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 ΛK^0 AT 4 GeV/c**

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► **To cite this version:**

I. Arai, J. Chiba, N. Kato, H. Kitayama, T. Kobayashi, et al.. PRODUCTION AND POLARIZATION OF STRANGE QUARKS FROM NUCLEAR MATTER: POLARIZATION OF Λ HYPERONS AT BACKWARD ANGLES IN THE REACTIONS $\pi A \rightarrow \Lambda X$ AND $\pi A \rightarrow \Lambda K^0$ AT 4 GeV/c. Journal de Physique Colloques, 1990, 51 (C6), pp.C6-591-C6-594. 10.1051/jphyscol:1990680 . jpa-00231095

HAL Id: jpa-00231095

<https://hal.science/jpa-00231095v1>

Submitted on 4 Feb 2008

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**PRODUCTION AND POLARIZATION OF STRANGE QUARKS FROM NUCLEAR MATTER :
POLARIZATION OF Λ HYPERONS AT BACKWARD ANGLES IN THE REACTIONS $\pi A \rightarrow \Lambda X$ AND
 $\pi A \rightarrow \Lambda K^0 X$ AT 4 GeV/c**

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L'hypéron lambda est une sonde intéressante permettant d'étudier la production de quarks étranges et leur polarisation dans la matière nucléaire. Nous avons mesuré les polarisations et les sections efficaces différentielles des hypérons lambda produits sur cible de ^{12}C aux angles arrières ($70^\circ < \theta_{lab} < 145^\circ$). Les polarisations ne sont pas reproduites du tout par un calcul basé sur une superposition de processus élémentaires alors que polarisation et section efficace sont bien reproduites par un modèle de quarks et de partons.

Abstract - A Λ hyperon is a fascinating nuclear probe at quark level. By using it, we can study the production of strange quarks from nuclear matter and their polarizations. Actually, we have measured the polarizations and the differential cross sections of Λ hyperons produced on ^{12}C target at backward angles ($70^\circ < \theta_{lab} < 145^\circ$), where the production of Λ hyperon is strongly forbidden in the quasifree interaction of incident pions with nucleons in nucleus, using large-aperture spectrometer. The polarizations are not reproduced at all by calculation based on the superposition of elementary processes, while both the polarizations and the cross sections are reproduced well in calculation based on the quark-parton models. As a next step, we have just finished the experiment on ^6Li target, which is also mentioned a little bit.

1 - INTRODUCTION

A Λ hyperon has several characteristic features as an interesting nuclear probe. At first, the Λ hyperon consists of u, d and s quarks as shown in Fig.1. It is the lightest baryon with s quark. The s quark does not exist in nuclear matter. Secondly, the production of Λ hyperon on nuclear matter is associated with a production of $s - \bar{s}$ quarks pair because there is no s quark anywhere. Fig.2 shows the production of Λ hyperon in proton fragmentation, for example. The Λ hyperon production means the production of $s - \bar{s}$ quarks pair from nuclear matter followed by the recombination of them with other quarks. Thirdly, the Λ hyperon decays into π and p via weak interaction. Because of the parity non-conservation in weak interaction, the decay angular distribution shows a characteristic asymmetry according to Λ hyperon's polarization as shown in Fig.3. Inversely, this fact enables us to measure the polarization of Λ hyperon easily.



Fig.1-Quark structure of Λ hyperon.

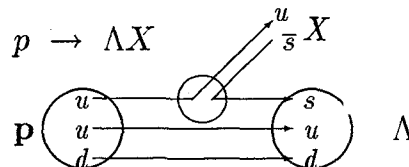


Fig.2-Production of Λ hyperon in proton fragmentation.

It should be noted that there is a tight correlation between Λ hyperon's polarization and its quark structure. Assuming (I) dominance of (diquark, s quark) recombination in Λ production and (II) SU(6) quark model, it is concluded straightforward that Λ hyperon's polarization is just s quark's polarization itself as shown in Fig.4.

The production of Λ hyperon substantially incorporates the reaction dynamics at quark level; production of $s - \bar{s}$ quarks pair and recombination of s quark with other quarks. In this context, Λ hyperon works as a fascinating nuclear probe at quark level and its polarization provides a critical information on the quark dynamics incorporated.

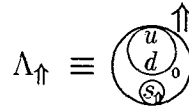
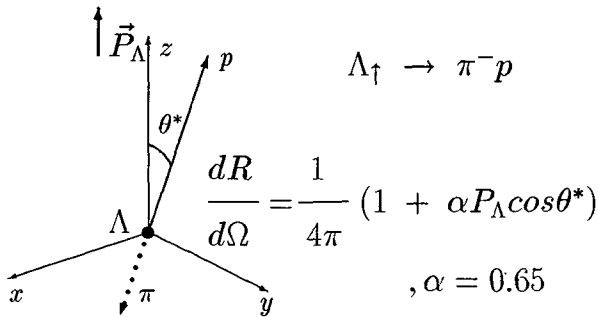


Fig.3-Asymmetry in decay angular distribution of Λ .

Fig.4-Polarization of Λ and its quark structure.

2 - BACKWARD Λ PRODUCTION

The backward particle production means a particle production under the extreme kinematics, which is highly selective and favours the appearance of special nuclear many body effect, e.g., the possible existence of "something heavier than a nucleon" or various many-particle correlations in nuclear matter. Fig.5 shows kinematics for the reaction $hA \rightarrow aX$. The particle a should be produced only inside the elastic circle under the quasifree hadron-nucleon interaction in nucleus. The backward particle production is a particle production in the shaded region, which is strongly forbidden in the quasifree hadron-nucleon interaction. Therefore, it needs the contribution of some exotic reaction mechanism, which should be a purely nuclear many body effect. We have a chance to pick up such a effect by measuring the backward particle production.

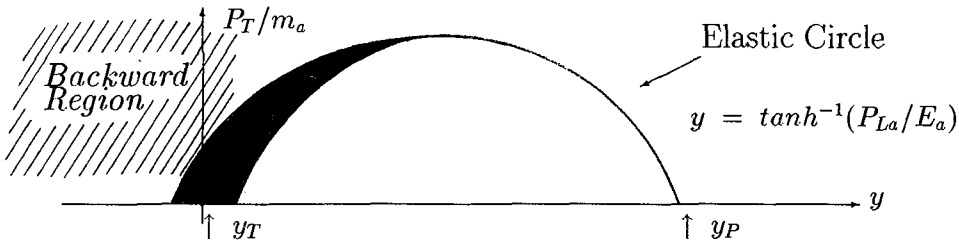


Fig.5-Kinematics for $hA \rightarrow aX$.

Taking into account the arguments in preceding section, we recognize the specific features of Λ production itself as follows:(I)strangeness production;it provides a new information, (II)polarization;we can measure a substantially new observable, (III)small final state interaction;the Λ hyperon is not distorted so much, (IV)quark dynamics;there should be the production of $s - \bar{s}$ quarks pair followed by the recombination of them with other quarks.

Now, it is a time to summarize the meaning of studying the backward Λ production. Based on the arguments so far, we can confirm that it is to study nuclear many body effect by using a probe at quark level.

3 - EXPERIMENT AT KEK

Motivated by these consideration, we have carried out two experiments of backward Λ production; $\pi A \rightarrow \Lambda X$ and $\pi A \rightarrow \Lambda K^0 X$ at 4 GeV/c. As for the former, we already have some physical results/1/, while the latter is now at the stage of data analysis.

In the former, we have measured differential cross sections and polarizations of Λ hyperons produced at the backward angles from 65° to 145° in lab.. The experiment was done by using a large-aperture multiparticle spectrometer, FANCY/2/. To identify the Λ hyperon, we installed new detectors in the most inner part of FANCY: the target chamber, which is 1mm spacing MWPC, and the vertex chamber, which is a compact cylindrical drift chamber with many tiny drift cells(see Fig.6). The Λ hyperon decays into π^- and p in its flight of few cm. These detectors are used to detect Λ 's decay vertex directly.

The Λ hyperon has its life of 2.6×10^{-10} sec, which is 7.89cm in ct . We have two criteria to discriminate the Λ :(I)direct detection of decay vertex and (II)invariant mass calculated by using momenta of π^- and p . The vertex cut is essential for clear discrimination of Λ . In Fig.7, you can see the clear discrimination of Λ

hyperon.

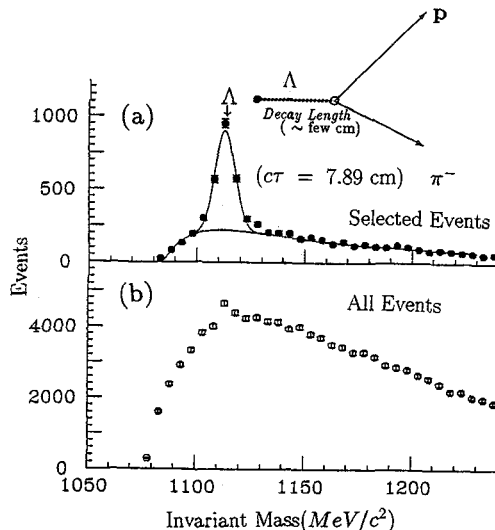
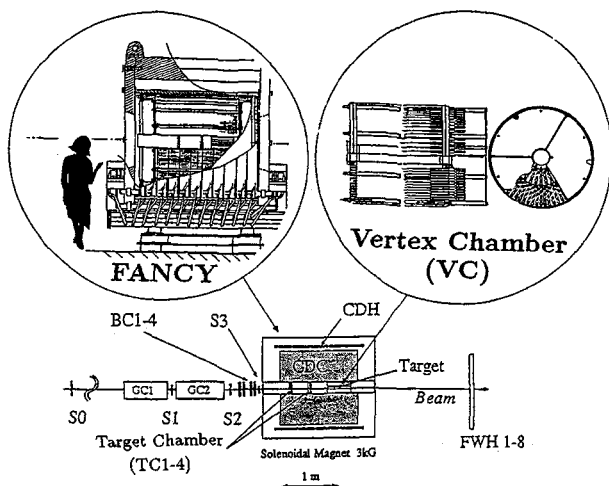


Fig.6-Experimental set up for $\pi^- {}^{12}\text{C} \rightarrow \Lambda X$ at 4 GeV/c. Fig.7-Invariant mass spectra of (π^-, p) system: (a)with vertex cut,(b)without vertex cut.

Fig.8 and Fig.9 show our experimental results. As for the invariant cross sections, you can see exponential-like behavior, which is common in other backward particle productions. As for the polarizations, you can see definite positive polarizations around 100° . Recognizing the poor statistics of previous bubble chamber experiment (unpublished; Shahbarzian, B. A. *et al.*, Joint Institute for Nuclear Research Reports No. E1-11519 and No. P1-12138, 1979), it may be said that we established the data for the first time. Indeed, our experiment is the first counter experiment of backward Λ production. In this experiment, we established the method of counter experiment for backward Λ production and achieved about ten times good statistics in comparison with the previous experiment.

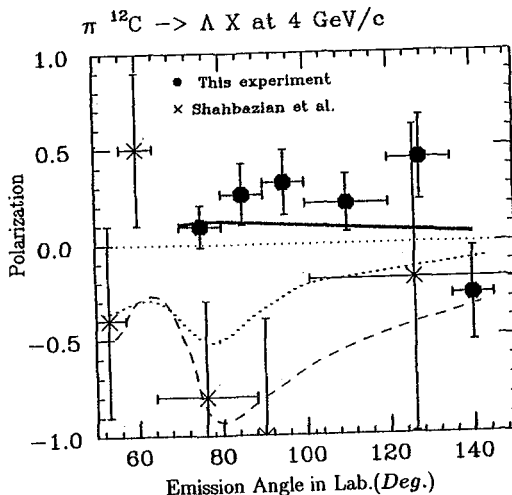
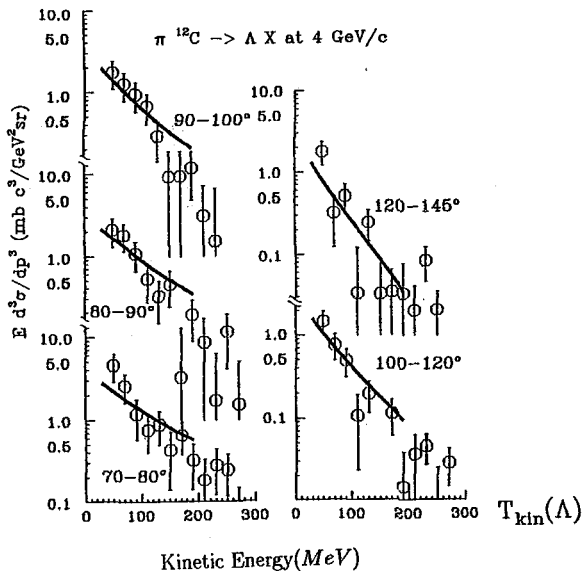


Fig.8-Invariant cross sections for $\pi^- {}^{12}\text{C} \rightarrow \Lambda X$ at 4 GeV/c. Fig.9-Polarizations for $\pi^- {}^{12}\text{C} \rightarrow \Lambda X$ at 4 GeV/c;

Then, we want to mention the theoretical calculations. Kobo *et al.* (private communication) have

calculated the polarizations based on the superposition of Regge pole amplitudes of elementary process $\pi^- N \rightarrow K^0 \Lambda$ incorporating the effect of nucleon's Fermi motion. In Fig.9, the dotted curve and the dashed curve are the calculations with the Fermi motion of 250 MeV/c and with that of 500 MeV/c, respectively. As you see, the calculations do not reproduce the experimental data at all. On the other hand, we have calculated based on quark-parton models. One is the quark-parton model of nuclear production by Berlad *et al.* (the coherent tube model at quark level)/3/. It provides a diquark structure function. The other is Thomas precession model of hyperon polarization by DeGrand and Miettinen/4/. It provides a quark dynamics to generate hyperon polarization. Our calculations for cross sections and polarizations are shown as solid curves in Fig.8 and Fig.9, respectively. Both the polarizations and the cross sections are reproduced very well. The data are reproduced so well by these rather naive calculations without any arbitrary parameter.

4 - FUTURE DIRECTION

Finally, we want to mention a little bit the future direction of our study. Because we have just established the method of experiment, the next step should be a systematic study as follows: (I)A-dependence, (II) the correlation with other particles, for example, K^0 ; for this study, we need large aperture forward spectrometer, (III) dependence of Λ 's polarizations on emission angles and kinetic energies; for this study, we need ten times more statistics than the present, and so on.

Along this direction, we have just finished the second experiment $\pi^- {}^6\text{Li} \rightarrow \Lambda K^0 X$ at 4 GeV/c (see Fig.10). In this experiment, we studied the A-dependence and the correlation with K^0 . The analysis is now under progress. The results will appear in near future.

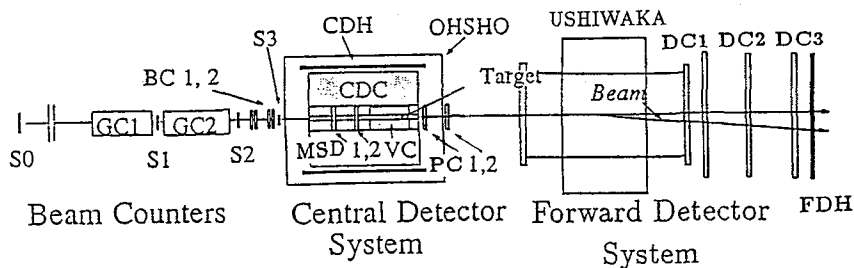


Fig.10-Experimental set up for $\pi^- {}^6\text{Li} \rightarrow \Lambda K^0 X$ at 4 GeV/c.

5 - CONCLUSIONS

The Λ hyperon has several specific features as a fascinating nuclear probe at quark level. By using the Λ hyperon, we can study the production of strange quarks from nuclear matter and their polarizations. Especially, we have studied the backward Λ production $\pi^- {}^{12}\text{C} \rightarrow \Lambda X$ at 4 GeV/c with at least ten times higher statistics than that of previous experiments. Our experiment is the first counter experiment which has measured the polarization of Λ hyperons produced in hadron-nucleus reactions over a wide range of backward angles. The polarizations are not reproduced at all by calculation based on the superposition of elementary processes, while both the polarizations and the cross sections are reproduced well in calculation based on the quark-parton models. As a next step, we have just entered into a systematic study. There are many possibilities in future direction. We have already finished the backward Λ production $\pi^- {}^6\text{Li} \rightarrow \Lambda K^0 X$ at 4 GeV/c. The analysis is now under progress. The results will appear in near future.

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