

GEM Timing Work

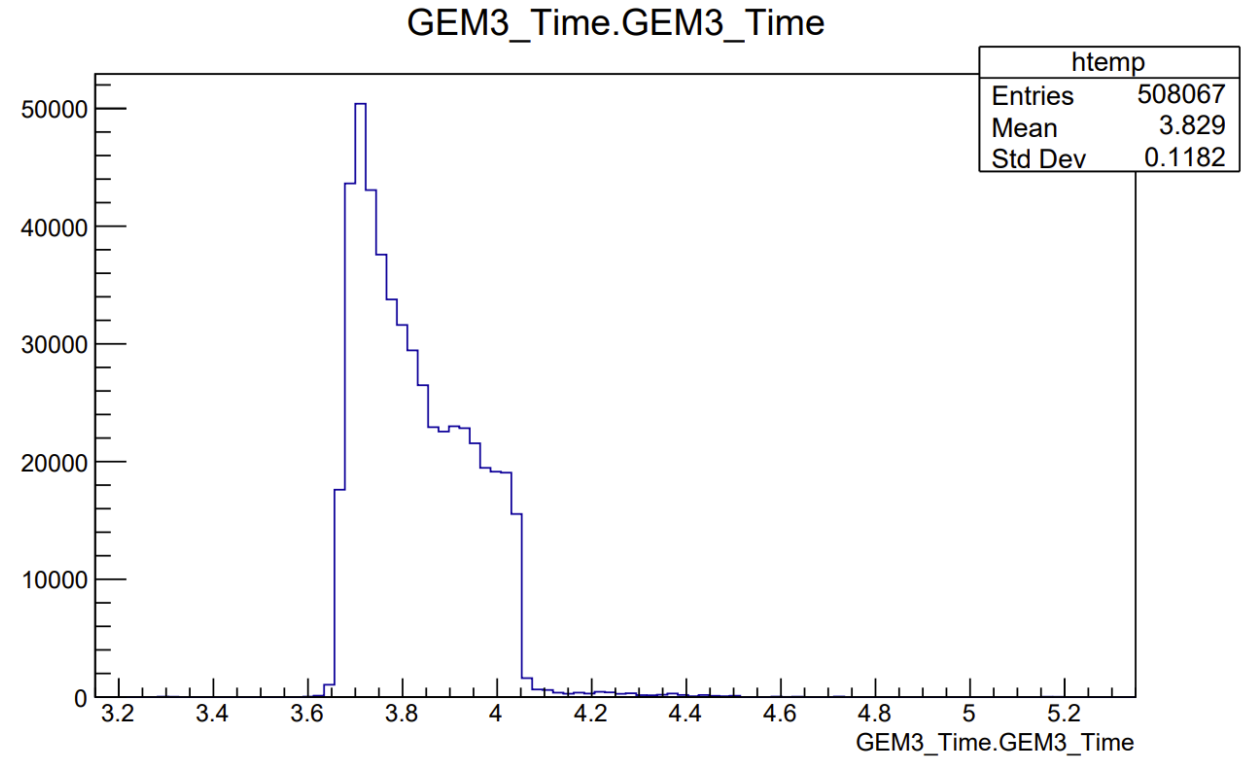
November 6, 2025

Using timing for track reconstruction

- Trying to use timing information to improve GEM track reconstruction
 - Ultimately add timing as a parameter in XGBoost
- First step: add timing information to simulation

Hit times in Geant4

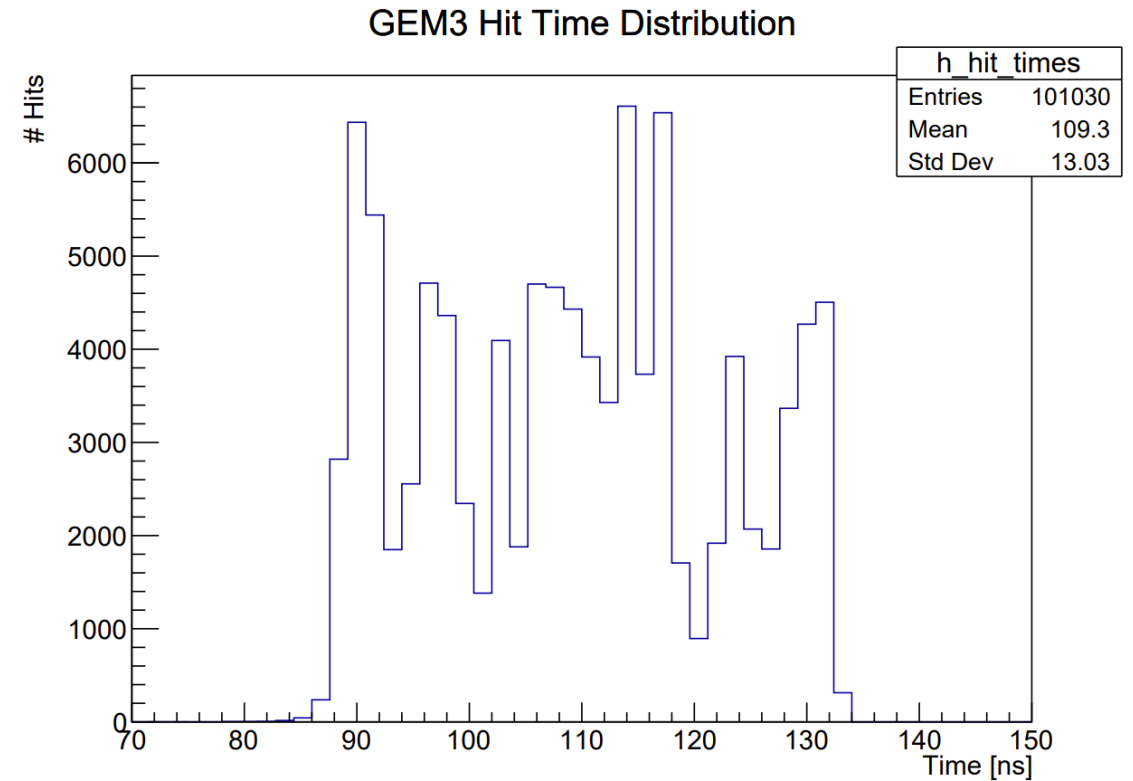
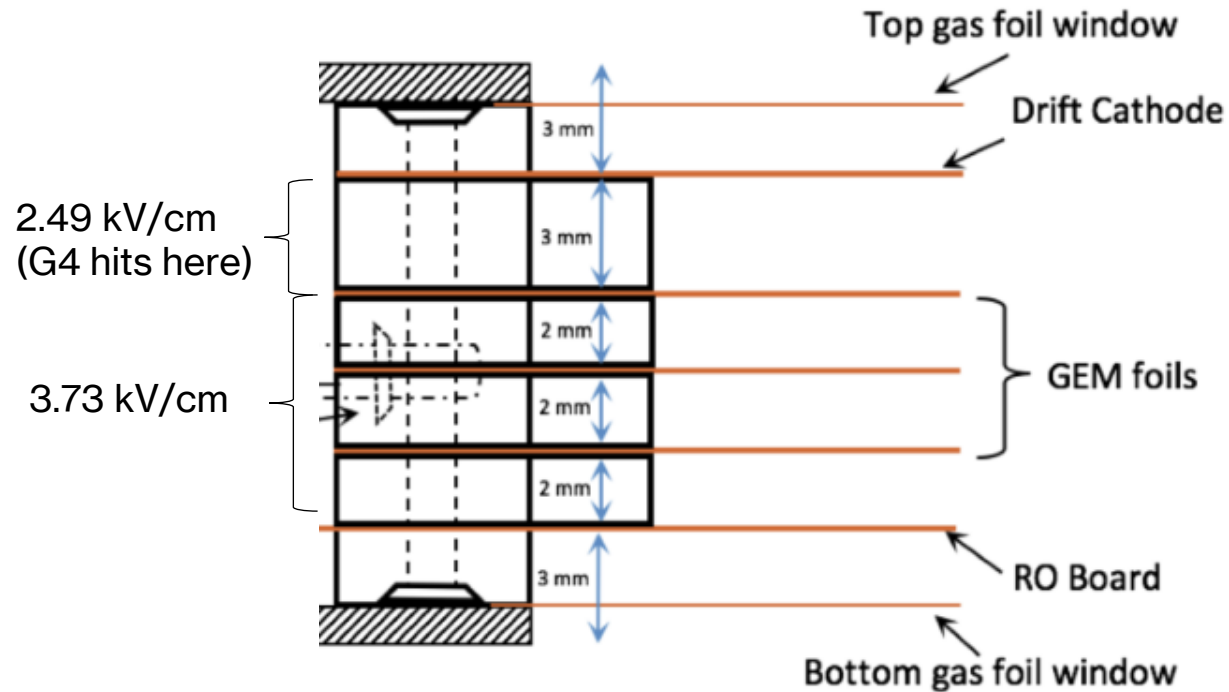
- Added timing information to hits in Geant4
 - Using global time (time since event was created)
- This is the time of the energy deposit/primary ionization



Geant4 hit times

Drift time calculation

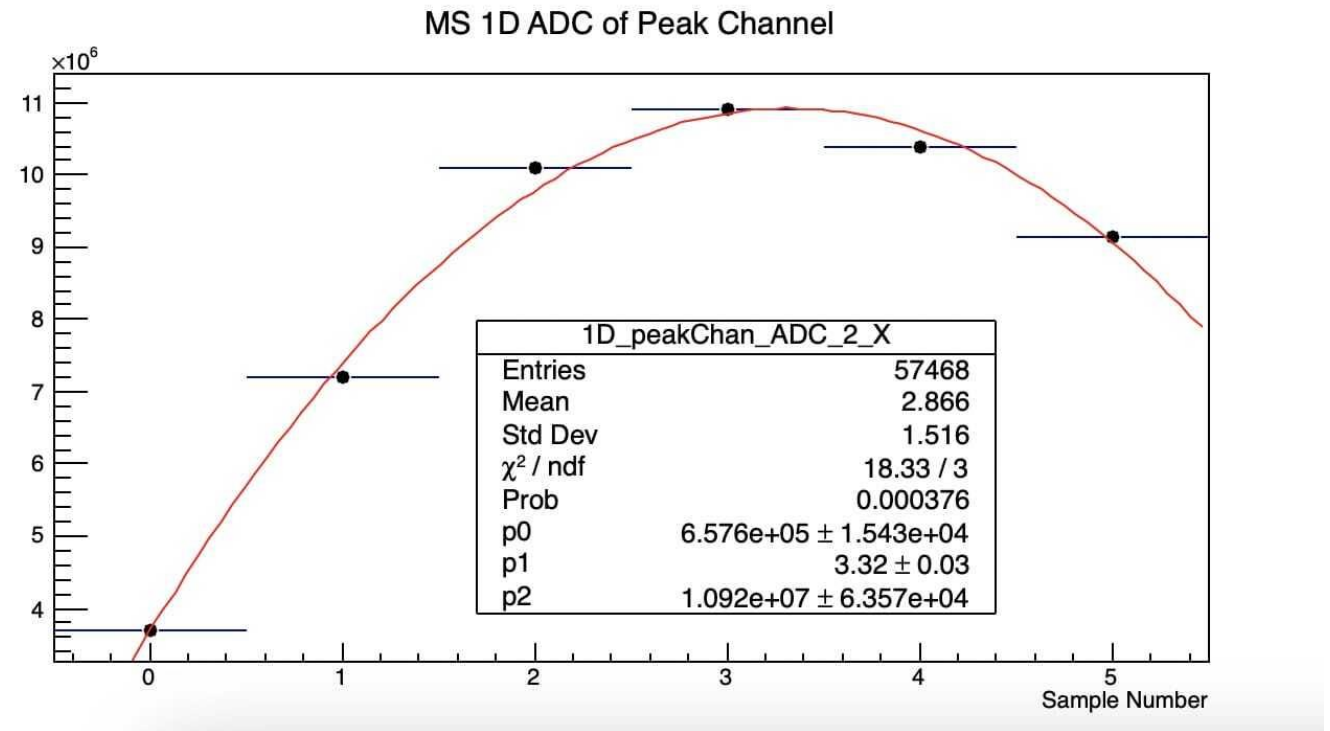
- Time of arrival at readout board = Geant4 hit time + electron drift time
- Drift time calculation based on (provisional) drift speeds/voltages from Andy's work



Arrival times in digitization

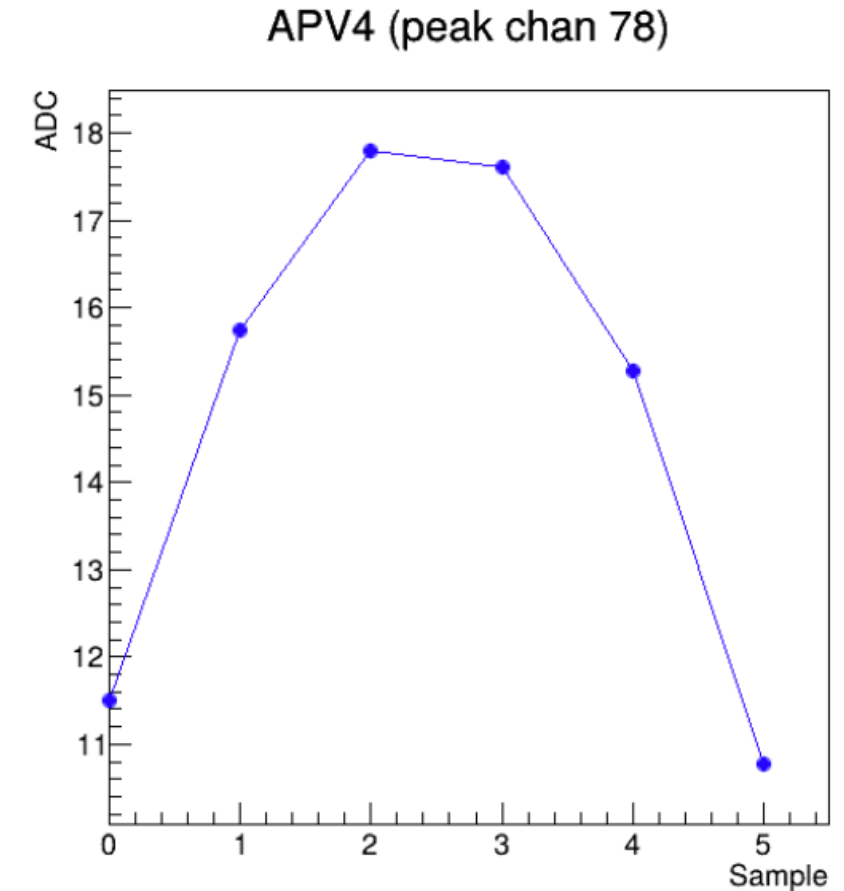
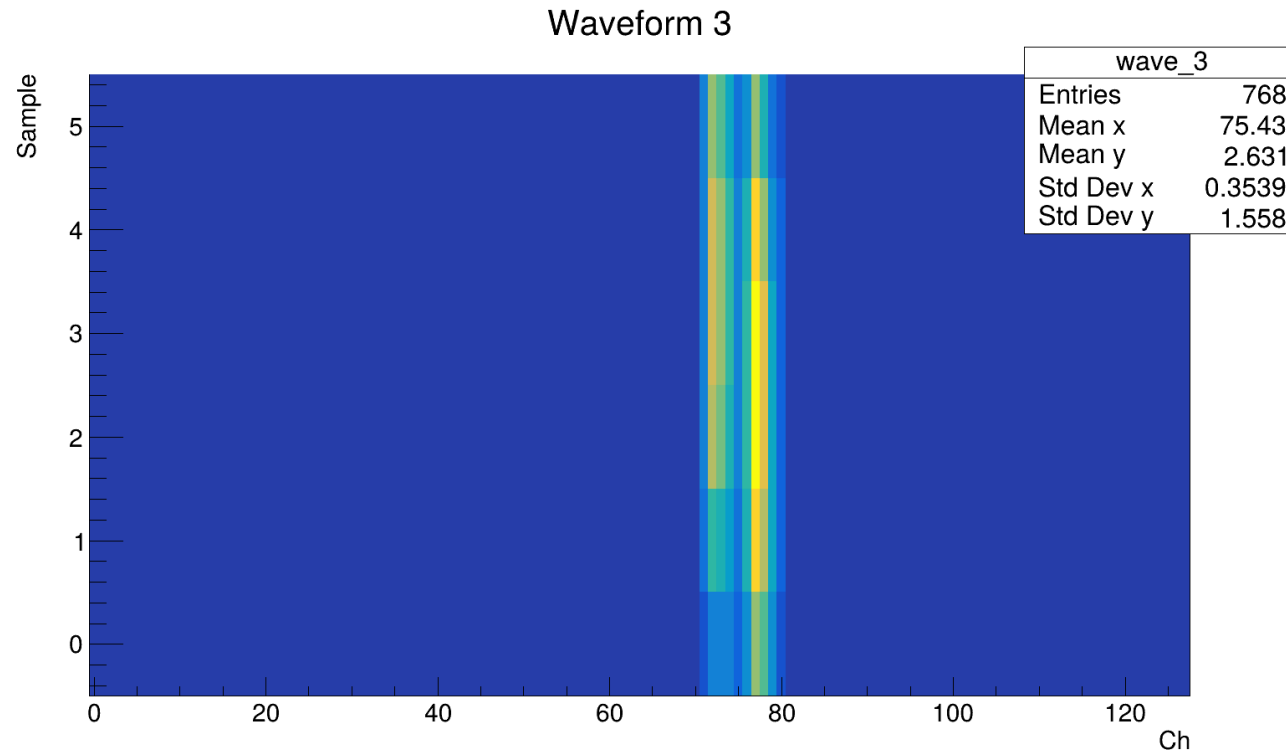
Creating timing samples

- Create 6 time-dependent samples spaced 25 ns apart
- For each hit, scaling the amount of charge deposited based on time of sample relative to time of hit
 - $t_{\text{sample}} = t_{\text{trigger}} + t_{\text{delay}} + 25 \times s$
 - $t_{\text{pulse}} = t_{\text{sample}} - t_{\text{hit}}$
- Temporarily using fit to MUSE data (normalized to 1 at peak value)



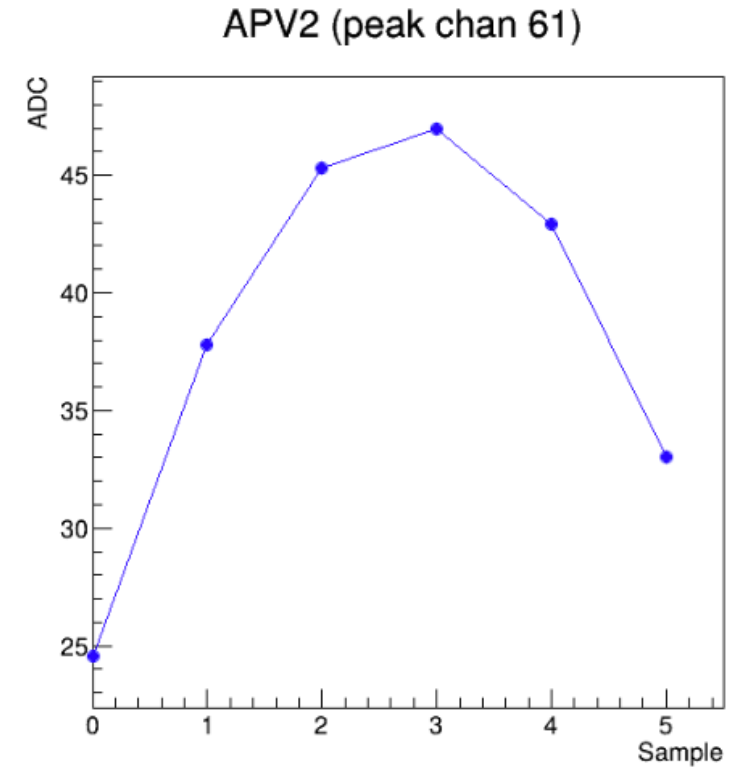
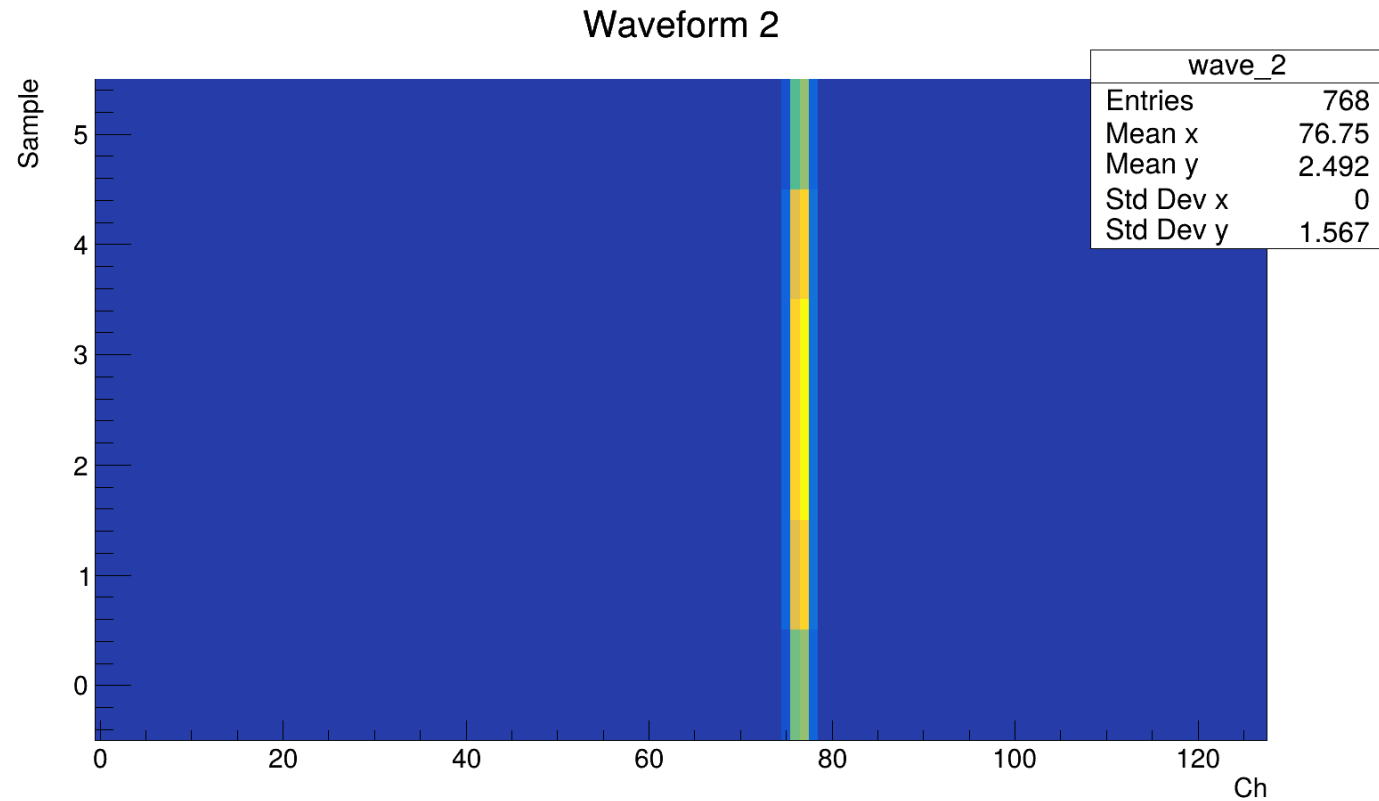
Plot from Tanvi

Results: x-axis (dispersive)



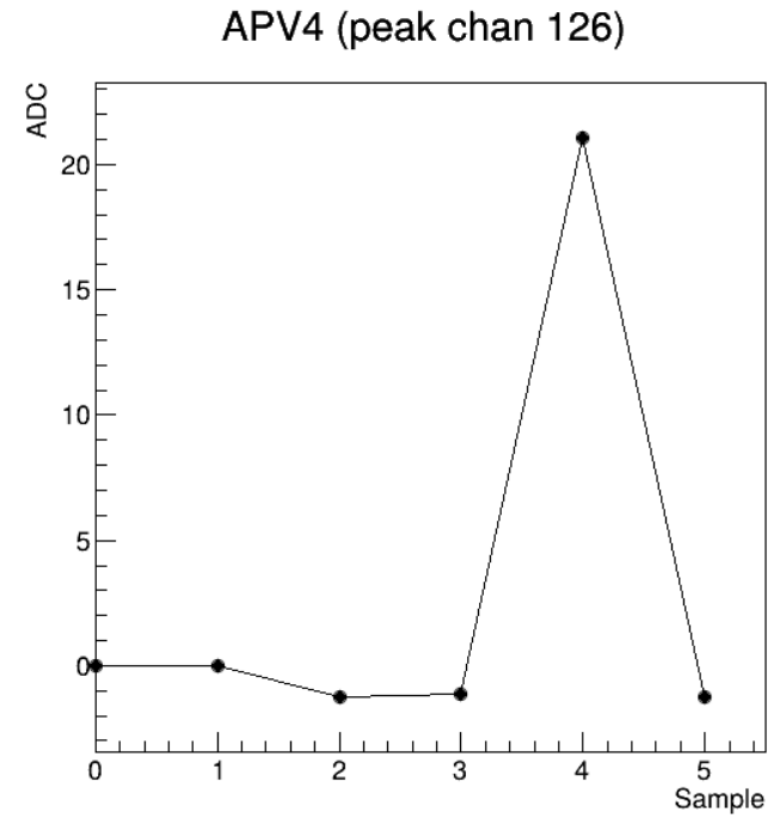
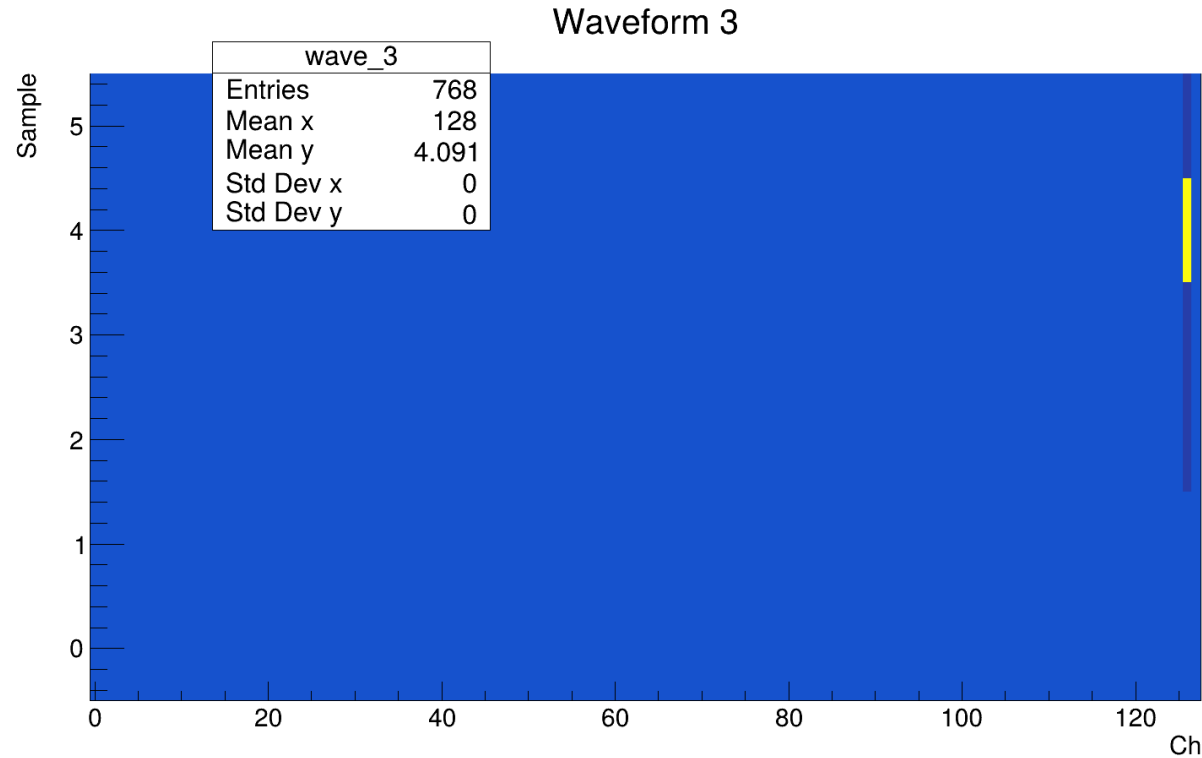
- Left is 2D histogram of ADC as a function of channel number and sample number, right is ADC of peak channel vs. sample number
- This is for a single event
- There is some variation in the waveform (mostly for x-axis)

Results: y-axis (non-dispersive)



- Narrower charge deposition and higher peak ADC as y-axis is non-dispersive

Weird spike

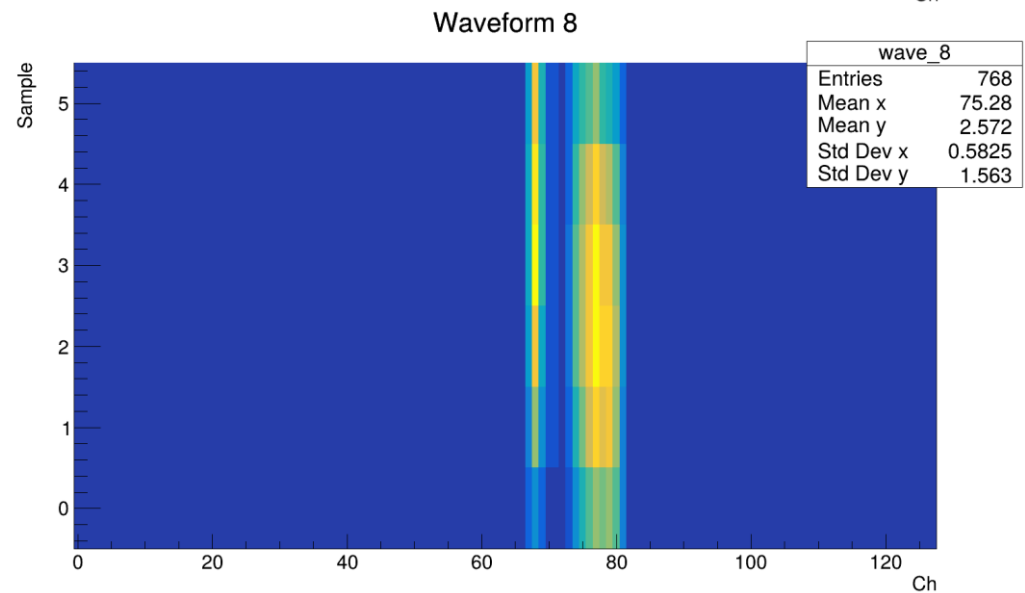
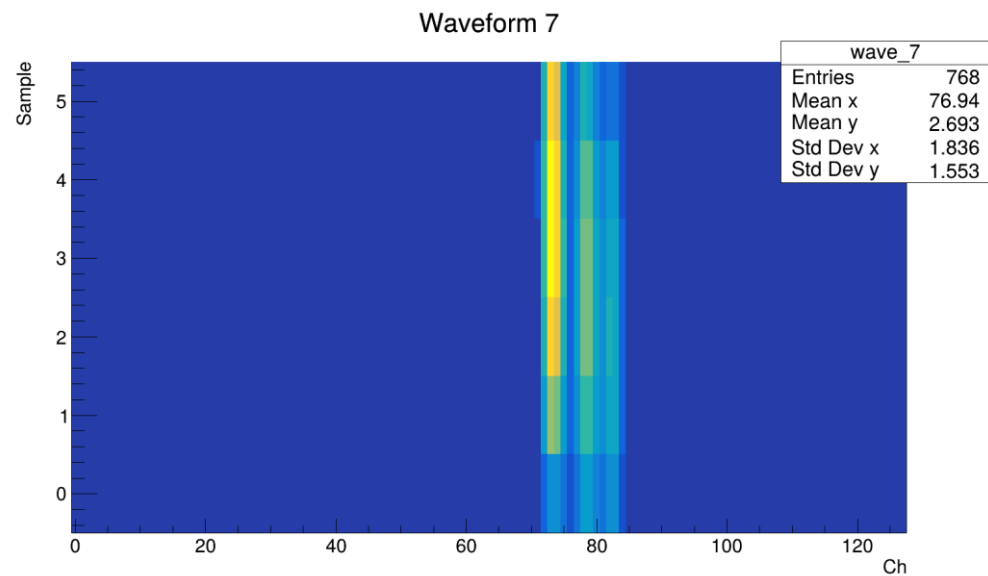
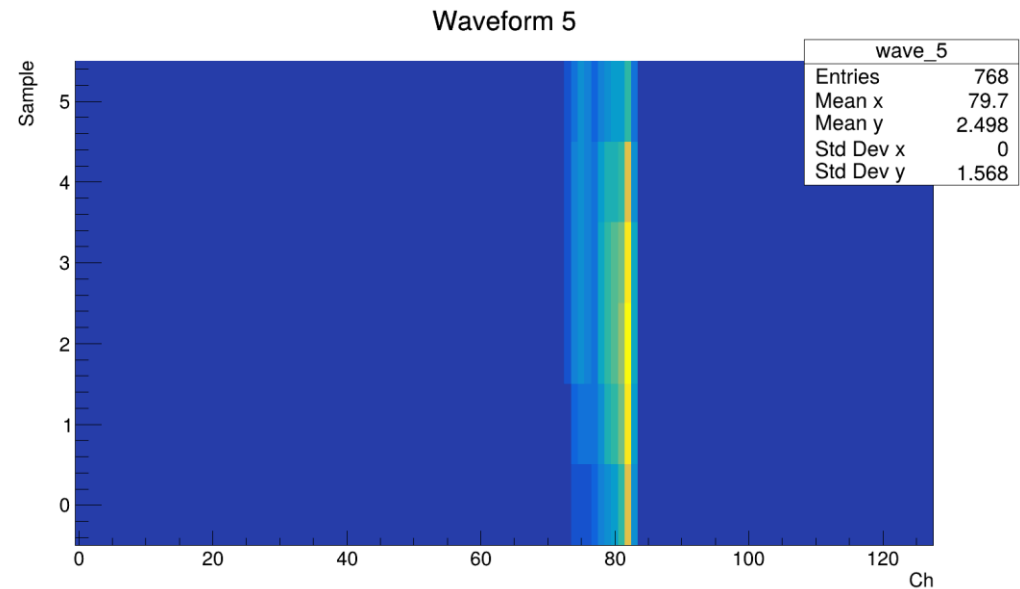
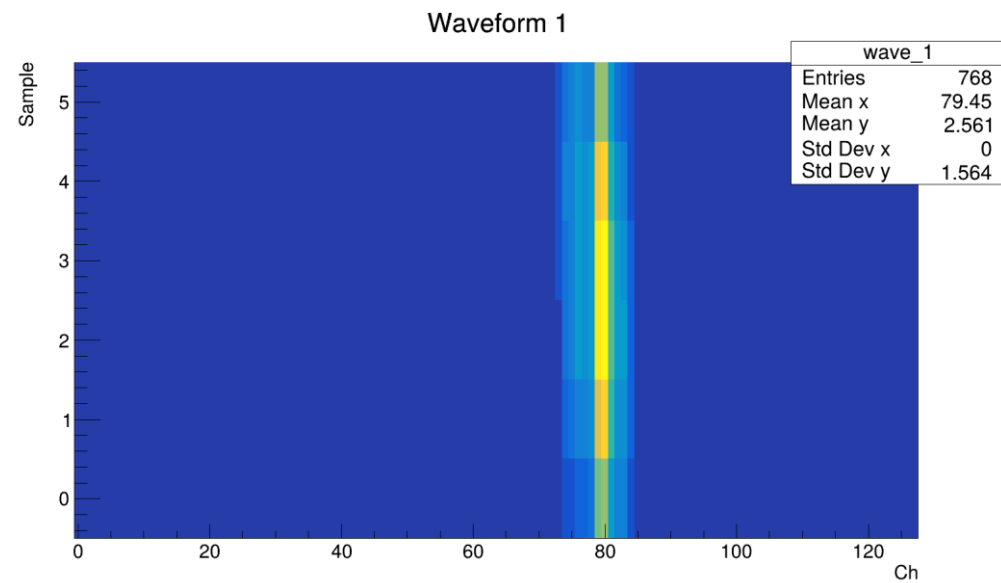


- Appears in raw data for all 4 GEMs (even without timing)
- Always time sample 4, channel 126, y-axis APV 4 (index starts at 0)
- ADC either approx. 22 or -1.7

Next steps

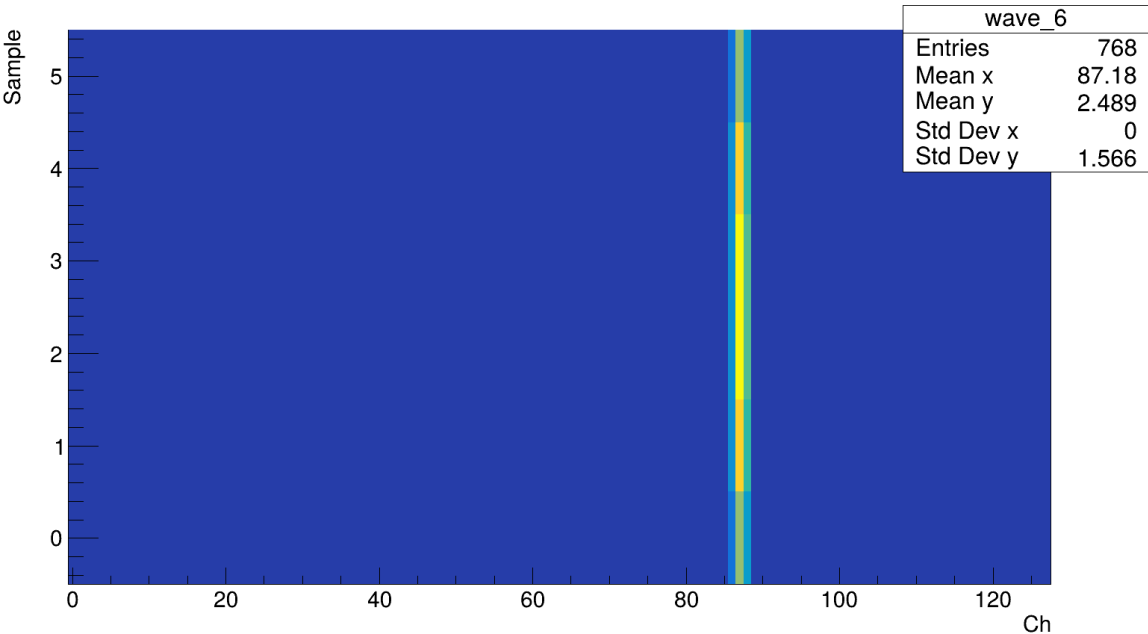
- Use MUSE/DarkLight data (possibly with lookup table) instead of fit to MUSE data for pulse shape
- Add to XGBoost
- Once they're known, put in actual voltages/drift speeds + trigger delay instead of placeholder values

X-axis waveforms



Y-axis waveforms

Waveform 6



Waveform 8

