MASSACHUSETTS INSTITUTE OF TECHNOLOGY
HAYSTACK OBSERVATORY
WESTFORD, MASSACHUSETTS 01886

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Telephone: 617-715-5533
Fax: 781-981-0590

To: EDGES Group

From: Alan E.E. Rogers

Subject: Evidence that EDGES lowband results are limited by scattering near transit of the Galactic center.

1] Introduction

In order to confirm the true global nature of the absorption the parameters need to be obtained over the full range of GHA. In the 2018 Nature paper the amplitude of the absorption was obtained for 4 and 6 hour bins of GHA over the full 24 hours. In memo 339 the center frequency, the width and amplitude were obtained for 4 hour bins over all GHA for low1 and low2-45 but attempts to use bins with fewer hours per bin are limited by systematics in the 5-term residuals within 1 hour bins closer than 3 hours of the transit of the Galactic center.

The residuals after correction for the beam chromaticity using FEKO models which include the soil properties like those shown in Figure 4 of memo 335 for low1 and low2-45 are too large for a determination of 3 absorption parameters. Note that the residuals for low1 and low2-45 are different especially at GHA = 21 hours which is included in the plot in Figure 4 of memos 337 and 341. The key question is:

What is the source of the systematics that produces the large residuals?

Memo 341 looks at the effects of rocks and brush southeast of low-45. This memo shows that items beyond the limits of the ground plane result in added beam chromaticity that changes from 1 hour of GHA to the next. This memo looks at how different sources of error appear in the residuals of plots of the residuals with 5 physical terms removed versus GHA and how the effects of the scatter which was introduced in memo 340 change rapidly with GHA.

2] Sources of systematic residuals vs GHA

a) Instrumental errors

Figure 1 shows the residuals for simulation of an error 0.5 dB in antenna S11 as an example of instrumental error. All S11 or calibration errors as well errors in the balun loss estimate have a structure in the residuals which scale with sky noise and change smoothly with GHA.

b) Antenna tilt and pointing error

Figure 2 shows that tilt and pointing errors change the residuals smoothly with GHA as shown in memo 343.

c) Map errors

Map errors which include added regions with very different spectral index and curvature also change the residuals smoothly with GHA. As an example Figure 3 shows an added a strip at all latitudes of 0.35 deg wide at longitude 14 hours. The added spectrum follows 1 + cosine curve with peak of 2e5 K at 75 MHz dropping to zero at 50 and 100 MHz. This added “test” source in the sky increases the power at GHA=14 hours from 1843 K to 2366 K.

A simulation using Guzman 45 MHz map with the Haslam 308 MHz as reference results in a maximum residual for 5-terms removed of 9 mK at GHA = 0 and lower residuals at all other GHA.

d) Errors due to scattering

Figure 4 shows the scattering from a circular metal wall of 30m diameter and 0.5m height centered on the antenna has an effect which changes the residuals on the time scale of an hour and introduces a large chromaticity with 5 terms removed. The scatter effectively increases the fine structure in the beam so that the time scale for a change in the residuals with GHA is approximately given by

$$h=12\ \lambda/((\pi d))$$

where h = time scale in hours

λ= wavelength in meters

d = distance of scattering object from the antenna in meters

3] Conclusion

The large residuals in low1 and low2-45 are most likely from the scattering from objects outside the ground plane and consequently not in the current beam models. Lack of information of structure, spectral index, curvature and a higher order term in the sky maps produce a smooth variation with GHA on time scales much longer than one hour. The residuals in all cases are for 5 physical terms removed. Ideally the 48x48m ground plane planned should be even larger and be on flat open land without trees and brush out to about 100m from the antenna and tall objects even further away. An alternate might be a ground plane with outer absorbing walls to prevent scatter from objects outside the ground plane but so far no design has been found to yield acceptable low beam chromaticity and isolation from objects outside the walls.

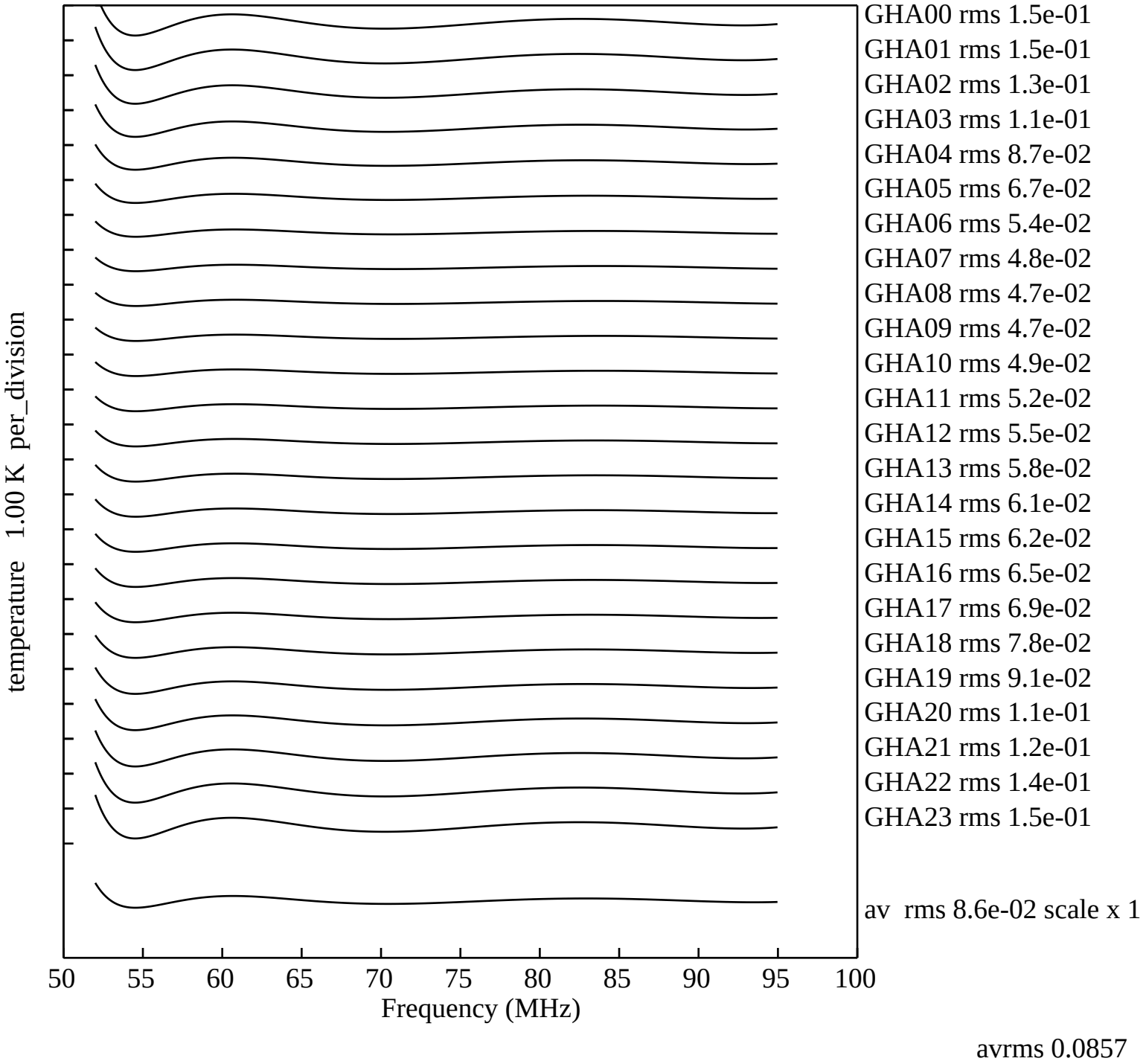

Figure 1. 5-term residuals for simulation of 0.5 dB error in antenna S11.

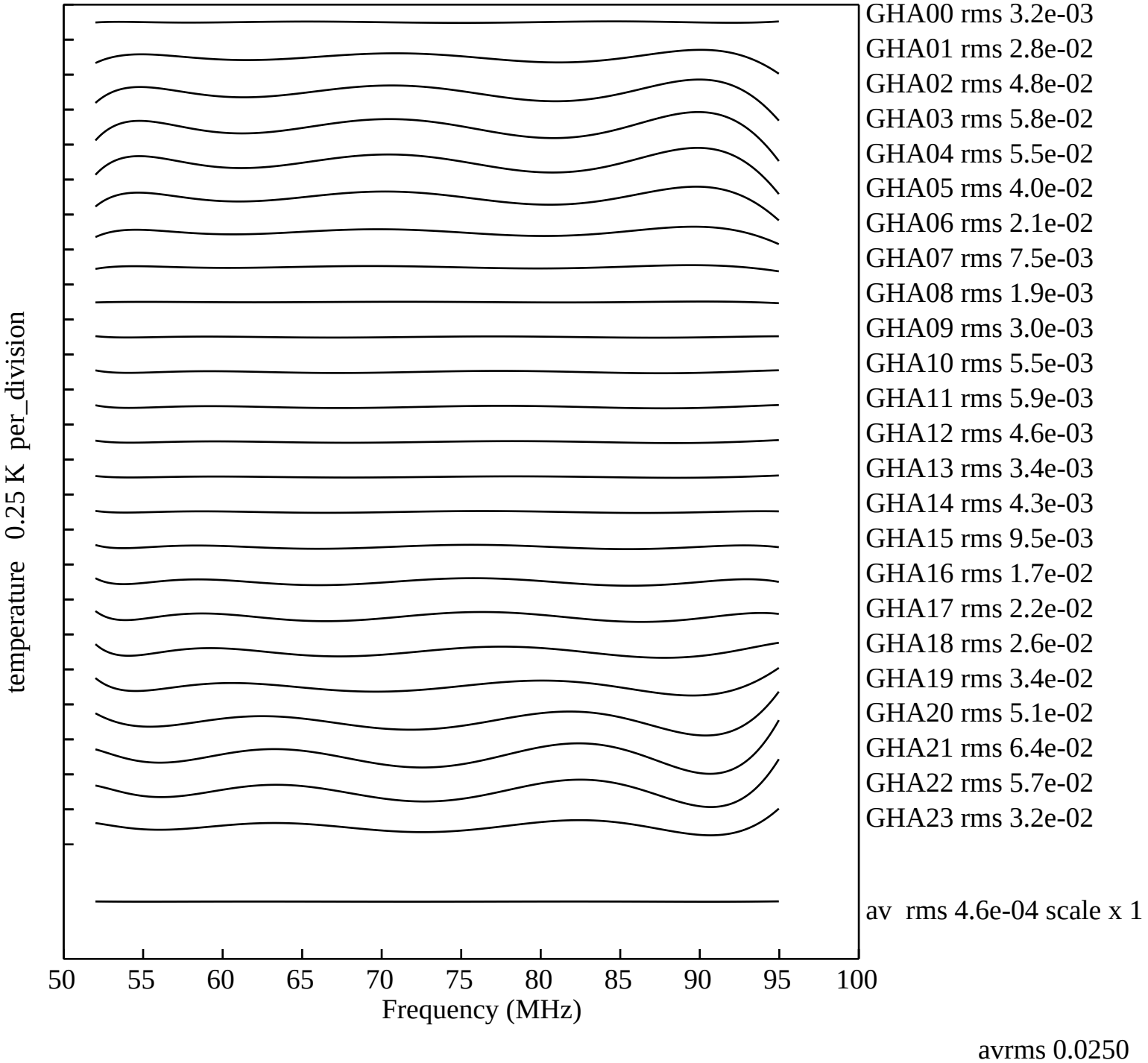

Figure 2. 5-term residuals for simulation of an EDGES-2 low1 antenna on an infinite PEC ground plane with -1 degree rotation ("roll") of the antenna about the axis of the E-field between panels using FEKO model without rotation as the reference as in Figure 1 of memo 343.

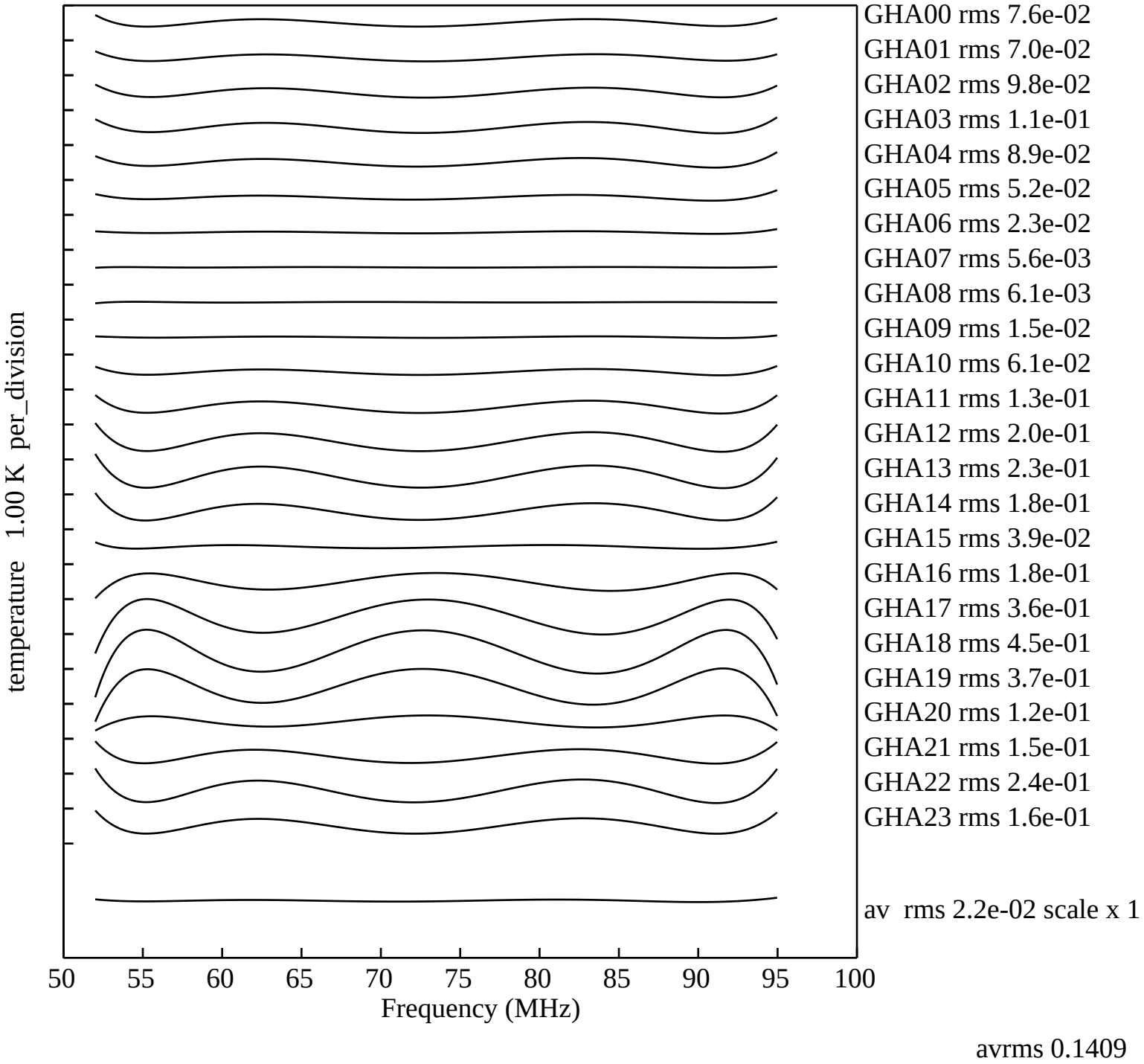

Figure 3. Simulation with added a strip at all latitudes of 0.35 deg wide at longitude 14 hours. Added spectrum follows 1 + cosine curve with peak of 2e5 K at 75 MHz dropping to zero at 50 and 100 MHz.

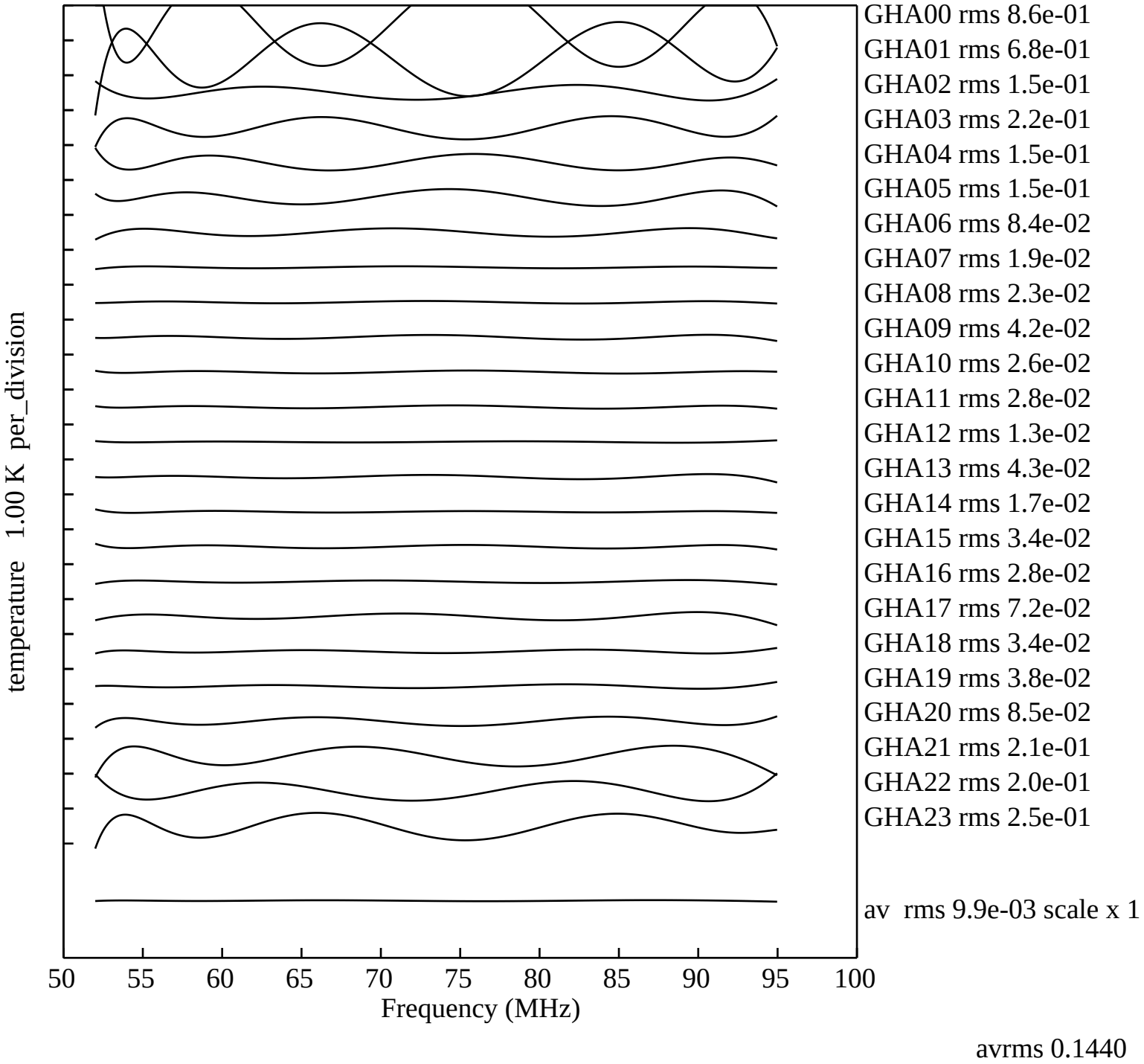

Figure 4. Simulated residuals for scattering from a circular metal wall of 30m diameter and 0.5m in height around the antenna.