

'Tantalizing' results of 2 experiments defy physics rulebook

April 7 2021, by Seth Borenstein



In this 2018 photo made available by CERN, Nikolai Bondar works on the LHCb Muon system at the European Organization for Nuclear Research Large Hadron Collider facility outside of Geneva. Preliminary results published in 2021 of experiments from here and the Fermilab facility in the U.S. challenge the way physicists think the universe works, a prospect that has the field of particle physics both baffled and thrilled. (Maximilien Brice, Julien Marius Ordan/CERN via AP)

Preliminary results from two experiments suggest something could be wrong with the basic way physicists think the universe works, a prospect that has the field of particle physics both baffled and thrilled.

Tiny particles called muons aren't quite doing what is expected of them in two different long-running experiments in the United States and Europe. The confounding results—if proven right—reveal major problems with the rulebook physicists use to describe and understand how the universe works at the subatomic level.

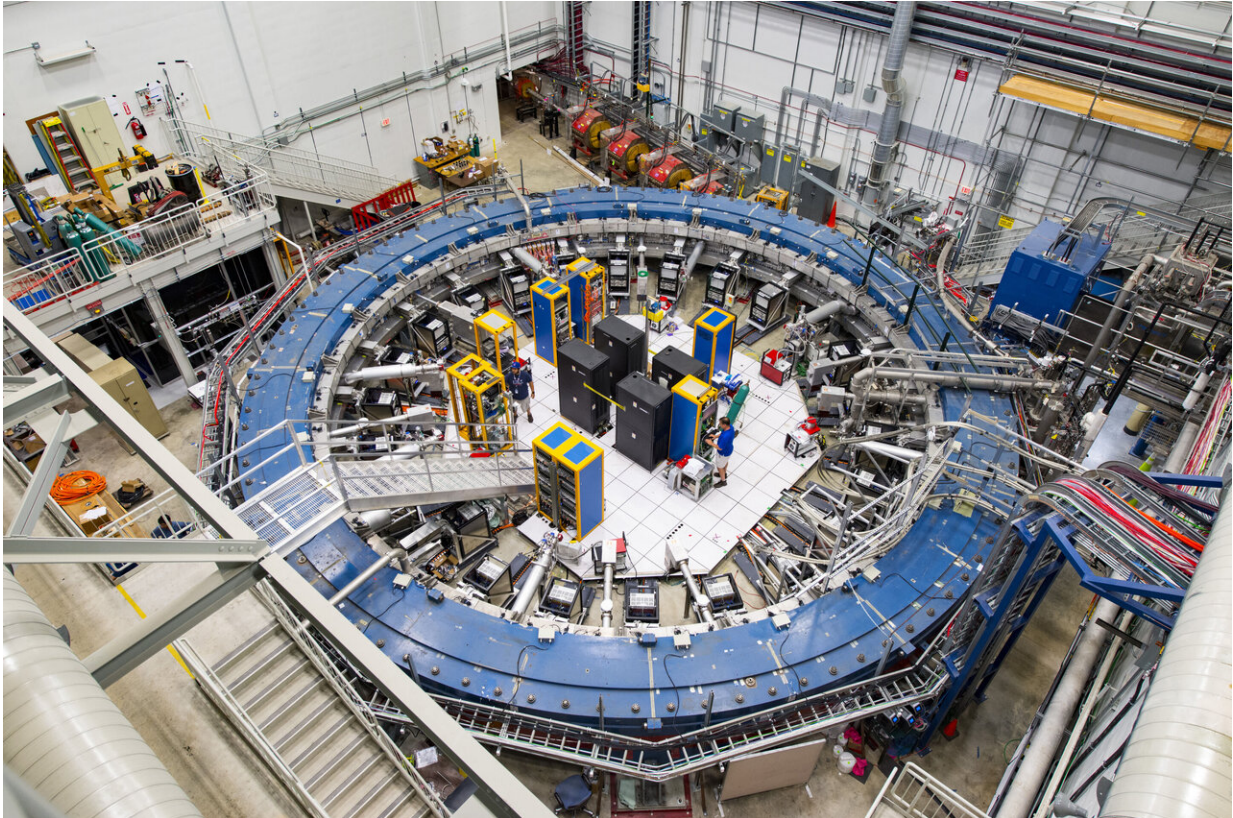
"We think we might be swimming in a sea of background particles all the time that just haven't been directly discovered," Fermilab experiment co-chief scientist Chris Polly said in a press conference. "There might be monsters we haven't yet imagined that are emerging from the vacuum interacting with our muons and this gives us a window into seeing them."

The rulebook, called the [Standard Model](#), was developed about 50 years ago. Experiments performed over decades affirmed over and over again that its descriptions of the particles and the forces that make up and govern the universe were pretty much on the mark. Until now.

"New particles, new physics might be just beyond our research," said Wayne State University particle physicist Alexey Petrov. "It's tantalizing."

The United States Energy Department's Fermilab announced results Wednesday of 8.2 billion races along a track outside Chicago that while ho-hum to most people have physicists astir: The muons' magnetic fields don't seem to be what the Standard Model says they should be. This follows [new results](#) published last month from the European Center for Nuclear Research's Large Hadron Collider that found a surprising proportion of particles in the aftermath of high-speed collisions.

If confirmed, the U.S. results would be the biggest finding in the bizarre world of subatomic particles in nearly 10 years, since the discovery of the Higgs boson, often called the "God particle," said Aida El-Khadra of the University of Illinois, who works on theoretical physics for the Fermilab experiment.



This August 2017 photo made available by Fermilab shows the Muon g-2 ring at the Fermi National Accelerator Laboratory outside of Chicago. It operates at -450 degrees Fahrenheit (-267 degrees Celsius) to detect the wobble of muons as they travel through a magnetic field. Preliminary results published in 2021 of experiments from here and the CERN facility in Europe challenge the way physicists think the universe works, a prospect that has the field of particle physics both baffled and thrilled. (Reidar Hahn/Fermilab via AP)

The point of the experiments, explains Johns Hopkins University theoretical physicist David Kaplan, is to pull apart particles and find out if there's "something funny going on" with both the particles and the seemingly empty space between them.

"The secrets don't just live in matter. They live in something that seems to fill in all of space and time. These are quantum fields," Kaplan said. "We're putting energy into the vacuum and seeing what comes out."

Both sets of results involve the strange, fleeting particle called the [muon](#). The muon is the heavier cousin to the electron that orbits an atom's center. But the muon is not part of the atom, it is unstable and normally exists for only two microseconds. After it was discovered in cosmic rays in 1936 it so confounded scientists that a famous physicist asked "Who ordered that?"

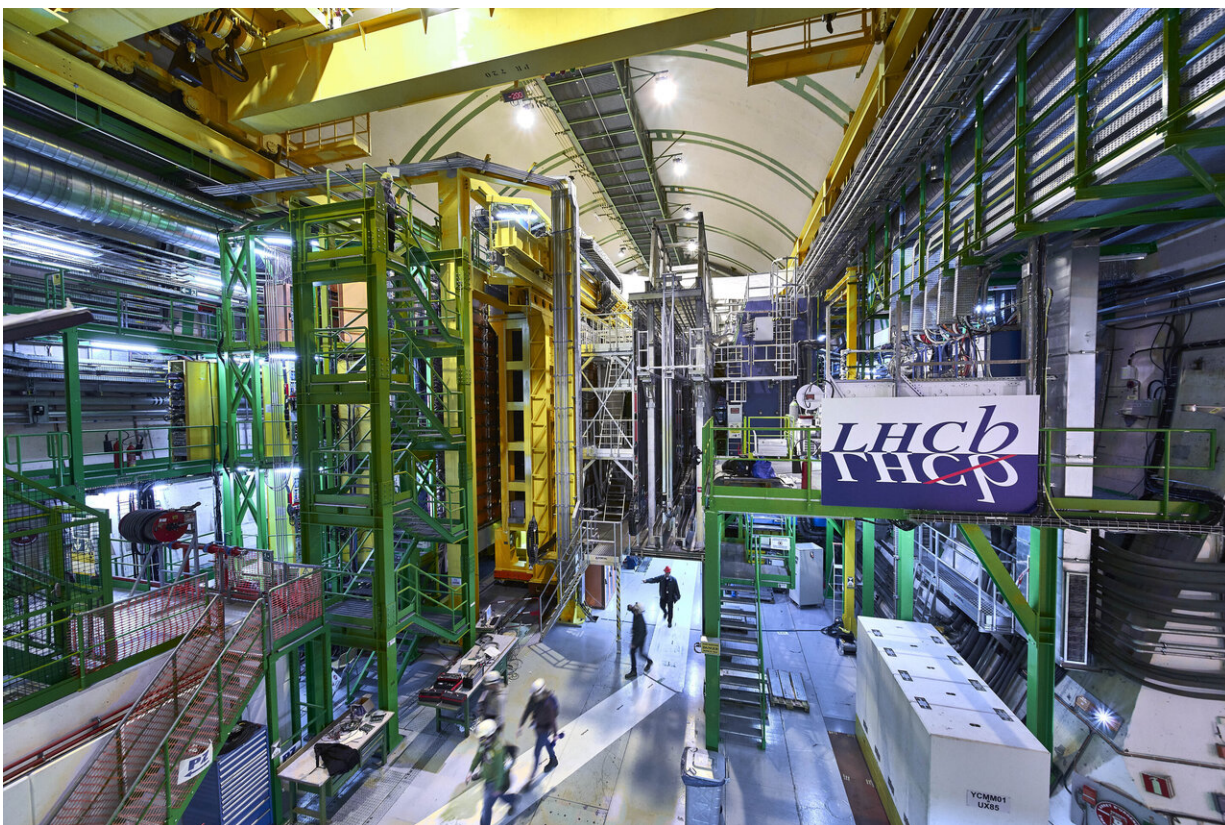
"Since the very beginning it was making physicists scratch their heads," said Graziano Venanzoni, an experimental physicist at an Italian national lab, who is one of the top scientists on the U.S. Fermilab experiment, called Muon g-2.

The experiment sends muons around a magnetized track that keeps the particles in existence long enough for researchers to get a closer look at them. Preliminary results suggest that the magnetic "spin" of the muons is 0.1% off what the Standard Model predicts. That may not sound like much, but to particle physicists it is huge—more than enough to upend current understanding.

Researchers need another year or two to finish analyzing the results of all of the laps around the 50-foot (14-meter) track. If the results don't change, it will count as a major discovery, Venanzoni said.

Separately, at the world's largest atom smasher at CERN, physicists have

been crashing protons against each other there to see what happens after. One of the particle colliders' several separate experiments measures what happens when particles called beauty or bottom quarks collide.



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The Standard Model predicts that these beauty quark crashes should result in equal numbers of electrons and muons. It's sort of like flipping

a coin 1,000 times and getting about equal numbers of heads and tails, said [Large Hadron Collider beauty experiment](#) chief Chris Parkes.

But that's not what happened.

Researchers pored over the data from several years and a few thousand crashes [and found](#) a 15% difference, with significantly more electrons than muons, said experiment researcher Sheldon Stone of Syracuse University.

Neither experiment is being called an official discovery yet because there is still a tiny chance that the results are statistical quirks. Running the experiments more times—planned in both cases—could, in a year or two, reach the incredibly stringent statistical requirements for physics to hail it as a discovery, researchers said.

If the results do hold, they would upend "every other calculation made" in the world of particle physics, Kaplan said.

"This is not a fudge factor. This is something wrong," Kaplan said. That something could be explained by a new particle or force.

Or these results may be mistakes. In 2011, a strange finding that a particle called a neutrino seemed to be traveling faster than light threatened the model, but it turned out to be the result of a loose electrical connection problem in the experiment.

"We checked all our cable connections and we've done what we can to check our data," Stone said. "We're kind of confident, but you never know."

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