MeV-scale internal calibration sources for large LXe detectors

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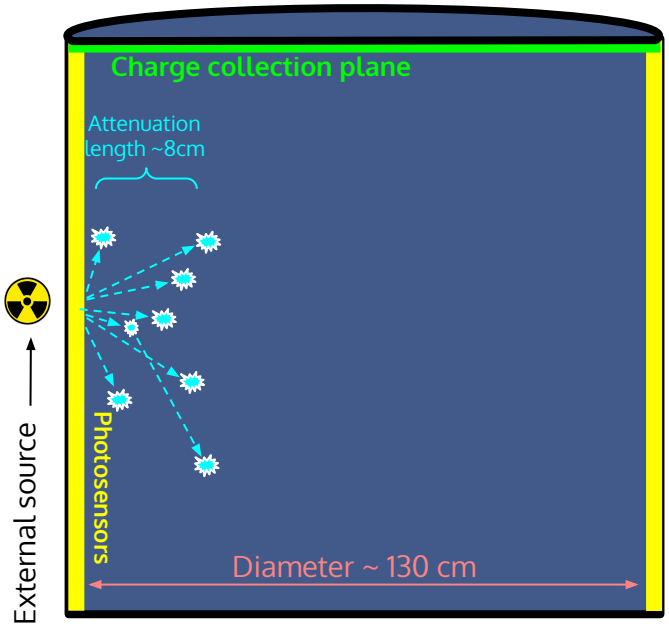
Calibration techniques for LXe detectors

External gamma ray sources



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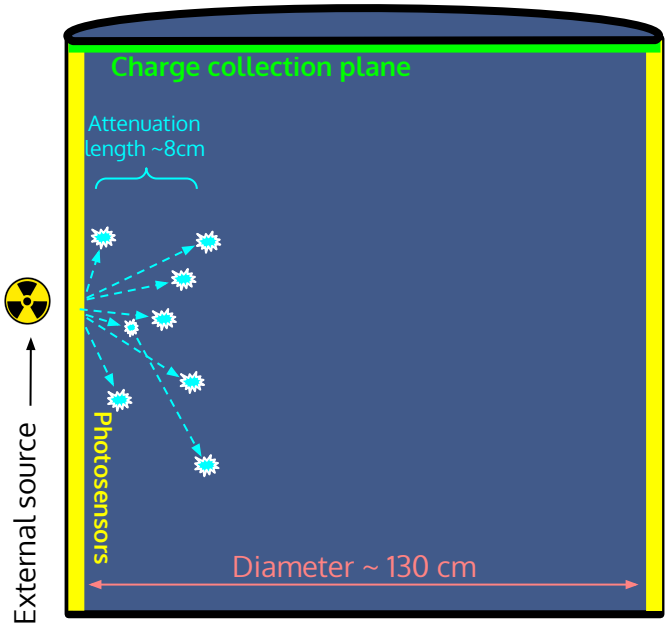
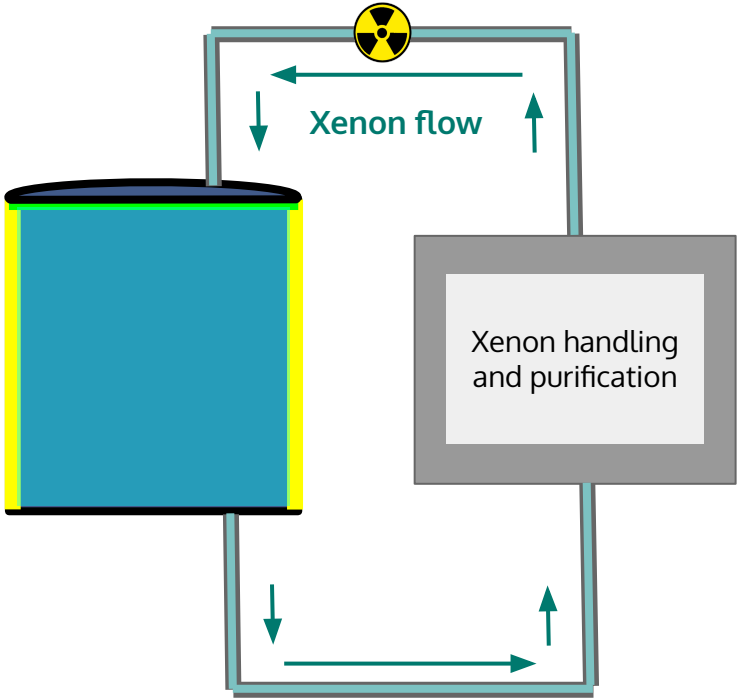


Internal gamma ray sources



Desirable qualities for multi-tonne-scale detectors

1. **Mixes easily into xenon**

   Doesn't stick to surfaces or get removed by purifiers; noble gases ideal

2. **Half-lives of O(day)**

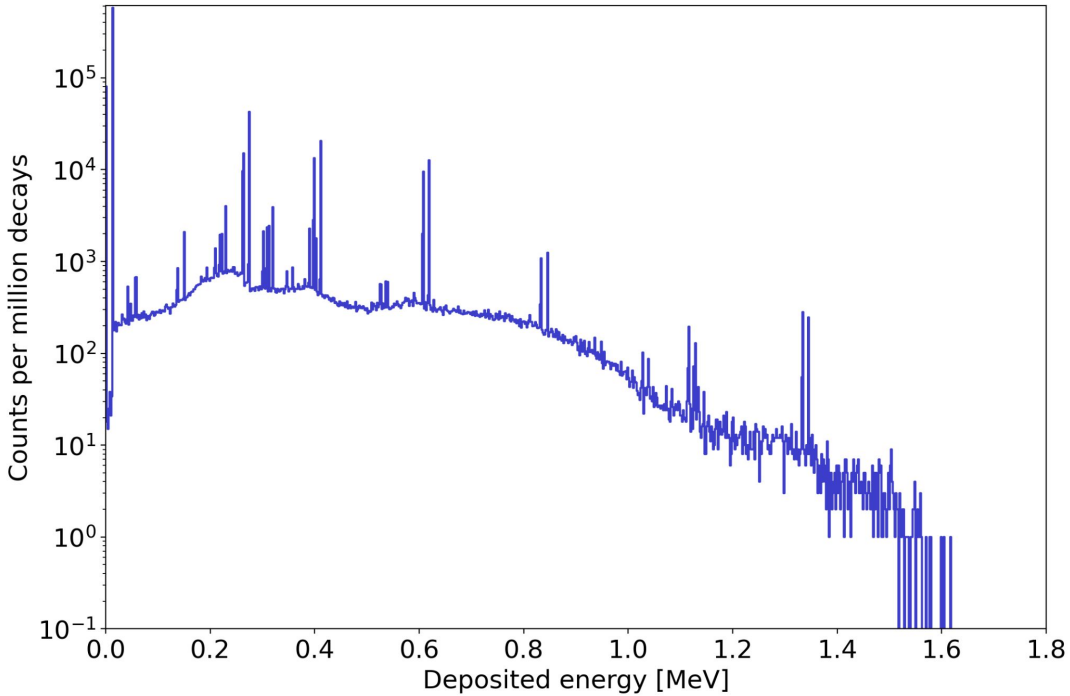
   Ensure good mixing of the source into the detector, assuming recirculation timescales of O(day), but also doesn't hang around forever

3. **Gamma lines at O(MeV) energies**

   Provide calibration lines at energies relevant for 0nuBB, but not alphas (which have dramatically different charge/light response in LXe)

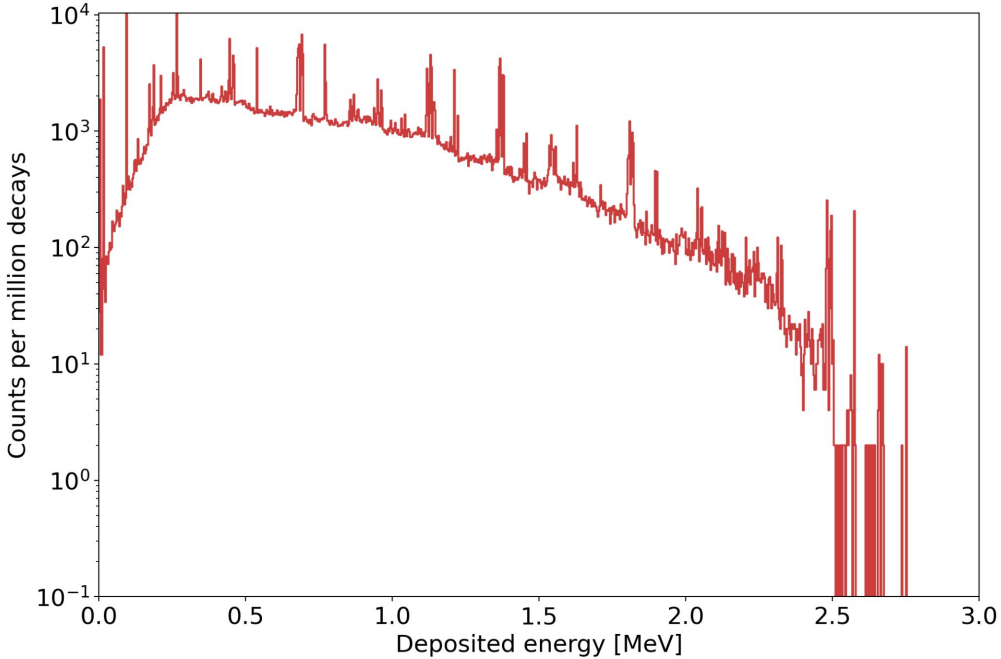
→ **Are there new isotopes that could be useful for gigantic detectors?**

Proposal #1: ^{79}Kr



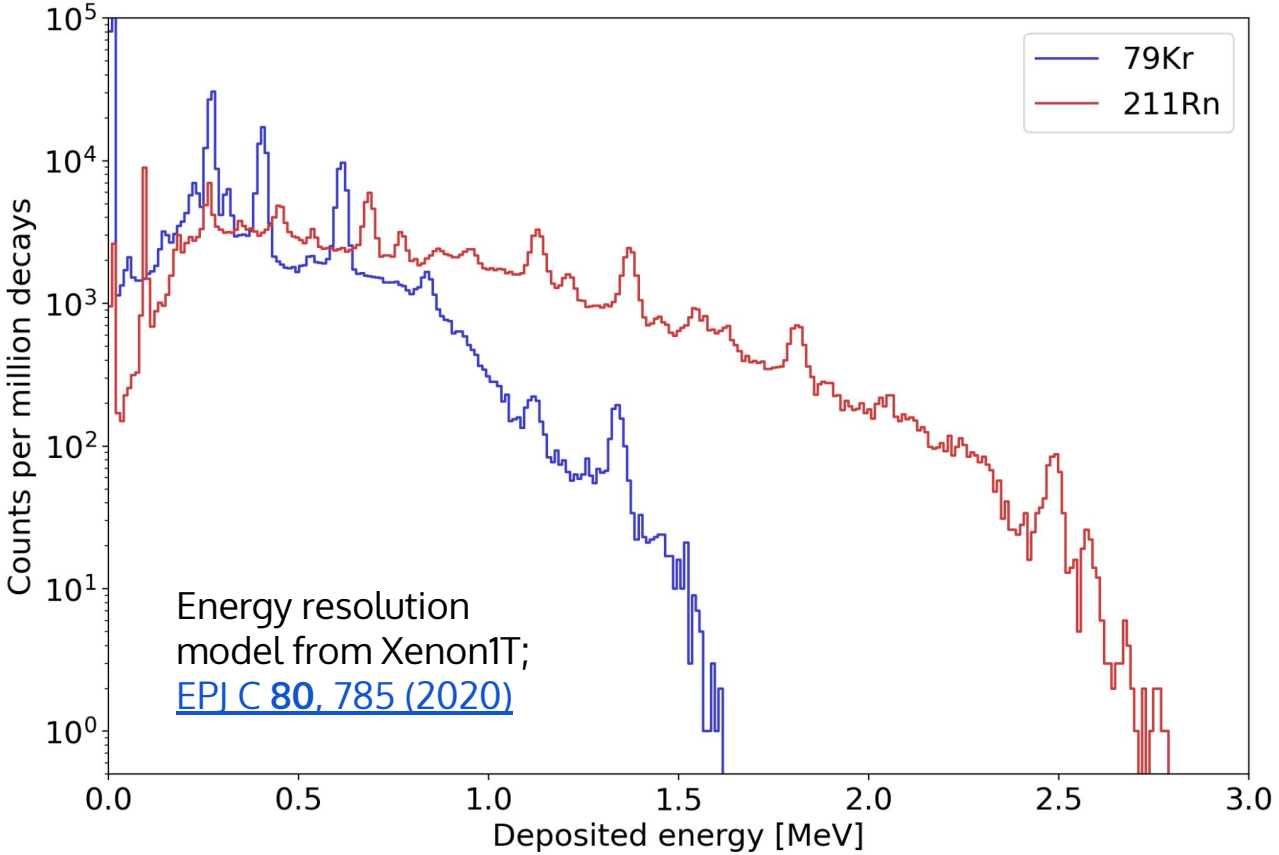
Half-life	35.04 hr
Production mechanism	(n,g) on 78Kr -- Commercial DD generator with water moderator could produce O(kBq) per gram of 78Kr
Q-value	1.626 MeV
Long-lived radioactive daughters?	No

Proposal #2: ^{211}Rn



Half-life	14.6 hr
Production mechanism	Nuclear reactions at accelerator facilities: ^{209}Bi(^{6}Li,4n)^{211}Rn; EC decay of ^{211}Fr beams; etc. Existing literature describes production of O(GBq) per run (used in medical isotope production)
Q-value	2.892 MeV
Long-lived radioactive daughters?	Yes (^{207}Bi)

Simulated decay spectra in a liquid xenon medium



Conclusions

Detectors beyond the tonne scale may require new calibration tools for characterizing the energy scale in the ~MeV regime

- External sources will only calibrate the outer edges of the detectors
- Many dissolvable sources currently in use, but they do not produce ~MeV-scale EM radiation signals (gammas/betas) at fixed energies

High-Q-value electron capture sources may be promising in this regard

- Can emit gamma rays (not alphas) at known energies, producing peaks rather than broad spectra
- Two such sources shown here: ^{79}Kr and ^{211}Rn
- There are certainly more possibilities to explore!