

## TARGET RAPIDITY PROTON DISTRIBUTIONS FOR SI+Au COLLISIONS AT THE AGS.

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Preliminary results are presented for the production of protons in 14.6 A-GeV/c Si+Al and Si+Au collisions measured by the E859 Phoswich Array at the BNL AGS. The proton data presented cover the laboratory angles of 50-130 degrees and kinetic energies of 40-180 MeV. Slopes and integrated distributions are extracted and comparisons with other experimental data are discussed.

Experiment 802<sup>1</sup> at the BNL AGS has measured the distributions of protons and other identified charged particles over a broad range of rapidity (0.5 to 2.5 units) and transverse momentum (0.2 to 2.5 GeV/c) for a variety of projectile and target combinations ranging from p+Be to Si+Au<sup>2,3,4</sup>. The addition of the E859 Phoswich

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Array to the E802 experimental setup extends the original measurements down to pseudo-rapidities of  $\eta = -0.76$ , where  $\eta \equiv -\log(\tan \theta/2)$ . Here we present preliminary results for protons produced in Si+Al and Si+Au collisions for pseudo-rapidities of  $|\eta| \leq 0.76$  and kinetic energies of  $40 \leq E_{kin} \leq 180$  MeV (280–610 MeV/c in momentum). Since protons produced at  $\theta > 90$  degrees cannot be produced in simple free nucleon-nucleon collisions, our results serve to constrain and quantify proposed “collective” effects (such as secondary rescattering and nuclear mean fields) invoked to explain other phenomena observed in relativistic nucleus-nucleus collisions.

The Phoswich Array consists of 42  $\Delta E - E$  scintillator telescopes, which were previously part of the Pagoda Detector at the Bevalac<sup>5</sup>. The  $\Delta E$  and time-of-flight information is provided by 5 mm of “fast” plastic (BC412: 1.0 ns rise time, 3.3 ns decay time) and the  $E$  section consists of 26 cm of “slow” plastic (BC444: 19.5 ns rise time, 260 ns decay time). The modules used have two different angular sizes, with the smaller modules being used at the more forward angles where the hit density is largest. Surrounding the target on the side of the beam opposite the E802 spectrometer, the modules are mounted approximately 65 cm from the target and subtend a polar angular range of 50.2–129.8 degrees and an azimuthal range of  $\Delta\phi \simeq 24$  degrees.

The use of two different ADC gates (60 and 220 ns in duration, respectively) permits the unfolding of the two signal components which are read out through a common photomultiplier tube. The  $\Delta E - E$  and time-of-flight information allow the separation of “neutrals” (gammas and neutrons), charged pions, protons, deuterons and tritons over a broad range of kinetic energy (up to 250–300 MeV for protons). The lower energy threshold for proton detection (25–45 MeV) is mainly determined by the energy loss in the target (817 mg/cm<sup>2</sup> Al or 944 mg/cm<sup>2</sup> Au). Unambiguous determination of the proton energy is possible for energies up to 120–220 MeV, depending upon the proton spectrum.

In Figure 1, the proton momentum density distribution  $d^3N/dp^3$  is plotted at fixed laboratory angles as a function of kinetic energy for minimum bias Si+Au collisions. The cross sections are normalized per event (systematic scale uncertainty is  $\leq \pm 15\%$ ) and have been corrected for energy loss, target-out contributions, proton identification efficiency (protons which scatter out of the module before stopping may not be identified as protons) and geometrical acceptance. Because the multi-hit probability is small ( $\leq 3\%$  for all modules), no corrections for this effect have been performed. The background due to non-target related interactions (target-out rate) is negligible for Si+Au ( $\leq 3\%$ ) but appreciable for Si+Al (10–15%).

As indicated by the solid lines in Figure 1, the spectra are well described by exponentials in kinetic energy for  $E_{kin} \geq 50$  MeV. The dependence of the proton yield and the slope of the distribution upon angle is relatively strong for Si+Au collisions in contrast to central Si+Al collisions where the dependence is mild (not shown). (Central collisions are defined by a hardware cut on the charged particle multiplicity as measured by the Target Multiplicity Array<sup>1</sup> and approximately correspond to the upper 7% of

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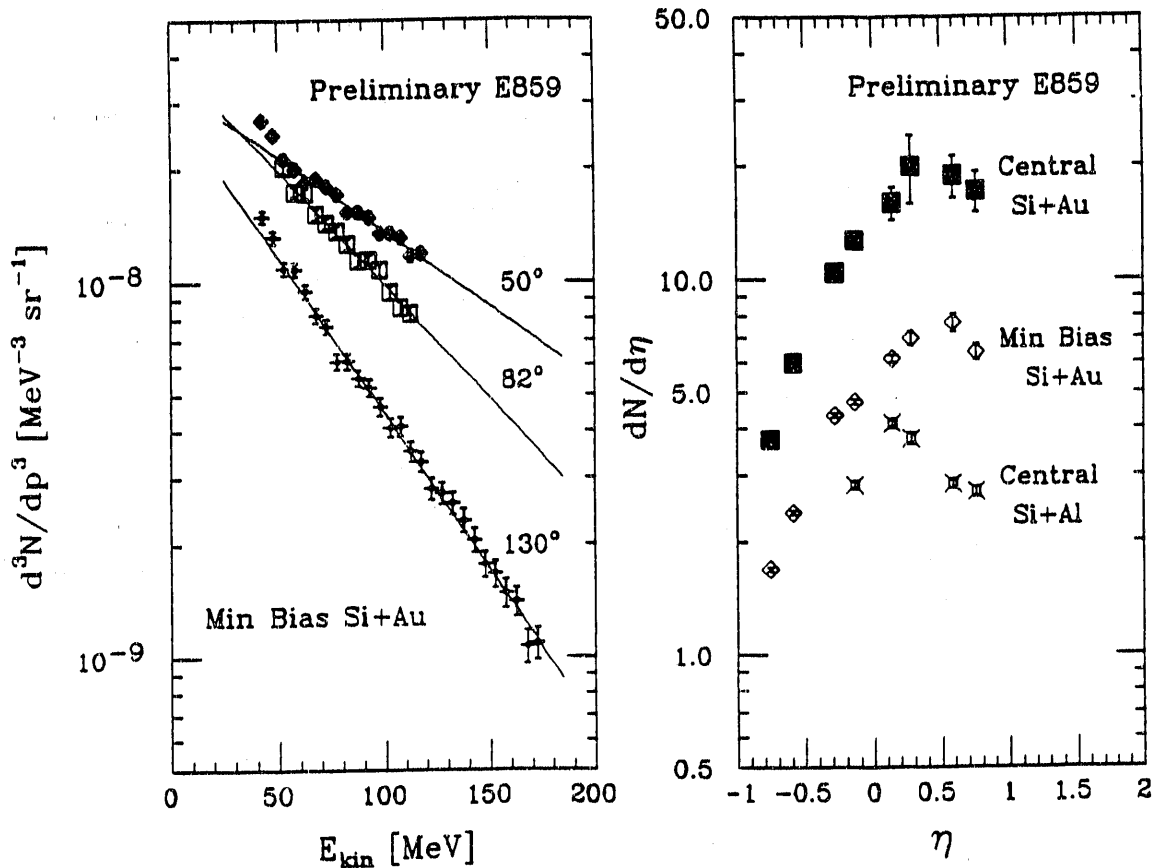


Figure 1 (left): Momentum density distribution  $d^3N/dp^3$  plotted at fixed angles as a function of kinetic energy for protons produced in minimum bias Si+Au collisions. Solid lines indicate exponential fits for  $E_{kin} \geq 50$  MeV.

Figure 2 (right): Pseudo-rapidity density distribution as a function of pseudo-rapidity for protons produced in Si+Al and Si+Au collisions. The distributions only include the contributions exhibiting exponential behaviour at large  $E_{kin}$ . See text for details.

the multiplicity distribution.) The inverse logarithmic kinetic energy slopes are approximately constant for central Si+Al proton spectra (60–70 MeV for  $-0.14 \leq \eta \leq 0.76$ ), but for Si+Au spectra the slopes vary from 50–130 MeV, increasing with increasing pseudo-rapidity ( $|\eta| \leq 0.76$ ) and being slightly higher for central collisions than for minimum bias collisions. These slopes represent appreciable mean kinetic energies for protons being produced at such large angles.

Below 50 MeV, the proton spectra indicate a faster rise. Although several mechanisms could contribute to such an enhancement at low kinetic energies, a dominant one should arise from the evaporation of target spectator protons.

In order to quantify the large kinetic energy ( $E_{kin} \geq 50$  MeV) behaviour of the proton spectra, the pseudo-rapidity density distribution ( $dN/d\eta$ ) of these energetic protons is determined by extending and integrating the exponential behaviour over all

kinetic energies. Figure 2 displays the results of such integrations for both Si+Al and Si+Au collisions. The absolute yield of protons per collision increases as the target mass is increased (Al to Au) and as the centrality is increased for Si+Au collisions. The logarithmic scale in Figure 2 emphasizes the similarity in shape of the proton pseudo-rapidity density distributions for minimum bias and central Si+Au collisions; i.e., the shape does not exhibit a strong dependence on centrality. In addition, the Si+Au distributions clearly peak above  $\eta = 0$ , although the exact location of the peak cannot be determined from these results alone.

Previous E802 results<sup>2</sup> indicate that the proton invariant cross sections ( $E d^3N/dp^3$ ) plotted at fixed rapidity are well described by exponentials in transverse mass,  $m_{\perp} \equiv (m^2 + p_{\perp}^2)^{1/2}$ , for all rapidities measured ( $0.5 \leq y \leq 1.7$ ). Our current results provide additional support for this finding. Exponential fits to our  $m_{\perp}$  distributions result in non-significant increases of the  $\chi^2/dof$  relative to those obtained from the exponential fits in kinetic energy described above. In addition, comparisons of Phoswich spectra and E802 spectrometer spectra at fixed laboratory angle (overlap exists for  $48 \leq \theta \leq 58$  degrees) reveal good agreement in absolute normalization and trend.

In summary, proton production cross sections have been measured for Si+Al and Si+Au collisions at 14.6 A·GeV/c using the E859 Phoswich Array. Our preliminary results indicate a substantial yield of energetic protons at large angles ( $\theta \geq 50$  degrees). The shape of the proton pseudo-rapidity density distribution appears to be relatively insensitive to the centrality of Si+Au collisions, although the kinetic energy slopes display a small dependence on centrality. Finally, only a small fraction of the information available from the E859 Phoswich Array has been presented here, and, with the currently planned E859 silicon run in 1992 as well as the following E866 gold beam experiment, we expect the array to provide more valuable information regarding dynamical processes involving target nucleons.

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