# Low Energy Data Cleaning for LEGEND

UNC Chapel Hill/TUNL

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Large Enriched





## **LEGEND** Overview



**Mission:** "The collaboration aims to develop a phased, **Ge-76 based** double-beta decay experimental program with discovery potential at a **half-life beyond 10<sup>28</sup> years, using existing resources as appropriate to expedite physics results."** 

**Select best technologies**, based on what has been learned from GERDA and the MAJORANA DEMONSTRATOR, as well as contributions from other groups and experiments.

MAJORANA - Radiopurity of nearby parts (FETs, cables, Cu mounts, etc.) - Low noise electronics improves PSD - Low energy threshold (helps reject cosmogenic background)	<b>GERDA</b> - LAr veto - Low-A shield, no Pb	<b>Both</b> <ul> <li>Clean fabrication techniques</li> <li>Control of surface exposure</li> <li>Development of large point-contact detectors</li> <li>Lowest background and best resolution 0νββ experiments</li> </ul>
<ul> <li>First phase:</li> <li>Deploy 200 kg in upgrade of existing infrastructure at LNGS</li> <li>BG goal: &lt;0.6 cts /(FWHM t yr)</li> <li>Discovery sensitivity at a half-life of 10<sup>27</sup> years</li> <li>Currently taking data</li> </ul>		<ul> <li>Subsequent stages:</li> <li>1000 kg, staged via individual payloads</li> <li>Timeline connected to review process</li> <li>BG goal &lt;0.03 cts/(FWHM t yr)</li> <li>Location to be selected</li> </ul>

## L-200 Current Status

LEGEND

- Germanium detectors operated in bath of atmospheric LAr for scintillation detection
- 142.3 kg of Ge detectors installed
  - Goal: reach 200 kg by end of 2023
- Taking data
  - Regular physics data and calibration data



## Why LEGEND BSM?

LEGEND



Slide Credit: Samuel L. Watkins (LANL)

### Low-Energy Background

LEGEND

#### L-1000 Background Model

#### For BSM physics sensitivities, we need a model for all energies

- Geant4-based simulations on the LEGEND-1000 geometry
- Realistic detectors



Slide Credit: Samuel L. Watkins (LANL)

## **Tracklike Signature Example: Composite DM**

- Ultraheavy DM with large cross sections
  - Would interact multiple times
  - Would interact in a line (track)
  - Potentially can be background free via requirement of multiple scatters in a line
- Thanks to large exposure, potential to probe very high masses



Slide Credit: Samuel L. Watkins (LANL)



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## **Tests of Fundamental Symmetries**





## **Some LEGEND BSM Analyses**

- Slow pulse cut
  - Remove energy-degraded events from near detector surface
- Liquid Ar veto
  - Remove events that generated significant numbers of photoelectrons in fibers
  - Ar-39 dominates at low energies
- Multiplicity
  - Remove events that interacted with multiple Ge detectors





# **A/E for Multi-Site Rejection**

- Used A/E parameter as tool for creating cuts
- Multi-site events have low A/E values
- Made cuts to look only at events in circled region

#### Sample of Detectors Over 1 Week of Data Taking



- Used Waveform Browser to view
   waveforms of events in circled region
- Example of a multi-site event (what we tend to see at higher energies) that we would like to cut

#### **Example Waveform for a Muti-Site Event**



# **A/E for Slow Pulse Rejection**

- Same 2D Histogram as on previous slide, but looking specifically at low energies
- Slow pulses also have low A/E values
- Made cuts to look only at events in circled region

#### Sample of Detectors Over 1 Week of Data Taking



- Used Waveform Browser to view waveforms of events in circled region
- Example of Slow Pulse event (what we see at low energies) that we would like to cut
- Demonstrates A/E can be useful at higher and lower energies to cut different types of events

#### Example Waveform for a Slow Pulse Event



#### **LEGEND** Collaboration





~50 institutions, ~300 members MAJORANA + GERDA + more:



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### Conclusions

- LEGEND has a rich BSM physics program
  - Dark matter, test of fundamental symmetries, etc.
- The physics can encompass a wide-range of energies
  - From keV scale to 10's of MeV
- First step: data cleaning (underway)
- A detailed BSM white paper is planned to be out this summer





Slide Credit: Samuel L. Watkins (LANL)

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