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SCIENCE

The Particle That Wasn't

By DENNIS OVERBYE AUG. 5, 2016

A great "might have been" for the universe, or at least for the people who study it, disappeared Friday.

Last December, two teams of physicists working at CERN's Large Hadron Collider reported that they might have seen traces of what could be a new fundamental constituent of nature, an elementary particle that is not part of the Standard Model that has ruled particle physics for the last half-century.

A bump on a graph signaling excess pairs of gamma rays was most likely a statistical fluke, they said. But physicists have been holding their breath ever since.

If real, the new particle would have opened a crack between the known and the unknown, affording a glimpse of quantum secrets undreamed of even by Einstein. Answers to questions like why there is matter but not antimatter in the universe, or the identity of the mysterious dark matter that provides the gravitational glue in the cosmos. In the few months after the announcement, 500 papers were written trying to interpret the meaning of the putative particle.

On Friday, physicists from the same two CERN teams reported that under the onslaught of more data, the possibility of a particle had melted away.

"We don't see anything," said Tiziano Camporesi of CERN, the European Organization for Nuclear Research and a spokesman for one of the detector teams known as C.M.S., on the eve of the announcement. "In fact, there is even a small deficit exactly at that point."

His statement was echoed by a member of the competing team, known as Atlas. James Beacham, of Ohio State University, said, "As it stands now, the bumplet has gone into a flatline."

"This is the success of science, this is what science does," he added.

Dr. Camporesi said, "It's disappointing because so much hype has been made about it." But, he added, noting that the experimenters had always cautioned that the bump was most likely a fluke, "we have always been very cool about it."

The new results were presented in Chicago at the International Conference of High Energy Physics, ICHEP for short, by Bruno Lenzi of CERN for the Atlas team, and Chiara Rovelli for their competitors named for their own detector called C.M.S., short for Compact Muon Solenoid.

The presentations were part of an outpouring of dozens of papers from the two teams on the results so far this year from the collider, all of them in general agreement with the Standard Model.

The main news is that the collider, which had a rocky start, exploding back in 2008, is now running "swimmingly" in CERN's words, producing up to a billion proton-proton collisions a second.

"We're just at the beginning of the journey," said Fabiola Gianotti, CERN's director-general, in a statement.

But perhaps nature has not gotten the memo.

The non-result has further deepened an already deep mystery about the famous Higgs boson, which explains why other particles have mass, and whose discovery resulted in showers of champagne and Nobel Prizes four years ago.

The Higgs, one of the heaviest elementary particles known, weighs about 125 billion electron volts, in the units of mass and energy favored by particle physicists — about as much as an entire iodine atom. That, however, is way too light by a factor of trillions according to standard quantum calculations, physicists say, unless there is some new phenomenon, some new physics, exerting its influence on the universe and keeping the Higgs mass from zooming to cataclysmic scales. That would mean new particles.

"We have seen the Higgs, we expect to see something else," said Lisa Randall, a Harvard particle theorist who was not part of the CERN experiments. Hence the excitement over the December bump. Its mass, about 750 billion electron volts, was in the range where something should happen.

"It would have been great if it was there," Dr. Randall said. "It is the sort of thing they should be looking for if we want to understand the Higgs."

For a long time, the phenomenon physicists have thought would appear to save the day is a conjecture known as supersymmetry, which comes with the prediction of a whole new set of elementary particles, known as wimps, for weakly interacting massive particles, one of which could comprise the dark matter that is at the heart of cosmologists' dreams.

But so far, wimps haven't shown up either in the collider or in underground experiments designed to detect wimps floating through space. Neither has evidence for an alternative idea that the universe has more than three dimensions of space.

The Large Hadron Collider is expected to run for another 20 years. So, these could still be exciting times.

The CERN collider was built at a cost of some $10 billion, to speed protons around an 18-mile underground track at more than 99 percent of the speed of light, and smash them together with a combined energy of 14 trillion electron volts, in search of new particles and forces of nature. The more energy they can pour into these collisions, microscopic samples of primordial fire, by virtue of Einstein's equivalence of mass and energy, the more massive particles can come out of them.

During its first two years of running the collider, hampered by electrical problems, ran at only half power but still managed to find the Higgs boson.

Since last spring, after a two-year shutdown, CERN physicists have been running their collider at nearly its full energy, 13 trillion electron volts, or 13 TeV. "The potential for discovery is the biggest we've had since it first turned on," said Kyle Cranmer of New York University, a member of the Atlas team.

Whether this is enough to break through to new physics — if in fact there is new physics to be found — depends on who is talking. "It might be we don't have the firepower," Dr. Randall said, suggesting that physicists might eventually have to build a more powerful machine, "If we didn't see it at 8 TeV, it's not a shocker if it is not at 13."

Michael Turner, a cosmologist at the University of Chicago, said, "Energy is the great tool of discovery, so going from 8 TeV to 13 TeV is a really big deal. Keep your fingers crossed."

Dr. Camporesi said it was too soon to tell. So far physicists have only had time to pluck the low-hanging fruit from their new machine, and more subtle, difficult analyses would take time. "I would consider us lucky if we discovered new phenomena or a new state of matter in two or three years," he said, adding, "It would mean nature has been kind to us, but nature might be more subtle."

Dave Charlton of the University of Birmingham, the Atlas spokesman, said, "We don't know what nature has in store for us."

Modern particle physics, in particular, is a counting game in which a small deviation from calculated expectations building up in the course of millions or billions of individual events — a bump on a graph — can rewrite the laws of nature.

Last December's bump first manifested as an excess of pairs of gamma rays produced in the collisions.

They could have been produced in pairs by the radioactive decay of a new particle. This was exciting because the Higgs boson itself had first showed up as pairs of gamma rays, except this new particle was six times more massive than the Higgs and — unlike the Higgs — was not expected.

But as Dr. Cranmer noted at the time, there was a one-in-93 chance this was a fluke — far from the 1-in-3.5-million odds of mere chance, known as five-sigma, that is considered the gold standard for a discovery. But the fact that both teams saw something was enticing. Theoretical papers started flowing immediately, suggesting, among other things, that the new particle might be a cousin of the Higgs — good for supersymmetry — or a graviton, the conjectured quantum carrier of gravity.

"Had the bump been real, it would have without a doubt been the most important discovery in particle physics in the past half century," said Lawrence Krauss, a cosmologist at Arizona State University. "Which is why the odds were that it probably wasn't."

In three months of this year, Dr. Beacham said, his team had collected more than a quadrillion proton collisions, four times as much data as in all of 2015.

As experimentalists, Dr. Beacham and his colleagues had to ignore the theory papers about what it all might mean. "We can't be chasing ambulances," he said. "Let the data do the talking. In this case it turned into this flat line."

Maria Spiropulu of the California Institute of Technology and a member of the C.M.S. team, said, "So there is no gloom and doom in my opinion that this is gone. As we have said multiple times, it could have been anything, including nothing."

Correction: August 5, 2016
An earlier version of this article misstated the number of collisions the CERN collider can produce in one second. It is up to a billion, not a million.

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