Multi-Wire Proportional Chamber Simulation in Garfield-9: Comparing Scaled Geometries

Sean McGrath, Nuclear Physics, UMASS Amherst

Preliminary designs for the UMASS MWPC called for a chamber with a half gap of 1 cm, a sense wire separation of 2 cm, and a plane voltage of -1837V. This configuration is referred to as Full Scale in the context of this report. In the interests of reducing drift times to approximately 200 ns, an alternate half-scale geometry has also been proposed, with a half-gap of .5 cm, a sense wire separation of 1 cm, and a plane voltage of -968V. Both chamber designs use a 90% argon 10% carbon dioxide gas mixture.

This report summarizes the simulated effects of chamber scale and impact parameter on drift times and tracks. All simulated tracks represent the passage of a 10 GeV positive muon moving on a path normal to the plane of the detector. The impact parameter will be denoted as IP, and represents the smallest distance between the path of the muon and the closest sense wire. We will use the induced current on a sense wire as a way to measure the drift times of ionized electrons.

<u>Full Scale – IP = 0 cm</u>

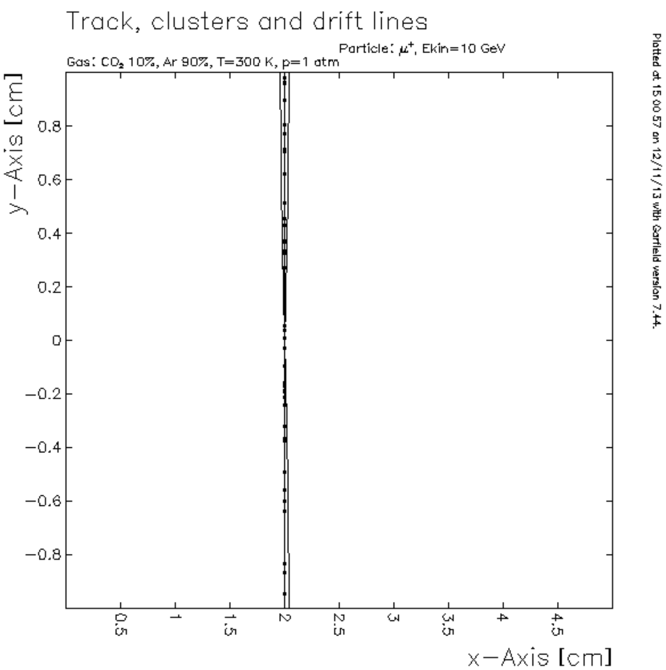

Fig 1.1 – Drift Tracks at Full Scale, IP =0 cm

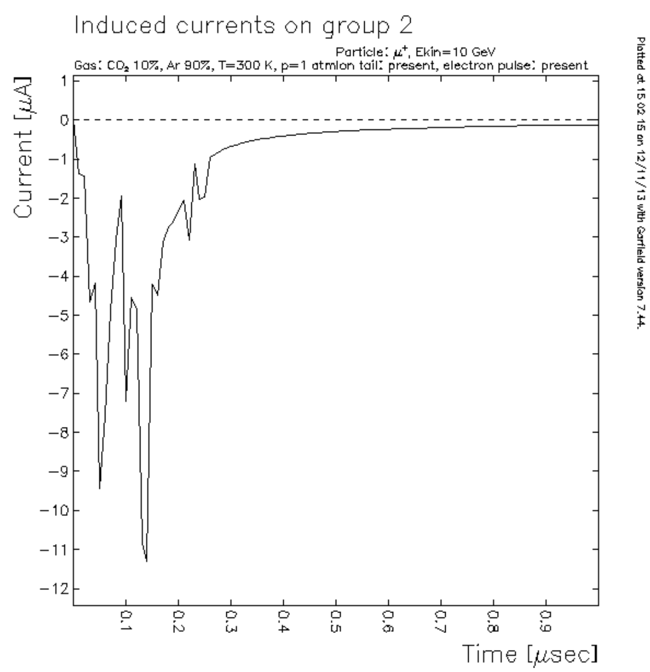

Fig 1.2 – Sense wire current at Full Scale, IP =0 cm

IP = 0 denotes a muon crossing directly through a sense wire. We can see from Figure 1.2 that the majority of the electrons created by the passage of the muon are collected within 200 ns, but total drift time approaches 300 ns, even with the high cluster density this track provides.

Full Scale – IP = 0.25 cm

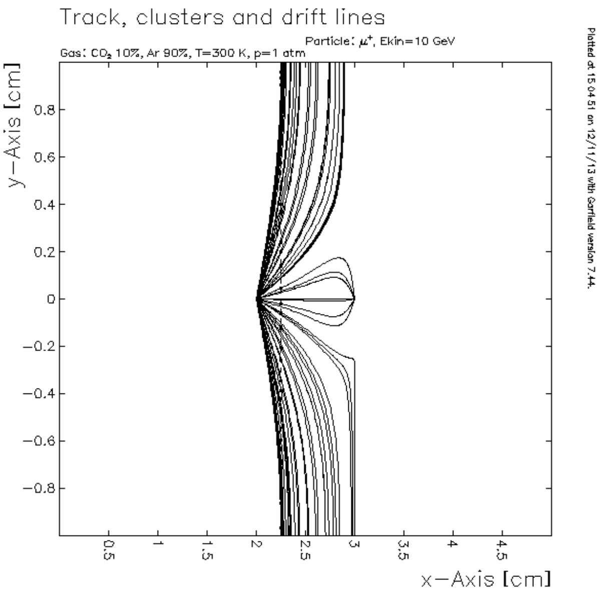

Fig 1.3 – Drift Tracks at Full Scale, IP =0.25 cm

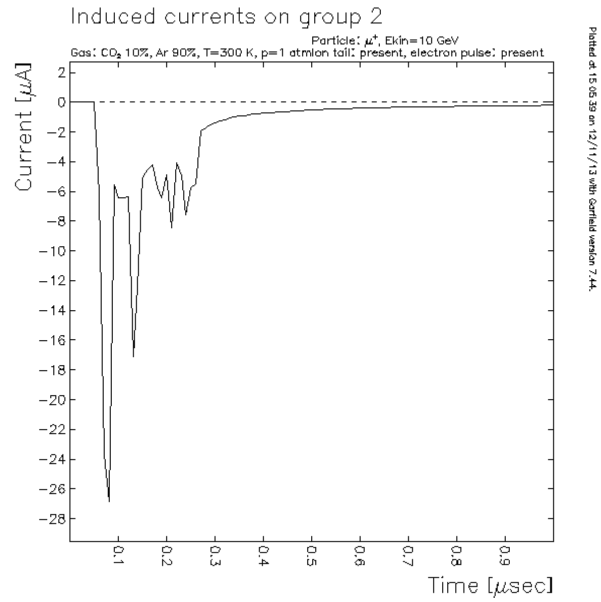

Fig 1.4 – Sense wire current at Full Scale, IP =0.25 cm

Here, with IP = 0.25 cm, the total drift time is approximately 300 ns. Note that the amplitude of the induced currents is roughly twice what was observed with IP = 0.

Full Scale – IP = 0.50 cm

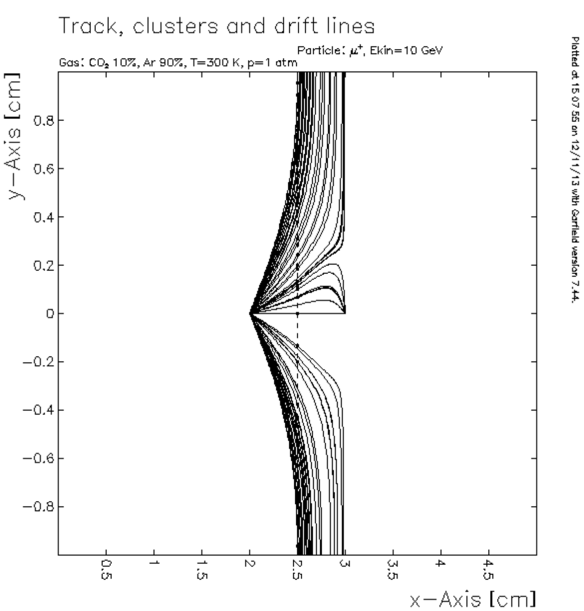

Fig 1.5 – Drift Tracks at Full Scale, IP =0.50 cm

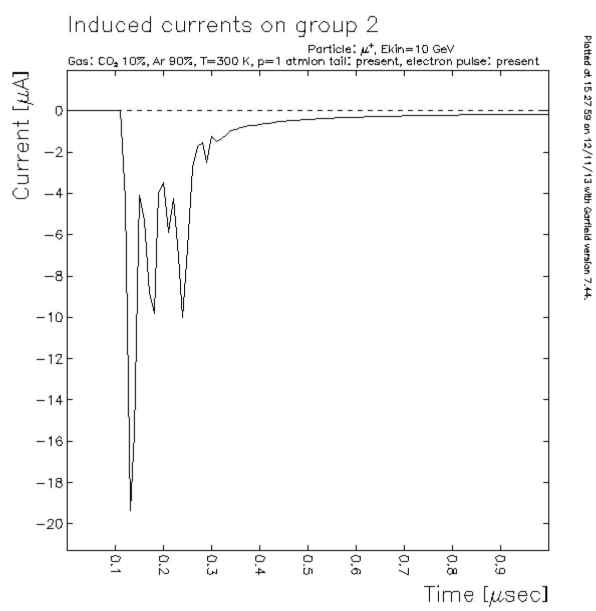

Fig 1.6 – Sense wire current at Full Scale, IP =0.50 cm

Total drift time remains on the order of 300 ns. Current amplitude is intermediate.

<u>Full Scale – IP = 0.95 cm</u>

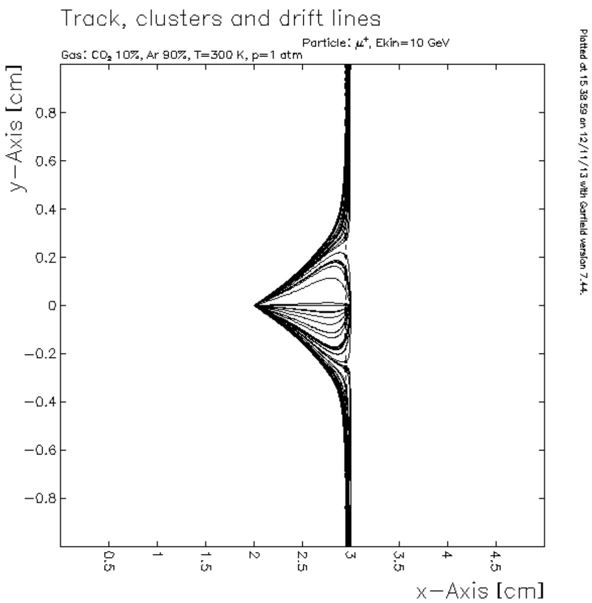

Fig 1.7 – Drift Tracks at Full Scale, IP =0.95 cm

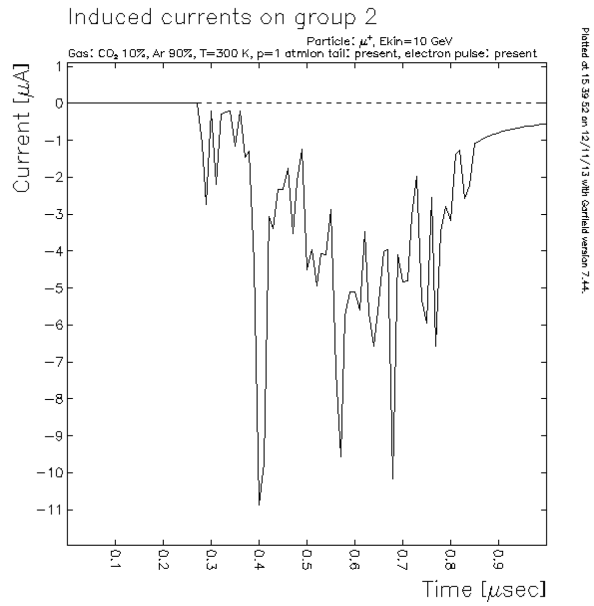

Fig 1.8 – Sense wire current at Full Scale, IP =0.95 cm

At IP = 0.95 cm, the incident particle comes through the chamber very close to one of the high-voltage field wires. The drift times here are much more spread out, with a width of approximately 500 ns and a total drift time approaching a microsecond. Current amplitude is similar to IP = 0 cm.

<u>Half Scale – IP = 0 cm</u>

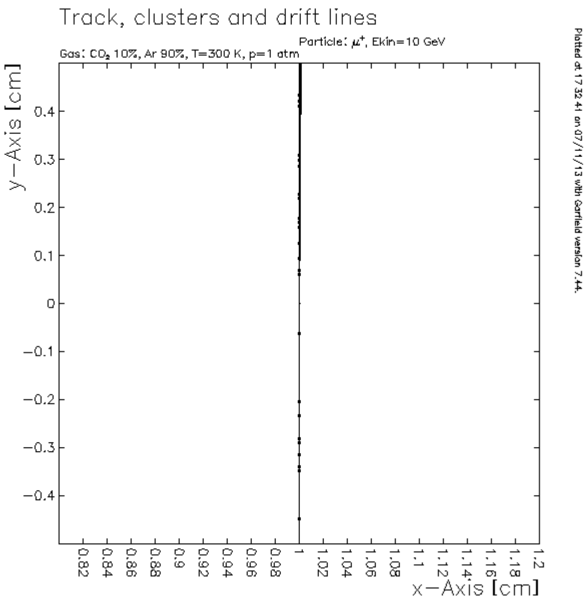

Fig 2.1 – Drift Tracks at Half Scale, IP =0 cm

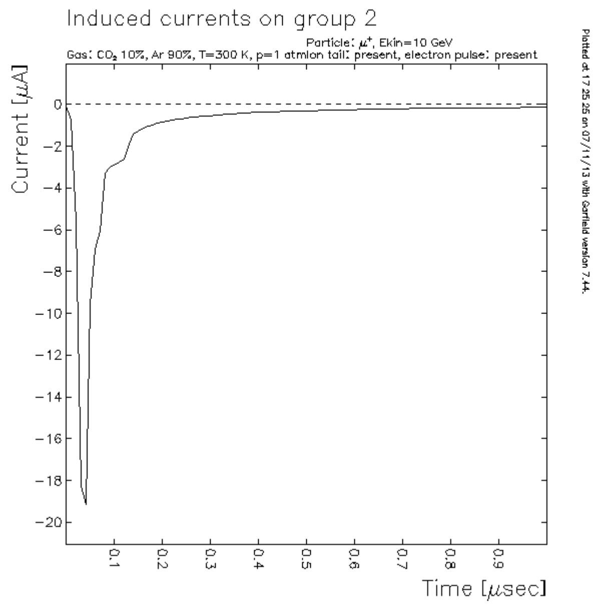

Fig 2.2 – Sense wire current at Half Scale, IP =0 cm

Drift times at half scale immediately show a much smoother distribution, as we can see in figure 2.2. They are also shorter, below 200 ns in this case.

<u>Half Scale – IP = 0.25 cm</u>

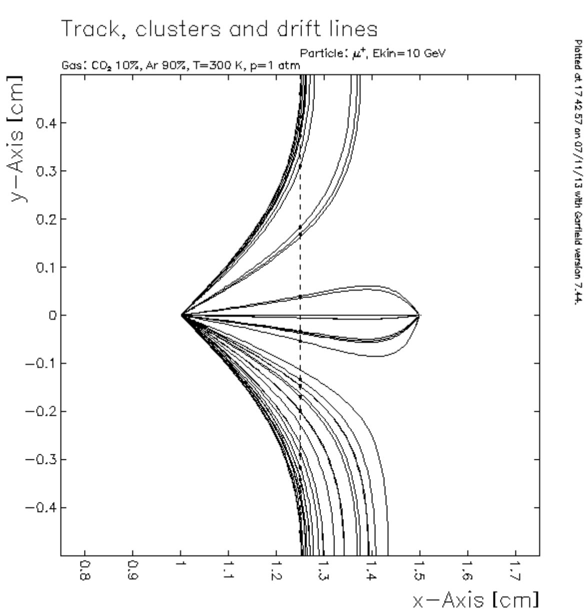

Fig 2.3 – Drift Tracks at Half Scale, IP =0.25 cm

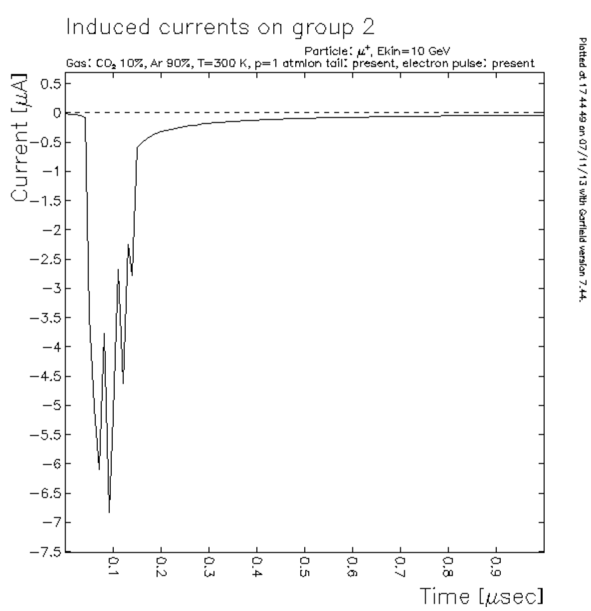

Fig 2.4 – Sense wire current at Half Scale, IP = 0.25 cm

Again, drift times are sub-200 ns, though current amplitude is about 1/3 of above.

Half Scale – IP = 0.49 cm

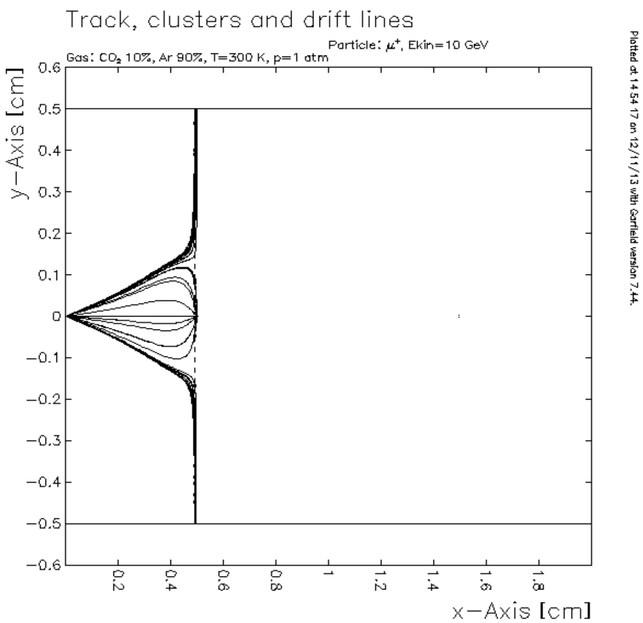

Fig 2.3 – Drift Tracks at Half Scale, IP =0.25 cm

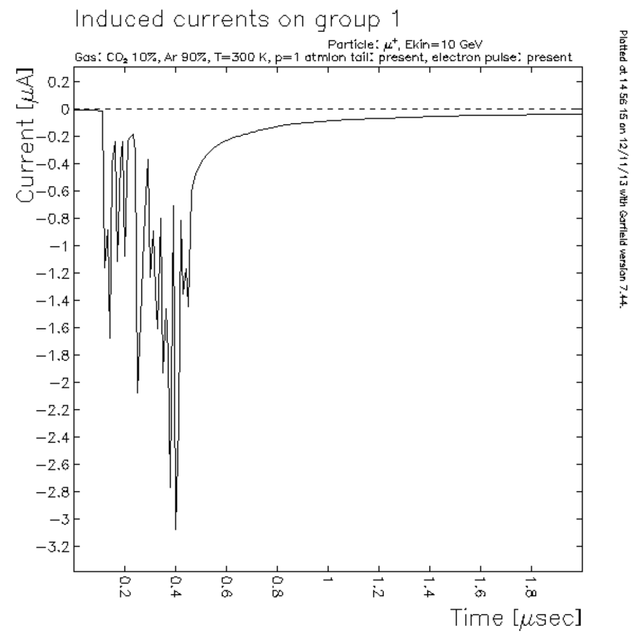

Fig 2.4 – Sense wire current at Half Scale, IP = 0.25 cm

Here, the incident particle is crossing very near to the field wire. Total drift time is approximately 500 ns, much better than in the same situation at full scale. Unfortunately, the current is very small.

Analysis

Several measurements of a ¾ scale chamber were also made.

	Approximate Total Drift Time (ns)		
IP (cm)	Full Scale	Half Scale	¾ Scale
0	250	150	180
.25	300	150	200
.33	300	200	200
.5	300	500	250
.75	550	-	750
.95	900	-	-

Conclusions

If the primary objective of our design is to maintain average drift times below 200 ns, it seems that the half-scale geometry is most effective.