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The greatest achievements of the Large Hadron Collider

In September 2005, issue 43, titled "Better structures, fewer disasters", featured an article called "The new Babel and the Building Blocks of the Universe", which explored the importance of the Large Hadron Collider. But what has happened to this ambitious project over the years? Join us as we revisit its history and discover some of its most remarkable achievements.

Eighteen years after the Large Hadron Collider began operations, it remains the largest scientific and technological project in the world—and in human history. Throughout this time, both the accelerator's performance and the capabilities of its detectors have been significantly enhanced. This program, dedicated to exploring the microscopic world and the fundamental laws of nature, is expected to continue until at least 2040—and perhaps even beyond.

Here are five of its most important scientific milestones so far:

1.. The discovery of the Higgs boson announced in July 2012, the discovery of the Higgs boson was one of the most anticipated and significant goals of the LHC project. Its observation confirmed theoretical predictions made in the 1960s regarding both its existence and its properties. The Higgs boson is associated with the Higgs field, which gives

mass to the elementary particles linked to three of the fundamental forces described by the Standard Model. At the same time, photons and gluons remain massless, exactly as the theory predicts. This discovery completed our current description of the structure of matter and helped explain the origin of mass in elementary particles.
2. The discovery of new exotic hadrons. The Large Hadron Collider has uncovered numerous new particles, including an entire "bestiary" of exotic hadrons. Among them are particles composed of four and five quarks, known as tetraquarks and pentaquarks, respectively. These unusual combinations of quarks are providing valuable insight into the strong force, the fundamental interaction that binds protons and neutrons together. To date, more than seventy new quark configurations have been observed.
3. Measuring the top quark's coupling to the Higgs field. As the heaviest known elementary particle, the top quark interacts very strongly with the Higgs field. In 2018, experiments at the LHC measured the production of Higgs bosons through the fusion of two top quarks, confirming that the Higgs field is indeed responsible for giving mass to the heaviest matter particles. If there is new physics waiting to be discovered, this interaction may provide clues. Any deviation from theoretical predictions could reveal itself through subtle changes in the way the Higgs boson couples to the top quark. For this reason, the process continues to be studied in great detail.
4. Recreating and studying quark–gluon plasma. The ALICE collaboration (A Large Ion Collider Experiment) successfully produced and studied the hottest and densest form of matter ever created in a laboratory: quark–gluon plasma. This extraordinary state of matter is believed to have existed briefly after the *Big Bang*. ALICE demonstrated that quark–gluon plasma behaves like an almost perfect liquid with extremely low viscosity. By studying it in detail, scientists can reconstruct the physical conditions that prevailed when the universe was only about one microsecond old.
5. The decay of rare particles. Researchers have observed rare particle decay processes, including the decay of the Higgs boson into *tau leptons* and *bottom quarks*. These processes are essential for testing the Standard Model of particle physics and provide strong evidence that the Higgs boson interacts with matter exactly as predicted. Scientists have also observed the decay of B mesons—particles containing a bottom quark—into two muons. This process occurs naturally only a few times in every billion decays. Precise measurements of such rare events offer some of the most stringent tests of our current understanding of matter and its fundamental structure.

These are only five examples of the many areas in which research at the Large Hadron Collider has expanded our understanding of the universe. Beyond its scientific discoveries, the LHC has also driven major advances in technology and innovation. The achievements described here provide only a brief glimpse into the remarkable contributions this extraordinary project has made to science.

References

- Energy, U. D. (s.f.). *Energy.gov*. Obtenido de DOE Explains... Muon: https://www.energy.gov/science/doe-explainsmuons

A muon is an elementary subatomic particle with a negative electric charge similar to that of an electron, but approximately 207 times heavier.