Towards Measuring Longitudinal Electron Diffusion in the MicroBooNE LArTPC
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1. MicroBooNE
- Liquid Argon Time Projection Chamber (LAr-TPC)
- 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 ($\sigma_t$), can be extracted from $\sigma_t^2$ vs. drift distance
  - Measurement allows for independent method to verify true track drift distance
  - Few current measurements \cite{1, 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 $\sigma_t$
- Plot $\sigma_t^2$ 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 $D_L$ 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)

References
\cite{1} P. Cennini et al. Performance of a 3-ton liquid argon time projection chamber. Nucl. Instrum. Meth., 1994

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