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To: EDGES Group
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Subject: Possible resonance at 75 MHz in EDGES-3 at the MRO

Figure 1 shows the residuals from 2022:319 to 2023:006 with 5-physical terms from 55 to 100 MHz vs one hour blocks of GHA. It is noted that the broad bump at 75 MHz discussed in memos 403 and 405 might be the result of a resonance rather than the result of the ionosphere discussed in memo 405.

The bump at 75 MHz in Figure 1 shows a peak at GHA 14 hours which is then examined in Figures 2 through 5 using 30 minute blocks of only nighttime data for which the sun is more than 5 degrees below the horizon.

Figures 3 though 5, which are averaged from blocks of independent days show a fair level of repeatability of the broad bump at 75 MHz. For example GHA = 14.0 and 14.5 hours are a maximum while and 12.5 and 15.0 hours are a minimum. GHA = 15.5 hours also has the bump at 75 MHz.

Tests of the residuals with 4-terms removed from 60-100 MHz at GHA half hour intervals from 0.5 to 3.5 hours are shown in Figure 6 for four independent set of days. In this case daytime data is needed to cover this range of GHA. These show a similar level of repeatability which strengthens the conclusion that a beam effect is involved in the formation of the broad bump at 75 MHz rather than the extreme curvature of the spectrum introduced by the ionosphere shown in Figure 2 of memo 405.

In summary it looks like the bump is probably a beam effect due to a resonance. Simulations and experience with EDGES-1 and EDGES-2 show that poor conductive contact of metal tape onto metal surfaces can result in resonant slots at surprisingly low frequencies owing to the capacitance of the region where contact is lost as discussed in memo 168. Simulations show that the resonance could be due to the formation of a resonant slot on regions of the antenna base plate which are attached to the steel frame (see ASU EDGES memo 162 for details of the design) and currently not covered with tape. The photo in Figure 7 shows that there might be gaps in contact between due to corrosion between the aluminum plate and the outer steel frame. A FEKO simulation shows that if there is loss of contact which forms a gap of about 0.3 mm over the 15 cm between bolts forming an equivalent 40 pf capacitance load at the center the slot will resonate at about 75 MHz. To check this possibility we plan to have someone at the MRO check for loss of contact between the bolts using a typical metric feeler gauge to cover 0.03 to 0.88 mm. Then if gaps are found they could be fixed with a thin metal shim or possibly use copper tape for a test. Unfortunately both the aluminum plate and the steel have threaded tapped holes so that tightening the bolts doesn't help close a gap but it might be possible to remove the threads in the aluminum with a special tool or special bolts could be machined to remove the threads on the bolts in the region of contact with the aluminum. Another method of checking for resonant slots is to connect a handheld VNA across the center of a suspected slot location and check for a "dip" in the reflection coefficient in the frequency range 50 -120 MHz. It requires a cable with "crocodile" clips or probes to connect across the gap. There is some concern expressed in memo 209 that there could be resonance slots between the welds described in ASU memo 170 but this is probably unlikely.

A simple test simulation using FEKO of the effect on the spectrum of a 15cm long slot loaded with 40 pf in the middle of a 0.8x0.8m metal plate and placed 1m away from the antenna on soil without ground plane is shown in Figure 8. The residuals are with 4-terms removed and beam corrected with the beam obtained with 0.8x0.8m plate without a slot. A more complete FEKO simulation test of the effect of a gap between bolts on the base plate might be possible but is very difficult because of the meshing required to include all the details of what is actually in the field at the MRO.

Another possible source of a resonance is from the DC power cable which could be long enough to reach 2m half-wave resonant length between ferrite filters so another ferrite will be added just above the base plate to effectively shorten length of the cable exposed to the electric field of the antenna. Simulation of the scattering effects of the hut are small and should not be resonant so the hut is unlikely to be the cause of the broad bump at 75 MHz.

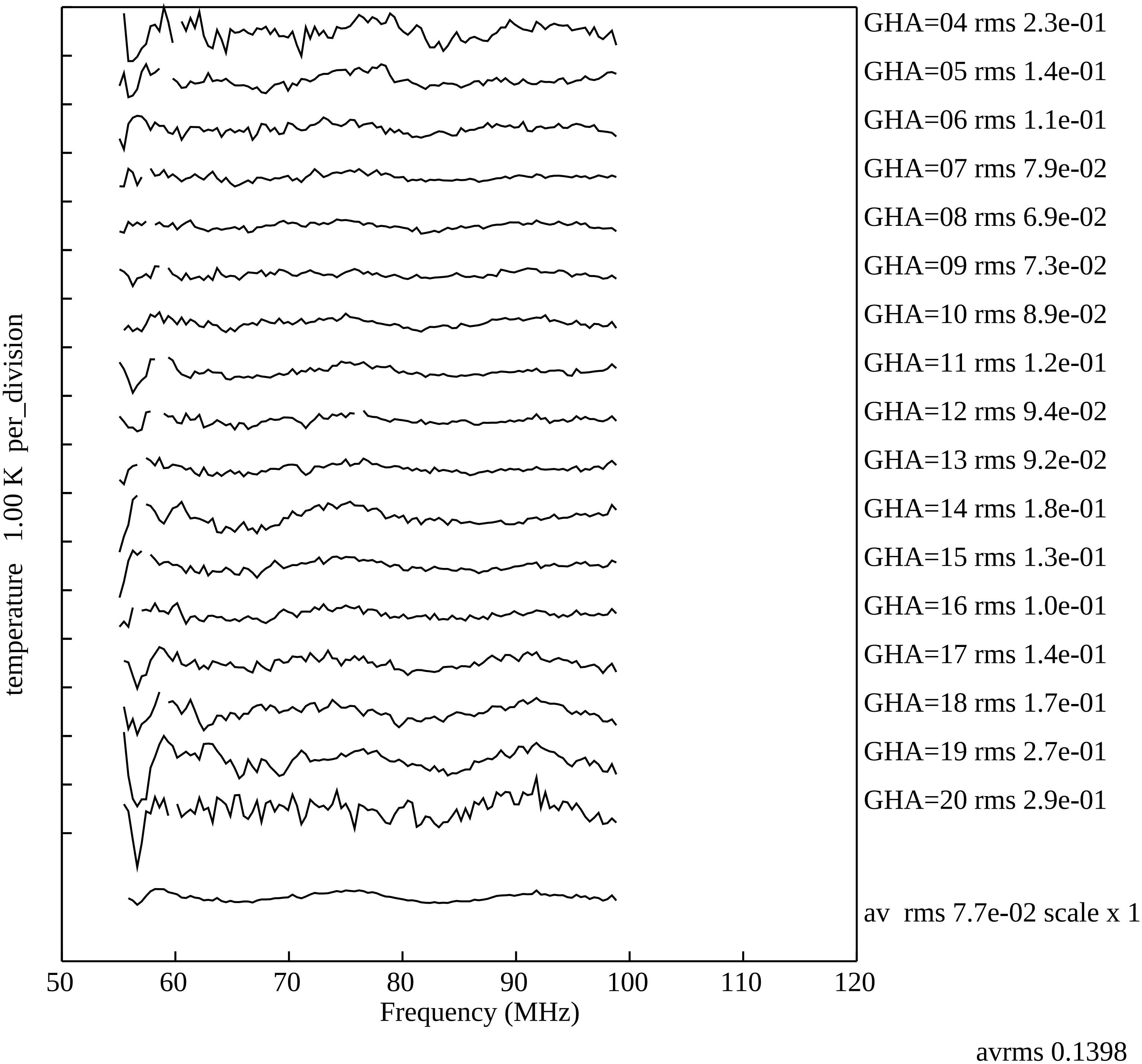


Figure 1. Residuals EDGES-3 data from from 2022:319 to 2023:006 with 5-physical terms removed in one hour blocks of Galactic Hour Angle (GHA).

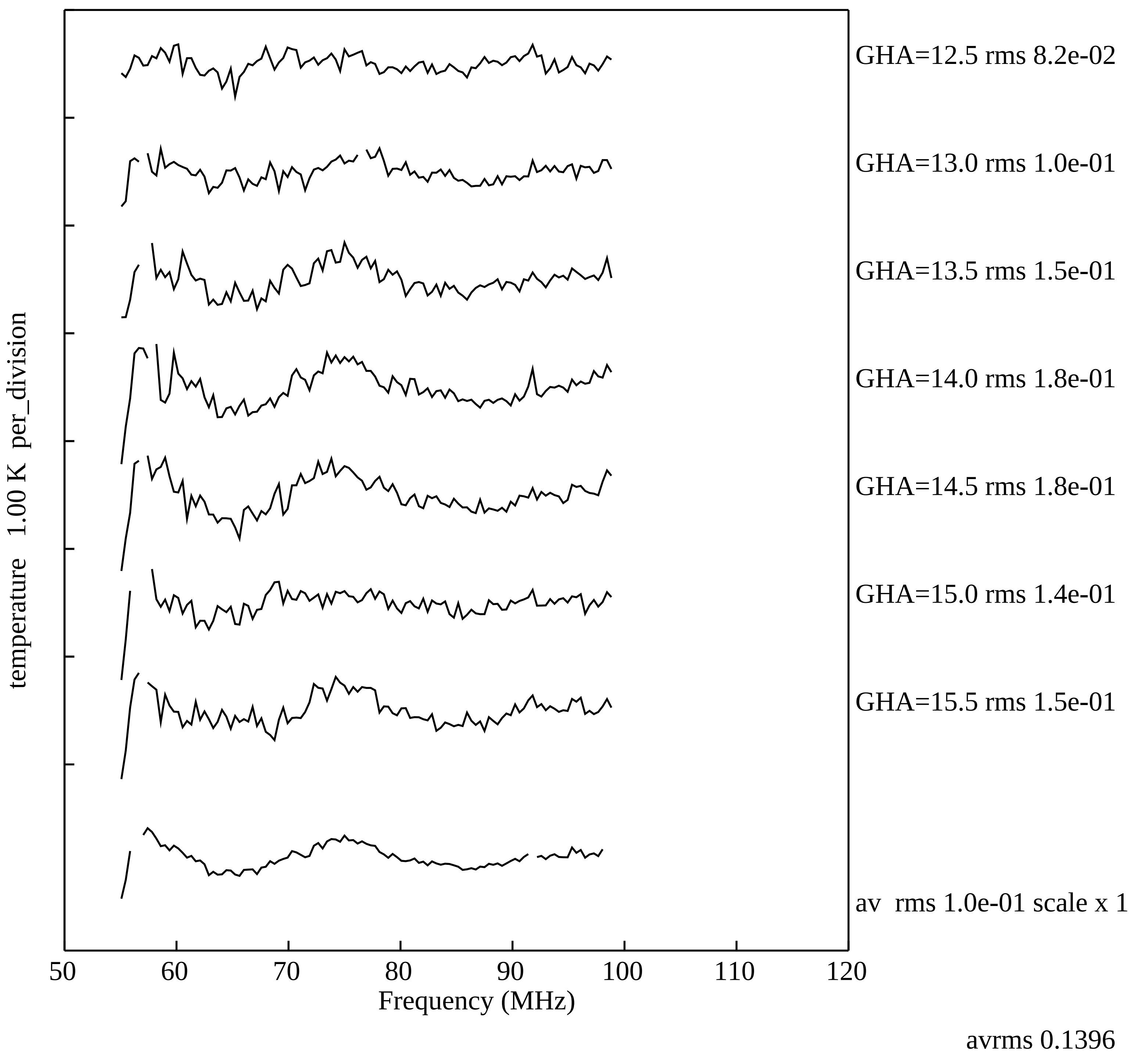


Figure 2. Residuals in 30 minute blocks for data from 2022:319 to 2023:006.

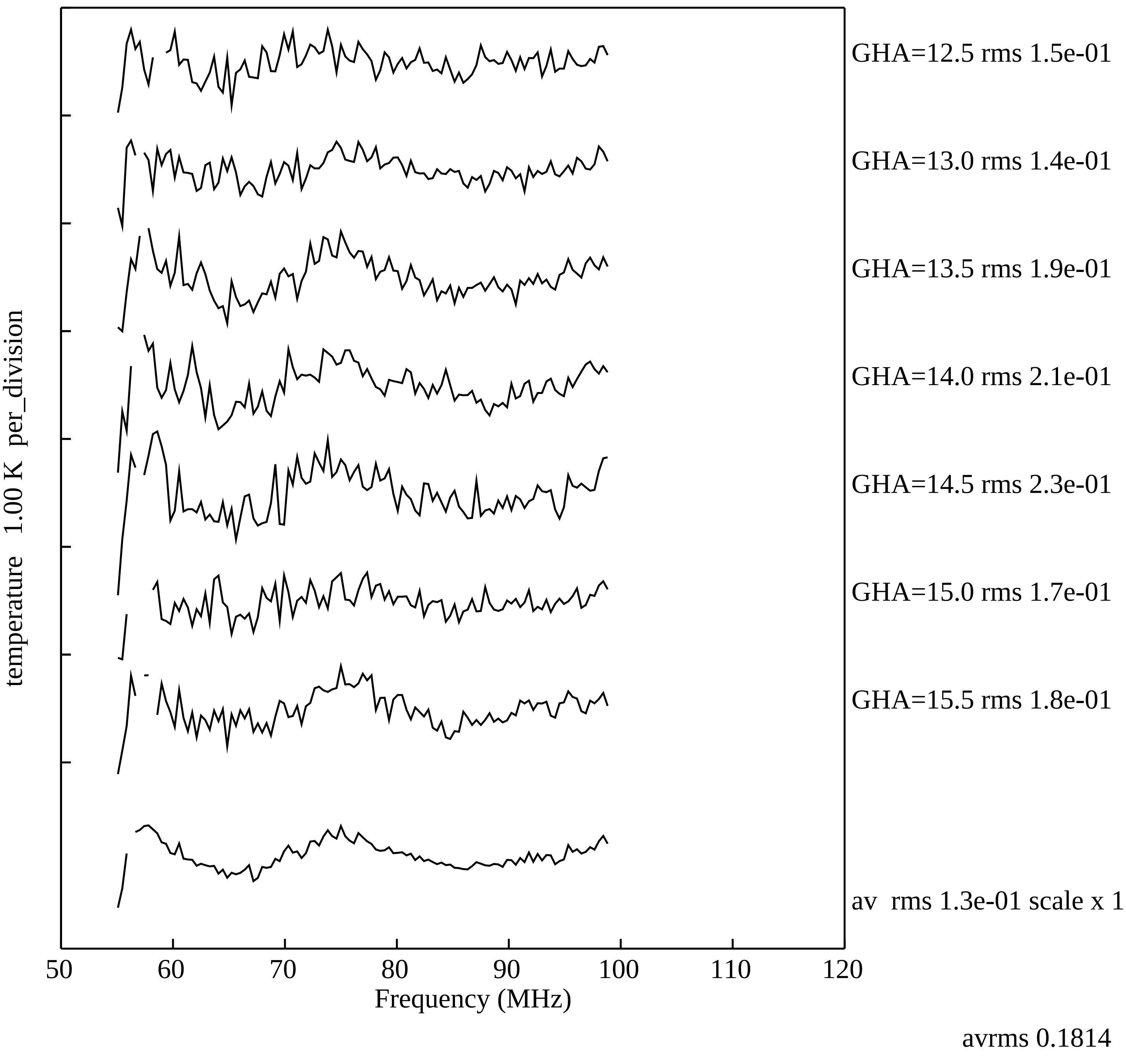


Figure 3. Residuals in 30 minute blocks for data from 2022:319 to 2022:332.

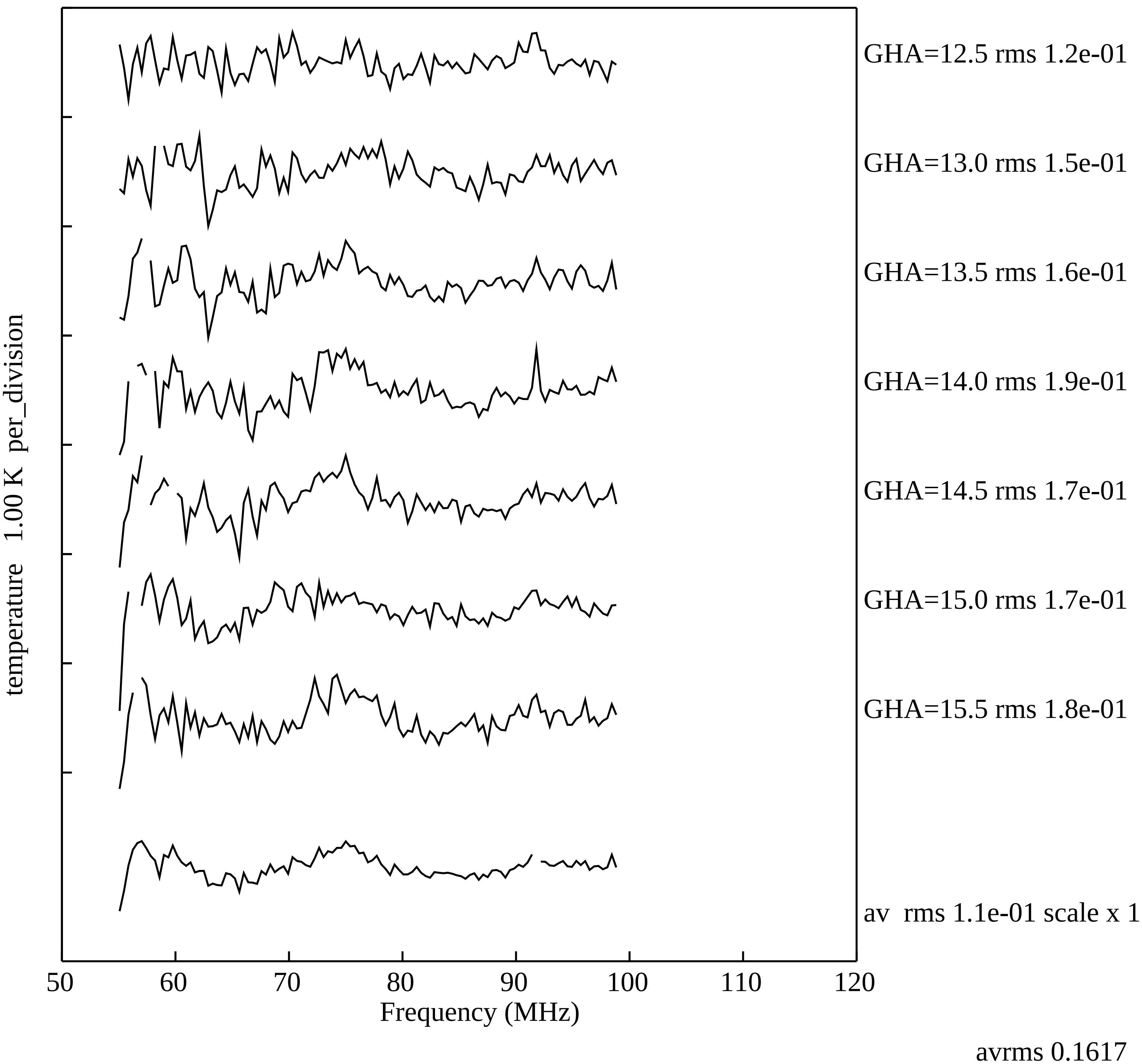


Figure 4. Residuals in 30 minute blocks for data from 2022:349 to 2022:362.

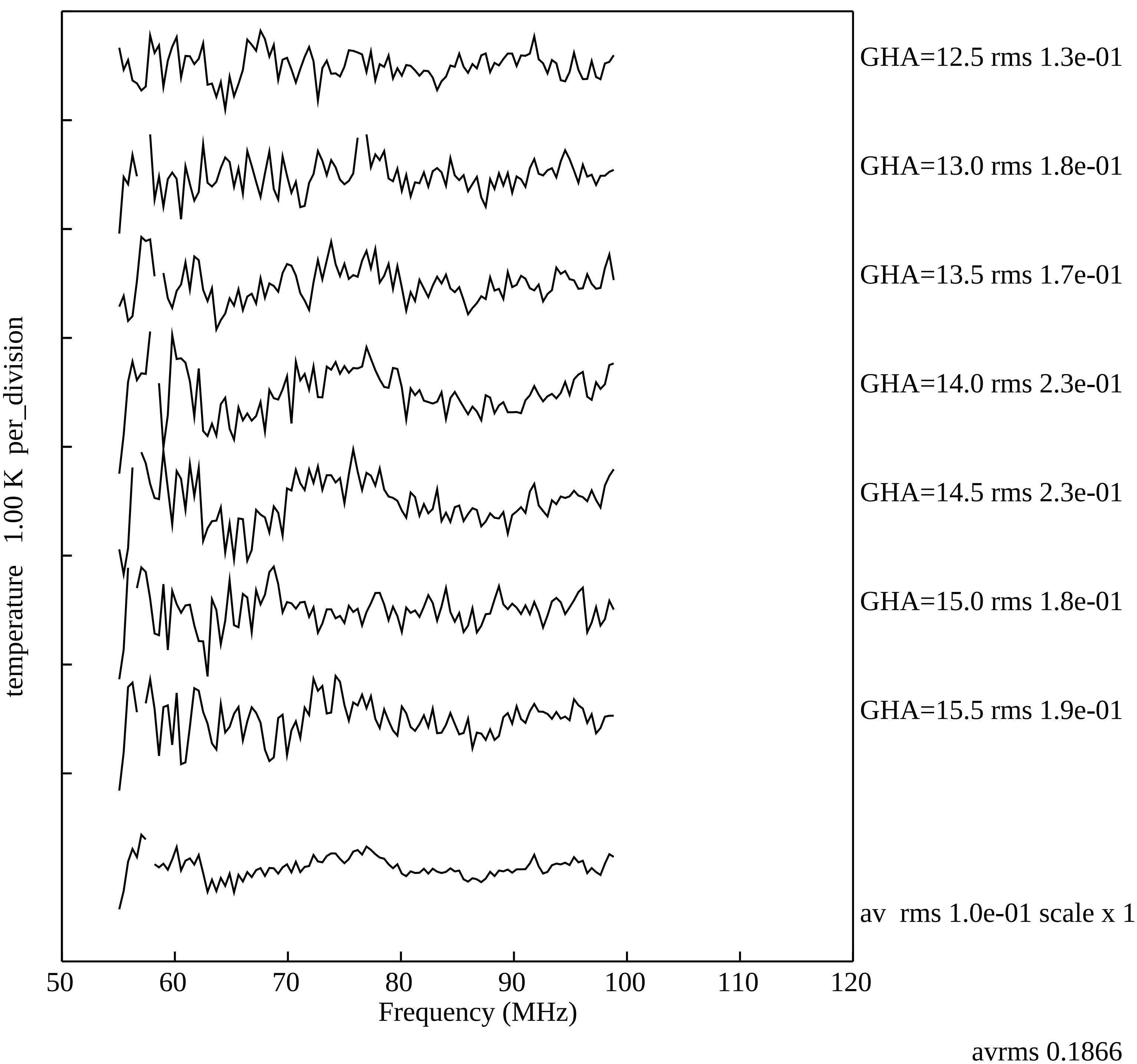


Figure 5. Residuals in 30 minute blocks for data from 2022:363 to 2023:006.

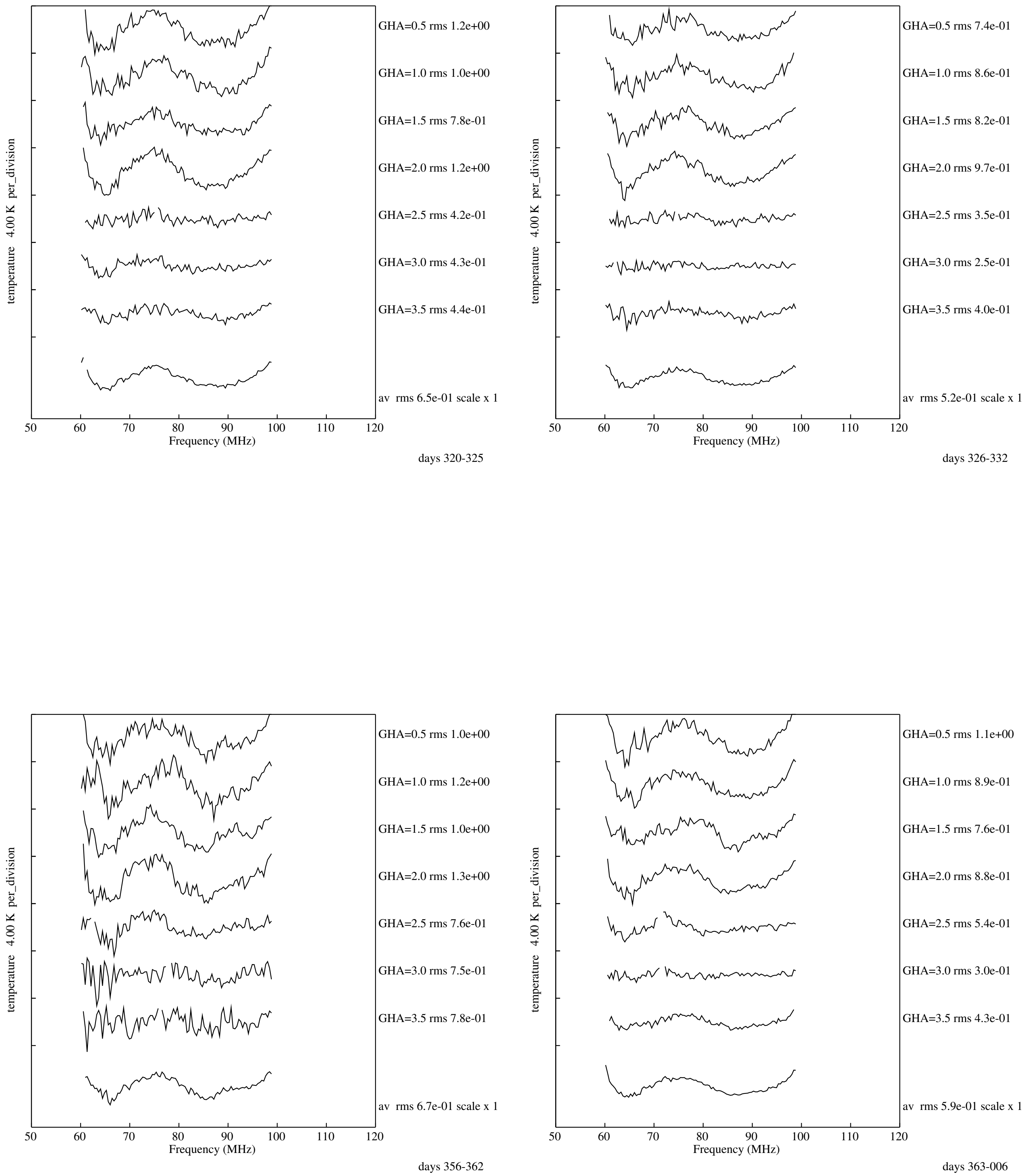


Figure 6. Residuals in 30 minute blocks with 4-terms removed for four different sets of days Plate.

Figure 7. Photo of EDGES-3 at the MRO on base

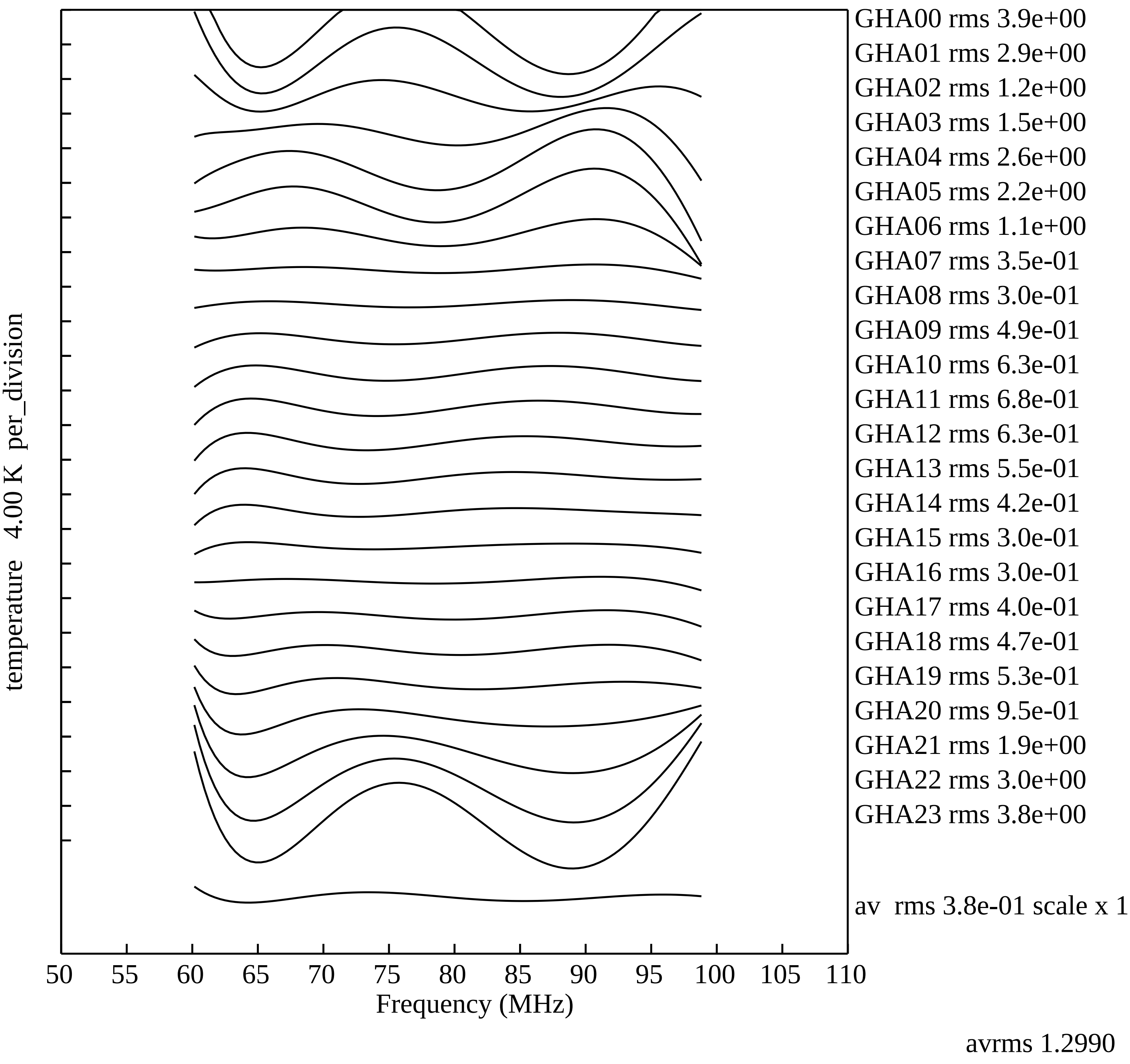


Figure 8. FEKO test effect on the spectrum of 15cm long slot in the middle of a 0.8x0.8m plate 1m away from the antenna on soil without ground plane.