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Early results of a Phased Array Feed system at Effelsberg

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Abstract. The overview of a Phased Array Feed (PAF) system and the early results with it on the 100 m diameter telescope at Effelsberg are presented in the paper.

Keywords. instrumentation: detectors, (stars:) pulsars: individual (PSR J0358+5413), etc.

1. Introduction

In a collaboration, the Australia Telescope National Facility and the Max-Planck-Institut für Radioastronomie have embarked on a project to install and utilize a Phased Array Feed (PAF) system on large-gain, single-dish telescope with significant direct access for astronomers.

After the initial commissioning observations on the Parkes 64 m telescope, the system was shipped to Effelsberg and tested in Spring this year. In order to commission it, we re-installed it in the primary focus of Effelsberg 100 m telescope from 3rd to 10th August. Here we give an overview of the system and represent two early observations† we did with it at that time.

2. System overview

A PAF receiver is a dense array of antenna elements at the focus of a reflector telescope and the output of these elements can be combined to form beams on the sky. The direction of these beams is controlled by varying the weights of individual elements. The PAF (Hampson *et al.* 2012) described here was designed for the Australian Square Kilometre Array Pathfinder (ASKAP) telescope, but slightly modified for use on the Effelsberg telescope (Chippendale *et al.* 2016).

An array of 188 connected "chequerboard" antenna elements is distributed over approximately a 1.2 m diameter circle. It is a dual-polarisation receiver and each polarisation has 94 elements. The analog signals from all elements, each of up to 600 MHz bandwidth, are transmitted to the digital receiver via RF-over-fibre links and sampled there by 12 "Dragonfly" digital receivers. The digital receivers also channelize the data to 1 MHz via a multi-stage oversampled filterbank (Tuthill *et al.* 2012). With 16 ports per receiver this results in a 192-port digital system, with four spare ports beyond the 188 connected to

† Please look at the poster for the observations which we can not present in the paper.

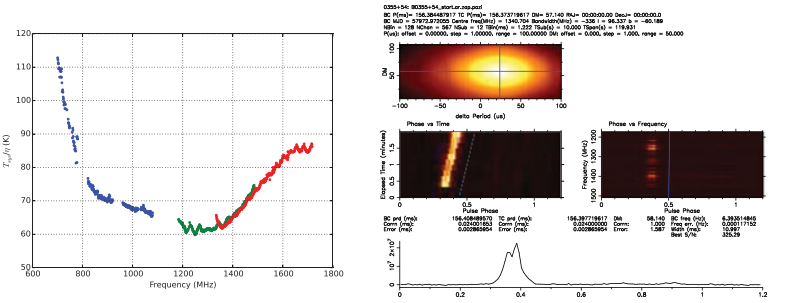

Figure 1. Early results of a PAF system at Effelsberg 100 m telescope. The left sub-figure represents the system temperature over efficiency of PAF's central beam. From left to right are the results for 1200 MHz, 1450 MHz and 1800 MHz bands separately. The right sub-figure shows the observation of PSR J0358+5413 (B0355+54) with the same beam.

the PAF receiver. The digitised signals are processed by eight "Redback" beamformers to form up to 36 dual-polarisation beams of 384 MHz bandwidth (48 MHz per beamformer) in 1 MHz frequency channels. We stream 336 MHz of 16-bit beamformed baseband data (42 MHz per beamformer) at the full sampling rate into Graphics Processing Unit (GPU) nodes via Ethernet switches in 7 MHz frequency chunks. The beamformed data is converted to filterbank format files on these GPU nodes for further processing.

3. Observations

We measured the system temperature over efficiency of PAF's central beam with on and off-source observations of Cas A. The left sub-figure of Figure 1 is the result with Radio Frequency Interference (RFI) channels manually removed. We can see that the system temperature over efficiency is around 70 K for the central band. It increases towards the edges of band, with much better performance between 800 MHz to 1400 MHz.

We used the same beam to observe strong pulsars to check the behaviour of the end-to-end system. The right sub-figure of Figure 1 shows one of these observations (the observation of PSR J0358+5413, which is also known as PSR B0355+54).

4. Conclusion

We installed a PAF system on a large-gain, single-dish telescope. We successfully measured the system temperature over efficiency of it and observed strong pulsars to check the behaviour of it.

5. Acknowledgements

This project represents the combined efforts of a large number of people. We are especially grateful to the highly motivated and skilled staff at Effelsberg.

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