A STUDY OF ΛK^0 AND $K^0\bar{K}^0$ PAIR PRODUCTION IN π^-p AND π^-C INTERACTIONS AT THE π^- MESON MOMENTUM OF 7—8 GeV/c

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(presented by Nguyen Dinh-Tu)

INTRODUCTION

The present work has been performed with a 24-litre propane bubble chamber and is a continuation of investigations of strange particle production, the momentum of π^--mesons being 7-8 GeV/c [1-3]. The chamber was operated in the constant magnetic field of 13.700 oersted.

The experimental set-up, beam characteristics, scanning technique, the analysis of the photographs, the introduction of different corrections, as well as the selection of π^-p-events in the propane have been described in papers [1-4].

I. ΛK^0 AND $K^0\bar{K}^0$ PAIRS GENERATED IN π^-p INTERACTIONS

In order to find pairs, we have scanned 60 000 photographs.

After the identification and the measurements of the V^0 were made, all the events were classified as follows:

$\Lambda+K^0$	$K^0+\bar{K}^0$	$(\Lambda\sim K)+K^0$	$\Lambda+K^0+\bar{K}^0$
52	37	16	2

16 events fit equally well the kinematics of the Λ and K^0 decay, but we considered them to be Λ particles since, according to our estimates, 80% of all non-identified events are Λ's.

(a) The momentum distributions of Λ and K^0 from ΛK^0 pairs in the CMS are shown in Fig. 1a, b, and of K^0 from $K^0\bar{K}^0$ pair in Fig. 2. There were taken into account the corrections for the probability of Λ and K^0 detection in the fiducial volume of the chamber.

The momentum spectrum of Λ^0 from ΛK^0 pairs is similar to that of the Λ from the paper by Veksler *et al* [2]. A group of Λ particles having a large momentum in the CMS can be clearly seen.

The momentum distributions of K^0 mesons from $K^0\bar{K}^0$ and from ΛK^0 pairs are alike. The average value of the momentum of K^0 mesons from ΛK^0 pairs was found to be (702±54) MeV/c and of K^0 mesons from $K^0\bar{K}^0$ pair was (604±55) MeV/c.

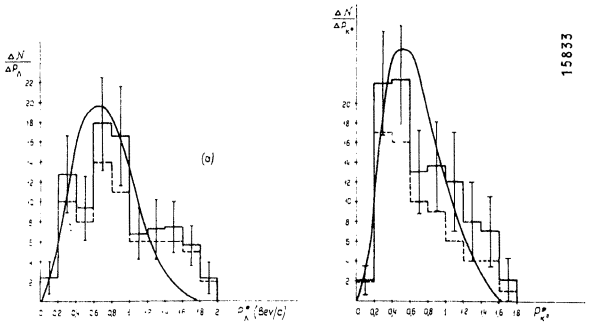

Fig. 1 The momentum distribution in the π^-p CMS (a) of Λ-hyperons and (b) of K^0 mesons from ΛK^0 pairs. The solid line shows the spectrum after introducing the correction for the recording probability of Λ and K^0 particles in the fiducial volume of the chamber. The smooth curve was calculated according to the statistical model.

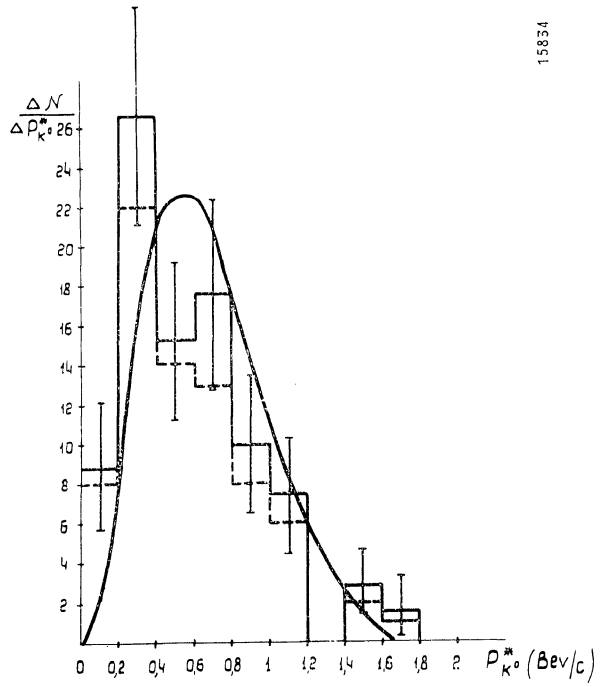

Fig. 2 The momentum distribution in the $\pi^- p$ CMS of K^0 mesons from $K^0\overline{K}^0$ pairs. The smooth curve was calculated by the statistical model.

(b) Figs. 3 and 4 show the CMS angular distributions of Λ and K^0 from ΛK^0 pairs and K^0 from $K^0\overline{K}^0$ pairs. There were taken into account the corrections for the probability of particle recording in the fiducial volume of the chamber. It follows from these results that:

(1) In the CMS most of Λ particles are flying backward and form a sharp peak in the region of cos $\theta^*_\Lambda = (-1.0 \rightarrow -0.8)$.

In these cases the baryon follows the direction of its initial motion. Another group of Λ particles is distributed isotropically.

(2) The K^0 from ΛK^0 pairs, besides the isotropic part, have a peak forward in the CMS. Such a characteristic of the angular distributions has already been pointed out for single Λ and K^0 in our papers[2, 3] and CERN publications [2, 3, 5].

(3) In the angular distribution of K^0 mesons from $K^0\overline{K}^0$ pairs in the CMS of $\pi^- p$ interactions a maximum in the region of cos $\theta^*_K = (+0.6 \rightarrow +1.0)$ can also be seen above the isotropic part.

A comparison between the angular distributions of K^0 mesons from $K^0\overline{K}^0$ pairs and that of the ' single ' K^0 mesons is given in Fig. 5. As is seen, within the statistical errors they coincide. A half of all the observed $K^0\overline{K}^0$ pairs $(47 \pm 12)\%$ are such that the particles are flying in opposite directions. In other cases either both K^0 mesons are flying backward $(25 \pm 7)\%$ or both forward $(28 \pm 8)\%$. The angular distribution obtained does not make it possible to prefer any peripheral diagram to some possible ones (Fig. 6).

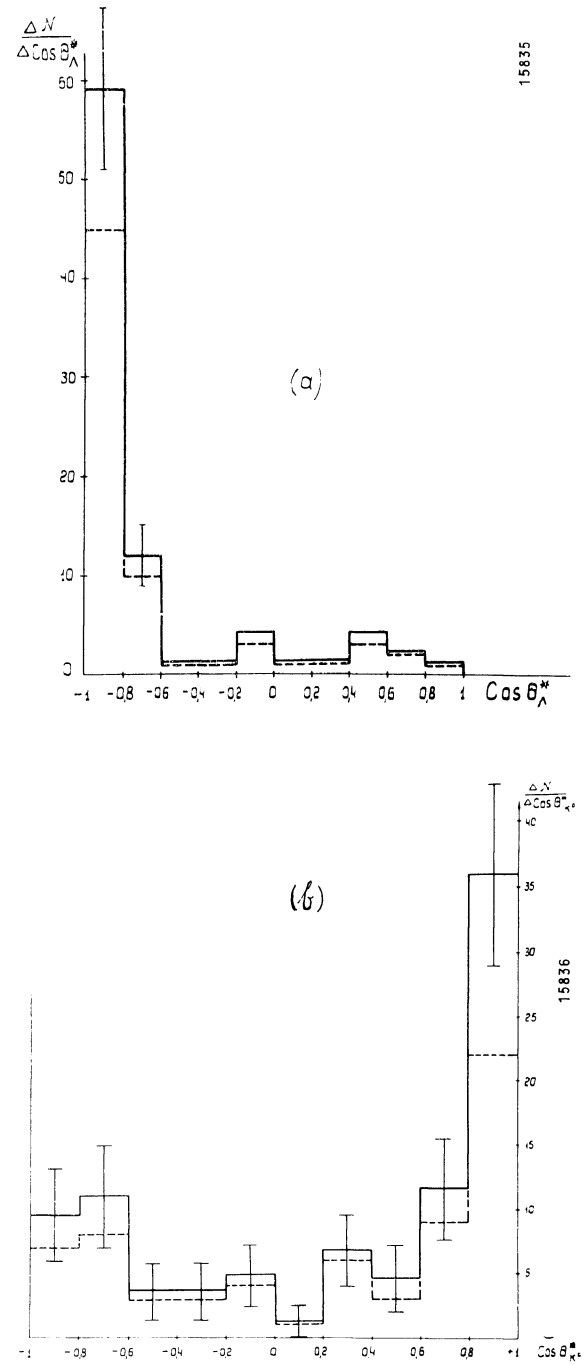

Fig. 3 The angular distributions in the $\pi^- p$ CMS (a) of Λ-hyperons, (b) of K^0 mesons from ΛK^0 pairs. The solid line shows the spectrum after introducing the correction for the recording probability of Λ and K^0 particles in the fiducial volume of the chamber.

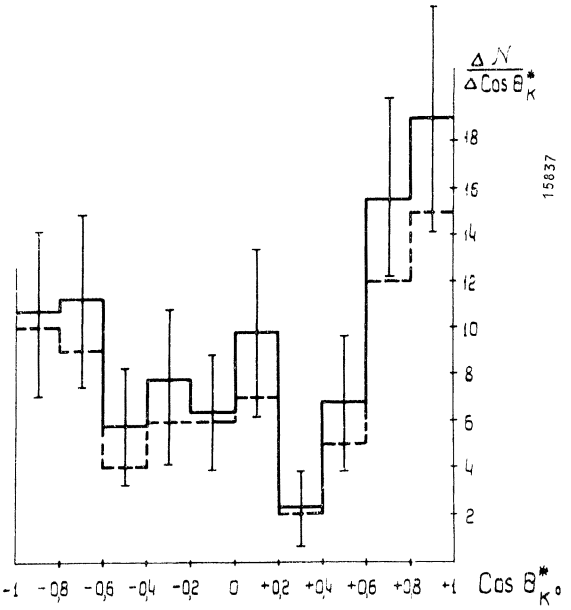

Fig. 4 The angular distribution in the $\pi^- p$ CMS of K^0 mesons from $K^0\overline{K}^0$ pairs. The solid line represents the spectrum after introducing the correction for the recording probability of K^0 and $\overline{K}^0$ particles in the fiducial volume of the chamber.

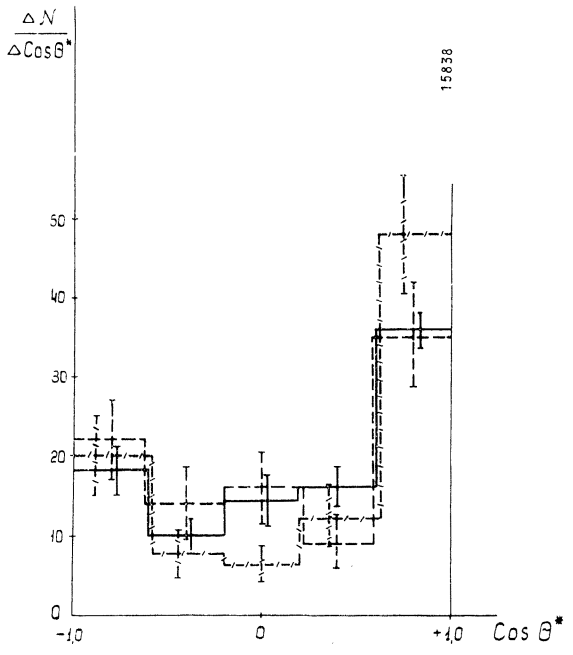

Fig. 5 Comparison of the angular distributions in the CMS of "single" K^0 mesons (solid line), of K^0 mesons from $K^0\overline{K}^0$ pairs (dotted line) and K^0 mesons from ΛK^0 pairs (dash-dot-line). All the distributions are normalized to the same area.

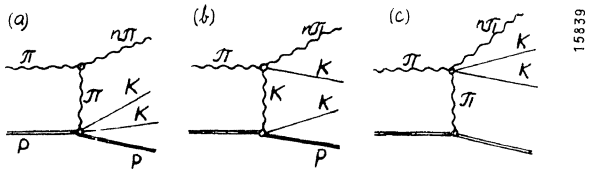

Fig. 6 Feynman diagrams.

For a complete analysis of the $K^0\overline{K}^0$ pair production in $\pi^- p$ interaction it is very important to consider the nucleon behaviour in this interaction. There were analysed 34 ' stars ' which generate the $K^0\overline{K}^0$ pair and it was established that only in six of them are there slow protons which can be identified with certainty. If the number of slow neutrons is assumed to be the same, it turns out that in most events of the $K^0\overline{K}^0$ pair production ($\sim$65%) fast nucleons in the lab. system are also produced. This is likely to indicate that the process of $K^0\overline{K}^0$ pair production is not, in the main, peripheral. The comparison of our angular distribution of the K^0 from $K^0\overline{K}^0$ pairs with the data obtained by a CERN group who use a 1 m propane bubble chamber (Peyrou report [6]) shows (Fig. 7) that these distributions coincide within the statistical error.

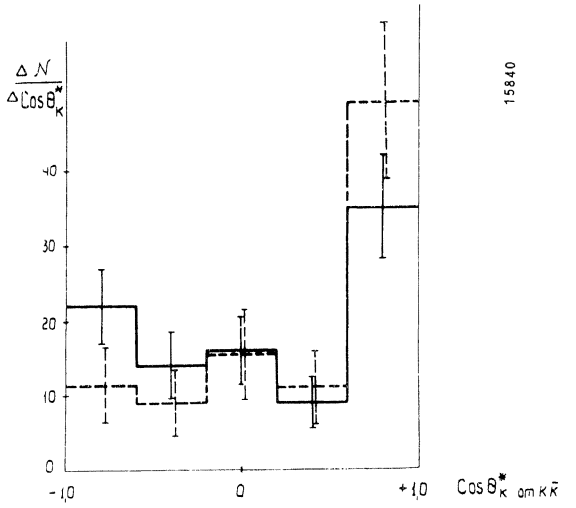

Fig. 7 Comparison of the angular distributions of K^0 mesons from $K^0\overline{K}^0$ pairs in the CMS of $\pi^- p$ interactions. The solid line shows the experimental data obtained by us (7-8 GeV/c). The dotted line is from the CERN data (6 GeV/c).

Fig. 8 shows the angular distribution of the $K^0(\overline{K}^0)$ in the CMS of the $K^0\overline{K}^0$ pair. This distribution points to the fact that in the $K^0\overline{K}^0$ pair production besides the S wave, the states with higher relative orbital momenta are present. As far as we detect only the K_1^0, there can arise the states with even l only as Ogievetski *et al.* pointed out [7].

The angular and momentum distribution of Λ hyperons from ΛK^0 pairs are similar to those of single Λ particles. Out of all ΛK^0 pairs there are $(55\pm9)\%$ of events when Λ hyperons are flying backward, while

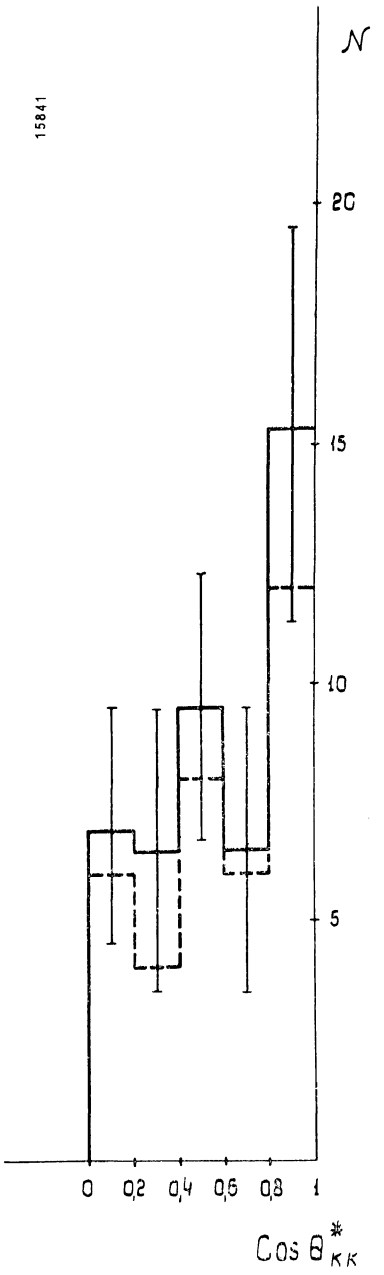

Fig. 8 The angular distribution in the CMS system $K^0\overline{K}^0$ of $K^0(\overline{K}^0)$ mesons from $K^0\overline{K}^0$ pairs.

K^0 mesons are flying forward; $(33\pm7)\%$ of the events when both particles are flying backward, and the remaining $(12\pm4)\%$ are the events in which Λ and K^0 are flying forward, or it may be that Λ hyperons are flying forward, while K^0 mesons backward. Such a nature of the angular distribution of Λ and K^0 from ΛK^0 pairs in the $\pi^- p$ CMS is likely to point out the possibility of an essential contribution of the peripheral diagrams, Fig. 9.

One can expect that the K^0 produced in the upper vertex of the diagram (a) will fly predominantly for-

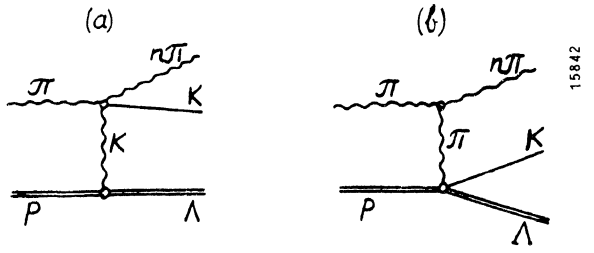

Fig. 9 Feynman diagrams for peripheral ΛK^0 production.

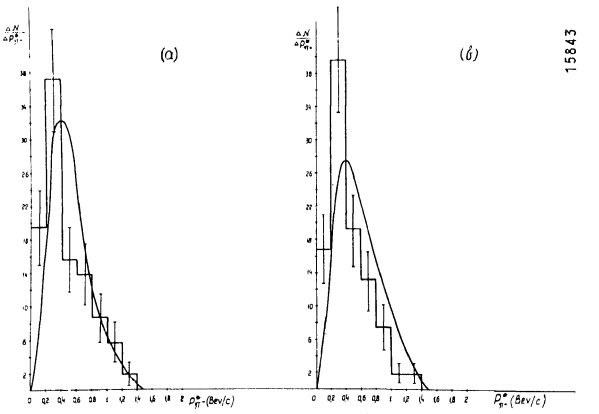

Fig. 10 The momentum distributions of $\pi^{\pm}$ mesons from ΛK^0 pairs. (a) of π^- mesons from ΛK^0 pairs, (b) of π^+ mesons from ΛK^0 pairs. A smooth curve represents the result of the calculation by the statistical model (with account of the isobars).

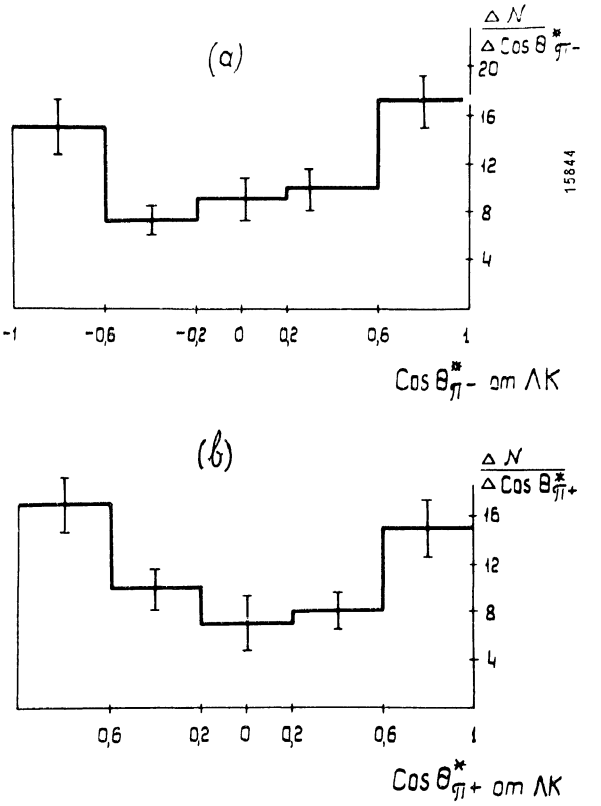

Fig. 11 The angular distributions of $\pi^{\pm}$ mesons from ΛK^0 pairs. (a) of π^- mesons, (b) of π^+ mesons.

ward in the CMS, and Λ hyperons backward, whereas in the diagram (b) K^0 and Λ will fly backward. We do not discuss here some other possible diagrams, for instance, those showing the production of π-mesons not only in the upper vertex, but in the lower one.

(d) The CMS momentum and angular distributions of $\pi^{\pm}$-mesons which accompany the ΛK^0 pairs are shown in Figs. 10 and 11. Fast π^- mesons are absent in the CMS momentum distribution of π^- mesons which are produced together with strange particles. This is the difference between this momentum distribution and that of the usual multiple production [8]. The momentum spectra of π^- and π^+ mesons produced together with ΛK^0 pairs are identical. The comparison of these spectra by Smirnov-Kolmogorov's method yields the coincidence probability of 0.95.

The angular distributions of $\pi^{\pm}$-mesons accompanying the production of ΛK^0 pairs are anisotropic and almost symmetrical. Here π-mesons are likely to be emitted forward more rarely than in the usual multiple production of π-mesons.

II. ΛK^0 AND $K^0\bar{K}^0$ PAIRS FROM π^-C INTERACTIONS

At present the investigations of π^-C pair events are being completed. On the basis of 150 pair events, the same distributions are being constructed for ΛK^0 and $K^0\bar{K}^0$ from π^-p interactions. A comparison is being made of the pairs produced in π^-p and π^-C.

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DISCUSSION

NAUENBERG: The low energy peak in Q-value distribution in the $K^0-\bar{K}^0$ system may simply be an s-wave attraction and not necessarily a resonance.

SAKURAI: In connection with Dr. Nauenberg's remark I have made a very preliminary calculation on this s-wave effect based on the data Dr. Walker will present and it may be that we need a very large scattering length, something of the order of 4-5 Fermi in order to observe a very sharp peak at low energy.

NGUYEN DINH-TU: About this question I will make a remark that the Q-value of the $K^0-\bar{K}^0$ pair will be reported by another reporter, but Ogievetski showed that the $K^0-\bar{K}^0$ pair which we have recorded in the chamber as $K_1^0\,\bar{K}_1^0$ must be in a state with an even number of orbital momentum. Our analysis gives some indication of the presence of $l>0$.

SALAM: If you can remember the Q-value reported elsewhere, why not report it now?

NGUYEN DINH-TU: It was a value like the one Wroblewski has reported here.

LEITNER: I just want to mention that we have found in the Syracuse-Brookhaven collaboration a similar effect in the $K-\bar{K}$ system and the total mass of this potential resonance is found to be about 1020 MeV. Samios will discuss this a bit later. Concerning Nauenberg's remark we have made a very rough analysis to find out whether a bound state is a sensible model for this system and the results of this, if I remember correctly, are that we needed an effective range analysis to do it and, because of its very small observed width the effective range turned out to be about 6 Fermi. It seemed to us rather large for this kind of thing.

M. GOLDHABER: Has anyone of these workers seen any correlation between K^+ and K^- in these investigations?

LEITNER: Our data combines both $K^0\,\bar{K}^0$ and $K^+ + K^-$, but the number of charged events is small.

ROSENFELD: The "$\pi 72$" group at Berkeley see a similar peak in $K^0\,\bar{K}^0$. Interesting enough, in $K^0\,K^-$ or $K^0\,K^+$, that is the charged pairs, the effect disappears.

WROBLEWSKI: In our experiment we have very few $K^0\,K^{\pm}$ pairs and only 2, if I remember well, $K^+\,K^-$ pairs, so we did not make this analysis.