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Development of an accelerator-driven Ba-ion source to optimize Barium tagging techniques

Neutrinoless double-beta decay ($0\nu\beta\beta$) offers a way to probe for physics beyond the Standard Model. Observation of $0\nu\beta\beta$ will validate the Majorana nature of neutrinos, demonstrate violation of lepton number explaining the observed baryon asymmetry in the universe, and probe new mass generation mechanisms up to the GUT scale. The planned nEXO experiment will search for $0\nu\beta\beta$ decay in ^{136}Xe with a projected half-life ($t_{1/2}$) sensitivity exceeding 10^{28} years at the 90% confidence level over 10 years of livetime, using a tonne-scale liquid xenon (LXe) time projection chamber (TPC). In parallel, research is ongoing for future upgrades to nEXO to suppress background and further increase this sensitivity. One such approach is the extraction and identification of the $\beta\beta$-decay daughter Ba ion, also known as Ba tagging, which will confirm $\beta\beta$ events irrefutably. In addition to nEXO, Ba tagging would help other next-generation, tonne-scale Xe TPC experiments, like XLZD, approach $t_{1/2}$ sensitivities of 10^{28} years and beyond. To that end, an accelerator-driven ion source is currently being developed at TRIUMF, where radioactive ions of ^{139}Cs and ^{139}Ba will be implanted inside an LXe volume, extracted electrostatically, and identified via γ spectroscopy. Past measurements at the ISAC yield station demonstrate that both isotopes can be delivered at sufficient intensities using a UC_x target. A commissioning phase using Ar gas has been approved for beam time by the Nuclear Physics Experiments Evaluation Committee at TRIUMF with high priority, and the experimental set up is in its final stages of completion for this phase. ARIEL coming online points to an exciting future for science at TRIUMF with higher probability of beam-time allotments for detailed systematic studies of extraction efficiency and ion mobility. The upcoming CANREB facility equipped with an Electron Beam Ion Source will facilitate background reduction, a crucial requirement for this experiment. Once developed, the ion source will be used to optimize ion extraction methods under development by other groups within the nEXO collaboration. The background for the project, the apparatus, and recent updates will be presented along with planned measurements.

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