Diagonising quark gluon plasma formation by studying the radial flow in In+In collision at 158 A GeV SPS energy

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Introduction

Study of the collective phenomena like radial flow and anisotropic flow is a subject of high importance in relativistic nuclear collisions. Radial flow plays a crucial in diagonising the matter produced in such collisions [1–3]. Again the study of flow of the lepton pairs is more important becuase of the distinct nature of the interactions of the lepton pairs with the produced medium. The lepton pairs are produced at each stage of the evolution of the matter formed in these collisions and carry undistorted informations of the medium. The transverse momentum (p_T) and mass ($m_T = \sqrt{p_T^2 + M^2}$) distributions of these lepton pairs are the observables which carry the thermodynamic informations of the medium. But radial flow, v_r which develops at very early stage of matter and grows with the evolution, affects the p_T spectra of these particles. The nature of the evolution of the flow is different for the matter evolving through single phase(hadronic) and the matter evolving with multi phases (partonic and hadronic phases) [1]. Hence the study of the evolution of the radial flow in relativistic heavy ion collision has the special importance to diagonise the matter. Thus the study of the p_T or m_T spectra of lepton pairs and thereby extracting the radial flow from the spectra sheds light on the all evolving phases of matter produced in heavy ion collisions.

Here we focus on the study of v_r extracted from the p_T (m_T) spectra of lepton pairs measured from In+In collisions at 158 A GeV, SPS energy by NA60 collaborations [2].

Extraction of the radial flow

Let's assume that there is a gradual change (decrease) in temperature (avarage temperature, T_{av}) of evolving zones from which the lepton pairs originate. *i.e,* the change from T_i to T_f (initial to final temperature, these are average temperatures) is uniform by an amount ΔT. Ofcourse the assumption is very strong for the case of a first order phase transition encountered by the matter during the evolution. Still the effect can be verified theoretically by studying the effect of different equation of states. The p_T spectra of thermal lepton pairs can be written as $dN/p_T dp_T dy = dN/m_T dm_T dy \sim exp(-m_T/T_{eff})$, where T_{eff}=$T_{av} + Mv_r^2$ with T_{av} as the average temperature, M is the invariant mass of the lepton pairs, v_r is the radial flow. The effective temperatures from the spectra for different p_T or m_T windows (for a particular invariant mass window) can be extracted and can be written as follows;

$$\begin{aligned} T_1 &= T_{av1} + Mv_{r1}^2 \\ T_2 &= T_{av2} + Mv_{r2}^2 \\ T_3 &= T_{av3} + Mv_{r3}^2 \\ .. &= .. \\ .. &= .. \\ T_n &= T_{avn} + Mv_{rn}^2 \end{aligned} \quad (1)$$

Where T_i's are the effective temperatures extracted from the p_T spectra for different p_T windows but for a particular invariant mass window. Where v_{ri} are the radial flow for the corresponding T_i and p_T windows ($p_{T(i+1)} < p_T < p_{Ti}$). With the assumption of uniform decrease in average temperature through these

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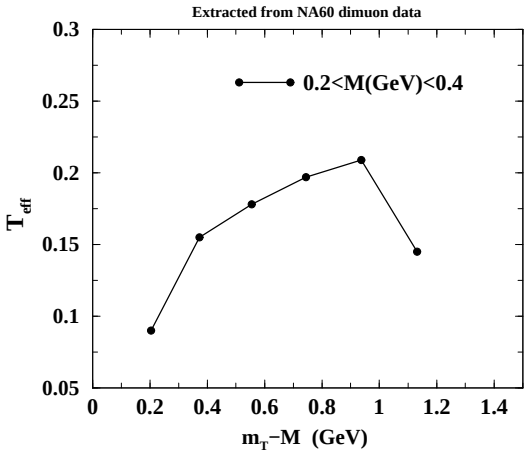

FIG. 1: The effective temperatures have been extracted for different m_T windows of the dimuon data presented by NA60 Collaborations from In+In collisions at 158 A GeV, SPS energy. The data are for the invariant mass window $0.2 < M(GeV) < 0.4$ [2].

p_T windows we can write $T_{av2} = T_{av1} - \Delta T$, $T_{av3} = T_{av2} - \Delta T$, and so on. With these substitution we can get

$$T_n = [T_{av1} - (n-1)\Delta T] + M v_{rn}^2 \qquad (2)$$

When p_T is very high one can assume that $T_1 = T_{av1}$, with v_{r1}=0, representing the initial period of the evolution of the matter. The above equation then simplifies to

$$T_n = [T_1 - (n-1)\Delta T] + M v_{rn}^2 \qquad (3)$$

. There are n-equations with (n+1) unknowns. Constraining the T_n from the experimental observations by choosing the proper p_T and M window, (n+1) unknowns can be reduced to n-unknowns. Solving these equations the evolution of the radial flow with p_T can be obtained. The study is done for different invariant mass windows.

We study for different mass windows. Here the effective temperature for mass window $0.2 < M(GeV) < 0.4$ have been extracted for various m_T bins from the dimuon data measured by NA60 collaborations and given below in the table.

TABLE I: Extracted effective tempearures as plotted in fig. 1.

T_{eff} (GeV)	$m_T - M$ (GeV)
0.145	1.034-1.229
0.209	0.84-1.034
0.198	0.64-0.84
0.178	0.46-0.64
0.156	0.28-0.4
0.09	0.12-0.28

Summary & Conclusions

The detail study of the evolution of the radial flow v_r with p_T or m_T for different mass windows of lepton pairs will be presented. The effect of the equation of state (with and without QGP phase) on the nature variation of v_r with p_T will also be discussed.

References

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