LoCo Lab EDGES Memo 155
WIPL-D Simulations of the EDGES Mid- and Low-Band Antennas

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1 Description

Here we show results of EM simulations with WIPL-D of the EDGES Mid and Low-Band antennas with ground planes of sizes up to 30m × 30m. We compare these results with simulations from FEKO.

Specifically, the following Mid-Band WIPL-D simulations were done over $50 - 200$ MHz at 1-MHz resolution:

- Mid-Band antenna, 10m × 10m ground plane.
- Mid-Band antenna, 'perforated' (triangle edges) 15m × 15m ground plane.
- Mid-Band antenna, 15m × 15m ground plane.
- Mid-Band antenna, 20m × 20m ground plane.
- Mid-Band antenna, 'perforated' (triangle edges) 30m × 30m ground plane.
- Mid-Band antenna, 30m × 30m ground plane.
- Mid-Band antenna, infinite PEC ground plane.

To evaluate the impact of different automatic meshing (which seems to be determined from the highest frequency of the simulation), the cases above were repeated but in the range $50 - 120$ MHz.

Also, we simulated with WIPL-D the following Low-Band cases:

- Low-Band antenna, 10m × 10m ground plane.
- Low-Band antenna, 'perforated' (triangle edges) 30m × 30m ground plane.

In the models above, the ground planes not indicated as 'perforated' are square. Also, except for the cases with infinite PEC ground plane, the ground planes are placed above soil that is infinite in $+/-x$, $+/-y$, and $-z$. The soil has $\epsilon_r = 3.5$ and $\sigma = 0.02$ S/m.

The FEKO simulations that we use for comparison correspond to the following cases, which were computed by Alan:

- Low-Band antenna, 10m × 10m ground plane ($50 - 120$ MHz).
- Low-Band antenna, 'perforated' (triangle edges) 30m × 30m ground plane ($40 - 120$ MHz).
- Mid-Band antenna, 'perforated' (triangle edges) 30m × 30m ground plane ($50 - 200$ MHz).

To the best of our understanding, in these simulations the soil has the same characteristics as in the WIPL-D simulations.

The results are shown in Figures 1 through 13. They are presented in four formats:

- Integrated gain above horizon: Figures 1 and 2, and 4.
- Loss: Figure 3.
- Gain at specific coordinates: Figures 5 and 6.
- Gain derivatives with frequency for two cuts in ϕ: Figures 7 through 13.

2 Summary

- The integrated gain above the horizon from WIPL-D does not show glitches.
- The integrated gain above the horizon from WIPL-D follows reasonable trends as a function of ground plane size, although the results are less consistent toward higher frequencies.
- Different meshing has an effect on the integrated gain. The results 'seem' more self consistent across ground plane size when the computations are done up to 200 MHz, but we cannot judge the absolute accuracy. At lower frequencies, the ripple patterns are consistent between the two meshing cases tested.
- The results from WIPL-D show significantly more ripples than those from FEKO. This discrepancy is the main aspect to clarify in the future.

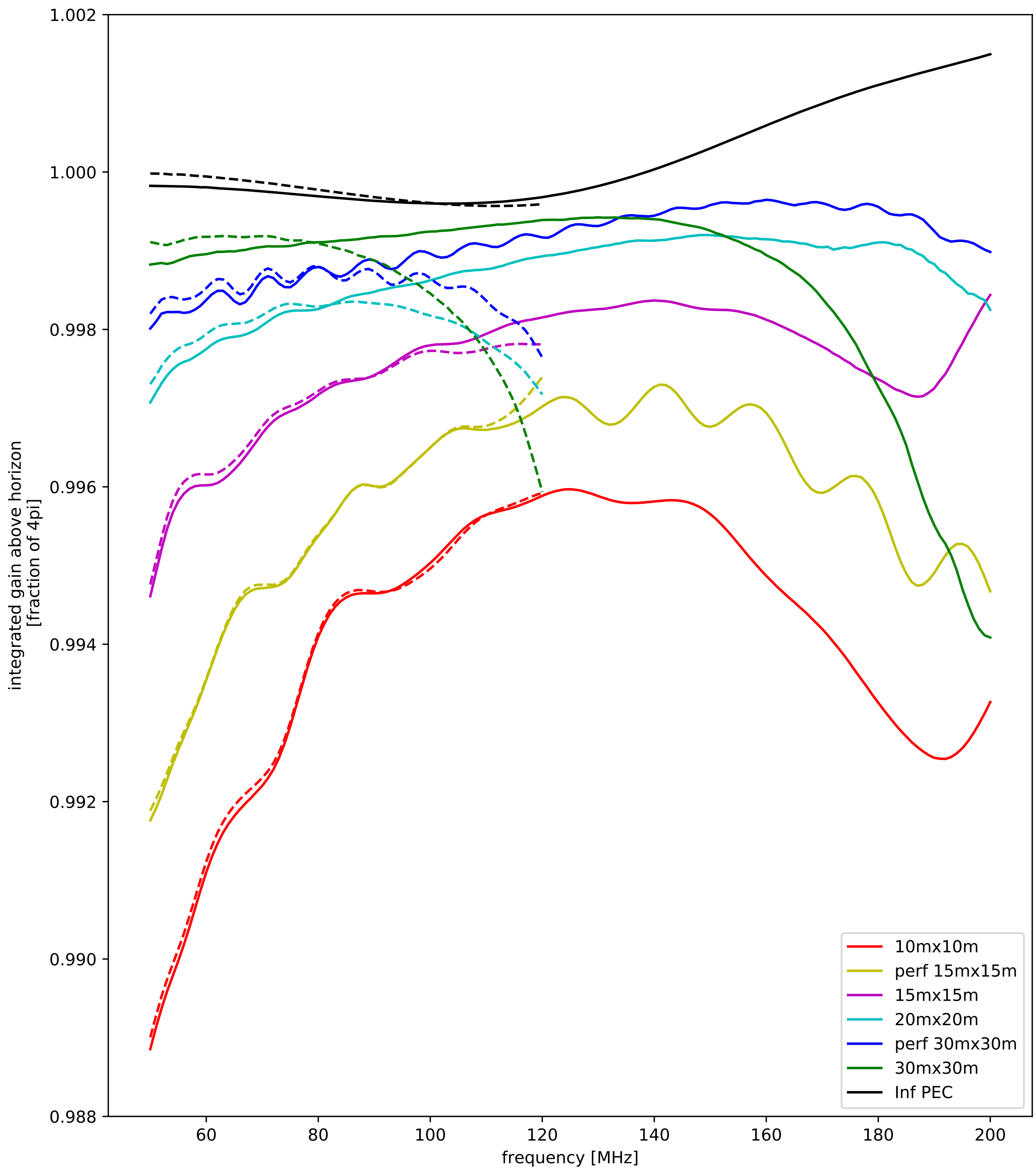

Figure 1: Integrated gain above the horizon from WIPL-D, for different ground plane sizes (from 10m $\times$ 10m to infinite). The solid lines correspond to simulations over $50 - 200$ MHz. The dashed lines are simulations over $50 - 120$ MHz. Even though the antenna models are kept the same, changing the highest simulation frequency produces different results, especially for large finite ground planes. The results change even in the infinite PEC case.

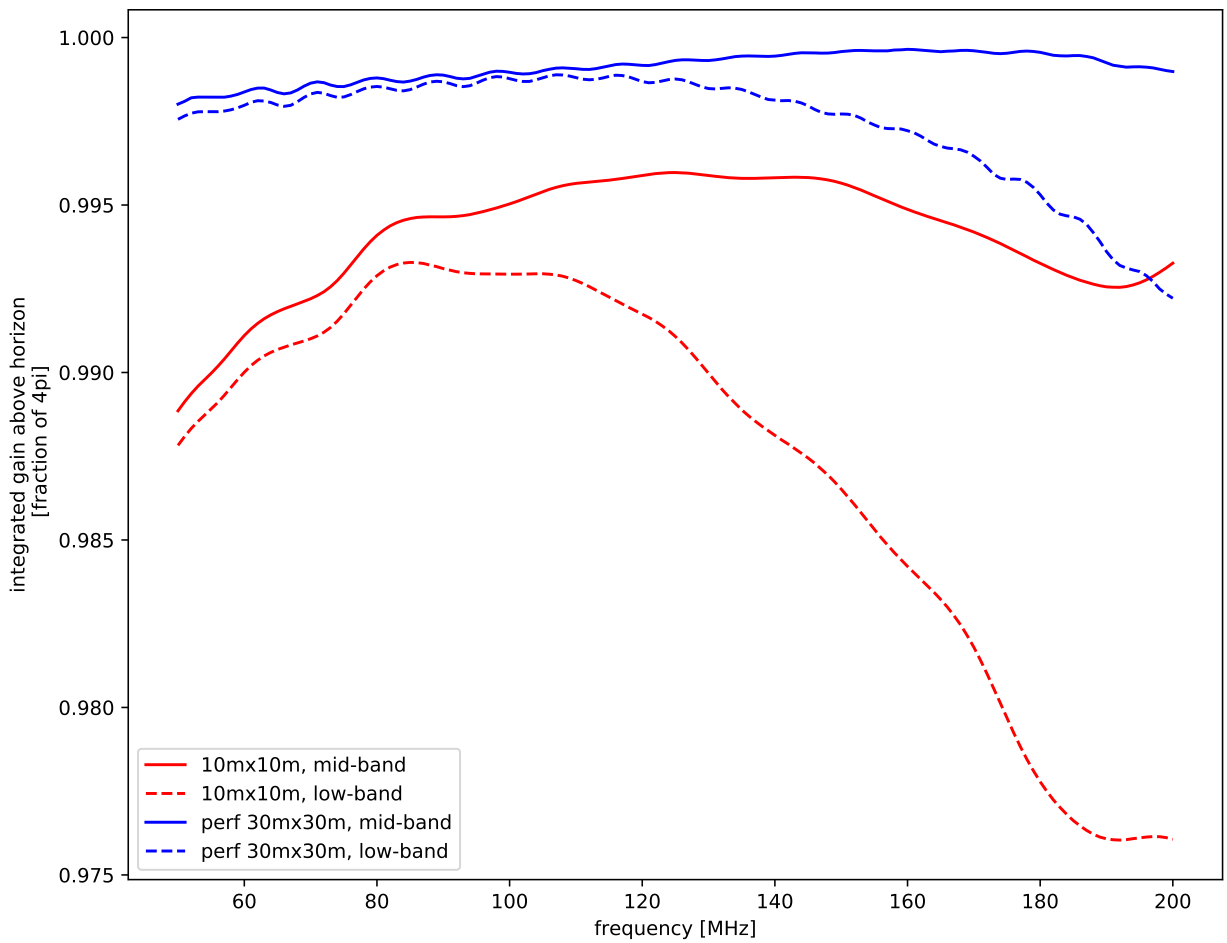

Figure 2: Integrated gain above the horizon from WIPL-D, for two antennas (Mid- and Low-Band) and two ground planes (square 10m $\times$ 10m, and perforated 30m $\times$ 30m). The Low-Band antenna shows less gain than Mid-Band, but the ripples are consistent when the same ground plane is used.

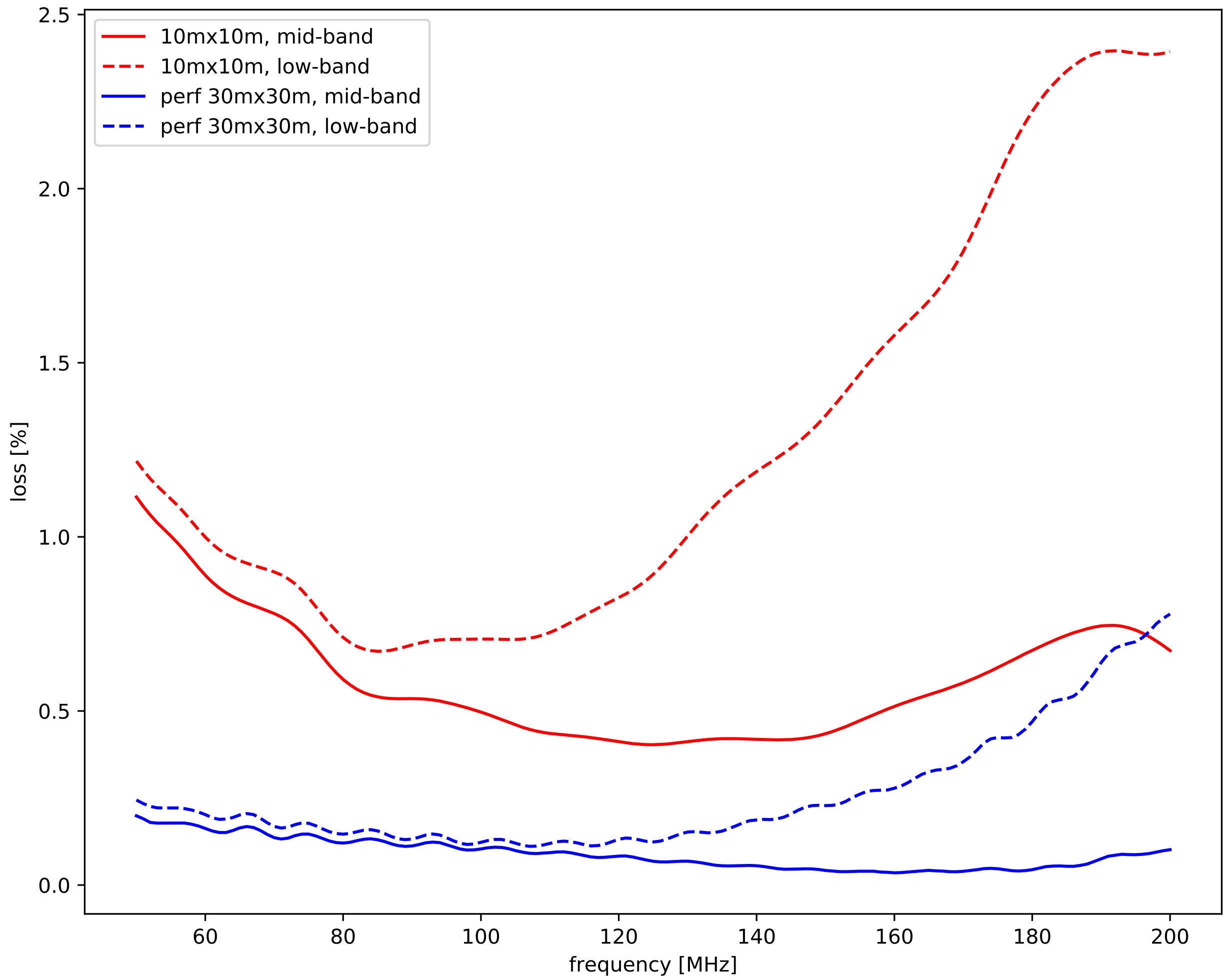

Figure 3: Same as Figure 2 but represented as loss percentage.

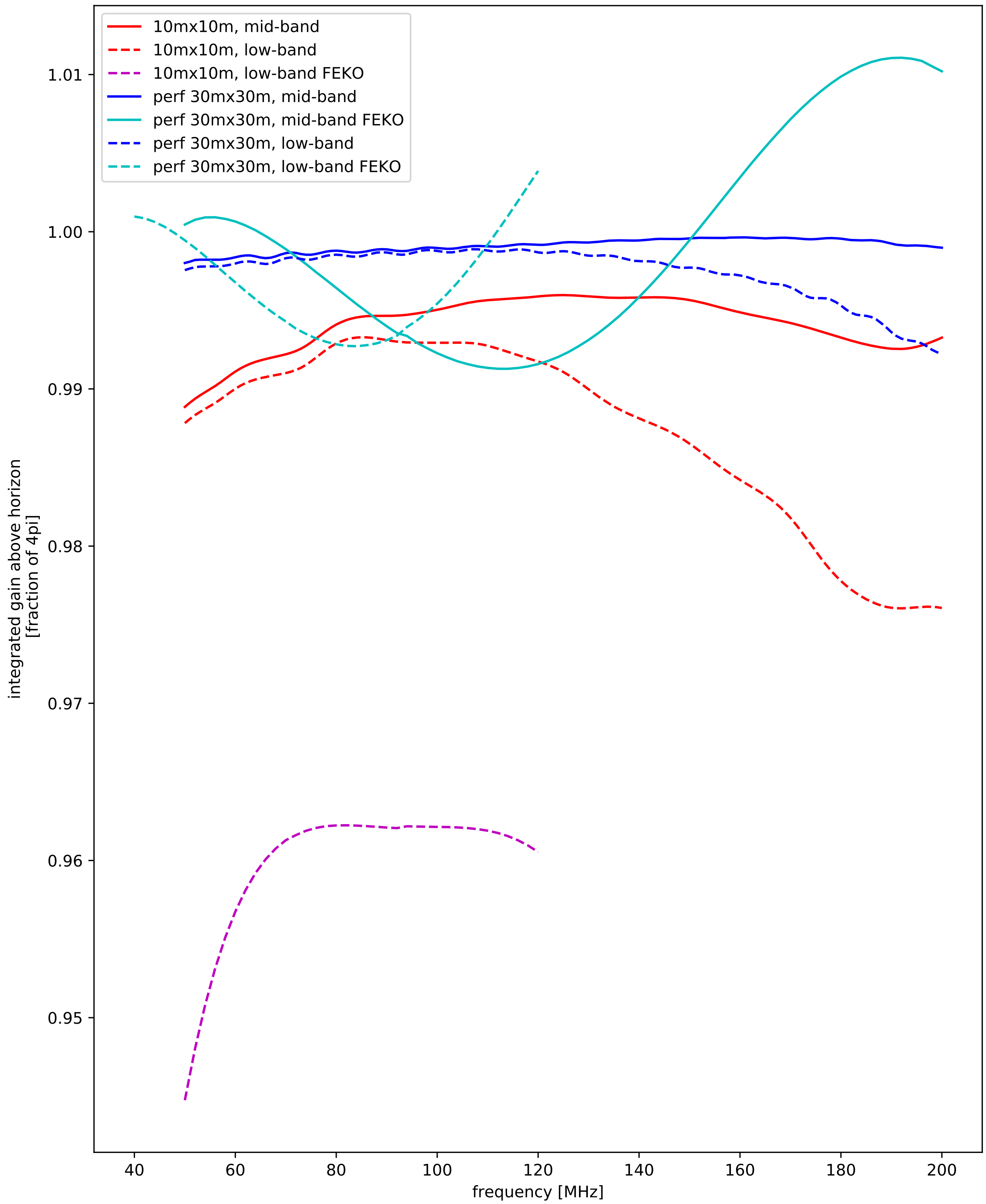

Figure 4: Same as Figure 2 but adding results from FEKO for comparison.

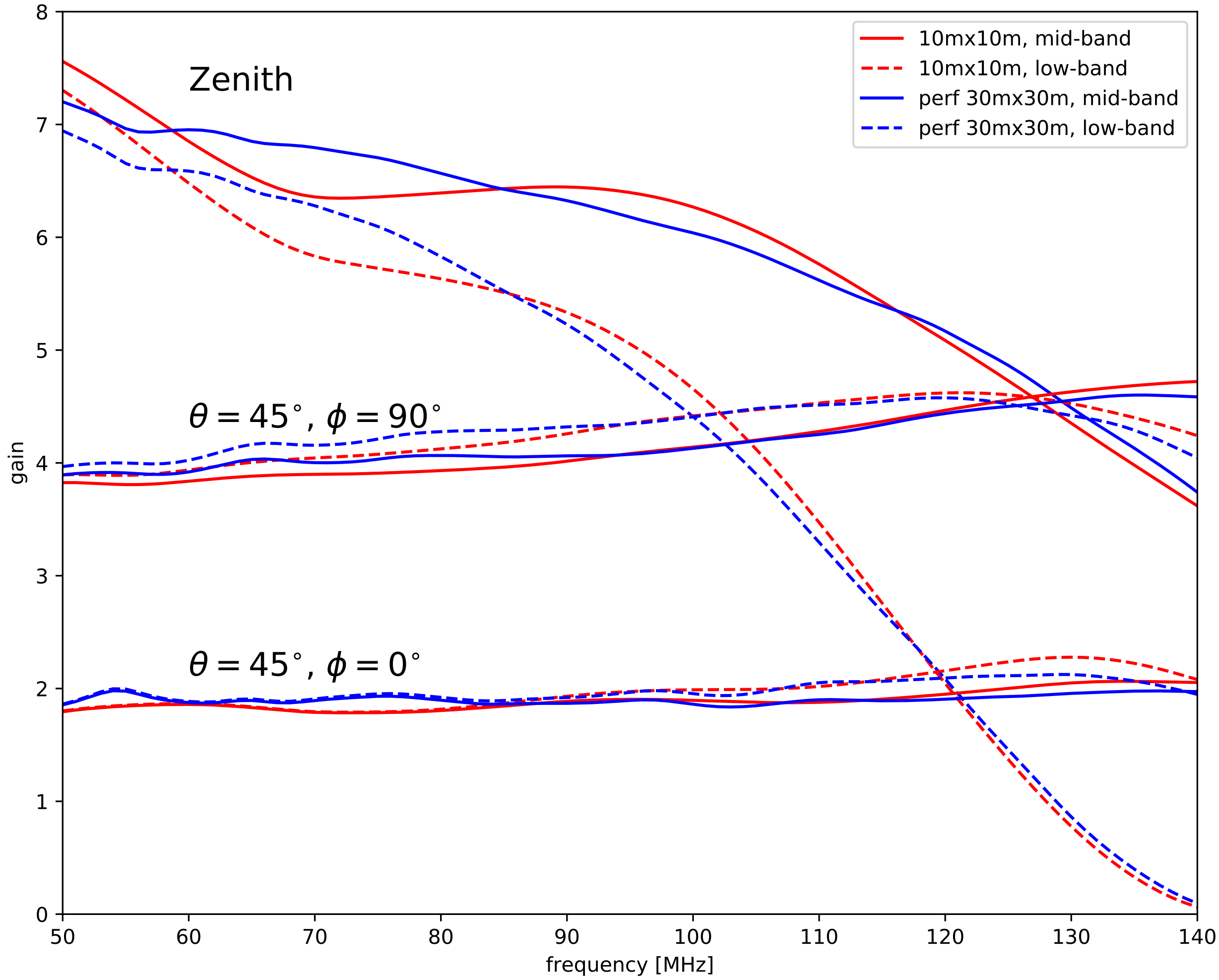

Figure 5: Gain from WIPL-D, at three specific angles.

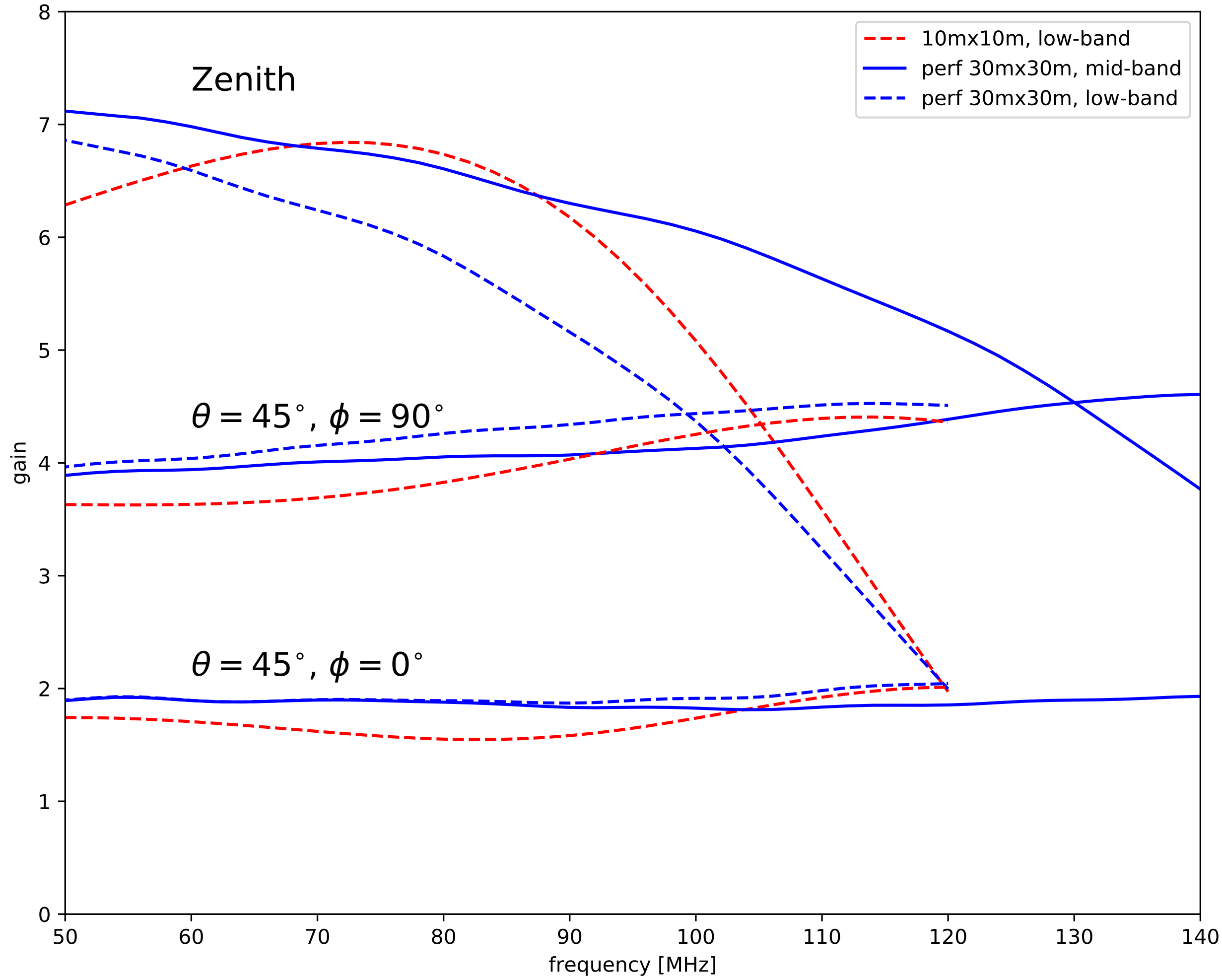

Figure 6: Same as Figure 5 but from FEKO.

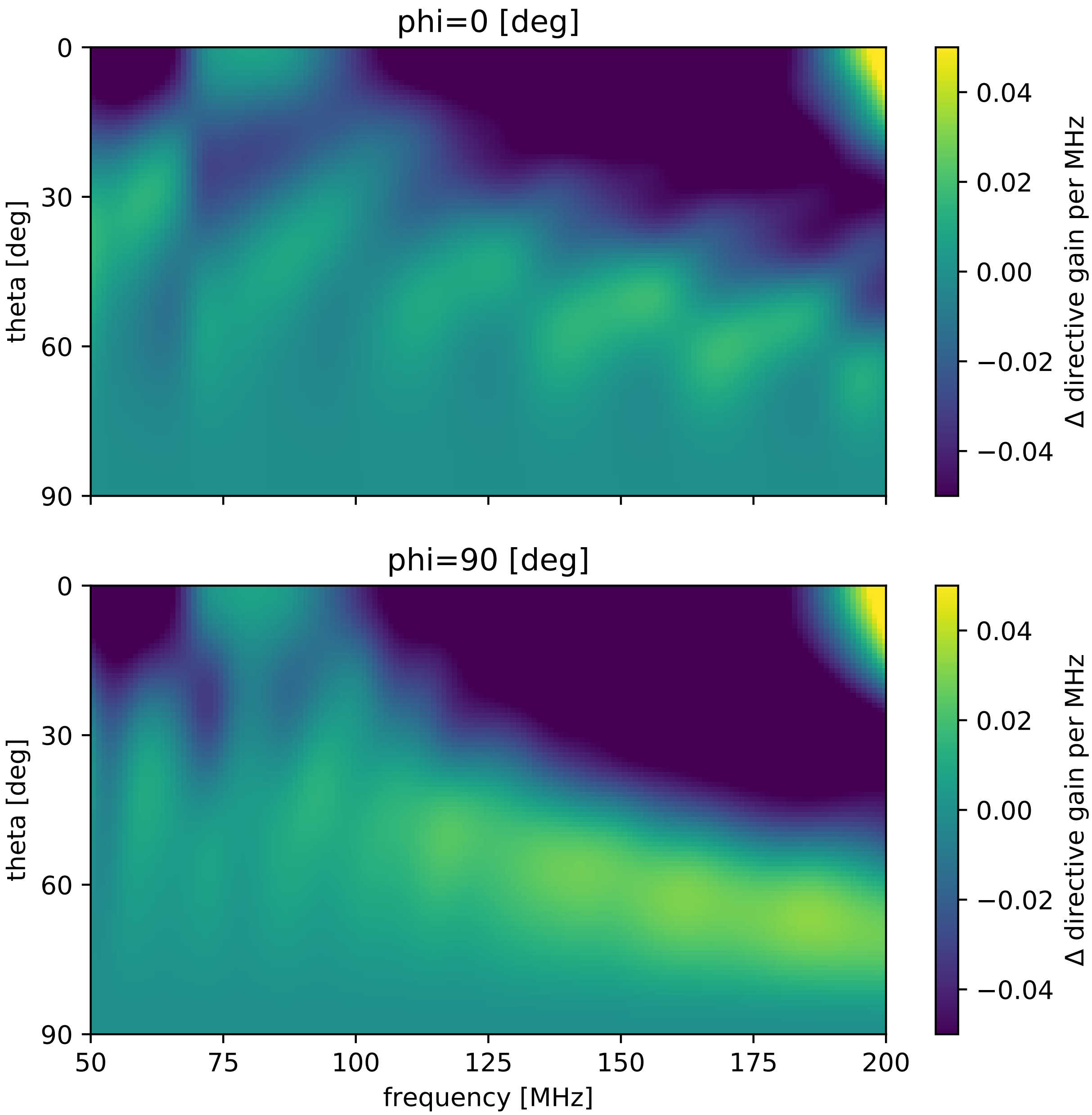

Figure 7: Gain derivative from WIPL-D. Mid-Band, square 10m × 10m ground plane.

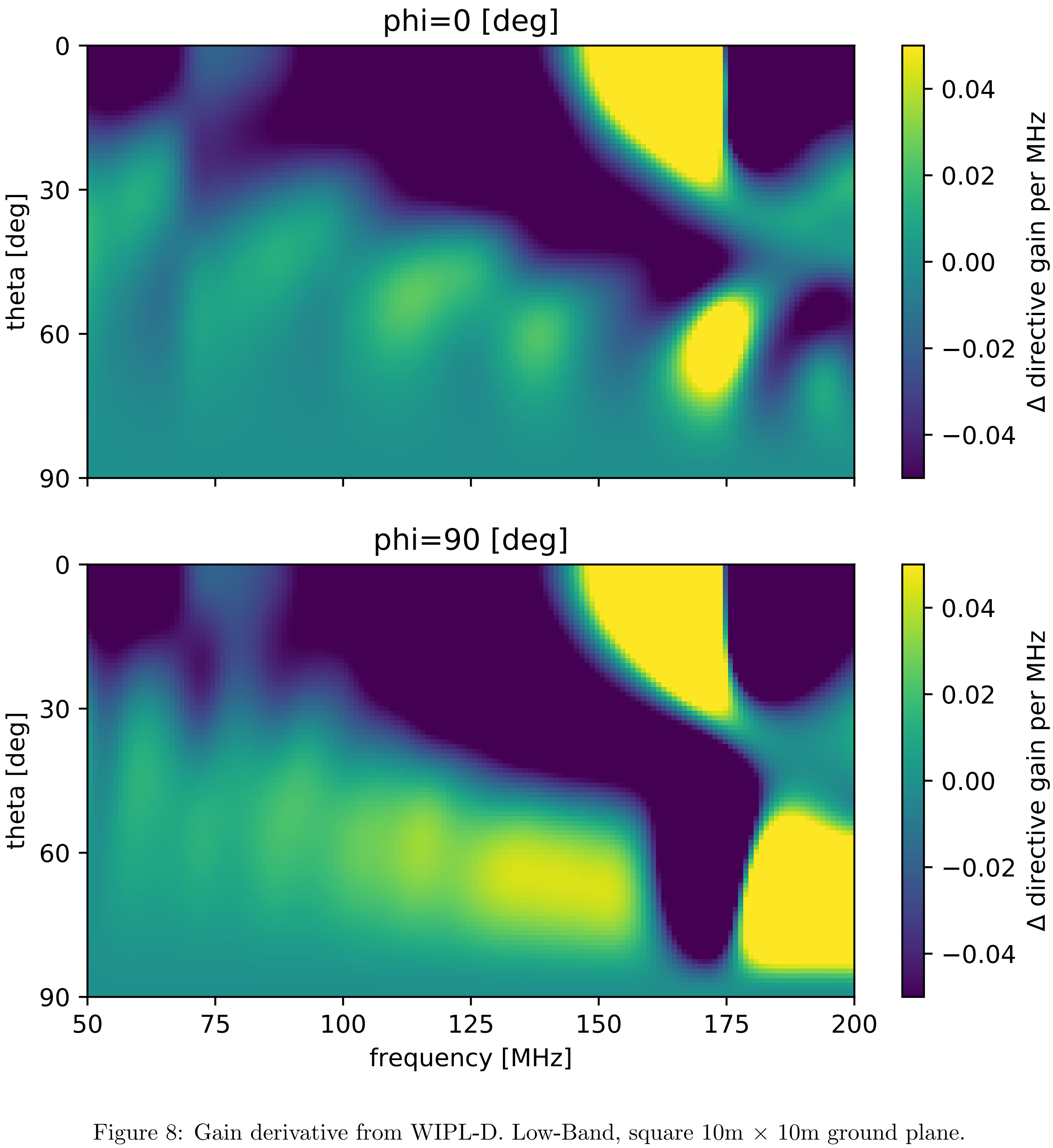

Figure 8: Gain derivative from WIPL-D. Low-Band, square 10m × 10m ground plane.

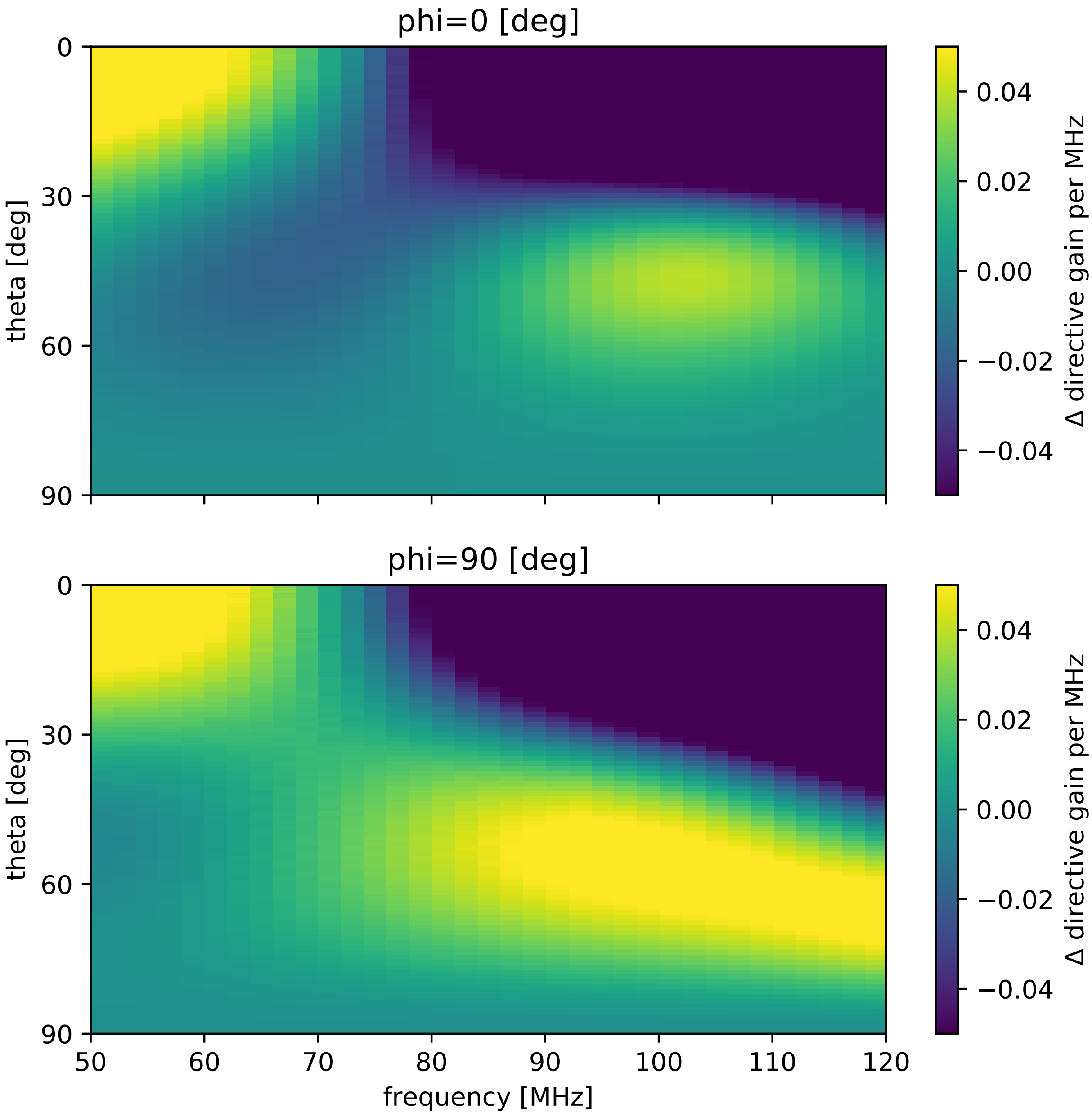

Figure 9: Gain derivative from FEKO. Low-Band, square 10m $\times$ 10m ground plane ($50 - 120$ MHz).

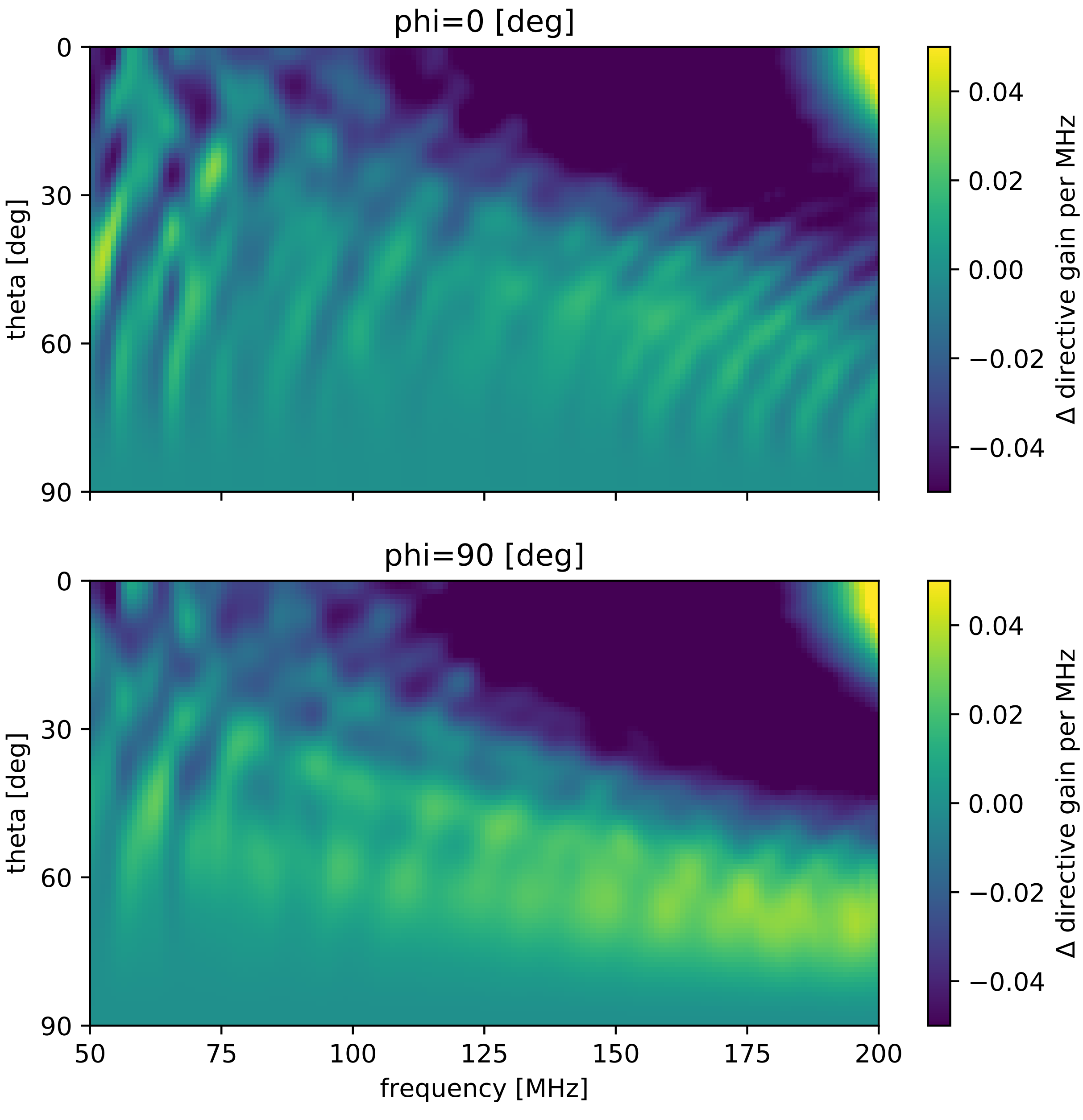

Figure 10: Gain derivative from WIPL-D. Mid-Band, perforated 30m × 30m ground plane.

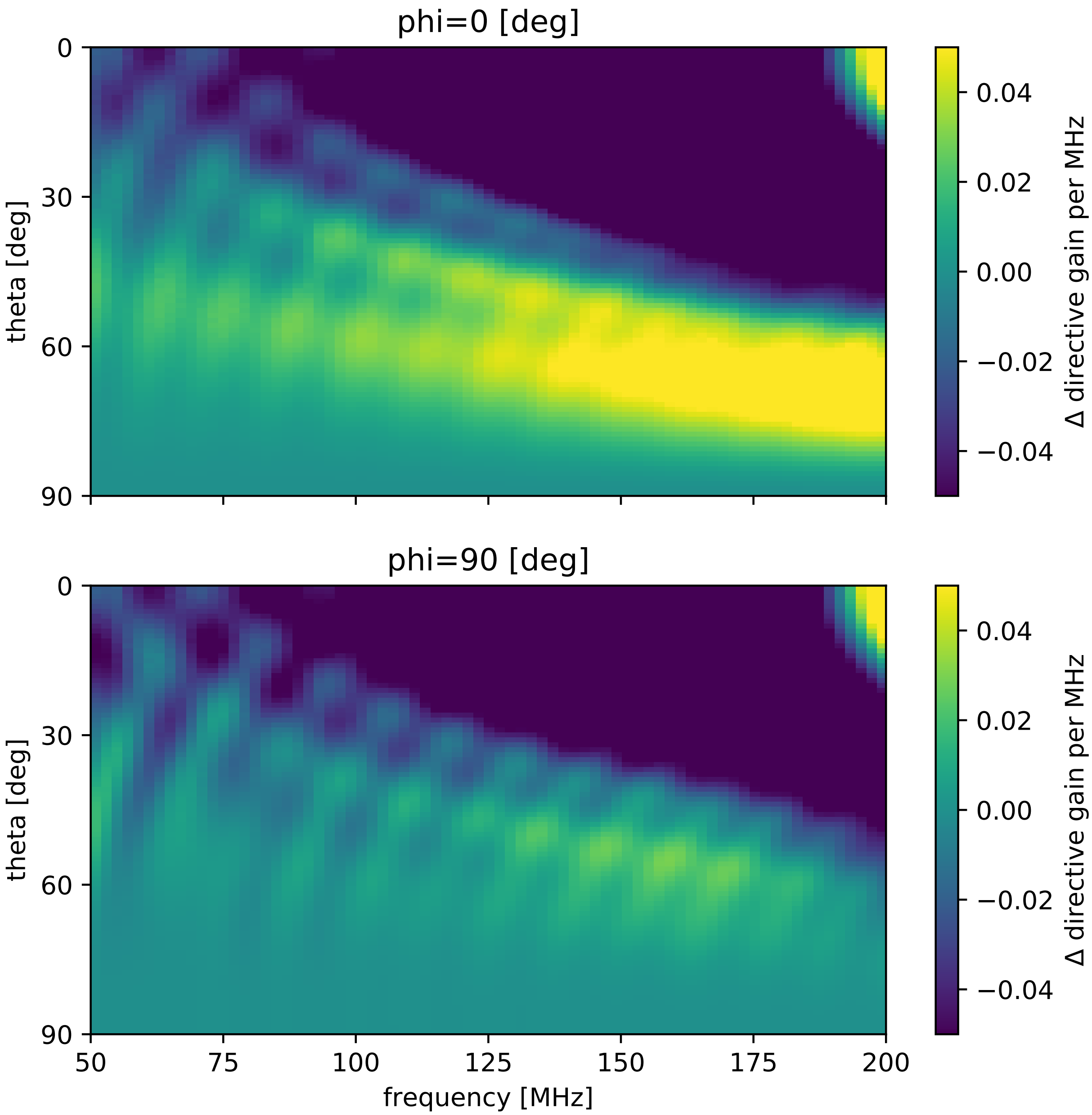

Figure 11: Gain derivative from FEKO. Mid-Band, perforated 30m × 30m ground plane.

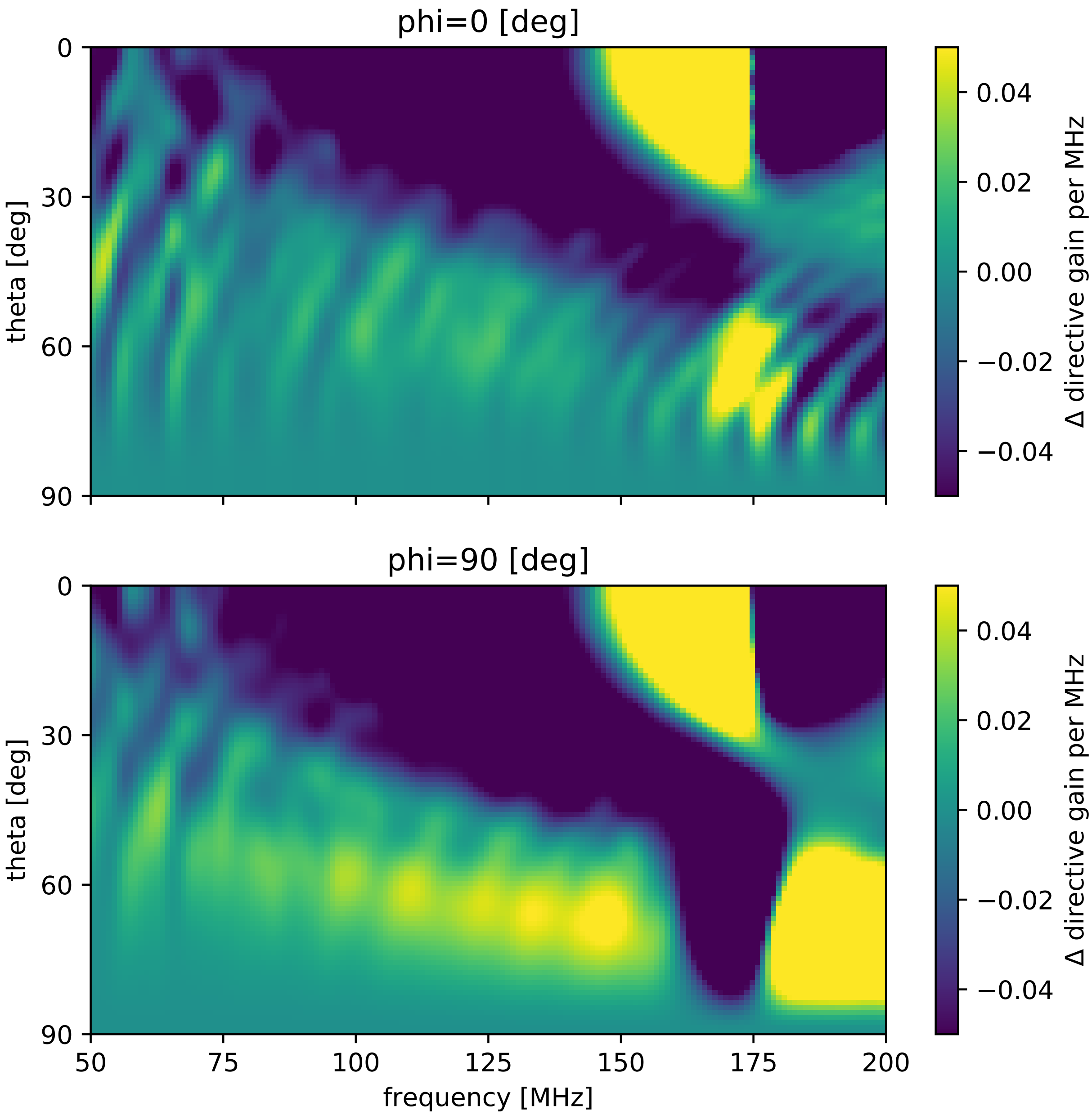

Figure 12: Gain derivative from WIPL-D. Low-Band, perforated 30m × 30m ground plane.

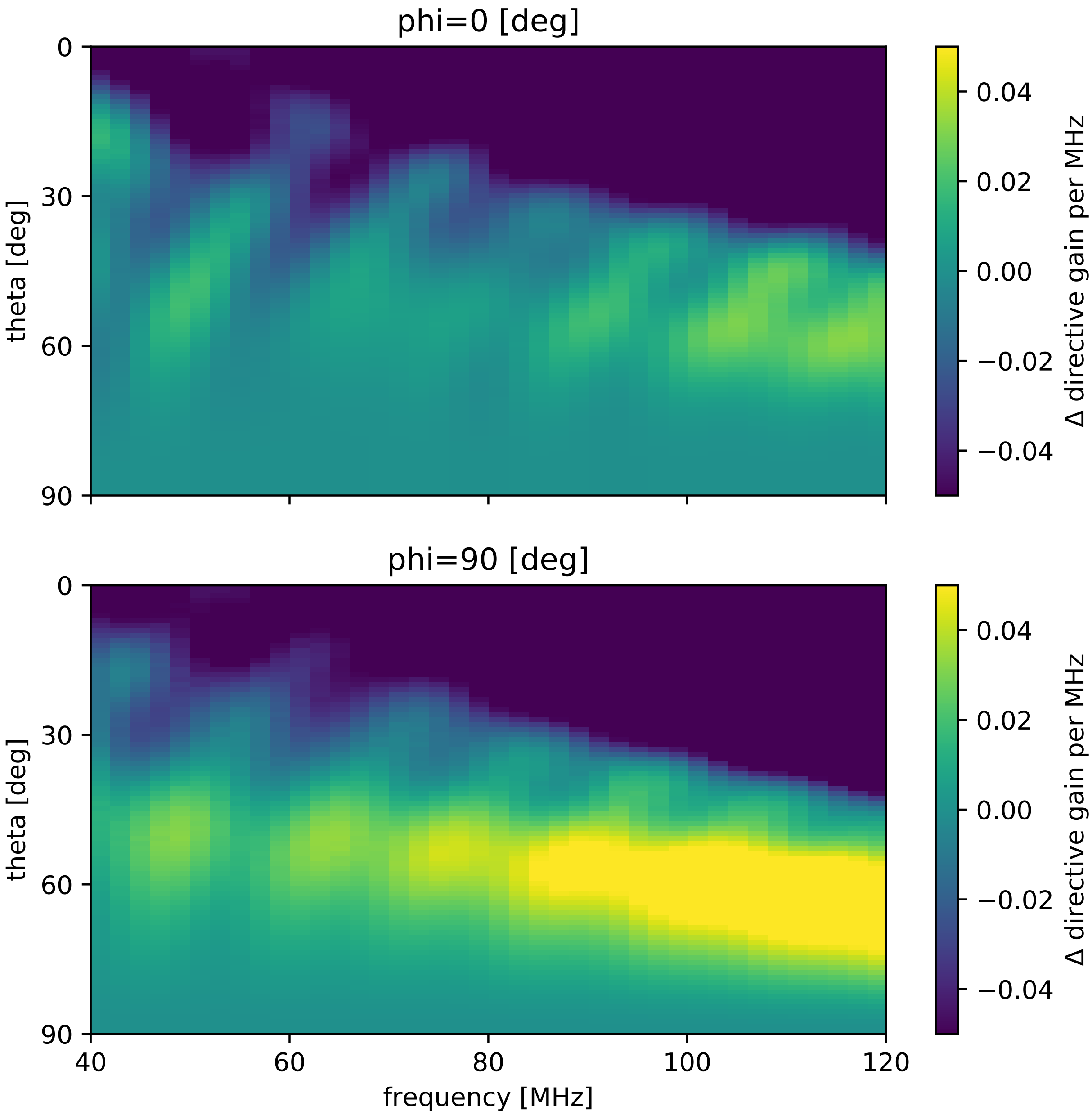

Figure 13: Gain derivative from FEKO. Low-Band, perforated 30m × 30m ground plane (40 − 120 MHz).