Accelerating DUNE Physics with AI Discovery of Neutrino Interaction Uncertainties (Genesis 14b)

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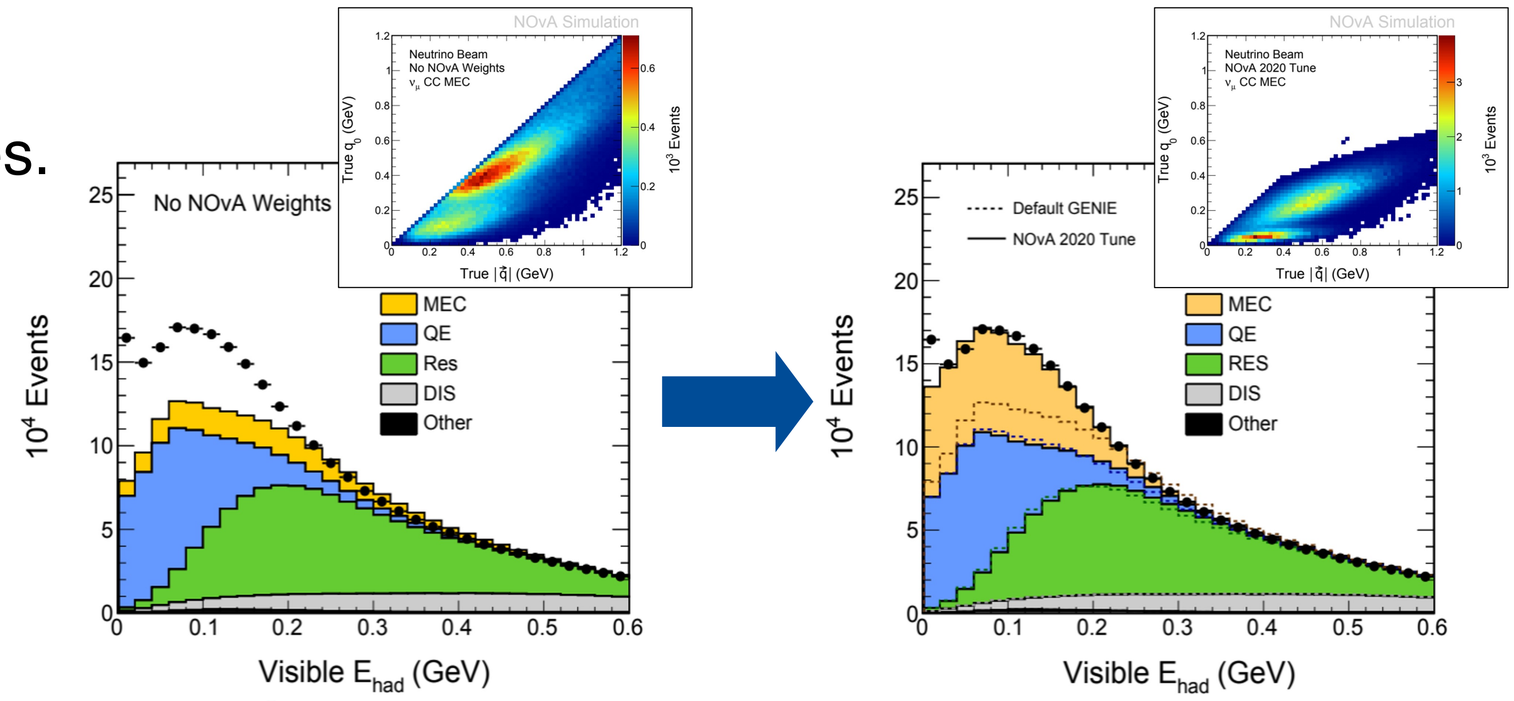
Interaction modeling sets DUNE's precision floor

- DUNE needs **percent-level control** of interaction uncertainties.
- Tough nuclear physics: MC disagrees with data in mode, energy, and final-state.
- Manual tuning is slow and limited in dimensionality, increasing the risk of mis-attributing effects.



Phase I: automated, interpretable, transferable pipeline

Find:

Residual Mapper

Parameterized classifier compares NOvA ND data with GENIE Exploring both vectors of reco. info and embedded event images. Produces a "residual atlas."

Distill:

Symbolic Regression

Residual atlas is compressed into closed-form equation on truth-level operators (Q^2, q_0, q_3, W, final state, etc.).

Transfer:

NOvA → DUNE

NOvA-derived operators applied to DUNE simulation without retraining. Test with matched, injected model changes.

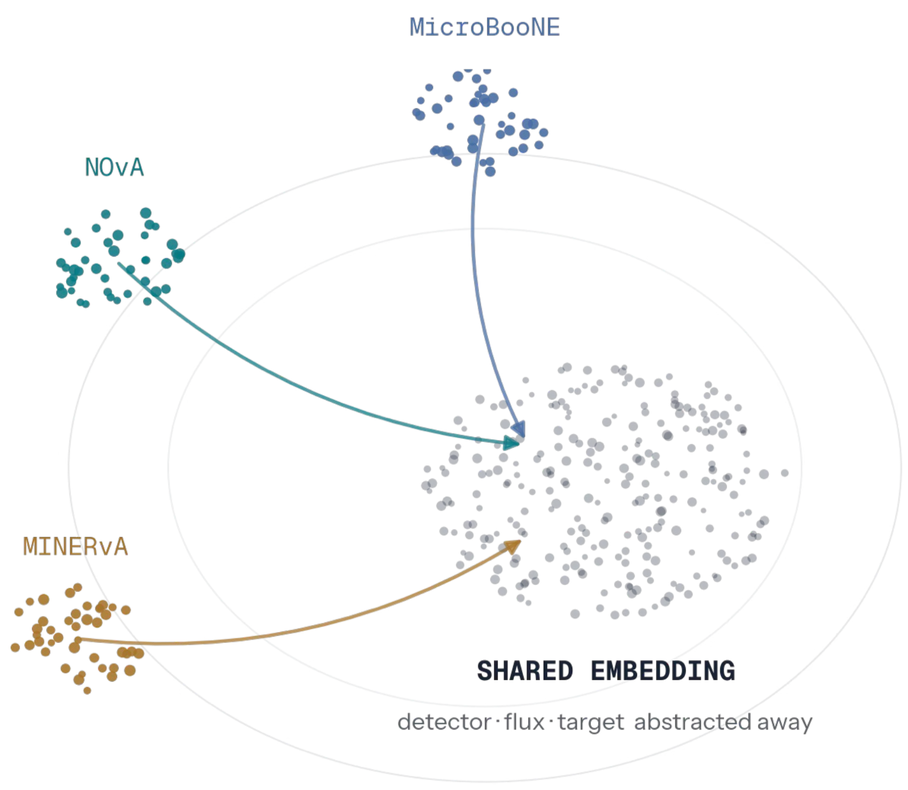
Phase II: A foundation model for neutrino interactions

50M+ events

4+ nuclei
CH, Ar, H_20, Fe

3+ flux spectra
0.3 – 6 GeV

- Phase II will aim to scale the Phase I tools across multiple experiment datasets.
- Goal is to develop a general tool for improving the interaction model and developing uncertainties.
- Our phase I is a first prototype – **open to collaboration** with parallel efforts.



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