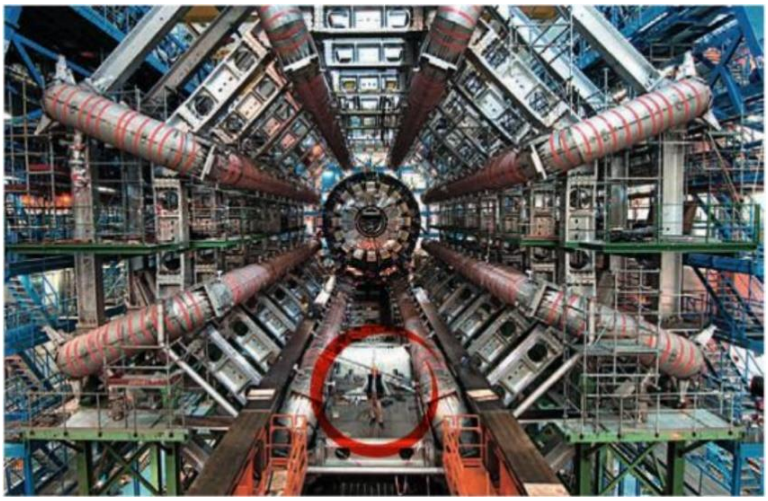
Particle Hunters

Two of the four LHC detectors are general-purpose detectors: they are designed to investigate a great variety of events. The ATLAS (A Toroidal Large hadron collider ApparatuS) and CMS (Compact Muon Solenoid) experiments are both competitors and collaborators.



Credit: CERN

View of ATLAS

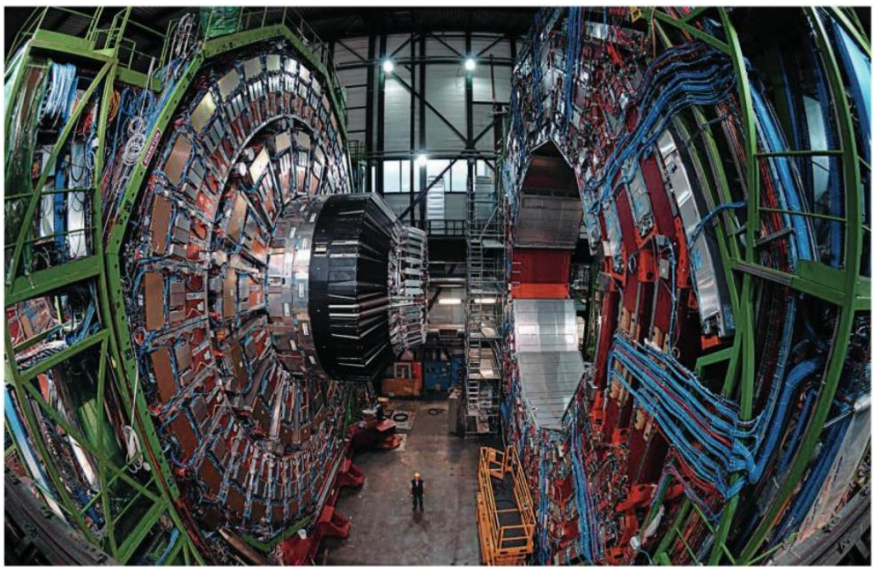
In the photo, you can see the eight large toroidal magnet structures. The central empty space is now filled with detectors, as is the outermost area. The tiny silhouette visible in the forefront gives an idea of the colossal dimensions of ATLAS.

In the LHC family, ATLAS is the big one. As a 46-m long, 25-m high and 25-m wide detector, its dimensions are unrivalled. Its size is due to a gigantic magnet system comprising eight elongated tyre-shaped coils ('toroidal magnets') used to study muons.

These elementary particles are essential, as they can result from the decays of particles that haven't been observed yet but are predicted by theories beyond the Standard Model.

Muons are also found in the name of CMS, a smaller but highly compact detector. This 21-m long, 15-m high and 15-m wide detector is much heavier than ATLAS – 12,500 tonnes (heavier than the Eiffel Tower) versus 7,000. These respectable dimensions are due to the presence of a large iron cylinder containing a coil (or 'solenoid') whose strong magnetic field is again used to measure muons' trajectories.

Inside these volumes, ATLAS and CMS have a concentric structure of nested cylinders. Two calorimeters measure the energies of hadrons, electrons and photons. Progressing towards the centre, you will find the trajectograph, which tracks the charged particles and measures their speed, and, finally, the vertex detector, as close as possible to collision points.



Credit: CERN

Assembly of the CMS detector

This photo shows various elements of the detectors in an assembly hall located on the surface, prior to their installation in the CMS cavern on the LHC ring.

Each detector is made up of millions of separate elements operating in parallel. Picture the kilometres of cables that had to be laid to supply power to these modules and their electronics, or to retrieve their data. The trigger system selects the events of interest (around 1 out of 100,000), which are the only ones to be recorded. Despite this drastic filtering, the LHC produces an immense amount of data: every second, one to two DVDs of data are written on magnetic bands – an admittedly old but very robust and reliable technology.

When the LHC is operating, each experiment implements a complex organisation to track and process the data, from the raw electric signals recorded by detectors to the final lists of identified particles, whose properties (charge, energy, mass, etc.) are used for physics analysis. Between two data-collection periods, the detectors are serviced and repaired. They are also regularly upgraded to adapt to the latest developments of the LHC accelerator. Like the collider, the detectors are expected to operate for more than two decades!

ATLAS and CMS detectors at scale 1!

This photomontage superimposes the ATLAS (red) and CMS (yellow) detectors on a photo of a five-storey high CERN building. Of course, in the LHC tunnel, detectors are not placed on the ground as they are in this image. They are positioned so that the proton beams pass through their centres.

Credit: CERN

Translated from 'Les chasseurs de particules',* Passeport pour les deux infinis, *IN2P3/Dunod, https://pass2i.ijclab.in2p3.fr/ (French); updated with ICHEP2024 conference (https://ichep2024.org) for IPPOG