MicroBooNE Signal Waveform Simulation Using Garfield

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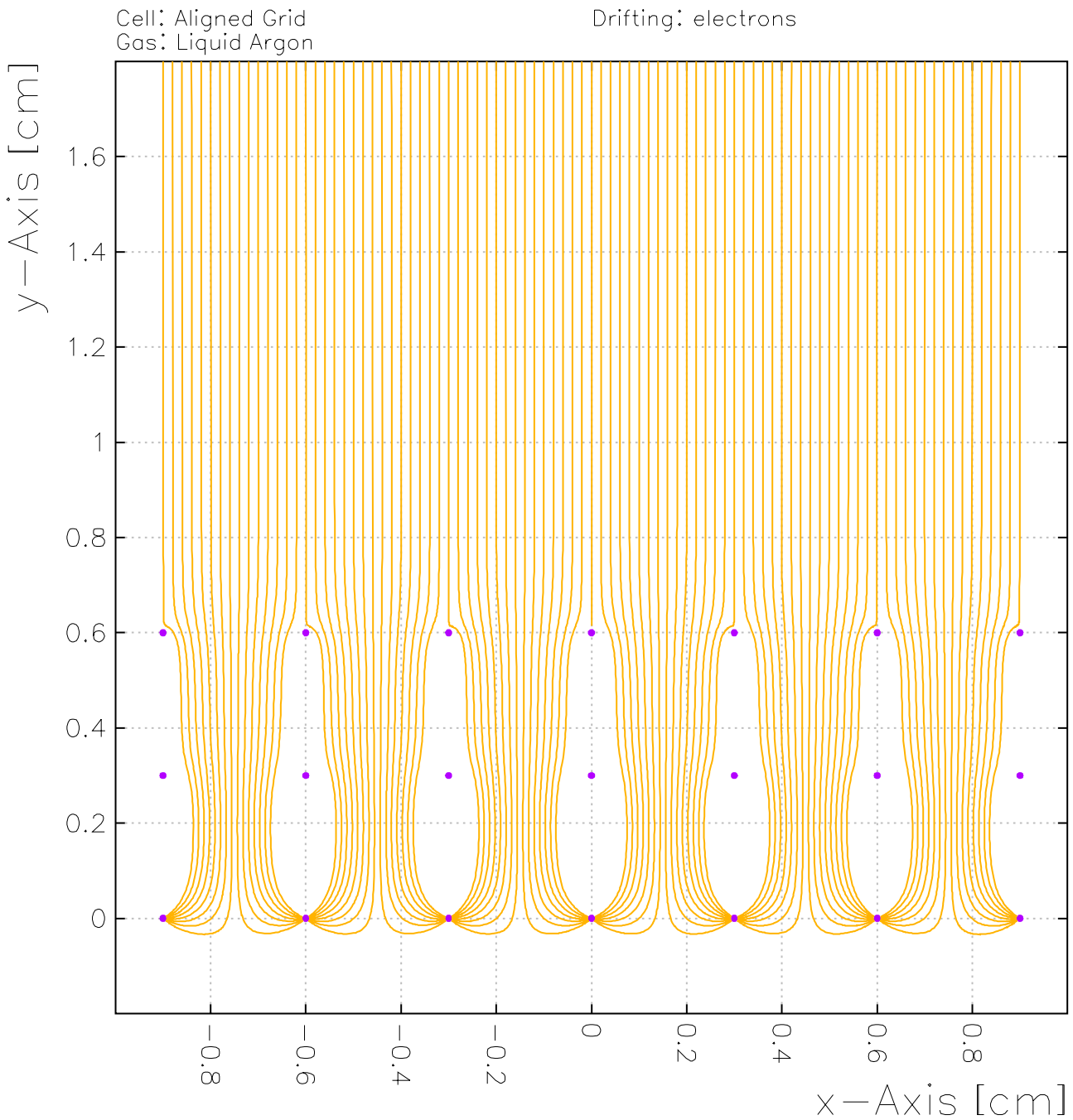
Electronics Working Group Meeting
Jan. 7, 2009

Limitations

- 2D Field Simulation: all wires are parallel
  - Should not affect the large scale time structure
  - Smaller scale features in the waveform will be different, most likely to be smoothed out in a crossed wire configuration
- Limited drift distance (1000 data points in time) and number of wires
  - Amplitude of the U wire “DC” current is exaggerated.

Wire Grid Layout and Electron Drift Lines



This wire arrangement should give a smoother waveform because the electrons do not pass close to the V wires.

U wire plane

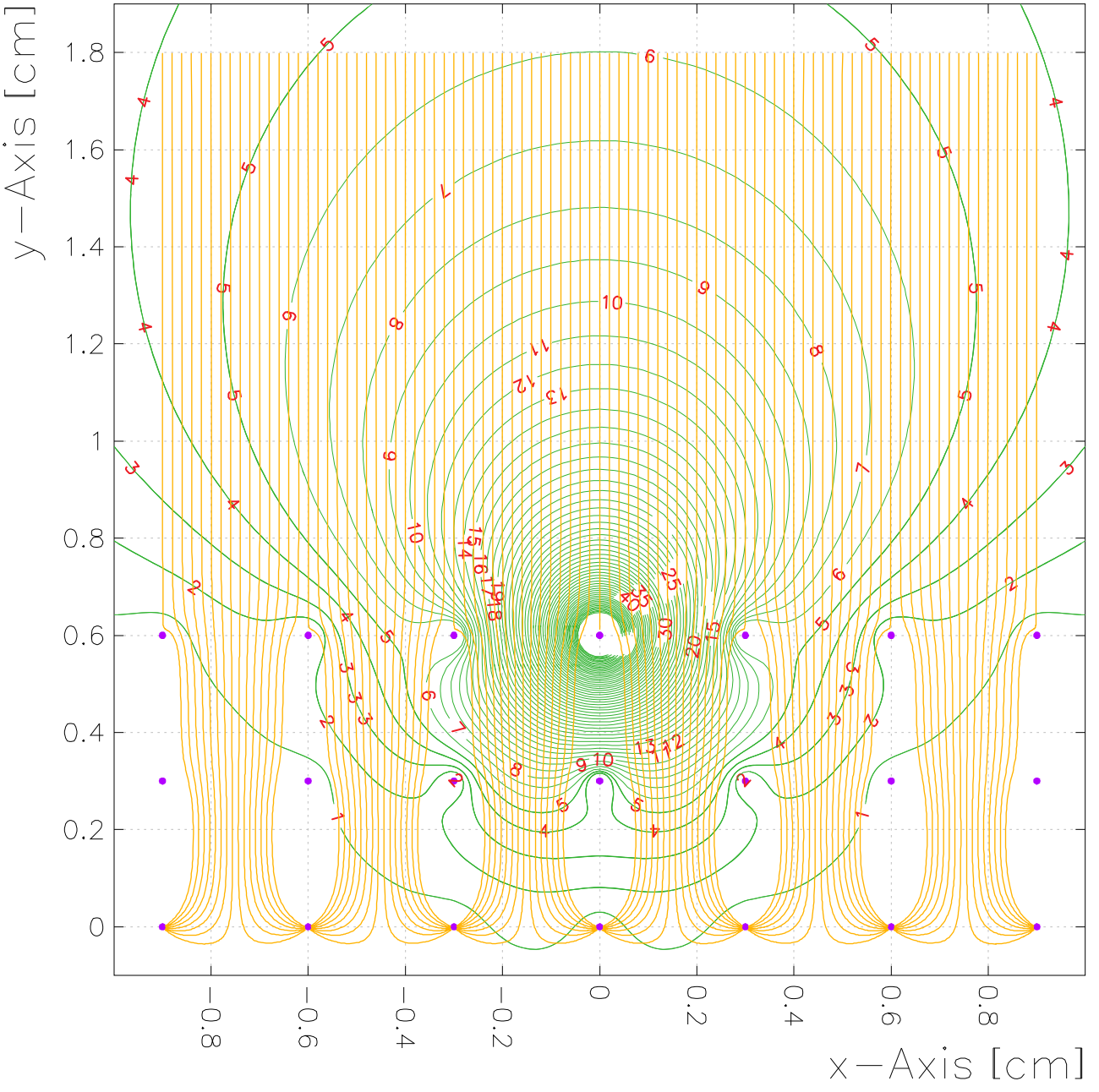
V wire plane

Y wire plane

Weighting Potential Distribution

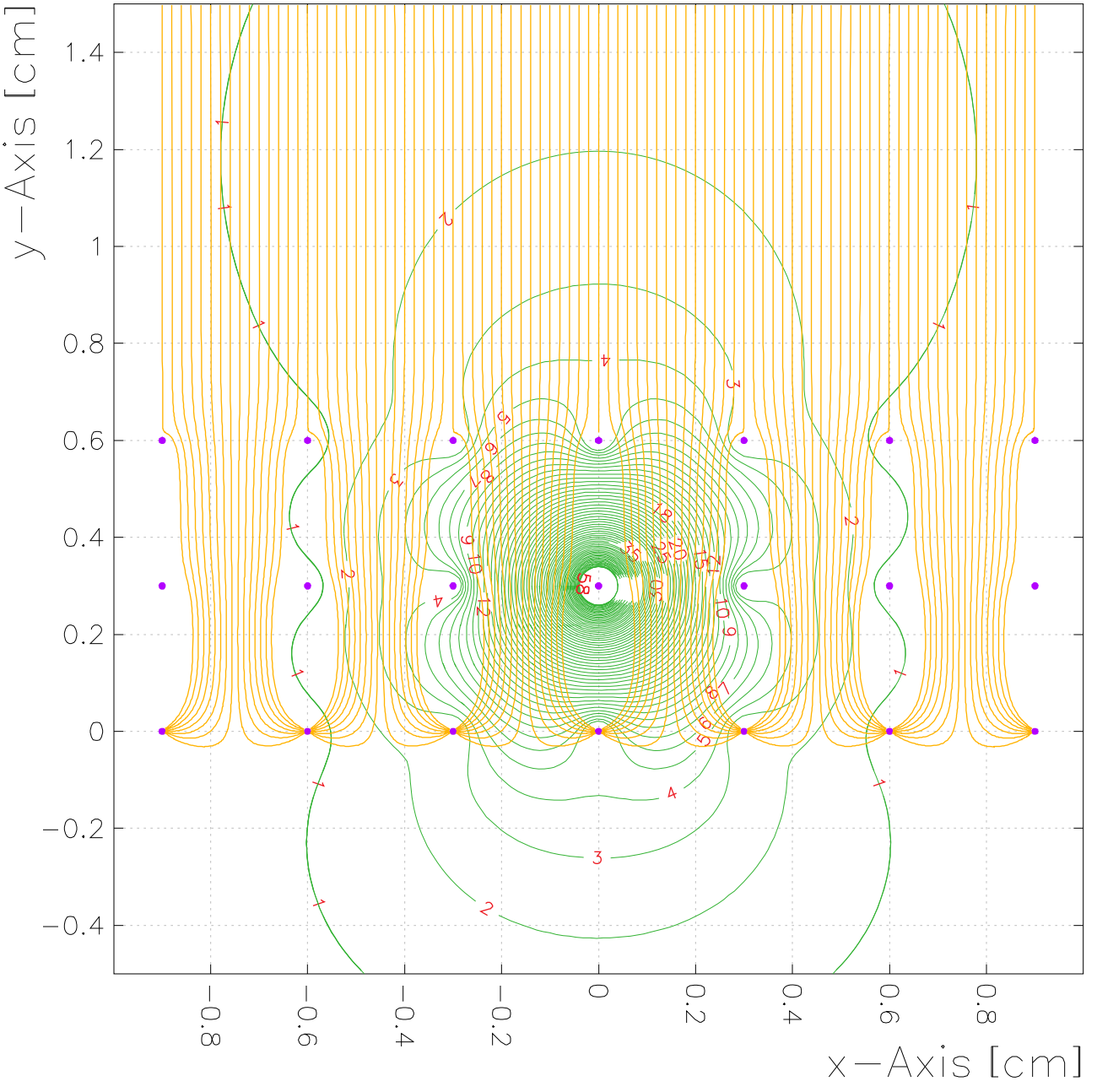
- The following 3 plots show the weighting potential contours of U, V, Y wire respectively.
- The electron drift lines (orange color) are superimposed on the weighting field contours.
- The induced current on each wire is derived by calculating $\vec{v}_d \cdot \vec{E}_w$ along the drift line of each electrons.

Weighting Field of a U Wire



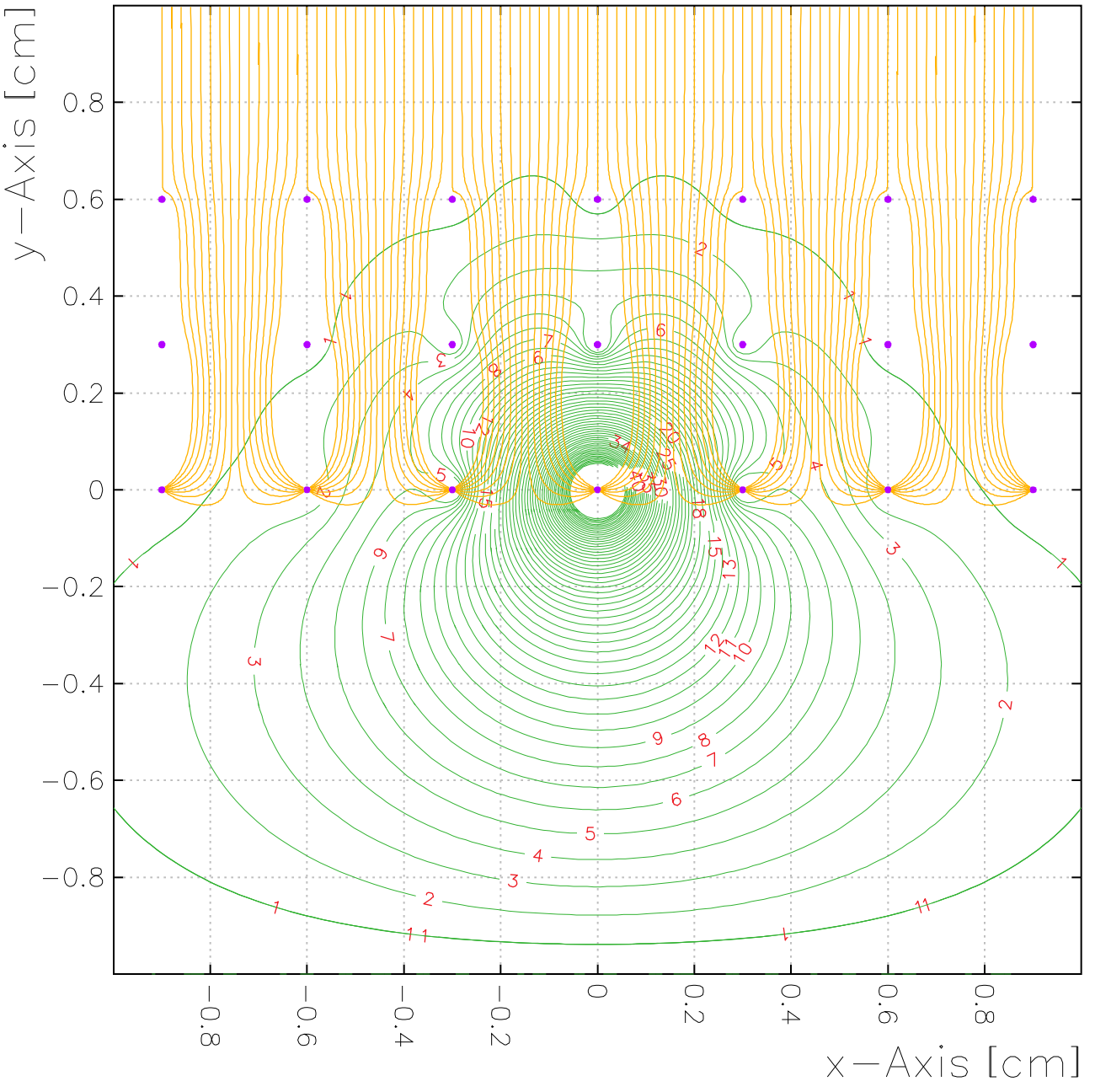
Plotted at 05.18.03 on 05/01/09 with Garfield version 7.13.

Weighting Field of a V Wire



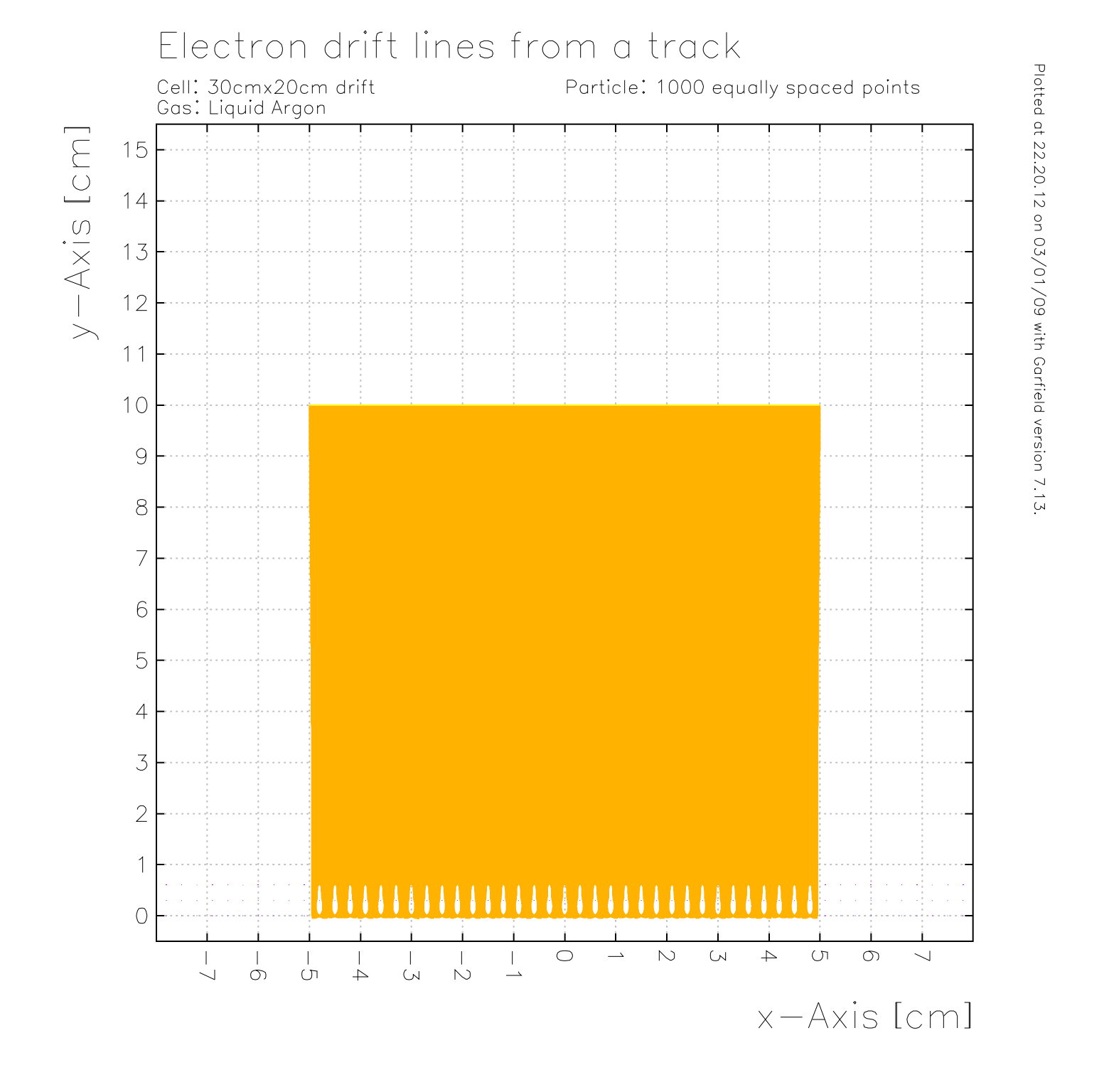
Plotted at 05.15.31 on 05/01/09 with Garfield version 7.13.

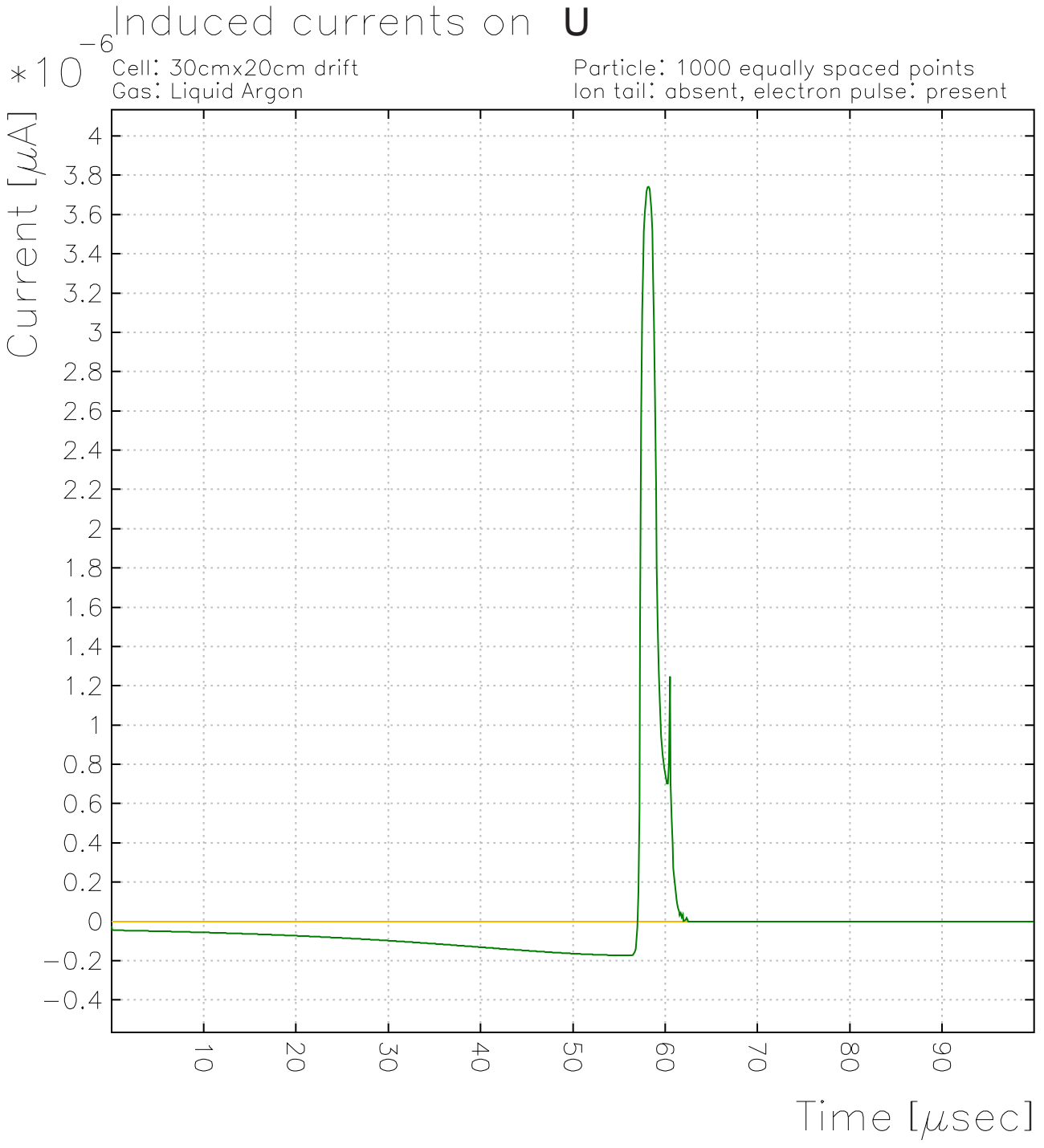
Weighting Field of a Y Wire



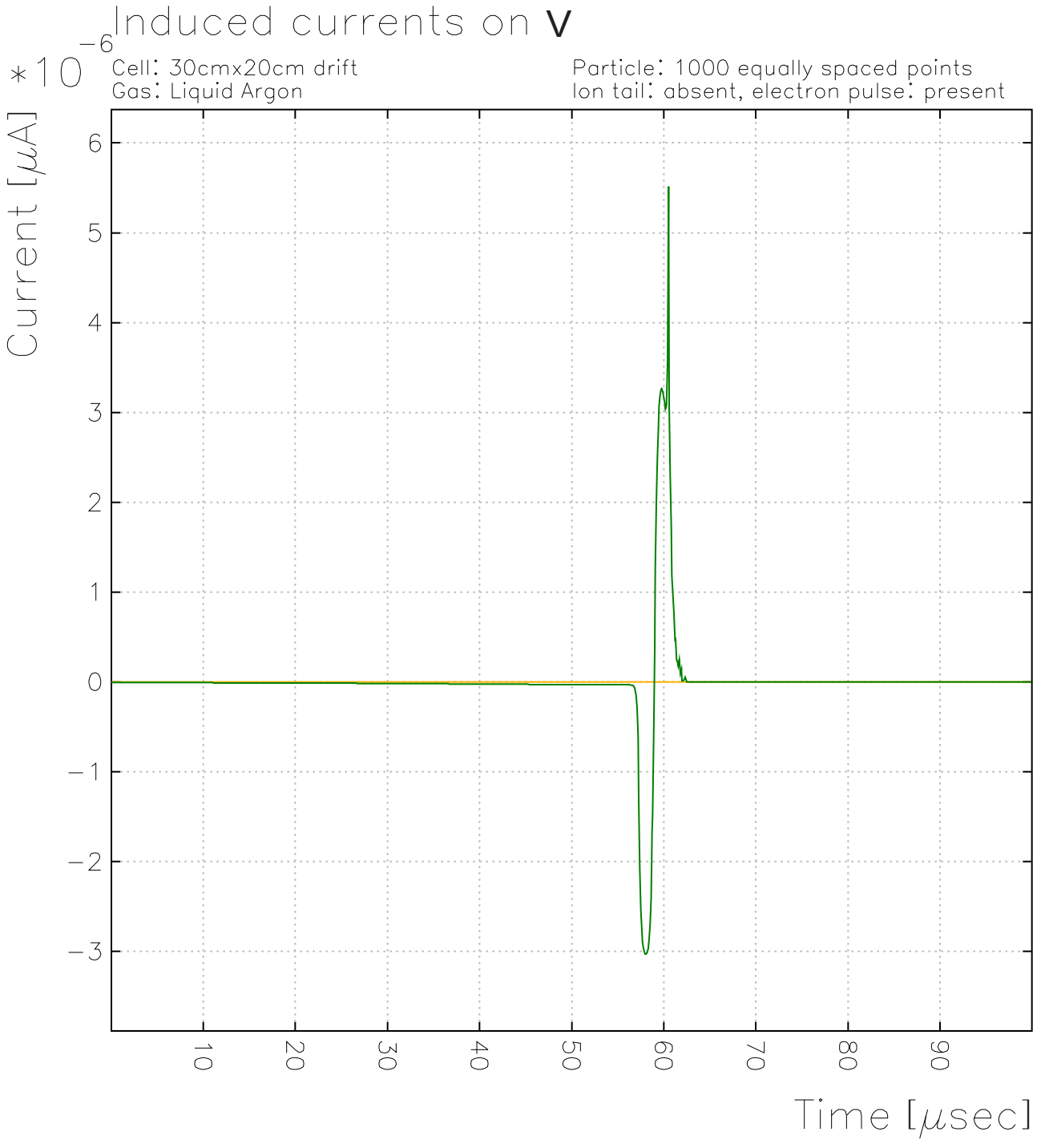
Plotted at 05.14.17 on 05/01/09 with Garfield version 7.13.

- The following plots show the induced current waveform from the central U, V and Y wire.
- The tracks are 10cm long, with 1000 electrons uniformly distributed. The center of the track segment is fixed at 10cm above the Y wire plane

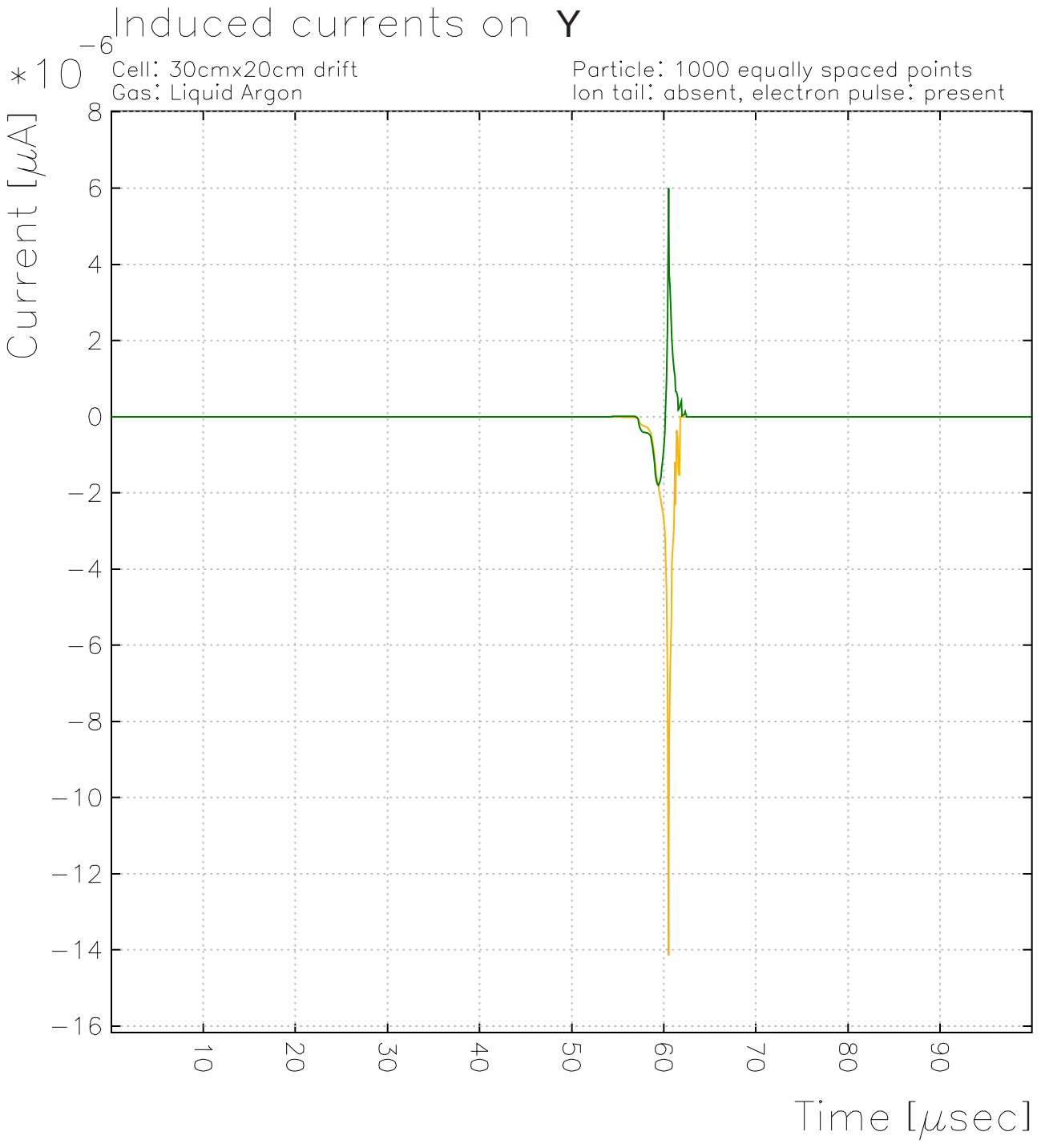

Electron drift lines from a track
Cell: 30cmx20cm drift
Gas: Liquid Argon
Particle: 1000 equally spaced points
y−Axis [cm]
x−Axis [cm]
Plotted at 22.20.12 on 03/01/09 with Garfield version 7.13.



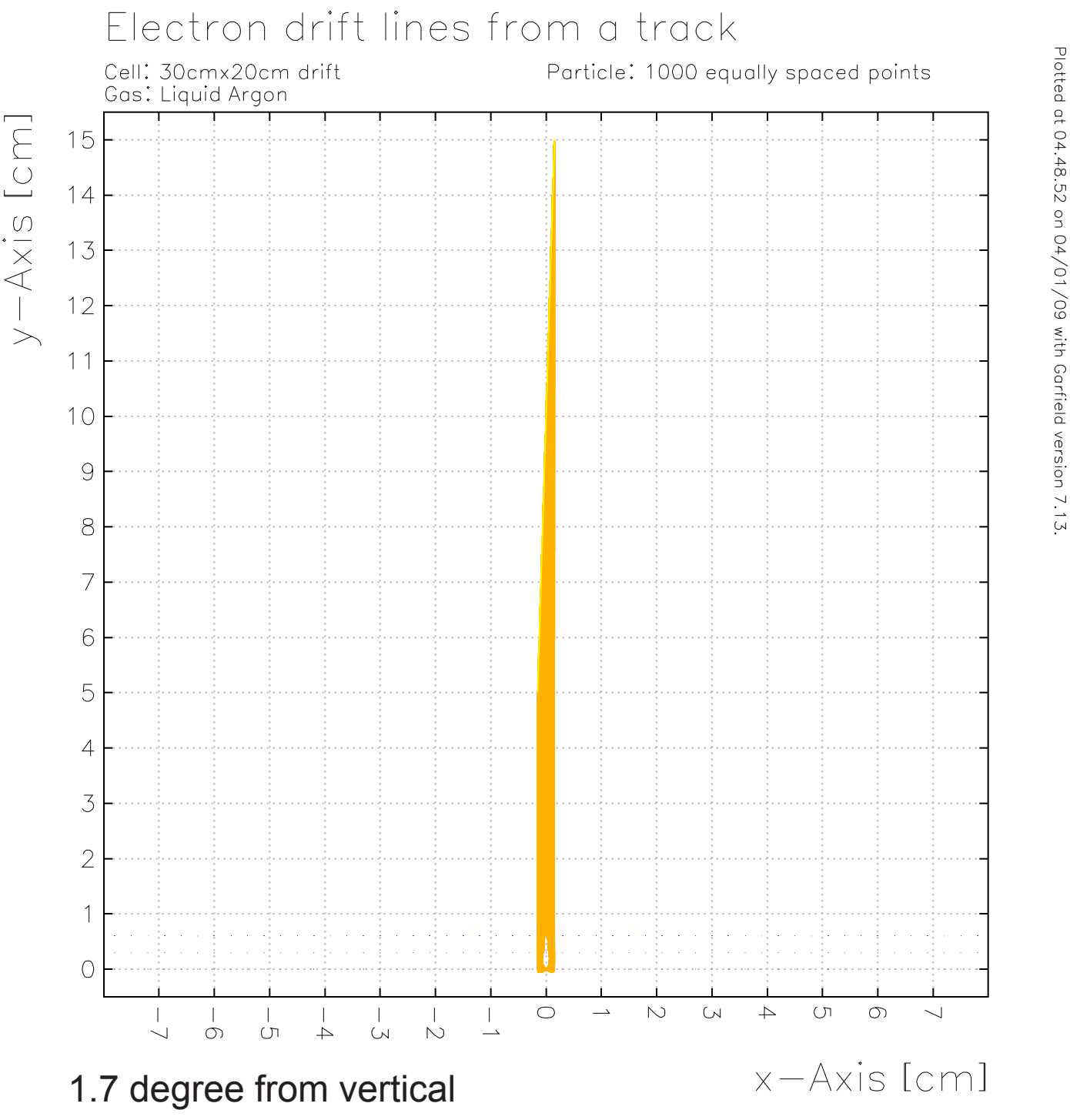
Plotted at 22.09.38 on 03/01/09 with Garfield version 7.13.



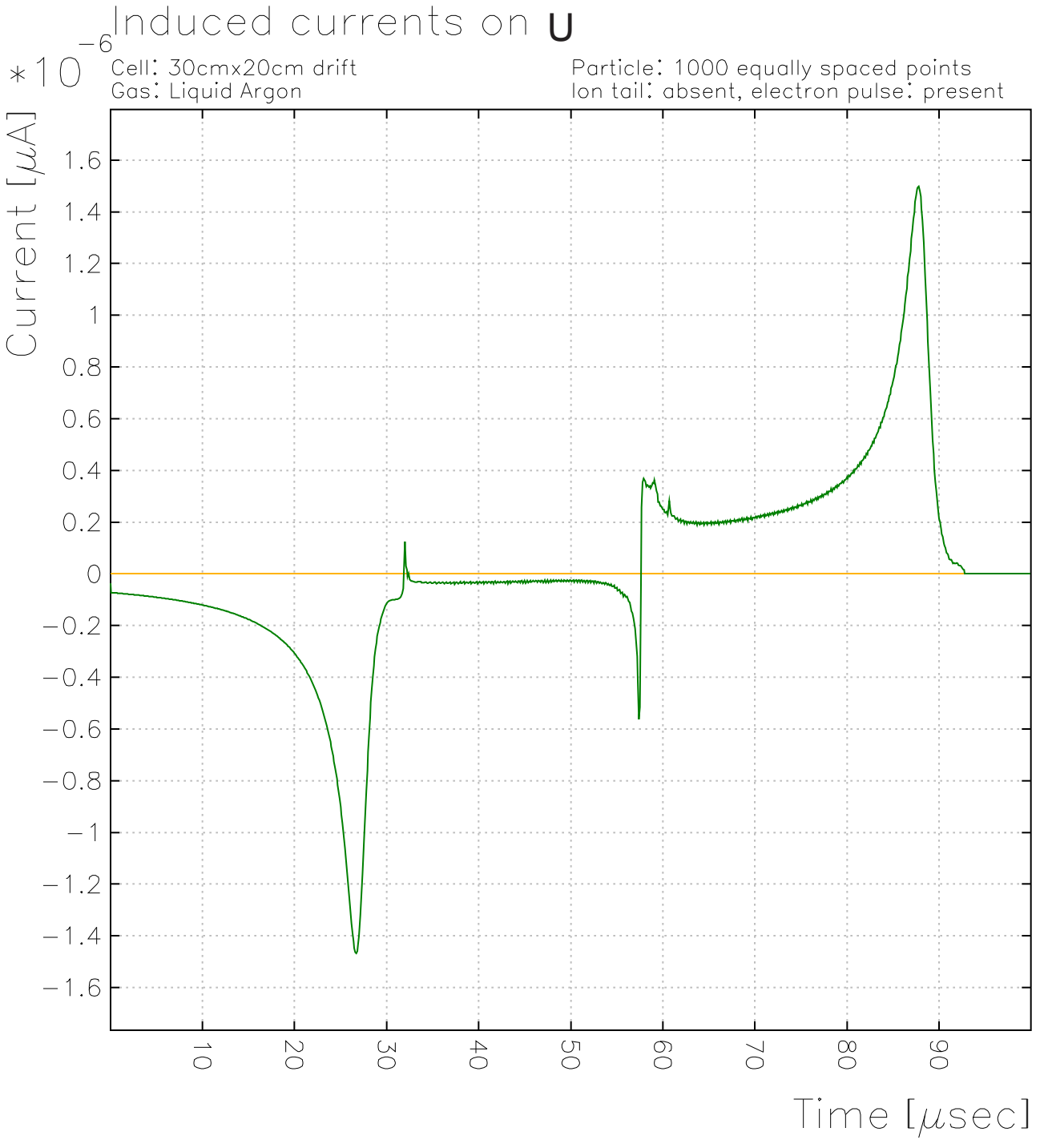
Plotted at 21.29.11 on 03/01/09 with Garfield version 7.13.



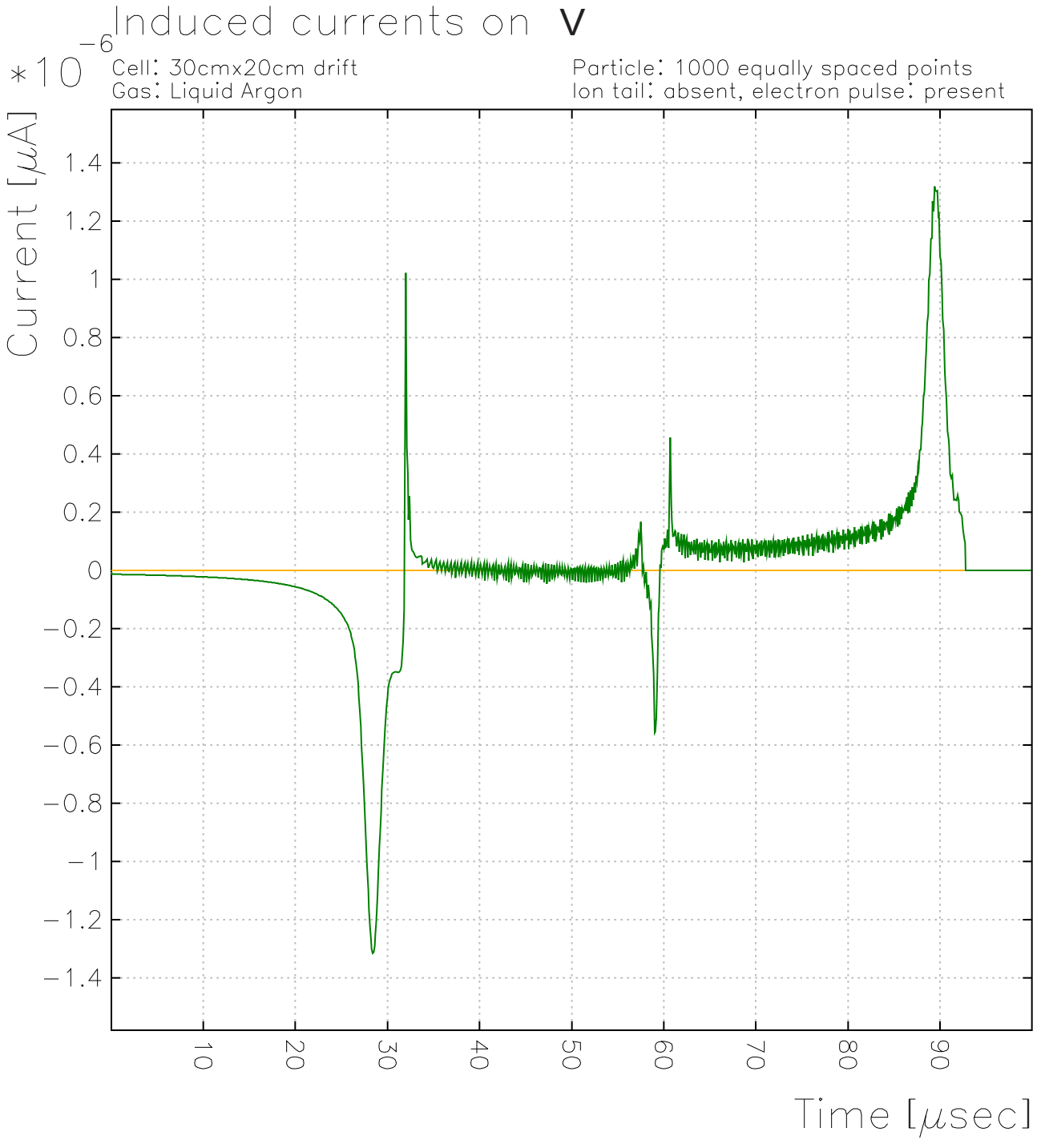
Plotted at 20.49.11 on 03/01/09 with Garfield version 7.13.



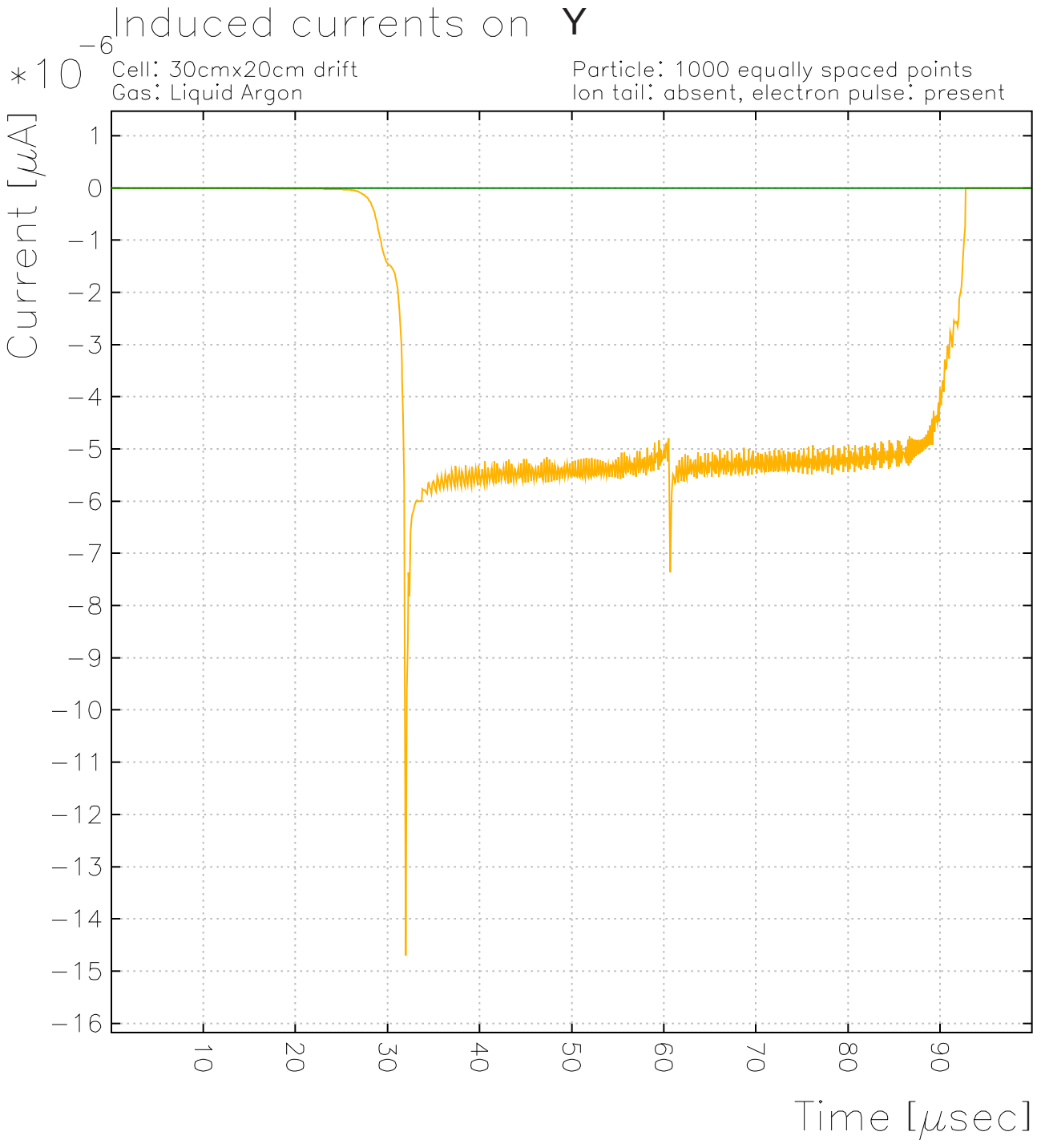
1.7 degree from vertical



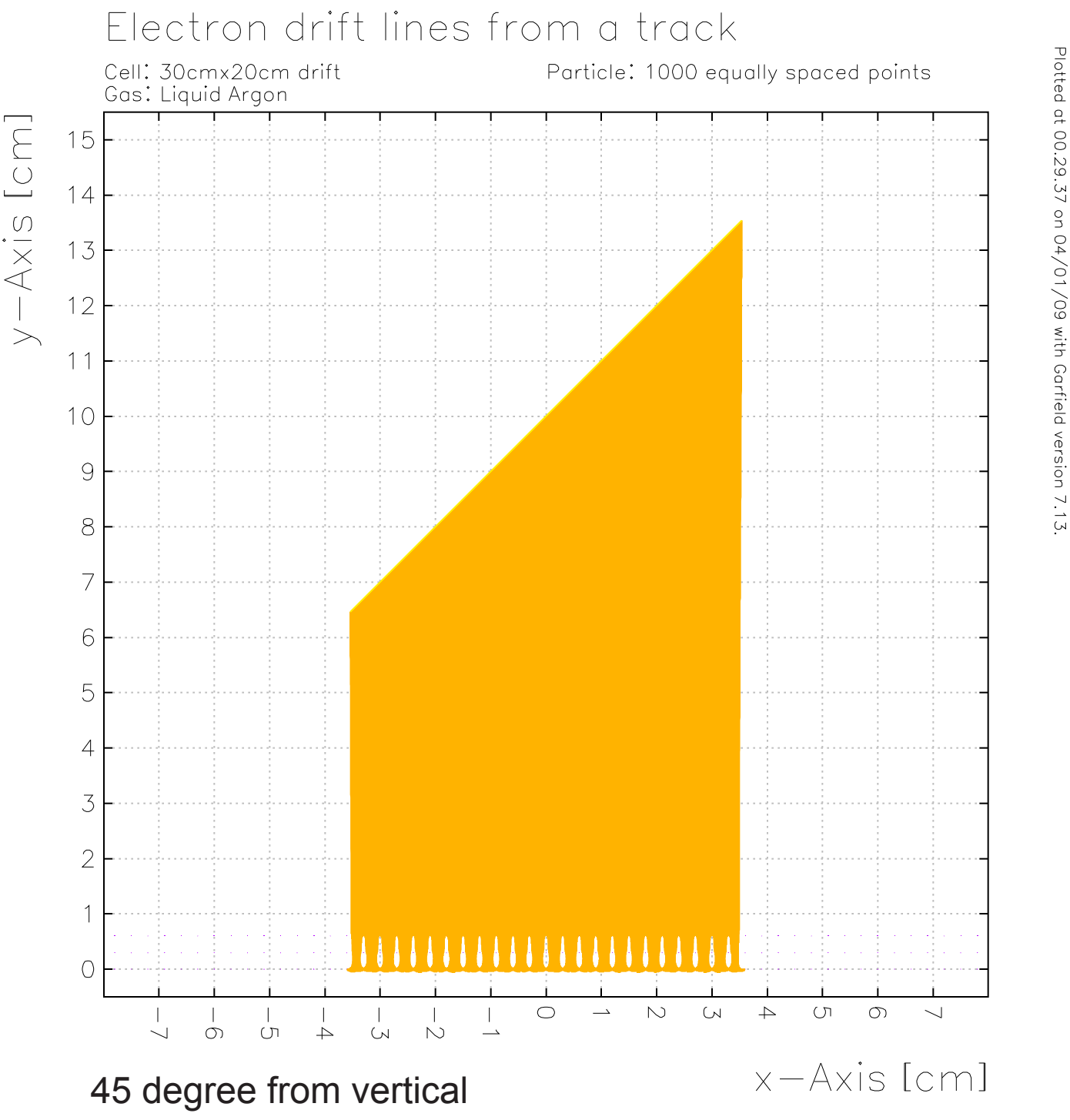
Plotted at 04.38.52 on 04/01/09 with Garfield version 7.13.

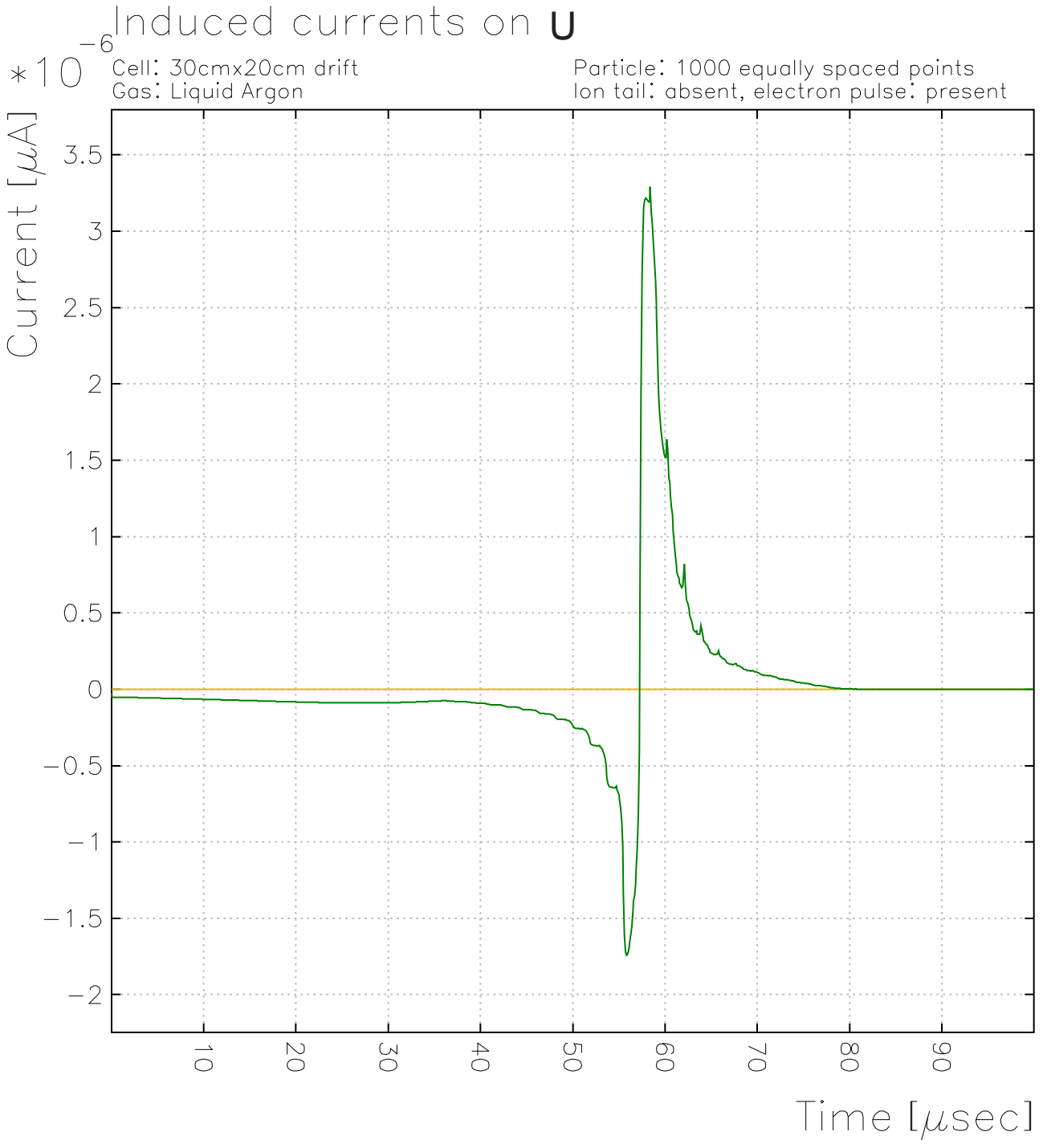


Plotted at 03.58.42 on 04/01/09 with Garfield version 7.13.

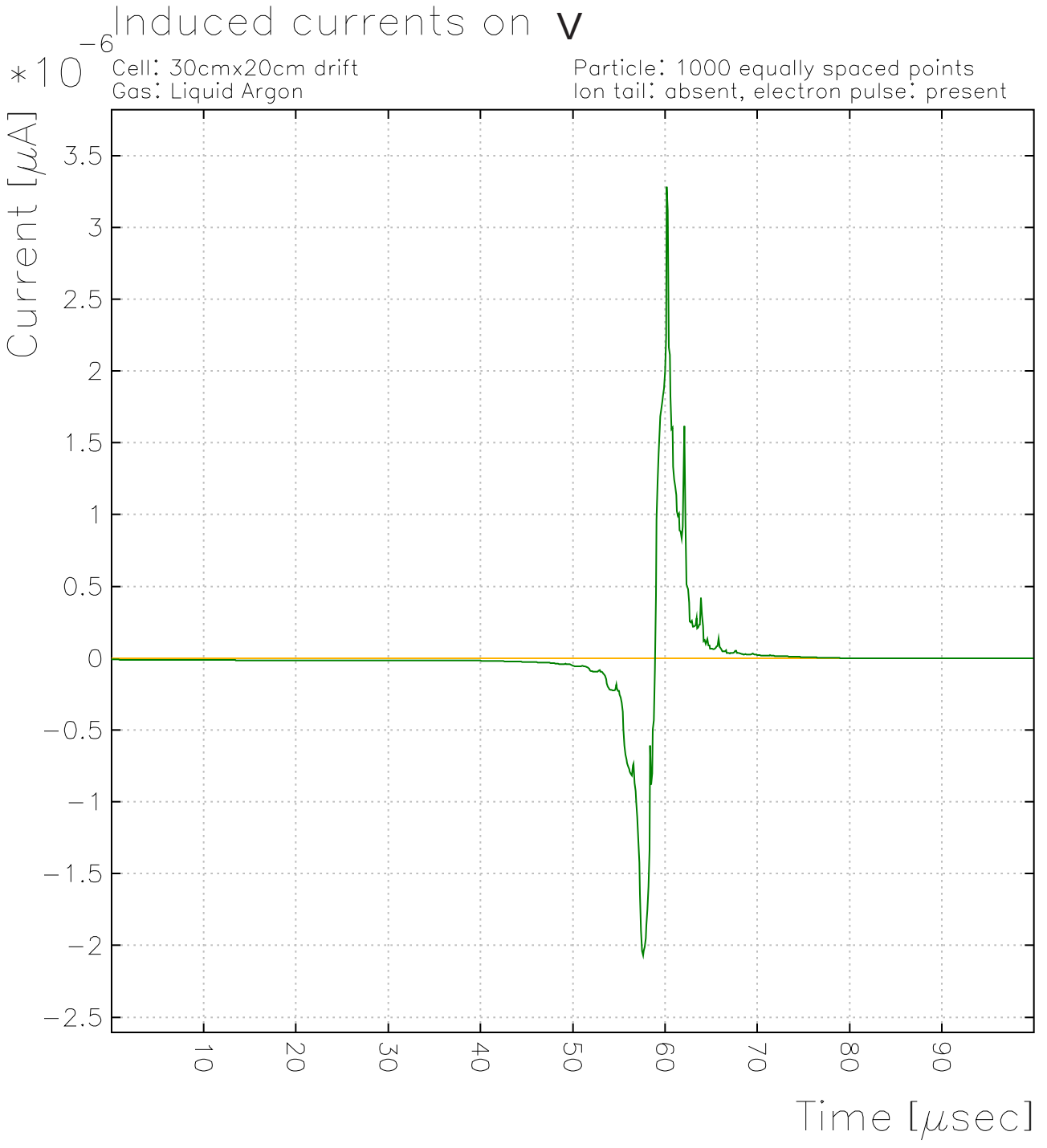


Plotted at 03.18.59 on 04/01/09 with Garfield version 7.13.

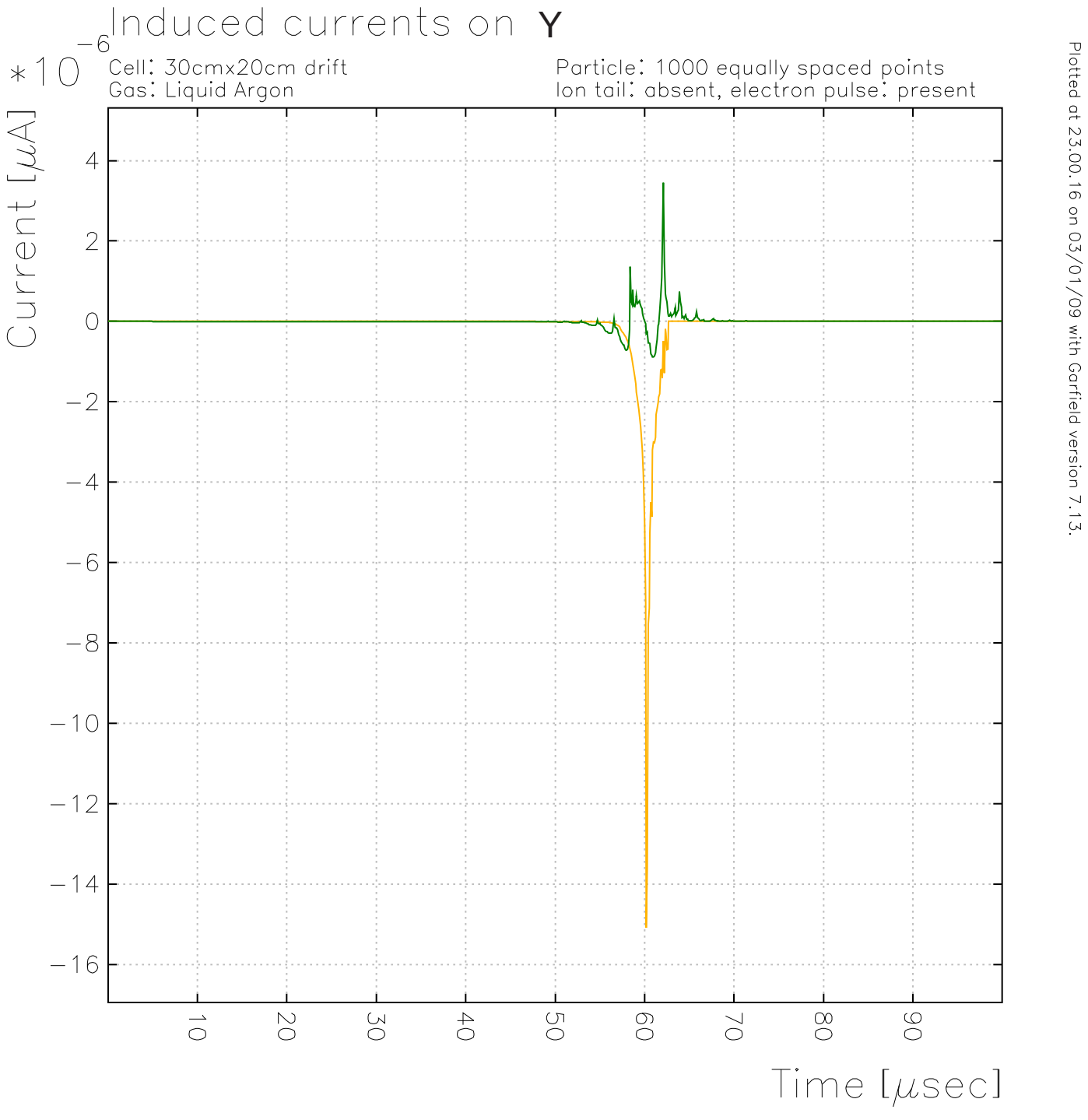

Electron drift lines from a track
Cell: 30cmx20cm drift
Gas: Liquid Argon
Particle: 1000 equally spaced points
y−Axis [cm]
x−Axis [cm]
45 degree from vertical
Plotted at 00.29.37 on 04/01/09 with Garfield version 7.13.



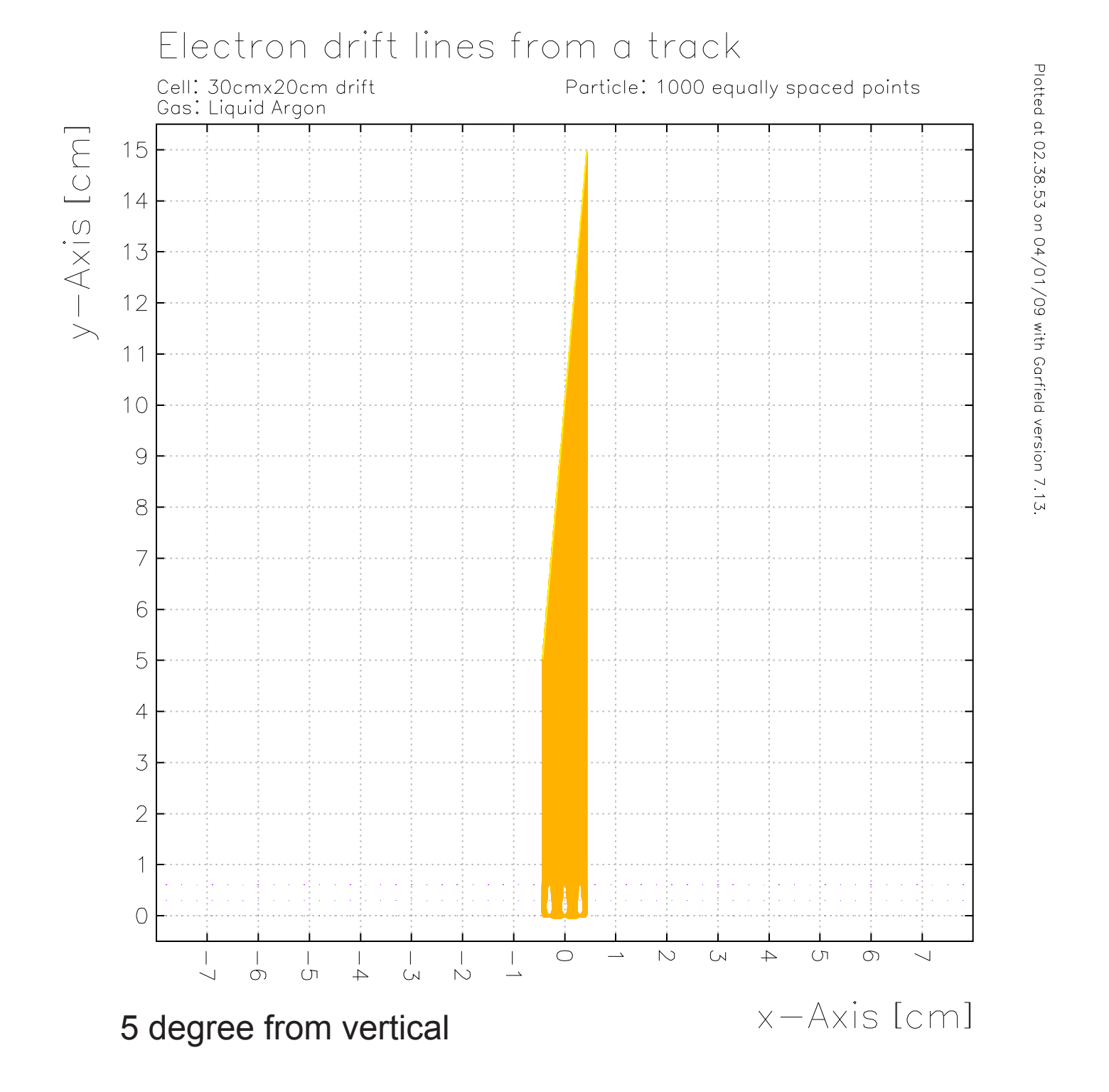
Plotted at 00.19.34 on 04/01/09 with Garfield version 7.13.

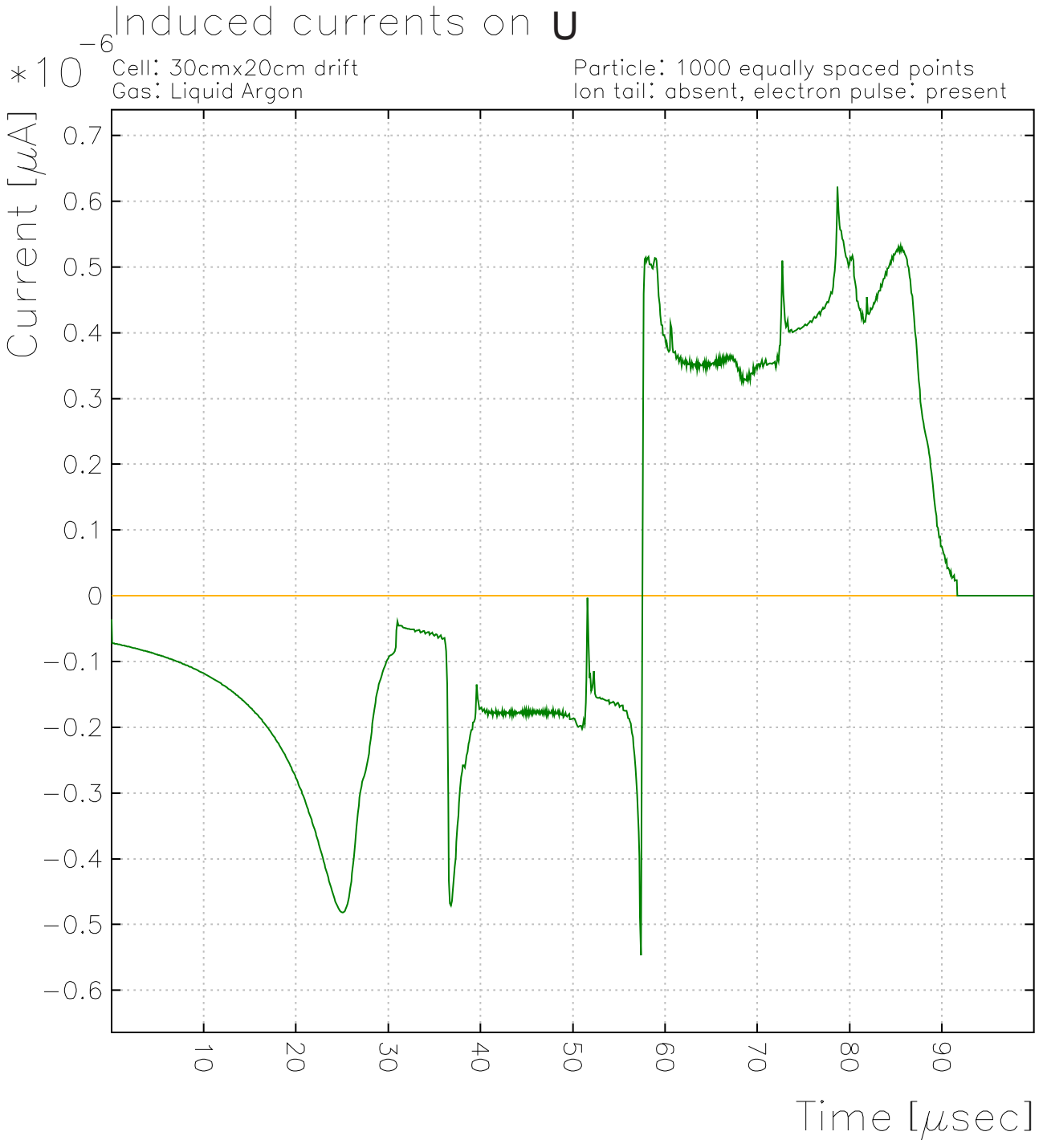


Plotted at 23.39.34 on 03/01/09 with Garfield version 7.13.

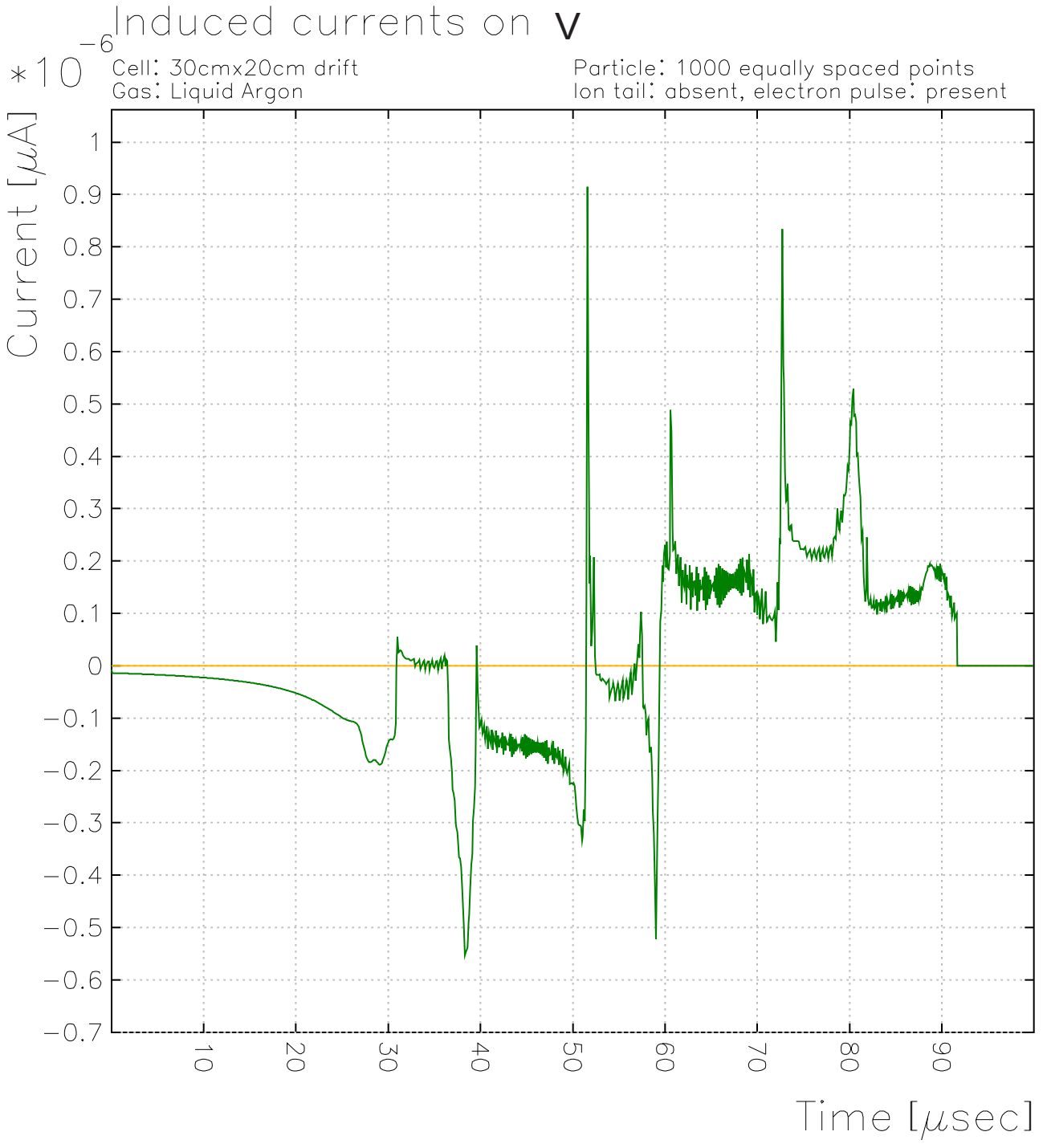


Plotted at 23.00.16 on 03/01/09 with Garfield version 7.13.

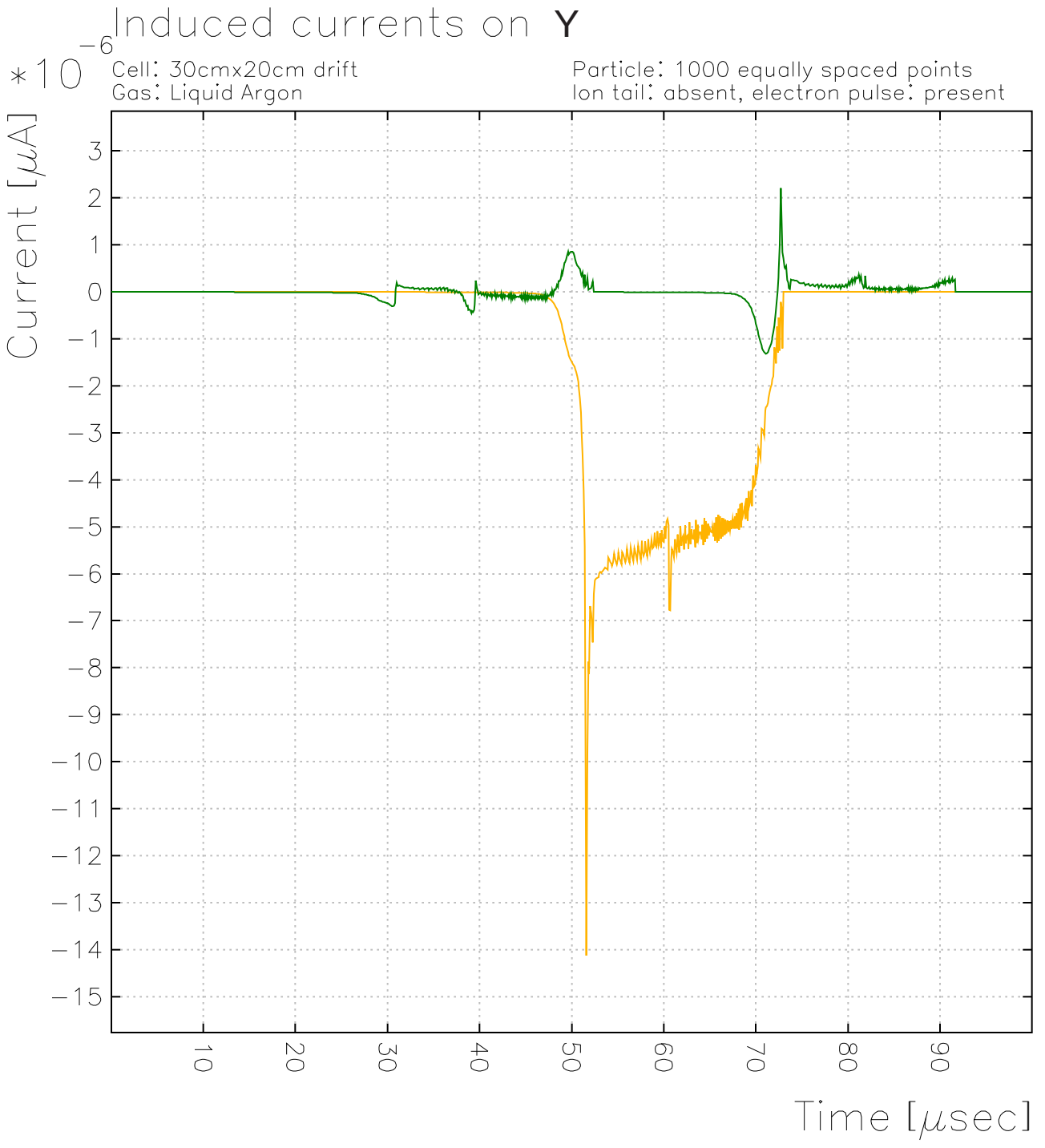

Electron drift lines from a track
Cell: 30cmx20cm drift
Gas: Liquid Argon
Particle: 1000 equally spaced points
y−Axis [cm]
x−Axis [cm]
Plotted at 02.38.53 on 04/01/09 with Garfield version 7.13.
5 degree from vertical



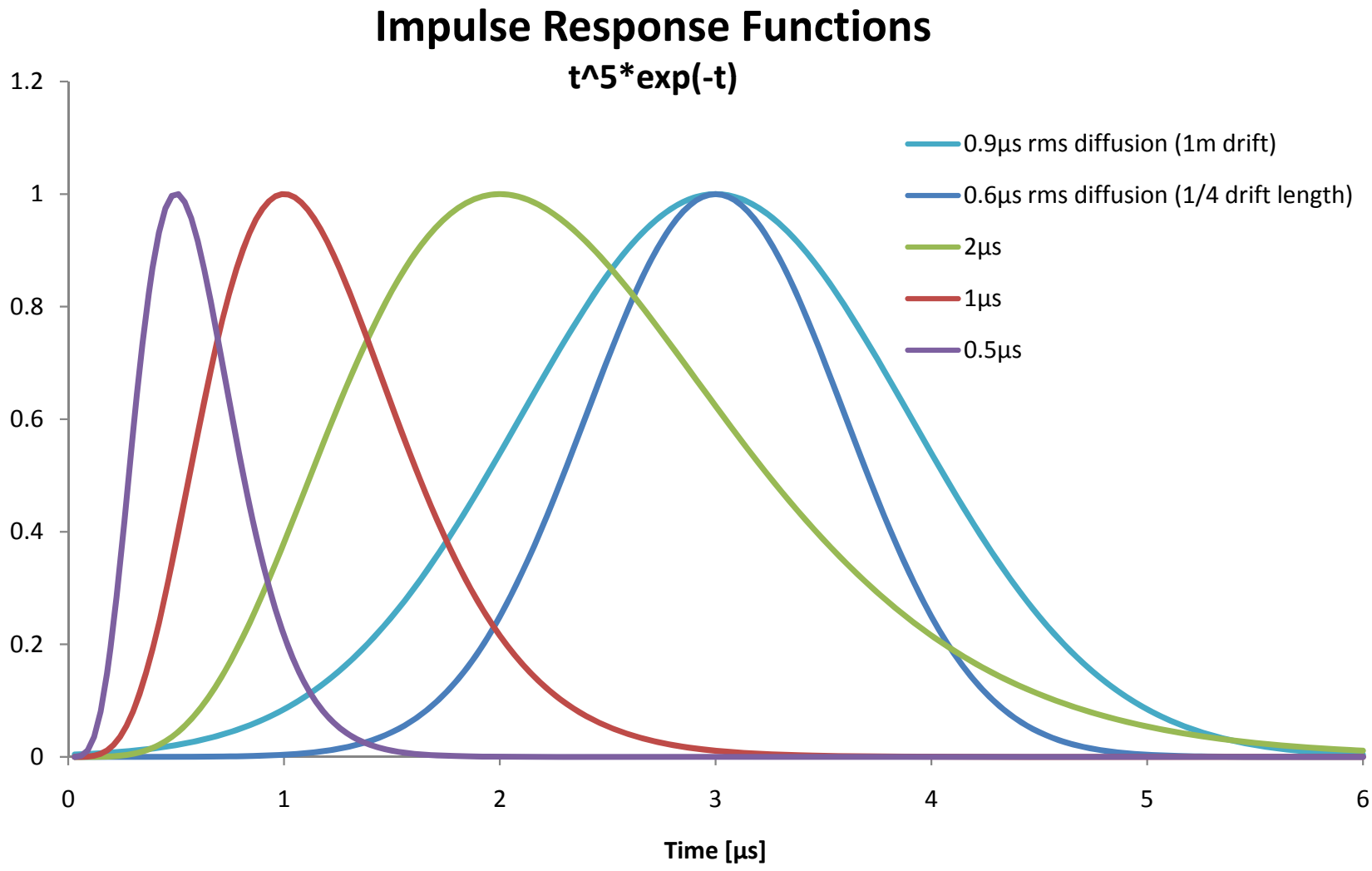
Plotted at 02.28.39 on 04/01/09 with Garfield version 7.13.



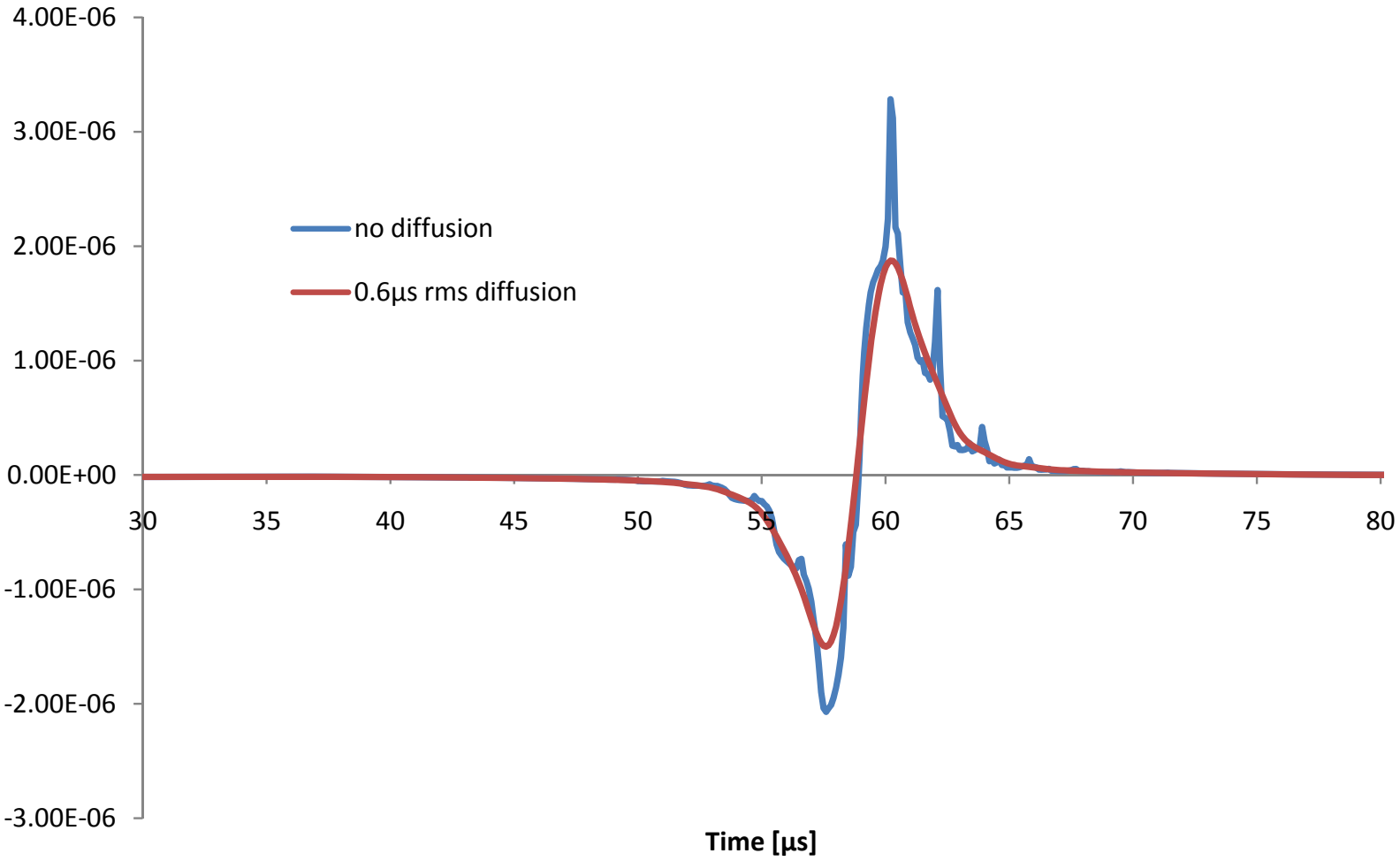
Plotted at 01.49.23 on 04/01/09 with Garfield version 7.13.

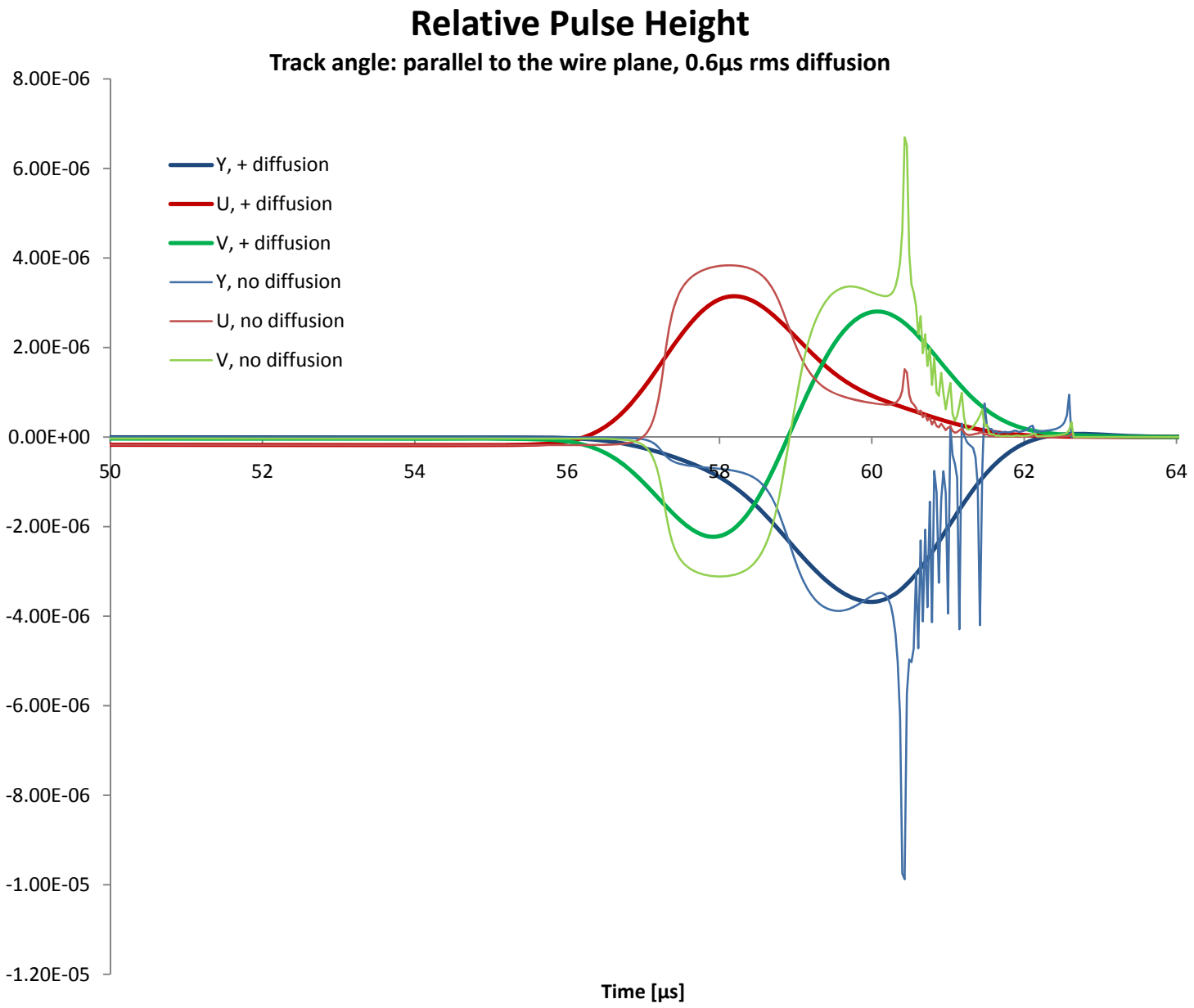


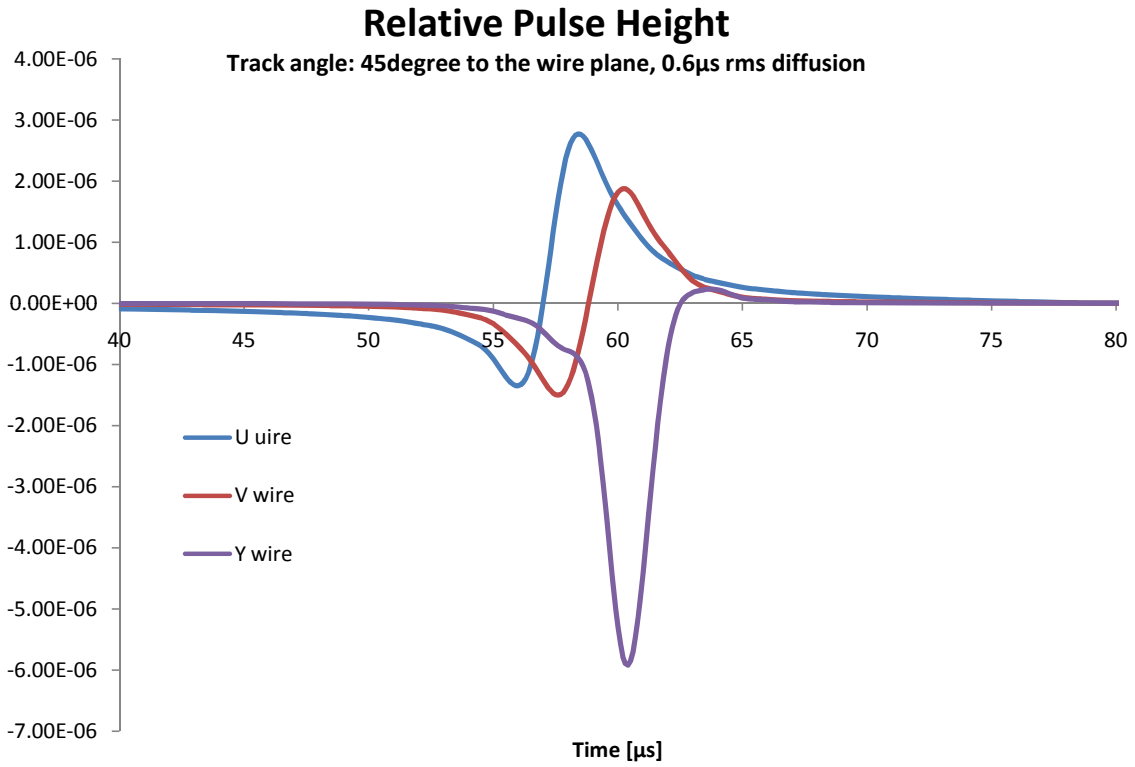
Plotted at 01.10.00 on 04/01/09 with Garfield version 7.13.

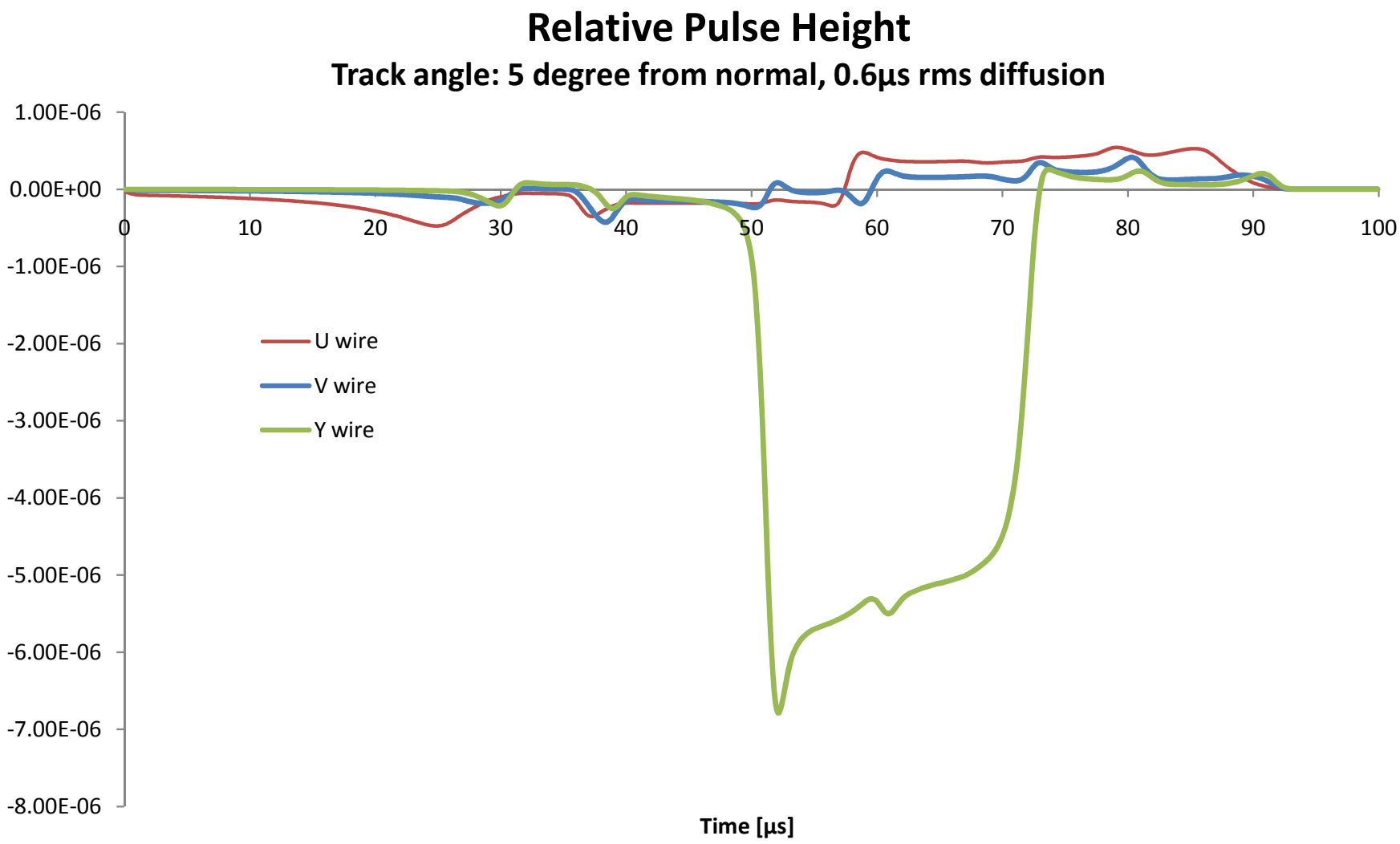

Impulse Response Functions
t^5*exp(-t)
1.2
1
0.8
0.6
0.4
0.2
0
0
1
2
3
4
5
6
Time [µs]
0.9µs rms diffusion (1m drift)
0.6µs rms diffusion (1/4 drift length)
2µs
1µs
0.5µs

Induced Current on a V Wire, 45 degree track angle



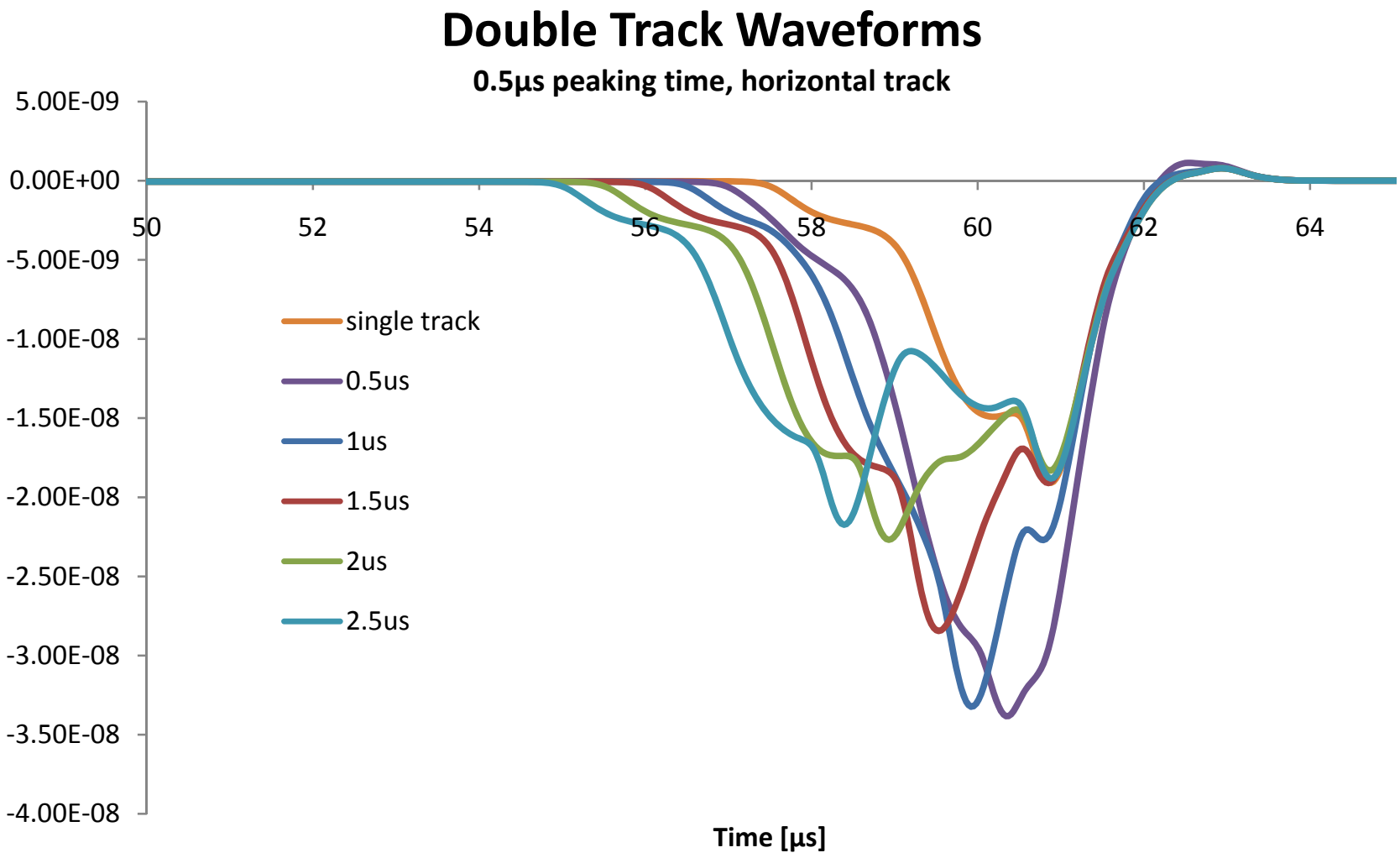

Relative Pulse Height
Track angle: parallel to the wire plane, 0.6µs rms diffusion
8.00E-06
6.00E-06
4.00E-06
2.00E-06
0.00E+00
-2.00E-06
-4.00E-06
-6.00E-06
-8.00E-06
-1.00E-05
-1.20E-05
50
52
54
56
58
60
62
64
Y, + diffusion
U, + diffusion
V, + diffusion
Y, no diffusion
U, no diffusion
V, no diffusion
Time [µs]

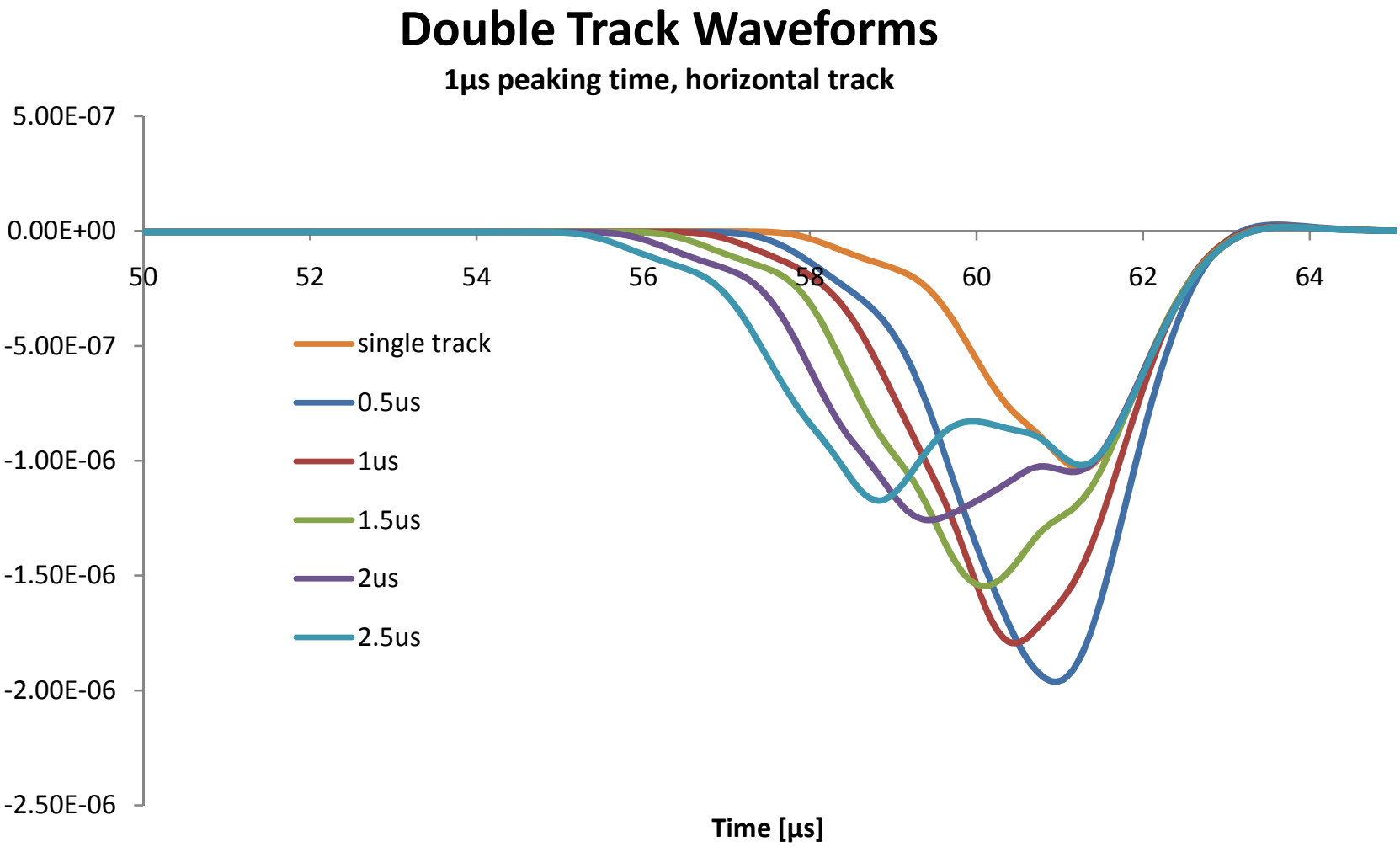

Relative Pulse Height
Track angle: 45degree to the wire plane, 0.6µs rms diffusion
4.00E-06
3.00E-06
2.00E-06
1.00E-06
0.00E+00
-1.00E-06
-2.00E-06
-3.00E-06
-4.00E-06
-5.00E-06
-6.00E-06
-7.00E-06
40
45
50
55
60
65
70
75
80
U uire
V wire
Y wire
Time [µs]

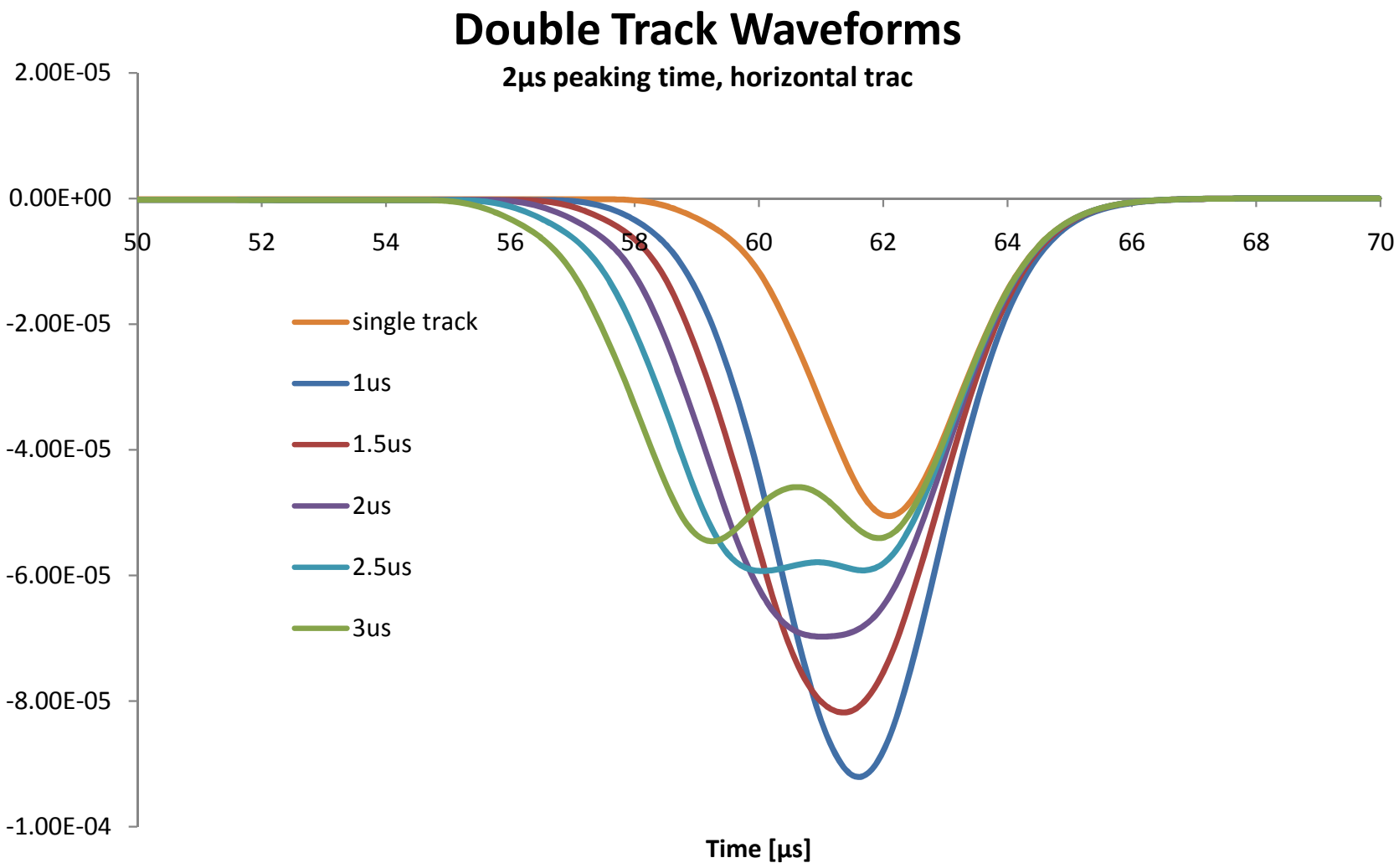

Relative Pulse Height
Track angle: 5 degree from normal, 0.6µs rms diffusion
1.00E-06
0.00E+00
-1.00E-06
-2.00E-06
-3.00E-06
-4.00E-06
-5.00E-06
-6.00E-06
-7.00E-06
-8.00E-06
0
10
20
30
40
50
60
70
80
90
100
U wire
V wire
Y wire
Time [µs]

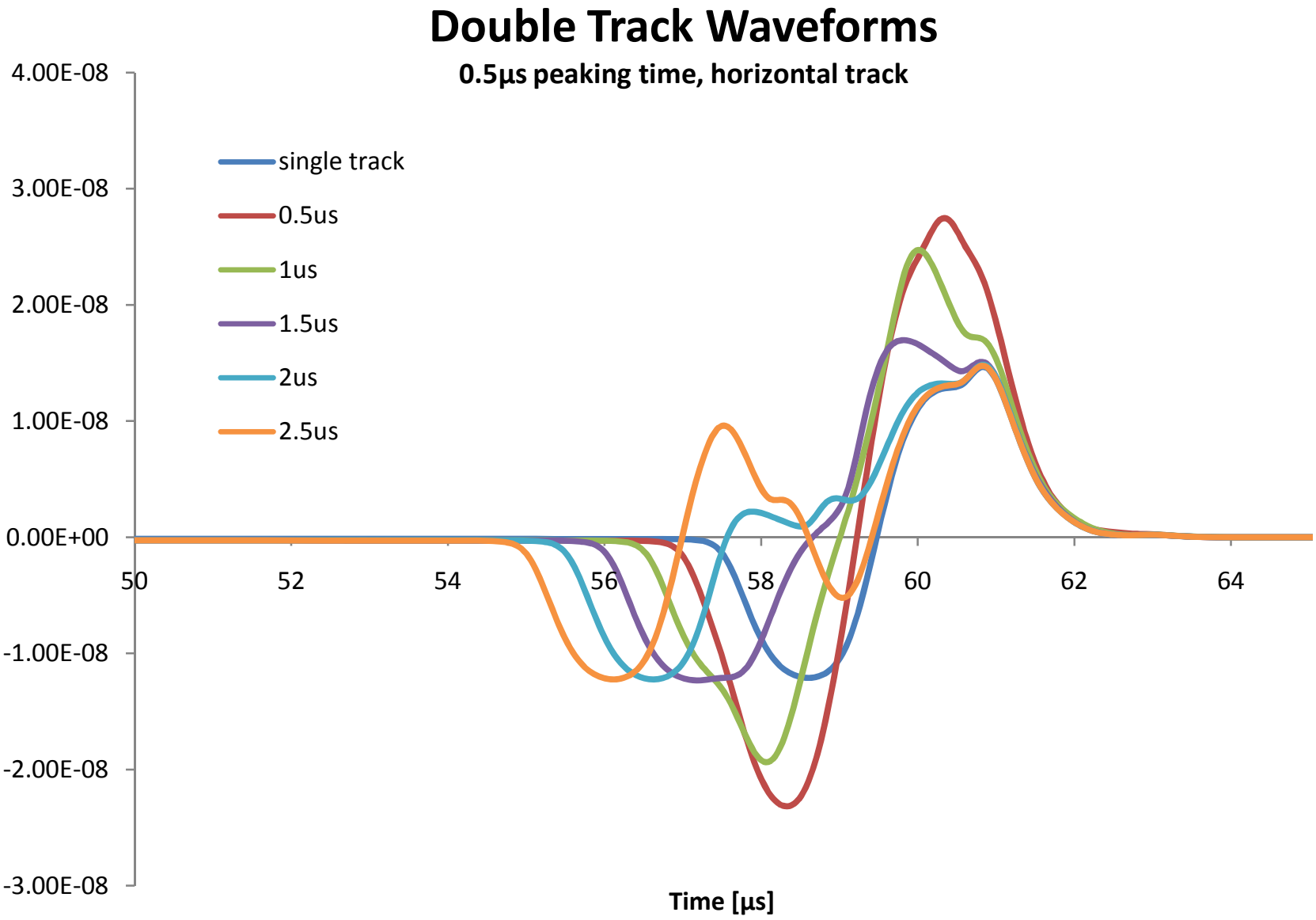
Simulated Double Track Waveform

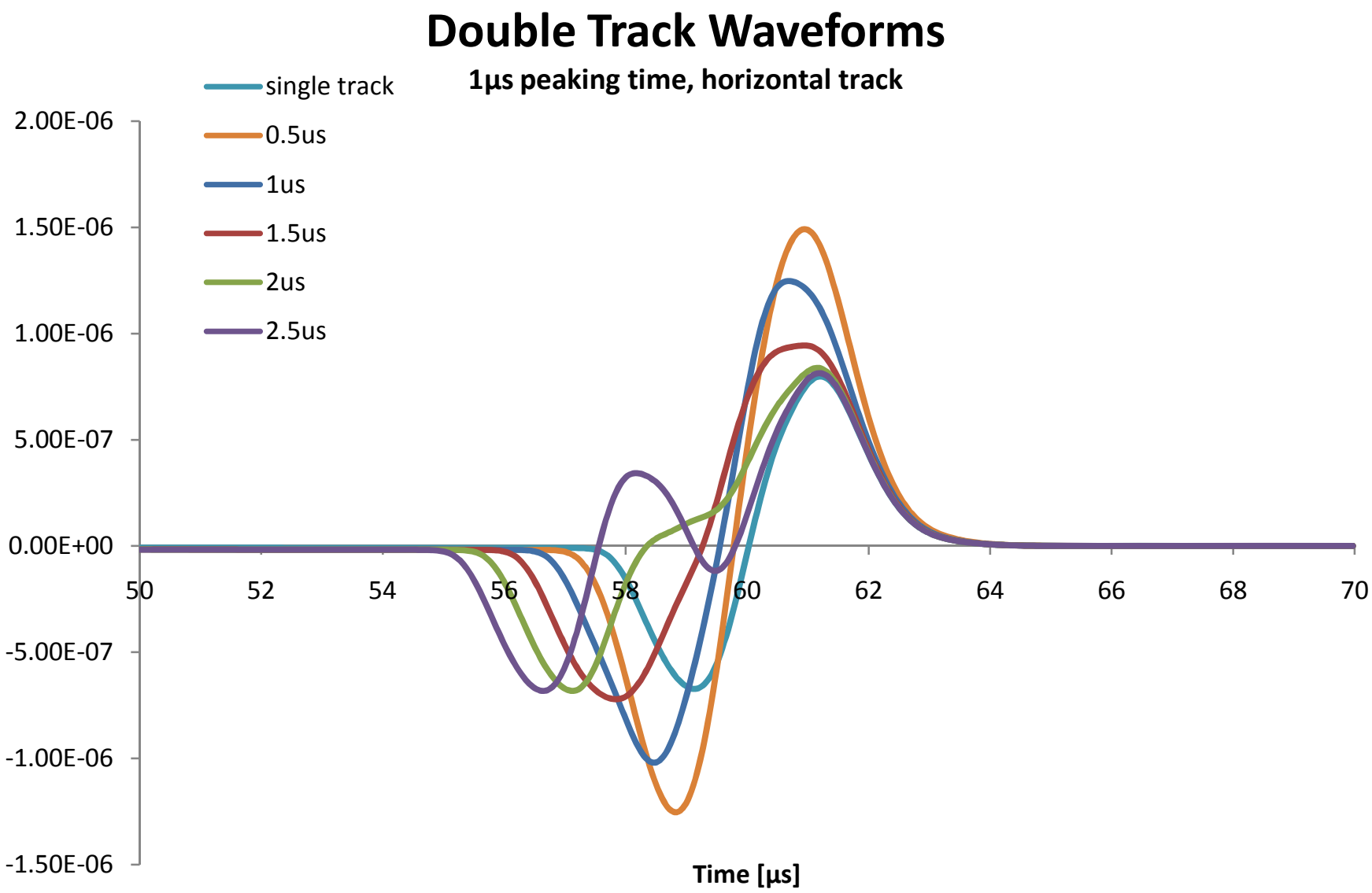
- The current waveform of two horizontal track segments are added together with an offset in time to simulate two tracks with a drift time delay between them.
- The summed waveform is convolved with a 5^{th} order CR-RC impulse response with different peaking time.
- The drift velocity at 500V/cm in LAr is 1.6mm/µs.
- Contribution from diffusion (equivalent to about 1µs peaking time shaping) is NOT included in these plots.

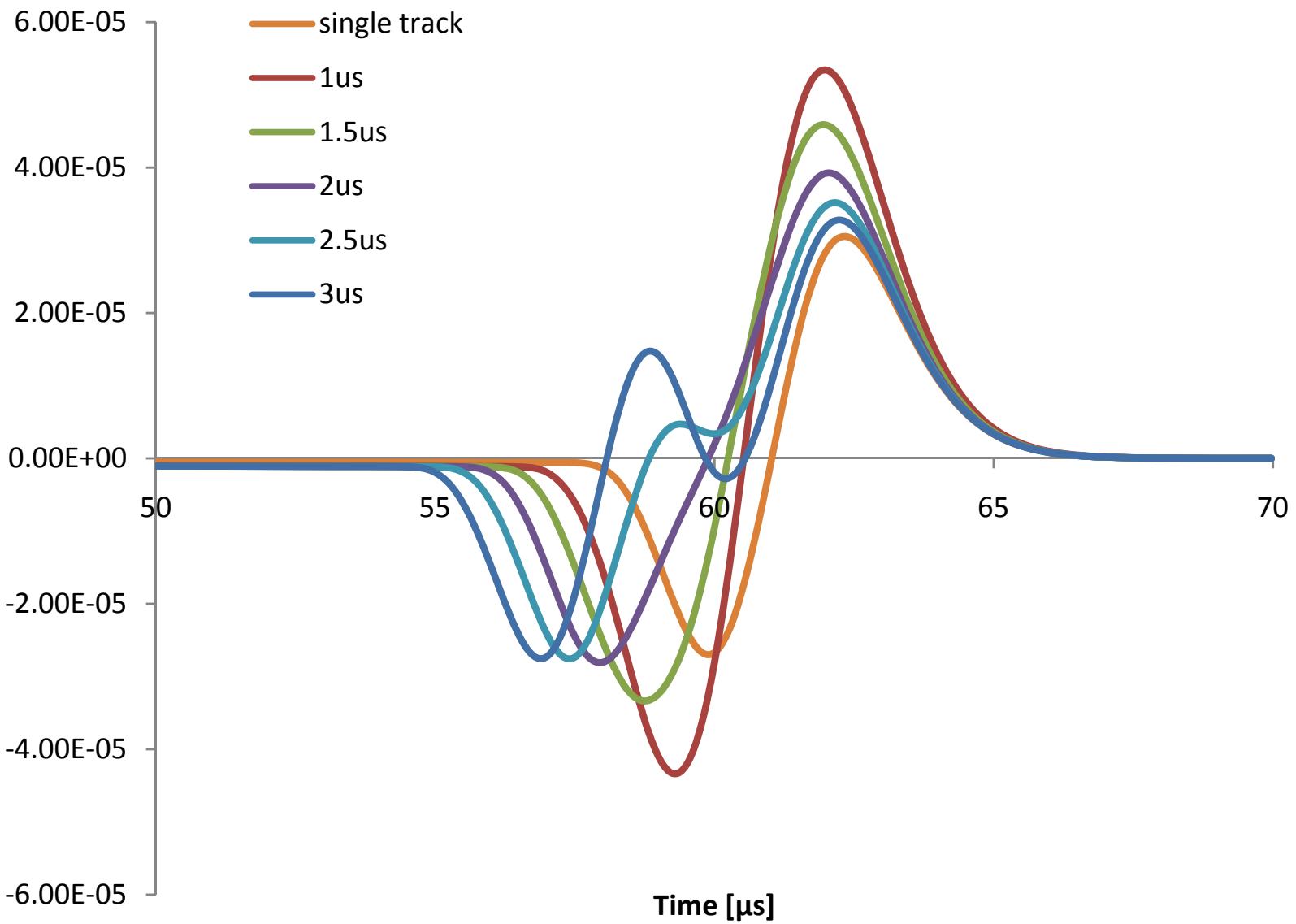

Double Track Waveforms
0.5µs peaking time, horizontal track
5.00E-09
0.00E+00
-5.00E-09
-1.00E-08
-1.50E-08
-2.00E-08
-2.50E-08
-3.00E-08
-3.50E-08
-4.00E-08
50
52
54
56
58
60
62
64
single track
0.5us
1us
1.5us
2us
2.5us
Time [µs]


Double Track Waveforms
1µs peaking time, horizontal track
5.00E-07
0.00E+00
-5.00E-07
-1.00E-06
-1.50E-06
-2.00E-06
-2.50E-06
50
52
54
56
58
60
62
64
single track
0.5us
1us
1.5us
2us
2.5us
Time [µs]


Double Track Waveforms
2µs peaking time, horizontal trac
2.00E-05
0.00E+00
-2.00E-05
-4.00E-05
-6.00E-05
-8.00E-05
-1.00E-04
50
52
54
56
58
60
62
64
66
68
70
single track
1us
1.5us
2us
2.5us
3us
Time [µs]


Double Track Waveforms
0.5µs peaking time, horizontal track
4.00E-08
3.00E-08
2.00E-08
1.00E-08
0.00E+00
-1.00E-08
-2.00E-08
-3.00E-08
50
52
54
56
58
60
62
64
single track
0.5us
1us
1.5us
2us
2.5us
Time [µs]


Double Track Waveforms
1µs peaking time, horizontal track
single track
0.5us
1us
1.5us
2us
2.5us
2.00E-06
1.50E-06
1.00E-06
5.00E-07
0.00E+00
-5.00E-07
-1.00E-06
-1.50E-06
50
52
54
56
58
60
62
64
66
68
70
Time [µs]

Double Track Waveforms

2µs peaking time, horizontal track