Energy dependence of integrated suppression fraction from R_{AA} and R_{CP} in relativistic heavy-ion collisions

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Introduction

The primary goal of the present work is to study the properties of the strongly interacting partonic medium formed in relativistic heavy ion collisions. Partons produced in the early stages of the collisions, while passing through the medium, loose energy via multiple scatterings and gluon radiations [2–4]. This leads to modified p_T spectra of final state hadrons for A-A collisions with respect to p-p collisions, the key physical quantity being the Nuclear modification factor (R_{AA}) and the ratio of transverse momentum (p_T) differentiated spectra from central over peripheral collisions, studied through the quantity R_{CP}.

Based on the available results of R_{AA} (p_T) and R_{CP} (p_T) measurements from various experiments, we have calculated the p_T integrated suppression fraction (ISF) and plotted this as a function of collision energy for central collisions. Moreover, the value of ISF has been estimated for Pb–Pb collisions at $\sqrt(s) = 5.02$ TeV at the CERN Large Hadron Collider.

Formalism and Results

The R_{AA} is defined as

$$R_{AA} = \frac{d^2N_{AA}/dp_Td\eta}{< T_{AA} > d^2\sigma_{pp}/dp_Td\eta}, \qquad (1)$$

where $d^2N_{AA}/dp_Td\eta$ represents the differential particle yield in nucleus-nucleus collisions and $d^2\sigma_{pp}/dp_Td\eta$ is the cross-section in proton-proton collisions. In the above expression, nuclear overlap function $< T_{AA} >$ is obtained from Glauber model and is proportional to the number of binary collisions ($< N_{coll} >$). At high p_T, and in the absence of medium effects, R_{AA} is expected to be unity. In the region of low transverse momentum,the soft scatterings are the dominant processes, and so R_{AA} deviates from unity.

The R_{CP} is thus defined as,

$$R_{CP} = \frac{< N_{coll}^{peri} > d^2N_{cent}/dp_Td\eta}{< N_{coll}^{cent} > .d^2N_{peri}/dp_Td\eta}, \qquad (2)$$

where $< N_{coll}^{cent} >$ and $< N_{coll}^{peri} >$ are the average number of binary collisions in central and peripheral $Au-Au$ collisions, respectively. Nuclear medium effects are expected to be much stronger in central relative to peripheral collisions, which makes R_{CP} an important physical quantity to study these effects.

We have systematically plotted R_{AA} and R_{CP} for all charged particles as a function of beam energies in Fig (1). In the upper panel, R_{AA} is plotted as a function of p_T for Pb-Pb collisions at 2.76 TeV for ALICE [1] and 200 GeV, 62.4 GeV and 39 GeV for Au-Au collision at STAR respectively [2].

We define the ISF as the ratio of two quantities integrated over a range of p_T,

$$ISF = \frac{\int_{p_T^{min}}^{p_T^{max}} [R_{AA} = 1]dp_T - \int_{p_T^{min}}^{p_T^{max}} R_{AA}dp_T}{\int_{p_T^{min}}^{p_T^{max}} [R_{AA} = 1]dp_T} \qquad (3)$$

In the analysis, we choose two p_T ranges, (a) 1 GeV/c to 2 GeV/c and (b) 1 GeV/c to 4 GeV/c to study the p_T dependence of the ISF. In Fig. 2 we show ISF as a function of collision energy from both R_{AA} and R_{CP} values. A curve is fitted through the data points and extrapolated to PbPb collisions at 5.02 TeV.

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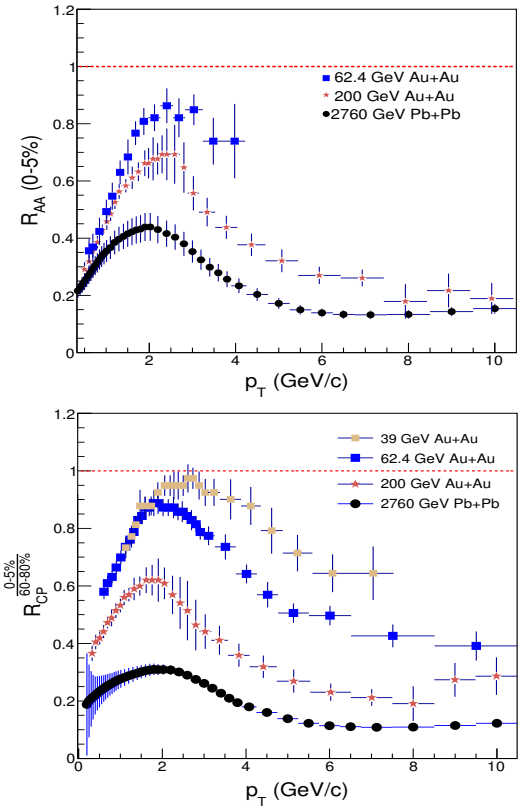

FIG. 1: Energy dependence of R_{AA} and R_{CP} as a function of p_T with different beam energies for $0-5\%$ central collisions at ALICE and STAR experiments.

Summary

We have defined a new quantity, called the integrated suppression fraction from the nuclear suppression factors over a range of p_T. The evolution of ISF as a function of collision energy has been studied. In addition, an extrapolation has been made for $Pb-Pb$ collisions at 5.02 TeV. The predicted ISF for 5.02 TeV is 0.63 ± 0.03. The observations presented here can prove to be a novel initation in understanding the jet quenching mechanisims as relavent for the upcoming 5.02 TeV run at LHC.

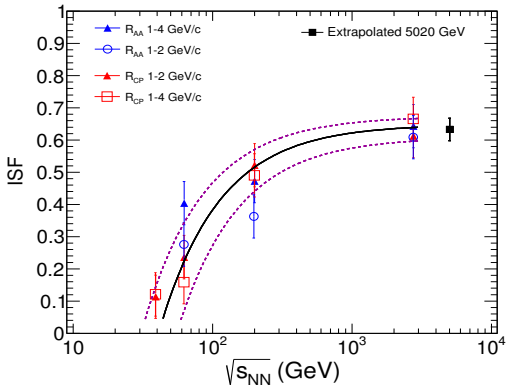

FIG. 2: Integrated Supression Fraction as a function of beam energies at different p_T range in 0-5% central collisions fitted with a power law.

References

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