



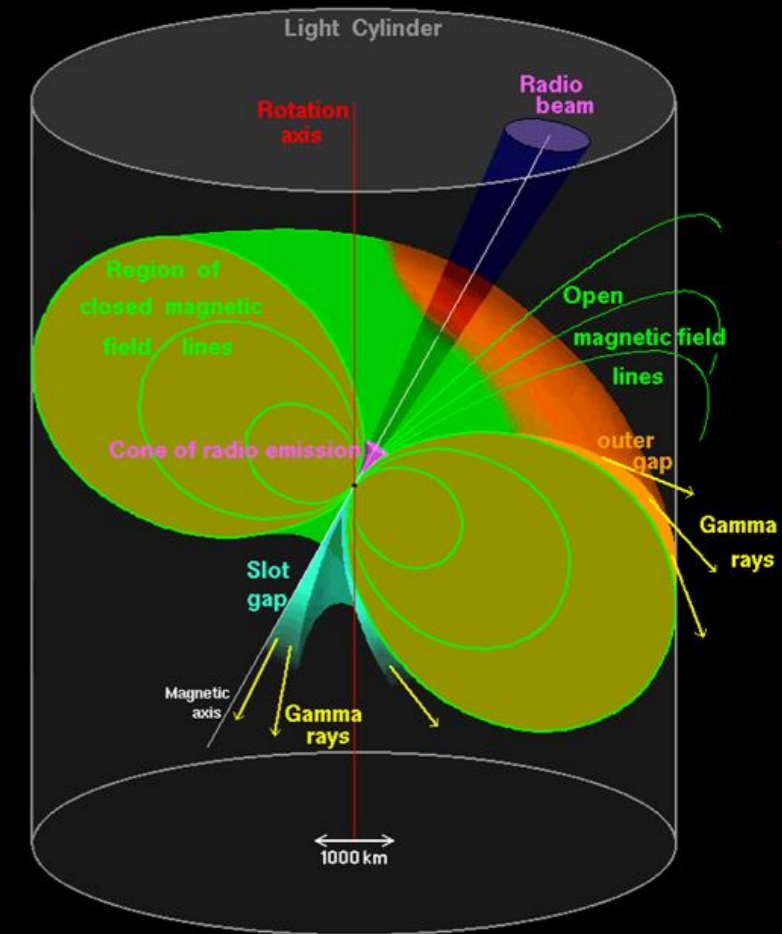
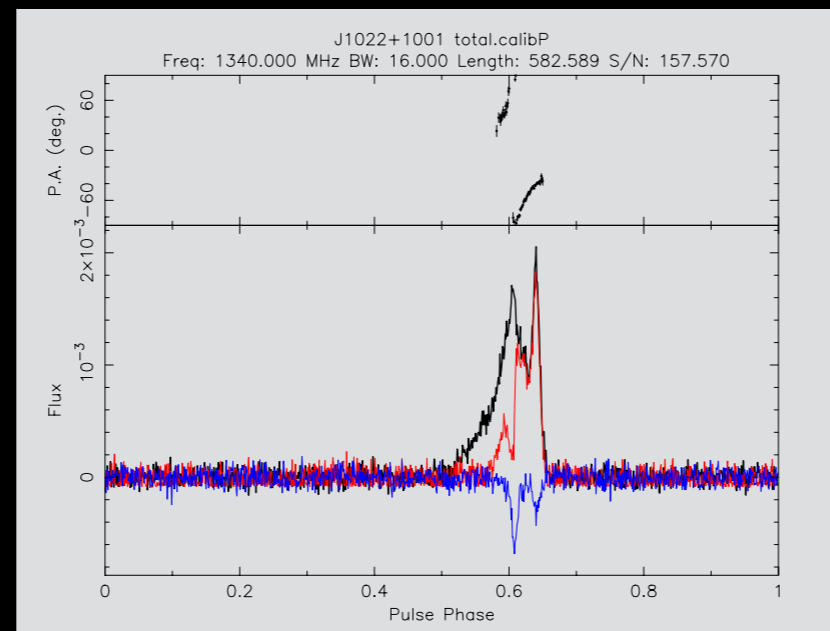
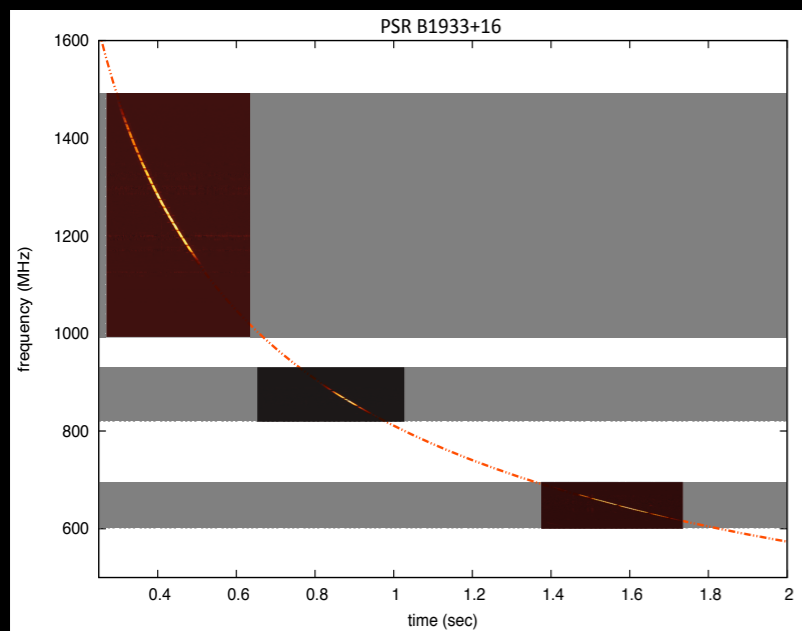
# The Pulsar Timing Instrument at Effelsberg

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# Pulsar signals

- very broadband  $\sim 10$ 's gigahertz wide
- dispersed and scattered in the ISM
- Steep spectrum, typically  $\sim \nu^{-1.8}$
- Highly polarised



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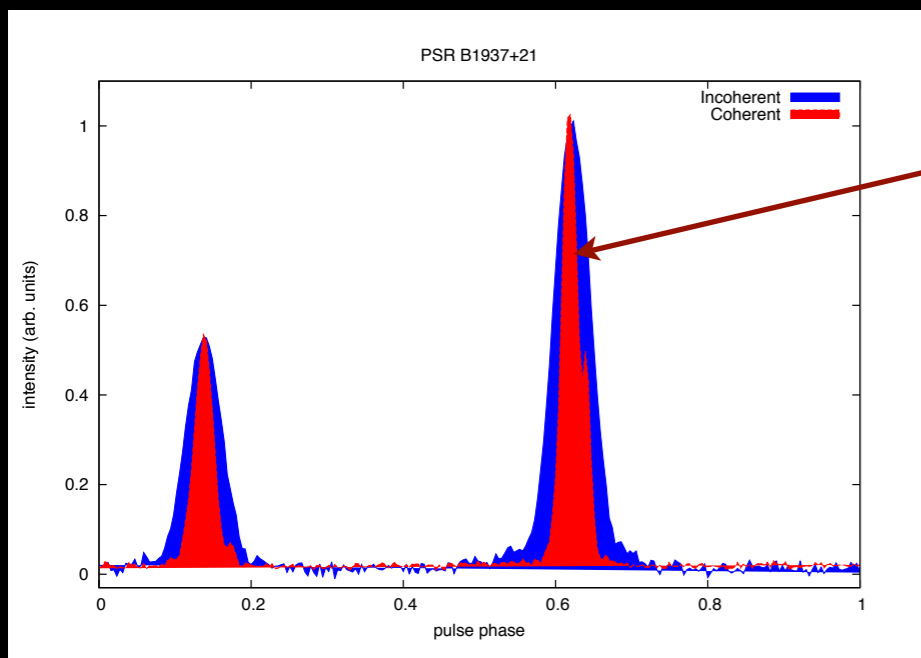
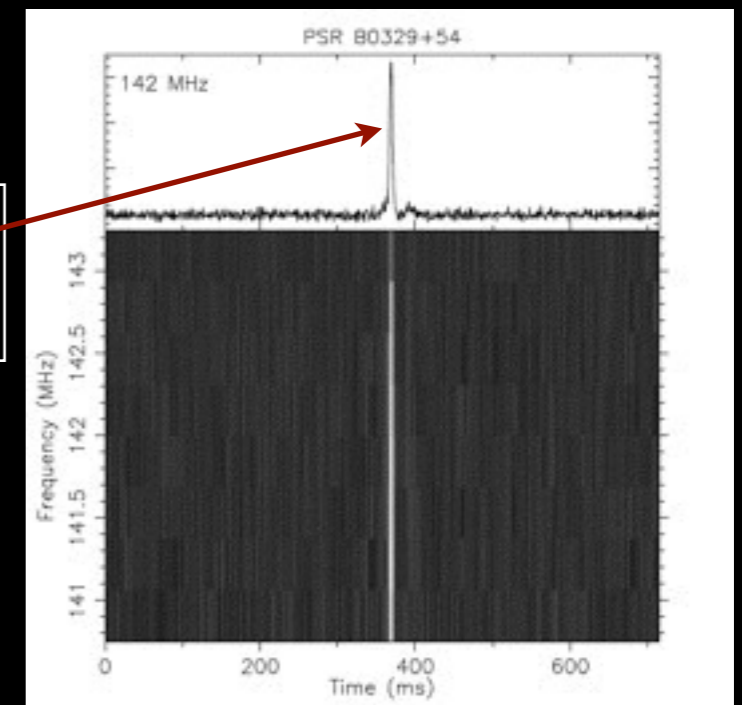
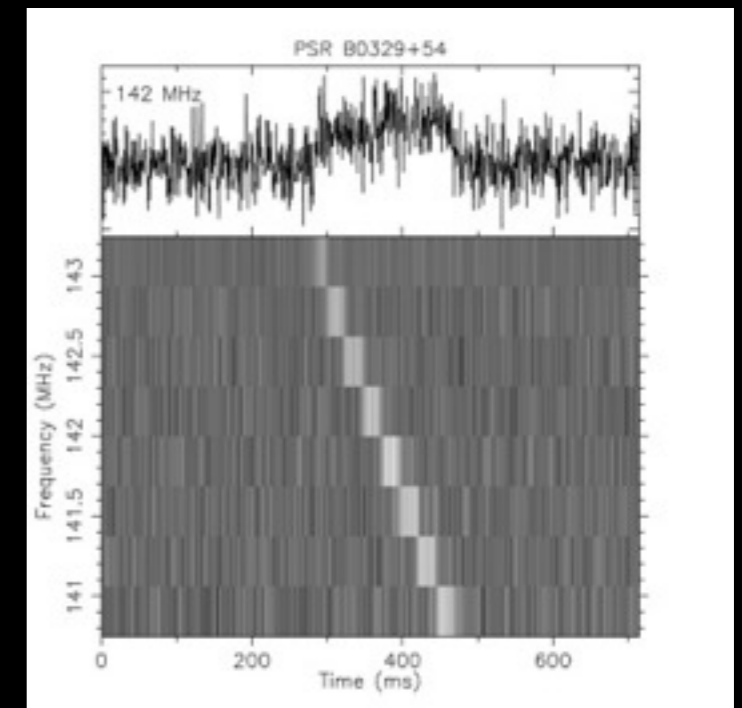
Image credit: Dany Page



# Dedispersion

- Coherent dedispersion
  - undo ISM's effect by deconvolution
  - need raw voltages - large data rate
  - computationally intensive

$$H(\nu + \nu_0) = \exp \left[ \frac{i2\pi D\nu^2}{\nu_0^2(\nu_0 + \nu)} \right]$$



- ✓ Sharper profiles - better S/N
- ✓ much better timing accuracy



# Pulsar signal processing

- The problem ... wide bands and coherent dedisp.
  - Eg. 20cm ~250 MHz, 6/3.6cm ~500MHz, UBB 0.6–3.0 GHz (6 GSPS)
  - Eg. UBB at 8bits/sample ~ large data rate 12 Gbytes/s
  - dedispersion at full time res. is formidable for DMs 10--300
  - impulse response is ~160 -- 4470ms and  $T_{\text{samp}} = 0.16$  ns
  - 800 MB -- 22.3 GB/pol.  $\Rightarrow$  multi-gigapoint FFTs!!

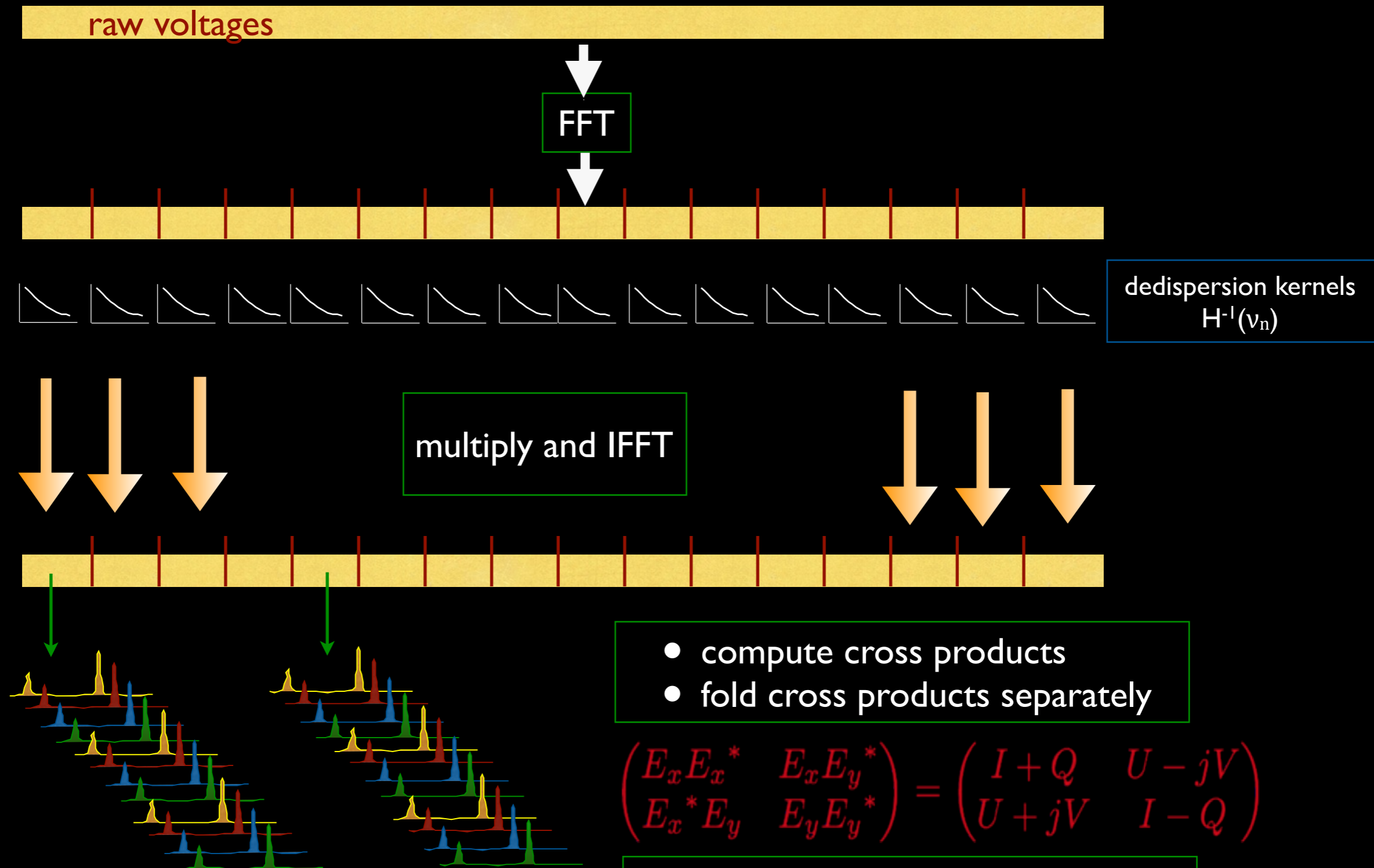


# Pulsar signal processing

- Solution ... chop wide band to ~25 MHz chunks
  - digital PFB (FPGA) generates subbands ~100MB/s UDP streams
  - network switch to farm out the streams
- Dedisperse ~25MHz bands with CPU/GPUs
  - STILL at ~40ns  $\Rightarrow T_{\text{smear}}=342\text{ms} \sim 16\text{Mpoint}$ .
  - AND ~40ns is not needed  $\Rightarrow$  channelise further  $\Rightarrow$  aids RFI-removal
  - eg. 2 MHz @600MHz,  $T_{\text{smear}} = \sim 23 \text{ ms}$  for DM=300
  - FFT sizes reduce to 1M-points (sustained)
  - ~7 Gflops (includes 2x FFTs, dedispersion and folding)

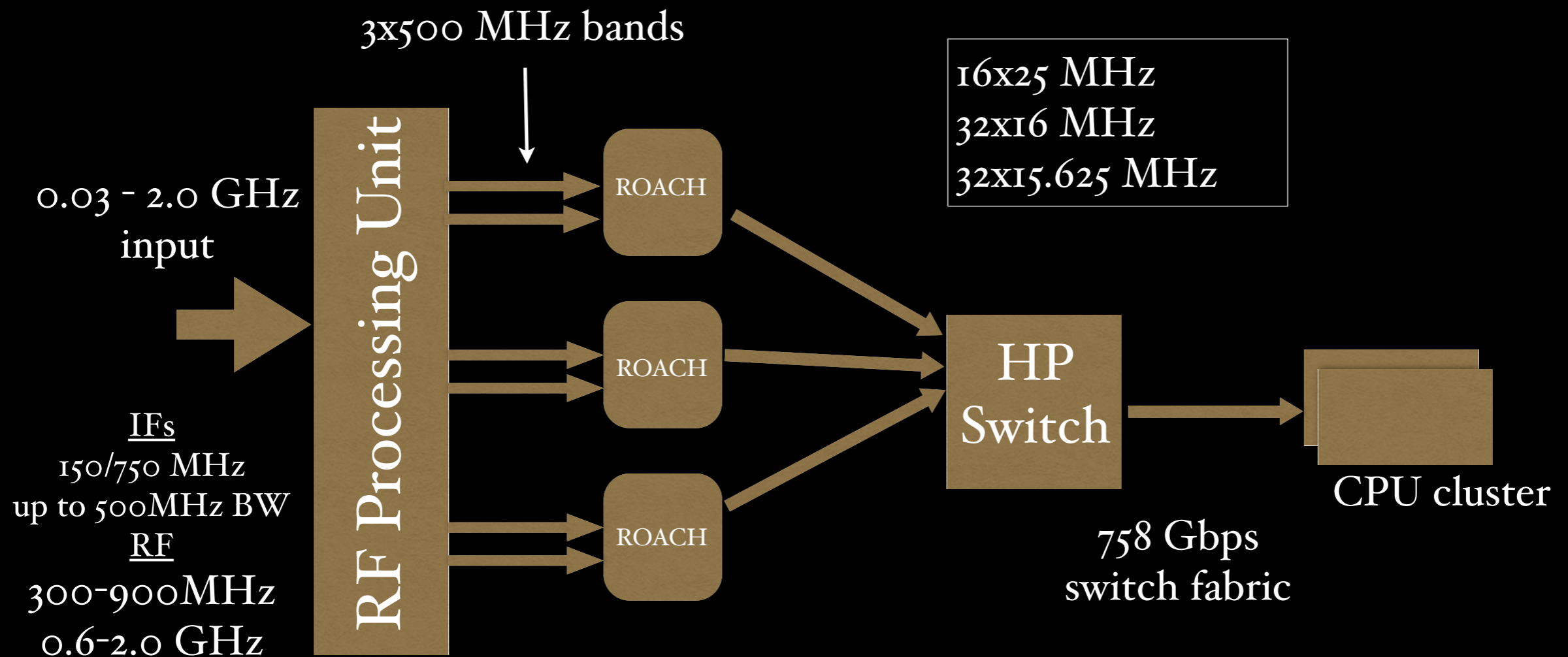


# Coherent dedispersion





# The PSRIX Instrument



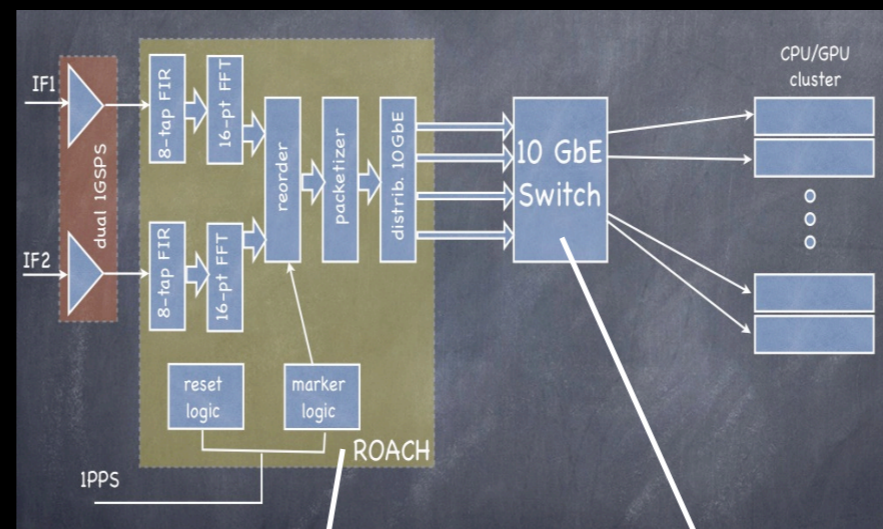
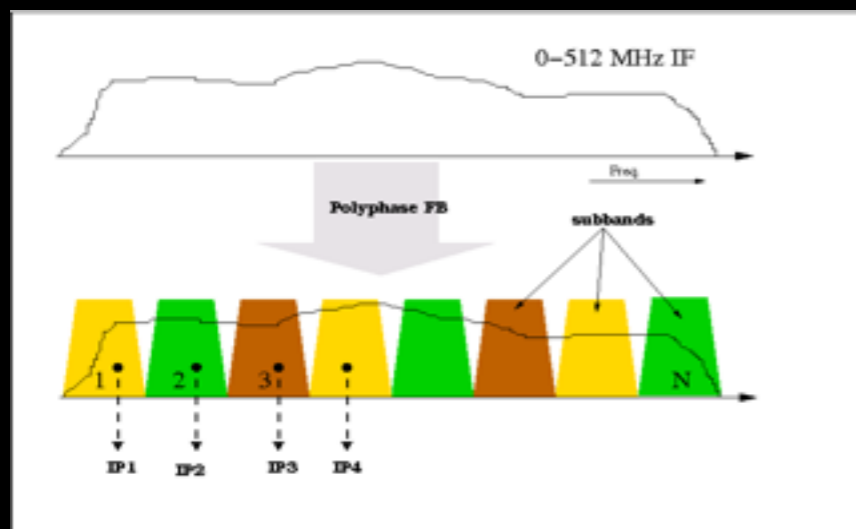
flexible and scales up nicely!



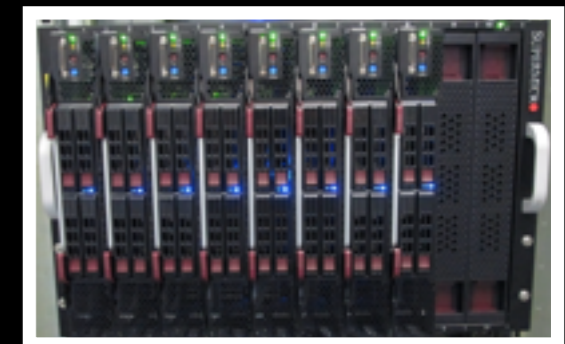
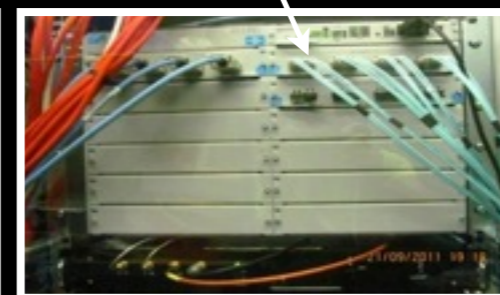
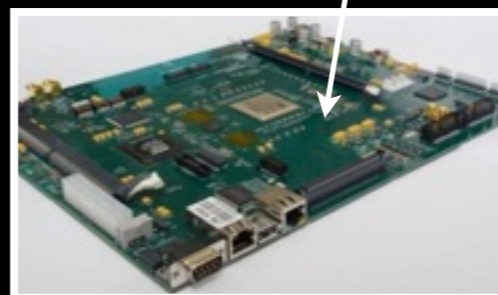


# PSRIX...

- ~1100 core CPU cluster, 244TB storage
- 1250 MHz coherent dedisp. + folding
- ~750 MHz baseband recording



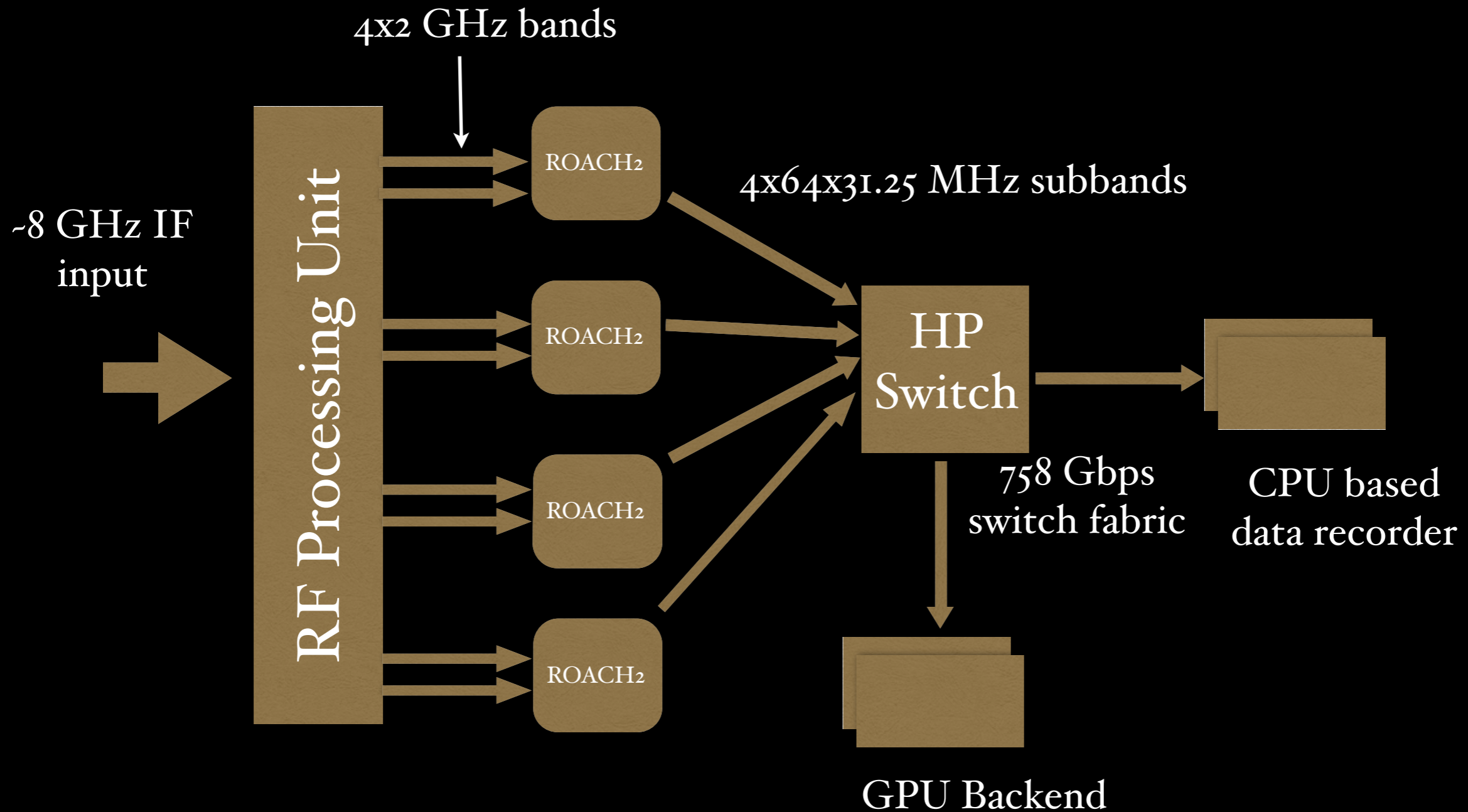
- ▶ 8192-byte UDP packets
- ▶ low overhead: 16-bytes
- ▶ Unique IP/port tagging
- ▶ Multicasting support







# Near future





# Summary

- We can process 8 GHz BW soon
- Ready (nearly!) for C+/K Band system and to measure polarisation of pulsar signals