

Multi-Differential Charged Current ν_μ – Argon Cross Section without Pions in the Final State Measurement in MicroBooNE, and Current Status of Simultaneous Cross Section Extraction with ANNIE



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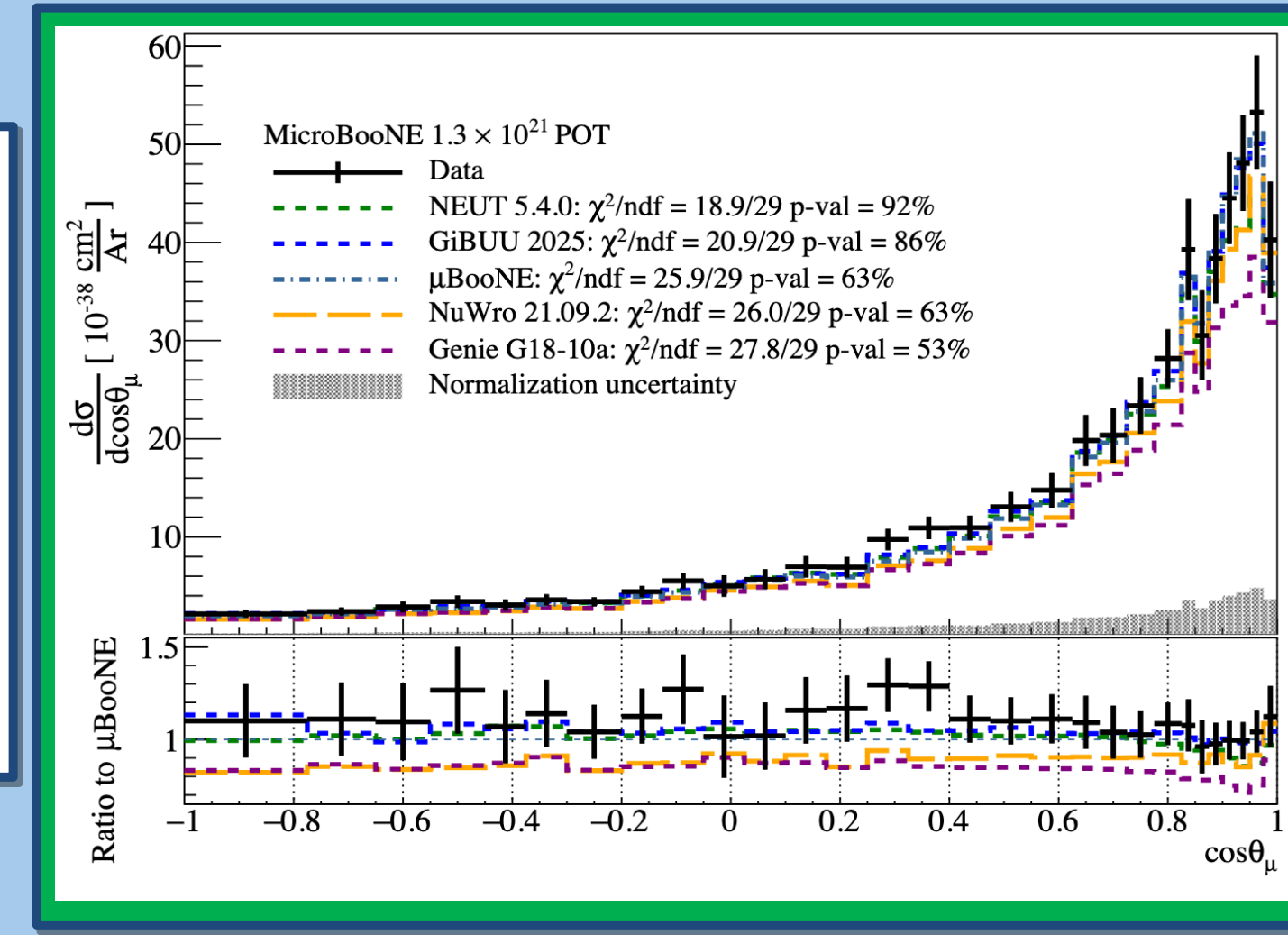
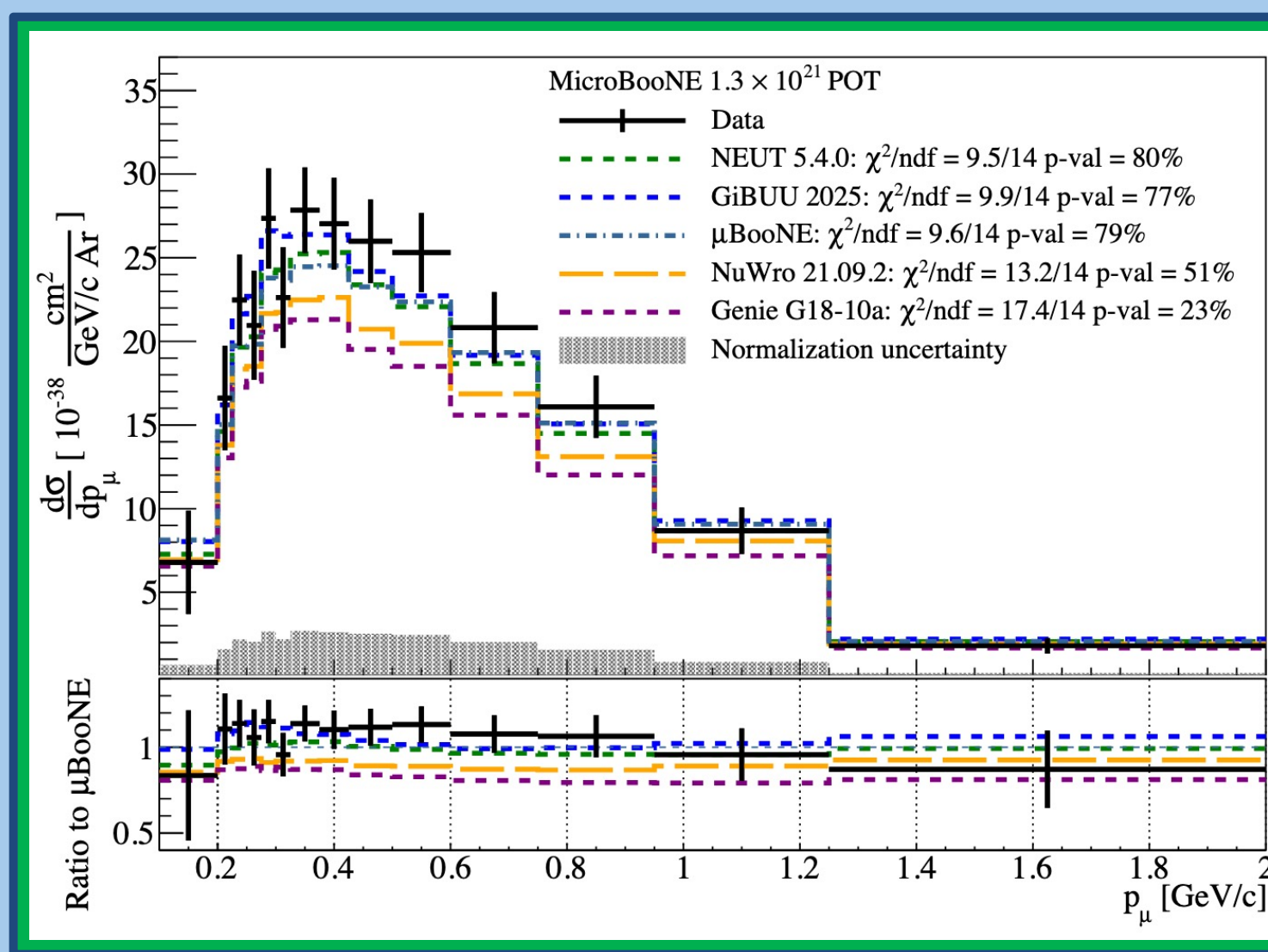
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on behalf of MicroBooNE and ANNIE Collaboration

Overview

- $^{40}\text{Ar} + \nu_\mu \rightarrow \mu^- + \text{Np}/\text{Op} : (\text{CC}0\pi)$
- $\text{CC}0\pi$ measurements constrain the neutrino interaction and nuclear physics uncertainties that limit oscillation measurements.
- We present recently published $\text{CC}0\pi$ multi-differential cross section measurements
 - Phys. Rev. D 112, 072007 (2025)
- Joint ANNIE-MicroBooNE $\text{CC}0\pi$ cross-section analysis underway; publication planned for 2026.

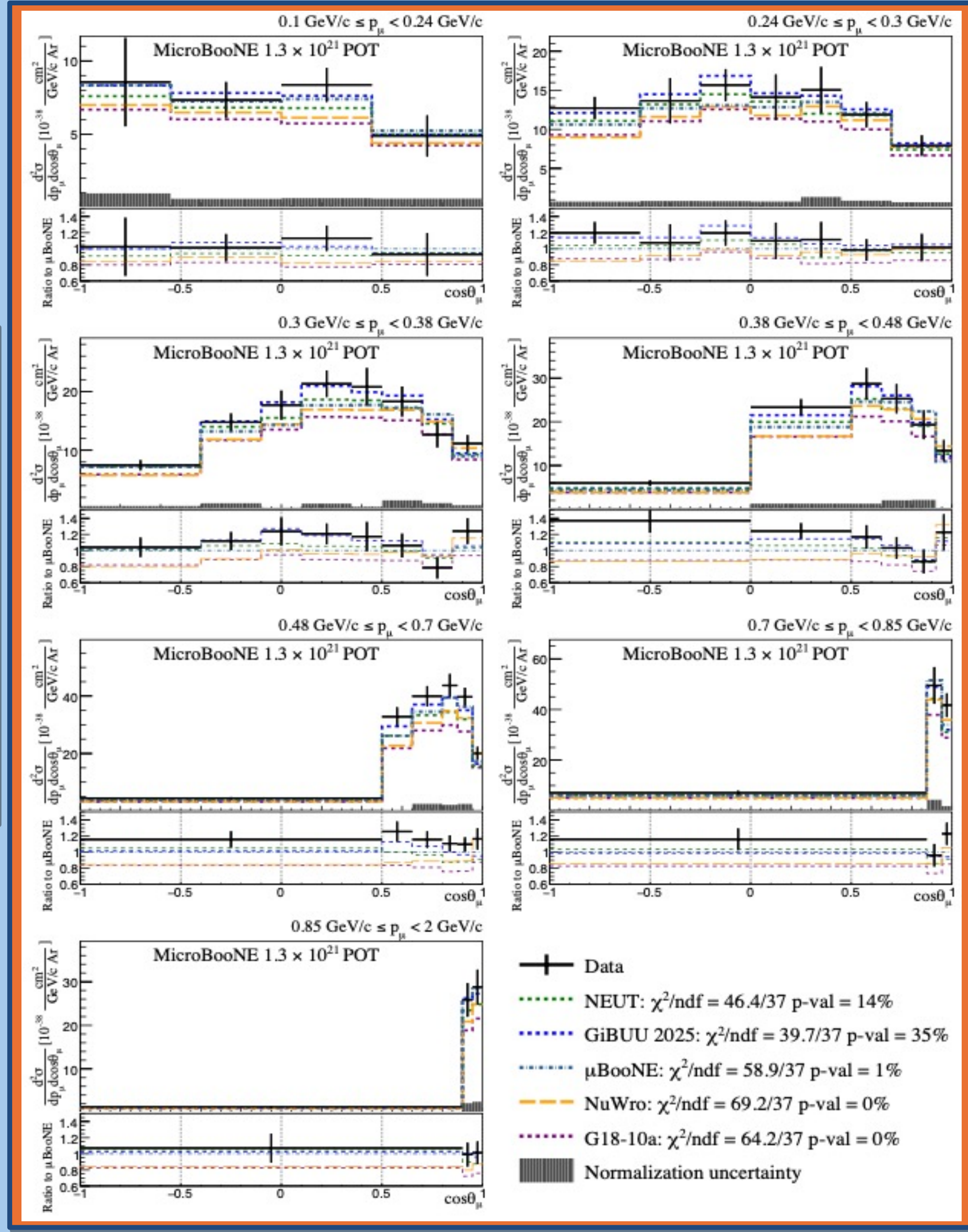
CC-0 π Signal Definition

- Charged-current ν_μ interaction with ^{40}Ar
- $0.1 < p_\mu^{\text{true}} < 2.0 \text{ GeV}/c$
- No final state charged pions (π^\pm) with $p_\pi^{\text{true}} > 70.0 \text{ MeV}/c$
- No final state neutral pions (π^0)

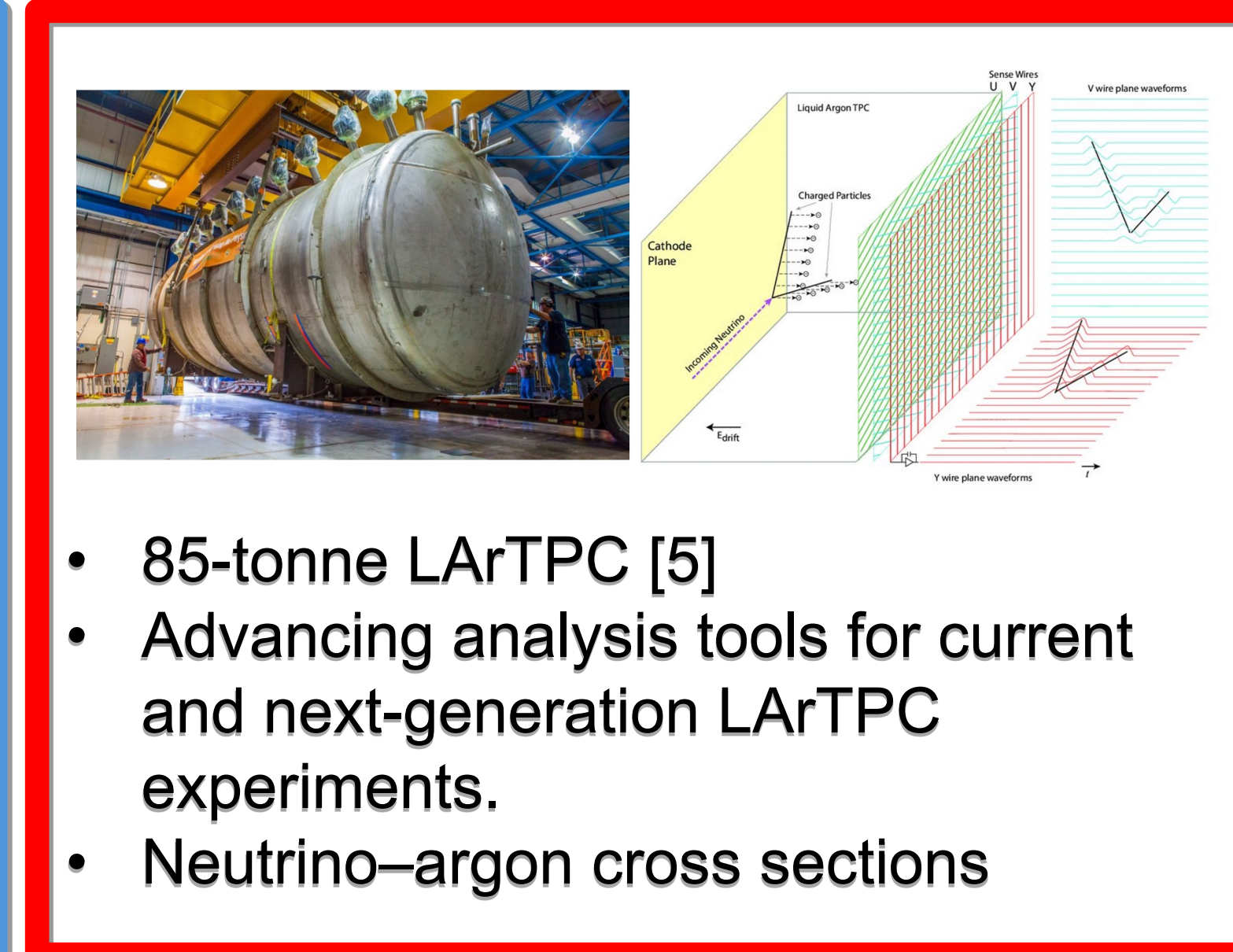
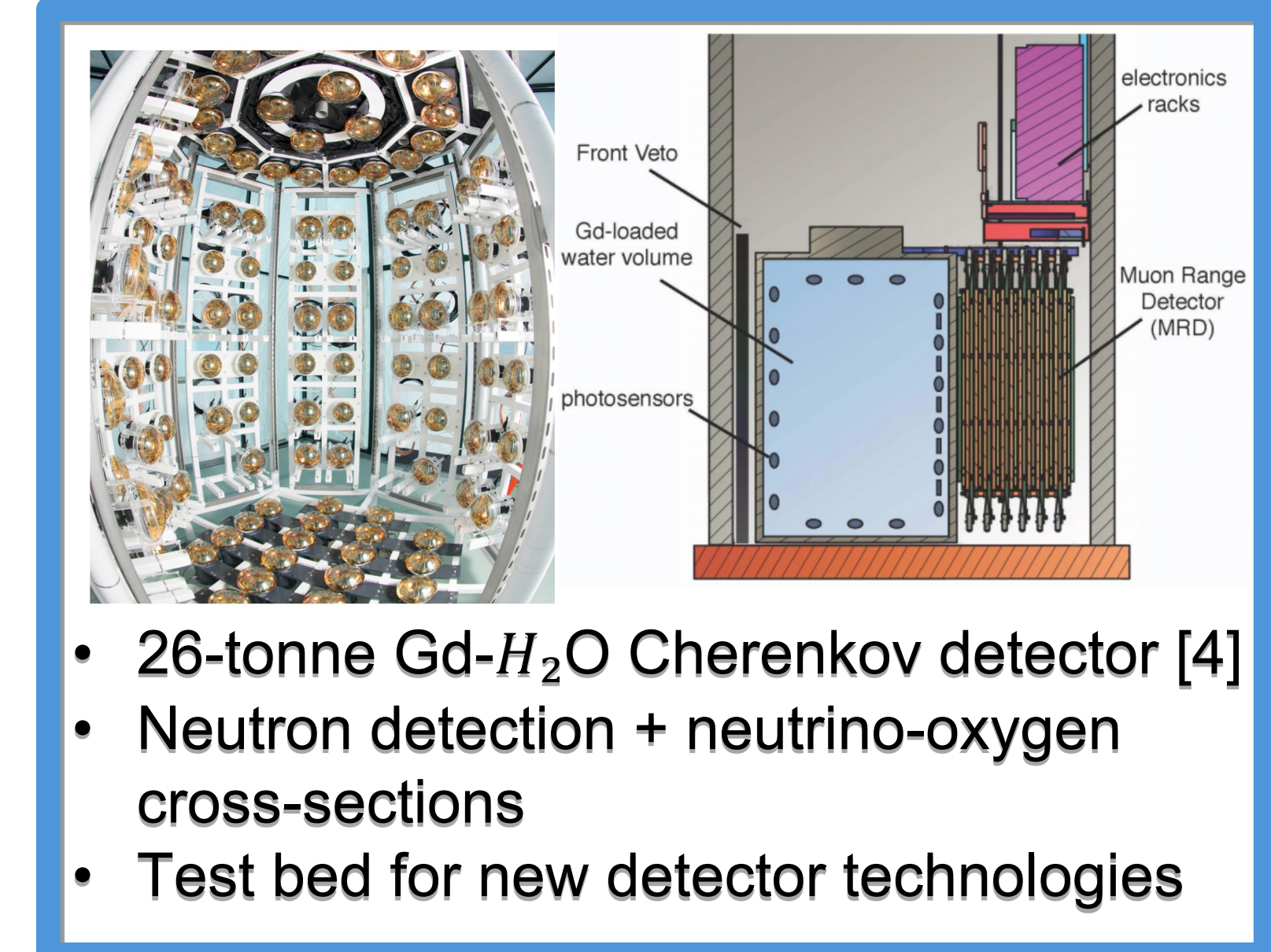
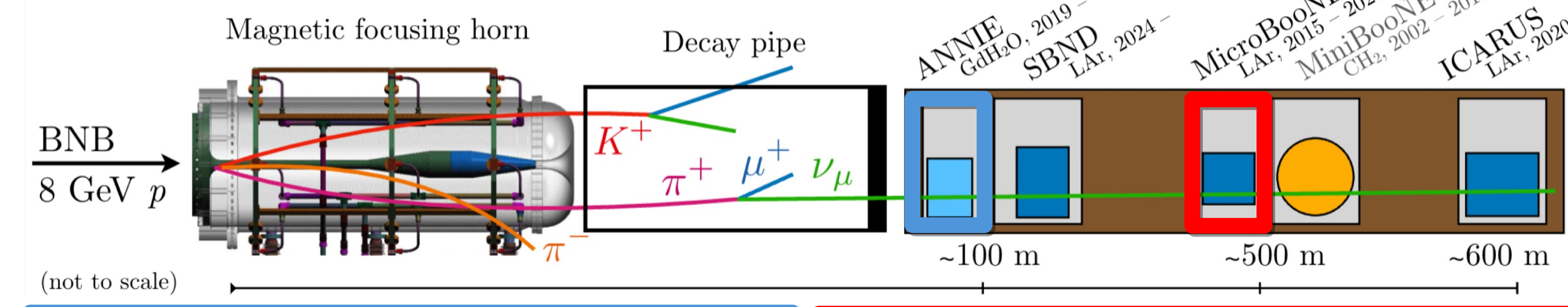


Results

- Extracted **1D** and **2D** flux-integrated differential $\text{CC}0\pi$ cross section.
- Applied Wiener–SVD unfolding [3].
- Cross-section measurements and associated regularization (A_C) and covariance matrices are publicly available.



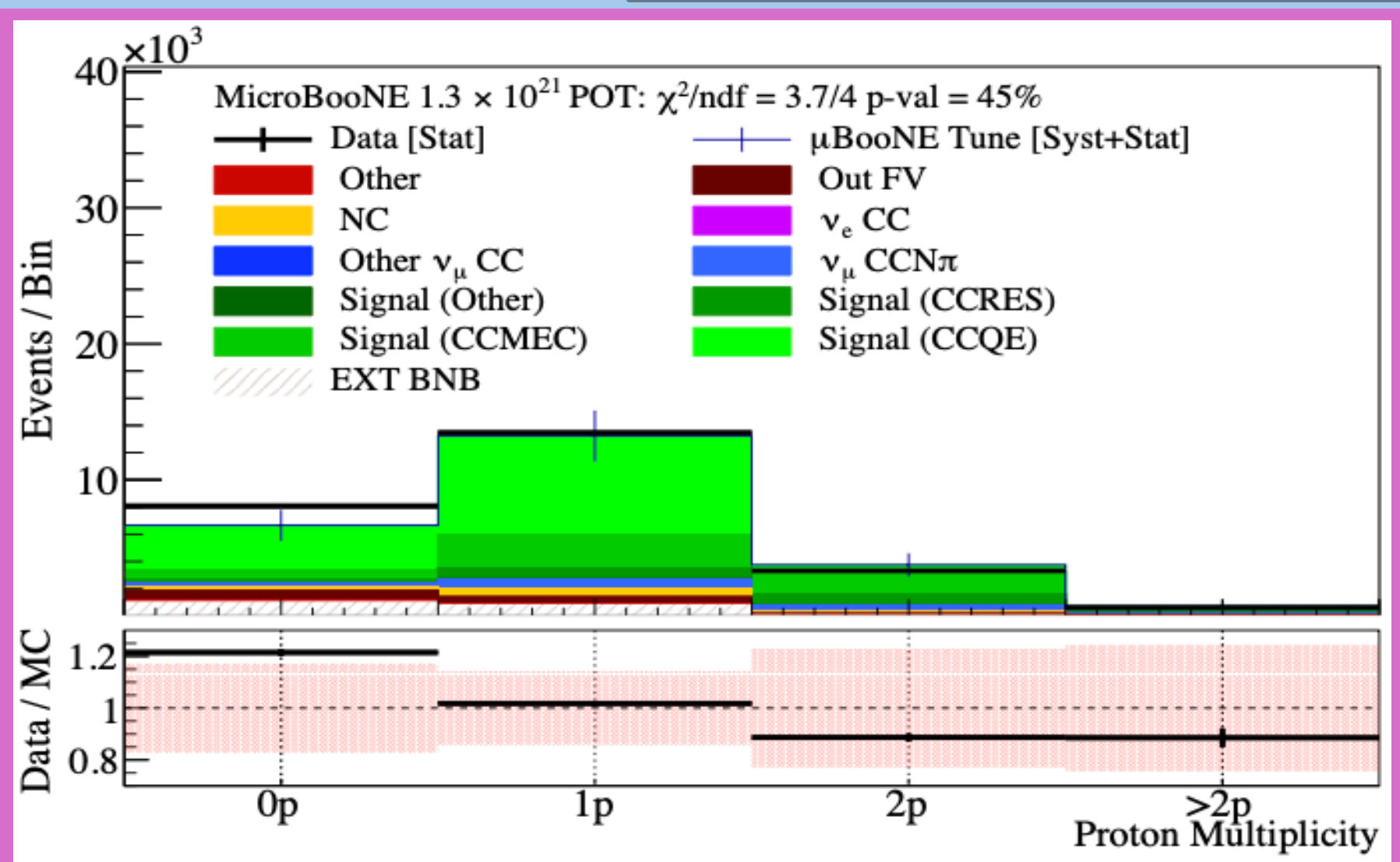
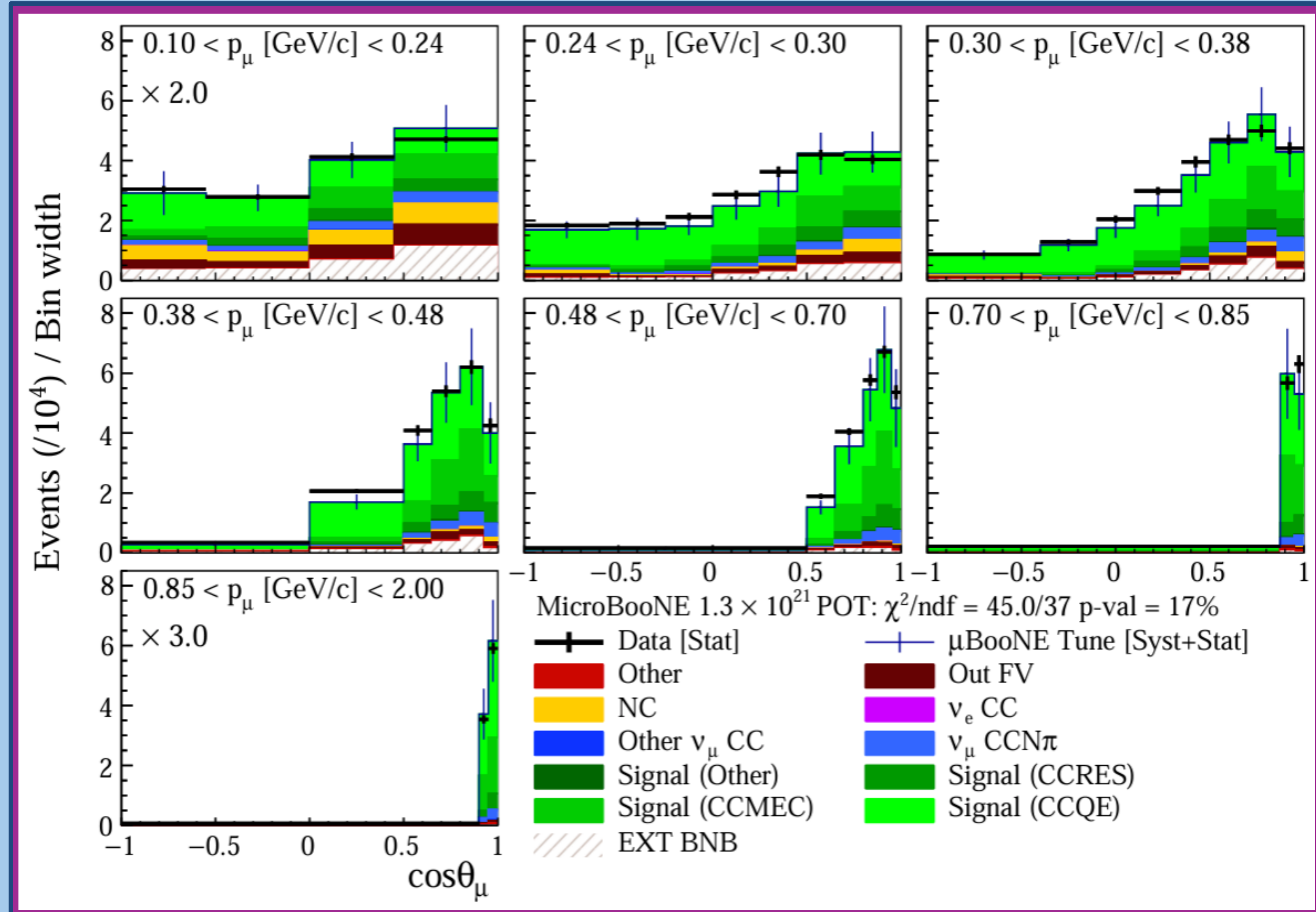
Simultaneous Multi-Detector Cross Section Measurements on Water and Argon



- 85-tonne LArTPC [5]
- Advancing analysis tools for current and next-generation LArTPC experiments.
- Neutrino–argon cross sections
- 26-tonne Gd- H_2O Cherenkov detector [4]
- Neutron detection + neutrino-oxygen cross-sections
- Test bed for new detector technologies

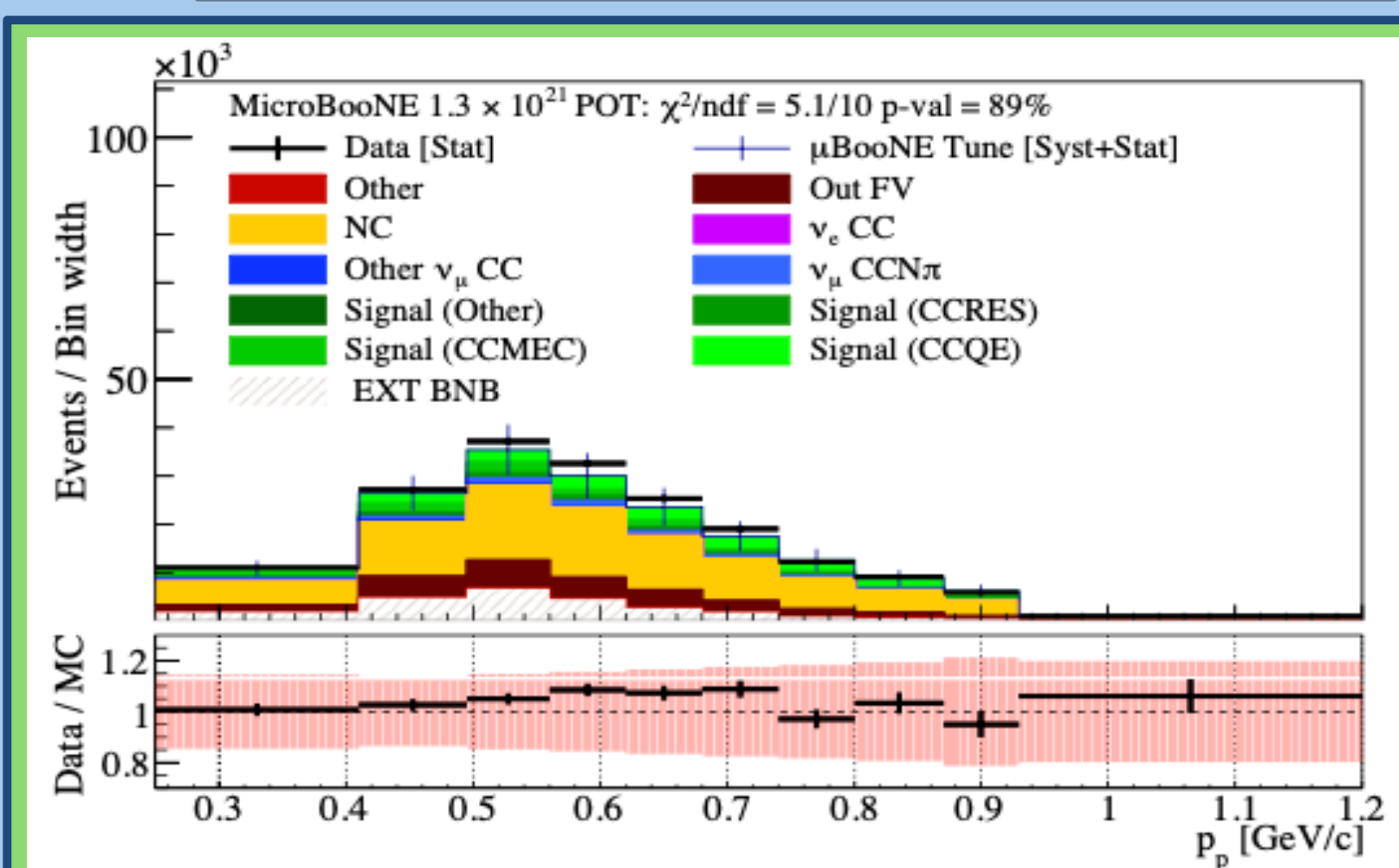
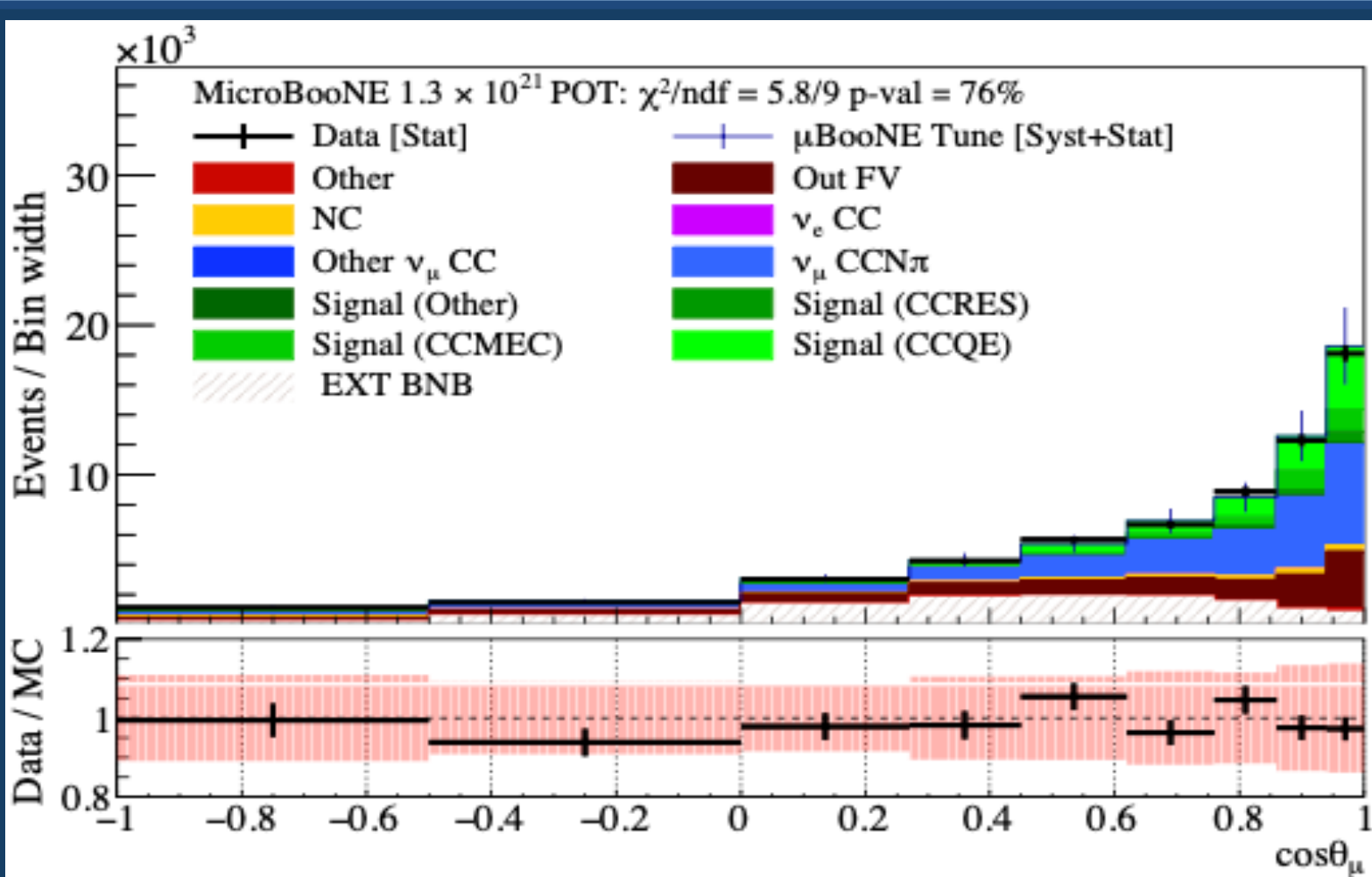
Event Selection ($\cos\theta_\mu$ in p_μ slices)

- Purity ~ 79% Efficiency ~ 13%
- Using the full MicroBooNE dataset (1.3×10^{21} POT).
 - The central value is defined by the MicroBooNE tune [1].
 - PID is performed using an XGBoost gradient boosted decision tree (BDT) model [2].
 - The stacked histograms present the contributions from signal and background categories.



Proton Multiplicity and Sidebands

- Good data–MC agreement in the sideband regions:
- Proton Multiplicity
- CCN π Sideband ($\cos\theta_\mu$)
- NC Sideband (p_p)



Summary

- We developed an event selection to extract multi-differential cross sections using a $\text{CC}0\pi$ signal definition with MicroBooNE.
 - Presented planned joint cross-section analysis with the ANNIE detector.
- Next Step**
- Unblinding the Joint analysis and moving forward with extracting the cross section from the data.

References

- New $\text{CC}0\pi$ GENIE model tune for MicroBooNE. Phys. Rev. D 105.7 (2022)
- XGBoost: A Scalable Tree Boosting System. arXiv: 1603.02754.
- Data Unfolding with Wiener-SVD Method. In: JINST 12.10 (2017), P10002.
- ANNIE: Neutron multiplicity in neutrino interactions and new technologies. J. Phys. Conf. Ser., 1468(1), 012226
- Design and Construction of the MicroBooNE Detector. JINST, 12(2), P02017

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