Novel positron emission measurements with the LUX-ZEPLIN experiment

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on behalf of the LZ Collaboration
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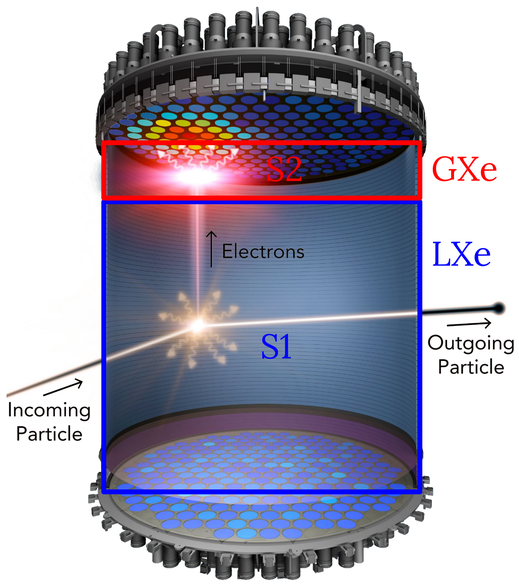
The LZ Experiment 1

The LUX-ZEPLIN (LZ) experiment is a dark matter direct detection experiment located at the Sanford Underground Research Facility, South Dakota, USA.



LZ employs a dual-phase xenon time projection chamber

- Scatters induce primary scintillation (S1), ionization, heat in liquid xenon (LXe)
- Electrons drifted to gaseous xenon (GXe), extracted creating secondary electroluminescence (S2)
- Good energy and 3D position reconstruction from S1 and S2 signals
- Multiple scatter interactions will have merged S1, but may have separately resolvable S2
- Natural Xe highly stable and purifiable
  - ^{124}Xe 2νDEC ($\tau_{1/2} \sim 10^{22}$ yr), ^{136}Xe $2\nu\beta\beta$ ($\tau_{1/2} \sim 10^{21}$ yr)
- High density (self-shielding), effective fiducial volume selection

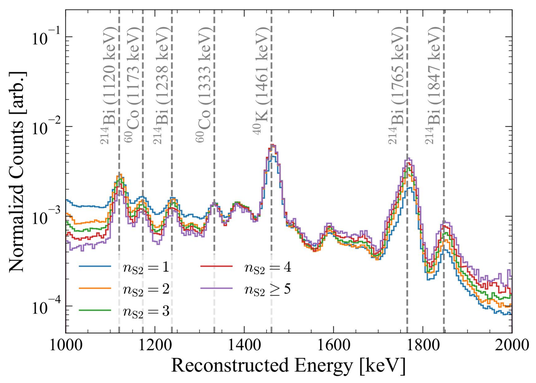
MeV-Scale Interactions 2

- Electronic recoils at the MeV-scale may travel up to several millimeters.
- Multiple particles or sufficiently spaced deposits may provide multiple resolved interactions
- Above 1 MeV, only bottom array area is used for S2 to avoid PMT saturation
- Weighted analysis variables (x,y,z, S1c) defined as:

$$\chi = \frac{\sum_i \chi_i \cdot \mathrm{S2}c_i^{bot}}{\sum_i \mathrm{S2}c_i^{bot}}$$

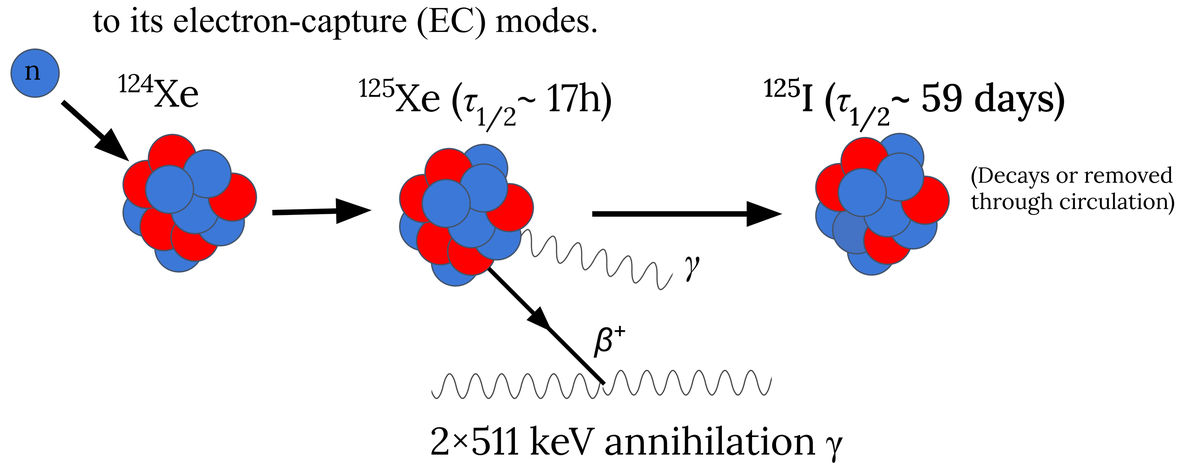
- Total energy calculated from sum of all resolved scatters

$$E = W \cdot \left(\frac{\mathrm{S1}c}{g_1} + \frac{\sum_i \mathrm{S2}c_i^{bot}}{g_2^{bot}} \right)$$



Neutron Activation 3

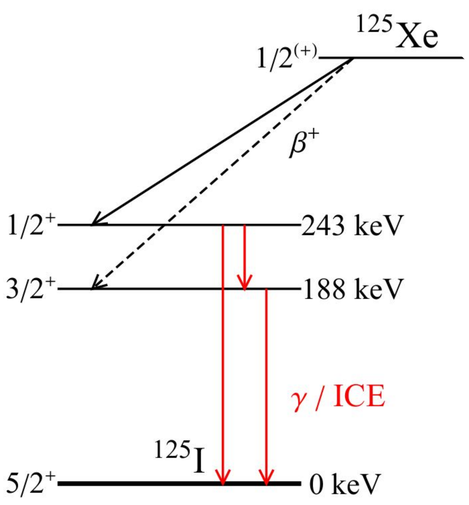
Neutron calibrations performed in LZ provide a period of short-lived xenon activation isomers and radioactive isotopes, whose intrinsic properties can be further studied. An example being ^{125}Xe, which exhibits a loosely constrained positron emission process with respect to its electron-capture (EC) modes.

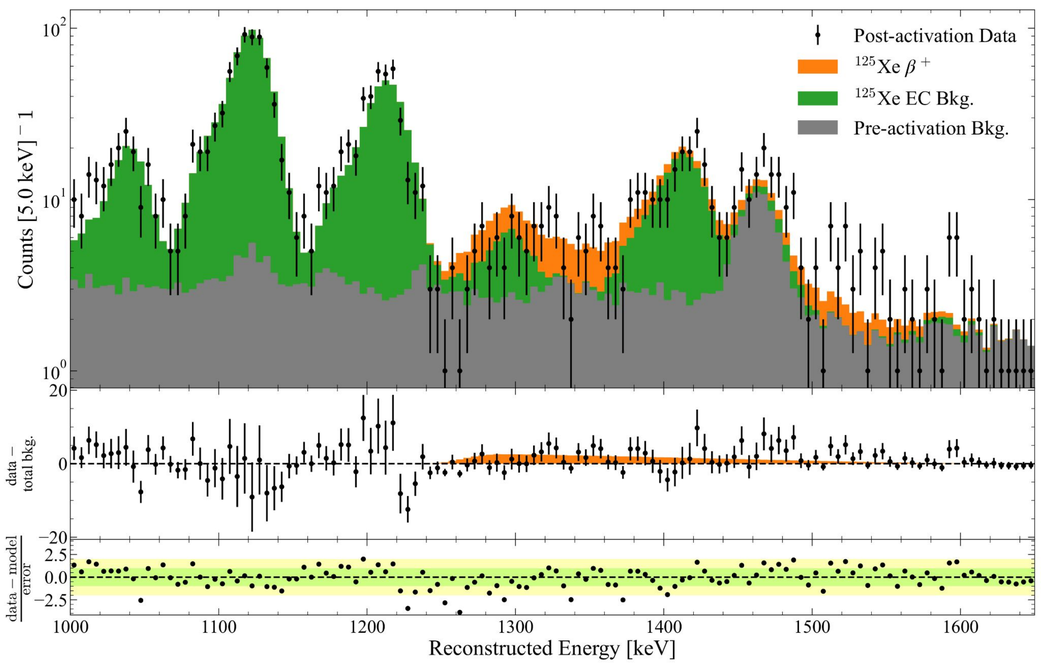


^{125}Xe BR Measurement 4

LZ has measured the ^{125}Xe positron decay branching ratio with improved precision [1]

- BR(β^+): **0.29 ± 0.09** %
- Data and model agreement, p(χ^2) = **0.057**
- High significance against background only hypothesis, σ = **5.47**
- First simultaneous measurement of all ^{125}Xe β^+ emitted quanta and constraint on individual branching levels
- Consistent with existing measurement of **0.3 ± 0.1 %** [2]





Summary and Future Outlook 5

- LZ has measured the ^{125}Xe positron decay branching ratio with improved precision
- A uniformly distributed positron source can prove to be useful for future rare positron emission analysis searches (^{124}Xe $2\nu\beta^+$EC)
- As LZ continues to take data, many exciting new physics prospects recently published and in the works
  - ^{8}B CEνNS [3], ^{214}Pb flow tagging [4] and muon flux measurement [5] papers in preprint
  - Additional higher energy ER searches (^{136}Xe $0\nu\beta^-\beta^-$, ^{134}Xe $2\nu\beta^-\beta^-$)

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Science and Technology Facilities Council
SANFORD UNDERGROUND RESEARCH FACILITY
Fundação para a Ciência e a Tecnologia
Institute for Basic Science
Swiss National Science Foundation
DARK MATTER

[1] LZ Collaboration • D.S. Akerib et al. e-Print: 2604.21503 [hep-ex] (2026)
[2] J.Ludziejewski et al. Phys. Polon. 36, 939, (1969)
[3] LZ Collaboration • D.S. Akerib et al. e-Print: 2512.08065 [hep-ex] (2025)
[4] LZ Collaboration • J. Aalbers et al. e-Print: 2508.19117 [physics.ins-det] (2025)
[5] LZ Collaboration • D.S. Akerib et al. e-Print: 2602.16799 [hep-ex] (2026)