SRS TIMING ANOMALY

RD51 Mini-Week

June 9, 2015

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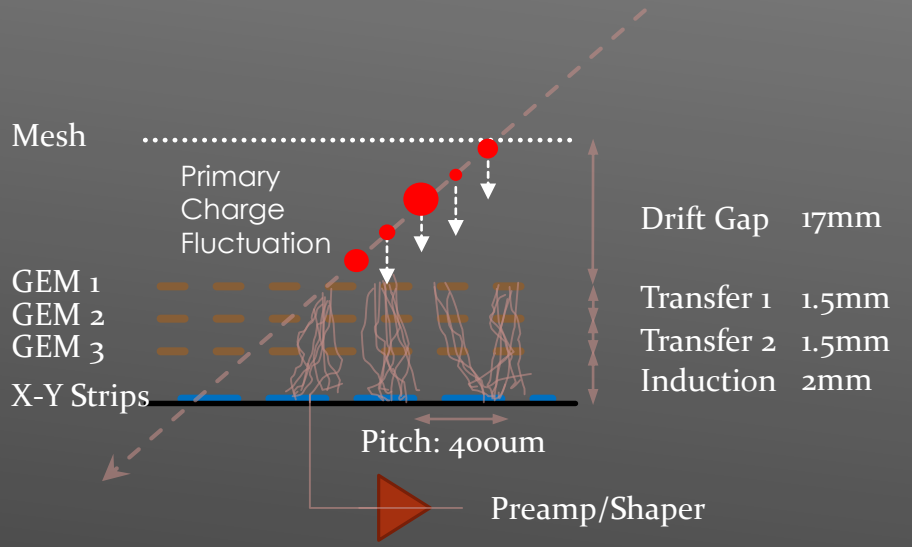
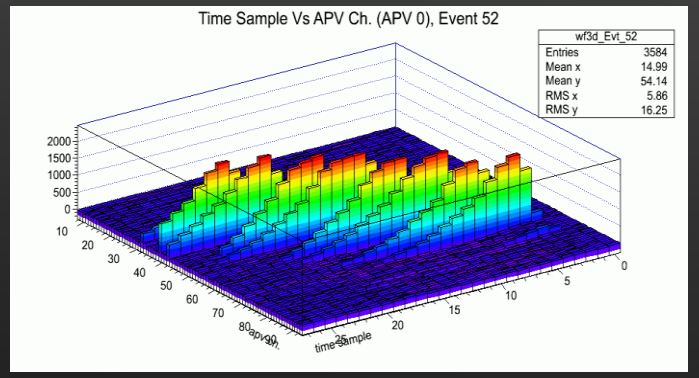
USING THE SRS TO MEASURE TIME WITH AN EXTENDED DRIFT GEM DETECTOR

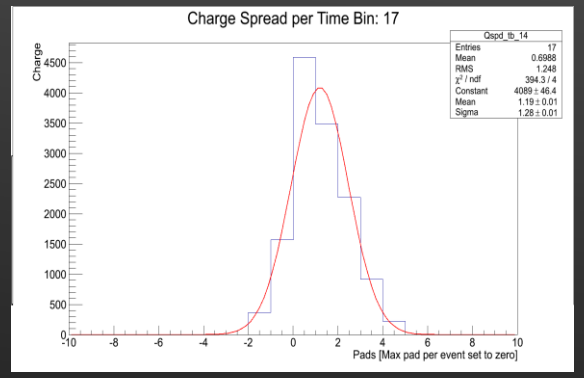
- Detector concept: Improve GEM resolution at large angles by widening drift gap and allowing vector reconstruction
- Dependent on timing resolution and shaping time of readout system



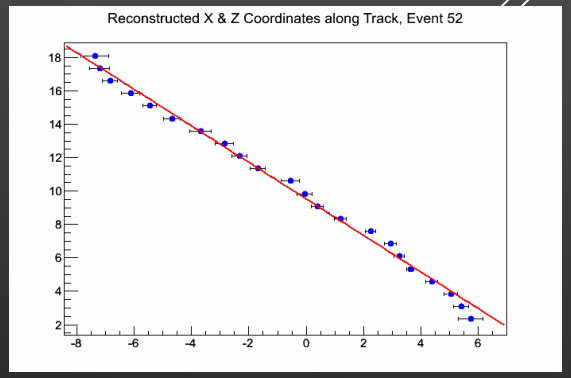
Angled track from test beam data



Track reconstruction: Find centroid for each time slice

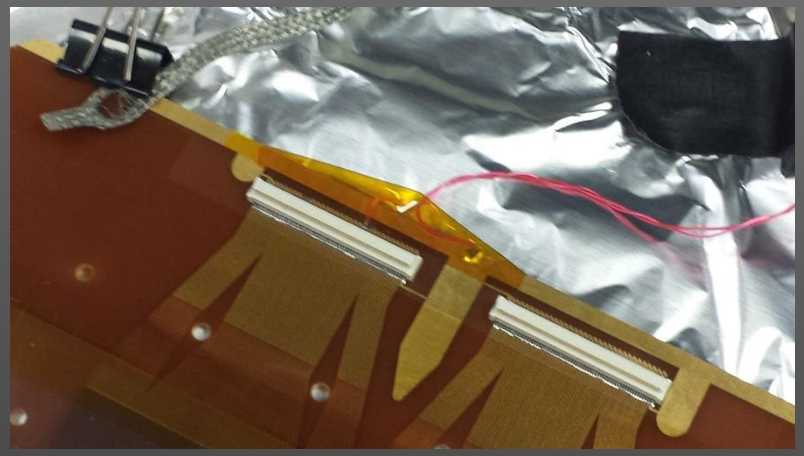


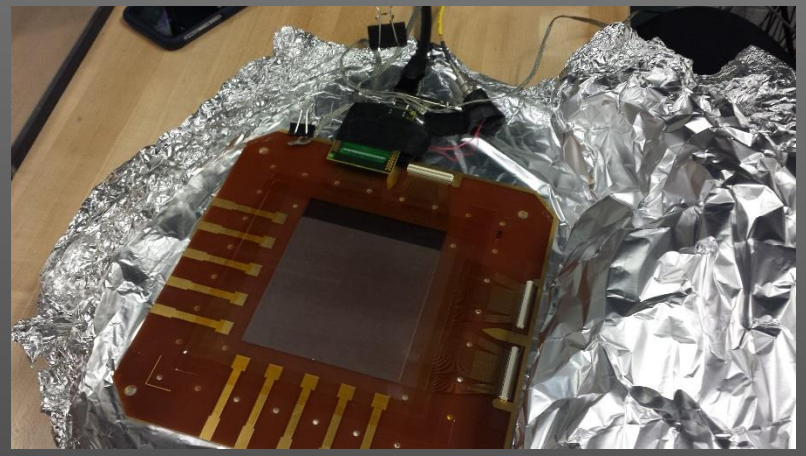
Track reconstruction: Use edge of time bin to reconstruct z coordinate

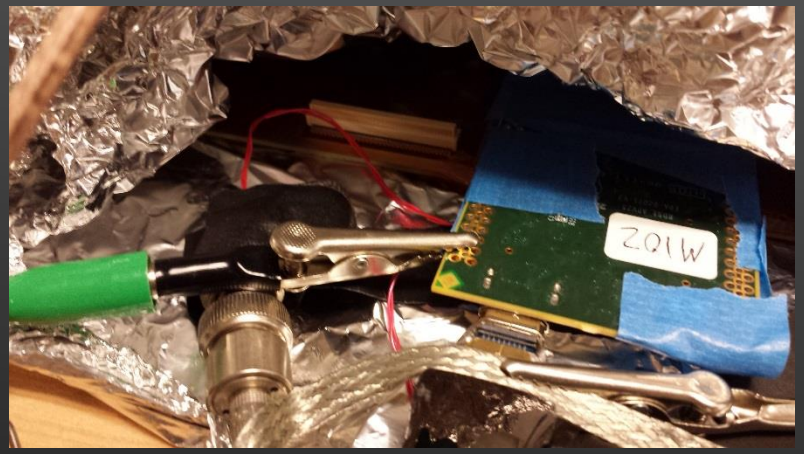


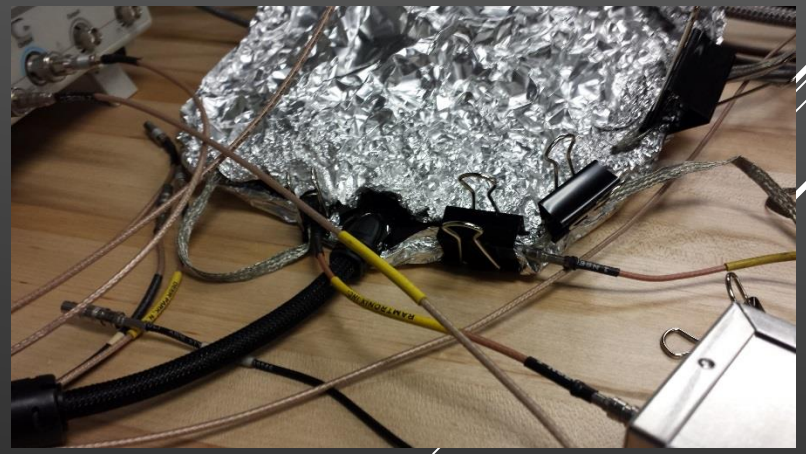
Timing Resolution of SRS Studied In-Lab Using Function Generator

- Twisted pair soldered directly to 2 separate readout strips
- Circuitry on APV protected
- Grounding connections made and board wrapped in aluminum foil for shielding
- Signal In: Function gen -> capacitor box -> Compass board
- Signal Out: SRS



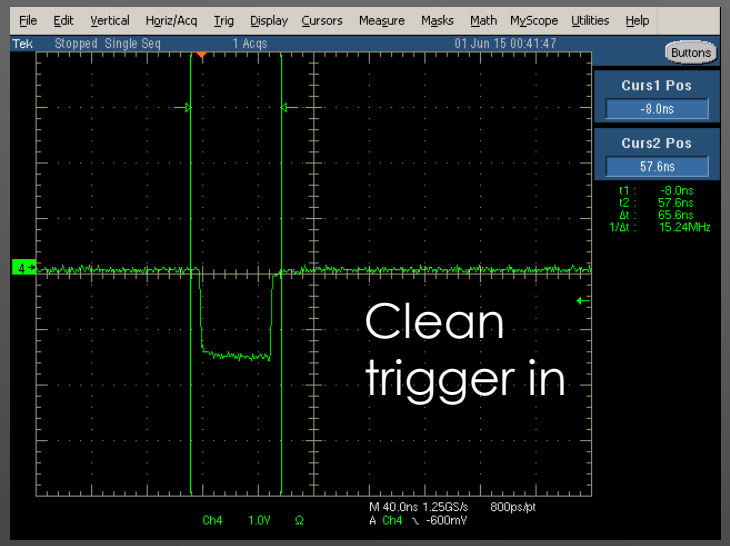






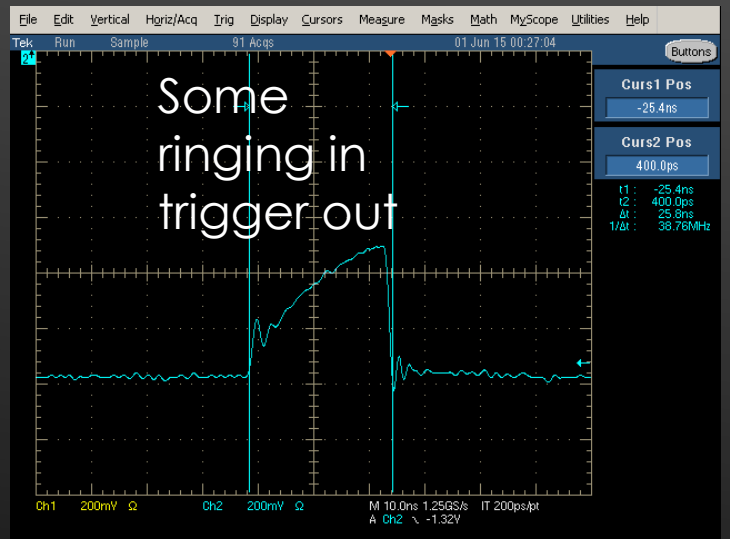
EXPECTED TIMING JITTER: 25/SQRT(12) EFFECT FROM UN-SYNCED CLOCKS

NIM Trg In to SRS



Trigger on Trg In on scope

Trg Out from SRS



Measure SRS Trigger Jitter

25 / Sqrt(12)

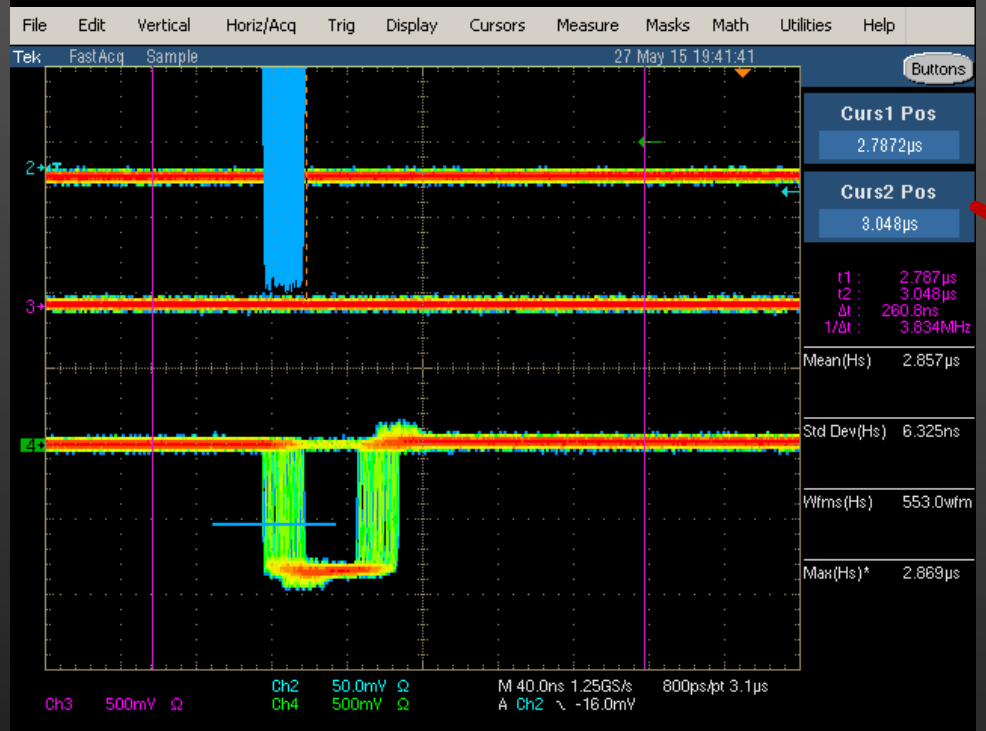
4

Use Function Generator to Go In and Out of Phase with SRS

"In phase" External Pulser

"Out of phase" External Pulser

Note:
- **Pulser and SRS clocks drift over time**
- **Cannot be perfectly in phase w/o synching clocks**



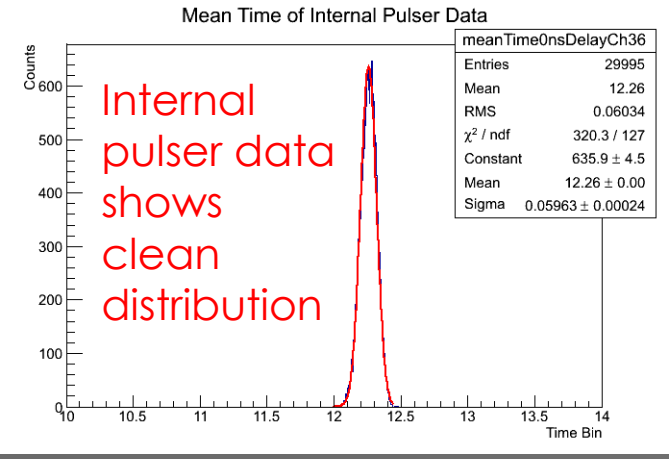
Mean time of waveform

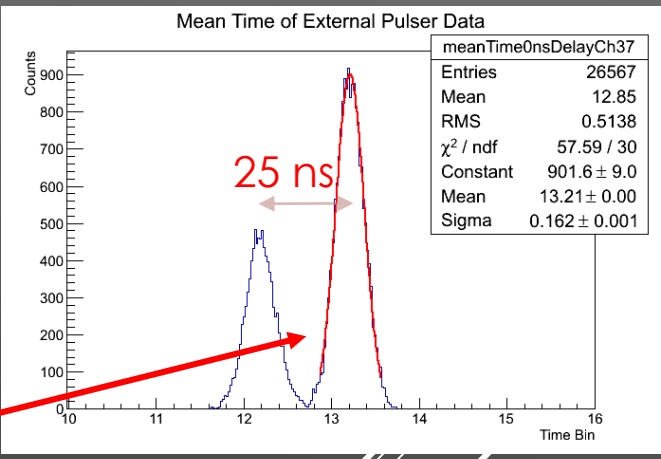
SRS Internal Pulser

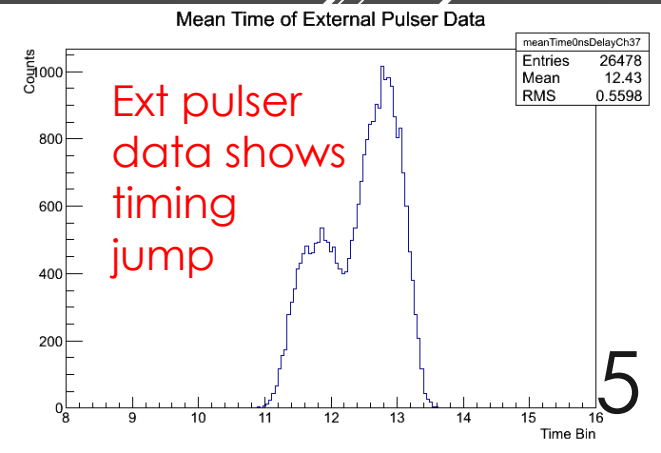
In Phase External Pulser

UNEXPECTED TIMING JITTER

Out of Phase External Pulser

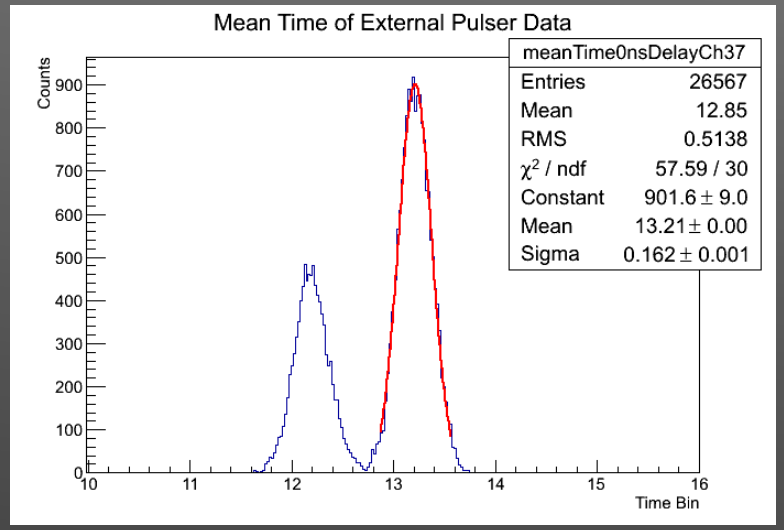




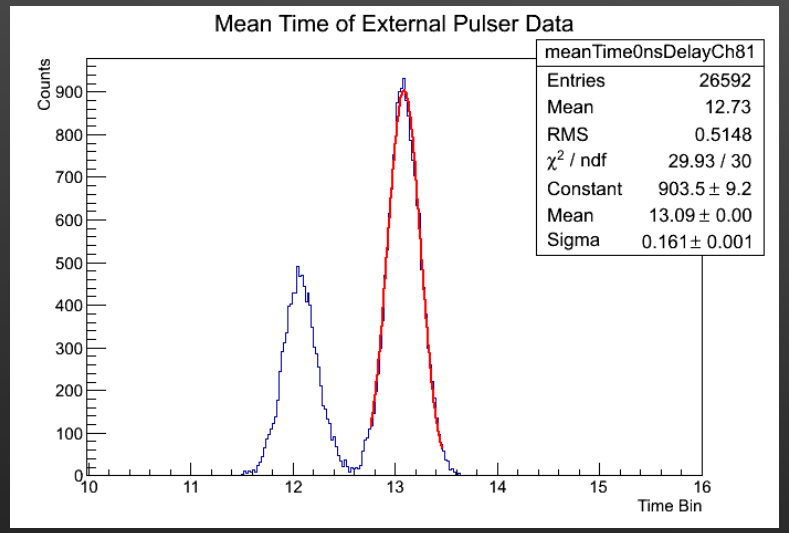


Investigating the Timing Jump Further: "Measure our Measurement" from In Phase (sigma = 0.97 ns) External Pulser Data

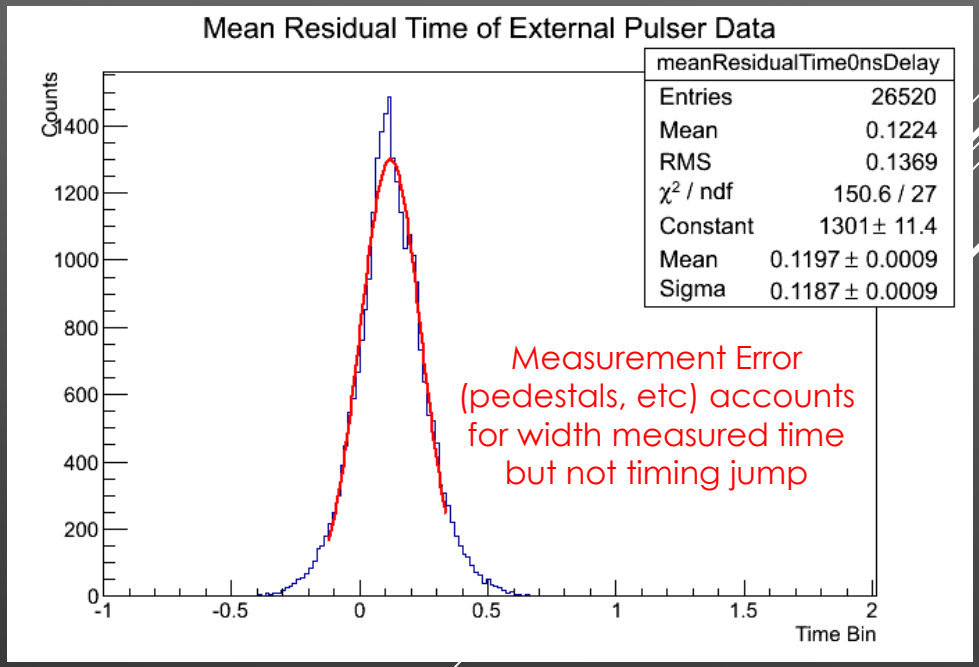
Mean Time of Channel 1



Mean Time of Channel 2



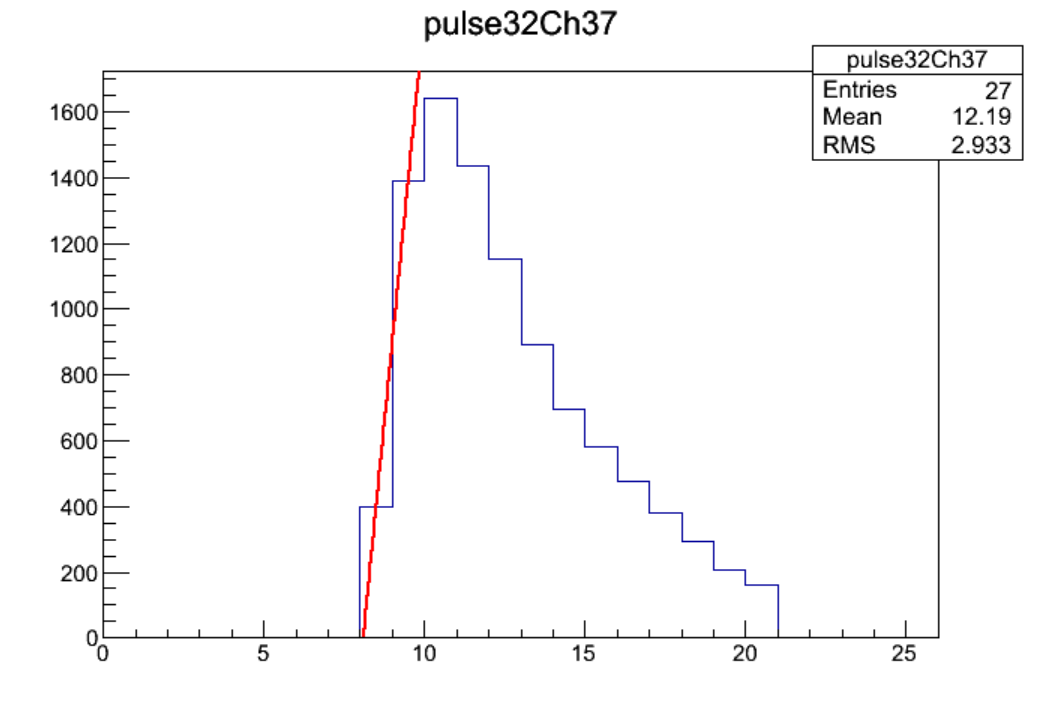
Residual Mean Time of Two Channels



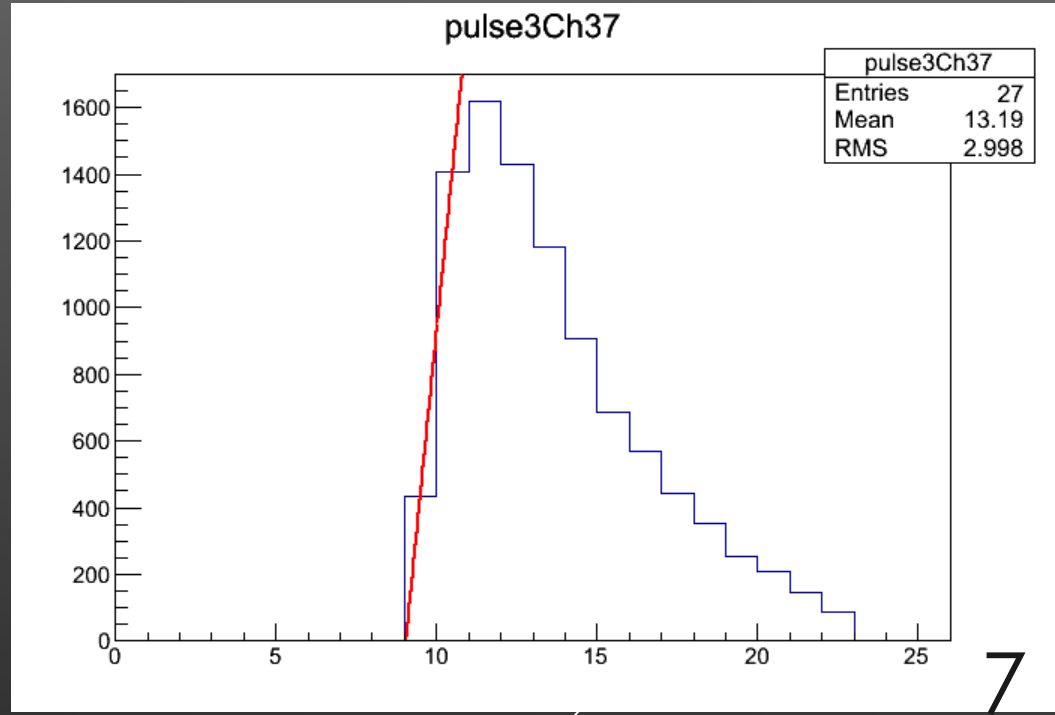
Investigating the Timing Jump Further: Waveforms from the two timing peaks are identical

- Same pulse shifted in time
- Discreteness visible in raw data plots

Peak 1

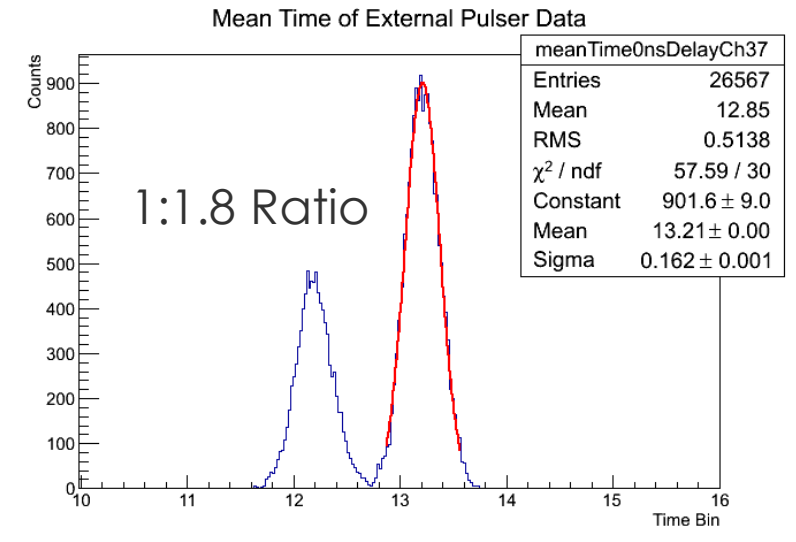


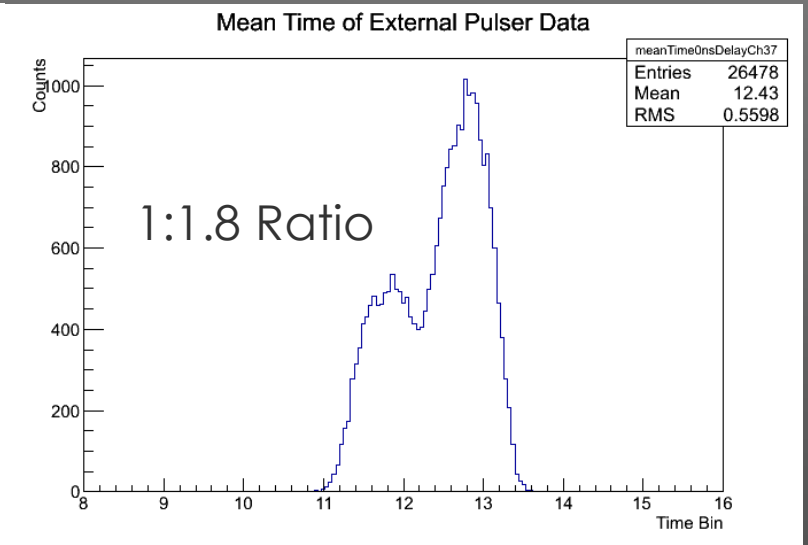
Peak 2



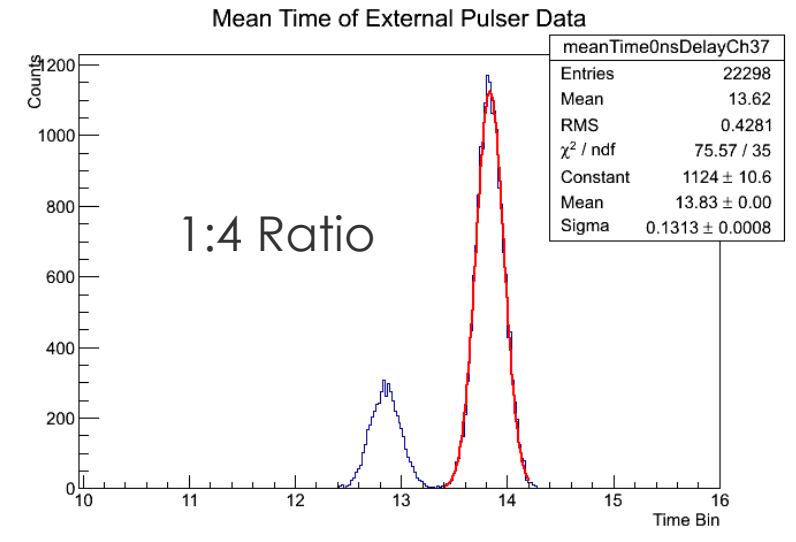
Investigating the Timing Jump Further: Fluctuations in Frequency of Timing Jump

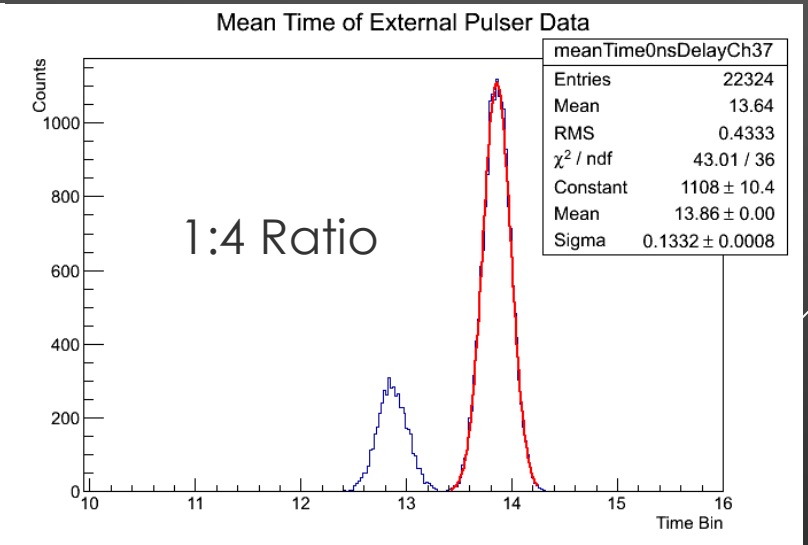
In Phase/Out of Phase Ext. Pulser Data Shown On Previous Slides





In Phase Ext. Pulser Data Taken on Same Day … Different Day/Same Test Conditions as Upper Plots

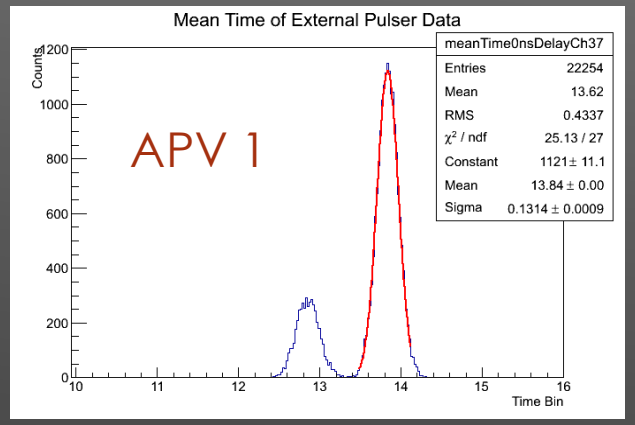


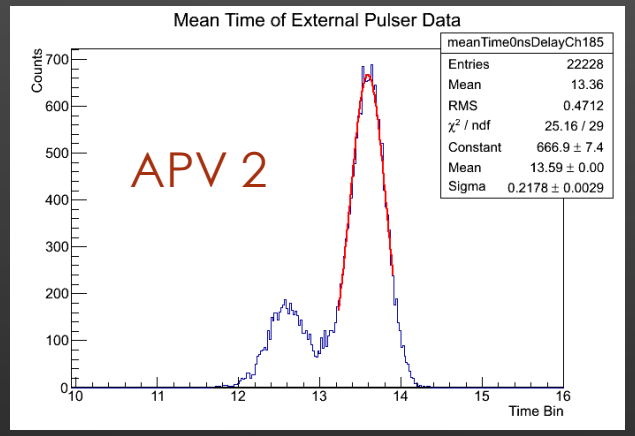


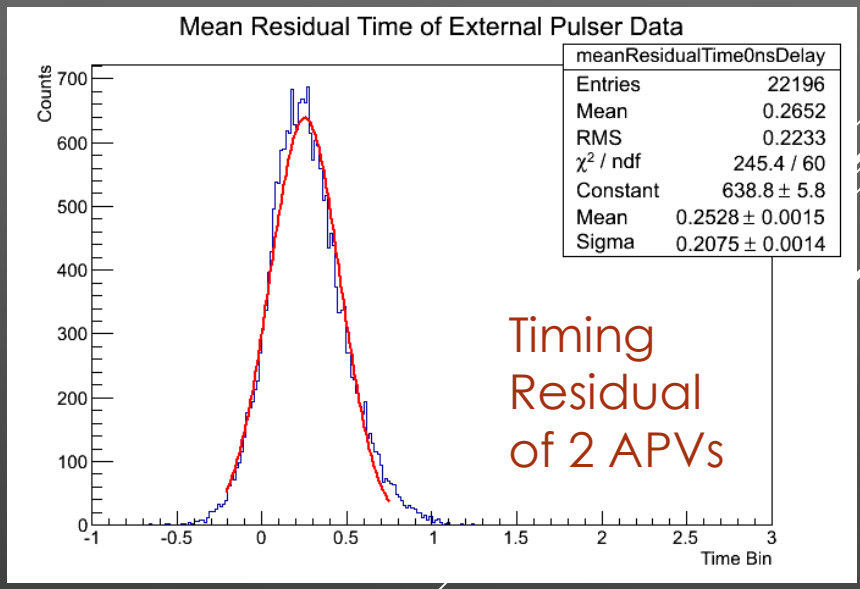
- Ratio Consistent in Short Term
- Fluctuates on Different Days (Strange – Temperature Dependence?)

INVESTIGATING THE TIMING JUMP FURTHER:
DO 2 APVS JUMP TOGETHER? … YES

- Tested external pulser on channels from two separate APVs
- Both showed timing jump
- But timing residual between the two channels was single peaked -> jump happens together





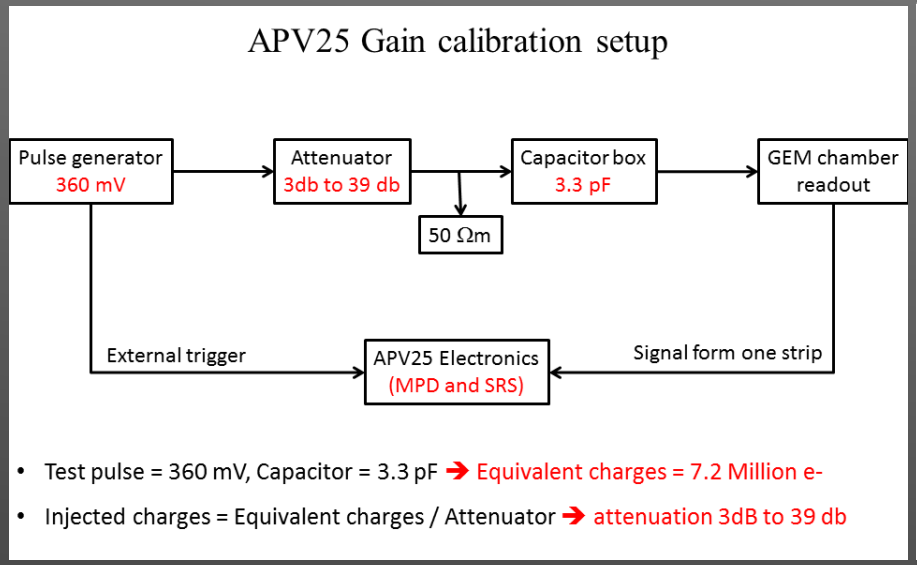


Similar Results at University of Virginia

SLIDES FROM KONDO GNAVO

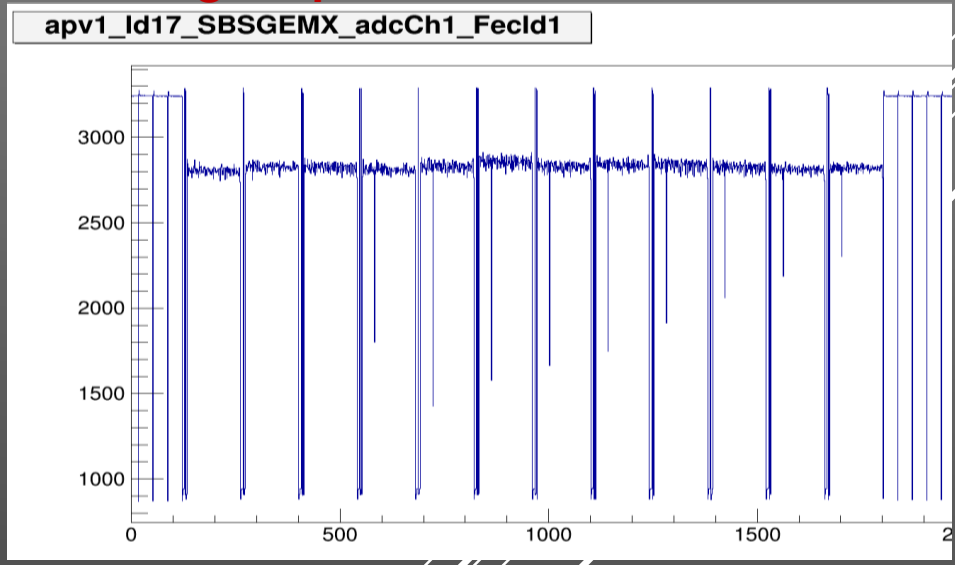
APV25 signal timing with external pulse generator (U of Virginia: Oct. 2012)

Setup APV25-SRS with external pulse

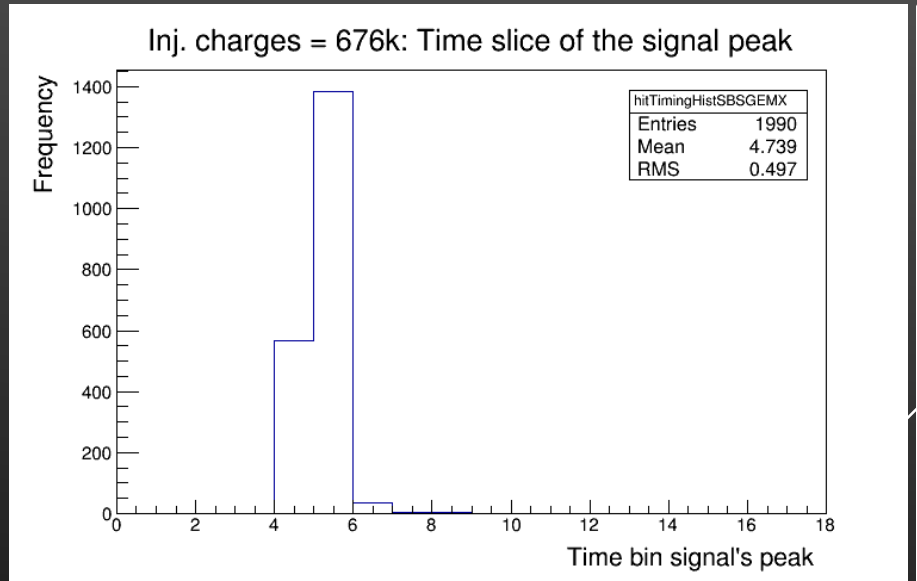


- Test pulse = 360 mV, Capacitor = 3.3 pF ➔ Equivalent charges = 7.2 Million e-
- Injected charges = Equivalent charges / Attenuator ➔ attenuation 3dB to 39 db

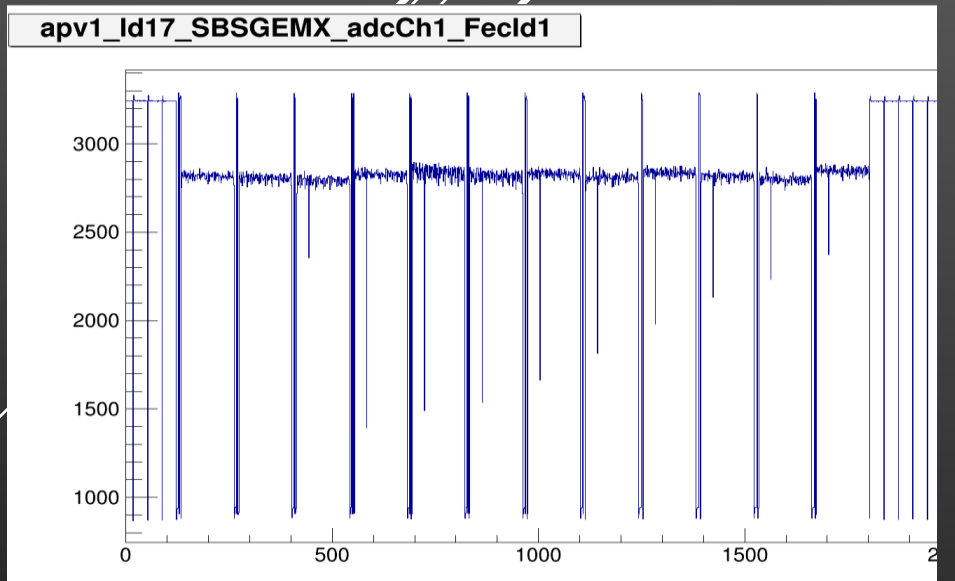
Signal peak at time slice 5



Distribution of time slice of the peak



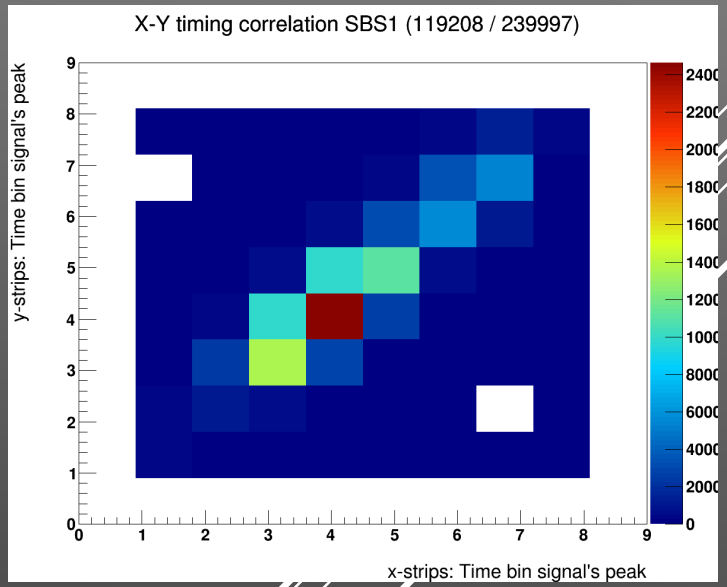
Signal peak at time slice 4



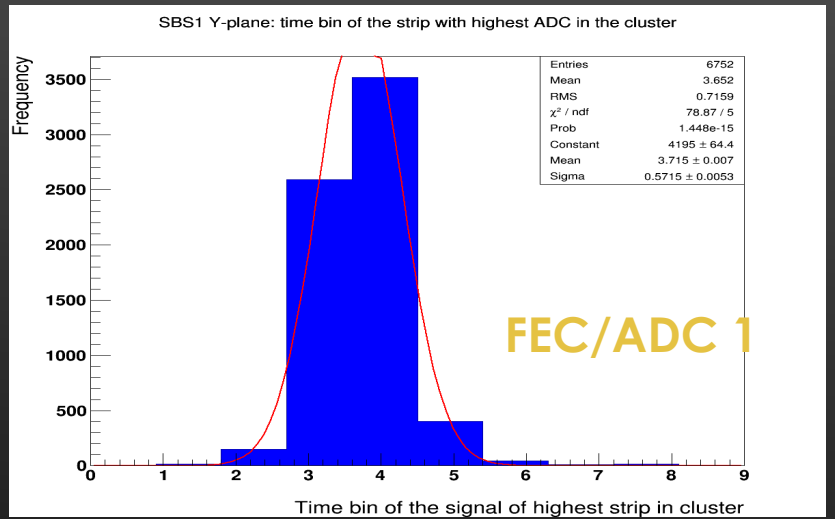
APV25 signal timing with FTBF Test beam data (U of Virginia: Oct. 2013)

- Study of the timing of the APV25-SRS signal from test beam data taken with SBS GEM at Fermilab
- Distribution shown for hit x and y strips
- APV25 on x and y on to different FEC/ADC combos
- Good timing x/y correlation
- Peak of the timing spread over at least two time slices

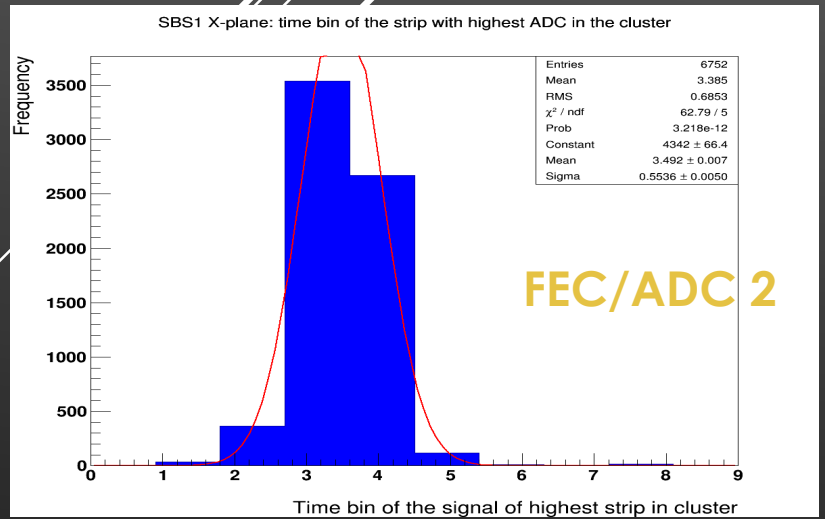
Timing correlation x-strips/y-strips



Time slice of signal peak x-strips



Time slice of signal peak x-strips



SRS Timing Jump

What it Isn't

- Not dependent on width of discriminated NIM pulse
- Apparently not caused by ringing on our end
- Not dependent on test setup. Present when we directly inject on strips as well as normal GEM operation
- Not dependent on relative location within time bin. Same distribution for 5, 10, 15, … ns delay between external pulser channels
- Not dependent on particular APV: ie when one APV jumps both jump

What it Is (or might be)

- Appears to be caused by something in external trigger pipeline – timing jump not there for internal pulser triggered data but is for external pulser triggered data
- Smaller (trigger) peak seems to come first
- Ratio of timing jumps consistent in the short term but changes by the day
- ~25 ns apart. One clock cycle.
- Discreteness is visible by eye in raw data plots. Obvious 1 time bin shift in line with observed ratio
- Present for random as well as cyclic (function generator) triggers. Random triggers have full sqrt(12) effect convoluted in data, while cyclic triggers have < sqrt(12) convoluted
- Ringing effect within FEC/SRS?
- Ideas???