The NOvA Experiment

NOvA [1] is a long-baseline neutrino oscillation experiment aiming to determine:

- Neutrino mass hierarchy
- Neutrino oscillation parameters
- CP violating phase \( \delta_{CP} \)
- Searching for sterile neutrinos and other

Beyond the Standard Model physics models

Feldman-Cousins Unified Approach

Compare data and prediction for a given set of oscillation parameters, using a negative log-likelihood and relate it to a chi-square distribution \( \chi^2 = -2 \log L(\theta) \).

Build a test statistic \( \Delta \chi^2 = \chi^2(\theta) - \chi^2(\theta_{best}) \) comparing the best fit point \( \theta_{best} \) to the best fit for a given set of parameters \( \theta \).

Compute a \( p \)-value analytically (Wilks’ theorem) and derive a significance.

Generate and fit thousands of pseudoexperiments to empirically build a \( \Delta \chi^2 \) distribution for each point of the parameter space.

Compute the fraction of pseudoexperiments with a \( \Delta \chi^2 \) larger than the one observed in data.

Compute a significance from that \( p \)-value.

The generation and fitting of millions of pseudoexperiments is an ideal problem for massive parallel computing.

NOvA’s Feldman-Cousins framework can be containerized and ported to High Performance Computing platforms [4].

Improvements were developed to fully leverage NERSC’s computing power, like advanced domain decomposition using Message Passing Interface (MPI):

DIY block-parallel environment and tools [5] are used to efficiently distribute the workload across \( 10^6 \) parallel processes.

The Feldman-Cousins unified approach is a computationally expensive Frequentist approach to determine statistically accurate confidence intervals for parameters of interest.

Empirically built \( \Delta \chi^2 \) distributions can be skewed to the left or to the right of the standard distribution, therefore respectively increasing or decreasing NOvA’s physics sensitivities compared to Gaussian assumptions.

See Erika’s poster 3 flavor neutrino oscillations in NOvA and Latest results from the NOvA experiment Thursday morning.

References


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