A look at LAr lifetime from cosmic rays

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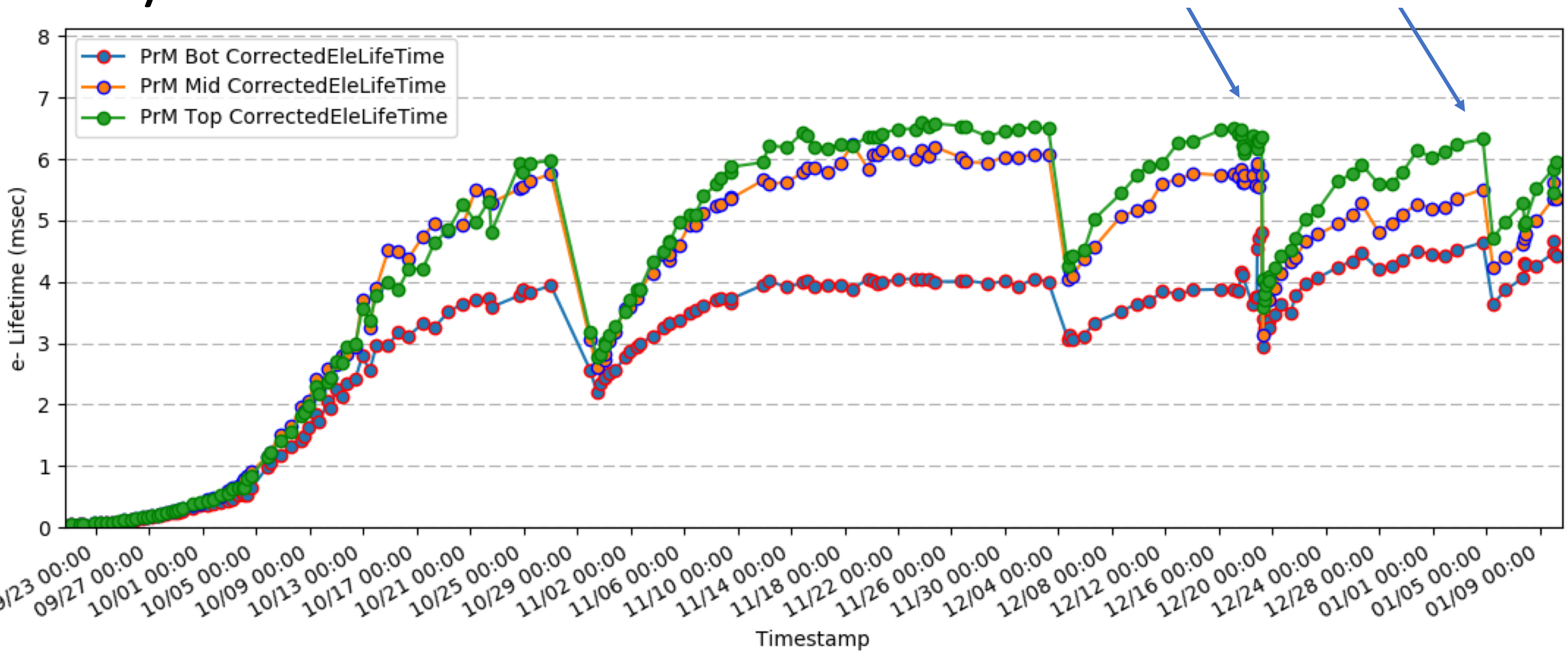
LBNL

2018-01-23

Purity monitor data



Things to look into:

- Comparison to purity monitor data over time
- Deviations across APA, vertical position, and finer binning (if possible)

Techniques

Two approaches:

- Single track analysis - 1 lifetime fit : 1 track
  - Pros: Many lifetime fits, better time resolution (each track is an instantaneous measurement)
  - Cons: Lower quality fits, fundamentally limited by intrinsic track dq/dx deviations
- Aggregated track analysis - 1 lifetime fit : many tracks
  - Pros: Less susceptible to dq/dx deviations, better quality of fit
  - Cons: Must bin detector/run into x,y,z,t to aggregate, requires good t0-tag

I’ve been working on both of these, though this presentation will be mostly on the single track analysis

Single track analysis

Select tracks that are:

- Through-going
- Large x-dim (time) length
- Large number of hits

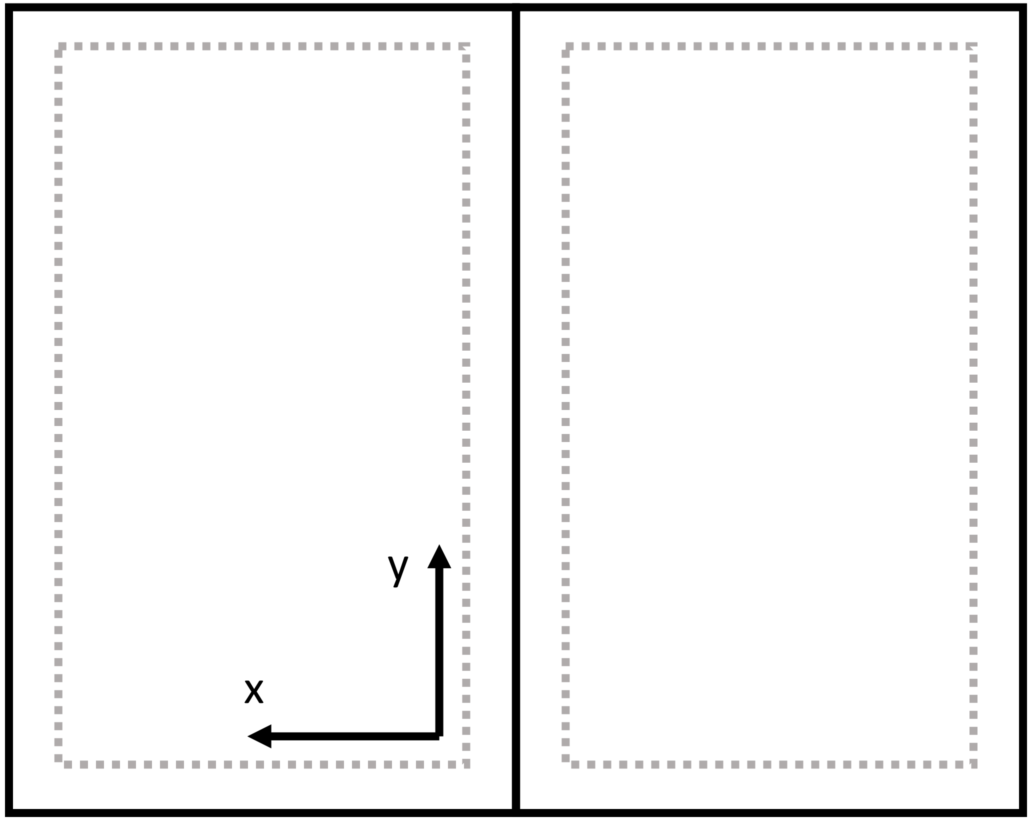
With the track:

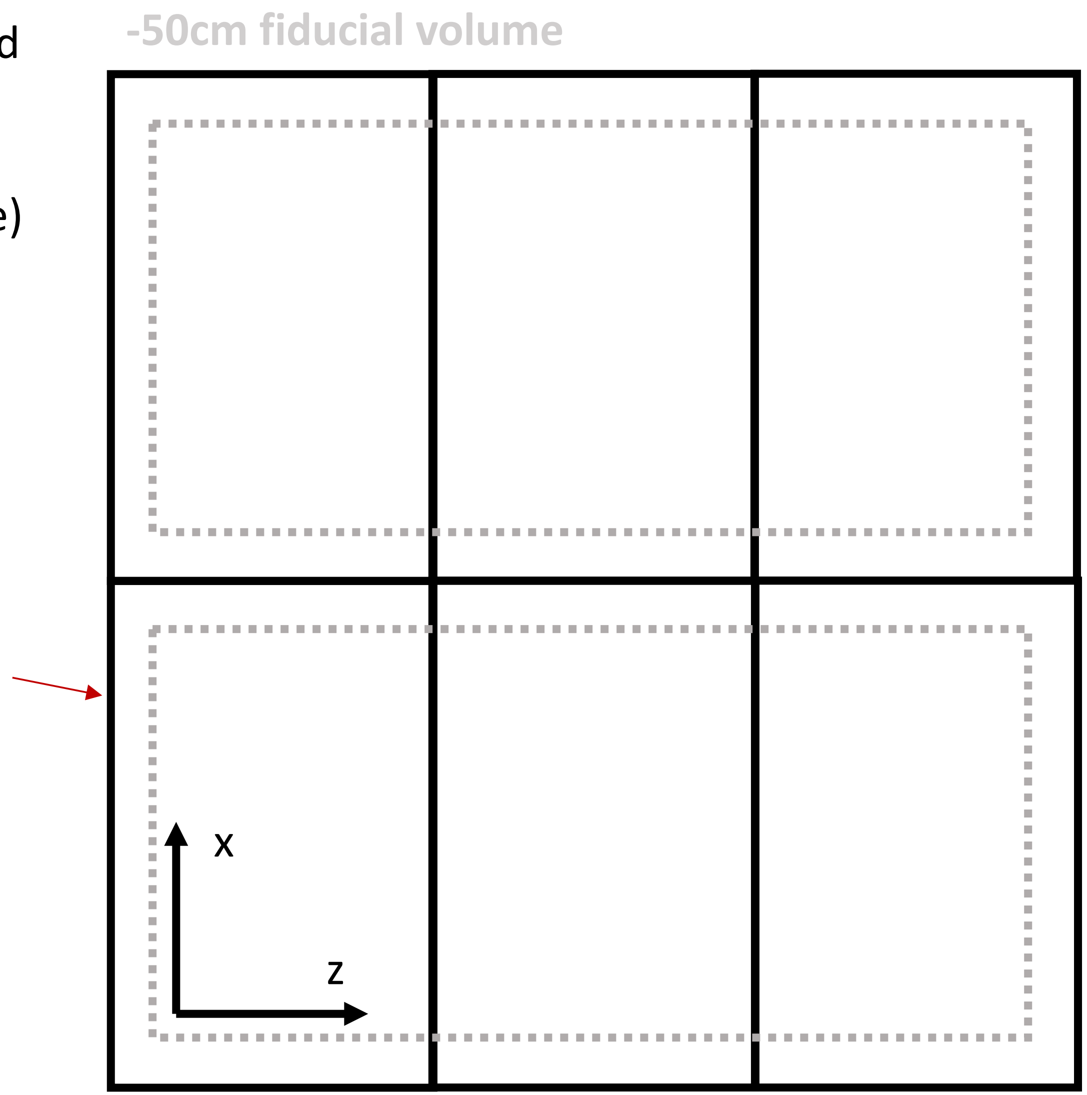
- Exclude hits outside of a fid. volume
- Fit the median dqdx in 10cm x-dim bins to an exponential decay

Track selection fid. volume

Limit track distortions due to edge effects near TPC field cage and cathode

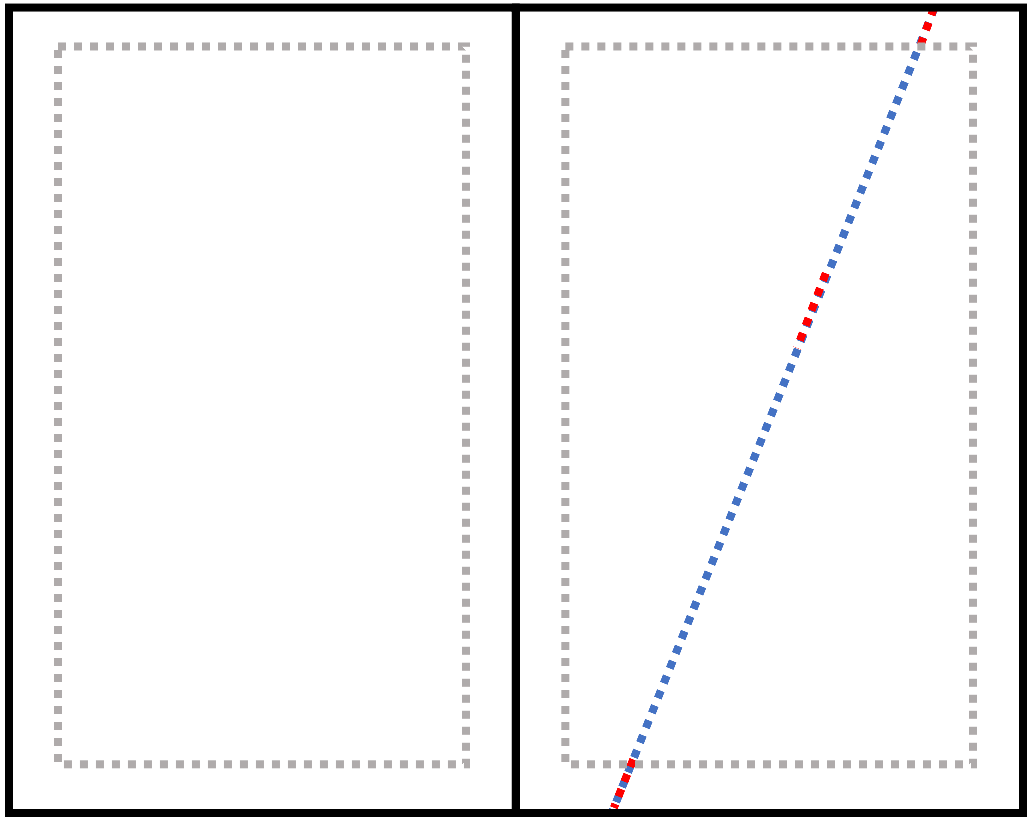
- Err on the side of caution (50cm)
- Might be able to get away with a smaller cut (esp. near anode)

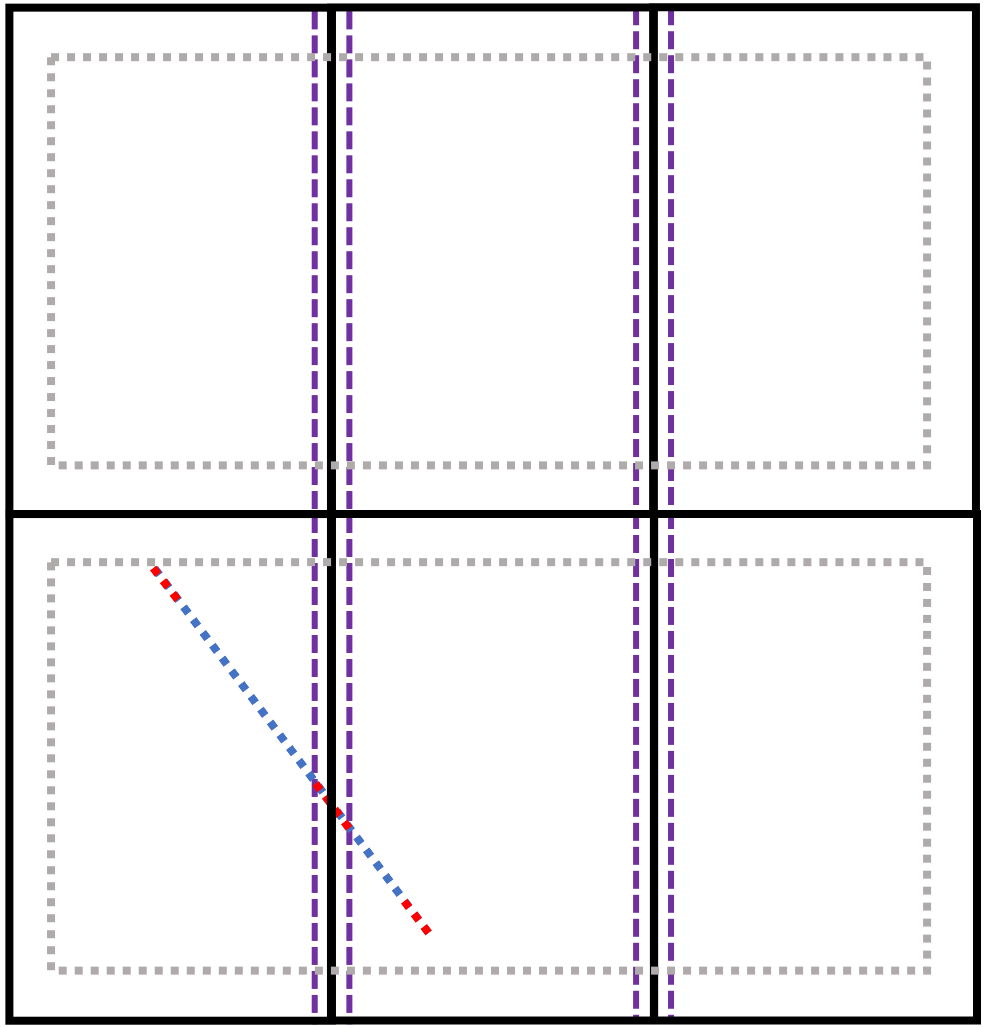




Hit selection

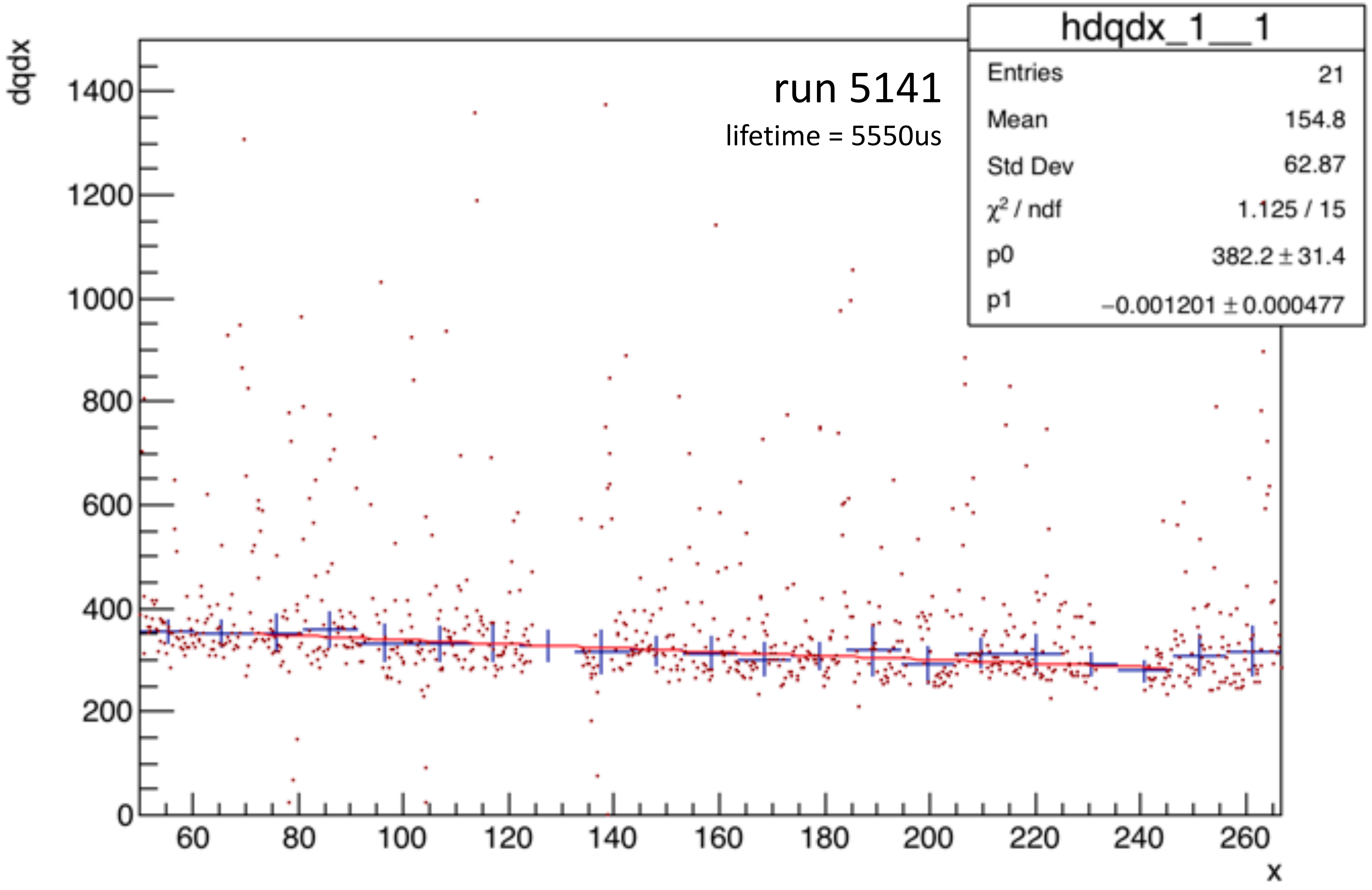
Exclude hits outside of fid. volume and near APA boundaries



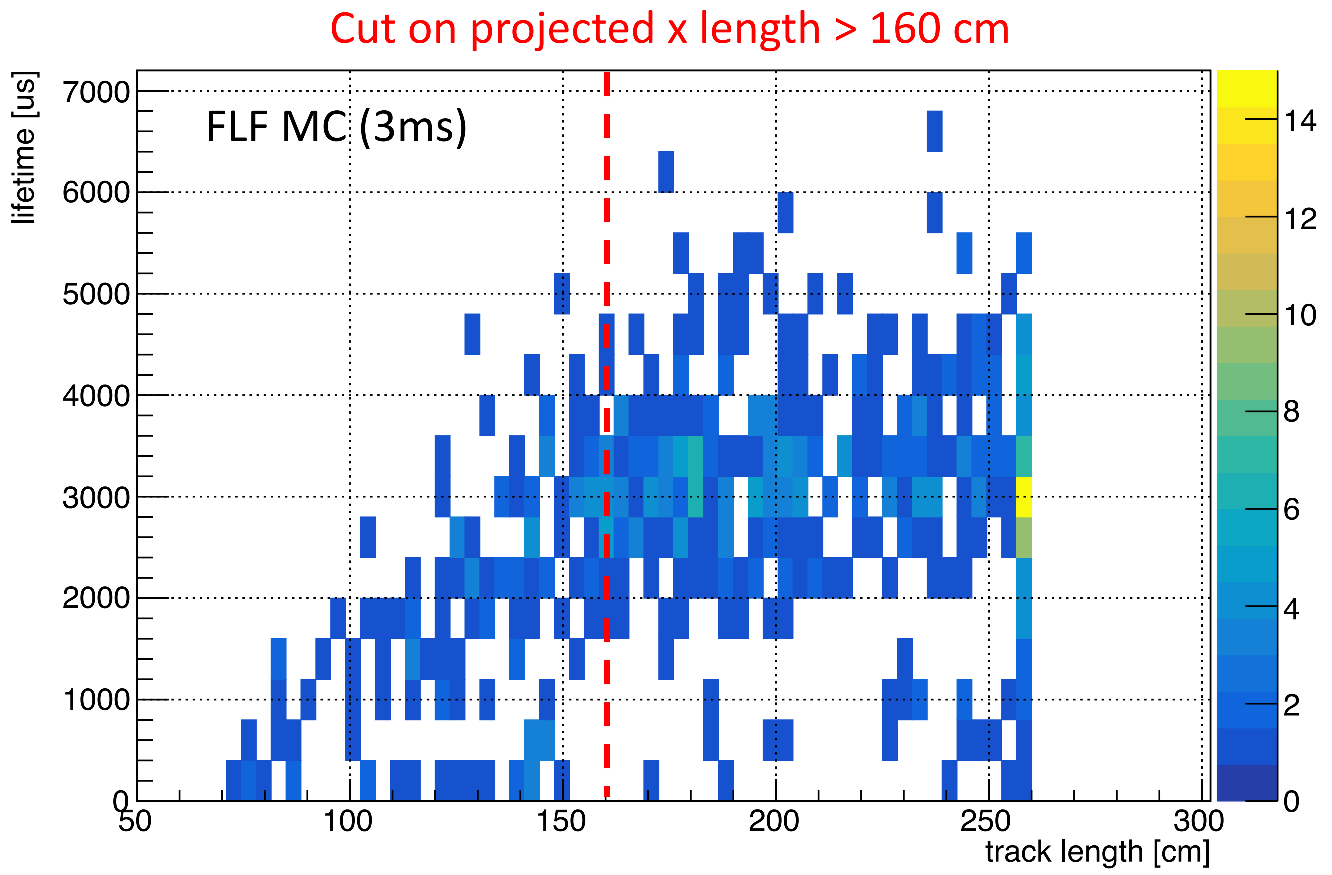


Example track fit

- Track is binned in 10cm segments
- Hits falling into ±10cm electron diverter region are excluded
- Within each segment, the median dqdx and the median deviation of the dqdx is used for bin value and weight
- Fit is simple exponential

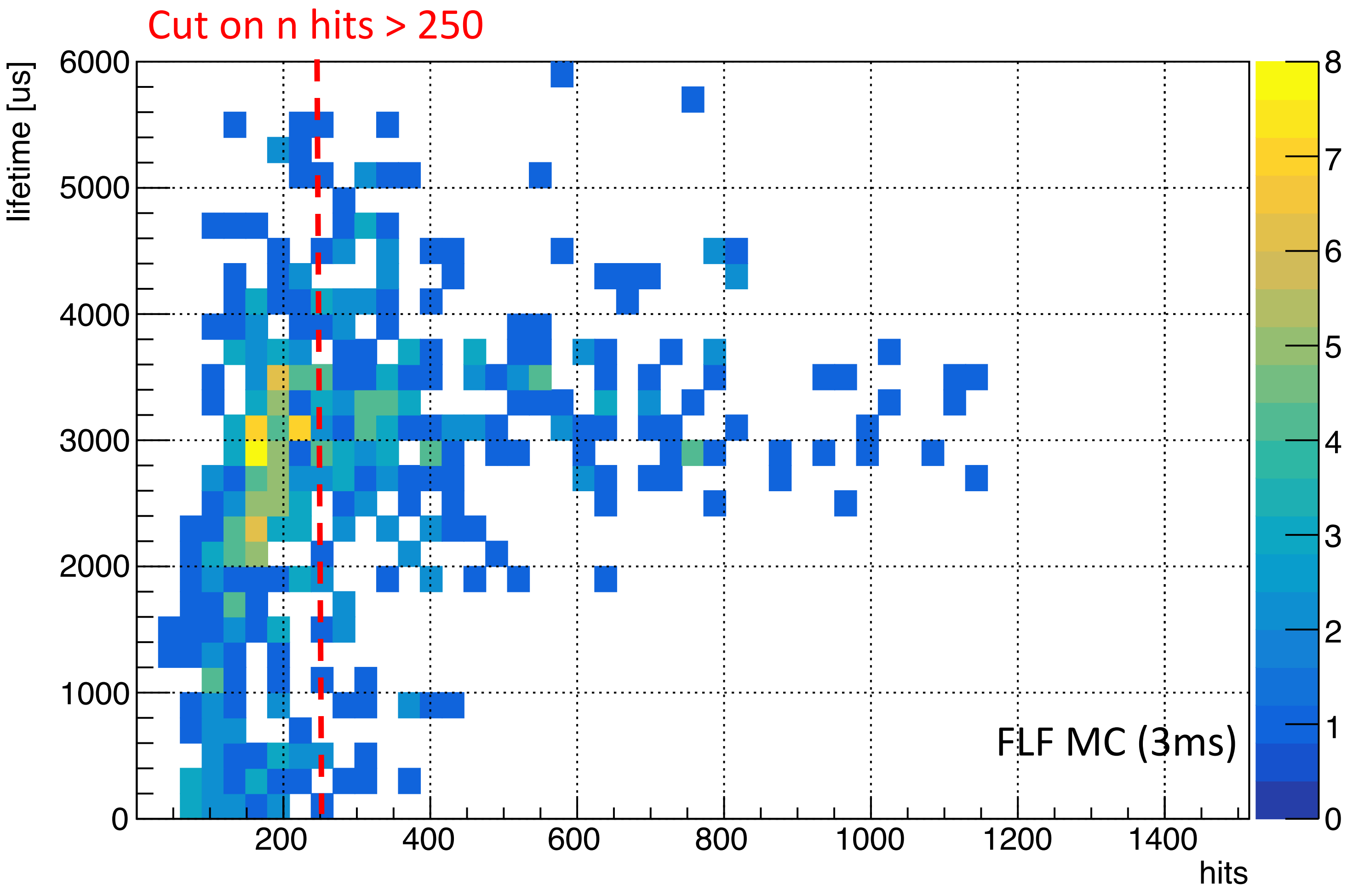


Track selection



Short x-length tracks are biased towards shorter lifetimes

Track selection

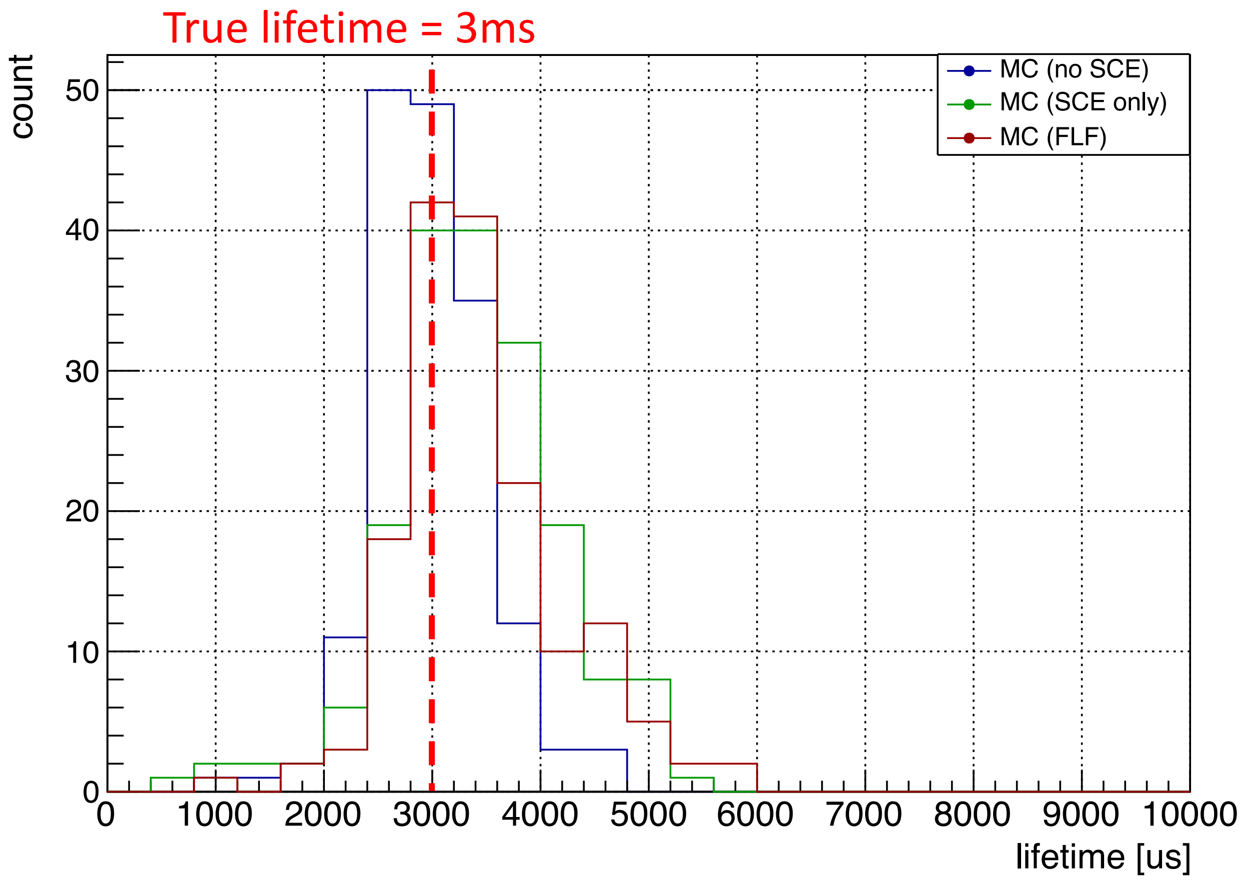


Tracks with fewer hits are more susceptible to dq/dx fluctuations

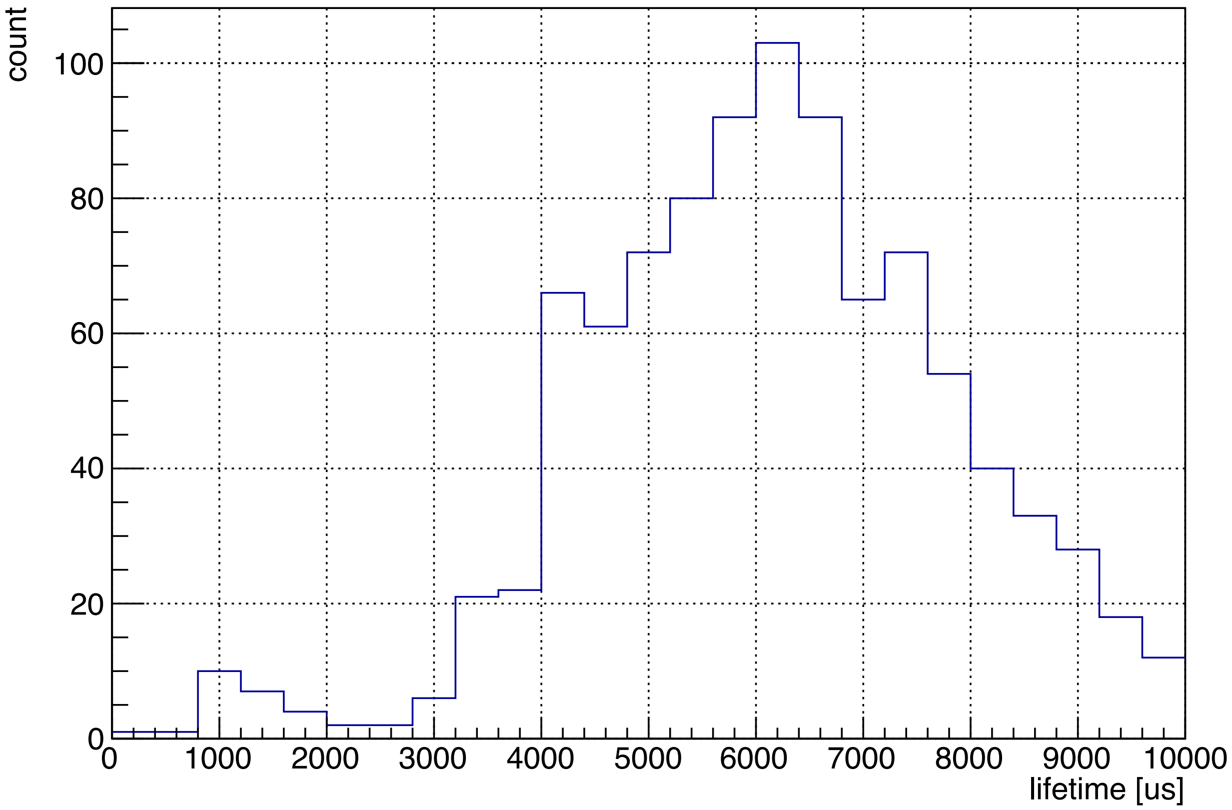
Verification of method using mcc11

Proof of principle using MC samples
- SCE biases towards slightly longer lifetimes
- While this works well at 3ms, will it hold up at 6ms?

Dataset (mcc11)	Mean lifetime [us]	Std lifetime [us]
3ms 1GeV + 3ms -1GeV	2980	530
sce 1GeV + sce -1GeV	3400	780
flf 1GeV + flf -1GeV	3450	760

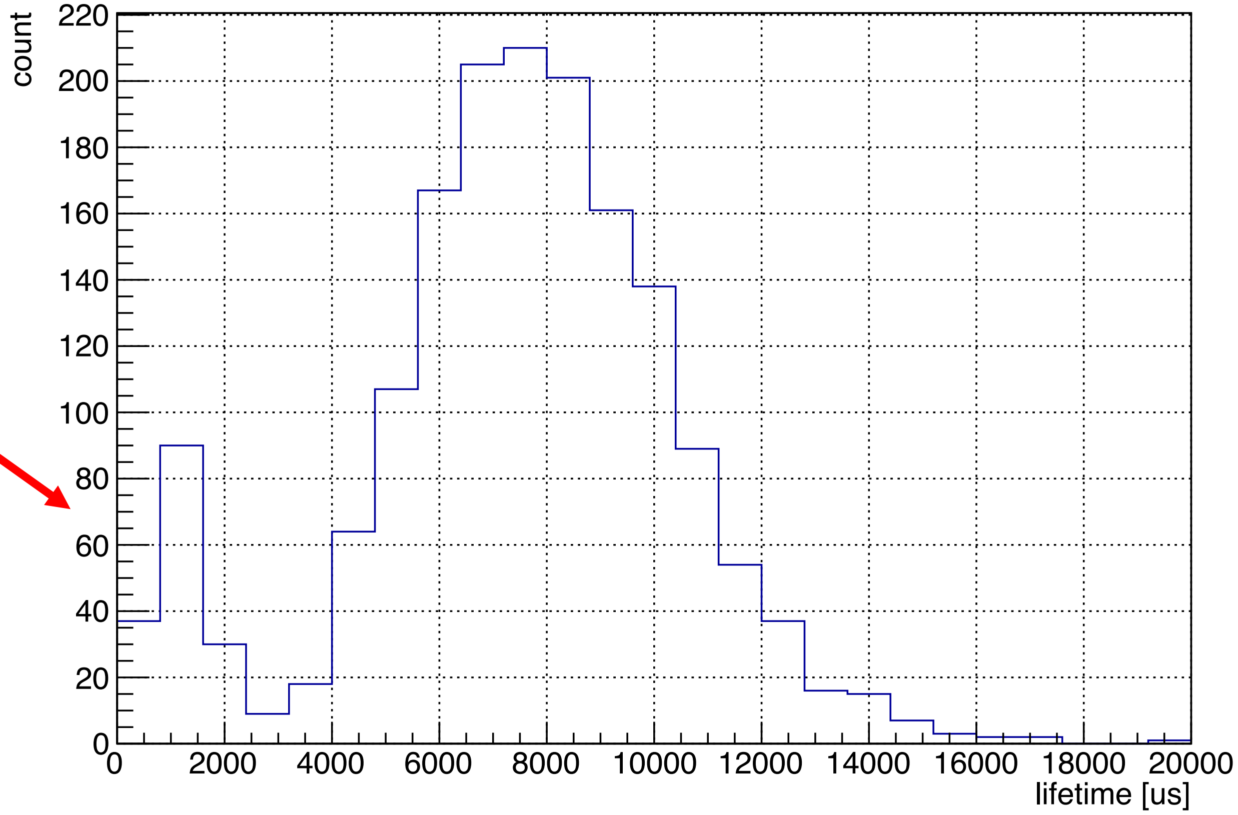


run 5141 (the good)

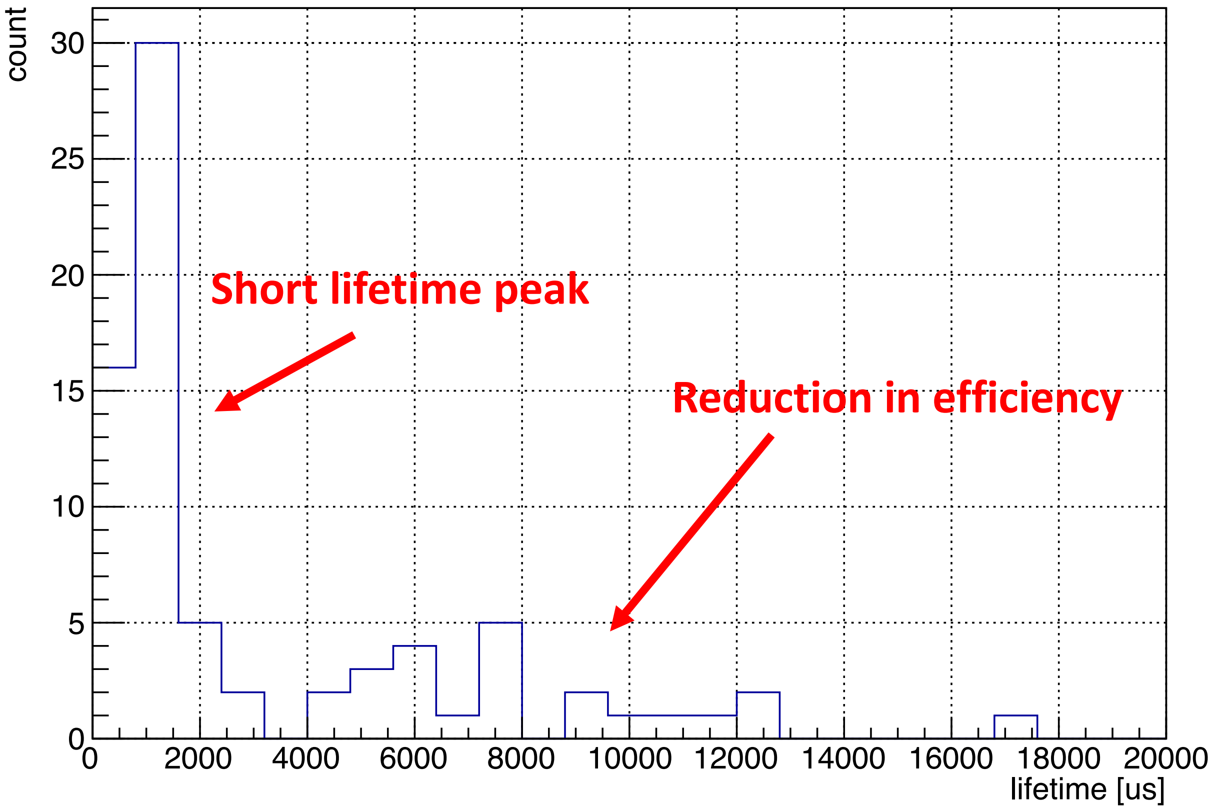


run 5759 (the bad)

Short lifetime peak



run 5442 (the ugly)



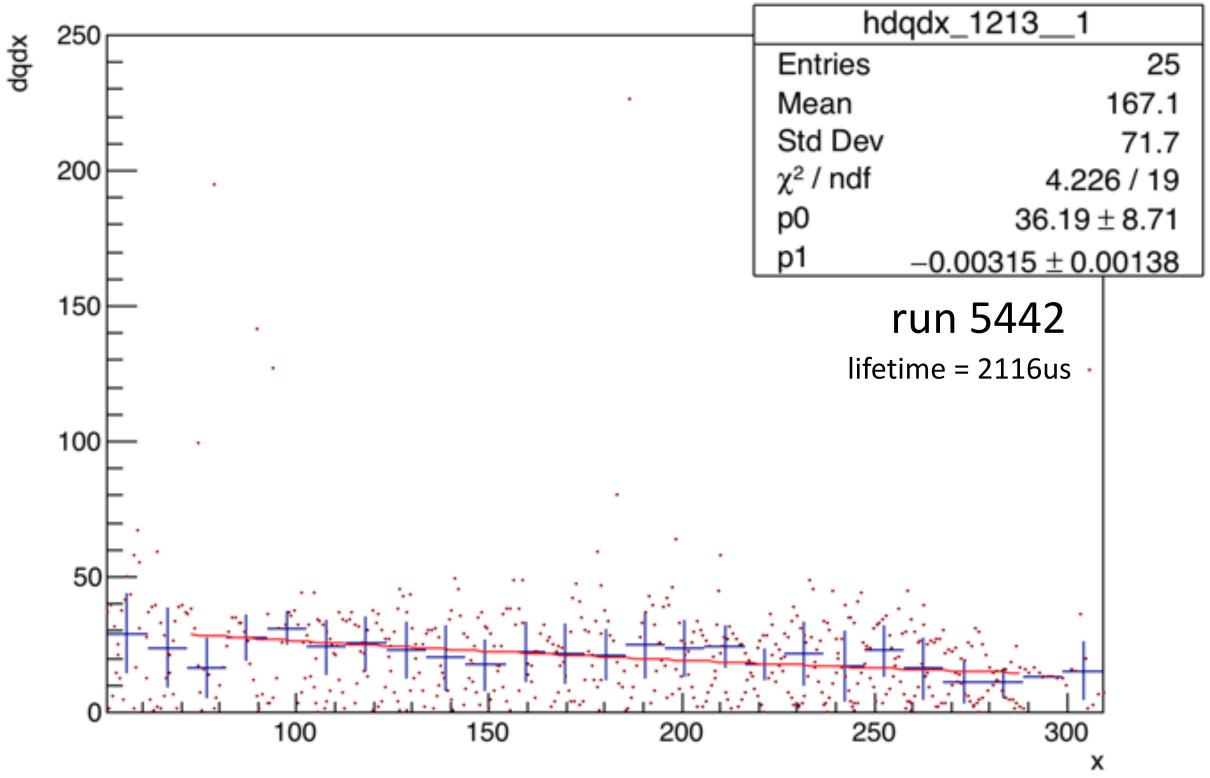
What is going wrong?

Two things:

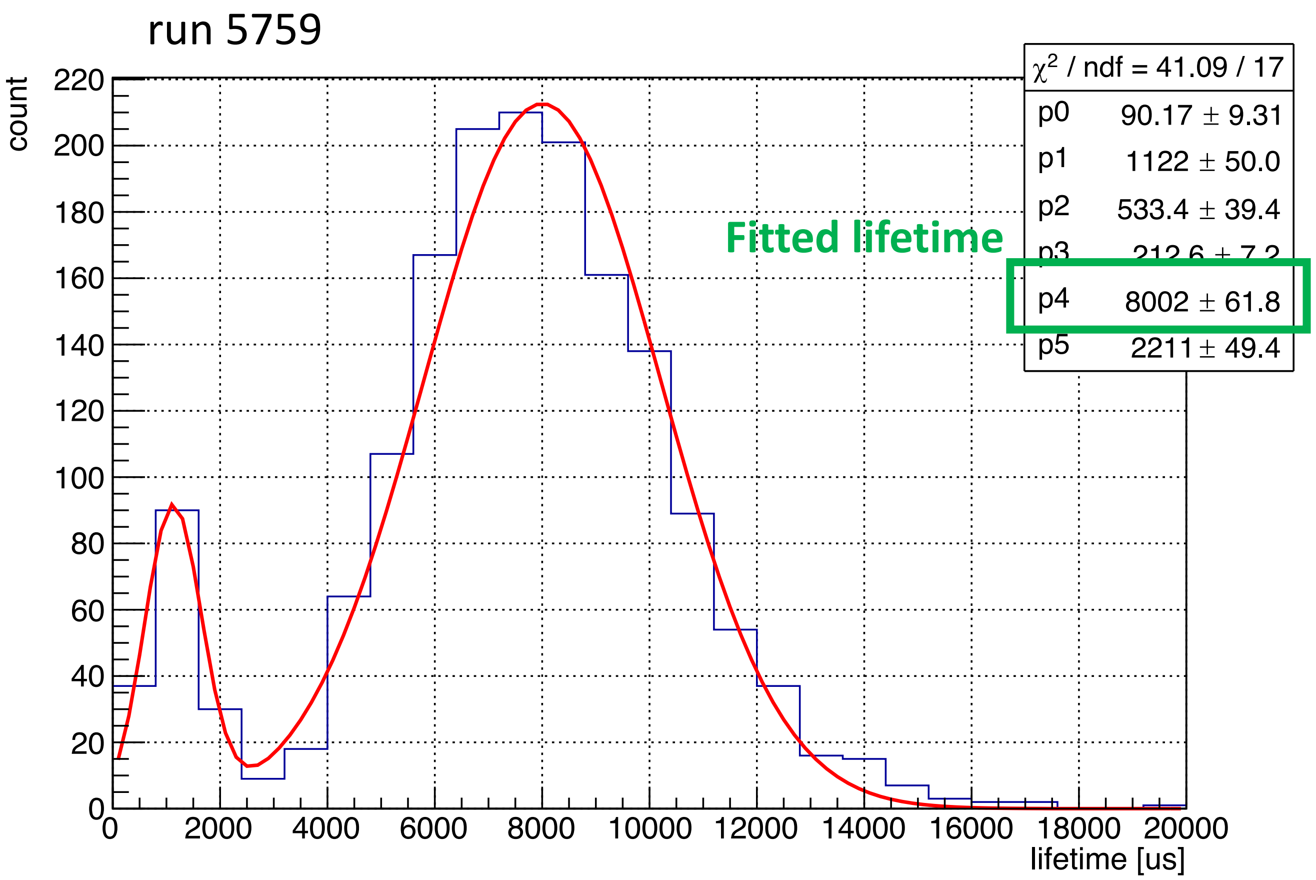
1. Some tracks have odd dqdx values (likely due to poor reconstruction) – I need to look at some event displays to pinpoint this issue
2. I have been ignoring negative lifetime fits thus far and is likely why the efficiency decreases in runs with longer lifetimes

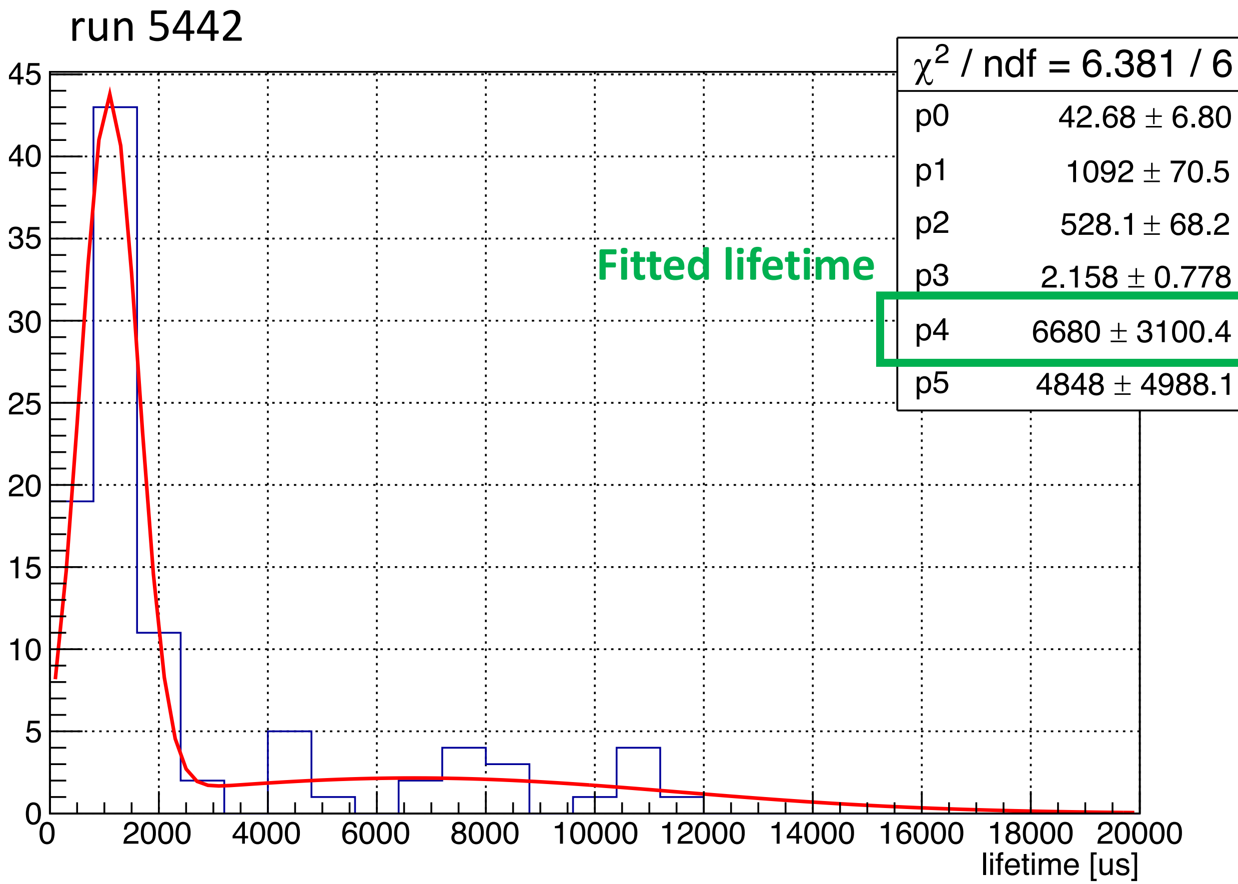
More work is needed before I can say anything conclusive…

Example of a track from the short-lifetime peak



Quick-fix: Double Gaussian fit to extract a run lifetime





Comparison with purity monitor

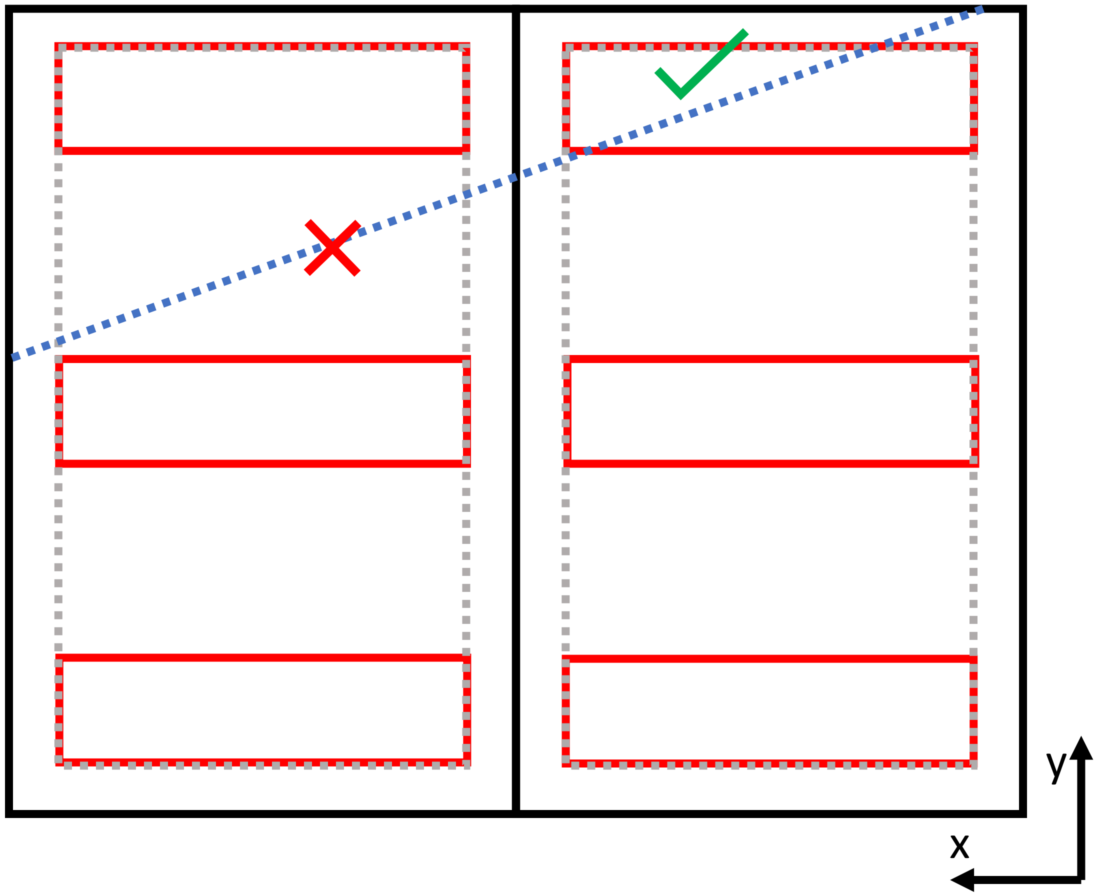
Run number	Date	Fit lifetime (fit error) [ms]	Purity monitor reading [ms]	t0-tagged lifetime (from Lisa Lin and Tianle Liu) [ms]
5141	2018-10-10	6.30±0.03	2.6	9.9
5308	2018-10-15	8.3±0.2	4.1	-70.3
5430	2018-10-19	8.1±0.3	6	--
5442	2018-10-22	6.7±1.5*	6	--
5759	2018-11-01	8.00±0.06	3.6	--
5780	2018-11-05	9.2±0.4	4.4	--
5841	2018-11-11	6.6±0.3*	5.5	--

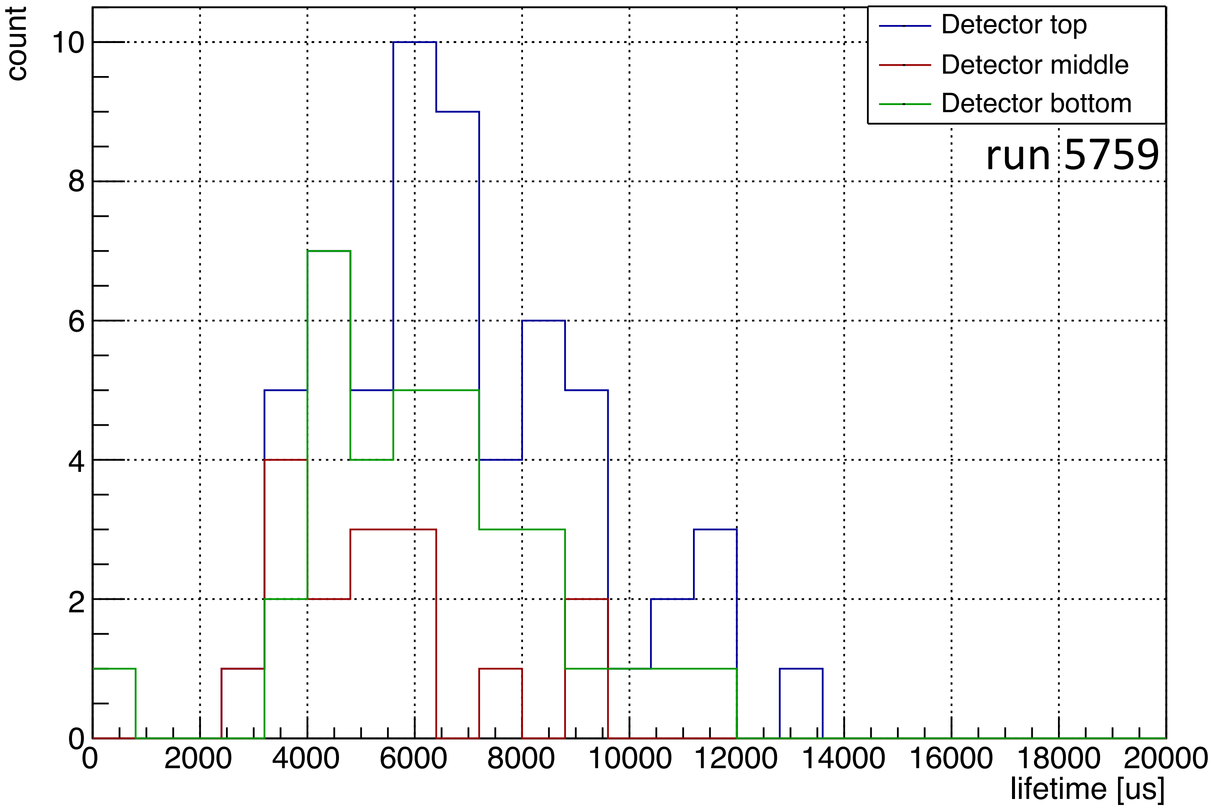
Would also be good to compare these to the DQM values

*runs with abnormal lifetime distributions

Looking at lifetime at top/mid/bot of detector

Only fit lifetime to hits within three regions of detector:





Limited by stats for most individual runs

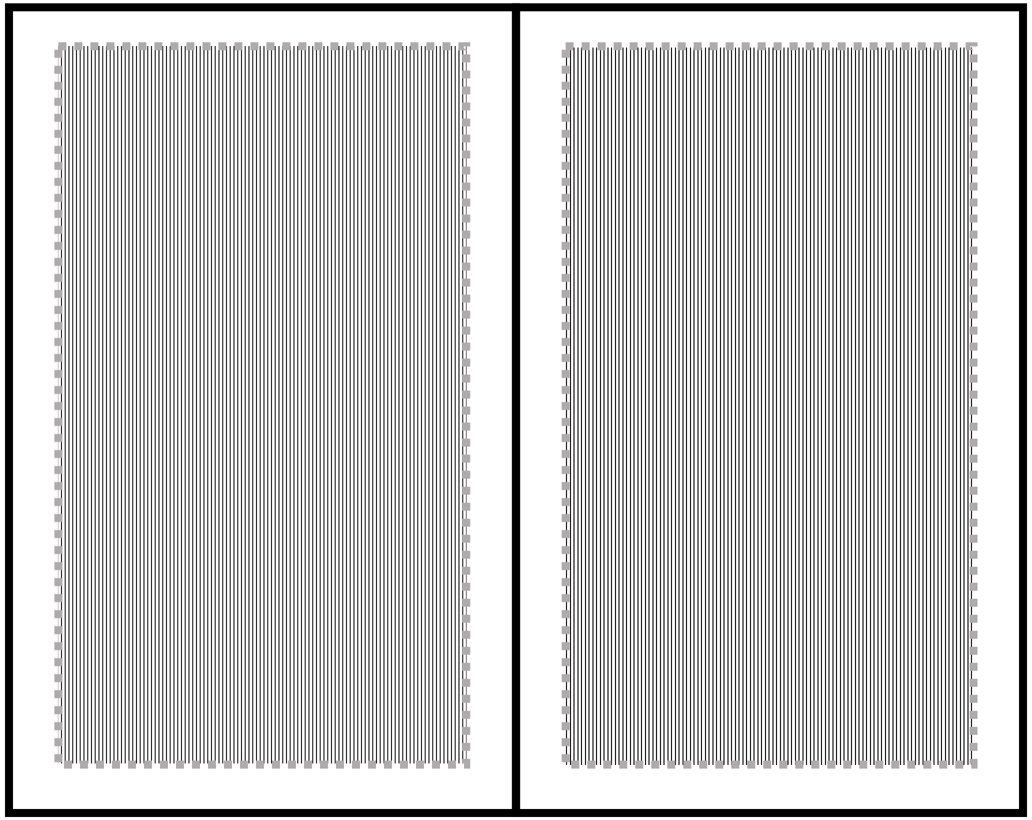
- No significant difference between top/mid/bot
- Distribution widths are large, so I am not sure this method can measure variations of ~<1ms with only a handful of tracks

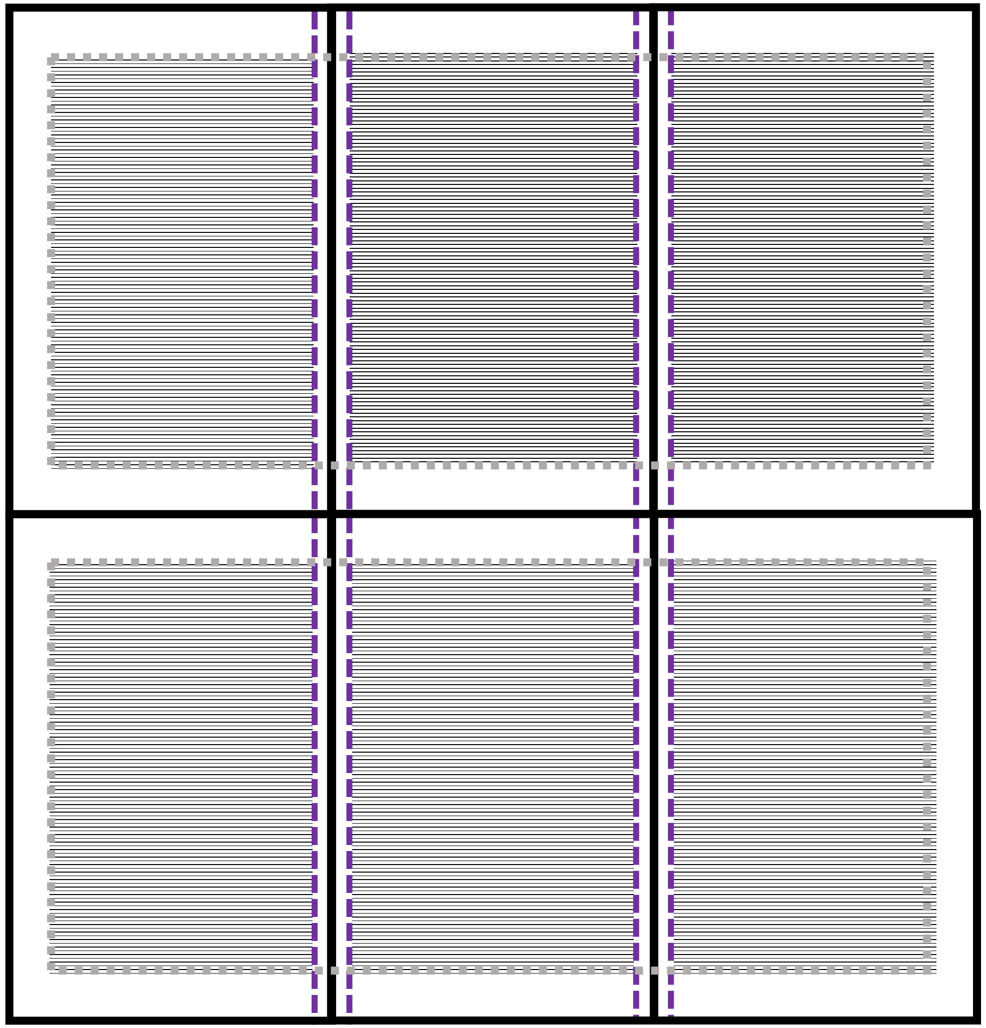
Summary of single track method

- Still requires some more investigation into the unreliable fits before I am willing to say this is an adequate measurement of the electron lifetime
- So far, I can say that my measurement suggests a lifetime much longer than the purity monitor – this is unlikely to change with more investigation

Aggregate track method

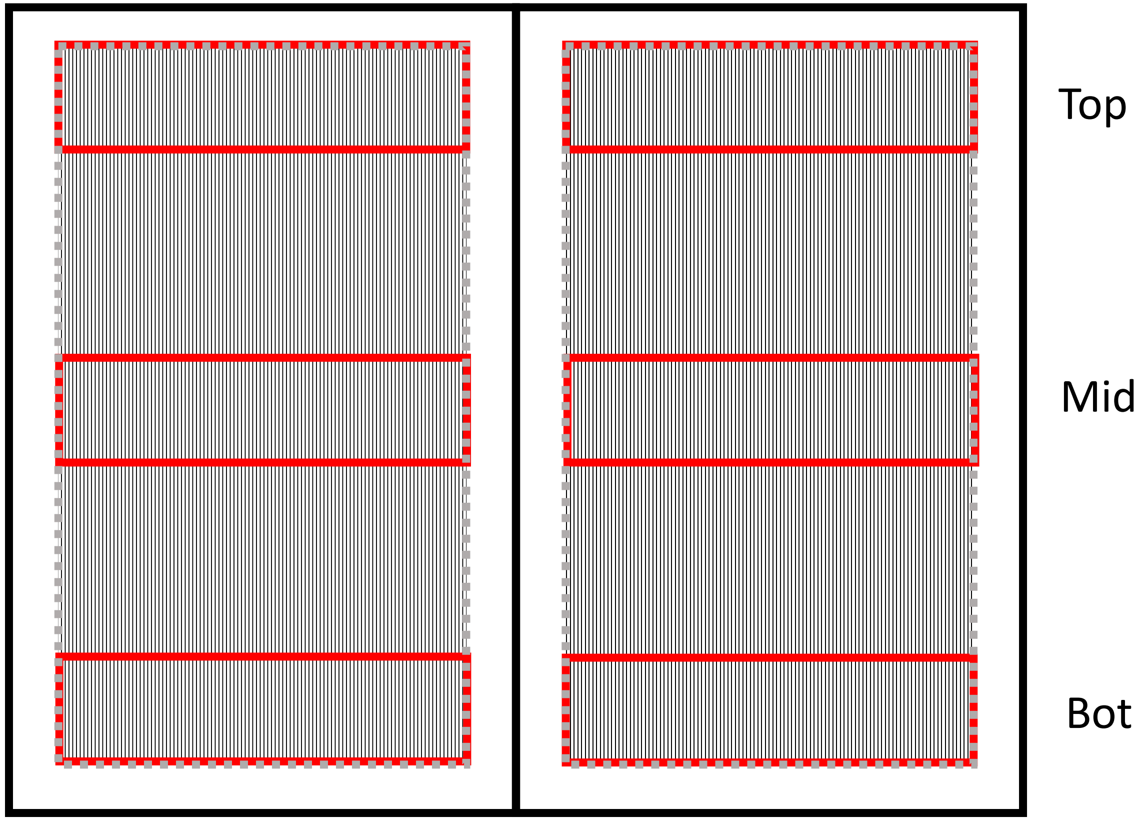
Bin x-dim and make fid. cut:

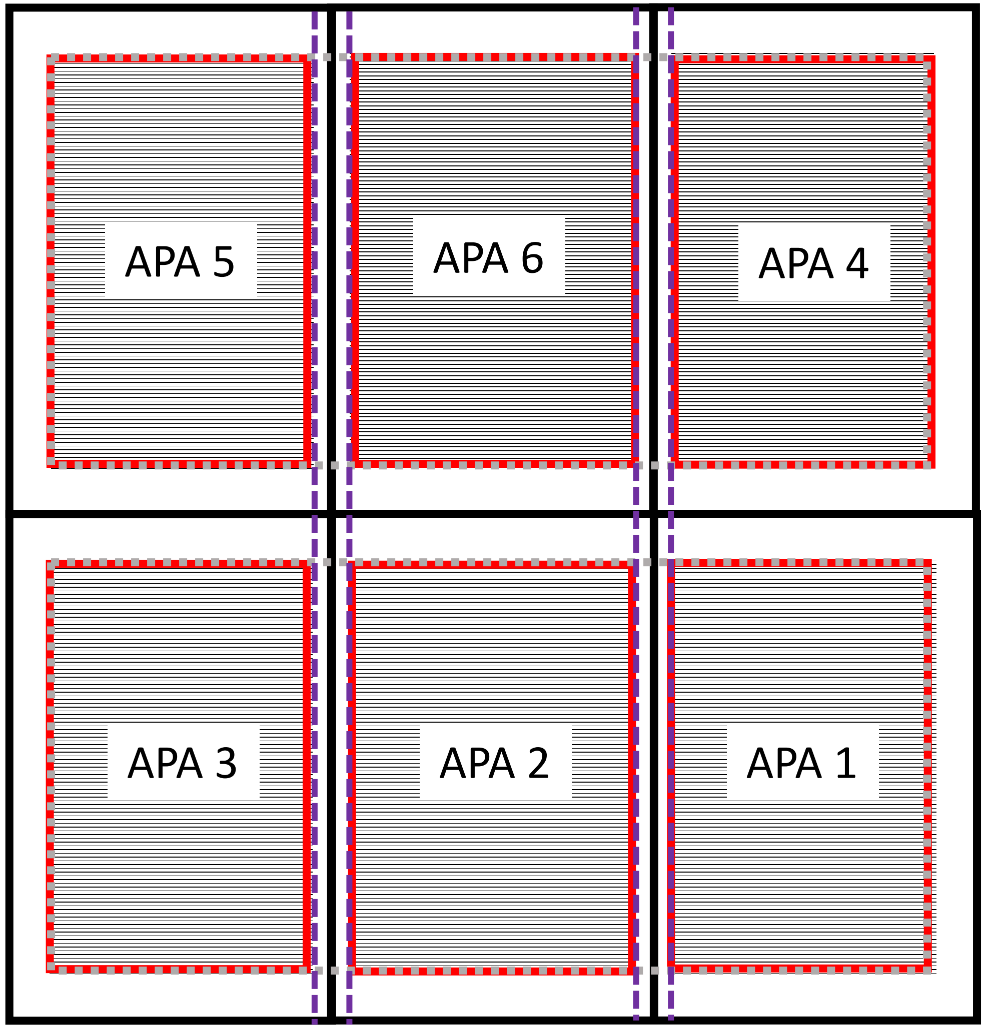




Aggregate track method

Divide into 18 regions (3x y-pos, 6x APA):

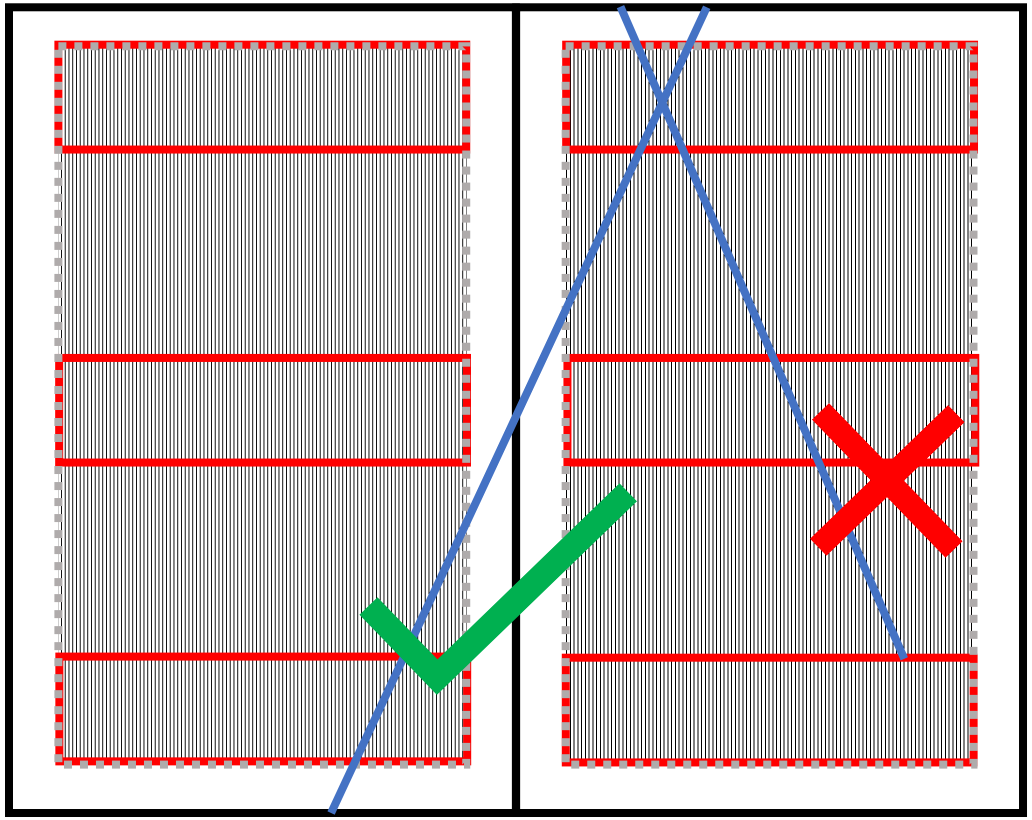


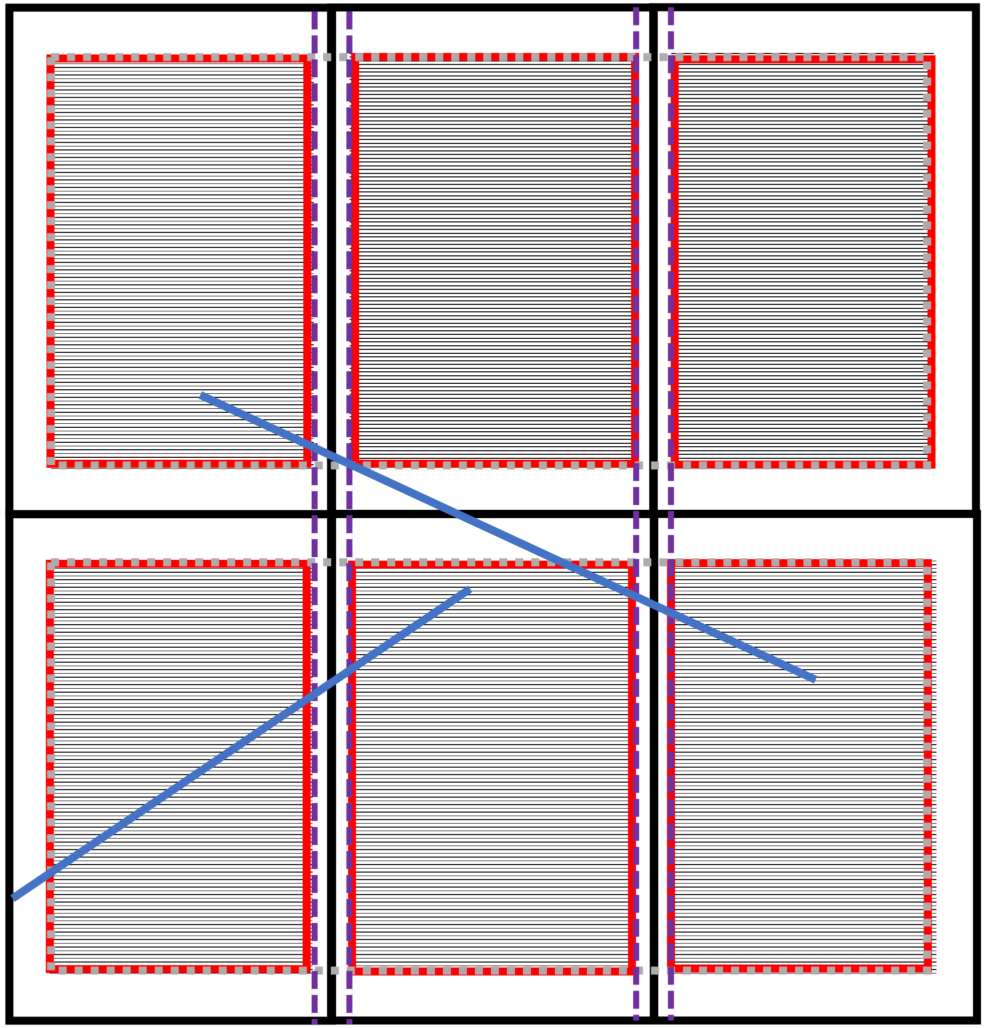


e.g top - APA 3, etc…

Aggregate track method

Select only cathode crossing tracks (good t0)





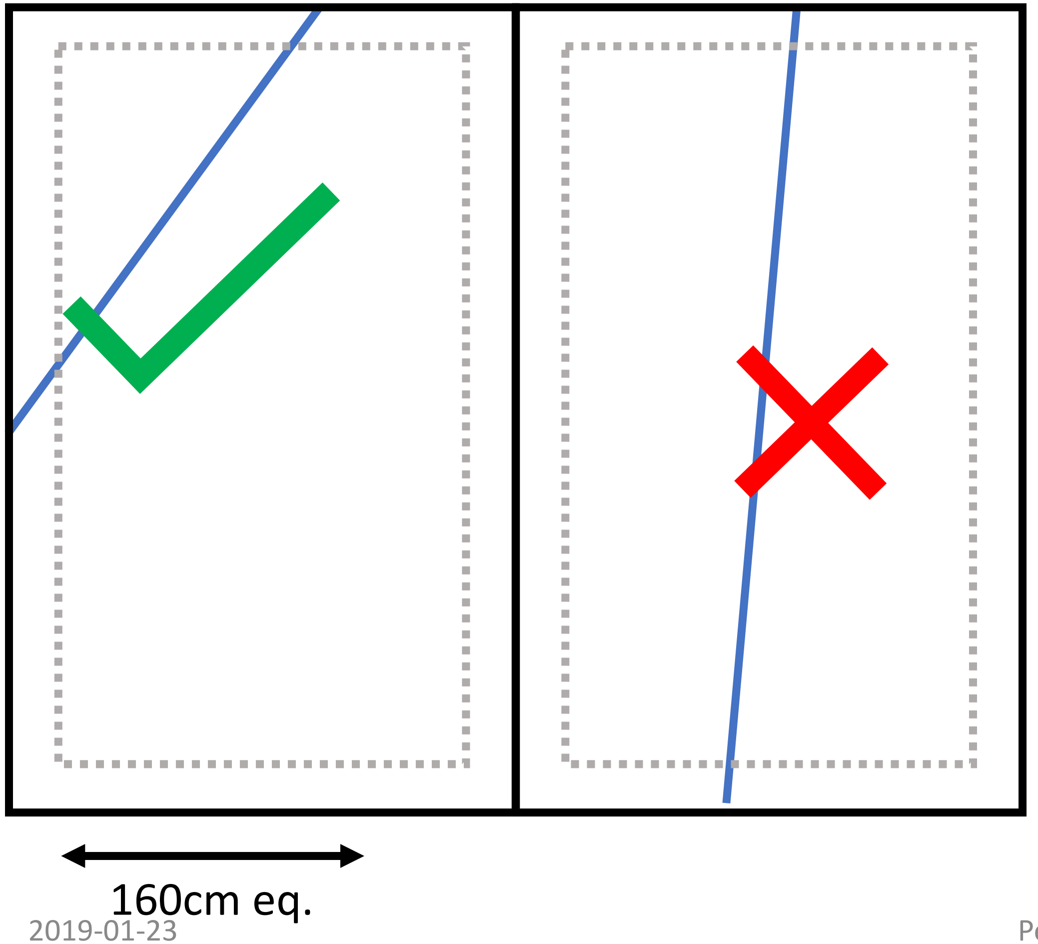
Aggregate track method status

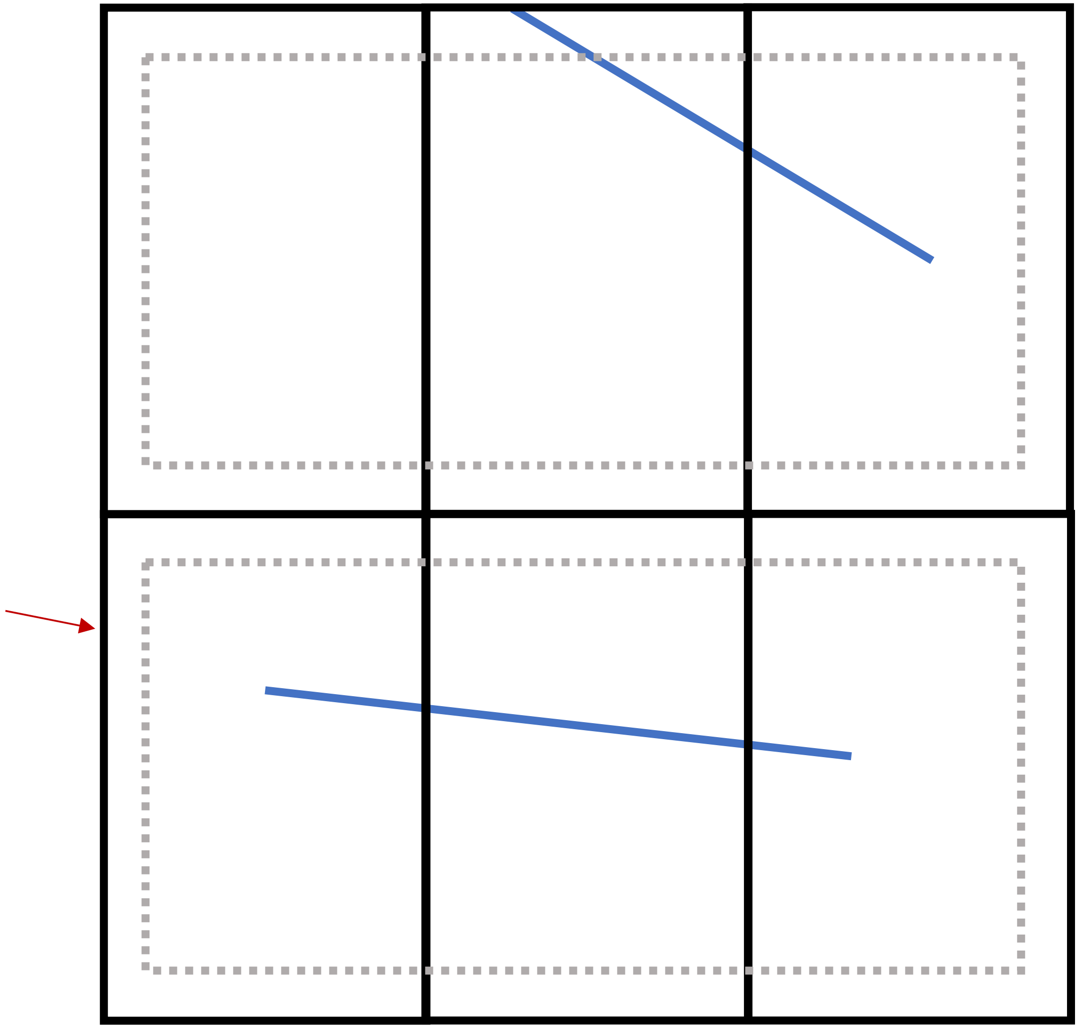
- Still working on getting the binning correct to insure adequate statistics in each before applying fits

Backup

Track selection

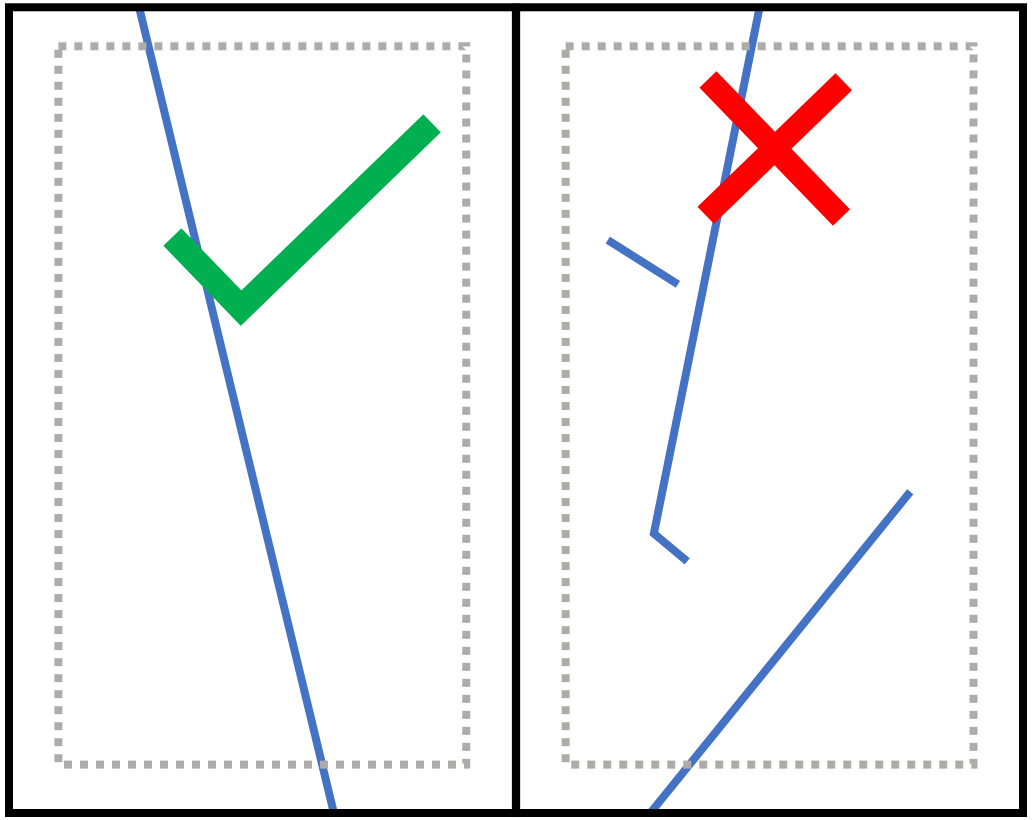
160cm eq. minimum drift time within fid. volume

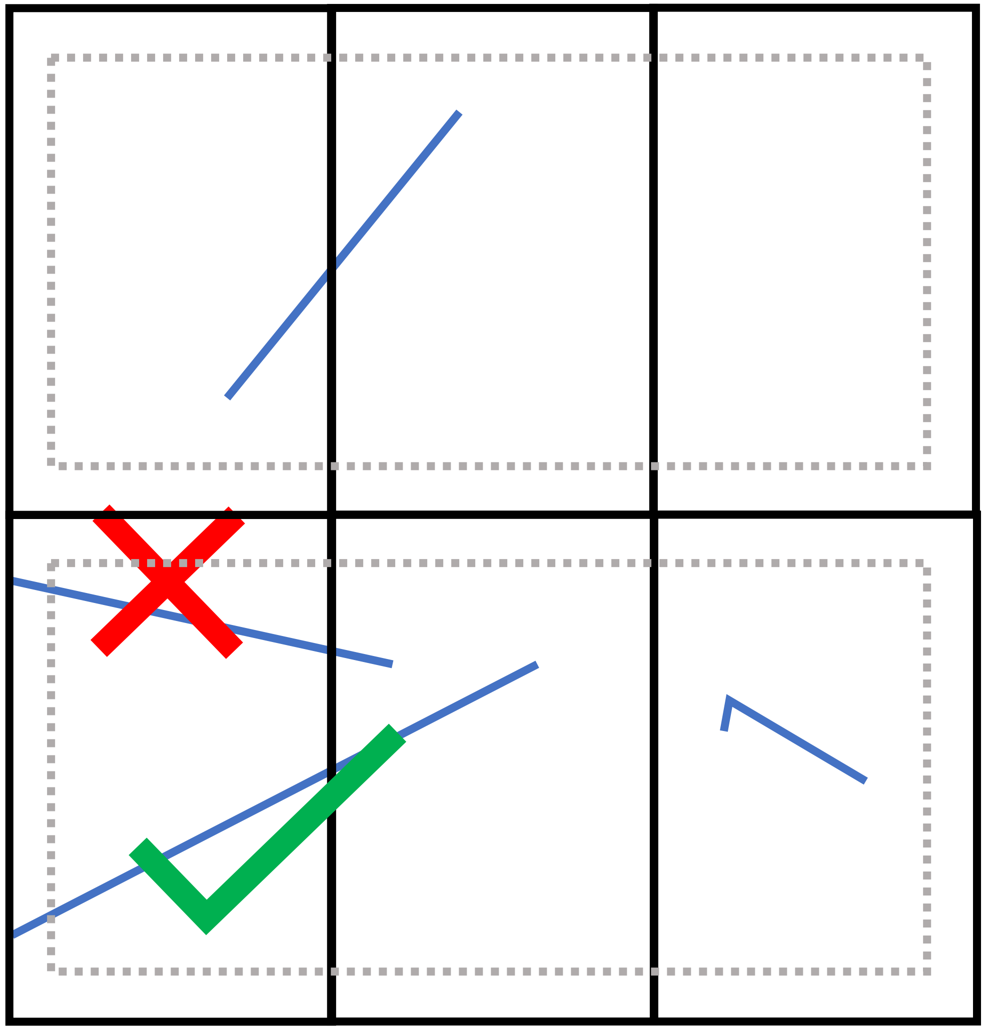




Track selection

Through-going





Track selection

Not cathode crossing (isolate BL and BR)