

# The NOvA Cross-Section Model, Version 3

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## Introduction

Cross-section modeling is a critical input to neutrino flavor inference in oscillation experiments, yet neutrino cross sections remain under-constrained [1]. Model adjustments in event generators like GENIE provide flexibility whereas off-the-shelf models fall short [2]. NOvA is beginning its third round of adjustments, starting from GENIE v3.4. using Comprehensive Model Configuration (CMC) N24\_20i\_02\_11b based on AR23\_20i\_00\_000—the model used for cross section development on DUNE.

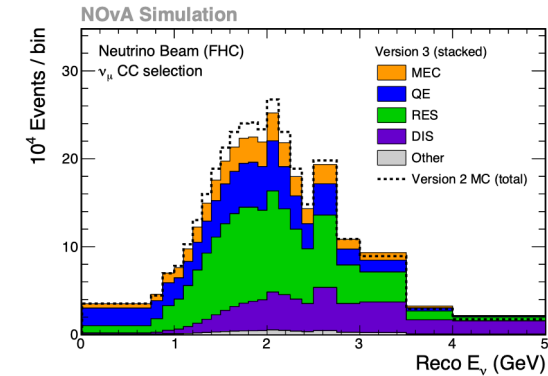


Figure 1: The NOvA Cross Section Model, Version 3, Neutrino Energy. The total reconstructed neutrino energy of the existing model decomposed by interaction channel compared to the total sample distribution of version 2, the outgoing model

This decision represents a major evolution of the modeling efforts of the NOvA Collaboration. For the first time, all Fermilab experiments use slightly different versions of the same underlying cross section model.

NOvA Version	CMC	Initial State	QE	Res	MNI/MEC	DIS	FSI	FSI Tune
Version 2	N18_10j_00_000*	LFG	Valencia	Berger-Seghal	Valencia	Bodek-Yang*	IntraNuke hN2018	None
Version 3	N24_20i_02_11b	LFG*	Valencia*	Berger-Seghal	SuSAv2 2p2h*	Bodek-Yang*	IntraNuke hA2018	Free-Nuke

Table 1: CMC of the NOvA Cross Section Model. The charged current contribution of the new CMC compared to the contents of the old model. \*Asterisks indicate sight changes to the GENIE standard component. Version 2 is the outgoing model

## Updates to Central Value

### Local Fermi Gas

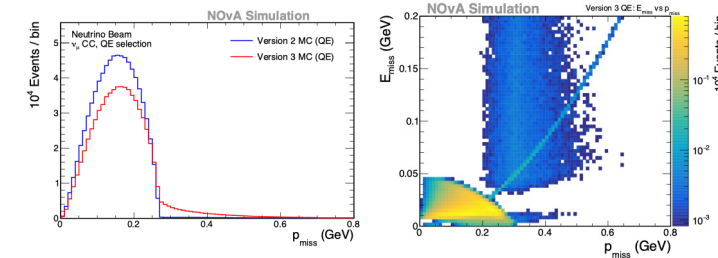


Figure 2: Adjustments to the Local Fermi Gas. Implementation of the NOvA adjustments are primarily in the tail beyond the peak

- Base is DUNE's Local Fermi Gas model
- Added a Maxwell-Boltzman reweightable correlated tail

### 2p2h/MEC

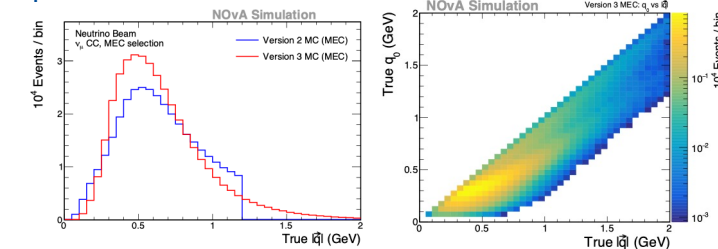


Figure 3: Updates to 2p2h/MEC Channel. The new 2p2h/MEC implementation adds considerable area in true momentum-energy transfer above 1.2 GeV/c

- New implementation adds area in momentum-energy transfer above 1.2 GeV/c
- DUNE model extends MEC into DIS region, improving high energy constraints. [3]

## Updates to Uncertainties

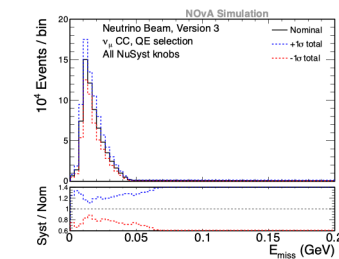


Figure 4: Missing Energy Knobs Implemented in NuSystematics. NOvA has implemented three new parameters— Correlated tail, Linear, and Shift Peak. The effect of all three is shown here.

- Adopted the NuSystematics package, integrated into NOvARwgt
- Shared systematics across Fermilab experiments

## Future Directions

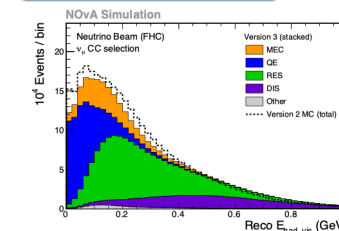


Figure 5: NOvA Cross Section Model, Visible Hadronic Energy. Reconstructed Visible Hadronic energy in Version 3 broken down by interaction channel compared to total sample distribution of Version 2

NOvA is now working on building a new and robust systematics model, with attention on the low visible hadronic energy.

**Stay Tuned!**

## References

[1] Rev. Mod. Phys. 84, 1307 (2012), arXiv:1706.03621 [hep-ph], arXiv:2511.05413 [hep-ph]  
 [2] arXiv:0905.2517 [hep-ph], arXiv:2104.09179v2 [hep-ph], arXiv:2006.08727v3 [hep-ex]  
 [3] arXiv:2203.12308 [nucl-th]

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