Structure near the $K^- + p + p$ threshold in the in-flight ${}^3He(K^-, \Lambda p)n$ reaction

~ J-PARC E15 Collaboration ~

2023. 7. 27 Yuto Kimura

Log- likelihood method (対数尤度法)とは?

- 最尤推定法：分布の形と限られたデータから、全体の分布を推定する。
- 正規分布における平均・分散のように、分布の特徴を示すものをパラメタという。
- 最も「それっぽい」分布となるパラメタを探す。
- Likelihood function $L = \prod_{k=1}^{n} f(x_k)$ が最大となるf を求めることにより、分布を推定
- logをとると微分しやすい—>log likelihood function

4. Result

多核子吸収では説明できない
unknown peak structure

このピークが説明できない。

n_{miss} のピーク

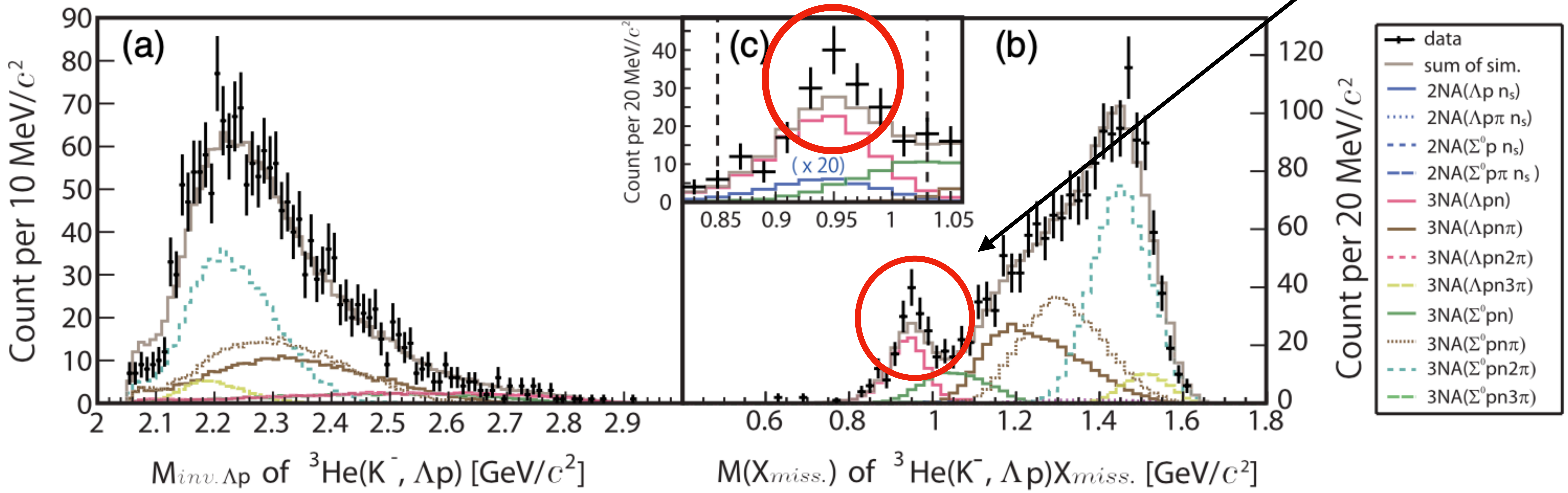


Fig. 4. Inclusive spectra of the ^{3}He$(K^-, \Lambda p)$ reaction and the global fit result of simulation with multi-nucleon absorption processes. (a) Λp invariant mass distribution. (b) Missing mass $M(X_{\text{miss.}})$ spectra of ^{3}He$(K^-, \Lambda p)X_{\text{miss.}}$. (c) Close-up view of (b) around the missing neutron region. In panel (c), 2NA$(\Lambda p n_s)$ is vertically scaled 20 times. The dashed vertical lines in (c) show n-window selection.

4. Result

- n_{miss} peakが見えた時のyieldは$3NA(\Lambda pn)$,$3NA(\Sigma^0 pn)$,$2NA(\Lambda pn_s)$が支配的。
- $\Lambda \to p\pi^-, n\pi^0$ 後者はΛを再構成できないのではないか？(そもそもですが
- なぜ$3NA(\Lambda pn + 3\pi) > 3NA(\Lambda pn + 2\pi)$?

Table 1. Relative yield of each component to the number of obtained events in the global fit, normalized to that of data (the same for each component in the n-window normalized by the yield of data in the n-window). Note that the spectral shapes of some reaction channels are quite similar, especially for the channels given in a row.

Process	Relative yield		Process	Relative yield	
	all	n-window		all	n-window
$2NA(\Lambda pn_s)$	0.001	0.01	$2NA(\Sigma^0 pn_s)$	$<10^{-4}$	$<10^{-2}$
$2NA(\Lambda pn_s + \pi)$	$<10^{-4}$	$<10^{-2}$	$2NA(\Sigma^0 pn_s + \pi)$	0.010	$<10^{-2}$
$3NA(\Lambda pn)$	0.072	0.62	$3NA(\Sigma^0 pn)$	0.058	0.20
$3NA(\Lambda pn + \pi)$	0.199	$<10^{-2}$	$3NA(\Sigma^0 pn + \pi)$	0.239	$<10^{-2}$
$3NA(\Lambda pn + 2\pi)$	$<10^{-4}$	$<10^{-2}$	$3NA(\Sigma^0 pn + 2\pi)$	0.354	$<10^{-2}$
$3NA(\Lambda pn + 3\pi)$	0.039	$<10^{-2}$	$3NA(\Sigma^0 pn + 3\pi)$	$<10^{-4}$	$<10^{-2}$

4. Result

- acceptanceはフラット(左上と右上はp, ΛのE_{kin}がdetector threより小さい)
- 引き算の意味はなんだ？普通pとΛを別々に見るのでは？
- $T_n^{CM}/Q^{CM} = 0.4$あたりにevent多い。—> structure有り

Q-value of the reaction

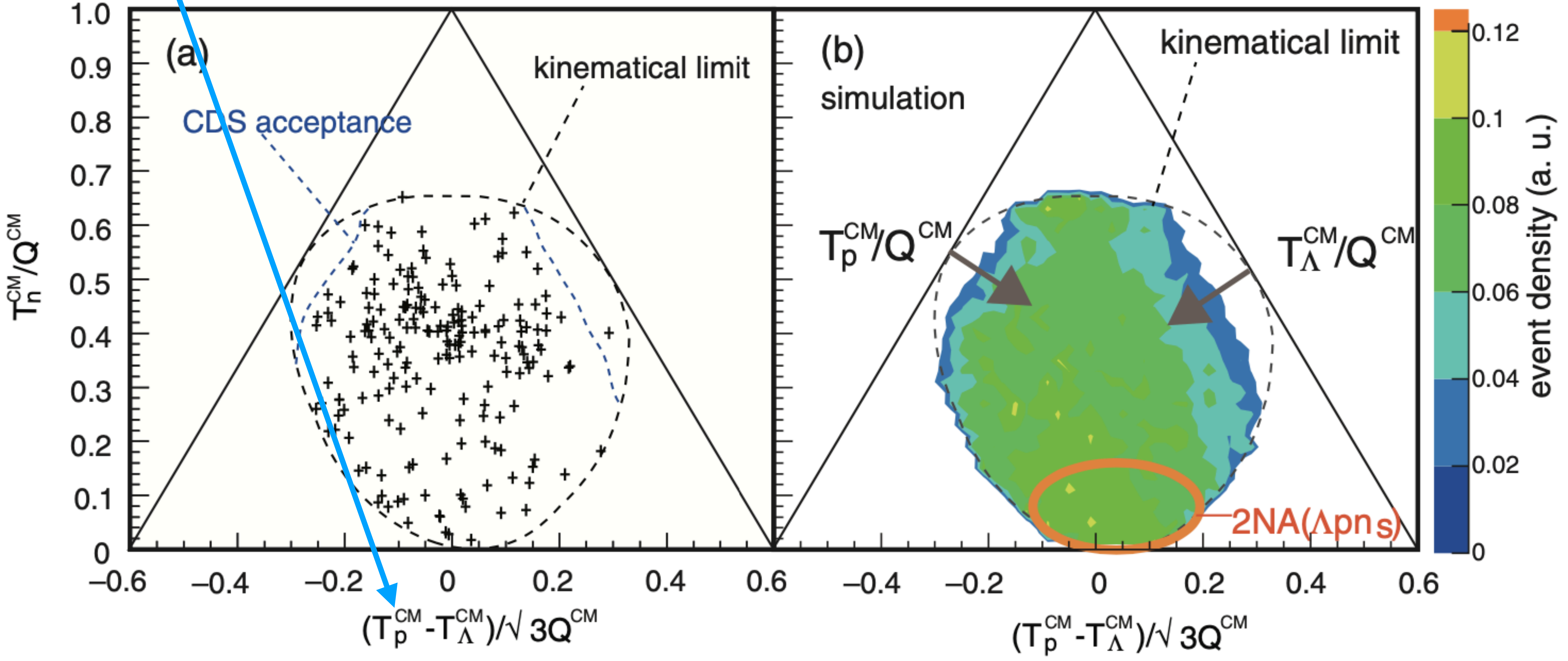


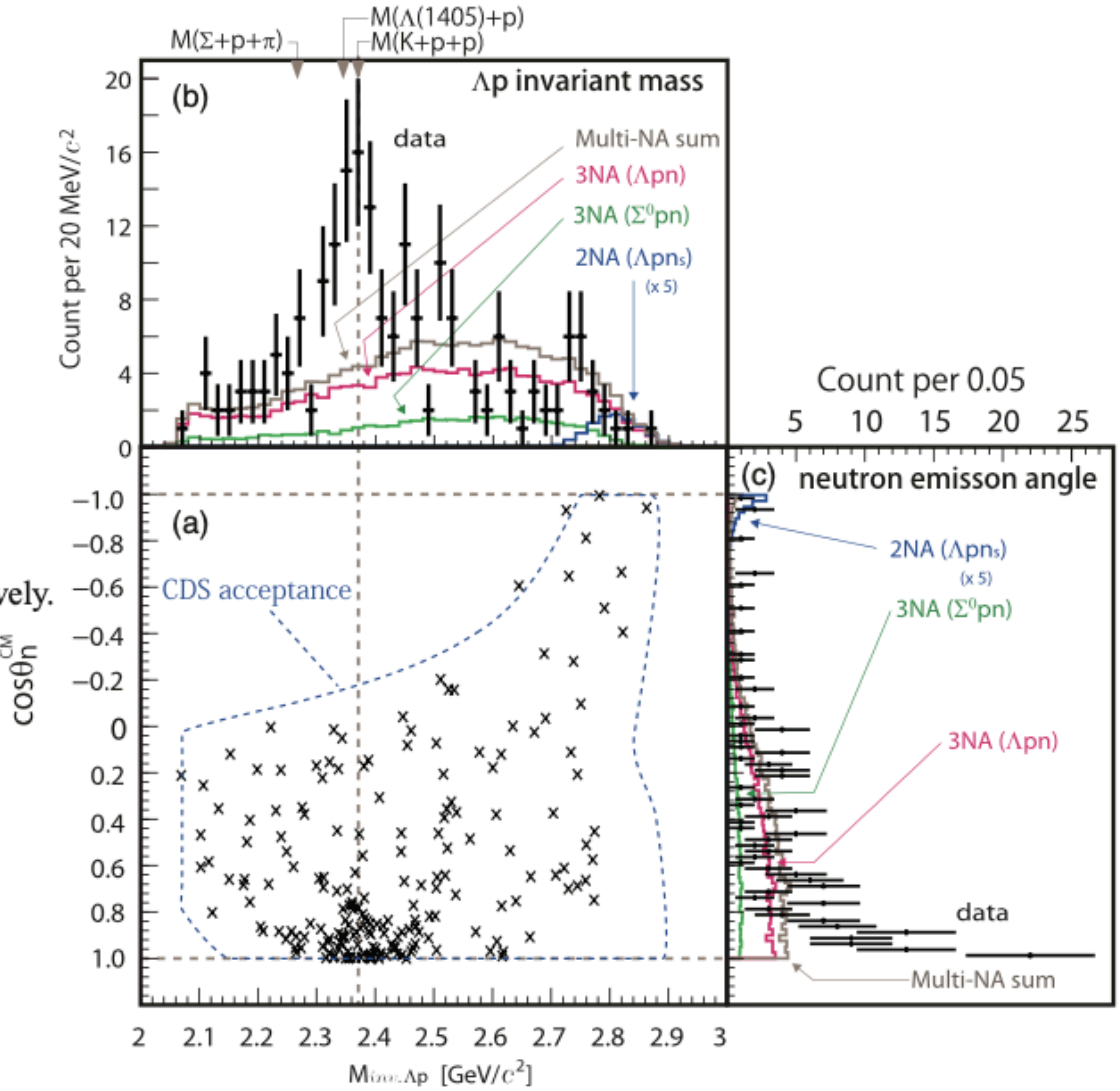
Fig. 5. (a) Dalitz plot of the selected Λpn events in the CM frame. (b) The simulated detector acceptance in a Dalitz plot.

4. Result

- n-windowのデータ
- nは前方に飛ばされやすい？
- やはり多核子吸収では❌

χ^2/DOF in Fig. 6(b) and (c) are 135/43 and 138/76, respectively.

probabilityはどちらも0.5%未満



5. Discussion

- Single finite-size S-wave single-pole structure over the three-body phase space which decays to Λp in the final state is assumed.

$$\frac{d^2\sigma_X}{dM_{\mathrm{inv.}\Lambda p}dq_{\Lambda p}} \propto \rho_3(\Lambda pn) \times \frac{(\Gamma_X/2)^2}{(M_{\mathrm{inv.}\Lambda p} - M_X)^2 + (\Gamma_X/2)^2} \times \left|\exp\left(-q_{\Lambda p}^2/2Q_X^2\right)\right|^2$$

Breit-Wigner   Form factor (Gaussian)

Resonanceの存在を仮定している？

- This can be also be interpreted as the sticking probability of a plane wave having $q_{\Lambda p}$ to a harmonic oscillator having finite size $\sim \hbar/Q_X$.   ??

- この仮定のもとでsimulationした。—>次項

5. Discussion

- $3NA(\Lambda pn)$のyieldをfree parameterに。残りの2つ$3NA(\Sigma^0 pn)$,$2NA(\Lambda pn_s)$のyieldはすでに出てきたfitの値で固定。

- χ^2を最小にするようにM_X, Γ_X, Q_Xを決定。

$$M_X = 2355^{+6}_{-8}\,(\text{stat.}) \pm 12\,(\text{syst.})\,\text{MeV}/c^2,\ \Gamma_X = 110^{+19}_{-17}\,(\text{stat.}) \pm 27\,(\text{syst.})\,\text{MeV}/c^2,\ \text{and}\ Q_X = 400^{+60}_{-40}\,(\text{stat.})\,\text{MeV}/c.$$

- Statistical error
- Systematic error
  - ・The magnetic field strength in the CDS
  - ・the likelihood threshold to select the Λp pair
  - ・binning of the invariant mass spectra

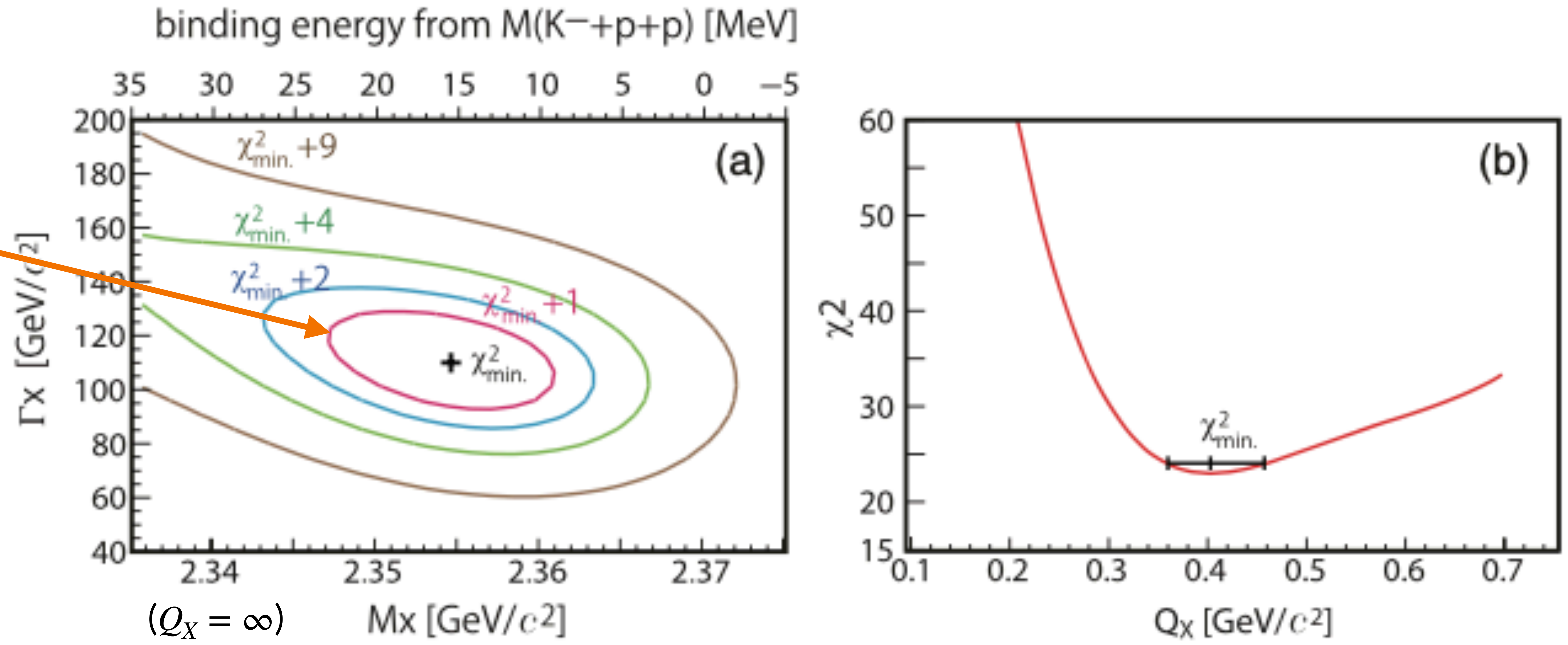


Fig. 7. (a) Two-dimensional χ^2 map of mass and width of pole structure. (b) χ^2 distribution of Q_X.

5. Discussion

- $\cos\theta$ の代わりに$q_{\Lambda p}$でプロット。

97%. ~20%

χ^2/DOF in Fig. 8(b) and (c) are 68/45 and 23/27,

To obtain the cross section, one needs to know the detailed event distribution and the acceptance. If we assume that all the angular distributions can be given by the fit results, the acceptance correction can be applied under this assumption. ??

—> as pole: 7 ±1 μb,
3NA(Λpn): 17 ±2 μb, and 2NA(Λpn_s) : $0.8^{+2.7}_{-0.8}$ μb.

Global fit とn-windowの外を信じるなら$3NA(\Sigma^0pn)$: $28 \pm 5\,\mu$b