A closer look into the peak shape in nuclear modification factor in relativistic heavy ion collisions

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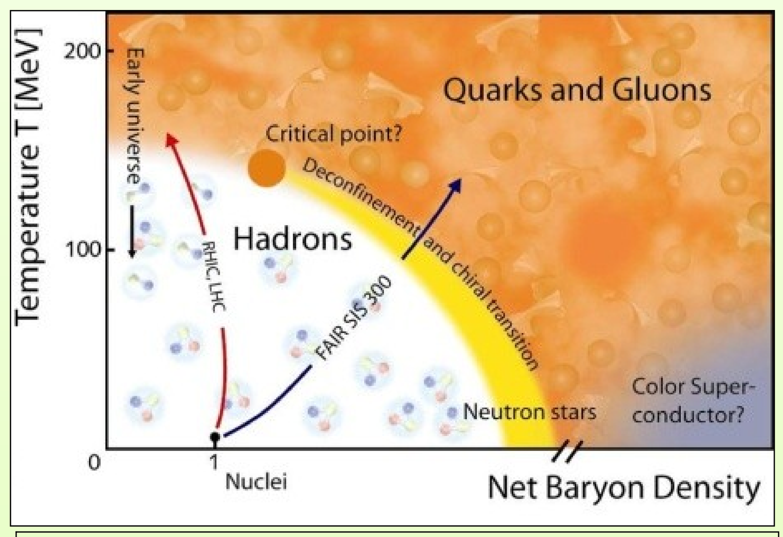
Physics Motivation:

At very high temperature and energy density, a phase transition occurs from hadronic matter to de-confined quarks and gluons, known as Quark Gluon Plasma(QGP). Partons produced in the early stages of the collisions, while passing through the medium, loose energy via multiple scatterings and gluon radiations [1-3]. 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 transventum (p_T) differentiated spectra from central over peripheral collisions, studied through the quantity R_{CP}.



Phase Diagram for Hadronic matter to QGP.

Based on the available results of $R_{AA}(p_T)$ and $R_{CP}(p_T)$ measurements from various experiments and that obtained from EPOS we have systematically studied shape of the Cronin peak [4] for all charged as well as identified charged particles for different energies. For the quantitative understanding of the Cronin peak, we have defined a quantity called the Integrated Suppression Fraction (ISF) and we studied it for different identified charged particles at different $\sqrt{s}$ obtained from EPOS and inclusive charged particles from available experimental data.

Definition:

The R_{AA} and R_{CP} are defined as:

$$R_{AA} \equiv \frac{d^2N_{AA}/dp_T d\eta}{\langle T_{AA}\rangle d^2\sigma_{pp}/dp_T d\eta} \qquad R_{CP} \equiv \frac{\langle N_{coll}^{peri}\rangle d^2N_{cent}/dp_T d\eta}{\langle N_{coll}^{cent}\rangle d^2N_{peri}/dp_T d\eta}$$

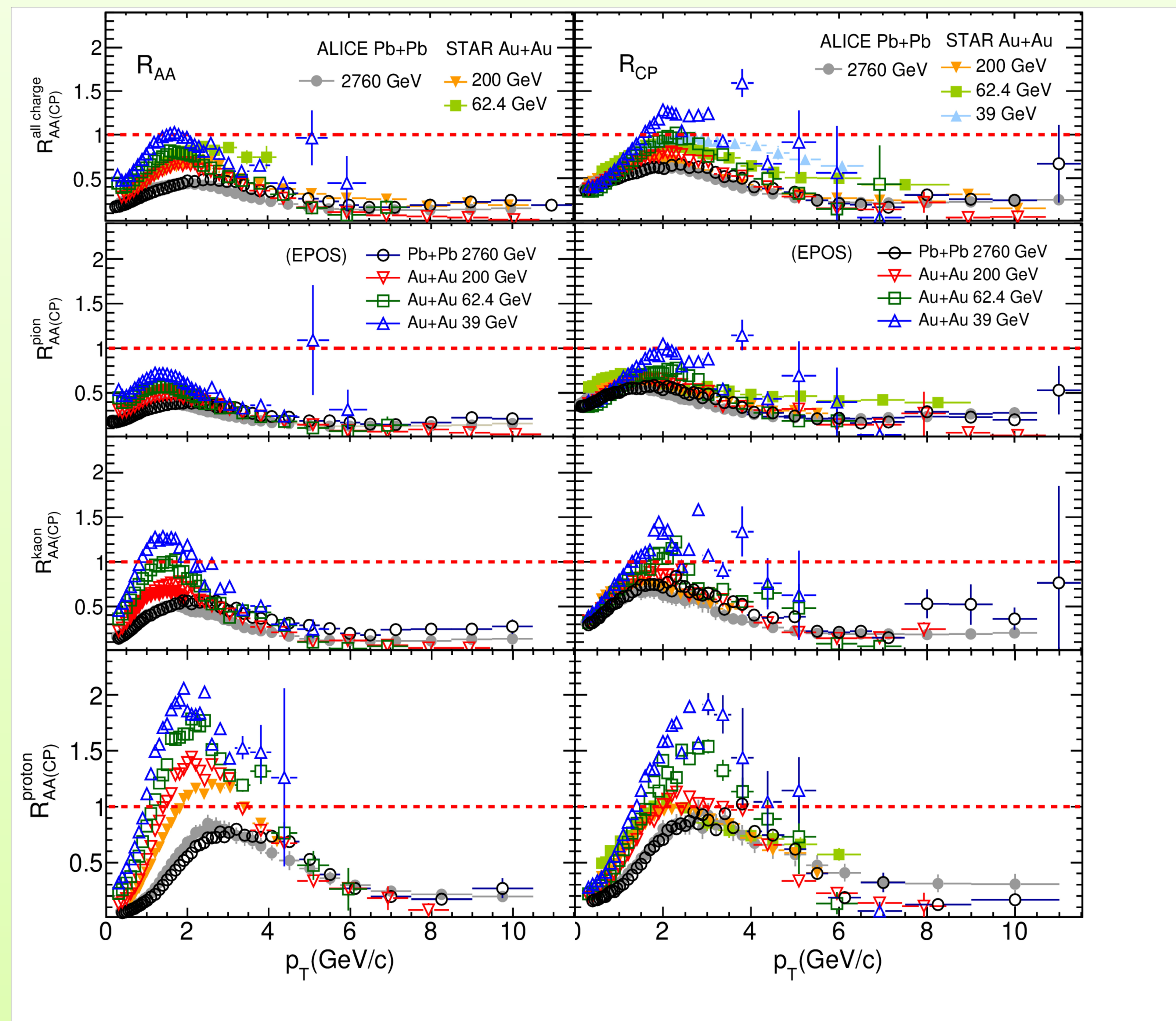
Where $d^2N_{AA}/dp_T d\eta$ represents the differential particle yield in nucleus-nucleus collisions and $d^2\sigma_{pp}/dp_T d\eta$ is the cross-section in proton-proton collisions. In the above expression, nuclear overlap function $\langle T_{AA}\rangle$ is obtained from Glauber model and is proportional to the number of binary collisions ($\langle N_{coll}\rangle$). $\langle N^{cen}_{coll}\rangle$ and $\langle N^{peri}_{coll}\rangle$ are the average number of binary collisions in central and peripheral A-A collisions, respectively.

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

$$ISF = \frac{\int_{p_T^{min}}^{p_T^{max}} [R_{AA}=1]\,dp_T - \int_{p_T^{min}}^{p_T^{max}} R_{AA}\,dp_T}{\int_{p_T^{min}}^{p_T^{max}} [R_{AA}=1]\,dp_T}$$

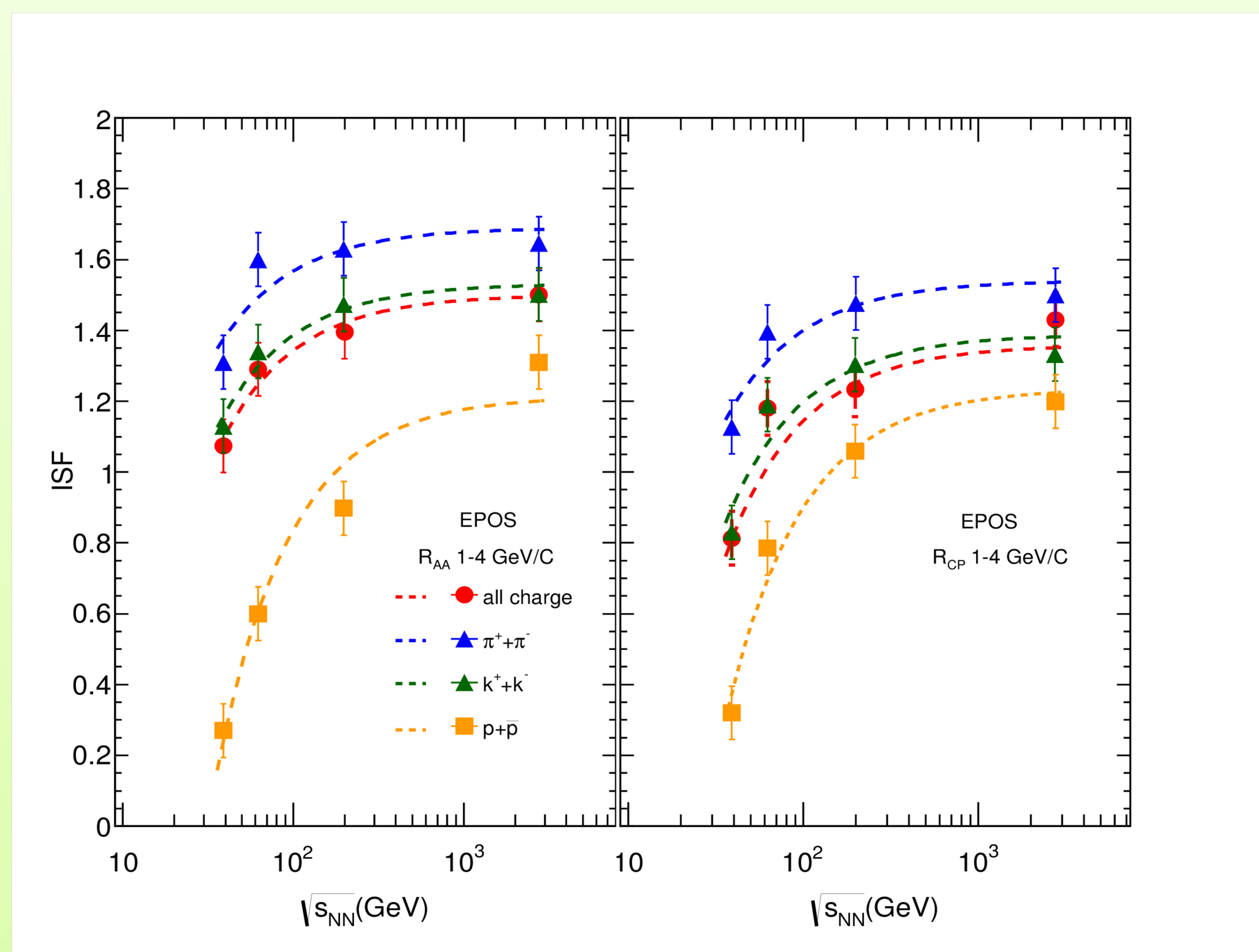
we choose two p_T ranges, (a) 1 GeV/c to 2 GeV/c and (b) 1 GeV/c to 4 GeV/c to study the p_T dependence of the ISF. We show ISF as a function of collision energy from both R_{AA} and R_{CP} values

Evolution of Cronin peak



Energy species dependence of R_{CP} and R_{AA} as a function of p_T with different beam energies for available central collisions at ALICE [5] and STAR [1] experiments with EPOS comparison.

Integrated Suppression Fraction (ISF)



ISF as a function of beam energies at different p_T range in available central collisions for inclusive charged particles and for identified charged particles from EPOS. The left plot stands for ISF measured from R_{AA} and the right one from R_{CP}

Summary

- We observe a shift of the peak position with energy as well as with different identified species for RAA. But for RCP, we only observe species dependency or in other words mass dependency.
- The mismatch in the trends of the peak shifting suggests that for RCP it is not coming from collectivity. Whether this is coming from the radial boost or the mass hierarchy in the final states or both, is yet to conclude as the analysis is going on.
- For all species, ISF follows a particular trend at different beam energy both from RAA and RCP measurements. In addition at a particular beam energy, the ISF value is mass dependent, for example, pions have a lower mass than kaon and proton and show a larger ISF value.

References:

[1] J. Adams et al. [STAR Collaboration], Nucl. Phys. A 757 (2005) 102.
[2] K. Adcox et al. [PHENIX Collaboration], Nucl. Phys. A 757 (2005) 184.
[3] S. Basu et. al., Phys. Rev. C. 93 064902 (2016).
[4] J.W. et al. 1975 Phys. Rev. D 11 3105
[5] B. Abelev et al. [ALICE Collaboration], Phys. Lett. B 720 (2013) 52.