γ. C-2964

BNL 36012

Conf-8410210--7

STOPPING POWER MEASUREMENTS WITH 17-GEV/C PROTONS AT THE AGS

or

INCLUSIVE PROTON SPECTRA FROM PROTON-NUCLEUS INTERACTIONS AT 17 GEV/C

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BNL--36012

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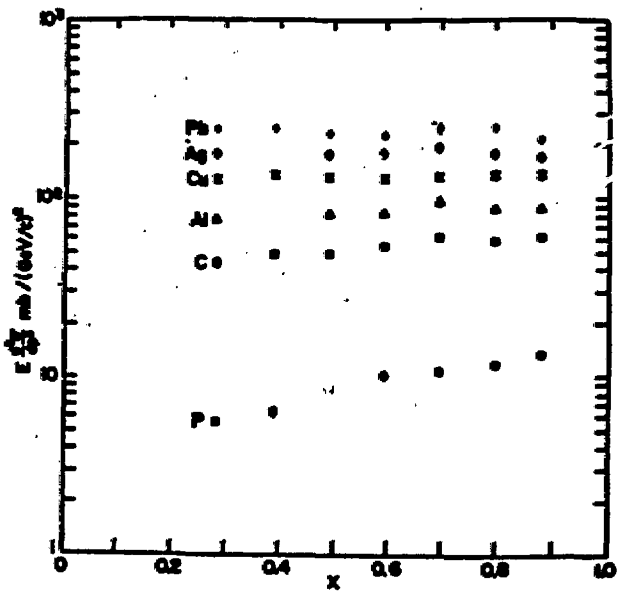
Research performed, in part, under the auspices of the Department of Energy

The problem of nuclear stopping power and its importance to the study of nucleus-nucleus collisions at very high energies was brought to general attention one year ago at Quark Matter 83 by Busza and Goldhaber.[1] In this context, nuclear stopping power can be thought of as the rate of energy (or rapidity) loss of a proton traversing nuclear matter. It does not directly address the important question of energy deposition. Busza and Goldhaber showed that knowledge of nuclear stopping power is needed to estimate the minimum center-of-mass energy required in nucleus-nucleus collisions to ensure the production of very high temperatures at low baryon density. At cm energies of about 1-10 GeV/A, the stopping power is important in the estimation of the maximum baryon densities attainable in nucleus-nucleus collisions.[2] The data presented here are more relevant to this latter point.

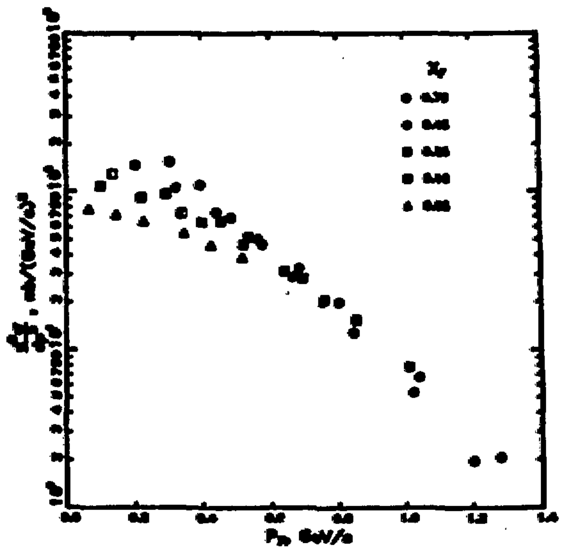
Information on the slowing down of baryons in nuclear matter is obtained from inclusive proton spectra from proton-nucleus collisions on the assumption that the leading baryon is the projectile remnant. The cross sections should be integrated over p_T, and an estimate must be made of the fraction of leading baryons which emerge as neutrons. There are only two sets of published data which are suficiently complete to bear on this question. That discussed by Busza and Goldhaber[1] (and others[3-5]) was obtained with 100-GeV/c protons[6] and is summarized in Fig. 1. Except for a few points at p_T = 0.5 GeV/c, these

Fig. 1. Inclusive proton cross sections at p_T = 0.3 GeV/c from 100-GeV/c protons (ref. 6).



cross sections are all at p_T = 0.3 GeV/c. In their analysis Busza and Goldhaber[1] were thus forced to assume that the p_T distributions were independant of x_F and A (x_F is defined in the nucleon-nucleon cm system), and that they were sufficiently peaked near zero that the cross sections at p_T = 0.3 GeV/c could be scaled to represent the p_T-integrated cross sections. However, data obtained with 24-GeV/c protons[7] suggests that this may not be a very good assumption. The p_T spectra for inclusive protons from 24-GeV/c protons on Al are shown in Fig. 2 for various x_F-values. It is clear that the

Fig. 2. Inclusive proton spectra from 24-GeV/c protons on Al (ref. 7).



shapes of the p_T-distributions vary considerably with x_F. Although the 24-GeV/c cross sections cover a wider range in x_F and p_T than those at 100 GeV/c, they are reasonably complete for Be and Al targets only. Also, it is difficult to integrate the p_T-spectra at the larger x_F-values.

There appears to be an apparent discrepancy between the 24-GeV/c and the 100-GeV/c data. The invariant cross sections at p_T = 0.3 GeV/c for inclusive protons from Al as a function of x_F are shown in Fig. 3 for the two energies.

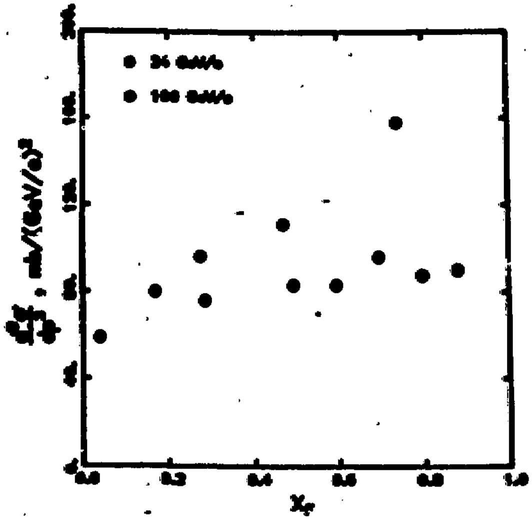


Fig. 3. Inclusive proton cross sections at $p_T = 0.3$ GeV/c from 24-GeV/c (ref. 7) and 100-GeV/c (ref. 6) protons on Al.

That the slopes of the two lines differ is not surprising, because it is not necessarily expected that Feynman scaling should extend down to 24 GeV/c for these reactions. It does not seem reasonable, however, that the magnitude of the cross sections should be higher at the lower energy.

Because of the fortuitous existance of a suitable single-arm spectrometer at the AGS and the cooperation of those who built it and used it previously, it was possible to quickly carry out a new set of measurements of inclusive proton spectra from nuclear targets. The layout of the spectrometer is shown in Fig. 4. Particle trajectories were determined by pairs of wire chambers

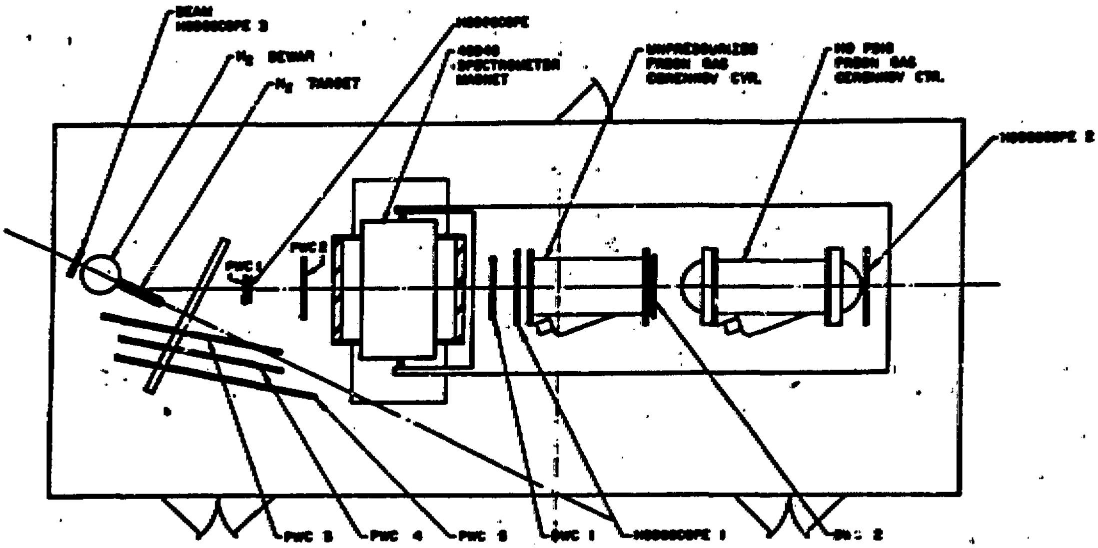
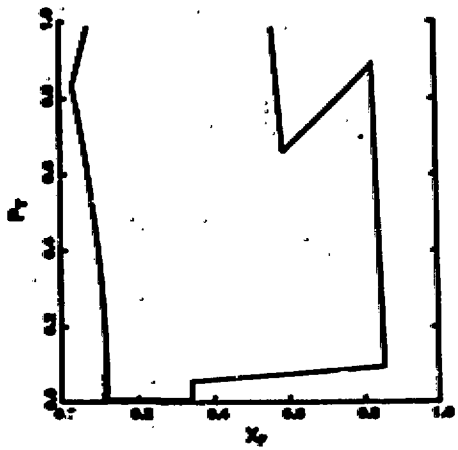


Fig. 4. Plan of the spectrometer used at the AGS.

both upstream and downstream of the magnet, which bent charged particles in the vertical plane. Particle identification was accomplished with two Freon-12 Cherenkov counters, one at atmospheric pressure and one at a higher pressure which was varied to match the momentum bite of the spectrometer. The 17-GeV/c beam contained about 90% protons and 10% pions which were tagged by two identical differential Cherenkov counters. The coordinates of each beam particle and the beam intensity were measured with a pair of scintillator hodoscopes just upstream of the target.

The goal of the experiment was to obtain inclusive proton spectra over the ranges of 0 to 1 GeV/c in p_T and 0 to 1 in x_F. The region actually covered is shown in Fig. 5; it should expand somewhat when the data are

Fig. 5. Region covered in the variables p_T and x_F.



analyzed more carefully. The targets used were C, Al, Cu, Ag, and Pb. A limited set of data was also taken with a liquid hydrogen target in order to check some of the calibrations, but this has not yet been analyzed. All of the data from the nuclear targets has been analyzed once, but further refinement is needed. The results available now must therefore be considered preliminary and subject to change, but nevertheless the general features of the results are clear.

The invariant cross sections are shown as a function of p_T and x_F for both Al and Pb in Figs. 6 and 7. The shapes of the spectra are seen to be

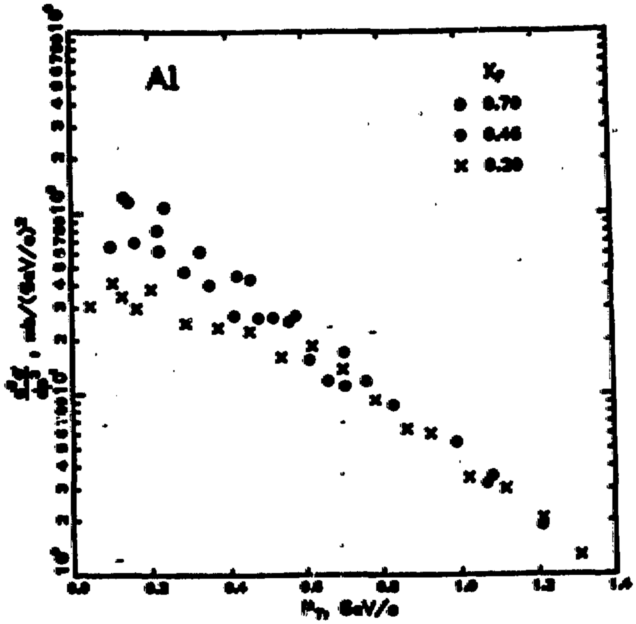


Fig. 6. Inclusive proton spectra from 17-GeV/c protons on Al (preliminary).

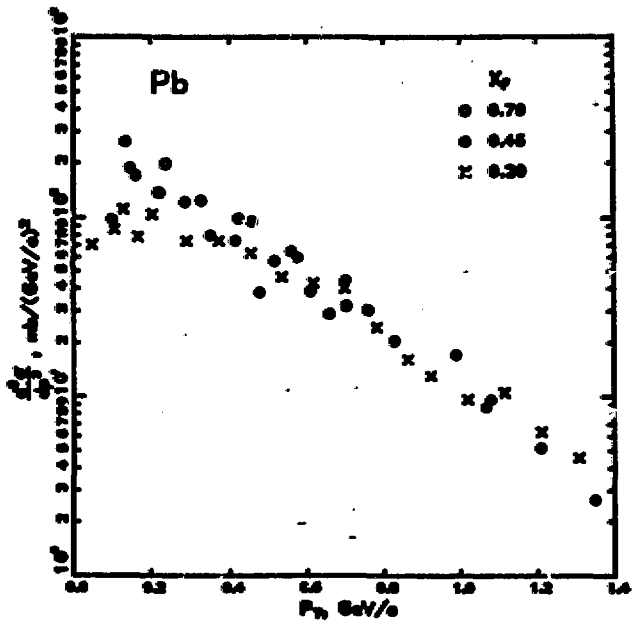


Fig. 7. Inclusive proton spectra from 17-GeV/c protons on Pb (preliminary).

similiar for the two targets, differing only in magnitude, and are similiar to those observed at 24 GeV/c. The invariant cross sections of inclusive protons from Al at p_T = 0.3 GeV/c are plotted in Fig. 8 along with the earlier data

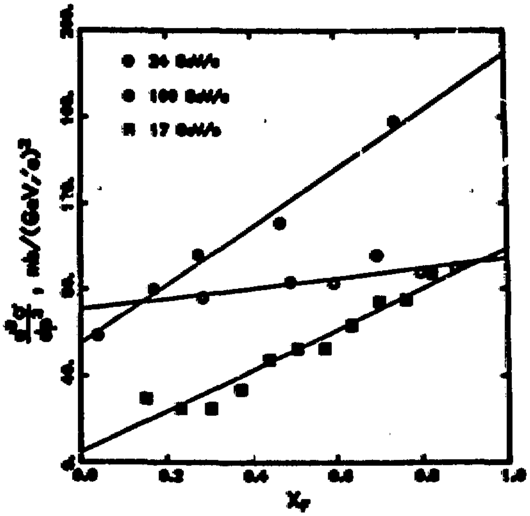


Fig. 8. Inclusive proton cross sections at p_T = 0.3 GeV/c from 24 (ref. 7), 100 (ref. 6), and 17 (this work) GeV/c protons on Al. The lines are straight line fits.

at 24 and 100 GeV/c. The 17-GeV/c data are about a factor of two lower than those at 24 GeV/c and converge on the 100-GeV/c data at x_F = 1. This strongly suggests that the 24-GeV/c cross sections are high by a factor of two. If the 24-GeV/c cross sections are reduced by a factor of two, they lie between the 17- and 100-GeV/c data and extrapolate to about the same intercept at x_F = 1. The present data confirm that the inclusive proton spectra from nuclear targets do not follow Feynman scaling down to 17 GeV/c.

The 17-GeV/c data have not yet been analyzed in a manner similiar to that employed by Busza and Goldhaber for the 100-GeV/c data. It is possible, however, to reach a conclusion from the data shown in Fig. 8 about the change in nuclear stopping power between 100 and 17 GeV/c. If one assumes that the fraction of leading baryons emerging as neutrons is the same at the two energies and that the shapes of the p_T distributions are the same at the two energies, then both sets of cross sections at p_T = 0.3 GeV/c can be scaled to the leading baryon cross sections with the same factor. Since there is one leading baryon per interaction, the areas under the two curves (multiplied by the appropriate Jacobian factor and integrated over x_F from -1 to +1) must be identical. This is only possible if the cross sections at 17 GeV/c rise above those at 100 GeV/c at low and negative values of x_F. This in turn implies that there is substantially more nuclear stopping at 17 GeV/c. This conclusion obviously has favorable implications for the formation of high baryon-density nuclear matter with 15-GeV/A heavy-ion beams.

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