Calibrations with Muons in ArgoNeuT

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on behalf of the ArgoNeuT Collaboration
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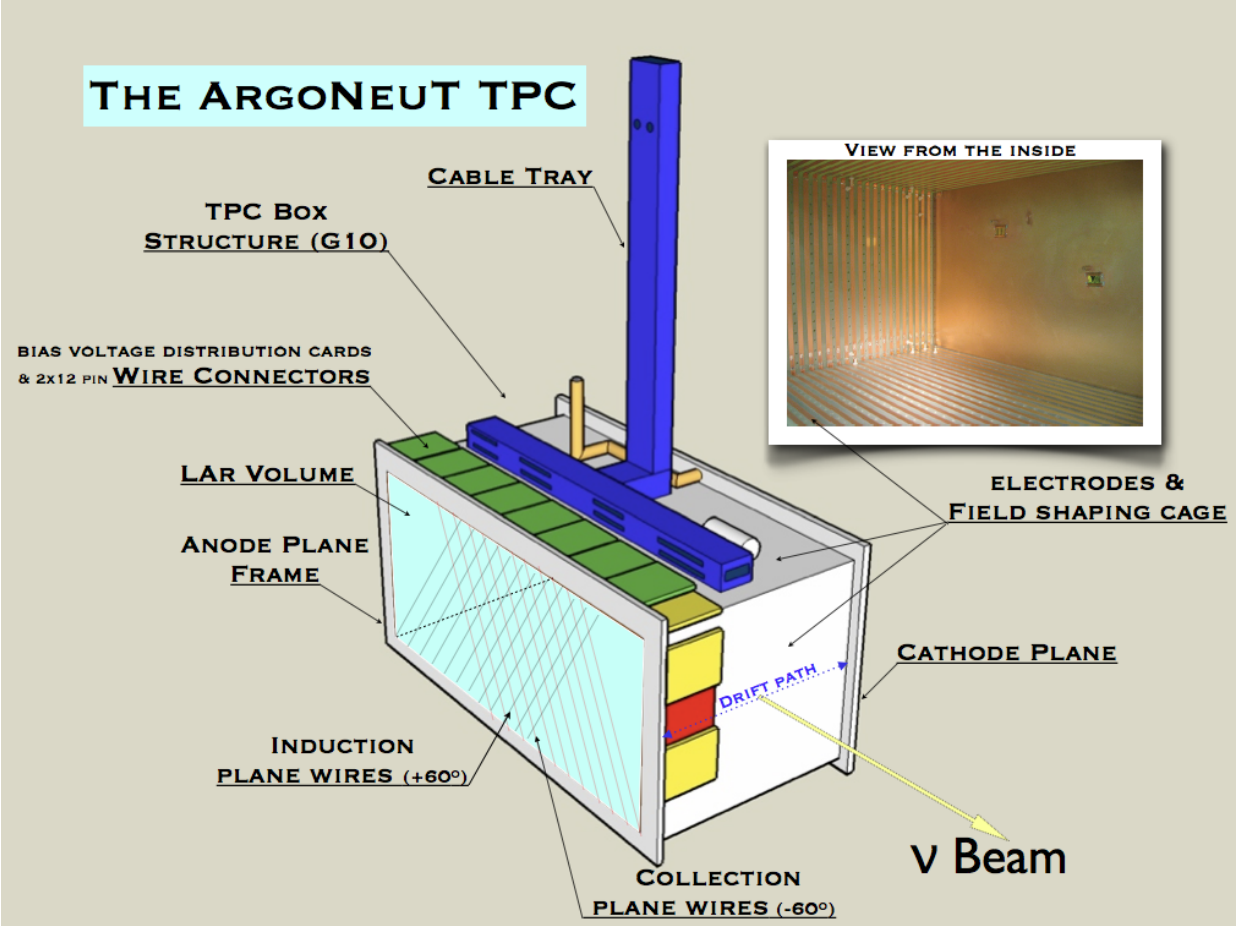
Introduction

- I was specifically asked about calibrations with muons, so I'll focus on that.
- I'll briefly explain how we have used muons to:
  - measure argon purity
  - measure electron drift-velocity
  - measure MIP energy
  - understand reconstruction/geometry

The ArgoNeuT Project



Cryostat Volume	500 Liters
TPC Volume	175 Liters (90cm x 40cm x 47.5cm)
# Electronic Channels	480
Electronics Style (Temp.)	JFET (293 K)
Wire Pitch (Plane Separation)	4 mm (4 mm)
Electric Field	500 V/cm
Max. Drift Length (Time)	0.5 m (330 μs)
Wire Properties	0.15mm diameter BeCu

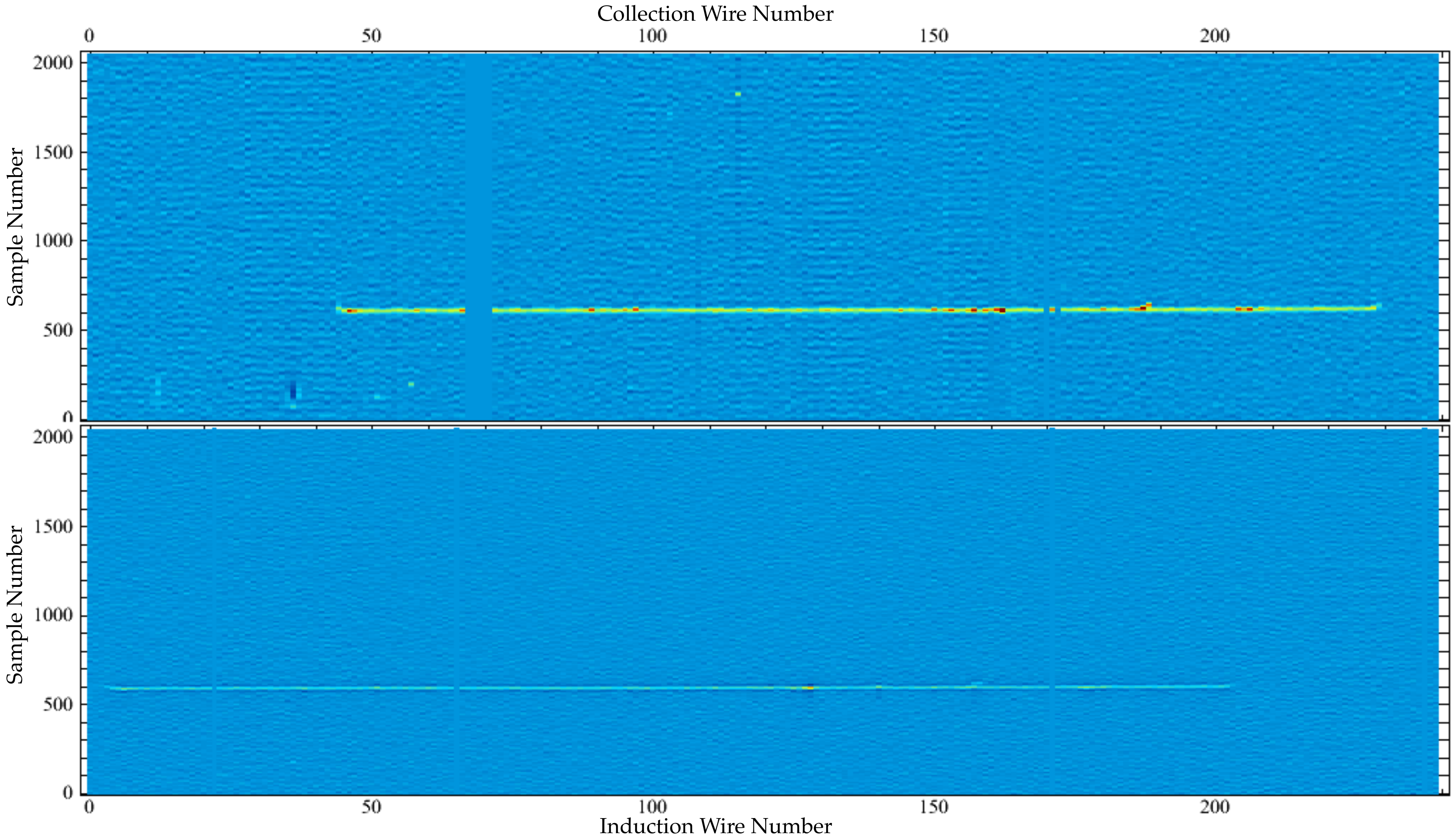
ArgoNeuT in the NuMI Tunnel

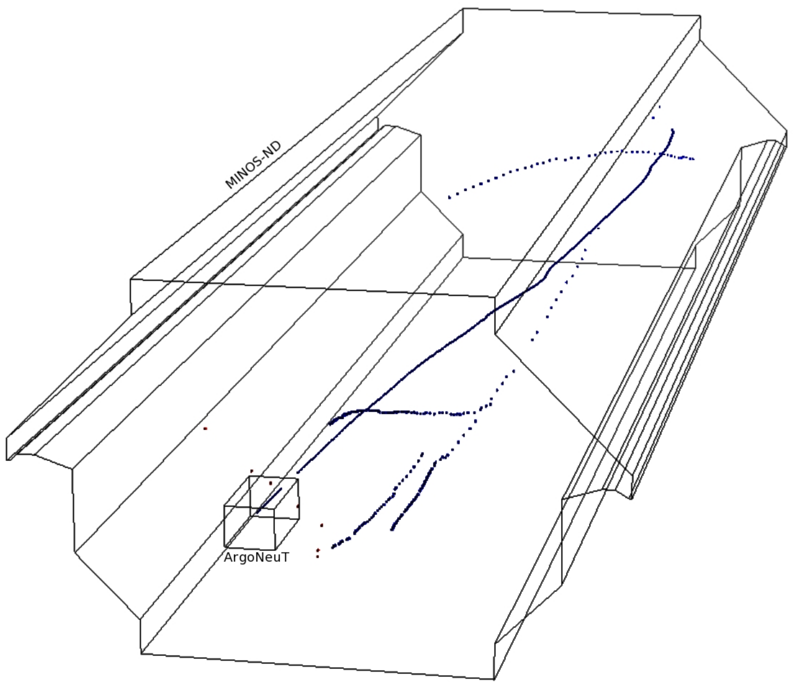
Refs:

1.) ***The ArgoNeuT detector in the NuMI low-energy beam line at Fermilab*, C. Anderson et al., 2012 JINST Vol. 7 P10019, arXiv:1205.6747**

Through-Going Muons

Typical through-going muon in ArgoNeuT, with corresponding MINOS information.



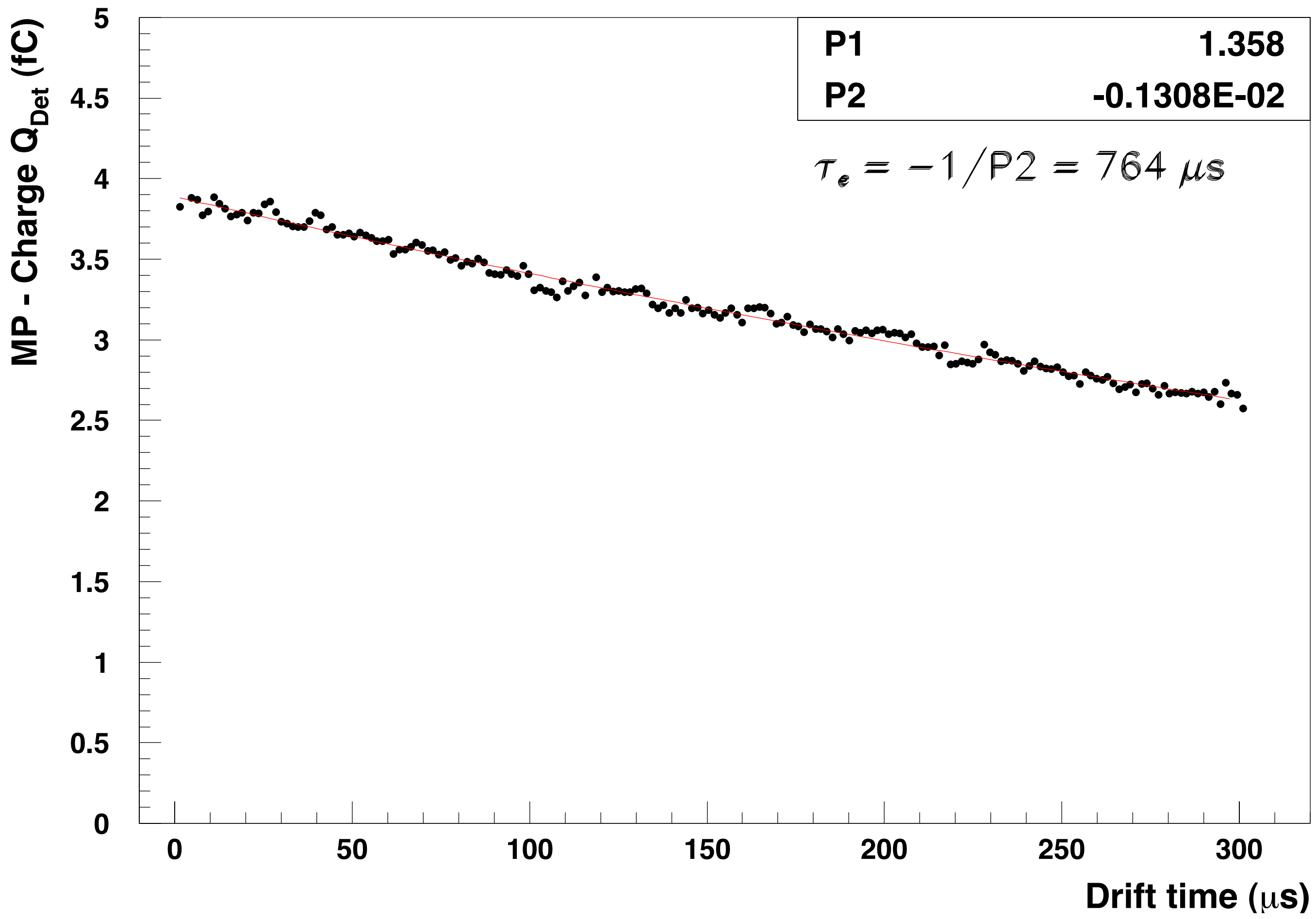


These are muons associated with beam, not cosmics.

Refs:

1.) Analysis of a Large Sample of Neutrino-Induced Muons with the ArgoNeuT Detector, C. Anderson et al., 2012 JINST Vol. 7 P10020, arXiv:1205.6702

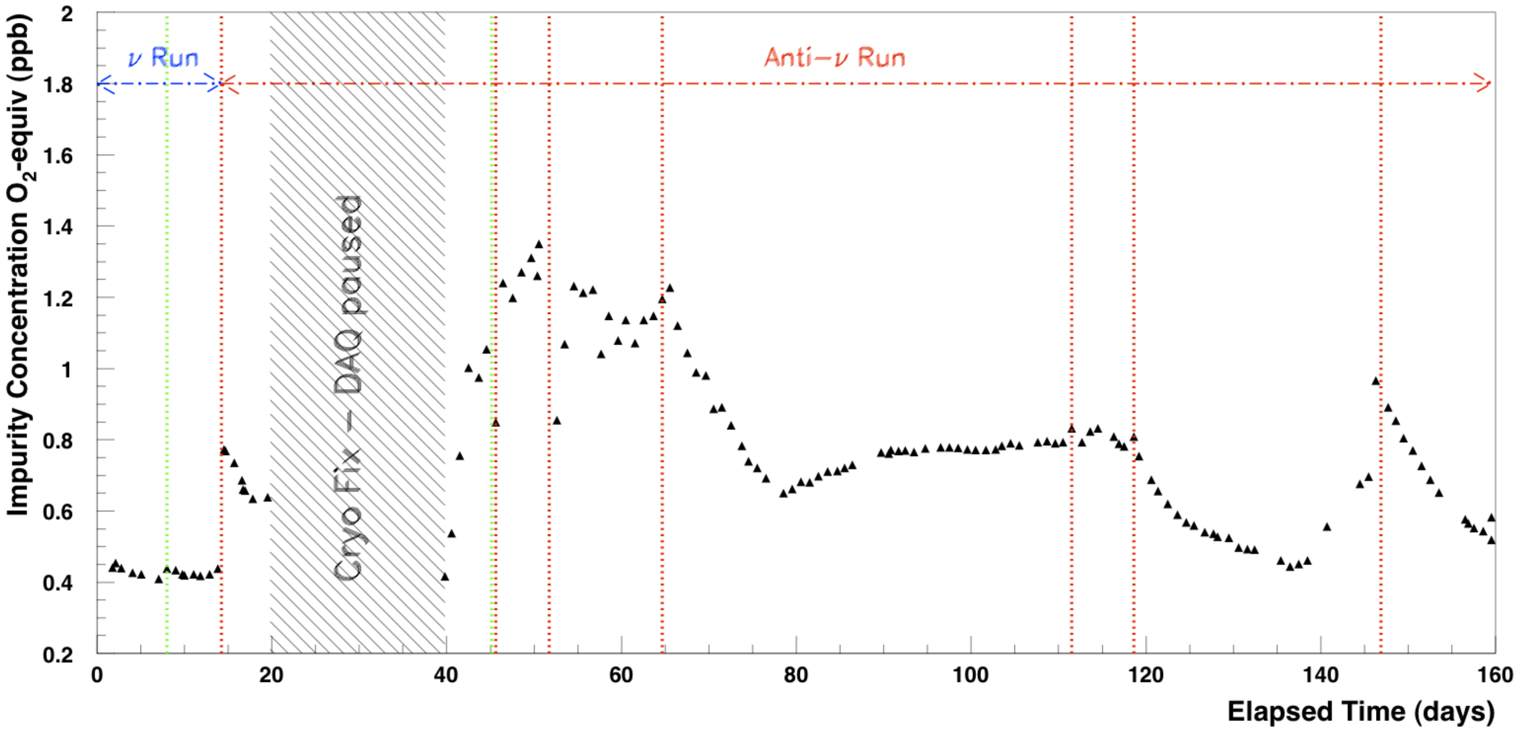
Electron Lifetime



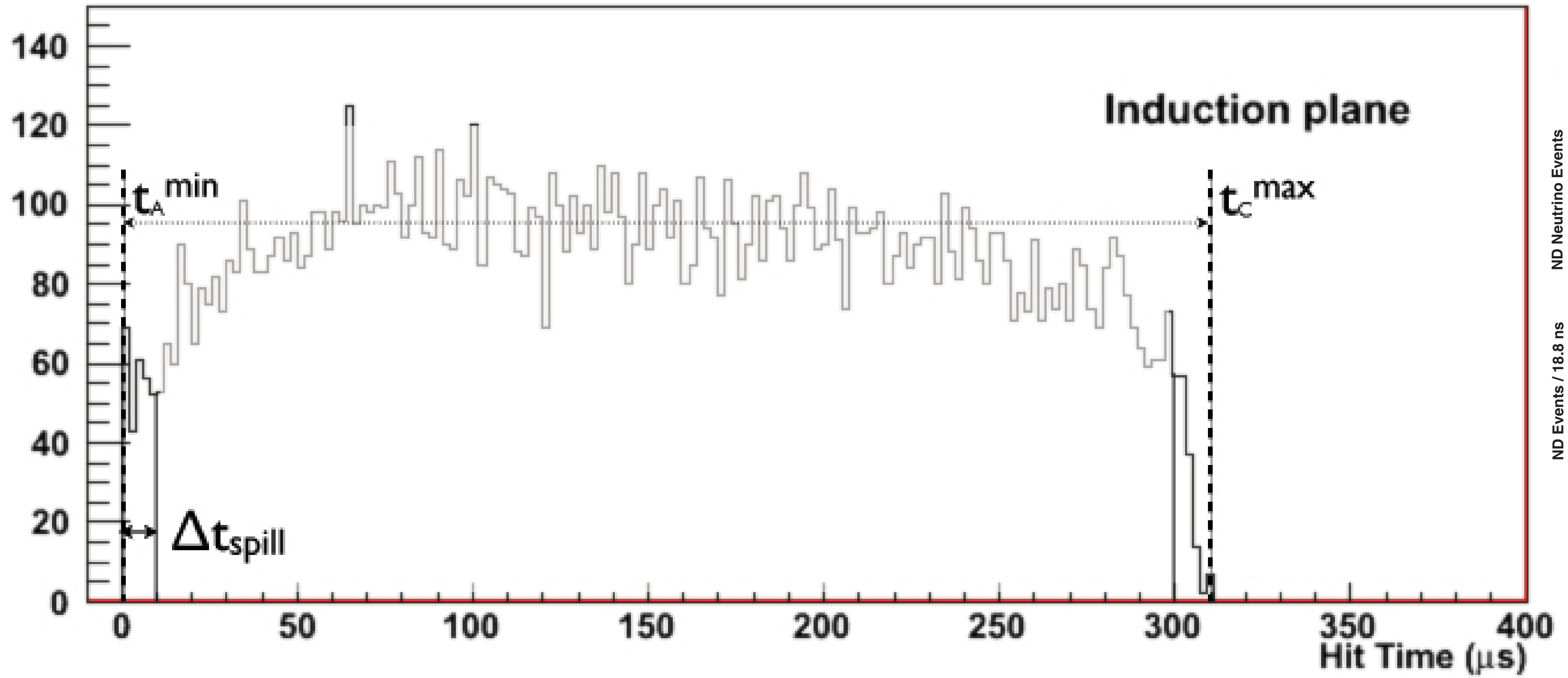
Selected long tracks (spanning >120 wires in a wireplane), plot Hit charge vs. hit time. Fit to exponential.

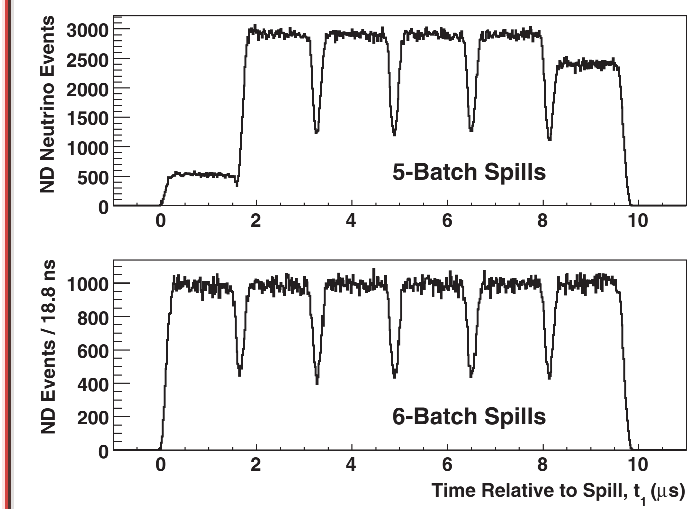
Found consistent results using either collection or induction hits.

Did this for all Runs (~1500 muon tracks/ run), which shows fluctuations of impurity in ArgoNeuT vs. Time



Drift Velocity



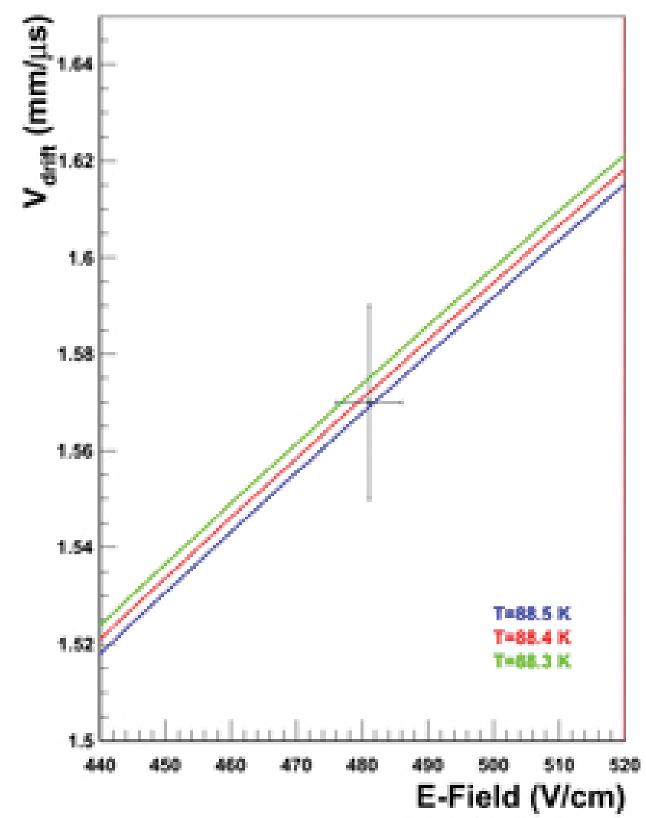


MINOS: PRD 76, 072005 (2007)

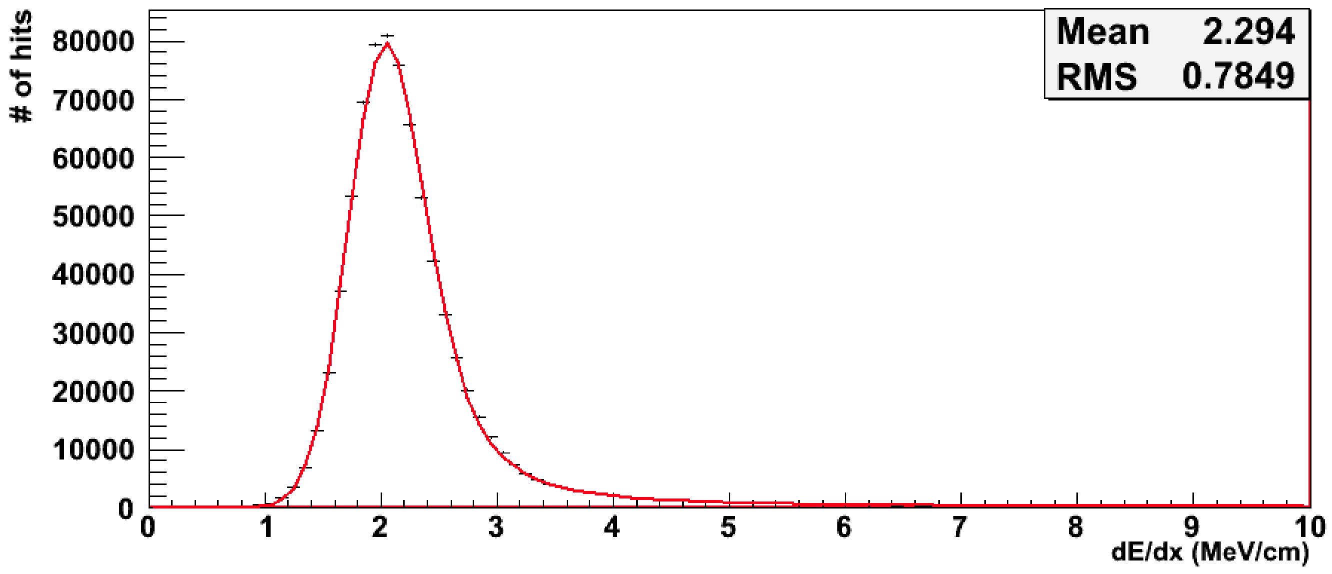
Hit time distribution from the Induction plane for a sample of crossing muons.

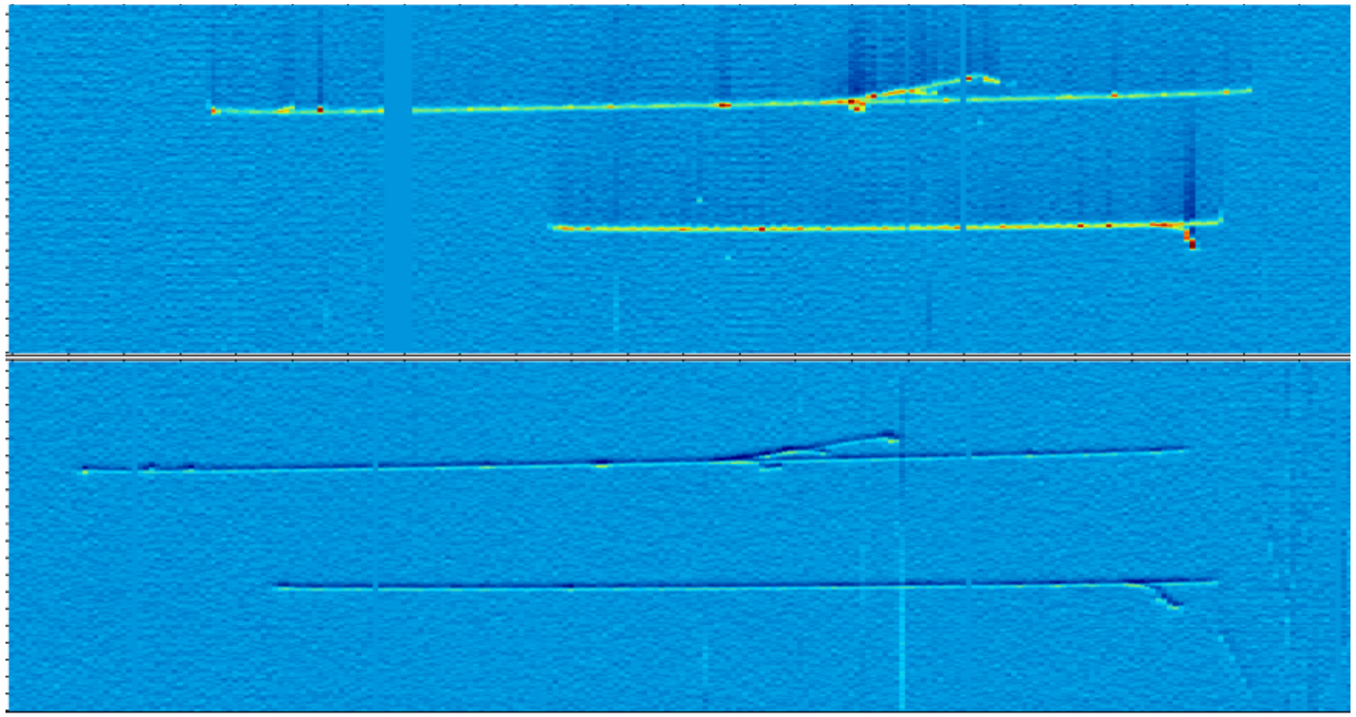
$$v_d = \frac{\ell_d + \ell_g / r_{T1} - \Delta\ell}{t_d} = 1.57 \pm 0.02 \text{ mm}/\mu s$$

Divide max. drift length (corrections for thermal contraction and inter-plane velocity) by max. drift time to get velocity.



MIP dE/dx

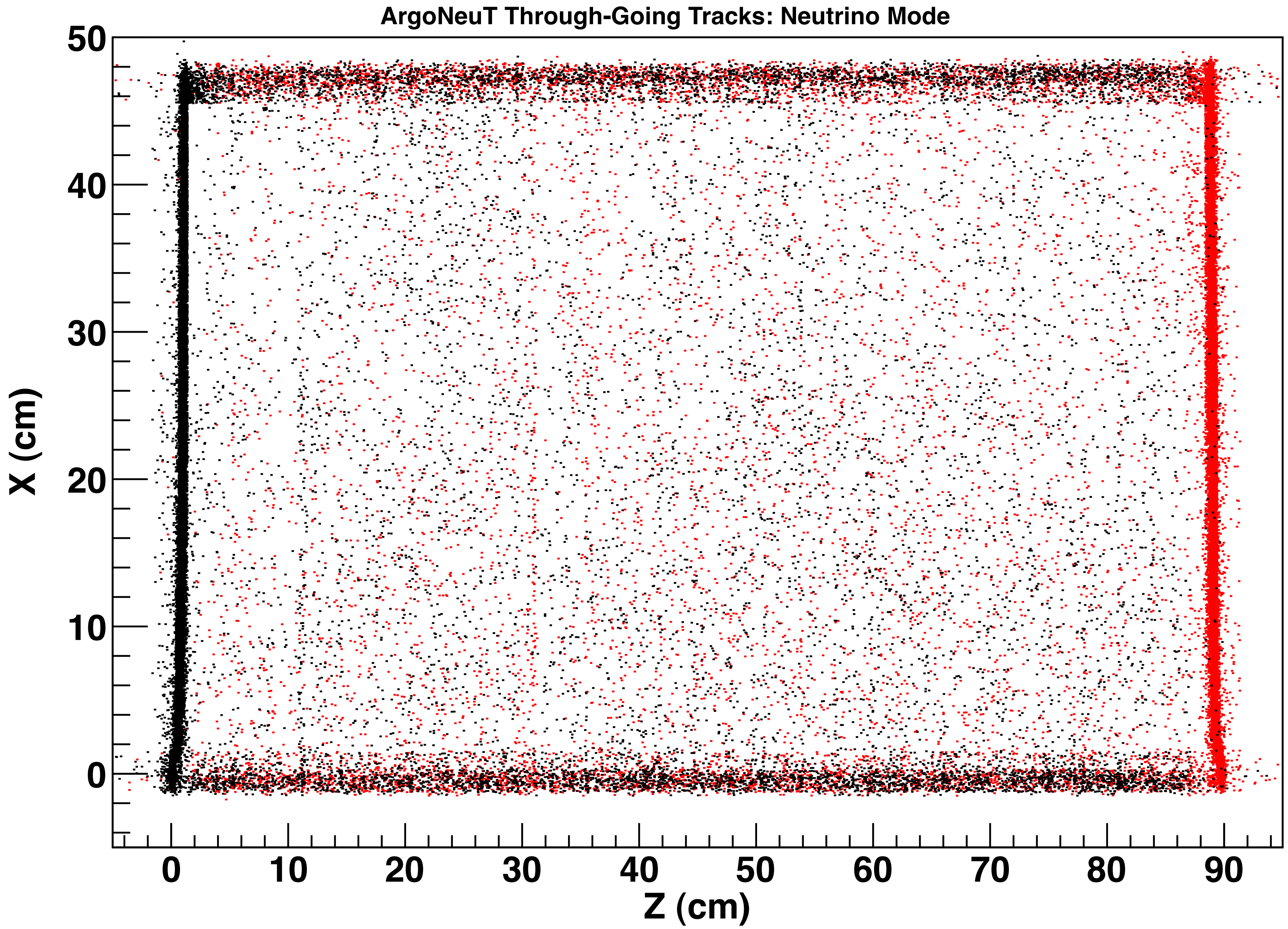




- Accounted for hits from delta-rays
- Fit of dQ/dx with Landau+Gaussian.
- $\langle dE/dx \rangle = 2.3 \pm 0.2$ MeV/cm

Reconstruction / Geometry

- With enough crossing muons, an "x-ray" of the detector emerges.
- Can reveal E-field distortions, as well as reconstruction issues.



Conclusions

- Crossing muons are a very useful sample for calibrations.
- Laser system may very well be better for much of this, but muons are free and readily available in most detectors.
- More in depth studies of recombination using heavily ionizing stopping tracks (not muons) are also underway.

ArgoNeuT

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