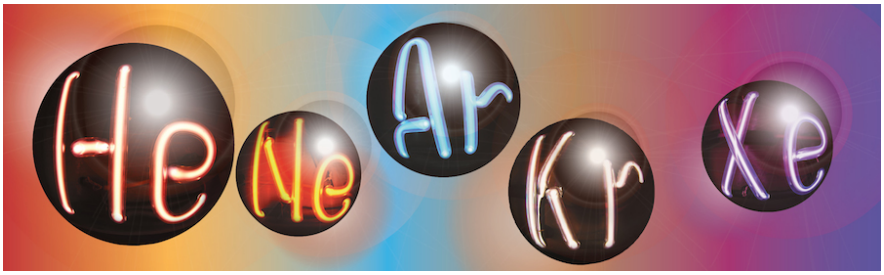

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A vacuum-insulated liquid argon purifier for removing nitrogen, oxygen, and water featuring a novel Li-FAU molecular sieve

LEGEND is searching for neutrinoless double-beta ($0\nu\beta\beta$) decay of ^{76}Ge using isotopically enriched high-purity germanium detectors operated bare in liquid argon (LAr), which serves as coolant, shielding, and active detector. Achieving and maintaining excellent LAr purity is essential, as oxygen, water, and nitrogen impurities degrade scintillation and optical properties and thus deteriorate background rejection. [1]
Molecular sieves and copper catalysts are routinely used to remove water and oxygen from noble gases [2], whereas removing nitrogen has historically been more challenging. A recently identified Li-FAU molecular sieve effectively removes nitrogen from liquid argon. We developed, commissioned, and operated a liquid argon purification system for the 1-tonne LAr test stand SCARF at the Technical University of Munich, combining a Li-FAU molecular sieve and a copper catalyst. The system operates in batch and loop mode, is actively cooled and vacuum-insulated to minimize heat influx.
The LAr quality is monitored in-situ with the triggered SiPM array LLAMA [3], which measures scintillation light yield, triplet lifetime, and attenuation length. Following commissioning, an initial purification run validated system performance and guided optimization. A subsequent long, continuous purification campaign recovered the effective triplet lifetime of air-contaminated liquid argon from 0.61 ± 0.01 µs to 1.35 ± 0.01 µs. Here, we present the system design, commissioning, and purification performance results providing operational input for future LEGEND applications.

[1] M. Harańczyk et al., Procurement and Purification of Liquid Argon for the LEGEND-200 Experiment, arXiv:2605.20507
[2] C. Vogl et al., A liquid-phase loop-mode argon purification system, 2024 JINST 19 C03030
[3] M. Schwarz et al., Liquid Argon Instrumentation and Monitoring in LEGEND-200, EPJ Web Conf. 253 (2021) 11014.

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