



Electrode backgrounds in the LUX-ZEPLIN (LZ) experiment

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IMPERIAL

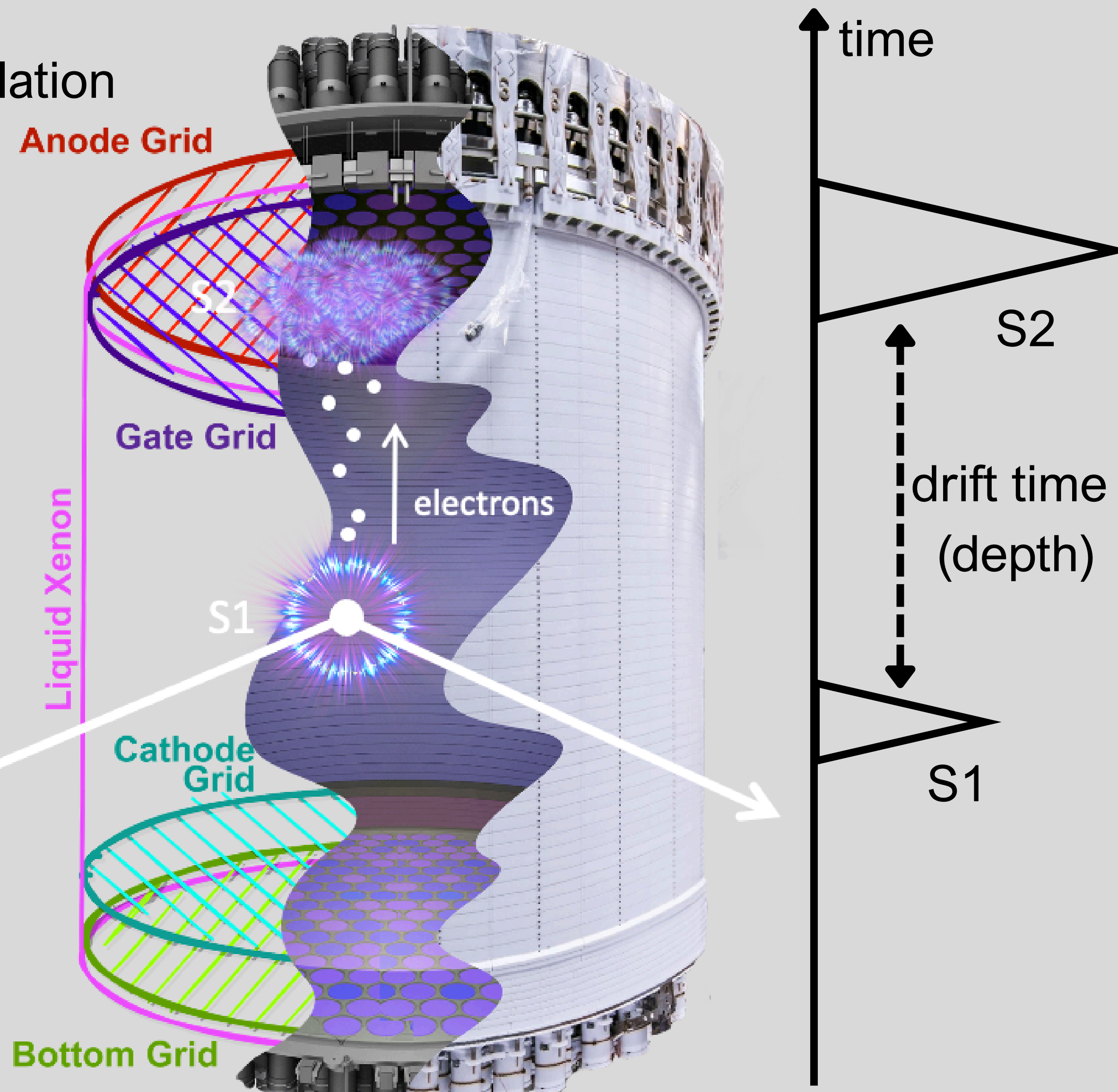
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LZ experiment

Dual phase xenon time projection chamber (TPC)

- S1 - prompt scintillation
- S2 - delayed electron signal
- Top PMT pattern → (x, y)
- Time separation → (z)
- S1-S2 relative sizes → Nuclear / Electron Recoil discrimination

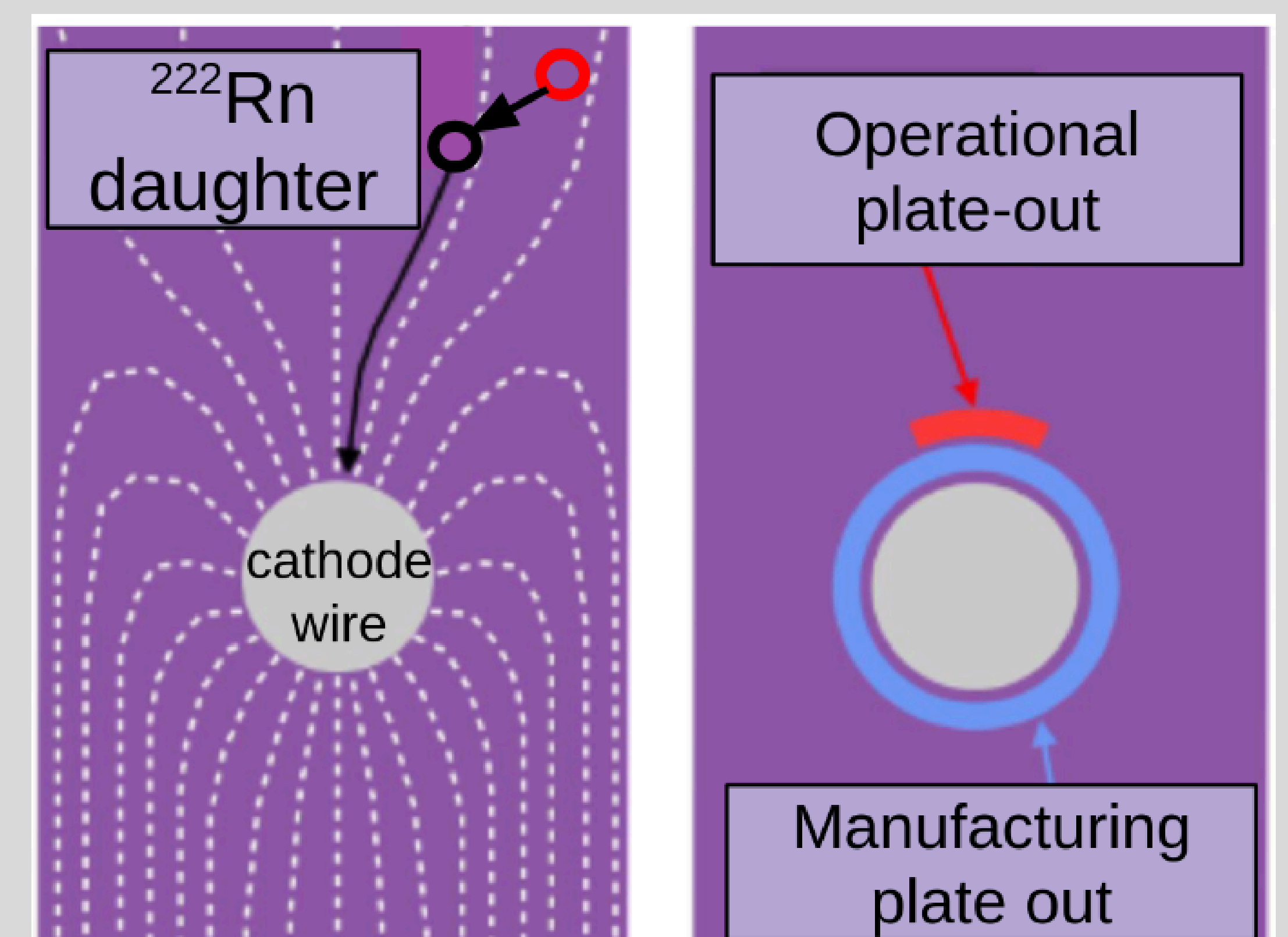


- World-leading sensitivity to DM particles with masses above 5 GeV/c² [1, 2]

Motivation

- S2-only analysis enables light DM searches [3]
- Electrode backgrounds hinder the sensitivity

Electrode backgrounds



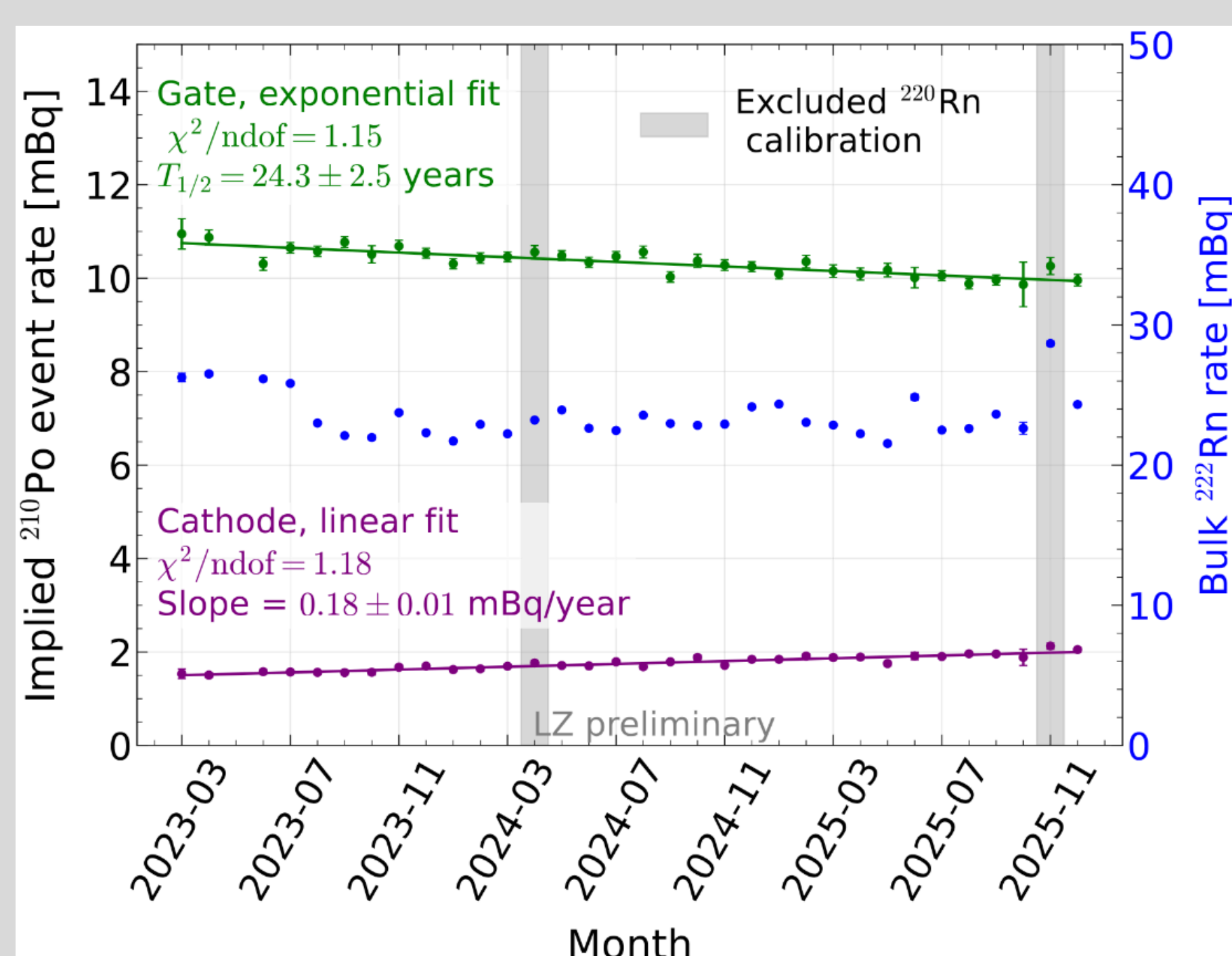
- ²²²Rn daughter plate-out (fabrication & operation)[4]
- Field-induced grid electron emission below 5-6 e⁻[5]

Problems to solve

- Electrode ²¹⁰Pb radioactivity evolution
 - Prolonged impact of operational plate-out
- Grid electron emission mechanism
 - Electron multiplication or not
 - Emitted photons are Xe VUV or not

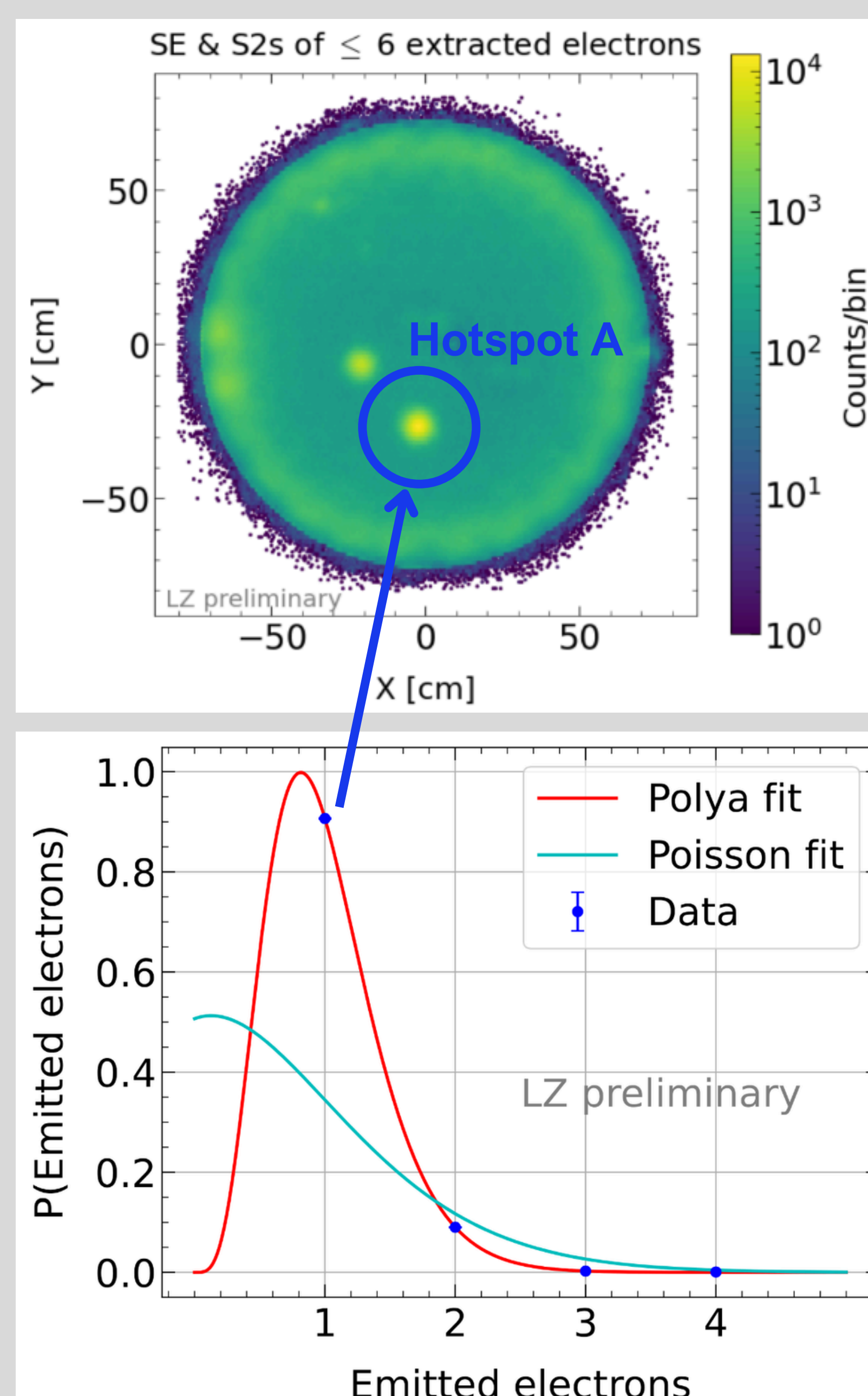
Electrode ²¹⁰Pb evolution

- Under secular equilibrium, ²¹⁰Pb activity equals that of ²¹⁰Po



- Gate ²¹⁰Po activity drops as ²¹⁰Pb half-life
- Cathode forward field activity increases 0.18 ± 0.01 mBq per year

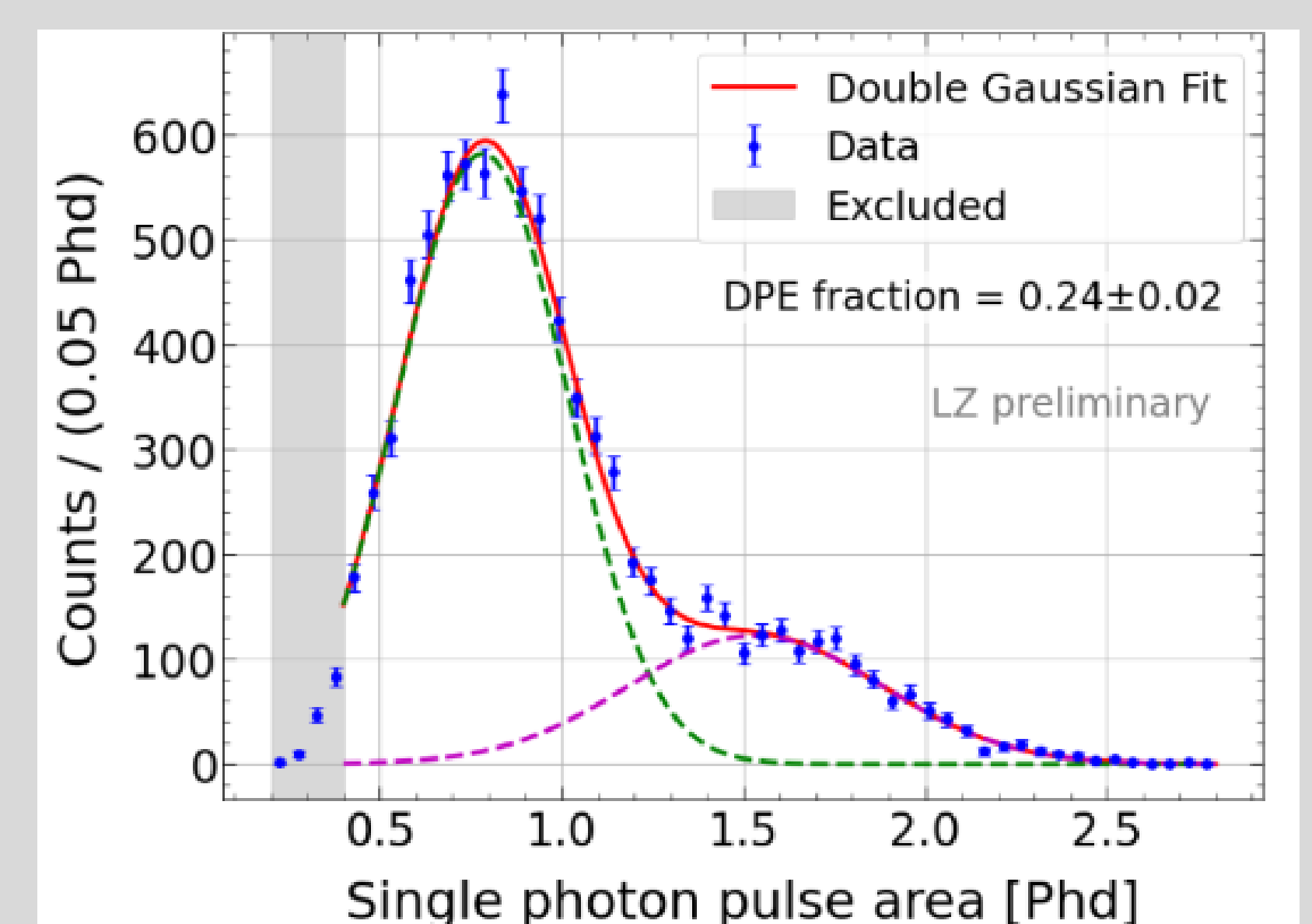
Grid electron emission



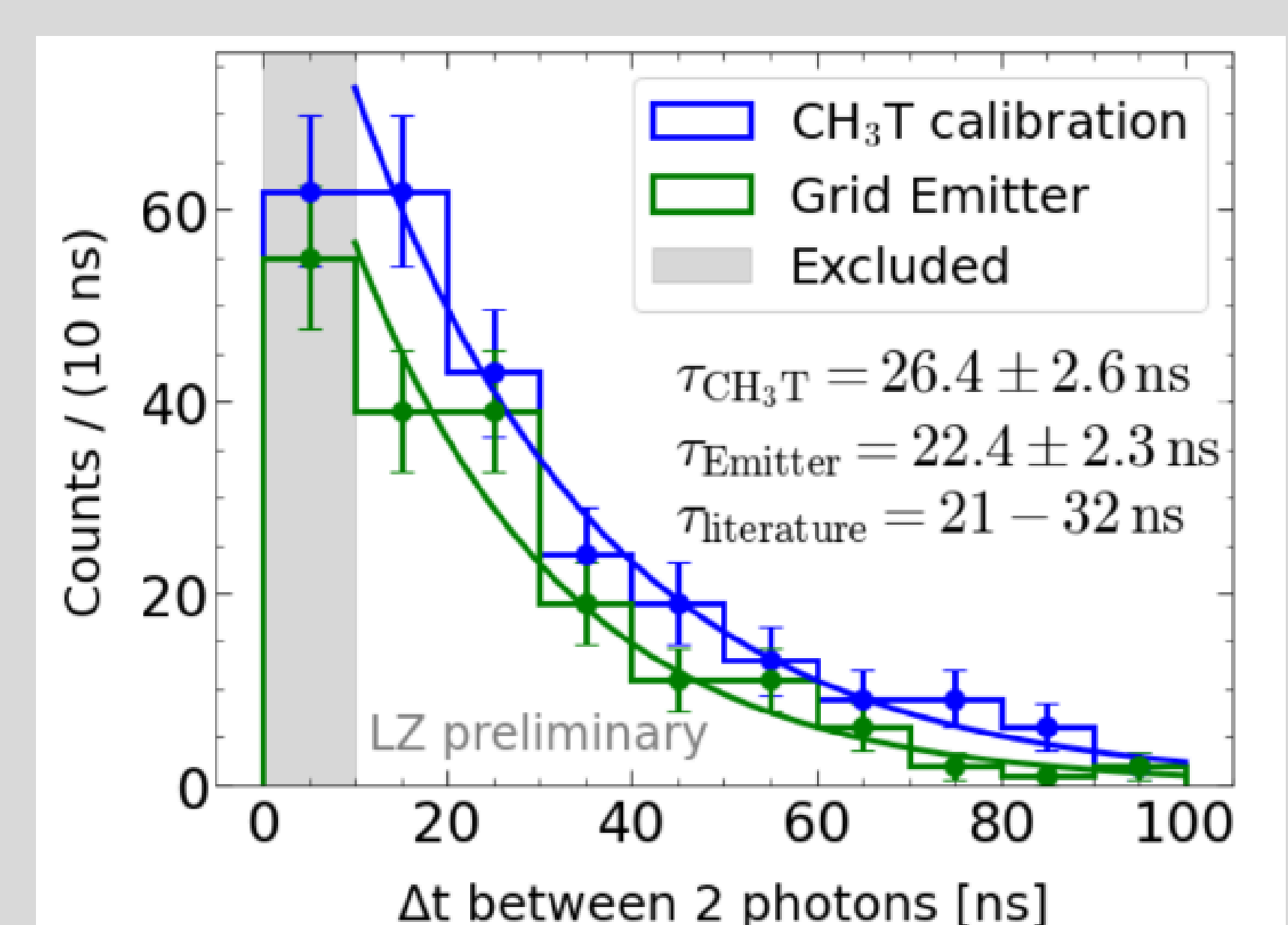
- Polya function better models[6]
- Electron multiplication preferred

Grid photon emission

- Accompany electron emission



- Double photo-electron peak consistent with VUV photons [7]



- Time constant consistent with Xe excimer emission

Conclusions

- Operational ²²²Rn daughter plate-out on cathode wires increases ²¹⁰Pb related S2-only backgrounds over time, which is non-negligible for long-term operation.
- Grid photon & electron emissions are consistent with xenon triplet decay and avalanche multiplication, motivating further surface-treatment studies to reduce these backgrounds.

References

- [1] Aalbers, J., et al. "Dark matter search results from 4.2 tonne-years of exposure of the LUX-ZEPLIN (LZ) experiment." Physical review letters 135.1 (2025): 011802.
- [2] Akerib, D. S., et al. "Searches for Light Dark Matter and Evidence of Coherent Elastic Neutrino-Nucleus Scattering of Solar Neutrinos with the LUX-ZEPLIN (LZ) Experiment." arXiv:2512.08065.
- [3] Aprile, E., et al. "Light Dark Matter Search with 7.6 Tonne-Year of Ionization-Only Data in XENONnT." arXiv preprint arXiv:2601.11296 (2026).
- [4] Akerib, D. S., et al. "Low-Energy Radon Backgrounds from Electrode Grids in Dual-Phase Xenon TPCs." arXiv preprint arXiv:2602.21177 (2026).
- [5] Akerib, D. S., et al. "Study of few-electron backgrounds in the LUX-ZEPLIN detector." arXiv:2510.06500.
- [6] Bailey, A. J. "Dark matter searches and study of electrode design in LUX and LZ." PhD thesis (2016).
- [7] Paredes, B. López, et al. "Response of photomultiplier tubes to xenon scintillation light." Astroparticle Physics 102 (2018): 56-66.