

COMPARISON OF K^+ AND K^- INCLUSIVE SCATTERING
AT 10.4 AND 14.0 GeV*

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ABSTRACT

A systematic study of the inclusive scattering process
 $K^\pm p \rightarrow K^\pm X$ for $|t| < 1.0 \text{ GeV}^2$ at 10.4 and 14 GeV/c is presented.

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A systematic study of the inclusive scattering process $A^\pm p \rightarrow A^\pm X$ in the target fragmentation region has been performed with $A^\pm = \pi^\pm, K^\pm, p^\pm$ at 10 GeV/c and $A^\pm = K^\pm$ at 14 GeV/c. The experiment was part of a program investigating particle and antiparticle elastic scattering with high statistics and minimal systematic uncertainties. In this paper we present the results for K^\pm inclusive scattering at 10 and 14 GeV/c. The data were obtained using the SLAC rf-separated hadron beam and a large aperture wire chamber spectrometer [1]. The number of events obtained in the mass region $1.2 < M_X < 3.0$ GeV was typically between 10^5 and 3×10^5 for each reaction.

The trigger for the spectrometer during these studies demanded a valid beam particle and that one and only one forward particle was detected going through the spectrometer as defined by three sets of scintillation counter hodoscopes. A large aperture Cerenkov counter at the end of the spectrometer was set to detect pions with momenta greater than half the beam momentum. This counter, in anticoincidence, helped to suppress triggers from K decays. No requirement was made on detecting the recoil particles. The pole-tips and walls of the analyzing magnet aperture were lined with scintillation counters which vetoed events in which particles hit the magnet.

Inefficiencies in the Cerenkov counter ($\sim 10\%$) give rise to a contamination due to $K^\pm \rightarrow \mu^\pm \nu$ and $K^\pm \rightarrow \pi^\pm \pi^0$ decays in the region of small four momentum transfer. To avoid this contamination of the K-scattering data, we limited the missing mass range studied to masses less than 3 GeV, and the momentum transfer range studied to $|t|$ -values greater than $|t_0|$, a cutoff which depended on the missing mass. This cutoff varied from $|t_0| = 0.02 \text{ GeV}^2$ for the lowest

missing mass to $|t_0| = 0.12 \text{ GeV}^2$ for a missing mass of 3 GeV.

The data were corrected for geometric acceptance, decays in flight, spark chamber and counter inefficiencies, nuclear absorption, and the veto counter losses. This latter correction was found to depend only on the charged multiplicity of the recoil system and to be largely independent of the detail of the breakup. A phase space model, in which the charged multiplicity grows logarithmically with the missing mass [2], was used and gave a correction of 1.25 for a multiplicity of 1, growing to 1.4 for a multiplicity of 3 representing the extreme multiplicities in the mass range studied.

To obtain the inelastic cross section down to threshold, it is necessary to separate out the fraction of events belonging to the elastic and inelastic reaction respectively.* A good parametrization of the elastic peak was developed for the study of the elastic scattering [3], and thoroughly tested on a sample of elastic events, in which the recoil proton was also detected. The resolution was found to be $\sigma(M_p^2) = 0.190 \text{ GeV}^2$ at 10 GeV/c and $\sigma(M_p^2) = 0.250 \text{ GeV}^2$ at 14 GeV/c. The inelastic fraction was then obtained by fitting the missing mass distribution in each momentum transfer interval to a form:

$$f(M_x^2) = f_{el} + f_{inel} ,$$

where f_{el} is the elastic peak, and f_{inel} is a second order polynomial in missing mass squared folded with the resolution. This parametrization gave a good fit to the missing mass distribution and the inelastic fraction obtained was insensitive to the range of missing mass taken for the fit.

Having isolated the inelastic events, the double differential cross section

*For K^+ at 14 GeV the ratio $\sigma_{inel}/\sigma_{el}$ in the missing mass region $M_x < 1.2 \text{ GeV}$ is $\sim 0.8\%$ for $|t| < 0.6 \text{ GeV}^2$.

$\frac{d^2\sigma}{dM_X dt}$ was studied for the reactions:

$$K^+ p \rightarrow K^+ X \quad (1)$$

$$K^- p \rightarrow K^- X \quad (2)$$

at 10 and 14 GeV/c. Strong structures as a function of both missing mass and momentum transfer were observed. The same features are found for both K^+ and K^- scattering. In Fig. 1 the differential cross sections for three representative mass regions for the $K^+ p$ reaction at 14 GeV/c are shown: (a) the low mass region ($M_X < 1.2$ GeV), (b) a medium mass region ($1.4 < M_X < 1.5$ GeV), and (c) a high mass region ($2.0 < M_X < 2.2$ GeV). In the low mass region we observe a sharp forward peak, significantly steeper than for the elastic scattering. Between $|t| = 0.25 - 0.35$ GeV² the slope is changing very fast, roughly by 8 GeV⁻². A similar structure in $|t|$ - at low M_X - has been observed in high energy pp scattering and in pn scattering at 12.5 GeV [4]. In the medium mass range, $\frac{d\sigma}{dt}$ can be described by two exponentials in the regions $|t| < 0.25$ GeV² and $|t| > 0.25$ GeV², respectively. As the missing mass increases, these two exponentials merge gradually into each other. Finally, in the high mass region $\frac{d\sigma}{dt}$ is well described by a single exponential.

These cross sections include all possible processes and, in general, it is difficult to isolate a particular contribution. However, it is of interest to extract the diffractive component in reactions (1) and (2). Fortunately, we have independent information on the reactions:

$$K^+ p \rightarrow K^+ \Delta^+ \quad (3)$$

$$K^- p \rightarrow K^- \Delta^+ \quad (4)$$

which are the dominant nondiffractive contribution in the low mass region.

This is achieved through a study of the reactions:

$$K^+ p \rightarrow K^0 \Delta^{++} \quad (5)$$

$$K^- p \rightarrow \bar{K}^0 \Delta^0 \quad (6)$$

in a high statistics experiment using the identical spark chamber spectrometer at 13 GeV/c [5]. By isospin invariance the $K^0 \Delta$ cross sections may be related to that for the $K^\pm \Delta$ reactions. Using the known energy dependence [6] for these processes, the differential cross section at 10 and 14 GeV/c may be obtained. An estimate of the diffractive cross section may then be found by subtracting the Δ -contribution from the measured data. Fig. 2 shows the results of such a subtraction for reaction (1) at 14 GeV/c and for $M_x < 1.2$ GeV.*

The dependence of the data on the missing mass M_x was studied by fitting the differential cross section with an exponential form $e^{-B|t|}$ for each interval of the missing mass. Because the slope, B , in the small $|t|$ -region is in general different from the large $|t|$ -region, we discuss each region separately:

- (i) Small $|t|$ -region, $|t| < 0.25$ GeV²
- (ii) Large $|t|$ -region, $0.4 < |t| < 1.0$ GeV² .

In both regions an exponential gives a good fit to the data.

(i) Figures 3a and 3b show the M_x -dependence of B in the small $|t|$ -region for the 10 and 14 GeV data, respectively. At both energies the K^+ and K^- data are very similar. In the threshold region, for $M_x < 1.3$ GeV, the slope is significantly steeper (10.5 GeV⁻² at 14 GeV, 9.5 GeV⁻² at 10 GeV) than for the elastic scattering: for K^+ the elastic slope is ~ 6 GeV⁻², and for K^- it is ~ 8 GeV⁻². Between $M_x = 1.3$ and 1.8 GeV, the slope falls steeply and levels off above $M_x = 1.8$ GeV at ~ 3 GeV⁻² for the 10 GeV data and at ~ 3.5 GeV⁻² for the 14 GeV data. Several experiments studying specific single scattering

*To obtain the total Δ -contribution in this mass region we integrated a Δ -Breit-Wigner function - folded with the experimental resolution - over this mass interval.

reactions have indicated a similar dependence of the slope on the mass of the diffractive system [7].

After the subtraction of the Δ^+ contribution the slope of the forward peak of $\frac{d\sigma}{dt}$ at 14 GeV for $M_x < 1.3$ GeV is larger by $\sim 2 \text{ GeV}^{-2}$, while the difference increases to $\sim 4 \text{ GeV}^{-2}$ for $M_x < 1.2$ GeV. Again, the slopes for K^+ and K^- are very similar. For the 10 GeV data the corresponding increase of the slope is $\sim 4 \text{ GeV}^{-2}$ for $M_x < 1.3$ GeV and $\sim 5 \text{ GeV}^{-2}$ for $M_x < 1.2$ GeV, but with somewhat larger errors ($\sim 2 - 3 \text{ GeV}^{-2}$). After the Δ contribution has been subtracted, the slope in the small M_x region is consistent with no energy dependence. Therefore we conclude that the shrinkage from 10 to 14 GeV by $\sim 1 \text{ GeV}^{-2}$, as seen in the unsubtracted differential cross section, may be explained by the different Δ^+ production at 10 and 14 GeV.

(ii) In the large $|t|$ -region, as can be seen in Figs. 3c and 3d, the slope does not show any strong variation with the missing mass. But the slope for K^- is larger than for K^+ by $\sim 0.5 - 1.5 \text{ GeV}^{-2}$, independent of the energy.

In conclusion, this study of inclusive scattering for $K^\pm p \rightarrow K^\pm X$ at 10 and 14 GeV in the diffractive proton dissociation region shows the following features of the differential cross section $\frac{d\sigma}{dt}$:

(1) For low mass excitation $\frac{d\sigma}{dt}$ shows a steep forward peak, significantly steeper than for the elastic scattering, the slope being about twice as large. Between $|t| = 0.25 - 0.35 \text{ GeV}^2$ there is an abrupt change in the slope of the differential cross section.

(2) In contrast, for high mass excitation, $\frac{d\sigma}{dt}$ is almost a single exponential, the slope being $\sim 1/2$ of the elastic slope.

(3) These features are independent of energy between 10 and 14 GeV and as such are characteristic of diffractive phenomena.

(4) The inclusive scattering for K^+ is very much the same as for K^- , indicating that the $C = -1$ exchanges are very small. The differential cross sections for K^+ and K^- scattering are equal to within 5% for $|t| < 0.25 \text{ GeV}^2$ at 10 and 14 GeV. This is in contrast to the elastic scattering, where the difference is $\sim 20\%$ at 10 GeV, and the $C = -1$ exchanges are quite significant.

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References

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Figure Captions

1. The differential cross section $\frac{d\sigma}{dt}$ for $K^+p \rightarrow K^+X$ at 14 GeV/c for the missing mass region:

- (a) $M_X < 1.2$ GeV
- (b) $1.4 < M_X < 1.5$ GeV
- (c) $2.0 < M_X < 2.2$ GeV.

The solid lines in (a) and (b) represent the result of the fit with an exponential $e^{-B|t|}$ for $|t| < 0.25$ GeV². The slope B is (a) 10.5 ± 0.2 GeV⁻² and (b) 7.2 ± 0.2 GeV⁻². In (c) the exponential fit was done for the whole $|t|$ range, $|t| < 1.0$ GeV². The slope obtained is 2.8 ± 0.1 GeV⁻².

2. The differential cross section $\frac{d\sigma}{dt}$ for $K^+p \rightarrow K^+X$ at 14 GeV/c for $M_X < 1.2$ GeV with $K^+p \rightarrow K^+\Delta^+$ subtracted.
3. The dependence of the slope on the missing mass M_X for $K^+p \rightarrow K^+X$ (\blacklozenge) and $K^-p \rightarrow K^-X$ (\blacklozenge) in the region:
 - (a) and (b) $|t| < 0.25$ GeV² for 10 and 14 GeV/c, respectively.
 - (c) and (d) $0.4 < |t| < 1.0$ GeV² for 10 and 14 GeV/c, respectively.

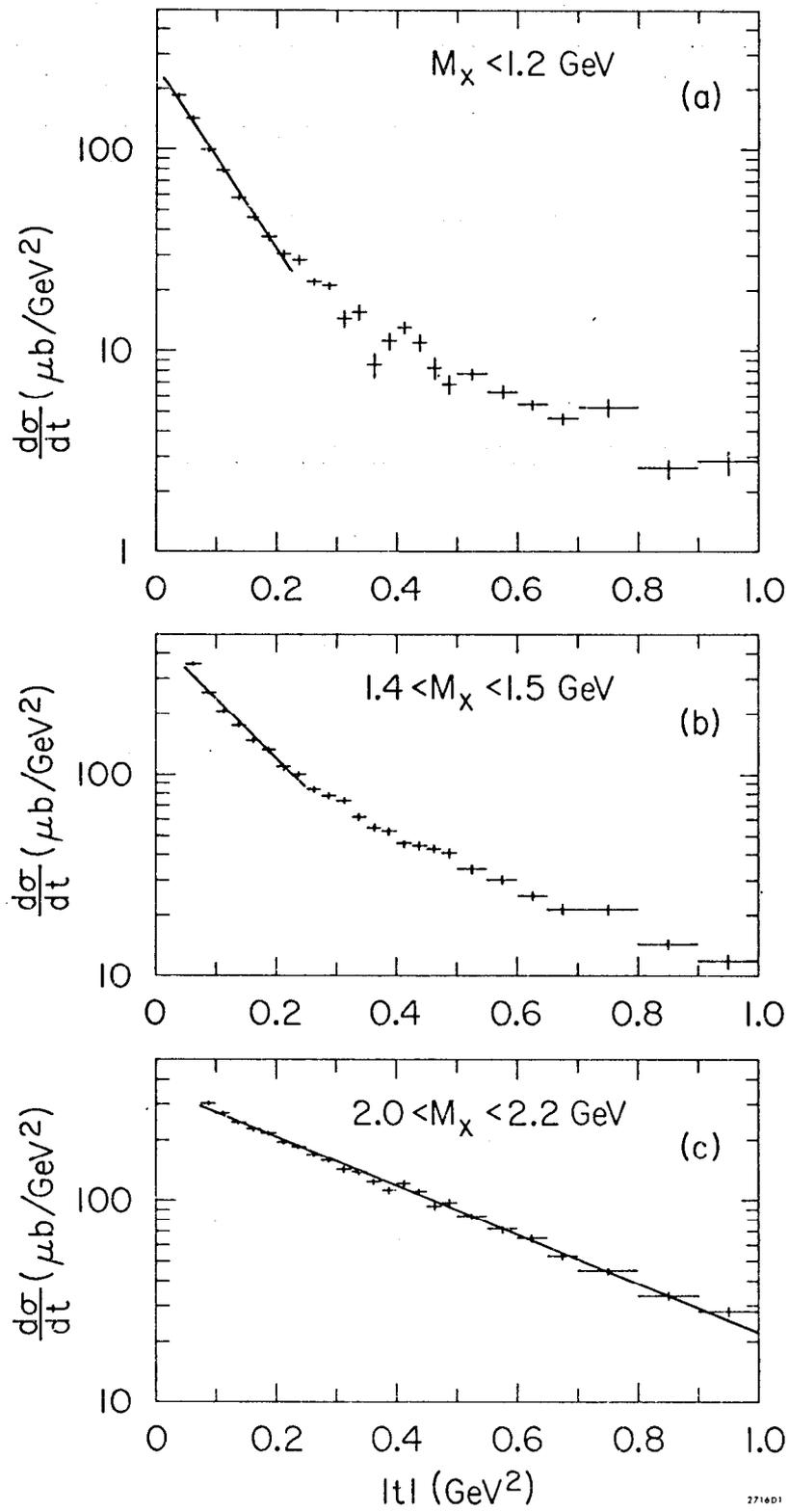


Fig. 1

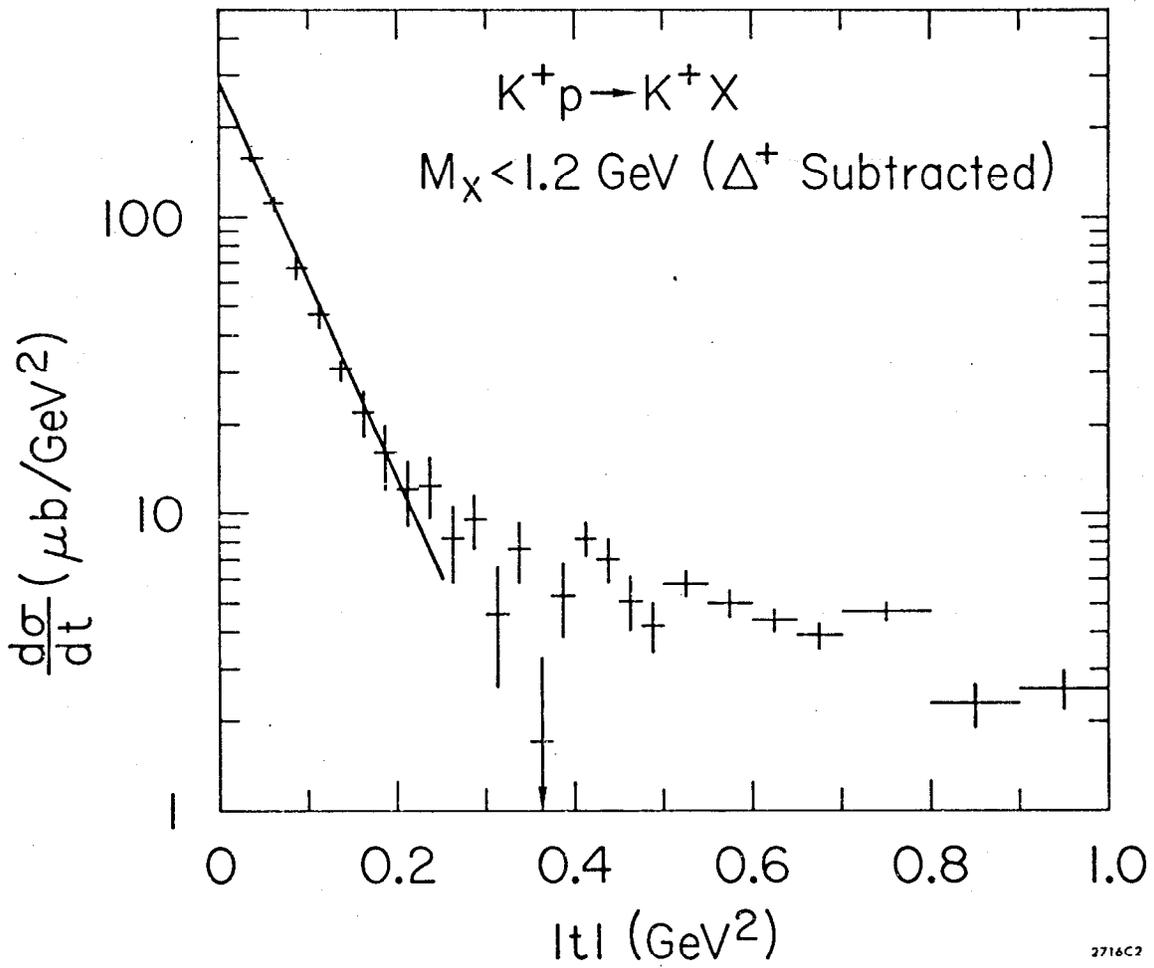


Fig. 2

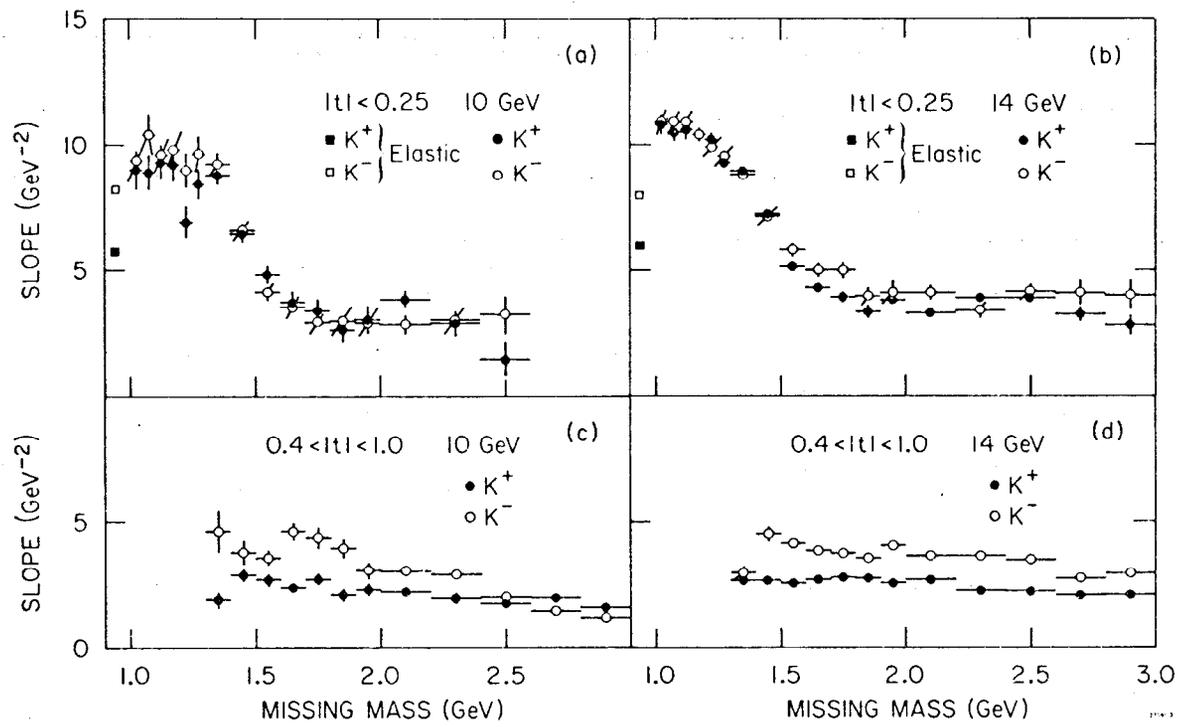


Fig. 3