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To: EDGES Group

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Subject: Simulations of averaging beam effects over local sidereal time and antenna orientation.

The frequency dependence of the antenna beam on a finite ground plane is a large source of systematic error in the EDGES data. While the beam can be modeled and the data corrected the accuracy of the model is limited by

1] The limited knowledge of the foreground
2] The uncertainty in the mechanical details of the antenna and ground plane especially due to ground tilt.
3] The changes in dielectric constant and conductivity of the ground in the case of small ground plane.

While comparisons of the measured data and simulated data in memo 195 show a high correlation the application of beam corrections fails to remove the small scale structure and is not accurate enough to remove all the large scale structure for the LST around transit of the Galactic Center. Since the beam effects change with LST there is some advantage in averaging over a chosen range of LST. Since the beam effects also change with orientation of the antenna there is also some advantage in deploying more edges systems with antennas with different orientations.

In this study the effect of averaging using the blade antenna with the current 9.9×9.8 m ground plane, a large ground plane using 5 10×10 m sections arranged as a “plus” sign oriented NS or equivalently EW, and an infinite ground plane is examined. The advantage of averaging the antenna NS and EW orientations is also examined.

Table 1 shows that the current ground plane results is much larger beam effects for a LST range close to transit of the Galactic center. In the range of GHA=4 to 16 hours the effects after removing a 4 or 5 physical (Ph) or polynomial (Poly) are only about a factor of 2 higher than with a large or infinite ground plane.

Averaging over a range of GHA=4 to 16 hours doesn’t help significantly. The bottom 2 lines of Table 1 show the effect of applying the beam correction for an infinite ground plane for data taken with the current and extended ground plane which illustrates that the lack of the knowledge of the ground effects is the major contributor to a large systematic errors which cannot be fit with 4 or 5 terms over the frequency wider range of 51 to 99 MHz.

	51-99 MHz mK				67-99 MHz mK				
Beam	4T Ph	4TPoly	5T Ph	5TPoly	4TPh	4TPoly	5TPh	5TPoly	GHA
A	5241	3270	1810	1860	273	720	137	259	0
B	3301	745	238	458	541	107	58	53	0
A	274	134	83	103	26	17	17	16	12
B	168	75	73	41	37	10	7	10	12
A	311	182	86	89	42	24	26	24	4-16
B	363	105	79	18	70	18	13	15	4-16
C	375	107	85	13	82	22	10	2	4-16
A*	268	36	53	35	76	33	17	7	4-16
B*	360	86	72	16	67	16	11	13	4-16
C*	348	90	72	10	73	18	9	3	4-16
A-inf	177	284	163	99	51	30	16	20	4-16
B-inf	22	18	19	18	23	21	18	17	4-16

Table 1. Simulations of rms residuals to beam effects for Blade on current ground plane (A), large ground plane (B) and infinite ground plane (C). A*, B*, C* are for antenna orientation rotated from NS to EW.

With the current “small” ground plane the simulation of an E-W orientation results in lower rms residuals than the N-S orientation. Using 2 lowband systems with the same antenna orientation would provide a good test of the consistency of the receiver calibration and antenna S11 measurement while using the average of data from the 2 antenna orientations would provide some increase in sensitivity to an EoR signature by averaging out some of the beam effects. In the case of the large ground plane there is only a modest improvement.