

Bayesian Simultaneous Joint Detector Sampling for the NOvA Experiment

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1 The NOvA experiment

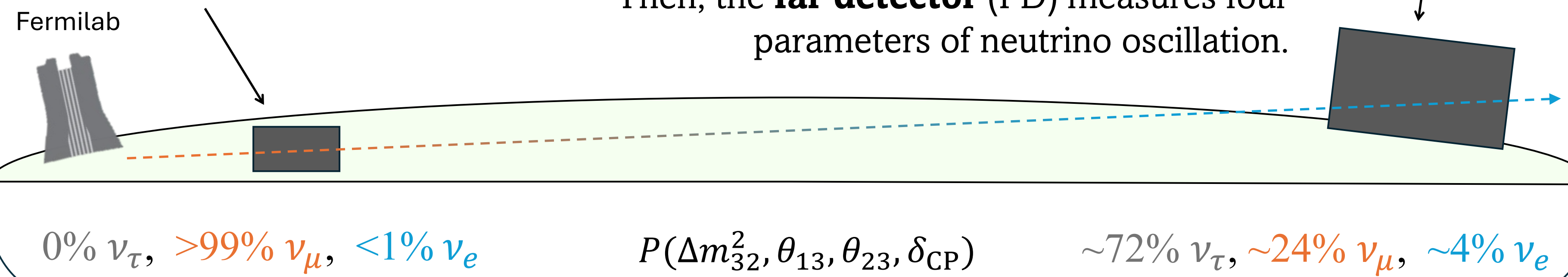
- NOvA is a long baseline neutrino oscillation experiment using the NuMI beam at Fermilab with $E_\nu \approx 2$ GeV.
- Uses extrapolation to control systematic uncertainties.
- Data-driven: corrections at ND are propagated to FD.
- Detectors are functionally identical, and any differences are modelled during extrapolation.



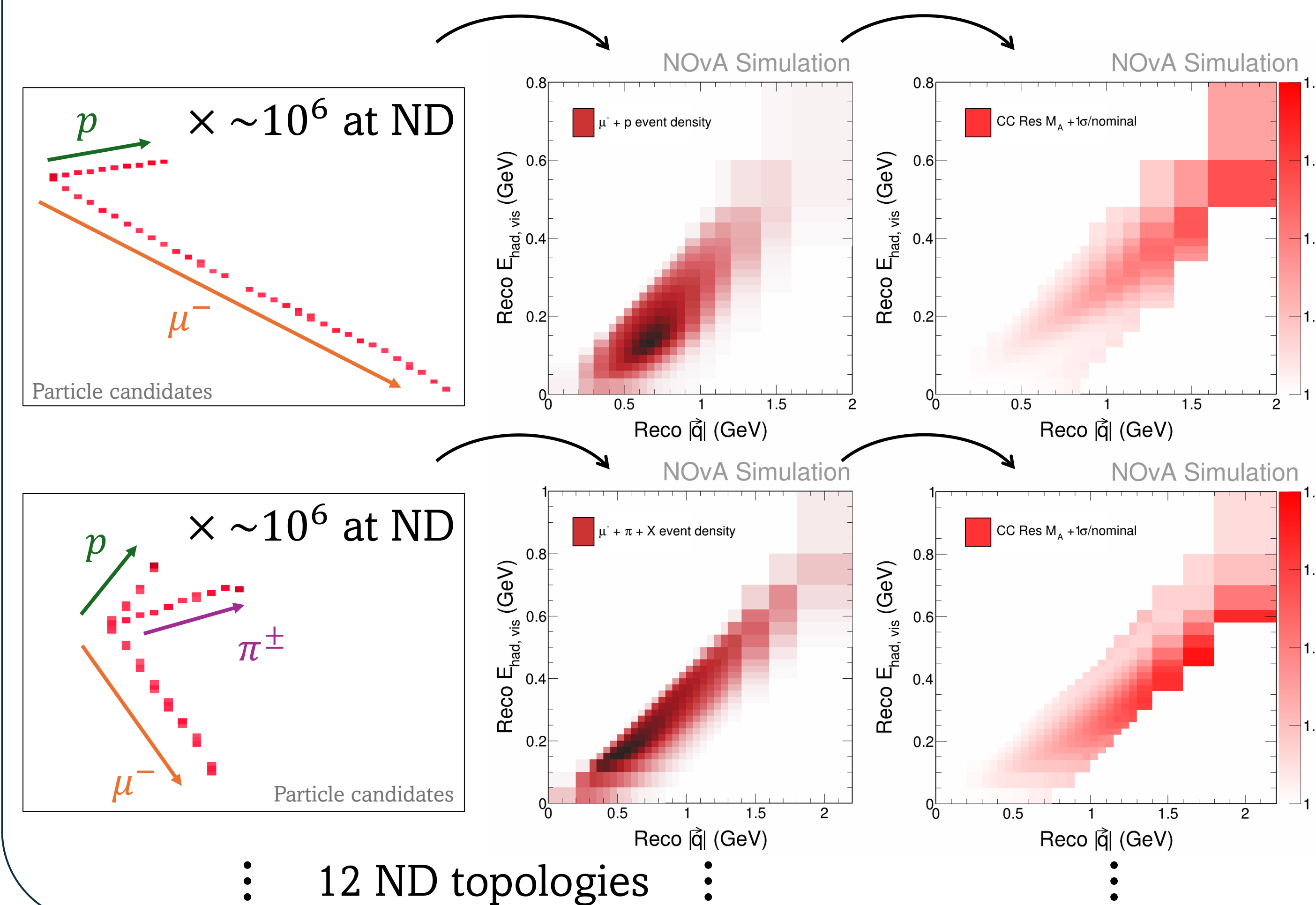
The **near detector** (ND) controls systematic uncertainties by correcting NOvA simulation.



Then, the **far detector** (FD) measures four parameters of neutrino oscillation.

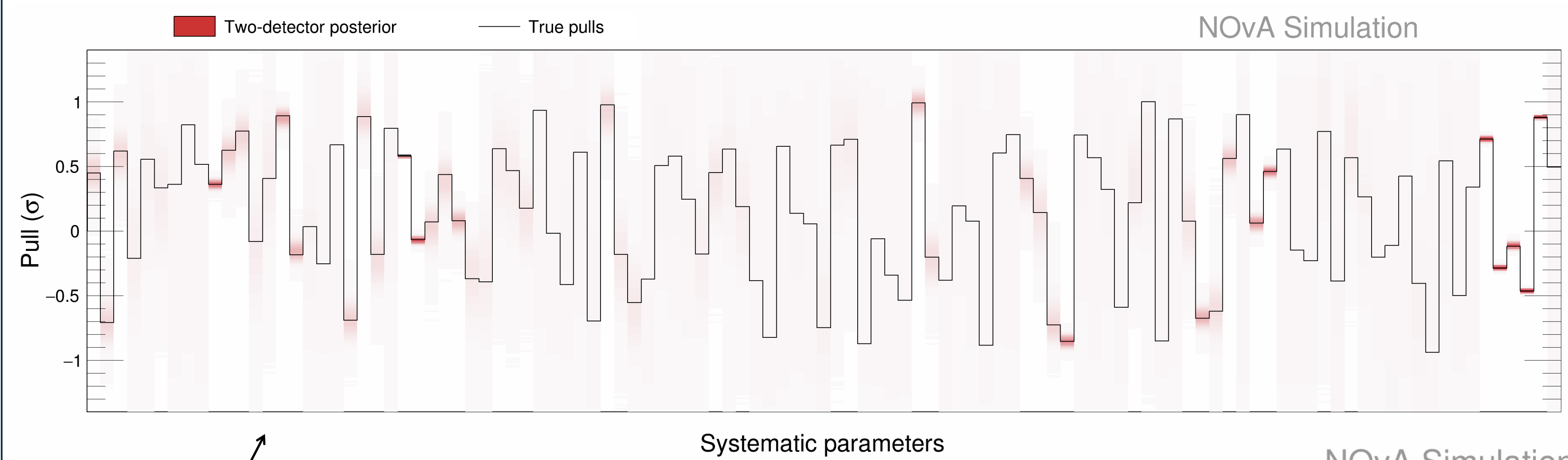


2 The two-detector technique: simultaneous sampling



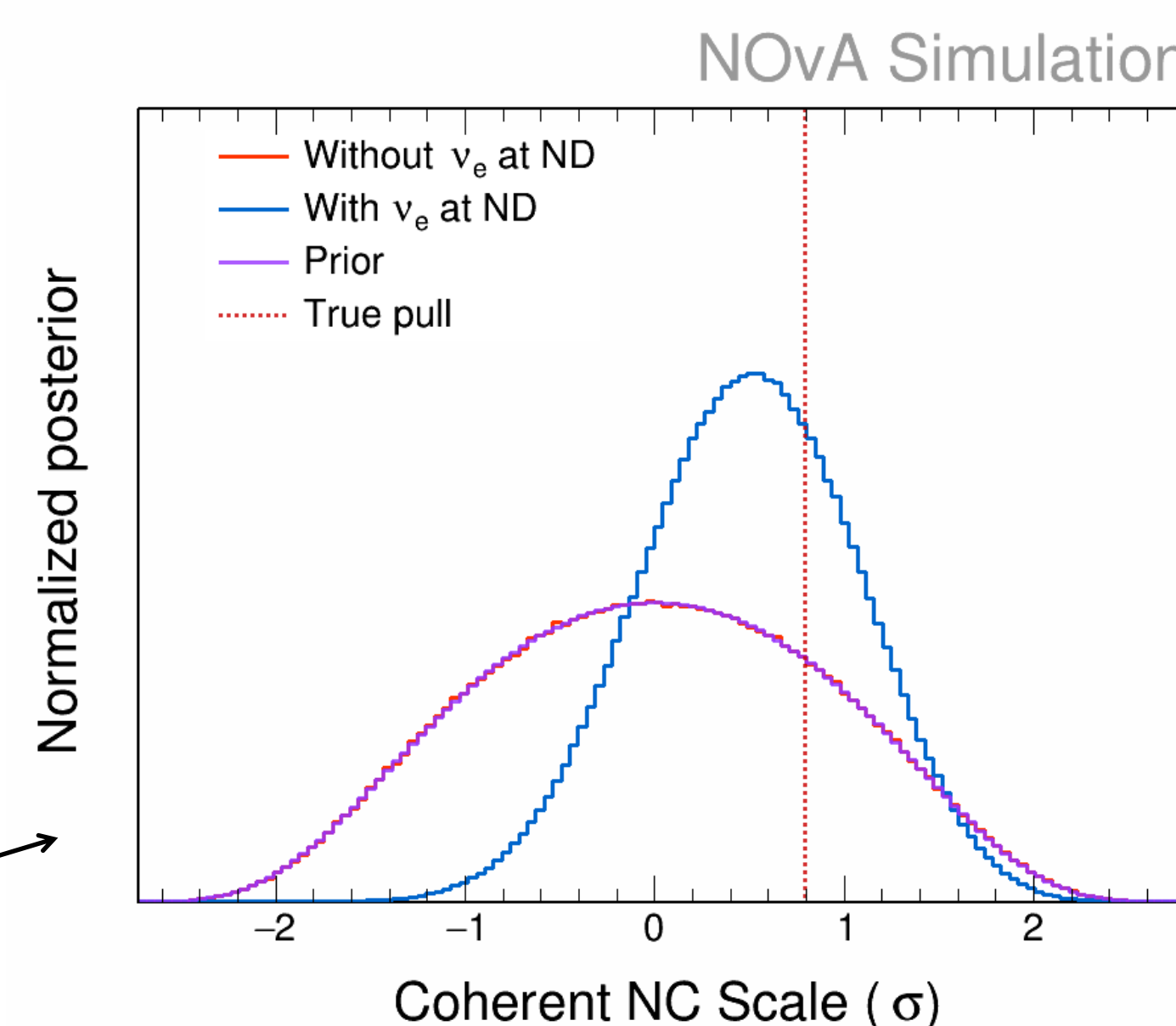
- Alternative approach to extrapolation.
- Tracking calorimetry enables partitioning by hadronic topology.
- The two-detector technique **constrains ~120 systematic parameters** in-situ using (anti)neutrino-mode ND data while inferring oscillation parameters.
- **Hamiltonian MCMC efficiently explores** systematic + oscillation space.

3 Constraining systematic uncertainties

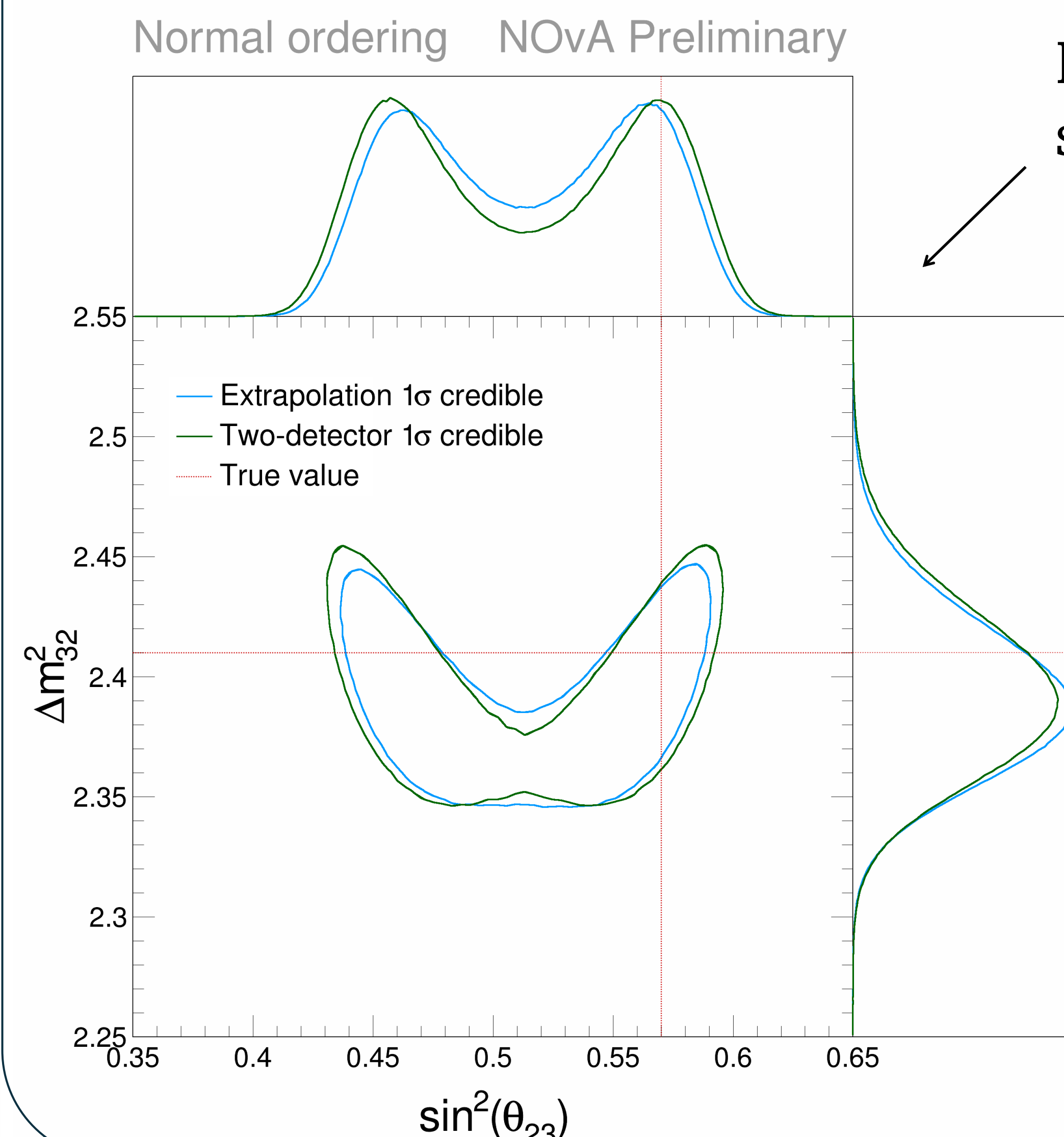


Fake data studies show two-detector can constrain many beam, cross-section, and detector systematic parameters simultaneously.

Two-detector is flexible: New configurations of ND data (like adding ν_e topologies) improve constraints and teach us about the systematic model.



4 Constraining oscillation parameters



Fake data study exploring beam and some cross-section systematic and oscillation parameters.

- Two-detector agrees with extrapolation in this study. Understanding the interactions between the systematic and oscillation subspaces is a work in progress.
- **Future studies will test robustness and quantify performance** of the two-detector technique.
- Work with the new GENIE AR23 model is ongoing, and more fake data studies will guide how to make the NOvA systematic model complete enough for a two-detector oscillation analysis.