

Cosmic-ray background in the RECODE experiment

摘要

相干弹性中微子-核散射 (CEvNS) 为探测中微子属性和检验超出标准模型的新物理提供了独特的探测渠道。反应堆相干中微子散射探测实验 (RECODE) 旨在利用高纯度锗 (HPGe) 探测器测量反应堆 CEvNS 过程。本研究通过蒙特卡罗 (MC) 模拟, 对主导实验本底——宇宙射线辐射——进行了系统评估与优化。分析表明, μ 子诱导的本底在高能区占主导地位, 而中子诱导的本底在低能区迅速上升, 且其反符合效率显著低于 μ 子诱导事例。在屏蔽系统的作用下, 主导实验本底为宇宙射线本底。若无覆岩层遮挡 ($<5\text{m.w.e}$), 中子诱导本底将变得比 μ 子诱导本底更为显著, 后续改进中需要着重考虑进一步屏蔽宇宙线中子。而对于高穿透性的 μ 子, 将塑闪时间窗口延长至 100 微秒可使 μ 子诱导本底进一步降低一倍。

关键词

中微子弹性散射、宇宙射线、蒙卡模拟

Abstract

Coherent Elastic Neutrino-Nucleus Scattering (CEvNS) offers a unique channel for probing neutrino properties and testing physics beyond the Standard Model. The REactor COherent neutrino scattering Detection Experiment (RECODE) aims to measure reactor CEvNS using high-purity germanium (HPGe) detectors. In this work, the dominant experimental background—cosmic-ray radiation—is systematically evaluated and optimized through Monte Carlo (MC) simulations. The analysis reveals that the muon-induced background dominates at high energies, whereas the neutron-induced component rises rapidly in the low-energy regime and exhibits a substantially lower veto efficiency compared to that achieved for muon-induced events. With the shielding system, the dominant experimental background is cosmic-ray background. In the absence of overburden, the neutron-induced background becomes more significant than the muon-induced background, and further shielding of cosmic-ray neutrons should be a key consideration in subsequent improvements. For highly penetrating muons, extending the time window of the plastic scintillator to 100 μs would reduce the muon-induced background by an additional factor of two.

Keywords

CEvNS、Cosmic-ray、Monte Carlo

Author: GUO, Tao (Tsinghua University)

Presenter: GUO, Tao (Tsinghua University)

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