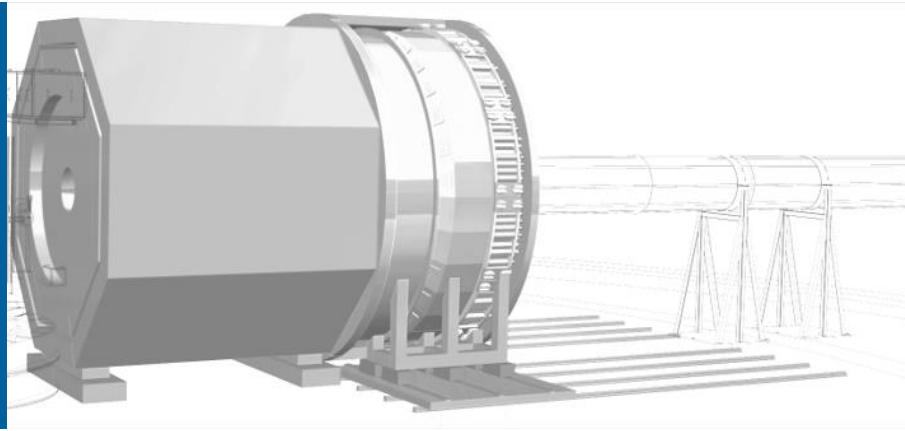
SoLID Collaboration Meeting 2021/06

ANALYSIS AND SIMULATION FOR THE BEAM TEST OF TELESCOPE CHERENKOV PROTOTYPE



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06/10/2021

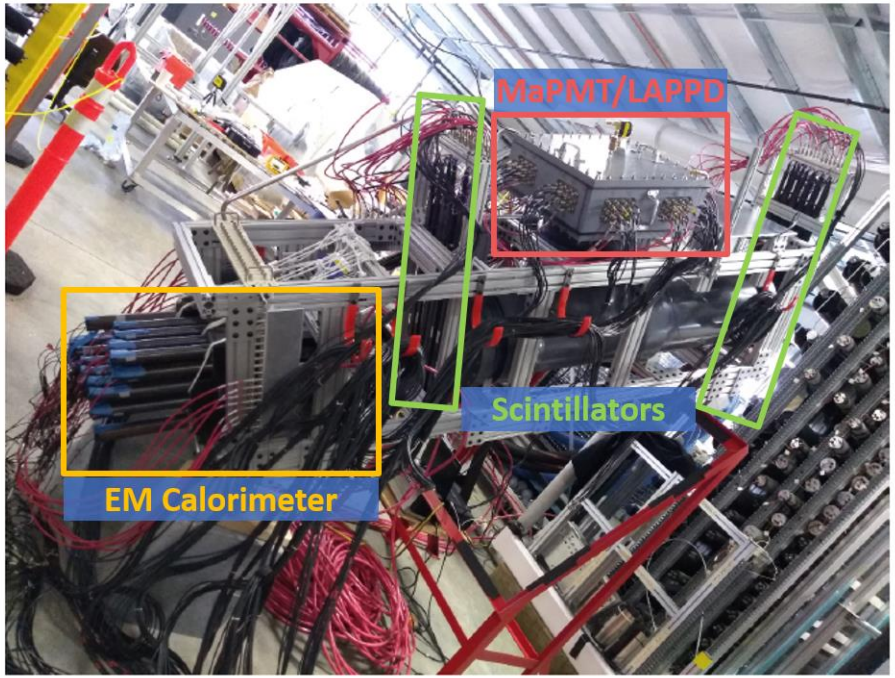
Outline

- Beam Test at Jefferson Lab
- Waveform Data Analysis
- Performance of LAPPD/MaPMT
- Summary and Plans

Telescope Cherenkov Detector Prototype

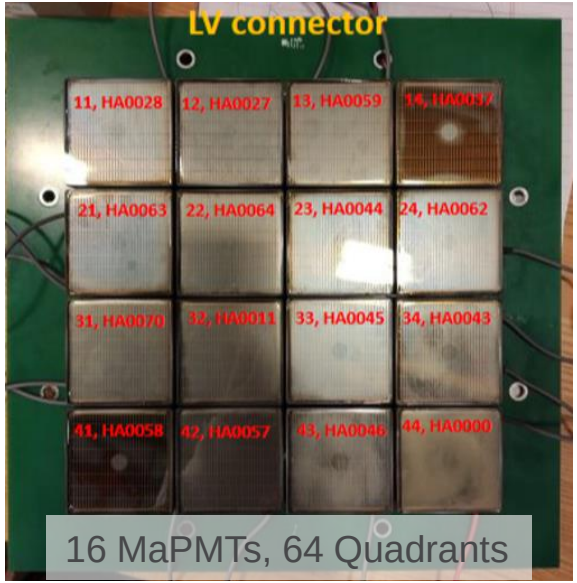
- Detector package includes
  - Cherenkov tank (CO_2 at 0.3 psi)
  - 2 scintillator planes
  - 9 calorimeter blocks
  - 16 MaPMTs (quadrant and sum channels) or LAPPD (64 pixels)

- Readouts: JLab FADC250
  - Raw waveform data recorded
  - 64 samples in 256 ns



Photosensors

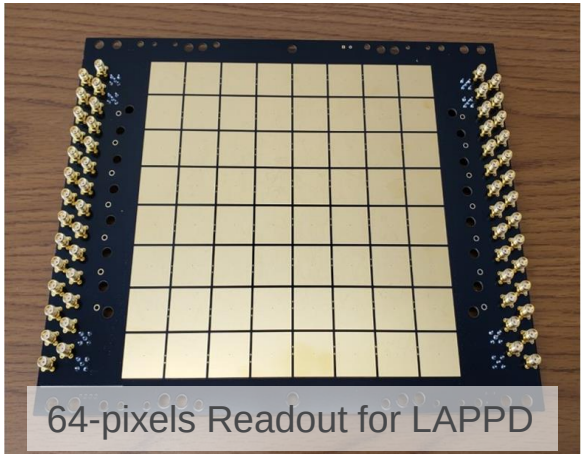
Hamamatsu H12700-03



16 MaPMTs, 64 Quadrants

Incom LAPPD Gen-II


Incom LAPPD 20x20 cm^2


64-pixels Readout for LAPPD

Refer to J. Xie' s talk for more details about LAPPD

Beam Test at JLab

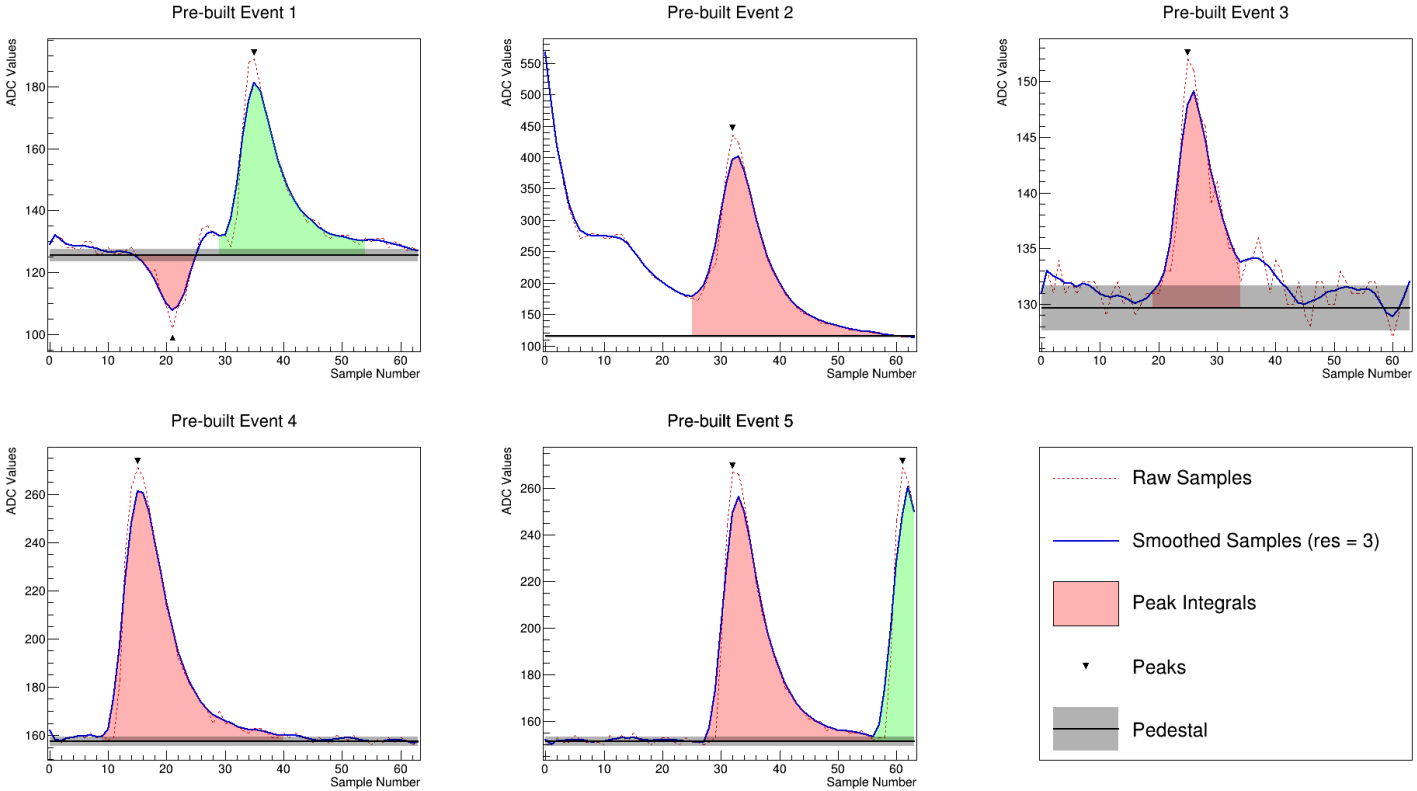
- High rate beam test
  - Parasitic runs in June - August, 2020
  - Small angle with 0.5 – 2 μA beam
  - MaPMTs tested with total rates > 8 MHz per PMT (300 kHz per cm^2)

- Low rate beam test
  - Parasitic runs in August - September, 2020
  - Large angle, rates is one order of magnitude lower

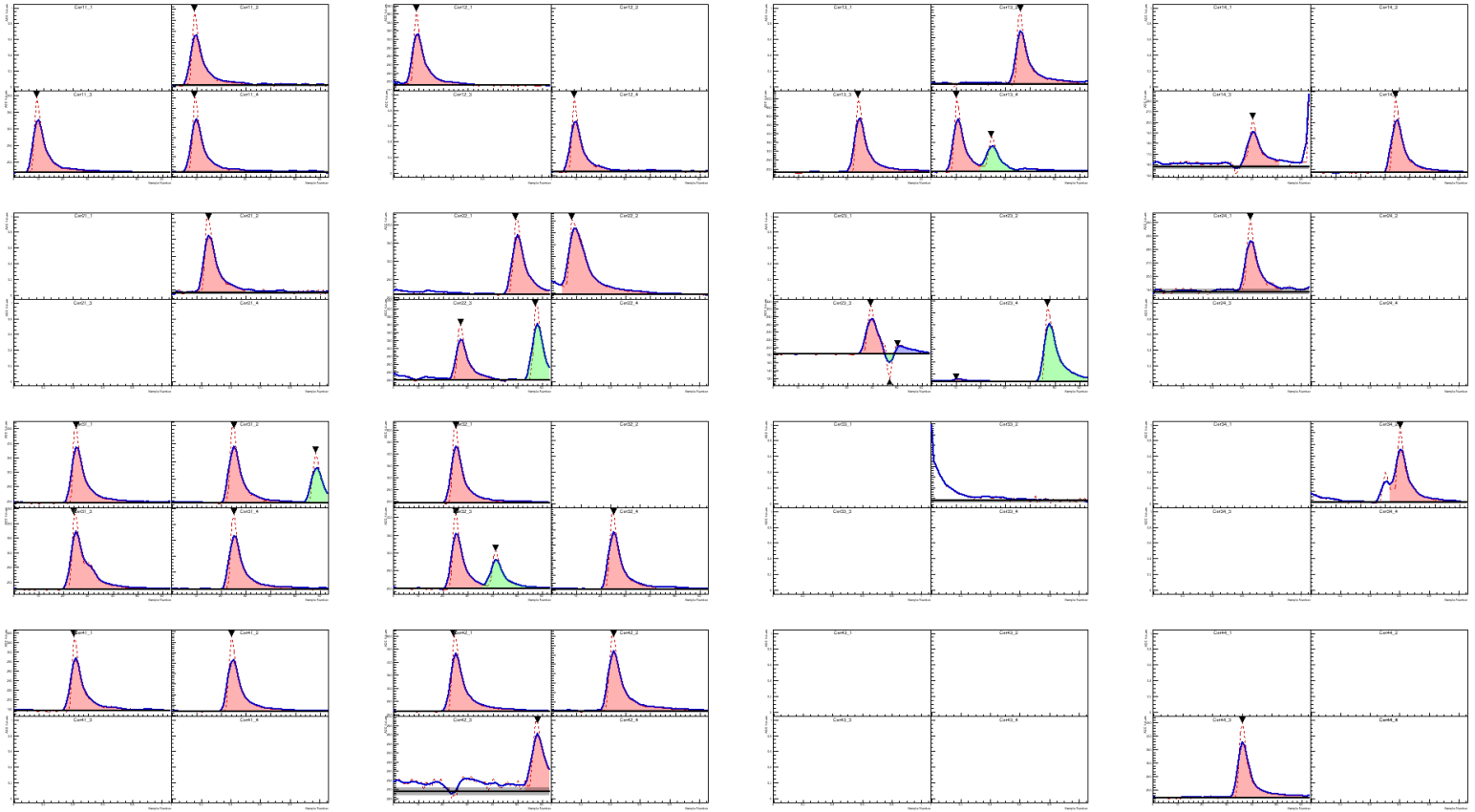
- Bench test for LAPPD and MAROC readouts
  - Analysis is ongoing

Waveform Data Analysis

- 64 samples
- Pedestal
- Peak height
- Peak integral
- Peak timing



Waveform Data Event Samples



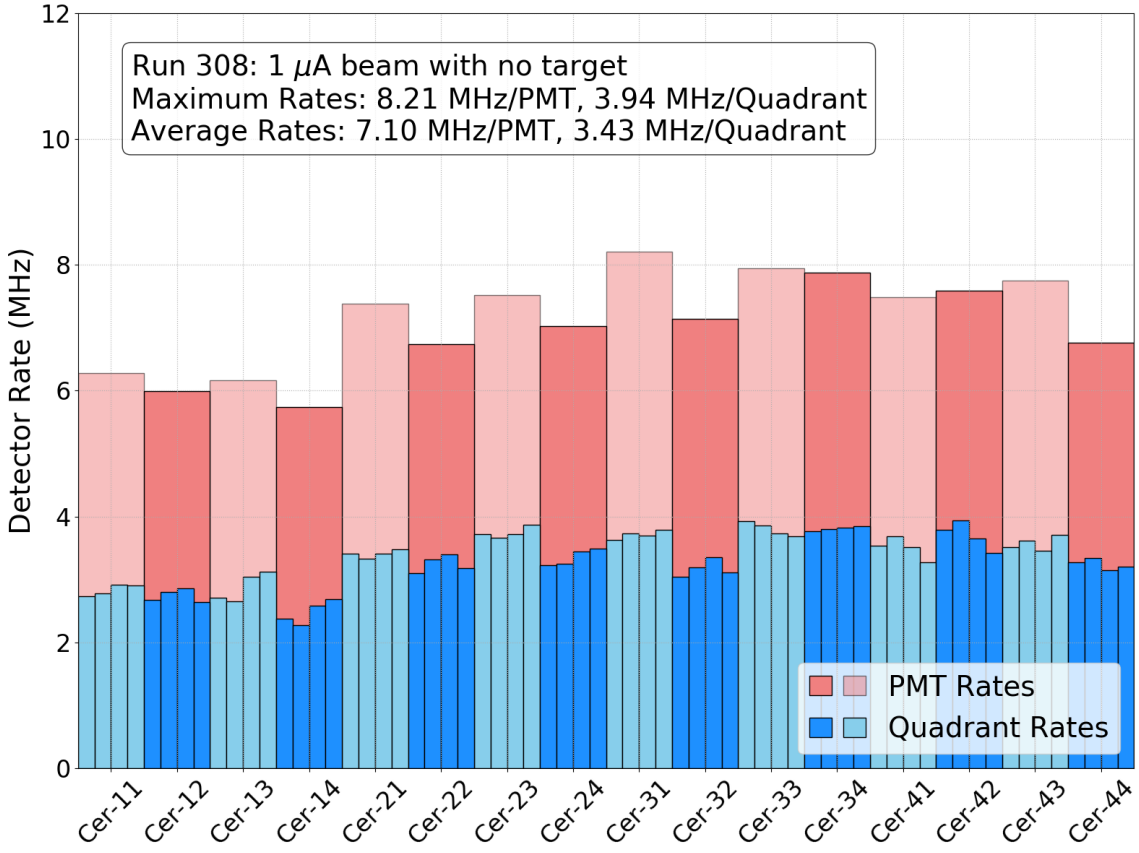
Total Rates from Pulser Triggered Runs

- Reference runs taken before production run
  - Triggered by pulser

- Total rates calculation

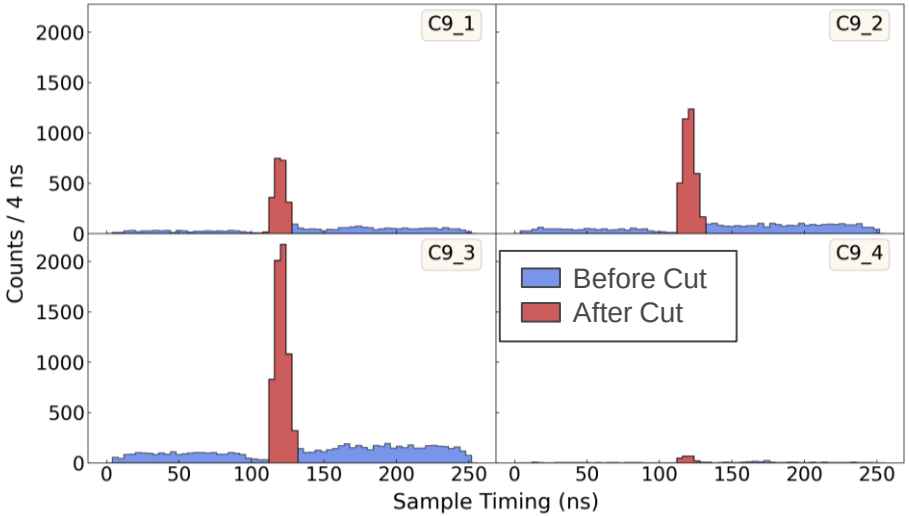
$$\frac{\overline{N_{peak}}\ per\ window}{T_{win}(256\ ns)}$$

- Peak height threshold
  - 0.25 SPE, max. 8 MHz/PMT
  - 1.0 SPE, max. 7 MHz/PMT

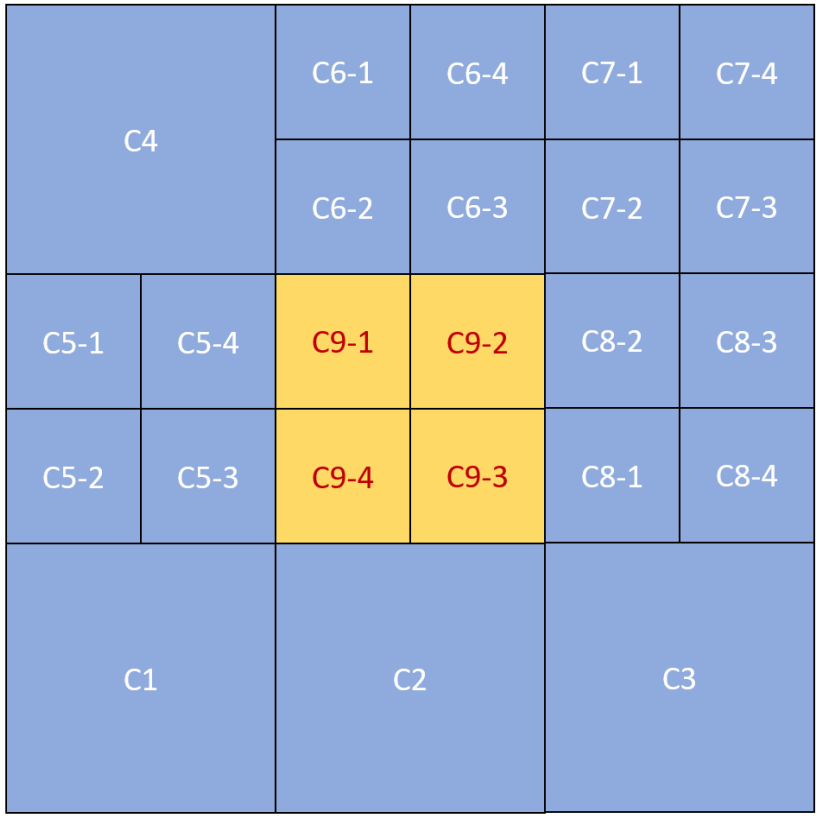


Calorimeter Trigger Cut

- Cut on central sub-blocks to select events with full acceptance
- Cut calorimeter timing with 20 ns window

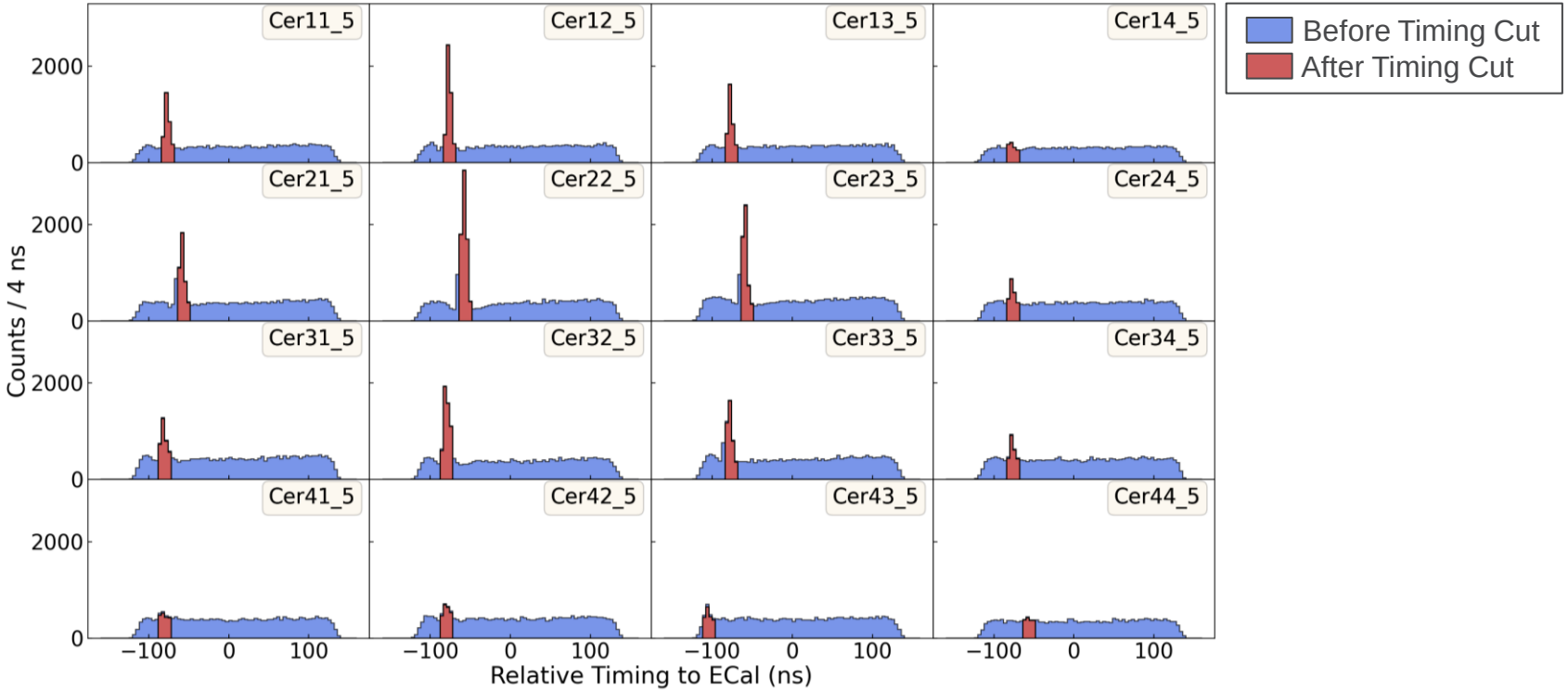


Back View

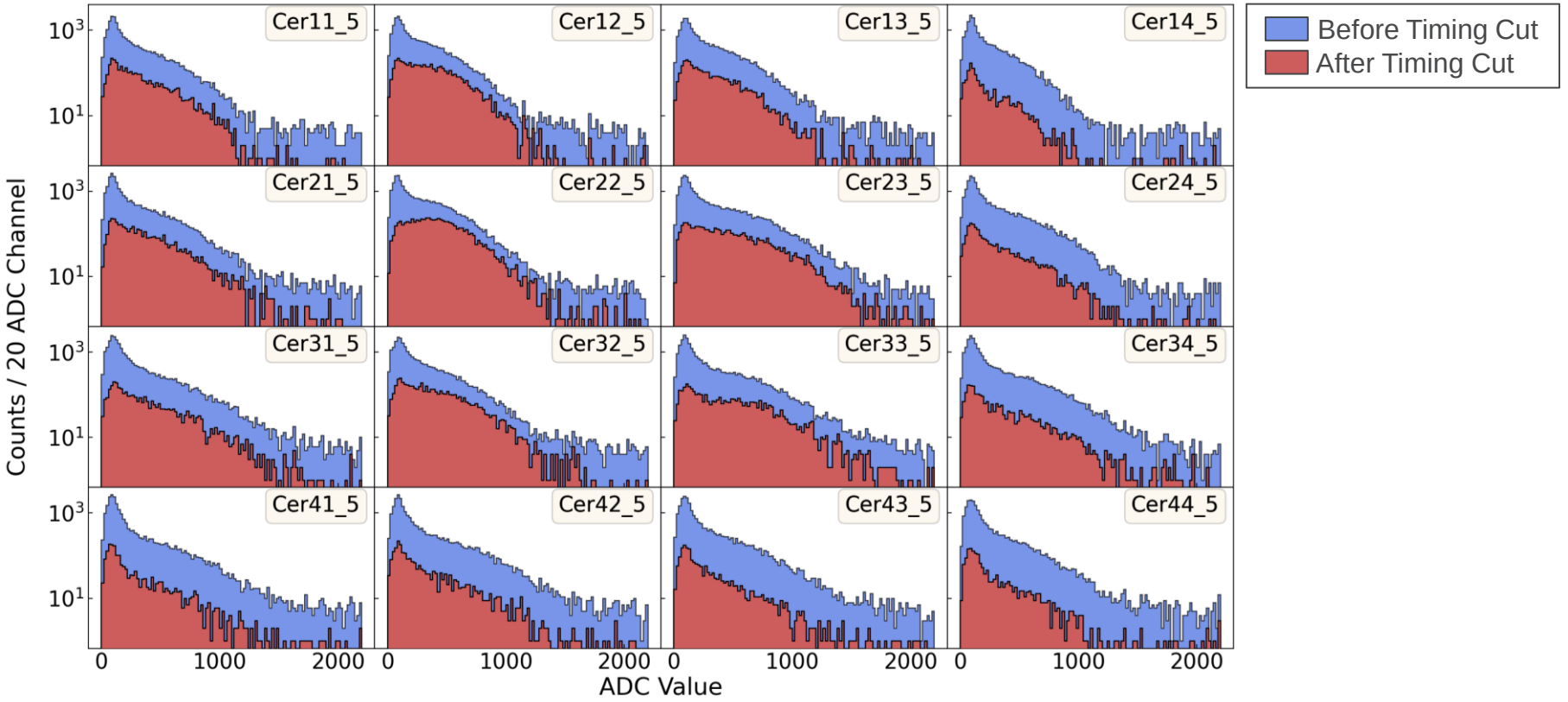


Signal Timing Cuts

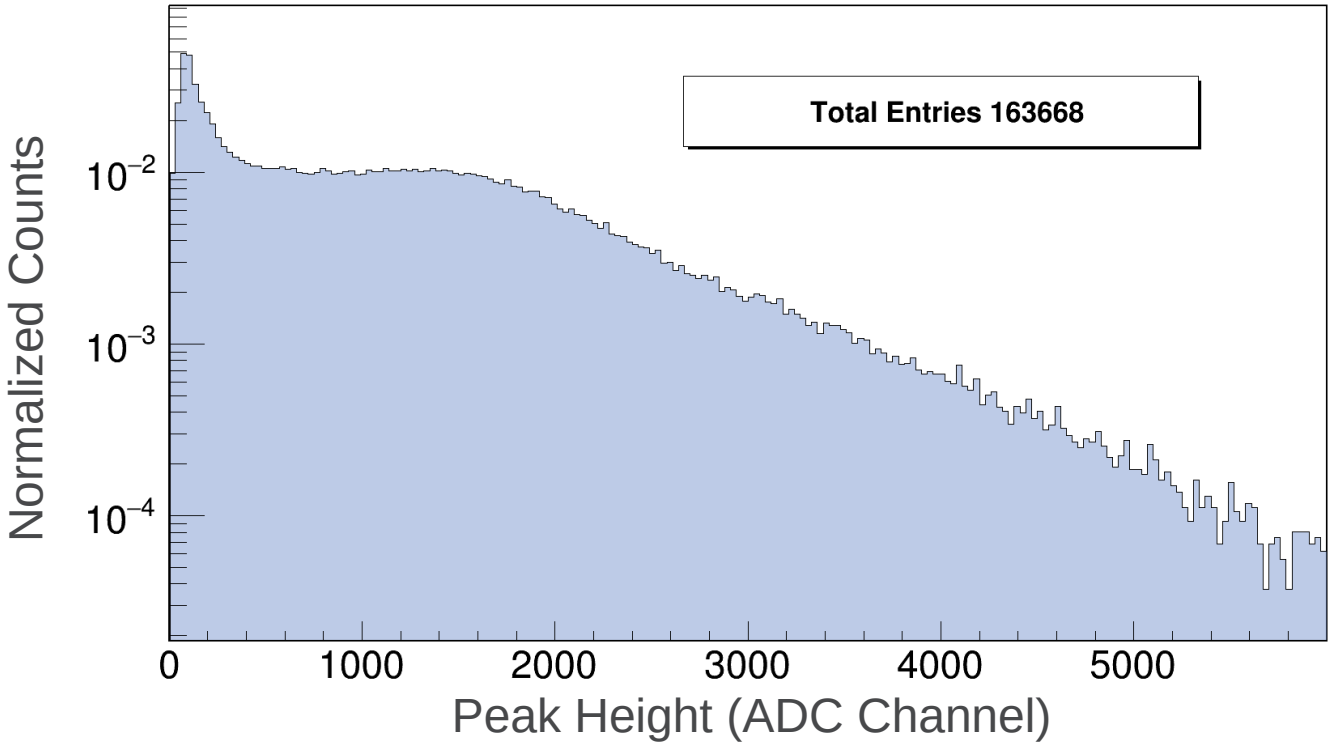
- Timing relative to the triggered calorimeter channel, ± 10 ns



Signal Height Distributions

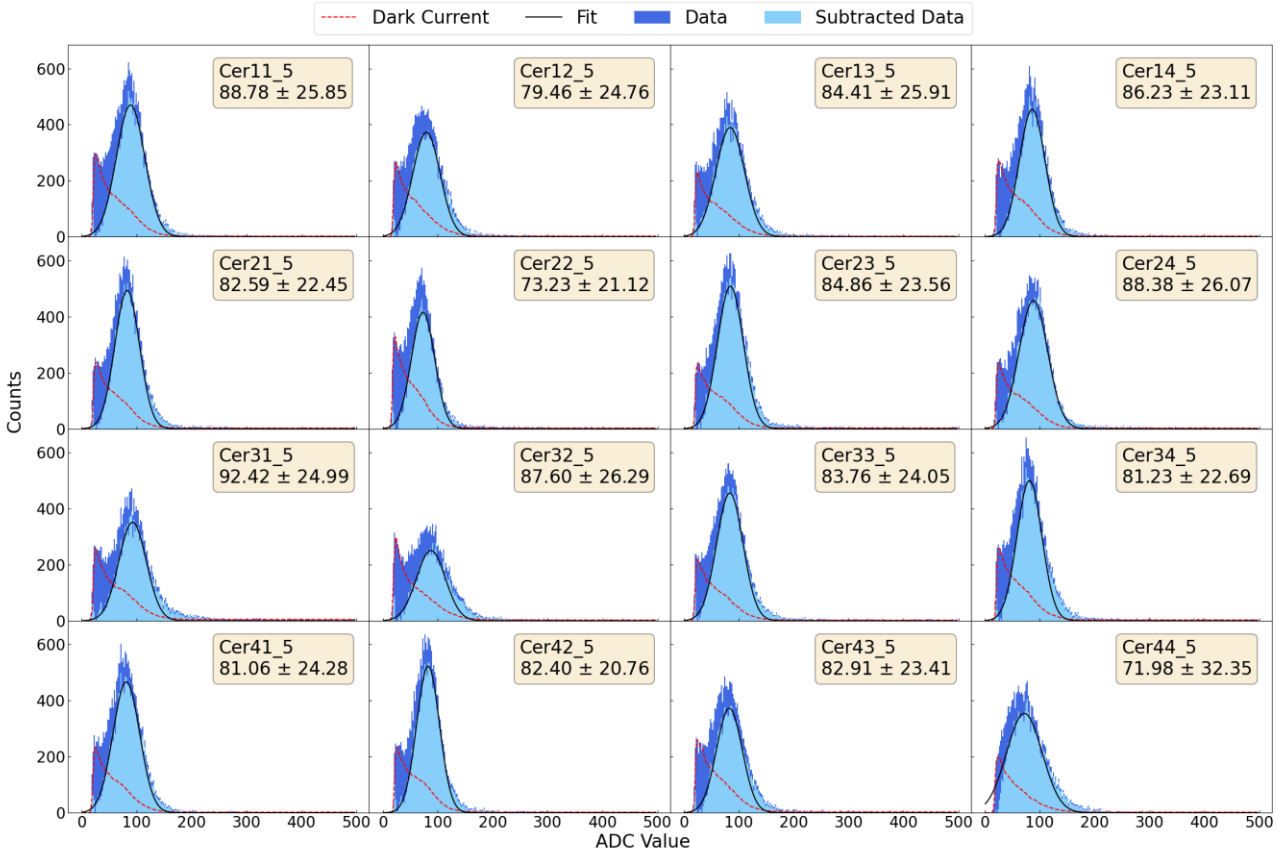


Signal Sum

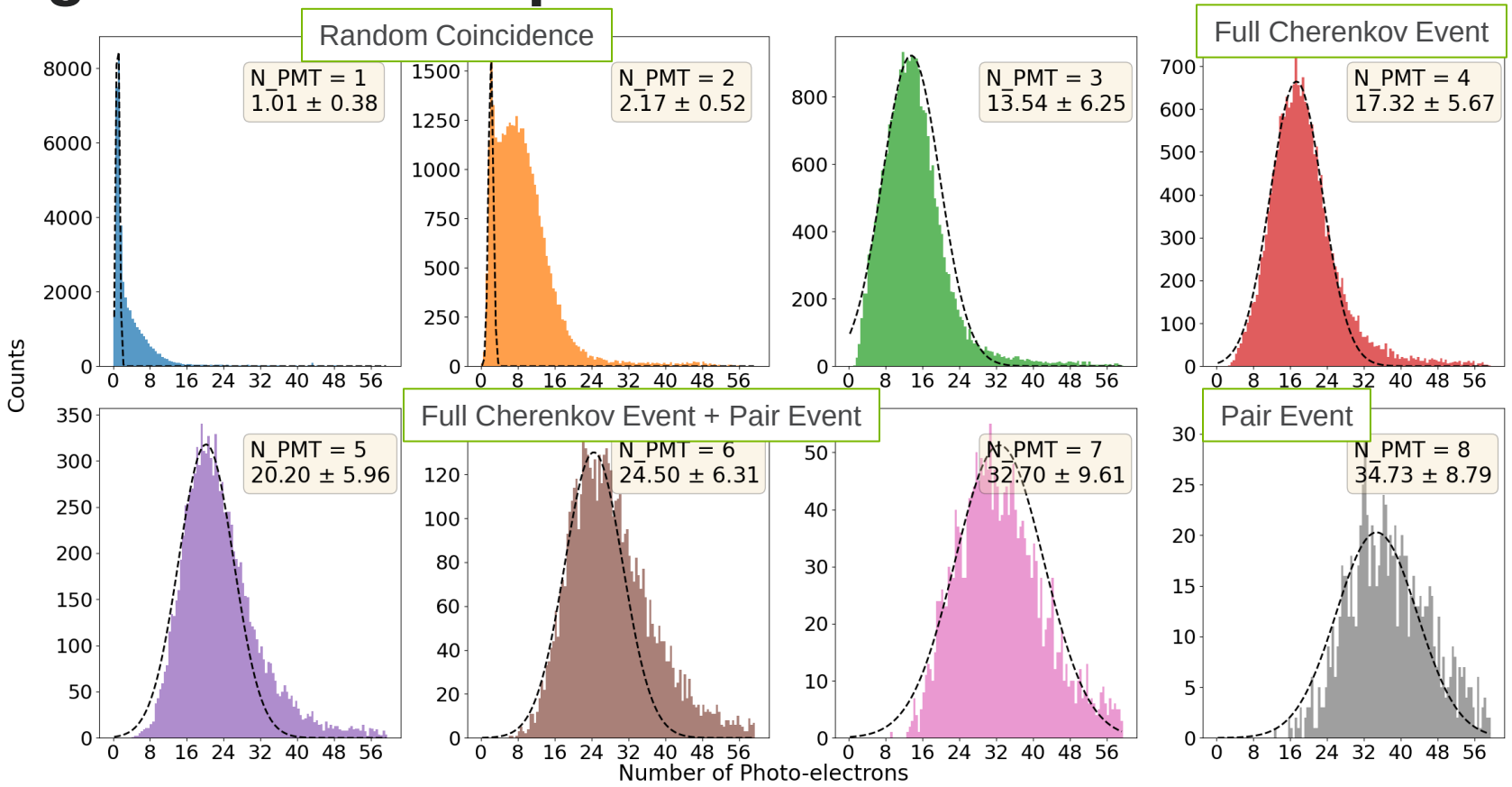

Total Entries 163668
Normalized Counts
10^{-2}
10^{-3}
10^{-4}
0
1000
2000
3000
4000
5000
Peak Height (ADC Channel)

Single Photo-Electron Signals

- Data off the timing cuts
- SPE ~ 80 ADC Channel
- Used to calculate NPE for each channel



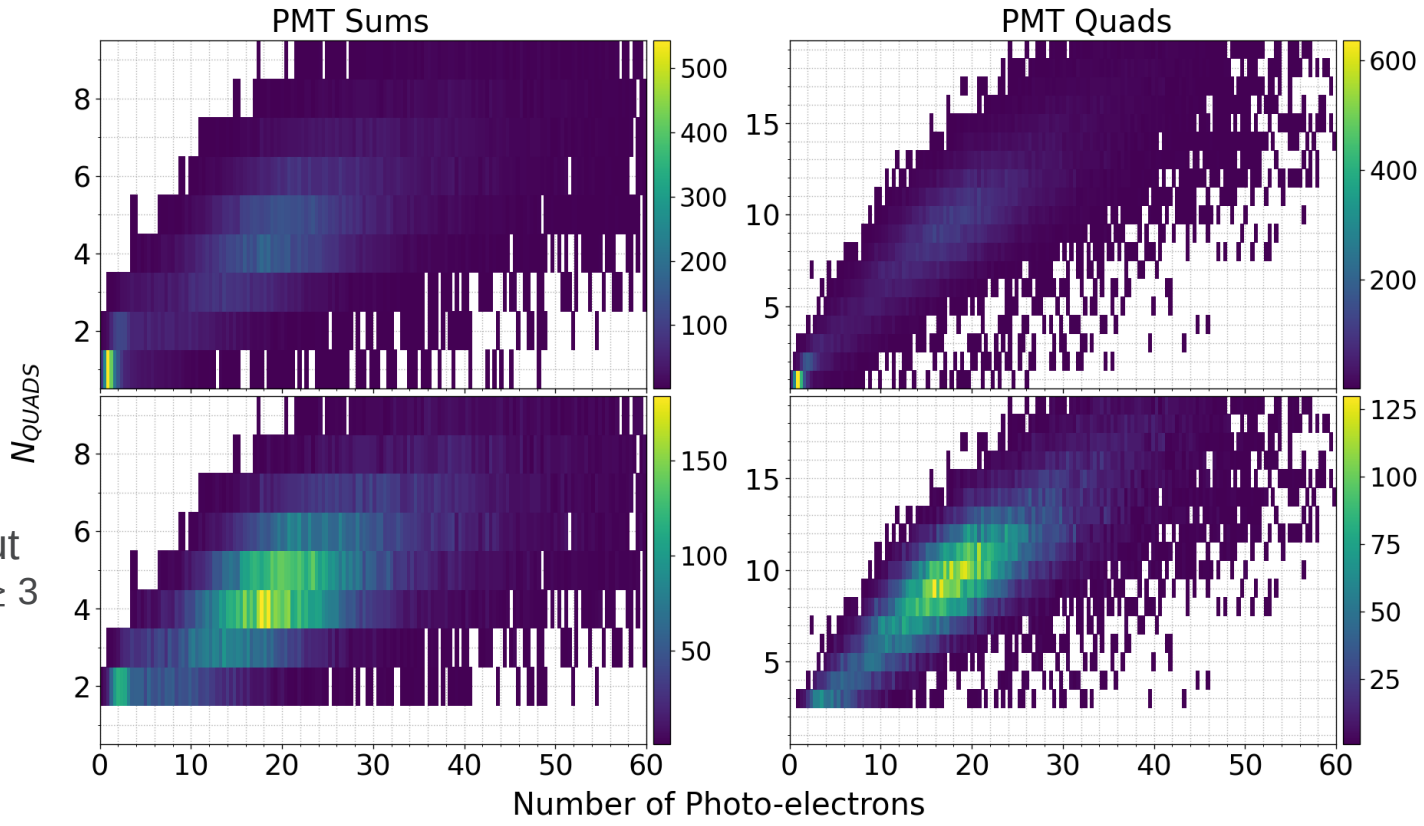
Signal Sum Groups



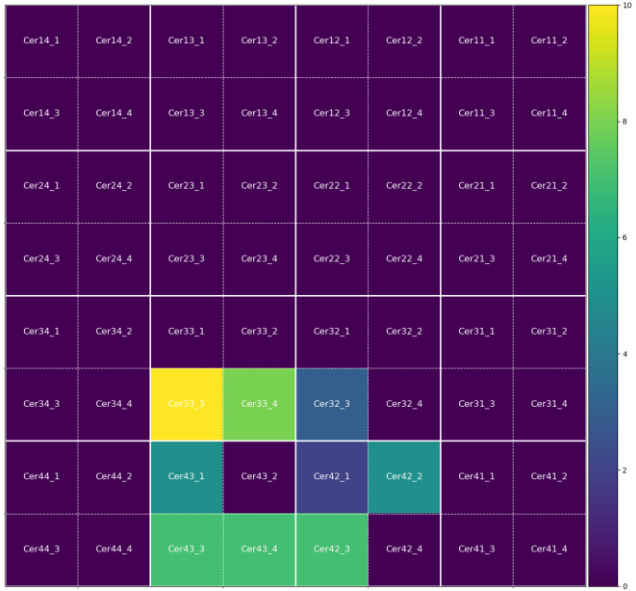
MaPMT Performance

- Signal Center
  NPE = 18
  N_{PMT} = 4
  N_{Quad} = 9,10

- Coincidence Cut
  $N_{PMT} \geq 2$, or $N_{Quad} \geq 3$



Event Samples



Cherenkov Signal

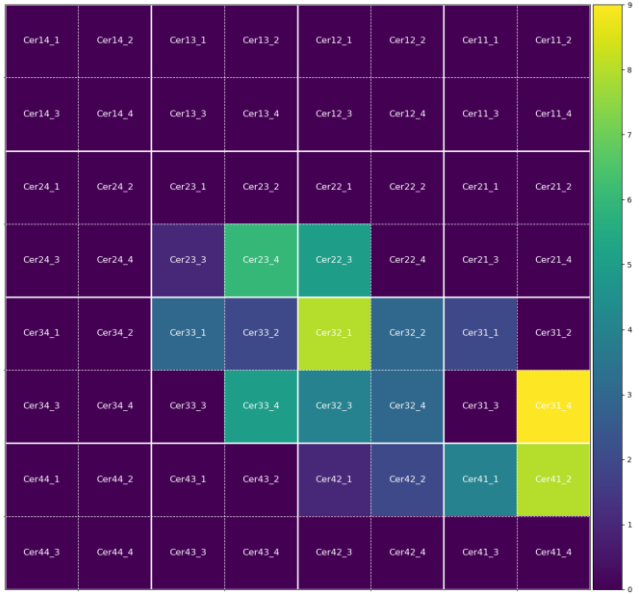
4 PMT Sum Channels

9 Quadrant Channels

Pair Production Signal

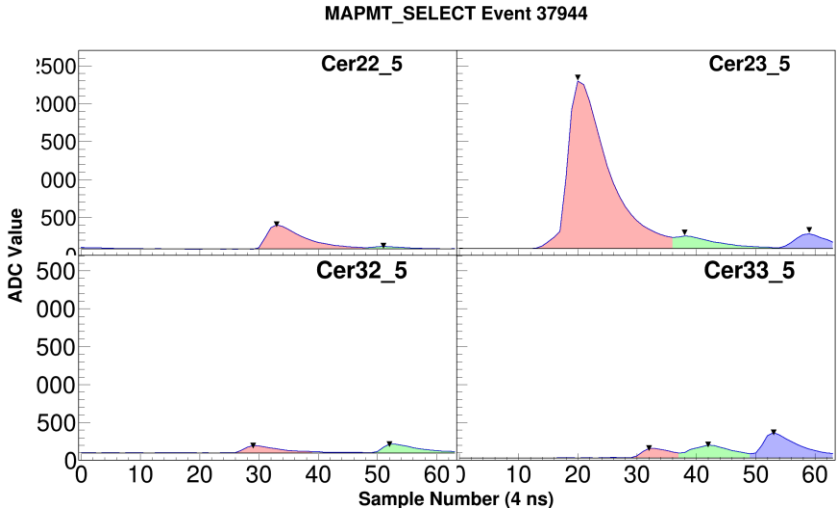
7 PMT Sum Channels

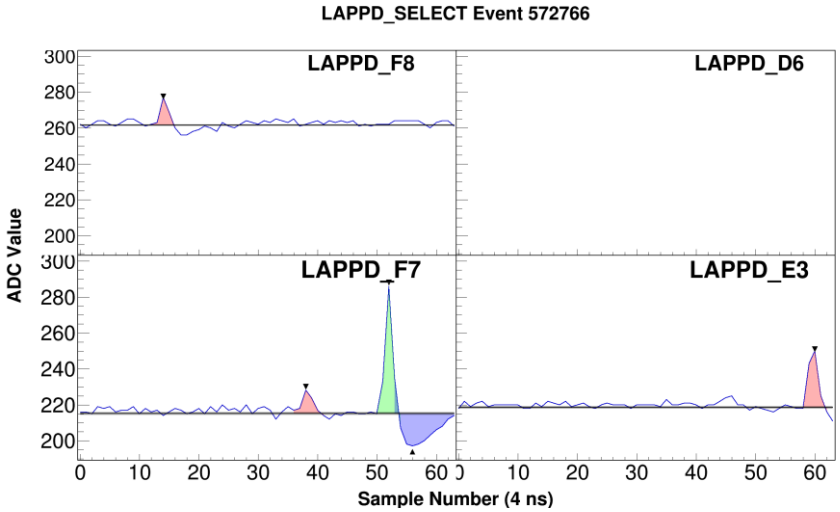
16 Quadrant Channels



MaPMT/LAPPD Comparison

- LAPPD signals are much narrower, but with lower amplitudes

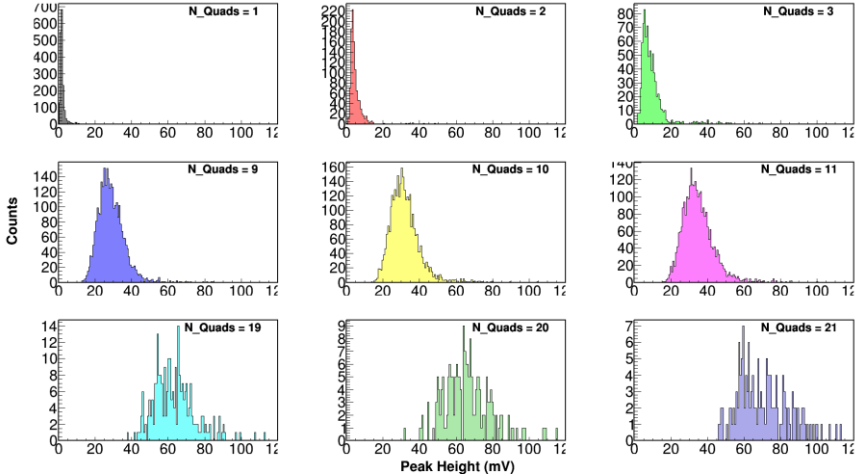




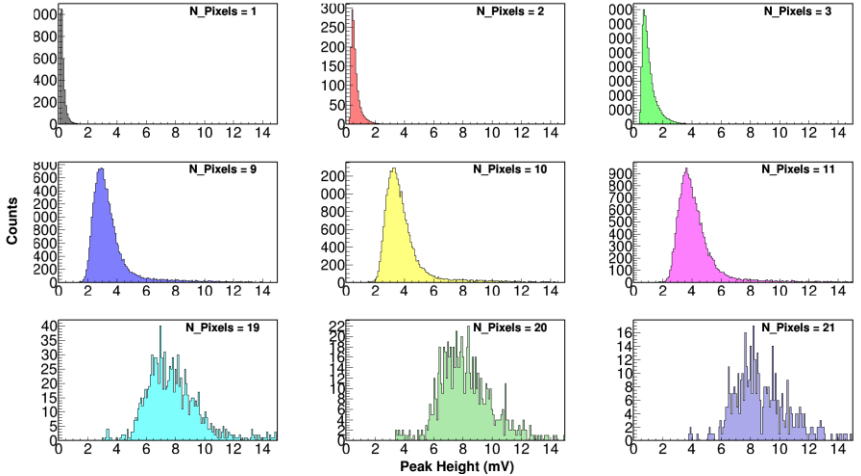
MaPMT/LAPPD Comparison

- Similar analysis has been performed on LAPPD data (low rate)
- LAPPD results behave similarly to MaPMT (low rate)
- Signal amplitudes are significantly lower in beam-test than that in gain-matching

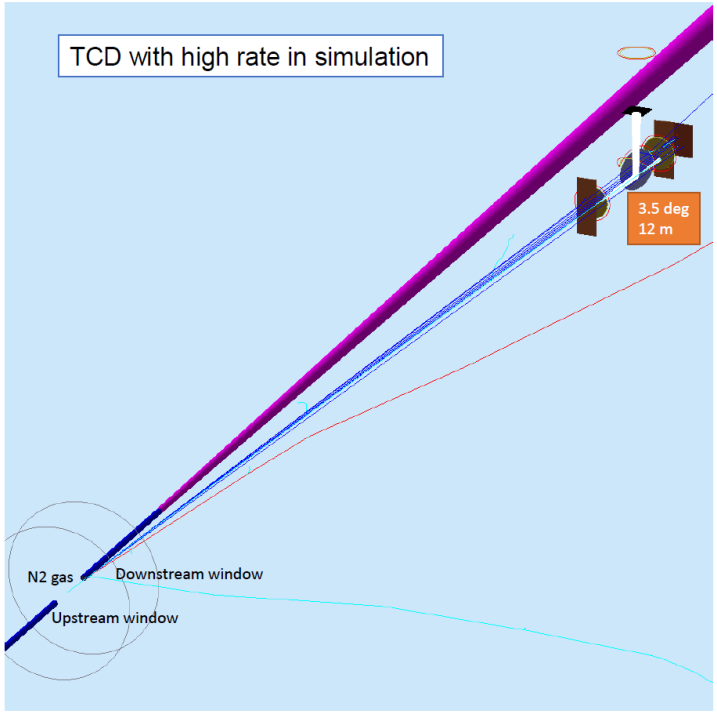
MaPMT



LAPPD



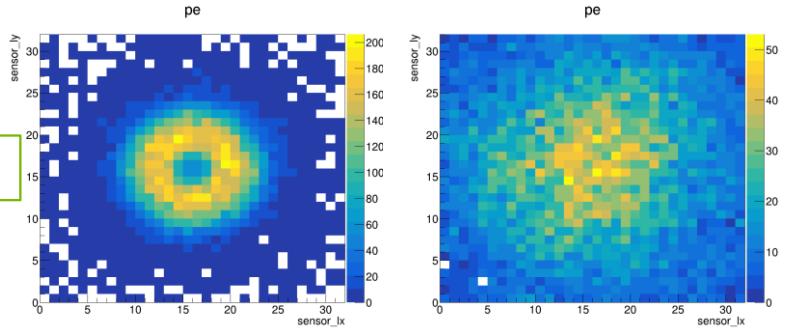
Simulation



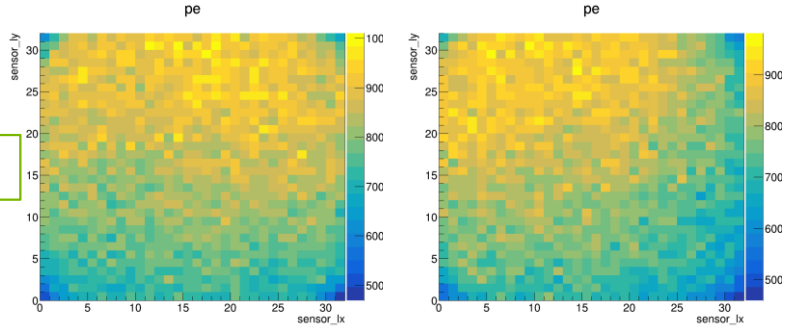
TCD only

TCD + beamline

e central



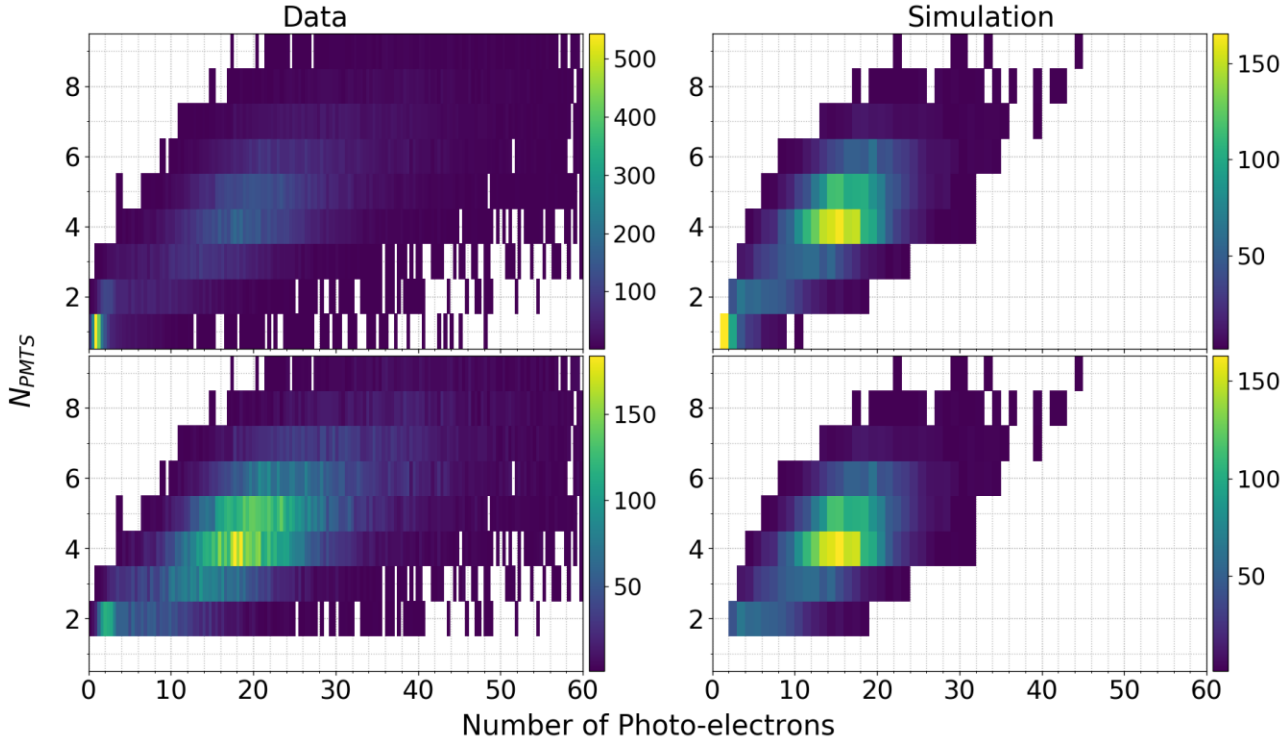
e broad



Courtesy of Zhiwen Zhao

Simulation vs. Data

- Simulation results of NPE scaled by 0.6



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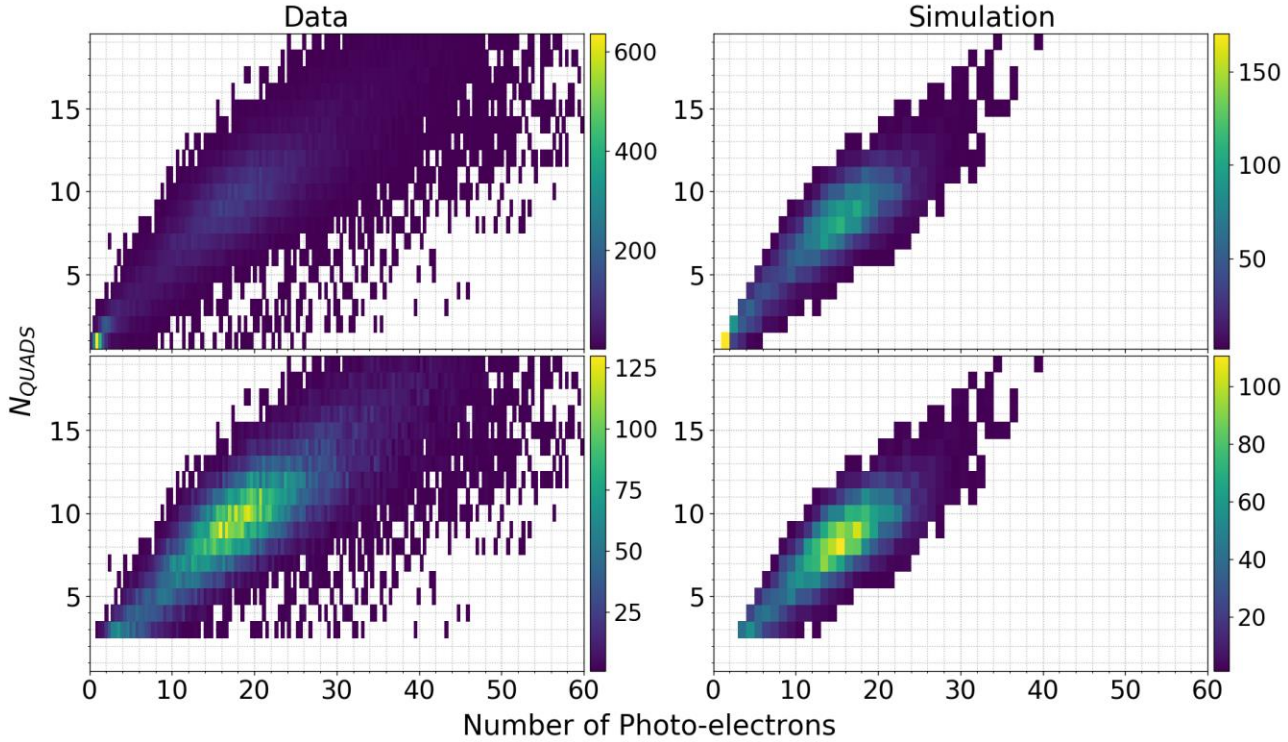

Summary and Plans

- MaPMT works well in a high-rate environment of 300 kHz per cm^2
  - Satisfy the requirement
  - Majority of the random background can be rejected by requiring coincidence between different PMTs/Quadrants

- LAPPD exhibits a similar performance
  - High magnetic field tolerance, narrow signal
  - Significantly lower amplitudes from beam-test data than that from oscilloscope

- Plans
  - Comparison study of MaPMT high-rate test taken with different beam currents
  - Investigate the “0.6” factor needed for simulation to match the data
  - Investigate the LAPPD signal amplitudes with bench test data