EDGES MEMO #457

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To: EDGES group

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Subject: Proposed ground plane for the Adak site

The proposed site at Adak Island Alaska is to use the decommissioned AN/FRD-10 radio direction finder area at 51.94339, -176.59865. This area is flat and has an abandoned building at the center of the circular area of about 400m in diameter. Most of the above ground parts of the original antenna have been removed leaving 8-gauge copper wire radials just below the surface. Initial tests using FEKO simulations show that there can be a resonant coupling of a mesh or wire grid ground plane put on the surface of the old AN/FRD. Figure 1 shows the resonance of the EDGES-3 on a 5x5m wire grid placed over 50m long radials separated by 2.9m over a reflecting surface of water. This potential coupling can be minimized by having the electric field of the antenna and direction of the grid wires perpendicular to the 50m long radials. More tests show that this resonance frequency changes with the wire length of the wire grid and not the length of the radial and is not problem for a wire grids larger than 5x5m and even with a small wire grid this resonance can be suppressed by including a high soil dielectric and conductivity soil below and in contact with the radials. A test of the effect of making a single connection of the antenna to the closest radial has little effect. Multiple connections with might be useful but the spacing of the radials is too large to rely on the existing radials for a ground plane.

The effect of the buildings at about 170m from the antenna is a concern but the distance large enough the reflections only produce a ripple in the residuals at certain GHA. Figure 2 shows a “worst case” in which a 20m tall pole with a 2.5m horizontal dipole on it’s top is added to the 40x40mx5m building.

Table 1 shows results of simple tests that show that if conductivity of the soil below the 8-gauge copper wire radial rods is 1e-1 S/m or higher the antenna on the “rods” would have a lower beam chromaticity than the 48x48m ground plane at the WA as judged by the average rms of the 5-term residuals of 1 hour blocks from GHA 0-23. But the loss is about 20% and significant spectral structure is likely to be present in this high loss. The reason for the loss being so high is because of the large spacing of the rods. Memo 88 shows a spacing of less than a twentieth of a wavelength is needed for low loss. One way to lower this loss is to add more ground wires or mesh above the rods but the area needs to be more than about 1000 square meters to get loss at the 1% level along with low beam chromaticity.

In each case of the simulations the EDGES 2018 21-cm absorption has been added to the sky and a check is made of the absorption without beam or loss correction to show that the absorption can be retrieved except in the case of the resonance level in figure 1 for which the presence of the resonance makes the absorption extraction very marginal. Figure 1 used a 5x5 wire grid. When a 50x25m meandering wire grid with the dimensions of the wire grid used at Devon Island described in memo 393 is used the orientation of the wire grid relative to the AN/FRD-10 radials is not critical and makes little difference. The last two entries of table 1 are for the perpendicular and aligned simulations respectively. If there is no particular direction of significant RFI then pointing the antenna at the buildings to minimize the gain in this direction is probably best as the ripples in Figure 2 are avoided.

Ground plane	average rms mK	loss at 50 MHz %	loss at 120 MHz %	diel	S/m
48x48m perf. welded mesh	70	0.1	0.1	3.5	1e-2
existing radial rods	34	20	10	78	1e-1
existing radial rods	61	22	15	3.5	1e-1
existing radial rods	220	40	30	3.5	1e-2
50x25 wire grid rods removed	88	0.1	1.1	6.5	1e-1
rods plus 2x2.6m wire grid	184	8	4	3.5	1e-2
rods plus 50x25m wire grid	108	0.3	0.9	3.5	1e-2
rods plus 50x25m wire grid	93	0.24	0.87	3.5	1e-2
rods plus 50x25m wire grid	56	0.59	0.92	6.5	1e-1
rods plus 50x25m wire grid	60	0.53	0.88	6.5	1e-1

Table 1. Average of the residuals rms for one hours blocks 58-102 MHz along with estimates of loss

The azimuth of the AN/FRD buildings and the town from the antenna are about 240 and 200 degrees respectively so “aligned” or antenna azimuth of 220 degrees might be the best choice to minimize RFI and reflections from the buildings but being perpendicular with the existing radials might be a better mechanical choice.

Antenna orientation	Azimuth of ant	Az of max gain	Az of min gain
perpendicular	330	60,240	150,330
aligned	240	150,330	60,240

Table 2. Azimuths of maximum and minimum antenna gain at low elevation

The proposed power system is to generate DC using a generator to charge batteries in one of the used AN/FRD buildings and send 24v from the batteries on 6/2 UFB cable along with a fiber optic cable in a ¾ inch LA12 “Liquidtight” flexible galvanized metal conduit. FEKO tests show that bringing in the conduit on top across the wire grid and up to the EDGES-3 cable box has a minimal effect on the beam chromaticity whereas running parallel to the wire grid wires is very prone to resonances. In order minimize the antenna gain in the direction of the building with the batteries and generator as well as in the direction of the town the conduit needs to make a curve at about 50 meters from the EDGES antenna to cross over the wire grid normal to the grid wires which run in the direction on the antenna.

The results of the FEKO test made with antenna pointed at 240 deg azimuth with the conduit run to the antenna over the 50x25m ground plane as shown in Figure 4 are given in Table 3 and the results of a grid search shown in Figure 5. The FEKO simulation of the building in figures 4 and 5 is 40x4m wall with a 20m pole plus a 2.5m horizontal dipole. These simulations are run over 1-hour blocks of all GHA and the residuals are obtained with 5-physical terms removed.

Ground plane	average rms mK	loss at 50 MHz %	loss at 120 MHz %	diel	S/m
50x25m plus cable	72 55-102 MHz	0.55	0.79	3.5	1e-1

Table 3. Average of the residuals rms for one hours blocks along with estimates of loss

In summary low beam chromaticity and low loss close to the performance of EDGES-3 at the WA should be achievable at the Adak site with a 50x25m meandering wire ground plane, similar to that used at Devon Island, placed on the gravel over the remaining radial wires of the AN/FRD. In order to avoid resonances the conduit should be run perpendicular to the ground plane wires.

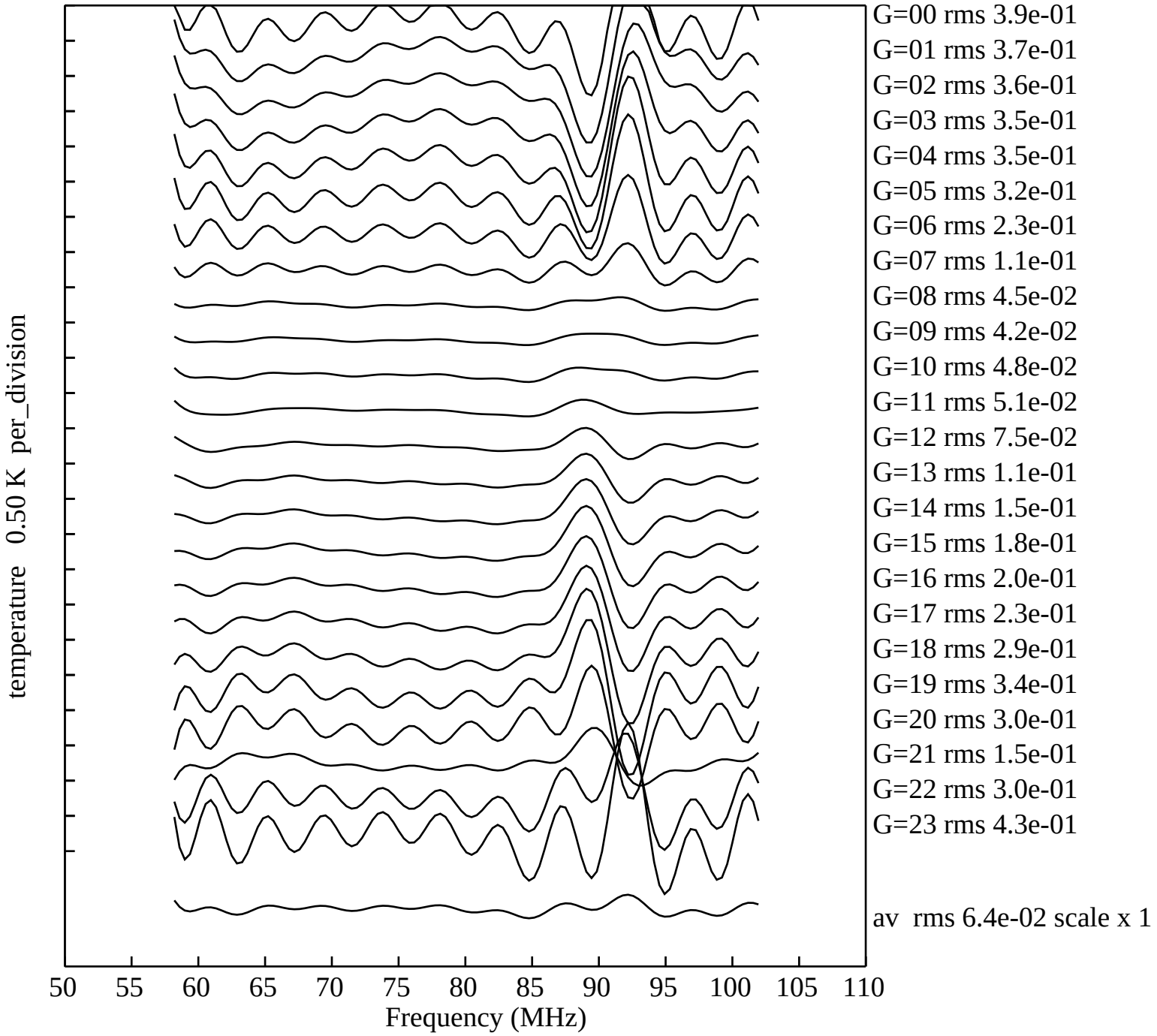


Figure 1. Resonance at 92 MHz produced by coupling of 5x5m wire grid over 50m radials

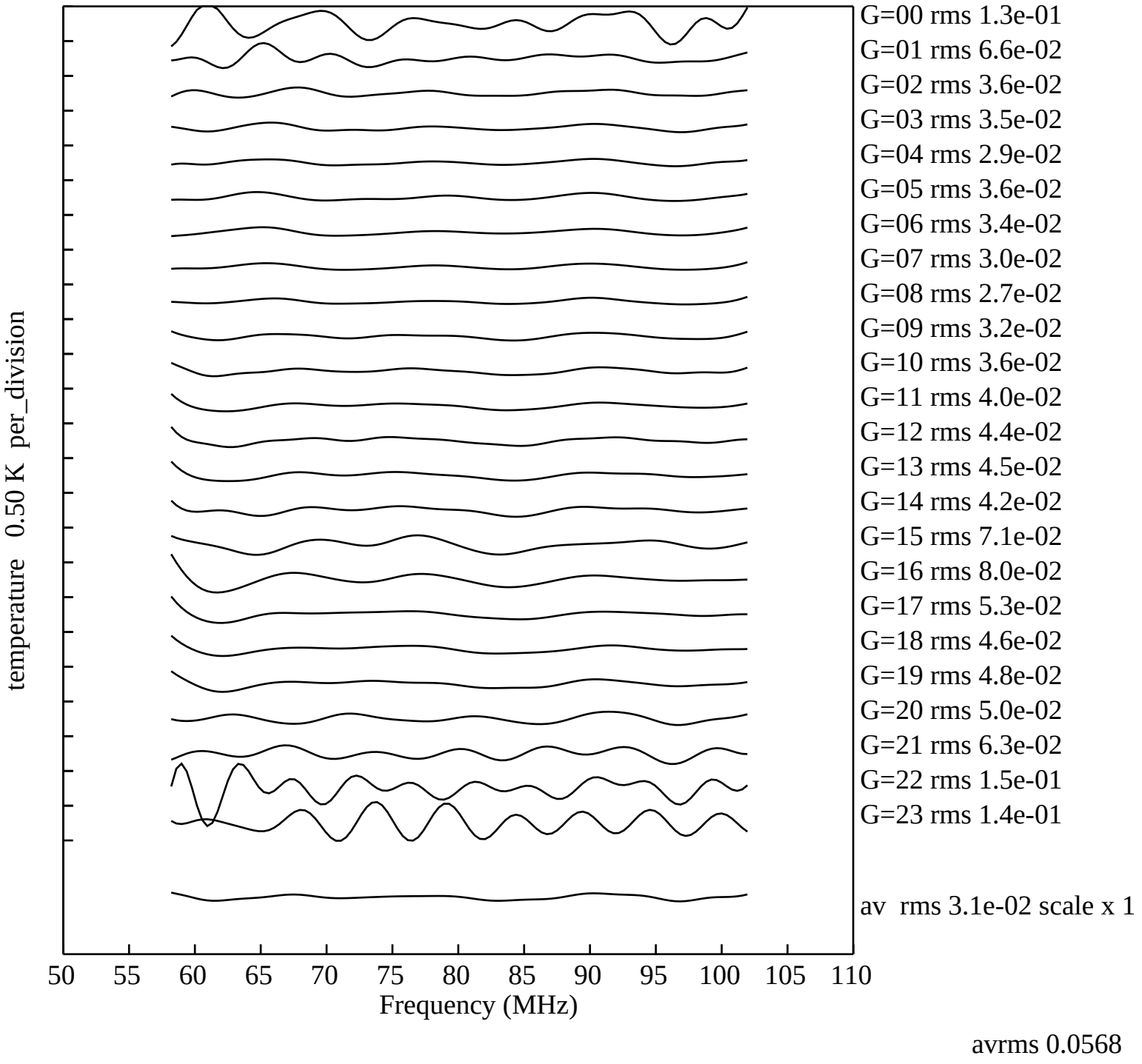


Figure 2. Residuals to simulated spectra of building reflections with 5-terms removed for GHA 0-23 hours.

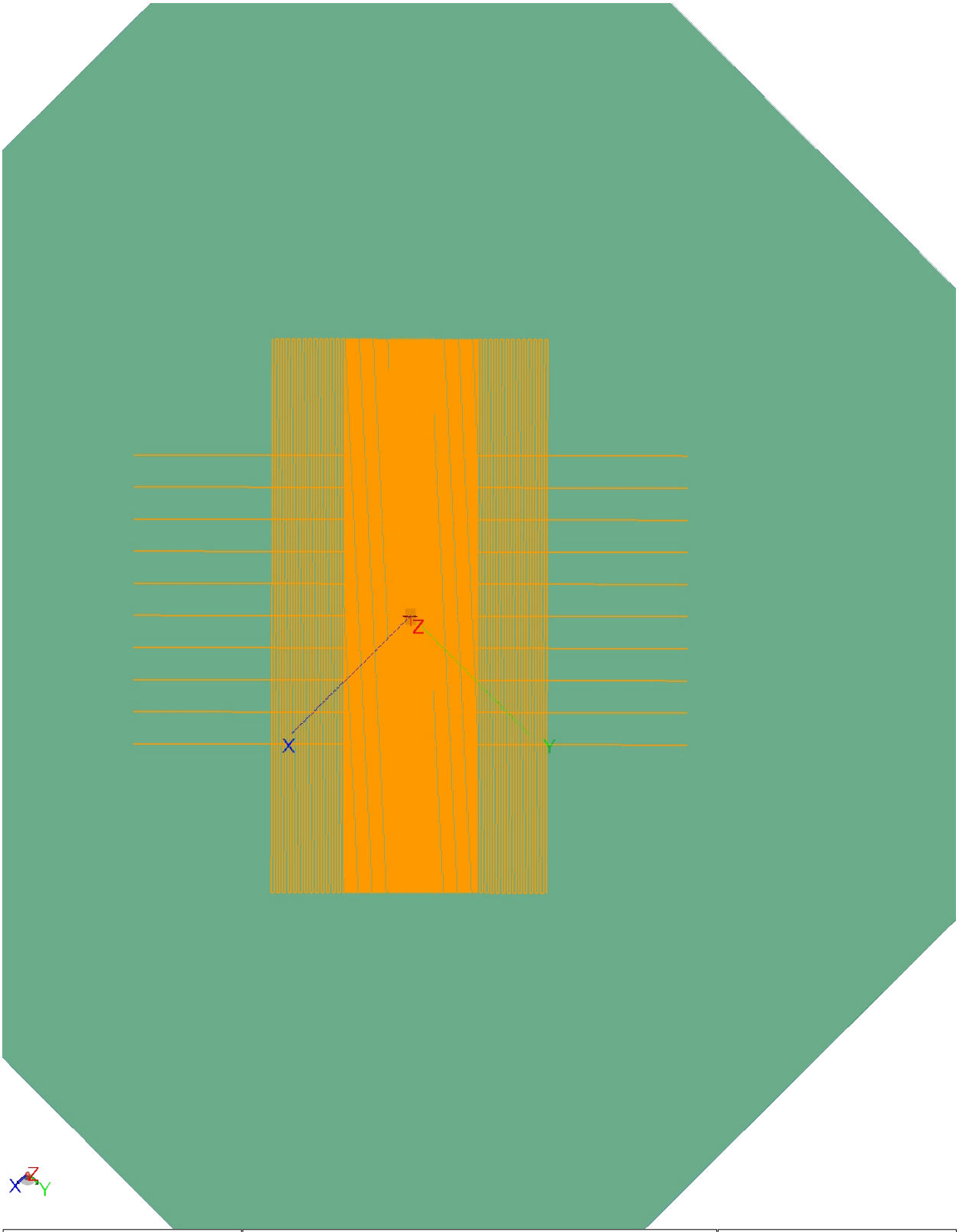
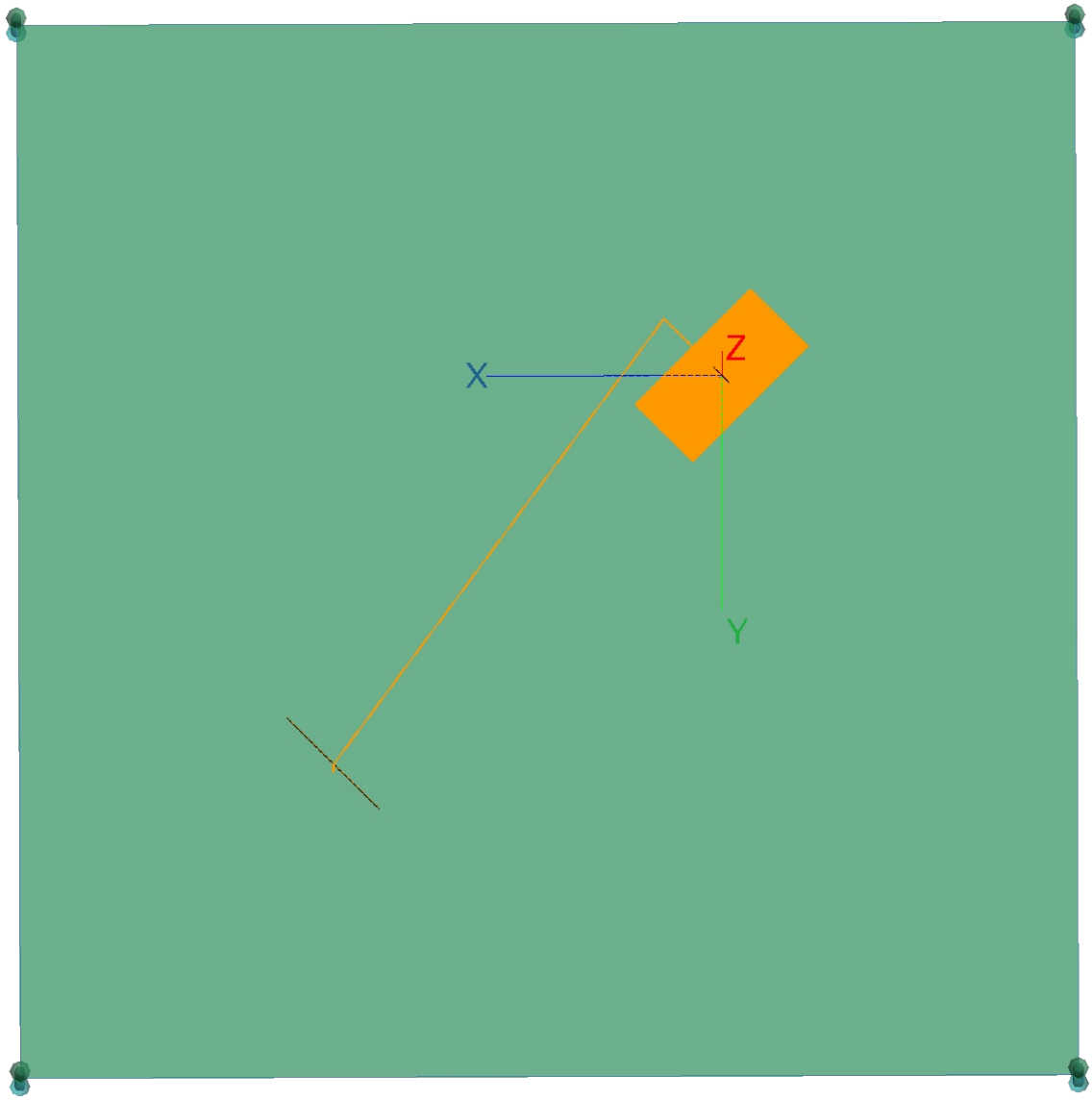
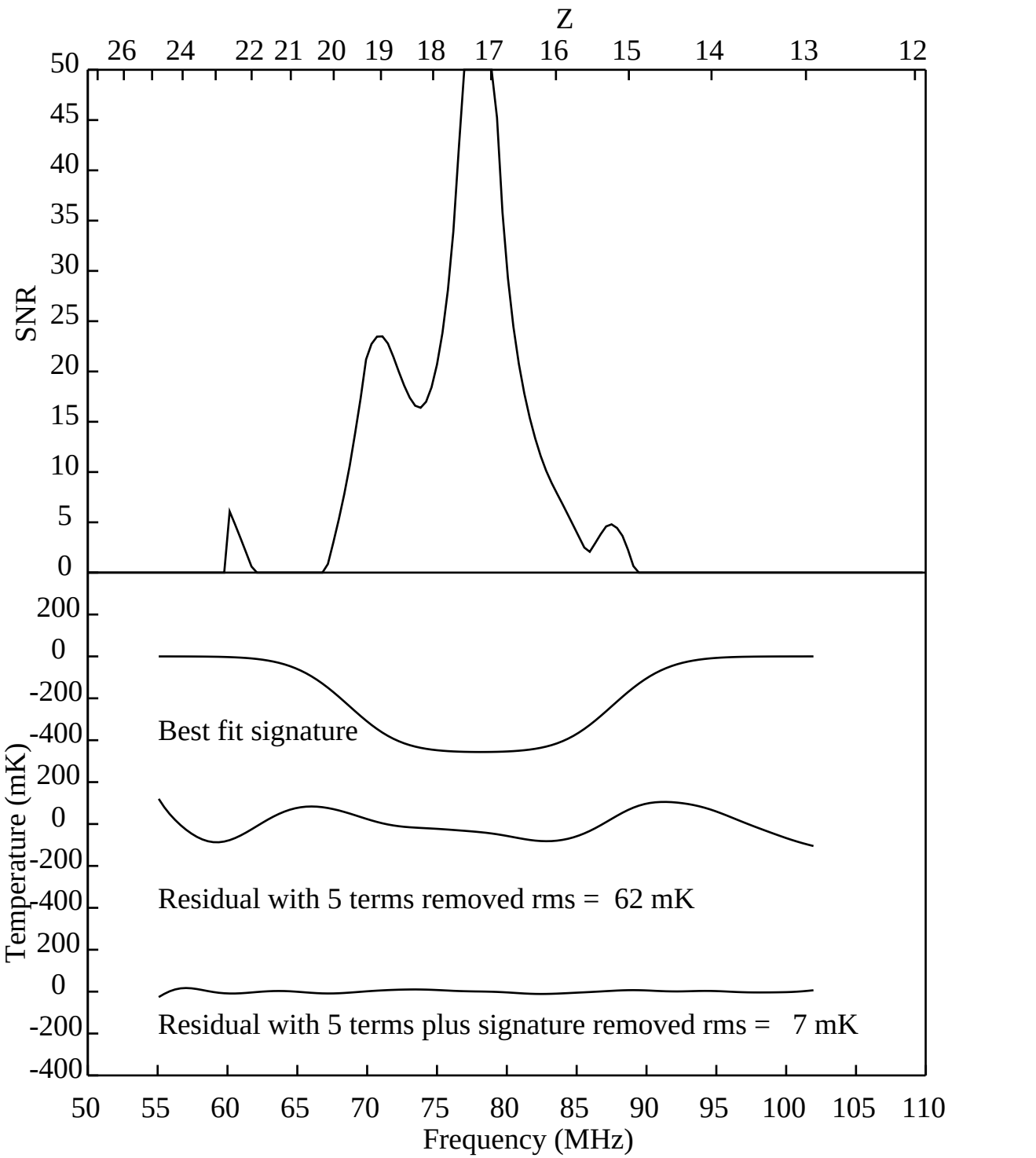


Figure 3. FEKO model for antenna perpendicular to AN/FRD radial wires



Altair Feko™	test7 2024-09-14 08:25	View direction Theta = 5° Phi = 89°

Figure 4. FEKO model with 50x25m wire grid and conduit from the building



freq 78.1 snr 101.2 sig 0.46 wid 19.10 tau 4 rmsin 0.0616 rms 0.0067 55 - 102

Figure 5. Grid search without beam correction with Nature 2018 21-cm result added to the sky