UW scientists play key role in largest physics experiment to date

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After nearly two decades of preparation, dozens of University of Wisconsin-Madison scientists and engineers are eagerly anticipating Wednesday's scheduled startup of the Large Hadron Collider -- billed as the largest physics experiment in history.

This $10 billion endeavor is a collaboration of thousands of scientists and engineers from around the globe, and is expected to eventually revolutionize our understanding of the universe.

"We are taking another step in the exploration of the world around us," UW-Madison physics professor Wesley Smith, who is directly involved with the project, wrote in an e-mail to The Capital Times. "Since people first walked on Earth, each generation has learned more about the world and passed this knowledge on to the next. Each gain in understanding has resulted in substantial dividends in technology, many completely unpredictable except that they have always followed these gains in understanding."

The Large Hadron Collider -- or LHC -- is located near Geneva, Switzerland, at the European Organization for Nuclear Research (CERN) and is the world's most powerful particle accelerator. Inside a 17-mile underground ring that sits about 300 feet beneath the French-Swiss border, the accelerator will smash two beams of protons together at nearly the speed of light in search of exotic atomic particles and other unknown phenomena that scientists hope will help explain unsolved questions about the nature of matter and the physical universe.

"Like they say, it's like we'll be looking for a needle in a haystack," UW-Madison physics professor Sau Lan Wu said in a phone interview from Geneva, Switzerland. "But this is a very exciting time."

This week, scientists hope to have a successful injection of the first beam of protons in the accelerator -- a critical step to show that the device is working properly.

Then, perhaps a month or two from now -- once stable beams are circulating in both clockwise and counterclockwise directions -- the machine will be ready for its first collisions. Then, protons will be hurled around the 17-mile underground ring 11,000 times per second until they crash headlong into one another in the most energetic particle collisions ever recorded.

"This project is one of the great accomplishments of human civilization," said Terry Millar, UW-Madison's associate dean in the graduate school for the physical sciences. "For several millennia western civilization has tried to better understand our physical reality."

Millar said the project "is a wonderful example of common resolve, setting the stage for the operation of individual and group genius. The fact that countries, and organizations across countries, can collaborate in this manner and produce something that requires a long-term commitment with lots of money changing hands -- that organizational phenomenon is pretty unparalleled in the nonmilitary sectors of the world."

Among other things, researchers are hoping to detect evidence of extra dimensions, invisible "dark matter" and an elusive particle called the Higgs boson -- popularized as the "God Particle," because it has not yet been scientifically proven to exist.

"If it's found, great," said Millar. If it's not found, it will shake up the way scientists generally understand the physical world.

Several UW-Madison faculty, staff and students are involved in the collider project, and the university is one of the few institutions that has made major contributions to both of the main particle detectors, called ATLAS and Compact Muon Solenoid (CMS).

UW-Madison's Wu leads the first American research team that was invited to work on the ATLAS experiment at the collider project back in 1993. Her team specializes in studying simulations of particle collisions, preparing for the data that in time will be produced by the LHC. Today, ATLAS is comprised of more than 150 universities and laboratories in more than 35 countries.

As a young scientist in the early 1970s, Wu was on one of the teams that discovered the "J particle," which confirmed the existence of a subatomic bit known as the charm quark. Samuel Ting, Wu's team leader, shared the 1976 Nobel Prize in physics for the finding. A few years later, while working as an assistant professor at UW-Madison, Wu developed the approach that led to the discovery of the gluon -- a particle that "glues" together the pieces of an atom's nucleus.

Up next, Wu is hoping to make the biggest discovery of her career.

"I have spent a substantial part of my career chasing after the elusive Higgs boson," Wu said. "I am really looking forward to the moment of the Higgs boson discovery, which could be one of the greatest discoveries of the century in particle physics."

Wu says such a discovery could come as soon as 2010.

UW-Madison's Smith heads a team that has built more of the 14,000-ton CMS detector than any other university group. As part of the senior management of the CMS project, Smith also has been put in charge of designing, building and running the CMS "trigger system," a filter that sorts all but the most interesting patterns from the mounds of collected data. The trick for Smith and his team is to find those physical interactions that reveal interesting new phenomena.

"We have climbed to the top of a scientific mountaintop and are about to peer out into a new realm where we hope to see revealed the mystery of what causes mass, possibly view hints of where is the 90 percent of the mass and energy of the Universe that is missing, and maybe experience signs of extra dimensions," Smith said.

To help process the mountains of data from this particle-smashing experiment, dozens of top computing centers from around the world will be involved in the "LHC Grid," a worldwide network of about 60,000 computers that will analyze what happens when protons are hurled at each other inside the collider.

Miron Livny, a UW-Madison computer science professor, leads a national initiative among universities and institutions that collects and divides data from the collider project.

"The computational contributions from UW are pretty profound," Millar of Livny's team.

The vast computing power is needed to help researchers find what they are looking for when four giant detectors -- 10 times more accurate than any previous instruments -- begin measuring activity at the subatomic level.

The data are sent via high-speed lines to 11 top research institutions in Europe, North America and Asia, and from there to a wider network of some 150 research facilities around the world where they can be scrutinized by thousands of researchers.

Already the experience of collaborating on such a large computing project has proved invaluable, says Ruth Pordes, executive director of the Open Science Grid at Fermilab in Chicago. The U.S.-government funded project is a major contributor to the LHC Grid.

"We are doing things that are at the boundaries of science," Pordes told The Associated Press. "But the technologies, the methods and the results will be picked up by industry."

Scientists expect grid computing to become more widely used in the future for research ranging from new drugs to more effective nuclear power. Eventually, consumers will start seeing it used in daily life to regulate traffic, predict the weather or even boost a flagging economy.

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The Associated Press contributed to this report.

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