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Cosmic Neutrino Background Detection with Tritium

The Cosmic Neutrino Background (CNB) is a robust thermal relic of the Big Bang and a potential probe of neutrino mass properties and of the Universe at O(1) second. A leading direct-detection strategy is neutrino capture on tritium, where observing a distinct capture peak requires excellent effective energy resolution. In practice, binding and solid-state effects can broaden the endpoint spectrum, potentially pushing experiments into a background-dominated regime with significant modeling uncertainties. In this ongoing work, we perform a unified sensitivity study for (i) an energy-only endpoint analysis and (ii) a joint energy–angle analysis that exploits the CNB dipole anisotropy. Using profile-likelihood methods with nuisance parameters, we quantify the exposure and systematic-control requirements for discovery. The energy-only approach can hit a systematic "floor," where increasing exposure no longer improves significance, while an angular analysis can cancel leading normalization systematics and provide a complementary handle on backgrounds.

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