## Supplementary Document: Partner Institutions and Roles

Listed below are the partner institutions that are to be funded via subawards, along with the role of each in the project.

### University of California, Berkeley (UCB)

UCB, building on Parsons' and Werthimer's expertise in digital instrumentation for correlator development for PAPER/LEDA and DeBoer's expertise in antenna development for the Allen Telescope Array, will develop the node, correlator, and dish design for HERA, drawing on the resources of several engineers and technicians in the UCB Radio Astronomy Laboratory. These efforts will be coordinated and supervised by Werthimer. UCB engineers and staff, together will a graduate student focused on instrumentation, will perform hardware commissioning, and will perform data analysis for characterizing antenna and system performance on the basis of the delay-space metrics that are central to controlling foregrounds.

UCB will be responsible for issuing contracts for the fabrication, shipment, and deployment of the HERA instrument, including the antennas, analog electronics, nodes, the correlator, and infrastructure. DeBoer will oversee the design, construction, and operational phases of the project, coordinating efforts with the site team in South Africa leading infrastructure development, the leaders of the fabrication, shipment, and deployment contracts, the site manager and Project Engineer, Goeke, and the leads of the analog, digital, data, and software subsystems.

Parsons will lead two graduate students and a postdoctoral researcher in continuing to develop and apply software for power-spectrum data analysis based on the delay-spectrum and covariance-diagonalization techniques that have been successfully applied on PAPER data.

### University of Pennsylvania (UPenn)

The UPenn group will host the central computing cluster and data archive for HERA. Penn currently performs this function for PAPER. The cluster will be maintained by an IT professional. Penn will also manage the flow of data flow from South Africa to the central storage, and thence to collaborators as necessary. In addition, building on experience with the PAPER data compression, UPenn will provide the quality assurance (QA) of raw data, including both software and hardware checking and reporting on the data in real time. This will be the responsibility of the postdoctoral fellow and the graduate student, with the goal of making science quality data available as soon as possible after observation. Finally, UPenn will continue efforts begun on PAPER investigating polarization effects on measured reionization power spectra, providing feedback on the performance of the antenna design, providing polarization calibration, and pioneering polarization leakage mitigation techniques as necessary. This, combined with power spectrum analysis, will form the basis for a graduate student thesis.

### Massachusetts Institute of Technology (MIT)

Hewitt and Tegmark, with two graduate students and a postdoctoral researcher, will be responsible for operational data analysis, performing routine imaging and calibration for the purpose of

evaluating instrument performance, and generating and distributing data products to the broader community outside of HERA. Additionally they will develop and apply optimal estimator techniques for power spectrum analysis with HERA data, and will undertake analysis of low-frequency (¡100 MHz) HERA data to characterize foregrounds and perform the Dark Ages science component of this proposal.

Goeke, building on experience as a System Engineer for the MWA, will ensure that site construction proceeds on schedule and according to plan, and will engage with the antenna subcontractor hired by UCB to optimize the antenna design for manufacturability.

**University of Washington (UW)**

develop and apply FHD & related techniques for imaging and power spectrum analysis, focusing on direction-dependent gain/leakage issues. Characterize primary beam based on celestial sources. monitor/control client calibration and model subtraction software subtraction-based power spectrum pipeline

**National Radio Astronomy Observatory (NRAO)**

Using the PAPER analog subsystem as a baseline, NRAO (Bradley, assisted by a technician) will develop the RF electronics design and optimize the feed design to maximize the illumination of the parabolic dish and minimize the beam ellipticity that gives rise to raw polarization leakage of the instrument. These systems will be installed and evaluated on two two prototype parabolic reflectors in Green Bank whose construction is provided for in the UC Berkeley budget. The optimized and tested design will be furnished to UC Berkeley for fabrication.

In addition, NRAO scientists (Carilli, assisted by a Cambridge graduate student) will perform data analysis for foreground and 21cm reionization science, investigating flagging, calibration, and imaging using the CASA software, and collaborating with the related efforts of other HERA partners. NRAO will develop CASA software with enhancements for imaging with wide-field, wide-band data, and will support analysis efforts by handing debugging, instruction, and enhancement requests.

**Arizona State University (ASU)**

Develop and apply In-situ beam calibration systems (octocopter?) and develop some absolutely-calibrated balun/receivers. Application of higher-order statistics to 21cm reionization science. science commissioning total-power balun development octocopter beam calibration data calibration

**University of California, Los Angeles (UCLA)**

At UCLA, Furlanetto will develop tools for the final stages of data analysis in the HERA project, building tools to bridge the gap between the data products and the physics questions of galaxy formation and evolution. Specifically, this work entials updating Furlanettos two existing semi-numerical codes (the public codes 21cmFAST and DexM) to match the parameters and strategy of the HERA experiment, and then simulating sources of the spin-flip background, identifying

and varying the key parameters that HERA measurements will constrain. Experimental data will then be compared to these simulations in order to extract quantitative constraints on these parameters. This work will be done by Furlanetto and a graduate student, for whom this project will constitute their Ph.D. thesis.