LoCo Lab EDGES Memo 189
Alternatives for Beam Correction

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1 Introduction

The antenna temperature spectrum for a sky temperature T_{sky} measured with an achromatic antenna beam $B(\Omega, \nu_0)$ is given by

$$T(\nu) = \int T_{sky}(\Omega, \nu) B(\Omega, \nu_0) d\Omega. \tag{1}$$

In general, however, the beam is chromatic and the measured spectrum is given by

$$T_m(\nu) = \int T_{sky}(\Omega, \nu) B(\Omega, \nu) d\Omega. \tag{2}$$

A spectrum corrected for beam chromaticity can be obtained from the measured spectrum by dividing the measured spectrum by the chromaticity correction factor C,

$$C(\nu) = \frac{T_m^*(\nu)}{T^*(\nu)}, \tag{3}$$

where

$$T^*(\nu) = \int T_{sky}^*(\Omega, \nu) B^*(\Omega, \nu_0) d\Omega \tag{4}$$

and

$$T_m^*(\nu) = \int T_{sky}^*(\Omega, \nu) B^*(\Omega, \nu) d\Omega \tag{5}$$

are simulated spectra for an achromatic and chromatic beam, respectively. They are computed using the models T_{sky}^* and B^* for the sky temperature and antenna beam, respectively.

2 Beam Correction Alternatives

Two possible beam corrections approaches are presented for consideration when integrating measurements across time (LST or GHA). Here, $t1$, $t2$, $t3$, ... represent the time stamps of the raw spectra and N_t is the total number of raw spectra.

2.1 Alternative 1: Time-averaging the corrected spectra

$$\left\langle \frac{T_m}{C} \right\rangle_t = \frac{1}{N_t} \left[\frac{T_m(t1)}{C(t1)} + \frac{T_m(t2)}{C(t2)} + \frac{T_m(t3)}{C(t3)} ... \right] \tag{6}$$

2.2 Alternative 2: Correcting the time-average of uncorrected spectra

$$\frac{\left\langle T_m \right\rangle_t}{\frac{\left\langle T_m^* \right\rangle_t}{\left\langle T^* \right\rangle_t}} = \frac{\frac{1}{N_t}\left[T_m(t1) + T_m(t2) + T_m(t3)...\right]}{\frac{\frac{1}{N_t}\left[T_m^*(t1) + T_m^*(t2) + T_m^*(t3)...\right]}{\frac{1}{N_t}\left[T^*(t1) + T^*(t2) + T^*(t3)...\right]}} \tag{7}$$

Both alternatives approach the following average

$$\frac{1}{N_t}\left[T(t1) + T(t2) + T(t3)...\right] \tag{8}$$

as the models for the sky temperature and beam approach the true values.