A SEARCH FOR DEEPLY-BOUND KAONIC NUCLEAR STATES

RCNP, OSAKA UNIVERSITY

KENTARO INOUE

FOR THE E15 COLLABORATION

E15 COLLABORATION LIST

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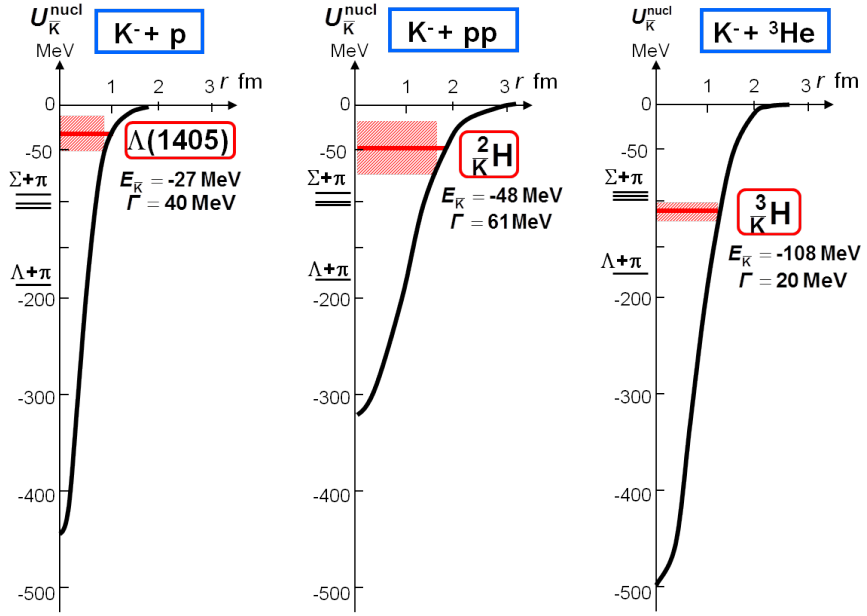
Contents

- Introduction
- E15 experimental
  - Set up
  - Detector Performance
- Analysis result
  - Semi-inclusive $^{3}He(K^{-}, n)$
  - Exclusive spectrum
  - $^{3}He(K^{-}, d)$ analysis
- Summary

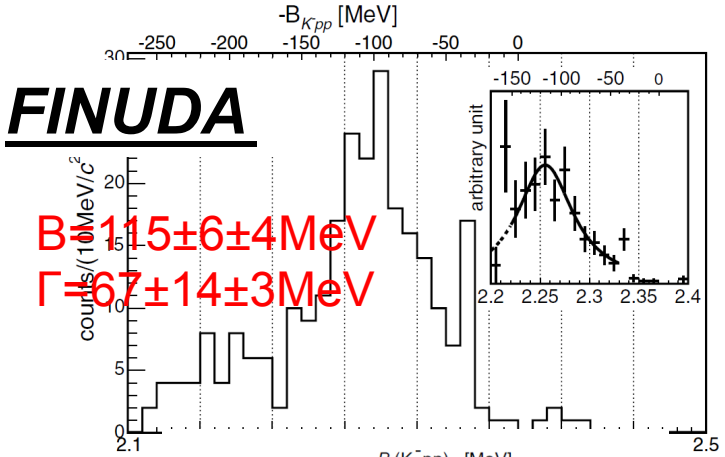
Introduction

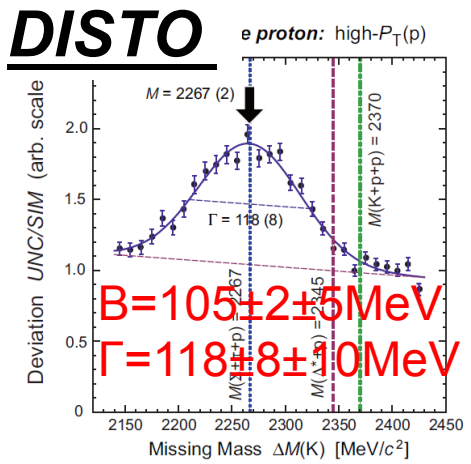
- We know $\bar{K}N$ interaction is strongly attractive.
- A deeply kaonic nucleus may be formed when anti-kaon is embedded in nucleus.
- K^-pp is the lightest one.



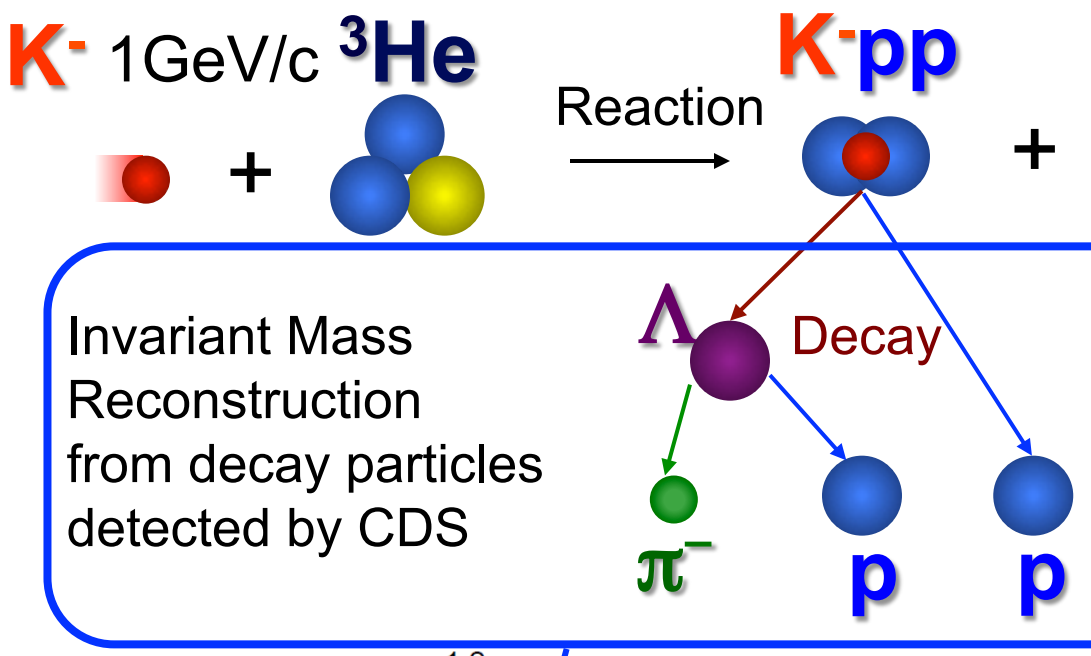
Y. Akaishi & T. Yamazaki, Phys. Rev. C65 (2002) 044005.

Y. Akaishi & T. Yamazaki, Phys. Lett. B535 (2002) 70.



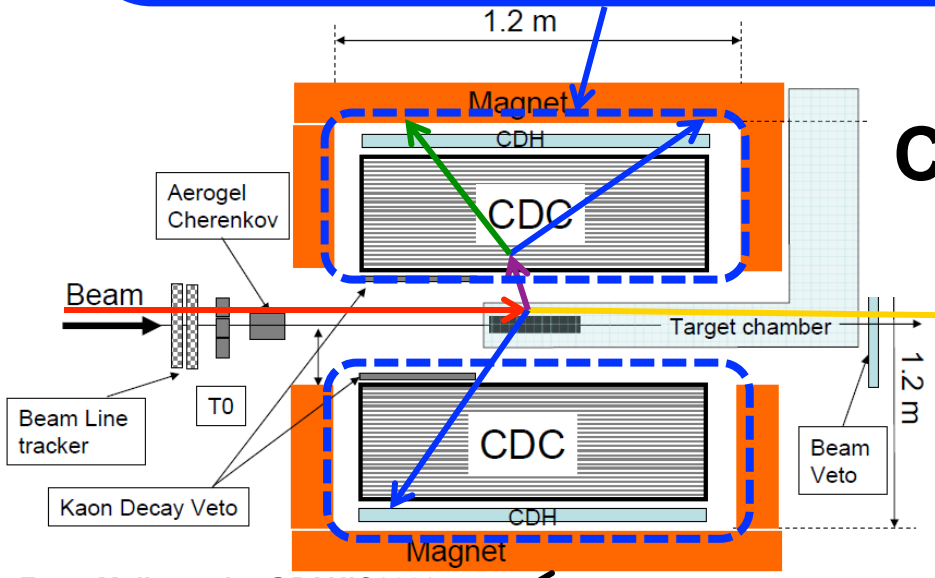


E15 Experiment



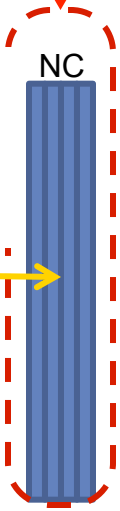
Missing Mass Spectroscopy

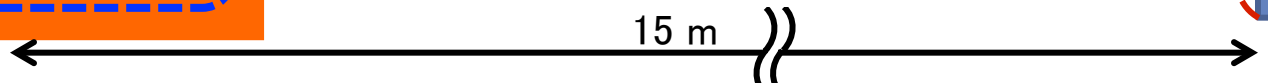
Neutron momentum measured by TOF.



Complete measurement for K-pp

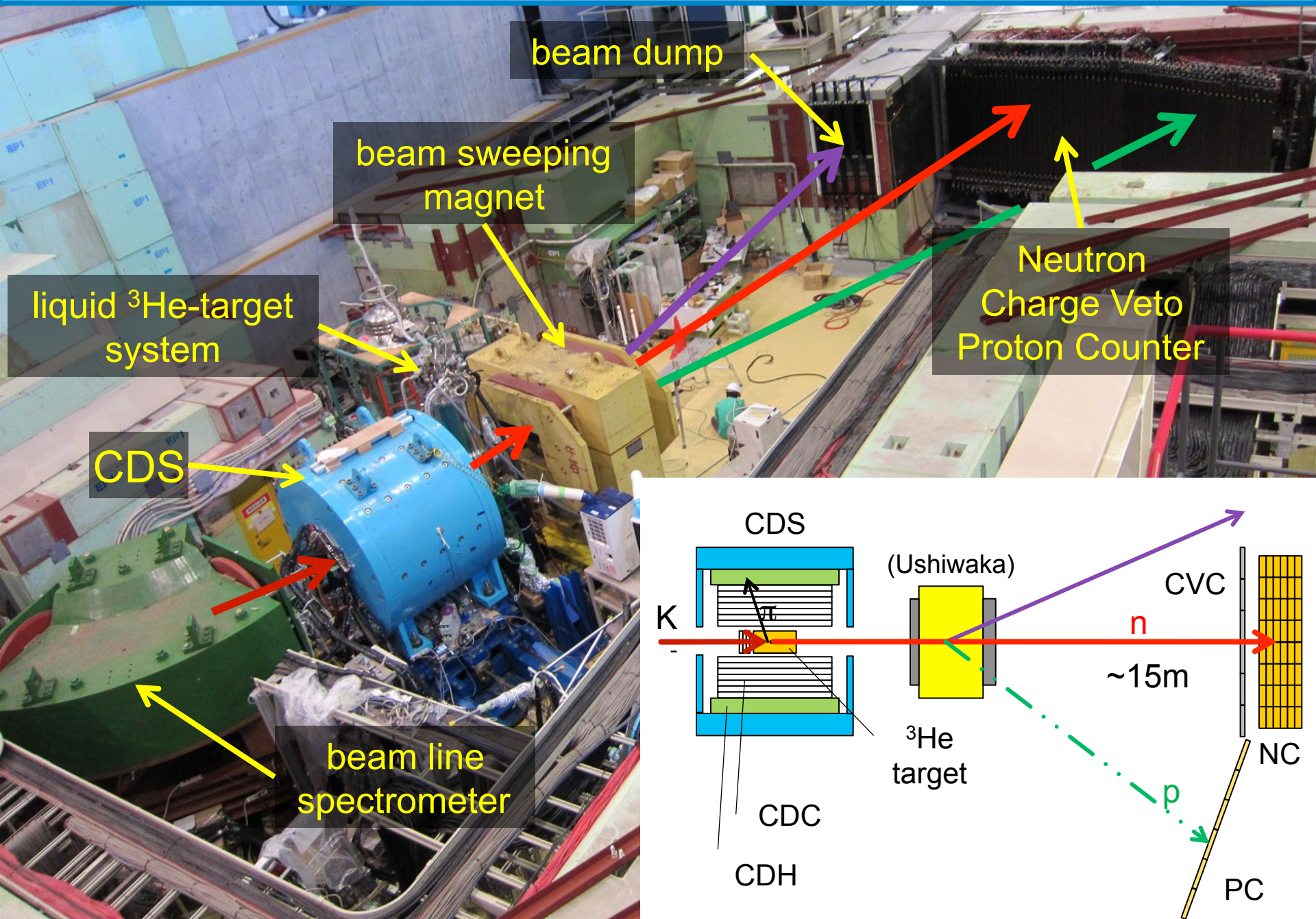
- **formation**
- **decay particles**



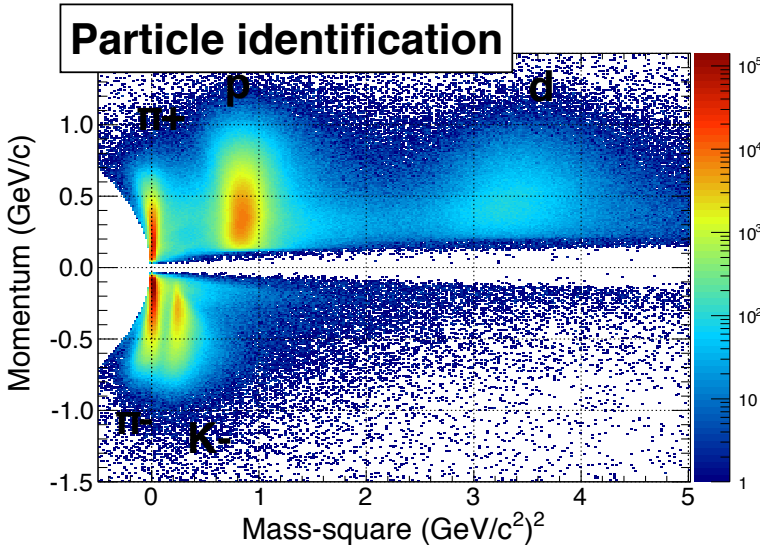


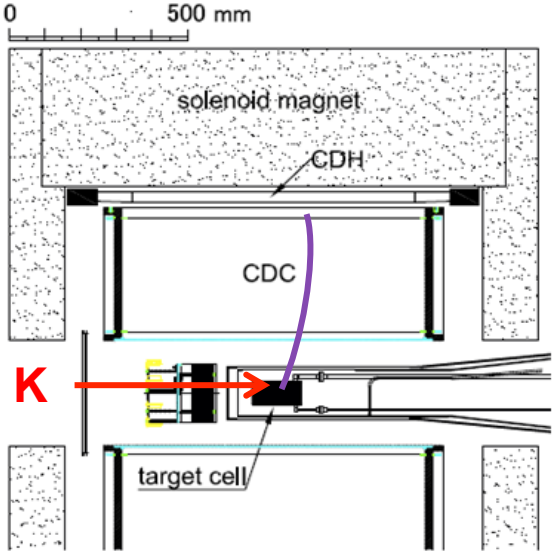
From M. Iio et al. @PANIC2008

K1.8BR spectrometer [Jun. 2012]

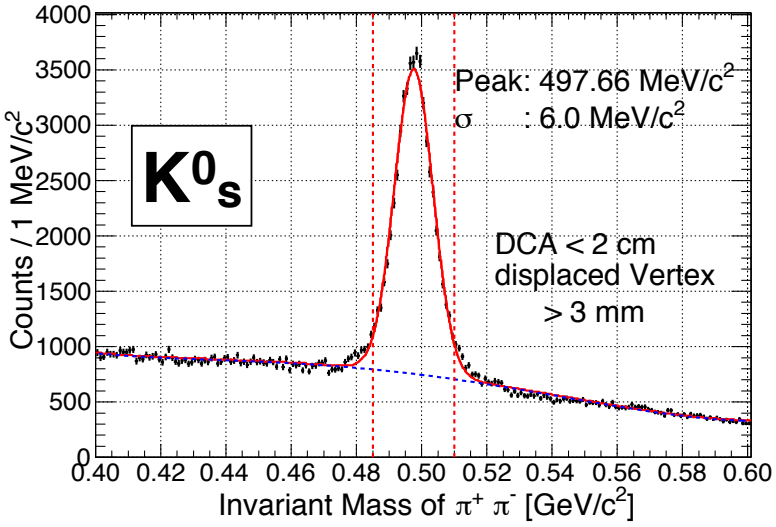


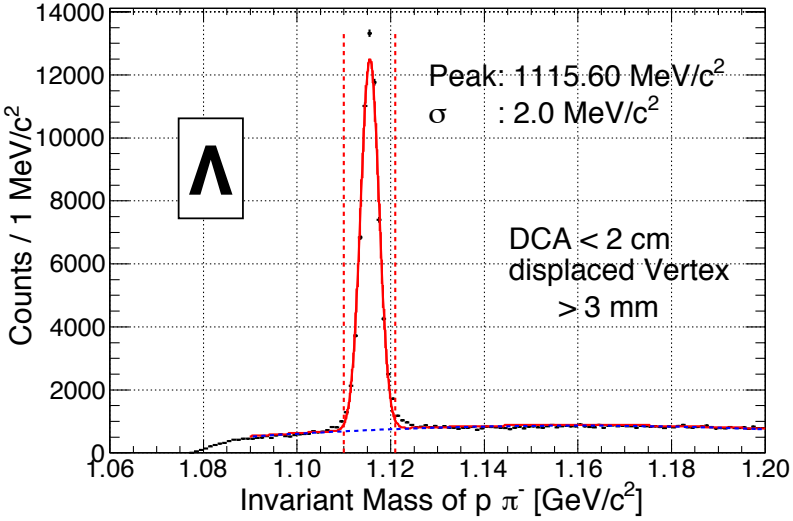
CDS Performance





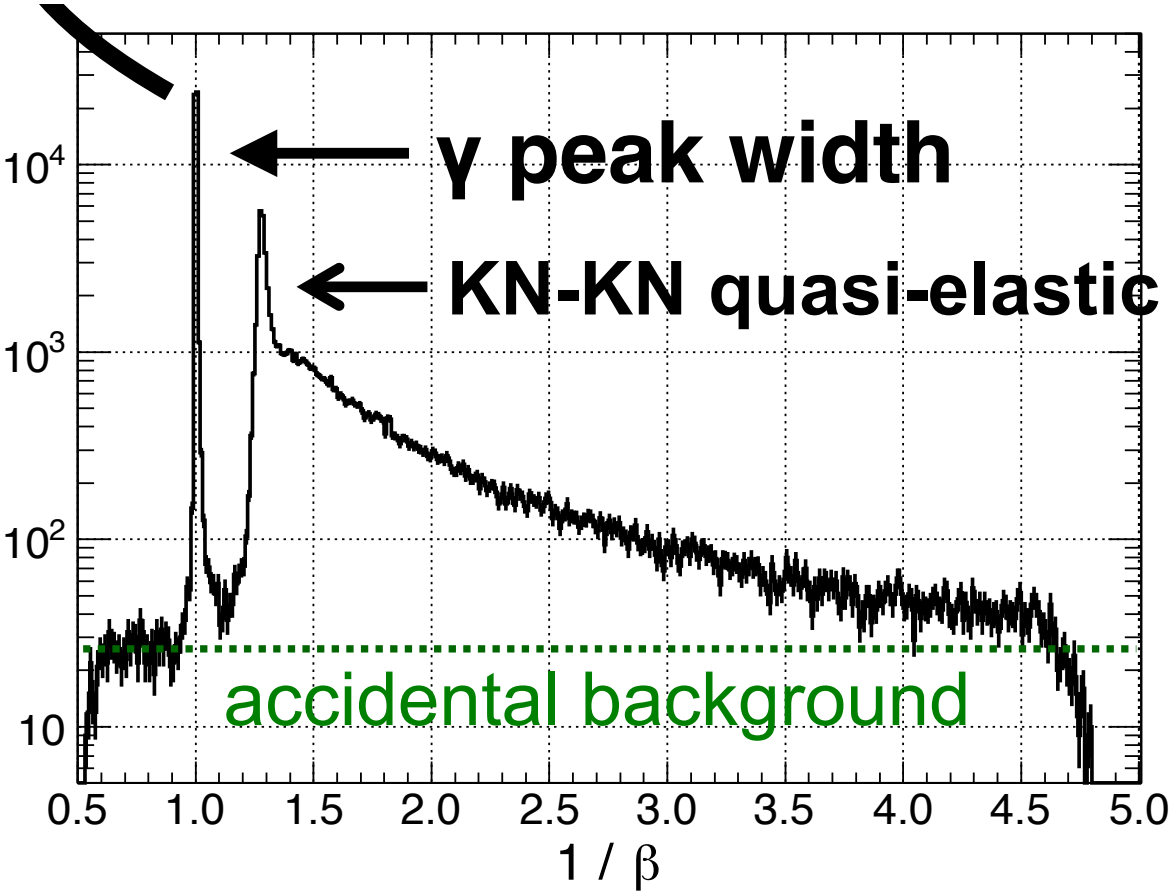
CDC: Drift Chamber
CDH: Hodoscope
Magnet: 0.7T
Cover 60% of the solid angle.





Design performance was achieved!!

NC Performance



S/N～100@QF neutron peak

→Offline threshold is 8MeVee

σ_{TOF}~160ps @ γ

→**σ_{MM}~10MeV/c^2 at the interested region**

J-PARC E15 1st stage physics run

Accumulated data

w/ liquid helium-3 target: ~1% of original proposal

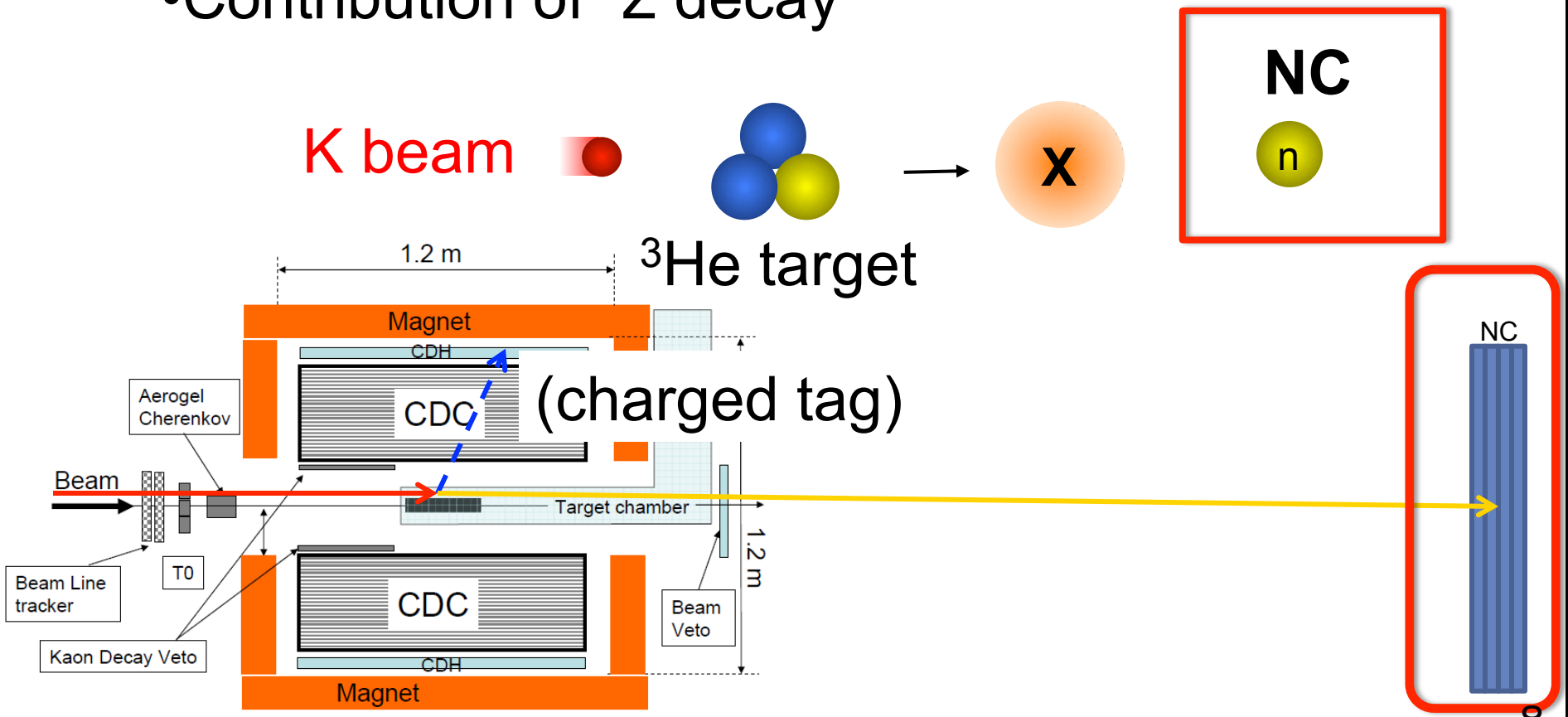
period	Primary beam intensity	duration	Kaon on target
March,2013	14.5kW(18Tppp, 6s cycle)	30 hours	1.1×10^{9}
May, 2013	24kw (30Tppp, 6s cycle)	88 hours	5.1×10^{9}

Analysis Result

1. Semi-inclusive $^{3}He(K^{-}, n)$ spectrum
2. Exlusive spectrum
3. $^{3}He(K^{-}, d)$ analysis

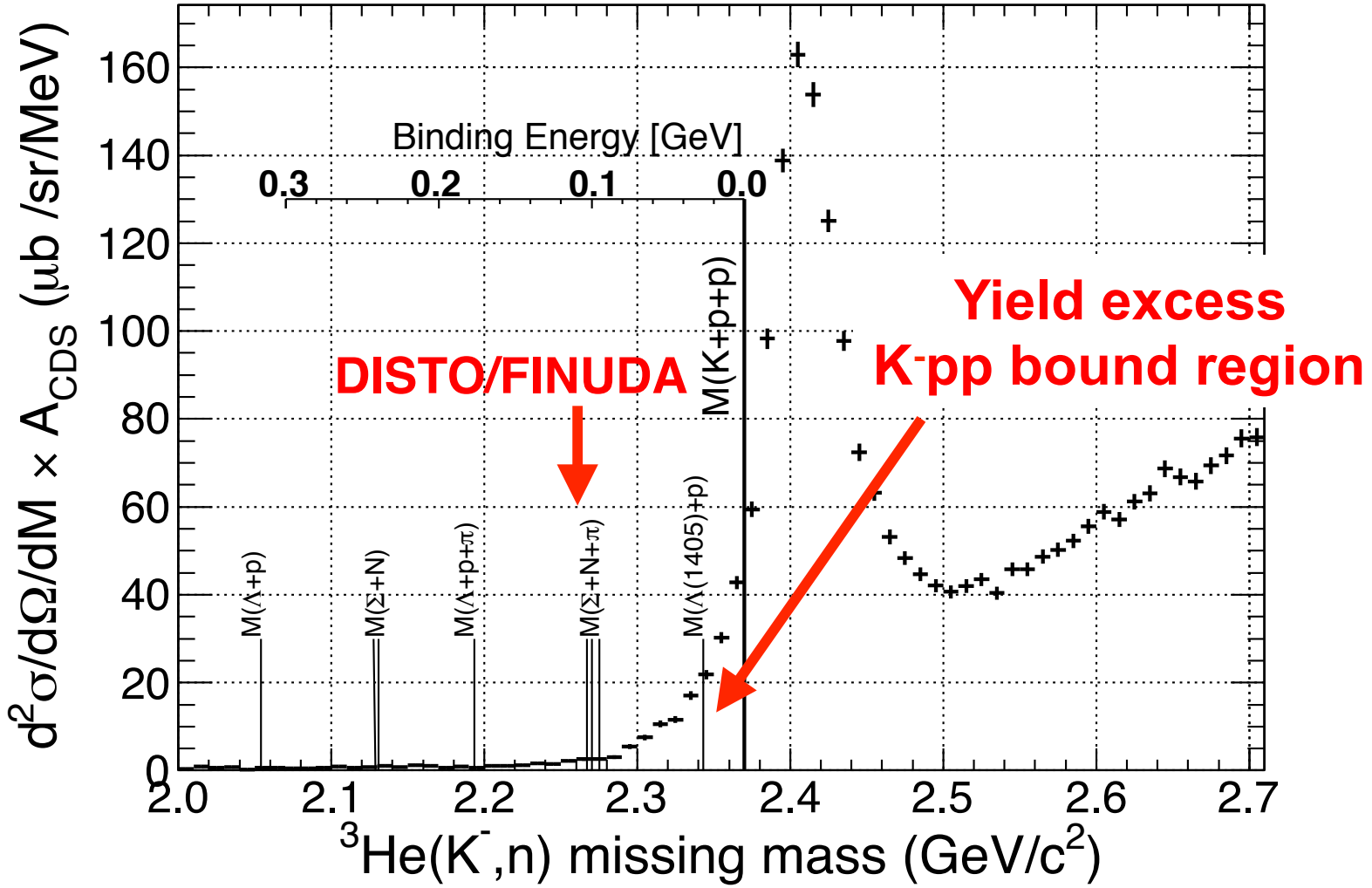
Semi-inclusive ^{3}He(K^-,n) spectrum

- ^{3}He(K^-, n) missing mass spectrum
- Compression with quasi-free K^0 Spectrum
- Contaminate target cell
- Contribution of Σ decay

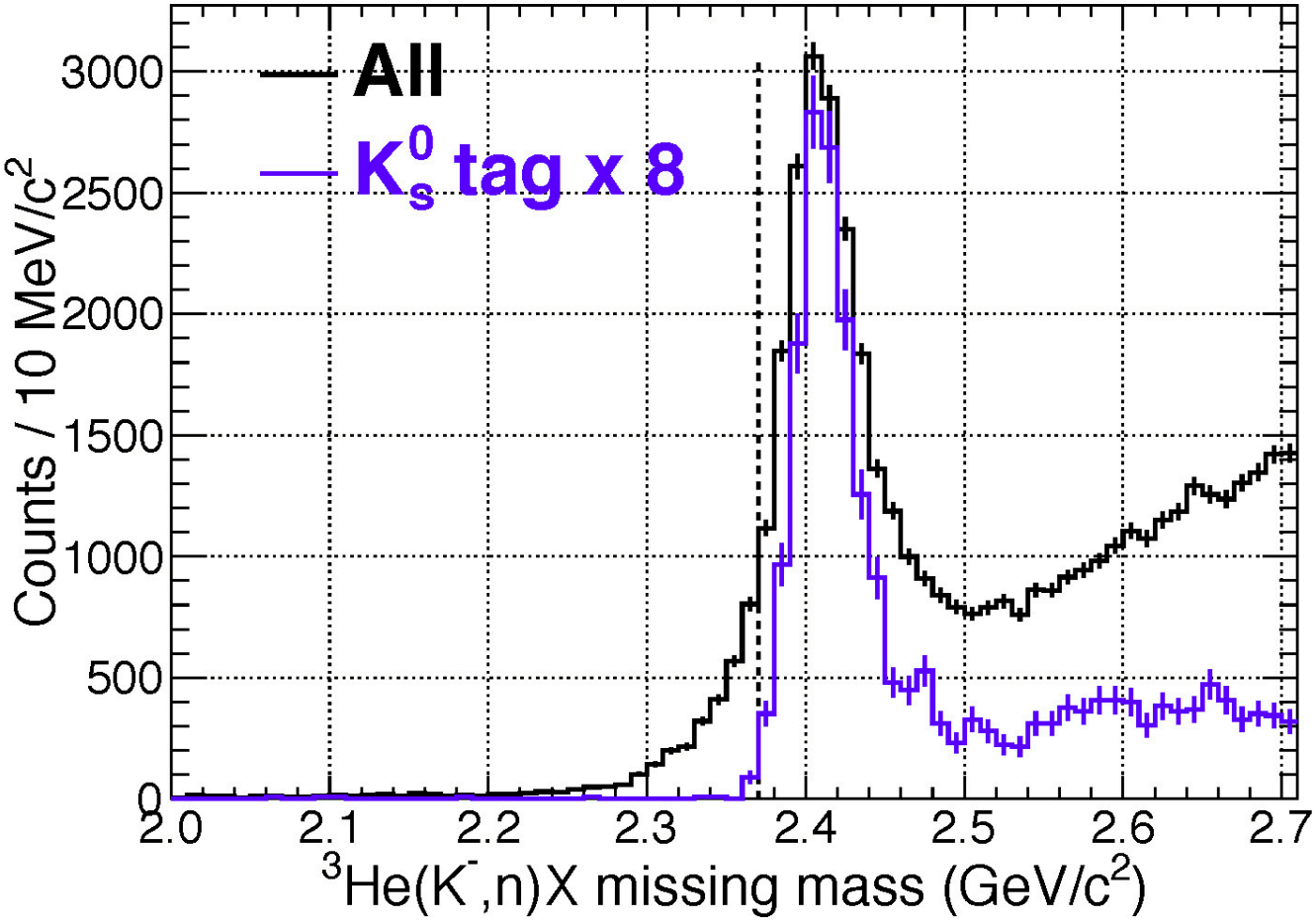


Semi-inclusive ^{3}He(K^{-},n) spectrum

biased by the request of charged track(s) in the CDS

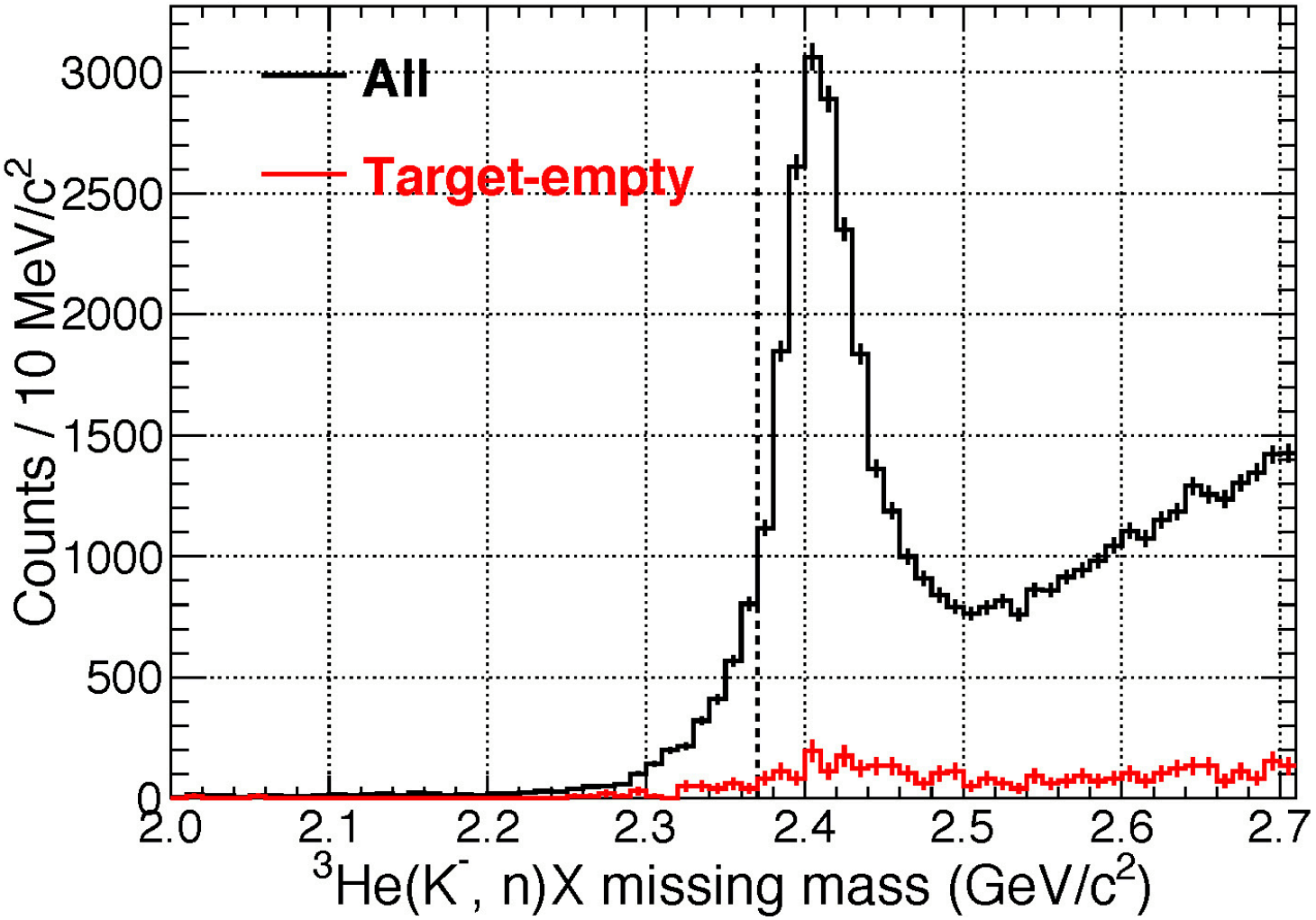


Compression with quasi-free K^0 Spectrum



Tail component in bound region is not due to detector resolution

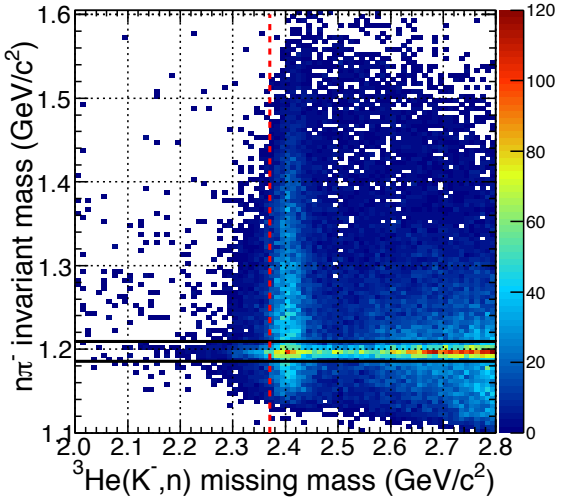
Contamination from other than ^{3}He target

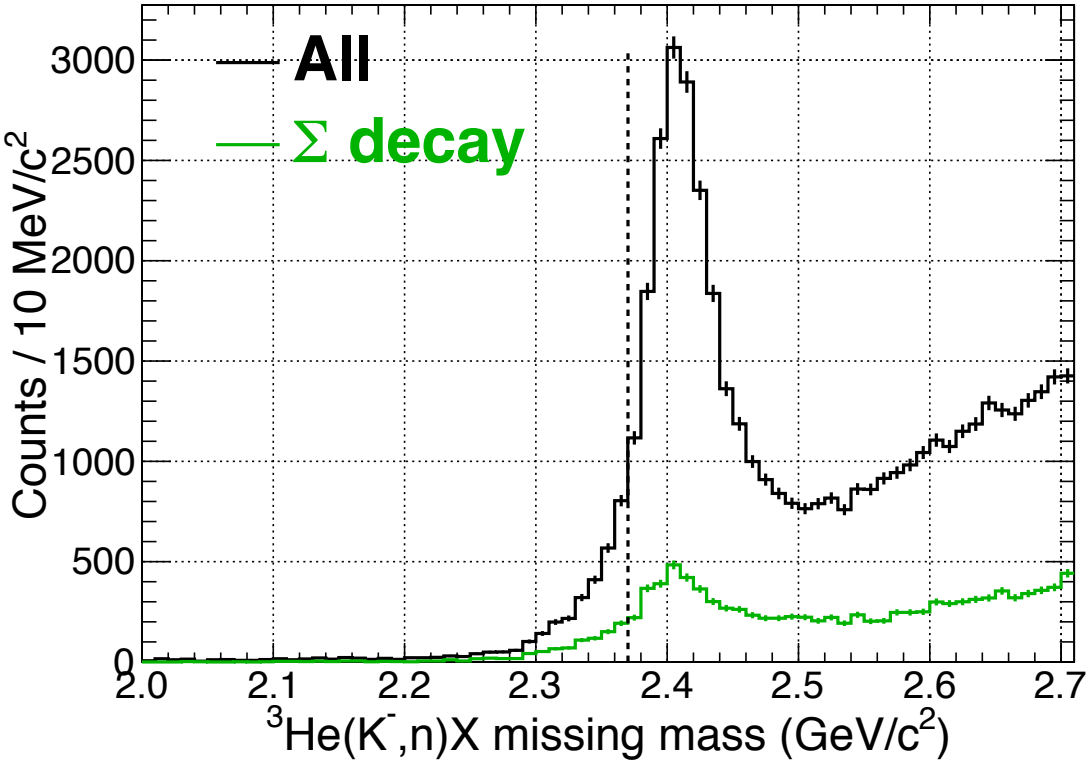


Contamination contribution is too small

Single-nucleon processes

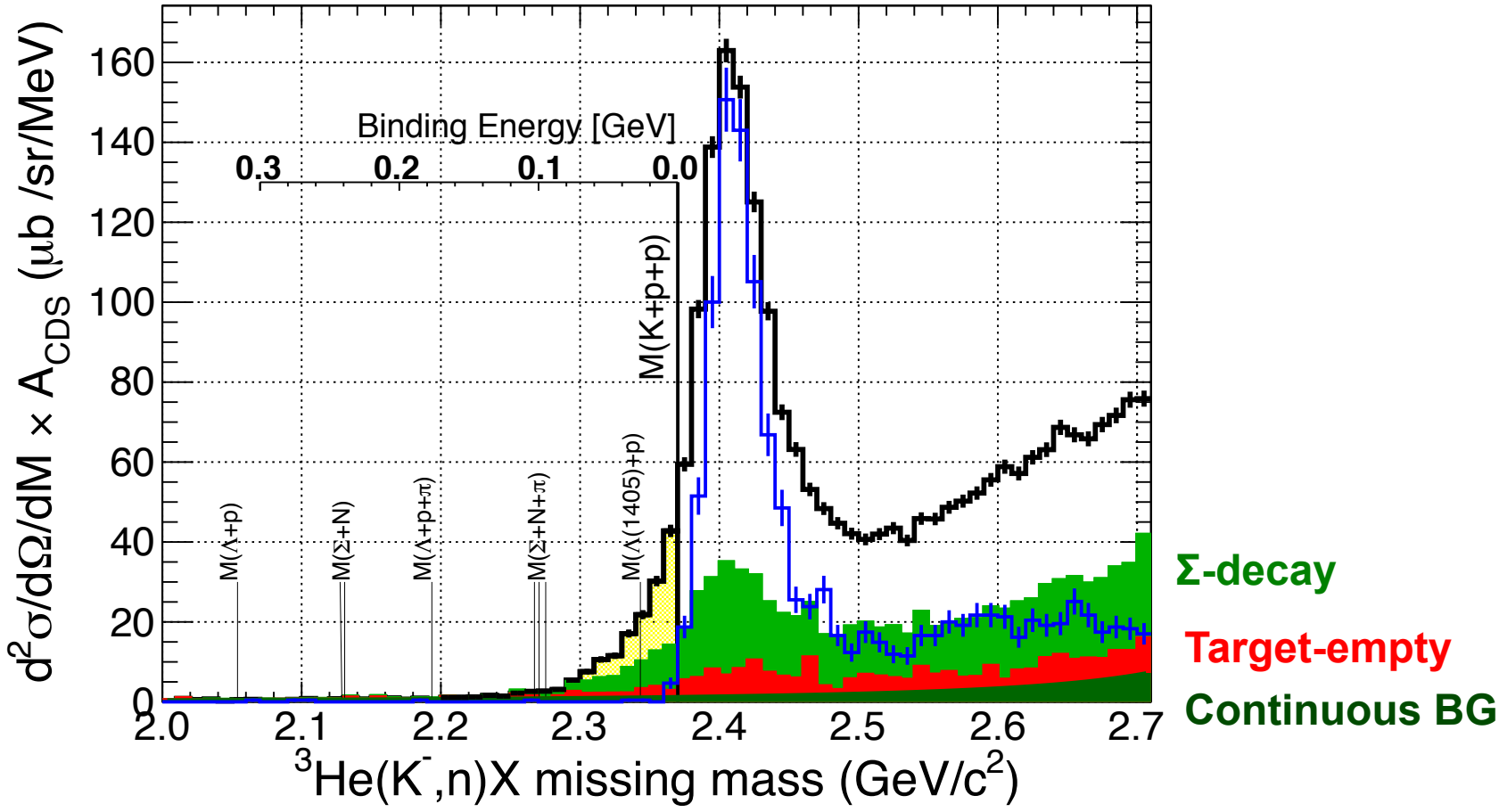
$$K^- + {}^3\mathrm{He} \rightarrow \Sigma^\pm + \pi^\mp + d_s$$
$$K^- + {}^3\mathrm{He} \rightarrow \Sigma^- + \pi^0 + p_s + p_s$$
$$\Sigma^\pm \rightarrow n + \pi^\pm,$$





- **Only KN→Σπ, Σ→nπ can contribute to the bound region**
  - **~90% can be removed event by event**
  - **KN→Λπ, Λ→nπ is not triggered**

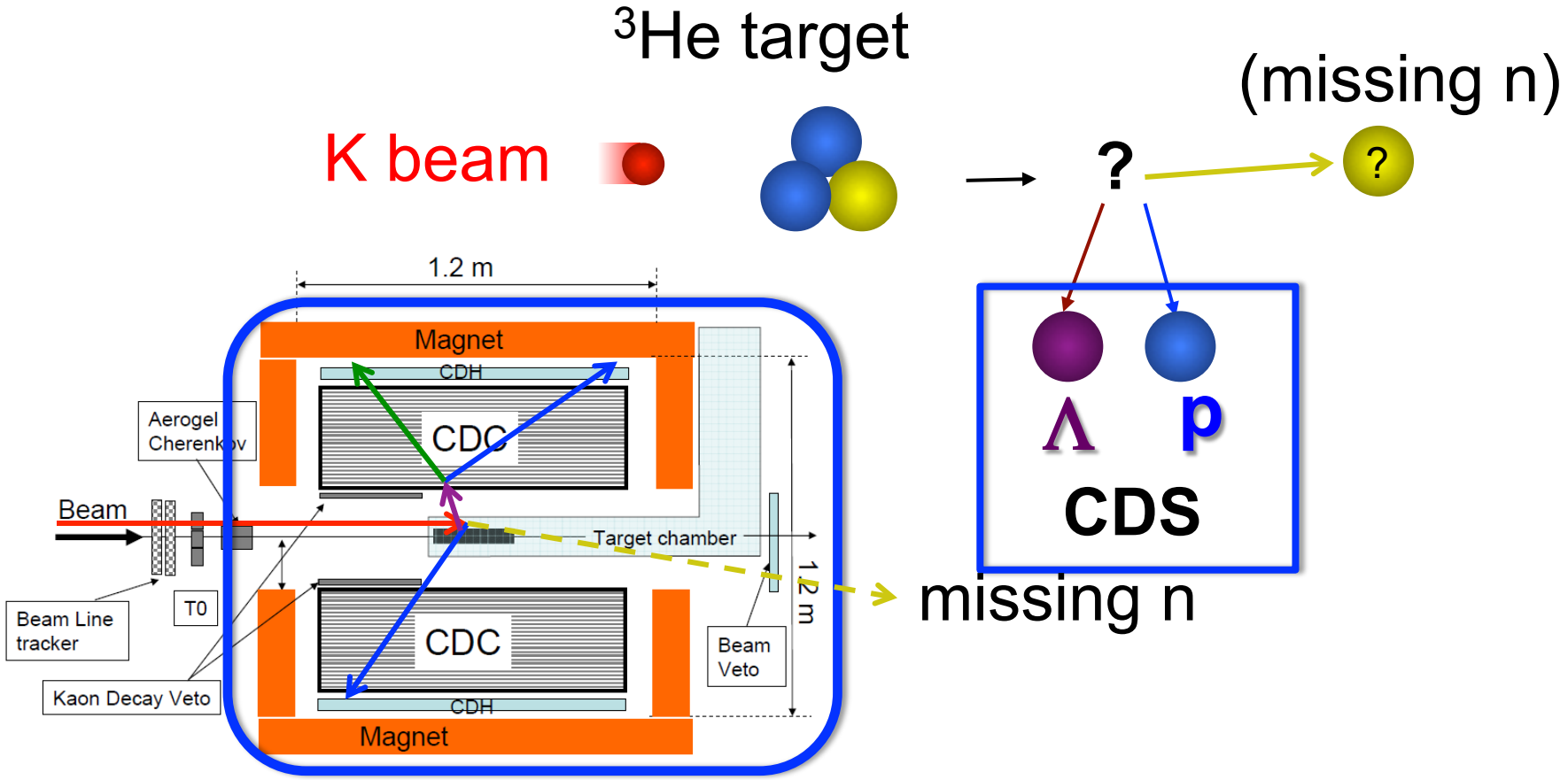
Unknown excess



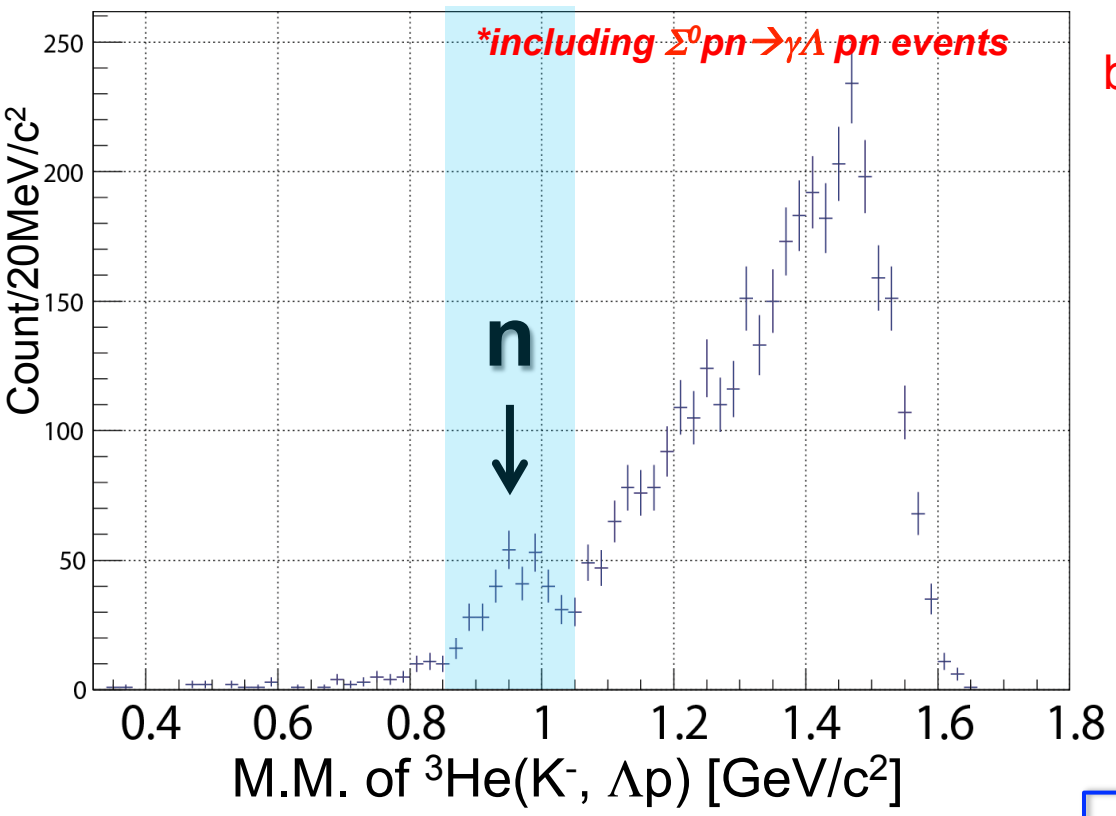
There remains a statistically significant excess.

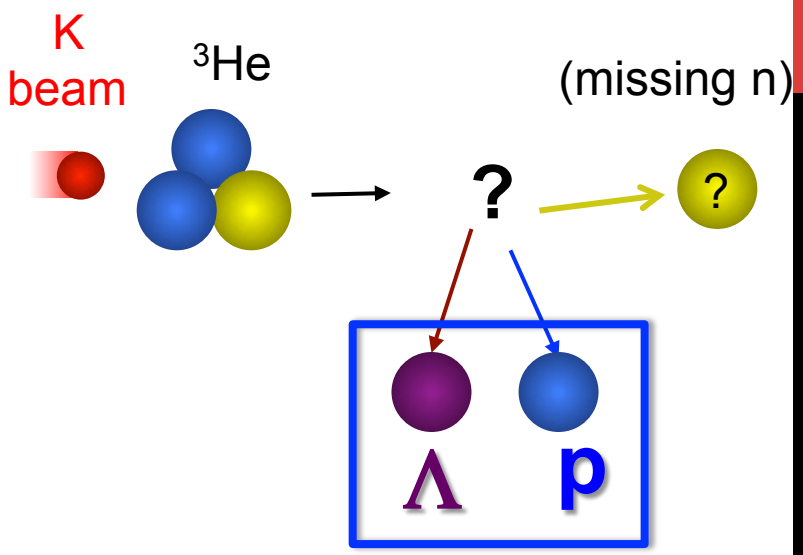
Exclusive Spectrum

- $^{3}He(K^{-}, \Lambda p)$ missing mass
- Λp"n" energy correlation diagram



^{3}He(K$^-$, Λp) Missing Mass

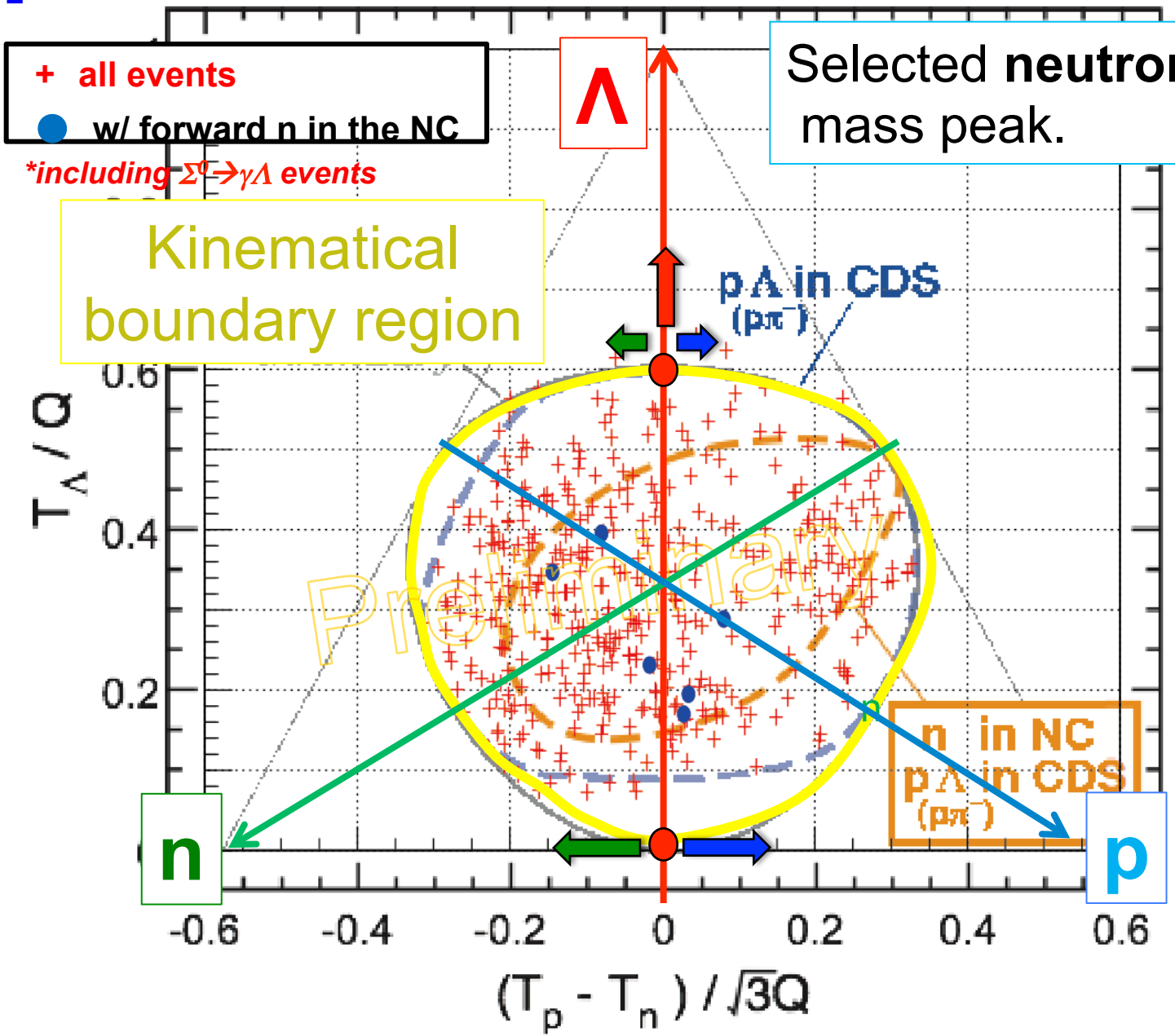




- **Missing neutron peak is clearly seen.**
- **This include Σ^0(γΛ)pn.**

To study origin of Λpn events.
Next, check energy correlation.

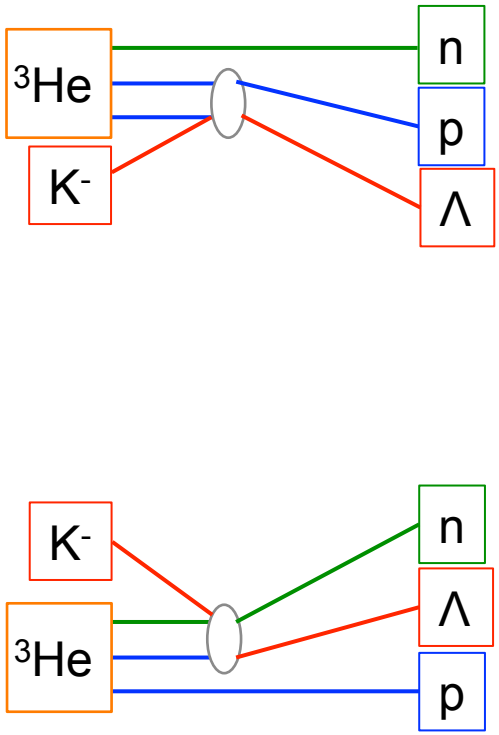
Λ p missing "n" correlation



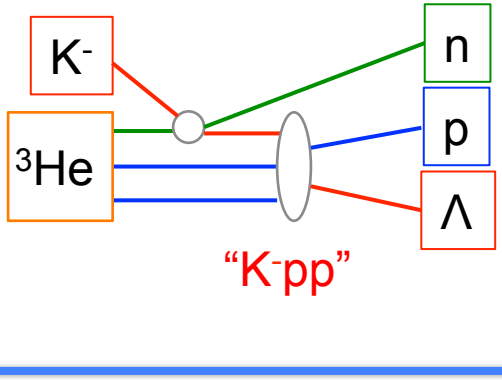
Selected **neutron missing** mass peak.

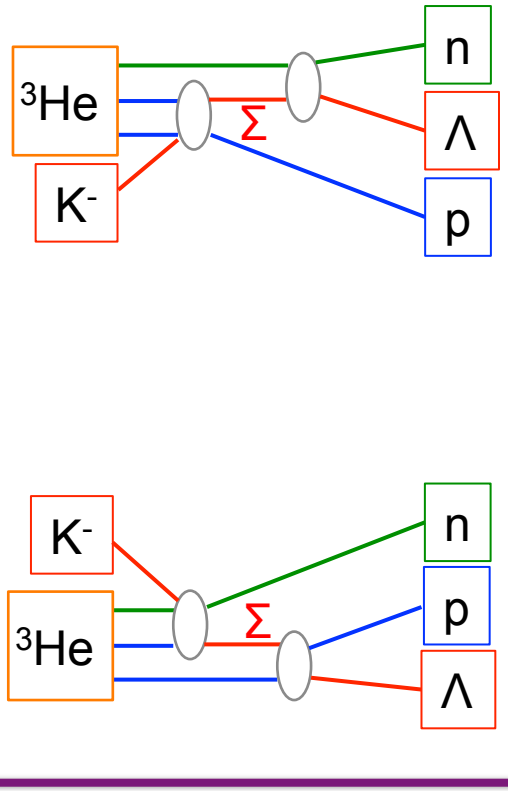
Σ-Λ conversion (2 step)

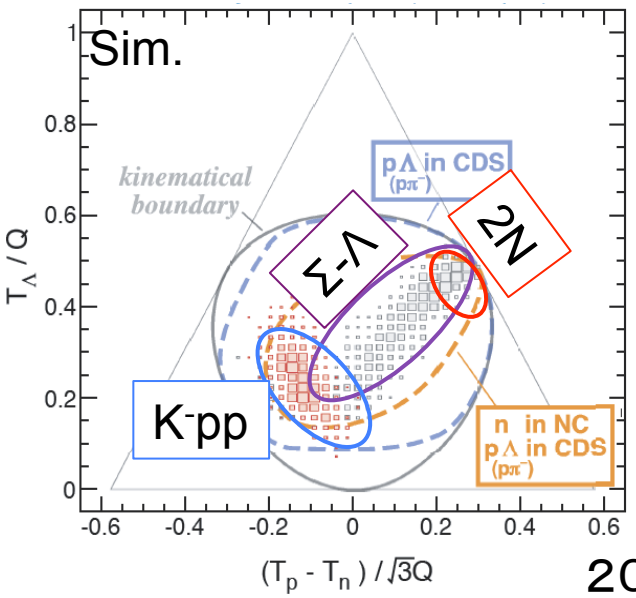
2N-abs



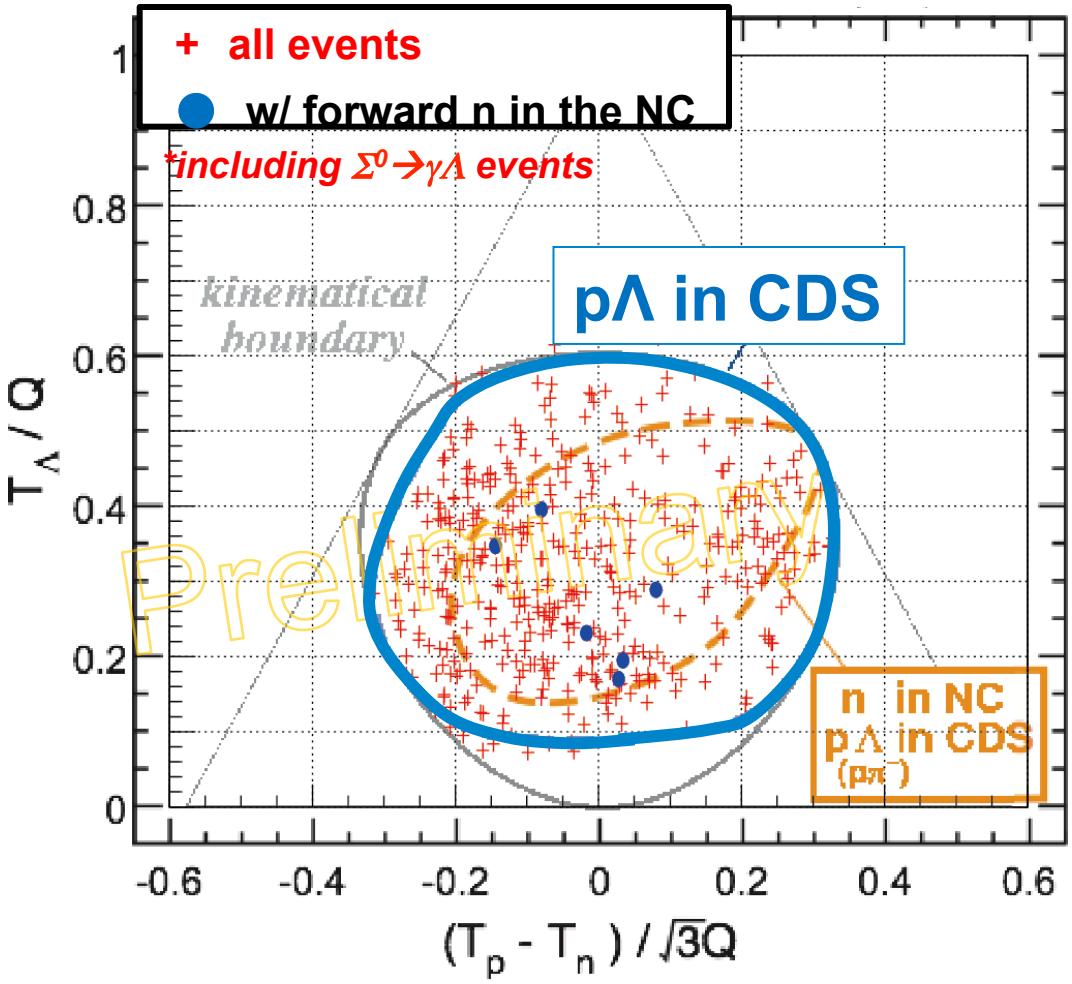
K$^-$pp







Λ p missing "n" correlation

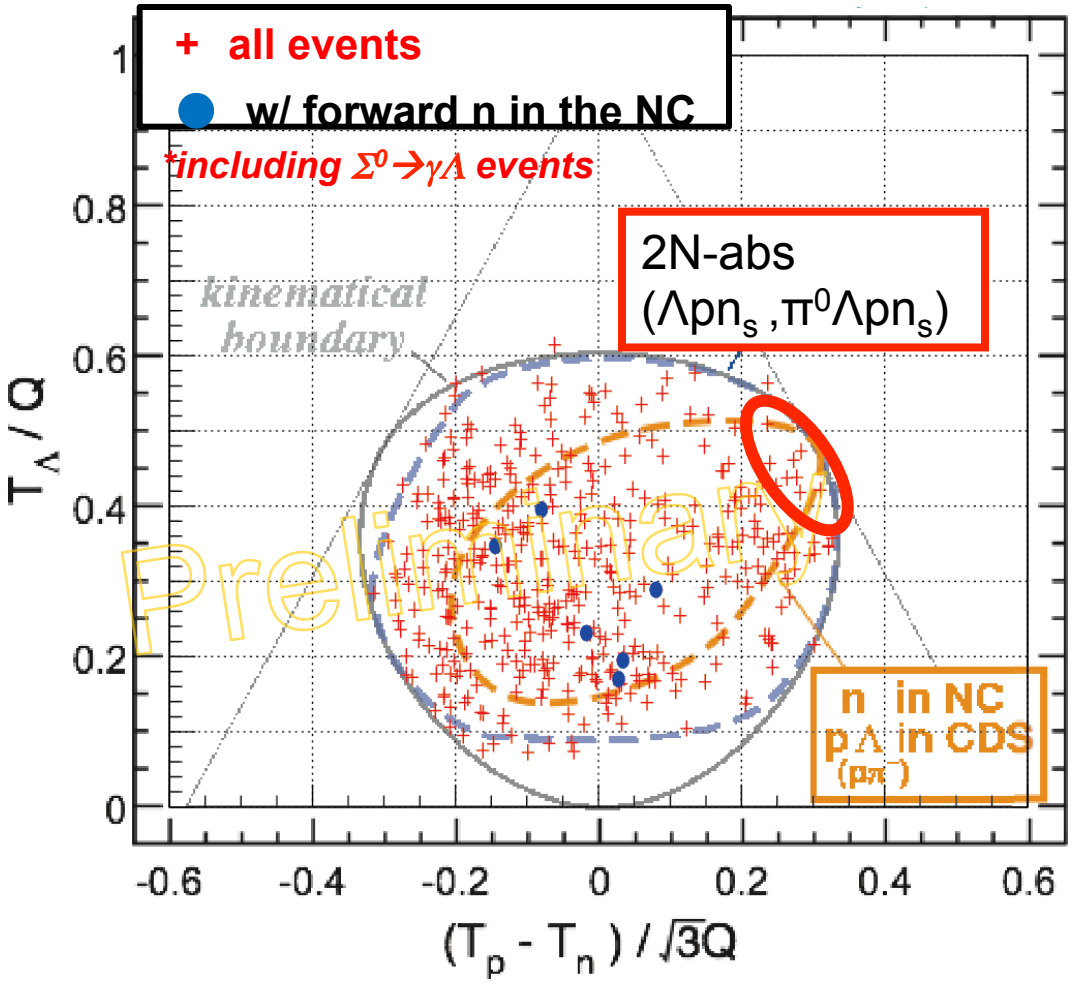


Selected **neutron missing** mass peak.

- Events are scattered widely in phase space.
- Multi-N absorption processes exist.

☑ **It seems 3N-abs(Λpn) exists**

Λ p missing "n" correlation



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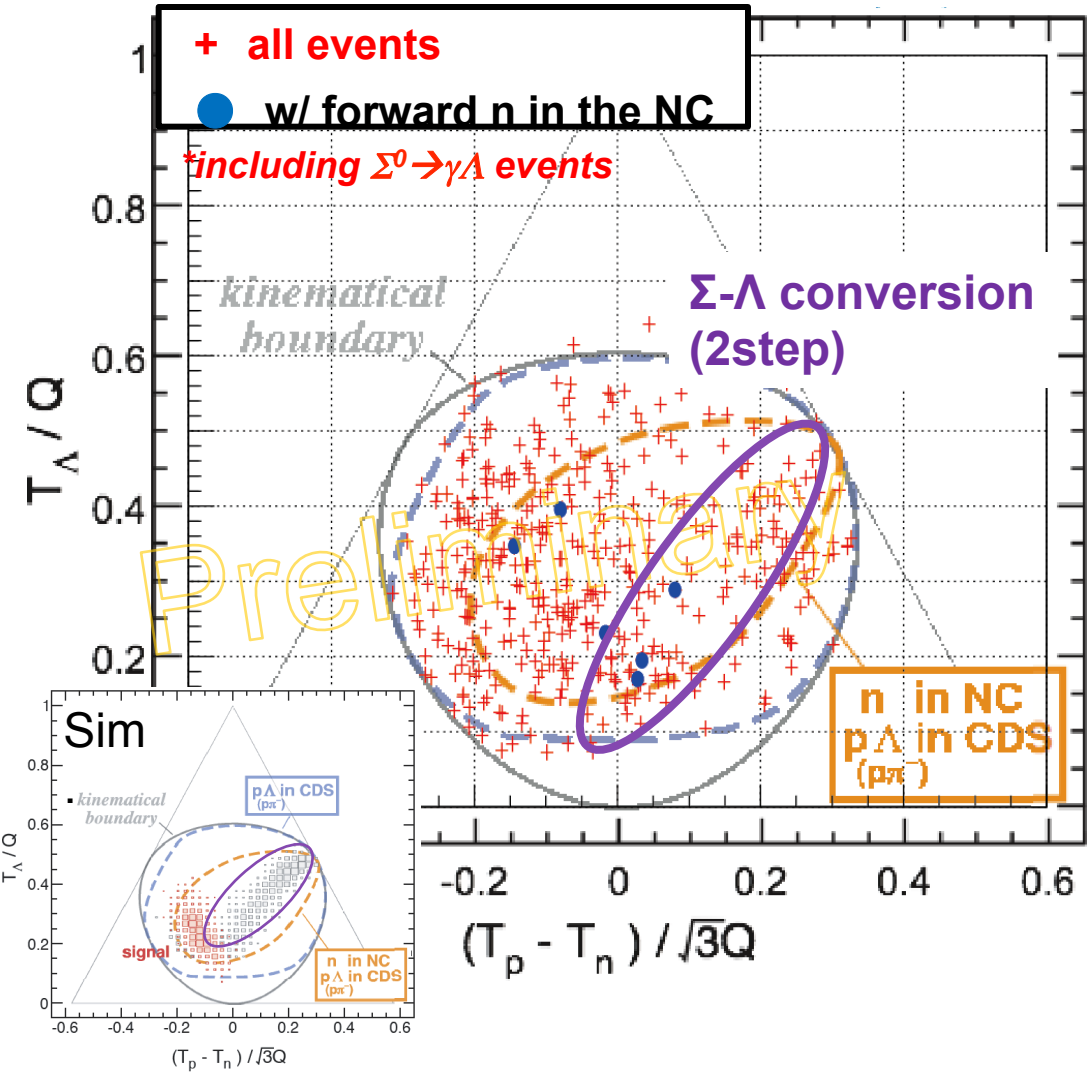
☑**2N-abs is very weak.**

- **"Λpn" w/ forward n in the NC are a few events.**

☑We would like to carry out high statistical experiments !

Λ p missing "n" correlation



Selected **neutron missing** mass peak.

- Events are scattered widely in phase space.
- Multi-N absorption processes exist.

☑ It seems 3N-abs(Λpn) exists

☑ 2N-abs is almost nothing.

☑ **can not see Σ-Λ conversion line?**

- **"Λpn" w/ forward n in the NC is a few events.**

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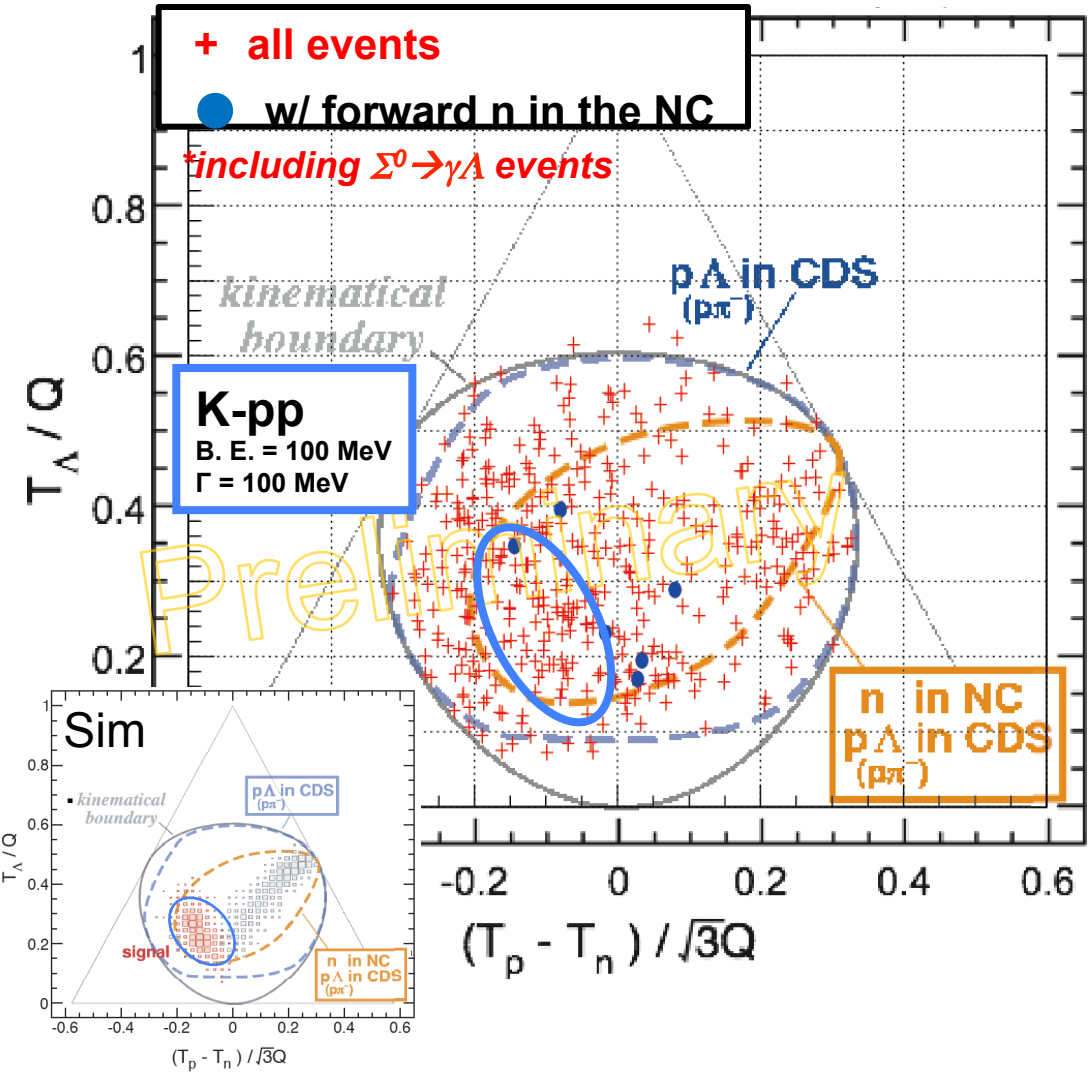
Λ p missing "n" correlation



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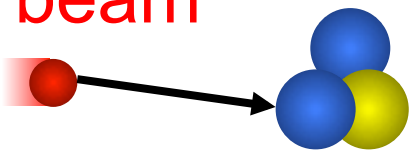
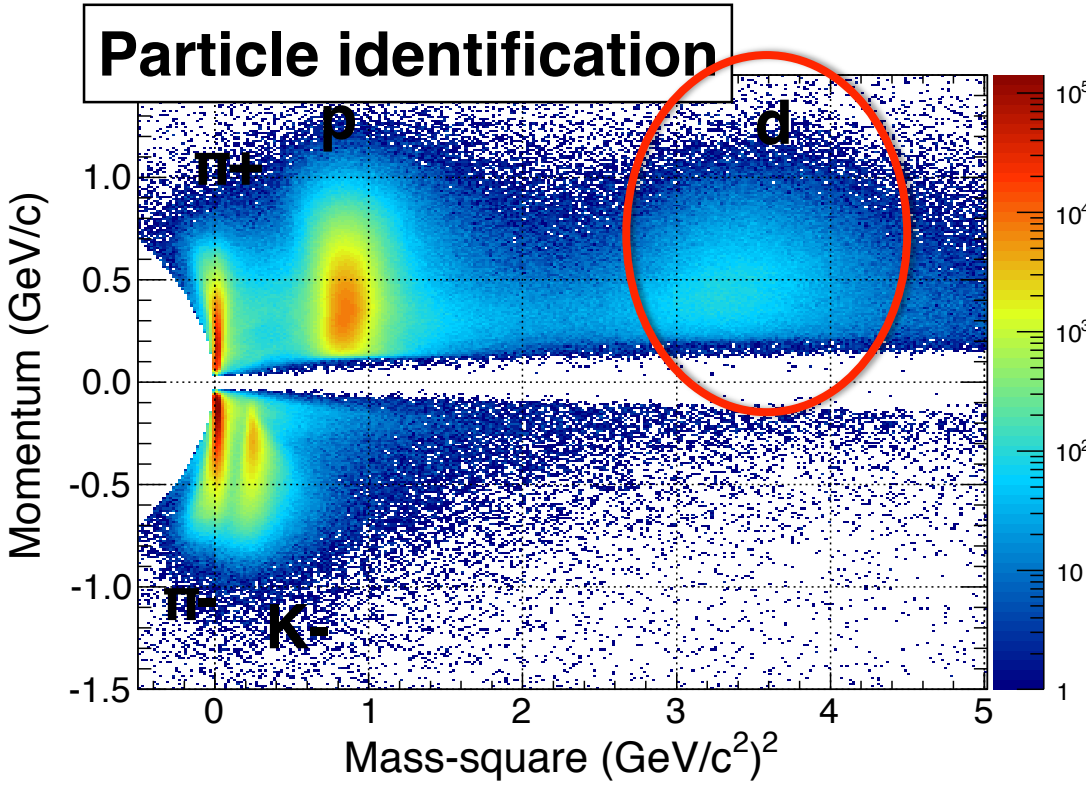
^{3}He(K$^-$, d) Spectrum

- ^{3}He(K$^-$, d) missing mass spectrum
- ^{3}He(K$^-$, d K$^-$) missing mass spectrum
- ^{3}He(K$^-$, d) missing mass tagged K$^-$ “p”

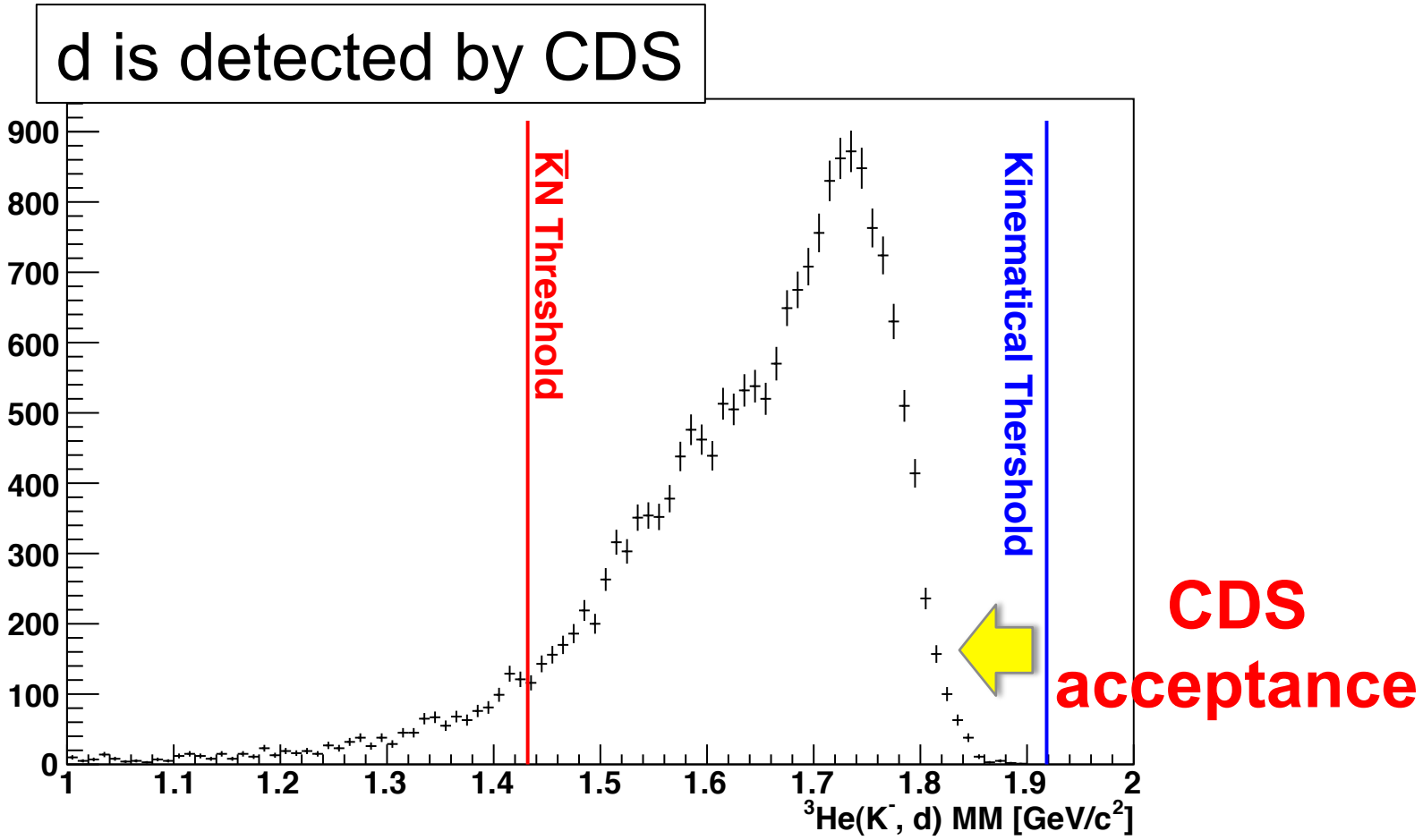
K beam



Elastic scatter?
Hyperon?
3N-absorption?



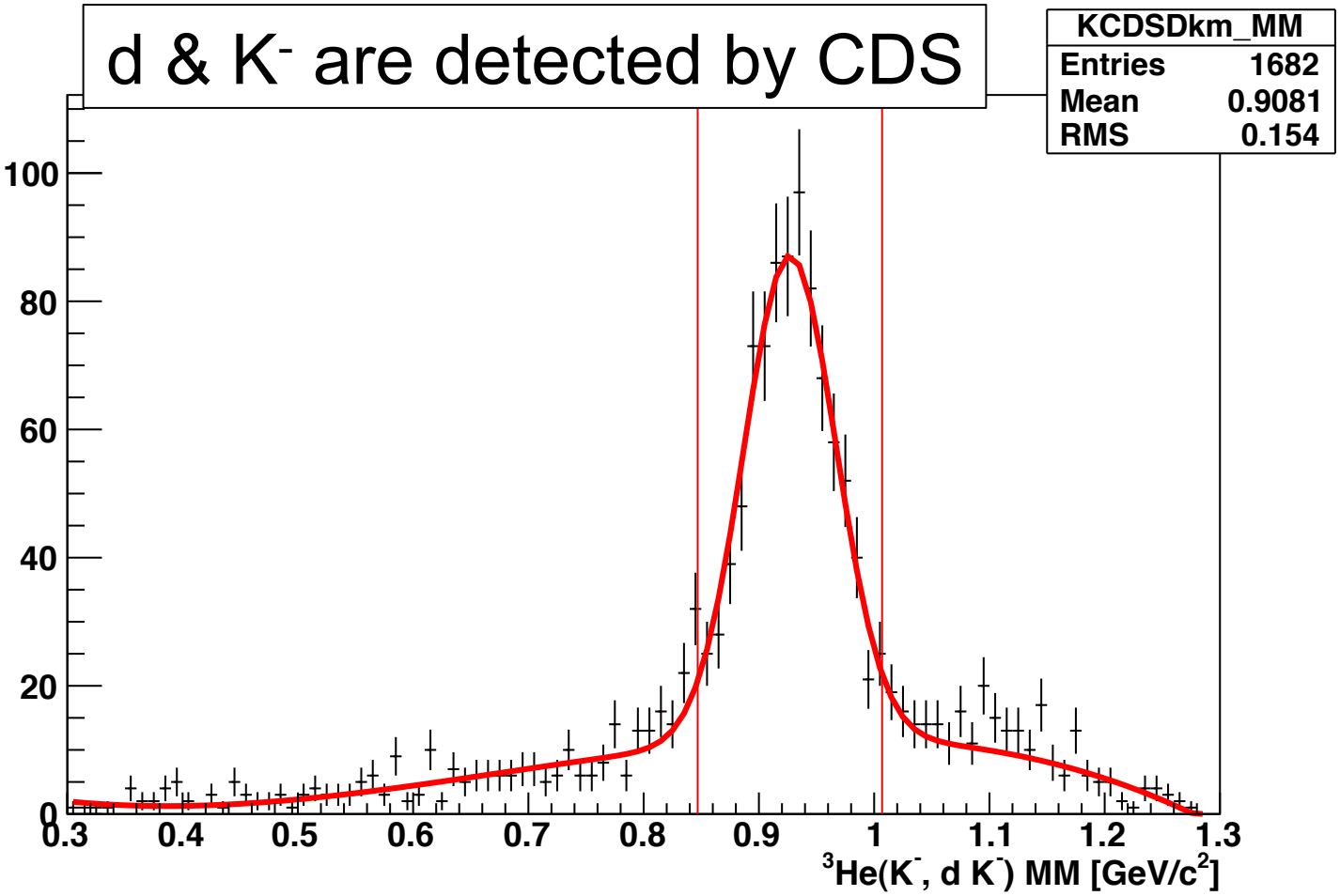
^{3}He(K$^-$, d) missing mass spectrum



^{3}He(K$^-$, d) spectrum is widely spared.

This spectrum is hard to explain by elastic scatter

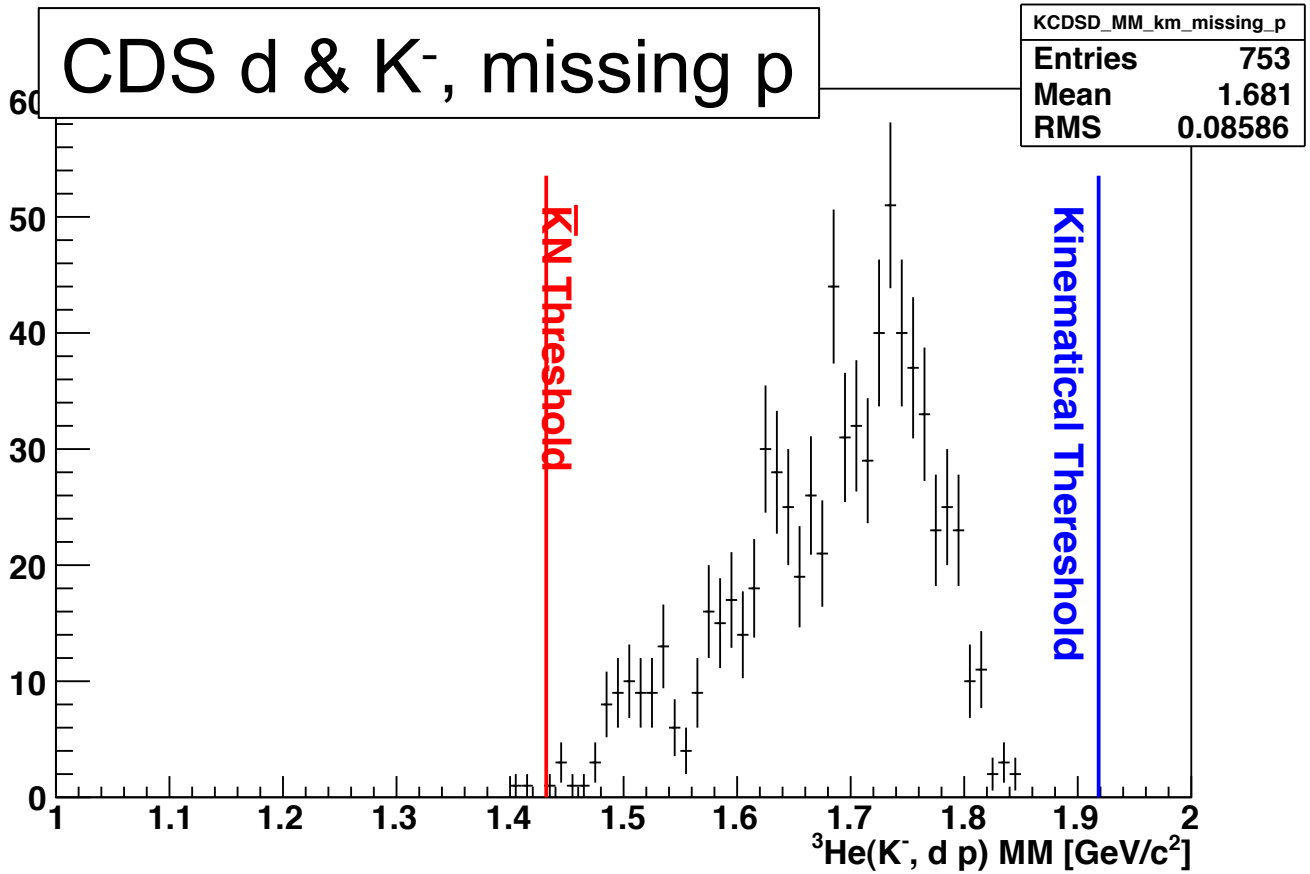
^{3}He(K$^-$, d K$^-$) missing mass



^{3}He(K$^-$, d K$^-$) MM is clearly seen **missing proton**.

K$^-$+^{3}He→d+K$^-$+"p" has low BG

^{3}He(K$^-$, d) missing mass w K$^-$ “p”



^{3}He(K$^-$,d) spectrum don’t change by K$^-$ “p” tag.

K$^-$ is absorbed in ^{3}He, decay into d K$^-$ p.

- directly? via Y*? Analysis is in progress.

This channel is very interesting.

Summary

- **J-PARC E15 1st physics run was performed.**
  All detectors are working well and design values.
  Unfortunately, stopped at only 24kW*4day running time
  (<1% of full proposal)

- **Semi-inclusive ^{3}He(K^{-}, n) spectrum has an yield excess below the K-pp threshold.**

- **Λp missing n analysis indicate existence of 3-N absorption process**

- **^{3}He+K^{-}→d+K^{-}+p channel is clearly seen.**
  →The spectrum suggests 3-N kaon absorption.

Thanks your attention!