Charged particle to photon ratio in heavy-ion collisions at RHIC: a different point of view

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Introduction

High energy experiments are being performed for last so many years to study the Quark Gluon Plasma (QGP) which is a strongly interacting hot and dense medium of quarks and gluons having very short life time. Measurement of the multiplicity of charged particles provides the information about the underlying physics processes occuring during the medium formation such as fragmentation and hadronization. Measurement of photon multiplicity provides the complementary information to that of charged particles thus helps in understanding of QGP medium [1].

Traditionally the production of particles in heavy-ion collisions is explained by measuring the density of particles in pseudorapidity η. The density of particles in pseudorapidity η within the configuration of some model calculations provides the information about the properties of the medium formed in the collisions such as density of energy, early temperature and velocity of sound in the medium. The longitudinal flow and rescattering effects strongly modify the widths of the pseudorapidity distributions. The density of particles in pseudorapidity η varying with the centrality of collision helps us to understand the importance of the comparison of soft and hard processes. This particular quantity acts as a testing tool to test different models of particle production based on the concept of parton saturation and color glass condensate (CGC) [2]. The particle production mechanism could be different in different regions of pseudorapidity at Relativistic Heavy-ion Collider (RHIC). In Au+Au collisions [3] at midrapidity, it has been observed that there is an increase in the charged particle production per number of participating nucleons. The reason being the hard processes scaling with the number of binary collisions but the number of the total charged particles produced per participant pair over the entire η range does not depend upon the centrality in Au+Au collisions. The production of particles at midrapidity depending upon the centrality indicates the increase in the density of gluons which is due to the decrease in the strong coupling constant within the configuration of color glass condensate model of particle production.

The detailed study of the increase in particle production at midrapidity with increase in the center-of-mass energy has been done at RHIC. The experimental data describing the multiplicity of hadrons and their dependence on centrality, rapidity and energy is in good agreement with the models based on parton saturation. This saturation occurs somewhere in the center-of-mass energy $\sqrt{s_{\mathrm{NN}}}$ = 17 GeV to 130 GeV has been argued.

Charged particle and photon production at forward rapidities

The variation of the number of particles which includes both charged particles and photons produced per number of participant pair with $\eta - y_{beam}$, where y_{beam} is the beam rapidity, does not depend upon the energy of beam at forward rapidities. This phenomenon is known as limiting fragmentation, which is the scaling of the production of particles longitudinally. The centrality independent limiting fragmentation behavior is observed to be followed by the inclusive photon production (primarily from decay of π^0) at $\sqrt{s_{\mathrm{NN}}}$ = 62.4 GeV. The inclusive charged particles

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at 19.6 GeV and 200 GeV follow the limiting fragmentation behavior which is dependent upon centrality. The limiting fragmentation for inclusive charged particles may be due to the baryons coming from nuclear leftovers and from the baryon transport.

Results and discussions

The ratios of the number of charged particles to photons in the pseudorapidity range $-3.7 < \eta < -2.3$ are found to be 1.4 ± 0.1 and 1.2 ± 0.1 for $\sqrt{s_{NN}} = 62.4$ GeV and 200 GeV, respectively in Cu+Cu and Au+Au collisions as shown in Fig1 [4]. Theoretically the ratio should be one in any system at any energy if we consider only decay photons as majority of the particles produced in any collision are pions and neutral pions decay into two photons. The ratio here is varying as a function of collision energy but not with the system size. It has been conjectured that baryons contribute to charged particles [5], while mesons are the dominant contributors to photon production in a given system at given energy so the ratio is more than one. Also the contribution of baryons to charged particles is suppressed as we go to the higher energies so the ratio is approaching to unity.

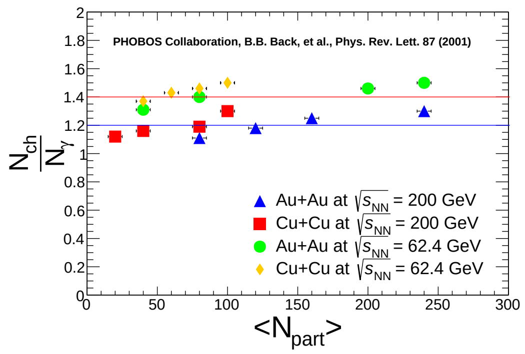

FIG. 1: Varaition of the ratio of number of charged particles to the number of photons with the average number of participating nucleons $< N_{part} >$ in Au+Au and Cu+Cu collisions at $\sqrt{s_{NN}} = 200$ GeV and 62.4 GeV in η region $-3.7 < \eta < -2.3$.

In this work we will try to convince that the energy dependence of the charged particle to photon ratio may be due to the varying contribution of the direct photons keeping the keeping the energy to charged particle production fraction same based on the theoretical model predictions and experimental results. The remaining part of the work is under progress.

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