October 16, 2005

EoR Memo N: Configuration Study for PAPER

D. C. Backer

Astronomy Department and Radio Astronomy Laboratory

University of California, Berkeley

1. 8-Dipole Array Configuration

Cornwell (1988) conducted a study of optimum sampling of the *uv*-plane for snapshot imaging using the numerical technique of simulated annealing. Fig. 1 is derived from his paper using rough estimation of *xy* coordinates; Table 1. has relative locations. Fig. 2 shows the *uv* sampling from this configuration with multifrequency observations at 150 MHz, 175 MHz and 200 MHz. Fig. 3 shows the resulting beam. No iteration was done on this to minimize sidelobe level.

Table 1 : 8-Dipole Antenna Locations (m)

EW	NS
0	0
20	-50
50	110
120	-100
130	150
200	120
220	-60
250	0

The optimum configuration for an 8-dipole PAPER is not entirely clear at this time. Minimum redundancy (in *uv*) for snapshot viewing at zenith would seem to be a good choice. This provides maximum resolution and minimum sidelobe at wide angles. Natural weighting will, of course, produce some Airy lobes close in. This beam degrades in all directions away from zenith. We can't do anything about degradation for declinations south of the site latitude. For declinations north of the site latitude there will be sampling at upper and lower culmination, but for the moment let's ignore consideration of this point. One day we may consider tilting antennas toward the celestial pole (like PAST/21CMA). This would lead to further consideration of optimum configuration.

In this optimum configuration discussion, imaging the foreground sky components – point sources, confusion from unresolved point sources and galactic synchrotron – is the main concern, not optimum detection of the redshifted 21cm-line emission. However, we do want as much resolution as possible for this scientific goal, and so the minimum redundancy criterion would seem to be appropriate.

For the 85-1 site layout of the 8-dipole PAPER the available land constrains us to approximately 3:1 ratio of EW to NS maximum baseline extent. Table 1. provides the approximate locations in this configuration that A. Parsons and D. Backer laid out during their Green Bank visit in 2005 Oct. Antenna locations are numbered from East to West. Dipole #5 is the one alongside the 85-1 telescope to the West. The array center is that of the coordinate system laid out by H. Morton (ref memo n) – the east edge of the double door on the north face of the 85-1 lab.

Table 2 : 8-Dipole Antenna Locations (m)

	EW	NS
1	-100	0
2	-70	-20
3	-50	+40
4	+20	+50
5	+30	-33
6	+100	+37
7	+130	-17
8	+150	0

2. 32-Dipole Array Configuration

With 32 (and more dipoles) we have considerable opportunity to explore optimum configurations. PAPER will be reconfigurable with roughly a days work, and so more than one configuration will be used in understanding precise and accurate imaging of the sky. One choice, which is stimulated by design work for the Allen Telescope Array, is a bivariate Gaussian probability density of number of antennas in the xy (EW,NS) plane. The zenith snapshot beam is the Fourier transform of the autocorrelation function of the electric field samples, and so this too will approach a Gaussian as the number of antennas grows. Multifrequency sampling means one will have a sum of Gaussian beams with natural weighting. Again with large number of antennas, one can think of weighting the data from the different frequency channels to obtain a frequency independent response from each band. Particular uv-sampling is obtained then from different baselines at different frequencies. This fact will enter into the accurate calibration procedure.

A quick program was developed to make a Gaussian distribution with 32 antennas. Fig. 4 shows the antenna locations and Fig. 5 shows the uv sampling with 0.7, 0.9, 1.1 and 1.3 times the nominal frequency. There is arbitrary scale to these plots.

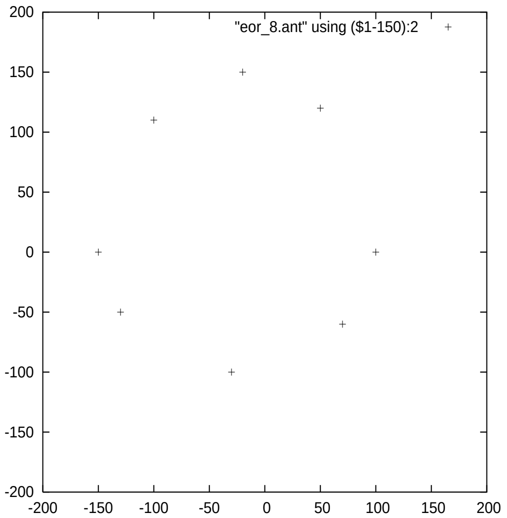

Figure 1. An 8-antenna array configuration based on study by Cornwell (1988).

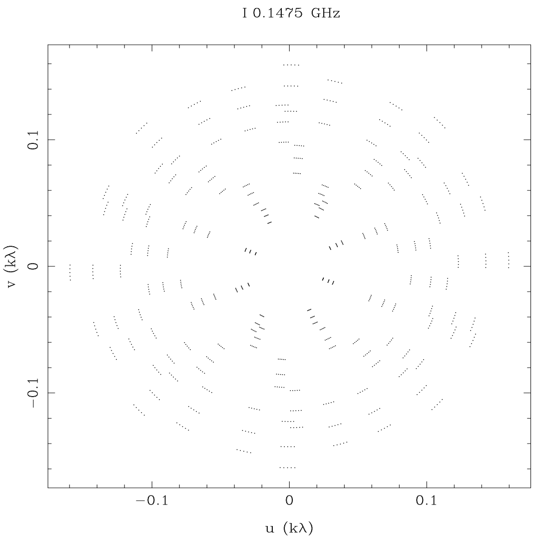

Figure 2. uv-plane sampling of the 8-antenna array configuration in Fig. 1 for snapshot multi-frequency imaging at the zenith.

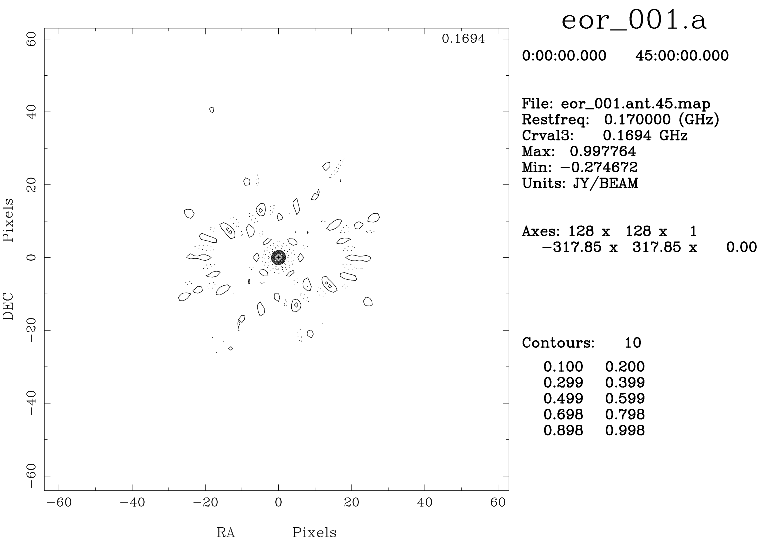

Figure 3. Beam of the 8-antenna array configuration in Fig. 1 for snapshot multi-frequency imaging at the zenith.

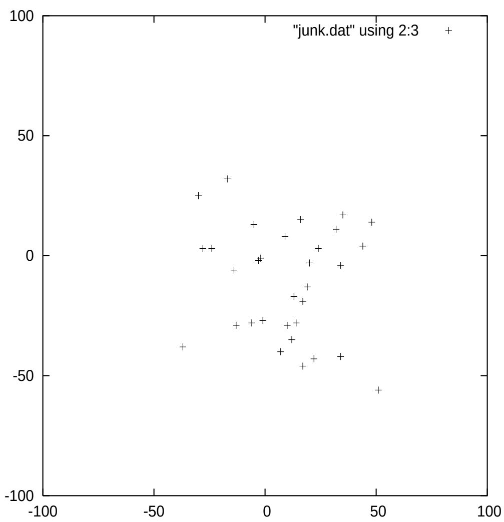

Figure 4. A 32-antenna array configuration based on Gaussian distribution.

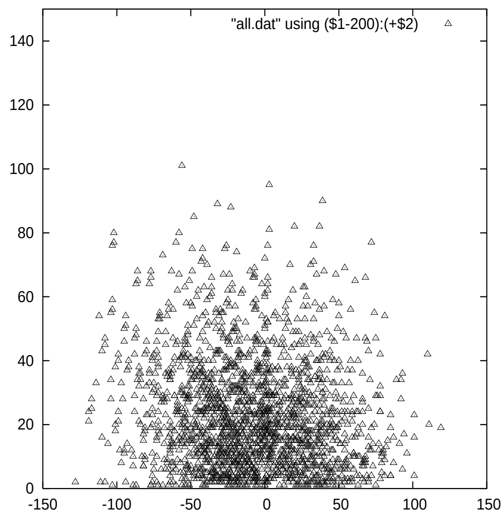

Figure 5. uv-plane sampling of the 32-antenna array configuration in Fig. 4 for snapshot multi-frequency imaging at the zenith.