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Tagging Pb-214 Decay Events via Toy Monte Carlo Method

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Introduction:

Dark matter detectors, such as LUX-ZEPLIN (LZ), require environments with no background radiation in order to detect rare interaction events. LZ will use a liquid xenon (LXe) filled time projection chamber (TPC) to try to detect dark matter in the form of Weakly Interacting Massive Particles (WIMPs) [1].

Background:

LZ will be sensitive enough to detect individual atomic decay. This can negatively affect results when radon, a radioactive, inert element, emanates within the TPC as its decay chain can create false positives within the system. To combat this problem, we create simulations to “tag” and filter out these false positives.

Toy Monte Carlo Overview:

The Monte Carlo Method is essentially rolling dice over and over until a pattern emerges. I opted for a “Toy” Monte Carlo approach as I created certain restraints and conditions that we would not see in real life; it was simplified. This method mimics real life well since many random events come together to form patterns.

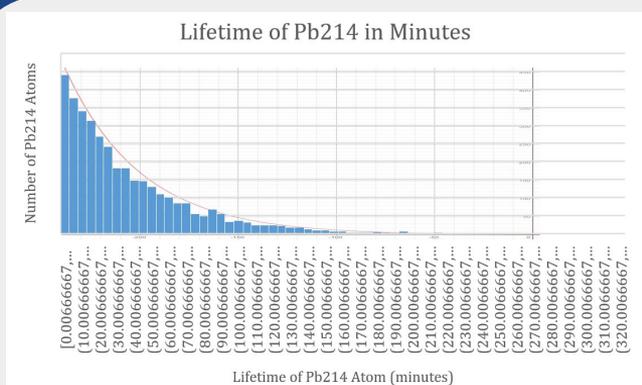


Fig. 1. A histogram comparing the lifetime of simulated Pb-214 atoms (blue) and real-life observations (red)

Pb-214 Tagging:

All other progeny of Rn-222 (Fig. 2) can be tagged accurately except for Pb-214. 9% of the time when it decays, it does not release a photon, allowing it to possibly look *exactly* like a WIMP [2]. If we can tag the other isotopes’ decays, we should be able to piece the entire decay chain together like a puzzle, nullifying any Pb-214 interference.

Results:

I was able to accurately model the decay of each isotope in the Rn-222 chain (Fig. 1) and also piece together small parts of it by tagging the times and positions of decay events. This allowed me to reconstruct the chain of one initial parent atom. However, sometimes the wrong atom would be tagged, so more work must be done.

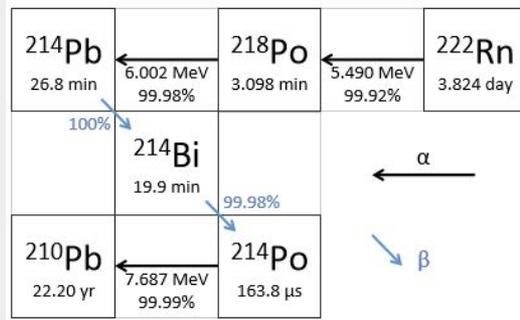


Fig. 2. An illustration of the decay chain of Rn-222

Citations & Acknowledgements:

[1]Mount, B. J., et al. *LUX-ZEPLIN (LZ) Technical Design Report*. United States: N. p., 2017. Web. doi:10.2172/1365579.

[2]Albert, J. B., et al. "Measurements of the ion fraction and mobility of α - and β -decay products in liquid xenon using the EXO-200 detector." *Physical Review C* 92.4 (2015): 045504.

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