Multihadron production in high-energy collisions and forward rapidity measurement of inclusive photons in Pb+Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV in ALICE experiment at LHC

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Quantum Chromodynamics (QCD), the theory of strong interaction, predicts a phase transition from ordinary nuclear or hadronic matter to a deconfined state of quarks and gluons, called Quark-Gluon Plasma (QGP). Such a phase transition occurs at very high temperatures and/or net baryon densities. It is possible to create these extreme conditions of high temperature and/or net baryon density in the laboratory by colliding heavy-ions at relativistic velocities.

Over the last three decades, a large number of dedicated experimental programs have been taken place all over the world to explore the QCD phase diagram. Systems of various temperatures and densities are expected to be formed in the laboratory by colliding heavy nuclei. Around 1980's, Lawrence Berkeley National Laboratory (LBNL) started heavy-ion program with a beam of heavy-ions up to 1 GeV/nucleon energy, colliding with a fixed target. After that Relativistic Heavy-Ion Collider (RHIC) took forward these studies by colliding Au+Au ions in a wide range of centre of mass energies per nucleon ($\sqrt{s_{\rm NN}}$) from 5.5 to 200 GeV. Now-a-days, the Large Hadron Collider (LHC) is continuing with the collisions of Pb+Pb ions at $\sqrt{s_{\rm NN}} = 2.76$ and 5.02 TeV at the European Organization for Nuclear Research (CERN). The properties of this new phase of partonic matter, QGP, has been discovered first at RHIC and possibly at the SPS energies, but it needs to be studied in details for better understanding of the new state of deconfined matter. For further studies of QGP, A Large Ion Collider Experiment (ALICE), one of the largest experiments in the world at the LHC at CERN, has been designed to study the physics of QGP in heavy-ion collisions.

The ALICE experiment is made up of several sub-detectors. These sub-detectors can be divided in two parts: central barrel detectors and the forward detectors. The central detectors have pseudorapidity coverage of $|\eta| < 1$ and mainly devoted for tracking and particle identification in the very high-multiplicity environment. A few specialized small detector systems are installed in the forward region of ALICE ($|\eta| > 1$). Photon Multiplicity detector (PMD) is one of the forward detectors in ALICE with full azimuthal coverage in the pseudorapidity region $2.3 < \eta < 3.8$. The PMD is designed to measure the multiplicity and the spatial distribution of photons in the forward rapidity region.

Most of the photons are the decay product of π^0, produced in heavy-ion collisions. Therefore the photon measurements provide complimentary information of the charged particles. In addition, the study of global observables of multiparticle production and their universality in different type of high-energy collisions is of crucial importance to understand the underlying dynamics of strong interaction.

In the present thesis a very first ALICE measurement of photon multiplicity distributions at forward rapidities ($2.3 < \eta < 3.8$) is presented using a highly granular preshower Photon Multiplicity Detector (PMD) in Pb+Pb collisions at $\sqrt{s_{\rm NN}} = 2.76$ TeV. This study is done for various collision centrality classes and are compared with corresponding results for charged particles. Also,

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we present charged particle and transverse energy production as a function of collision centrality and collision energy, in the framework of nucleon and quark participants. These participants are estimated using a Monte Carlo-based nuclear overlap model [1].

Further, we analyze the midrapidity pseudorapidity density of charged particles and transverse energy, measured in nucleus-nucleus collisions in the whole available range of $\sqrt{s_{NN}}$ from a few GeV at GSI up to a few TeV at LHC. The dependency of these key variables on $\sqrt{s_{NN}}$ and on the number of participants have been revealed within the participant dissipating energy (PDE) approach [2].

To find a solution to the RHIC "puzzle" of the difference between the centrality independence of the mean multiplicity vs. the monotonic decrease of the midrapidity pseudorapidity density with the increase of centrality. We study the centrality and $\sqrt{s_{NN}}$ dependance of charged particle mean multiplicity within the PDE approach. In the last we make predictions for the observables namely mean multiplicity, midrapidity pseudorapidity density of charged particles and midrapidity transverse energy density for the upcoming LHC collision energies [3]. In addition, within the PDE approach, recent measurement by ALICE for Pb+Pb collision at $\sqrt{s_{NN}} = 2.76$ TeV is reproduced very well [4].

The thesis is organized in the following chapters:

Chapter 1 gives an introduction of the relativistic heavy-ion and proton-proton collisions, the concept of Quark Gluon Plasma (QGP), and the proposed signatures of QGP in heavy-ion collisions.

In **chapter 2**, we introduce the world's largest and most powerful particle accelerator LHC and the experiment dedicated to study heavy-ion collisions, ALICE with its all subdetectors.

Chapter 3 describes the step by step analysis procedure for measurement of multiplicity and pseudorapidity distributions of photons at forward rapidity using PMD in the ALICE experiment for Pb+Pb collisions at $\sqrt{s_{NN}} =$ 2.76.

In **chapter 4**, we study the charged particle and transverse energy production mechanism from AGS, SPS, Relativistic Heavy-Ion Collider (RHIC) to Large Hadron Collider (LHC) energies in the framework of nucleon and quark participants [1].

In **chapter 5**, we analyze the mean multiplicity (N_{ch}), midrapidity pseudorapidity density of charged particles $(dN_{ch}/d\eta)$ and of the transverse energy $(E_T/d\eta)$ measured in nucleus-nucleus collisions in the whole available range of the collision c.m. energy per nucleon within the approach of the dissipation of the effective energy pumped in by the participants of the collisions, which forms the effective-energy budget in the multiparticle production process [2–4].

Chapter 6 provides the summary and conclusions drawn from this thesis work and some future insights are also provided in the area of relativistic heavy-ion collisions.

Acknowledgments

I acknowledge the financial support from MHRD and DST at various stage of my PhD program. Also, I would like to thank Prof. Raghunath Sahoo (supervisor), Prof. Edward K. G. Sarkisyan, Prof. B. K. Nandi and Prof. Tapan K. Nayak for their kind support and encouragement.

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