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TOTAL CROSS-SECTION MEASUREMENTS OF K^+-p AND K^+-n INTERACTIONS IN THE MOMENTUM REGION 0.77 TO 2.83 Bev/c*

V. Cook, D. Keefe, L. T. Kerth, P. G. Murphy,† W. A. Wenzel, and T. F. Zipf
Lawrence Radiation Laboratory, University of California, Berkeley, California
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Total K^+-p and K^+-n cross-section measurements have been made previously up to 0.8 Bev/c with emulsions,[1] counters,[2] and bubble chambers,[3] in the region 0.8 to 2.4 Bev/c by the M.I.T. group,[4] and at momenta above 2.7 Bev/c by the CERN[5] and Dubna[6] groups. From the data of the M.I.T., Dubna, and CERN experiments, it is difficult to arrive at a satisfactory description of the K^+-p cross section, σ_p, in the region of a few Bev/c. At the highest momentum measured by the M.I.T. group (2.4 Bev/c), σ_p was found to be 12.9 ± 1.0 mb, whereas at 2.9 Bev/c, the CERN group found $\sigma_p = 24.5 \pm 2.5$ mb. The present experiment was undertaken partly for the purpose of resolving this difficulty.

The experimental technique was similar to that used by Cook et al. to measure K^--p total cross sections.[7] The beam is illustrated in Fig. 1. A feature of the present beam not encountered in the K^- beam described in reference 7 was that the high proton counting rate (approx 2×10^6/sec) could cause accidental background. This source of accidentals was eliminated with an anticoincidence circuit designed to reject any K^+ meson that was accompanied by another beam particle within a time of ± 50 mμsec.

The hydrogen-deuterium target was 4 ft long, 6 in. in diameter, made of 0.007-in. stainless steel, and was vacuum insulated. Two transmission counters, T_1 and T_2, were used. The T_1 counter was a 12-in.$\times$12-in.$\times\frac{1}{4}$-in. scintillator, and T_2 was a circular scintillator 9 in. in diameter and $\frac{1}{4}$

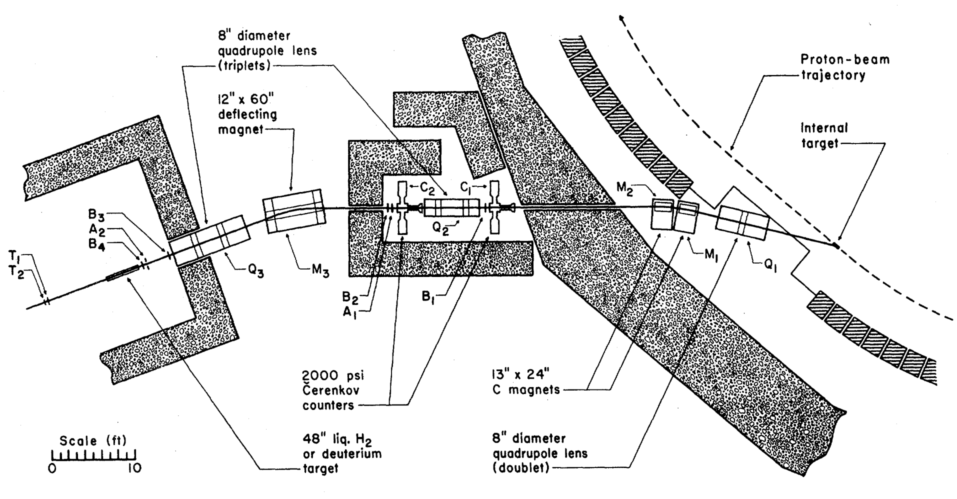

FIG. 1. Arrangement of the variable-momentum K^+ beam. M_1, M_2, and M_3 are bending magnets; Q_1, Q_2 and Q_3 are magnetic quadrupole lenses; B_1, B_2, B_3, and B_4 are coincidence counters; A_1 and A_2 anticoincidence counters; and C_1 and C_2 are gas Čerenkov counters. The transmission of the hydrogen target was measured by the scintillation counters T_1 and T_2.

Table I. Total cross sections: K^+-p, K^+-d, and K^+-n. The corrections that have been included are described in the text. The quoted errors include all known random uncertainties; in addition, there may be a systematic error of—at most—±0.3 mb, which would translate all values together. The σ_n has not been corrected for Pauli principle effects in the deuteron. The $\Delta\Omega_1$ is the solid angle subtended by T_1 at the center of the hydrogen target.

Momentum (Bev/c)	0.77	0.97	1.17	1.30	1.44	1.69	1.97	2.26	2.55	2.83
σ_p(mb)	13.0 ±0.9	15.4 ±0.6	18.1 ±0.6	17.9 ±0.9	18.1 ±0.7	17.5 ±0.6	16.9 ±0.4	17.1 ±0.5	17.1 ±0.6	16.7 ±0.5
σ_d(mb)	27.3 ±0.6	32.4 ±0.5	35.4 ±0.5	35.6 ±0.6	35.4 ±0.5	35.1 ±0.5	34.6 ±0.5	33.9 ±0.6	33.4 ±0.5	33.4 ±0.7
σ_n(mb)	15.5 ±1.1	17.8 ±0.8	18.2 ±0.8	18.5 ±1.1	18.1 ±0.9	18.5 ±0.8	18.6 ±0.6	17.7 ±0.8	17.1 ±0.8	17.5 ±0.9
$\Delta\Omega_1$(msr)	40.0	22.5	19.8	17.8	15.9	13.6	11.9	10.0	10.0	8.6

in. thick. The distance of T_1 and T_2 from the target was varied between 5 ft and 10 ft, depending on the momentum, to minimize the corrections for Coulomb scattering, decay in flight, etc. Several alternate "target full" and "target empty" runs were made at each momentum. The results are shown in Table I and are plotted in Figs. 2(a) and 2(b), together with data from other experiments.

Corrections have been included for the following: (a) There is a change in the decay-in-flight rate due to energy loss in the full target—this is largest at low momenta (approx 3 mb) but can be calculated reliably. (b) Forward scattering and forward recoil corrections to the hydrogen data were calculated using values for the 0-deg and 180-deg cross sections obtained by interpolation from angular-distribution measurements at 1.0, 1.2, and 2.0 Bev/c.[8] For the larger counter this correction amounted, at most, to 0.4 mb. The forward scattering corrections to the deuterium data were calculated using optical theorem values for the forward scattering cross sections. For the larger counter this correction varied from 0.5 mb to a maximum of 1.3 mb at the highest momentum. (c) Multiple scattering in the target introduced a correction to the smaller counter results at 770 Mev/c (0.7 mb) and 970 Mev/c (0.1 mb). (d) The Glauber screening correction,[9] used to derive σ_n from $\sigma_d - \sigma_p$, amounted to about 5% at all energies. In arriving at σ_n from $(\sigma_d - \sigma_p)$, a further correction should be applied for the effect of

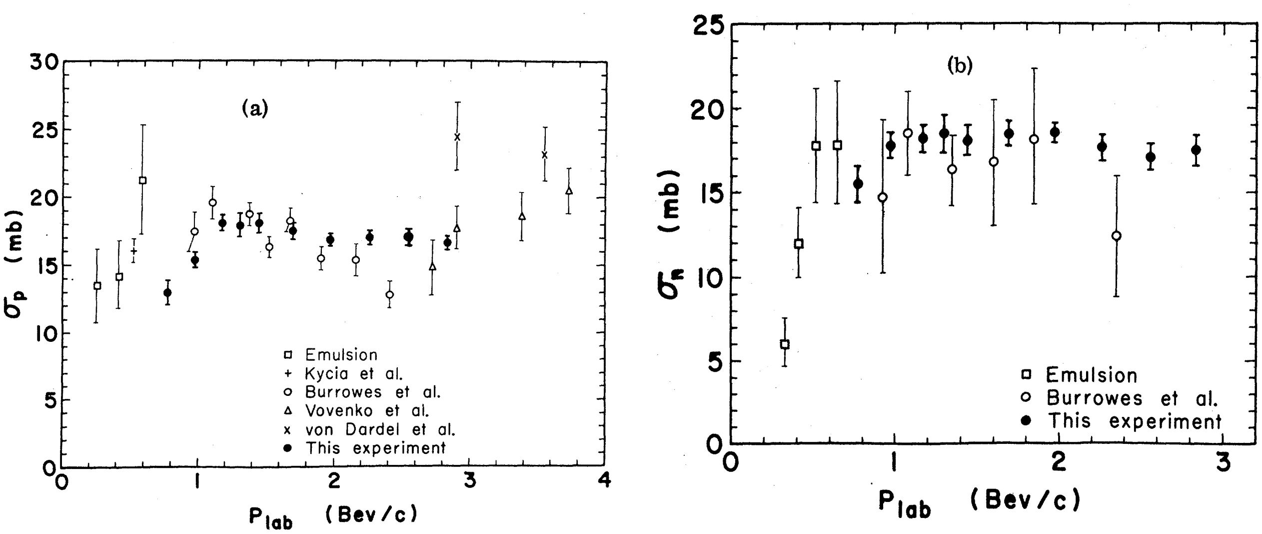

FIG. 2. The K^+ total cross sections as a function of momentum: (a) K^+-p cross section, σ_p, and (b) K^+-n cross section, σ_n.

the Pauli exclusion principle in suppressing forward charge-exchange scattering in deuterium. Until relevant data becomes available this correction cannot be estimated accurately, and therefore no correction was included.

There is a small systematic difference between the cross sections measured by the counters T_1 and T_2, the former giving a smaller value at each energy. The results given in Table I are averages of the corrected cross sections obtained from the two counters, and may therefore contain a systematic error of – at most – ±0.3 mb, affecting all the values equally.

Both σ_p and σ_n appear to remain remarkably constant at about 17 to 18 mb in the momentum range 1 to 3 Bev/c, implying that the $I=0$ and $I=1$ interactions are of approximately equal strength. The present measurements give a value of σ_p above that for the highest energy point of the M.I.T. group, below that for the lowest energy point of the CERN group, and in good agreement with the points of the Dubna group. At lower energies the present results are in good agreement with those of the M.I.T. group. The K^+-p cross section at 0.77 Bev/c is significantly below the value at higher energies, in agreement with recent bubble chamber measurements.[10]

The K^+-p interaction up to 0.8 Bev/c has been explained almost exclusively in terms of an S-wave interaction,[1-3] but it is clear that the approximately constant value of σ_p persisting to higher energies cannot be due to $l=0$ contributions alone, since $4\pi\lambda\!\!\!^{-2}$ is 18 mb at 1.0 Bev/c and 10 mb at 1.5 Bev/c. The results of reference 8 show that there is a rapidly developing anisotropy in the elastic angular distribution at 1 Bev/c and above, indicating that higher angular momentum states contribute strongly to the elastic scattering at these energies. Furthermore, the K^+-p interaction shows an increasing contribution from inelastic processes above 1 Bev/c.

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