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Upgrading the Phased Array Feed for the ASKAP Telescope

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1 Extended Abstract

The ASKAP telescope [1] is located within Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio-astronomy Observatory, an area in the mid-west region of Western Australia in which terrestrial radio transmissions are managed under a legislative framework. The telescope is comprised of 36 dish antennas with a maximum separation of six kilometres. Each antenna is 12 meters in diameter and supports a planar phased array feed (PAF) at its focus. The remote site provides an exceptional location for ground-based radio astronomy far from sources of terrestrial radio frequency interference, but places numerous engineering and practical constraints on the design of the ASKAP PAF. Cryogenic cooling of the array is impractical in such a location and so the PAF is realised as a 188-channel, room-temperature receiver. The receiver utilises a Peltier cooling system to stabilise the temperature effects on the low-noise amplifier (LNA) gain. In the interest of minimising potential emissions, the primary power supply for the PAF is a convection cooled, high current linear supply located externally and adjacent to the PAF.

The development and subsequently successful use of the “rocket” element in the recently installed CryoPAF – cryogenic PAF for Murriyang, our Parkes radio telescope [2], has demonstrated the suitability of this element for PAF applications. Based on a conical solid of revolution, the rocket has a significantly flatter frequency response than the planar “chequerboard” array of the current ASKAP PAF.

Improving the sensitivity of the ASKAP PAF has been identified as offering the largest impact from any subsystem upgrade. Additionally, it will provide a solid RF foundation on which to base future digital system upgrades as computing power improves. With this comes the opportunity to modernize related systems such as cooling, control and monitoring and improve power efficiency and connectivity. To achieve this, we will produce a new prototype PAF that can be installed on an ASKAP antenna and evaluated over time.

The PAF will feature a new LNA design utilising Diramics state-of-the-art RF transistors to provide the lowest possible noise temperature. The planar array will be replaced with an array of “rocket” elements to provide improved frequency response across the band of interest. The combination of these is expected to result in a sensitivity improvement of 2 to 3 times over the current system. In addition, the use of rocket elements with a physical barrier (radome) will protect the elements from the harsh environment. The nature of the rocket design allows the elements to be grounded, thereby reducing susceptibility to lightning events. To address power efficiency, we will leverage our experience from recent radio astronomy receiver projects and develop a highly shielded, switched-mode power supply that can be located within the PAF structure. Options for a more efficient cooling system will be investigated and a system designed to allow year-round operation of the PAF while minimising LNA gain variation.

The project is scheduled to run over three years with the LNA development currently underway and mechanical work due to start in the near future.

References

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[2] A. Dunning et al., "A Wideband Cryogenic Phased Array Receiver for Radio Astronomy," 2023 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting (USNC-URSI), Portland, OR, USA, 2023, pp. 757-758