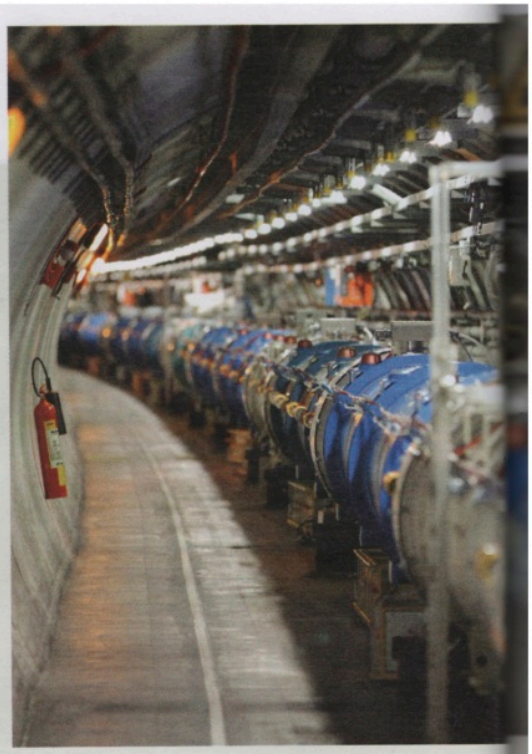


CERN. The Large Hadron Collider is back in business

One of the most important examples of European scientific collaboration is ready to show all its potential

by Marco Fosci

One of mankind's most impressive scientific endeavours, the Large Hadron Collider (LHC), returned to action in June, following a two-year break for maintenance work and a considerable upgrade.

Often referred to as one of the Old Continent's finest examples of international cooperation, the particle accelerator of the European Organization for Nuclear Research (commonly known as CERN) involves over 10,000 scientists from over 100 countries and connects some of the world's most important research centres in 42 nations.

Its Worldwide LHC Computing Grid gives leading institutes outside Europe including in the US, Russia, Canada, South Korea and Taiwan almost instant access to LHC data. And the project further involves universities in almost every country in the developed world.

In 2012, proton collisions that took place along the LHC's 27-km ring of underground tunnels led to the 'first sighting' of the Higgs boson, the elementary particle theorised in 1964 by Nobel Prize winner Peter Higgs, of which there were numerous indications but for which direct experimental evidence was missing.

Inaccurately nicknamed the "God particle" this particular boson provides mass to all elementary particles, and its detection enabled physicists to complete the Standard Model, a complex theoretical puzzle that descends below the atomic scale to describe the infinitesimal world, classifying the elementary particles (in quarks, leptons and bosons) and explaining all the fundamental forces between these particles (electromagnetic, weak and strong), except for gravity.

Physicist Joseph Incandela, then spokesperson for the Compact Muon Solenoid (CMS) detector, explained during a press conference in Geneva how it should be considered one of the most important observations of new phenomena for decades. Higgs, present at the event and genuinely moved by the news, commented, "For me it's really an incredible thing that it's happened in my lifetime"

Scientific research still has much ground to cover: the Standard Model does not include a complete gravitational theory it is often considered incompatible with Albert Einstein's general theory of relativity and it does not explain phenomena such as the movement of the galaxies, the expansion of the universe or the prevalence of matter over antimatter in the cosmos.

However, the research of Europe's LHC is pointed in this direction now. The new cycle of experiments will see two proton beams travelling through the tunnel near the border between France and Switzerland at a speed nearly double what it was before.

Over the coming months, particle collisions will take place at 14 TeV (teraelectronvolts), a level of collision energy never previously achieved in experiments and which could hopefully recreate the conditions of the universe during the moments immediately following the Big Bang, the explosion that prompted the origin of the universe. The four main detectors (Atlas, CMS, Alice and LHCb) will search for clues that can bridge the unknown and perhaps lead to the discovery of new particles.

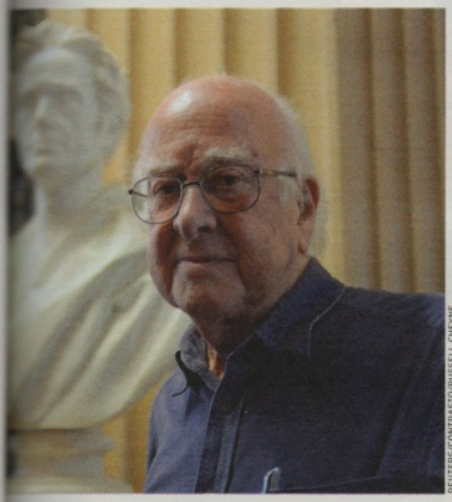
"The conversion of energy into matter is one of the most democratic phenomena



REUTERS/ CONTRASTO/PIERRE ALBOUY

The Large Hadron Collider (LHC). Having been closed down for two years of maintenance work, it's now ready to start up again.

Professor Peter Higgs, awarded the Nobel Prize for Physics in 2013.



REUTERS/CONTRASTO/RUSSELL CHEYNE

that exists in nature" says physicist Tiziano Camporesi. He assures that "if it is possible to create the energy levels sufficient to produce them, these particles will be produced" Camporesi, who is the current spokesperson for the CMS, says the potential discovery of dark matter is one of the forthcoming goals of the LHC.

"(Dark matter) is different from what we have experienced and does not interact according to the forces that we know" he explains. "We know that it will be in the form of something that is intrinsically a particle and it will be up to us to understand how to observe it"

But the scientific community is also focused on researching hidden dimensions, studying the behaviour of matter at extremely high energies and possibly proving mathematical models such as supersymmetry or string theory. These fields of research are so complex that they are often difficult to comprehend. Which is why, in Europe's current economic climate, some fail to understand the ultimate goal of the huge investments behind a scientific endeavour of such magnitude.

In 2012 *Forbes* magazine claimed that from its creation until the discovery of Higgs boson, the LHC cost €10.5 billion. Each year, 70% of CERN's funding essentially comes from its largest member states: Germany, France, the United Kingdom and Spain.

In June, an analysis commissioned by the European Investment Bank estimated that during the accelerator's life cycle (1993-2025), total costs will reach €13.5 billion. However, the study directed by University of Milan professor Massimo Florio pointed out that there is "currently a 92% probability that social benefits of the LHC exceed its costs"

According to this analysis, it is possible today to estimate returns of over €16 billion in terms of socioeconomic wellbeing. This calculation takes into account published scientific studies, the training and qualification of human capital, CERN-related economic development activities, cultural effects and potential value attributed by European citizens to the LHC.

Yet this is even a cautious estimate and one likely to increase since researchers chose not to calculate the value of future discoveries and factors that are not easily quantifiable, such as the commercial consequences of what will emerge from the Geneva laboratories. Lest we forget, in 1990 Tim Berners-Lee developed a software tool in the same CERN labs that allowed the physics community to speed up the exchange of documents, a task that previously took hours. And the World Wide Web was born.

"None of us understood its potential back then" says Camporesi, indicating similar examples connected to the construction of the LHC. The avalanche photodiode was developed to read the light produced from the interaction of particles in the crystals of the CMS detector. Today, it is used in hospitals for diagnostic exams and allows a combination of magnetic resonance and positron emission tomography.

Those of us alive today will doubtfully reap all the benefits of the Large Haldron Collider's discoveries, which will be enjoyed by future generations. But Europe can already be proud of this unprecedented organisational model. The discovery of the Higgs boson is very much proof of this: the paper that described the physical characteristics of the particle set a record number of collaborators and was signed by over 5,000 authors. ■

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