Muon Calibration Studies

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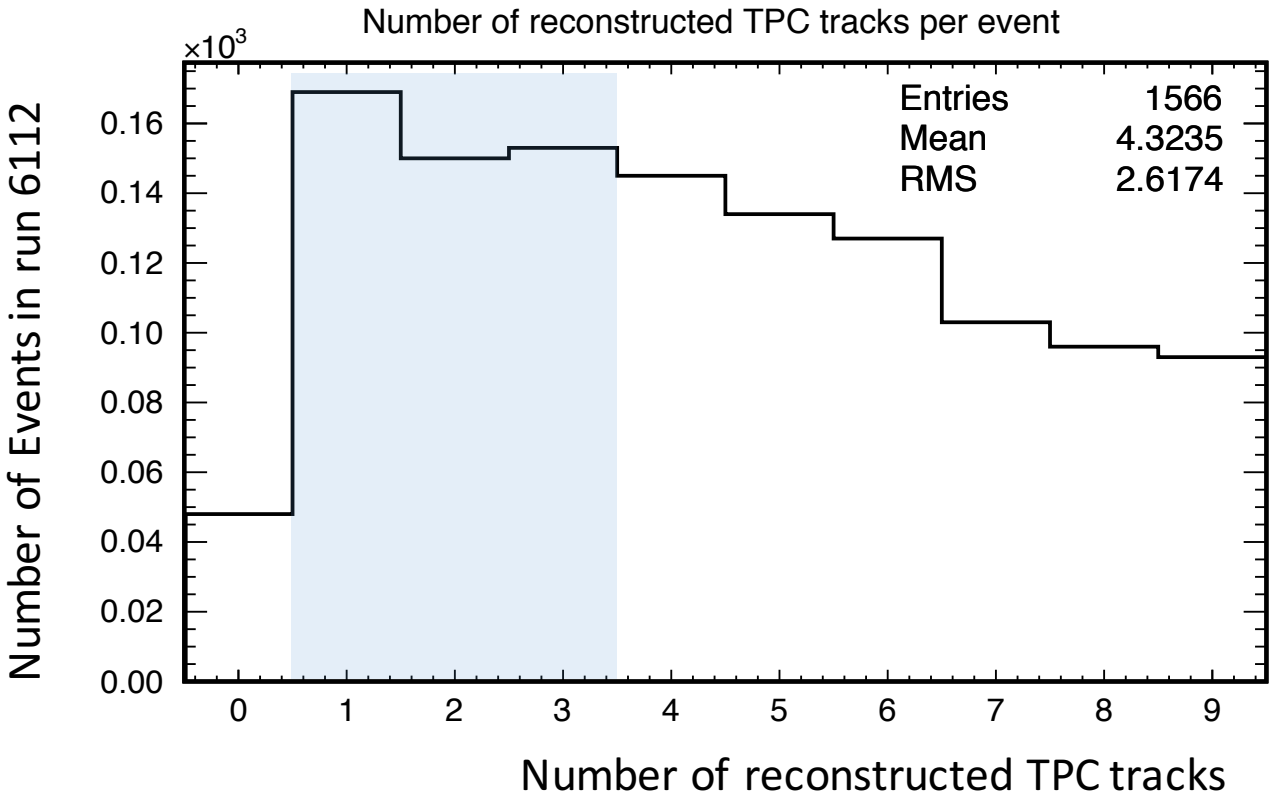
Dataset

- Used whatever Runs that I could find digits files for with SAM (amounted to runs between 3978-6380)
- Filtered to select events with BEAMON using a configuration of TriggerFilter.fcl
- Reconstructed all BEAMON events with Reco.fcl
- Quality cuts (see next slides) were on TPC data. Their aim was to select muons from all events

Quality Cuts: Number of reconstructed TPC tracks

- Cut number of reconstructed TPC tracks in the event
- Histogram is from run 6112 (chosen simply for having lots of events)
- Cut to select events with 1-3 reconstructed TPC tracks (highlighted region)

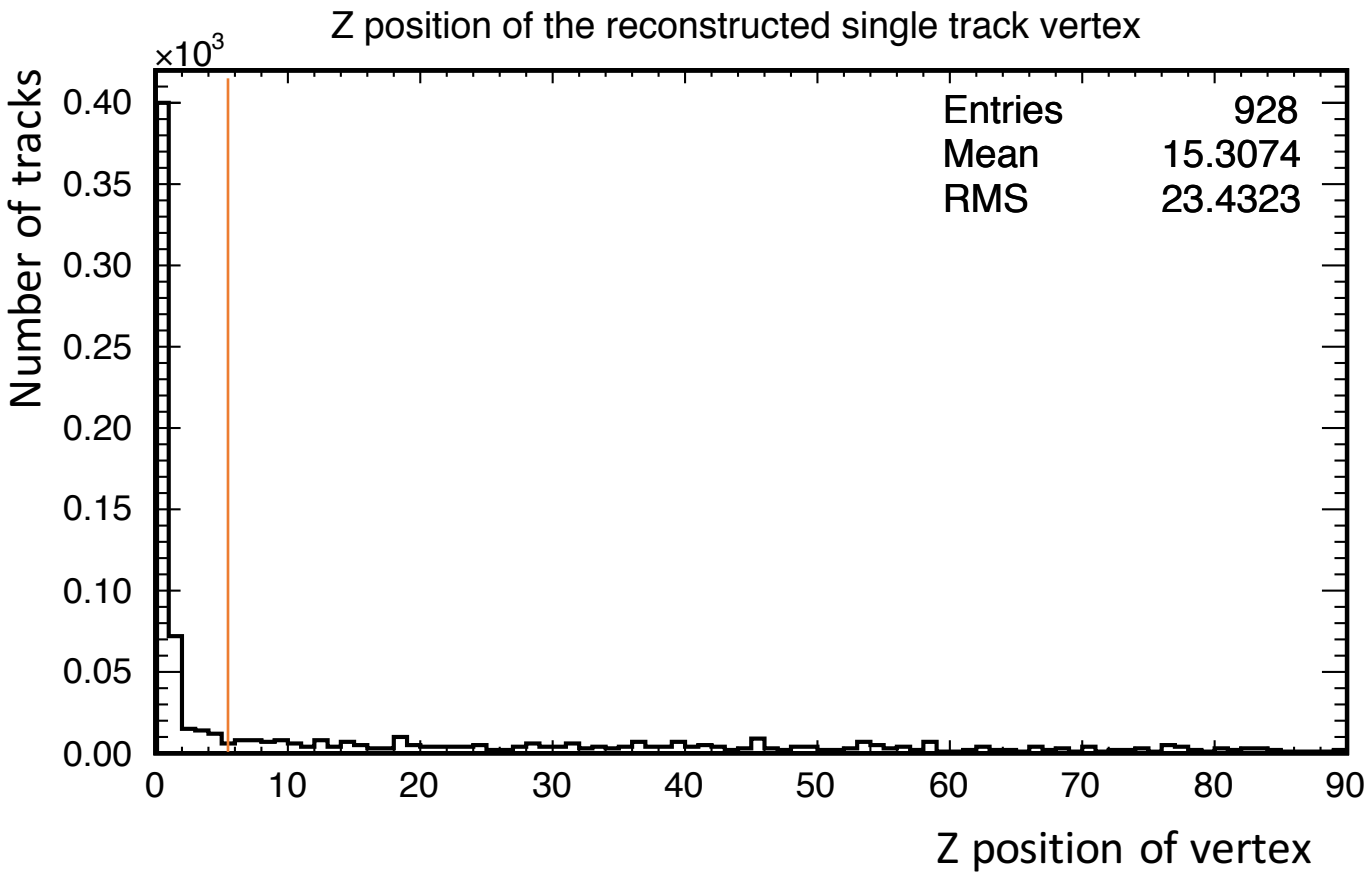


Quality Cuts: Cuts on individual tracks

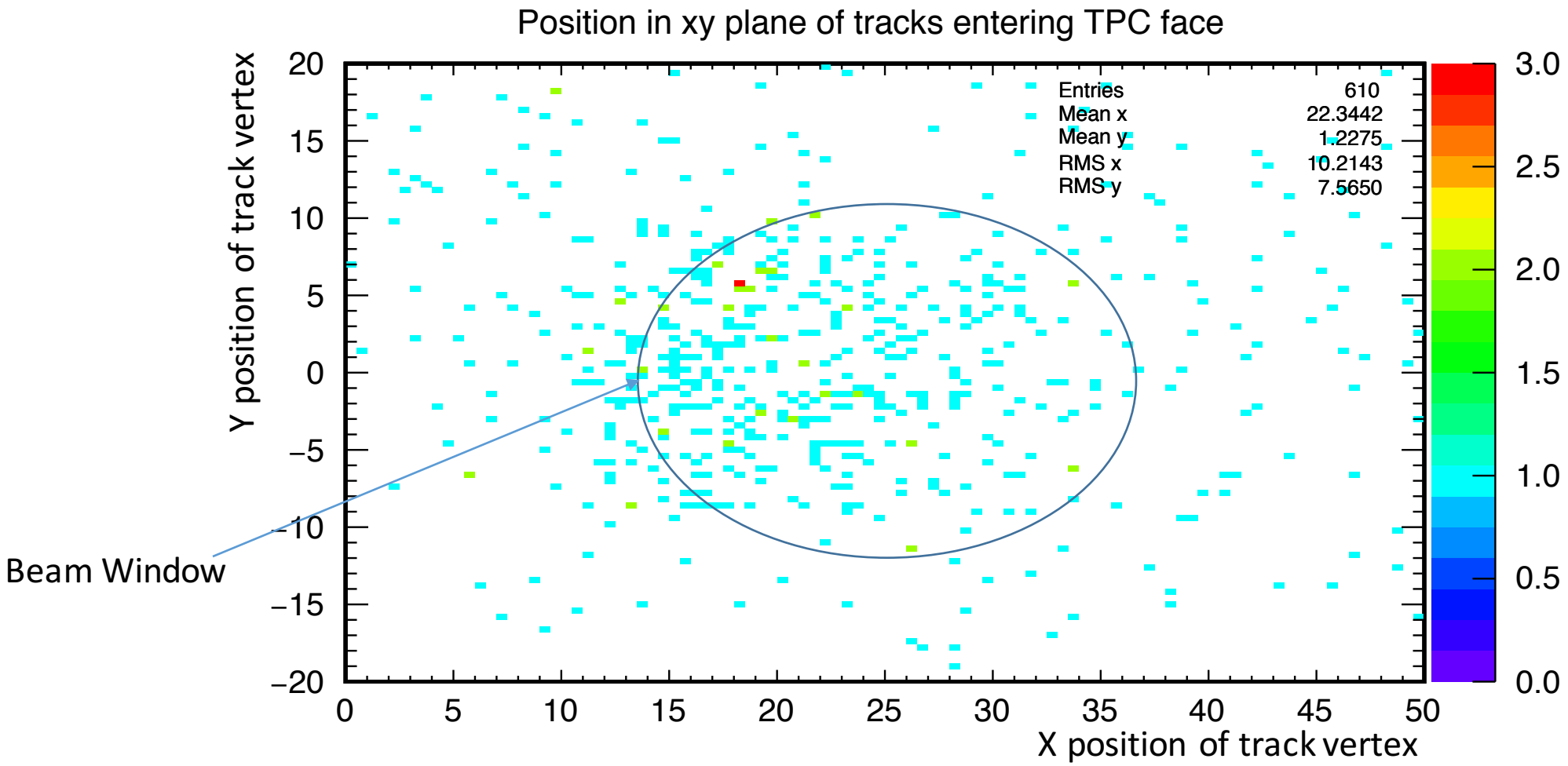
- Events with 1-3 reconstructed TPC tracks were then filtered track by track, making it possible for an event with 3 tracks to have 0-3 tracks passing the next three quality cuts

Quality Cuts: Track Vertex Z position

- Require that tracks also have a vertex in the first 5cm of the detector
- Keep only tracks to the left of this red line

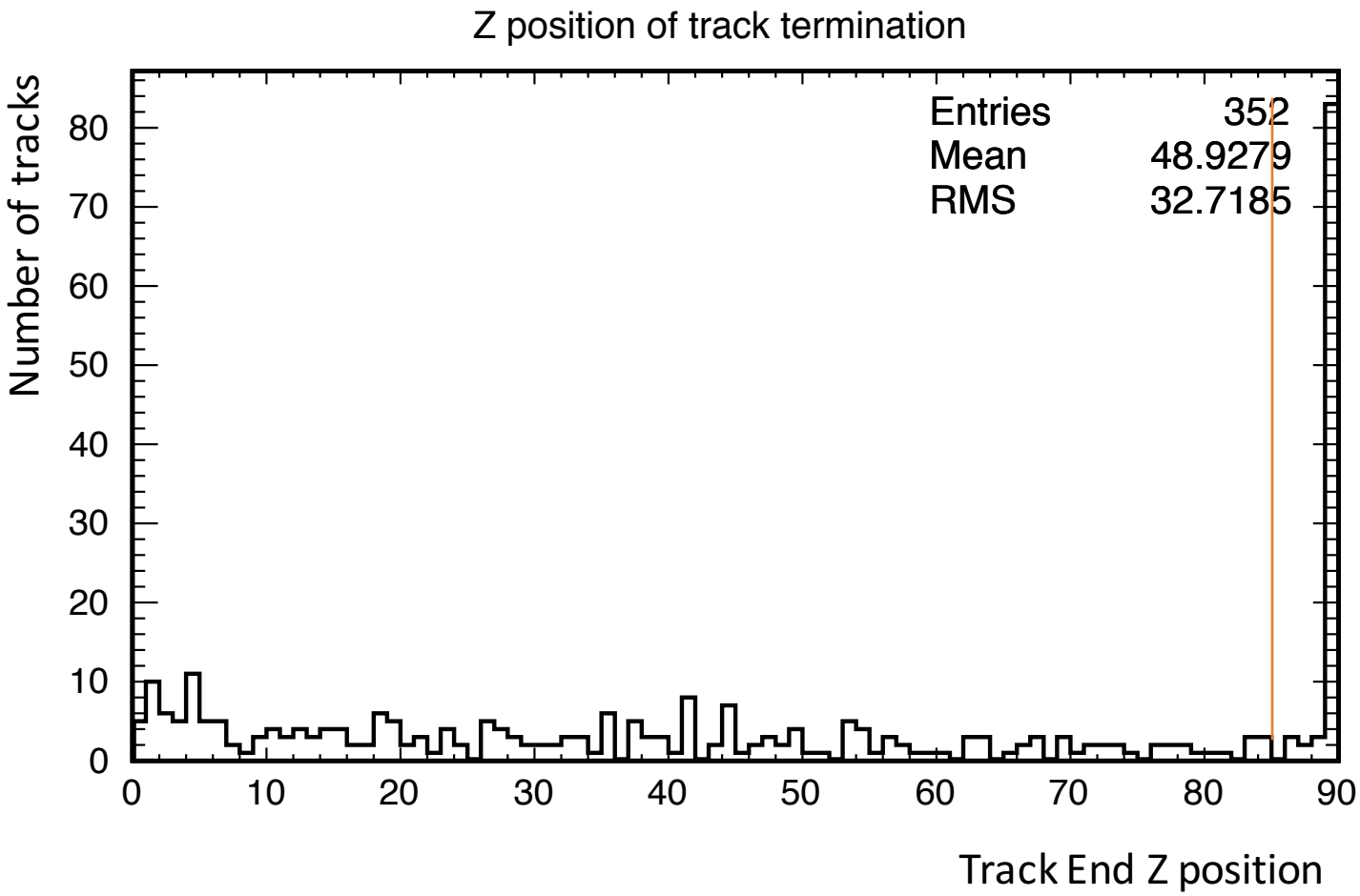


Quality Cuts: Tracks entering through beam window



Quality Cuts: Track End Z position

- Require that tracks also terminate in the last 5cm of the detector
- Keep only tracks to the right of the red line

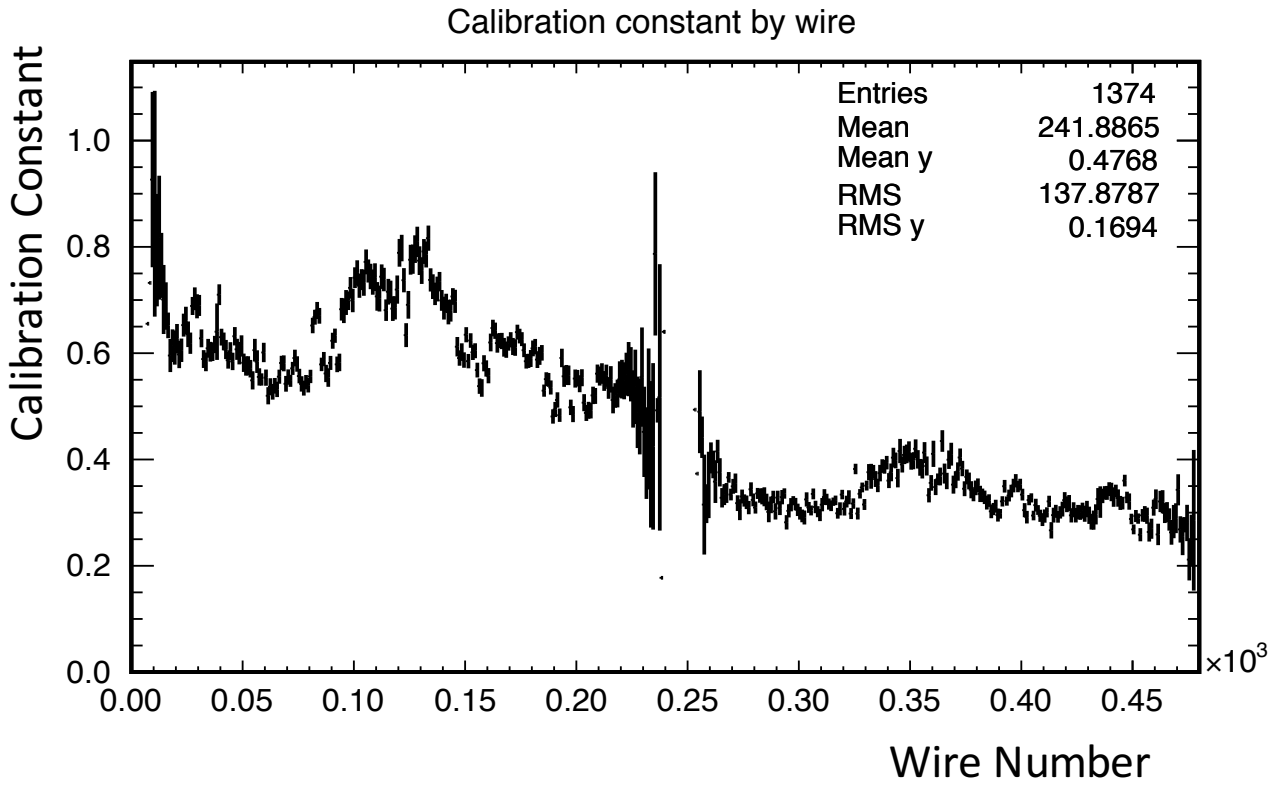


Quality Cuts Summarized

- On target, throughgoing, BEAMON, non-pileup (1-3 reconstructed tracks) tracks passed my quality cuts

Calibration Tables

- This analysis produces a calibration table for each run based on the particles selected in the quality cuts
- Calibration constant is the scale factor needed to scale the mean energy deposition on each wire to 100 ADC/mm

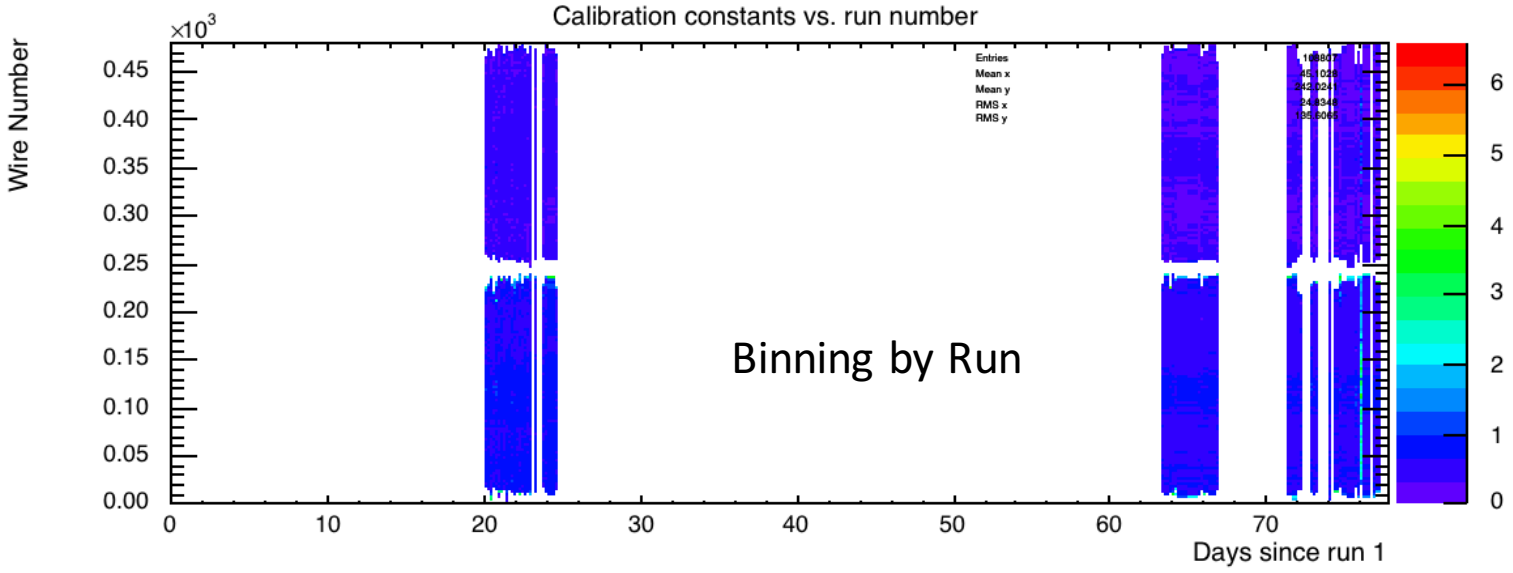


Calibration Constants over time

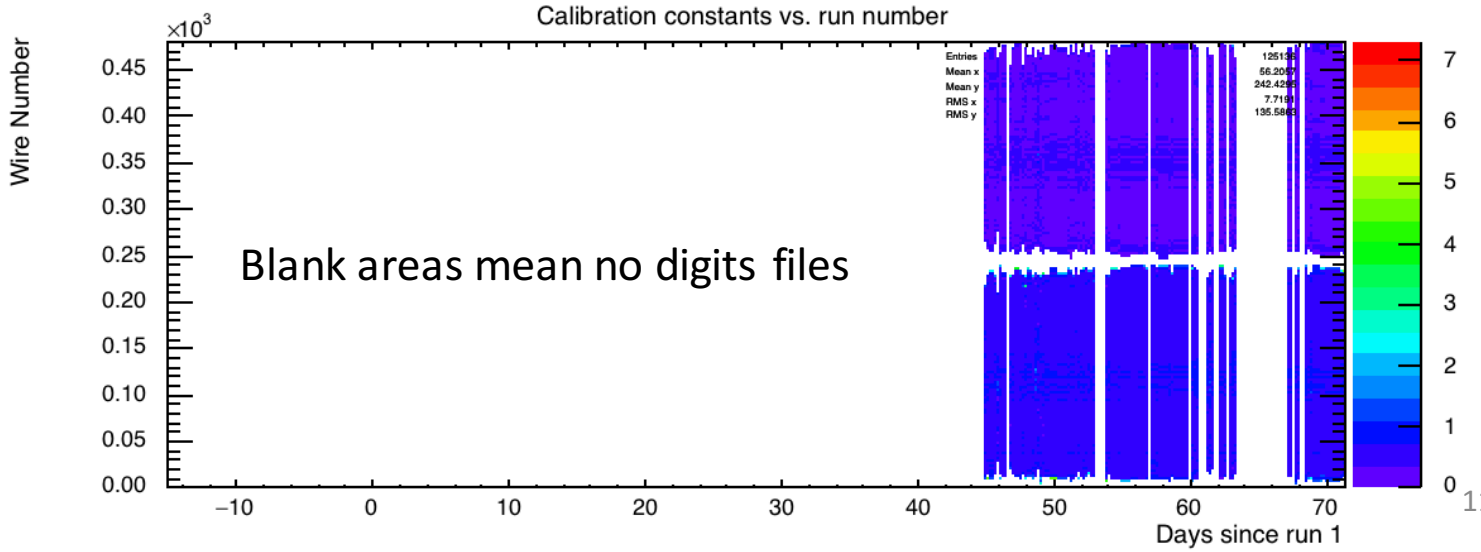
- With data spanning ~2 months we can investigate how calibration constants for a certain wire change over time
- I separated runs with positive and negative magnet currents, but can easily expand to more variables
- I will fit a graph of calibration constants over time to a constant and examine the goodness of fit to evaluate whether or not the detector response amplitude changes over time

Calibration Constants over time

Positive magnets

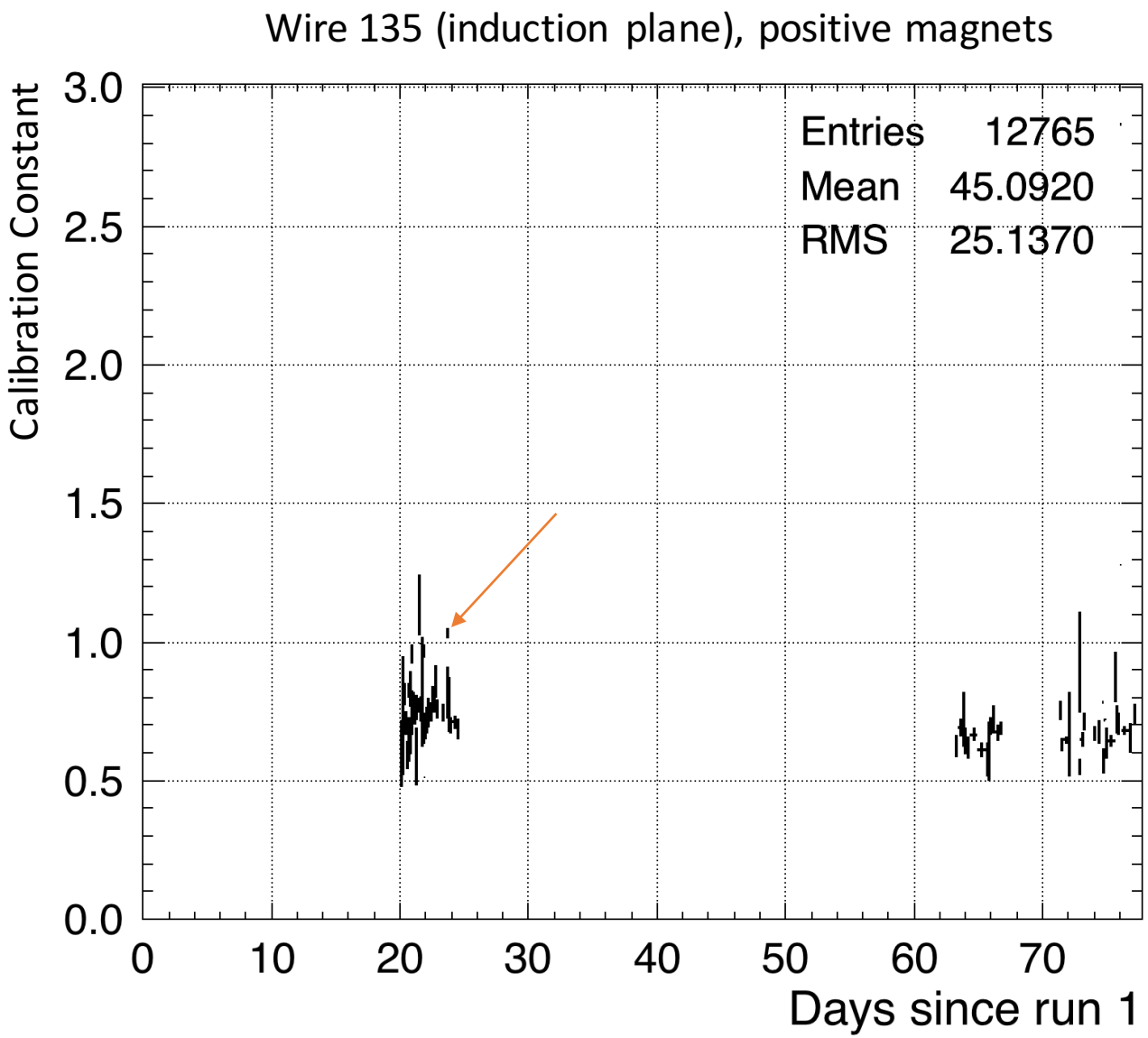


Negative magnets



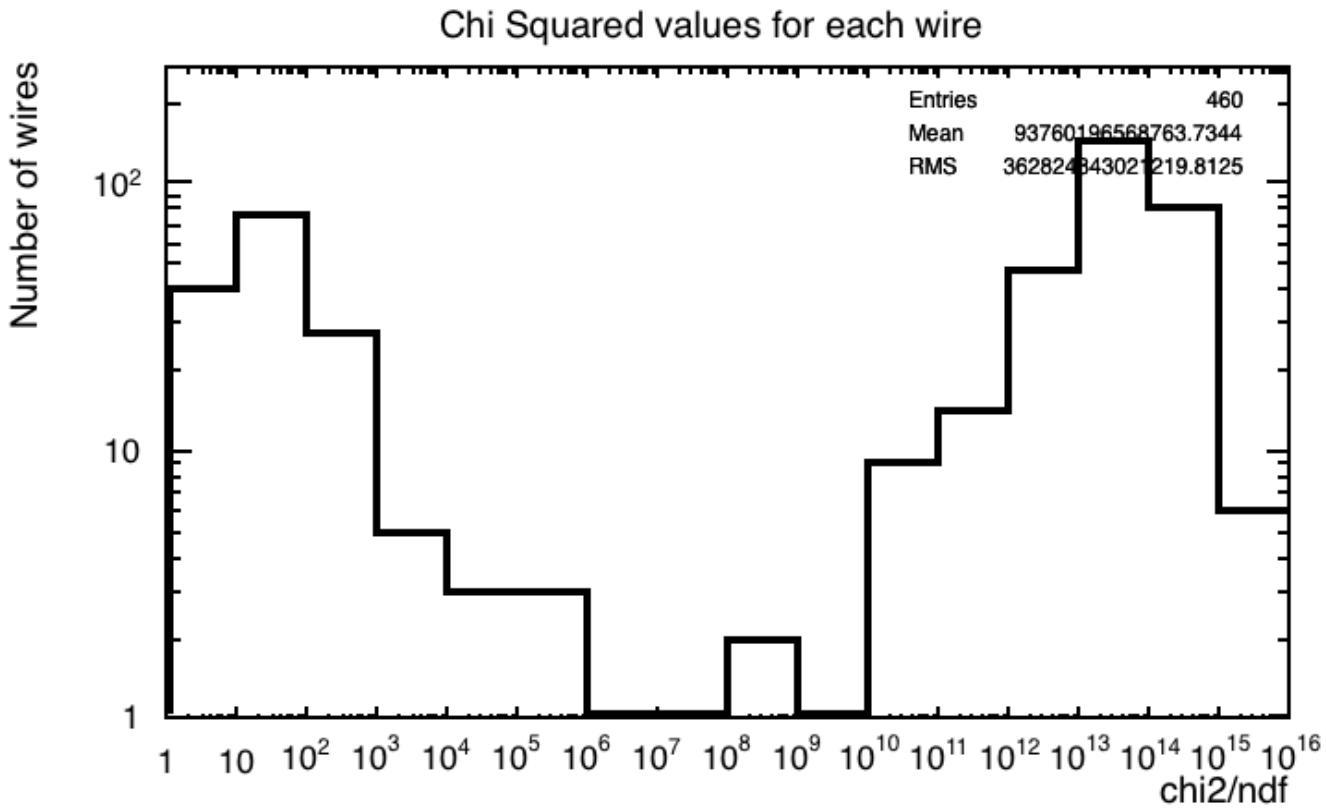
Problems with calibrating run by run

- Some runs can have both low statistics and low error if there are few particles and they happen to be very similar in energy deposition
- This example is a run with 2 identified through-going tracks



Problems with calibrating run by run

- Runs with low statistics and low error cause huge values for chi^2/ndf (on the order of 10^14), implying no stability in detector response over time
- However, adjusting our binning will remove this effect

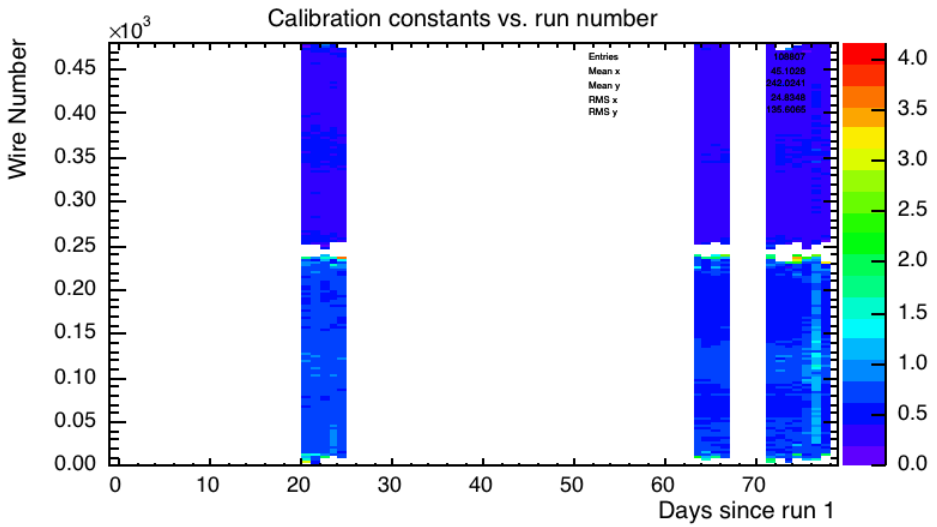


Alternatives to calibrating by each run

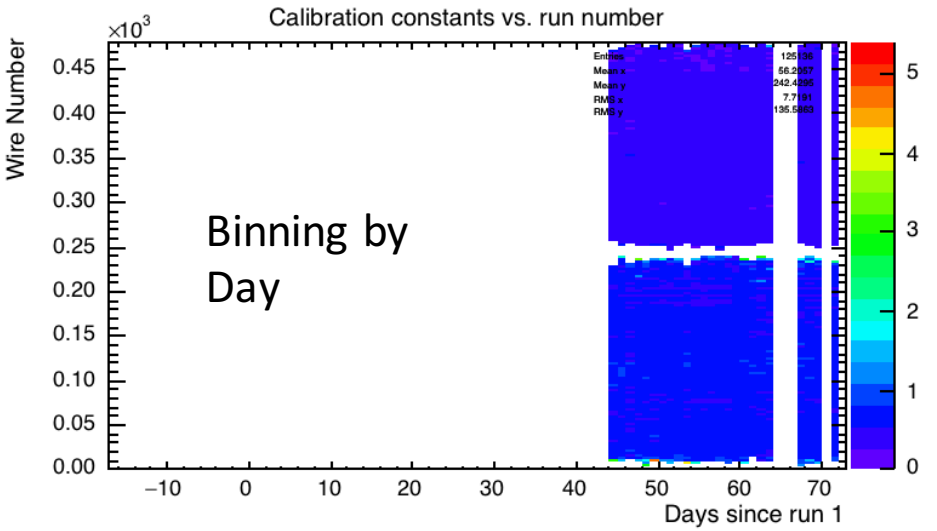
- We need a solution that ensures that calibration constants are only produced with sufficient statistics to back them up. Some options are:
  - Do not produce calibration constants for short runs
  - Produce a constant for a set number of particles
  - Produce a constant for a set amount of time (which I will pursue)

Calibration Constants over time – daily binning

Positive magnets

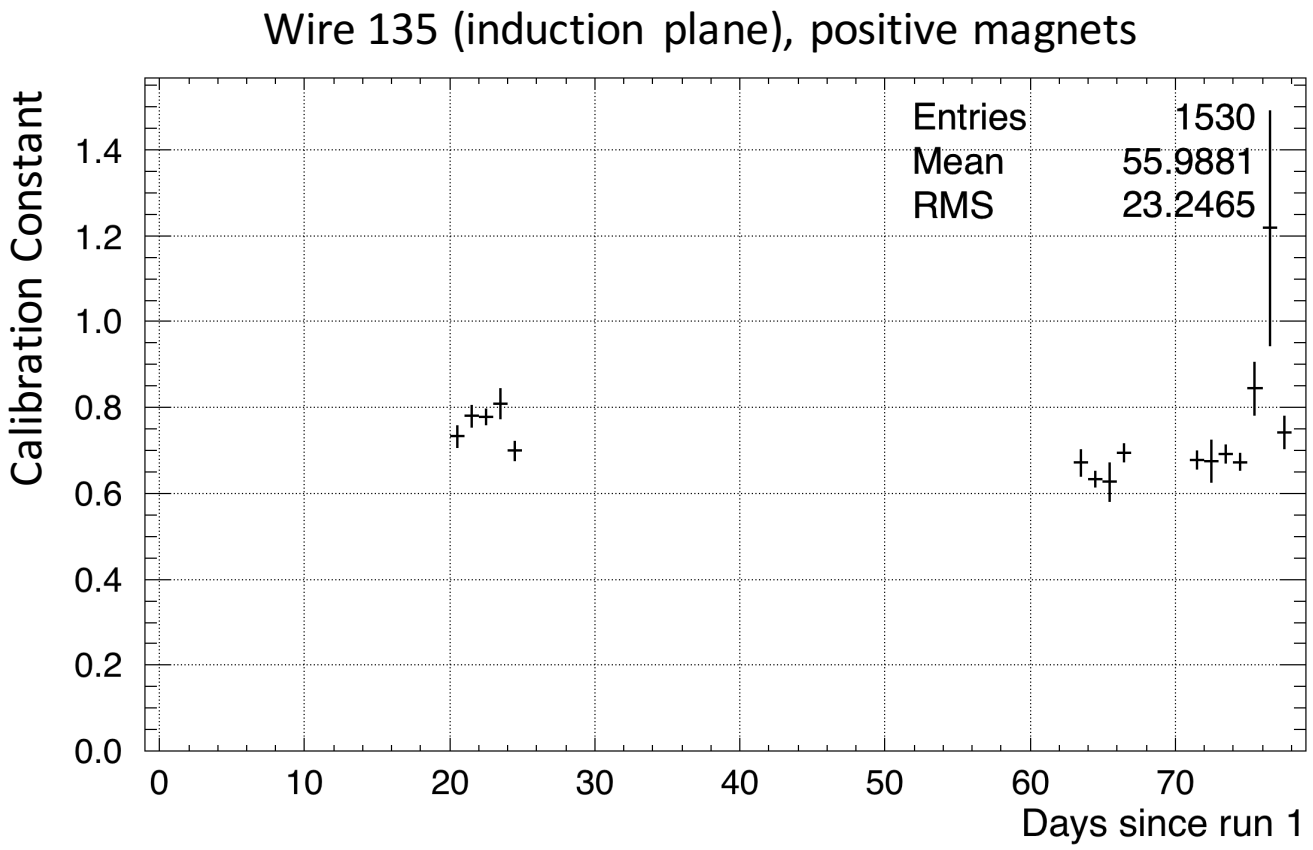


Negative magnets

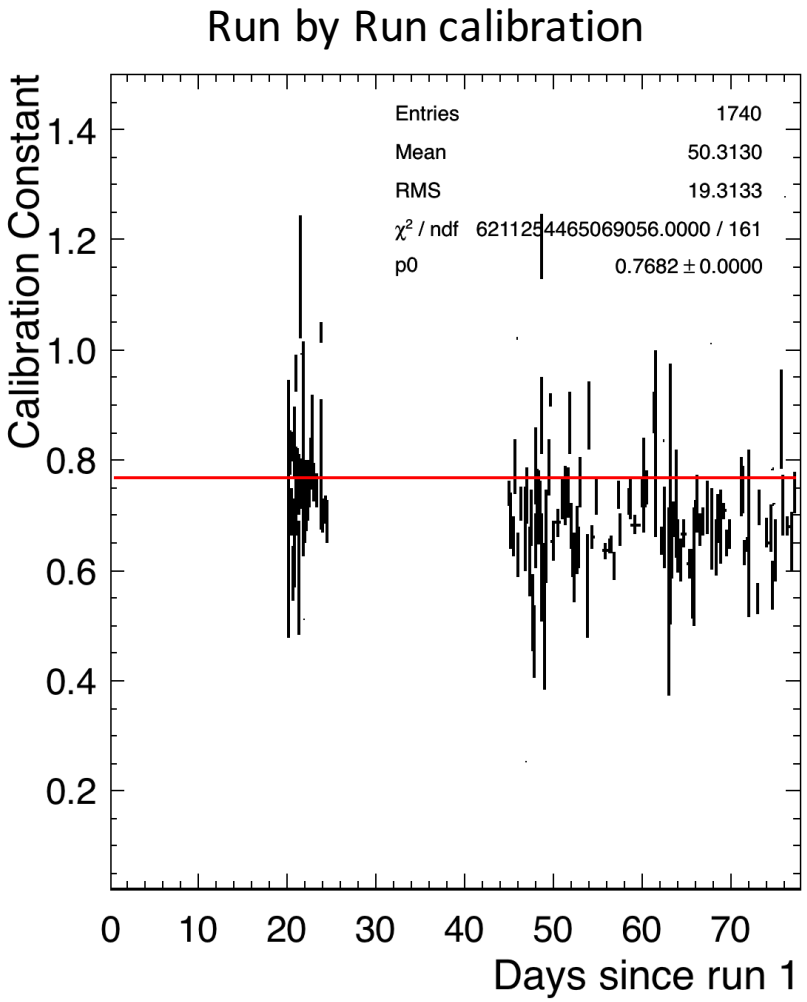


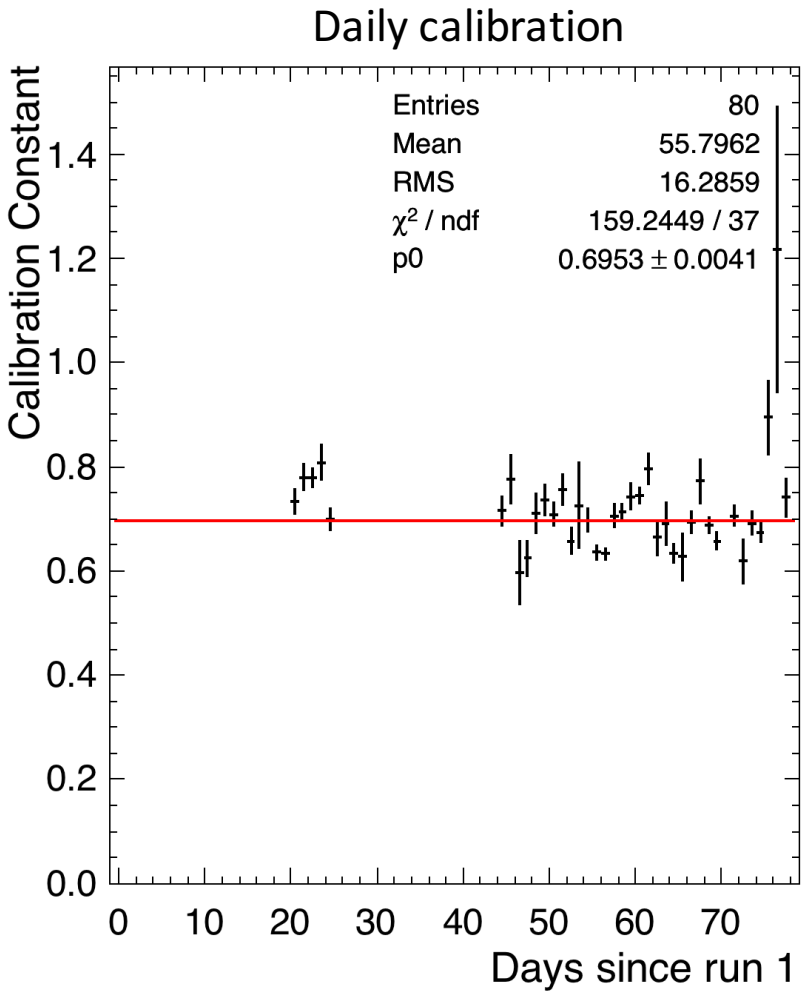
Calibration Constants over time

- Binning by a set time interval (daily binning shown here) means it is much less likely that a bin has low statistics paired with small error bars
- Reduces chi^2 of a constant fit by a factor of 10^13



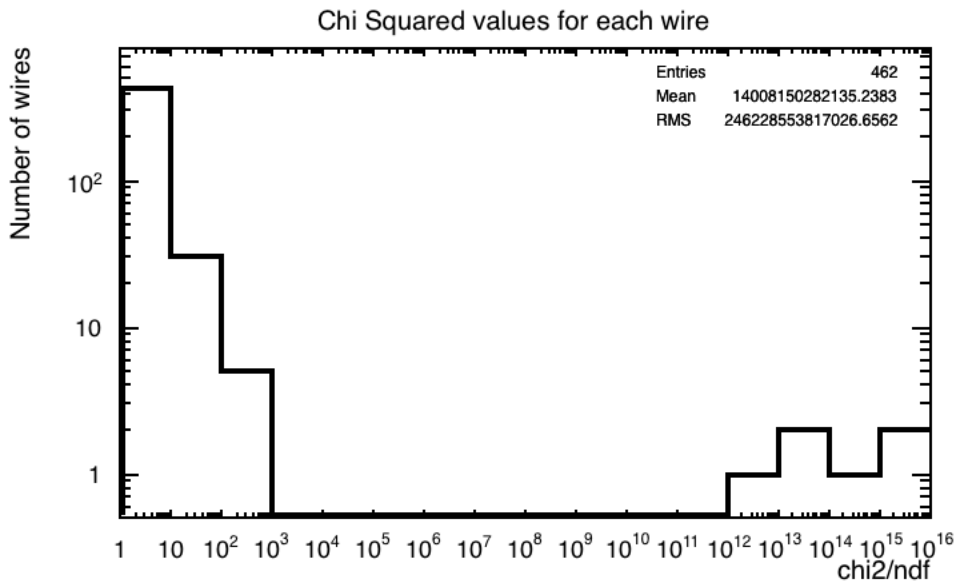
Improvements seen with daily calibration





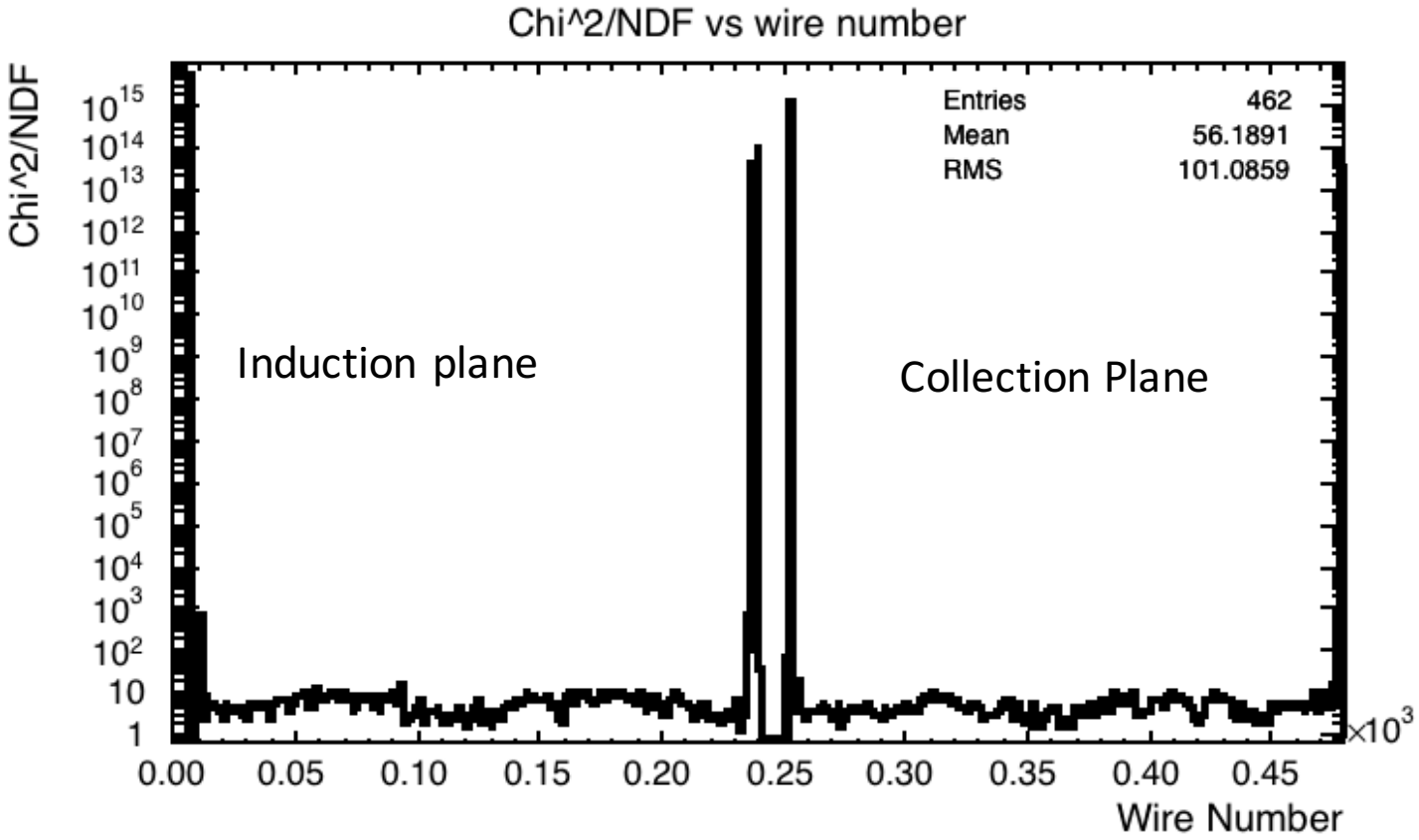
Improvements seen with daily calibration

- Now only 6 wires are outliers
- These wires have low statistics and are in the corners of the detector (see next slide)



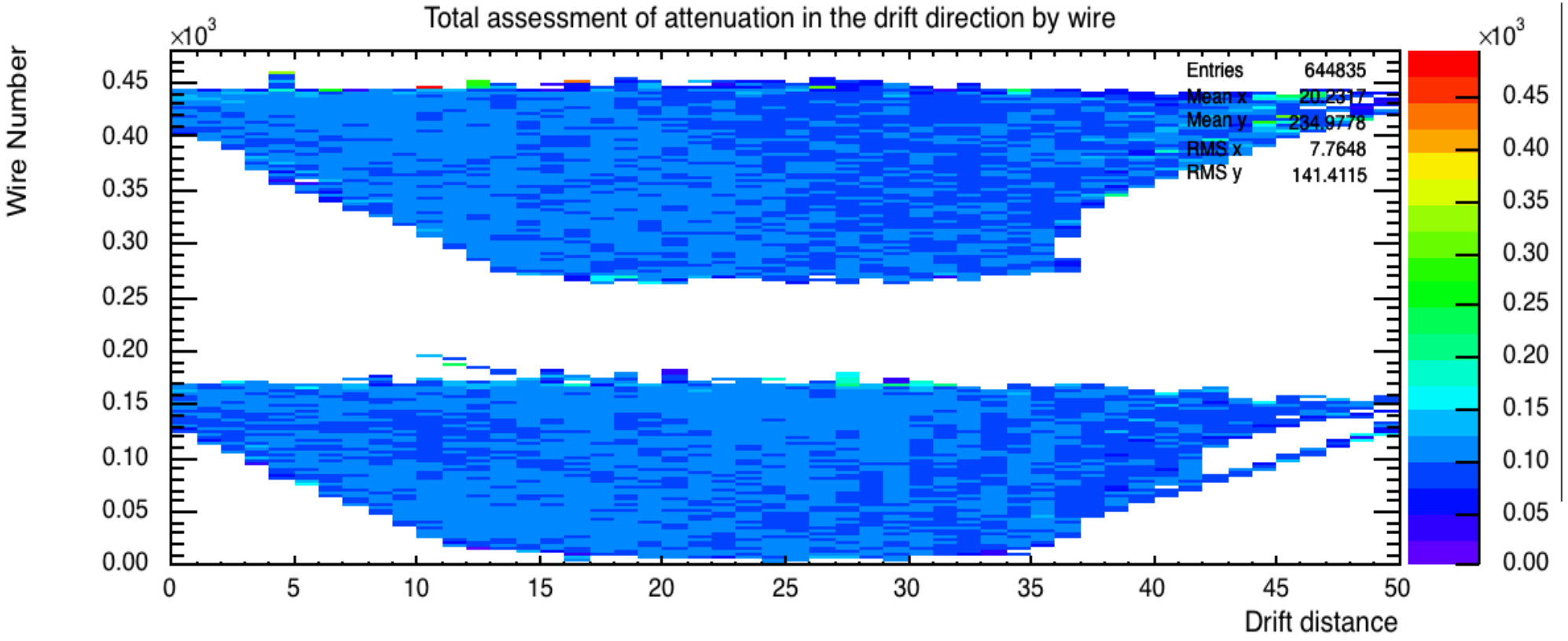
Improvements seen with daily calibration

- The wires that have large chi^2/ndf are in the corners of the detector



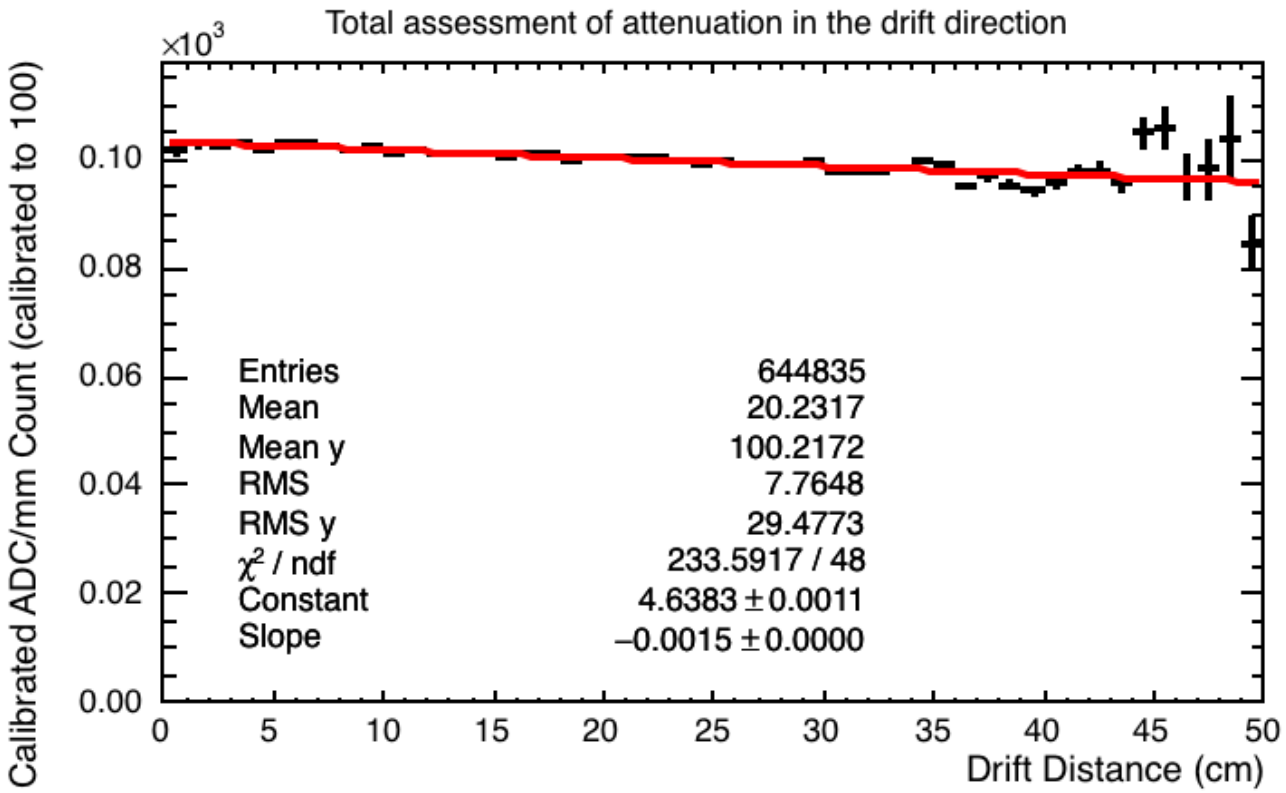
Attenuation Correction

- Currently no attenuation correction is applied in this analysis. All wires are calibrated by the mean energy deposition they see.



Attenuation Correction

- This implies an apparent electron lifetime of 4192 +/- 126 microseconds
- We believe that this is result of using events with multiple tracks in the analysis



Conclusions

- Calibrating run by run leaves us vulnerable to runs with low statistics that have ~10 subruns.
- Calibrating with a constant time interval demonstrates that the detector response amplitude is fairly constant over time, even when only controlling for magnet current and not for incident particle momentum
- Our attenuation fit implies a much longer electron lifetime than any measurements to date (more than 5x ArgoNeuT)
- I will continue to investigate attenuation with only single tracks to see if the lifetime is more consistent with previous measurements