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To: EDGES Group

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Subject: Estimate of ground plane mesh and antenna loss

1] Mesh Shielding Loss

Estimates for the shielding and resistive loss of the welded wire mesh have been made to access the effect of using a 10×10 cm mesh on the extension of an existing 30×30 m perforated ground plane at the MRO. In order to obtain a FEKO solution in a few days for a single frequency first a single run was made for a 10×10 cm mesh of 20×20 m then several runs were made with 20×20 cm mesh used to extend a solid inner ground plane of various sizes. In each case the loss was made for EDGES-3 at 100 MHz. The results are given in Table 1.

Mesh cm	Mesh size m	Solid center size m	Loss %	Corrected
-	-	20×20	0.211	-
40	20×20	-	15.23	15.02
20	20×20	-	3.68	3.47
10	20×20	-	0.665	0.454
20	20×20	2×2	2.316	2.105
20	20×20	4×4	1.14	0.93
20	20×20	8×8	0.35	0.14
20	20×20	16×16	0.22	0.01

Table 1 FEKO simulations of mesh loss at 100 MHz.

These results show that for a 20×20 m square ground plane a mesh with 10 cm wire spacing would increase the loss from 0.211% for a solid 20×20 m ground plane to 0.665% from which a 0.454 % loss is inferred for the shielding. The table shows that a factor of 2 change in wire spacing would only contribute an additional loss of about 0.454/8 ~ 0.06% loss to the ground plane and an even smaller additional loss by a factor of 2 if the inner 4×4 m is solid. The table also shows that if the inner 16×16 m is solid an added loss of only about 0.01% would arise if the outer mesh had a 20 cm wire spacing and a negligible increase if the outer mesh had 10 cm wire spacing compared with matching the inner mesh with 5 cm wire spacing.

2] Mesh Resistive Loss

FEKO was also used to simulate the resistive loss of the mesh. A resistive loss of 0.008 and 0.016% were obtained for 5 and 10 cm wire spacing respectively assuming a 4 mm wire diameter with 1e6 S/m conductivity. The loss estimates were obtained directly from FEKO using the “SK” card and the “WG” card for a 10×10 m mesh under the antenna. It found that this is very small and has a smooth frequency structure.

3] Antenna Resistive Loss

The antenna resistive loss consists of the following components

a) Loss in the aluminum box panels

b) Loss in the connection between panels
c) Loss in the brass tubes which act as a shorted balanced parallel conductor transmission line.

At 100 MHz the loss for the box panels is 0.004% and the connection loss is also very small.

The loss in the brass tubes is the largest at about 0.01% and rises fairly sharply below 55 MHz. The total antenna resistive loss is shown in Figure 1. Figure 2 in units of kelvin using a 1 term fit to

$$T_{loss} = 300(f/150)^{-2.55}(1 - loss) + 300\ loss$$

and with the residuals to a 5-term fit in Figure 3. The effects of the loss in the pipes is large enough even over 60 – 120 MHz shown in Figure 4 that corrections should be made to the data.

The resistive loss from FEKO is obtained from one minus the efficiency, which is the fraction of the radiated power, times one minus the reflected power from the antenna S11. Conductivity values of 2e7 and 3.5e7 S/m were assumed for the brass tubes and aluminum parts respectively.

		rms residual 1-term mK		rms residual 5-terms mK	
Antenna	Loss at 75 MHz	50-130	60-120	50-130	60-120
EDGES-3	0.0275%	400	48	61	6
midband	0.0237%	474	108	22	9
lowband	0.0244%	65	15	7	7

Table 2. Resistive antenna loss

Table 2 shows the results are similar for EDGES-3 and midband while lowband has less frequency structure below in the loss below 60 MHz.

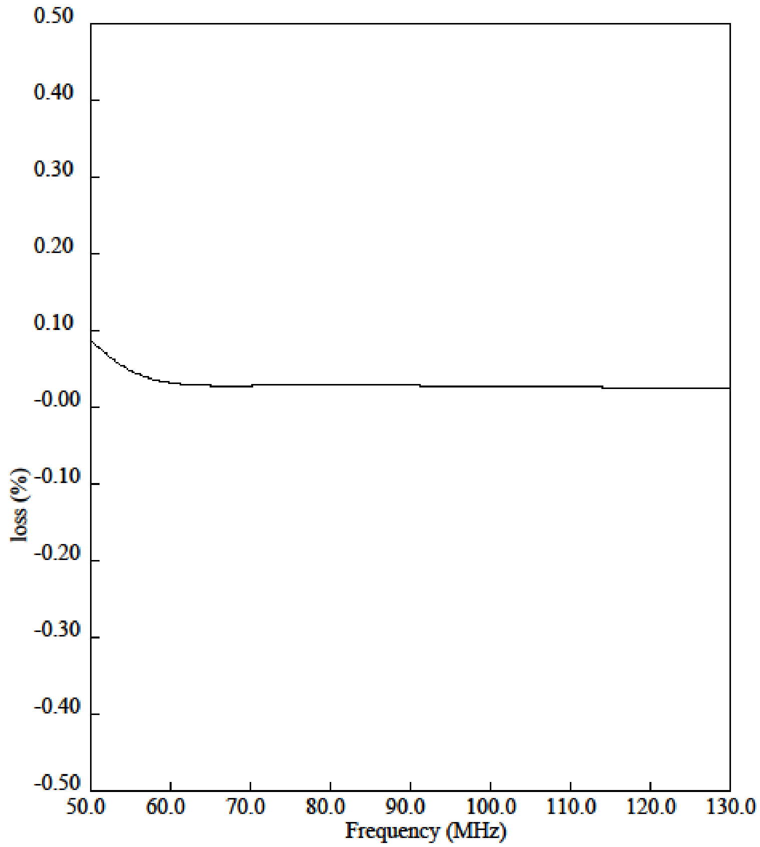

Figure 1. Total resistive loss in the EDGES-3

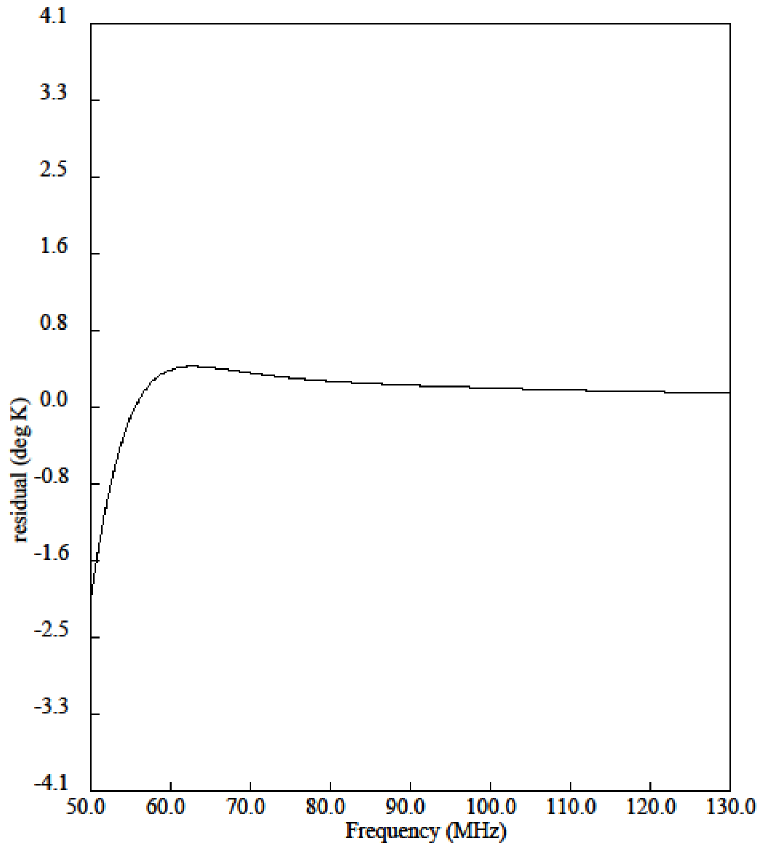

Figure 2. Loss contribution to sky temperature with 1-term removed.

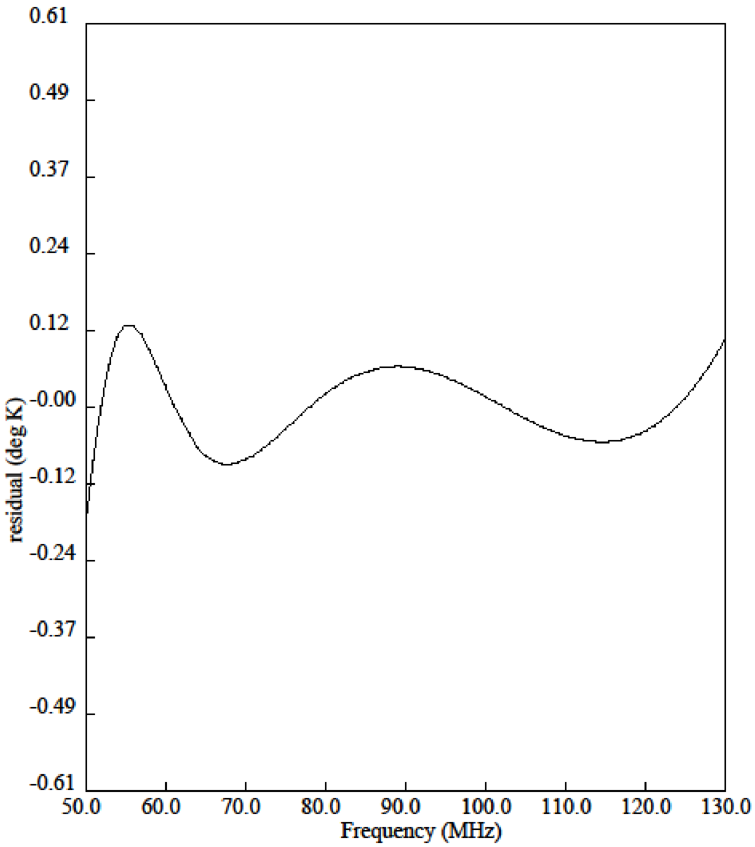

Figure 3. Loss contribution to sky temperature with 5-terms removed.

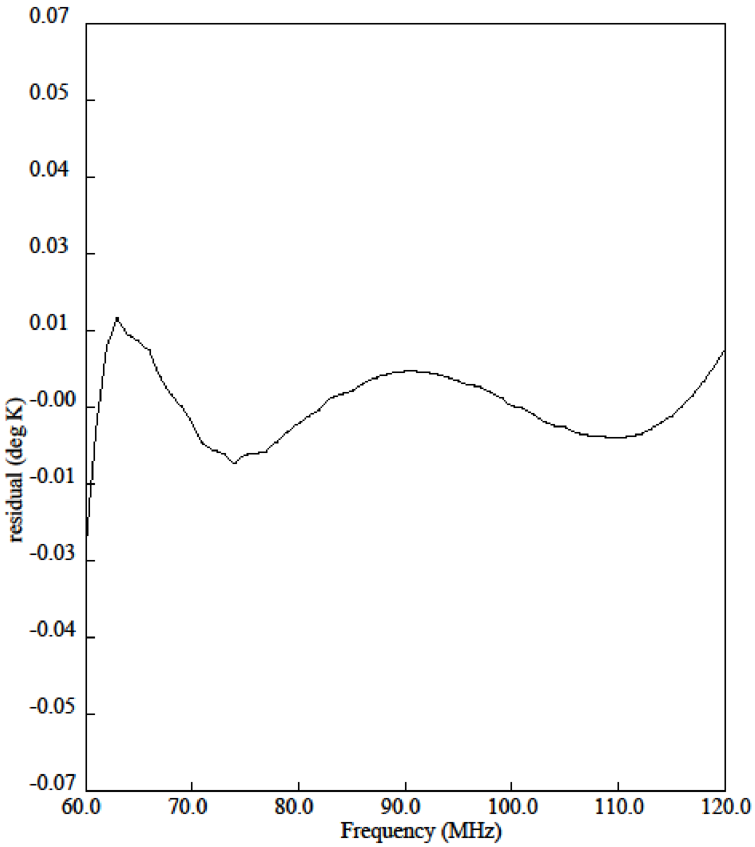

Figure 4. Residuals to 5-terms removed over a smaller frequency range.