Upgrade to Large Hadron Collider - CERN

What is the issue?

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- CERN (the European Organization for Nuclear Research) recently found that Higgs boson decays to fundamental particles known as bottom quarks.
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- Testing this and understanding more particles, require an upgradation to the Large Hadron Collider.
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Why to study particles?

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- Particle physics probes nature at extreme scales, to understand the fundamental constituents of matter.
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- Particles communicate with each other in accordance with certain rules.
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- These are embedded in what are known as the ‘four fundamental interactions’.
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- The particles and three of these interactions are successfully described by a unified approach known as the Standard Model (SM).
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- The SM is a framework that required the existence of a particle called the Higgs boson.
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- The Large Hadron Collider (LHC) is the world’s largest and most powerful particle accelerator.
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- One of the major aims of the Large Hadron Collider (LHC) was to search for the Higgs boson.
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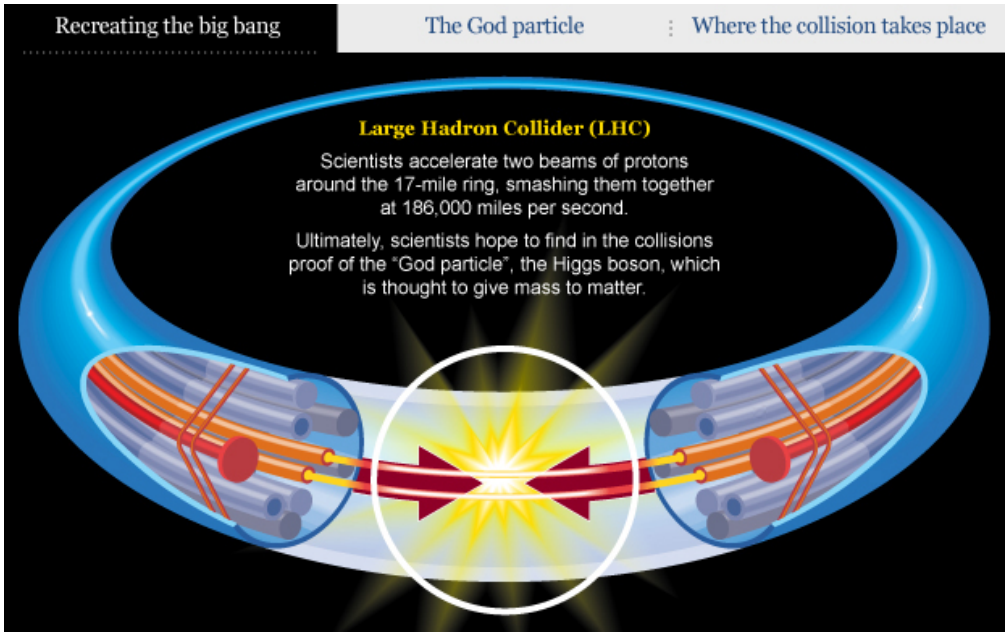

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How are such tiny particles studied?

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- Protons are collected in bunches.
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- They are then accelerated to nearly the speed of light and made to collide.
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- Many particles emerge from such a collision, termed as an event.
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- The emergent particles exhibit an apparently random pattern.
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- But they follow the underlying laws that govern part of their behaviour.
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- Studying the patterns in the emission of these particles help understand the properties and structure of particles.
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What is CERN's proposal?

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- Higgs boson was discovered at the CERN Large Hadron Collider (LHC).
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- The Higgs boson was detected by studying collisions of particles at different energies.
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- But they last only for one zeptosecond which is 0.00000000000000000001 seconds.
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- So, detecting and studying their properties requires an incredible amount of energy and advanced detectors.
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- CERN has thus announced earlier this year that it is getting a massive upgrade to the LHC.
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- This will be completed by 2026.
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Why an upgrade?

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- *Luminosity* is a measure of the number of protons crossing per unit area per unit time.
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- Initially, the LHC provided collisions at unprecedented energies.
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- This allowed scientists to focus on studying new territories.
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- But, it is now time to increase the discovery potential of the LHC by recording a larger number of events.
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- So upgrading (increasing the luminosity) will increase the rate of collisions.
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- Eventually, the probability of most rare events will also increase.
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- This offers scope for studying the properties of newly discovered particle and its effect on all other particles.
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- In addition, understanding the properties of the Higgs boson will require their abundant supply.
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- But the SM has its shortcomings, and there are alternative models that fill these gaps.
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- It thus necessitates a High Luminosity LHC (HL-LHC).
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How will it help?

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- The beam in the LHC has about 2,800 bunches, each of which contains about 115 billion protons.
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- The HL-LHC will have about 170 billion protons in each bunch, contributing to an increase in luminosity.
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- After the upgrade, the total number of Higgs bosons produced in one year may be about 5 times the number produced currently.
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- The experiments will be able to record about 25 times more data in the same period as for LHC running.
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How will it be upgraded?

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- The protons are kept together in the bunch using strong magnetic fields of special kinds.
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- These are formed using quadrupole magnets.
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- Focusing the bunch into a smaller size requires stronger fields.
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- Therefore greater currents are employed, necessitating the use of superconducting cables.
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- Newer technologies and new material (Niobium-tin) will be used to produce the required strong magnetic fields.
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- The creation of long coils for such fields is being tested.
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- New equipment will be installed over 1.2 km of the 27-km LHC ring.
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- This will help in focusing and squeezing the bunches just before they cross.
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- The LHC gets the protons from an accelerator chain.
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- This will also need to be upgraded to meet the requirements of the high

luminosity.
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- Moreover, the length of each bunch is just a few cm.
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- So, to increase the number of collisions a slight tilt is being produced in the bunches just before the collisions.
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- This is to increase the effective area of overlap.
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Source: Indian Express

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