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PAFINDER – Searching for FRBs and pulsars using Phased Array Feeds

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Abstract. The challenges of detecting and localising Fast Radio Bursts in real time can be met with the use of Phased Array Feeds. One such system, capable of creating up to 36 simultaneous beams, is currently being commissioned at the Effelsberg radio telescope in Germany following testing at the 64 m Parkes radio telescope. The PAFINDER (Phased Array Feed FRB Finder) pipeline will be used with this receiver to enable real–time single–pulse detection and localisation.

Keywords. instrumentation: miscellaneous, pulsars: general

1. Introduction

A Phased Array Feed (PAF) makes use of digital beamforming to generate and electronically steer a large number of simultaneous beams on the sky. The system that is currently being commissioned at the Effelsberg radio telescope is capable of generating 36 beams, more than doubling the number of beams available with the current state–of–the–art Parkes feed–horn based system. Fast Radio Burst (FRB) surveys will benefit from the quick identification and better localisation offered by these systems. To better understand the nature of FRBs, it is necessary to obtain more information about their immediate neighbourhood and potential host galaxies, as so far only a small fraction of objects has been localised (Caleb 2017; Chatterjee 2017). This is one of the biggest limiting factors for FRB progenitor studies, as any possible associations require sub–arcminute localisation. Currently, large beams with minimal overlap on the sky make it challenging to obtain the position of an FRB to better than 10 arcminute precision, an obstacle overcome by digitally formed beams. It is therefore important to develop and test new techniques that will provide short response times to any potential events and enable prompt follow–up observations at different wavelengths.

2. Pipeline overview

The data generated by the beamformers is evenly distributed between 18 compute nodes. 336 1 MHz dual–polarization channels are sent for each beam, resulting in a combined data rate of almost 50 Gbps. Due to high speed demands each beam is processed by a single GPU. Filterbank data files are generated by running 336 32-point FFTs and removing 5 channels to account for the oversampling. At this stage both polarisations are

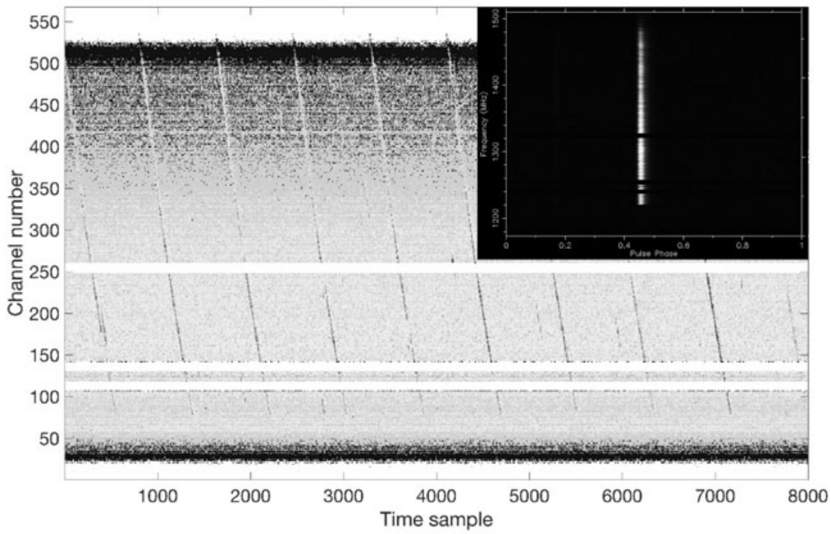

Figure 1. Bright single pulses from the Vela pulsar as observed during the Parkes testing. White horizontal stripes indicate missing data. Inset: the folded profile.

combined to form only the total intensity. Other Stokes parameters are not used in the later stages of the pipeline, but the original voltage data is stored in the buffer, which can later be saved to disk when triggered by an event. The resulting data stream is then summed in both time and frequency. The current setup outputs 567 channels, $\sim$0.5 MHz each, with a time resolution of 54 μs. These parameters can be adjusted, depending on the project requirements. The resulting filterbank files are then scaled down to 8 bits to lower the RAM and storage requirements. The scaling factors are made available to the user so that the original signal can be recovered if necessary.

3. Current status and future developments

Observations conducted as part of the tests at Parkes and more recently at Effelsberg proved that the pipeline is capable of generating real–time filterbank files. This has been confirmed by observations of two bright pulsars, Vela at Parkes and Crab at Effelsberg, with bright single pulses from Vela clearly visible in Figure 1.

Current single–pulse detection is limited to offline processing, which does not meet the requirements for real–time FRB detection. The final version of the pipeline will allow the user to connect software of their choice to the output buffer of the pipeline, as long as it has support for the DADA buffers. The filterbank data and raw signal will only be saved to the disk if the event is detected across a fraction of all beams, which will reduce the number of false positives due to RFI. Having the ability to change the separation between the beams will allow us to test a new localisation technique (Obrocka 2015), which will make it possible to localise events down to $\sim 1'$ with a single dish.

References

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