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A REVIEW OF RECENT E802 RESULTS

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ABSTRACT

Some recent results are presented from AGS E802, a survey experiment which is studying reactions of 14.6 $A \cdot GeV$ beams of protons, ^{16}O and ^{28}Si on targets ranging from ^{9}Be to ^{197}Au . Spectra for the global forward and transverse energy are shown; in nucleus-nucleus collisions these two quantities are anticorrelated, consistent with a large amount of stopping. Slope parameters from inclusive particle spectra are presented, with the most interesting effect being an apparent "heating" of mid-rapidity protons which emerge from the collisions of the largest nuclei. Also given are preliminary data on the production of antiprotons.

1. Overview of E802

Systematic study of relativistic heavy ion collisions is crucial in understanding hadronic matter under conditions of extreme energy and baryon density. Towards this goal, BNL AGS Experiment 802 has an ongoing program using beams of protons, ^{16}O and ^{28}Si at 14.6 $A \cdot$GeV on targets ranging from ^{9}Be to ^{197}Au . The main tool consists of a 25 msr magnetic spectrometer with clean particle identification which swings to cover the laboratory polar angles $5° \leq \theta \leq 55°$. This is complemented by several types of global event characterization.

The spectrometer has an analyzing dipole magnet with $\int Bdl \leq 1.5$ T-m, and tracking is performed by four projective geometry drift chambers. Momenta of charged particles are determined for $0.5 \leq p \leq 5$ GeV/c with a resolution of $\Delta p/p \approx 0.5\%$. Particle identification for pions, kaons and protons with $p < 2.2$ GeV/c is accomplished by a time-of-flight (TOF) wall with an rms timing resolution of 75 ps which is located 6.5 m downstream of the target. Further identification up to 5.0 GeV/c is performed by a segmented gas Čerenkov counter behind the TOF wall.

There are three detectors for characterizing events globally. The first is the Target Multiplicity Array (TMA), a set of proportional streamer tubes which measures the multiplicity of all charged particles in the region $6° \leq \theta \leq 149°$. A central trigger on the highest 7% of the TMA distribution is formed in hardware. Second is the lead-glass array (PBGL) of 245 blocks covering $8° \leq \theta \leq 32°$ and 180° in azimuth. The PBGL is most sensitive to electromagnetic radiation, but also responds to relativistic charged hadrons; it provides a good measure of the global pion yield in the central rapidity region. Finally, the zero-degree calorimeter (ZCAL) is a iron-scintillating stacked array which measures the projectile spectator energy for $0° \leq \theta \leq 1.6°$. For more details concerning the apparatus, see Ref. 1 .

2. Forward and Transverse Energy

The differential cross-section versus ZCAL forward kinetic energy, T_{zcal} , is shown in Fig. 1a. Note that T_{zcal} is proportional to the number of spectator projectile nucleons. For all targets, a peak appears at $T_{zcal} \approx T_{beam}$, as is expected for peripheral reactions. An interesting feature is the large cross-section for Si+Au near $T_{zcal} = 0$, indicating that the Au target is thick enough to "stop" the incident nucleons in the most central reactions.

Evidence that the forward beam energy is being converted into transverse energy of produced particles is shown in Fig. 1b, where the mean value of E_T^{PbGl} measured by the PBGL is seen to be anti-correlated with T_{zcal} . Here the global transverse energy is defined by

$$E_T^{PbGl} = \sum_{\text{PBGL blocks } i} E_i \sin\theta_i \quad , \tag{1}$$

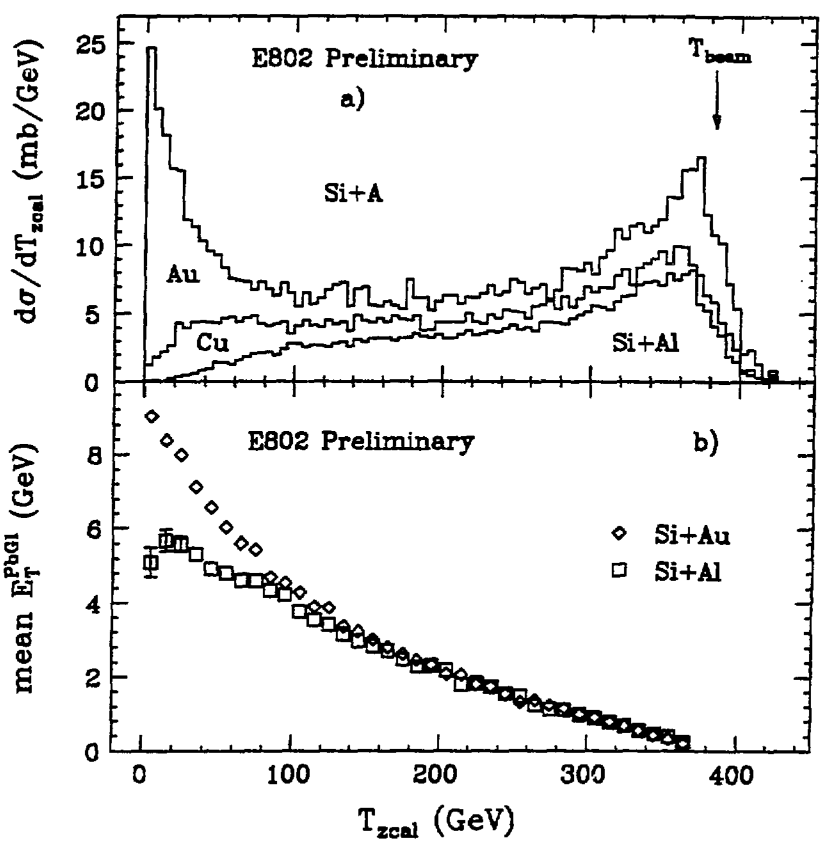

Fig. 1. a) Differential cross-section in forward kinetic energy measured by ZCAL for Si+A. b) mean E_T^{PbGl} versus forward kinetic energy for Si+A.

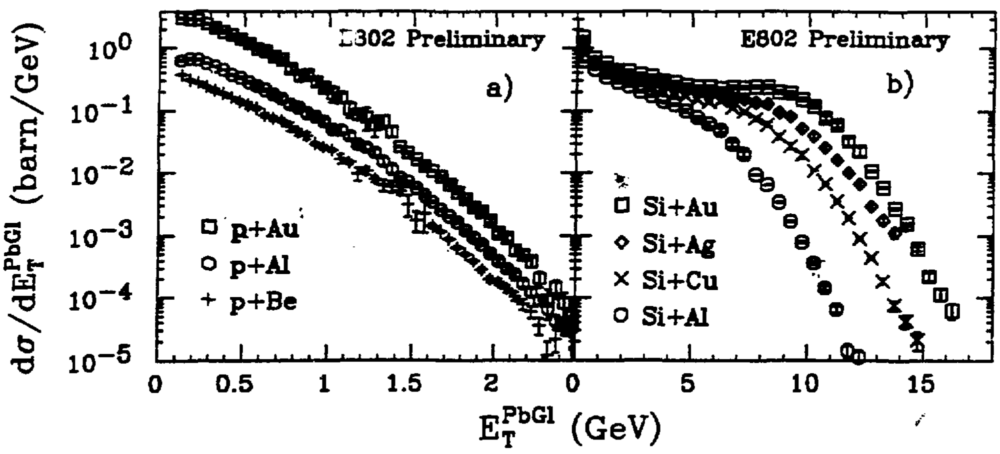

Fig. 2. Transverse energy spectra in the PBGL a) for p+A reactions. b) for Si+A reactions.

where E_i is the energy deposited in block i and θ_i is the polar angle to block i from the target. For peripheral reactions with $T_{zcal} > 150$ GeV, the curves for Si+Al and Si+Au appear identical; however, evidence for greater particle production in Si+Au than in Si+Al appears for the most central reactions ($T_{zcal} < 50$ GeV.)

The differential cross-section $d\sigma/dE_T^{PbGl}$ is shown in Fig. 2a for p+A reactions, and in Fig. 2b for Si+A reactions. Over five decades of cross-section, the shapes of the p+A spectra appear remarkably independent of the target. Indeed, the p+ ^{9}Be spectrum — which is very close to p+p — differs from the p+ ^{197}Au spectrum by only a geometric factor, and we conclude that particle production in p+A is dominated by the *first* collision of the incident proton with a target nucleon. The shapes of the Si+A E_T^{PbGl} spectra depend more on nuclear geometry; but, the high-energy "tail" of the Si+ ^{108}Ag distribution is clearly observed to be following that of Si+ ^{197}Au . This indicates an exhaustion of the ability to produce particles in targets of Ag and heavier.

3. Slope Parameters from Inclusive Spectra

Inclusive spectra for $\pi^{\pm}$, $K^{\pm}$ and $p^{\pm}$ as measured in the main spectrometer have been previously reported[2,3,4] . For the case of central (TMA-triggered) Si+Au, Fig. 3 shows the invariant cross-section, $E\cdot d^3N/dp^3$, versus $m_\perp - m$, where $m_\perp = \sqrt{p_\perp^2 + m^2}$ and m is the rest mass. The rapidity bin is $1.2 \leq y \leq 1.4$; for comparison, the nucleon-nucleon center-of-mass rapidity, y_{NN} , is 1.72. Note that *within the acceptance of*

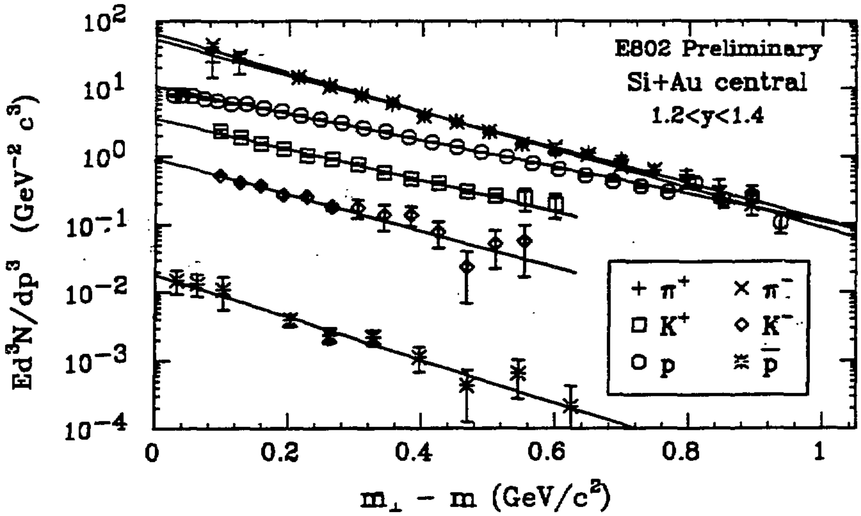

Fig. 3. Invariant cross-sections at $1.2 \leq y \leq 1.4$ for central Si+Au. The lines are fits of the form given in Eq. 2.

this experiment the spectra are well described by simple exponentials:

$$E\frac{d^3N}{dp^3} \propto e^{-m_\perp/T_0} \quad , \qquad (2)$$

where T_0 is the (inverse) slope parameter, sometimes called the "temperature."

Values of the slope parameter near mid-rapidity[3] are displayed in Fig. 4a for minimum bias p+Be, minimum bias p+Au and central Si+Au. The pion slope parameters all sit near 150 MeV, while the proton slope parameter shows a dramatic rise from p+A (T_0 $\approx$ 150 MeV) to central Si+Au (T_0 $\approx$ 215 MeV.) For reference, the proton slope parameter for p+p collisions at 12 GeV/c has been measured[5] to be roughly 125 MeV. Also shown is the antiproton slope parameter[4], which is clearly lower than the corresponding value for the proton.

The rapidity dependence of the proton slope parameter is explored in Fig. 4b. Two trends are very clear: T_0 is larger near y_{NN} than at lower rapidity, and T_0 increases as the colliding system becomes larger. Explaining this behavior is at present a problem for theoretical string models such as VENUS[6] and RQMD[7] .

4. Antiproton Production

Antiproton production in heavy ion reactions at AGS energy ($\sqrt{s}_{NN}$= 5.5 GeV) is only somewhat above the N+N production threshold ($\sqrt{s}$= 3.8 GeV), and hence

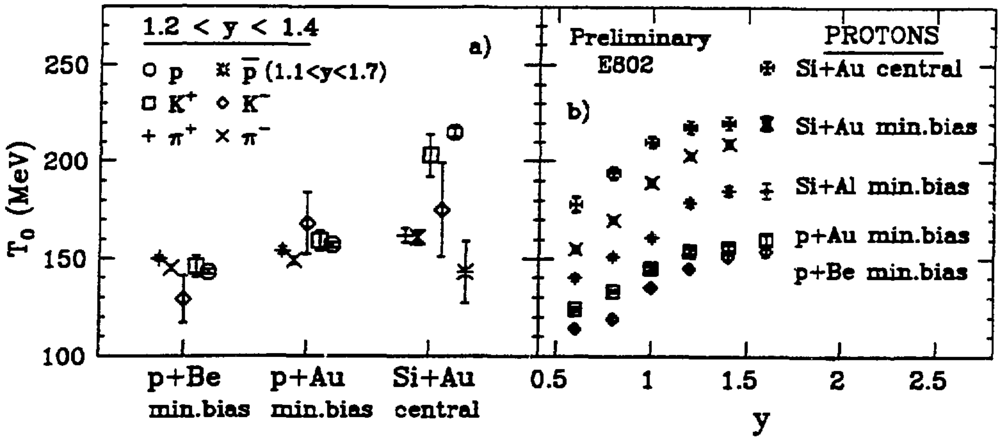

Fig. 4. Inverse $m_\perp$ slope parameters. a) for different particle species near mid-rapidity. b) for protons as a function of rapidity.

should be dominated by the *first* collision of each projectile nucleon with a target nucleon. Competing with this process is a large p+ $\bar{p}$ annihilation cross-section, which is most important in the thickest targets. Table 1 summarizes $\bar{p}$ production in Si+A near mid-rapidity. By comparison, from p+p measurements[8] at 19 GeV the $\bar{p}$ slope parameter is $\approx$ 120 MeV and the $\bar{p}/\pi^-$ ratio is $\approx 1 \times 10^{-3}$.

5. Future Plans

This is merely a sampling of data which was of interest at this workshop. Other topics with results include charged-particle multiplicity distributions (TMA), centrality dependence of particle production, strangeness production, high $p_\perp$ spectra,

Table 1. Preliminary results for $\bar{p}$ production. The uncertainties quoted are statistical only. The systematic uncertainty is 10% for the slope parameters and 15% for the ratios. The $\bar{p}/\pi^-$ ratio may be lower if one accounts for possible low $p_\perp$ enhancements.

System	Trigger	Inverse $m_\perp$ slope parameter for $\bar{p}$ (MeV)	$\bar{p}/\pi^-$ Ratio of integrated yields
		$1.1 \le y \le 1.7$	$0.9 \le y \le 1.7$
Si+Al	Min. Bias	122 ± 27	$(2.1 \pm 0.4) \times 10^{-3}$
	Central	141 ± 18	$(1.3 \pm 0.2) \times 10^{-3}$
Si+Au	Min. Bias	151 ± 38	$(1.1 \pm 0.2) \times 10^{-3}$
	Central	143 ± 16	$(0.73 \pm 0.07) \times 10^{-3}$

deuterons, and two-particle correlation measurements (Hanbury-Brown, Twiss.) This year a new second-level hardware trigger will be providing on-line particle identification, which will lead to improved K^- (and $\bar{p}$) statistics and improved H.B.T. (including K^+K^+.) The AGS Booster is scheduled to provide a ^{197}Au beam in 1992 and a second spectrometer arm will be built to cover the forward angles where the particle density from Au+Au is too great for the present spectrometer.

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