



## Upgrade At CERN

Six years after the Higgs boson was discovered at the CERN Large Hadron Collider (LHC), particle physicists have recently observed how the elusive particle decays.

- Higgs boson has been observed to decay into fundamental particles known as **bottom quarks**.
- The Higgs boson was detected by studying collisions of particles at different energies. But they last only for one zeptosecond, which is  $10^{-21}$  seconds, so detecting and studying their properties requires an incredible amount of energy and advanced detectors.

## What is Higgs Boson?

- In 2012, the Nobel-winning discovery of the Higgs boson (also known as 'God particle') validated the **Standard Model of physics**, which also predicts that about 60% of the time a Higgs boson will decay to a pair of bottom quarks.
- In 1960s Peter Higgs was the first person to suggest that this particle might exist.
- The Standard Model of particle physics is the theory which describes three of the four known fundamental forces (the electromagnetic, weak, and strong interactions, and not including the gravitational force) in the universe, as well as classifies all known elementary particles.
- Scientists do not yet know how to combine gravity with the Standard Model.
- The Higgs particle is a boson. Bosons are thought to be particles which are responsible for all physical forces. Other known bosons are the photon, the W and Z bosons, and the gluon.

## What is Large Hadron Collider (LHC)?

- It is a kind of **atom smasher** machine.
- It is the world's largest and most powerful **particle accelerator**.
- It is essentially two 16-mile-round rings that overlap in four places.
- Bunches of protons (or heavier atoms) race around the tracks at nearly the speed of light and collide in one of the four intersections.
- Enormous detectors surround those crossings and record the particles that coalesce out of the high-energy collisions. Discoveries are made when these resulting collisions behave differently than the existing laws of physics would predict—or when they behave in predicted but never-before-seen ways.
- It first started up in 2008, and remains the latest addition to CERN's accelerator complex.
- It consists of a 27-kilometre **ring of superconducting magnets** with a number of accelerating structures to boost the energy of the particles along the way.

## Significance

- Particle physics probes nature at extreme scales to understand the fundamental constituents of matter. Just like grammar and vocabulary guide (and constrain) our communication, particles communicate with each other in accordance with interactions through fundamental forces.
- Studying the patterns in the emission of these particles help us understand the properties and structure of particles.
- Testing the prediction is crucial because the result will either lend support to the Standard Model — which is built upon the idea that the Higgs field endows quarks and other fundamental particles with mass — or rock its foundations and point to new physics.

- Experiments like these allow physicists to not only validate what the Standard Model predicts about the Higgs boson and bottom quarks but also challenge what the Standard Model predicts.

## Why is Upgradation Needed?

- CERN announced earlier this year that it is getting a massive upgrade, which will be completed by 2026.
- It will allow scientists to conduct even bigger and better physics experiments.
- It will turn the LHC into the High-Luminosity Large Hadron Collider (HL-LHC). The upgrade will allow the machine to collide even more particles, potentially helping physicists see new stuff.
- The upgrade could also make discoveries happen faster.
- Making new discoveries faster requires making more collisions and that's exactly what the High-Luminosity LHC will do. Currently, the LHC can produce a billion collisions between protons per second which would be increased by five to seven times.
- Such an upgrade would make measurements of particles like the Higgs boson more accurate.

## India and CERN

- India in **2016** became an **associate member** of the European Organisation for Nuclear Research (CERN).
- India's association with CERN goes back decades with an active involvement in the construction of the Large Hadron Collider (LHC), in the areas of design, development and supply of hardware accelerator components/systems and its commissioning and software development and deployment in the machine.
- India was inducted as an 'Observer' at CERN in 2004. Its upgrade as associate member allows Indian companies to bid for lucrative engineering contracts and Indians can apply for staff positions at the organisation.
- The associate membership would cost India Rs. 78 crore annually though it still wouldn't have voting rights on decisions of the Council.
- Indian scientists have played a significant role in the A Large Ion Collider Experiment (ALICE) and Compact Muon Solenoid (CMS) experiments that led to the discovery of the Higgs Boson.

## About CERN

- European Organisation for Nuclear Research (CERN) is the world's largest nuclear and particle physics laboratory and best known as operator of the Large Hadron Collider, which found the elusive Higgs boson in 2012.
- CERN is based in Geneva on the French-Swiss border. It has 22 member states.