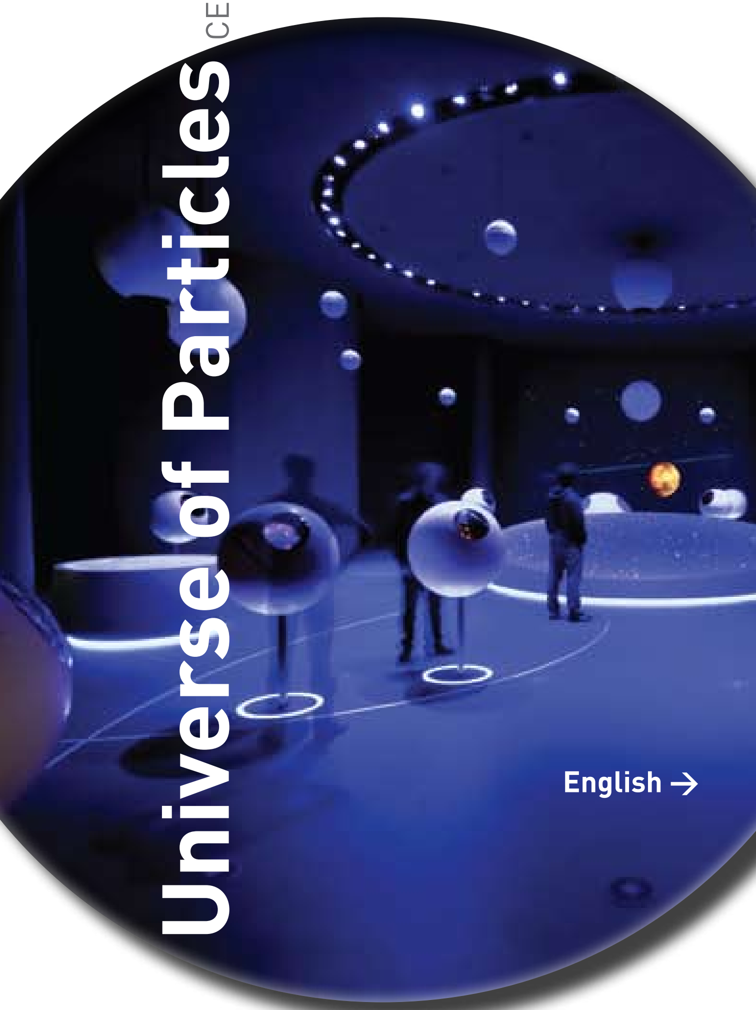
CERN visitor centre

Universe of Particles



English →

The entire Universe is made up of particles.

But where do they come from?
What is the origin of the laws of Nature?

The permanent exhibition **"Universe of Particles"**, installed on the ground floor of the Globe of Science and Innovation, invites you to discover CERN by taking you on a journey all the way back to the Big Bang.

What is the purpose of this research?
How do you accelerate particles?
How do you detect them?
What are today's theories on matter and the Universe?
How does this affect our daily life?

Admission free
Monday to Saturday - 10:00 to 17:00
(with the occasional exception)
www.cern.ch/expoglobe
CERN - Globe of Science and Innovation
385 route de Meyrin – CH 1217 Meyrin
Information: Tel. 022 767 76 76

ROLEX is proud to support the
UNIVERSE OF PARTICLES exhibition at CERN

ROLEX

Foundation for the Globe of Science and Innovation
Fondation pour le Globe de la science et de l'innovation

Six exhibition areas

1. MYSTERIOUS WORLDS

T1: Explore ...

An invitation to find out more about the Universe, from the smallest to the largest scales of space, time and energy.

T2: Mysteries of the universe

Five big questions for the LHC, about the origin of mass, the darkUniverse, antimatter, extra dimensions, and the primordial state of matter.

E1: Fundamental equations

Two formulas are shown: one for the ‘Standard Model’, describing the known laws for particles and fields, and one for ‘string theory’, a theory that may lead the way to the unification of all forces.

E2: Birth of the ‘Higgs’ boson

Scientific papers published in 1964, showing that the ‘Higgs boson’ has more than one inventor.

2. LARGE HADRON COLLIDER (LHC)

T3: LHC interactive table

A large satellite-map of the CERN area invites you to explore CERN’s accelerators and experiments. By pressing the ‘start’ button, you can follow the path taken by the particles from source to collision in the LHC.

T4: LHC and detector engineering

Time-lapse movies show the installation of huge detectors in just a few minutes - instead of years.

E3: The cyclotron - the first circular accelerator
A replica of Ernest Lawrence's cyclotron - the first circular accelerator in 1930.

E4: The LHC hydrogen bottle
The origin of all protons in the LHC

E5: LHC dipole magnet
Cross-section through an LHC dipole magnet

3. DETECTING PARTICLES

T5: How a detector works
This touch ball shows how particles are detected and what measurements are needed for finding new particles like the elusive Higgs boson.

T6: A virtual visit to the four LHC detectors
An interactive tour to the four large LHC detectors, for exploring their complex structure by touching the 'hot spots'.

E6: Antimatter trap
How antiparticles can be stored using oscillating electric fields produced by a 'Paul trap'.

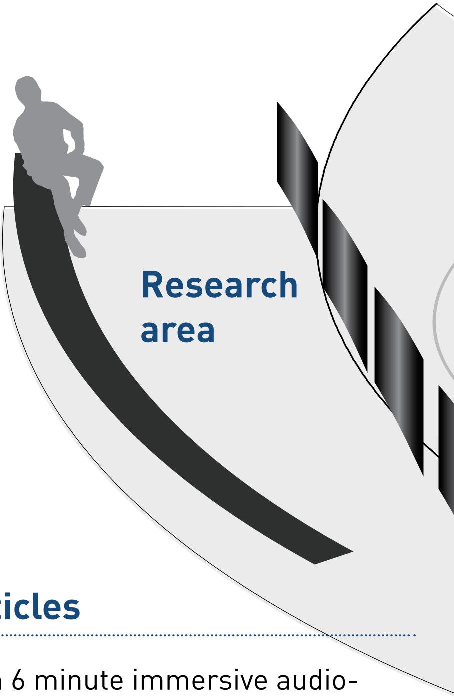
E7: Detector crystals
Six out of the 100 000 lead tungstate ($PbWO_4$) crystals used in LHC detectors.

E8: Tile calorimeter
A real part of a huge detector to measure the energies of 'hadrons' (protons, neutrons, pions).

E9: Silicon pixel detectors
120 pixel detectors, each containing 8192 sensors with the diameter of a human hair.

Central event display

Real events from proton-proton collisions, recorded by the LHC experiments, are displayed on a 6 m diameter screen in the center of the exhibition.

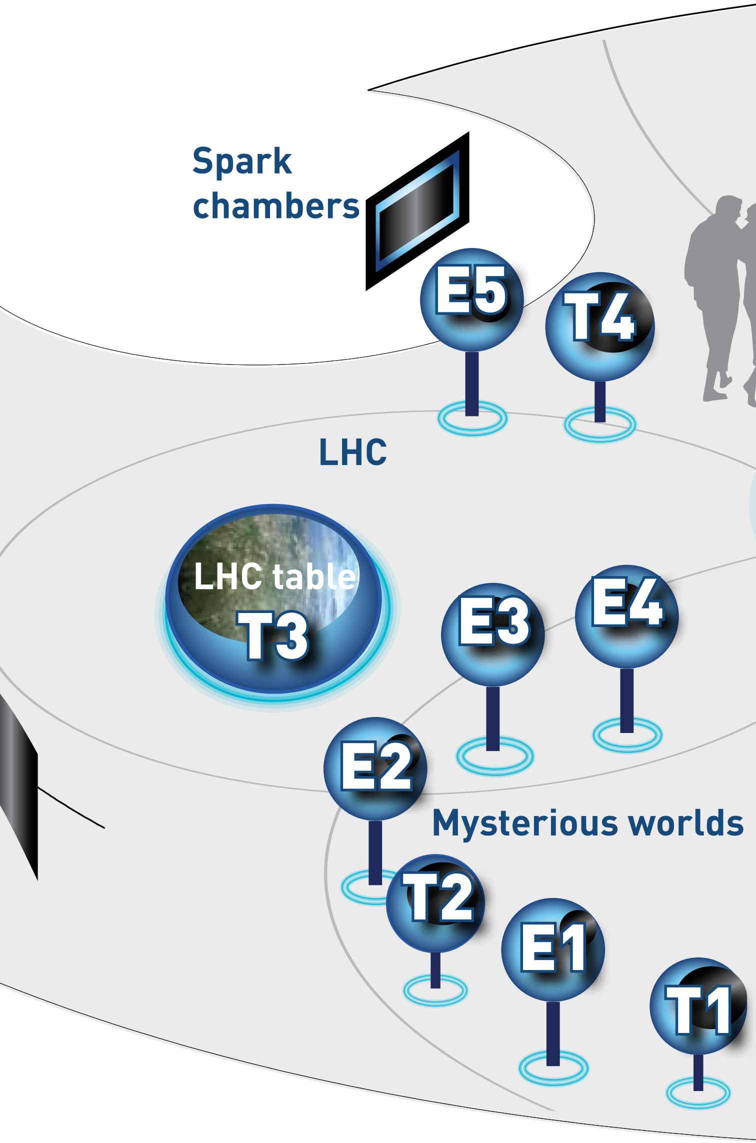


Universe of Particles

Every half hour, a 6 minute immersive audio-visual experience tells the story of our universe - and the mysteries that physicists want to solve with the LHC.

Spark chambers

Cosmic rays from outer space impinge on our atmosphere and create new particles whose tracks are made visible in these detectors.



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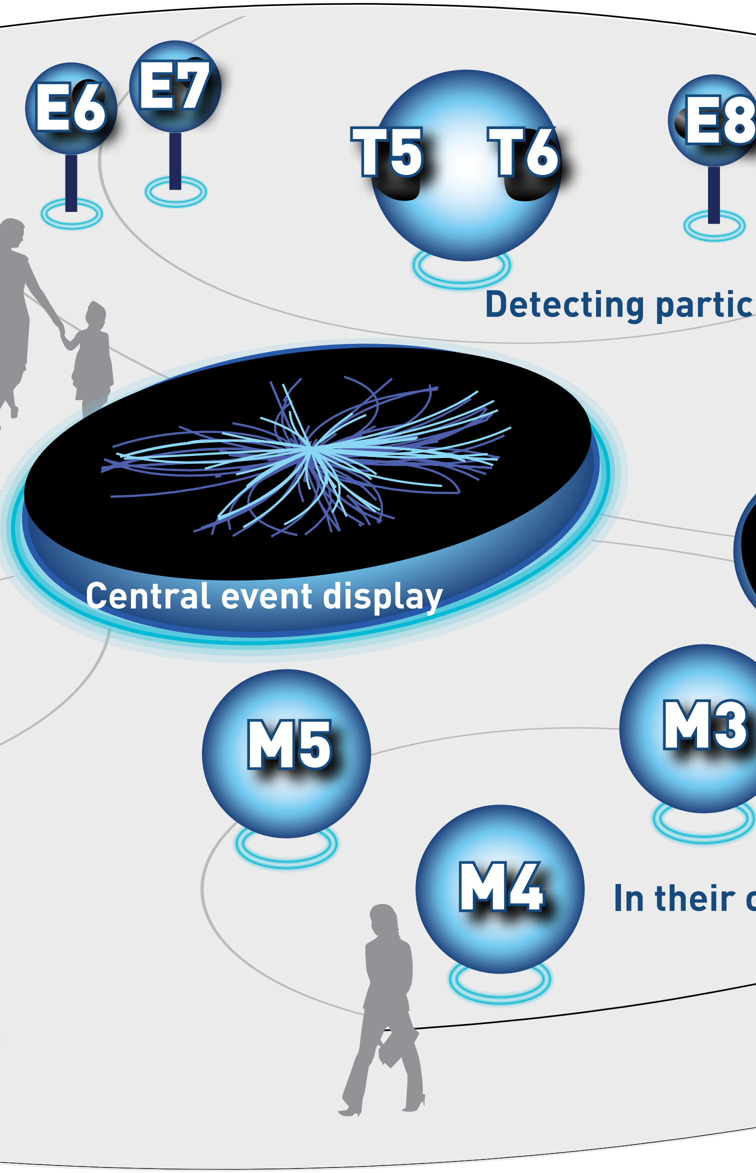
T4
LHC
LHC table
T3
E3
E4
E2
Mysterious worlds
T2
E1
T1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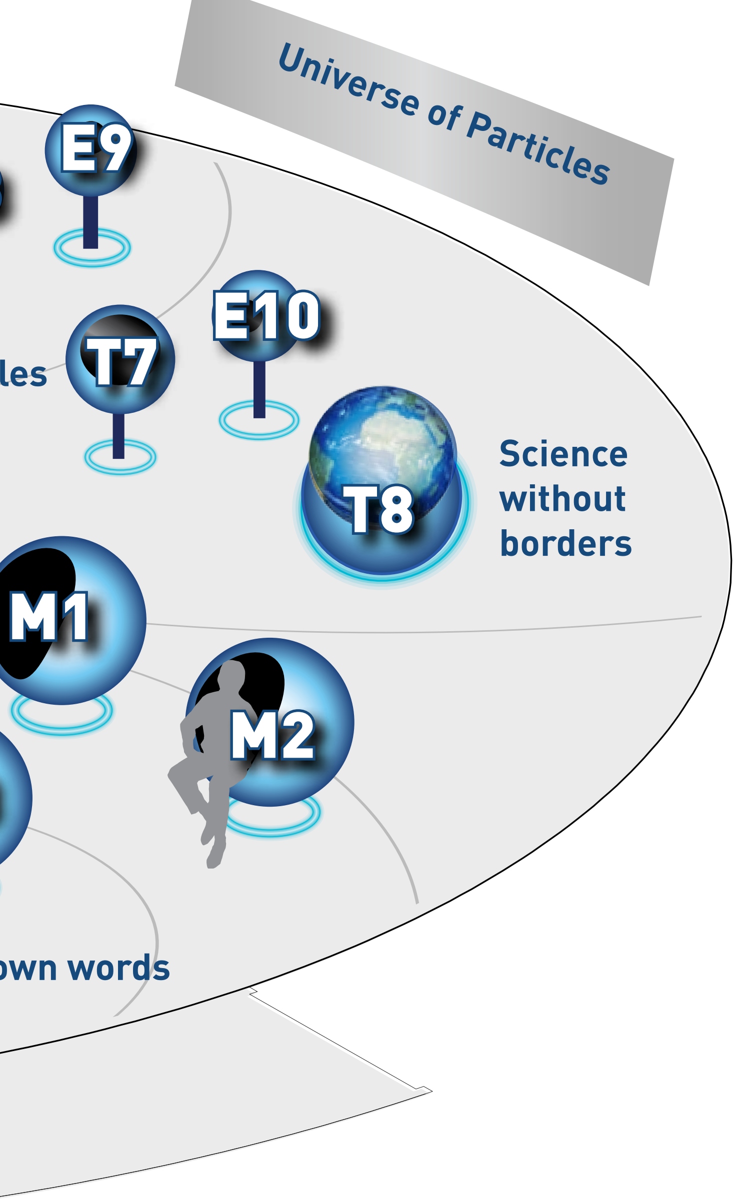
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T8
Science without borders
M1
M2
own words

4. SCIENCE WITHOUT BORDERS

T7: The seeds of technology

Basic research has always been the seed of new technologies. This touch ball shows the basic research leading to modern technologies that are used in our daily life, in computing, communication, electronics, power generation and medicine.

T8: World-Wide CERN

Scientists from more than 100 countries work at CERN. Turn the 'CERN sphere' to find out which countries participate in CERN, the LHC experiments and Grid computing. Press on 'history' to find highlights from more than 50 years of CERN history, or learn about CERN's activities in the education area.

E10: First WWW server

The NeXT workstation used by Tim Berners-Lee as the first 'World Wide Web' server in 1990.

5. IN THEIR OWN WORDS

Scientists tell you in their own language about their favourite mysteries .

M1: Why do particles have mass?

M2: What is the destiny of the Universe?

M3: Are there hidden dimensions?

M4: What are the dark secrets of the Universe?

M5: Why has antimatter disappeared?

6. RESEARCH AREA

The research area offers you an opportunity to follow the actual state of CERN activities:

R1: A question of power

How much power does CERN consume at present?

R2: The CERN accelerator labyrinth

An animation showing how the many CERN accelerators work relentlessly to supply beams to many different experiments.

R3: Live events from LHC

Live display of particle collisions at the LHC, from each of the four large experiments.

R4: The world-wide computing Grid

LHC data are distributed world-wide via the GRID for reconstruction and analysis in computing centres around the world.

Glossary

Accelerator : A machine in which beams of charged particles are accelerated to high energies. Electric fields are used to accelerate the particles. These fields oscillate at radio-frequency (RF) and are produced in RF-cavities. Magnetic fields are used to steer and to focus the particles.

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.

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

Calorimeter : An instrument for measuring the amount of energy carried by a particle. An electromagnetic calorimeter measures the energy of electrons and photons. A hadron calorimeter determines the energy of hadrons (protons, neutrons, pions).

Collider : 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.

Cosmic ray : A high-energy particle that strikes the Earth's atmosphere from space, producing many secondary particles that can be made visible by using detectors such as a spark chamber.

Dark matter : Only 4% of the matter in the Universe is visible. The rest is known as dark matter (26%) and dark energy (70%). Finding out what dark matter consists of is a major question for modern science.

Detector : A device used to measure the momentum and the energy of particles. Some detectors measure the tracks left behind by particles, others measure their energy. In the large detectors at the LHC each layer has a very 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 used in particle physics. One eV is the energy of a particle with elementary charge that has been accelerated in an electric potential of 1 V. The mass of a particle is also expressed in eV by using the relation $E = mc^2$. For example, the mass of the proton is about 938 000 000 eV (938 MeV). The LHC accelerates protons to an energy of 7 000 000 000 000 eV (7 TeV). However, this is only the energy of motion of a flying mosquito.

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.

Grid (also: Worldwide LHC Computing Grid, WLCG). An infrastructure for computing and data-storage for the entire high-energy physics community using the LHC. It presently involves more than 90 institutions in over 30 countries worldwide, and unites the computing power of more than 100,000 state-of-the-art PCs.

Hadron : A subatomic particle that contains quarks and that is held together by the strong force, for example protons and neutrons.

Higgs boson : A particle predicted by theory for explaining how particles acquire their mass.

Kelvin : A unit of temperature, beginning at absolute zero (0 K = -273.15°C). One Kelvin is equal to one degree Celsius.

LHC : The Large Hadron Collider, CERN's biggest accelerator (27 km circumference), accelerating protons to an energy of 7 TeV.

LHC Experiments : The four large experiments studying collisions at the LHC are called ALICE, ATLAS, CMS, and LHCb. There are also three smaller experiments called LHCf, Moedal, and TOTEM.

Muon : A particle similar to the electron, but some 200 times more massive.

Neutrino : A very light and neutral particle that hardly interacts at all. Neutrinos are very common and could hold the answers to many questions in physics.

Quark : A particle that carries a 'strong' charge. There are six types of quarks (up, down, charm, strange, top, bottom). A combination of the lightest two types (up, down) constitute protons (uud) and neutrons (udd).

Particles : There are two groups of elementary particles, quarks and leptons. Both types of particles seem to be point-like (i.e. smaller than 10^{-19} m) and are characterised by few properties like mass, charge, and spin. Protons and neutrons (commonly called 'nucleons'), and hence all nuclei are made of up- and down quarks. The lightest leptons are the electron and its neutrino (produced in particle decays). This first 'family' of four(up, down, electron, electron-neutrino) is replicated two more times, with similar types of quarks and leptons but having much higher mass.
There are also 'exchange particles', called bosons, that carry the forces between particles. Electromagnetism is carried by the 'photon', the weak force by the 'W- and Z-boson', and the strong interaction by the 'gluon'. (See also 'Forces').

PS : The Proton Synchrotron, the oldest accelerator at CERN (built in 1959) and backbone of CERN's accelerator complex.

Quark–gluon plasma (QGP) : A new state of matter in which protons and neutrons break up into their constituent parts, a state that should have existed just after the Big Bang.

Synchrotron : An accelerator in which the magnetic field bending the orbits of the particles increases with the energy of the particles. This makes the particle move on the same circular path.

SPS : The Super Proton Synchrotron. A 7 km diameter 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 at very low temperatures that allows them to carry electricity without resistance.

Supersymmetry : A theory predicting the existence of heavy 'superpartners' to all known particles that may explain the origin of 'dark matter' in the universe.

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.