Liquid Argon Instrumentation for Background Suppression in LEGEND-200 Experiment

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NEUTRINO 2024

2. LAr Scintillation

The LAr scintillation light emission is superposition of two excimer states (Ar_2^*) , which both decay producing **128 nm** Vacuum-Ultra-Violet (VUV) light

LEGEND-200 experiment for neutrinoless double beta decay search, using HPGe detectors immersed in LAr cryostat

1. LAr Instrumentation Setup

- The Liquid Argon (LAr) instrumentation is an essential detector system of LEGEND-200 experiment:
- designed to detect and supress background events through detection of LAr scintillation light;



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consists of two concentric curtains of WaveLength Shifting (WLS) fibers coupled to SiPMs. NIMA 1048 (2023) 167943



1 μm TetraPhenyl Butadiene **(TPB)** surface **coating** by evaporation; 0 58 SiPM channels: 58 x 9 Ketek PMT33100T 3x3 mm² SiPMs. \bigcirc

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3. LAr Instrumentation Characterization

The 9 SiPMs are read out in parallel and differentially by the front-end electronics! 80- $\mu - 2\sigma = 5.48$ Overall noise level of 250 μ V (peak-to-peak) and RMS = 58 μ V (meam+value). JINST 18 (2023) 09 Charge and time reconstruction performed ψ_{40} be a sed on 2_{40} rising edge of the trace and differing in the signal filtering





To optimize the LAr instrumentation performance the LAr was **purified** from N_2 , O_2 and H_2O . Pos PANIC2021 (2022) 102

The **LAr quality** is monitored continuously by the LEGEND LAr Monitoring Apparatus (LLAMA). EPJ Web Conf. 253 (2021) 11014



- HyperCurrent algorithm a Gaussian filter is applied to smooth the electronic noise: 95% charge reconstruction efficiency.
- DPLMS filter-based algorithm Eur.Phys.J.C 83 (2023) 2 an bitimum filter is synthetized and applied to SiPMs traces: **96% charge reconstruction efficiency** s)
- The obtained Single Photo-Electron (SPE) resolution from both algorithms is FWHM@SPE = 0.3 PE (mean value).
- The Light Yield (LY) obtained from ¹³⁷Cs Compton continuum calibration is LY ~ 0.1 p.e./keV (source position dependent). PoS TAUP2023 (2024) 256.



The **population ratio** of excimers in the singlet (N_s) and triplet (N_t) states, depending on the nature of primary radiation, allows particle discrimination.

Event Topology Classifier (ETC) parameter ratio of the light emitted in the single component to the total light intensity of an event (N = N_s+N_t): ETC = $\frac{N_s}{N_t}$ Counts/0.01/p.e

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Application: **Bi-Po tagging** ²¹⁴Po, ²¹⁴Bi β-decays to which produces α -decays (T_{1/2} = 164 μ s) time correlated generates and events.





5. Performance in LEGEND-200

LAr veto condition:

- **Test statistic-based classifier** that categorizes events as **true** (TC) or **random coincidences** (RC) based on the **time** and **energy** information of the LAr signals.
- Time PDF of TC weights the pulses depending on their arrival time relative to the HPGe trigger position.
 - **Comptom continuum** suppressed by a factor **2** up to 1700 keV.
 - Events in the region of the interest (around $Q_{\beta\beta}=2039$ keV) suppressed by a factor 5.







