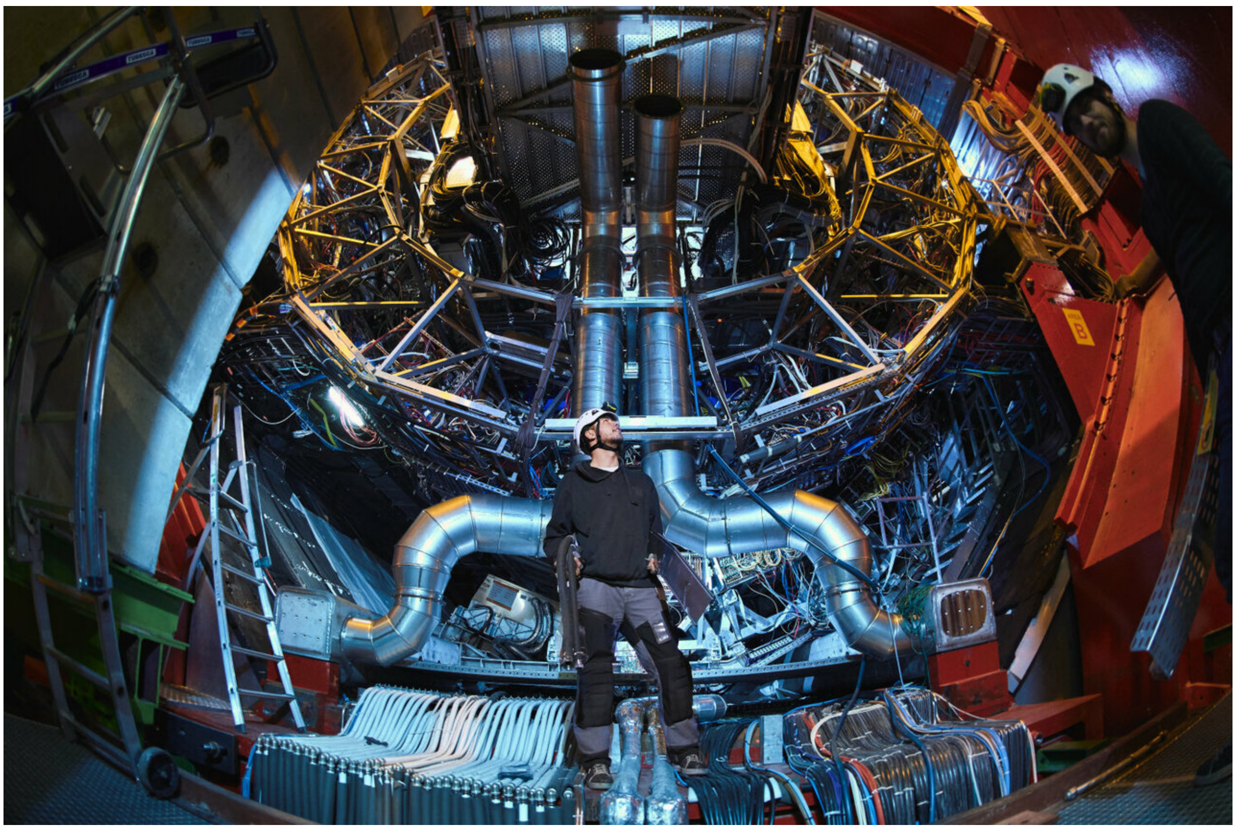
Upgrading ALICE: What's in store for the next two years?

February 12 2019, by Letizia Diamante



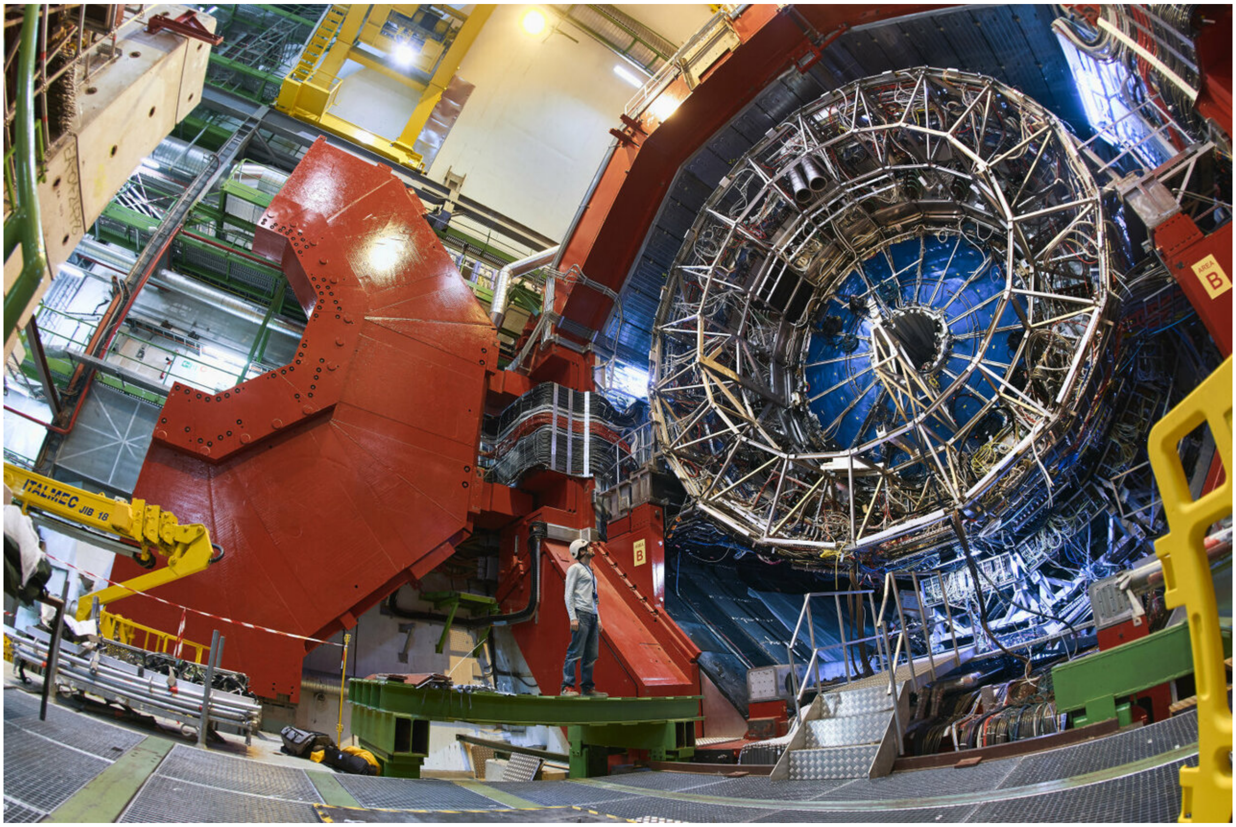
The ALICE team is ready for the challenge of upgrading the detector. Credit: Maximilien Brice, Julien Ordan/CERN

With massive red doors weighing 350 tonnes each, it takes more than uttering "open sesame" to open the ALICE detector. Behind the doors lie the inner workings of a unique detector built to study the conditions of matter moments after the birth of the Universe, conditions which are recreated in the LHC.

When the CERN accelerator complex was switched off in December 2018, scientists and technicians entered the ALICE cavern, 56 metres underground, to open the massive shielding around the magnet and to start work on the detector. This maintenance and upgrade work will last two years, the time CERN has allocated for a technical break called Long Shutdown 2 (LS2). For ALICE, LS2 activities started at a fast pace, with a full programme planned of upgrades or replacements of subdetectors as well as of trigger and data-acquisition systems.

ALICE is dedicated to the study of quark-gluon plasma (QGP), a state of matter that prevailed in the first instants of the Universe. By colliding particles, namely protons and lead nuclei, from the Large Hadron Collider (LHC), ALICE can harvest data at the high-energy frontier.

Increased luminosity, first in 2021 and later in the High-Luminosity LHC (HL-LHC) project, will open up a range of possibilities and challenges for ALICE. An increase in luminosity – a measure of the number of collisions per unit of time – will allow ALICE to study rare phenomena and perform high-precision measurements, shedding light on the thermodynamics, evolution and flow of the QGP, as well as on quark and gluon interactions.

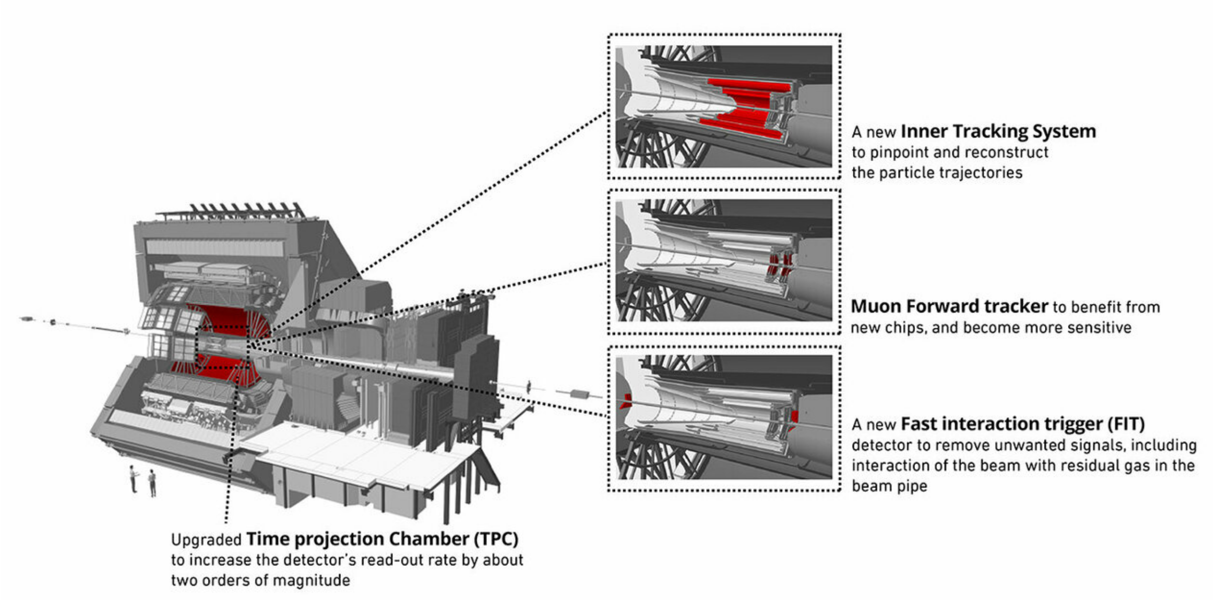


The 16-metre-tall doors of the ALICE experiment magnet, each weighing 350 tonnes, are now open to allow scientists and technicians to work on the detector upgrade. Credit: Julien Marius Ordan/CERN

During this upgrade, a smaller-diameter beam pipe will replace ALICE's existing one. Inside the beam pipe, particles travel at almost the speed of light and smash together inside the core of the detector, generating many new particles. Scientists are interested in determining the position of the interaction point, and reducing the beam pipe's diameter improves this measurement by a factor of three with respect to the present detector. ALICE will also become better at detecting particles with a shorter lifetime, i.e. those decaying closer to the interaction point.

The need for a new beam pipe is linked to the replacement of the inner tracking system (ITS), which surrounds it. The new ITS will be equipped with innovative, compact pixel sensor chips. This tracking system measures the properties of the particles emerging from the collisions, so it must be fast-acting and fine-grained to handle the higher collision rates in the future. The new system will dramatically improve the capacity of the detector to pinpoint and reconstruct the particle trajectories.

The sensor and readout chips built into the same piece of silicon for the new inner tracking system will also be employed in the muon forward tracker (MFT), which tracks muons close to the beam pipe. This promises excellent spatial resolution, making ALICE not only more sensitive to several measurements, but also able to access new ones currently beyond reach.



This diagram of the ALICE detector shows some of the maintenance and upgrade work in store in the coming two years. Credit: CERN

A major upgrade of the ALICE time projection chamber (TPC), an 88-cubic-metre cylinder filled with gas and read-out detectors that follows particles' trajectories in 3-D, is also ongoing. Charged particles spraying out from the collision point ionise the gas along their path, liberating clouds of electrons that drift towards the endplates of the cylinder. These make up a signal that is amplified and then read. The current read-out, based on multi-wire proportional-chamber technology, will not be able to cope with increased interaction rates, so it will be replaced with multi-stage gas electron multiplier (GEM) chambers. This upgrade will increase the read-out rate of the detector by about two orders of magnitude.

In addition, a new fast interaction trigger detector (FIT) will detect particles that scatter with a small angle relative to the beam direction and will replace three current trigger detectors. It will remove unwanted signals, including interactions of the beam with the residual gas in the beam pipe.

Work has begun on the inner sub-detectors of the ALICE experiment ahead of the installation of new equipment. Credit: Maximilien Brice/Julien Marius Ordan/CERN

A factor of 100 gain in statistics

As a consequence of the increased luminosity and interaction rate, a significantly larger amount of data will have to be processed and selected. More powerful electronics, data processing and computing systems have therefore been designed to sustain high throughput and performance. The ALICE collaboration is currently installing a new data centre above ground to improve computing capacity. When the new LHC run starts in 2021, the significantly improved detector will offer a factor of 100 gain in statistics.

When ALICE's magnet doors close again in summer 2020, they will hide an even more powerful instrument, ready to embark on more collisions and more data-taking.

Provided by CERN

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