Fermilab

NOvA joint $\nu^e + \nu^\mu$ oscillation results in neutrino and antineutrino modes

FERMILAB-POSTER-18-0044-STUDENT

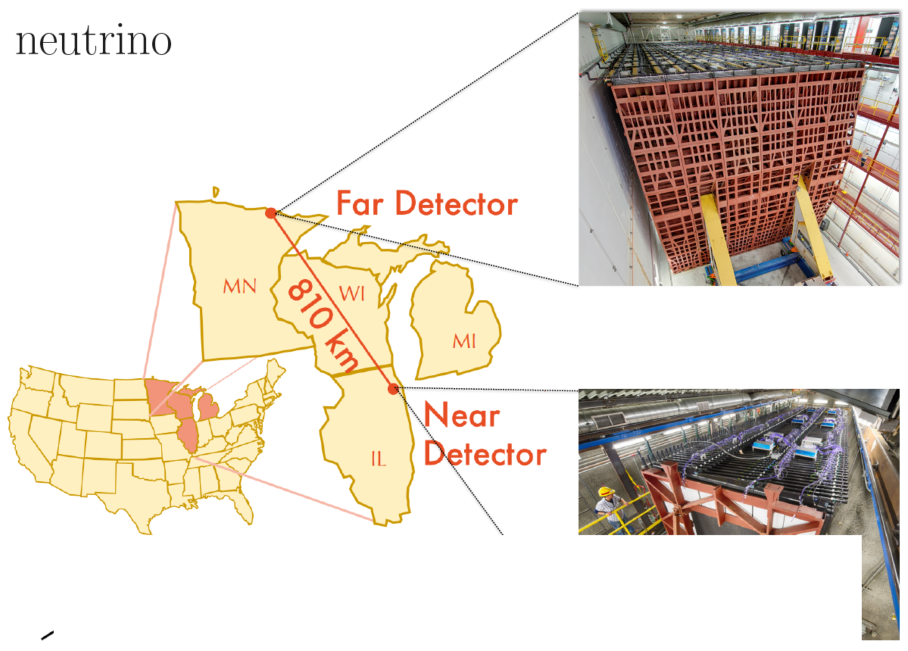
This manuscript has been authored by Fermi Forward Discovery Group, LLC
under Contract No. 89243024CSC000002 with the U.S. Department of Energy,
Office of Science, Office of High Energy Physics.

NOvA joint $\nu_e + \nu_\mu$ oscillation results in neutrino and antineutrino modes

Ashley Back (Iowa State University) and Liudmila Kolupaeva (JINR) for the NOvA collaboration

The NOvA experiment

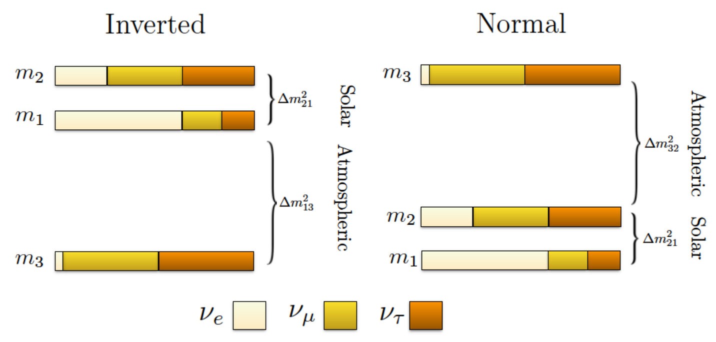
The NOvA experiment is a **long baseline** neutrino oscillation experiment utilizing the world's most powerful ν_μ beam—the NuMI beam at **Fermilab.**



- ⁕ Two functionally identical detectors (**Far** and **Near**)
- ⁕ Fine-grained, low-Z liquid scintillator calorimeters
- ⁕ **14 mrad** off the NuMI beam axis

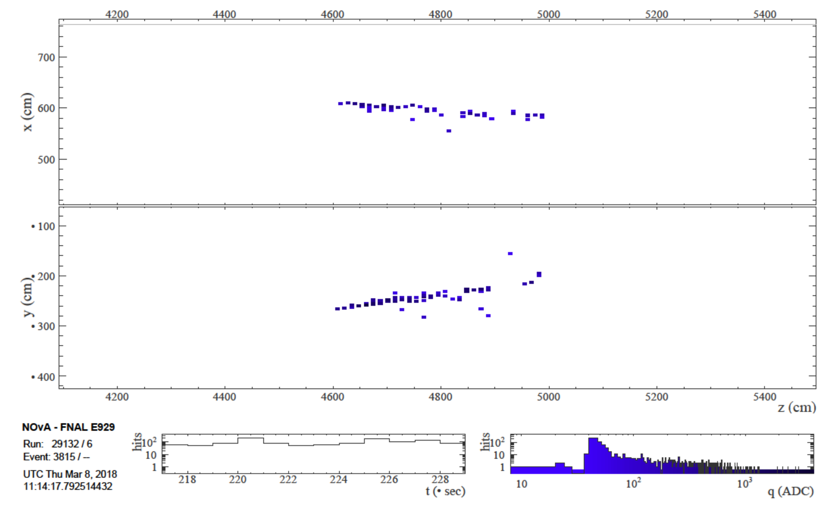
Physics motivations for studying ν_e appearance and ν_μ disappearance:

- ⁕ Determine Neutrino **Mass Hierarchy**
- ⁕ Probe δ_{CP} violating phase
- ⁕ Resolve the octant of θ_{23} mixing angle

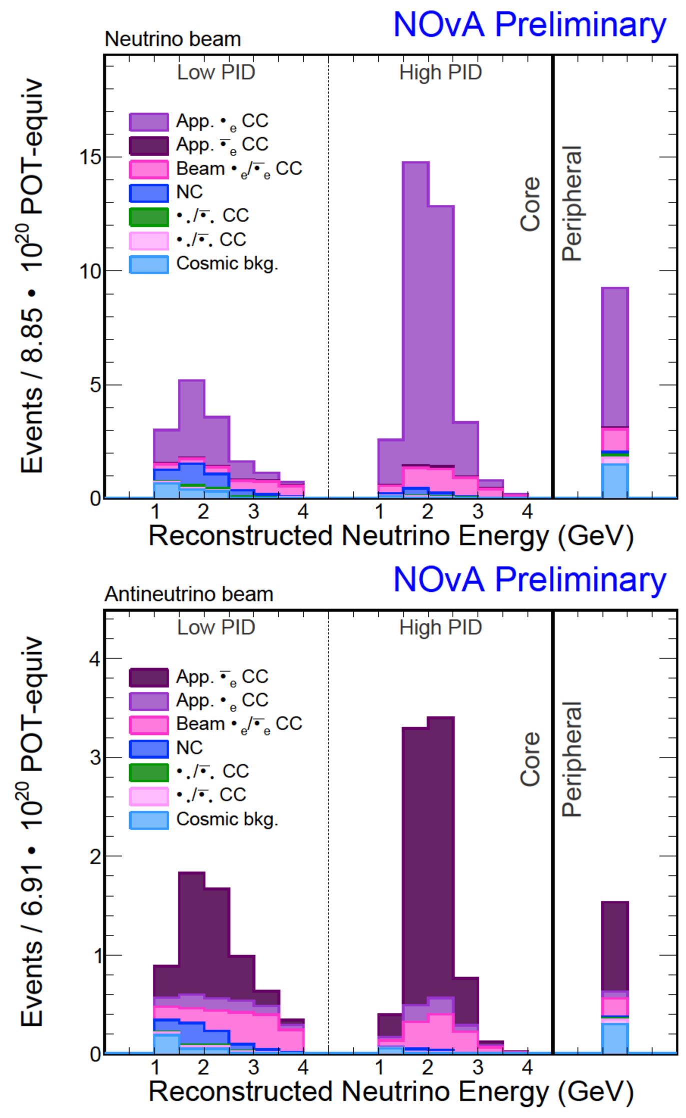


Event predictions

Our ν_e event selection includes cosmic rejection, data quality and pre-selection cuts, along with particle identification via a Convolutional Visual Network (**CVN**) (see the poster №79 for details). For details of the ν_μ event selection see the poster №75.

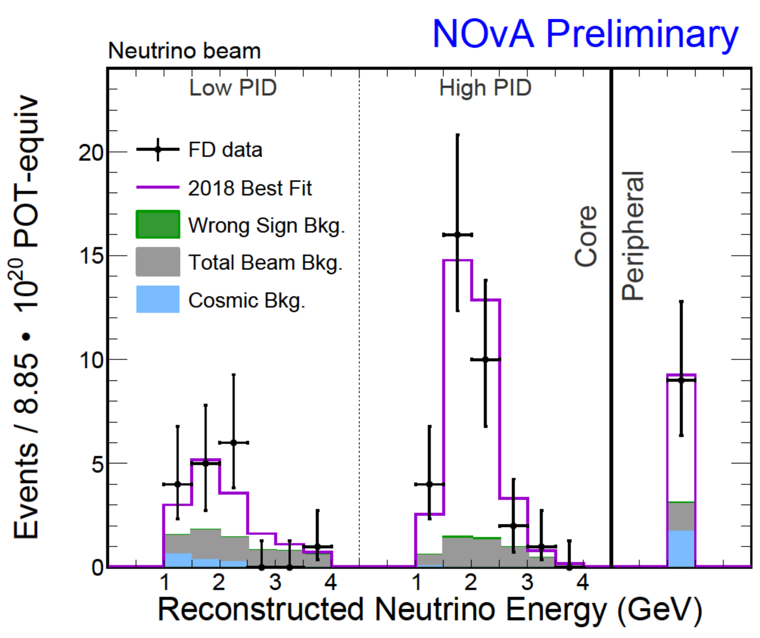


⁕ Use **data-driven techniques** to predict the FD Monte-Carlo spectrum based on a fit to the ND data (see the poster №80 for details).

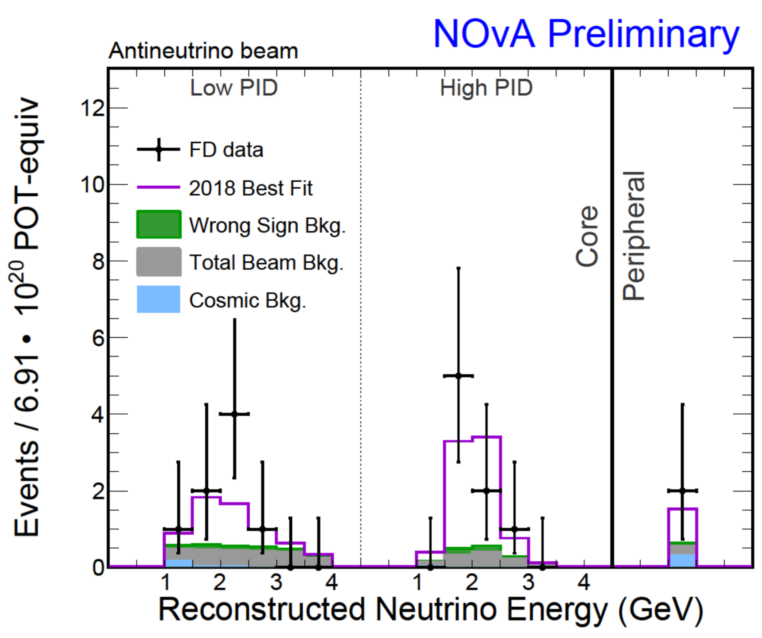


Results in the 2018 NOvA joint $\nu_e + \nu_\mu$ analysis in neutrino and antineutrino modes

With 8.85×10^{20} POT in neutrino beam and 6.91×10^{20} POT in antineutrino beam NOvA obtained the following results:



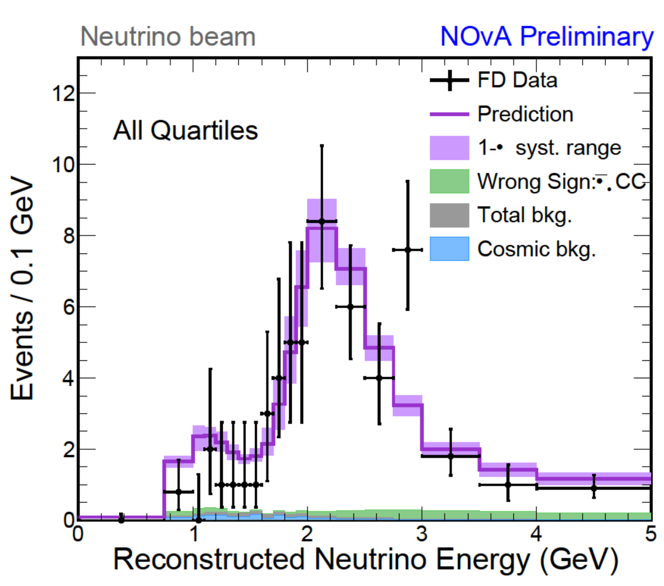
Observed 58 ν_e CC events					
Expected 30 ($\pi/2$ IH) - 75 ($3\pi/2$ NH) events					
Total background 15.1 events					
$\bar{\nu}_e$ CC	beam ν_e	ν_μ CC	ν_τ CC	NC	cosmic
0.66	6.85	0.63	0.37	3.21	3.33

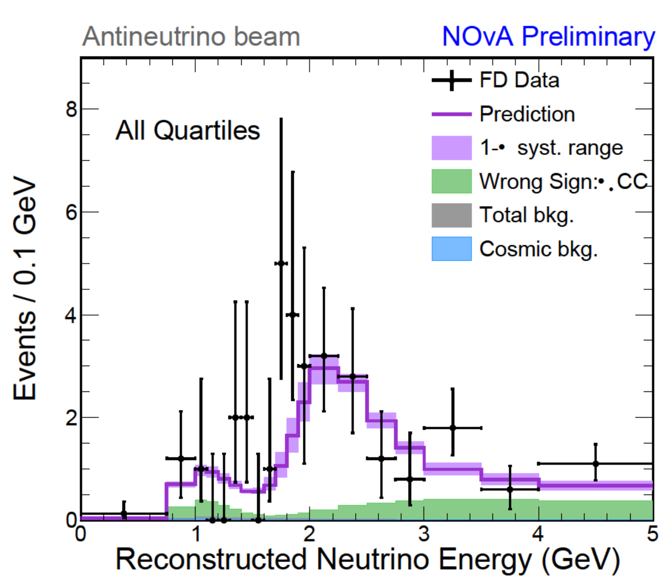


Observed 18 $\bar{\nu}_e$ CC events					
Expected 10 ($3\pi/2$ NH) - 22 ($\pi/2$ IH) events					
Total background 5.3 events					
ν_e CC	beam ν_e	ν_μ CC	ν_τ CC	NC	cosmic
1.13	2.57	0.07	0.15	0.67	0.71

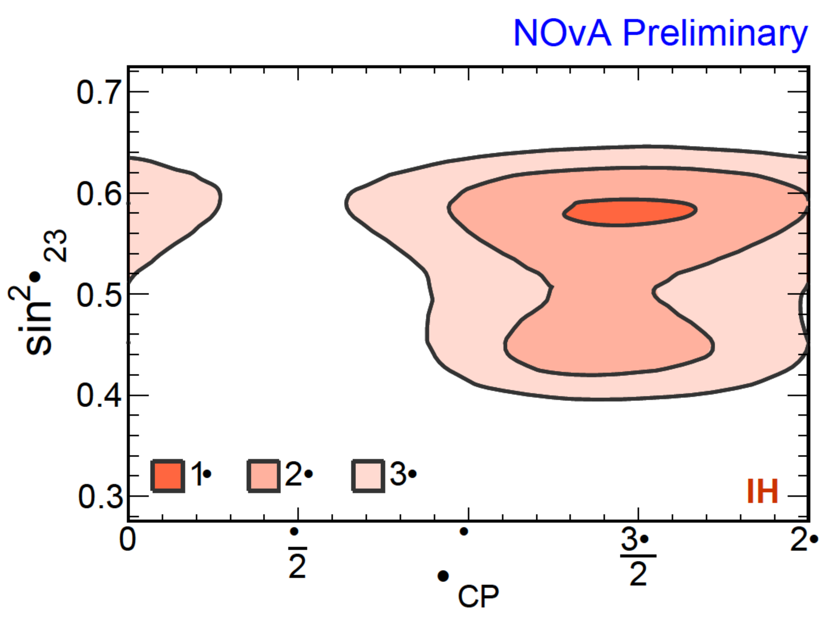
Observed 113 ν_μ CC events			
Total background 11.0 events			
$\bar{\nu}_\mu$ CC	NC	other beam bkg	cosmic
7.24	1.19	0.51	2.07

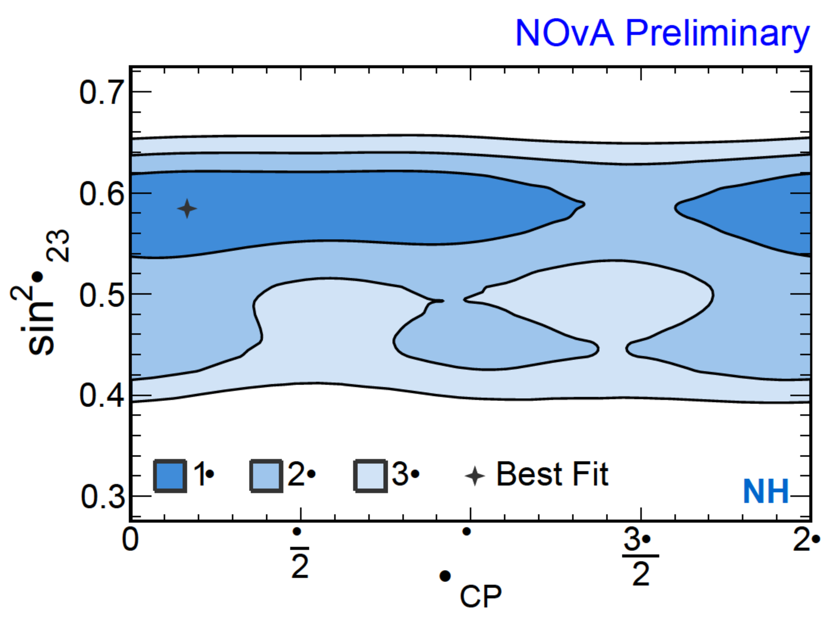
Observed 65 $\bar{\nu}_\mu$ CC events			
Total background 13.7 events			
ν_μ CC	NC	other beam bkg	cosmic
12.58	0.39	0.23	0.46





For the ν_μ disappearance analysis details see the poster №66.

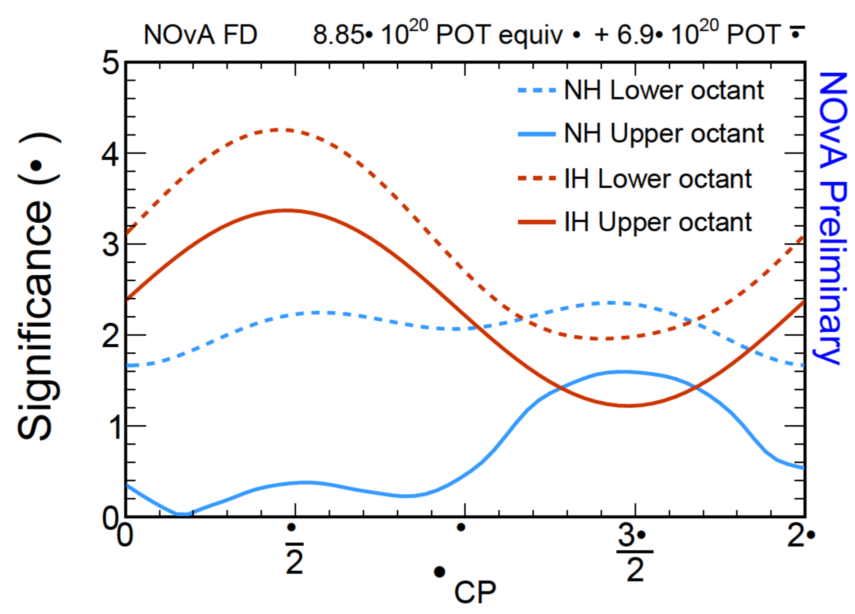




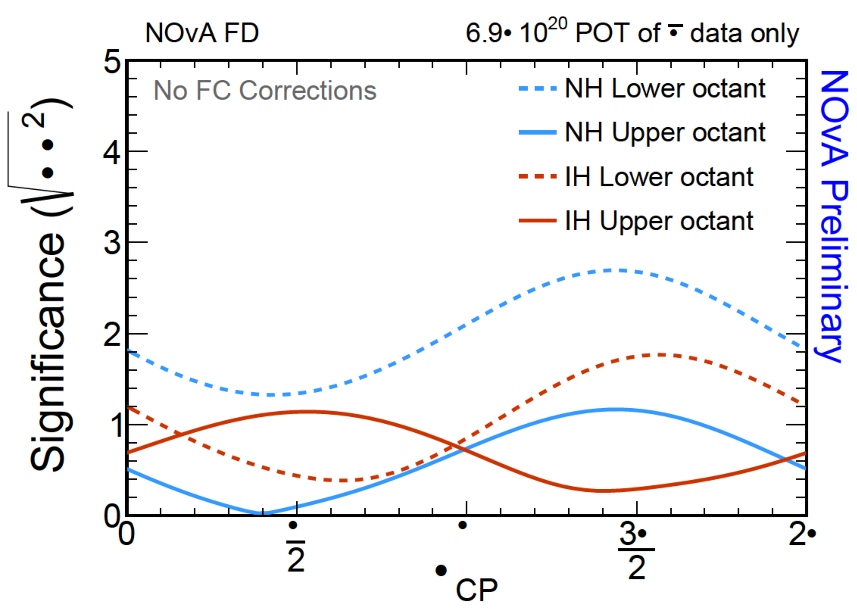
The joint $\nu_e + \nu_\mu$ **fit** in both neutrino and antineutrino modes with systematic uncertainties (see the posters №81 (ν_e) and №88 (ν_μ)) produced the next results:

⁕ **Best fit**:
NH, $\delta_{CP} = 0.17\pi$,
$\sin^2\theta_{23} = 0.58 \pm 0.03$ (UO),
$\Delta m^2_{32} = 2.51^{+0.12}_{-0.08} \times 10^{-3}$ eV^2

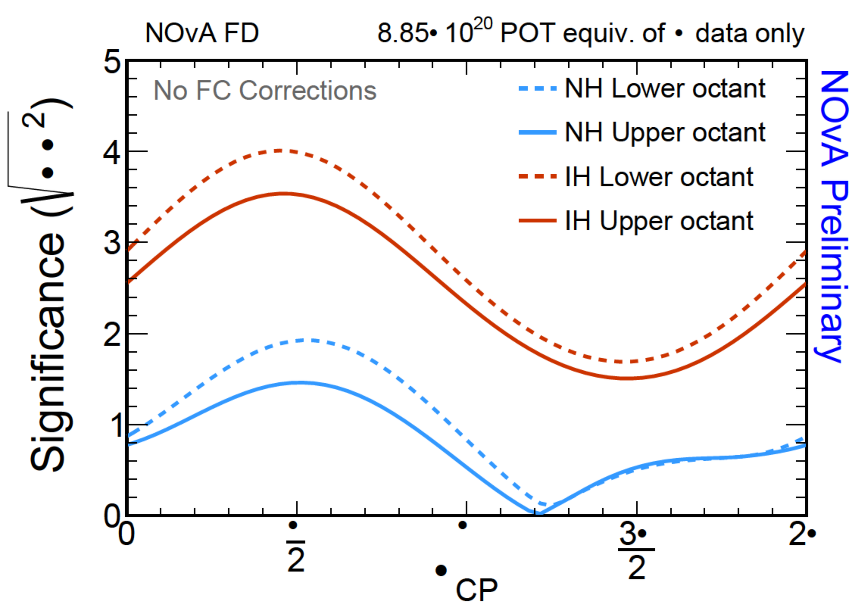
⁕ Reject the area IH, $\delta_{CP} = \pi/2$ at $>3\sigma$, reject IH, all values of δ_{CP} at 1.8σ.



We performed the joint fit ν_e+ν_μ separately in neutrino and antineutrino modes as well:



⁕ Our antineutrino data prefer the $\delta_{CP} = 0.4\pi$, NH and IH are close.



⁕ Our neutrino only joint fit results remain unchanged in comparison with 2017's.

Future sensitivities

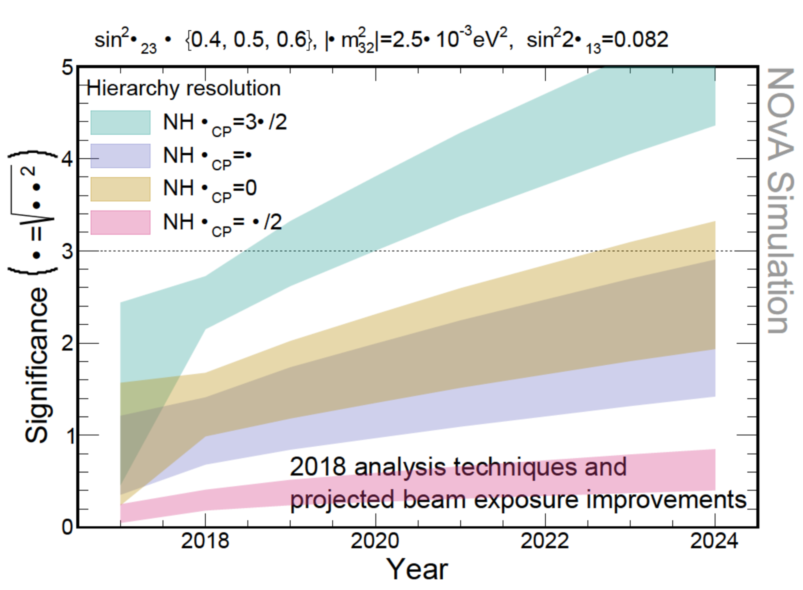
⁕ For **future prospects** we assume:

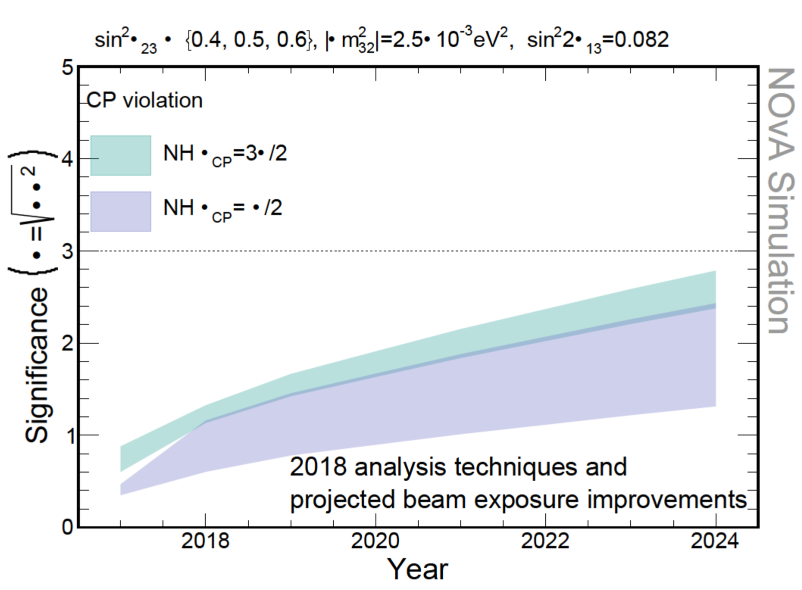
- 50% neutrino beam and 50% antineutrino beam data per year.
- 2018 analysis techniques, projected beam intensity improvements and reduced systematic uncertainties from NOvA's test beam (see the poster №58).

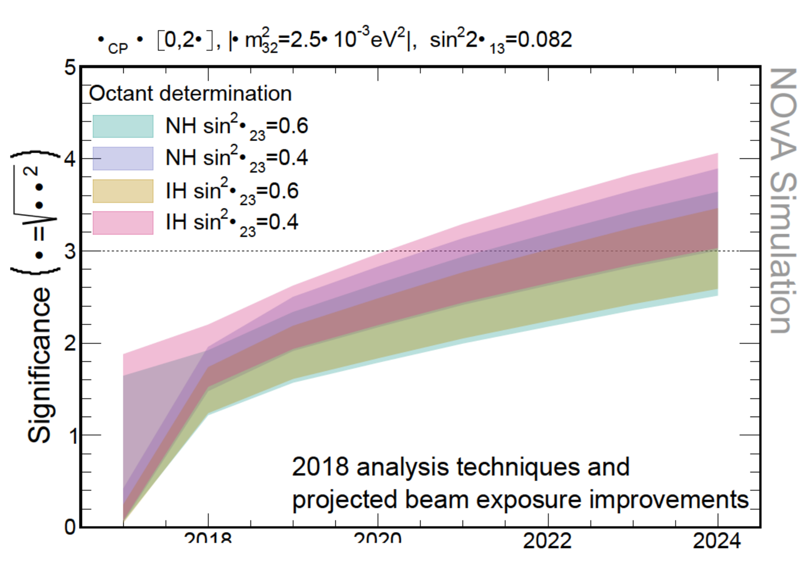
⁕ **By 2020** expect 3σ sensitivity to **mass hierarchy**, for all allowed values of θ_{23}, if hierarchy is normal and $\delta_{CP} = 3\pi/2$.

⁕ **By 2022** expect 2σ sensitivity to δ_{CP} determination if hierarchy is normal and $\delta_{CP} = 3\pi/2$.

⁕ **By 2024** expect 3σ sensitivity (depends on hierarchy) to **octant** determination for $\sin^2\theta_{23}$ near 0.4 or 0.6







http://novaexperiment.fnal.gov
Fermilab