ID contributo: **149** Tipo: **Poster**

Studies of radioactive background from environment for a potential LXe dark matter experiment at Boulby

mercoledì 10 luglio 2024 17:10 (20 minuti)

Rare event searches, such as those targeting dark matter interactions and neutrinoless double beta decay ($0\nu\beta\beta$), face challenges from gamma-rays originating in rock, contributing to electron recoil background. This report presents a dual investigation: measurements of natural radioactivity in rock samples from Boulby Mine and a simulation assessing shielding thickness for a future detector. The measurements provide data for normalising conditions in prospective experiments at Boulby. The simulation studies the effectiveness of water shielding around a detector, focusing on the Weakly Interacting Massive Particle (WIMP) energy range (0 –20 keV) and the energy range near the $0\nu\beta\beta$ Q-value (2.458 MeV).

The study design features a simplified xenon-based detector with a 70-tonne active volume, encompassed by veto systems and water shielding. Our findings indicate that gamma-ray background is unlikely to persist through analysis cuts in the WIMP energy range. However, for $0\nu\beta\beta$ decay signal searches, adjustments will be required; the sensitivity of a next-generation detector demands a background of < 1 event per 10 years, necessitating a reduction in the fiducial volume of the detector.

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Classifica Sessioni: Poster session

Classificazione della track: Poster session: Direct detection