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To: EDGES group
From: Alan E.E. Rogers
Subject: Simulations of adding rods to broaden the bandwidth of the EDGES-3 antenna

Simulations of ways to obtain a version of the EDGES-3 antenna to cover 40 – 150 MHz are made starting with the current design and adding rods to complement the study of adding extended cover plates in memo 409. After experimenting with adding rods in various ways it was found that the geometry shown in Figure 1 gave the best results with the criteria that the beam chromaticity should not be significantly increased by the rods compared with the beam chromaticity of the antenna with the rods removed. Tests were made of adding a single rod and two rods per box and the best results were obtained using two rods per box oriented to make the antenna have a shape approaching that of a bowtie dipole.

Current EDGES-3 design

Box length at center 74.3 cm

Box width 95.3 cm

Box height 15.11 cm

Box length reduction at sides 6.6 cm

Pipe diameter 2.54 cm

Pipe separation 2.54 cm

Pipe length 34 cm increased to 50 cm for broadband

Height of bottom of box above ground plane 88 cm

Gap between boxes 3.6 cm increased to 6.0 cm

rod length 42.4 cm rod diam 1.0 cm angle of rods 135 degrees to box sides

Table 1. EDGES-3 dimensions with changes for broadband version

Figure 2 shows the antenna S11 from 40 to 150 MHz for the FEKO simulation with the rods and changes listed in table 1 on an infinite PEC ground plane.

The average rms for 1 hour blocks over all GHA at the MRO with 5-physical terms removed are given in Table 2. The approximate frequency range of antenna S11 less than -10 dB is given in column 4. The Haslam 408 MHz sky map scaled using a spectral index of -2.5 was used.

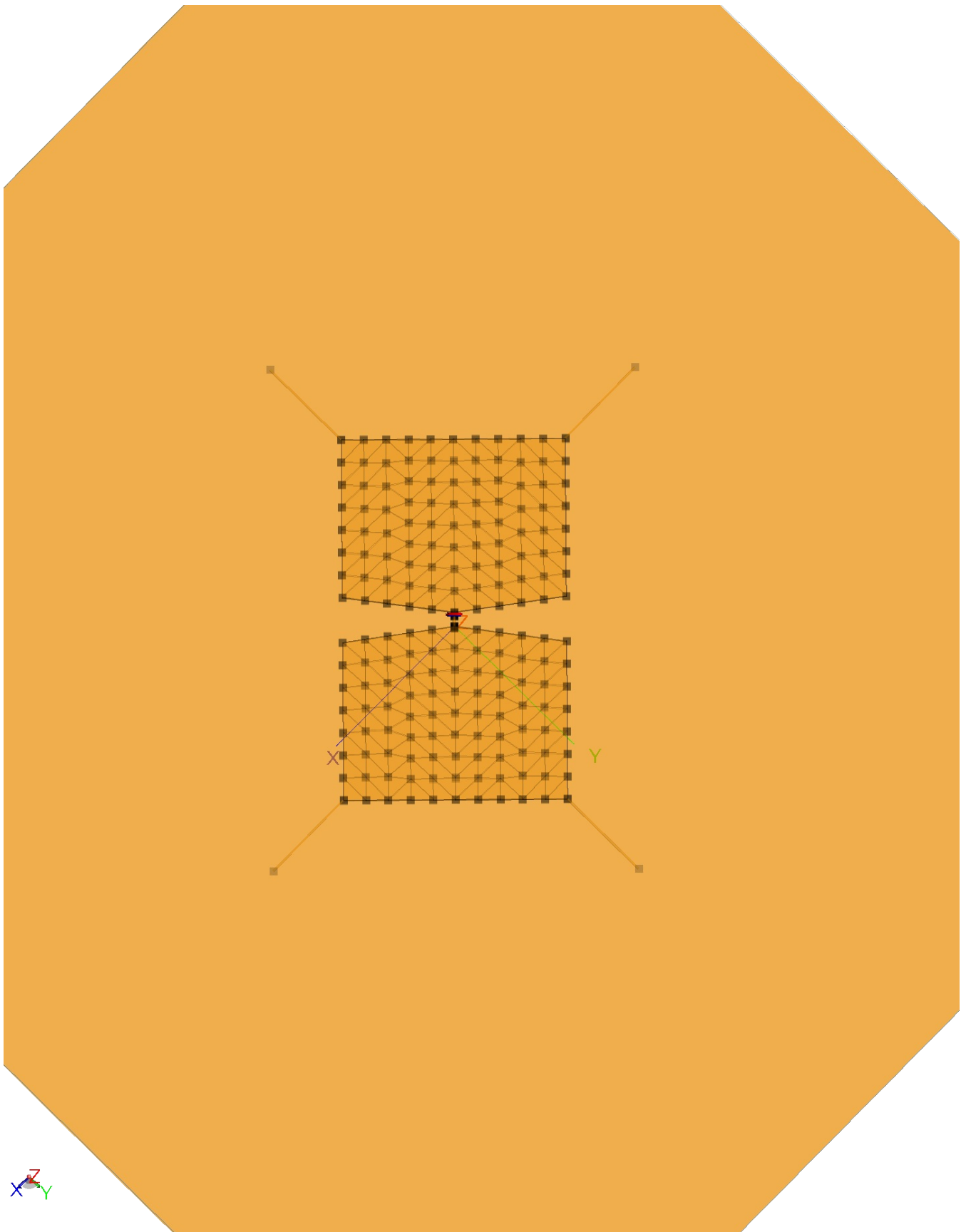
antenna	Ground plane	Freq range MHz	S11 range MHz	av. rms mK	comments
lowband	PEC	51 - 100	50 - 110	161	
midband	PEC	60 - 120	60 - 120	80	
EDGES-3	PEC	52 - 100	55 - 120	75	25 mK at Devon
EDGES-3	50x25m wire grid	52 - 100			137mK at Devon
EDGES-3	48x48m mesh				58mK at Devon
broadband	PEC	50 - 100	50 - 120	97	
broadband	PEC	60 -120	50 - 120	89	

broadband	PEC	60 -120	60 - 120	70	without rods
broadband	PEC	50 - 100	60 - 120	82	without rods
broadband	50x25m wire grid	52 - 100			145mK at Devon
broadband	48x48m mesh	52 - 100			61 mK at Devon

Table 2. Beam chromaticity of the broadband antenna compared with lowband, midband and EDGES-3

These simulations show that the broadband antenna on a PEC ground plane with added rods has similar beam chromaticity to the lowband, midband EDGES-2 and standard EDGES-3 antennas when covering the same frequency range. In practice the frequency range for the 21-cm absorption will be limited to 50 - 120 MHz but extending down to 40 MHz and above 120 MHz will be useful for evaluation of Sporadic E and other effects of the ionosphere along with other low frequency science like the study of recombination lines.

The average of the rms values for the Devon Island site, which are given in the last column of table 2, are about a factor of three smaller because the average at the MRO is dominated by the approximately three fold increase in the sky temperature at GHA = 0.



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Figure 1. View of rods the 4 rods electrically connected to the outer corners of the top of the boxes.

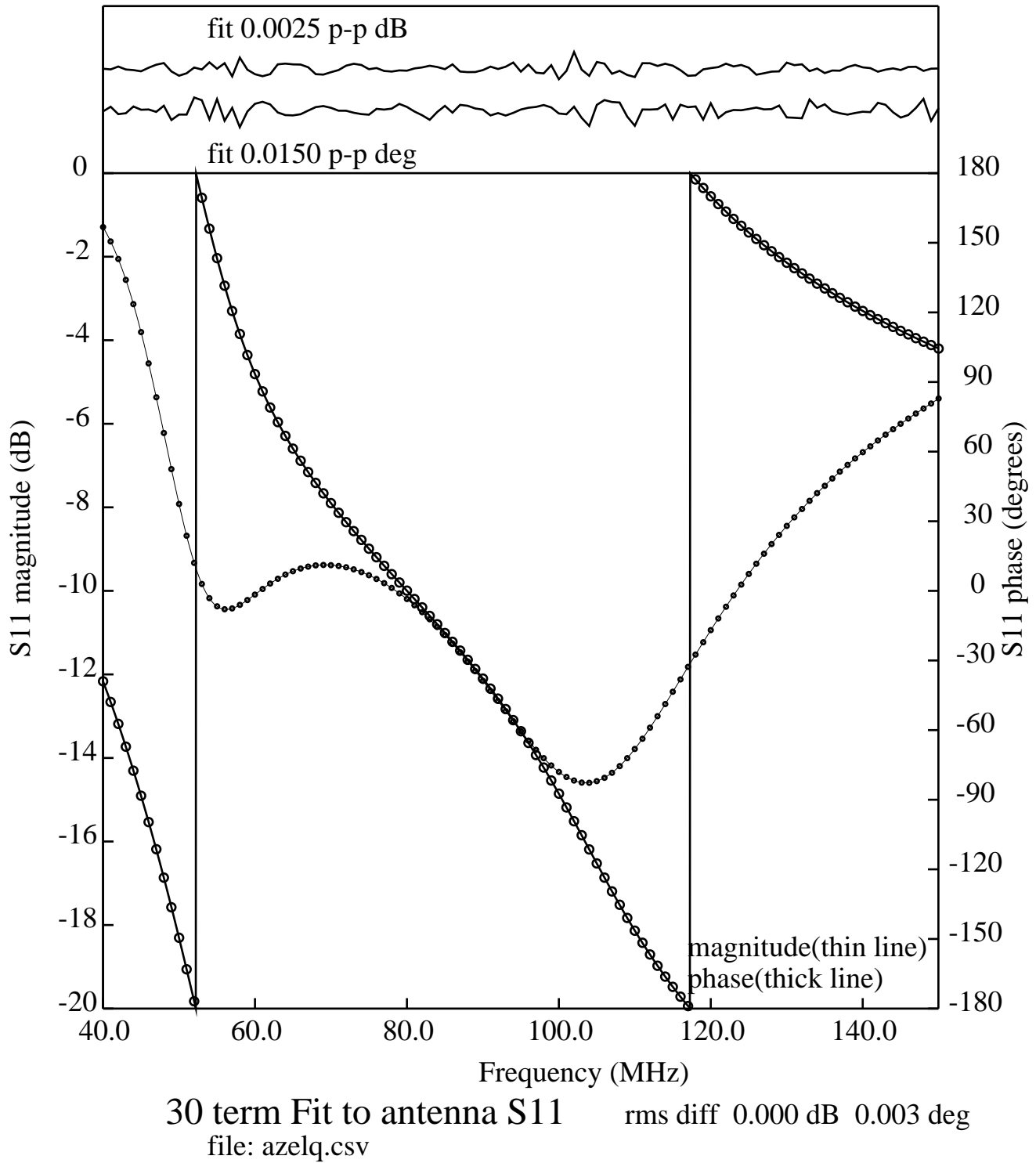


Figure 2. S11 of broadband antenna on PEC ground plane from FEKO model in Figure 1.