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# The Design of a Cryogenic Phased Array Receiver for the Parkes Radio Telescope

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The Parkes Radio Telescope is a 64 m prime focus radio astronomy antenna. For many years, a 13 beam multibeam receiver has been the principal instrument for wide field of view observations and mapping. In order to enhance both the field of view and the frequency range of the telescope, a cryogenic phased array system is under development, with installation onto the telescope expected in mid-2022.

The phased array feed will consist of a regular grid of antenna elements with 196 ports, 98 for each polarization. It will cover a frequency range of 0.7-1.9 GHz from which an arbitrary 300MHz band may be beamformed. The octagonal array, presented in fig. 1, contains three distinct element designs: central elements, edge elements and corner elements. The central elements are similar in design to the 'rocket' elements presented in [1]. The edge and corner elements form a simple tapered slot with the central elements and improve the match and radiation pattern at the edges of the array.

Differential low noise amplifiers (LNAs) with integrated calibration noise coupling are attached directly to the base of the elements. These LNAs have been integrated into groups of 8 to form 26 LNA modules. The 8 signals from each of these LNA modules are processed in a single electronics module containing RF signal conditioning, digitization, preliminary digital signal processing and optical data transmission. The signals are then combined in a remotely located digital beamformer, implemented using commercial FPGA cards. The beamformer will allow 72 dual polarization beams to be formed which will subsequently be processed in a GPU cluster.

The receiver is cooled with two single stage cryocoolers to approximately 30 K. The use of single stage cooling, rather than the more common two stage cooling, results in a small degradation in the noise temperature of the LNAs. However, this is offset by the elimination of a thermal transition between the receiving elements and the LNAs. Single stage cooling also results in a substantial simplification in the mechanical structure of the array and avoids the complication of interstage transitions between the large number of electrical connections.

An end to end system simulation of the array has been performed yielding metrics such as the system temperature and aperture efficiency over the field of view. We discuss the key features of the array derived from these simulations and present preliminary measurements of system performance.

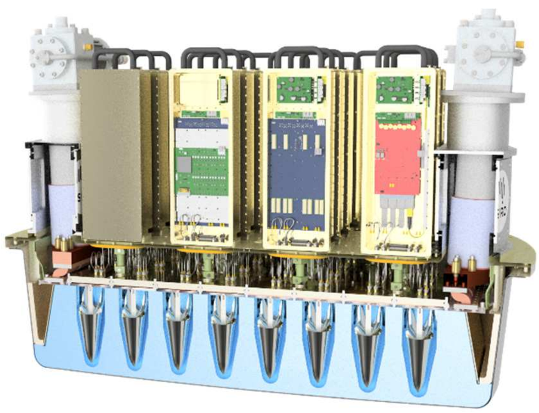

**Figure 1.** A rendered cross section of the cryogenic phased array receiver displaying the array elements at the base, the ambient temperature electronics modules and the two cryocoolers.

1. A. Dunning, M. Bowen, D. B. Hayman, K. Jeganathan, H. Kanoniuk, R. Shaw, S. severs, "The development of a wideband 'rocket' phased array feed," 2016 European Radar Conference (EuRAD), London, 5-7 Oct. 2016