# Negative Signal Tracking

Sean Jeffas
March 7, 2022

# Negative Signal Tracking

- Implemented changes in the analyzer to handle negative strips on tracks.

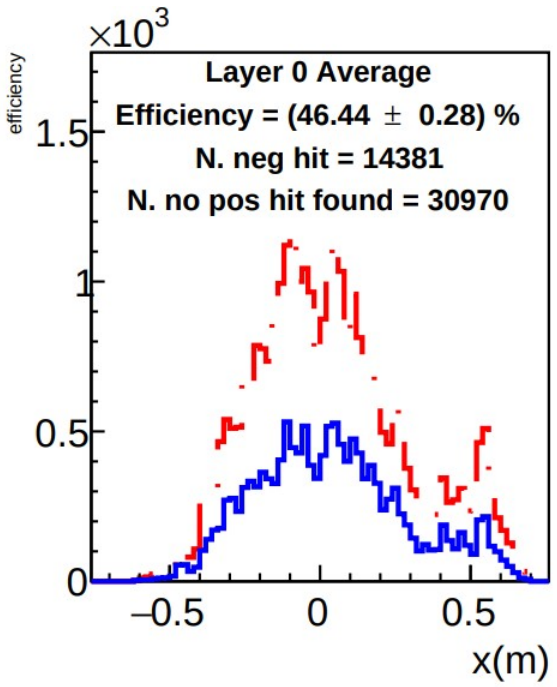
1) Goes through normal tracking procedure for positive strip signals.
2) Stores all negative strips passing “negative” zero suppression ( < -5 sigma cut).
3) After tracking loop through all modules on tracks that do not have hits found.
4) Loops over all possible 2D combinations of negative matched with negative or negative matched with positive strips.
5) Check if the 2D position is withing 2 mm of the expected track hit.
6) Record this as negative strip on track or not on track.

- All raw negative strips passing zero suppression are used.
  - There is no correlation cuts or clustering.
- **This is extremely biased in favor of finding negative tracks.**
- Creating a more robust method would take a bit more work.

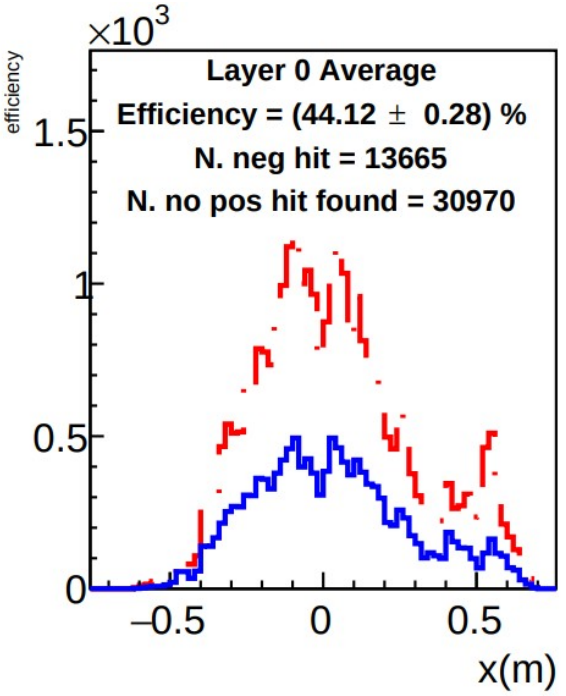
# Negative Tracking Efficiency

- The red histograms are tracks where no positive hit is found.
- The blue histograms are the tracks where a negative hit is found instead of a positive hit.
- Not a true efficiency, but the fraction of how often we find a negative hit on the tracks when the positive hits are missing.
- 1D tracking simply checks if any negative hits on one axis are within 2 mm of the track.
  - ~40% numbers are expected for random noise.
- 2D tracking checks using all 2D combinations between negative and positive hits.
- In all results the 1D tracking and 2D tracking fractions are very similar.

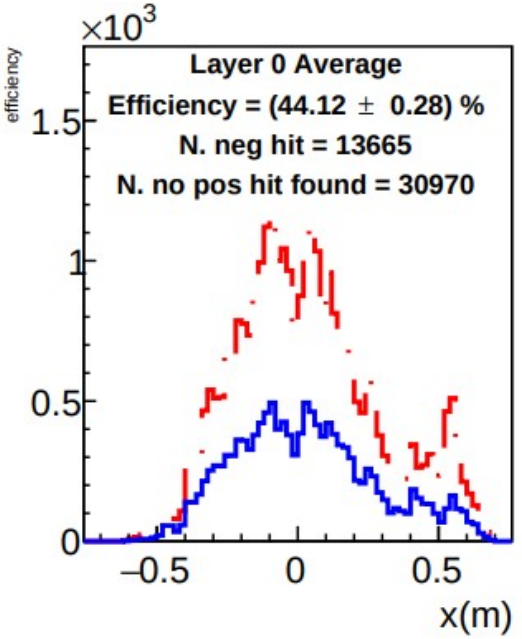
**1D tracking**

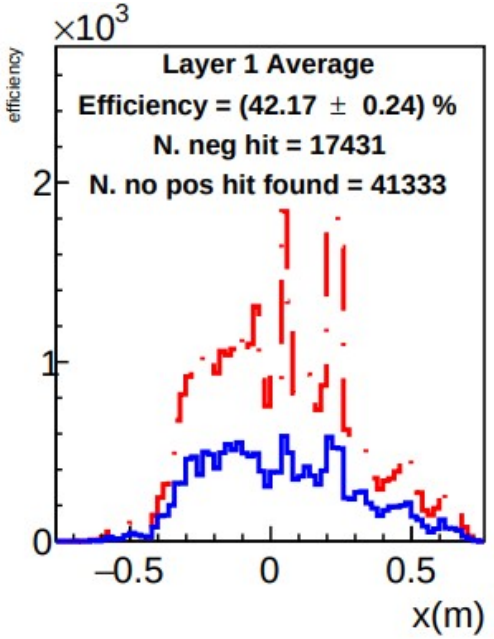


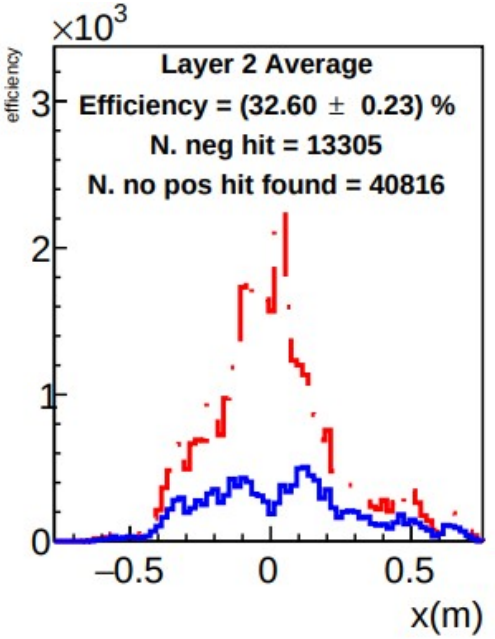

**2D tracking**

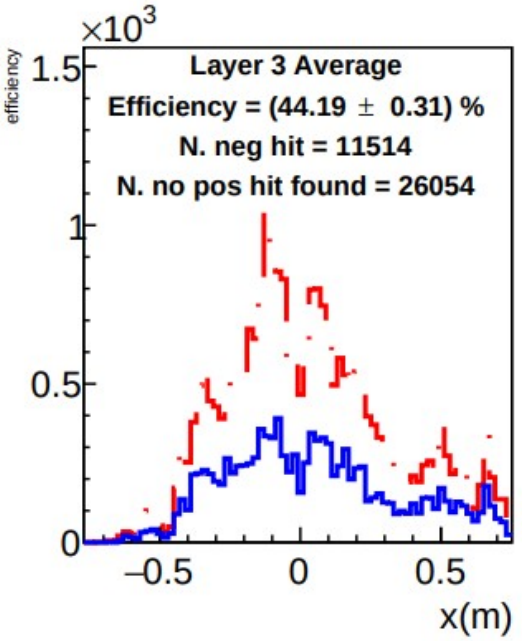


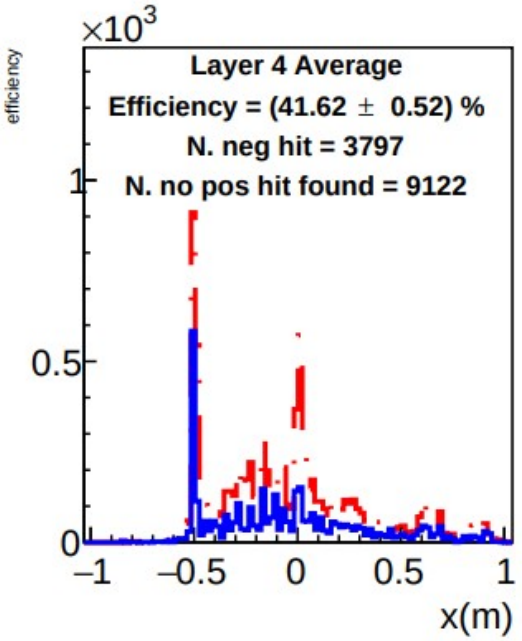
# 2D Tracking Efficiency



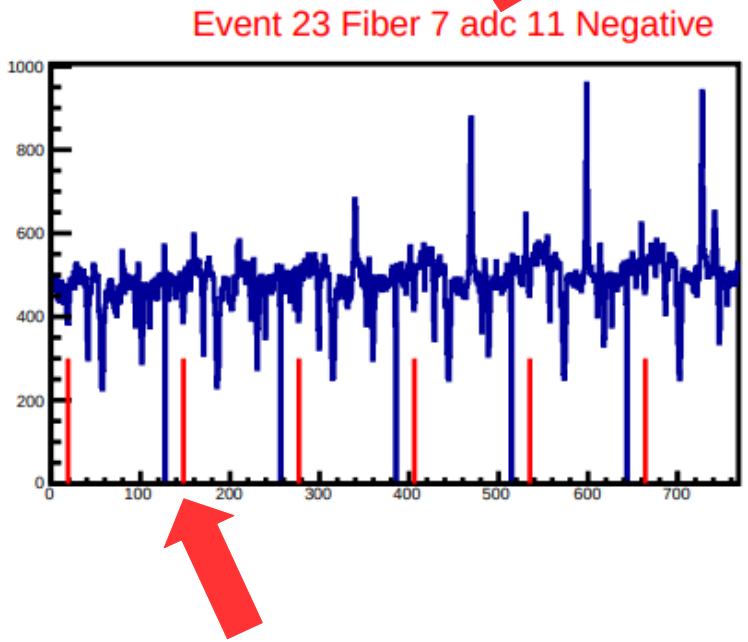



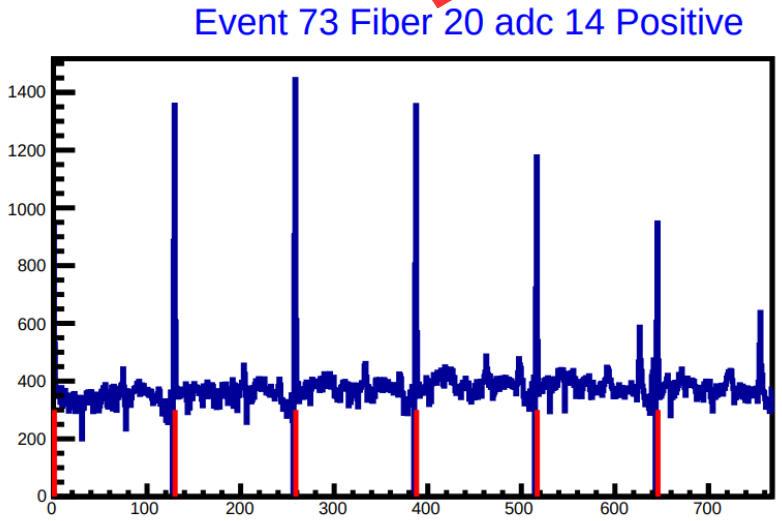
# Negative Tracking Displays

- On the HALOG I have posted 100 events with negative tracks found, and highlighted their position.
  - https://logbooks.jlab.org/entry/3986717

Large red title shows which APV had the negative hit on a track

Large blue title shows which APV had the positive hit on a track




Red line shows the hit strip location.

# Negative Event Types

- 70 events from 7 uA on LD2 have been investigated by eye.
- Three main types of negative events I see.

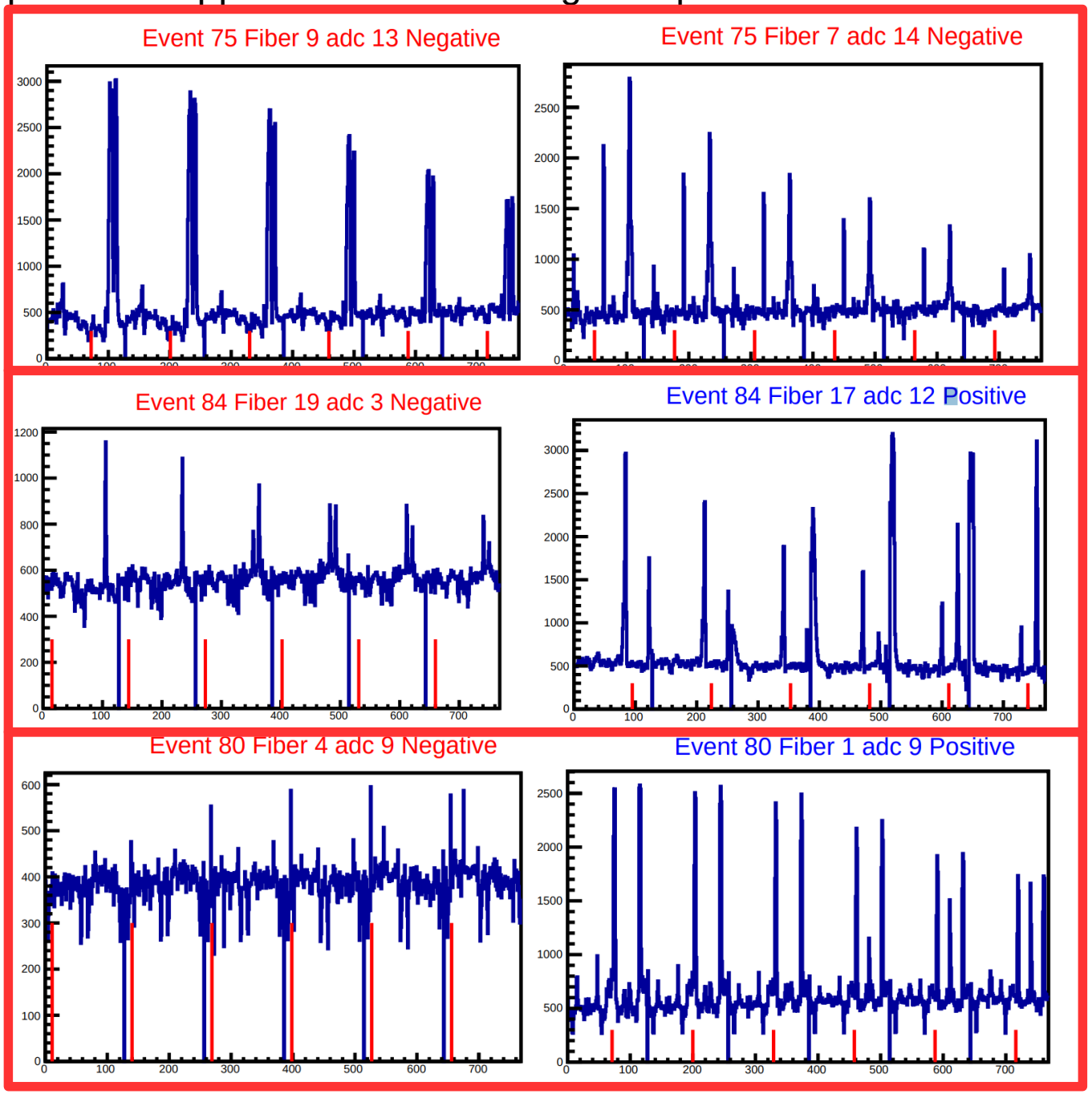
1) Noisy negative strips that coincidentally fire inside the track
   - 56% of events.

2) Negative strips on the edge of a positive cluster.
   - 30% of events.
   - Not real negative strip tracks. The negative strips are often found around the edges of positive strips.
   - Most likely these events should be positive hits but did not pass some tracking cuts.

3) Negative strips that looks like normal clusters.
   - 14% of events.

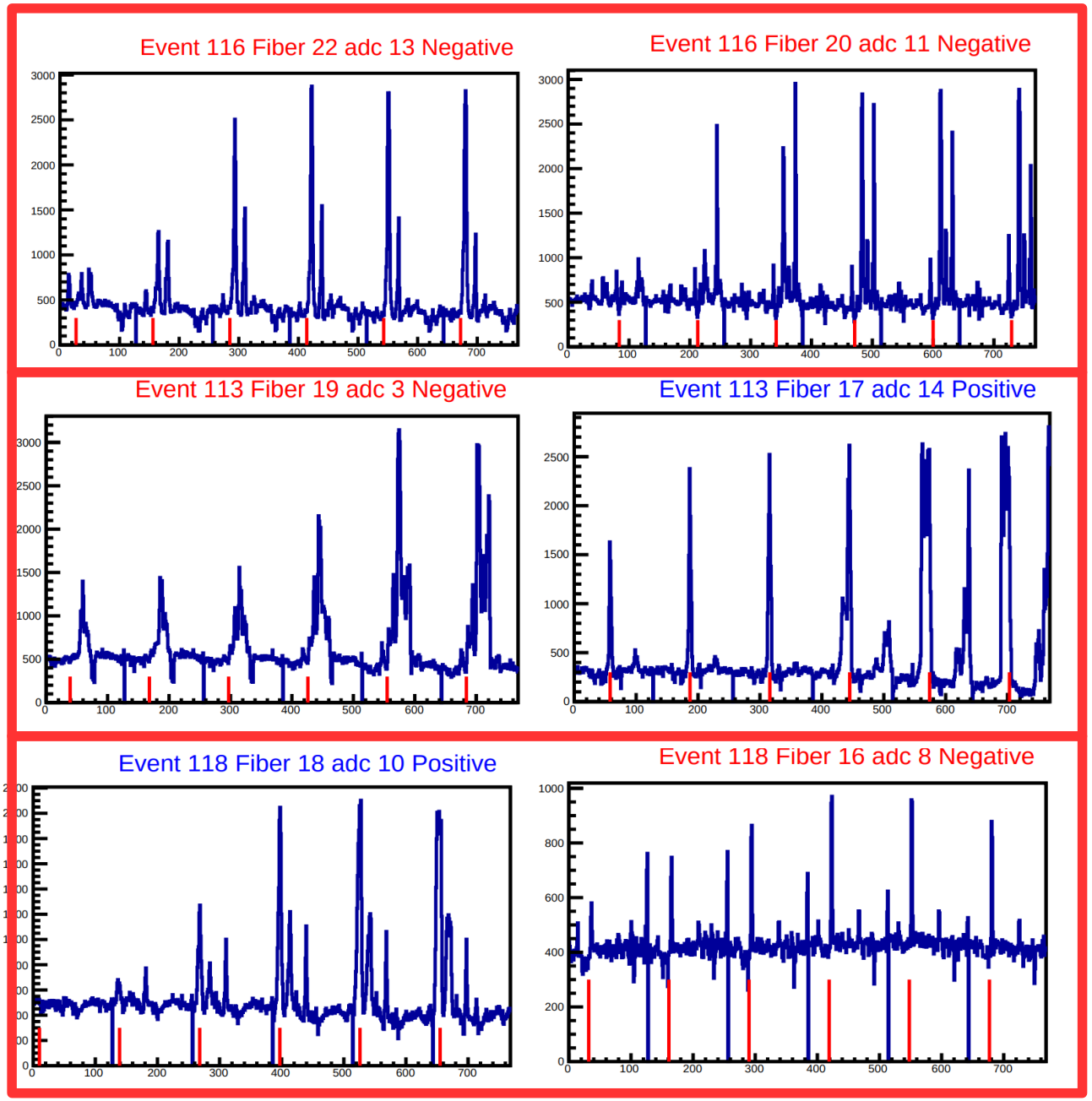
# Event Examples

- Negative strip noise “happens” to be on the right strip



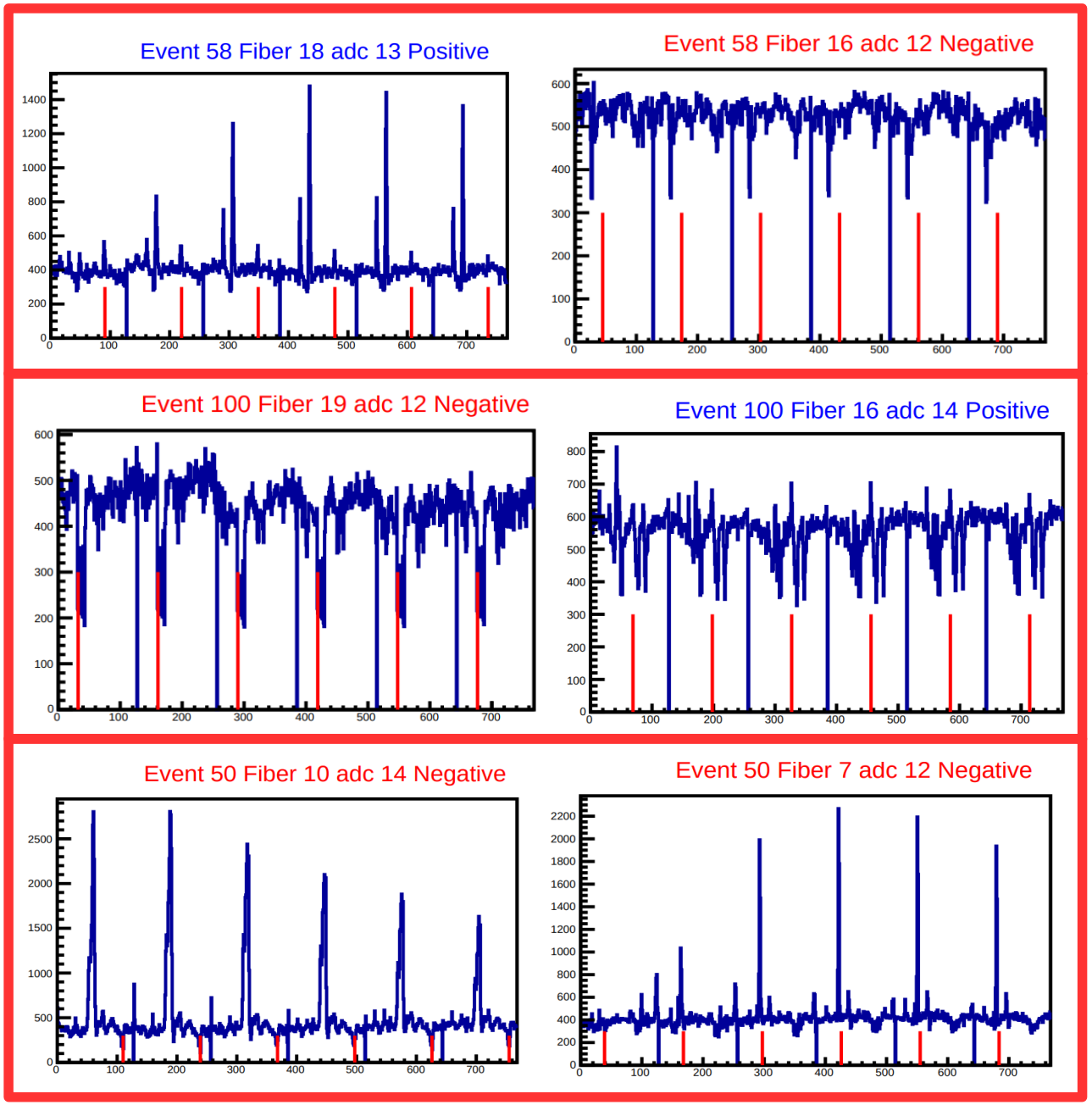
# Event Examples

- Negative strips on the edge of positive clusters.
  - Normal hit that does not pass other tracking cuts.



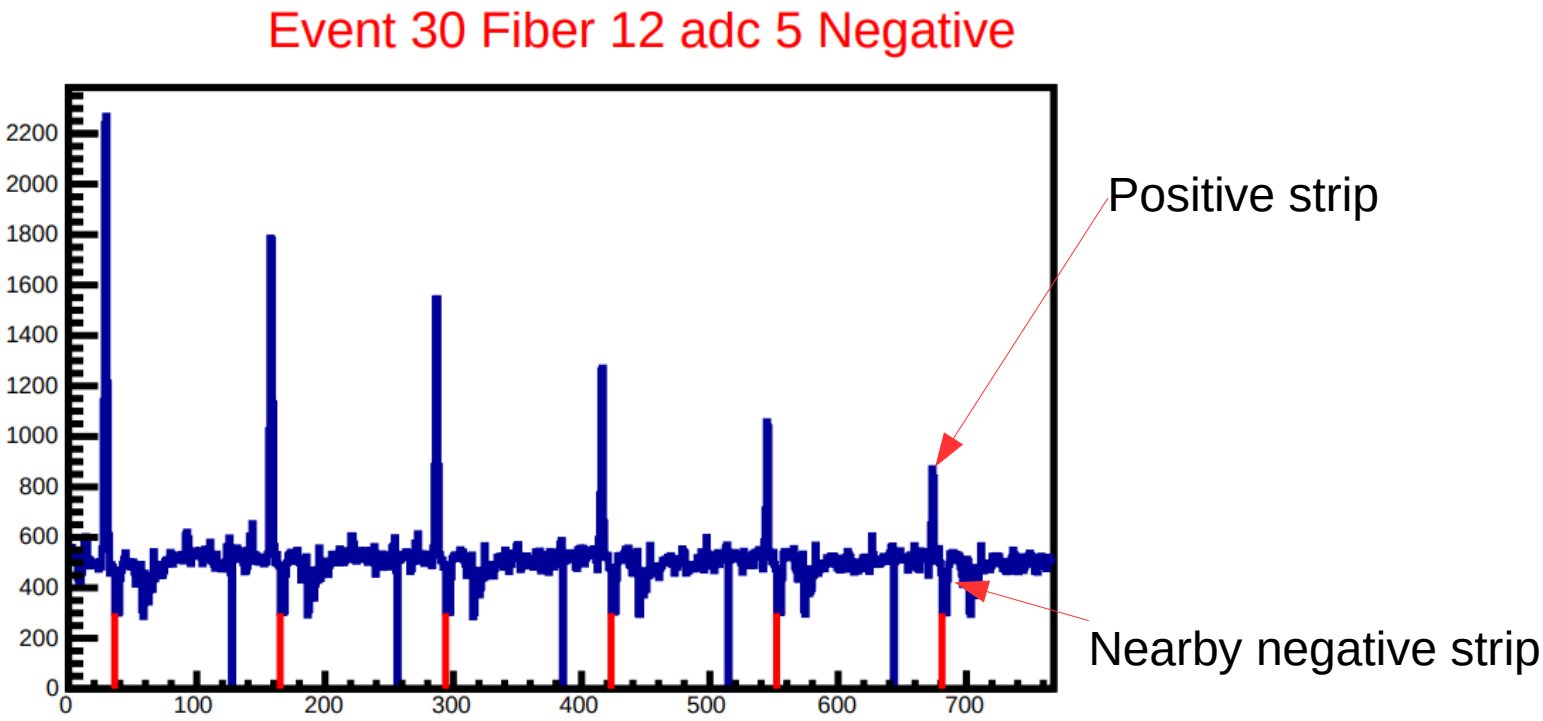
# Event Examples

- Negative strips that looks like real clusters on tracks.
  - Extremely rare.



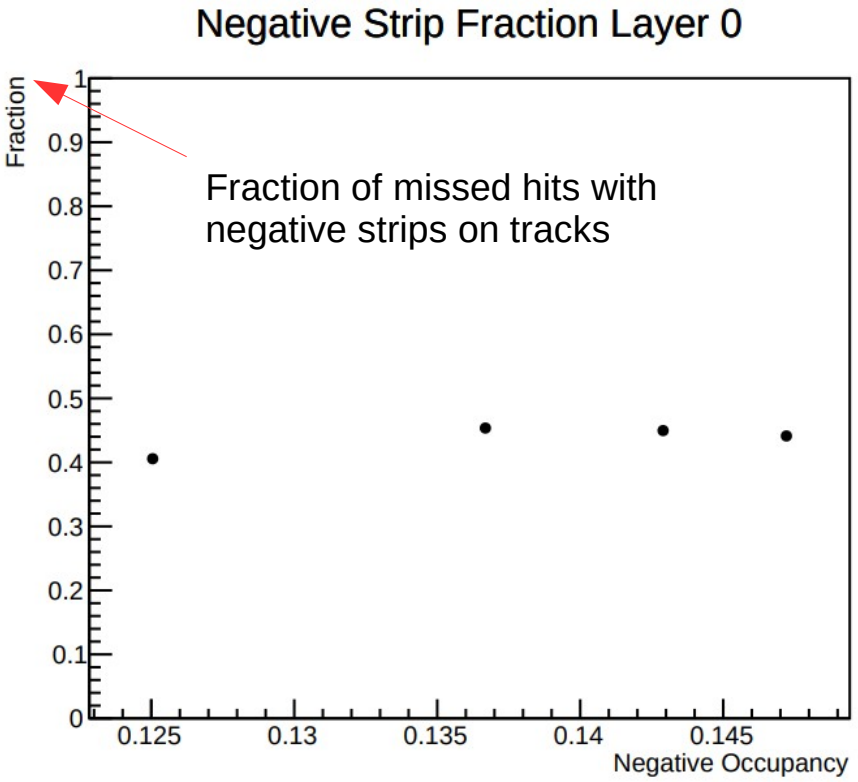
# Negative Strips Near Positive Clusters

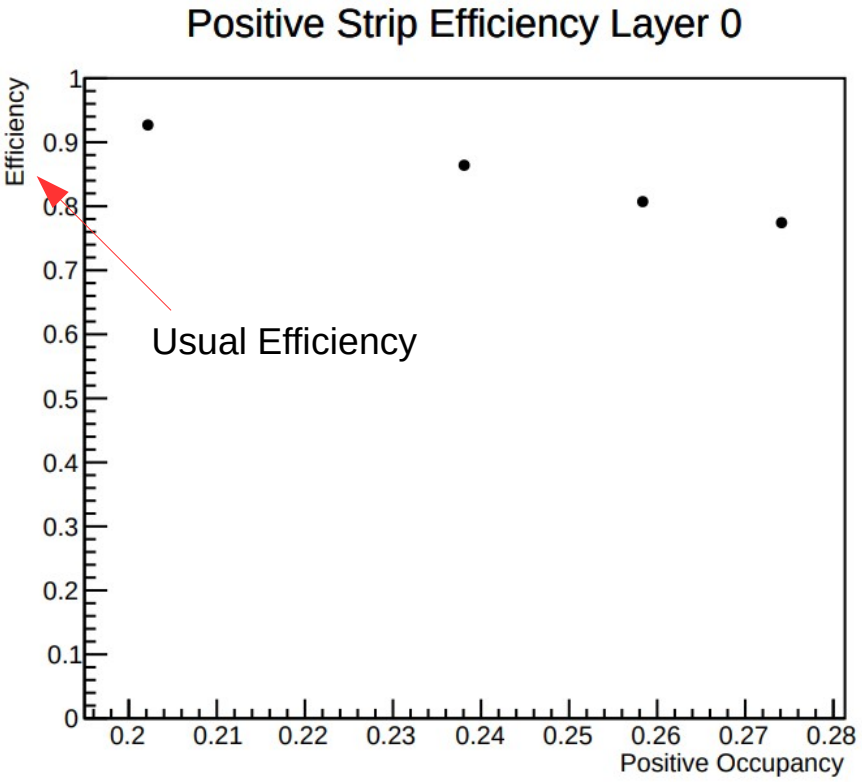
- Often we find the ADC swings from positive to negative on the sides of large positive hits.
- From the event display, this happens very often.
- Likely causes many of the coincidences of negative strips being near tracks.



# Tracking Efficiency Comparison

- Below is the tracking results for different beam currents, shown on the x-axis as different negative and positive occupancy
- The negative track fraction stays constant at all beam currents.
  - If the polarity flip was causing our positive efficiency decrease, we would expect this number to increase.
- Constant result would also be explained by random chance that negative strips are on tracks.
  - Negative occupancy only increases from 12.5% to 15%, which should yield about the same result.

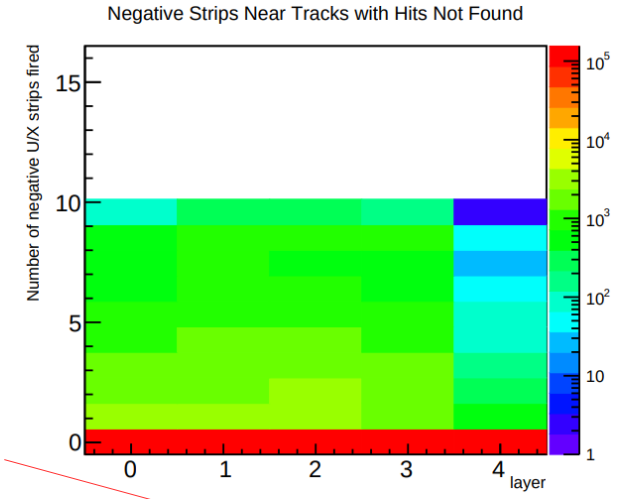


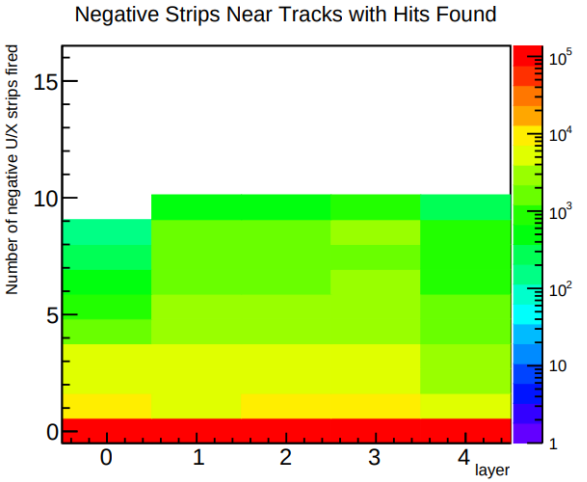



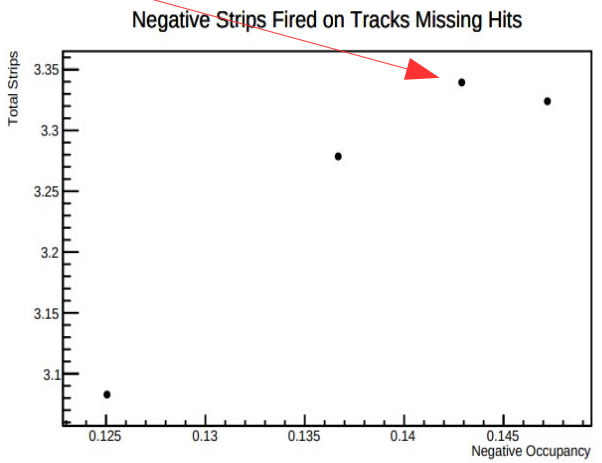
# Strip Number on Tracks

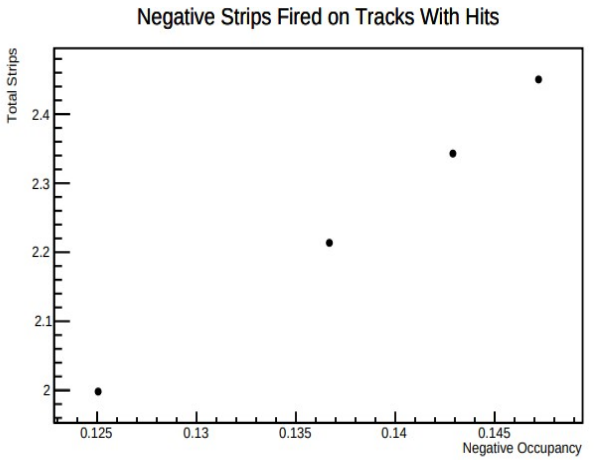
- We expect more strips to fire within 2 mm of the track when hits are not found, due to negative clusters.
- Actually we find less negative strips when hits are not found.
  - We have shown before that negative occupancy is correlated with positive occupancy.
- As beam current increases, the number of strips with no hits, is consistently lower.
- This points to the strips being noise, and uncorrelated to the track passing through.

Turning point where negative occupancy is overcome by increasing positive occupancy with beam current



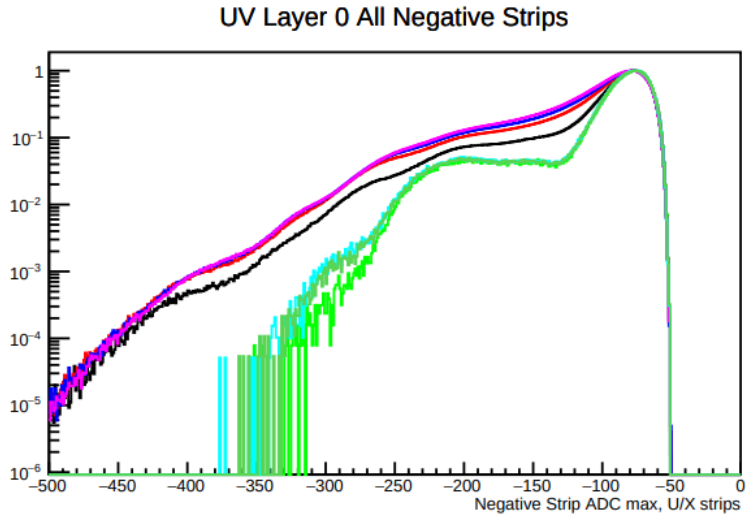



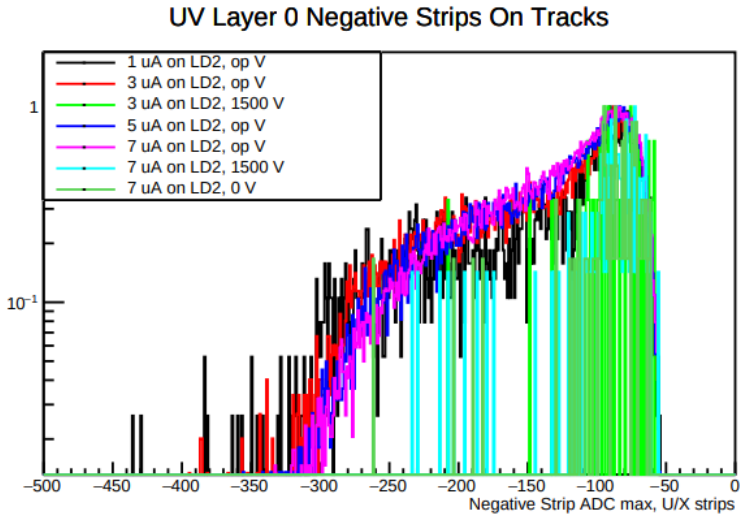



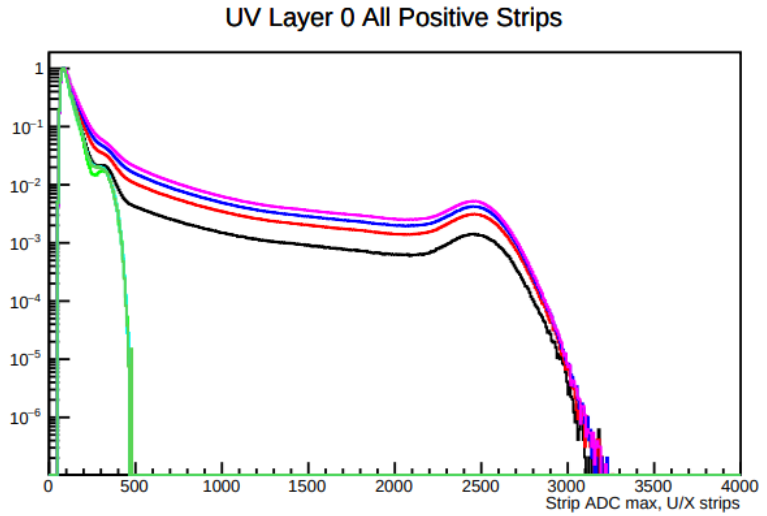



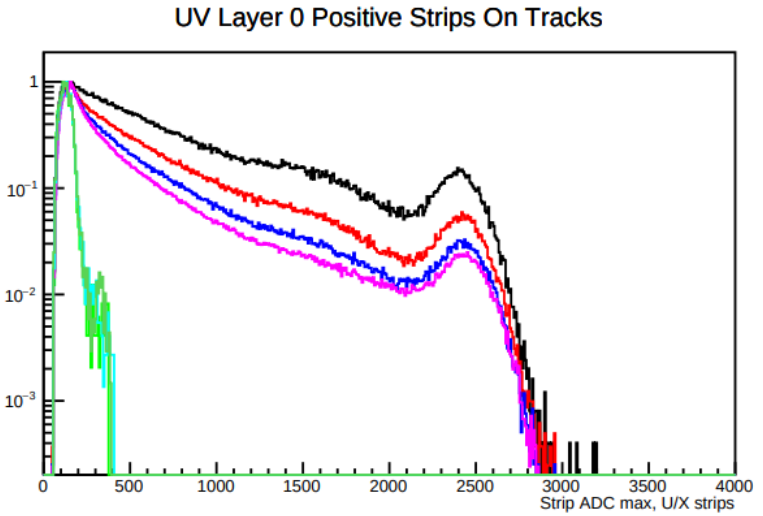
# ADC Comparisons

- Unlike the positive ADC distributions, the average negative ADC is significantly reduced when cutting from all strips to just strips on tracks.
  - Another sign that the strips on tracks are mostly lower ADC noise.



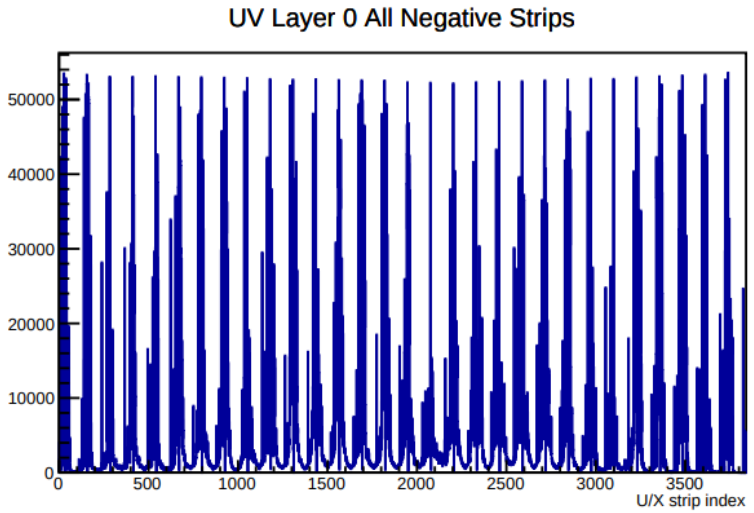



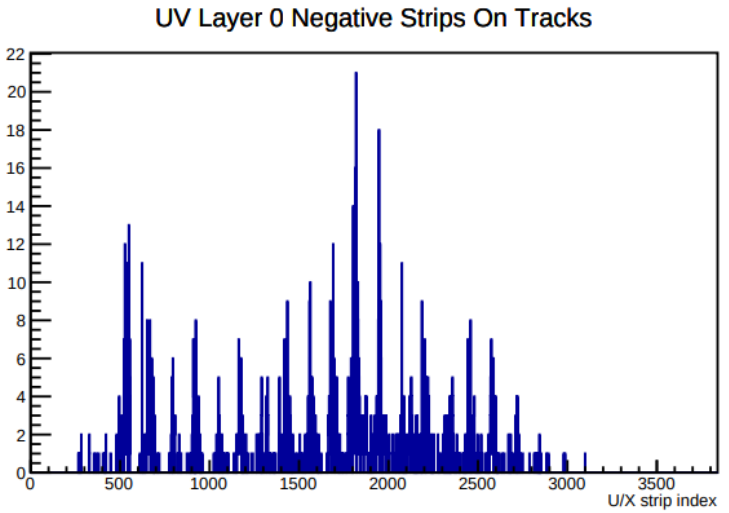



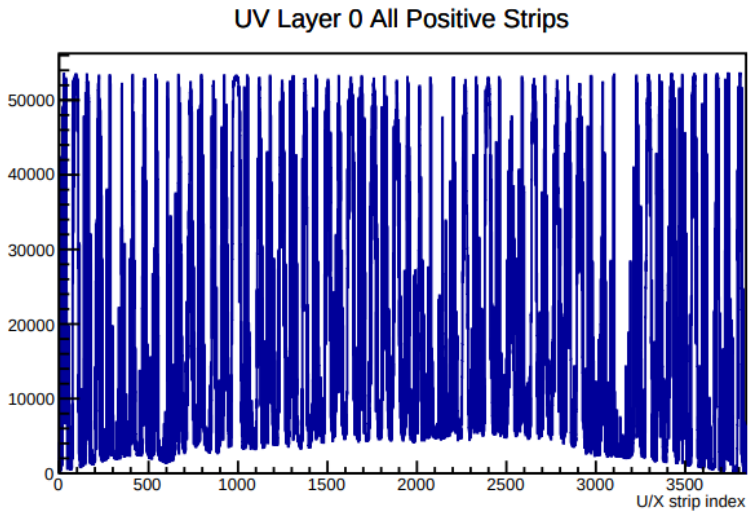



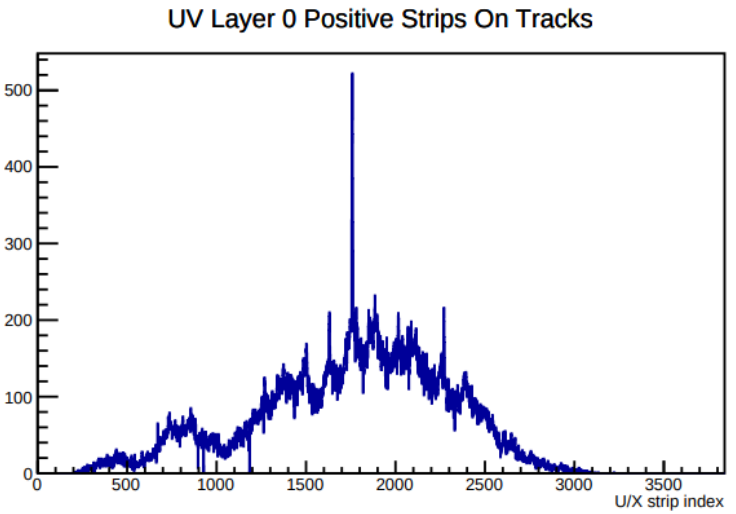
# Strip Distributions

- The left plots show many noise effects for both positive and negative, which is usual.
- When tracking cuts are added we see the negative strips retain most of the noise effects.



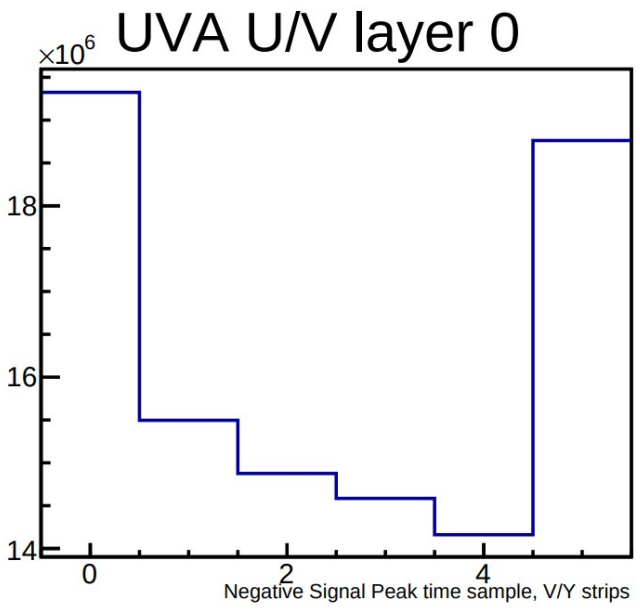



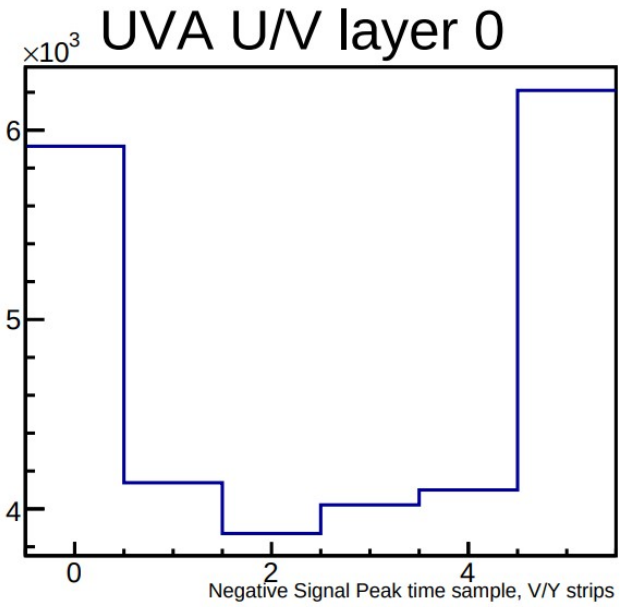
# Timing Distributions

- Negative hits on good tracks does not give a good timing distribution, peaking in the center.
- I am not sure if anything can be concluded from this distribution.

**All Negative Hits**




**Negative Hits on Tracks**



# Conclusions

- See all plots and event displays here, https://logbooks.jlab.org/entry/3986717
- Most results of negative hits on tracks point to random noise fluctuations.
  - Very basic tracking done with no clustering
  - Could be improved but would take time
- By including positive clusters in the 2D correlations, we get many “false positive” negative hits on tracks, due to negative strip frequencies being increased near positive strips.
- Visually from event displays ~3% of all events looks like they could be a negative cluster that is on a track, at 7 uA on LD2.
-