Dirt Neutrons in MicroBooNE

Katherine Woodruff
with
Vassili Papavassiliou  Stephen Pate  Tia Miceli

New Perspectives

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MicroBooNE

- MicroBooNE is a liquid Argon time projection chamber (LArTPC) designed to detect neutrino interactions
- The liquid argon serves as a target for a neutrino beam
- Charged particles ionize the argon
- Ionization electrons follow electric field to anode
- Three wire anode planes on the TPC record the signals
MicroBooNE

- MicroBooNE physics goals
  - Investigate neutrino oscillations at low energies
    → Look at MiniBooNE low-E excess
  - Measure neutrino cross sections at low energies

- NMSU-MicroBooNE physics goals
  - Want to understand proton structure
  - Measure low $Q^2$ neutral current interactions
  - At low $Q^2$, NC-elastic cross section dominated by axial form factor
  - Can measure strange quark contribution to proton spin, $\Delta s$
    - $\Delta s$ has been a puzzle for over 30 years
Neutral current (NC) neutrino interaction:

- Exchange of $Z^0$ boson
Neutral Current Neutrino Interactions

Neutral current (NC) neutrino interaction:

- Exchange of $Z^0$ boson

Simulated example proton event in MicroBooNE
Dirt Neutrons

- Dirt neutrons are produced in dirt and interact inside MicroBooNE
  - Worst background to NC-elastic events
Dirt Neutrons

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- Signal looks like NC-elastic protons
Dirt Neutrons

- Very large Monte Carlo Sample generated
  - Genie to generate neutrino events
  - Geant4 to simulate geometry and propagate tracks
- \( \sim 5,000,000 \) events generated
  \[ \rightarrow 5.09 \times 10^{19} \text{ POT} \sim 10\% \text{ of total MicroBooNE POT} \]
Dirt Neutrons

Plot shows origin of neutrons that scatter protons in the TPC

From Monte Carlo:
- 1277 protons from NC-elastic interactions
- 1371 protons from dirt neutrons
- Without any cuts — roughly one-to-one
Dirt Neutrons

- Ratio of signal to background varies by energy, angle and position of proton
- A clean sample of dirt neutron data would allow us to study these distributions
Dirt Tagger Wall

- Dirt neutron produced upstream in the dirt
- Other charged particles may be produced in interaction
- Scintillator detector just upstream of $\mu$BooNE could detect these
  - Potential upgrade currently under study
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Dirt Tagger Wall

- 14% of dirt neutron events tagged
- Less than 1% of NC-elastic events tagged
- Tagged sample is 95% dirt events
Dirt Tagger Wall

Protons from dirt neutrons
TAGGED protons from dirt neutrons

Proton Kinetic Energy [MeV]
0.1
1
10
100
1000

Protons from dirt neutrons
TAGGED protons from dirt neutrons

Proton Theta Angle [rad]
0
20
40
60
80

Dirt tagger gives a representative subset of dirt neutron events for certain variables
Conclusion

- Dirt neutrons are a very large background to NCE proton scattering
  - These are not easily separable
  - We need to be confident in the dirt neutron distributions
  - A dirt event tagger could provide us with a clean sample

- Next Steps:
  - Study which variables can be represented by the dirt tagger subset
  - Determine how much impact this will have on NC-elastic analysis
Thank you!