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Searching for Susy: Collider to push physics frontier

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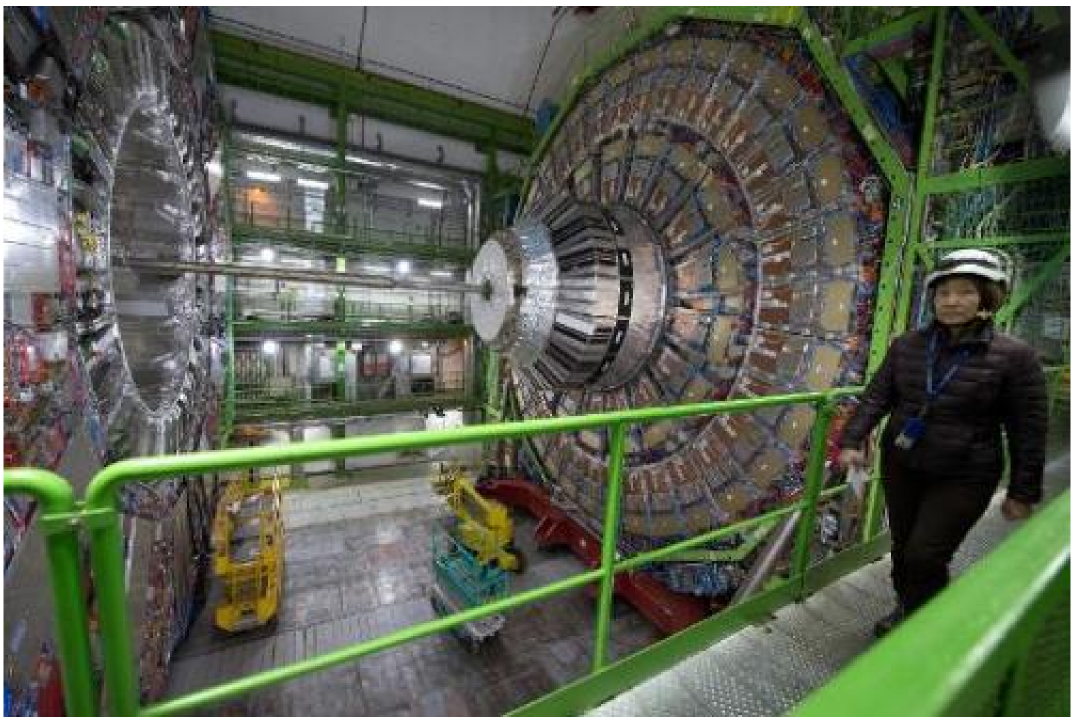


Scientists at the European Organisation for Nuclear Research (CERN) are close to launching a superpowered hunt for particles that may change our understanding of the Universe

Excitement is mounting at the world's largest proton smasher, where scientists are close to launching a superpowered hunt for particles that may change our understanding of the Universe.

Physicists and engineers are running the final checks after a two-year upgrade that nearly doubled the muscle of the Large Hadron Collider (LHC), which in 2012 unlocked the putative Higgs boson and, with it, a Nobel Prize.

Now it has its sights on finding exotic new particles in a previously-inaccessible realm that can sometimes resemble science fiction.

"The most exciting thing is we really don't know what we are going to find," said Rolf Landua of the European Organisation for Nuclear Research (CERN), which hosts the LHC.

Experiments at the collider seek to unlock clues as to how the Universe came into existence by studying fundamental particles, the building blocks of all matter, and the forces that control them.

During its next run, researchers will look for evidence of "new physics". They will probe 'supersymmetry'—a theoretical concept informally dubbed Susy, seek explanations for enigmatic dark matter, and look for signs of extra dimensions.

In late March, beams containing billions of protons travelling at 99.9 percent the speed of light will shoot through the collider's 27-kilometre (17-mile) ring-shaped tunnel straddling the Franco-Swiss border.

By about the end of May or early June, the mighty machine should be calibrated and start its long-awaited proton collisions—brief but super-intense smashups recorded in four labs dotted around the ring.

Physicists scour the debris for clues of new, hopefully exotic, sub-atomic particles.

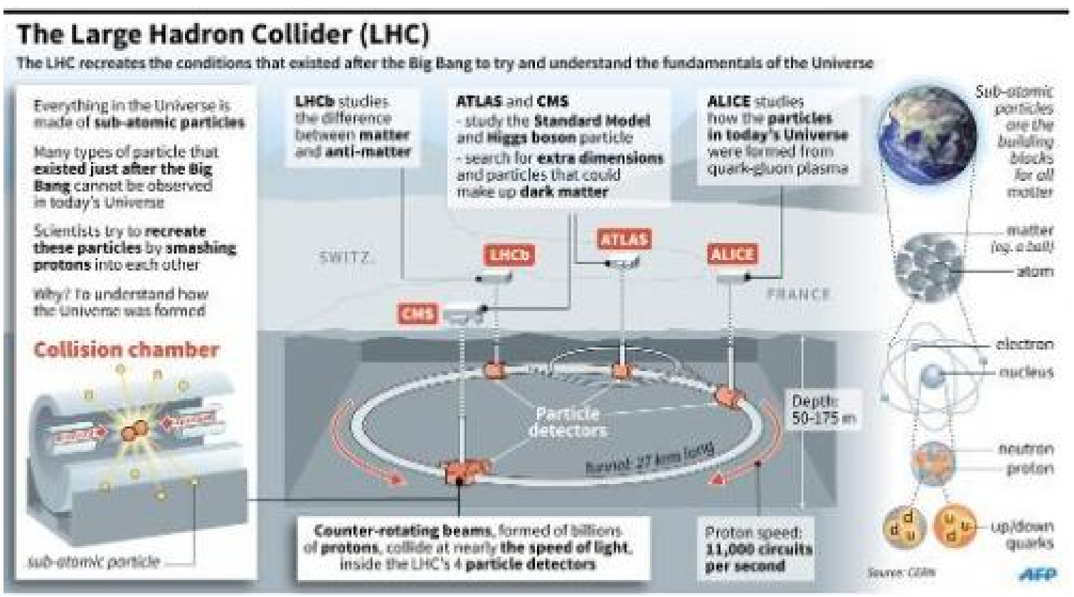
"The most important thing which we would like to find is a new type of particle which could help to explain what this mysterious dark matter is," said Landua.

Ordinary, visible matter comprises only about four percent of the known Universe.

There is believed to be five to 10 times more dark matter, which together with equally mysterious dark energy accounts for 96 percent of the cosmos.

'Fixing' the Standard Model

Fresh from its Higgs exploit, the LHC was shut as scheduled in 2013 to boost its collision capacity to 13 teraelectronvolts (TeV)—6.5 TeV for each of the two counter-rotating beams that zip around the ring.



Presentation of the Large Hadron Collider

"Thirteen TeV will be a new record, which will open the door hopefully for new physics, new discoveries," operator Mirko Pojer said at the bustling CERN control centre.

"LHC Run 2 will certainly help the physicists to better explain our Universe."

The collider's previous highest power was 8 TeV reached in 2012.

"I am pretty sure now with the new energy in the accelerator we will discover something," said Frederick Bordry, CERN director for accelerators and technology.

"By increasing the energy, the potential of discovery is higher by... maybe two orders of magnitude," or a hundred-fold, he said.

During its second three-year run, the LHC will seek to fill gaps in the "Standard Model"—the mainstream theory of how our visible Universe is constructed.

The model doesn't explain dark matter or dark energy—and seems incompatible with the theory of gravity.

Leading the pack of additional theories, "Susy" postulates the existence of a more massive, "supersymmetric" sibling for every known Standard Model particle.

This may explain dark matter, which is observable only through its gravitational effect on visible matter—holding galaxies together, for example.

Scientists believe the LHC must now be powerful enough to find supersymmetric particles, if they exist.

Higgses galore?

The Large Hadron Collider Magnet, which is used to train engineers and technicians, is seen after the LHC's collision's capacity was boosted

"Susy is super beautiful and would fix the Standard Model in many ways," said Rebeca Suarez of the LHC's Compact Muon Solenoid (CMS) experiment.

"But honestly, the hopes of supersymmetry are really low at the moment... we have really looked. Lighter particles of supersymmetry should have been accessible already.

"We are losing hope more every day about it. But there were also those losing hope of finding the Higgs and in the end we found it!"

The Higgs boson, theorised to confer mass on matter, was the last undiscovered particle predicted by the Standard Model.

Supersymmetry postulates there must be additional types of Higgs.

LHC operator Mirko Pojer watches screens at the CERN Control Center (CCC) in Meyrin, near Geneva

"Something very important will be to measure really well the Higgs boson that we have, to finally characterise it as a Standard Model particle," said Suarez.

"Any tiny deviation that we may find in the properties of the Higgs boson or any other Standard Model particle that does not follow the predictions could be a clear sign of new phenomena."

With the upgrade, the LHC can potentially be cranked up to a maximum 14 TeV, but even this may not be enough to find explanations for the strange phenomenon of dark matter, she said. A further, anticipated update may be required for that.

"To find extra Higgses would be nice, to find extra anything would be really great," said Suarez.

"If there is nothing, also it is interesting," she added, adding in all earnestness: "But of course to me, that is the worst-case scenario... It would be the worst thing to happen."

The Large Hadron Collider: A factfile

The most powerful particle smasher in the world, Europe's Large Hadron Collider (LHC), will start a new run this year.

The LHC in numbers:

- Hydrogen protons (a type of hadron) are accelerated to 99.9 percent the speed of light and rammed into one another in an attempt to create conditions similar to those that existed just after the "Big Bang" that formed the Universe 13.7 billion years ago.

- More than 1,200 superconducting dipole magnets guide two particle beams in parallel but opposite directions in an ultra-high vacuum, about 20 centimetres (eight inches) apart.

- The beams run into each other at four points along a 27-kilometre (17-mile) ring-shaped tunnel that runs about 100 metres (328 feet) underground. Some of the protons collide but the others survive and continue around the racetrack.

- The collision points represent the LHC's four experiments—ATLAS, CMS, LHCb and ALICE, where physicists look for new particles.

- The beams will each have a maximum potential energy of 7 teraelectronvolts (TeV), thus a collision energy of 14 TeV, though the experiments will start at 13 TeV—the highest ever achieved in a lab.

- One TeV is about the energy of a flying mosquito, but at the LHC it is squeezed into a space about a million million times smaller than a mosquito.

- At full energy, each beam will have energy equivalent to a 400-tonne train travelling at 150 km (93 miles) per hour.

- Every beam contains about 2,800 "bunches" or "packets" travelling with about seven metres (23 feet) between them. Each bunch contains about 100-150 billion protons.

- Each proton will go around the ring more than 11,000 times a second.

- A beam may circulate for 10 hours, travelling more than 10 billion kilometres, which is enough to get to Neptune and back.

- The LHC magnets produce a magnetic field of about 8 tesla, about 150,000 times bigger than Earth's magnetic field.

- To create resistance-free conditions inside the tunnel, the magnets must be chilled with liquid helium to 1.9 Kelvin (-271.3 degrees Celsius), which is colder than outer space.

- There will be a collision every 25 nanoseconds (one nanosecond is a billionth of a second), yielding about 15 million gigabytes of data per year—representing a stack of CDs about 20 km high.

- The LHC cost about 6.5 billion Swiss francs ($7 billion, six billion euros) to build, with an annual budget of a billion francs a year.

- More than 10,000 scientists work directly or indirectly on the LHC's four experiments.

Source: European Organisation for Nuclear Research (CERN)