

Upgrade to boost capacity of CERN's giant particle smasher (Update)

June 15 2018



Aerial View of the CERN. Credit: CERN

A major upgrade began Friday for the world's most powerful proton

smasher to increase the number of particle collisions inside the Large Hadron Collider and help further explore the fundamental building blocks of the universe.

The work involves heavy civil engineering at the LHC's two main sites in Switzerland and France which are run by Europe's physics lab CERN, that will allow it to operate in a high-luminosity mode from 2026.

"By 2026, this major upgrade will have considerably improved the performance of the LHC, by increasing the number of collisions in the large experiments and thus boosting the probability of the discovery of new physics phenomena," CERN said.

The aim is increase tenfold the amount of data which can be picked up by the LHC, which is housed in a 27-kilometre (17-mile) ring-shaped tunnel buried more than 100 metres underground that runs beneath the border of Switzerland and France.

The powerful accelerator, which began operating in 2010, smashes high-energy protons into each other at velocities near the speed of light.

These collisions generate new particles, giving physicists an unprecedented look at the laws of nature in the hope of better understanding particles and matter.

Until now, the LHC has been able to generate nearly a billion collisions per second but the so-called high-luminosity upgrade will allow it to increase the collision rate, thereby allowing for the accumulation of 10 times more data between 2026 and 2036.

"The High-Luminosity LHC will extend the LHC's reach beyond its initial mission, bringing new opportunities for discovery, measuring the properties of particles such as the Higgs Boson with greater precision,

and exploring the fundamental constituents of the universe ever more profoundly," said CERN Director-General Fabiola Gianotti.

In 2012, the LHC was used to prove the existence of the Higgs Boson—also dubbed the God particle—which has allowed scientists to make great progress in understanding how particles acquire mass.

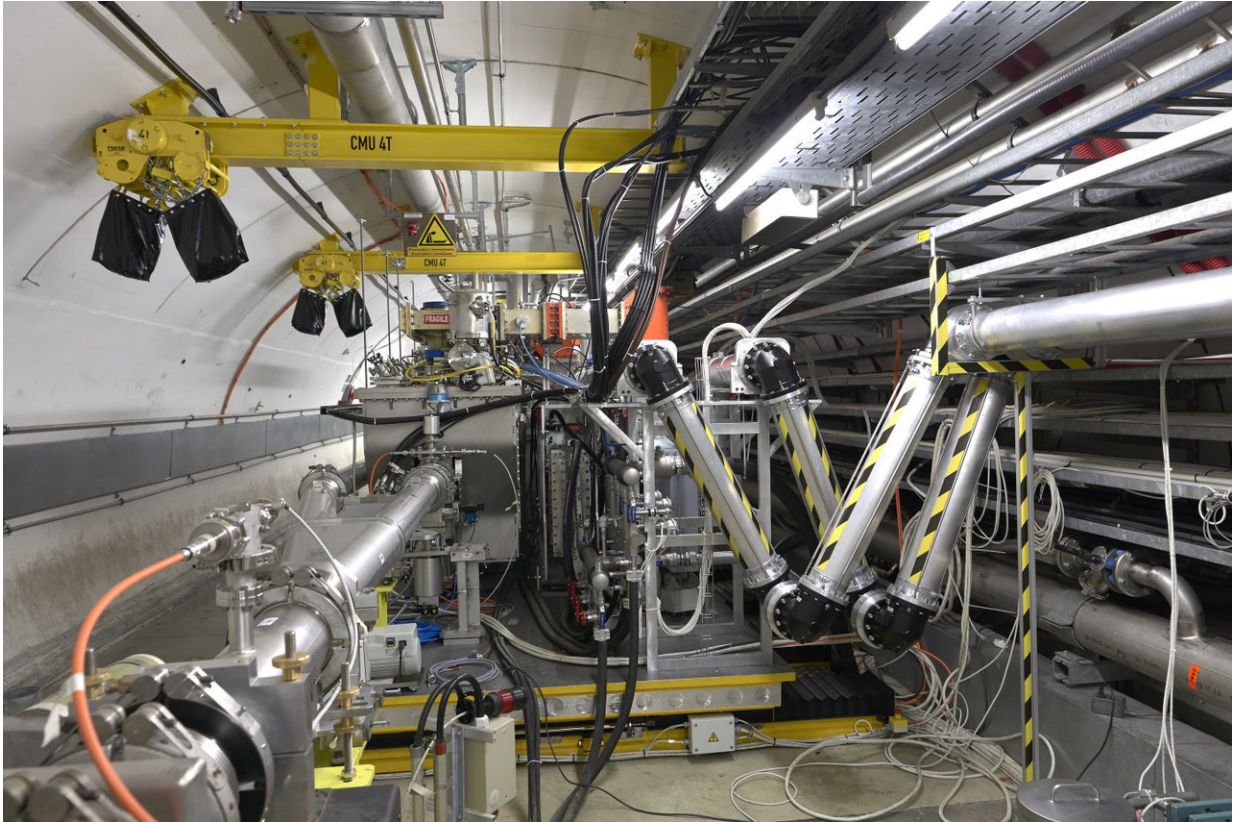
A year later, two of the scientists who had theorised the particle's existence nearly five decades earlier, won the Nobel physics prize for its discovery.

In the works since 2011, the upgrade will allow the LHC to start producing data in high-luminosity mode from 2026.

The project will involve the replacement of high-tech components along 1.2 kilometres of the machine, such as magnets, collimators and radiofrequency cavities.

It will also see the construction of new buildings, shafts, caverns and underground galleries, as well as tunnels and halls to house the new cryogenic equipment, as well as power supplies and cooling and ventilation kit.

CERN announcement:



Crab cavity test in the SPS tunnel. Credit: CERN

Major work starts to boost the luminosity of the LHC

The Large Hadron Collider (LHC) is officially entering a new stage. Today, a ground-breaking ceremony at CERN celebrates the start of the civil-engineering work for the High-Luminosity LHC (HL-LHC): a new milestone in CERN's history. By 2026 this major upgrade will have considerably improved the performance of the LHC, by increasing the number of collisions in the large experiments and thus boosting the probability of the discovery of new physics phenomena.

The LHC started colliding particles in 2010. Inside the 27-km LHC ring,

bunches of protons travel at almost the speed of light and collide at four interaction points. These collisions generate new particles, which are measured by detectors surrounding the interaction points. By analysing these collisions, physicists from all over the world are deepening our understanding of the laws of nature.

While the LHC is able to produce up to 1 billion proton-proton collisions per second, the HL-LHC will increase this number, referred to by physicists as "luminosity", by a factor of between five and seven, allowing about 10 times more data to be accumulated between 2026 and 2036. This means that physicists will be able to investigate rare phenomena and make more accurate measurements. For example, the LHC allowed physicists to unearth the Higgs boson in 2012, thereby making great progress in understanding how particles acquire their mass. The HL-LHC upgrade will allow the Higgs boson's properties to be defined more accurately, and to measure with increased precision how it is produced, how it decays and how it interacts with other particles. In addition, scenarios beyond the Standard Model will be investigated, including supersymmetry (SUSY), theories about extra dimensions and quark substructure (compositeness).

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The HL-LHC project started as an international endeavour involving 29 institutes from 13 countries. It began in November 2011 and two years later was identified as one of the main priorities of the European Strategy for Particle Physics, before the project was formally approved by the CERN Council in June 2016. After successful prototyping, many new hardware elements will be constructed and installed in the years to

come. Overall, more than 1.2 km of the current machine will need to be replaced with many new high-technology components such as magnets, collimators and radiofrequency cavities.

The secret to increasing the collision rate is to squeeze the particle beam at the interaction points so that the probability of proton-proton collisions increases. To achieve this, the HL-LHC requires about 130 new magnets, in particular 24 new superconducting focusing quadrupoles to focus the beam and four superconducting dipoles. Both the quadrupoles and dipoles reach a field of about 11.5 tesla, as compared to the 8.3 tesla dipoles currently in use in the LHC. Sixteen brand-new "crab cavities" will also be installed to maximise the overlap of the proton bunches at the collision points. Their function is to tilt the bunches so that they appear to move sideways – just like a crab.

Another key ingredient in increasing the overall luminosity in the LHC is to enhance the machine's availability and efficiency. For this, the HL-LHC project includes the relocation of some equipment to make it more accessible for maintenance. The power converters of the magnets will thus be moved into separate galleries, connected by new innovative superconducting cables capable of carrying up to 100 kA with almost zero energy dissipation.

"Audacity underpins the history of CERN and the High-Luminosity LHC writes a new chapter, building a bridge to the future," said CERN's Director for Accelerators and Technology, Frédérick Bordry. "It will allow new research and with its new innovative technologies, it is also a window to the accelerators of the future and to new applications for society."

To allow all these improvements to be carried out, major civil-engineering work at two main sites is needed, in Switzerland and in France. This includes the construction of new buildings, shafts, caverns

and underground galleries. Tunnels and underground halls will house new cryogenic equipment, the electrical power supply systems and various plants for electricity, cooling and ventilation.

During the civil engineering work, the LHC will continue to operate, with two long technical stop periods that will allow preparations and installations to be made for high luminosity alongside yearly regular maintenance activities. After completion of this major upgrade, the LHC is expected to produce data in high-luminosity mode from 2026 onwards. By pushing the frontiers of accelerator and detector technology, it will also pave the way for future higher-energy accelerators.

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Citation: Upgrade to boost capacity of CERN's giant particle smasher (Update) (2018, June 15) retrieved 27 April 2024 from <https://phys.org/news/2018-06-cern-major-reap-atom-smasher.html>

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