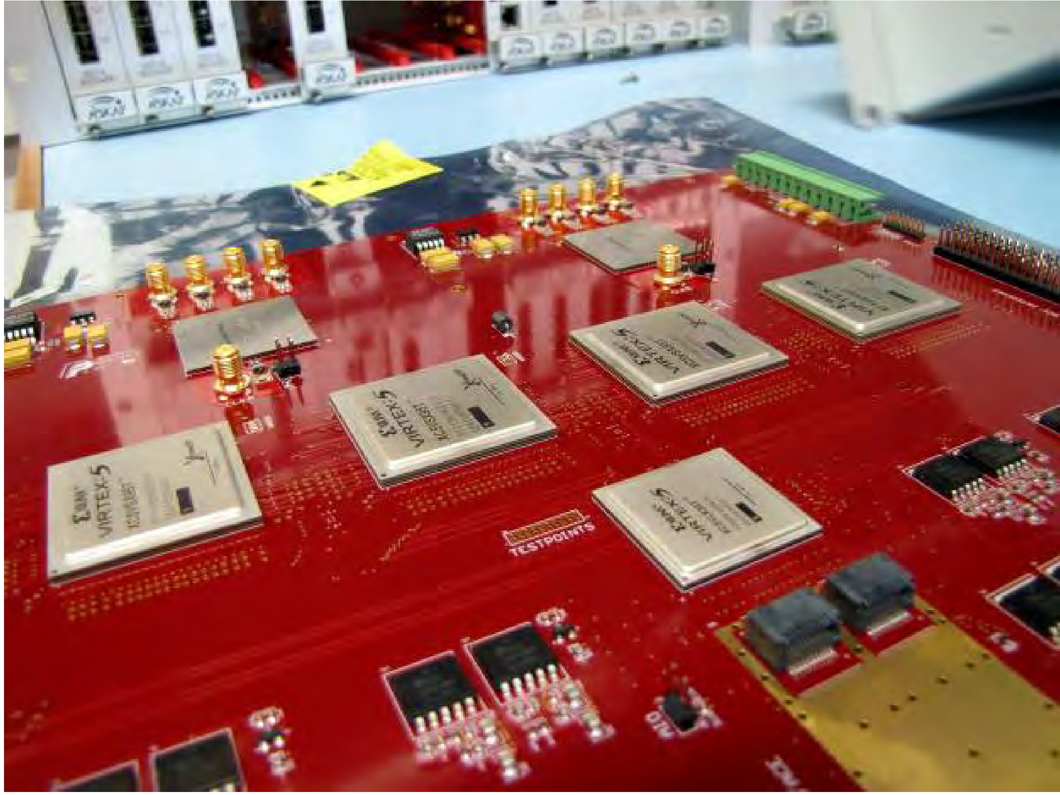

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High Speed Digital Signal Processing - the Bedlam Board

Paul Roberts – CASS Engineering Development Group

EoR Workshop November 2012

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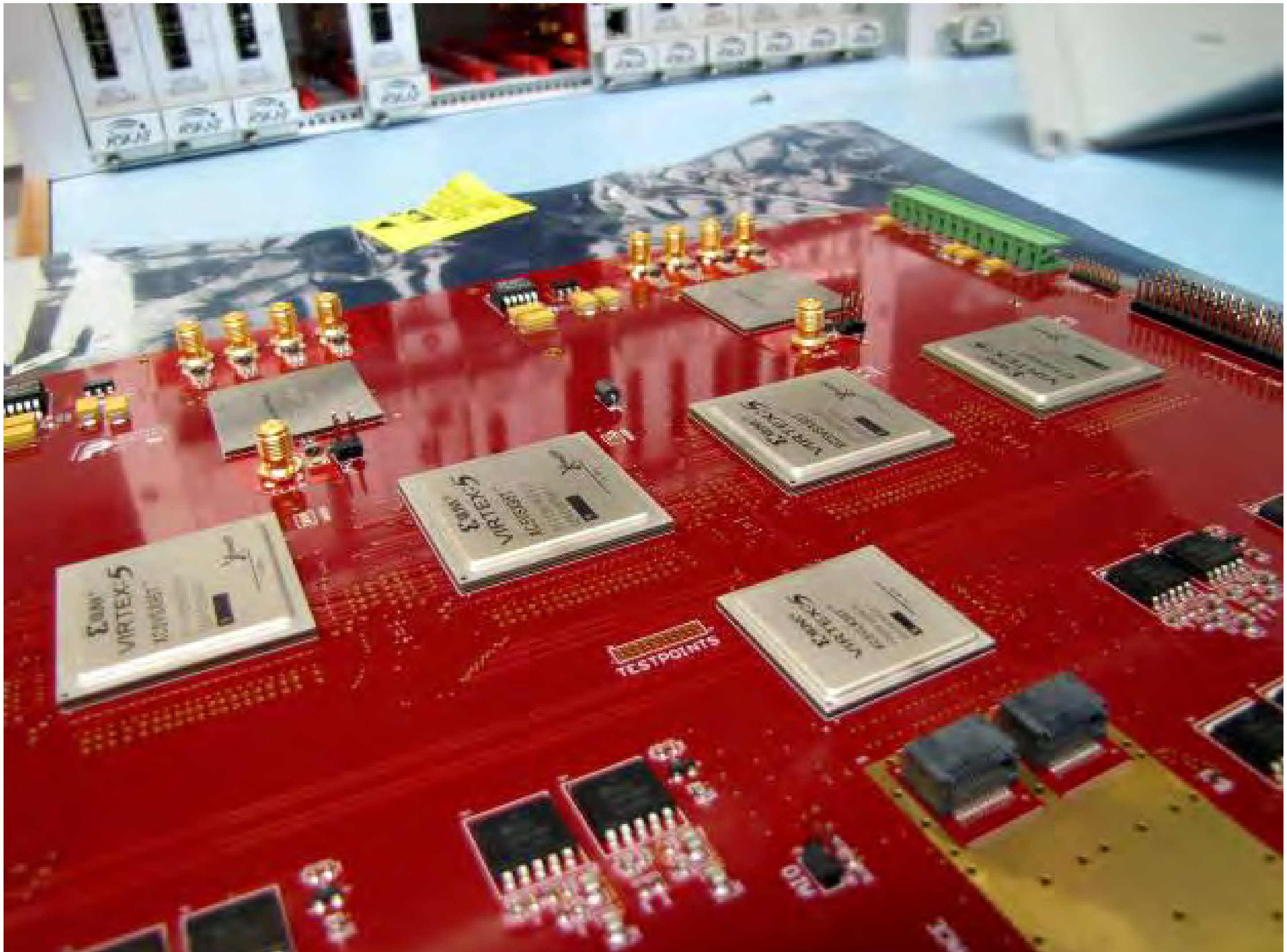
Introduction

- Background on the Bedlam System
  - Developed for a lunar Cherenkov experiment at Parkes
    - Influenced design choices and peripherals
  - General purpose enough for many applications
  - Used in several observation and measurement applications including EoR
  - Representative of typical DSP backend available for EoR experiments

Bedlam DSP Board



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Bedlam Key Specifications

- 8 input channels at 512 MHz bandwidth
  - 4 input channels 1024 MHz bandwidth
- 2 x EV8AQ160 8-bit quad channel 1.25 GHz ADC
- RF input bandwidth DC-2GHz (-3dB)
- 4 x XC5VSX95T DSP oriented FPGAs
- 1 x XC5VLX30T I/O FPGA
- Simple parallel control/data interface to external PCI card
- Dual 1 Gbit optical SFP ethernet interface
- Add on mezzanine interface to 16 x 3.75 Gbit/s transceivers per DSP FPGA (10 GbE CX4 etc)
- Power 75W @ 12V DC or AC

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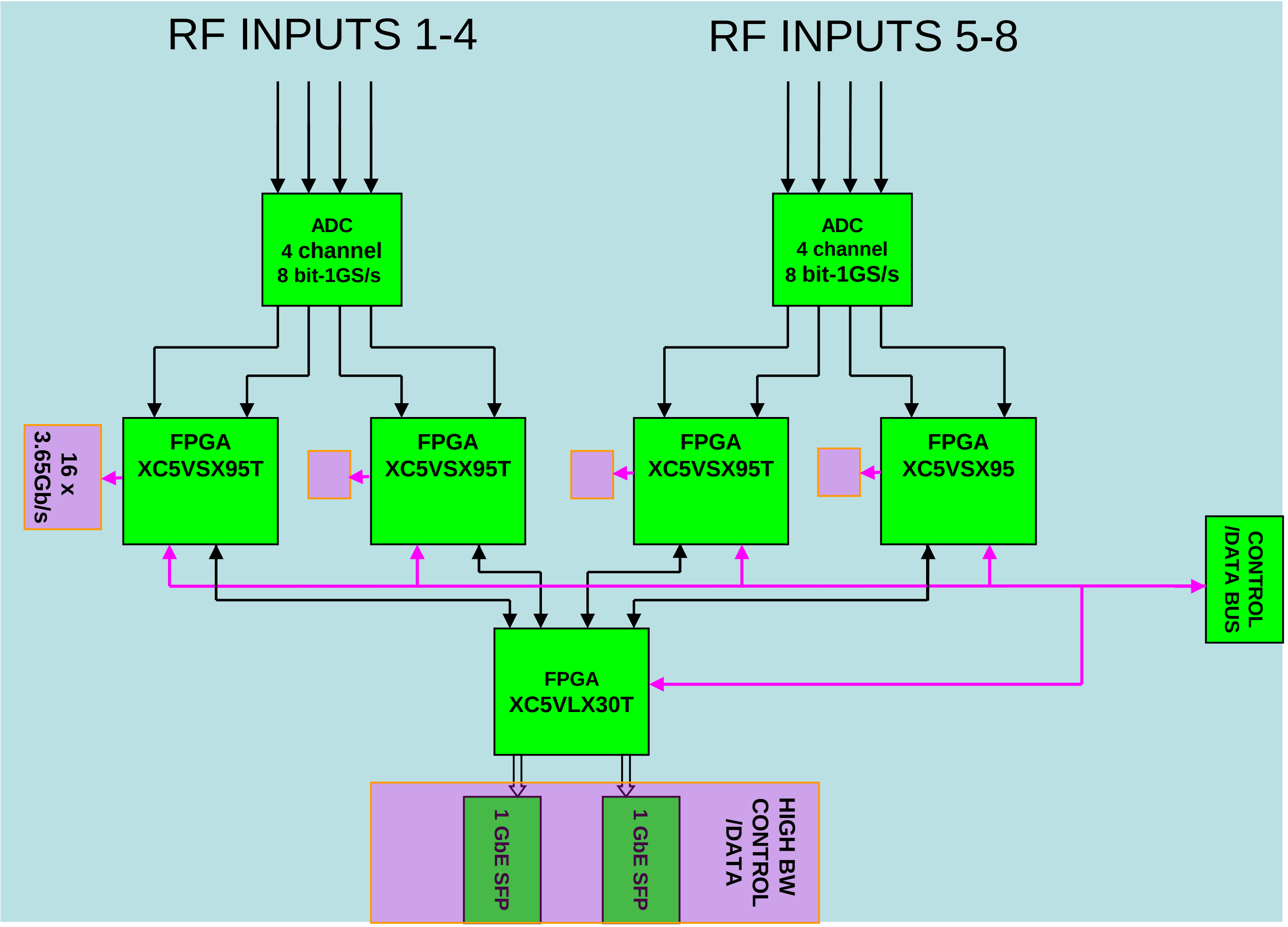
Bedlam System Schematic



DSP Resources per SX95 (4 off)

SLICES (4 LUTs 4 FFs)	14,720
RAM	8784 kbit
MULTIPLIERS (25x18)	640
3.65 Gbit/s Serial I/O	16
Ethernet MAC	4

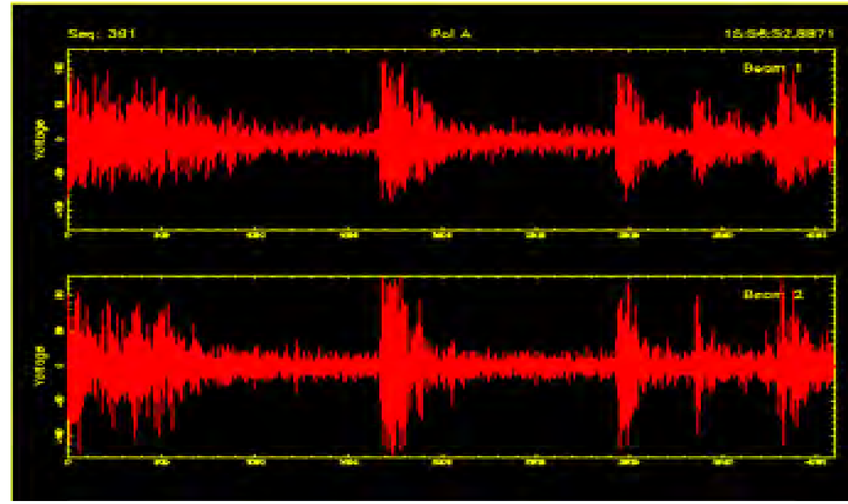
Example

2 input 4096 channel DFB auto/cross correlator
(2 auto / 1 cross with 64 bit accumulators)

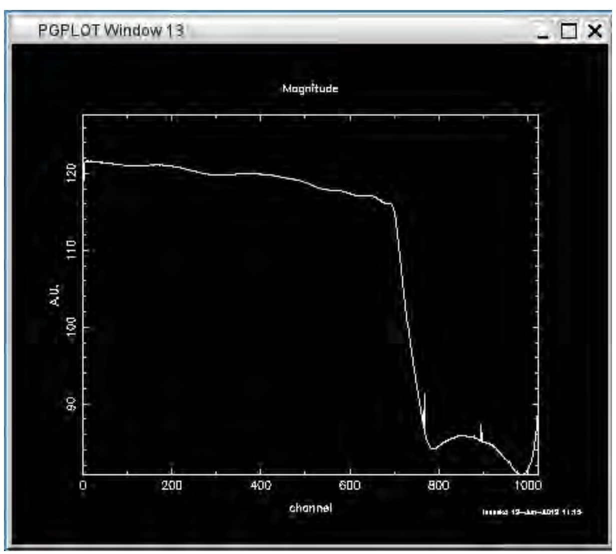
SLICES (67%)
MEMORY (81%)
MULTIPLIERS (37%)

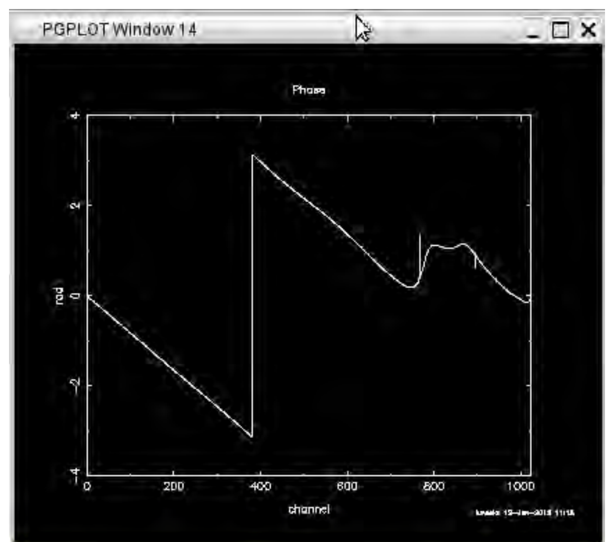
Typical Operation Modes

Transient Mode



Spectrometer/Correlator Mode





Several reference designs

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Features

Attractive features

Simple standalone instrument – 2U Rack case

Easy to understand and use

Simple to manufacture

Reference designs available

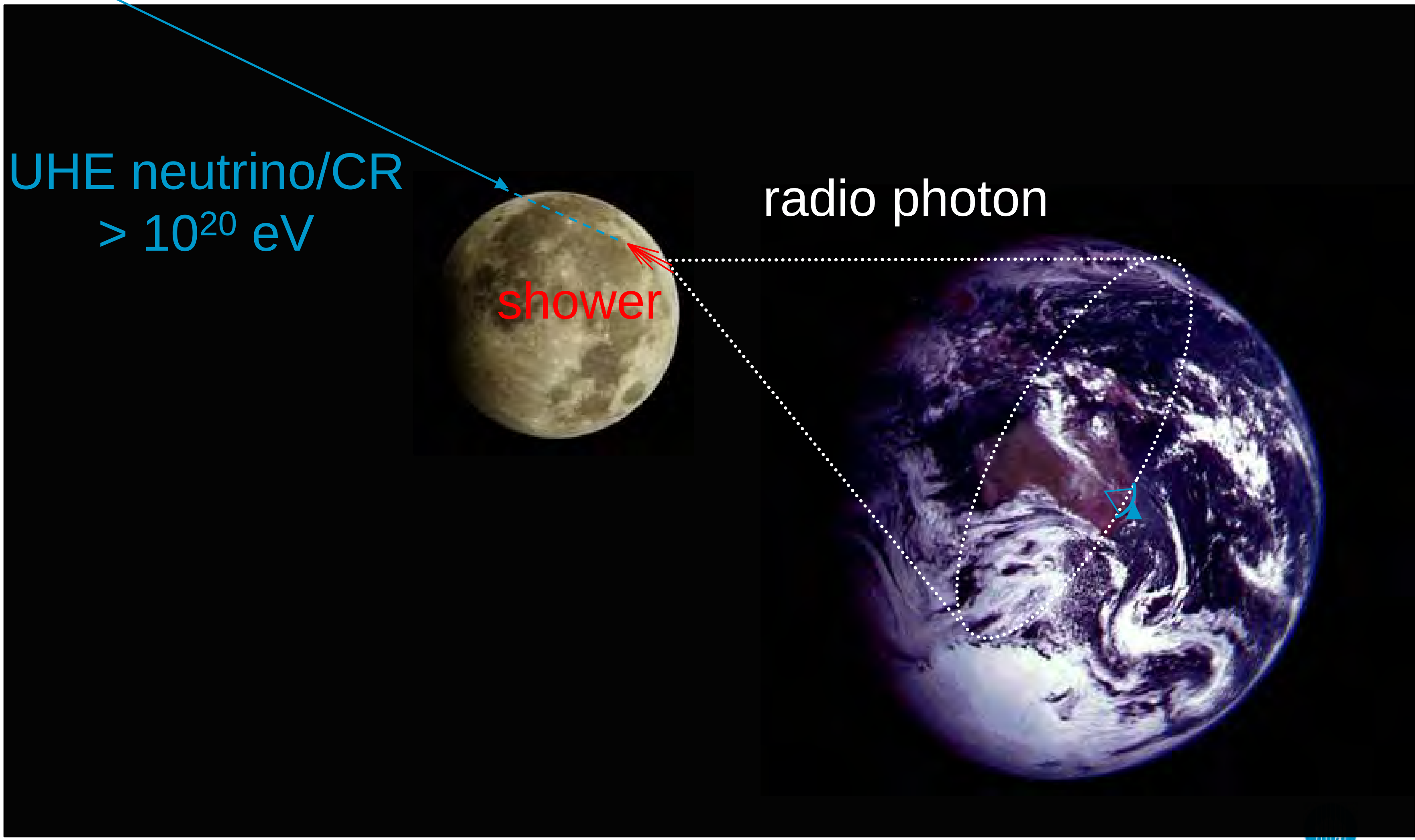
Can use open source (CASPER) high-level DSP blocks for easy adoption and customization

Limitations

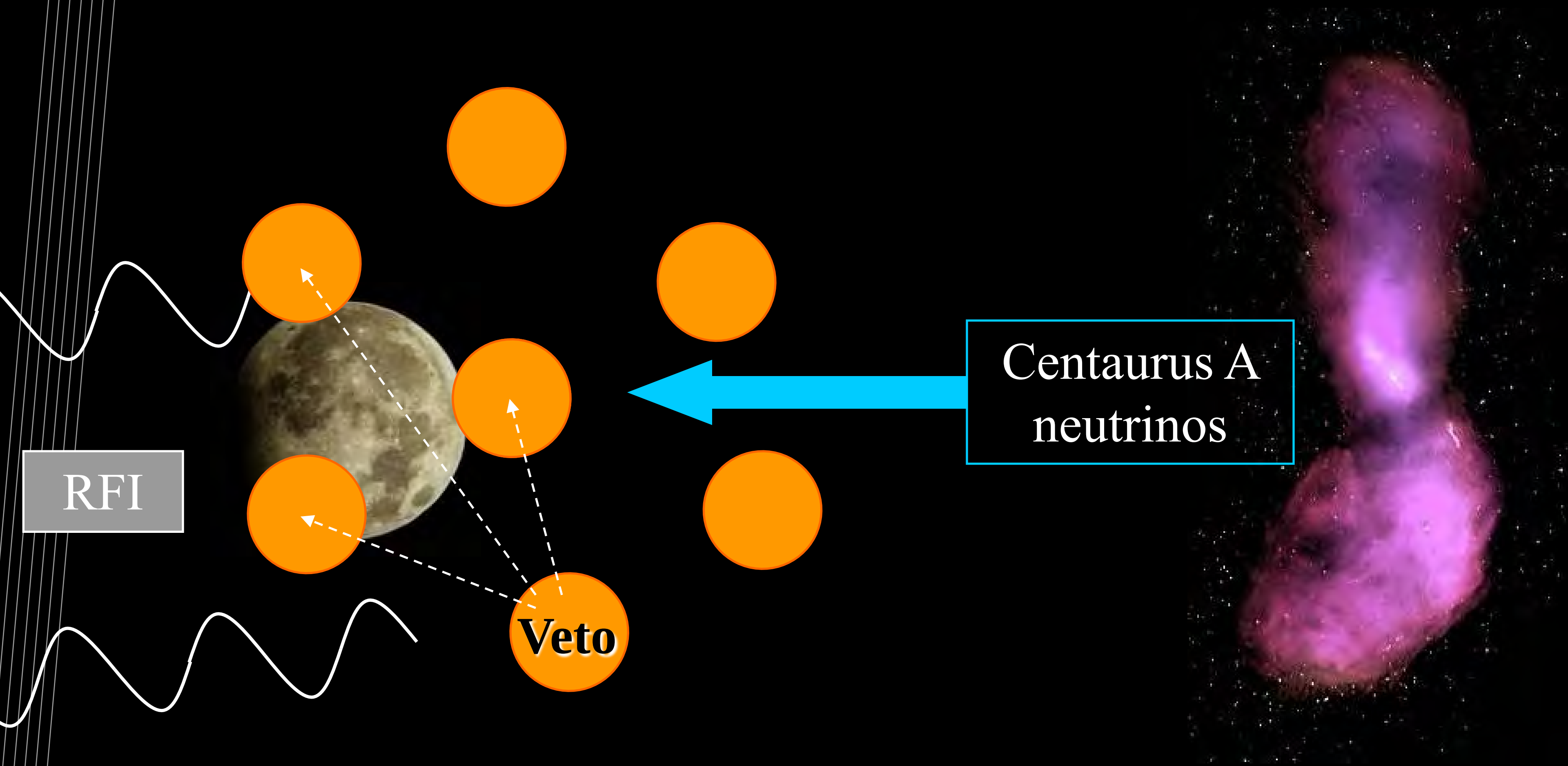
No external memory on board

Applications

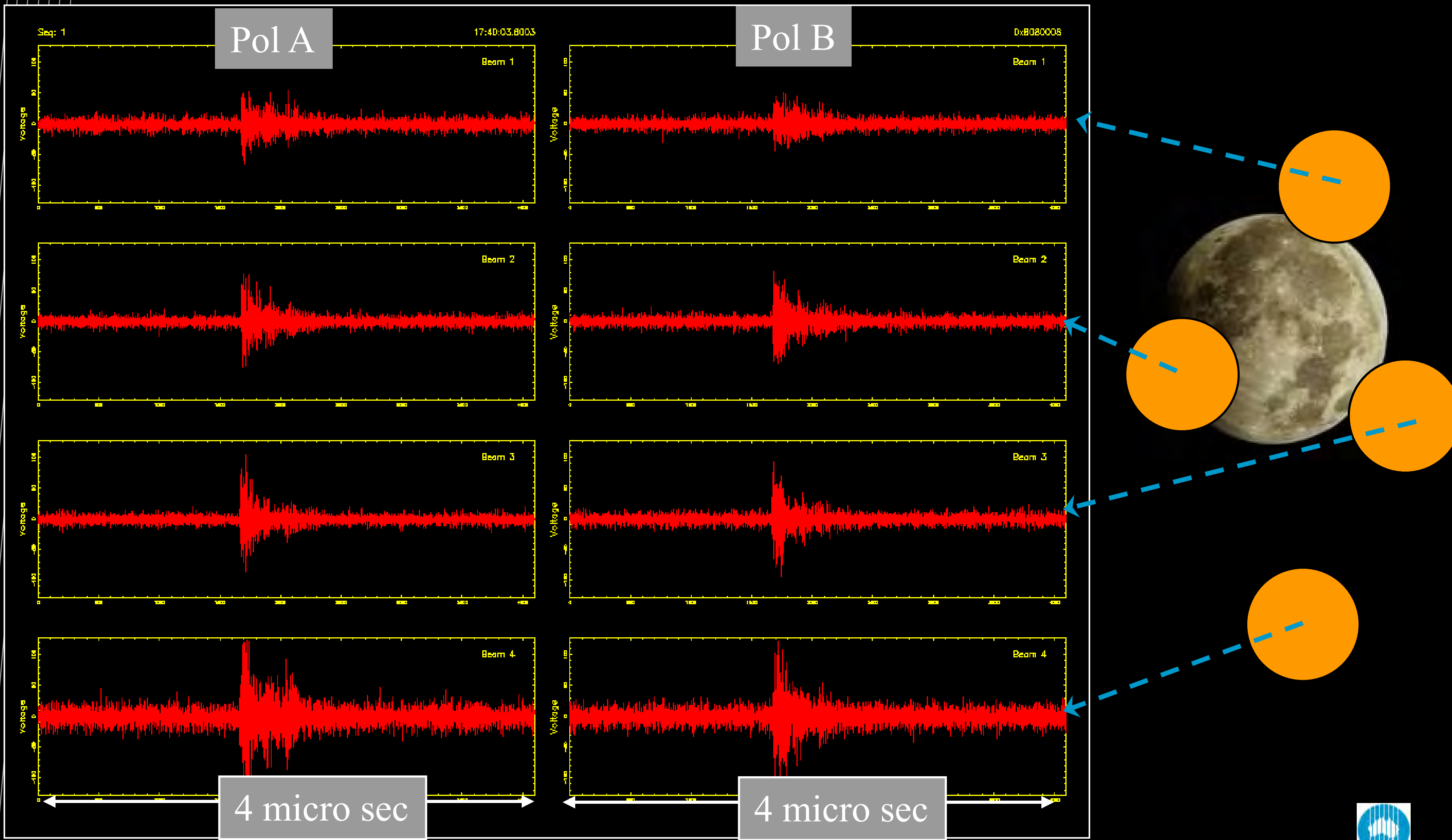
High Energy Particle detection via radio Cherenkov emission - Ekers et al



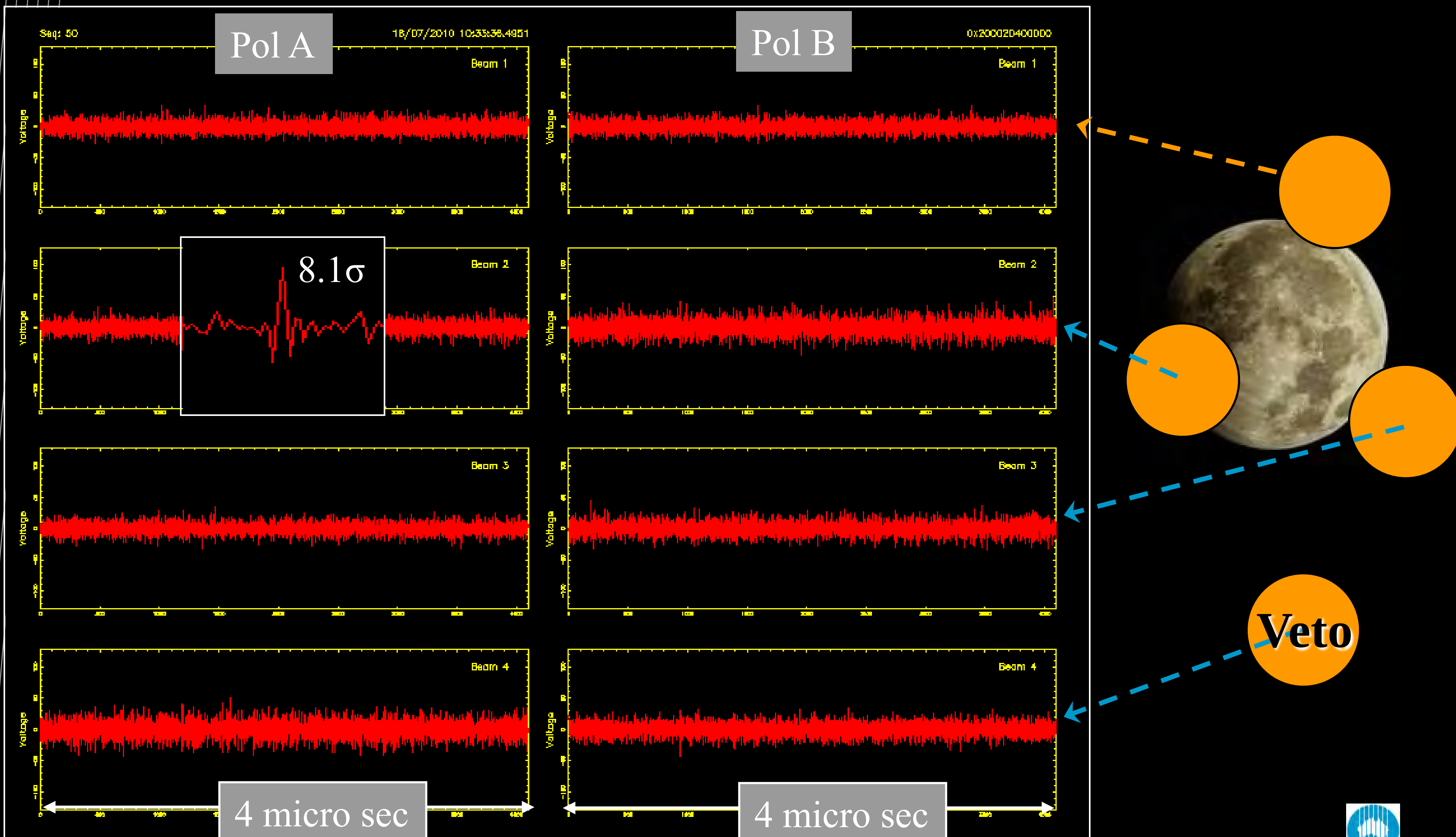
Parkes 21cm Multibeam Experiment



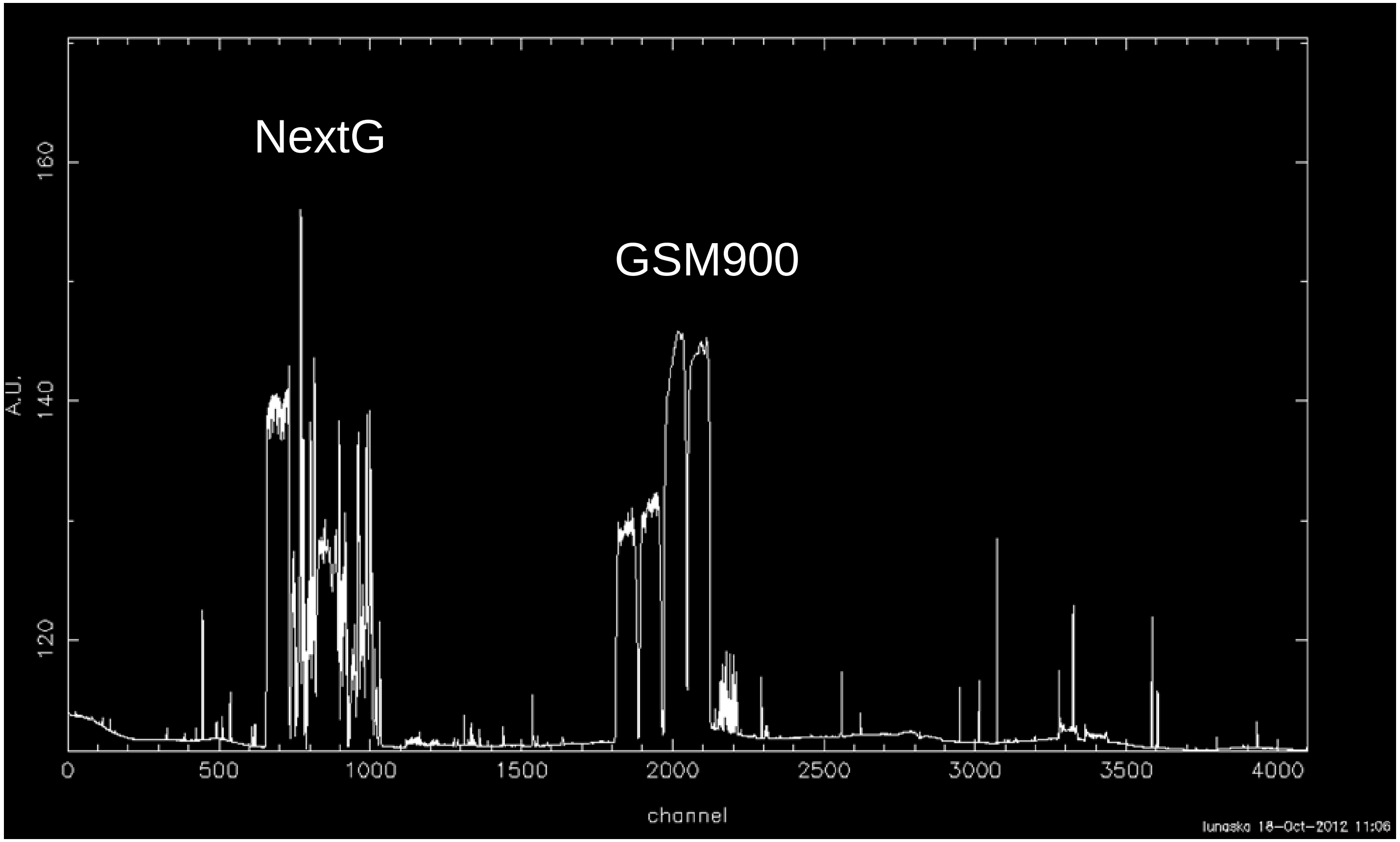
Parkes: RFI pulse



Parkes: Possible Event

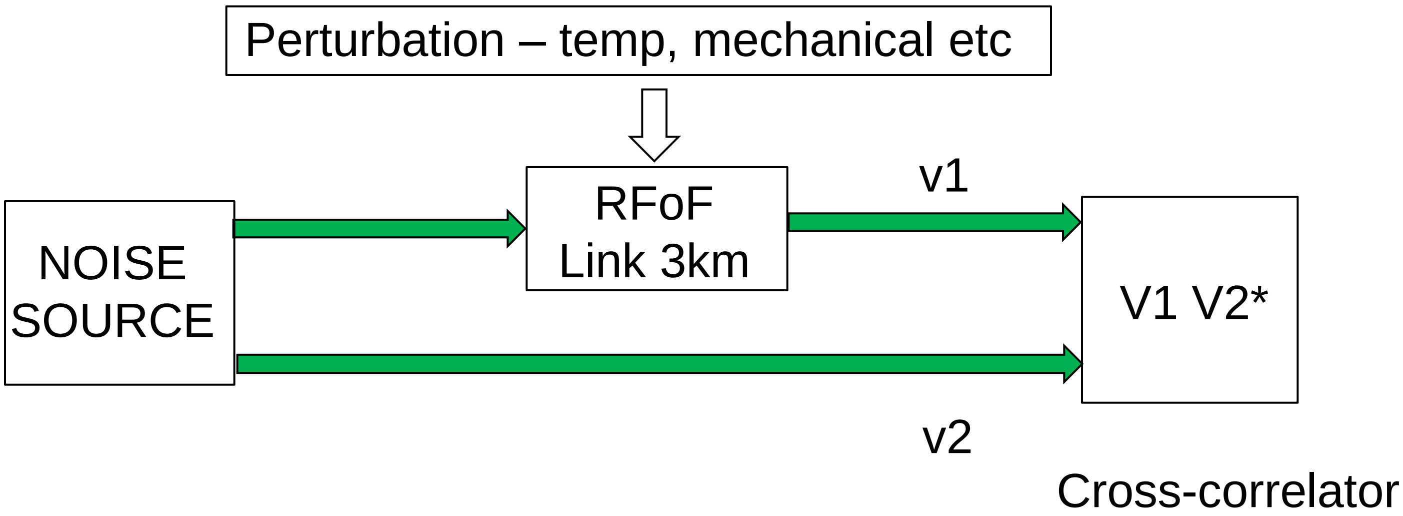


Applications – Spectral RFI Monitoring



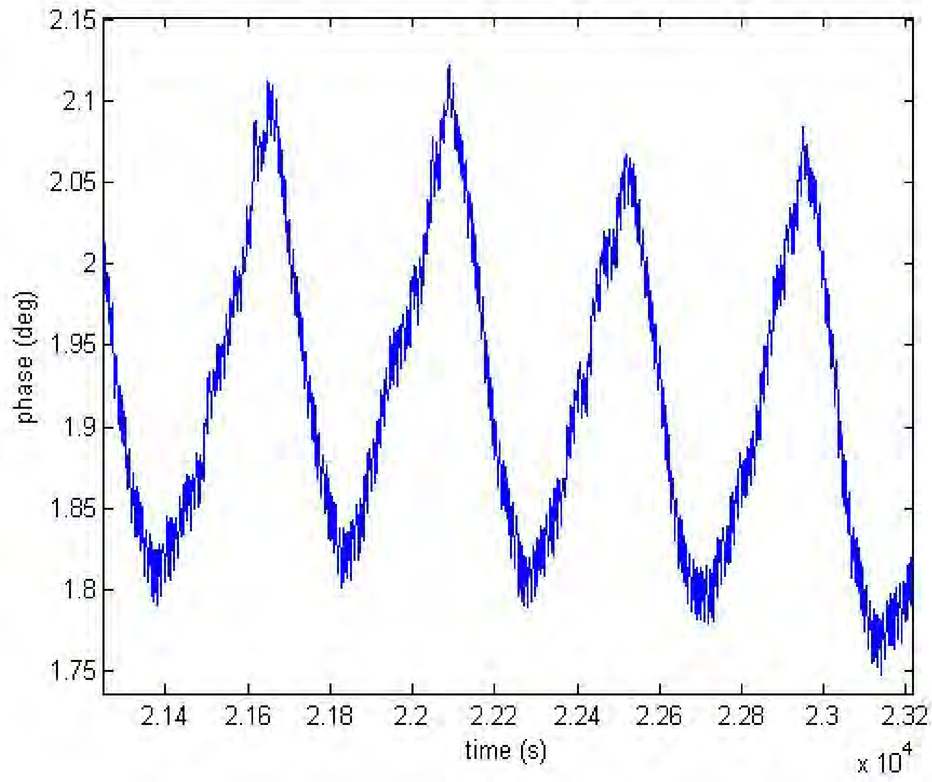
4096 Channel DFB Spectrometer - Band 800-1000MHz

Applications - Precision system testing ASKAP RFoF link stability

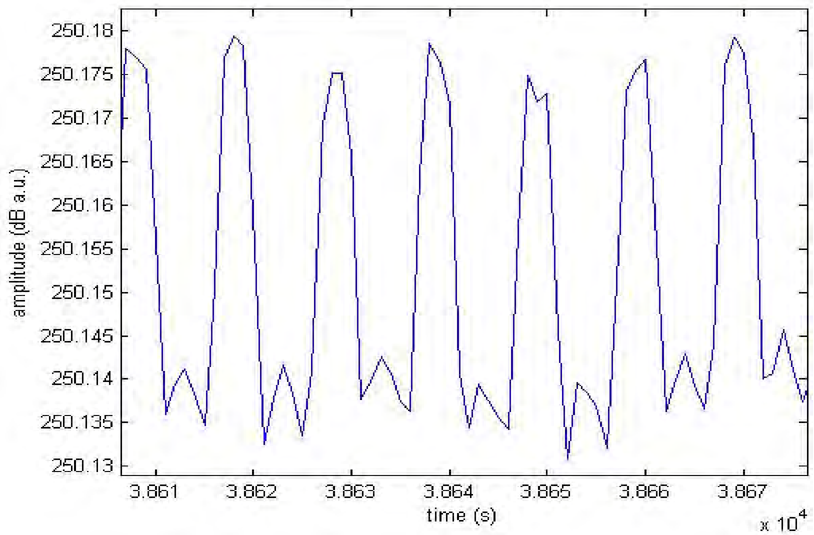


Applications - Precision system testing ASKAP RFoF link stability

Phase @ 1.4 GHz vs time



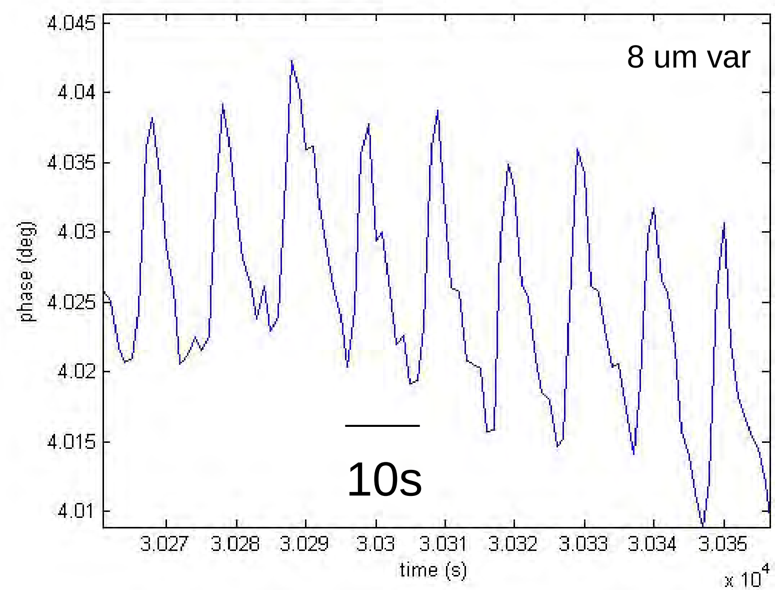
Applications - Precision system testing ASKAP RFoF link stability



Amplitude @ 1.4 GHz vs time

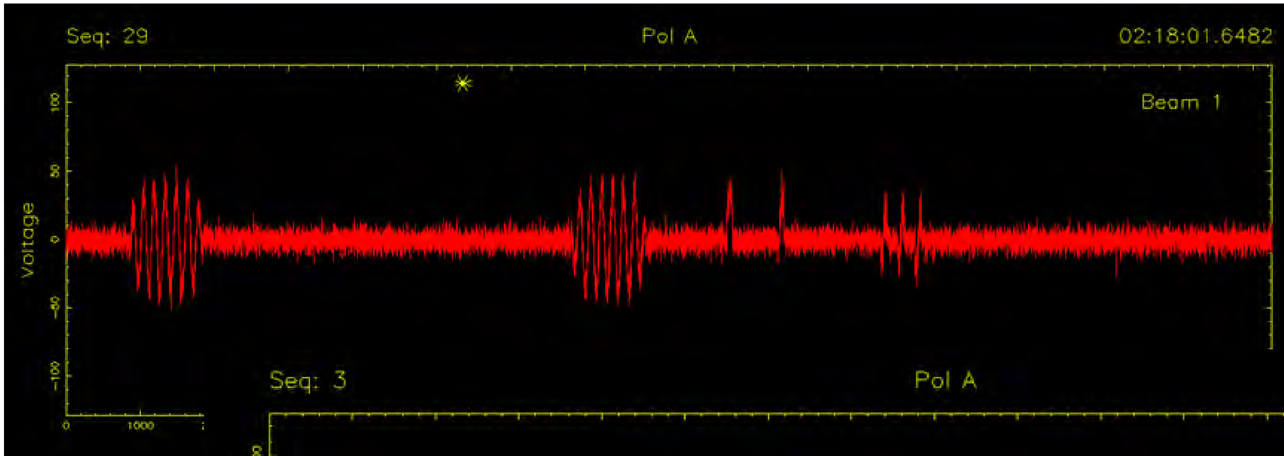
Mechanical perturbation – oscillating pedestal fan

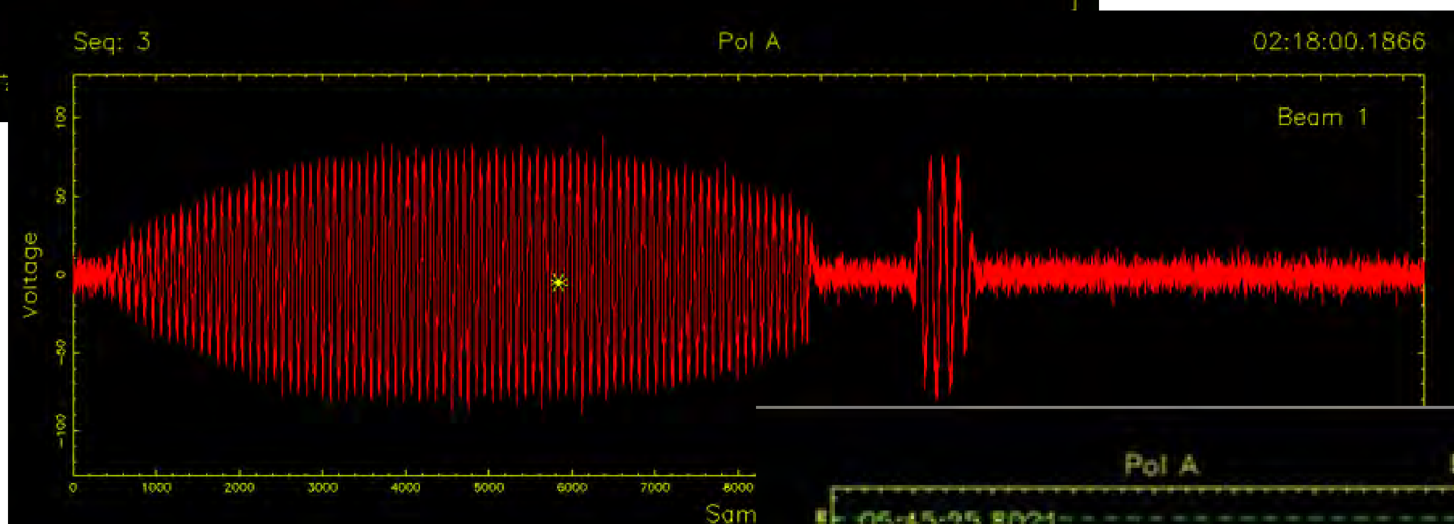
Phase @ 1.4 GHz vs time

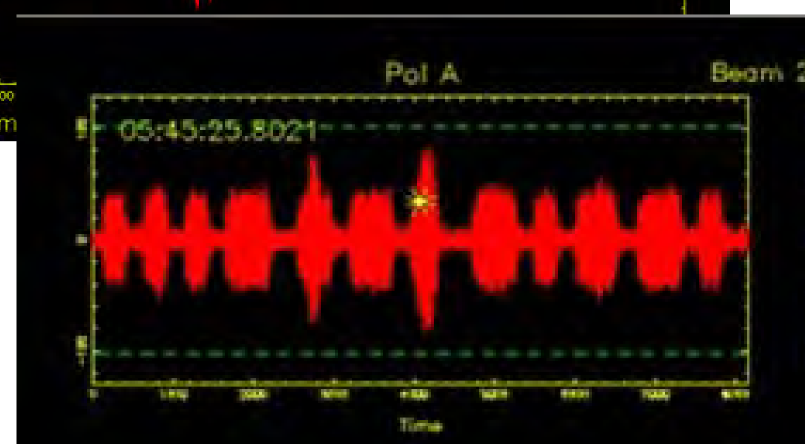


Measurement variance -
0.001 db
0.001 deg

Applications-Transient RFI Monitoring and Mitigation

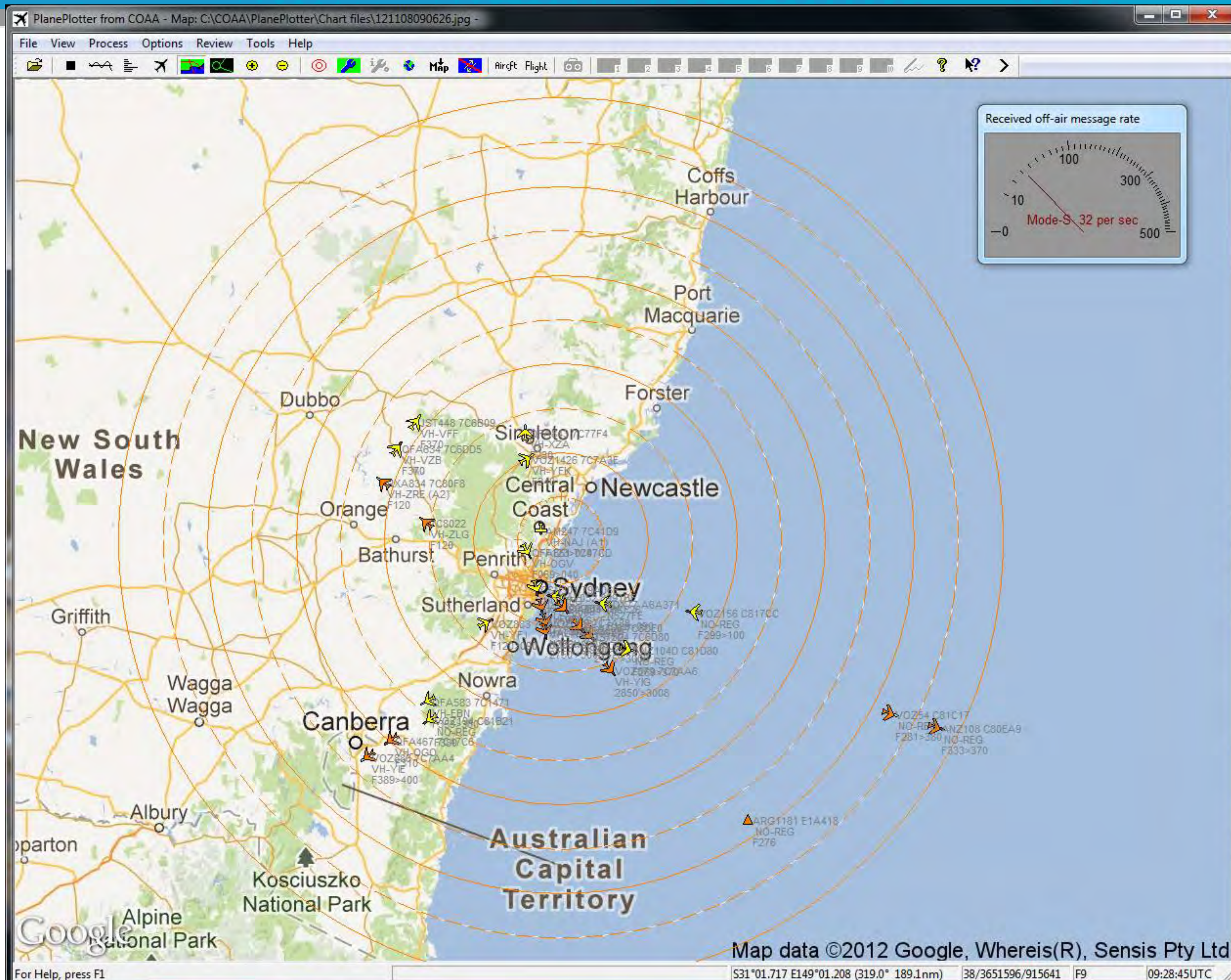






Parkes 0.5-6GHz survey
Boolardy RFI site monitor

Applications-Transient RFI decoding – Aircraft Tracking



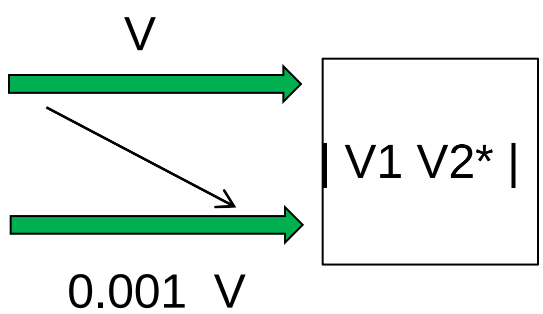
Use in cross-correlation

Question of input coupling in cross-correlation mode

ADC has inter-channel isolation typically -57 db from datasheet

⇒ Voltage coupling ~ 0.001

⇒ Correlator muliplies voltages



= 0.001 |VV|

Compare with other uwave components in coupled signal chain

⇨ Include in model and/or
Use phase switching to reduce

Current developments

EoR – other talk

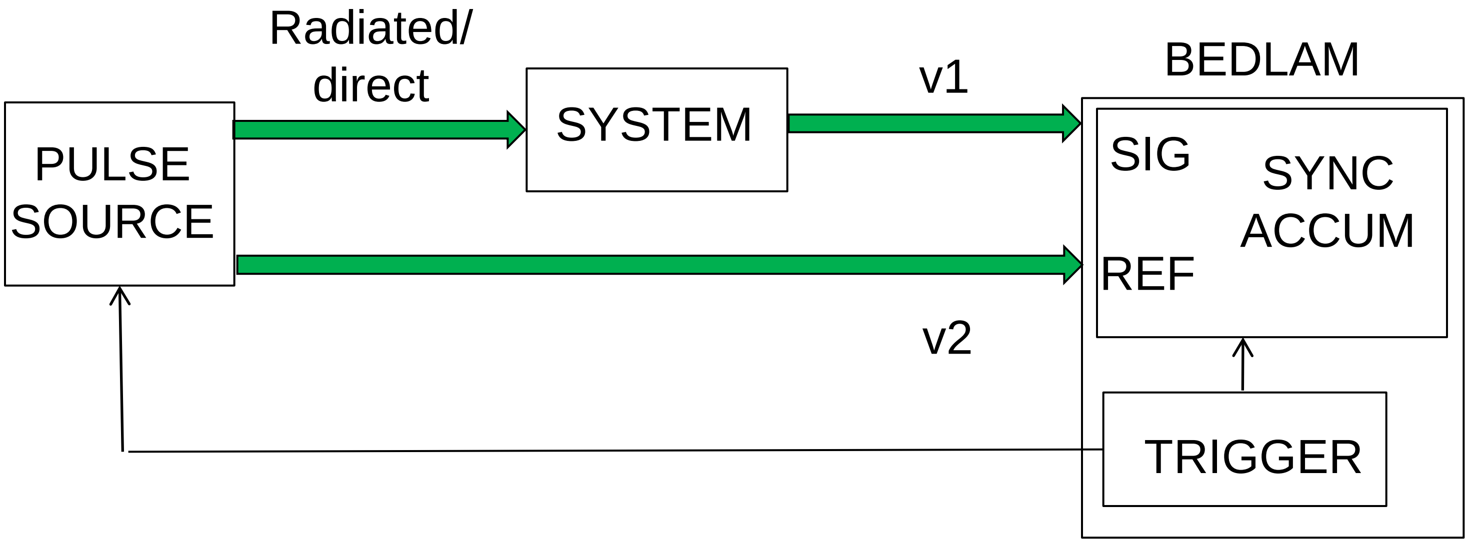
- BIGHORNS
- Self-Calibrating receiver –Keith's talk

Short pulse calibration methods -Nipanjana

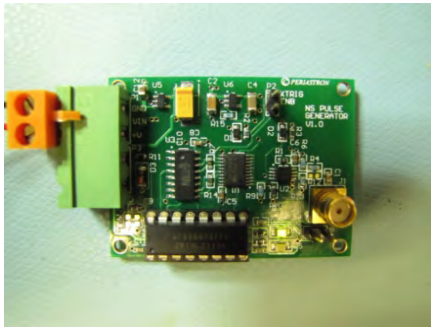
broadband pulses
can be gated out
simple identification of discontinuities
unambiguous time/phase

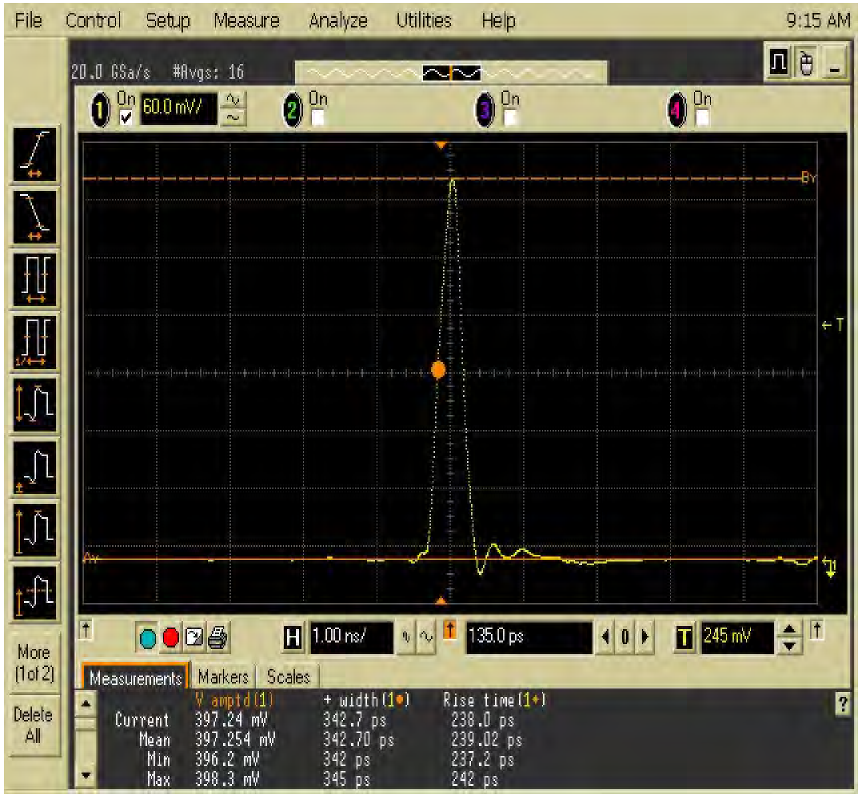
other uses-
direct ionospheric dispersion (TEC) measurement etc ?

Pulse calibration



Pulse calibration – making pulses

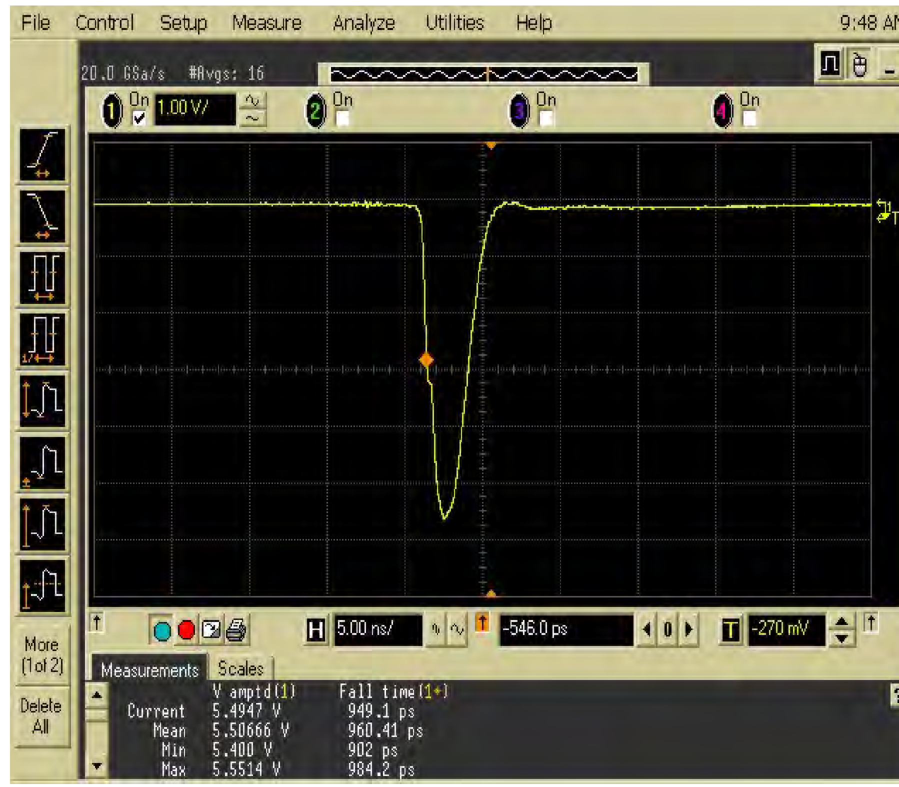




Pulse width : 350 ps

Pulse amplitude 400 mV into 50 ohm.

Pulse calibration – making pulses



Pulse amplitude 700V into 50 ohm (10kW).

Pulse rise time 950 ps

Summary

Real-time digital signal processing can help solve many of the problems encountered in EoR experiment design

Cheap, easy to use hardware platforms exist.

Should be fully exploited

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