Ultra Wideband and Phased Array Feeds for Radio Astronomy

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CSIRO operates three radio astronomy observatories around Australia that are collectively known as the Australia Telescope National Facility (ATNF). The Parkes radio telescope, Murriyang, is a 64m diameter prime focus single reflector telescope located near Parkes in NSW. The Australia Telescope Compact Array (ATCA) is a six-element interferometer consisting of 22m diameter Cassegrain reflectors located near Narrabri in NSW. The ASKAP radio telescope is a 36-element interferometer consisting of 12m prime focus reflectors with room temperature phased array feeds located at Inyarrimanha Ilgari Bundara, the CSIRO Murchison Radio astronomy observatory approximately 800km north of Perth in WA.

Periodic receiver upgrades can extend the life of these high value assets by improving overall performance targeted to planned astronomical surveys. A survey speed figure of merit has been defined for radio telescopes which is proportional to the product of the sensitivity squared, the bandwidth and the field of view [1]. Hence, sensitivity, bandwidth and field of view are the key performance metrics for receiver upgrades. The sensitivity can be improved by decreasing noise in the receiving system or by increasing the collecting area. With collecting area of existing radio telescopes fixed, and limited opportunity to decrease noise further, increases in bandwidth and field of view have been the focus at CSIRO over the past decade.

A dual polarised wideband feed (Fig. 1, left) with almost constant beamwidth over a 6:1 bandwidth and system temperature of 22K from 0.7 – 4GHz was designed and installed on Parkes in 2018 [2, 3]. High aperture efficiency was achieved by combining a quad ridged feed with a graded dielectric insert to maintain stable beam patterns at low frequencies. Similar wideband feeds have been designed and installed on the Effelsberg 100m radio telescope with 5:1 bandwidth from 1.2 – 6GHz, and designed for the next generation very large array (ngVLA) to operate over the band 3.4 – 12.3GHz.

A cryogenic phased array feed receiver (Fig. 1, right) is currently being developed for Parkes to replace the multibeam receiver, operating over the frequency range 0.7 – 1.95GHz and enabling 72 dual polarised beams and significantly increasing the field of view of the telescope [4].

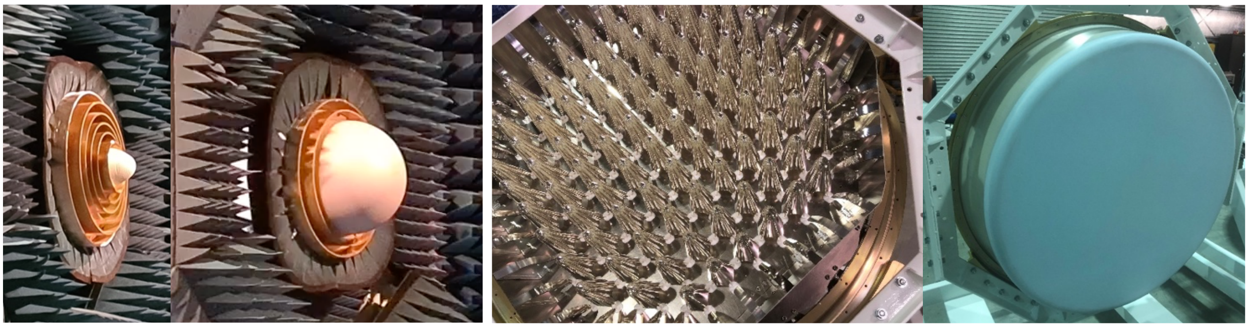

Fig. 1: An ultra wideband feed (left 2 pictures) and phased array feed (right 2 pictures).

[1] J.D. Bunton, “Figure of merit for SKA survey speed,” SKA Memo 40, 2003.
[2] A. Dunning, M. Bowen, M. Bourne, D. Hayman and S.L. Smith, “An ultra-wideband dielectrically loaded quad-ridged feed horn for radio astronomy,” in IEEE-APS Topical Conference on Antennas and Propagation in Wireless Communications (APWC), pp. 787-790, 2015.
[3] G. Hobbs et al, “An ultra-wide bandwidth (704 to 4032 MHz) receiver for the Parkes radio telescope,” Publications of the Astronomical Society of Australia (PASA), vol. 37, 2020.
[4] A. Dunning et al, “A wideband cryogenic phased array receiver for radio astronomy,” IEEE Int Symp Ant Propagat., 2023.