Investigating Ground planes for EDGES Low
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This report analyses the different ground planes (in shape and size) below the EDGES blade antenna and summarises its effect on the beam chromaticity. For each case, I plot the beam derivative plot and the residues to a 5 term loglog fit. In most cases, in the residue plots, I show the curves corresponding to either the 10m X 10m or extended GP for comparison. All the simulations are done with EDGES lowband panels and soil parameters: permittivity=3.5; conductivity = 0.02S/m.

This table summarizes the average RMS of the residues on fitting a 5 term loglog foreground model to the simulated spectra from each case. The fit was done on 2 hr GHA binned spectra. The residues were averaged and the rms was calculated for this averaged residues.

<table>
<thead>
<tr>
<th>Size/ Configuration</th>
<th>Avg RMS (LogLog) (52-98MHz)</th>
<th>Area(m²)</th>
<th>Freq Res (MHz)</th>
<th>Avg RMS (LinLog) (52-98MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10x10m (old ground plane)</td>
<td>280 mK</td>
<td>100</td>
<td>2</td>
<td>220 mK</td>
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<tr>
<td>10x10m (old ground plane)</td>
<td>340 mK</td>
<td>100</td>
<td>1</td>
<td>330 mK</td>
</tr>
<tr>
<td>30x30m perforated</td>
<td>60 mK</td>
<td>600</td>
<td>2</td>
<td>40 mK</td>
</tr>
<tr>
<td>30x30m perforated</td>
<td>70 mK</td>
<td>600</td>
<td>1</td>
<td>40 mK</td>
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<tr>
<td>Circle 4.9m radius</td>
<td>370 mK</td>
<td>75.43</td>
<td>2</td>
<td>300 mK</td>
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<td>Circle 9.8m radius</td>
<td>170 mK</td>
<td>301</td>
<td>2</td>
<td>180 mK</td>
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<tr>
<td>Circle 15m radius</td>
<td>70 mK</td>
<td>706</td>
<td>2</td>
<td>80 mK</td>
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<td>Hexagon 5m sides</td>
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<td>130 mK</td>
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<td>200mK</td>
</tr>
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<td>50mK</td>
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<td>Hexagon 17m sides</td>
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<td>40mK</td>
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<td>Square 50x50m</td>
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<td>2500</td>
<td>2</td>
<td>40mK</td>
</tr>
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<td>600</td>
<td>1</td>
<td>30mK</td>
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<tr>
<td>Perforated 40m X 40m; (6/side)</td>
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<td>1200</td>
<td>1</td>
<td>30mK</td>
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<td>Perforated 49.2 X 49.2m; (3/side)</td>
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<td>1</td>
<td>40 mK</td>
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<td></td>
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<tr>
<td>Staggered 7 by 7</td>
<td>110</td>
<td>312.5</td>
<td>1</td>
<td>60 mK</td>
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<td>425</td>
<td>1</td>
<td>30 mK</td>
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<tr>
<td>Staggered 7 by 9</td>
<td>90</td>
<td>562.5</td>
<td>1</td>
<td>60 mK</td>
</tr>
</tbody>
</table>
1.) Simple Circle - 4.9 m radius (area<10m X 10m GP)

Fig1: Gain derivative Vs Frequency for a circular ground plane with radius of 4.9m. (Right): The Gain vs derivative plot for the 10m X 10m GP for comparison.

Fig2: Residues to a 5 term loglog foreground model Vs Frequency for the 10m X 10m GP and a 4.9m radius circular GP. The RMS of the averaged residues of the circular one is larger. The circular GP covers less area compared to the 10m X 10m GP.
2.) Simple Circle - 9.8 m radius (area <extended GP)

Fig3: Gain derivative Vs Frequency for a circular ground plane with radius 9.8m. (Right): The Gain vs derivative plot for the extended GP.

Fig4: Residues to a 5 term loglog foreground model Vs Frequency for the extended GP and a 9.8m radius circular GP. The RMS of the averaged residues is 3 times higher for the circular GP. The circular GP covers roughly half the area as the extended GP.
3.) Simple Circle - 15 m radius (area~extended ground plane)

Fig5: (Left) Gain derivative Vs Frequency for a circular ground plane. (Right): The Gain vs derivative plot for the extended GP.

Fig6: Residues to a 5 term loglog foreground model Vs Frequency for the extended GP and a 15m radius circular GP. The RMS of the averaged residues is roughly the same.
4.) Rectangle (20m across); + Saw tooth (20 triangles)

Fig 7: (Left) Gain derivative Vs Frequency for the extended GP with more triangles. (Right): The Gain vs derivative plot for the extended GP.

Fig 8: Residues to a 5 term loglog foreground model Vs Frequency for the extended GP and the extended one with more triangles. The RMS of the averaged residues is almost the same. Adding more triangles helped a little.
5.) Hexagon - 5m edge (area < 10m x 10m) 65m^2 Vs 100m^2

Fig9: (Left) Gain derivative Vs Frequency for a Hexagon shaped GP with edge side of 5m. (Right): The Gain vs derivative plot for 10m X 10m.

Fig10: Residues to a 5 term loglog foreground model Vs Frequency for the 10m X 10m GP and a hexagon (5m) GP. The RMS of the averaged residues is lower. The hexagon GP covers roughly the lower area than the 10m X 10m!!.
6.) Hexagon - 7.5m edge (area > 10m x 10m) 146m^2 Vs ~100m^2

**Fig11:** (Left) Gain derivative Vs Frequency for a Hexagon shaped GP with edge side of 7.5m. (Right): The Gain vs derivative plot for the 10m X 10m GP.

**Fig12:** Residues to a 5 term loglog foreground model Vs Frequency for the extended GP and a hexagon (7.5m) GP. The RMS of the averaged residues is larger than the 10mX10m GP.
7.) Hexagon - 15m edge (area < 30m x 30m) 586m^2 Vs ~600m^2

Fig13: (left) Gain derivative Vs Frequency for a Hexagon shaped GP with an edge side of 15m. (Right): The Gain vs derivative plot for the extended GP.

Fig14: Residues to a 5 term loglog foreground model Vs Frequency for the extended GP and a hexagon (15m) GP. The RMS of the averaged residues is a little larger than the extended.
8.) Hexagon - 17m edge (area > 30m x 30m) 750m^2 Vs ~600m^2

Fig15: (Left) Gain derivative Vs Frequency for a Hexagon shaped GP with edge side of 17 m. (Right): The Gain vs derivative plot for the extended GP.

Fig16: Residues to a 5 term loglog foreground model Vs Frequency for the extended GP and a hexagon (17m) GP. The RMS of the averaged residues of the hexagon is lower than the extended.
9.) Square - 50m side (area > 30m x 30m) 2500m^2 Vs ~600m^2

Fig17: (Right) Gain derivative Vs Frequency for a 50m X 50m square GP. (Left): The Gain vs derivative plot for the extended GP.

Fig18: Residues to a 5 term loglog foreground model Vs Frequency for the extended GP and a square 50m X 50m GP. The RMS of the two are roughly the same.
10.) Perforated- 40m (6triangles/side) (area > 30m x 30m) 2500m^2 Vs ~600m^2

Fig 19: Gain derivative Vs Frequency for a perforated 40m X 40m.

Fig 20: Residues to a 5 term loglog foreground model Vs Frequency for the extended GP and a perforated 40m X 40m GP. The RMS of the two are roughly the same.
11.) Staggered - 7by7 (area ~ 30m x 30m) 700m^2 Vs ~600m^2

**Fig21:** Gain derivative Vs Frequency for a Staggered GP with 7 titles and 7 rows.

**Fig22:** Residues to a 5 term loglog foreground model Vs Frequency for the extended GP and a staggered 7by 7 GP.
12.) Staggered - 8 by 9 (area < 40m x 40m) 900m^2 Vs ~1200m^2

Fig23: Gain derivative Vs Frequency for a Staggered GP with 8 titles and 9 rows.

Fig24: Residues to a 5 term loglog foreground model Vs Frequency for the extended GP and a staggered 8 by 9 GP.
13.) Staggered - 7 by 9 (area < 40m x 40m) 787m^2 Vs <1200m^2

Fig25: Gain derivative Vs Frequency for a Staggered GP with 7 titles and 9 rows.

Fig26: Residues to a 5 term loglog foreground model Vs Frequency for the extended GP and a staggered 7 by 9 GP. The RMS of the two are roughly the same.
14.) Perforated 49.2 X 49.2 m (3 triangles/side) - inner square of 30m X 30m and triangles of 10m base and 9.6 m height

Fig 27: Gain derivative Vs Frequency for a perforated ground with a central 30 X 30m and 3 triangles on each side of height 9.6m and base 10m.

Fig 28: Residues to a 5 term loglog foreground model Vs Frequency for the extended GP and a perforated 48.6 X 48.6 m. The RMS of the two are roughly the same.
Fig28b: Residues to a 5 term linlog foreground model Vs Frequency for the extended GP and a perforated 48.6 X 48.6 m. The RMS of the two are roughly the same.
15.) Perforated 49.2 X 49.2 m (3 triangles/side) - inner square of 30m X 30m and triangles of 10m base and 9.6 m height

Soil conductivity changed from 0.02S/m to 0.002S/m. And the simulation frequency from 50 to 100MHz to 60 to 120 MHz. The size is slightly different from memo 317.

One side of Inner square = \(2m + 6\times5m = 32m\)

2nd side of inner square = \(2m + 12\times2.4m = 30.8 m\)

If the triangles are 9.6 m tall on each side, the extents are = \(50m \times 51.2, m\) ?

![Fig29: Gain derivative Vs Frequency for a perforated ground with a central 30 X 30m and 3 triangles on each side of height 9.6m and base 10m with soil conductivity being 0.002S/m](image)

![Fig30: Residues to a 5 term linlog foreground model Vs Frequency for the perforated 49.2 X 49.2m.](image)
Notes

- There is still the difference that in Memo 317 it was simulated for EDGES-3. And the extent of a ground plane is a bit larger.
- But as noted in memo 317, the residues lower from 122 mK to 87 mk from 30 X 30 to the new perforated A case. This drastic improvement I don't see in my simulations.