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To: EDGES group
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Subject: Simulations of extending antenna box covers for improved S11 of EDGES-3

The EDGES-3 optimization in the current design described in memo 313 was based on obtaining a low S11 in the frequency range 60 110 MHz with low beam chromaticity up to 120 MHz. Unfortunately the greater S11 accuracy required at the low end of the band due to the very high sky noise at the MRO especially when the Galactic center is up at low values of GHA was not adequately considered to obtain performance as good as EDGES-2 lowband at frequencies below 60 MHz.

An improvement in S11 can be obtained by replacing the box top covers in the current design with covers that extend an additional 6 cm to increase the cover length from 73.4 to 79.4 cm. Additional changes are an increase in height of the antenna, a shortening of the pipes and decrease in the gap. These are changes which could be made without a new design of the antenna boxes.

Current EDGES-3 design	current	Changes to improve S11
Box length at center	74.3 cm	Cover length at center 79.3 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	Reduce to 30 cm
Height of bottom of box above ground plane	88 cm	Increase to 107.63 cm
Gap between boxes	3.6 cm	Decrease to 3.0 cm

Table 1. Changes to EDGES-3 dimensions for improved antenna S11

The S11 of the design for improved s11 on a PEC ground plane, compared the the current design shown in Figure 1 of memo 313 is shown in Figure 1. I have also tried maintaining a fixed height of 88 cm to avoid the need for a higher fiberglass frame but have been unable to make a significant improvement over the current design.

A good measure of performance or "figure of merit" is to simulate the effect of an error in LNA s11 delay and magnitude as discussed in memo 368. Table 1 shows the results azimuth of 250 degrees at the MRO averaged all GHA. The table shows that the lowband is less sensitive to LNA error than the current EDGES-3 for a frequency coverage 55-99 MHz. This could be corrected with the changes listed in Table 1 judging by the fairly similar values of SNR and rms2 which are the rms residuals following the 5-physical term fit.

The values of rms2 for all entries in Table 2 all drop below 10 mK for all three systems for a frequency range of 60-99 MHz. Midband is also very sensitive to S11 errors and was initially limited to frequencies from 65-120 MHz and owing to some cable ripple as described in memo 276. Later a good

result was obtained in memo 281 and was combined with lowband to obtain a frequency range of 51-120 MHz as described in memo 286.

antenna system	change	center	snr	amp	width	rms1	rms2
lowband	lna 100 ps	77.7	87	0.59	18.8	0.0852	0.0103
	lna 0.5 dB	77.7	96	0.59	18.8	0.0846	0.0093
	ant 100 ps	77.7	55	0.57	18.5	0.0849	0.0160
	ant 0.05	77.7	80	0.61	18.7	0.0879	0.0115
EDGES-3	lna 100 ps	78.1	18	0.28	19.9	0.0415	0.0215
	lna 0.5 dB	77.7	40	0.36	20.0	0.0463	0.0118
	ant 100 ps	78.1	18	0.28	19.9	0.0400	0.0201
	ant 0.05 dB	77.7	38	0.77	18.5	0.1177	0.0313
EDGES-3 with cover	lna 100 ps	78.1	37	0.36	19.4	0.0492	0.0137
	lna 0.5 dB	77.7	84	0.42	19.5	0.0559	0.0070
	ant 100 ps	78.1	43	0.36	19.4	0.0498	0.0120
	ant 0.05 dB	77.7	50	0.69	18.6	0.1022	0.0213

Table 2. Effects of 100 ps error in LNA S11 on Nature feature search using 55-99 MHz 5-physical terms. Units are MHz and degree K. For lowband and EDGES-3 the calibration and antenna s11 are from data. FEKO simulation is used for changes listed in table 1.

In summary EDGES-3 should be almost as good as lowband. A marginal improvement could be made with cover plates to lengthen the dipole by 12 cm.
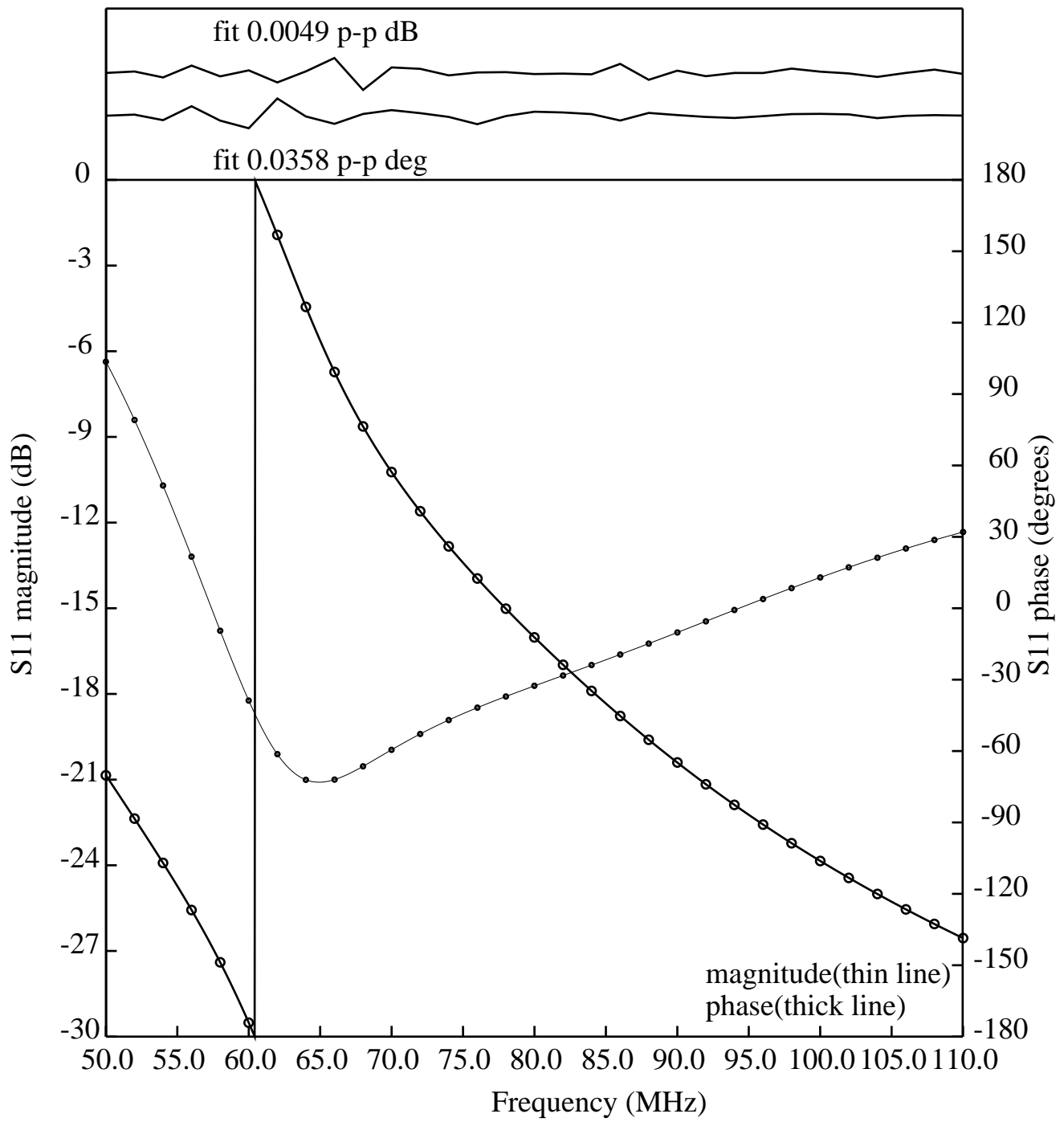
Figure 1. FEKO simulation of antenna S11 with changes listed in table 1.