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

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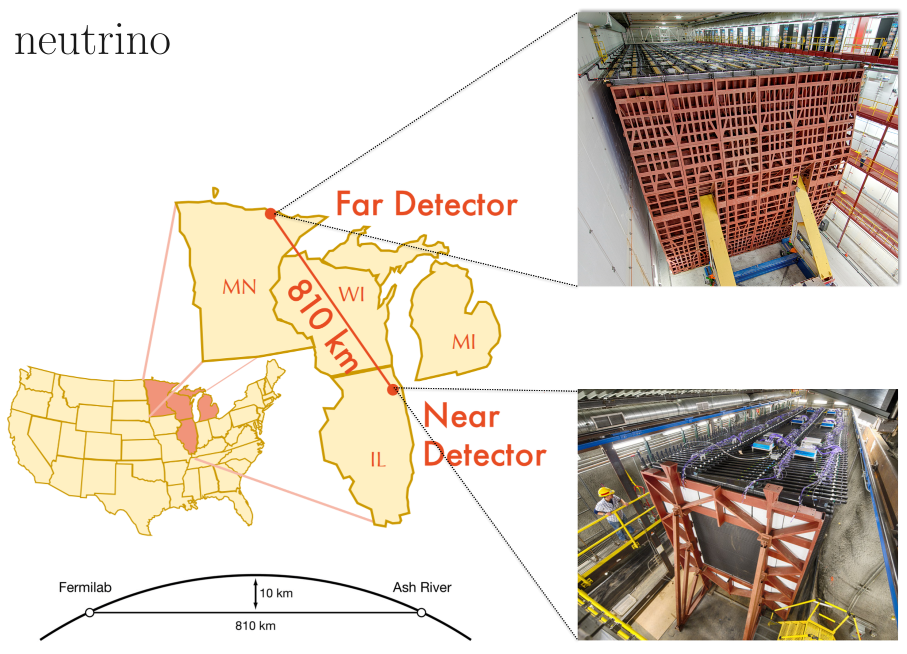
The NOvA experiment

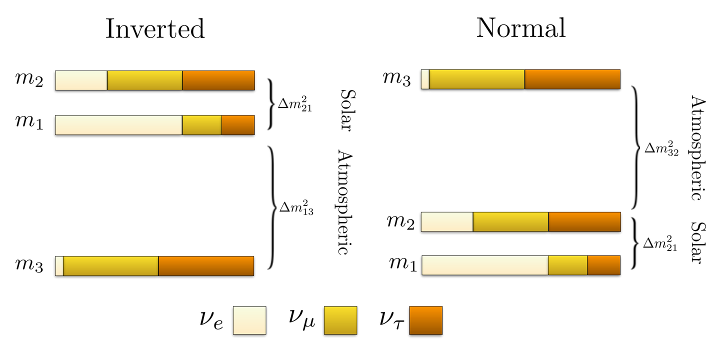
The NOvA experiment is a **long baseline** neutrino oscillation experiment utilizing the world's most powerful ν_μ beam—the NuMI beam at **Fermilab.**

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



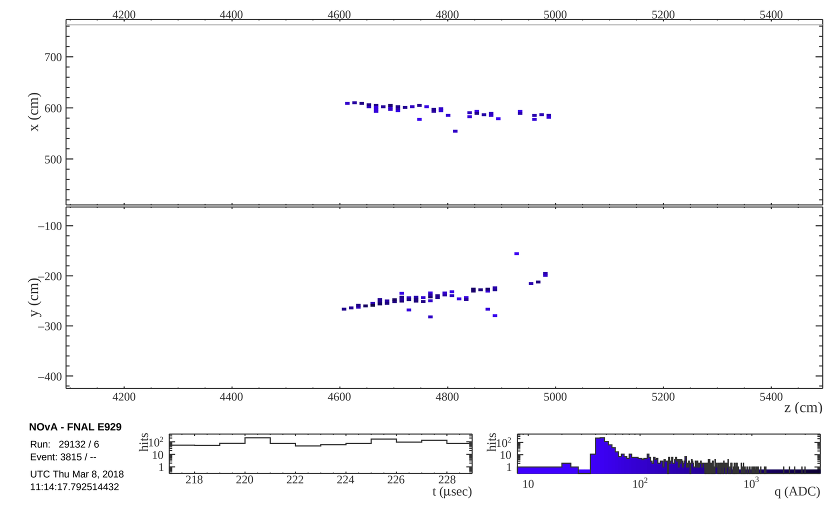
Physics motivations for studying ν_e appearance and ν_μ disappearance:

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

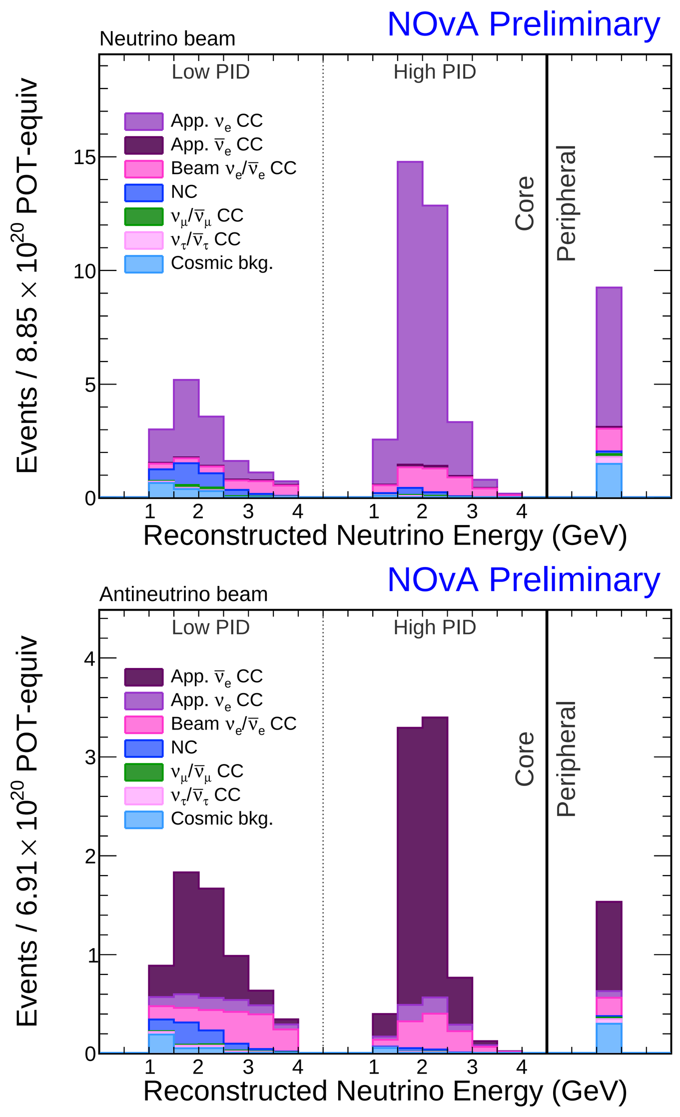


Event predictions

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.

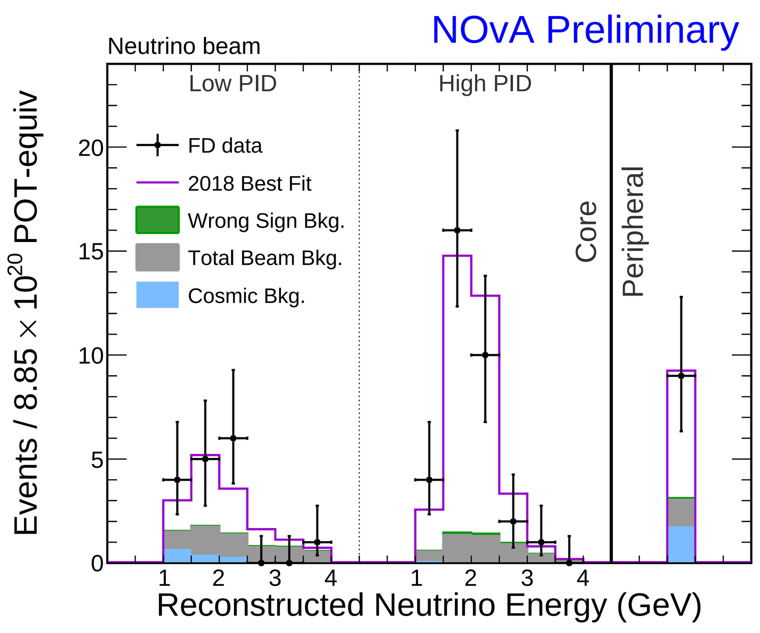


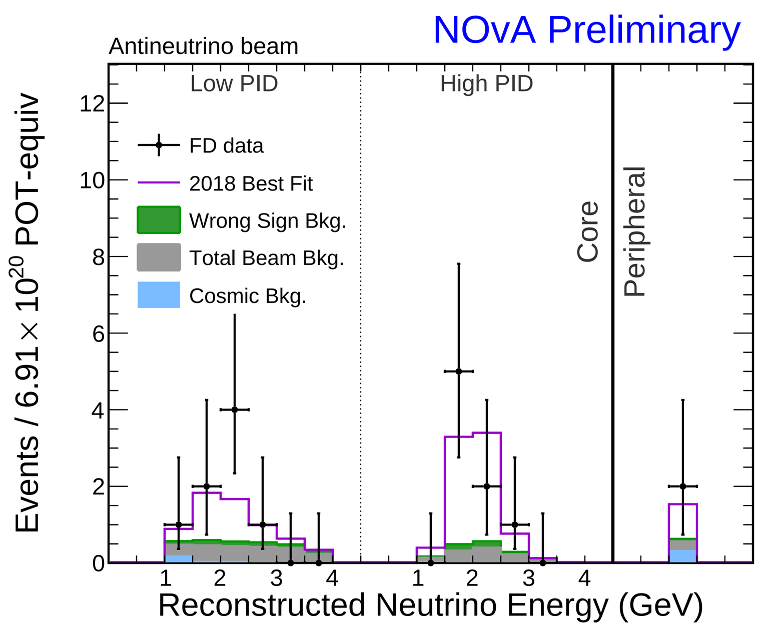
- ⁕ Use **data-driven techniques** to predict the FD Monte-Carlo spectrum based on a fit to the ND data (see the poster №80 for details).



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:



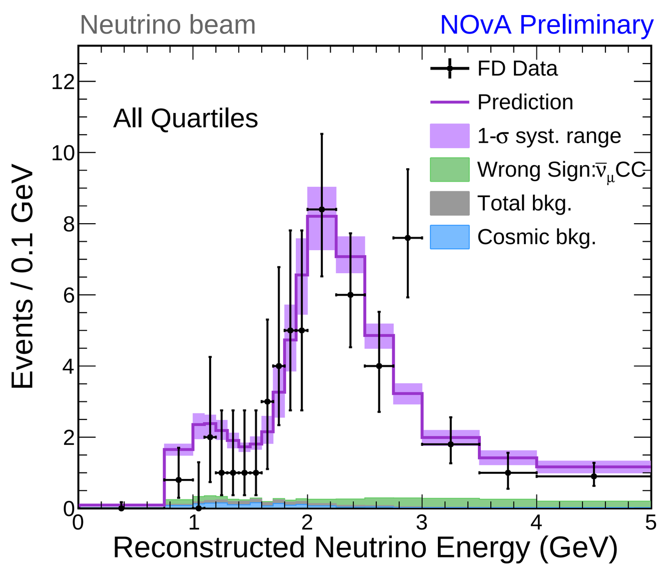


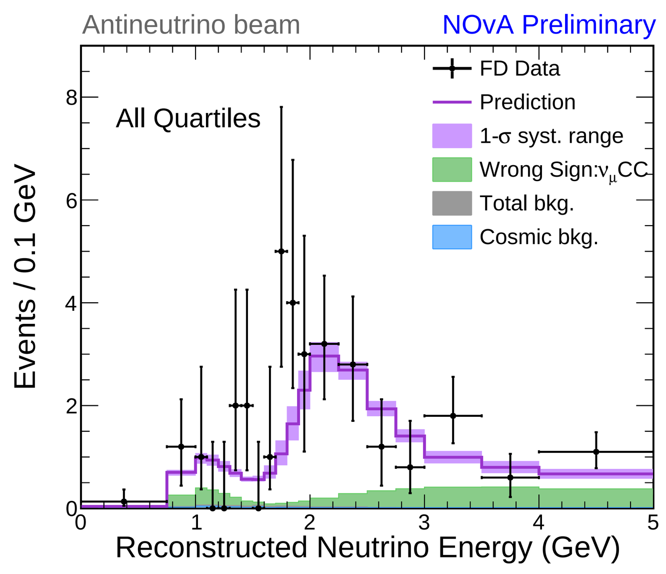
Observed 58 ν_e CC events					
Expected 30 ($\pi/2$ IH) - 75 ($3\pi/2$ NH) events					
Total background 15.1 events					
$\bar{\nu}_e$ CC	beam ν_e	ν_μ CC	ν_τ CC	NC	cosmic
0.66	6.85	0.63	0.37	3.21	3.33

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

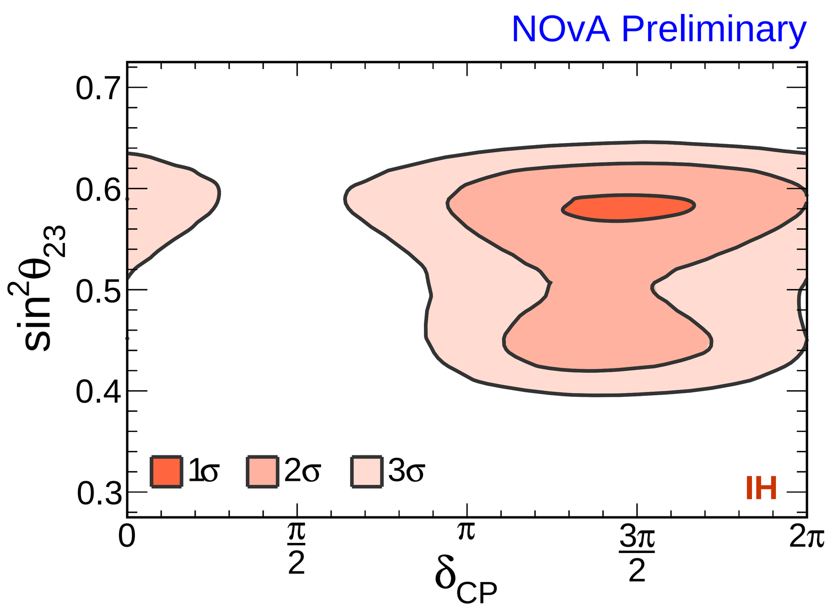
Observed 113 ν_μ CC events			
Total background 11.0 events			
$\bar{\nu}_\mu$ CC	NC	other beam bkg	cosmic
7.24	1.19	0.51	2.07

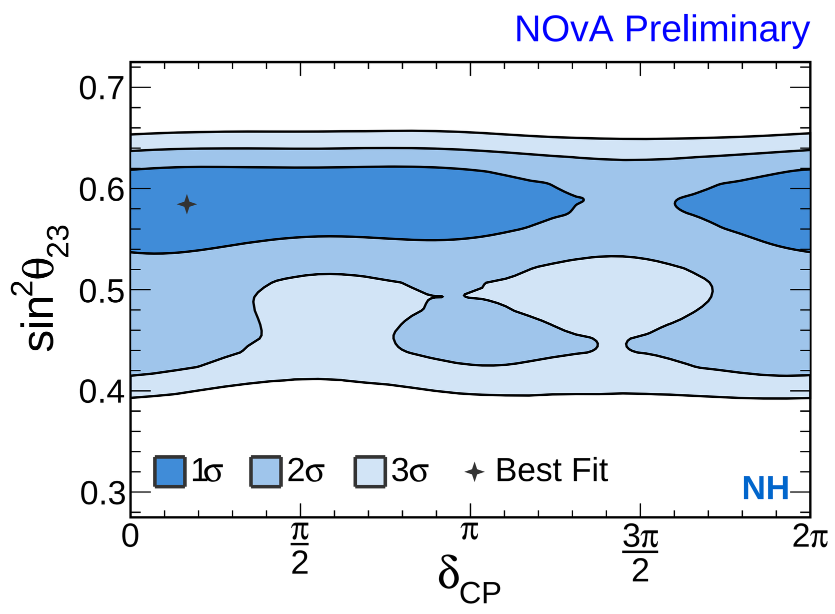
Observed 65 $\bar{\nu}_\mu$ CC events			
Total background 13.7 events			
ν_μ CC	NC	other beam bkg	cosmic
12.58	0.39	0.23	0.46





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

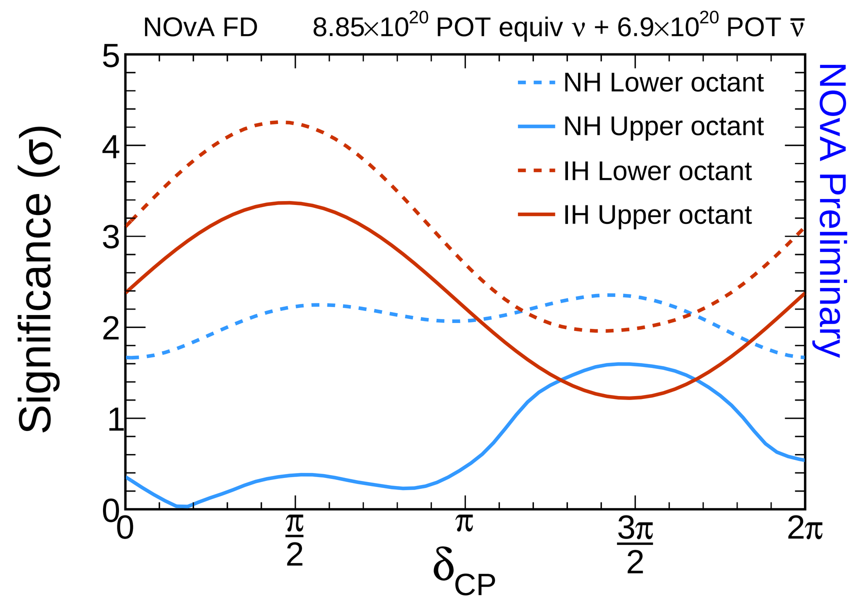




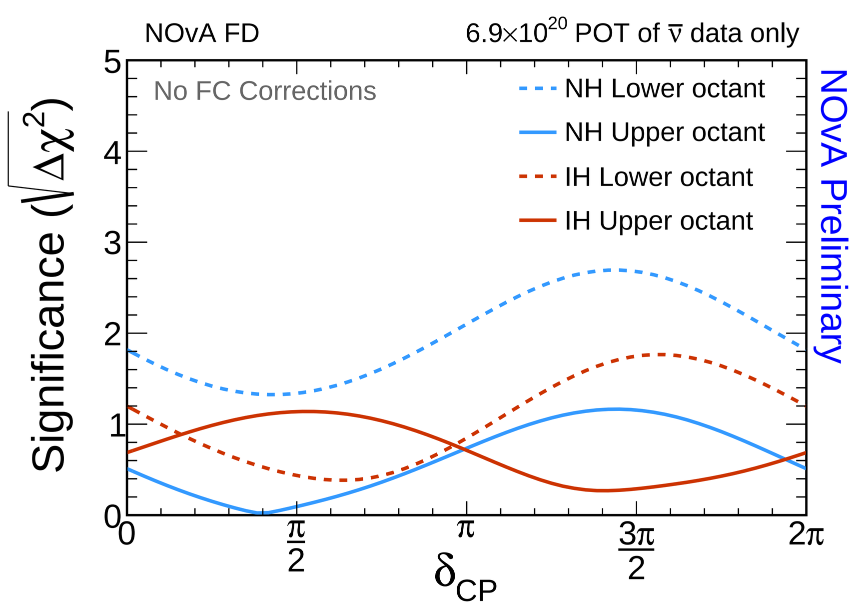
The joint $\nu_e + \nu_\mu$ **fit** in both neutrino and antineutrino modes with systematic uncertainties (see the posters №81 (ν_e) and №88 (ν_μ)) produced the next results:

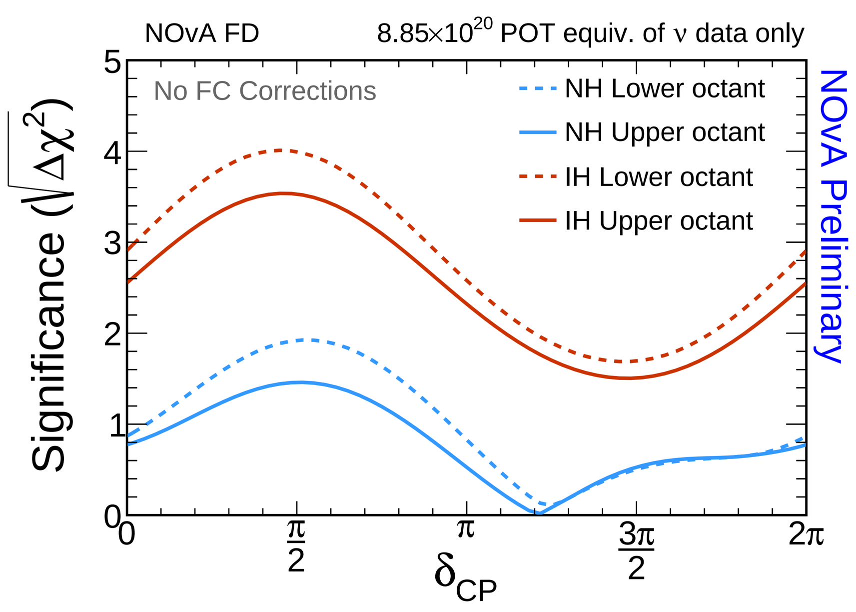
⁕ **Best fit**:
NH, $\delta_{CP} = 0.17\pi$,
$\sin^2\theta_{23} = 0.58 \pm 0.03$ (UO),
$\Delta m^2_{32} = 2.51^{+0.12}_{-0.08} \times 10^{-3}$ eV^2

⁕ 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 $\nu_e+\nu_\mu$ 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.

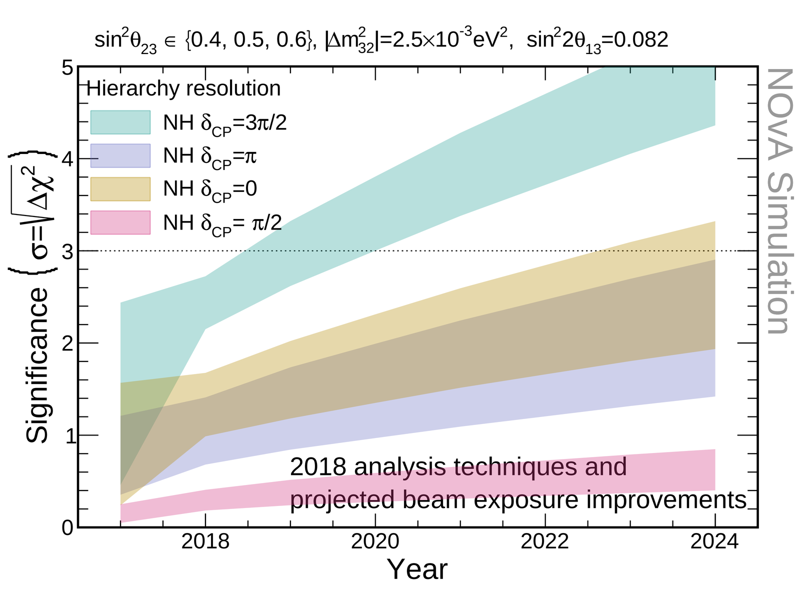
Future sensitivities

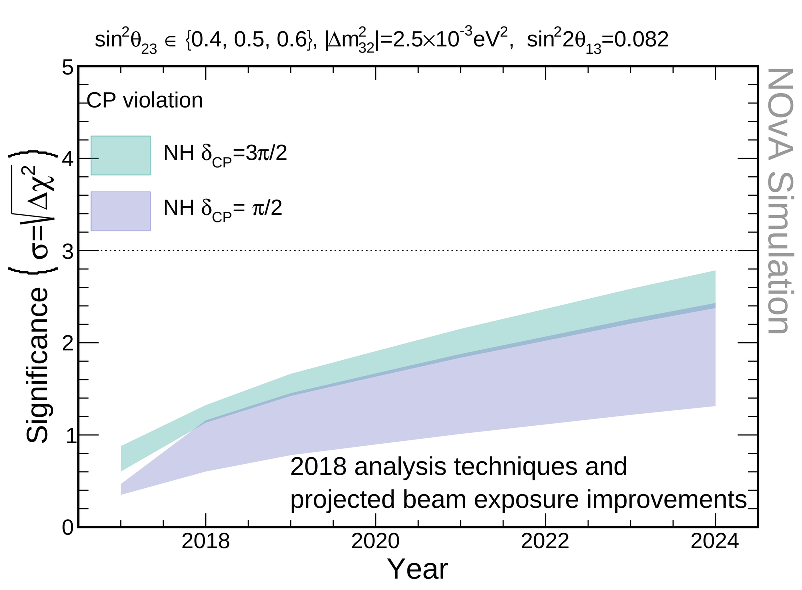
⁕ For **future prospects** we assume:
- 50% neutrino beam and 50% antineutrino beam data per year.
- 2018 analysis techniques, projected beam intensity improvements and reduced systematic uncertainties from NOvA's test beam (see the poster №58).

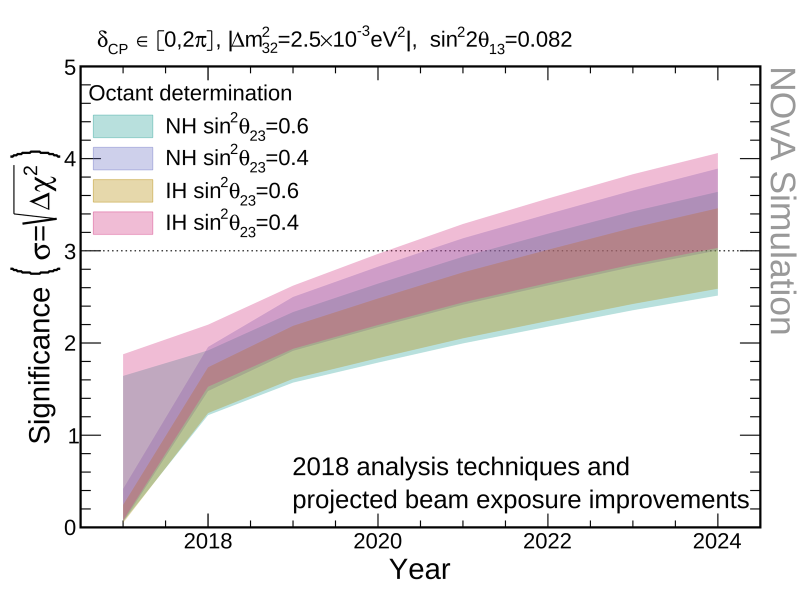
⁕ **By 2020** expect 3σ sensitivity to **mass hierarchy**, for all allowed values of θ_{23}, if hierarchy is normal and $\delta_{CP} = 3\pi/2$.

⁕ **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