Parkes Pulsar Backends

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The Analogue Filter Bank (AFB)

The pulsar filterbank data acquisition system was designed for pulsar observations using the 13-beam 20cm (Multibeam) receiver at Parkes. It can however, be used with any other receiver.

It was built as a collaboration between ATNF and Jodrell Bank Observatory and was commissioned in 1997. Narrow band filters were built by the Pulsar Group of the Astronomical Observatory of Bologna (now at the Cagliari Observatory, Sardinia - INAF).

The Parkes 20cm Multibeam receiver has 13 beams, each with two polarizations. Signals from these 26 channels are down-converted and sent to the AFB. This provides 2 x 96 x 3 MHz channels for each beam. Signals from the centre beam are tapped off and can be sent to other backends via the Parkes conversion system.

The AFB employs 1-bit digitisation. Several standard configurations are currently available:

- 96 x 3 MHz
- 128 x 1.0 MHz
- 384 x 0.5 MHz
- 256 x 0.125 MHz
- 128 x 0.25 MHz
- 512 x 0.5 MHz

Nichi D'Amico with the AFB in the Parkes Control Room.

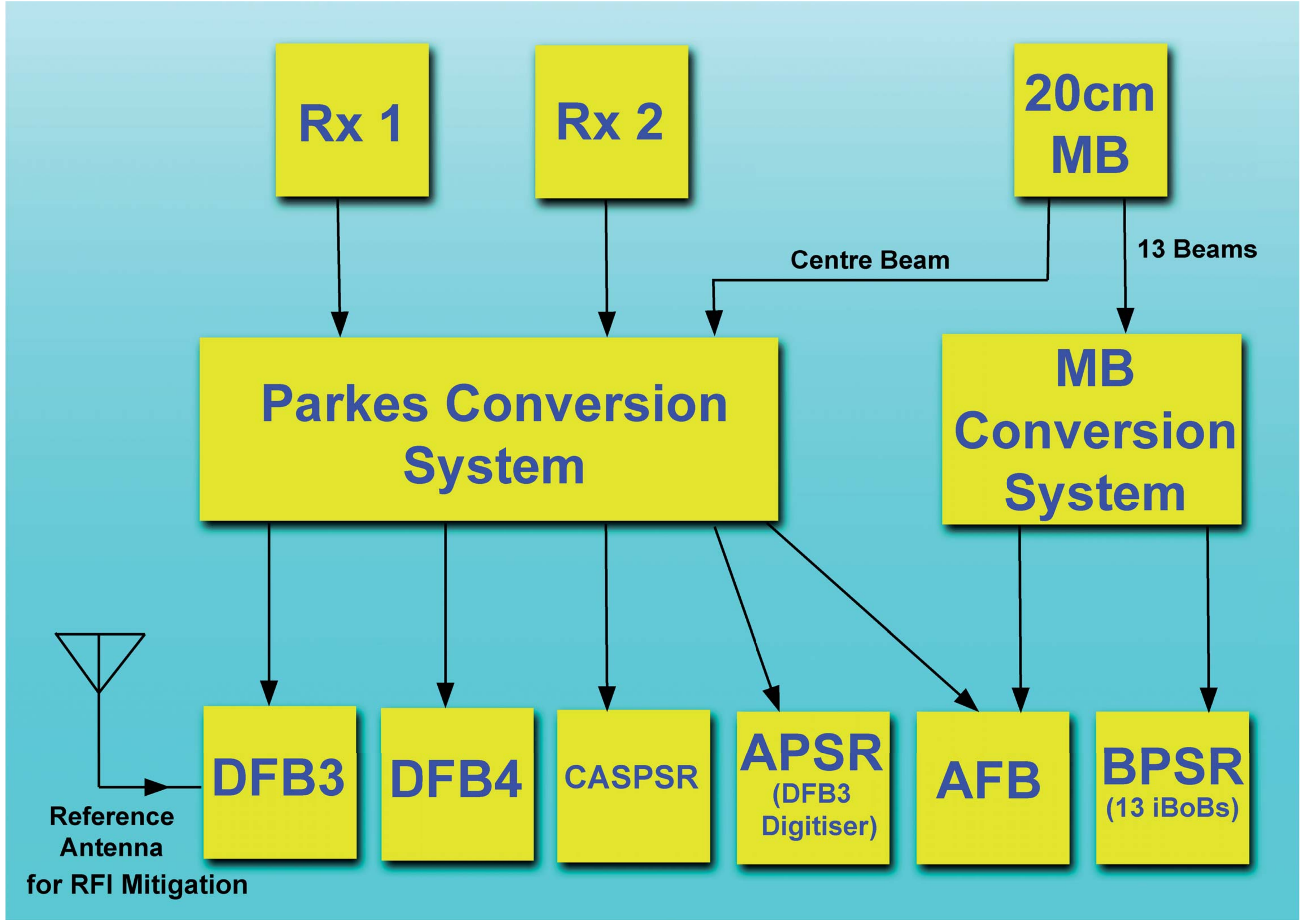
The Digital Filter Banks DFB3/4

The ATNF pulsar digital filterbanks (DFB) were designed mainly for the Parkes pulsar timing array project and they aim to achieve better than sub-microsecond timing precision for many millisecond pulsars.

The DFBs give 8-bit Nyquist-sampled data over bandwidths of up to 1 GHz, synchronous folding at the pulsar period, and the ability to provide real-time interference-mitigation (DFB3 only). They also provide a flexible system for searching for pulsars and studies of individual pulse emission: the number of stored bits, bandwidth, polarisation products and sampling time can all be set by the user. Data in folding and search modes are outputted as FITS files. The DFB3 also has a mode that provides digitized baseband output suitable for the next generation of real-time coherent dedispersion systems.

The DFBs can run in several modes:

- **Folded data mode:** In this mode the data will be folded on-line by the DFB system. The output file will be a standard, pulsar folded profile with full polarisation and a given number of phase bins, frequency channels and subintegrations.
- **Search mode:** This mode will provide streamed data for pulsar searches or individual pulse studies. The data will be recorded using 2, 4 or 8 bit resolution, will be integrated in memory before output into a standard FITS file.
- **APSR baseband mode (DFB3 only):** Required for the new generation of baseband recorders. It will provide multiple streams of baseband data with a maximum bandwidth of 1 GHz for input into APSR.
- **RFI Mitigation (DFB3 only):** DFB3 has a second dual IF input that allows a reference antenna to be connected for RFI mitigation of the data in real-time.



Schematic of the Parkes Pulsar Backends

APSR

The ATNF Parkes Swinburne Recorder (APSR) is a next-generation baseband data recording and processing system developed in collaboration between Swinburne University of Technology and the Australia Telescope National Facility (ATNF).

The APSR hardware consists of:

- The Parkes Digital Filter Bank (DFB3) digitisers;
- Two Cisco 3750E high-performance commercial network switches;
- A Beowulf-style cluster of 20 Dell 1950 server-class machines, each with dual quad-core Intel Clovertown processors, 16 GB of RAM, and 1.5 TB of disk.

APSR has 8 times the bandwidth (from 128 MHz to 1 GHz) and greater dynamic range (from 2 to 8 bit sampling) than previous instrumentation (CPSR2) developed by Swinburne University.

BPSR

A High Resolution Multibeam Digital Filterbank. The Berkeley Parkes Swinburne Recorder (BPSR) is a high resolution digital filterbank data acquisition and processing system for the Parkes Multibeam receiver, developed in collaboration between Swinburne University of Technology and the University of California at Berkeley. BPSR is an integral part of the High Time Resolution Universe Survey currently underway at Parkes.

The BPSR hardware consists of:

- 13 Interconnect Break-out Board (iBOB) developed by the CASPER group at the University of California, Berkeley.
- The APSR Beowulf-style cluster of 20 Dell 1950 server-class machines.

Each iBOB divides dual-polarization 400 MHz bands into 1024 channels using a polyphase filterbank. Compared to the AFB, the major technical innovations of BPSR include:

- much higher time resolution (32 vs 125 microseconds), frequency resolution (1024 vs 96 channels), and dynamic range (2 bit vs 1 bit).
- remote administration capability in preparation for future remote operation of ATNF observatories.

CASPSR

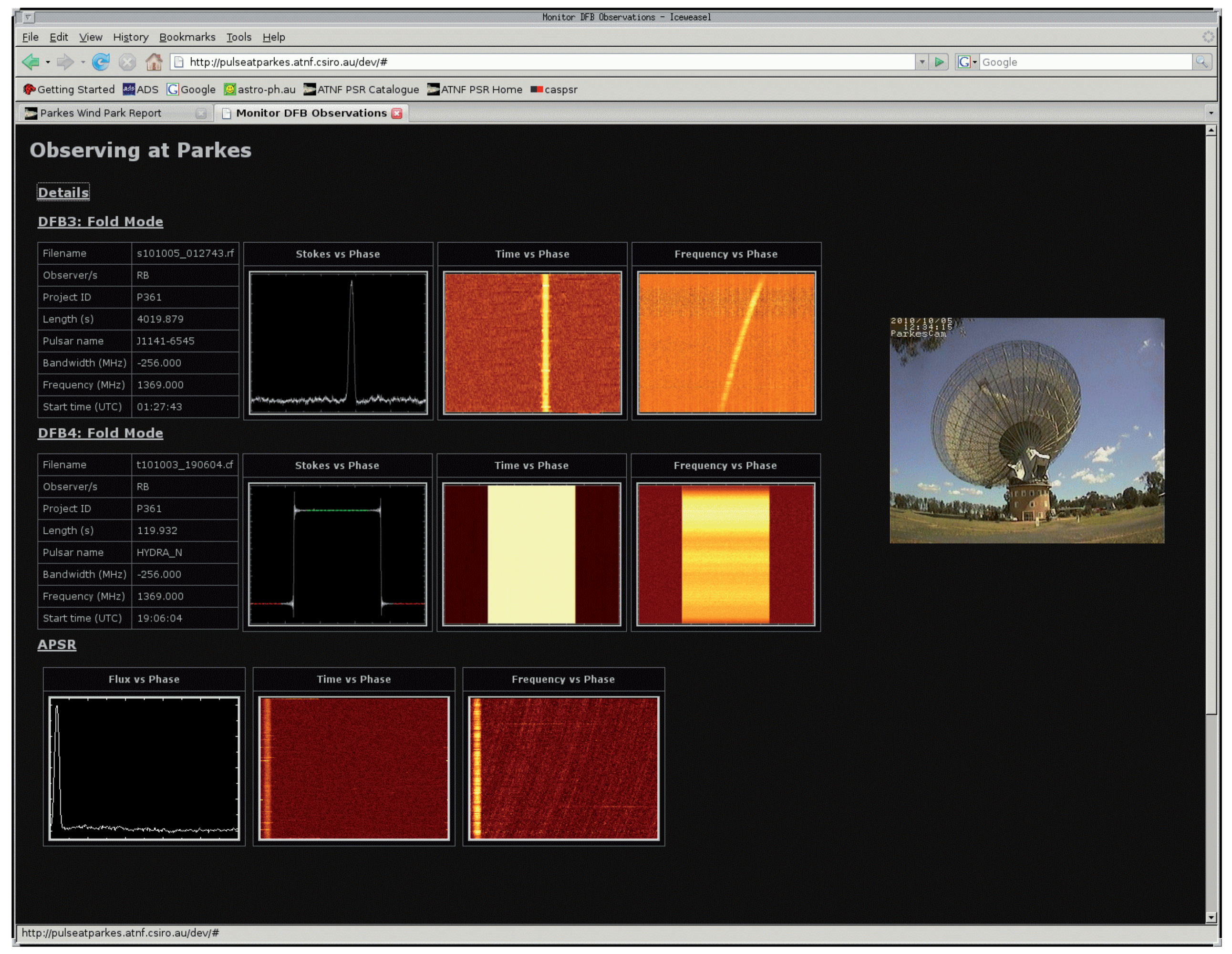
Phase-coherent dispersion removal using Graphics Processing Units. In collaboration with the Center for Astronomy Signal Processing and Electronics Research (CASPER) at Berkeley, the Swinburne Pulsar Group has designed and installed a new pulsar instrument at Parkes, the CASPER Parkes Swinburne Recorder (CASPSR). ***It is not available as a National Facility instrument (yet).*** This next-generation baseband data recording and processing system consists of:

- 1 Interconnect Break-out Board (IBOB), developed by CASPER;
- 1 Cisco® SFS 7000 InfiniBand Server Switch;
- Dell R610 Server Nodes, each with 48 GB of RAM;
- 4 Supermicro® NITRO G5 Tesla GPU Compute Nodes.

The iBOB performs analog-to-digital conversion of two dual-polarization signals, each with a maximum total bandwidth of 400 MHz. These signals are streamed via 2 × 10 GbE connections to the 2 R610 servers, which buffer the data and remultiplex the UDP packets to deliver contiguous streams to the 4 GPU-based processing nodes.

CASPSR is an integral part of the development path toward pulsar instrumentation for next-generation facilities like the Australian Square Kilometre Array Pathfinder (ASKAP) and the Karoo Array Telescope (MeerKAT).

All of the instruments developed at Swinburne make use of DSPSR, a high-performance, open-source digital signal processing software library and application suite for use in radio pulsar astronomy.



Remote monitoring of the DFB3/4 and APSR observations is possible via a browser based system produced by Jonathan Khoo of the ATNF.

For more information see:

http://www.atnf.csiro.au/research/pulsar/ppta/index.php?n=Hardware.DFB

http://astronomy.swin.edu.au/pulsar/?topic=instrumentation

http://dspsr.sourceforge.net