A re-analysis of PAPER-64 with the simpleDS pipeline.

Matthew Kolopanis*[1], Daniel C. Jacobs[1], Carina Cheng[2], and the PAPER collaboration[3]

[1] School of Earth and Space Exploration, Arizona State U., Tempe AZ
[2] Astronomy Dept., U. California, Berkeley, CA
[3] http://eor.berkeley.edu/

Understanding the evolution of large scale structure during the Cosmic Dawn and Epoch of Reionization will help resolve questions of when and where the first luminous bodies formed, how structures currently visible in the Universe evolved, and how the Universe underwent a global phase transition from a neutral to ionized state. Mapping the redshifted 21cm emission from the hyper-fine splitting of neutral Hydrogen during these eras will provide a wealth of knowledge about the evolution of the Universe. A first detection of this signal is expected to be made statistically via a power spectrum measurement. Experiments hoping to make this first detection include radio interferometers like the MWA, LOFAR, GMRT, HERA, and PAPER.

The best upper limit results from the PAPER experiment in Ali et al. (2016) have been found to contain higher levels of signal loss than had been previously estimated (Cheng et al. *in review*). Signal loss in the original result was primarily incurred by empirical covariance estimation and weighting. An analysis using an independent delay spectrum pipeline (simpleDS) on data from the PAPER 64 element deployment provides an alternative view. Previous analyses of PAPER data (Ali et al. 2016, Jacobs et al. 2015, Parsons et al. 2014) have reported low levels of systematics causing statistically significant power spectrum excess, however the sources of these excesses are obscure. Using this pipeline to perform multiple jacknives, these systematics are explored. Several processing steps including empirical covariance estimation, delay-based foreground filtering, and fringe rate filtering, have been simplified or removed. Analysis steps which are still common with other PAPER results include redundant calibration and LST-Binning.

We apply this independent analysis to data spanning the full range of redshifts probed by PAPER ($z \sim 7.5$ to 11) and include three different redundant baseline types. Previous PAPER results included detections at high levels of significance, ranging two to hundreds of times the theoretical noise prediction, well beyond the horizon for PAPER baselines. Using the expanded data range, we examine these detections using redundancy between paper baselines and power spectrum jackknives to understand how errors in analysis steps can influence power spectrum estimation.

For reasons described in (Cheng et al. *in review*), the upper limits placed by this analysis supersede all previous PAPER power spectrum limits.