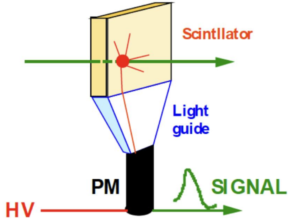
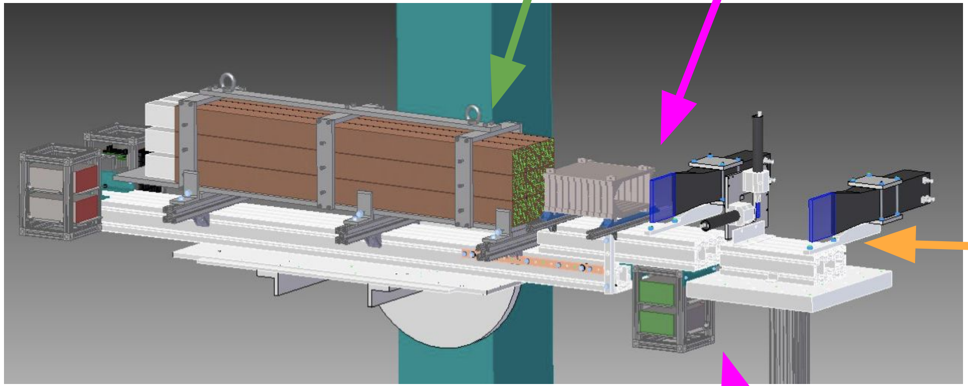
Updates from the lfHCal Test Beam

Iris Ponce
lfHCal & Insert Meeting 11/08/2023

September Test Beam Set Up

The test beams were done at the SPS beam line at CERN.
For our runs we ran e^- (30 - 100 GeV) and π^- (5,10,15 GeV).





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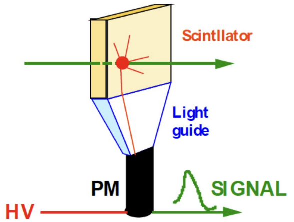
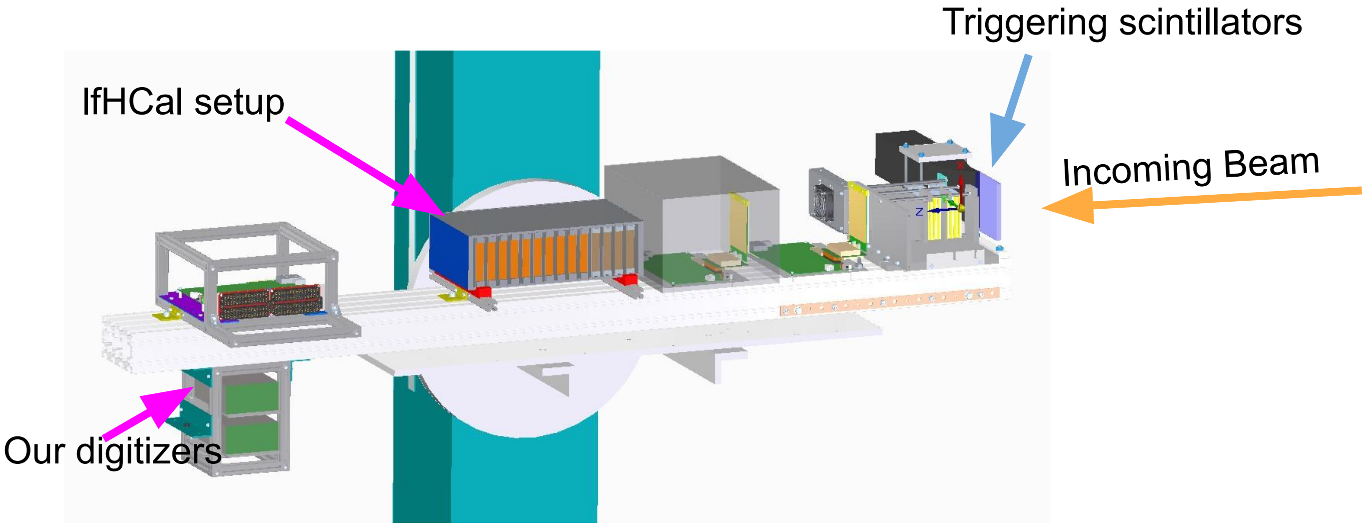
October Test Beam Set Up

The test beams were done at CERN.[1]
For our runs we ran e^- (1-5 GeV) and π^- (5,10,15 GeV).



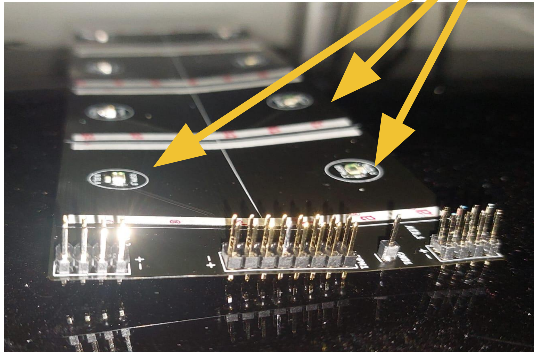


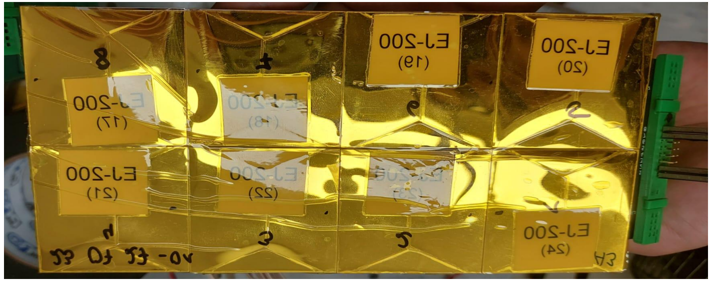
[1]https://indico.cern.ch/event/700446/contributions/2873562/attachments/1719056/2774358/blfs2018_beams.pdf

Goals for the lfHCal Test Beam

- Measure shower profiles with different absorbers.
  - Different layers of Tungsten at different particle species and energies
- First test beam using absorbers between layers.
  - Smaller version of final design.
  - Second test beam using the flexible PCB and 8 tile boards.
- Different energy deposits as the setup was moved in x and y.

SiPMs soldered directly on the flexible PCB

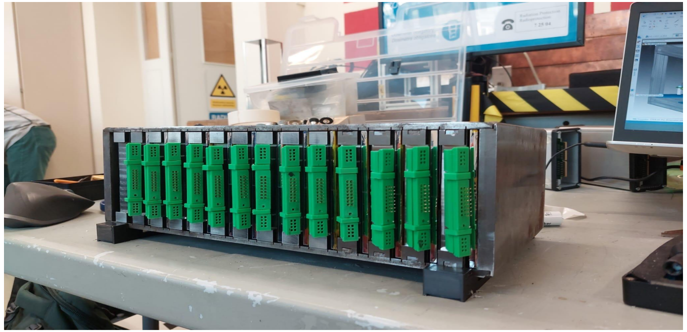




October lfHCal SetUp

4 layers are Tungsten rest are steel

Scintillator+SiPM boards placed in between the absorber



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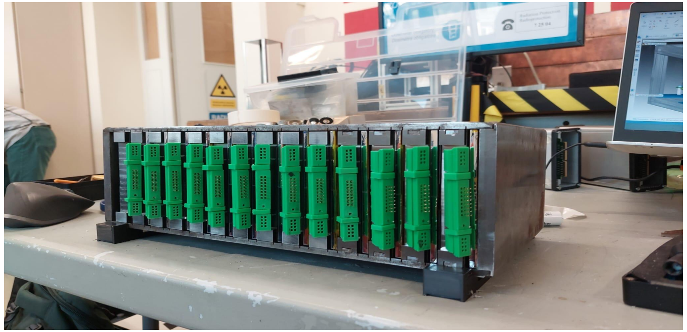
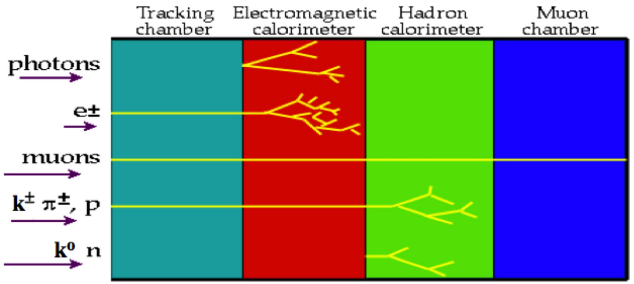


Ananya putting the absorber plates (heavier than they look)

All the boards connected to the two CAEN readout

Electron Shower Profiles

- Our Expectations:
  - The electron showers won't traverse as far into our set up as much as pions wil.
    - Differences in electromagnetic showers to hadronic showers. I.e. the calorimeters in ATLAS at the top corner[2]



[2]https://people.na.infn.it/~elly/TesiAtlas/SeminariAtlas/Detector/lengoAtlasCalo.pdf

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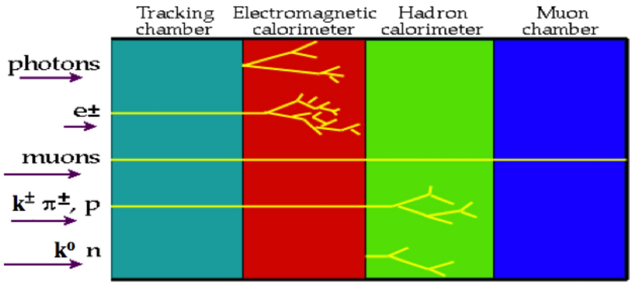

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  - Beam alignment will affect the energy deposition in the tiles.
    - Inner tiles vs outer tiles

8	7	6	5
1	2	3	4

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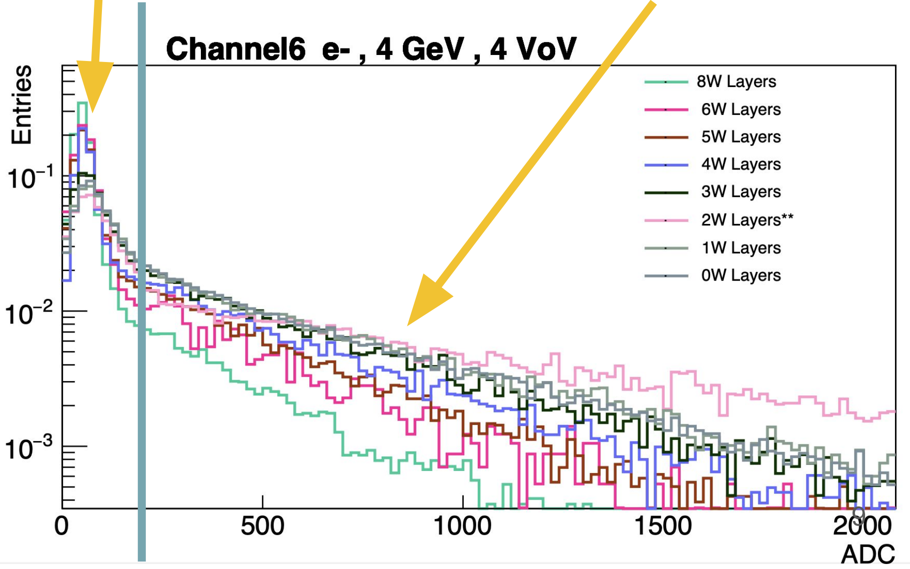
Without pedestal subtraction*

Noise ~ 100 ADC

Signal



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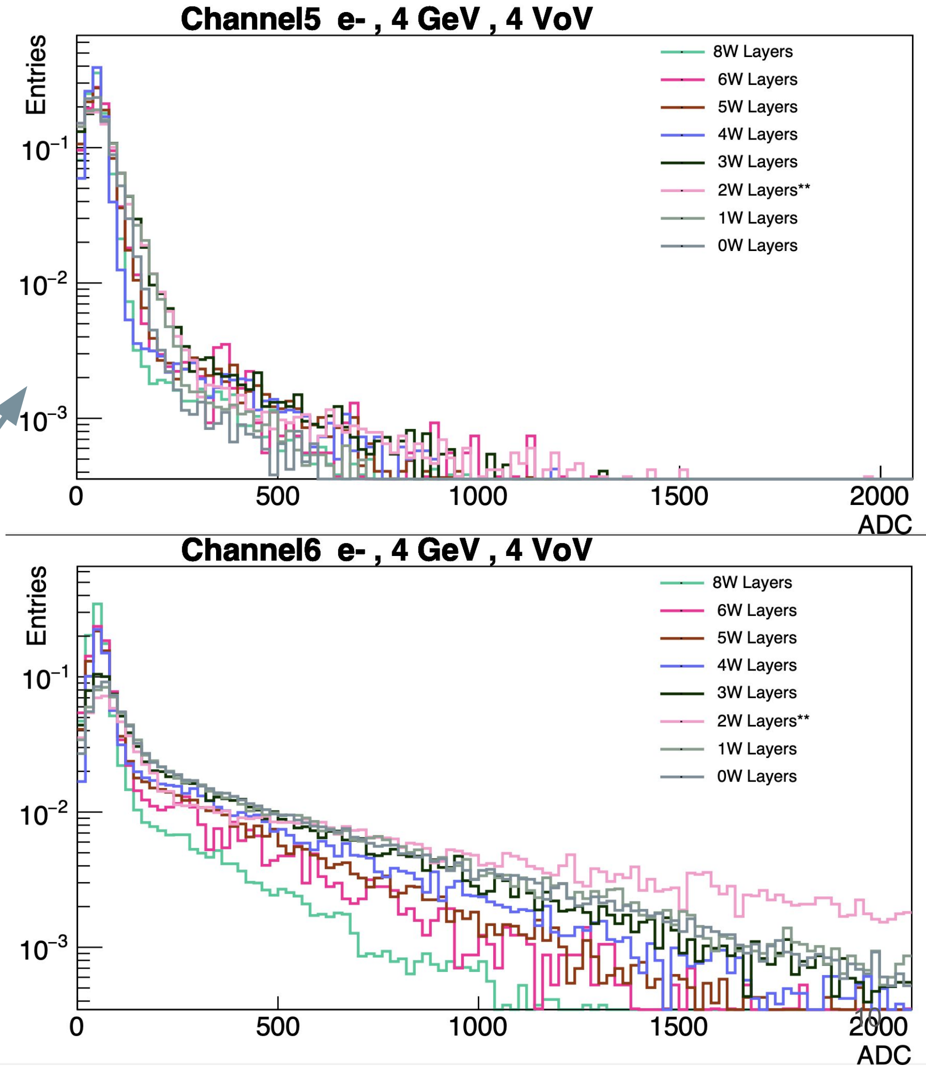

Electron Shower Profiles

- Our Expectations:

far

e.

top

in

We see that outer channels have less energy deposited. Is this true for all the boards?

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    - Inner tiles vs outer tiles

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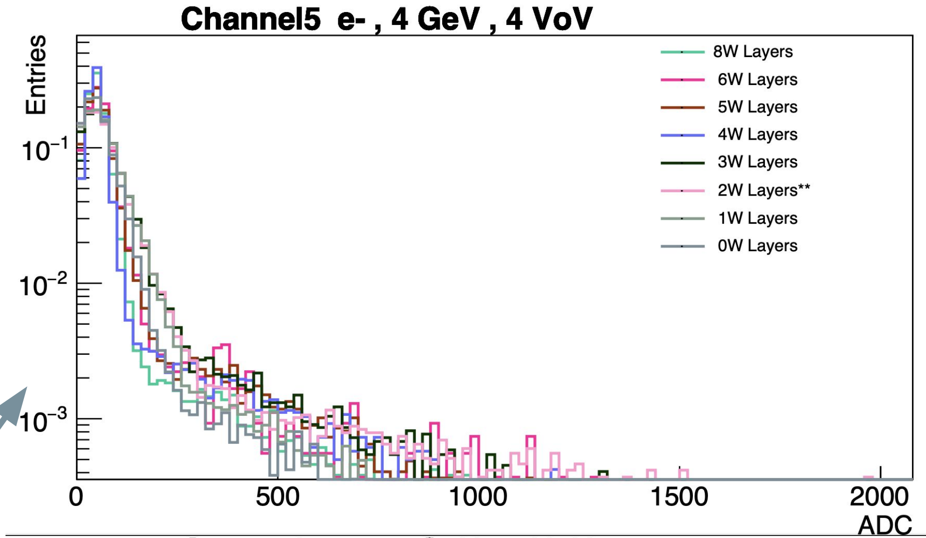
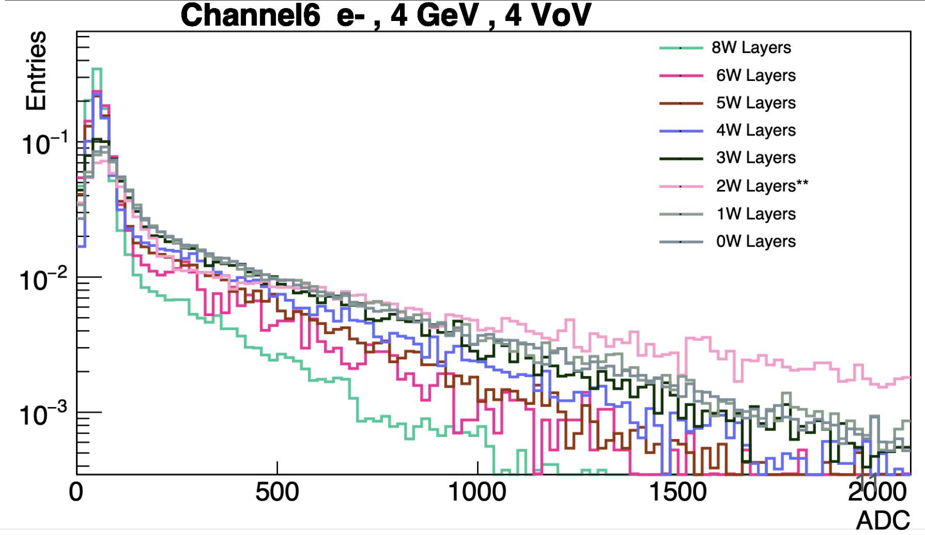
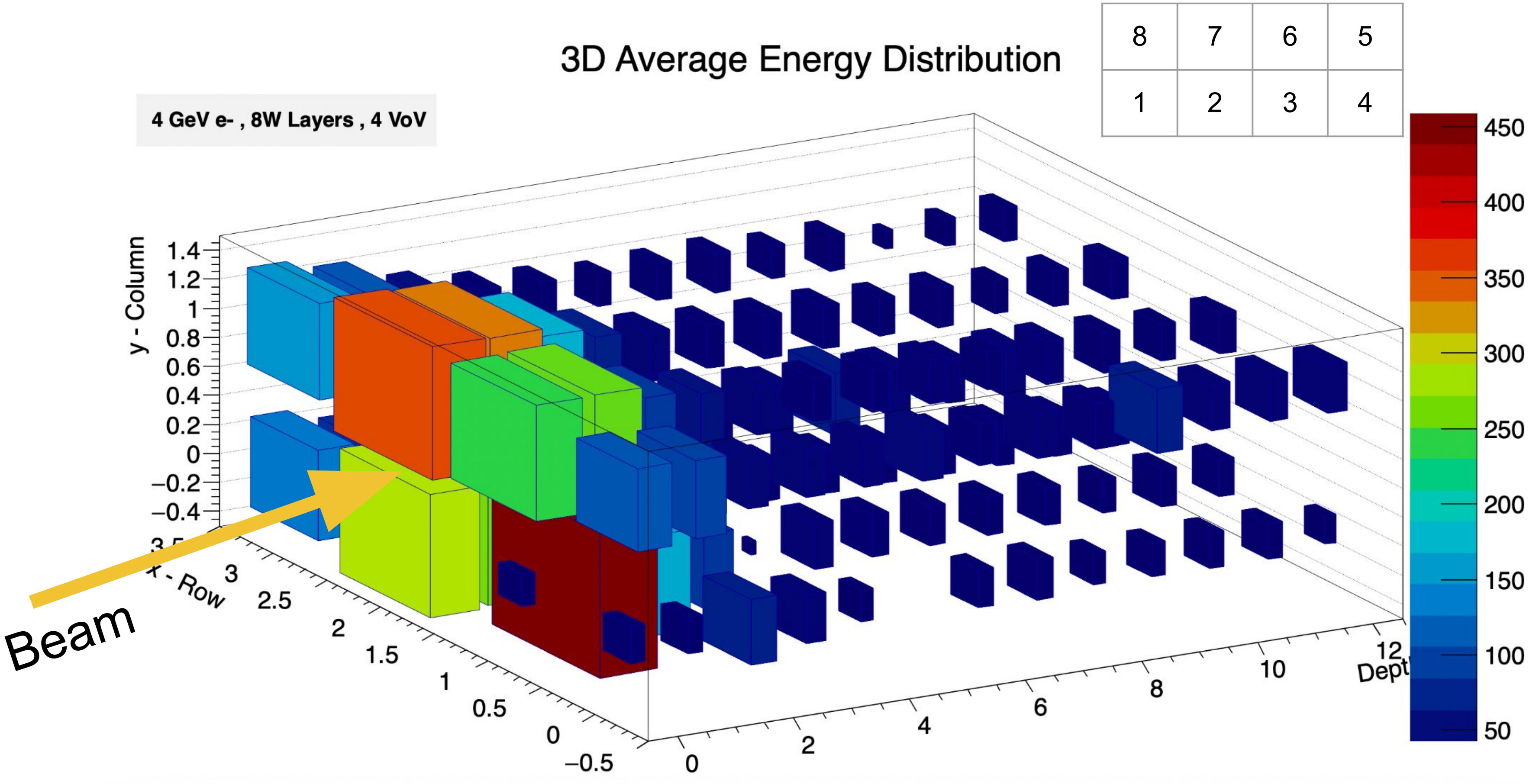
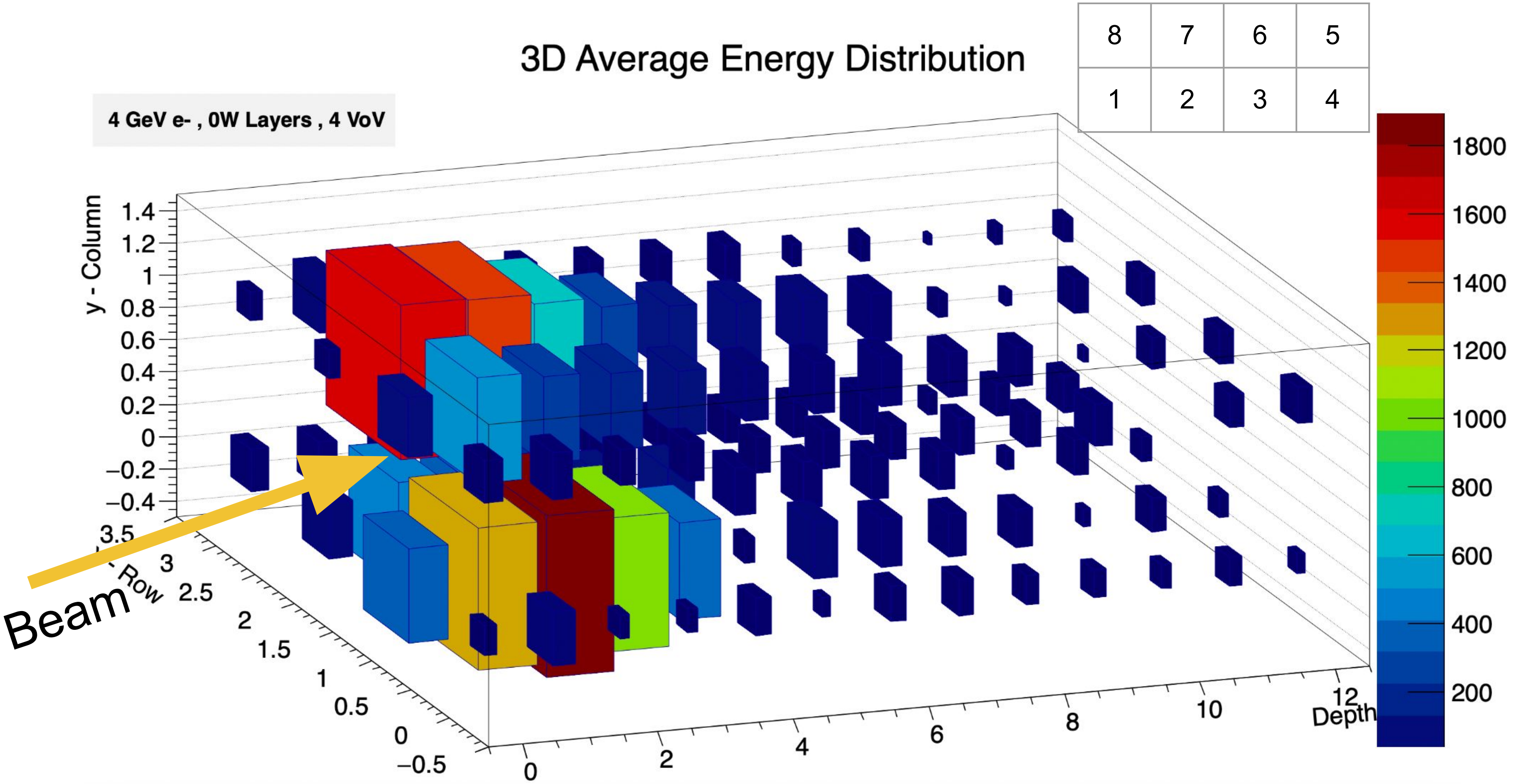






We see that most of the energy is deposited in the boards closest to the beam. Past the third board there isn't a lot of energy depositions. The outermost channels have a lower energy deposition as well.



We see that most of the energy is deposited in the boards closest to the beam. The highest energy deposited is 1800 ADC compared to 450 ADC with the 8 W layers. Boards 3 and 4 still have a high-ish activity.

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Energy Scans

- Instead of focusing on a single energy, we can focus on a # of W layers and scan through different energies.
    - We expect higher energies to deposit more energy on tiles
    - Inner tiles have higher signals than outer ones

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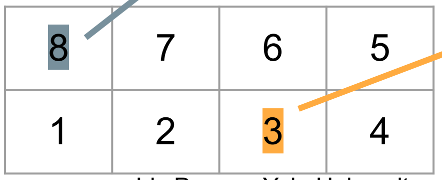

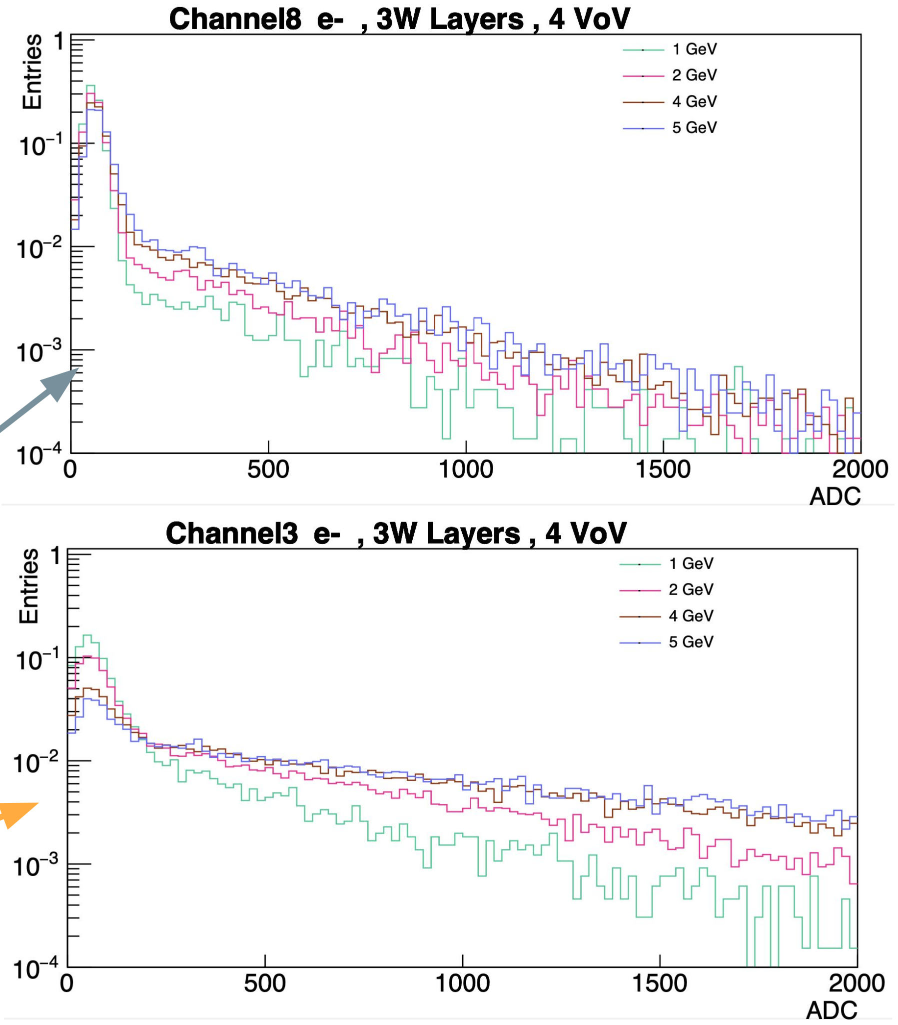

Energy Scans

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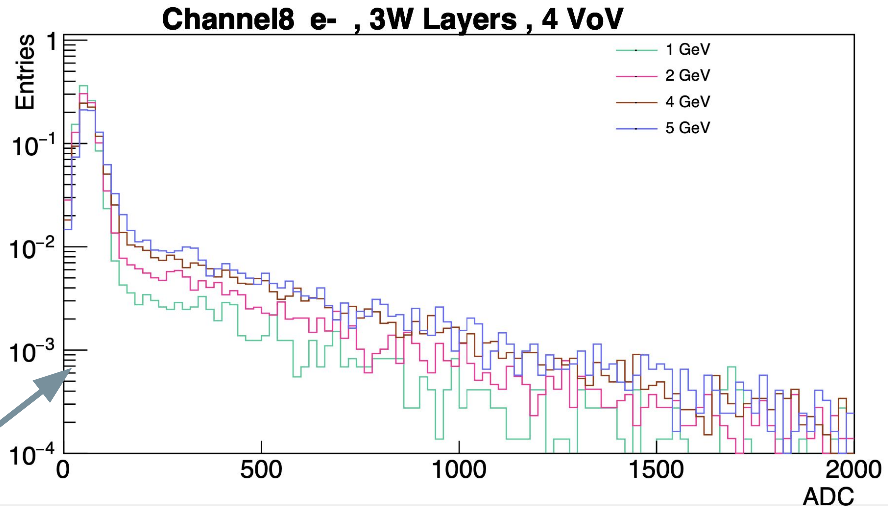
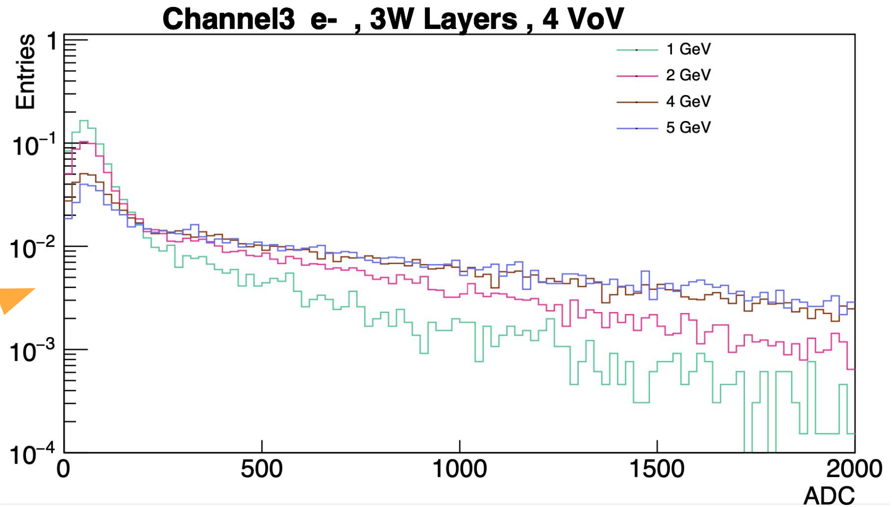
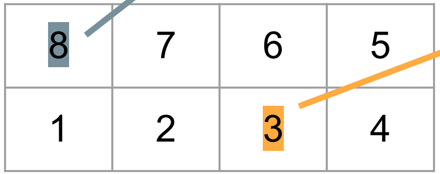
Now we can take a look at the pion beam which is more relevant to the lfHCal

ones

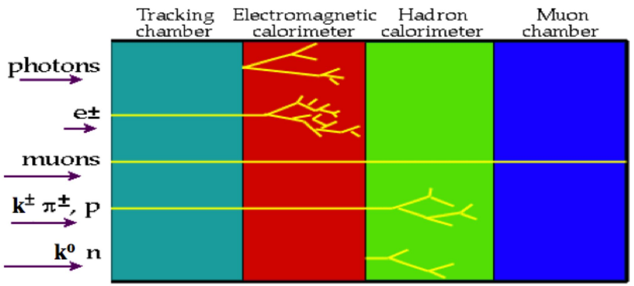






Pion Beam Results

- We expect the pions to go through our entire set up since our setup is small.
    - Should not look like MIPs.
- Have inner vs outer tile dependence as before.



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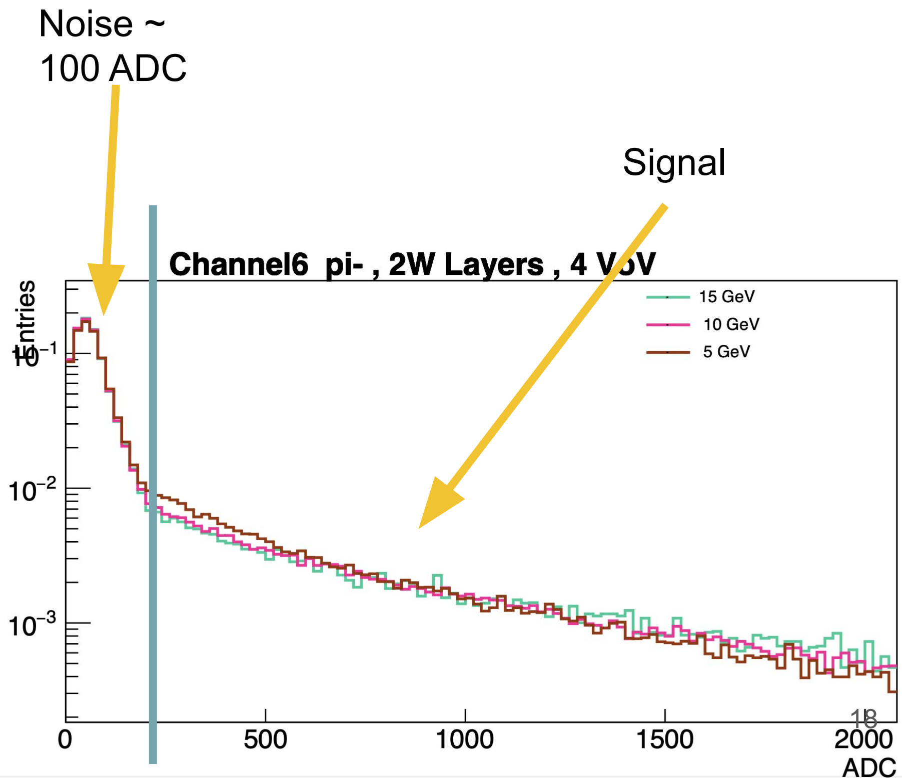

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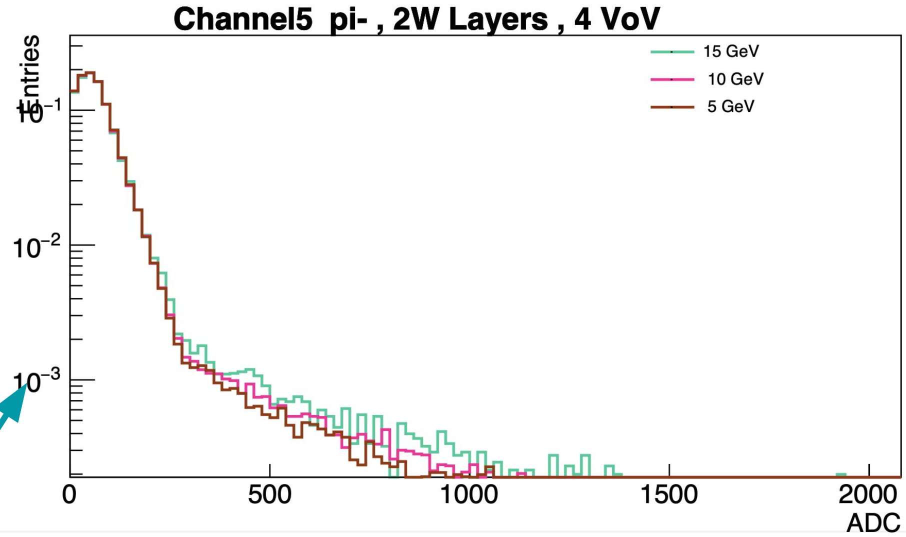

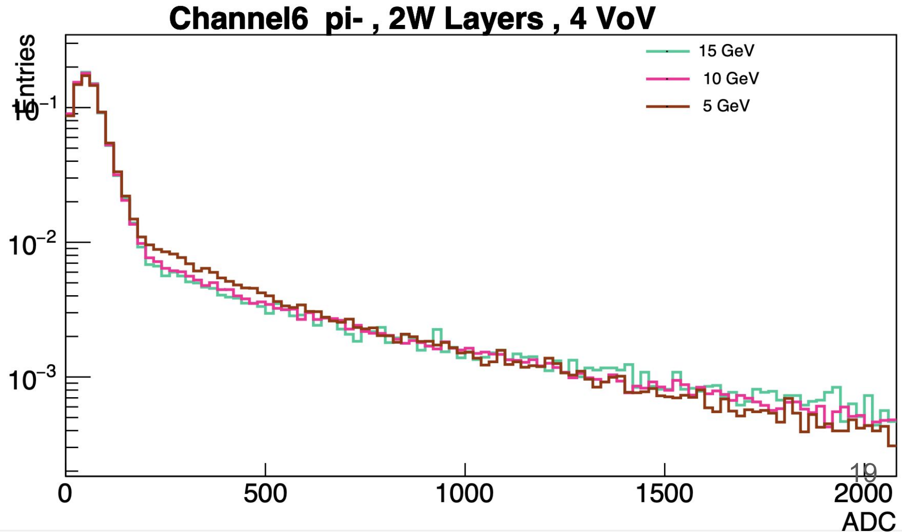

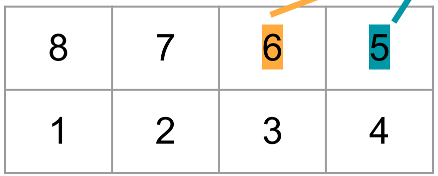

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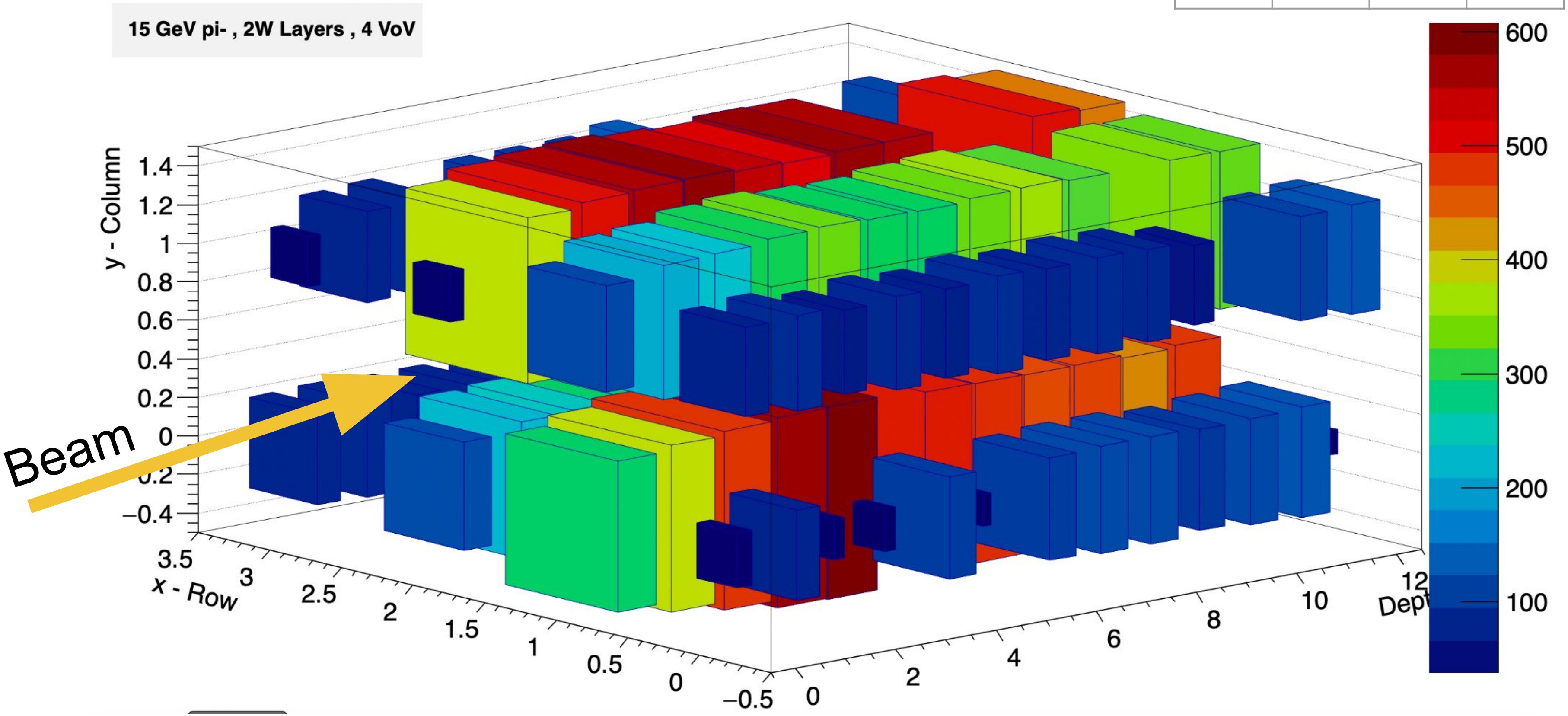
3D Average Energy Distribution



Unlike the electron beam the pions traverse through all the boards. We still see the inner versus outer tile dependence though.

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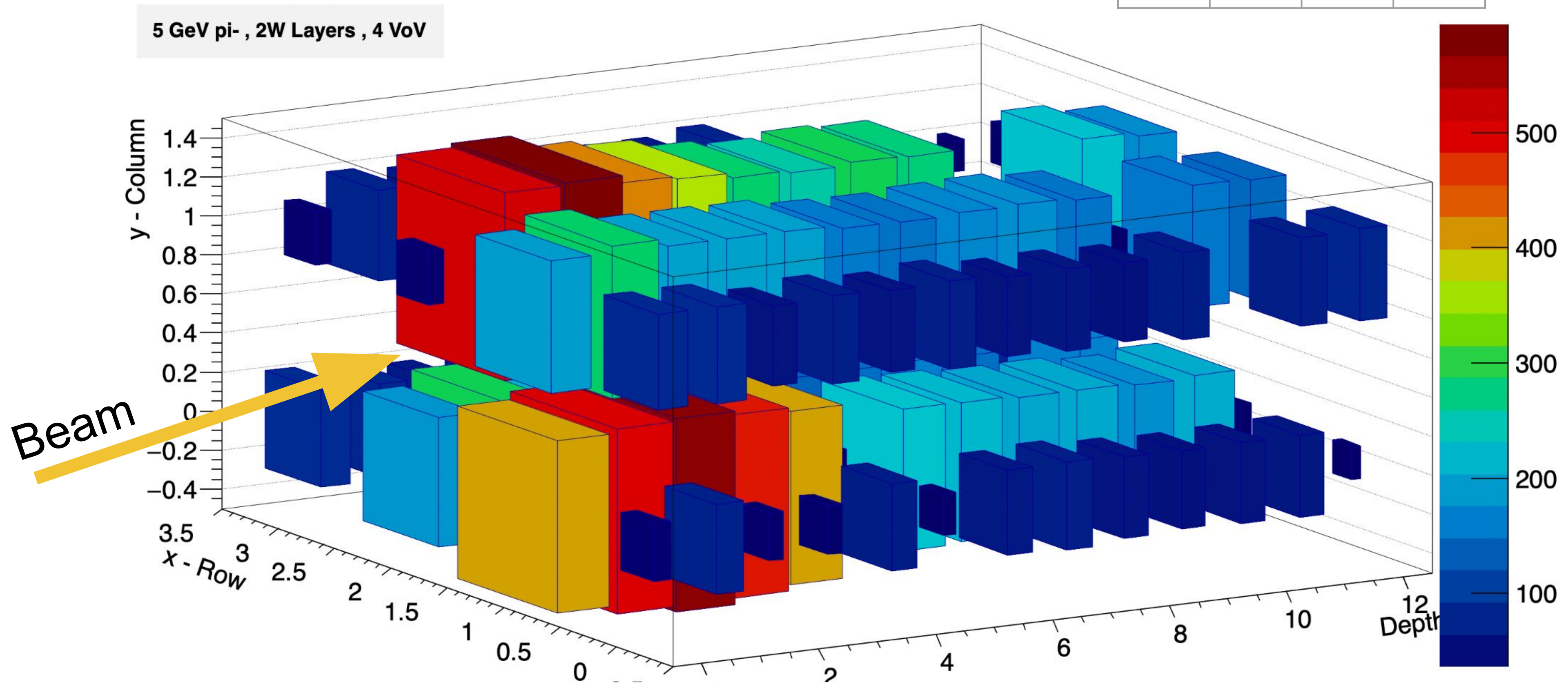
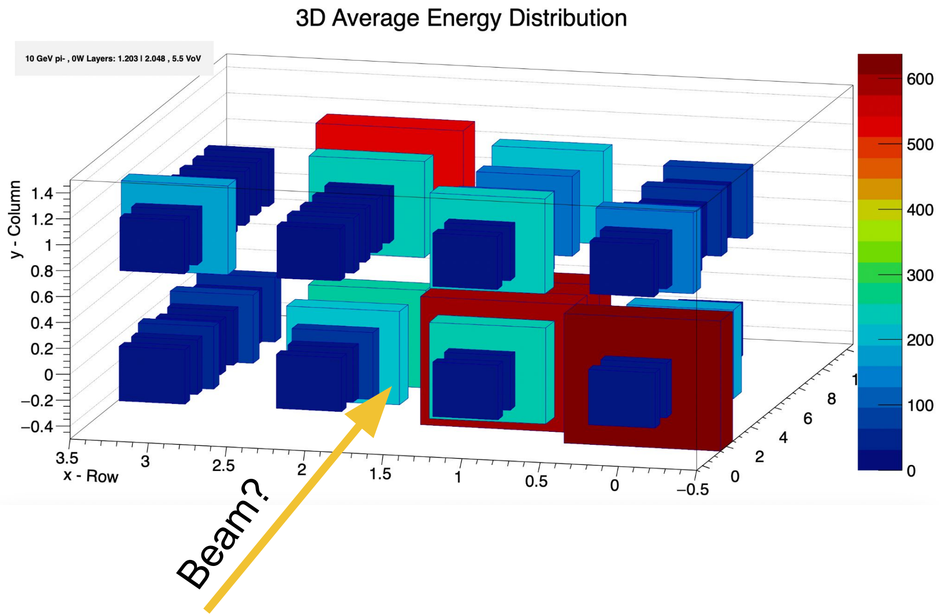
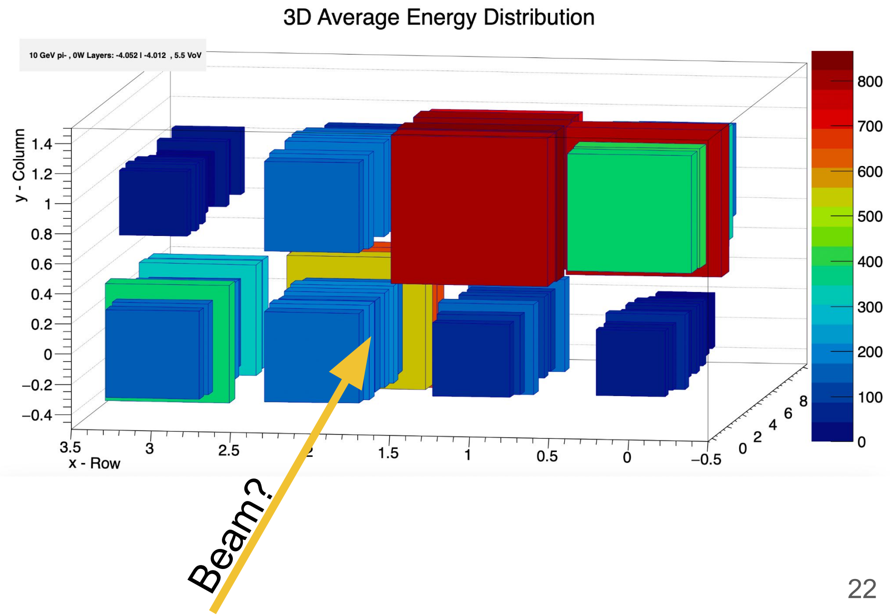


The 5 GeV pions deposits less energy than the 15 GeV pions but still traverse most of the layers.

Position Scans

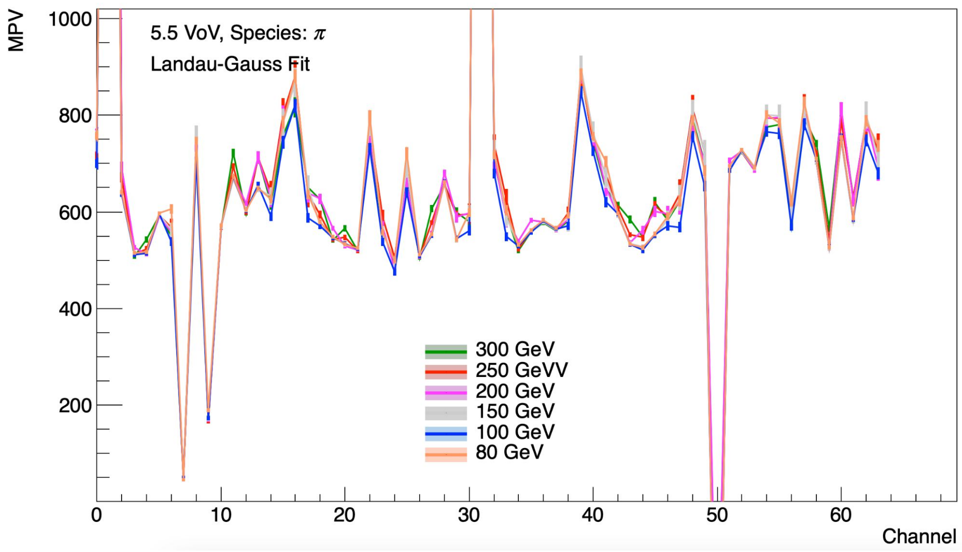
The last day the focal group wanted to do position scans for their setup. So they moved the setup through varies x-y positions.





Looking at MPV Values for September Test Beam

- We can look at the mips from the first team bean in September.
  - For every channel get the MPV and compare through the different channels
  - Compare different Voltages (soon)
  - Compare with second test beam



Next Steps and Lessons Learned

- We have more runs to analyze
  - Voltage Scans
  - Gain Scans
  - Hold Delay Scans
  - Self-trigger runs
  - Noise reduction run re-do. (These are voltage dependent so we need to be mindful of the bias). Working on the code to automate this.
- Need to determine a method on how to analyze the pion runs with all the dead channels.
- Determine if there is time dependence performance factor for the setup both throughout the individual test beams and then between both test beams.

Back Up

Plots

Energy Scan

Tungsten Scan

Hold Delay Scan

Shape Time Scan

Species

Electrons and pions

Fitting

Noise (Gaussian)

Landau Gauss (Signal)

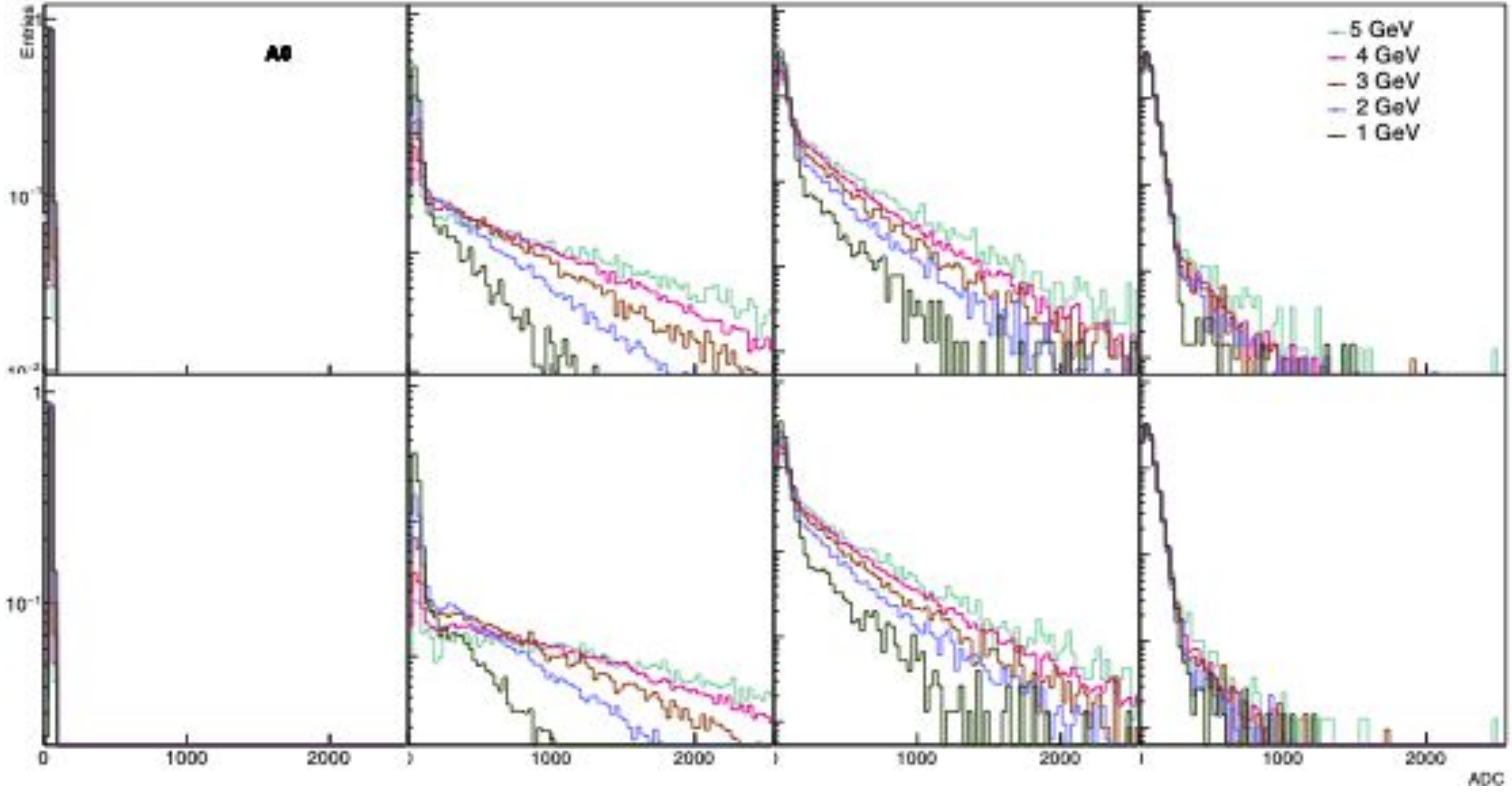
Runs used are documented in shared Notion page

Energy Scan (electrons)

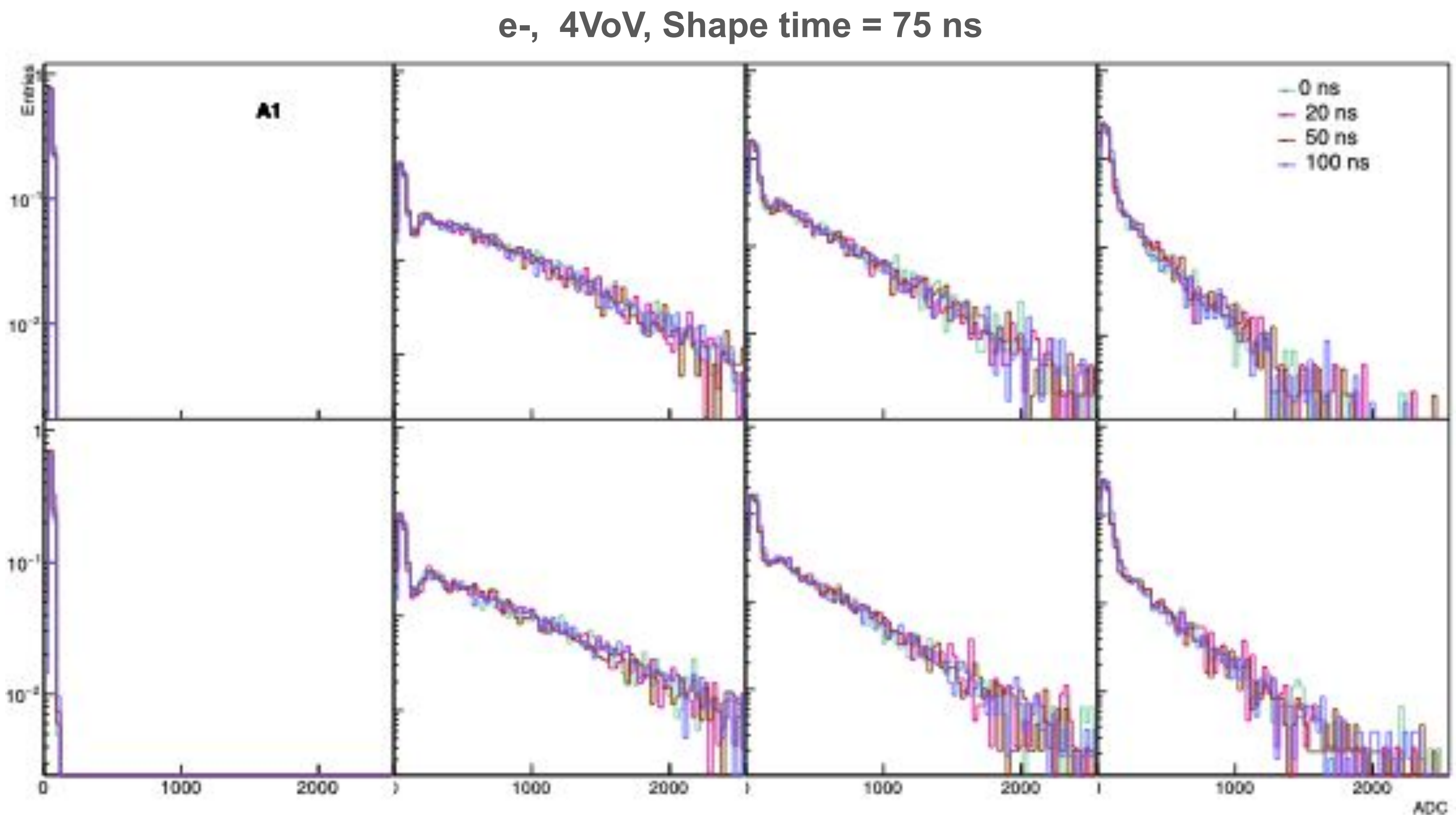
Tungsten Plates	Energy (GeV)	Run	Volt (V)	Comments
0	1 done	286	56	A0 removed
0	2 done	285	56	29k to EOF, A0 removed
0	3 done	285	56	0-26k files, A0 removed
0	4 done	284	56	A0 removed
0	5 done	283	56	A0 removed
1	1	279	56	
1	2	280	56	
1	3	206	56	
1	4	281	56	
1	5	282	56	
2	1	272+273 done	56	272 —beam stopped in the middle
2	2	271 done	56	
2	3	205	56	run with different assembly
2	4	270 done	58	
2	5	269 done	58	Missed part of the run due to connection issues

Energy Scan (noise un-subtracted)

e-, 4VoV, 0 W



Hold Delay Scan (noise un-subtracted)



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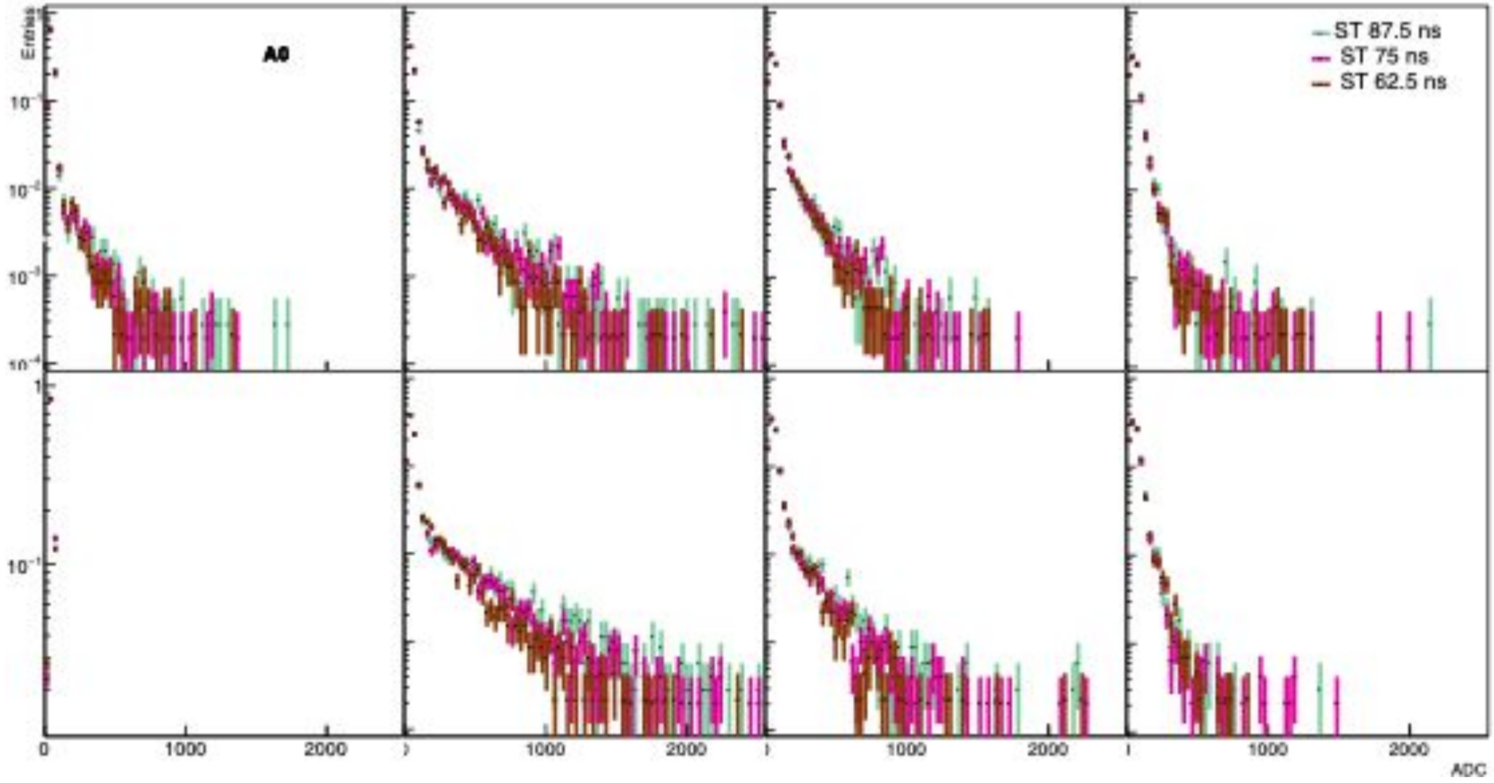
Shape Time Scan (noise un-subtracted)

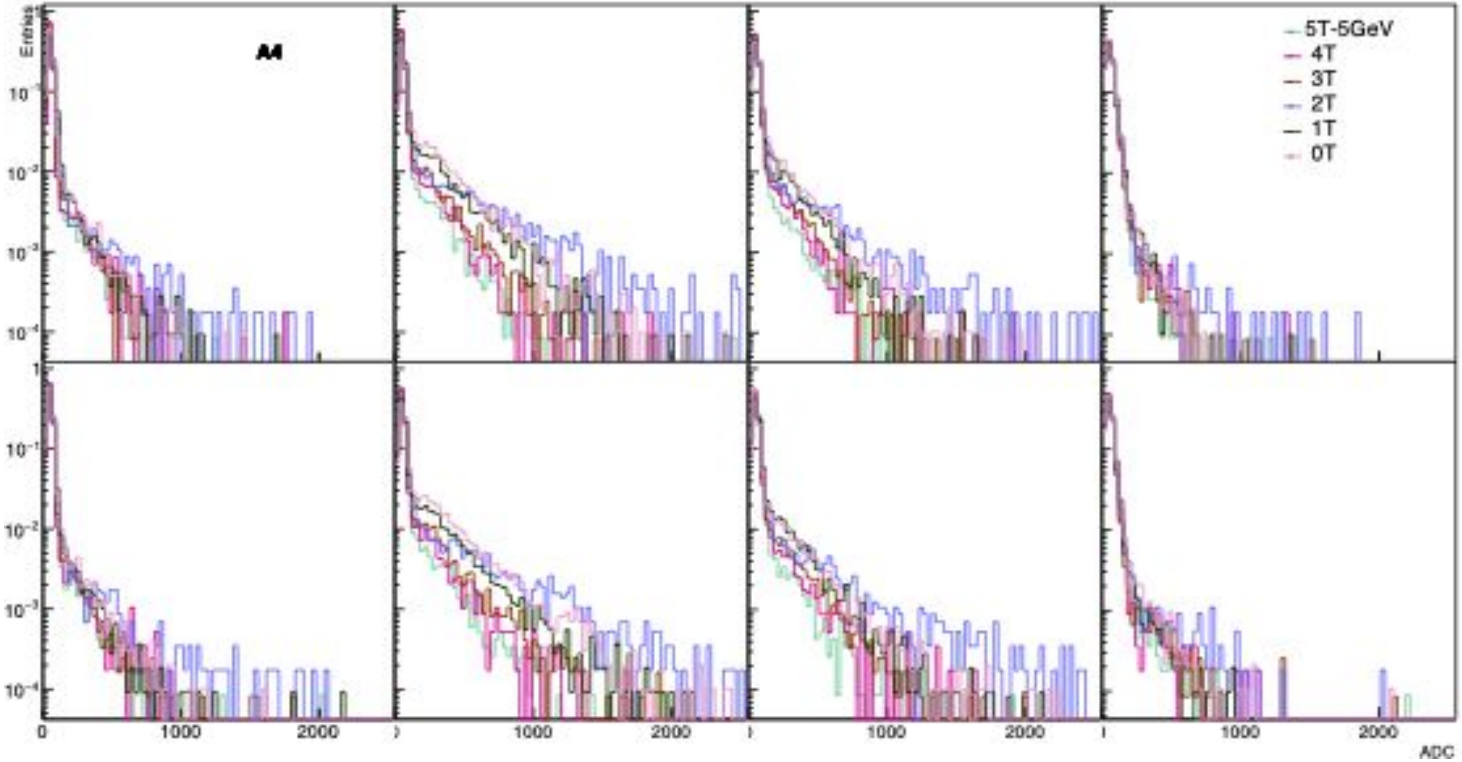
e-, 4VoV, Hold Delay = 50 ns



Not a very useful plot, this should have lines joined for clarity

Tungsten Scan (noise un-subtracted)

e-, 5GeV, 4VoV



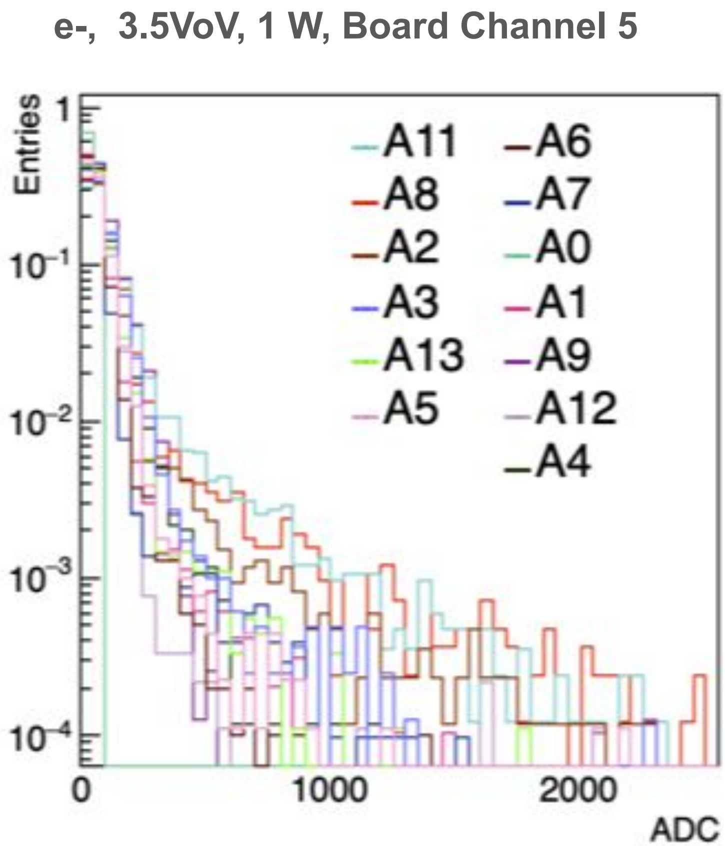
Noise subtraction

Fit noise sweeps to a Gaussian (fit until 80 ADC).

Draw from this Gaussian distribution randomly and subtract from the triggered dataset.

Then fill histograms with this subtracted value.

Overlaid Boards (noise subtracted)



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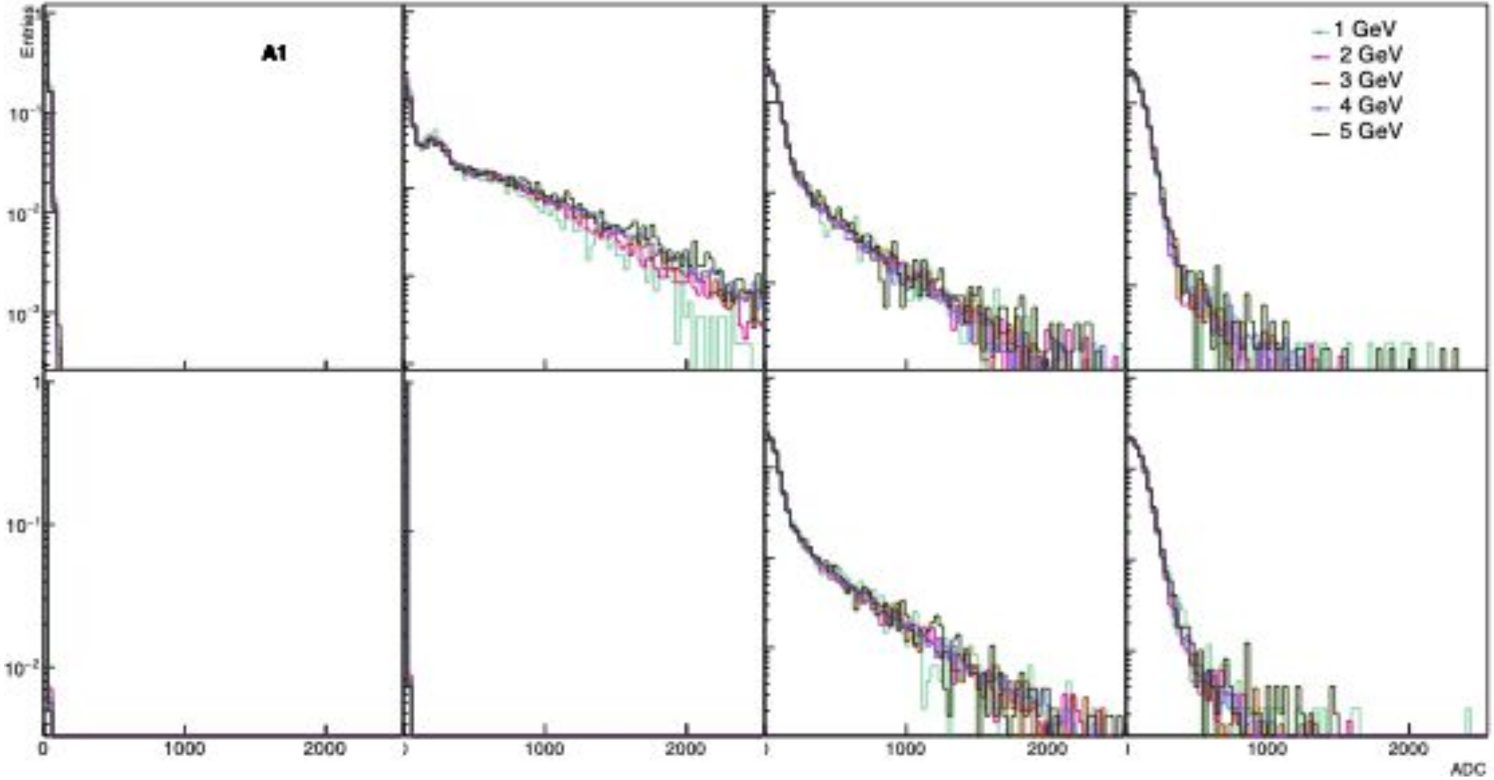
Energy Scan (noise subtracted)

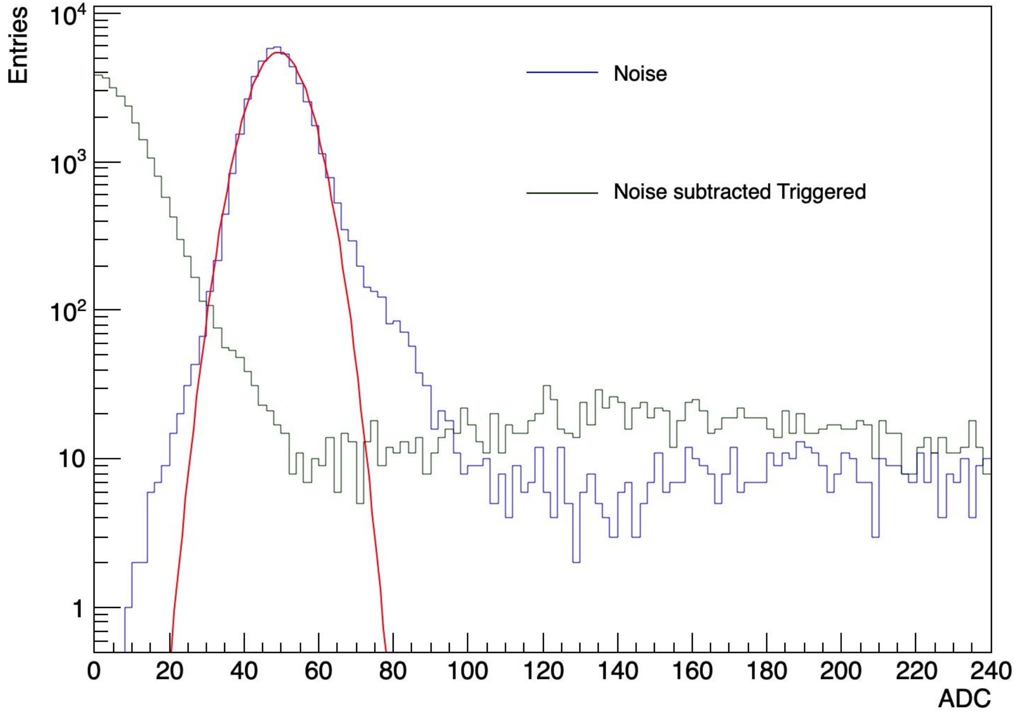
e-, 4VoV, 0 W



Noise subtraction for pions

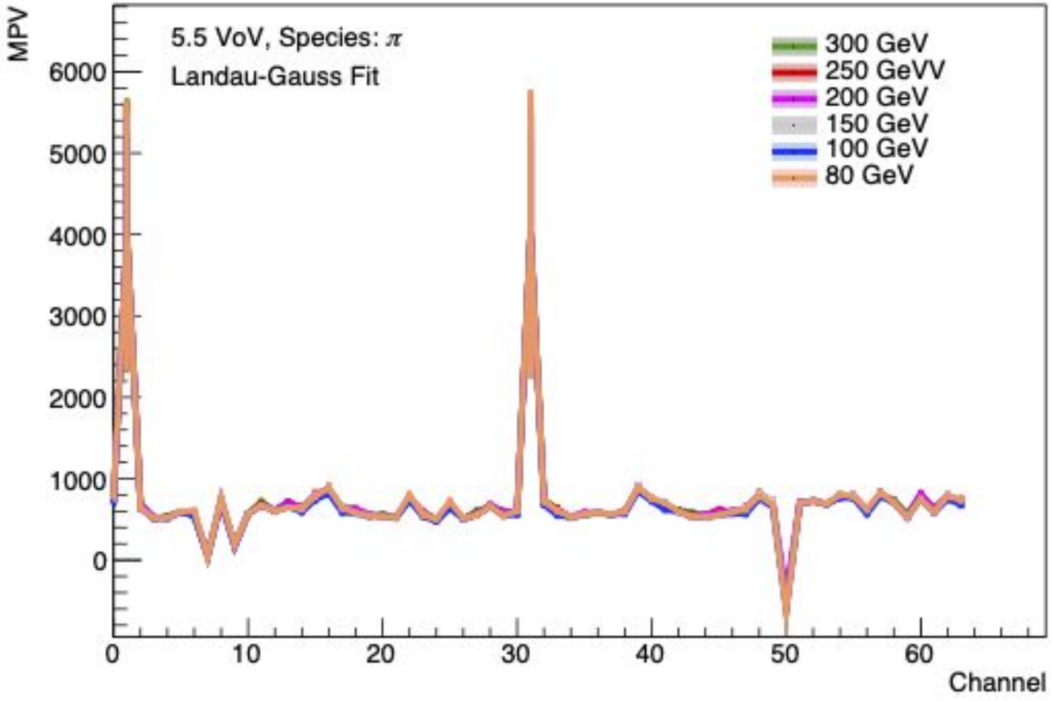
Question: For the pion data, are the noise sweeps within the data file?

Not sure I understand why the noise doesn't reduce the entries but only shifts ADC values (Ananya). Also, here do we mean electronic noise or is it photons (which should be Poissonian)?



MPV values from Lan-Gauss Fit: Energy Scan

This is after noise subtracting and fitting with Landau-Gauss for Pion data. Need to plot this better and improve fitting. The weird fits are overshadowing all features of the curve here.



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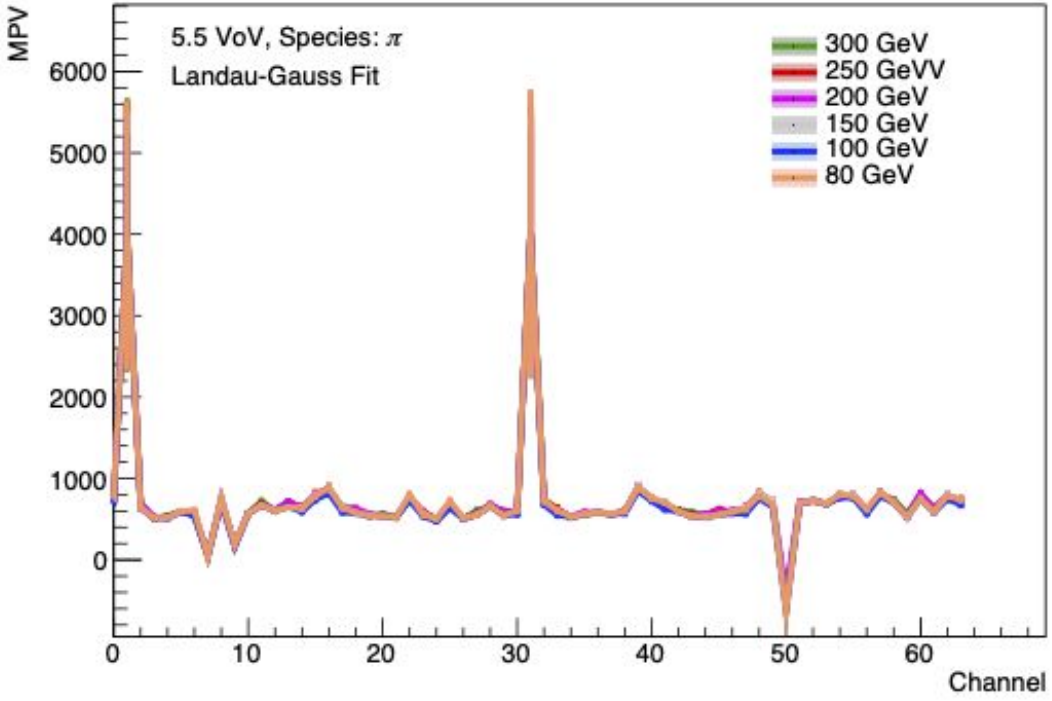
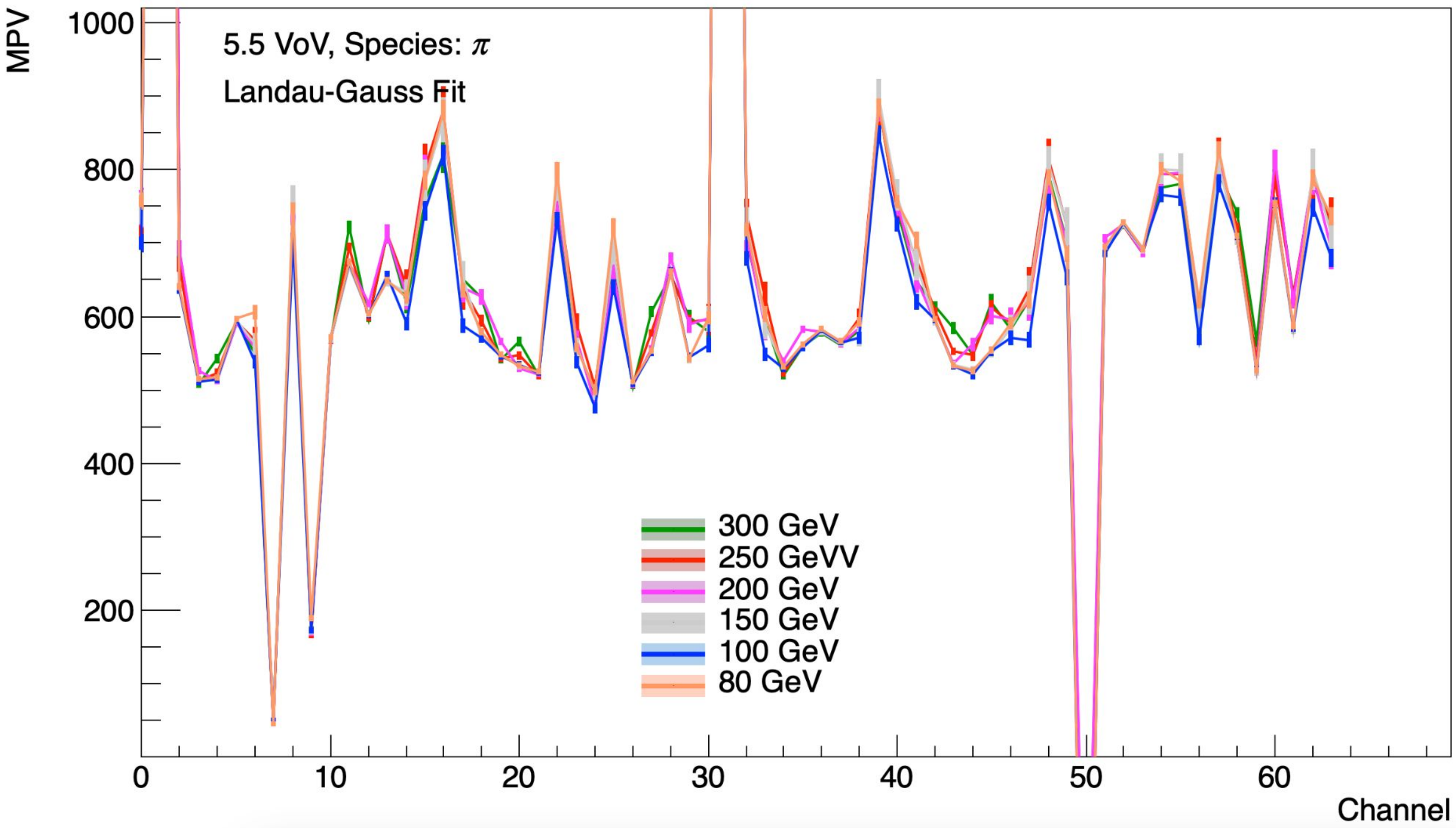
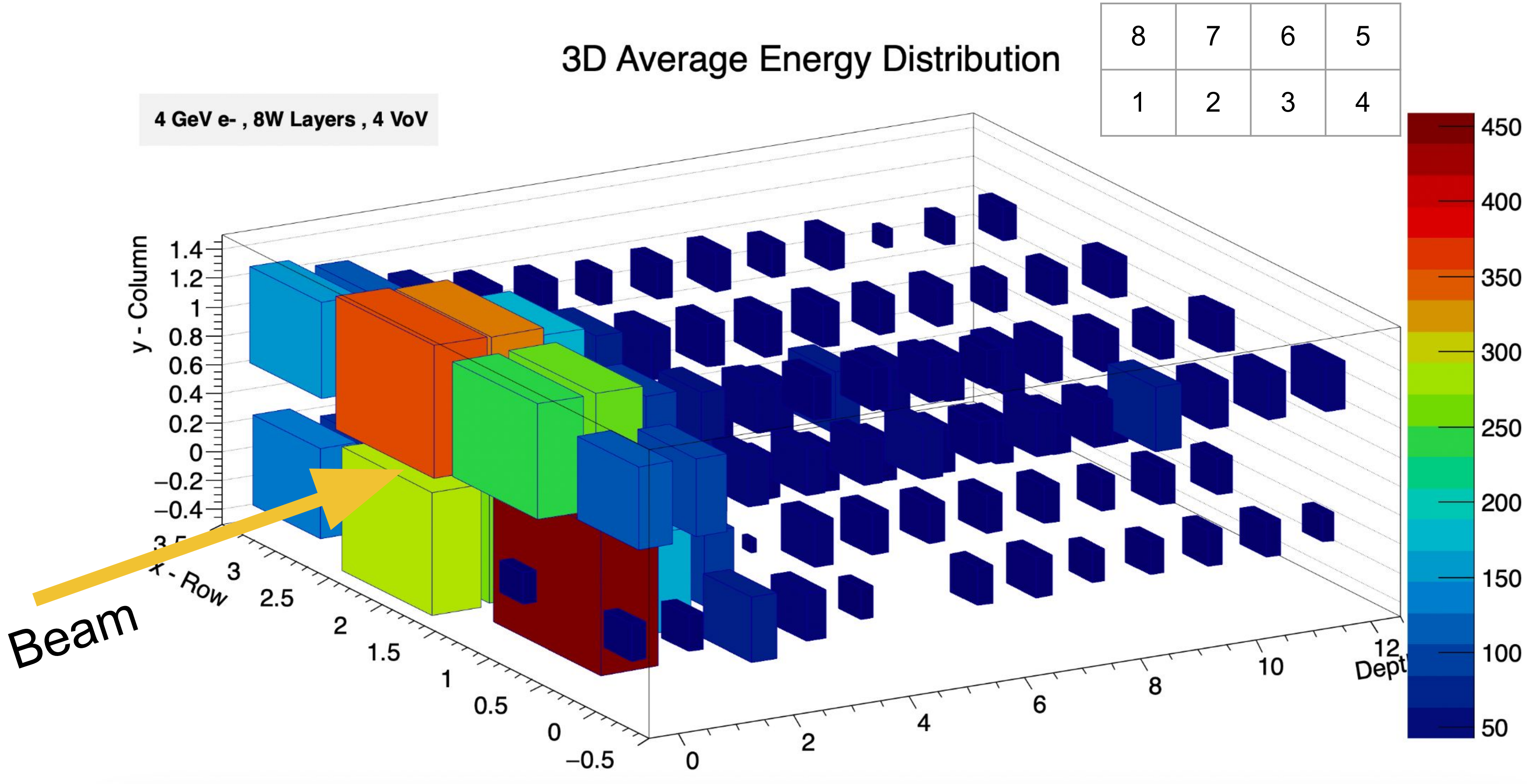




5.5 VoV, Species: π
Landau-Gauss Fit
MPV
Channel
300 GeV
250 GeVV
200 GeV
150 GeV
100 GeV
80 GeV



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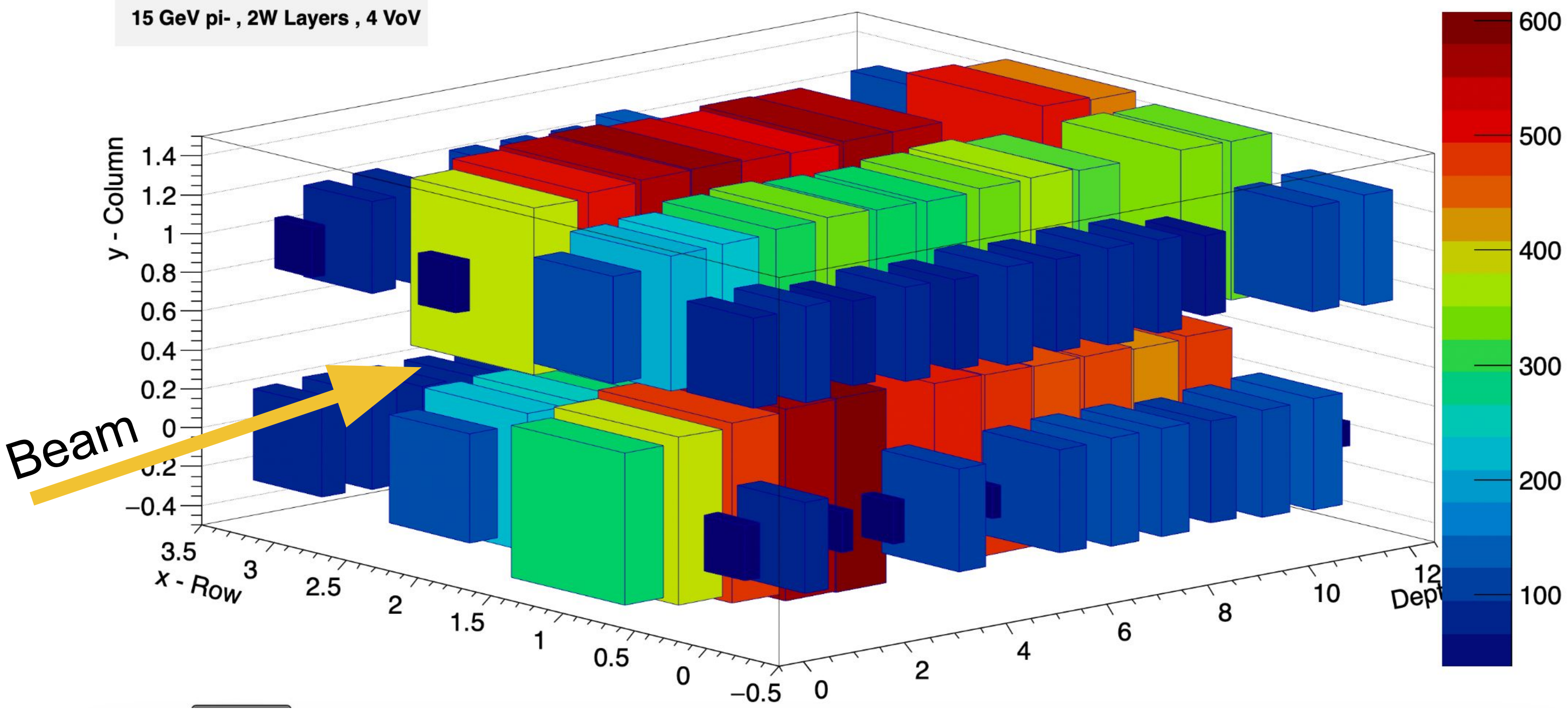

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