Collection time Simulations for n3He Target Chamber

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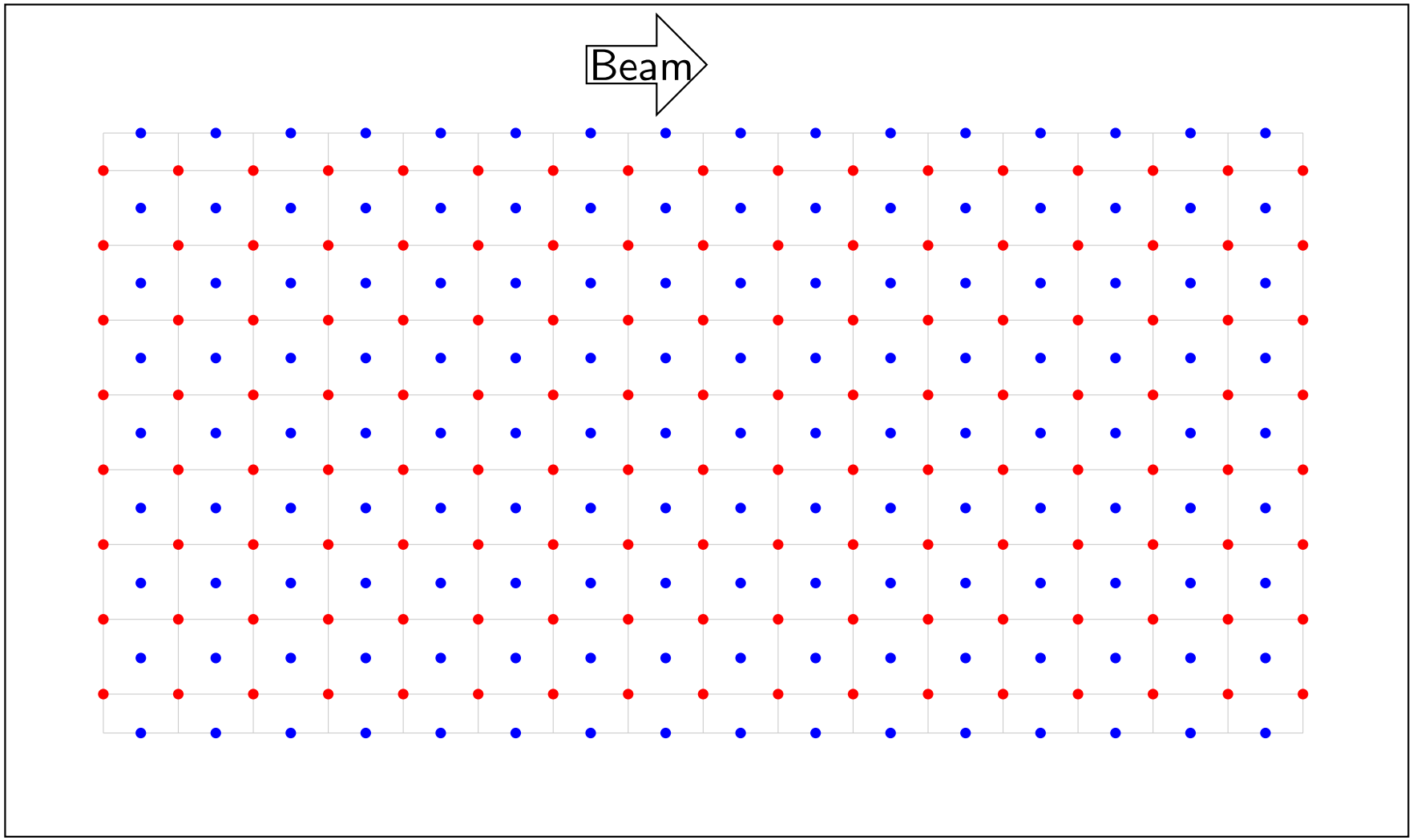
Source and DAQ

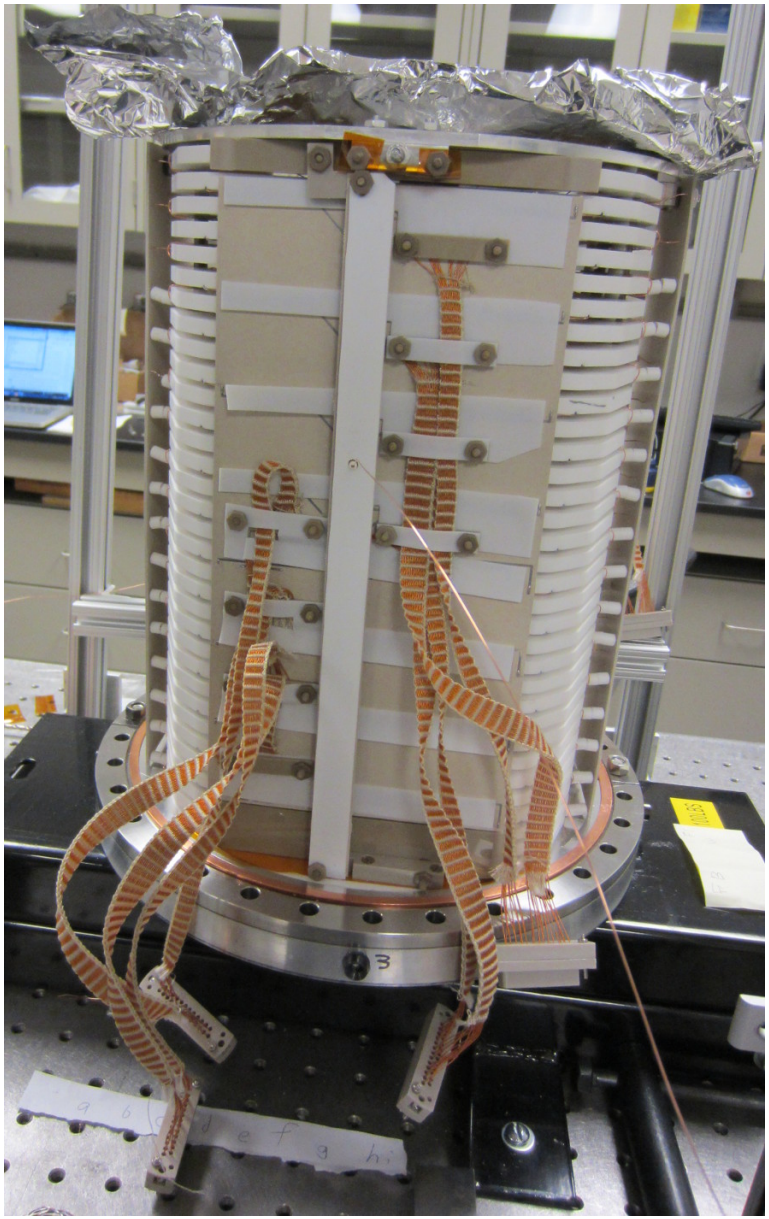
- Located at the Oak Ridge National Laboratory (ORNL) in Tennessee
- 60 Hertz pulsed spallation source
- 49 time bins per pulse from DAQ
- $1s/(60 * 49) = 3.4 \times 10^{-4} s = 3.4 \times 10^{5} ns/\mathrm{bin}$
- charge of electron $160.2 \times 10^{-21} C$

n3He Target Chamber



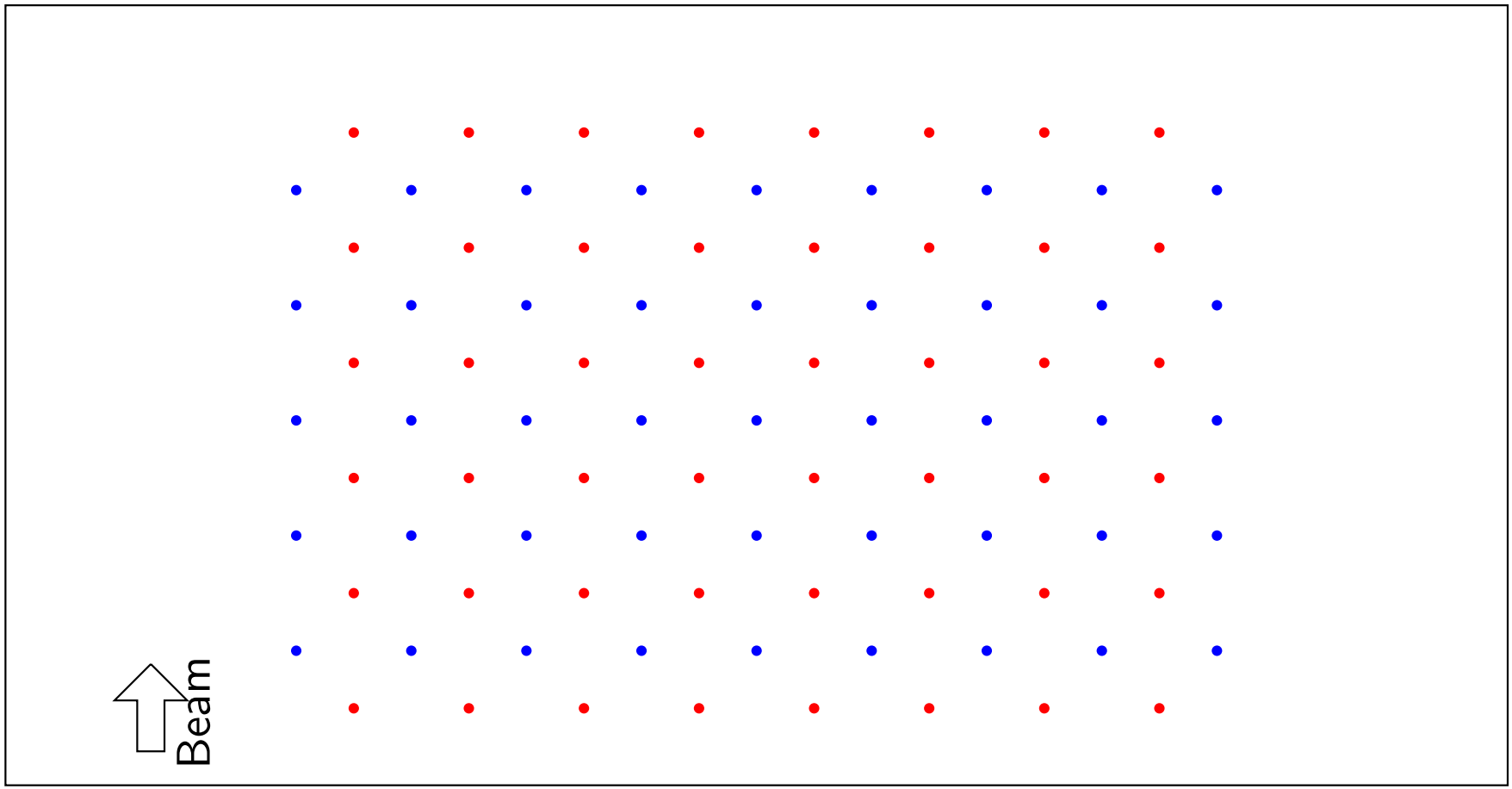
- HV 17 HV Frames with 8 wires each
- Signal 16 signal Frames with 9 wires each

Assembled Frame Stack



- 17 HV frames
- 16 signal frames
- 9 signal wires per frame
- 144 signals to read out

Simulation Geometry



Ion Chamber Simulation - Garfield++

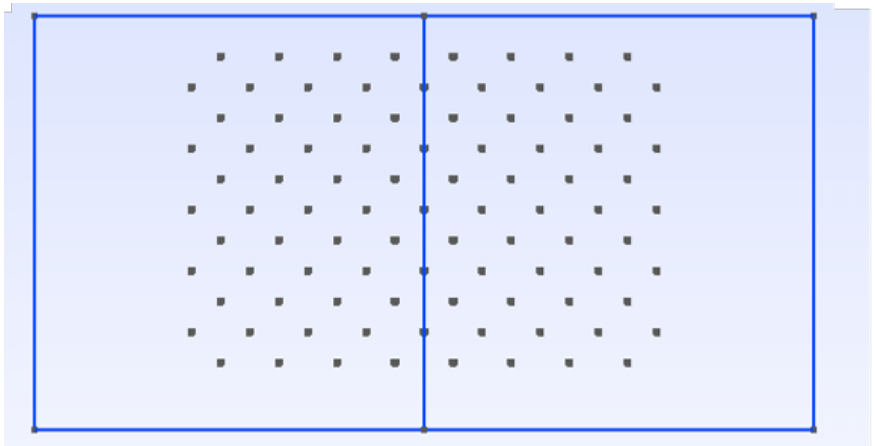
Garfield++ is a toolkit for the detailed simulation of particle detectors that use gas and semi-conductors as sensitive medium.

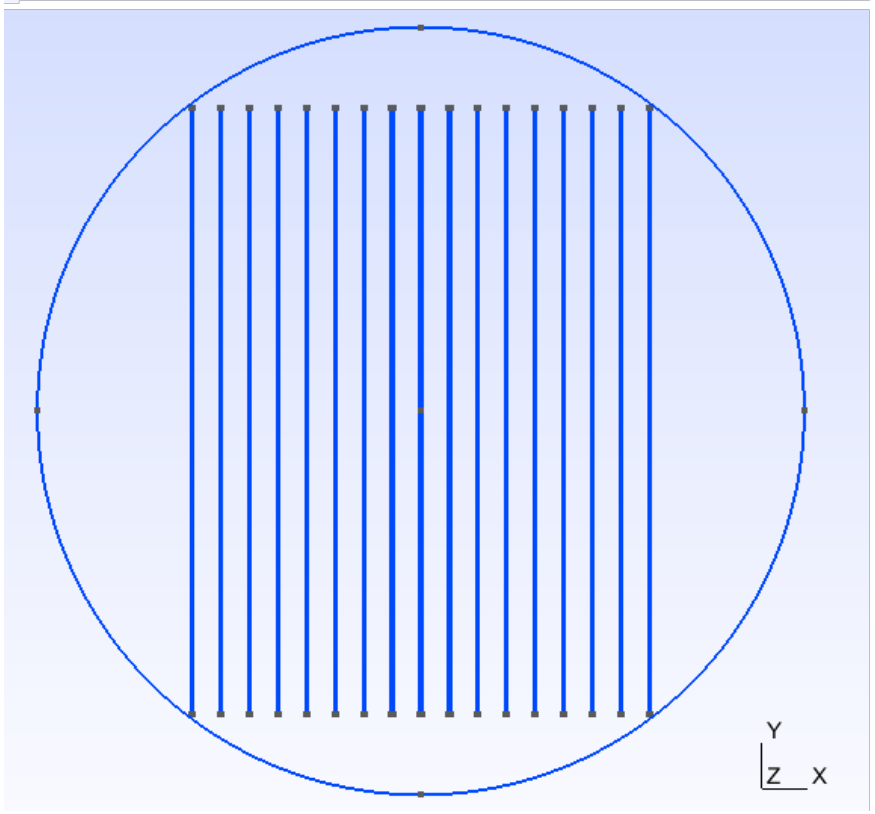
- Gas properties calculated using Magboltz
- Ion Mobility from Data from Atomic Data and Nuclear Data Tables 17, 177-210 (1976)
- Signal calculated with Shockley-Ramo Theorem:

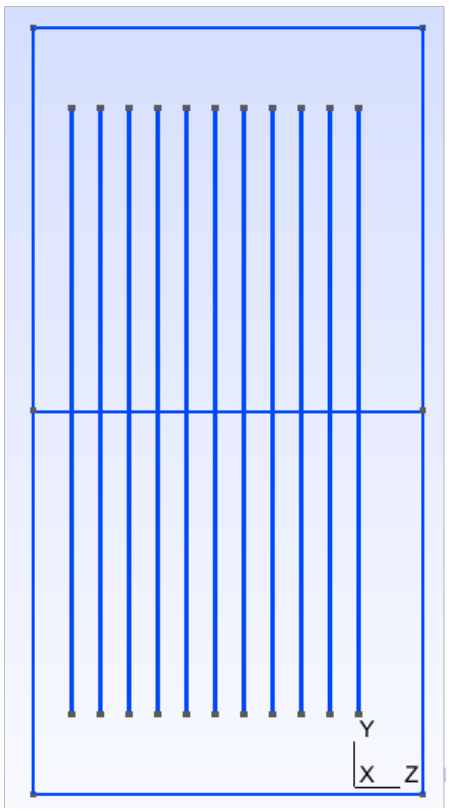
$$i(t) = -q\mathbf{v} \cdot \mathbf{E}_w(\mathbf{r})$$

- $\mathbf{E}_w(\mathbf{r})$ is a calculated weighting field as though the electrode had a potential of 1V and everything else is ignored
- $E_w = \lambda/2\pi\epsilon R$ for wire
- Fields and Electrode locations from Gmsh and Elmer
- Looking at charge collection times and signals

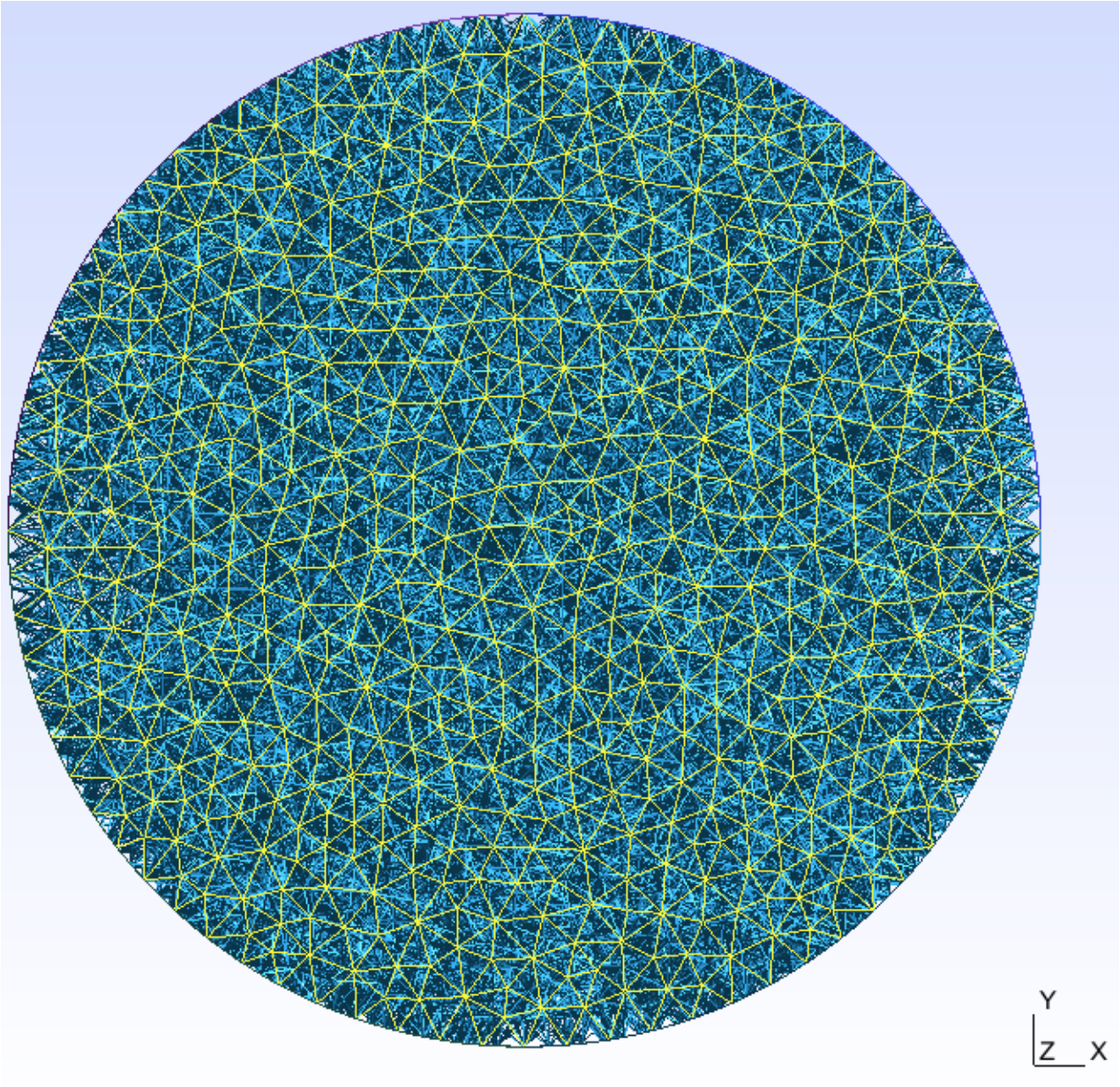
Geometry - Gmsh



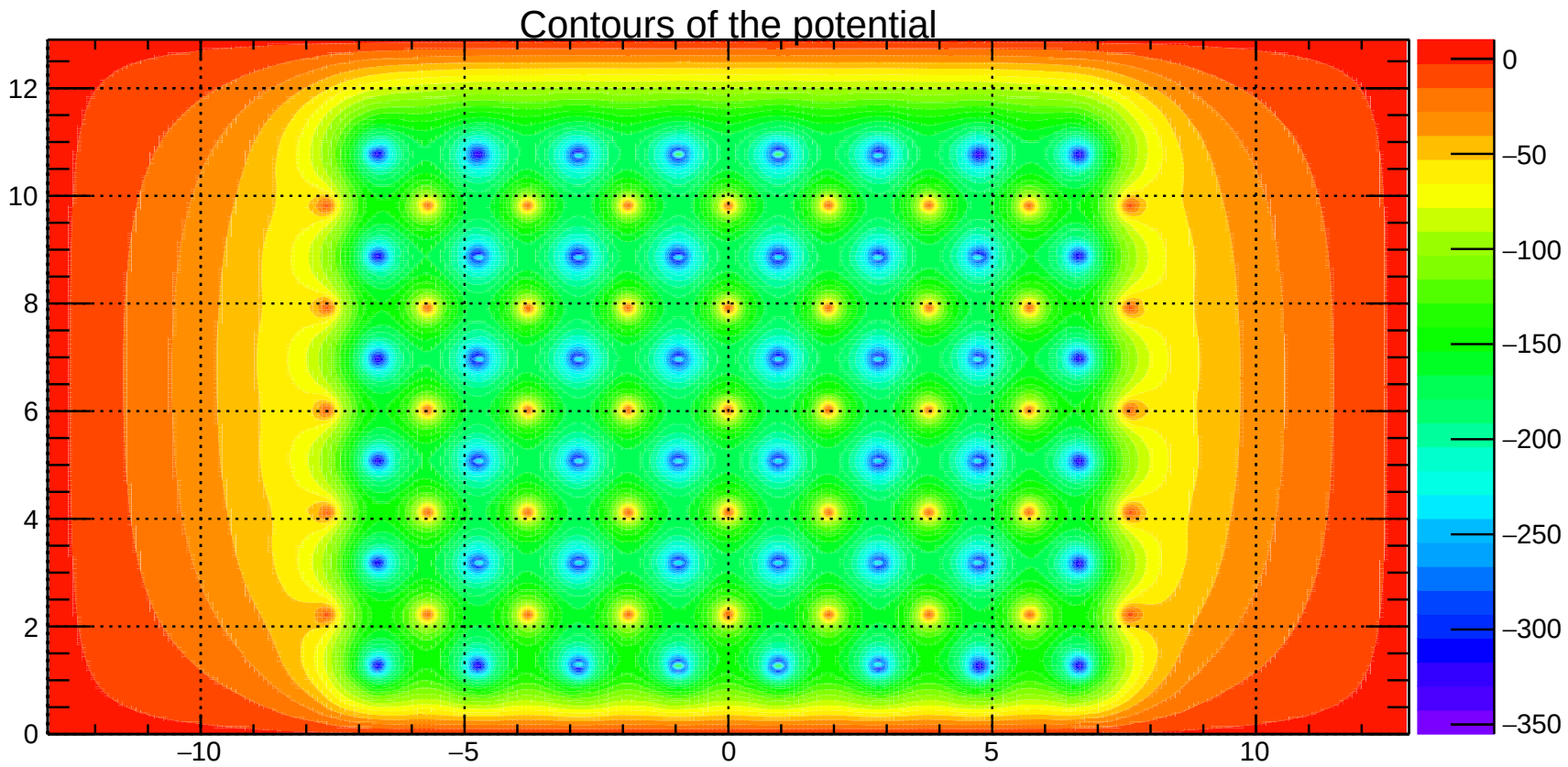




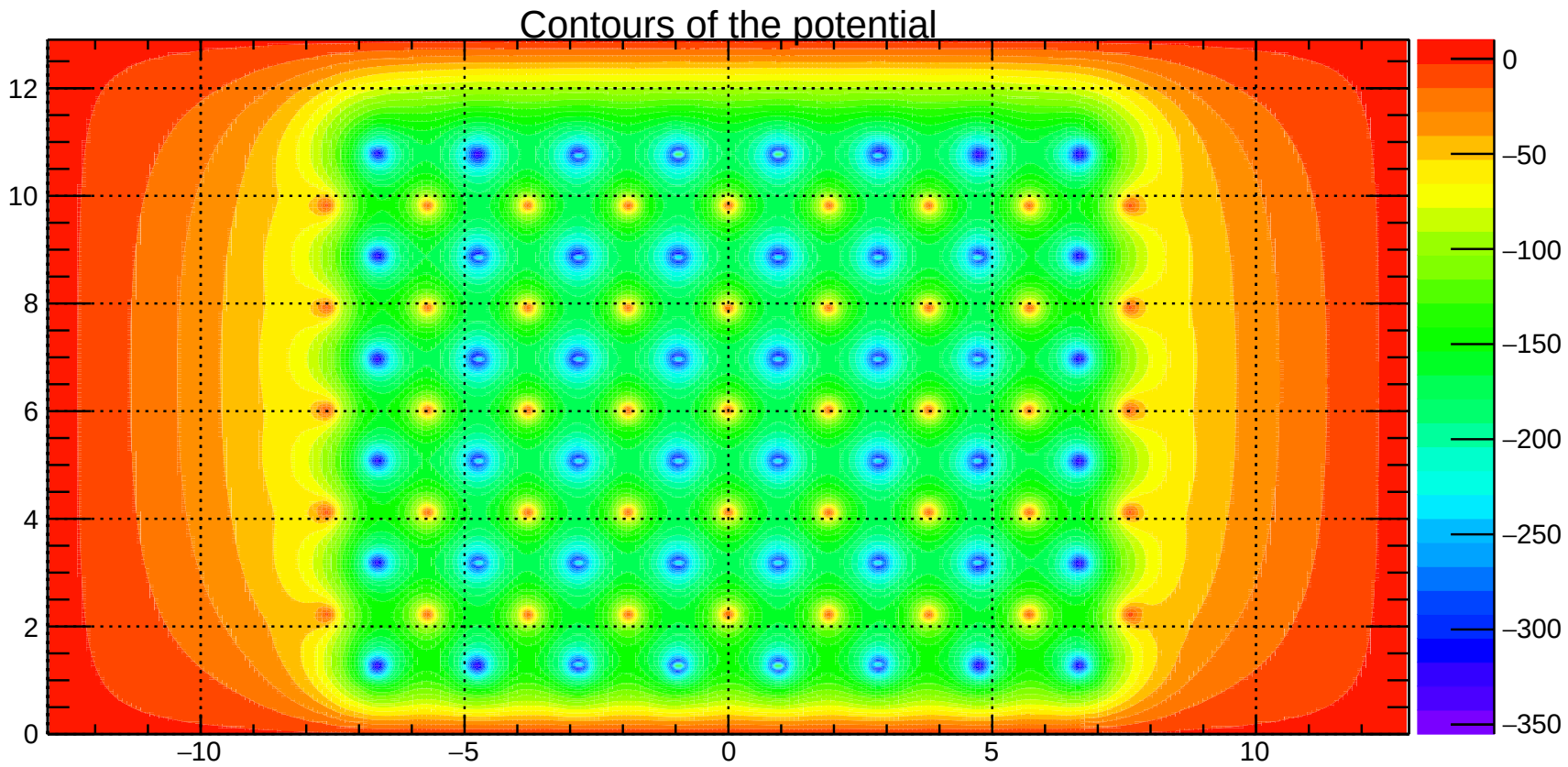
Geometry - Gmsh



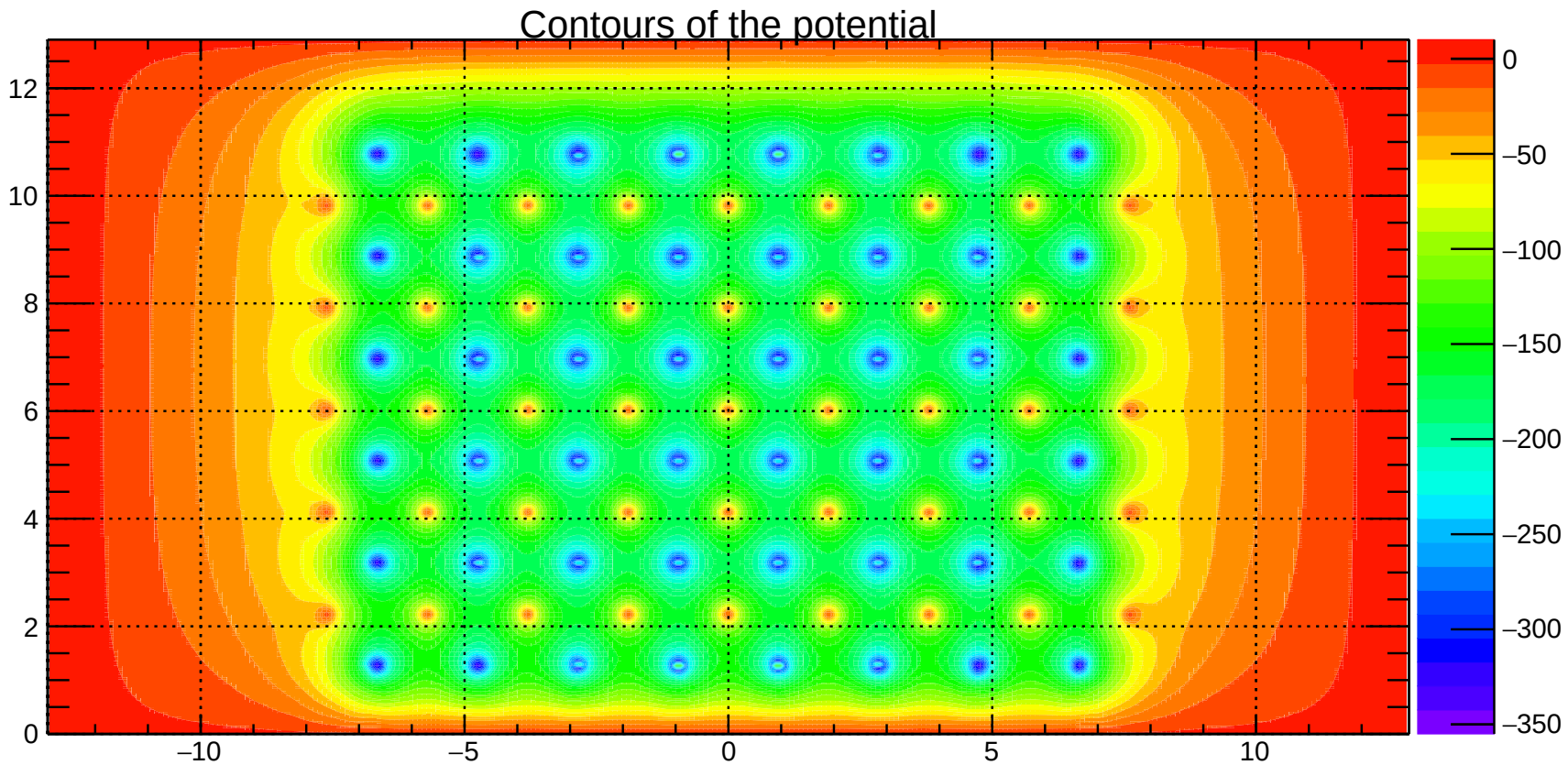
Fields - Elmer FEM



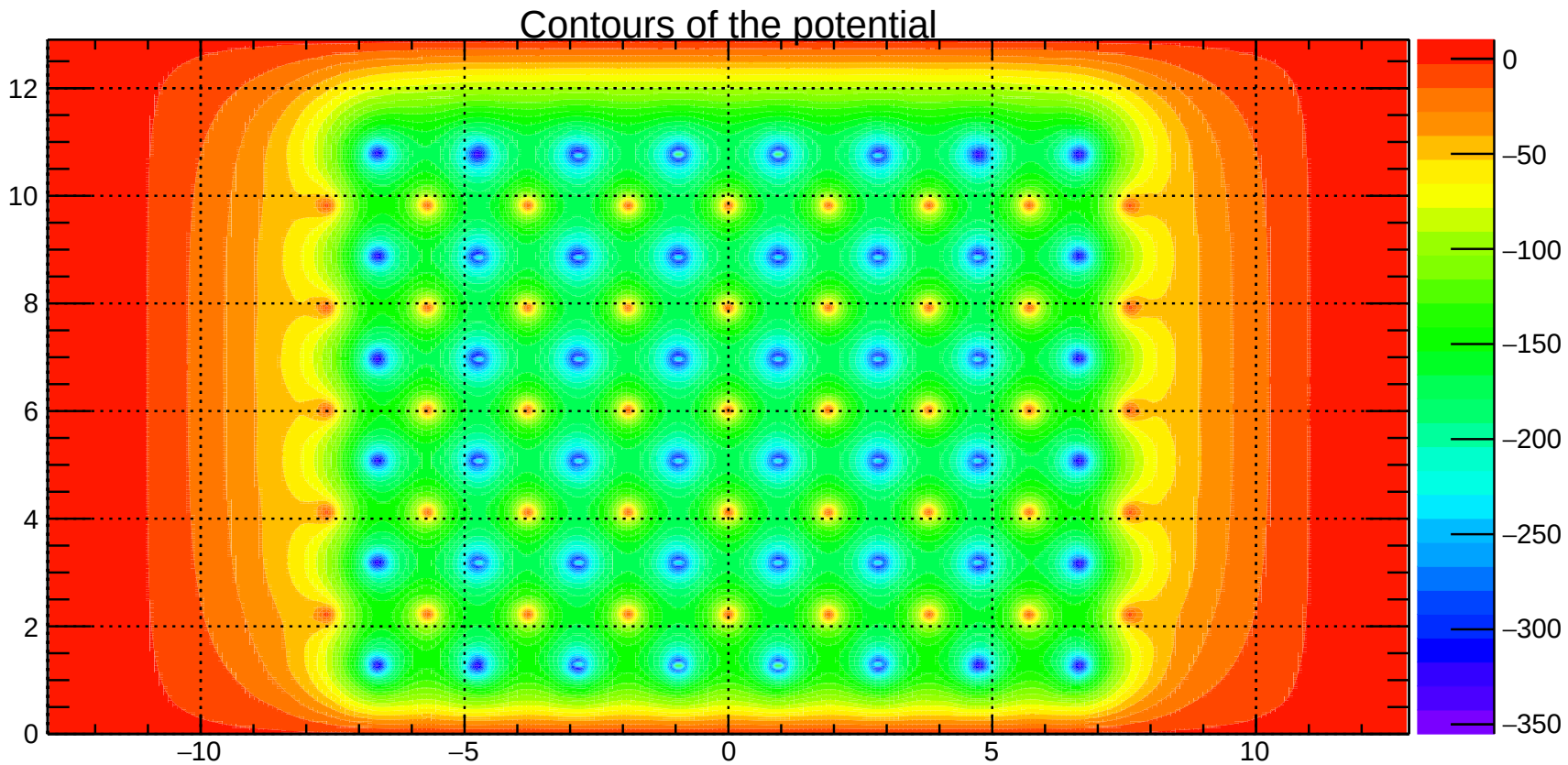
Fields - 2cm offset



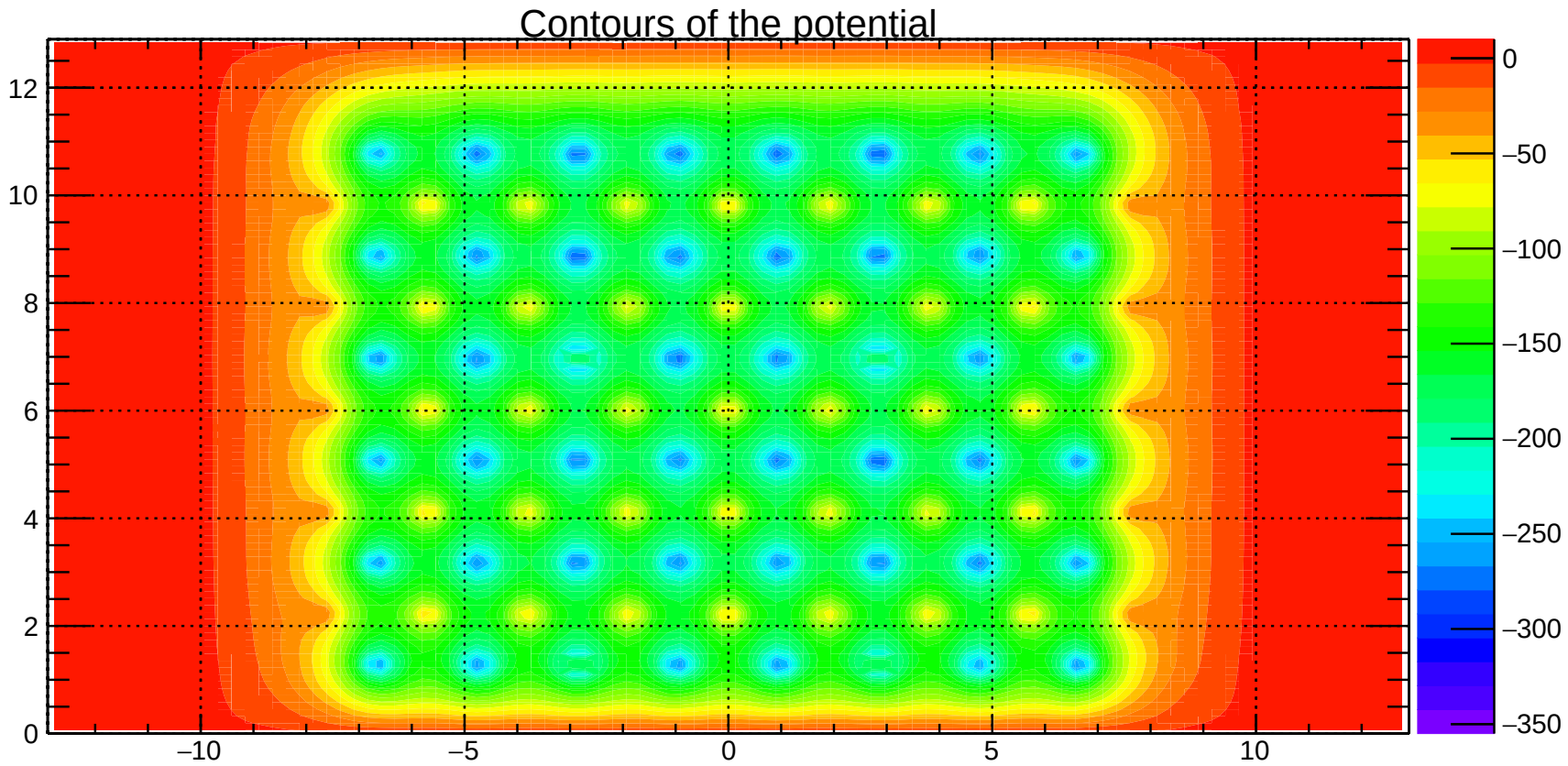
Fields - 4cm offset



Fields - 6cm offset

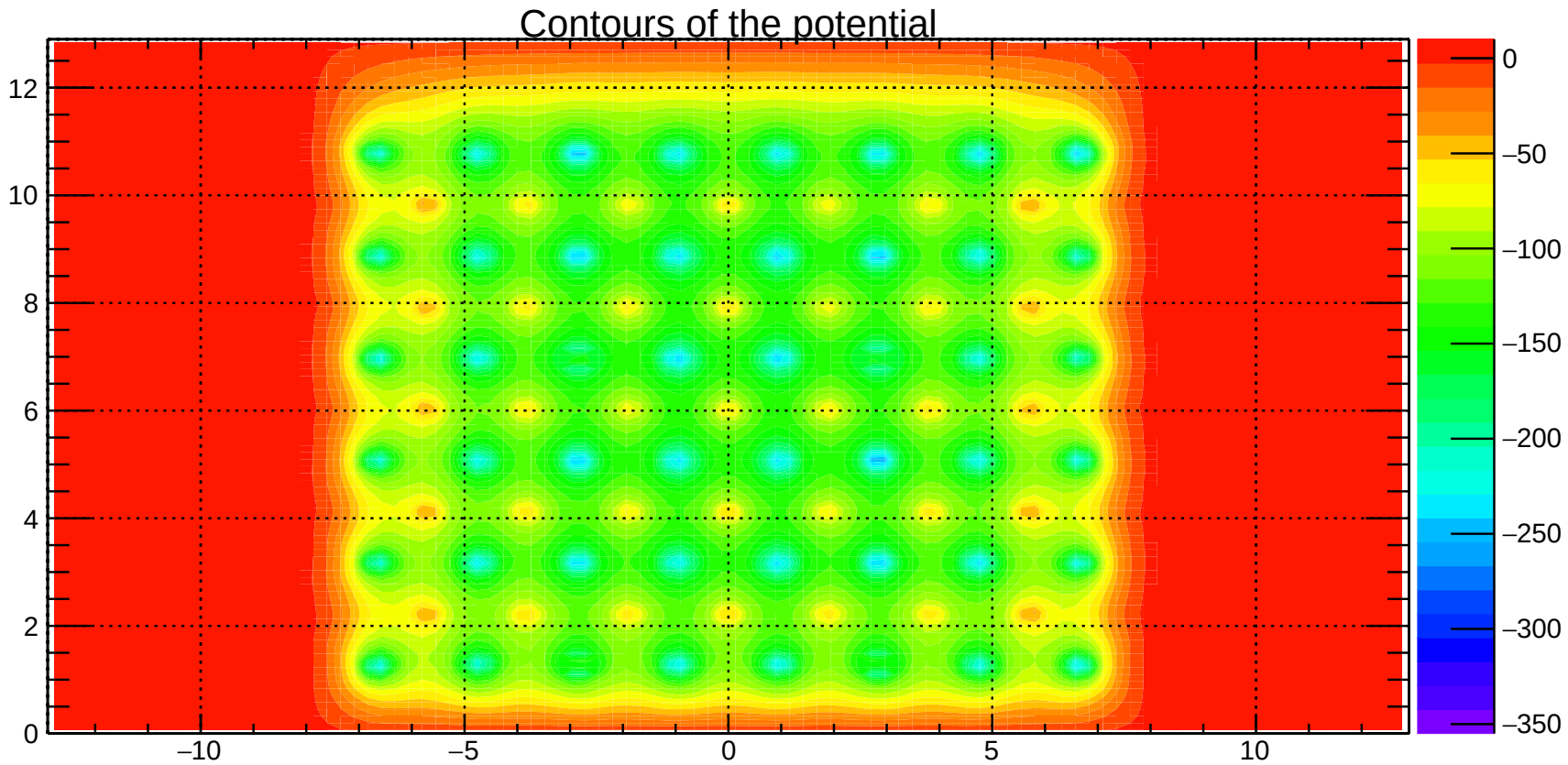


Fields - 8cm offset



Inside of wire frame 8cm from origin.
wires extend 10 cm from origin

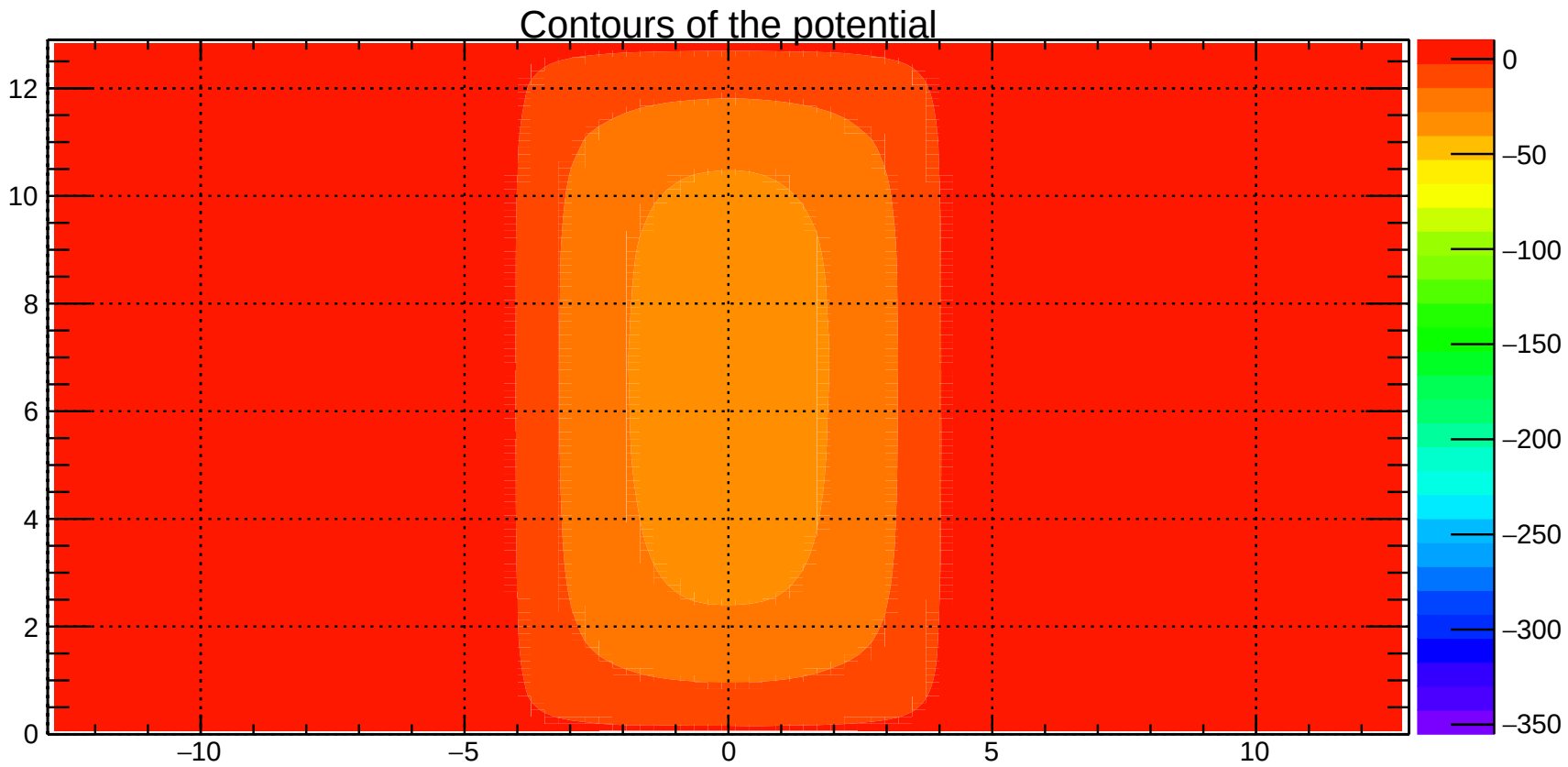
Fields - 10cm offset



Low Resolution Version

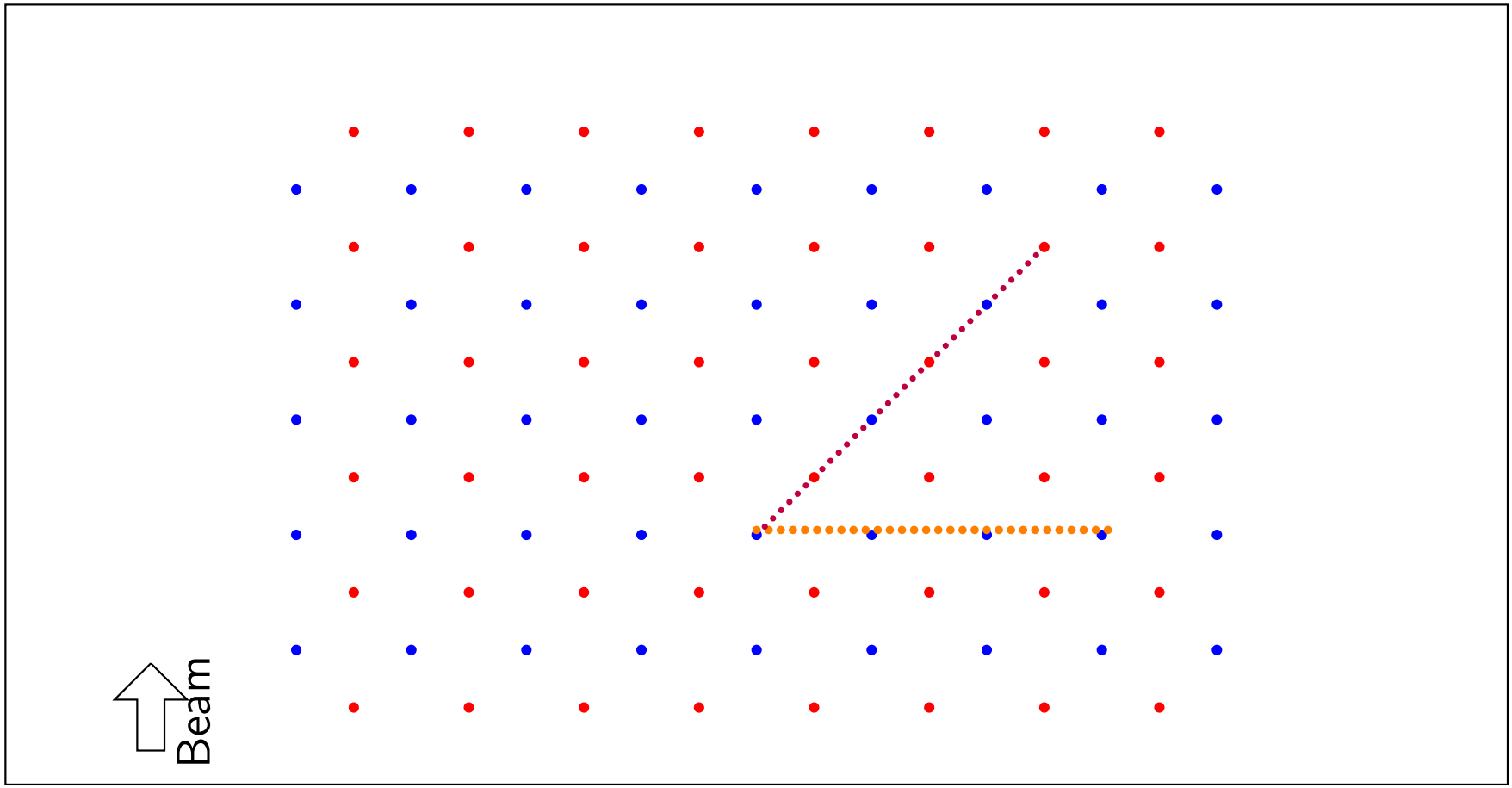
wires extend 10 cm from origin

Fields - 12cm offset



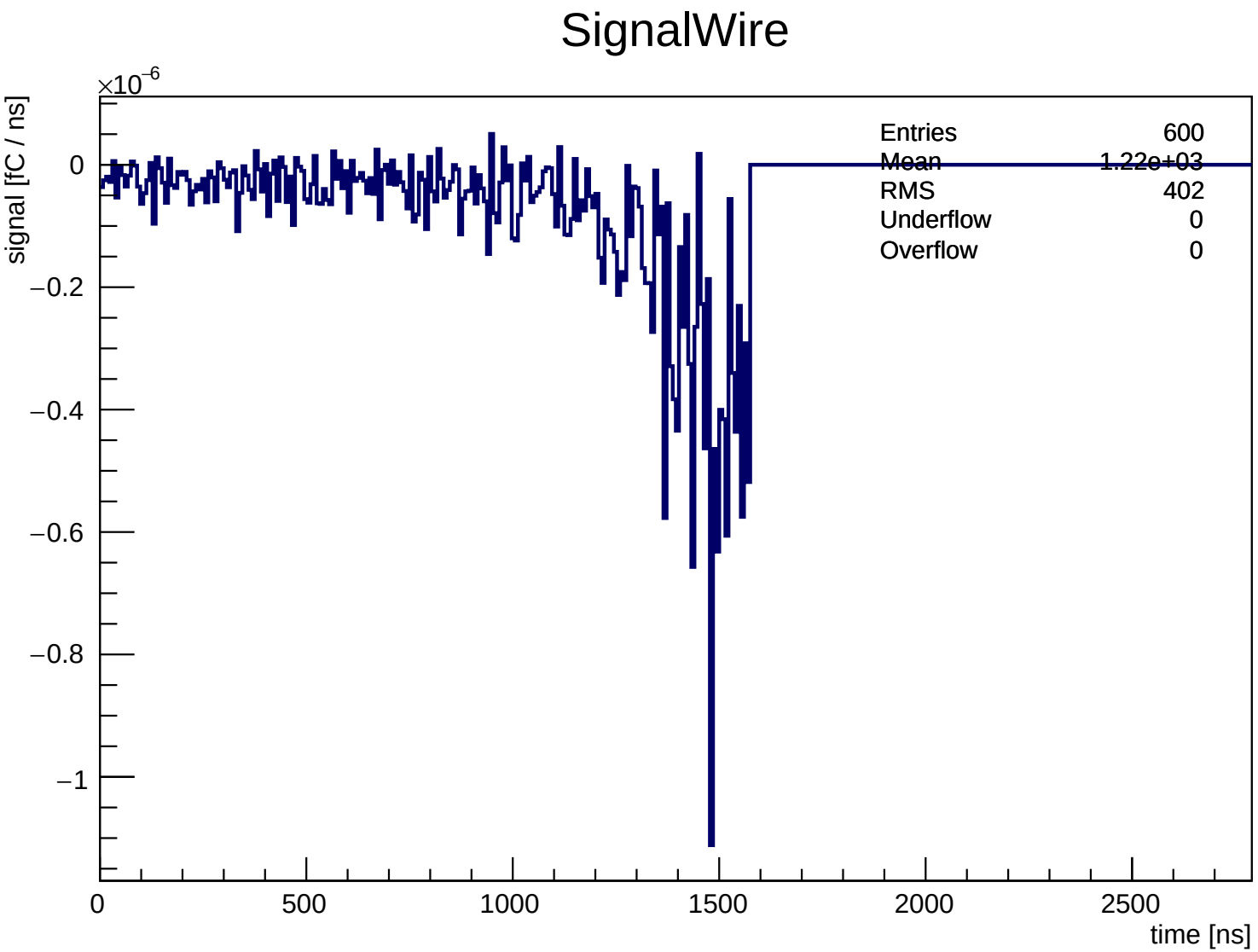
Low Resolution Version

Simulation Details

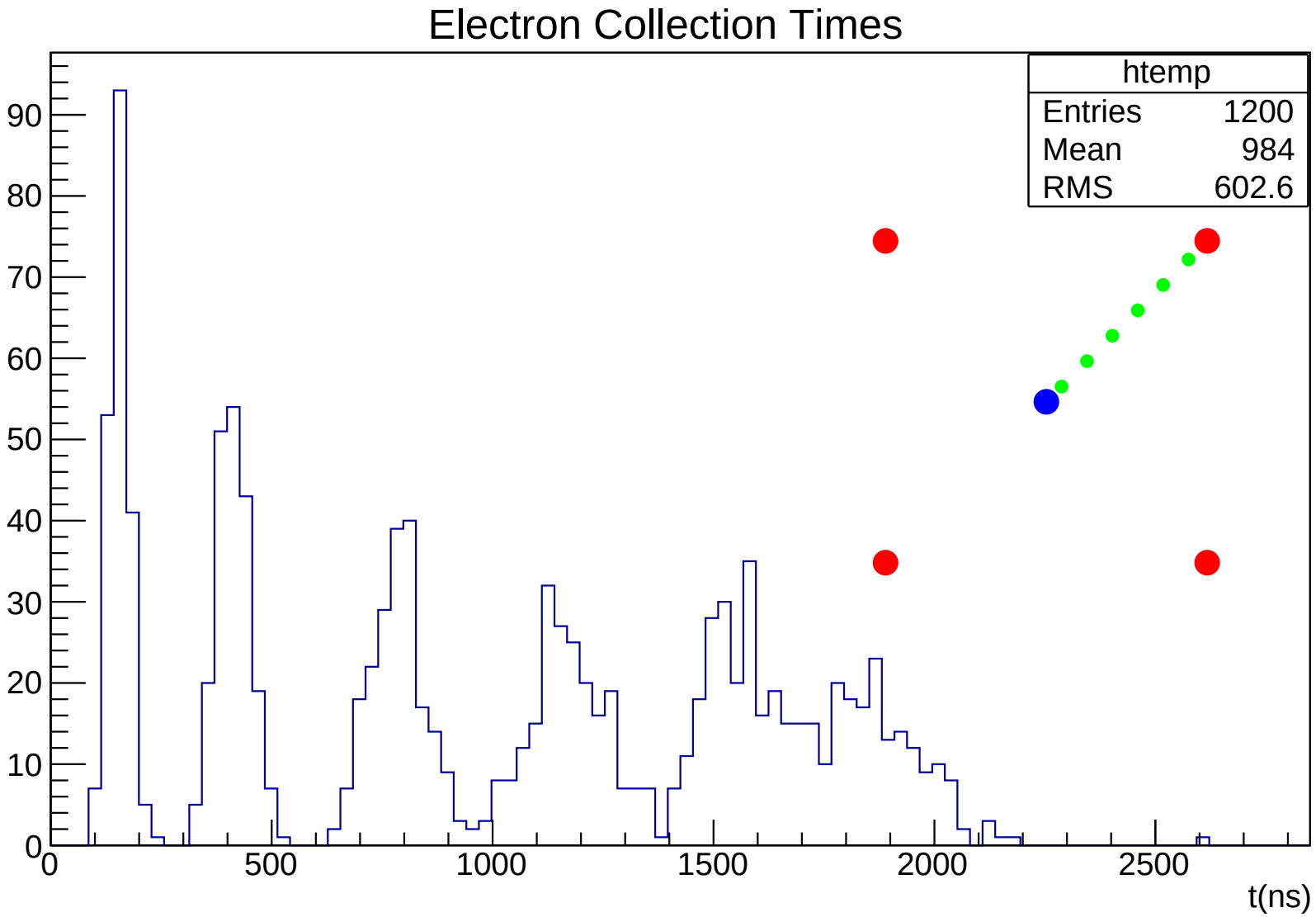


- 200 ion and electron pairs propagated from each point

Signal Particle Signal

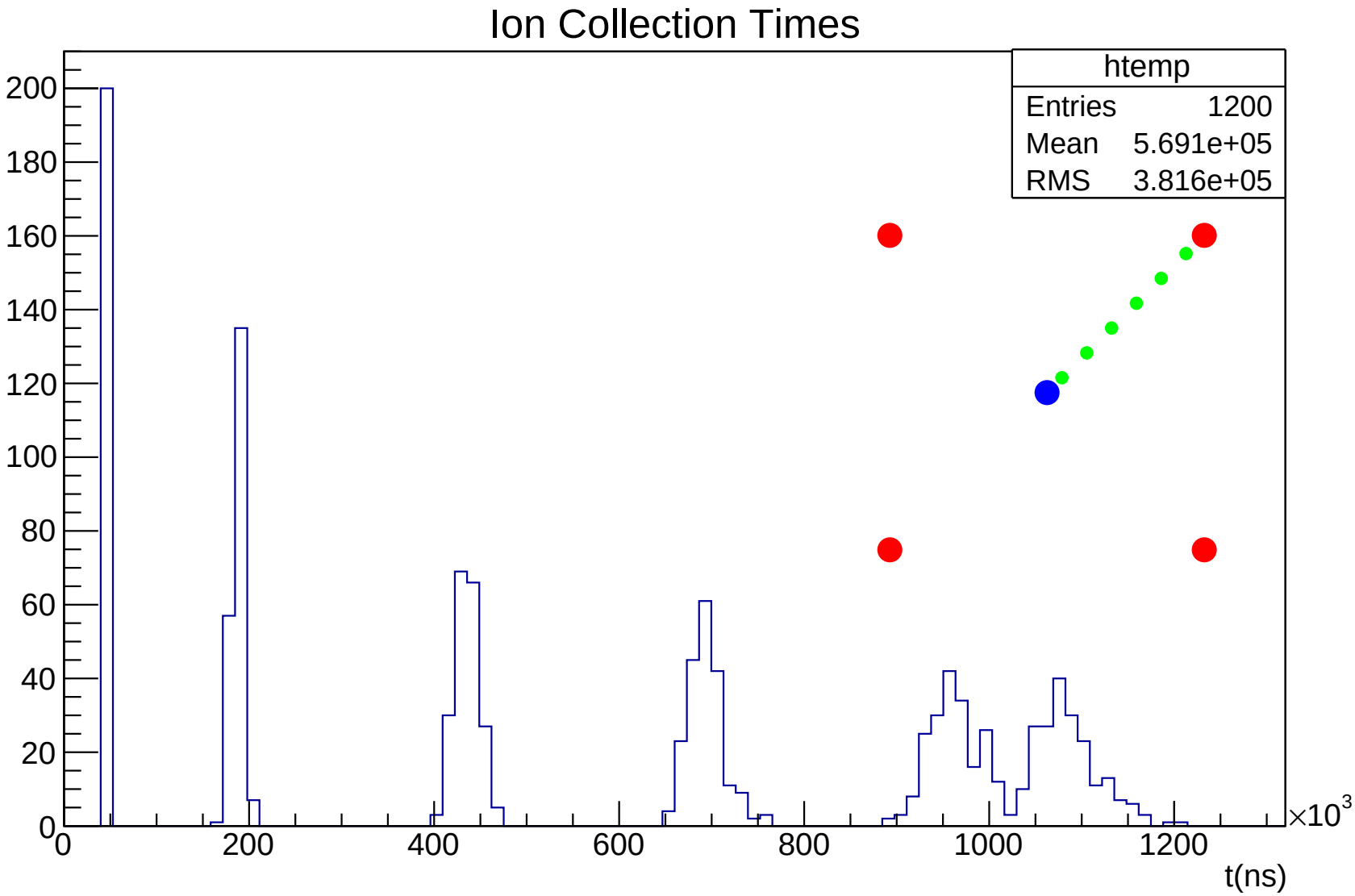


Electron Collection Times



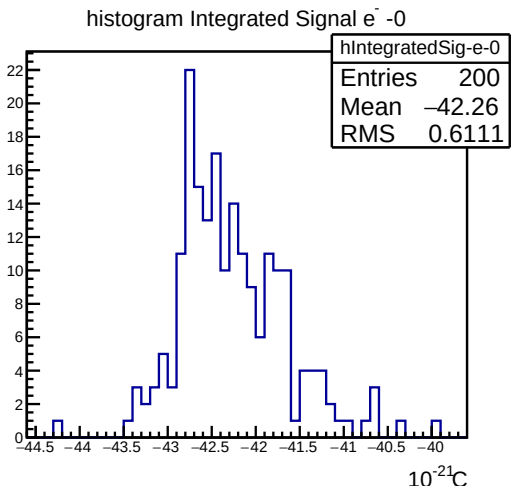
- Six equally spaced starting positions gave 6 peaks

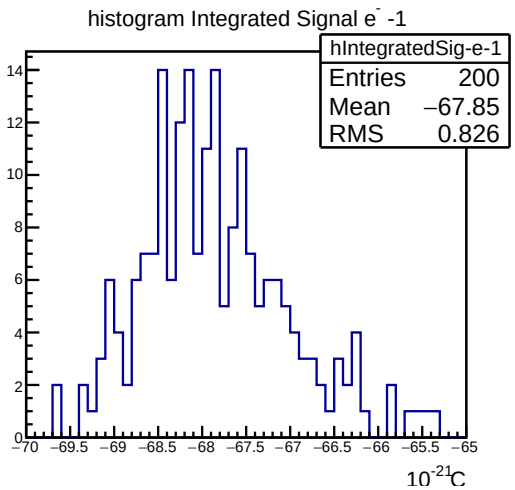
$^3He^+$ Ion Collection Times

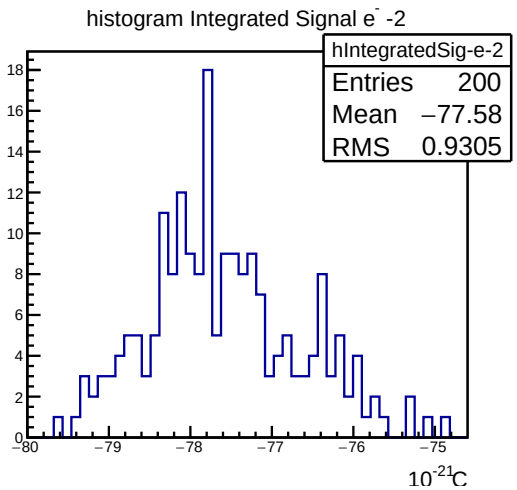


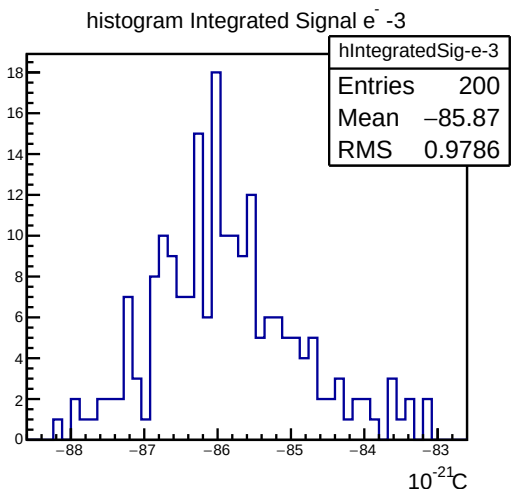
- Six equally spaced starting positions gave 6 peaks

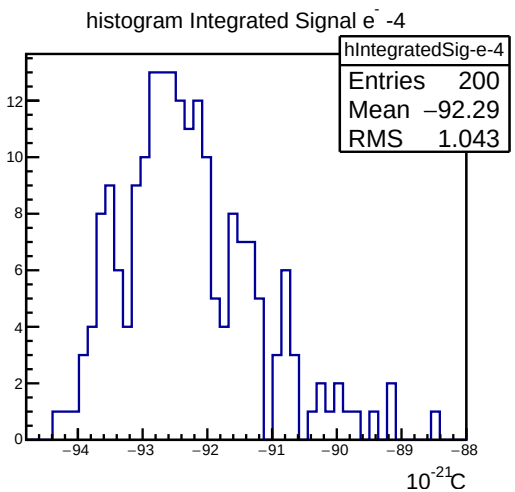
Integrated Signal - electron

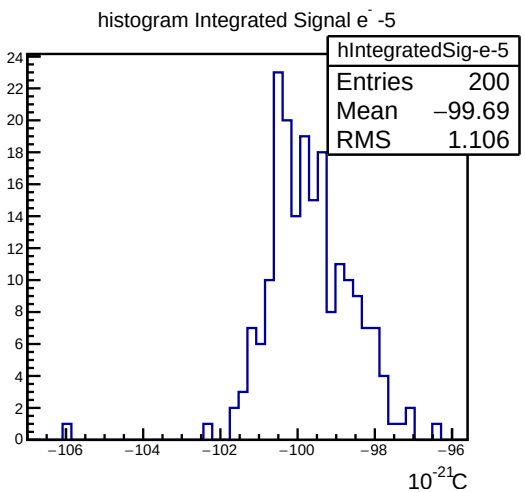






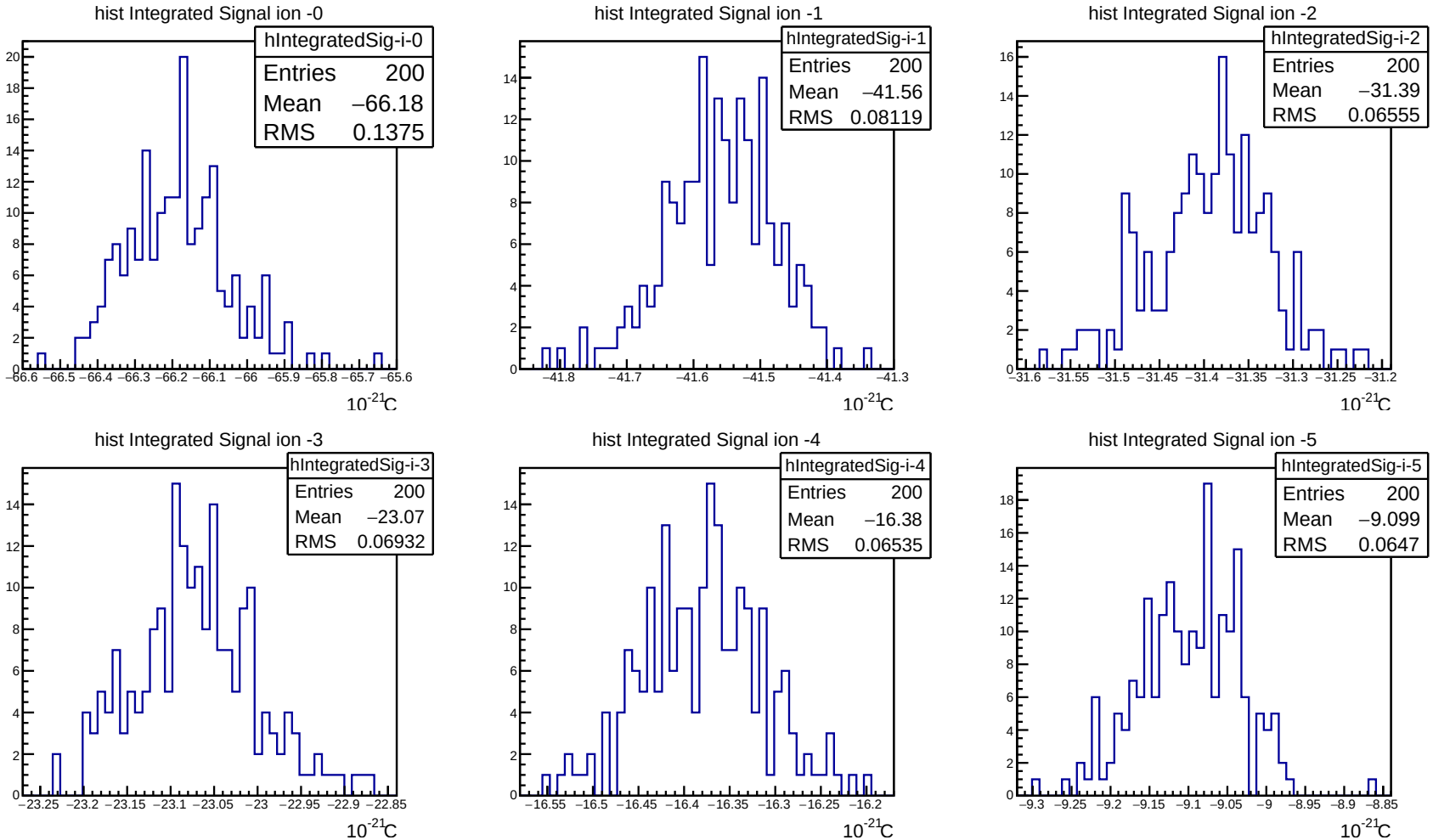






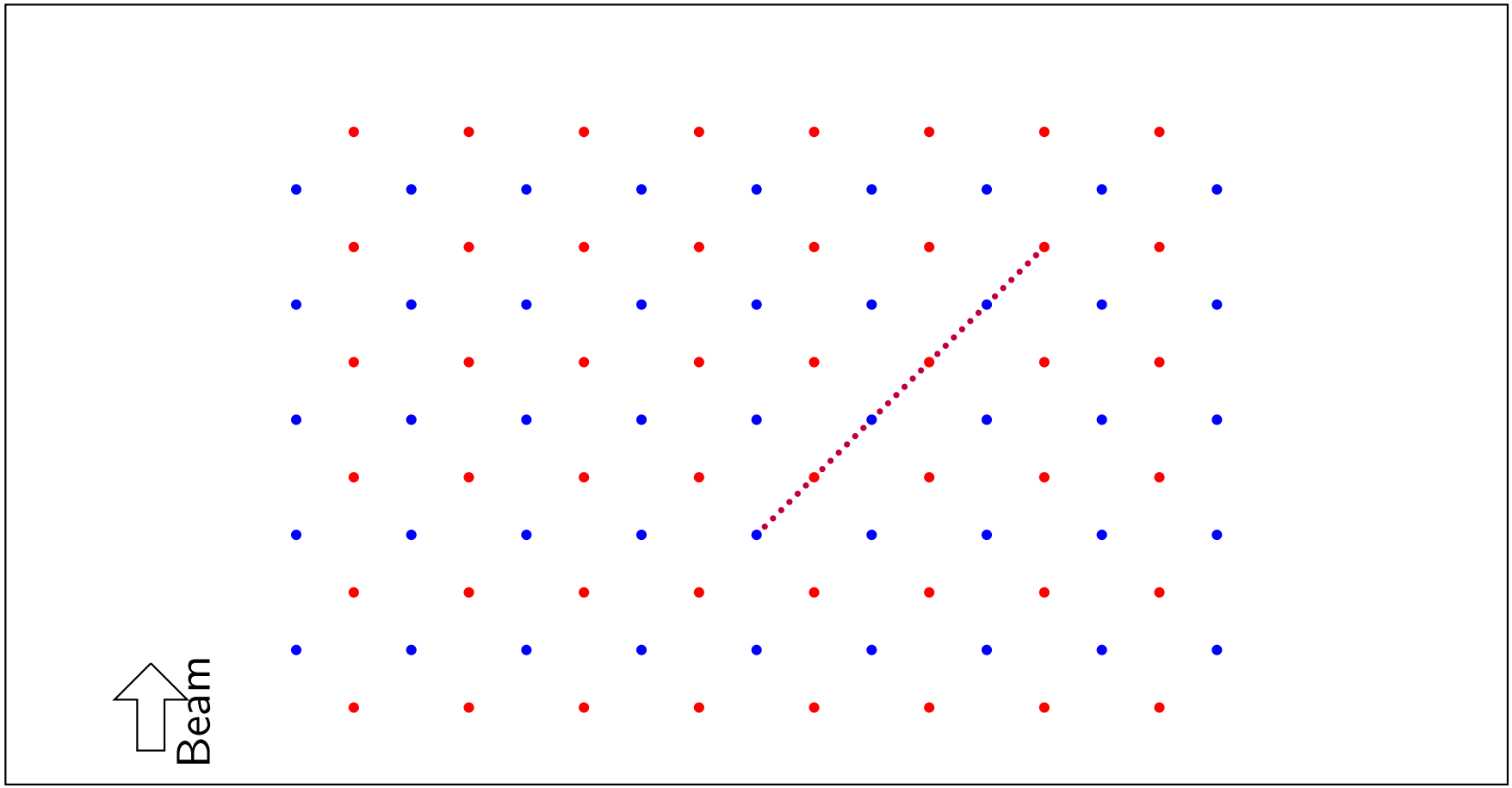
Electron integrated signal measure from 6 positions

Integrated Signal - $^3He^+$ ion



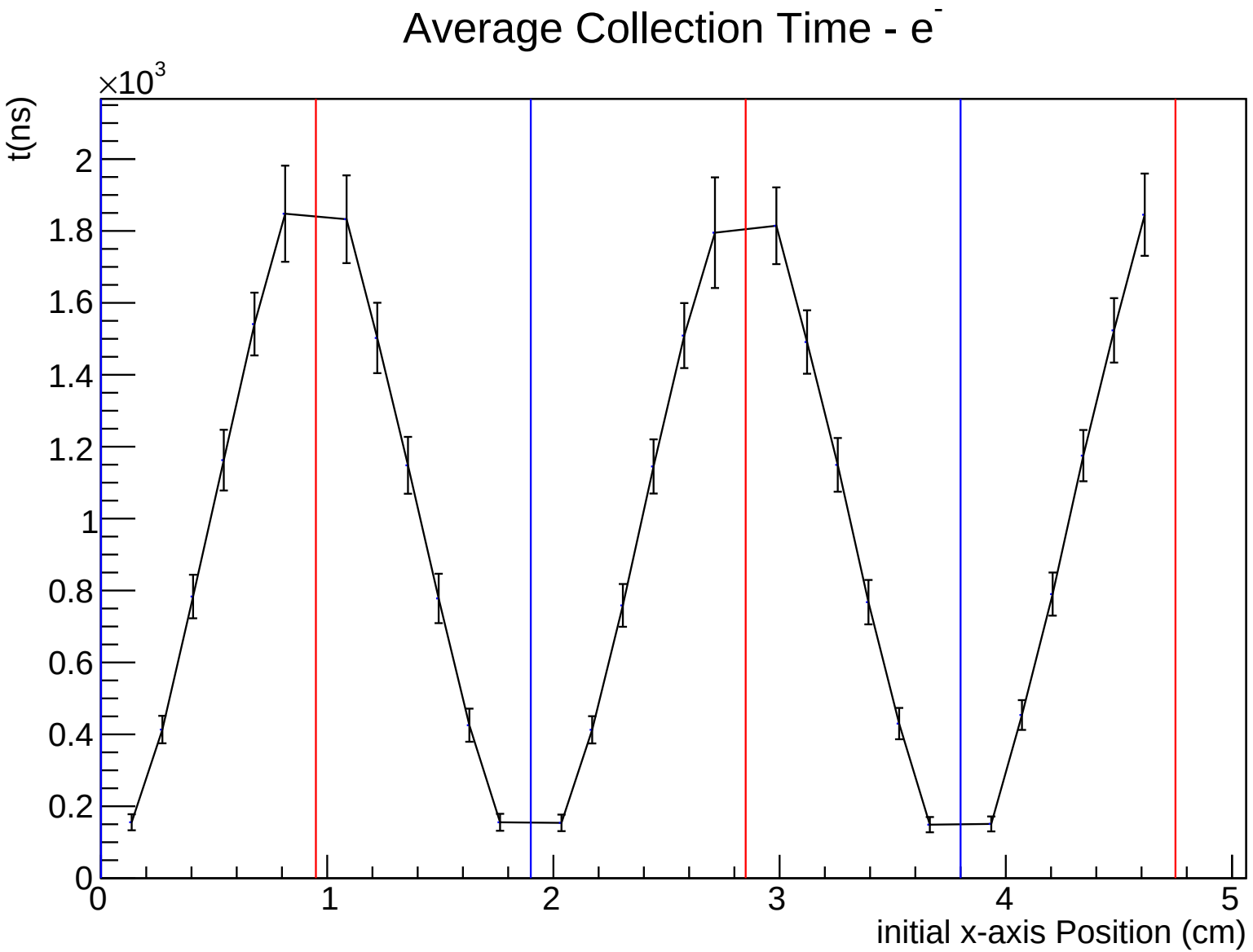
Ion integrated signal measure from 6 positions

Extended Diagonal Over Multiple Cells

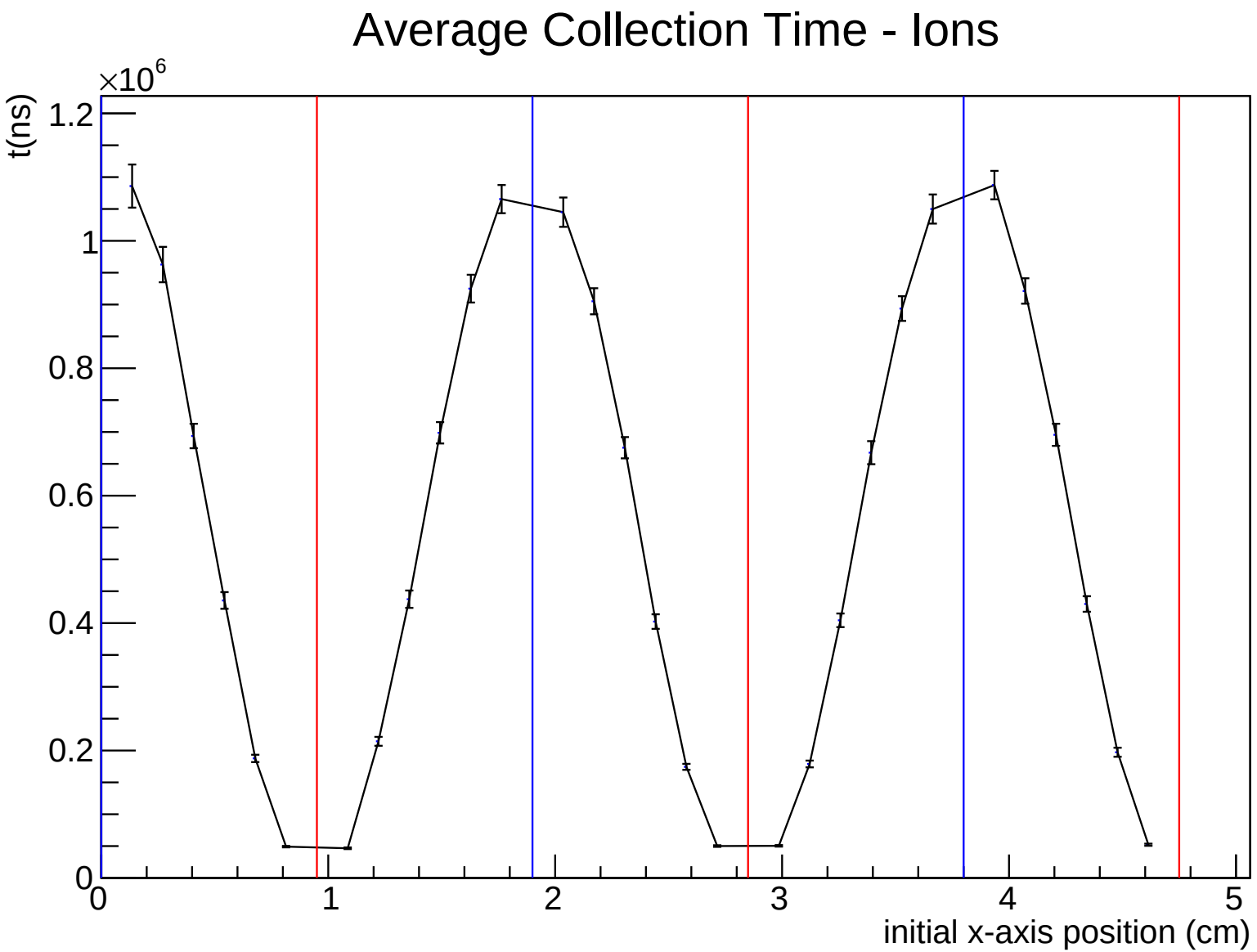


Repeating pattern extended 4 times

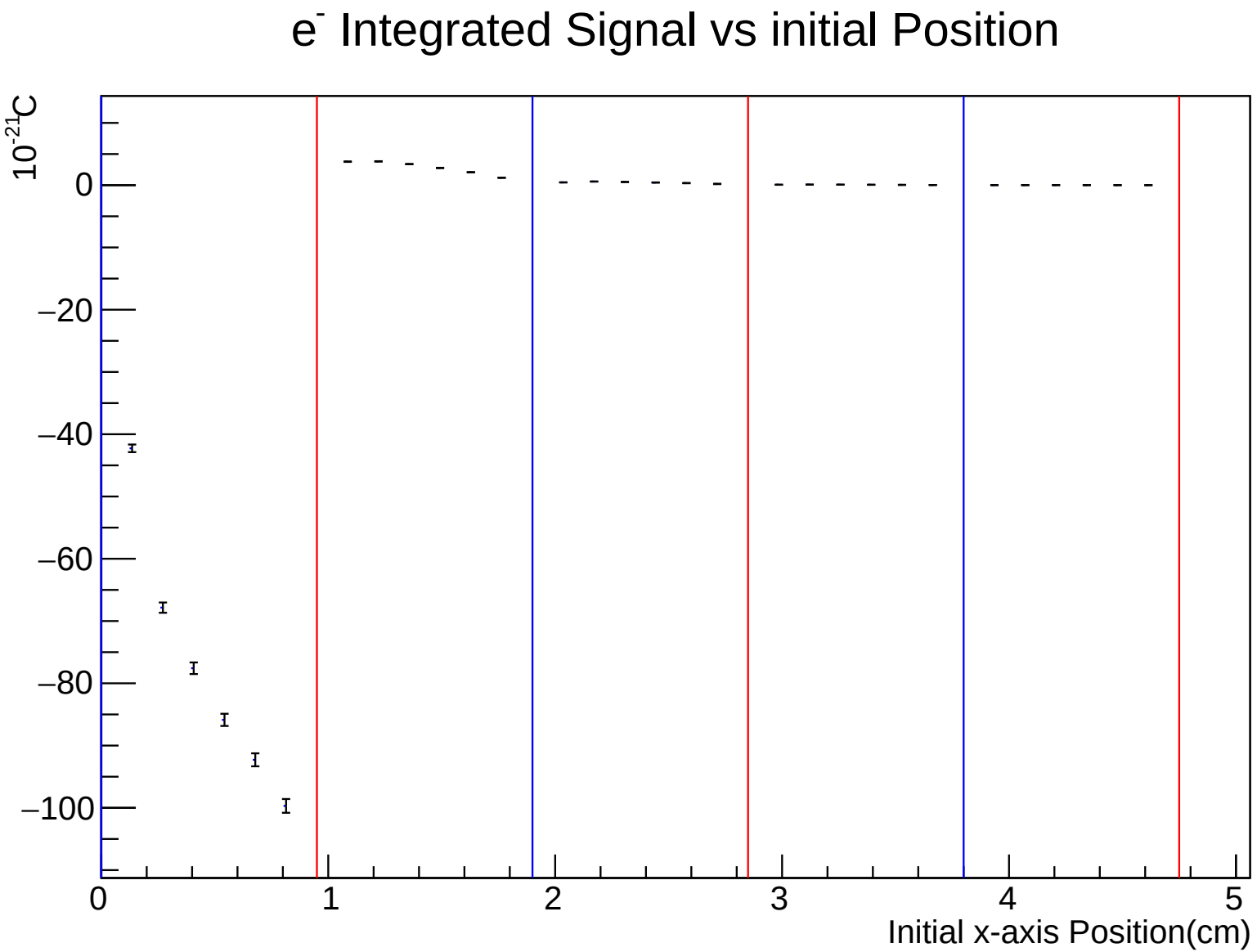
Extended Diagonal - Collection Time - electron



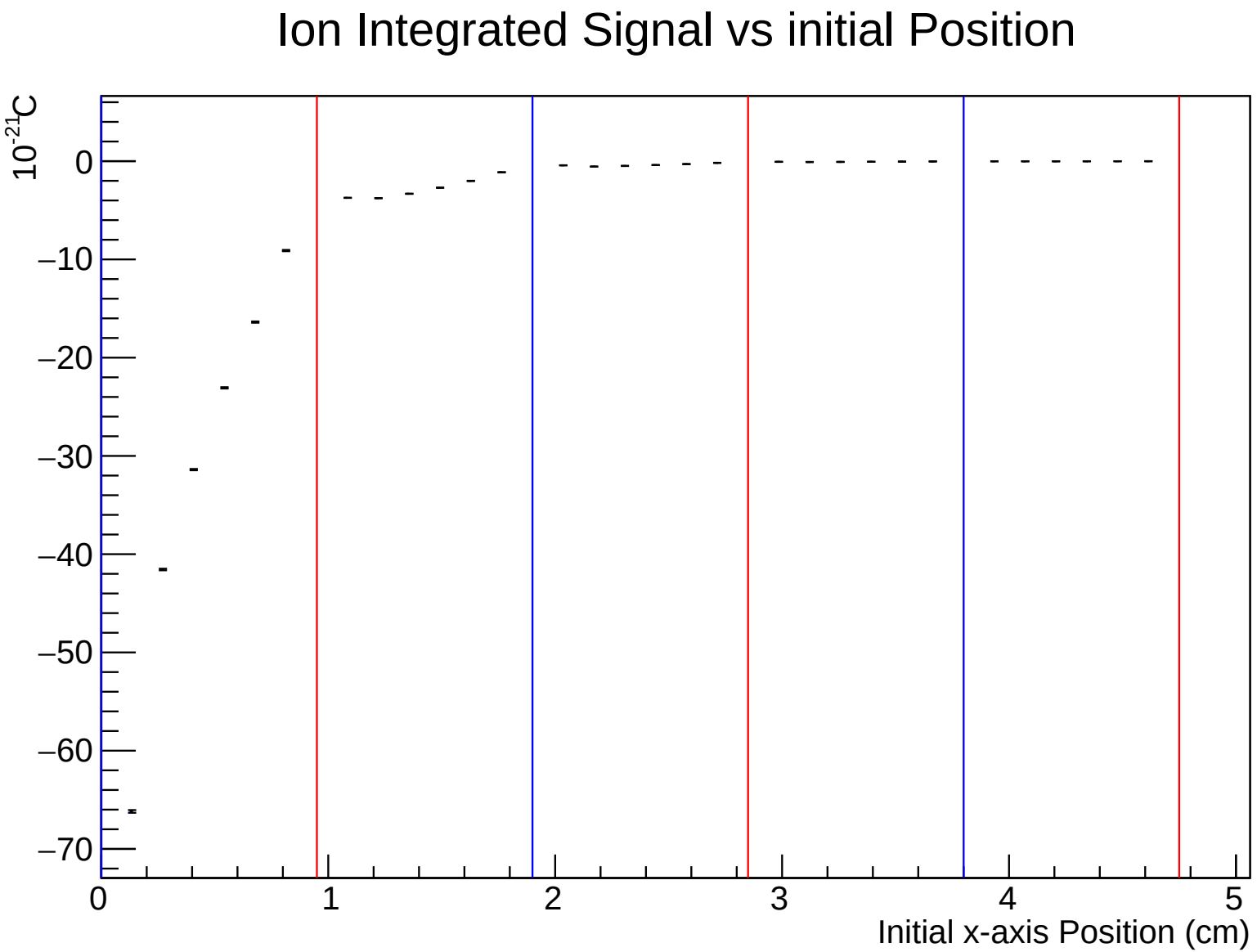
Extended Diagonal - Collection Time - ions



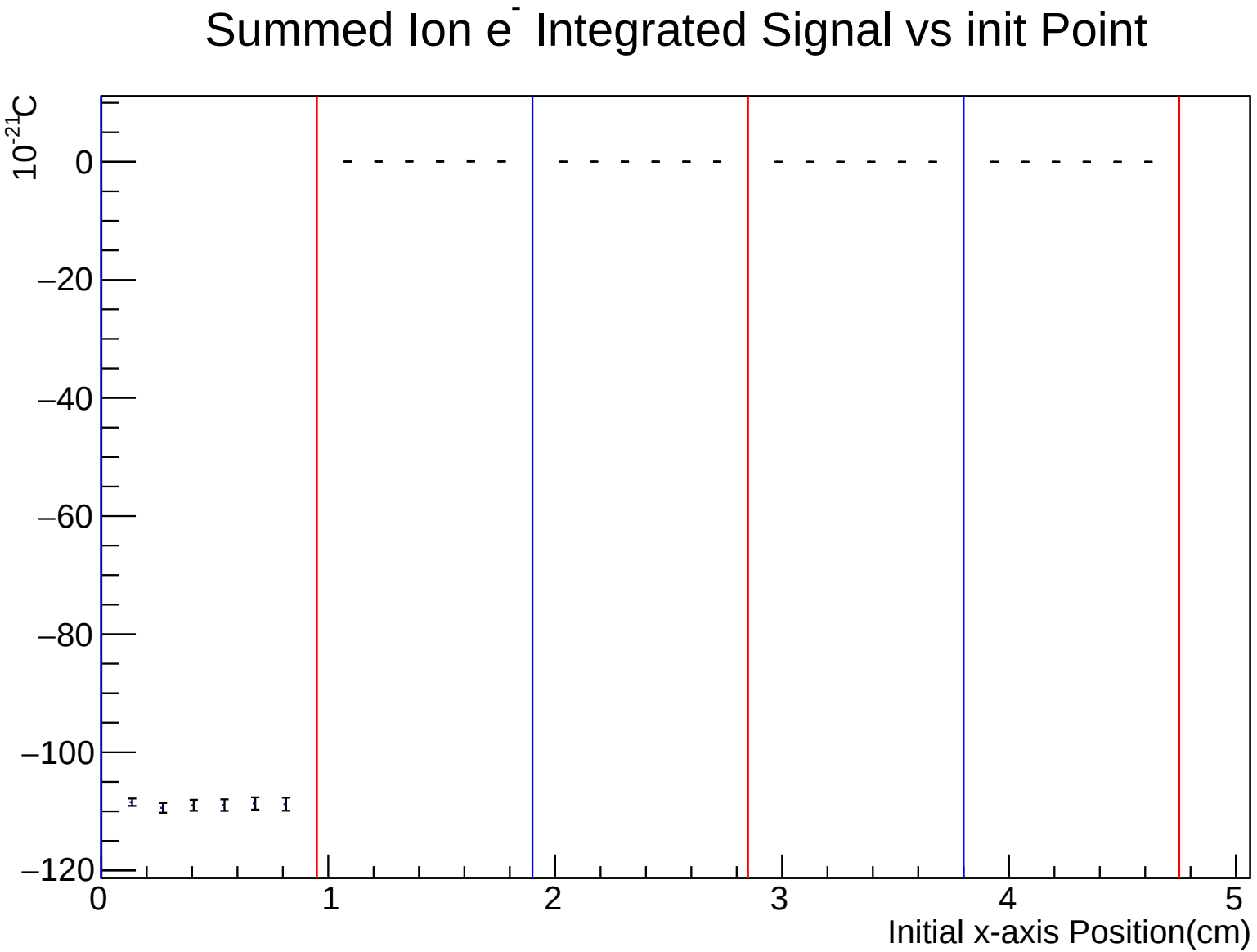
Extended Diagonal - Average Integrated Signal - electron



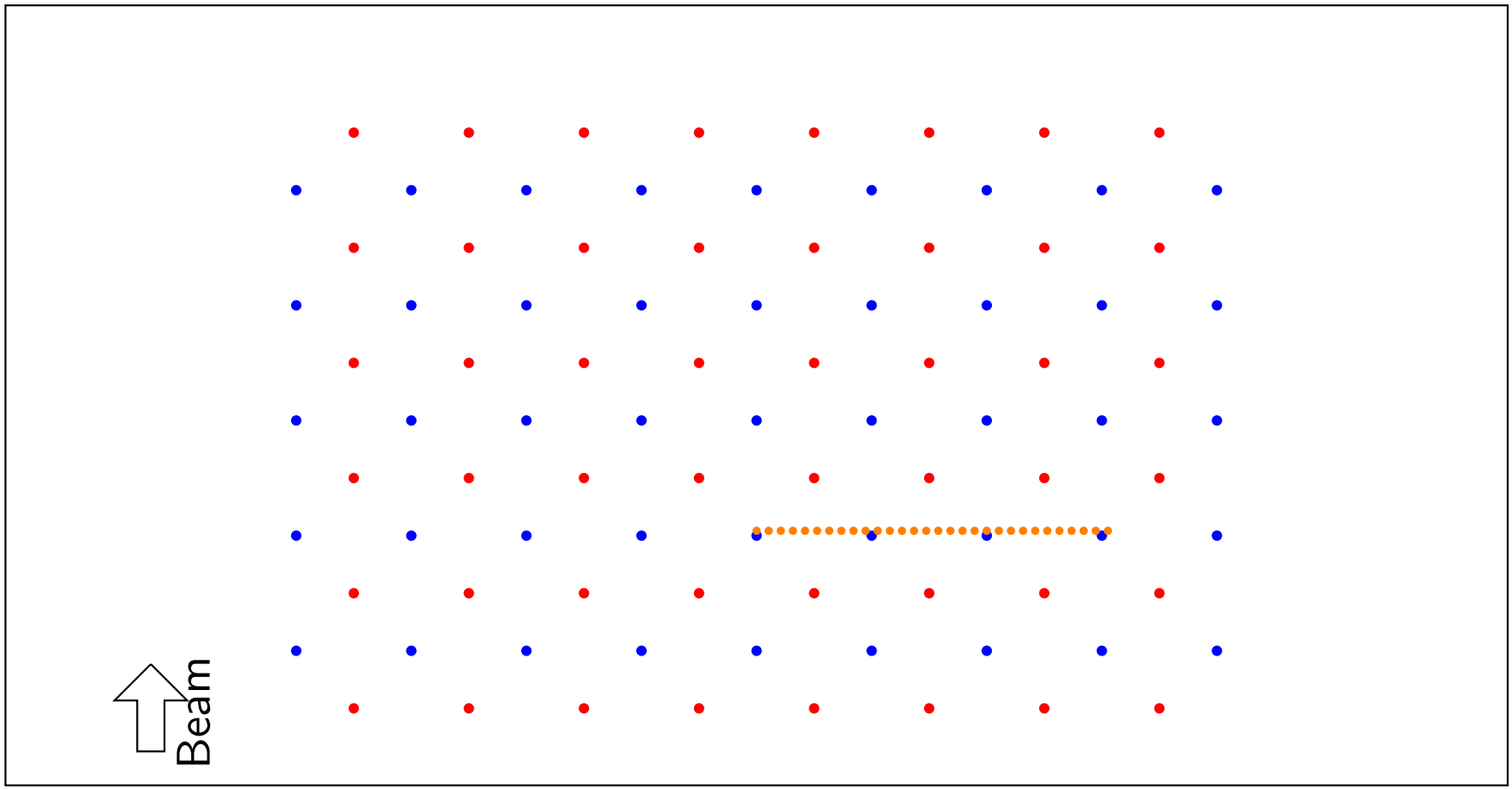
Extended Diagonal - Average Integrated Signal - ions



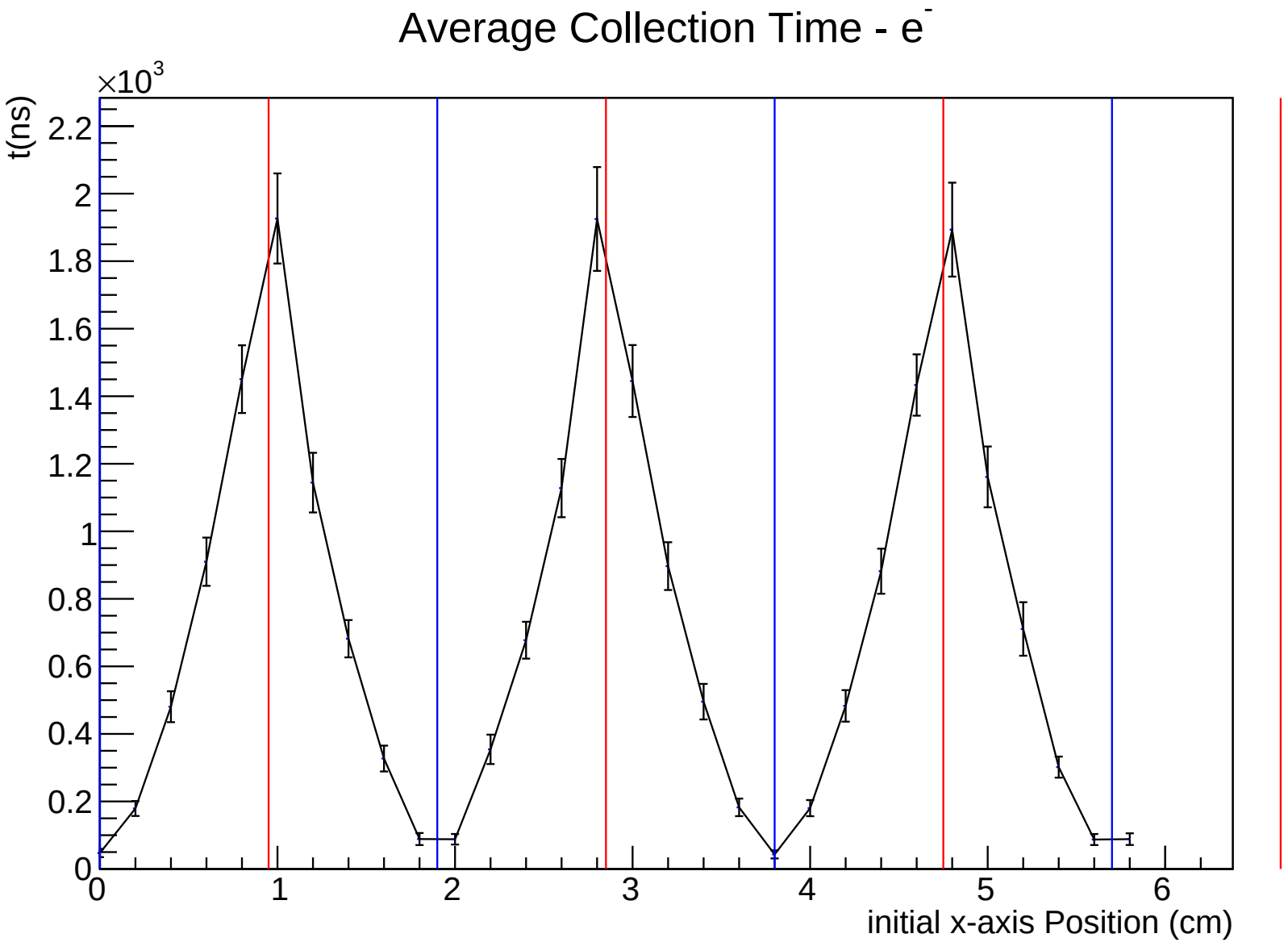
Extended Diagonal - Average Integrated Signal - summed



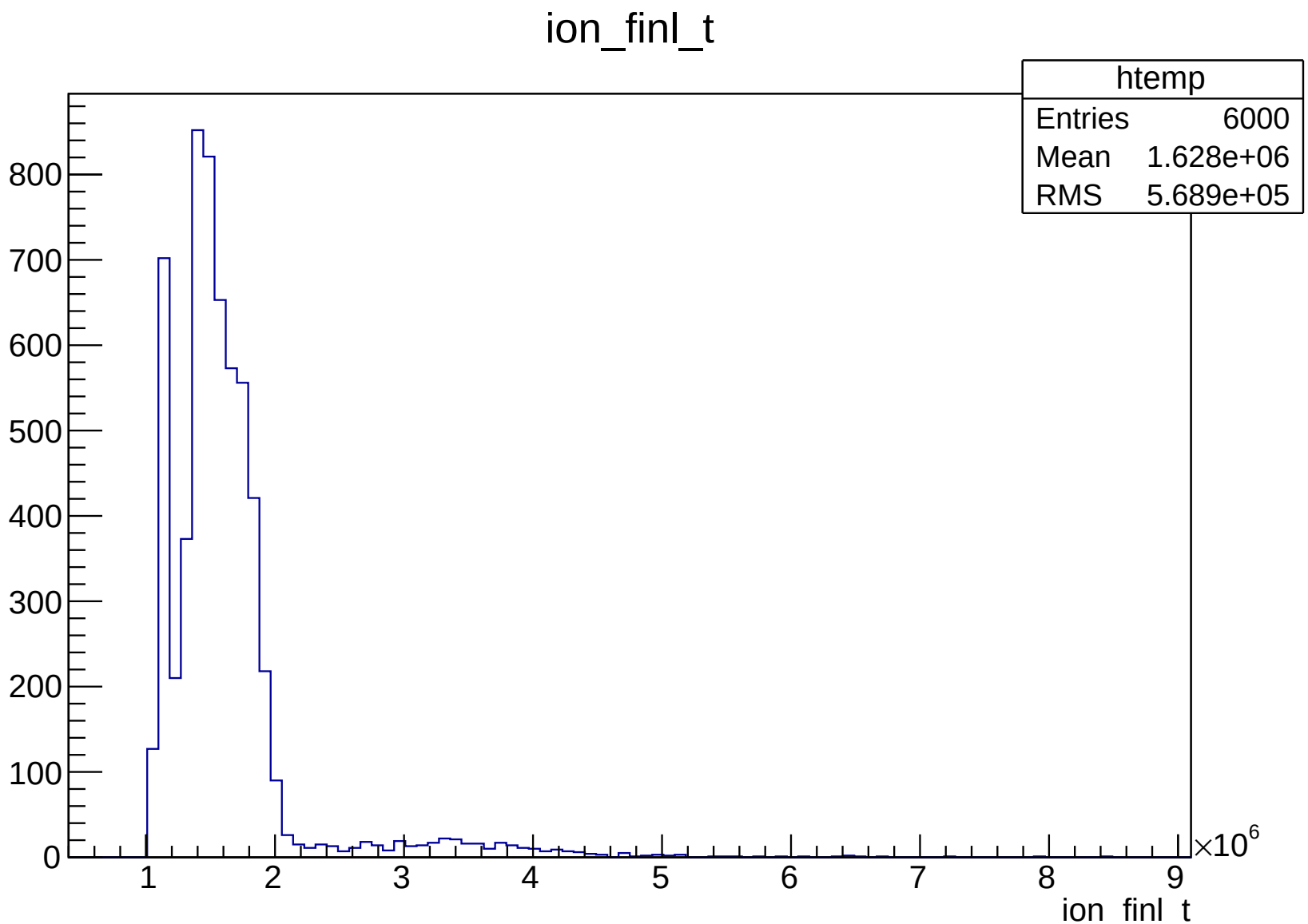
Straight Line Across Cells



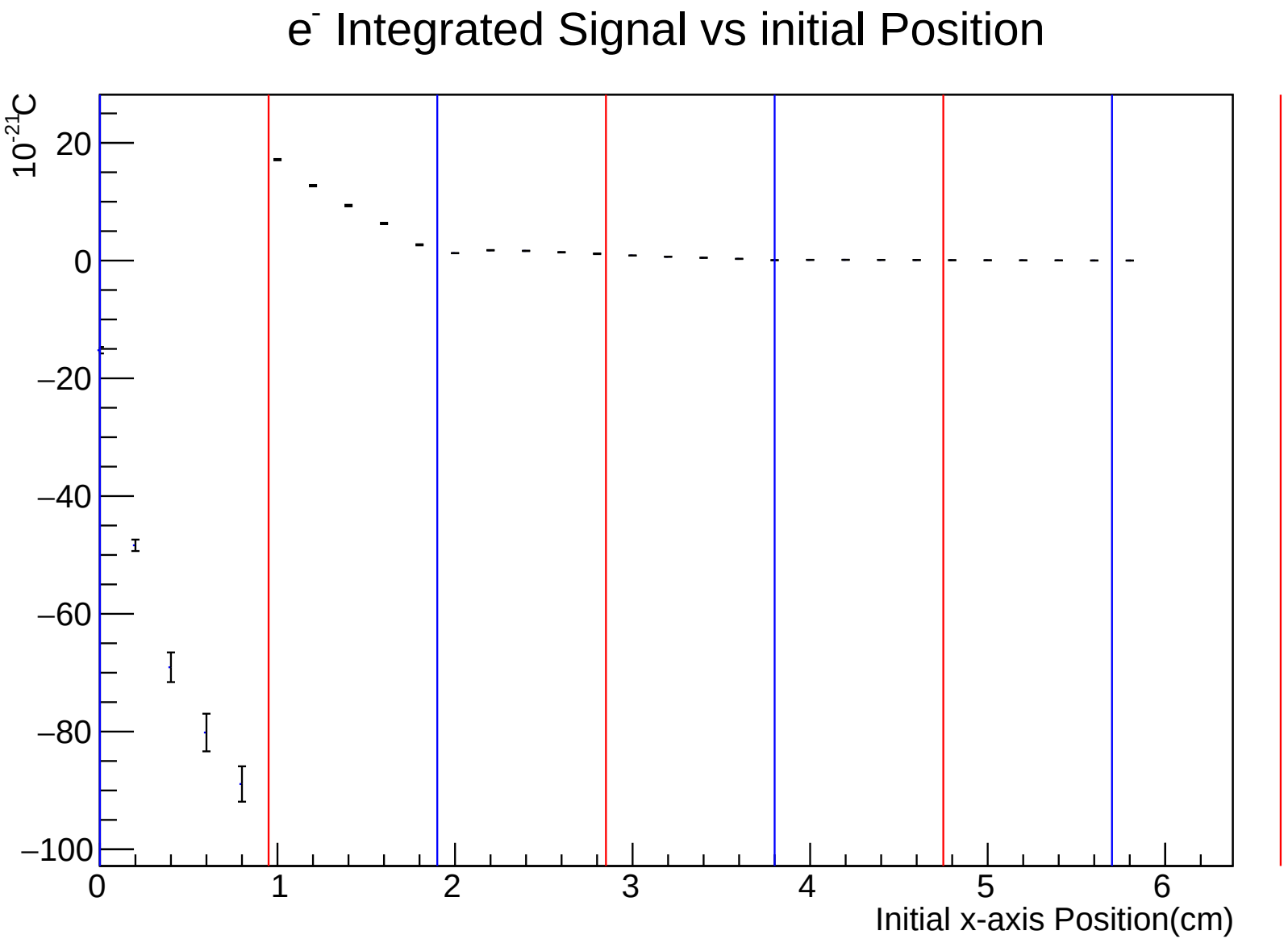
Straight Line - Collection Time - electrons



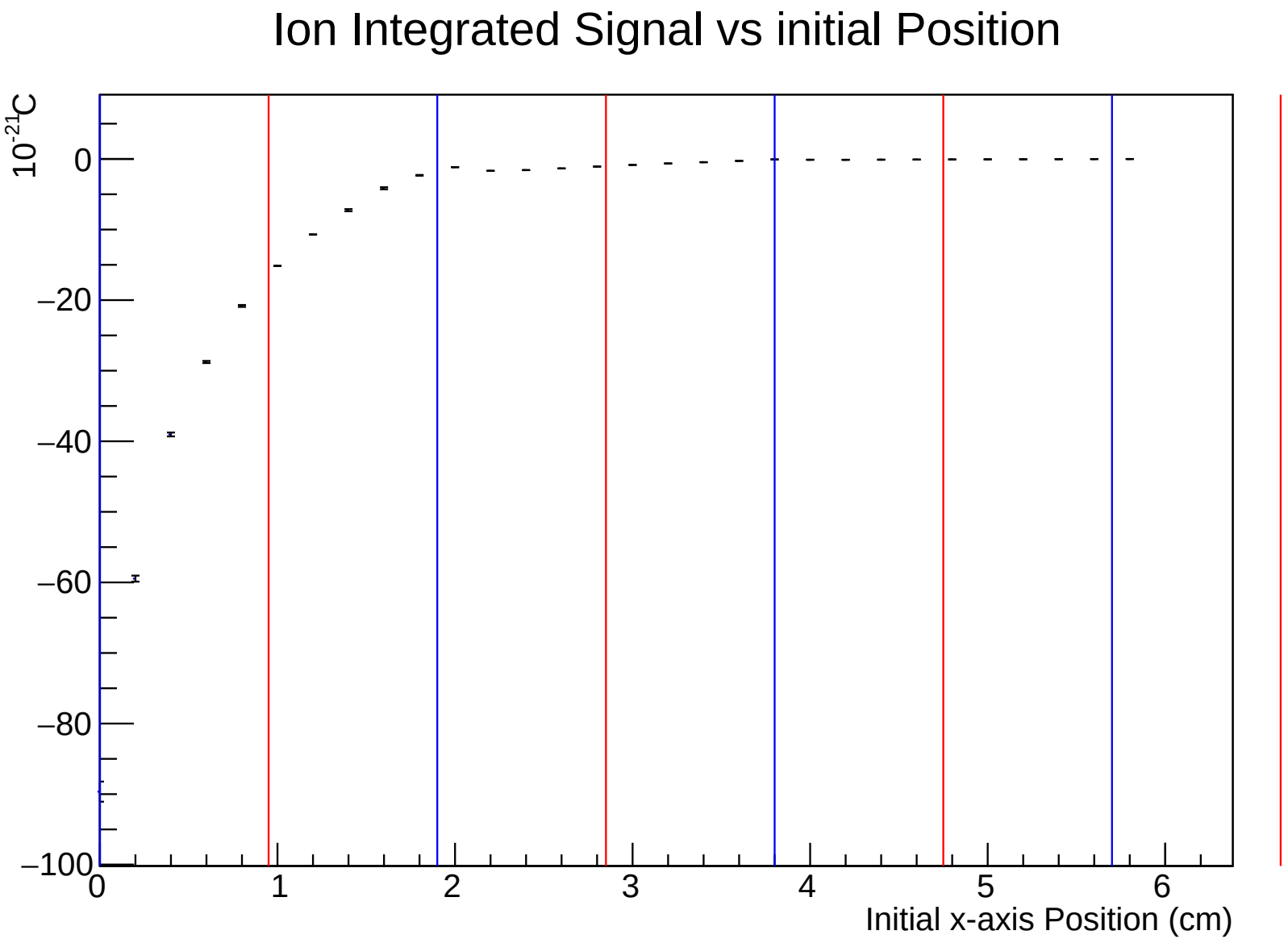
Straight Line - Collection Time - ions



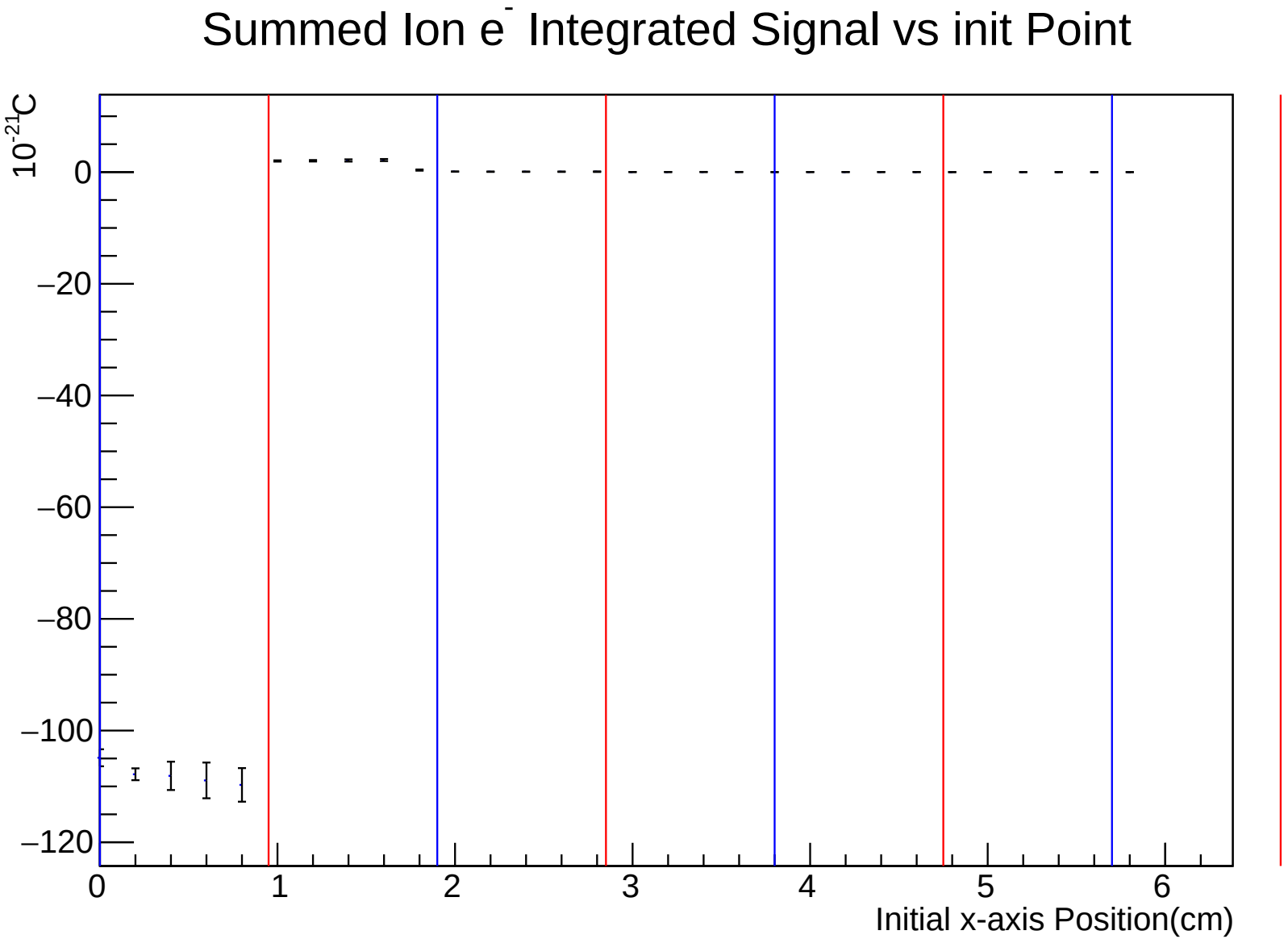
Straight Line - Integrated Signal - electrons



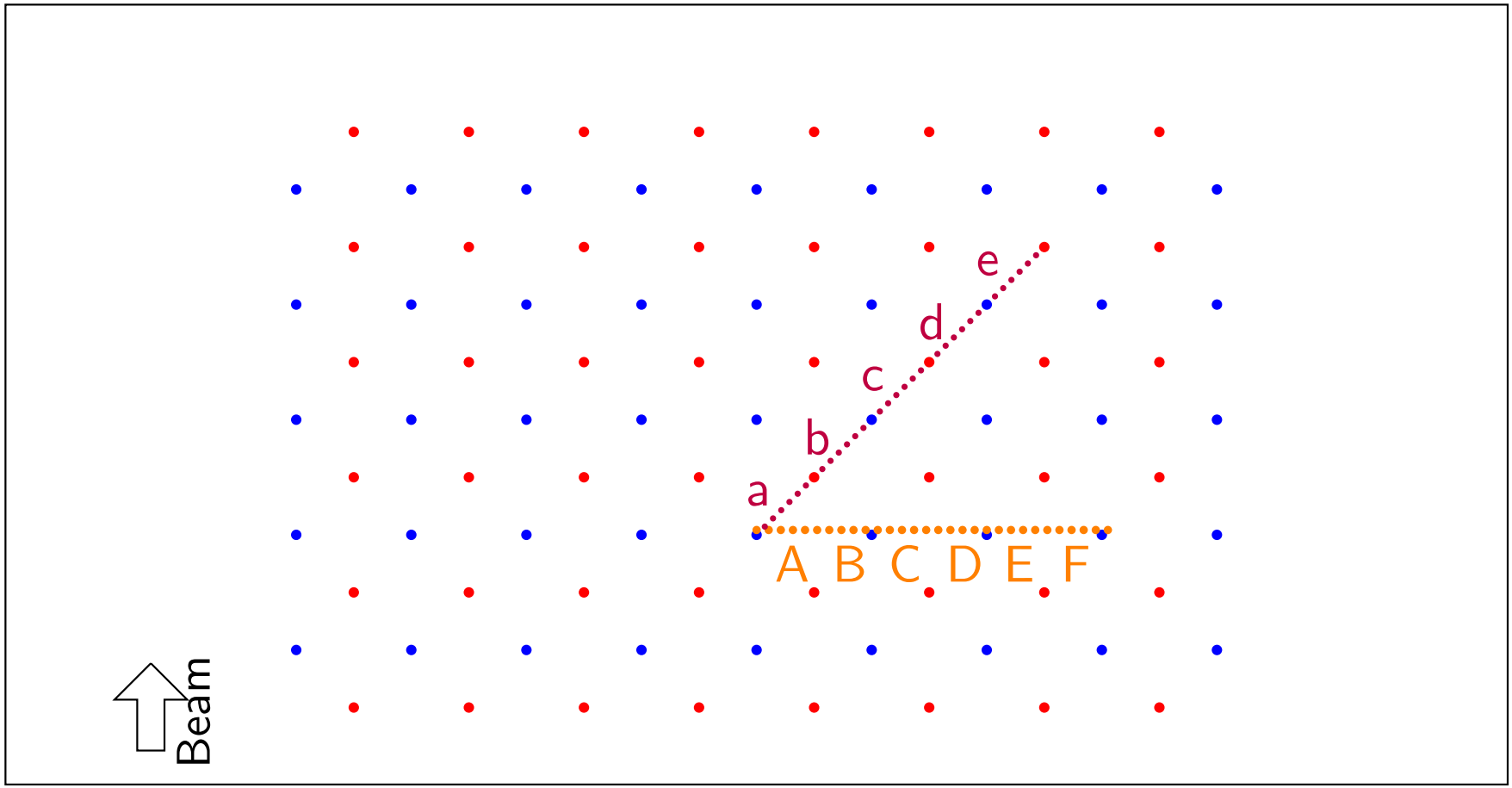
Straight Line - Integrated Signal - ions



Straight Line - Integrated Signal - summed



Simulation Details



Signal Diagonal Straight
HV

- 200 ion and electron pairs propagated from each point

Cell Cross Talk

Diagonal	1/2 Cell Avg of Int.Signal	Stdev.	fraction of in cell
a	-108.87	2.2875	
b	0.057868	0.0693	1881
c	0.028498	0.0435	3820
d	0.001436	0.0017	75794
e	0.000726	0.0021	149946
Str. Line			
A	-107.89	4.48	
B	1.72469	0.322	62.5
C	0.12451	0.119	866
D	0.01782	0.025	6053
E	0.12451	0.119	9717
F	0.00136	0.002	79036

Summary

- Collection times are usually less than DAQ time bin width
  - $3.4 \times 10^5 ns$ time bins
  - ions collect in $< 6 \times 10^6 ns$
    - 92% collect in under $2 \times 10^6 ns$
    - 97.5% collect in under $3.5 \times 10^6 ns$
  - electrons collect in $< 2 \times 10^3 ns$
- Induced signal is uniform over cell
- Induced signal between cells is small.
  - nearest cell induced signal between 1/62.5 to 1/1881
- Possible Future Simulation:
  - to investigate long collection time ions
  - to find average nearest cell cross talk