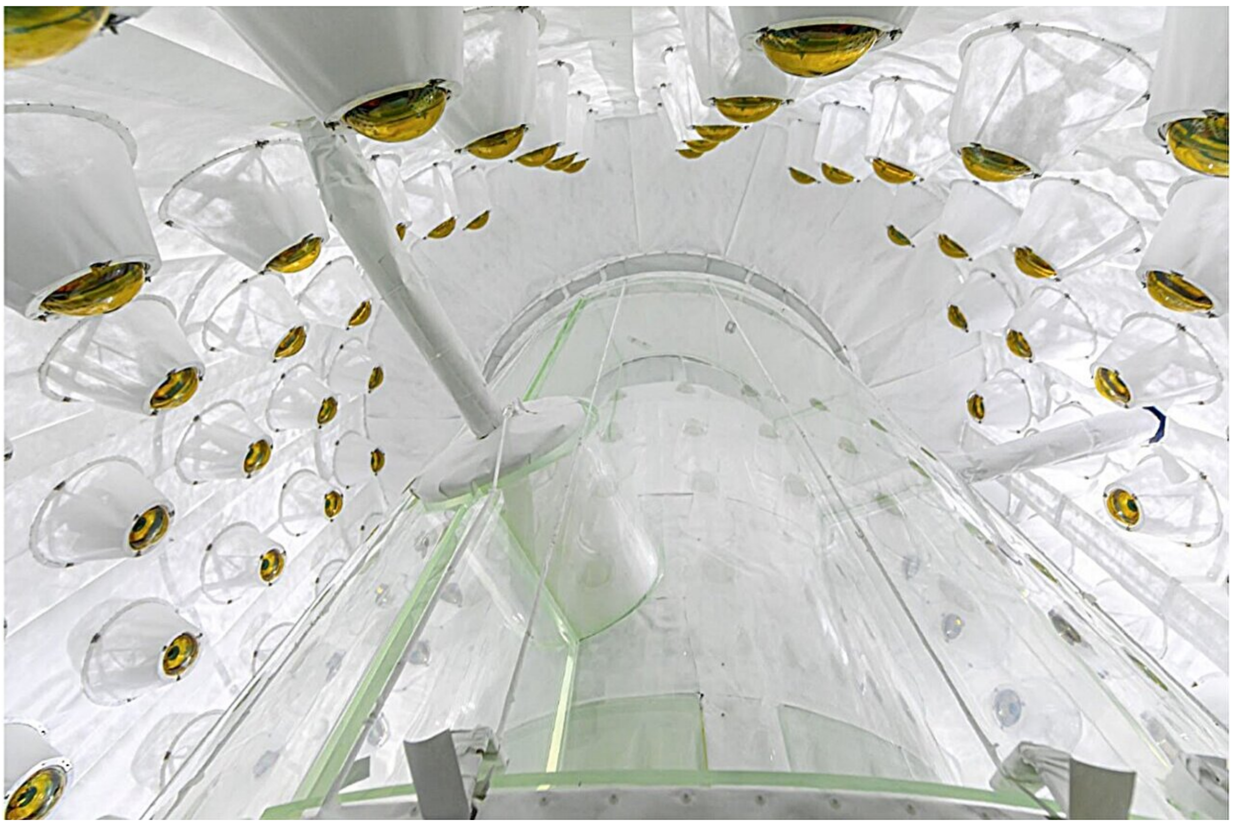
# The LZ experiment's first science run sets new constraints on dark matter interactions

January 8 2025, by Ingrid Fadelli



The LZ detector is a set of three nested detectors meant to sense the smallest amounts of energy deposited by radioactive materials or dark matter. Seen here is the LZ Outer Detector that encloses the skin veto, and the 10 tons of liquid xenon in the LZ TPC. Credit: LZ Collaboration.

The LUX ZEPLIN (LZ) Dark Matter experiment is a large research effort involving over 200 scientists and engineers at 40 institutions worldwide. Its key objective is to search for weakly interacting massive particles (WIMPs) by analyzing data collected by the LZ detector, situated at the Sanford Underground Research Facility in South Dakota.

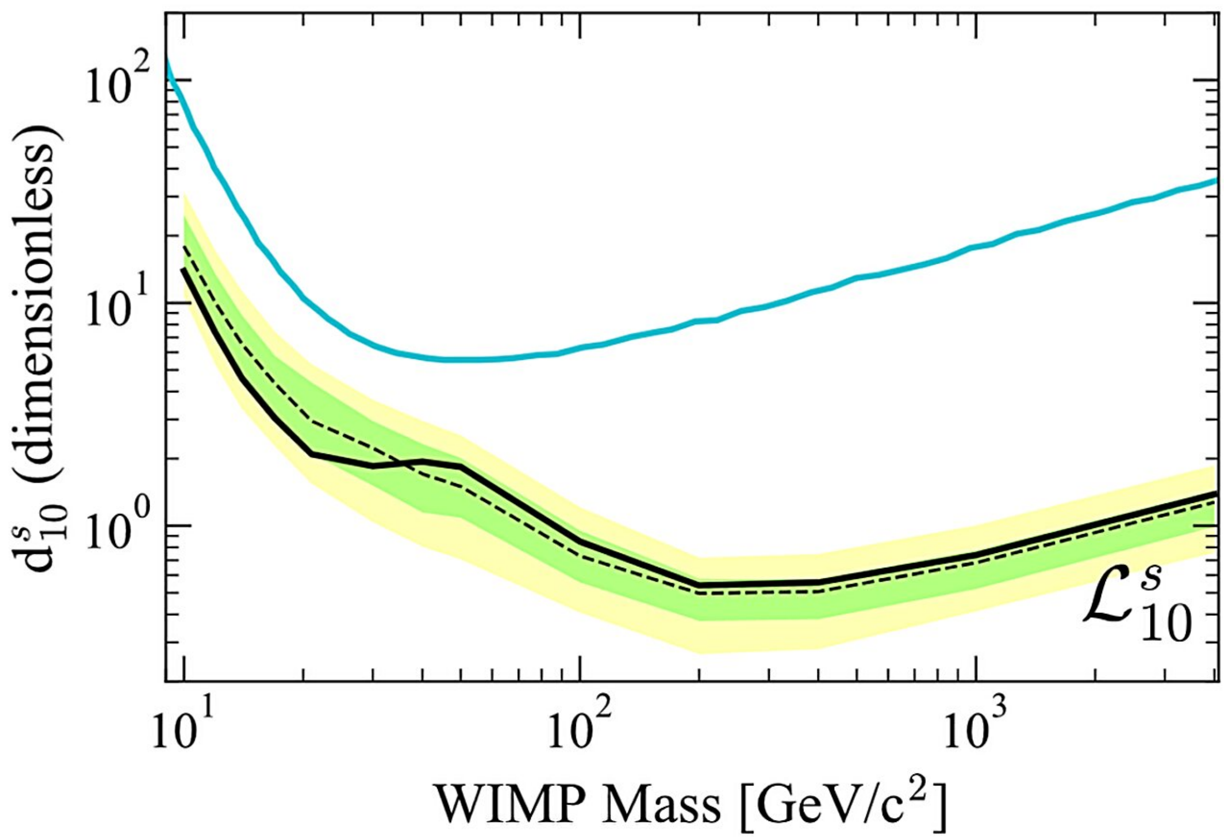
The LZ Collaboration recently released the results of the first experimental run of the LZ dark matter experiment. These results, published in *Physical Review Letters*, set new constraints on the interactions between dark matter and other particles, which could inform future searches for weakly-interacting dark matter candidates.

"There is no reason to believe that dark matter will interact with regular matter in the simplest way, so it is important to consider more complex interactions," Sam Eriksen, co-author of the paper, told Phys.org.

"There are five very well physically motivated interactions which we tested in this work. For example, evidence of one of these interactions can indicate that a WIMP consists of multiple charged particles rather than a single particle."

The LZ detector contains 7 tons of liquid xenon, the dense liquid phase of the noble gas found in the Earth's atmosphere. When a particle interacts with this liquid xenon it produces a flash of light, a phenomenon that the team has been leveraging to search for weakly interacting dark matter.

"Despite this being a very clean rare event search with just a few events a day in the detector, making this the most radioactively pure volume of space on the Earth for nuclear recoils, we are still searching for something that we only expect a handful of times a year," said Michael Williams, co-author of the paper. "We use a statistical analysis to pick out the dark matter interactions from these regular matter interactions."




The limit on the couple strength of a WIMP-nucleon interaction as a function of WIMP mass at the 90% confidence limit (black line). Results from PandaX-II (blue) are shown for reference. We can think of "d" as the strength of this particular interaction type. Credit: LZ Collaboration

The LZ collaboration has been analyzing the signatures collected by the LZ detector at the Sanford Underground Research Facility, with the aim of distinguishing those resulting from something bouncing off a nucleus and those associated with a particle knocking an electron off a xenon atom. The difference between these two types of signatures is subtle, yet their detector is designed to detect it.

"Though our first search resulted in no dark matter signals, it has constrained properties of dark matter, which in turn allows for dark matter theories to be refined," said Williams. "Many of the signals we searched for in this work had not been searched for before."

The results of the LZ Experiment's first science run could soon also help to improve dark matter theories. Specifically, it could allow theoretical physicists to better model the behavior of dark matter, including WIMPs.

"From a detector standpoint, we've significantly improved our understanding of the detector, pushing out to higher energies," explained Eriksen. "This has opened up the possibility of detecting new types of dark matter interactions."

Over the next few years, the LZ detector will continue to collect data, which will then be analyzed by the collaboration. This additional data could allow the team to set further constraints on WIMP interactions, potentially contributing to the future detection of signatures associated with these elusive particles.

"We are now much more sensitive to any dark matter interaction since we have more events to analyze and perform statistical measures with," added Eriksen.

"We will continue searching for hints of these interactions in the dataset and hope to find evidence in the near future. We'll either be making a revolutionary discovery within the next few years, or we'll be ruling out more types of dark matter, closing the net further."

**More information:** J. Aalbers et al, Constraints on Covariant Dark-Matter–Nucleon Effective Field Theory Interactions from the First Science Run of the LUX-ZEPLIN Experiment, *Physical Review Letters*

(2024). DOI: 10.1103/PhysRevLett.133.221801.