Q Pix Physics simulations

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Motivation

- Develop a fundamental electron transport and collection simulation
- Develop basic tools for simulating pixel response
  - Bypass larsoft for ease of use and quick implementation
- Gain fundamental understanding of the parameters we can tune to get the most physics out of Q PIX.

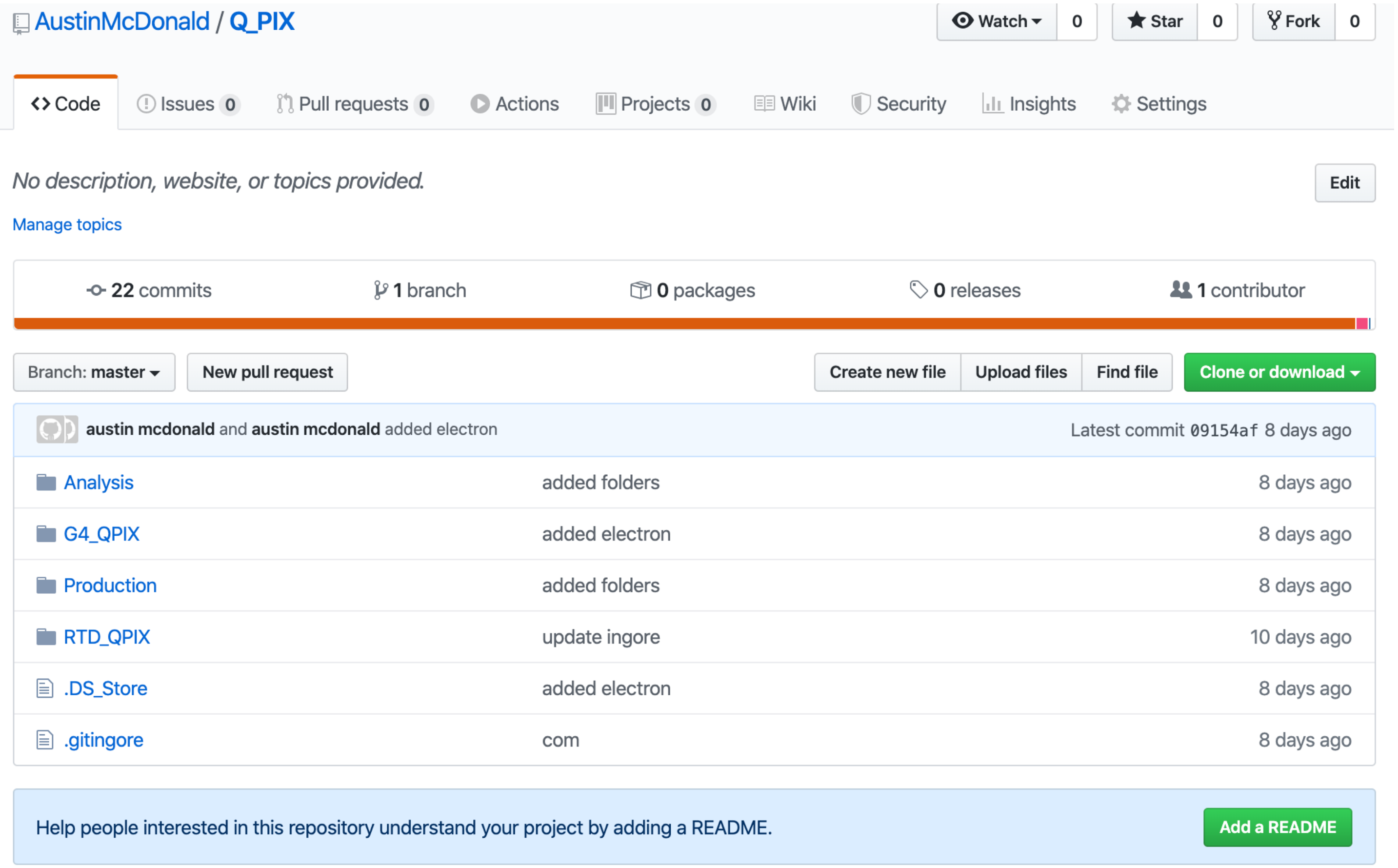
Software

All the code is located here

https://github.com/AustinMcDonald/Q_PIX

However I have not had time to comment it yet

If you need or want anything urgently just ask and we will get it figured out!



Geant4

The Geant4 is LAr volume that is 1 meter in X and Y and 5 meters in Z with XY being the pixel plane.

It is currently setup for very specific partial generation

Radioactive decay of Ar39 uniformly throughout the volume

10GeV Muon across the XY plane at any Z

100MeV Proton at any XYZ with momentum in the XY plane.

These particle configurations were set up to get a handle on the type of physics we “need” and “want”

Each truth hit is added to a list then saved as a txt file (I know blasphemy).

RTD simulation

The goal of this was to simulate the charge collection electron by electron

The Geant4 truth is read in and the hit is split into N electrons by diving the hit energy by the W value (23.6)
These N electrons are then diffused around the hit position with the proper diffusion constants, at this step the lifetime is also accounted for.

These electrons are then projected with noise onto a pixel plane (4mmx4mm) which has an adjustable reset threshold.

The noise was added every microsecond as a gaussian with a width of 30 centered around 0 and a leakage current of 100 atto amps (is 625 electrons a second) that was added probabilistically.

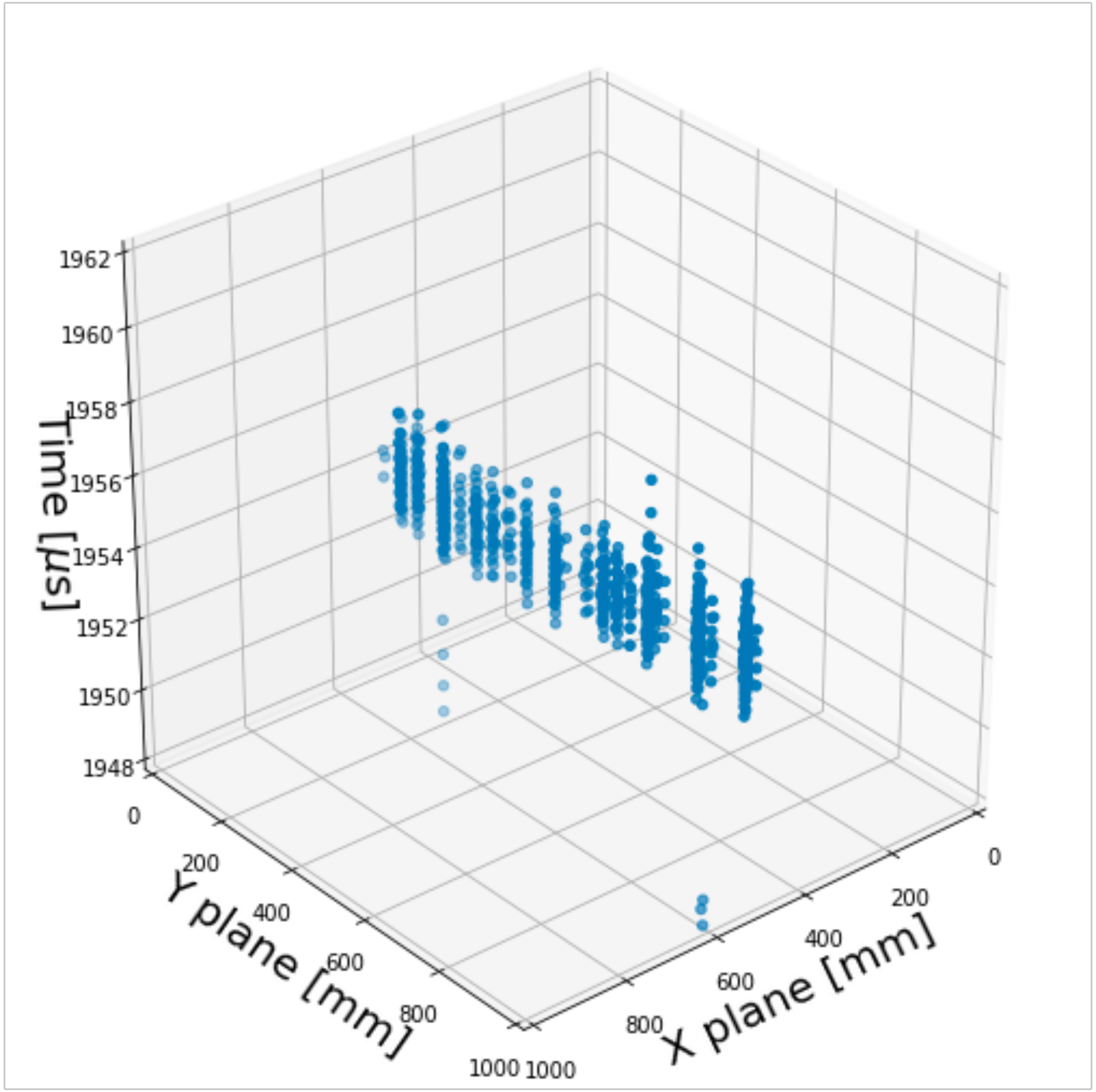
A “dead time” was add for 100 ns after the reset during this time the pixel would not reset again but could collect charge and would reset when possible.

Physics

In order to study the impact of changing the parameters the figure of merit will be a chi squared based on if there was no noise and infinite electron lifetime.

This is visualized by taking the one active pixel from the Muon in the previous slide and histograming the resets

Taking the into account all the pixels gives a chi squared for the full event.



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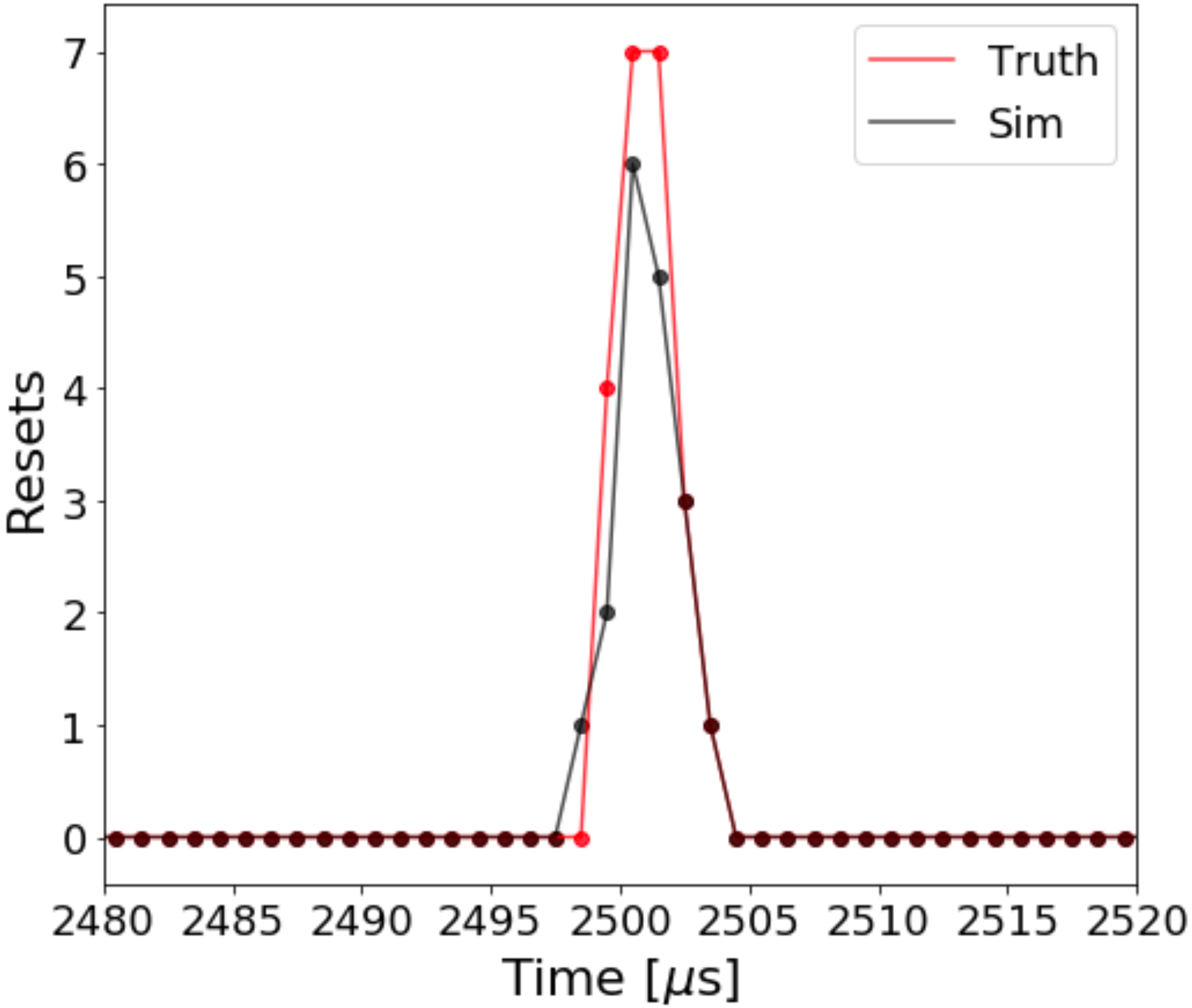
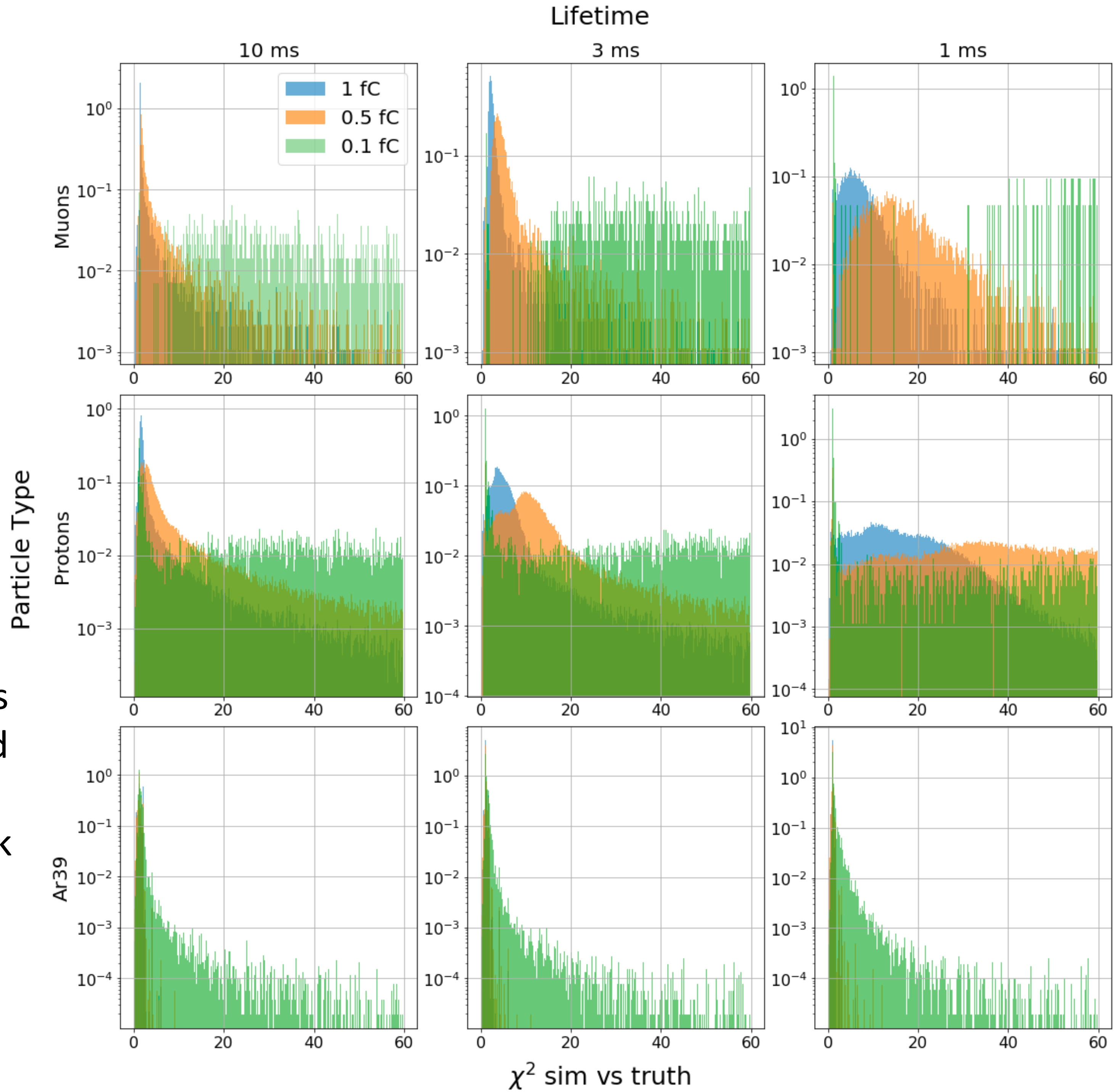


Physics

This is NOT correct!

1 million events of each particle was generated and due to some cluster issues not all the jobs finishing

Regardless of this there are some issues that need to be sorted out that I missed before submitting and this is wrong. However, this is what the study will look like.



Drift position from RTD (preliminary)

Must be mindful of the different diffusion constants units one is expressed in time the other is as a velocity.

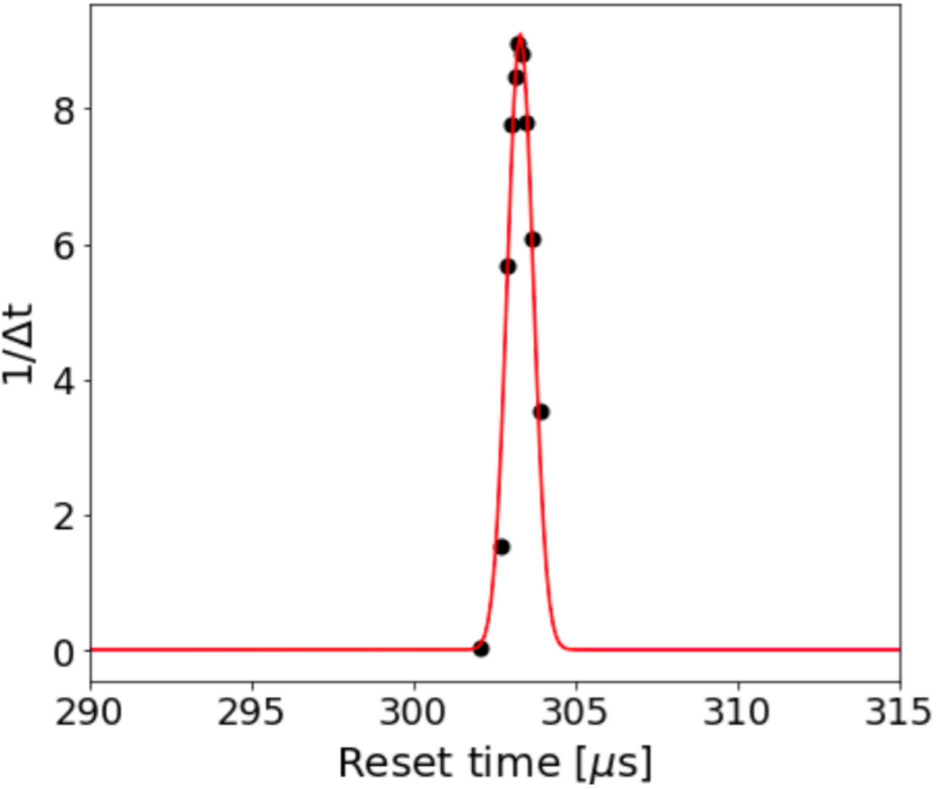
$$\sigma_{cm} = \sqrt{2D_{cm^2/s}t}$$

$$v^2 D_s = D_{cm^2/s}.$$

$$\sigma_s = \sqrt{2D_s t}$$

The width of the pulse is related to the initial width of the electron distribution, the diffusion constant and the drift time.

$$\sigma_t = \sqrt{\sigma_{0(t)}^2 + 2D_{L(t)}t_d}.$$



This is a 1 pixel RTD from a muon that was 500mm away when it is fitted with a gaussian the sigma is used to calculate the drift distance and yields 524.3mm

Not perfect but not a bad first pass and appears that the the drift distance can be extracted with some rough precision.