

## Facilities, Equipment, Other

The work described in this proposal will take place at XXX locations:

### 0.1 *Arizona State University*

### 0.2 *Massachusetts Institute of Technology*

#### *NRAO Green Bank*

Our 500 sq. ft. field station is located on the NRAO Green Bank, WV observatory site. It houses a work area and plenty of space to deploy instrumentation. Positioned within the National Radio Quiet Zone, this site is an ideal venue for very sensitive radio frequency measurements due to its remoteness from large urban areas and its exceptional laboratory infrastructure. A relatively large amount of outdoor space is available adjacent to the station for the deployment of antennas under test. The satellite downlink measurement system is here, and the PAPER array is located nearby. Electromagnetic enclosures are used to house all instrumentation to prevent self-interference as well as interference with Observatory telescopes, in strict adherence to the radio emissions control policy of the Observatorys Interference Protection Group (IPG).

There warehouse facilities located in Green Bank are ideal for staging our shipments to South Africa. Wooden crates are built in the carpenter shop and moved to the warehouse for packing and short term storage. Heavy lift equipment and the expertise to use them safely are also available to transport these crates to the truck mounted shipping containers destined for the cargo ship.

#### *South Africa*

PAPERS been given the use of a 300m diameter cleared, level, circular area located within the protection of South Africas Astronomy Geographic Advantage Act. A 120dB RFI shielded 12m container has been placed in the center to house electronics. The entire system is powered by 20kVA diesel generator though installation of a grid connection is under investigation. The container houses work space and two 19 42U racks for PAPER systems. It is cooled by a 5 kW capacity chiller plant. This should provide sufficient capacity for up to a 128 antennas.

In addition, SKA-SA assists with the unloading, assembly and storage of shipping crates. Two on-site mobile truck cranes are available along with use of a 30m x 18m dish construction shed, shared with the KAT-7 construction. Accommodation is provided for on-site PAPER visitors and off-road pickup trucks are available for use to, from and while on site.

A digital electronic laboratory is available in the Cape Town SKA-SA offices, complete with hot-air rework stations and high frequency test equipment (bench power supplies, signal generators, network analyzers, spectrum analyzers, oscilloscopes up to 100GHz etc). There is an off-site RFI measurement facility near Cape Town (Houwteq) able to perform measurements to, amongst others, MIL-STD-461E (18GHz) with a greater than 100dB 11.5m x 7.5m x 8.5m anechoic chamber, large hangar shed, open area test site and vibration room for testing transmitters and receivers.

#### *University of California, Berkeley*

The UC Berkeley Radio Astronomy Laboratory (RAL) is located adjacent to the UC Berkeley Astronomy Department. It provides laboratory space and access to digital and radio-frequency

test equipment necessary for the detailed characterization and performance testing of components of the proposed correlator development work. Such items include power supplies, signal generators, network analyzers, oscilloscopes, noise generators, filters, attenuators, amplifiers, and other miscellaneous electronic equipment. RAL also hosts the programming environment targeting the Field-Programmable Gate Array processors on which the proposed correlator work is based. This facility is available to members of the UC Berkeley Astronomy Department.

The Berkeley Wireless Research Center is located adjacent to the UC Berkeley campus. It provides access to additional high-end digital test equipment and software for digital signal processing. Available to members of the Collaboration for Astronomy Signal Processing and Electronics Research.

### *University of Pennsylvania*

J. Aguirres laboratory at the U. Pennsylvania contains signal processing equipment, hard drives, and data backup systems necessary for the analysis of PGB-32 and PSA-32 array data. Extra space is available to house the additional data analysis hardware described in this proposal to support the PSA-128 array.

### *University of Virginia / NRAO Charlottesville*

Our 800 sq.ft. research laboratory is located at the NRAOs Technology Center. It is equipped with two complete micro-assembly workstations for component fabrication and rework as well as a suite of basic instruments necessary for evaluation and repair. In addition, the laboratory contains several signal generators, power meters, spectrum analyzers, an impedance bridge, network analyzers, and noise figure meters for radio frequency applications. A small anechoic chamber is available for antenna impedance measurements, and an computer-controlled environmental chamber is ready for studies of thermal and humidity induced effects on component and subsystem designs. We routinely make use of the NRAO machine shop facilities.

We also have access to the latest computer-aided design software. Autocad Inventor is used for three-dimensional mechanical drawings. Agilent's Advanced Design System (ADS) is available for circuit and subsystem modeling while CST Microwave Studio is used for electromagnetic simulations of antenna and other RF structures. In addition, CF Design is available for modeling thermal conduction and radiation pathways.

As for human resources, we currently have a research engineer, two technical specialists, and an electronic technician in our laboratory. We also have three graduate students and one high school student working on a variety of projects. Recently completed and current projects include the Green Bank Solar Radio Burst Spectrometer (GB/SRBS), component and system development for the Frequency Agile Solar Radiotelescope (FASR), the Lunar Energetic Neutrino Search (LENS), a new sinuous-type broadband feed (being adopted for FASR and the MIT/Lincoln Labs bi-static radar project), and the analog systems for PAPER.

The digital laboratory is equipped with instrumentation to build and evaluate large scale signal processing systems such as digital correlators for telescope arrays. The ALMA correlator was recently developed here. In addition, the laboratory also contains a sealed room having a raised floor and air handling system with a 50 kW capacity chiller. The room is also equipped with an inert gas fire extinguishing system.

### **0.3**   *University of Washington*

M. Morales' laboratory at U. Washington provides access to precision radio development laboratory equipment, including a vector network analyzer, spectrum analyzer, mixed-mode oscilloscope, and precision power and clock equipment. This laboratory also provides computing resources for software development, testing, and basic data analysis.