NOvA's Latest 3-Flavor Neutrino Oscillation Results

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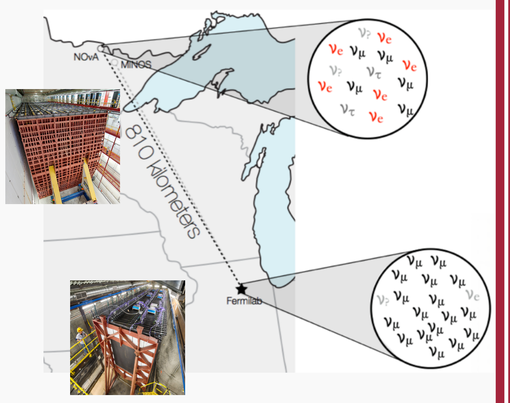
The NOvA Experiment

NOvA is a long-baseline neutrino oscillation experiment that sits in front of Fermilab's 700 kW NuMI muon neutrino beam.

The experiment is composed of two functionally identical detectors that:

- Utilize liquid-scintillator
- Are placed 809km apart
- Sit 14.6 mrad off-axis from the NuMI beam



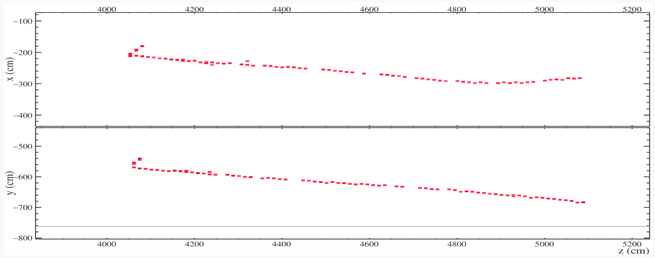
The Physics Goals of NOvA

NOvA uses measurements of $\nu_\mu(\bar{\nu}_\mu)$ disappearance $(\nu_\mu \to \nu_\mu, \bar{\nu}_\mu \to \bar{\nu}_\mu)$ and $\nu_e(\bar{\nu}_e)$ appearance $(\nu_\mu \to \nu_e, \bar{\nu}_\mu \to \bar{\nu}_e)$ at the far detector to:

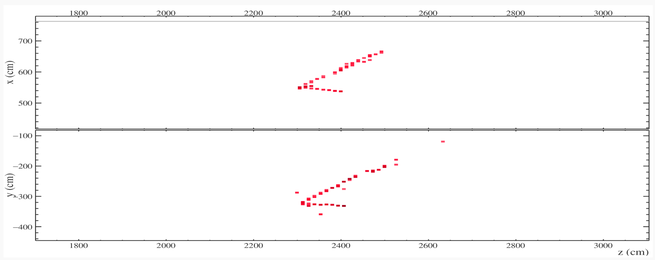
- Resolve the mass hierarchy (related to appearance)
- Probe the CP violating phase δ_{CP} (related to appearance)
- Determine the octant of the mixing angle θ_{23} (disappearance and appearance)
- Constrain the mass squared difference Δm^2_{32} (related to disappearance)

Observing Neutrinos at the Far Detector

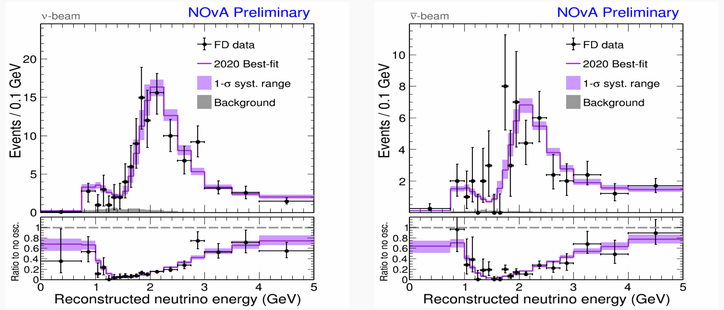
An example of a ν_μ interaction in the NOvA FD selected in the analysis.



An example of a ν_e interaction in the NOvA FD selected in the analysis.

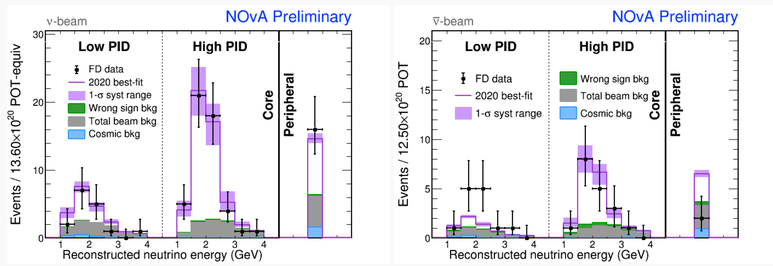


NOvA's 2020 ν_μ and $\bar{\nu}_\mu$ Energy Distributions



Reconstructed energy of NOvA's ν_μ and $\bar{\nu}_\mu$ FD data along with best-fit predictions. **For the 2020 analysis NOvA observed 211 ν_μ and 105 $\bar{\nu}_\mu$ events with an expected background of 8.2 and 2.1 respectively.**

NOvA's 2020 ν_e and $\bar{\nu}_e$ Energy Distributions

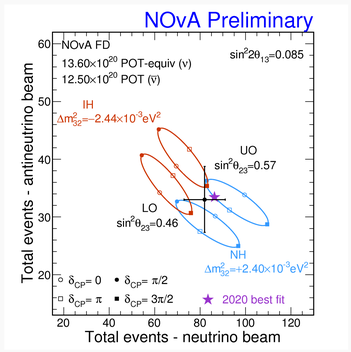


Reconstructed energy of NOvA's ν_e and $\bar{\nu}_e$ FD data along with the best-fit predictions. Here the data and predictions are separated into threes bins based on how well the event was identified using a PID and if was contained far from detector edges. **For the 2020 analysis NOvA observed 82 ν_e and 33 $\bar{\nu}_e$ events with an expected background of 26.8 and 14 respectively.**

Combined ν_e and $\bar{\nu}_e$ Results

The CP violating phase and the mass hierarchy have opposite effects on the neutrino and antineutrino oscillations so measuring both probabilities helps with resolving the questions we have. The distribution shows values of δ_{CP} (ellipses) for combinations of mass hierarchies and octants of θ_{23}.

The NOvA best fit slightly favors the upper octant and normal hierarchy.

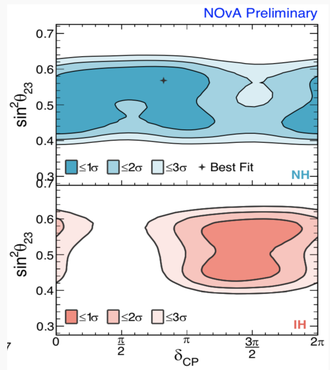


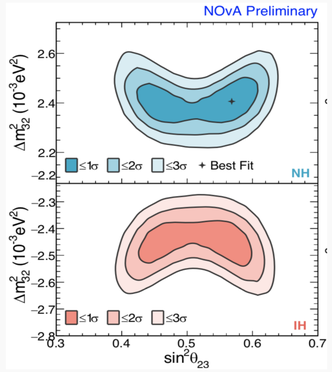
2020 Analysis Best Fits

The distribution on the left shows the regions of δ_{CP} and $sin^2\theta_{23}$ that are within 3σ of NOvA's data.

The best fit values fall in the normal hierarchy and are:

- $\delta_{CP} = 0.8\pi$
- $sin^2\theta_{23} = 0.57^{+0.04}_{-0.03}$





The distribution on the right shows the regions of Δm^2_{32} and $sin^2\theta_{23}$ that are within 3σ of NOvA's data.

The best fit values fall in the normal hierarchy and are:

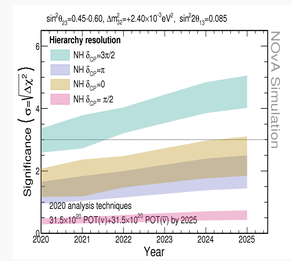
- $\Delta m^2_{32} = 2.41 \pm 0.07 \times 10^{-3} eV^2$
- $sin^2\theta_{23} = 0.57^{+0.04}_{-0.03}$

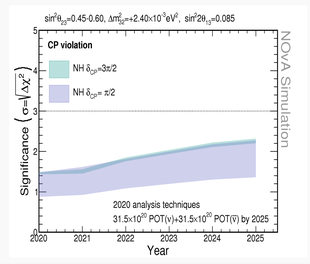
Looking Toward the Future

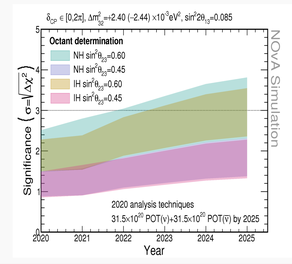
NOvA is expected to run through 2025. For the future sensitivities we assume to take 50% neutrino and 50% antineutrino data for the remainder of the run resulting in an exposure of 31.5×10^{20} POT for each beam mode.

By the year 2025 we predict:

- 5σ sensitivity to the mass hierarchy in the most favorable case (NH and $\delta_{CP} = 3\pi/2$)
- 2σ sensitivity to CP violation determination if NH
- 3σ sensitivity to octant determination







http://novaexperiment.fnal.gov

More NOvA this week: C. Sullivan, "Investigating Improvements to the NOvA Event Selection Efficiency for Events in the Mass-hierarchy-sensitive Energy Range", Poster
E. Cantano-Mur, "NOvA 3-Flavor Oscillation Results", Talk, Wednesday
W. Wu, "NOvA Cross Section Measurements", Talk, Thursday

NOvA 2019 Results: Phys.Rev.Lett. 123 (2019) 15, 151803