Cherenkov pre-R&D Beam Test

SoLID Collaboration Meeting – Oct 8-9 2020

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Outline

Update since the last SoLID Collaboration meeting: we tested maPMTs in a high-rate environment and LAPPD in a low-rate environment

→ Low-rate beam test of maPMTs: March 14 – March 24 2020
(see my update at the previous SoLID Collaboration meeting)

→ High-rate beam test of maPMTs: June 10 – August 7 2020
- → installation
- → calibrations
- → data taking
- → online data analysis

→ Low-rate beam test of LAPPD: August 11 – September 21 2020
- → installation
- → calibrations
- → data taking
- → online data analysis

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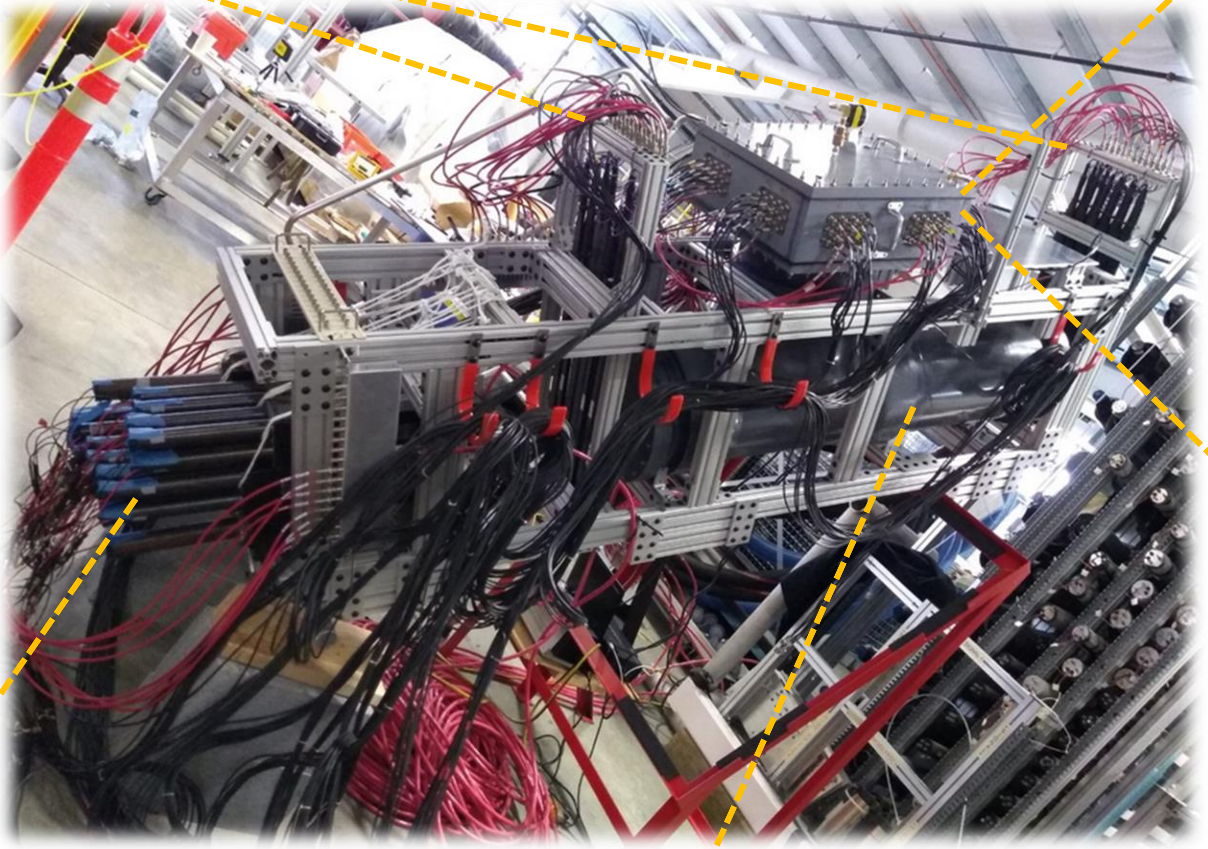
The Detector Package: TCD

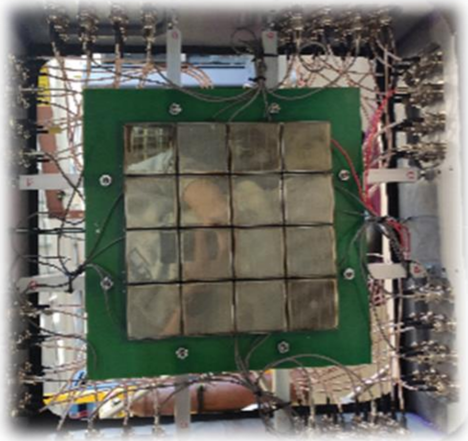
→ Two scintillator planes flanking the Cherenkov tank

22 paddles: ~ 1 inch width, 0.25 inch overlap between paddles; readout 0.5 inch Hamamatsu PMTs

I calibrated the paddles/PMTs with a ^{60}Co source to get a signal of ~ 200 mV amplitude



1) Box containing the 16 maPMTs tile on the electronics board



2) Box containing the LAPPD

→ 9 calorimeter blocks (Shashlyk type) arranged in a 3 x 3 array; 4 locks are read by one PMT only (per block) while the remaining 6 are read by 4 PMTs (per block) – I gain matched the blocks with comics

→ Cherenkov tank (PVC) - 5 feet long and 1.25 feet diameter – and support (cradle) built at Temple U and delivered to JLab at the beginning of February

22 scintillator channels
24 calorimeter channels
80 maPMT/64 LAPPD channels

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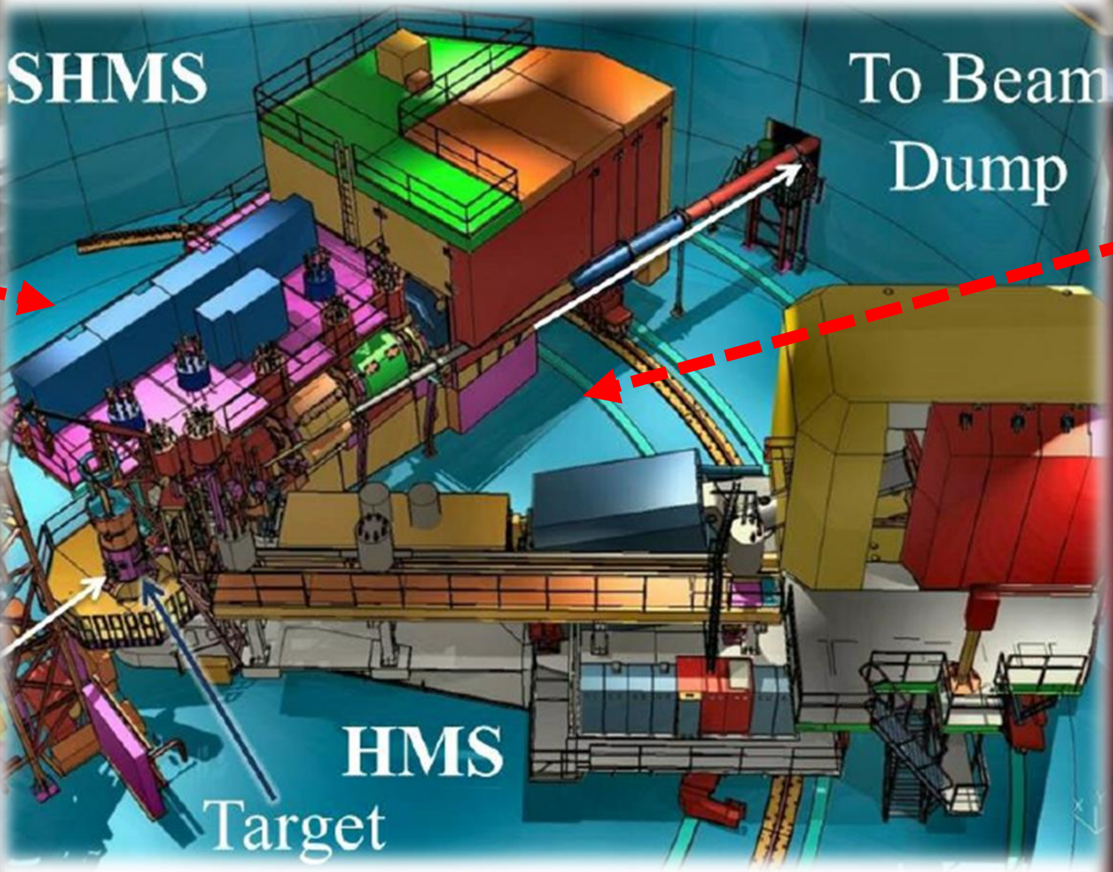
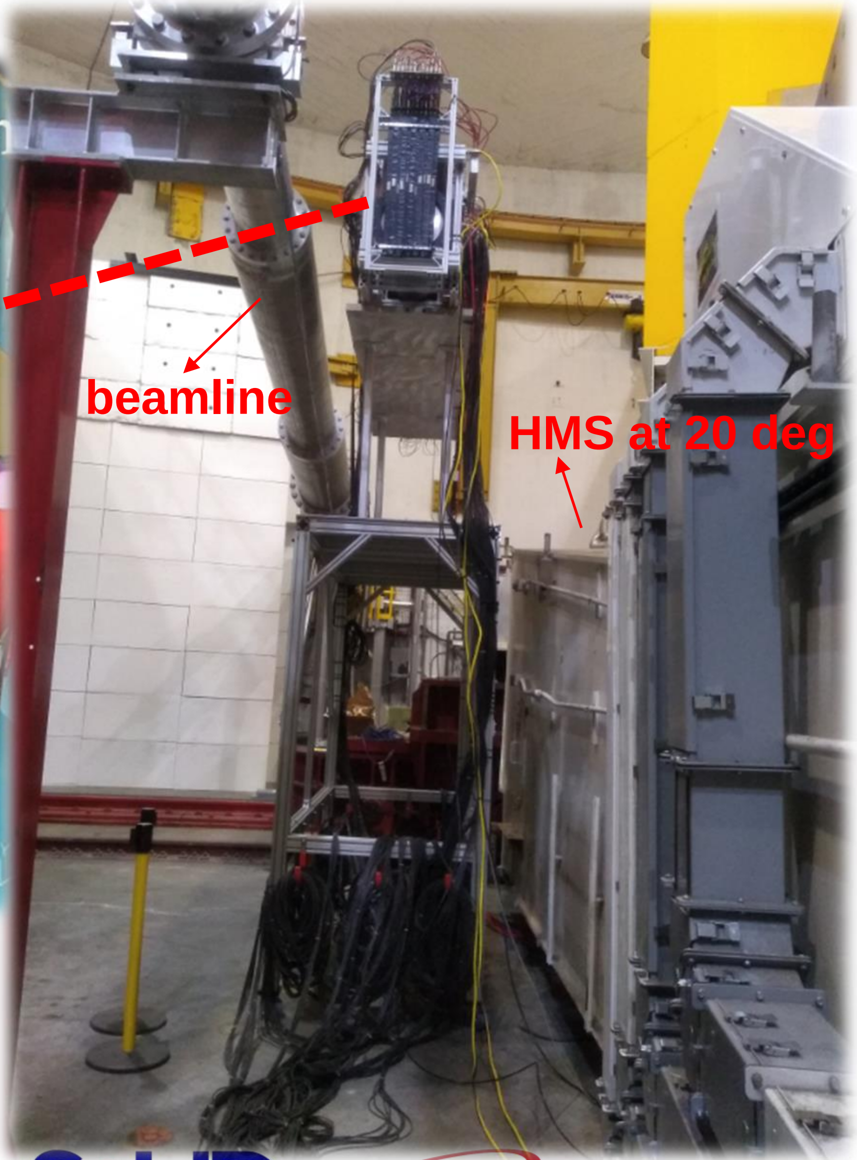
Installation in Hall C: **maPMT Test** from *low-rate to high-rate* Configuration

Installation at **large angle** (low rate) on the SHMS side: March 14-20 2020

Installation at **small angle** (high rate) between HMS and beamline: June 10 – July 29 2020

see my update at the previous SoLID Collaboration meeting

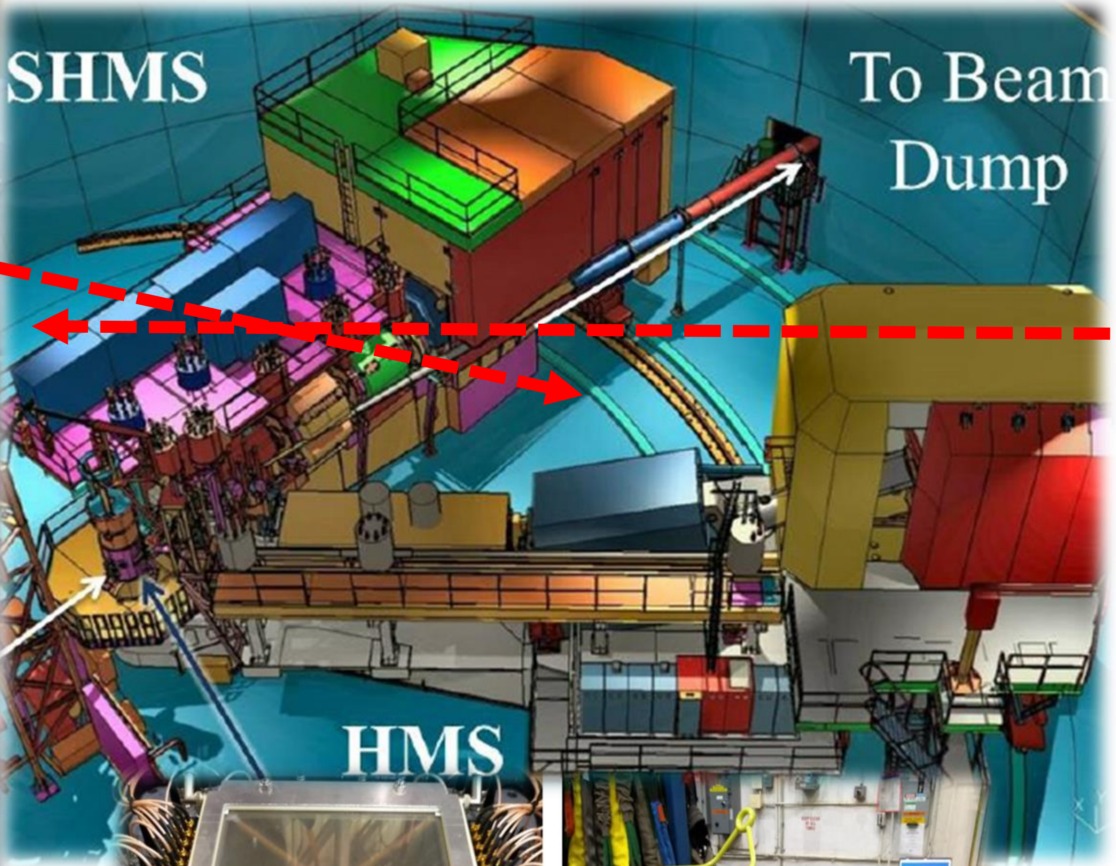


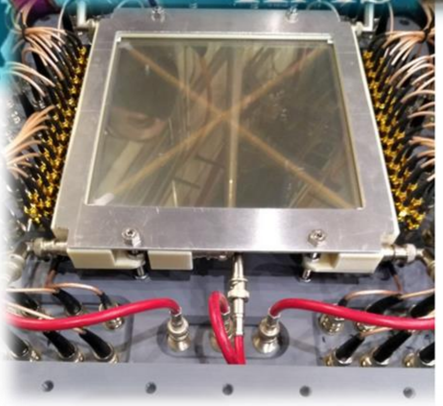


Installation in Hall C: from *high-rate to low-rate* Configuration for **LAPPD Test**

Installation at **small angle** (high rate)
between HMS and beamline:
June 10 – July 29 2020 (maPMT test)

Installation at **large angle** (low rate)
on the SHMS side for LAPPD test:
August 10 – August 21 2020





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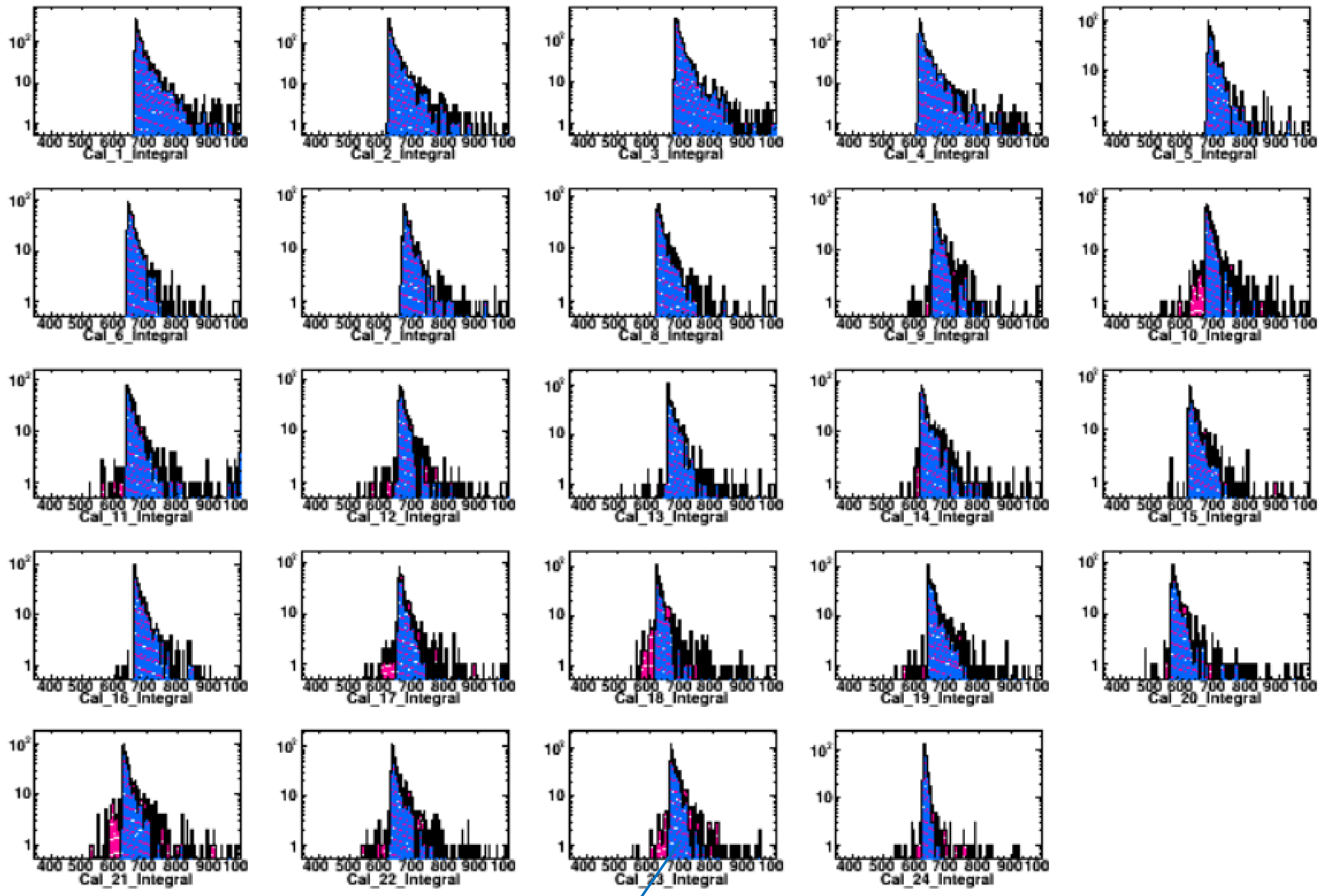
Installation in Hall C: Miscellaneous

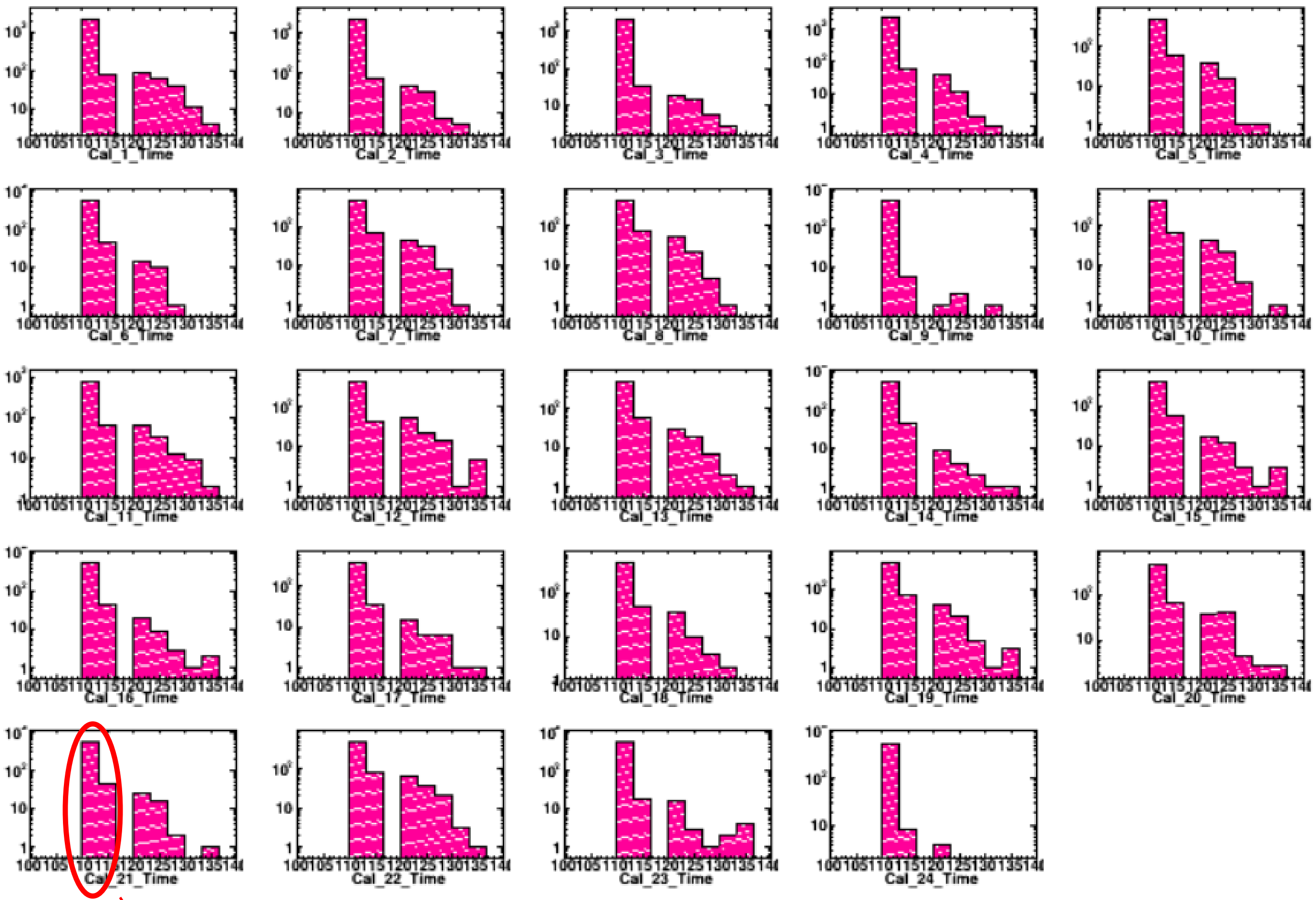
- → Low-rate configuration: on the SHMS side at ~ 105 deg, 17 feet away from the target
- → High-rate configuration: between HMS and beam line at ~ 3.5 deg, ~39 feet away from the target
- → 100 meter signal cables run from the detectors to a patch panel behind the green wall and from there to the VXS crate that houses the FADC250s and the VTP
- → The HV to detector channels is provided via 16 bundle HV cables by a CAEN SY403 power supply
- → The CO_2/C_4F_8 gas pressure in the tank is maintained by a gas controller in a range from 0.25 to 0.3 psi above 1 atm
- → All the power supplies and the gas controller are protected from radiation by a bunker

Detector Calibrations: Calorimeter

Charge integral from all 24 calorimeter channels from a cosmics run (triggering on calorimeter)



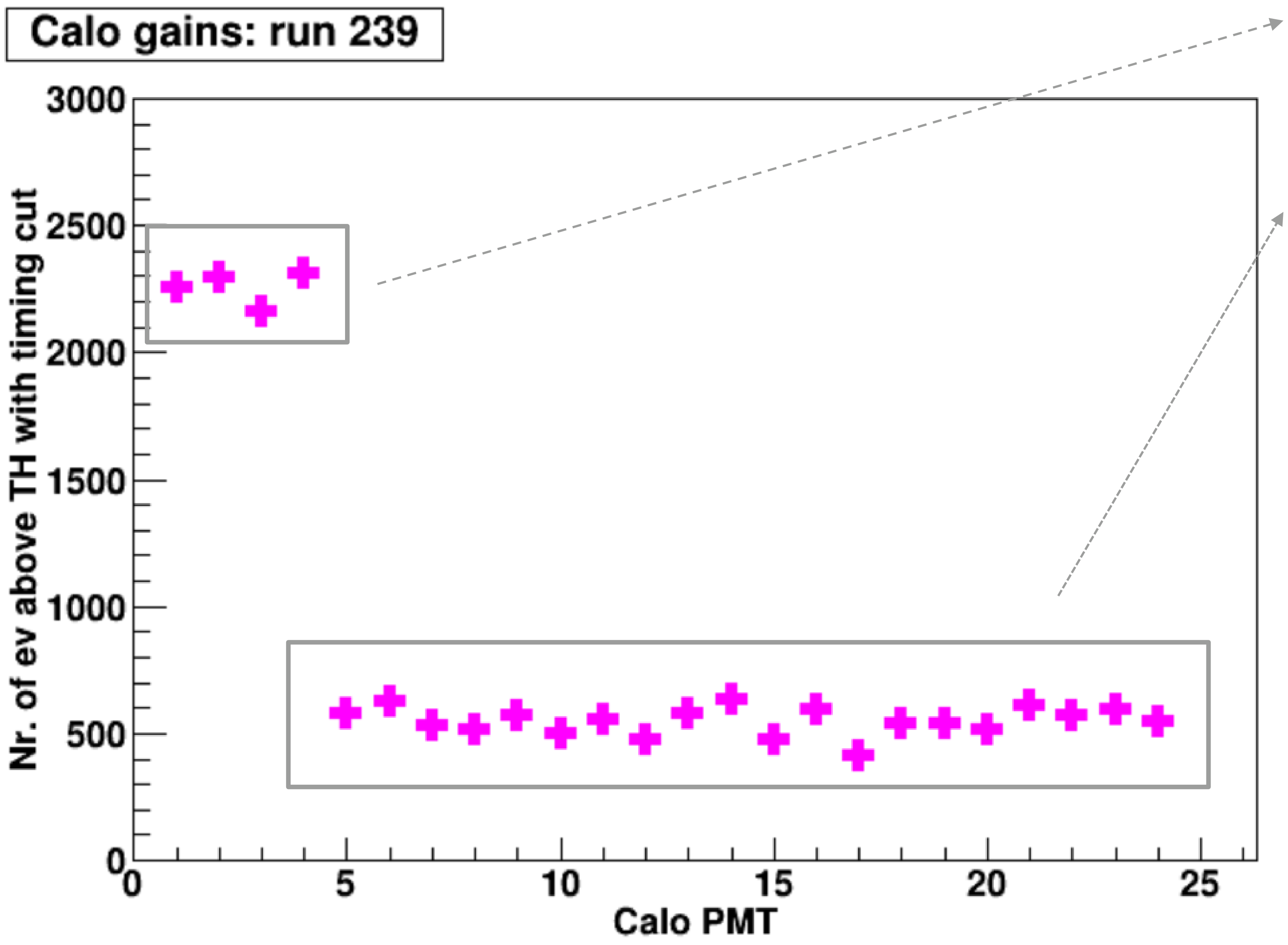
Timing distributions from all 24 calorimeter channels from a cosmics run (triggering on calorimeter)



Blue: charge integral when the self-timing peak only is selected

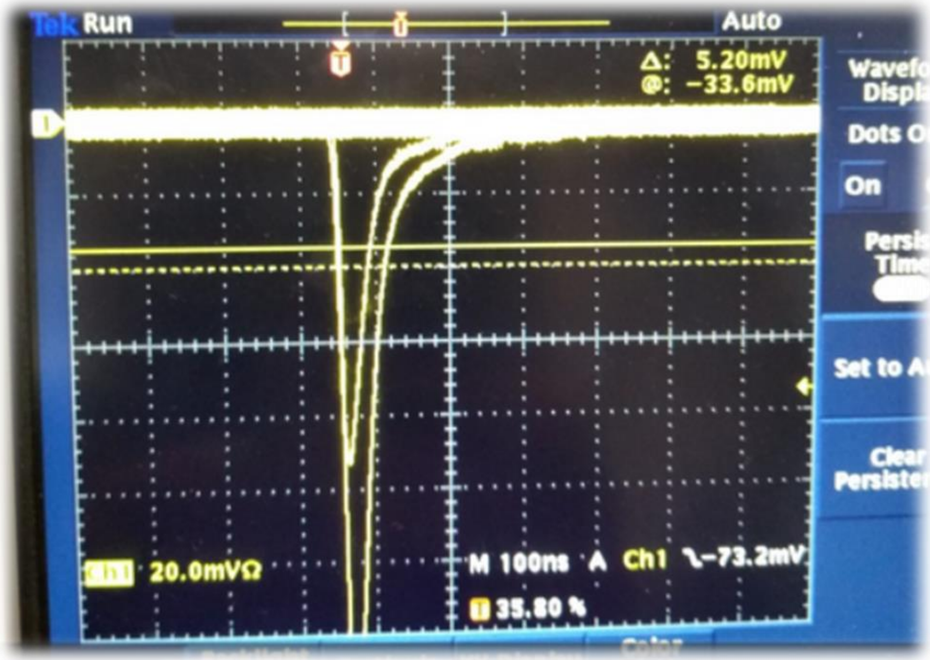
Calorimeter self-timing peak

Detector Calibrations: Calorimeter



→ The number of events in the charge integral distributions from the calorimeter blocks read by one PMT only were equalized

→ The number of events from the blocks read by 4 PMTs were also equalized and made ¼ of the number of events from blocks read by one PMT only



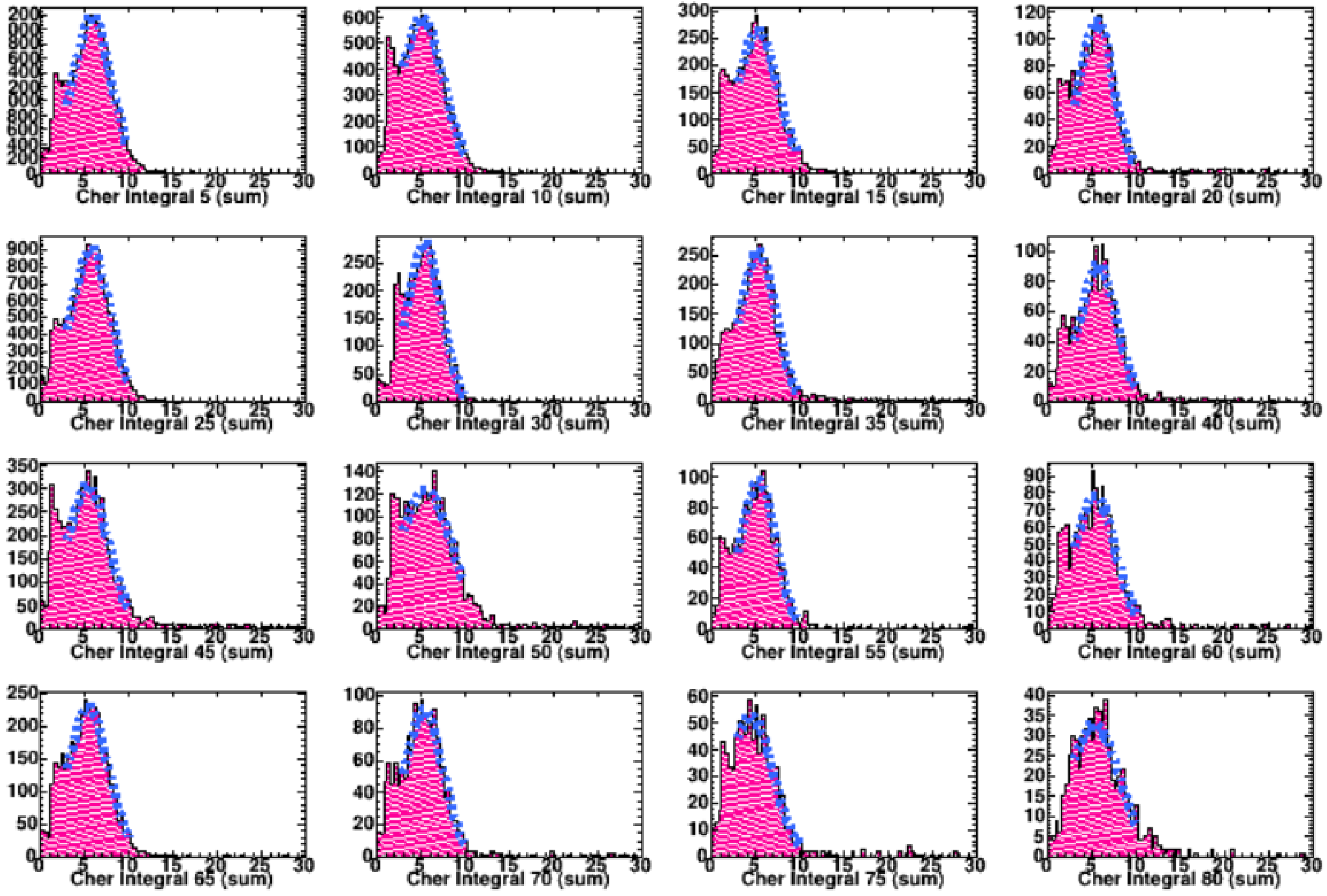
Detector Calibrations: maPMTs

→ I gain matched the 16 maPMTs on the scope to yield a 10 mV amplitude for the single photoelectron (SPE)

→ I took data triggering on a random pulser (VTP pulser) and I refined the gain matching by fitting the FADC distributions from each PMT and changing the High Voltage until all the charge integrals were ~equal

→ At the calibration stage and for the beam test the FADC threshold was kept low (2.4 mV) so the SPE can be detected

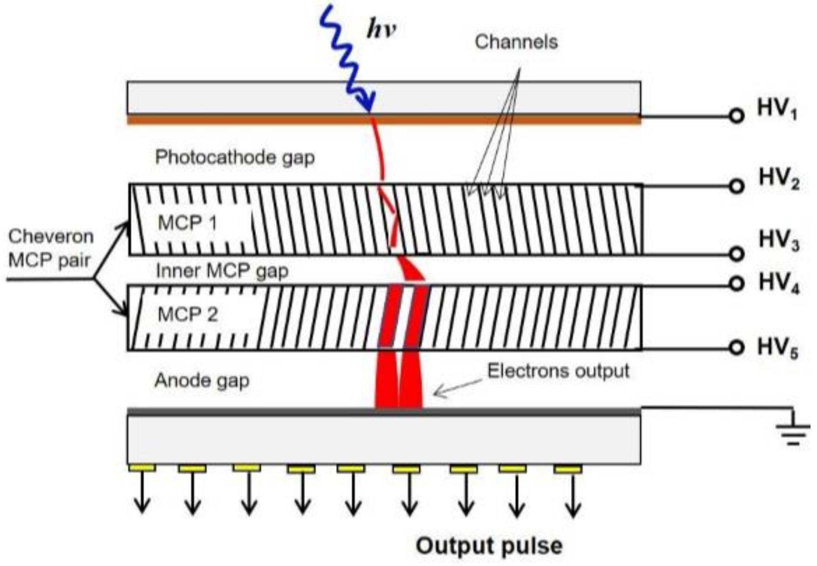
SPE Charge Integral distributions from all 16 maPMTs



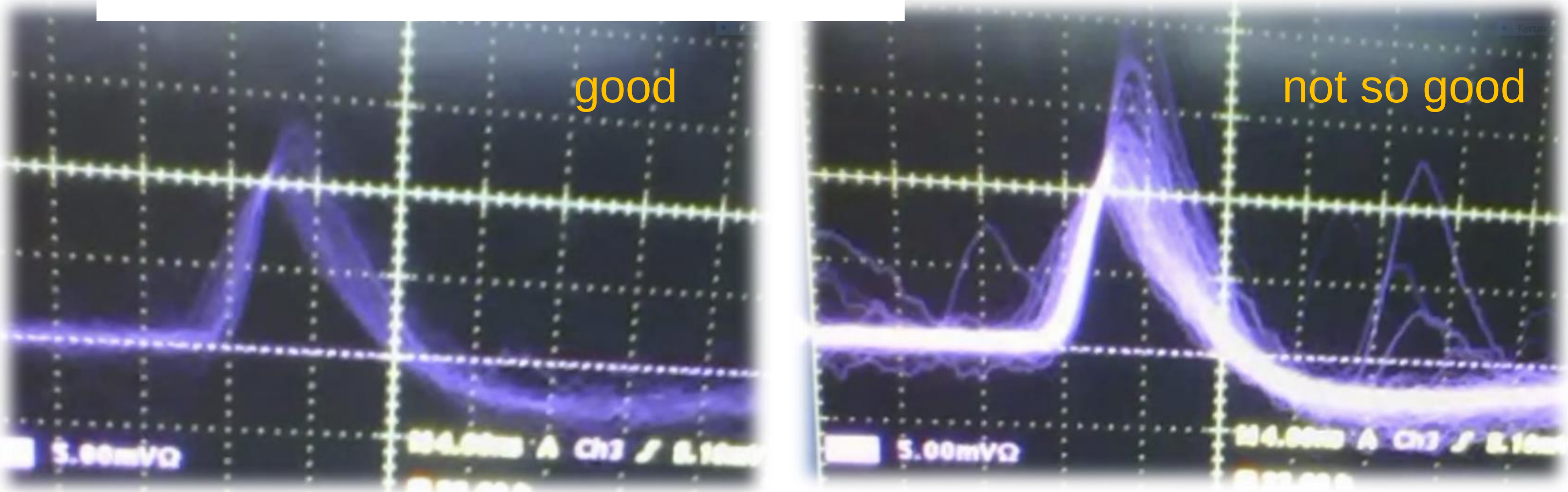
My HVs were quite different (and correctly chosen) than what previous bench tests proposed (people should check their bench tests)

Detector "Calibration"/Parameters: LAPPD Gain

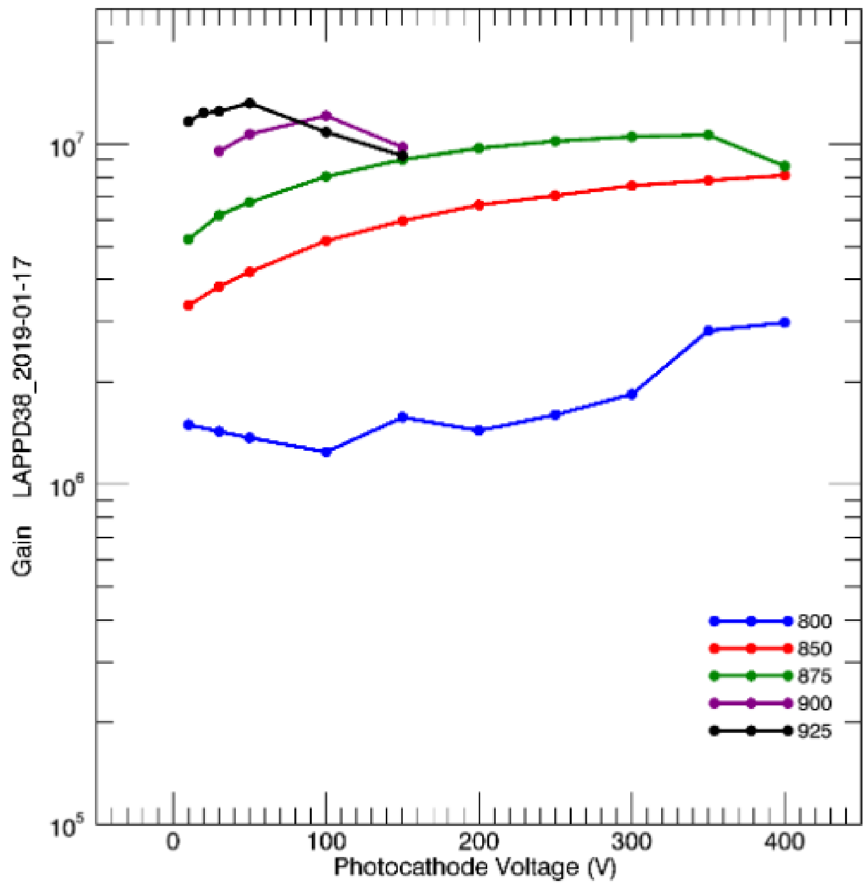
→ Initially we used LAPPD scope traces as guidance determine the best HV configuration



good
HV1: 2275
HV2: 2225
HV3: 1300
HV4: 1100
HV5: 200



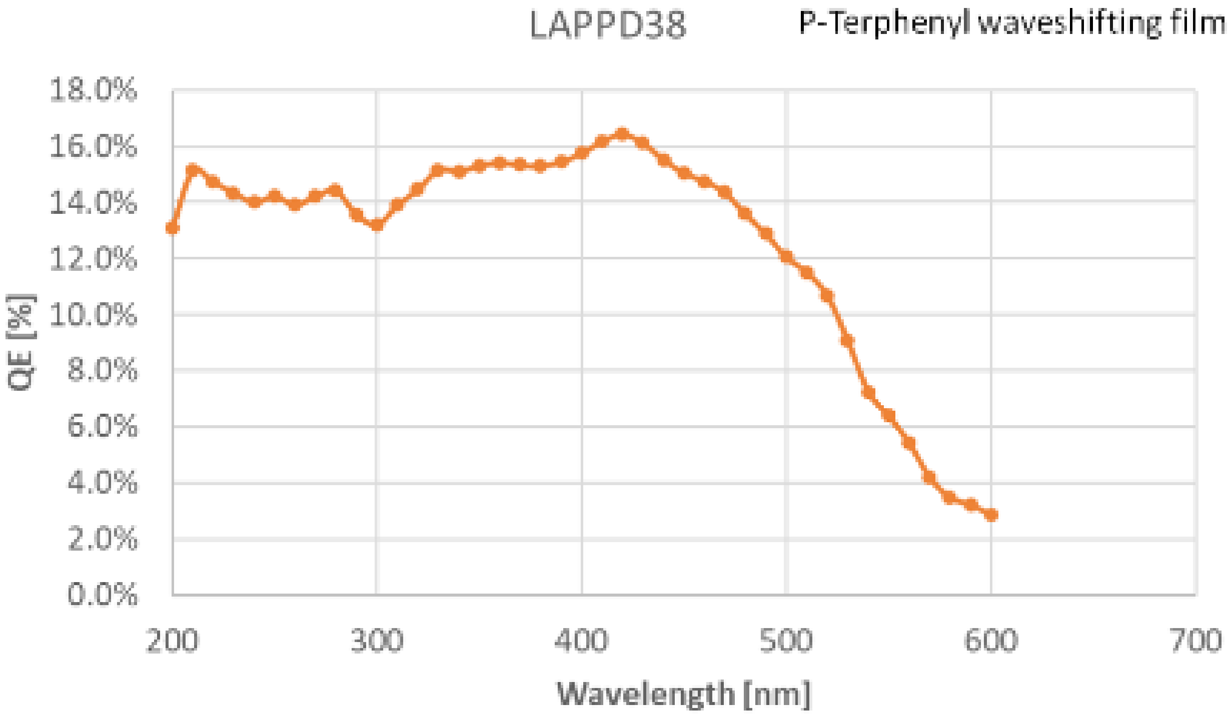
Results from Incom



→ According to the characterization done by Incom we ran with a gain of approx. 10^7

Detector Parameters: LAPPD QE

→ LAPPD quantum efficiency a factor of ~2 lower than that of the maPMTs



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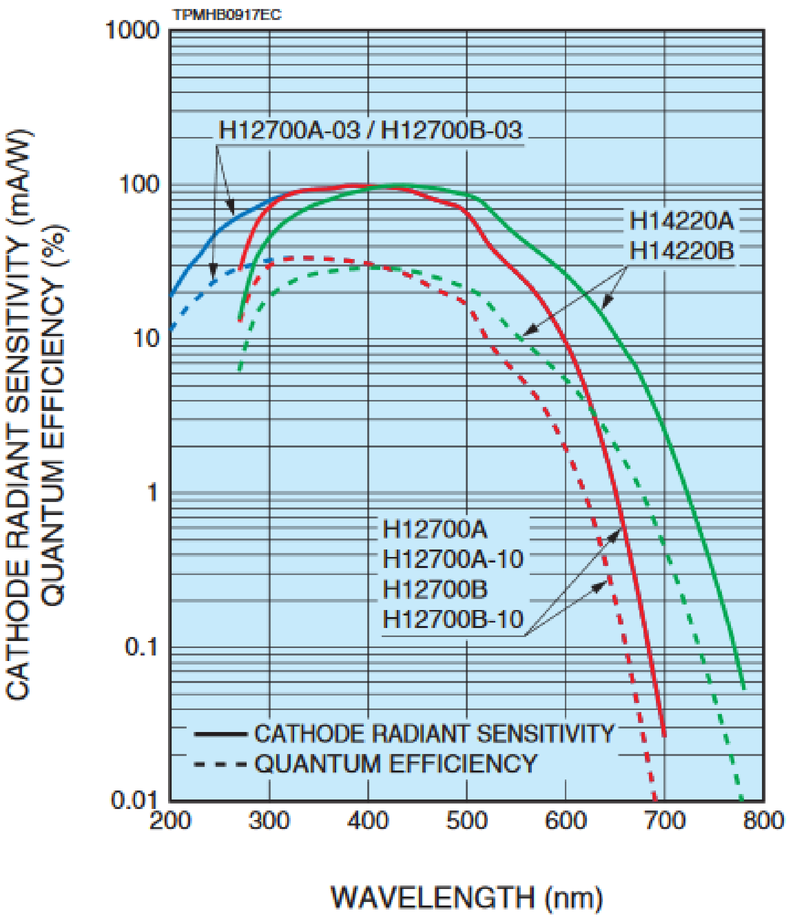


QE of maPMT H12700, for comparison

Summary of Data Taking

Mode 1: raw waveform
Mode 3: integrated quantities

Low-rate configuration data taking, March 21-23 2020: rate per **maPMT** ~ 300 kHz

Scintillator 2 + Calorimeter trigger (VTP)

→ Mode 3 data: 30 muA beam on a C and ^{3}He target

→ Mode 1 data: 30 muA beam on a C and ^{3}He target

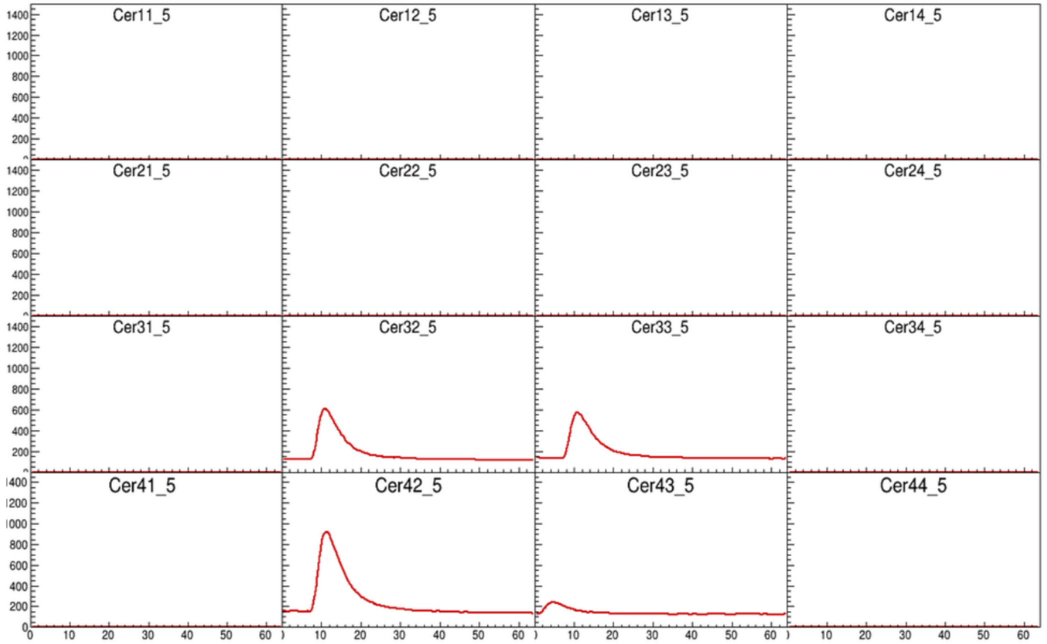
High-rate configuration data taking, August 2-6 2020: rate per **maPMT** larger than 4 MHz

Calorimeter trigger (VTP), Mode 1 data

→ Tune beam data: lowest rate

→ CW beam data on “no target”: 0.5, 1., 1.4, and 2 muA

one event display



August 7: DOE mandated review - went very well for the Cherenkov part of the pre-R&D

Low-rate configuration data taking, Sep 3-21 2020: **LAPPD**

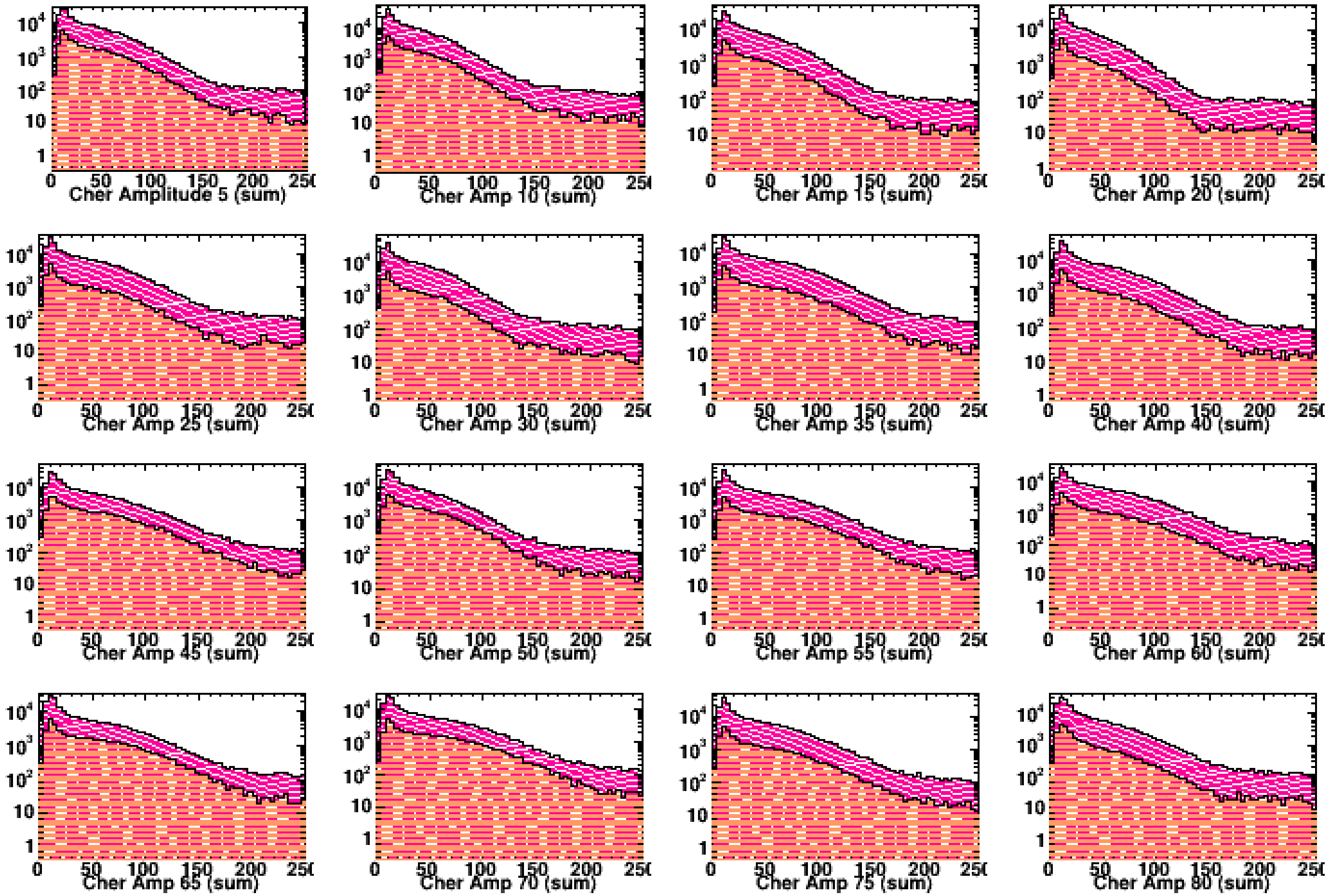
Calorimeter trigger OR Calorimeter + LAPPD trigger (VTP), Mode 1 data

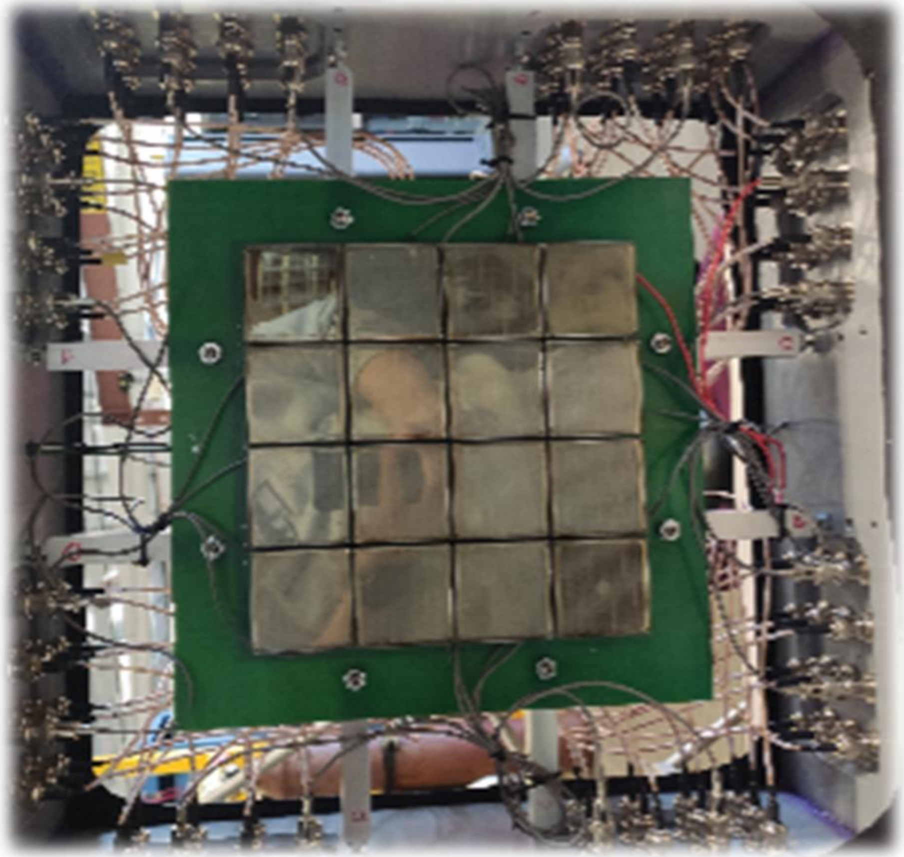
→ CO_2 and C_4F_8 gas

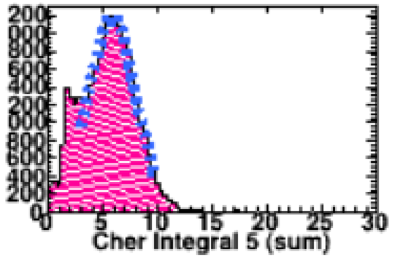
→ CW beam data on C and ^{3}He at < 30 muA

Small Angle, High Rate: maPMT Online Analysis of Beam Data

→ Signal Amplitudes from each of the 16 maPMTs: I am applying timing cuts on both the calorimeter and the Cherenkov timing (similar plots available from quads)





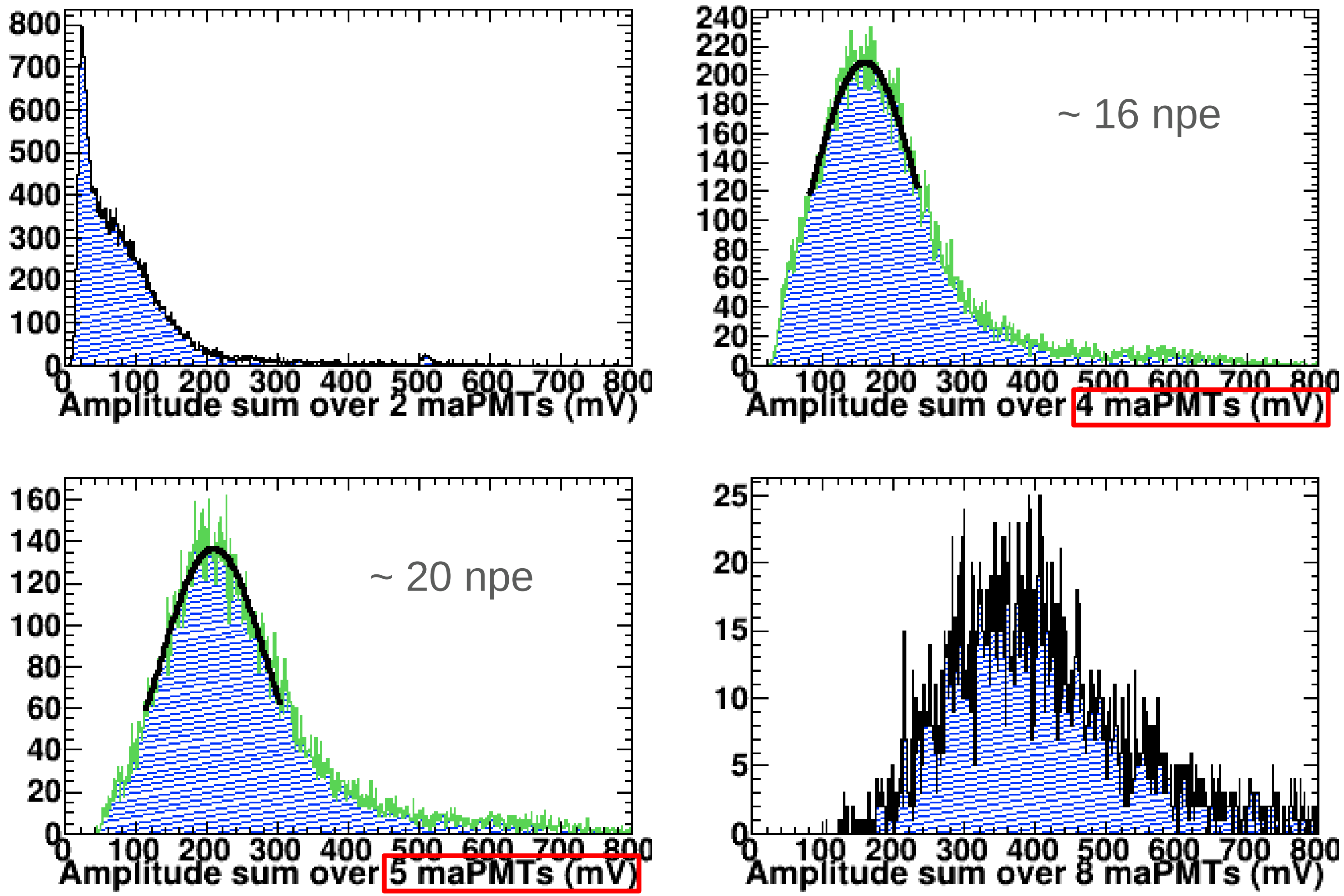


I gain matched all maPMTs so that the SPE Amplitude ~10 mV for each maPMT

Small Angle, High Rate: maPMT Online Analysis of Beam Data

→ I am applying timing cuts on both the calorimeter and the Cherenkov timing

→ I am summing the amplitude per event over all PMTs per event



For more see Chao's talk

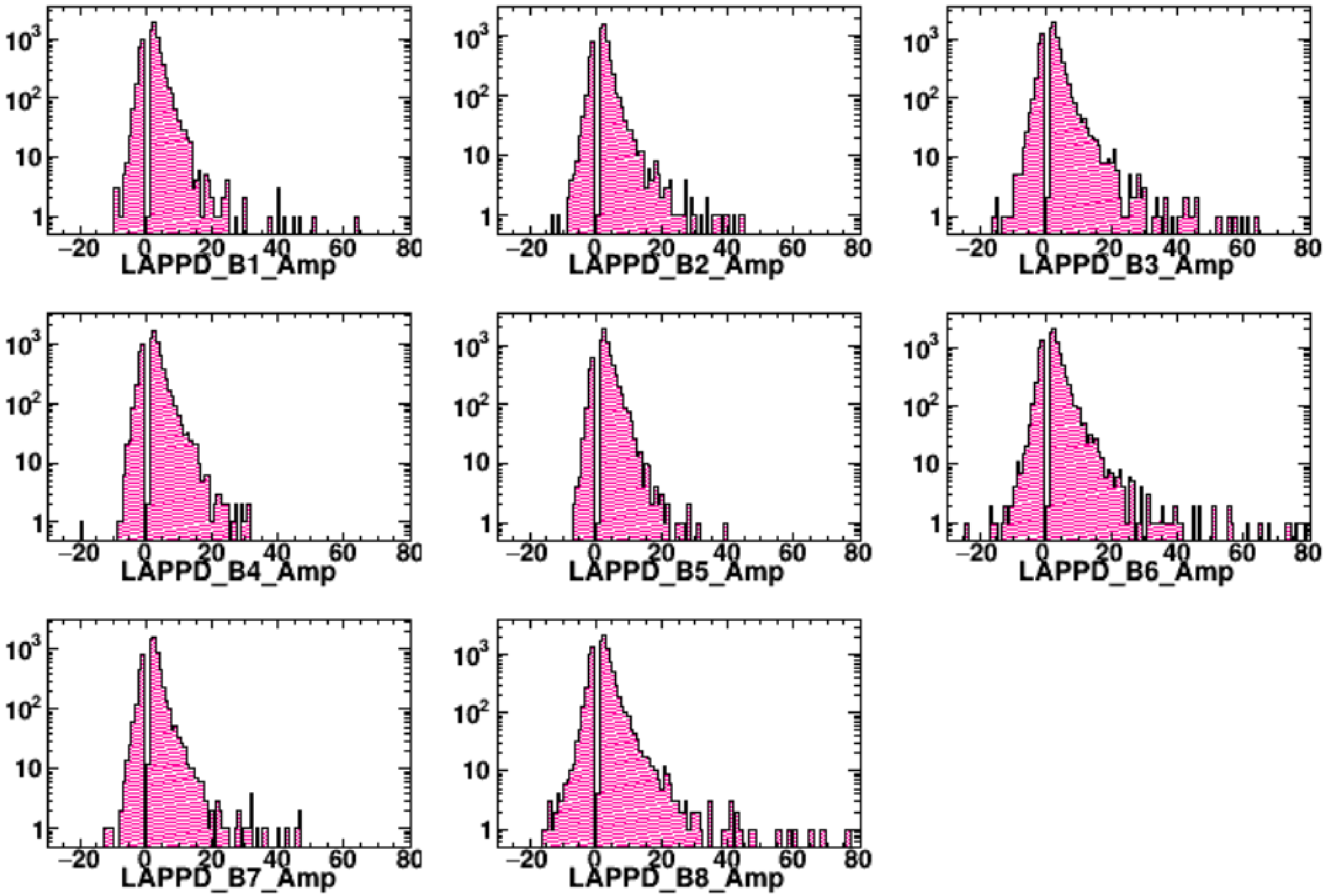
Large Angle, Low Rate: LAPPD Online Analysis

→ Signal Amplitudes from 8 of the 64 LAPPD channels (CO_2)

→ Data taken with C4F8 as well (not shown)

→ Couldn’t clearly identify the SPE

Just a postcard: no timing cuts applied here, no summing over all pixels per event



For an in-depth analysis of the LAPPD data see Chao’s talk

Future: LAPPD Bench Tests

→ Incom allowed us to keep the LAPPD until Dec 12 so I can characterize it

Specifically, I would like to be able to identify the single photoelectron signal and study its change with various high voltage configurations.

The source of photons will be a blue LED which will be mounted in a black box that will contain the LAPPD box.

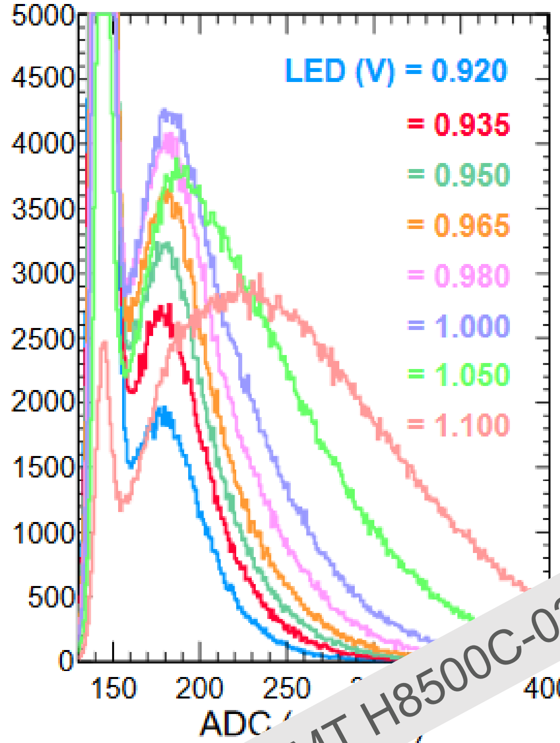
The trigger will be the signal that drives the LED.

LAPPD data will be taken using FADC250s.

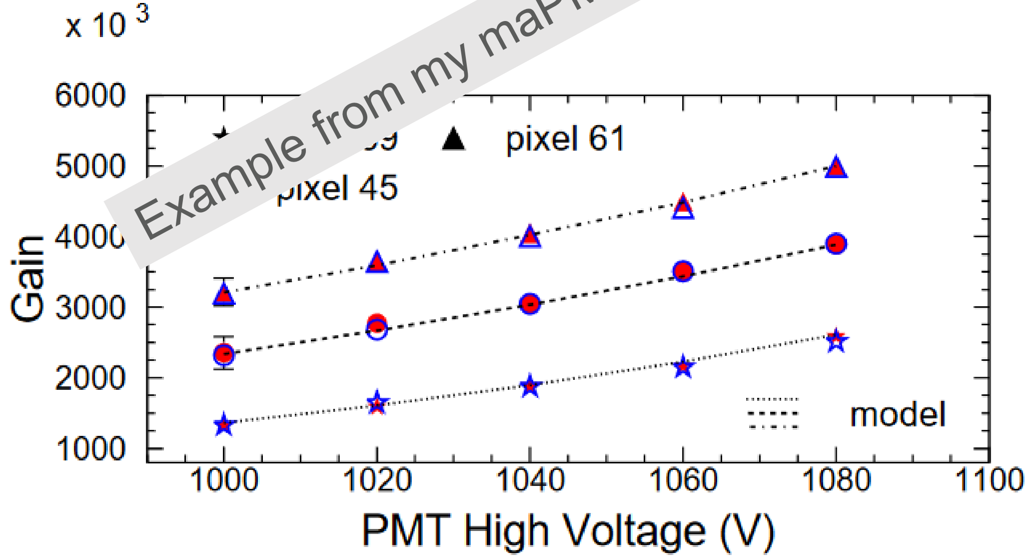
I will have a maPMT as witness (linearity study will be bonus :)

I envision a study similar to what I’ve done few years back on a maPMT H8500C-03 (for SolID) – a picture of single photoelectron distributions is shown here from that study

I am now setting up for this test in the ESB at JLab



Example from my maPMT H8500C-03 study



Summary: SoLID Cherenkov Prototype Beam Test is DONE

→ Both the low-rate and the high-rate maPMT data taking have been completed

→ LAPPD data taking completed as well

→ LAPPD bench test characterization next

→ Data analysis ongoing