LST analysis of beam coverage on the sky.

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1 Introduction

This memo summarizes the analyses carried out in efforts to explain a few LST dependent features noted while Raul was analysing the data from all the lowband systems. [Memos]

Specifically, the high and low frequency edges of the flattened Gaussian was not noted at all LSTs in the binned data. The low frequency edge was more significant at a few LSTs and the high frequency edge at other LSTs. In this memo we focus on checking if the antenna beam could explain the LST dependence of the features. We use accurately simulated beam models of the EDGES antenna (Mahesh et al. 2021) and the simulated radio sky maps to aid our analysis.

2 Preliminary Test

In Mahesh et al. 2021, we compared the simulated spectra generated using the EDGES beam models with calibrated data from the field. We look at those plots here again (Fig. 1) for a simple and quick check if product of the beam and the sky could explain what was noted in the data.

From the plot, we observe that the simulated residuals without the feature, don't show the questioned features appearing in any of the LSTs. This to the first order confirms that sky convolved edges beam doesnt produce the features in simulation. On including the feature in the simulation, The feature(s) are consistent over all LSTs (as expected).

But in the data, as noted by Raul, the feature close to 90 MHz is not seen between 18 to 24 hr And the feature close to 70 MHz is not see in bins centered on 5, 23? Furthermore, bins - 17 & 19 are too noisy to make any inference.

So the variability of the feature with LST seen in the data cannot be explained using beam and sky simulations.

3 Analysis Procedure

To further confirm the effects of the beam on the sky spectra, we carry out a more detailed analysis of the beam and convolution products by looking the sky maps at each LST, fitting a standard foreground model and analysing the residuals obtained. All this is done with the simulated spectra using the 3 different EDGES antenna models using different ground planes: PEC ground, 10m $\times$ 10m ground and Extended ground.

Following are the key steps of the analysis:

- Haslam sky map scaled with -2.5
- Generate beam convolved 2D sky maps using the Lowband antenna model
- Frequency range: 55 - 97 MHz
- LST range: 0 to 24 hr
- To obtain residuals we use foreground model : 5 term Linlog

The simulated sky is generated from the Haslam sky map scaled down to frequencies between 55 to 97 MHz with a constant spectral index of -2.5.

In figure 2 we show the sky spectra and beam product at 76 MHz for the EDGES lowband 10m $\times$ 10m configuration as individual sky map for each 2 hour LST bin. The maps are centered at the latitude of the EDGES site location in Western Australia (MRO, -26^o). The galactic plane is overhead at $\approx$ 17hr. The spectral energy of the maps reduces with increasing frequency, as expected.

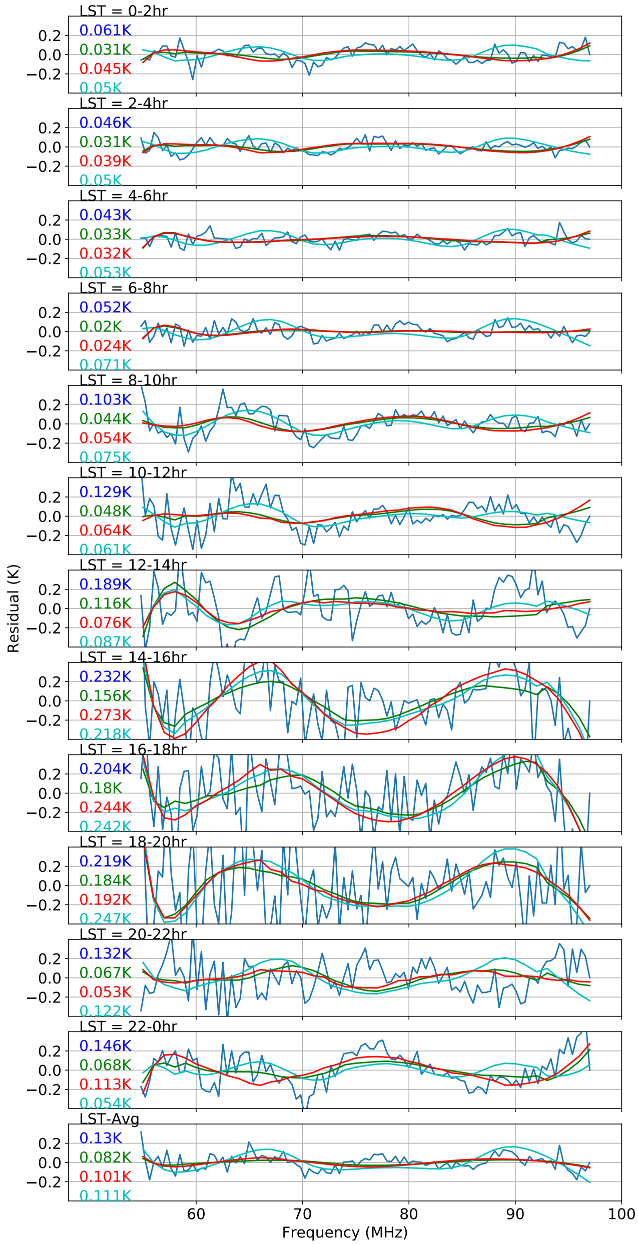

Figure 1: Residuals from the extended ground plane after fitting and removing a five-term LinLog model to the data and the simulated data for each LST bin. Each row corresponds to a different LST bin and shows the residuals to the data (blue), simulated data using the FEKO beam model (green), simulated data using the CST-I beam model (red), and simulated data including the absorption feature using the FEKO beam model (cyan) . The values displayed for each row indicate the FoM derived from the RMS of the residuals between 55 and 97 MHz. The bottom row shows the residuals to the full 24-hour averages of the data and simulated data. The values listed for the bottom row are the LST-average FoMs, which differ slightly from the RMS of the average data because they are the average of the RMS values from each of the LST bins.

We are interested in studying and analysing the structures in the spectra at the mK level (level of the cosmological signal's amplitude). To do this, we fit a 5 term linlog model across frequency to each pixel for each LST binned data and obtain the residuals. We show the residuals obtained on fitting a 5 term linlog to the simulated spectra from the 10m × 10m configuration.The masked pixels are the ones below the horizon. When the galactic plane is overhead, the residuals are seen to be higher (close to 17 hr LST). From these plots we do not notice anything particular in any of the LSTs. So we go on to make more plots with RMS calculations and sky maps.

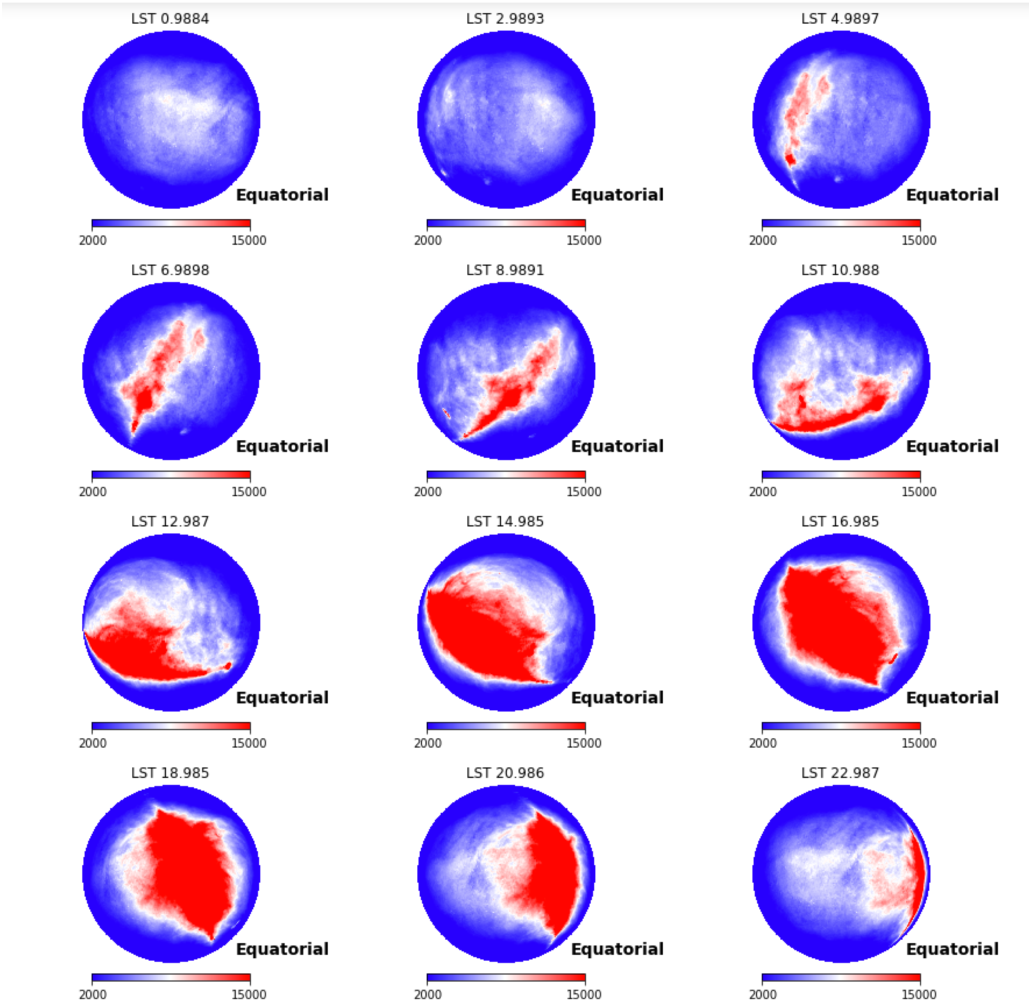

Figure 2: Beam convolved sky map at 76 MHz for each 2hr LST bin. The beam in this map is obtained from the FEKO simulations of the 10m $\times$ 10m configuration of EDGES lowband system (Mahesh et al. 2021). The sky maps are centered at the latitude of the EDGES site location in Western Australia (MRO, -26^o). The LSTs at the zenith of the beam are indicated for each subplot.

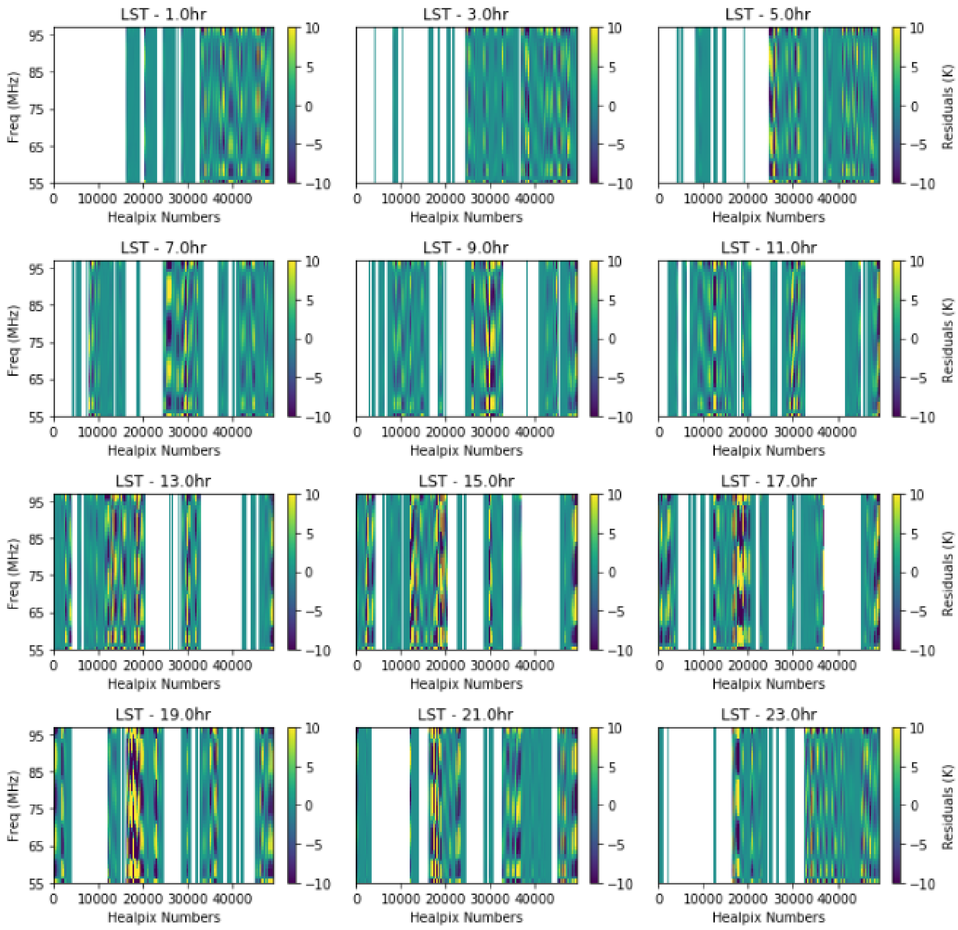

Figure 3: Residuals for to a 5 term linlog for the simulated spectra from a 10m × 10m EDGES system. The residuals are shown as a function of frequency for each pixel on the sky and for each LST bin. The masked pixels are the ones below the horizon. When the galactic plane is overhead, the residuals are seen to be higher (close to 17 hr LST).