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Global Rare Anomalous Nuclear Decay Experiment (GRANDE): Pioneering the Detection of Rare Nuclear Decays and Exotic Dark Matter

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The Global Rare Anomalous Nuclear Decay Experiment (GRANDE) aims to push the frontiers of nuclear and modern physics through the experimental measurement of rare nuclear decays. A key focus of GRANDE is the search for exotic dark-matter particles, including axion-like particles, anapole dark matter, and dark photons in nuclear transitions. Based on observations of rare electron-capture decay branching of 57Co and 139Ce isotopes, the potential detection of mimic dark-matter particles in underground experiments is theoretically promising [1].

This work presents the innovative research and development of a Cerium Bromide (CeBr3) detector, specifically designed for this mission, conducted at the Yemi Underground Lab, Korea. The detector employs a source-as-detector technique utilizing 57Co and 139Ce isotopes. The CeBr3 scintillation crystal, known for its rapid decay time, high light yield, excellent energy resolution, and high density, is ideally suited for detecting low-energy events and utilizing time-tag techniques.

In GRANDE, we have successfully fabricated and developed CeBr3 source-detector scintillation crystals using the Bridgman technique, incorporating radiation source doping to embed radiation sources within the crystal lattice. The integration of a 4π veto system is considered to enhance performance and detection limits. A 5x5x7.5 cm3 Bismuth Germanate (BGO) crystal is tested for this task. The electronic for data acquisition have been considered for this mission with the capability of time decay coincidence technique to eliminate backgrounds, particularly in isomeric state measurements, thus enabling precise photon identification.

To achieve accurate measurements of rare decay processes, a zero-background environment is essential. Therefore, GRANDE is divided into two stages: the first stage involves understanding and enhancing the radiation background. At the Yemi Underground Lab, we investigated the background levels of the detector and shielding setup using a ϕ1x1 inch pure CeBr3 detector to study internal and external backgrounds. Enhancements were made to achieve a suitable radiation background for dark matter search. The second stage focuses on source-as-detector measurements. We will present the fabrication and measurement R&D of our detector setup, highlighting results and detailed experiments from this pioneering effort in rare nuclear decay and dark matter detection.

[1] A. Anihotri, J. Suhonen, H.J. Kim, "Constraints for rare electron-capture decays mimicking detection of dark-matter particles in nuclear transitions", Physical Review Letters 1333 (2024) 232501.

Consent

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