Discovery prospects at the Large Hadron Collider

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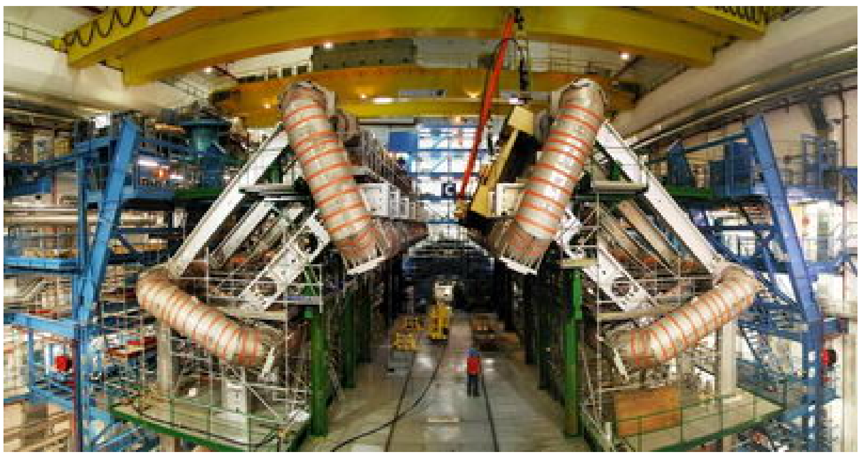

The ATLAS project

Will scientists ever find the elusive Higgs particle, the last of the fundamental particles predicted by the Standard Model of particle physics and postulated to play a major role in how fundamental particles get their masses? Are there undiscovered particles "beyond" those described by the Standard Model? Experiments expected to begin next year at the Large Hadron Collider (LHC), a new particle accelerator at the European Center for Nuclear Research (CERN), will take up the search and explore other intriguing questions about matter in our universe.

Ketevi Assamagan, a physicist at the U.S. Department of Energy's

Brookhaven National Laboratory, has been helping to build and coordinate analysis tools for ATLAS, one of the LHC's multipurpose detectors. He will give a talk on LHC preparations and the facility's prospects for discovery at the April meeting of the American Physical Society in Dallas, Texas on Sunday, April 23.

"The Standard Model has been quite successful in explaining the known particles, their properties, and the main interactions of matter -- but there are problems," Assamagan says.

For example, the Standard Model assumes there is only one type of Higgs particle. With this restriction, computations aimed at correcting the mass of the Higgs diverge so that physicists cannot get a finite result they could measure. Another problem is the enormous energy gap between the scale of gravity (the Planck scale) and the scale of the electroweak force, which governs the Standard Model.

To resolve these problems, scientists have proposed alternative theories or extensions to the Standard Model. In addition to searching for the Higgs particle, the LHC -- a 27-kilometer ring- shaped accelerator capable of colliding protons or heavy ions -- will probe these theories by searching for the kinds of particles they predict.

One extension theory is known as the Minimal Supersymmetric Standard Model (MSSM). "Instead of having only one Higgs particle, you end up with five of them," Assamagan says. And as in all versions of the theory of Supersymmetry, each of these particles -- and each of the other particles of the Standard Model -- has a yet-to-be-discovered companion supersymmetric partner. "The existence of supersymmetric particles would protect the Higgs mass against divergent radiative corrections," Assamagan says.

"Since no one has ever detected a sypersymmetric particle, it would be a very significant finding if we see one or more at the LHC," he adds. The prospects for such as discovery at the LHC are quite good, he suggests, because the LHC machine will have sufficient energy and collision rates to produce these particles.

The LHC will also explore the idea that "large extra dimensions" exist to bridge the energy gap between the electroweak and Planck scales, as well as other theories that suggest the supposed fundamental particles of the Standard Model are not fundamental at all, but instead are themselves composites -- that is, composed of even smaller, more fundamental building blocks yet to be discovered. In addition to exploring these realms "beyond the Standard Model," LHC experiments will also probe the mysterious missing mass and dark energy of the universe, investigate the reason for nature's preference for matter over antimatter, and probe matter as it existed at the very beginning of time.

"The ATLAS detector is truly multipurpose, with many different systems for detecting a wide array of particles and reconstructing what happened in the interaction region," Assamagan says, "so it is not bound to any particular discovery. We hope it is made well enough to discover whatever the case is -- even if it is a complete surprise."

First collisions at the LHC are expected to take place in the summer of 2007. Brookhaven Lab's role in this work is funded by the Office of High Energy Physics within the U.S. Department of Energy's Office of Science. Brookhaven Lab is the headquarters for the 33 U.S. institutions contributing to the ATLAS project. Worldwide, more than 2,000 scientists are collaborating on ATLAS.

Source: Brookhaven National Laboratory