Compton polarimeter possible FAC DAQ for EIC

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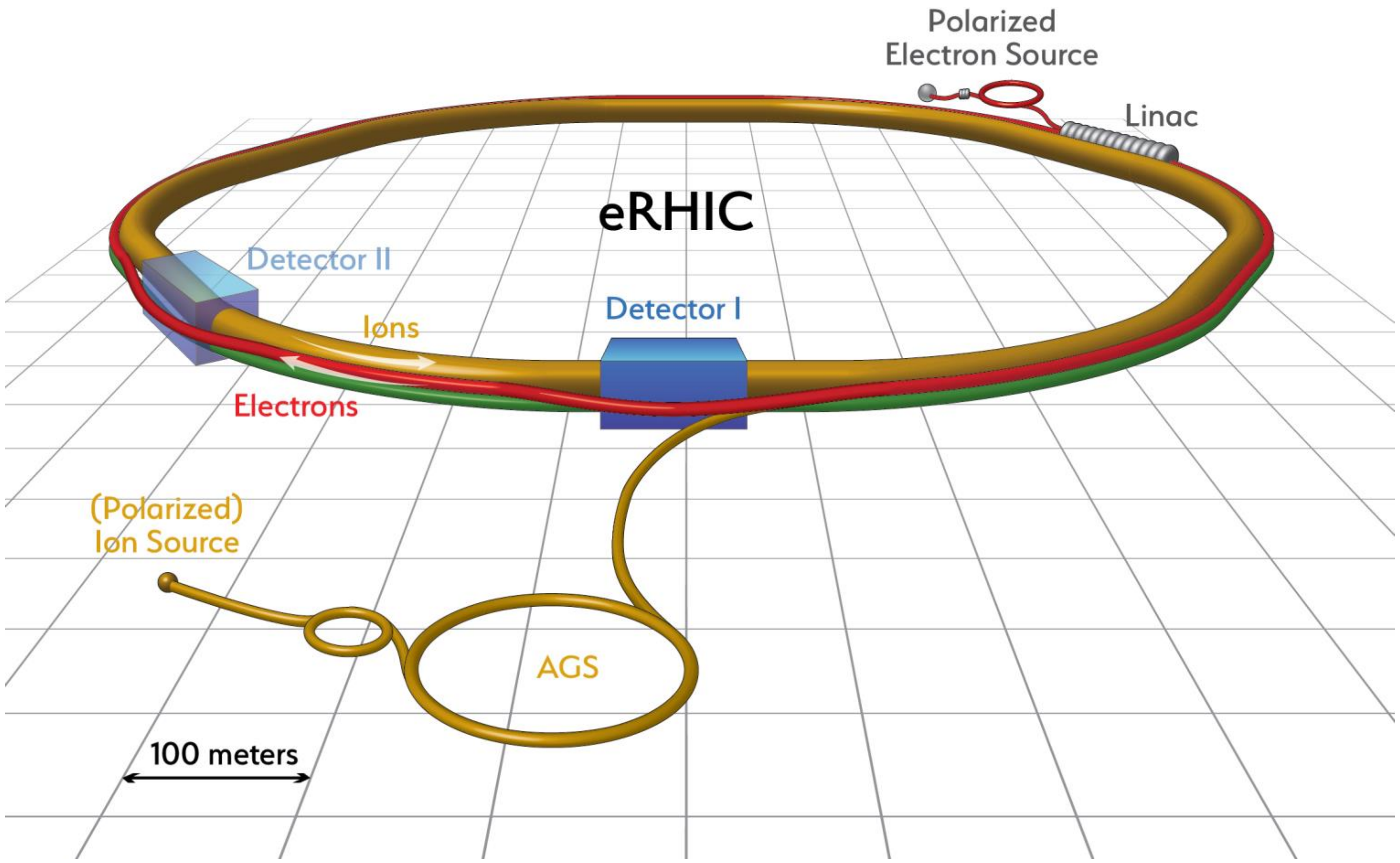
Outline

- **eRHIC beam parameters**
- **Signals with FADC**
- **Histogramming**
- **Conclusion**

eRHIC



Lower luminosity
560 MHz RF
330 bunches
33 ns between bunches
Electron current up to 1.2A
Ion current up to 0.46 A

High luminosity
560 MHz RF
1320 bunches
10 ns between bunches
Electron current up to 2.4 A
Ion current up to 0.92 A

High luminosity polarized electrons on polarized and unpolarized ions
For electron beam asymmetry measurements polarization can be the dominating error.
Aiming for 1% or better electron polarization accuracy

Main Parameters eRHIC ring-ring for Maximum Luminosity

E_p = 275 GeV, E_e = 10 GeV

		No Hadron Cooling		Strong Hadron Cooling	
Parameter	**Units**	**Protons**	**Electrons**	Protons	Electrons
Center of Mass Energy	GeV	100		100	
Beam Energy	GeV	275	10	275	10
Particles/bunch	10^{10}	11.6	31	5.6	15.1
Beam Current	mA	456	1253	920	2480
Number of Bunches		330		1320	
Hor. Emittance	nm	17.6	24.4	8.3	24.4
Vertical Emittance	nm	6.76	3.5	3.1	1.7
β_{x^*}	cm	94	62	47	16
β_y^*	cm	4.2	7.3	2.1	3.7
$\sigma_x'^*$	mrad	0.137	0.2	0.13	0.39
$\sigma_y'^*$	mrad	0.401	0.22	0.38	0.21
Beam-Beam ξ_x		0.014	0.084	0.012	0.047
Beam-Beam ξ_y		0.0048	0.075	0.0043	0.084
τ_{IBS} long/hor	hours	10/8	-	4.4/2.0	-
Synchr. Rad Power	MW	-	6.5	-	10
Bunch Length	cm	7	0.3	3.5	0.3
Luminosity	$10^{34} cm^{-2} s^{-1}$	0.29		1.21	

New eRHIC ring ring design : beam interaction frequency going from initial RHIC 10 MHz to 30 MHz with 330 bunches and 100 MHz with 1320 bunches in a 3.8 km ring

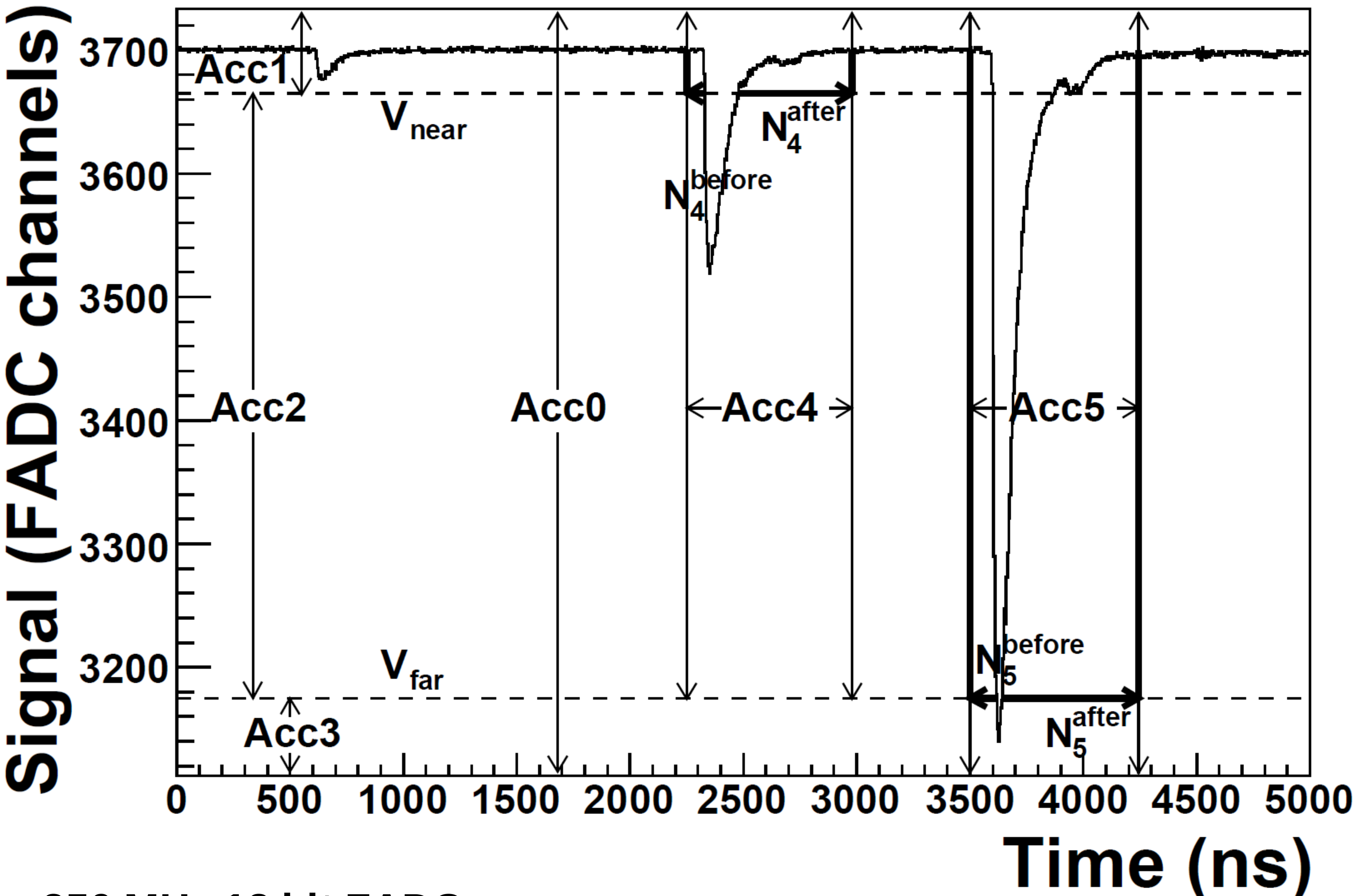
Bunch replacement 2 Hz

1 turn = 3.8 km / c = 12.6 us or 13.2 us

39682 revolutions / 0.5s

Time to replace all bunches in ring : 660s = 11 mins

Hall A FADC

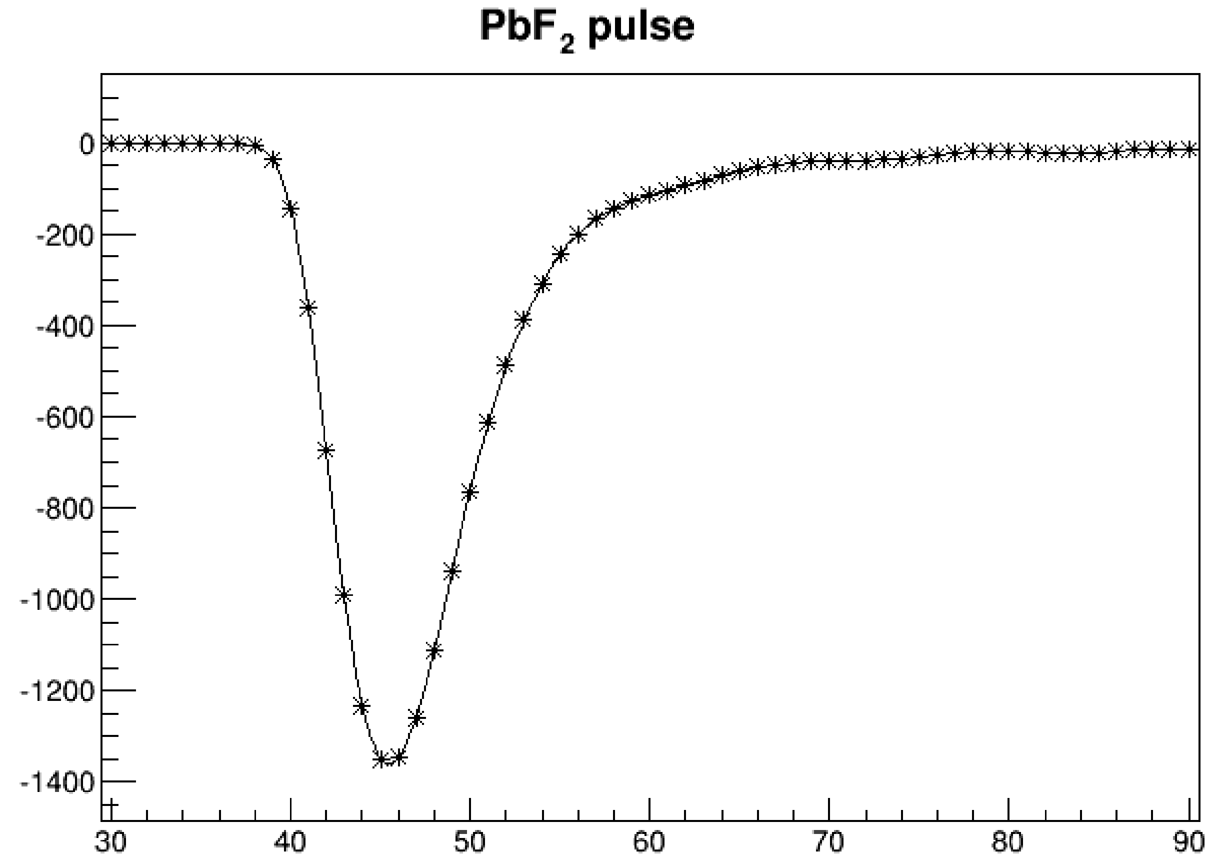


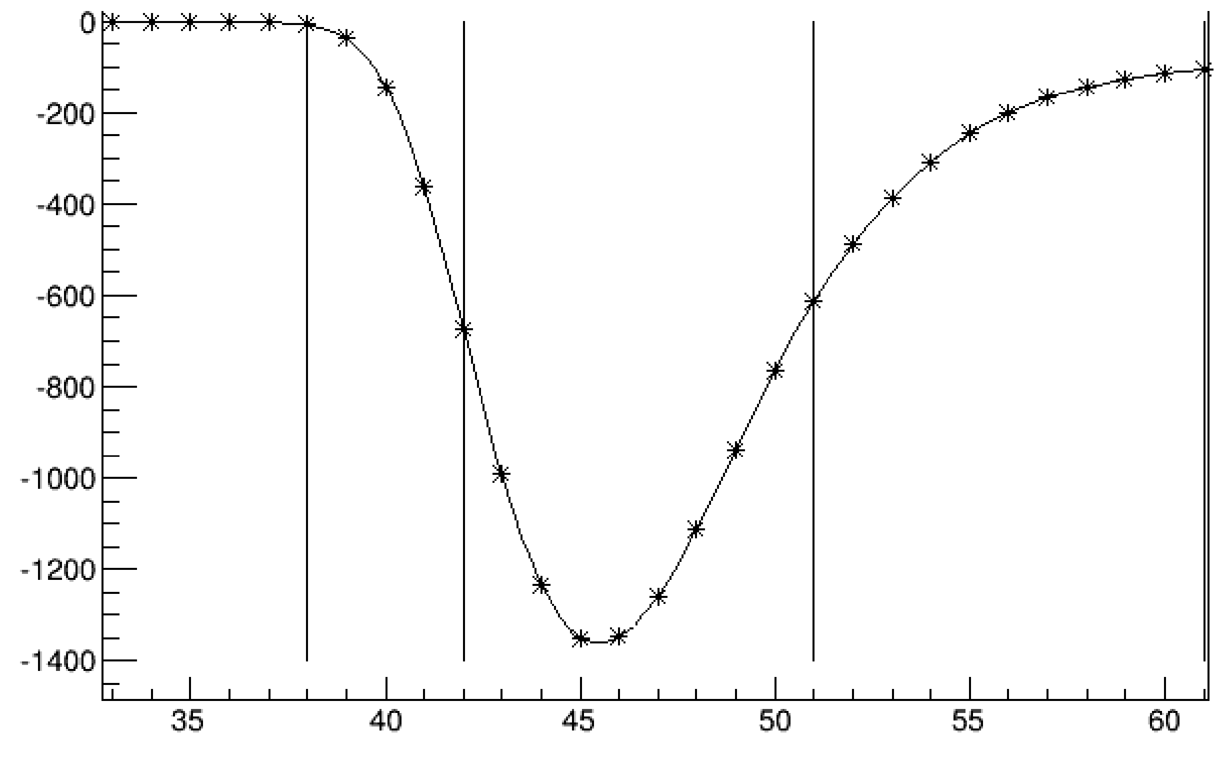
250 MHz 12 bit FADC

Digital integration over time window , CAEN or Alphacore 1 GHz 10 bits

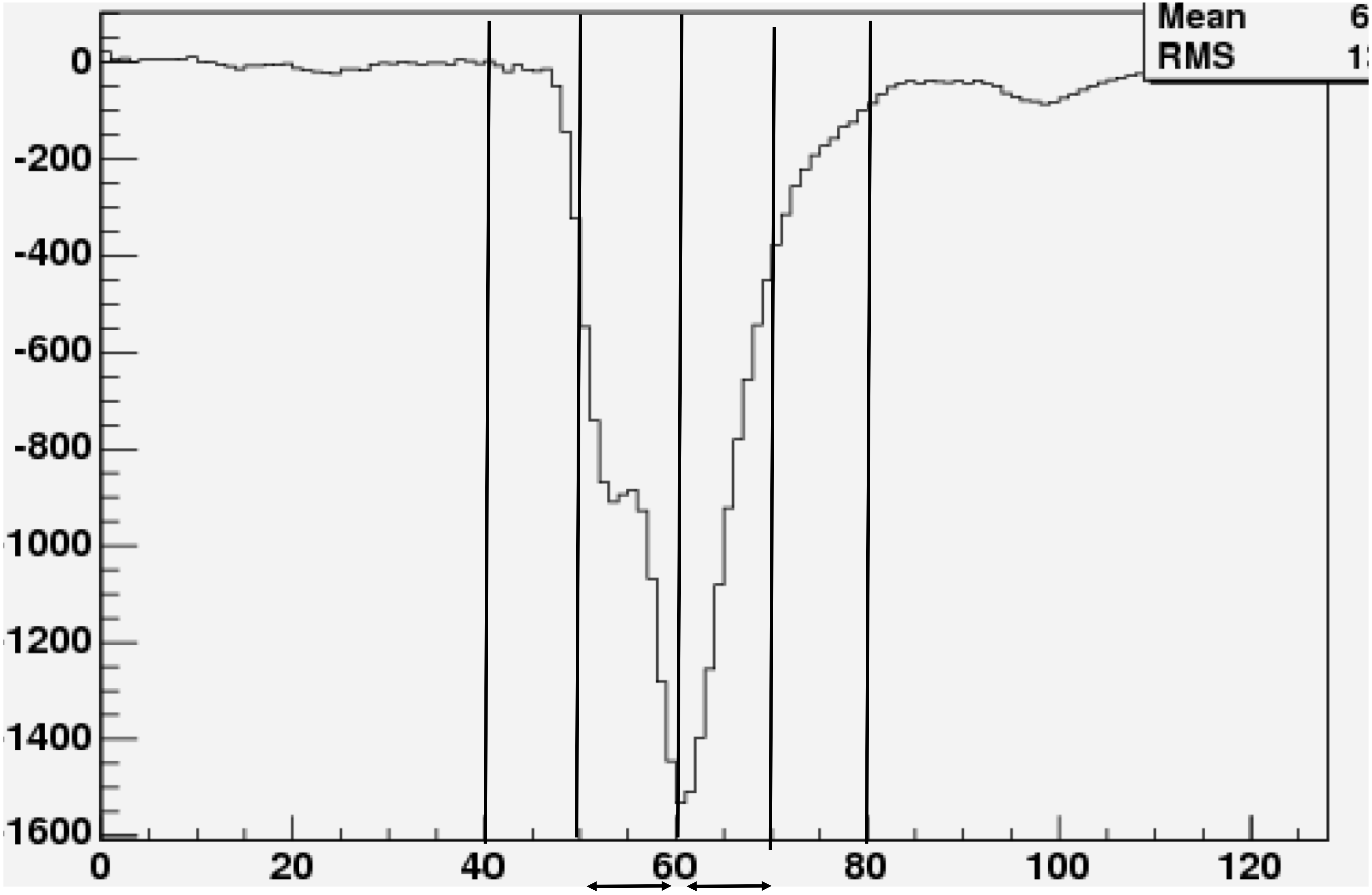
PbF2 pulses from DVCS

- 1 GHz sampling
  128 ns
- PbF2
- Hamamatsu R5900
- Pure Cerenkov

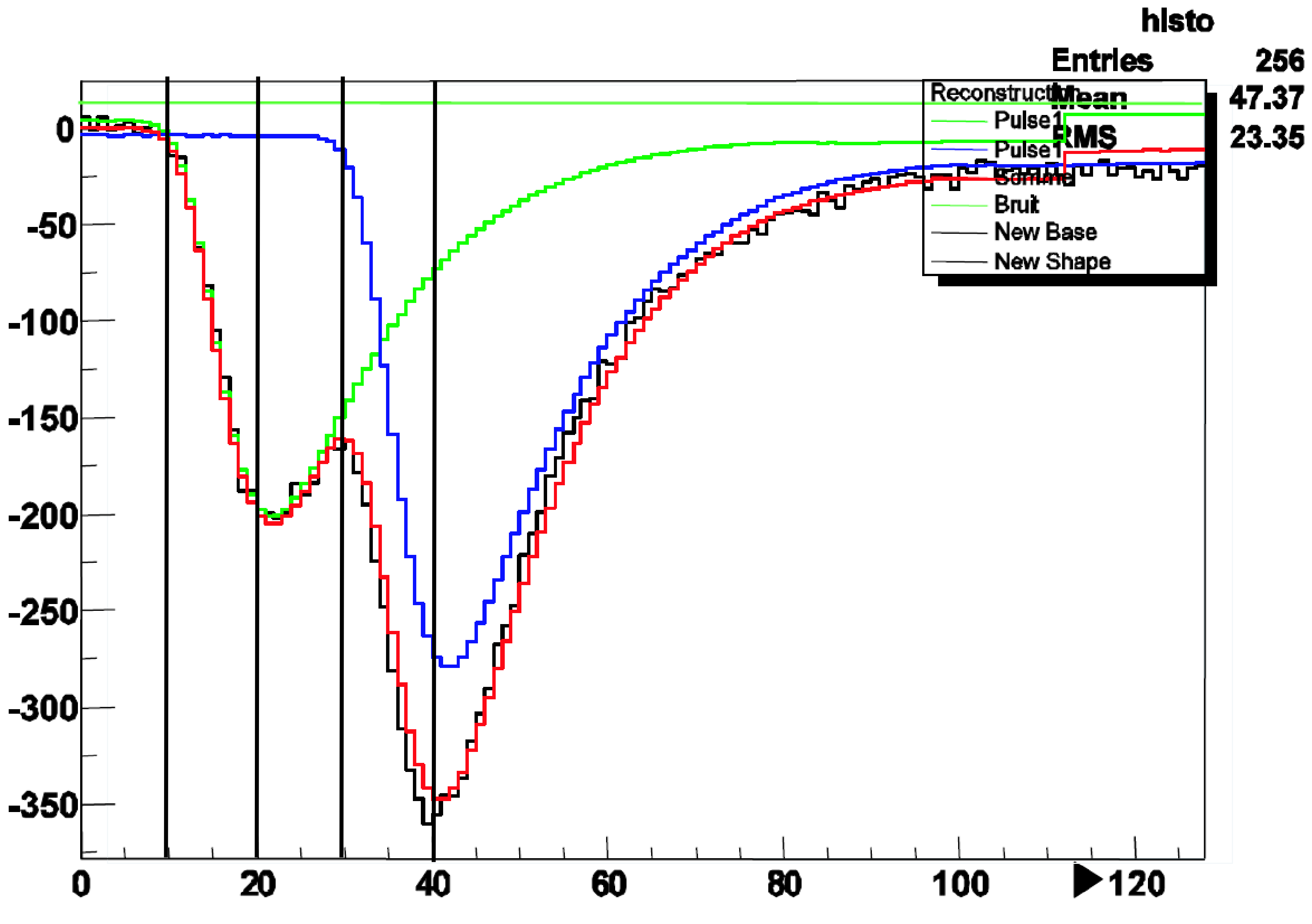




PbF2 pile-up event



Scintillator pile-up event



Histogramming electron

- Photon detector
  - 1320 histograms (200 bins x32 bits) x 2 (laser polarization) fill with pulse amplitude
  - 2 histograms saved and resets every 0.5 s when bunch replaced = 200 x 32 x 2 / 0.5 = 25.6 kBytes/s per channel
  - Could increase by factor 10 or 100 to monitor polarization during different time of fill
- Electron detector
  - 1320 histograms x 2 (laser polarization)

Histogramming proton

- Photon detector
  - 1320 histograms x 2 (laser polarization)
  - 2 histograms saved and resets every 0.5 s when bunch replaced
- Electron detector
  - 1320 histograms x 2 (laser polarization)

Event by event

- 1GHz x 10 bit = 10 Gbit /s per channel
- Need to check rate after zero suppression
- Prescale for correction on histogramming

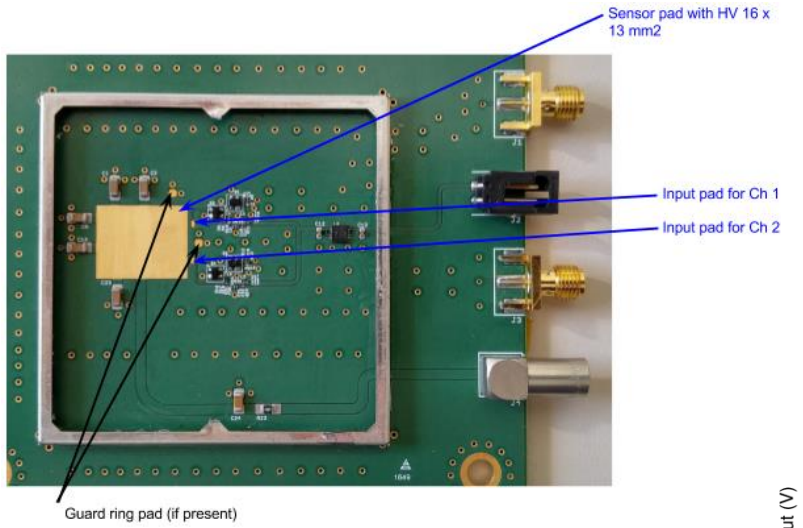
Luminosity monitor

- Photon detector
  - 1320 histograms
  - 2 histograms saved and resets every 0.5 s when bunch replaced
  - 1320 x 10 ns integral
  - Is signal DC or pulses ?

Electronics for very fast detectors

TOTEM electronics designed by Kansas University

A two channels board was designed and manufactured for the characterization of different solid state detectors.



Sensors up to 16x13 mm^2 can be glued and bonded.

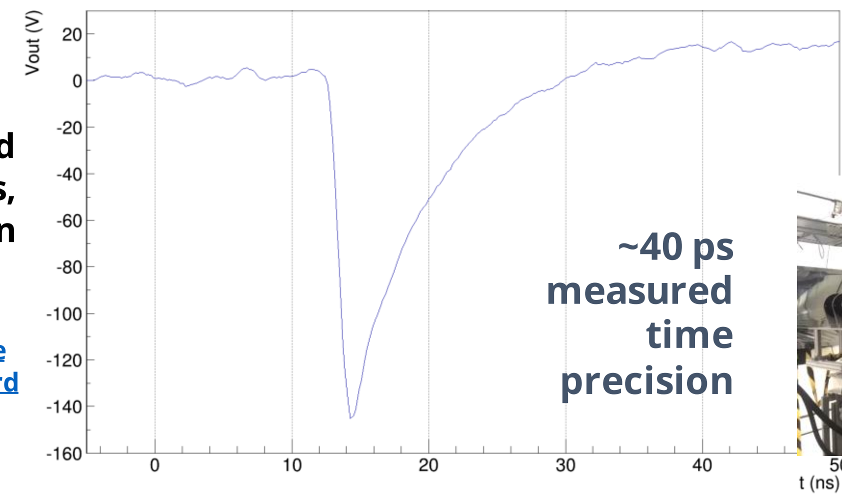
The components can be easily adapted to accommodate:

- **Diamond sensors: ~1 nA bias current, both polarities, small signal**
- **Silicon sensors: ~100 nA bias current, small signal**
- **UFSD ~100 nA bias current, ~ larger signal**
- **SiPM: ~ 5 uA bias current, large signal**

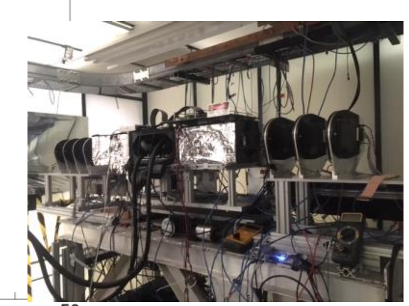
3x3 mm^2 UFSD MIP beam test @ Fermilab

The board was optimized to achieve a good time precision with different sensors, however it can be modified to have an output signal shorter (but less precise)

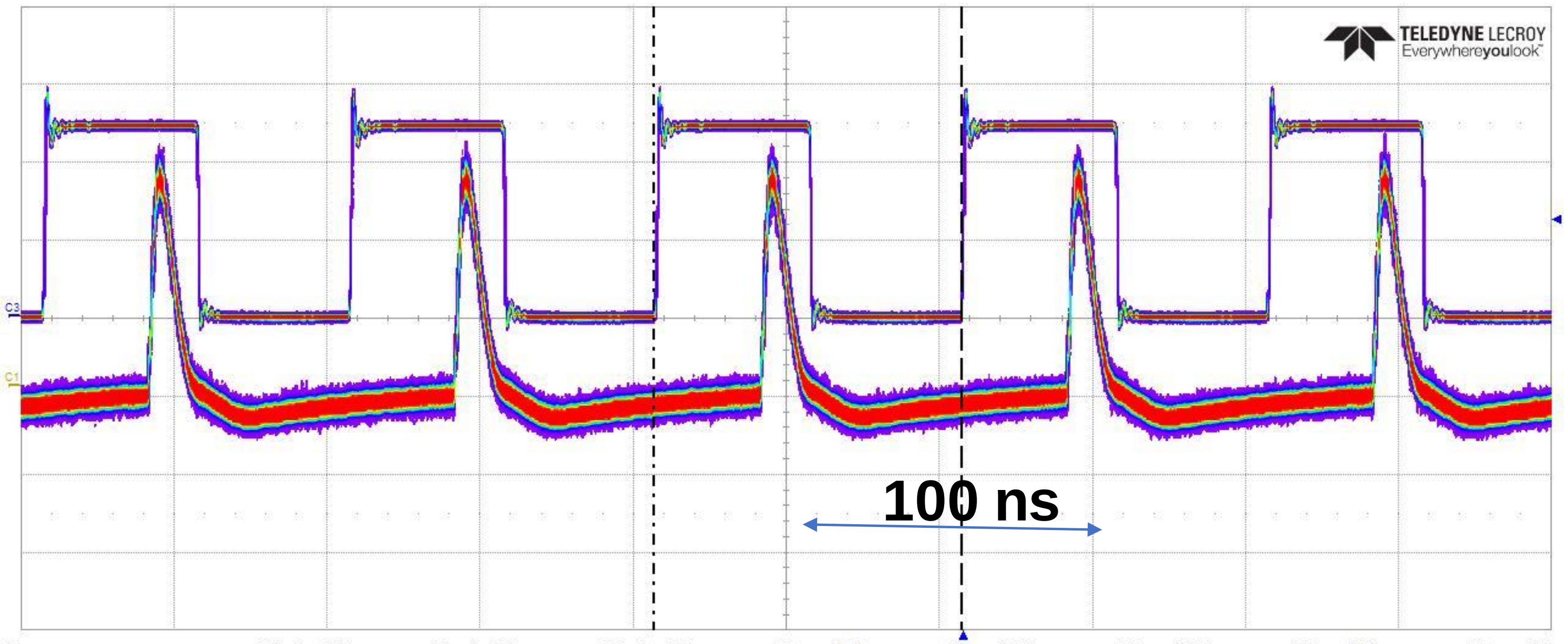
[Test of Ultra Fast Silicon Detectors for Picosecond Time Measurements with a New Multipurpose Read-Out Board](#)

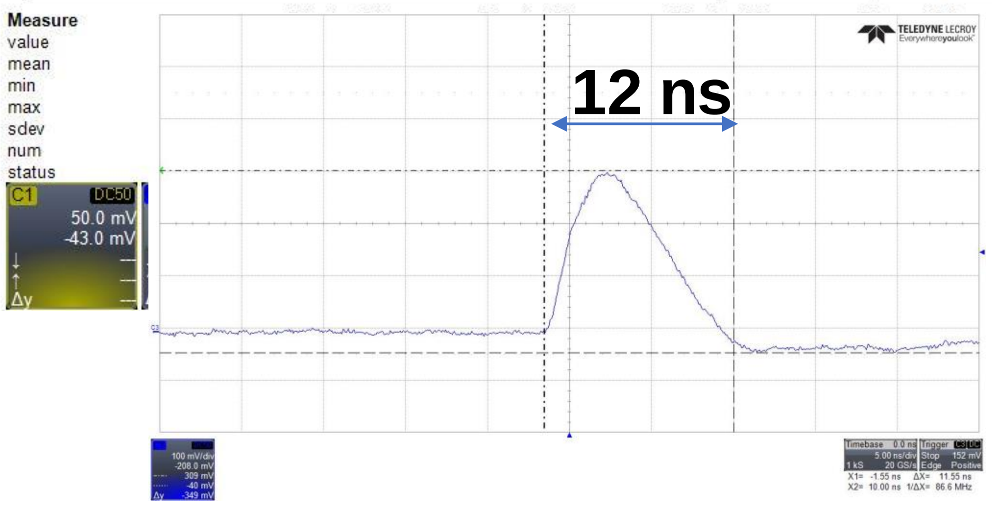


~40 ps measured time precision



Silicon pulsed with laser at 10 MHz



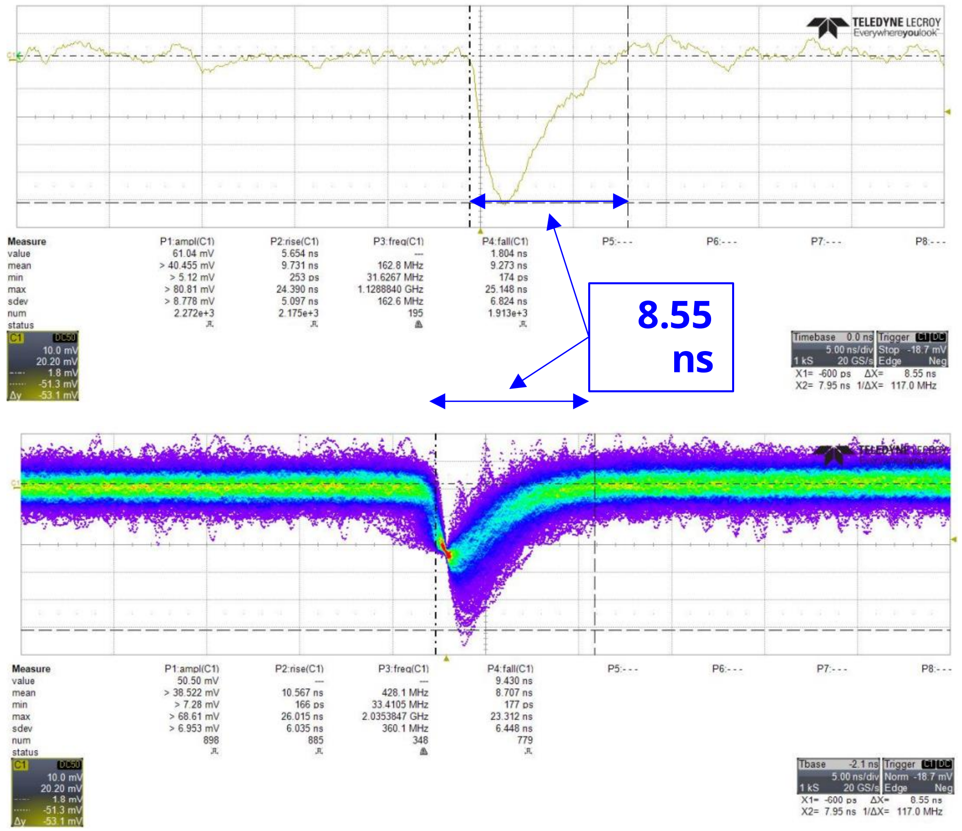


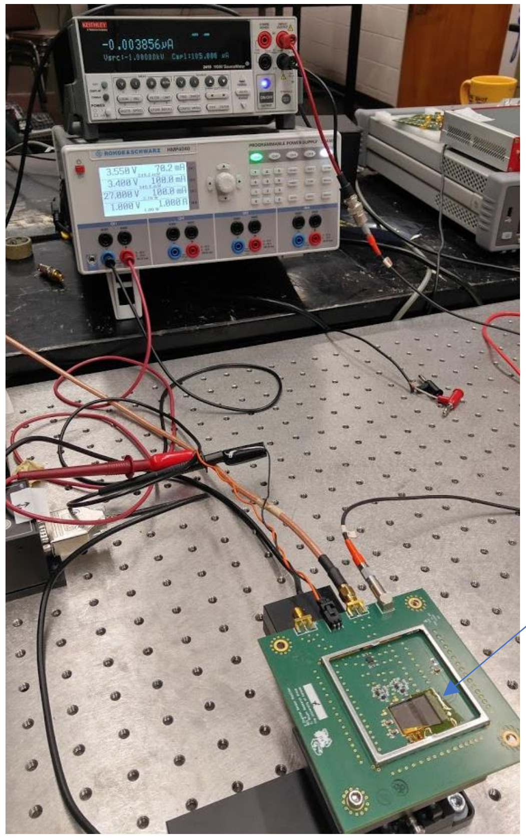
Amplifier with silicon detector fast enough to separate successive sources for eRHIC Linac Ring at 10 MHz

(New proposal for up to 476 MHz)

Electronics for very fast detectors

This board was also used to test the performance of a diamond sensor using a Sr^{90} β^- source.





Conclusion/question

- 1 to 2 GHz FADC seems good to resolve 10 ns beam structure
- Histogramming reduces amount of data vastly, is it ok to average over several turns ?
- How much event of event data needed
- PbF2 seems to be fast enough for 10 ns bunch structure
- Diamond or silicon with Kansas preamp might be fast enough for 10 ns beam structure (Other detectors / preamps ?)