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A Wide-Bandwidth Digital Filterbank

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1. Hardware Design and Construction

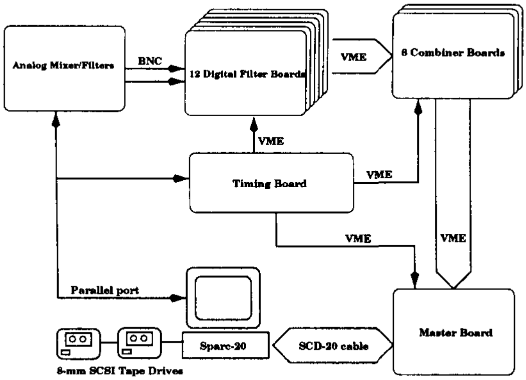
The Navy/Berkeley Pulsar Processor (NBPP) is a digital filterbank which is based on the successful Digital Filter Boards constructed for the University of California Coherent Dispersion Removal Processor (CDRP). One 9U VME crate holds a complete system with 96 channels $\times$ 2 polarizations. Running at maximum speed, the full crate will cover 1.8 MHz/channel = 172 MHz total bandwidth. Narrower bandwidths are available by running the system clock slower. The digitization has 4 bits of precision for good dynamic range and minimal quantization effects. The output data has variable time resolution; typically 50–100 μs for search mode, and 2.4 μs for timing mode. A flexible analog mixer/filter front end provides variable width filters, programmable attenuators, and input power level measurements, along with IF-to-baseband mixing and amplification capability. Data acquisition software running on a Sun Sparcstation-20 is based on software developed for controlling the Penn State Pulsar Machine (PSPM).

2. Scientific Application: High-Frequency Surveys

The initial application of the NBPP will be a high-frequency survey of the Galactic plane with good sensitivity to fast pulsars at relatively large dispersion measure (DM). Two primary previous surveys (Clifton *et al.* 1992, Johnston *et al.* 1992) have searched the Northern and Southern Galactic plane at 1.4 GHz with less sensitivity than this proposed Nançay search. High frequencies minimize the contribution of galactic background emission to the total noise temperature whereas it dominates the sensitivity at 400 MHz. In addition, the effects of dispersion and scattering are greatly reduced, allowing for the potential discovery of more distant pulsars.

High-frequency surveys tend to find a younger, more distant population of pulsars than traditional surveys. Discovery of new highly scattered pulsars will allow the study of the ionization structure of ISM in the inner Galaxy. New distant pulsars can constrain the radial distribution of pulsars which has become interesting due to suggestions that high-velocity neutron stars may populate a galactic halo and be the sites of gamma-ray bursts.

The fast sampling of the NBPP (50 μs) allows pulsars with periods as short as 0.1 ms to be detected. The maximum rotation rate of a neutron star is still



unknown. Finding pulsars rotating faster than the current fastest pulsars (1.5 ms) will begin to make serious constraints on possible neutron star equations of state. Fast pulsars with high rotational stability can rival the accuracy of the atomic time standards for time scales longer than 6 months and are useful for improving the solar system ephemerides. Sub-ms pulsars could be short-lived, high luminosity objects, thus requiring searches of a large volume of the Galaxy. Dispersion and scattering render most 400 MHz surveys insensitive to pulsars at rather low DM.

Since young pulsars are close to their birth sites (in the Galactic plane) they are likely to be in high sky-temperature regions with large dispersion measures and short periods. Thus, surveys at high frequency are likely to be more effective at discovering them. Discovering new young pulsars will aid in birthrate comparisons between pulsars and SNRs, and help establish the initial kick velocity of pulsars. Although pulsars are presumed to have formed in supernovae, only $\sim$ 18 PSR-SNR associations are known (Gorham *et al.* 1996), many of which are still very uncertain. Young pulsars tend to show interesting behavior such as glitching, and are more likely to be detectable at optical, X-ray, or γ-ray wavelengths.

The Nançay telescope is a dual-reflector system with a 40 $\times$ 200 m telescope tiltable flat reflector and a 300 m $\times$ 35 m fixed curved reflector with a moving feed system. The resultant beam size is $4' \times 22'$ at the survey frequency of 1.4 GHz. We plan to use two observing seasons to cover about 1000 square degrees within 3° of the Galactic plane with $\sim$ 131 s integrations for each beam.

References

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