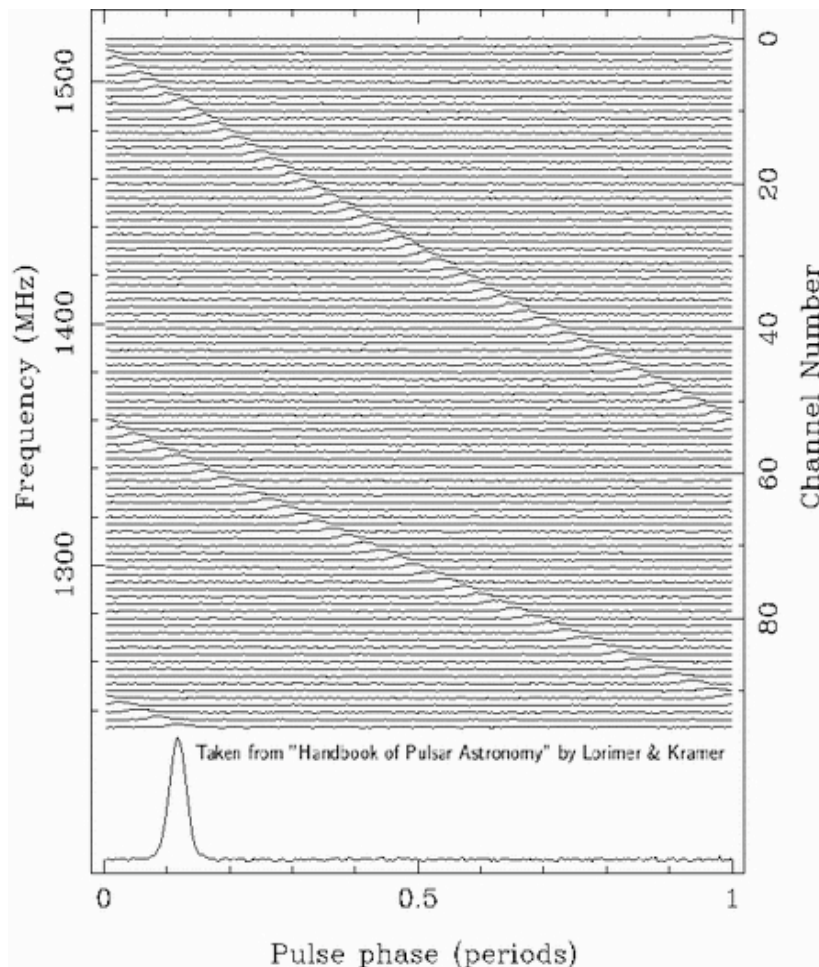




# *“Real-time pulsar processing on GPUs”*

Grégory Desvignes  
RAL

# Pulsar observing



- Always want high resolution and increased bandwidth
- The radio signal is delayed with respect to frequency  $f$

$$t = k \times \frac{DM}{f^2}$$

$$k = 4148.808 \text{ MHz pc}^{-1} \text{ cm}^{-3}$$

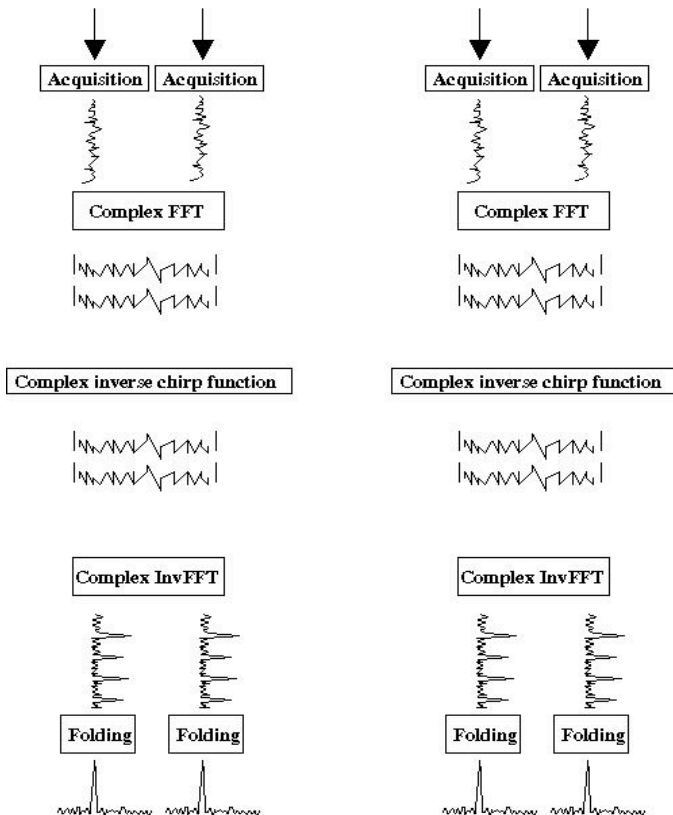
$$DM = \int n_e dl$$

- Need to correct for dispersion
- This delay can be represented as a transfer function in the Fourier domain

# The coherent dedispersion

## NUMERICAL COHERENT DE-DISPERSION

2 complex polarizations



- Baseband
- Complex sampling
- FFT
- Apply the inverse transfer function of the ISM
- $\text{FFT}^{-1}$
- Detection
- Folding

# The coherent dedispersion

- Minimum number of points to transform:

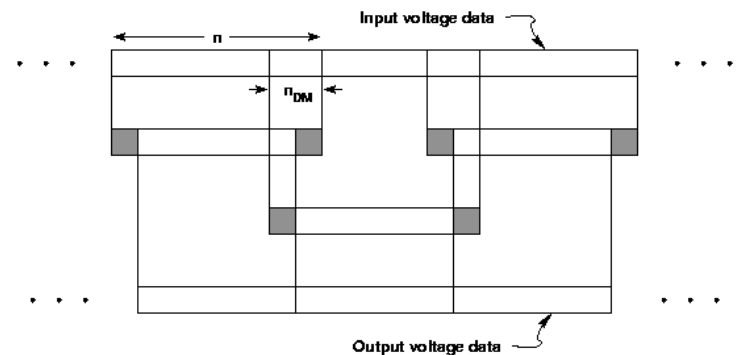
$$N_{pts} = \frac{2 * k * \Delta f^2}{f^3} DM$$

- Edge effects : need to discard  $N_{pts}/2$  points at the beginning and the end of the buffer  
→ take at least  $fft\_len = 2 * N_{pts}$   
→ Overlap the buffers

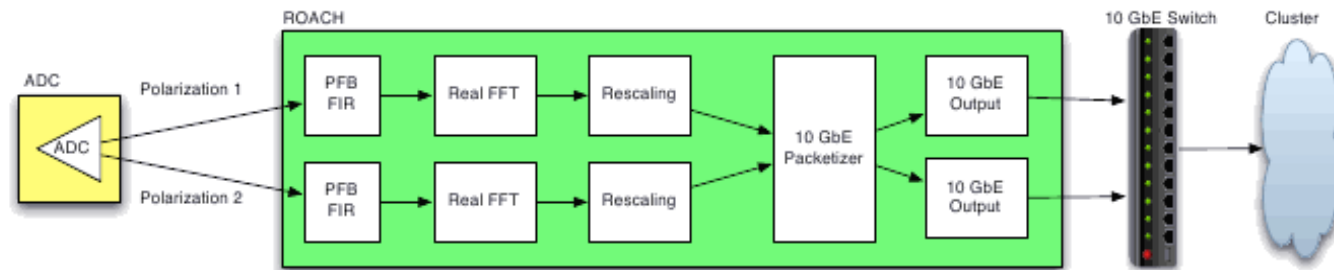
$$DM = 71, f = 1.4 \text{ GHz}, \Delta f = 100 \text{ Mhz} \rightarrow fft_{len} > 4.2 \text{ Mpts} !!$$

$$DM = 71, f = 900 \text{ MHz}, \Delta f = 100 \text{ Mhz} \rightarrow fft_{len} > 16 \text{ Mpts} !!!!$$

- Need to channelize the data !

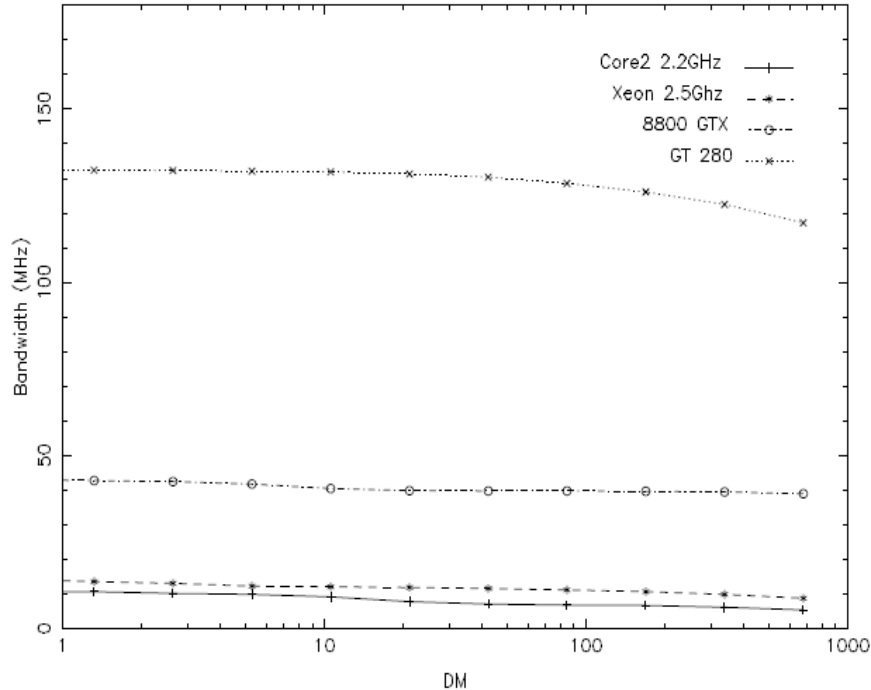


# Packetized Astronomy Signal Processor



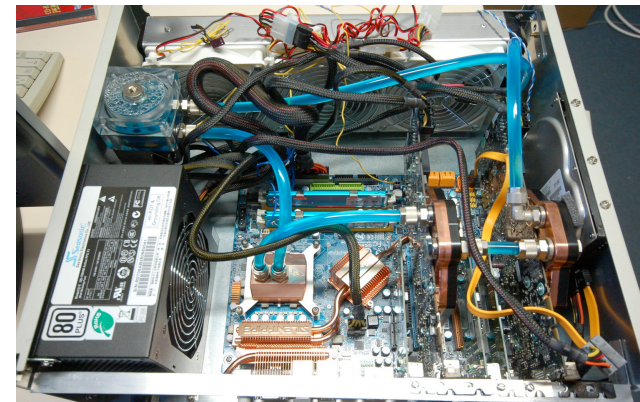
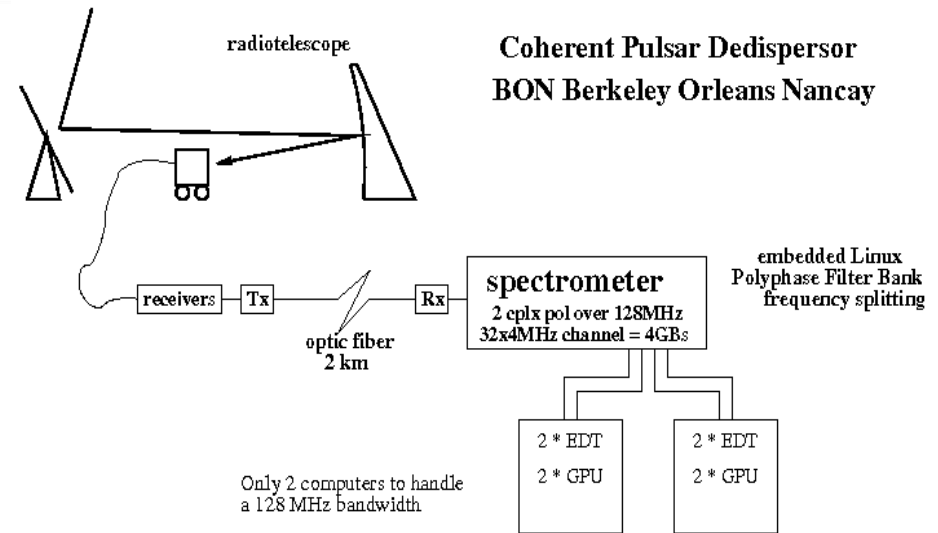
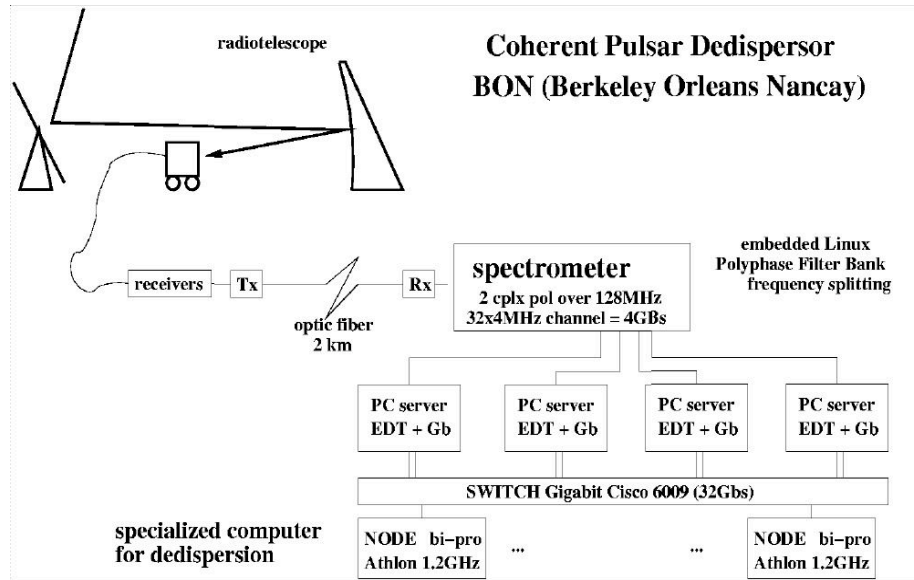
- ▶ Currently implemented on the IBOB and ROACH boards
- ▶ Each polarization is channelized in the PFB/FFT
- ▶ FFT data is rescaled on a per channel basis
- ▶ 4 bits are selected from the rescaled FFT output and sent to the packetizer
- ▶ Use a 10 GbE (or 10 GbE to 1 GbE) switch to scale the instrument to an arbitrary cluster size
- ▶ A cluster of computers or more FPGAs can be used to do fine channelization and additional processing

# CPU vs GPU



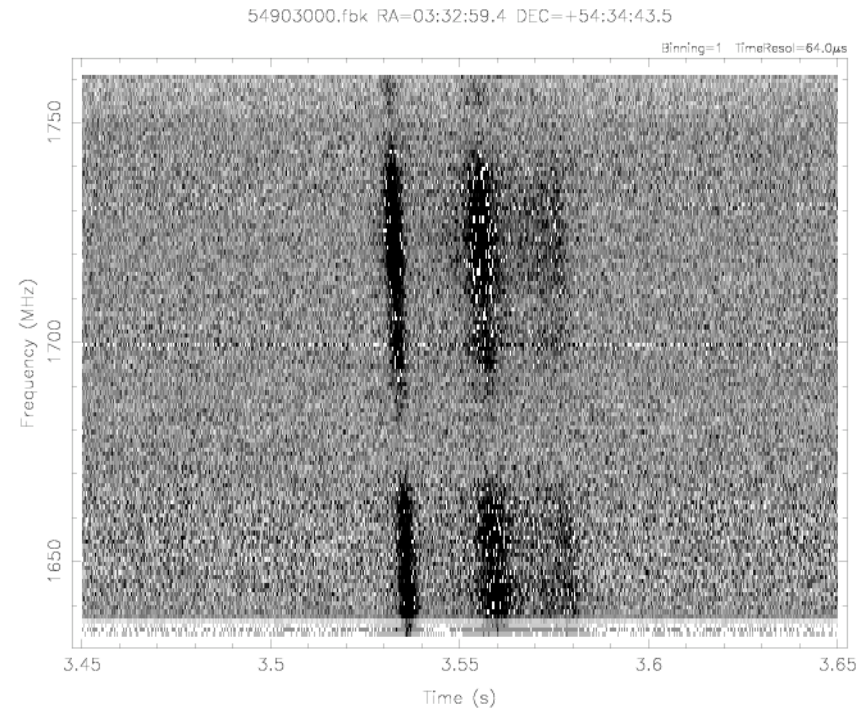
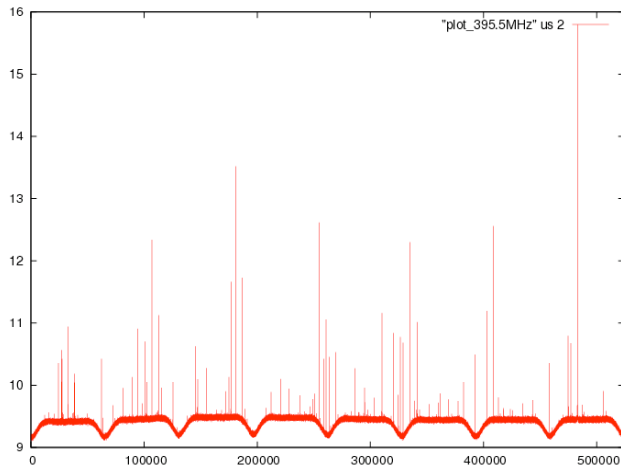
- Data Memcpy (hundreds of MB/s)
- Byte to float
- Overlap (memcpy)
- CuFFT
- Kernel to do multiplication of arrays
- CuFFT
- Folding inside the GPU (complex kernel)
- Copy data back (a few kB/s)

# A GPU based instrumentation at Nançay



# A GPU based instrumentation at Nançay

- A filterbank mode for pulsar surveys  
128 MHz  
Up to 512 channels  
Up to 32  $\mu$ s
- A high resolution (and reconfigurable) spectrometer mode (Up to 2Hz)





# New developments

- Nançay  
512 MHz from a ROACH (PASP)  
4 x PCs with 1 x 10 GbE  
8 GPUs GT280
- ATA  
100 MHz from the beamformer  
1 x PC with 1 x 10GbE  
1 GPU Fermi 480  
Record all raw data to reprocess later

Software based on GUPPI (Paul Demorest) in PSRFITS format

- + Multiple dedispersion and folding
- + Detection and recording of Giant Pulses