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To: EDGES Group

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Subject: Effects of different ground plane models on low band results

The effect of the smaller ground plane for low band has been discussed in memos 184 through 190. Memo 192 shows that the beam chromaticity and ground loss are probably the largest source of systematic error in the low band data. The effect of reflections from the electronics hut which is 50 m from the low band antenna is estimated in memo 194 but so far there is no definite evidence of the effect of the hut in the data.

In this memo the ability to evaluate FEKO models of the blade antenna are examined. The following tests for best model are tried:

1] Compare beta vs LST with curve derived from 45 and 408 MHz sky maps for different FEKO models
2] Compare rms residuals averaged over LST of beam corrected data for different FEKO models

Figure 1 shows the spectral index derived from the low band data using only nighttime data from 2015_284 to 2016_129. The beam correction was applied using the FEKO model of the blade antenna on an infinite ground plane. The result is in poor agreement with the high band result and the index from 408 and 45 MHz maps shown in memo 200.

The spectral index shown in Figures 2 and 3 use FEKO models for the finite ground plane assuming a ground dielectric of 3.5. The ground plane conductivity was taken as 1e-2 and 5e-2. The results is a spectral index in relatively good agreement with the high band result and that from the sky maps. However a more sensitive comparison of small changes of the FEKO model is needed. One possibility is to compare the rms residuals to a 5 term physical term fit over 51 to 97 MHz for the full range of LST. Table 1 shows the results for an average rms using the full range of LST in steps of 2 hours.

Beam correction	Dielectric	Conductivity (s/m)	rms (mK)	
None	-	-	441	0
Blade9_hgt52_inf	-	-	494	0
Blad11_3.5_1e-2	3.5	1e-2	181	0
Blade11_3.5_5e-2	3.5	5e-2	213	0
Blade10_gfb_3.5_1e-2	3.5	1e-2	197	0
Blade10_gfb_2.5_3e-2	2.5	3e-2	166	0
Blade10_gfb_3.0_2e-2	3.0	2e-2	169	0
Blade9_gf_4.5	4.5	1e-3	283	0
Blade10_gfb_3.5_3e-2	3.5	3e-2	161	0
Blade10_gfb_3.5_3e-2	3.5	3e-2	154	1
Blade10_gfb_3.5_3e-2	3.5	3e-2	264	5
Blade10_gfb_2.5_3e-2	2.5	3e-2	169	1
Blade10_gfb_3.5_3e-2	3.5	3e-2	189	1

Table 1. Average rms residuals for different blade antenna beam models based on the finite ground plane on soil with different values of dielectric and conductivity. The last column is the height of the ground plane off the ground cm.

While beam correction based on an infinite ground plane results in values of spectral index are not unreasonable the average rms of the 5 term fit in Table 1 is made a little worse than without beam correction. This is because the beam chromaticity has more fine scale structure produced by the finite ground plane. The table shows that the lowest rms is for a dielectric constant of about 3 or lower. Models with the ground plane off the ground by about 1 cm fit well probably because the effect of a gap between the ground plane and the ground has the effect of a lower dielectric constant. A gap might explain why the best dielectric constant is a little lower than the lowest measured dielectric of 3.7 reported by Sutinjo et al. 2015.

The last entry in table 1 is for the model which gives the lowest rms rotated from an azimuth of -6° to 0° showing that this model gives the best result for the azimuth estimated from the google map showing the EDGES deployment. A search for the azimuth for lowest average rms gave an rms of 151 mK at -7°.

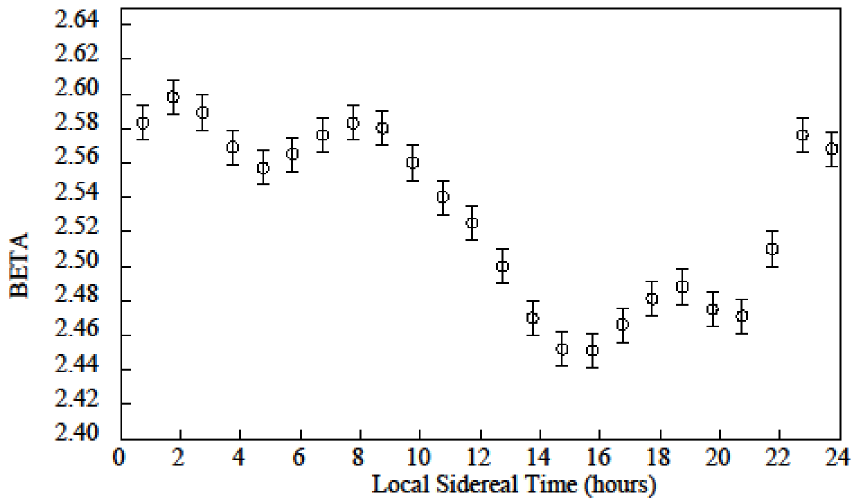

Figure 1. Infinite ground plane

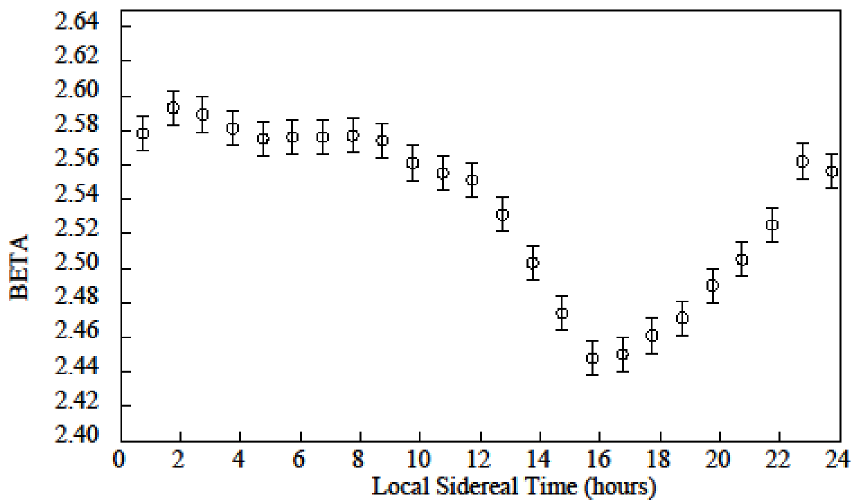

Figure 2. FEKO model with $\varepsilon = 3.5 \quad \sigma = 1e - 2$

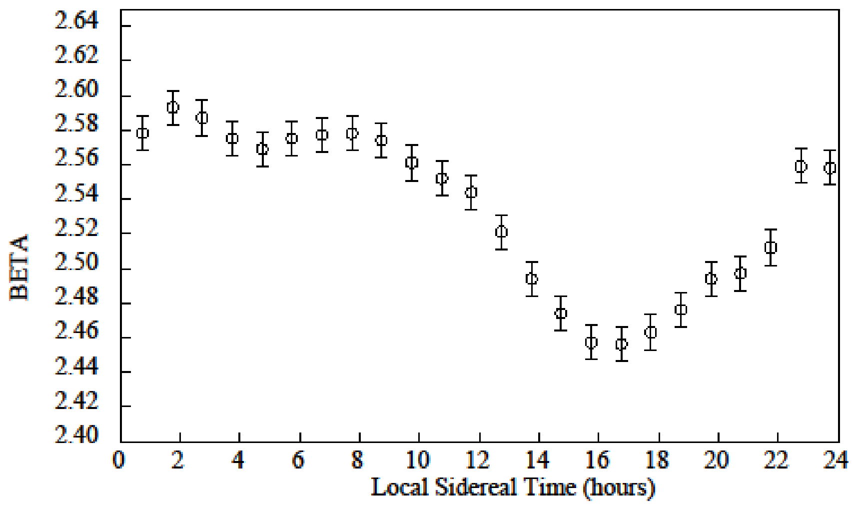

Figure 3. FEKO model with $\varepsilon = 3.5$ $\sigma = 5e - 2$