Large Hadron Collider

Why in news?

Engineers are warming up the LHC for its 3rd season of operations with upgrades, that makes it more sensitive and accurate than before.

What is Large Hadron Collider (LHC)?

> ***Large*** *- It is the world's largest science experiment (27 km long circular pipe).*
>
> ***Collider*** *- It accelerates 2 beams of particles in opposite directions and smashes them head on*
>
> ***Hadron*** *- The particles used here are Hadrons*

- **Hadrons** - A hadron is a subatomic particle that contains quarks, antiquarks, and gluons.
- The LHC typically uses protons, which are made up of quarks and gluons.
- The LHC, built by the *European Organisation for Nuclear Research (CERN)*, conducts experiments with highly energized particles.
- It energizes the protons by accelerating them through a narrow circular pipe.
- The LHC consists of 9 detectors, including CMS, ALICE, LHC-B and ATLAS, located over different points on the beam pipe and study particle interactions in different ways.

How it works?

- **Objective** - The LHC collides two beams of protons together at the highest energies ever achieved in a laboratory and study the results of these collisions with massive detectors built in underground caverns.
- **Working** - The circular pipe encircles two D-shaped magnetic fields, created by almost 9,600 magnets.
- A proton is made to move by turning on one hemisphere of magnets and turning off the other, such that the magnetic field acting on the proton causes it to move clockwise.
- Then, the magnetic polarity is reversed by turning off the first hemisphere and turning on the second and causes the proton to move in an anticlockwise direction.
- By *switching the direction of the magnetic field* more and more rapidly, protons can be accelerated through the beam pipe.
- There are also other components to help them along and to focus the particles and keep them from hitting the pipe's walls.
- Eventually, the protons move at 99.999999% of the speed of light.

- The LHC's various components are built such that scientists can tweak all these parameters to study different particle interactions.

What are the goals of LHC?

- The primary goal is to understand the nature of the most basic building blocks of the universe and how they interact with each other.
- To discover Higgs boson and determine how particles acquire mass.
- To search for possible new generations of quarks or leptons.
- To confirm/disprove the elementary nature of quarks/leptons.
- To discover direct evidence for the particle responsible for the dark matter in the Universe.
- **Higgs Boson** - Sometimes referred to as the "God particle" Higgs Boson was first discovered by the ATLAS and CMS detectors in 2012.
- The Higgs boson was the last remaining piece of the standard model of particle physics.

The Standard Model of particle physics is the theory describing 3 of the 4 known fundamental forces in the universe (excludes gravitational forces) and classifying all known elementary particles.

Fundamental forces

1. Weak force
2. Strong force
3. Gravitational force
4. Electromagnetic force

Quick facts

The European Organization for Nuclear Research (CERN)
• It is an intergovernmental organization that operates the largest particle physics laboratory in the world. • Established in 1954, it is based in a northwestern suburb of Geneva, on the France–Switzerland border. • The CERN convention was signed in 1953 by the 12 founding state. • India was granted Observer status to the CERN Council in 2002. • CERN has 22 member states. • *India, Turkey, Pakistan, Ukraine are Associate members*.

Forward Search Experiment (FASER) Experiment

• The Forward Search Experiment (FASER) is a particle detector that was designed and built by CERN.
• FASER team detected neutrinos after smashing two beams of particles at extremely high energy inside the LHC.
• FASER might also become the first to detect dark matter.
• Every time atomic nuclei come together (like in the sun) or break apart (like in a nuclear reactor), they produce neutrinos.
• Neutrinos are the most abundant particles that have mass in the universe.

References

1. The Hindu | Large Hadron Collider
2. India At CERN | India's Contributions
3. CERN | About LHC
4. Interesting Engineering | About FASER

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