Cluster Counting in Helium Based Gases

By Sam Dejong

Outline

- Introduction
    - Ionization
    - Cluster counting
    - Helium

- UVic Test Chamber

- Sample Traces in various mixtures

- Cluster Counting algorithm
    - Example
    - Choosing a threshold

- TRIUMF Testbeam

Ionization

- Charged particle deposits energy via ionization

- Ionization is a Poisson process

- Ejected electron ionizes gas around it forming clusters

- Counting primary ionization allows for improved particle identification, by reducing the spread around the mean
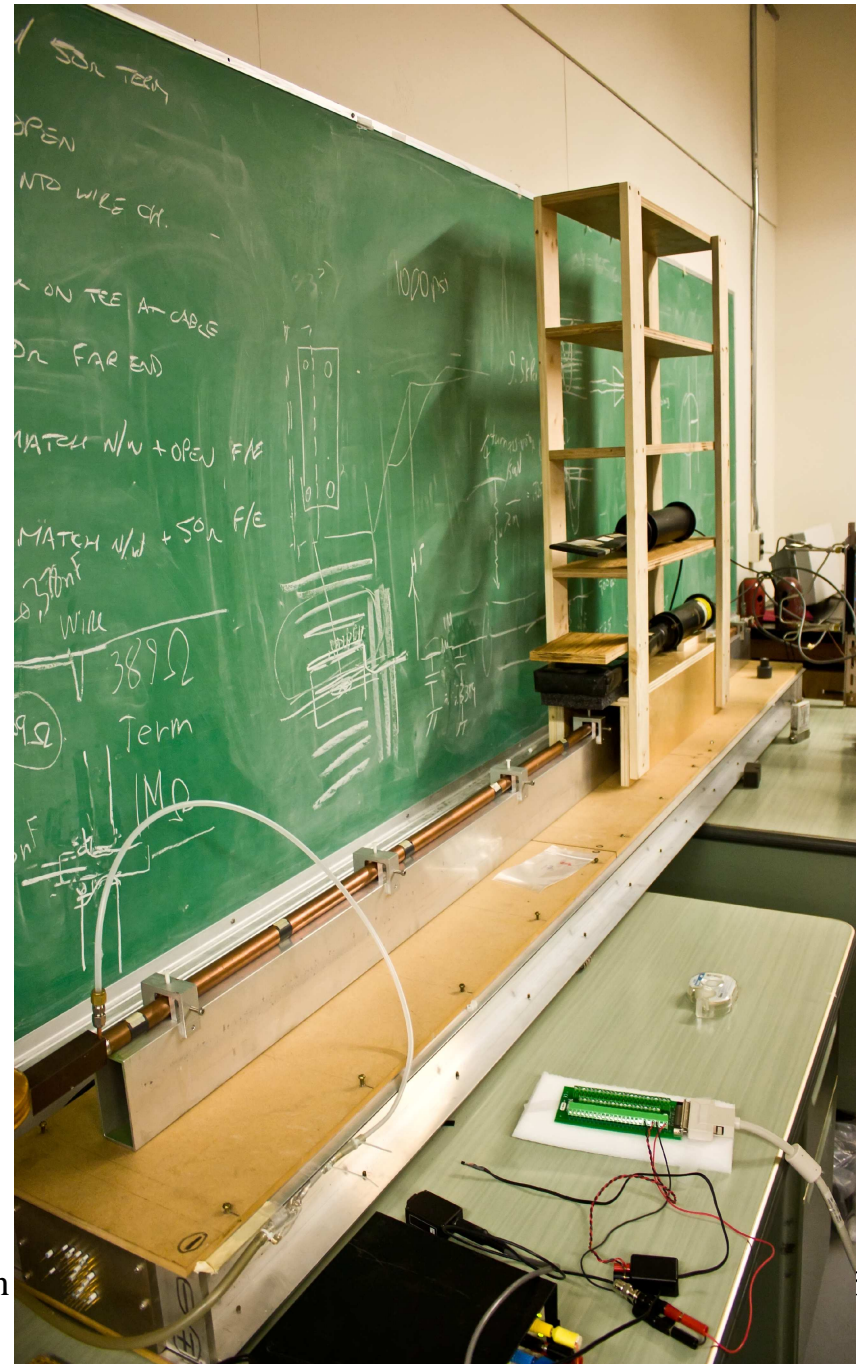
Cluster counting

- Need to single out structures from arrival of electrons from the same structure

- Pulses from different clusters must not overlap in time

- Time between pulses from same cluster must be small to prevent over counting

- Incompatible requirements, must use optimal conditions

Helium

- High ionization potential
    - Fewer clusters, so larger gap between them
- Low drift velocity
    - Amplifies cluster seperation
- High ion mobility
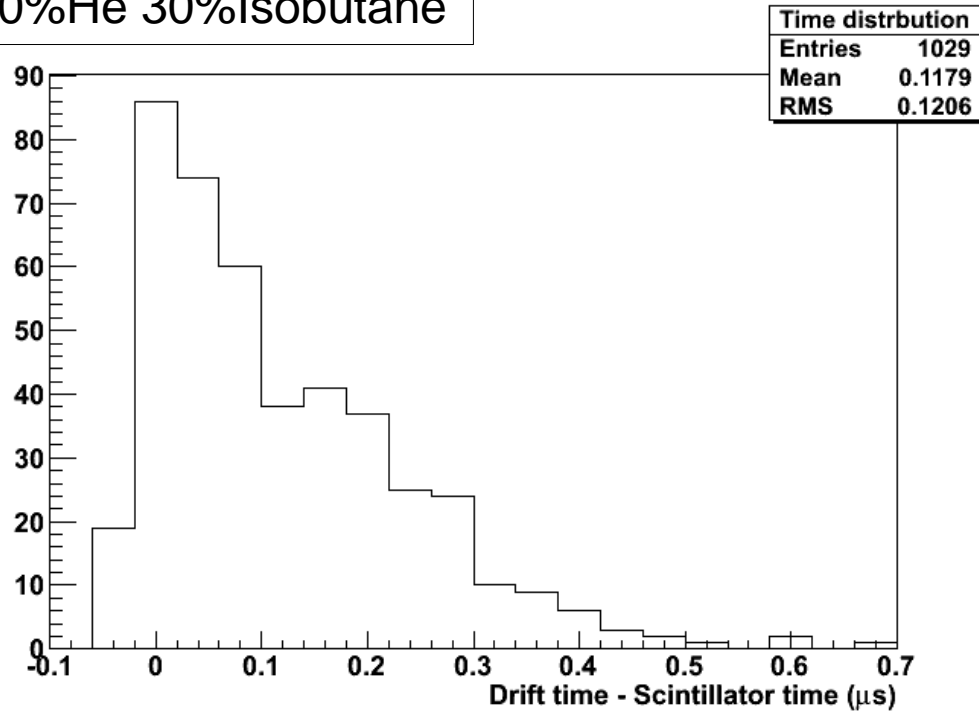   - Clear up space charge region quickly

UVic Test chamber

- 2.7m long copper 2cm diameter tube

- Ran with various Helium based gas mixtures:

  - 70% He, 30% Isobutane

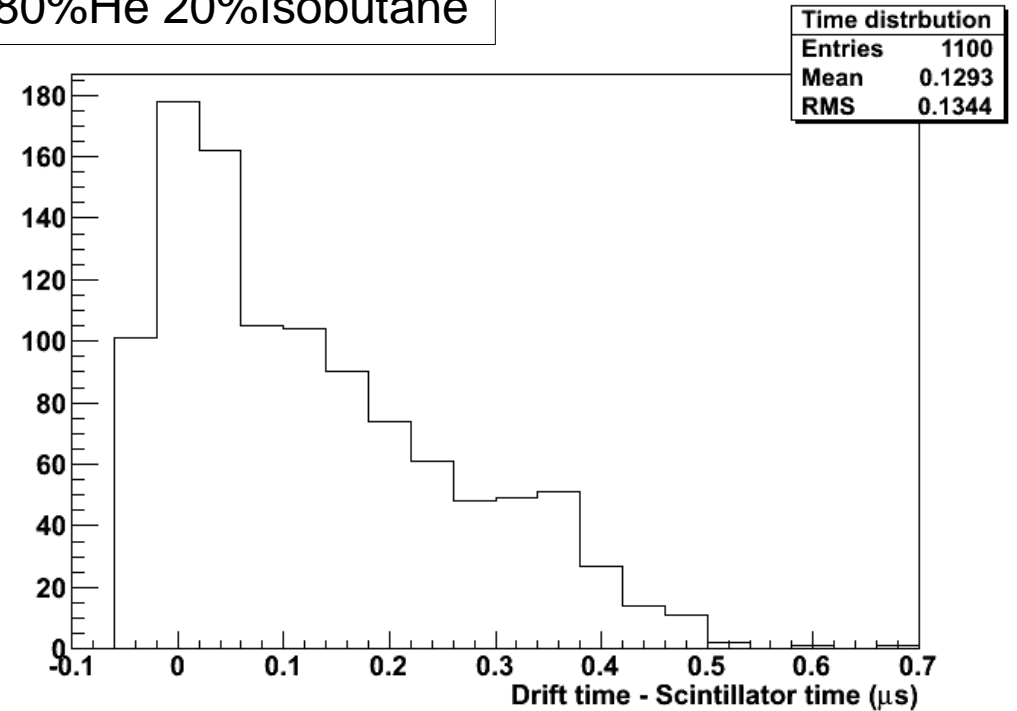 - 80% He, 20% Isobutane

  - 90% He, 10% Isobutane

SuperB Collaboration

Time Distribution

70%He 30%Isobutane

Time distrbution	
Entries	1029
Mean	0.1179
RMS	0.1206

80%He 20%Isobutane

Time distrbution	
Entries	1100
Mean	0.1293
RMS	0.1344

Drift time - Scintillator time (µs)

- Pair of scintillators used to trigger on chamber.

- Time difference between scintillator and drift chamber is plotted here

- Measuring cosmic rays

Sample traces

- Garfield is still in the process of being tuned.

- Using transfer function:

$$1 \times 10^{-13} \left(\frac{6t}{0.01} \right)^6 e^{\frac{6t}{0.01}}$$

- Gaussian noise has been applied.

- Garfield looks superficially like real signals, but is still not quite finished.

- May result in few clusters detected in algorithm

Signal for 70-30 He-Iso mix, 1950V on bias wire

Garfield

Detector
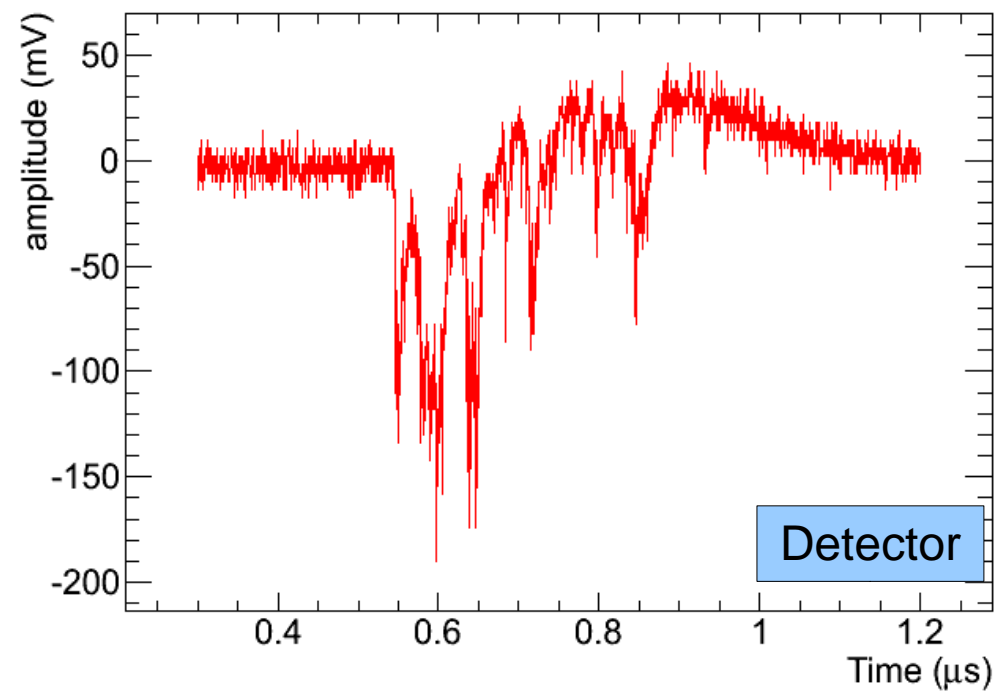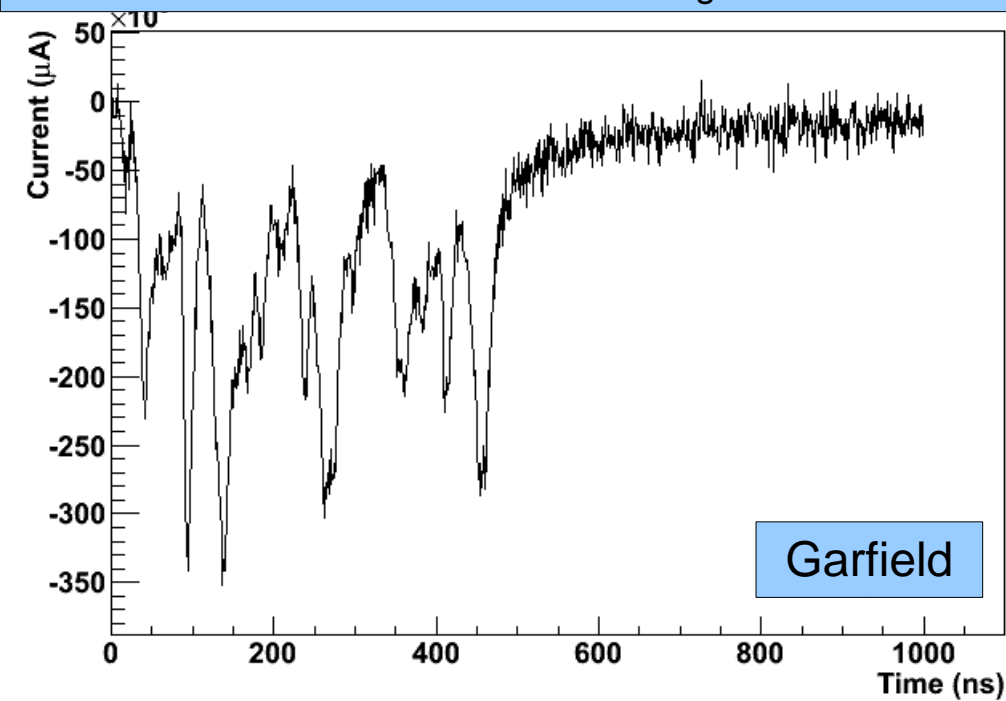
Signal for 80-20 He-Iso mix, 1950V on bias wire

Garfield
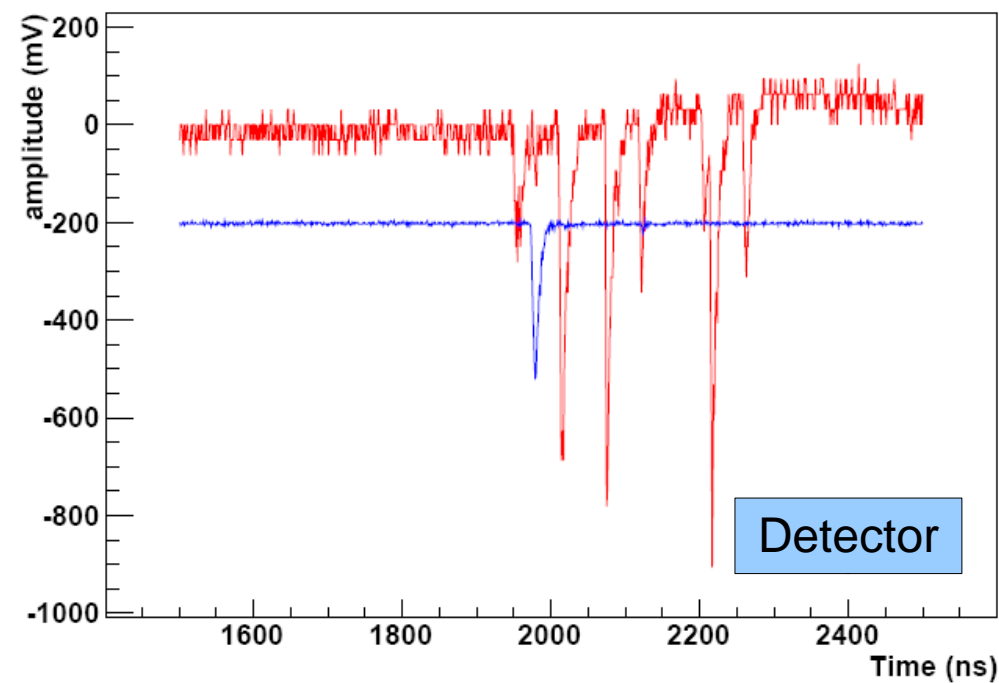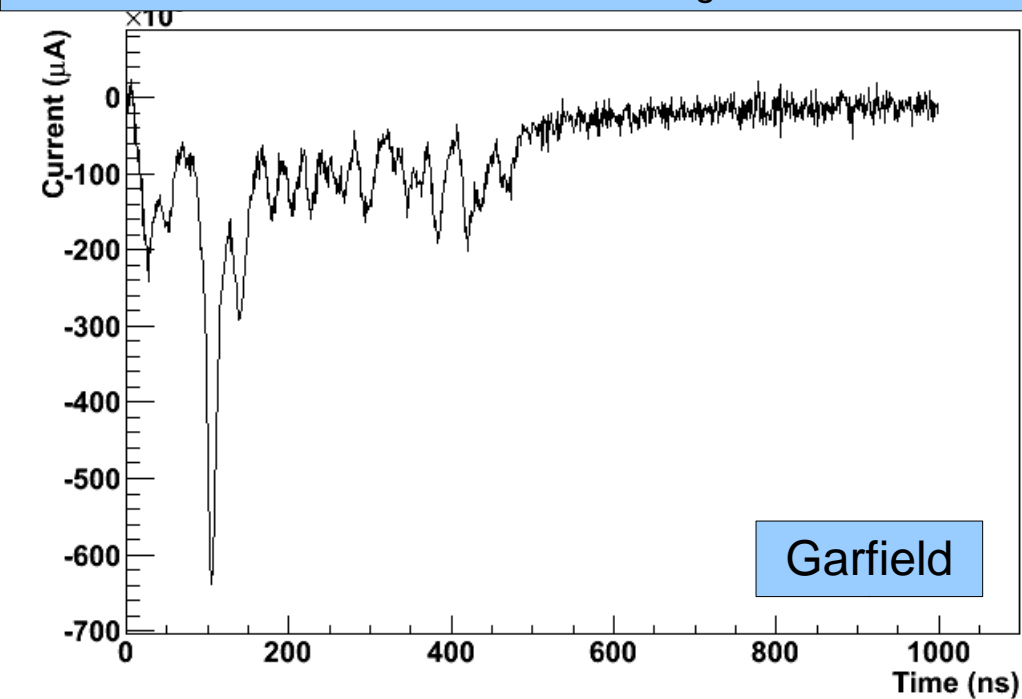
Detector

Cluster Counting Algorithm

- Smoothing of noisy data:

$$v_i^{Smooth} = \frac{(v_{i-1} + v_i + v_{i+1})}{3}$$

- Counting Clusters (Algorithm from Marcello Piccolo in previous meeting)

$$a_i = v_i - \frac{(v_{i-1} + v_{i-2} + v_{i-3} + v_{i-4} + v_{i-5})}{5}$$

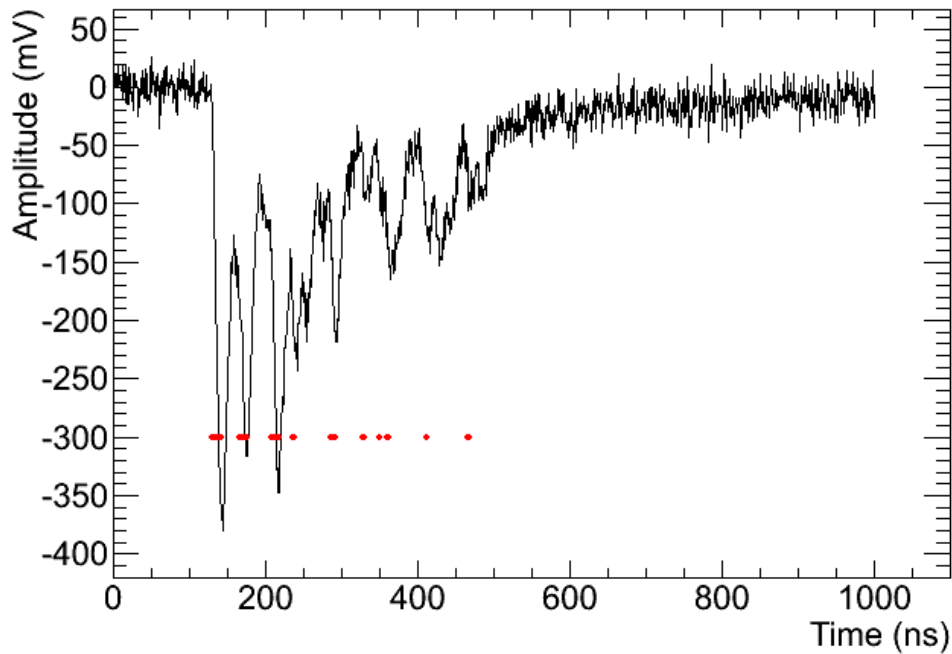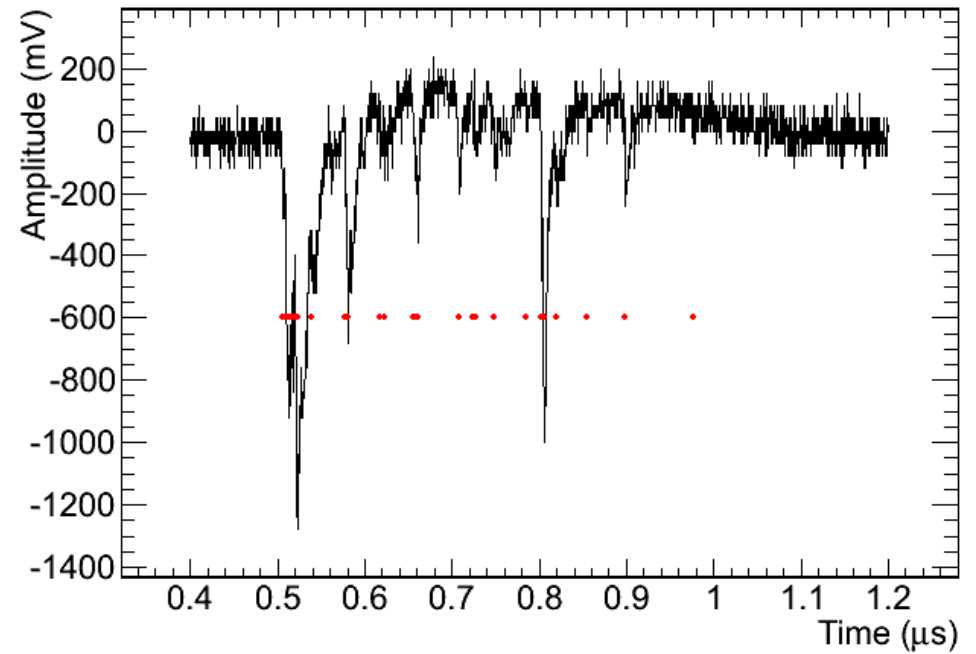- When value is past some threshold, a cluster is detected

Smoothing
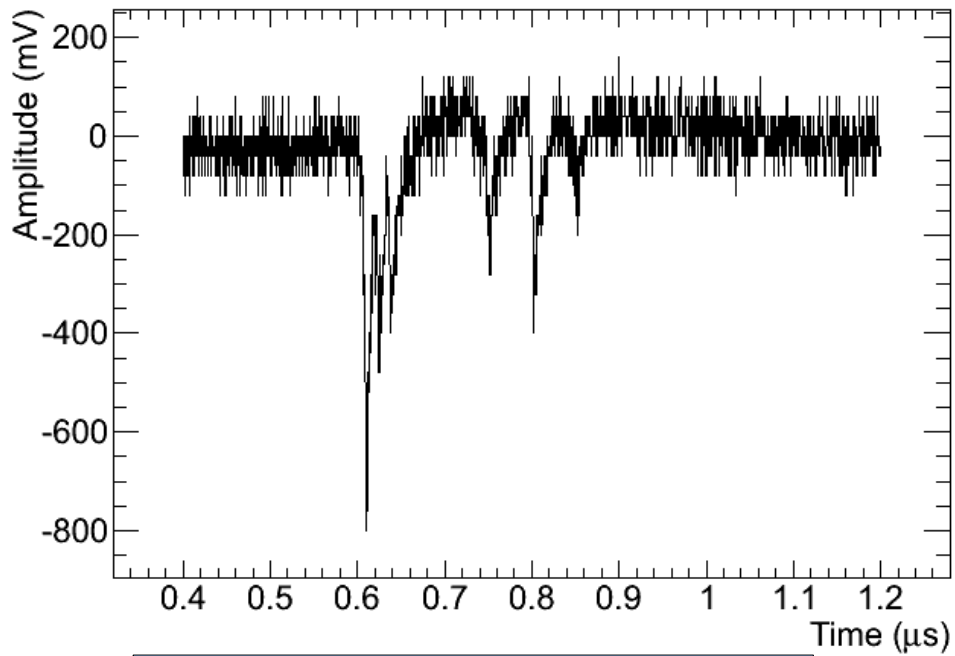
Data before smoothing
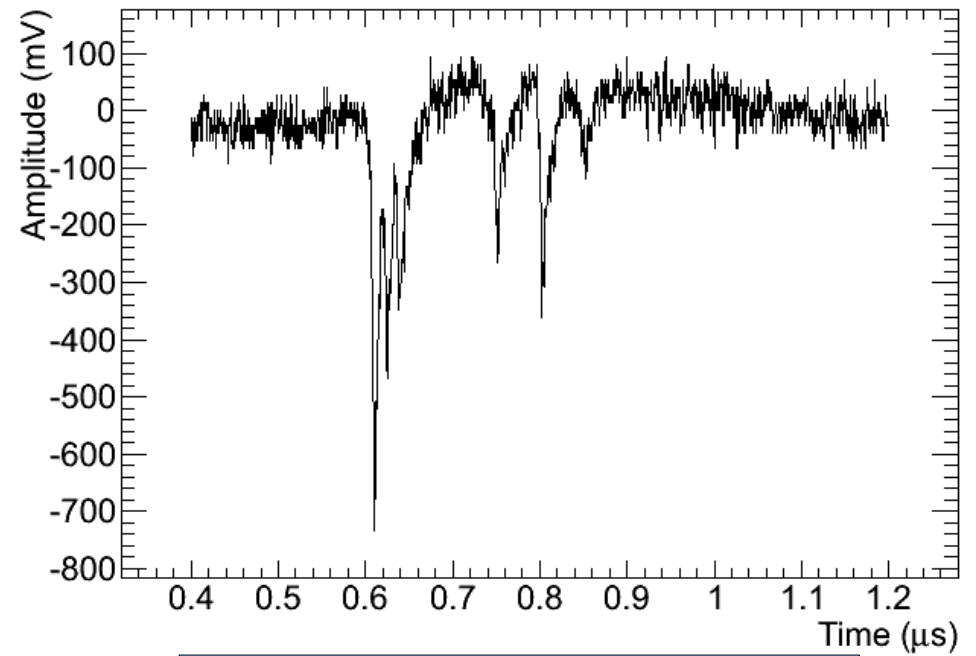
Data after smoothing
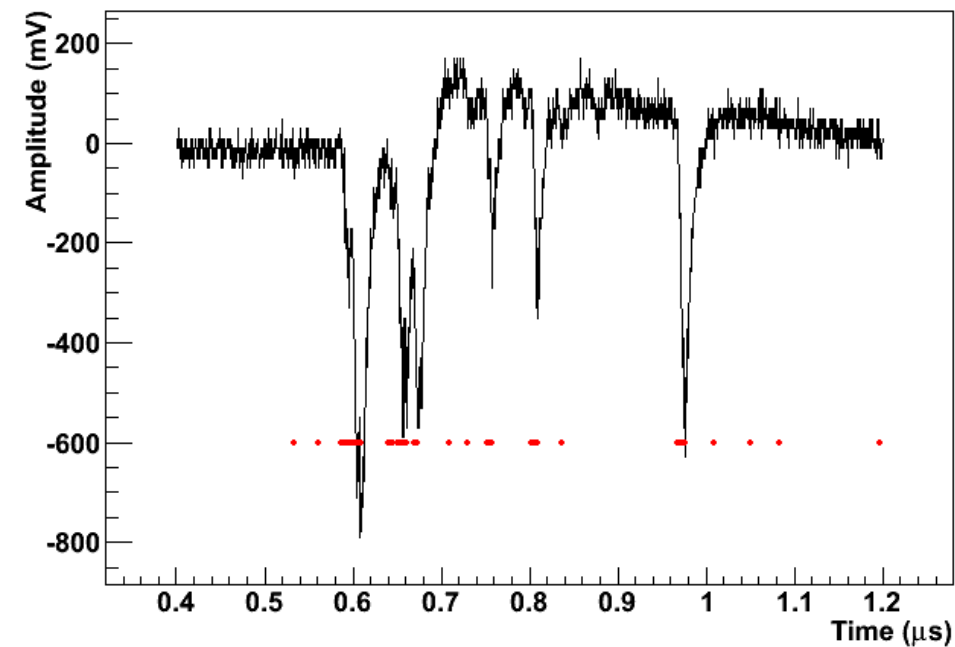
Algorithm Applied

Algorithm applied to Garfield Signal

Algorithm applied to real signal

Problems

- ## Sensitive to Threshold value

Threshold of 30

Threshold of 120

Sample trace, Cluster counting prediction: 16, event #536
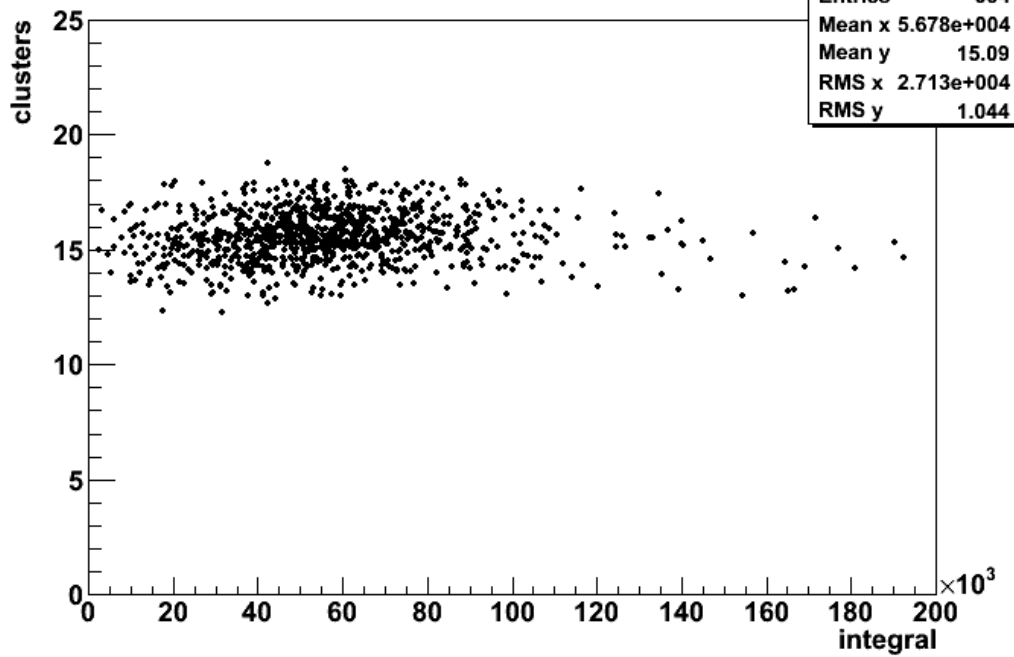

Sample trace, Cluster counting prediction: 4, event #536
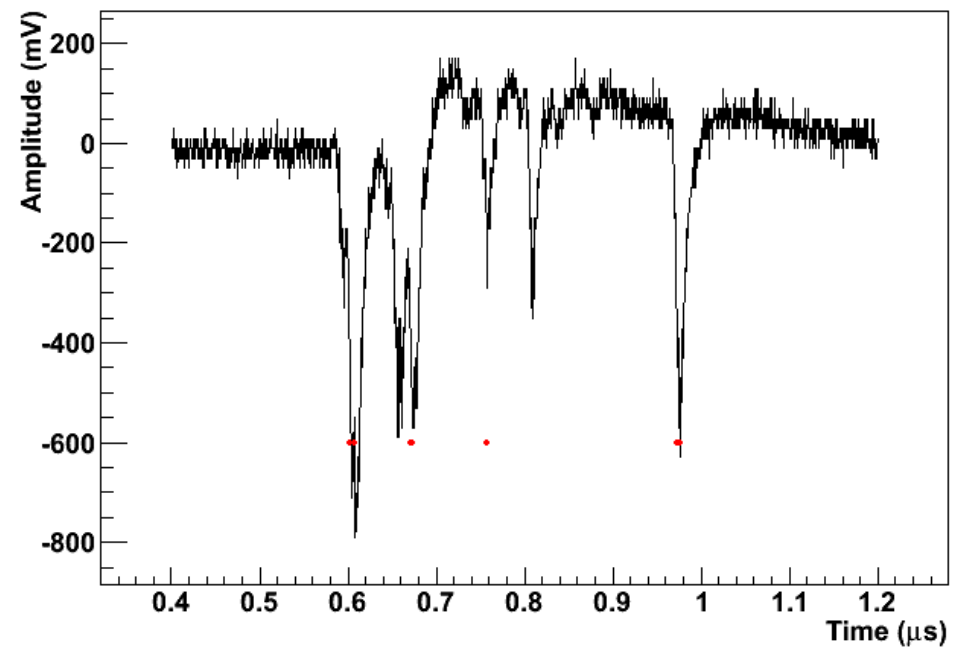
Integrated signal vs Clusters detected

- The integrated signal was plotted against the number of clusters detected by the algorithm for different threshold values
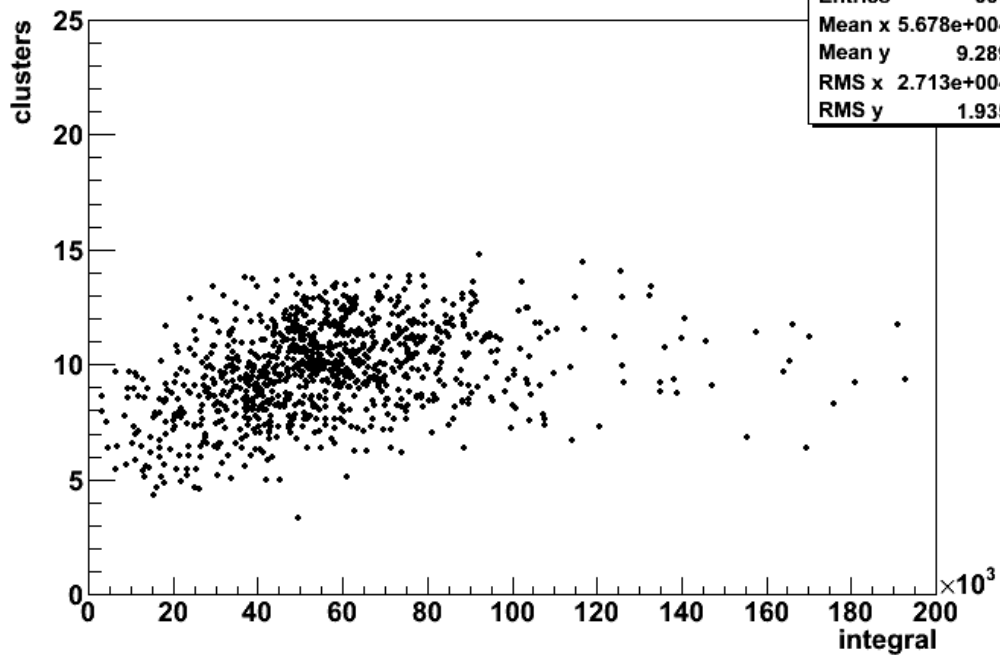
80He 20Isobutane

Garfield
threshold of 15
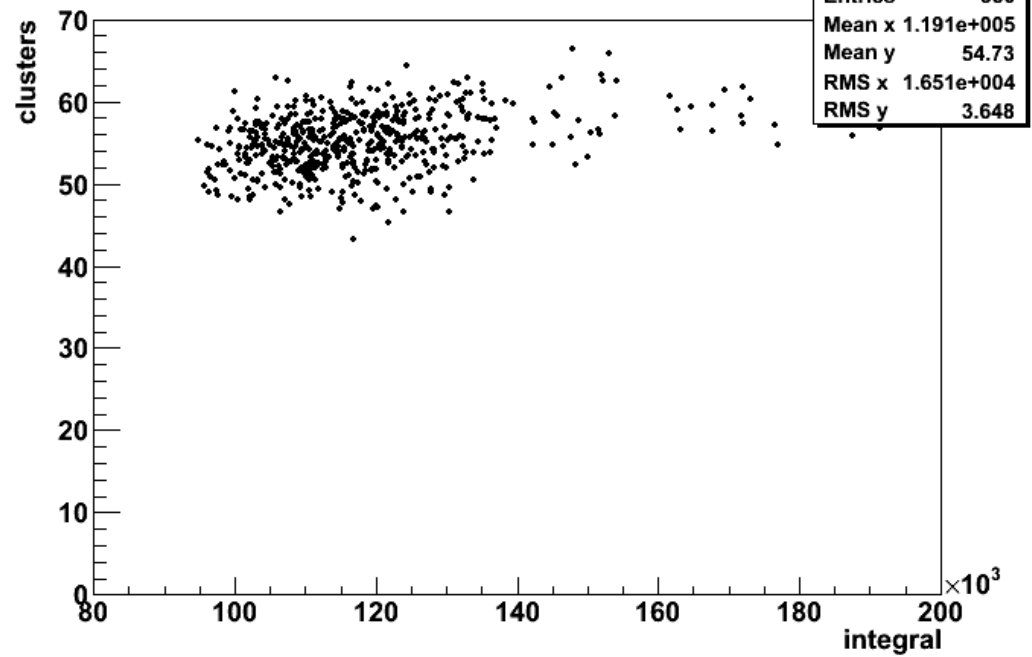
Signal
threshold of 50

80He 20Isobutane

Garfield
threshold of 20
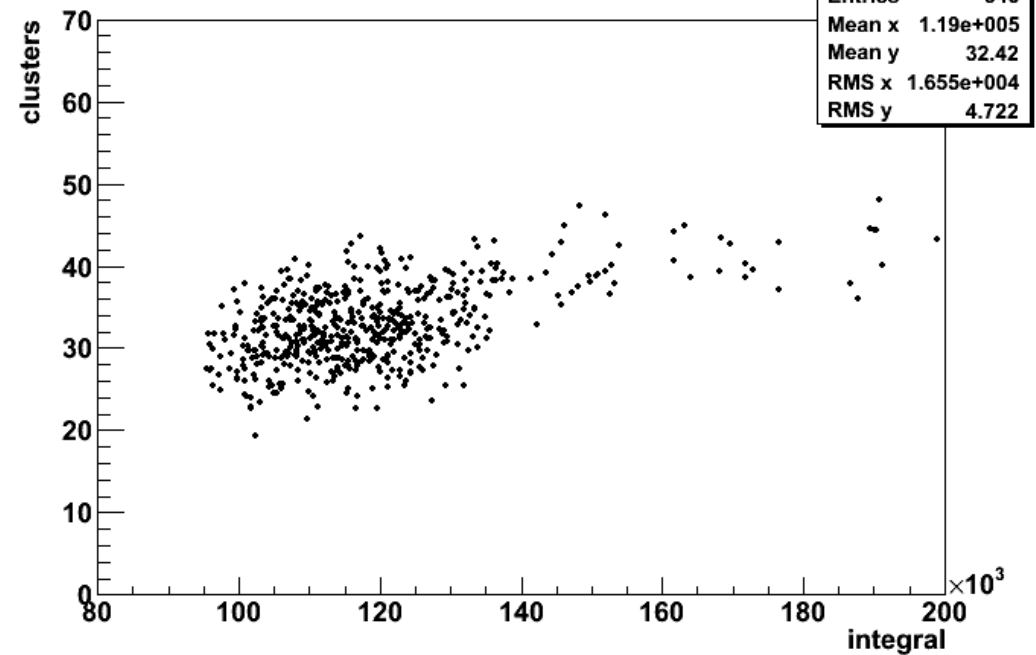
Signal
threshold of 60

80He 20Isobutane
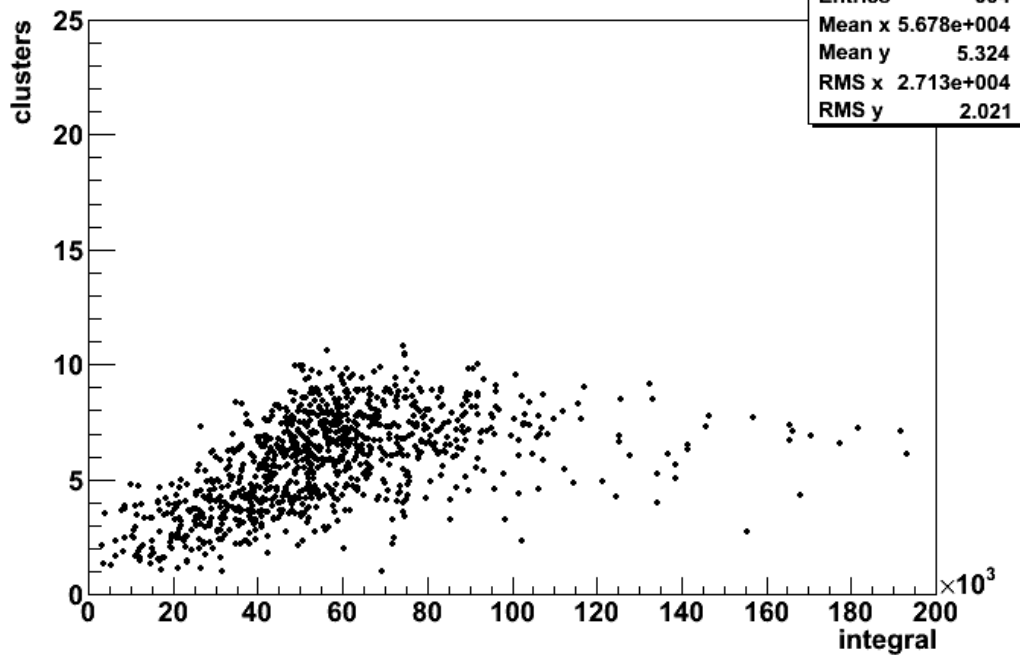
Garfield
threshold of 25
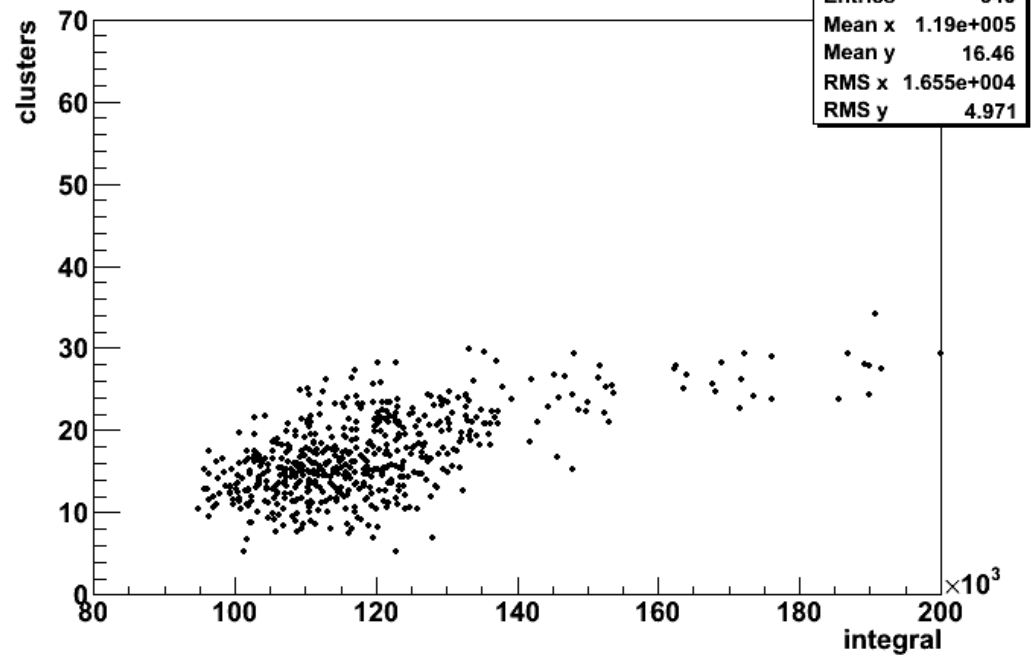
Signal
threshold of 70

80He 20Isobutane
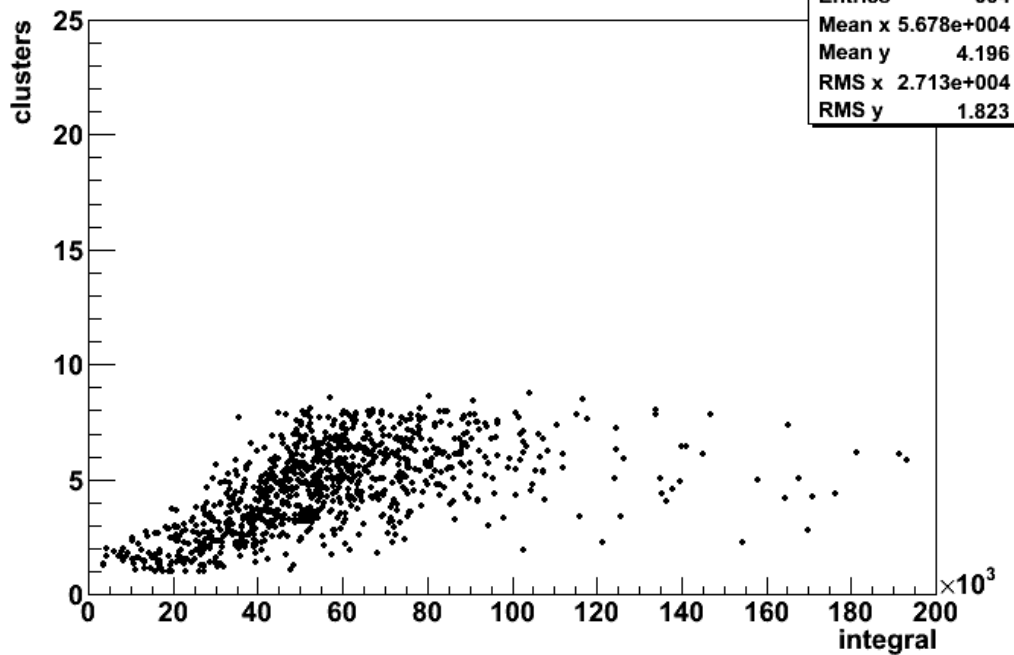
Garfield threshold of 30
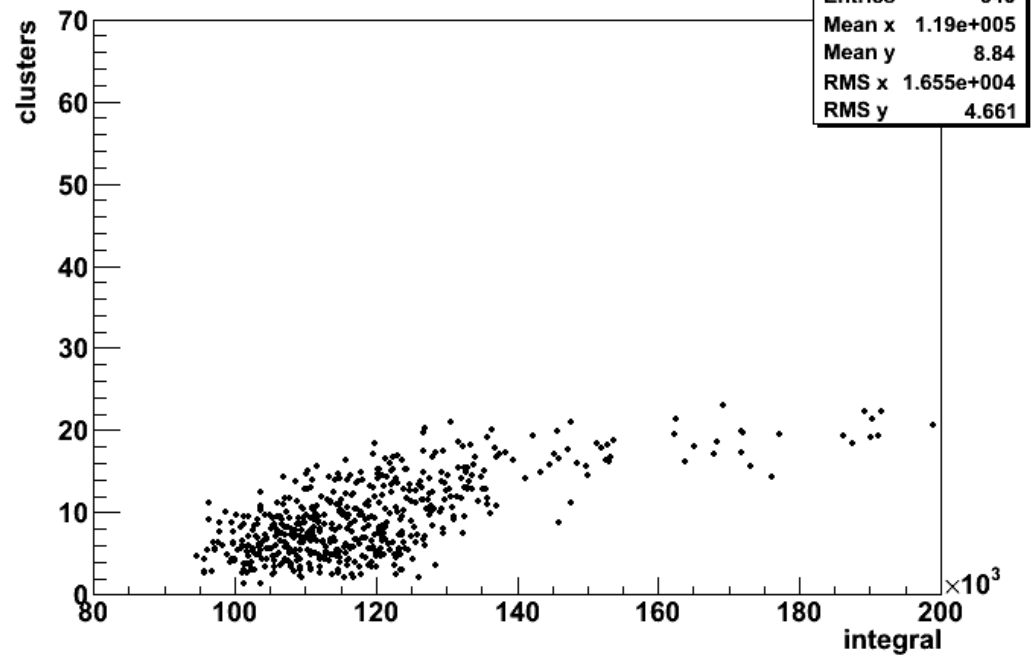
Signal threshold of 80

80He 20Isobutane
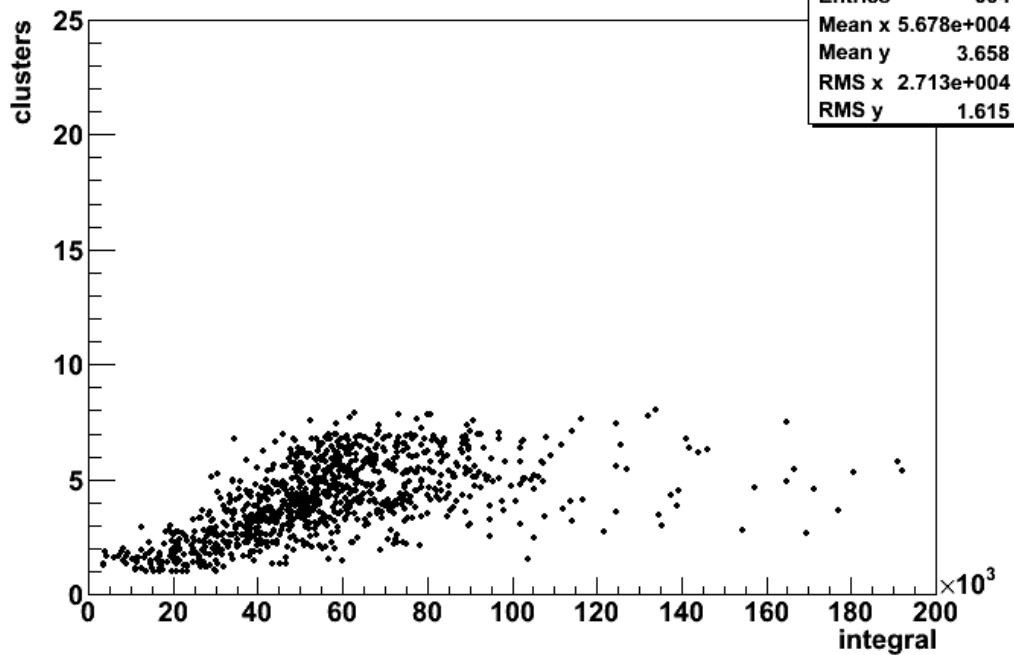
Garfield
threshold of 35
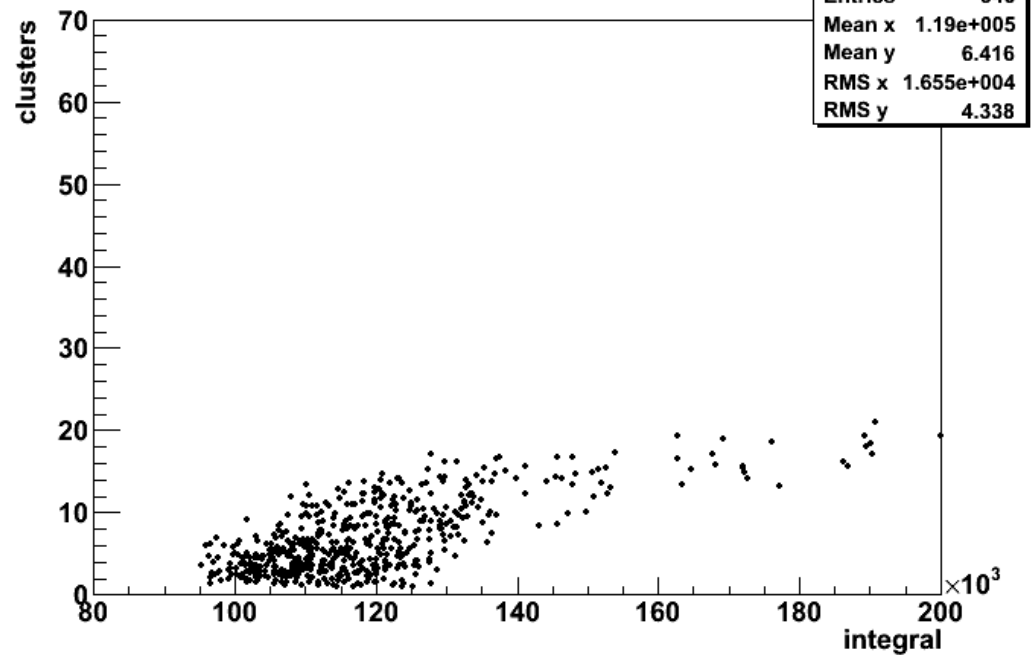
Signal
threshold of 90

80He 20Isobutane
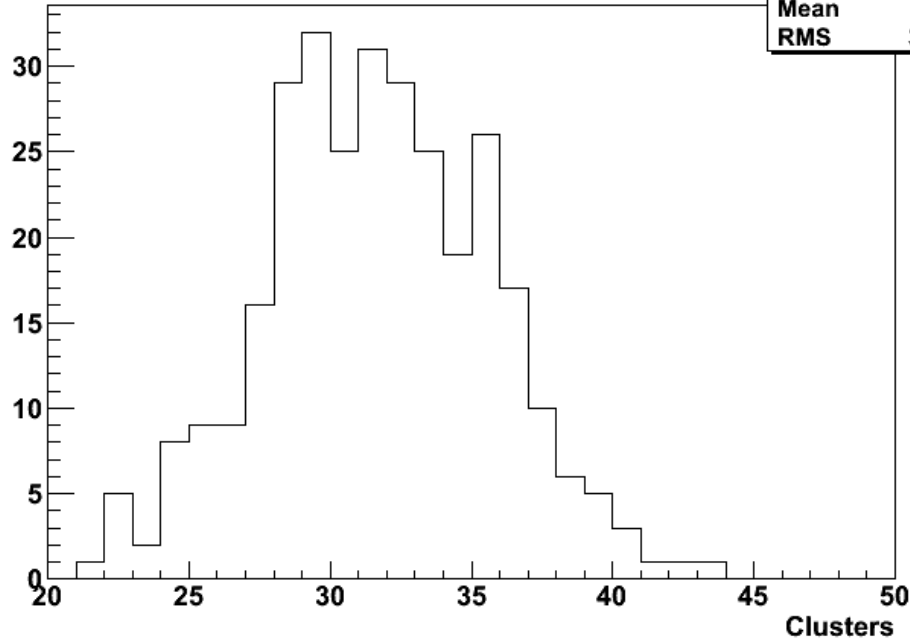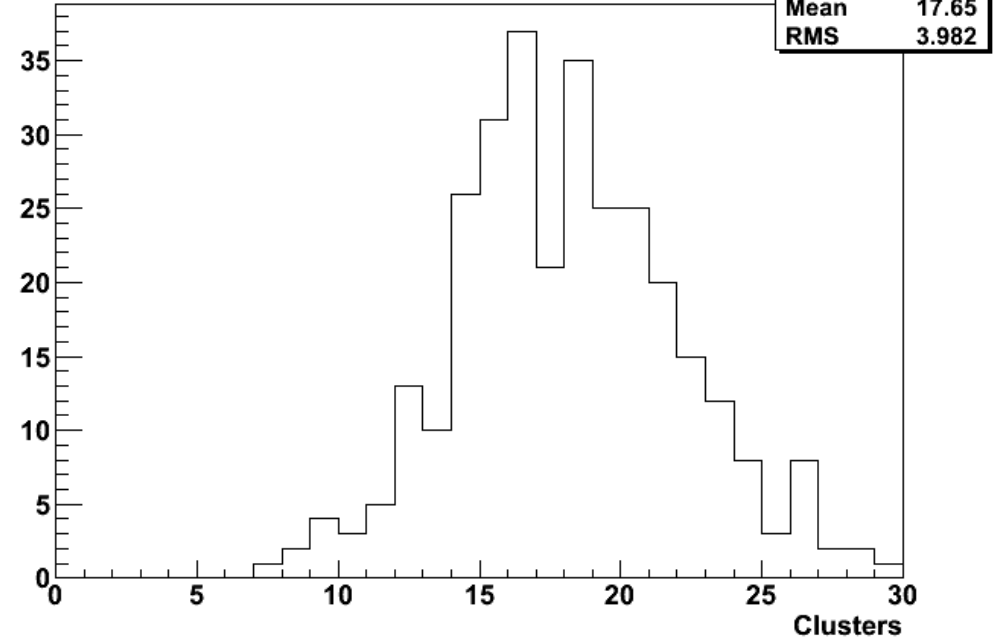
Threshold of 60

Threshold of 68
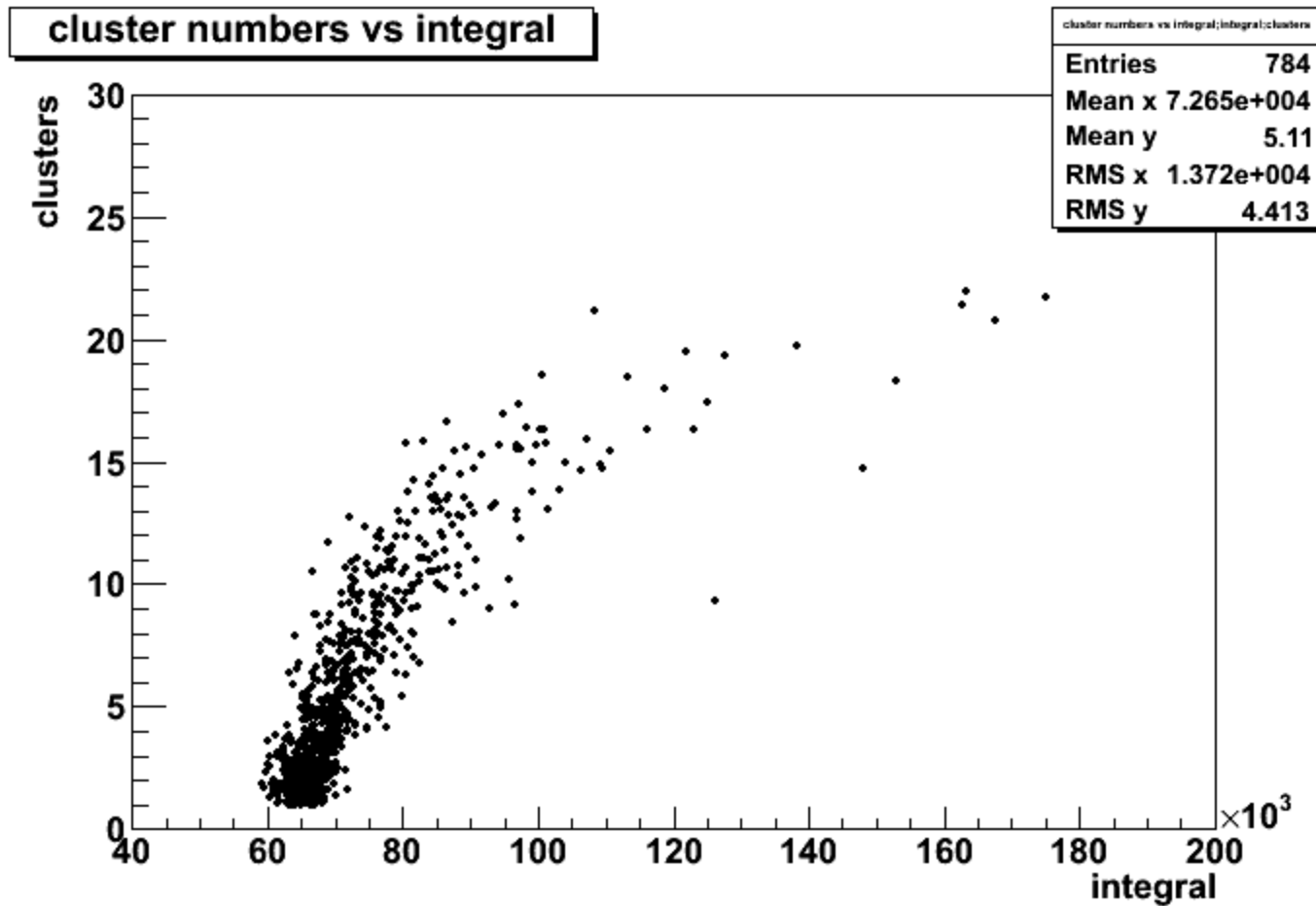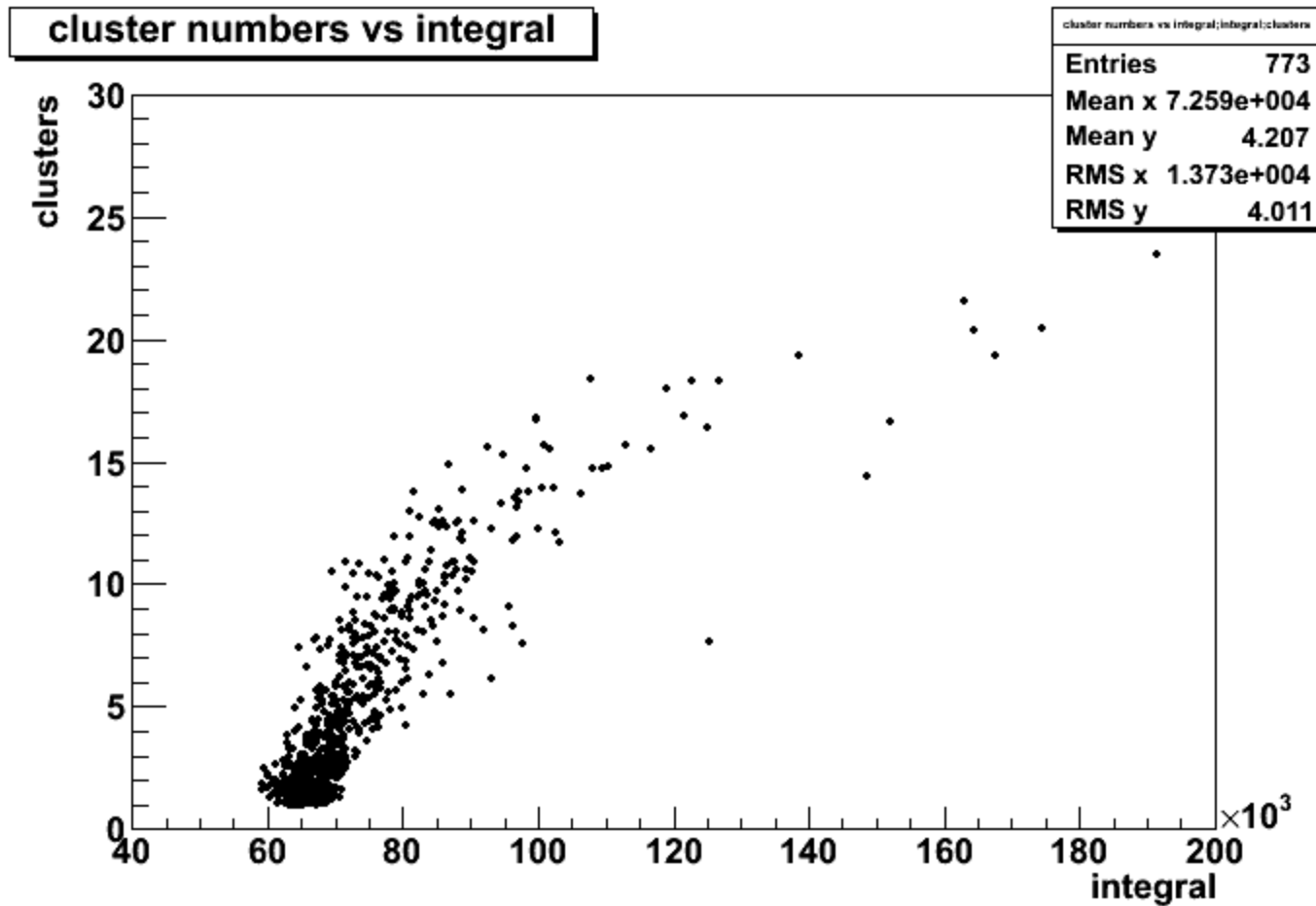
- Events with integrals between $1e^5$ and $1.2e^5$ are plotted

90He 10Isobutane

Threshold of 50
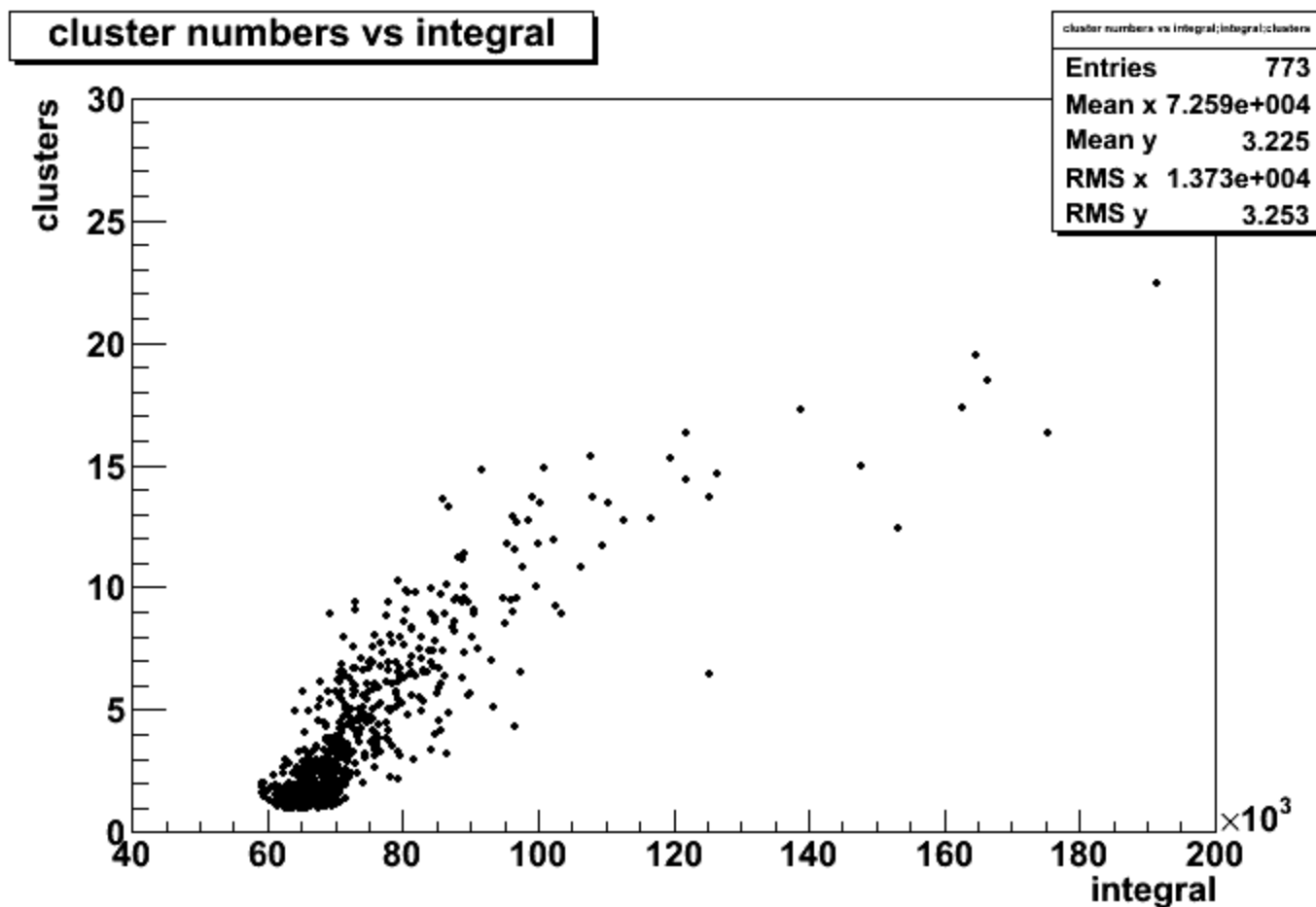
90He 10Isobutane

Threshold of 60

90He 10Isobutane

Threshold of 80

Comments on previous plots

- Clear correlation between integral and no. of clusters produced by algorithm

- Qualitatively, correlation is described by Garfield, but there are fewer clusters in the Garfield data – still trying to understand the differences

- Garfield studies on other gas mixtures in progress

TRIUMF testbeam

- A prototype detector was placed in a beam of pions, muons, and electrons at TRIUMF

- Testbeam ran from Nov 25 to Dec 5 of this year

- Gas mixtures used (Helium/Isobutane):
    - 80/20
    - 90/10
    - 95/5

Future Work

- Improve Preamp transfer function and noise simulation in Garfield

- A lead brick and scintillator will be placed below chamber to trigger on harder cosmic rays

- Algorithm explored will be applied to TRIUMF testbeam data

- Will use UVic chamber to study other potential gas mixtures

- Develop other counting algorithms