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A new pulsar instrumentation at the Allen Telescope Array and the Nancay Radio Telescope

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Abstract.
In the prospect of the gravitational wave background detection with high precision pulsar timing, we recently installed a new coherent dedispersion backend at the Allen Telescope Array (ATA) and the Nançay Radio Telescope (NRT).

Keywords: Instrumentation; pulsars
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INTRODUCTION

The detection of the gravitational wave background (GWB) from massive black holes mergers requires to precisely monitor an array of millisecond pulsars (MSPs) spread throughout the Galaxy. To achieve high precision pulsar timing of MSPs, high time resolution and wide bandwidth are required and the dispersion by the interstellar medium (ISM) has to be removed. We report here the installation of new real-time coherent dedispersion backend at the ATA and also the NRT.

THE ALLEN TELESCOPE ARRAY

The Allen Telescope Array is a radio interferometer which consists of 42 six-meter dishes, located at the Hat Creek Radio Observatory, in California. Operationnal since 2007, the array will eventually consist of 350 antennas after completion. It is the first array built following the Large-Number Small-Diameter (LNSD) concept. Its main characteristics are: a wide field of view: 2.45° at $\lambda = 21$ cm, an instantaneous bandwidth from 0.5 to 10 GHz provided by the log periodic feed and multiple simultaneous backends, based on CASPER[1] hardware. There is currently three correlators and three beamformers at the ATA. The real-time FPGA based beamformers [1] are in operation[2]

[1] `http://casper.berkeley.edu`
[2] `http://casper.berkeley.edu/doc/ata_beamformer_2008.pdf`

and can provide a bandwidth of 104 MHz, but only 80 MHz are currently usable.

Two of them have an independent and tunable IF, allowing to observe at two widely spaced frequencies simultaneously. This unique capability can enable us to monitor the effects of the turbulent ISM for a set of strong MSPs. We can also configure the IFs to place the two bands side by side (and hence increase the bandwidth) for coherent dedispersion observation and targeted pulsar searches. The ATA is also well suited for other projects such as giant pulse studies.

To process the data, a new GPU (Graphics Processing Unit) pulsar machine is connected to a 10 GbE ouput of the beamformer which can send either raw data over the full 100 MHz band or channelized data, 32 subbands and 1024 subbands, for real-time coherent dedispersion and targeted pulsar searches.

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The Radio Sky Surveys Project (RSSP) has the goal to expand the Allen Telescope Array to 256 antennas. Expansion to 256 elements will make the ATA the dominant radio telescope for surveys in the world. Also, as the electronics improve with time (for the same price), the processing of wider bandwidths become feasible and only the backends have to be upgraded, not the feeds or antennas. The ATA is a flexible instrument which can contribute to the GWB detection with pulsar timing when completed.

THE NANÇAY RADIO TELESCOPE

The Nançay Radio Telescope is a meridian instrument with a collecting area equivalent to a 100-meter dish. Currently the BON (Berkeley-Orléans-Nançay) backend which use a Serendip V board and two computers with GPUs provide a limited bandwidth of 128 MHz for real-time coherent dedispersion.

To use the full bandwidth provided by the receivers of the NRT, we adopted the CASPER ROACH board. First an iADC connected to the ROACH digitizes a 512 MHz band dual-polarization to 8-bits samples. The FPGA then split the whole band into 128 channels PFB and send directly the sampled data through four 10GbE links to four computers, each equipped with 2 GPUs (Nvidia GT280). Inside the GPUs, the signal is coherently dedispersed in real time and folded using the apparent pulsar period to produce the mean pulse profiles, recorded in the PSRFITS format. Designs with 1024 and 2048 channels are also available for pulsar survey. In the framework of the European Pulsar Timing Aray (EPTA), the NRT will continue to perform a dense monitoring of $\sim$25 MSPs with an improved sensibility due to its greater bandwidth.

REFERENCES

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