Characterization of Charged Pions with the NOvA Detectors

Poster #565


Camilo Cortés Parra

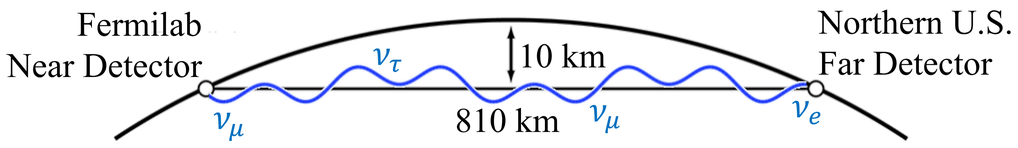

Rafael Maldonado Agudelo


Juan Villamil Santiago


Enrique Arrieta Díaz

for the **NOvA Collaboration**

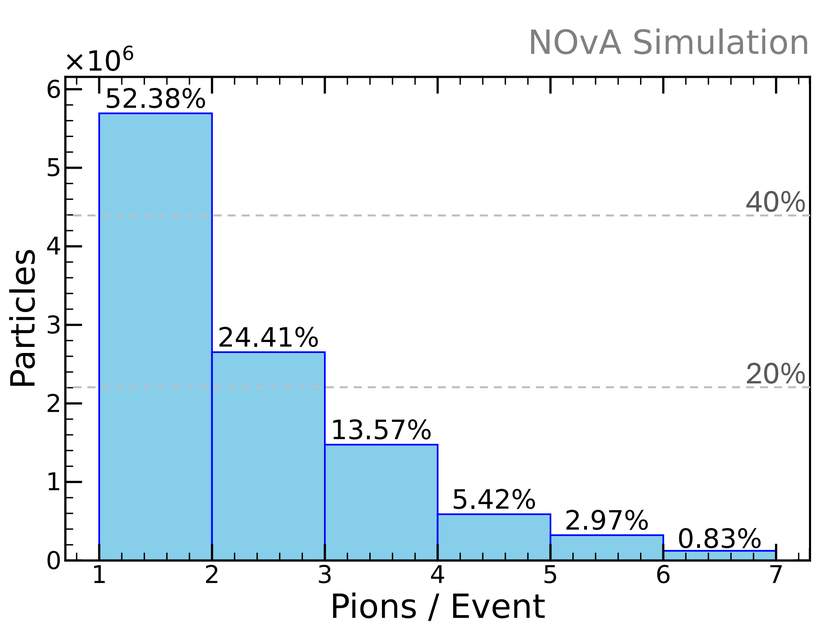
1. The NOvA Experiment

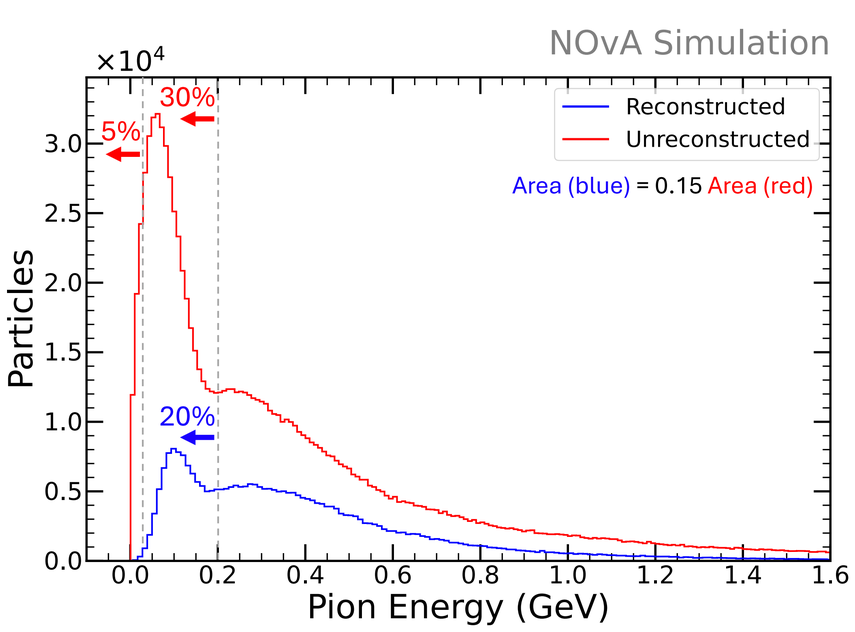


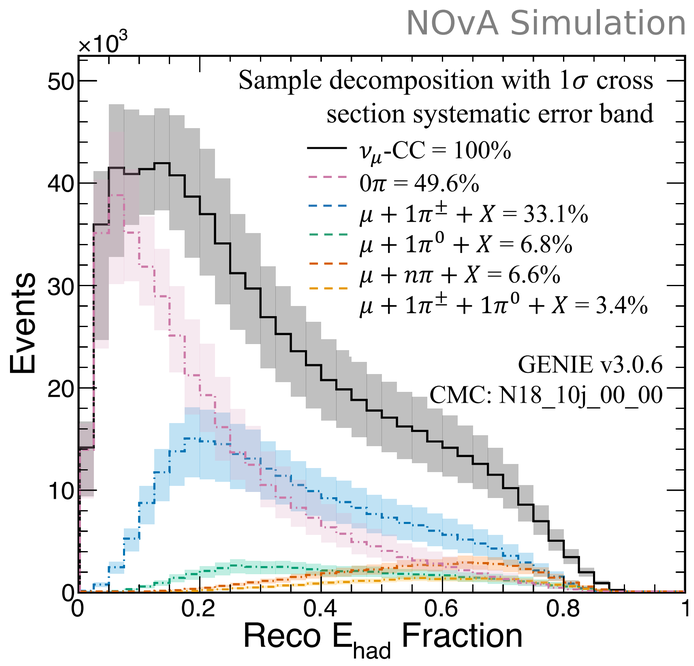
- NOvA is a long-baseline neutrino oscillation experiment
- Main goals to measure the oscillation parameters: θ_{23}, Δm^2_{23}, δ_{CP}
- High intensity neutrino beam for cross section measurements with Near Detector: $\sim 10^{13}$ protons on target per second, 900 kW
- Detectors designed for efficient muon and electron reconstruction
- Detectors are active calorimeters: important contribution to neutrino energy from hadronic activity

2. Charged Pions in NOvA

- 52% (95%) of simulated (reconstructed) charged pions ($\pi^\pm$) come from $1\pi^\pm$ muon neutrino charged current (ν_μ-CC) events
- Wide energy spectrum for unreconstructed $\pi^\pm$
- Relevant systematic uncertainties in neutrino energy estimation from hadronic energy (E_{had}) [1-3]
- NOvA's latest GENIE simulation (CMC) yields prominent uncertainties for: E_{had} Fraction $= 1 - \frac{E_\mu}{E_\nu}$
- 37% of ν_μ-CC events yield $1\pi^\pm$ plus other hadrons (π^0 or X)

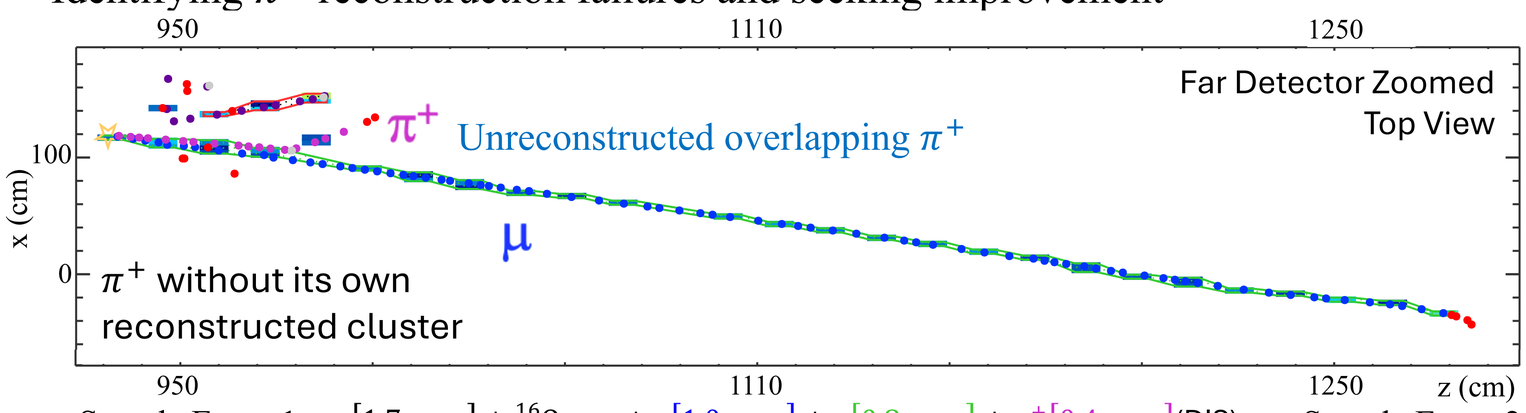




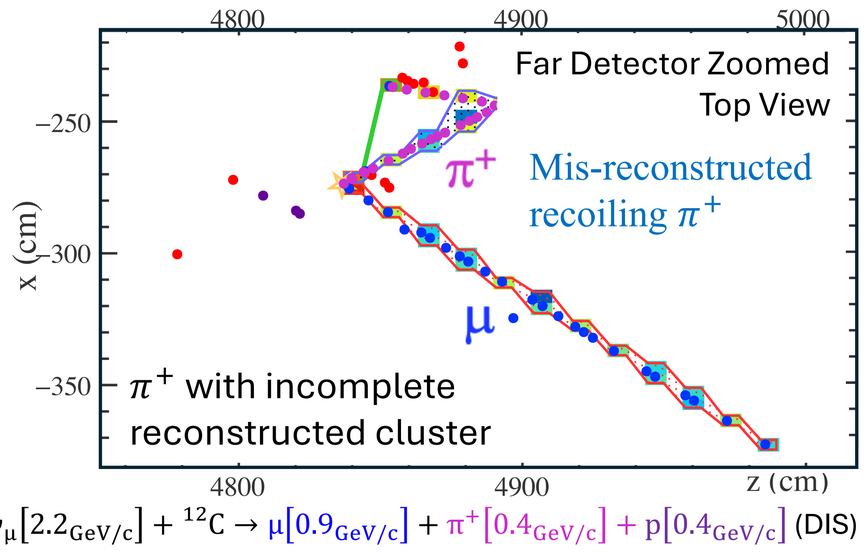


3. Charged Pion Reconstruction in NOvA

- Identifying $\pi^\pm$ reconstruction failures and seeking improvement



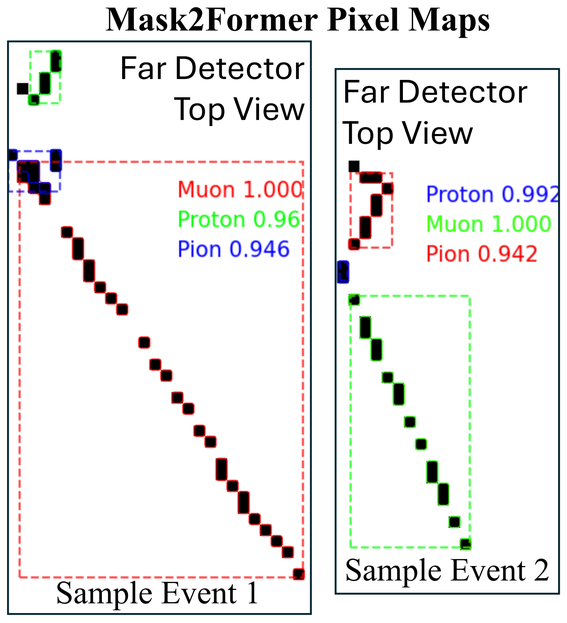
Sample Event 1: $\nu_\mu[1.7_{\mathrm{GeV/c}}] + {}^{16}O \rightarrow \gamma + \mu[1.0_{\mathrm{GeV/c}}] + n[0.8_{\mathrm{GeV/c}}] + \pi^+[0.4_{\mathrm{GeV/c}}]$(DIS)



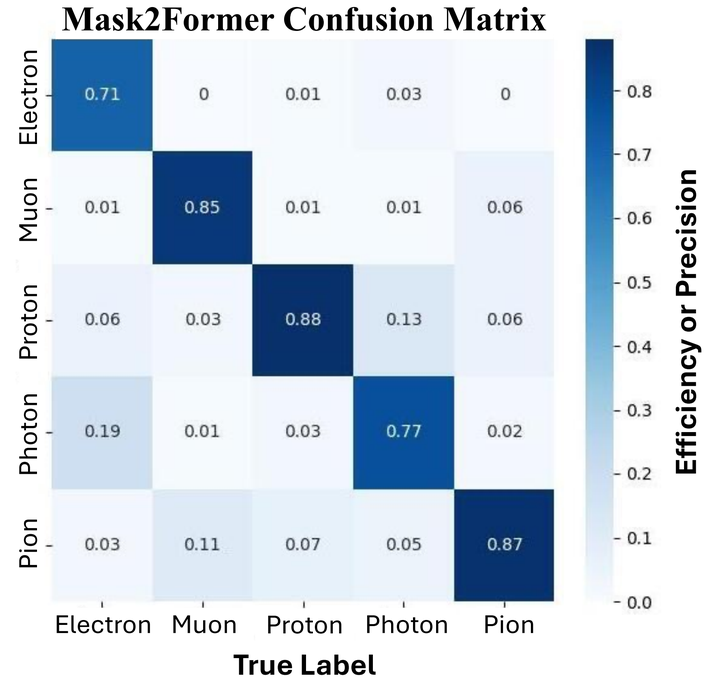
Sample Event 2: $\nu_\mu[2.2_{\mathrm{GeV/c}}] + {}^{12}C \rightarrow \mu[0.9_{\mathrm{GeV/c}}] + \pi^+[0.4_{\mathrm{GeV/c}}] + p[0.4_{\mathrm{GeV/c}}]$ (DIS)

- Improvement in $\pi^\pm$ reconstruction → improvement in neutrino energy estimation → improvement in systematics
- NOvA exploring various deep learning techniques for particle identification and reconstruction from images
- Mask2Former: architecture for image segmentation [4]
- Identification tasks performed for $E_\pi > 50$ MeV
- Improved cluster reconstruction (sample events)
- Competitive efficiencies and usage of computational resources against other NOvA deep learning techniques

Mask2Former Pixel Maps



Mask2Former Confusion Matrix



4. Looking Forward

- Further testing to achieve maximum efficiency
- Tests for energy estimation of individual particles

References

[1] MINERvA Collaboration, DOI 10.1103/PhysRevD.100.072005 (2019)
[2] T2K Collaboration, DOI 10.1103/PhysRevD.101.012007 (2020)
[3] NOvA Collaboration, DOI 10.1140/epjc/s10052-020-08577-5 (2020)
[4] B. Cheng *et. al.*, DOI 10.48550/arXiv.2112.01527