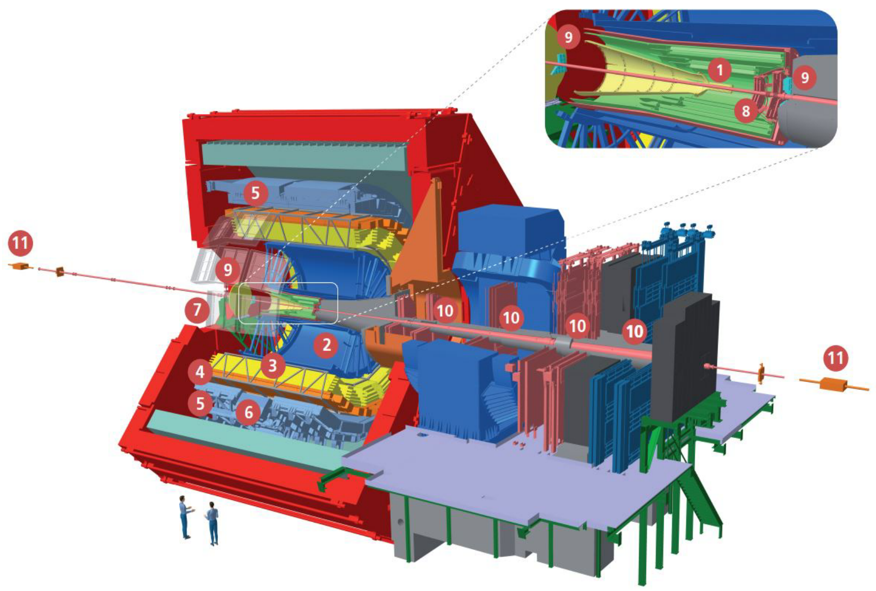
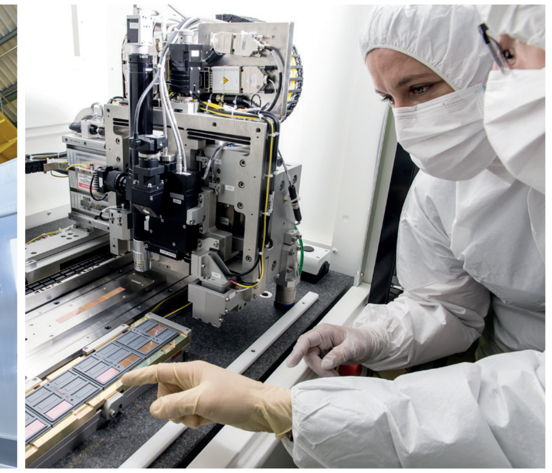
The ALICE Detector

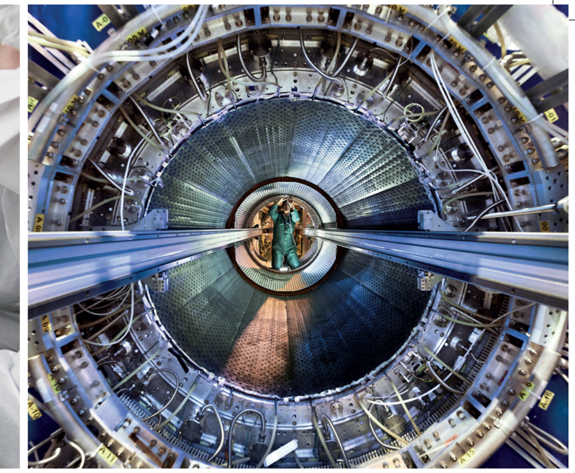


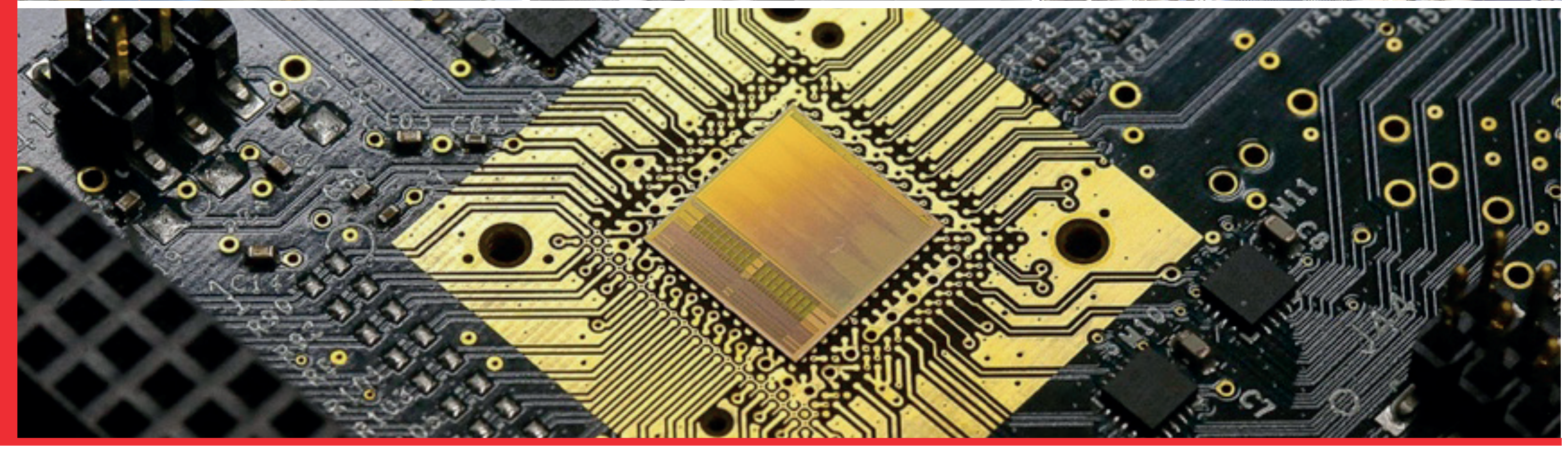
1. **ITS** | Inner Tracking System
2. **TPC** | Time Projection Chamber
3. **TRD** | Transition Radiation Detector
4. **TOF** | Time Of Flight
5. **EMCal** | Electromagnetic Calorimeter
6. **PHOS / CPV** | Photon Spectrometer
7. **HMPID** | High Momentum Particle Identification Detector
8. **MFT** | Muon Forward Tracker
9. **FIT** | Fast Interaction Trigger
10. **Muon Spectrometer**
11. **ZDC** | Zero Degree Calorimeter

Weighing 10 000 tonnes and with a height of 16 m and a length of 26 m, ALICE is a large and complex detector composed of 11 sub-detectors to track and identify the tens of thousands of particles produced in each heavy-ion collision. To record up to 8000 collisions per second, the ALICE detector is based of state-of-the-art technologies:

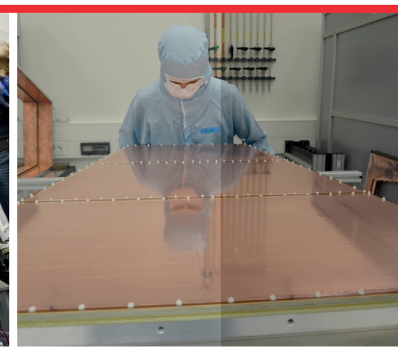
- high precision systems for detecting and tracking the particles;
- ultra miniaturized systems for processing electronic signals;
- a worldwide distribution of computing resources for data analysis (the GRID).

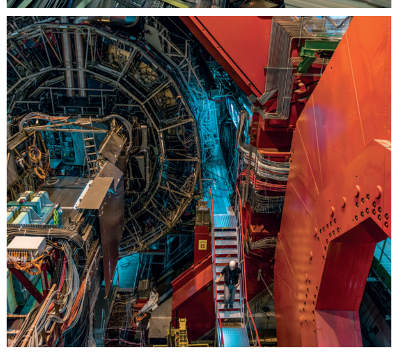




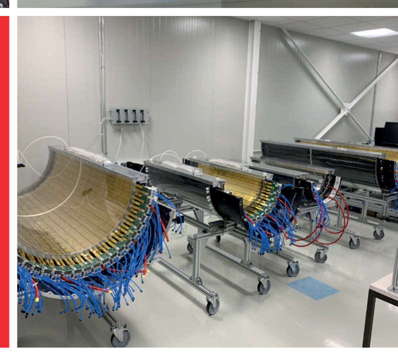


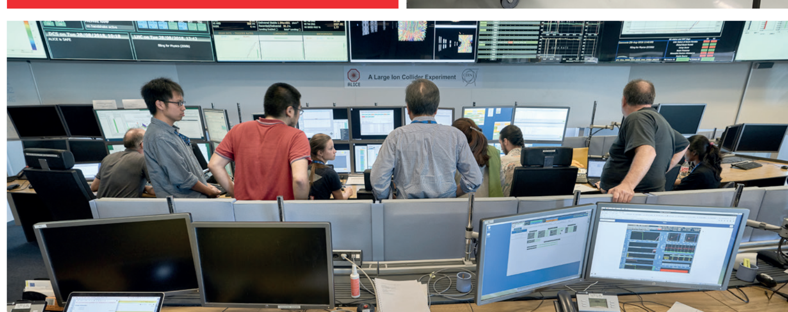
An International Collaboration





ALICE counts more than 2000 collaborators, including around 380 PhD students, from 174 physics institutes in 40 countries across the world. A wide variety of skills are needed to build and operate such a large experiment.





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ALICE

The ALICE Experiment

A journey to the beginning of the Universe...

What happens to matter when it is heated to 100000 times the temperature at the centre of the Sun?

Why do protons and neutrons weigh 100 times more than the quarks they are made of?

Can the quarks inside the protons and neutrons be freed?

ALICE is searching for answers to these questions, using the extraordinary tools provided by the LHC.

CERN was founded in 1954. It has become a prime example of international collaboration, with currently 23 Member States. It sits astride the Franco-Swiss border near Geneva and is the biggest particle physics laboratory in the world.

ALICE

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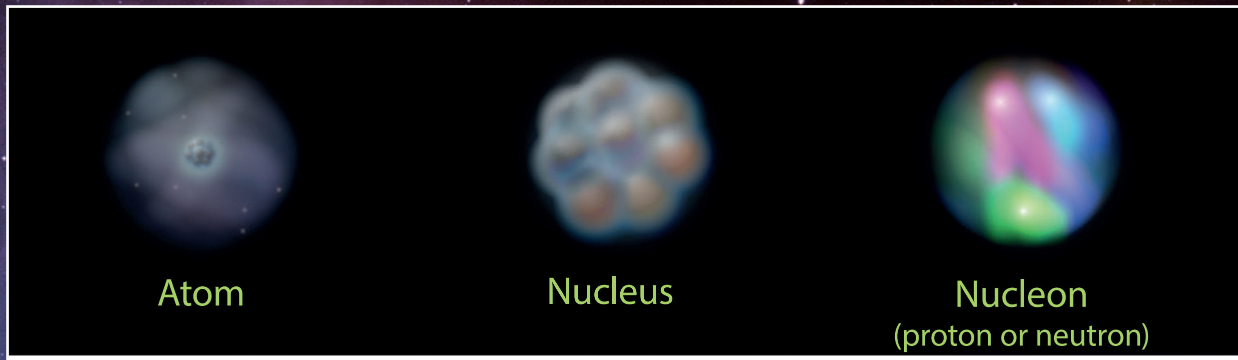

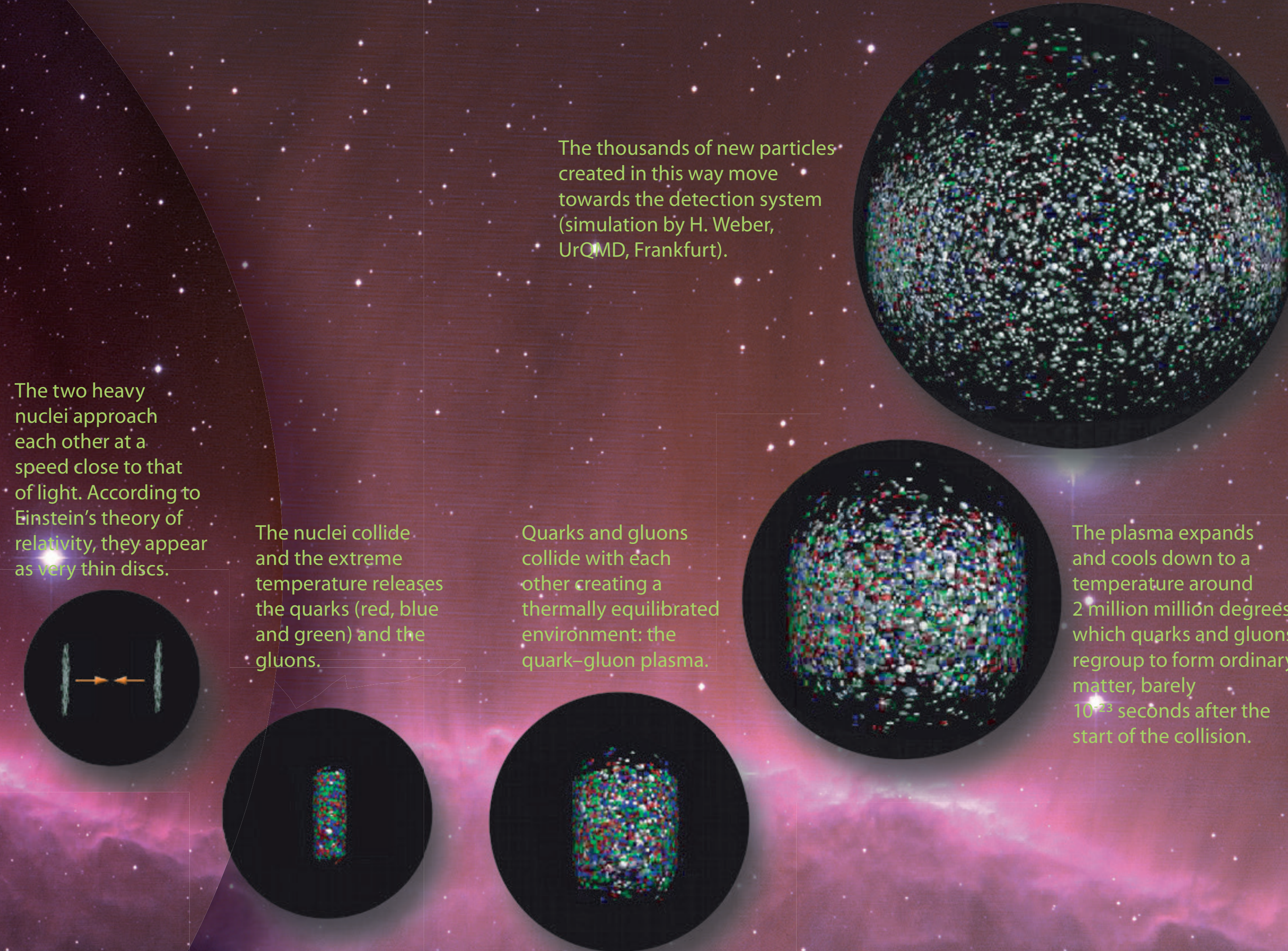

The strong interaction

Ordinary matter is made of atoms, each of which consists of a nucleus surrounded by a cloud of electrons. Nuclei are made of protons and neutrons, which in turn are made of quarks. As far as we know today, the quarks seem to be elementary constituents.

Quarks are bound together into protons and neutrons by a force known as the strong interaction, mediated by the exchange of force-carrier particles called gluons. The strong interaction is also responsible for binding together the protons and neutrons inside the atomic nuclei.

Although much of the physics of strong interaction is today well understood, two very basic issues remain unresolved: the origin of confinement and the mechanism of the generation of mass. Both are thought to arise from the way the properties of the vacuum are modified by the strong interaction.

Confinement

No quark has ever been observed in isolation: the quarks, as well as the gluons, seem to be bound permanently together and confined inside composite particles, such as protons and neutrons. This is known as confinement. The exact mechanism that causes it remains unknown.

Generation of mass

Protons and neutrons are known to be made of three quarks, but by adding together the masses of the three quarks one gets... only about 1% of the proton or neutron mass. Where does the remaining 99% come from?

Is the mechanism that confines quarks inside protons and neutrons also responsible for the generation of most of the mass of ordinary matter?

Free quarks and gluons

The current theory of the strong interaction (called quantum chromodynamics) predicts that at very high temperatures and very high densities, quarks and gluons should no longer be confined inside composite particles. Instead they should exist freely in a state of matter known as quark-gluon plasma.

Such a transition should occur when the temperature exceeds a critical value estimated to be around 2000 billion degrees... about 100 000 times hotter than the core of the Sun! Such temperatures have not existed in Nature since the birth of the Universe. We believe that for a few millionths of a second after the Big Bang the temperature was indeed above the critical value, and the entire Universe was in a quark-gluon plasma state.

Back to the beginning

Can this scenario be studied experimentally? Can such extreme conditions be recreated in the laboratory?

By inducing head-on collisions of heavy nuclei (such as nuclei of lead atoms) accelerated by the LHC to a speed close to the speed of light, we should be able to obtain – albeit over a tiny volume, only about the size of a nucleus, and for a fleetingly short instant – a drop of such primordial matter and observe it as it reverts to ordinary matter through expansion and cooling.

By studying such collisions at the LHC, ALICE should be able to explore deep into the physics of confinement, to probe the properties of the vacuum and the generation of mass in strong interactions, and to get a glimpse of how matter behaved immediately after the Big Bang.