SiPM on Tile Uniformity and Cross-Talk Measurements

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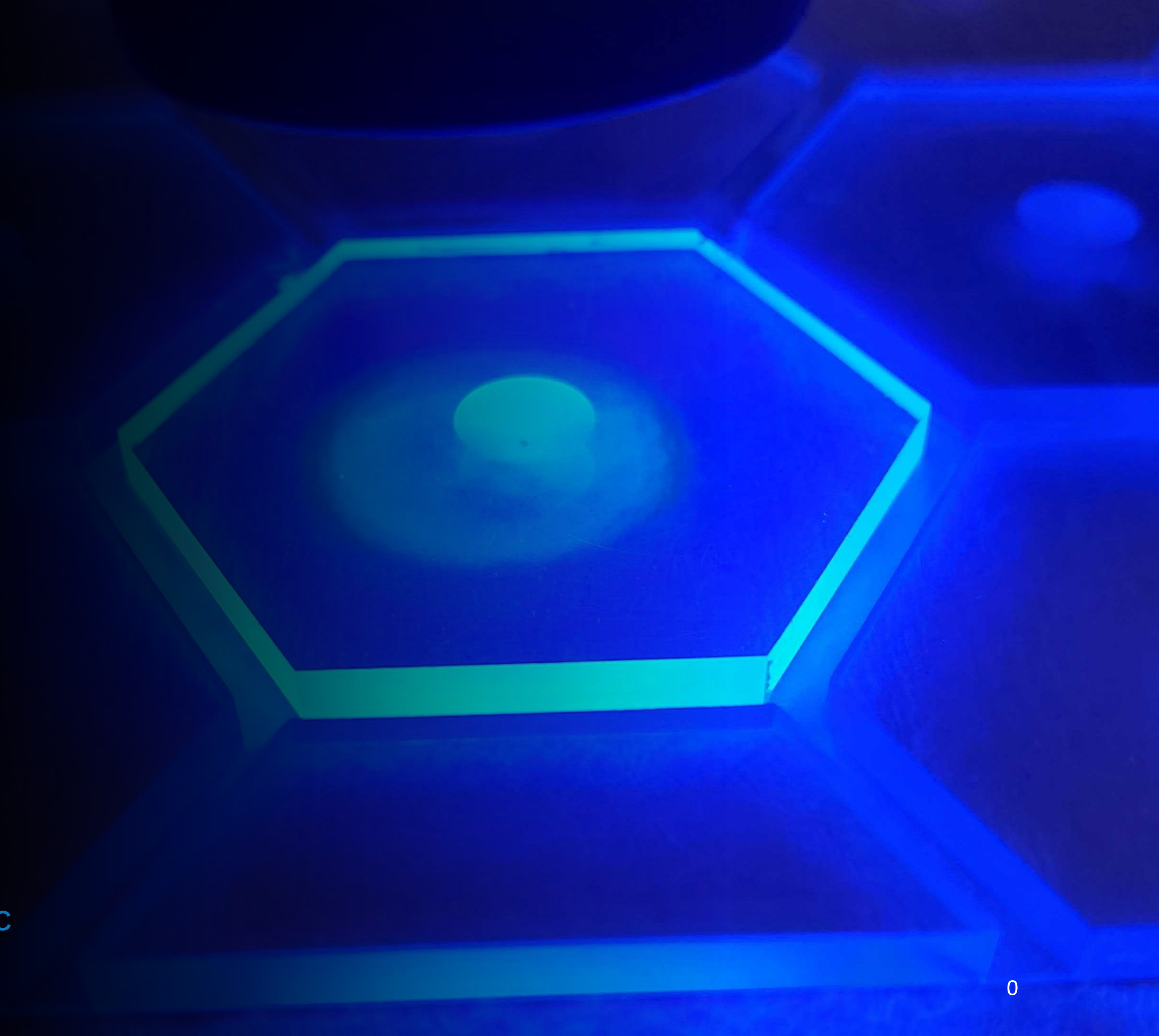


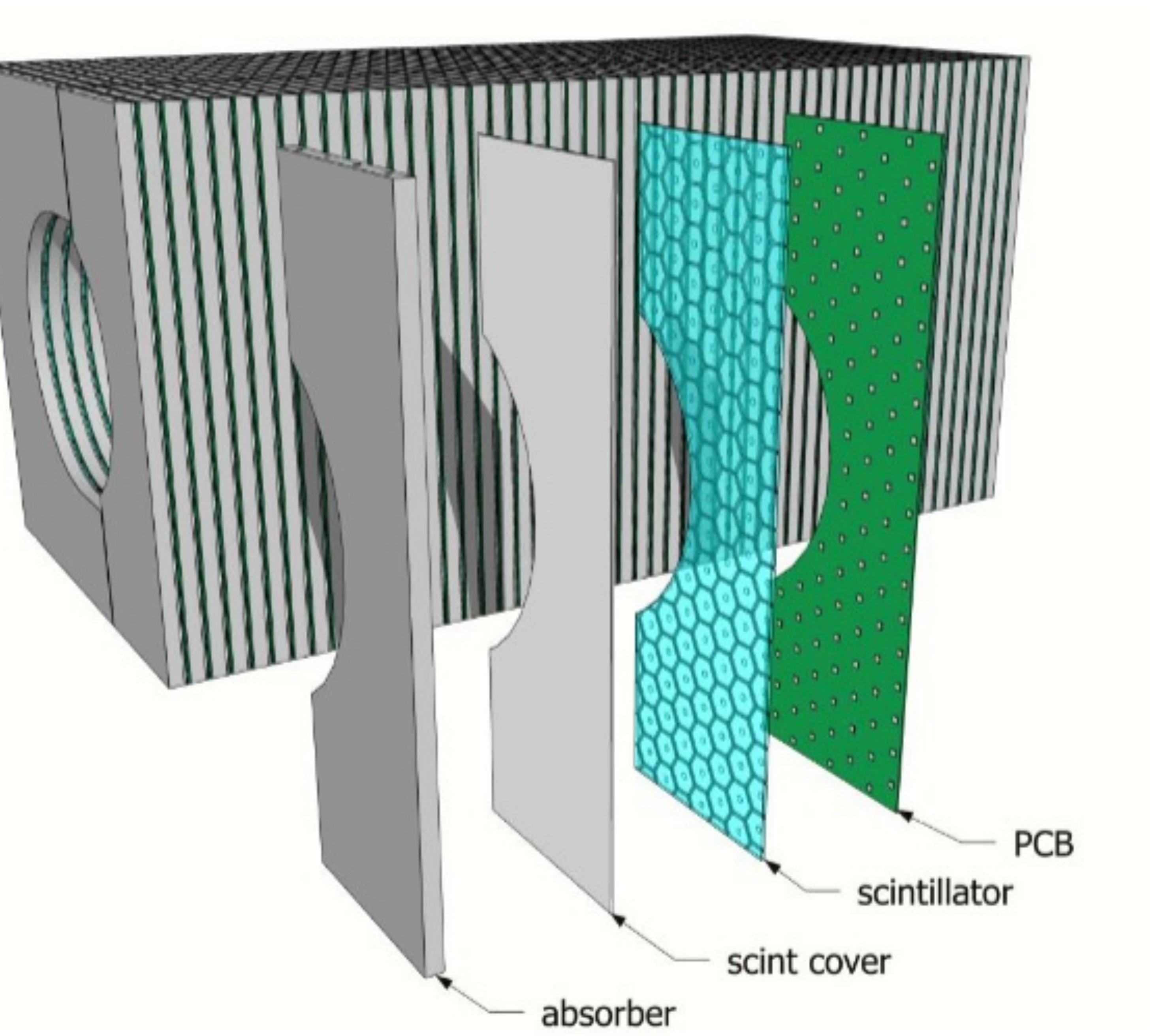


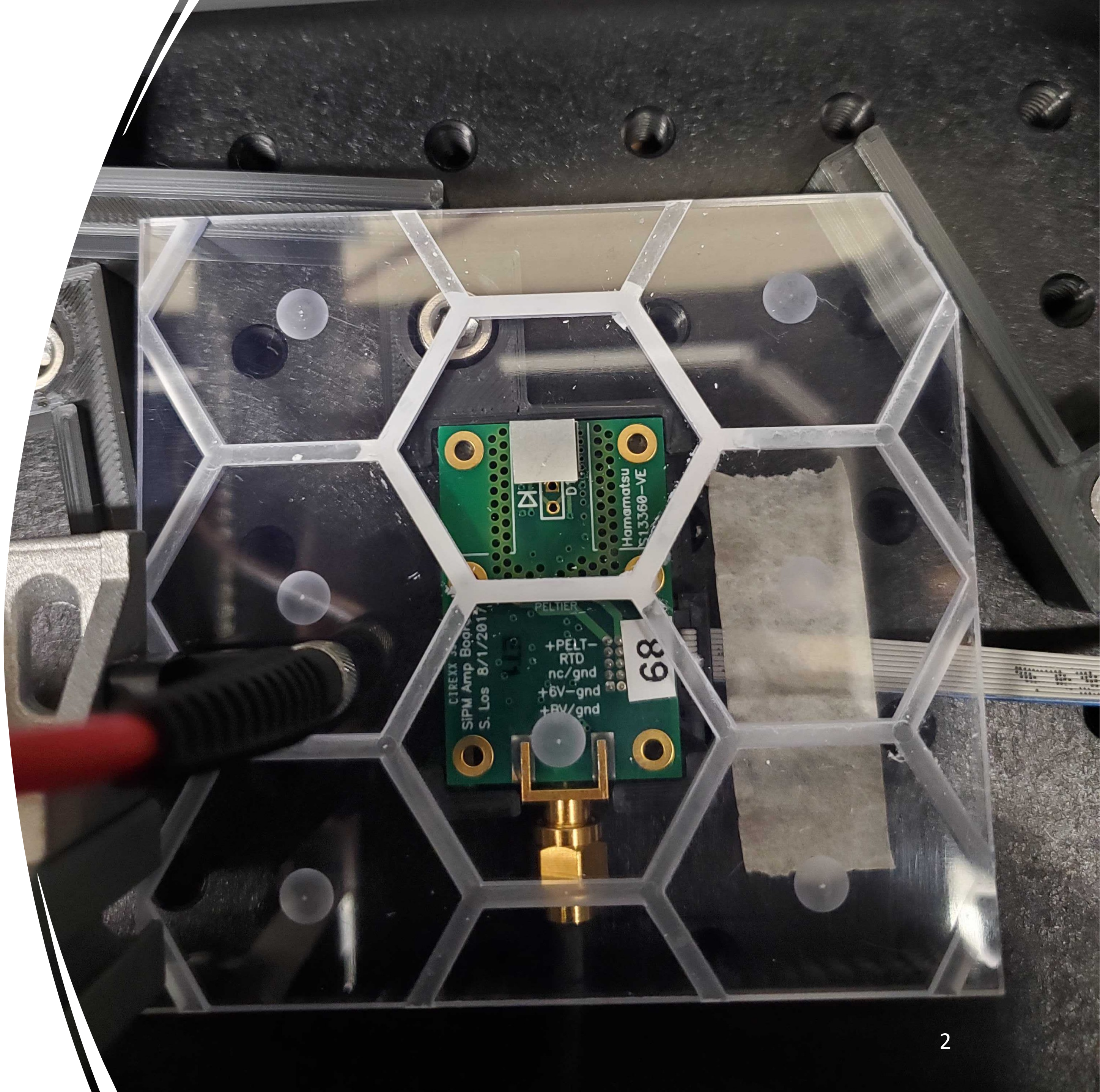
Photo Credit: Sebouh Paul

Scintillating Tiles for the HCAL Insert

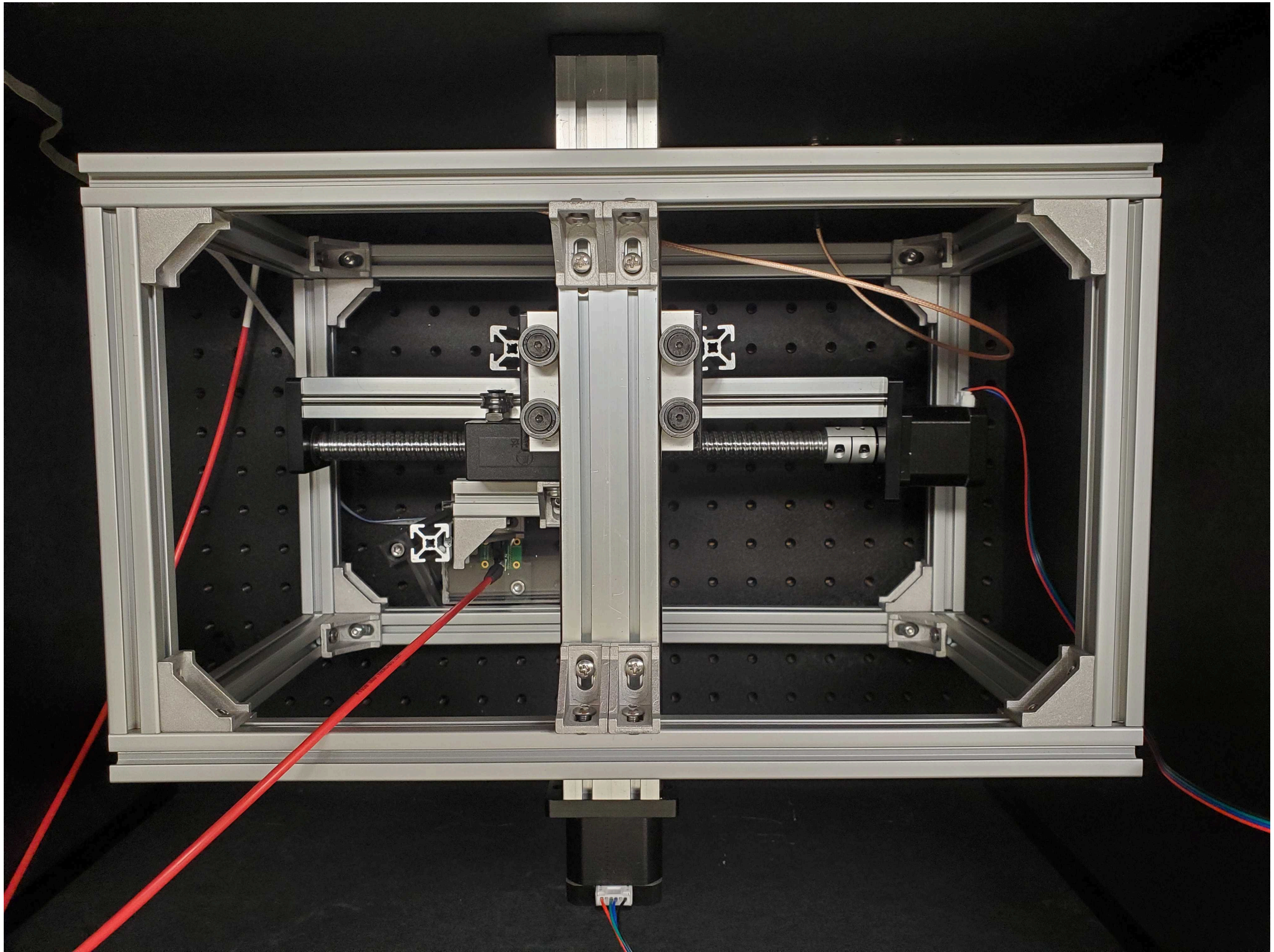
- The high granularity insert design uses EJ-200 plastic scintillating tiles segmented into hexagonal cells
- Each cell is centered on a silicon photomultiplier
- To properly characterize the performance of these tiles for simulations, we must determinize uniformity and cross-talk
- We will also investigate methods of improving these properties

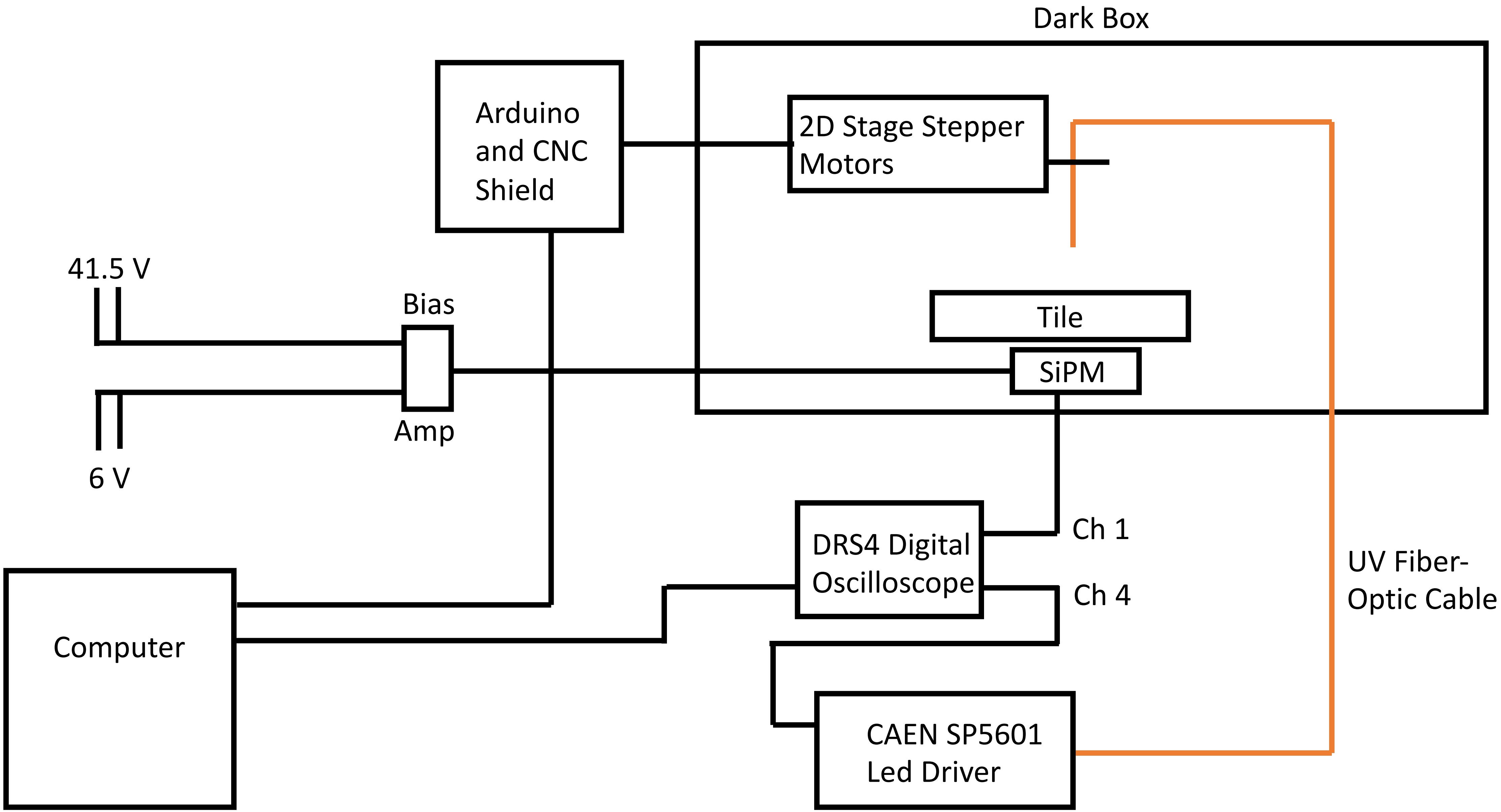
Methodology Overview

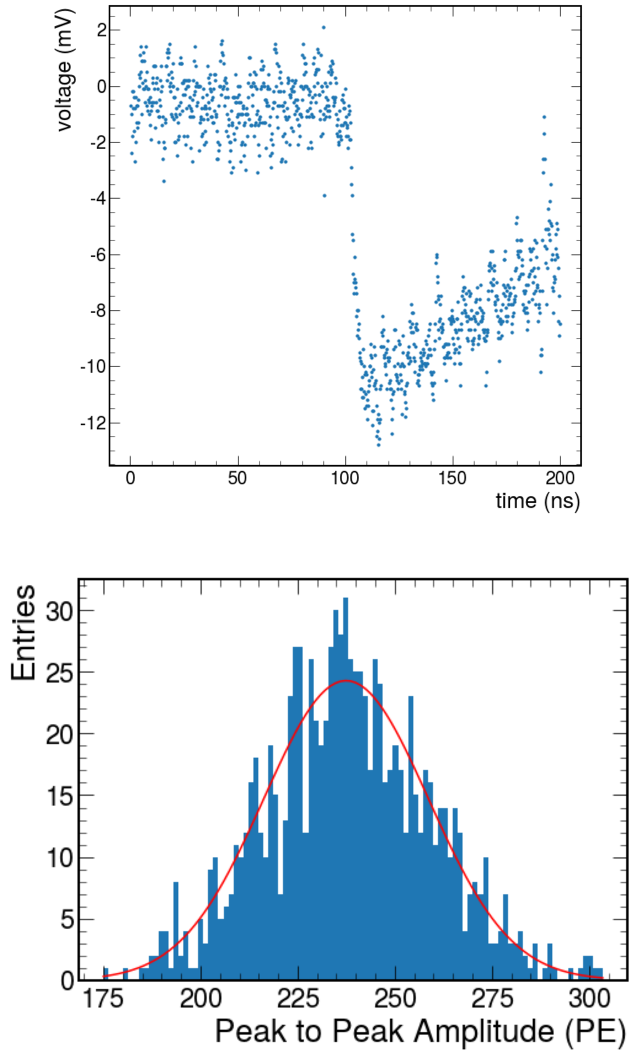
- Within a dark box, place a scintillating tile on top of a SiPM
- Adjust the UV LED intensity / SiPM bias voltage for the dynamic range to cover the portion of the tile of interest
- Using a low intensity LED, calculate the signal voltage to photoelectron conversion factor
- Use XY stage stepper motors to scan the surface of the tile
- Scan the surface of a non-scintillating tile to determine background



Apparatus Overview




Dark Box
Arduino and CNC Shield
2D Stage Stepper Motors
41.5 V
Bias
Amp
6 V
Tile
SiPM
DRS4 Digital Oscilloscope
Ch 1
Ch 4
UV Fiber-Optic Cable
Computer
CAEN SP5601 Led Driver

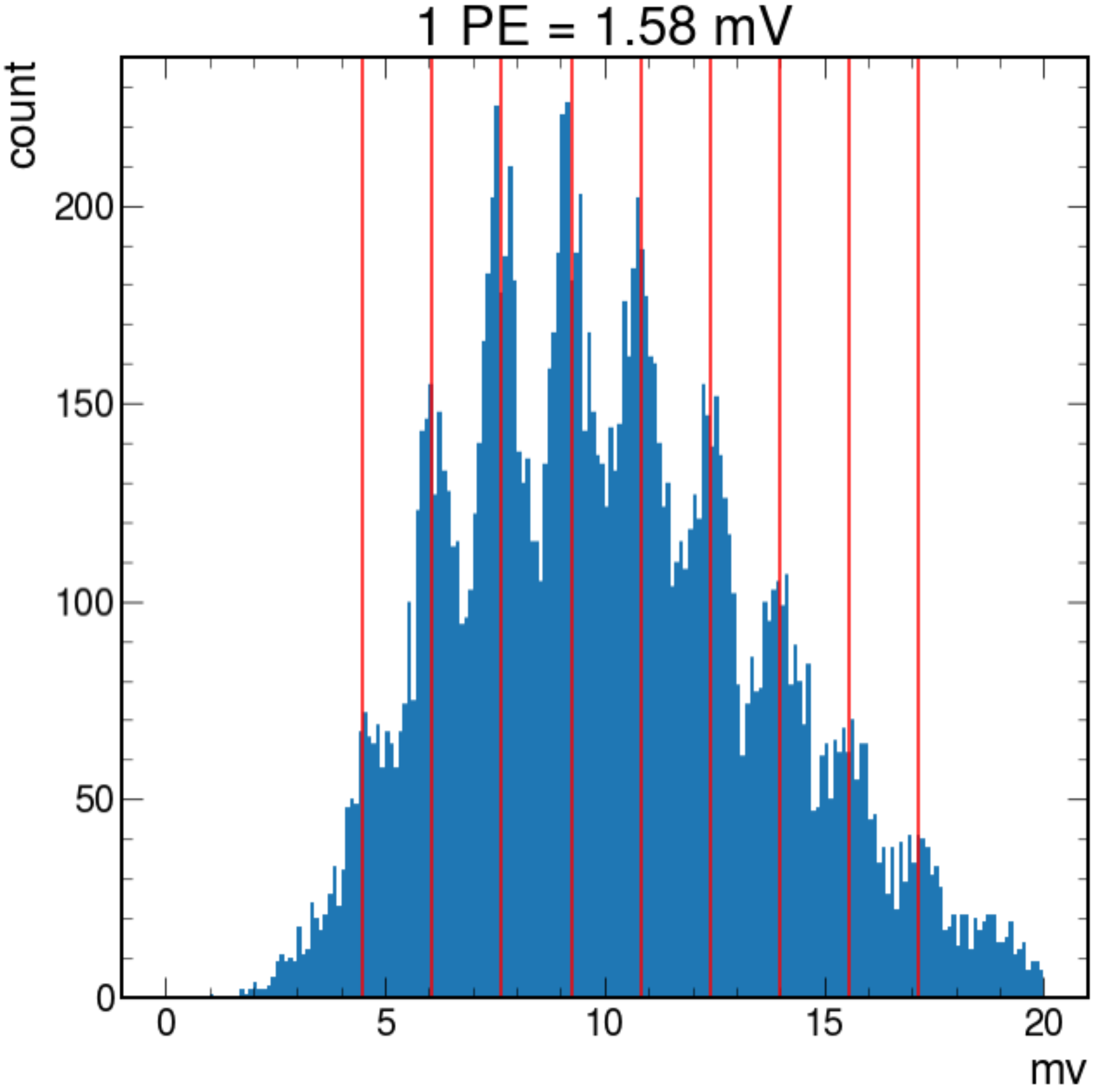


Data Acquisition

- Used a DRS4 Digital Oscilloscope for SiPM readout, and recorded the waveforms using the RCDAQ data acquisition software
- Triggered the data acquisition using a pulsed UV LED source
- Recorded 1,000 waveforms for each point on the tile, and fit the distribution of peak-to-peak values to a gaussian
- The signal strength at a point on the tile is defined by the mean of the gaussian

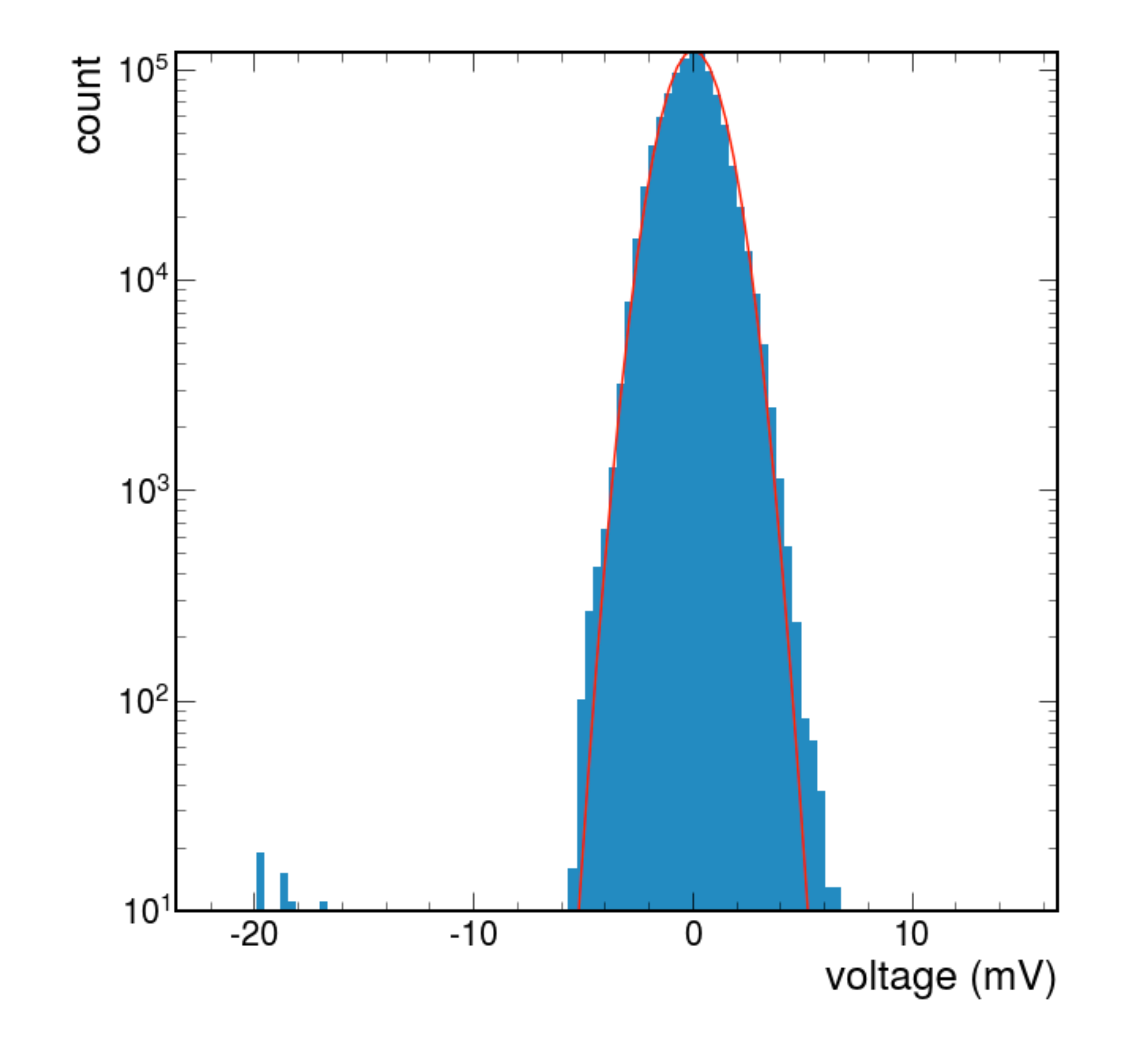
Photoelectron Conversion

- Once a bias voltage is determined, we converted the voltage output from the SiPM to photoelectrons by analyzing a finger spectrum
- We pulsed the UV LED onto the SiPM, and observed the discretization of baseline-to-peak values



Noise Runs

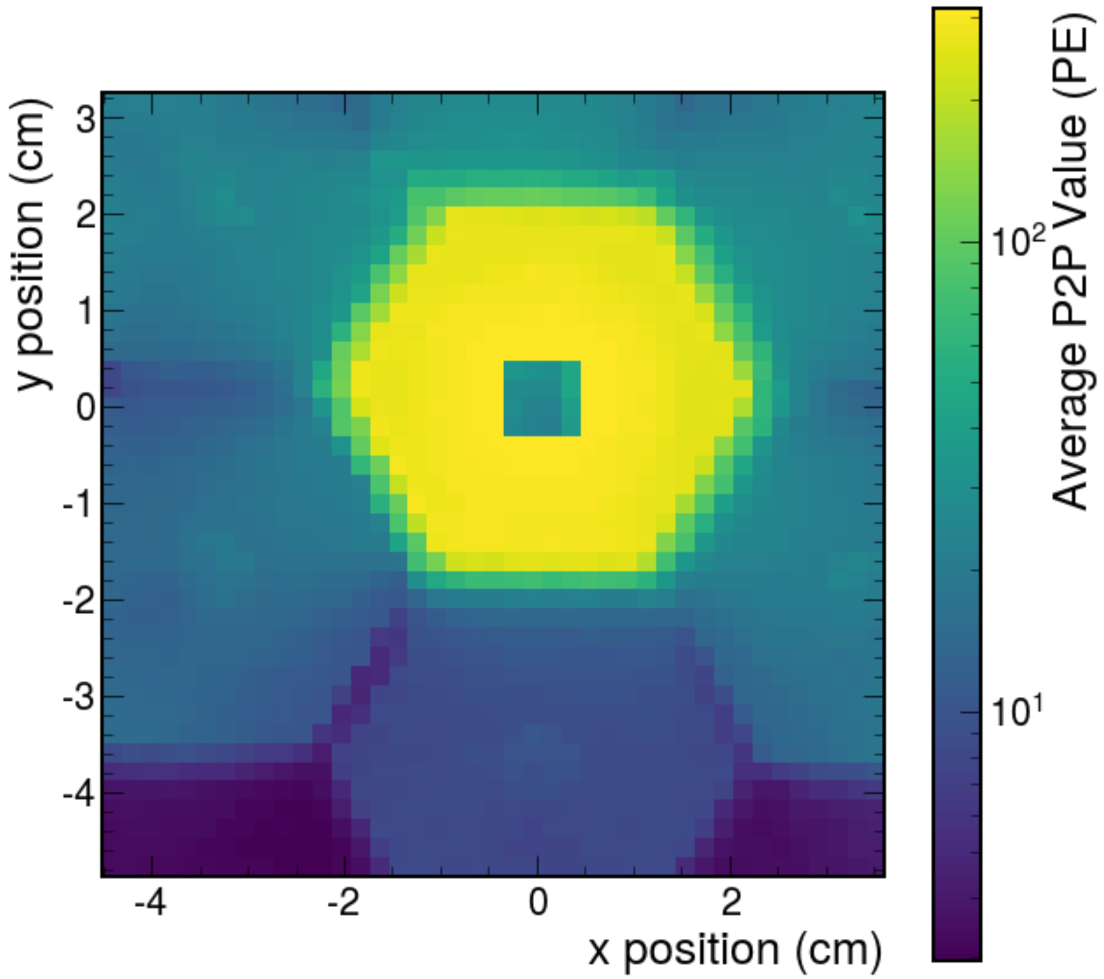
- Before each scan, we recorded noise runs with the SiPM bias turned off, and the LED moved far off to the side
- The voltage distributions were measured as the difference between the value at a point in the waveform, and the average voltage for the entire waveform, across 1k waveforms
- The noise was found to be gaussian, with sigma = 1.2 mV (converts to 0.76 PE)



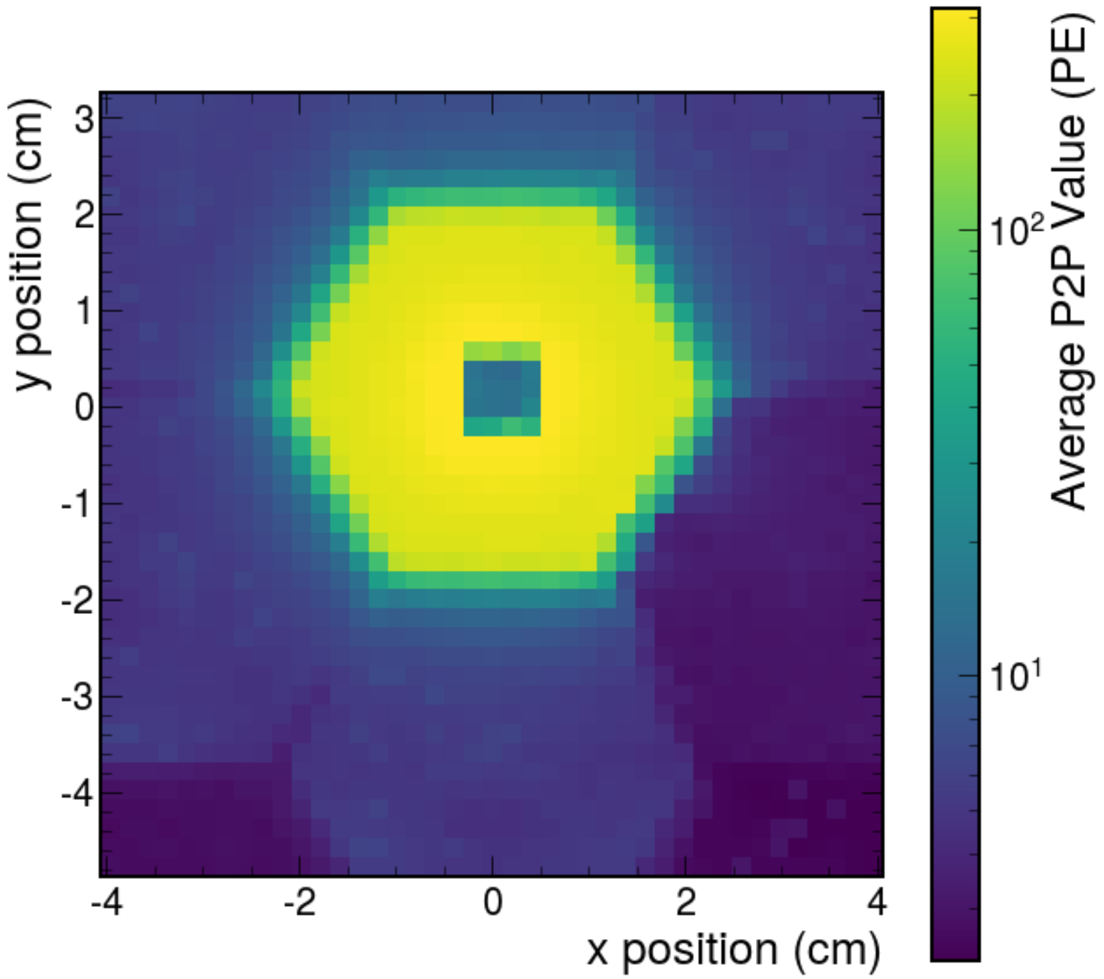
Tile Boarder Painting

- We painted the boarder of a single cell to test how this improves signal containment and yield
- We used highly reflective white SAINT-GOBAIN paint

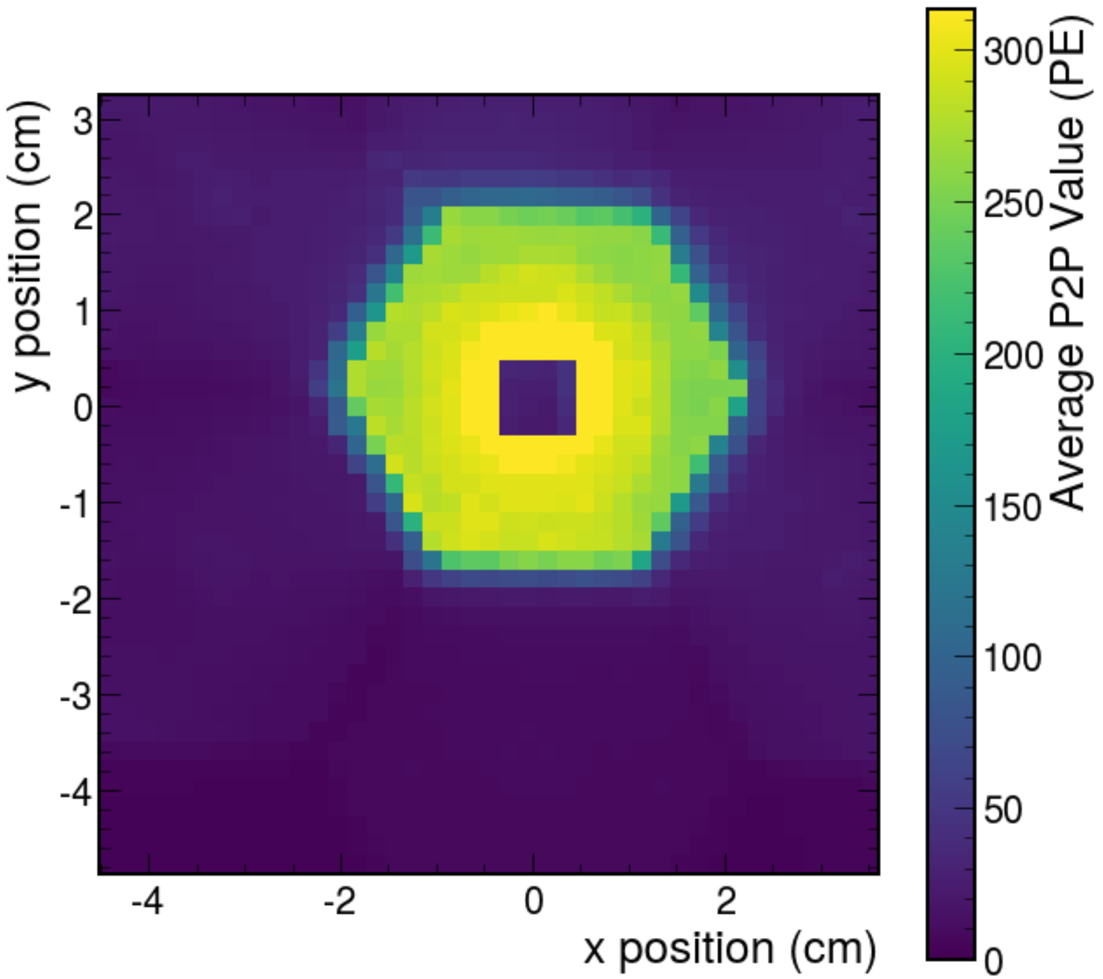
Unpainted



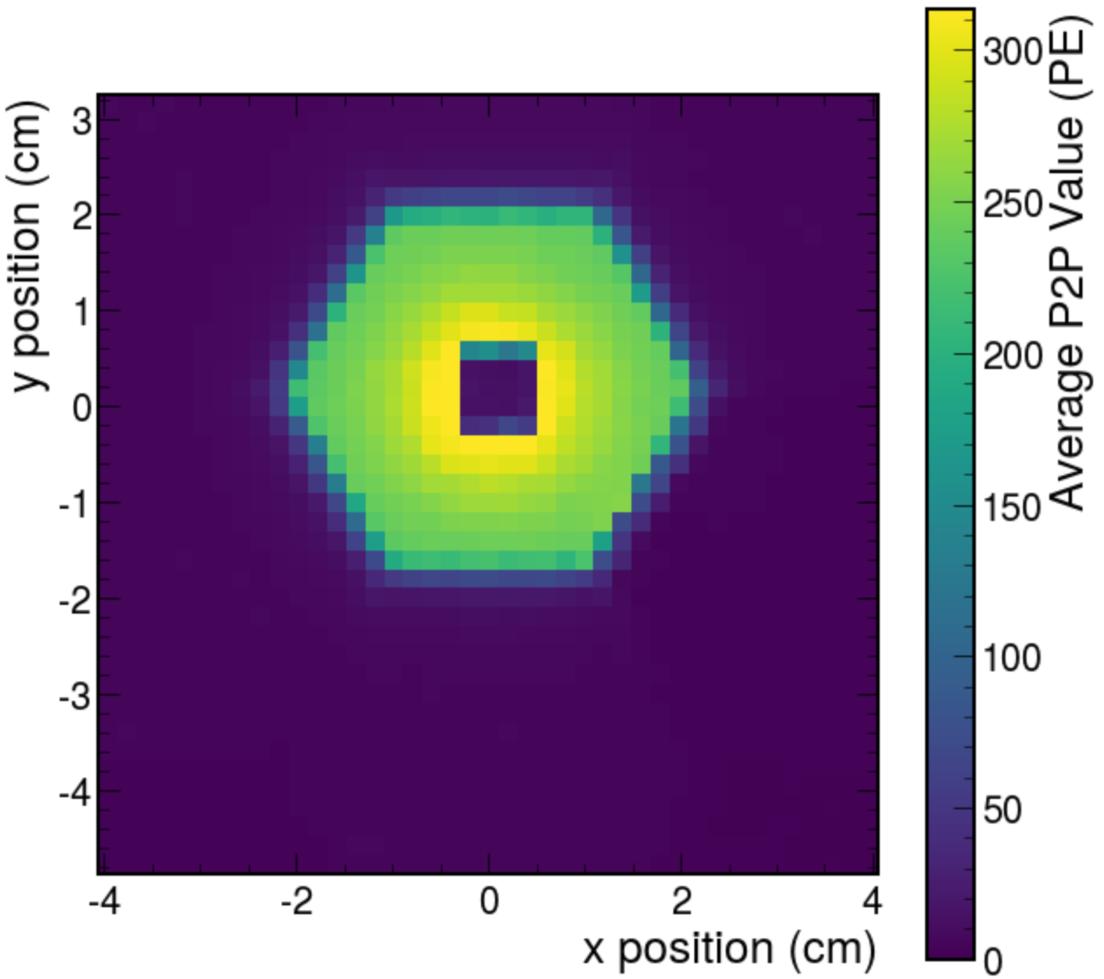
Painted



Unpainted

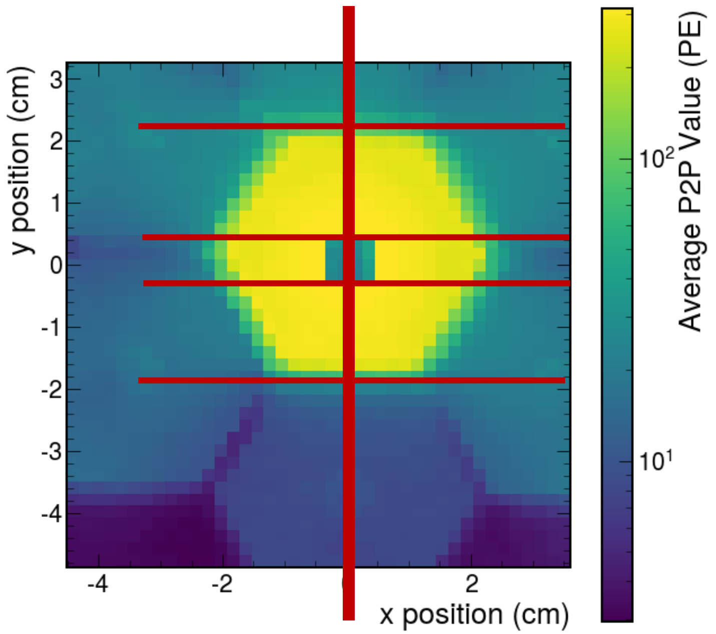


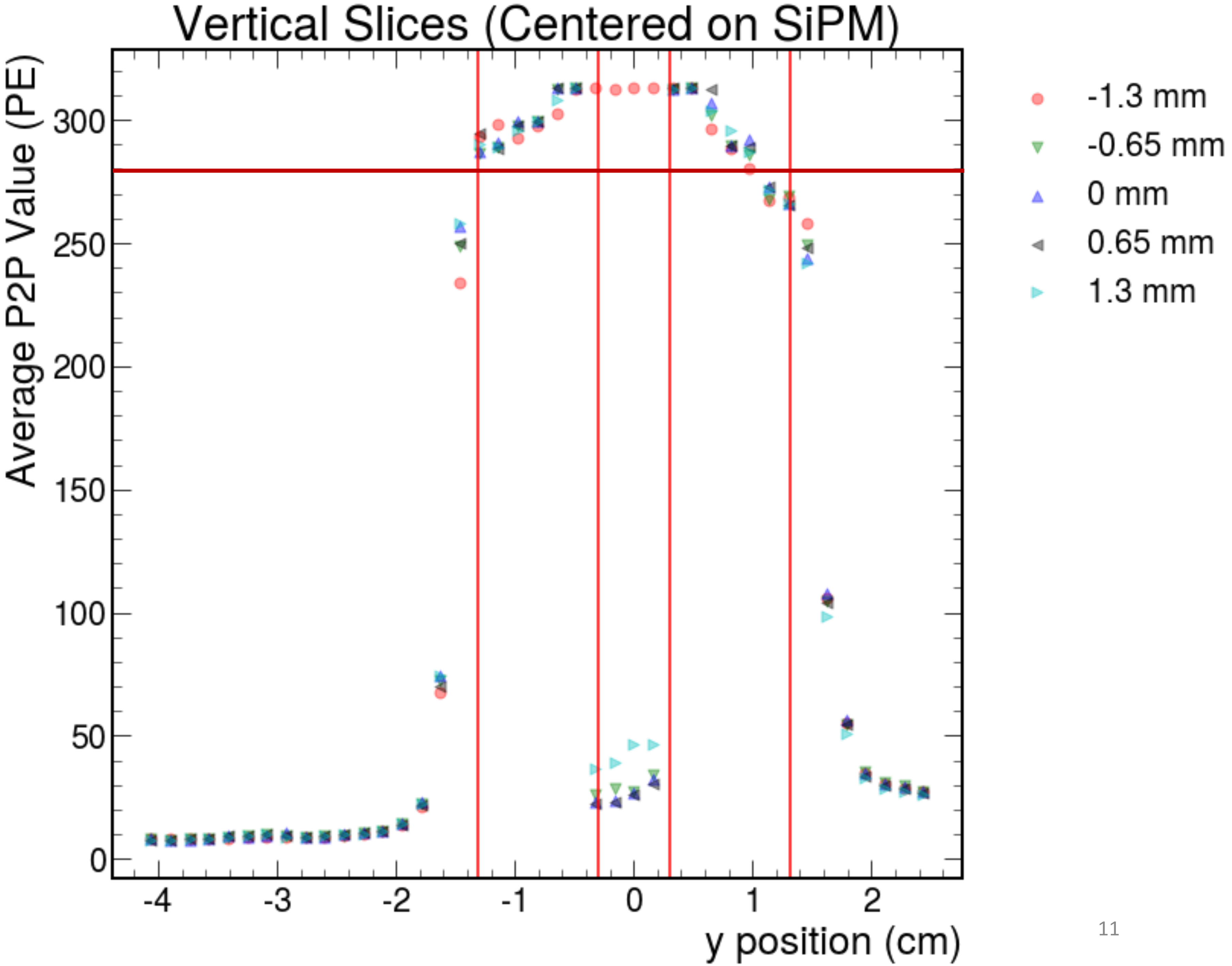
Painted



SiPM Centered on Unpainted Cell

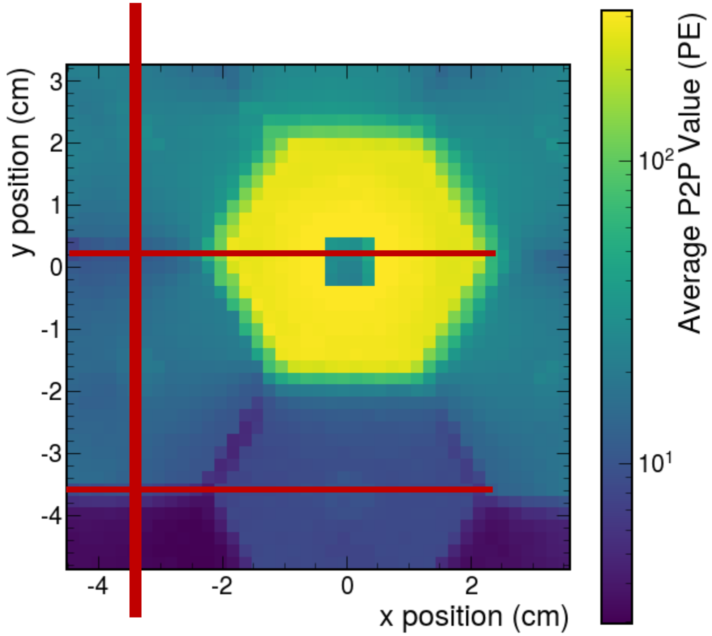
Nonuniformity: 280 +/- 30 PE
(excluding SiPM region)

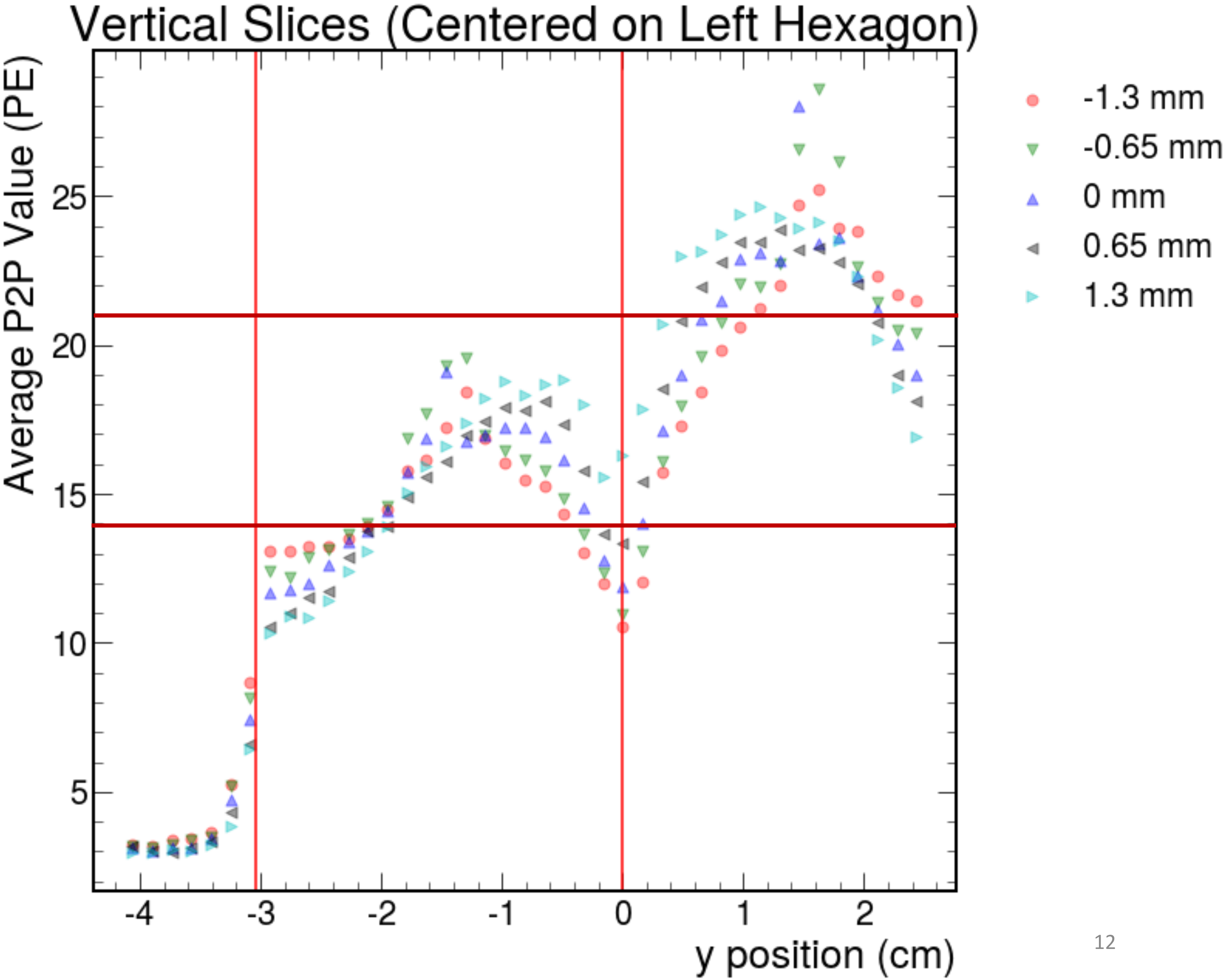




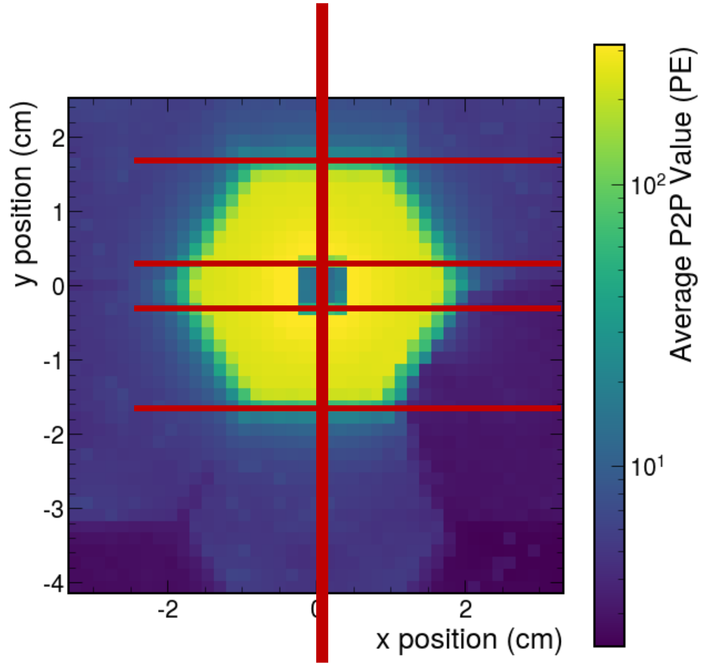
SiPM Centered on Unpainted Cell

280 PE -> 21 PE or 14 PE
7.5% or 5% crosstalk





SiPM Centered on Painted Cell



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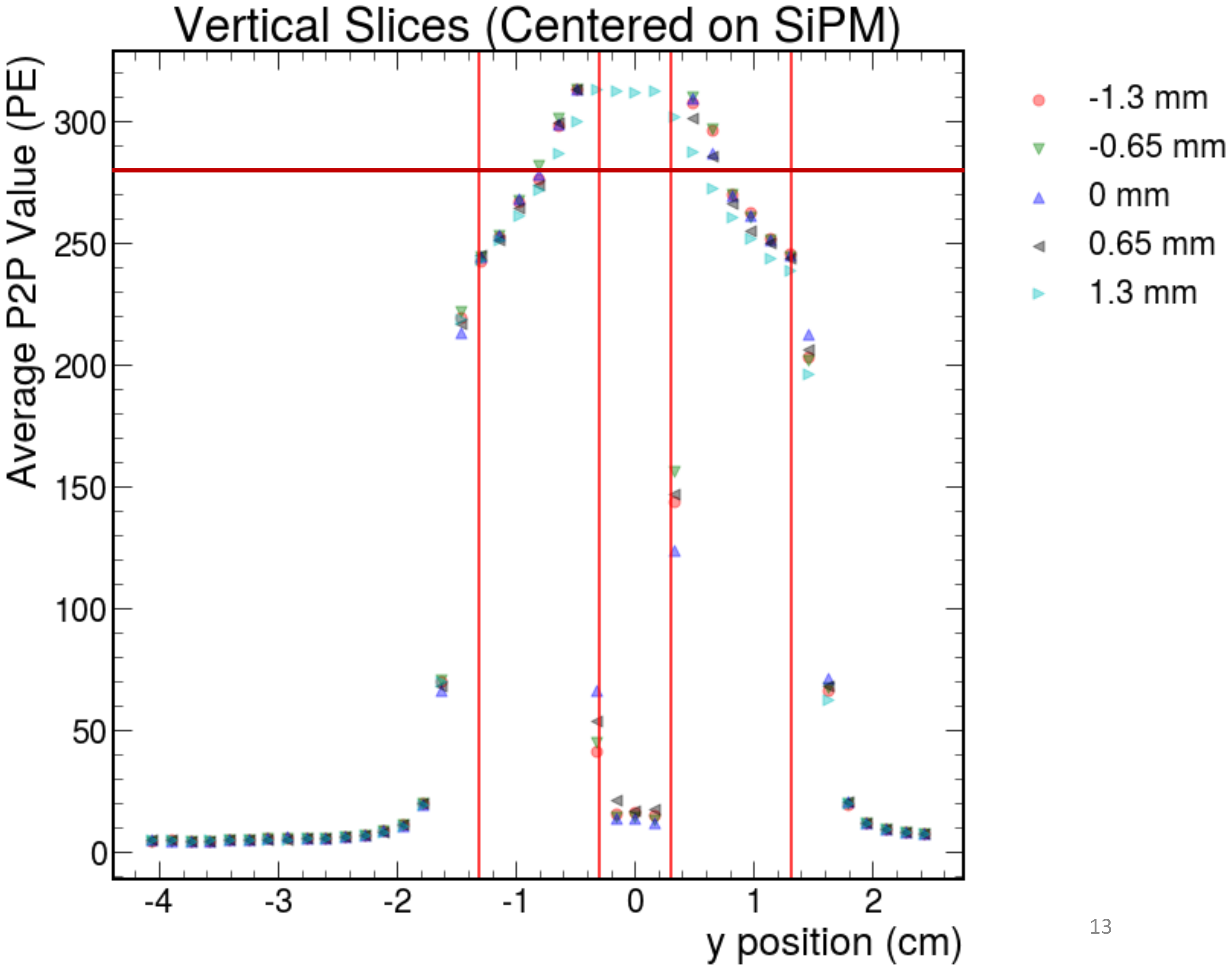
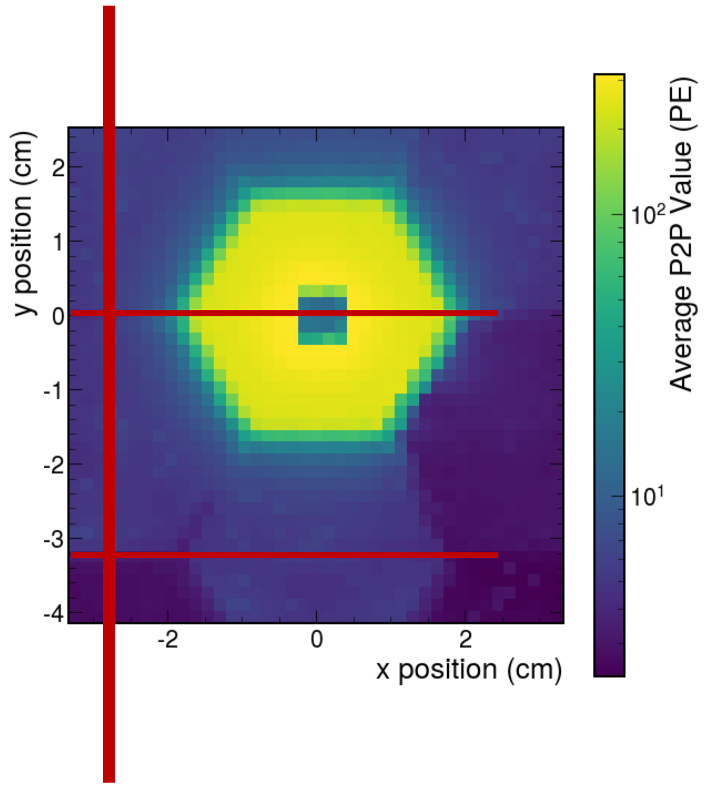
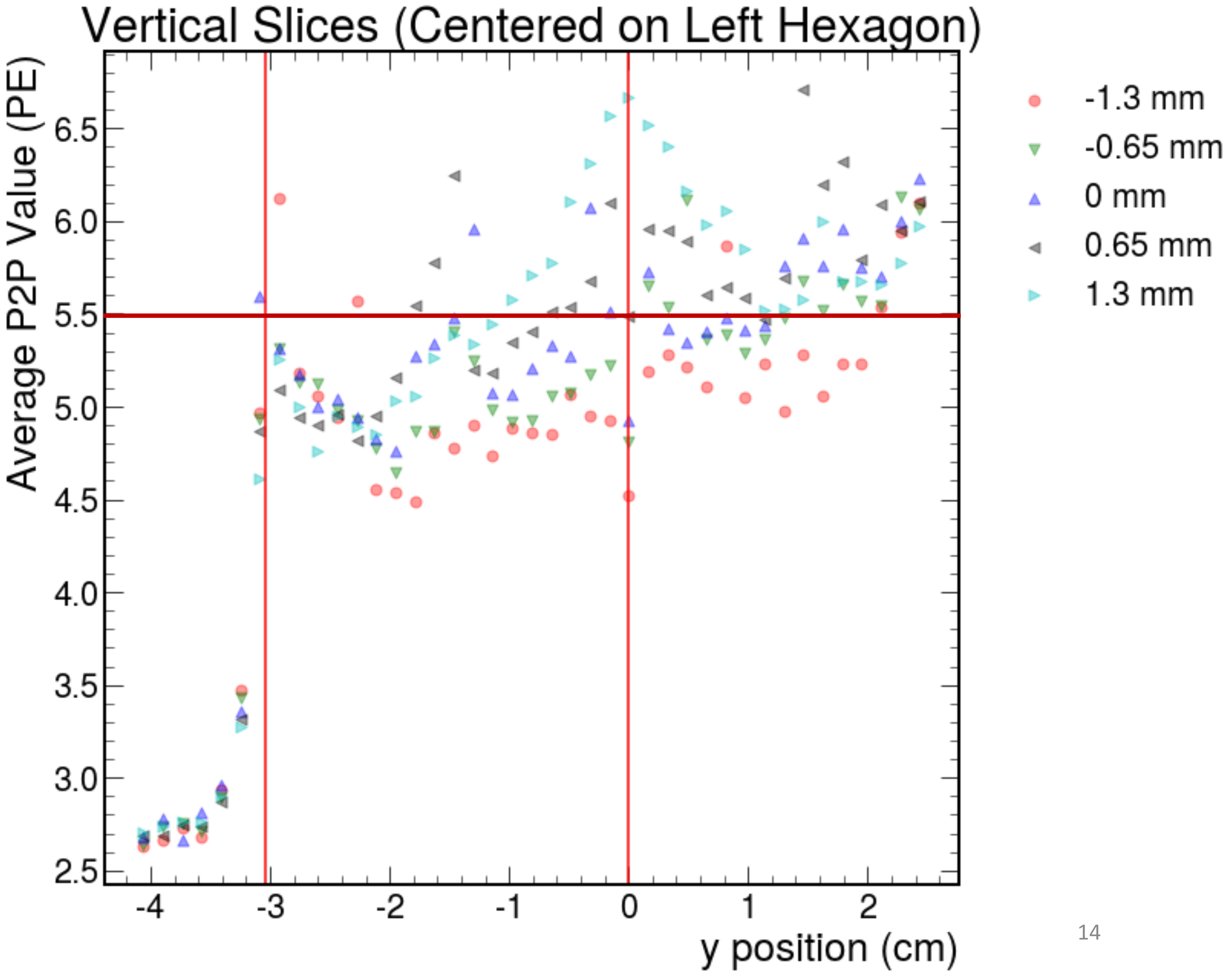
(excluding SiPM region)



SiPM Centered on Painted Cell





280 PE -> 5.5 PE

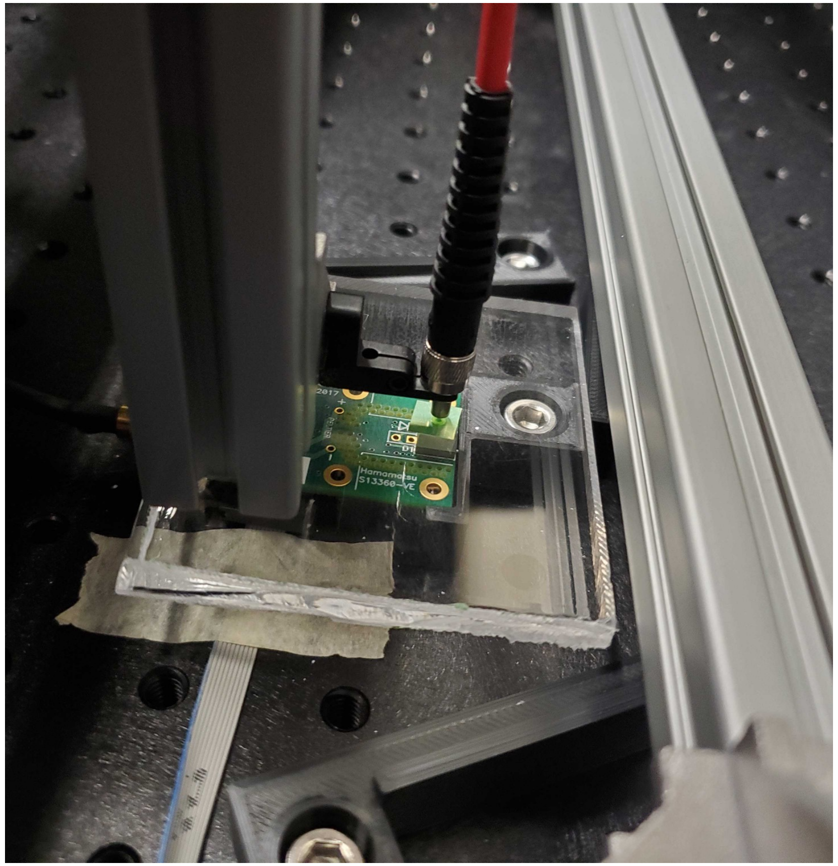
2% crosstalk

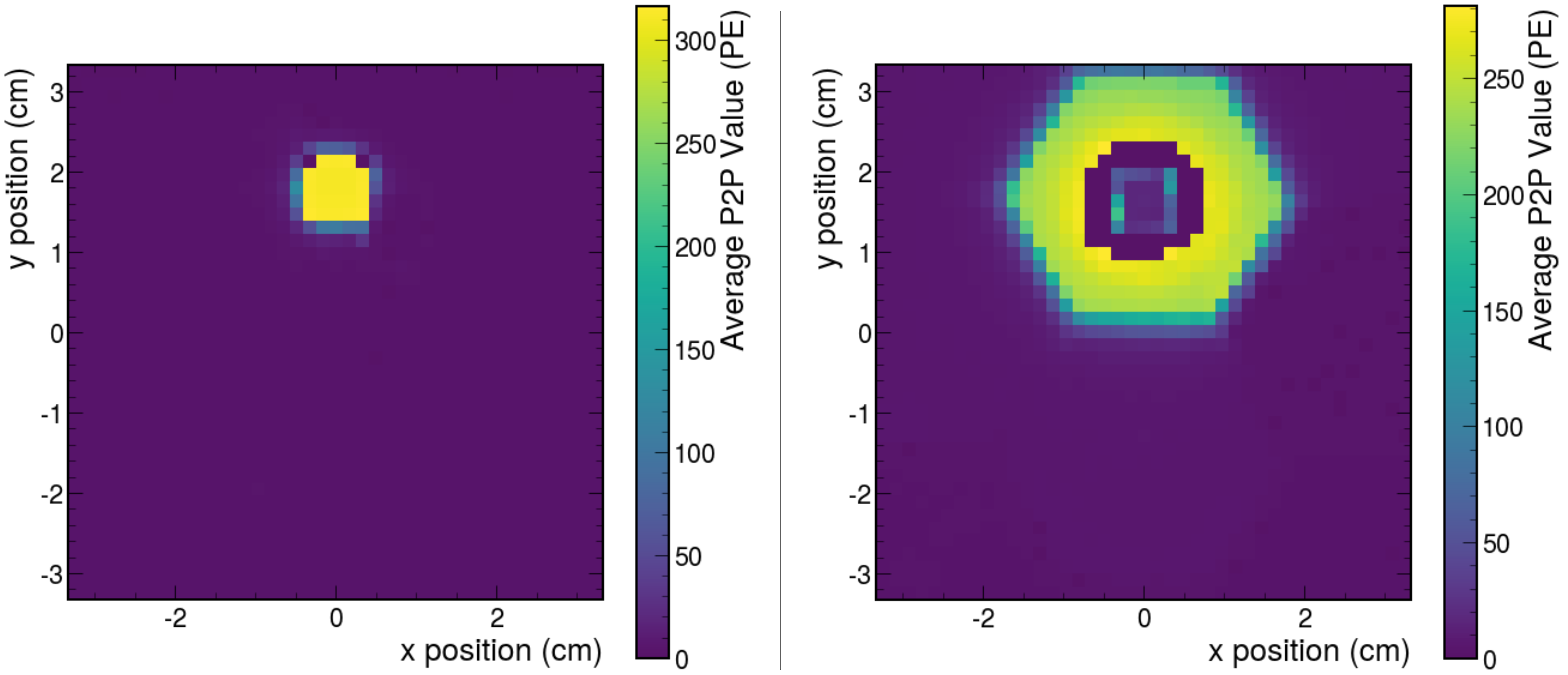
Preliminary Painted Tile Results

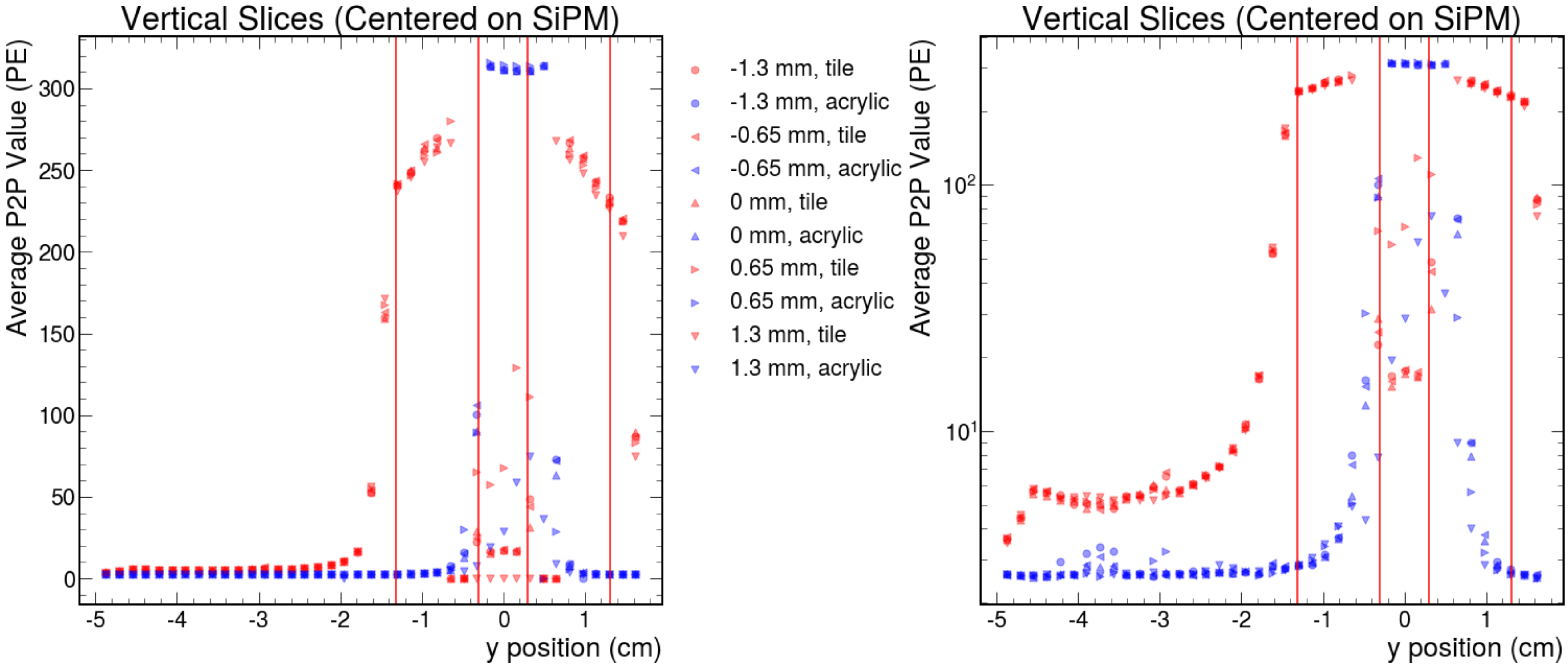
- Painting the tile resulted in a ~61% to ~73% decrease in signal strength from adjacent cells
- The total nonuniformity within the painted cell did not measurably improve, although the region directly above the SiPM was not measured, and the area immediately around it was likely influenced by a “spotlight” effect

Background Scan

- To estimate the effects of a “spotlight effect” from the LED (light traveling directly into the SiPM without scintillating), we scanned an acrylic tile
- We will want to repeat this study with a tile of similar thickness to the scintillating tile, and determine the relative opacities between the two materials at the wavelength generated by the UV LED
- Once these are determined, we will be able to scale the signals appropriately and subtract out the background generated by this spotlight effect
- Before then, this scan determines the affected region




y position (cm)
x position (cm)
Average P2P Value (PE)
3
2
1
0
-1
-2
-3
-2
0
2
300
250
200
150
100
50
0
y position (cm)
x position (cm)
Average P2P Value (PE)
250
200
150
100
50
0



The ”spotlight effect” appears limited to the region directly above the SiPM

Plans

- Optimize the new fitting method to determine signal strength values
- Add reflecting foil across nearly the entire front and back of the tile, leaving a small slice open to do a vertical scan down the middle
- Repeat the acrylic background scan using an appropriate tile, foil, and LED intensity
- Adjust the various parameters of the apparatus to achieve a wider dynamic range, or limit the scans to specific regions within the tile
- With a clean tile and using foil, study the impacts of painting boarders, and polishing the dimples