Sanford Underground Research Facility

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Deep Thoughts

Notes from the underground by Communications Director Constance Walter

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Last, but not least, the poly shield

For nearly seven years, the Majorana Demonstrator Project's "shield team" has been building the six-layered shield that surrounds the experiment on the 4850 Level. In early March, they placed the last piece of polyethylene on the outermost layer of the shield.

"I'm proud of what the team has produced," said Vince Guiseppe, assistant professor of physics at the University of South Carolina. "This was a complicated project. Every layer was added at the right time and fit perfectly."

The Majorana collaboration uses germanium crystals to look for a rare form of radioactive decay called neutrinoless double-beta decay. The discovery could determine whether the neutrino is its own antiparticle. Its detection could help explain why matter exists. The shield is critical to the success of the experiment.

Each layer of the shield was designed to target certain forms of radiation. "The closer the layer is to the experiment, the greater its impact," Guiseppe said.

The most important layer is the electroformed copper that sits closest to the experiment. Comprised of 40, half-inch thick copper plates, it was grown and machined underground. "This is clearly the hallmark of our shield system in terms of purity and cleanliness protocols," Guiseppe said. Surrounding that portion of the shield, is a 2-inch thick layer of ultrapure commercial copper.

Next is a "castle" built with 3,400 lead bricks. Two portable monoliths, each holding 570 bricks, support the cryostats filled with strings of germanium detectors and cryogenic hardware, what Guiseppe calls "the heart of the experiment."

An aluminum box encapsulating the lead castle protects the experiment from naturally occurring radon. Every minute, the team injects eight liters of nitrogen gas to purge the air within the enclosure. "We don't want any lab air getting in."

Left: Vince Guiseppe stands next to an extra lead brick monolith, which keeps the shield sealed if a working module needs to be removed for service. Right: Jared Thompson stands in front of the completed shield. The shield team is encasing the poly shield in aluminum as a fire suppression element.

Attached to the aluminum box are scintillating plastic "veto panels" designed to detect muons, the most penetrating of all cosmic rays.

Finally, there's the 12 inches of polyethylene enclosing the entire experiment, including the cryogenics (chilled water heat exchangers moderate the temperature). The poly slows down neutrons that could cause very rare backgrounds. Why worry about such rare events? High-energy neutrons can bounce through just about anything, including the 22 inches of lead and copper shielding. If a neutron hits a copper atom, it could create a gamma ray right next to the experiment.

"The poly is the final defense against backgrounds in an experiment that requires extreme quiet," Guiseppe said.

The entire shield, weighing 145,000 pounds, rests on an over floor made of steel with channels for the poly.

Jared Thompson, a research assistant, began his work with Majorana in 2010, etching lead bricks for the shield. In fact, in March 2014, he placed the last brick on the castle. And he was part of the group that recently placed the last piece of poly.

"It's really exciting," Thompson said. "A complete shield could mean a whole new data set down the road."

By the numbers

The total passive shield weight (copper, lead, poly) is 144,500 pounds. Here's the breakdown:

- **Poly shield: 31,000 pounds (190 4′ x 8′ x 1″ sheets)**
- **Lead castle: 108,000 pounds (over 4500 bricks)**
- **Outer copper shield: 3300 pounds**
- **Inner electroformed copper shield: 2200 pounds**