the latter may be subject to depolarization processes during acceleration and passage through various electric and magnetic fields in the cyclotron system. On the other hand, the ^{3}He polarization may be predicted by using the cross sections of the atomic processes involved. From the relevant data reported in Ref. 1 it follows that the expected value is between 0.35 and 0.40. Comparing the measured and predicted figures we conclude that no measurable depolarization takes place during acceleration, and in this respect, the polarized ^{3}He is similar in behavior to polarized protons and deuterons.

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Neutron Total Cross Sections on Nuclei from 30 to 270 GeV/c*

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We present results of measurements of the total cross section for neutrons on a variety of nuclei in the momentum range 30 to 270 GeV/c. The measurements were made with the standard transmission technique and have a typical accuracy $\sim 1\%$. The cross sections are compared with theoretical predictions. It is found that a correction for inelastic screening in the nucleus is required. The cross sections are found to vary as $A^{0.77}$ over the entire energy range.

A series of measurements of total cross sections for neutrons on various nuclei (^{2}H, Be, C, Al, Fe, Cu, Cd, W, Pb, and U) in the momentum range 30 to 270 GeV/c has been carried out in a neutron beam at the Fermi National Accelerator Laboratory. In this paper we present the results of the measurements, which are the first in this momentum region. The experimental arrangement is shown in Fig. 1. A previous paper[1] has described the experimental technique, method of data analysis, and our results for n-p total cross sections. Briefly, the standard transmission technique was used in conjunction with a total-absorption calorimeter to determine the neutron energy. Seven circular transmission counters, D_1–D_7, with radii ranging from 1 to 5 cm were placed in front of the calorimeter about 200 m from the target. A 1.25-cm-thick iron converter plate was placed immediately in front of the transmission counters. Charged particles produced by neutron interactions in the iron were then detected by the transmission counters. Partial cross sections were determined for each counter from the ratio of beam transmitted with and without the target. The measured cross sections are independent of the efficiency of the neutron detector, provided the efficiency is the same with target in and out. Great care was taken to ensure this was the case.

Targets could be placed in or out of the beam

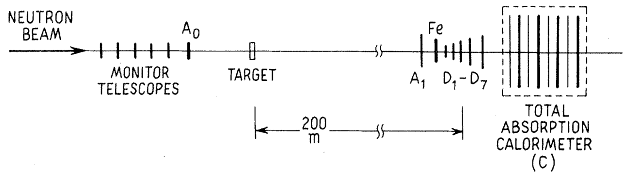

FIG. 1. Schematic of experimental arrangement.

automatically, and were cycled about once per minute. For the deuterium cross sections a 1.2-m liquid target[1] was used. The vapor pressure was monitored continuously so that the density could be determined accurately from pressure versus density curves.[2] Data were taken in a series of "runs" with each run lasting between 30 and 90 min during the same running period as the n-p measurements. Cross sections were measured at all energies simultaneously. Each event was binned according to the incident neutron energy from the calorimeter pulse-height information. The energy resolution of the calorimeter was ~15 GeV.

For each element and energy, six partial cross sections were obtained. A small correction was made for the effect of Coulomb scattering because of the magnetic moment of the neutron. Total cross sections were obtained by extrapolating the partial cross sections to zero solid angle using least-squares fits with various fitting functions, each containing between 2 and 5 terms.[3] Fits containing polynomials, exponentials, or both were tried. Good fits were obtained in all cases provided sufficient terms were included. The uncertainty in the extrapolated cross sections was estimated from the spread in the extrapolated values. The difference between the extrapolated cross section and that measured with the smallest counter ranged from 0.3% for deuterium to 7% for U. The errors assigned to these corrections were always at least 15% of the correction. A correction (usually < 1%) was made to the extrapolated cross sections for a rate effect caused by pileup of pulses from the calorimeter. Also, because of contamination in the beam at low energies, a correction was made for the presence of K^0's, γ's, and $\bar{n}$'s.[1,4] The errors in the total cross sections were obtained by adding in quadrature the statistical, extrapolation, rate correction, and beam contamination errors. For each nucleus between 6 and 30 measurements were made over a period of about 10 months. During this period the accelerator performance improved markedly, but after the rate corrections described above were made the measured cross sections showed a high degree of consistency with good values of χ^2.

TABLE I. Total cross sections and errors (mb).

Nucleus	Mean Momentum (GeV/c) 34	80	131	180	215	240	273
D	71.74 ±1.87	72.78 ±0.83	73.30 ±0.39	74.16 ±0.34	74.48 ±0.36	75.08 ±0.38	75.18 ±0.55
Be	263.9 ± 5.7	269.7 ±2.8	266.5 ±1.3	271.1 ±1.1	273.5 ±1.3	270.8 ±1.3	273.8 ±1.6
C	331.1 ±8.6	331.4 ±3.4	329.5 ±1.7	331.1 ±1.5	333.5 ±1.8	331.9 ±1.8	328.2 ±2.1
Al	628.5 ±13.5	636.0 ±6.1	633.3 ±3.0	634.8 ±2.8	633.3 ±3.4	634.4 ±3.5	629.5 ±3.7
Fe	1100 ±29	1122 ±11	1110 ±7	1110 ±7	1112 ±8	1113 ±8	1107 ±10
Cu	1213 ±30	1239 ±11	1228 ±7	1223 ±6	1238 ±9	1231 ±9	1225 ±11
Cd	1884 ±46	1912 ±16	1890 ±11	1885 ±12	1887 ±16	1873 ±16	1882 ±18
W	2840 ±72	2804 ±28	2786 ±23	2751 ±24	2746 ±35	2748 ±34	2720 ±36
Pb	2973 ±85	2986 ±25	2981 ±21	2951 ±28	2959 ±32	2926 ±32	2919 ±48
U	3402 ±113	3410 ±29	3399 ±26	3361 ±32	3353 ±39	3365 ±46	3297 ±60
n	0.779 ±.007	0.774 ±.004	0.776 ±.003	0.771 ±.003	0.768 ±.003	0.770 ±.004	0.768 ±.005

The results for the various cross sections are given in Table I. The deuterium errors include a scale error of 0.35% for the deuterium density uncertainty. The total cross sections obtained for deuterium, aluminum, and copper are plotted in Fig. 2 together with previous measurements[5-10] above 5 GeV/c. The scale errors assigned by the experimenters have been included in the deuterium data. Theoretical curves, calculated using the Glauber theory,[11] are shown for aluminum and copper. In the calculations, a Woods-Saxon nuclear density was assumed. The nucleon-nucleon total cross section above 20 GeV/c was assumed to be given by

$$\sigma_{NN} = 38.4 + 0.85|\ln(s/95)|^{1.47} \text{ mb} \tag{1}$$

from Ref. 1. The slope of nucleon-nucleon forward elastic scattering and the ratio of the real to the imaginary part of the amplitude were obtained from the recent papers of Bartenev and co-workers.[12,13] The dashed curves in Fig. 2 are calculated from straightforward Glauber theory, while the solid curves include a correction for the effect of inelastic screening in the nucleus[14] as calculated by Karmanov and Kondratyuk.[15] The nuclear half-density radii c were chosen to give good agreement for the solid curves at the

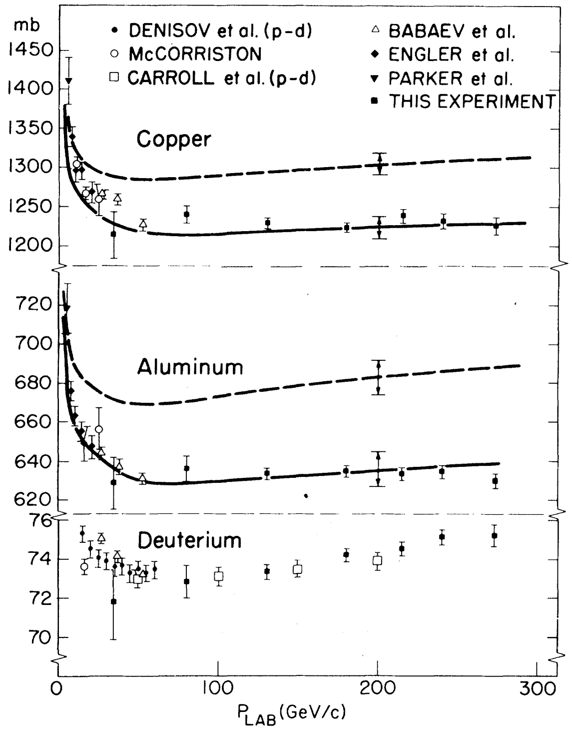

FIG. 2. Total cross sections obtained for deuterium, aluminum, and copper. The dashed and solid curves are theoretical curves without and with inelastic screening, respectively, as explained in the text. The half-density radii c have been chosen to give good agreement between the solid curves and the 180-GeV/c points. The error bars at 200 GeV/c indicate the sensitivity of the calculated cross sections to a ± 0.9-mb change in the nucleon-nucleon total cross section.

higher energies. The values used are 3.15 and 4.19 fm with skin thicknesses of 0.52 and 0.57 fm for aluminum and copper, respectively. These are consistent with accepted values.[16] The sensitivity of the calculated cross sections to a ± 0.9-mb change in the nucleon-nucleon total cross section is indicated.[17]

There has been considerable discussion concerning the existence and magnitude of the inelastic screening corrections.[14,15] Comparison between theory and experiment is made difficult by the relatively large uncertainty in nuclear radii.[18] Now with accurate neutron-nucleus total cross sections available over a large energy range, it is possible to compare the energy dependence of the data with theory. Careful comparison shows that the energy dependence of the data is much more consistent with the solid curves with inelastic screening included. It should be emphasized that there are large uncertainties in the calculated values of the inelastic screening corrections, which require cross-section data for nucleon diffraction dissociation.[15] The total-cross-section data suggest that the inelastic screening increases somewhat more rapidly with energy than the calculation of Karmanov and Kondratyuk would indicate.

Fitting our cross sections (excluding deuterium) with the expression $\sigma \propto A^n$ gives $n \cong 0.77$ (see Table I) with no evidence for any variation with energy.[19] If we assume the nucleon-nucleon total cross sections vary according to Eq. (1), we can use our n-d total cross sections to obtain values for the parameter $\langle r^{-2}\rangle$ used in the Glauber-Wilkin formula[11,20] for deuteron screening. We find $\langle r^{-2}\rangle$ is almost independent of energy above 80 GeV with a value ≈ 0.041 mb^{-1}, in good agreement with the results of Carroll *et al.*[7] for incident pions. The large discrepancy between the nucleon-nucleon total cross sections of Refs. 1 and 7 makes it difficult to assign realistic errors to our values.

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Like- and Unlike-Charged Pion Correlations in π^+p and pp Interactions at 100 GeV/c

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Charged-pion rapidity correlations are compared and found to have a similar peaked structure when studied inclusively. However, when the same data are studied semi-inclusively *no correlation* is found for like-charged pions and for unlike-charged pions in the central region. Inclusive correlations in these cases appear then from the convolution of the uncorrelated spectra at each multiplicity and the multiplicity distribution. Correlation in $\pi^+\pi^-$ is observed at small Δy only for y large.

Strong positive correlations between pions with small rapidity separations were observed in experiments at 10 to 30 GeV/c,[1-5] and in pp interactions at 200 GeV/c.[6] These observations were made in terms of the usual inclusive correlation function:

$$C(y_1,y_2)=\frac{1}{\sigma_{\text{in}}}\frac{d^2\sigma}{dy_1dy_2}-\left(\frac{1}{\sigma_{\text{in}}}\frac{d\sigma}{dy_1}\right)\left(\frac{1}{\sigma_{\text{in}}}\frac{d\sigma}{dy_2}\right). \quad (1)$$

This is the difference between the coincidence of two particles at rapidities y_1 and y_2, normalized by the inelastic cross section σ_{in}, and the product of the singles counts at y_1 and y_2, both normalized by σ_{in}. Alternatively one can use

$$R(y_1,y_2)=\frac{C(y_1,y_2)}{\sigma_{\text{in}}^{-2}(d\sigma/dy_1)d\sigma/dy_2}$$
$$=\frac{\sigma_{\text{in}}d^2\sigma/dy_1dy_2}{(d\sigma/dy_1)d\sigma/dy_2}-1. \quad (2)$$

This ratio has experimental advantages over the correlation function (1) in that uncorrelated measurement inefficiencies, as well as the overall cross-section normalization, cancel. One can evaluate it directly in terms of the number of coincidences and the number of inelastic events in the data sample.

The data we used are from an exposure of the Fermi National Accelerator Laboratory 30-in. hydrogen bubble chamber to a mixed, tagged, positive beam and include 1903 inelastic π^+p events and 3477 inelastic pp events. The average charge multiplicities are 6.80 ± 0.14 and 6.49 ±0.10 for π^+p and pp interactions, respectively.[7] The events were measured twice on a Lawrence Berkeley Laboratory spiral reader, resulting in a better than 96% measuring efficiency for tracks going backward in the center of mass system, independent of multiplicity. An average of 80% for tracks going forward in the c.m. system was obtained, with a decreasing efficiency for increasing multiplicity.[8] Although the correlation behaviors in π^+p and pp interactions are found to be similar, data from both reactions will be presented for comparison.

The correlation function defined in (2) for π^-