Search for Beyond the Standard Model physics with LEGEND-1000

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(arXiv:1709.01980)

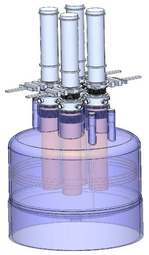
Overview

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

Staged approach

LEGEND-200

- 200 kg in upgrade of existing infrastructure at Gran Sasso
- 2.5-keV FWHM at Q-value @ 2 MeV
- Start data taking in ’21
- BG goal in 0νββ ROI: < 0.6 cts/(FWHM-t-yr) **< 2x10^{-4} cts/(keV kg yr)**



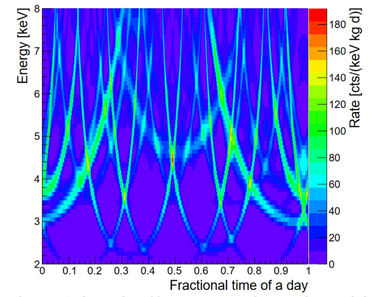
LEGEND-1000

- 1000 kg of ^{enr}Ge, staged via individual payloads
- Timeline connected to DOE review process
- Location: TBD
- BG goal in 0νββ ROI: < 0.03 cts/(FWHM-t-yr) **< 1x10^{-5} cts/(keV kg yr)**

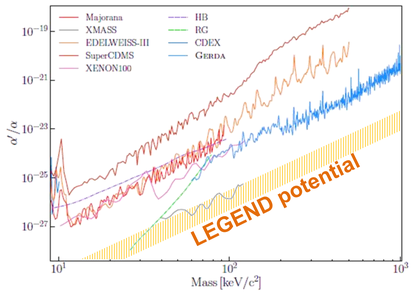
48 institutions, ~240 members

Ongoing searches in Ge

- World leading limits in current generation experiments GERDA [1,2], MAJORANA [3-6], CDEX [7], EDELWEISS [8], CDMS [9] in competition with large Xe-experiments, NaI and others
- Small exposures of tens of kg·yr
- Results for **:**
  - ❑ Low mass WIMPS [1,7]
  - ❑ Bosonic dark matter [3,8]
  - ❑ Axion like particles and solar axions [3,8]
  - ❑ Lepton number violating dark matter [3]
  - ❑ Lightly Ionizing Particles / Fractional charges [4,9]
  - ❑ Exotic decays (e.g. 3-Nucleon decay) [5]
  - ❑ Electron decay [3]
  - ❑ Pauli Exclusion Principle [3]
  - ❑ 2νββ shape distortions [2]



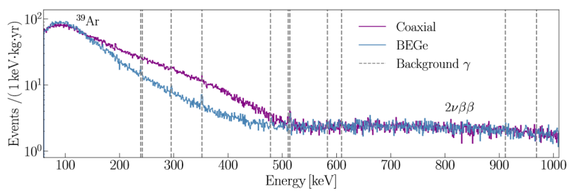
Axion Primakoff conversion signal in a single detector [6]



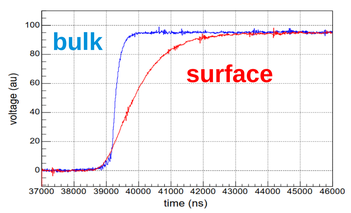
Overview on Results for bosonic DM searches [1] with an expected LEGEND sensitivity based on exposure scaled GERDA and MAJORANA’s results (yellow)

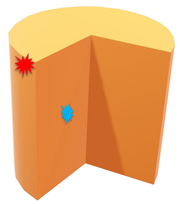
Searches for BSM physics in LEGEND

- Low Background
  - ❑ ~ 0.01 cts /keV/kg/d achieved in current generation
  - ❑ ^{39}Ar decay potential background that can be eliminated by using underground sourced Argon
  - ❑ Pulse shape discrimination to reject backgrounds
- **Excellent energy resolution**
  - ❑ 0.1 keV @ 10 keV, 0.3 keV @ 300 keV
- Individual crystals orientation
  - ❑ **Crystal structure** allow unique searches like the time variation of an Axion-Primakoff conversion signal
  - ❑ Combination of individual units allow track like searches
  - ❑ timing in µs range allows to distinguish between signals and background events (external γ, µ’s)
- **Multi-Element** data set using Ge (1t) and Ar (~300t)

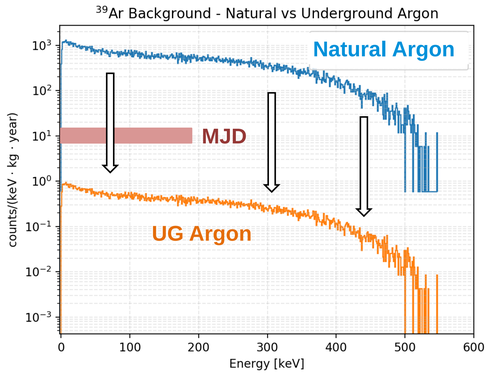


Spectrum of Ge-detector immersed in ^{nat}Ar [1]





Pulse shapes for a bulk event and a surface event



Background reduction when using natural argon or Argon from underground sources compared to the MAJORANA background (red bar). Both curves take into effect an active veto using argon scintillation light. (Fig: R. Hegedus (UNC))

Recent publications:

[1] arxiv 2005.1418
[2] EPJ C75, 416
[3] PRL 118, 161801
[4] PRL 120, 211804
[5] PRD 99, 072004
[6] AstroPhys 89, 39
[7] PRL 120, 241301
[8] PRD 98, 082004
[9] PRL 114, 111302

Acknowledgments:

U.S. NSF, Nuclear Physics, U.S. DOE, Office of Nuclear Physics (DOE-NP), U.S. DOE, Through the LANL, ORNL & LBNL LDRD programs (LDRD), German Federal Ministry for Education and Research (BMBF) German Research Foundation (DFG), Excellence Cluster Universe, German Max Planck Society (MPG), Italian Istituto Nazionale di Fisica Nucleare (INFN), Swiss National Science Foundation (SNF), Polish National Science Centre (NCN), Foundation for Polish Science, Russian Foundation for Basic, Research (RFBR), Research Council of Canada, Natural Sciences and Engineering Canada Foundation for Innovation, John R. Evans Leaders Fund, European Research Council, Science and Technology Facilities Council, part of UK Research and Innovation
We thank our hosts and colleagues at LNGS and SURF. We thank the ORNL Leadership Computing Facility and the LBNL NERSC Center.

LA-UR-20-23958

University of New Mexico, L'Aquila University and INFN, Laboratori Nazionali del Gran Sasso, University of Texas - Austin, Tsinghua University, Beijing, Lawrence Berkeley National Laboratory, Univ. California Physics, Berkeley, Univ. California Nuclear Engineering, Leibniz Institute for Crystal Growth (IKZ Berlin), Comenius University, University of North Carolina, Chapel Hill, Sichuan University, University of South Carolina, Tennessee Tech University, University of Warwick, Jagiellonian University, Krakow, Technical University - Dresden, Joint Institute for Nuclear Research (Dubna), Duke University, Triangle Universities Nuclear Laboratory, Joint Research Centre, Geel, Max Planck Institute - Heidelberg, Queens University, University of Tennessee, Lancaster University, University of Liverpool, University College London, Los Alamos National Laboratory,

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Istituto Nazionale di Fisica Nucleare - Milano Bicocca, Milano University and Milano INFN, National Research Center Kurchatov Institute (NRC KI), Institute of Nuclear Research, Russian Academy of Sciences, Laboratory for Experimental Nuclear Physics of MEPhI (Moscow Engineering and Physics Institute), Max Planck Institute - Munich, Technical University - Munich, Oak Ridge National Laboratory, Padova University and Padova INFN, Istituto Nazionale di Fisica Nucleare - Padova, IEAP Czech Technical University in Prague, North Carolina State University, South Dakota School of Mines and Technology, Roma Tre University and INFN Roma Tre, University of Washington, University Tuebingen, Academia Sinica, Taiwan, University of South Dakota, Williams College, University of Zurich

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