Measuring LAr purity from cosmics tracks

Episode #4

LArIAT Meeting
September 29th, 2015

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Previously on...

- Two approaches adopted: standard (Multi-track method), requiring many crossing tracks, and a new one working on single tracks independently (Single-track method)

- Details on both methods on DocDB 1583 and 1507

- I've left you last time with the following to-do list:
  - Tune cuts for Single-track method on real data and test them on simulated ones
  - Tune cuts and test Multi-track method on both simulated and real data
  - Reconstruct data and measure lifetime!

Let's see where I've got so far....

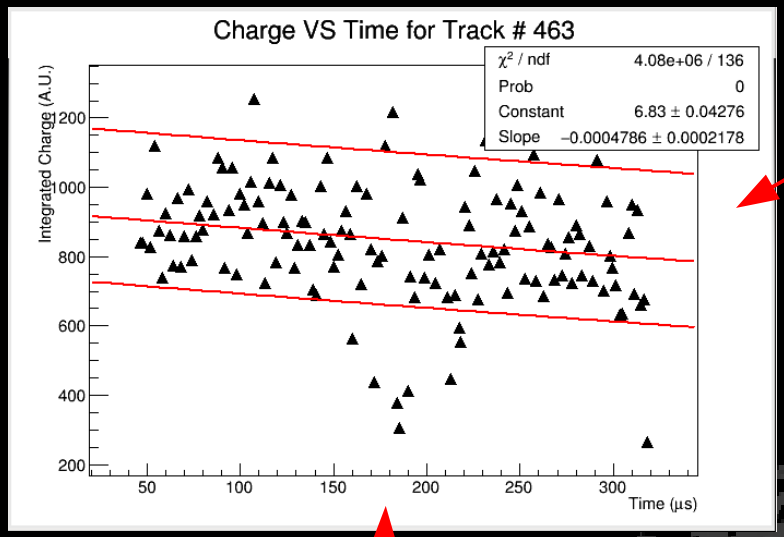
Single-track method

- Tuned cuts on hand-picked spills from Runs 5478, 5545, 5605,5684, 5834, 5854,5871, 6003,6018,6243 and 6256, as well as on cosmic-filtered events from Run 6100

- Cuts applied for track selection:
  - **Track ID == 0** *look for events with a single clean cosmic track*
  - **Hit_plane == 1** *select only hits from the collection plane*
  - **Hit_charge/track pitch < 2000 (ADC·cm)** *first cut to remove deltas*
  - **Track straightness** *fit hit_wire VS hit_time to a straight line and keep only the hits who are less than 2% far from the fit line. Repeat fit and hit selection with the hits surviving the first pass*
  - **Number of track hits surviving previous cuts > 80**
  - **Normalized χ^2 of linear fit < 2.0**
  - **Slope of linear fit between 0.35 and 2.0 or -2.0 and -0.35** *reject z-aligned tracks*
  - **Boundary conditions:** *track must start/end within 6 cm of cathode and anode plane*

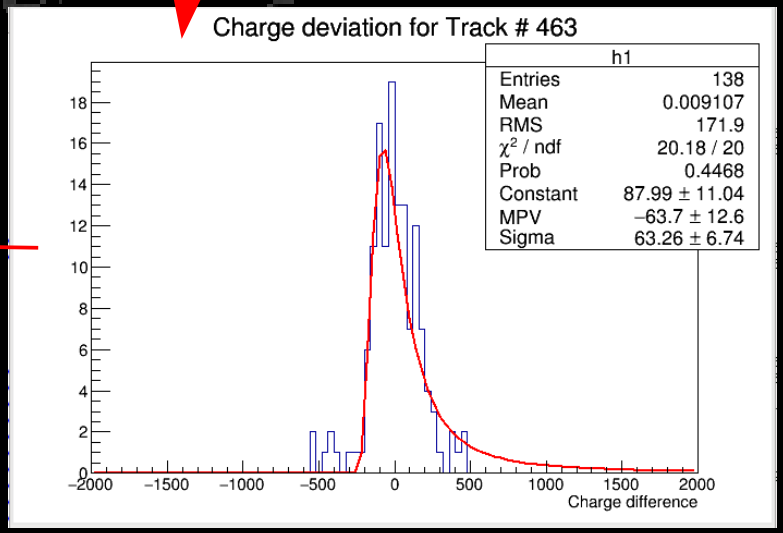
Single-track method

Once a track is selected, an additional cut to exclude hits with charge too high (delta surviving the first cut) or too low (partially-collected charge on wire, “sagging” problem) is performed



Step 1: plot hit charge VS hit time and fit to an Exponential (middle red line)

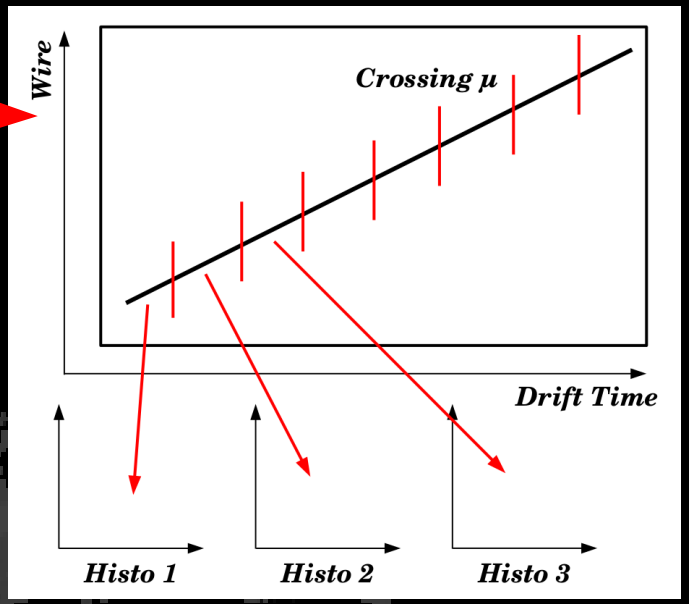
Step 2: Fill a histogram with the difference, hit by hit, between the hit charge and the charge value given by the fit at the hit time

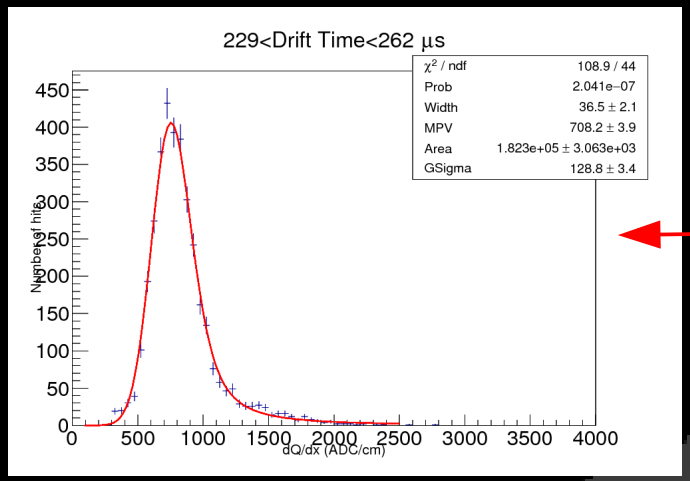


Step 3: Fit the histogram to a Landau and get the sigma value. Draw two exponential lines in the chargeVStime plot distant +4 and -3 sigma from the fit line (external red lines). Select for the lifetime measurement only the hits between this external lines

Multi-track method

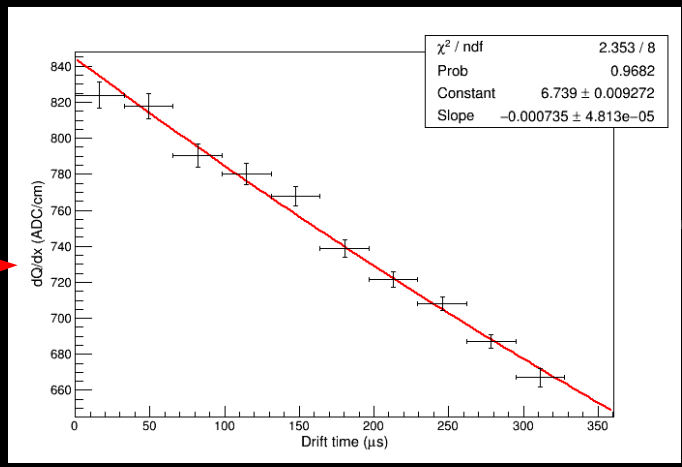
Step 1: drift time divided in 8 bins of ~ 33 μs each. For each track, calculate the charge falling in each drift time bin and use it to fill the histogram of deposited charge for that bin





Step 2: Fit each histogram independently with a Gaussian ⊗ Landau function and extract the fit parameters

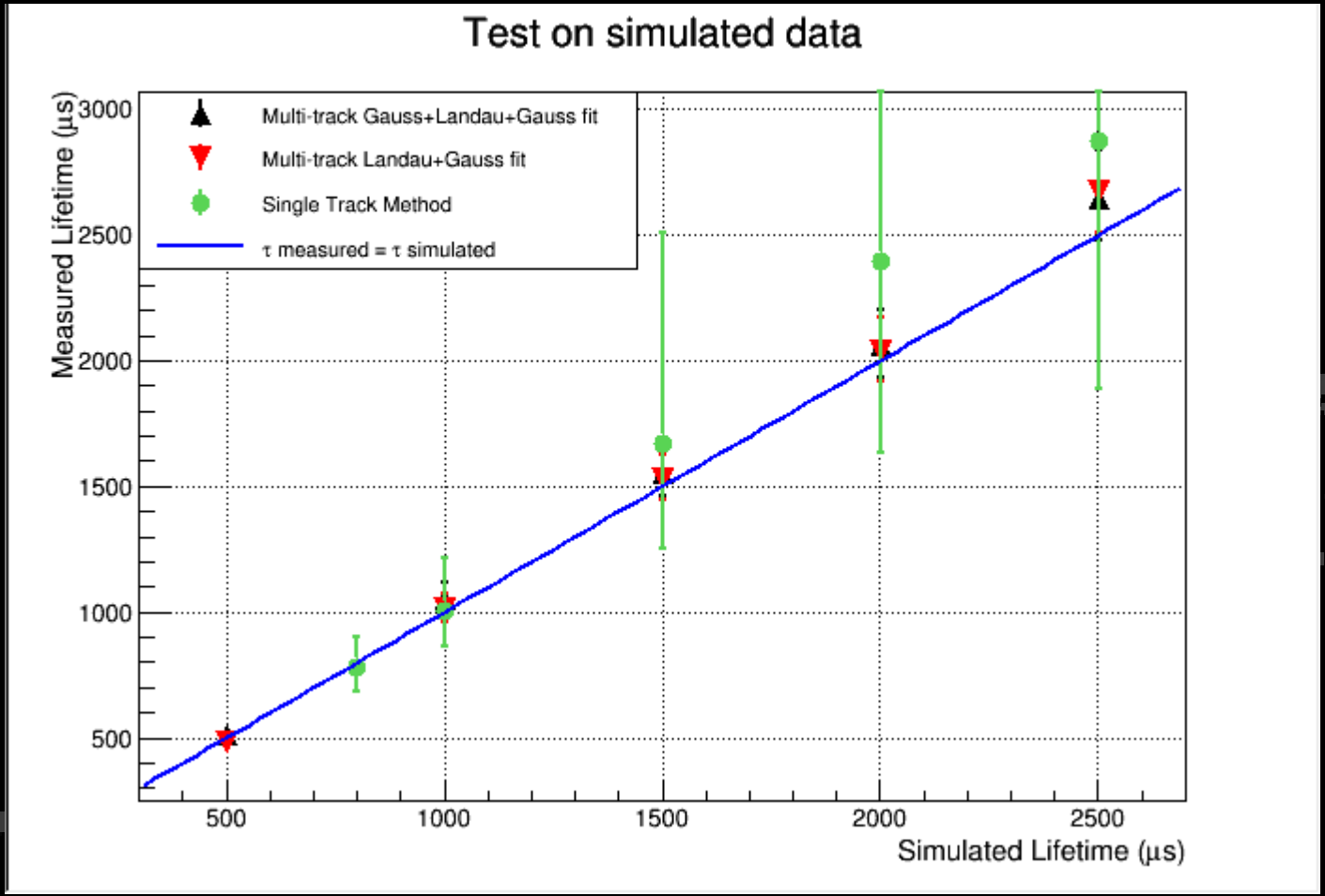
Step 3: Plot the deposited charge MPV as a funciton of drift field and fit to an Exponential to extract the lifetime (slope of the fit)



Multi-track method: cuts

- **Track ID > 0**
- **Hit_plane == 1** *select only hits from the collection plane*
- **Delta cut** if a hit has *charge > 2000 (ADC·cm) AND both the hit in the previous and following wire have charge > 2000 (ADC·cm) , flag them as delta and remove them*
- **First/last wire cut** *due to incomplete charge collection*
- **Track length > 15 cm**
- **Track angle 10° < ϑ < 240°**
- **Hit charge and hit peak height > 0**

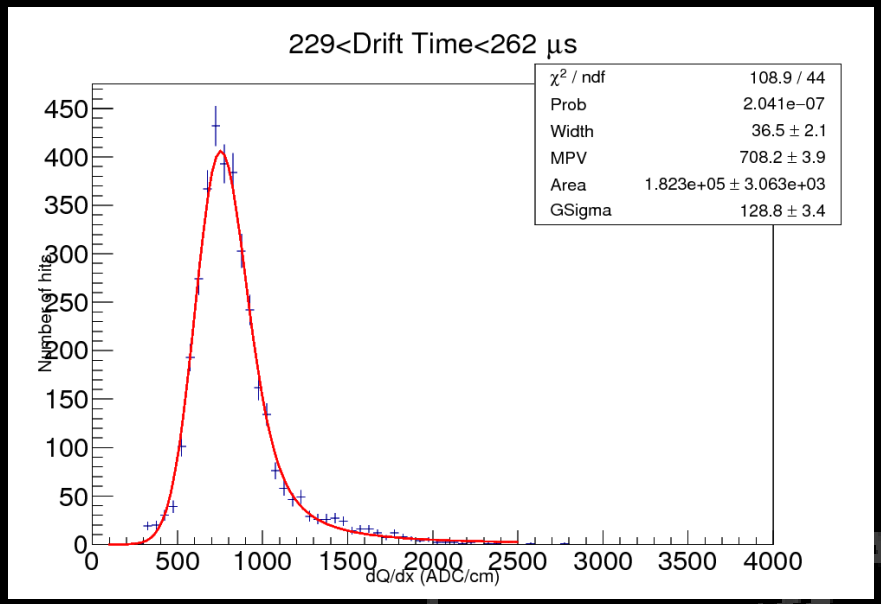
Check of tuning against simulated data



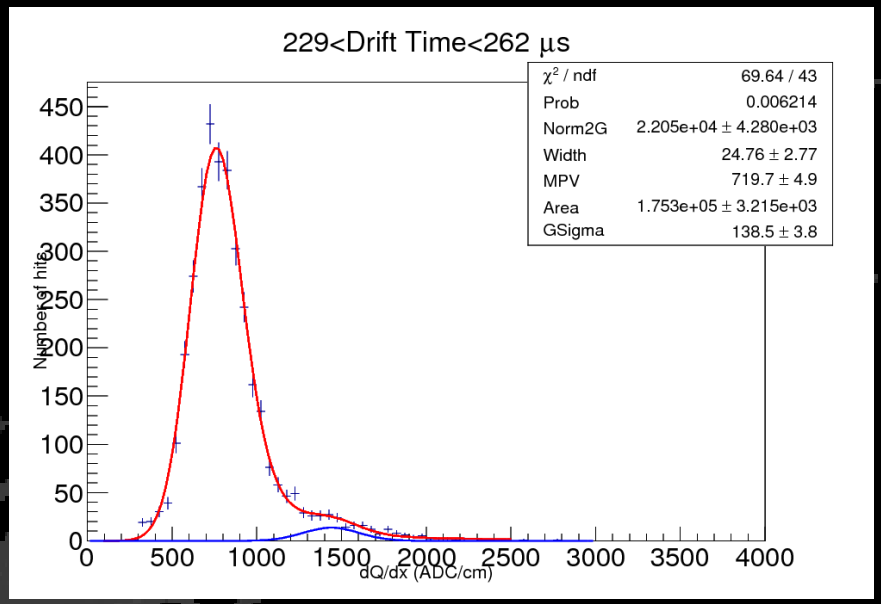
There are two fitting functions for the mulit-track method because the charge distribution in each drift time bin has a bump at high charge due to one-wire deltas surviving the cuts

Charge distribution fit

Run 6373-6378 – Landau ⊗ Gaussian fit



Run 6373-6378 – Landau ⊗ Gaussian ⊕ Gaussian fit



Three different approaches to the L ⊗ G ⊕ G fit were considered:

1) *Leave all the three parameters of the extra G free* (bad idea, discarded soon)

2) *Extra G mean equal to double the L ⊗ G MPV* (good but integral of the extra G can become comparable or larger than that of the L ⊗ G)

3) *Extra G mean equal to double the L ⊗ G MPV AND G sigma equal to the sum of the L ⊗ G sigmas (fastest minimization and ensures the integral of the extra G not getting too large)*

Yes...

all very nice...

but what about real data??!!!

About data

- Through the SAM database, created a data sample by selecting all the runs where the TPC operated with default values of drift time, ASICs gain and shaping time: ~ 70000 spills

- Divided the data in subsamples each containing roughly 12 hours of data, but taking care of not splitting any run between subsamples (~500-1100 spills per subsample, 96 total subsamples)

- Subsamples reconstruted in LArSOFT using the following modules:
  - Slicer
  - Filter *select any event triggered by at least COSMIC or COSMICON*
  - Caldata
  - ClusterCrawler hit (cchit)
  - Linecluster
  - Pmtrack
  - Anatree

About data

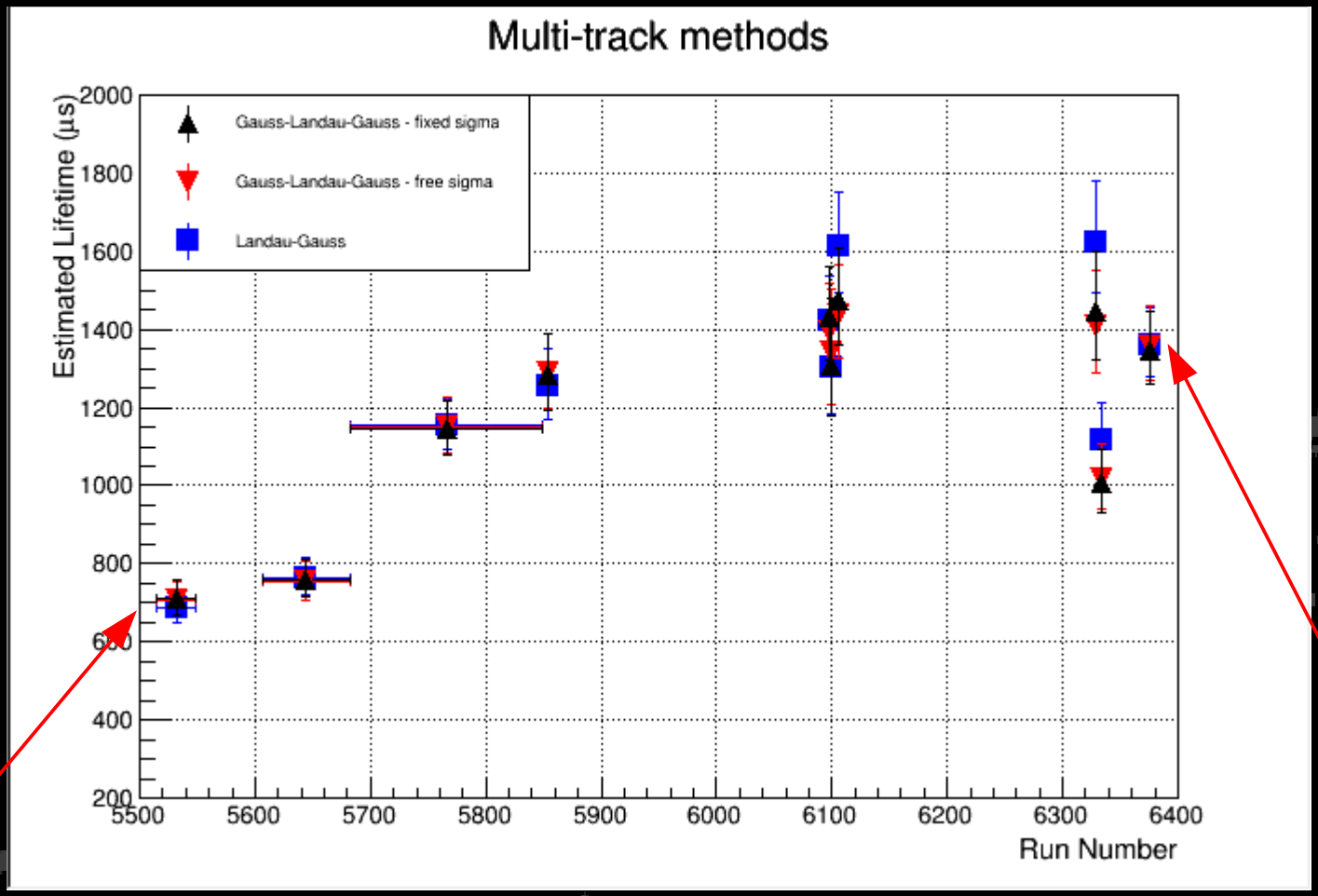
- As of last Sunday, all the subsamples are reconstructed

- Started to run both the Single-track and Multi-track analysis codes on the subsamples

- Using three different versions of the Multi-track code: one where the fit function for the charge distribution is the L $\otimes$ G, one where the fit function is the L $\otimes$ G $\oplus$ G with both mean and sigma parameters constrained, and one where the fit function is the L $\otimes$ G $\oplus$ G with only the mean parameter constrained

- In some cases subsamples are merged to have enough statistic for the Multi-track analysis

Lifetime Plot: Multi-track methods

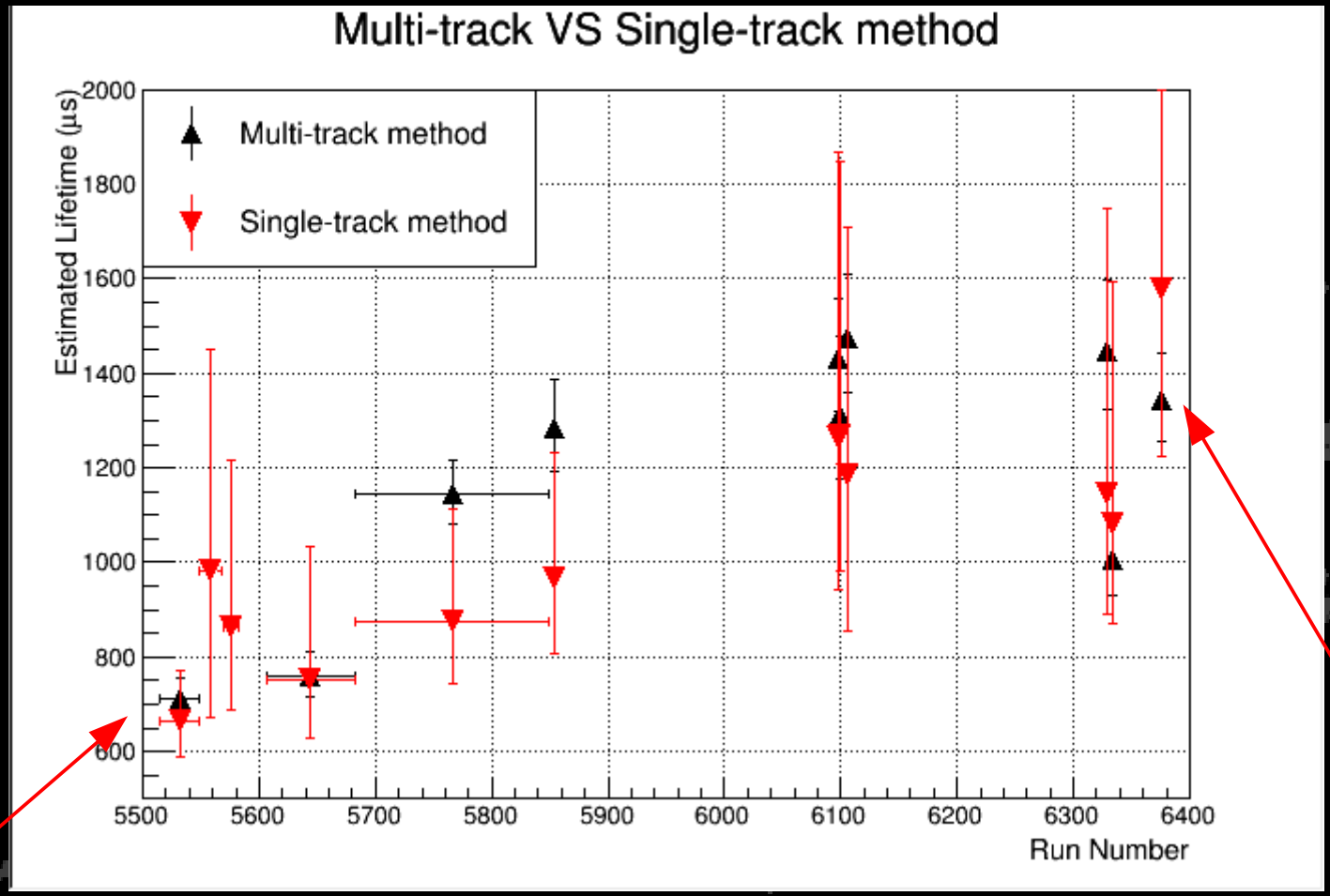


May 7th-8th

July 2nd-3rd

- X-axis "error" visualize the runs used for that specific measurement
- Fitting methods are almost always consistent among themselves
- There seems to be an increase of Ar purity with time

Lifetime Plot: Multi-track VS Single-track

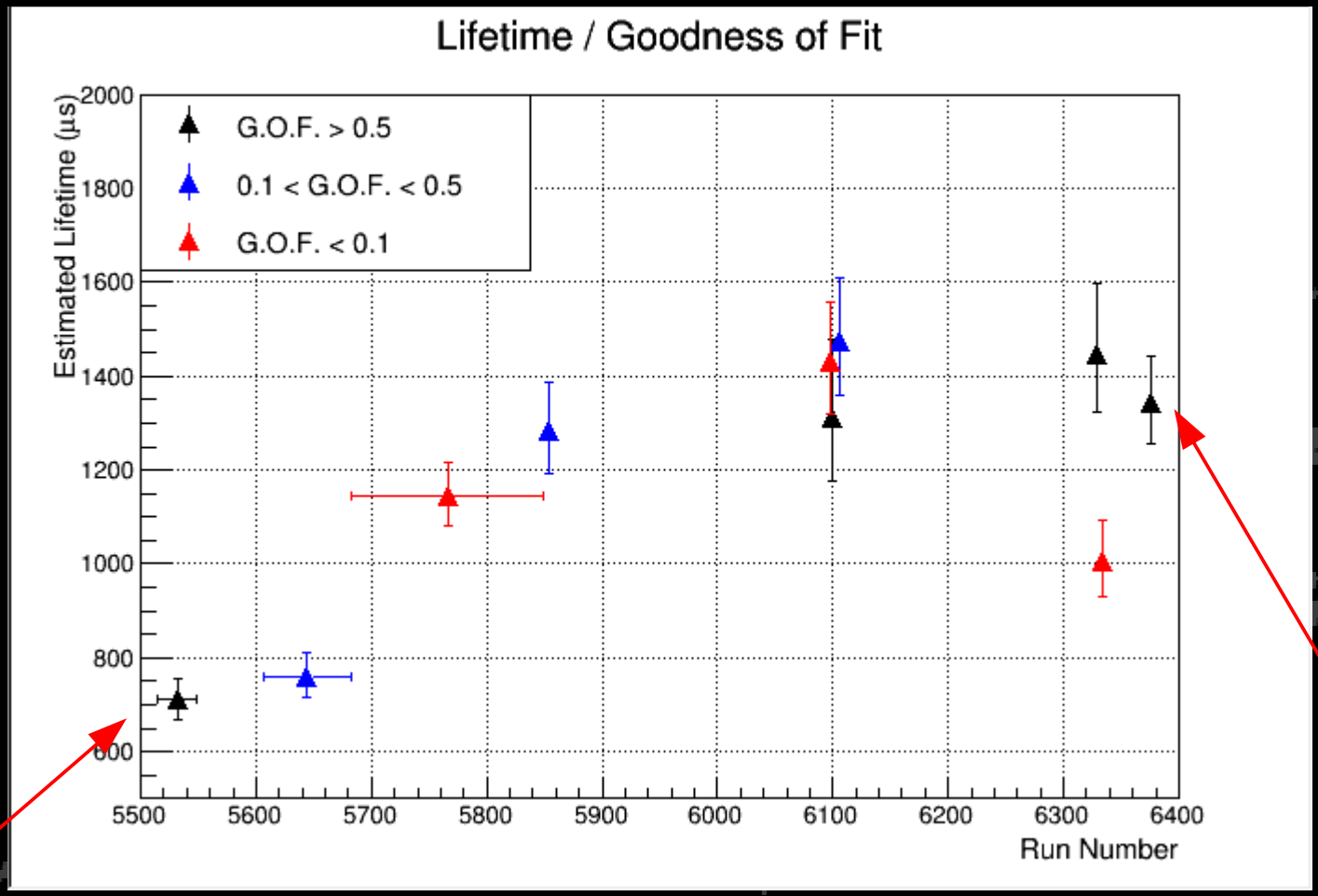


May 7th-8th

July 2nd-3rd

- Lifetime increase is lower for Single-track method, but errors are bigger
- Wonder whether fluctuantions between narrow points are expected or hints to fit problems for the Multi-track method

Lifetime Plot: Multi-track analysis



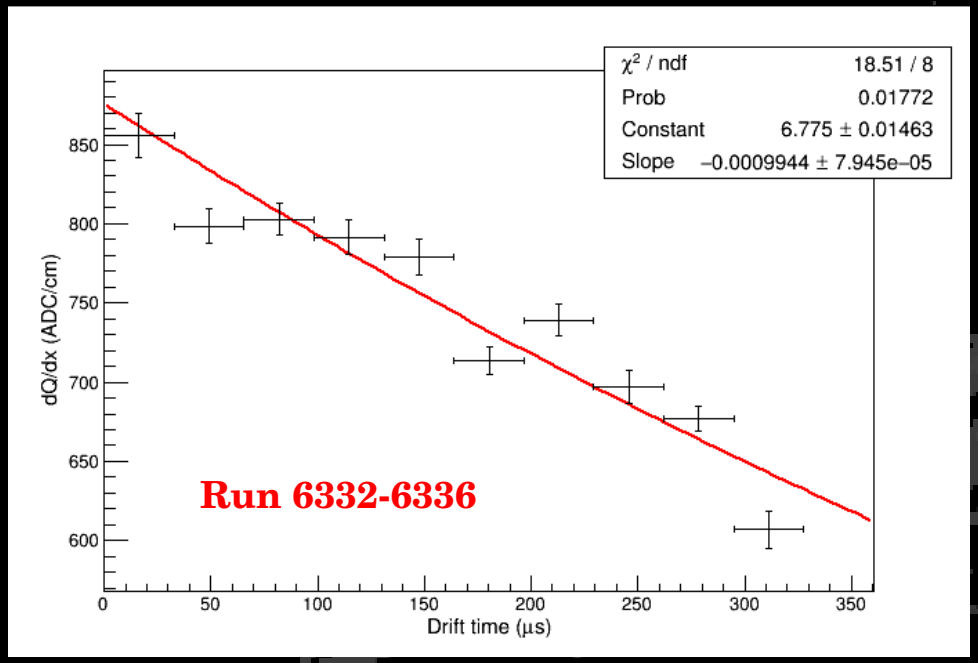
May 7th-8th

July 2nd-3rd

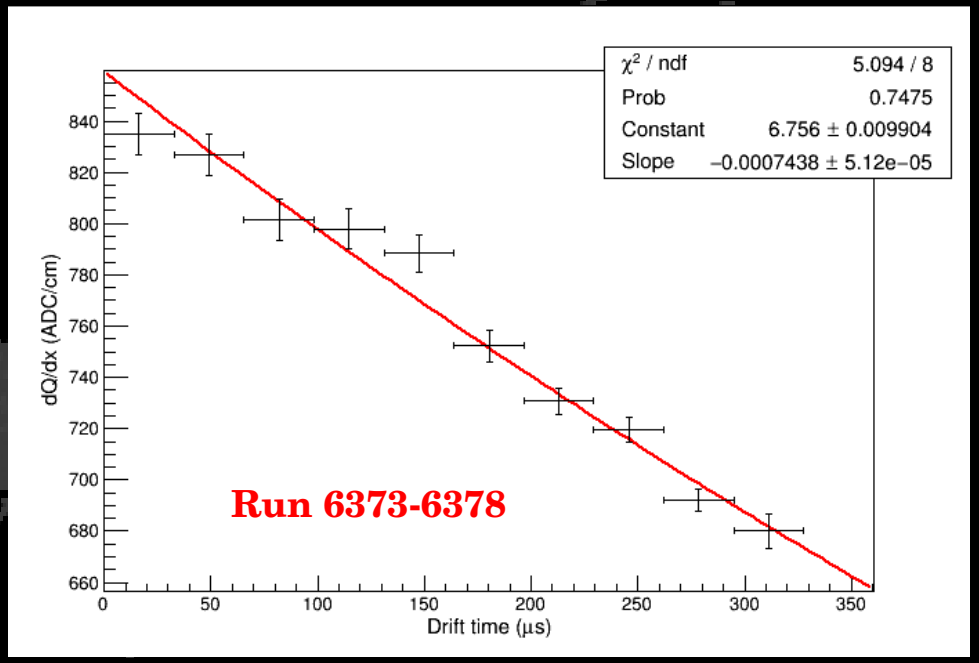
Looking at one single method. Colors represent how good the exponential fit of the charge VS drift time is: red=bad (χ^2 derived probability < 0.1), blue=not so good (0.1 < probability < 0.5), black =ok (probability > 0.5)

Lifetime Plot: Multi-track analysis

This is how a bad fit look like



This is how a good fit look like



I'm updating the lifetime plots as new subsamples are analyzed....

BACKUP SLIDES

Single-track Method

✔ Select straight tracks crossing the whole TPC

✔ Given a track, extract for each hit the probability *l (according to a Landau function)* to obtain the observed dQ/dx as a function of the "uncontaminated" value dQ_0/dx and the lifetime τ

✔ Minimize the logarithm of the sum of *l* over all the hits - max likelihood -ln(L) - respect to τ, dQ_0/dx and width of the probability function

✔ Average the values of τ obtained for the selected tracks to be less sensitive to fluctuations in single track measurement