

# Glossary

## Accelerating cavity

Accelerating cavities produce the electric field that accelerates the particles inside particle accelerators. Because the electric field oscillates at radio frequency, these cavities are also referred to as radio-frequency cavities.

## Accelerator

A machine in which beams of charged particles are accelerated to high energies. Electric fields are used to accelerate the particles while magnets steer and focus them. Beams can be made to collide with a static target or with each other.

- A collider is a special type of circular accelerator where beams travelling in opposite directions are accelerated and made to interact at designated collision points.
- A linear accelerator (or linac) is often used as the first stage in an accelerator chain.
- A synchrotron is an accelerator in which the magnetic field bending the orbits of the particles increases with the energy of the particles. This makes the particles move in a circular path.

## AD (Antiproton Decelerator)

The research facility that produces the low-energy antiprotons for the experiments AEGIS, ALPHA, ASACUSA, ATRAP, BASE and GBAR.

## ALICE (A Large Ion Collider Experiment)

One of the four large experiments studying the collisions at the LHC.

## Antimatter

Every kind of matter particle has a corresponding antiparticle. Charged antiparticles have the opposite electric charge to their matter counterparts. Although antiparticles are extremely rare in the universe today, matter and antimatter are believed to have been created in equal amounts at the time of the Big Bang.

## ATLAS

One of the four large experiments studying the collisions at the LHC.

## Beam

The particles in an accelerator are grouped together in a beam. Beams can contain billions of particles and can be divided into discrete portions called bunches. Each bunch is typically several centimetres long and just a few microns wide.

## Boson

The collective name given to the particles that carry forces between particles of matter. (See also Particles.)

## Calorimeter

An instrument for measuring the amount of energy carried by a particle. In particular, an electromagnetic calorimeter measures the energy of electrons and photons, whereas a hadronic calorimeter determines the energy of hadrons, that is, particles made of quarks, such as protons, neutrons, pions and kaons.

## CLIC (Compact Linear Collider)

A site-independent feasibility study aiming at the development of a realistic technology at an affordable cost for an electron-positron linear collider for physics at multi-TeV energies.

## CMS (Compact Muon Solenoid)

One of the four large experiments studying the collisions at the LHC.

## Cosmic ray

A high-energy particle that strikes the Earth's atmosphere from space, producing many secondary particles, also called cosmic rays.

## CP violation

A subtle effect observed in the decays of certain particles that betrays nature's preference for matter over antimatter.

## Cryostat

A refrigerator used to maintain extremely low temperatures.

## Dark matter

Only about 5% of the matter in the universe is visible. The rest is of an unknown nature and is referred to as dark matter (27%) and dark energy (68%). Finding out what it consists of is a major question for modern science.

## Detector

A device used to measure properties of particles. Some detectors measure the tracks left behind by particles, others measure energy. The term "detector" is also used to describe the huge composite devices made up of many smaller detector elements. In the large detectors at the LHC each layer has a specific task.

## Dipole

A magnet with two poles, like the north and south poles of a horseshoe magnet. Dipoles are used in particle accelerators to keep particles moving in a circular orbit. In the LHC there are 1232 dipoles, each 15 m long.

## Electronvolt (eV)

A unit of energy or mass used in particle physics. One eV is extremely small, and units of a million electronvolts, MeV, or a thousand million electronvolts, GeV, are more common. The LHC collision energy reaches 13 million million electronvolts, or 13 TeV. One TeV is about the energy of motion of a flying mosquito.

## Event

Particle collisions generate sprays of new particles that are observed by detectors. When a collision is considered potentially interesting, information about the emerging particles is recorded for further study. Such a collision is referred to by physicists as an event.

## FCC study

By 2019, the Future Circular Collider collaboration (FCC) will produce a conceptual design report for a next generation large-scale particle collider on a timescale of 20 to 30 years. It studies the possibility of a 100-TeV hadron collider, a lepton collider as a potential intermediate step, and a lepton-hadron collider as an option. The study also covers a possible high-energy version of the LHC in the existing tunnel.

## Forces

There are four fundamental forces in nature. Gravity is the most familiar to us, but it is the weakest. Electromagnetism is the force responsible for thunderstorms and carrying electricity into our homes. The two other forces, weak and strong, are confined to the atomic nucleus. The strong force binds the nucleus together, whereas the weak force causes some nuclei to break up. The weak force is important in the energy-generating processes of stars, including the Sun. Physicists would like to find a single theory that can explain all these forces. A big step forward was made in the 1960s when the electroweak theory uniting the electromagnetic and weak forces was proposed. This was later confirmed in a Nobel-prize-winning experiment at CERN.

## GeV

See Electronvolt.

## Hadron

A subatomic particle that contains quarks, antiquarks, and gluons, and so experiences the strong force. (See also Particles.)

## Higgs boson

The particle linked to the Brout-Englert-Higgs mechanism that gives mass to elementary particles.

## High-Luminosity LHC

The High-Luminosity LHC (HL-LHC), scheduled to be commissioned after 2025, will extend the discovery potential of the LHC by increasing the luminosity by a factor 5-10. To achieve this, new equipment will be installed in 1.2 km of the current accelerator.

## Injector

System that supplies particles to an accelerator. The injector complex for the LHC consists of several accelerators acting in succession.

## Ion

An ion is an atom with one or more electrons removed (positive ion) or added (negative ion).

## ISOLDE

A radioactive ion beam facility that directs a beam of protons from the Proton Synchrotron Booster onto special targets to produce more than 1000 different isotopes for a wide range of research. (See also Isotope.)

## Isotope

Slightly different versions of the same element, differing only in the number of neutrons in the atomic nucleus — the number of protons is the same.

## Kelvin

A unit of temperature. One kelvin is equal to one degree Celsius. The Kelvin scale begins at absolute zero,  $-273.15^{\circ}\text{C}$ , the coldest temperature possible.

## Lepton

A class of elementary particle that includes the electron. Leptons are particles of matter that do not feel the strong force. (See also Particles.)

## LHC

The Large Hadron Collider, CERN's biggest accelerator.

## LHCb (Large Hadron Collider beauty)

One of the four large experiments studying the collisions at the LHC.

## Linac

See Accelerator.

## Luminosity

In particle physics, luminosity is a measure of how many particles pass through a given area in a certain amount of time. The higher the luminosity delivered by the LHC, the larger the number of collision events happening at each experiment. Hence, more luminosity means more precise results and an increased possibility to observe rare processes.

## Muon

A particle similar to the electron, but some 200 times more massive. (See also Particles.)

## Muon chamber

A device that identifies muons, and together with a magnetic system creates a muon spectrometer to measure momenta.

## Neutrino

A neutral particle that hardly interacts at all. Neutrinos are very common and could hold the answers to many questions in physics. (See also Particles.)

## n\_TOF

A facility that uses protons from the PS to create a high-intensity neutron beam to study neutron-induced reactions over a broad range of energies.

## Nucleon

The collective name for protons and neutrons.

## Particles

There are two groups of elementary particles, quarks and leptons. The quarks are up and down, charm and strange, top and bottom (beauty). The leptons are the electron and electron neutrino, muon and muon neutrino, tau and tau neutrino. The quarks and leptons, which are all particles of matter, are referred to collectively as fermions. There are four fundamental forces, or interactions, between particles, which are carried by special particles called bosons. Electromagnetism is carried by the photon, the weak force by the charged W and neutral Z bosons, the strong force by the gluon; gravity is probably carried by the graviton, which has not yet been discovered. Hadrons are particles that feel the strong force. They include mesons, which are composite particles made up of a quark-antiquark pair and baryons, which are particles containing three quarks. Pions and kaons are types of meson. Neutrons and protons (the constituents of ordinary matter) are baryons; neutrons contain one up and two down quarks; protons two up and one down quark.

## Positron

The antiparticle of the electron. (See also Antimatter.)

## PS

The Proton Synchrotron, backbone of CERN's accelerator complex.

## Quadrupole

A magnet with four poles, used to focus particle beams rather like glass lenses focus light.

## Quantum chromodynamics (QCD)

The theory for the strong interaction, analogous to QED.

## Quantum electrodynamics (QED)

The theory of the electromagnetic interaction.

## Quark

The smallest known elementary particle that feels the strong force. (See also Particles.)

## Quark-gluon plasma (QGP)

A state of matter in which protons and neutrons break up into their constituent parts. QGP is believed to have existed just after the Big Bang.

## Sextupole

A magnet with six poles, used to apply corrections to particle beams. At the LHC, eight- and ten-pole magnets are also used for this purpose.

## Sigma

A representation of standard deviation — the error margin on a measurement — where 5 sigma is the probability that a measurement is 99.99994% correct.

## Spectrometer

In particle physics, a detector system containing a magnetic field to measure momenta of particles.

## SPS

The Super Proton Synchrotron. An accelerator that provides beams for experiments at CERN, as well as preparing beams for the LHC.

## Standard Model

A collection of theories that embodies all of our current understanding about the behaviour of fundamental particles.

## Superconductivity

A property of some materials, usually at very low temperatures, that allows them to carry electricity without resistance. If you start a current flowing in a superconductor, it will keep flowing forever — as long as you keep it cold enough.

## Supersymmetry

A theory that predicts the existence of heavy “superpartners” to all known particles. It is being tested at the LHC.

## Transfer line

Carries a beam of particles, e.g. protons, from one accelerator to another using magnets to guide the beam.

## TeV

See Electronvolt.

## Trigger

An electronic system for spotting potentially interesting collisions in a particle detector and triggering the detector's read-out system to record the data resulting from the collision.

## Vacuum

A volume of space that is substantively empty of matter, so that gaseous pressure is much less than standard atmospheric pressure.

## WLCG (Worldwide LHC Computing Grid)

The mission of the WLCG is to provide data-storage and analysis infrastructure for the entire high-energy physics community using the LHC.