Cooled down and charged up, a giant magnet is ready for its new mission

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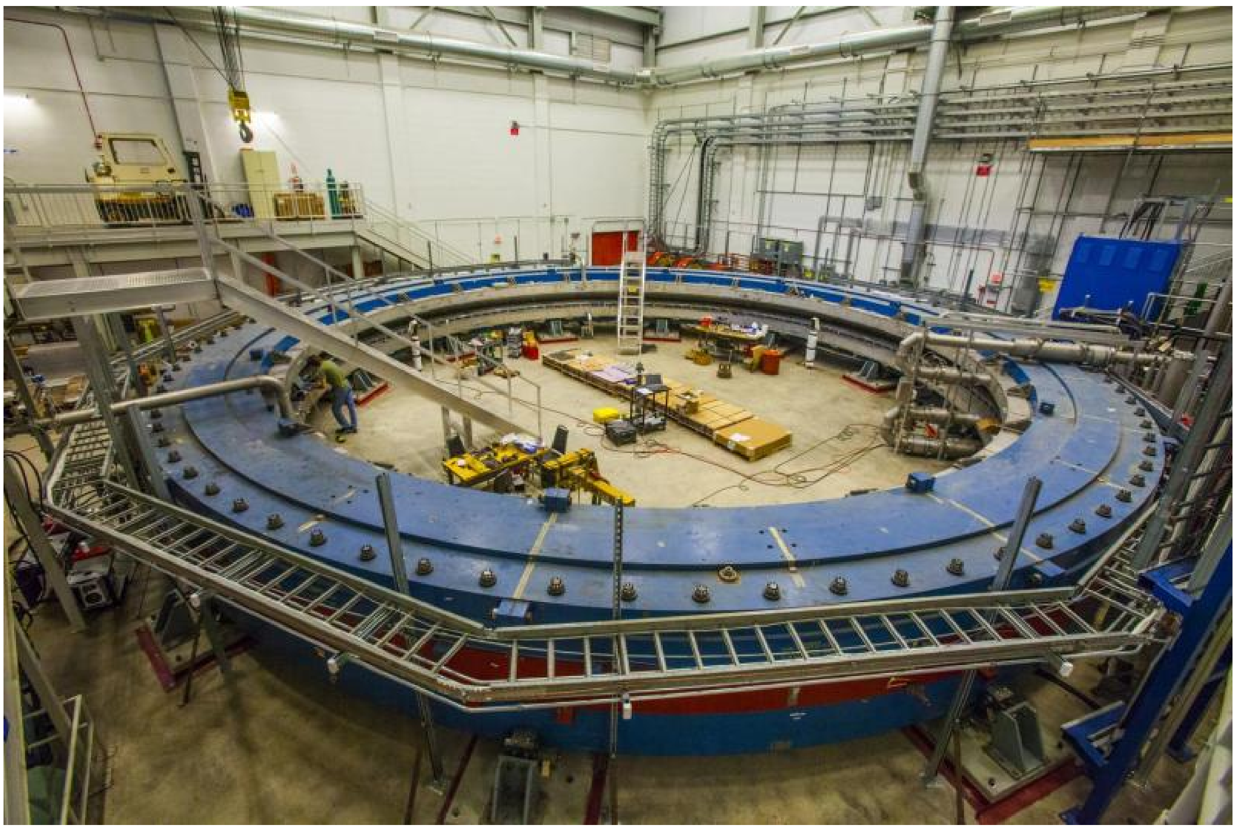

The fully assembled magnet in its new home at Fermilab. Credit: Fermilab

The Fermi National Accelerator Laboratory—or Fermilab—announced that a 680-ton superconducting magnet is secure in its new home and nearly ready for a new era of discovery in particle physics. This achievement follows the delicate, 3,200-mile transport of the magnet's 17-ton, 50-foot-wide housing ring to the U.S. Department of Energy facility outside Chicago two years ago. The fully assembled magnet will drive high-energy particle experiments as part of an international partnership among 34 institutions, of which the University of Washington is a leading contributor.

"The engineering team that put this back together at Fermilab is amazing," said UW physics professor David Hertzog, co-spokesperson for this partnership, known as the Muon g-2 collaboration. "It's all very exciting."

Hertzog's UW group will be involved in experiments over the next few years that will test whether there are any missing pieces to the Standard Model—the theoretical framework physicists use today to describe the fundamental particles and forces in the universe.

"There are lots of reasons why the Standard Model isn't complete," Hertzog said. "It really has deficiencies, and that's why we think something might be seen in these experiments."

The Standard Model currently cannot account for dark matter or dark energy, which together make up the bulk of the universe, Hertzog said. Theoretical physicists have also predicted new types of interactions among particles that have thus far eluded discovery. Hertzog and his colleagues believe the Muon g-2 collaboration could indicate if there are more particles and forces out there.

The centerpiece of these experiments are muons, subatomic particles that are similar to electrons but exist for only fractions of a second. Observations of how muons decay could reveal whether holes exist in the Standard Model, but these particles are too rare and short-lived to scrutinize with ease. Hertzog and his colleagues will use the existing accelerators at Fermilab—plus the new addition of the superconducting magnet—to generate and hold large amounts of muons for precise measurements.

The magnet for the Muon g-2 collaboration arrived at Fermilab on July 26, 2013, after a 35-day, 3,200-mile journey from Long Island to Illinois. Credit: Fermilab

"Muons have incredibly attractive features," said Hertzog. "A muon is heavy enough to reveal 'new physics' in its decay properties, and it lives long enough—a couple of microseconds—to allow beams to be formed and detailed studies to be made."

From a research perspective, he said, "They're fantastic!"

An accelerator at Fermilab will use beams of protons to generate muons through an intermediary particle. The massive magnet will then house these muons until they decay, while sensors record muon alignment and position. These brief, high-energy experiments could reveal whether "new physics" beyond the Standard Model exists.

To get the magnet ready to hold muons, project managers at Fermilab had to cool it to a temperature of about minus 450 F—a balmy 10 degrees above absolute zero. They then charged the magnet gradually with a 5,300-amp current, a milestone they reached on Sept. 22. This power-up procedure is a necessary step to prepare the magnet for the first muon experiments, currently slated for 2017.

This week's announcement comes after a long journey to Fermilab from the powerful magnet's original home. The magnet was first housed in Brookhaven National Laboratory on Long Island, where it performed a similar muon experiment that ended in 2001. When Brookhaven's research goals shifted away from particle physics, the magnet sat idle until Hertzog and his colleagues initiated an effort to repeat the muon experiments with much higher precision. Brookhaven did not have the capacity to provide the muon intensity that the Muon g-2 collaboration sought, but Fermilab did.

"It turned out that Fermilab had a much better infrastructure to create and deliver lots of muons," said Hertzog. "We're going to get 21 times the data we were able to get at Brookhaven."

In 2013, project managers used ship, barge and truck to move the magnet from Brookhaven to Fermilab. The journey was challenging—the magnet's three superconducting coils could not be disassembled for the trip, and also could not be twisted or bent more than a few degrees without causing permanent damage. After the magnet's celebrated arrival in Illinois, Fermilab assembled the superconducting coils and steel yoke structure around the ring. Though this complex move took years to plan and execute, it was about 10 times cheaper to move the magnet from Brookhaven to Fermilab than to build a new one from scratch.

Hertzog moved to the UW from the University of Illinois in 2010. His group in the UW physics department makes up one of the larger teams within the Muon g-2 collaboration. UW researchers, postdoctoral scientists and graduate students travel to Fermilab regularly during the construction, cooling and installation phases. UW scientists—led by UW physics professor Alejandro Garcia's group—developed and tested new delicate sensors to measure the magnetic field. Hertzog's team is building the detector system to measure muon decay within the magnet.

Now that the magnet is cooled and charged, scientists will spend months refining the magnetic field. Once muon experiments begin, Hertzog said, he expects their discoveries to complement particle physics collision experiments at Europe's Large Hadron Collider. Both facilities will likely provide useful information for "new physics" beyond the Standard Model.

"I don't want to root for a particular theory, I just want us to do this carefully, correctly and accurately," said Hertzog. "The physics will be what the physics will be."

More information: www.symmetrymagazine.org/artic … -down-and-powered-up

Provided by University of Washington