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NEW RESULTS FROM AGS HEAVY-ION EXPERIMENTS

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We review the most recent data from Experiments 802, 810 and 814 of the heavy-ion program at the Brookhaven Alternating Gradient Synchrotron (AGS).

1. E802

Experiment 802[1] has recently completed, among its many goals, a survey of semi-inclusive particle production over a broad range of projectiles (p, ^{16}O and ^{28}Si) and targets (Be, Al, Cu and Au) at p_{beam} = 14.6 A·GeV/c. With such measurements it is easier to identify directly from the data interesting nuclear effects on particle production.

Measurements of inclusive cross sections for pA collisions have confirmed what had already been observed in central ^{28}Si + Au collisions[2]; namely, the invariant cross sections of $\pi^{\pm}$, $K^{\pm}$ and protons, within the available statistics and $p_{\perp}$ range of the spectrometer ($p_{\perp} > 0.3$ GeV/c) are well described by exponential curves in transverse mass:

$$E\frac{d^3\sigma}{dp^3} = Ae^{-(m_{\perp}-m_o)/T_0},$$

where $m_{\perp} = \sqrt{m_o^2 + p_{\perp}^2}$, m_o is the particle rest mass, and $p_{\perp}$ is its transverse momentum. A and T_0 are parameters, where the inverse slope parameter T_0 (at a given rapidity) uniquely characterizes the shape of the spectral distributions.

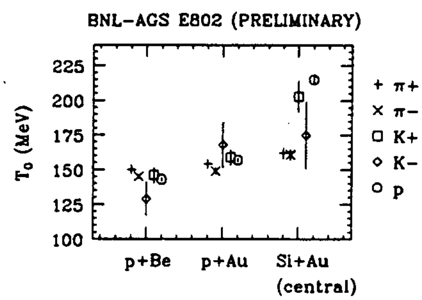

Fig. 1 Inverse slope parameters T_0 for $\pi^{\pm}$, $K^{\pm}$ and p, as obtained from the inclusive spectra between $1.2 \leq y \leq 1.4$ of pBe, pAu and central ^{28}Si + Au collisions. Preliminary data from E802 AGS collaboration.

Fig. 1 displays T_0 for $\pi^{\pm}$, $K^{\pm}$ and protons from pBe, pAu and central (i.e., high multiplicity) ^{28}Si + Au collisions, obtained from spectra measured within the rapidity range $1.2 \leq y \leq 1.4$.

The inverse slope parameters for K^+ and protons increase dramatically as one goes from light systems (pBe and pAu) to heavier systems (central ^{28}Si + Au), in stark contrast to the slope parameters of $\pi^\pm$.

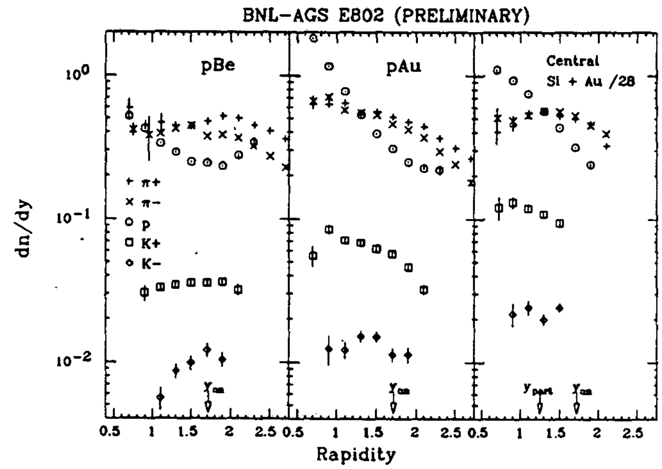

Fig. 2 dN/dy for $\pi^\pm$, $K^\pm$ and protons for pBe, pAu and central ^{28}Si + Au collisions. Note that dN/dy for central ^{28}Si + Au has been divided by the number of ^{28}Si projectile nucleons (= 28). Preliminary data from E802 AGS collaboration.

The invariant cross sections for the same systems were integrated to yield the rapidity densities dN/dy as a function of rapidity. Fig. 2 is a plot of dN/dy for $\pi^\pm$, $K^\pm$ and protons for pBe, pAu and central ^{28}Si + Au collisions. Note that for ^{28}Si + Au, the rapidity distributions for all particles have been divided by the number of ^{28}Si projectile nucleons (= 28). The rapidity distribution of K^+ differs significantly in shape and peak position from that of $\pi^\pm$ for central ^{28}Si + Au, even though they have similar shapes for pBe and pAu. In addition, dN/dy for $K^\pm$ increases more quickly than dN/dy for $\pi^\pm$ at all measured rapidities as one goes from pBe to central ^{28}Si + Au collisions. These facts strongly suggest that for heavy-ion collisions, $K^\pm$ and $\pi^\pm$ are produced via different mechanisms, presumably due to the presence of a large amount of nuclear matter.

2. E814

Brookhaven AGS Experiment 814 combines nearly complete 4π calorimetry with a high-resolution forward spectrometer. Details of the experimental setup may be found in reference 3. Data have been taken with a 14.6 A·GeV/c ^{28}Si beam on targets of Al, Cu and Pb in a program to investigate global energy flow as well as the simultaneous measurement of forward-going nucleon spectra ($\theta_{lab} < 1°$) in central relativistic heavy-ion collisions.

Energy flow is studied in a 992 element NaI(Tl) calorimeter surrounding the target and covering the pseudorapidity interval $-.5 < \eta < .8$. Distributions of transverse energy (E_T)

for the three targets are shown in Fig. 3. These data[3] have not been corrected for energy leakage due to the finite depth of the NaI(Tl) crystals. Superimposed on the data are spectra from the event generator HIJET[4] after tracking with the detector simulation program GEANT to properly include detector response and acceptance. Two separate HIJET predictions are shown for each target, representing the model with and without rescattering of the secondary particles within the target and projectile nuclei. The Pb target presents more opportunities for rescattering in spectator matter; HIJET can only reproduce these data if this process is included. The effect lessens, as expected, as the mass of the target decreases.

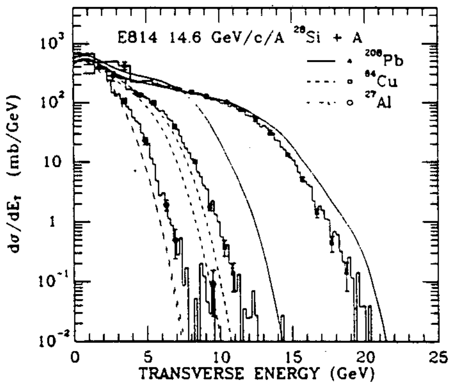

Fig. 3 Transverse energy (E_T) distributions[3] in the target calorimeter of E814 for ^{28}Si on Al, Cu and Pb. HIJET results are shown for each target with (upper curve) and without (lower curve) rescattering.

A more detailed picture of the collision may be obtained by studying the simultaneous distributions of forward-going nucleons. Reference 3 presents neutron rapidity distributions; the corresponding p_T spectra are shown here. E814 is unique in its ability to measure these distributions down to $p_T = 0$. Neutron kinetic energies and positions are measured in a series of six uranium-copper calorimeters.

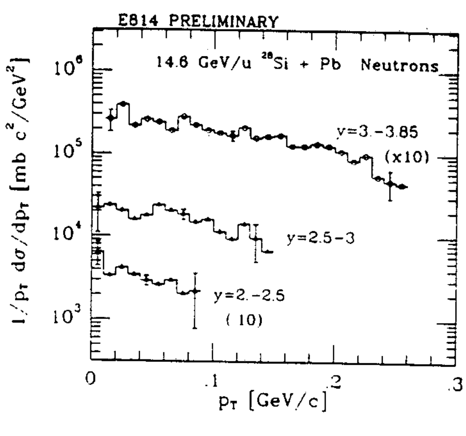

Fig. 4 Transverse momentum spectra of neutrons for ^{28}Si + Pb measured by E814[5] with E_T in the target calorimeter greater than 6 GeV, for various rapidity regions.

Shown in Fig. 4 are $(1/p_T)(d\sigma/dp_T)$ distributions of neutrons[5] in three rapidity regions for ^{28}Si on Pb. The distributions include all events with $E_T > 6$ GeV in the NaI(Tl) calorimeter, approximately 20% of the geometric cross section. The data are corrected for the acceptance of the forward spectrometer which, due to the constant cone angle, varies as a function of rapidity. The top curve corresponds to projectile fragmentation and is consistent in shape with the corresponding rapidity distribution[5]. Both are accounted for by the Fermi momentum distribution of nucleons in the fragmenting ^{28}Si nucleus. The two lower distributions, corresponding to nucleons that have interacted strongly, show the flat behavior expected for thermal distributions as $p_T \to 0$. Plans are now underway to increase the spectrometer acceptance, thereby extending these spectra to higher values of p_T, where their shape is more sensitive to the detailed emission mechanism.

3. E810

AGS Experiment 810 uses a Time Projection Chamber[6] (TPC) to measure all charged tracks forward of $\theta_{lab} \simeq 20°$. The TPC contains 36 rows of short anode wires which give 3-D space points but no dE/dx information. The data presented here are from a short run with a ^{28}Si beam in June 1989 using thin (< 0.01 radiation lengths) Au and Cu targets to reduce contamination of the events by electrons from converted π^0 photons. A multiplicity cut of 50 or more TPC tracks was used to select central collisions, yielding 2291 Au events and 2170 Cu events, corresponding to cross sections of 0.59 and 0.20 barns, respectively. These were the "central" samples for the charged particle distributions presented here.

Assuming the pion mass for all negative tracks, we obtain the acceptance-corrected π^- rapidity distribution shown in Fig. 5. The Cu and Au π^- distributions are very similar. By computing the rapidity of all tracks using the proton mass and subtracting the negatives from the positives, we obtain an approximation to the proton rapidity distribution. This "difference" distribution is also shown in Fig. 5, plotted one decade lower for clarity. The "protons" emerging from Cu are substantially more forward than those from Au.

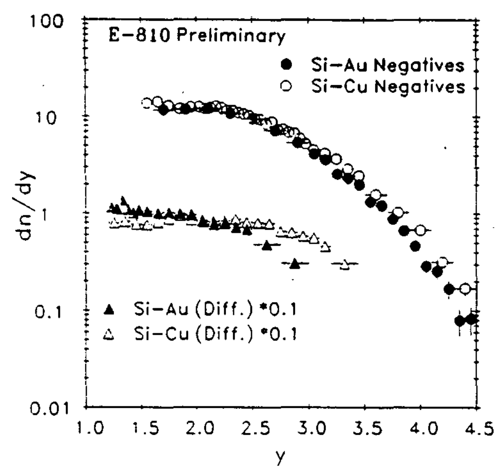

Fig. 5 Rapidity distribution of negatives (circles) and "difference" (scaled × 0.1), for ^{28}Si + Cu and Au.

In Fig. 6 the transverse momentum distribution $(1/p_\perp)(dn^2/dp_\perp dy)$ is plotted versus $m_\perp - m_o$. The pion mass is used for the negative spectra, the proton mass for the spectra obtained by subtracting the negatives from the positives. The negative spectra show substantial deviation from an exponential, unlike pion production in pp collisions in this energy region[7]. Since the electrons contribute less than 1% and the K^-/π^- ratio was measured by E802 to be about 4%[2], this effect represents an excess production of low $p_\perp$ pions in nuclear collisions.

The large aperture of the TPC detector yields a good acceptance for detecting Λ, $\bar{\Lambda}$ and K^0_s by the characteristic V^0 decay. We have reconstructed approximately 750 (850)

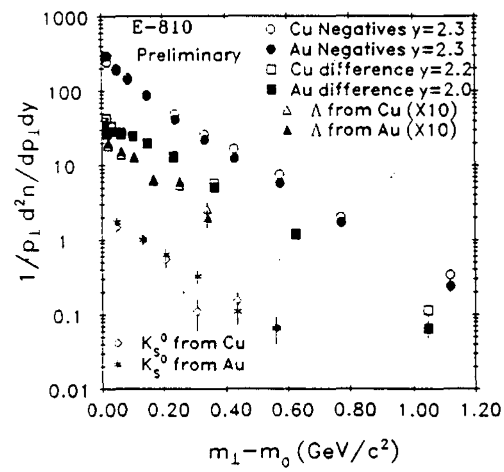

Fig. 6 Transverse momentum spectra of pions, protons, K_s^0 and Λ ($\times 10$), for ^{28}Si + Cu and Au.

Λ and 300 (400) K_s^0 from the Au (Cu) events[8]. The $m_\perp$ distributions for Λ's in the region $1.2 < y(\Lambda) < 3.0$ and K_s^0's in the region $2.2 < y(K_s^0) < 3.0$ are also plotted in Fig. 6. The Λ points are plotted one decade high for clarity. The V^0 data correspond to "central" events with no multiply-charged projectile fragments, as determined by a veto counter behind the TPC. Using a negative particle multiplicity cut to select events of yet greater centrality we measure a small sample with a net Λ yield of 1.9 ± 0.2 per ^{28}Si + Au event in our rapidity region. When we remove the Λ and the K_s^0 tracks, and plot the effective mass for the $\pi^+\bar{p}$ hypothesis, no detectable $\bar{\Lambda}$ signal is observed. With a 95% confidence upper limit, $n(\bar{\Lambda})/n(\Lambda) < 0.07$.

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