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To: EDGES Group

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Subject: Simulations of 30x30m uneven ground plane with random panel offsets

Random height offsets of plus and minus 2.5 cm for 2.5x2.5m square panels and 5x5m triangles on PEC are modeled to approximate the effects of bumps and dips in the EDGES 30x30m ground plane.

Figure 1 shows the ground plane panels on the left and on the right shows just the panels raised by 2.5 cm to form bumps above the other panels which are lowered by 2.5 cm to form dips on a PEC ground plane for the first random selection of raised and lowered panels. This arrangement is chosen to get a "first order" estimate using a relatively simple FEKO model that runs in about an hour for a frequency range of 50 to 100 MHz in 2 MHz steps. All panels are connected to the PEC ground at the edges of the panels. The peak to peak variation across the ground plane is 5 cm. The average height of panels is 7.5 cm above the infinite PEC ground.

The FEKO model beam with random bumps and dips was used to simulate midband data with antenna pointed north and processed using a "reference" model beam with all panels at 7.5 cm height on the PEC ground plane.

Figure 2 shows the difference of the beam with random bumps and dips compared with the reference beam for the random selection 1 and the complement of selection 1 for 66 and 96 MHz.

random selection	reference map	average1 rms mK	average2 rms mK
1	Haslam	79	68
2	Haslam	56	47
3	Haslam	56	78
3	Guzman	38	47

Table 1. Effects of randomly selected ground plane panels with +/- 2.5 cm deviation

The average1 and average2 rms are the average of the rms residuals for the selection and the complement for which the bumps become dips respectively. The average of the residuals are for each hour of GHA 5-physical terms removed 55-98 MHz. The rms values are lower when the Guzman map is used because the 5 degree resolution Guzman map is insufficient to match the fine scale of the structure in the beam due to the uneven ground plane. This is most important in the Galactic center region for which the approximately 1 degree resolution of the Haslam map is needed. Figure 3 shows the residuals vs GHA for the first entry of Table 1.

Some tests were also done of the effects of a signature search when the Nature result is added to the sky map in generation of the simulated data. The search results for 4 hour blocks for random selection 3 are in Table 2.

GHA	center freq MHz	SNR	Amp	width MHz	rms1 mK	rms2 mK
00	72.2	21	0.87	29.9	67	30
04	78.1	22	0.47	20.3	56	24
08	78.1	164	0.50	19.4	62	39
12	78.1	38	0.52	19.0	67	19
16	73.1	19	0.79	29.9	59	27
20	74.4	41	0.69	17.1	116	28

Table 2. Simulation of signature search using random selection 3

These simulations show that departure from a flat ground plane at the level in these simulations can result in enough systematic structure in the beam to make it difficult to recover the global absorption over all GHA using 4 hour blocks and the ability to recover the absorption with 1 hour blocks even more difficult without a more even ground plane or site where the Galactic center is always below the horizon as discussed in memo 345.

There is a surprisingly high sensitivity to ground plane deviations from flatness of only 5 cm peak to peak. However, in this analysis 80 panels are perturbed from the average height and tests with only a single perturbed panel find it needs to be perturbed by about 20 cm to produce an average rms of about 80 mK. A very approximate estimate is that the average rms increases with the square root of the number of independently perturbed panels. Simulations of tilt, roll, bumps and dips show that the effects on the residuals are proportional to their magnitude and change sign when tilts and rolls change from positive to negative and bumps change to dips when a reference without tilt, roll, bumps and dips is used. As discussed in memos 337 and 356 the effects of tilt and roll are reduced for an electrically small antenna the effects of a uneven ground plane are not significantly reduced for an electrically small antenna. Figures 4 and 5 show examples of making a change of 4.5 cm height to only one panel of the uneven ground plane of random selection 1.

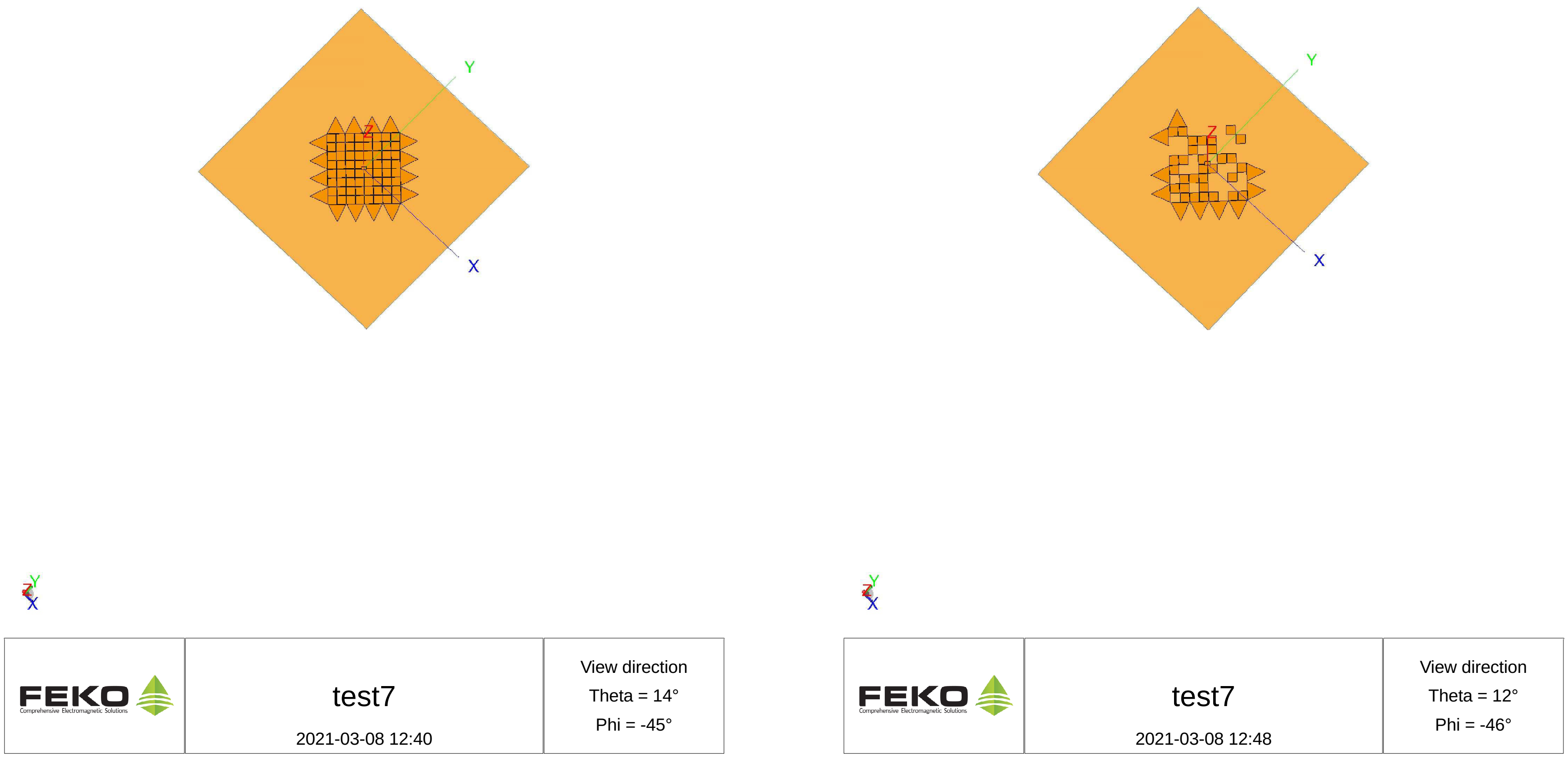

Figure 1. The layout of the panels on the left and only those which are raised above the others of the right for the first random choice. In the FEKO simulation the top of the raised panels height are 10 cm above the PEC, the depressed panels are 5 cm above the PEC while all other panels are at 7.5 cm above the PEC ground.

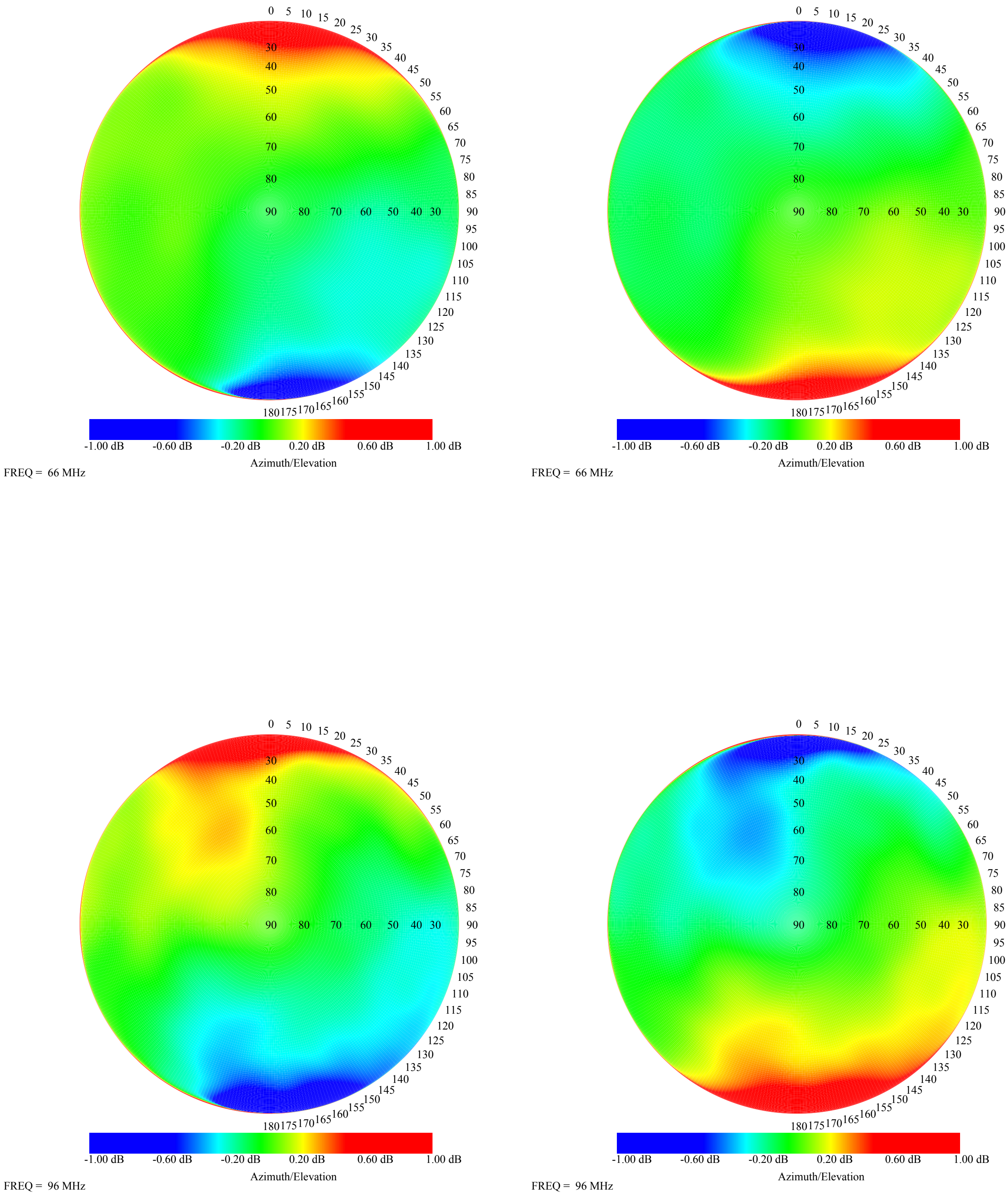

Figure 2. Shows the beams for the first random selection of bumps of the left and for the complement of the first selection for which the bumps becomes dips on the right. The top plots are for 66 MHz while the bottom plots are for 96 MHz.

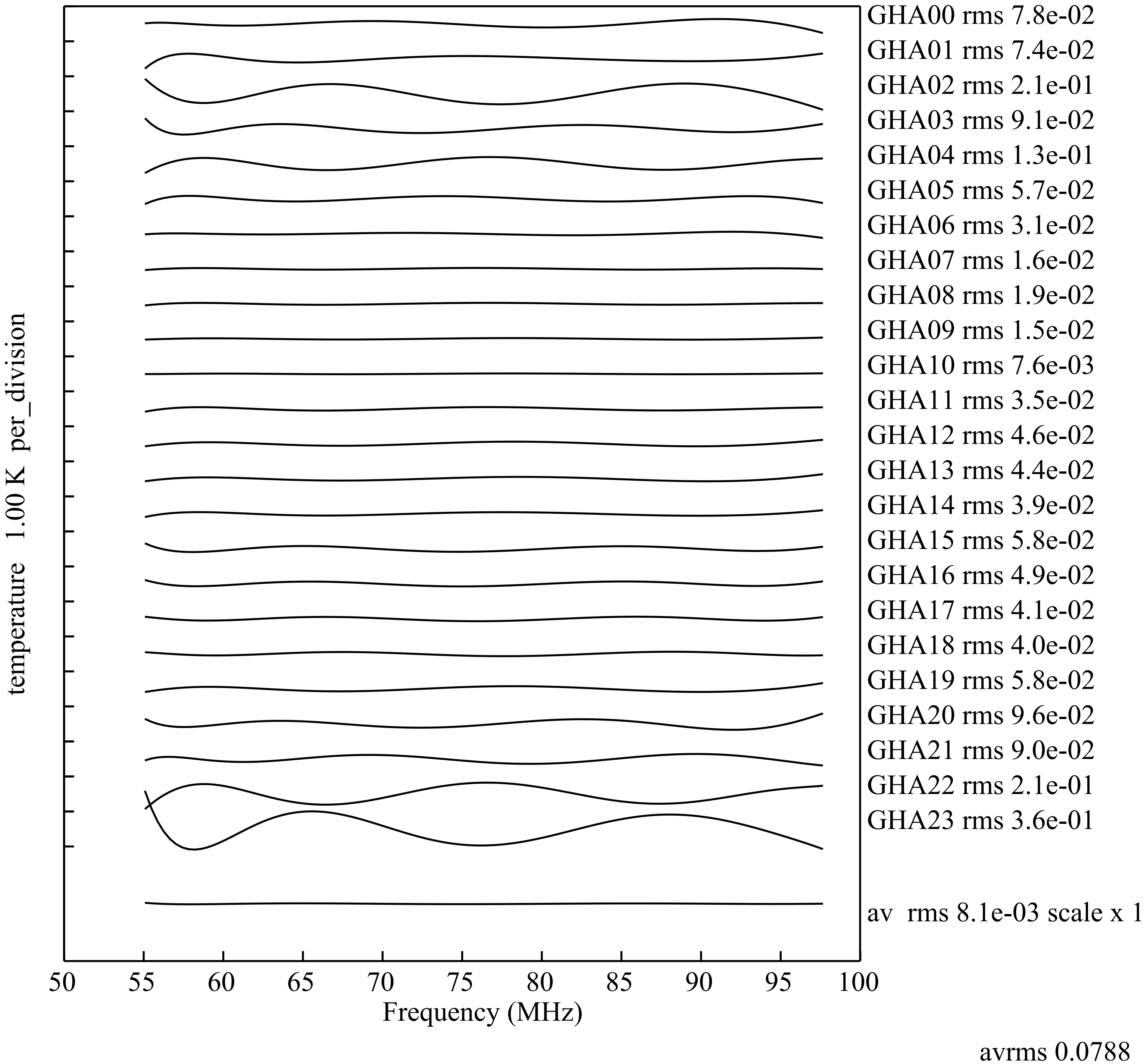

Figure 3. Residuals with 5-physical terms removed for first random selection which is the first entry of Table 1.

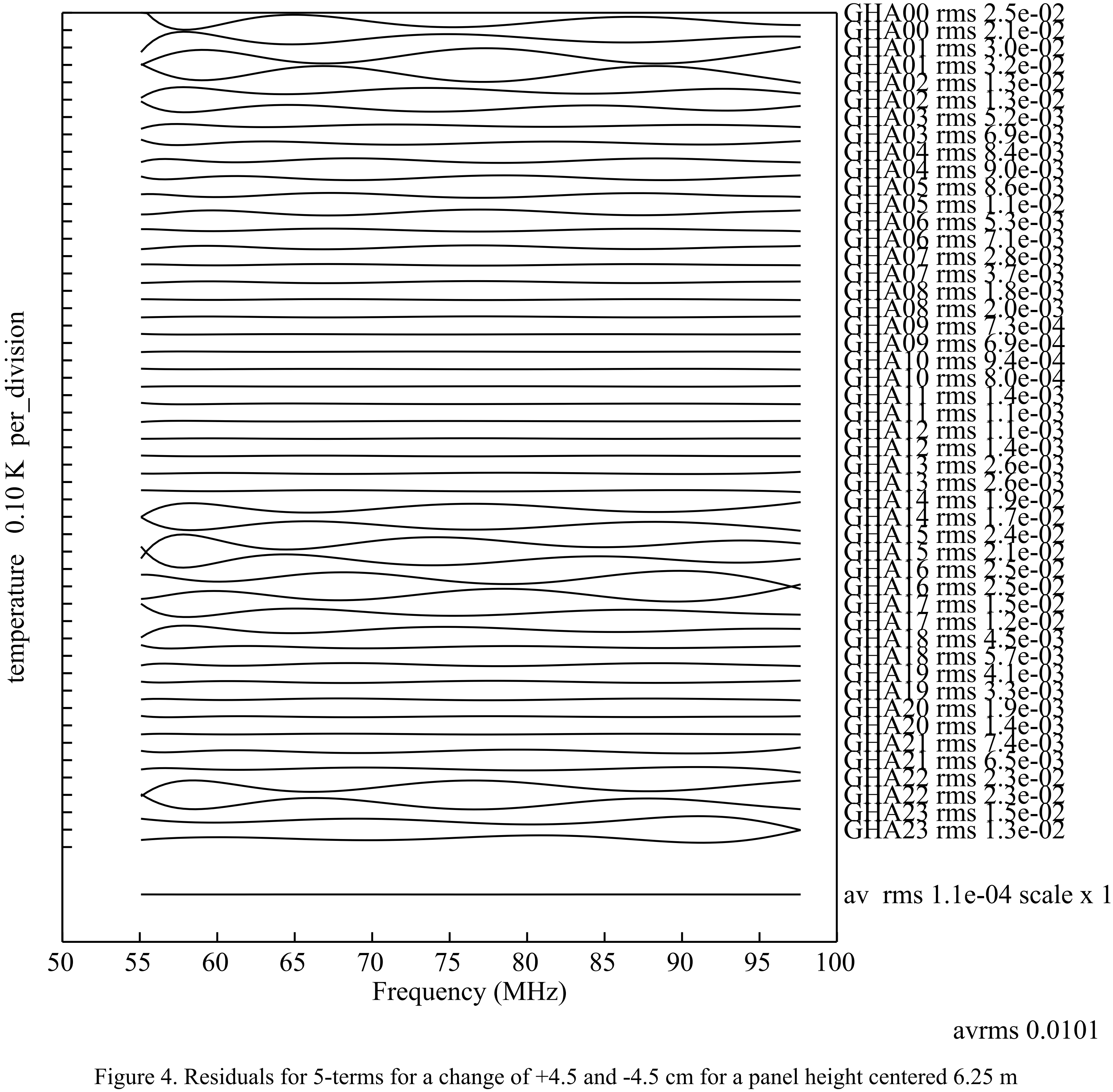

Figure 4. Residuals for 5-terms for a change of +4.5 and -4.5 cm for a panel height centered 6.25 m north and 6.25 m east of the antenna using the beam without change as reference. This shows the sign reversal of the residuals with change in sign of height. The reference beam is from random selection 1. The average of the rms values for one hour blocks over all GHA is 10.2 mK and 10.0 mK for the change of +4.5 and -4.5 cm respectively.

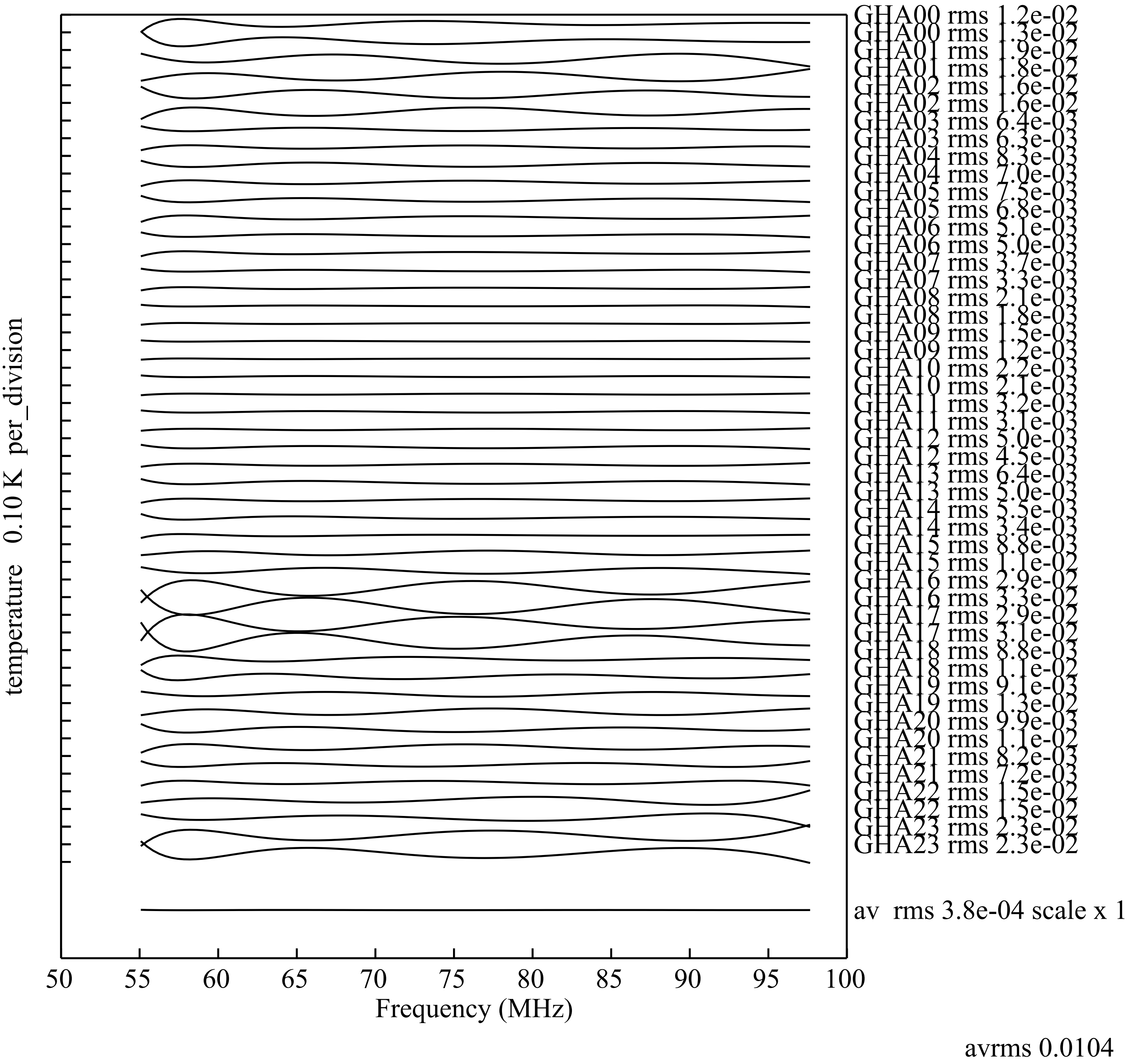

Figure 5. Residuals for 5-terms for a change of +4.5 and -4.5 cm for a panel height centered 6.25 m north and 3.76 m east of the antenna using beam without change as reference. The average rms for one hour blocks is 10.2 mK and 10.5 mK for the change of +4.5 and -4.5 cm respectively.