

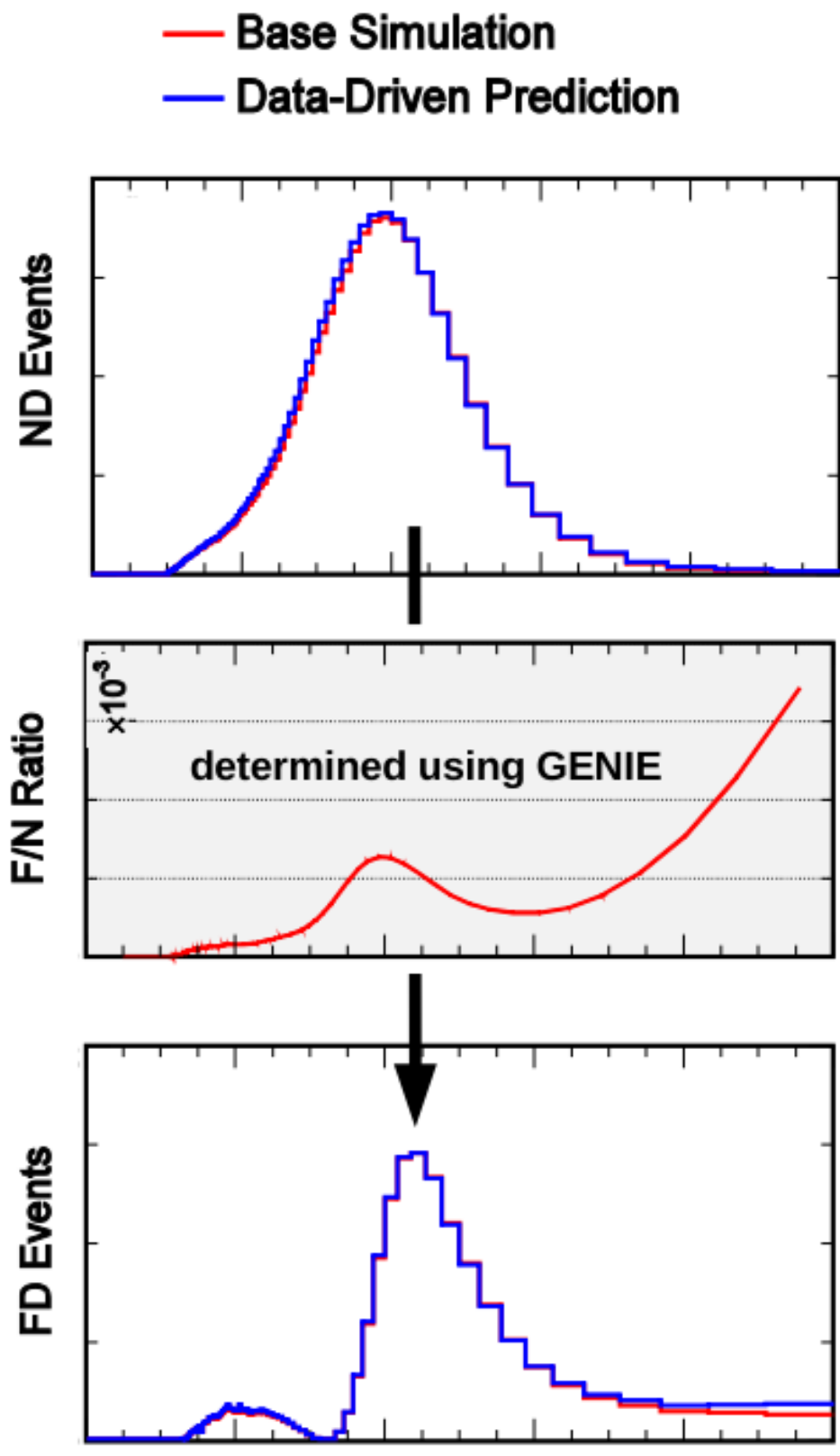
Neutrino Interaction Model Tuning at NOvA

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Introduction

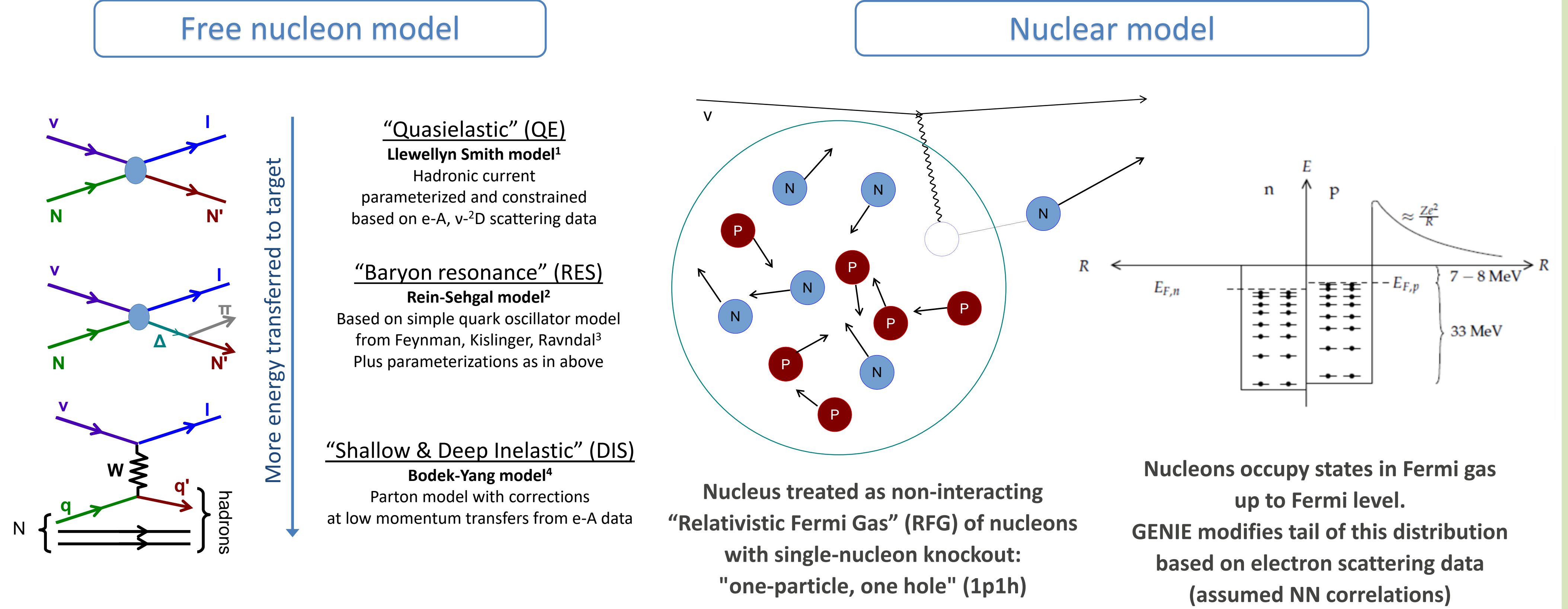


NOvA uses full beam and detector simulations based on the GENIE neutrino event generator to extrapolate from near detector (ND) data into far detector (FD) neutrino oscillation predictions.

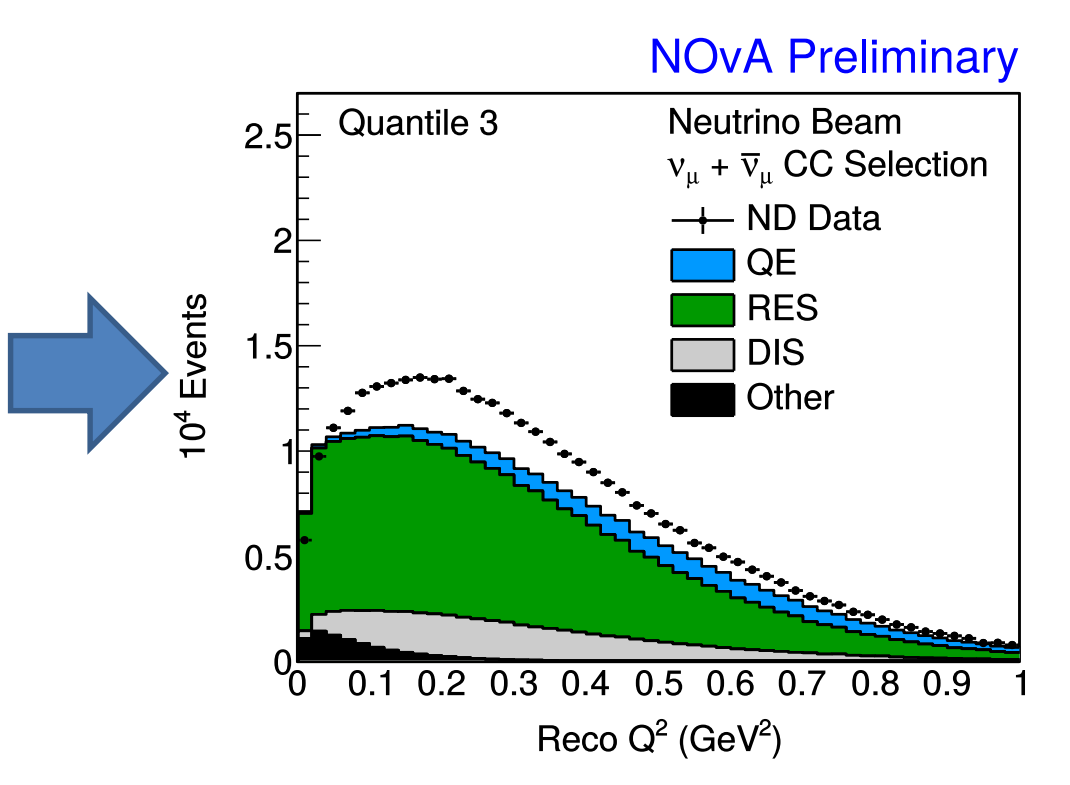
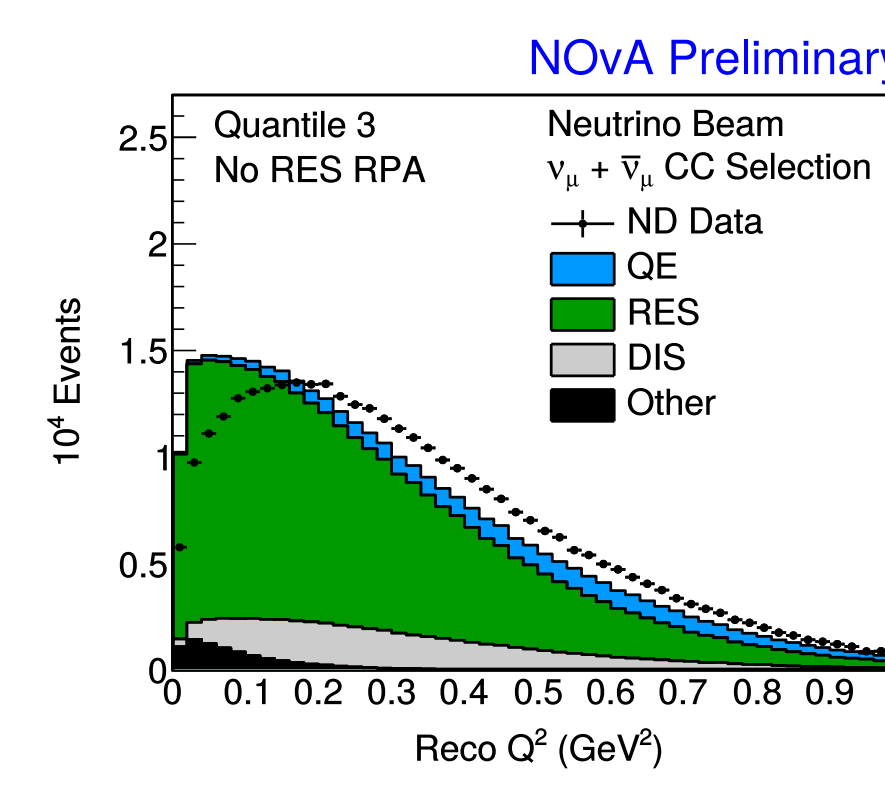
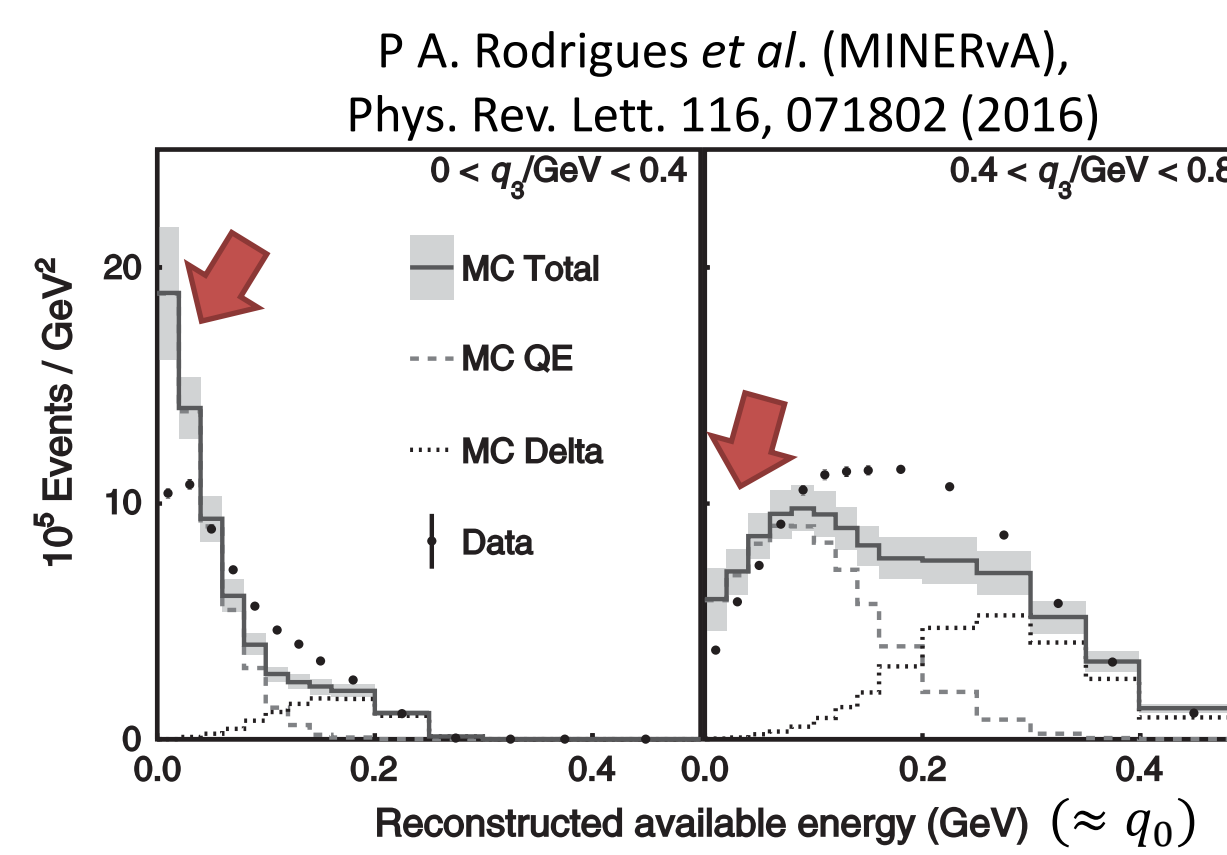
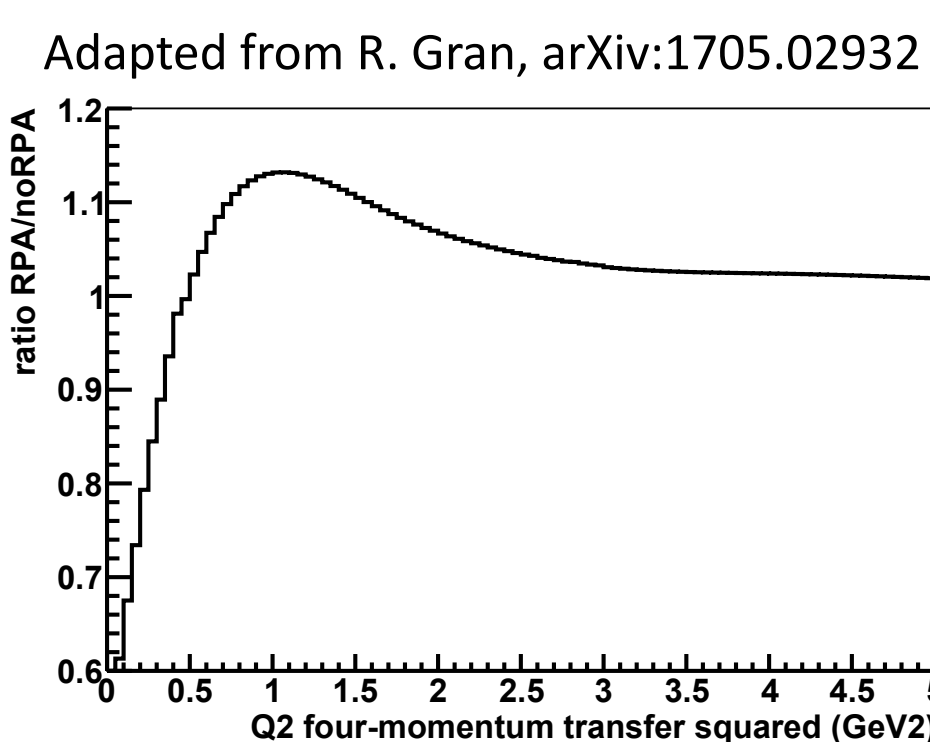
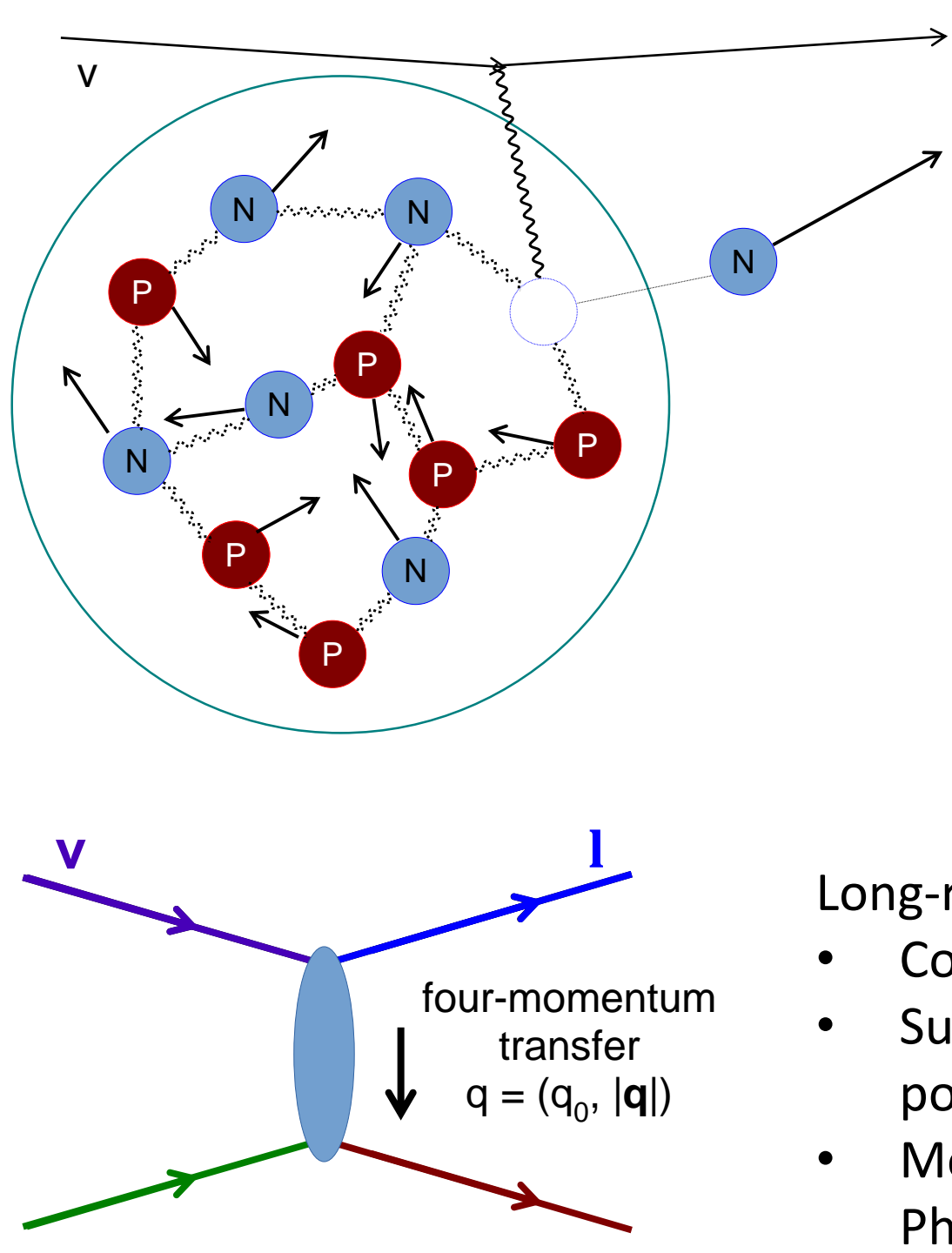
Neutrino interaction model uncertainties are important uncertainties in the NOvA oscillation analyses (see R. Pratap Gandrajula & M. Groh, Poster #81)

Base model

GENIE 2.12.2's base model consists of two "layers":



Adjustments to Base Model: Long-Range Correlations



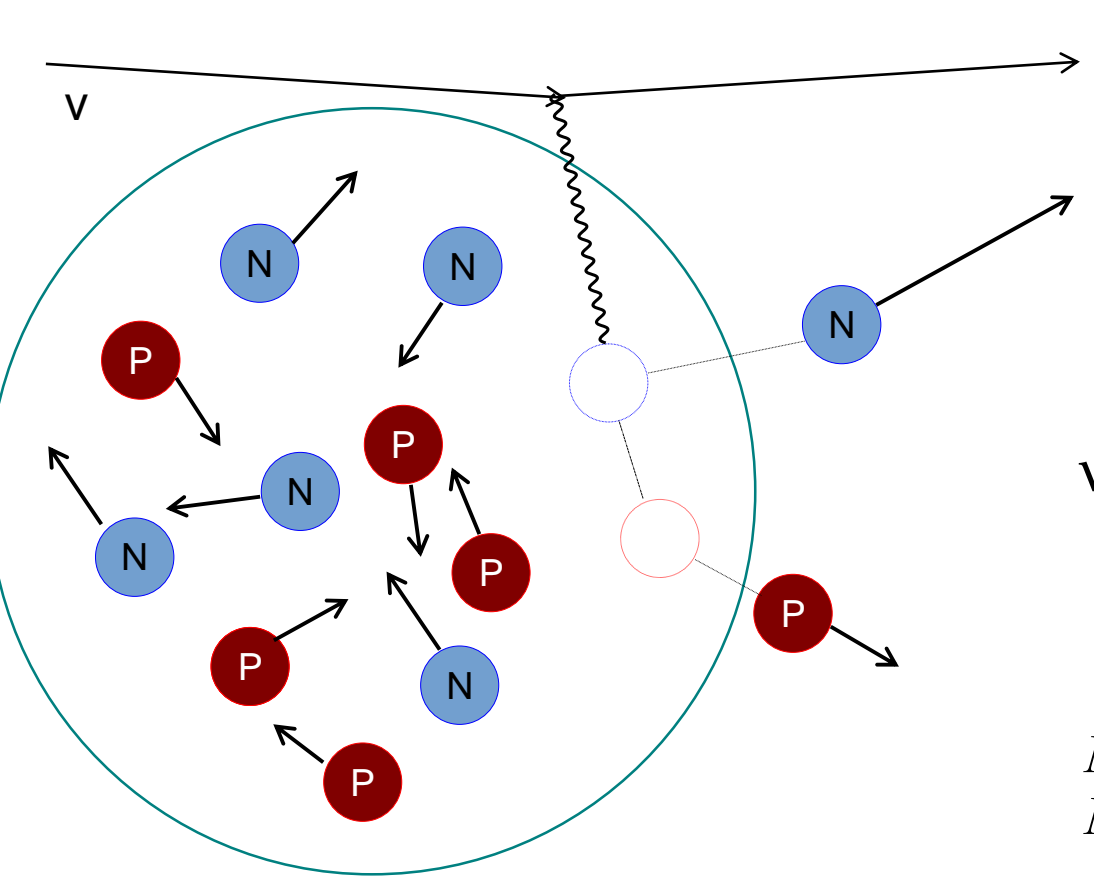
Long-range nucleon correlations:

- Collective excitations of the whole nucleus
- Suppress (enhance) the free nucleon interaction potential at low (higher) $Q^2 = -q^2$ relative to RFG
- Modeled for QE scattering using the Random Phase Approximation (RPA)

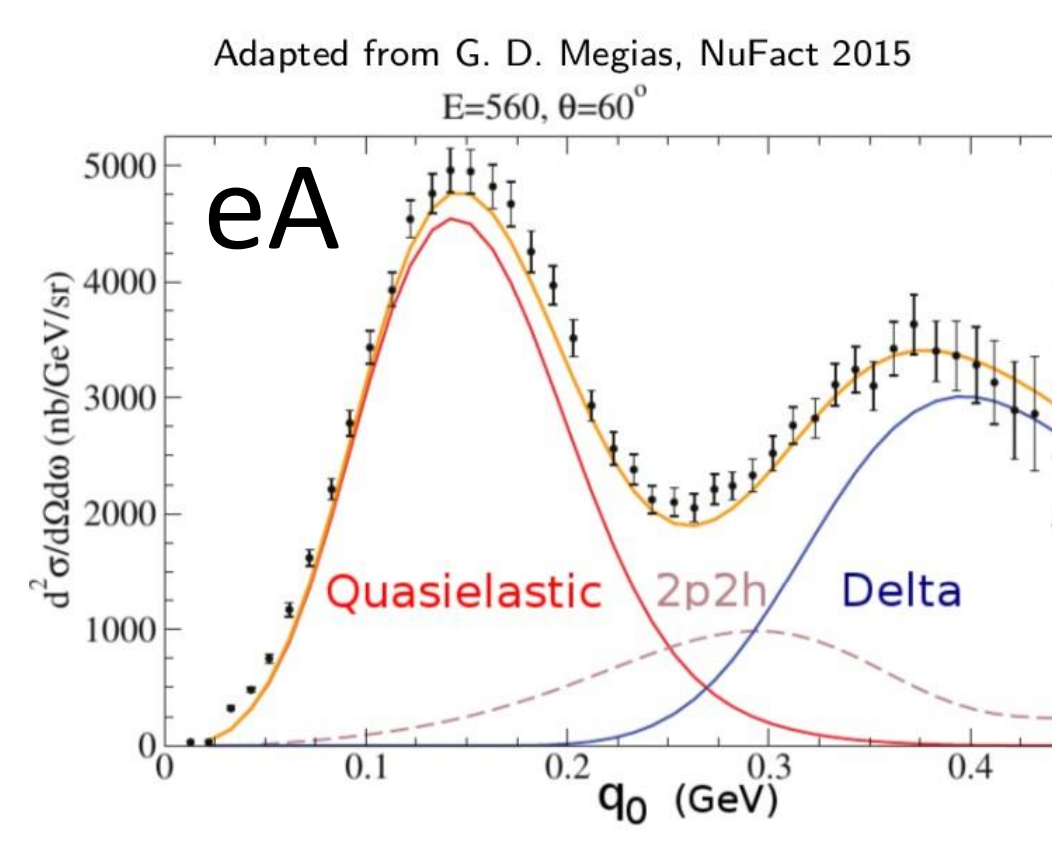
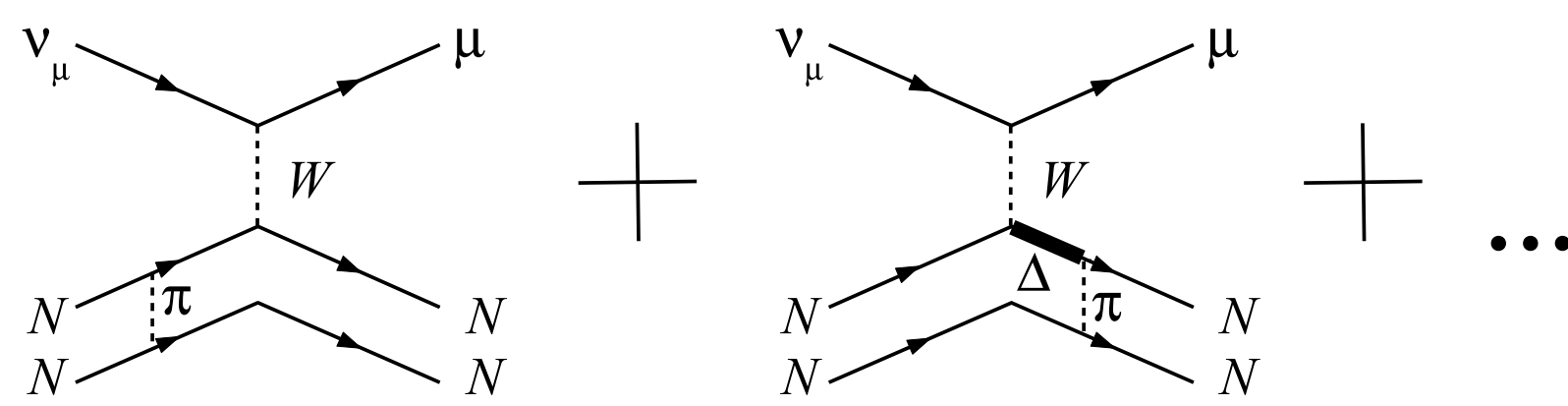
- Relative to RFG treatment of the nucleus, neutrino scattering data exhibit a deficit at low $(q_0, |q|)$ characteristic of long-range nucleon correlations
- Above: MINERvA ν_μ CC data vs. GENIE

- NOvA applies the València RPA model for QE scattering⁵ adapted to GENIE's default QE model using code developed by MINERvA⁶
- Long-range correlations are also plausible for RES for similar reasons
- A RPA model for RES does not (yet?) exist
- As a stand-in, NOvA also applies the València RPA model for QE scattering to RES production \rightarrow significantly improves prediction in RES-dominated region

Adjustments to Base Model: Multinucleon Knockout

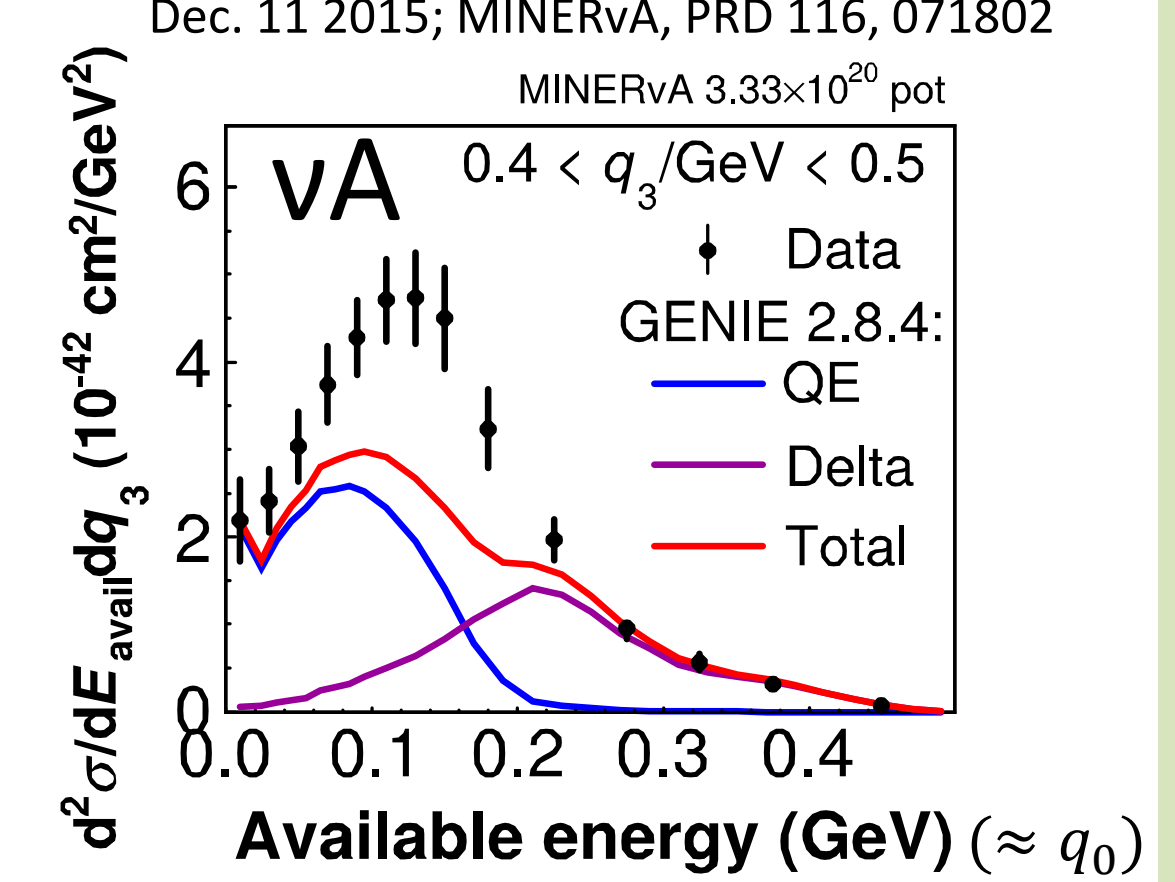


Two-nucleon knockout (2p2h): scatter from a nucleon pair via Meson Exchange Currents (MEC)

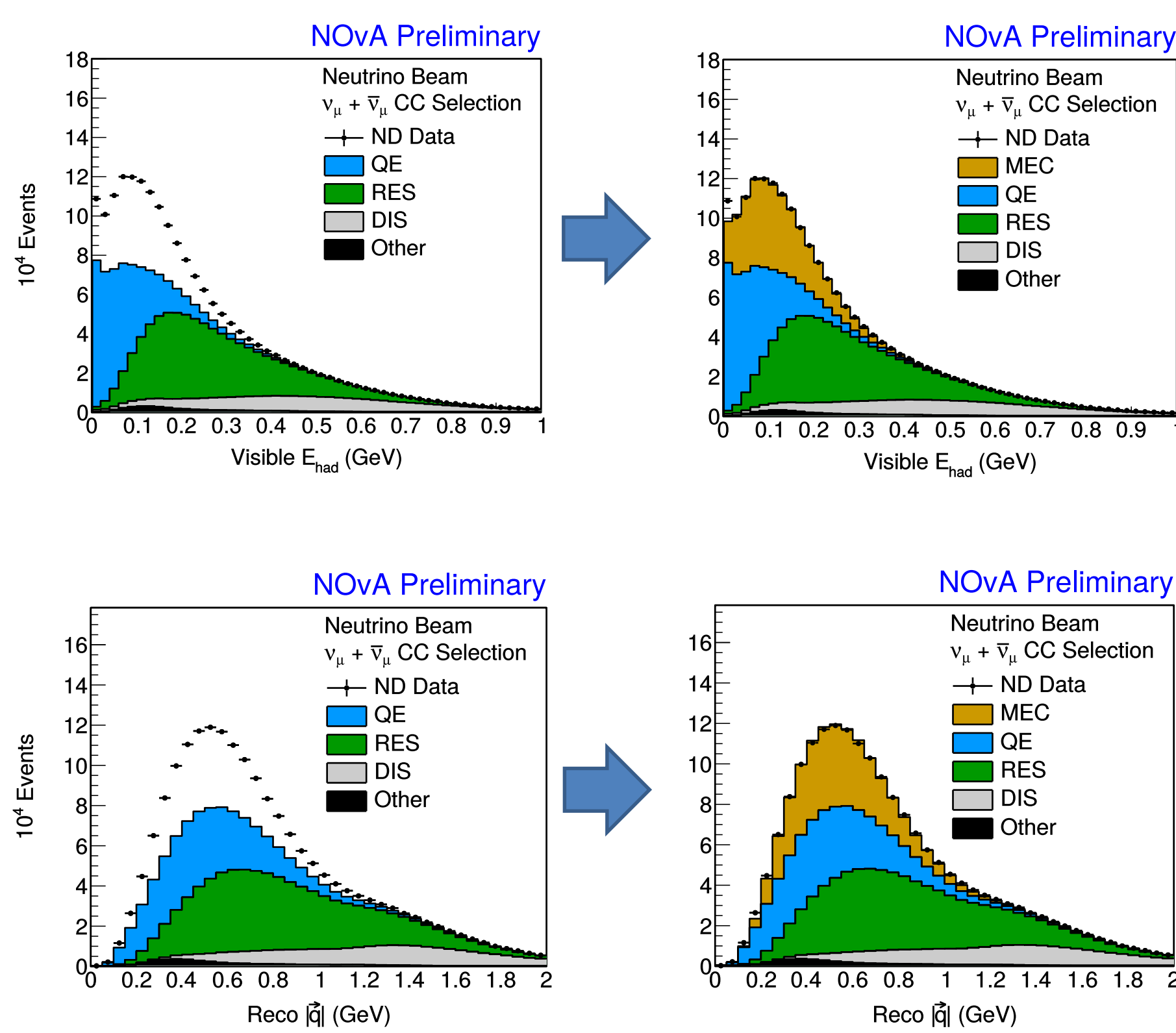


Expect 2p2h-MEC between QE and RES in $(q_0, |q|)$ from theory; supported by electron and other neutrino scattering data (MINERvA^{7,8})

NOvA data exhibit similar behavior (see below)



Neutrino 2p2h Tune

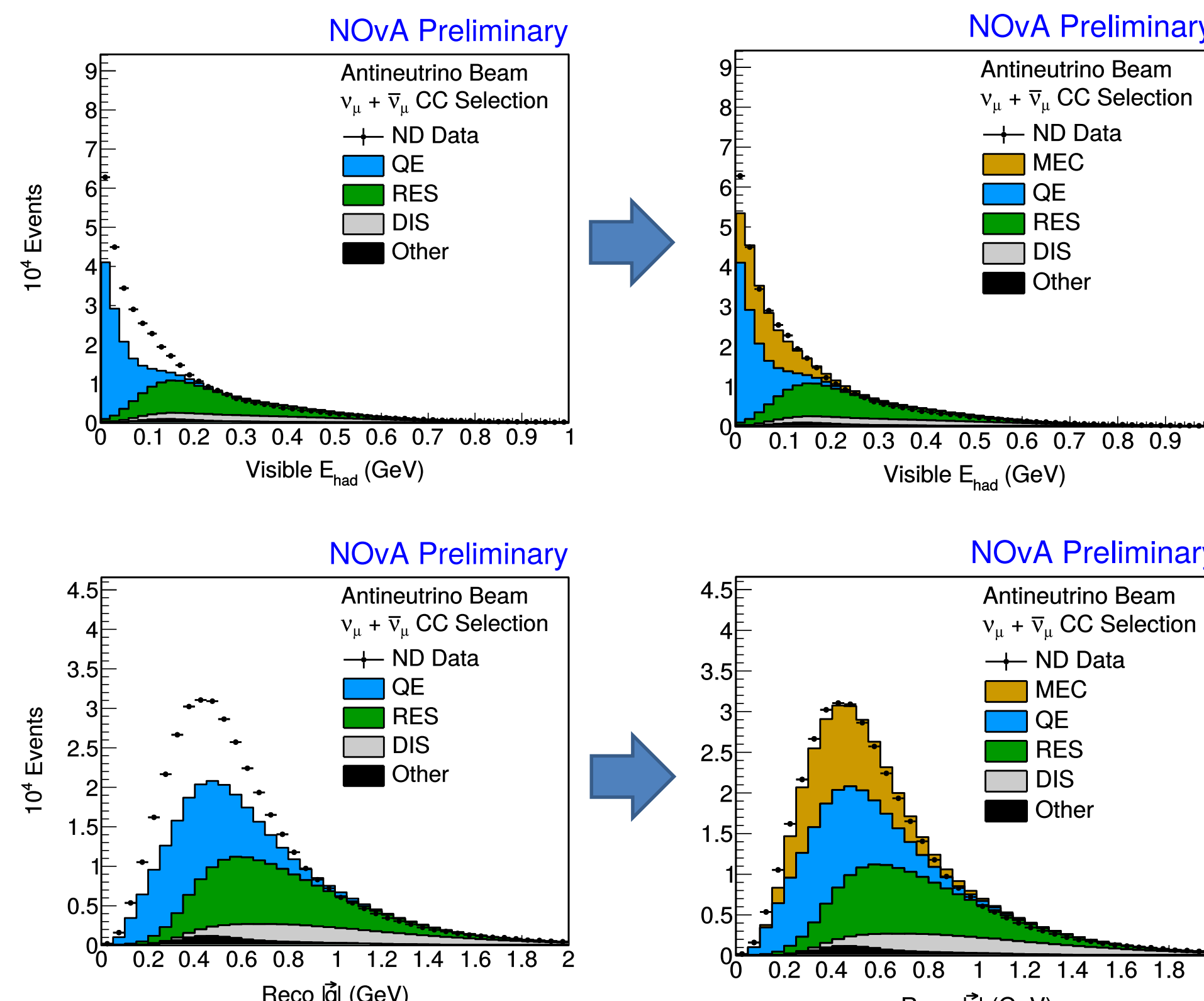


NOvA adds the GENIE "Empirical MEC" 2p2h model which is inspired by electron scattering data

NOvA tunes this model to data at the NOvA Near Detector in two-dimensional $(q_0, |q|)$ space using closely-related observables

Separate tunes for neutrinos and antineutrinos

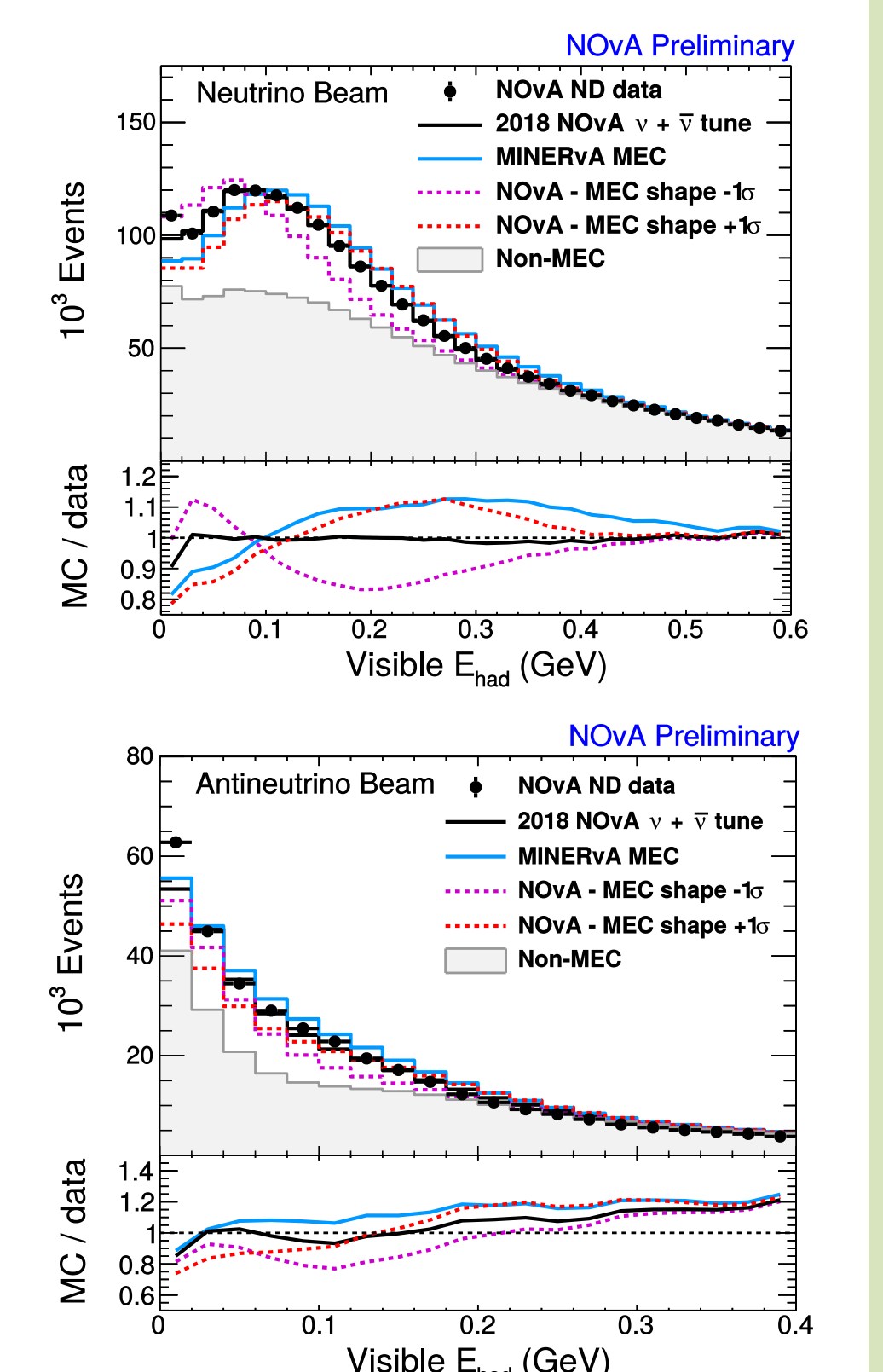
Antineutrino 2p2h Tune



The NOvA 2p2h tune attributes disagreement with data entirely to 2p2h

Shape uncertainty on the NOvA 2p2h tune is established by re-tuning with correlated systematic shifts to QE and RES

A similar tuning procedure applied by the MINERvA collaboration to their data^{7,8} resulted in similar features



References

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