Chemical freeze-out temperature from slope parameters in high energy heavy-ion collisions

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Introduction

Experiments in the heavy ion collisions are on the quest to unearth the nature of the QCD phase transition and to get a glimpse of how matter behaves at extreme conditions.The matter produced due to the collisions at ultra-relativistic energies,are traversed several intermediate stages and finally produce particles at freeze-out. According to the theory, it has two successive freeze-outs, chemaical and kinetic respectively. For the former, particle species get fixed and kinetic energies (momentum) get freezed for the later.

Motivation

Temperature obtained from the p_T spectra of the produced particles, is known as T_{eff} from fitting with exponential functions by assumiung thermally equilibrated system and applying Maxwell-Boltzmann statistics because of high temperature; as, $F(p_T) \approx \frac{1}{p_T}\frac{dN}{dp_T} = Ae^{-p_T/T_{eff}}$.
This T_{eff} has contributions from both (T_{kin}) and a thermal part due to radial velocity β_T of the medium because the medium is expanding: as,

$$T_{eff} = T_{kin} + Am < \beta_T >^2 \qquad (1)$$

T_{kin} and β_T is obtained from the p_T spectra of different species by applying Blast-Wave(BGBW) model, where as T_{ch} is obtained from the particle yield by applying Thermal statistical model ($T_{ch} > T_{kin}$).

From Fig.1 we have taken the values of $< \beta_T >$ for different $\sqrt{S_{NN}}$ and from Fig.2 the temperature difference for the corresponding energies. From these values, we have plotted the temperature difference d as a function of $m < \beta_T >^2$ . .A is taken as 3/2 or 1/2. The

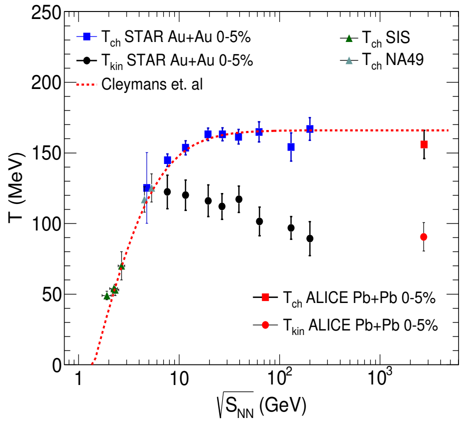

FIG. 1: Beam energy dependence of temperature.

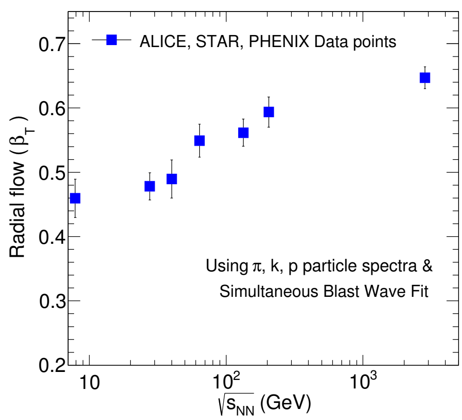

FIG. 2: Radial flow velocity(β) as a function of beam energy.

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mass m can be taken as the pion mass as 90% of the produced particles are pions.
The event-by-event fluctuation on flow velocity β_T need to be taken for the measurement of temperature fluctuation[1].

Analysis

We know the relation between T_{kin} and T_{eff} . Now our aim is to find the relation between T_{ch} and T_{eff}.

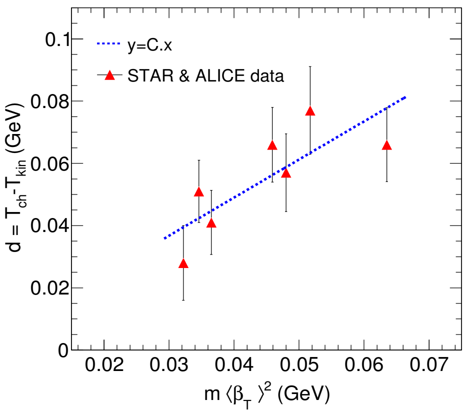

FIG. 3: Difference between chemical and kinetic temperature as a function of thermal part in T_{eff} due to radial flow velocity.

$$\begin{aligned} T_{eff} &= T_{kin} + A.m < \beta_T >^2 \quad (2) \\ &= T_{ch} - (T_{ch} - T_{kin}) + A.m < \beta_T >^2 \\ &= T_{ch} - d + Am < \beta_T >^2 \end{aligned}$$

Now, if this difference can be written as a linear function of $m < \beta_T >^2$ such that, d $= \alpha.m < \beta_T >^2$. Then, from eqn. 3 we can write,

$$T_{eff} = T_{ch} + (A - \alpha).m < \beta_T >^2 \quad (3)$$

m is taken the effective mass of Charged particle = 0.15 GeV.We have calculated T_{ch} from Fig.1 and $m < \beta_T >^2$ from Fig.2 and then we plot them and fit it with a straight line passing through origin y=C.x. The slope is found to be ≈ 1.2. So,

$$d = 1.2m < \beta_T >^2 . \quad (4)$$

Therefore,

$$T_{eff} = T_{ch} + (A - 1.2)m < \beta_T >^2 \quad (5)$$

This is the relation between T_{eff} and T_{ch}. Using Eqn.5 one can calculate directly T_{ch} from p_T spectra itself.

Discussion

This work has been done by assuming that d and m $< \beta_T >^2$ has a linear relationship. It can be further extended by exploring other non-linear dependencies for more accurate predictions. In future, the relation between $(T_{ch} - T_{kin})$ and μ_B will be further explored.

References

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[2] arXiv:1408.4209v1[nucl-ex]2014[STAR collaboration]