Production and collective behavior of strange particles in Au + Au collisions at 2–8 AGeV

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The E895 experiment at the AGS measured strange particle production and collective behavior in Au+Au collisions between 2–8 AGeV. The production of Λ Baryons and K^0 Mesons as function of energy rises smoothly and exhibits a nonlinear impact parameter dependence. Neutral and positively charged Kaons exhibit a strong anti-flow behavior. Λ Baryons show a smaller flow signal than protons.

The production of strange particles in relativistic heavy ion collisions is an important probe for high density nuclear matter. Of particular interest are suggestions that strange particle yields can be used to investigate the nuclear equation of state [1] or possible signatures of a change of the in-medium mass [2]. The flow effects of strange particles offer a good probe for their in-medium potentials [3,4].

Motivated by these suggestions the E895 collaboration has performed an extensive set of measurements at the Alternating Gradient Synchrotron (AGS) at the Brookhaven National Laboratory. These measurements were performed for Au+Au collisions in a beam energy range of 2–8 AGeV. Charged reaction products were detected in the EOS

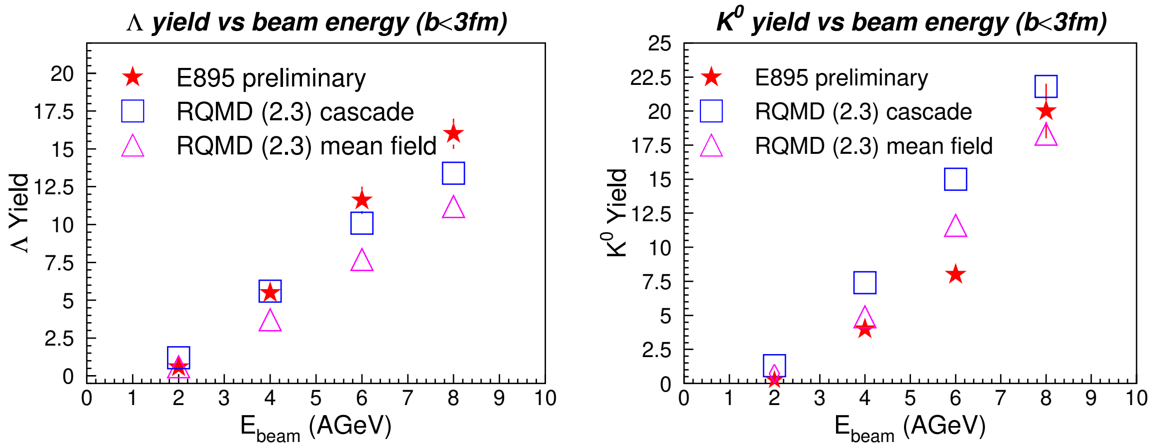

Figure 1. *Mean Λ Baryon and K^0 Meson multiplicities per event for central events.*

Time Projection Chamber (TPC) [5] situated in a uniform magnetic field. The TPC provides continuous 3D tracking and particle identification for particles with $-1 \leq Z \leq 6$ with full azimuthal coverage. The method of identification via the rigidity of the track and the energy loss in the TPC gas leads to ambiguities for certain rigidities, thus restricting the identification of charged kaons to low transverse momenta at backward rapidities. This restriction does not affect our neutral strange particles measurements (Λ Baryons and K^0_s Mesons) which were reconstructed from their charged decay products by means of a neural network [6–8].

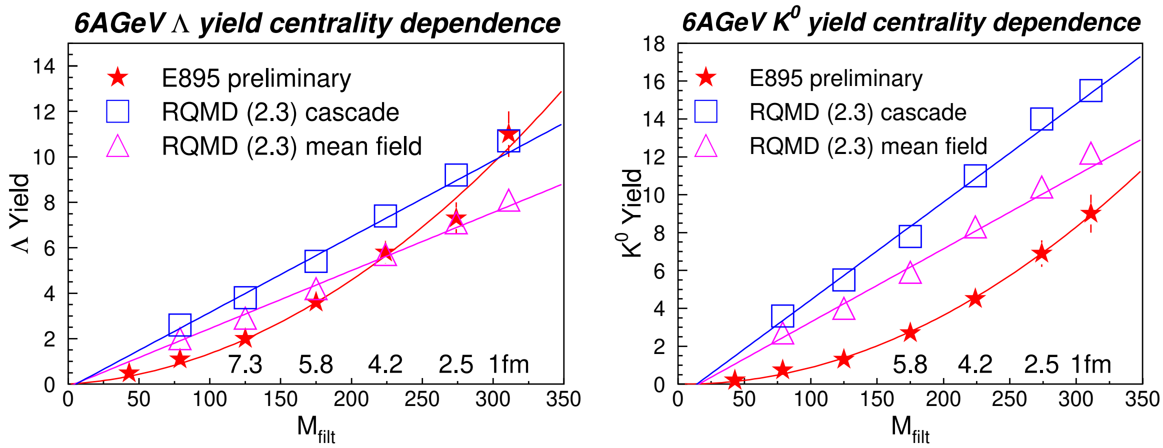

Figure 2. *Centrality dependence of the mean multiplicity of Λ Baryons and K^0 Mesons in Au+Au collisions at 6 AGeV. The lines are line/parabolic fits to guide the eye.*

Fig. 1 shows the mean multiplicities of Λ baryons and K^0 Mesons in central events corrected for acceptance and reconstruction efficiency. The yields show a monotonic increase with beam energy and are roughly reproduced by the RQMD [9] Model. They exhibit no obvious features which would support a threshold phenomenon. RQMD fails to reproduce the impact parameter dependence at 6 AGeV depicted in Fig. 2. The data exhibit a strong nonlinear dependence which was previously observed for charged Kaons[10] for Au + Au collisions in the same energy range.

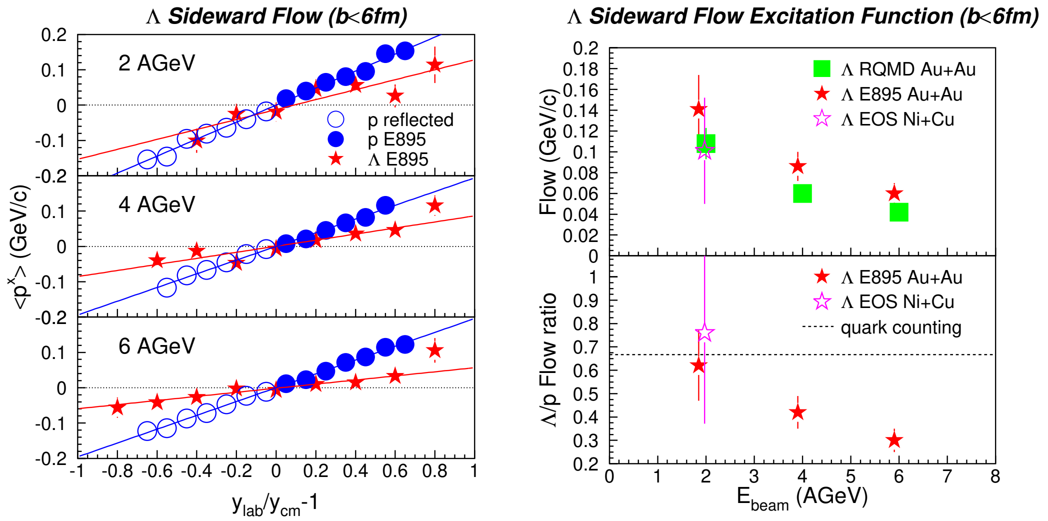

Figure 3. Λ *Baryon sideward flow excitation function. The strength of the sideward flow is decreasing as a function of beam energy. With increasing beam energy, a deviation from the simple quark counting rule is observed, indicating the influence of the* Λ *potential in dense matter.*

The sideward flow analysis used the procedure outlined in [11] to reconstruct the reaction plane for each event with the necessary corrections for the reaction plane dispersion. Subsequently the projection of the momentum of each strange particle on its associated reaction plane vector was obtained. The average momentum transfer ($\langle p^x \rangle$) into the reaction plane for protons and Λ Baryons is shown in Fig. 3. The Λ Baryons exhibit a smaller sideward flow than protons which where sampled from the same events in which a Λ Baryon was reconstructed. This condition results in a bias of the proton sideward flow towards more central events than reported in [12]. A comparison to a previous measurement in the Ni+Cu System at 2.0 AGeV [13] shows an increase of the flow with system size similar to protons [14]. If flow effects of Λ Baryons are only due to interactions of its non-strange quark constituents, one would expect a 2/3 ratio of the strength of the Λ/proton flow [15] shown in fig 3 left. This is indeed the case for the 2 AGeV data but it deviates significantly at higher energies, indicating that there may be additional contributions by the strange quark.

The K^0_s Mesons depicted in Fig. 4 exhibit a strong anti-flow signal which increases strongly with beam energy. The RQMD model, which does not contain a kaon potential, can serve as a baseline for the effects of scattering. Its failure to reproduce even the sign of the flow is a strong hint for the existance of a repulsive Kaon potential. Invoking a strong density dependence of the Kaon potential, a calculation with ART is able to reproduce the sign and the strength of the K^0_s Meson flow [16]. Since the K^0_s Mesons at these energies originate mainly from K^0 Mesons – according to RQMD the $\bar{K}^0/K^0$ ratio is smaller than 0.1 – one would expect a similar flow pattern for the K^+ Mesons. Indeed, even though the acceptance for charged Kaons in E895 is very limited ($y_{Lab}/y_{c.m.}$-1<-0.6) with a rapidity dependent low and high p_t cut, the K^+ Meson shows a clear anti-flow signal displayed in fig 4 which also increases with beam energy. The flow signal of the K^- Mesons is compatible with no flow.

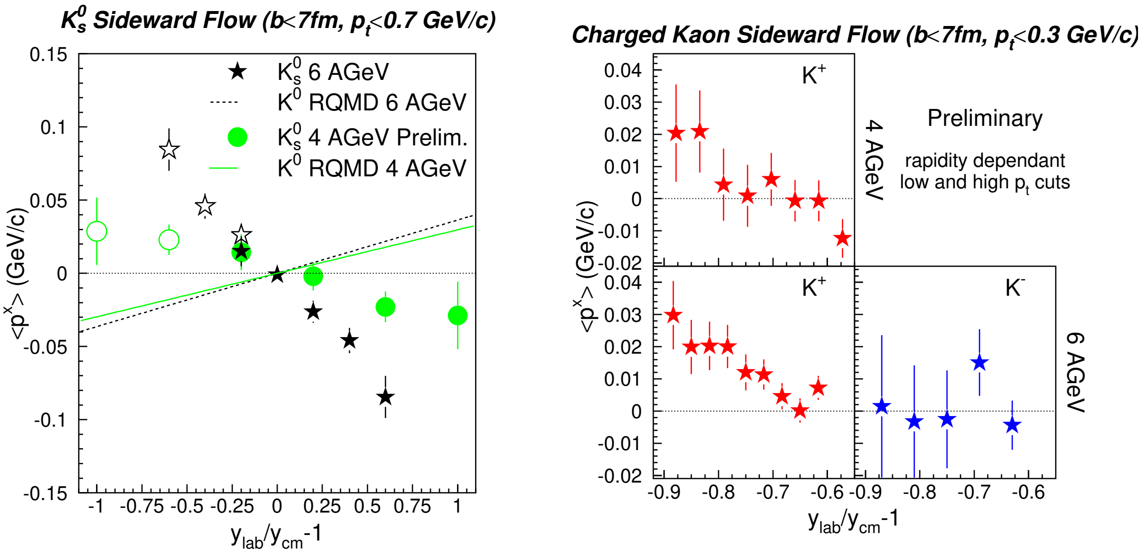

Figure 4. *K_s^0 Mesons (open symbols represent reflected data) show a strong anti-flow signal which increases with beam energy. The same behavior is qualitatively observed in preliminary results for positively charged Kaons while the flow behavior of K^- Mesons is compatible with no flow.*

The E895 collaboration has measured neutral strange particle production and flow at AGS energies. The results indicate that production yields are consistent with existing systematics and show no apparent dramatic increase with beam energy. The transverse momentum analysis shows that Λ Baryons flow with protons but with smaller magnitude. K^0 and K^+ Mesons follow an anti-flow pattern indicating a repulsive Kaon potential.

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