

Reaction cross section of ${}^3\text{H}(\gamma^*, \text{K}^+)\text{X}$

HIEI 2022/3/22

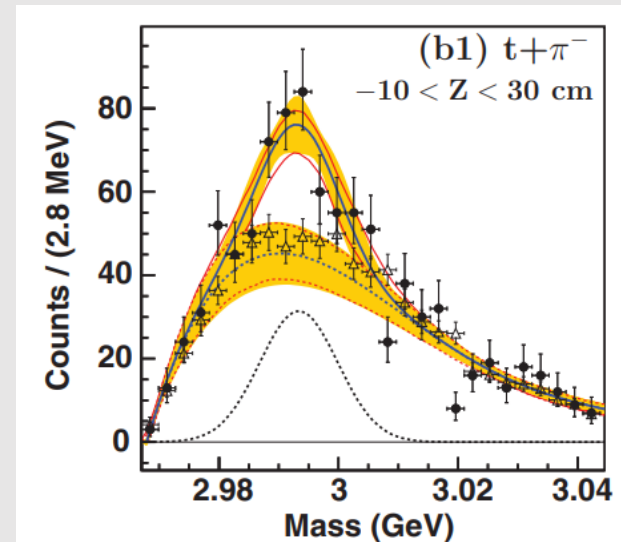
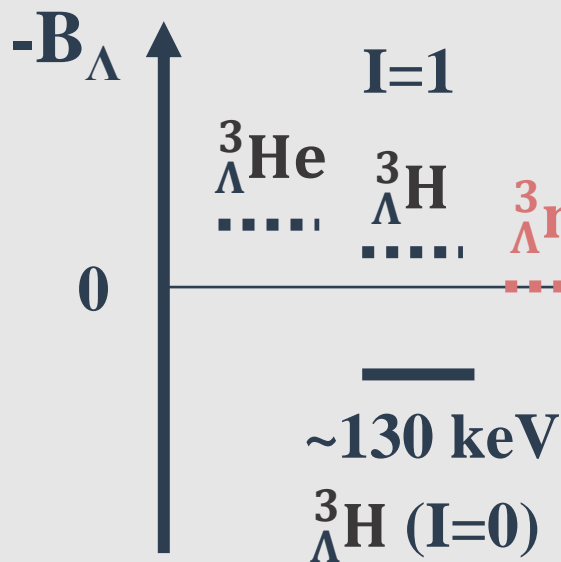
NH 鈴木一輝





Introduction

- ${}^3_{\Lambda}\text{H}$ ($I=0$) is the only established state in $A = 3$ hypernuclear system.
- HypHI collaboration indicated $nn\Lambda$ signal at GSI in 2013.



C. Rappold et al., Phys. Rev. C **88**, 041001 (2013)

- Almost all calculations have shown that the existence of the bound state is difficult.

Author	Method	YN interaction	Bound	Regards
Downs [12]	variational method	exponential	×	-
Miyagawa [13]	Faddeev	Nijmegen89	×	-
Hiyama [14]	variational method	NSC97f	×	-
Gal [15]	Faddeev	NSC97e,f	×	-
Garcilazo [16,17]	Faddeev	CCQM	×	-
Ando [18]	coupled integral equation	π EFT	Δ	Efimov state
Belyaev [19]	hyperspherical harmonics	Minesota	×	V \uparrow 50% bound
Afnan [21]	Faddeev	Yamaguchi etc.	×	Λn \uparrow 25% bound
Filikhin [22]	Faddeev	NSC97f	×	-
Kamada [23]	Faddeev	Nijmegen89	×	YN \uparrow 20% bound

- Many papers have suggested the existence of the resonant state.
- There are large uncertainties in their binding energies and widths.

Author	Method	YN interaction	Resonance	Regards
Belyaev [19]	hyperspherical harmonics	Minesota	○	-
Afnan [21]	Faddeev	Yamaguchi etc.	×	$\Lambda n \uparrow$ 5% resonance
Filikhin [22]	Faddeev	NSC97f	○	-
Kamada [23]	Faddeev	Nijmegen89	○	-
Schäfer [24, 25]	IACCC, CSM	NSC97f etc.	○	-

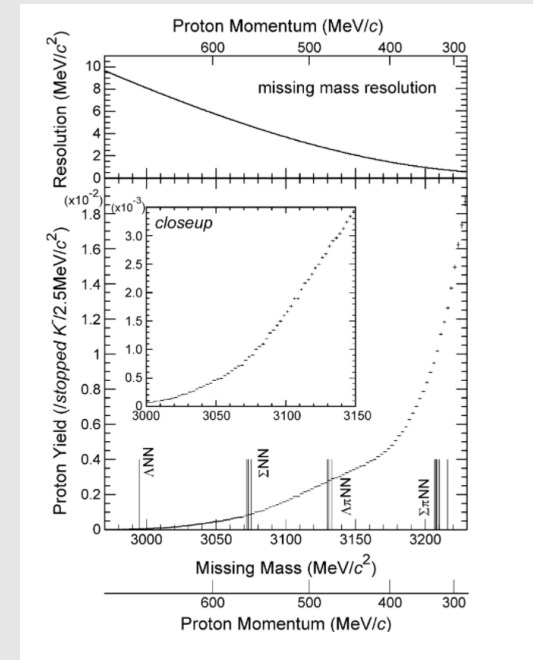
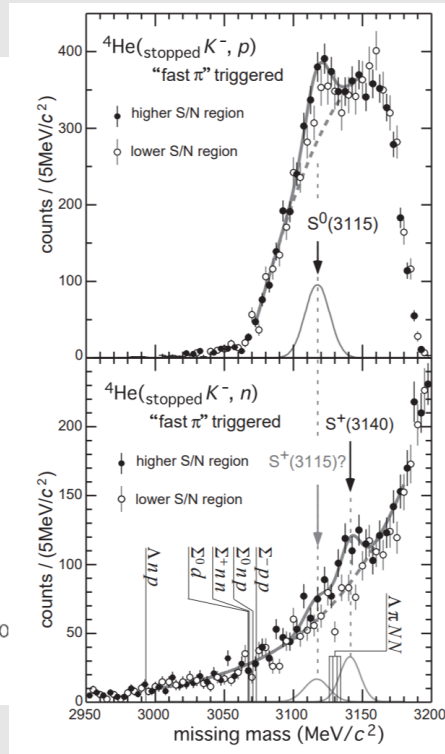
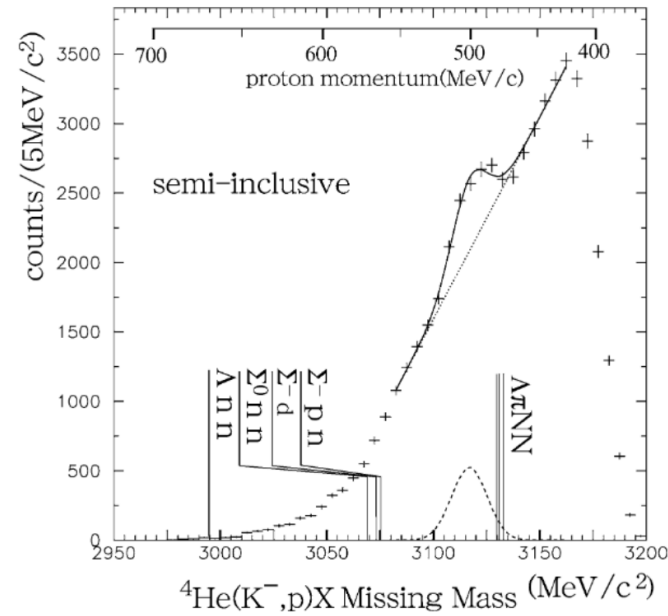
2004

Discovery of a strange tribaryon $S^0(3115)$ in ${}^4\text{He}(\text{stopped } K^-, p)$ reaction

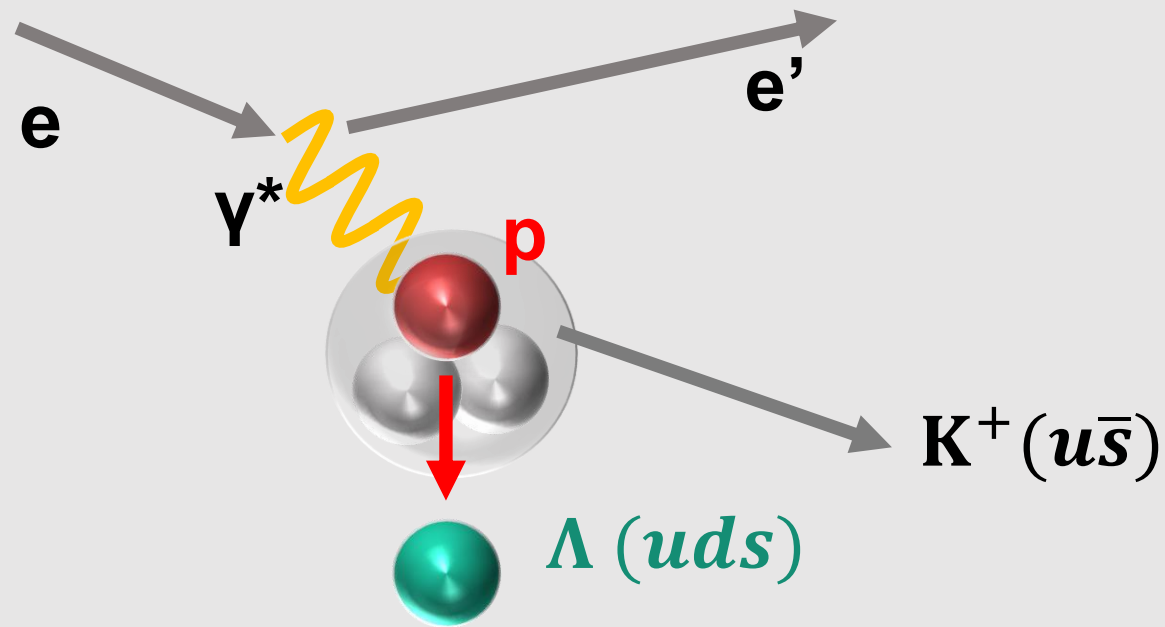
2007

Search for strange tribaryon states in the inclusive ${}^4\text{He}(K^-_{\text{stopped}}, p)$ reaction

M. Sato ^{a,*,1}, H. Bhang ^b, J. Chiba ^c, Seonho Choi ^b, Y. Fukuda ^a, T. Hanaki ^c, R.S. Hayano ^d, M. Iio ^e, T. Ishikawa ^d, S. Ishimoto ^f, T. Ishiwatari ^g, K. Itahashi ^e, M. Iwai ^f, M. Iwasaki ^{a,e}, P. Kienle ^{g,h}, J.H. Kim ^{b,2}, Y. Matsuda ^c, H. Ohnishi ^e, S. Okada ^e, H. Ota ^c, S. Suzuki ^f, T. Suzuki ^e, D. Tomono ^e, E. Widmann ^g, T. Yamazaki ^{d,e}, H. Yim ^b

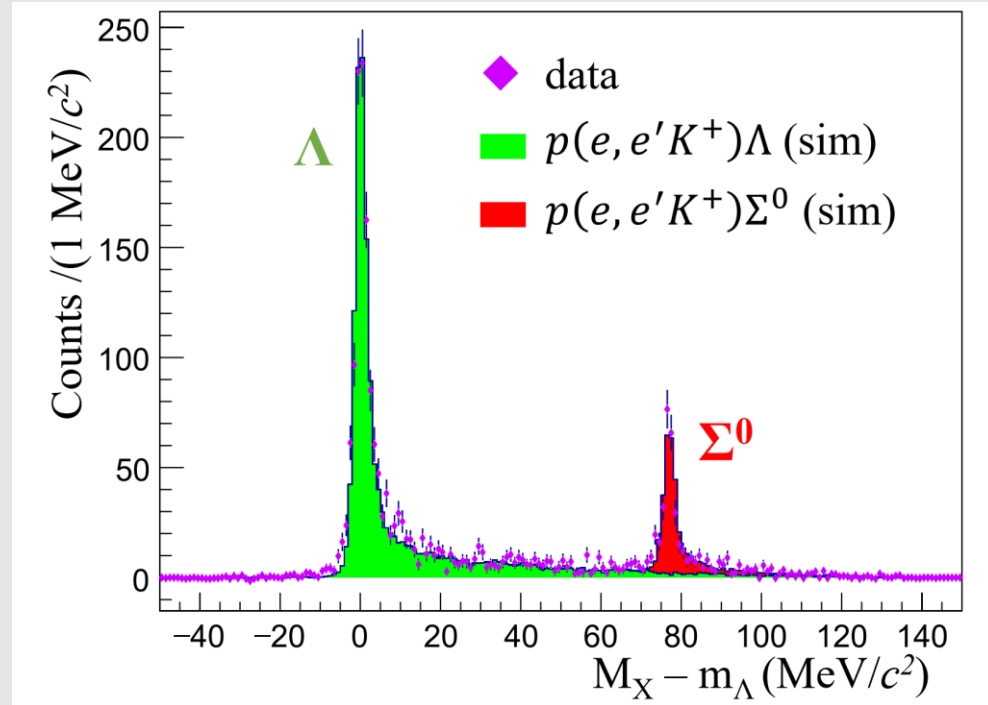
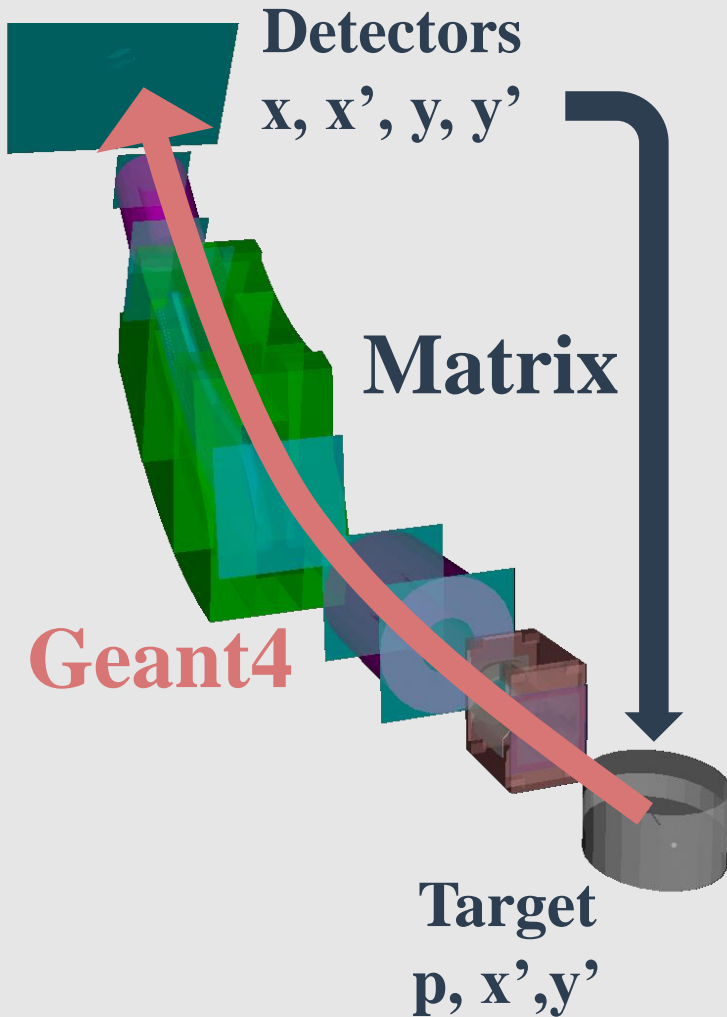


- Changing p to Λ \longrightarrow np target to $nn\Lambda$
- High resolution primary beam \longrightarrow $\Delta M = 1.5$ MeV (σ)
- Missing mass method \longrightarrow Sensitive to bound/resonance





Analysis



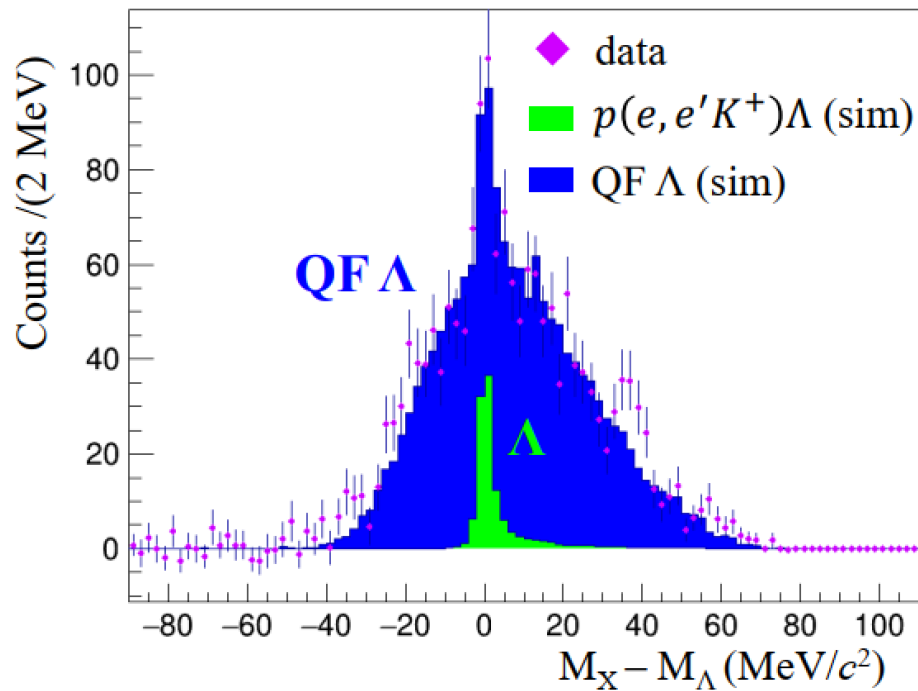
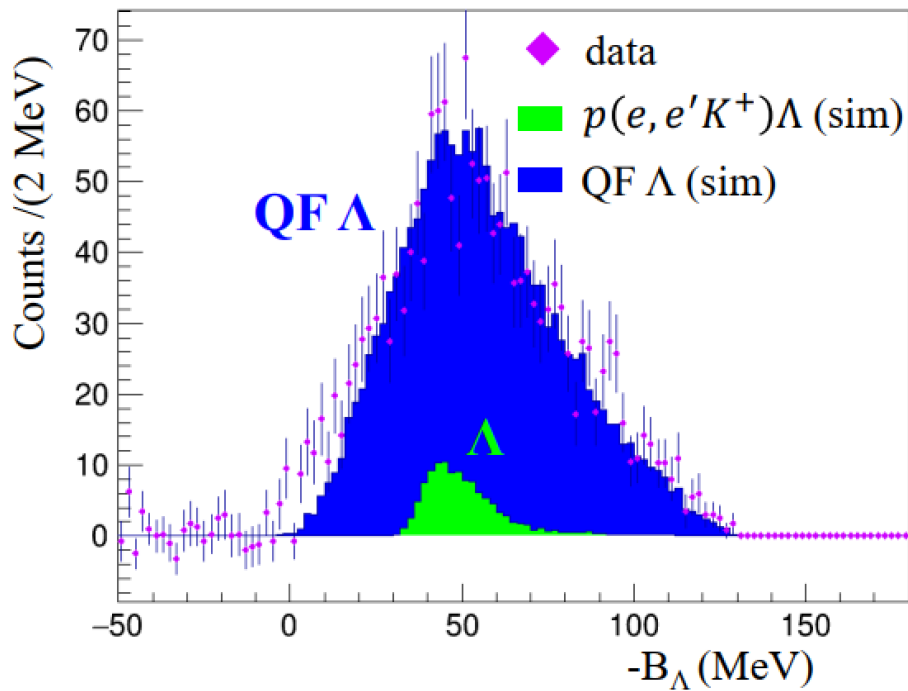
Estimated Resolution

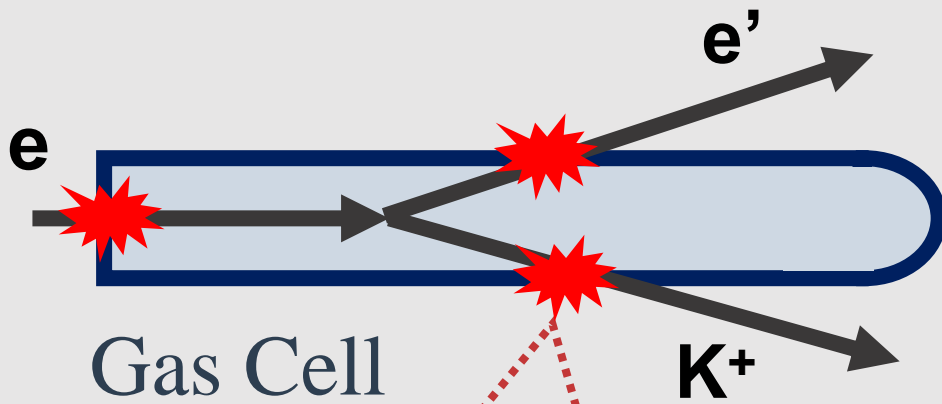
$\Lambda: 1.4 \pm 0.1$ MeV \rightarrow $nn\Lambda: 1.5 \pm 0.2$ MeV

- ${}^3\text{H}(e, e'K^+)X$ reaction
 - Quasi Free Λ , proton contamination
 - The data and simulation are consistent in the high mass region.
 - Λ n final state interaction or on-mass-shell approximation near threshold

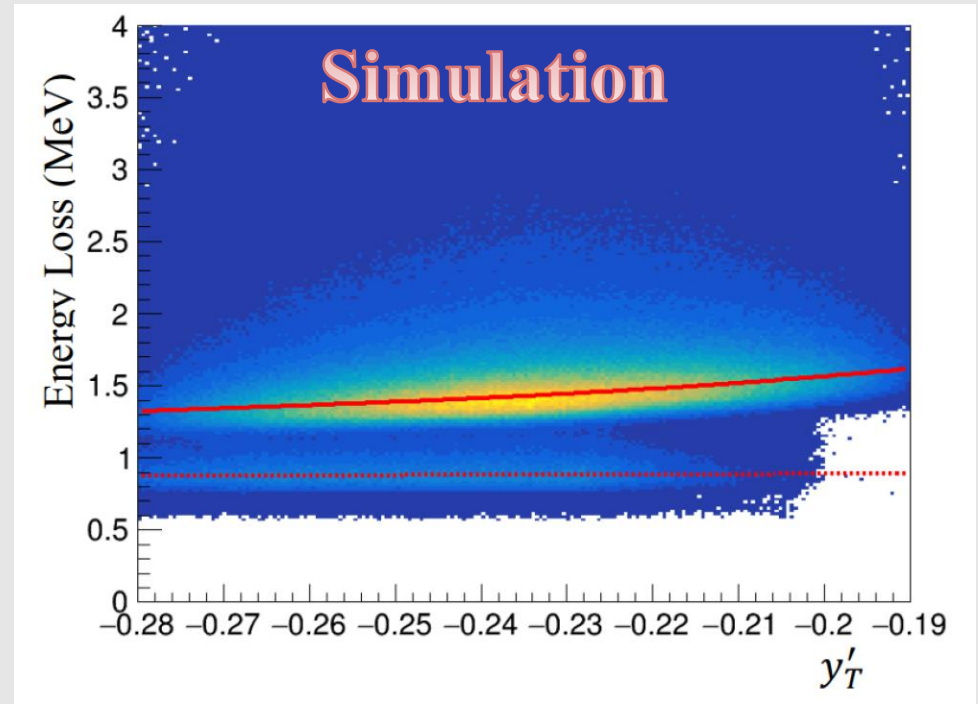
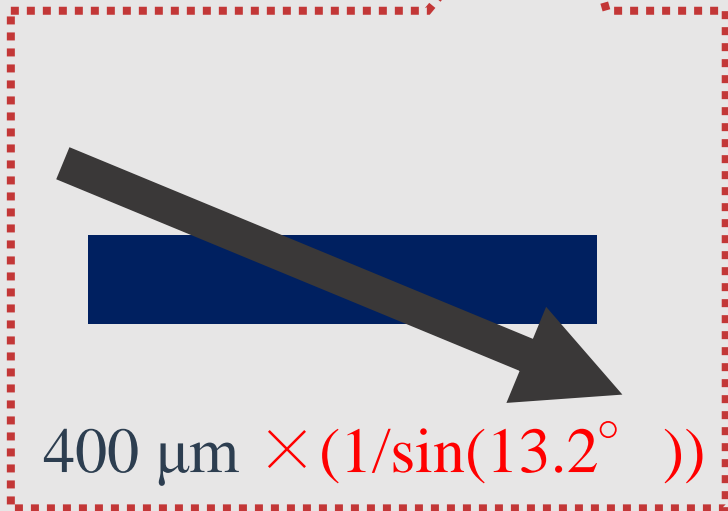
${}^3\text{H}$ mass

H mass

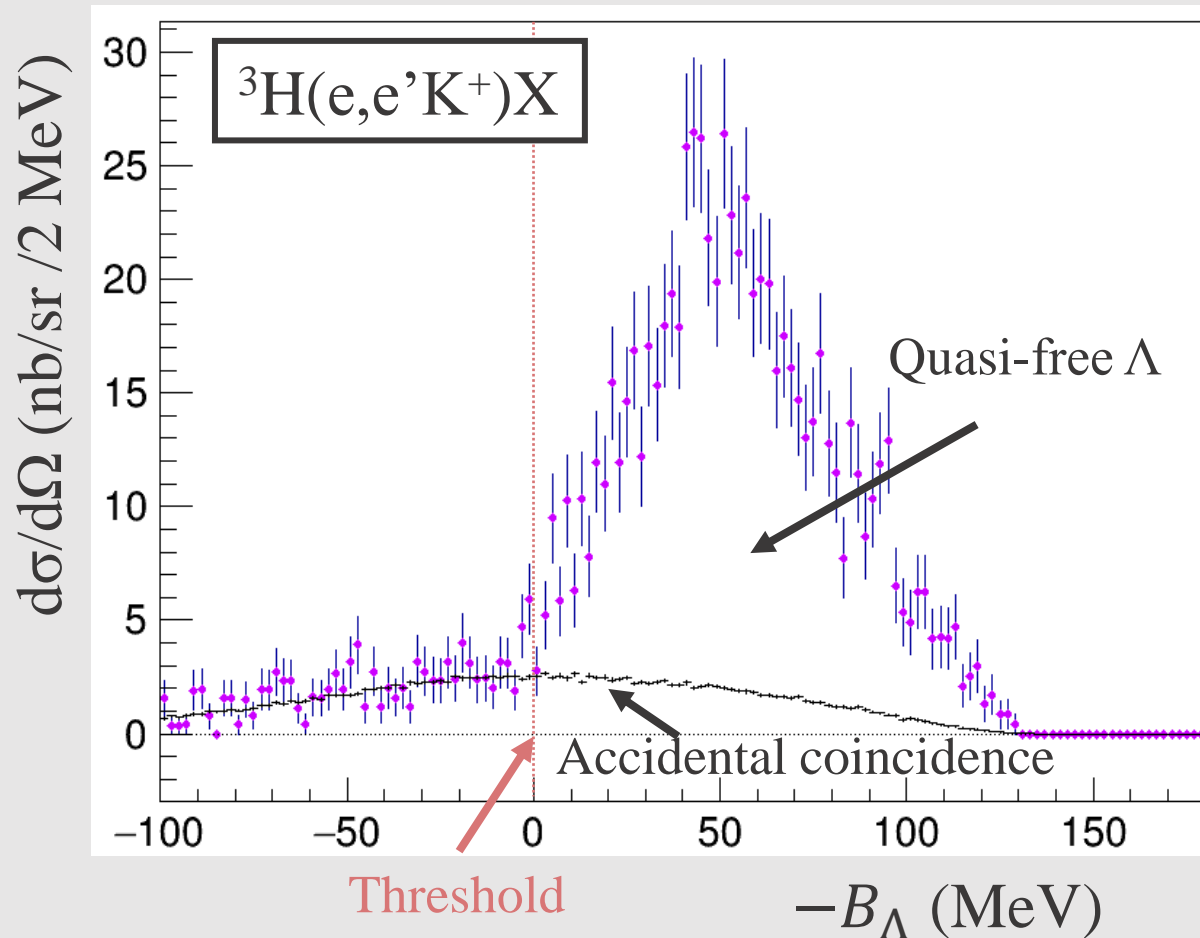




- The particles lose their energies in the Al cell.
- Energy loss was estimated by simulation.

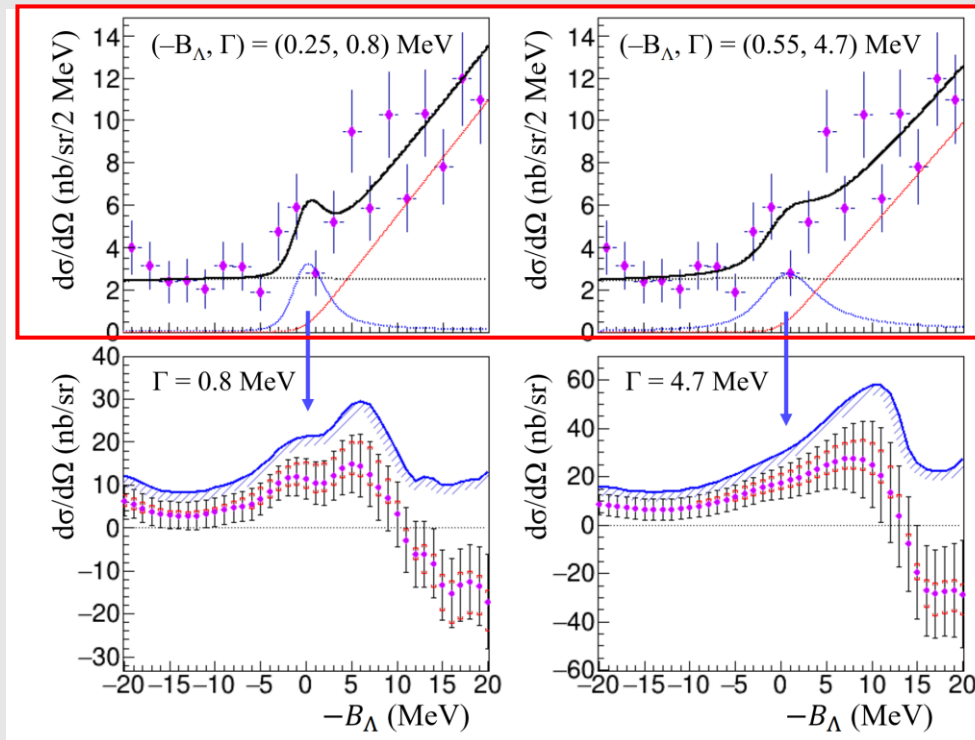


- Accidental BG was estimated with mixed event analysis.



- Theoretical predictions: $(-B_\Lambda, \Gamma) = (0.25, 0.8)$ [1] and $(0.55, 4.7)$ MeV [2] .
- No peak structure with a significance exceeding 3σ was found.
- The bottom show the 90% upper limit. $(0.25, 0.8)$ MeV : 21 nb/sr
 $(0.55, 4.7)$ MeV : 31 nb/sr

Fitting

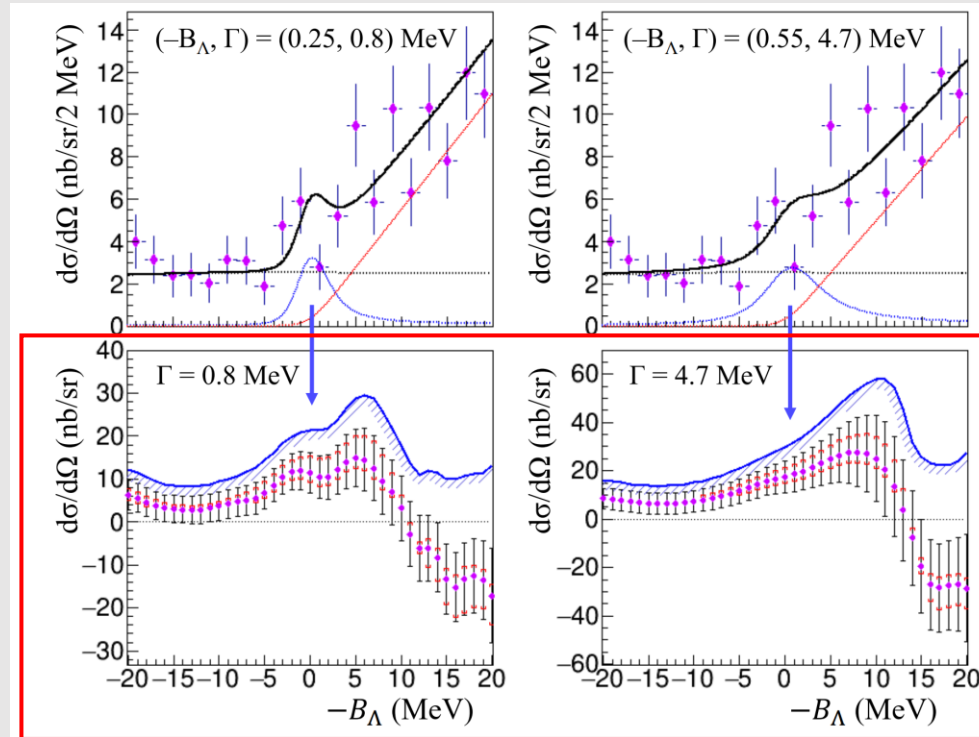


**Upper
Limit**

[1] H. Kamada et. al, EPJ Web Conf **113**, 07004 (2006)
 [2] V. B. Belyaev et. al, Nucl. Phys. A **803**, 210-226 (2007)

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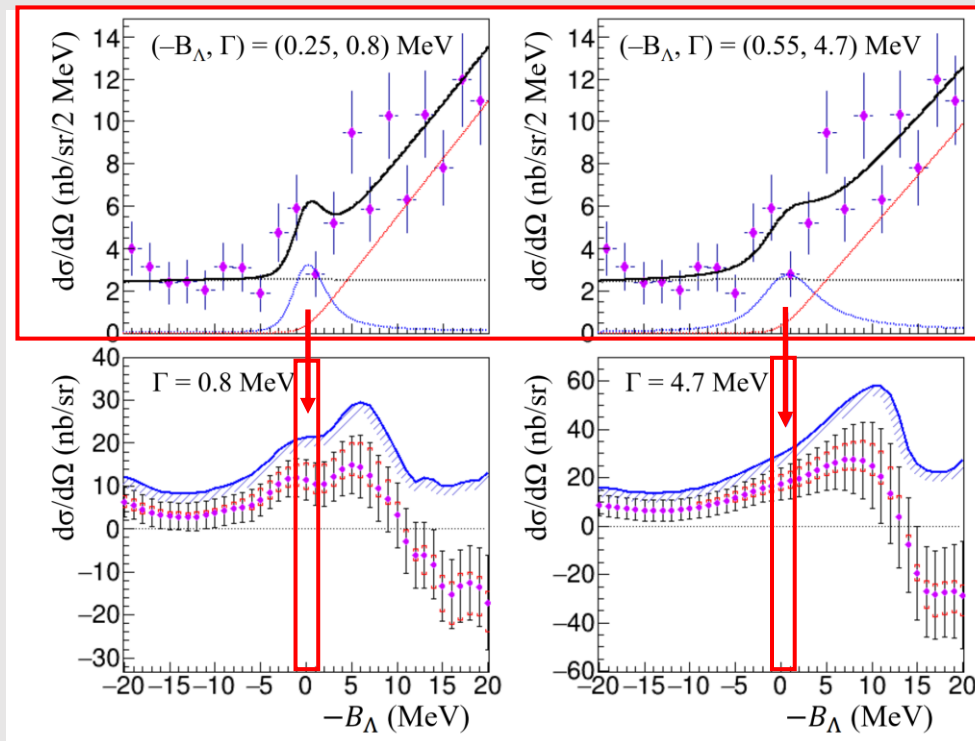


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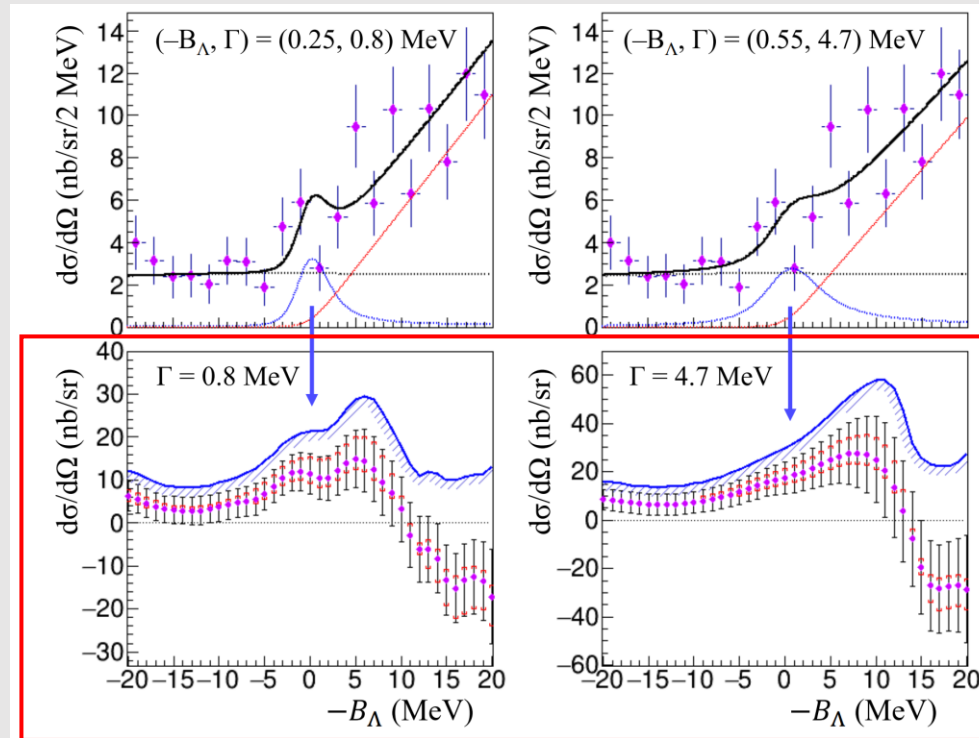


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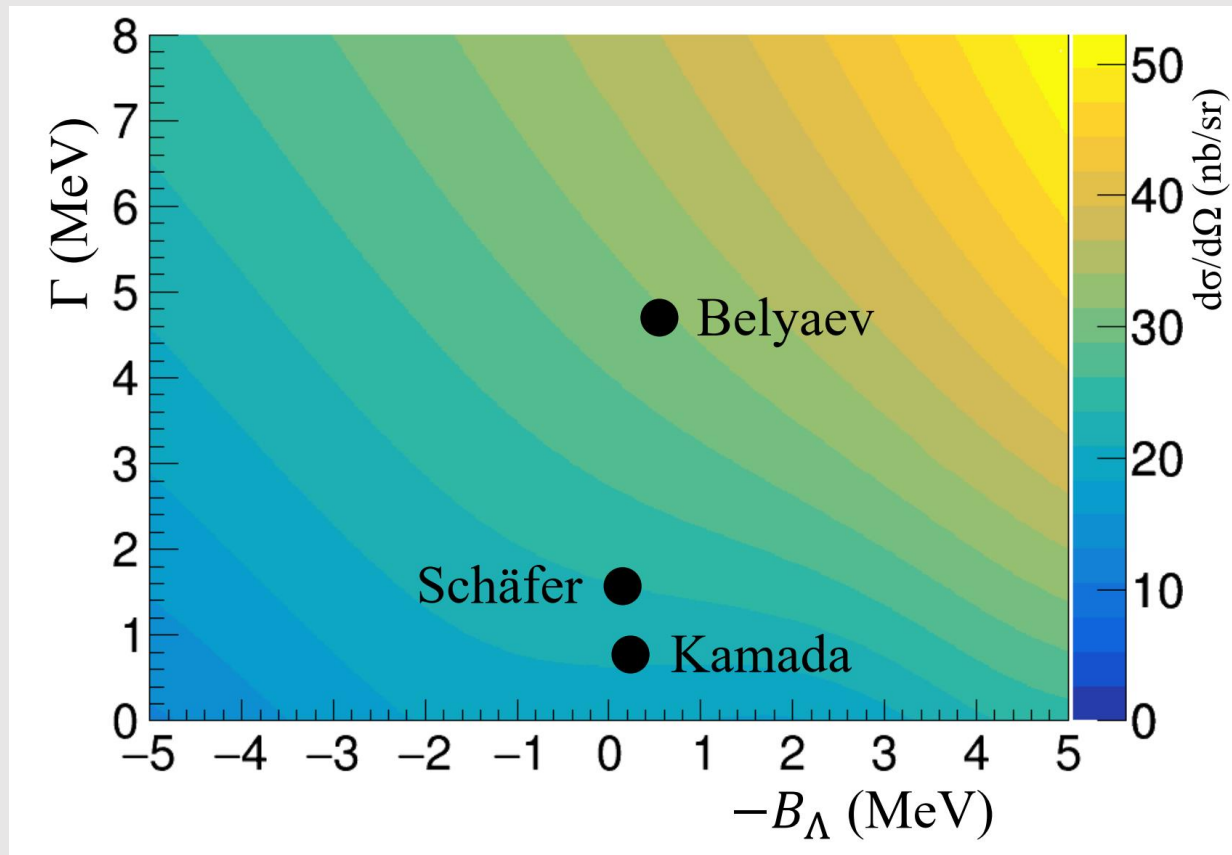
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- Two-dimensional scans of B_Λ and Γ for upper limit were performed.



The cross section for the ${}^3\text{H}(e,e'\text{K}^+)\text{X}$ reaction was obtained for the first time.

- We did not observe the $nn\Lambda$ peak reported by the HypHi collaboration.
- Upper limit were obtained to be 21 nb/sr and 31 nb/sr, when $(-B_\Lambda, \Gamma) = (0.25, 0.8)$ and $(0.55, 4.7)$ MeV were assumed.
- This is expected to provide significant information on the $nn\Lambda$ existence and Λn interaction