APEX Trigger and DAQ

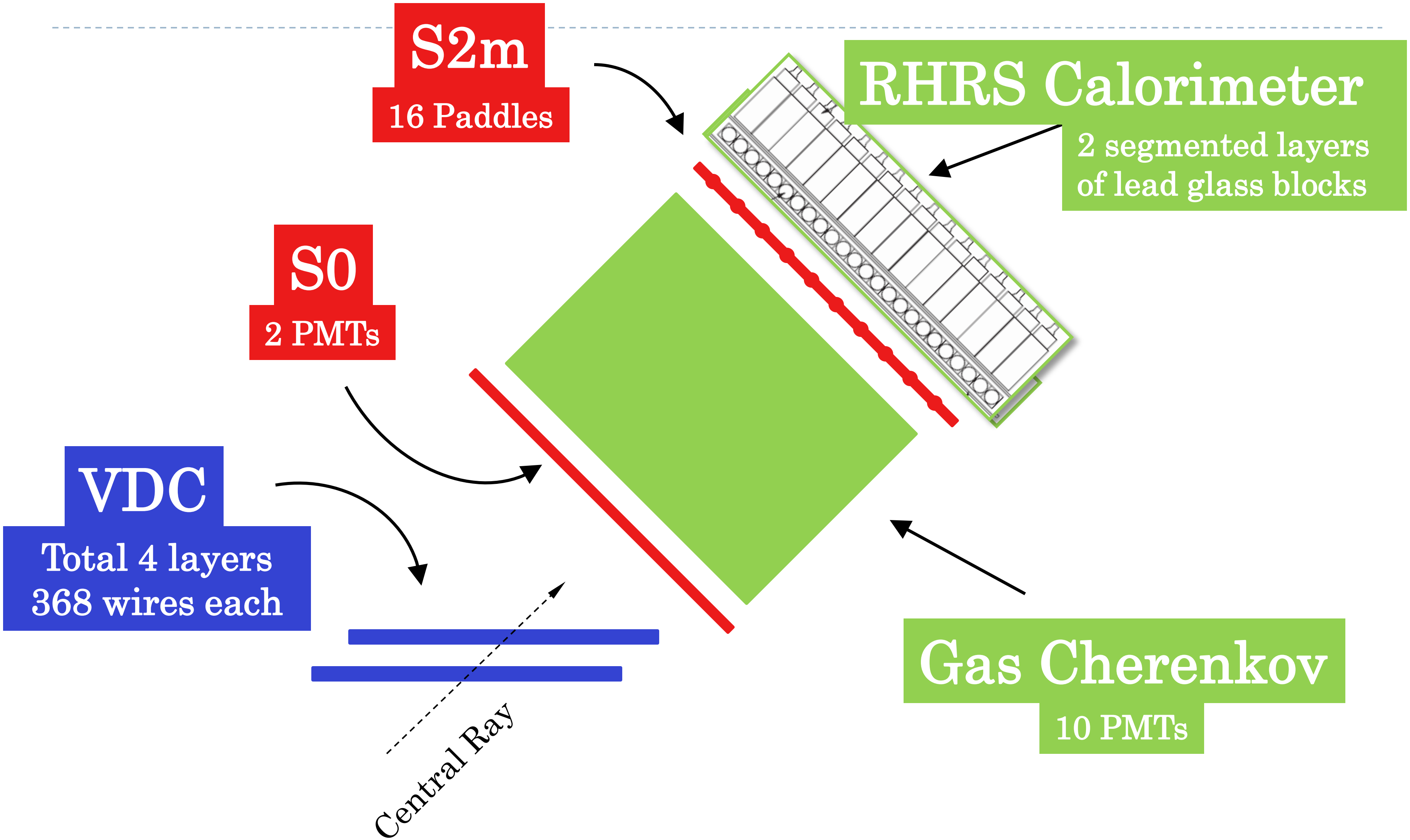
Sergey Abrahamyan
Yerevan Physics Institute

APEX collaboration

Overview

- Requirements
- Trigger improvements
- DAQ improvements
- Summary

HRS Detectors



Detector channels

Detector	Detector Channels	DAQ channels
Gas Cherenkov	10	10 time 10 amplitude
Scintillators	17	17 time 17 amplitude
Calorimeter	128 – RHRS 68 – LHRS	128 amplitude 68 amplitude
VDC	1472	1472 time

LHRS
112 amplitude channels – 2 ADC modules
1516 time channels – 16 TDC modules

RHRS
172 amplitude channels – 3 ADC modules
1516 time channels – 16 TDC modules

Trigger rate

Setting	A	B	C	D
Energy (GeV)	**2.2**	**4.4**	**1.1**	**3.3**
e^- (kHz)	4500	700	6000	2900
π^- (kHz)	100	2200	36	1000
e^+ (kHz)	31	3.6	24	23
π^+ (kHz)	100	2200	36	1000

Possible Improvements

Trigger

- **Reduce coincidence timing**
  - **Suppress pions**

DAQ

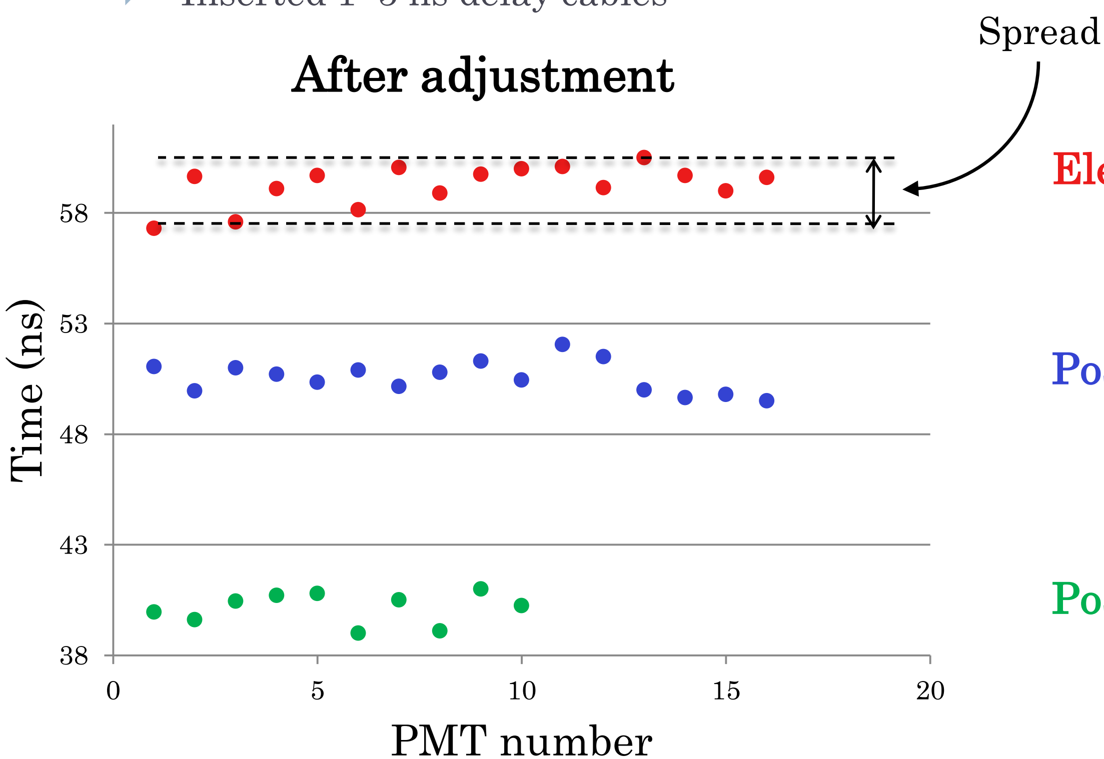
- **Using of sparsification**

Trigger Logic

- Electron Arm Trigger (T1)
  - Electron S2m
- Positron Arm Trigger (T3)
  - Positron S2m
- Coincidence Trigger (T4)
  - Electron S2m + Positron S2m
- "Golden" Coincidence Trigger (T6)
  - Electron S2m + Positron S2m + Positron Gas Cherenkov

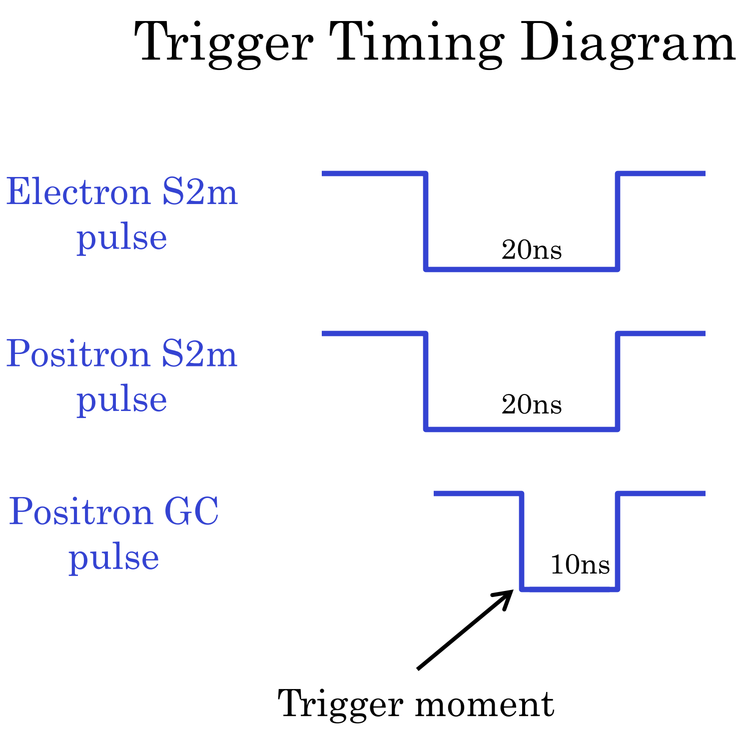
Timing Alignment in Hardware

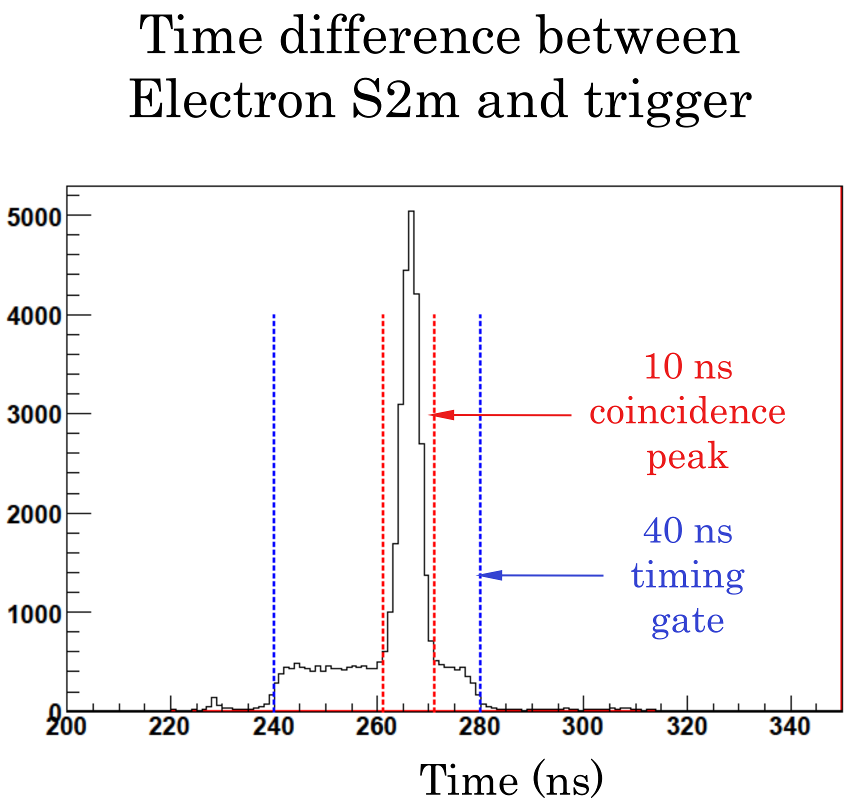
- Run at high rates, small timing gate is important
- Must align timing of the trigger detectors
  - S0 counter as a reference
  - Inserted 1–5 ns delay cables



	σ	Spread
Electron S2m	0.9 ns	3.2 ns
Positron S2m	0.7 ns	2.6 ns
Positron GC	0.7 ns	2 ns

Coincidence Timing



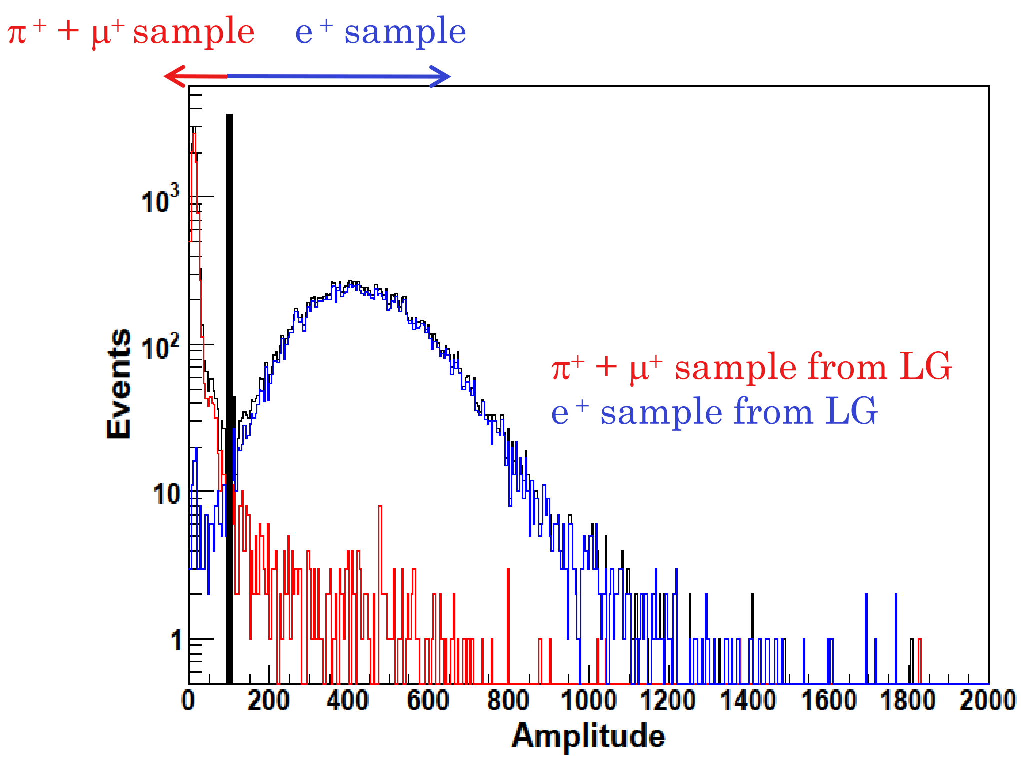


20 ns coincidence time easily achievable

Ideally 10ns could be used

Gas Cherenkov in Positron Arm (high rate)

30 μA on Pb Target
Positron arm rate – 765 kHz
(close to maximum expected rate)



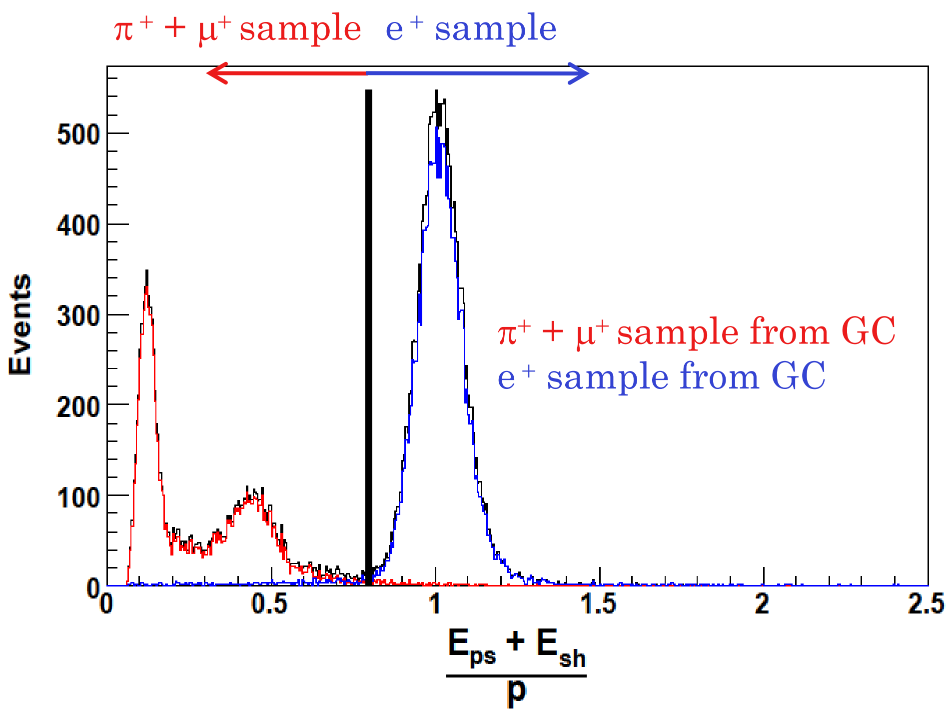
Electron detection eff.	0.992
Pion rejection eff.	0.970

Meson background rejected by a factor of 30

This analysis didn't use timing and coordinate information

Lead Glass Particle ID in Positron Arm (high rate)

30 μA on Pb Target
Positron arm rate – 765 kHz



Electron detection eff.	0.977
Pion rejection eff.	0.985

Meson background rejected by a factor of 60

This analysis didn't use coordinate information

- E_{PS} – Energy deposition in 1st layer
- E_{SH} – Energy deposition in 2nd layer
- p – Particle momentum

Trigger rate

Setting	A	B	C	D
Energy (GeV)	**2.2**	**4.4**	**1.1**	**3.3**
e^- (kHz)	4500	700	6000	2900
π^- (kHz)	100	2200	36	1000
e^+ (kHz)	31	3.6	24	23
π^+ (kHz)	100	2200	36	1000
T6 rate (kHz) 20ns window π^+ rejection = 30	3.2	4.5	3.0	4.4

For 4 kHz DAQ dead time is 10%
APEX can run without any
improvement to DAQ!

3 Crate configuration

LHRS

112 amplitude channels – 2 ADC modules
1516 time channels – 16 TDC modules

Crate 1: 5 TDC + 1 ADC
Crate 2: 5 TDC + 1 ADC
Crate 3: 6 TDC

RHRS

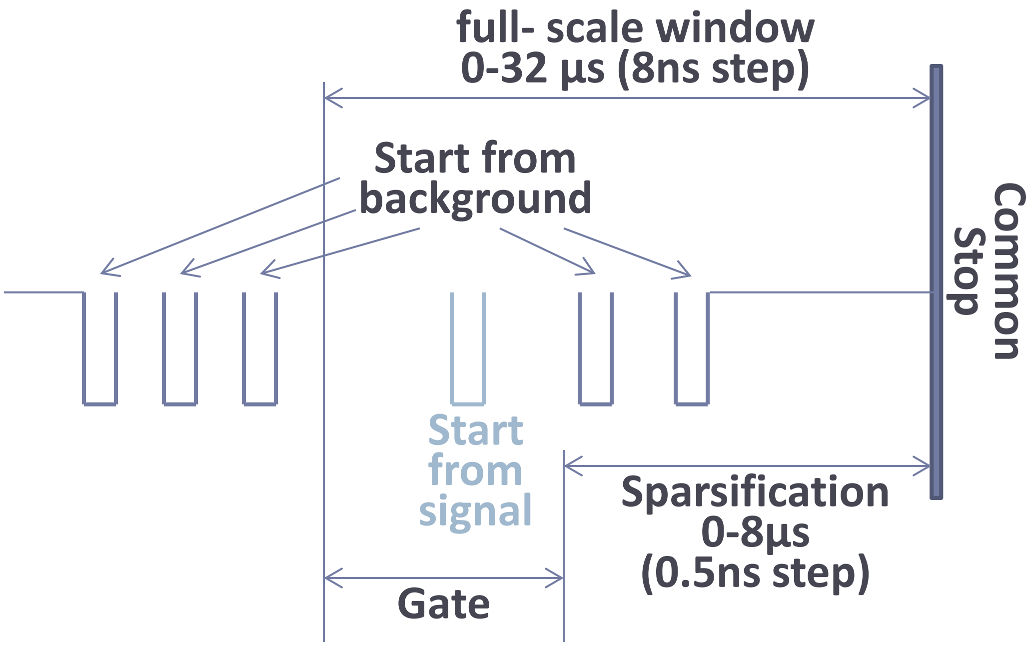
172 amplitude channels – 3 ADC modules
1516 time channels – 16 TDC modules

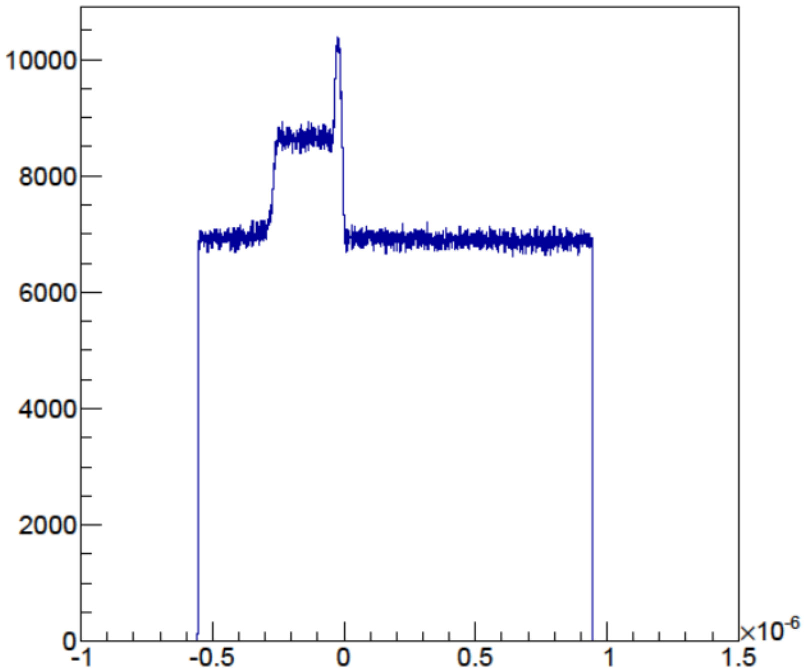
Crate 1: 5 TDC + 1 ADC
Crate 2: 5 TDC + 1 ADC
Crate 3: 6 TDC + 1 ADC

By reducing number of channels which go to each crate we reduce the amount of data to be recorded and improve dead time.

Sparsification

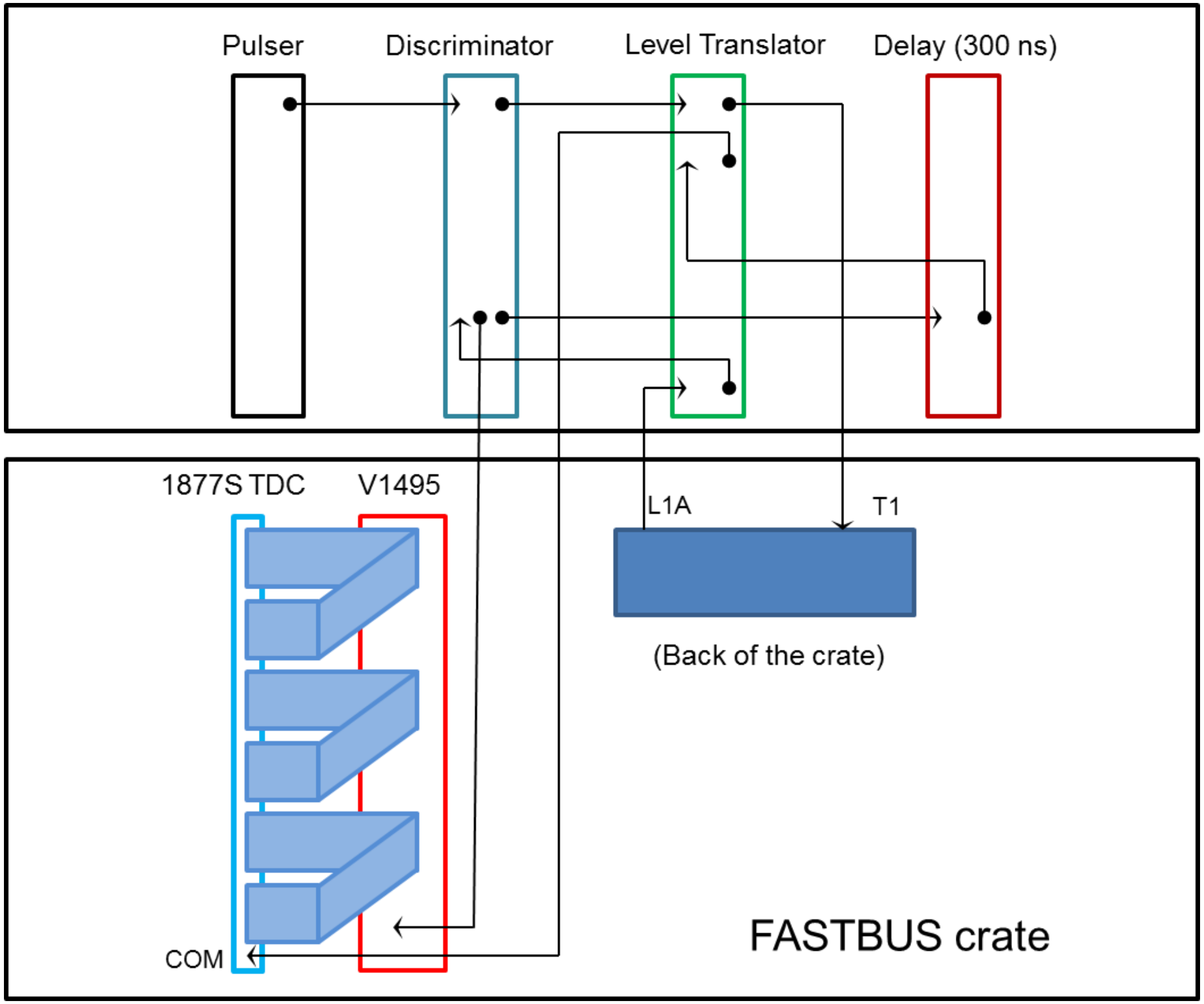
Typical TDC spectrum without sparsification. Only 300ns window out of 1.5µs full scale window has useful data





Enabling of sparsification allows to significantly reduce event size. All TDC modules have been tested to work in sparsification mode.

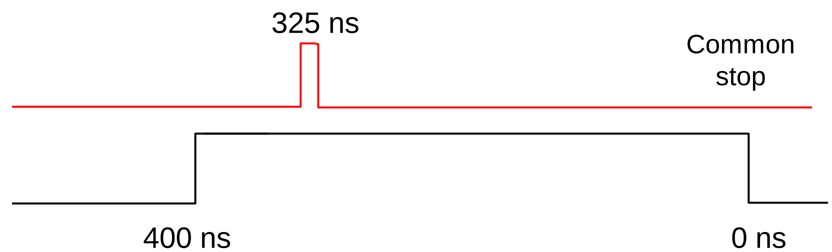
TDC test setup



TDC test procedure

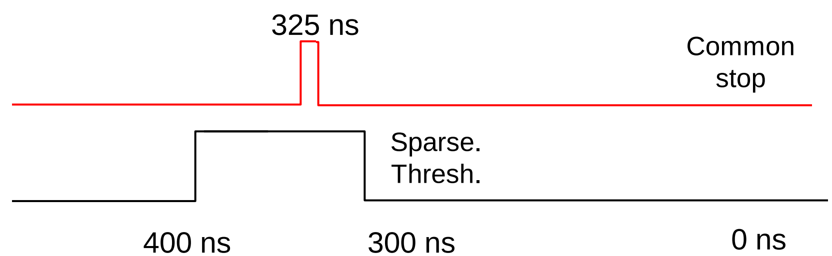
Sparsification CRL #1

Full scale time window = 400 ns
Sparsification threshold = 0 ns



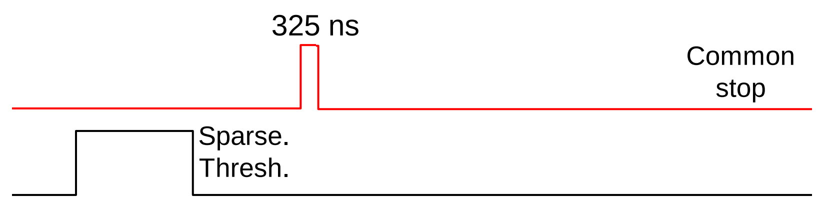
Sparsification CRL #2

Full scale time window = 400 ns
Sparsification threshold = 300 ns



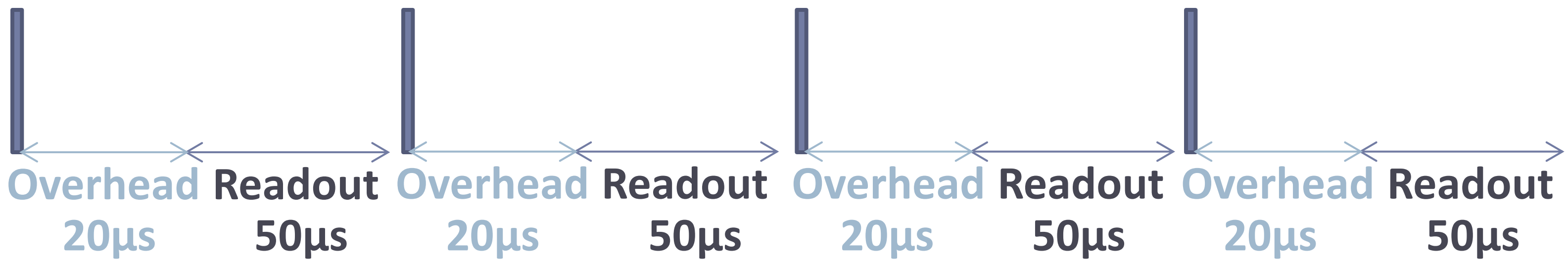
Sparsification CRL #3

Full scale time window = 496 ns
Sparsification threshold = 424 ns



Event Blocking

Triggers



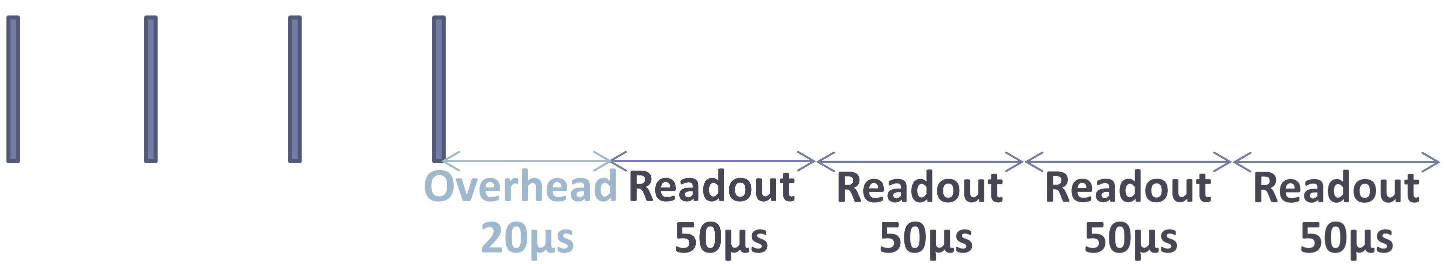
For one channel readout.

4 events no EB – 280 µs
4 events with EB – 220 µs

Readout time is 50 µs +
2 µs per 16 channel.

64 channels – 58 µs
128 channels – 66 µs

Triggers



Event Blocking test results

- 20 kHz rate
- New TI version 3
- Linux CPU

Event Blocking	Number of channels	Number of modules	Life time (%)
1	1	1	71
4	1	1	90
1	64	3	65
4	64	3	80

Summary

- 20 ns coincidence window and factor 30 online pion rejection in Right HRS should be enough to keep DAQ rate under 4.5 kHz
- 10 ns window and factor 50 online rejection is not impossible

- DAQ can operate with 10% dead time at 4 kHz
- DAQ dead time can be improved by easy steps of implementing sparsification and using 3 crate configuration (both hardware and software are ready to use)
- Further improvement could be done by using event blocking