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To: EDGES Group

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Subject: Limitations of the MOM in calculating the antenna beam using Green's functions for lossy ground.

It has been noticed that when the antenna beam patterns are calculated by FEKO and NEC2C that there are discontinuities in the results which become evident which beams are calculated at closely spaced frequencies. The problem arises in the Sommerfeld integrals used to incorporate the effects of an infinite loss dielectric below a finite ground plane. The problem is recognized in the literature with many papers.

For example:

Firouzeh, Z.H., G. A.E. Vandenbosch, R. Moini, S.H.H. Sadeghi, R. Faraji-Dana (2010) Efficient Evaluation of Green's Functions for Lossy Half-Space Problems, Progress In Electromagnetics Research, Vol. 109, 139–157, 2010.

Krzysztof A. Michalski & Juan R. Mosig (2016) Efficient computation of Sommerfeld integral tails – methods and algorithms, Journal of Electromagnetic Waves and Applications, 30:3, 281-317, DOI: 10.1080/09205071.2015.1129915

While it is possible that FEKO may improve its accuracy in the future it is assumed that FEKO uses the most accurate algorithm and EDGES needs to fit the beam correction as a function of frequency in order to remove the effects of the "glitches" which occur at certain frequencies. To this end, I have evaluated the effectiveness of fitting the beam corrections with a polynomial or a Fourier series.

Figure 1 shows an example of a glitch or discontinuity at 92 MHz in the beam correction for the midband antenna on the large perforated ground plane. This figure shows the beam convolved with the Haslam Sky map scaled to 75 MHz using a spectral index of -2.5 for GHA = 22 hours using the midband blade antenna oriented NS. The top plot shows the residuals to a 9-term polynomial fit. The beam file used was

azelq_blade9mid0.78_1MHz.txt

Figure 2 shows plot using the beam file

FEKO_midband_realgnd_Simple_blade_niv.txt

Made by Nivedita Mahesh at ASU. Apart from the glitch there are other differences in the residuals which result from a different frequency spacing of 2 MHz and mesh details.

Figure 3 shows the residuals fit with a 5-term polynomial removed generated with the beam correction fit with 9-terms and processed with the beam correction fit with 7-terms. Figure 4 shows the results generated with 9-terms and processed with 8-terms. Figure 5 shows the residuals with fit with a 5-term polynomial generated with a 9-term polynomial and fit with a 50-terms Fourier series for the 151 frequencies of beam data. The problem with using a Fourier-series with 50 terms for 151 frequencies is that it fails to filter out structure in the FEKO results which are probably the result of inaccuracy in the Green's function calculations. Figure 6 shows that these features remain even when the residuals are fit with 7 terms. On the other hand there may be real fine scale structure in the beam correction that is not fit with a polynomial. For example, a reflection from 15 m away produces a ripple period of 10 MHz or half period of 5 MHz. For a particular antenna and ground plane the best choice of Fourier series vs polynomial should be based on looking at the residuals to the fit and making a judgement based seeing if the fit reduces the effect of a glitch or glitches if they are present and significant.

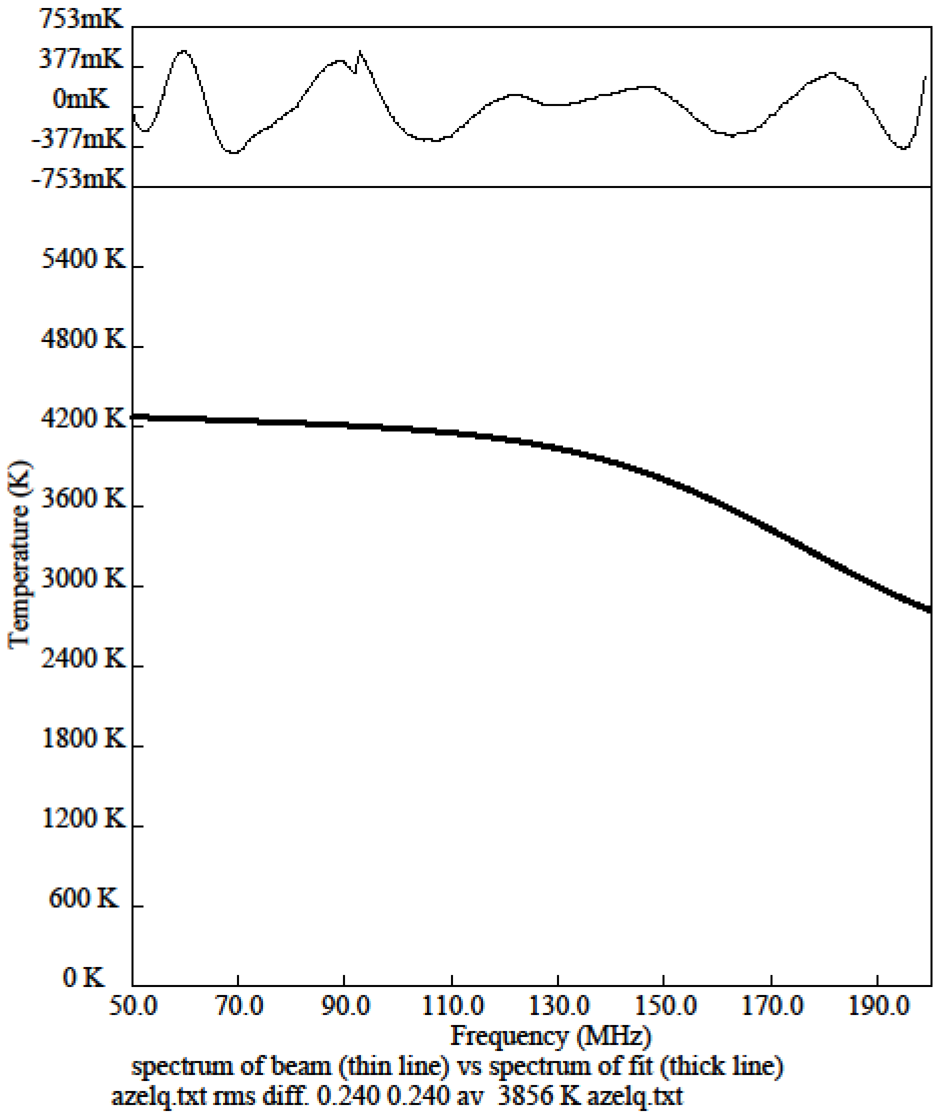

Figure 1 Glitch in FEKO beam calculation at 92 MHz shown in residuals to 9-term polynomial fit to beam corrections.

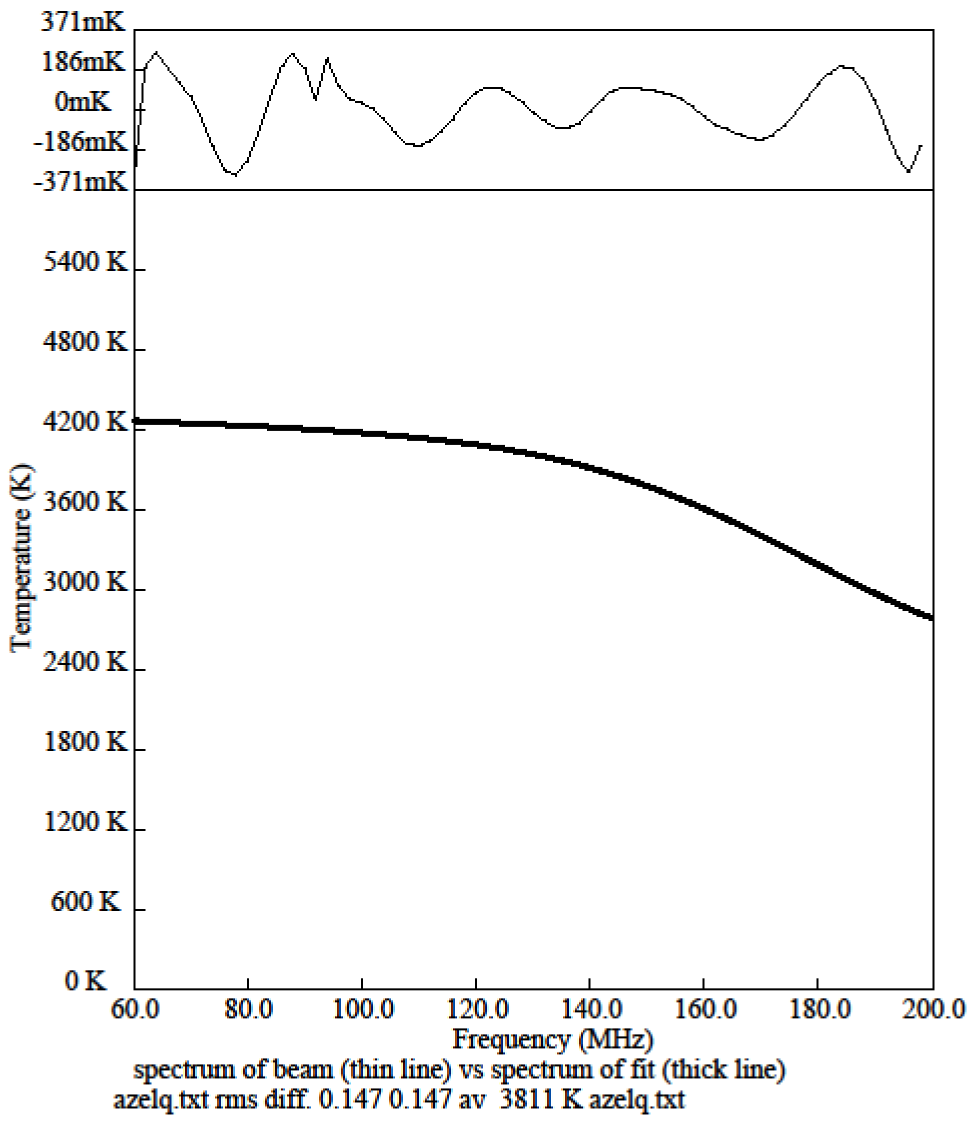

Figure 2. Similar glitch in separate FEKO processing.

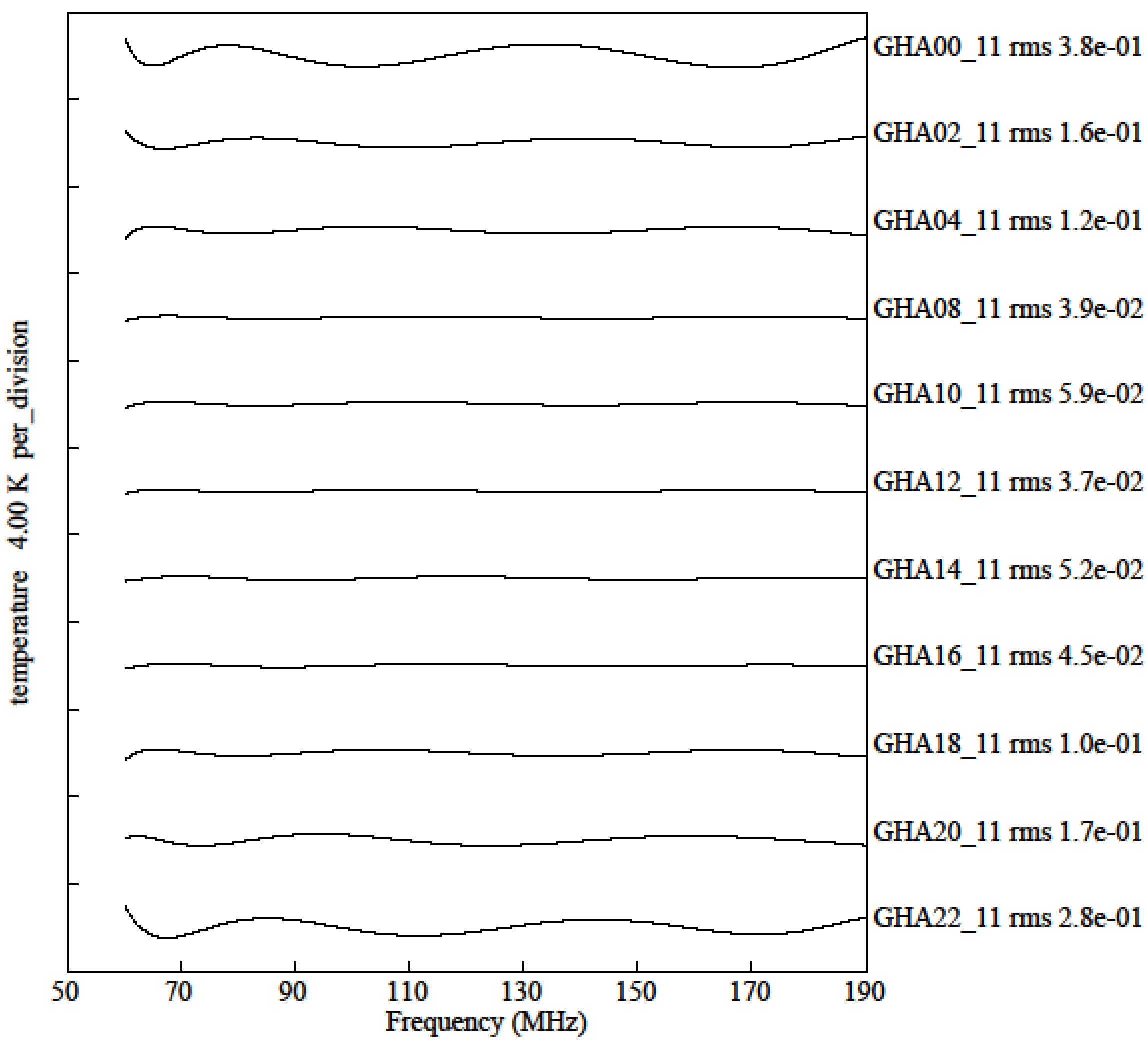

Figure 3. Residuals vs GHA in data simulated with 9-term polynomial fit and processed with 7-term fit.

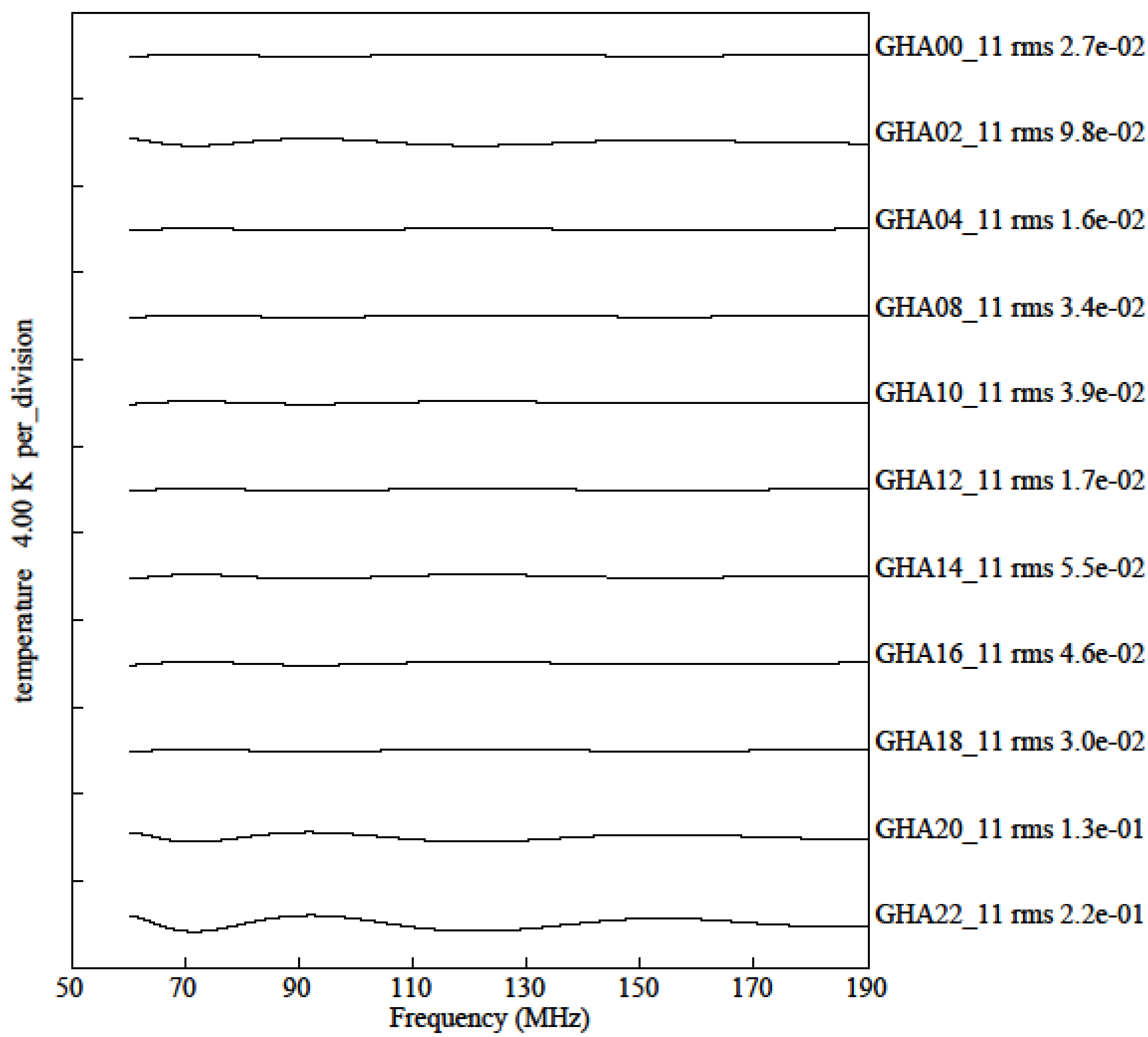

Figure 4. Same as Figure 3 but processed with 8-term fit to beam corrections.

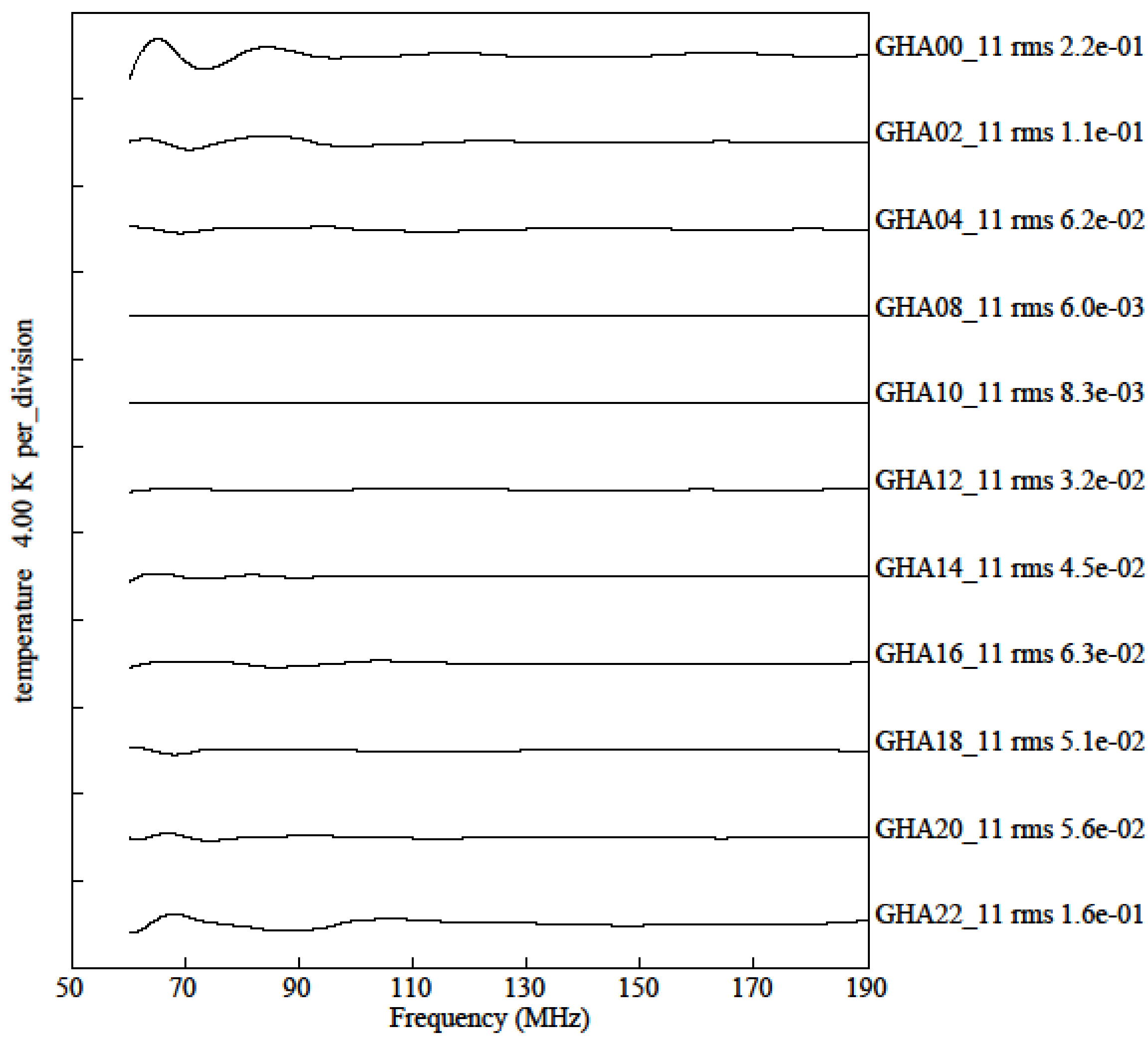

Figure 5. Similar to Figure 3 but processed with 50 term Fourier-series fit to beam correction.

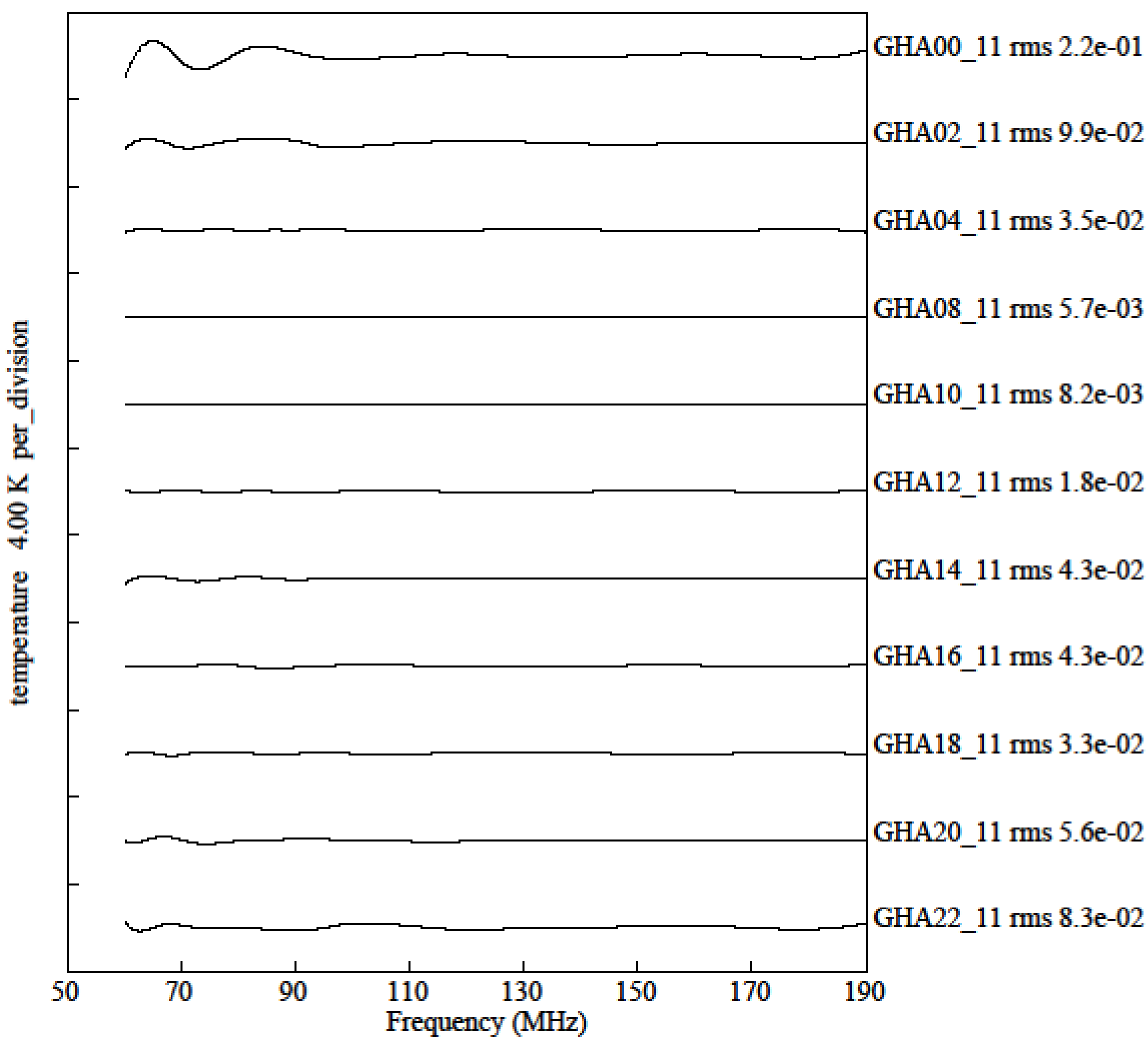

Figure 6. Similar to Figure 5 but with residuals fit using a 7-term polynomial.