Probing Quark Gluon Plasma in PbPb collisions at LHC

Prashant Shukla*
Nuclear Physics Division,
Bhabha Atomic Research Centre,
Mumbai - 400085, INDIA

The gaint detectors placed at Large Hadron Collider (LHC) in CERN are studying fundamental particles and their interactions in the collisions of protons and nuclei at TeV energy scale. The aim of proton proton collisions is to study Higgs bosons, Standard model and also search for new physics beyond Standard model. An important aspect of LHC is to collide lead ions with design energy $\sqrt{s_{NN}}$ = 5.5 TeV to produce temperatures of the order of 500 to 800 MeV, where quarks and gluons are no longer bound within hadrons. A detailed study of this phase called quark gluon plasma (QGP) is important to understand the collective dynamics of fundamental particles in early universe before everything was sealed permanently inside hadrons such as protons and neutrons.

I would start with an introduction with the LHC and particularly CMS experiment. Various detectors have been made in India such Resistive Plate Chamber (RPC) and Gas Electron Multipliers (GEM). As the LHC machine is being tuned for high luminosity, many detector components in CMS are being upgraded. High Granularity Silicon detectors where Indian Institutes are participating in big way will be useful in establishing the production process for Higgs boson in pp collisions. It will be able to identigy jets and their charges and thus can distinguish between quarks and gluon jets and will have important implications for heavy ion physics at LHC. The salient features of these detectors will be described.

The physics analysis of the Pb+Pb collisions data at $\sqrt{s_{NN}}$ = 2.76 TeV and at 5.02 TeV will be presented which gives out signals for QGP. One of the most interesting tool to study heavy ion collisions are Quarkonia, the bound states of charm and beauty quarks. A series of systematic measurements of quarkonia states and their ratios in PbPb collisions have helped establishing the colour screening behaviour of QGP. These studies have resulted in the observation of sequential suppression (as per their binding energies) of quarkonia states in Pb+Pb collisions and discovery of final state effects in p+Pb collisions at LHC. A study of different processes responsible for the modification of quarkonia yields in the medium produced in PbPb collisions will be presented. At high transverse momentum (p_T), J/ψ is more suppressed at LHC as compared to low energy collisions at RHIC. The enhancement of low p_T J/ψ as compared to RHIC shows that that there is substantial regeneration at LHC.

Fully reconstructed open heavy flavoured mesons, light charged particles and jets measured in wide kinematic ranges in PbPb collisions at LHC trace detailed properties of the medium produced in such collisions. The nuclear modification factors as a function of transverse momentum p_T are obtained for open charm and bottom mesons in PbPb collisions. The radiative energy loss process is shown to be dominant for charm quarks while for the bottom, both the radiative process and the elastic collisions are important. The LHC hints mass hierarchy in suppression of hadrons at $p_T < 8$ GeV/c. For $p_T > 10$ GeV/c, the suppression of light hadrons, charm mesons and bottom mesons are consistent.

We also present an analyis of nuclear modification factor of light charged particles and jets in PbPb collisions at LHC energies. The energy loss for light charged particles is found to

*Electronic address: pshuklar@barc.gov.in

increase linearly with p_T in low p_T region below 8 GeV/c and approaches a constant value in high p_T region above 30 GeV/c. It is found that for jets, the energy loss increases linearly even at very high p_T suggesting that their is no one to one correspondence between high p_T charged particle and high p_T jet. How the more controlled measurements like Di-jet and photon-jet measurements have yielded robust estimates of jet energy loss in p+Pb and Pb+Pb collision systems will be described.

The talk will review the results on quarkonia, open heavy flavour as well as light charged particles and jets created in the proton proton and PbPb collisions at LHC. Calculations demonstrating the manifestation of different processes responsible for the modification of yields of these particles in PbPb collisions will be presented.