

Quark gluon plasma

Heavy ion collisions at ultra-relativistic energies are expected to offer, in the laboratory, the conditions suitable for a nuclear phase transition, from a hadronic to a partonic state. At sufficiently high temperatures and densities, quarks and gluons are deconfined and this particular state, called Quark Gluon Plasma (QGP), is supposed to be the state of the Universe a few fractions of second after the Big Bang.

The experimental search of the quark gluon plasma has really started in the eighties in the frame of challenging heavy ion programs at CERN (Conseil Européen pour la Recherche Nucléaire) in Europe and at BNL (Brookhaven National Laboratory) in the United States. Since the middle of the nineties, Subatech participates to these programs and more specifically to the PHENIX and STAR experiments at the RHIC collider in Brookhaven (USA) and to the ALICE experiment at the LHC collider at CERN (Geneva).

Starting operation for the first time in 2000, RHIC is the most powerful heavy ion collider in the world, until the LHC starts in 2008 with energies 30 times. The signatures of the plasma formation are investigated via different observables in adequacy with the instrumental performances of the detectors. But globally, the approaches and methods are almost always the same : an observable is measured in collisions offering the optimal conditions for the QGP creation, with the heaviest ions and the most central collisions. Then the observable is measured in collisions unable to offer a phase transition : lighter ions, peripheral collisions....

In the PHENIX experiment, electromagnetic probes (leptons and photons) are investigated with the aim to probe the QGP phase of the collision. In particular, photons are not affected by the nuclear medium they crossed, they provide a prime footprint of the extreme initial conditions under which the QGP may occur. Furthermore, the Subatech group has collaborated to the PHENIX electromagnetic calorimeter.

In STAR experiment, Subatech pursues three physics programs with the aim to obtain a complete description of the heavy ion collision. The first topic concerns the characterisation of the strange particle production, motivated by the fact that since strange quarks do not exist in the incident nucleons, their presence in the final state (as hadrons) allow to inform on the different steps of the collision. The second topic is related to particle correlations which provide information on the particle interaction potentials, size, lifetime of the emitting sources as well as the emission sequence if non-identical particles are considered. The third topic is dedicated to the search of exotica particles like pentaquarks for which a discovery would serve as a drastic test for the Standard Model.

Besides the physics programs, Subatech in collaboration with IPHC of Strasbourg has built the Silicon Strip Detector, part of the inner tracking system, installed in STAR in 2004. The SSD improves the tracking performances as well as the identification of short lived particles such as the strange and charm particles.

LHC has delivered its first proton beams in September 2008. Subatech has participated to the construction of two detectors of the ALICE experiment : the Inner Tracker System and the Dimuon Spectrometer. Concerning this latter, besides the technical realisations, a huge effort has been done on the offline developments associated to the detector functioning as well as for the physics analyses. The Dimuon Spectrometer is mainly dedicated to the charm and beauty production whose characterisation is expected to provide a strong signal of the deconfined phase. An original study is also performed on the electroweak boson W to characterise the parton distribution functions of the neutron and proton, and to establish an alternative baseline too the QGP studies.

The implication of Subatech in the ALICE experiment has been extended these last two years with two other involvements. One is related to the fact that Subatech is a secondary computing site (called Tier 2) of the LHC Computing Grid, CERN being a Tier 0, Lyon Computing Centre (CCIN2P3) being a Tier 1. The second involvement concerns the construction of a part of the new ALICE ElectroMagnetic Calorimeter (EMCal). This detector is composed by 11 ensembles which are the assembly of elementary modules. The goal is to complete one of these 11 ensembles in order to be installed in ALICE during the first LHC shutdown foreseen between January and March.. The aim is to provide to

ALICE the necessary tools to study particles at very high energies which is a very interesting and informative topic by revealing the inner structure of the quark gluon plasma, as RHIC demonstrated it.