Multiplicities and Particle Ratios from AuAu Collisions at $\sqrt{S_{NN}}$ = 200 GeV: The Brahms Experiment at RHIC

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A central question in the study of collisions between heavy nuclei at the maximum energy of the RHIC facility, $\sqrt{S_{NN}}$ = 200 GeV, is the role of hard scatterings between partons and the interactions of these partons in a high-density environment. It has been conjectured that new phenomena such as a saturation of the number of parton (mainly gluon) collisions in central nucleus-nucleus collisions may come into play at this energy. Such an effect would limit the production of charged particles [1], [3]. The production of charged particles in these highly energetic nuclear collisions can be due to hadronic as well as partonic collision processes and thus depends on the presence of gluon shadowing effects and, in general, on the relative importance of soft and hard scattering processes.

Fig. 1 shows the pseudorapidity distributions of charged particles in the range ∗Z|<4.7 as a function of collision centrality [4]. We fmd that the production of charged particles at midrapidity increases by 14±1% for the most central collisions relative to $\sqrt{S_{NN}}$ = 130 GeV collisions [5]. We also observe an increase in particle production with energy for more peripheral collisions. The width of the distribution grows by about 15%, from $\sqrt{S_{NN}}$ = 130 GeV to 200 GeV. In addition, a saturation of the excitations at larger rapidities is seen for all centralities.

We have estimated the number of participant nucleons in these collisions using the HIGING model. Fig. 2 shows the dependence of the multiplicity of charged particles per pair of participant baryons as a function of the number of participants N_{part} for three narrow

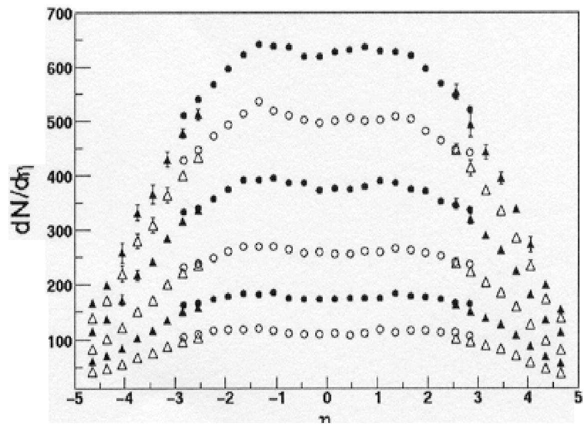

Figure 1: Pseudorapidity distributions of charged particles for AuAu collisions at $\sqrt{S_{NN}}$ = 200 GeV for centrality ranges of 0-5% (top) 5-10%, 10-20% 20-30%, 30-40% and 40-50% (bottom).

pseudorapidity regions (∗0 ≈ 0.2) around 0 = 0, 3.0 and 4.5.

Particle production per participant pair is remarkably constant and near unity at the forward rapidities characteristic of the fragmentation region but this is not the case for the central rapidities. Indeed, we find a significant increase of particle production per pair of participant nucleons for the more central

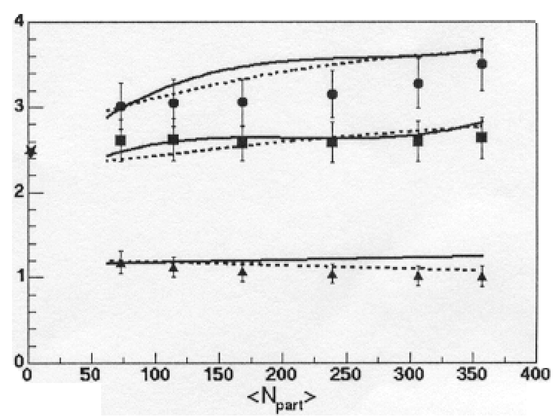

Figure 2: dN_{ch}/dZ per participant pair as a function of the number of participants for Z=0, 3.0 and 4.5. The curves show predictions by the Kharzeev and Levin model (solid line) [5] and the AMPT model (dashed) [6]. The star shows the proton-antiproton point at Z=0.

collisions at 0=0. This has previously been attributed to the onset of hard scatterings which are dependent on the number of binary nucleon collisions N_{coll} rather than N_{part}. We fit our data to the form $dN_{ch}/d0$ =∀ N_{part}+∃ N_{coll}. At 0=0(4.5) we find: ∀=1.26±0.09±0.20 (0.66±0.03±0.10) and ∃=0.15 ±0.04±0.05(-0.06±0.01±0.03), where the first uncertainty assumes a 3% point-to-point error for the $dN_{ch}/d0$ values and the second uncertainty results from the theoretical uncertainties in N_{coll} rather than N_{part}.

For central events at 0=0 we find that the hard scattering component to the charged particle production is almost constant, with values of 20±7% and 25±7% at $\sqrt{S_{NN}}$ = 130 and 200 GeV, respectively. The data are well reproduced by calculations based on high density QCD with gluon saturation and by the AMPT/HIJNG microscopic parton model.

We can gain a deeper insight into these collisions by studying the distribution of different particles versus rapidity. A particularly robust variable is the ratio of a particle to its antiparticle at a given rapidity. Since the mass is the same many systematic errors cancel in the ratio. Fig. 3 shows the ratios of K^+/K^- versus $\overline{p}/p$. Our data falls below and to the right of the AMPT model. In a simple model of quark coalescence the $K^-K^+ = (K^-K^+ =)^{1/3}$ exp (-2:$_s$/T).

Here :$_s$ is the strange quark chemical potential and T is the temperature of the system of quarks. Our data are close to this line while lower energy data are above it. Thus, the strange quark chemical potential drops with energy and is almost zero for $\sqrt{S_{NN}}$ > 130 GeV. For $\sqrt{S_{NN}}$ = 130 and 200 GeV there seems to be a universal curve for K^-/K^+ versus $K^-K^+ =$. That is the data from all rapidities lie on the same line.

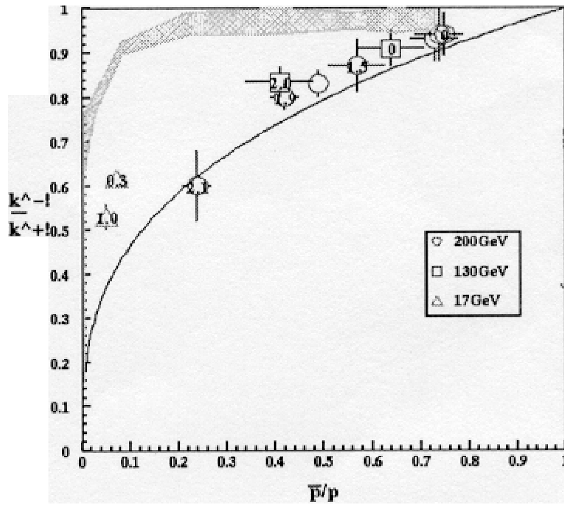

Figure 3: K^-/K^+ versus $\overline{p}/p$ for the data (open symbols) and the AMPT model (shaded band). The numbers in the data points show the rapidity of the data. The 130 GeV data are from [8] while the 17 GeV results are from NA44 and NA49. The line shows K^-/K^+= $(\overline{p}/p)^{1/3}$ expected in a simple model of quark coalescence with :$_s$=0.

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