



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

Amit Pal, Sanjay Swain, NISER, Bhubaneswar, India
Bryan Ramson, Fermilab

FERMILAB-POSTER-24-0149-PPD



NOvA Experiment

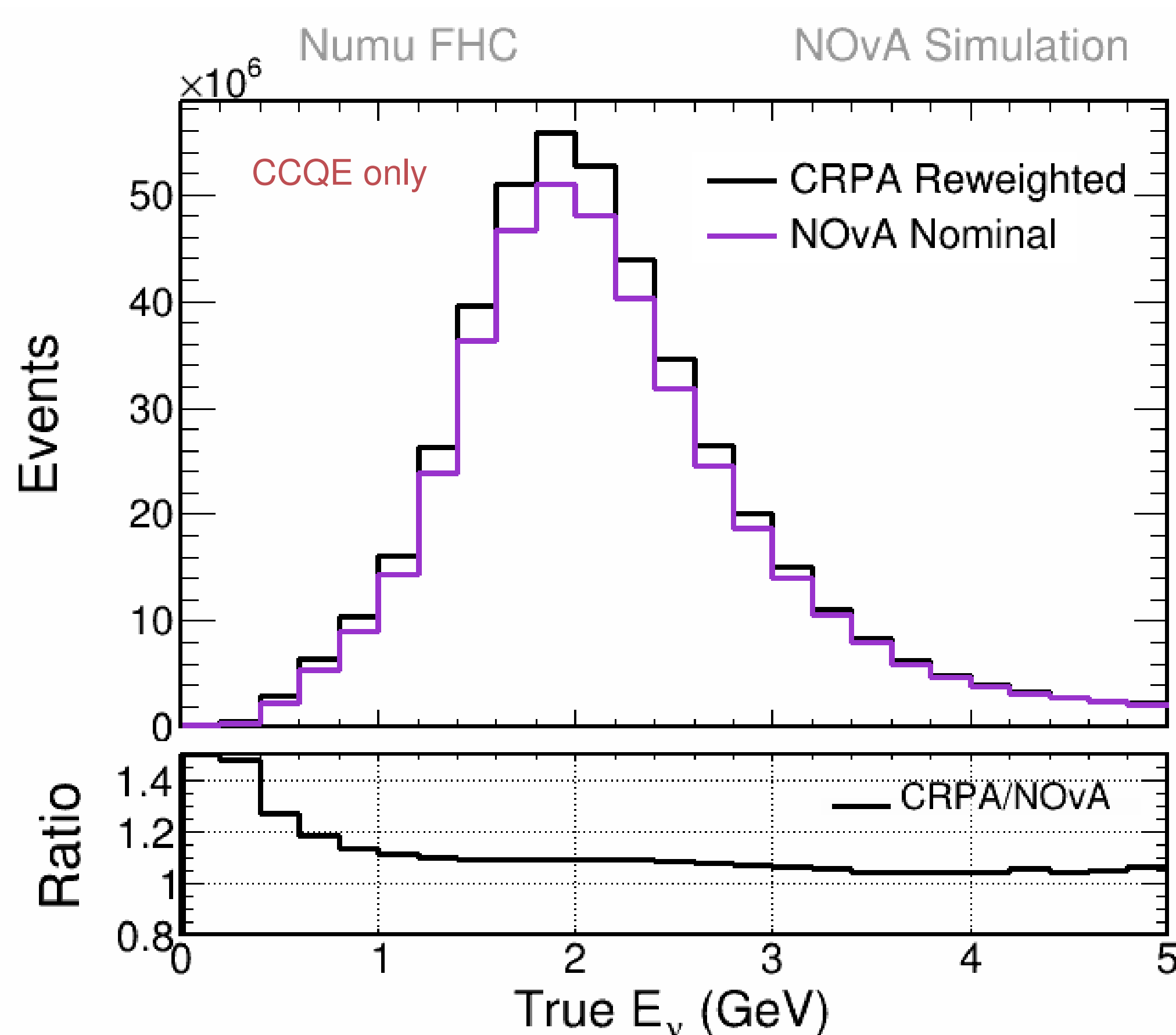
- The NuMI off-axis ν_e Experiment (NOvA) [1] is a long-baseline neutrino oscillation experiment
- Two identical liquid scintillator detector
- The near detector (ND) is at Fermilab, whereas the far detector (FD) is at Ash River, Minnesota, 810 KM away from Fermilab
- It is designed to measure three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

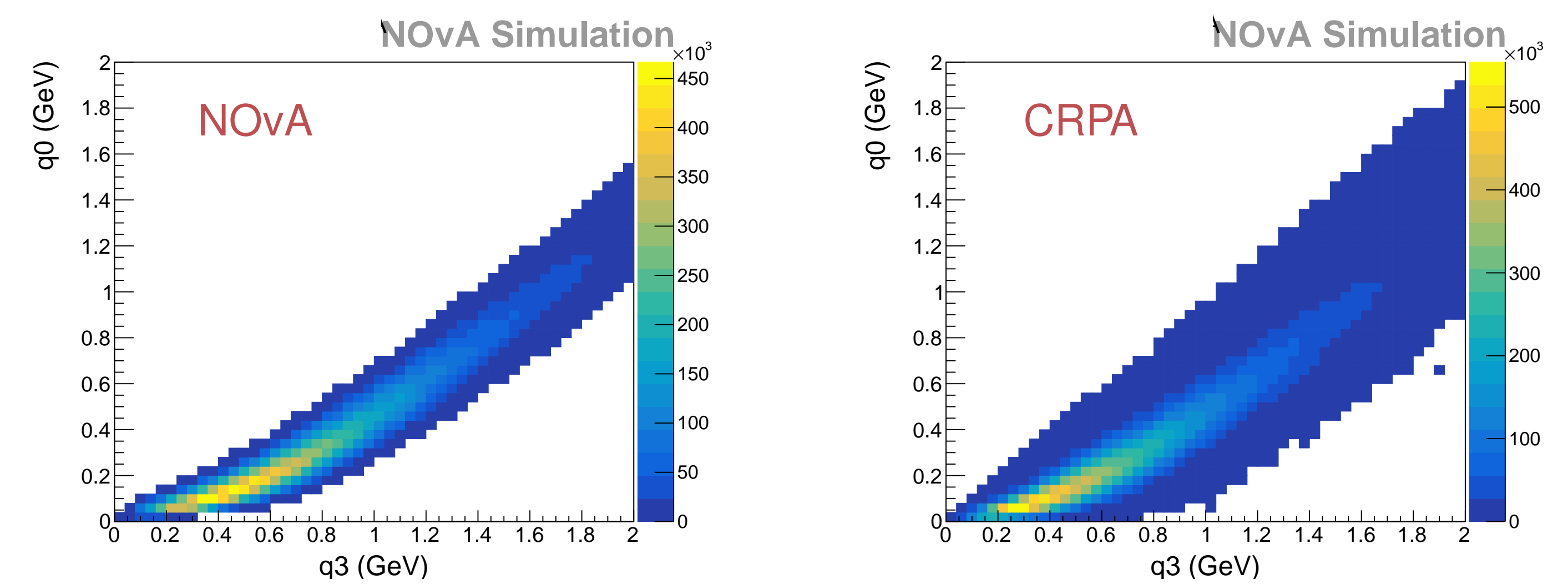
HF-CRPA CCQE model

- 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 $\sim 8-10\%$ increase in cross-section



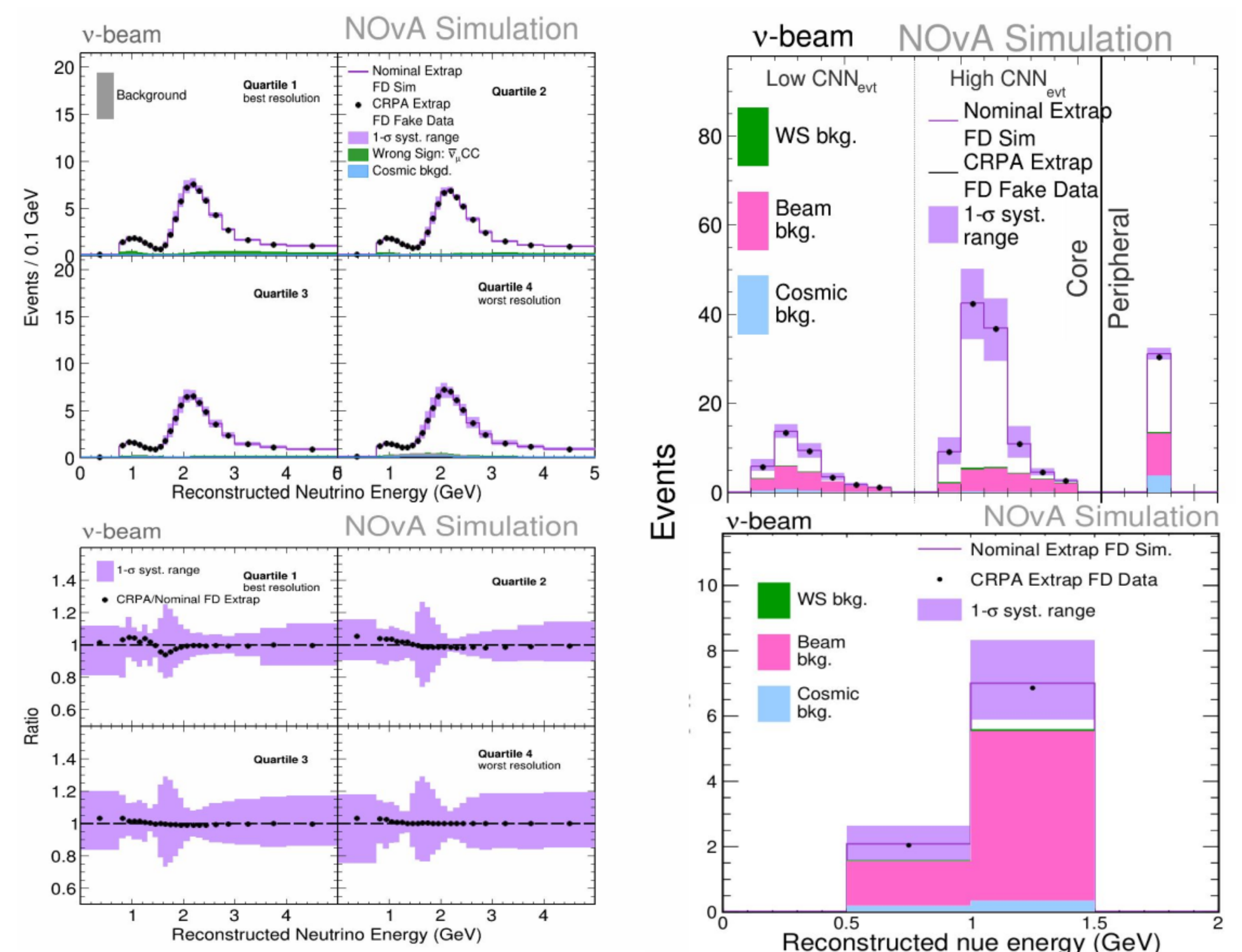
Implementation of HF-CRPA model in NOvA

- 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

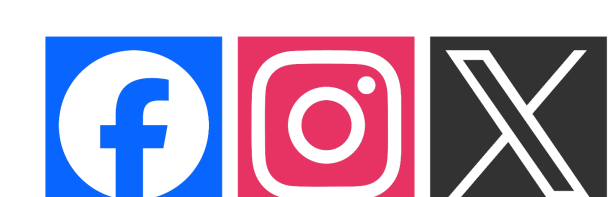
- [1] P. Adamson et al., Phys. Rev. D 93, 051104 (2016)
- [2] Pandey, V et al., Phys. Rev. C 92, 024606 (2015)
- [3] Dolan, S et al., Phys. Rev. D 106, 073001 (2022)

ACKNOWLEDGEMENT

This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.



विज्ञान एवं
प्रौद्योगिकी मंत्रालय
MINISTRY OF
SCIENCE AND
TECHNOLOGY



<https://novaexperiment.fnal.gov>

57th Annual Users
Meeting
July 10-12, 2024

amit.pal@niser.ac.in