MASSACHUSETTS INSTITUTE OF TECHNOLOGY
HAYSTACK OBSERVATORY
WESTFORD, MASSACHUSETTS 01886

July 26, 2016

Telephone: 781-981-5414
Fax: 781-981-0590

To: EDGES Group

From: Alan E.E. Rogers

Subject: Evidence of possible resonance at 70 MHz in the low band data.

Figure 1*a* shows the low band data from 62 to 80 MHz with a 4 term polynomial removed vs GHA 8 to 16 hrs with no beam correction. A narrow dip centered at 70 MHz is seen clearly at 9, 10, 11 and 12 hrs. Figure 1a uses all the available data from 2015_286 to 2016_189. Tests show that the "dip" is present in the first and second half on the data and in both daytime and nighttime data. Figure 1b shows the residuals over the full range of GHA and Figure 1c shows the result with beam correction using dielectric constant 2.0 and conductivity $2e^{-2}$ S/m. Given the narrow frequency width of the dip the beam correction has little effect in the 8 to 16 hr range. Fairly strong ripples can be seen at GHA 19 and 20 hrs. These are consistent with the simulation of reflections from the hut. Assuming the dip at 70 MHz is from a "resonance" the changeover about 2 to 3 hours suggest at distance from the antenna up to about 10 m. If the resonance was from the region of the hut, which is 50 m from the antenna change with GHA would be more rapid.

Figure 2*a* shows the residuals over 50 to 99 MHz. The narrow dip at 70 MHz is most evident at GHA 10 hrs. The wider frequency range shows other relatively narrow feature which change from one hour to the next. For example at 90 MHz between 14 and 15 hrs.

Figure 2b shows the spectra using only nighttime data. Apart from a small change at 90 MHz for GHA =14 hrs the spectral features are very close to those of Figure 2a. The other tests were a comparison of the first and second half of the data and the exclusion of data with the moon above the horizon. These show little difference above the noise. Figure 2c shows the spectra using a beam correction with soil dielectric increased to 3.5. The changes are relatively small. Figure 2d shows the spectral residuals over the full range of GHA. It is noted that the sharp dip at 72 MHz at GHA= 2 hrs is probably produced by the same mechanism at the dip at GHA= 10 hrs.

Figure 3*a* shows simulations based on FEKO models for different soil dielectric and conductivity as well as ground plane irregularity. In each case the reference was the beam chromaticity using dielectric constant 2.0 and conductivity $2e^{-2}$ S/m. The plots are for ground plane panel slopes measured, and inner panel raised by 2 cm, dielectric 3.5 and conductivity $2e^{-2}$ and dielectric 3.5 and conductivity $2e^{-3}$.

In most cases there is little change from one hour to the next and except the case of the lower conductivity the spectra are smooth in frequency. Figure 3b shows the simulations over the full range of GHA. Note the change of scale. As expected the rms deviations are much larger within a few hours of Galactic center transit. The deviations are largest for the case of low conductivity. None of the simulations explain the sharp dip at 70 MHz at GHA 10 hrs and the associated sharp dip at GHA 2 hrs. The simulations in Figure 3, except for the low conductivity, are all within the range of reasonable variations in the current ground plane and soil properties.

Figures 4*a* and 4b attempt to simulate an “effect” which might explain the dip at 70 MHz and the residual spectra in Figure 2d. The figures show the residuals to a simulation of a resonant structure close to the eastern edge of the ground plane. A structure on the east side produces beam effects that are larger after Galactic center transit.

The first resonant structure considered is a quarter wavelength metal rod lying on the ground at a distance of 6m from center of blade antenna. The residuals to a 5-term are shown in Figure 4a. The second resonant structure considered is a capacitevely loaded slot of 30 cm in length formed at the overlapping mesh panels at a distance of 4m from the blade antenna. The orientation of the length of the slot is perpendicular to the currents in the ground plane. The capacitance of 24 pf could be produced by the overlapping portions of the mesh which fail to make contact with each other. The residuals are shown in Figure 4b. While neither structure accurately reproduce the spectral residuals shown in Figure 2d both structures result in the characteristics which are seen in EDGES data:

1] Large fine frequency structure from GHA 0 to 5 hrs

2] Less structure before Galactic transit than after transit.

3] Some structure at GHA 10 hrs especially in the case of a resonant slot.

Figure 5 illustrates the sources of resonance simulated using FEKO. While there is no definite indication in the EDGES low band data of a resonance in the ground plane there is concern that resonances can be formed at the joints between panels. Resonances had been seen in previous high band deployments and are discussed in memos 138, 140, 150, and 168. Memo 168 discusses the capacitevely loaded slot resonance. This type of resonance is recognized by the studies of electromagnetic shielding. For high isolation a spacing of less than 1/20 wavelength, which is about 6 inches for the high end of the low band is recommended for the screw spacing on box lids. Figure 5 emphasizes the potential for capacitive loading, which lowers the resonant frequency, when panels are overlapped.

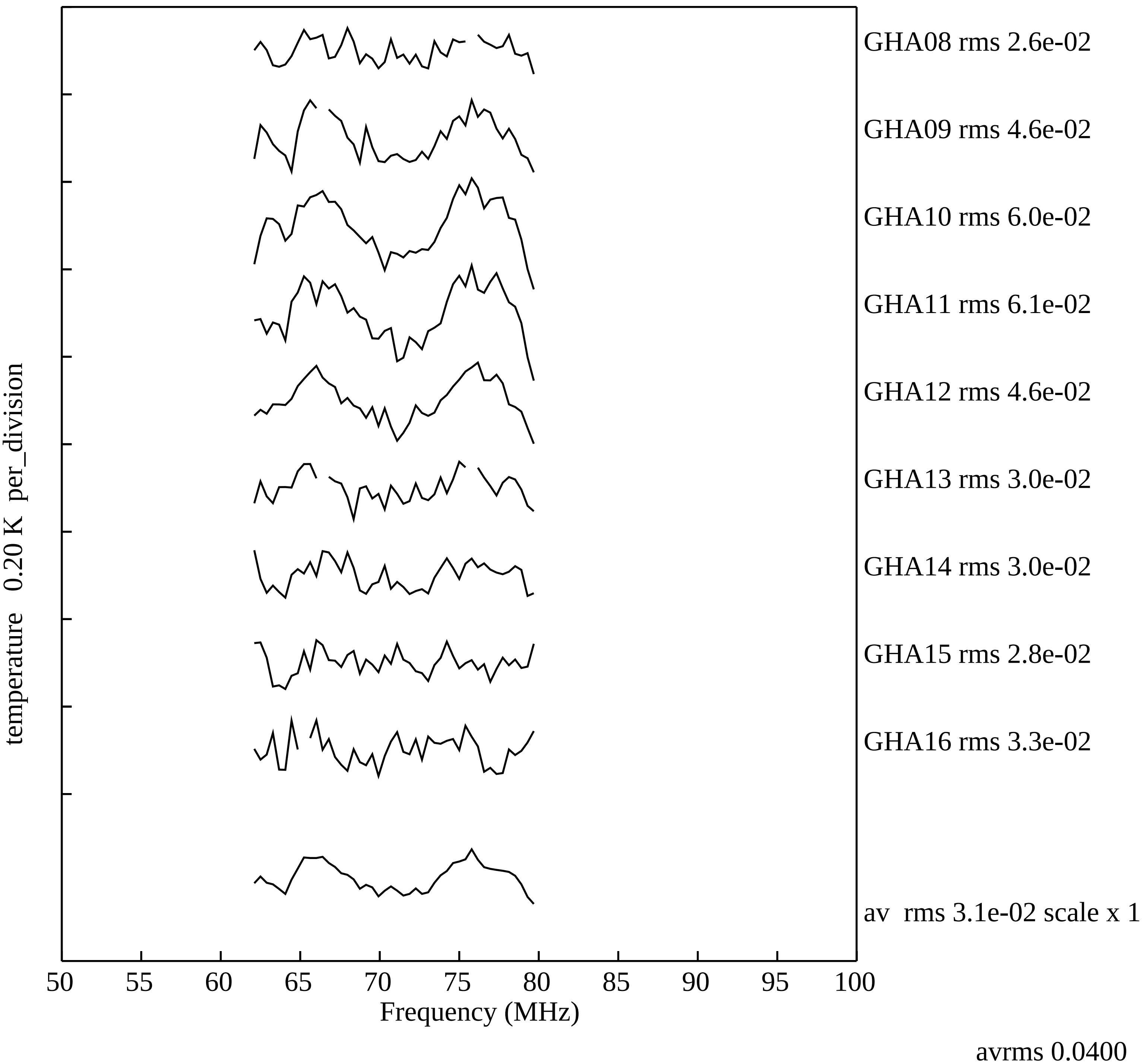


Figure 1a. Residuals to 4-term polynomial fit without beam correction.

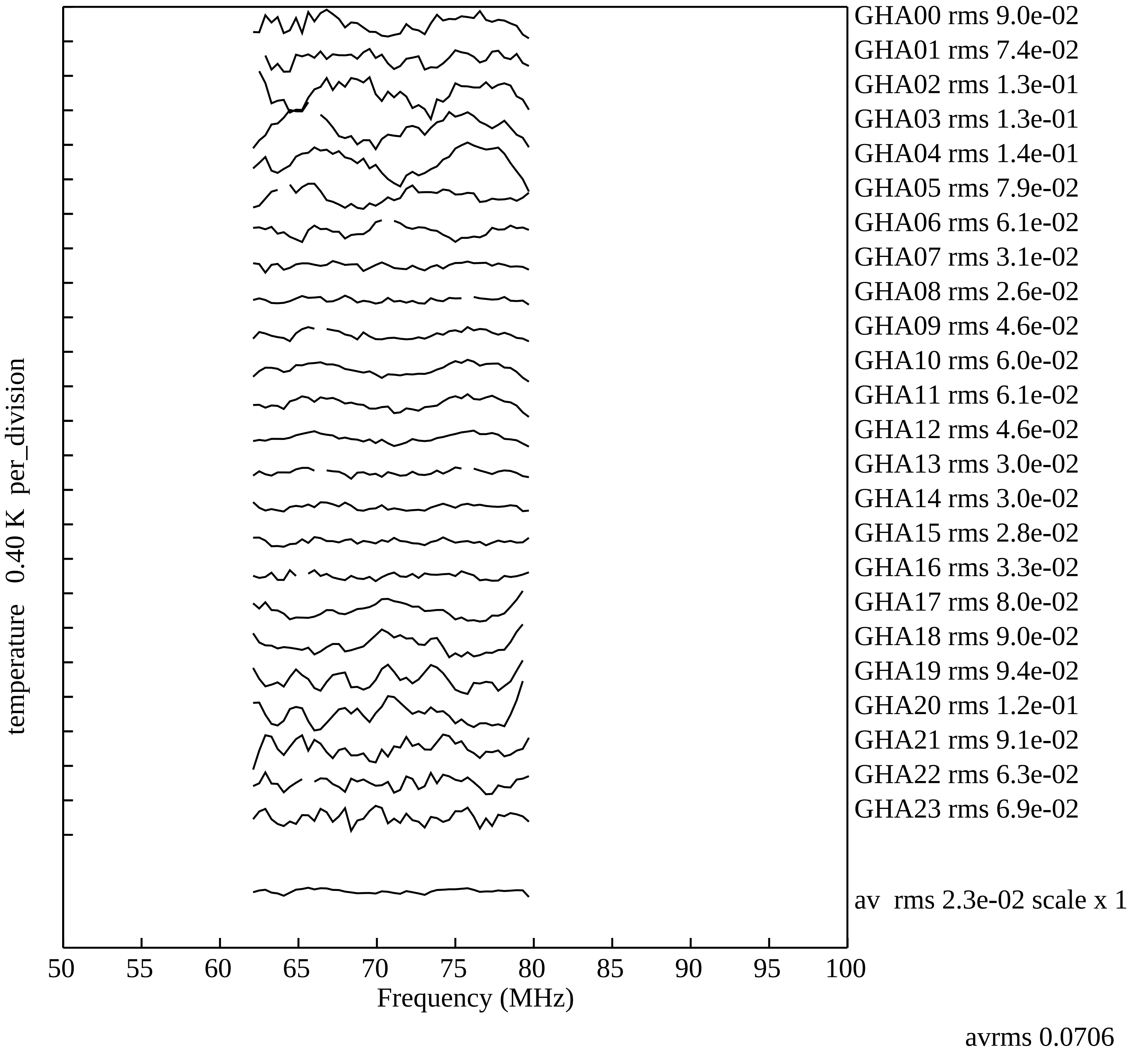


Figure 1b. Residuals over full range of GHA. Note scale change.

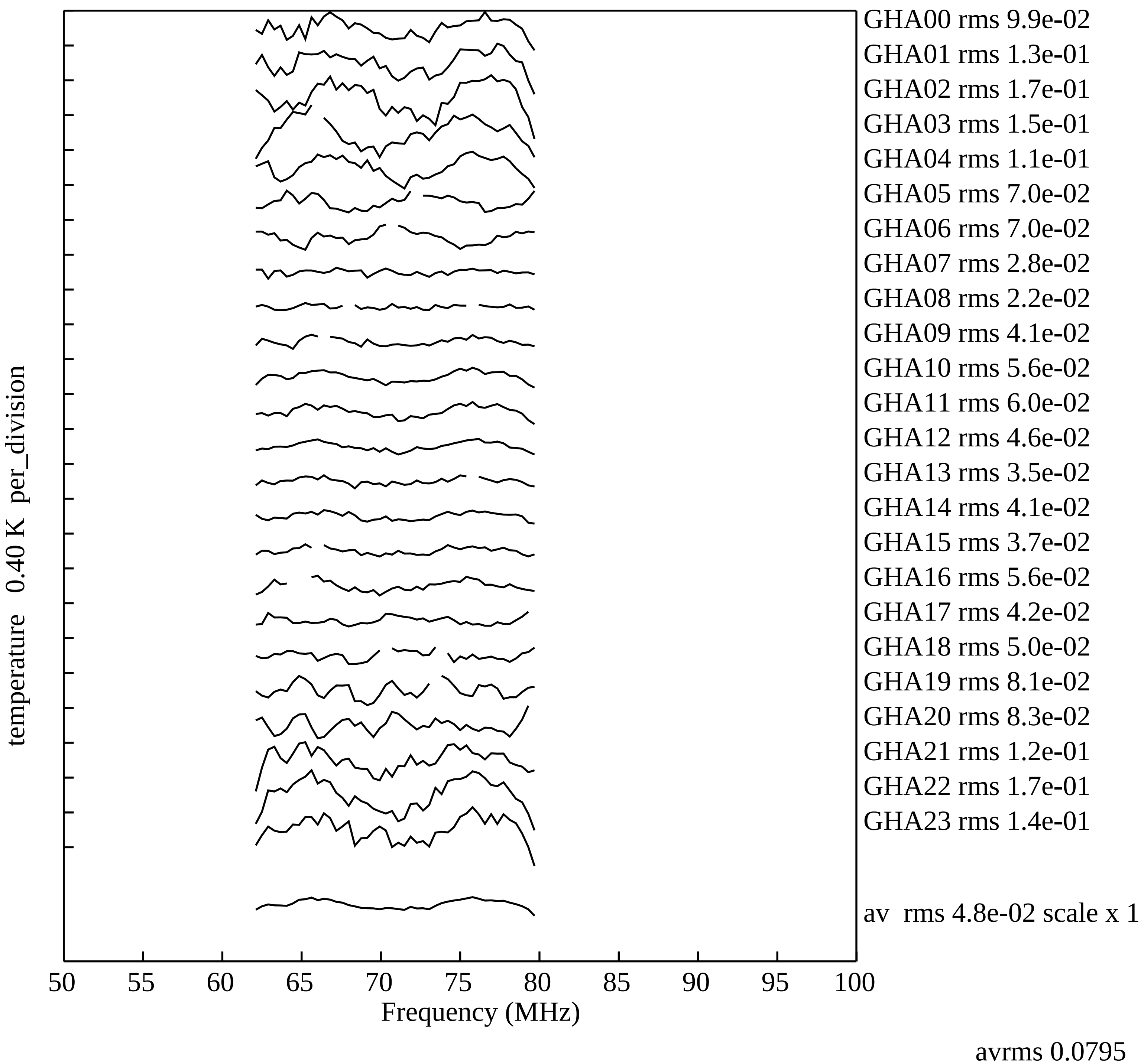
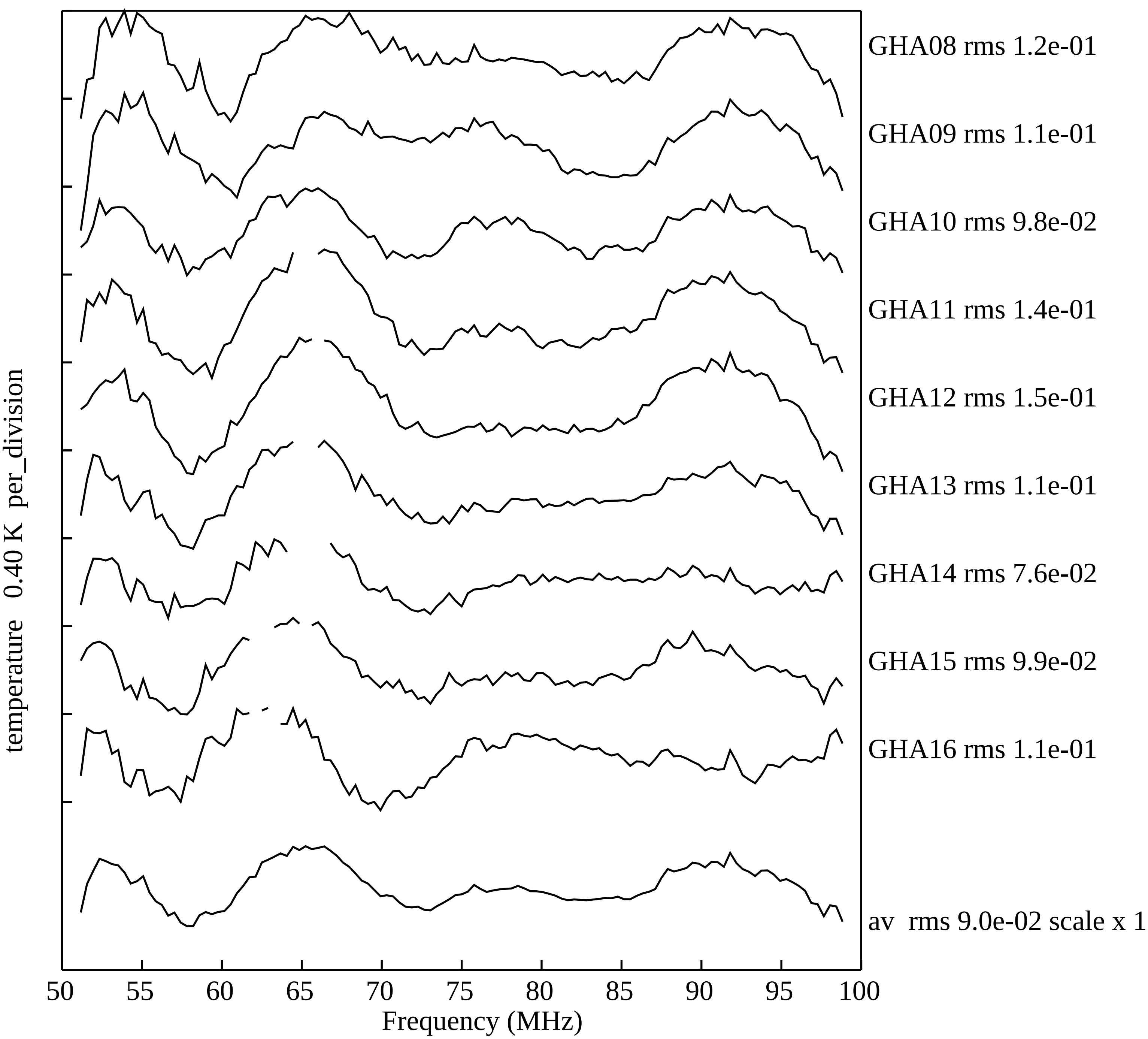


Figure 1c. Adding beam correction using dielectric constant 2.0 conductivity 2e-2 S/m.



avrms 0.1125

Figure 2a. Residuals to 5-term polynomial fit with beam correction dielectric 2.0 conductivity 2e-2 S/m.

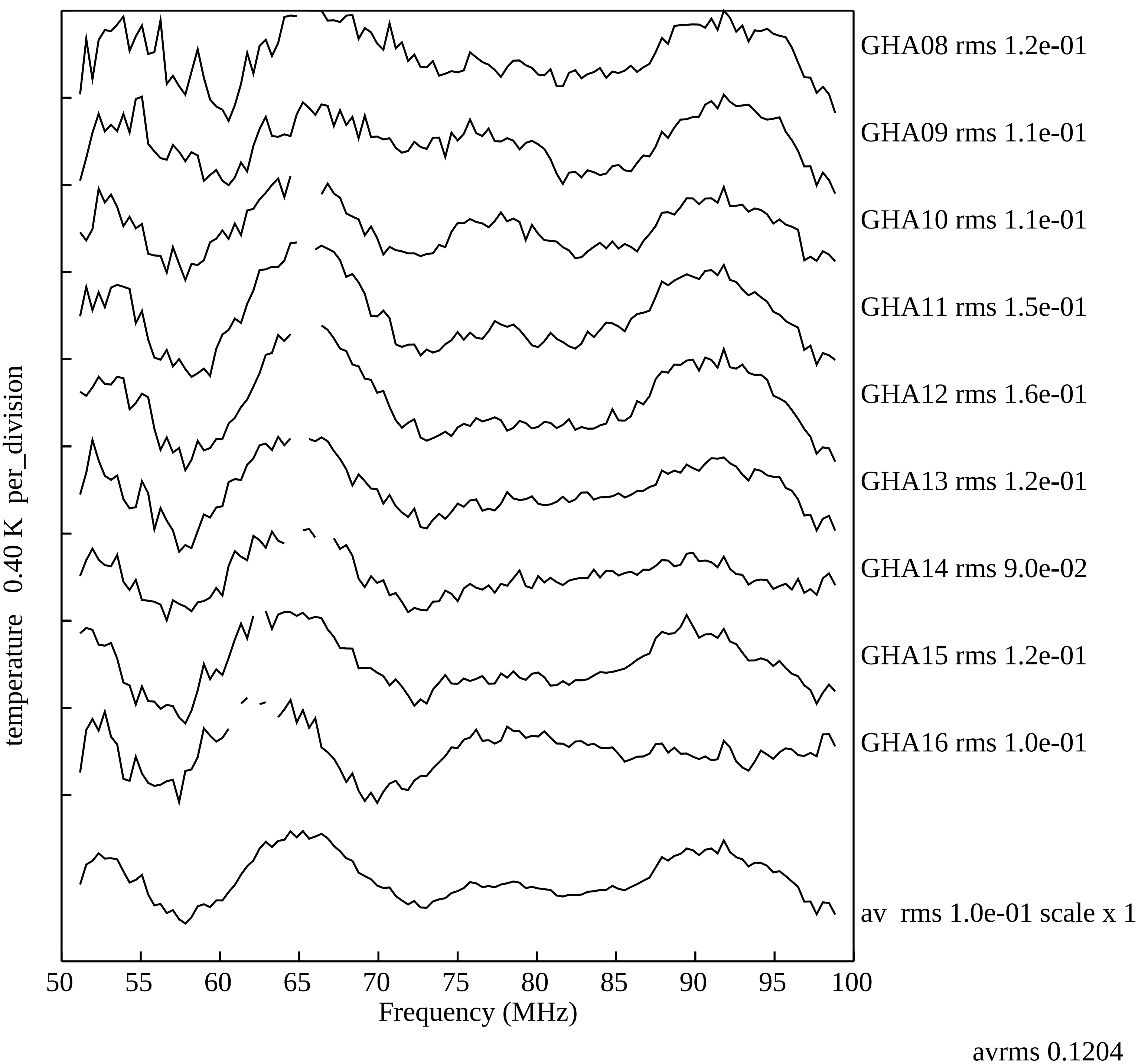


Figure 2b. Nighttime only.

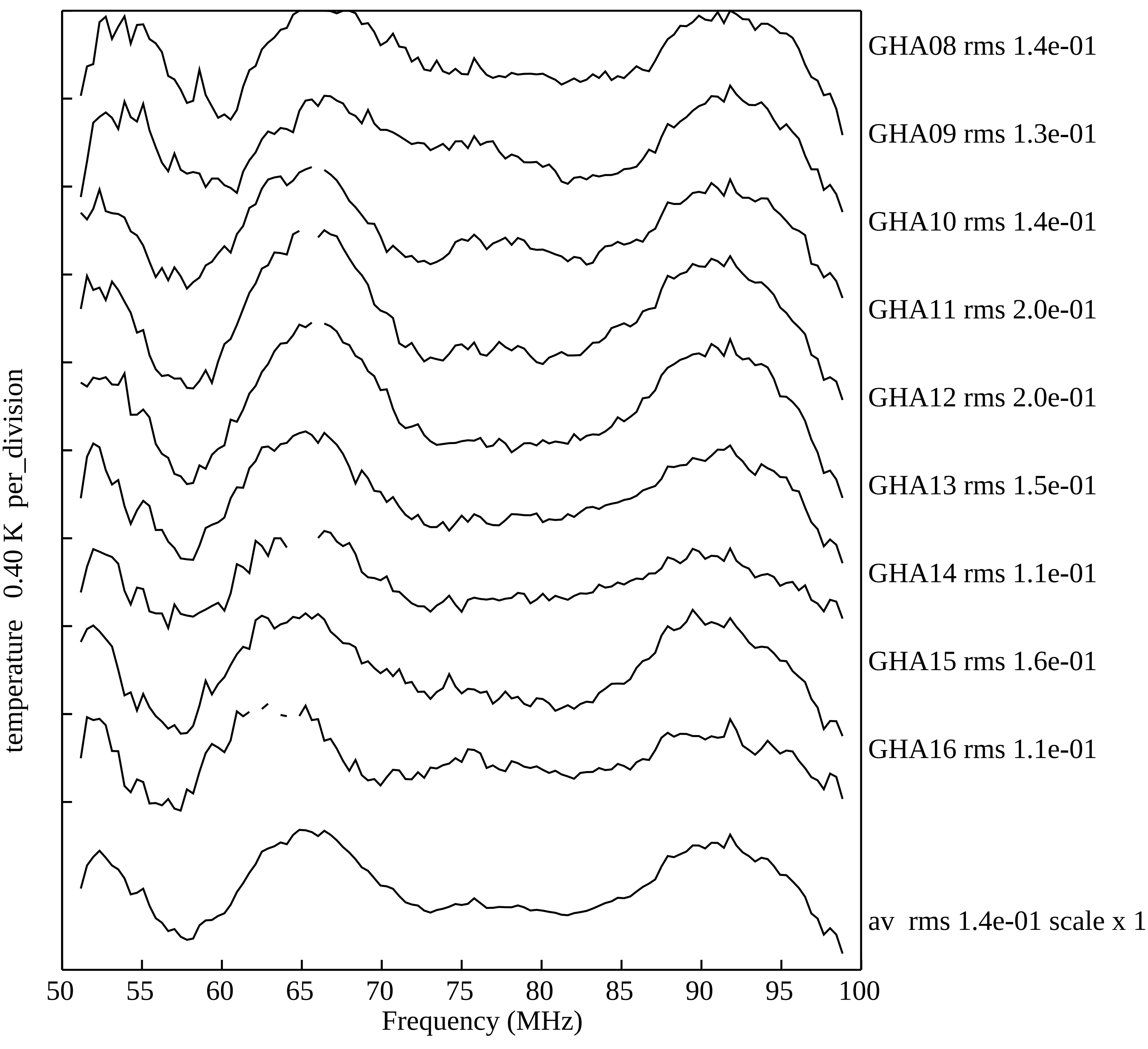


Figure 2c. Beam correction with dielectric 3.5 and conductivity 2e-2 S/m.

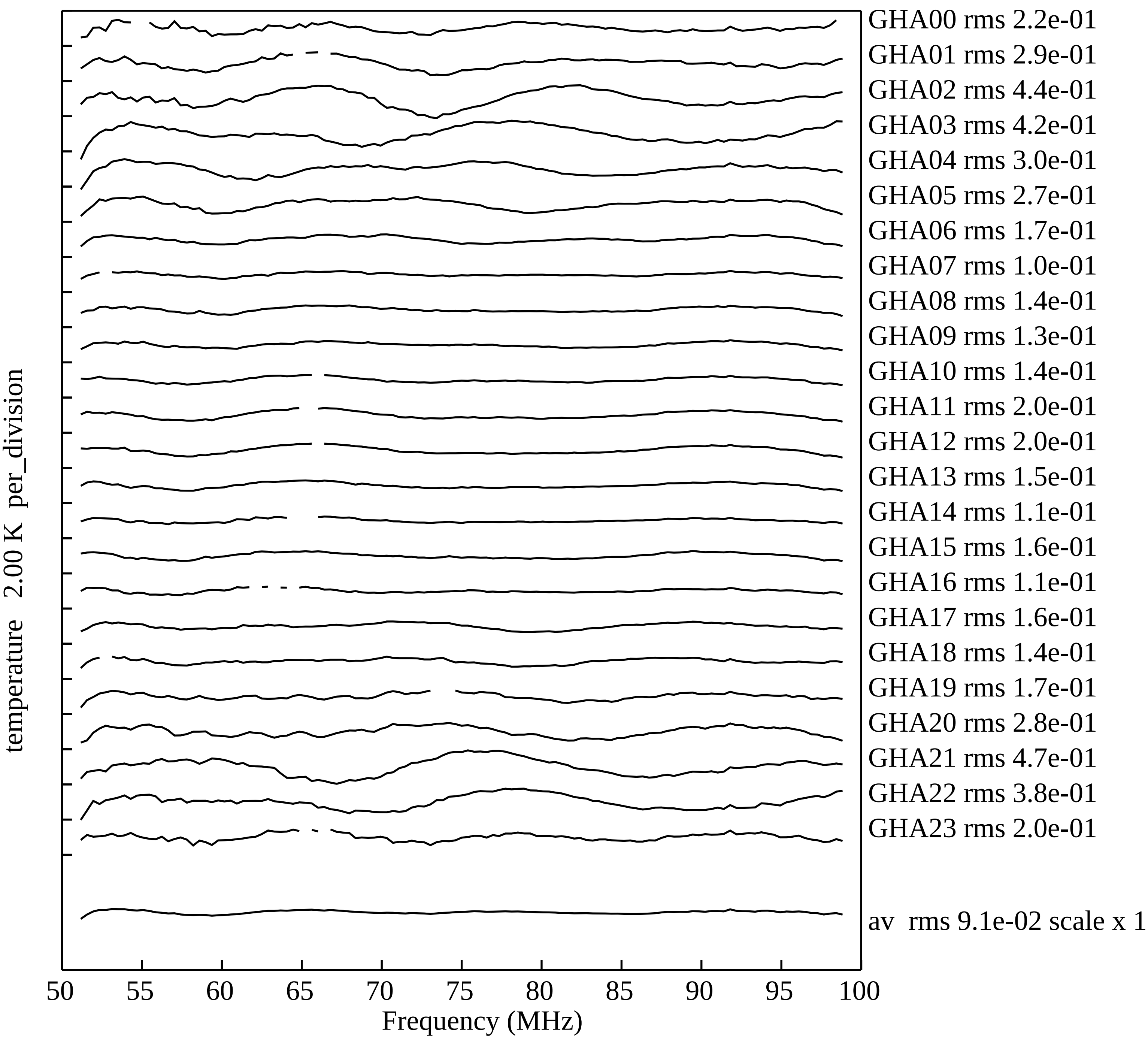


Figure 2d. Beam correction with dielectric 3.5 and conductivity 2e-2 S/m.

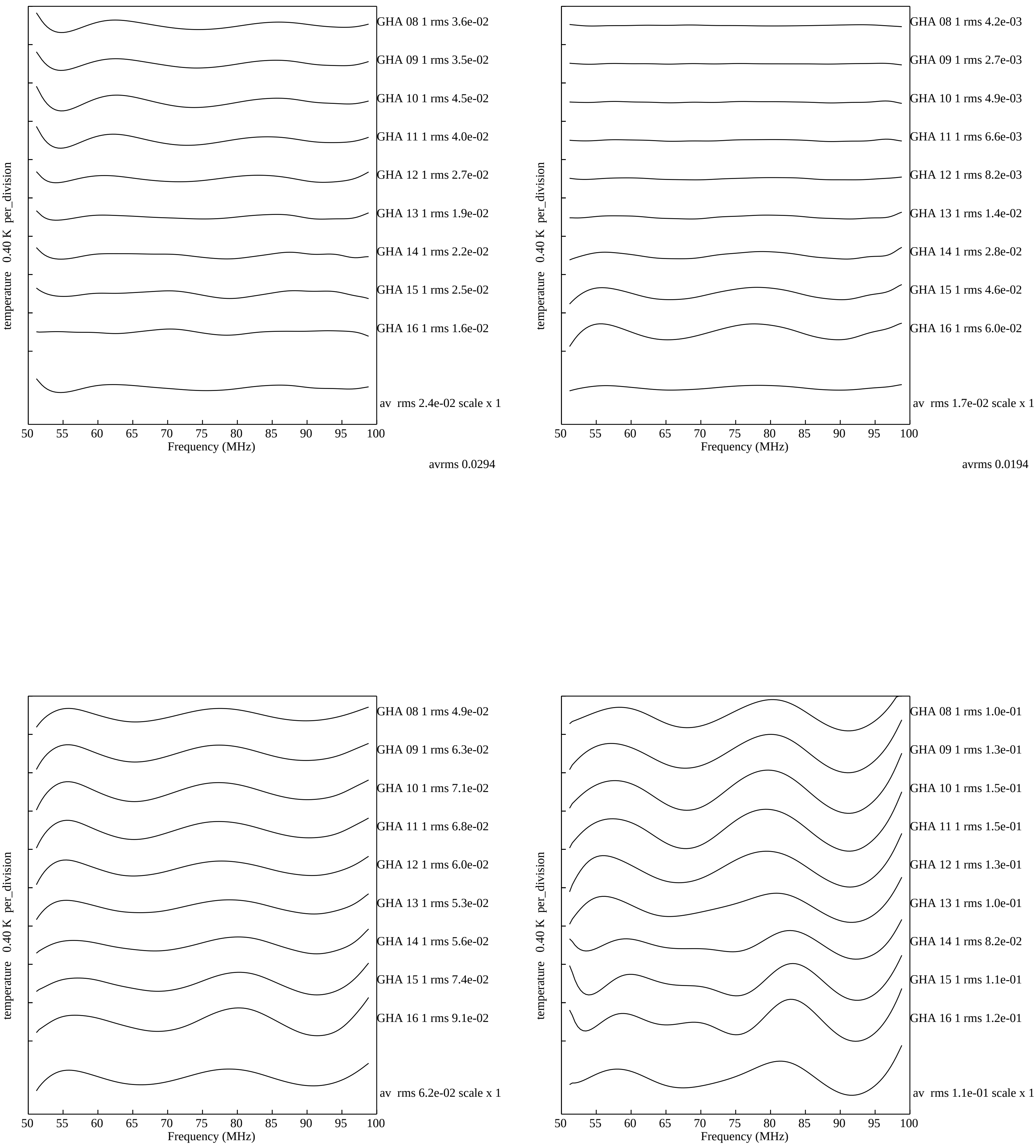


Figure 3a. Simulations of panel slope, panel displacement change in dielectric and conductivity.

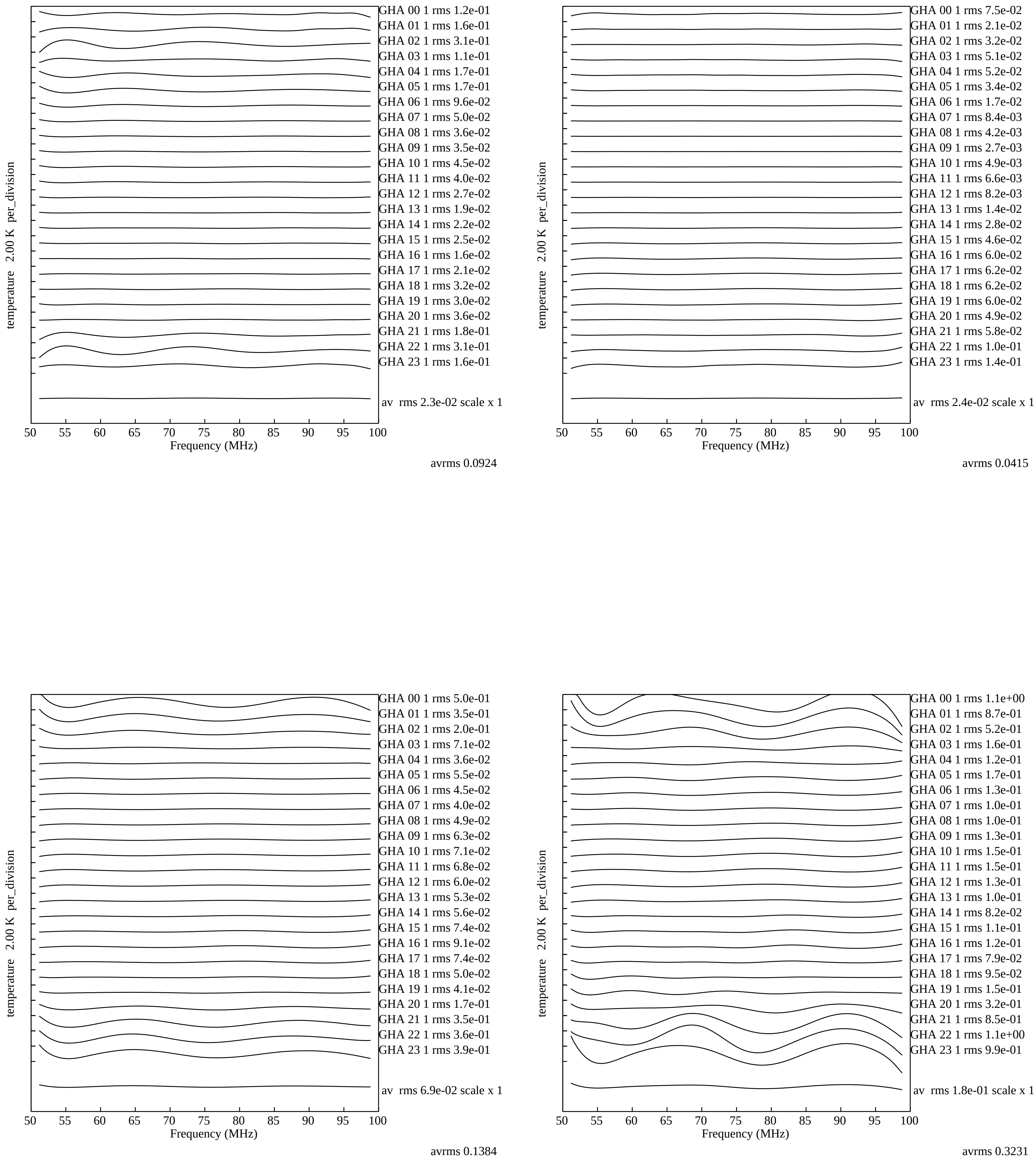


Figure 3b. Simulations over full range of GHA.

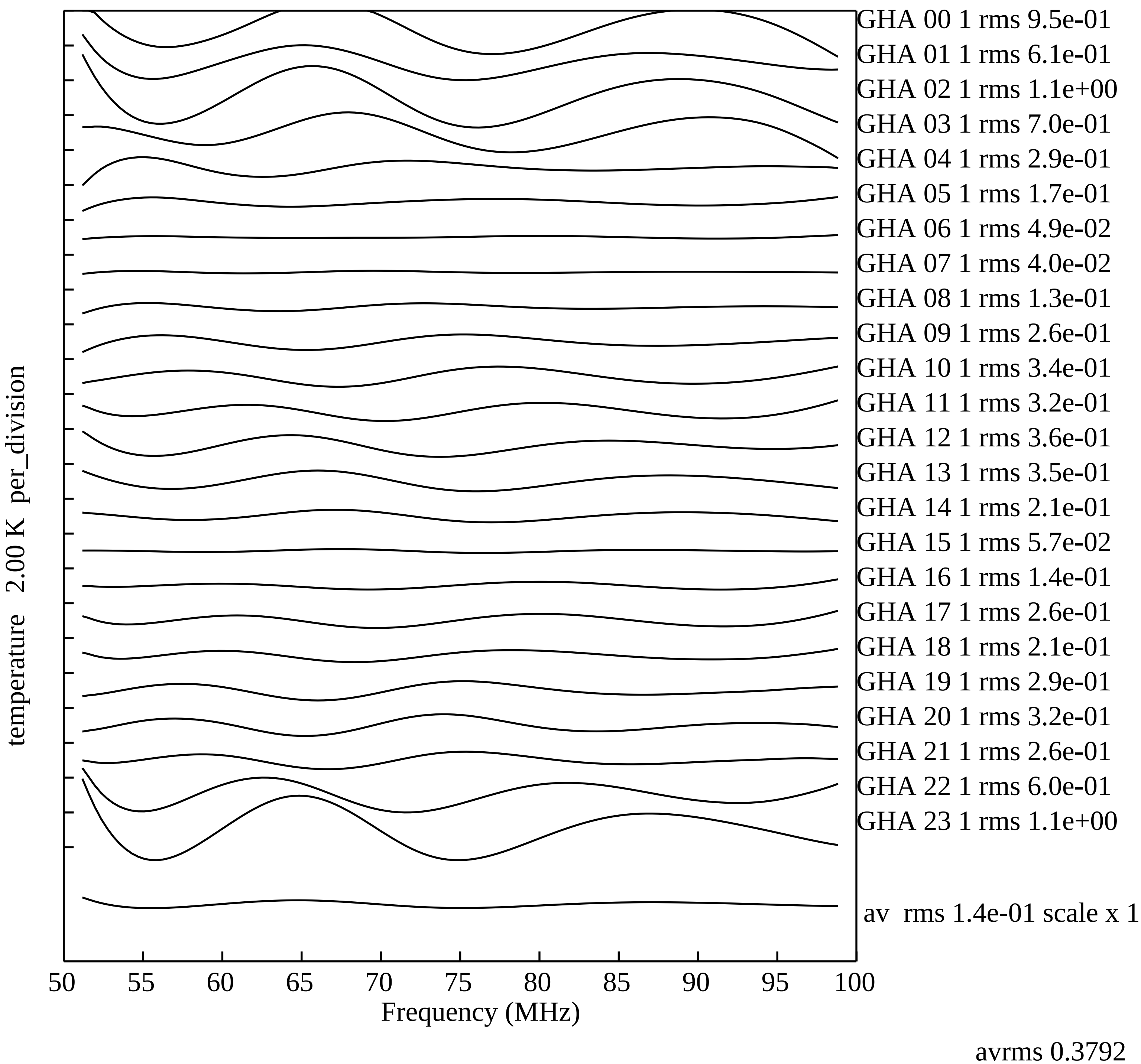


Figure 4a. 5-term residuals for simulated beam effects of rod resonance.

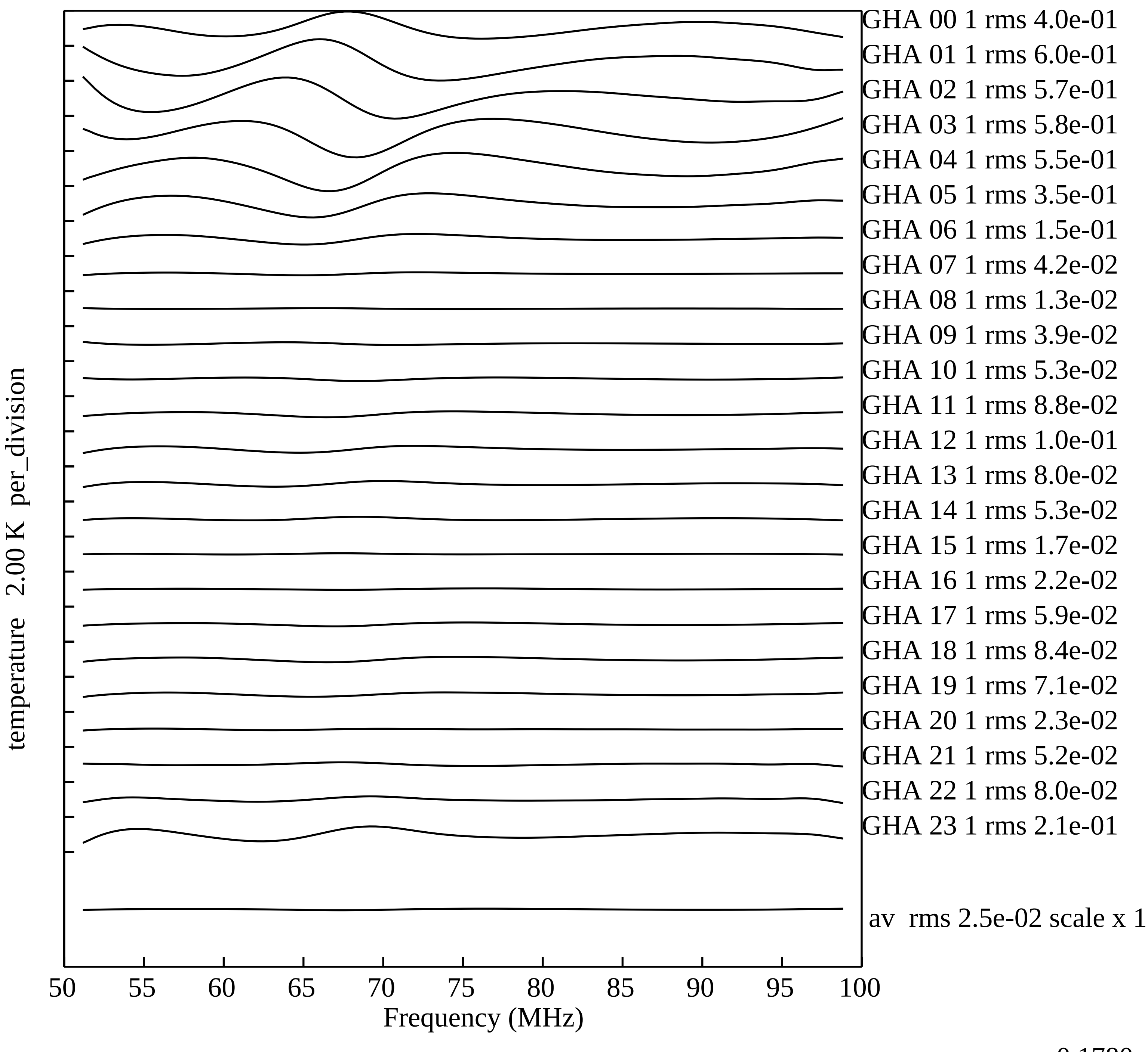


Figure 4b. 5-term residuals for capacitively loaded slot resonance.

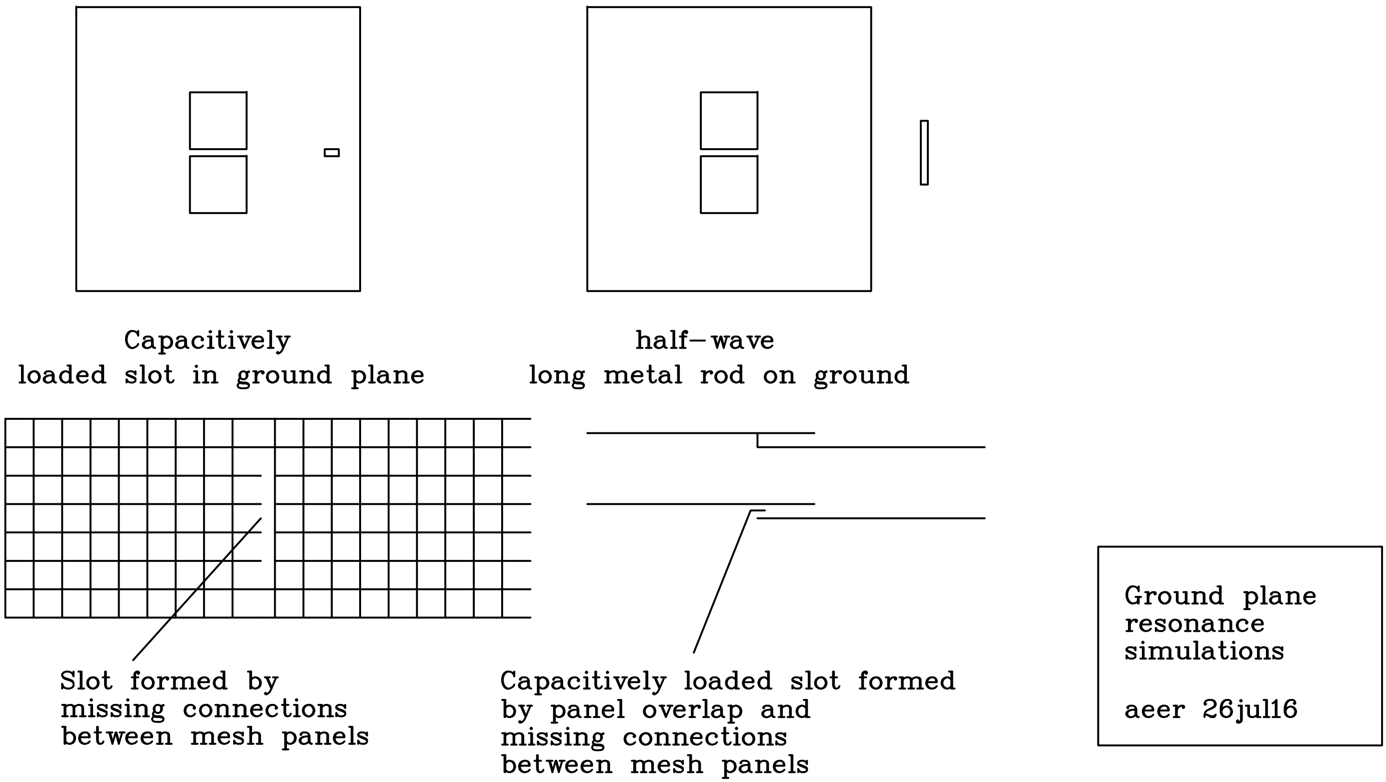


Figure 5. Sketch of slot and rod resonance models - see text for details.