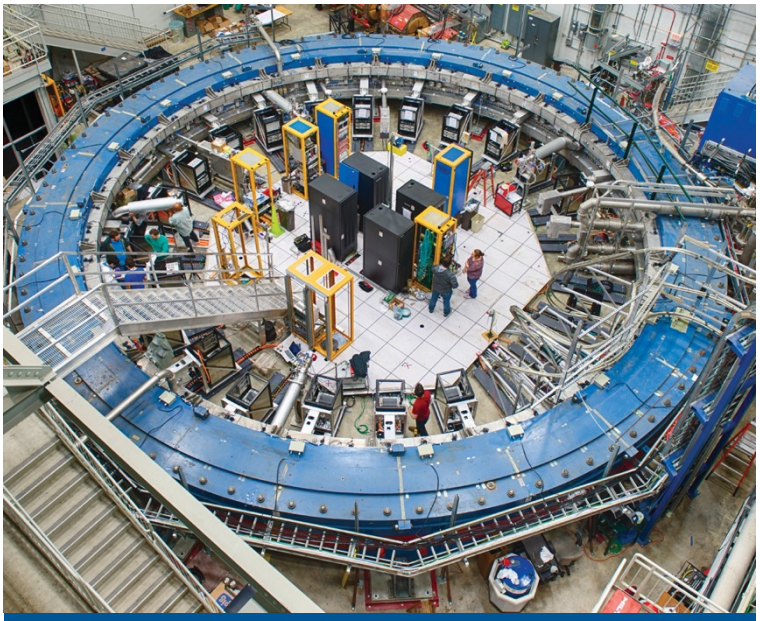
Muon g-2 Experiment

By studying the properties of muons, scientists at Fermilab hope to learn whether there are elementary particles beyond the ones we know.

The experiment

The Muon g-2 experiment probes the magnetic properties of the muon— a heavy sibling of the electron— in the search for new physics. Muon g-2 (pronounced gee-minus-two) is an international collaboration between Fermilab and dozens of labs and universities in seven countries.

The Muon g-2 experiment studies the precession or "wobble" of muons when placed in a magnetic field. Based on what we already know about muons and other particles, scientists can predict with great precision the value of the muons' wobble. If the experiment comes up with something different, it means that our current understanding of physics is incomplete, and it may indicate the presence of additional particles or hidden subatomic forces. It would open the door to exciting new realms of science.



The Muon g-2 experiment, built around the 50-foot-wide magnet from Brookhaven, began taking data in May 2017.

What are muons?

Muons are subatomic particles similar to electrons, but 207 times heavier.

They carry the same electrical charge as an electron.

They exist for only about 2.2 millionths of a second.

Scientists at Fermilab can make and store large quantities of muons.

When placed in a magnetic field, muons behave much like a gyroscope, and it is this property, called the g-factor, that the Muon g-2 experiment measures.

The Muon g-2 team transported this 50-foot-wide electromagnet 3,200 miles over land and sea on a 35-day journey to Fermilab from Brookhaven National Laboratory in New York.

An ultraprecise measurement

The centerpiece of the Muon g-2 experiment is a particle storage ring made of steel, aluminum and superconducting wire. It measures 50 feet in diameter and was built at Brookhaven National Laboratory in New York, where it was the heart of a predecessor experiment in the 1990s. That experiment provided evidence for — but not definitive proof of — a departure from the expected value of the muon's wobble.

With its powerful accelerator complex, Fermilab has the ability to generate more muons than any other laboratory in the United States. The storage ring was transported from Brookhaven to Fermilab in 2013 to make the world's most precise measurement of the muon's behavior. In the experiment's first data run in 2018, more than 8 billion muons were captured. In 2021, the collaboration's analysis of that first data set confirmed the Brookhaven result, showing muons behaving in a way not predicted by scientists' best theory.

The combined results from Fermilab and Brookhaven show a difference with theory at a significance of 4.2 sigma, a little shy of the 5 sigma (or standard deviations) that scientists require to claim a discovery but still compelling evidence of new physics. Theorists continue to improve their calculations and the experiment continues to run, accumulating data that will paint an even more precise picture of the muon's behavior.

More information

Muon g-2 experiment website:
muon-g-2.fnal.gov

If you have questions about this project, please contact the Fermilab Office of Communication, 630-840-3351, or send an email to fermilab@fnal.gov.