RECEIVED MAY 10 1963

BNL 6962

American Physical Society
1963 Spring Meeting
Washington, D. C.,
April 22-25, 1963

CONF-46-47

The K^--p Total Cross Section Between 2.7 and 5.2 BeV/c*

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ABSTRACT

The K^--p total cross section has been measured between 2.7 and 5.2 BeV/c, by means of a transmission experiment. Points with about 3% statistical errors have been obtained at momenta approximately 200 MeV/c apart.

Previous measurements of the K^--p total cross section at momenta of about 4 BeV/c[1,2,3] are widely spaced but collectively they are not consistent with a smooth variation of the cross section with momentum. In order to investigate this region more thoroughly, a transmission experiment was undertaken, the results of which are reported.

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DISCLAIMER

The experimental arrangement for the present measurements, on the inside of the Alternating Gradient Synchrotron, is shown in Fig. 1. The secondary beam, produced at 15^{o}, passed through a 1" x 1¼" collimator. It was subsequently magnetically analyzed and defined by 2" diameter scintillation counters S_1 and S_2. The K mesons were identified by means of a gas Cerenkov counter[4] taken in coincidence with S_1 and S_2 to form a K meson telescope.

The Cerenkov counter was of the differential type using compressed CO_2 as a radiator. The pressure of the gas was set so that for the selected momentum K mesons would emit light at the acceptance angle of 10^{o}. Cerenkov light from electrons, muons and π mesons was emitted at large enough angles to be collected in the anticoincidence channel. Under the experimental conditions $\Delta\beta/\beta$, the resolution of the counter, was approximately 10^{-3}. Fig. 2 shows a typical pressure curve taken at a momentum of 4.0 BeV/c. The fraction of the beam counted in the Cerenkov counter is plotted as a function of the CO_2 pressure. The K^- meson peak is well separated from the π^- meson peak, the contamination of the K's being less than one part in 1000. Similar high selectivity was obtained at all the other momenta. The amount of material presented by the windows and gas of the Cerenkov counter to the beam varied from 11 g/cm^2 at 2.7 BeV/c to 7 g/cm^2 at 5.2 BeV/c. Any K mesons interacting in the Cerenkov counter were swept away by a second bending magnet.

The flux in the telescope varied from 80 per pulse at 2.7 BeV/c to 25 per pulse at 5.2 BeV/c, for an internal circulating beam of 3×10^{11} protons per pulse. The accepted beam, whose absolute

momentum was known to $\pm 1\frac{1}{2}\%$ and had a spread of 6% full width at half height, was then incident upon a 47.0" long liquid hydrogen target, 6" in diameter and with .007" mylar walls. The K mesons which passed through the target were detected in four scintillation counters, S_3, S_4, S_5, and S_6. The outputs from these counters were separately taken in coincidence with the telescope and scaled. The counters subtended solid angles at the target of 1 to 4 millisteradians and were large enough to contain the multiple Coulomb scattering of the beam.

The partial total cross sections as measured by counters S_3 - S_6 were linearly extrapolated to zero solid angle. Fig. 3 shows one such extrapolation. The error bar drawn on the cross section as measured by counter S_5 gives the error in the difference of the cross sections as measured by S_5 and S_6, and similarly for the error bars on S_4 and S_3.[5] These relative errors were used in the extrapolation, but the final statistical error in the extrapolated cross section contains, in addition, the statistical error in the partial cross section obtained from counter S_6.

Some corrections had to be applied to the cross section obtained from the extrapolation to zero solid angle. The largest of these arose from the change in decay rate of the K mesons between the target and the transmission counters, due to the additional energy loss suffered by transmitted K mesons when the target contained liquid hydrogen. At 3.6 BeV/c, for example, this correction amounted to -0.42 mb. The random coincidence rate between the telescope and one of the transmission counters was continuously monitored and found

to be very small. The correction to the final cross sections due to this cause was of the order of 0.05 mb.

A final correction was made to the measured cross sections to allow for the residual gas in the target during the target-empty runs. This raised all the values by $0.8 \pm 0.5\%$, the uncertainty being due to a lack of precise knowledge of the temperature of the residual gas. The density of the liquid hydrogen for the target-full runs was assumed to be .0708 g/cm^3.

The results are tabulated in Table I and plotted in Fig. 4 as a function of the laboratory momentum of the K^- meson, together with previous K^--p total cross sections. The errors are statistical and do not include the systematic error due to the uncertainty in the residual gas density. The new results extrapolate smoothly to the higher momentum points of Baker, et al. At lower momenta, the data lie slightly higher than those of Cook, et al, although there is no significant disagreement. Fig. 5 summarizes the present knowledge of the behavior of the K^--p total cross section as a function of the total c.m. energy.

In summary, the results of the present measurements are consistent with a smooth fall off of the total cross section with momentum in the range between 2 and 6 BeV/c. However, the existence of some structure at about 3.5 BeV/c cannot be ruled out and the region is worthy of further study.

We wish to acknowledge the invaluable cooperation of Dr. G. K. Green, M. H. Blewett, and the AGS staff. The technical assistance of George Munoz, Frank Seier, and Oscar Thomas is greatly appreciated.

FOOTNOTES

* Work performed under the auspices of the U. S. Atomic Energy Commission.

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5. From the relative position of these four counters - S_4, S_3, S_5, S_6 in sequential order in the beam, but S_3, S_4, S_5, S_6 in order of increasing solid angle - it is clear that only S_3 and S_4 are ordered such that the relative error in their partial cross sections can be calculated exactly from the measured coincidence rates. In this case the effects of the absorption of the beam in S_4 and of the smaller size of S_3 are additive in producing the measured partial cross section. This is not the case for any other pair of counters and therefore the error bars drawn in Fig. 3 involve a certain amount of estimation.

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FIGURE CAPTIONS

Fig. 1 Experimental arrangement.

Fig. 2 Pressure curve taken with the gas Cerenkov counter at a momentum of 4 BeV/c.

Fig. 3 Typical extrapolation of the partial total cross sections to zero solid angle.

Fig. 4 The experimental results plotted as a function of laboratory momentum.

Fig. 5 Summary of K^--p total cross sections as a function of the total energy in the center of mass system.

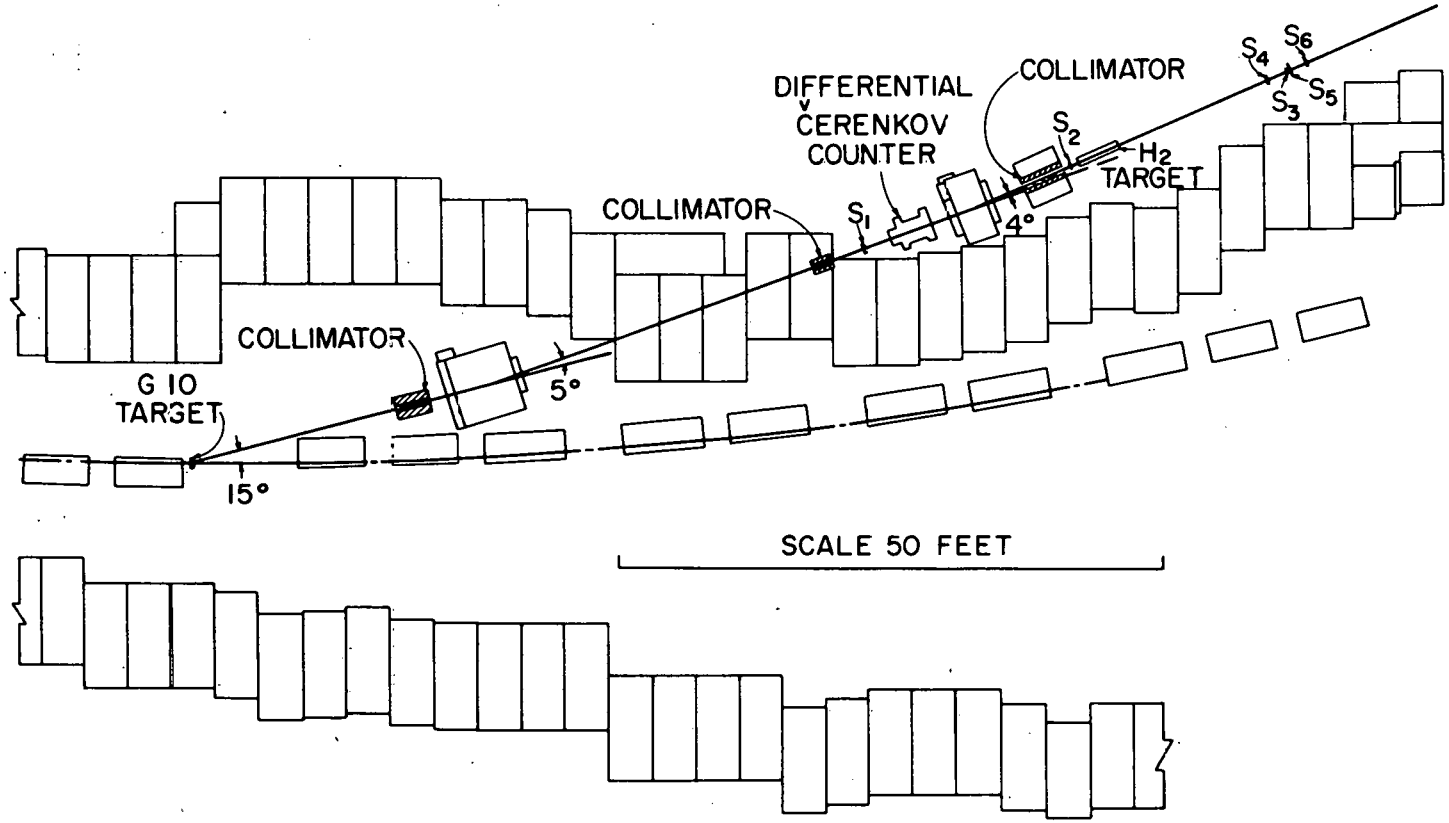
DIFFERENTIAL
CERENKOV
COUNTER
COLLIMATOR
S_4
S_6
S_3
S_5
S_2
H_2
TARGET
COLLIMATOR
S_1
4°
COLLIMATOR
5°
G 10
TARGET
15°
SCALE 50 FEET

FIGURE 1

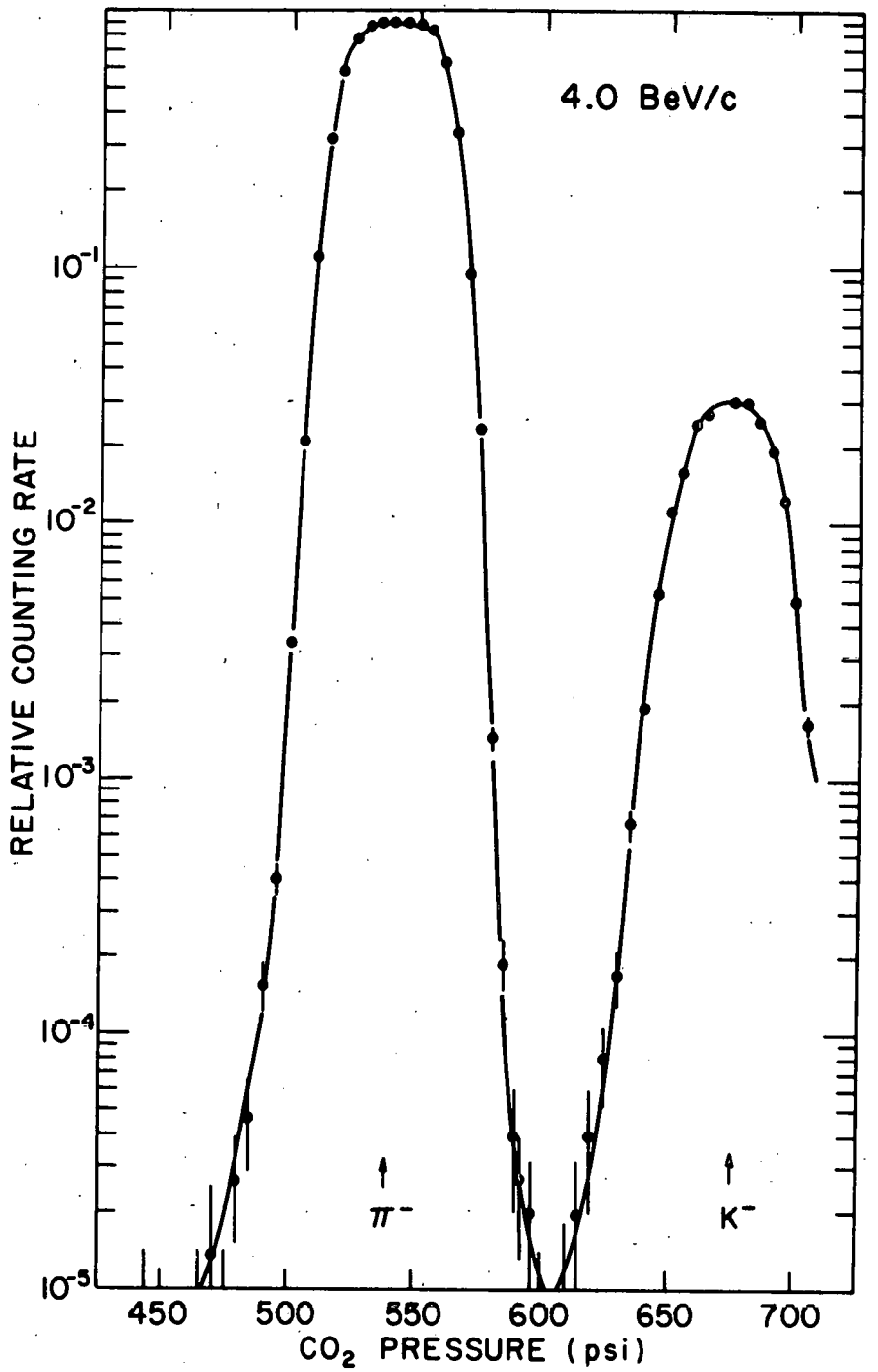
4.0 BeV/c
RELATIVE COUNTING RATE
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
π^-
K^-
450
500
550
600
650
700
CO_2 PRESSURE (psi)

FIGURE 2

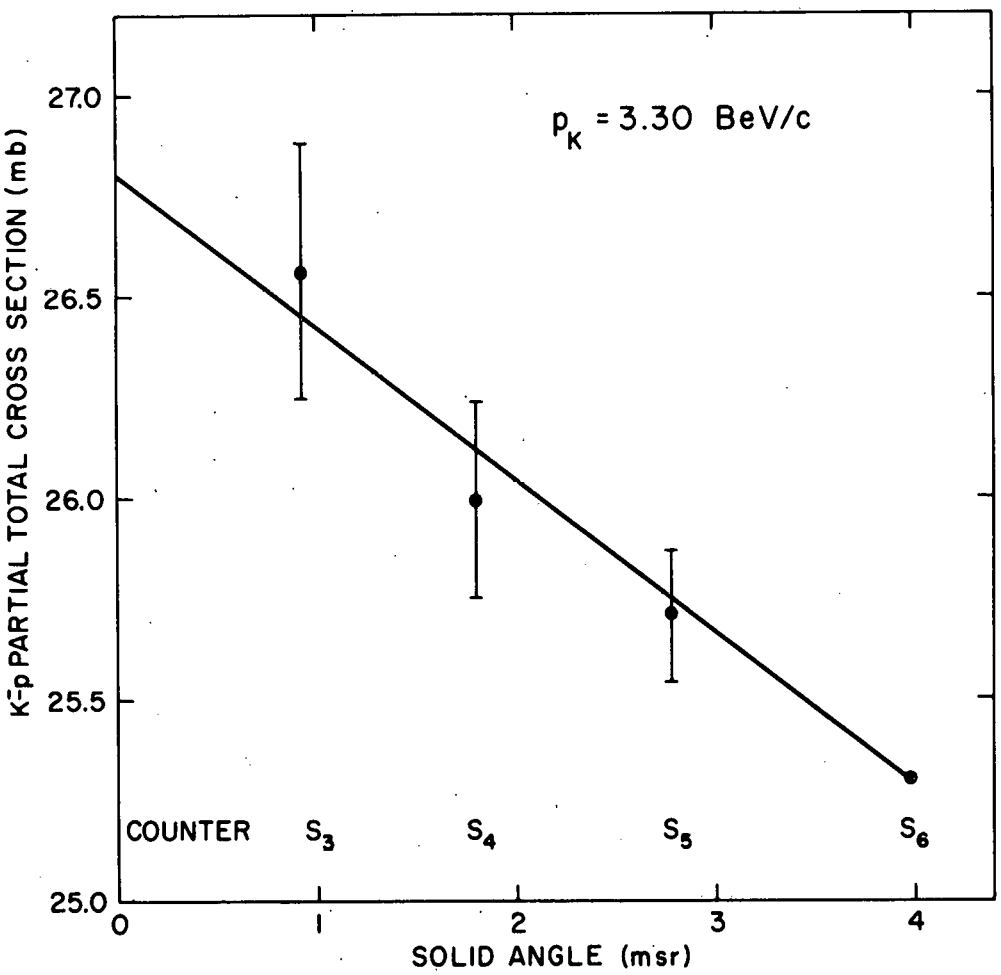
p_K = 3.30 BeV/c
K^-p PARTIAL TOTAL CROSS SECTION (mb)
27.0
26.5
26.0
25.5
25.0
COUNTER
S_3
S_4
S_5
S_6
0
1
2
3
4
SOLID ANGLE (msr)

FIGURE 3

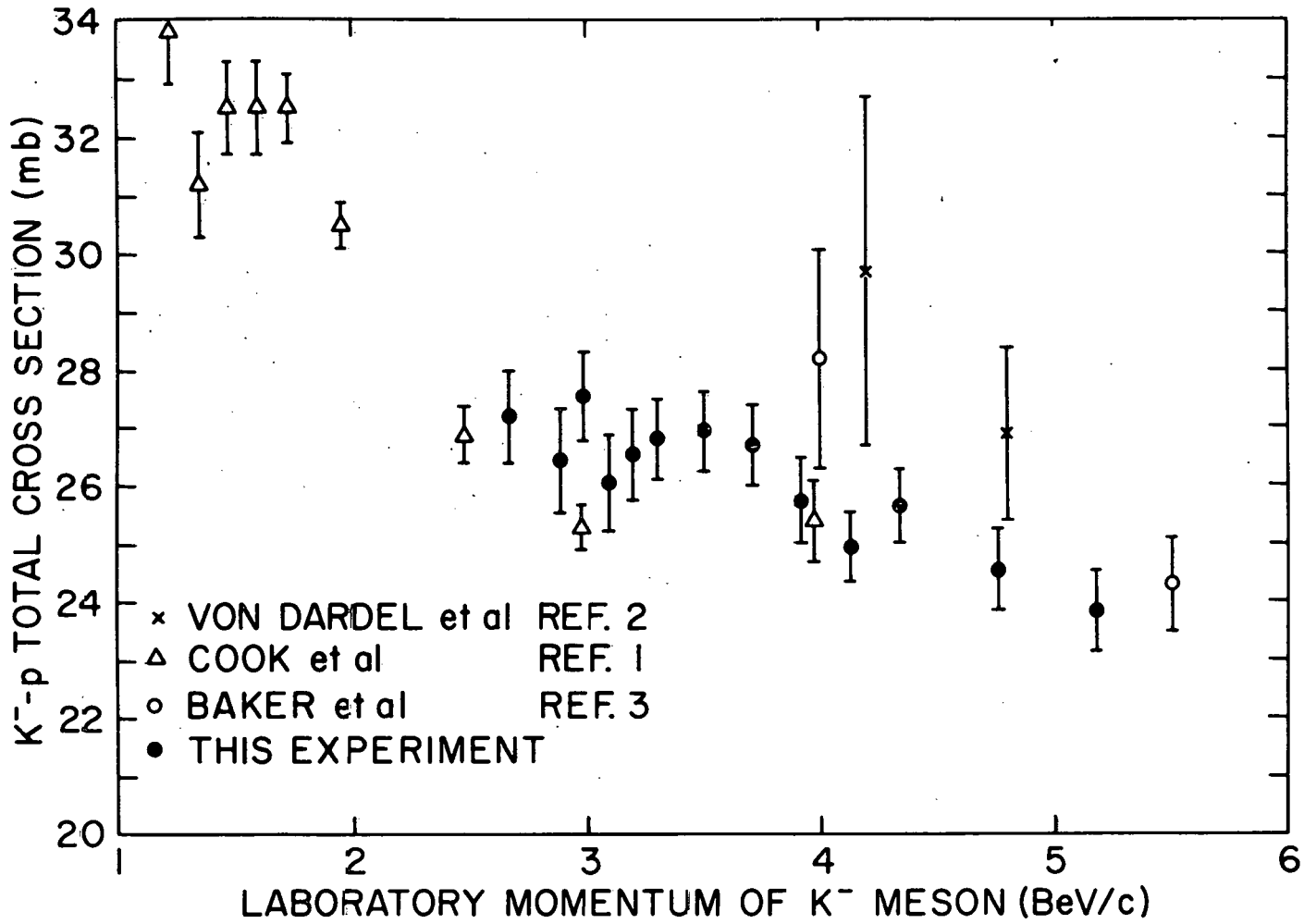
34
32
30
28
26
24
22
20
1
2
3
4
5
6
K⁻-p TOTAL CROSS SECTION (mb)
LABORATORY MOMENTUM OF K⁻ MESON (BeV/c)
× VON DARDEL et al REF. 2
△ COOK et al REF. 1
○ BAKER et al REF. 3
● THIS EXPERIMENT

FIGURE 4

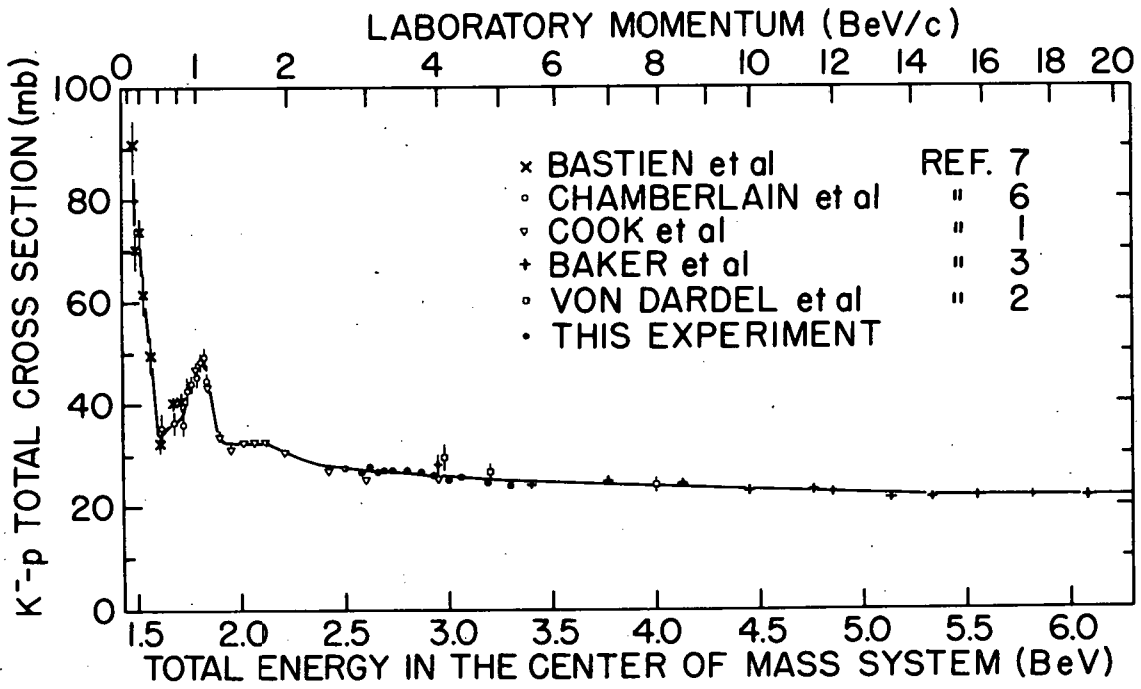
LABORATORY MOMENTUM (BeV/c)
0 1 2 4 6 8 10 12 14 16 18 20
K⁻-p TOTAL CROSS SECTION (mb)
100 80 60 40 20 0
× BASTIEN et al REF. 7
◦ CHAMBERLAIN et al " 6
▿ COOK et al " 1
+ BAKER et al " 3
▫ VON DARDEL et al " 2
• THIS EXPERIMENT
1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
TOTAL ENERGY IN THE CENTER OF MASS SYSTEM (BeV)

FIGURE 5

Table I. The K^--p Total Cross Sections

Laboratory Momentum (BeV/c)	Center of Mass Total Energy (BeV)	$\sigma(K^-p)$ (mb)
2.67	2.49	27.20 ± 0.80
2.88	2.57	26.45 ± 0.90
2.98	2.61	27.55 ± 0.80
3.09	2.65	26.05 ± 0.85
3.19	2.68	26.55 ± 0.80
3.30	2.72	26.80 ± 0.70
3.50	2.79	26.95 ± 0.70
3.71	2.86	26.70 ± 0.70
3.92	2.92	25.75 ± 0.75
4.13	2.99	24.95 ± 0.60
4.34	3.05	25.65 ± 0.65
4.76	3.18	24.55 ± 0.70
5.18	3.30	23.85 ± 0.70