

K^+p ELASTIC SCATTERING IN THE BACKWARD DIRECTION AT 2.76 BeV/c*

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The differential cross section for backward ($\cos\theta^* \leq -0.84$) K^+p elastic scattering has been measured at 2.76 BeV/c. No evidence is seen for the $Z_1(2505)$ or for a dip in $d\sigma/du$ at 180° . A good fit with an exponential in $\cos\theta^*$ is obtained, yielding a slope 13.0 ± 2.4 and an intercept $d\sigma/d\Omega(180^\circ) = 87 \pm 16 \mu\text{b/sr}$.

Previous measurements of π^\pm backward elastic scattering have shown that the energy dependence of the differential cross section at 180° is a sensitive method of looking for s -channel resonances.¹

Precise measurements of the K^+p total cross section have observed an $I=1$ structure at 2.505 BeV ($p_{\text{lab}} = 2.700$ BeV/c).² In this Letter, we present the results of a measurement of the differential cross section for K^+p elastic scattering in the backward direction at a laboratory momentum of 2.76 BeV/c with $\Delta p/p = \pm 1\%$.

In addition to the data previously published on backward K^+p elastic scattering,^{3,4} data now exist from an extensive set of measurements in the momentum interval 1.0-2.5 BeV/c.⁵ In contrast to the rich structure observed in π^\pm elastic scattering at 180° , the data are consistent with a monotonic decrease of the 180° differential cross section with the exception of possible shoulders at 1.15, 1.45, and 2.0 BeV/c.⁵ The present experiment extends the data to 2.76 BeV/c and offers the possibility of observing interference effects between the $Z_1(2505)$ and the direct-channel amplitude.

As part of a systematic survey of the K^+p interaction at intermediate momenta, 160 000 pictures were exposed at the Argonne National Laboratory 30-in. hydrogen bubble chamber to a 2.76-BeV/c K^+ beam. From a count of τ -like events, the path length was measured to be 3.0 ± 0.2 events/ μb in a centrally chosen chamber fiducial volume.

The entire film was scanned for beam interactions or decays with two or more outgoing prongs; $\frac{1}{5}$ of the film was double scanned to determine scanning efficiencies. All of the two-prong events which were found on this complete scan of the film were reexamined on the scanning table, using a template⁶ to eliminate obvious inelastic or nonbackward events. This selection process yielded 1200 candidates for backward K^+p elastic scattering. From the double scan we have determined our scanning efficiency for backward

two-prong events to be 0.92 ± 0.02 , which agrees well with efficiencies calculated for other topologies.

All candidates were measured on a scanning and measuring projector and processed through standard University of Illinois geometric reconstruction and kinematic fitting programs. After a remeasurement pass,⁷ and after restricting the candidates to the same fiducial volume as the τ -like events, 110 events were obtained which fit the hypothesis $K^+p \rightarrow pK^+$ with a $\chi^2 \leq 40$. The χ^2 probability distribution for these events, none of which fits the hypothesis of backward π^+p elastic scattering, is shown in Fig. 1(a) and has the ex-

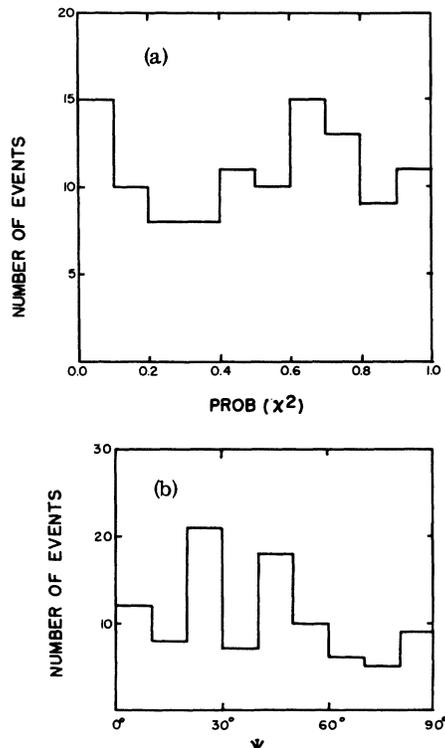


FIG. 1. (a) The χ^2 probability distribution for the 110 backward-elastic-scattered events produced by the reaction $K^+p \rightarrow pK^+$. (b) The distribution of the production plane about the beam direction for the 96 events with $\cos\theta^* \leq -0.84$.

pected uniform behavior.

The possible presence of a scanning bias for backward elastic scatters was studied using the distribution of the production plane about the beam direction. Defining Ψ by the equation

$$\cos \Psi = \hat{n} \cdot \hat{Z}, \quad (1)$$

where \hat{n} is a unit vector normal to the production plane and \hat{Z} is a unit vector normal to the chamber window, we plot in Fig. 2(b) the observed distribution of Ψ folded about 90° . Since the template criteria result in a rejection of events where neither outgoing track appears backward, we consider only center-of-mass K^+p scattering angles θ^* satisfying

$$-1.0 \leq \cos \theta^* \leq -0.84.$$

96 events satisfy this condition. In this region, Ψ is expected to be uniformly distributed. The small depletion in the observed number of events for $60^\circ \leq \Psi \leq 90^\circ$, indicated by Fig. 1(b), was considered to be evidence for a bias⁸ in the template scan, and due corrections to the data were made.

In Table I the data both before and after corrections are shown for this experiment. The magnitude of these corrections is generally small and does not significantly affect our conclusions. The differential cross section in the backward direction as a function of θ^* is plotted in Fig. 2; also shown in this figure is a straight line obtained by a least-squares fit of the data with the function

$$\frac{d\sigma}{d\Omega} = \frac{d\sigma}{d\Omega}(180^\circ) \exp \{-A(1 + \cos \theta^*)\}.$$

Table I. Summary of data for K^+p elastic scattering in the backward direction at 2.76 BeV/c. A scanning efficiency of 0.92 ± 0.02 is included in the calculation of the corrected number of events.

Interval in $\cos \theta^*$	Interval in $u(\text{BeV}/c)^2$	Observed Number of Events	Corrected Number of Events	$\frac{d\sigma}{d\Omega} (\mu\text{b}/\text{sr})$	$\frac{d\sigma}{du} (\mu\text{b}/(\text{BeV}/c)^2)$
-1.0, -0.98	0.065, 0.023	23	30.4 ± 6.7	80 ± 18	241 ± 53
-0.98, -0.96	0.023, -0.020	15	18.5 ± 5.0	49 ± 13	146 ± 40
-0.96, -0.94	-0.020, -0.062	17	19.6 ± 4.9	52 ± 13	155 ± 39
-0.94, -0.92	-0.062, -0.104	10	12.0 ± 3.9	32 ± 10	95 ± 31
-0.92, -0.90	-0.104, -0.146	9	10.9 ± 3.8	29 ± 10	86 ± 30
-0.90, -0.88	-0.146, -0.188	6	7.6 ± 3.3	20 ± 9	60 ± 26
-0.88, -0.86	-0.188, -0.230	6	6.5 ± 2.7	17 ± 7	52 ± 22
-0.86, -0.84	-0.230, -0.272	4	4.4 ± 2.2	12 ± 6	35 ± 18
TOTAL		90	110		

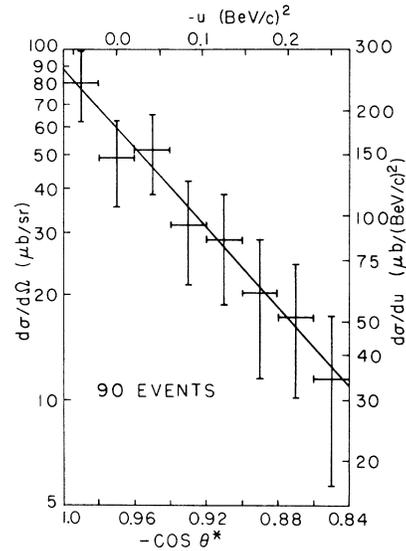


FIG. 2. Backward differential cross section for K^+p elastic scattering at 2.76 BeV/c. The solid line represents a fit with an exponential function as explained in the text.

The value obtained for the slope, A , was

$$A = 13.0 \pm 2.4,$$

while the extrapolated cross section at 180° was

$$\frac{d\sigma}{d\Omega}(180^\circ) = 87 \pm 16 \mu\text{b}/\text{sr}.$$

If we express the data in terms of u (the square of the four-momentum transfer between the inci-

dent K^+ and the outgoing proton), the slope is 6.5 ± 1.2 $(\text{BeV}/c)^{-2}$, and the intercept at $u = 0.065$ $(\text{BeV}/c)^2$, corresponding to 180° , is 261 ± 48 $\mu\text{b}/(\text{BeV}/c)^2$.

Our results are consistent with the shoulder reported earlier at 2.0 BeV/c for the cross section at 180° and indicate a rapid decrease in the differential cross section between 2.76 and 3.5 BeV/c . If we use the functional form $d\sigma/d\Omega \propto 1/P_{\text{lab}}^n$, we find $n = 4.7 \pm 1.8$.⁹ A single Regge-trajectory calculation of the differential cross section would predict $n \approx 3$.¹⁰ Below 2 BeV/c the differential cross section at 180° has an average slope with n approximately equal to 2.5, which is consistent with the expected energy dependence of a single Regge trajectory. It is difficult to see, however, how the observed energy dependence in the momentum interval 2.0-2.7 BeV/c can be fit with a single Regge trajectory.

The shoulder may also be due to interference with a resonating background. From the measured total cross sections, however, it is known that the $Z_1(2505)$ has an elasticity $x \leq 0.04$, and we would expect to see it in the inelastic final states. In our preliminary analysis of the inelastic states K^*p , K^0N^* , and K^*N^* at this energy, we have seen no evidence for any resonant behavior.

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¹Data are summarized by M. Derrick, Argonne National Laboratory Report No. ANL/HEP 6802 (unpublished).

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⁵A. S. Carroll, J. Fischer, R. H. Phillips, C. L. Wang, B. R. Martin, A. Lundby, F. Lobkowicz, A. C. Mellissinos, Y. Nagashima, C. A. Smith, and S. Tewksbury, in *Proceedings of the Fourteenth International Conference on High Energy Physics*, Vienna, Austria, 1968 (to be published).

⁶A two-prong event was eliminated as a candidate for K^+p elastic scattering in the backward direction if one (or more) of the following conditions was satisfied: (i) Both outgoing tracks emerged on the same side with respect to the beam; or (ii) neither outgoing track had a projected angle (in a specified view) of greater than 85° with respect to the beam direction; or (iii) the track satisfying the backward condition (ii) stopped in the chamber without decaying; or (iv) the other (non-backward) track had a measurable curvature corresponding to a momentum of less than 1.8 BeV/c .

⁷Forward elastic scatters and well-measured inelastic events were readily eliminated as candidates. All other events (34), which did not fit the hypothesis of elastic scattering in the backward direction with a $\chi^2 \leq 40$, were remeasured and found to be inconsistent with that hypothesis.

⁸The events lost in a systematic fashion by the template scan were considered by the scanner to have both outgoing tracks on the same side of the beam track. This resulted in a right-left asymmetry in the projected angle distributions which was readily corrected by discarding events on the biased side and repopulating using events on the unbiased side.

⁹At 3.55 BeV/c we use the value $d\sigma/d\Omega(180^\circ) = 26.1 \pm 12.0$.

¹⁰V. Barger and D. Cline, *Phys. Rev.* **155**, 1792 (1967).