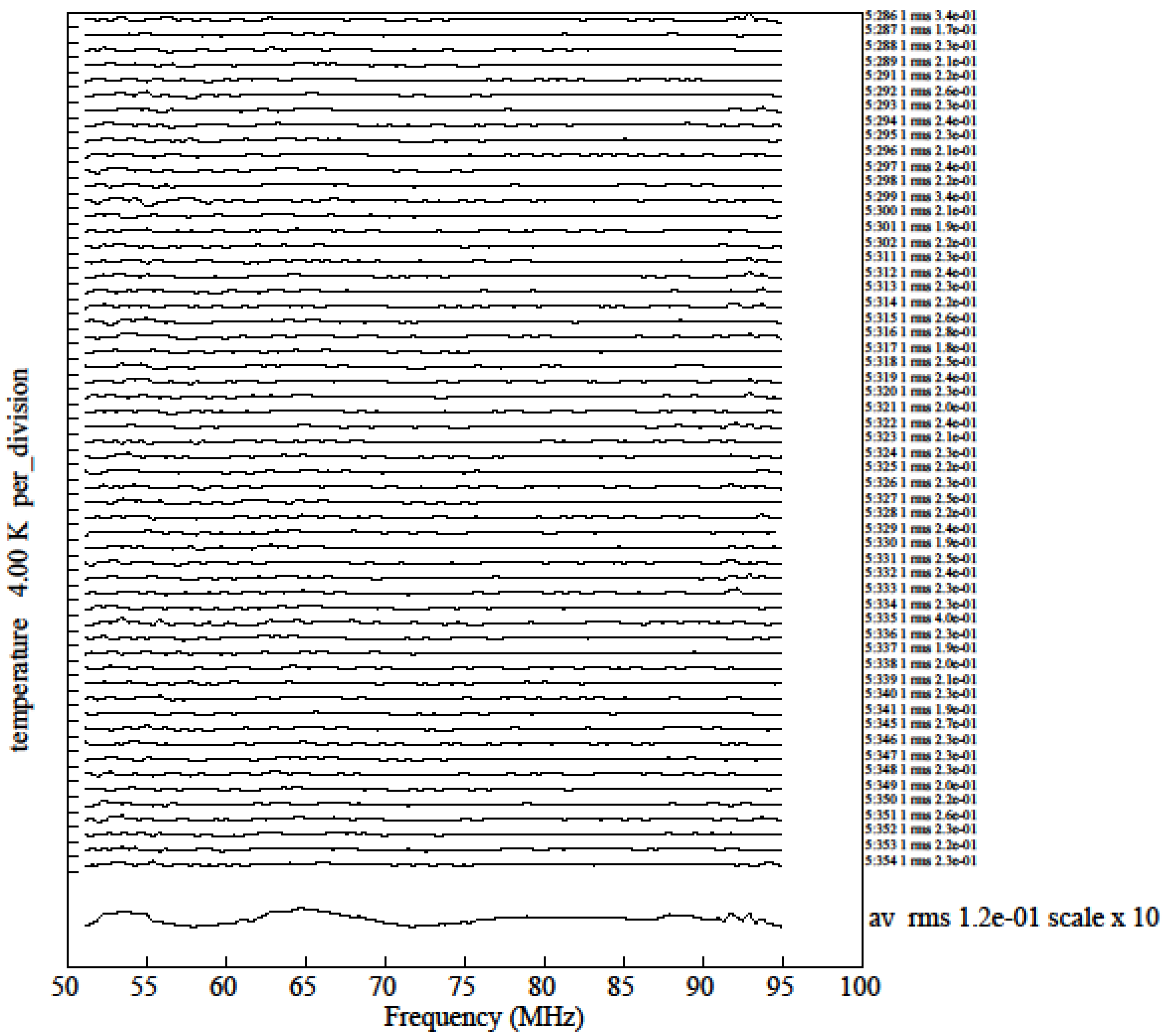

Figure 3. Low band residuals at GHA = 10 with 5-terms removed and corrected with GF beam.