MWPC Gas Gain Results

Andrew Schick, Michael Roberts

June 11, 2015

Outline

Gas Gain Studies

- $Ar:CO_2$ 80:20 Gas Mixture
  - Iron-55 Studies (Finished)
  - Monte Carlo and Cosmic Ray Studies (Nearly Finished)
- $Ar:CO_2:CF_4$ 88:2:10 Gas Mixture

Cleanroom update

Gas Gain Studies

How much charge arrives at one wire cell for a given ionizing event when the detector is at a certain voltage?

Two different gas mixtures will be tested.

1. $Ar:CO_2$ in an 80:20 ratio
2. $Ar:CO_2:CF_4$ in a 88:2:10 ratio

Two ionizing sources will be looked at for these tests: an Iron 55 radioactive source and cosmic rays.

Ar:CO_2 80:20 Gas Mixture

Iron-55 Studies (Finished)

- Iron-55 source placed on top of detector
- MWPC signal is read out on oscilloscope
- ScopeOut program communicates with oscilloscope, integrates the area under the signal and histograms those integrals.
- Histograms are created for each voltage level tested. We measured from 1600 V to 2200 V in increments of 100 V.

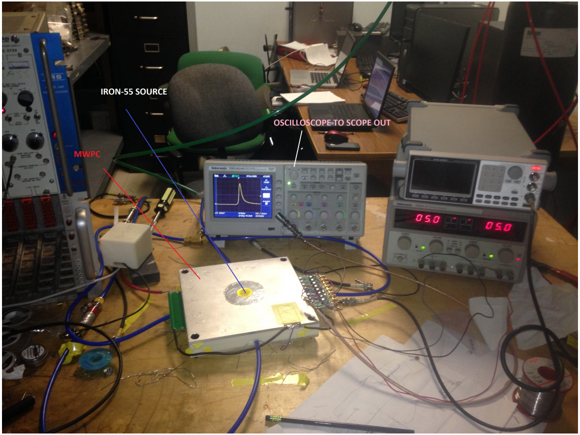


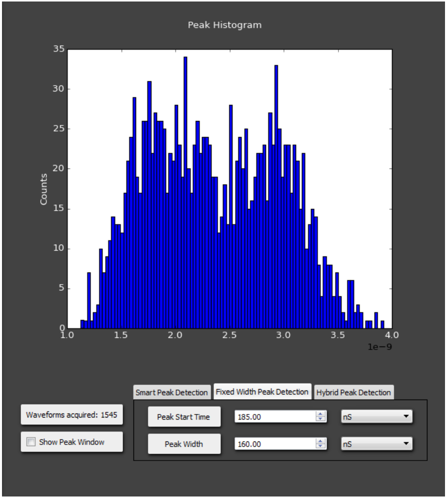
Figure 1: A picture of our setup

The charge on the sense wire can be determined from the integrated scope signal. From Ohm's Law

$$\begin{aligned} Q &= \int I dt \\ &= \frac{1}{R}\int V dt \end{aligned} \tag{1}$$

iron-55 source produces x-rays of 5.9 keV.
average ionization energy of argon is 26 eV.
An x-ray which loses all its energy to the detector produces $\frac{5900}{26} = 227$ electrons.
This gives a gain of $\frac{\mathbf{Q}}{\mathbf{227\times1.6\times10^{-19}}\mathrm{C}}$.

MWPC Studies



Voltage	Gas Gain
1600 V	624.01
1700 V	1459.25
1800 V	3668.77
1900 V	9085.90
2000 V	20374.45
2100 V	35792.95
2200 V	52312.77

Table 1: Iron-55 Gas Gain Results

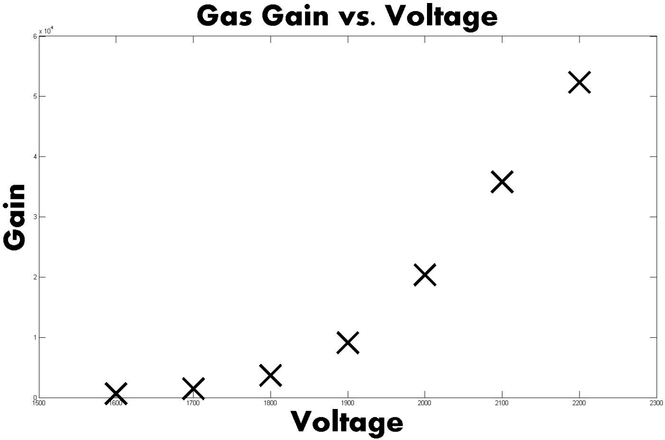


Figure 2: Plot of Iron-55 Gas Gain Results

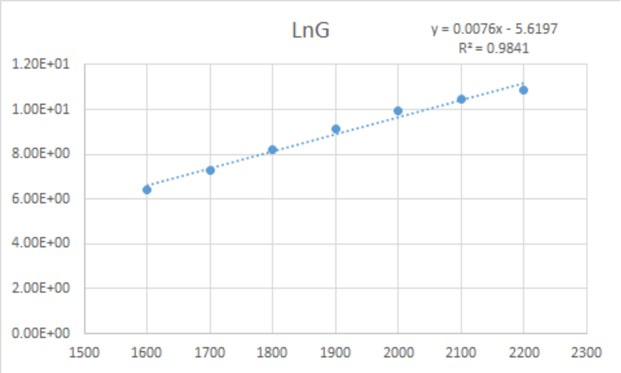


Figure 3: Log plot of Iron-55 gas gain results

Monte Carlo and Cosmic Ray Studies (Nearly Finished)

- Measure the gas gain of the detector using cosmic rays
- Fit gain to Monte Carlo of passing cosmic rays through the detector.

Determine the path length from cosmic ray angular distribution

$$\frac{\partial P}{\partial \Omega} = \frac{3}{2\pi}\cos^2(\theta) \tag{2}$$

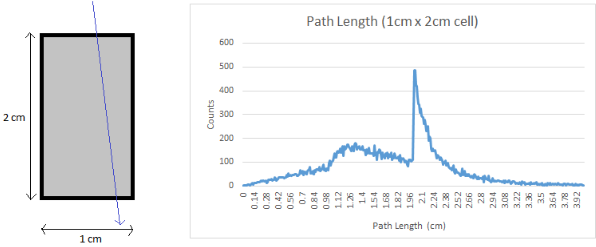
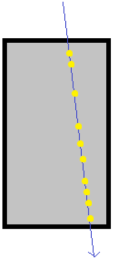


Figure 4: Histogram of the average path length through cell

Determine the number of primary ion clusters produced. The average number of clusters for Ar-CO_2 80:20 is n $= 30.3/\text{cm}$. The interactions of charged particles with argon atoms are random, discrete events, giving a Poisson distribution for the number of interactions.

$$P(n,k) = \frac{n^k}{k!}\mathrm{e}^{-n} \tag{3}$$

$$P(n,k) = \frac{n^k}{k!}\mathrm{e}^{-n}$$



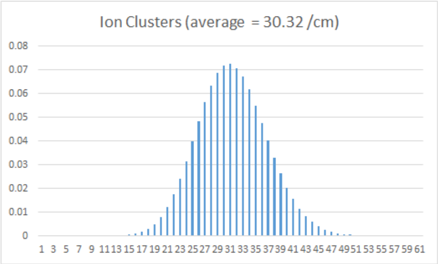


Figure 5: Distribution of Ion Clusters

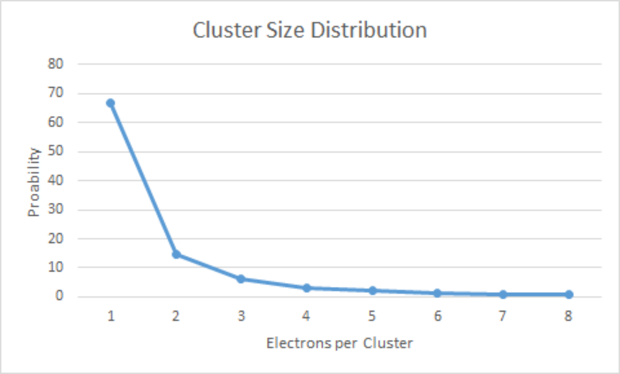
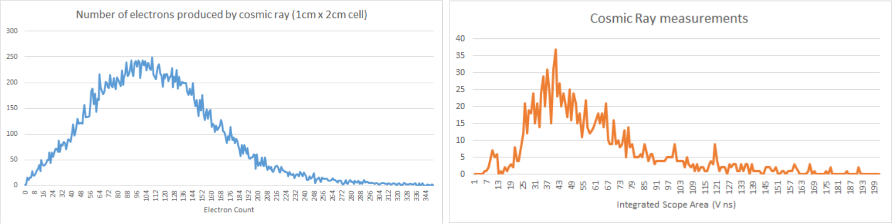


Figure 6: For each cluster, determine the cluster size. The sum of electrons for each cluster is the total charge produced by the incident cosmic ray.



(a) (b)

Figure 7: plots of Monte Carlo electron count and histogram of integrated scope signal at 2100 V for cosmic rays

Ar:CO_2:CF_4 88:2:10 Gas Mixture

Next week: Repeat iron-55 and cosmic ray studies and determine the gas gain for new gas mixture.

Cleanroom update

- Vestibule extension built
- Panels arriving next week
- Organizing lab area
- Preparing for assembly of large detectors

As soon as the panels arrive, the lab's main focus will be temporarily diverted to finalizing the cleanroom, before resuming