Proc. HIPAGS Workshop
Brookhaven National Laboratory, Upton, NY
March 5-7, 1990

CONF-900331--8
BNL-44672

BNL--44672
DE90 012112

Spectra and Strangeness Production

E802 collaboration
Yasuo MIAKE, BNL

E-802 Collaboration, Brookhaven National Laboratory, Upton, NY 11973
ANL-BNL-UCBerkeley-UCRiverside-Columbia-Hiroshima-INS-Kyushu-LLNL-MIT-Tokyo

Abstract

Particle production ($\pi^{\pm}$, $K^{\pm}$ and $p^{\pm}$) has been measured in p+A and Si+A reactions using the E802 spectrometer. The comparison of the particle production (rapidity distributions, momentum distributions, and the integrated yields ratios) between p+Be, p+Au and central Si+Au collisions and the effects of rescattering is discussed.

1 Introduction

The experiment E802 has a magnetic spectrometer with good particle identification and with various event characterization detectors for the selection of charged multiplicity, neutral transverse energy and forward energy. The E802 experimental apparatus is shown in Fig. 1 and is described in Ref.[1]. The main spectrometer consists of dipole magnet ($\leq$ 1.5 Tm), high-multiplicity tracking-chambers (T1,T2,T3 and T4)[2], and the particle identification (PID) detectors (AERC[3], TOF[4] and GASČ). For the event characterization, we have target multiplicity array (TMA), a lead glass calorimeter (PBGL) and a zero degree calorimeter (ZCAL)[5].

By using the time-of flight counter which has a timing resolution of $\sigma_{tof} \approx 75\ ps$, kaons and pions are identified up to 2.5 GeV/c. The Gas Čerenkov counter extends PID up to 5 GeV/c. In Fig. 2, PID with the time-of flight counter is shown. For the data shown in this paper, PID is done solely by the time-of flight counter.

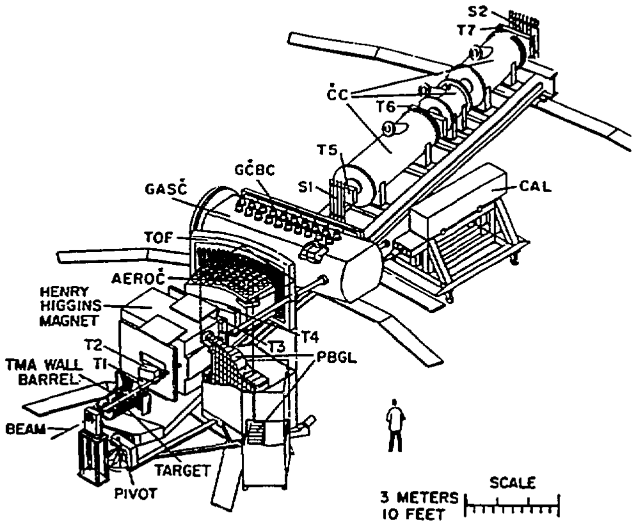

Figure 1: The E802 experimental setup[1]. The single arm spectrometer with 25 msr of solid angle, Čerenkov complex, and event characterization detectors.

In order to clarify the difference between pp, pA and AA reactions, we compare p+Be ($\approx pp$), p+Au, and central Si+Au, which is the largest colliding system available at AGS now.

2 Particle spectra

Particle spectra obtained in the central Si+Au collisions at the rapidity $1.2 \leq y \leq 1.4$ are shown in Fig. 3[7]. Invariant cross sections per central triggers are plotted against the transverse kinetic energy, $T_{\perp}$. The central trigger is obtained by requiring upper $\approx 7\%$ of charged particle multiplicity distribution in TMA. These spectra seem to be well described by a simple exponential shape. At Cern, WA80 and other experiments have observed the increase of the slope in the low p_t region of π spectra[8]. Within the E802 acceptance, $p_t \geq 0.3\ GeV/c$ at $2.0 \geq y \geq 0.6$, no such second component is observed. If there is such a second component below the E802 acceptance limit, with steeper slope by a factor of $2 \sim 3$, we would underestimate

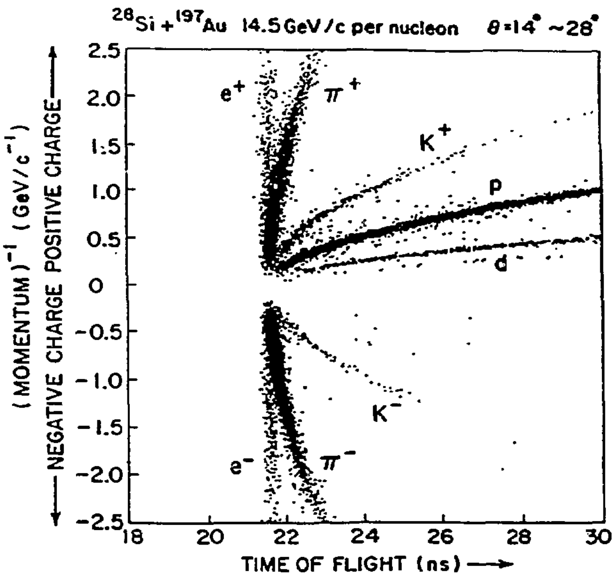

Figure 2: Scatter plot between TOF and the inverse of momentum for positive and negative charge particles [1,6].

the pion yield by 10 ~ 20%. Obviously, this missing second component is not enough to explain the discrepancy of theoretical calculations from the measured pion yield [1].

As seen in Fig.3, the slopes of proton and kaon distributions are less steep than those of pions in central Si+Au collisions: $T_{p,K^+} > T_{\pi^\pm}$. It is observed that $T_{\pi^\pm}$ stays 140 ~ 160 MeV over the measured rapidity region ($y = 0.7 \sim 2.0$) with a tendency of getting smaller at high rapidity region, while T_p shows clear rapidity dependence, having a maximum at mid-rapidity. The difference of behaviour between T_p and $T_{\pi^\pm}$ is also seen in centrality dependence: T_p increases from minimum bias to central collisions, while T_π does not increase much. According to the p+A measurement at the energy of 14.6 GeV/c with the E802 spectrometer, all the particles in p+A collisions also show the exponential shape in m_t, but, the inverse slope parameters, T, for p, K^+ and $\pi^\pm$ are almost the same, $T_{p,K^+,\pi^\pm} = 140 \sim$

[1]For example, FRITIOF[9] predicts roughly a factor of 2 larger pion yield than the measured yield.

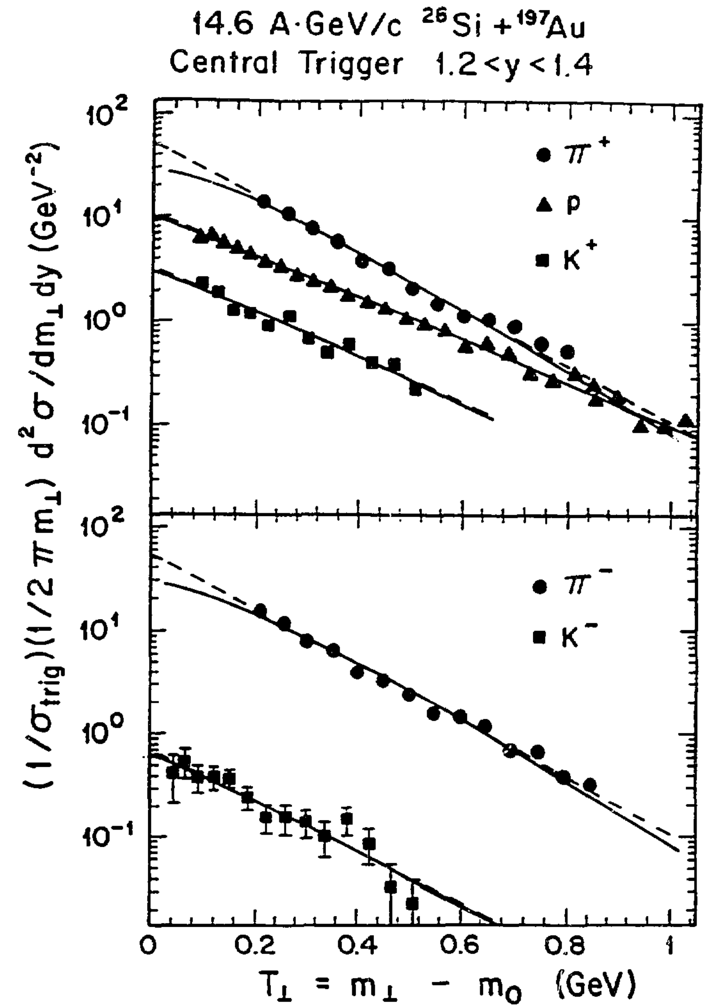

Figure 3: Invariant cross sections per central trigger versus $T_\perp$ for $\pi^\pm$, $K^\pm$, and proton in the rapidity range $1.2 \le y \le 1.4$[7].

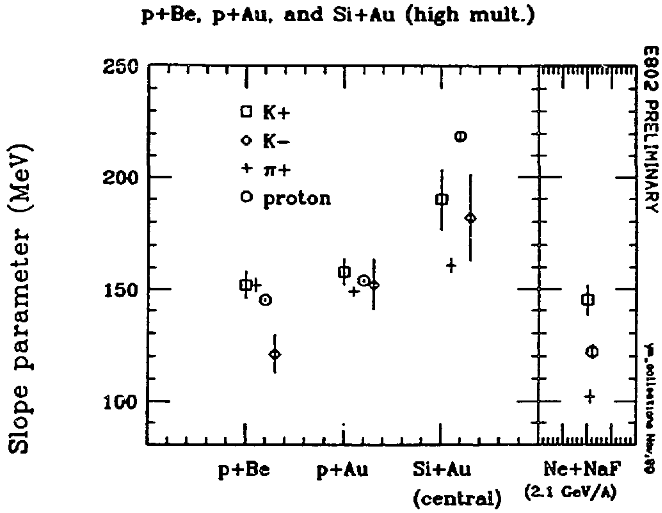

Figure 4: The inverse slope parameters for proton, K^+ and π^+ at $1.0 \leq y \leq 1.5$ in p+Be, p+Au and central Si+Au collisions. Also Bevalac data shown[10].

160 MeV at $1.0 \leq y \leq 1.5$.

The increase of the slope parameters of proton and K^+ seems to be a heavy ion effect[2]. The inverse slope parameters at $1.0 \leq y \leq 1.5$ observed in p+Be, p+Au and central Si+Au collisions are summarized in Fig. 4.

3 The dn/dy distributions

By integrating the $T_\perp$ spectra with the assumption of the exponential shape, multiplicity of each particle per trigger, dn/dy, is obtained for $\pi^\pm$, $K^\pm$ and proton as shown in Fig. 5. The rapidity of nucleon-nucleon center of mass, y_{nn}, and the center of mass rapidity for the participant nucleons, y_{part}, are also shown.

Both $\pi^\pm$ and K^+ show a broad peak, but a distinct difference is seen: the K^+ peaks at lower rapidity than $\pi^\pm$'s. While the $\pi^\pm$'s maximum lies in between y_{nn} and y_{part}, the K^+'s maximum is lower than the $\pi^\pm$'s peak and

[2]At the Bevalac, $T_0(\pi) < T_0(p) < T_0(K^+)$ was observed at 2.1 GeV/A Ne+NaF collision. This relation is discussed in terms of the mean free path differences[10].

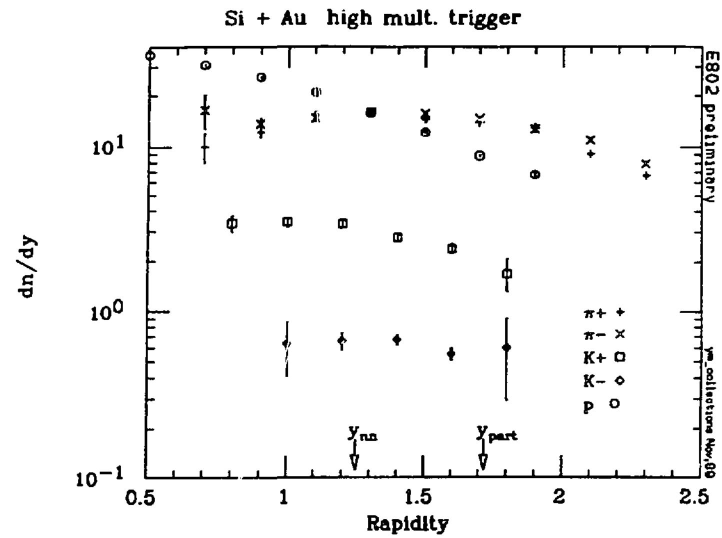

Figure 5: Rapidity distribution, dn/dy for $\pi^{\pm}$, $K^{\pm}$, and protons in central Si+Au collisions. The rapidity of nucleon-nucleon center of mass, y_{nn}, and the center of mass rapidity for the participant nucleons, y_{part}, are also shown.

is even lower than y_{part}! This may be an evidence of rescattering effects in the K^+ production. Either the K^+ production by an intra-nuclear cascade process (for example, the K^+ production via $\pi n \rightarrow K^+\Lambda$) or a rapidity shift of K^+ (or its parent particle) by rescatterings may be a possible explanation. The dn/dy ratio of K^+ to π^+, K^+/π^+, obtained in Fig.5 for the central Si+Au, is $\approx$ 16 % at $y = 1.5$ and $\approx$ 20 % at $y = 0.6$ while the K^-/π^- stays $\approx$ 5 % within the errors.

In Fig. 6, the dn/dy distributions are compared for p+Be, p+Au and central Si+Au collisions. In this figure, the central Si+Au data are plotted as $(dn/dy)/28$ for comparison. In p+Be collisions, $\pi^{\pm}$ and K^+ show broad or almost flat rapidity distributions, which might be symmetric with respect to y_{nn}. The π^+ yield at $y \geq 2$ is $\approx$ 30 % larger than π^-yield, which is known as the projectile fragmentation. The K^+/π^+ is $\approx$ 8 %, which is the same as the pp data[11] (6 $\pm$ 2 %). The K^-/π^- is $\approx$ 2 %, which is also consistent with the pp data (2.4 $\pm$ 2.0 %).

In p+Au collisions, the shapes of the dn/dy distributions are different from those of the p+Be collisions. The distributions for pions and for K^+

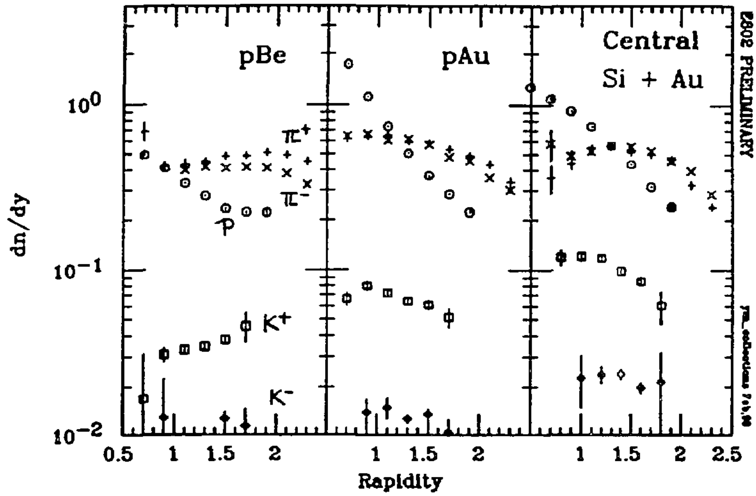

Figure 6: Rapidity distribution, dn/dy for $\pi^{\pm}$, $K^{\pm}$, and protons in p+Be, p+Au, and central Si+Au collisions. The central Si+Au data are plotted as $(dn/dy)/28$.

shift towards target rapidity, which is not seen in FRITIOF predictions. The yield for π^+ and π^- are the same within 10 %. The K^+/π^+ is about 12 % at mid-rapidity, which is larger than the one in p+Be, with the tendency of getting larger at lower rapidity, while the K^-/π^- stays the same as the one in p+Be.

Interesting features are observed in p+Au: The cross over of $(dn/dy)_{\pi^+}$ between p+Be and p+Au is seen at $y \sim 1.7$. The π^+ yield in p+Au is smaller than the one in p+Be at $y \geq 2$! The integrated yield over the measured rapidity range ($0.6 \leq y \leq 2.0$) increases only by a factor of 1.2 from p+Be to p+Au for π^+ [3]. These ratio is smaller than the scaling factor observed at higher energy experiment[12], $(1+\nu_{pAu})/(1+\nu_{pBe}), \approx 1.9$, where ν is the average number of collisions. These facts might relate to the stopping picture at AGS energy [13,14]: after passing through the thickness of Au target, the projectile does not have enough energy to produce pions.

In Fig. 6, the gradual K^+ enhancement from p+Be to p+Au and to central Si+Au is clearly seen. The K^- yield seems to stay the same from p+Be to p+Au, but, from p+Au to central Si+Au and there may be an

[3] 1.5 for π^- and 2.0 for K^+.

enhancement,which may imply the secondary production of kaons via $\pi\pi \rightarrow K^+K^-$ in the central Si+Au collisions. We need more statistics to confirm this effect.

4 Summary

Particle production ($\pi^\pm, K^\pm, p^\pm$) has been measured in both Si+A and p+A collisions using the E802 spectrometer. The invariant cross sections are well described by an exponential in m_t. The inverse slope parameters, T, in p+A collisions are observed as: $T_{p,K^+,\pi^\pm} = 140 \sim 160\ MeV$, while in central Si+Au collisions, $T_{p,K^+} > T_{\pi^\pm} \approx 140 \sim 160\ MeV$ at mid rapidity.

In p+Au, rapidity distributions for $\pi^\pm$ and K^+ shift towards the target rapidity. The pion yield at high rapidity in p+Au is smaller than the one observed in p+Be. This effect might be related to the degree of stopping at AGS energy.

In central Si+Au, the rapidity distributions show a broad peak for $\pi^\pm$, K^+ with the K^+ peaking at lower rapidity than $\pi^\pm$'s and y_{part}. This may be an evidence of rescattering effects. The dn/dy ratios for K^+ to π^+ show a gradual increase from p+Be to p+Au to central Si+Au collisions at mid rapidity, while the K^- to π^- ratios stay the same within errors.

This work has been supported by the U.S. Department of Energy and by the U.S.-Japan High Energy Physics Collaboration Treaty.

References

[1] E802 collaboration, T. Abbott et al. Nucl. Inst. and Meth in press.

[2] G. Stephans et al. to be submitted to Nucl. Inst. Meth.

[3] P. Vincent, R. Debbe, A. Pfoh, and M. Abreu, Nucl. Inst. Meth. A272(1988)660.

[4] T. Sugitate et.al. Nucl. Inst. and Meth. A249(1986)354.

[5] D. Beavis et.al. Nucl. Inst. Meth. A281(1989)367.

[6] E802 collaboration, Y. Miake et al., Z. Phys. C38(1988)135.

[7] E802 collaboration, T. Abbott et al. Phys. Rev. Lett. 64(1990)849.

[8] WA80 collaboration, R. Santo et al. Nucl. Phys A498(1989)391c, NA35 collaboration, J.W. Harris, et al. Nucl. Phys. A498(1989)133c. NA34 collaboration, J. Schukraft, et al. Nucl. Phys. A498(1989)79c.

[9] B. Nilsson-Almqvist, E. Stenlund, Comp. Phys. Commun. 43(1987)387; B. Andersson, G. Gustafson, and B. Nilsson-Almqvist, Nucl. Phys. B281(1987)289.

[10] S. Nagamiya, Phys. Rev. Lett. 49(1982)1383.

[11] J.V. Allaby et al., CERN Preprint 70-12(1970); H. Bøggild, et al., Nucl. Phys. B57(1973)77; D. Dekkers et al., Phys. Rev. 137(1965)B962; U. Becker et al., Phys. Rev. Lett. 37(1976)1731.

[12] W. Busza et al. Phys. Rev. Lett. 34(1975)836.

[13] E802 collaboration, T. Abbott et al. Phys. Lett. B197(1987)285.

[14] E814 collaboration, J. Barrette at al. Phys. Rev. Lett. 64(1990)1219.