Electromagnetic Radiations from Partons and Hadrons

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The search of Quark Gluon Plasma (QGP) has been the major driving force behind research activities in the field of heavy ion collision for the last three decades. The motivation of the present work is to study the signature of for QGP. The hot and dense matter expected to be formed in the partonic phase after ultra-relativistic heavy ion collisions dynamically evolve in space and time due to high internal pressure. Consequently the system cools and reverts to hadronic matter from the partonic phase. Just after the formation, the entire energy of the system is thermal in nature and with progress of time some part of the thermal energy gets converted to the collective (flow) energy. In other words, during the expansion stage the total energy of the system is shared by the thermal as well as the collective degrees of freedom.

It is well known that the average magnitude of radial flow at the freeze-out surface can be extracted from the transverse momentum (p_T) spectra of the hadrons. However, hadrons being strongly interacting objects can bring the information of the state of the system when it is too dilute to support collectivity *i.e.* the parameters of collectivity extracted from the hadronic spectra are limited to the evolution stage where the collectivity ceases to exist. These collective parameters have hardly any information about the interior of the matter. On the other hand electromagnetic (EM) probes, *i.e.* photons and dileptons are produced and emitted from each space time points. Therefore, estimating radial flow from the EM probes will shed light on the time evolution of the collectivity in the system.

The photon and dilepton spectra measured at SPS and RHIC energies by different experimental collaborations have been analyzed to understand the evaluation of collectivity in the system. The calculations of EM probes from thermal sources depend on the parameters like initial temperature (T_i), thermalization time (τ_i), chemical freeze-out temperature (T_{ch}), kinetic freeze-out temperature (T_f) etc, which are not known unambiguously. To minimize the dependence of thermal sources on these parameters the importance of the ratio of the transverse momentum spectra of photon to dilepton has been considered in order to partially overcome the above mentioned uncertainties. Therefore, the evaluation of the ratio of the p_T spectra of photons to dileptons for various invariant mass bins along with a judicious choice of the p_T and M windows will be very useful to extract the properties of QGP as well as that of hadronic phase. This is demonstrated in the present

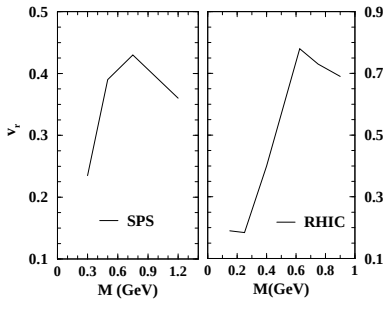

FIG. 1: The variation of radial flow with invariant mass pairs for SPS (left) and RHIC (right) energies.

work by analyzing WA98 and PHENIX photons and NA60 and PHENIX dilepton spectra. It is shown that simultaneous measurements of photon and dilepton spectra in heavy ion

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collisions will enable us to quantify the evolution of the average radial flow velocity for the system and the nature of the variation of radial flow with invariant mass will indicate the formation of partonic phase.

In this thesis work, we present a new proposal for carrying out an experimental measurement of dilepton interferometry both for RHIC and LHC. We establish through a hydrodynamical model based space-time evolution the promise of such a dilepton interferometry analysis will be useful to understand the properties of the partonic phase. We have evaluated the correlation function, C_2 for two dilepton pairs for various invariant mass domains and extracted the HBT radii, i.e. R_{side} and R_{out} as a function of M. These HBT radii show a non-monotonic dependence on the invariant mass, reflecting the evolution of collective flow in the system which can be considered as a signal of the QGP formation in heavy ion collisions. The M dependence of the R_{out}/R_{side} and $\sqrt{R_{out}^2 - R_{side}^2}$ which can be experimentally measured could be used to characterize the source size at various instances of the evolution.

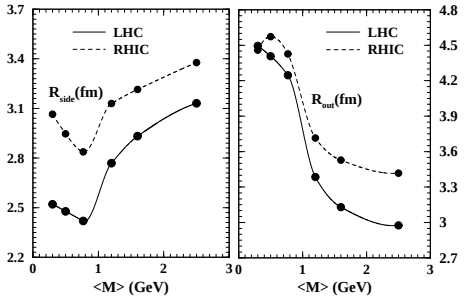

FIG. 2: The variation of R_{side}(left panel) and R_{out}(right panel) as a function of $\langle M \rangle$ for RHIC (dashed line) and LHC (solid line) energies. .

We have also evaluated the elliptic flow (v_2) of dileptons originating from the Pb+Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV for $30-40\%$ centrality. The differential elliptic flow, $v_2(p_T)$ has been evaluated for different invariant mass windows. We found an increasing trend of v_2 with p_T. Our study shows that $v_2(M)$ provides useful information on the collective motion of the evolving QCD matter formed in high energy heavy-ion collisions. Our calculation indicates that a reduction of $v_2(M)$ with increasing M beyond ϕ mass would reflect the presence of small momentum space anisotropy through modest collective motion in the QM phase. We observe that $v_2(\langle M \rangle)$ of the penetrating probe (lepton pairs) for $\langle M \rangle = m_\pi$ and m_K is similar to the hadronic v_2^π and v_2^K when the medium induced change in the ρ spectral function is included in evaluating the dilepton spectra. The medium effects are large during the dense phase of the hadronic system, therefore, this validates the findings that the hadronic v_2 carry the information of the dense part of the hadronic phase. Our study also establishes the fact that the invariant mass dependence of dilepton v_2 can in principle act as a clock for the space time evolution of the system formed in HIC.

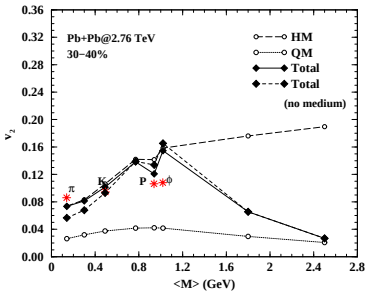

FIG. 3: Variation of dilepton elliptic flow as function of $\langle M \rangle$ for QM, HM (with and without medium effects) and for the entire evolution. The symbol $*$ indicates the value of v_2 for hadrons *e.g.* π, kaon, proton and ϕ.

References

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