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Study of the Elementary (K^-, n) Reactions to Search for the $\bar{K}NN$ Bound State via the $^3He(\text{in-flight } K^-, n)$ reaction at J-PARC

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For the J-PARC E15 collaboration

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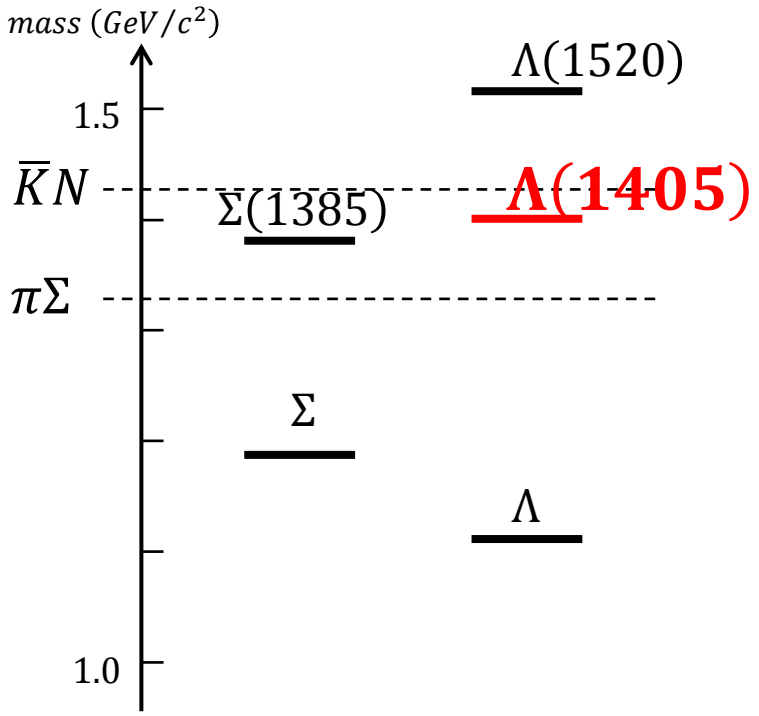
$\bar{K}N$ interaction and $\Lambda(1405)$ resonance

- $\bar{K}N$ interaction is strongly attractive in I=0.
  - X-ray measurement of kaonic hydrogen
  - $\bar{K}N$ scattering

- $\Lambda(1405)$

Mass	Width	J^π
$1405\ MeV/c^2$	$50\ MeV/c^2$	$\frac{1}{2}^-$

  - The nature of $\Lambda(1405)$
    - K^-p bound state or other?



$\bar{K}N$ interaction has important role in nature of $\Lambda(1405)$.

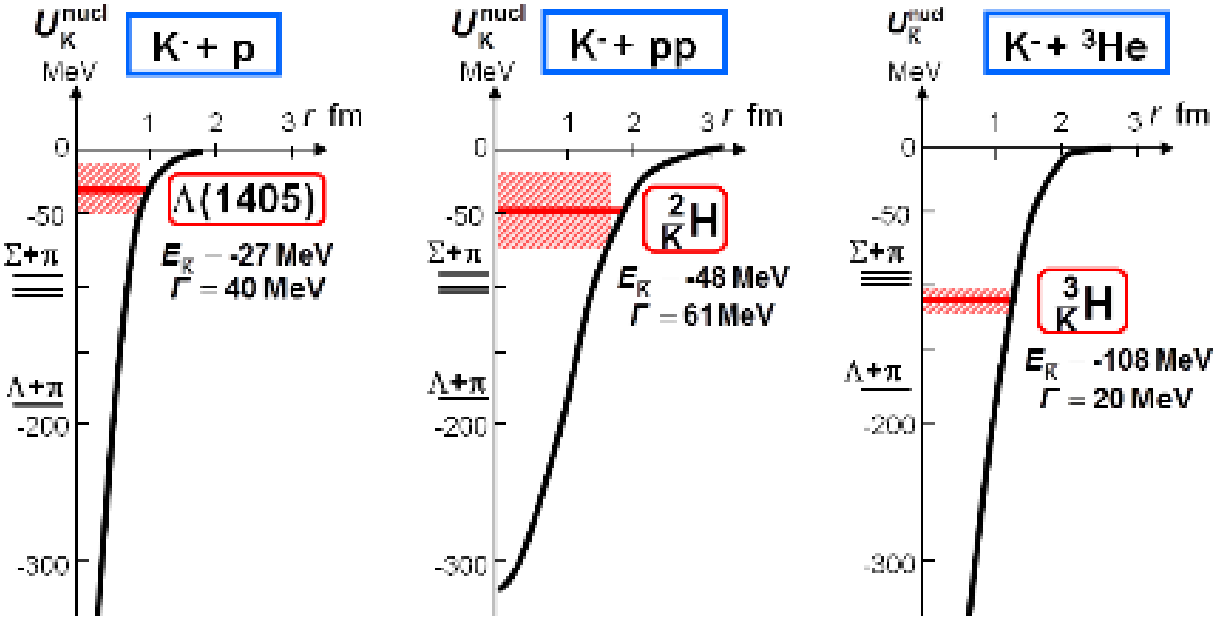
Kaonic nuclei

If $\Lambda(1405)$ is bound state of $K^- p$…

- B.E. is about 27 MeV (Deeply-bound state)

Extended to the light nucleus,

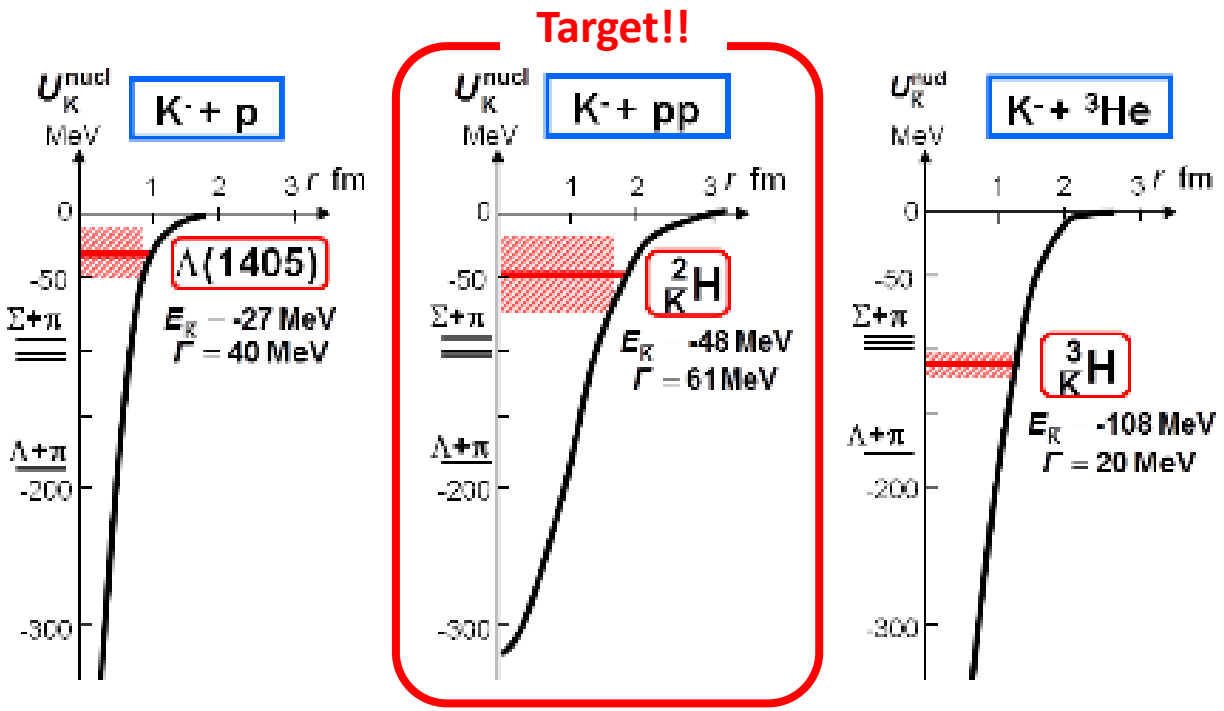
- Bound state of $\bar{K}$ and Nucleus (Kaonic nucleus) would exist.



Y.Akaishi & T.Yamazaki, PLB535, 70(2002).

Kaonic nuclei

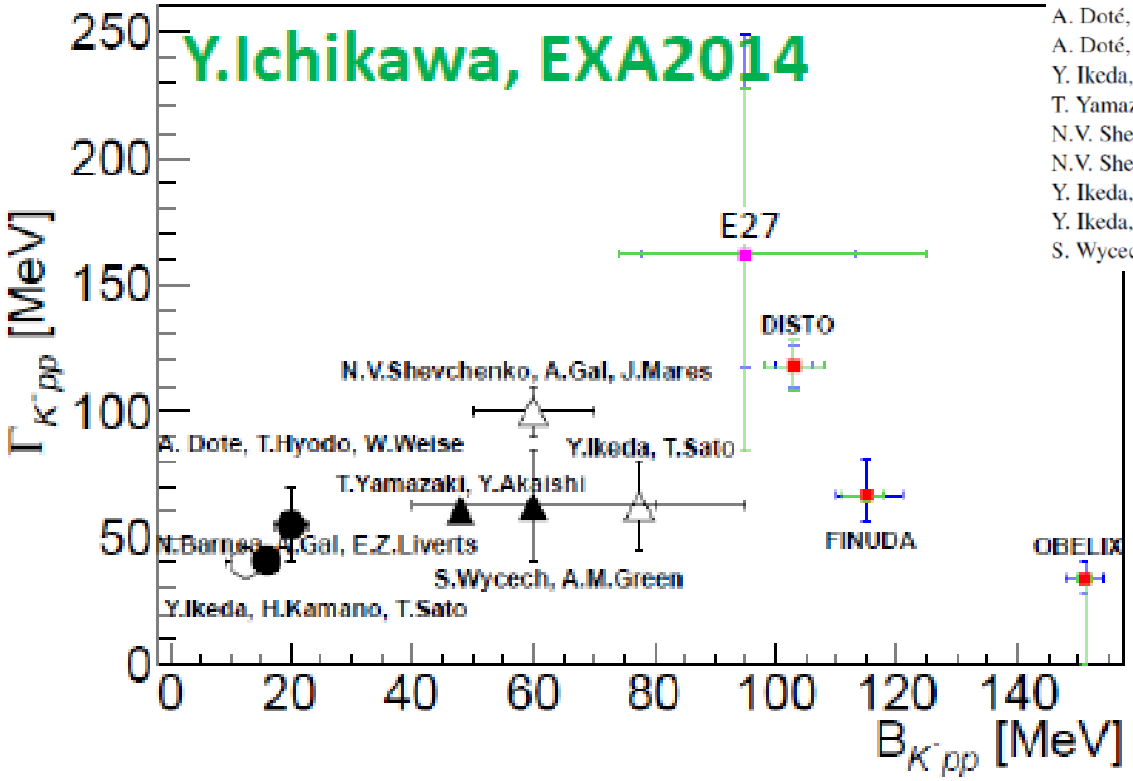
- We search for the simplest Kaonic nucleus, "$\bar{K}NN$" bound system.



Y.Akaishi & T.Yamazaki, PLB535, 70(2002).

Recent status of $\bar{K}NN$

- There are many Theoretical/Experimental results.



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A. Doté, T. Hyodo, W. Weise, Nucl. Phys. A 804 (2008) 197;
A. Doté, T. Hyodo, W. Weise, Phys. Rev. C 79 (2009) 014003.
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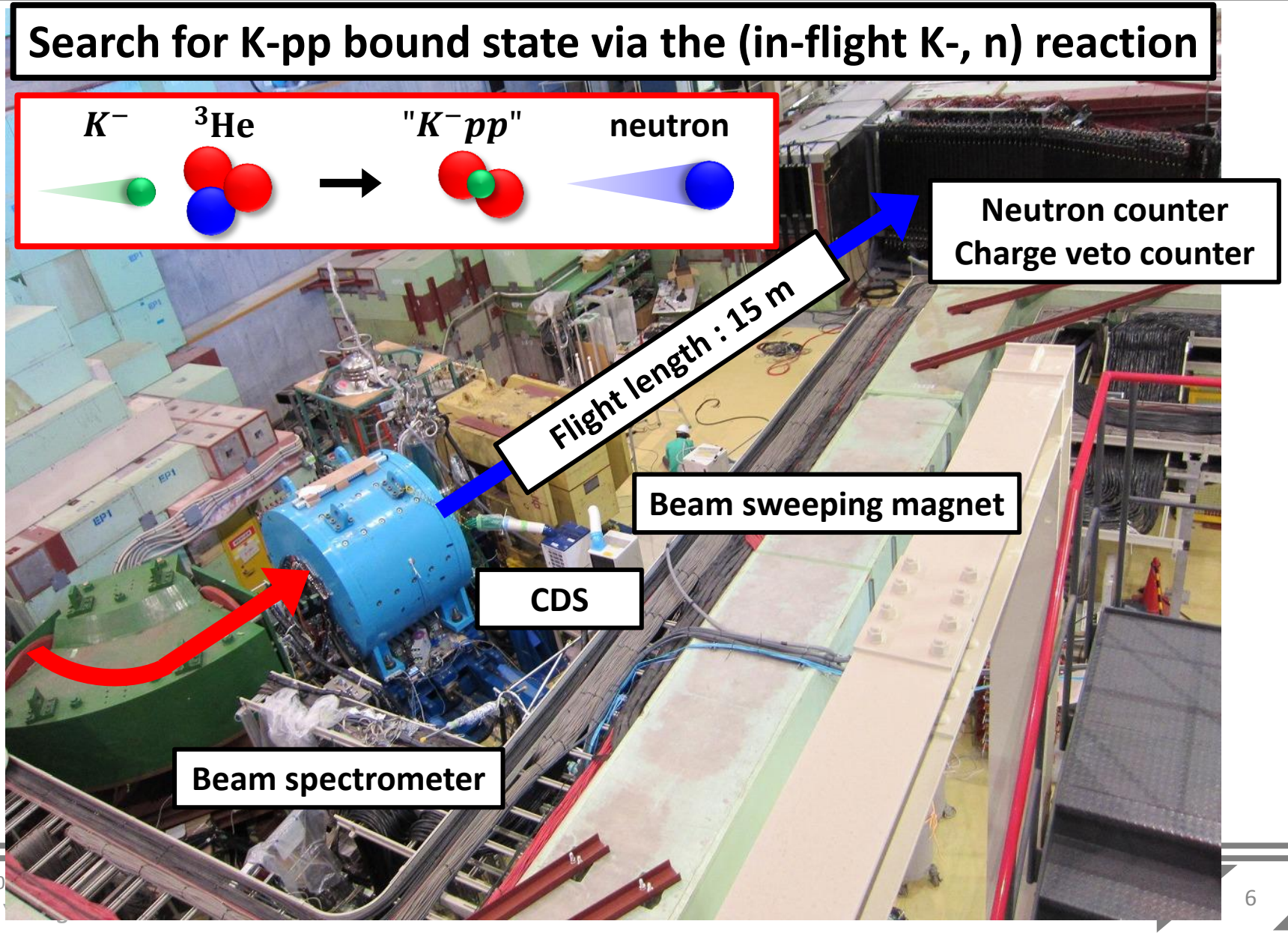
- $\bar{K}NN$ bound state is still unclear…

J-PARC E15 experiment

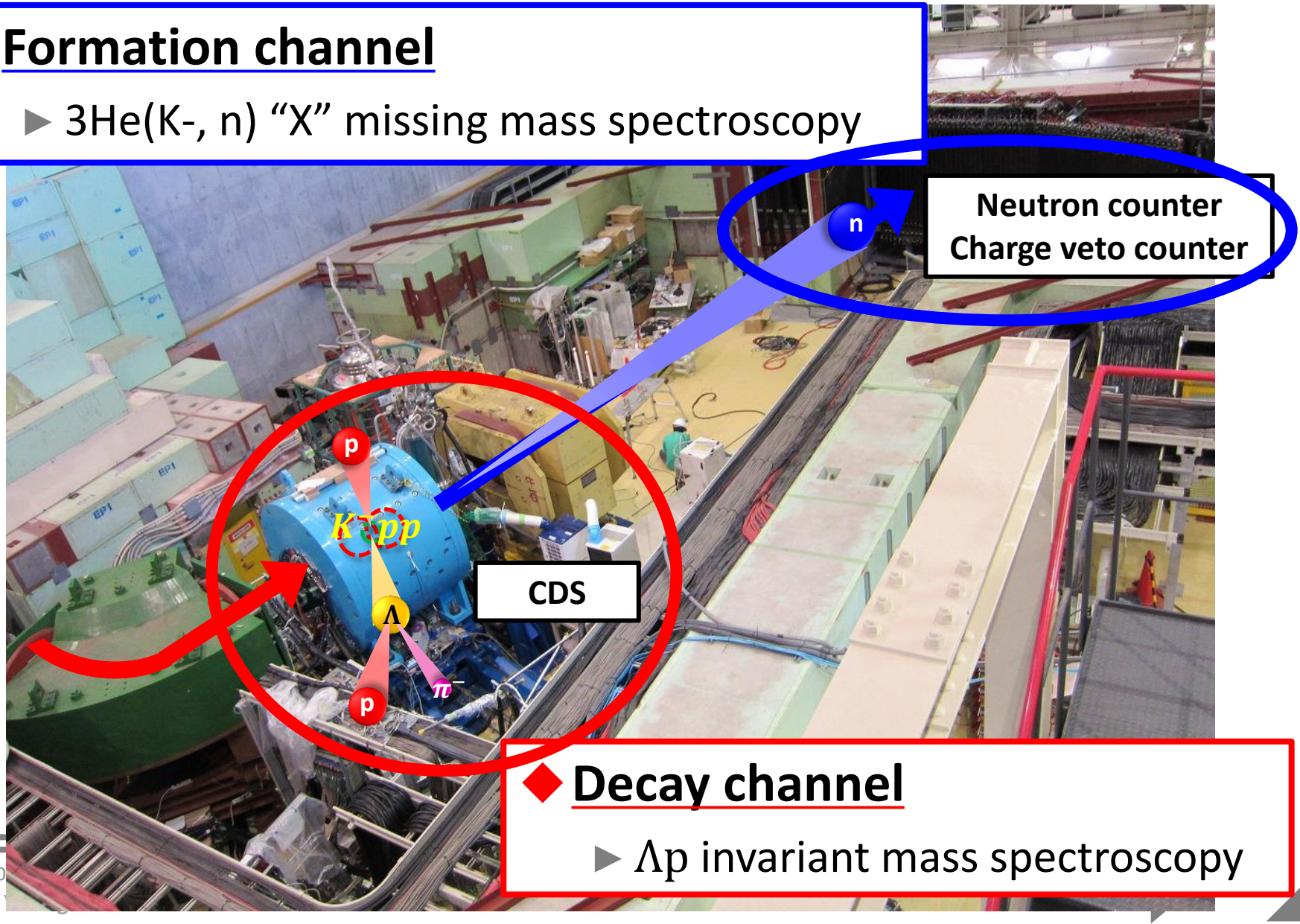
Search for K-pp bound state via the (in-flight K-, n) reaction



J-PARC E15 experiment

Formation channel

- 3He(K-, n) "X" missing mass spectroscopy

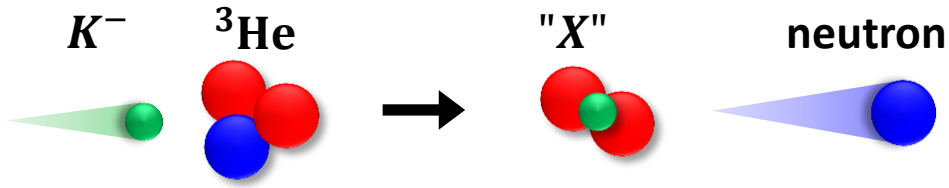


Decay channel

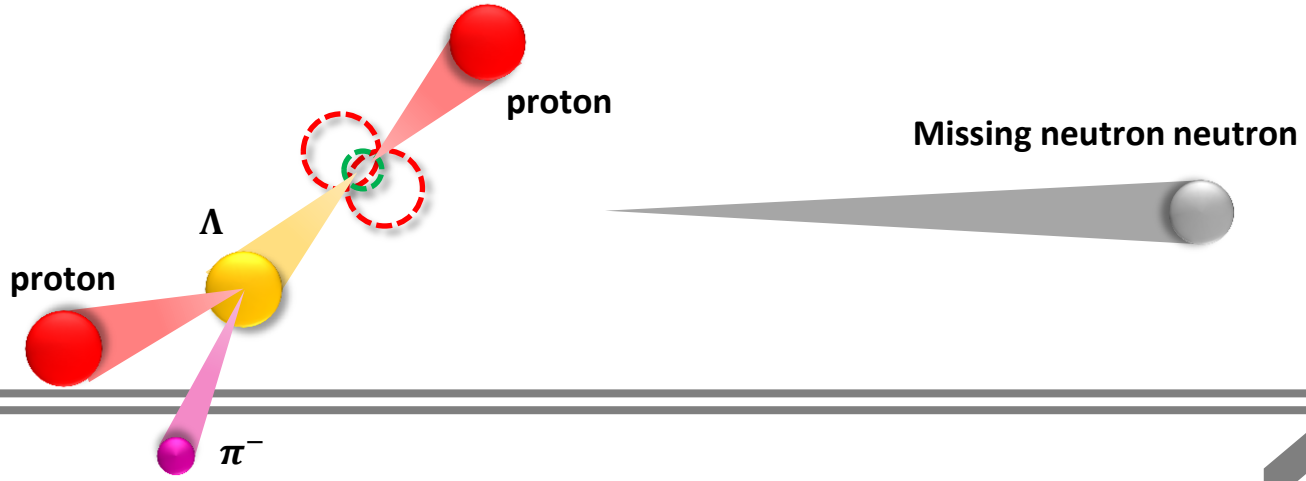
- Λp invariant mass spectroscopy

Analysis overview

- **Formation channel**
  - 3He(K-, n) “X” missing mass spectroscopy
  - Comparison with H2 and D2 data

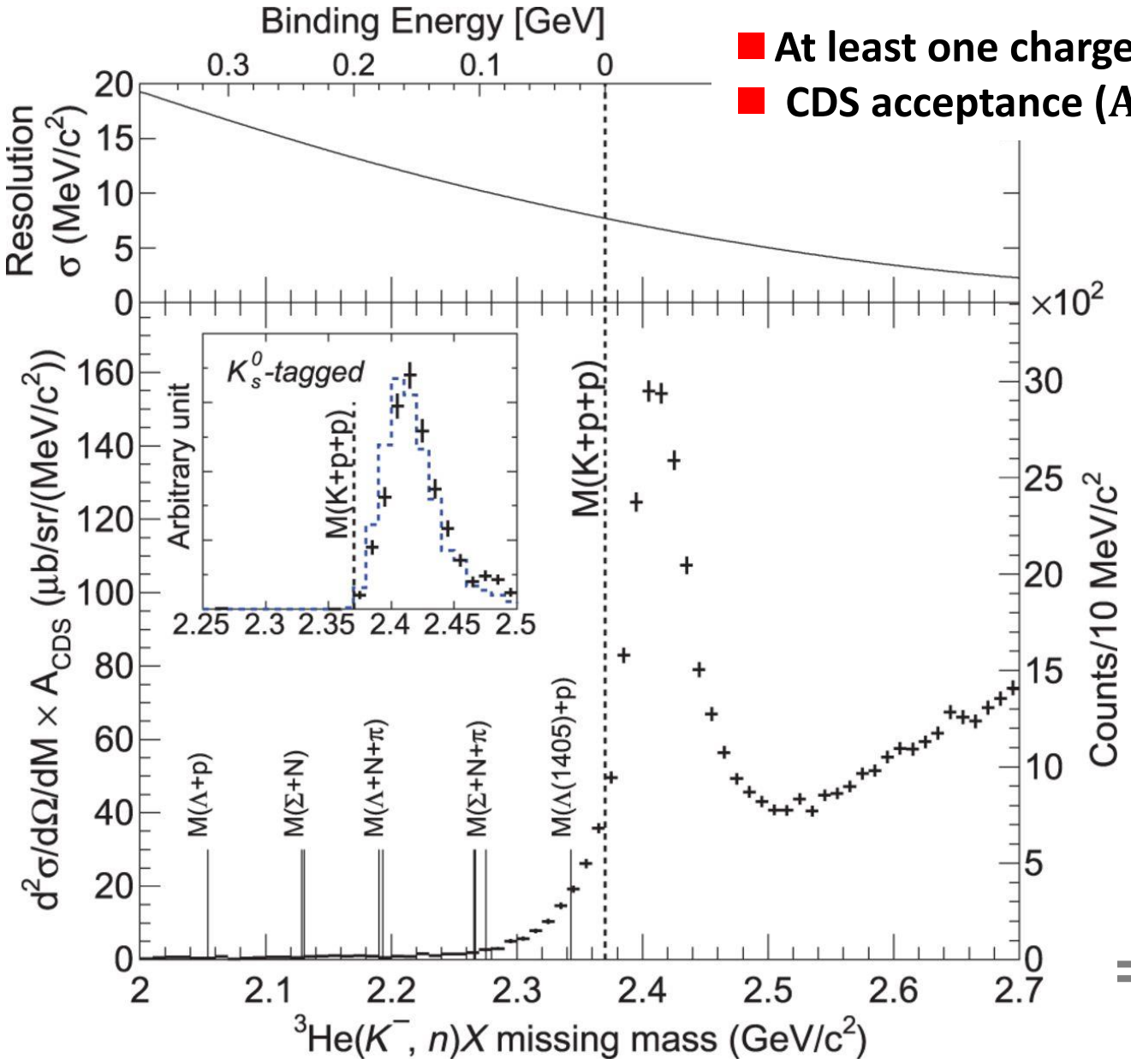


- **Decay channel (Exclusive channel)**
  - Λp invariant mass spectroscopy in 3He(K-,Lp)”n” reaction

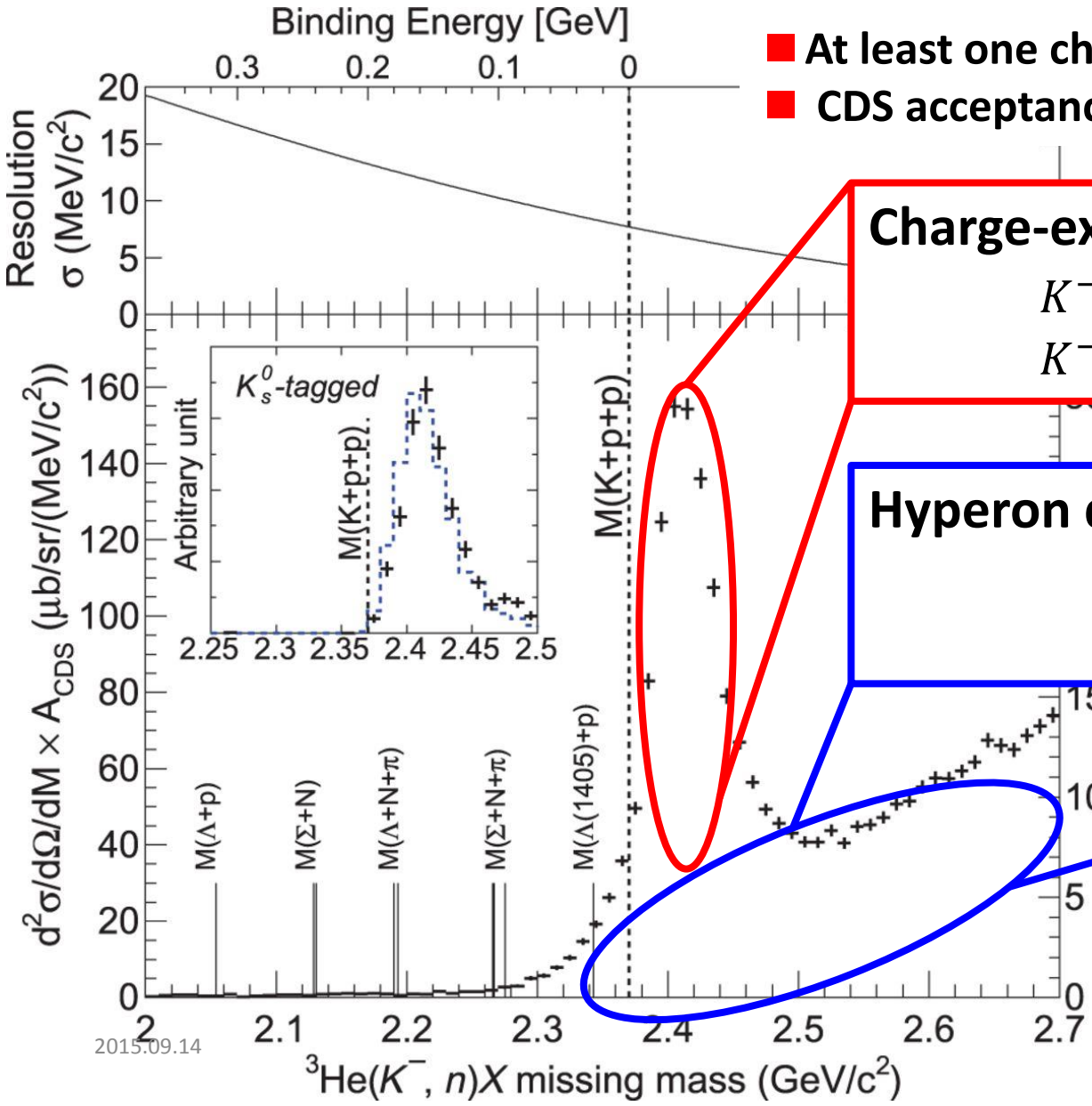


Semi-inclusive 3He(K-, n)"X" spectrum

- At least one charged track in CDS is required.
- CDS acceptance (A_{CDS}) is not corrected.



Semi-inclusive 3He(K-, n)"X" spectrum



- At least one charged track in CDS is required.
- CDS acceptance (A_{CDS}) is not corrected.

Charge-exchange/Quasi-elastic

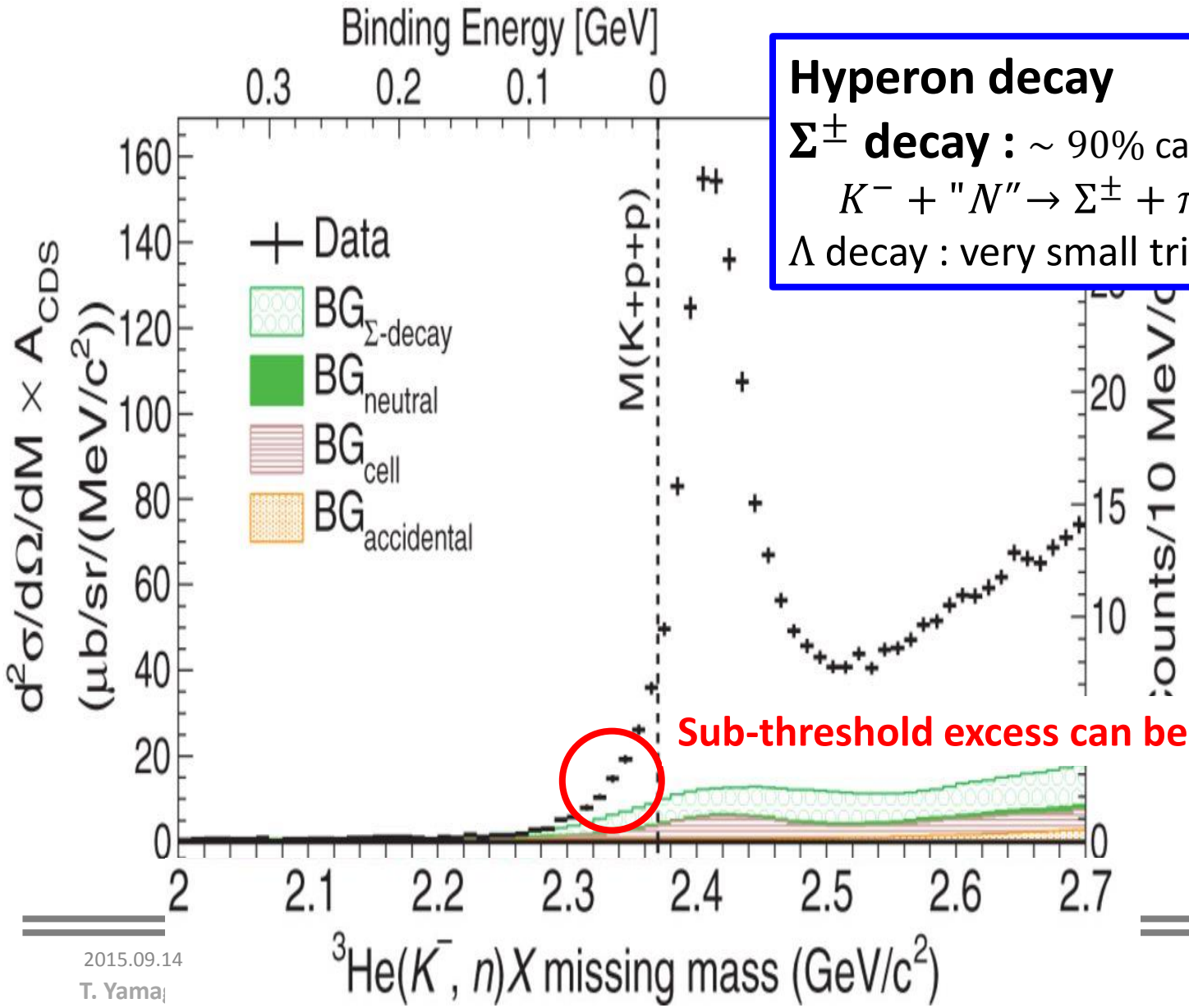
$$K^- + {}^3He \rightarrow K^0 + \boldsymbol{n} + d_{spec}$$
$$K^- + {}^3He \rightarrow K^- + \boldsymbol{n} + 2p_{spec}$$

Hyperon decay

$$K^- + {}^3He \rightarrow Y + \pi + 2N_{spec}$$
followed by $Y \rightarrow \pi + \boldsymbol{n}$

⇨ **Evaluate the Background**

Semi-inclusive 3He(K-, n)"X" spectrum



Hyperon decay

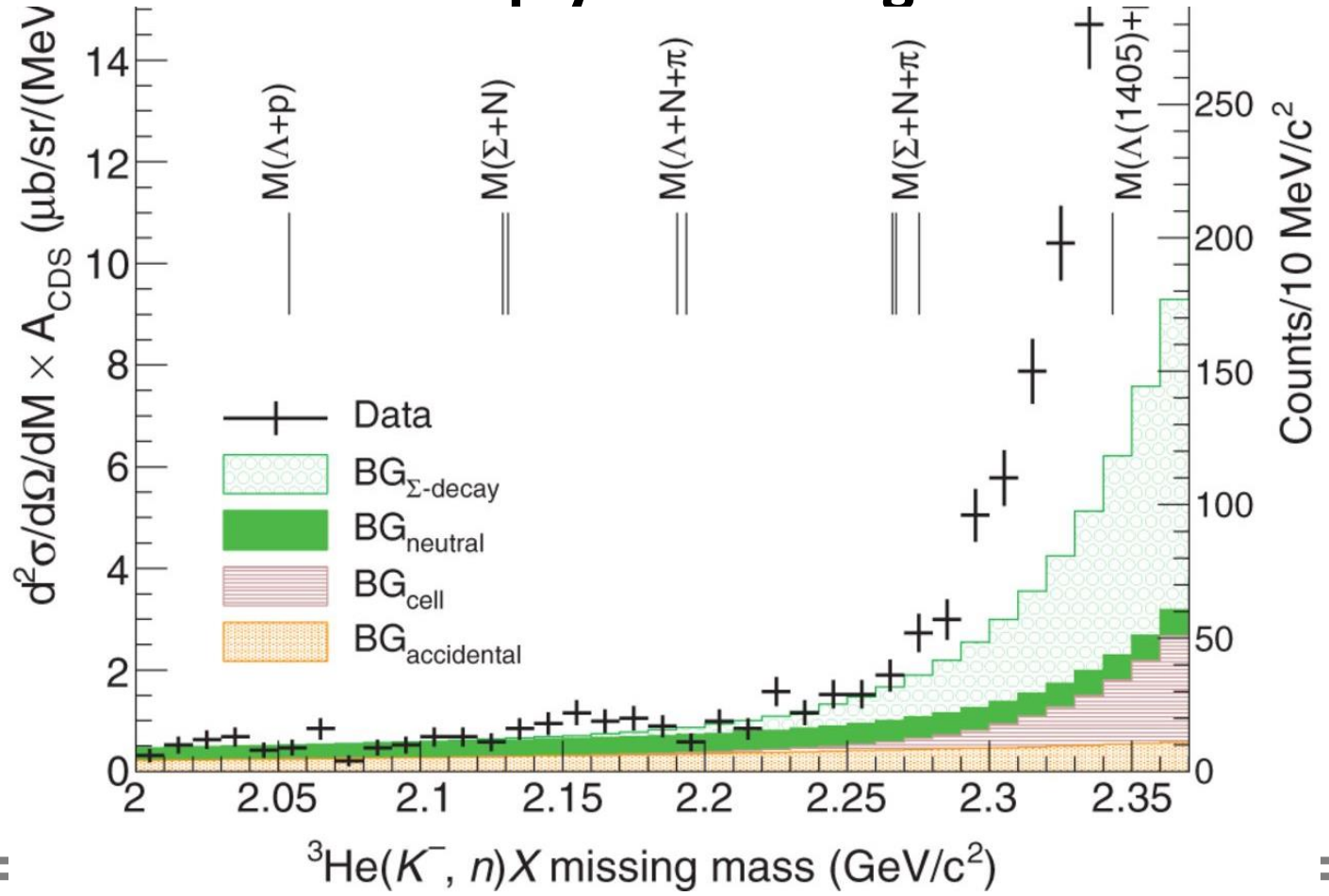
$\Sigma^{\pm}$ decay : $\sim 90\%$ can be reconstructed

$K^- + "N" \rightarrow \Sigma^{\pm} + \pi \rightarrow \boldsymbol{n} + \pi^{\pm} + \pi$

Λ decay : very small trigger acceptance

Result of semi-inclusive analysis

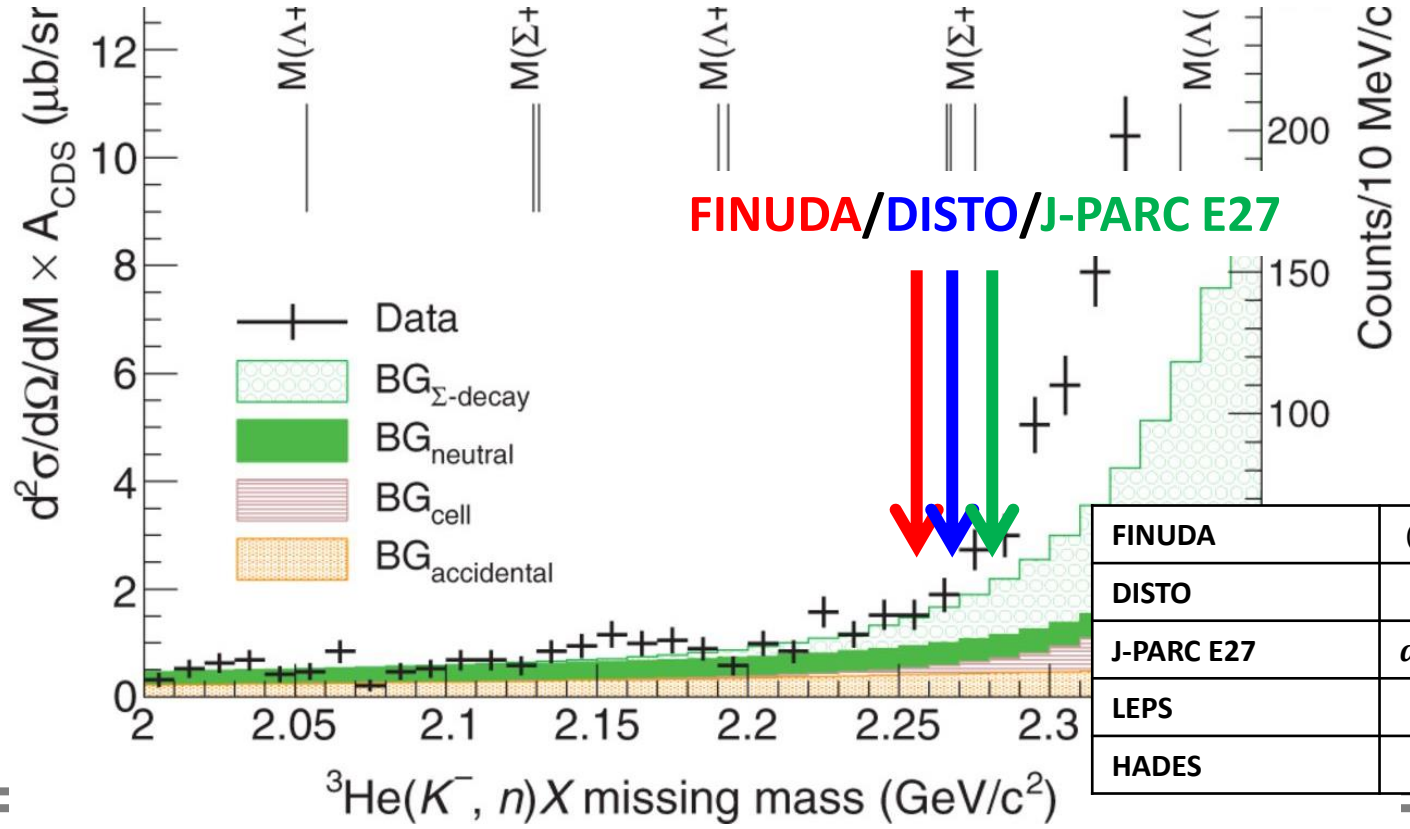
- Sub-threshold excess was observed
- NO structure in deeply-bound region was observed



Comparison with other experiments

- **LEPS/SPring-8 and HADES/GSI also reported NO structure**

Decay analysis is important.

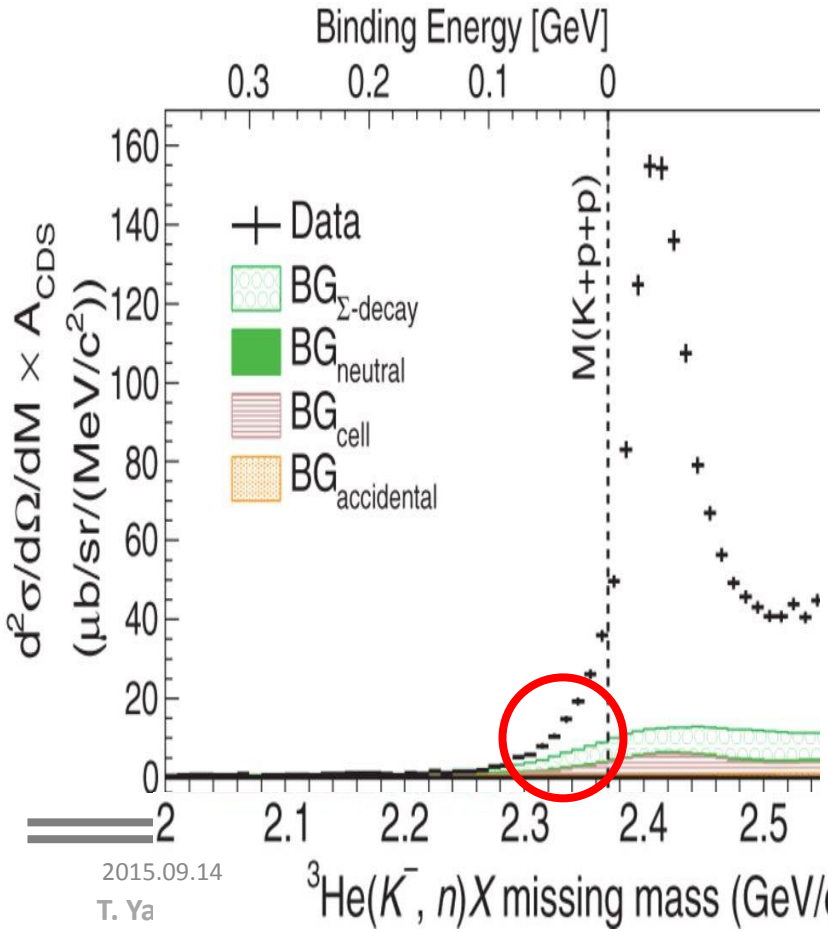


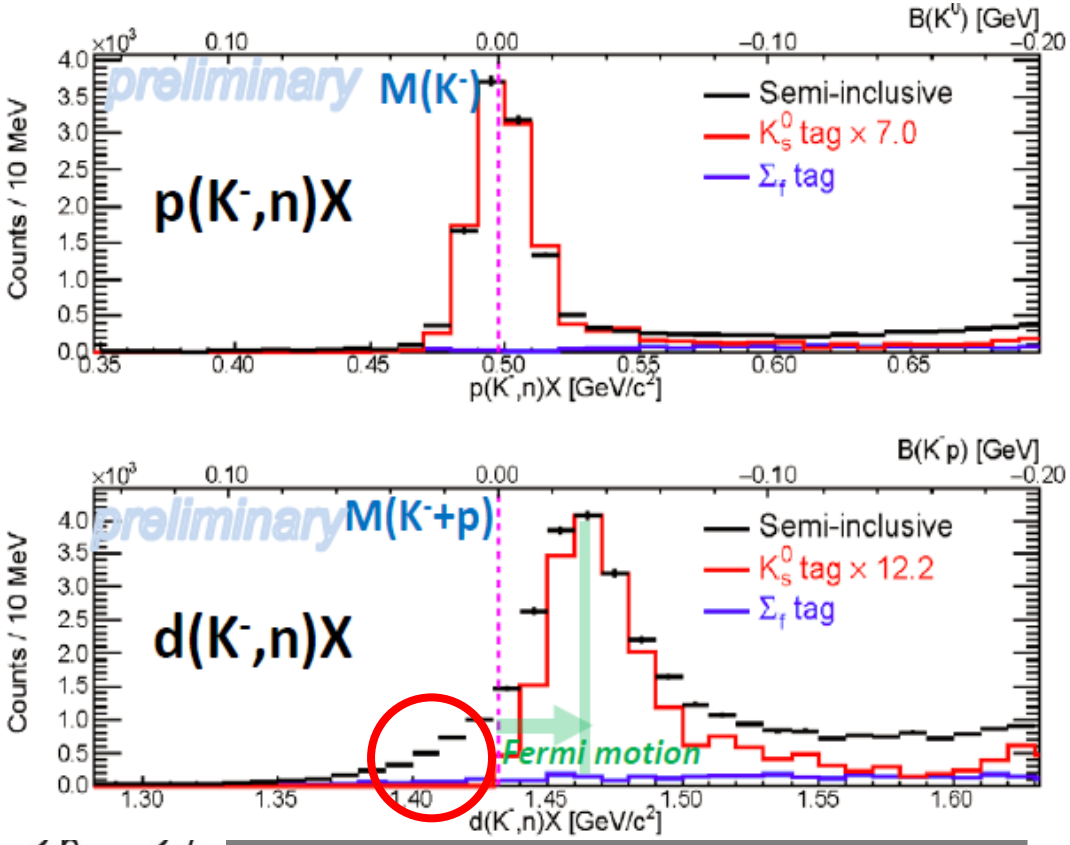
FINUDA	(stopped K^-, Λp)
DISTO	$pp \rightarrow \Lambda p K^+$
J-PARC E27	$d(\pi^+, K^+)X$, $2p$ coi
LEPS	$\gamma N \rightarrow K^+ \pi^- Y$
HADES	$pp \rightarrow \Lambda p K^+$

Comparison with H2 and D2 data

- Sub-threshold excess comes from Y^*N ?

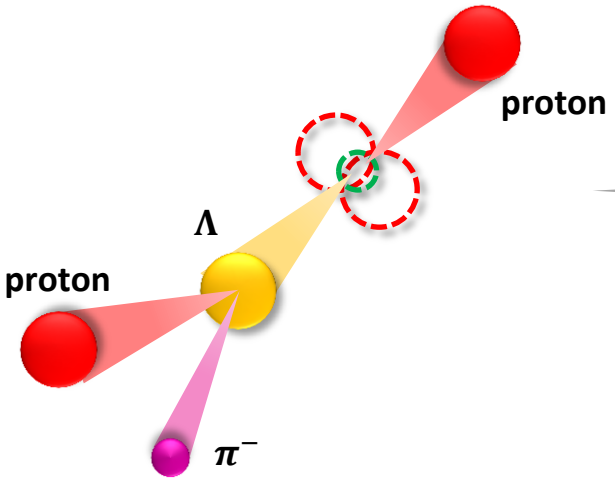
Exclusive analysis is desired.

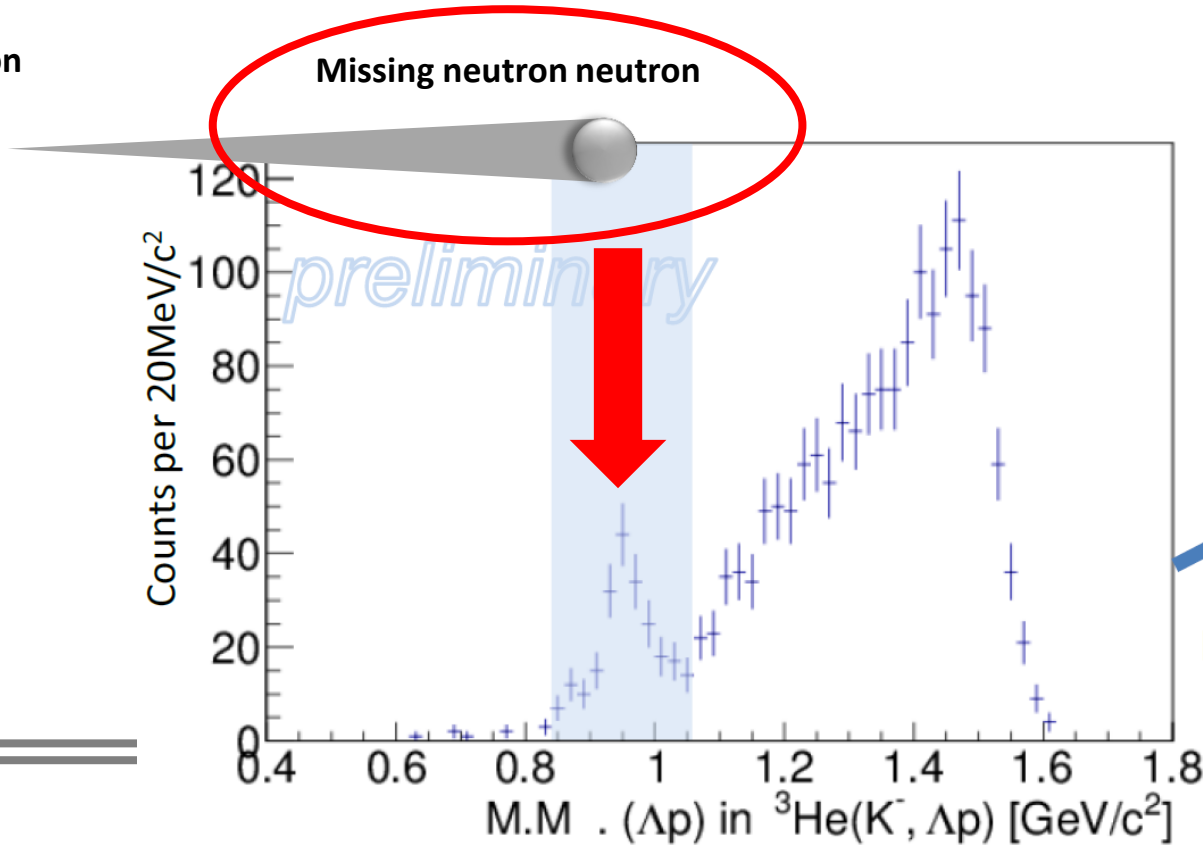




Decay channel analysis

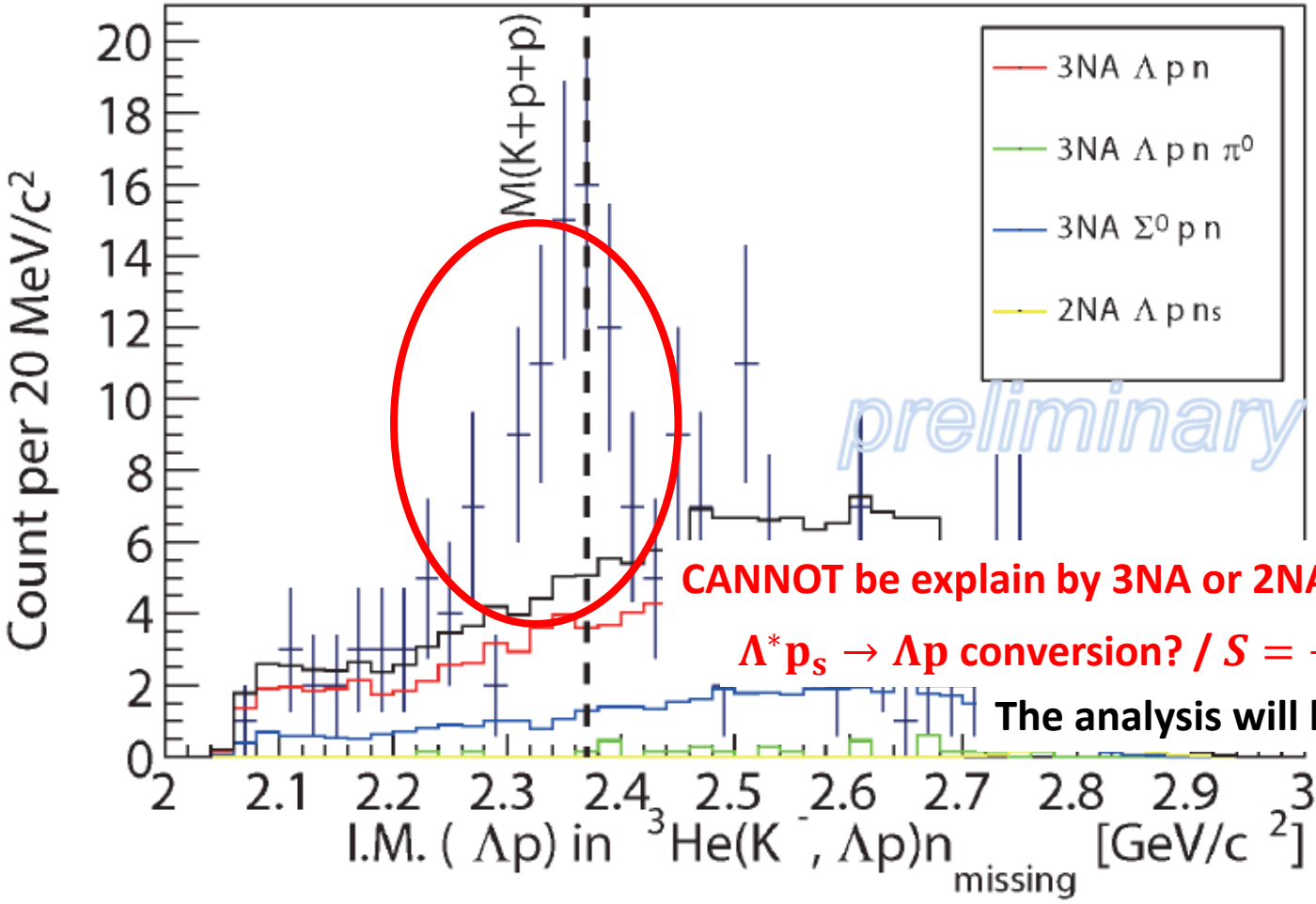
- **Λp invariant mass spectroscopy in $^3He(K^-, \Lambda p)$"n" reaction**
  - **Select missing neutron in MM(Λp)**





Λp invariant mass spectrum in $^3He(K^-, \Lambda p)$"n" reaction

- Missing neutron is required in $MM(\Lambda p)$.



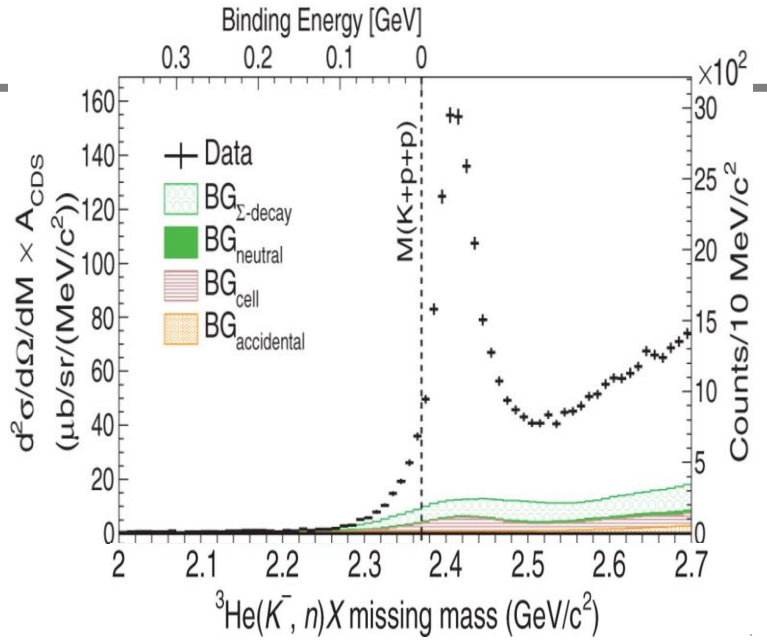
CANNOT be explain by 3NA or 2NA Λpn final state

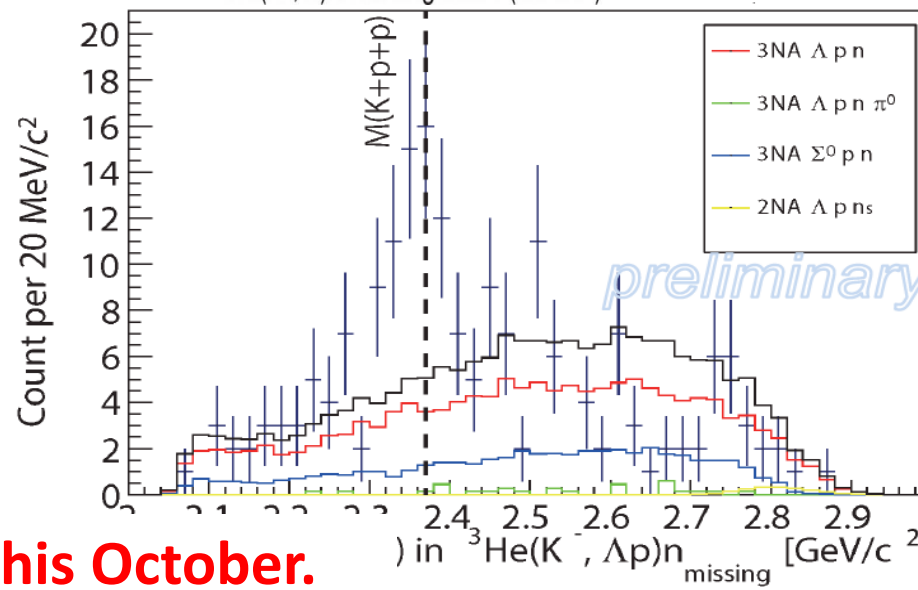
$\Lambda^* p_s \rightarrow \Lambda p$ conversion? / $S = -1$ dy-baryon state?

The analysis will be fixed quite soon.

Summary

- **Formation channel**
  - **3He(K-, n) "X" missing mass spectrum**
    - **Excess bellow the threshold was observed.**
    - **NO structure in deeply-bound region**
- **Decay channel**
  - **Λp invariant mass spectrum**
    - **A structure was observed bellow K-pp threshold.**





The experiment will resume in this October.

Thank you for your attention

~ The E15 collaboration ~

S. Ajimura[a], G. Beer[b], H. Bhang[c], M. Bragadireanu[e], P. Buehler[f], L. Busso[g,h], M. Cargnelli[f], S. Choi[c], C. Curceanu[d], S. Enomoto[i], D. Faso[g,h], H. Fujioka[j], Y. Fujiwara[k], T. Fukuda[l], C. Guaraldo[d], T. Hashimoto[k], R. S. Hayano[k], T. Hiraiwa[a], M. Iio[o], M. Iliescu[d], K. Inoue[i], Y. Ishiguro[j], T. Ishikawa[k], S. Ishimoto[o], T. Ishiwatari[f], K. Itahashi[n], M. Iwai[o], M. Iwasaki[m,n*], Y. Kato[n], S. Kawasaki[i], P. Kienle[p], H. Kou[m], Y. Ma[n], J. Marton[f], Y. Matsuda[q], Y. Mizoi[l], O. Morra[g], T. Nagae[j$], H. Noumi[a], H. Ohnishi[n], S. Okada[n], H. Outa[n], K. Piscicchia[d], M. Poli Lener[d], A. Romero Vidal[d], Y. Sada[j], A. Sakaguchi[i], F. Sakuma[n], M. Sato[n], A. Scordo[d], M. Sekimoto[o], H. Shi[k], D. Sirghi[d,e], F. Sirghi[d,e], K. Suzuki[f], S. Suzuki[o], T. Suzuki[k], K. Tanida[c], H. Tatsuno[d], M. Tokuda[m], D. Tomono[n], A. Toyoda[o], K. Tsukada[r], O. Vazquez Doce[d,s], E. Widmann[f], B. K. Weunschek[f], T. Yamaga[i], T. Yamazaki[k,n], H. Yim[t], Q. Zhang[n], and J. Zmeskal[f]

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