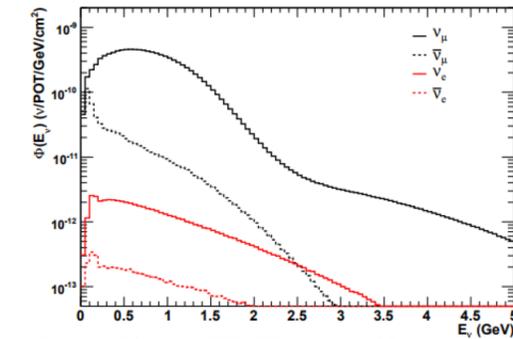


## Introduction to MicroBooNE

- LArTPC with 85 tonne of LAr.
- Three wire planes detect ionized electron signals.



R. Acciarri *et al* 2017 *JINST* 12 P02017



Cryostat covered in insulating foam

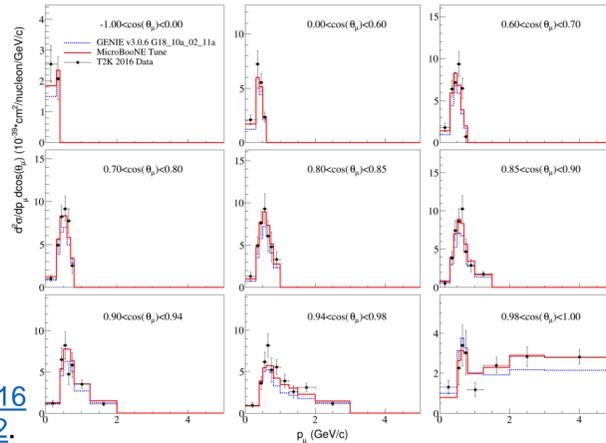
- On-axis and ~500 m away from Fermilab's Booster Neutrino Beam (standard horn flux, left).

*Phys. Rev. D* 79, 072002

## MicroBooNE Event Generator Tune

- Base sim. is GENIE v3.0.6 G18\_10a\_02\_11a
- Tune to 2016 T2K ND280 CC0pi data with pars. on:  $M_{A,CCQE}$ , CC2p2h norm., CCQE random phase approximation strength, and 2p2h lepton kinematics.

Fit with NUISANCE: *JINST* 12 P01016  
ND280 Data: *PRD* 93 (2016) 112012.

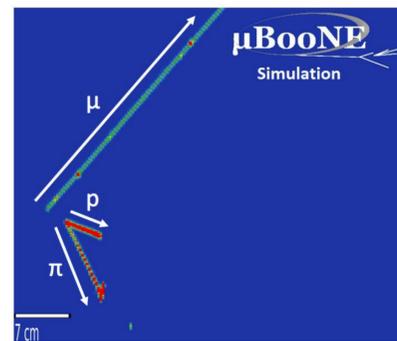
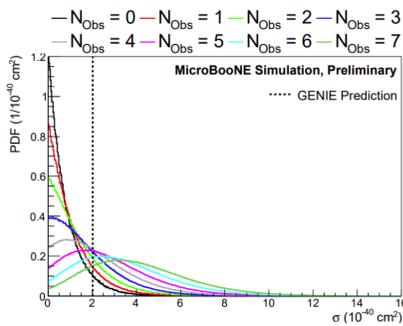


Comparisons of the MicroBooNE Tune to T2K CC0pi data.

## Progress at Lambda Production Cross Section

- Uses Fermilab's NuMI beam to measure muon antineutrinos scattering to a final state with a muon and a lambda.
- Sensitivity studies developed a PDF for this Cabibbo suppressed interaction.

PDFs of the cross section based on event rate  $2.2 \cdot 10^{20}$  POT (neutrino mode) and  $4.9 \cdot 10^{20}$  POT (antineutrino mode) for the NuMI beam

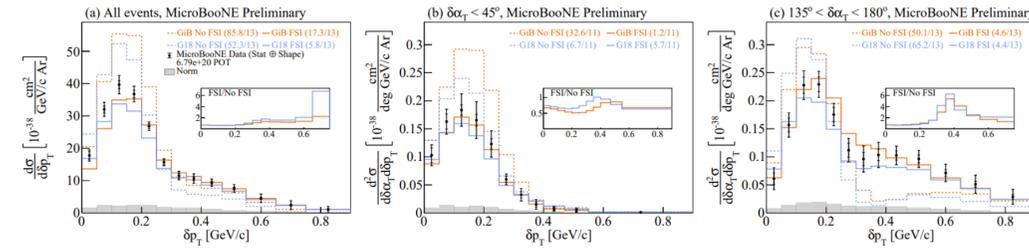


Simulated event display, the event selection is restricted to events where the lambda decays to only a proton and pion.

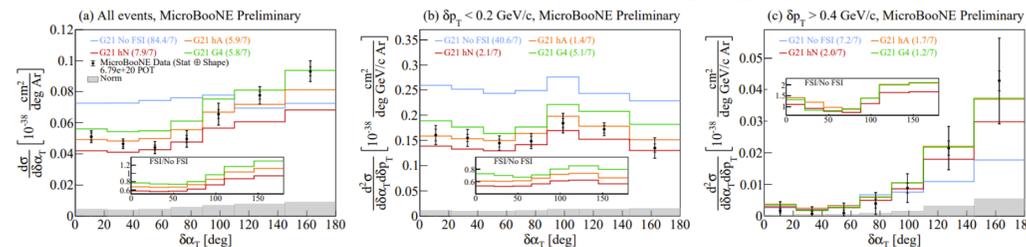
MICROBOONE-NOTE-1112-PUB

## $\nu_\mu$ CC1p Measurement of Transverse Kinematic Imbalance

- Analyzes transverse momentum ( $\delta p_T$ ) and angle ( $\delta\alpha_T$ ) imbalances between outgoing CCQE( $1\mu 1p$ ) muon and proton.
- 1<sup>st</sup> double-differential transverse kinematic imbalance meas. on any target
- Use log-likelihood of hit dE/dx fitter to find 1 proton track and 1 muon track: *J. High Energ. Phys.* 2021, 153 (2021).



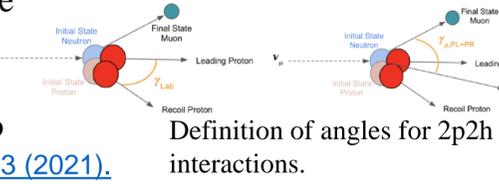
Double-differential cross section as a function of momentum imbalance sliced by the angle imbalance (G1=GiBUU 2021, G18=GENIE v3.0.6 G18\_10a\_02\_11a).



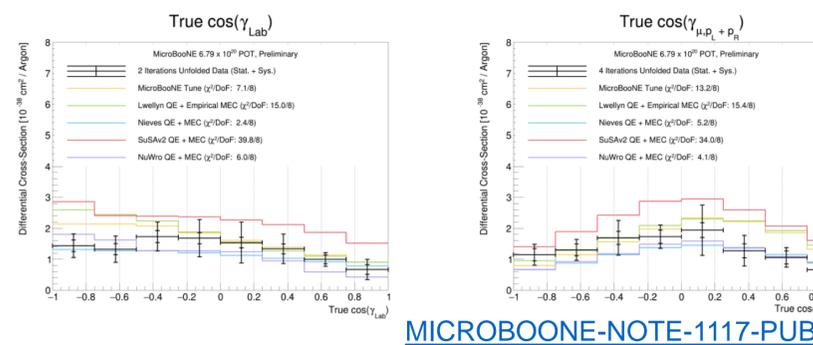
Double-differential cross section as a function of transverse angle imbalance sliced by the momentum imbalance (G21=GENIE v3.2 SuSAv2).

## $\nu_\mu$ CC2p2h

- Measurement of 2 proton final states with implications for nuclear physics modeling as most events predicted are CC2p2h.
- Extracted as a function of proton opening angle and center angle relative to the outgoing muon.
- Selection uses dE/dx log-likelihood algorithm to find one muon and two protons: *J. High Energ. Phys.* 2021, 153 (2021).



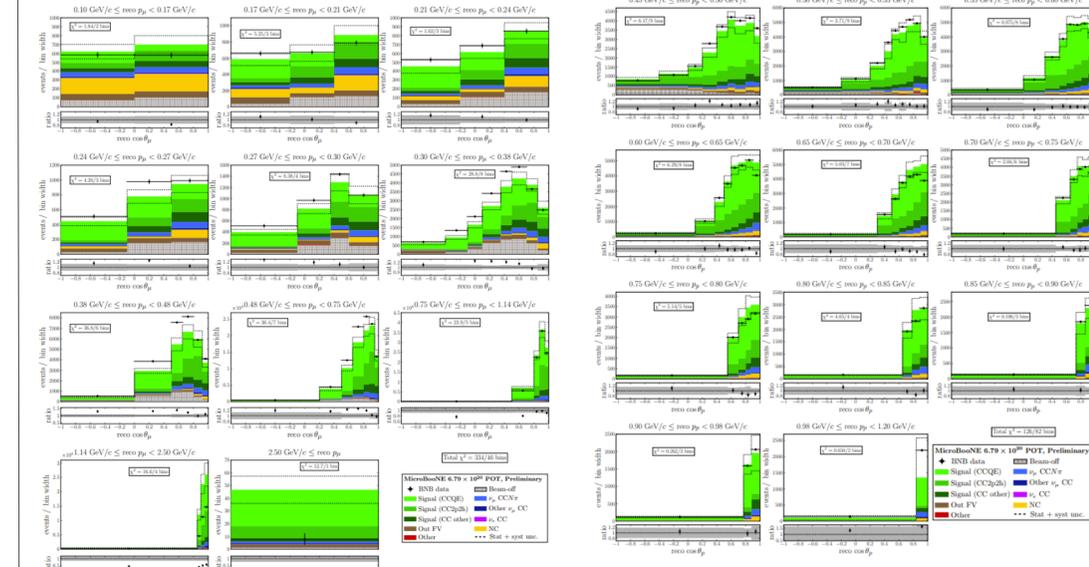
Cross section as a function of opening angle (left) and angle between total proton mom. and muon (right).



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## $\nu_\mu$ CCNp0π

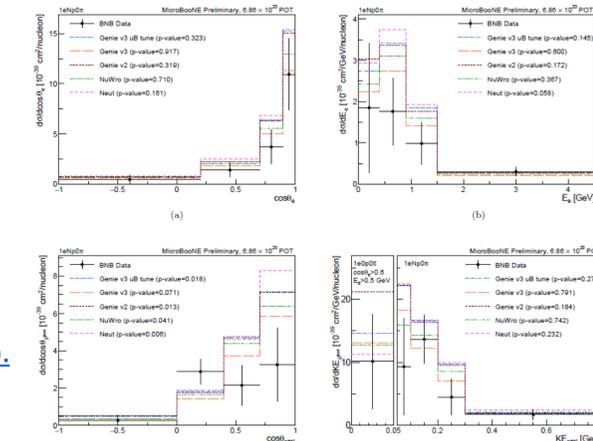
- Presented here as raw event rates between sim and data



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## $\nu_e$ CCNp0π

- Extracted as four 1D-differential cross section
- Uses Kalman fitter to select events with an electron and MicroBooNE's log-likelihood dE/dx fitter for protons: *Phys. Rev. D* 105, 112004
- *J. High Energ. Phys.* 2021, 153 (2021).



MICROBOONE-NOTE-1109-PUB

Extracted cross section in terms of muon and leading proton kinematics.

## Conclusion

- MicroBooNE has an expansive set of analyses probing final state and nuclear modeling through interactions involving final state baryons.
- Results can inform event generator models for the future of MicroBooNE, the Short Baseline Neutrino program, and DUNE.

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