EDGES MEMO #283

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To: EDGES Group

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Subject: Simulations of resonances in lowband ground plane due to poor connectivity.

It has been suggested that the lowband absorption signature reported in Nature (Bowman et al. 2018) could be influenced by loss of connectivity between the inner 2.2×2.2 m solid ground plane and the outer mesh of the ground plane.

While concern about potential resonances due to poor connections has been studied in memos 196 and 208 this memo looks at the effects of a layered soil under the ground plane which might enhance the effects of poor or missing connections.

Since the parameter space of potential poor connectivity is large in combination with the range of soil parameters a few short tests resulted in the following:

1. No resonances with 50-100 MHz with soil layer depth less than about 30 cm.
2. Significant resonance only with discontinuity between inner and outer panels.
3. Resonant frequency depends mainly on the soil depth.
4. Resonance is seen in both beam chromaticity and ground loss.
5. No resonances with uniform soil below ground plane.
6. Strength of resonance depends on the width of the gap between the inner and outer – but the frequency does not.
7. Strength of resonance also depends on the size of the inner ground plane – getting stronger for smaller inner ground plane.
8. Resonance strength drops sharply as connections are made between inner and outer. 4, 8 and 16 wire connections uniformly spaced around the inner ground plane have been tested. 16 wire connections give chromaticity close to a continuous connection all the way around.
9. 16 wire connections (i.e. about 55 cm between connections) gives a slightly different but smooth loss vs frequency.
10. The frequency of the resonance changes from 75 to 80 MHz as the inner dimensions are changed from 2.2×2.2 to 1.98×1.98 m.
11. The frequency of the resonance changes from 75 to 68 MHz with change of sol dielectric from 3.5 to 4.5.
12. The resonance is present with only the 2.2×2.2 m center plate and shows that a small ground needs an absorber to shield the reflection from bedrock.

To explore the resonance seen with soil depth greater than 30 cm the following cases were examined

Case	gap (cm)	# connections
1	1	0
2	1	4
3	1	8
4	1	16
5	0	continuous

Table 1.

In all 5 cases the dry soil layer had a thickness of 50 cm, a dielectric of 3.5 and conductivity of $1e^{-3}$ S/m. The conductive rock layer below was assumed to extend to infinite depth with a dielectric of 14 and conductivity of $1e^{-1}$ S/m. The inner panel was a fixed 2.2×2.2 m and the outer panel covered an outer dimension of 6.6×6.6 m. In case 1 the gap of 1 cm was free of any connections while in case 5 the gap was closed to provide a continuous solid ground plane of 6.6×6.6 m. In cases 2 to 4 the gap was filled with 4, 8 and 16 0.2" diameter wire connections between the inner and outer panels. A test using wire mesh outer panels was tried but required an excessive computation so only wires between panels were used.

Figure 1 shows the simulated beam chromaticity with 5-polynomial terms removed. The top 5 plots for GHA=12 hours and the bottom for "Galaxy up" with GHA=0 hours. Figure 2 shows the loss for the 5 cases calculated from the integrated beam over the upper hemisphere. Both the chromaticity rand the loss show that the effects of the resonance are small, if present, are smooth with 16 wires. The lowband ground planes have 176 wires connecting the inner panels to the mesh so it seems unlikely that a few bad connections could be a problem.

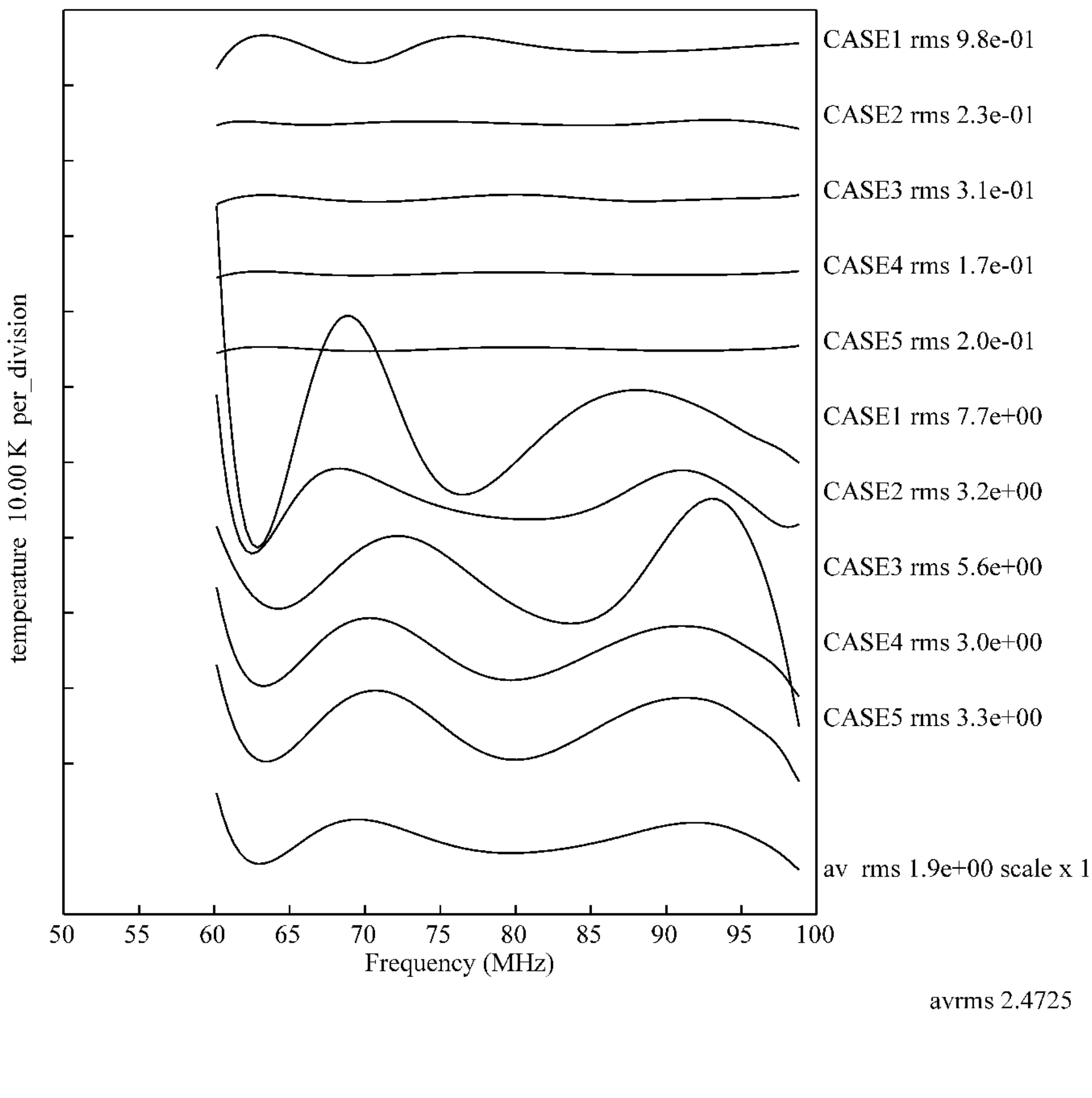

Figure 1. Beam chromaticity residuals with 5-terms removed. Top 5 curves for GHA=12 and bottom 5 for GHA=0.

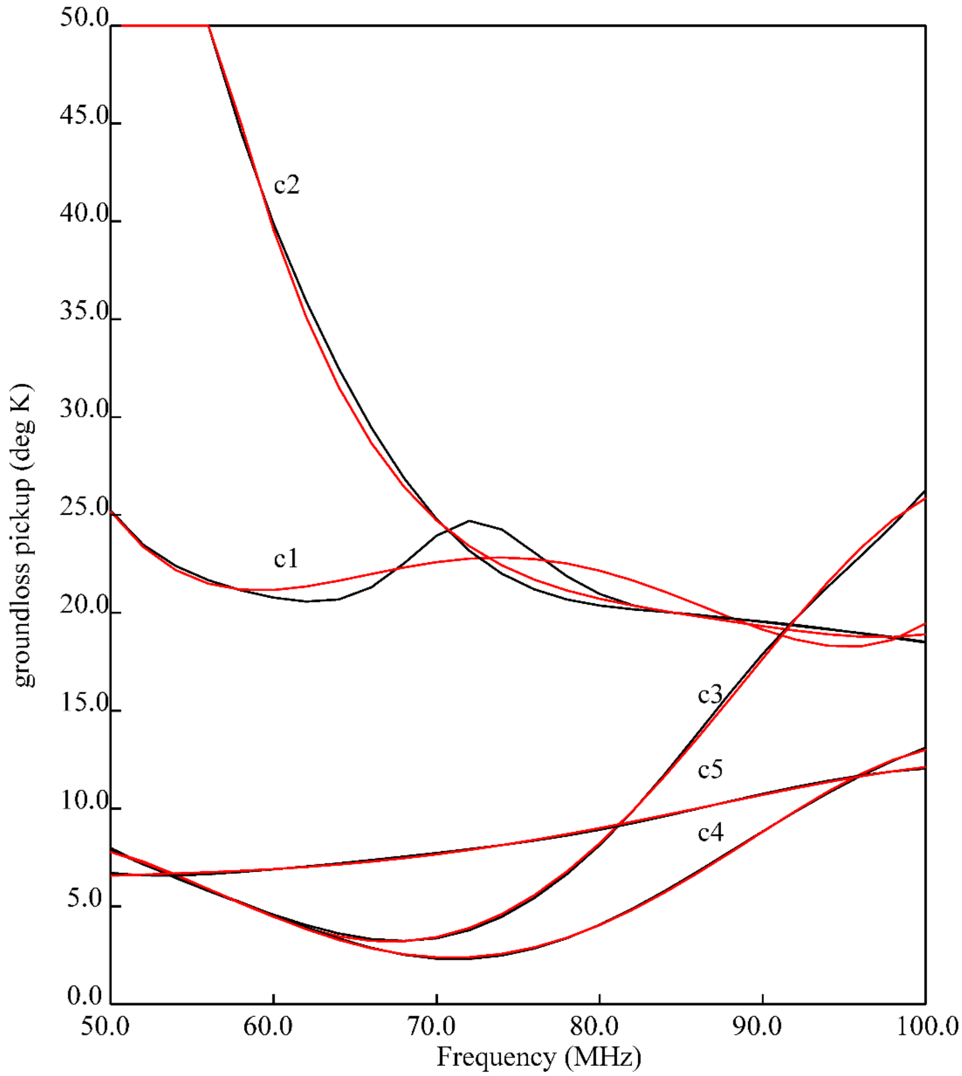

Figure 2. Antenna loss due to ground plane for cases 1 to 5 labeled C1 to C5. Red curves are the best fit with 5-terms and the differences between the black and red curves are the residuals to the 5-term fit.