RADIOGENIC NEUTRONS AND EXTERNAL GAMMA-RAY BACKGROUNDS AT LEGEND-1000

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On behalf of LEGEND Collaboration

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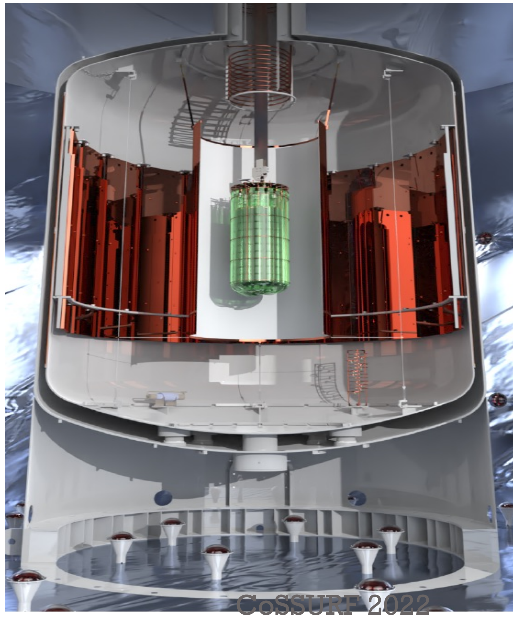
3-minute poster presentation, CoSSURF 2022

LEGEND:

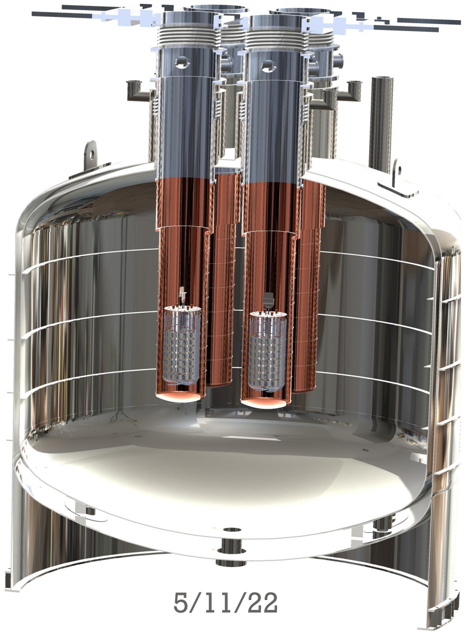
Mission: "The collaboration aims to develop a phased, **Ge-76 based** double-beta decay experimental program with discovery potential **at a half-life beyond 10^{28} years, using existing resources as appropriate to expedite physics results.**"

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	GERDA	Both
- Radiopurity of nearby parts (FETs, cables, Cu, mounts, etc.) - Low noise electronics improves PSD - Low energy threshold (helps reject cosmogenic background)	- LAr Veto - Low-A shield, no Pb	- Clear fabrication techniques - Control of surface exposure - Development of large point-contact detectors - Lowest background and best resolution



	LEGEND-200	LEGEND-1000
Active detector mass (kg)	200	1000
Expected runtime (yrs)	5	10
$T_{1/2}$ sensitivity (yrs)	10^{27}	10^{28}
mββ upper limit (meV)	34 – 78	9 – 21
Background index cts/(keV kg yr)	$2x10^{-4}$	$1x10^{-5}$

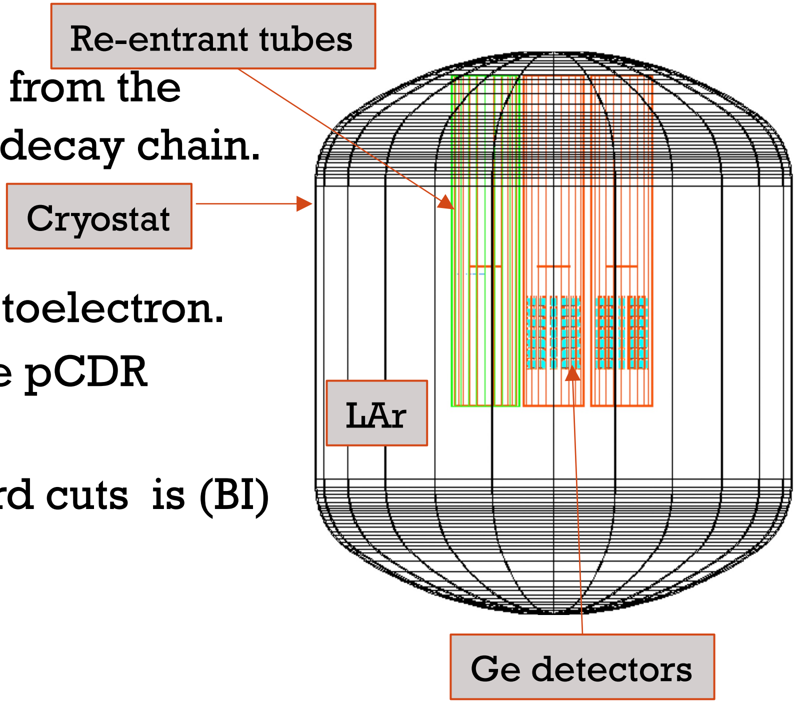


Pre-Conceptual Design Report (pCDR) of L1000 http://arxiv.org/abs/2107.11462

Gamma and neutron background from the cryostat:

Cryostat gammas:

- The main contribution to the background at $Q_{\beta\beta} = 2039$ keV of ^{76}Ge comes from the 2614-keV gamma line of ^{208}Tl, which is a shorter-lived progeny of the ^{228}Th decay chain.
- Sampling the entire cryostat with 2614-keV gammas in MaGe*.
- Analysis cut efficiency for cryostat gamma from simulation:
  - ~ half of the 400-keV ROI events escape the LAr veto due to lack of Photoelectron.
  - $\frac{1}{20}$ events in 400-keV ROI remain after (LAr+ PSD) cut --- confirming the pCDR assumption
- The contribution to the background index from the cryostat after all standard cuts is (BI) $= (5.3 \pm 1.0) \times 10^{-7} \frac{Cts}{KeV\ Kg\ Yr}$, or 5 % of the total background budget



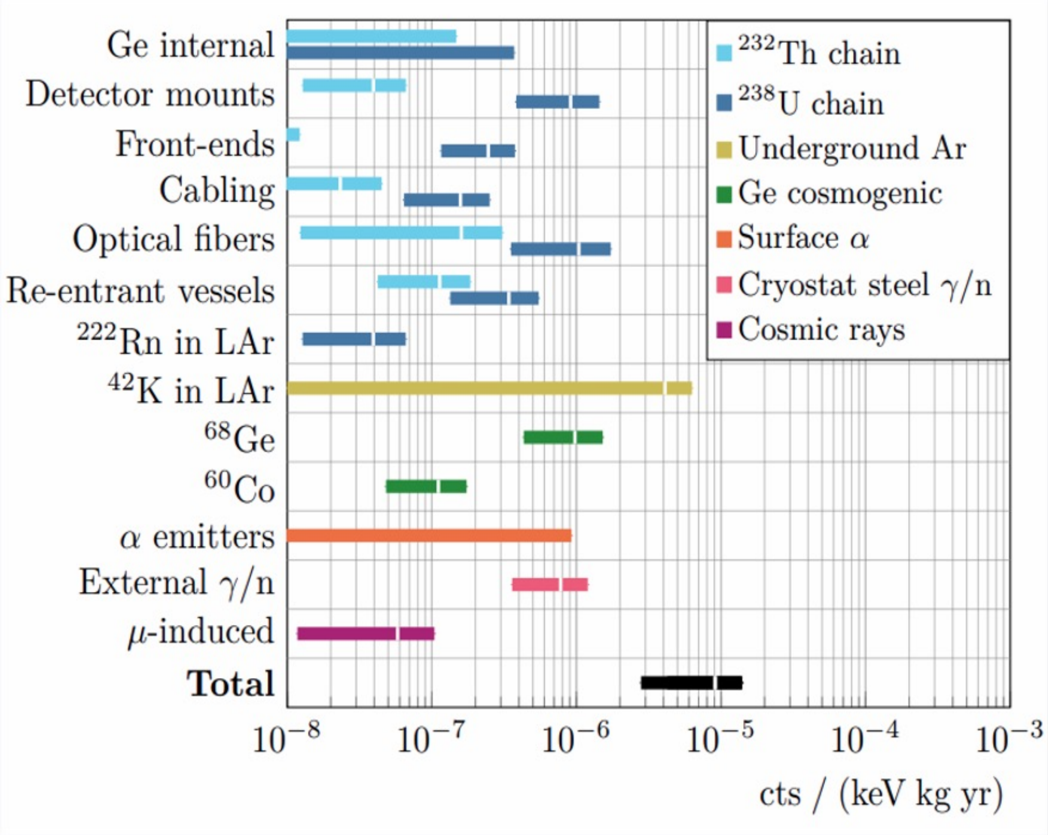
Cryostat neutrons:

- Neutrons can be captured in ^{76}Ge and produce ^{77}Ge and ^{77m}Ge, Q-value of which is greater than $0\upsilon\beta\beta$ decay region of interest (ROI).
- Radiogenic neutrons via (α, n) reactions and fissions from within the cryostat are simulated.
- About 20 events in 1 million radiogenic neutrons contributes to the 400-keV ROI.
- Because neutrons are all highly moderated in LAr, prompt signals are found to be mostly due to secondary gammas, which can be effectively suppressed.
- Delayed signals are more difficult to reject due to a lack of timing information
- The contribution to the background is $(2.0 \pm 0.5) \times 10^{-7} \frac{\text{cts}}{\text{keV Kg Yr}}$, or 2% of background budget.

* See this poster for more details

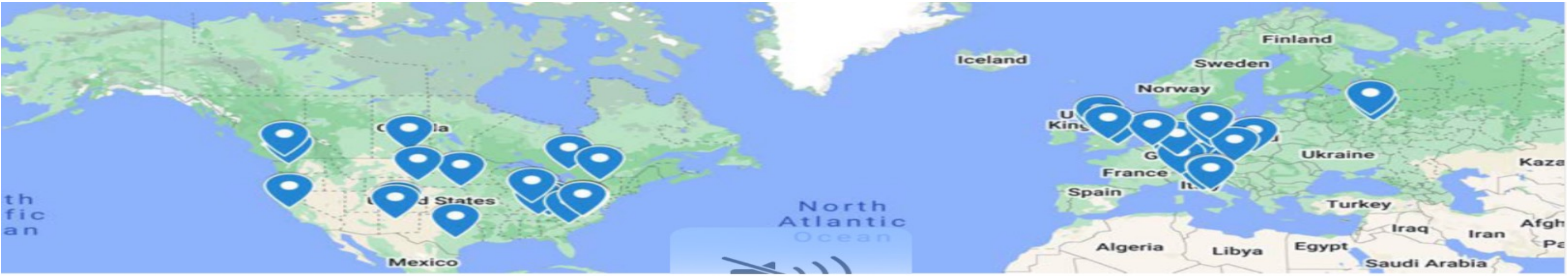
Summary:

Source	Contribution to background budget	comments
External gammas	≈ 5%	Main contributor is LAr cryostat. Negligible contribution from the water tank and laboratory environment.
Cryostat neutrons	≈ 2%	Without Delayed Coincidence cut
Room neutrons	Negligible	Due to water shielding
Near-by parts neutrons	Negligible	Due to extra-clean and low mass material



For more details, I recommend you visit the poster.

Acknowledgement:



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