Optimizing MWPCs for Detection Speed

Sean McGrath - 12/4/13

Objective:

Design a particle detector that works as fast as possible

Method:

Maximize drift speed of ionized electrons

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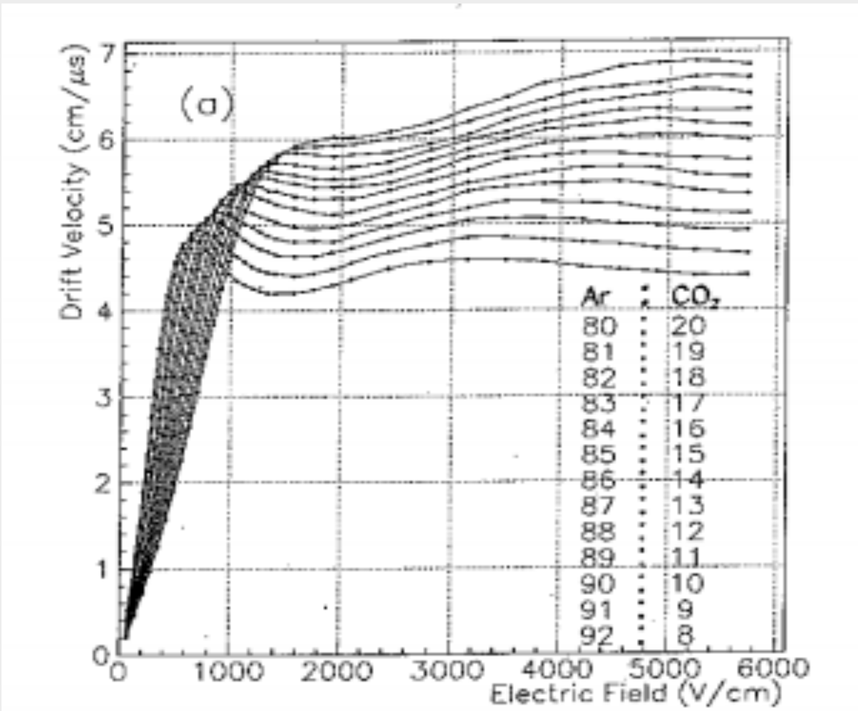
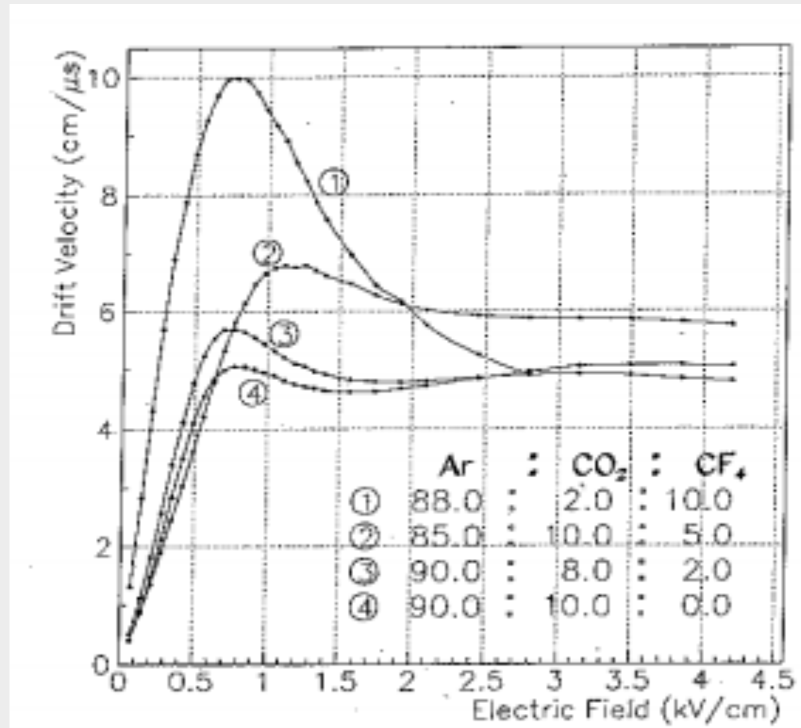
What Gas to Use?





Zhao et al, Nucl. Inst. & Methods, 1993

Maximum attainable speed is 10 cm/microsec for Ar-88-CO_2-2-CF_4-10 and ~750 V/cm

Refined Design Objectives:

1. Drift field = 750 V/cm

2. Wire Field = 254 KV/cm

<u>Asset</u>: lots of simulated data for various chamber scales & voltages

Gap	E wire	E plane		V	E wire	E plane
0.1	613859	9868		-500	68935	117
0.2	534351	4403		-600	82722	140
0.3	496980	2761		-700	96509	164
0.4	473569	1987		-800	110297	187
0.5	456913	1541		-900	124084	211
0.6	444170	1253		-1000	137871	234
0.7	433746	1052		-1100	151658	258
0.8	425479	905		-1200	165445	281
0.9	418084	792		-1300	179232	305
1	412051	703		-1400	193019	328
1.1	406768	632		-1500	206806	351
1.2	401705	573		-1600	220594	375
1.3	397141	524		-1700	234381	398
1.4	393362	482		-1800	248168	422
1.5	389741	446		-1900	261955	445
1.6	386415	415		-2000	275742	469
1.7		388		-2100	289529	492
1.8	384118	364		-2200	303316	516
1.9	381435	343		-2300	317103	539
				-2400	330981	563
V = -3000				-2500	344678	586
				-2600	358465	610
				-2700	372252	633
				-2800	386039	657
				-2900	399826	680
				-3000	413613	703
				Gap = 1	-137.8752547	-0.234646154

These data isolate the effect of two parameters (gap g and voltage v) on two outputs (drift field D and wire field W)

If we consider the fields as functions of these parameters, we write

$$W(g,v) \text{ and } D(g,v)$$

Analyzing our data, we find;

We can use these derivatives and our data to construct Taylor polynomials $T_W(g,v)$ and $T_D(g,v)$ that approximate W and P.

Solving the system for $T_W = 254{,}000$ and $T_D = 750$ gives us a guess for the optimal gap and voltage.

In Garfield, simulate a chamber with these new parameters g_0 and v_0

Use the fields this chamber produces as new data to construct new, more accurate Taylor polynomials.

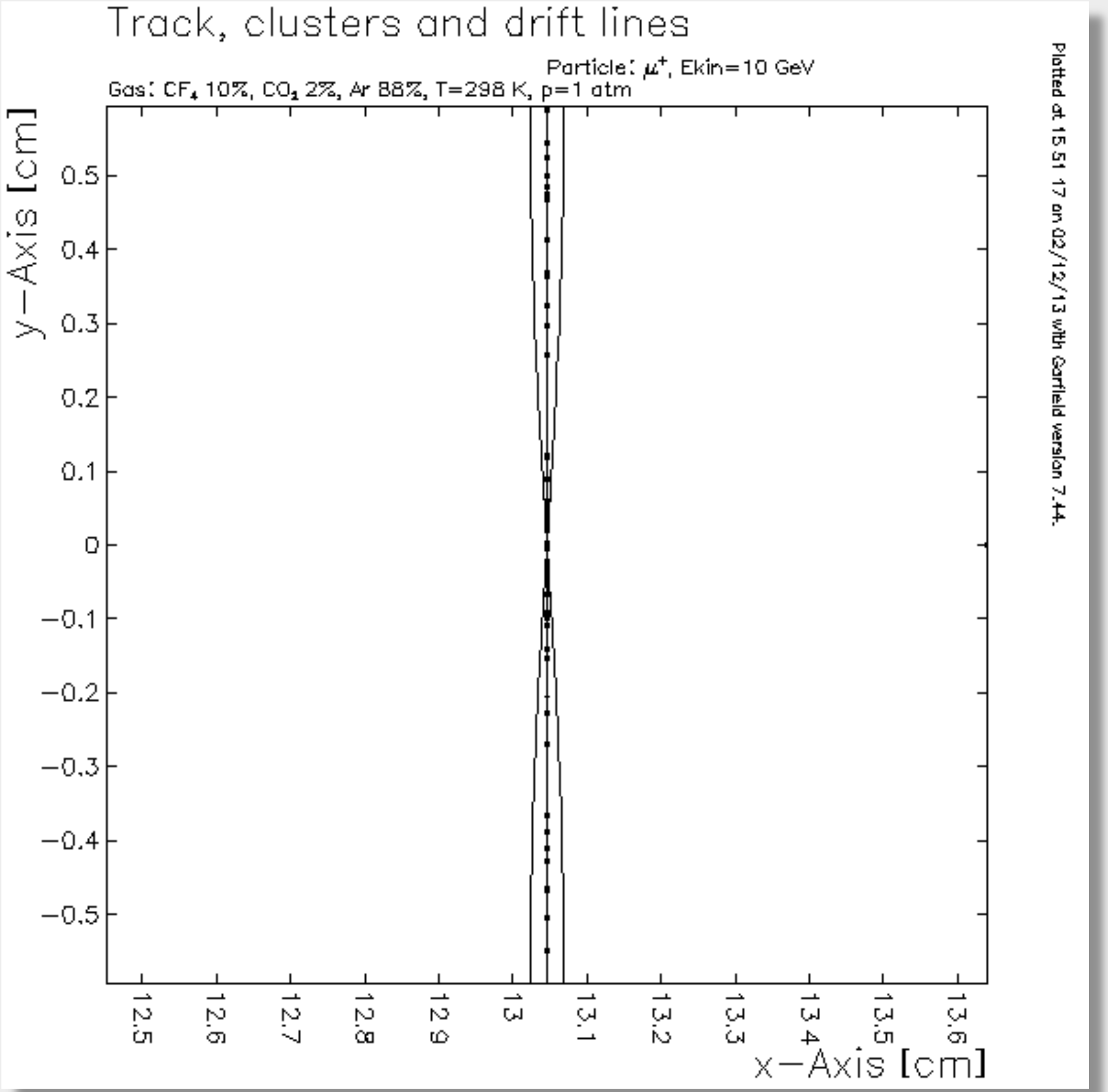
Iterate until simulated fields are correct.

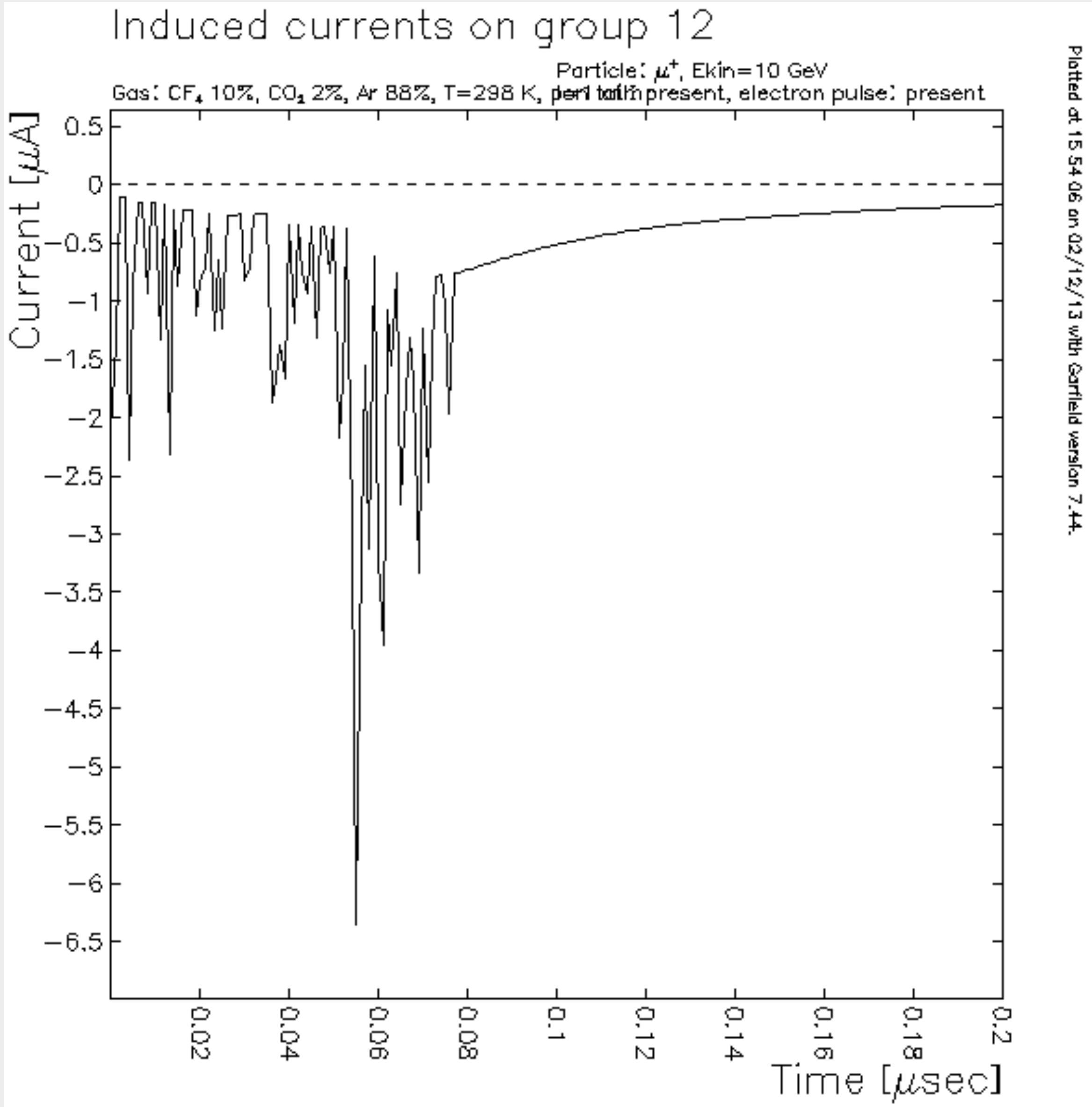
Results:

$$g = 0.593 \text{ cm}$$

$$v = -1680 \text{ V}$$

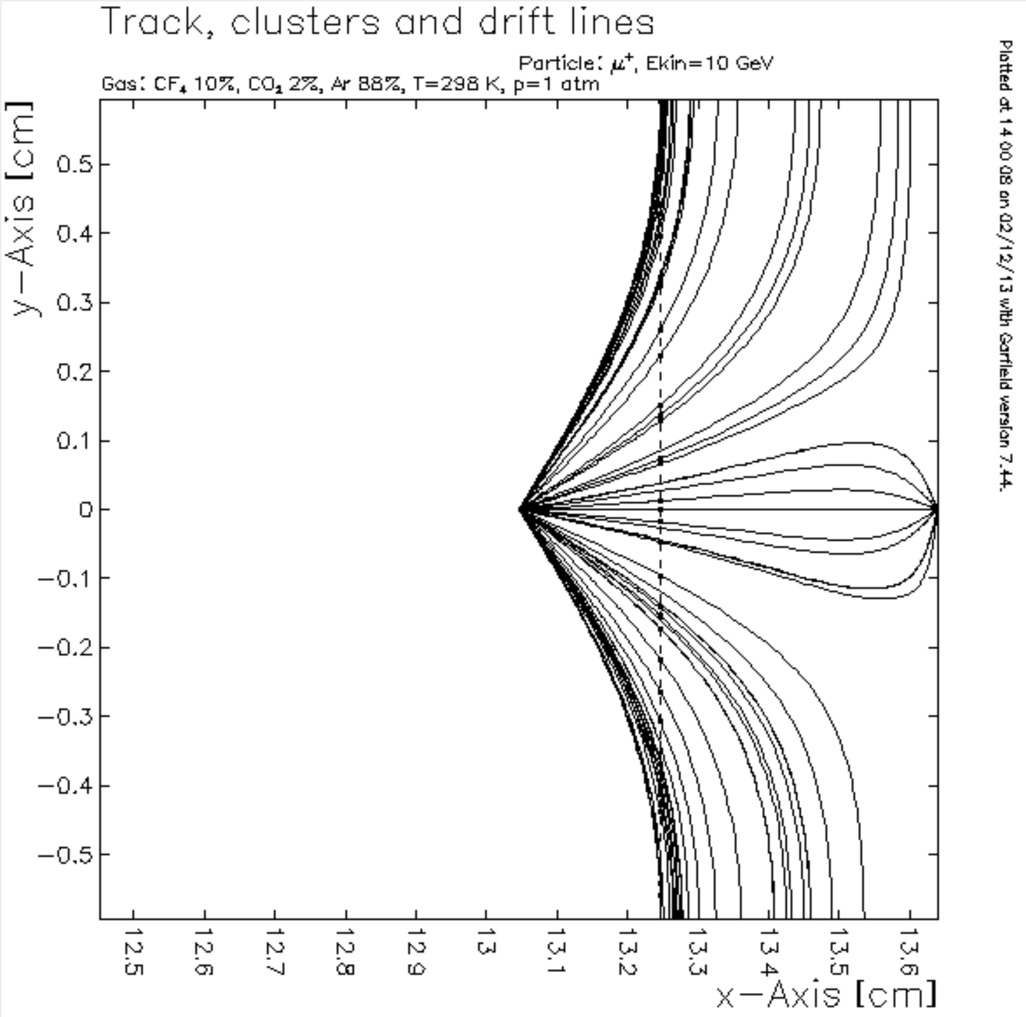
Impact Parameter = 0 cm

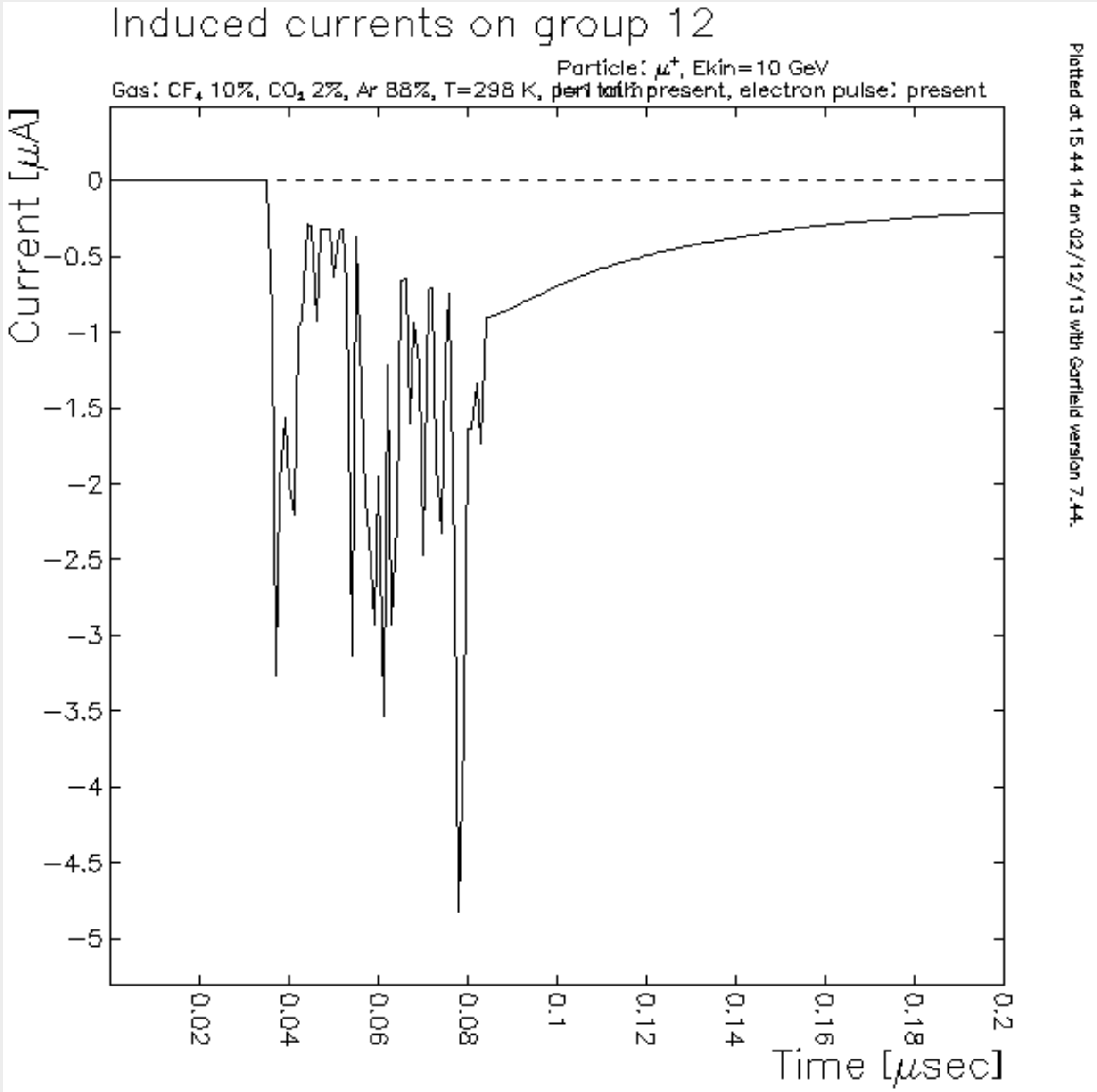




Drift times < 80 ns

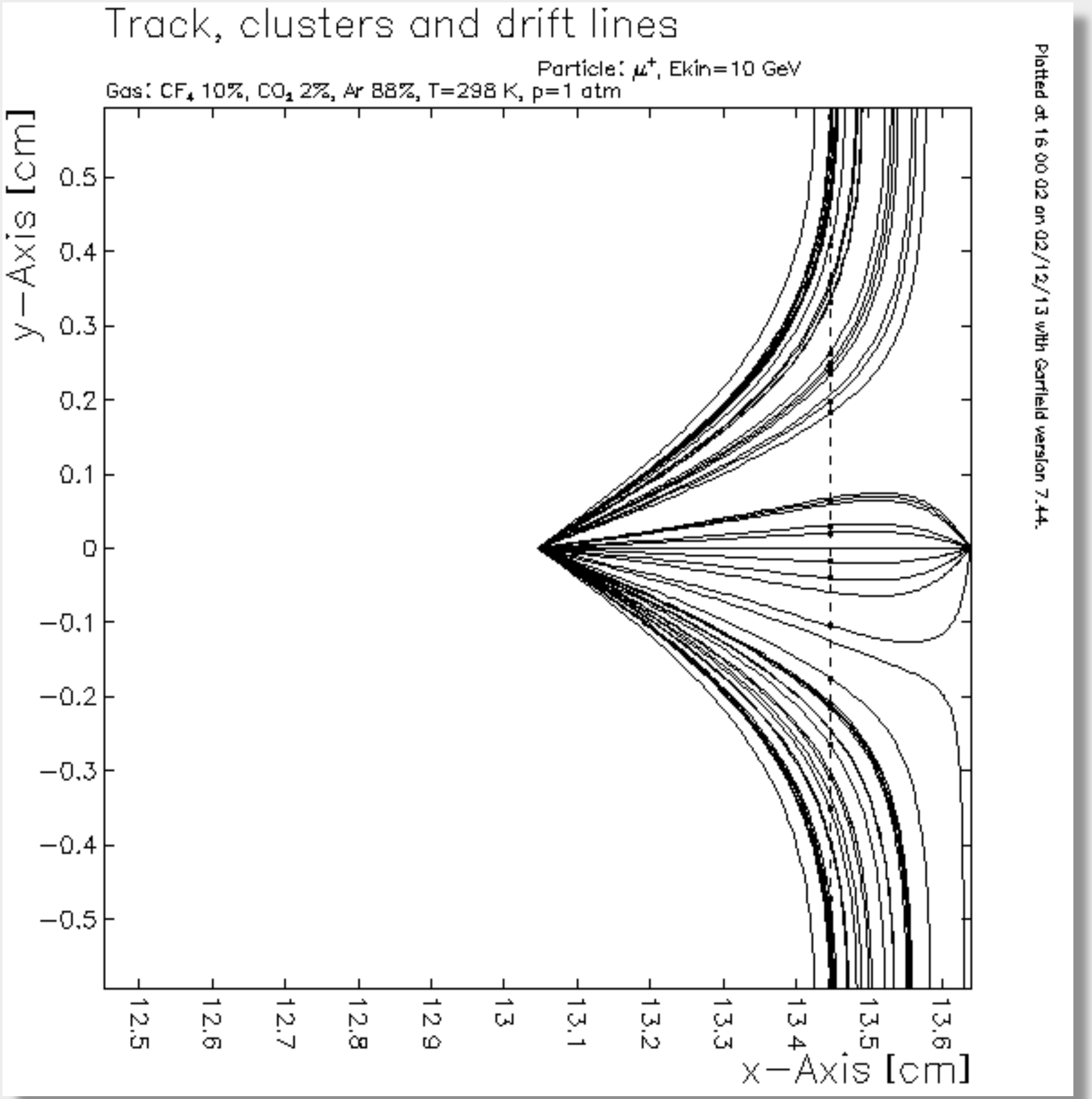
Impact Parameter = .2 cm



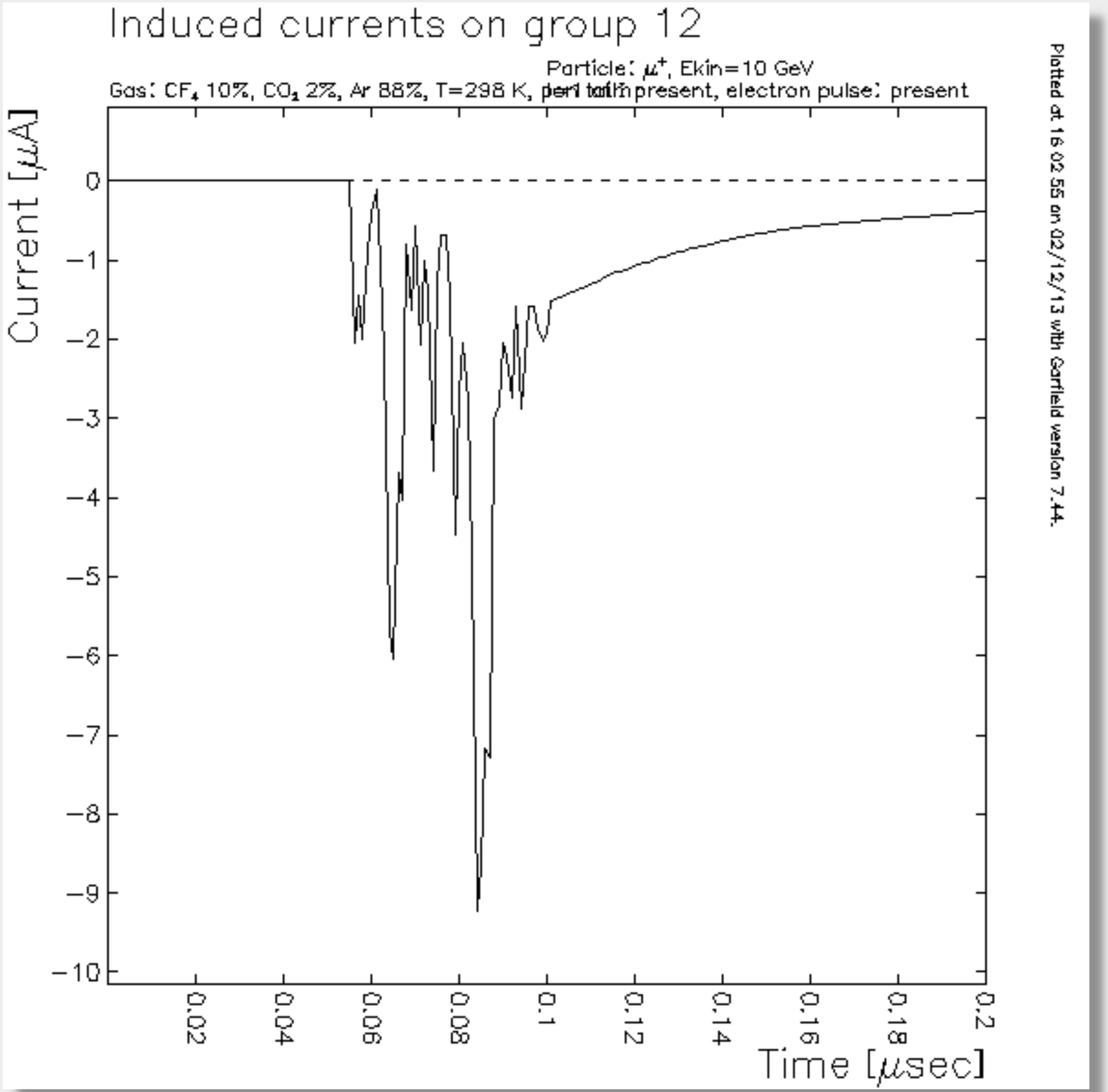


Drift times < 80 ns

IP = .4 cm

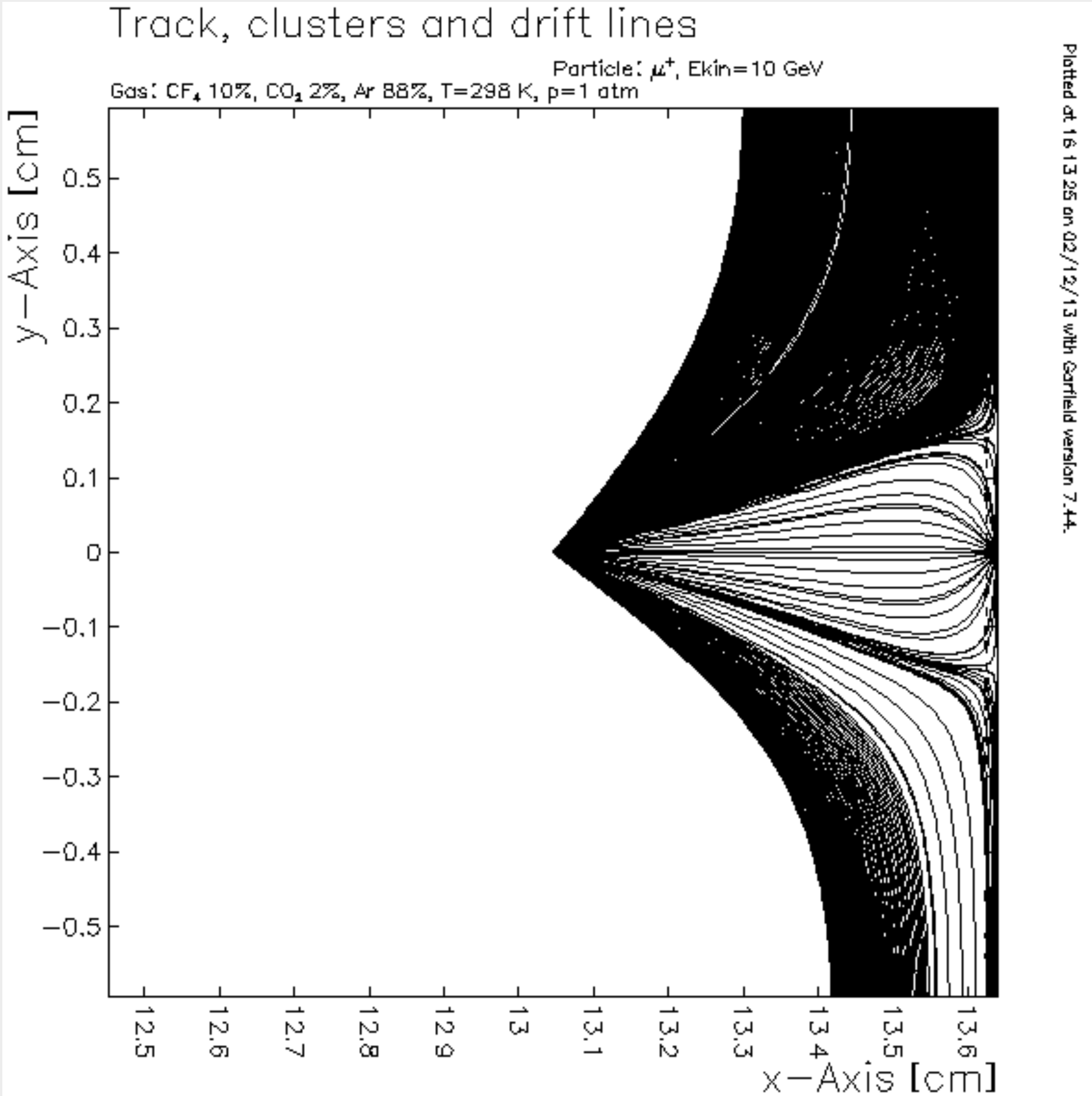


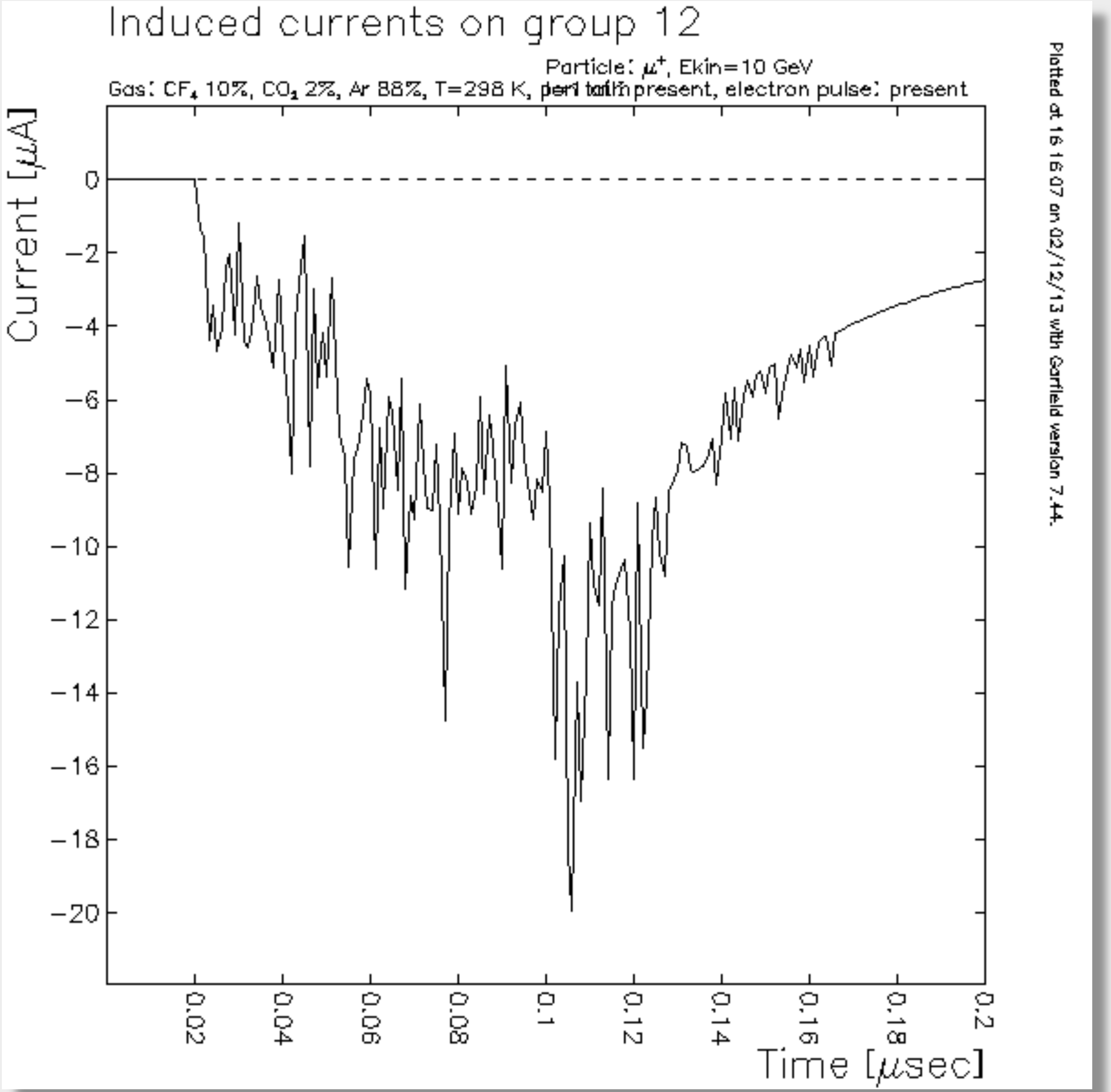
Track, clusters and drift lines
Particle: μ^+, Ekin=10 GeV
Gas: CF_4 10%, CO_2 2%, Ar 88%, T=298 K, p=1 atm
y−Axis [cm]
x−Axis [cm]
0.5
0.4
0.3
0.2
0.1
0
−0.1
−0.2
−0.3
−0.4
−0.5
12.5
12.6
12.7
12.8
12.9
13
13.1
13.2
13.3
13.4
13.5
13.6
Plotted at 16.00.02 on 02/12/13 with Garfield version 7.44.



Drift times < 100 ns

IP = *g*


Track, clusters and drift lines
Particle: μ+, Ekin=10 GeV
Gas: CF4 10%, CO2 2%, Ar 88%, T=298 K, p=1 atm
y−Axis [cm]
0.5
0.4
0.3
0.2
0.1
0
−0.1
−0.2
−0.3
−0.4
−0.5
12.5
12.6
12.7
12.8
12.9
13
13.1
13.2
13.3
13.4
13.5
13.6
x−Axis [cm]
Plotted at 16.13.25 on 02/12/13 with Garfield version 7.44.



Drift times < 150 ns

Conclusion:

This optimized geometry results in a much faster detector.

Low drift times are maintained even for large values of impact parameter.