Instrument Development for the Precision Array to Probe the Epoch of Reionization (PAPER)

R. Bradley*[1], D. Backer[2], C. Carilli[3], M. Lynch[5], A. Parsons[3], E. Mastrantonio[1], C. Parashare[4], N. Gugliucci[4], and D. Herne[5]

[1] National Radio Astronomy Observatory, Charlottesville, VA
[2] University of California, Berkeley, CA
[3] National Radio Astronomy Observatory, Socorro, NM
[4] University of Virginia, Charlottesville, VA
[5] Curtin University, Perth, Australia

There are three guiding principles that influence the design of the PAPER instrument: performance, reliability, and cost. One must keep in mind that PAPER is a science-directed experiment, focused clearly on the task of detecting the Epoch of Reionization (EoR) HI signature and, as such, the instrument design parameters have been optimized toward this end. Simplicity is a genuine, fundamental feature of the design. Over the past several years, our group has been working to understand those subtle, yet critical aspects of the PAPER instrument that directly affect the quality of the data and the complexity of the calibration process. Reliability of components and subsystems, to ensure satisfactory operation over the expected lifetime of the experiment, is also reflected in the design. And, of course, all of this must be accomplished within the bounds of a budget that is both reasonable and sufficient to support the tasks at hand.

The PAPER instrument is a precision imaging spectrometer that must operate effectively in both the spatial and temporal Fourier domains within specifications that flow from the requirements for our single-task experiment. Each element of the array consists of an orthogonal pair of sleeved dipoles mounted above a screened platform. Signals from the two dipoles are amplified by a specially developed differential preamplifier and then directed, via 75 ohm coaxial cables, to the central instrument hut where the dual-channel receiver provides additional amplification and passband filtering. Once the signals are sampled, FPGA-based signal processors perform the auto- and cross-correlation operations and directs the resulting data to a local storage device. This processing architecture, a set of analog-to-digital converters and modular FPGA-based signal processing engines, and a software environment for programming, debugging, and running them, have been developed in collaboration with the Center for Astronomy Signal Processing and Electronics Research (CASPER) at the University of California, Berkeley.

We will present a summary of our PAPER instrument development activities and the results from our three significant array deployments at our field sites in Green Bank , WV and in Western Australia. Preliminary results from our current effort, a sixteen-element array in Green Bank, will also be shown. Plans for building our EoR array in Australia will also be presented.