Characterizing 2p2h interactions using low momentum protons

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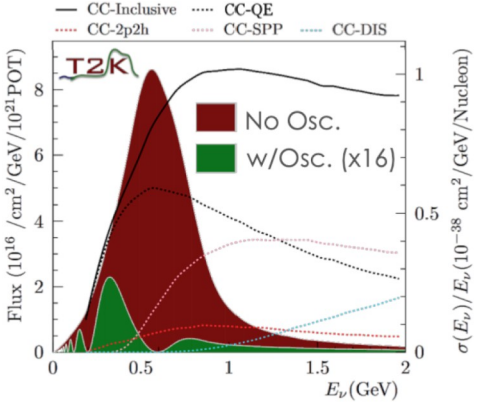
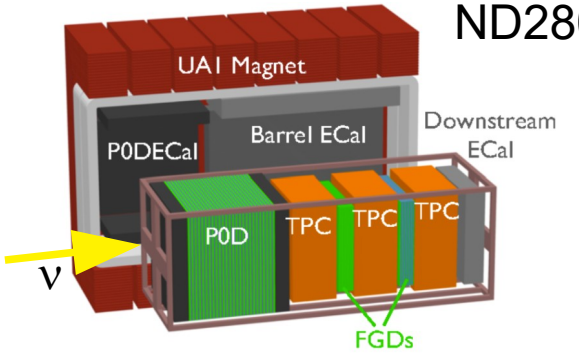
on behalf of the T2K Collaboration

ν interactions in Near Detector

- Measures unoscillated ν flux in order to predict spectrum in the far detector

- Thanks to large statistics of collected data measure cross-sections for neutrino interactions



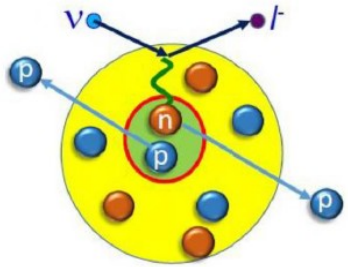


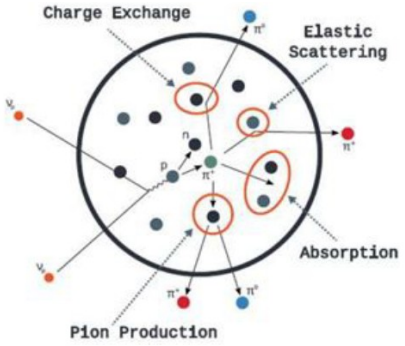
- interactions on correlated nucleon pairs called 2p2h together with Fermi motion and Final State Interactions affect protons leaving the nucleus after interaction

- 2p2h are important uncertainty for oscillation fit

- 2p2h measured by the global near detector fit

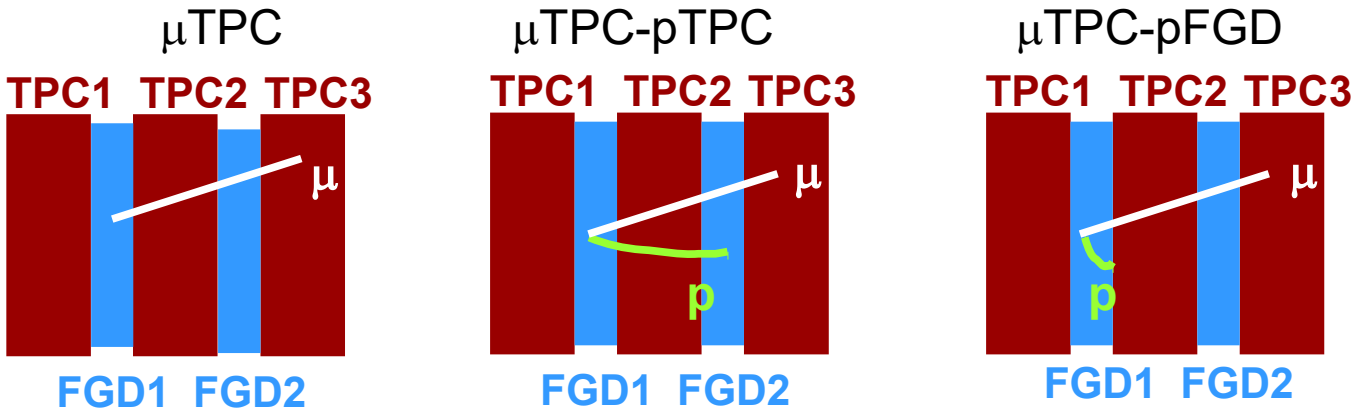
- Characterized by protons which leave nucleus after the interaction



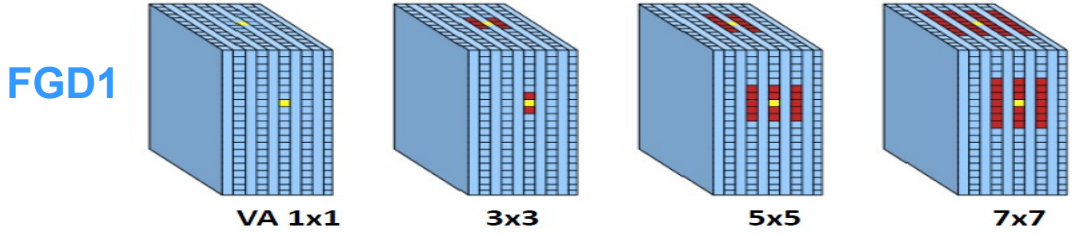


Samples used for analysis

- **Define sub-samples** depending on reconstructed proton track in CC0π selection

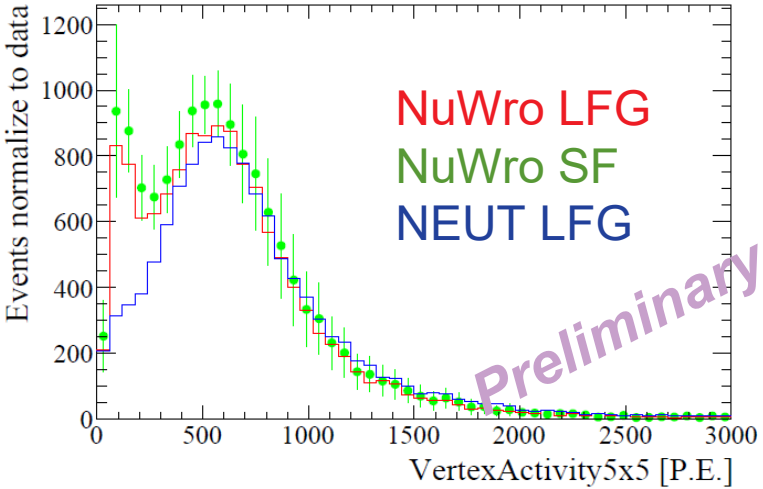


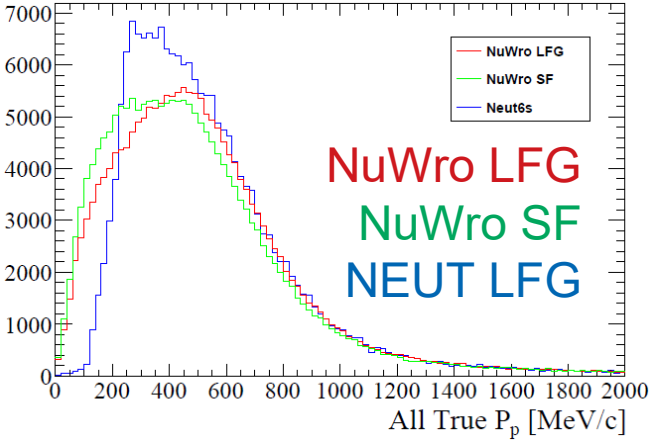
- **Vertex Activity** – energy deposits near the neutrino interaction vertex



- **Compare generators**: NEUT, NuWro Local Fermi Gas, NuWro Spectral Function

Simulate low momentum protons



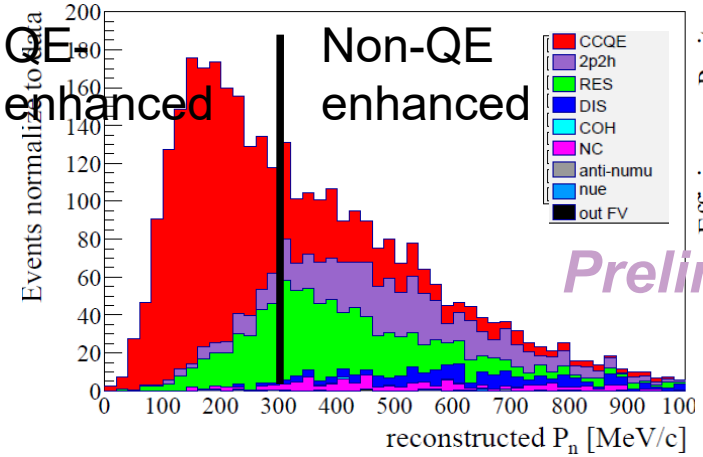


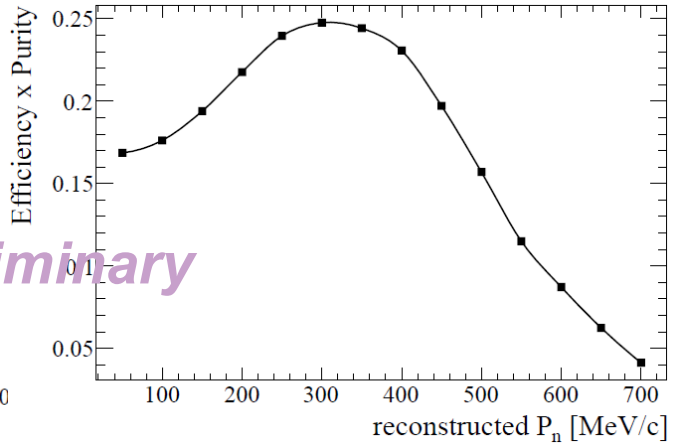
μTPC sub-sample with reconstrcuted μ track only, protons below threshold for track reconstr.

- Low values of Vertex Activity (VA) shows differences between generators. Difference between NEUT and NuWro SF is bigger then statistical+systematic (flux+detector) uncertainty.
- Difference in VA related to different distribution of generated proton momentum, NEUT and NuWro. NEUT is falling down very fast around 200MeV/c.

Sample with reco. proton in TPC

Reconstruct target neutron momentum *Phys.Rev.C 95:065501,2017*:





Select 2p2h-enhanced region

Optamized cut:

$P_{neutron}$ > 300 MeV/c

NuWro SF

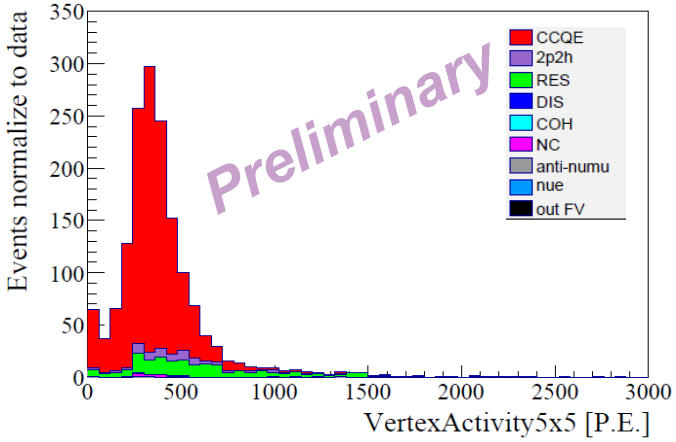
Interaction	Total	non-QE enhanced	QE enhanced
CCQE	0.54	0.27	0.82
RES,DIS	0.26	0.38	0.13
2p2h	0.17	0.28	0.04
Other	0.03	0.07	0.01

Characterizing 2p2h signal

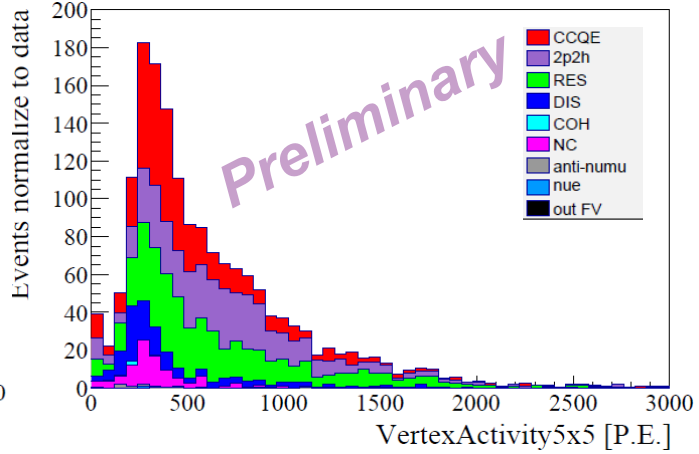
Sample with rec. proton track

Check if QE-enhanced region describes data and compare non-QE enhanced region with ν data

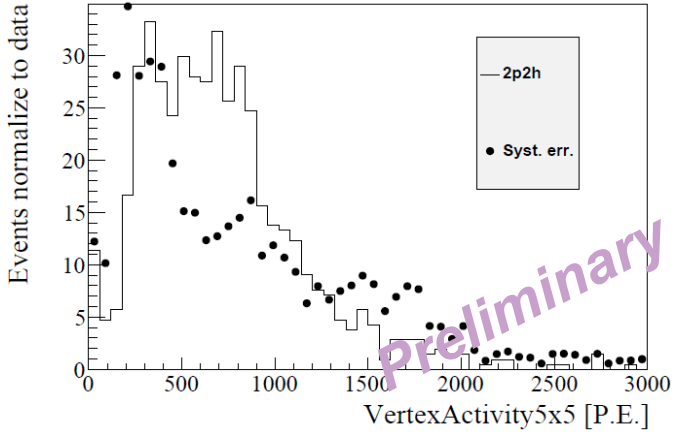
QE enhanced



non-QE enhanced



2p2h contribution is bigger than flux+detector uncertainty of the Vertex Activity measurement, so we can see low momentum protons from 2p2h within the NuWro Spectral Function generator using the Valencia model



Summary

- 2p2h interactions are important for oscillation analysis and are characterized by protons which leave nucleus after interaction
- Selection which base on reconstructed proton tracks was developed
- Low momentum protons are detected using energy deposited near the neutrino interaction vertex – Vertex Activity
- Sample with reconstructed muon track only will be used to verify generator model depending on protons with low momenta which affect Vertex Activity distribution
- Sample with reconstructed muon track will be used to characterize non-QE events enhanced with 2p2h interactions using low momentum protons seen in Vertex Activity