Preliminary study of the missing mass spectra via the $^{12}\text{C}(p,K^0_s)$ and $^{12}\text{C}(p,\Lambda)$ reactions at 10 GeV/c.

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Abstract The missing mass spectra for the $^{12}\text{C}(p,K^0_s)$ and $^{12}\text{C}(p,\Lambda)$ reactions have been studied by using of the propane bubble chamber(PBC) data from 700000 stereo photographs or $10^6$ inelastic interactions. The momentum spectrum of $\pi^-$ in range of 100-200 MeV/c have observed the significant enhancement from the $p+C \rightarrow \pi^-AX(p+C \rightarrow \pi^-K^0_sX)$ reaction. The missing mass spectra have been observed signals for the $p(p,\pi^-K^0_sX)$, $^3\text{H}(p,pK^0_s)$, $p(p,\Lambda\pi^-\gamma)$ and $p(p,\pi^-\Lambda)$ reactions. This experimental study will need to continue by a different method of identification for a reaction channels.

Keywords hyperon · hypernucleus · strangeness · $4\pi$ geometry

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1 Introduction

The properties of hypernuclei reflect the nature of the underlying baryon-baryon interactions and, thus, can provide tests of models for the free-space hyperon-nucleon (Y,N) and hyperon-hyperon (Y,Y) interactions[1]. The missing mass(MM) method makes it possible to obtain unique information on the masses and the structure nuclei. The possibility to produce hypernuclei in the $(p,K^+)$ reaction was firstly mentioned by [2]. In fact, the recent studies on the $(p,K^+)$ reaction confirm a quite substantial production of associated $\Lambda$-hyperons leading to production cross sections for $\Lambda$-hypernuclei in the order of a few 100 $\mu$b for $p + \text{Pb}$ at 1.5 - 1.9 GeV[3]. The paper presents the preliminary experimental results from the MM spectra in $p+C$ interactions[4]. This analysis with the MM is the first step to explore hadronic systems with strangeness. The event by event analysis will be the next step.

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2 Experimental data

The events with $V^0$ (Λ and $K^0_s$) were identified by using the criteria\[^5\]. The mass of the identified 9838-events with Λ hyperon and 4964-events with $K^0_s$ mesons is consistent with their PDG values. The FRITIOF model and experimental data comparison shown that there are observed significant enhancement for Λ hyperons production in ranges of the scattering $\theta < 0$ and azimuth $\phi \approx 0$ angles\[^4\] in the spherical system of coordinates. The missing mass error is equal to $\approx 80-100$ MeV/$c^2$ for the $p(p,K^0_s)$ and $p(p,\Lambda)$ reactions.

3 The missing mass spectra with $K^0_s$ meson

Fig. 1a shows the missing mass(MM) spectrum for 3428 events in the $p(p,K^0_sp\pi^-)$ reaction with a bin size of 34 MeV/$c^2$. The curve(Fig. 1a) is the sum of the background by the 9 order polynomial and 1 Breit-Wigner function. The peaks in the MM range of 3.35 GeV/$c^2$ with $\Gamma_{\text{exp}} \approx 90$ MeV/$c^2$, S.D.( statistical deviation)$5.7\sigma$(≈ 90 events in peak) and $\approx 3.00$ GeV/$c^2$ with S.D.= $4.5\sigma$ (≈40-50 events in peak.) have been observed.

Fig. 1b shows the MM spectrum for p($p,K^0_sp$) reaction (7150 events) with a bin size of 44 MeV/$c^2$. There are observed signals in the MM range of 1020, 2050 and 2580 MeV/$c^2$, with S.D.$\approx 4\sigma$\[^4\]. A signal is not observed in the MM spectrum for the p($p,K^0_sp$) reaction by FRITIOF model. Fig. 1c shows the MM spectrum for 11118 events in the $^3H(p,K^0_sp)$ reaction with a bin size of 40 MeV/$c^2$. The curve(Fig. 1c) is the sum of the background by the 9 order polynomial and 1 Breit-Wigner function. There is observed signal in mass range of $^6\text{He}(5.78$ GeV/$c^2$) with $\Gamma=90$ MeV/$c^2$, S.D.= $5.7\sigma$(120-150 events in the peak).

4 The missing mass spectra with Λ hyperon

Fig. 2b shows the momentum distribution for $\pi^-$ with a bin size of 33 MeV/c for $^{12}C(p,\Lambda)$reaction. The fluctuation is observed in the momentum range of 100-200 MeV/c. The 9-order polynomial did not describe the momentum distribution for $\pi^-$ in Fig. 2b.

Fig. 2c shows the MM spectrum for the p($p,\pi^-$) reaction (for events with Λ) with a bin size of 30 MeV/$c^2$. The background is the 9-order polynomial function. The peak in the MM range of 4200 MeV/$c^2$ with S.D.= $3.8\sigma$ have been observed. There are observed small signals in the MM ranges of $^4\text{He}(3.8$ GeV/$c^2$) and $^4\text{He}(3.9$ GeV/$c^2$)(Fig. 2c).

Fig. 2d shows the MM spectrum for the p($p,\Lambda$) reaction (with $\pi^-$ andγ events) with a bin size of 41 MeV/$c^2$. The background is the 9-order polynomial
The missing mass spectrum (MM) of the \((p,K^0\pi^-)\) reaction. a) The MM spectrum for the \(p(p,K^0\pi^-)\) reaction (7150 events). The dashed histogram is simulation by FRITIOF model. b) The MM spectrum for the \(^3\text{H}(p,K^0\pi^-)\) reaction (11118 events).

The peak in MM range of 3200 MeV/c\(^2\) with \(\Gamma_{\text{exp}} \approx 90\) MeV/c\(^2\), S.D. = 6\(\sigma\) have been observed. The same peak is observed from this data in\([5]\) and OBELIX data in\([6]\), what had been interpreted as S=–1 tribaryon states.

5 Conclusion

The signals in the MM spectra have been observed only a few possible channels from these \(^{12}\text{C}(p,K^0)\) and \(^{12}\text{C}(p,\Lambda)\) reactions. These signals for the same reactions have observed with \(\pi^-\) events too. The momentum spectrum of \(\pi^-\) in range of 100-200 MeV/c from the \(p+C\rightarrow \Lambda\pi^- X(p+C\rightarrow \pi^- K^0\pi^- X)\) reactions have observed the significant enhancement(Fig.2b). Then the event-by-event analysis of \(^{12}\text{C}(p,K^0)\) and \(^{12}\text{C}(p,\Lambda)\) collisions will be the next step what allow identify a channel of reactions by kinematic fits for different hypothesis.

References

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