

PMT activities

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ICARUS technical working group meeting

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Combined TPC & PMT daq test

- Synchronized trigger is established by a pulser, rate 5 Hz, width 200 ns, amp. 5V for PMT
- artdaq v0_04_02 installed
- We ran 8 TPC minicrates + 1 PMT board: no problem in run; PMT data looks ok;
- We ran 2 PMTs boards: no problem

- Later when we ran >2 boards, there is problem, got errors like “missing fragments”, run crashes; also it can not run with boards that are mounted in different computers (for PMT we use 3 computers, each with 12 boards)

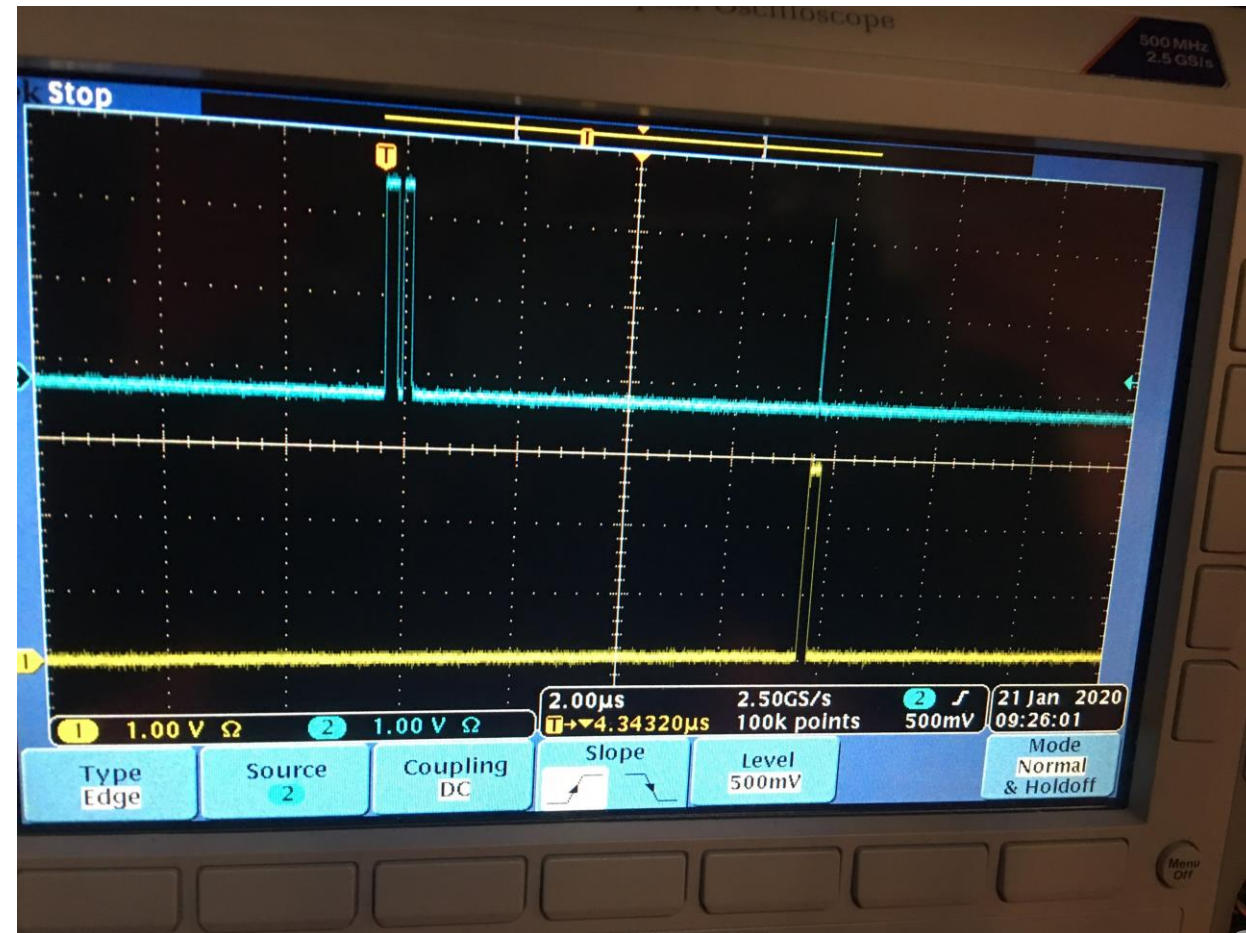
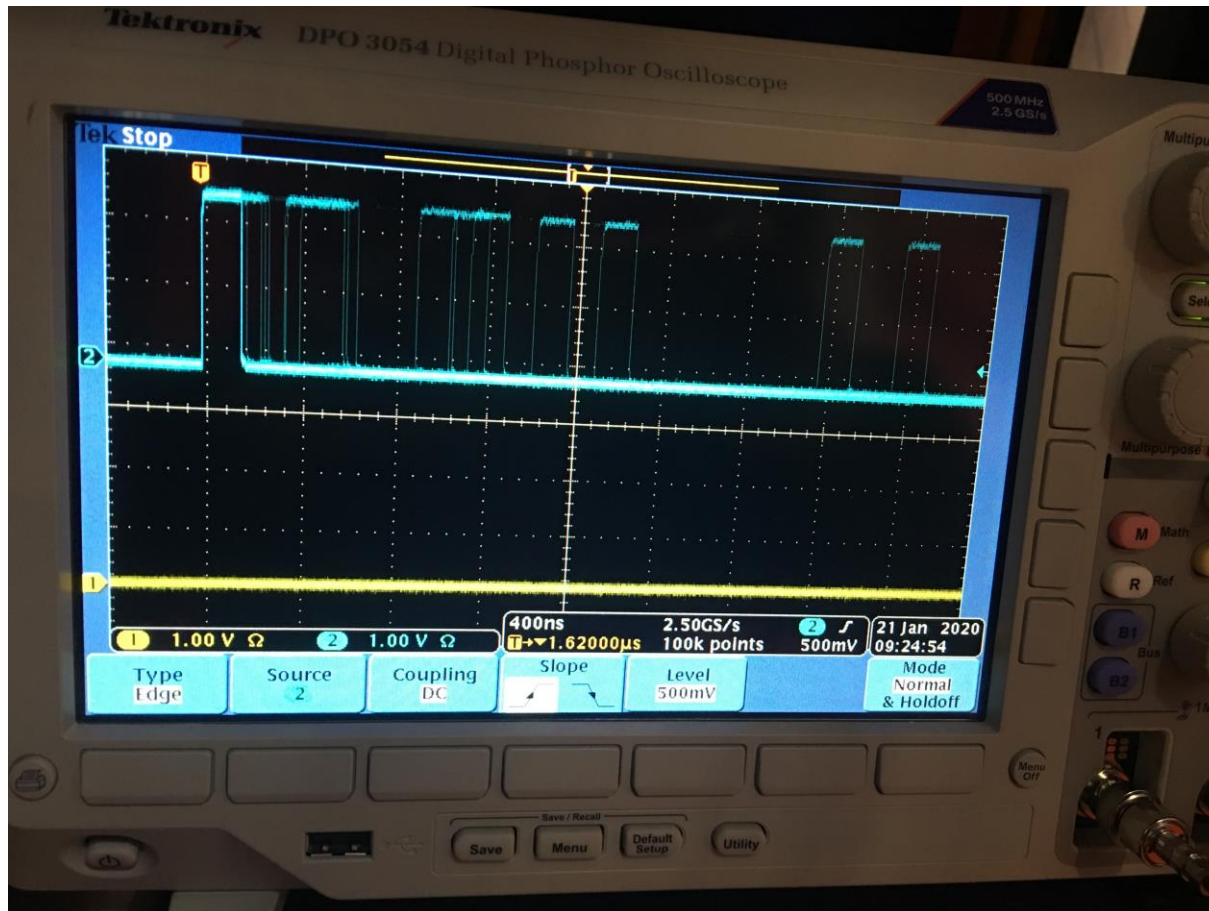
- Also, notice there is no output signal from digitizer’s TrigOut when run

- We’re waiting for Gennadiy’s help on daq software ...

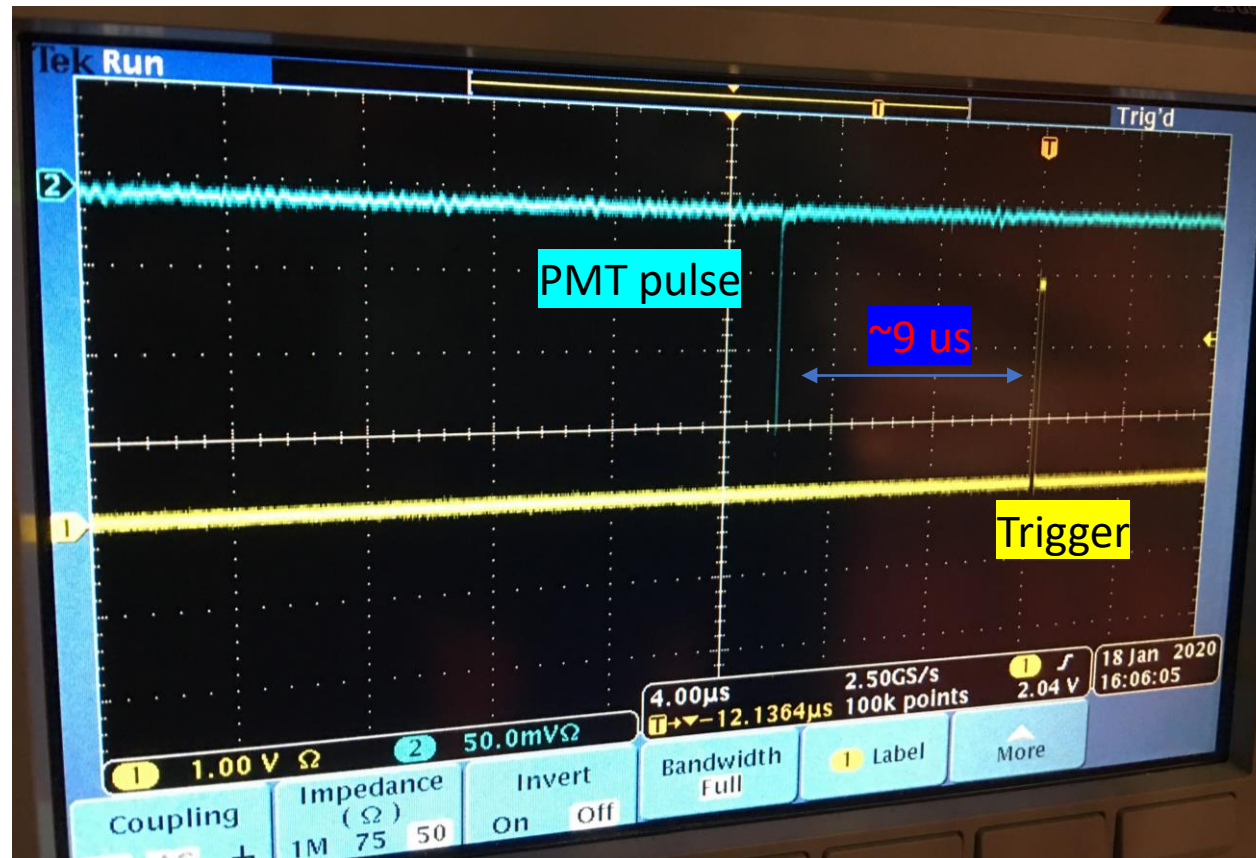
- I end up using the old artdaq version: v0_02_06
 - > it can only run digitizers in the same computer. In pmt03, I can run max. 7 boards; in pmt02 and pmt01, I can run max. 4 boards;
 - > I need to log onto the same computer when run the connected boards;
 - > there is output signal from TrigOut, but the output is strange (and crashes daq if use it, because it produces extra trigger to the next board), see next page

TrigOut issues

- We need TrigOut signal to trigger the next board, but the TrigOut signal is shown like the picture below (with daq v0_02_06)
- There is always ~ 8 ns pulse at the same time as the trigger input to the first board (right above the yellow pulse)
- We need the TrigOut signal to be nearly at the same time as the TrigIn signal, but in this example TrigOut is ~ 8 μ s earlier than TrigIn; there is delay set to the TrigIn signal (we'll explain on next page)
- We don't understand these two problems, we will ask CAEN.



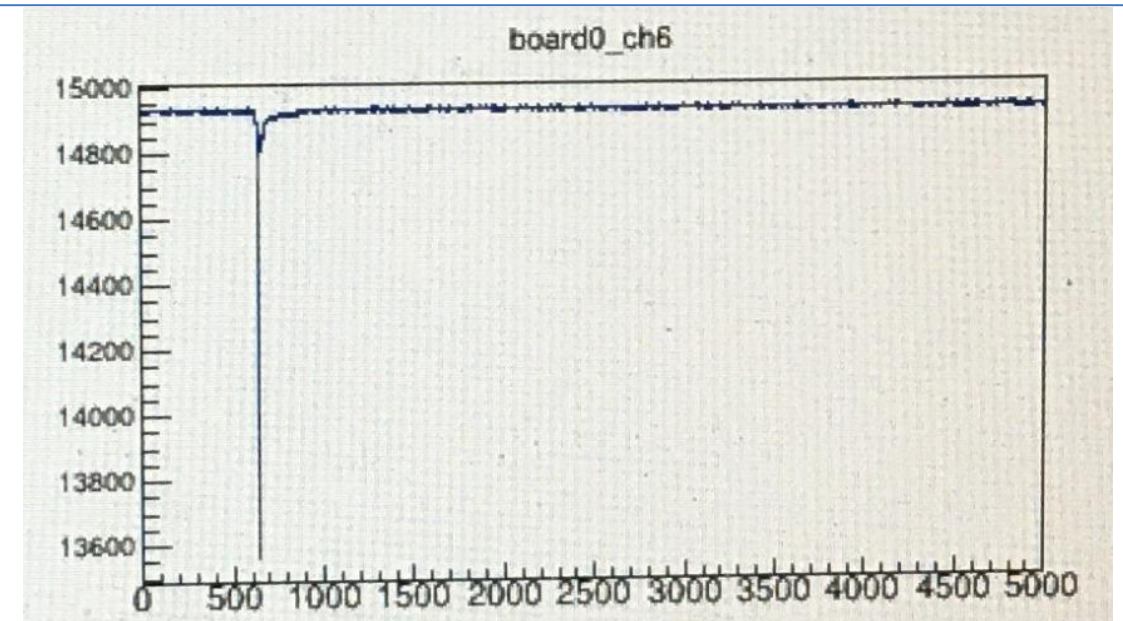
Find the pulse in the digitizer window:



On the left side shows PMT pulse is about 9 us earlier than the trigger, in the waveform captured by digitizer with a 10 us window, the pulse would show at ~1 us in the window (show below).

Once the waveform window is determined, if one wants to have the pulse to show in the beginning, the trigger should be delayed by ~ the length of the waveform window.

In the current configuration in digitizer, I don't know of any more settings to control this except the postTrig parameter (set at 50%)



- We end up using a spare TT-Link fan out module to produce 12 TTL signals to trigger 12 digitizer boards;
- (if daq can run well, in principle we can run 12 digitizers in one run, will be curious about this test later)

Scan through all PMTs:

- To check PMTs are alive
- To check daq
- To gain experience on PMT calibration

- Set voltages to PMTs near gain 10^7 , found **one HV channel (PMT2-RA3-37) in the SY1527 module can not go higher than $\sim 1080V$** (the connected PMT was moved to another channel) ;
- We still need epics to be fully working, for now we can connect to HV SY1527 from server and set values manually (no need to use a monitor); we have not tested epics for the Bertan HV
- Inject light by LED, with fixed settings: triggered by the 5 Hz pulse from the TPC side
- For PMTs in the east module: data were taken for all 180 PMTs when light is in each chimney. We observe photon signals in neighbor PMTs; daq was run with 4 digitizer boards.
- For PMTs in the west module, data were taken with one digitizer (when 10 PMTs are all connected to that board) or two digitizers (when 5 PMTs in one and another 5 in the other) when light is in one chimney.
- **All PMTs are confirmed to be working, except the 3 known dead PMTs**

Time consumption estimate

Initially I thought taking a small waveform window would save time, but it was not obvious:

Take 180 PMTs for example:

- All PMT voltages are fixed, I manually switch LED to the chimneys
- I run **one board at a time**, with **1 us window (500 samples)**, and **1000 waveforms, 5 Hz trigger rate**
- Because for some chimneys, 5 PMTs are connected to one digitizer, and the other 5 PMTs to another digitizer, I need two runs. I took **24 runs for the 180 PMTs** in the west module
- And the time **needed 2 hours!**
- This can be reduced with higher rate (briefly verified). **Starting and stopping the daq take ~ 2 minutes.**

Another example:

- 4 boards at a time, **1 us window (500 samples)**, and **1000 waveforms, 5 Hz trigger rate**
- 27 runs (for 90 PMTs)
- 2 hours

Update on time estimate for a LED scan at fixed voltage:

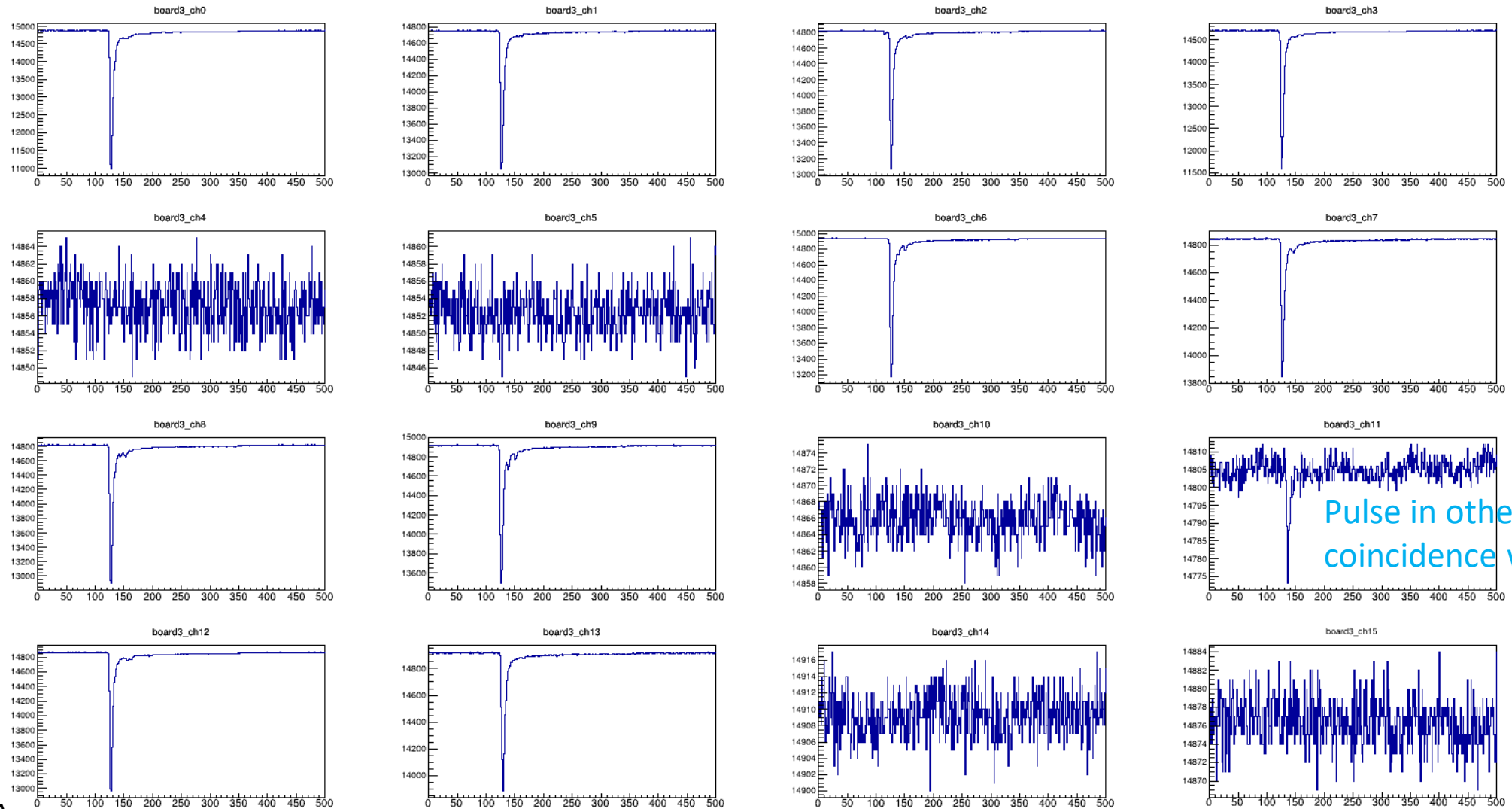
- $24 \text{ runs} * 2 * 2 = 96 \text{ minutes}$ (just for starting and stopping daq), the number of runs can be reduced to 40 because we can run two boards for the case when 5 PMTs in one board and 5 PMTs in another.
 - $24 \text{ runs} * 2 * 10k/50 = 16 \text{ minutes}$, assuming 50 Hz (I think too high will be trouble) and take 10k waveforms at 1 us window.
- **Total time, 120 minutes, for a gain monitoring calibration at fixed voltages.**

Event rate in daq test

- I didn't have time to do more careful test, but some brief idea
- The rate is surely affected by the waveform length
- At 50 Hz, I can run up to 2 boards in pmt02, but can not run 2 boards in pmt01 (at 1 us waveform length)
- Tried to run 4 boards at 50Hz in pmt02, it ran for ~5000 waveforms and crashed;
- The data recording speed, according to what displays in artdaq, is ~130 Mb/s when two boards were run. This is consistent with the ~70Mb/s limit by the data transfer fiber.

Looking at the data

- After each run was taken, I plot one event to make sure pulses show in the correct location
- Everything looked fine: mapping all is correct; and yes, photons (mostly single p.e.) can be seen by neighbor chimneys

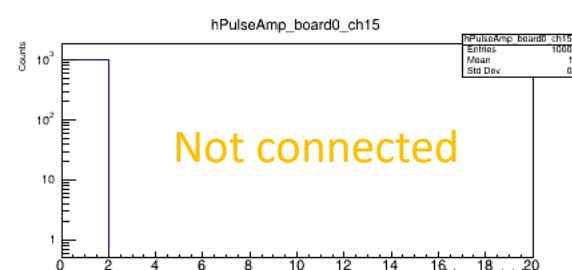
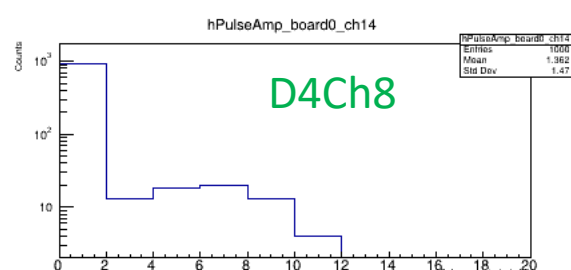
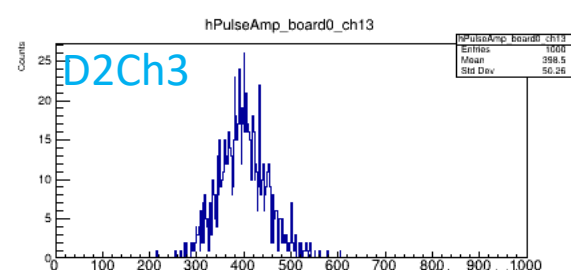
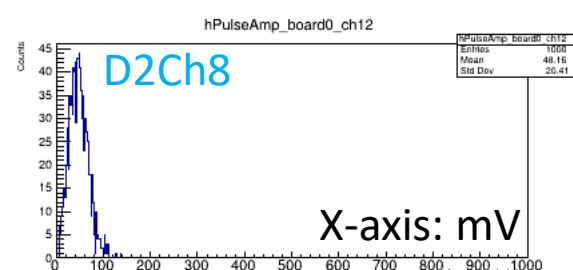
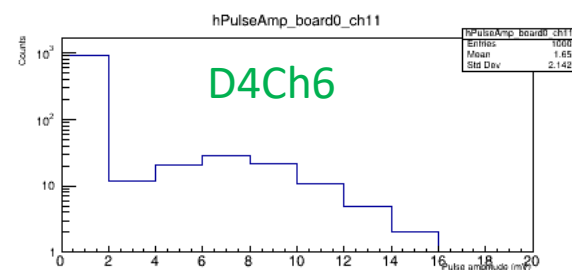
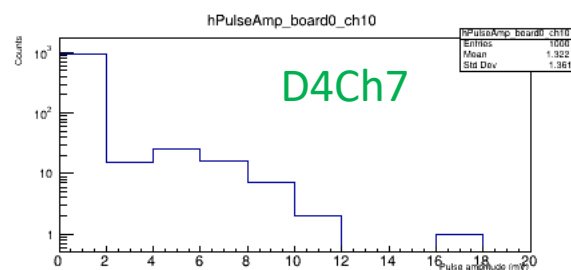
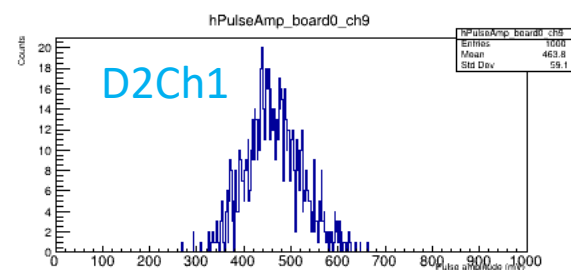
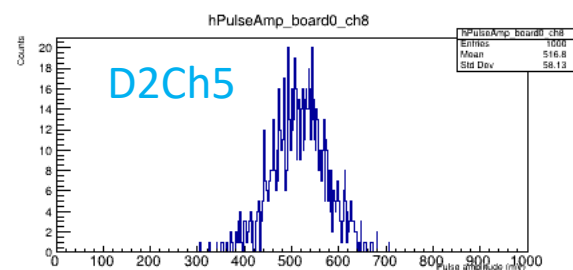
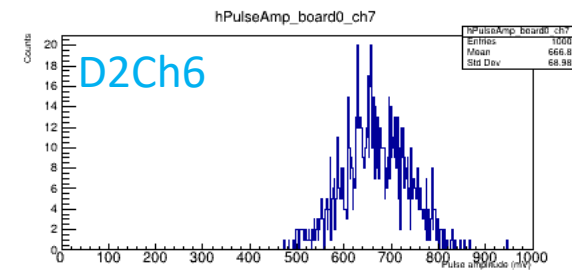
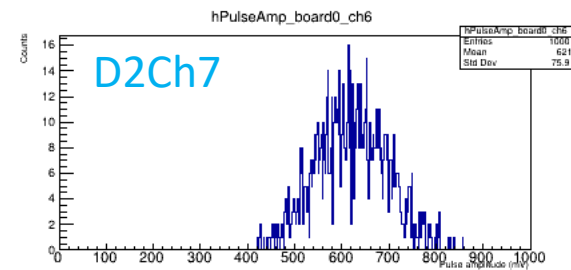
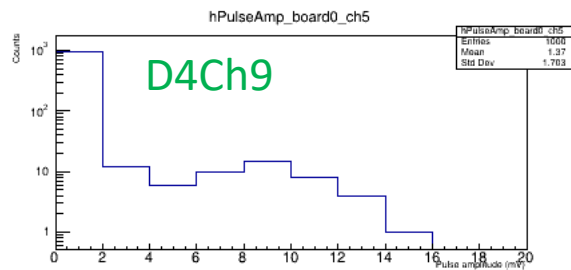
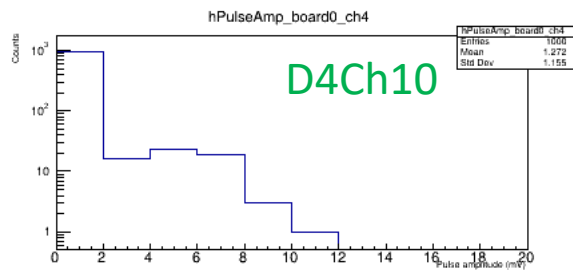
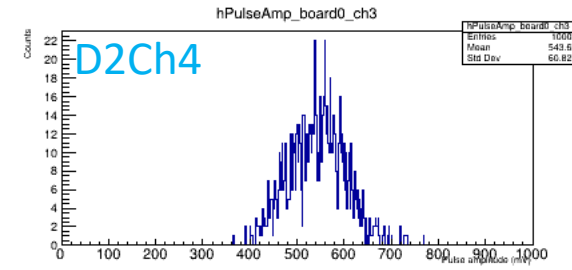
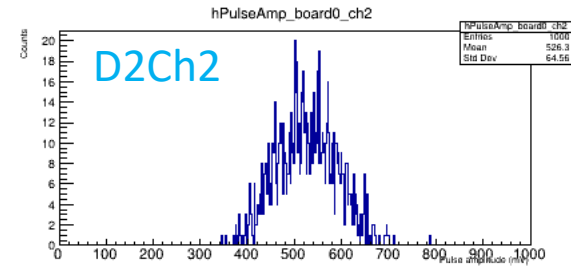
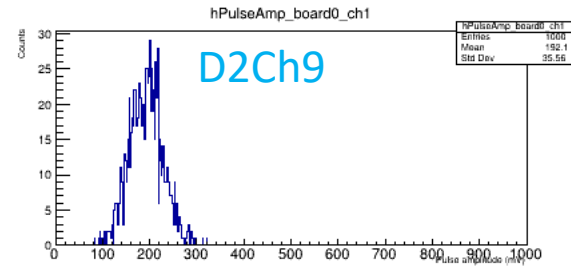
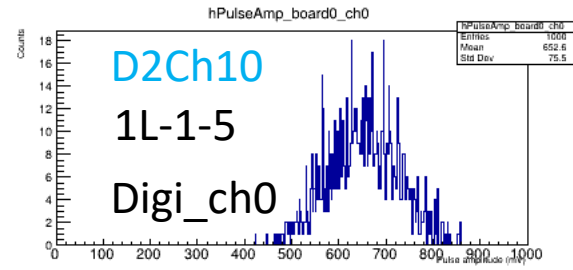


Run330_01
Evt 10
Digi EE-TOP-A

1 us window

Looking at the data

Pulse amplitude distributions



Data: run390_01, from **Digi-WW-TOP-A**

Summary / Conclusions / to do

- PMTs all work!
- We obtained plenty of data to look at, analysis will be followed up
- On calibration:
 - With LED on for one chimney, it looks like we could get plenty single photons in the neighbor chimneys.
 - In the same data, we could get both high p.e. charge distributions (for the PMTs with LED directly) and low p.e. charge distributions (with LED indirectly).
 - This is another way of calibrating the PMTs? Eg., turn light on in the middle chimney, measure spe for PMTs at the side... (to be revealed by the data)
- Need to work on:
 - Get PMT data: three voltage points with LED on & off before cooldown (for gain and dark rate, to compare with cold)
 - Latest daq to run with all digitizer boards
 - Test both PMT and TPC: ideally, need trigger from SPEXI, global trigger to TPC, multiple PMT triggers in one TPC trigger, etc.
 - Digitizer trigOut issue
 - Control the optical switch online from outside
 - Get laser pORC
 - The Epics to control HV (both SY1527 and Bertan HV)