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INCLUSIVE γ, K^0_s, Λ^0 and $\bar{\Lambda}^0$ PRODUCTION BY 205 GeV/c $\pi^- p$ INTERACTIONS†

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ABSTRACT

Neutral decays and γ conversions have been analyzed in an exposure of the NAL 30" hydrogen bubble chamber to 205 GeV/c pions.

This paper presents preliminary results on inclusive cross sections for the production of γ's, K^0_s's, Λ^0's and $\bar{\Lambda}^0$'s by 205 GeV/c $\pi^- p$ interactions. The experiment was done in the NAL 30" hydrogen bubble chamber. Six hundred and sixty-four neutral decays (or conversions) found in a scan of 3058 $\pi^- p$ interactions[1] were measured. During measurement, three percent of these events were rejected as not pointing to the primary vertex. Another 29% were discarded by a fiducial volume cut on the neutral vertex.[2]

The remaining events were processed through TVGP and SQUAW. Kinematic fits to $\gamma(p) \rightarrow e^- e^+(p)$, $K^o \rightarrow \pi^- \pi^+$, $\Lambda^o \rightarrow \pi^- p$, $\bar{\Lambda}^o \rightarrow \bar{p}\, \pi^+$ were attempted. Acceptable fits were defined as having a chi-squared less than 20. A cut on the transverse momentum of the two outgoing charged tracks relative to the neutral track resolved most of the gamma-neutral particle decay ambiguities. The results were 312 events with one and only one acceptable fit; 20 events with more than one acceptable fit; and 117 events that failed reconstruction in TVGP or else failed to have any acceptable fit in SQUAW. All neutral decays (conversions) were classified during scanning according to whether an electron was identified and whether the opening angle between the two charged particles was zero or not. The ambiguous fits were resolved using this scanning information or by choosing the fit with the lowest chi-squared. The events with no fits were apportioned among the four fits using the scanning information and the known distribution of the events with fits into the various scan classifications.

K^o's, Λ^o's and $\bar{\Lambda}^o$'s produced forward in the $\pi^- p$ center of mass generally escape the chamber before decaying. Thus 13% of the neutral decays were discarded by requiring the neutral particle to be produced backwards in the center of mass frame of the $\pi^- p$ interactions. Thus this experiment can be considered a study of K^o_s, Λ^o and $\bar{\Lambda}^o$ production associated with the target proton. Finally, small corrections (10% to 15% depending on fit) were made for events missed by the scan because they were too close to the primary interaction vertex to be resolved, and also a correction for the 98.5% scan efficiency (after two independent scans) for neutral events was made.

The above analysis determines the number of each type of decay (conversion) inside the fiducial volume. In order to determine the total number produced at the primary vertex each event with a fit was weighted by the inverse of the decay (conversion) probability as determined by the particle's momentum[3] and potential length inside the fiducial volume. Also each event was weighted by the inverse of the branching ratio for the particular decay mode observed. The events with no fits were given the average weight of the fit they were assigned to (61.0 for γ, 1.86 for K^o_s, 2.03 for Λ^o, 4.61 for $\bar{\Lambda}^o$).

Table I gives the number of events and inclusive γ cross sections as a function of the associated charged particle multiplicity. The average number of π^o's produced, $\langle \pi^o \rangle$, is calculated assuming all γ's come from the decay $\pi^o \to \gamma\gamma$. Likewise Table II gives results for K^o_s production into the backward hemisphere. Figures 1 and 2 plot $\langle \pi^o \rangle$ and $\langle K^o_{s(\text{backward})} \rangle$ as a function of the associated charged particle multiplicity, n_{ch}. The dashed line in Fig. 1 is $(n_{ch} - 2)/2$, which can be thought of as the number of produced charged pairs.

$\langle K^o_{s(\text{backward})} \rangle$ is consistent with 0.077, independent of n_{ch}.

Fits to 41 backward Λ^o's and 4 backward $\bar{\Lambda}^o$'s were obtained. The corresponding cross sections are: $\sigma(\pi^- p \to \Lambda^o_{(\text{backward})} + \text{Anything}) = 0.91 \pm 0.23$ mb and $\sigma(\pi^- p \to \bar{\Lambda}^o_{(\text{backward})} + \text{Anything}) = 0.2 \pm 0.2$ mb. The average numbers of each particle produced per inelastic interaction are; $\langle \Lambda^o_{(\text{backward})} \rangle$ / Inelastic $\pi^- p$ interaction $= 0.044 \pm 0.011$

$\langle \bar{\Lambda}^o_{(\text{backward})} \rangle$ /Inelastic $\pi^- p$ interaction $= 0.01 \pm 0.01$.

The neutral particle decay results can be roughly compared with 205 GeV/c pp results. If one assumes one can "factorize" an interaction

into a forward part associated with the beam particle and a backward part associated with the target then the backward results on particles produced per inelastic collision for $\pi^- p$ at a given momentum should be $\sim$ same as backward results for pp interactions at the same momentum. Table III shows that the results of this experiment agree very well with the corresponding results for 205 GeV/c pp.[4]

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[1]D. Bogert, et al., $\pi^- p$ Interactions at 200 GeV/c. NAL-CONF-73/30-EXP.

[2]The neutral vertex was required to be inside a cylinder of radius 25 cm and height 23 cm centered in the bubble chamber. The fiducial volume for the primary $\pi^- p$ interaction was the same as in reference 1.

[3]For gamma conversion the pair production cross sections given in T. M. Knasel, DESY Reports Nos. 70/2 and 70/3, 1970 (unpublished) were used.

[4]K. Jaeger, et al., Production of Strange Particles and of γ-Rays in Proton-Proton Interactions at 205 GeV/c. Paper submitted to Berkeley Meeting of the American Physical Society, August 13-17, 1973. Their Λ° and $\bar{\Lambda}^\circ$ result for $\langle n \rangle$ has been divided by two in order to get backward result (making use of forward-backward symmetry in pp experiment). The K° result has been divided by four. The additional factor of two takes care of their inclusion of K°_L.

Table I. Cross sections for $\pi^- p \to \gamma$ + Anything.

m = Number of Charged Particles	Number of Fit γ's	Corrected and Weighted Number	$\sigma_m(\pi^- p \to \gamma$ + anything) mb	$\langle n_{\pi^-} \rangle$ / Inelastic $\pi^- p$ Interaction
2	6	724 ± 330	5.5 ± 2.5	1.6 ± 0.8
4	21	1861 ± 560	14.1 ± 4.2	2.1 ± 0.7
6	28	2711 ± 750	20.6 ± 5.7	2.7 ± 0.8
8	30	2438 ± 660	18.5 ± 5.1	2.3 ± 0.7
10	37	3071 ± 800	23.3 ± 6.1	3.4 ± 1.0
12	39	3299 ± 850	25.1 ± 6.5	5.8 ± 1.6
14	15	1313 ± 430	10.0 ± 3.3	3.8 ± 1.4
16	9	731 ± 290	5.6 ± 2.2	5.4 ± 2.3
18	6	599 ± 280	4.6 ± 2.1	7.3 ± 3.7
20	3	219 ± 140	1.7 ± 1.1	8.3 ± 6.0
TOTAL	194	16,966 ± 2090	128.9 ± 15.9	3.1 ± 0.4

Table II. Cross sections for $\pi^- p \rightarrow K^o_{s(\text{backward})}$ + Anything.

n = Number of Charged Particles	Number of Fit K^o's	Corrected and Weighted Number	$\sigma_n(\pi^- P \rightarrow K^o_{s(\text{backward})} + \text{Anything})$ mb	$\langle K^o_{s(\text{backward})} \rangle$ / Inelastic $\pi^- p$ Interaction
2	3	9.7 ± 6.8	0.07 ± 0.05	0.042 ± 0.030
4	9	28.3 ± 11.9	0.22 ± 0.10	0.062 ± 0.027
6	15	44.9 ± 16.2	0.34 ± 0.13	0.090 ± 0.033
8	16	45.3 ± 15.9	0.34 ± 0.12	0.085 ± 0.030
10	15	41.8 ± 15.1	0.32 ± 0.12	0.093 ± 0.034
12	9	25.3 ± 10.7	0.19 ± 0.08	0.088 ± 0.037
14	3	7.4 ± 5.2	0.06 ± 0.05	0.043 ± 0.031
16	3	7.6 ± 5.4	0.06 ± 0.05	0.110 ± 0.077
18	1	2.8 ± 2.8	0.02 ± 0.02	0.068 ± 0.068
TOTAL	74	213.1 ± 36.4	1.62 ± 0.28	0.077 ± 0.014

Table III. Comparison of neutral particles produced per inelastic interaction for 205 GeV/c $\pi^- p$ and pp.

Neutral Particle	$\langle n_i \rangle_{\pi^- p}$	$\langle n_i \rangle_{pp}$
$K^o_{s(\text{backward})}$	0.077 ± 0.014	0.085 ± 0.005
$\Lambda_{(\text{backward})}$	0.044 ± 0.11	0.055 ± 0.005
$\bar{\Lambda}_{(\text{backward})}$	0.01 ± 0.01	0.013 ± 0.004

[a]Reference 4

FIGURE CAPTIONS

Fig. 1. $\langle \pi^- \rangle$ produced per inelastic 205 GeV/c $\pi^- p$ interaction as a function of associated charged particle multiplicity, n_{ch}.

Fig. 2 $\langle K^o_{s(\text{backward in cm})} \rangle$ produced per inelastic 205 GeV/c $\pi^- p$ interaction as a function of associated charged particle multiplicity, n_{ch}.