Muon makes tracks in EXO-200 detector

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These four lines show four different views of a single muon track, captured during initial tests of the EXO-200 detector. One track appears in each of four measurement channels and shows variations in signal strength from lower (blue and green) to higher (red) intensities over time (left to right). The timing with which each channel receives the signal allows EXO researchers to deduce the location of the track inside the detector chamber. (Image courtesy the EXO team.)

(PhysOrg.com) -- The Enriched Xenon Observatory-200, a prototype observatory that will search for exotic decays of fundamental particles of matter, passed a significant if unofficial milestone last month: its detector registered the track of a cosmic-ray muon.

"For the first time we have everything going underground," said SLAC physicist and EXO collaboration member Marty Breidenbach. During commissioning of the experiment in the final two months of last year, the team filled EXO's central chamber with liquid xenon and tested the full experimental setup for the first time.

EXO-200 will use a detector filled with 200 kilograms of liquid xenon to detect a type of particle decay known as neutrinoless double-beta decay. Neutrinoless double-beta decay has been predicted but never seen. Seeing it—or even not seeing it within a certain time period—can help place bounds on the mass of the neutrino, that miniscule particle that streams through most matter, including us, by the billions each second with nary a clue.

Scientists also want to find out whether the neutrino is its own anti-particle, as a positron and an electron are anti-particles, canceling each other out in a flash of energy should they interact. The positron and the electron, though, differ in charge, while each neutrino of a particular flavor is an absolutely identical sibling of every other. Yet, if neutrinos are their own antiparticles, any two of the same ilk will annihilate each other should they come in contact.

To detect this phenomenon, the EXO-200 detector will look for signs from the decay of a xenon atom, including a flash of light from energetic electrons produced during the decay. So far, the EXO team has tested this setup using only liquid xenon with a natural balance of isotopes, or forms of xenon differing in the number of neutrons in each atom's nucleus, but according to Breidenbach that will change.

"As soon as possible we will move to enriched xenon," Breidenbach said when asked about next steps for the project. Using enriched xenon means the detector tank will contain 80 percent by volume xenon-136, one of a group of isotopes that—in theory—can undergo neutrinoless double beta decay. EXO team members should be able to distinguish the energy resulting from the decay of xenon-136 from that of other energetic decays, because of the precise amount of energy produced. That doesn't mean they don't need to protect their experiment from other types of radioactive decays. With detection of such a rare event as the goal, a radiologically quiet environment is an absolute must.

"We're going to add more shielding," Breidenbach said, which will help keep down the radioactive "noise." The location of the observatory helps too. It's at the north end of the Waste Isolation Pilot Plant, near Carlsbad, New Mexico, about 2000 feet underground and surrounded by salt. Breidenbach appreciates the ironies.

"WIPP is an active pilot plant for storing nuclear waste, but EXO moved in because it's so radiologically clean," he said.

If EXO-200 results show promise, an even larger EXO using even more liquid enriched xenon—ten tons of it, in fact—will be constructed, replacing its smaller sibling in the search for fantastically rare particle decays.

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