

Probing Nuclear Effects at the T2K Near Detector

Using Transverse Kinematic Imbalance

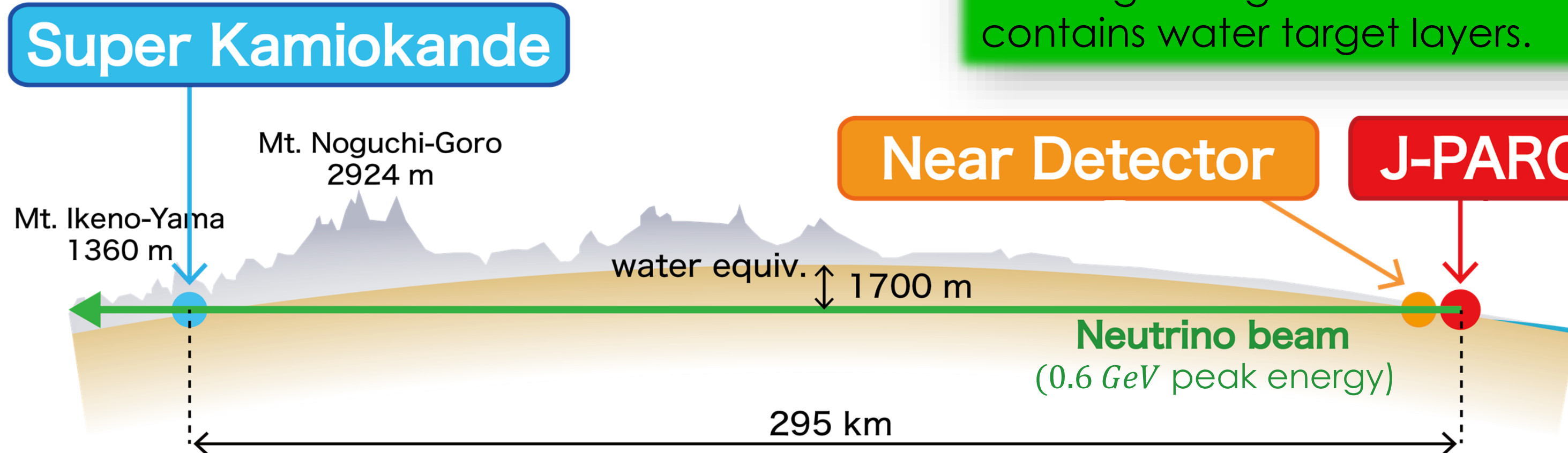
Stephen Dolan, Xianguo Lu, Luke Pickering and Alfons Weber for the T2K Collaboration



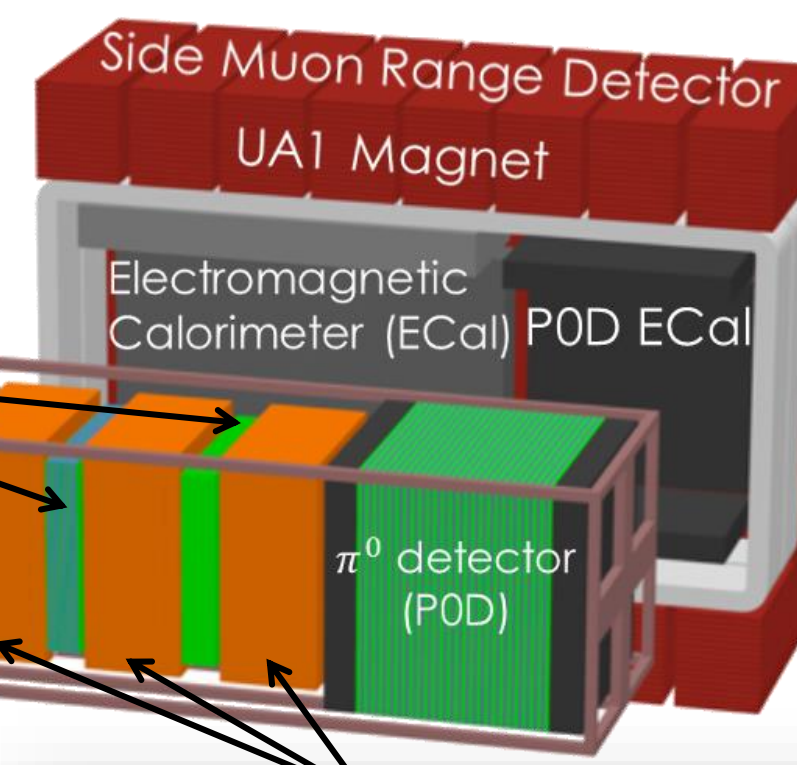
s.dolan@physics.ox.ac.uk



The T2K Experiment



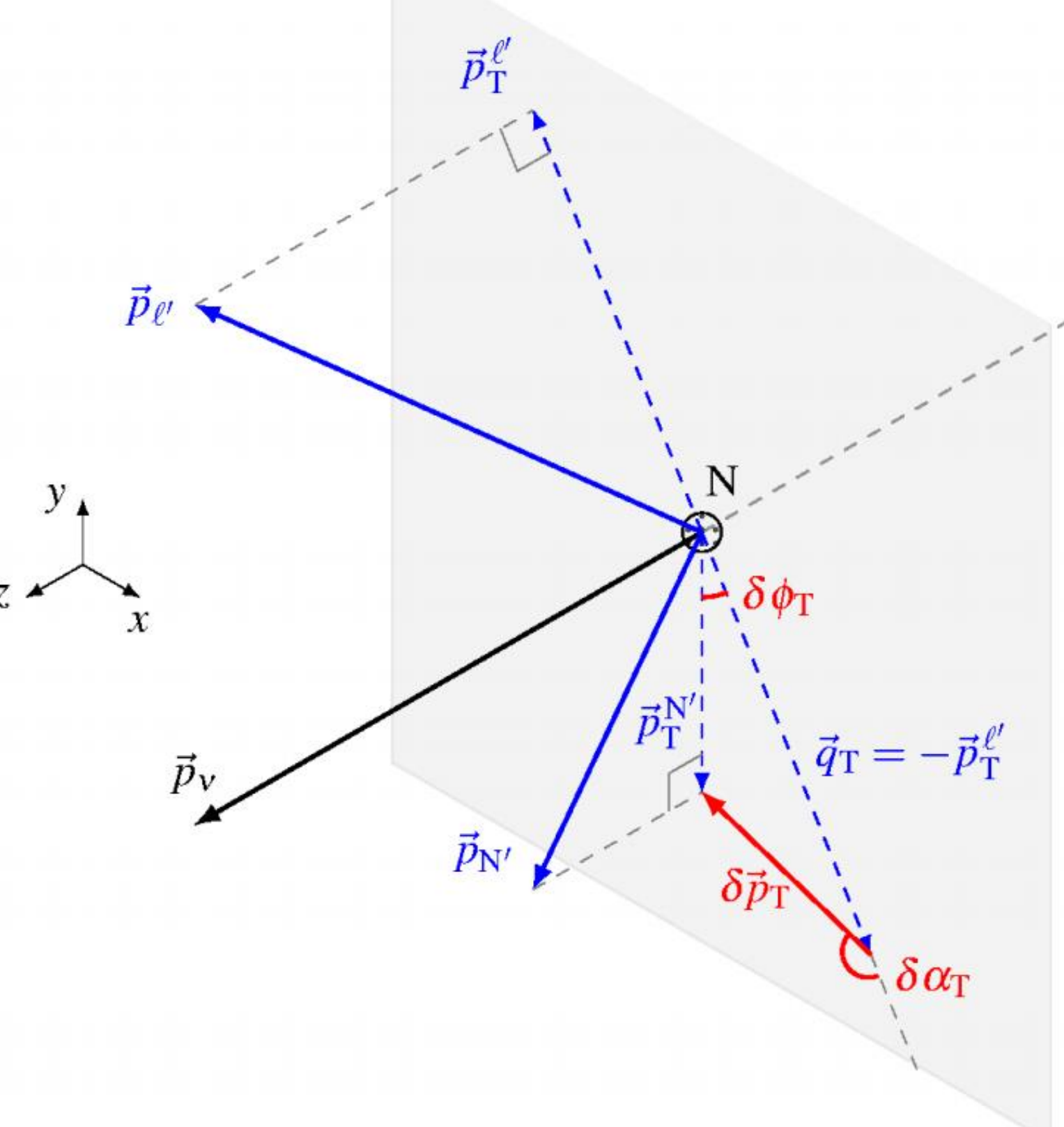
Fine-Grained Detectors (FGD 1/2): Polycarbonate scintillator bars provide tracking & target mass. FGD 2 also contains water target layers.



ND280 off-axis near detector

Time Projection Chambers (TPC): Excellent tracking allows for high resolution charged particle momenta and accurate particle ID.

Single Transverse Variables (STV) [*]

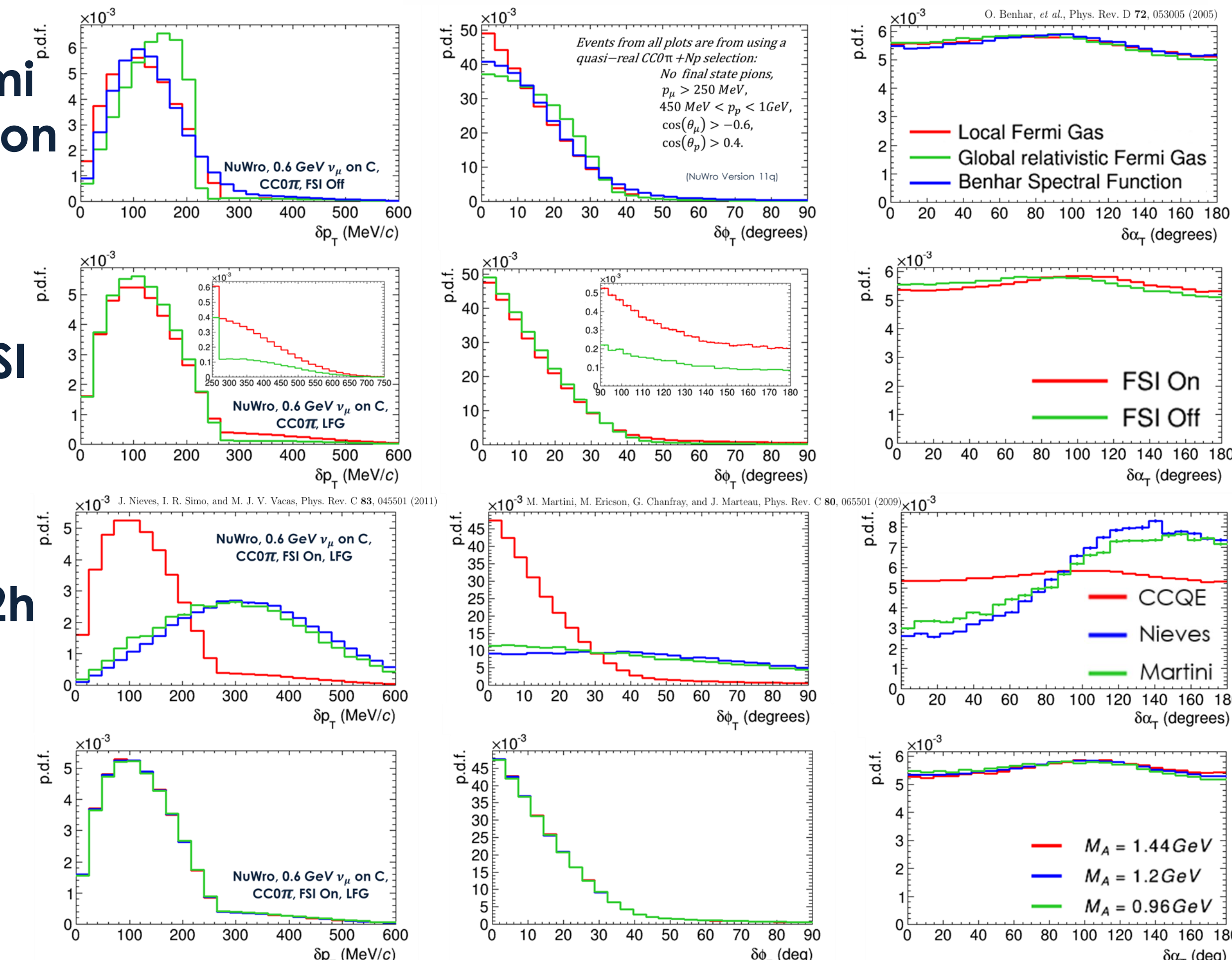


- For simple ν - n scattering, any deviation from $\delta p_T = 0, \delta \phi_T = 0$ is caused by **nuclear effects**.
 - Sensitivity to nuclear effects maintained when STV formed from accessible $CC0\pi$ events.
 - STV are shape invariant under changes to dominant CCQE cross-section parameter, M_A .
- **Measuring STV provides a direct probe of nuclear effects.**

Fermi Motion

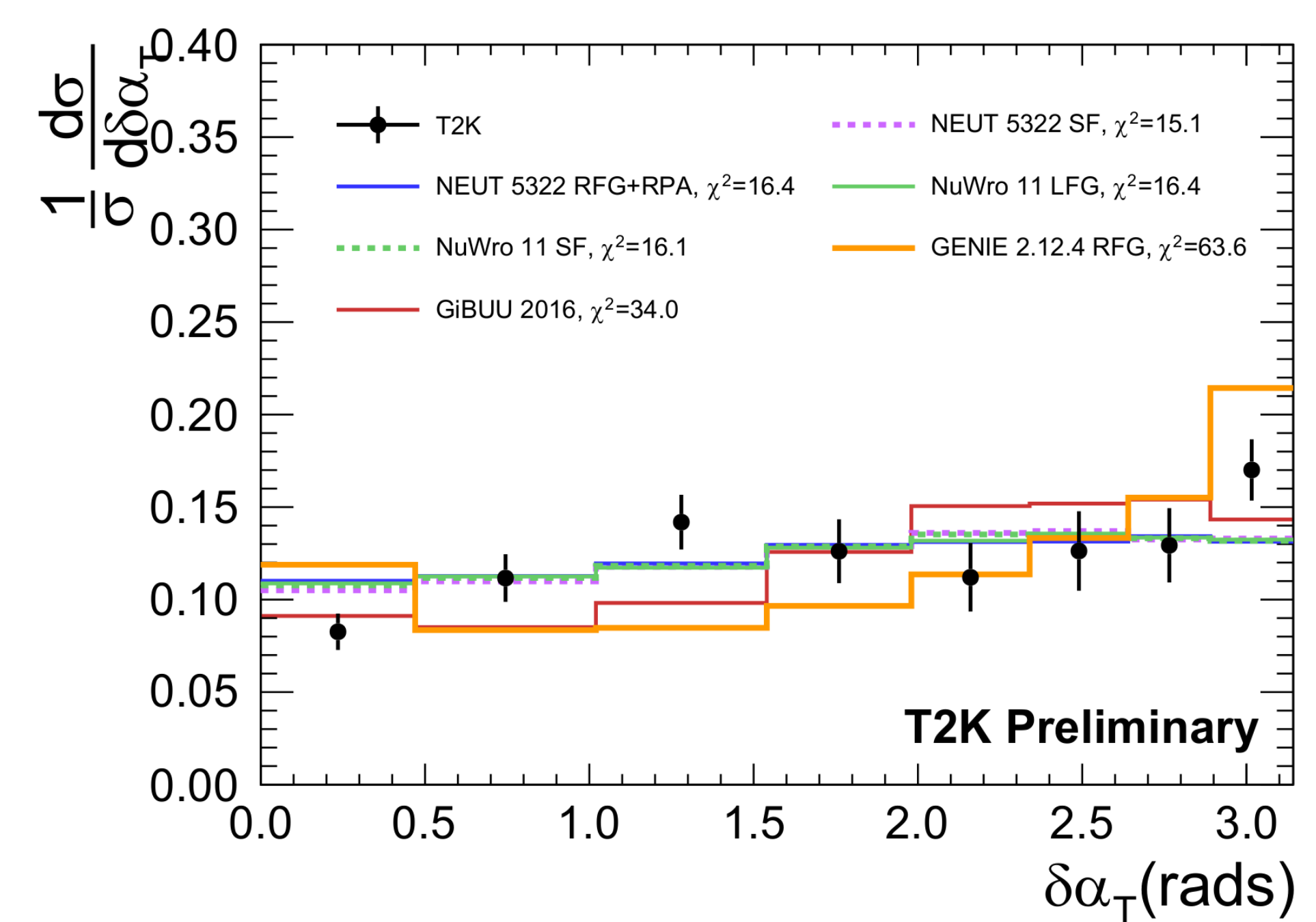
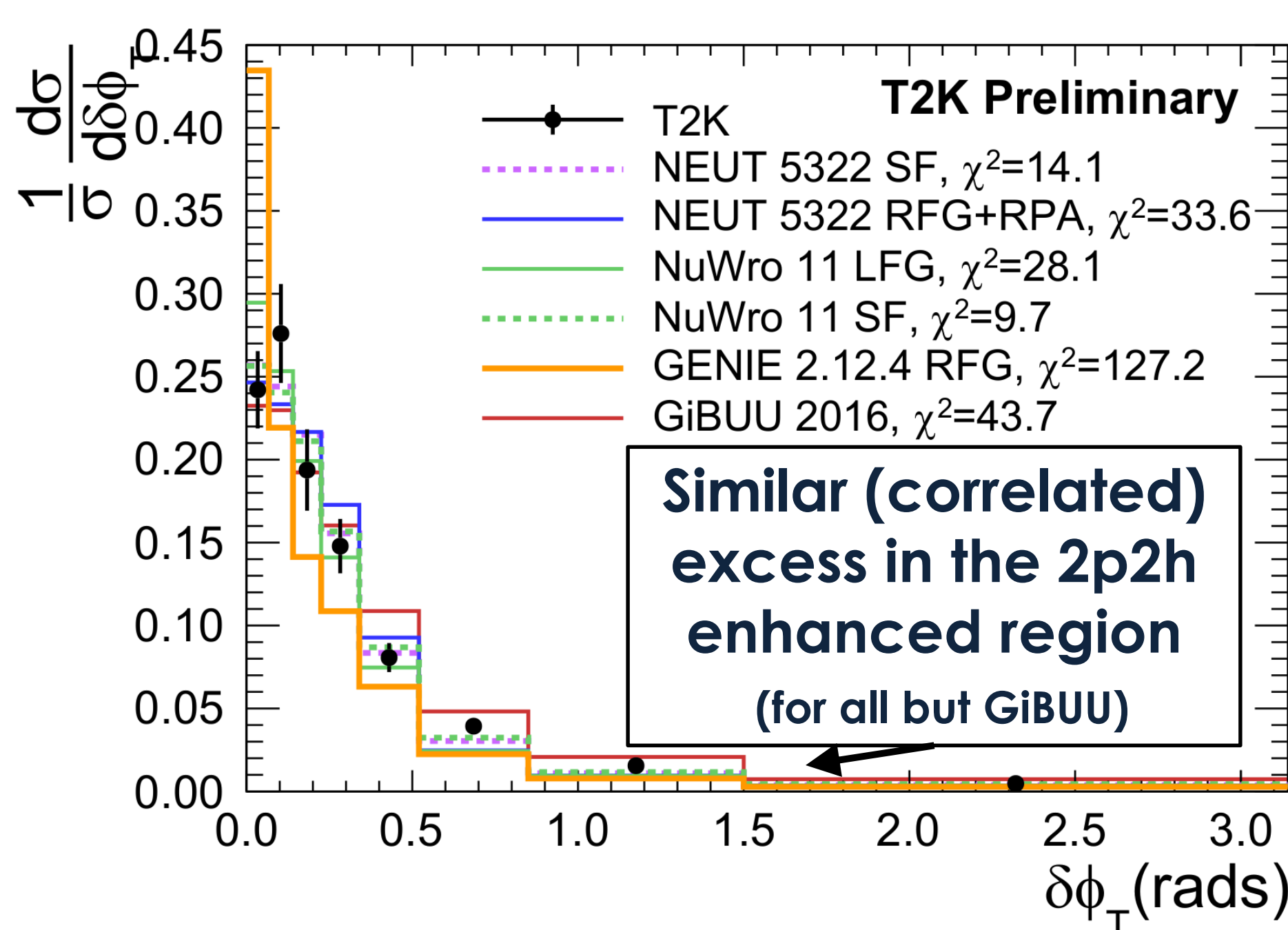
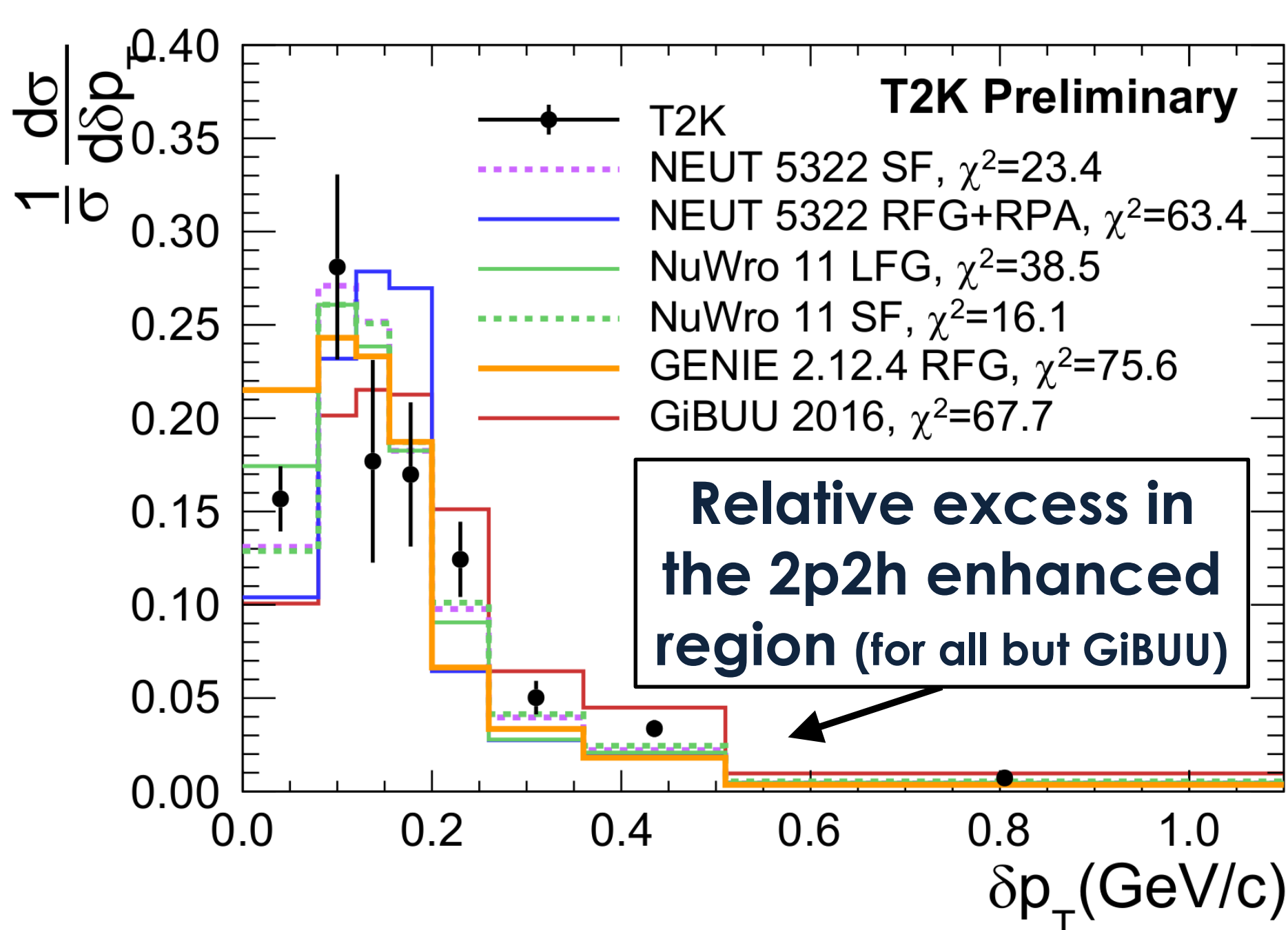
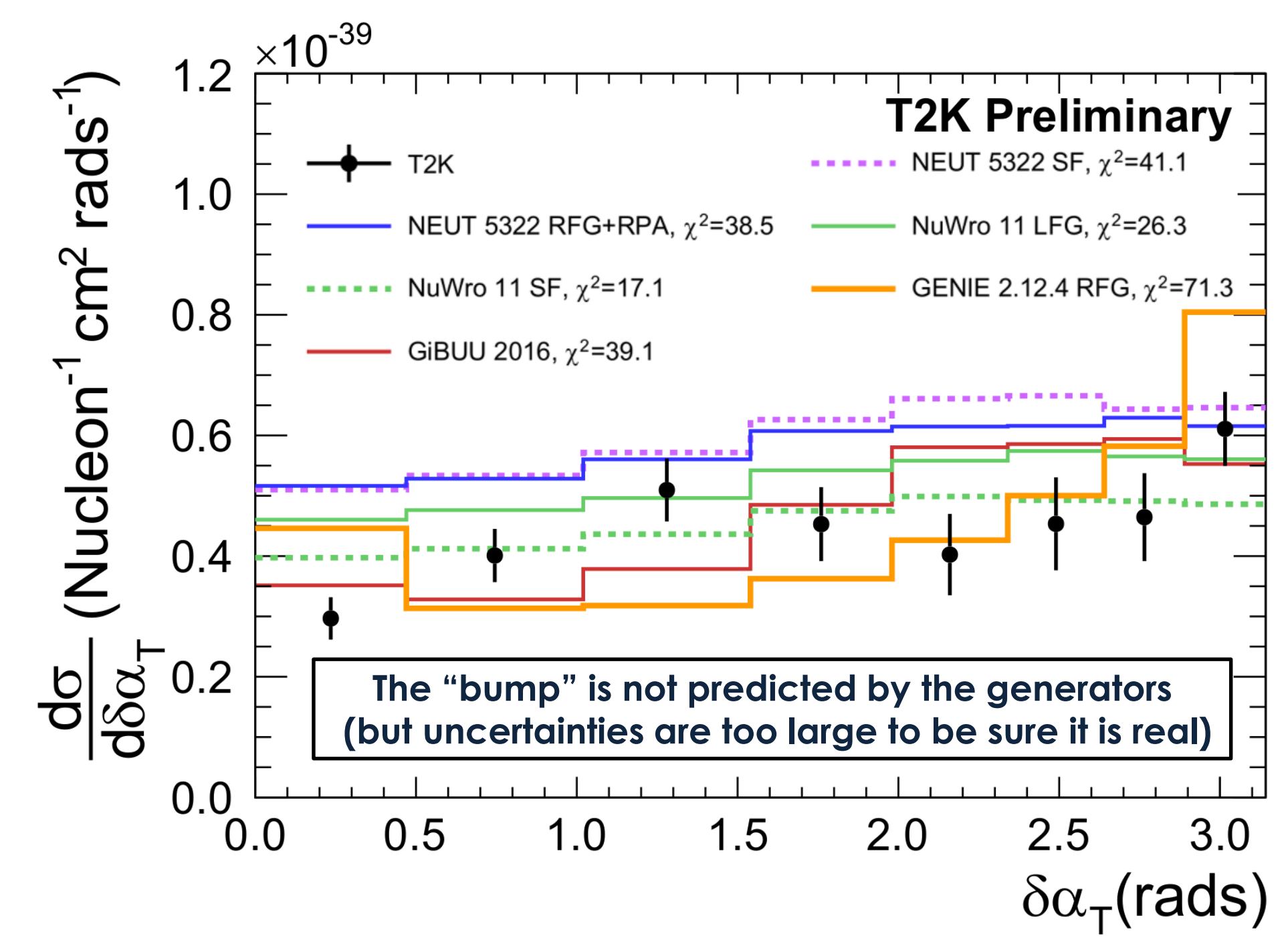
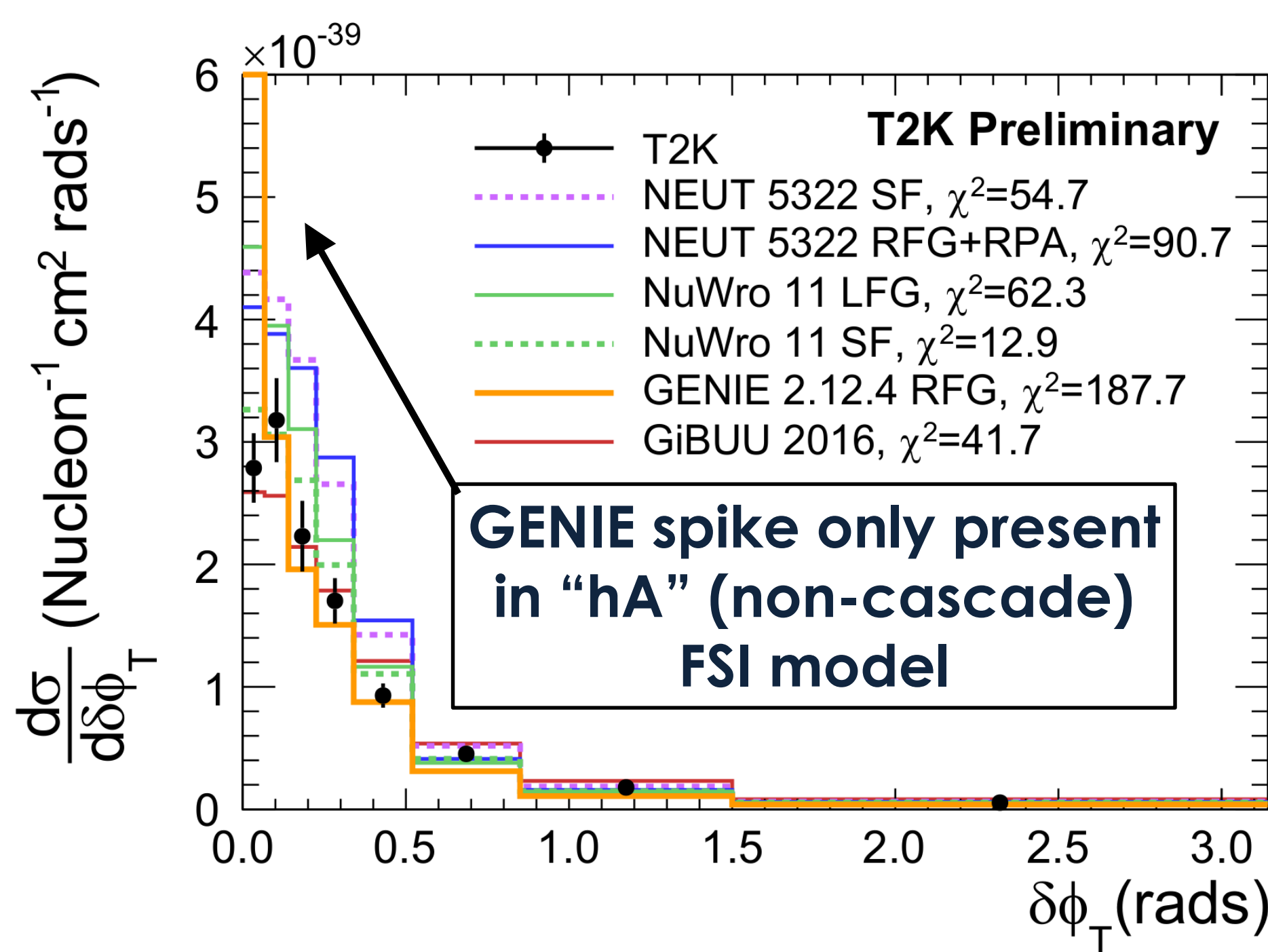
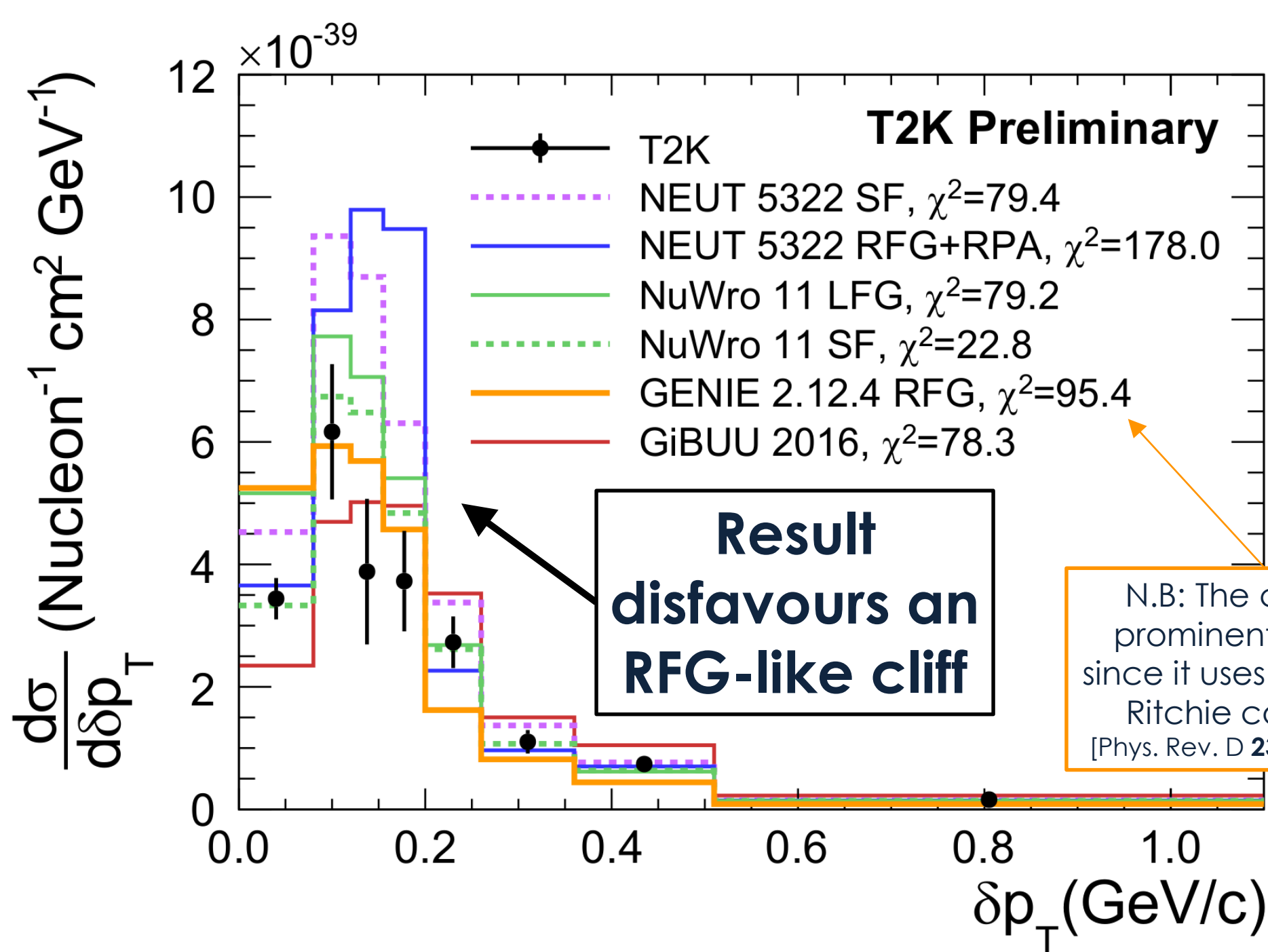
FSI

2p2h



Measuring the Single Transverse Variables

- We measure a fiducial differential $CC0\pi + Np$ ($N \geq 1$) cross section on CH using FGD1 and the TPCs.
 - $p_\mu > 250 \text{ MeV}, \cos(\theta_\mu) > -0.6, p_p > 450 \text{ MeV}, p_p < 1 \text{ GeV}, \cos(\theta_p) > 0.4$
- The cross-section extraction is via a binned likelihood fit of the number of signal events.
 - Data-driven regularisation and little other use of signal simulation → **minimal model dependence**



Conclusions

- Results lift important degeneracies:
 - Shape:** indep. of M_A^{QE} and RPA → tells us about: nucleon FSI, 2p2h and Fermi Motion
 - Full cross section:** normalisation is sensitive to: nucleon FSI and M_A^{QE}
- Results favour a 2p-2h contribution and prefer an SF or LFG nuclear model over RFG+RPA.

Characterised by separate STV features

Model separation

* X.-G. Lu, L. Pickering, S. Dolan et. al. (2015), "Measurement of nuclear effects in neutrino interactions with minimal dependence on neutrino energy", Phys. Rev. C **94**, 015503