



Impact of HF-CRPA CCQE model on the latest NOvA results

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NOvA Experiment

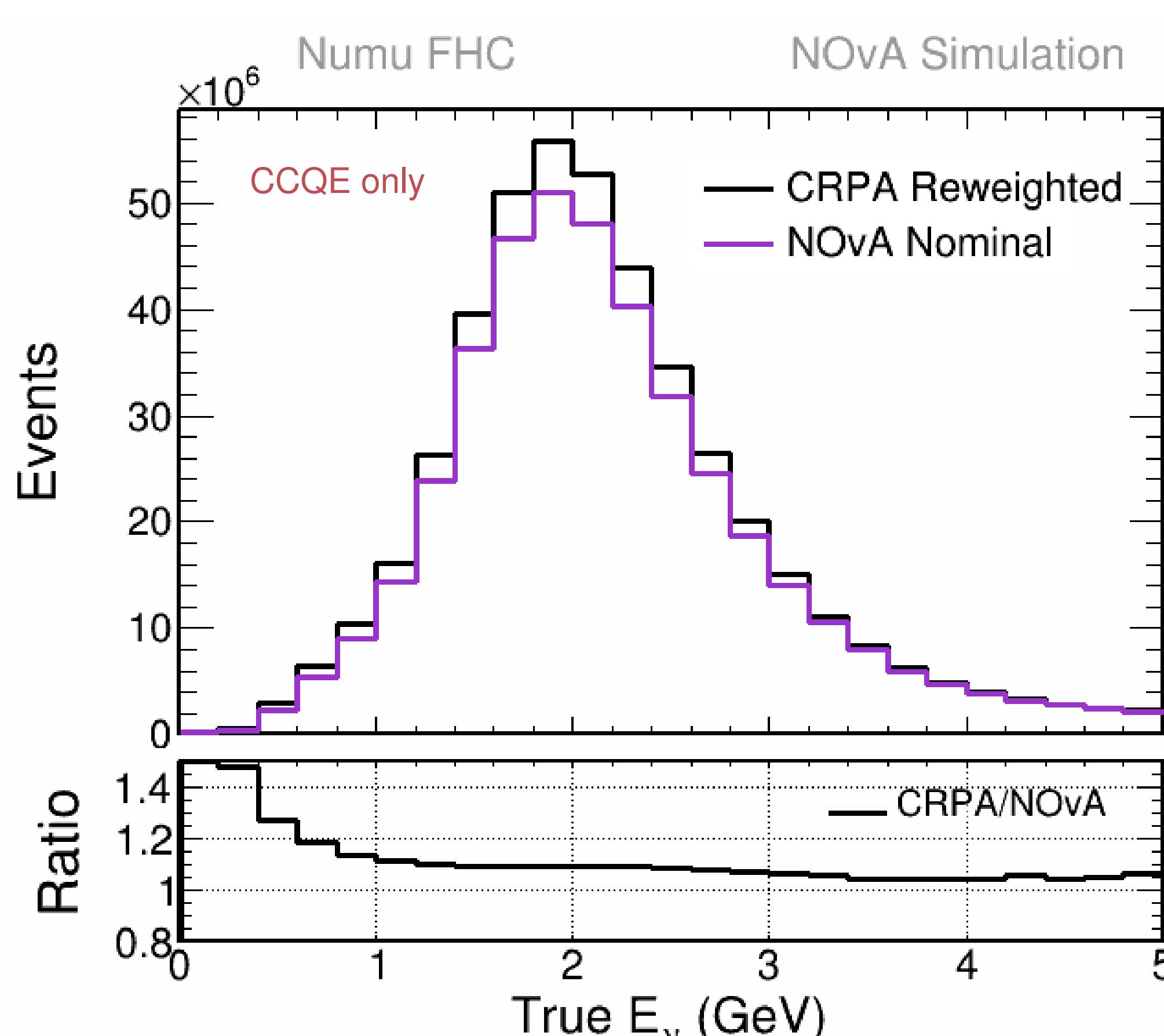
- The NuMI off-axis ν_e Experiment (NOvA) [1] is a long-baseline neutrino oscillation experiment
- Two identical liquid scintillator detector
- The near detector (ND) is at Fermilab, whereas the far detector (FD) is at Ash River, Minnesota, 810 KM away from Fermilab
- It is designed to measure three flavor oscillation parameters
- Uses NuMI neutrino beam of energy peaked at 2 GeV

Interaction model used in NOvA

- NOvA uses GENIE model-dependent simulations to extrapolate FD oscillated predictions from ND data
- It uses the GENIE 3.0.6 with NOvA tuned configuration N18_10j_00_000
- Model used for interaction
 - Quasi-elastic interaction (QE)**: Valencia 1p1h Z-expansion axial form factor
 - Resonance interaction (RES)**: Berger-Seghal
 - Deep inelastic interaction (DIS)**: Bodek Yang
 - Meson Exchange Current (MEC)**: Valencia MEC custom adjustment to NOvA data for 2p2h
 - Final state interaction (FSI)**: hN Semi Classical Cascade Custom fit to external pion scattering data

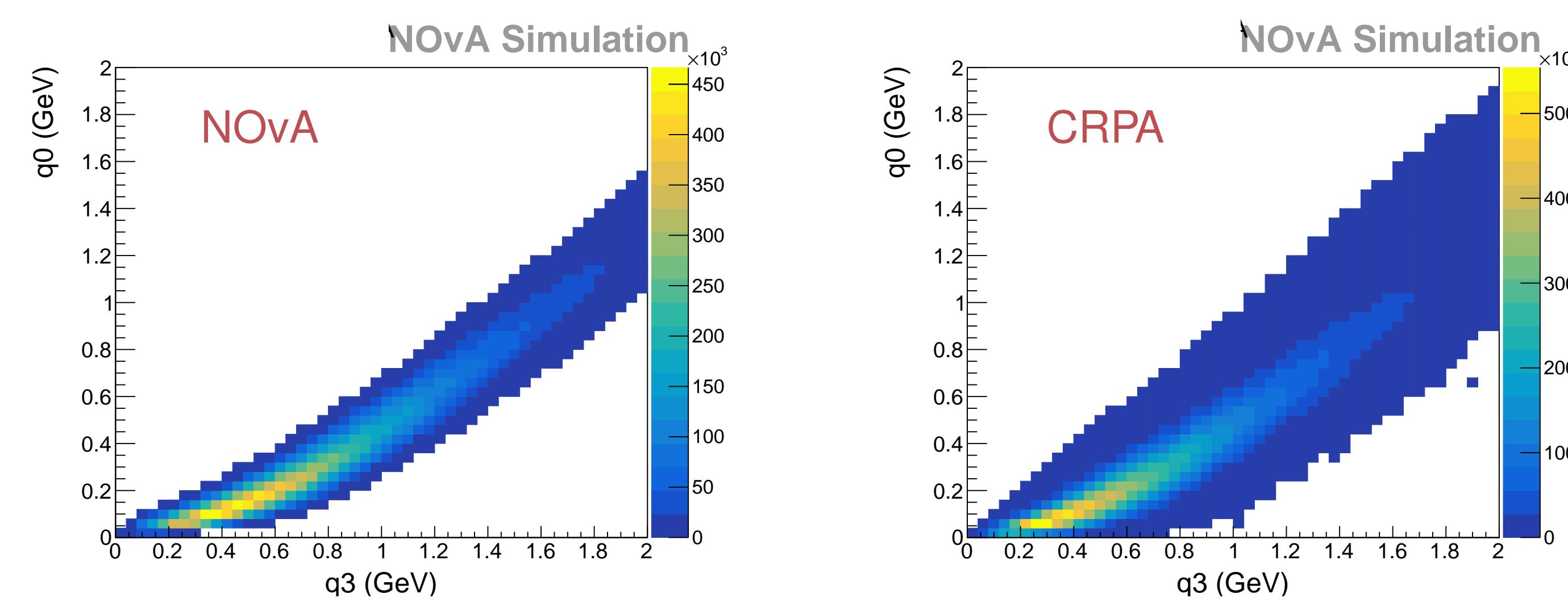
HF-CRPA CCQE model

- The current model used in NOvA is good at describing the general behavior of the QE cross-section
- But it can not describe low momentum transfer region very accurately.
- The Hartree-Fock (HF) mean field model for charge current QE with continuum random phase approximation (CRPA) [2] does a good job in that region
- It enhances the cross-section in the low energy region significantly and overall $\sim 8\text{-}10\%$ increase in cross-section



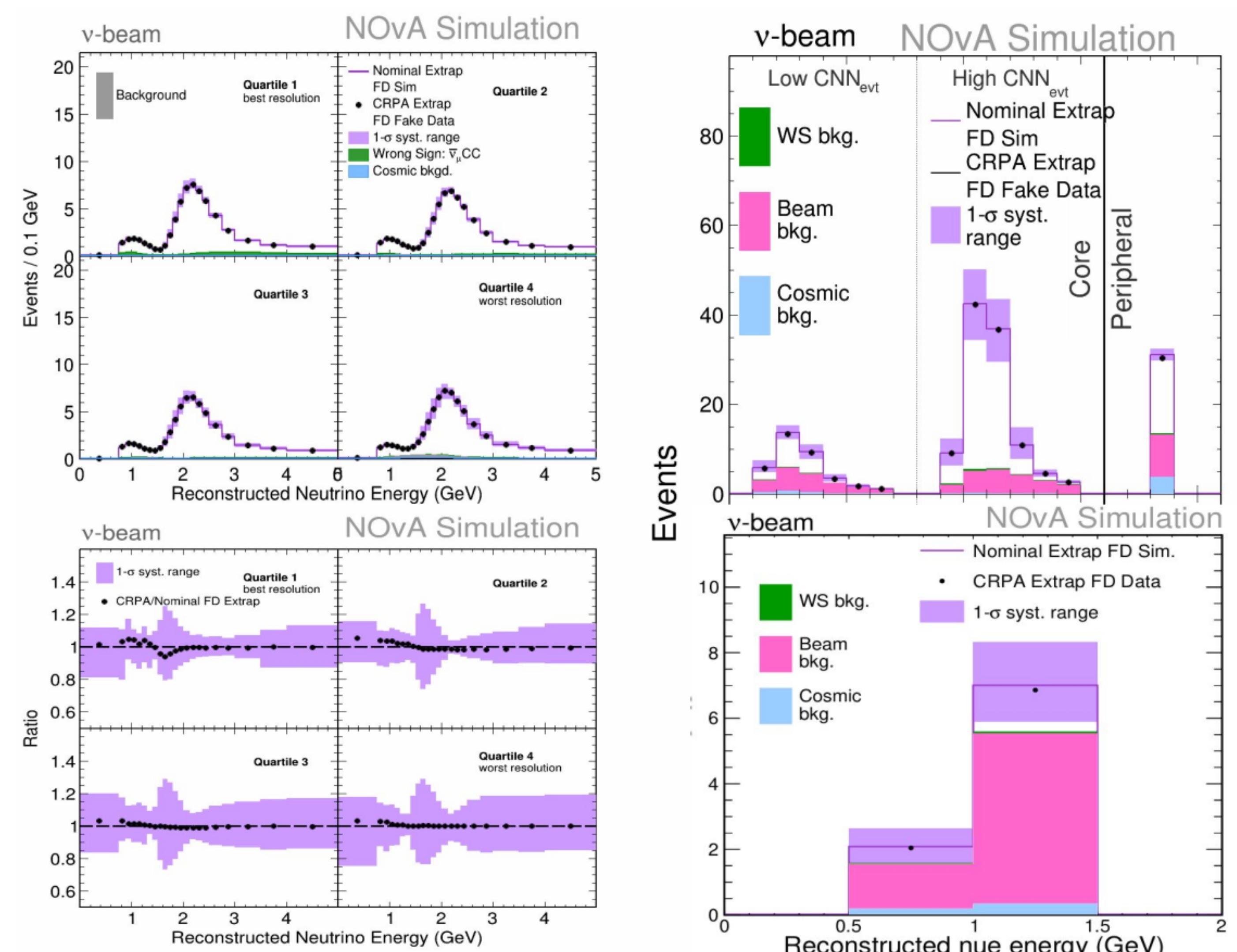
Implementation of HF-CRPA model in NOvA

- Used GENIE G21_11a_00_000 tune with CRPASuSAv2Hybrid-QEL model for QE [3]
- Took the ratio of CRPA sample with the NOvA tuned sample in q0-q3 phase space and reweighted NOvA tuned sample with the ratio
- Due to the mismatch in phase space of these two samples, the phase space in the lowest q0 bin was modified a little bit



Impact on the FD extrapolated prediction

- ND sample is reweighted with CRPA to NOvA ratio and then made the extrapolated prediction at the FD



Summary

- The HF-CRPA model provides $\sim 10\%$ enhancement in the CCQE scattering cross-section
- This has a relatively strong effect in the quartile 1 of FD extrapolated numu
- Overall, the CRPA extrapolated fake data are well within NOvA uncertainty.
- It has a very tiny effect on oscillation parameters
 - Δm_{32}^2 : resulting bias $\sim 0.1\%$ ($\sim 7\%$ of 1σ interval)
 - $\sin^2 \theta_{23}$: resulting bias $\sim 0.4\%$ ($\sim 4\%$ of 1σ interval)

KEY REFERENCES

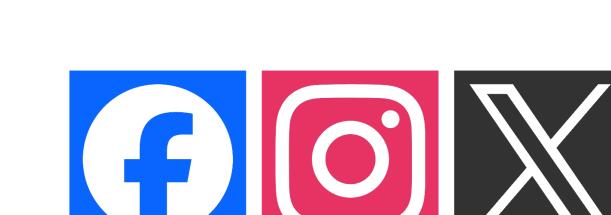
[1] P. Adamson et al., Phys. Rev. D 93, 051104 (2016)
 [2] Pandey, V. et al., Phys. Rev. C 92, 024606 (2015)
 [3] Dolan, S. et al., Phys. Rev. D 106, 073001 (2022)

ACKNOWLEDGEMENT

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