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The Quest for No Neutrinos: Advancing the Search with LEGEND-1000

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The LEGEND collaboration aims to unambiguously discover neutrinoless double-beta decay ($0\nu\beta\beta$) using high-purity germanium (HPGe) detectors enriched in the double-beta-decaying isotope ^{76}Ge (Q = 2039 keV). The HPGe detectors operate in liquid argon, which serves as a coolant and an active shield, enabling a quasi background-free search for $0\nu\beta\beta$ decay. The first phase, LEGEND-200, utilizes up to 200 kg of enriched HPGe detectors and is currently operational in Hall A of the Laboratori Nazionali del Gran Sasso (LNGS), Italy. The subsequent phase, LEGEND-1000, is scheduled to begin construction in Hall C of the LNGS in 2026 and aims to scale up to 1000 kg of detectors.

Achieving a discovery sensitivity of 3σ for $0\nu\beta\beta$ decay at a half-life of 10^{28} years requires maintaining a background contribution at Q of less than 10^{-5} counts/(keV kg yr). Strategies to meet this requirement include selecting radiopure materials and using underground liquid argon. Alternatives are being explored, such as optically active enclosures and specialized pulse shape discrimination. Furthermore, novel background suppression techniques have been developed for the in-situ produced isotope $^{77(m)}$Ge based on delayed coincidences. This poster will provide insights into the LEGEND-1000 baseline design and discuss various background reduction techniques, focusing on the suppression of the decays of in-situ produced isotopes.

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