KEK-PS-E521

Production of neutron-rich Λ hypernuclei by the (π^-,K^+) double-charge-exchange reaction

T. Fukuda[a], P. K. Saha[a] and H. Noumi[b] for E521 collaboration

[a]Osaka Electro-Communication University ; [b]KEK

In E521, we measured the (π^-,K^+) double-charge-exchange reaction on a ^{10}B target in order to produce neutron-rich Λ hypernucleus, $^{10}_{\Lambda}$Li. It was performed in the K6 beam line of KEK 12-GeV PS together with the SKS spectrometer system. Our primary motivation was to produce one neutron-rich Λ hypernucleus as a first step so as to understand the reaction mechanism, which would enable us to produce many neutron-rich Λ hypernuclei including a very exotic object like $^{6}_{\Lambda}$H or even $^{7}_{\Lambda}$H in near future, as well as to understand many new phenomena in the hypernuclear physics study such as the "coherent $\Lambda - \Sigma$ coupling" as intensively discussed in theory. During the approved beam time of 15 days we measured the (π^-,K^+) reaction at two different incident momenta (1.05 and 1.2 GeV/c) together with several calibration runs. A preliminary analysis has been completed recently, where we have clearly identified scattered kaons well separated from other backgrounds as shown in figure 1. The gated region shown by the two lines were used as good kaons for the analysis. Figure 2 shows the missing mass spectrum from the ^{10}B target in the (π^-,K^+) reaction at a scattering angle of 2° to 14°. The horizontal axis shows the binding energy of a Λ particle ($-B_\Lambda$) in MeV and vertical axis shows the counts/2MeV. In order to calibrate the horizontal axis, (π^+,K^+) data on a ^{12}C target was taken with same the beam momentum and the SKS excitation. The data was taken by about 4.5 days running and in total there were more than 1500 counts in the whole spectrum (figure 2), where about 17 counts found in the bound region although no clear peak was observed, unfortunately, because of limited statistics. However, it is already very interesting as we have seen some events in the bound region coming from a neutron-rich Λ hypernuclear production. From the data at 1.05 GeV/c we could also clearly identified kaons, where the total number of π^- injection was almost the same as 1.2 GeV/c run. However, the total number of yield was about one order magnitude lower, whereas in the bound region it was about half as compared to the 1.2 GeV/c run.

There is no extensive theoretical works on the production of neutron-rich Λ hypernuclei. The only calculation exists based on the two-step mechanism involving meson charge-exchange, which indicates a maximum production at the beam momentum of 1.05 GeV/c, similar to the Λ production by the (π^+,K^+) reaction (maximum at 1.05 GeV/c). The choice of the beam momentum in E521 at first was thus 1.05 GeV/c. However, in the off-line analysis during the experiment there was no hint for the bound state production as expected in the calculation. The beam momentum was then changed to 1.2 GeV/c, where the Σ^- production channel is open and may have contribution for the production by the following two-step process involving Σ^-;

$$\pi^- + p \rightarrow \Sigma^- + K^+ ; \Sigma^- + p \rightarrow \Lambda + n$$

In the first step a Σ^- is created and in the second step so-called Σ^- conversion happens, resulting in a neutron and a Λ. A bound hypernuclear production depends on the momentum transfer in each step, i.e. the sticking probability of the produced neutron and the Λ. The event rates at 1.2 GeV/c case were found to increase rapidly and almost one order of magnitude higher as compared to the 1.05 GeV/c. The present result thus already gives information on the reaction mechanism, however, for a better and clear understanding of the bound state production, an increased statistics is necessary.

The present experiment has been extended for another 15 days. We will use the beam momentum at 1.2 GeV/c, from which we hope to increase the present statistics (figure 2) by 4 times in total.

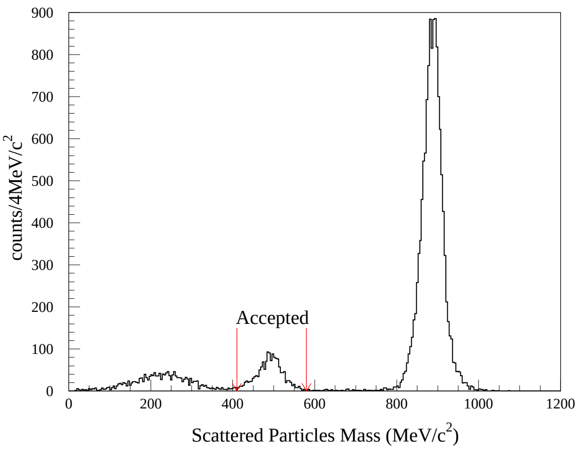

Figure 1: Reconstructed mass spectrum of the scattered particles from ^{10}B in the (π^-,K^+) reaction at the beam momentum of 1.2 GeV/c.

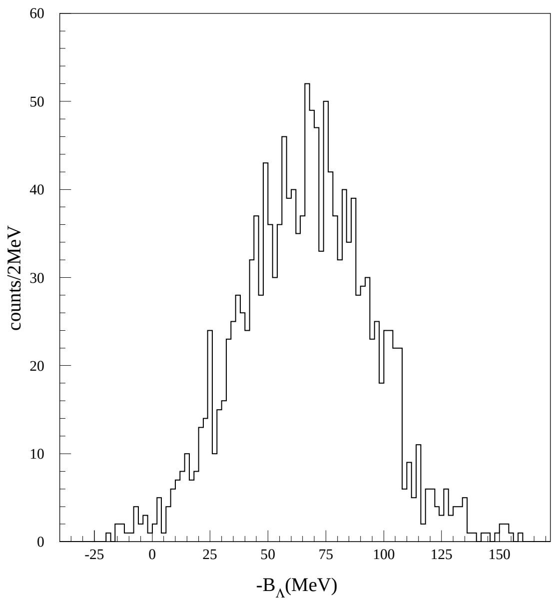

Figure 2: Preliminary missing mass spectrum of ^{10}B in the (π^-,K^+) reaction at 1.2 GeV/c. The horizontal axis is the binding energy of a Λ, whereas vertical axis shows the counts.