

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.
- 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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- \bullet Particles communicate with each other in accordance with certain rules. $\ensuremath{\backslash} n$
- 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).
- The SM is a framework that required the existence of a particle called the Higgs boson.

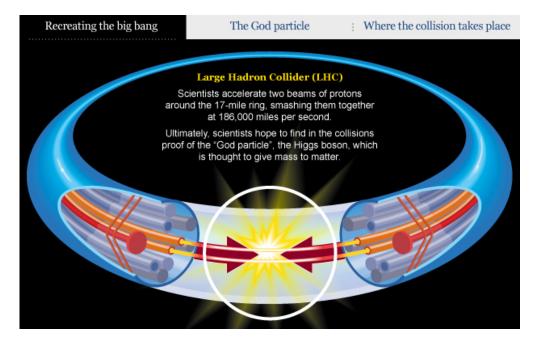
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• The Large Hadron Collider (LHC) is the world's largest and most powerful particle accelerator.

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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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How are such tiny particles studied?

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- <u>Protons</u> are collected in bunches.
- They are then <u>accelerated</u> to nearly the speed of light and made to <u>collide</u>. $\$
- Many <u>particles emerge</u> from such a collision, termed as an event.
- The emergent particles exhibit an apparently random $\underline{\text{pattern}}$.
- \bullet But they follow the underlying \underline{laws} that govern part of their behaviour. $\mbox{\sc h}$
- 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).
- The Higgs boson was detected by studying collisions of particles at different energies.

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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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 \bullet So upgrading (increasing the luminosity) will increase the rate of collisions.

 \bullet 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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 \bullet 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.

 \bullet This will help in focusing and squeezing the bunches just before they cross. \n

• The LHC gets the protons from an accelerator chain.

• 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.

- So, to increase the number of collisions a slight tilt is being produced in the bunches just before the collisions.
- \bullet This is to increase the effective area of overlap. $\ensuremath{^{\backslash n}}$

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Source: Indian Express

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