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Pulsar Applications of the Caltech Parkes Swinburne Baseband Processing System

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Abstract. The Caltech-Parkes-Swinburne Recorder (CPSR) was installed at the Parkes Radio-telescope in August of 1998. It is capable of continuously two-bit quadrature-sampling a 20 MHz bandpass in two polarizations, though other configurations are possible. Since its successful installation, over 17 Terabytes of observational data have been recorded. These data were processed using the Swinburne Baseband Processing System (SBPS), a suite of data management and reduction software executed using a Beowulf-style cluster of high-performance workstations. A description of CPSR and SBPS is presented herein, followed by a brief presentation of some results from the past year of observations, and an outline of possible future uses of the system.

System Description

CPSR is an enhanced version of the Caltech Baseband Recorder (CBR). Both were developed in the Astronomy department of the California Institute of Technology and are based on a similar recorder described by Jenet et al. (1997).

CPSR consists of: an analog dual-channel quadrature downconverter with anti-aliasing filters; the Fast Flexible Digitizer (FFD) board, which accepts an external sampling clock and is capable of 2, 4, or 8-bit sampling four analog channels; a Sun Ultra SPARC 60 with 512 MB RAM; commercial Direct-Memory-Access (DMA) card; six 8.5 GB disks; and four DLT 7000 tape drives.

Two orthogonal senses of polarization are input to the downconverter, which delivers the low-pass filtered, in-phase and quadrature components of each polarization to the FFD. On the FFD, the analog inputs are digitally sampled and sent via a high-speed, 16-bit parallel DMA channel to the Sun workstation. Once in RAM, control software stripes the data across all six disks while maintaining sampling statistics and performing corrections to the digitization thresholds. From disk, the striped data is re-assembled into segments of longer duration and written to tape, allowing single-drive playback.

Data are processed offline using a workstation cluster established as part of the Swinburne Supercomputer Initiative (SSI). The SSI cluster consists of 65 Compaq Alpha workstations, providing a collective disk space of 650 GB,

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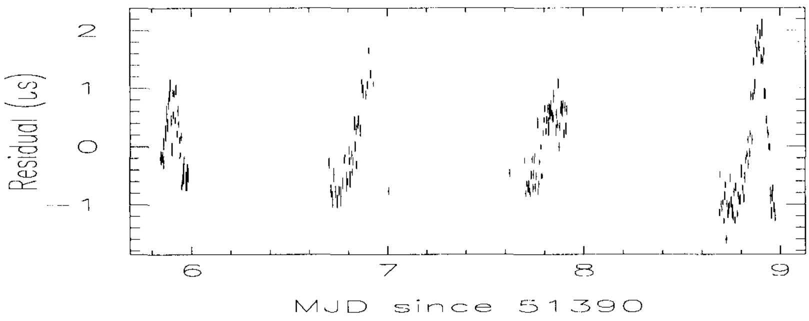

Figure 1. Time of arrival residuals of uncalibrated, five-minute integrations of PSR J0437−4715, obtained using the CPSR 20 MHz bandpass centered at 1413.26 MHz. With an RMS of 0.8 μs, the residuals exhibit the dominant signature of imperfect calibration and mixing of the impure linear polarizations (see Britton et al., these proceedings).

and total CPU power of 66 Gflops. For the purposes of pulsar timing, data reduction software has been developed that implements the dynamic level-setting and scattered power corrections described by Jenet & Anderson (1998), performs coherent de-dispersion on the undetected voltages (Hankins & Rickett 1975), and uses a TEMPO-generated polynomial to fold full Stokes information at the apparent topocentric period. This software is executed across the workstation cluster using the Message Passing Interface library for parallel computing.

Observations and Future Uses of CPSR

Since the installation of CPSR at Parkes, regular recordings of the millisecond pulsar, PSR J0437−4715, have been made at multiple wavelengths. Presented in Figure 1 are the arrival time residuals over four days of observation at 20 cm.

CPSR is a highly configurable and extensible baseband recorder able to capitalize on advancements in commercial data storage technology. It is capable of expanding to greater bandwidths with a change of the filters in the down-converter and the addition of recording media or contraction of the observation duration. As software-based correlation becomes more computationally feasible, CPSR may be seen as a highly flexible recorder for use in Very Long Baseline Interferometry (VLBI), possibly employing burst mode VLBI techniques as described by Wietfeldt & Frail (1991).

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