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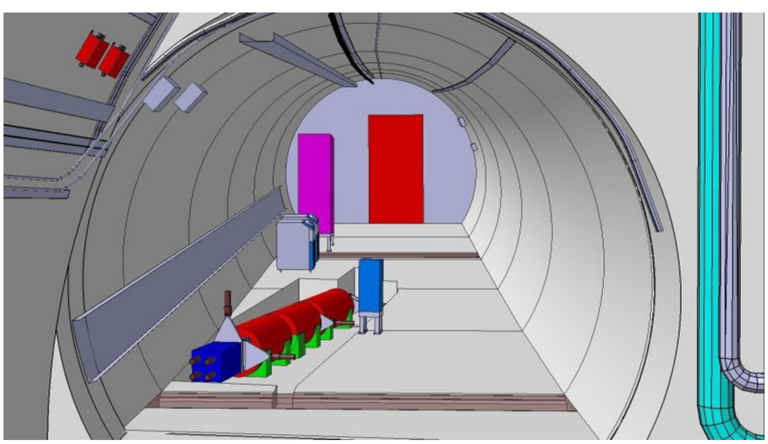
2 UCI professors aid search for dark matter particles in new experiment

By **LILLY NGUYEN** MAR 19, 2019 | 8:55 AM



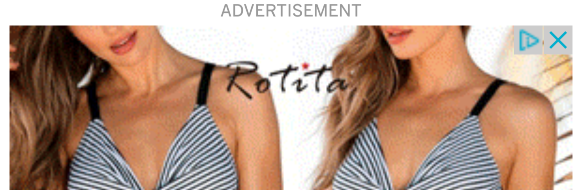
A rendering shows the FASER instrument in a tunnel at CERN's Large Hadron Collider near Geneva, Switzerland. FASER will try to find new particles of dark matter that makes up much of the known universe. (Courtesy of Forward Search Experiment)

A new instrument that two UC Irvine professors helped develop may shed light on the dark matter that makes up much of the known universe.

The European Organization for Nuclear Research, known as CERN, recently gave approval to the assembly, installation and use of the Forward Search Experiment, or FASER, at the Large Hadron Collider near Geneva, Switzerland.

Though the discovery of the Higgs boson in 2012 completed the "standard model," a theory in particle physics that describes how fundamental particles interact with one another, the particles observed in the standard model don't carry the same properties as dark matter.

"There must be something beyond the standard model to account for the other 85% of the matter in the universe," said Dave Casper, an experimental physicist and associate professor at UCI. "The problem is, no one really knows what the properties of this is. The only thing we can do … is to look anywhere else we can and hope we can find something there."



That's what FASER endeavors to do — find new particles that may make up dark matter.

“There’s a lot of evidence from astronomical observations that most of the universe is not visible to us and cannot be detected,” Casper said.

“We can see its gravitational influence, but [dark matter] isn’t like normal matter like the elements and particles that we know of that’s made of protons and neutrons. So these astronomical observations suggest that we only see about a fifth of the total matter in the universe.”

The FASER detector will be in this tunnel of the Large Hadron Collider near Geneva, Switzerland. It is expected to begin collecting data in 2021 after the collider restarts from its current two-year hiatus for upgrades. (Courtesy of Forward Search Experiment)

Casper joined a team of about 30 other international scientists, CERN collaborators and graduate students to work on the FASER project along with Jonathan Feng, a fellow UCI professor and a co-leader of the experiment.

The project was conceptualized in a paper Feng wrote with postdoctoral researchers Iftah Galon, Felix Kling and Sebastian Trojanowski in August 2017. Details of the design came later, followed by a technical proposal to CERN in November last year.

FASER received approval for assembly and operation in early March along with $2 million in funding from the Heising-Simons Foundation and Simons Foundation, in addition to support from CERN.

The detector will be set 1,574 feet from a larger detector called ATLAS, Feng said.

As proton beams pass through the ATLAS detector, which Casper also works on, new particles may be generated that pass through the concrete walls of the Large Hadron Collider and into the FASER detector, which will measure and track the rate of decay.

“Our detectors in some sense are staring at a wall. If you just stare at a wall, you expect to see nothing. But these special particles we’re looking for can pass through the wall totally unhindered and then turn into electrons and positrons on the other side,” Feng said. “If we see electrons and positrons coming out of the wall, there’s no standard explanation for that, given all the laws of physics.

“We know that if we see something very weird happening, it could be that we’ve discovered new particles that are related to dark matter. But the first step is to see something totally unexpected; the next is to explain it.”

The project will be assembled during the collider’s current two-year hiatus for upgrades and will collect data from 2021 to 2023. The short time frame is a challenge, the professors said, because if they don’t finish construction before the collider restarts, the FASER installation will need to wait until the collider’s next hiatus begins in 2024.

At the same time, however, the time frame is beneficial for graduate students, Feng said.

“Because our project is so quick, they can see everything,” he said. “They get to be involved with designing, then be involved in constructing the experiment … and at the end, they can be involved with collecting and analyzing the data.”

“It’s important [that graduate students] can point to the things they did: ‘This is my part of the experiment; this is my intellectual contribution.’ That’s the foundation for their career going forward,” Casper said. “Being on a small and fairly high-profile experiment … it’s becoming more rare for high-energy physics to do that, so it’s a really good opportunity for the students.”

The team hopes there will be support to expand the project with a larger detector — FASER 2 — to search for other hypothetical particles. The hope is to work on it during the collider’s next two-year hiatus.

“[FASER] might have other implications that we don’t know of, but the first goal is a very fundamental goal. We as humans are always curious about our world, what it’s made of and our place in it,” Feng said.

“Without understanding it, we’re kind of at a loss. This would shed light on our universe.”

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