JINR summer school report

Baryon stopping at heavy ion collisions

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MPD experiment

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Abstract

The rapidity distribution for net-proton at $\sqrt{s_{NN}}$ 9 GeV for simulated Au-Au collisions, are obtained. This work used Ultra-relativistic Quantum Molecular Dynamics (UrQMD) as event generator in the framework of multi-purpose detector root (MpdRoot). Detector effect was studied in the reconstructed events. This work was aimed to check whether the tip in rapidity distribution for net-proton is detector effect or not.

Keywords: NICA energies, baryon stopping power, net-proton distribution

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I. INTRODUCTION

The main goal of high-energy nucleus-nucleus collisions is to produce and study a the nuclear matter at extreme conditions of energy densities and temperature. The energy density become around 1 GeV/fm^3 which is around seven times the nuclear ground state one and temperature become 10^{12} Kelvin. The quarks under these conditions, are no longer confined but move freely. This deconfined matter, named the quark-gluon plasma(QGP) [1], was the state of the Universe within the first ten microseconds after the Big Bang [2] and may exist also in neutron stars core [3].

The work in heavy ion collisions started at Bevalac (Berkeley), these researches continued at relative higher energies at Brookhaven at the Alternating Gradient Synchrotron (AGS) and at CERN at the Super-Proton Synchrotron (SPS) ($\sqrt{s_{NN}}$ from about 5 to 18 GeV). At Schwerionensynchrotron (SIS) at GSI Darmstadt, low energy range measurements ($\sqrt{s_{NN}}$ few GeV) were done. At the Relativistic Heavy Ion Collider (RHIC) at Brookhaven spans $\sqrt{s_{NN}}$ from about 7 to 200 GeV, while the Large Hadron Collider (LHC), deliver the largest ever collision energy, $\sqrt{s_{NN}}$ =2.76 TeV. The future colliders will concentrate in relative low energy ($\sqrt{s_{NN}}$ from about 4 to 11 GeV) like Nuclotron-based Ion Collider fAcility (NICA) in JINR Russia.

Relative low energy, has a lot of puzzles. Some of them are followed.

- Some hadronic ratios show a horn [4] at this energy for instance k^+/π^+ and Λ/π^- ratios. What it mean? is this behaviour related to a kind of phase transition? [5].
- The max net baryon density occurs at these energies [6]. This will allow us to understand the equation of state at high net baryon density.
- Large area in phase diagram will be covered because the temperature and the chemical potential vary faster than in the higher energy regime.

To produce QGP in these interactions, this require creation of high energy density medium. The energy density is measured by the energy deposited in a certain volume. Whether the nucleus-nucleus collision will create a volume with high density sufficiently to create QGP depend on the degree of stopping and center of mass energy. In other words, it is related to the nuclear stopping power. The nuclear stopping power figure out the K.E which converted to degree of freedom. The nuclear stopping power was introduced in high energy collision by Busza and Goldhaber [7]. The nuclear stopping power can be studied from the rapidity distribution of net baryon content. It is also related to the max baryon density which happened at low energies (NICA energies) when the two colliding nucleus completely stopped. Experimentally, neutrons can not be detected easily. So, net baryons distribution can be studies through the study of net-proton distribution. In this work, I will obtain the transverse momentum distribution and rapidity distribution for the particle from the generated events and reconstructed ones using Mpdroot concentrating on the net-proton distribution.

II. METHOD

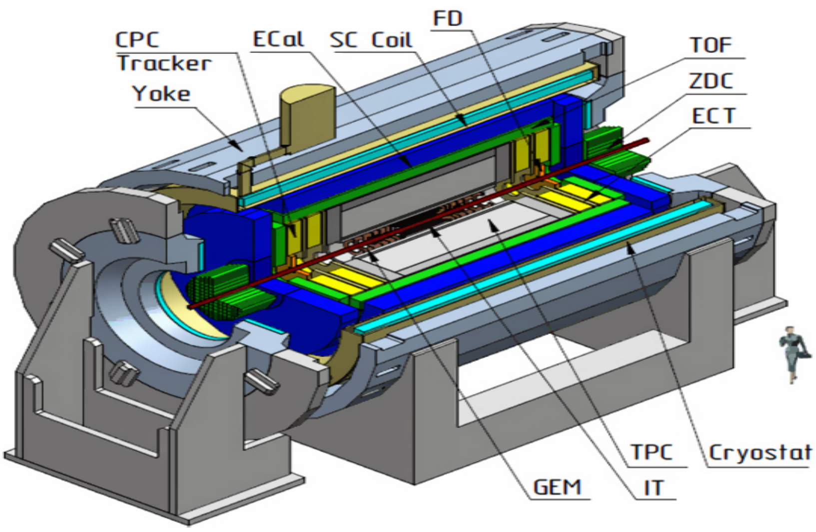

Fig. 1: The Multi-Purpose Detector (MPD) contents.

The Multi-Purpose Detector (MPD) is designed to study heavy-ion collisions at the Nuclotron-based heavy Ion Collider fAcility (NICA) at JINR, Dubna. Its main components located inside a superconducting solenoid are a tracking system composed of a silicon microstrip vertex detector followed by a large volume time-projection chamber, a time-of-flight system for particle identification and a barrel electromagnetic calorimeter. Zero degree hadron calorimeter is designed specifically to measure the energy of spectators [8] as seen in Figs. 1.

MpdRoot [9] is name MPD software framework for simulation, reconstruction and analysis.

It uses the ROOT [10] as base. Libraries, different particle simulators and MPD detector classses are implemented. MpdRoot can also be consider as an extension of FairRoot [11]. MpdRoot sturcture is shown in Figs. 2.

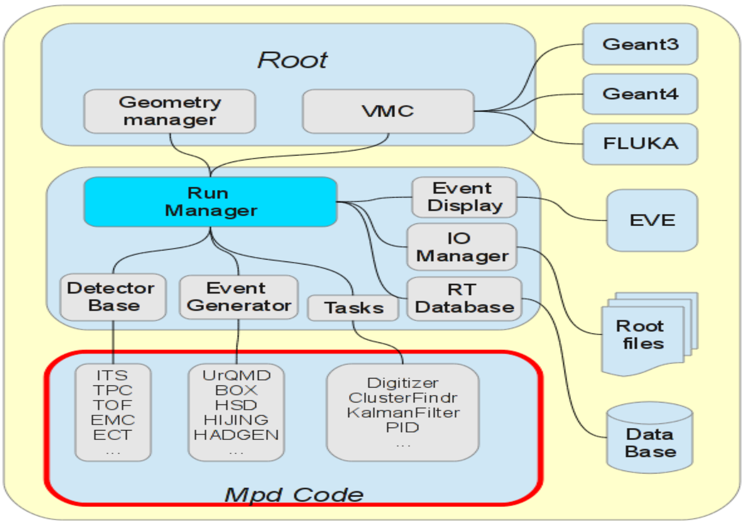

Fig. 2: The MpdRoot structure.

I will study the most central Au-Au collision at 9 GeV generated by Ultra-relativistic Quantum Molecular Dynamics (UrQMD). In the generating Monte-Carlo (MC) i.e without adding detector effect, the selection of the particle is very easy depending on them pdg code. The transverse momentum distribution and rapidity distribution are obtained for different particle species (pions, kaons and (anti)proton). After adding the detector effects (reconstructed Monte-Carlo (MC)), transverse momentum distribution and rapidity distribution are available but for the all charge particles. Identify articles is required depending on the energy loss and momentum.

First, some cuts on the tracts is required to select good tracks in TPC. The main cuts are the cut on the number of hits in TPC (see Figs.3.) , getting off the secondaries and selecting the high probability identified tracks.

III. RESULTS AND CONCLUSION

The transverse momentum distribution and rapidity distribution are shown in for pions (Figs. 4), kaons(Figs.4) and (anti)protons Figs.5) the generated and reconstructing MC. also the net-proton distributions are shown in Fig 5. The stopping of two nuclei in C.M.S will lead to rich-

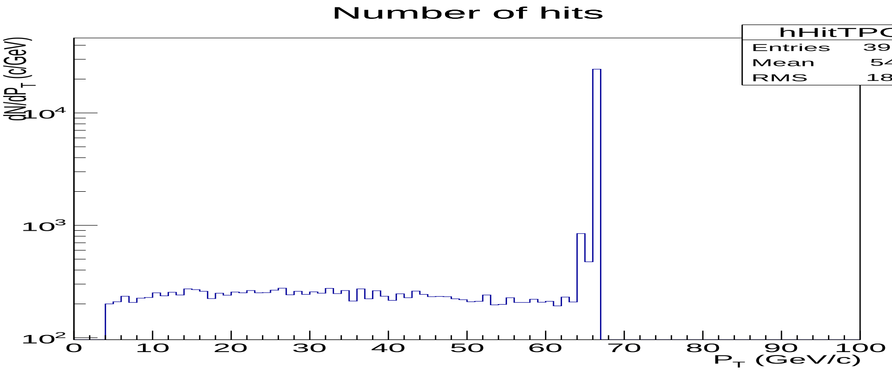

Fig. 3: The number of hits in TPC.

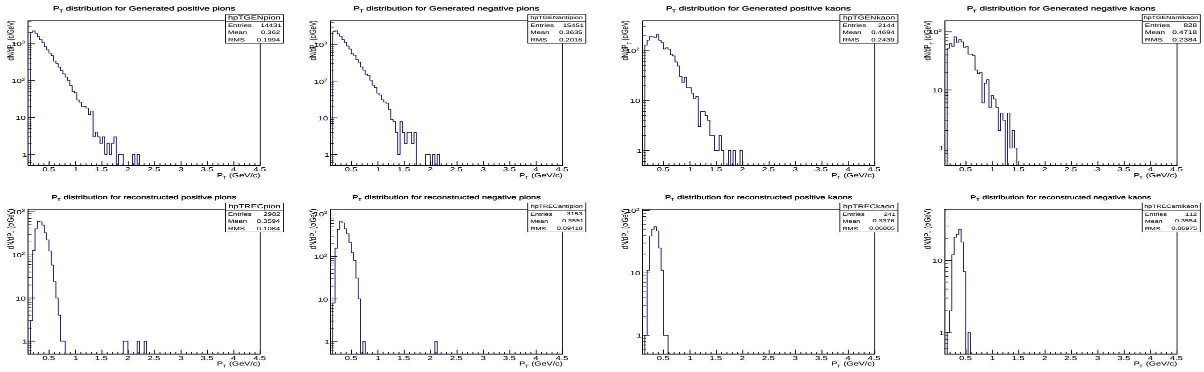

Fig. 4: Transverse momentum distribution of pions and kaons .

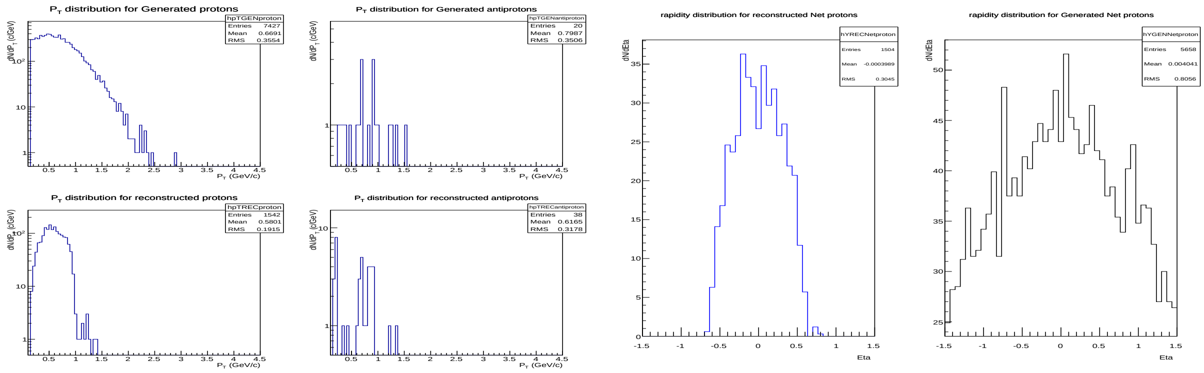

Fig. 5: Left panel; Transverse momentum distribution of anti(proton).Right panel; Rapidity distribution of net-proton.

baryon QGP which is likely to happened at lower energies range $\sqrt{s_{NN}}$ from about 5 to 10 GeV. This figures show high degree of nuclear stopping power. This will lead to low antibaryon-baryon ratio. The two nuclei might leave behind quark-gluon plasma with high baryon content.

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