protoDUNE e- lifetime analysis

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Before we begin, a big thanks to...

Ajib Paudel and Tingjun Yang!!

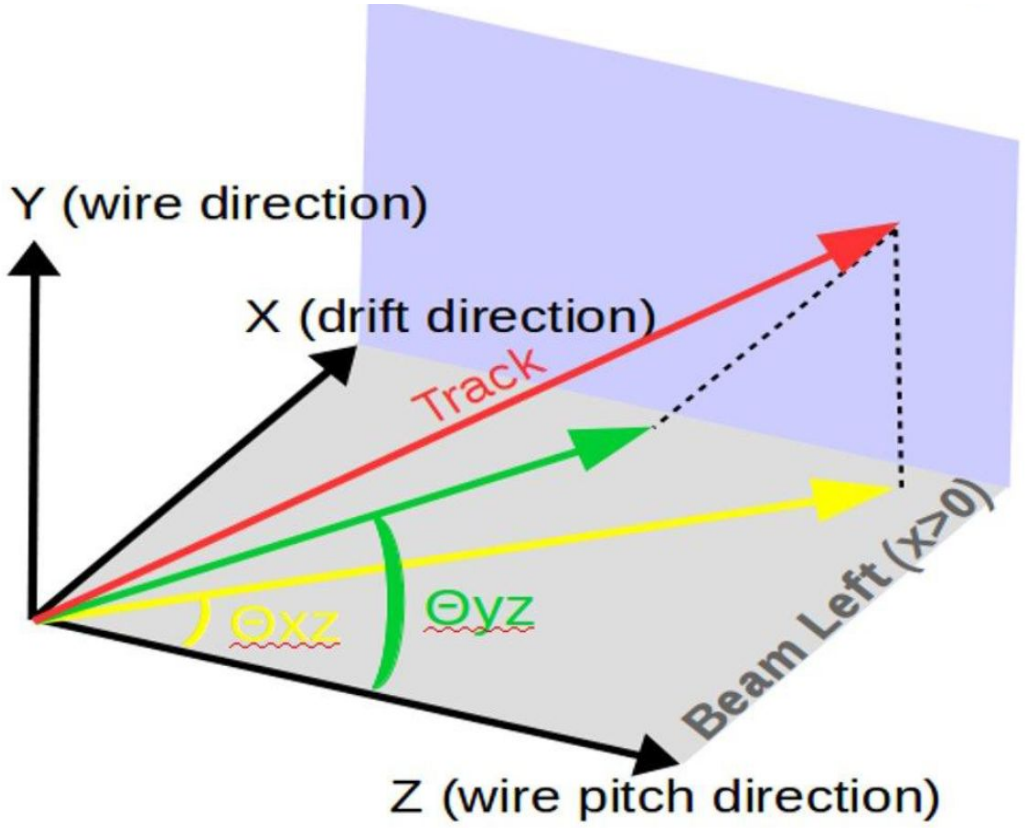
Objective

- Study protoDUNE's purity over time; impurities (e.g. O_2, H_2O) in LAr result in lower reconstructed dQ/dx values as hit distance from APAs increases

Procedure

- Only accept through-going, t_0-tagged cosmic rays
- Sort hit dQ/dx values into bins based on x-position
- Take median dQ/dx of each bin
- Graph and fit with exponential f(x)=exp(p0+p1*x) to get in form of $dQ/dx = (dQ/dx)_0 * \exp(-x/v_d * \tau)$
  - v_d = drift velocity = 0.16 cm/μs, τ = electron lifetime
- $\tau = 1/[v_d * p1]$

Angular cuts



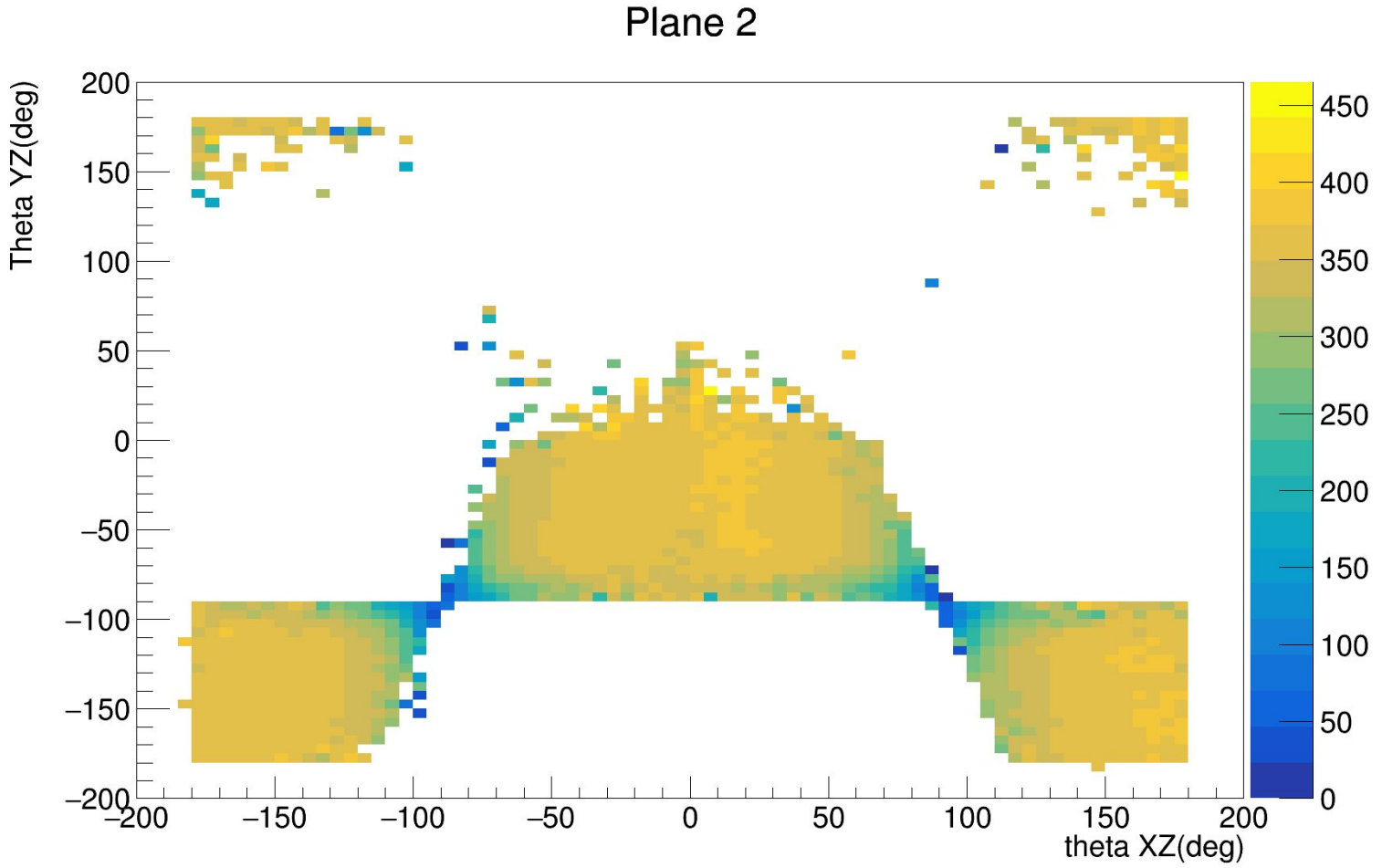
- Theta_XZ: the angle between the projection of the track on the XZ plane and the z-axis
- Theta_YZ: the angle between the projection of the track on the YZ plane and the z-axis

Angular cuts

- Tracks parallel and perpendicular to the wire planes are not well-reconstructed, so we want to remove these from our analysis
- We can single out these tracks using plots of the track projection angles on the XZ and YZ planes

Angular cuts

- Plot shows avg dQ/dx as a function of theta_XZ and theta_YZ
- All of these plots look pretty similar, so use same cut for all (MC + reco)

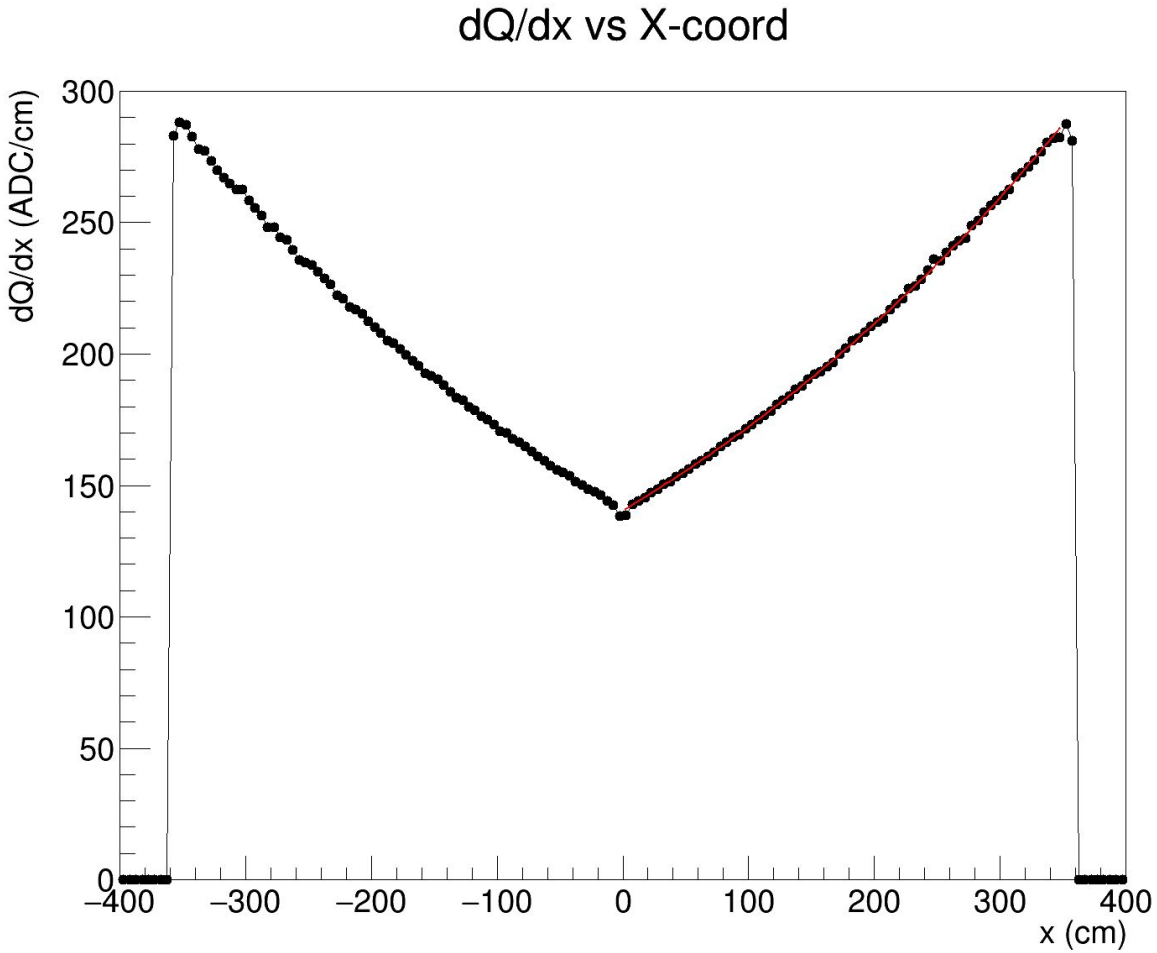


Monte Carlo simulations – no SCE

e- lifetime for x<0: 3060.51 µs

e- lifetime for x>0: 3054.98 µs

avg e- lifetime: 3057.75 µs

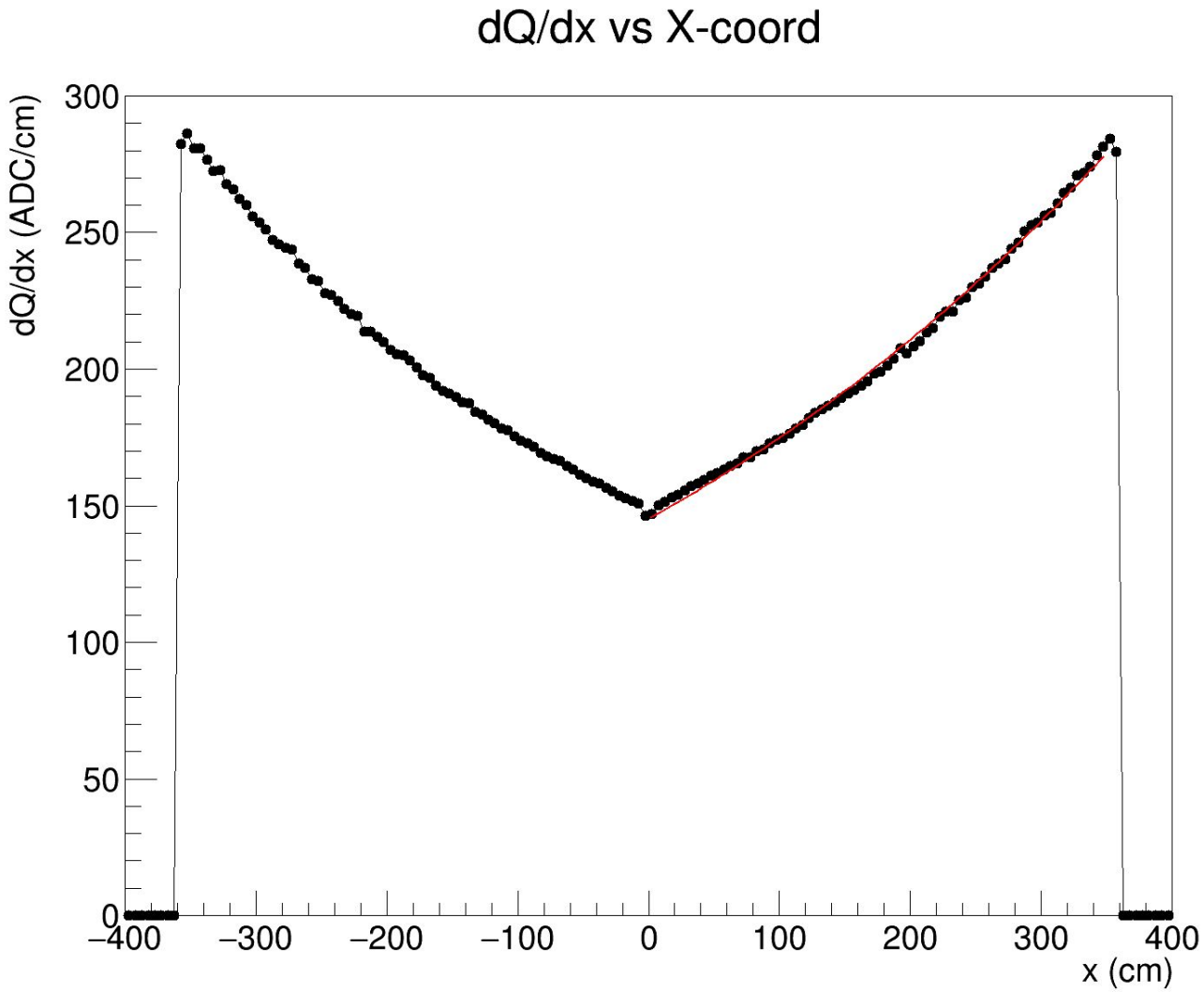


SCE

e- lifetime for x<0: 3322.25 µs

e- lifetime for x>0: 3345.06 µs

avg e- lifetime: 3333.66 µs

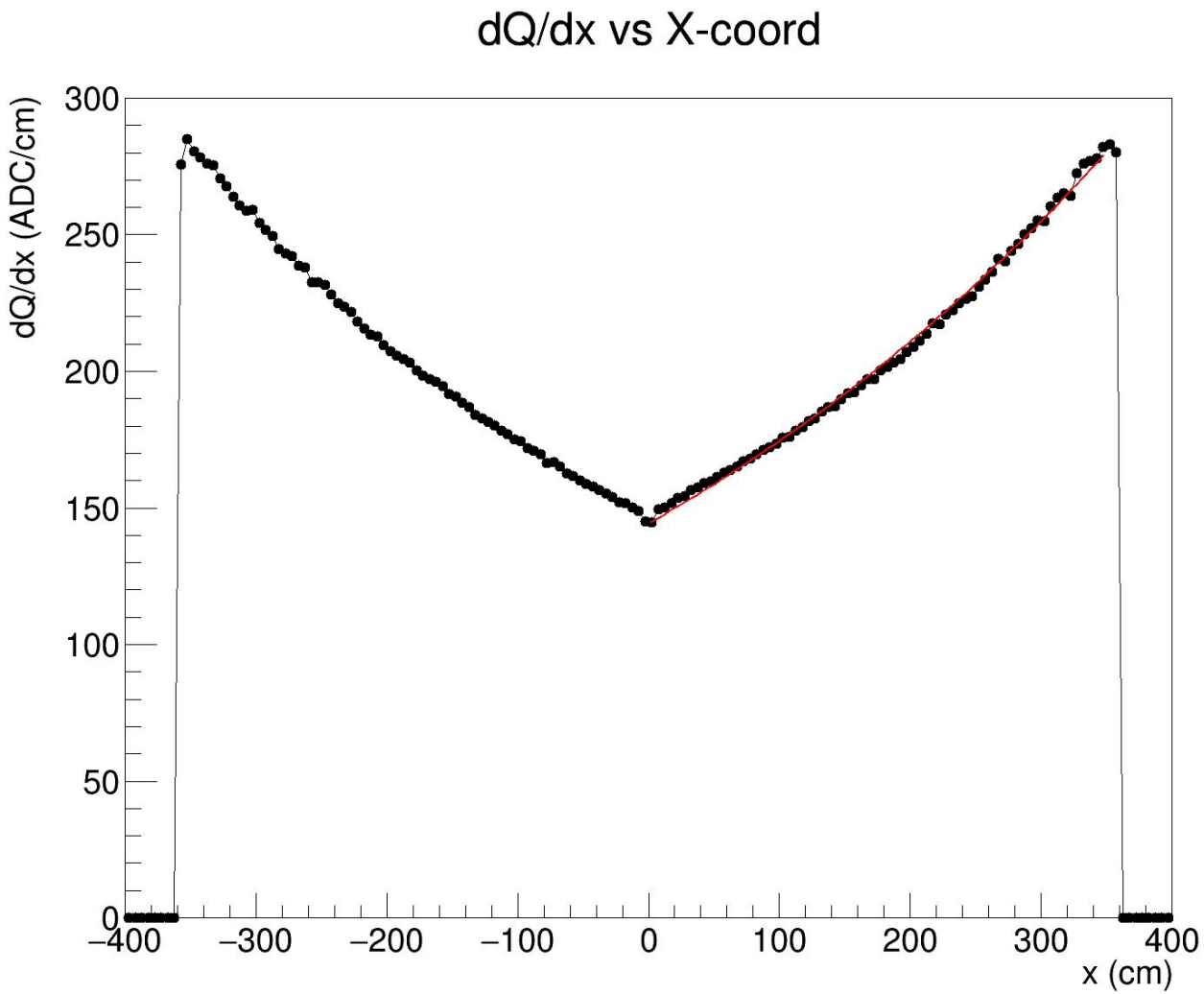


FLF

e- lifetime for x<0: 3293.57 µs

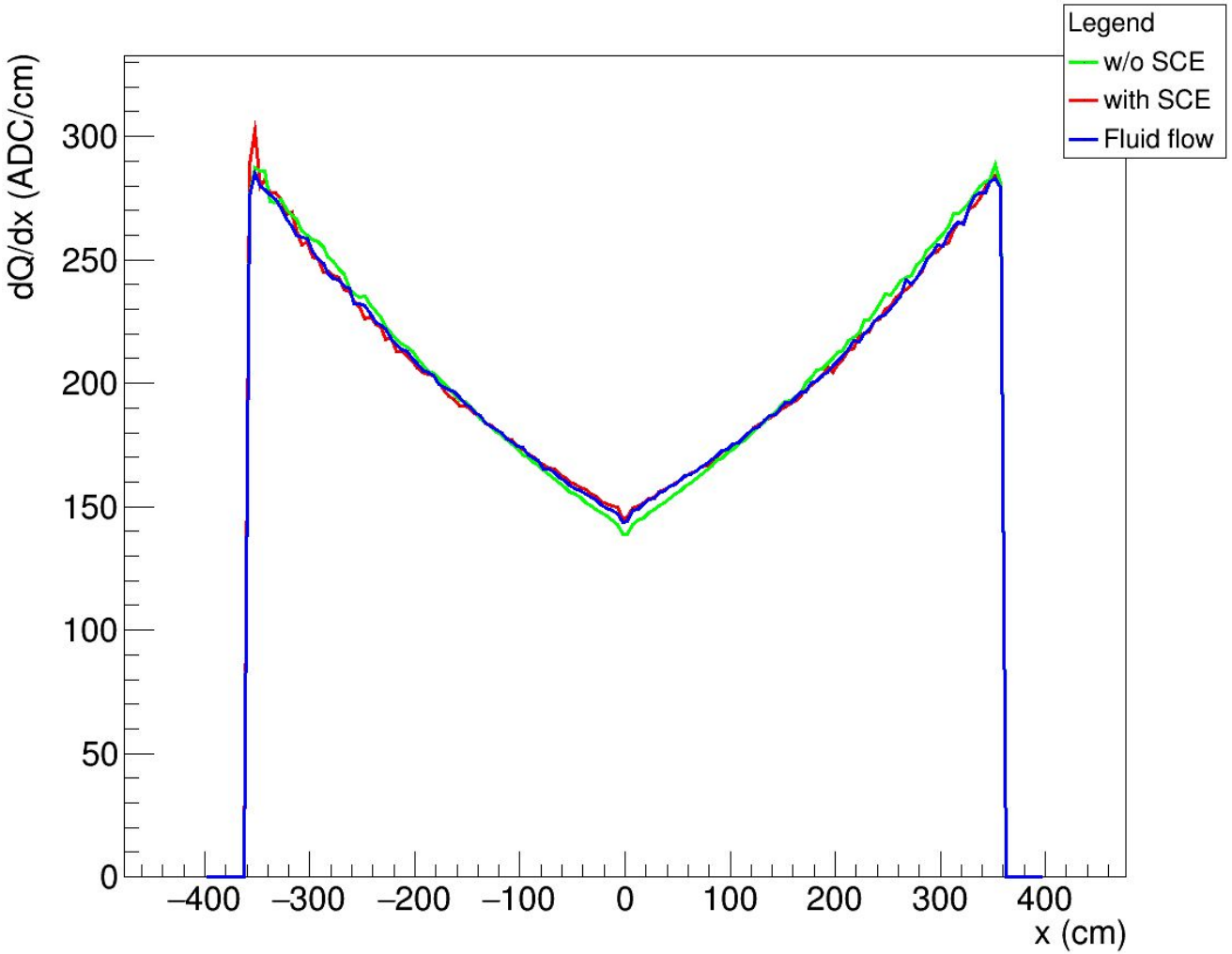
e- lifetime for x>0: 3299 µs

avg e- lifetime: 3296.29 µs



Space charge effect

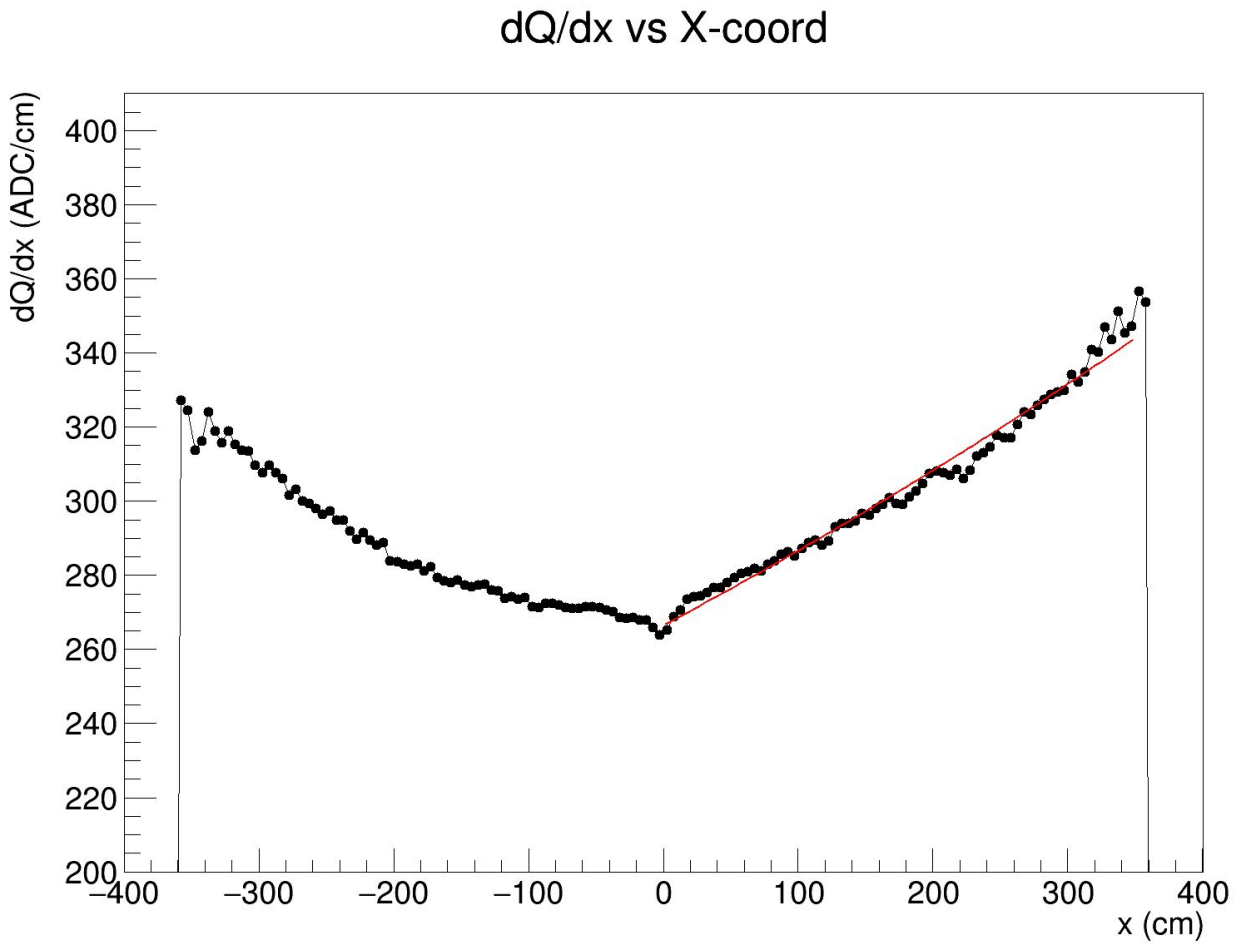
- MC data is shown
- Angular cuts applied



Run 5141

e- lifetime for x<0: 11222.4 µs

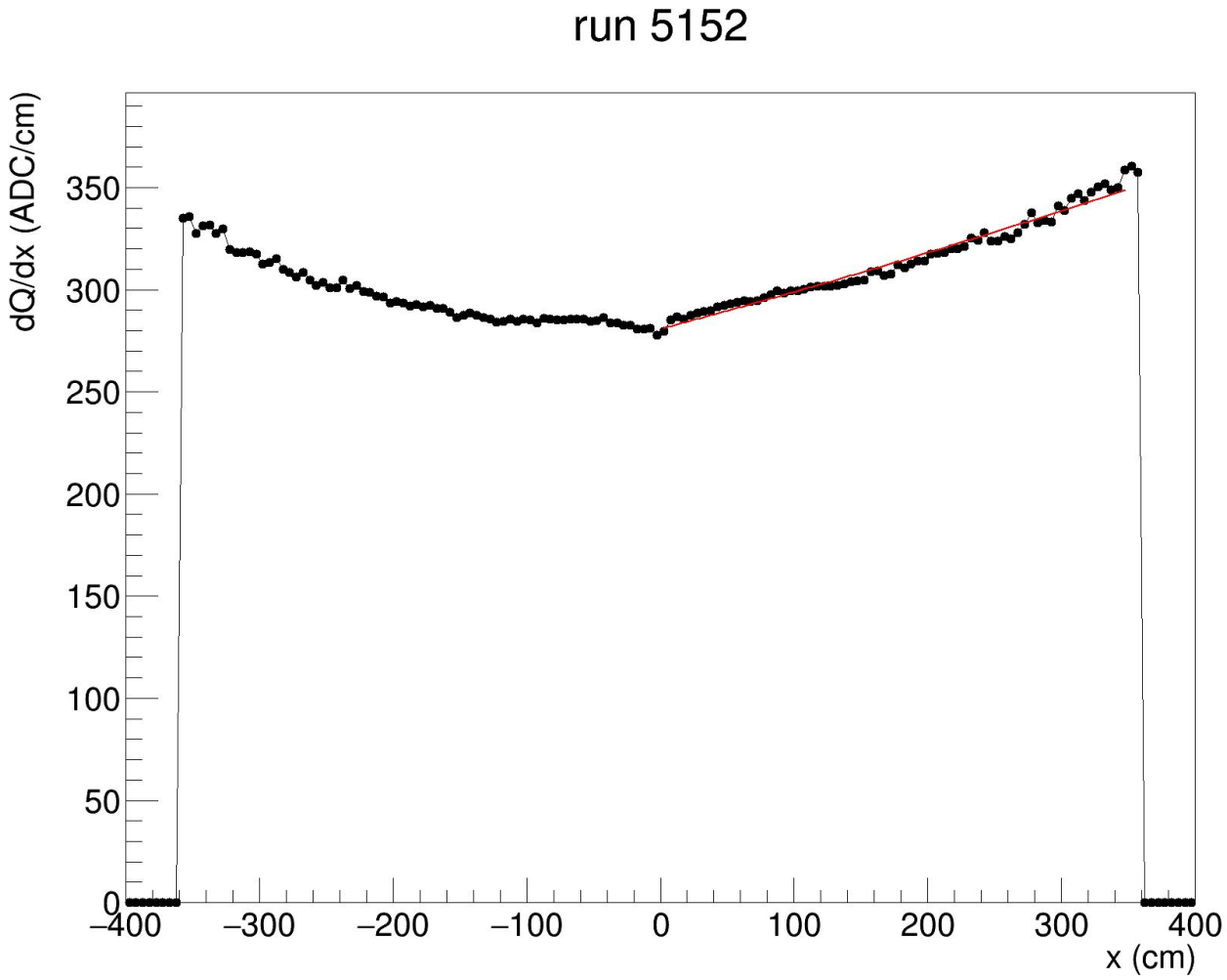
e- lifetime for x>0: 8572.03 µs



Run 5152

e- lifetime for x<0: 13821.3 µs

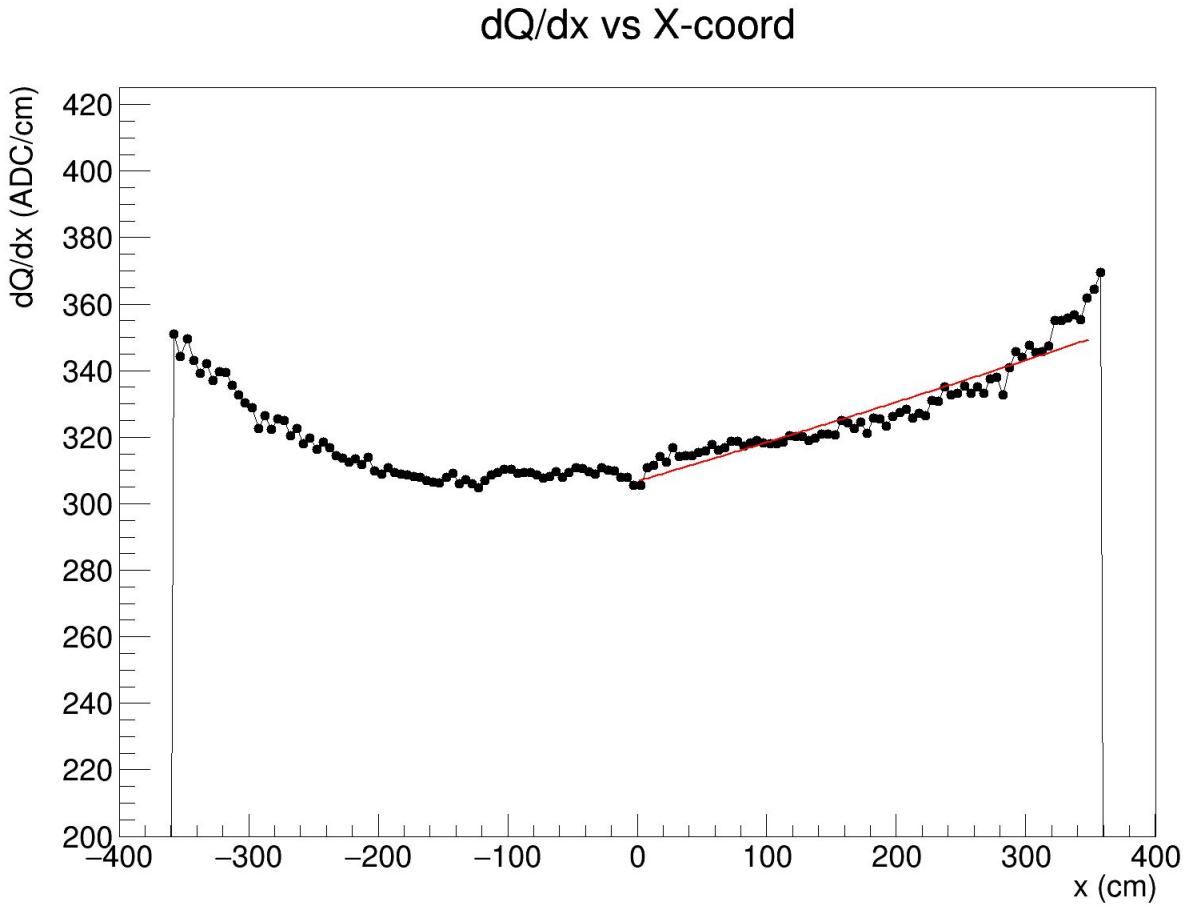
e- lifetime for x>0: 10016.7 µs



Run 5225

e- lifetime for x<0: 21782.4 µs

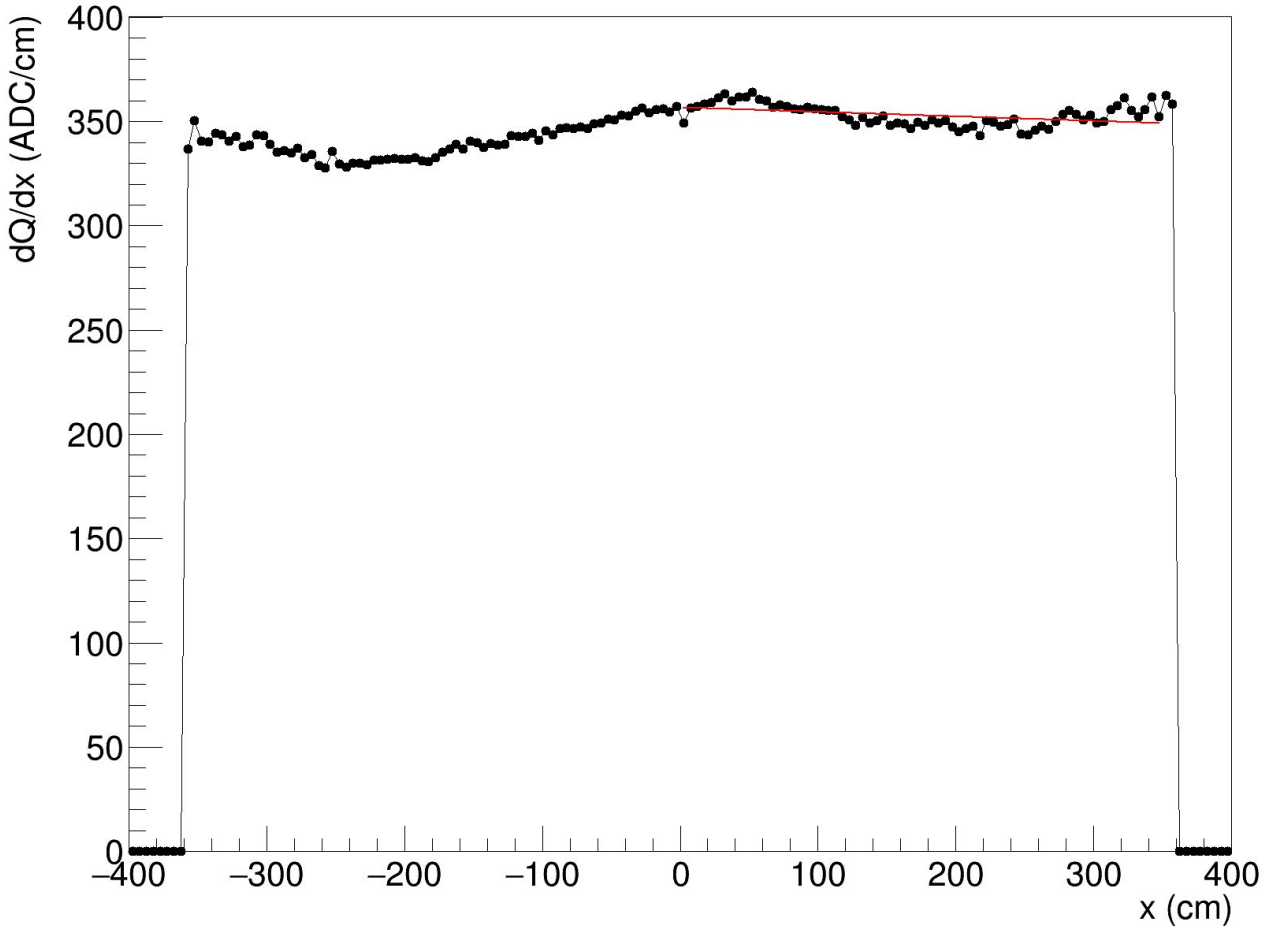
e- lifetime for x>0: 16745.2 µs



Run 5308

e- lifetime for x<0: -38849.8 µs

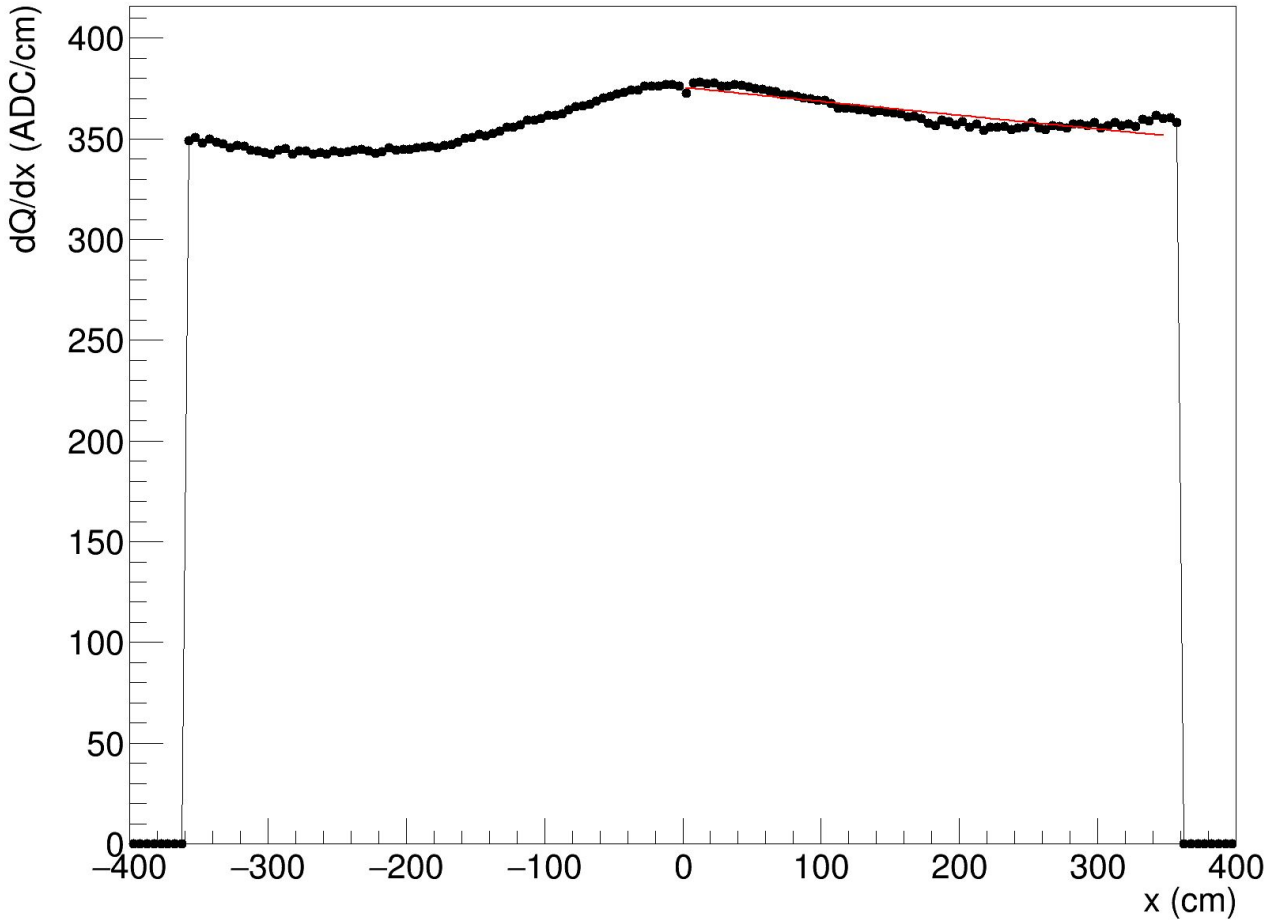
e- lifetime for x>0: -101754 µs



Run 5387

e- lifetime for x<0: -21438.1 µs

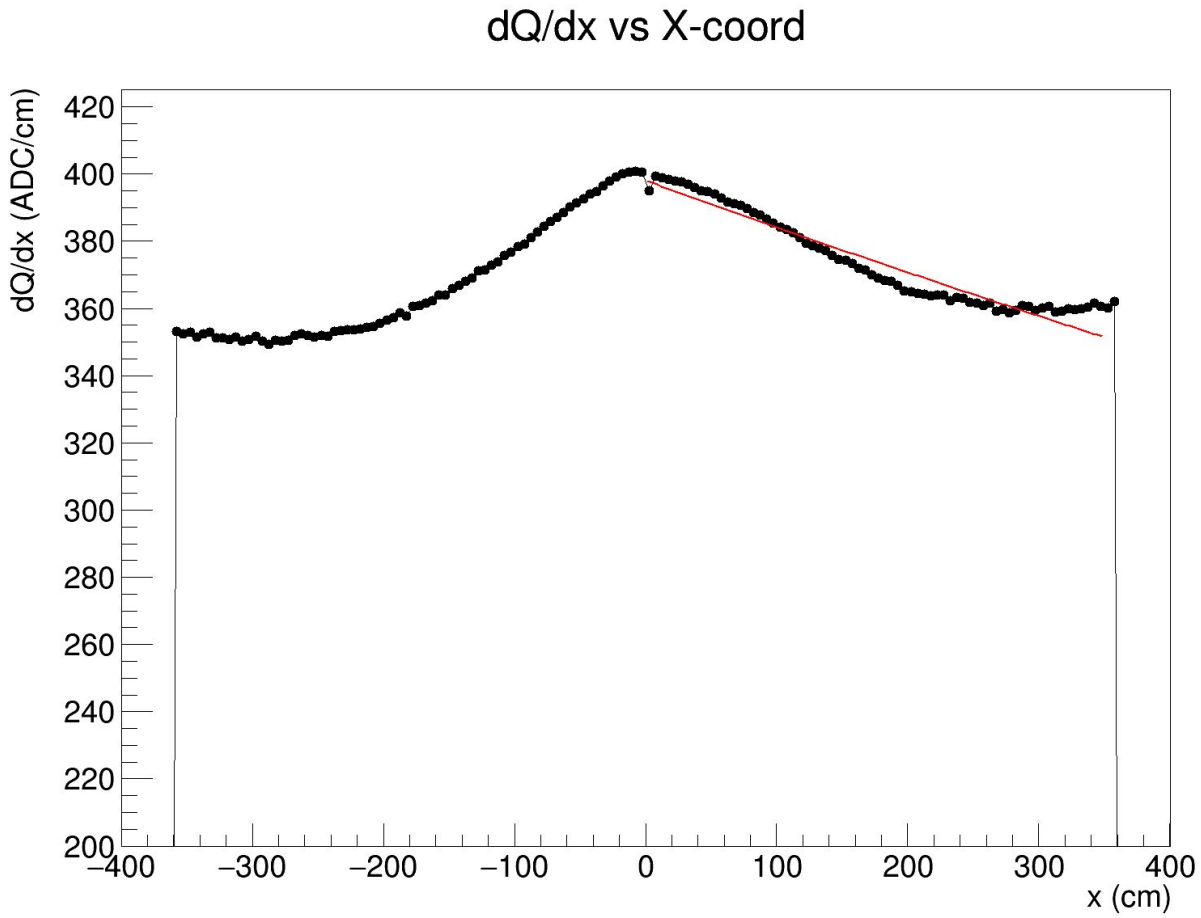
e- lifetime for x>0: -33131.2 µs



Run 5460

e- lifetime for x<0: -14201.9 µs

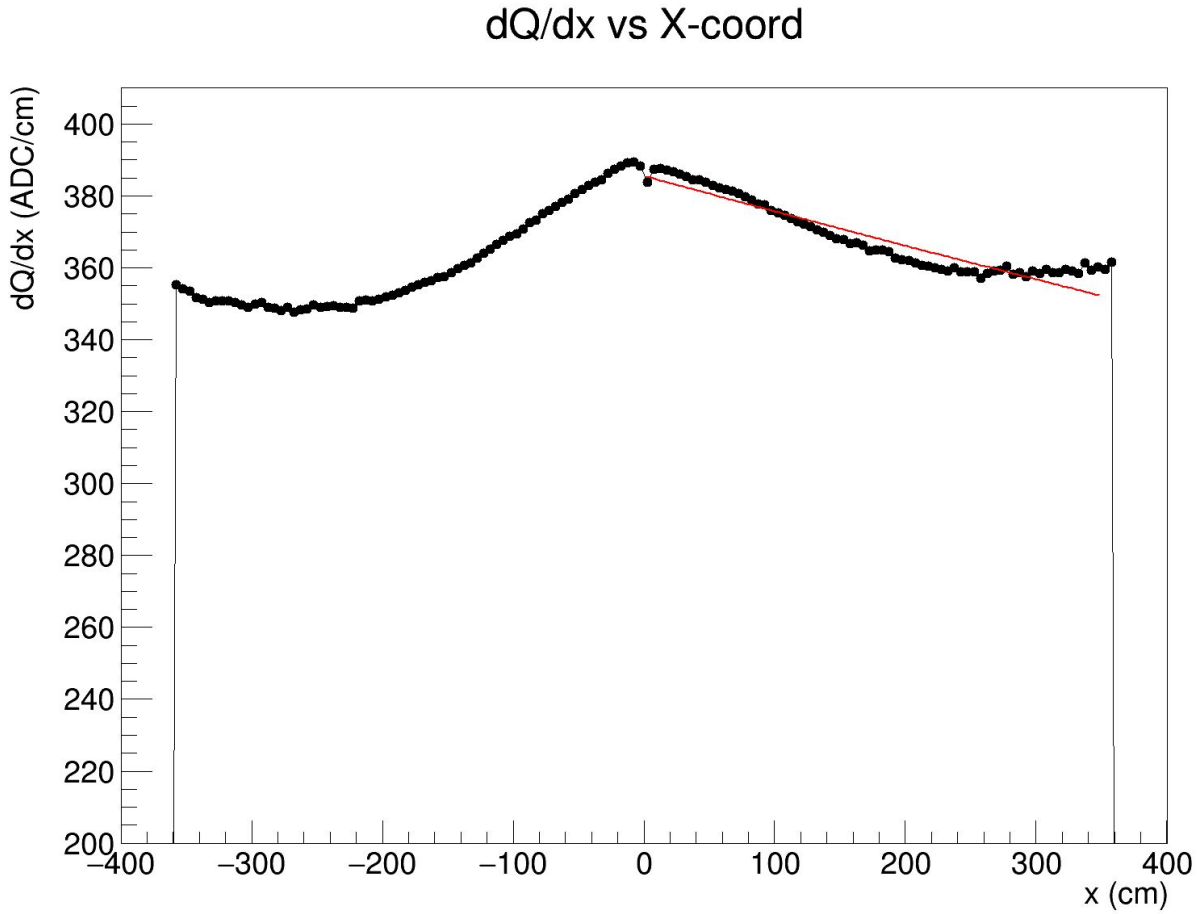
e- lifetime for x>0: -17566.1 µs



Run 5814

e- lifetime for x<0: -18155.2 µs

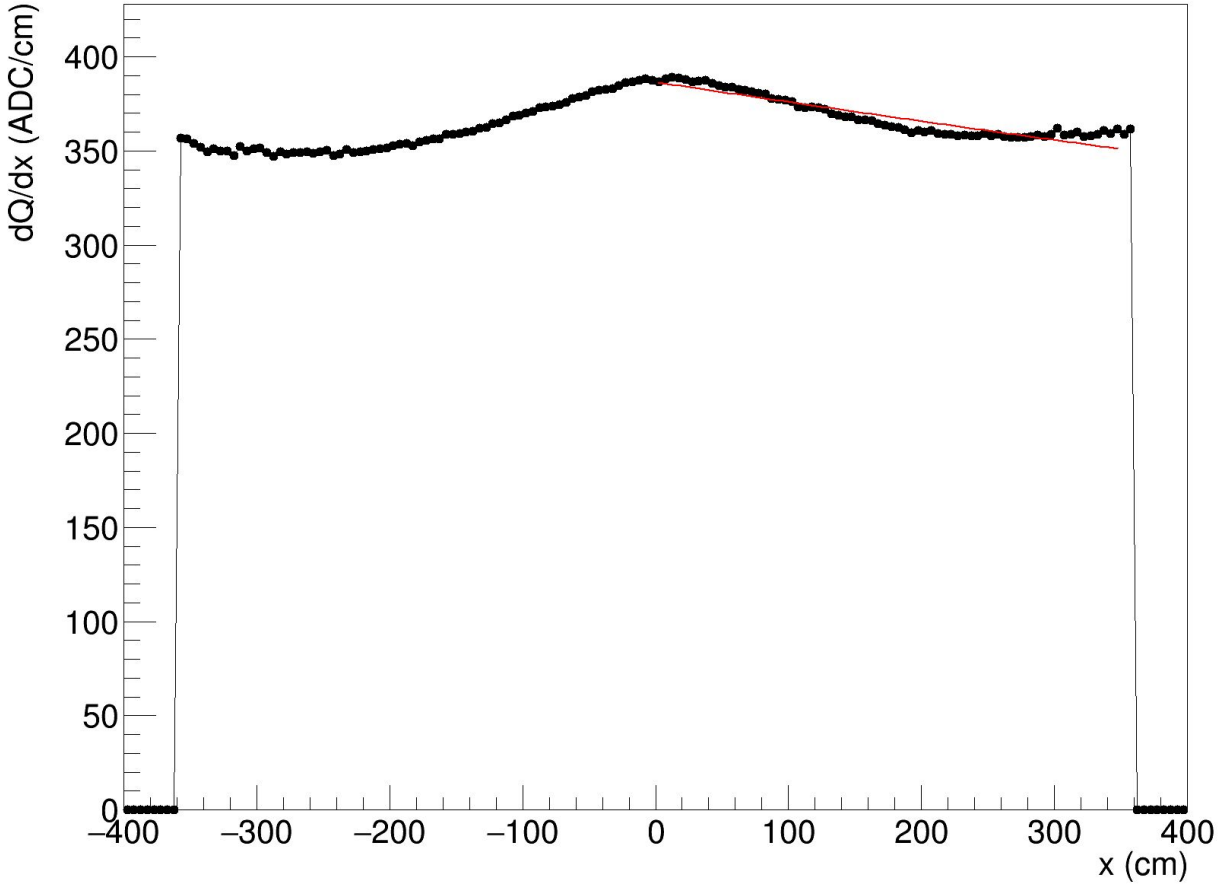
e- lifetime for x>0: -24171.6 µs



Run 5815

e- lifetime for x<0: -18649.2 µs

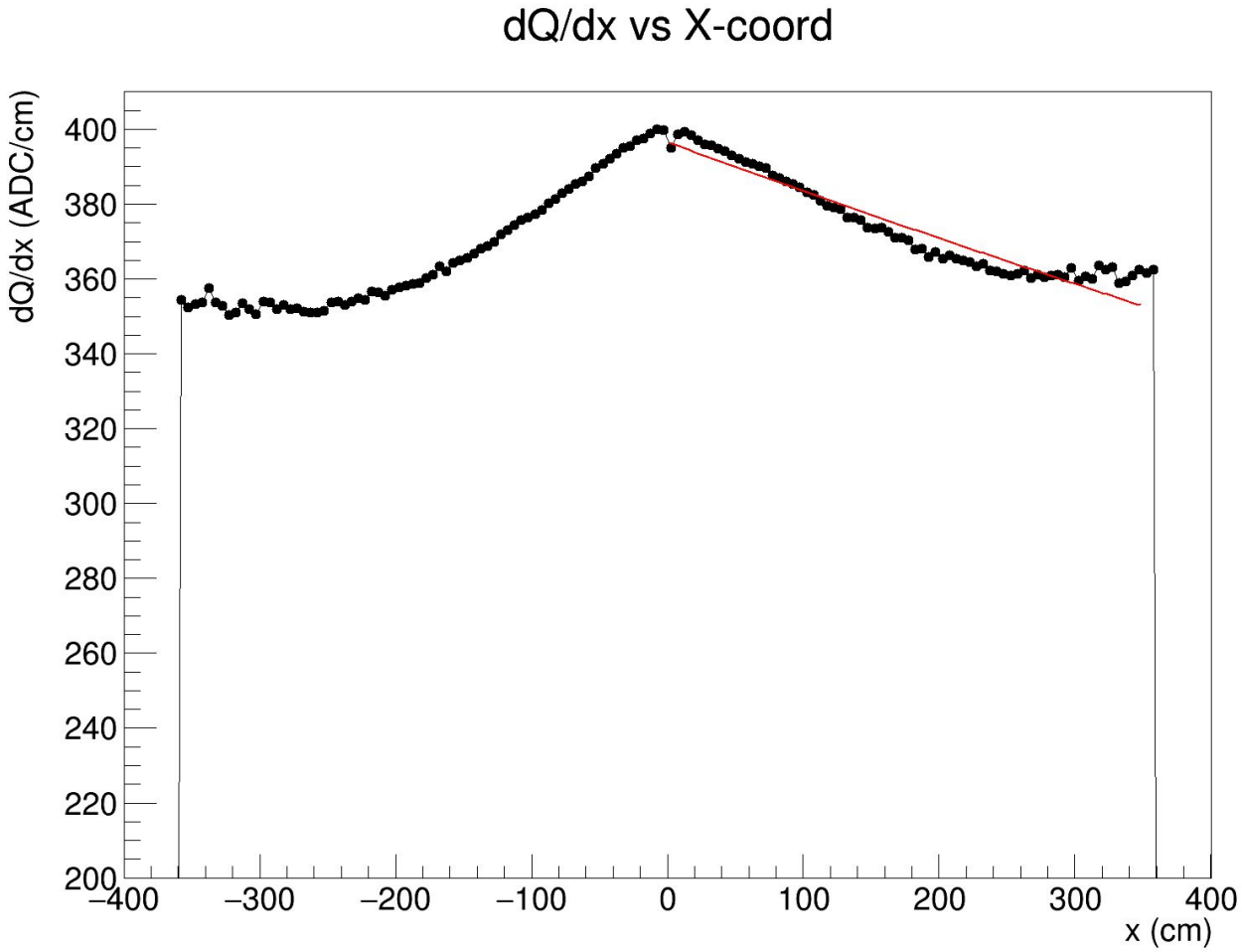
e- lifetime for x>0: -22659.1 µs



Run 5844

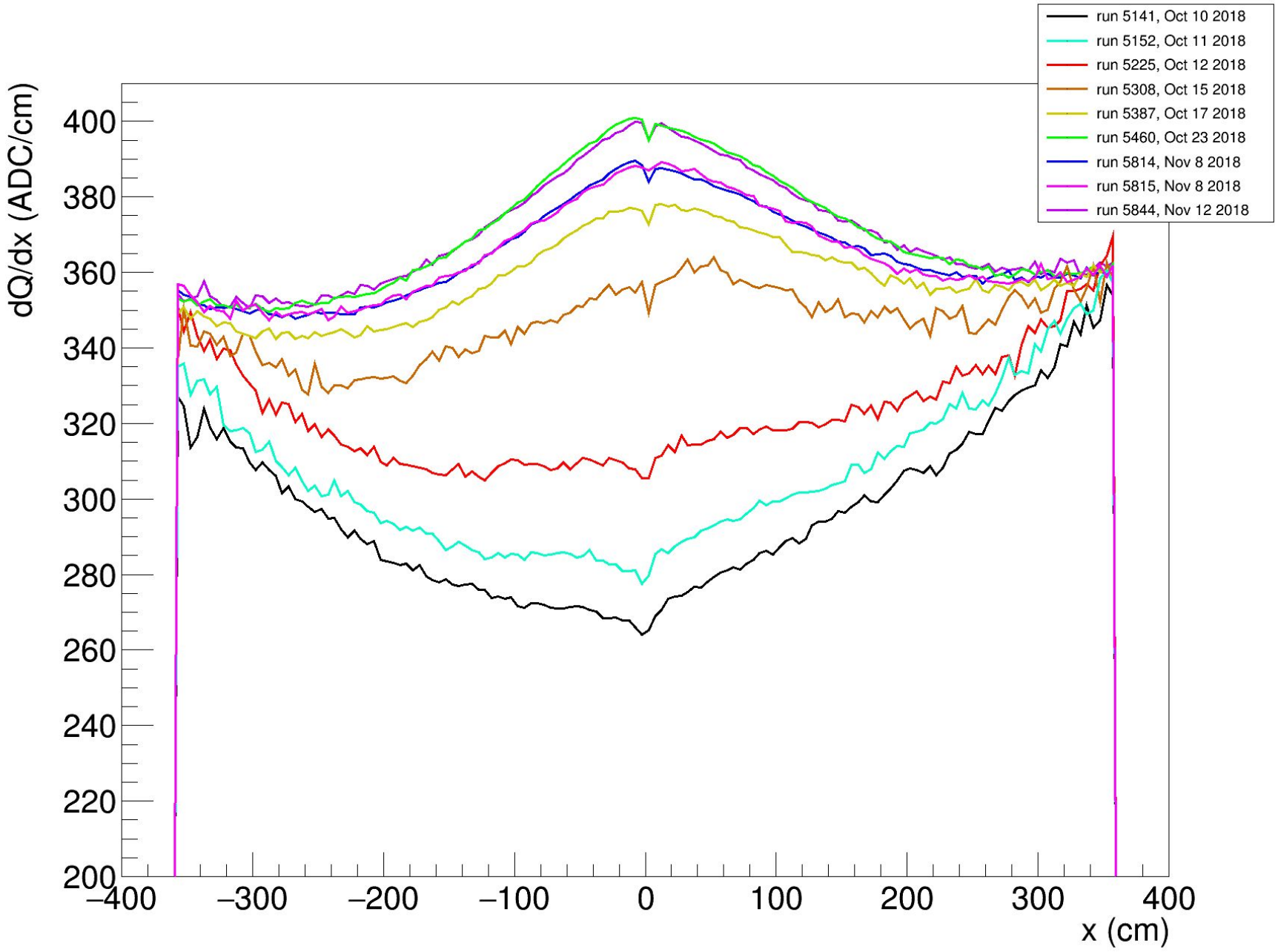
e- lifetime for x<0: -15321.6 µs

e- lifetime for x>0: -18685.5 µs



Summary

Date	Run	# Events	Processed Events	Lifetime (x>0) (μs)	Lifetime (x<0) (μs)	Avg. lifetime (μs)	Q_A/Q_C (x>0)	Q_A/Q_C (x<0)	Q_A/Q_C (avg.)
Oct 10 2018	5141	11328	11112	8572.03	11222.4	9897.21	0.769	0.818	0.794
Oct 11 2018	5152	8739	8739	10016.7	13821.3	11919	0.799	0.850	0.824
Oct 12 2018	5225	13434	6600	16745.2	21782.4	19263.8	0.874	0.902	0.888
Oct 15 2018	5308	2483	2483	-101754	-38849.8	-70301.9	1.02	1.06	1.04
Oct 17 2018	5387	20448	20448	-33131.2	-21438.1	-27284.6	1.07	1.11	1.09
Oct 23 2018	5460	91734	91734	-17566.1	-14201.9	-15884	1.14	1.17	1.15
Nov 08 2018	5814	94329	90145	-24171.6	-18155.2	-21163.4	1.10	1.13	1.11
Nov 08 2018	5815	28935	26471	-22659.1	-18649.2	-20654.1	1.104	1.13	1.12
Nov 12 2018	5844	25995	25995	-18685.5	-15321.6	-17003.6	1.13	1.16	1.14


run 5141, Oct 10 2018
run 5152, Oct 11 2018
run 5225, Oct 12 2018
run 5308, Oct 15 2018
run 5387, Oct 17 2018
run 5460, Oct 23 2018
run 5814, Nov 8 2018
run 5815, Nov 8 2018
run 5844, Nov 12 2018
dQ/dx (ADC/cm)
400
380
360
340
320
300
280
260
240
220
200
−400
−300
−200
−100
0
100
200
300
400
x (cm)

Backup slides!

Q_A/Q_C calculation

$Q_A/Q_C = \exp(-t/\tau)$

- Q_A = charge at anode
- Q_C = charge at cathode
- t = full drift time (2.25 ms for the 3.6 m drift)
- τ = e- lifetime