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Online LAr Purity Monitoring in DUNE 35t prototype

Thanks to **Michelle Stancari** for idea / guidance

Outline

Motivation

Plan of work

Details of DUNE 35t prototype and external counters

Work completed to date

Future plans

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These slides – picture of on going work on 35t – Work in progress!

LAr Purity directly impacts ionisation electron lifetime

Drift distance / time long for LAr TPCs

Impure Argon means collected charge reduces with distance from APA

Can we estimate the purity online from TPC data?

Needs to be fast – use simple crude metrics

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The Plan

Use external scintillator counters to tag sample of muons travelling parallel to APA (YZ plane, X bins using external counters)

Estimate electron lifetime -> LAr purity from sample of these muons

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Detailed Plan
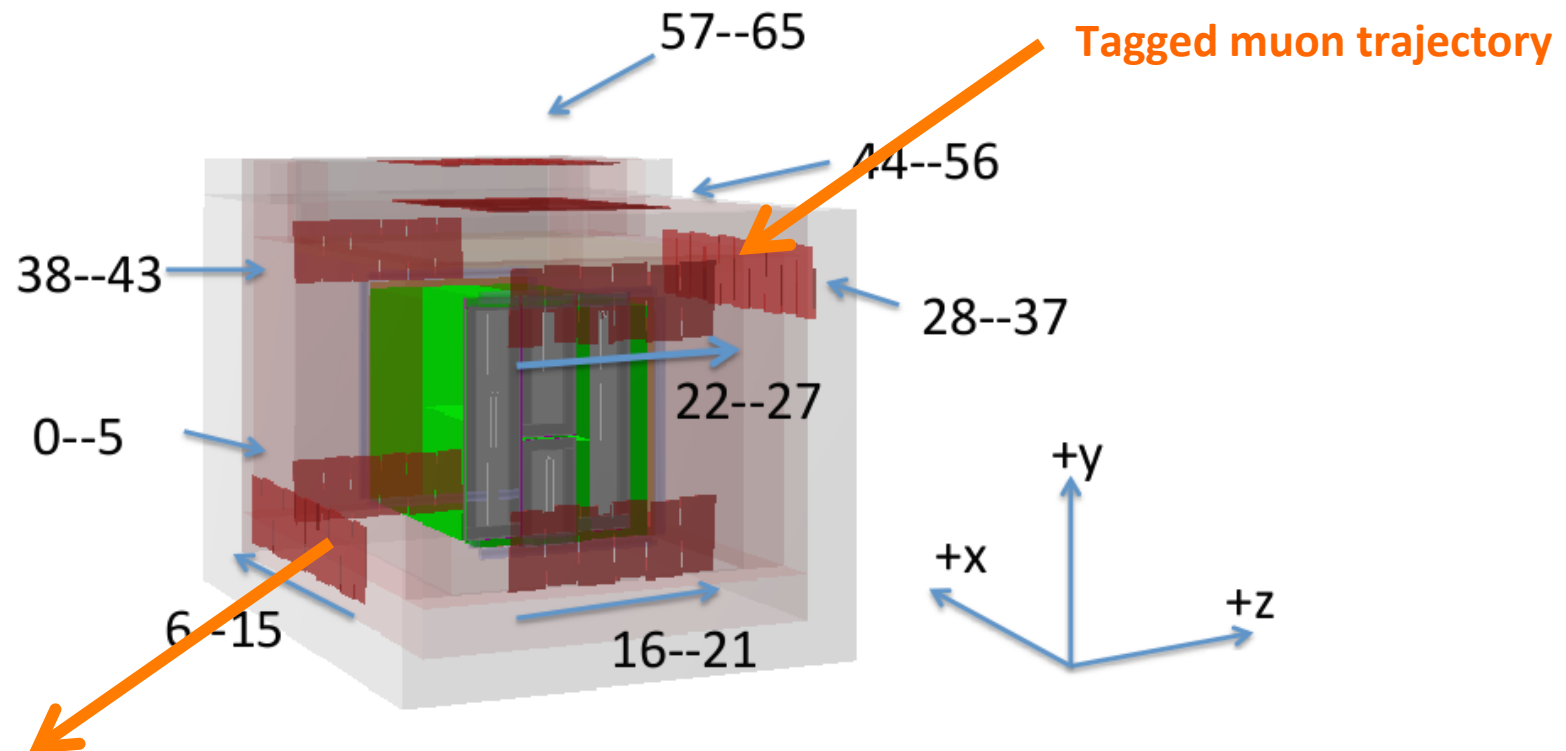
Use Monte Carlo simulated muons to develop lifetime / purity estimation methods

Start with muons with 'unrealistic spectrum' (in momentum, direction) to develop understanding and tools – **This talk**

Test tools with CRY simulated cosmic muons ('realistic spectrum') – **In development**

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Repurposed counters placed outside cryostat and structure (i.e. concrete wall + other material between them and the active volume)

Better counters / more segmentation would give greater variety of x positions + lower fake rates

Each counter highlighted is actually a pair – coincidence requirement lowers fake rate

External Scintillator Counters

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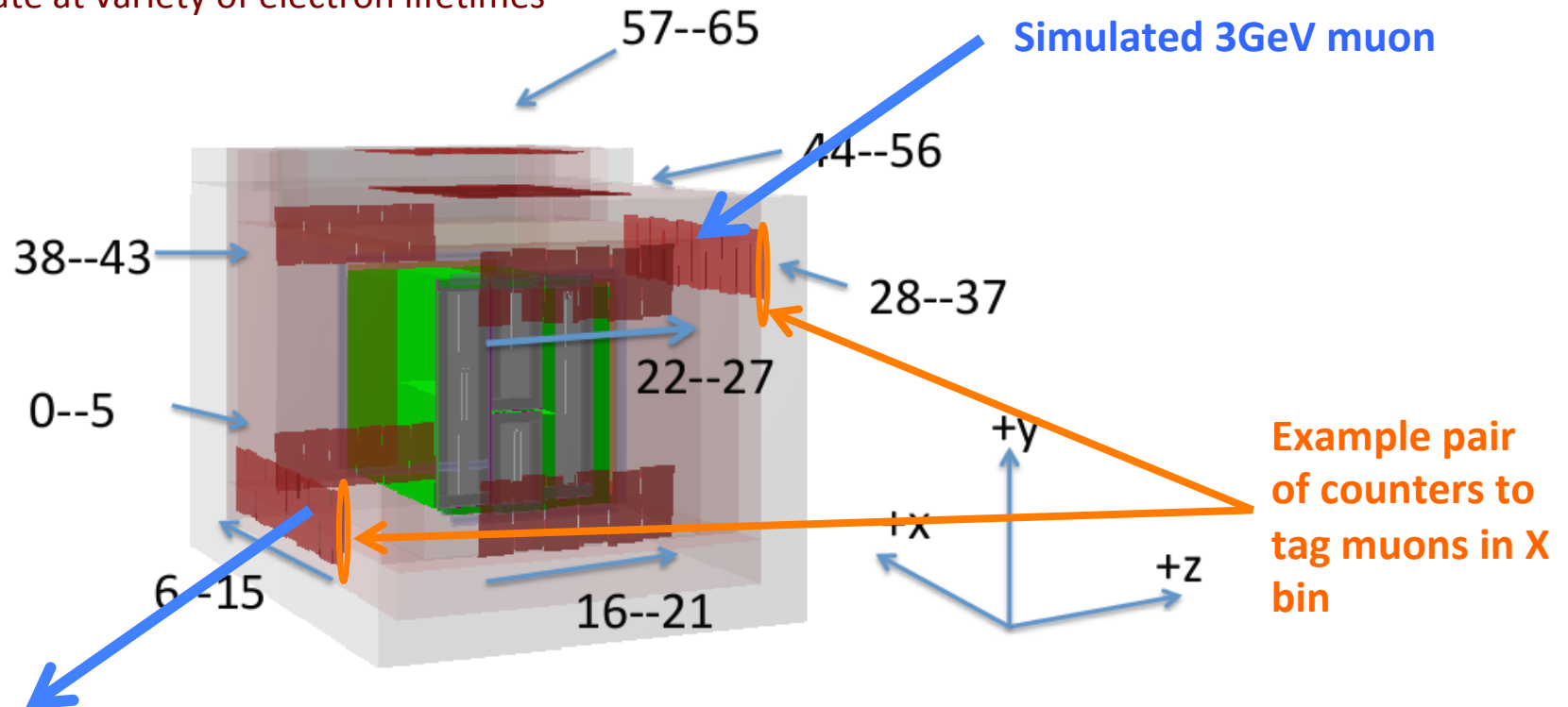
Data sample details
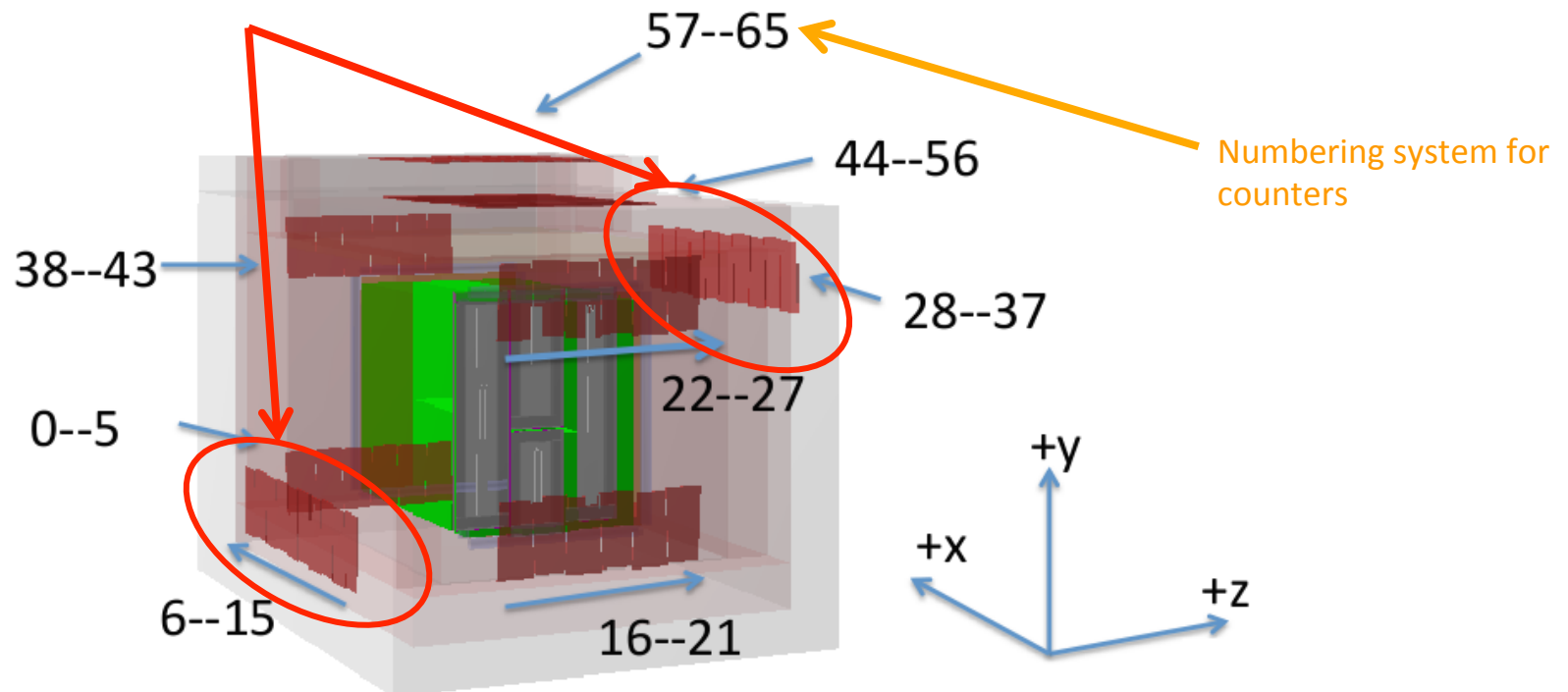
Simple (unrealistic spectrum) of 3GeV muons (no energy spread)

All travel in YZ plane, inclined such that they hit a pair of counters (on opposite walls)

Uniform distribution in XY plane (so we hit all the counter pairs of interest)

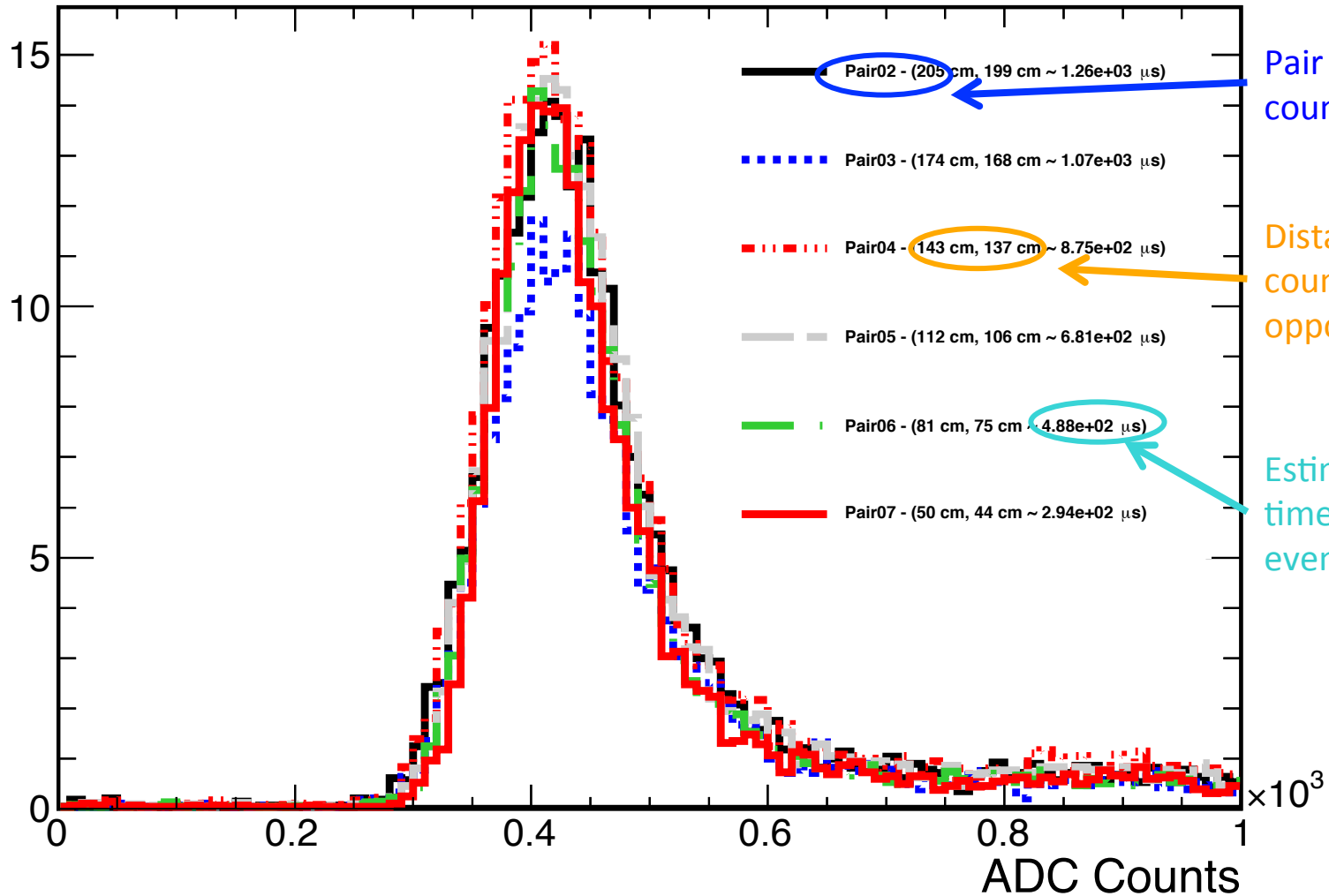Simulated using the DUNE 35t software framework (LArSoft + 35t specifics)

Simulate at variety of electron lifetimes

57--65

Simulated 3GeV muon

44--56

38--43

28--37

22--27

0--5

+y

Example pair of counters to tag muons in X bin

6--15

+x

+z

16--21

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Hit Charge - τ_e 1×10^5 μs

Legend:
- Pair02 - (205 cm, 199 cm ~ 1.26e+03 μs)
- Pair03 - (174 cm, 168 cm ~ 1.07e+03 μs)
- Pair04 - (143 cm, 137 cm ~ 8.75e+02 μs)
- Pair05 - (112 cm, 106 cm ~ 6.81e+02 μs)
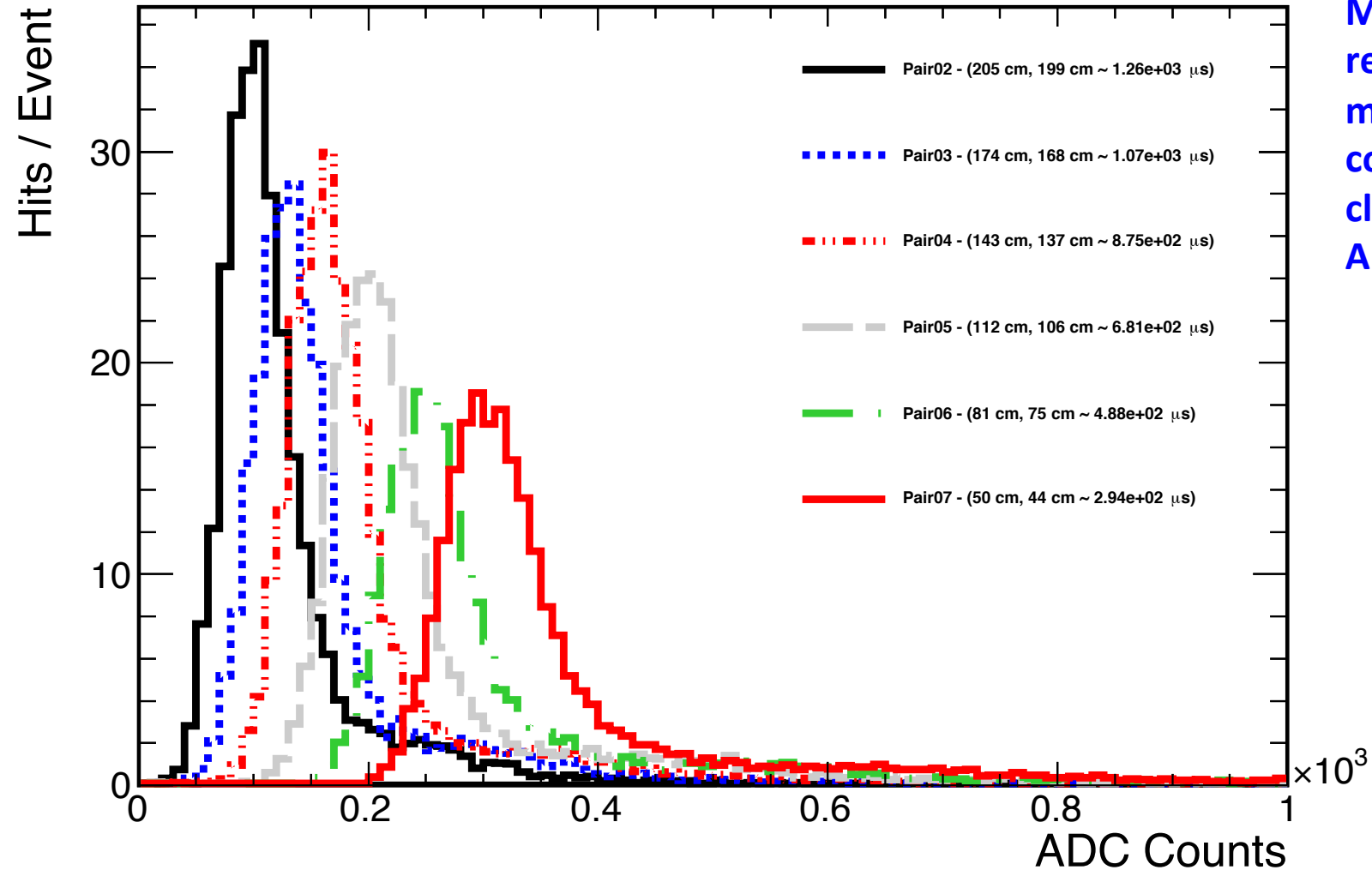- Pair06 - (81 cm, 75 cm ~ 4.88e+02 μs)
- Pair07 - (50 cm, 44 cm ~ 2.94e+02 μs)

Pair of simulated counters hit

Distance of centre of counters hit (on opposing walls)

Estimation of drift time for hits in events

Y-axis: Hits / Event
X-axis: ADC Counts ×10^3

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Hit Charge - τ_e 1×10^3 μs

Pair02 - (205 cm, 199 cm ~ 1.26e+03 μs)

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Pair04 - (143 cm, 137 cm ~ 8.75e+02 μs)

Pair05 - (112 cm, 106 cm ~ 6.81e+02 μs)

Pair06 - (81 cm, 75 cm ~ 4.88e+02 μs)

Pair07 - (50 cm, 44 cm ~ 2.94e+02 μs)

More charge recorded by muons hitting counters closer to the APA

Hits / Event

ADC Counts

9

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Average Charge vs Distance - With Diffusion
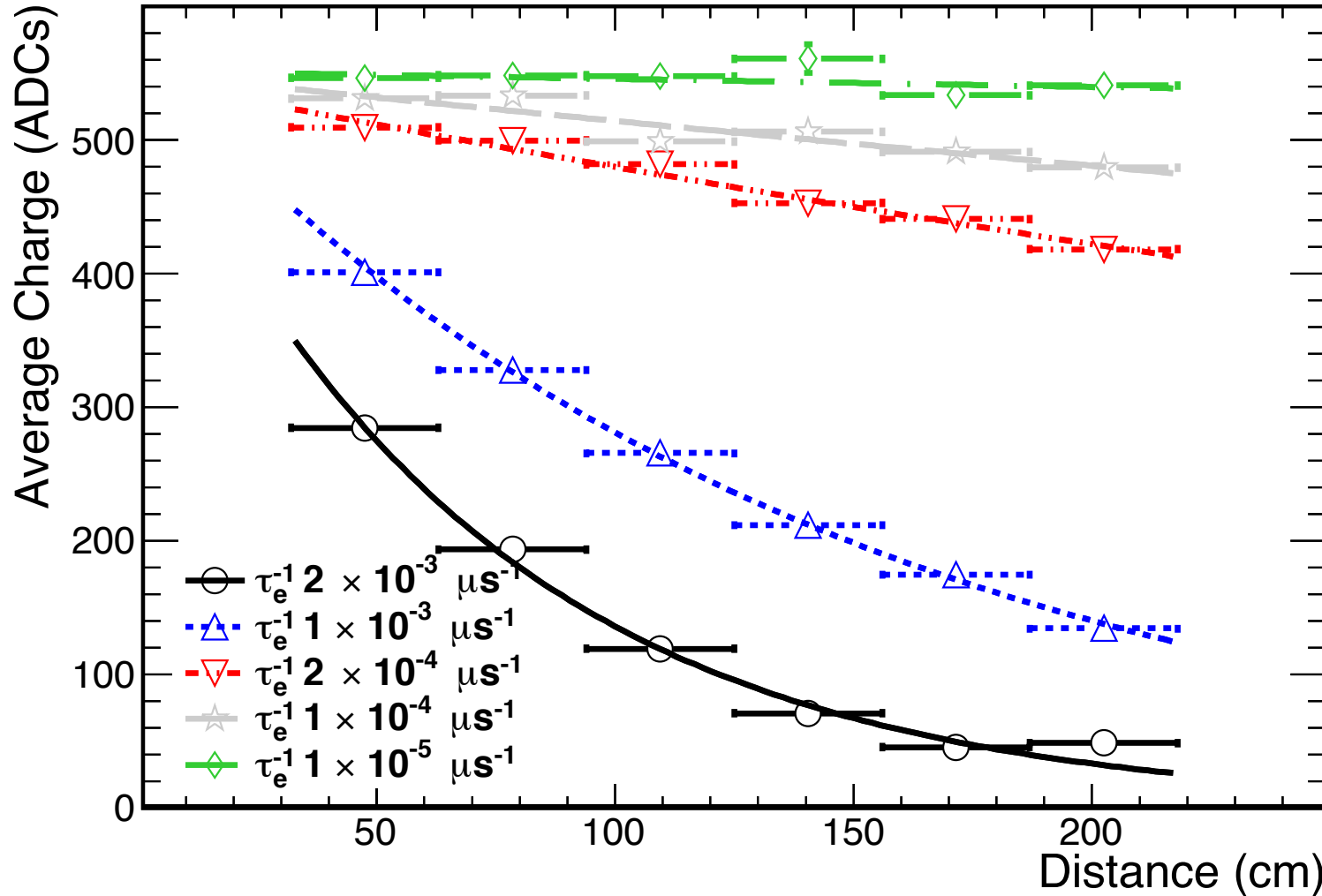
Lower life times

More pronounced exponential

Legend:
- τ_e^{-1} 2×10^{-3} μs^{-1}
- τ_e^{-1} 1×10^{-3} μs^{-1}
- τ_e^{-1} 2×10^{-4} μs^{-1}
- τ_e^{-1} 1×10^{-4} μs^{-1}
- τ_e^{-1} 1×10^{-5} μs^{-1}

Y-axis: Average Charge (ADCs)
X-axis: Distance (cm)

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Average Charge vs Distance - With Diffusion

Average Charge (ADCs)

10^2

10

1

○ τ_e^{-1} 2×10^{-3} μs^{-1} - fit 2.25e-03 +/- 3.07e-05

△ τ_e^{-1} 1×10^{-3} μs^{-1} - fit 1.11e-03 +/- 1.72e-05

▽ τ_e^{-1} 2×10^{-4} μs^{-1} - fit 2.05e-04 +/- 1.30e-05

☆ τ_e^{-1} 1×10^{-4} μs^{-1} - fit 1.08e-04 +/- 1.51e-05

◇ τ_e^{-1} 1×10^{-5} μs^{-1} - fit 1.76e-05 +/- 1.60e-05

Estimated lifetime^{-1} from exponential fit

50   100   150   200

Distance (cm)

Conclusions and next steps

With a simplistic sample of muons it is possible to use external counters to tag muons and extract electron lifetimes

Simple metrics such as the average charge in TPC hits can be calculated quickly

Further work being carried out on CRY cosmic ray samples

Techniques will develop as this will be a more challenging sample to work with

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