
Coordinate Detector Update

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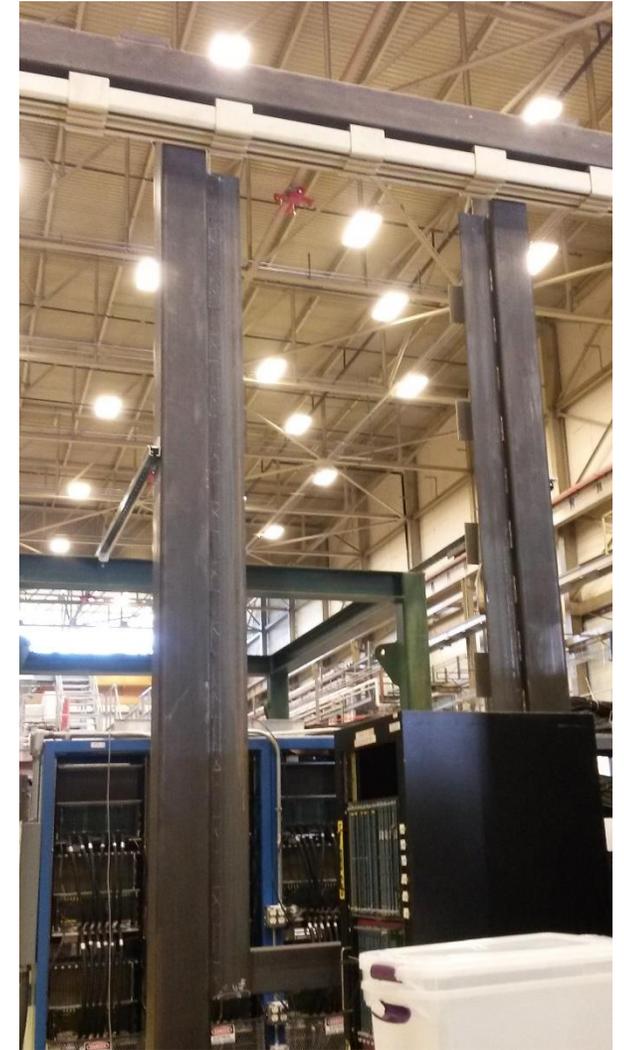
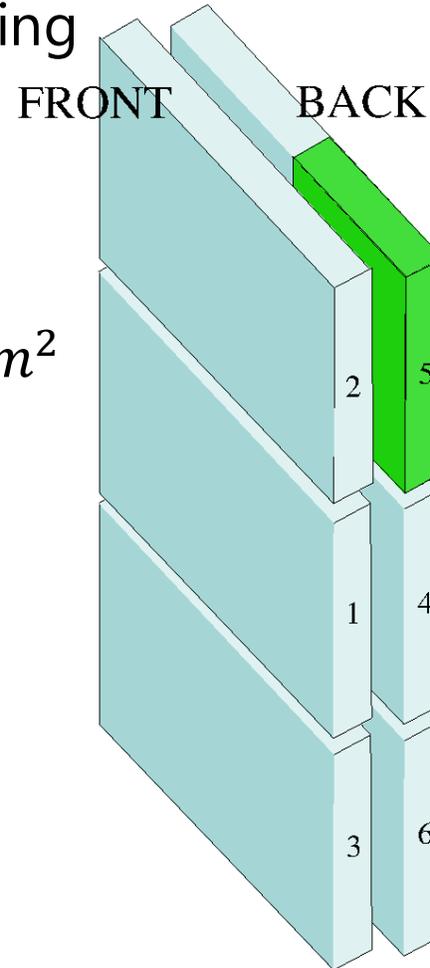
SBS Collaboration Meeting, 4th March 2026

Purpose and Analysis Design

- Determine out-of-plane scattering angle of scattered electron
- Composition: 5mm thick "paddles"005m/5m ~ 1 mr
- Challenges:
 - Even with absorber in front of CDet, background is still large (~100's to 1)
 - Only have TDC information:
 - Use LE time (and correlations with ECAL), time-over-threshold (crude ADC), and ECAL position correlation
 - Goal is to identify hits from primary electron, for use in electron tracking

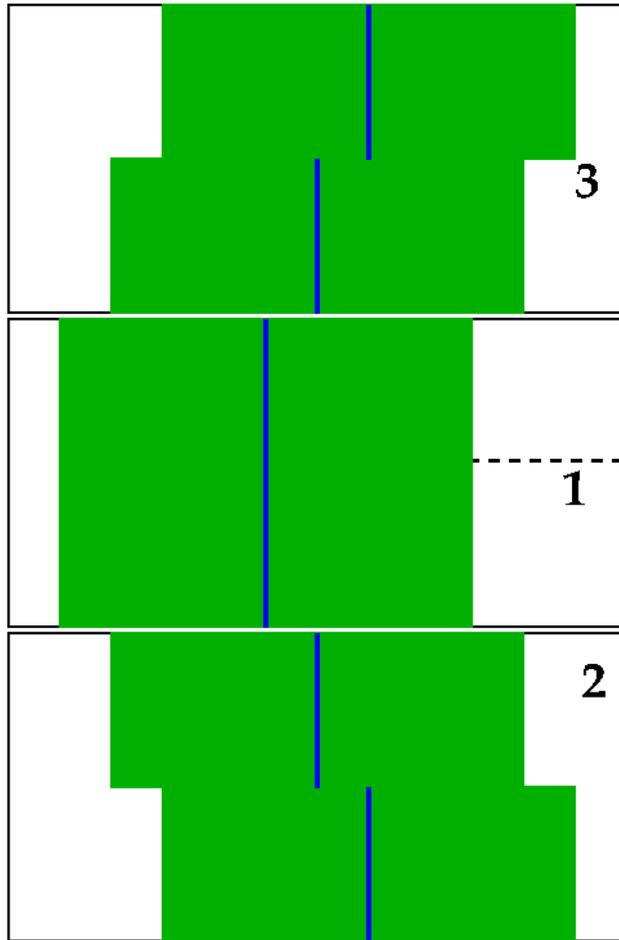
Coordinate Detector Overview

- Scintillator detector with wavelength shifting fibers used as lightguides
- Left/Right split by mirror
- Paddles have angular spread $\pm 17^\circ$
- Detector over 3 m tall; active $104 \times 294 \text{ cm}^2$
- 6 modules; 14 maPMTs per half module
- 2352 channels in total

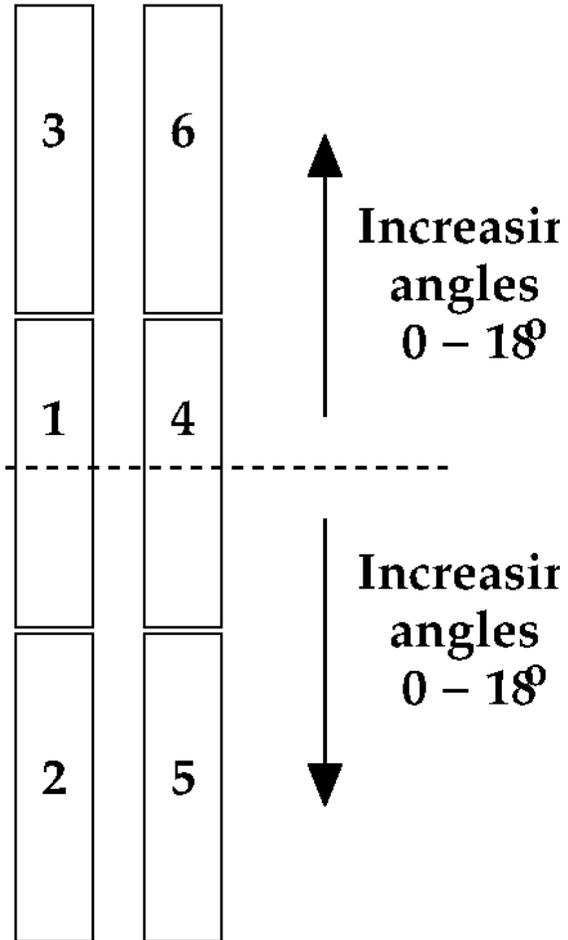


Detector Configuration

View from target to CDet

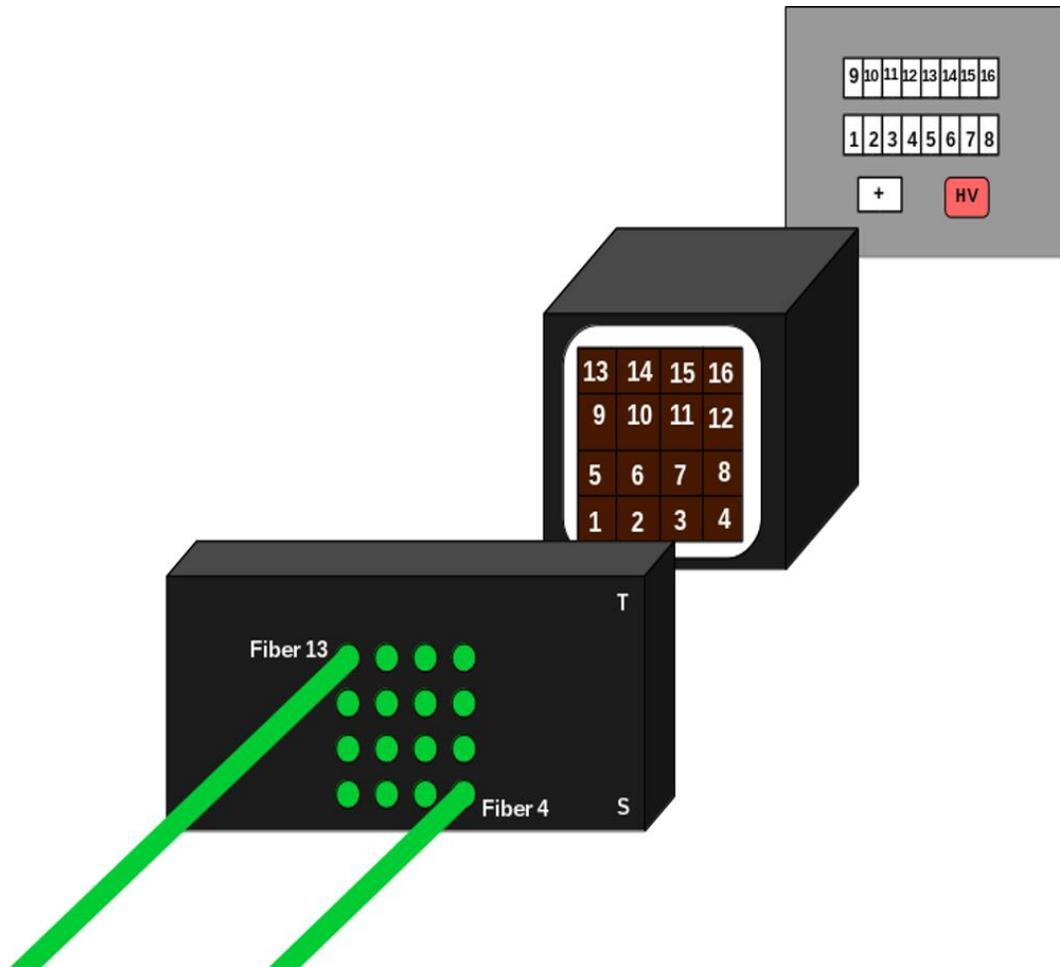


Side View



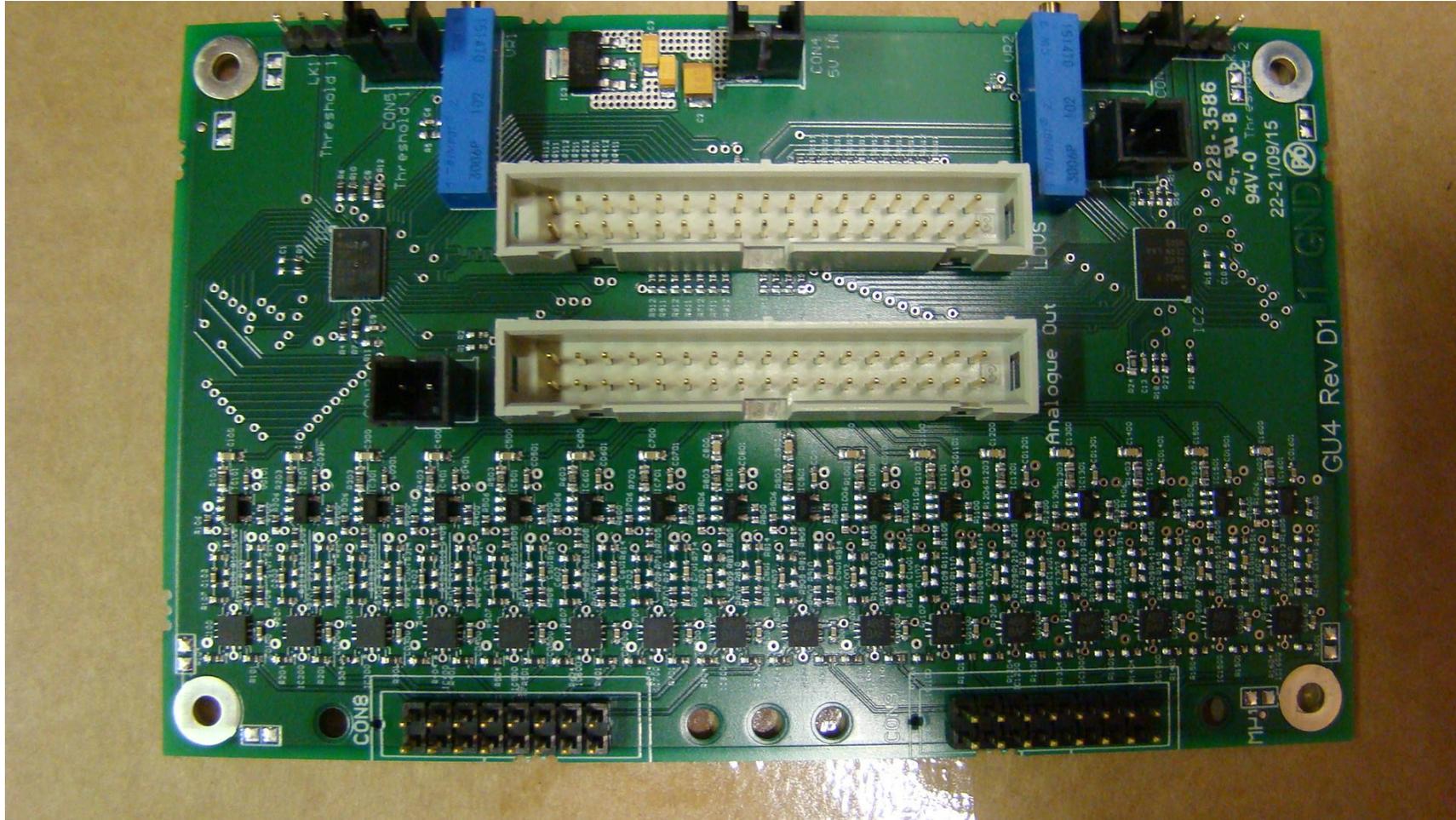
- Detector is fully symmetric
 - can rotate by 180°
- Acceptance matched to being on beam left

MultiAnode PMTs



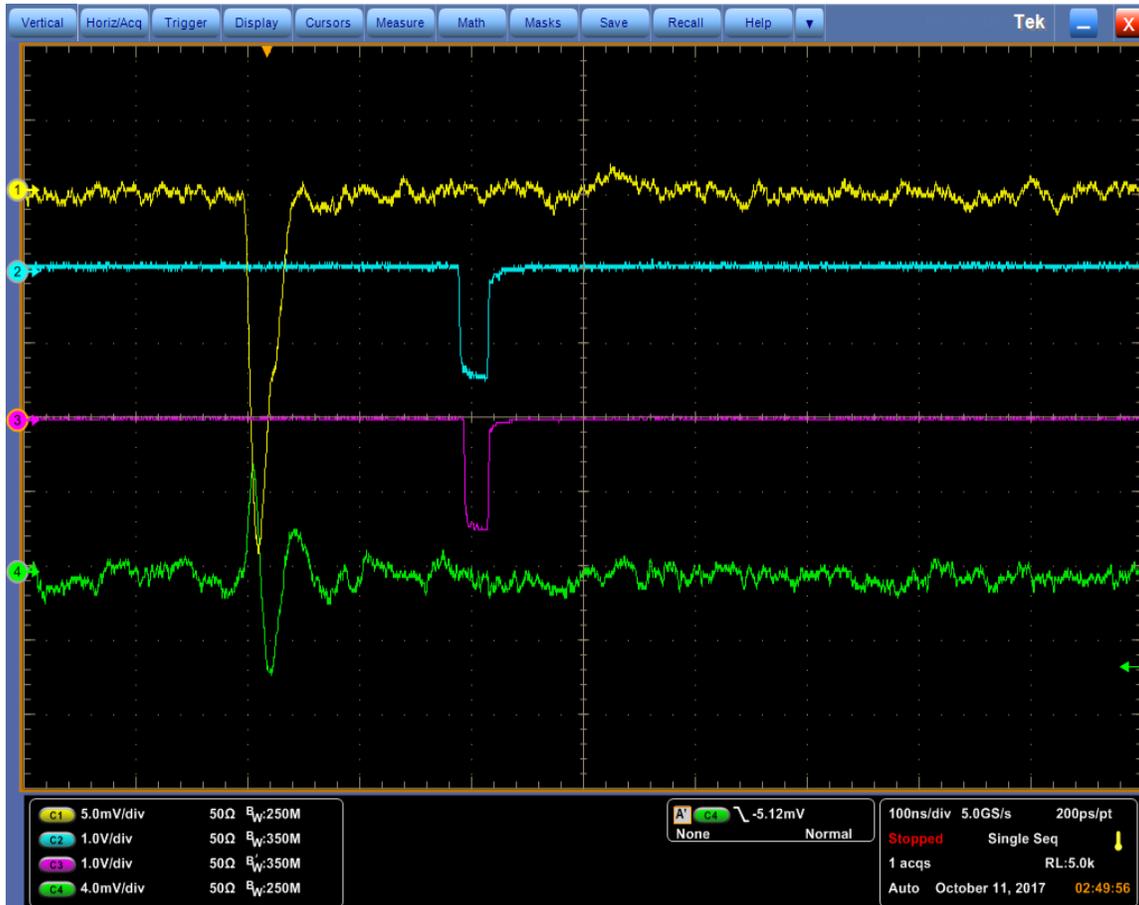
- 16 pixels in 4 x 4 array
- Thus, two unused pixels per PMT
- Single HV per PMT
- Approx. hardware "gain matching" achieved using resistor chain on output signal

NINO Amplifier/Discriminator Card



- NINO ASIC chip – 8 channels
 - 16 channel card; 2 chips
 - Analog output – x5 amplification
 - Digital output – LVDS
 - Time-Over-Threshold output as well
- leading and trailing edge times

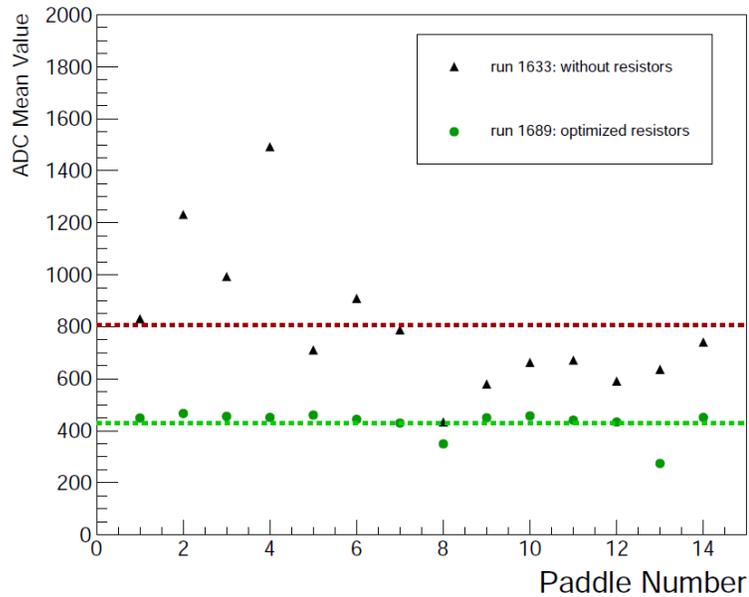
CDet Signals and Cross-Talk



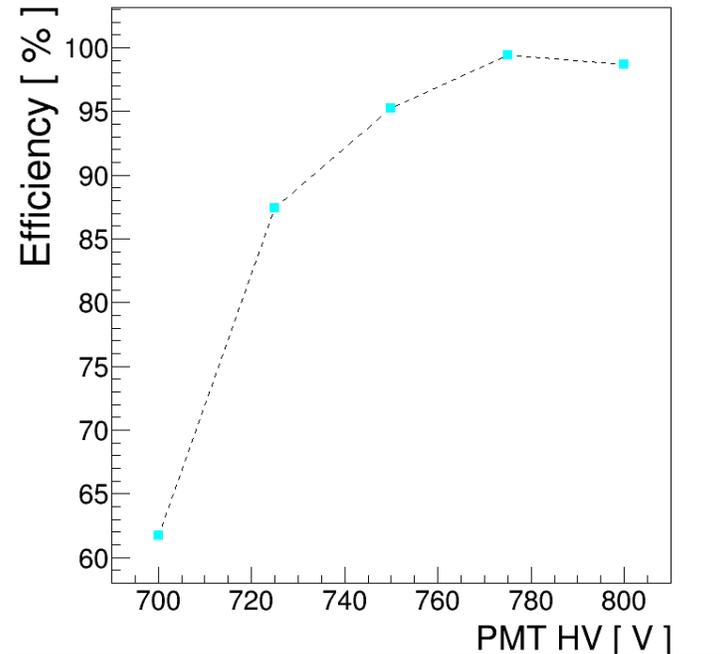
- Real Signal -> 20 mV unipolar negative, NINO output width ~20 ns (note that this is after x5 amplification in the NINO card!)
- Cross-talk Signal -> 5-10 mV bipolar signal, NINO output width similar!

Detector Commissioning

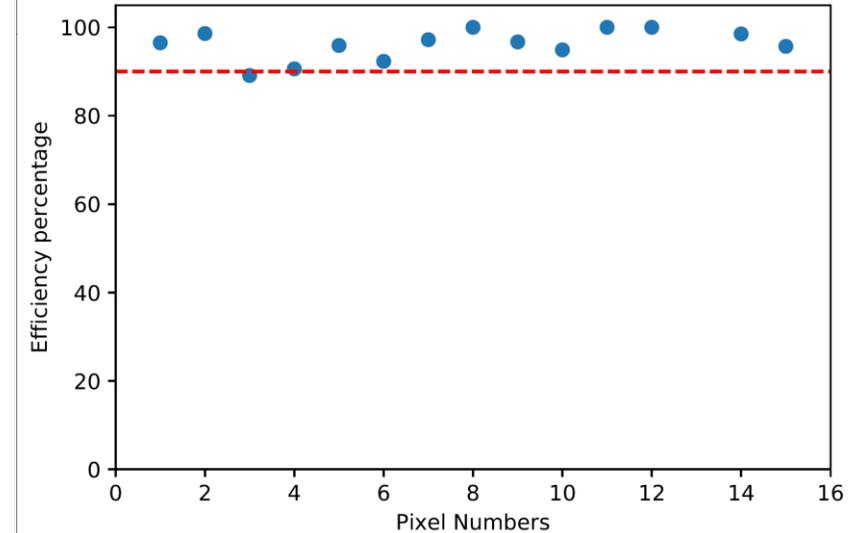
Comparison of Mean ADCs - PMT 5



Pixel 10 Efficiency



M3R PMT 11 Efficiency at 775 V

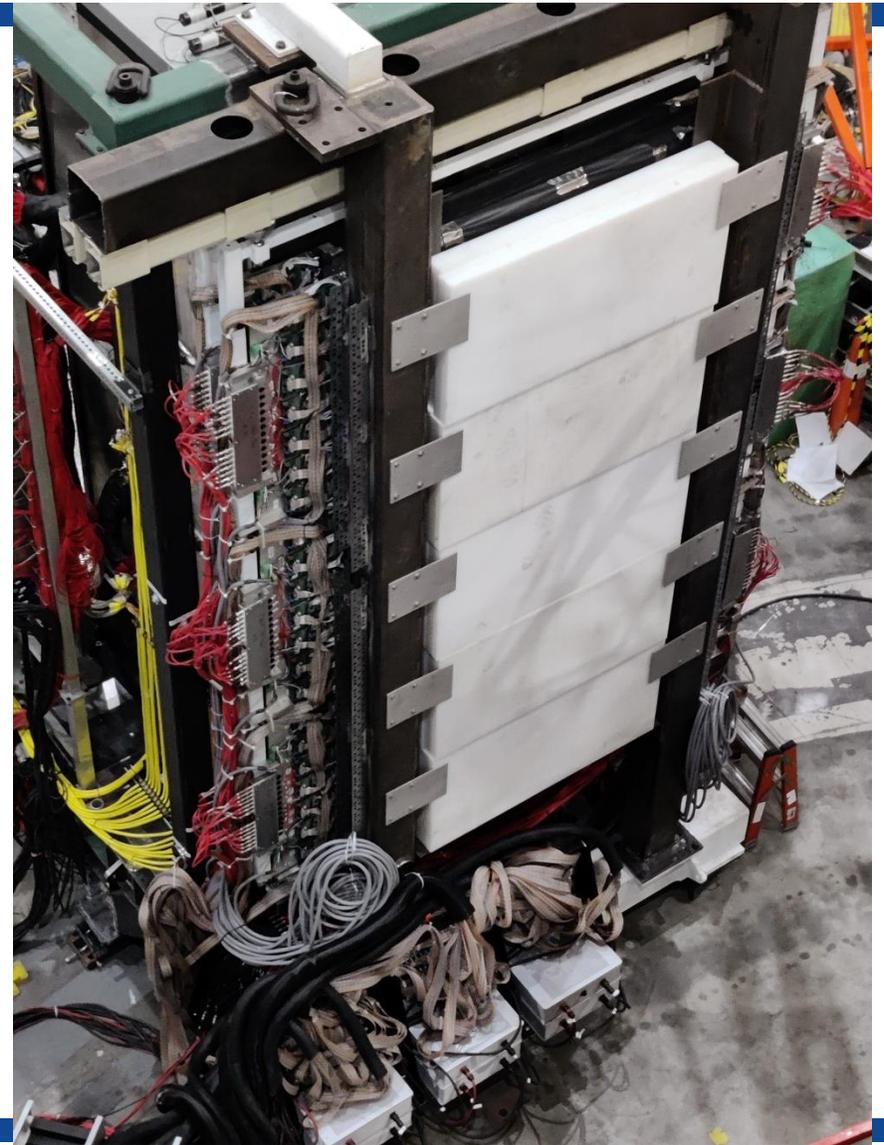
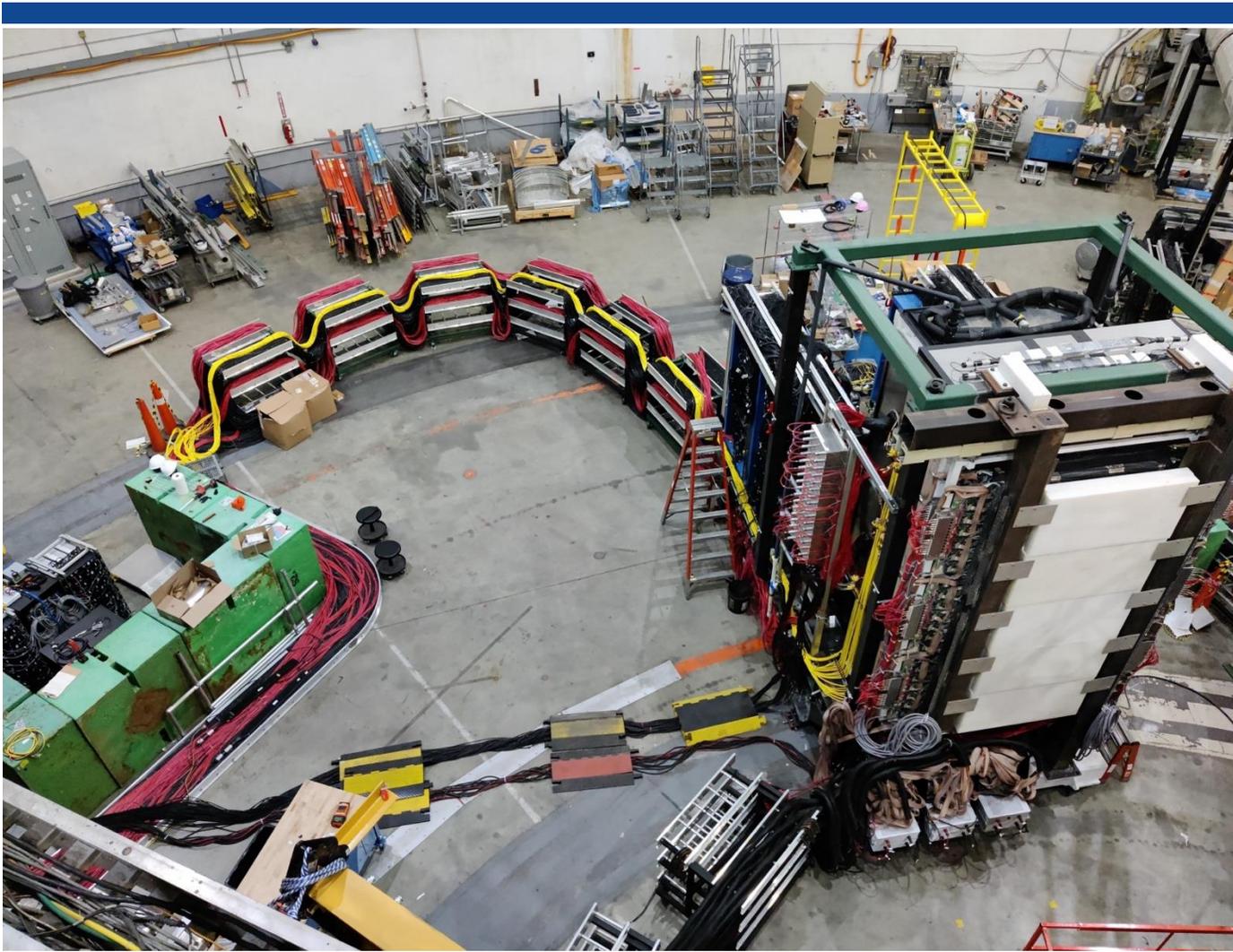


- Charge normalization for each PMT

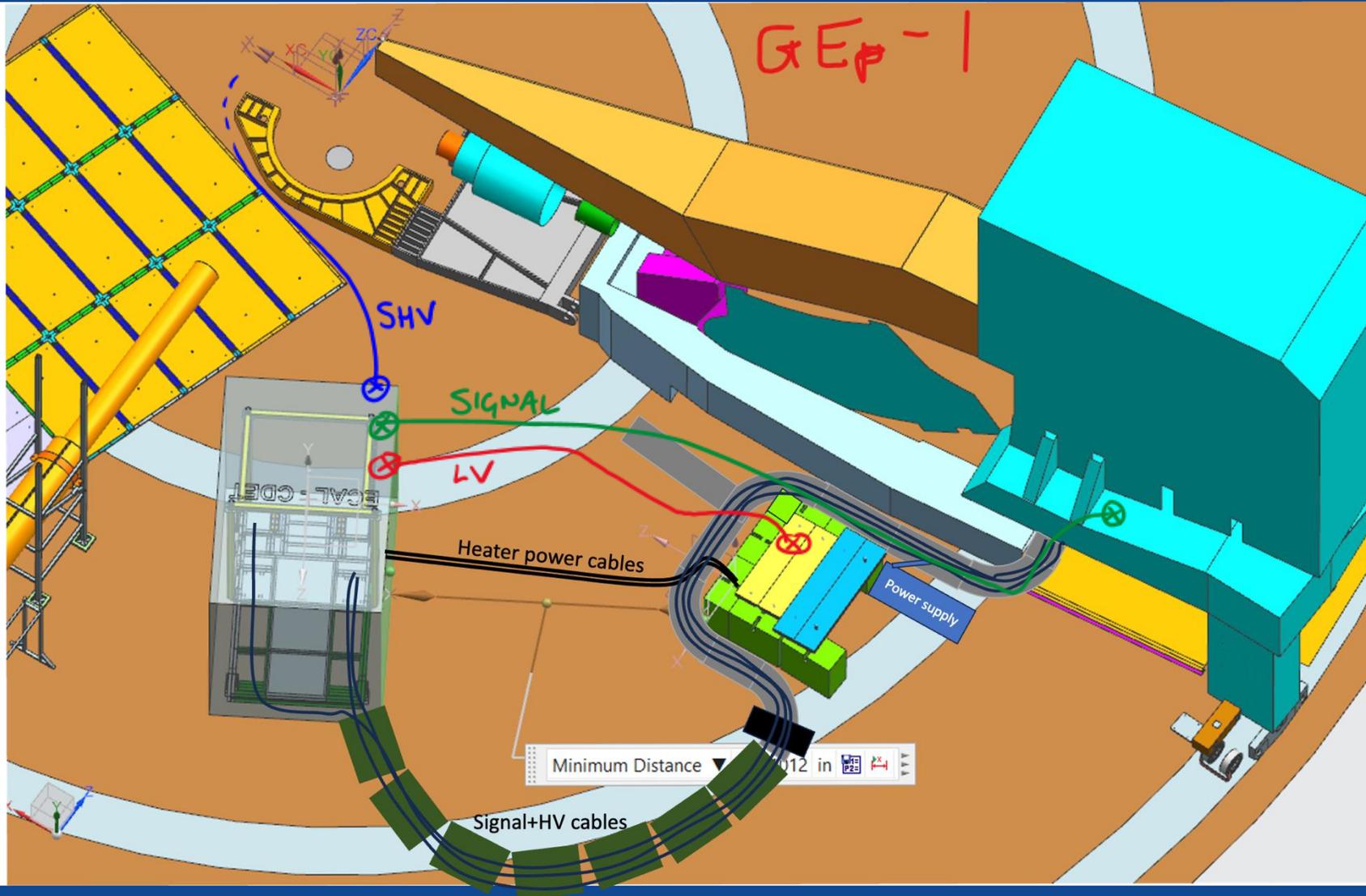
- Efficiency for each pixel at different HV settings

- Analyze efficiency for each PMT

Installed in the Hall



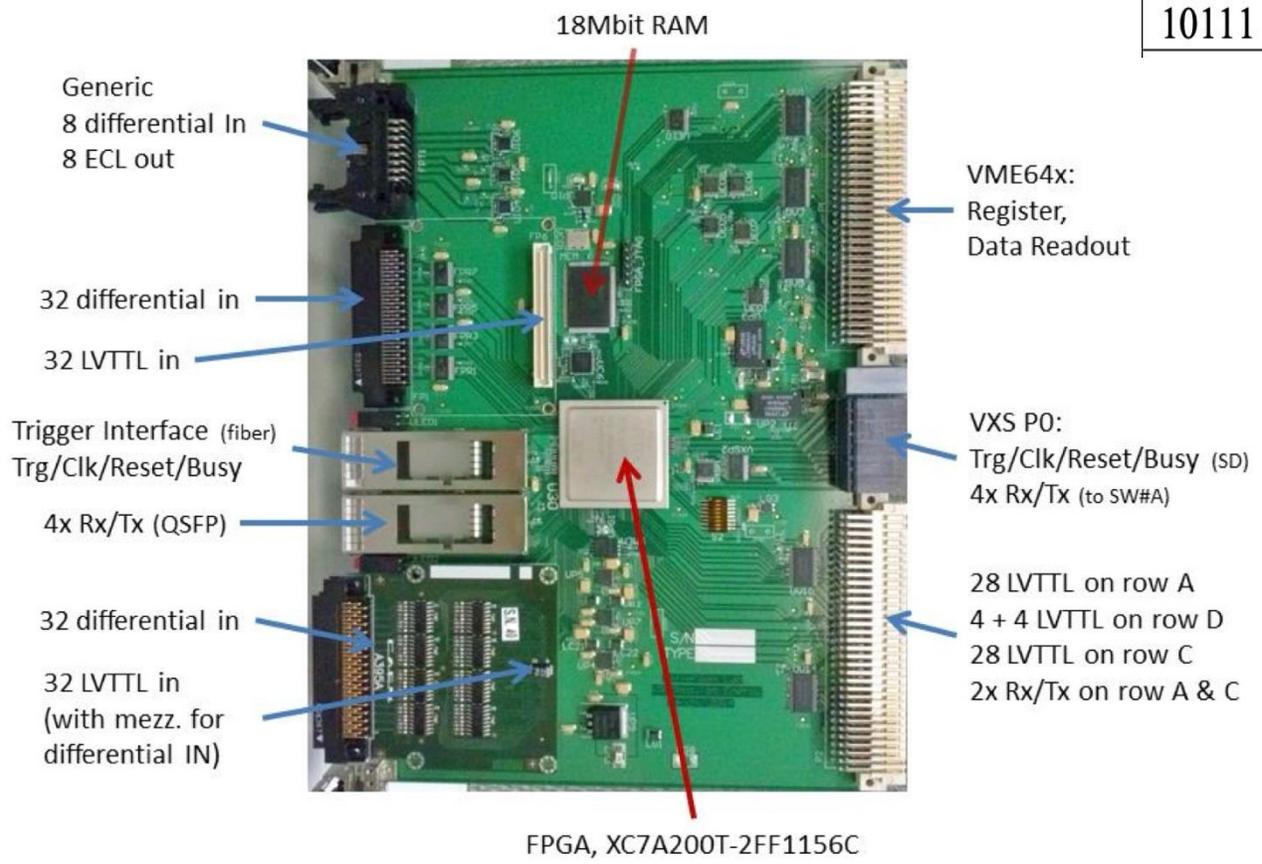
CDet Cable Layout



- **BLUE** : SHV
- around and under pivot, up to LHRS.
- **GREEN** : Signal
- run to lower platform
- **RED** : Low Voltage
- NINO power supplies in small bunker.

vfTDC Modules

Bit(31:27)	(26:24)	(23:19)	(18)	(17:8)	(7)	(6:0)
Xxxxx	Group#	Chan#	EdgeType	Coarse T	2ns	Fine Time
10111	0-6	0-31	1: R; 0: F	4*(0-1023)	0-1	0-127

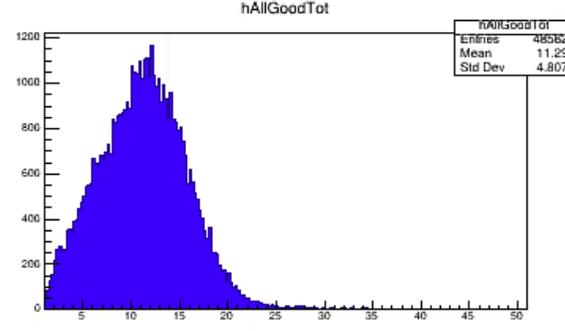
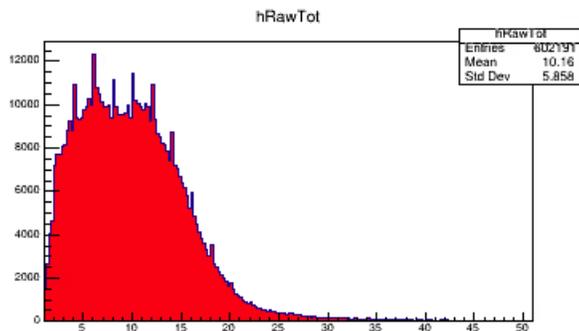
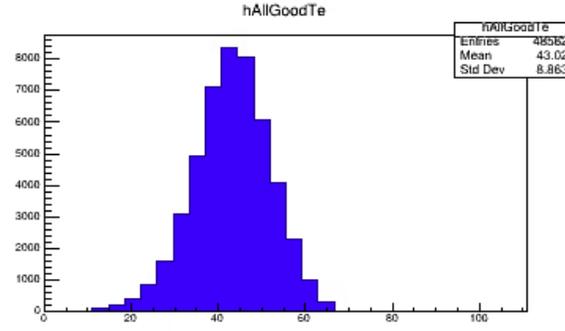
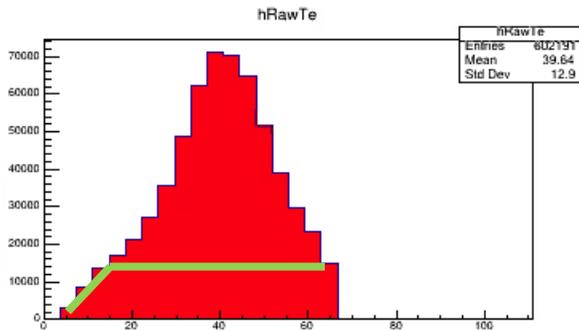
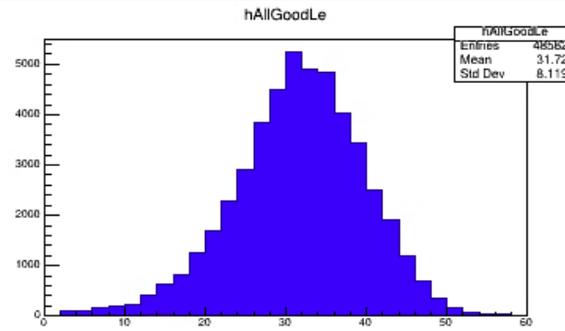
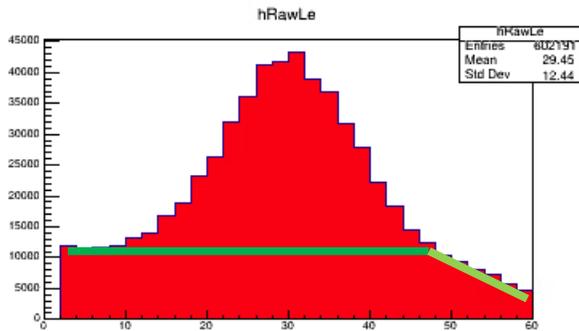


- 250 MHz clock speed -> 4ns trigger time inherent resolution -> Use of reference channel time subtraction
- Coarse Time -> 4ns resolution
- Additional 2ns bit
- Fine Time -> Divides 2ns / 127 = 15.7 ps resolution IN PRINCIPLE!!
- Non-linearities observed in Fine Time distribution ... developed a integral approach to linearize this
- Analysis to follow uses 2ns binning for LE and TE times!

Summary of Useful Experiment Data

- Low current (\sim few μA) runs with solid targets (ECal singles trigger)
 - 1 – 4 hits in CDet (both layers)
 - Determine latency and optimize window for vfTDC readout
 - Investigate ECal position and timing correlations to guide analysis of LH2 data
- “High” current runs ($\sim 20 \mu\text{A}$) with LH2
 - ~ 500 hits in CDet layer 1, ~ 250 hits in CDet layer 2

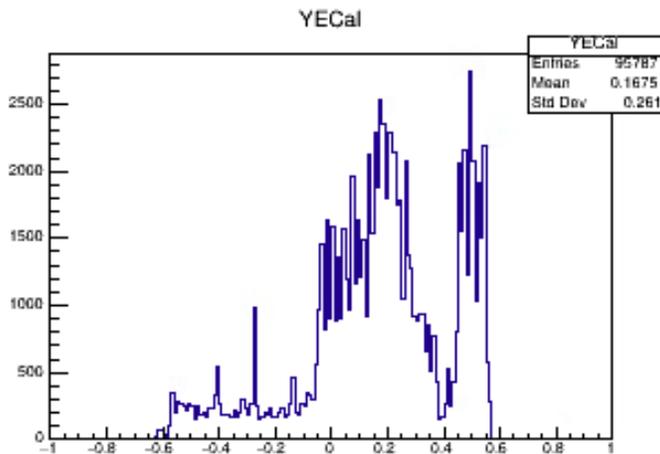
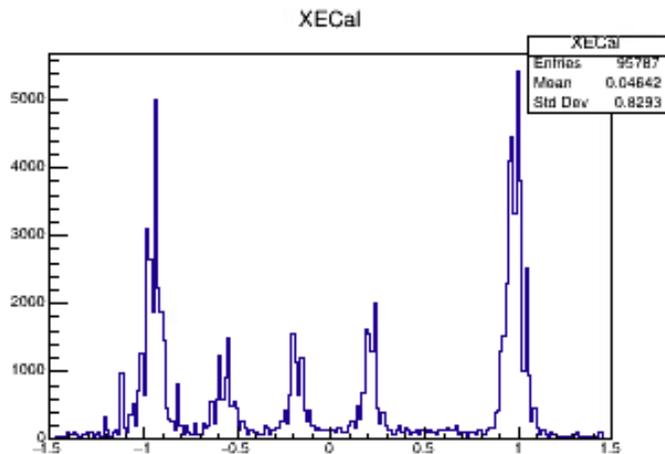
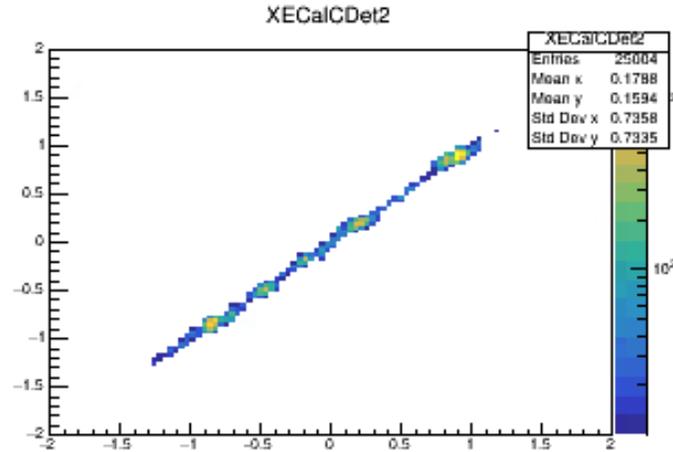
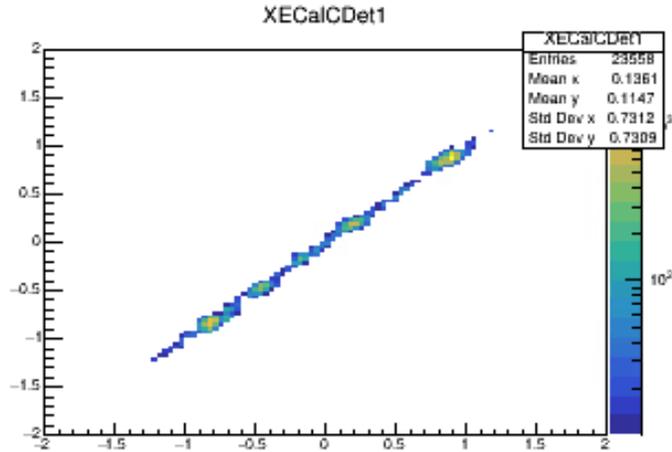
Analysis in Progress



- Run 3575 – 1 uA on carbon cross target – Kin 3 – ECal Singles trigger

- “Good” = hit in both layers of CDet, +/- 10 cm of projected ECal x-position

Analysis in Progress



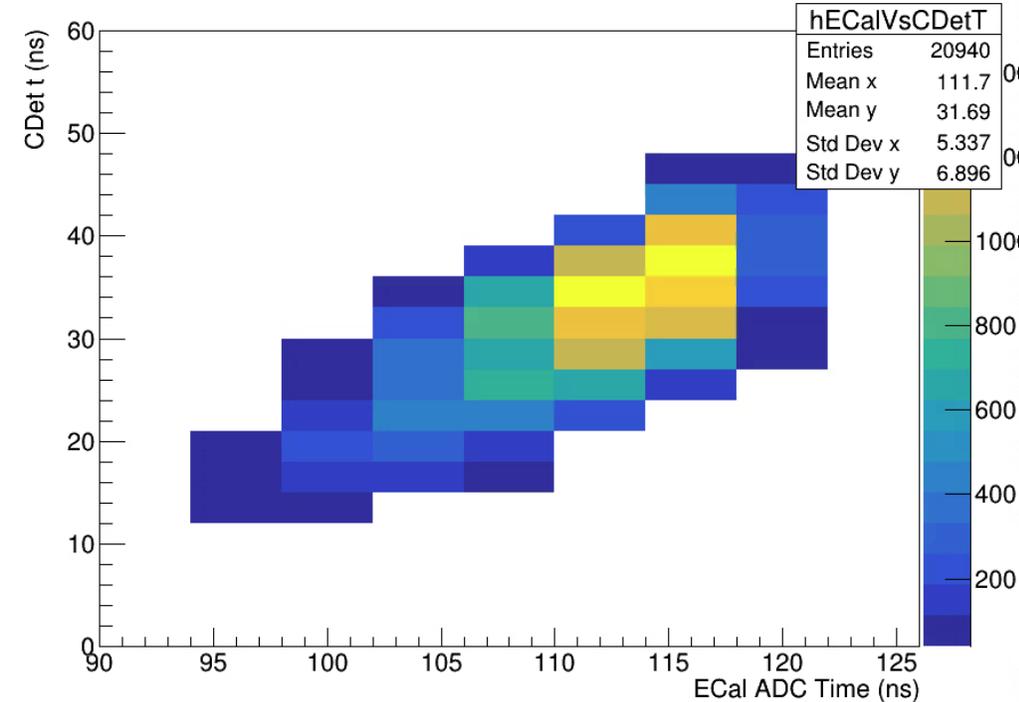
Run 3575 – 1 uA on carbon cross target – Kin 3 – ECal Singles trigger

- Non-optimized ECal thresholds/gains?

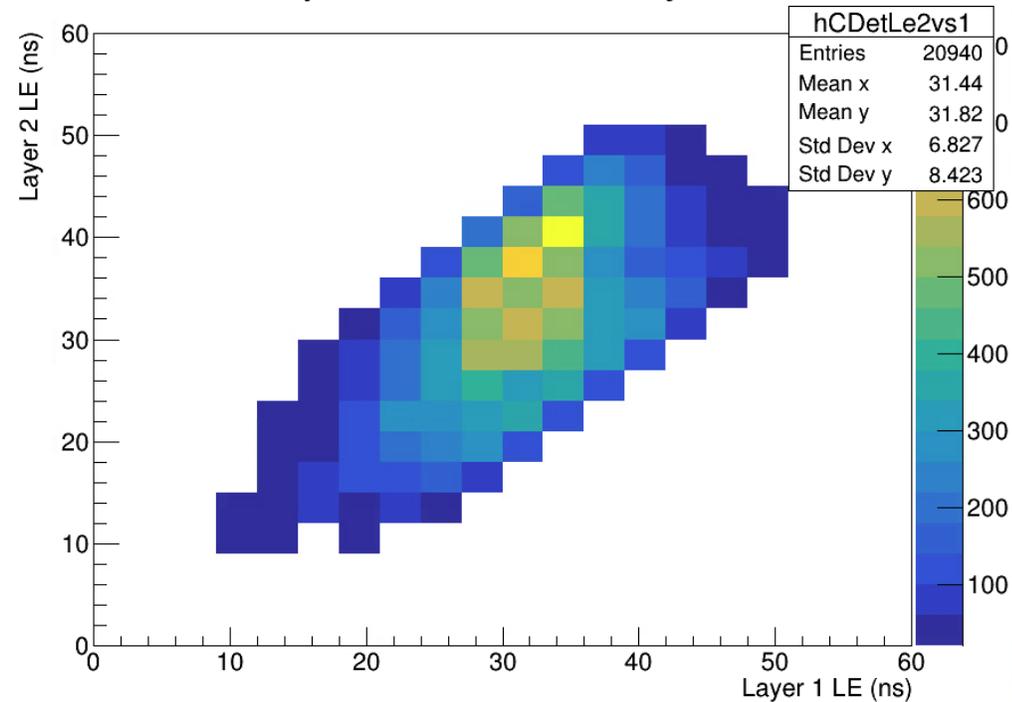
- Reasonable CDet efficiency given requirement for hits in both layers

Analysis in Progress

CDet t vs ECal Time



CDet Layer 2 Time vs CDet Layer 1 Time

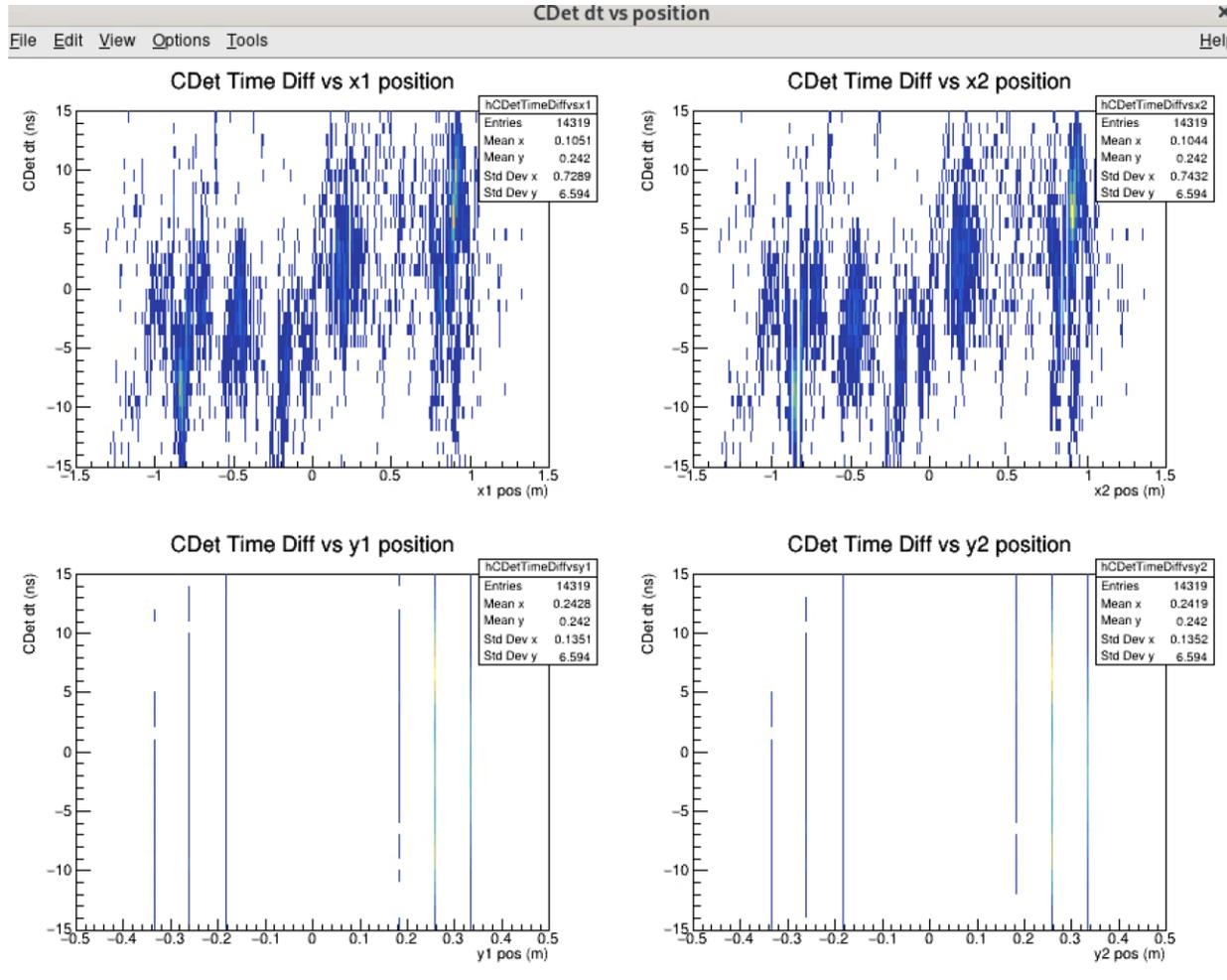


- Run 3575 – 1
uA on carbon
cross target –
Kin 3 – ECal
Singles trigger

- 4ns ECal ADC
Time
resolution

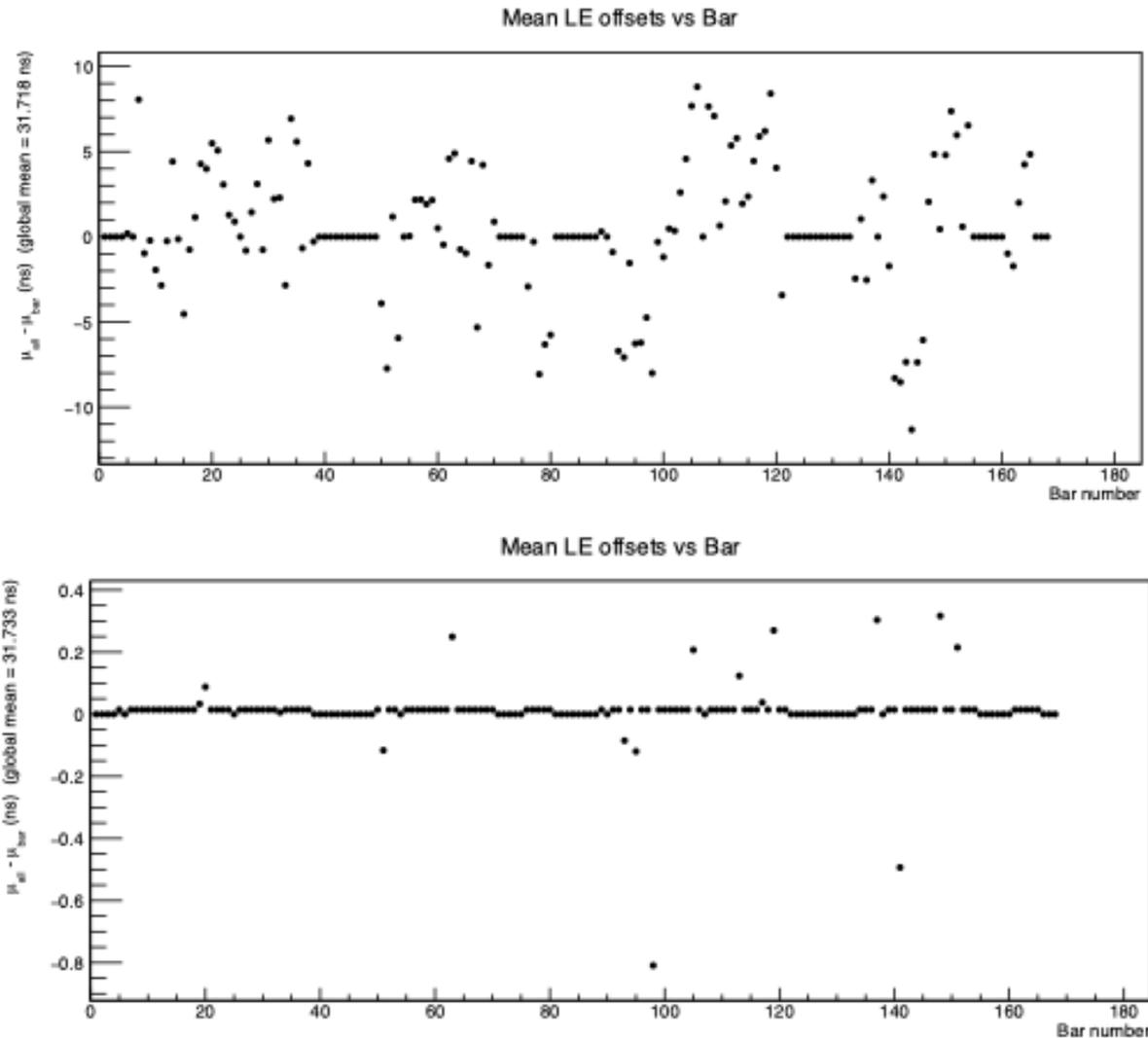
- Limited CDet
time resolution

Analysis in Progress



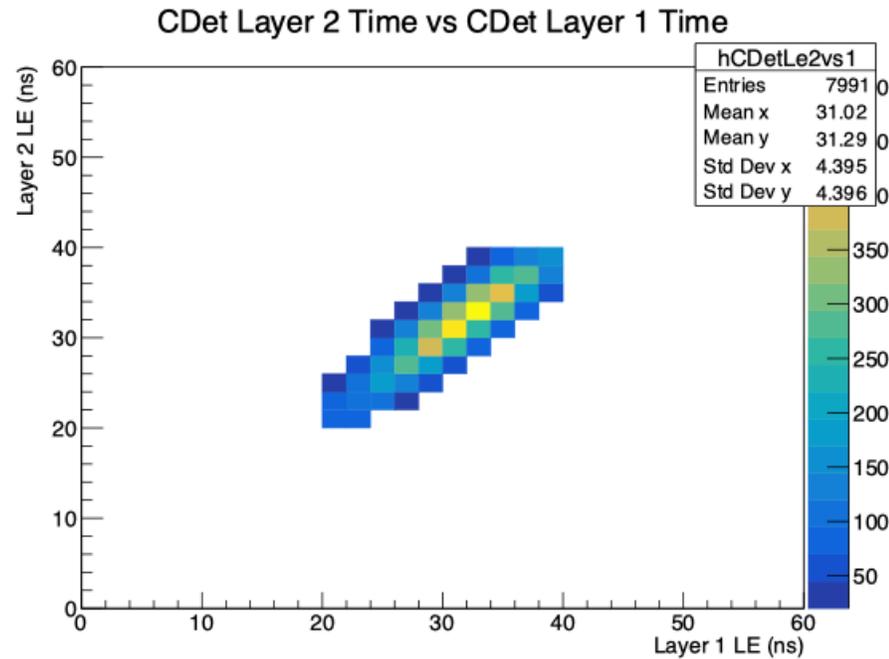
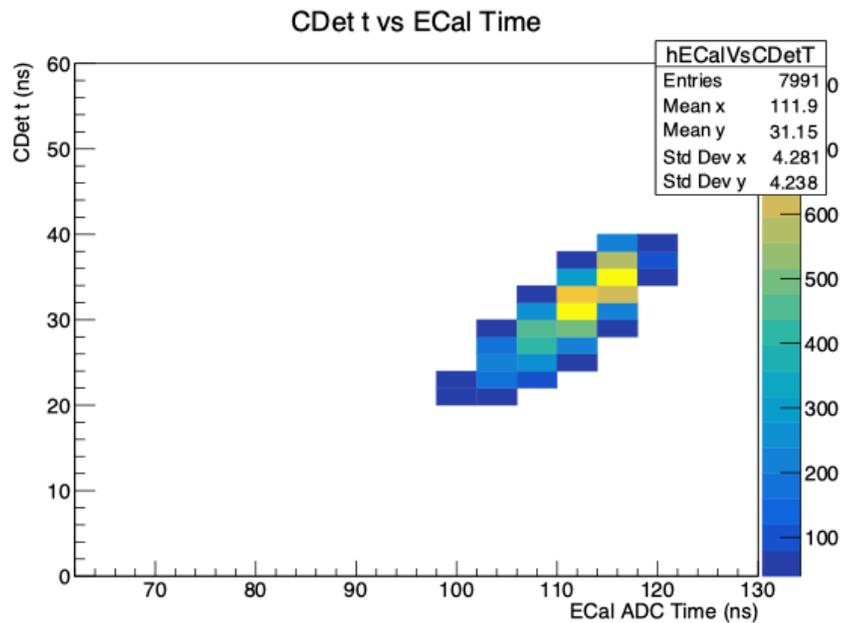
- Run 3575 – 1 uA on carbon cross target – Kin 3 – ECal Singles trigger
- Significant variation in CDet Layer1-Layer2 LE Time difference across the vertical range of the detector
- **Need to implement per PMT T_0 time offsets!**

Analysis in Progress



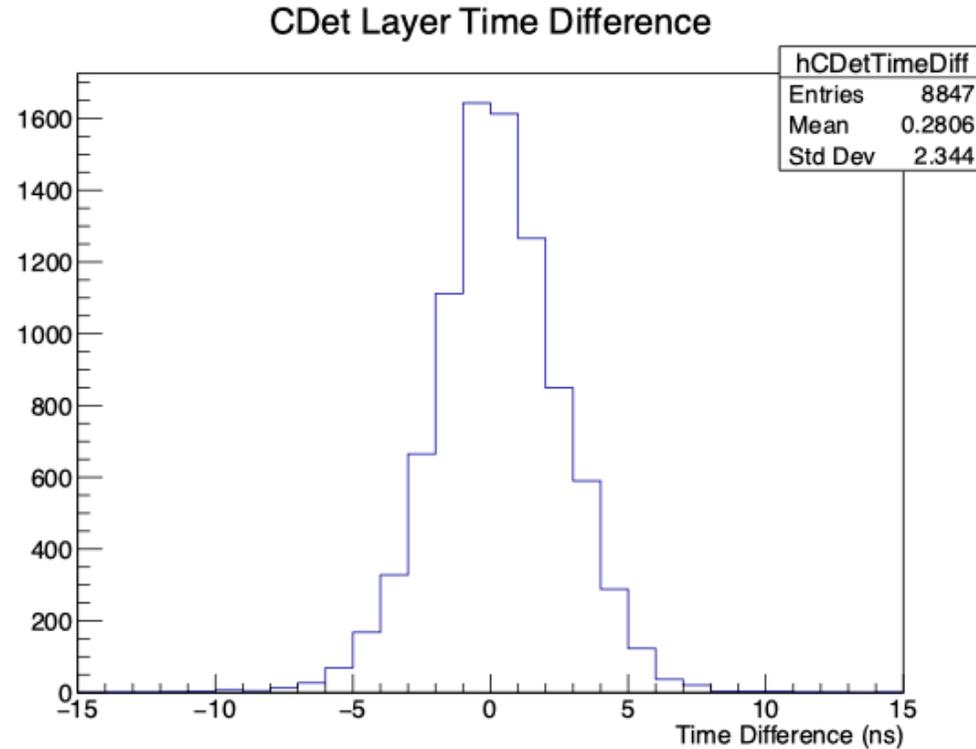
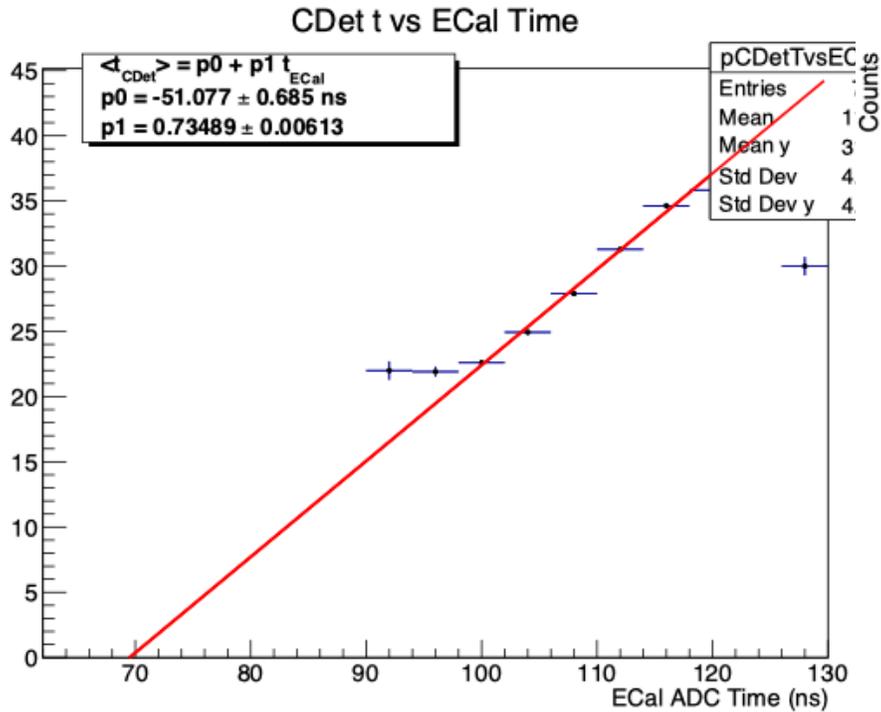
- Run 3575 – 1 uA on carbon cross target – Kin 3 – ECal Singles trigger
- Determine time offsets per bar/PMT
- Source?
 - PMT transit time $\sim 12 \pm 0.3$ ns
 - Cable length variation?

Analysis in Progress



- Run 3575 – 1 uA on carbon cross target – Kin 3 – ECal Singles trigger
- Fit ECal Time Dependence
- Correct Leading and Trailing Edge CDet Times

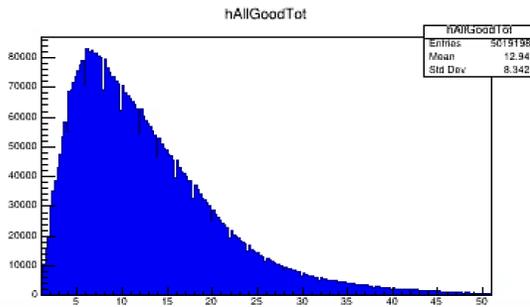
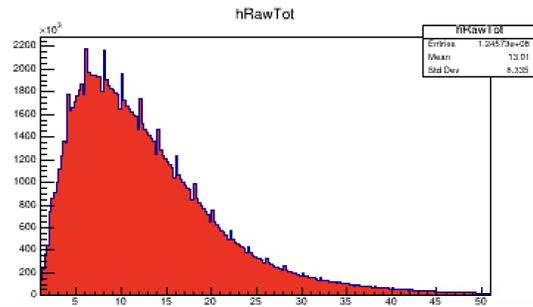
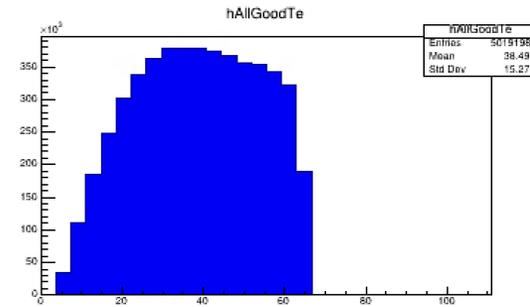
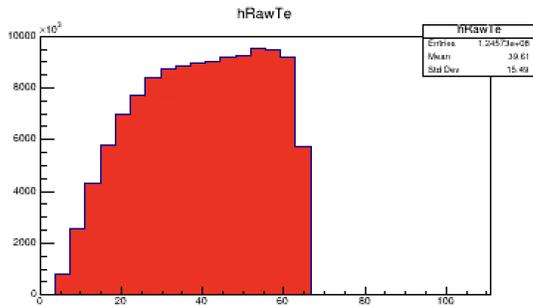
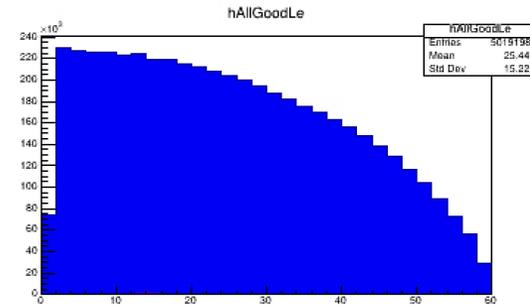
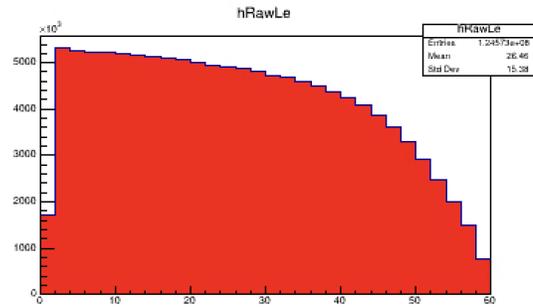
Analysis in Progress



- Run 3575 – 1 uA
on carbon cross
target – Kin 3 –
ECal Singles trigger

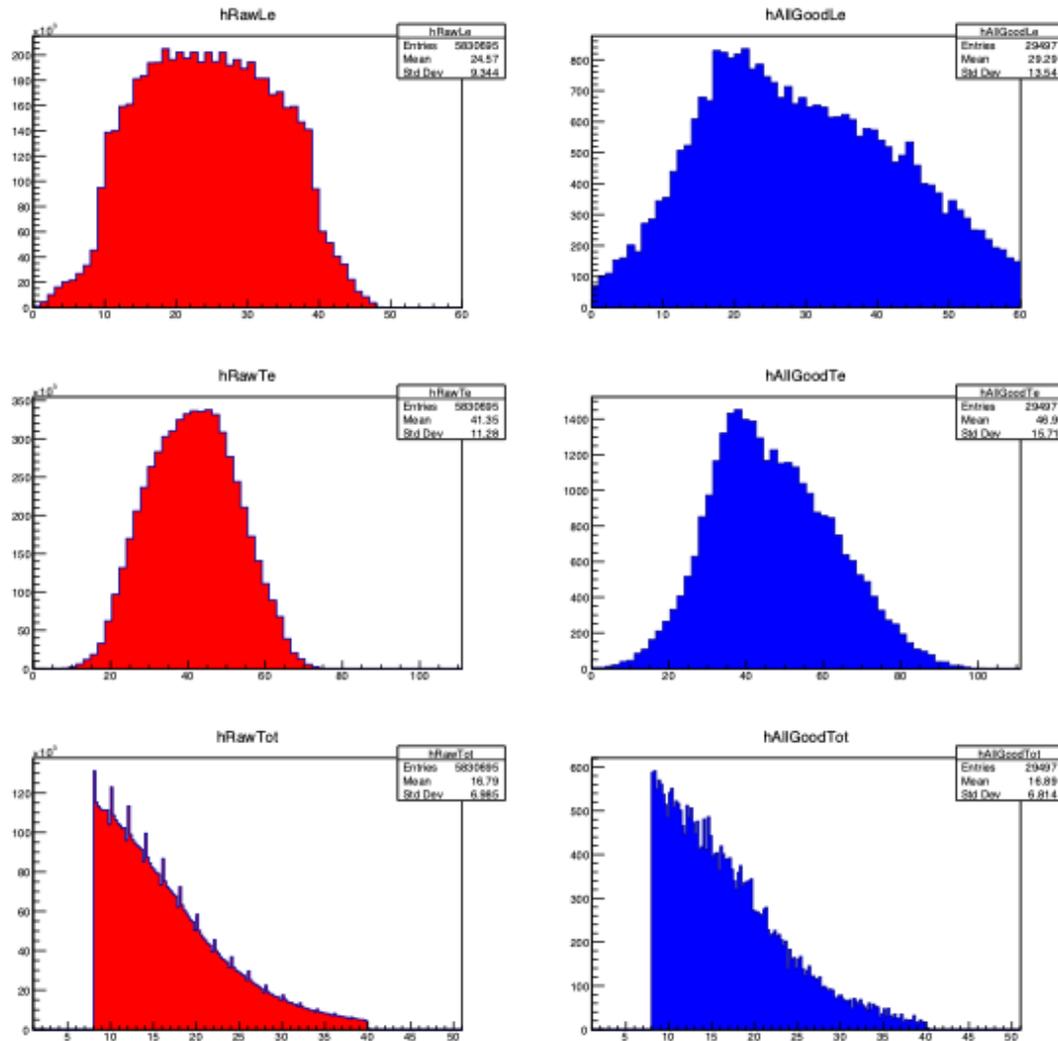
- Single Layer Time
Resolution:
sigma = 1.53 ns

Analysis in Progress



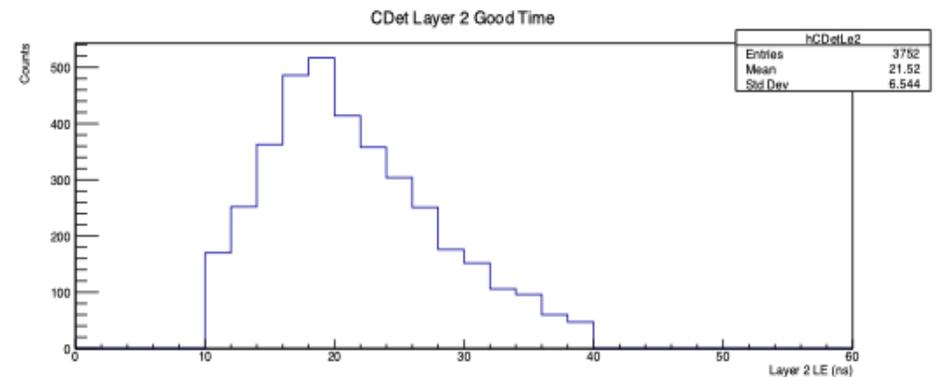
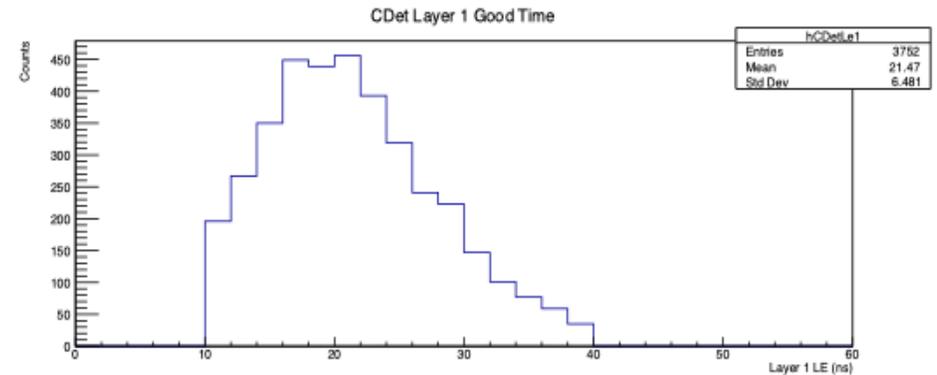
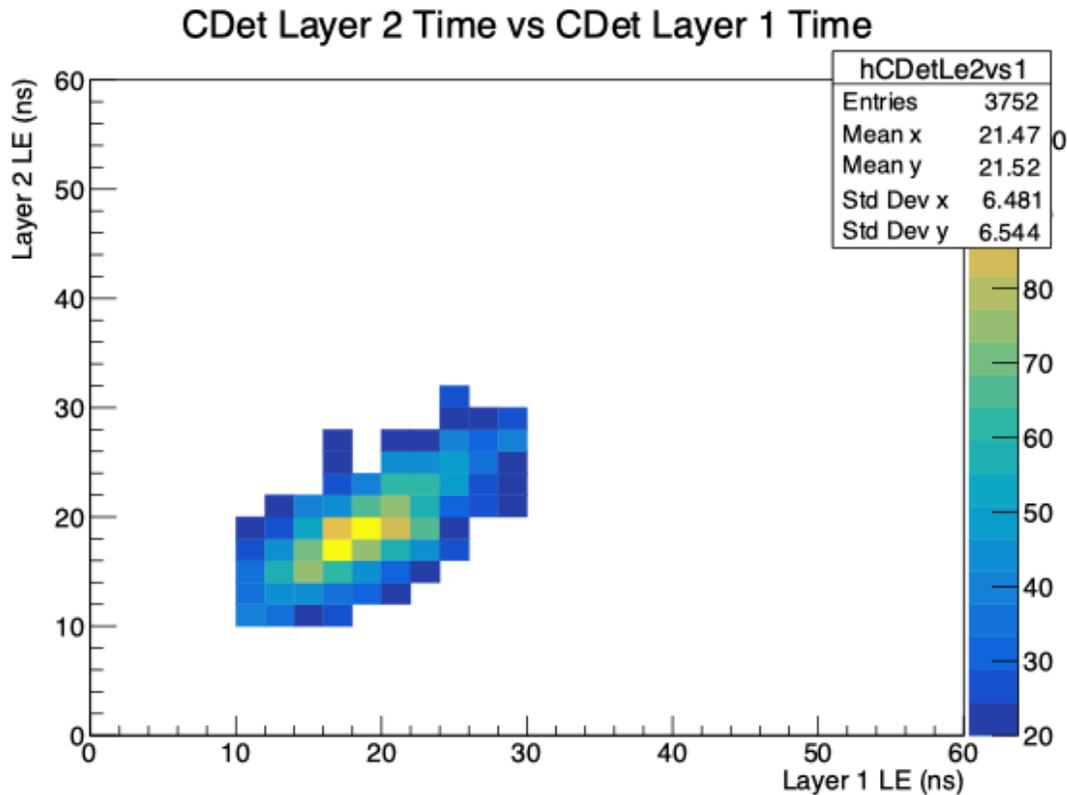
- Run 6077 – 20 uA on LH2 target
 - Kin 3 – Coincidence trigger
 - ~600 hits per event!
-
- “Good” = hit in both layers of CDet, +/- 10 cm of projected ECal x-position

Analysis in Progress



- Run 6077 – 20 uA on LH2 target – Kin 3 – Coincidence trigger
- ~600 hits per event!
- “Good” = hit in both layers of CDet, +/- 1 cm of projected ECal x-position

Analysis in Progress



-Run 6077 – 20 uA on LH2 target – Kin 3 – Coincidence trigger (30000 events)

4ns ECal ADC Time resolution, Limited CDet time resolution

Summary & Conclusions

- Two draft publications (NIM articles) are currently being prepared – one on construction, commissioning, and one on cross-talk studies.
- Please attend the student session, where Ben Spaude will present more details and additional work on LH2!!
- Challenges:
 - Even with absorber in front of CDet, background is still large (~100's to 1)
 - Only have TDC information:
 - Use LE time (and correlations with ECAL), time-over-threshold (crude ADC), and ECal position correlation
 - Goal is to identify hits from primary electron, for use in electron tracking