

**MASSACHUSETTS INSTITUTE OF TECHNOLOGY
HAYSTACK OBSERVATORY
WESTFORD, MASSACHUSETTS 01886**

October 18, 2023

Telephone: 617-715-5533

To: EDGES group
From: Alan E.E. Rogers
Subject: FEKO simulations of loop antenna for scanning welding slots for resonances

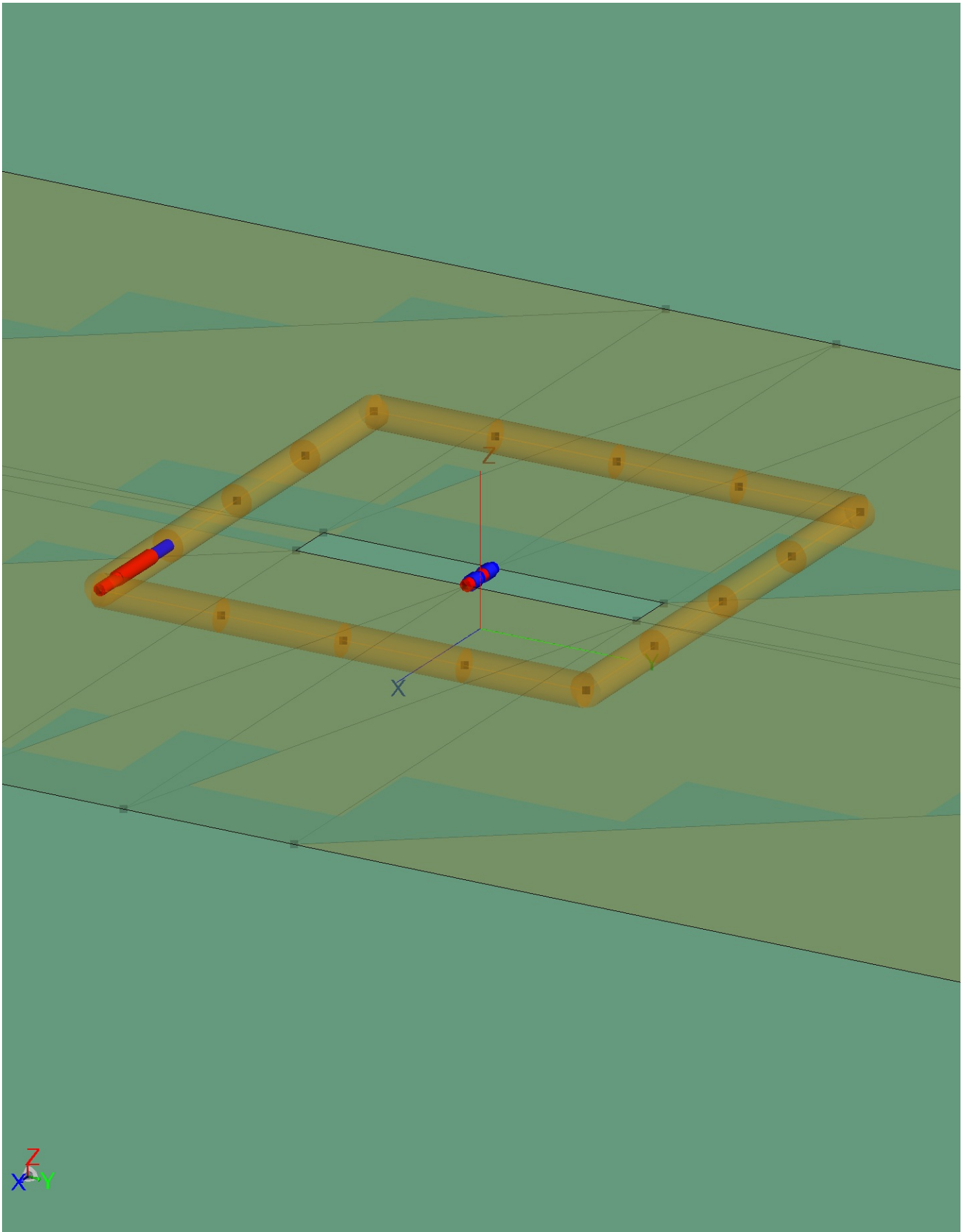
EDGES is sensitive to slot resonances and the problem of resonances is discussed in memos 168, 207, 208, 241, 407 and 408. A slot resonance was clearly present at 75 MHz as discussed in memos 407 and 408. This resonance was eliminated by adding screws to reduce the length of the slots between the baseplate and the steel frame structure that is welded to the ground plane mesh. The details of this frame are in ASU memo 162 and photos of the antenna and baseplate are in memo 406.

Following the removal of the resonance from the EDGES-3 data there is still a concern that there are other resonant slots in the ground plane. The details of this concern are discussed in memo 421. Figures 2 and 3 of memo 421 show the residuals from data taken from day 54 to 174 with and without nighttime data respectively. A further study of the bumps in the residuals along with simulations of the possible locations of resonant slots is made in memo 429 and based on these potential locations an inspection of the ground plane has been suggested and it is suggested in memo 407 that a potential slot with a gap in the 0.01 mm range should be tested for resonance using a VNA connected to the center of the slot using "crocodile" clips. However a FEKO simulation shows that a direct connection to the slot with a VNA will "damp out" the resonance and hence is not an adequate test.

Figure 1 shows a loop antenna made with 10 cm on a side placed 1cm above a slot with the dimensions given in memo 429 and Figure 2 shows the S11 which is obtained with a 0.1 dB dip at 63 MHz. Figure 3 shows the FEKO model with a direct connection and Figure 4 shows that the direct connection smooths out the presence of a resonance. This is not unexpected because a direct connection of the VNA to the slot loads it with 50 ohms.

Figure 5 an update of figure 2 of memo 421 shows the spectra from EDGES-3 at the WA for day 54 to 283. This is close to what is seen in memo 421 with lower noise owing to the increased amount of data.

In summary a loop antenna connected to a portable VNA should be tested as it might be what is needed for a complete survey of a ground plane put together with a geometry that is not guaranteed to be resonant free in the EDGES frequency range. If a survey is not practical perhaps shorting out every slot within 10m of the antenna with a gap under 0.01 mm with a metal hose clamp might be a solution.



Altair Feko™

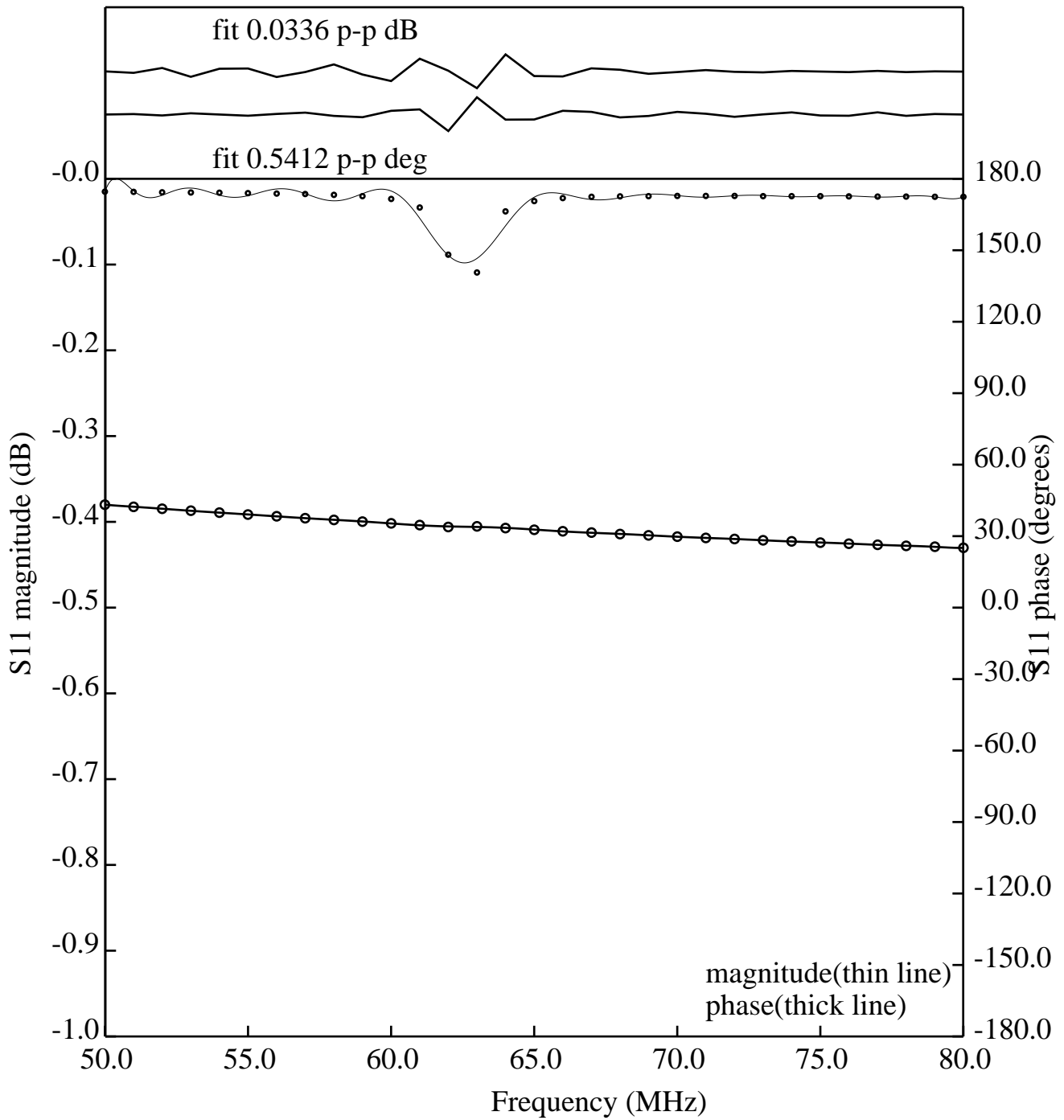
Figure 1. FEKO model of a loop antenna placed above slot in a ground plane on soil.

test7 2023-10-11 18:09

View direction

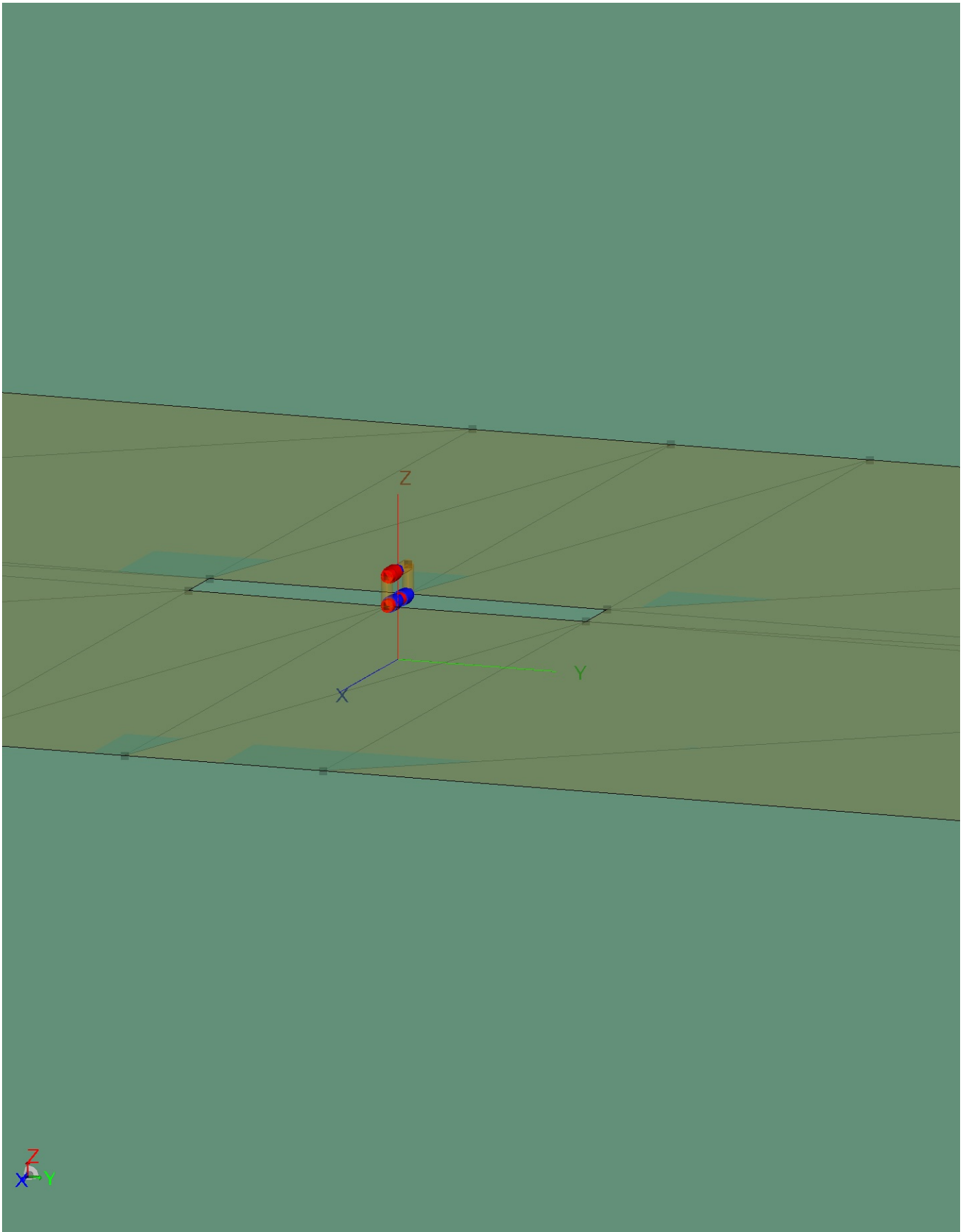
Theta = 68°

Phi = 29°



20 term Fit to antenna S11 rms diff 0.006 dB 0.077 deg
 file: azelq.csv

Figure 2. S11 results from the FEKO model with soil dielectric constant 3.5 and conductivity 1e-2 S/m.



Altair Feko™

Figure 3. FEKO model direct connection to a slot in a ground plane on soil.

test7 2023-10-11 14:51

View direction

Theta = 77°

Phi = 20°

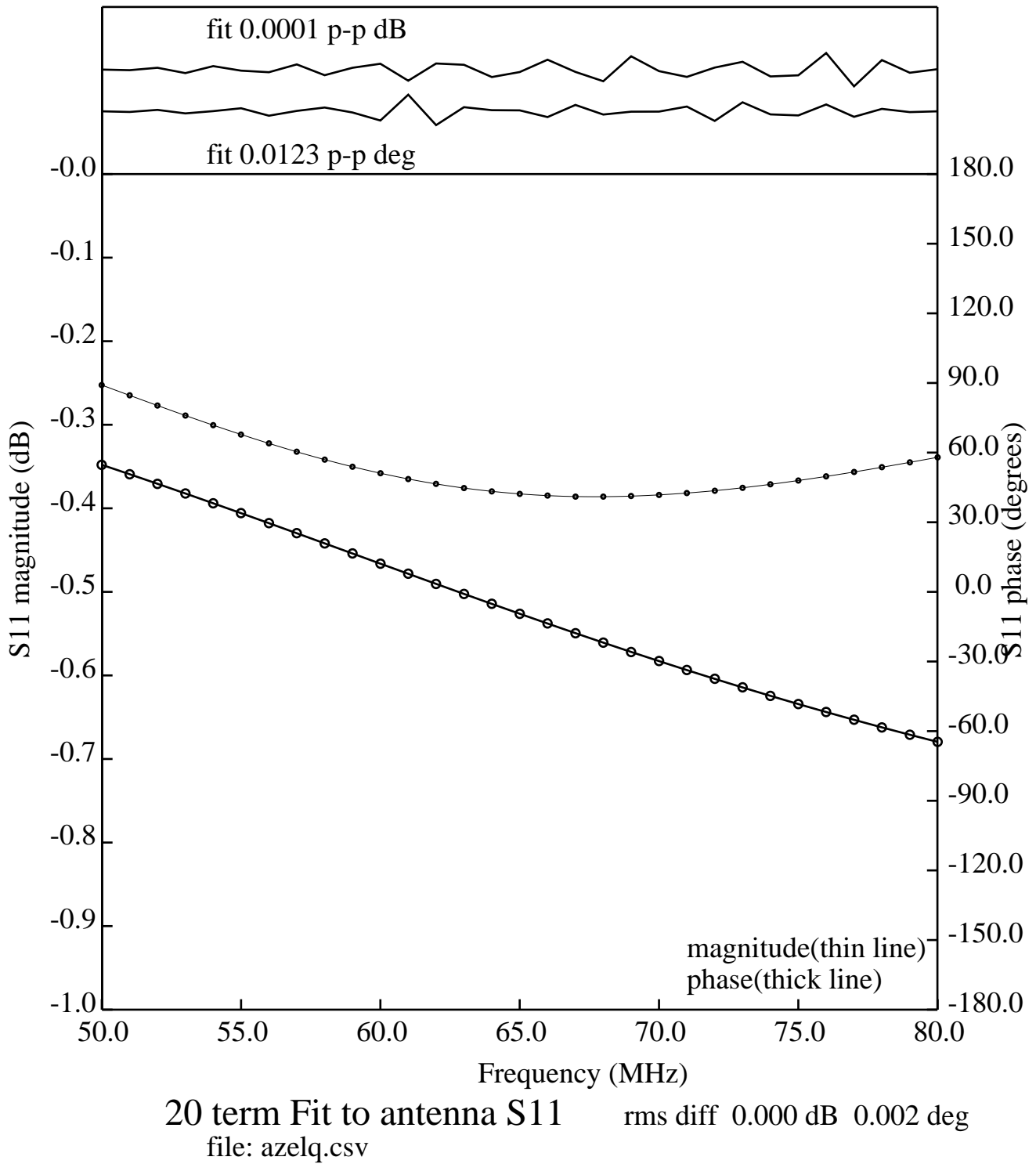
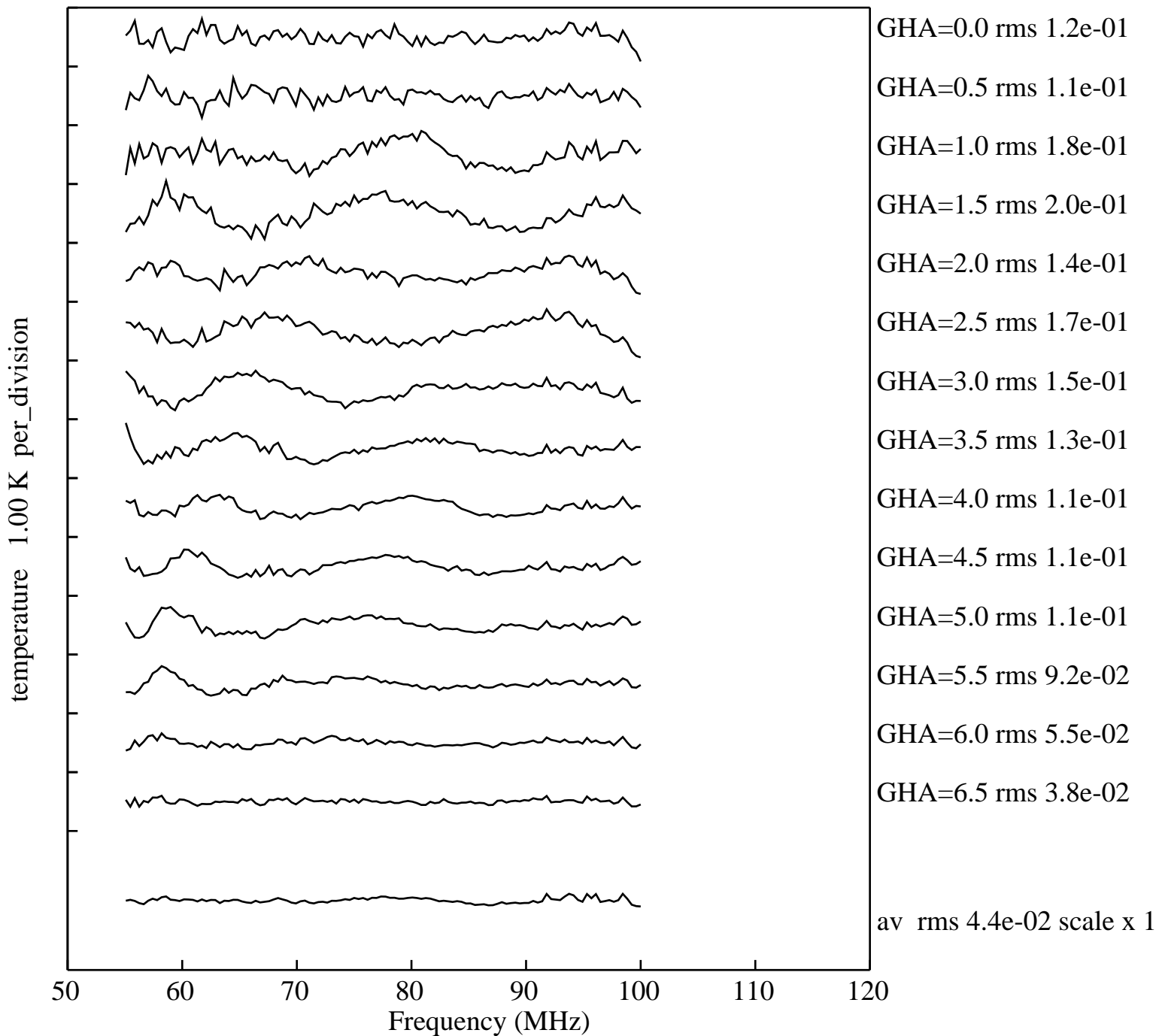


Figure 4. S11 results from the FEKO model with soil dielectric constant 3.5 and conductivity $1e-2$ S/m.



avrms 0.1228

Figure 5. Residuals with 5 physical terms removed for 30 min blocks from 0 to 6.5 hours GHA for data from 2023 day 54 to 283.