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INCLUSIVE STRANGE RESONANCE PRODUCTION IN pp, π^+p and K^+p INTERACTIONS AT 147 GeV/c

(Presented by M. Kalelkar, Rutgers University)

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ABSTRACT

We have studied the inclusive production of the $K^{*\pm}(890)$ and $Y^{*\pm}(1385)$ in pp, π^+p and K^+p interactions at 147 GeV/c. The experiment used the Fermilab 30-inch hydrogen bubble chamber with the hybrid spectrometer system. Results are based on a sample of 1916 observed K_s and 932 observed Λ. Inclusive cross sections are given for $K^{*\pm}$ and $Y^{*\pm}$ production from the three beams, and comparisons are made with experiments at other energies. Feynman x and transverse momentum-squared distributions are also calculated. The results suggest that the K^{*-} is entirely produced in the central region, while the K^{*+} includes a component from beam fragmentation. Comparisons are made with the additive quark model.

INTRODUCTION

In this paper we report final results on inclusive $K^{*\pm}(890)$ and $Y^{*\pm}(1385)$ production in pp, π^+p and K^+p interactions at 147 GeV/c, all in the same experiment. The experiment was performed in the Fermilab 30-inch hydrogen bubble chamber with proportional wire chambers (PWC) located both upstream and downstream. A total of 400,000 pictures was taken in two runs, with different beam ratios in each. The final sample had an overall composition of 51% π^+, 9% K^+, and 40% p.

A total of 6744 vees constituted the final data sample. After resolving ambiguities, there were 1916 K_s, 932 Λ, 164 $\bar{\Lambda}$ and 3732 γ's. Table I summarizes the event sample.

Table I. No. of K_s, Λ, $\bar{\Lambda}$ and γ for each beam type

Vee	p beam	π^+ beam	K^+ beam
K_s	882	912	122
Λ	464	414	54
$\bar{\Lambda}$	63	91	10
γ	1732	1755	245

INCLUSIVE $K^{*\pm}(890)$ CROSS SECTIONS

In order to calculate inclusive cross sections for $K^{*\pm}(890)$ production, we first weighted each observed K_s to correct for detection inefficiency due to the imposition of a minimum length cut and decay volume restriction. The average escape weight was 1.98 for K_s. We then made a weighted $K_s\pi^\pm$ effective mass distribution for K_s events from all three beams. The resulting distribution is shown in Figure 1. A clear peak is apparent in the vicinity of the $K^*(890)$.

Mass distributions for $K_S\pi^+$ and $K_S\pi^-$ were separately fitted for all three beam types to yield the numbers of resonant events in each channel. To determine the inclusive cross sections, the numbers of escape-weighted events were corrected to account for scan inefficiency, measurement and geometrical reconstruction losses, and neutral decay modes of the K_S. A further weight of 2.0 was applied to include the contribution from K_L, and finally the branching ratio of 2/3 for $K^{*\pm} \to K^o\pi^\pm$ was incorporated. Table II summarizes the inclusive cross sections.

Table II. Inclusive cross sections for K^{*+} and K^{*-} production.

Reaction	σ(mb)	$\sigma(K^*)/\sigma(K^o+\bar{K}^o)$
$pp \to K^{*+}$ + anything	1.5 ± 0.3	.15 ± .03
$pp \to K^{*-}$ + anything	1.2 ± 0.2	.12 ± .02
$\pi^+p \to K^{*+}$ + anything	1.3 ± 0.2	.16 ± .03
$\pi^+p \to K^{*-}$ + anything	0.7 ± 0.2	.08 ± .02
$K^+p \to K^{*+}$ + anything	3.2 ± 1.3	.27 ± .11
$K^+p \to K^{*-}$ + anything	0.6 ± 0.5	.05 ± .04

INCLUSIVE DISTRIBUTIONS FOR $K^{*\pm}(890)$

Figures 2 and 3 show the Feynman x dependence of K^* production by the proton and π^+ beams respectively. In both cases we note an approximate equality of the K^{*+} and K^{*-} cross sections in the central region, followed by an excess of K^{*+} over K^{*-} in the beam fragmentation region. In order to make a rough quantitative measure of this observation, we have chosen x = .2 as a dividing line between the central and beam fragmentation regions, and then calculated the cross section ratio $\sigma(K^{*-})/\sigma(K^{*+})$ in the two regions for both beams. This ratio is shown in Table III, and does exhibit a marked difference in the two regions. In particular, K^{*-} production is at least four standard deviations less than K^{*+} production in the beam fragmentation region.

Table III. Ratio of K^{*-} to K^{*+} cross sections

Beam	$\lvert x\rvert < .2$	$\lvert x\rvert > .2$
p	1.1 ± .4	.16 ± .17
π^+	.7 ± .3	.13 ± .20

We have also produced transverse momentum squared distributions for $K^{*\pm}$ from the proton and π^+ beams. Experiments at lower energies have found a universal slope of about 3.4 $(GeV/c)^{-2}$, independent of beam, for particles of mass about 1 GeV. Our values, shown in Table IV, are somewhat lower. However, there is some evidence[1] that all p_T^2 slopes drop slightly with incident beam energy. To this end we show in Figure 4 the variation of the slope with beam energy for K^{*+} and K^{*-} production by proton and π^+ beams. The trend of the data suggests a decrease.

Table IV. Fitted p_T^2 slope parameters in units of $(GeV/c)^{-2}$

Beam	K^{*+}	K^{*-}
p	2.7 ± .4	3.1 ± .5
π	2.9 ± .4	2.8 ± .6

INCLUSIVE $Y^{*\pm}(1385)$ PRODUCTION

We used our sample of Λ events to study $Y^{*\pm}$ production. We followed a procedure analogous to that for the K^* study. The observed Λ's were weighted for geometric detection efficiency, providing an average escape weight of 1.91. We than examined weighted $\Lambda\pi^+$ and $\Lambda\pi^-$ effective mass distributions from each of the three beams. In general we observed enhancements in the vicinity of the $Y^*(1385)$, but these were less pronounced than the peaks for the K^*.

Fits to these mass distributions were made using a smooth polynomial background and a simple Breit-Wigner shape for the Y^*, with a mass of 1385 MeV and a width of 40 MeV. To determine inclusive cross sections, the numbers of escape-weighted events were corrected to account for scan inefficiency, measurement and reconstruction losses, neutral decay modes of the Λ, and the branching ratio of .88 for the $Y^{*\pm} \rightarrow \Lambda\pi^\pm$ decay.

Table V summarizes the inclusive cross sections for Y^{*+} and Y^{*-} production. Where upper limits are given, they are at 95% confidence level. For the proton beam the cross sections for the two charge states of the Y^* are very close to each other, suggesting that the production is primarily in the central region. By contrast, the meson beams from this experiment do not provide any evidence for Y^{*-} production, while there is a non-negligible signal for Y^{*+}.

Table V. Inclusive cross sections for Y^{*+} and Y^{*-}

Reaction	σ(mb)	$\sigma(Y^*)/\sigma(\Lambda)$
$pp \to Y^{*+}$ + anything	.38 ± .13	.09 ± .03
$pp \to Y^{*-}$ + anything	.40 ± .13	.10 ± .03
$\pi^+p \to Y^{*+}$ + anything	.29 ± .07	.16 ± .04
$\pi^+p \to Y^{*-}$ + anything	<.10	<.06
$K^+p \to Y^{*+}$ + anything	.08 ± .18	.06 ± .13
$K^+p \to Y^{*-}$ + anything	<.17	<.12

Table V also gives the ratio of Y^* to Λ total cross sections. If we assume that Y^* production in pp reactions is primarily in the central region (as suggested by the equality of Y^{*+} and Y^{*-} cross sections) we can make a quantitative test of the additive quark model.[2] This model makes predictions for particle production ratios in the central region. Many of these predictions are dependent on a strange-quark suppression factor λ, whose numerical value is not predicted by the model. Moreover, experimental data have suggested a momentum dependence for λ. However, the Y^*/Λ ratio in the central region is independent of the suppression factor and is predicted to have the value 0.25, both for Y^{*+} and Y^{*-}. Using the fraction of our Λ cross section in the central region[3] and assuming that all the Y^* is central, we obtain $\sigma(Y^{*+})/\sigma(\Lambda)$ = .25 ± .09 and $\sigma(Y^{*-})/\sigma(\Lambda)$ = .27 ± .09, which are in excellent agreement with the additive quark model.

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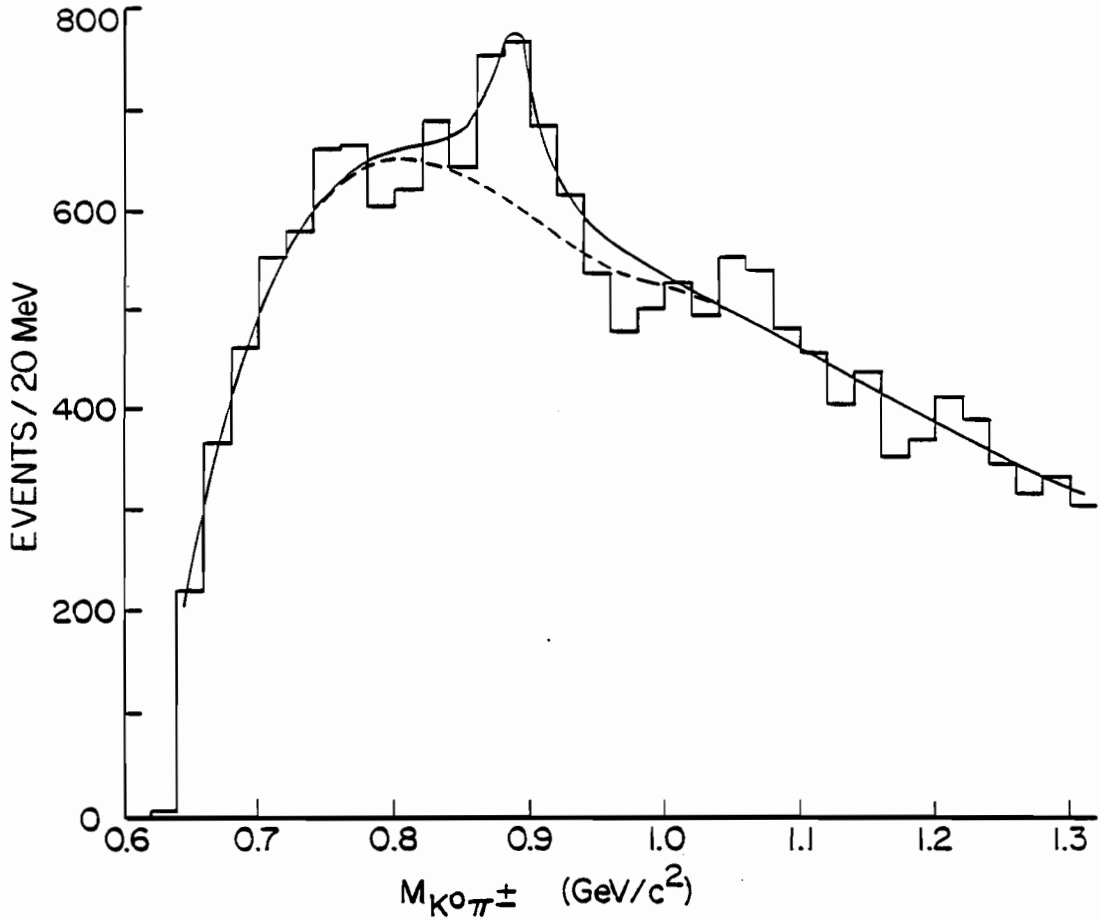

Fig. 1. Escape-weighted ($K^o\pi^+ + K^o\pi^-$) effective mass distribution from all three beams.

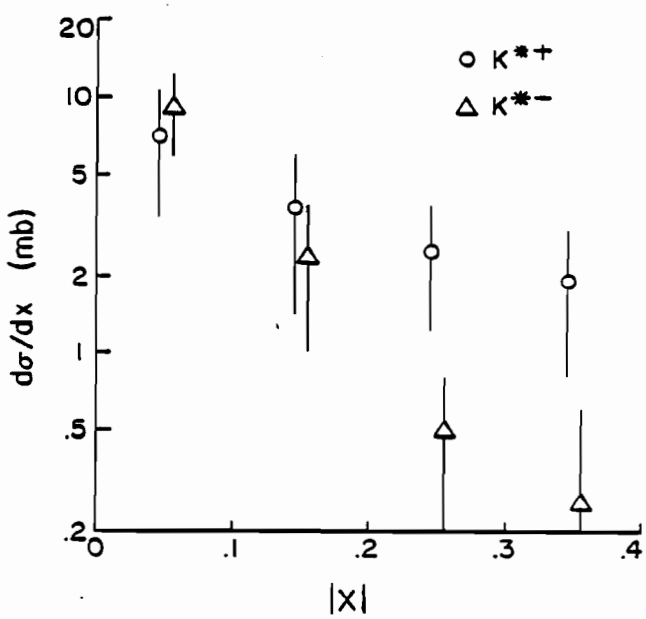

Fig. 2. Feynman x distribution for pp → K^* + anything.

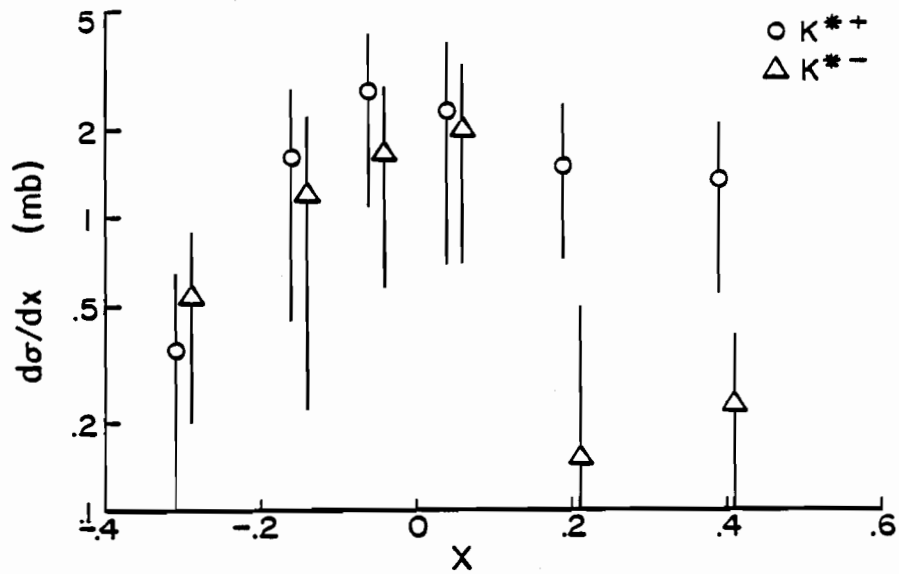

Fig. 3. Feynman x distribution for $\pi^+ p \rightarrow K^* +$ anything.

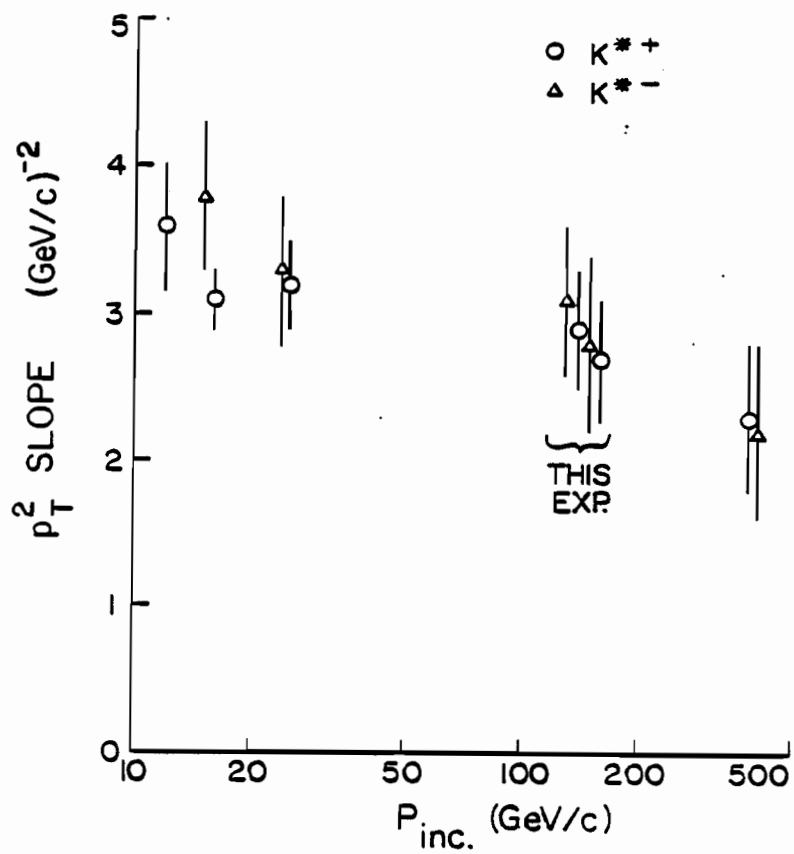

Fig. 4. Slope of the p_T^2 distributions for K^* production from proton and π^+ beams.