Invisible dark matter

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Credit: NASA

Deep beneath a mountain in the Apennine range in Italy, an intricate apparatus searches for the dark matter of the universe. University of Massachusetts physics students played a crucial part of the DarkSide-50 detector's latest discoveries—and, in fact, have been part of this project since its inception.

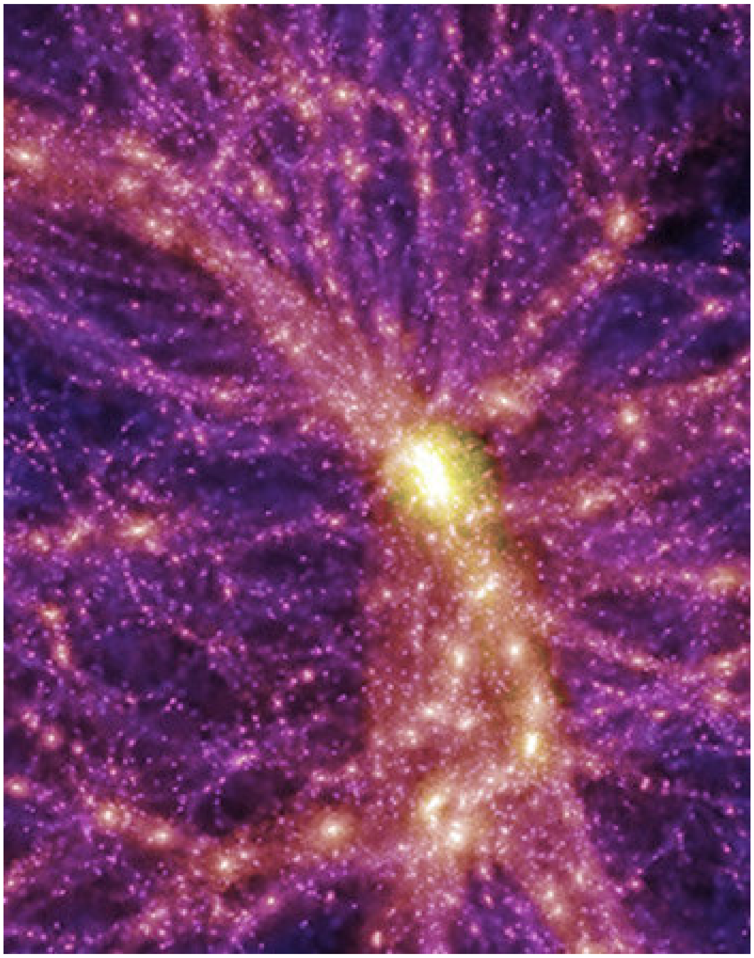
Professor of physics Andrea Pocar and his students designed and built a grid that is one of the key components of DarkSide-50, created in 2009 by an international coalition and housed in Italy's Gran Sasso National Laboratory. Undergraduates such as Arthur Kurlej '15 and Kirsten

Randle '15 designed, assembled, and welded this delicate apparatus into place.

While dark matter can be inferred from its gravitational effects, physicists have great difficulty identifying it, as it otherwise hardly interacts with "regular" matter. So they have to innovate ways to detect it.

DarkSide-50 uses a vat of liquid argon with a small pocket of argon gas at the top as a target to attract the particles that are believed to constitute dark matter. The liquid argon is the target for dark matter particles, while the gas pocket is instrumental in amplifying the resulting signal. The argon core is surrounded by a large volume of clean scintillating fluid that shields it from ambient radioactivity that can mimic dark matter signals.The flash of light produced when a particle hits the nucleus of an argon atom will be an indicator to researchers that they are on the right trail.

The process in discovering dark matter means becoming an absolute expert on everything that dark matter isn't. Graduate student Alissa Monte looks for events that happen at the boundaries of the detector where it is less efficient to collect light, where charge can get trapped, or events lose energy with edge effects. Her work in these less "ideal" regions helps researchers understand the behavior of the whole detector.



The Millennium Simulation by the Max Planck Institute for Astrophysics shows matter distribution in a cross-section of the known universe. Credit: Max Planck Institute for Astrophysics

Lying in wait for dark matter is a zen-like process. "If we want to see dark matter, it's a totally new signal," explains Pocar. "There's radioactivity in everything. So you have to know what those signals look like in your detector and how they could masquerade as dark matter."

"If we do see one event sneaking in," Pocar continues, "that's statistically extremely significant. We'd be forced to start claiming that is actually a signal."

Monte presented her poster at the Dark Matter 2018 symposium at UCLA, where she and the rest of Pocar's team gave its first report on the instrument's high sensitivity for a particular class of dark matter principles. The team had collected data for a measurement that they had not even expected to be able to make.

"It turned out we were more sensitive than any experiment that is currently running in a certain mass range," relates Pocar. "There have been a few decades of research pushing the limits looking for the heavy stuff but not finding anything. People started questioning maybe that's not the right place to look for it. So here we come with this experiment where several experiments are beginning to look."

The team has now gained an "exquisite understanding" of the way the detector indicates background events. "Nobody even expected us to say anything about this low-mass dark matter, and we set the best sensitivity in the world," says Pocar. "Suddenly, we are a player in this game."

Provided by University of Massachusetts Amherst