Cluster Counting Update

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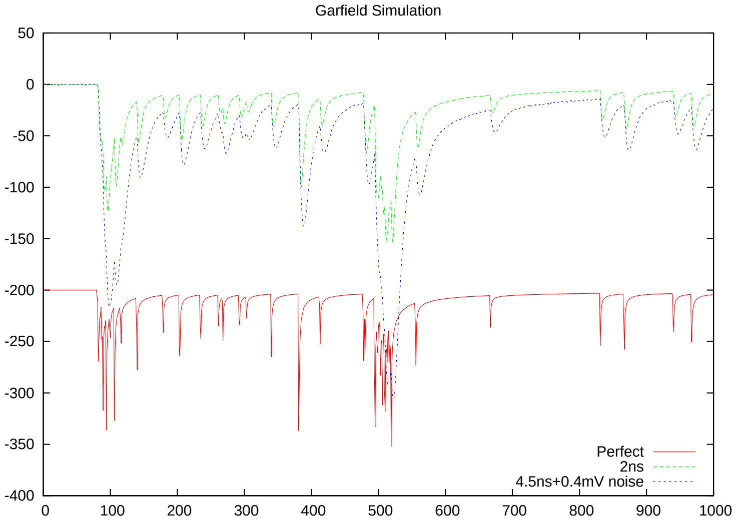
Overview

Here I present recent results in the cluster counting efforts. The approach is now to determine what gains can be obtained with a given cluster-counting efficiency. We isolate one source of nearly irreducible inefficiency. Pion-kaon separation is examined for the first time.

Technical Notes

All simulated data uses a single square 30mm cell, Helium:Isobutane 90 : 10, delta rays disabled.

Garfield Simulation Results



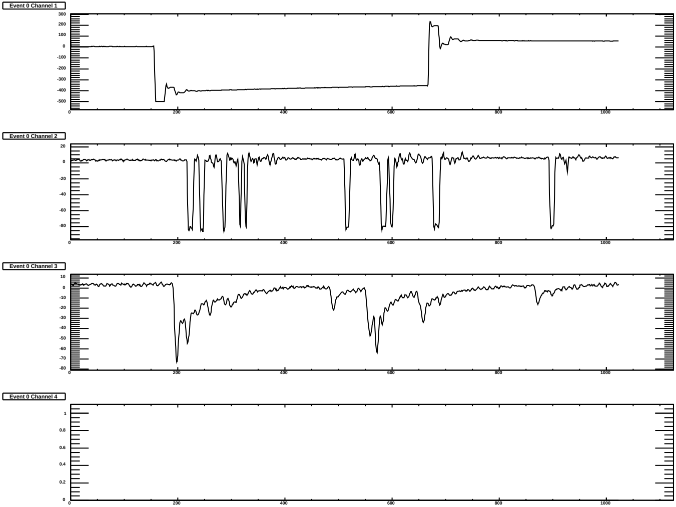
Shaping Function

$$s(t) = \frac{t}{\tau} e^{-\frac{t}{\tau}} \tag{1}$$

$$(f \star s)(i) = \sum_{j=-\infty}^{\infty} f(j) s(i-j) \tag{2}$$

This is all implemented using Python.

Data

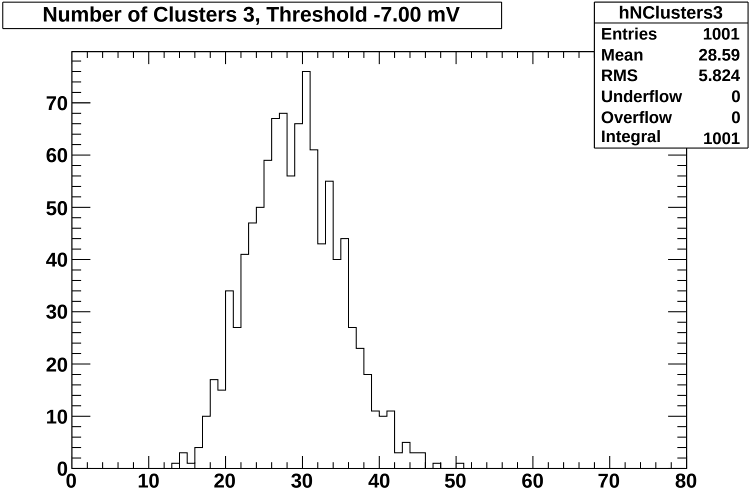

Event 0 Channel 1
Event 0 Channel 2
Event 0 Channel 3
Event 0 Channel 4

Shaping Time Constant

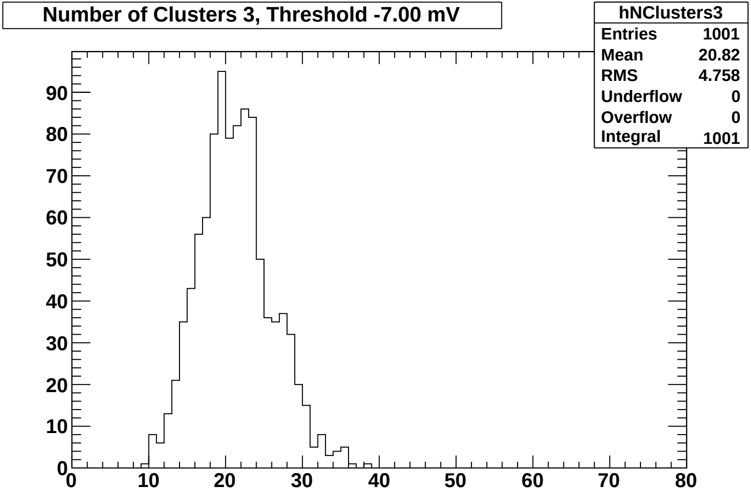
A shaping time constant of around 4 nanoseconds with some random noise converts the ideal Garfield results into something that looks like our data. The time constant is determined by the choice of electronics (shaping amplifier) but also by the electrical properties of the chamber. Note that the correct scaling factor for the shaping function is not well-determined, so though clusters can be counted, values of voltage (and thus charge deposited) should be taken as qualitative.

Unfortunately a long time constant hinders our ability to count clusters.

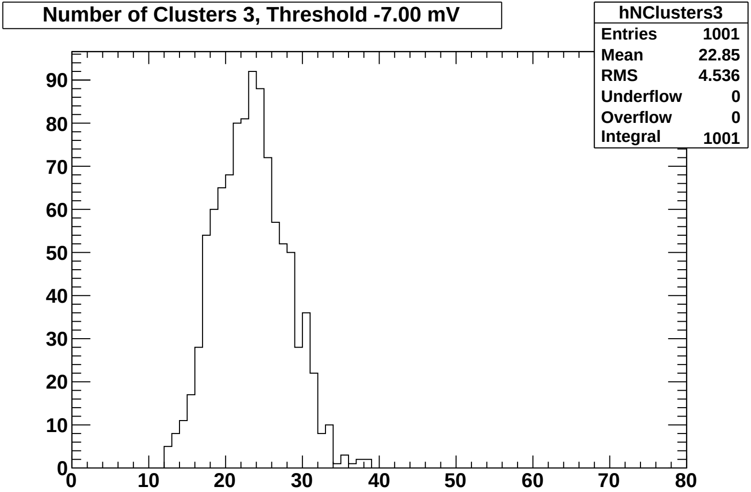
Clusters With “Perfect” Signals



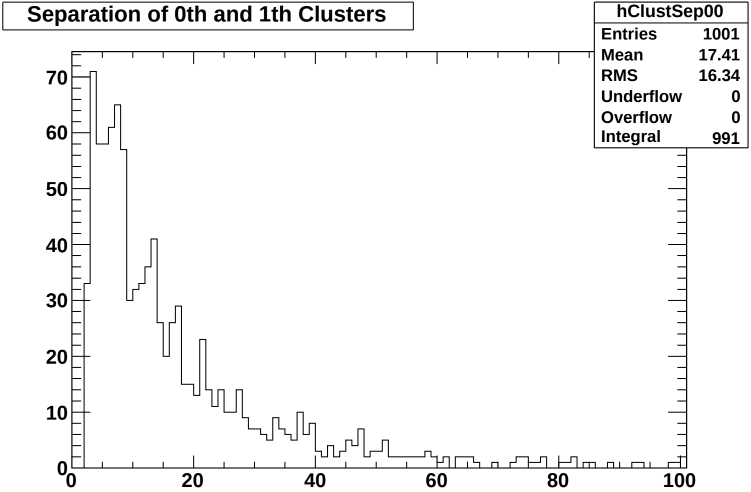
Clusters With $\tau = 2$ns



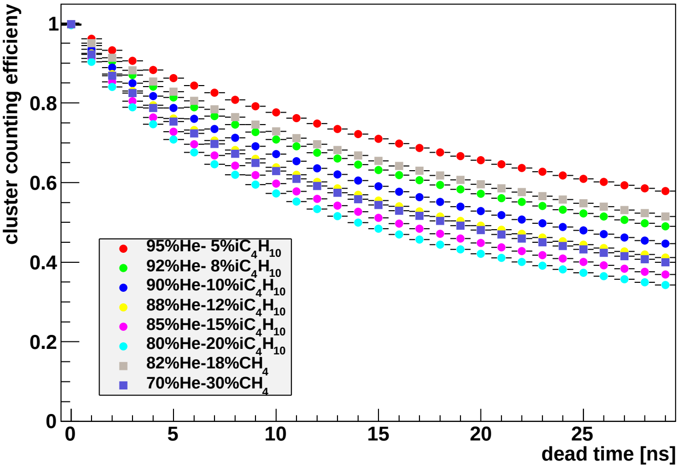
Clusters With $\tau = 4.5$ns and 0.4mV Noise



Cluster Separation ("Perfect")



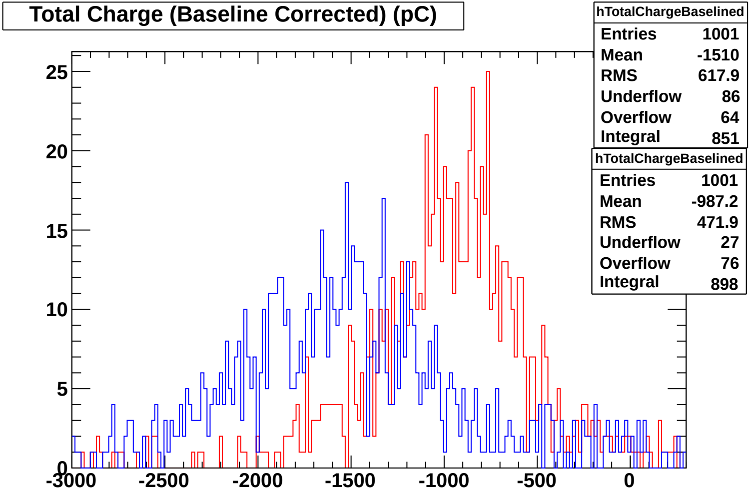
Cluster Counting Efficiency (from Giuseppe)



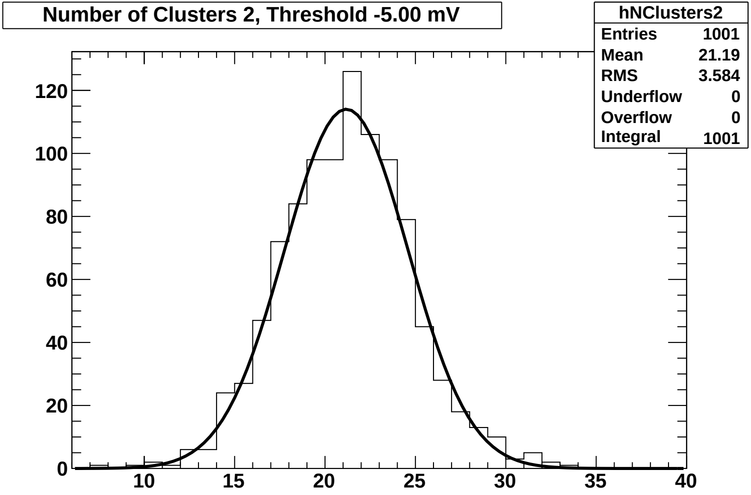
Pion-kaon separation

This is one area where cluster counting is hoped to dramatically improve results. The ionization behavior goes like $\frac{1}{m}$ whereas the actual tracks are nearly identical since they are relativistic. Even cluster counting which is not perfectly efficient could distinguish them.
We use 489 MeV momentum tracks, 4.5ns time constant for shaping, and 0.4mV RMS noise.

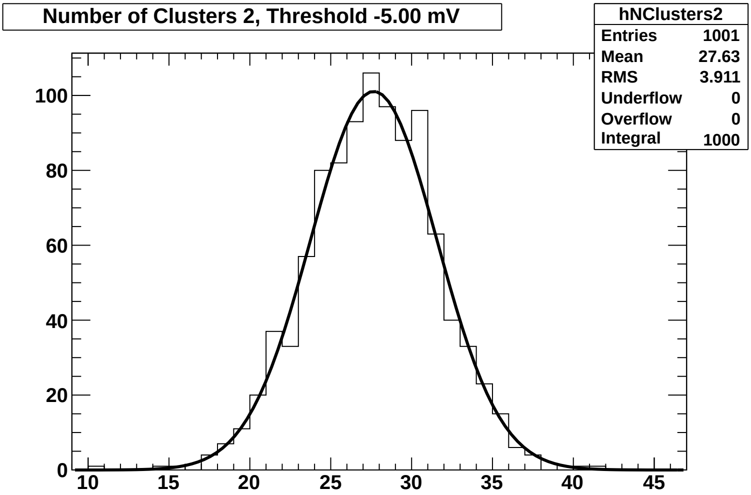
Deposited Charge (Red=π,Blue=K)



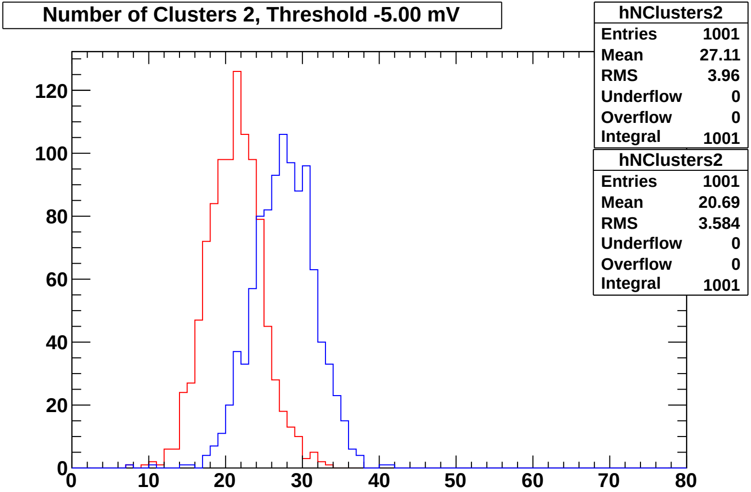
Counted Clusters for Pions $\mu = 21.2, \sigma = 3.4$



Counted Clusters for Kaons $\mu = 27.7, \sigma = 3.9$



Counted Clusters (Red=π,Blue=K)



Conclusions

It is encouraging that we notice any difference between the pions and kaons in terms of clusters. Once the effect of the electronics is better understood, a quantitative estimate of the gains from cluster counting can be made.
Now that garfield simulated tracks can be analysed in a similar manner as real data from our drift tubes, we can use comparisons to take advantage of both methods.