Single Transverse Variables in the MicroBooNE experiment

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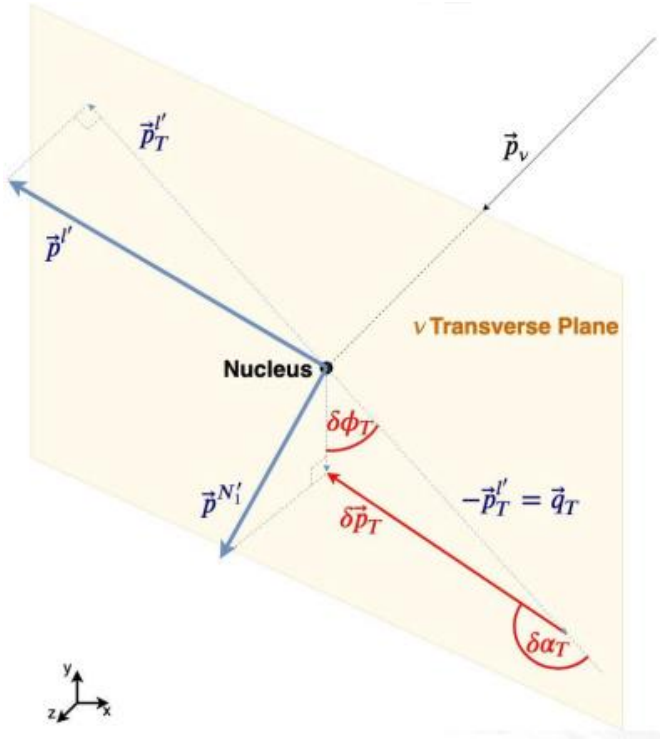
Background

- Neutrino oscillation experiments give insights into the study of some of the most intriguing problems at the frontier of particle physics.
- A detailed understanding of neutrino scattering cross-sections is essential in making precision neutrino oscillation measurements.
- Single Transverse Variables (STVs) are observables which are particularly useful for understanding neutrino-nucleus interactions.
- These observables have been measured previously by multiple experiments (T2K, MINERvA) for carbon
- Limited data are available for argon
  - Important because of its relevance to DUNE & SBN
  - MicroBooNE is pursuing a first measurement of STVs in neutrino-argon interactions

Single Transverse Variables (STVs)

- Three observables
  - Quantify the **momentum imbalance** between the final muon and leading proton
  - Defined in the **transverse plane**
- $\delta p_T \rightarrow$ magnitude
- $\delta\varphi_T$ and $\delta\alpha_T \rightarrow$ direction
- Provide a sensitive probe of nuclear physics effects



Nuclear effects lead to imbalance in the transverse momenta of the muon and leading proton

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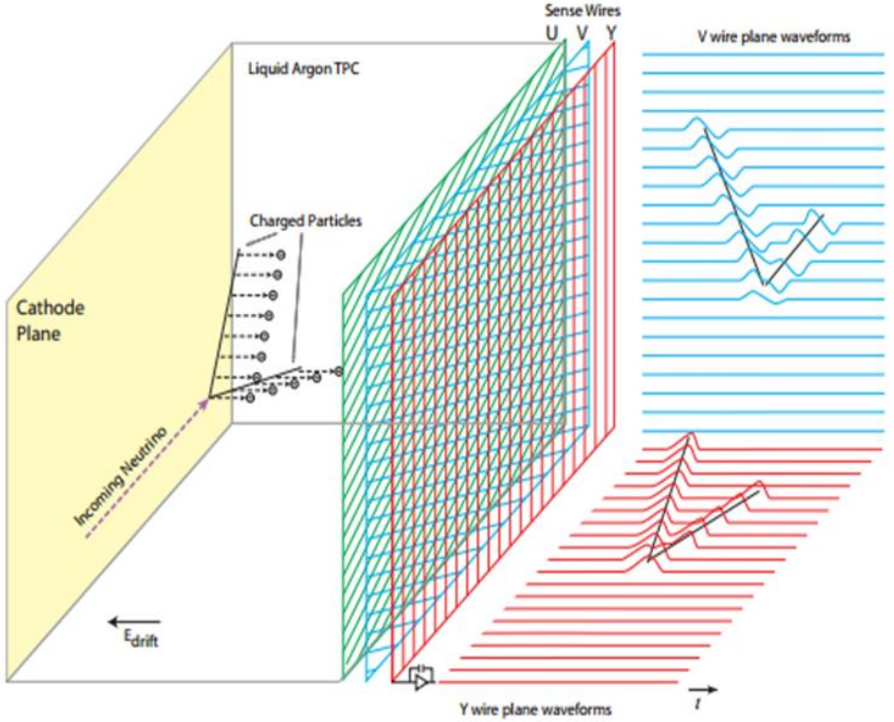
MicroBooNE - Liquid Argon Time Projection Chamber (LArTPC)

- LArTPCs
  - Limited neutrino-argon data available, theory challenging
  - Offer detailed 3D reconstruction capabilities.
- MicroBooNE
  - 170-ton LArTPC that operates in Fermilab Booster Neutrino Beam
  - Pursuing both cross-section and oscillation measurements

Two signals → Charge (TPC)

Two signals → Light (photomultipliers)



Operational principle of a LArTPC

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Main goals

- Simulate neutrino interactions in MicroBooNE using an alternative physics model
  - GENIE models the neutrino interactions
  - uboonecode models the detector response
- Run the STV analysis scripts using the simulated results as if they were real data
  - Output will be a “fake measurement” of cross-sections as a function of STVs
- Answer two key questions:
  - Does the “fake measurement” get the right answer when checked against the underlying GENIE models? Or is it biased?
  - Can the STV analysis scripts tell the difference between the alternative model and the default one?

What I have been doing?

- Getting familiar with background concepts:
    1. Neutrino oscillations
    2. Neutrino interactions: QE, MEC, RES, DIS
    3. Single Transverse Variables
- Learning how to use the required software tools
    1. C++
    2. Git: version control system.
    3. ROOT: a C++-based analysis tool
    4. GENIE: a neutrino event generator

3. Creating an account for the MicroBooNE remote machines

References

- S. Gardiner [MicroBooNE], PoSLeptonPhoton2019, 065 (2019) doi:10.22323/1.367.0065
- Dolan, Stephen. Probing Nuclear Effects in Neutrino-Nucleus Scattering at the T2K off-Axis near Detector Using Transverse Kinematic Imbalances. University of Oxford, 2017.
- M. Del Tutto, doi:10.2172/1515054