Large Hadron Collider upgrade aids exploration of the origin of mass

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One of the longstanding questions posed by nature is how the property of mass arises: what makes things heavy? How does the origin of mass connect with other physical theories?

The Large Hadron Collider (LHC), an underground particle accelerator which speeds and bends particles in counter-rotating beams of protons around a 27-kilometer (17-mile) course until they are made to collide at extreme energies, was built in Switzerland to experimentally test theoretical work that suggests an answer to these questions.

With the start of the 2012 data collection run, the LHC has upgraded operations to a new world-record collision energy of 8 trillion electron-volts (TeV). Though only a modest increase from the previous year, it increases considerably the chances of discovering new particles, including the elusive Higgs boson. The energy increase was decided upon after a successful running of the LHC at 7 TeV for two years with no significant issues, giving physicists the confidence to increase the energy at a very low risk to the collider.

Ultimately, the accelerator is designed to operate at 14 TeV, which is thought to be the optimal energy to search for the Higgs. New engineering methods had to be invented to create such a powerful device, one that creates temperatures 100,000 hotter than the core of the Sun, focuses the beams into a width on the order of millimeters, and can run continuously for days at a time.

The profound engineering problems were revealed on September 19, 2008, when a faulty electrical connection between two of the 1624 magnets directing the beams caused an explosion that vaporized six tons of liquid helium coolant and caused significant damage to the accelerator. Almost all of 2009 was taken up in partially repairing the damage caused and only in December of that year did the LHC recover to where it had been in September 2008.

The work done in 2010 was largely an extremely careful and meticulous commissioning of the collider. What was involved was not just reaching higher energies, but also being able to focus the beams into tighter and tighter areas as well as adding more and more protons into each beam.

Despite these steps forward, the operational energy has remained capped at this year’s maximum of 8 TeV. After this year’s operational session concludes, the collider will be shut down for 20 months to resolve the remaining engineering problems. It is expected that by 2014, the Large Hadron Collider will run at 13 TeV, with energies of 14 TeV to be achieved soon after.

There is a certain amount of excitement within the physics community looking forward to 2014. The experimental results of the past year gave hints towards discovering the Higgs boson, which has the potential to be found from the data collected this year. Whether it is conclusively discovered or not will be determined by data retrieved when the Large Hadron Collider is nearer to its full operational capacity, something which is greatly anticipated among particle physicists.

The year 2014 will also be an exciting time for another question of particle physics known as supersymmetry, which states that for every particle (and anti-particle) there exists a “supersymmetric” partner that is much more massive.

Supersymmetry has the potential to assist in answering a basic question of modern physics. Particle physics can describe most interactions of the most basic constituents of matter with a precision greater than brain surgery. Harnessing the principles of general relativity makes it possible for the Global Positioning System to work with an accuracy of within a square meter. Yet, attempts to combine these two theories, quantum mechanics and general relativity, fail spectacularly.

More importantly, the existence of black holes and the Big Bang itself make the question of a combined theory far from academic. Until such a theory of "quantum gravity" is developed, understanding such events will be impossible. While supersymmetry does not promise to fully resolve such questions, it may point researchers in the right direction.

As with all new physical theories, supersymmetry suggests many different models. The 2010-2011 experimental data was able to rule out many of the possible supersymmetric scenarios, but many still remain to be tested. It is expected that the higher energies of 2014 and beyond will be able to not only rule out certain models but begin finding actual particles generated based on supersymmetry, further adding to our insight of the physical world.

The LHC is the fruit of the organized effort of 10,000 of the most highly and carefully trained individuals on the planet, made possible by the intellectual and physical resources contributed by more than 100 nations. This experiment is the high point of a century's worth of study of the material world at the most fundamental level and demonstrates that when labor is put to use for creation and discovery, rather than destruction, humanity's potential is astounding.

The contradiction of the LHC is between its usefulness as a world-class scientific instrument, and its construction as a point of European pride, and an engine of European scientific might. The need of humanity to understand the universe plays a wholly secondary role to Europe wishing to "beat" the United States in the discovery of new physics. This sort of attitude is an anathema to all that science stands for.

What is more tragic is that the technological capacity for this project has existed for 20 years. A project known as the Superconducting Supercollider, a particle accelerator that was designed to have three times the energy of the LHC, was scrapped by the Clinton administration after the fall of the USSR.

The end of the Cold War eased the pressure on the American ruling elite to compete in such basic scientific research (which frequently has military applications), with the gargantuan cost of such projects becoming a strain even for the wealthiest country in the world.

The success of LHC, based on the resources of the entire European continent, demonstrates that no single nation-state can by itself realize such ambitious undertakings: such endeavors *must* be international in character.

The end of 2011 brought with it tantalizing hints that the LHC had indeed found a signature which if confirmed would represent a partial answer to the origin of mass question. The beginning of the 2012 run brings with it much promise.

Even if nothing is discovered beyond the disproving of certain models, that is part of physics as well. It is all well and good when experiments, after numerous checks and balances, agree with theoretical predictions, but it is infinitely more interesting when a contradiction arises, leading to new inquiries and the development of models that integrate old and new physics into an even greater whole.

Other articles on the WSWS have followed the beginning of operations and early results of this mammoth experimental undertaking.