Reducing and Constraining Radon Particles through Cleanliness in the LUX-ZEPLIN (LZ) Experiment

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What is the LUX-ZEPLIN experiment?

- The LUX-ZEPLIN (LZ) experiment uses a direct detection method of dark matter by looking for Weakly Interacting Massive Particles (WIMPs) through use of a liquid xenon time projection chamber (Figure 1).
- WIMPs are postulated as the top prospect for explaining dark matter.

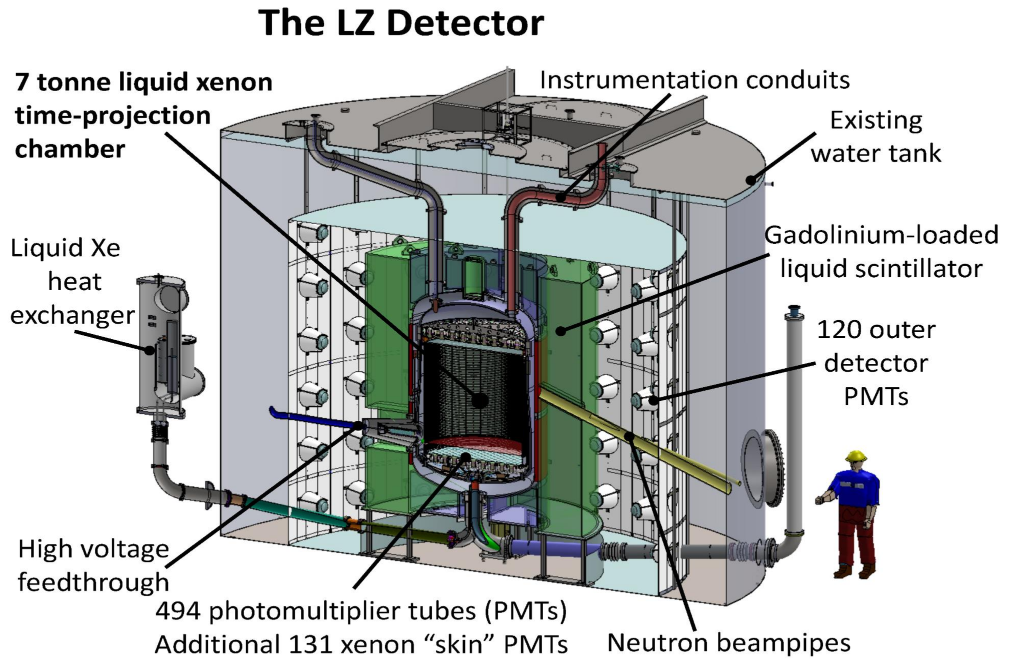

Figure 1. LUX-ZEPLIN detector

- The LUX-ZEPLIN experiment is located in Lead, South Dakota in the Sanford Underground Research Facility (SURF) which is the former Homestake gold mine (Figure 2).
- LZ will be at least 100 times more sensitive to finding signals from dark matter particles than its predecessor, the Large Underground Xenon experiment (LUX) [1].
- The LZ detector consists of 10 tonnes total of ultra-purified, liquified xenon to detect faint interactions between dark matter particles and xenon particles.[1]

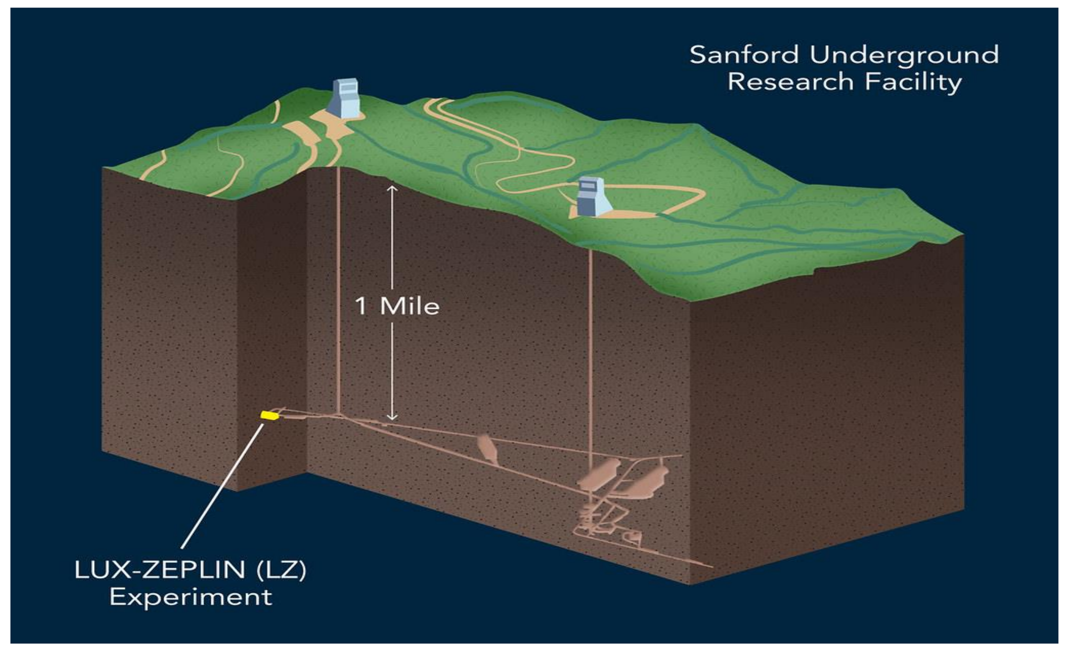

Figure 2. Sanford Underground Research Facility, 4850L.

What is Dark Matter?

- Dark matter is a non-baryonic type of matter that is "dark" because it does not interact with the electromagnetic force (light).
- Numerous astronomical and cosmological observations today can best be explained by the existence of such dark matter [1].
- Dark matter comprises about 85% of the mass of the universe, and its particle nature is still unknown.

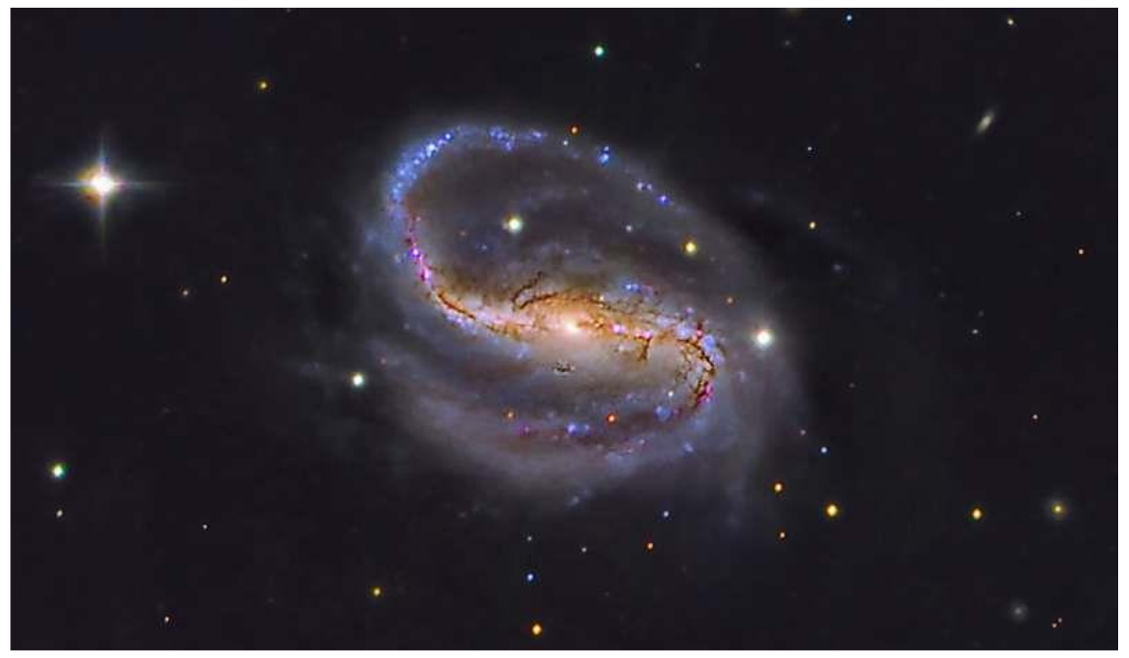

Figure 3. Barred spiral galaxy

Why Reduce and Constrain Radioactive Particles?

- Radon and radon daughter particles pose significant, and often dominant, backgrounds to low-background and rare-event search experiments [3].
- Within the LZ detector, radon and radon daughters can diffuse into the fiducial volume within the liquid xenon [3].
- Radon and radon daughter backgrounds may be indistinguishable from a dark-matter-induced nuclear recoil [3].
- Events derived from radon are expected to be the single largest background in the LZ detector [3].

Importance of cleanliness:

- The quantity of airborne dust in a specific location is found to vary significantly, with strong dependence on the local environment, geometry of any buildings, rate of airflow, and the use of air filtration to reduce the presence of dust, for example using cleanrooms [3].
- The effectiveness of a cleanroom is highly dependent on associated procedures, for example the level of use, gowning procedures of users, and supplementary cleaning activities [3].

Constructing a Soft-Wall Class 7,000 Cleanroom:

A cleanroom was constructed on the 4850L of SURF to conduct tests of the liquid scintillator for LZ. This cleanroom (see Figure 4) is a class 7,000 cleanroom, which means for every cubic foot of air there are 7,000 - 0.5 µm-sized particles. To construct the cleanroom, the perimeter of the outer walls in the Liquid Nitrogen Room at the Davis Campus were layed out. Then, the outer walls were secured and fastened to 80/20 T-Slot Aluminum posts to set the roof with the High Efficiency Particulate Air (HEPA) filters in place. Soft wall curtains were mounted, and aluminum tape used to prevent infiltrations of dust particles from entering vertically from the ceiling. The soft wall curtains were cleaned with soapy water and isopropyl alcohol.

Figure 4. Softwall Cleanroom on the 4850L of SURF.

Surface Assembly Lab (SAL)

- The SAL building is a wood-frame structure with four floors. The Radon Reduced Cleanroom (RRC) is a class 100 cleanroom within the SAL [3].
- The LZ Cleanroom, also in the SAL, will be used for cleaning and staging metal parts and bagged PTFE parts prior to detector assembly in the low-radon cleanroom, and for other assembly tasks not requiring a low-radon environment [3].
- A radon-reduced air system is required because radon is one the highest-risk contaminants for low-background experiments because it can easily escape from bulk material and quickly diffuse into active parts of the detectors [3].
- The radon reduction system pressurizes, dehumidifies and cools air to minus 60 degrees Celsius before sending it through two columns, each filled with 1600 kg of activated charcoal, which remove the radon [1].

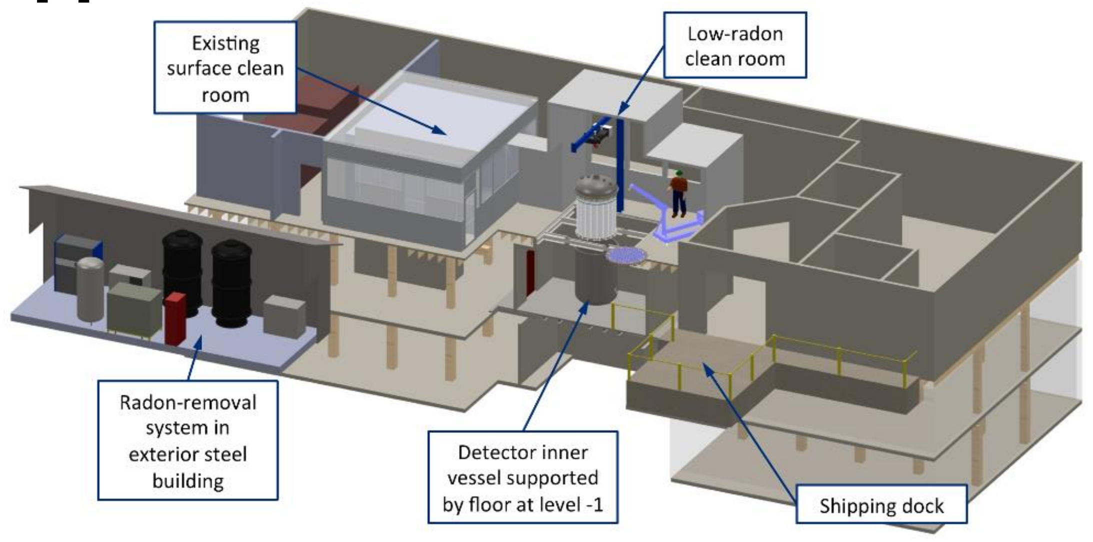

Figure 5. Surface Assembly Lab in Lead, SD

Bibliography

1. Facility, S. U. (2017). LUX-ZEPLIN. Retrieved from Sanford Underground Research Facility.
2. Pollman, T. (2012). Alpha Backgrounds in the DEAP Dark Matter Search Experiment. Kingston, Ontario , Canada: Queens University.
3. Collaboration, L.-Z. (2017, March Monday). LUX-ZEPLIN Technical Design Report . United States.

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