A look at the August 2012 beam test

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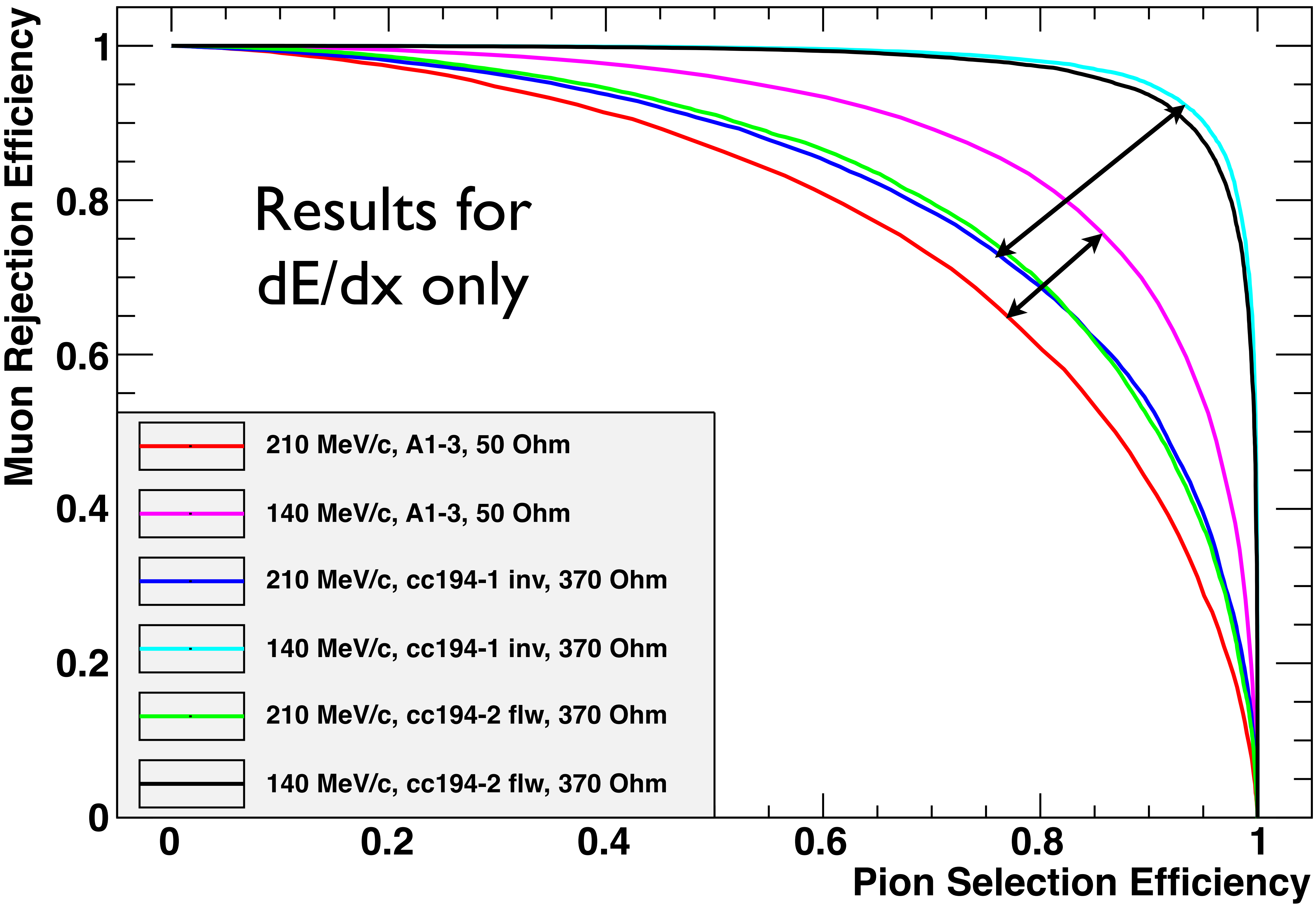
Warning!

The following results are still preliminary. The talk is titled "Analysis of..." on Indico, but the conclusions are far from final!

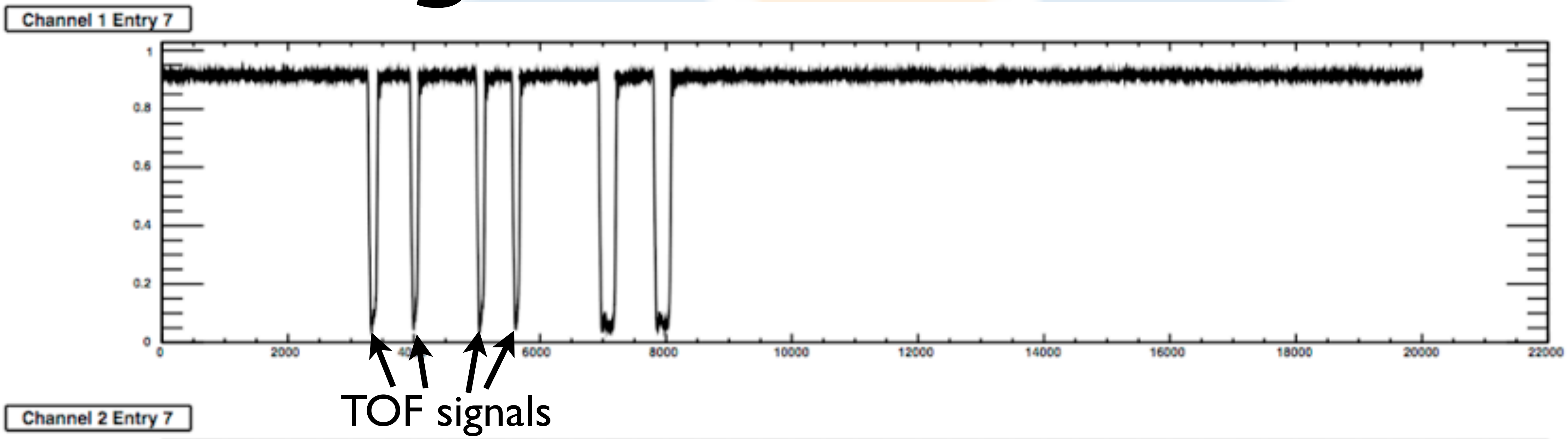
Goal & Overview

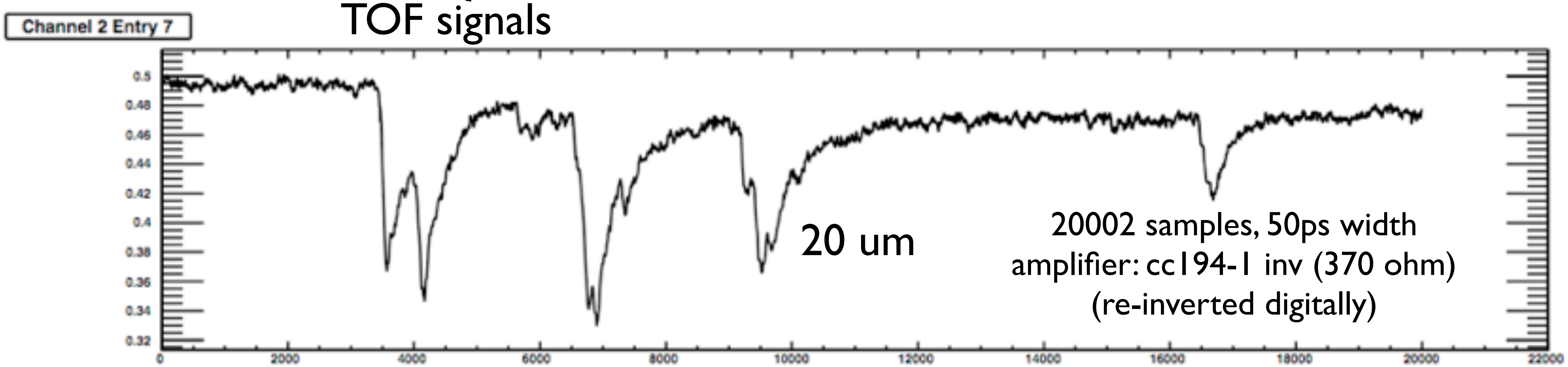
- Determine the best combination of amplifier, cable, gas gain, for particle identification.
- Muon/Pion separation at 210 MeV/c is similar to Kaon/Pion separation at typical SuperB momentum.
- Most plots shown here are for amplifier cc194-1 inv (370 Ohm).

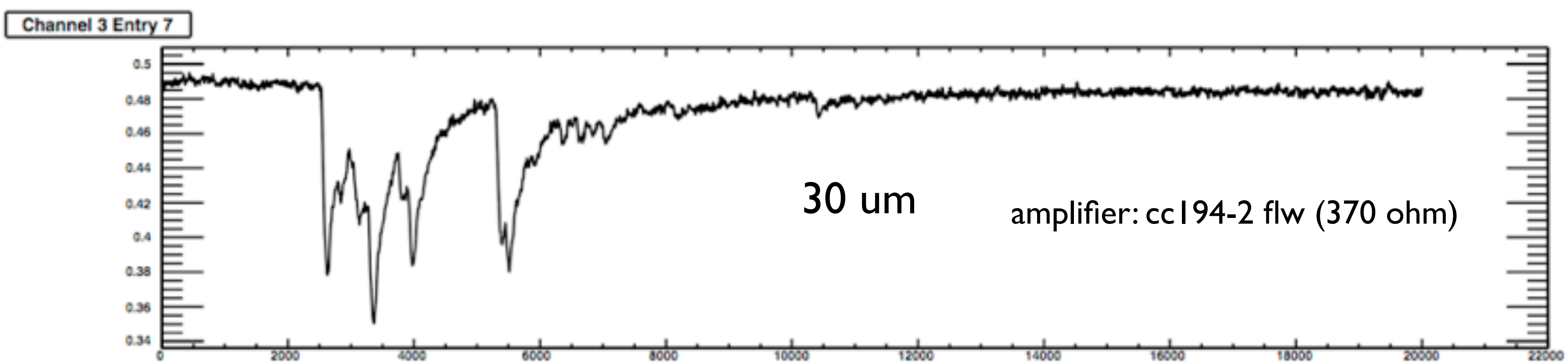
Spoiler Plot



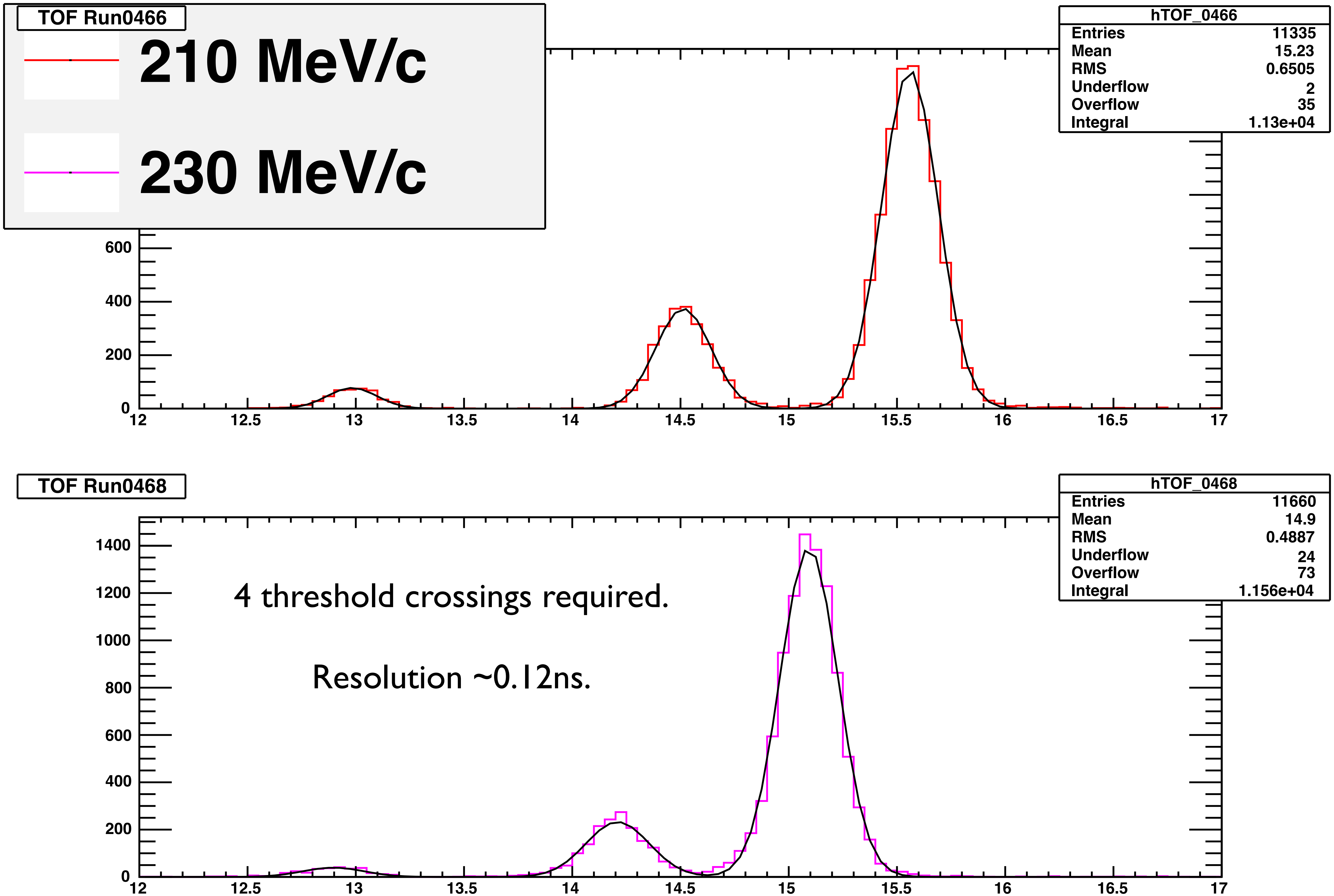
Digitized Waveforms



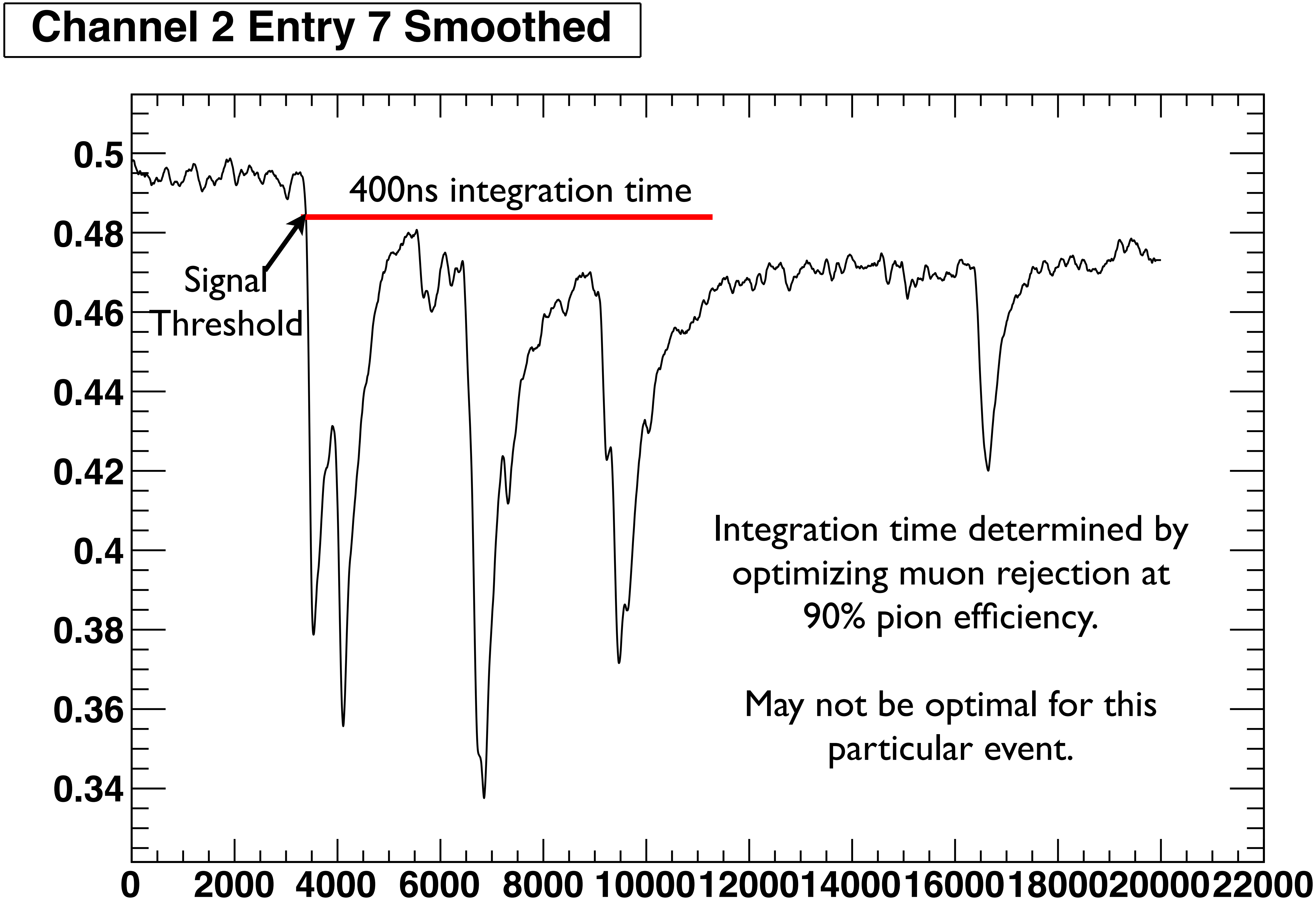




TOF Calculation



Signal Determination

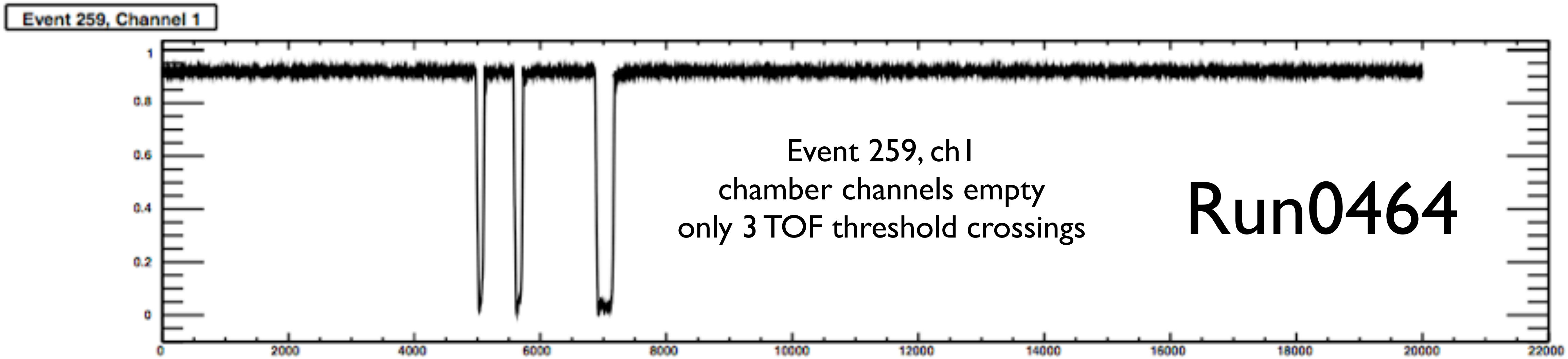


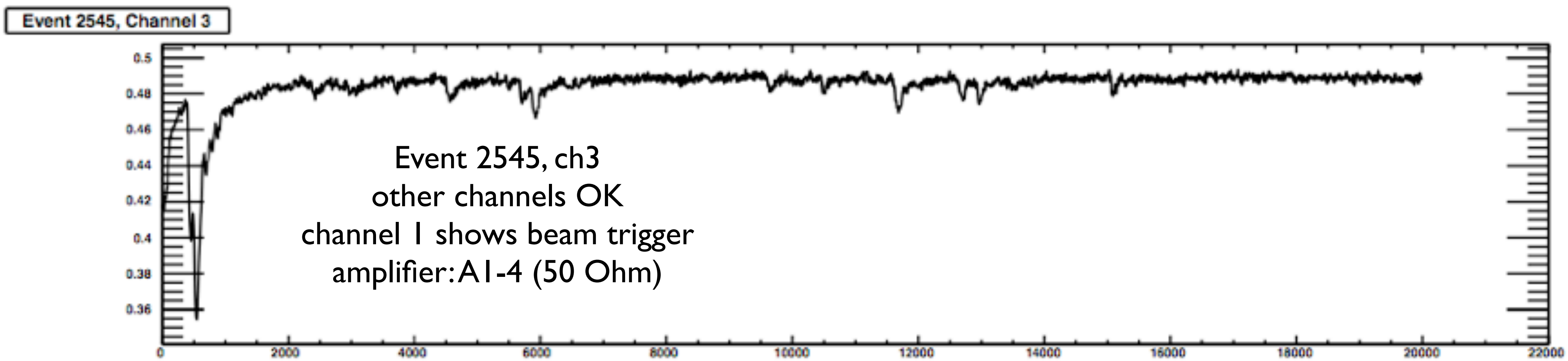
Integration time determined by optimizing muon rejection at 90% pion efficiency.

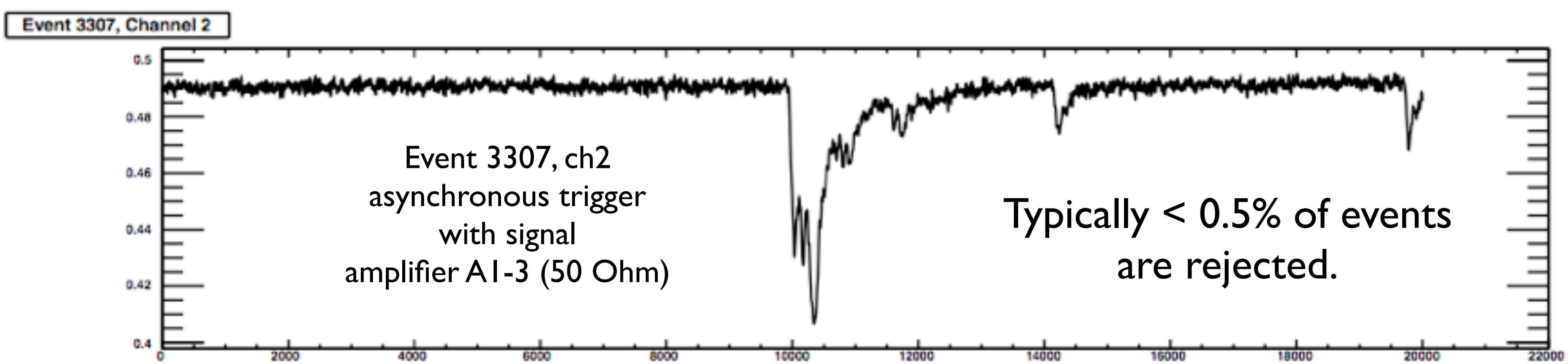
May not be optimal for this particular event.

amplifier: cc194-1 inv (370 ohm)

Rejected Signals

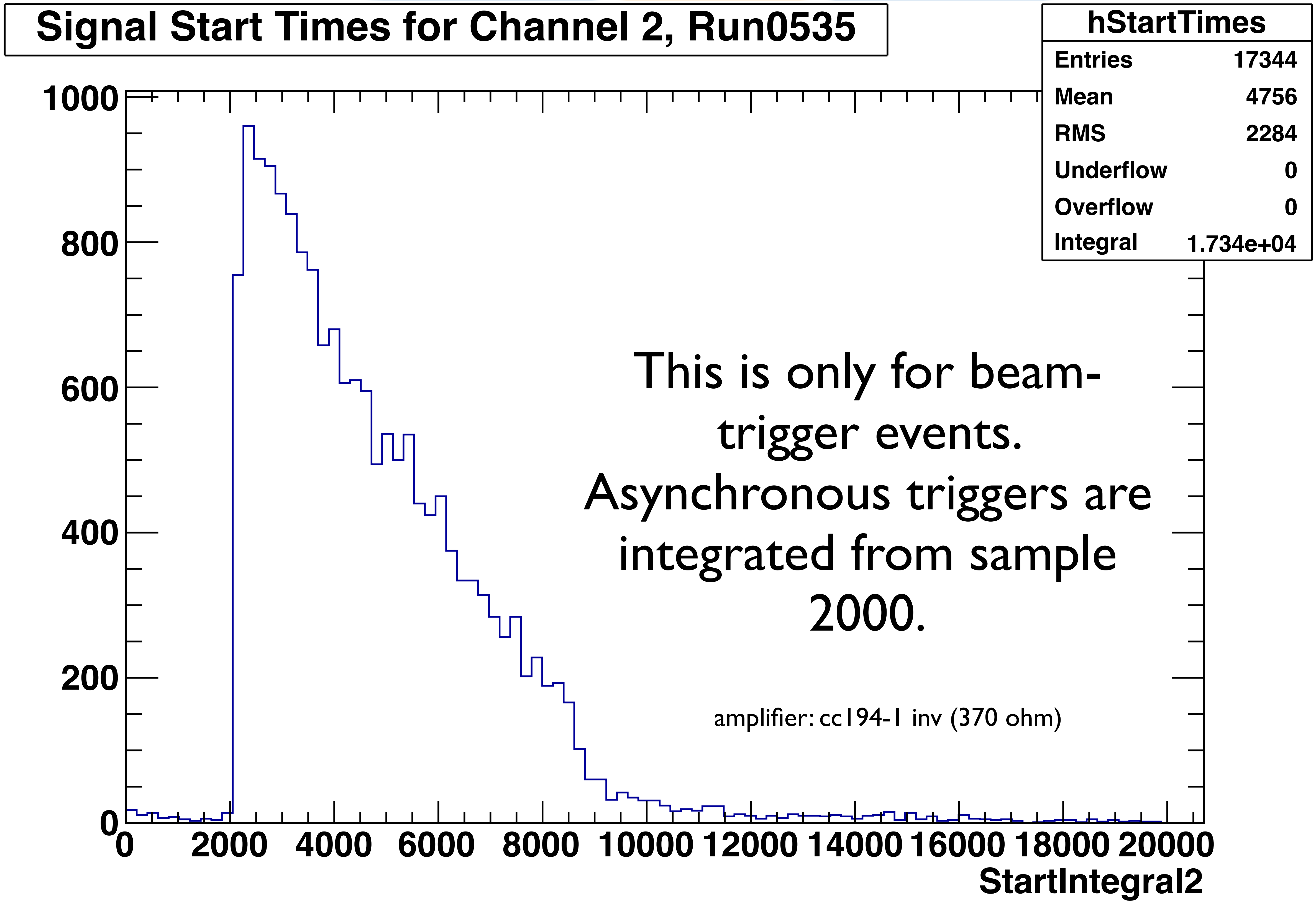






Typically < 0.5% of events are rejected.

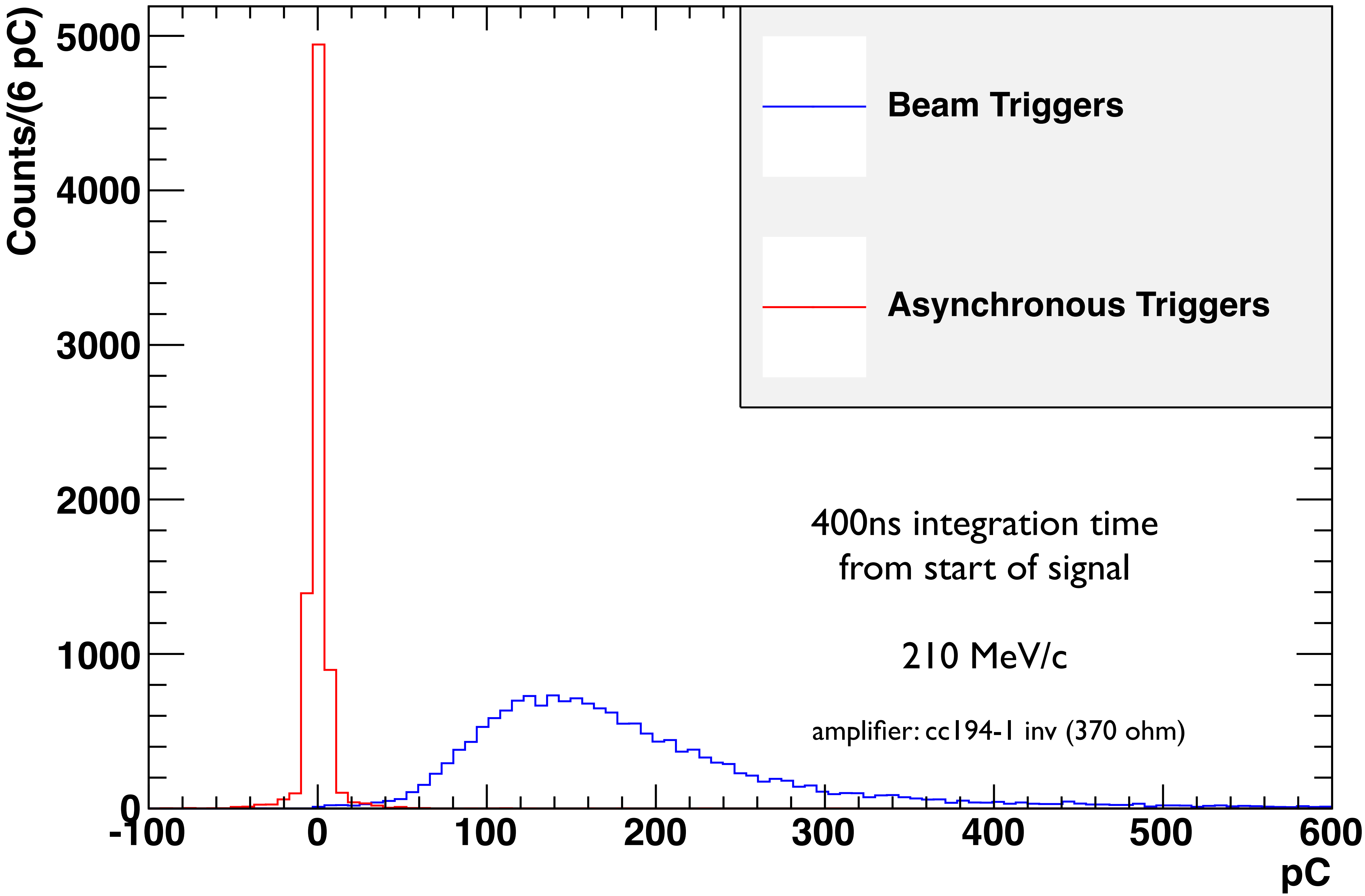
Signal Start Times



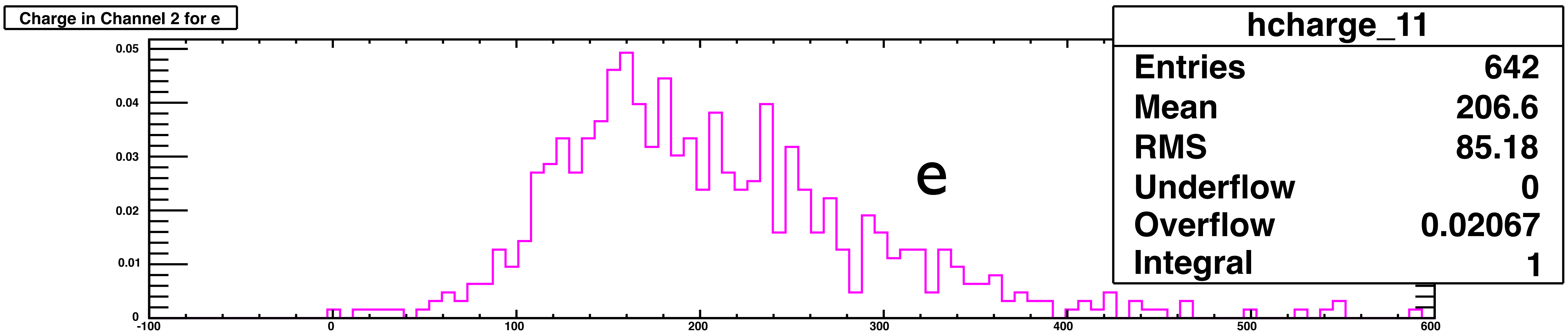
This is only for beam-trigger events. Asynchronous triggers are integrated from sample 2000.

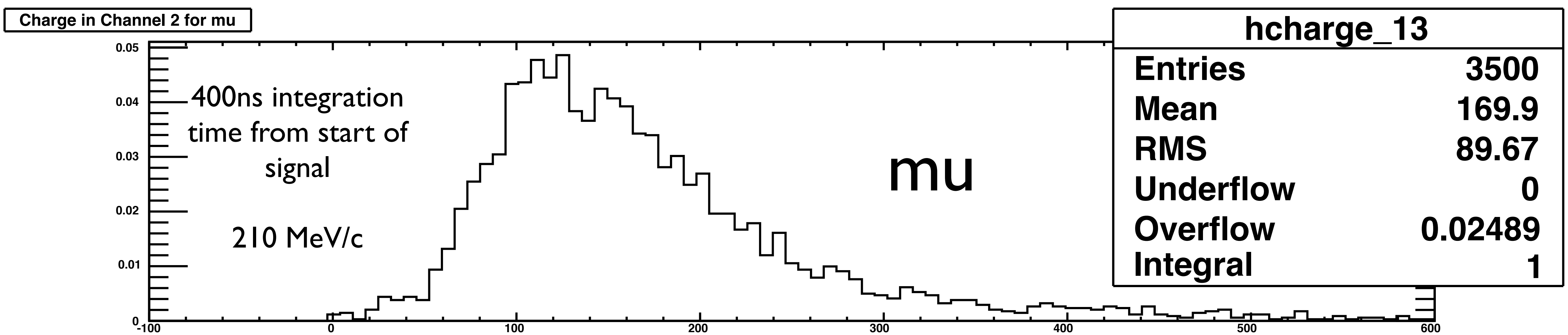
amplifier: cc194-1 inv (370 ohm)

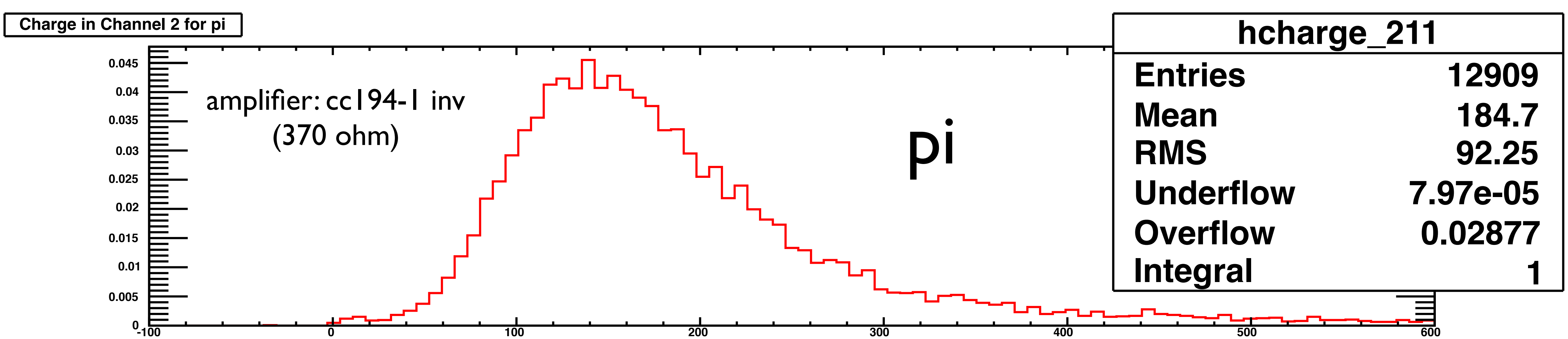
Integrated Charge (Single-Cell)



Integrated Charge (Single-Cell)







More Warnings!

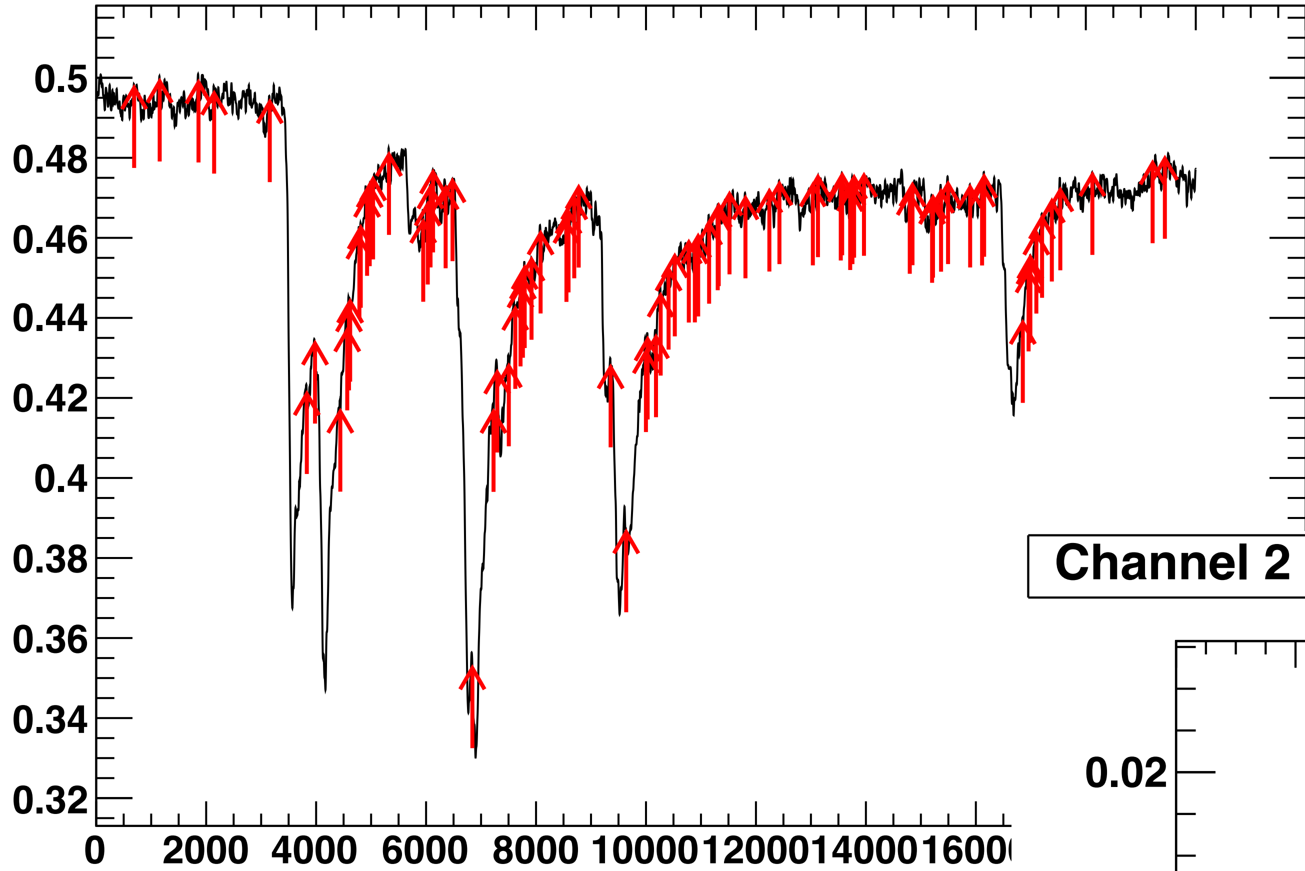
The cluster counting results you are about to see look very strange. You may wish to leave the room.

The parameters were optimized to give the best muon/pion separation at 210 MeV/c, but the best parameters give huge numbers of fake clusters.

Aesthetic judgements aside, it is not unreasonable that the best way to use cluster counting is by overcounting them.

Cluster Counting

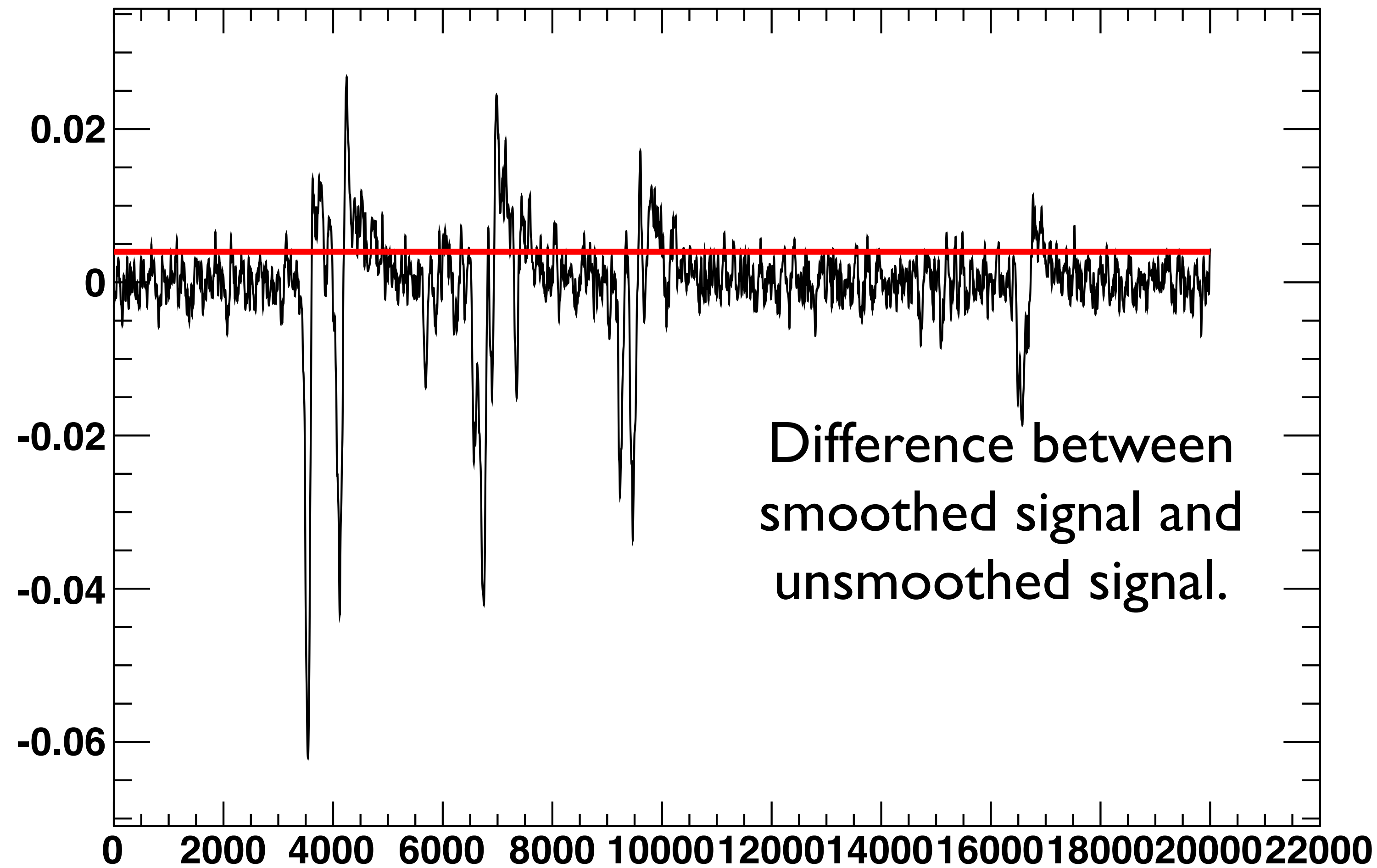
Channel 2 Entry 7



A moving average is formed, from which is subtracted the unsmoothed signal. The result must cross a threshold.

Threshold is accidentally set positive, but parameters were optimized this way.

Channel 2 Entry 7 CC

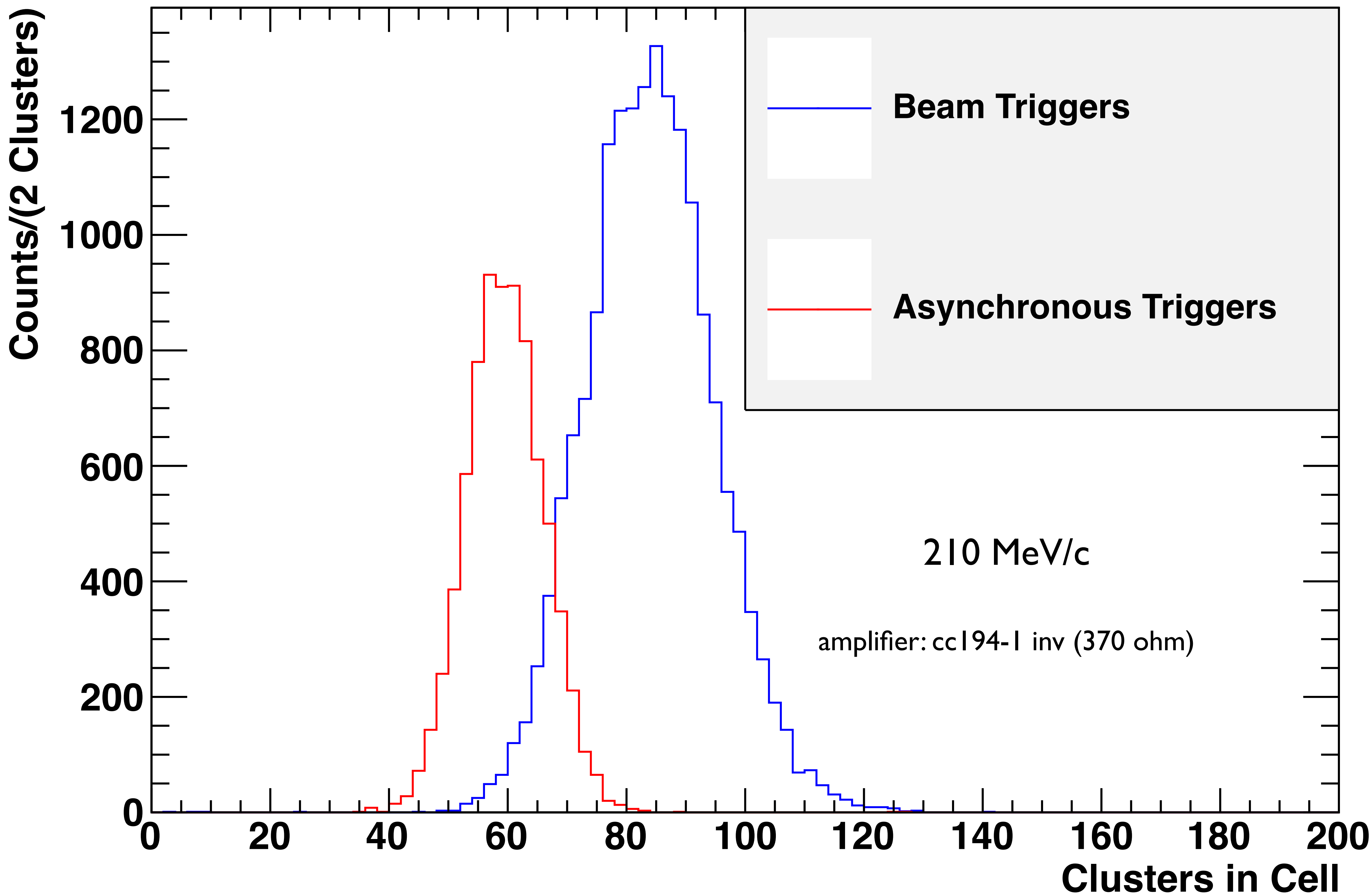


Difference between smoothed signal and unsmoothed signal.

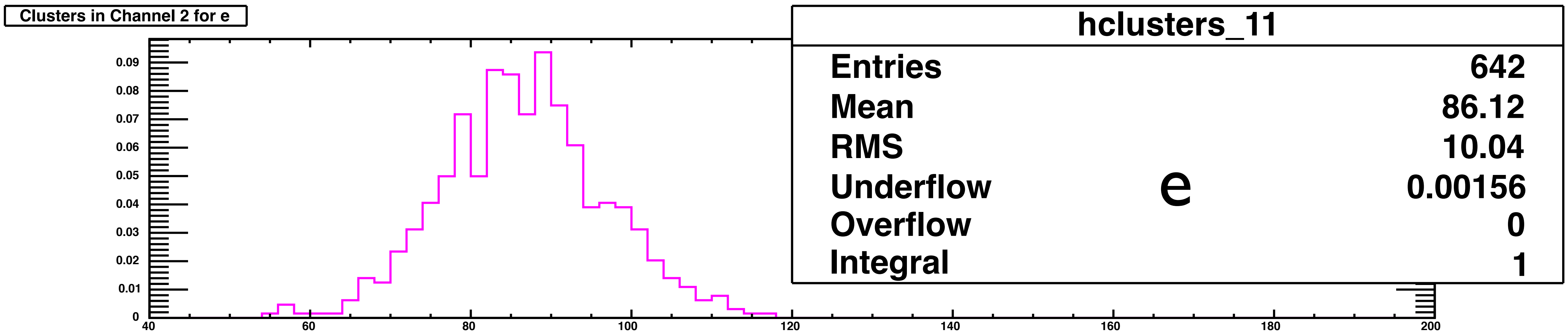
Averaging window and thresholds need to be fully optimized, but results indicate an even lower threshold would be better!

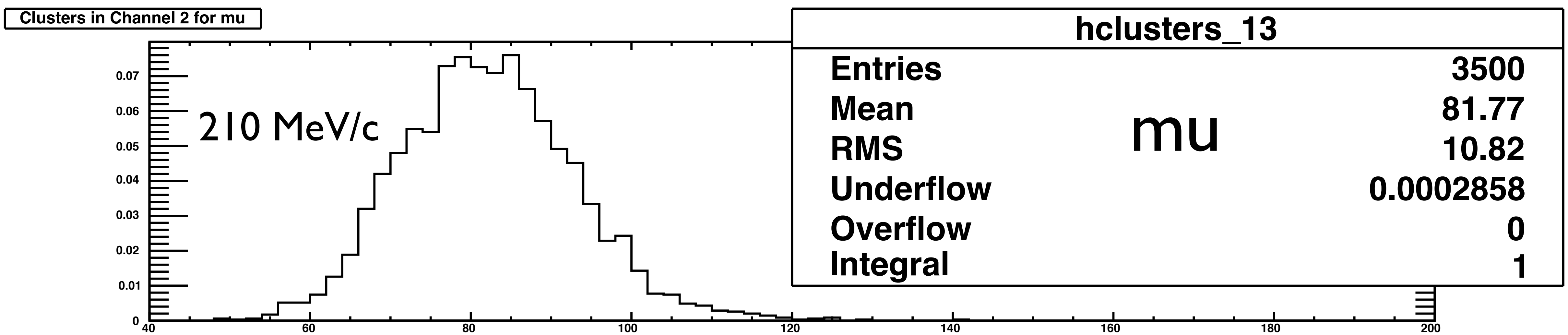
Here averaging is over 5ns, threshold 4mV.

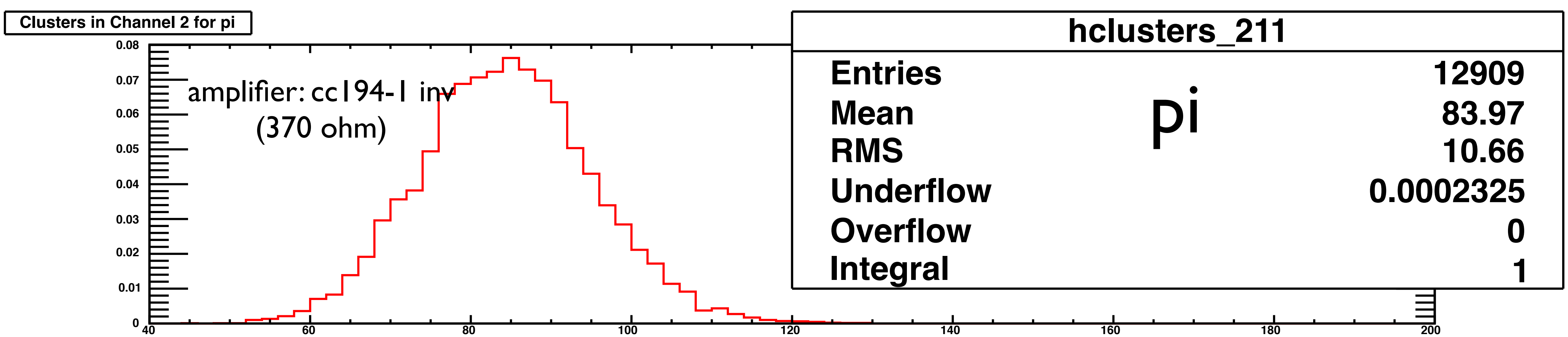
Cluster Counts (Single-Cell)



Cluster Counts (Single-Cell)







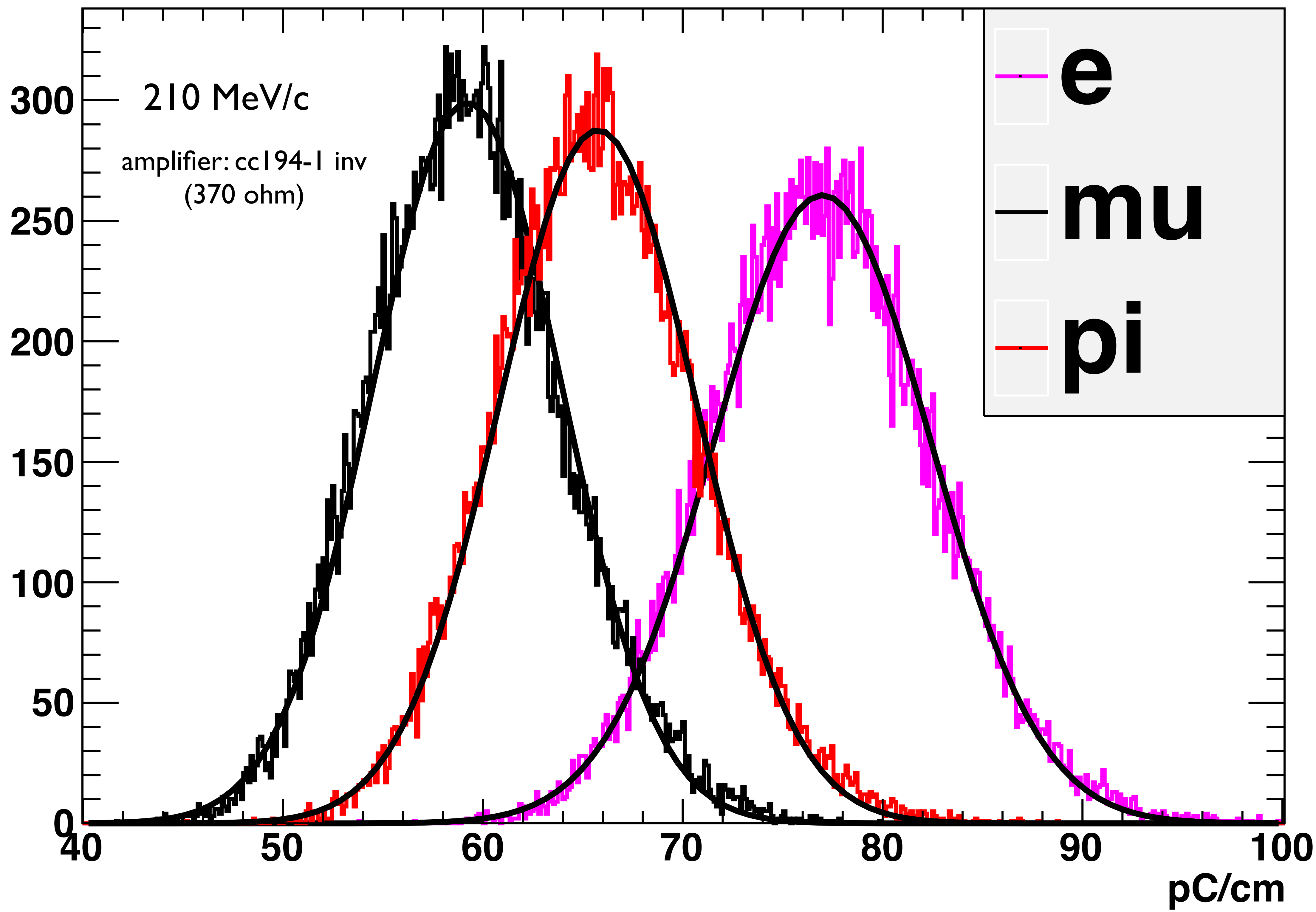
Bootstrapping Basics

Particles are identified by TOF: must be within 3 sigma of mean of Gaussian fit.

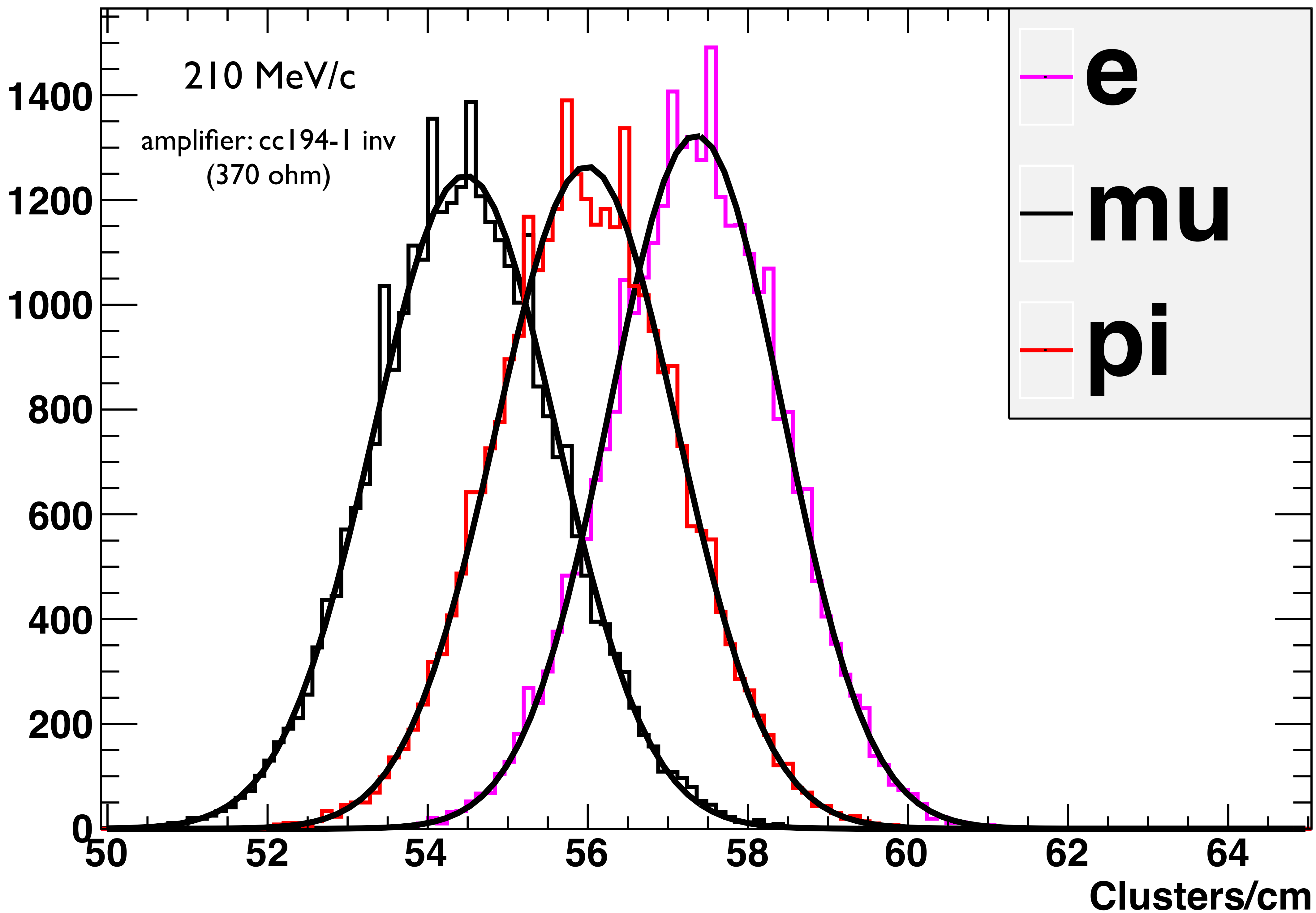
Tracks are composed of randomly-selected same-PID triggers.

Track-wise dE/dx and cluster counts are done.

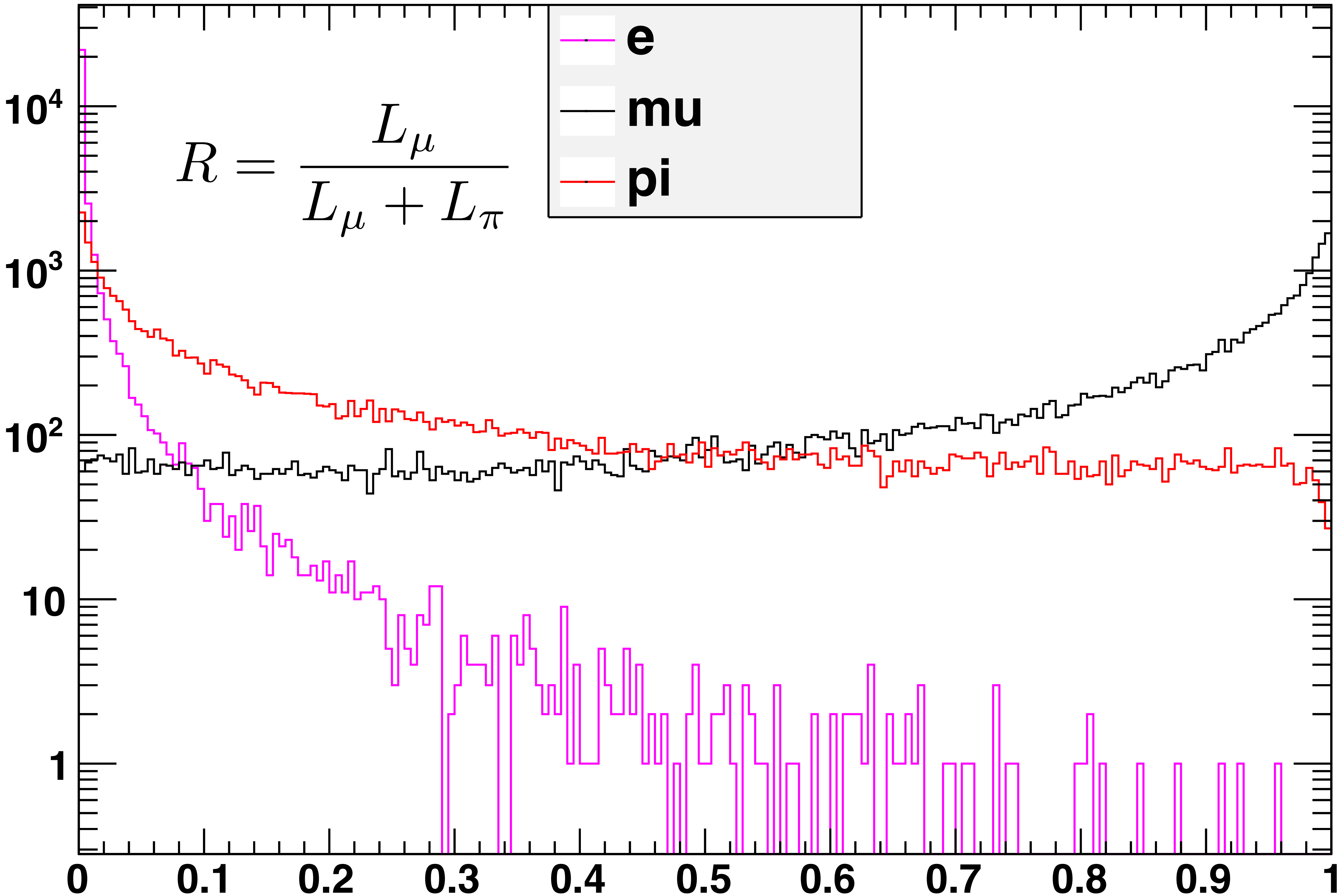
Truncated Mean Charge (70%)



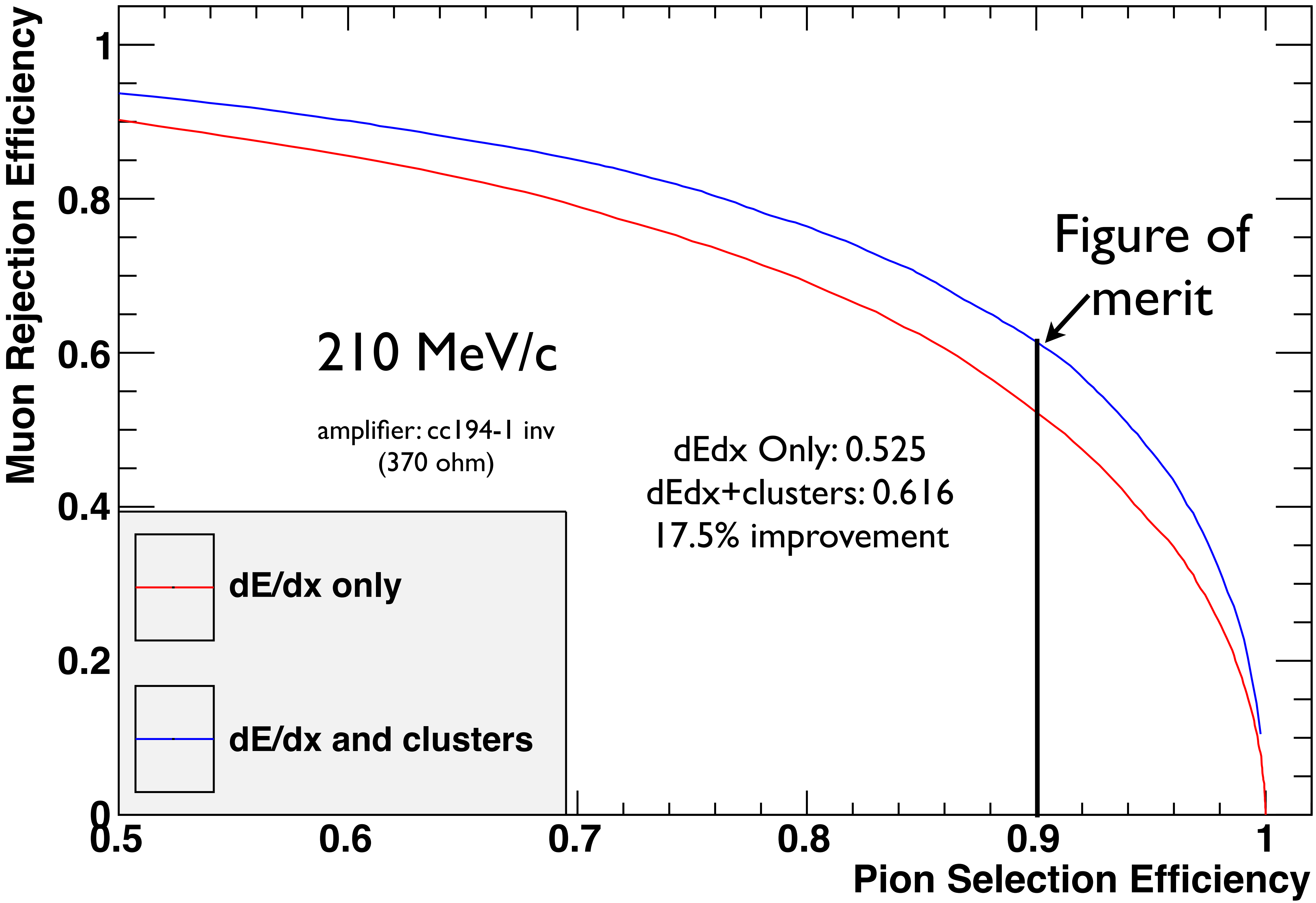
Cluster Counts (Full Track)



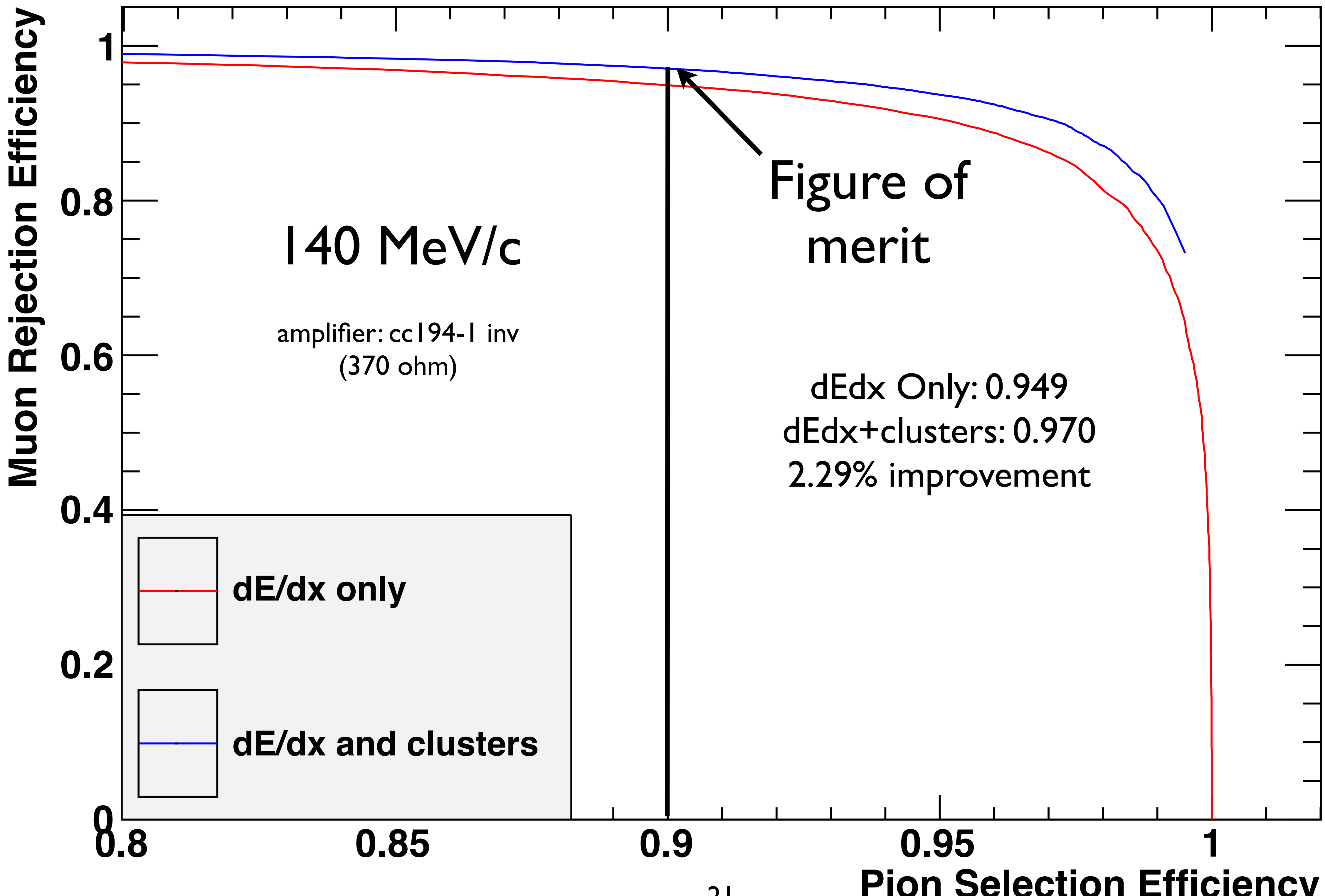
Combined Likelihood Ratio



Pion Selection/Muon Rejection



Pion Selection/Muon Rejection



Next Steps

- Optimize charge integration times for all amplifiers.
- Optimize cluster counting averaging time and thresholds.
- Test other CC algorithms.
- Calculate figure-of-merit for each setup variation (20/25/30 um wire, gas gain, connectors, amplifiers).
- Maybe use more sophisticated statistical tool than likelihood ratio?
- Current bottleneck is calculation of likelihood ratio: re-implement in C++ rather than Python?

Backup Slides

TOF Rejections

Events which have zero threshold crossings are usually asynchronous triggers.

Events with 4 TOF threshold crossings are usually beam triggers.

Events with neither 0 or 4 are rejected.

Signal Determination Details

Baseline and threshold is obtained from previous asynchronous trigger.

Baseline = average of smoothed asynchronous event.
RMS = true RMS of smoothed asynchronous event.

(Smoothed signal - Baseline) < 5*RMS is a threshold crossing.

Start time of signal taken 5ns before threshold crossing. Smoothing is an average done over 5ns.

Beam events whose signals did not properly cross the threshold are rejected.

This algorithm is also applied to asynchronous events, if they cross the threshold, a warning is printed but the event is not rejected.

Charge Integration Details

From the signal start, as described earlier, the unsmoothed signal is integrated over a fixed duration.

For asynchronous events, the integration starts at an arbitrary time of 2000ns.

The charge is baseline-corrected by subtracting the integral of the previous uncorrelated trigger.

I determined that an integration time of 400ns to be appropriate for the amplifiers used in the runs shown. The optimal value depends on the specific amplifier.

Cluster Counting

I implemented my own version of Sam Dejong's algorithm. It checks if the signal at time t exceeds the smoothed signal at time t-1 by more than a certain amount. If so, that is called a cluster.

The smoothing is an average over 5ns, the threshold is 0.004V. The values were chosen by optimizing a figure of merit. First-round optimization returned the boundary values, so we need to keep searching.

The code returns not just a count of the clusters, but the position of each. The implementation also allows easy drop-in replacement algorithms.

Bootstrapping

The TOF spectrum is fitted with the sum of three Gaussians, for electrons, muons, and pions. (See slide 3)

Each event is then assigned a PID value depending on its TOF value. If it is within 3 sigma of a fitted Gaussian peak, it is assigned that particle type, otherwise it is unknown.

40-cell tracks are constructed by putting together 40 events with the same PID value. The events are randomly selected with replacement.

For the tracks, the 70% truncated-mean charge and cluster counts are obtained.

The dE/dx and cluster information for each hit in each track are consistent, due to the way the code is structured.

Likelihood Ratio

Fit with Gaussians both dE/dx and cluster distributions for each species. Obtain mean and standard deviation for each.

Likelihood (for dE/dx or cluster count) for each track is the probability density of the actual dE/dx or cluster measurement according to the fit. Total likelihood is the product of the dE/dx and cluster probability densities.

The likelihood ratio is formed from the total likelihoods of being a pion and muon.

i Species

Q Track dE/dx

N Track Clusters

P pdf of Gaussian fit

$$L_i = P_{i,Q}(Q) * P_{i,N}(N)$$

$$R = \frac{L_\mu}{L_\mu + L_\pi}$$