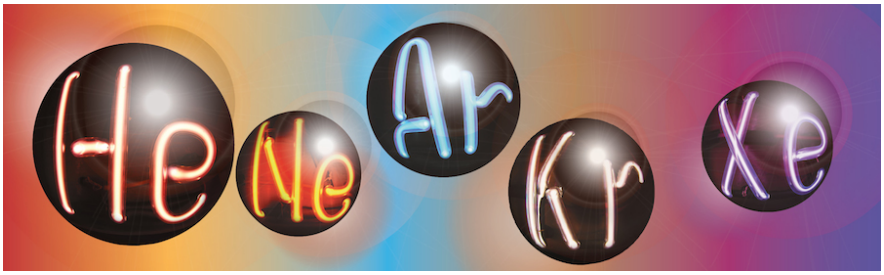

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LowRad & HERETIX: Low background for Dark Matter and neutrinoless double beta decay searches with XLZD

Next-generation liquid xenon (LXe) observatories such as XLZD aim to push the search for both Weakly Interacting Massive Particles (WIMPs) and neutrinoless double beta decay (0νββ) to unprecedented sensitivities. This requires an aggressive reduction of intrinsic backgrounds, dominated by the LXe-intrinsic isotopes of Kr and Rn, to a factor of ten below the unshieldable solar and atmospheric neutrino background. For XENONnT it could be shown that cryogenic distillation is a suitable method for reducing these backgrounds, but XLZD will require an approximately 20-times higher radon purification flow, necessitating new technologies for the associated cooling and heating power. Within the ERC Advanced Grant project LowRad, the technical foundations for the next-generation cryogenic krypton and radon removal systems are developed, including a krypton concentrator and a radon removal system with a cryogenic xenon heat pump. The concentrator aims to reduce krypton-enriched off-gas losses by another factor of 1000 (to 6 g/day), enabling continuous online distillation, while the heat pump addresses the heating and cooling power demands of 60 kW each (XLZD-sized, 1600 kg/h) required to reduce the Rn background below 0.1 µBq/kg.

Beyond background reduction, the HERETIX (Hermetic, Enriched, Rare-Event Time Projection Chamber in Xenon; arXiv: 2606.26876) concept explores a unified detector architecture serving both physics programs simultaneously, exploiting the large technological overlap between 0νββ and WIMP searches. We present a dual-phase, dual-chamber TPC, whereby an inner hermetic sapphire vessel holds about 5 tonnes of ^{136}Xe-enriched active LXe for 0νββ searches, embedded within a larger depleted active volume of about 60 tonnes optimised for WIMP searches. Monte Carlo studies indicate that material-induced backgrounds can be effectively eliminated, yielding a projected 0νββ half-life sensitivity of 3.2×10^{28} years at 90% confidence level after a 10-year exposure.

This talk presents the working principles, design choices, and status of the LowRad systems developed in Münster, together with the projected sensitivities and practical challenges of the HERETIX dual-volume approach, outlining the prospects towards the final XLZD observatory.

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