Measurement of the muon-neutrino charged-current cross section on water with zero pions in the final state

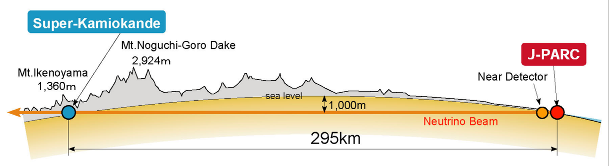
Tianlu Yuan

The T2K Collaboration

University of Colorado Boulder

1. T2K

Accelerator-based, long-baseline neutrino oscillation experiment in Japan

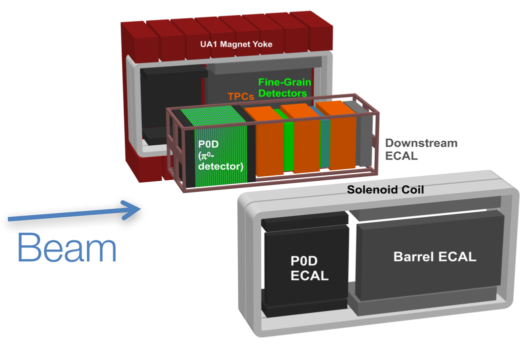


Beam mode	Total POT
Neutrino	7.6×10^{20}
Antineutrino	7.5×10^{20}

Near detectors useful for cross-section measurements

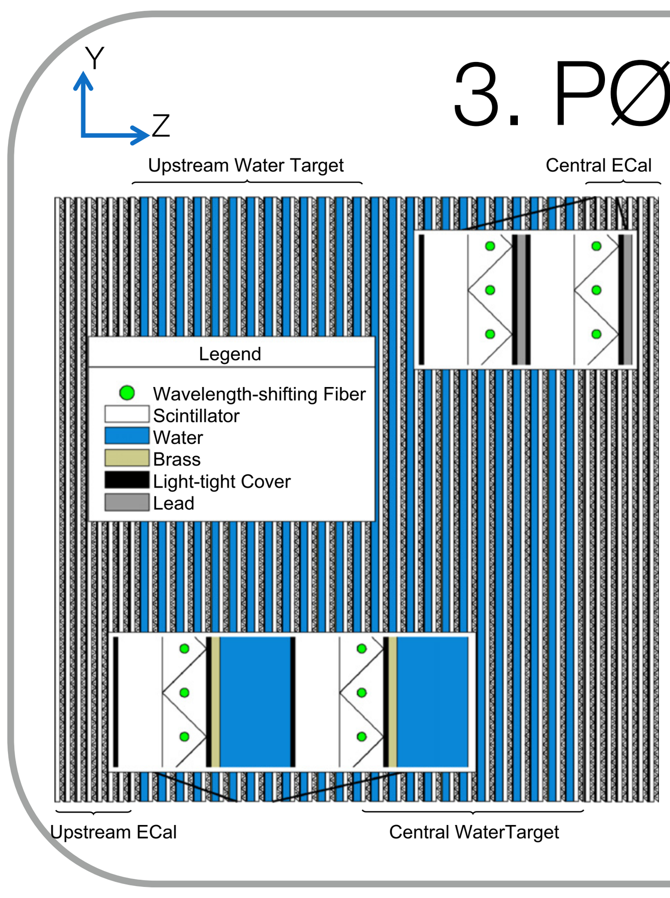
2. ND280

Near detector of T2K



Pi-zero detector (PØD) is upstream of tracker, which consists of 3 argon-based TPCs interspaced with 2 scintillator-based FGDs

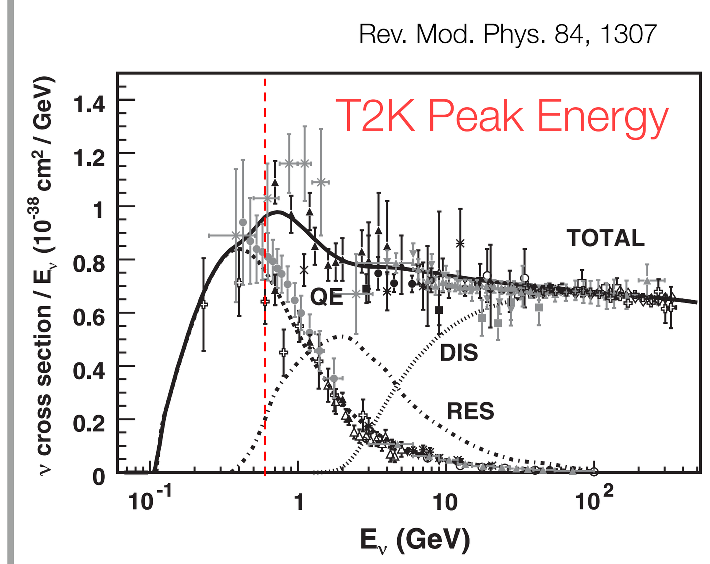
3. PØD



Water target consists of layers of scintillator, brass, and water which can be drained!

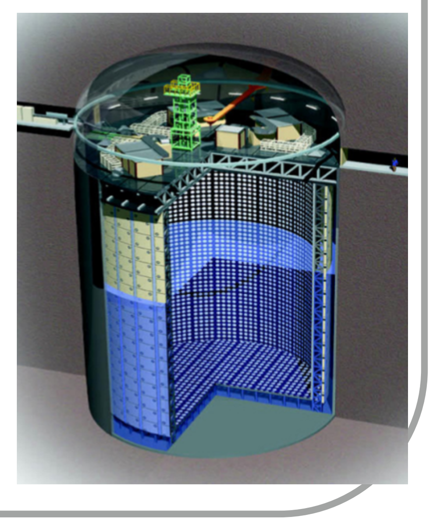
Water status	Good POT
PØD Filled	2.3×10^{20}
PØD Drained	3.5×10^{20}

4. Motivation



CCQE (box 5) is dominant interaction channel at T2K

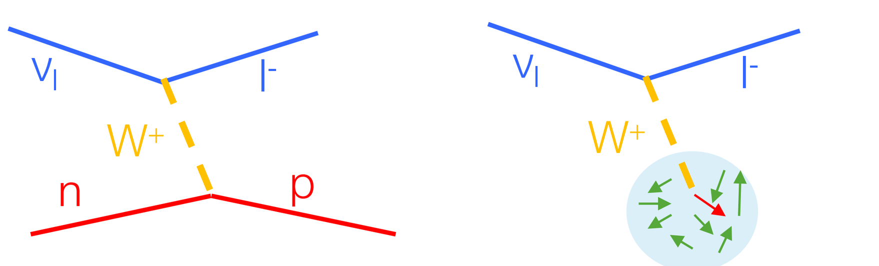
Water used as neutrino detector, including SK, T2K's far detector



5. Neutrino interactions

Detectors are not made of free nucleons and intranuclear effects can affect observables.

Measure a topology after final state interactions called $CC0\pi$ with outgoing μ, zero π, and any number of nucleons. Mostly due to CCQE interactions.



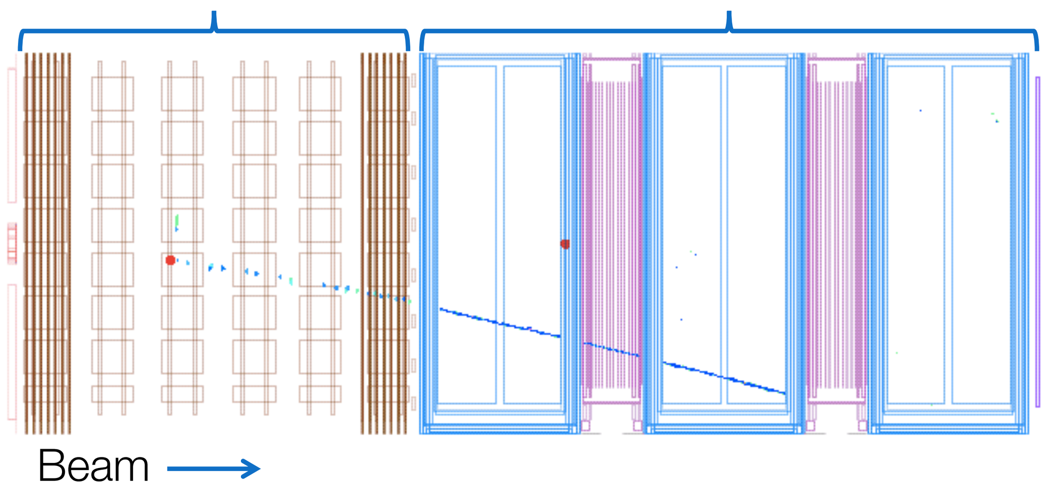
6. Event selection

1. Data quality
2. Interaction in PØD fiducial volume within water target
3. Track enters tracker
4. Select highest-momentum negative track consistent with neutrino beam timing
5. Single PØD reconstructed object per beam bunch

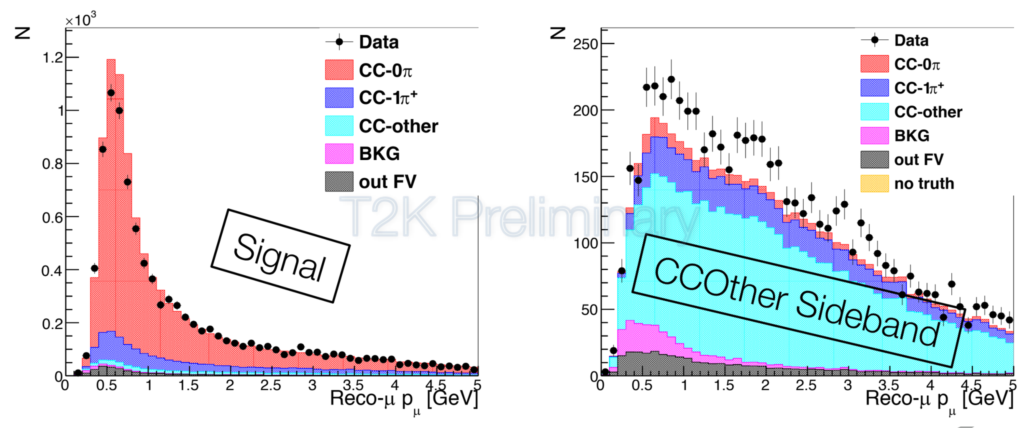
Two control samples (sidebands) selected by modifying cut 5

1. $CC1\pi^+$: 2 tracks+Michel electron
2. CCOther: More than 2 tracks

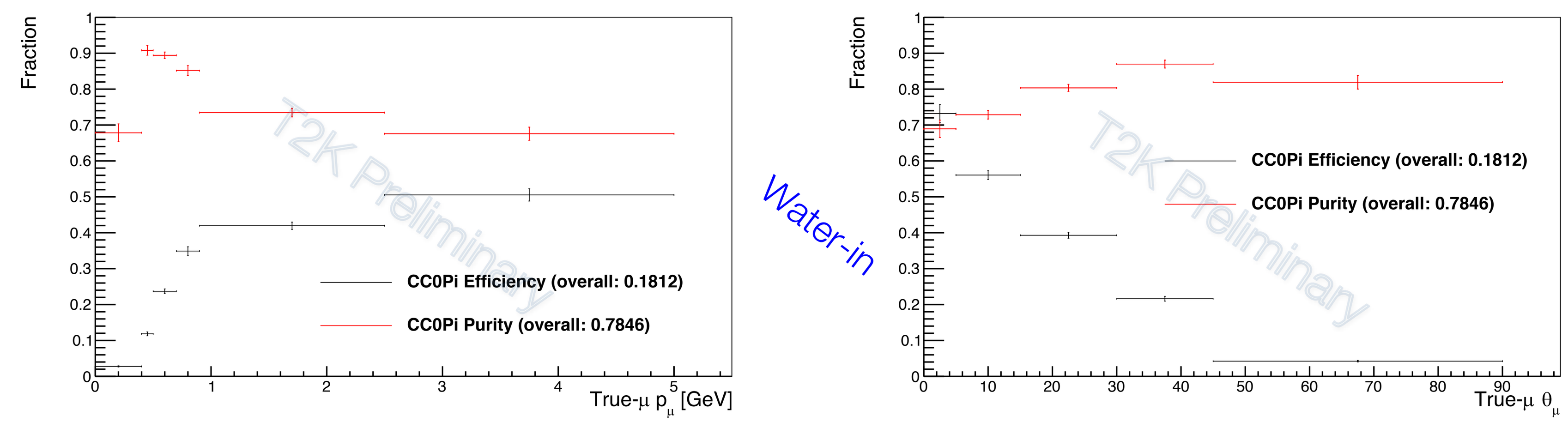
Interaction in PØD



Event distributions



7. Selection efficiency and purity



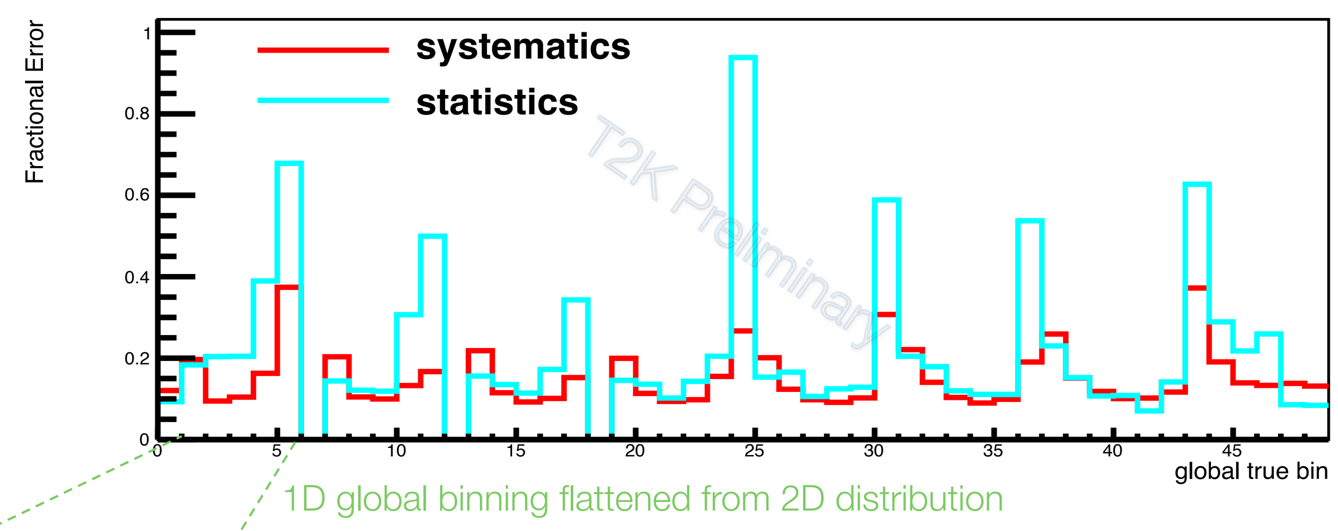
Tracker-going requirement → low efficiency in high-angle, low-momentum regions

Tracker is needed to ensure accurate momentum reconstruction

8. Corrections and systematics

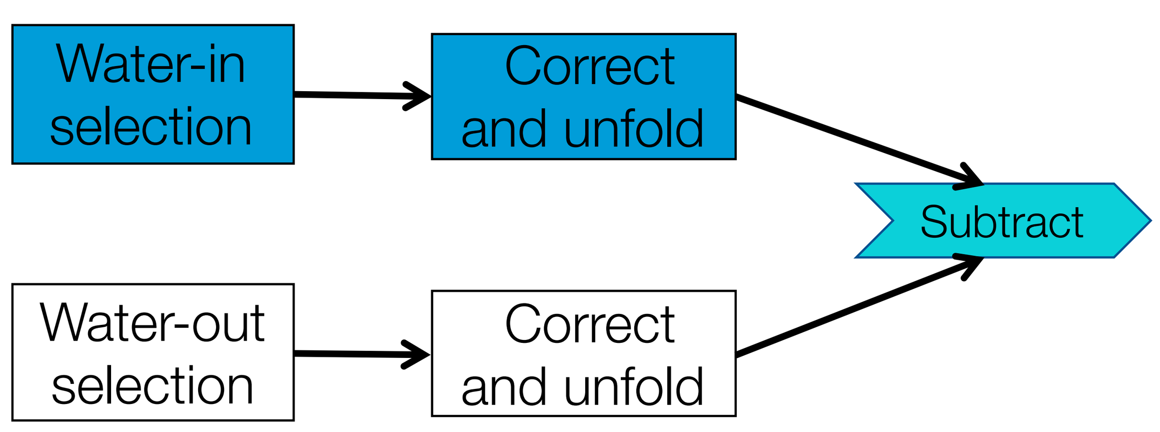
Nominal MC is corrected after production to account for unsimulated effects and better model predictions

Systematic uncertainties are numerically propagated by tweaking various parameters that perturb the MC



1D global binning flattened from 2D distribution

9. Analysis strategy



$$N_i^{H_2O} = \frac{U_{ij}^w N_j^w}{\epsilon_i^w} - R\frac{U_{ij}^a N_j^a}{\epsilon_i^a}$$

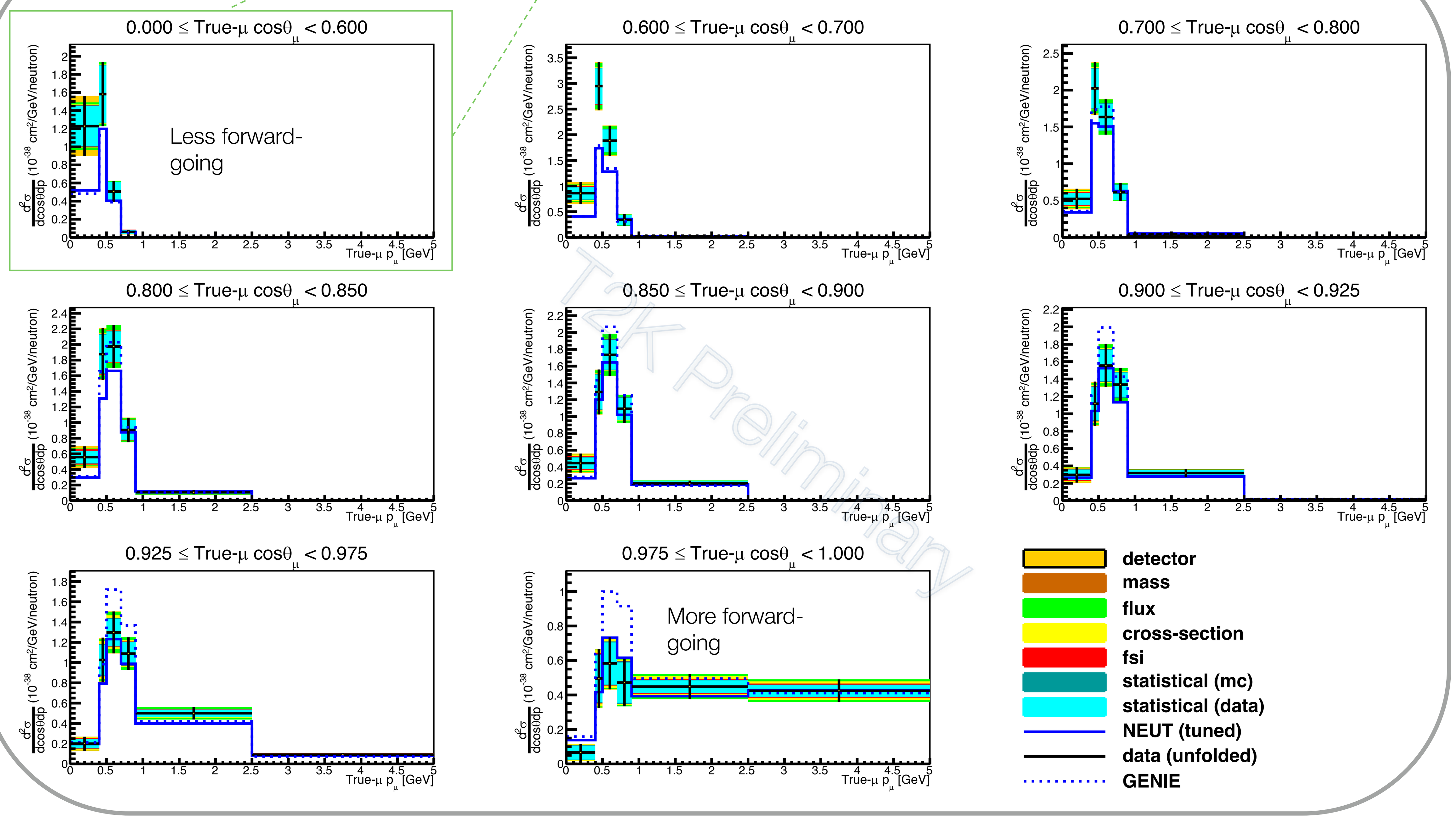
Data

MC

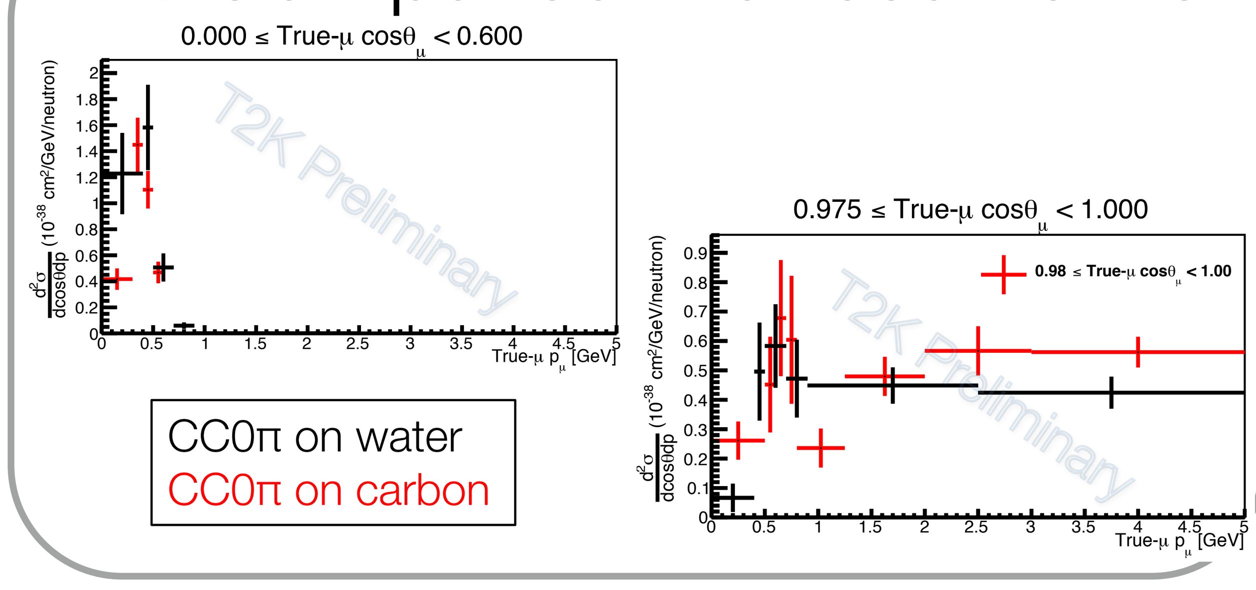
$$d\sigma = \frac{N_i^{H_2O}}{F^w N_n D_i}$$

Integrated flux, num nucleons, bin width

10. Double-differential cross section



11. Comparison to result on C



12. Conclusions

Overall, result agrees better with a corrected version of the NEUT generator than with GENIE, although there are some discrepancies with both models at the high-angle regions.

Good agreement with T2K's double-differential measurement on carbon *PhysRevD.93.112012*

Contact: tianlu.yuan@colorado.edu