Selection of Charged Current $\nu_\mu$ Events in the Near Detector of the T2K Neutrino Oscillation Experiment

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Conclusion

- Discussed neutrinos
- Introduced T2K experiment
- Production of T2K neutrino beam
- T2K ND280 overview (P0D and TPC)
- Inclusive CC selection criteria
- Agreeable comparisons between data and MC
Outline

I. Neutrino Introduction

II. Tokai to Kamioka (T2K) Introduction
   A) Beam
   B) Near Detector (ND280)
      1) Pi-Zero Detector (P0D)
      2) Time Projection Chambers (TPCs)

III. Selection Method

IV. Results

V. Conclusion
Neutrino Introduction

- Nearly mass-less, small, weakly interacting particles
- Lepton group
- Neutral charge fermions, spin \( \frac{1}{2} \)
- May be created as a result of radioactive decay of certain nuclear reactions
- Able to change flavors (oscillation)
T2K Introduction

- 295km baseline
- Starts at J-PARC in Tokai, Japan
- Ends Super-K in Kamioka mine in Japan
- 2009 – present
- Off-axis experiment
T2K Introduction: Beam

- 30 GeV protons
- Graphite target
- 0.6 GeV $\nu_\mu$ beam energy

\[
\pi^+ \rightarrow \mu^+ + \nu_\mu \\
K^+ \rightarrow \mu^+ + \nu_\mu
\]
3 sub-detectors: Side Muon Range Detector (SMRD), Pi-0 detector (POD), Tracker
- Tracker: 3 time projection chambers (TPCs), 2 fine grain detectors (FGDs), downstream electric calorimeter (DS ECAL)
- Enclosed in UA1 magnet
- 280m from target
- Measure initial neutrino beam energy spectrum and backgrounds
T2K Introduction: P0D

- Efficiently reconstruct neutral current $\pi^0$ production events on a water target.
- Triangular scintillator bars arranged into X and Y planes glued together to form a “p0dule”
- ECAL: 1 p0dule and 1 sheet of lead
- Water Target: 1 p0dule, 1 water bag, 1 brass sheet
- Water bags allow collection of neutrino interaction data in water as well as air (empty water bag)
T2K Introduction: TPCs

- 3D tracking momentum and charge measurements
- Passing particles ionize gas
- Ionized particles drift from applied E-field to read-out pads on either side
- High granularity of pads yields precise track reconstruction in one plane
Selection Method: Criteria

- Global Reconstruction algorithm used
- Highest momentum negative track
- Start position of track starts in P0D Fiducial Volume
- Part of track located in TPC 1
Results

- Black Dots = Data
- Colored Stacks = Monte Carlo (MC)
- Good agreement between Data and MC
- Modeling interactions well
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Questions?
Thank you very much!
Backup slides
Neutrino Introduction: Oscillations
Why off axis?

- Off-axis angle corresponds to an energy distribution peak at oscillation maxima at about 0.6GeV
- Reduces backgrounds from higher energy neutrino interactions

\[ P(\nu_\mu \rightarrow \nu_e) = \sin^2 2\theta_{13} \sin^2 \theta_{23} \sin^2 \left( 1.27 \Delta m_{\text{atm}}^2 \frac{L(\text{km})}{E(\text{GeV})} \right) + \ldots \]
Selection Method: Reconstruction Algorithms

POD Reconstruction
- Stand alone
- Combines measured scintillator bar hits into tracks and showers
- POD-only Track objects passed to Global Reconstruction

Global Reconstruction:
- Runs after all sub-detector algorithms are completed
- Matches, merges, and refits tracks from sub-detector algorithms
POD Fiducial Volume

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