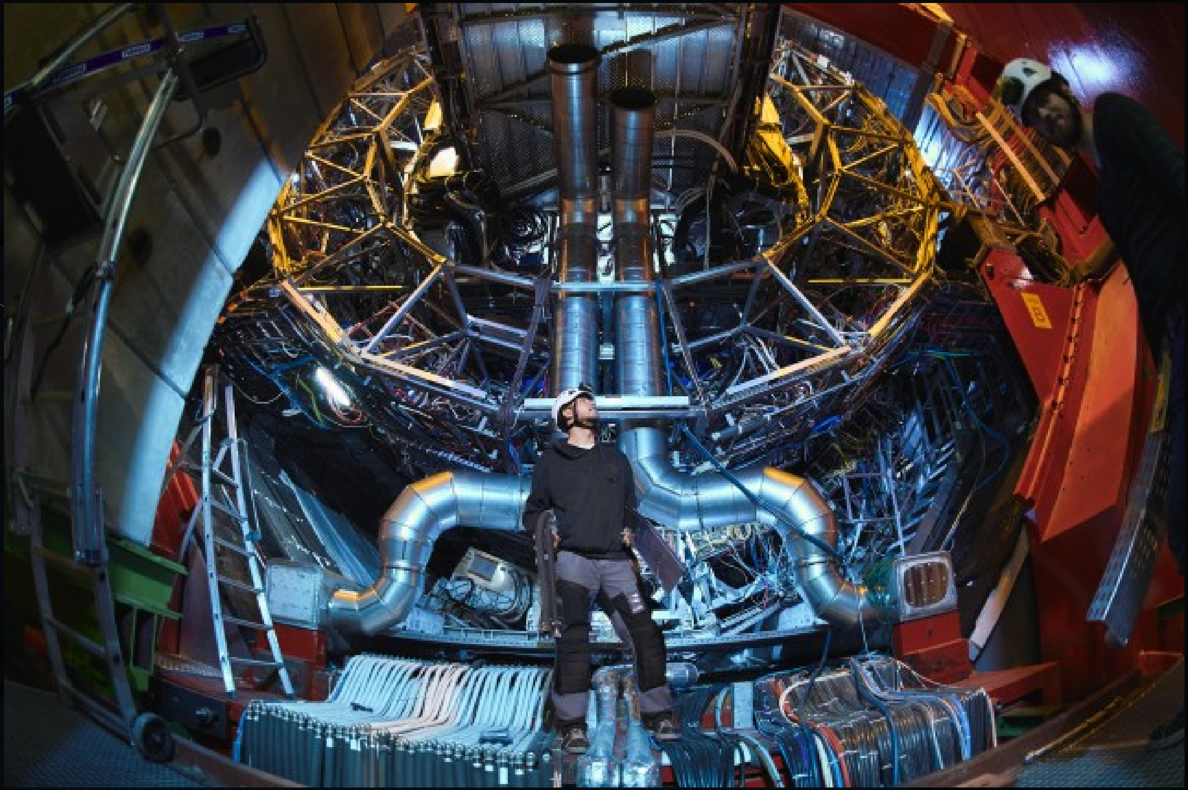

ALICE detector system

ALICE

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Thematics

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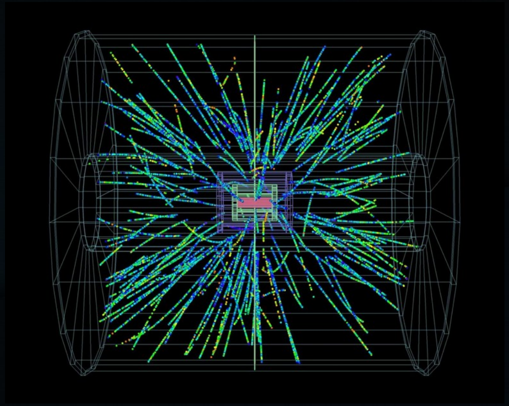
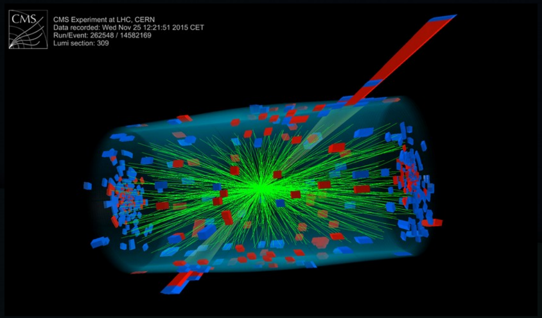
1.) Motivation

- One of four giant experiments with the Large Hadron Collider (LHC)
- Aims: to produce and study the early state of the Universe
  - - High energy
  - - Extrem energy densities
- "quark broth" (quark-gluon plasma)
- Constitutes a new and interdisciplinary approach to investigating matter and its interactions - study of the phase diagram of nuclear matter,

1.) Heavy-ion physics at LHC

- Proton-proton, proton-nucleus and nucleus-nucleus collisionsare foreseen - the initial experimental program at the LHC
- LHC is the only machine which will reach, and even extend, the energy range probed by cosmic ray nucleus–nucleus collisions
- all parameters relevant to the formation of the Quark–Gluon Plasma (QGP)
- → Heavy-ion collisions at the LHC are therefore expected to provide a very different, and significantly better, environment for the study of strongly interacting matter than existing accelerators!



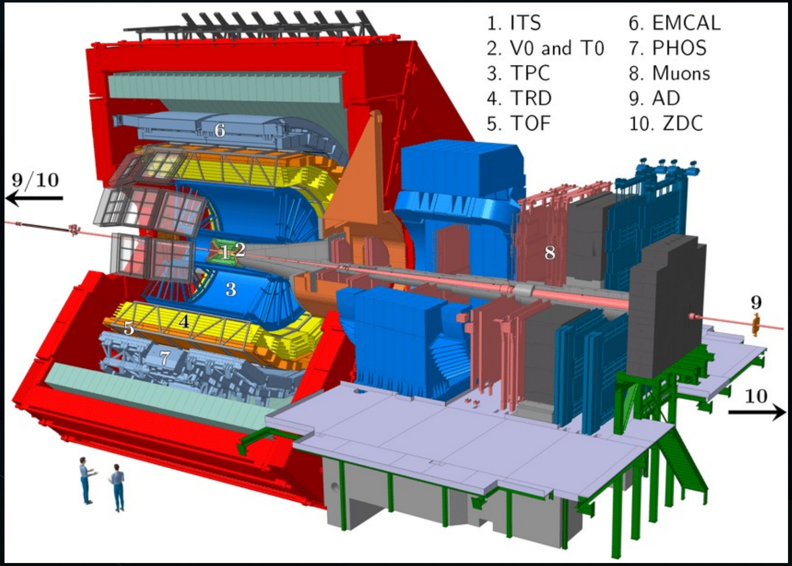


1.) The ALICE experiment

- It is a general-purpose heavy-ion experiment, sensitive to the majority of known observables (including hadrons, electrons, muons and photons), and it will be operational at the start-up of the LHC
- Measure: the flavour content, phase-space distribution – each event
- The experiment is designed to cope with the highest particle multiplicities anticipated
- will study:
    - collisions of lower-mass ions → which are a means of varying the energy density
    - protons (both pp and p–nucleus), which provide reference data for the nucleus–nucleus collisions.

1.) Data about ALICE

- ALICE (Large Ion Impact Experiment)
- weighs ~ 10,000 tons (bigger than Eiffel)
- height 16 m
- length 26 m
- 1,900 physicists, engineers (39 countries)

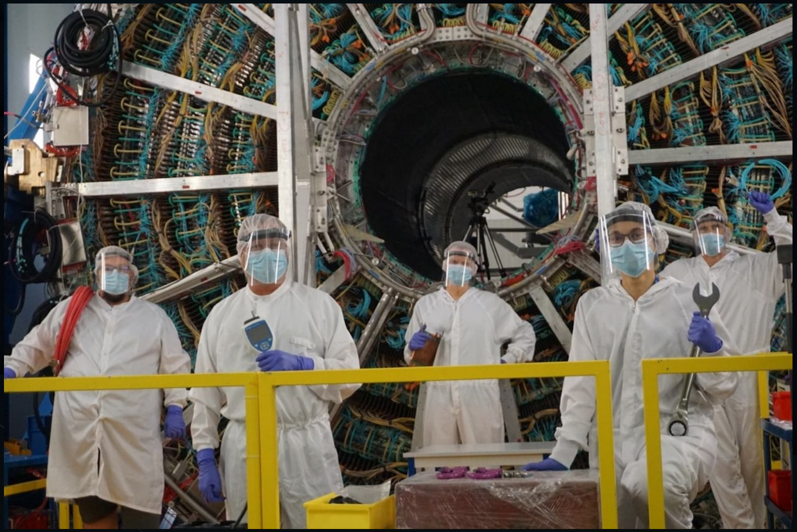


1.) The Hungarian ALICE Group

- Aim: to study the physics of this highly energy-dense, highly interacting material
- 59 Hungarian researchers, engineers have participated in the research (27 are currently active)

1.) Wigner Physics Research Center

- Basic research projekts:
  - Experimental study of quark-gluon plasma formation
  - Correlation and jet structure studies
  - Formation of heavy quarks
  - High energy nuclear effects
  - ...
- Research and development projekts:
  - ALICE TPC detector R&D
  - The LHC Interface Project (LHC_IF)
  - ALICE Detector Data Acquisition, Compression and Transmission System (DAQ)
  - ...



2.) Heavy-ion reactions

- Some observables are needed to characterize the global features of the state created during the collision in order to constrain theoretical models
  - relevant degrees of freedom
  - size
  - lifetime
  - density
  - dynamic evolution
- These observables yield information: the initial conditions, space–time evolution
- Strategy: study a number of these specific signals together with global information about the events, in the same experiment

2.) The signals accessible to detector

- Summarized (below according to the aspect of the collision on which they have a bearing):
  - **Initial Conditions**: global event features measure the number of colliding nucleons → give information on the energy density obtained
  - **Quark-Gluon Plasma**: open charm production will probe the parton kinematics in the very early stage
  - **Phase Transition**: strangeness production is sensitive to the large s-quark density expected from (partial) chiral-symmetry restoration in the plasma
  - **Hadronic Matter**: particle ratios, p_t distributions and resonance line-shape parameters are all sensitive to the dynamic evolution of the hadronic phase

3.) Design and performance

The ALICE detector has been designed according to the following criteria:

- single dedicated heavy-ion detector → at the initial stage of LHC → cover (as completely as possible) the full range of sensitive signatures
- search in an unbiased way for qualitative and quantitative differences: p-p vs nucleus–nucleus collisions
- concentrate on physics at midrapidity
- open geometry will facilitate future modifications and upgrades

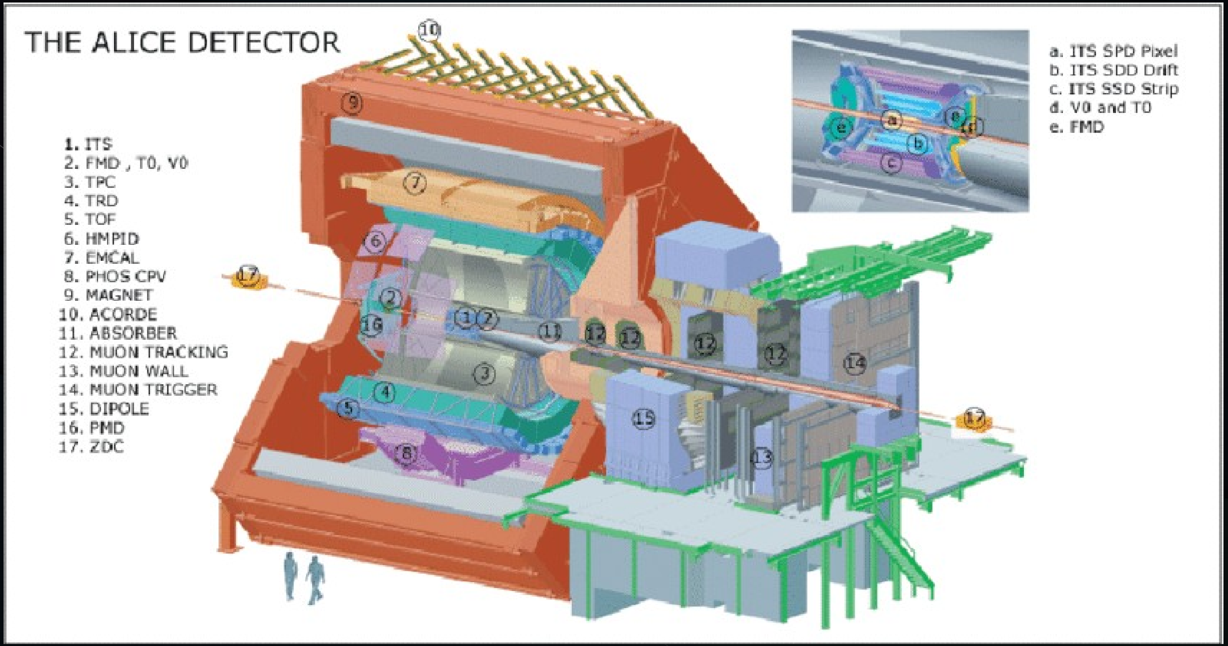
3.) Experimental conditions

- Pb–Pb collisions →will be of the order of 10000 minimum-bias collisions per second → 100 events/sec the most interesting collisions
- The main emphasis will be on <u>data taking</u>!
- **Acceptance**: rapidity acceptance has to be large enough to allow some variables to be studied
- **Tracking and momentum resolution**: one of the greatest challenges for the detector - uses mostly three-dimensional hit information, with many points and a weak magnetic field
- **Particle identification**: the momentum range for particle identification can be limited
- **Photon detection**: the primary goal is the measurement of direct photon spectra (besides measuring π^0 and η spectra)

4.) Detector overview

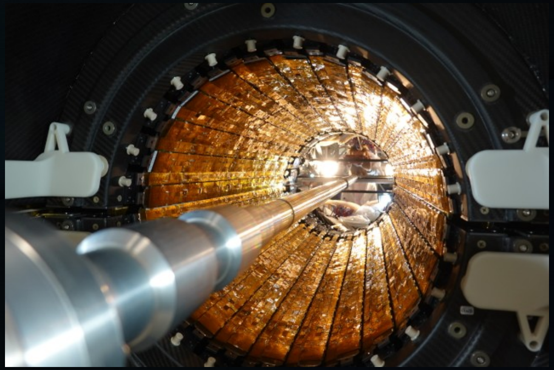
The overall detector layout (from the inside out):

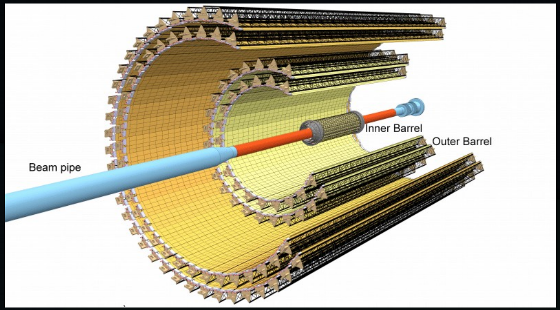
- inner tracking system (**ITS**) - six layers of high-resolution silicon tracking detectors
- cylindrical **TPC**
- large area PID array of **TOF** counters
- two small area single-arm detectors:
  - electromagnetic calorimeter (**PHOS**)
  - array of counters optimized for high-momentum inclusive particle identification (**HMPID**)
- **magnet**



4.) Inner Tracking System (ITS)

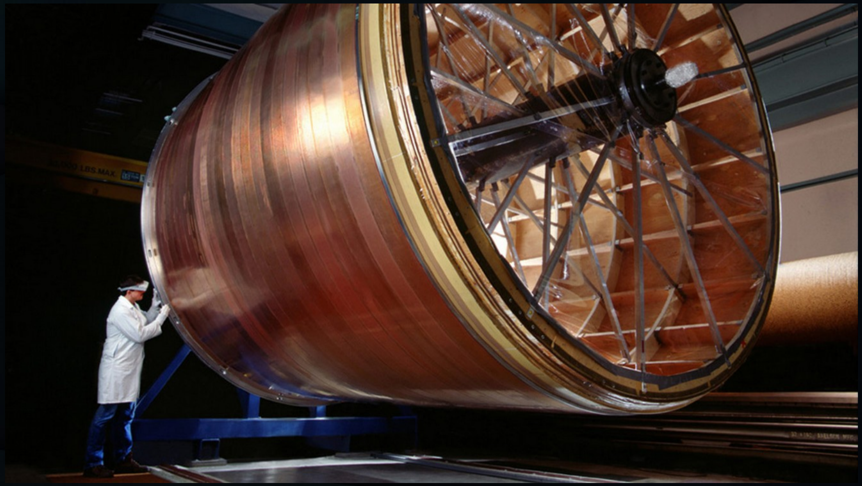
- basic functions of the inner tracker:
  - secondary vertex reconstruction (charm and hyperon decays)
  - particle identification
  - tracking of low-momentum particles
  - improvement of the momentum resolution
- six barrels of high-resolution detectors
- the number of layers and their position has been optimized for efficient pattern recognition and impact parameter resolution
- 4 innermost layers ($r \lesssim 24$ cm): two-dimensional devices e.g. silicon pixel detectors
- 2 outer superlayer ($r = 45$ cm): equipped with double-sided silicon micro-strip detector
- all layers will have analog readout \{2 innermost pixel planes} → independent particle identification





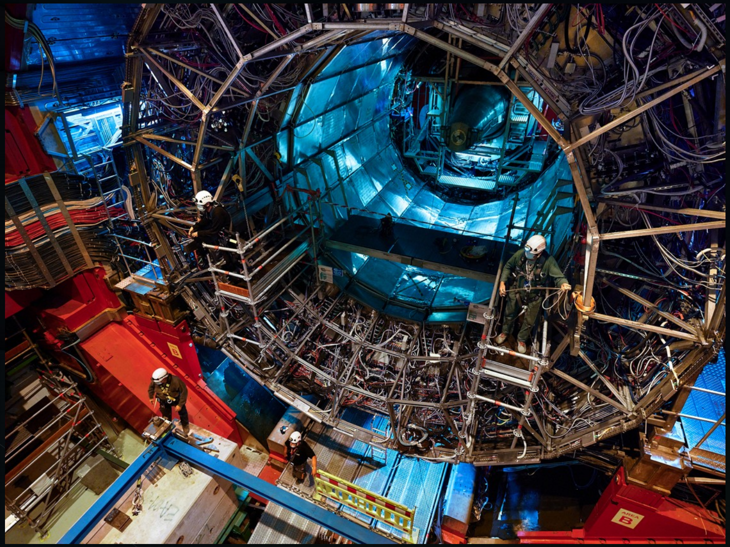
4.) Time Projection Chamber (TPC)

- the main tracking system
- drawbacks concerning speed and data volume → that only a conventional device and redundant tracking can guarantee reliable performance
- inner radius (90 cm) - given by the maximum acceptable hit density
- outer radius (250 cm) - determined by the length required for a dE/dx resolution (< 7%)
- up to ~ 2.5 GeV/c: detector for electron identification



4.) Particle Identification System (PID)

- Two TOF technologies:
  - Pestov spark counters - superior timing resolution, reliable
  - parallel plate chambers (PPC) - smaller acceptance, extend the accessible momentum range into the semi-hard region
- large area particle identification array → a radius of about 3.5 m

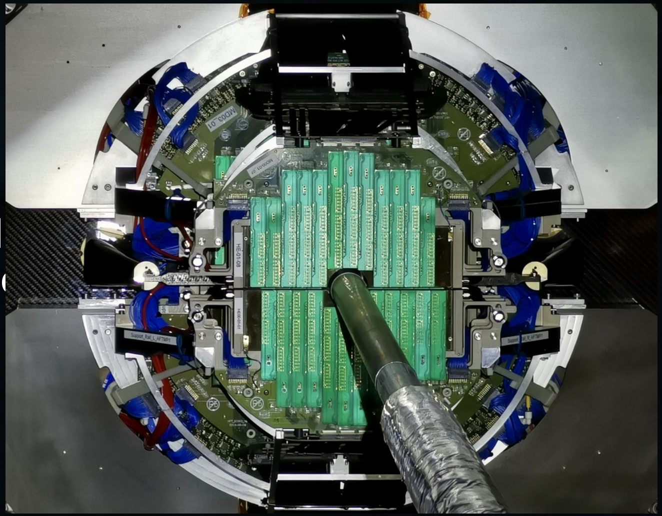


4.) Photon Spectrometer (PHOS)

- Measured: prompt photons, π^0, η
- high-resolution electromagnetic calorimeter
- located: 5 m (from the vertex)
- covers 18 m^2 (with around 36 000 channels)
- built from a material with small Moliére radius
  → reduce: occupancy, sufficient light output
- readout with silicon photodiodes appropriate
- $PbWO_4$ (lead tungstate) scintillating crystal
- cooled to -25 C

4.) Other detector layers

- Forward muon spectrometer:
  - cover the complete spectrum of heavy quark resonances
- Large rapidity detectors:
  - multiplicity counter array close to the interaction regionwill measure the pseudorapidity distribution of charged particl over a large fraction of the phase space
- Significant changes since the LoI
  - Inner tracking system
  - PID array
  - Photon Spectrometer
  - Multiplicity array



4.) Magnet

- large solenoid with a weak field (0.2 Tesla)
- field strength will be allowing full tracking and particle identification (~ 100 MeV/c)
- inner radius → must be large enough to accommodate a single-arm electromagnetic calorimeter for prompt photon detection (~ 5 m from the vertex), because of the particle density

The magnet of the L3 experiment fulfils all these requirements!

5.) Luminosity considerations

- Achievable luminosities at the LHC filled with ions - depend critically: ion accumulation, injection schemes ← have to be optimized taking
- In a number of cases the luminosity is limited by the short beam-lifetime, a consequence of the large cross-sections for electromagnetic processes
- electromagnetic processes are strongly dependent on the ion charge → much larger luminosities can be expected for lighter ions

6.) The Trigger

- The ALICE trigger system operate in both mode:
  - Ion-ion collision:
    - principal function is to enhance centrality
    - a pile-up is not tolerable ← owing to the very large multiplicities of the events
  - p-p collision:
    - the trigger is intended to select minimum bias events
    - up to 20 superimposed events in the TPC can be tolerated
- An interesting further option involving existing detectors would be to have a fast trigger output from PHOS - with a decision time of at most a few hundred nanoseconds → which could participate in the trigger

7.) Data Computing

Requirements:

- designed to be flexible enough to accommodate:
  - the different run periods of the experiment
  - the various types of physics and triggers investigated
- the heavy-ion run will last for a few weeks per year
- require the largest possible bandwidth to permanent storage
- a small fraction of the computing infrastructure will be used for data acquisition → the majority of the computing power will perform data analysis on the data acquired during the heavy-ion run
- the DAQ system an aggregate bandwidth of up to 2.5 GByte/s

8.) Planning and organization

- Schedule:
  - the first physics runs starting in 2004
  - further developed in 2015
  - the ALICE experiment can be done within years
- Cost estimates:
  - total detector cost: 116 - 123 MCHF /in 2003/
- Responsibilities:
  - A preliminary sharing of responsibilities for the different sub-systems of ALICE to the different institutes/national groups
  - e.g.: DAQ → Budapest, CERN, Oslo

Thank you for your attention!