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A Likelihood-Based Framework for CEvNS Analysis Using Reactor Rate Modulation

Wednesday, August 27, 2025 6:00 PM (2 hours)

Coherent elastic neutrino-nucleus scattering (CEνNS) experiments at research reactors benefit from regular reactor off-periods, allowing for effective background subtraction. At commercial reactor facilities, off-periods are rare and short due to the priority of continuous energy production. In facilities with two or more reactors, temporary shutdowns for maintenance naturally introduce time-varying neutrino fluxes - enabling reactor rate modulation analysis.

A key advantage of a pure rate-based analysis is its independence from background modeling, under the condition of a background constant in time - a powerful feature for robust and unambiguous CEνNS discovery.

We present a dedicated framework designed to perform CEνNS analyses by incorporating time-dependent reactor power profiles into the likelihood. The framework includes flexible signal and background models defined in energy, time, or both, enabling rate-only, shape-only, or combined analyses using either binned or unbinned likelihoods. It also provides tools to generate pseudo-experiments for sensitivity studies and robust frequentist statistical inference.

Originally developed with the NUCLEUS experiment in mind, the framework is broadly applicable to any CEνNS experiment operating under time-dependent reactor conditions. We will show how different systematic uncertainties, such as energy scale and background model, impact the various analysis strategies, providing guidance for experimental design and optimization to maximize discovery potential.

Collaboration you are representing

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