Evaluating Proton and Charged Track Reconstruction in 2x2

Elise Hinkle March 13, 2024



Previous Work → January Workshop

- At January Workshop, we showed preliminary particle kinematic data/MC comparisons for hand-scanned proton-like and muon-like track samples from Bern Module data and simulation flow files
 - Benchmarking charged, tracklike particle reconstruction is essential for the CC $\bar{\nu}_{\mu}$ -Ar mesonless cross section analysis and the charged track multiplicity analysis

Preliminary Comparisons: μ vs. p, final vs. prompt hits Selected Event Orientation w.r.t. Anode [Data] Anode 17.5 Event Count / 0.5 rad 10.0 10.0 7.5 5.0 5.0 otons, calib final hits 2.5 calib prompt hits 0.0 -3-2 $^{-1}$ Selected Event Track Orientation w.r.t Anode [rad] Small differences in proton angles in prompt vs. final hits datasets Indicates difference in how tracklets are formed using the two datasets



Current Work – Full Reco Benchmarking

- Still want to look at calibration-file-level comparisons of data/MC using Bern Module data and simulation (see my <u>presentation yesterday</u> for update on Bern module cosmics simulation status)
- Also want to investigate full proton reconstruction using CAFs by comparing reco and true particle kinematics
- As CAFs currently only contain ML Reco information, this is the reconstruction I'm evaluating
- Sample: MiniRun4.5 Beta 2 CAFs (300 files)
- As ML Reco has some known PID issues, I look at all reconstructed charged track-like particles and also just reconstructed protons in comparison to best match true particles
- Cut on ML Reco "Overlap" variable such that require reco/true match to have >=0.5 overlap



Charged Track and Proton Length



- Longer tail on ML Reco track length distributions
- More short true tracks

E. Hinkle | 2x2 Analysis Selection and Systematics Meeting | March 13, 2024

Δ

Charged Track Start Position



True vs. ML Reco Track Start Position for Reconstructed Charged Track Sample

- Significant differences in x-coordinate distribution
- Large spikes at edges for ML Reco



Proton Start Position



True vs. ML Reco Track Start Position for Reconstructed Proton Sample

- Significant differences in x-coordinate distribution
- Large spikes at edges for ML Reco



Charged Track End Position



True vs. ML Reco Track End Position for Reconstructed Charged Track Sample

- Significant differences in x-coordinate distribution
- Large spikes at edges for ML Reco



7

Proton End Position



True vs. ML Reco Track End Position for Reconstructed Proton Sample

- Significant differences in x-coordinate distribution
- Large spikes at edges for ML Reco



True vs. ML Reco Track Angle w.r.t. Beam Direction for Reconstructed Charged Track Sample Reco Track Lengths : 0 – 10 cm ML Reco Track Angle w.r.t. Bean True Track Angle w.r.t. Beam 2 30C 250 250 150 Reco Track Lengths: 10 – 20 cm L 250 Reco Track Lengths : 20 – 30 cm Reco Track Lengths: 30 – 40 cm 250 Reco Track Lengths : 40 - 50 cm D 300 2.5 Angle [rad]

- Binned by reconstructed track length in 10 cm bins
- For shorter tracks, clear difference in true vs. reco distributions

THE UNIVERSITY OF CHICAGO



Charged Track Angle w.r.t Beam



E. Hinkle | 2x2 Analysis Selection and Systematics Meeting | March 13, 2024

Proton Angle w.r.t Beam



- Binned by reconstructed track length in 10 cm bins
- For shorter tracks, clear difference in true vs. reco distributions



True vs. ML Reco Track Angle w.r.t. B

eco Track Lengths

Beco Track Lengths : 80 - 90

Bose Track Lengths - 00 100

Reco Track Lengths : 100 - 110 c

Reco Track Lengths : 110-120

ro Track Lengths - 120-

eco Track Lengths : 130

Reco Track Lengths : 140-150

10

ML Reco Track Angle w.r.t. E



E. Hinkle | 2x2 Analysis Selection and Systematics Meeting | March 13, 2024

NEUTRINO EXPERIMENT



E. Hinkle | 2x2 Analysis Selection and Systematics Meeting | March 13, 2024

12

NEUTRINO EXPERIMENT





E. Hinkle | 2x2 Analysis Selection and Systematics Meeting | March 13, 2024

True vs. ML Reco Track Pixel Plane Angle fo

co Track Lengths : 1

o Track Lengths : 110-

Proton Pixel Plane Angle Angle Directory Market Plane Angle





- Binned by reconstructed track length in 10 cm bins
- For all tracks, clear difference in true vs. reco distributions



Track Multiplicity at Vertex



- First bin may be cases where true particle match is shower-like
- In the future, will look at kinematics by true track multiplicity at vertex to get a better understanding of reconstruction fidelity in high activity environments

E. Hinkle | 2x2 Analysis Selection and Systematics Meeting | March 13, 2024



Summary + Future Studies

- Starting to study proton and charged track reconstruction (ML Reco) using CAFs
- Some unexpected features in true vs. reco distributions, especially for pixel plane angle
- Future areas of investigation:
 - Break down some of the plots I showed in terms of different variables (e.g. by charged track multiplicity at the vertex, by start/end position, etc.) to **identify specific failure modes**
 - Similar studies with reflowed Bern data/new Bern cosmics samples run through ML Reco

