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To: EDGES Group

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Subject: The sensitivity of midband to ground plane tilt and deviations from flatness

The sensitivity is first tested using simulated data obtained by convolving midband beam with the Haslam sky map scaled to 55 to 120 MHz plus the Nature paper absorption profile. This data is then processed with a grid search for the best fit amplitude, center frequency and width of a feature with fixed tau = 7 with a change compared with a reference case of the antenna on an infinite flat ground plane as follows in Table 1.

change	GHA	amp K	SNR	center	width	rms mK	comments
Add 50 mK noise	12	0.54	21	77.7	19.4	47	
No beam correction	12	0.54	34	77.0	19.4	26	
Process with Guzman map	12	0.51	200	77.7	19.1	5	
Process with Guzman map	04	0.58	25	76.6	19.6	37	
Ground plane tilt of 2 deg	12	0.51	44	78.3	19.0	25	
Ground plane tilt of 2 deg	00	0.49	24	76.2	18.9	35	
Ground plane tilt of 2 deg	04	0.72	50	105.9	19.4	43	diff. feature
Ground plane tilt of 1 deg	04	0.52	25	79.7	19.1	46	see Figure 1
Ground plane tilt of 2 deg	08	0.49	220	78.1	19.1	4	
Ground plane tilt of 2 deg	16	0.59	41	78.9	18.8	30	
Ground plane tilt of 2 deg	20	0.71	21	81.3	19.7	80	
Ground plane roll of 2 deg	04	0.58	35	77.0	19.3	28	

Table 1. Effects of ground plane tilt on simulated data for midband antenna at azimuth 85 degrees

Table 1 shows that not accounting for a ground plane tilt has a much larger effect on the feature search for the 6 hour block at GHA = 04 hours than the effect of a change from using the Haslam map to simulate the spectrum and processing with the Guzman map. The effect of only 1 degree in antenna tilt results in an asymmetry of the beam gain for a 180 degree change of azimuth of about 5 dB at 1 degree elevation. Figure 1 shows the effect of the tilt on the feature search. The effects of roll are significantly smaller than the effects of tilt at all GHA for midband at azimuth 85 degrees.

Applying a tilt and roll correction to midband using a ground plane slope of 2 degrees down from south to north and east to west makes an improvement in the results of feature search for the 6 4-hour blocks of GHA in table 1 of memo 287 as follows in Table 2 below:

GHA	center	SNR	amp K	width	rms1 mK	rms2 mK
00	79.3	16.8	0.70	22.4	113	65
04	83.2	22.1	0.71	16.6	183	87
08	79.3	34.4	0.55	17.1	112	37
12	80.1	29.5	0.38	16.5	86	32
16	79.3	34.5	0.77	20.0	129	42
20	79.3	24.5	0.49	16.3	111	48

Table 2. Results of applying a tilt and roll correction to the beam used to process the midband data from 2018 days 146 to 218 in 6 4-hour blocks of GHA. These results are also plotted in Figure 2.

The rms 1 and rms2 are the rms residuals to a 5-term fit before and after including the fit to the feature feature center frequency, width and amplitude respectively.

The poorest result is the 6-hour block at GHA=04. Simulations show that this time block is most sensitive to a "bump" in the ground plane in the azimuth range around 90 degrees from the antenna or East of the antenna whereas the block at GHA=20 is most sensitive to an uneven ground plane at azimuth around 0 degrees or North of the antenna.

Figure 3 shows a simulation of the effects of a section of 2.5x2.5m ground plane centered at 5m from the antenna which is raised by 10cm has on the beam correction for the 6-hour block at GHA=04 as a function of the azimuth of the bump. This shows how extremely sensitive beam correction is to the reflections of Galactic center region of the sky in a manner that requires a precise knowledge of the details of the ground plane deviations from flatness.

As an example, Figure 4 shows how the feature search at GHA=04 in figure 2 is changed by introducing a 5cm by at azimuth 60 degrees reduces the rms residual from 87 to 54 mK. But at this point we don't have detailed knowledge of the deviations from flatness of the EDGES ground planes.

In summary ground plane tilts at the level of a degree and deviations from flatness at the level of 5 cm introduce significant frequency structure in the antenna beam. Consequently, it is difficult to get the beam correction accuracy needed to get low residuals for data blocks of a few hours over GHA in order to accurately confirm the global nature of an absorption feature. It is hoped that when the ground plane survey information is available it will be possible to make additional improvements in the 2018 midband results vs GHA. However even with an accurate beam an accurate sky map is needed so the ultimate solution may be to have a very large flat ground plane and possibly an electrically small antenna remove both the sensitivity to the ground plane and its surrounding as well as the sensitivity to the sky map.

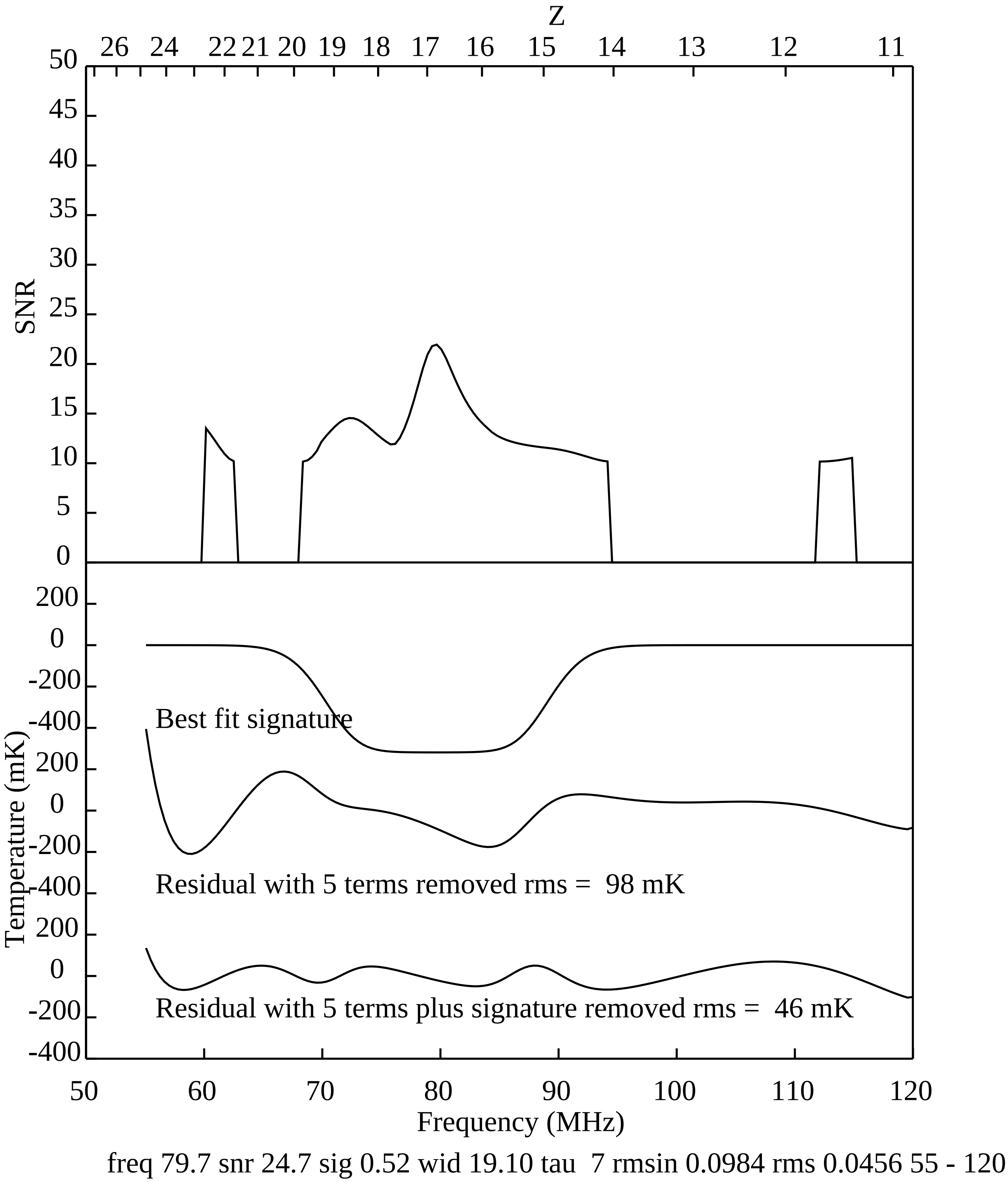

Figure 1. Feature search using simulated data for the 6 hour data block at GHA=4 for midband case of a 1 degree tilt in Table 1.

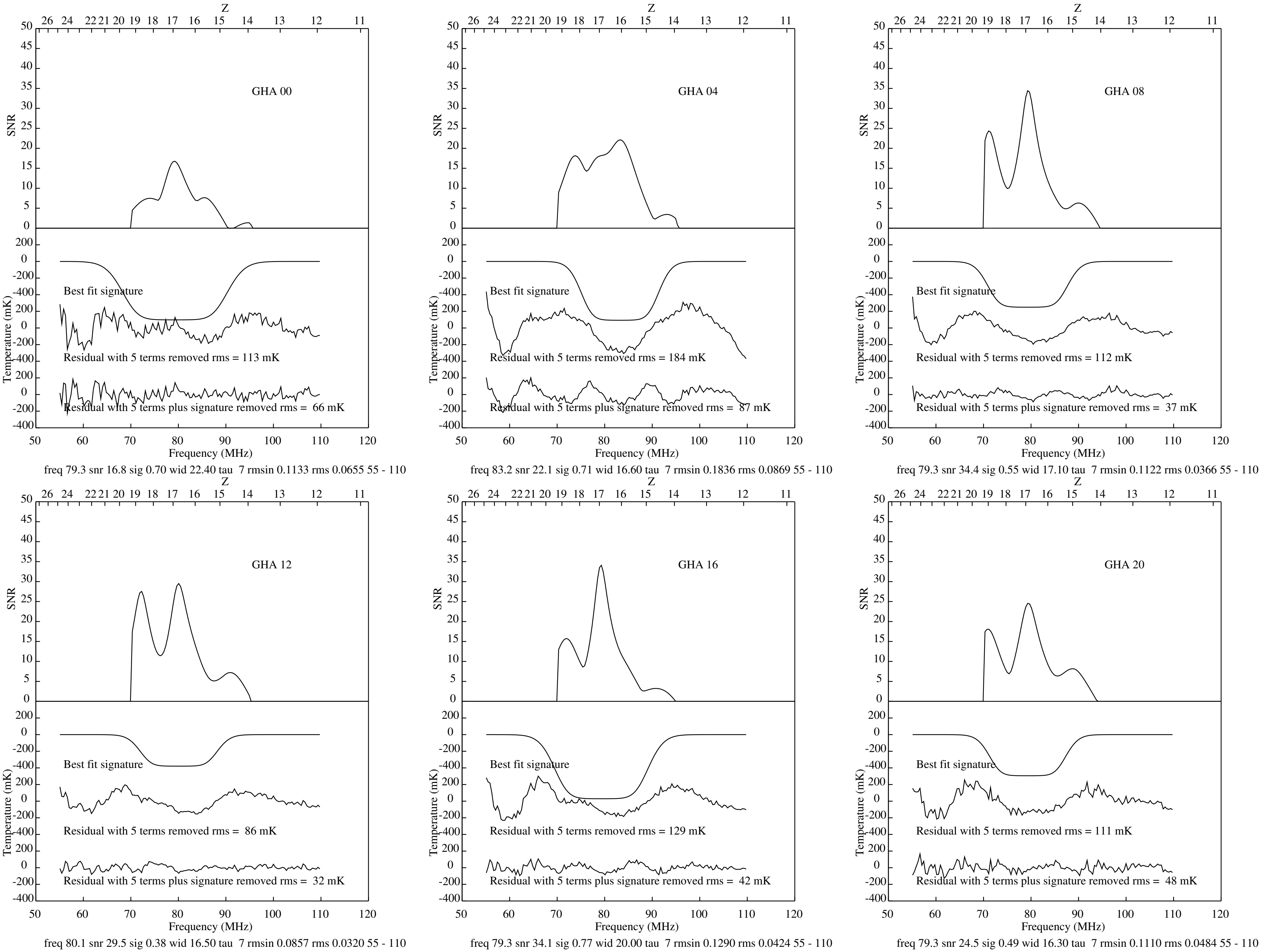

Figure 2. Feature search results for midband 2018 data using a beam correction with a FEKO model which includes a 2 degree tilt and minus 2 degree roll for correction of a ground plane tilt of 2 degrees down from south to north and down from east to west with the antenna pointing west.

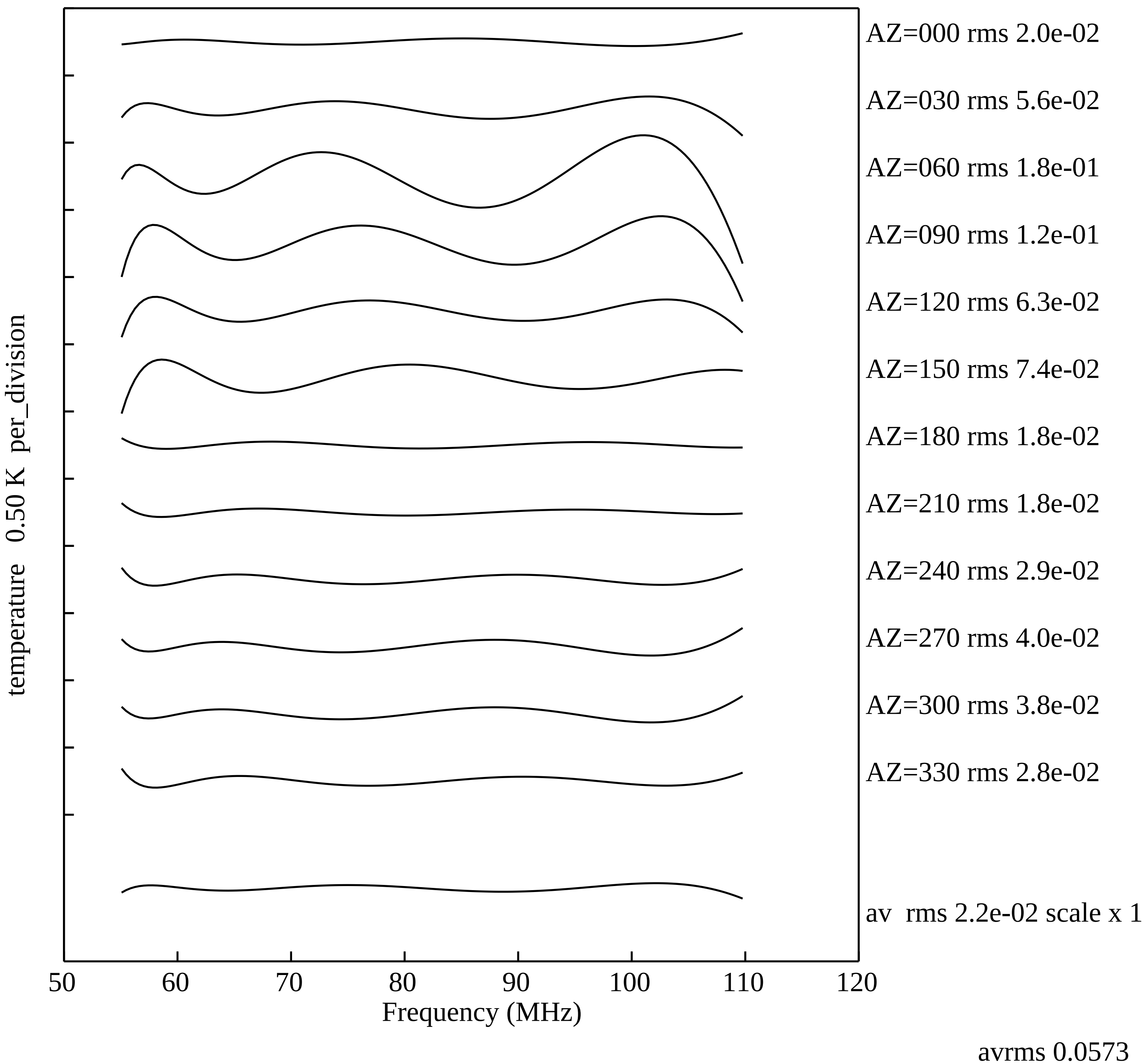

Figure 3. The rms residuals for a simulation of midband beam correction for 5-terms removed for a 6-hour block at GHA=04 hours for a 10 cm bump over 2.5x2.5m in the ground plane with center 5m from the antenna at different azimuths.

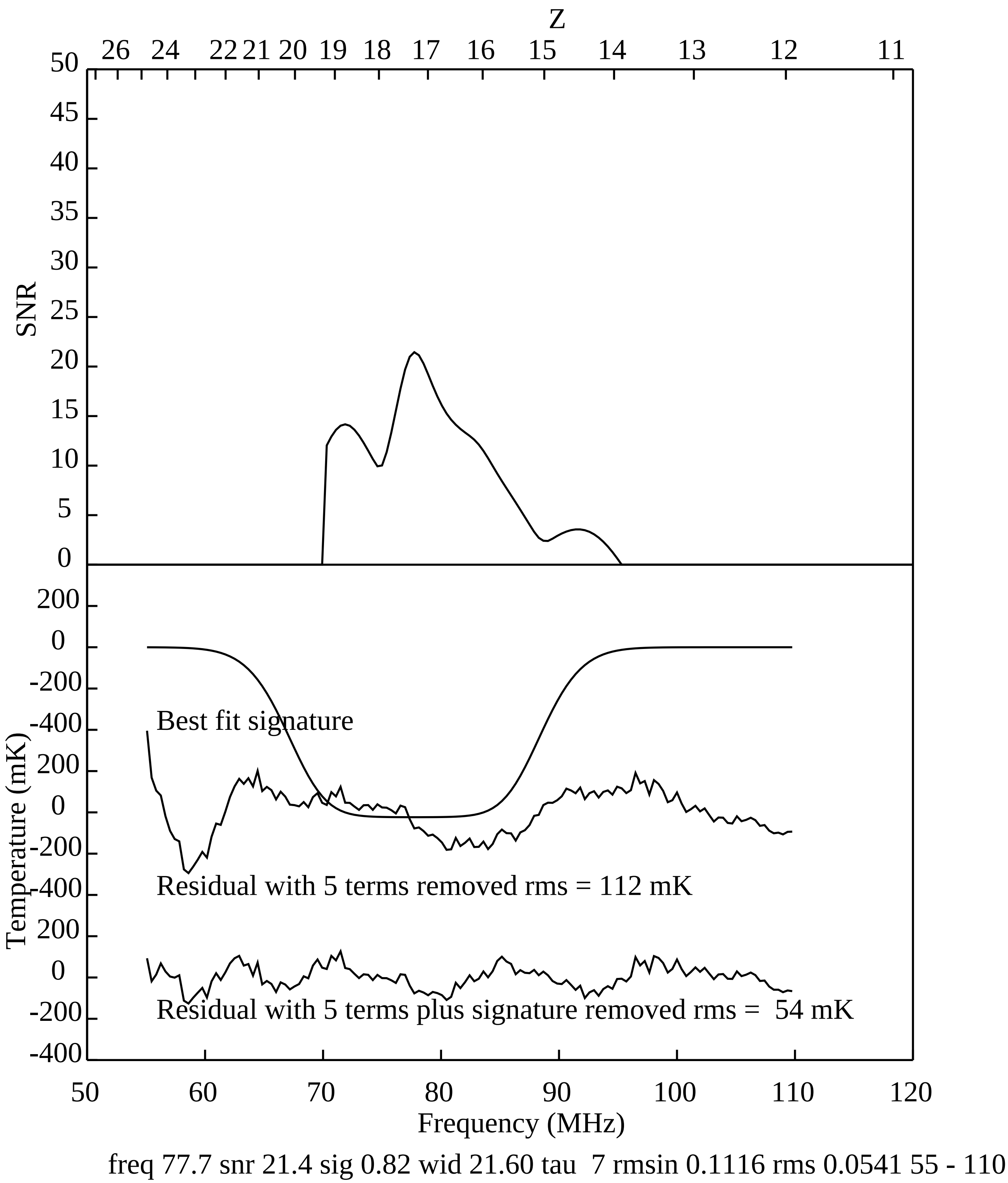

Figure 4. The effect of adding a 5 cm bump over 2.5x2.5m in the ground plane with center 5 m from the antenna at an azimuth of 60 degrees to the midband feature search using the 6 hour data block at GHA=04.