ρ^0(770) vector meson production and elliptic flow measurement in Cu+Cu and Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV in STAR at RHIC

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Introduction

The Relativistic Heavy Ion community at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL), New York, aims to study nuclear matter under extreme condition of temperature and density. This is supported by lattice QCD prediction [1]. The prediction is that at sufficiently high temperature and/or nuclear density, colored quarks and gluons, which are confined in a nucleon become de-confined resulting in a new phase of matter, called the Quark Gluon Plasma (QGP) [2]. In a QGP phase, quarks and gluons are able to move over regions larger than a hadronic length. Additionally, QGP is believed to have existed during the first few microseconds after the Big Bang. Understanding the properties of QGP could provide valuable insights on the evolution of our universe. The experimental investigation at RHIC and intensive theoretical calculations with state-of-the-art computers have led to the refinement of the physics goals. The task of the RHIC heavy-ion programme, therefore, will be to investigate the properties of the de-confined matter in much greater details.

So far, RHIC has produced a great amount of data on various resonances. The ρ^0 vector meson (m_{ρ^0} = 775.5 MeV/c^2, Γ_{ρ^0} = 150 MeV/c^2) is one among such resonances through which various properties of the hot and dense medium created in such heavy- ion (i.e. Cu+Cu and Au+Au) collisions can be studied. Because of the broad width, the ρ^0 vector meson is expected to decay, re-scatter, and re-generate all the way from the chemical freeze-out to the kinetic freeze-out. In the context of statistical models, the measured ρ^0 vector meson yield should reflect conditions at kinetic freeze-out rather than at chemical freeze-out. In p+p and d+Au collisions, the ρ^0 vector meson is expected to be produced predominantly by string fragmentation. Therefore, the measurement of the ρ^0 vector meson in p+p and heavy-ions, such as Cu+Cu and Au+Au, collisions at the same nucleon-nucleon center of mass energy can provide insight for the understanding of the dynamics of these systems.

In addition, in-medium modification of the ρ^0 vector meson mass and/or width due to the effects of increasing temperature and density has ben proposed as a possible signal of the phase transition of nuclear matter to a de-confined plasma of quarks and gluons, which is expected to be accompanied by the restoration of chiral symmetry. Therefore, the production of the ρ^0 vector meson is studied and compared with other resonances to investigate the evolution of the fireball. In addition, significant amount of the ρ^0 vector meson elliptic flow, ($v_2(p_T)$), has been measured in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. It has been observed in peripheral, i.e. 40% - 80% Au+Au collisions that in the intermediate p_T ($1.5 < p_T < 5$ GeV/c), the ρ^0 vector meson elliptic flow coefficient (v_2) followed the number of constituent quark, n=2, meson-scaling. This is a strong evidence for the partonic collectivity of the medium created in the collisions.

Data Analysis

The data used for the analysis in this thesis were taken with the Solenoidal Tracker at RHIC (STAR) detector. Measurement of the

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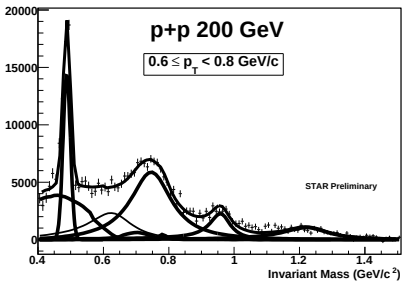

FIG. 1: $\pi^+\pi^-$ invariant mass distribution after background subtraction. The various curves represent the different function fit in the cocktail.

ρ^0 vector meson, through the hadronic decay channel $\rho^0 \rightarrow \pi^+ + \pi^-$, in peripheral Cu+Cu and Au+Au collisions and minimum bias p+p and d+Au collisions are presented. The invariant mass spectra of the ρ^0 vector meson are reconstructed using a combinatorial technique, and the same-event like-sign technique is applied to estimate the uncorrelated background. A line shape analysis is carried out to extract the various information for the ρ^0 vector meson. A much complicated hadronic cocktail function is fit to the background subtracted invariant mass spectra as shown in Fig.1 to extract the mass and the uncorrected yield for the ρ^0 vector meson. The corrected p_T spectra, inverse slope parameters, and yields of the ρ^0 vector meson in the mid-rapidity (i.e. -0.5 < y < 0.5) is studied. The average p_T ($< p_T >$) of the ρ^0 vector meson is compared with other particles to investigate effects of radial flow and particle production mechanism. The ρ^0/π^- ratio is studied and compared with K^*/K^- ratio to understand the regeneration vs. re-scattering effects.

Summary

Fig. 2 shows the number of constituent quark scaling of ρ^0 elliptic flow (v_2) where the number of constituent quarks for ρ^0 equals to 2. It is quite clear from Fig. 2 that the ρ^0 production mechanism is mainly dominated by the early stage quark-antiquark coalescence.

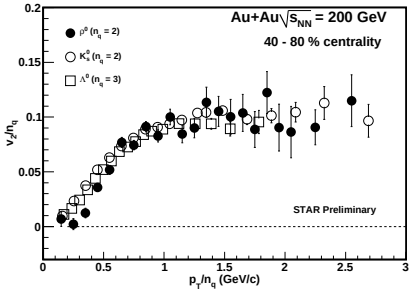

FIG. 2: Number of constituent quark scaling of v_2 (v_2/n_q vs. p_T/n_q) in 40-80% peripheral Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. ρ^0 v_2 scales with n=2 quarks.

References

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