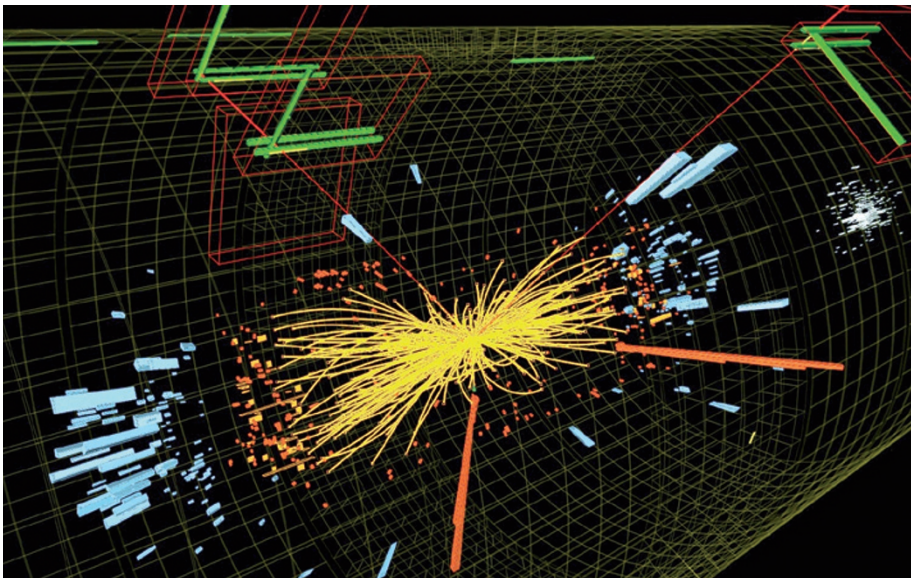

CERN

Particle collisions at the Large Hadron Collider — including this smash-up observed by the Compact Muon Solenoid detector — are not yet giving physicists many surprises.

PARTICLE PHYSICS

Hint of Higgs, but little more

No signs of exotic new physics have yet emerged from Europe's giant particle accelerator.

BY GEOFF BRUMFIEL IN GRENOBLE, FRANCE

When its experiments started in earnest earlier this year, many scientists hoped that the world's most powerful collider would turn up new particles, additional dimensions and perhaps even a small black hole or two. But beyond a handful of unusual events, the latest data from the Large Hadron Collider (LHC) are frustratingly ordinary.

Based at CERN, Europe's premier high-energy physics lab near Geneva in Switzerland, the LHC accelerates protons to almost the speed of light before slamming them together to create new, heavier particles. For more than a decade, theorists have hoped that the LHC might be powerful enough to generate previously unseen phenomena that would shake the sturdy standard model of particle physics to its core.

But the latest findings from the machine couldn't raise even a tremor inside the main auditorium of the Alpexpo centre in Grenoble, where scientists gathered last week for the International Europhysics Conference on High Energy Physics. In one session, Helen Hayward, an experimental physicist at the University of Liverpool, UK, flashed her data from the LHC's ATLAS detector onto the screen, along with the standard model's predictions of the particles that should have emerged from the smash-up. Her observations matched the predictions so perfectly that many of the numbers were identical. "You can see that there's good agreement," she said, with a hint of disappointment. She wasn't alone: in talk after talk, analyses followed the standard model's predictions with unwavering fidelity.

"Supersymmetry is clearly on the ropes."

There was one exception. On Friday afternoon, groups working on the two main detectors at the LHC presented evidence of a few extra particles corresponding to something new at energies around 140 gigaelectronvolts (GeV). For now, physicists are only willing to call them "excess events", but if the signal grows stronger as data accumulates, then it could be a sign of the Higgs boson, a vital component of the mechanism that endows other particles with mass. Since the 1960s, scientists have believed that the Higgs, or something like it, is needed to explain why some particles are heavy and others have no mass at all. The Higgs would also be the key to combining the weak nuclear force — which governs some forms of nuclear decay — with the electromagnetic force, into a single 'electroweak' force. This would see the carriers of the two forces — the W and Z bosons, and the photon, respectively — merge into a single entity at high energies.

But even the Higgs is technically part of the standard model. Instead of confirming the status quo, many physicists anticipated that the LHC might point them in new directions. In particular, theorists hoped the accelerator would turn up evidence supporting a theory called supersymmetry, dubbed SUSY, which postulates a shadowy world of heavy particles corresponding to familiar ones. These superparticles could explain dark matter, mysterious cosmic stuff that seems to interact with the visible world only through gravity. SUSY particles would also eliminate troublesome quantum fluctuations that appear in the standard model and threaten to make nonsense of calculations of the Higgs' mass.

Earlier findings had already cast doubt on SUSY (see *Nature* **471,** 13–14; 2011). Now data presented by Hayward and others suggest that superparticles predicted by the most common formulations of SUSY must be heavier than 1,000 GeV. The LHC will probe higher energies as it gathers more data, leaving a chance that it may yet find the superparticles. But even if it did, they would be much too heavy to quell the quantum fluctuations that the theory was originally designed to control. "Supersymmetry is clearly on the ropes," says Rob Roser, a physicist at Fermilab in Batavia, Illinois.

SUSY's supporters say that lighter superparticles could still exist, despite the data, in some formulations of the theory. "I'd say SUSY has a mild hangover for the moment," says Ben Allanach, a theoretical physicist at the University of Cambridge, UK. But, he adds, when the LHC begins operating at its full energy of 14 teraelectronvolts — twice its current level — in a few years time, that hangover could turn into a "fatal migraine".

Others say that data collected during the next six months may be enough to cause serious headaches for theorists. By that point, physicists expect to have gathered enough data to either build up the Higgs signal or prove, once and for all, that the mass-giving boson doesn't exist.

With petabytes of data to be gathered over its 20-year lifetime, the collider could still turn up something entirely new. But many at the meeting admitted disappointment that nothing unusual has popped up inside the machine so far. "I think a lot of people thought there would be some low-hanging fruit," says Roser. ■

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