H dibaryon search via the (K^-, K^+) reaction using a diamond target (BNL-E885)

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An experiment to study double strangeness system was performed at the BNL-AGS via the (K^-, K^+) reaction using a diamond target and scintillating fiber (SCIFI) blocks (E885). The search for the H dibaryon through the stopped Ξ^- process is one of the objectives. The number of stopped Ξ^-'s is about 9,000, and the expected sensitivity of the H dibaryon search is more than one order of magnitude higher than that of the previous experiment at KEK-PS (E224).

1. Introduction

The stopped Ξ^- process shown below is one of the most effective method for the H dibaryon search.

$$K^- +' p' \rightarrow K^+ + \Xi^- \quad (1)$$
$$(\Xi^-, A)_{atom} \rightarrow H + X \quad (2)$$

In eq. (1), $'p'$ means a proton in a nucleus. The Ξ^-'s are brought to rest in material in order to produce $(\Xi^-, A)_{atom}$. Several early experiments adopted this method to search for the H

dibaryon (KEK-E176[1–4], KEK-E224[5,6], BNL-E813[7,8]). But the number of stopped Ξ^-'s was less than 200. E885 was designed to obtain much higher statistics and sensitivity using the diamond as the Ξ^- production and absorption target. An advantage of the diamond is small mass number ($A = 12$) and high density ($\rho = 3.4\mathrm{g/cm}^2$). According to the previous experiment at KEK, the forward-angle cross section of the quasi-free $p(K^-, K^+)\Xi^-$ reaction scales by $A^{0.38}$[9]. The nuclear targets with small mass number are favorable to obtain large Ξ^- yield owing to the above A-dependence. And the diamond has the highest density among material of the small mass number nuclei, which can stop short-life particles such as Ξ^-'s very efficiently. Also (K^-, K^+) reaction on carbon nuclei has been well studied in the previous experiments (KEK-E176,KEK-E224,BNL-E813). This is important so as to make the Monte Carlo simulation for estimating the number of stopped Ξ^-'s.

If the H dibaryon is stable against strong decay, several weak decay modes can be observed. In this experiment we focused on search for $H \to \Sigma^- + p$ and $H \to \Lambda + n$ using image data obtained with the SCIFI blocks.

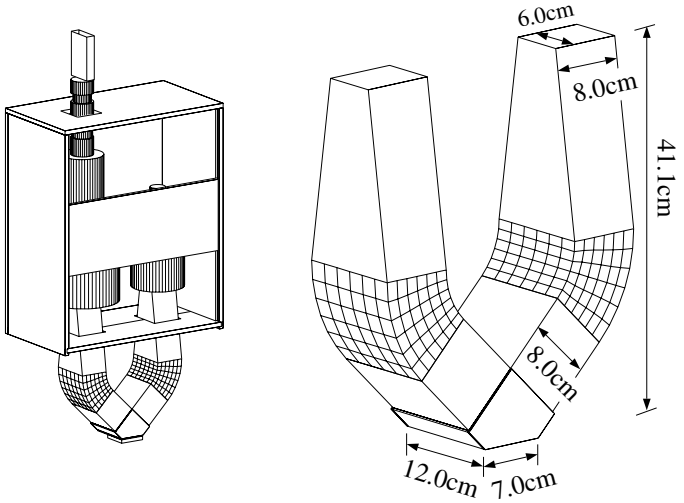

Figure 1. Schematic view of the scintillating fiber block used at E885. Images of particle tracks are read out from the end of each arm.

2. Experiment

The experiment was performed at the BNL-AGS D6 line[10] using 1.8 GeV/c K^- beam. The diamond target which consists of artificial diamond powder was placed at the final focusing point. The dimension was $8\mathrm{cm}(x) \times 1\mathrm{cm}(y) \times 5\mathrm{cm}(z)$ and the effective density was $3.3\mathrm{g/cm}^3$. Two SCIFI blocks were installed above and below the target respectively in order to observe the charged particle tracks of decay products. The schematic view of each block is shown in Figure 1 and it was viewed by two chains of an image intensifier tube (IIT) and a CCD camera. We can detect $\Lambda \to p + \pi^-$ and the decay chain of $H \to \Sigma^- + p$, $\Sigma^- \to n + \pi^-$ for the H search. Figure 2 is an example of image data obtained with the SCIFI block. The sequential decay of Ξ^- ($\Xi^- \to \Lambda + \pi^-$, $\Lambda \to p + \pi^-$)

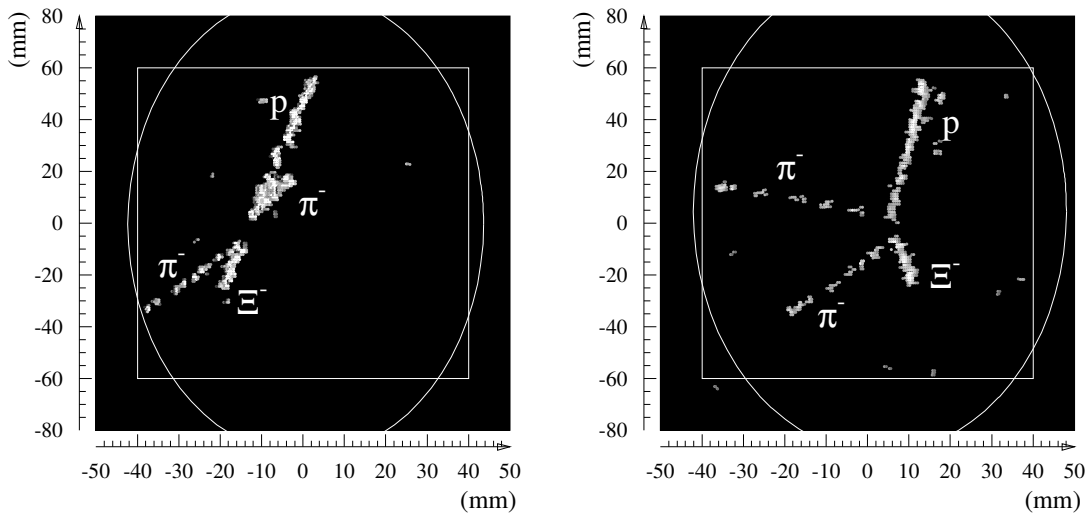

Figure 2. Example of image data in the SCIFI block. Each image was obtained in each read-out direction of the SCIFI block shown in Figure 1. The sequential decay of Ξ^- ($\Xi^- \to \Lambda + \pi^-, \Lambda \to p + \pi^-$) is observed.

is observed. On both right and left side of the diamond target, neutron counters were placed. We can detect neutrons from $H \to \Lambda + n$.

Data were collected in 1996. The diamond target was exposed to 8×10^{11} K^-'s and we obtained about 300,000 events of (K^-, K^+) reactions. Among them, the rate of Ξ^- stopping events in the diamond target is 5.6% according to the Monte Carlo simulation. Figure 3 shows the missing mass spectrum for $^{12}\mathrm{C}(K^-, K^+)X$ and the hatched area corresponds to the stopped Ξ^-'s obtained with the simulation. Since the rate of the image data acquisition was limited to $50 \sim 55\%$ of the total data, about 9,000 stopped Ξ^-'s have been obtained with the image data. It is two orders of magnitude higher statistics than that of the previous SCIFI experiment at KEK (E224).

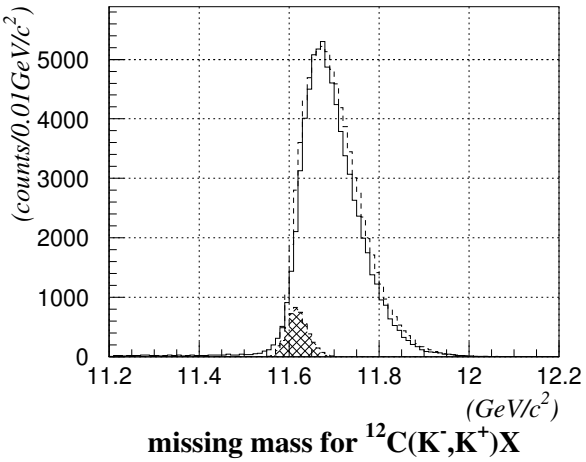

Figure 3. Preliminary missing mass spectrum for $^{12}\mathrm{C}(K^-, K^+)X$. The solid and dashed lines show the data and simulation respectively. The hatched area corresponds to the stopped Ξ^-'s obtained with the simulation.

3. Detection sensitivity of the H dibaryon

Owing to the size of the SCIFI blocks this experiment is sensitive to the H dibaryon of which lifetime is from 10^{-10} sec to 10^{-8} sec. Figure 4 shows expected upper limits of the parameter R for the H mass of 2200 MeV/c^2, where R is the product of branching ratio of the H production and the decay into $H \to \Sigma^- + p$ or $H \to \Lambda + n$ as follows:

$$R = R((\Xi^-, {}^{12}\mathrm{C})_{atom} \to H {}^{11}\mathrm{B}) \cdot R(H \to \Sigma^- p / \Lambda n) \tag{3}$$

Because of the high statistics of the stopped Ξ^-, detection sensitivity of the H dibaryon is more than one order of magnitude higher than that of the KEK-E224.

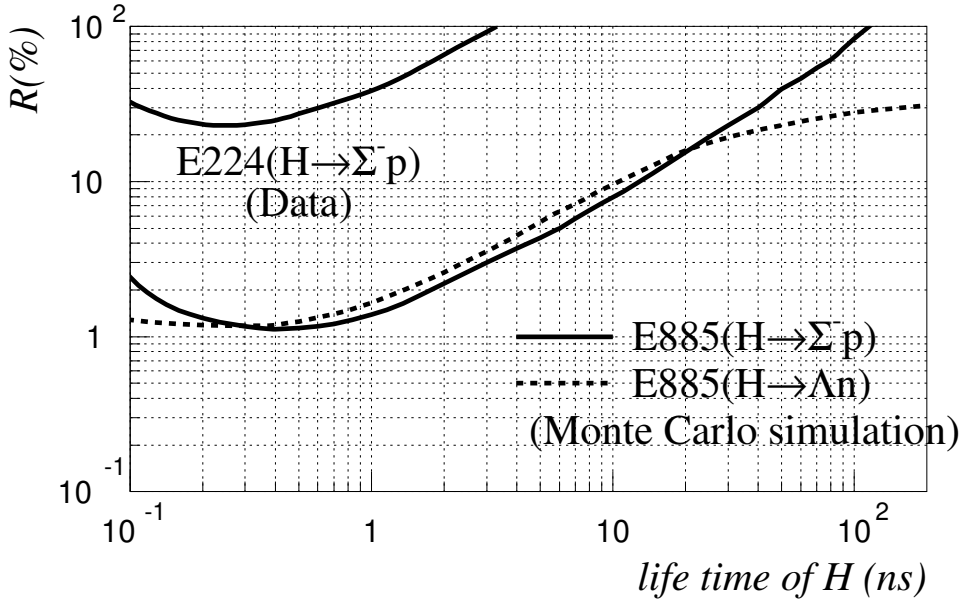

Figure 4. Expected upper limit of R (90% confidence level) at $M_H = 2200$ MeV/c^2. The result of KEK-E224 is also shown.

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