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Investigating exotic decays of the radon-222 chain with a contaminated liquid xenon detector

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In the search for dark matter, detectors have been built using liquid xenon as a detection medium. One of their most crucial background source is radon-222 and its daughter nuclides, as they can cause signals which look like those expected from dark matter particles. Consequently, it is important to understand how the radon-222 decay chain signals can be identified and suppressed from the dark matter signature. However, within the known radon-222 chain, there are some candidates for exotic decays which are theoretically allowed but have never been observed. One example of these exotic decays is the double-beta decay of the radon-222 into radium-222 which has a current limit on the half-life of $t_{1/2}$ > 8.0 years (at 90% C.L.). The radium-222 subsequently decays with a half-life of $t_{1/2}$ = 38s in a unique 3-fold alpha decays signature, which can be used for tagging the radon-222 double beta decay. In order to search for this signature, the R&D dark matter facility at Nikhef designed a customized liquid xenon detector called XAMSL (Xenon AMsterdam Liquid) in order to contaminate the xenon in the setup with high amount of radon-222, using a radium-226 source of 22.2kBq of activity. Using the known decay signals from the daughter nuclei of radon-222, it is possible to perform an energy calibration on its spectrum and measure the sensitivity required for the exotic decays.

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