EDGES MEMO #446

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To: EDGES group

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Subject: Analysis of surveys of the 48x48m ground plane taken in November 2022 and March 2024

Survey data reported in Haystack EDGES memo 406 and ASU EDGES memo 202 are analyzed using FEKO to produce beam maps of the EDGES-3 deployment on the 48x48m ground plane at the WA. A survey of 37 locations covering the full extent of the ground plane in November 2022 are shown in Figure 3 of memo 406 and a much bigger survey of 125 locations mainly at selected locations where there are uneven areas in the ground plane are shown in ASU memo 202.

Most of the concern of the initial results from the WA was the large 2K bump at 75 MHz seen in the spectra shown in memo 407 turned out to be due to slot resonances from gaps in the mounting of the antenna baseplate. These were simulated in memo 408 and fixed by adding additional screws in February 2023. In addition to fixing the resonance at 75 MHz there were improvements made in the accuracy of the S11 measurement made by averaging blocks of VNA s1p data in March 2023 as described in memo 412. Then in October 2023 some mechanical parts were added to ensure a constant separation of the antenna boxes. Prior to this there was evidence of some changes in the separation of the antenna boxes which is discussed in memo 416.

In May 2023 there was enough good EDGES-3 data to get reasonable confirmation of the 2018 absorption result shown in memo 418 but it was found that RFI filtering was critical.

The analysis in memo 421 found that there were some significant residuals in 30 minute blocks from 0 to 6.5 hours GHA which might be due to slot resonances in the mesh welds of the ground plane. However a search for slot resonances made during the survey described in ASU memo 202 found no resonances below 500 MHz.

The residuals of a 5 term loglog polynomial are shown in left side of figure 2 of memo 442 for all EDGES-3 data from day 54 2023 to day 50 2024 for which the sun was more than 20 degrees below the horizon. This restriction of the sun's elevation is needed to exclude the effect of the scintillations described in memo 438. Figure 1 shows the residuals using the same parameters and beam correction as used in plot in memo 442 extending the data range to day 91 of 2024.

Qualitatively the survey from November 2022 and March 2024 are similar and both show a slope of about 20 cm over the 48 m from the south down to the north. Figure 1 shows the residuals for a 5-term fit using the beam model with the flat 48x48m ground plane over soil with dielectric 3.5 and conductivity 1e-2 S/m on the left and with the surveyed bumps added over the same soil on the right.

Table 1 shows the results of obtaining an absorption from the data over the range of GHA from 0 to 6.5 hours GHA where the beam chromaticity is most sensitive to bumps in the ground plane.

case	fcenter MHz	amp K	width MHz	average rms K	rms of average mK	rms after fit mK
1	79.3	0.42	20.9	115.9	58	31
2	79.7	0.50	20.9	89.4	49	32

Table 1. Case 1 and case 2 use FEKO beam model for flat ground plane and with bumps respectively

In summary using the surveys to obtain FEKO beam models which include the bumps in the ground plane lowers the residuals which depend on the GHA but significant residuals still remain. In order to check for other sources of error some simulations of the effects of changes in tilt and roll were run by simulating data at the latitude and longitude of the site and processing with offsets in latitude and longitude. The effect average rms for various changes are shown in Table 2.

change	Average rms mK	comments
Latitude from -26.7 to -27.7	6	Changes each GHA differently
Latitude from -26.7 to -29.7	11	"
Longitude from 116 to 117	6	"
Change azimuth from 269 to 260	28	"
Change soil from 1e-2 to 2e-2 S/m	44	"
Change antenna loss from 0 to 1%	18	Changes all GHA almost equally
Add 100ps to S11 of antenna	26	"
Change beam filter from 9 to 8 terms	8	"
Change from Haslam to Guzman map	22	Changes each GHA differently

Table 2. Simulations of the effects listed in the first column

The plots in figure 1 show that while the FEKO beam model which incorporates the bumps reduces the residuals significant residuals are still present. The antenna azimuth of 269 degrees is obtained using google maps which is more accurate than the information in the surveys which used a magnetic compass. The antenna itself is oriented at a slightly lower azimuth at about an azimuth of 268 degrees but the simulation in table 2 is for a 9 degree rotation of the antenna and ground plane. The beam effect of chromaticity is reduced using the Guzman map because the Guzman sky is smoother since was made with an antenna with lower angular resolution than the Haslam map and at a lower frequency do some point sources in the Haslam map get scaled up to a flux that is higher than it should. For example the Cas A spectral index is -0.5 while the Haslam map is scaled up by a spectral index of -2.5 in the beam chromaticity correction. The comparison of the use of the Guzman map instead of the Haslam map is also discussed in memo 437.

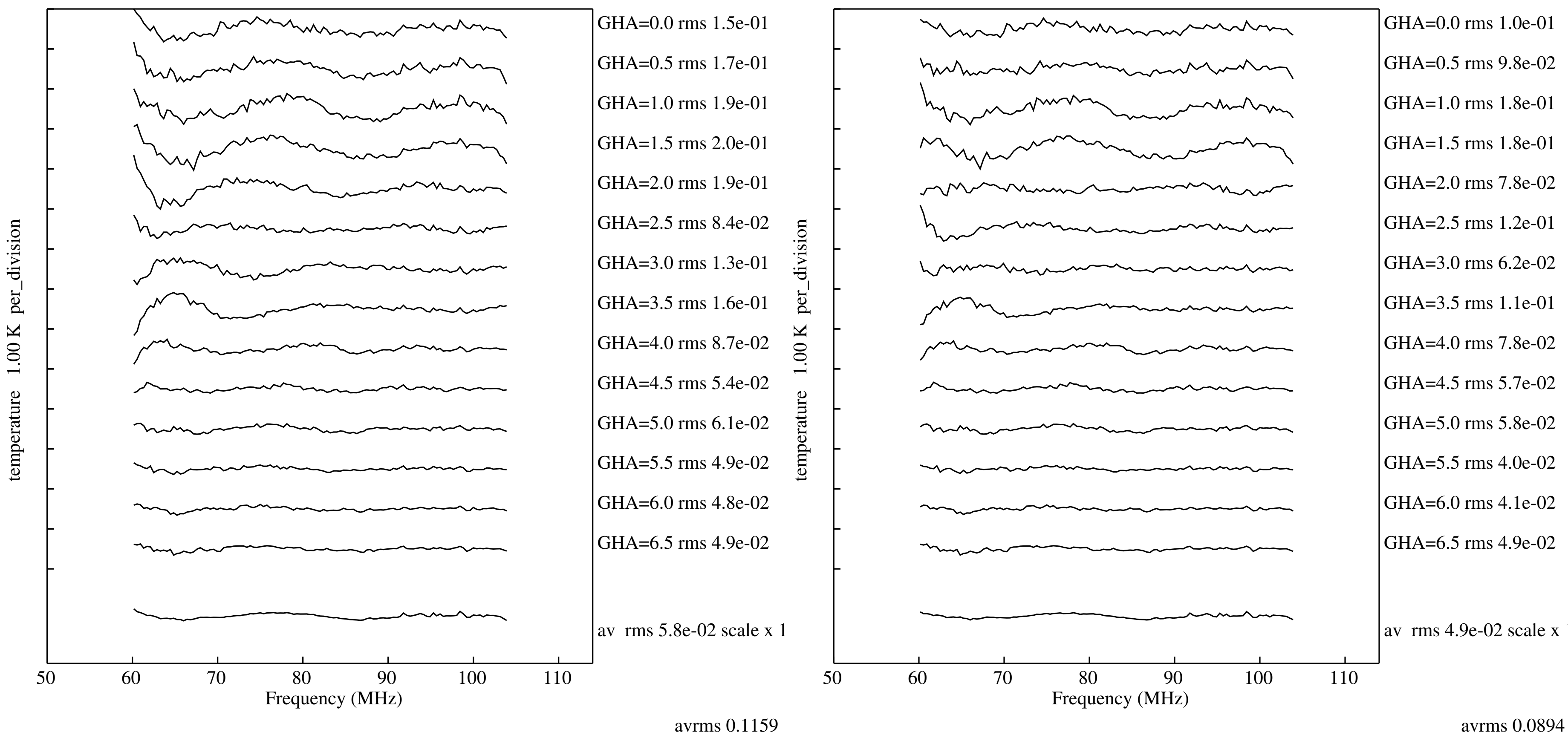

Figure 1. 5-term residuals vs GHA using FEKO beam model for flat ground plane on the left and with bumps on the right respectively.