Production of hypernuclei in Ni+Ni collisions at 1.91A GeV *

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In non-central HICs at the SIS18 energies (1-2A GeV), the emission pattern of sideflow and elliptic flow vividly illustrates that the hot fireball matter strongly interacts with the cold spectator matter [1]. Mesons like π, K and baryons like Λ, Σ, produced in the fireball, could react with the cold spectator matter in the nuclear medium. Since the properties of hadrons may be modified by the nuclear medium, the cross sections and reaction rates of such reactions may be modified as well. Hypernuclei are the possible products of these processes. In such collisions, hypernuclei can also be formed by the coalescence process, i.e. the Λ hyperon may bind with the spectator-like cluster(s) [2]. In our previous contributions [3, 4], the method for reconstructing $^3_\Lambda$H from its two-body π^--decay channel, i.e. $^3_\Lambda\mathrm{H}\rightarrow\pi^- + ^3\mathrm{He}$, the observed $^3_\Lambda$H signal and its mean lifetime were described. It has to be noted that the $^3_\Lambda$H signal was only observed in a limit phase space region, i.e. $0.2 < p_t/m_{^3_\Lambda\mathrm{H}} < 0.4$, $0.2 < y_{lab} < 0.4$ and $30^o < \theta_{^3\mathrm{He}} < 52^o$, where p_t and y_{lab} are the transverse momentum and the rapidity in the laboratory frame of $^3_\Lambda$H candidate, $m_{^3_\Lambda\mathrm{H}}$ is the nominal mass of $^3_\Lambda$H and $\theta_{^3\mathrm{He}}$ is the polar angle of ^{3}He. To obtain a significant signal, it is necessary to introduce in additional multiplicity cuts, i.e. $20 < T_{MUL} < 60$ and $50 < P_{MUL} < 45$, where T_{MUL} is the track multiplicity in the CDC, and P_{MUL} is the charged particle multiplicity in the forward plastic wall (PLW).

In this contribution, we show the identification of another hypernucleus, i.e. $^4_\Lambda$H, from its two-body π^--decay channel, i.e. $^4_\Lambda\mathrm{H}\rightarrow\pi^- + ^4\mathrm{He}$. The procedure for identifying $^4_\Lambda$H from the considered channel is the same as the one for $^3_\Lambda$H reconstruction by replacing ^{3}He to ^{4}He. Similarly, a clear signal of $^4_\Lambda$H can only be observed in a limited phase space region, i.e. $0.15 < p_t/m_{^4_\Lambda\mathrm{H}} < 0.35$, $0.15 < y_{lab} < 0.4$ and $30^o < \theta_{^4\mathrm{He}} < 52^o$, when applying multiplicity cuts of $30 < T_{MUL} < 50$ and $10 < P_{MUL} < 35$. In Fig. 1(a), the invariant mass distribution of selected (π^-,^{4}He) pairs in the above phase space region is depicted by the open circles. The obtained mixed-event background spectrum is shown by the solid blue curve. After subtracting the background, the resulting spectrum is shown in Fig. 1(b). An excess in the spectrum near the nominal mass of $^4_\Lambda$H is attributed to the decay of $^4_\Lambda$H . The fit of a Gaussian distribution revels a mean value of 3922.6±1.0 MeV/c^2 and a width of 4.0±1.6 MeV/c^2, compatible with the nominal mass of $^4_\Lambda$H and the detector response. The significance of signal is calculated to be 4.2 in the interval, marked by two vertical dashed lines in Fig. 1(b). About 74±29(sta.) $^4_\Lambda$H were identified.

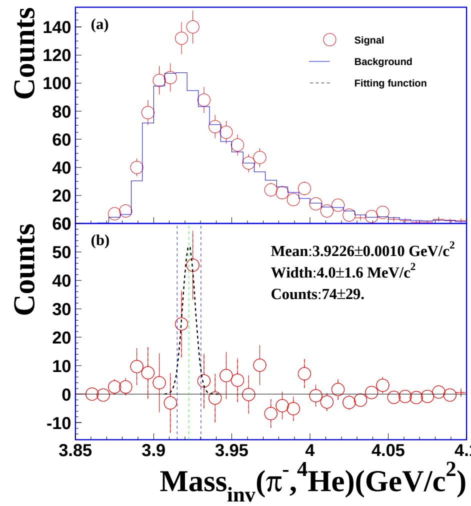

Figure 1: (a) Invariant mass spectrum of (π^-,^{4}He) pairs (open circles) and optimized mixed-event background (solid line); (b) Invariant mass spectrum after the background subtraction, the excess is fitted by a Gaussian function. For detailed desription see the text.

The reconstruction efficiency of $^3_\Lambda$H and $^4_\Lambda$H is studied by a full Geant simulation of the FOPI data analysis chain, and is found to be about 2% in the phase space regions where the signals were observed. After the efficiency correction, the yield of $^3_\Lambda$H and $^4_\Lambda$H is 7.7×10^{-4} and 1.3×10^{-4}, regarding to a total event number of 56×10^6, of which 51% (21%) passed the multiplicity selection for the $^3_\Lambda$H ($^4_\Lambda$H) case. The mean lifetime of particle species can be extracted from their efficiency-corrected decay time spectrum, as described in [4]. The mean lifetime of $^3_\Lambda$H is further evaluated and it has a value of 263±64(sta.)±44(sys.) ps. In the same manner, the mean lifetime of $^4_\Lambda$H is found to be 196±75(sta.)±43(sys.) ps. The quoted systematic errors are the quadratic sum of the contribution of individual cuts, which is obtained by varying the cut in a range of 10-20% around its fixed value. Within errors, the observed lifetimes are consistent with the measured lifetimes from other experiments.

References

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