ALICE

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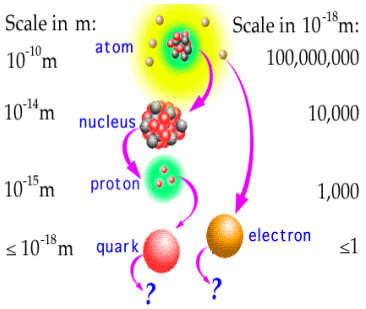
Introduction

- ALICE is one of the experiments set to run at the Large Hadron Collider accelerator at CERN
- ALICE is the only one of these experiments purpose built to explore the properties of a new state of matter – the Quark Gluon Plasma

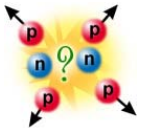
What is matter?

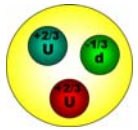
- All matter is made up of fundamental particles
- The nucleus of an atom is made of protons and neutrons which in turn are made of quarks



The Nucleus

- Because the nucleus contains charged particles with a total positive charge it should be unstable and explode due to electromagnetic repulsion
- The same is true for the proton as it contains charged quarks and has a charge of +1 overall



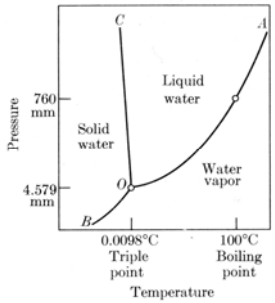


The Strong Interaction

- There is another force holding the nucleus and the proton together – the strong force
- The strong force binds the protons in the nucleus and the quarks in the proton
- It is this interaction which we study using the ALICE detector

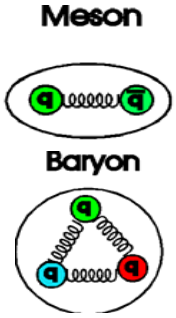
Phases of matter

- Ordinary matter can exist in different phases under different conditions e.g. varying temperature and pressure – represented in a phase diagram
- But can nuclear matter also exist in different phases?



The Strong Interaction Again

- One of the unique features of the strong interaction is that quarks are always bound e.g. in a proton or a neutron
- Unlike the electromagnetic interaction (where free charges e.g. electrons are seen) a free quark has never been observed



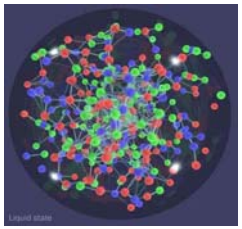
- But are quarks bound under all conditions?

Proton Mass

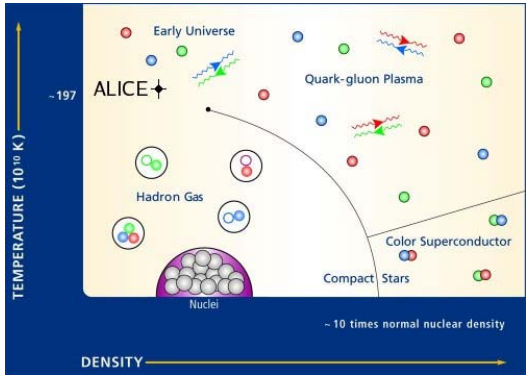
- Another strange thing about hadrons - the masses of the individual quarks are much smaller than the total mass of the hadron
- E.g the proton: u + u + d = proton
  mass: 0.003 + 0.003 + 0.006 ≠ 0.938
- Over 98% of the mass we see around is created by the strong interaction!

Quark Gluon Plasma

- We want to know what happens to quarks (and the strong interaction) when they are exposed to conditions of high temperature and density – like those shortly after the big bang
- The quarks and gluons become deconfined – they behave as free particles and their masses drop to their intrinsic values

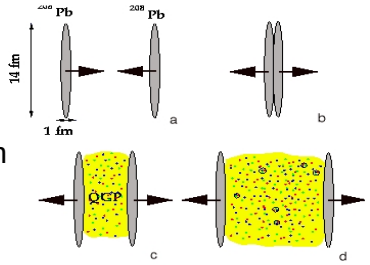


Nuclear Matter Phase Diagram



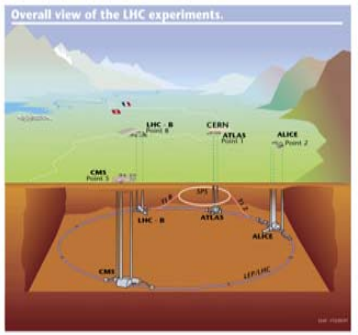
Creating the QGP

- Two heavy ions (Lead atoms stripped of all their electrons) are collided at high energy to create extremely high densities
- The temperature reaches 10^{12} Kelvin – 10,000 times hotter than the centre of the sun



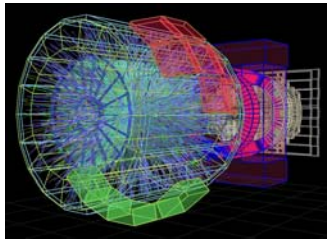
ALICE at the LHC

- The LHC is the highest energy collider ever built
- There are 4 experiments set to run at the LHC – ALICE is the dedicated heavy ion detector



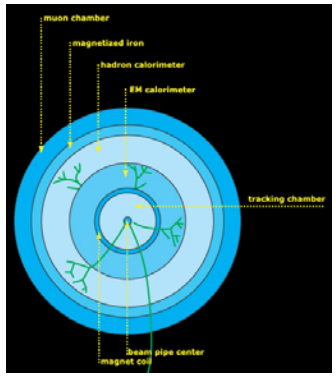
ALICE collisions

- ALICE studies the QGP by detecting particles resulting from the ion collisions
- ALICE also looks at proton-proton collisions as a reference to compare results from QGP creating collisions with “ordinary” particle collision



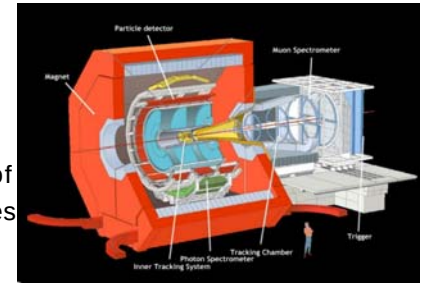
Particle Detectors

- Particle detectors are comprised of many sub-detectors – each to identify different kinds of particles. There is also a magnetic to separate the positive and negatively charged particles



ALICE detector

- ALICE Consists of sub-detectors in a magnetic field of 0.5 Tesla, 10,000 times as strong as the Earth's field
- The main sub-detectors are used to track and identify the thousands of charged particles produced per collision

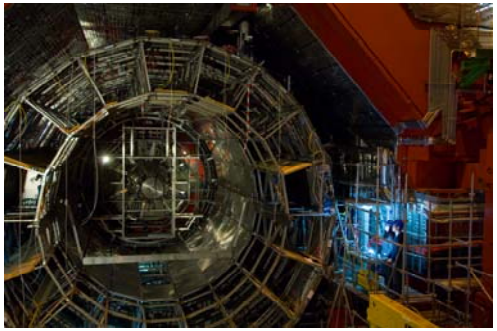


ALICE detector

- What it really looks like!

ALICE detector

- To give an idea of scale



ALICE Computing

- Computing and storage requirements are large.
- 1.2Gb of data stored per second - equivalent to a DVD film every 6 seconds.
- If stored on CDs, stack of CDs would be about a mile high.

All this detector information must be stored

Summary

- Normal nuclear matter is made of quarks, which are always confined (e.g in a proton)
- At sufficiently high temperature and density, there is a phase transition to a state in which quarks are free - the quark-gluon plasma.
- This state is studied at the ALICE experiment by colliding lead nuclei at high energy and measuring the particles emitted.
- Study of this should help us understand the strong interaction.

Lead-Lead Collision at Alice