Fault Diagnosis and RF Detection

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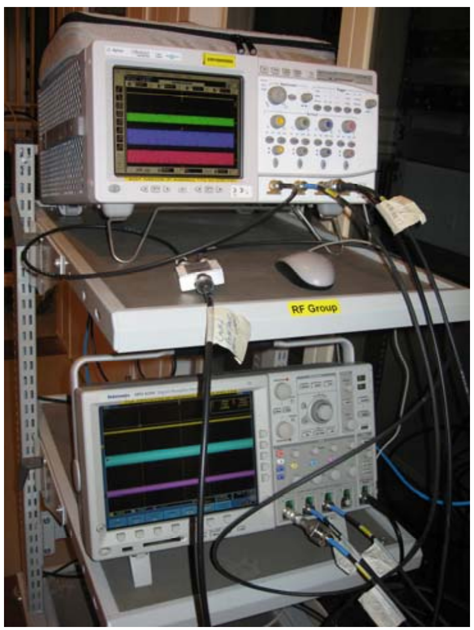
Current diagnostic tools

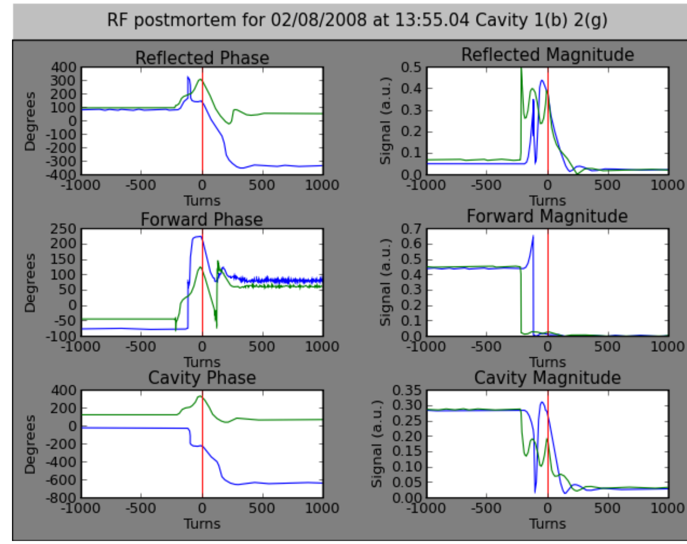
Data Archiver and EPICS Strip tool

- Good for slow (10 S/s) data and trends
- Also require much smaller time steps →



Multiple oscilloscopes

- Fast sample rates
- Crude sync via trigger IN/OUT



EBPM electronics

- Used to sample RF signals on MPS trigger
- Turn-by-turn sample rate (500 kHz) limits resolution

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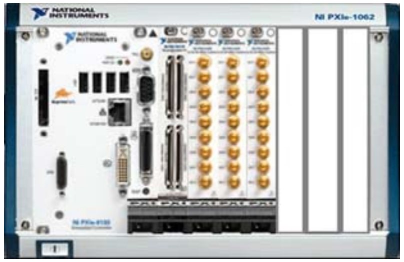
New data acquisition: main contenders



VME64X/EPICS

pros

- Easy integration with existing Diamond hardware and software
- Data archived

cons

- No high speed data acquisition cards currently in use at Diamond
- Suitable boards (e.g. CAEN 100 MS/s) need EPICS drivers
- High cost/channel

National Instruments PXI

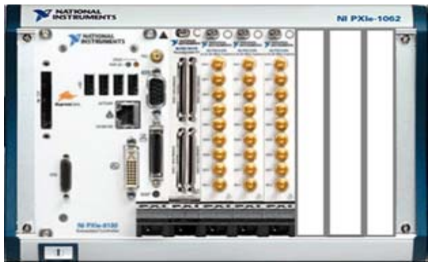
pros

- Large range of cards available - high speed DAQ & RF
- Good range of triggering and synchronisation functions (10 MHz ref)
- Flexible and expandable
- Widely used LabVIEW software

cons

- Not easily integrated into DLS control system: stand alone
- Unfamiliarity with PXI capabilities

Proposed system block diagram



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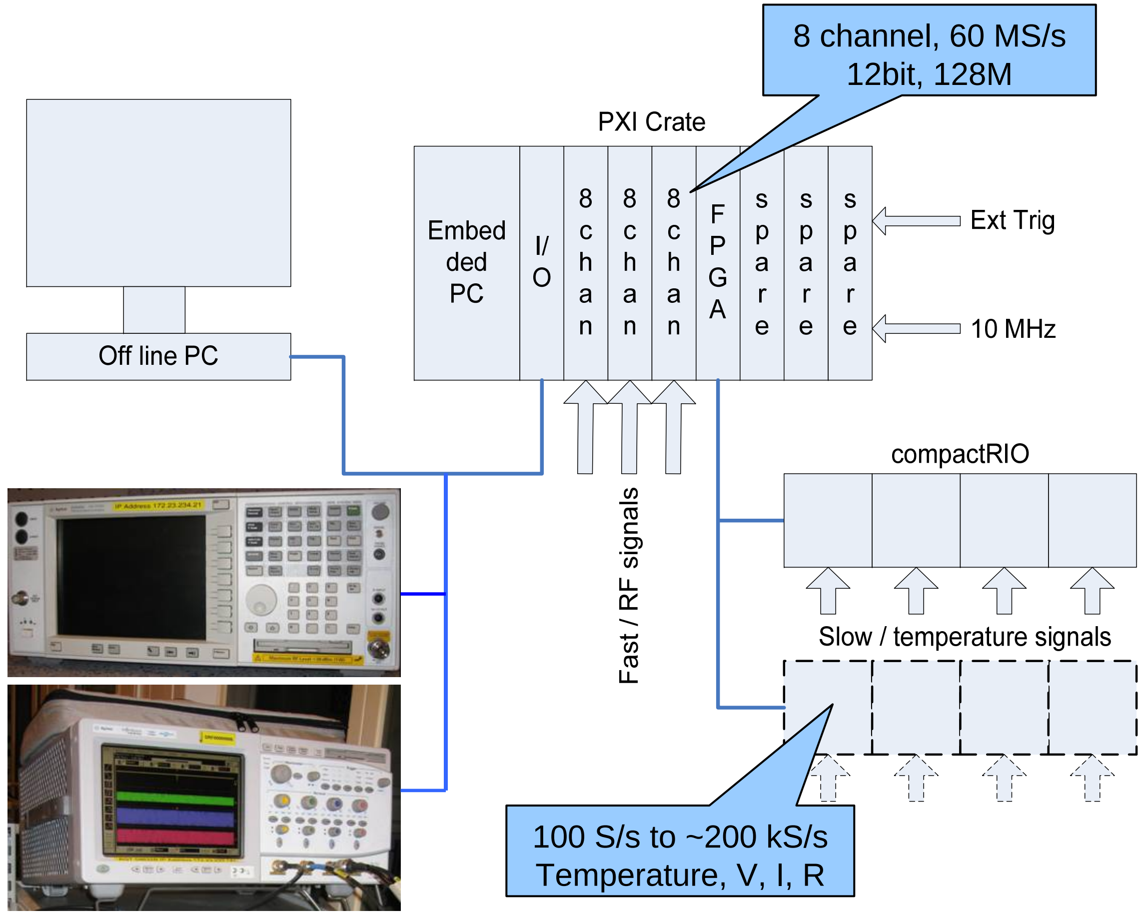


RF signal detection

- **Diode Detectors** (initially)
  - Slow rise/fall times into 1 MΩ, low output level into 50Ω
  - Simple and low cost, but only give amplitude information

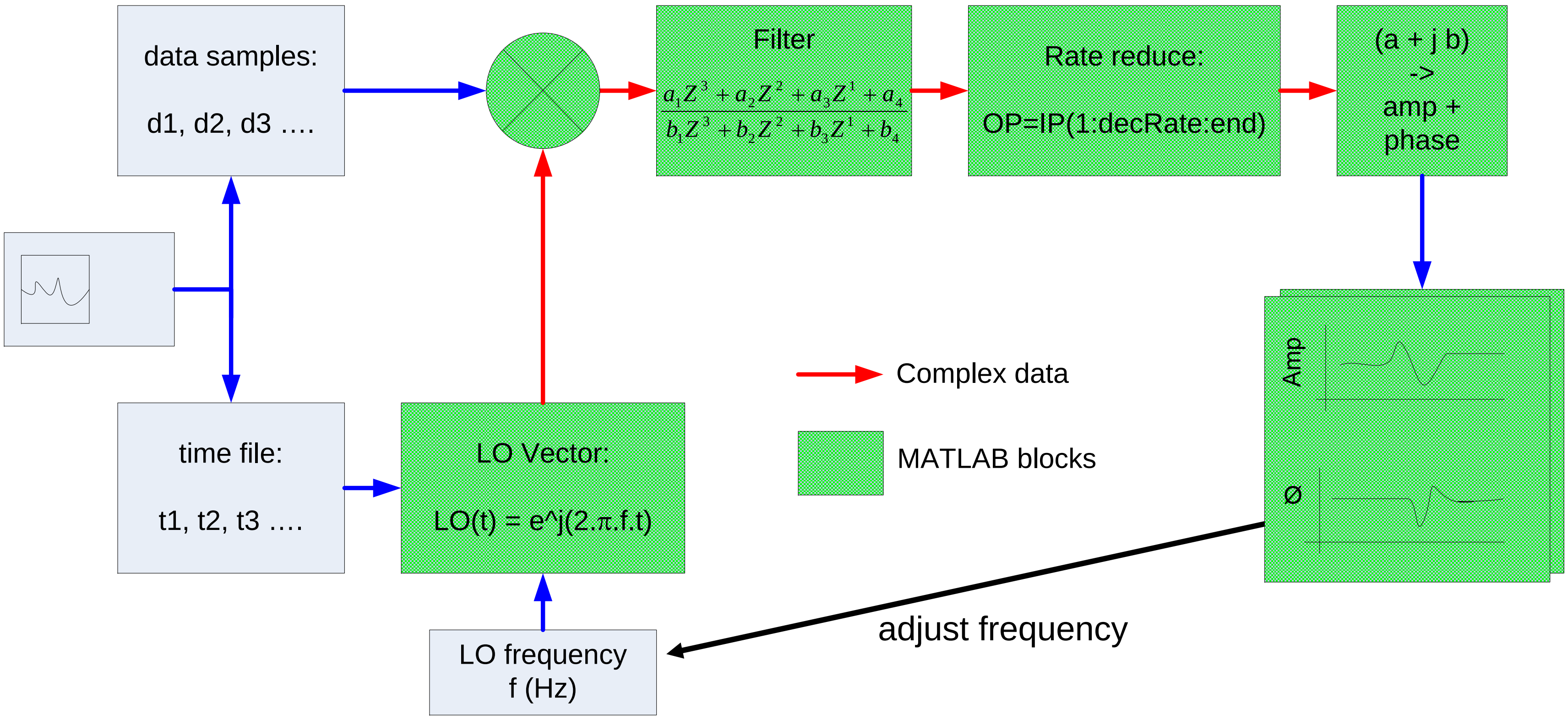
Then, options are:

- **Mix down to baseband**
  - IQ demodulator, I and Q into separate channels. Noise and offsets
- **Direct RF Sampling**
  - Few off-the-shelf 500 MHz BW digitisers with multiple inputs
- **Intermediate Frequency**
  - Hardware will be built to down convert RF signals to 15 or possibly 20 MHz (1.5x or 2x 10 MHz reference)
- **IQ sampling**
  - Sample IF at x4 sample rate to give **I, Q, -I, -Q**
  - e.g.15 MHz sampled at 60 MS/s

Obtaining phase information

- **Phase measurement has been accomplished in several ways:**
  1. Spectrum analyser (or ‘scope) with vector analysis software – high dynamic range but only single (or dual) channel
  2. Mixers used as phase detectors – amplitude sensitive and calibration required
  3. 4-port VNA used to measure amplitude and phase – slow sampling rate
- **Obtaining phase information**
  - Until the new DAQ system and RF down conversion is complete, how do we obtain phase information?
  - Phase can be recovered from ‘scope data in the following way:
    - **Capture RF signals at suitable sample rates (2 GS/s)**
    - **Save sampled data to file with time information**
    - **Calculate complex LO signal for each time point**
    - **Multiply sampled data and LO signal, then low pass filter**
    - **Extracted and plot amplitude and phase**

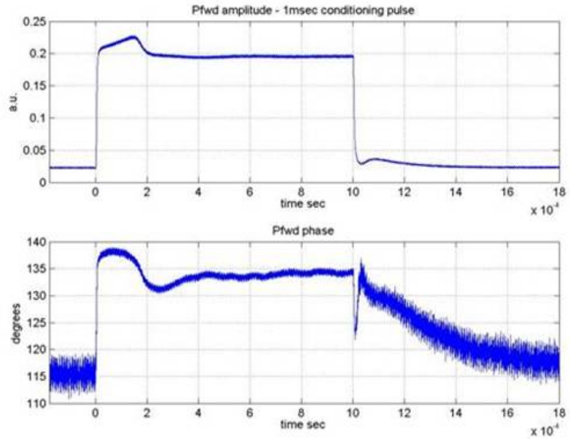
Numerical down conversion

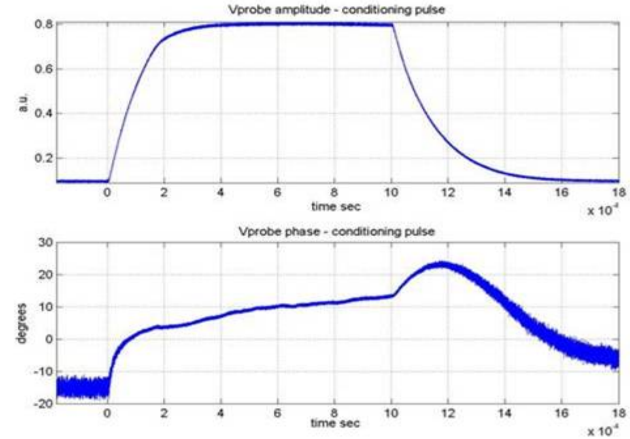


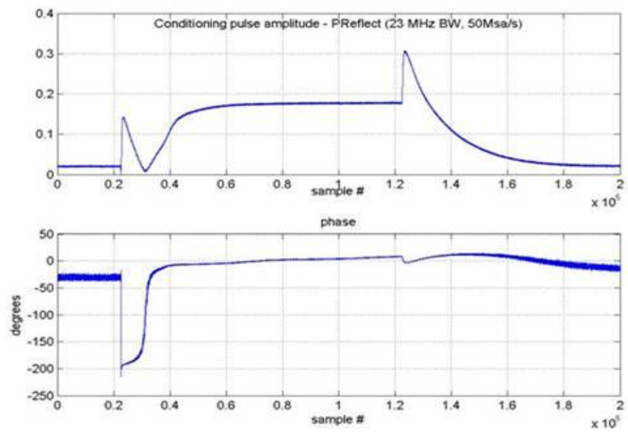
Problems encountered

- **Large files**
  - 16 MB/trace for 2 ms (.bin format helps)
  - Can ‘decimate’ (remember Nyquist needs to be obeyed)
  - Can we under sample to down convert RF?
    - **$f_k(k) = f_{rf} - k \times f_{samp}$**
    - **Requires sample rates not selectable on the scope (e.g. f_{samp}=70 MS/s, k=7)**
- **RF frequency determination**
  - Adjust phase slope by eye, takes time
  - Requires period of constant frequency
- **Oscilloscope noise and trigger jitter**
  - Affects phase measurement most
    - e.g. 2° p-p, 0.24° rms (20 MHz BW) measuring MO signal
  - Maximise scope signal amplitude
  - Apply filtering and smoothing

Example results – conditioning pulse



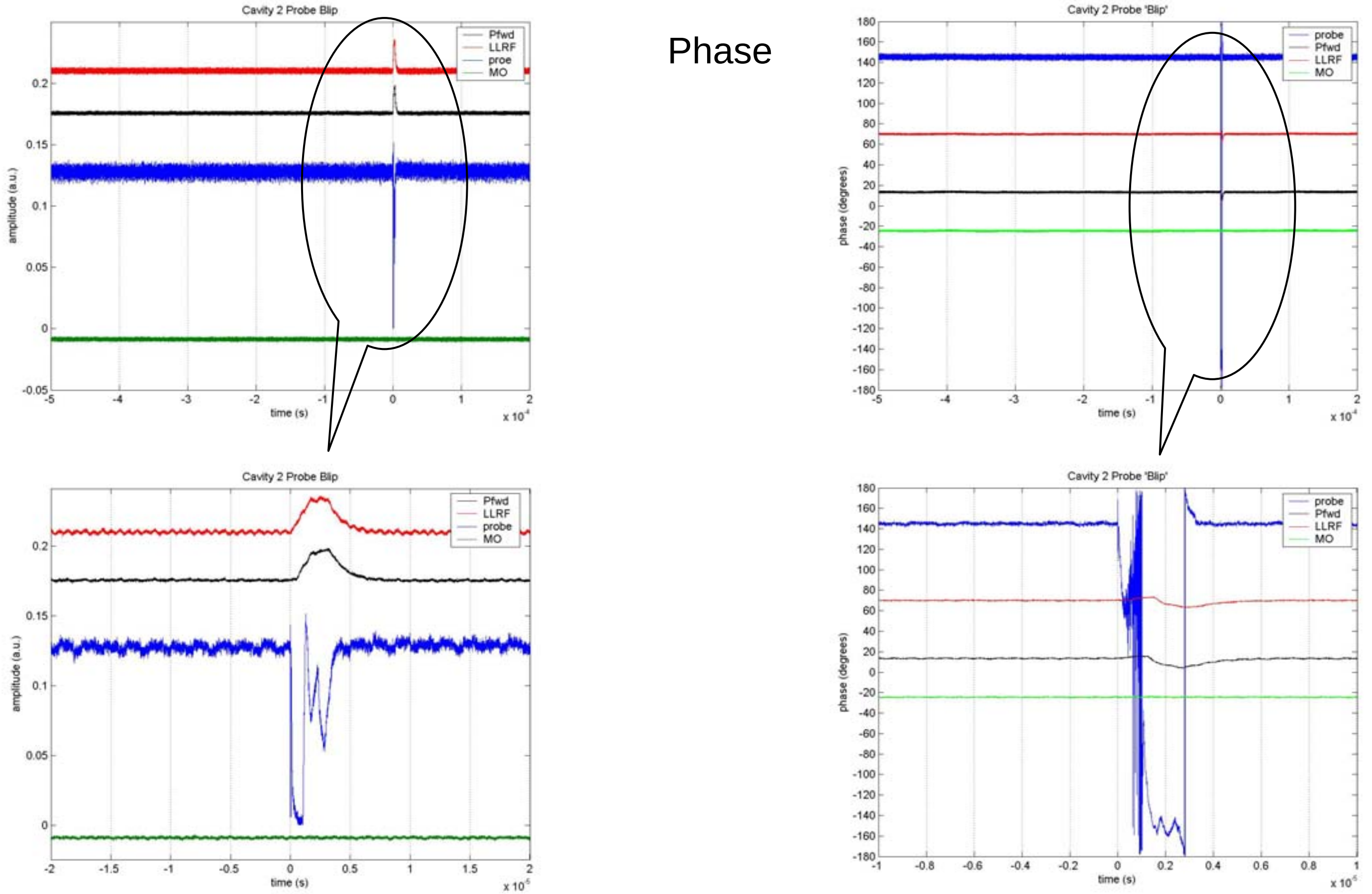




Example results – cavity pickup ‘blip’

Amplitude

Phase



Next steps

- **Install NI PXI hardware**
  - Located in new patch panel rack in RF Hall
- **Labview software to be written by NI Alliance partner**
  - Acquisition on selectable trigger
  - Data logging to file
  - Data display with search and zoom
- **Labview training for RF staff**
- **Gain experience with the system**
  - Hardware and software changes as required
- **Diagnose faults!**

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Cavity 2 trip