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Neutrino Induced Neutral Current to Charged Current Ratio of Neutral Pion Production in MicroBooNE

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MicroBooNE Experiment

The liquid argon time projection chamber (LArTPC) is located on the axis of the booster neutrino beam to collect neutrino interactions.

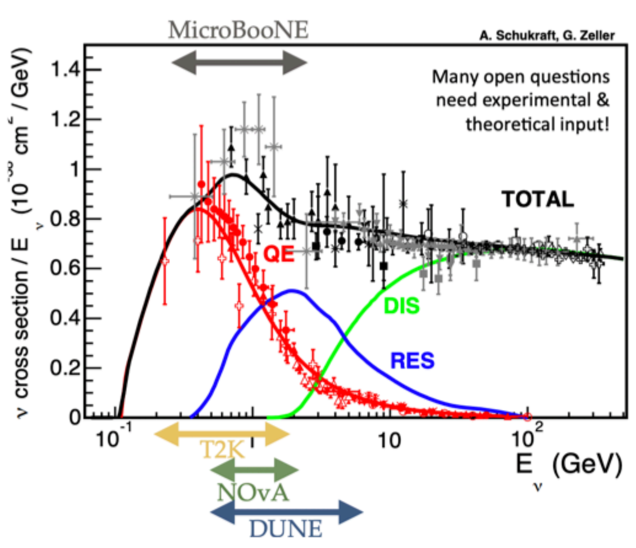

Fig. 2: MicroBooNE's energy is in the quasi-elastic and resonance region. This will give insight to other experiments with overlapping regions, such as DUNE.

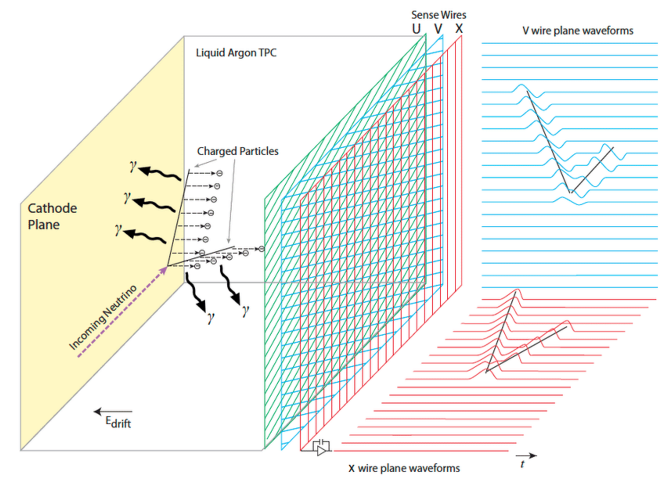

Fig 1: In the LArTPC, a neutrino interaction in the fiducial volume, producing ionization and scintillation light. The ionization charge drifts due to the electric field and is read out by precision wires and photomultiplier tubes.

The goal of this project is to extract the Neutral Current (NC) to Charged Current (CC) ratio to reduce the systematic uncertainties.

Neutrino Interactions

CC Signal: ν_μ + Ar → μ + 1 π^0 + 0 $\pi\pm$ + X (nucleons)

NC Signal: ν_μ + Ar → 1 π^0 + 0 $\pi\pm$ + X

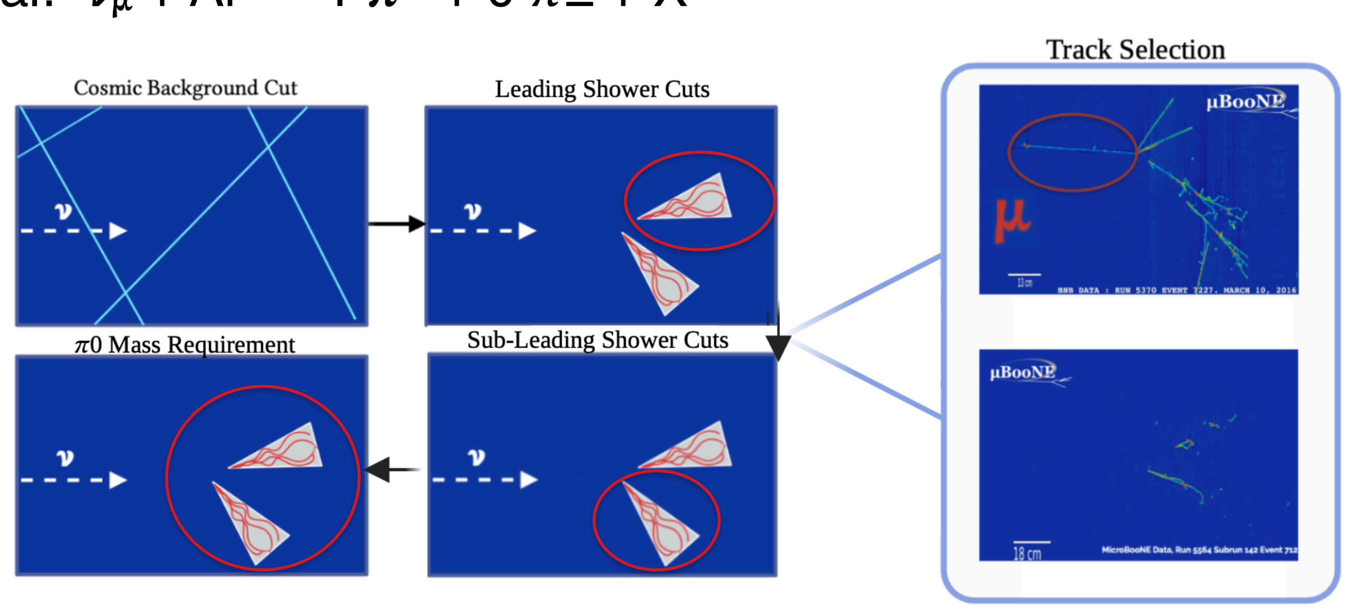

Fig. 3: Event selection cut process (left). CC (Top) and NC (Bottom) event displays (right). Unlike NC interactions, CC interactions are characterized by the presence of a muon track.

Adding cuts to our data reduces cosmic backgrounds and differentiates the types of interactions occurring in the fiducial volume, isolating the signal events.

Pion Kinematics

Charged Current

Neutral Current

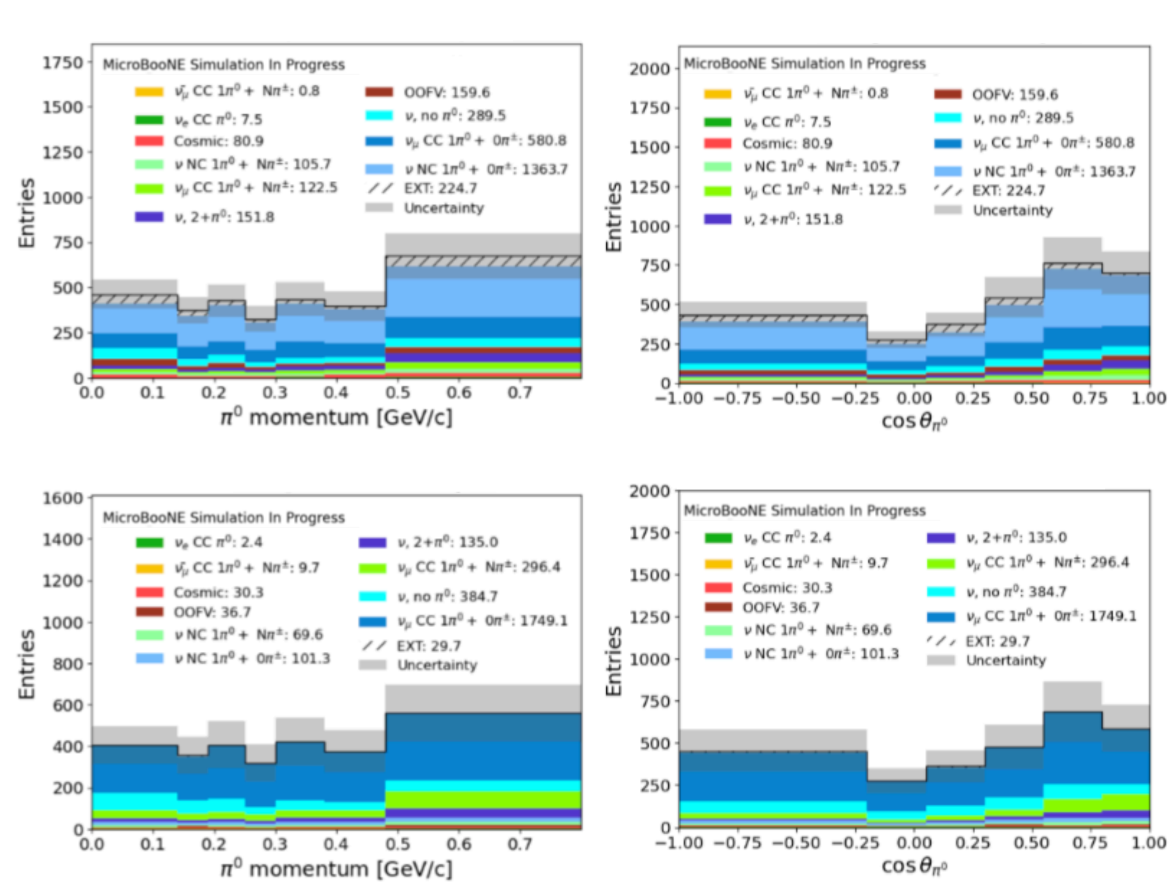

Fig 4: Basic cosmic background rejection and shower selection requirements (2 or 3 showers) are placed on CC and NC events for the whole MicroBooNE data set. Our CC/NC π^0 selection leads to ~65% π^0 purity for CC and ~63% for NC.

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μBooNE

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Absolute Efficiency

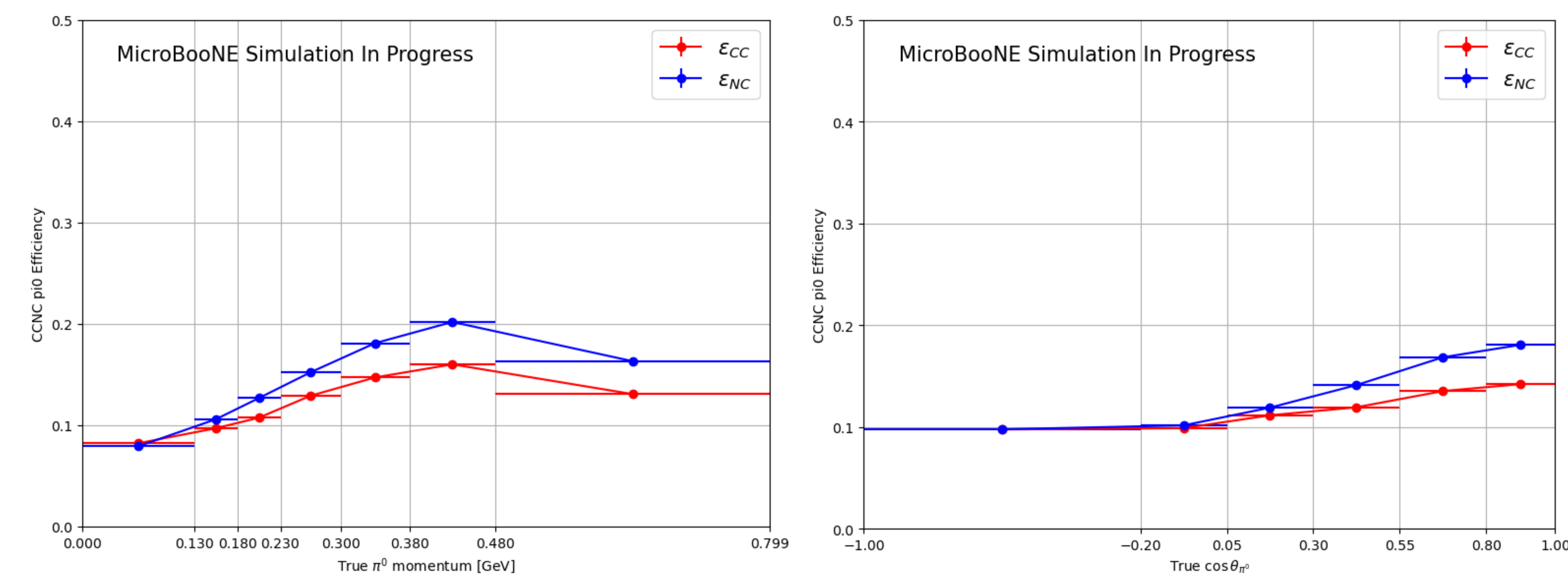

Fig 5: The absolute efficiency for CCπ0 (NCπ^0) events to pass CCNCπ^0 selection for the π^0 momentum (left) and angle (right).

The efficiency shows what fraction of true π^0 events have successfully been reconstructed, revealing how the detector performance and selection efficiency vary across the π^0 kinematic range.

Statistical and Systematic Uncertainty

- ✶The systematic uncertainties come from variation of Genie uni-sim and multi-sim, and the BNB flux.
- ✶Optimizing the kinematic bin widths minimized variations across bins.
- ✶Taking the ratio of NC/CC reduced dominant systemic uncertainties, from ~26% (CC) and ~28% (NC) to ~13%.

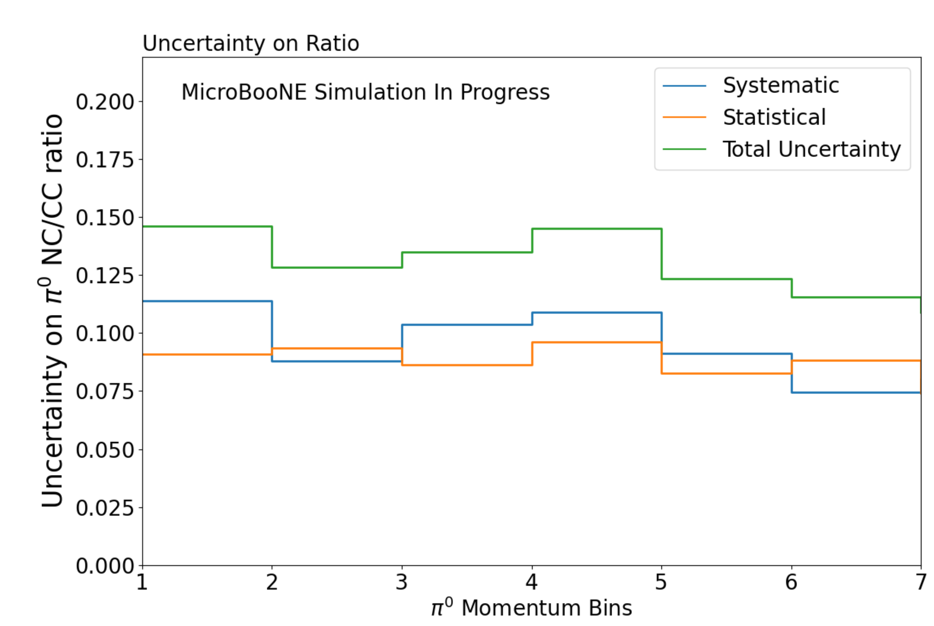

Fig 6: Statistical and systematic uncertainties on the π^0 NC/CC ratio. Uncertainties shown here are on the total number of predicted events.

Model Predictions

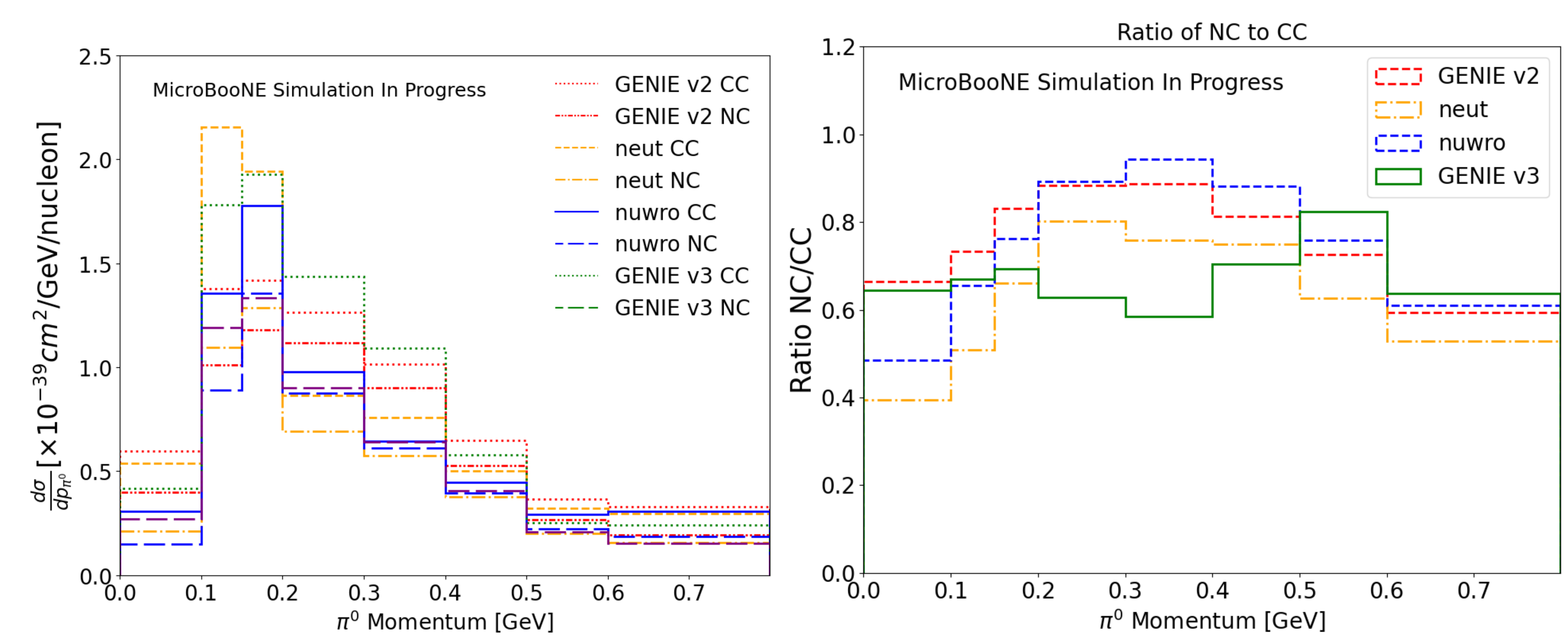

Fig 7: Various generator predictions on the calculation for CC and NC π^0 events (left) and for the ratio (right).

- ✶ Different neutrino interaction generators are compared.
- ✶ Qualitative differences stem from the different initial nuclear state possibilities that the models test.
- ✶ Cross section result will be compared to these distributions in order to establish which generator performs best.

Conclusion

- ✶Taking the NC/CC ratio reduced systematic uncertainties.
- ✶Future work include measuring the cross section ratio for the MicroBooNE detector.