Status of the MICE RF System

The MICE RF team

Headline update

- Distribution network
  - Components assembled into distribution network at DL
  - Components delivered to RAL from DL for installation
  - Adapted from components procured under NSF-MRI for earlier configuration
- Status of RF drive system
  - Upgraded triode modulator No.1 operational at Daresbury
  - Triode No. 2 under test, started mid March
    - Exploiting 1st tetrode, and upgraded No. 1 modulator racks
    - Triode achieved 1MW using ex-ISIS valve (close to limit of valve)
    - Modulator/RF glitches noted when tetrode > 50kW into triode
  - Interface channels for RF controls defined
  - LLRF system demonstrated on ISIS debuncher
- Muon-RF phase determination
  - Subsample method with Fourier domain signal reconstruction
  - Accurately rebuilding signals from MTA experiments
  - Digitisation hardware has been delivered
  - RF discriminator delivered, currently under test at Strathclyde

Work Needed for Cooling Demo

- Distribution network
  - Installation, calibration
  - Gas insulation scheme needs to be built
  - Adjustment of relative phase
- RF drive system
  - Resolution of the glitches issue on the test stand at Daresbury on Triode No 2
  - Completion of controls system- do we need such a 'hands off' system?
  - Installation in Hall and commissioning- provision of cooling water and controls cabling
  - LLRF system modified for MICE
- Muon-RF phase determination
  - Completion of testing of principles/hardware of both methods
  - Integration of two distinct methods
  - Integration with experiment DAQ/Analysis
- Cavities
  - Provision of auxiliary systems for cavities (cooling/air/vacuum)
  - Installation, integration with controls/monitoring/LLRF
  - Online commissioning

MICE: Muon-RF Timing

Alex Dick and Kevin Ronald

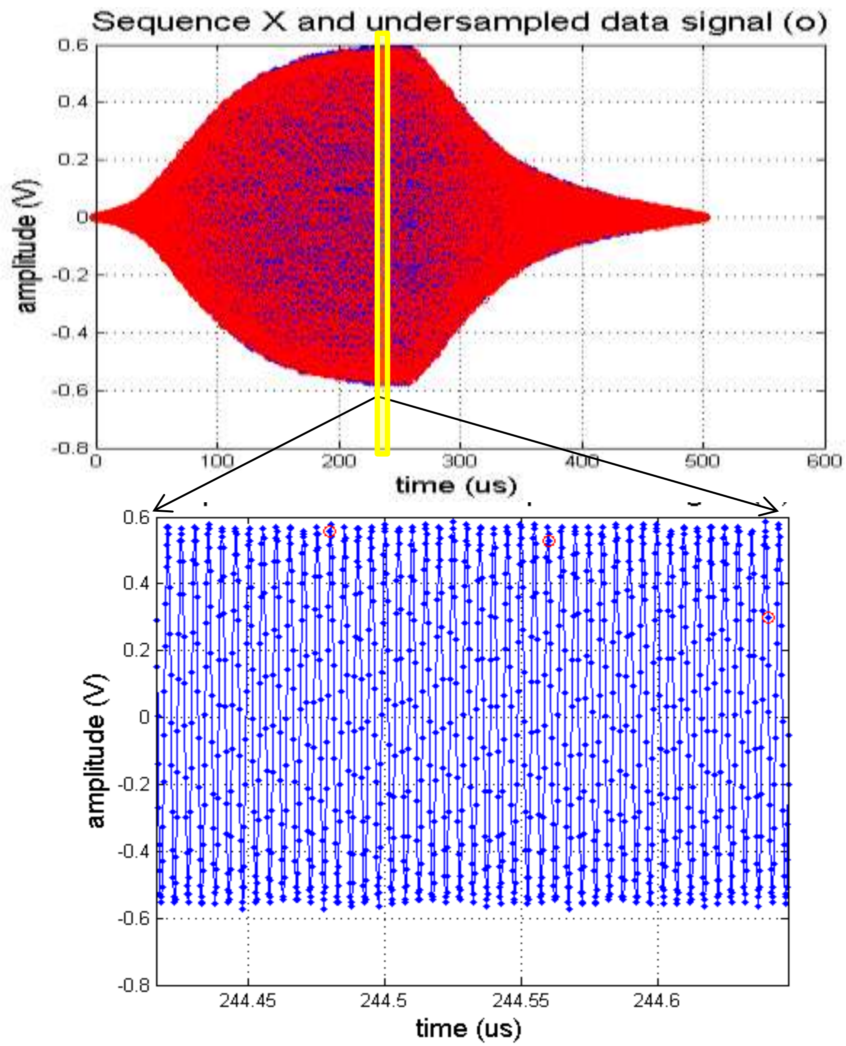
Muon Transit Phase Detection

- Need to be able to select particles for analysis by their RF transit phase
  - Allows the ‘bundling’ of particles for coherent analysis
  - i.e. As if we are considering the interactions of a real particle ‘bunch’

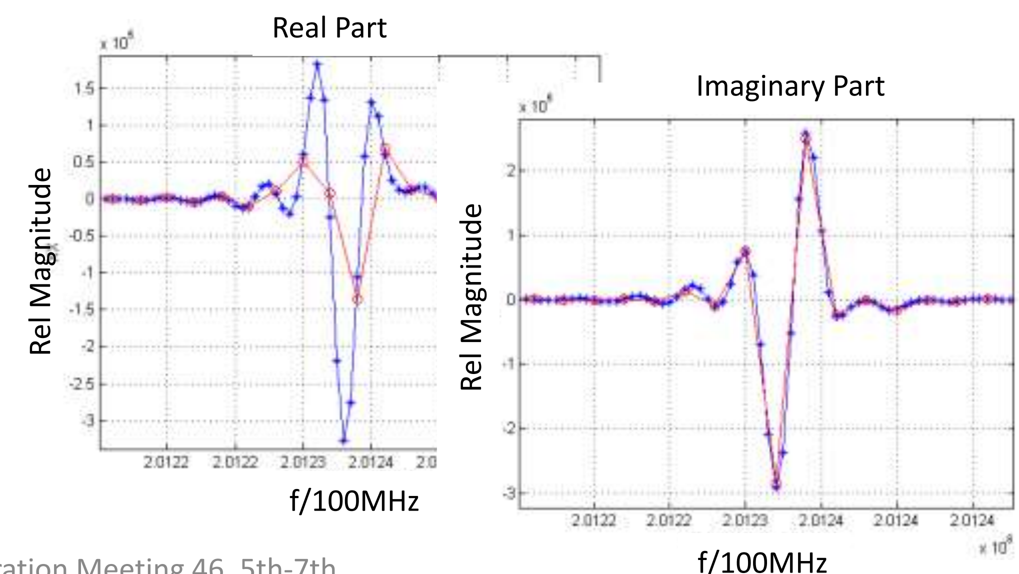
- Cavity transit time inferred by the ToF transit time and the tracker measurement of momentum
  - Combining ToF resolution and Momentum projection resolution ~ +/- 51.5ps
  - Desire to know RF phase to better than 0.3 of this ~ 17ps

- Two Approaches
  - Digitisation (subsampled) of the RF waveform on the pickup probes
  - Direct recording of the wave inside the cavity
  - TDC recording of the RF waveform
  - Records zero crossings of a reference oscillator/Cavity waveform - provides RF phase reference for TDC particle events

Muon Transit Phase Detection

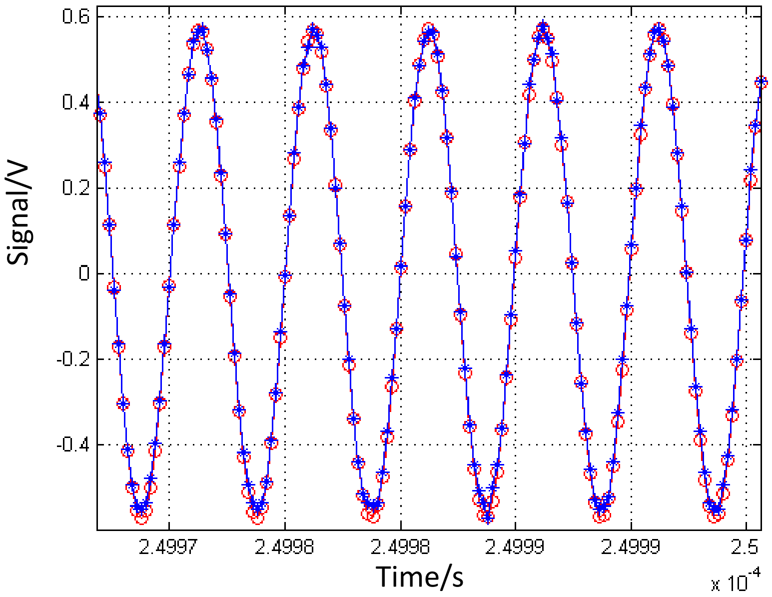


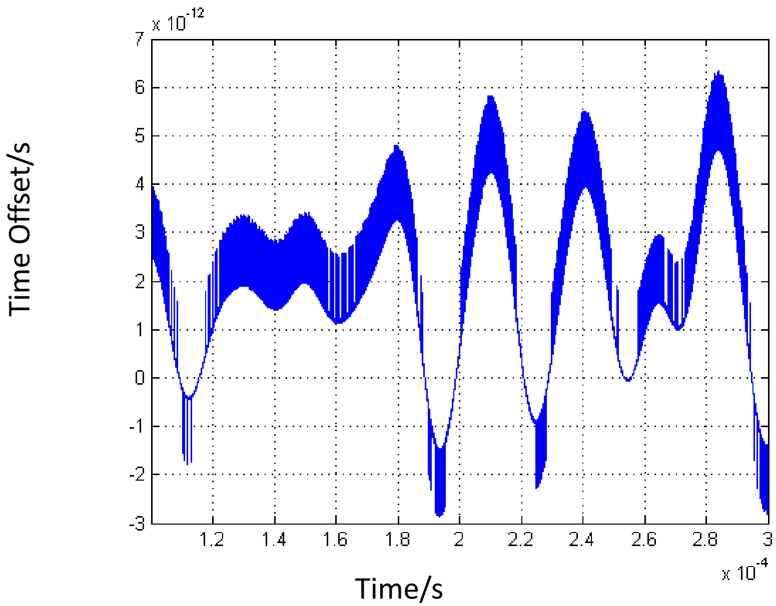
- Time domain: signal (blue) from FNAL cavity tests - 500μs window sampled at 5G.Sa/sec
- Subsample (red) at 12.5M.Sa/sec, reduce data by x400, and 48x < Nyquist @ 200MHz
- Note time domain signal 'windowed': New data from MTA will remove this process
- Freq. domain: Red fft of entire recorded data, Blue enhanced dft of subsampled data



Muon Transit Phase Detection

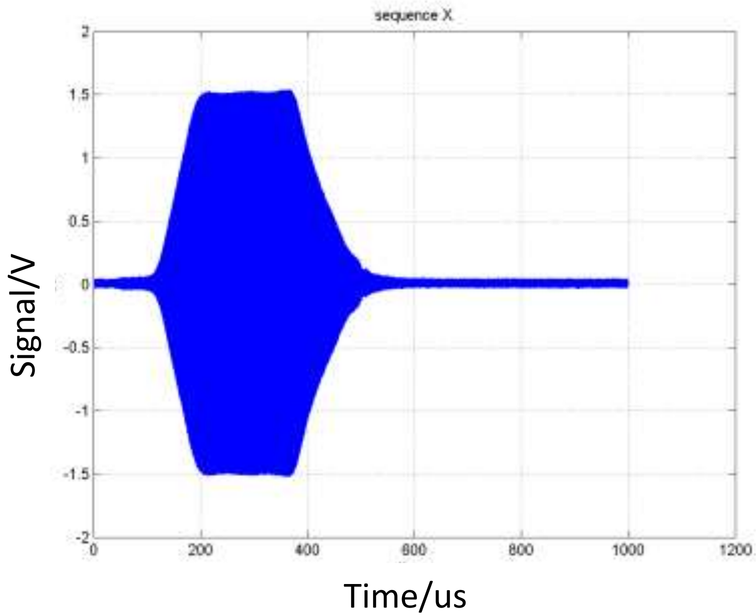
- Freq. domain reconstructions: high fidelity to raw signal over entire pulse duration (no spark)
- Blue is original data through 1MHz Butterworth filter, Red is reconstructed subsample data
- Note dft is effectively a (hard edged) 100kHz filter
- 10ps precision achieved on arbitrary pulses from MTA test- various dft widths analysed
- Further test on additional MTA data in different conditions also look promising

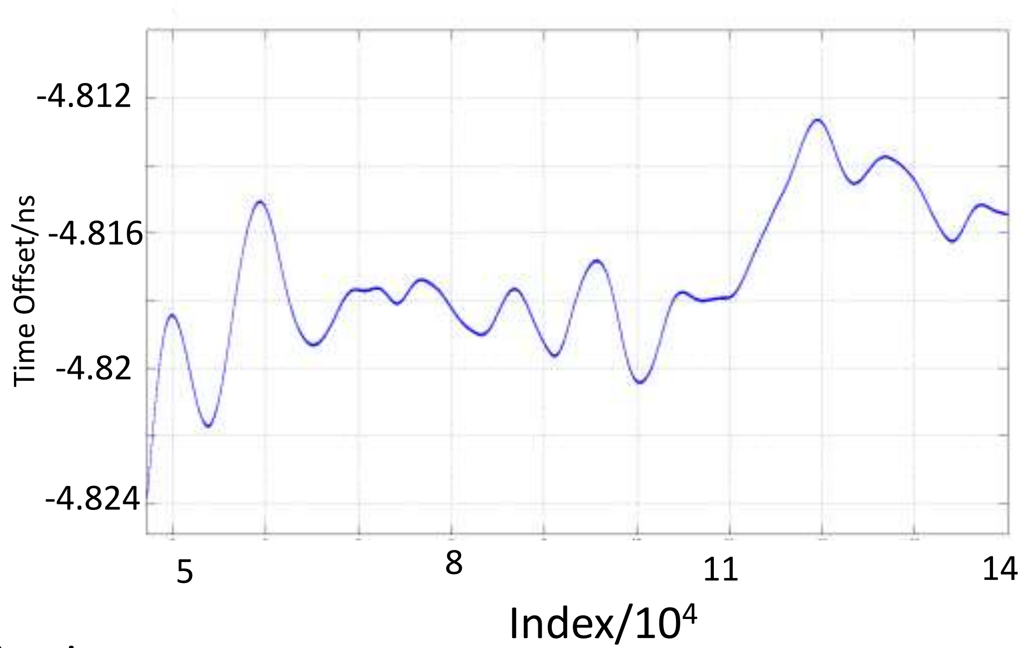




Muon Transit Phase Detection

- Signals on slide 14 had to be artificially windowed to zero at start/end of record
- New data provided by MTA used long record length
  - Note different pulse envelope form
- Processed in same way here as previous data
- ~ 12ps variation achieved

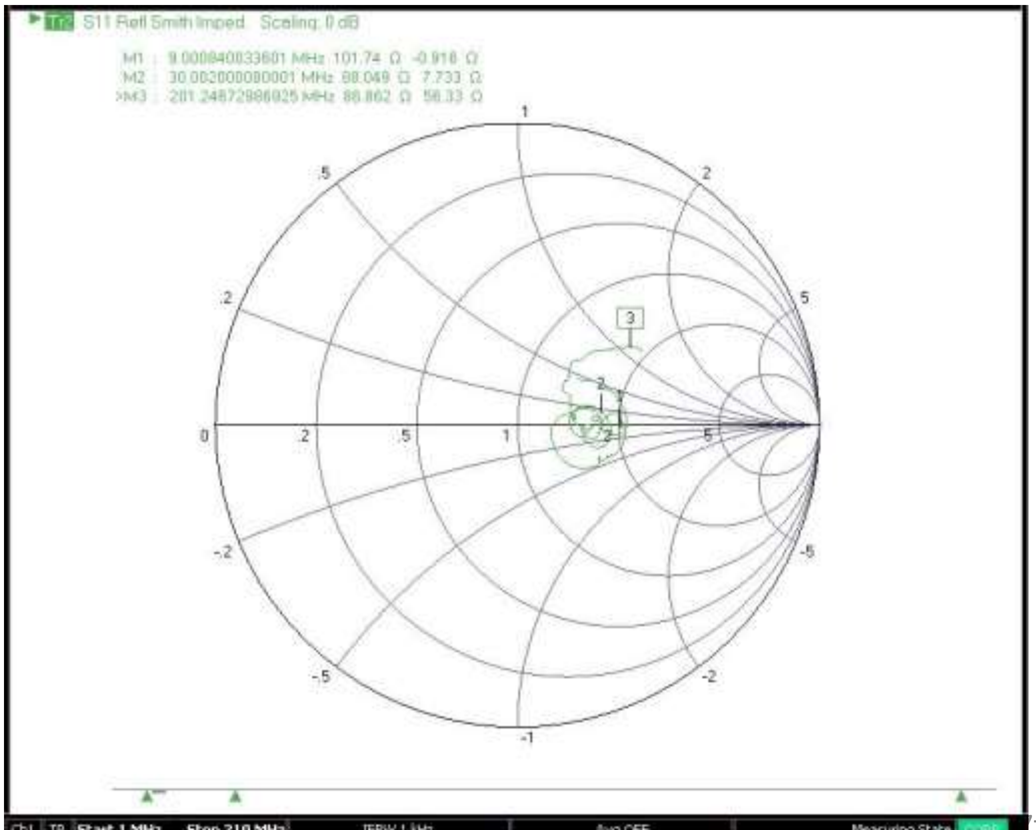




- Digitiser is in hand: CAEN V1760 VME unit
- Will need to synchronise digitiser trigger with TDC's TRST signal- discussion with CAEN suggests several routes

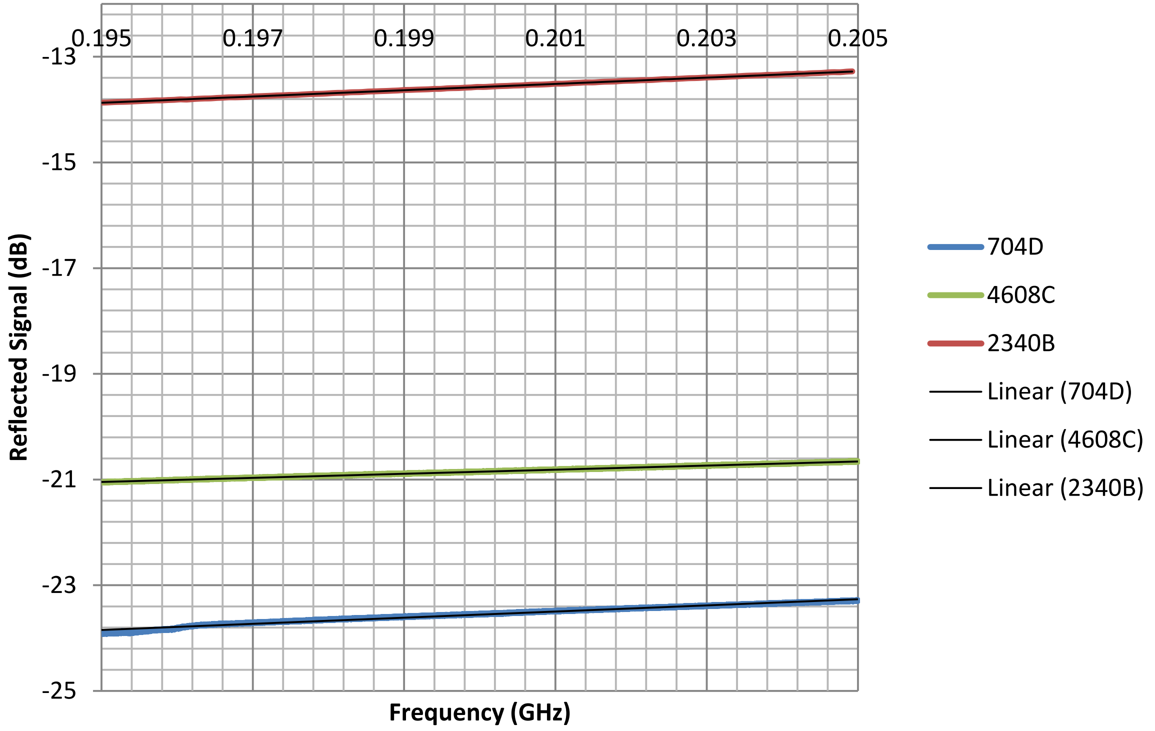
Muon Transit Phase Detection

- TDC approach originally proposed by Paul Smith
- Idea is to use as much of the digitising electronics as used for the ToF's
- Problem is the discriminator (LeCroy 4415) is ~ 9MHz part
- Note impedance presented at 200 MHz differs from spec (100 Ω)
- Impedance matching could be implemented, but rate issue will remain
  - Probably LeCroy 4415 cannot operate faster than 30MHz



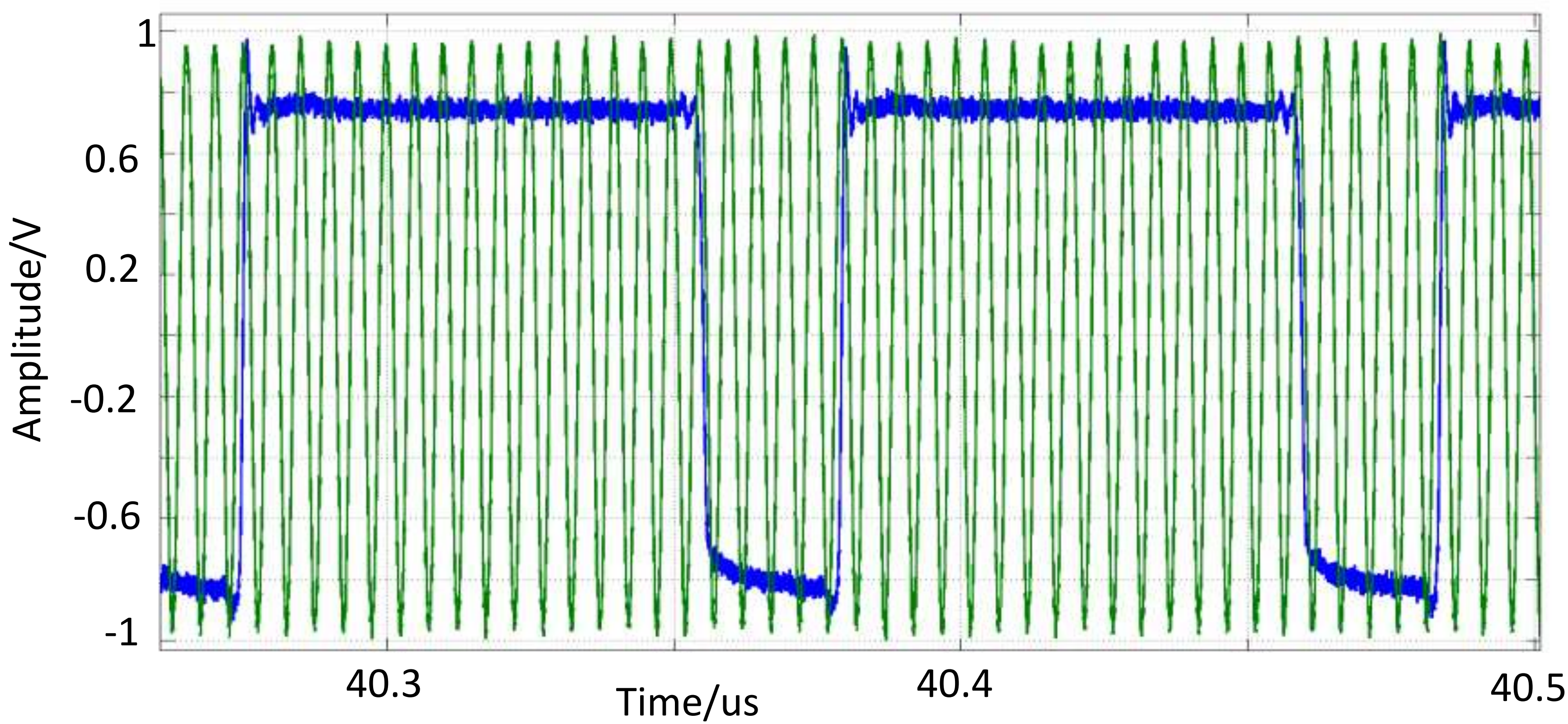
Muon Transit Phase Detection

- Hardware for TDC method now available
- 4 Ch. 300 MHz leading edge discriminator (Philips 704D) on test at Strathclyde
- Impedance matched at 200 MHz



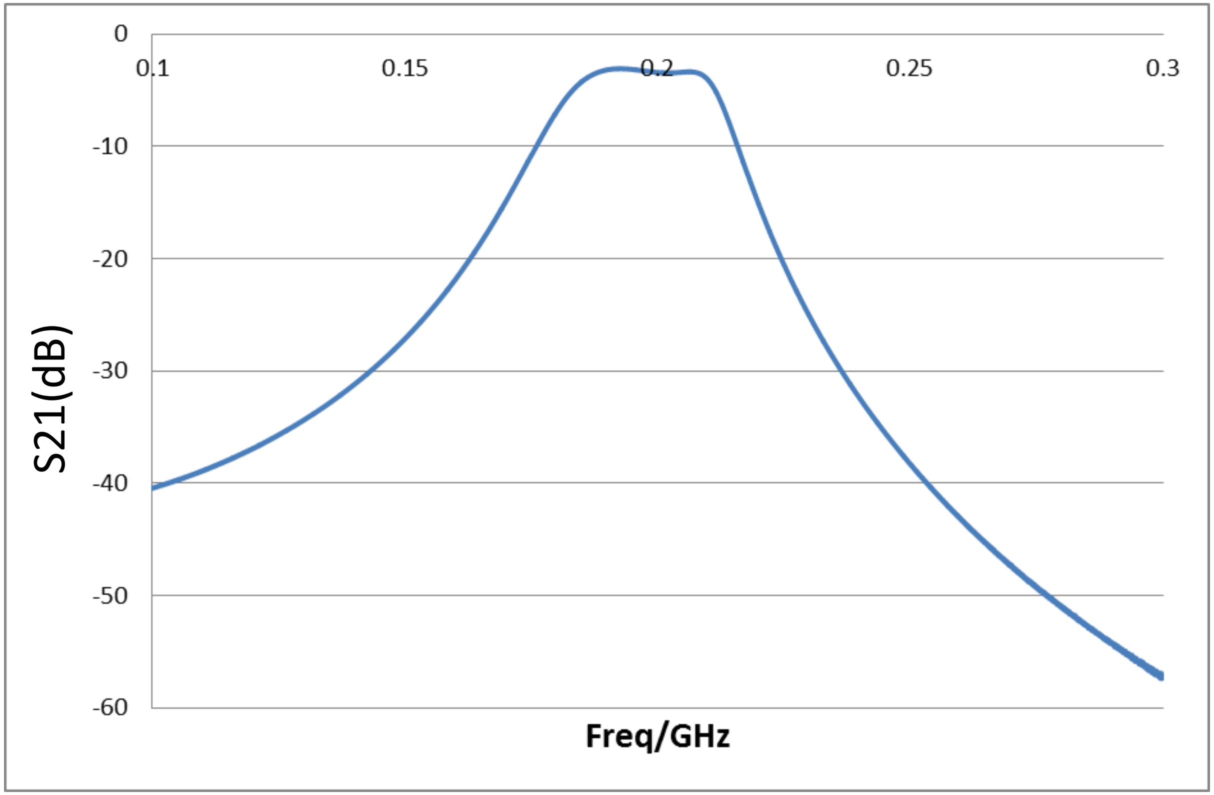
Muon Transit Phase Detection

- Hardware for TDC method now available
- 4 Ch. 300 MHz leading edge discriminator (Philips 704D) on test at Strathclyde
- Non-updating, gate on a single period on RF wave, use output to trigger second discriminator channel and use that to veto the discriminator- select 1 in 17 or so events
- Detail setting of trigger levels critical to edge stability



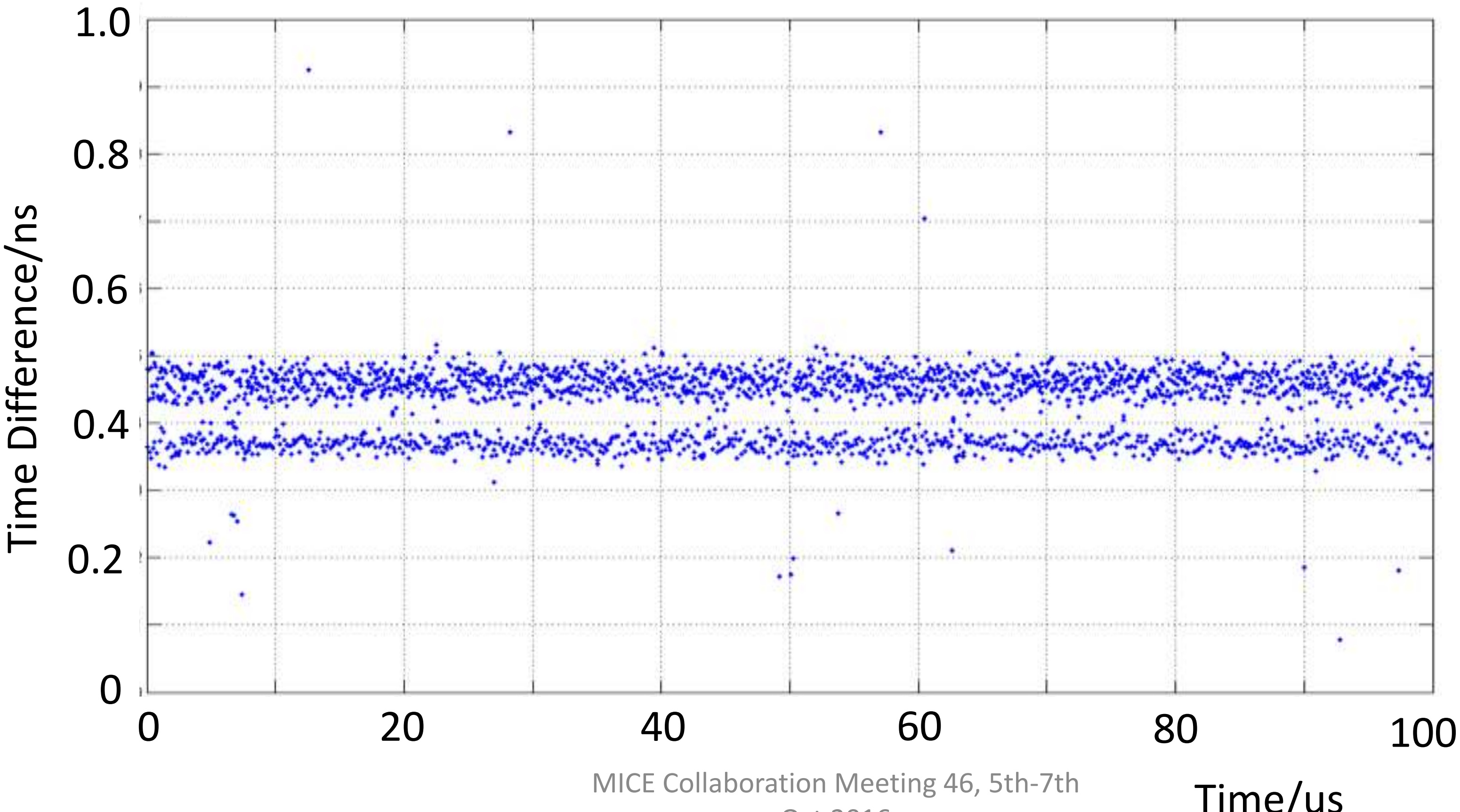
Muon Transit Phase Detection

- Filters used in input to CRO and Discriminator
- Prototype filters developed by Bob Anderson for LLRF (not quite ideal ~ 3dB insertion loss)
- CRO bandwidth s 20GHz- filters help suppress this



Muon Transit Phase Detection

- Filters reduce spread of delay offsets measured
- There are two bands visible
  - This might be related to jitter in veto'ing
- Work to be done to understand jitter (both the discrete bands and the random spread)
- Tighter filters may help, different veto arrangement will be tested



Summary

- Digitiser Hardware Status
  - 4GSa/s 2 Ch VME digitiser in hand- can record entire pulse at super Nyquist at need
  - Can be programmed to run with 40MHz external clock (shared by the TDC's)
  - Work required to capture waveforms at 1Hz at whatever subsample rate we choose
    - 12.5MSa/sec or 25MSa/s seem likely candidates
- TDC hardware status
  - 300MHz Discriminator available and running tests (others are available)
  - Spare MICE TDC is at Strathclyde and installed in VME crate
  - VME-PCI bus has been giving trouble- however resolved now (strange PCI board)
  - VME bus on crate at Strathclyde showing strange errors- investigation ongoing
    - Want communication to TDC before adding digitiser
- Integration
  - Acquisition software routines need to be produced
  - Clock required to sync TDC's and digitiser
  - Trigger alignment needs to be done between TDC's and Digitiser