Crosstalk and Position Resolution of the H8500

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Overview

- We have begun to study the cross-talk characteristics of the Hamamatsu H8500 MaPMT
  - Hamamatsu quotes 3% crosstalk when pixel illuminated in 5x5 mm^2 area
- One hope is that we would be able to use the pixel-to-pixel crosstalk to improve position resolution by interpolating between pixels
  - Earlier simulation studies have shown that we can improve the Cerenkov angle resolution by ~1mrad if we used the H9500 with 3x3 mm^2 pixels, suggesting that better position resolution would help
- At the very least, we need to characterize the cross-talk for single photon signals and put this effect into the simulation and analysis

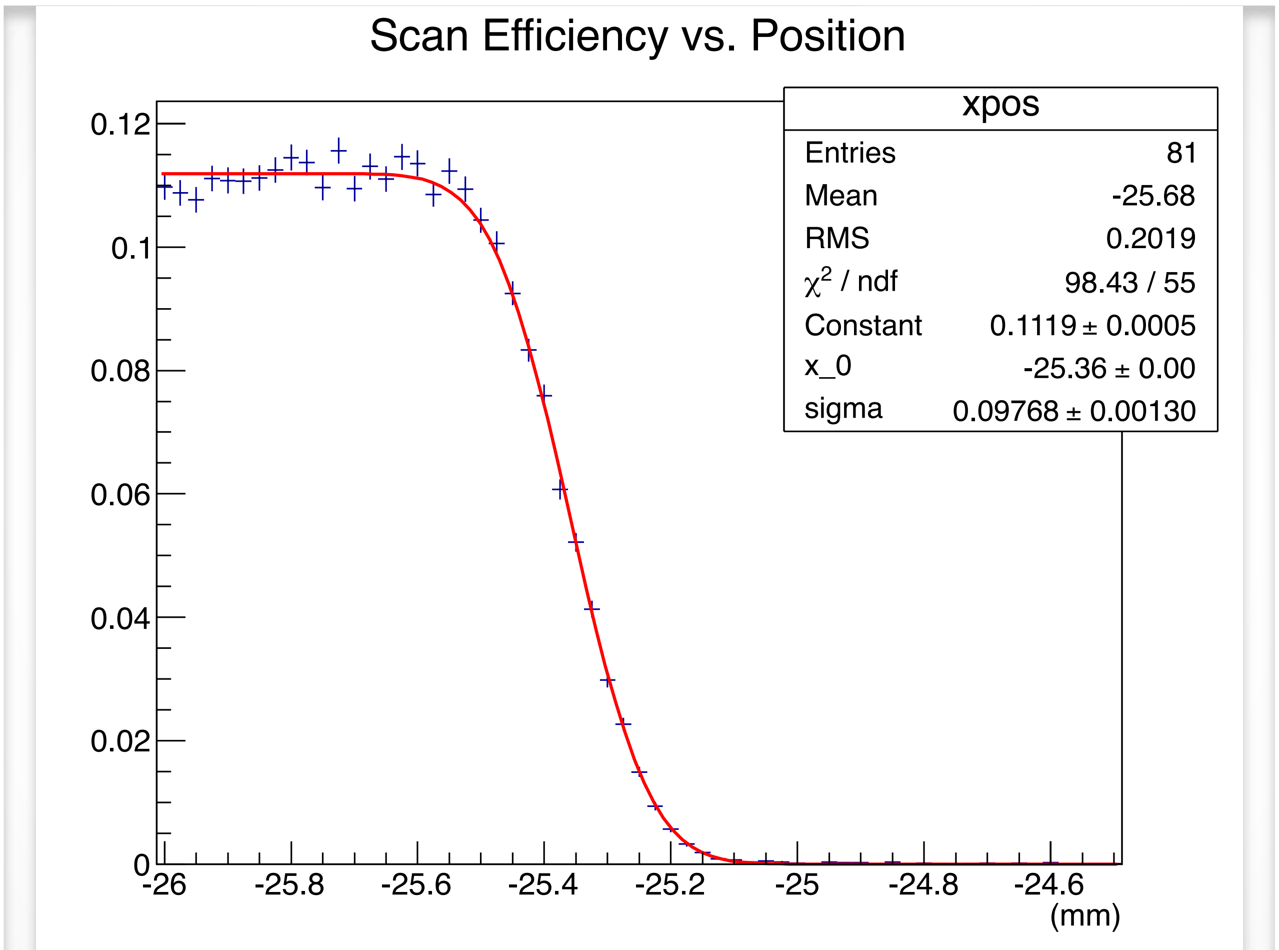
System Setup

- Tests have been done using the PMT scanning setup at Maryland
- PiLAS 405nm laser, focused on to PMT face, controlled by X-Y stepping motor system
- H8500 + SLAC/Maryland preamp cards (gain x40)
- CAEN V1742 waveform digitizer readout, all 64 pixels
- All controlled via LabVIEW
- Details presented at Elba meeting

Laser Spot Size

- First step was to measure and optimize the spot size of the laser on the PMT face
  - Want to make sure we are seeing tube effects and not just broad light distribution
- Light goes from fiber optic to a collimating lens and then a focusing lens with f = 12mm
- All mounted on a translating stage with micrometer head adjustment
- Used a conventional single channel PMT with a piece of tape over half the face
- Scanned over the tape edge in steps of 25μm and measured response as a function of micrometer setting
- Fit to error function to extract beam sigma

Scan to Determine Spot Size

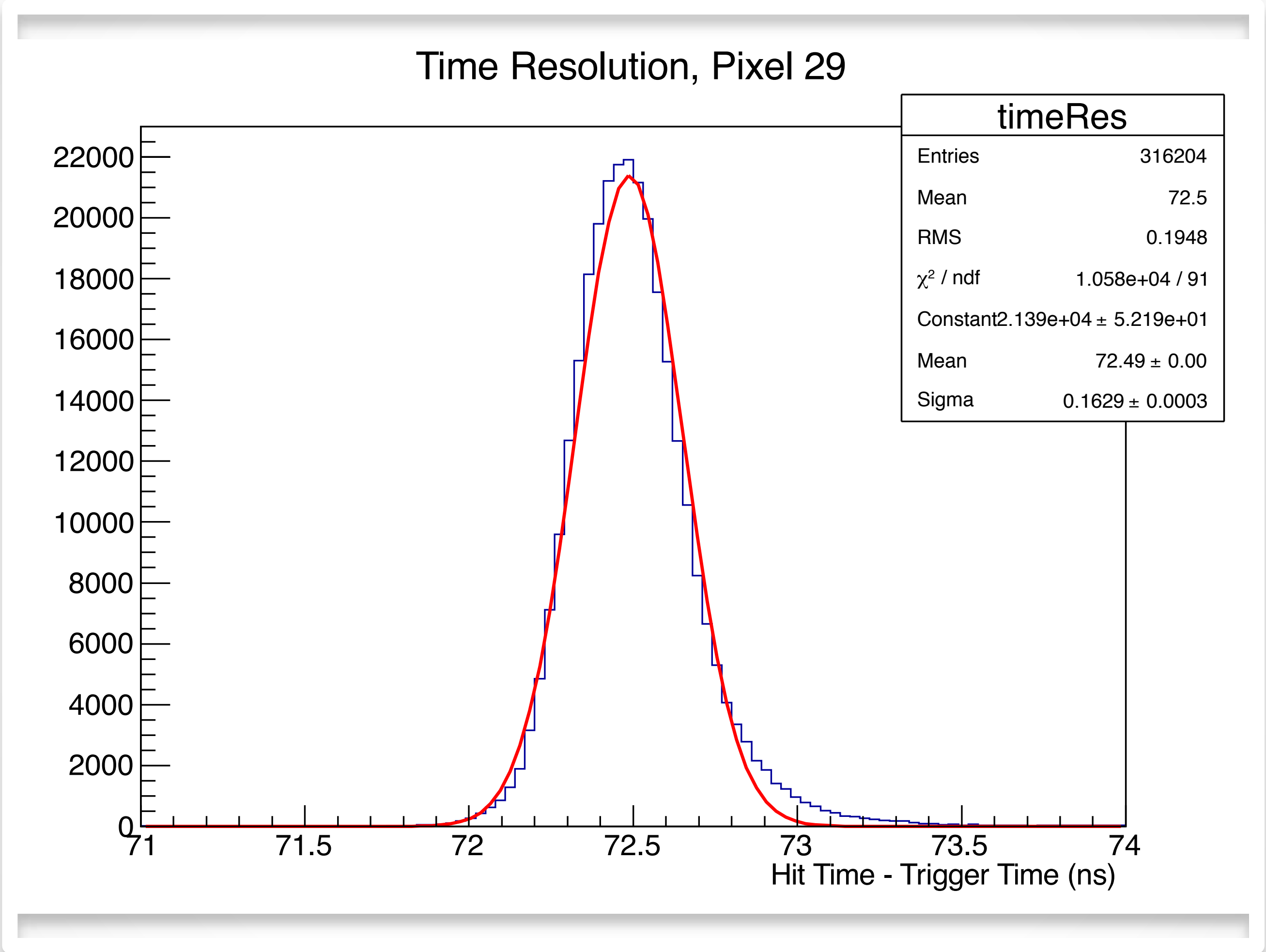


Result: Beam σ = 97.7 ± 1.3 μm

Scan Parameters

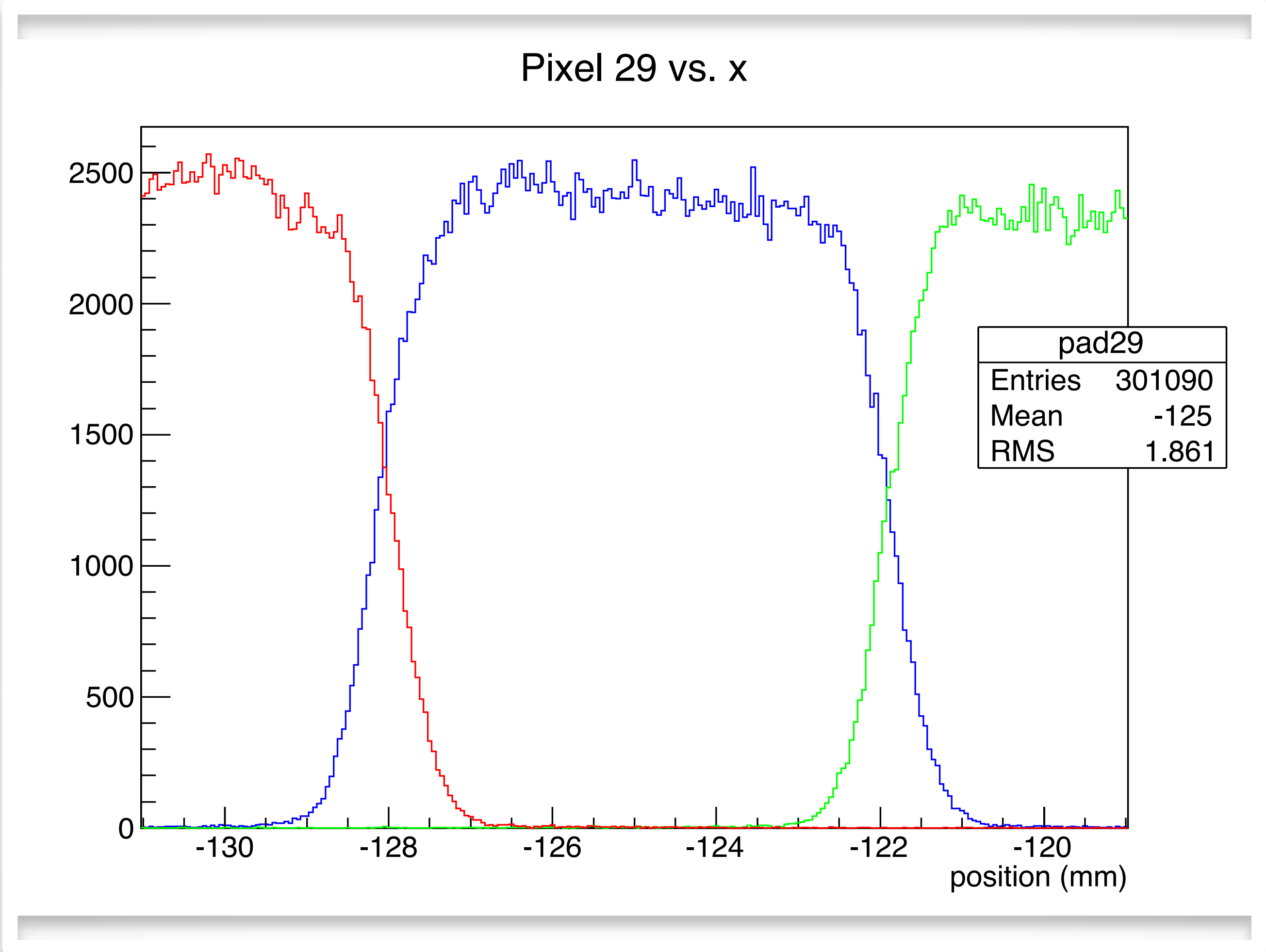
- Scan over one pixel near center of PMT, ± 3mm on either side
- Scan in *x*, at fixed *y* near center of pixel
- Step size = 50μm
- HV = -1000V
- Discriminator Threshold = -25mV
  - Implemented in software
- 30,000 laser pulses per step
- ~8% trigger rate (single-photon mode), ~2500 measured pulses per step
- Total scan time: ~13 hours

Timing Resolution

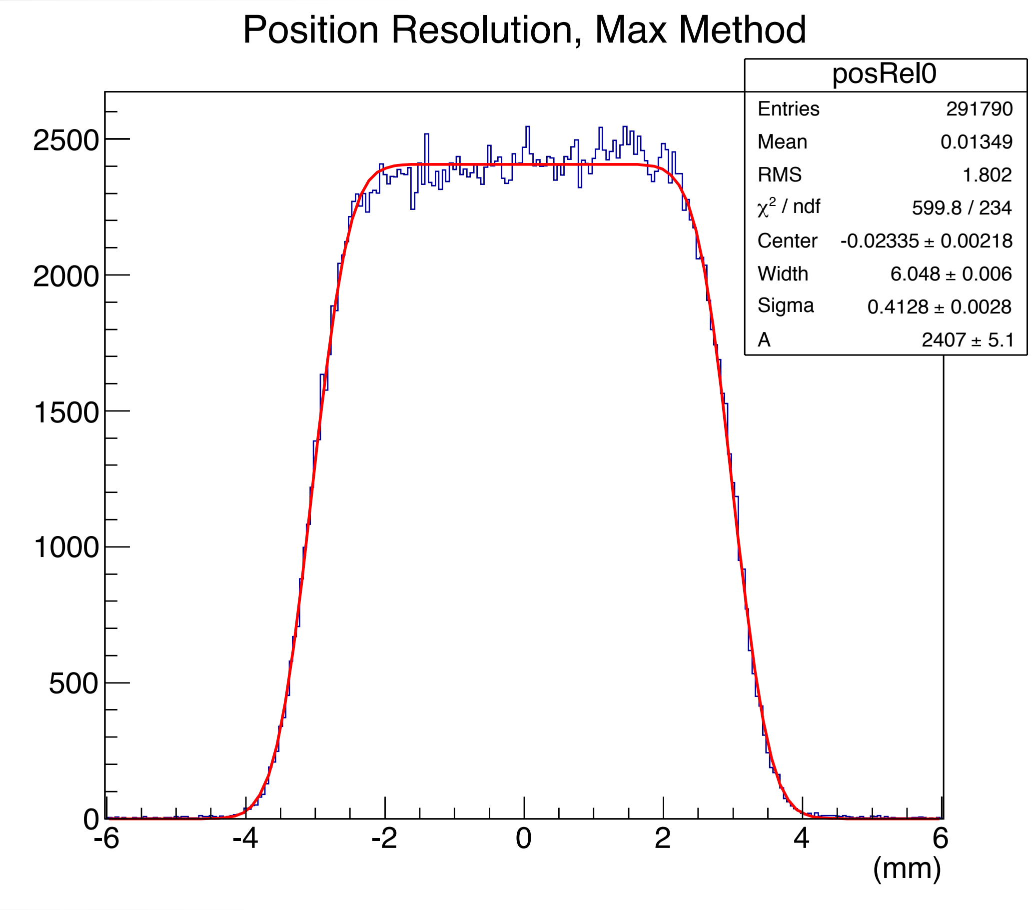


σ = 163 ps, other sources of jitter not accounted for
Require hits between 71.5ns and 73.5 ns

Scan Output



Pixel 29 vs. x
2500
2000
1500
1000
500
0
-130
-128
-126
-124
-122
-120
position (mm)
pad29
Entries 301090
Mean -125
RMS 1.861



Simple Position Measurement

- Most simple way to determine position is to just use center of pixel with maximum charge
  - Use ADC-like charge integration, not pulse peak
- Ideally, RMS should be 6.08mm/sqrt(12) = 1.76 mm
- Measured RMS = 1.80 mm
- Fit is box convoluted with Gaussian
- Gaussian σ = 413 μm, >> spot size

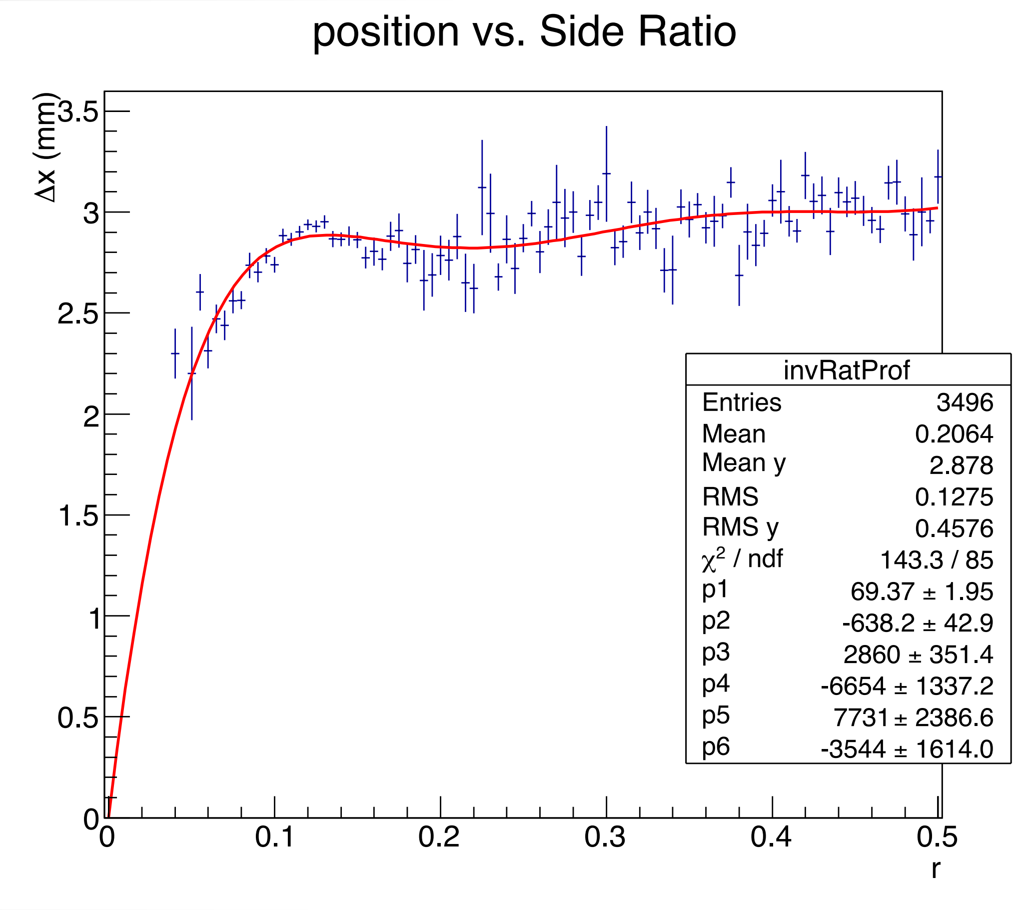
Using Neighboring Pixel

- Next level of position reconstruction is to use charge on neighbor cell:

$$r = \frac{Q_{Neighbor}}{Q_{Max} + Q_{Neighbor}}$$

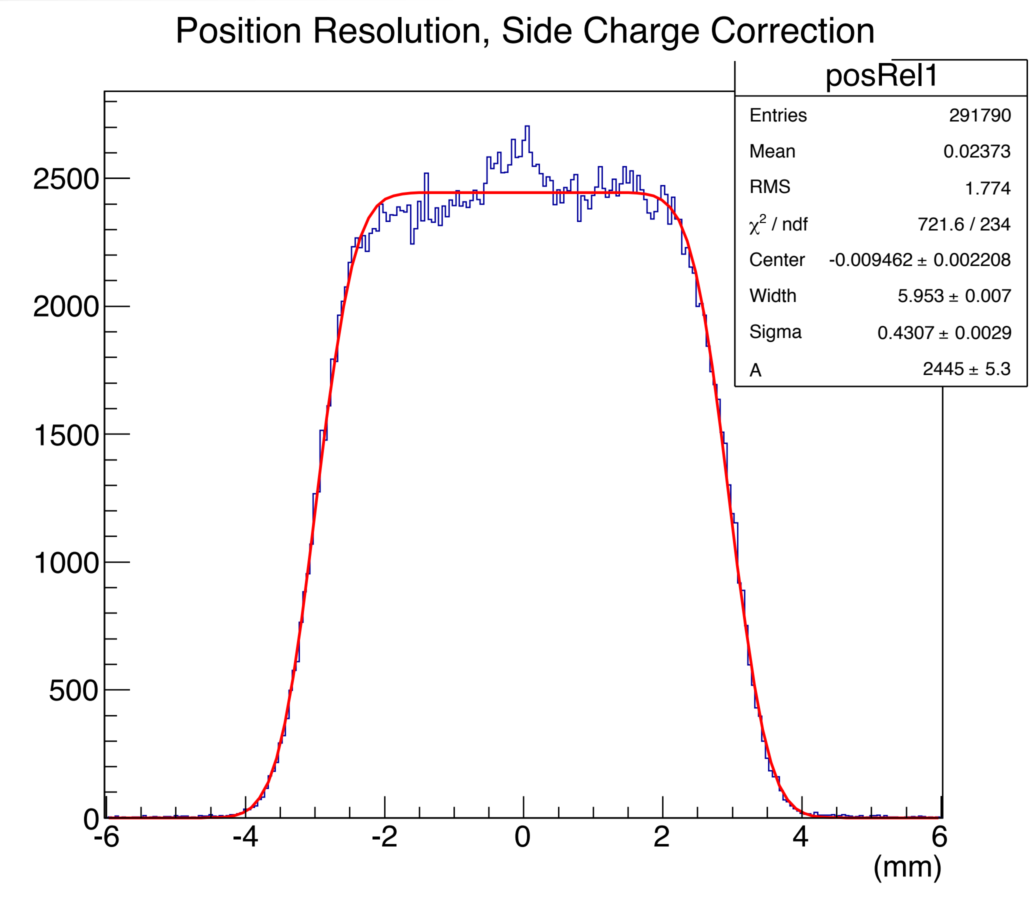
- Then, map position vs. r
- The problem is only a little more than 1% of the events have a hit on a neighboring pixel
  - Cross-talk isn't huge, so only happens near boundary
  - Function of discriminator threshold. We should run at a much lower threshold to see if this helps

Distance from Pixel Center vs. *r*

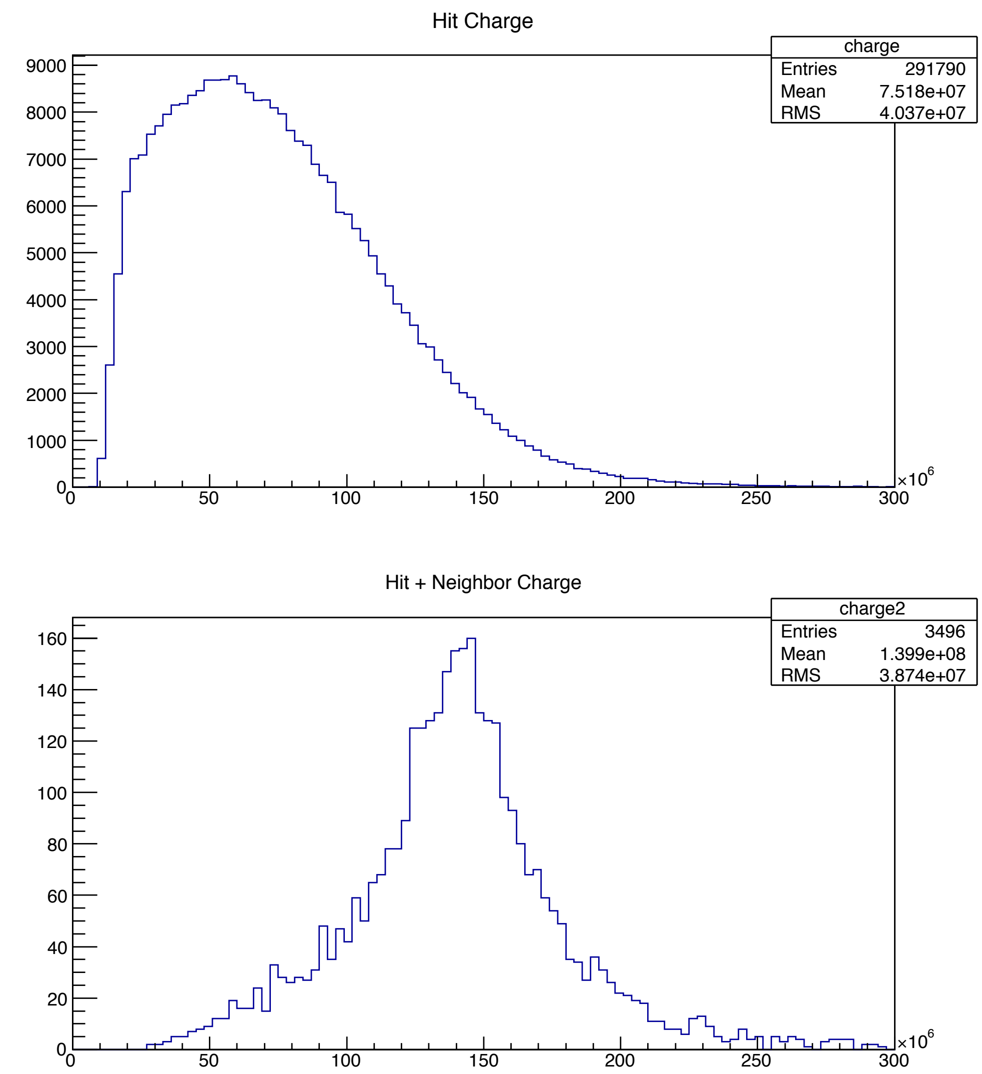


- Fit to a 6^{th} order polynomial
- Not sure if the structure is real…
- Probably sufficient to just say that if a neighbor pixel is hit, use the boundary as the position

Resolution With Neighbor Correction



- RMS goes from 1.80 mm to 1.77 mm
- Better, and close to 1.76 mm ideal box
- But nothing approaching resolution expected from H9500



BUT!!!

- Charge sum of events with a neighbor pad hit do not look like single PE events!
- Even though we are running in "single photon" mode, there is still contamination from double PE events
- **It looks like cross-talk isn't charge sharing**

Conclusion

- At this early stage, it doesn't look like there is much to be gained by trying to use cross-talk to improve position resolution
- Cross-talk doesn't appear to be from charge sharing of a single PE. Most likely comes from PE transport to first dynode. Electron multiplication seems to remain fairly focused after that.
- We can try to run with a lower discriminator threshold, but…
- Still need to account for cross-talk in simulation and analysis