Measurement of Low-Q$^2$ Protons from Neutral Current Events in Argon with MicroBooNE

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Introduction

- Neutral-current (NC) cross section measurements are of great interest for future neutrino oscillation experiments
- Studying NC elastic (NCE) scattering is a useful tool to determine the strange quark contribution to the spin structure of the nucleon $\Delta s$
- This study focuses on the inclusive differential cross-section measurement of NC1p events
  - Only one proton above momentum threshold (200 MeV/c) in the final state
  - Main component is NCE events

MicroBooNE

- A 85 ton active-mass liquid-argon TPC in the Booster Neutrino Beam (BNB) at Fermilab
- 32 PMTs collect fast scintillation light
- 8192 wires, wire spacing of 3mm provides excellent spatial resolution
- UV laser calibration system
- Started taking data in October 2015, has collected a total of $1.56 \times 10^{21}$ protons on target (POT)

Differential Cross Section Extraction

\[
\frac{d\sigma}{dT} = \frac{N_i - B_i}{\epsilon_i \cdot N_{\text{target}} \cdot \Phi_{\nu} \cdot (\Delta T)}
\]

- Background subtraction

\[
\begin{align*}
N_i & = \sum_{j=1}^{N_{\text{events}}} S_{ij} \cdot N_{\text{selected}} \\
B_i & = \sum_{j=1}^{N_{\text{events}}} S_{ij} \cdot N_{\text{generated}}
\end{align*}
\]

- Follow a “forward folding” approach
- Report the result as a function of reconstructed kinetic energy

Systematic Uncertainties

- Cross section model uncertainty is dominated by NC model uncertainties overall, and large charged-current cross section model uncertainties at high energy
- Detector simulation uncertainty is dominated by light yield modeling and detector’s response in x direction
- Flux uncertainty is dominated by uncertainties from $\pi^+$ production and horn current skin effect
- Secondary re-interaction uncertainty is dominated by proton re-interaction
- Uncertainties are expected to be reduced with improved MC statistics

Result and Outlook

- First NC1p inclusive differential cross section $d\sigma/dT$ on argon using $5.45 \times 10^{20}$ POT data
- Data-MC difference at low energy is being studied. Could be due to physics?
- It includes interactions down to $Q^2 = 2MT = 0.1$ GeV$^2$, which is significantly lower than previous measurements [1][2]
- Will reduce CC background and systematic uncertainties in the near future
- Ultimate goal is to extend to a measurement of the NC elastic scattering cross section and the extraction of $\Delta s$

References