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Science with PuMa, the new Dutch PulsarMachine

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Abstract. We have built a pulsar machine (PuMa) for operation at the Westerbork Synthesis Radio Telescope. The combination of PuMa and WSRT is capable of many types of pulsar research. We show the coherent dedispersion capabilities and the flexible frequency resolution. We discuss pulsar searching and simultaneous multifrequency observations.

1. Introduction

PuMa stands for "PulsarMachine". It is the name of the system that we have built for operation at the Westerbork Synthesis Radio Telescope (WSRT) in the Netherlands. It is a fully digital machine and its design is based on the use of Digital Signal Processors. PuMa contains 192 of these DSPs. The processors are programmable, which makes the machine very flexible: the observing parameters can be optimized for each observation.

We have developed two modes of operation. The first is a baseband recording system, which stores the raw voltages from the antennae for off-line data reduction, such as coherent dedispersion. The present maximum recordable bandwidth is two times 10 MHz for both linear polarization states. A new project has been started to increase this bandwidth. The bandwidth (and data rate) can be reduced by using so-called Finite Impulse Response filters.

Figure 1 displays a giant pulse of PSR B0531+21 observed at 382 MHz. Data were baseband sampled in two polarizations. No FIR filter was applied. The data were coherently dedispersed and the two polarizations were detected (squared) and added.

The second mode is a digital filterbank. In this mode the number of frequency channels and the sampling time are tunable, though 4096 channels in each 10 MHz band is the maximum. This flexibility is useful to compensate for the effects of dispersion smearing. This is shown in figure 2, which displays the dispersion curve of pulsar PSR B0531+21. It dispersion measure of 56.8 cm^{-3} pc smears a pulse over about 50 periods of 33 ms from 380 to 1500 MHz. Three short observations were made with PuMa. We used 32 channels over 10 MHz at 1380 MHz, 128 channels at 800 MHz and 512 channels over 5 MHz at 380

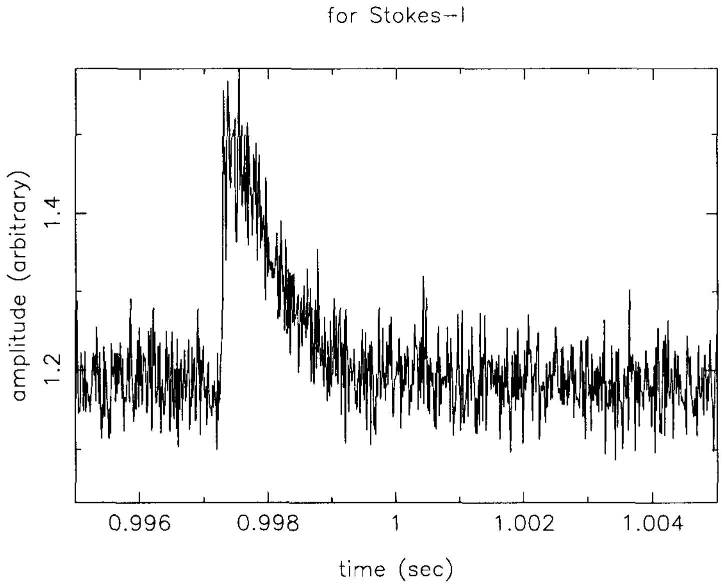

Figure 1. Giant pulse of the Crab pulsar PSR B0531+21. Data were baseband sampled and coherently dedispersed. The time series has a resolution of 12.8 μs.

MHz to keep the dispersion smearing within a channel to less than 100 μs. (For technical details on PuMa, see Kouwenhoven et al., these proceedings.)

2. Research

2.1. Pulsar searching

Since the Westerbork Telescope is a synthesis array, it has a pencil beam on the sky and this makes it very inefficient to do an untargeted sky survey. This limitation does not affect on targeted searches. We are performing searches towards globular clusters, isolated neutrons stars and towards highly polarised and steep spectrum sources (see Zang et al., these proceedings). Typical parameters for searchies in the 21 cm band are 80 MHz bandwidth, 156.25 kHz channel bandwidth, 102.4 μs sampling and two bit data recording.

2.2. Multifrequency studies

The Westerbork telescope is equipped with multifrequency frontends. The available frequencies are listed in table 1. The frontends enable the observer to switch frequencies in a very short time, but also to observe multiple frequencies at the same moment. For this the array is split in two or three subarrays and the 8 bands of 10 MHz are divided over these subarrays. All telescopes observe the same source, each subarray at a different frequency. A disadvantage is the reduction of the signal-to-noise ratio of the pulses.

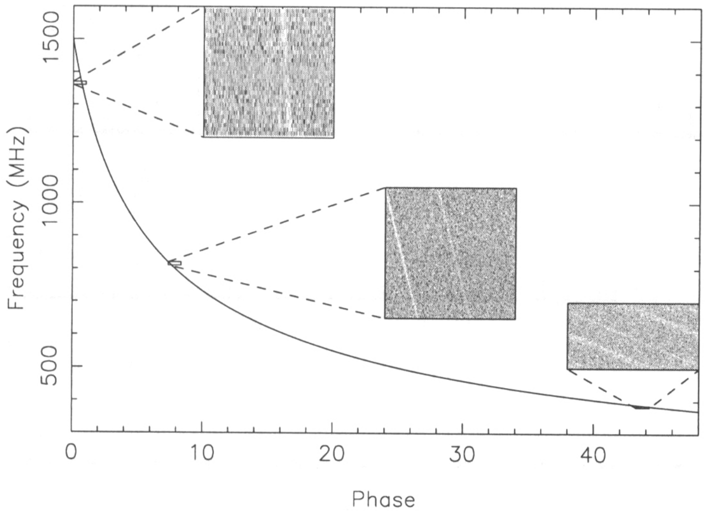

Figure 2. Dispersion curve of the Crab pulsar B0531+21. Observations were made at 384.5 (5 MHz band), 815 and 1365 MHz (10 MHz band). To prevent the pulse to be smeared over more than 100 μs, the number of channels are 512, 128 and 32 respectively. To keep the sampling time (102.4 μs) constant, the data are averaged over 1, 8 and 32 samples respectively.

Frontend	Frequency (MHz)	Syst.Temp (K)
UHF low	250 – 460	110 – 220
92 cm	210 – 390	105
49 cm	560 – 619	70
UHF high	700 – 1200	120 – 180
21 cm	1200 – 1450	27
18 cm	1590 – 1700	26
13 cm	2215 – 2375	58
6 cm	4470 – 5020	55
3.6 cm	8150 – 8650	110

Table 1. Observing frequency capabilities of the multifrequency frontends of the Westerbork Synthesis Radio Telescope.

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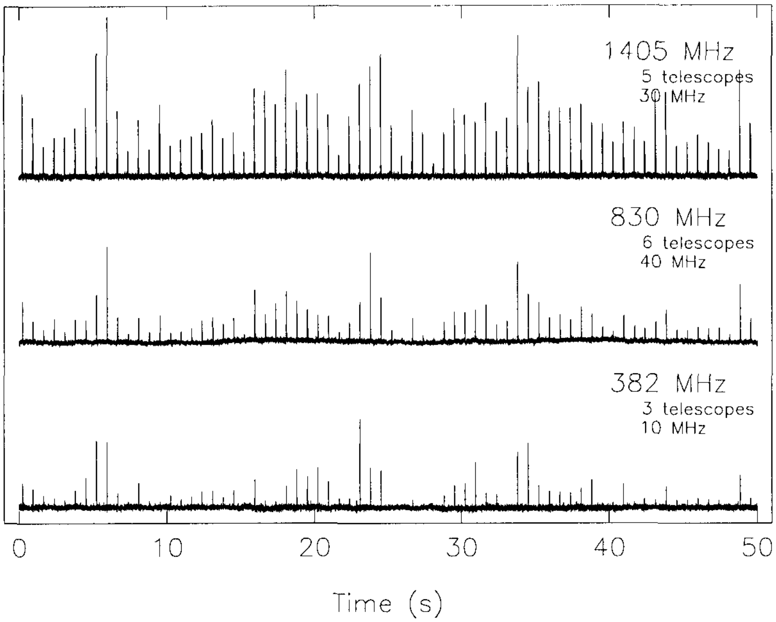

Figure 3. Simultaneous multifrequency observation of individual pulses from PSR B0329+54 at three different frequencies: 382, 830 and 1405 MHz.

These observations can be used effectively to study the temporal behaviour of single sub-pulses as a function of frequency. Figure 3 shows a multiple frequency observation of single pulses of the PSR B0329+54. Moreover, these observations can also be used to determine dispersion measure to high accuracy, which helps to study fine changes in the dispersion measure due to changes in the interstellar medium. At this moment, we are studying drifting sub-pulses and the nature of Giant pulses.

3. Conclusion

The combination of PuMa and WSRT is capable of many types of pulsar research. The large collecting area of WSRT, its multifrequency frontends and the flexibility of PuMa make it an excellent pulsar research observatorium.

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