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Grid-based minimization at scale: Feldman-Cousins corrections for light sterile neutrino search

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High Energy Physics (HEP) experiments generally employ sophisticated statistical methods to present results in searches of new physics. In the problem of searching for sterile neutrinos, likelihood ratio tests are applied to short-baseline neutrino oscillation experiments to construct confidence intervals for the parameters of interest. The test statistics of the form $\Delta\chi^2$ is often used to form the confidence intervals, however, this approach can lead to statistical inaccuracies due to the small signal rate in the region-of-interest. In this paper, we present a computational model for the computationally expensive Feldman-Cousins corrections to construct a statistically accurate confidence interval for neutrino oscillation analysis. The program performs a grid-based minimization over oscillation parameters and is written in C++. Our algorithms make use of vectorization through Eigen3, yielding a single-core speed-up of 350 compared to the original implementation, and achieve MPI data parallelism by employing DIY. We demonstrate the strong scaling of the application at High-Performance Computing (HPC) sites. We utilize HDF5 along with HighFive to write the results of the calculation to file.

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