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Physics

K^*(892)$^{\pm}$ resonance with ALICE detector at LHC

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Some quote here

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eg.. PYTHIA

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eg. EPOS

3 A LARGE ION COLLIDER EXPERIMENT AT LHC

ALICE (A Large Ion Colliding Experiment) has been collecting since the beginning of the second phase of the Large Hadron Collider experiments, since 2015 and will continue till the end of the year 2018 for the planned long shutdown. During the first three years of operations LHC provided pp collisions at 0.9, 2.76, 7 and 8 TeV, Pb‚ÄìPb collisions at 2.76A TeV and finally p‚ÄìPb collisions at 5.02 TeV and in the second phase, LHC reached it's designed maximum energies of 13 TeV for pp, and 5.02 TeV for Pb-Pb and p-Pb collisions. The first section of this chapter focuses on the LHC performance during the second phase. A detailed description of the ALICE detector follows. ALICE has been designed and optimized to study the high particle-multiplicity environment of ultra-relativistic heavy-ion collisions and its tracking and particle identification performance in pp and Pb-Pb collisions are discussed. Special attention shall be drawn to the particle identification in the central barrel detectors which ALICE is especially good at.

3.1 the large hadron collider

The Large Hadron Collider (LHC) is the world's largest and most powerful particle accelerator. It was inaugrated on 10 September 2008, and consists of a 27-kilometre ring of superconducting magnets with a number of accelerating structures to boost the energy of the particles along the way. The LHC has a circumference of 27 km. By design, the maximum energies reached in the accelerator are 7 TeV for a beam of protons and 2.76 TeV per nucleon for a beam of lead ions, thus providing collisions at $\sqrt{s}$ = 14 TeV and $\sqrt{s_{NN}}$ = 5.5 TeV, respectively. These are the largest energies ever achieved in particle collision experiments.

Inside the accelerator, two high-energy particle beams travel at close to the speed of light before they are made to collide. The beams travel in opposite directions in separate beam pipes - two tubes kept at ultrahigh vacuum. They are guided around the accelerator ring by a strong magnetic field maintained by superconducting electromagnets. The accelerator bends the beams around the ring, keeping the bunches focused and accelerate them to their collision energy. Finally, bunches are squeezed in order to ensure a high number of collisions per time interval at the collision points, i.e. a high luminosity[1]. A combination of magnetic and electric fields components perform the mentioned tasks. Despite the high luminosity reached, only a very small fraction of the particles from the two bunches collide in a single bunch crossing. The others leave the interaction region essentially uninfluenced, and continue to circulate in the accelerator.

Injection of bunches into the LHC (Figure 1) is preceded by acceleration in the LINAC2, PS booster, PS, and SPS accelerators. The acceleration sequence is slightly different for heavy-ions, in which case bunches pass the LINAC3, LEIR, PS, and SPS accelerators. Several injections to the LHC are needed until all bunches of both beams are filled.

3.1.1 The LHC as a heavy-ion accelerator

Since its early stages, LHC was designed to perform as well as heavy ion collider, in particular to feed ALICE with data, although also CMS and ATLAS included the study of ion collisions with similar luminosities in their physics program.[2]
The source of Pb ions is a 3 cm lead cylinder heated to about 500 C. This vaporises a small amount of atoms, that once partially ionised by strong electrical fields are accelerated in a linear device to strip the remaining electrons to create $^{208}\mathrm{Pb}^{82+}$ ions. These ions are then injected and accumulated in Low Energy Ion Ring (LEIR) and then sent to the Proton Synchrotron (PS). Further on, they follow the same injection procedure as protons. The ions can reach a centre of mass energy of 5.5 TeV/ nucleon or a total centre of mass energy of 1.15 PeV with the nominal magnetic field of 8.33 T in the dipole magnets.

1 For a particle accelerator experiment, the luminosity is defined by: $\mathcal{L} = fnN^2/A$ with n number of bunches in both beams, N number of particles per bunch, cross-sectional area A of the beams that overlap completely, and revolution frequency f. The frequency of interactions (or in general of a given process) can be calculated from the corresponding cross-section σ and the luminosity: $dN/dt = \mathcal{L}\sigma$.

2 LHCb did not participate in the Pb-Pb run in 2010 and 2011.

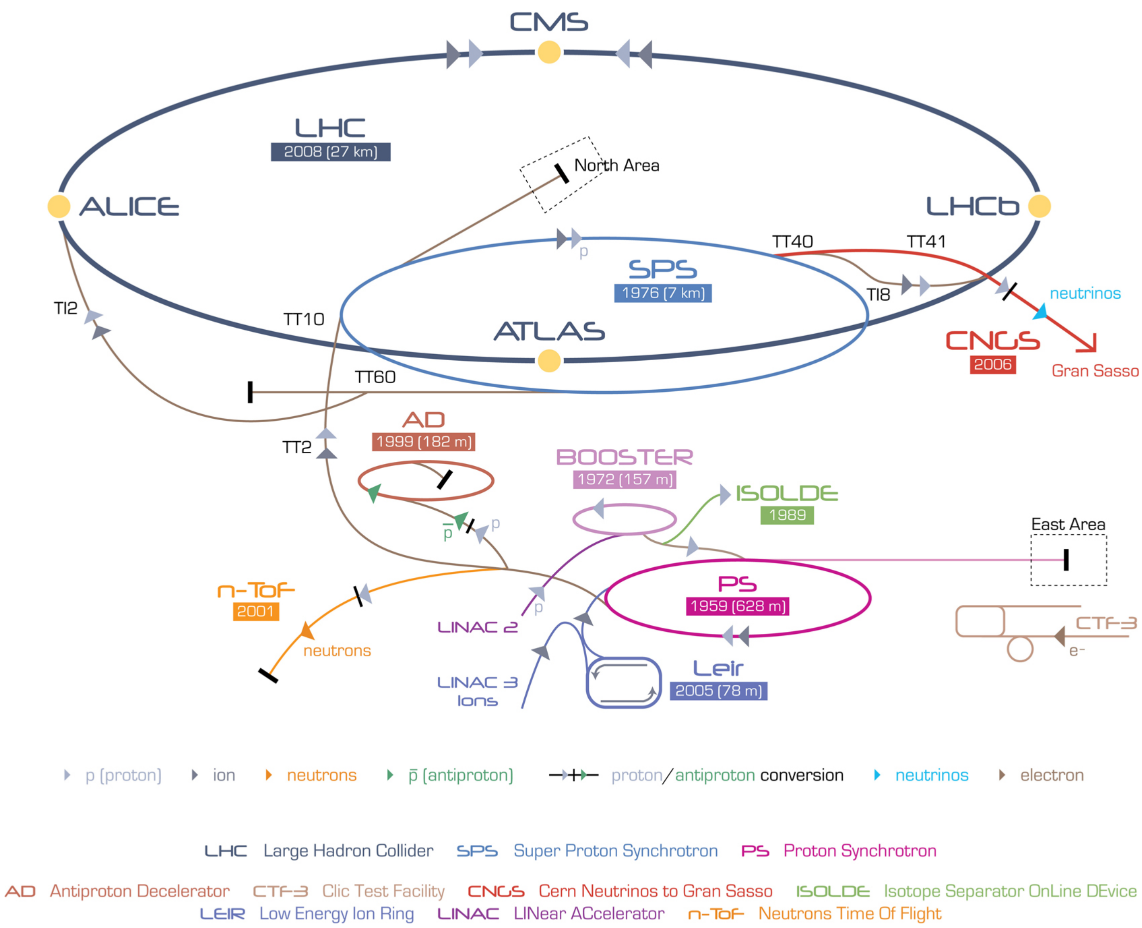

Figure 1: The CERN accelerator complex. [?]

3.2 the alice experiment

ALICE (A Large Ion Collider Experiment) is a general-purpose, heavy-ion detector at the CERN, LHC which focuses on Quantum Chromodynamics, the strong-interaction sector of the Standard Model. It has been designed to study the physics of strongly interacting matter and the quark-gluon plasma at extreme values of energy density and temperature in nucleus-nucleus collisions. ALICE allows for a comprehensive study of hadrons, electrons, muons, and photons produced in the collision of heavy nuclei (Pb-Pb), up to the highest multiplicities at the LHC. The physics programme also includes analysing proton-proton and proton-nucleus collisions to address various QCD topics.

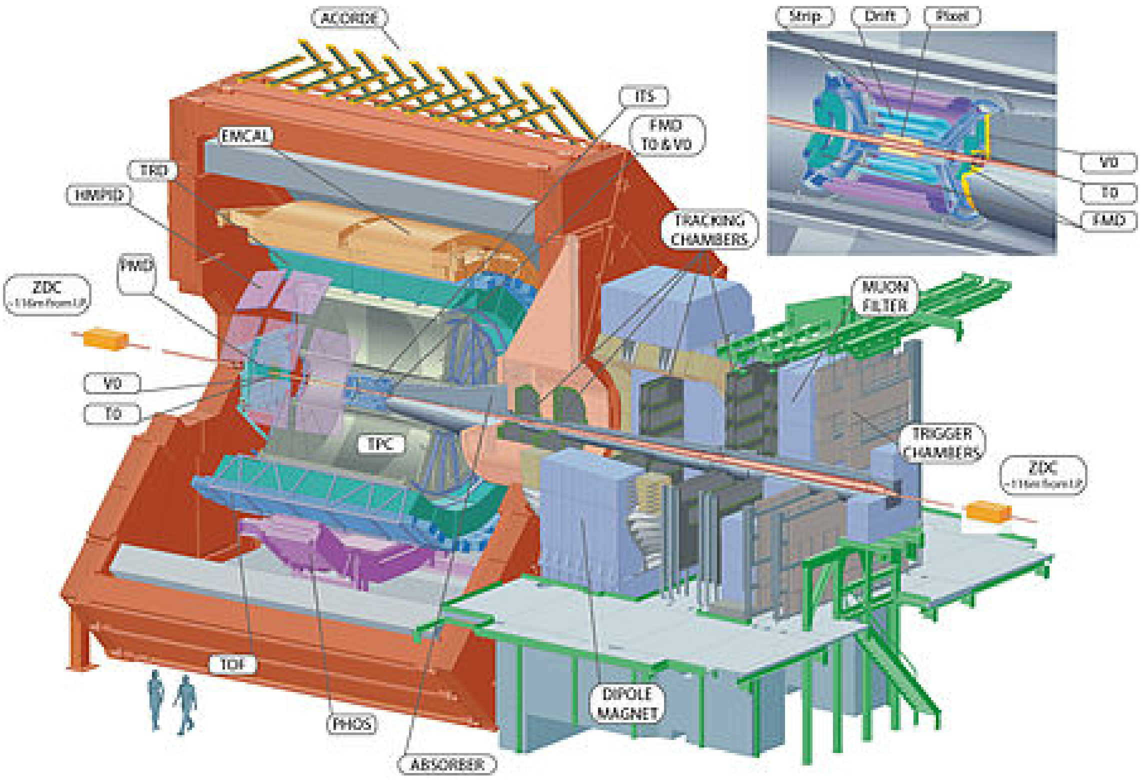

Figure 2: The ALICE detector

3.2.1 The ALICE detector

A Large Ion Colliding Experiment is an experiment whose main focus is studying the Quark Gluon Plasma (QGP) formed in the heavy-ion collisions which is mainly governed by the strong nuclear force. The detector, located at the interaction point 2 along the LHC ring, has been designed to cope with a high particle multiplicity environment and to provide unique particle identification (PID) performance that allow a comprehensive study of hadrons, electrons, muons, and photons produced in the collision, down to very low transverse momentum (0.1 GeV/c). Figure 3 shows the ALICE detector schema and Figure **??** shows the cross section of the central barrel.

The central barrel of the detector is enclosed in L3 solenoid magnet which provides a 0.5 T magnetic field, and is followed by a forward muon spectrometer which has its own dipole magnet providing a field of 0.67 T. The central barrel consists of, going from beam pipe outwards, a six layer Inner Tracking System (ITS) that provides precise tracking and vertex reconstruction, a large volume Time Projection Chamber (TPC) which is responsible for global track-

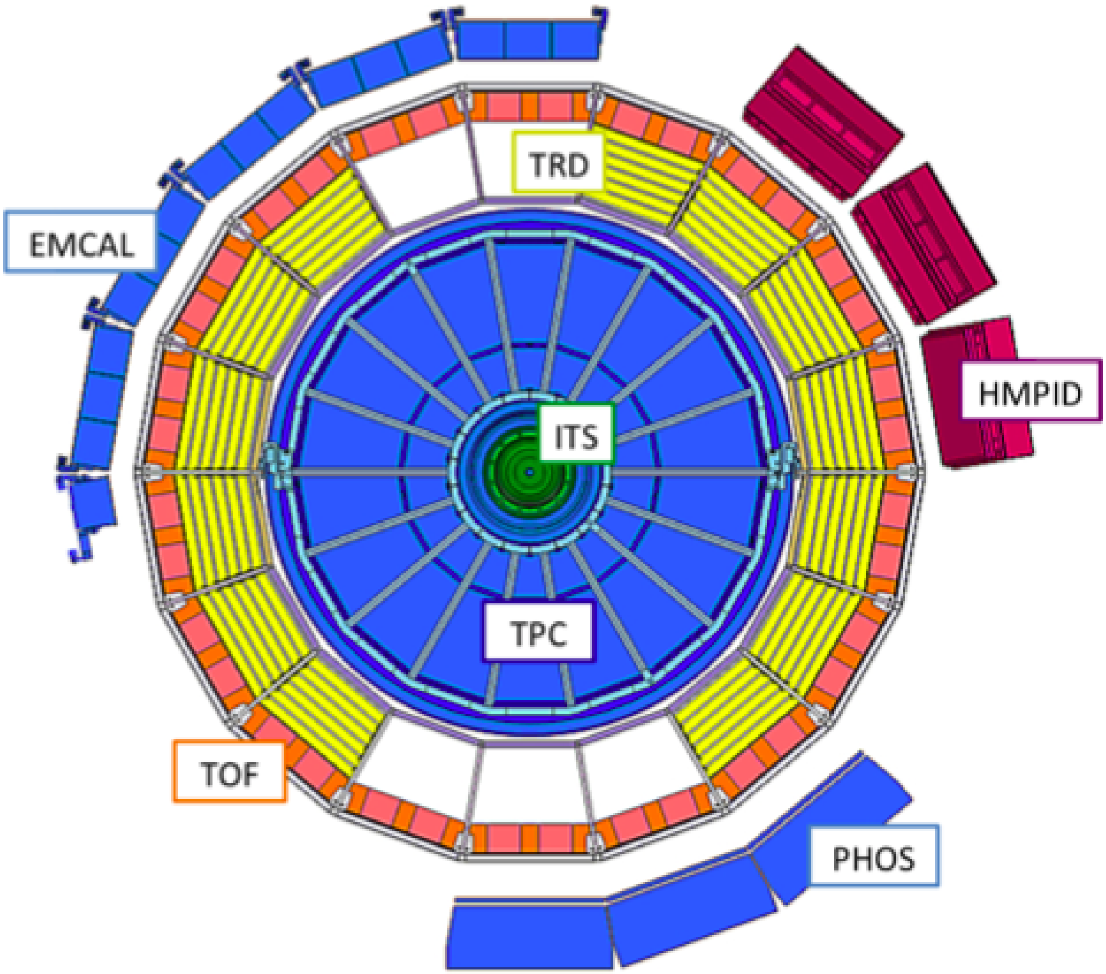

Figure 3: The ALICE detector

ing and particle identification (PID) through the measurement of specific energy loss in a gas, a Transition Radiation Detector (TRD) allowing for identification of electrons and the outermost of the central barrel is a Time of Flight detector (TOF) which allows for identification of charged hadrons. Together, all of these systems in the central barrel cover a mid rapidity region $|\eta| < 0.9$ and azimuthal range of 2π.

Besides the aforementioned detectors, the following detectors located inside the L3 magnet provide limited acceptance, outside the TOF:

- **HMPID**: High Momemntum Particle Identification detector is a dedicated detector for inclusive measurements of identified hadrons at p_T>1 GeV/c. It has been designed as a single-arm array with an acceptance of 5% of the central barrel phase space with the aim of enhancing the PID capability of ALICE by enabling identification of charged hadrons beyond the momentum interval attainable through energy-loss (in ITS and TPC) and time-of-flight measurements (in TOF). Identification of light nuclei and anti-nuclei (d, t, ^{3}He, α) at high transverse momenta in the central rapidity region can also be performed with the HMPID.

- **EMCAL**: The aim of ElectroMagnetic Calorimeter is to enable ALICE to explore in detail the physics of jet quenching (interaction of energetic partons with dense matter) over the large kinematic range accessible in heavy-ion collisions at the LHC. The EMCal is a large Pb-scintillator sampling calorimeter with cylindrical geometry, located adjacent to the ALICE magnet coil at a radius of ~ 4.5 metres from the beam line. It covers $|\eta| \leqslant 0.7$ and $\Delta\phi = 107°$, and is positioned approximately opposite in azimuth to the high-precision ALICE Photon-Spectrometer (PHOS) calorimeter.

- **PHOS**: Photon Spectrometer— details coming.

3.2.2 Data Acquisition (DAQ) and Trigger systems

3.2.3 Data flow: from the Online to the Offline

3.2.4 ALICE Offline software framework

3.2.5 Event reconstruction

3.2.6 Particle identification with the TPC

3.2.7 Centrality Determination?

Depends if we do the PbPb analysis or the high multiplicity analysis for the $K^{*\pm}$

4 K^{*0} AND $K^{*\pm}$ RESONANCE RECONSTRUCTION IN PP COLLISIONS

Short lived resonances are good probes to study the properties of strongly interacting matter produced in high energy heavy ion collisions.

4.1 signal extraction

We describe how hadronic resonances are usually reconstructed from the raw data

4.1.1 Uncorrelated background estimate

Description of event mixing, like-sign and rotating background

4.2 $k^{*\pm}$ mass determination

$K^{*\pm}$ mass has been extracted using the following procedure.

4.2.1 Systematic uncertainty on mass estimation

5 MEASUREMENT OF $K^{*\pm}$ PRODUCTION IN PP COLLISIONS

$K^{*\pm}$ is a resonance particle with a small lifetime (~ 4 fm/c), comparable to that of the fireball which is produced during the heavy ion collision. Due to its short lifetime, it can be used to study the re-scattering and regeneration effects. $K^{*\pm}$ can provide the information regarding strangeness enhancement as it contains a strange quark. Measurements of $K^{*\pm}$ in pp collisions can be used as a baseline to study the Pb–Pb collisions at the LHC energy and to provide a reference for tuning event generators.

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Comparison of K^{*0} and $K^{*\pm}$ spectra and efficiencies

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