Results on LAPPD 38 single photoelectron detection and measurements of charge cloud radius

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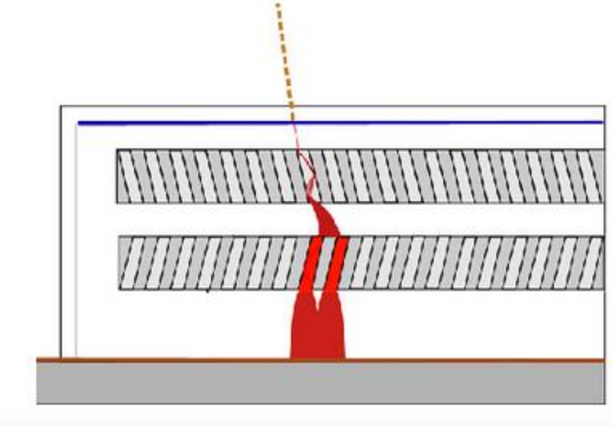
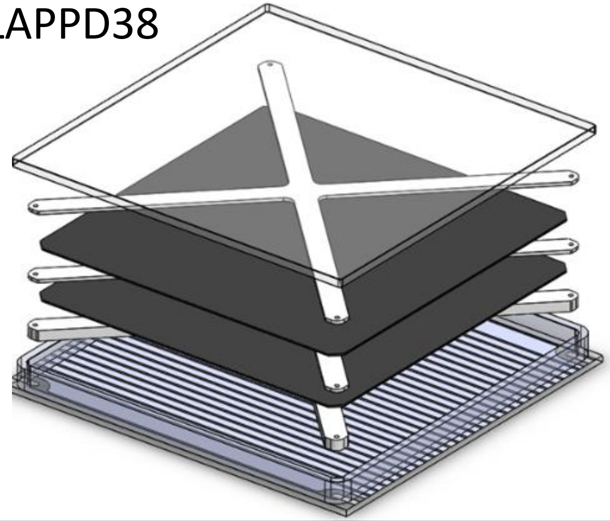
LDRD Funding in FY22 for LAPPD studies:

- → A new LAPPD with good quantum efficiency, uniform gain across the MCP area and optimized distance between MCP2-anode (3 mm instead of 6.6) would be fabricated by Incom Inc. specifically for this test
- → The smaller MCP2-anode gap is needed to reduce the spread of the charge cloud at the anode. This will minimize the possible active gain variations due to pore sharing.
- → The smaller distance between the second MCP and anode would also hopefully improve the resistance of the LAPPD to magnetic field
- → Once delivered the LAPPD would be characterized in terms of gain vs voltage curves and dark rates
- → An attempt at measuring the charge cloud radius would be made
- → Potential gain variation due to pore sharing would also be investigated
- → A test setup to use cosmic rays and a tank with C4F8 gas would be assembled to test the new LAPPD with Cherenkov light from cosmic rays using a scintillator and calorimeter as trigger



window	5 mm thick borosilicate
photocathode	potassium, sodium, antimony 0.345 μm thick
photocathode - first MCP gap	2.8 mm created via X-spacers
first MCP	borosilicate, 65% open area ratio 1.2 mm thick
gap between first and second MCP	1.1 mm created via X-spacers
second MCP	borosilicate, 65% open area ratio 1.2 mm thick
second MCP - anode gap	6.6 mm created via X-spacers
anode	3.8 mm borosilicate with 12 μm thick silver strips

LAPPD38



Status:

→ Several attempts at preparing the new LAPPD failed so far because of leaks, or excessive dark noise that reduced the operating range

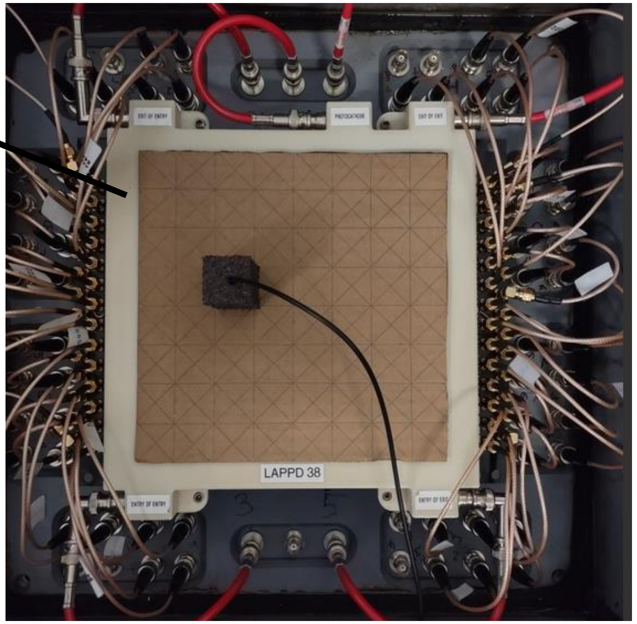
→ Incom is still working to fabricate the new LAPPD (new delivery date: sometime in January)

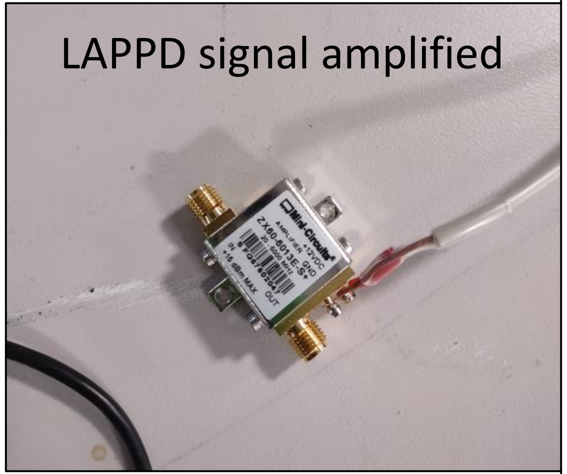
→ Meanwhile I am proceeding with tests using LAPPD 38

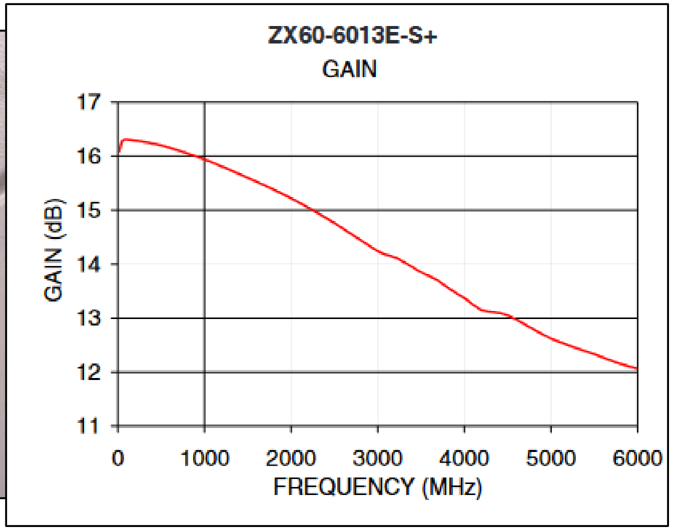
→ Bench tests are ongoing and the setup for tests with cosmic rays is ready and on standby

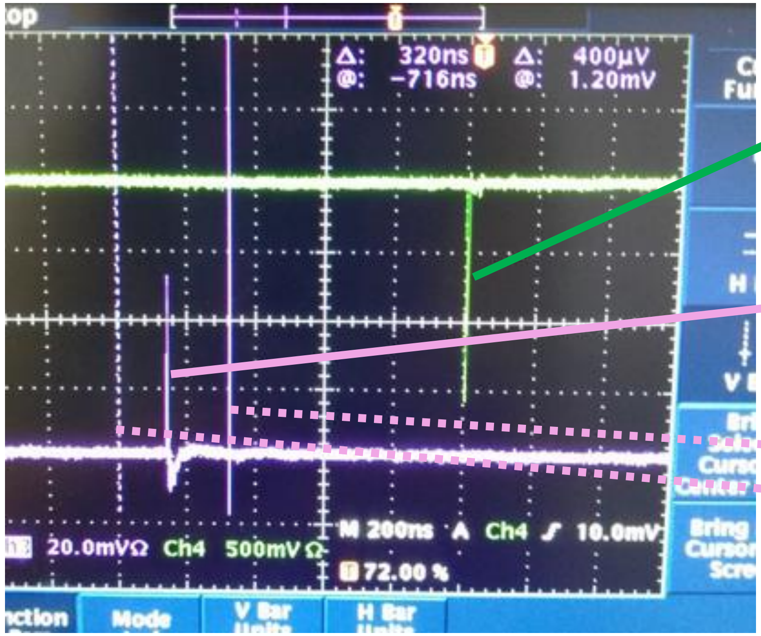
Setup for bench test characterization of the LAPPD

LAPPD 38 with a mask that allows LED light on photocathode through a 2 mm hole







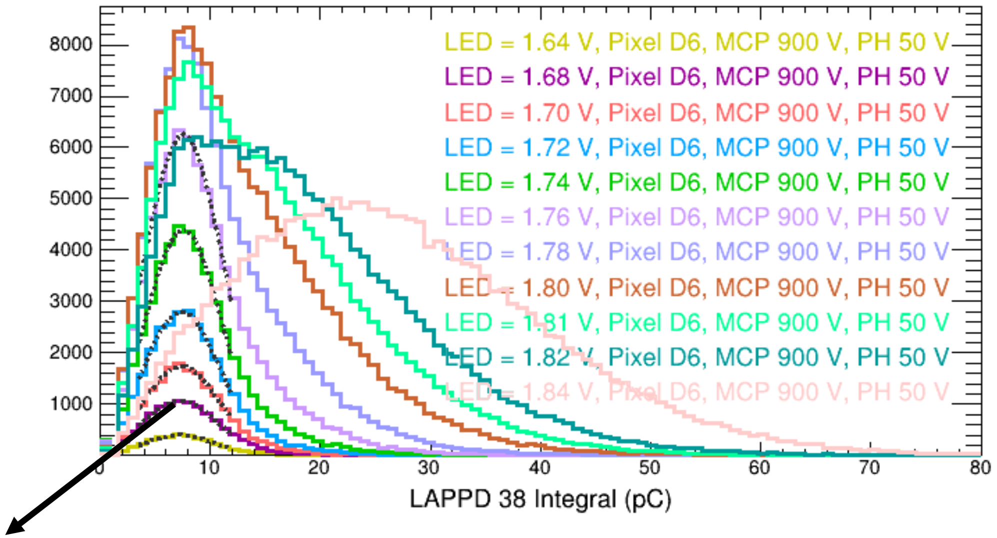


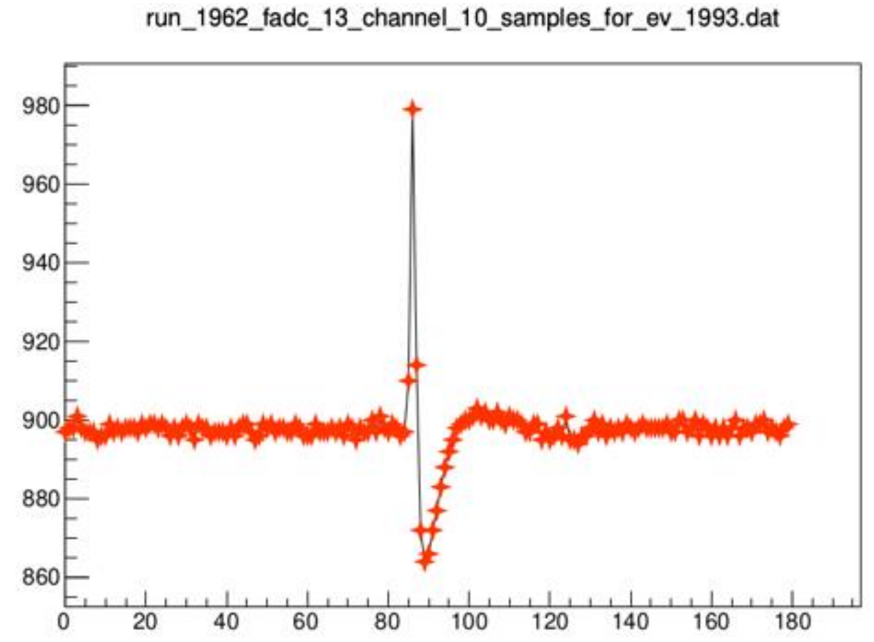
Trigger: pulse that drives LED

LAPPD pulse (unamplified)

FADC250 sampling window (samples every 4 ns)

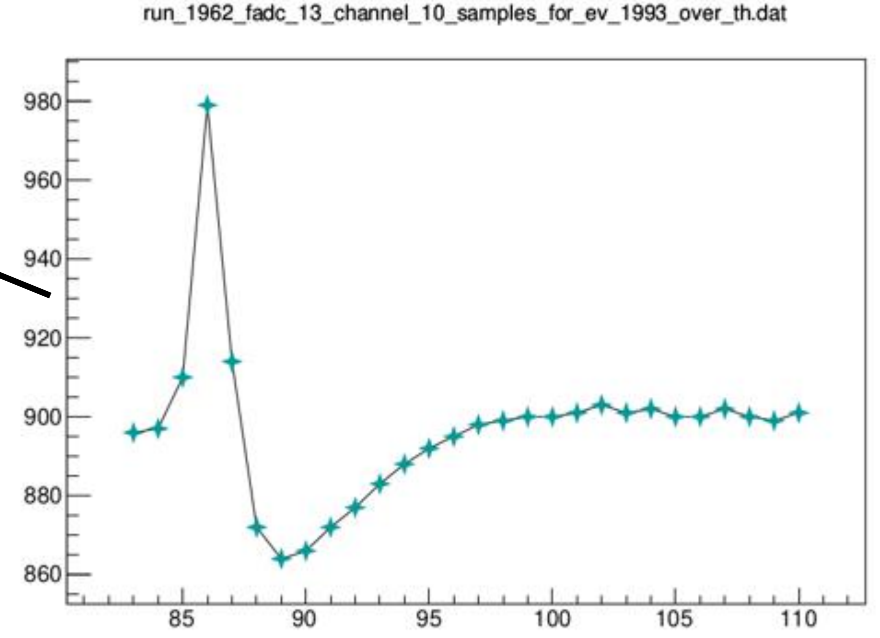
Setup for bench test characterization of the LAPPD





→ Each distribution of charge integral corresponds to a fixed LED voltage and a fixed number of triggers

→ Therefore comparing distributions means comparing probabilities for producing a certain number of photoelectrons



Definition of pulse integral from the FADC250 samples per trigger (or event)

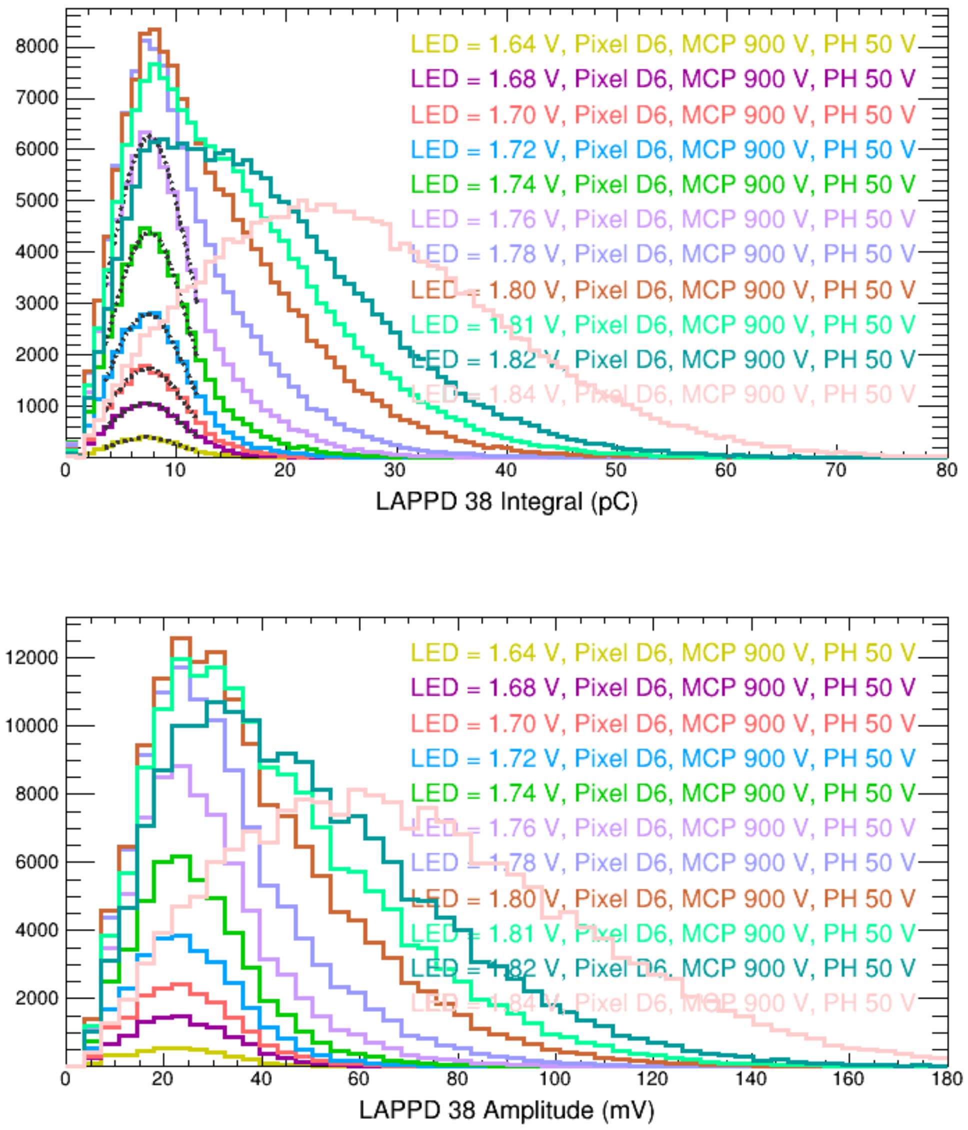
→ The FADC is sampling every 4 ns, the dynamical range is set to 1 V

→ The FADC thresholds are set to 20 channels above pedestal

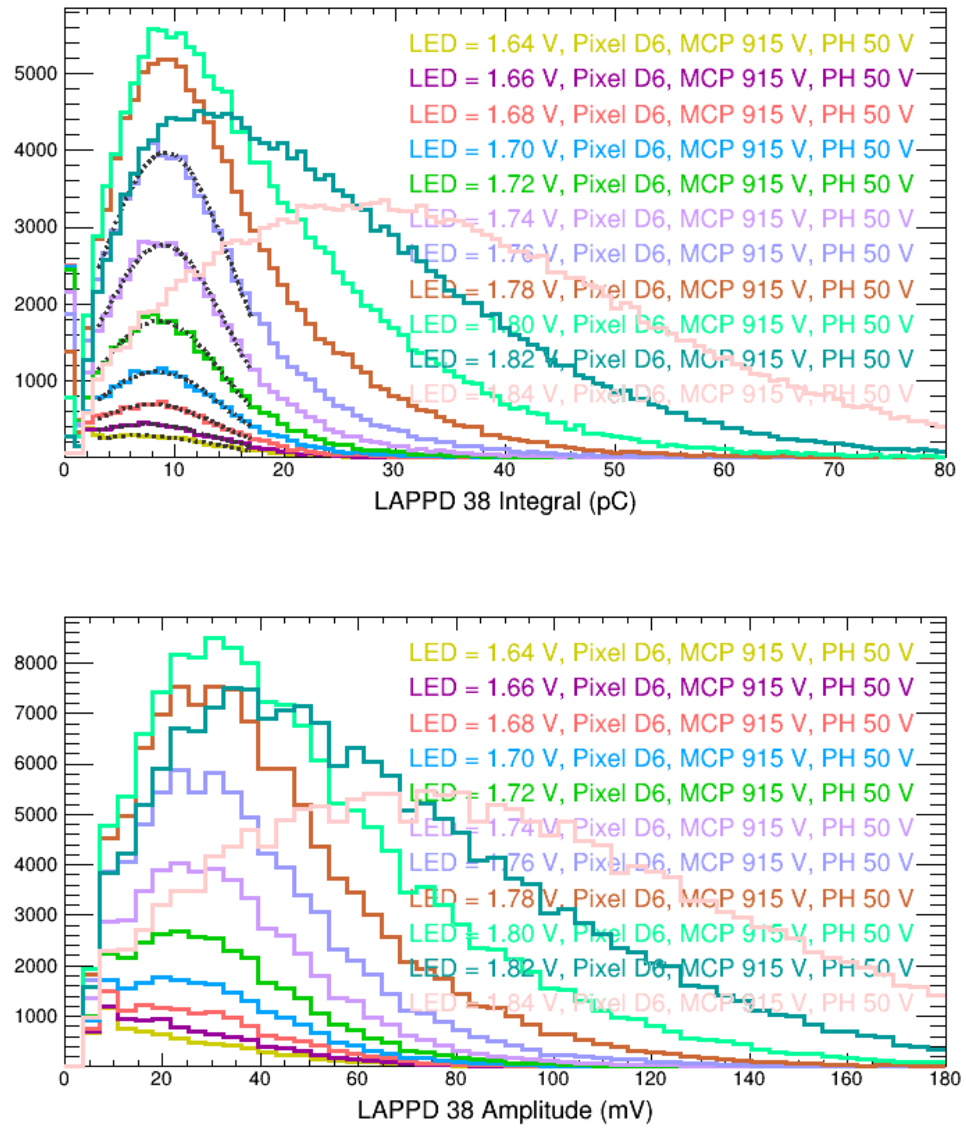
→ The pedestal is calculated as the average of the previous 4 samples once a sample registers above threshold

→ The pulse is defined as the first 28 samples above threshold once a sample registers above threshold

High voltage scan

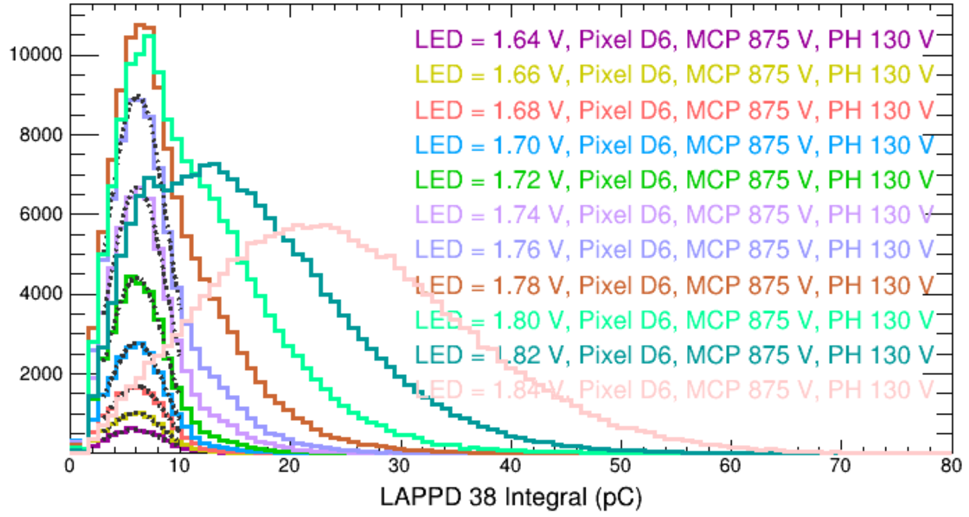


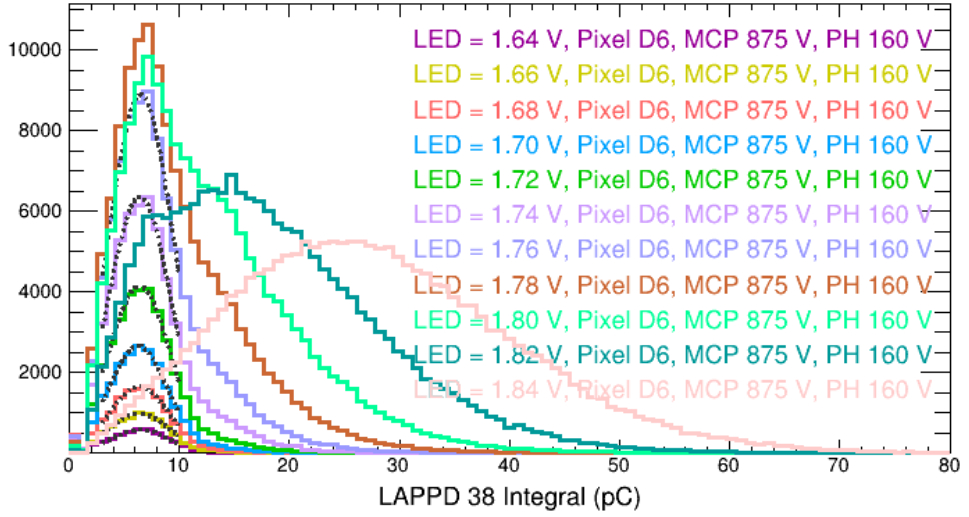
Single and multi photoelectron distributions obtained from LAPPD 38 at a **MCP voltage of 900 V and a photocathode voltage of 50 V**.

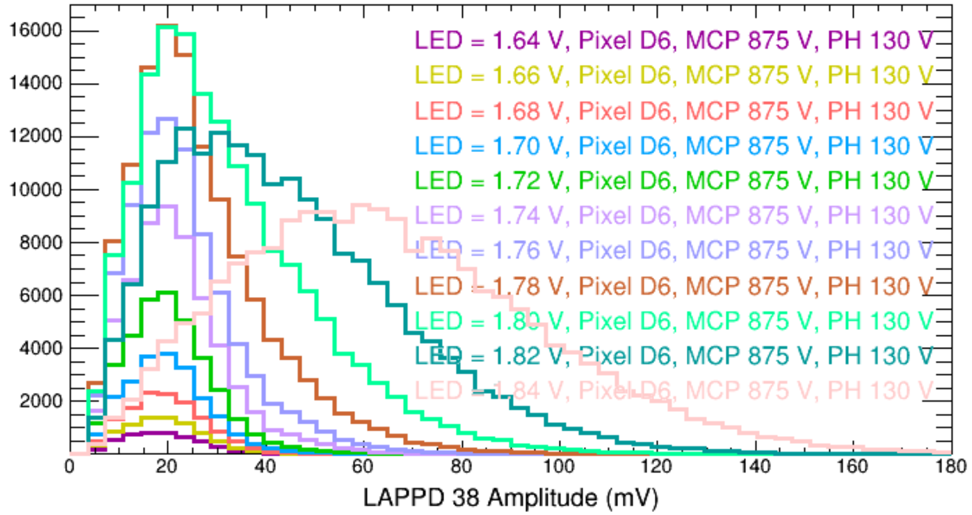


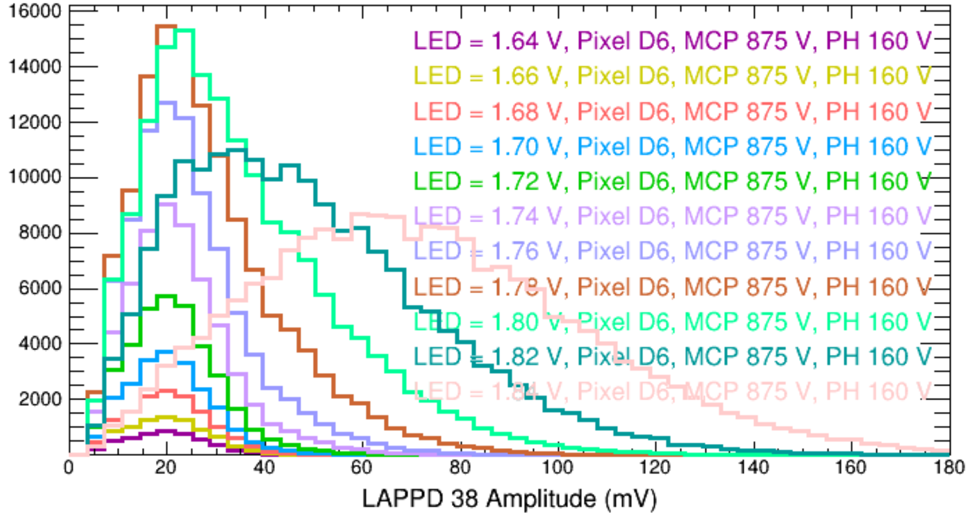
Single and multi photoelectron distributions obtained from LAPPD 38 at a **MCP voltage of 915 V and a photocathode voltage of 50 V**.

High voltage scan





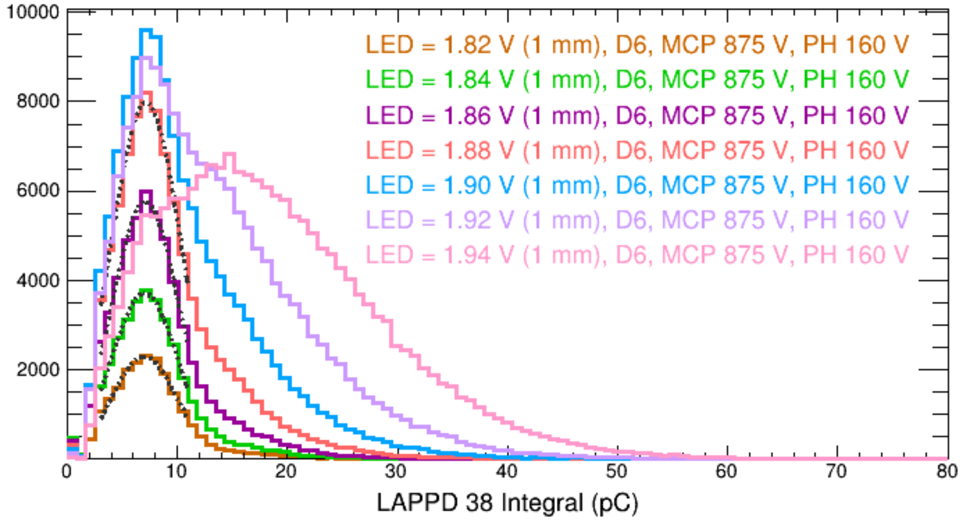


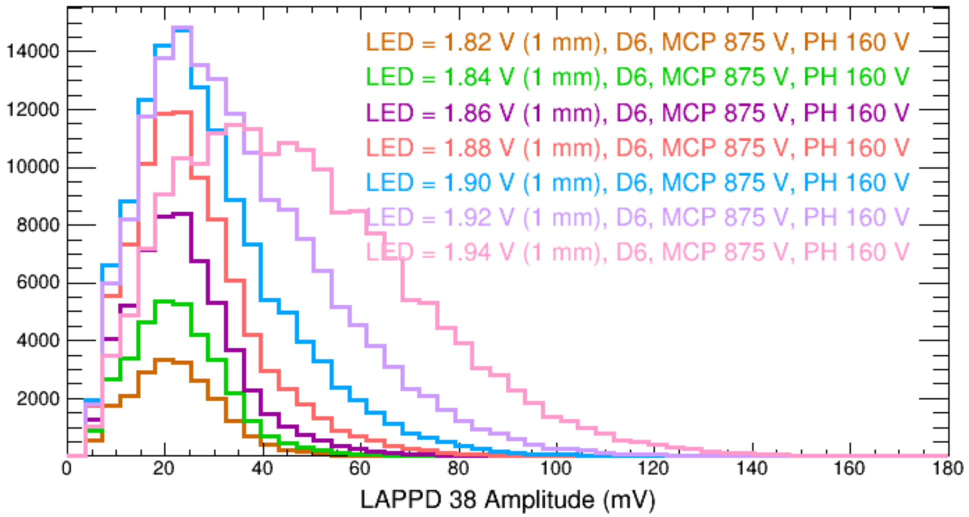


Single and multi photoelectron distributions obtained from LAPPD 38 at a **MCP voltage of 875 V and a photocathode voltage of 130 V**.

Single and multi photoelectron distributions obtained from LAPPD 38 at a **MCP voltage of 875 V and a photocathode voltage of 160 V**.

1mm hole collimation to attempt the measurement of the charge could radius





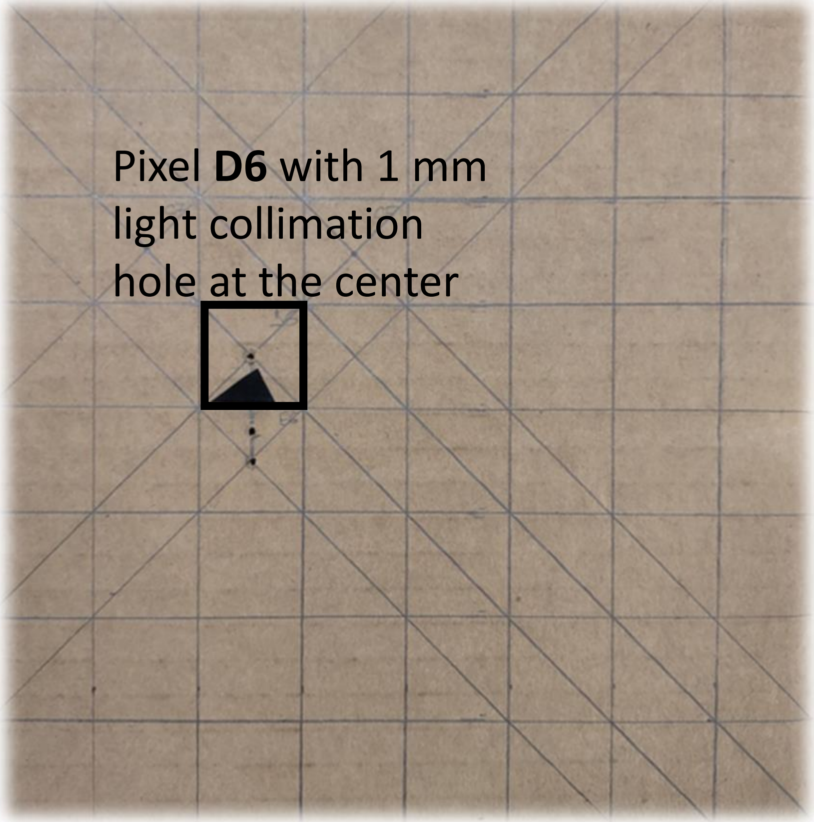
Single photoelectron distributions obtained from LAPPD 38 at a MCP voltage of 875 V and a photocathode voltage of 160 V with LED photons collimated through a 1 mm hole

- → Here the 1 mm hole is placed at the center of a "pixel"
- → No significant charge is registered on adjacent pixels meaning that the charge cloud is confined to the illuminated pixel
- → The idea is to "move" the 1mm hole towards the edge of the illuminated pixel and determine when the adjacent pixel registeres ~30% of the charge
- → Then the distance between the location of the collimation hole and the edge of the pixel ~ the radius of the charge cloud

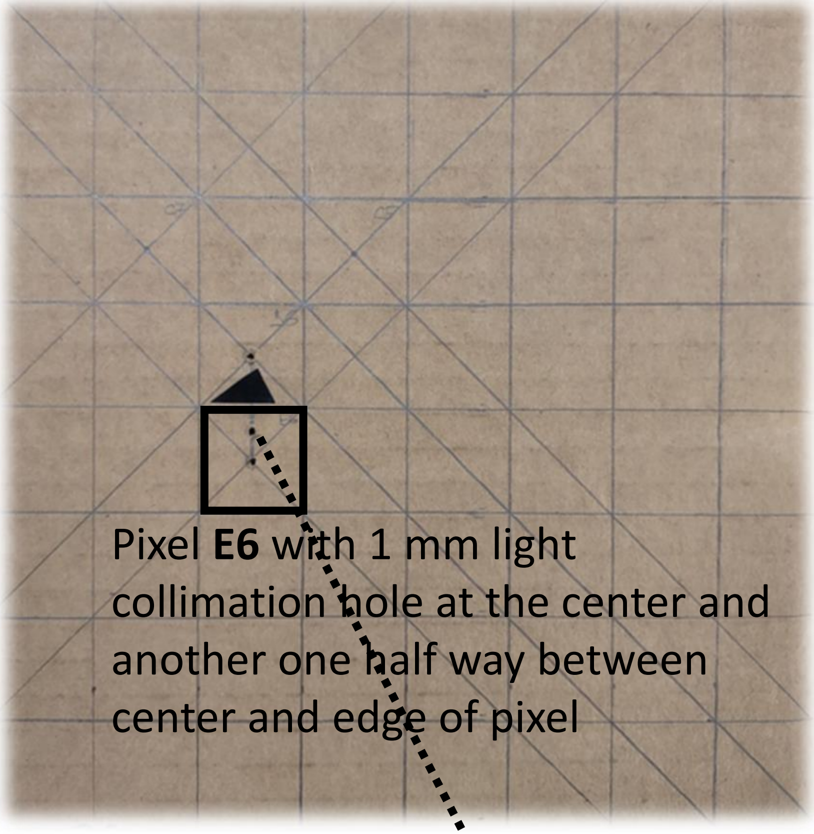
The size of the collimation hole was chosen to maximize the probability of going through 1 single amplification pore in the first MCP

This work is ongoing, I don't have yet a number for the radius of the charge cloud

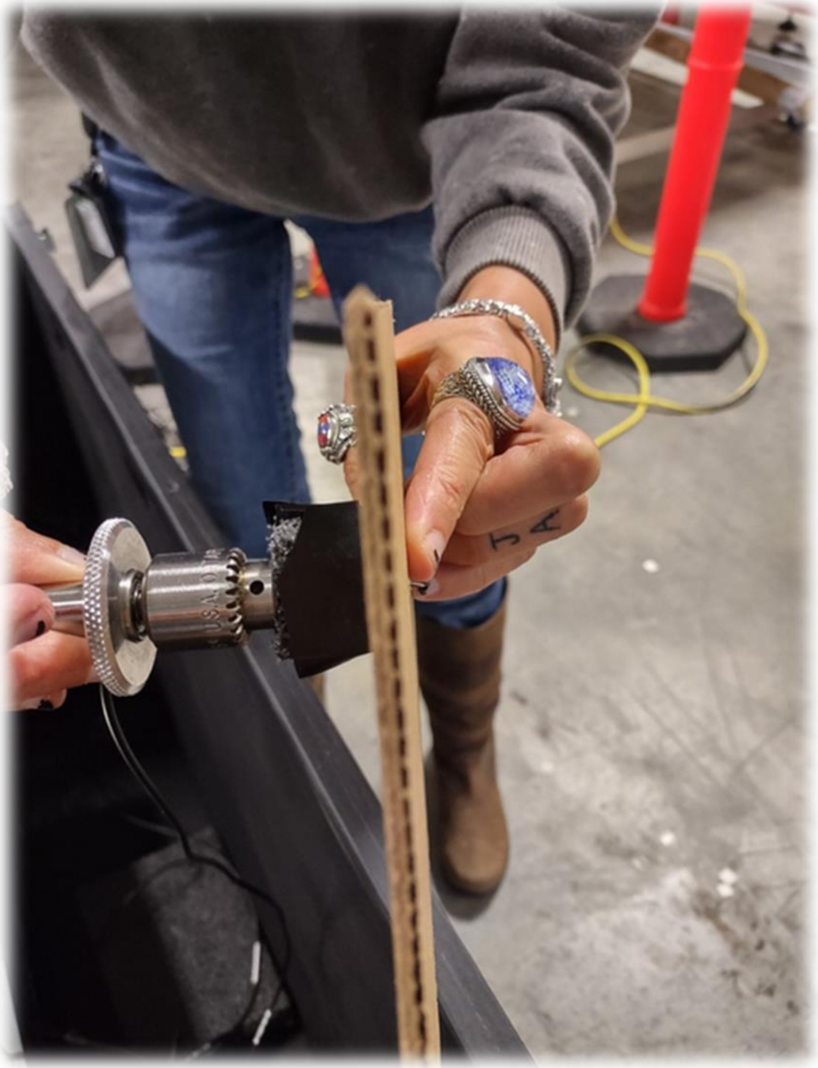
1mm hole collimation to attempt the measurement of the charge could radius

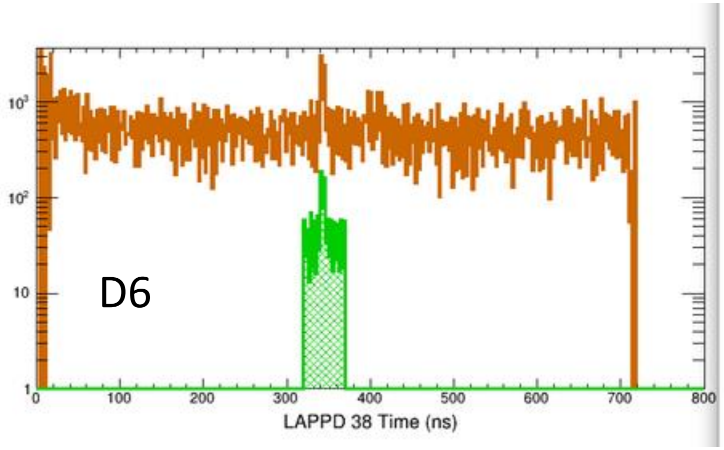


Pixel **D6** with 1 mm light collimation hole at the center

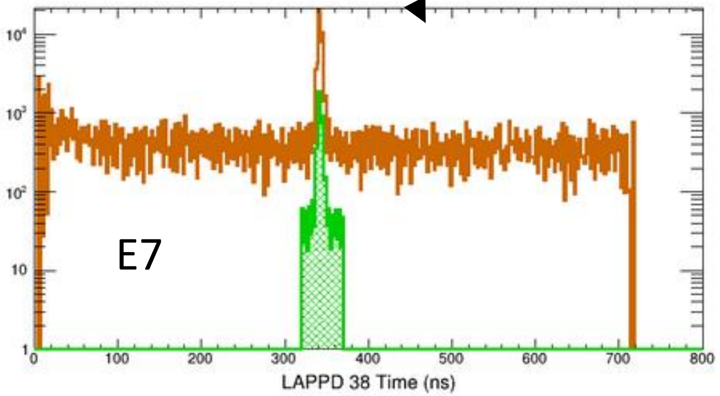


Pixel **E6** with 1 mm light collimation hole at the center and another one half way between center and edge of pixel

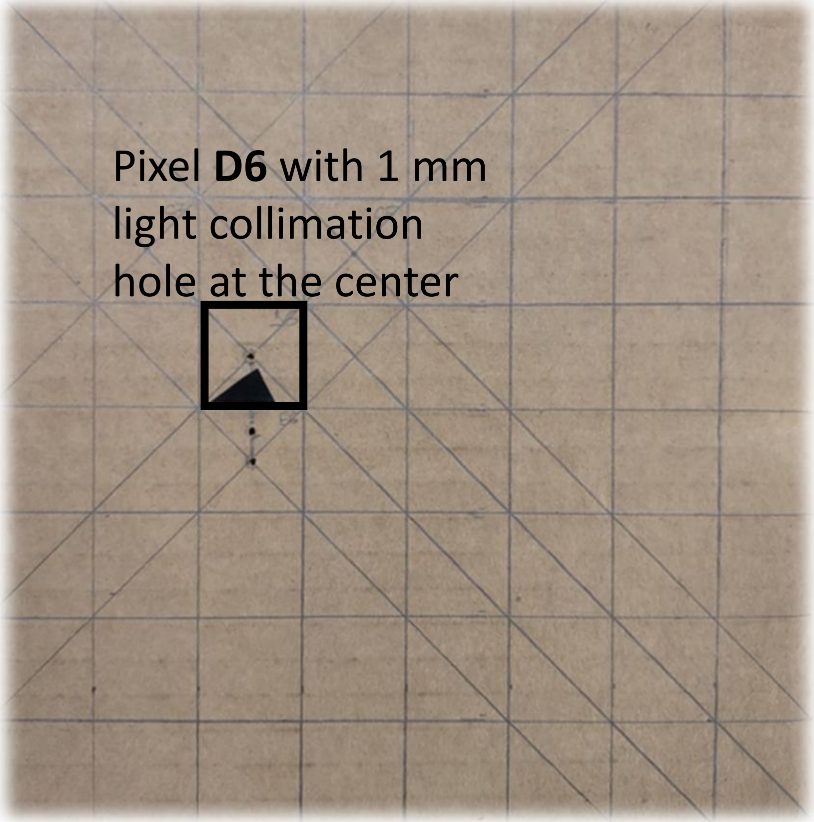




LED light through this hole only



1mm hole collimation to attempt the measurement of the charge could radius



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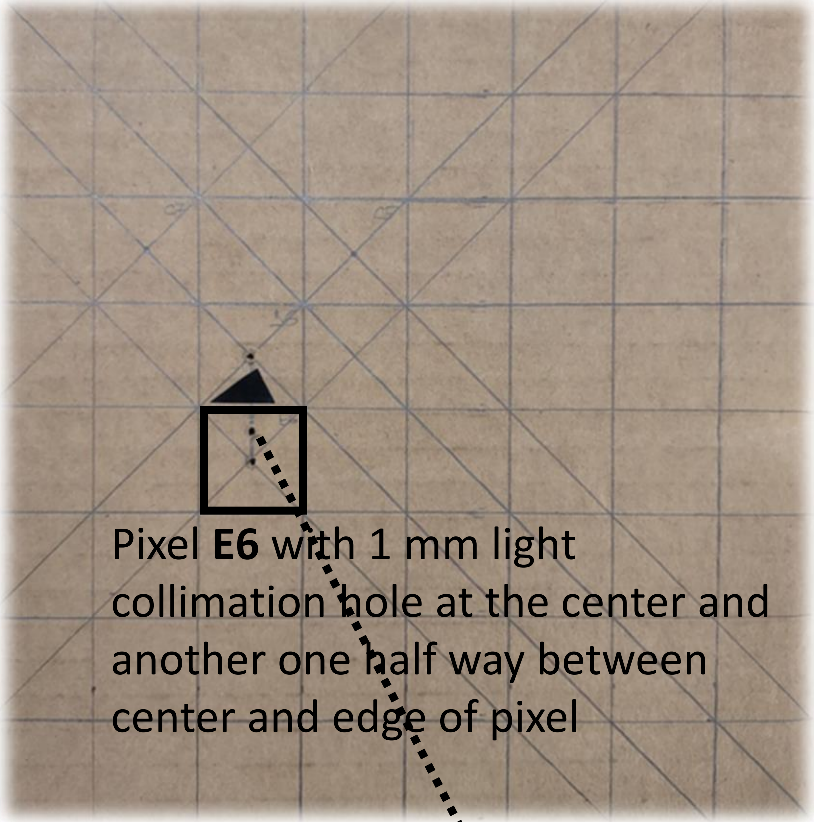

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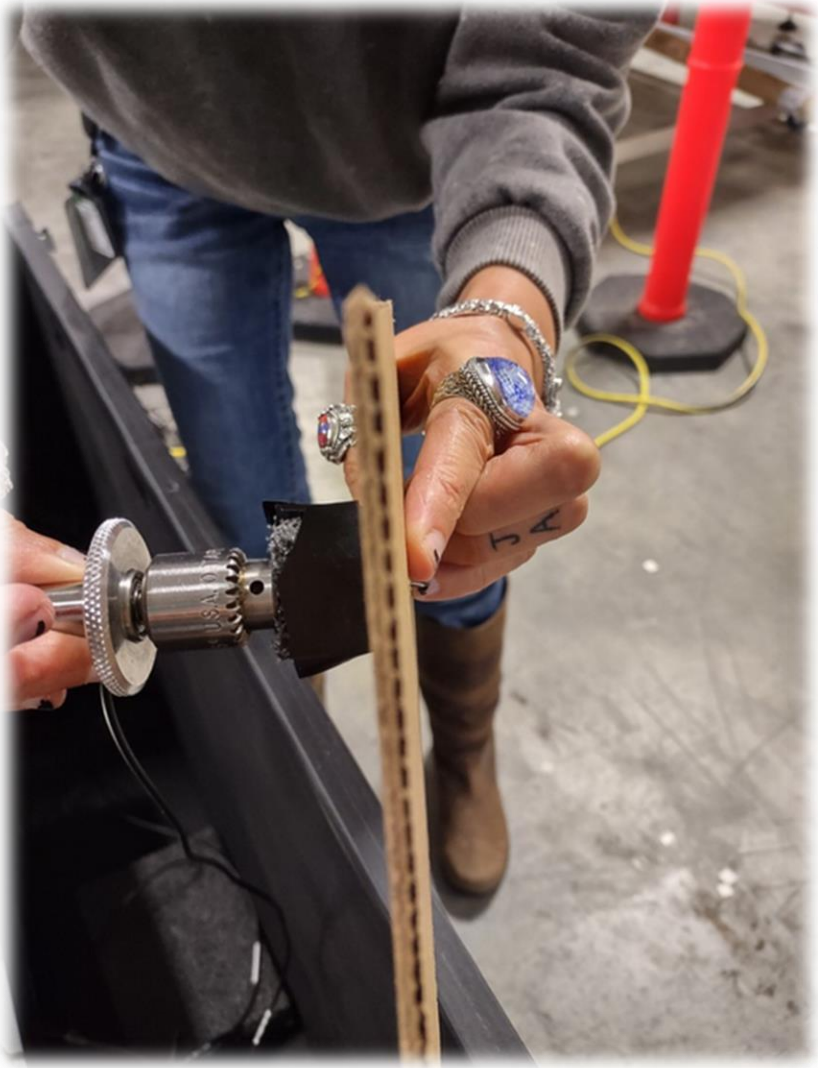

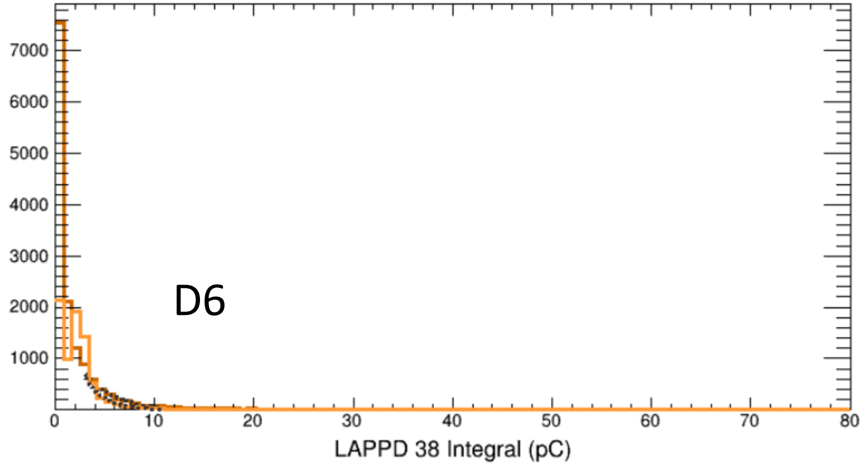

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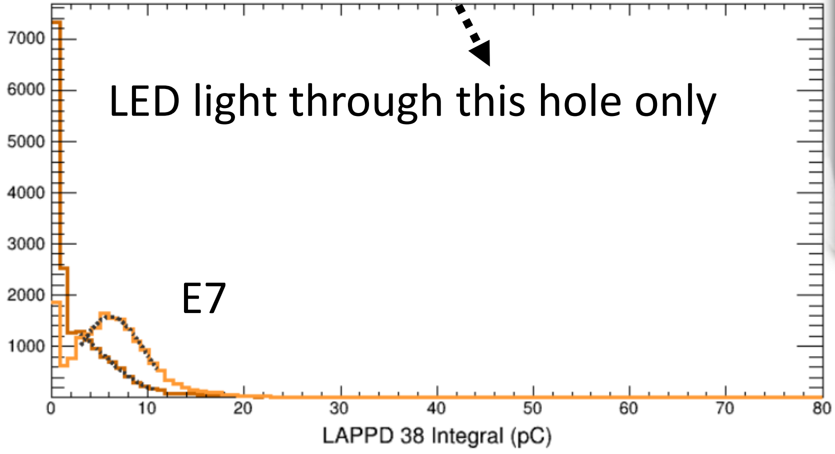
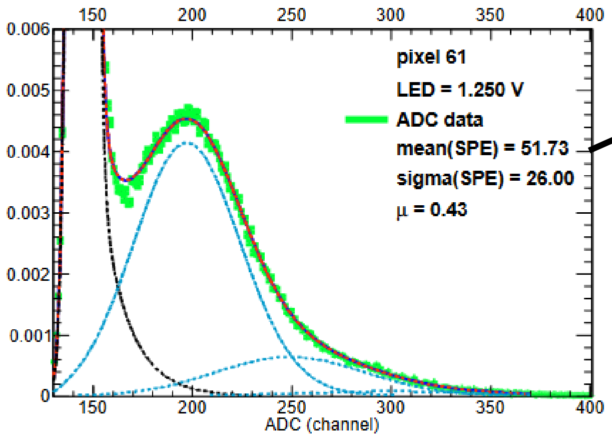


Coming up

- → Optimize the setup for measurements of the charge cloud radius
- → Attempt to overlap 2 charge clouds and check for gain variation due to pore sharing
- → Switch to a faster digitizer (CAEN V1742) and eliminate the usage of 100 m long RG-58 cables with FADC250 (bench tests only)
- → Perform fitting with a LAPPD response function to extract single photoelectron characteristics
- → Do it allover again with the new LAPPD
- → Attempt to take data with cosmic rays
- → Eventually install in beam at JLab once the LAPPD is fully characterized and understood on the bench
- → Investigate the possibility of performing magnetic field measurements with CLEO-II (up to 1.48 T)



→ Example of fitting Hamamatsu maPMT (H8500C-03) to extract SPE characteristics; I will try it on the LAPPD distributions