Presented at QUARK MATTER '90
Menton, France
May 7-11, 1990

BNL--44898

DE90 016325

PARTICLE PRODUCTION IN Si + A AND p + A COLLISIONS AT 14.6 A·GeV/c

Presented by Yasuo MIAKE, BNL

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

T. ABBOTT[4], Y. AKIBA[7], D. ALBURGER[2], D. BEAVIS[2], M.A. BLOOMER[10], P.D. BOND[2], C. CHASMAN[2], Z. CHEN[2], Y.Y. CHU[2], B.A. COLE[10], J.B. COSTALES[10], H.J. CRAWFORD[3], J.B. CUMMING[2], R. DEBBE[2], J. ENGELAGE[3,9], S.Y. FUNG[4], L. GRODZINS[10], S. GUSHUE[2], H. HAMAGAKI[7], O. HANSEN[2], R.S. HAYANO[11], S. HAYASHI[7], S. HOMMA[7], H.Z. HUANG[10], Y. IKEDA[8], I. JURICIC[5], S. KATCOFF[2], S. KAUFMAN[1], K. KIMURA[8], K. KITAMURA[6], K. KURITA[5], R.J. LEDOUX[10], M.J. LEVINE[2], Y. MIAKE[2], R.J. MORSE[10], B. MOSKOWITZ[2], S. NAGAMIYA[5], J. OLNESS[2], C.G. PARSONS[10], L.P. REMSBERG[2], H. SAKURAI[11], M. SARABURA[10], P. STANKUS[5], S.G. STEADMAN[10], G.S.F. STEPHANS[10], T. SUGITATE[6], M. TANAKA[2], M.J. TANNENBAUM[2], M. TORIKOSHI[7], J.H. VAN DIJK[2], F. VIDEBAEK[1], M. VIENT[4], P. VINCENT[2], V. VUTSADAKIS[10], W.A. WATSON III[2], H.E. WEGNER[2], D.S. WOODRUFF[10], Y.D. WU[5], AND W. ZAJC[5]

[1] Argonne National Laboratory, Argonne, IL 60439-4843
[2] Brookhaven National Laboratory, Upton, NY 11973
[3] University of California, Space Sciences Laboratory, Berkeley, CA 94720
[4] University of California, Riverside, CA 92507
[5] Columbia University, New York, NY 10027 and Nevis Laboratories, Irvington, NY 10533
[6] Hiroshima University, Hiroshima 730, JAPAN
[7] Institute for Nuclear Study, University of Tokyo, Tokyo 188, JAPAN
[8] Kyushu University, Fukuoka 812, JAPAN
[9] Lawrence Livermore National Laboratory, Livermore, CA 94550
[10] Massachusetts Institute of Technology, Cambridge, MA 02139
[11] Department of Physics, University of Tokyo, Tokyo 113, JAPAN

Particle production ($\pi^{\pm}$, $K^{\pm}$, p) has been measured in both Si+A and p+A collisions at 14.6 A·GeV/c. Comparisons of m_t and dn/dy distributions between p+Be, p+Au and central Si+Au collisions are discussed.

1. INTRODUCTION

Since 1986, heavy ion beams of ^{16}O, ^{28}Si accelerated at 14.6 A·GeV/c at the BNL-AGS by using the Dual Tandem Van de Graafs as an injector have been available for the experimental program. A booster synchrotron, now being under construction, will provide heavy ion beams up to Au nuclei in '92. As shown in Fig. 1, the experiment E802 has a magnetic spectrometer with various event characterization detectors for the selection of charged multiplicity, neutral transverse energy and forward energy. Details of the experimental apparatus are described in Ref. 1.

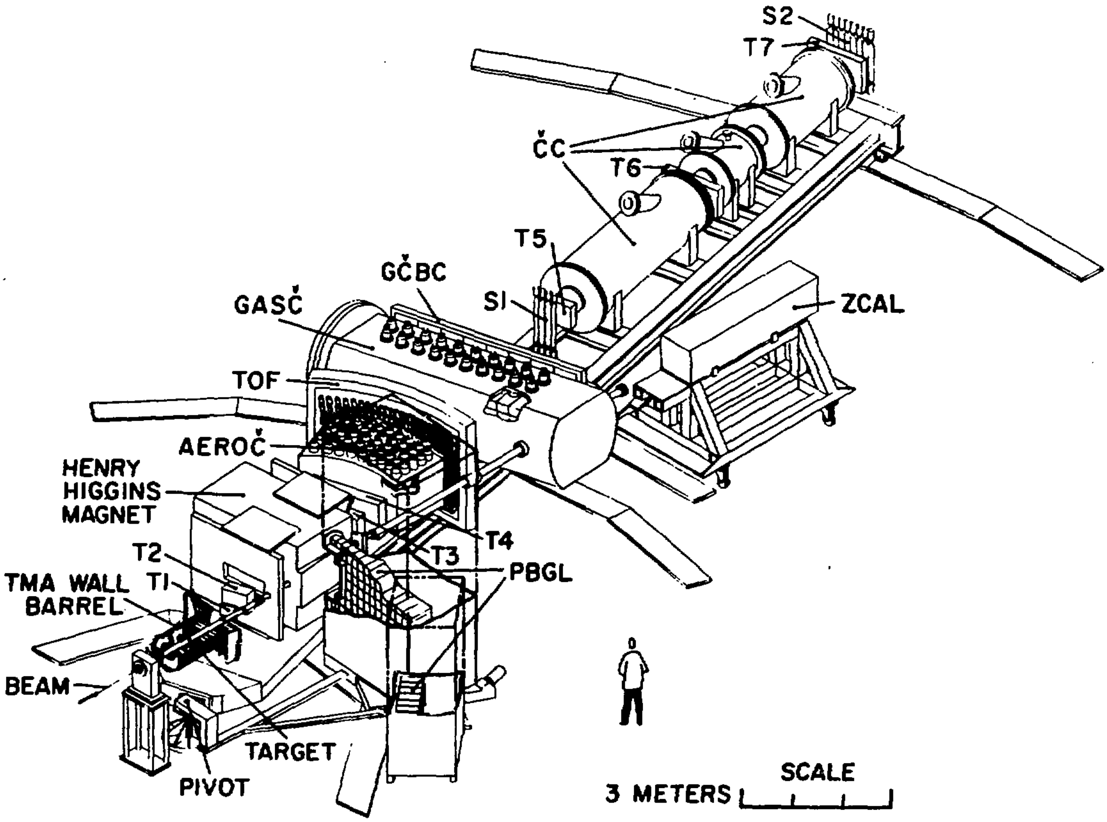

FIGURE 1
The E802 experimental setup[1]. Combination of a time-of flight (TOF) and a segmented gas Cerenkov counter (GASC) enables particle identification up to 3.5 GeV/c.

2. PARTICLE SPECTRA

Particle spectra obtained in a) p+Be, b) p+Au and c) the central Si+Au collisions at the rapidity $1.2 < y < 1.4$ are shown in Fig. 2. Invariant cross sections are plotted as a function of transverse kinetic energy, $T_{\perp} = m_t - m_0$, where $m_t = \sqrt{p_t^2 + m_0^2}$ is the transverse mass, p_t is the transverse momentum, and m_0 is the rest mass. The central trigger in Si+Au is obtained by requiring the upper ≈ 7 % of the charged particle multiplicity distribution in TMA. For p+A data, the particle identification has been done by a combination of a time of flight counter and a segmented gas Cerenkov counter. For Si+Au data, taken before the installation of the segmented gas Cerenkov counter, the particle identification was done solely by time of flight. As seen in the figure, the spectra of all the particles in both p+A and Si+A are well described by exponential in m_t, as seen in p-p collisions[3]. The inverse slope parameters, T_0, obtained by an exponential fit, $\exp(-m_t/T_0)$ to the spectra are plotted in Fig. 2d). Here, one can see a clear heavy ion effect: in central Si+Au, $T_0(p, K^+) \approx 210 \pm 10$ MeV > $T_0(\pi^\pm) \approx 150 \pm 10$ MeV, while in p+A, $T_0(\pi^\pm) \approx T_0(K^+) \approx T_0(p) \approx 150 \pm 10$ MeV, at $1.2 < y < 1.4$. At the Bevalac, larger T_0 for proton and K^+ was also observed at 2.1 A·GeV Ne+NaF collisions: $T_0(\pi) < T_0(p) < T_0(K^+)$[4]. There are a variety of attempts to explain the different T_0 for different particle species in heavy ion collision[5].

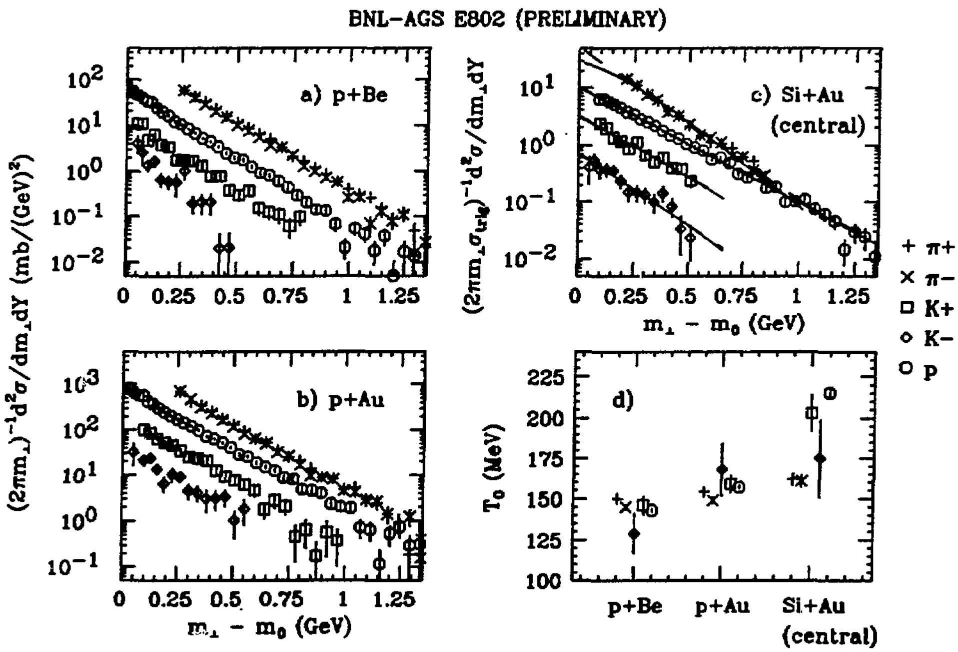

FIGURE 2

Invariant cross sections versus $T_\perp$ for $\pi^\pm$, $K^\pm$, and proton in the rapidity range $1.2 < y < 1.4$ in a) p+Be, b) p+Au, and c) central Si+Au[2]. The error bars in the figure show statistical uncertainties. d) Inverse slope parameters obtained in p+Be, p+Au and central Si+Au collisions at $1.2 < y < 1.4$.

3. RAPIDITY DISTRIBUTIONS

By integrating the $T_\perp$ spectra over the entire $T_\perp$ range with the assumption of the exponential shape, the rapidity distributions, $dn/dy = 1/\sigma_0 \, (d\sigma/dy)$, are obtained. Here, σ_0 is the inelastic cross section[6] for p+A and the trigger cross section for central Si+Au collisions. In Fig. 3, the dn/dy distributions are compared for p+Be, p+Au and central Si+Au collisions. The Si+Au data has narrower rapidity coverage due to the limited particle identification. The central Si+Au data are plotted as (dn/dy)/28 for comparison with p+A data.

In p+Be collisions, $\pi^\pm$ and K^+ show very broad distributions and they are roughly symmetric with respect to the nucleon-nucleon center of mass rapidity, y_{nn}. In p+Au, however, dn/dy distributions are not symmetric with y_{nn}: distributions shift towards the target rapidity. At $y > 2$, π^+ yield in p+Be is larger than π^- yield, which might be due to projectile fragmentation. At the same rapidity region, fewer particles (especially pions) are found in p+Au than in p+Be. On the other hand, a clear increase of particle production at lower rapidity region is observed from p+Be to p+Au, especially for $K^\pm$ and protons. The dn/dy in p+Au for protons increases very rapidly at lower rapidity and shows a target mass dependence of >A at $y < 1$.

The rapidity of y_{nn} and y_{part} are shown on the abscissa of the central Si+Au data in Fig. 3. Here, y_{part} is the center of mass rapidity of clean-cut participant nucleons, which are composed of incident Si and a core of 75 Au nucleons. Clear difference in shape is seen between pions and K^+'s in central Si+Au: the K^+ peaks at lower rapidity than $\pi^\pm$'s. While the $\pi^\pm$'s peak lies in between y_{nn} and y_{part}, the K^+'s peak is lower than y_{part}! Theoretical interpretation for this is still an open question, but this could be evidence of rescattering effects, which would also be consistent with the flatter $T_\perp$ distribution of K^+.

The dn/dy for K^+'s per projectile nucleon increases from p+Be, p+Au to central Si+Au, while it stays roughly the same for pions. Therefore, the increase of K^+/π^+ ratios ($\approx$8%, $\approx$13%, $\approx$20% at mid rapidity in p+Be, p+Au, central Si+Au, respectively) is due to the K^+ enhancement rather than the π^+ suppression. A hint of K^- enhancement from p+Au to central Si+Au is also observed. The enhanced K^+/π^+ ratio in heavy ion collisions has received much theoretical attention[7].

The integrated yield ratio between p+Be and p+Au over the measured region ($0.6 < y < 2.6$ for pions, $0.6 < y < 2.2$ for kaons, $0.6 < y < 2.4$ for protons) is 1.08 ± 0.03 for π^+, 1.27 ± 0.05 for π^-, 1.81 ± 0.18 for K^+ and 1.95 ± 0.02 for protons. From the neutral transverse energy and the beam rapidity particle measurements in the heavy ion collisions[8], it is believed that the projectile exhausts most of its energy after a few nucleon-nucleon collisions at AGS energy. Based on this energy loss argument, the K^+ yield ratio should be as small as pion's, and then, the measured large K^+ yield ratio suggests that copious K^+ are produced in secondary reactions (ex., π n -> K^+ Λ), while pions are not, which seems to be puzzling. The difference between pion and K^+ production is very interesting and is a key question to be answered for the understanding of the large K^+/π^+ yield ratio in heavy ion collisions.

In order to study the effect of selecting central collisions in p+Au, high multiplicity events have been analyzed. Particle production shifts more towards the target rapidity and slight increase in dn/dy for K^+ is observed. The K^+/π^+ ratios are found to be in between those for central Si+Au and minimum bias p+Au. Detailed analysis of high multiplicity p+Au collisions will be reported elsewhere.

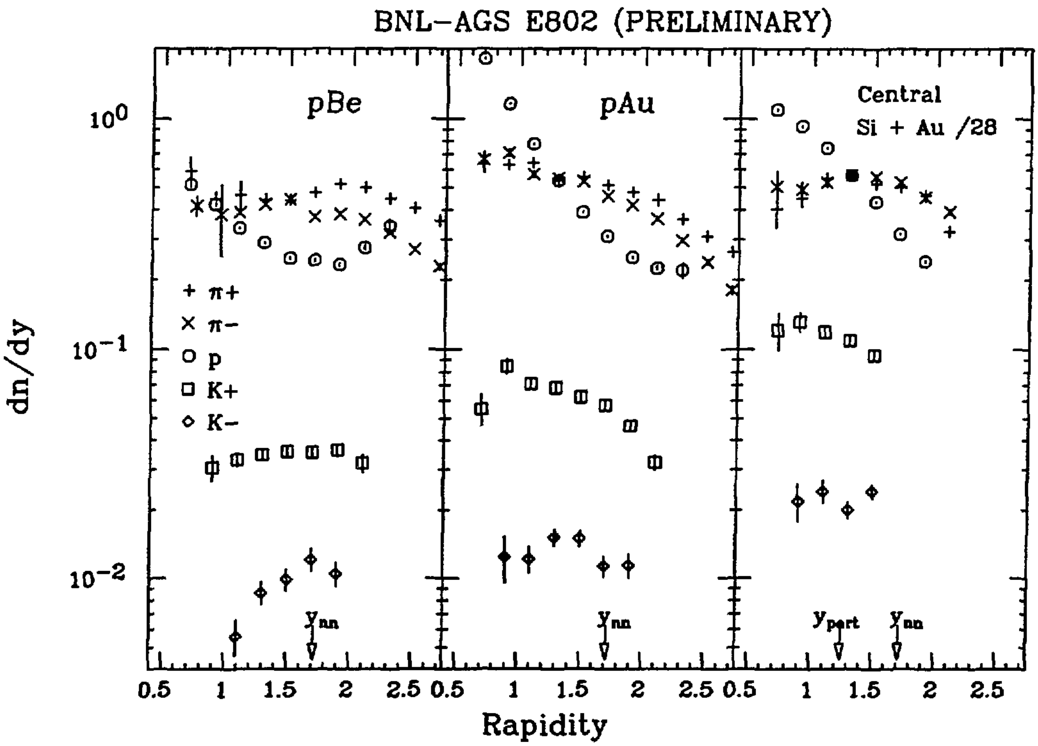

FIGURE 3

Rapidity distributions of $\pi^\pm$, $K^\pm$ and protons in p+Be, p+Au and central Si+Au[2] collisions at 14.6 A·GeV/c. The central Si+Au data are plotted as (dn/dy)/28 for comparison. The error bars show statistical uncertainties.

4. SUMMARY

In conclusion, particle production ($\pi^\pm$, $K^\pm$, p) has been measured in both Si+A and p+A collisions at 14.6 A·GeV/c. The invariant cross sections are well described by an exponential in m_t. The inverse slope parameters, T_0, obtained by an exponential fit, $\exp(-m_t/T_0)$, to the invariant cross section in p+A collisions are observed as: $T_0(p, K^+, \pi^\pm) = 150 \pm 10$ MeV, while in central Si+Au collisions, $T_0(p, K^+) \approx 210 \pm 10$ MeV $> T_0(\pi^\pm) = 150 \pm 10$ MeV at mid rapidity. In p+Au, rapidity distributions for $\pi^\pm$ and K^+ shift towards the target rapidity, while in p+Be they are broad and symmetric with respect to y_{nn}. 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}. The gradual increase of dn/dy for K^+'s per projectile nucleon from p+Be to p+Au and to central Si+Au collisions is observed, while it stays roughly the same for pions. A hint of K^- enhancement in central Si+Au collisions is also seen.

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

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