Development of an all Cryogenic PAF Camera for Radio Astronomy

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One of the main motivations for radio astronomy phased array feed (PAF) cameras is the inherent advantage in survey speed compared with discrete feed horn systems. This is achieved by placing multiple beams within the Field of View of the telescope. The ultimate survey speed will depend on the number of these beams combined with the square of the ratio of the telescope's effective area and the system temperature (Tsys).

Work on PAF systems has been ongoing in Australia with the Australian SKA pathfinder (Schinckel et al., 2011), the Netherlands with the Westerbork array (van Capellan et al., 2012), and Canada at the Dominion Radio Astronomical Observatory (DRAO). All these PAF systems work at room temperature. In the USA the effort has been directed to improving Tsys by cryogenic methods. A group at Brigham Young University (BYU) and the National Radio Astronomy Observatory (NRAO) have build a cryo PAF system for which only the LNA's are inside of a cryostat and special thermal transitions have been manufactured to connect the LNA's to room temperature antenna elements through the walls of the dewar.

At Cornell, we have designed and are building an all cryogenically cooled PAF system which has both the LNAs and the antenna elements cryogenically cooled. The goal is to achieve a Tsys of 35K or better. This cryogenically cooled PAF system consists of 19 dual polarized dipole elements placed on a hexagonal grid. The array is completely enclosed inside a cryostat 0.8 m in diameter and 0.6 m in height with two temperature stages; 70K and 18K. The cryostat vacuum window consists of a Kapton film supported by a very high strength foam which is transparent at 21 cm wavelength while opaque at IR frequencies reducing the IR load into the system The bottom layer of the foam rests on the ground plane at an estimated operational temperature of 80K. This layer of foam has cutout cavities to accommodate the dipole probes, at ~18K, without any contact with higher temperature surfaces. We have sucessfully completed both vacuum and cryogenic tests, and field tests of the prototype camera are expected to be completed within the first quarter of 2013. These will be done in collaboration with BYU and NRAO at NRAO's Green Bank site, followed by final system tests with BYU at the 305 m Arecibo telescope.