STRANGENESS IN AU+AU COLLISIONS BETWEEN 1 AND 10 AGEV

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(E895 COLLABORATION)

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The yield and spectra of strange particles produced in heavy ion collisions carry information about the properties of strongly interacting matter. The E895 experiment has recorded Au+Au reactions at beam energies of 2, 4, 6 and 8 AGeV. We report preliminary results on strangeness yields and ratios covering a broad range in rapidity and transverse momentum. We investigate chemical freeze out parameters and expansion velocities in central collisions.

1 Introduction

Strange particle yields are interesting since they can provide information on chemical equilibrium and possibly on the QGP. One of the first predicted

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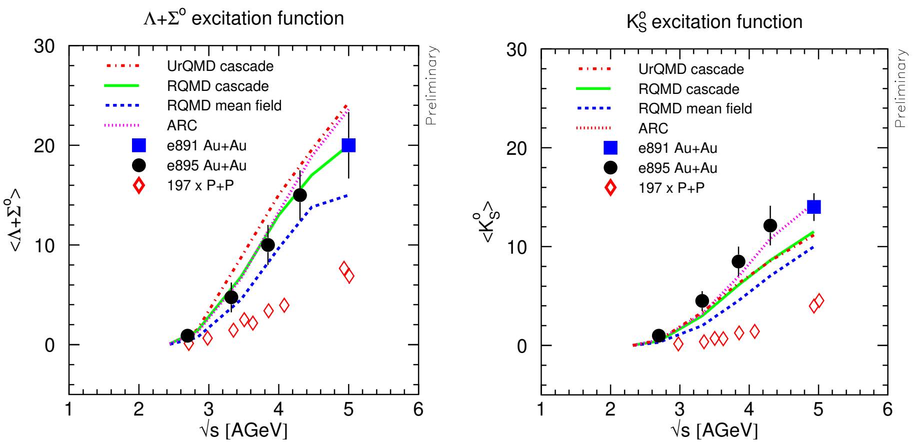

Figure 1. 4 π yields for Λ and K_s^0 particles in central Au+Au collisions between 2 and 8 AGeV kinetic beam energy (black symbols) in comparison to scaled pp data (diamonds) and several hadronic cascade models (lines).

signatures for the formation of a QGP was enhancement in production of strange particles. A system of quarks and gluons could reach chemical equilibrium quickly through the $gg \rightarrow s\bar{s}$ channel [1,2]. A measurement of the K/π ratio (or other related ratios) provides information on the relative concentration of strange and nonstrange quarks, i.e. $< (s+\bar{s})/(u+\bar{u}+d+\bar{d}) >$. This has been suggested as a diagnostic tool to differentiate between a hadronic gas and a QGP.

2 Results and Discussion

The E895 [3] experiment has recorded Au+Au reactions at beam energies of 2, 4, 6 and 8 AGeV. The centrality, percentage of σ_{geo}, was determined using multiplicity cuts of 150, 220, 280 and 350, respectively. At 2 AGeV centrality is 10%, 15% at 4 AGeV and 6 AGeV, and 11% at 8 AGeV. Analysis in progress will make this centrality more uniform. Efficiency corrections have been performed using a thermal model adjusted at each beam energy such that the transverse momentum spectrum of protons is reproduced at midrapidity.

Fig. 1 displays the measured Λ and K_s^0 yields as a function of $\sqrt{s}$ [4] in addition to earlier measurements from E891 [5] (square symbols, 5% centrality). Our Λs include those from decay of $\Sigma^0(1192) \rightarrow \Lambda\gamma$ ($c\tau = 2.2\ 10^{-11}$ m).

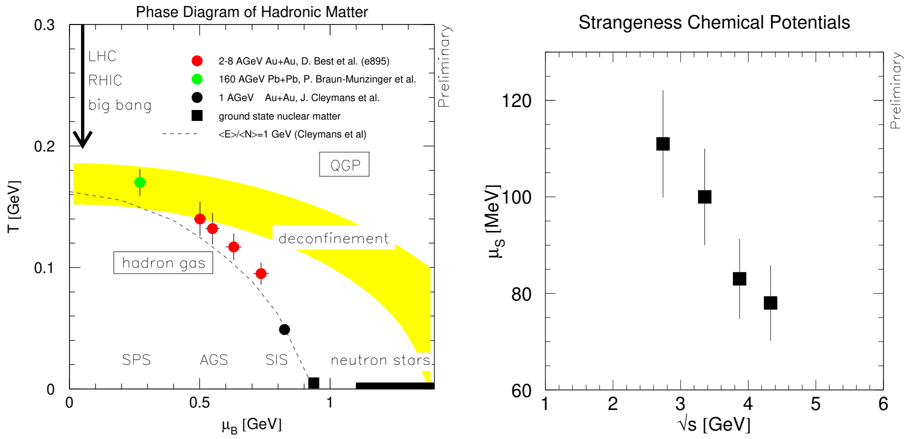

Figure 2. Preliminary results on chemical freeze out temperatures and baryon and strangeness chemical potentials for Au+Au collisions between 2 and 8 AGeV kinetic beam energy.

So far, the data show a monotonic increase with beam energy and no obvious features to support a threshold phenomenon. Results from pp collisions (diamonds) are overlayed after multiplying by the number of nucleons in a Au nucleus. This approximation supposes each nucleon in Au is involved in only one collision with a chance to produce a Λ (K_s^0) – probably an overestimate. Nonetheless additional processes seem to be needed to explain the measured yields in Au+Au collisions, e.g. multiple scattering. We also show several hadronic cascade codes (UrQMD [6], RQMD [7], ARC [8]). They match these preliminary data. These models show that strangeness yields are dramatically influenced by secondary particle interactions. The strangeness enhancement defined as the ratio of measured yield in AA to scaled yield from pp is 2–3 depending on beam energy and particle type.

In order to test thermal and chemical equilibrium [9] we have used a hadronic gas model [10] to fit simultaneously the Λ/π^- and K_s^0/π^- together with the π^-/baryon ratio. Our pion yields match well the yields at lower [11] and higher beam energies [12]. The model has two free parameters: the baryon chemical potential μ_B which is mainly influenced by the pion to nucleon ratio, and the temperature T. At each beam energy the experimental ratios are reproduced with $\chi^2 \approx 1$. In Fig. 2 the left panel shows our T and μ_B and earlier results for Pb+Pb [13] (SPS) and Au+Au [14] (SIS) collisions. The shaded area provides a simple reference bounded by lines of constant energy density

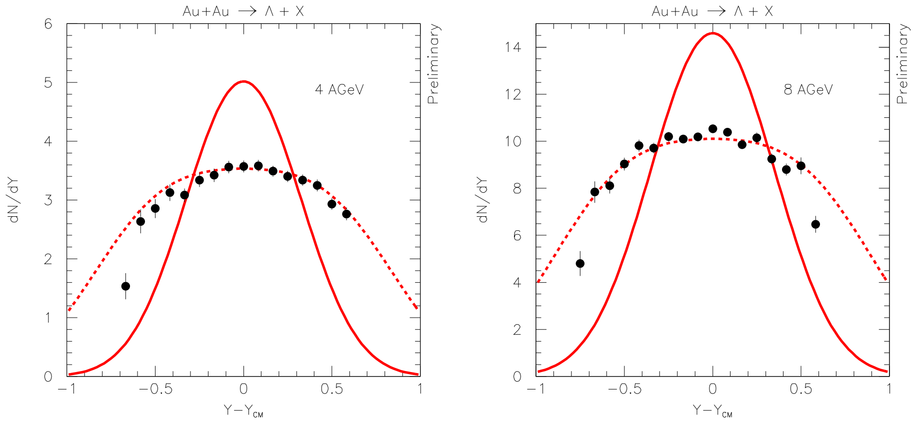

Figure 3. Λ rapidity spectra for central Au+Au collisions at 4 and 8 AGeV. The solid line shows the prediction of a stationary fireball model, the dashed curve incorporates a longitudinal expansion velocity (β_L) and provides a better description of the data.

(1–2 GeV/fm^3) using an equation of state for an ideal gas of massless quarks and gluons. The chemical potentials μ_B and μ_S (see Fig. 2 right panel) drop monotonically as the temperature T rises. A constant freeze–out density, for example, could impose such a correlation [14]. The dashed line maps the T–μ_B points subject to the constraint that the energy per baryon is equal to 1 GeV. Cleymans et al.[14] have noted that despite the wide variation in beam energy the data points, Fig. 2, fall close to this line. Recent attempts of a dynamical interpretation of chemical freeze–out parameters suggest that this line is intimately related to the softest point of the equation of state [15].

Thermal equilibrium imposes a particular form for the spectra [4] and rapidity distributions [4]. The influence of collective expansion appears in the rapidity plots (Fig. 3) where a single, stationary fireball is shown as a solid line. The dashed line incorporates a longitudinal expansion velocity (β_L) and provides a better description of the data. The value of β_L varies between 0.20 and 0.50 over the 2–8 AGeV beam energy span. These observations are consistent with incomplete stopping, or longitudinal expansion, or possibly a combination of the two.

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