EDGES MEMO #421

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July 12, 2023

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To: EDGES group

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Subject: Examination of possible 60 MHz resonance at GHA 4 to 6 hours at the MRO

Initially data from EDGES-3 at the MRO was effected by resonant slots in the attachment of the baseplate to the welded mesh as described in memos 407 and 408. Since these were fixed the data from the MRO is better but now with over 100 days of data there is evidence for 200-300 mK "bump" in the spectrum at 60 MHz which appears at primarily from GHA 4 to 6 hours. The residuals 5-term residuals vs GHA from days 151 to 174 are shown in Figure 1. Figure 2 shows the changes on a scale of 30 minutes and the bump at 60 MHz is strongest at GHA = 5.5 hours and may decrease slightly in frequency with an increase in GHA. Figure 3 shows that limiting the nighttime and reducing the threshold of the power in the FM band may reduce the bump but given the limited data makes the bump less visible in the plots.

The repeatability of this bump with GHA and the lack of dependence high galactic noise indicates that it is a beam effect and not the result of calibration or S11 errors. While a reflection from the hut (which should be weak for the antenna pointed with minimum gain in the direction of the hut which is 50m away - see memo 342) has not been completely ruled out. A reflection from the added mesh to the adjacent ground plane has been ruled out as the bump is in the spectrum is present before the additional welding was started in the middle of April.

The ground plane needs be inspected for possible gaps that could produce a resonant slot in the 50 to 150 MHz range by checking for gaps under 1 mm over a length of about 15 cm (check memos 150, 168, 209, 407). These gaps in could then be checked for their resonant frequency by connecting a VNA across the center of the gap with crocodile clips making sure that the clips don't short out the gap. If a resonance is found it can probably be fixed by using a metal hose clamp to short the gap in the middle of the gap.

The analysis in memo 209 shows that except for an open slot at the edge of the ground plane it would take a very small gap at the level of just a few microns separation of the wires, without actual contact to get a resonance below 80 MHz so the separation of the wires shown in top of figure 4 of ASU memo 170 should not be a concern. The resonances found at the baseplate occurred at the mm level because the capacitance between plates cover a much larger area than between wires. The separation of wires in the bottom of figure 4 of ASU memo 170 might be close enough to be of concern so a quick visual check would avoid having to measure the wire separations at all the welds. Unfortunately an obvious contact between the wires at the center of the gap cannot be ruled out as being a resonant slot as the zinc spray is probably non conductive as discussed in memos 209 and 327.

I have made simulations with FEKO to aid in selecting locations of slots which might be most likely to effect the data in a way similar to what is observed. The following test results have been obtained where I define a slot as being parallel to the antenna if the direction across the gap of the slot is parallel to the direction between the antenna boxes.

1] Resonant slots in the ground plane whose orientation is parallel to the direction of the antenna have the largest effect while slots whose direction across the gap is perpendicular to the antenna direction have little effect.

2] The magnitude of the effects are approximately inversely dependent on the distance from the antenna at least from 2 to 4m from the antenna and surprisingly don't depend strongly on the direction of the slot from the antenna. So a slot in the direction of the antenna has a similar effect on the magnitude of the antenna gain as one in the perpendicular direction have a similar effect despite the large difference in antenna gain in the two directions. This is because the inverse dependence with distance is consistent with the ripple fraction formula in memo 360 but from 4 to 8m there was a reduction of more than a factor of 2 and further simulation show that the coupling between the antenna and the slot involves the currents in the ground plane in a complex manner. The dependence of the effects on GHA depend on the azimuth of the slot in a manner similar to the dependence of the fractional ripple from scattering objects described in memo 360 but with effective antenna gain Gscat due to currents in the ground plane that couple the slot to the antenna. Coupling between the dipole and a slot via an EM wave is a minimum because the dipole creates horizontal polarization and the slot creates vertical polarization. So far simulations of a single slot resonance don't show a change in frequency in manner similar to what in seen in the data in Figure 2. However frequency shift is seen in the simulation of an open slot in memo 209.

I have been unable to get a significant reflection from the hut when EDGES-3 in pointed NS and the hut is 50 east of the antenna. The result is in figure 4 of memo 342. This simulation is for the antenna and hut on an infinite PEC ground plane and the result is just the beam chromaticity of the antenna on a PEC ground plane. However when the PEC is replaced with a 48x48m ground over soil the effects are at the 200 mK level independent of hut size when using the Green's Function (GF) in FEKO but drop to a level on 70 mK peak at GHA = 4 hours and an average rms of 30 mK when the reflection coefficient method is used. A plot of the residuals using 5-physical terms and using the beam without the hut as a reference is shown in Figure 4.

Another potential source of the bump at 60 MHz is possibly due to raised tips of one or more of the triangular sections of the mesh but a simulation of 5 cm raise results in only a 40 mK effect. Yet another possibility is the effect of the cable from the antenna to the hut which is a depth of about 1m. While a layered ground can be modeled by FEKO the effect of the pipe can only be estimated.

In summary the maximum around 5 GHA is consistent with a slot resonance, bump in the ground plane, reflection from the hut or possibly reflection from the cable from the hut to the antenna but no simulation has yet been found which matches the observations. The peak around 5 GHA suggests that the cause is most likely to be to east of the antenna.

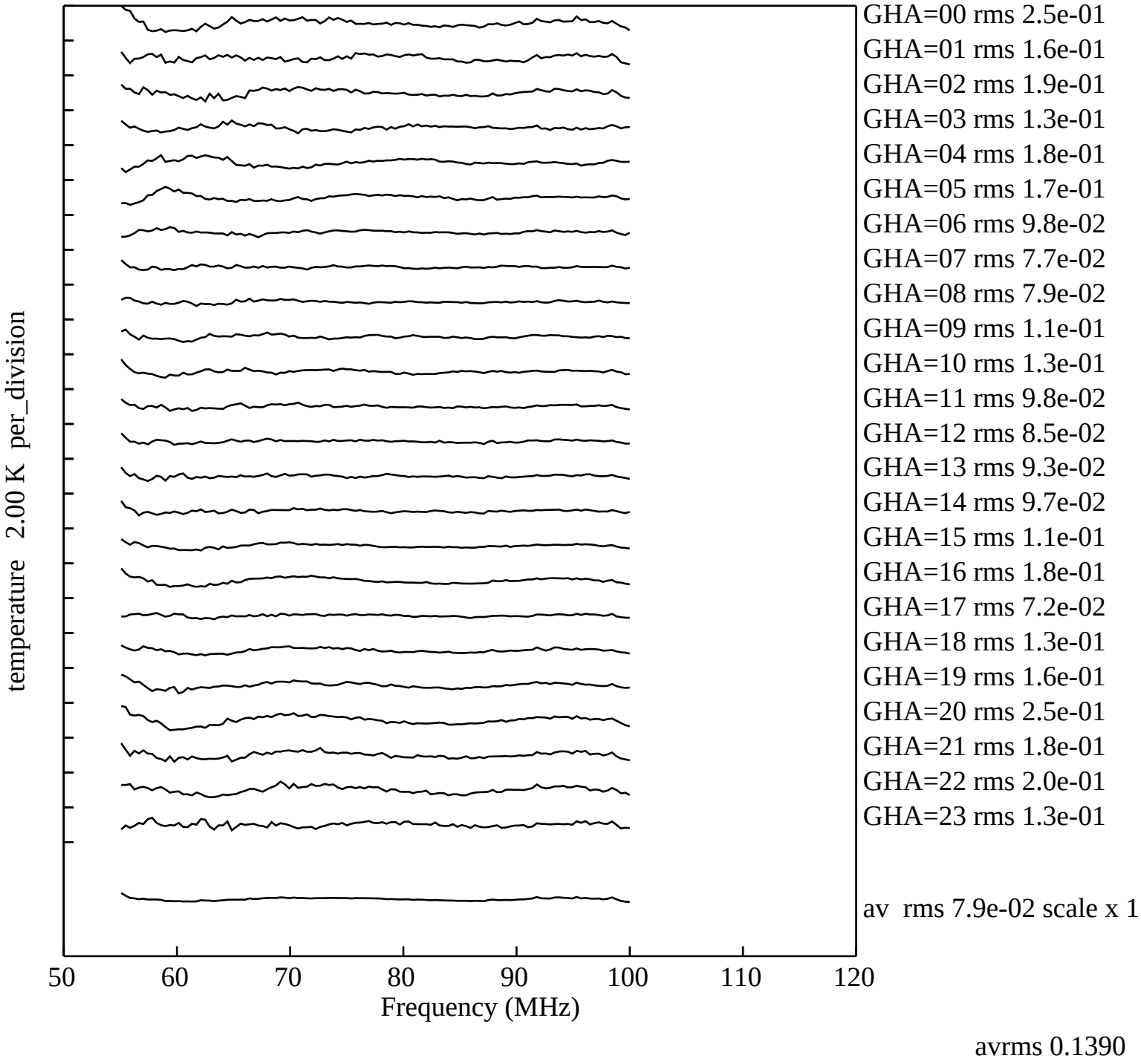

Figure 1. Residuals with 5 loglog terms removed for 1-hour blocks of GHA for data from day 54 to 174

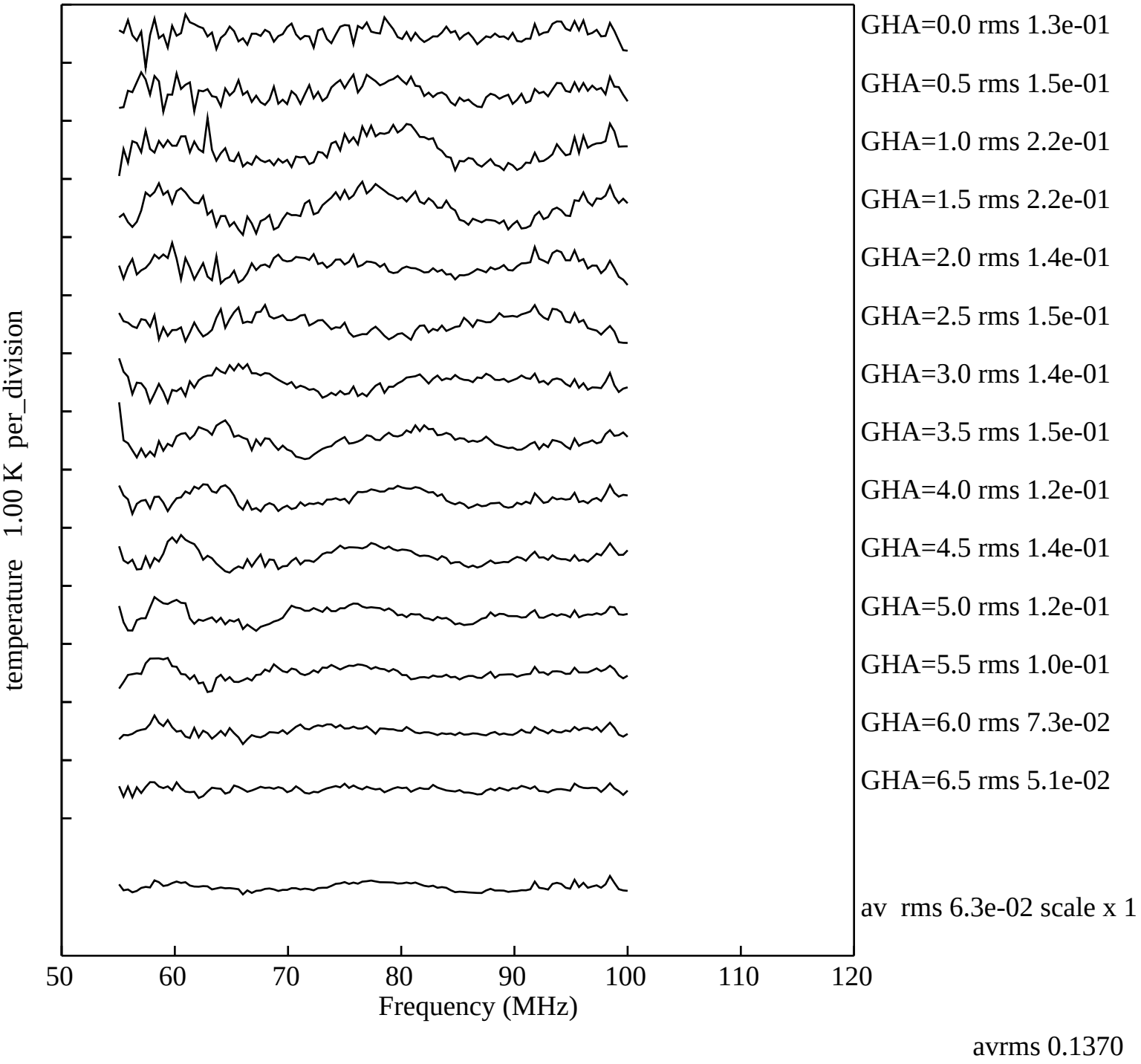

Figure 2. Residuals with 5 physical terms removed for 30 min blocks from 0 to 6.5 hours GHA for data from day 54 to 186

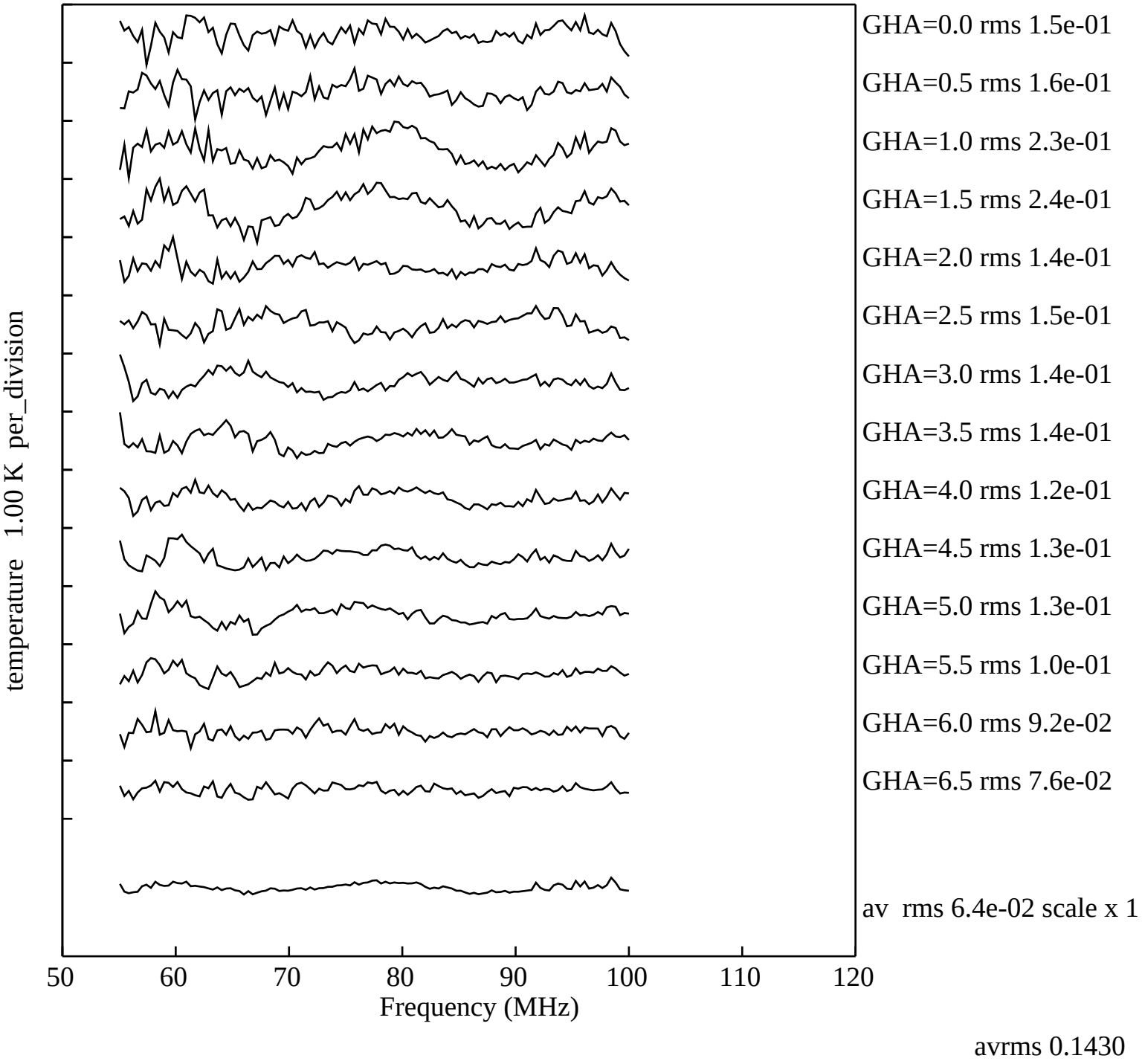

Figure 3. Residuals with 5 physical terms removed for 30 min blocks from 0 to 6.5 hours GHA for data from day 54 to 186 limited to nighttime and FM band threshold reduced from 500 to 300 mK

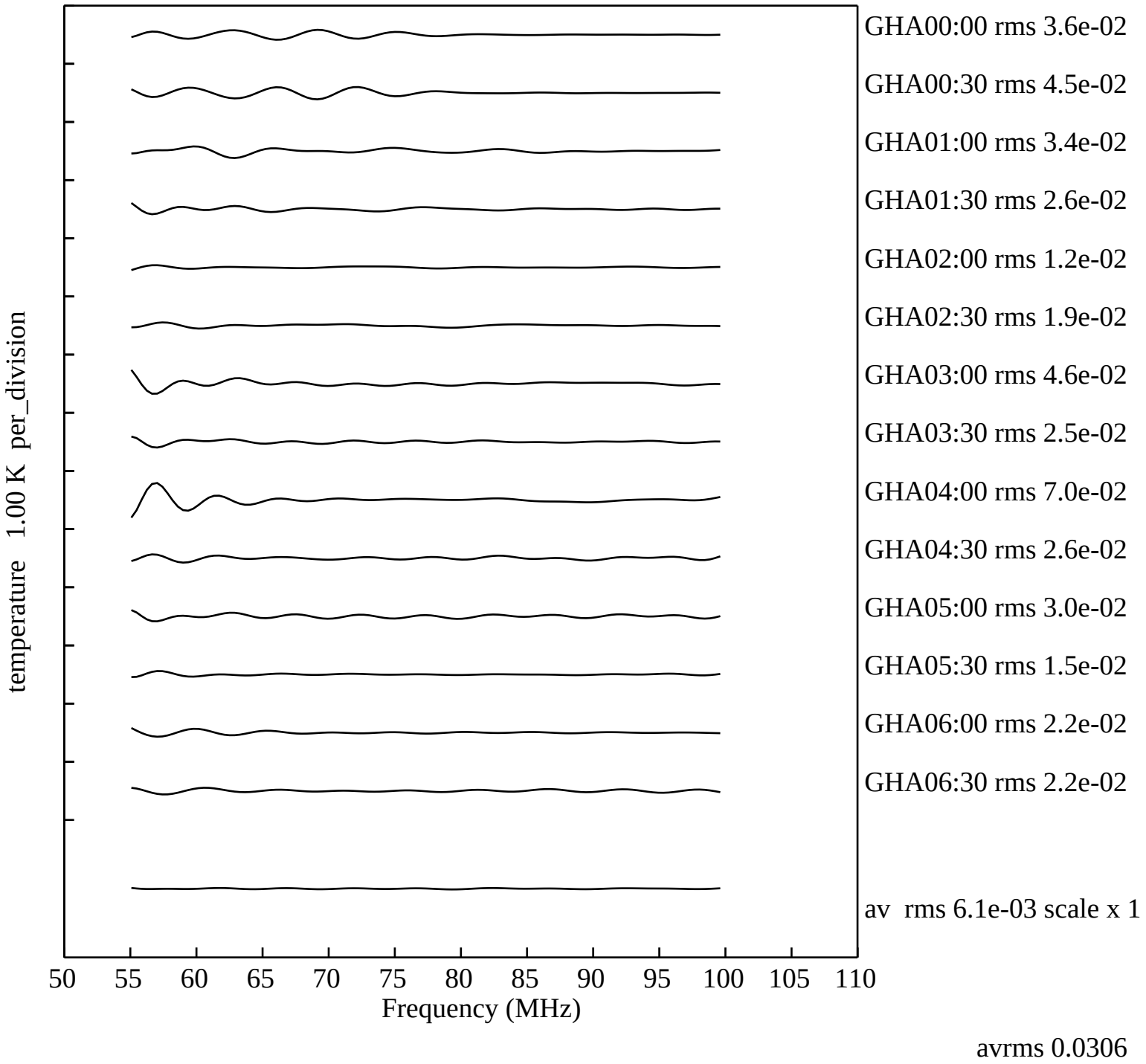

Figure 4. Simulations of hut which is 50m east of the EDGES-3 antenna using the reflection coefficient method.