LEGEND-200 Background Index and mitigation techniques

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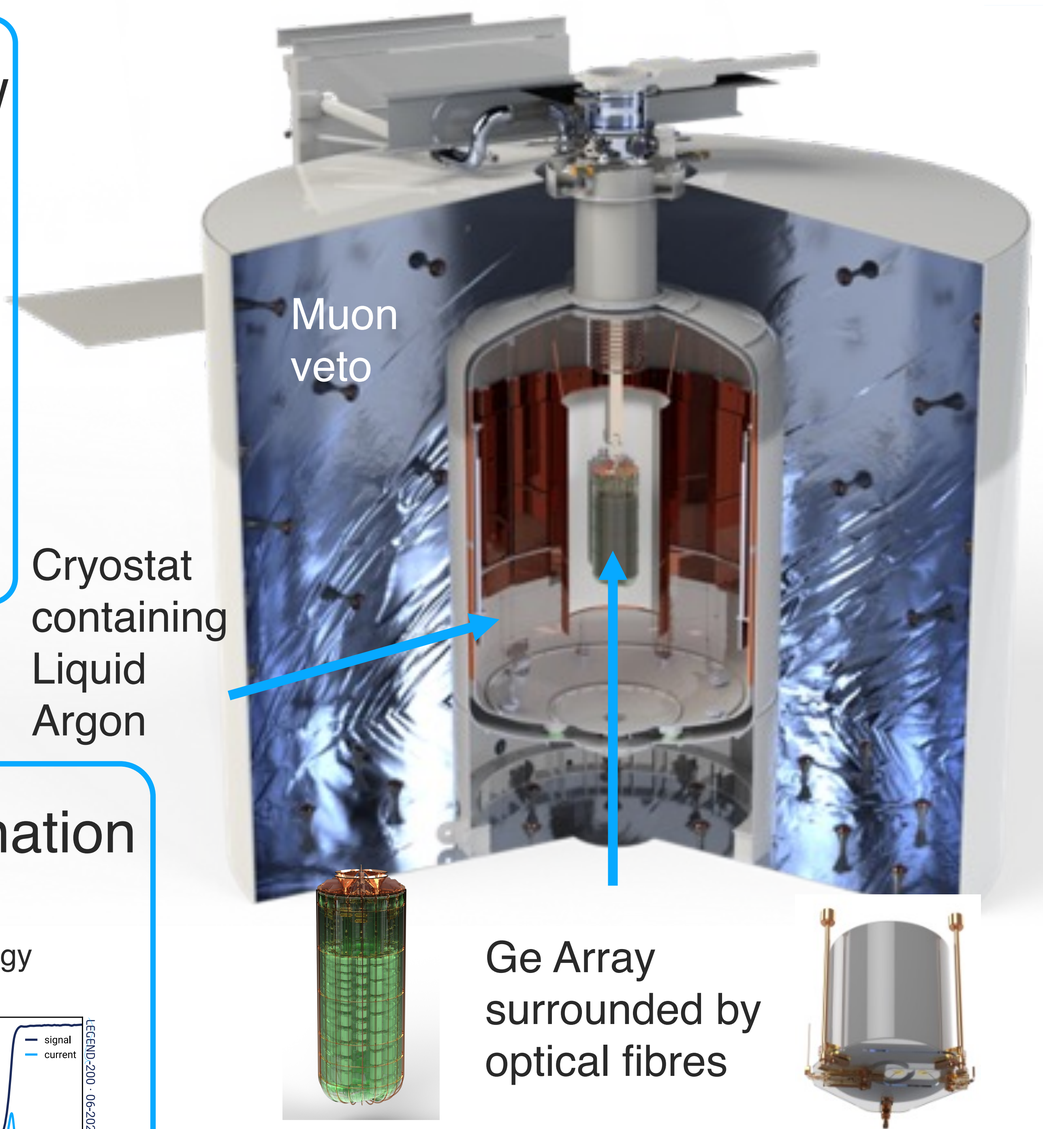
LEGEND Large Enriched Germanium Experiment for Neutrinoless ββ Decay

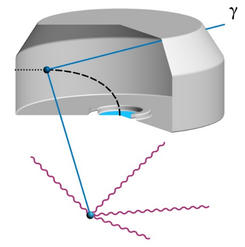
LEGEND-200 Overview

- Located in Gran Sasso, Italy
- Uses ^{76}Ge as isotope to search for 0vbb: $Q_{\beta\beta}$: 2039 keV
- Taking physics data since March 2023
- First dataset unblinded with 48.2 kg.yr exposure
- Will run for 5 years to achieve 1 ton.yr exposure
- Half life sensitivity of 10^{27} yr

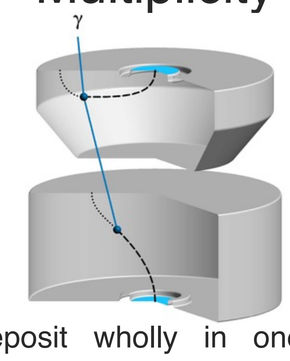


Analysis Background Suppression

Liquid Argon

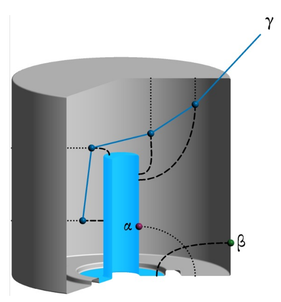


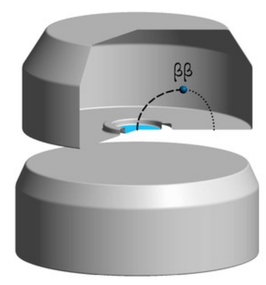
Multiplicity



- 0vββ expect energy deposit wholly in one detector

PSD

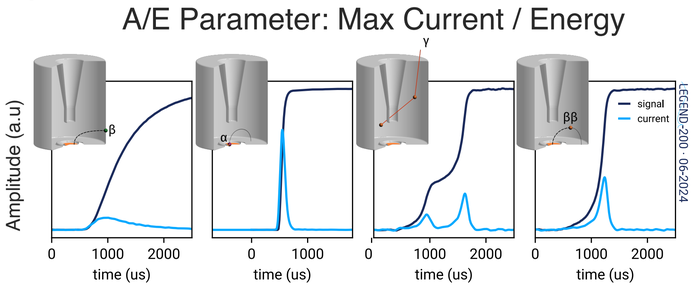




- 0vββ expect single site energy deposit in detector bulk
- Reject events with multiple energy deposits or at surface

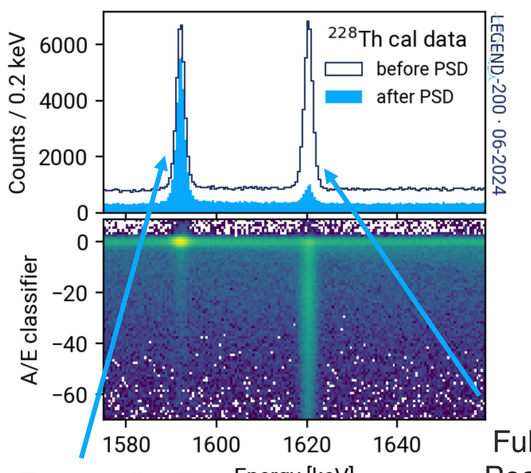
Pulse Shape Discrimination (PSD)

A/E Parameter: Max Current / Energy



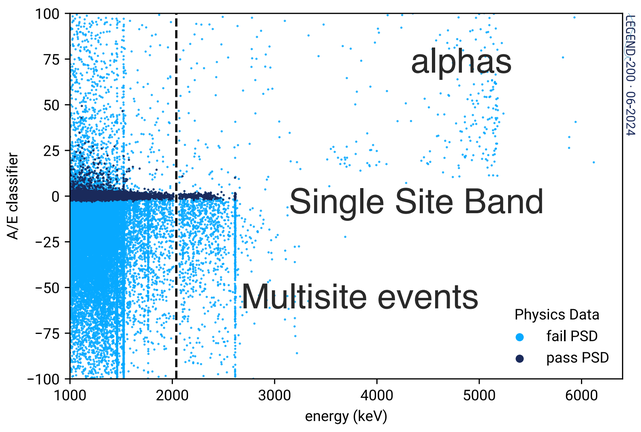
Surface Events — Bulk Events

Use weekly calibrations to tune acceptance and monitor



Double Escape Peak (single site proxy) preserved

Full Energy Peak (multi-site) suppressed

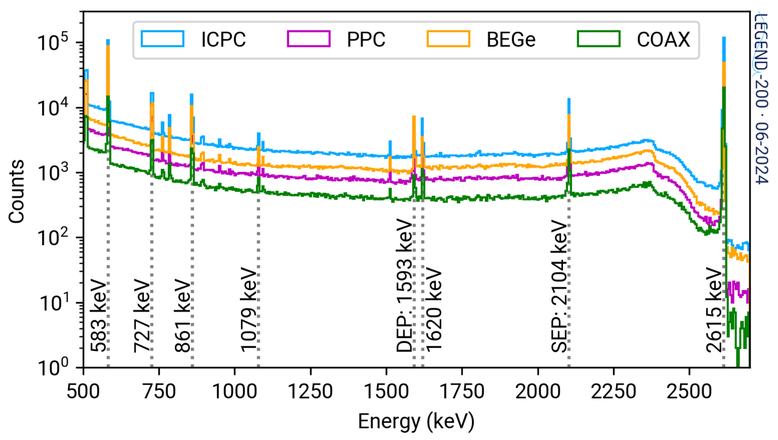


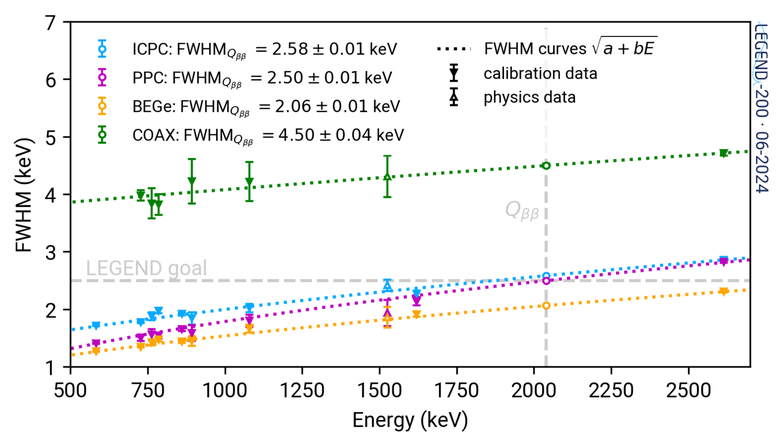
Suppress background by factor of 5 in ROI 0vββ acceptance efficiencies :

	ICPC	BEGe	PPC
Multi-site	$86.4 \pm 3.5\%$	$86.2 \pm 3.5\%$	$85.2 \pm 3.6\%$
Surface	$98.6 \pm 0.9\%$	$96.9 \pm 1.9\%$	$98.6 \pm 0.9\%$
Combined	$85.2 \pm 3.6\%$	$83.5 \pm 3.8\%$	$85.2 \pm 3.6\%$

Energy Calibrations

Weekly calibrations taken with Th-228 sources inserted in cryostat,
7 high statistics peaks from 583 to 2614keV used to monitor and assess energy scale





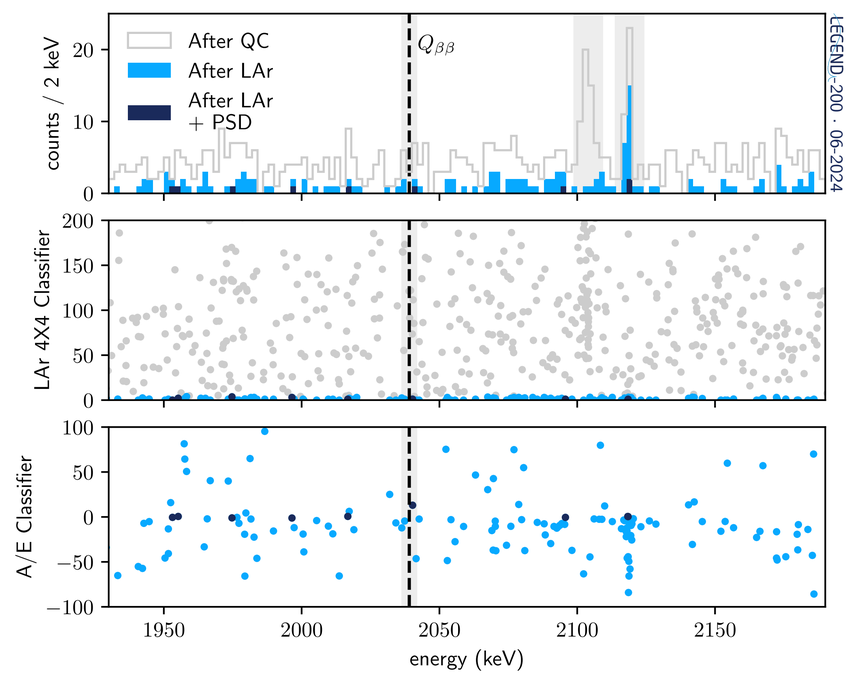
Systematics:
Average Energy Resolution: 2.54 +/- 0.03 keV
Mean energy bias at $Q_{\beta\beta}$ (evaluated from DEP/SEP residuals in calibrations) : 2.55 +/- 0.01 keV
Array Stable at below 0.1 keV level, sub dominant to energy resolution
Energy resolution compatible with LEGEND Goal, leading energy resolution in field
No mass dependence -> can build larger detectors

ROI and Background Index

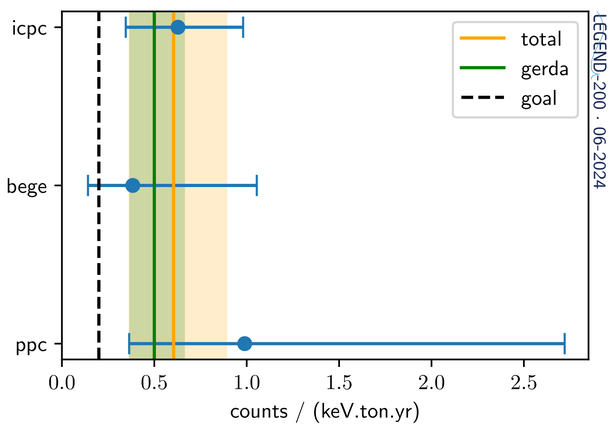
- Background Index:

  $0.60^{+0.29}_{-0.24}$ cts/(keV.ton.yr)

- Compatible with LEGEND-200 goal at 2 sigma level



Background Index by detector type



- Expect further improvements by:
  - Increasing active mass
  - Remove detectors with poor performance
  - Reducing background contamination
  - Change to likelihood-based LAr classifier
  - Optimisation of PSD

Scan for list of Legend Institutions!