Towards Measuring Longitudinal Electron Diffusion in the MicroBooNE LArTPC

Fermilab-Poster-18-082-ND

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μBooNE

U.S. DEPARTMENT OF ENERGY
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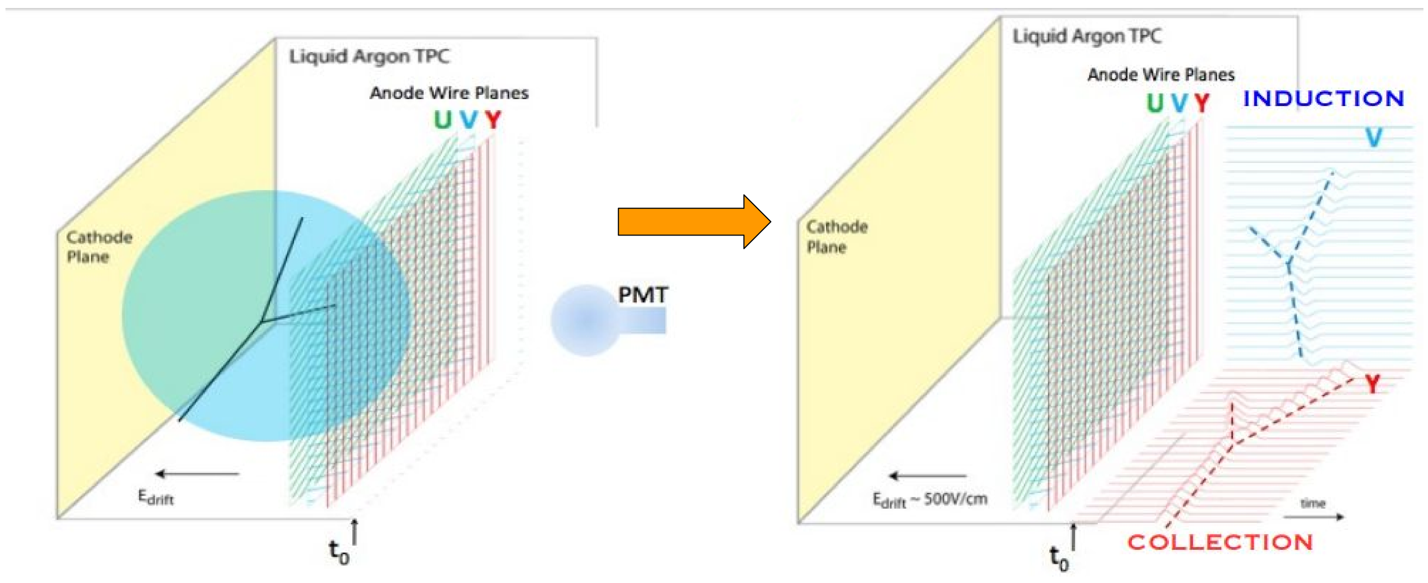
1. MicroBooNE

- Liquid Argon Time Projection Chamber (LArTPC)
- Neutrino interactions reconstructed based on ionization electrons and scintillation light
- Primary goals:
  - Investigate MiniBooNE low-energy excess
  - Neutrino-argon cross-sections
  - **LArTPC R&D**

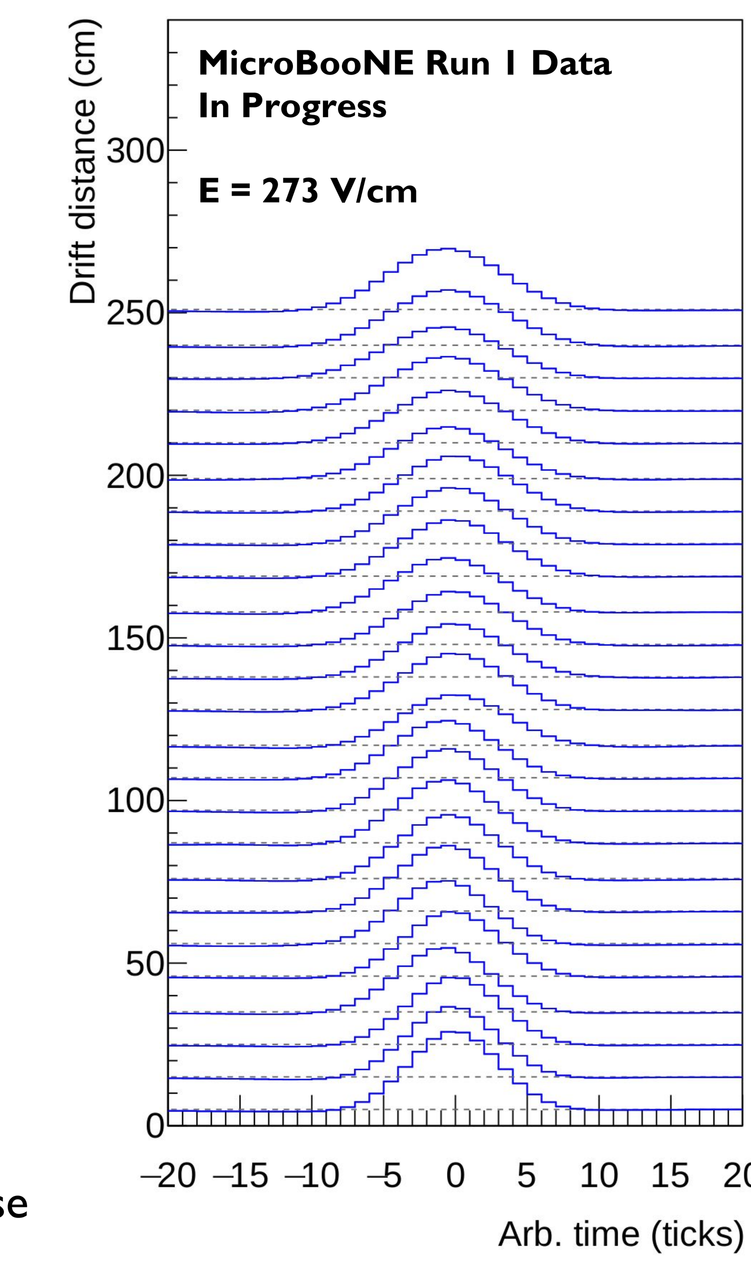


2. Electron Diffusion

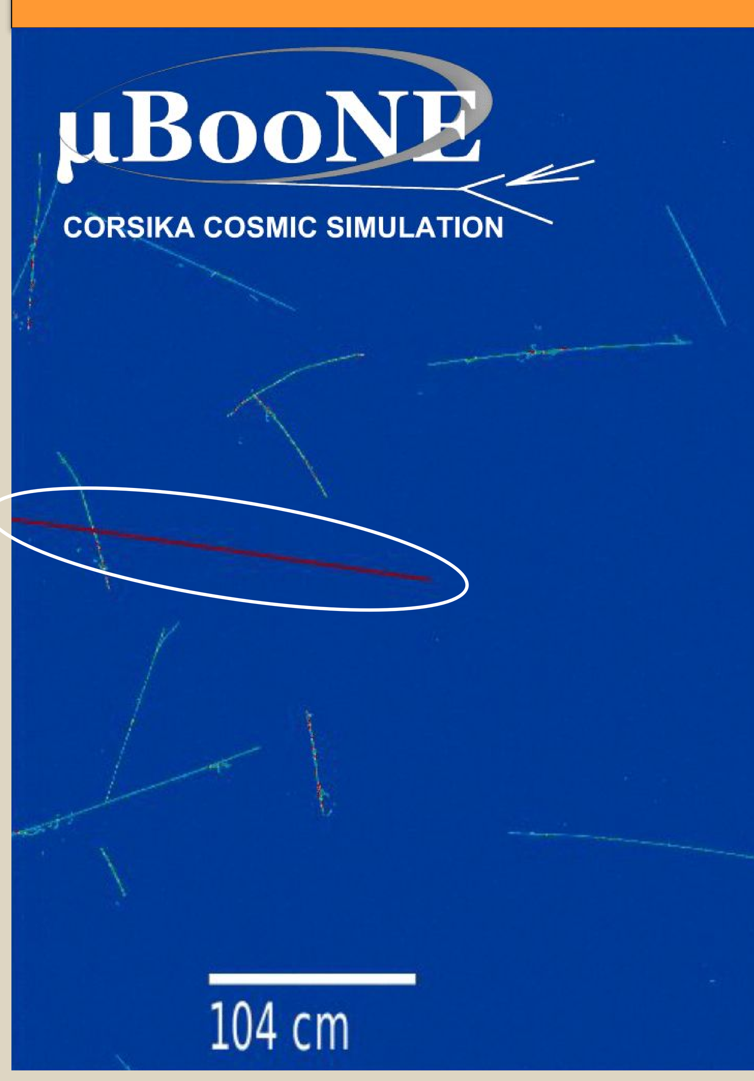
- "Spreading out" of ionization electrons as they traverse the detector
  - **Longitudinal (D_L)** and transverse (D_T) components with respect to drift direction
- D_L widens signal pulse width in time (σ_t), can be extracted from σ_t^2 vs. drift distance
- Measurement allows for independent method to verify true track drift distance
- **Few current measurements [1], [2]**

$$\sigma_t^2 = \left(\frac{2D_L}{v_d^3}\right) x + \sigma_0^2$$

Total time width of pulse (σ_t^2); Diffusion coefficient (D_L); Drift distance (x); Drift velocity (v_d); Inherent pulse width (σ_0^2)



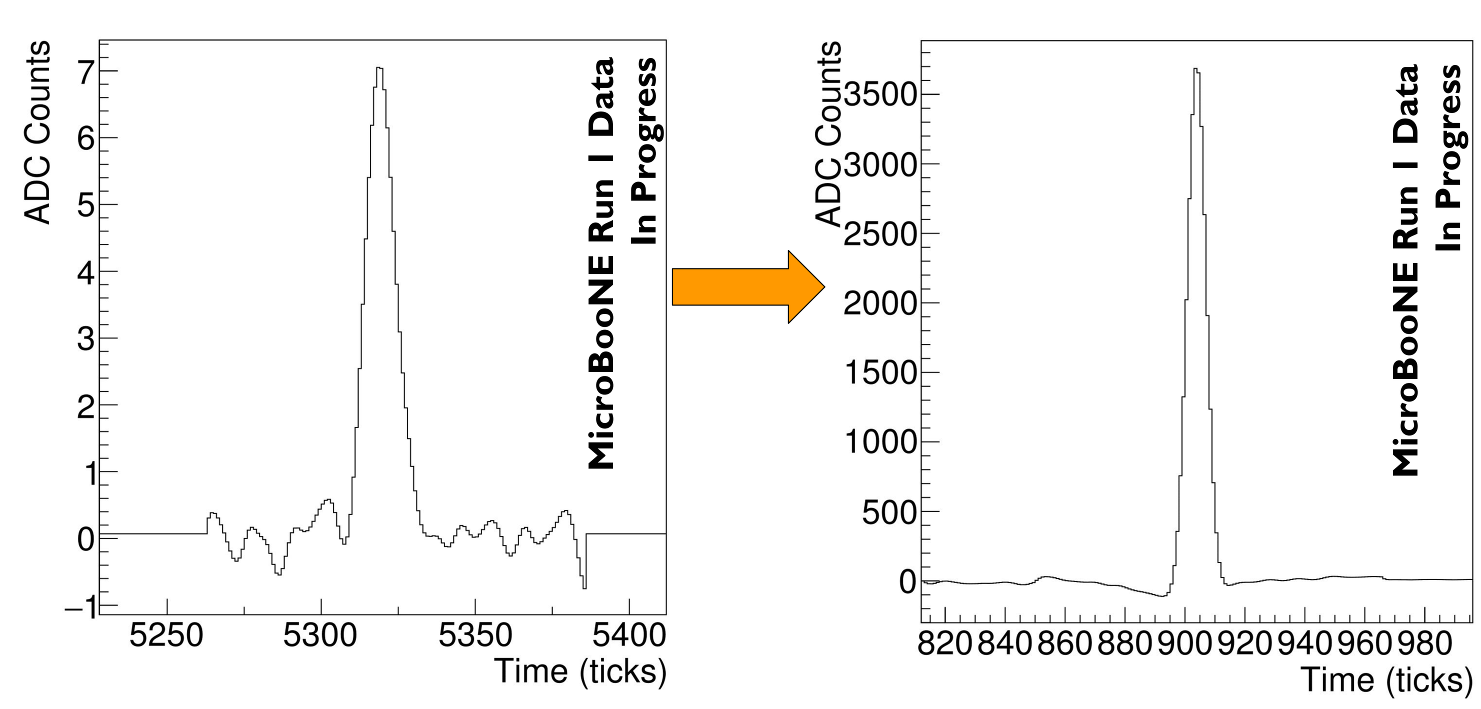
3. Simulation and Selection



- Simulate cosmic events, filter for high-quality muon tracks
  - Track length > 100 cm
  - Low-angle tracks
  - Gaussian waveforms
- Split drift distance (256 cm) into 25 bins

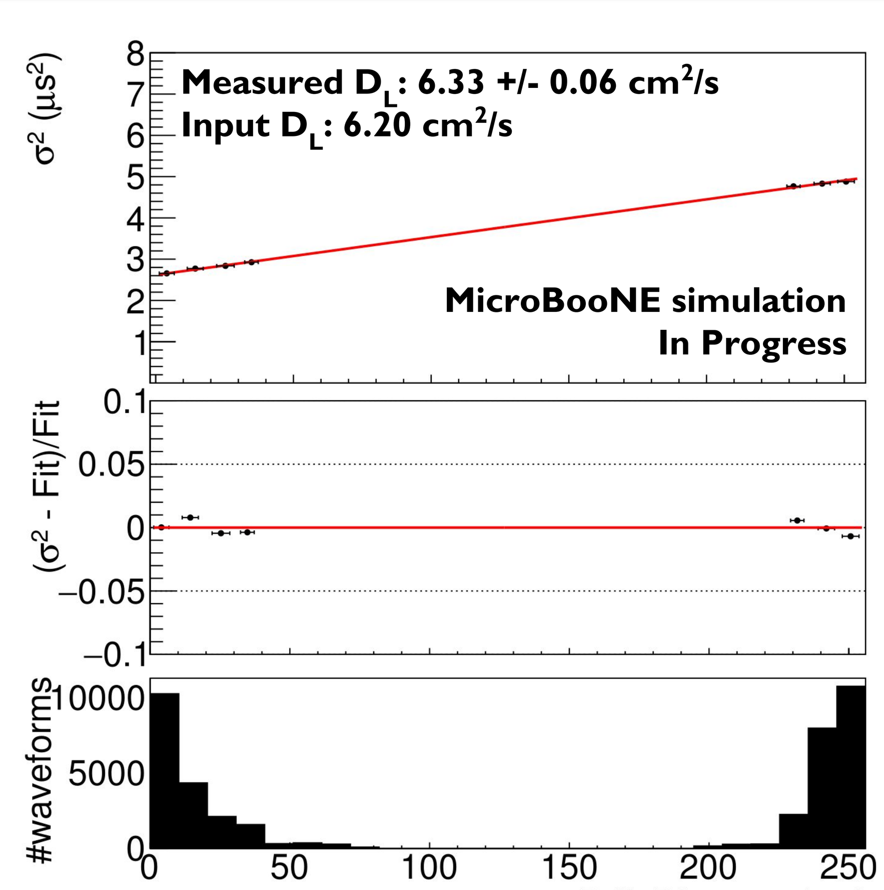
4. Waveform Averaging

- Sum waveforms in each bin
- Enhances signal, reduces noise



5. Extraction of D_L

- Fit Gaussian to summed waveform
  - Standard deviation gives σ_t
- Plot σ_t^2 vs. drift distance, extract D_L from slope
  - Ignore bins with < 500 waveforms
- Measured value within 2% of input value
  - Better than ~5% difference expected from effects of D_T



6. Challenges and Future Work

- Low-statistics due to stringent angular selection and t_0-tagging requirement
  - High-angle tracks cause problems, so we cut them out
  - ...but t_0-tagged cosmic ray tracks tend to be high-angle
- Pin down systematics
  - Detector response and D_T expected to be dominant
  - Space charge, delta rays, multiple Coulomb scattering, etc. expected to be < 1%
- **Perform analysis on Run 1 cosmic ray data soon**
- Informative to future experiments, especially the Deep Underground Neutrino Experiment (DUNE)

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References
[1] P. Cennini et al. Performance of a 3-ton liquid argon time projection chamber. *Nucl. Instrum. Meth.*, 1994
[2] Yichen Li et. al. Measurement of Longitudinal Electron Diffusion in Liquid Argon. *Nucl. Intrum. Meth.*, 2016

This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Workforce Development for Teachers and Scientists, Office of Science Graduate Student Research (SCGSR) program. The SCGSR program is administered by the Oak Ridge Institute for Science and Education (ORISE) for the DOE. ORISE is managed by ORAU under contract number DE-SC0014664.