Experimental search for K^-pp deeply bound state via in-flight $^3\mathrm{He}\,(K^-, n)$ reaction at J-PARC K1.8BR

Shingo Kawasaki for the J-PARC E15 collaboration

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J-PARC E15 collaboration

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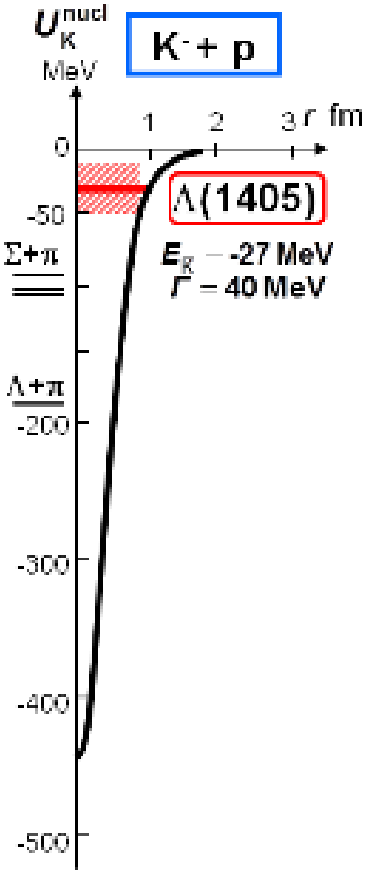
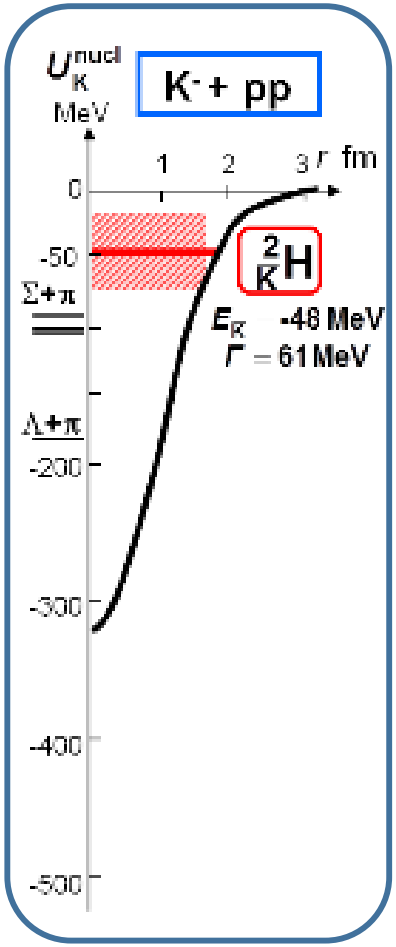
K-pp deeply bound state

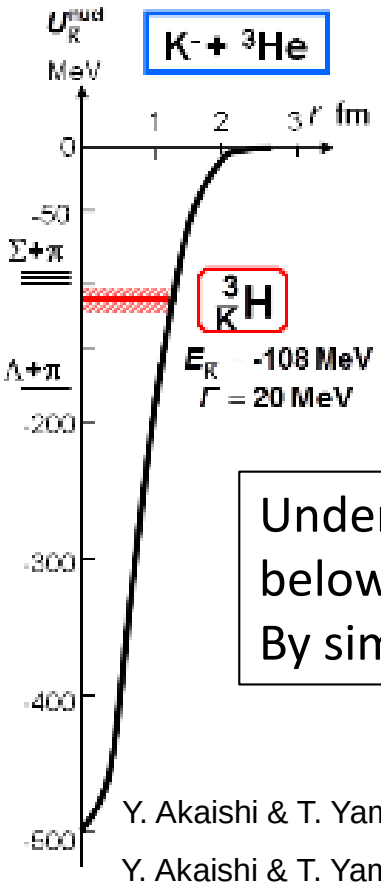
- $\bar{K}$N interaction of I=0 shows strongly attractive.

  Based on the data of experiment of X ray from Kaonic atom

  →Kaon deeply bound to nucleus ?





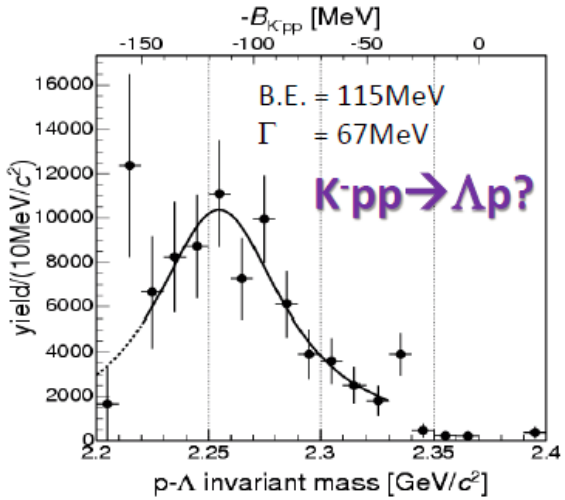


Understand KbarN interaction below the threshold
By simple K-pp bound system

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

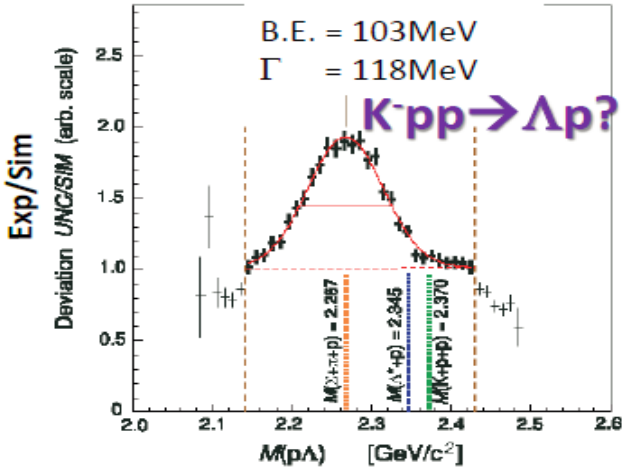
Y. Akaishi & T. Yamazaki, Phys. Lett. B535 (2002) 70.

Experimental suggestion of K-pp



FINUDA@DAΦNE

A(*stopped* K-, Λp)



DISTO@SATURNE

p + p → (Λ + p) + K+

Possible contiribution

2NA + Σ → γΛ

2NA + ΣN-ΛN conversion

p+p → p+N*

N* → $K^+\Lambda$

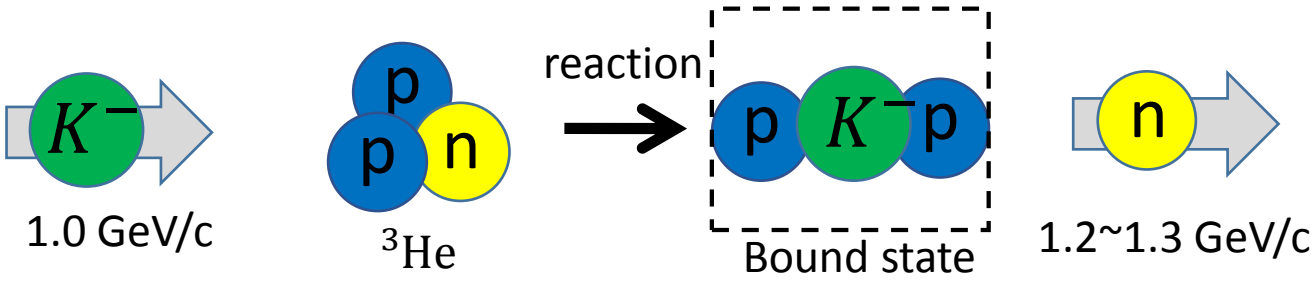
Theoretical calculation suggest various B.E and Γ

due to lack of information on KbarN int. below KbarN threshold

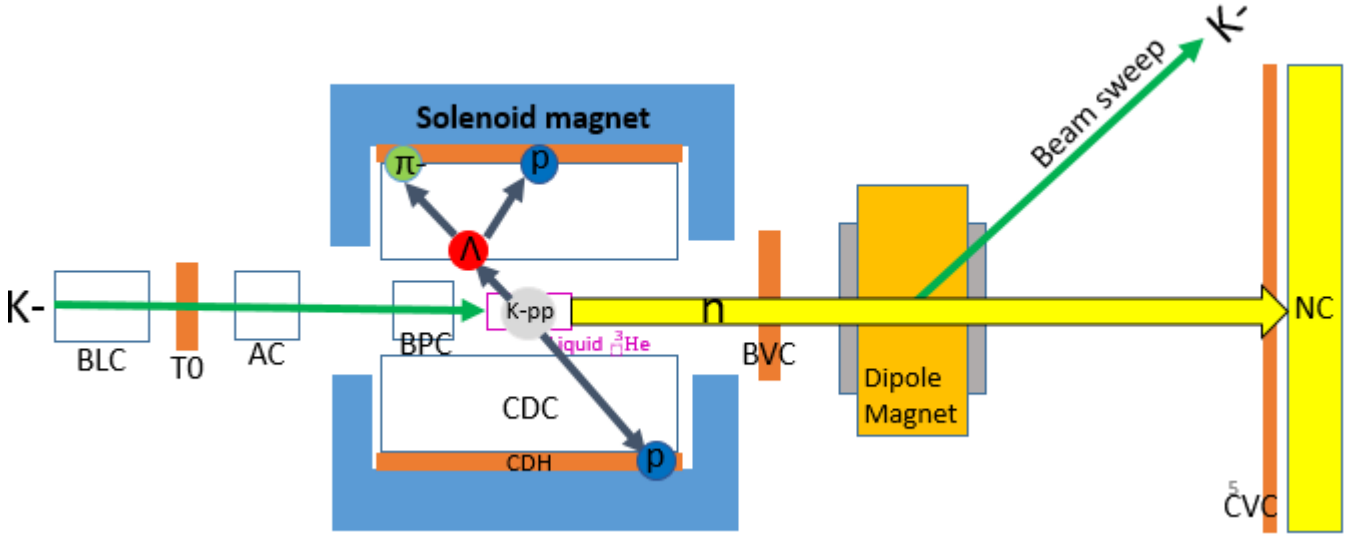
→ Experimental information of K-pp is necessary

K^-pp measurement via $^3\mathrm{He}\,(K^-, n)$

E15 experiment @ J-PARC K1.8BR

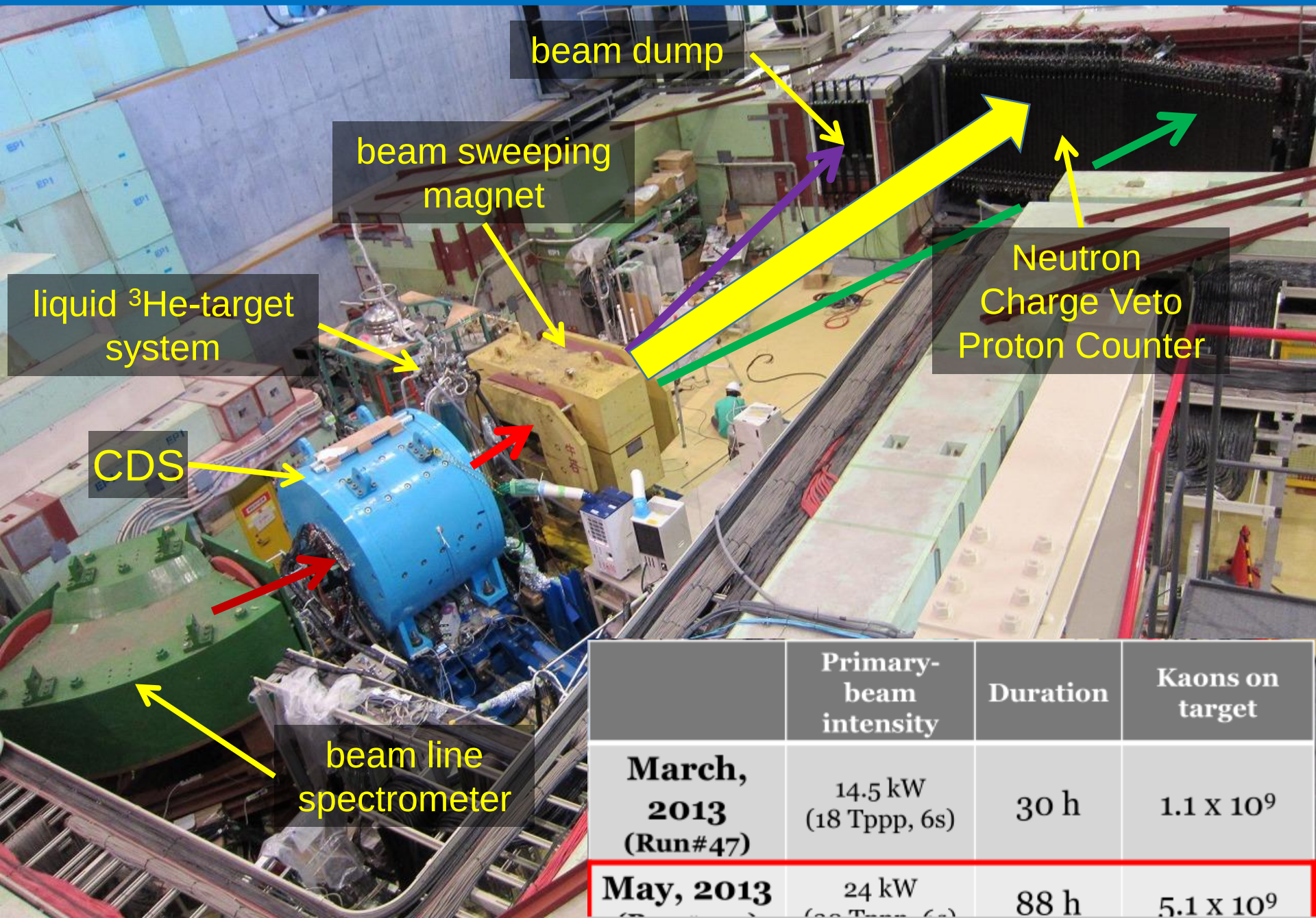


by forward scattered neutron



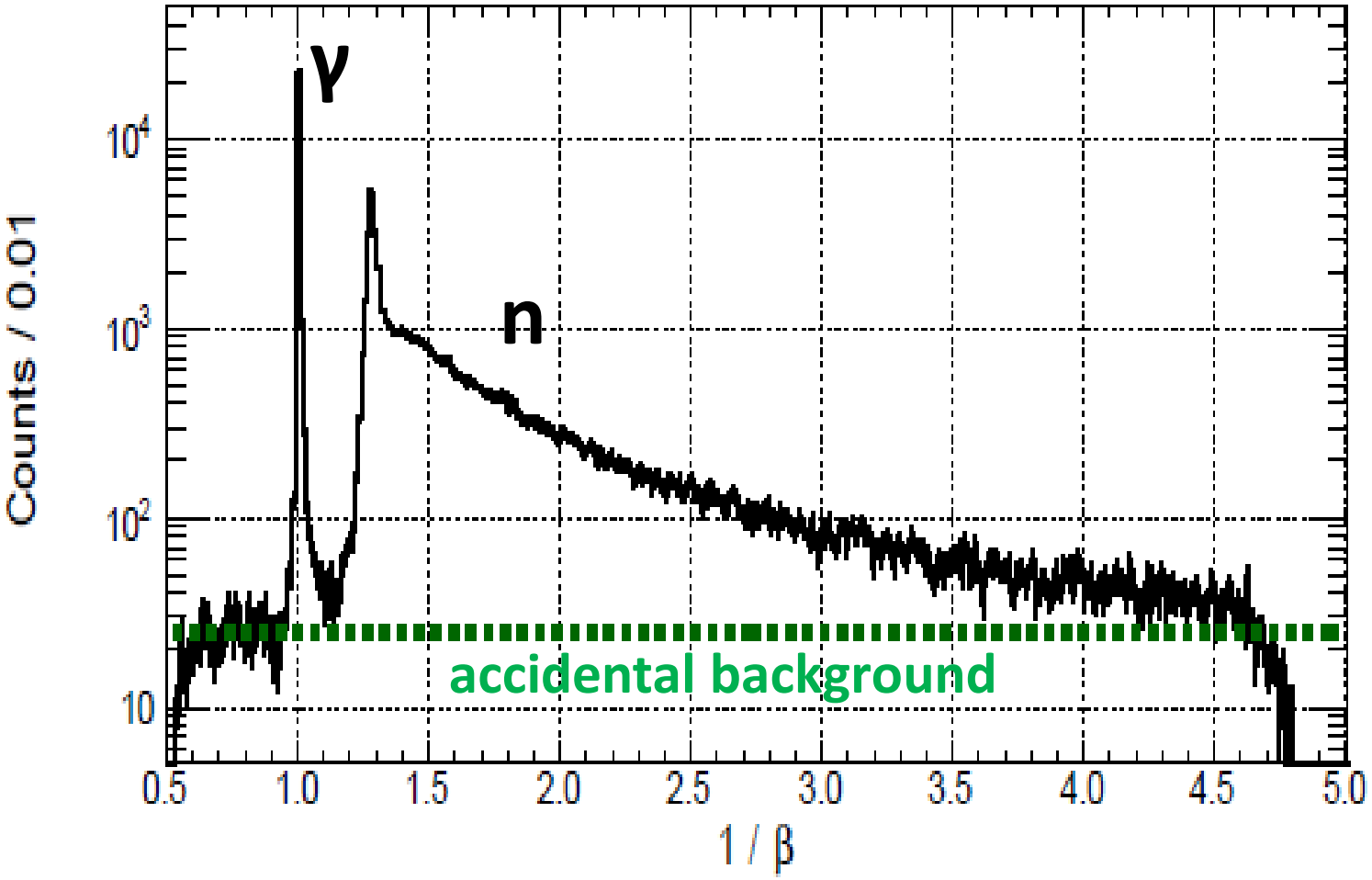
- Measurement of the formation by missing mass $^3\mathrm{He}\,(K^-, n)$X
- Λp final state is obtained exclusively

K1.8BR spectrometer [Jun. 2012]



	Primary-beam intensity	Duration	Kaons on target
March, 2013 (Run#47)	14.5 kW (18 Tppp, 6s)	30 h	1.1×10^9
May, 2013	24 kW	88 h	5.1×10^9

Neutron spectrum measured by NC

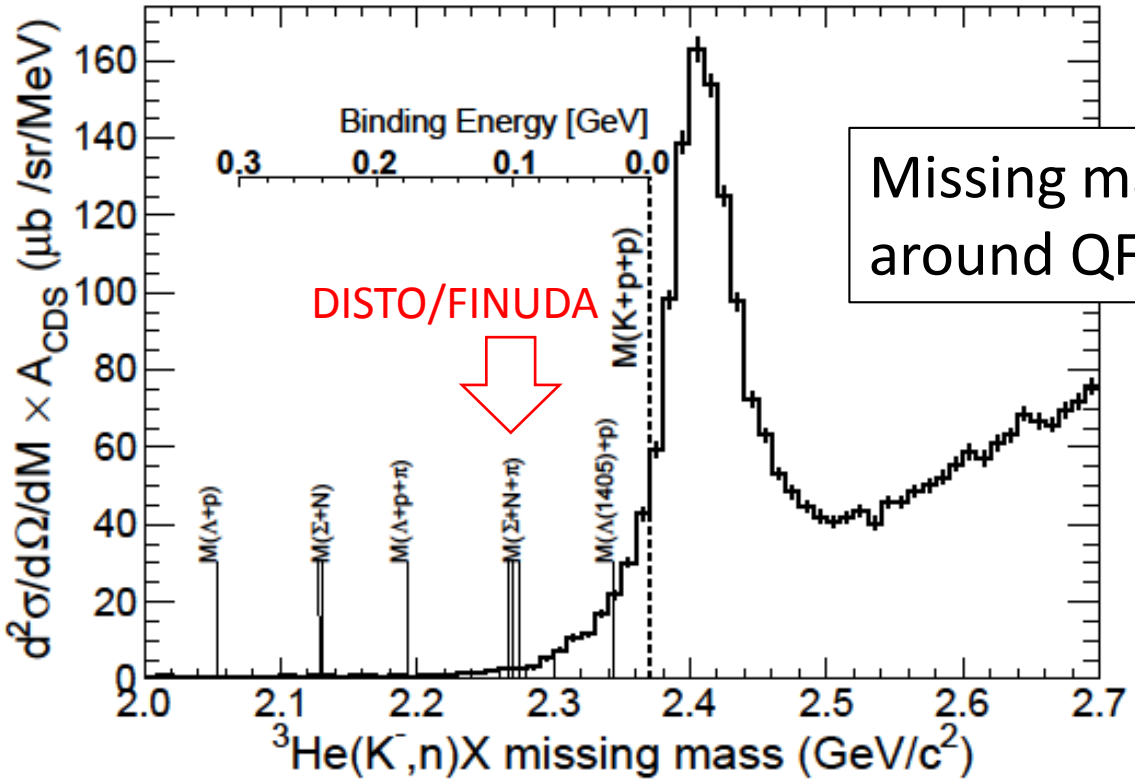


S/N ratio ~100@Quasi-free peak

Time resolution ~160 ps@γ peak

Semi-inclusive study of $^3He(K^-, n)$

$^3He(K^-, n)X$ missing mass

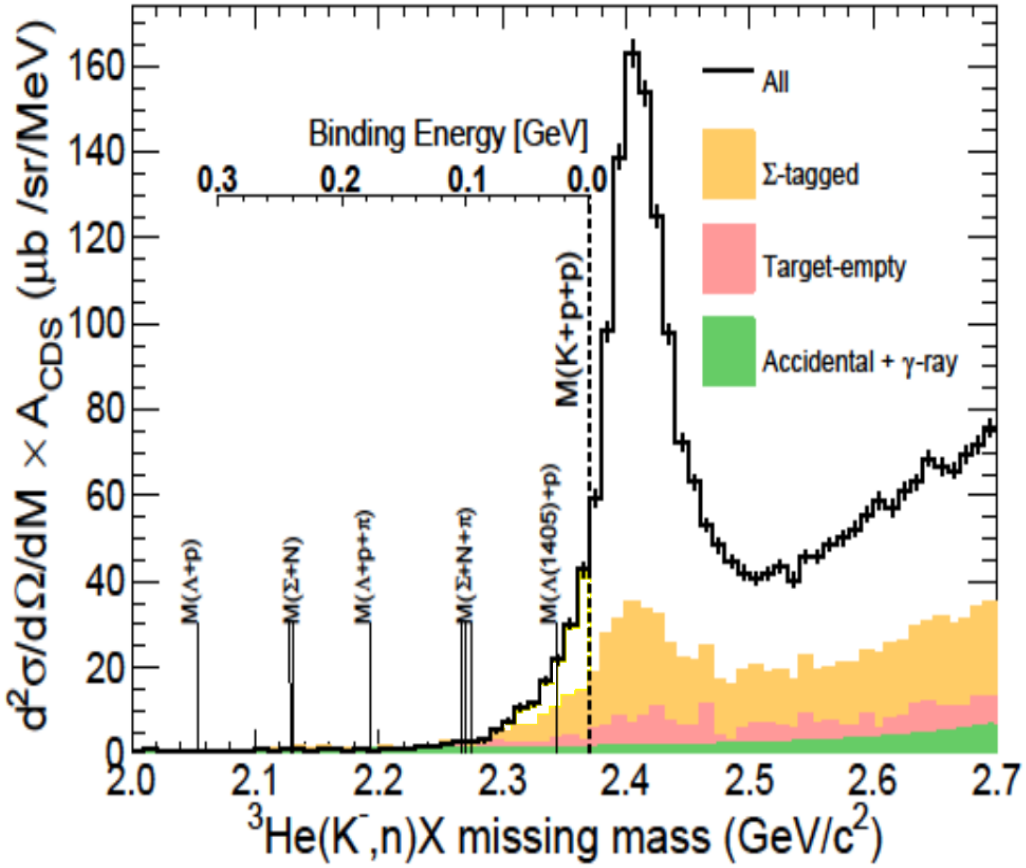


Missing mass resolution around QF peak ~10MeV/c^2

- The QF peak around 2.4 GeV/c^2 can be seen.
- Clear peak structure does not appear in the deeply bound region.

Kaon reaction with single-nucleon

Contamination of elementary Σ process in below the threshold $\overline{K}NN$



reconstruction $\Sigma^{\pm} \rightarrow \pi^{\pm}\mathrm{n}$

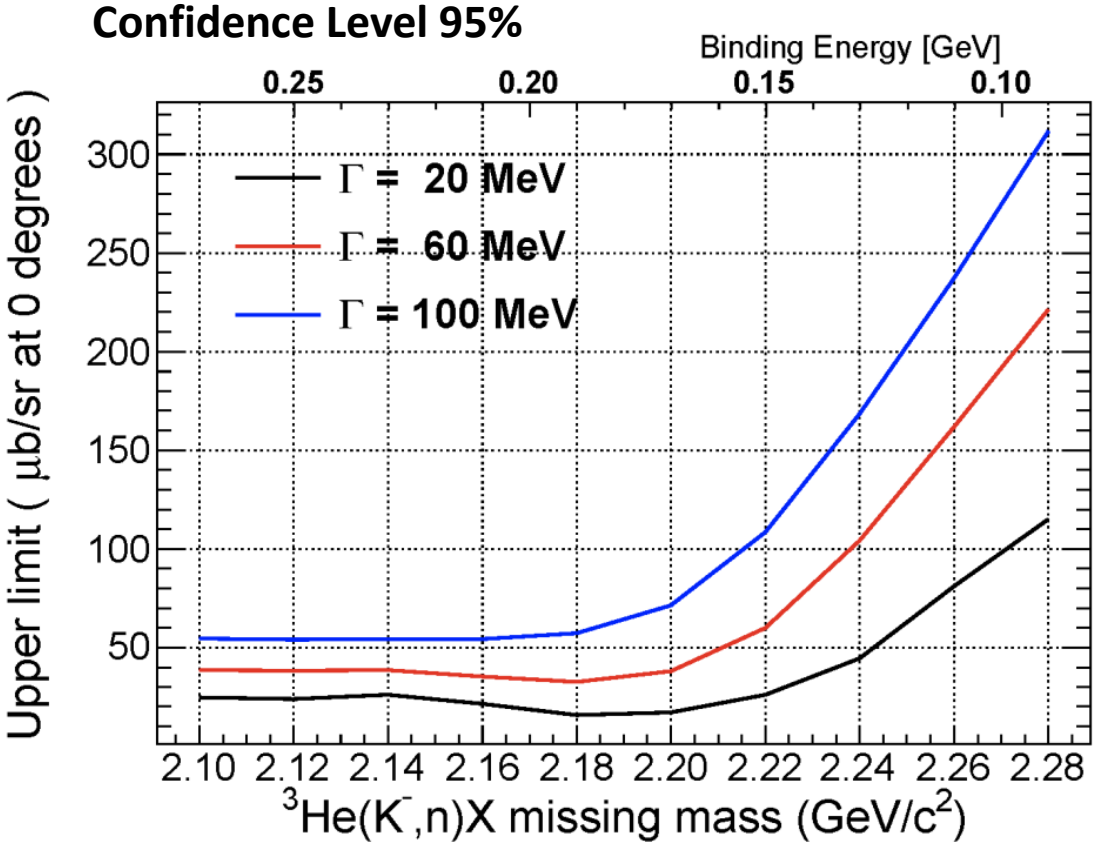
$K^- N \rightarrow \pi\Sigma^{\pm}$

$\Sigma^{\pm} \rightarrow \pi^{\pm} n_{Forward}$

reconstruction efficiency ~90%

- Σ contributions and background are estimated.

Upper limit of K-pp→Λp cross section for a deeply bound region



(B.E, Γ)=(115, 67) MeV FINUDA
(B.E, Γ)=(103, 118)MeV DISTO

FINUDA ~200 μb/sr
DISTO ~300 μb/sr

K-pp

Shape: Breit-Wigner distribution

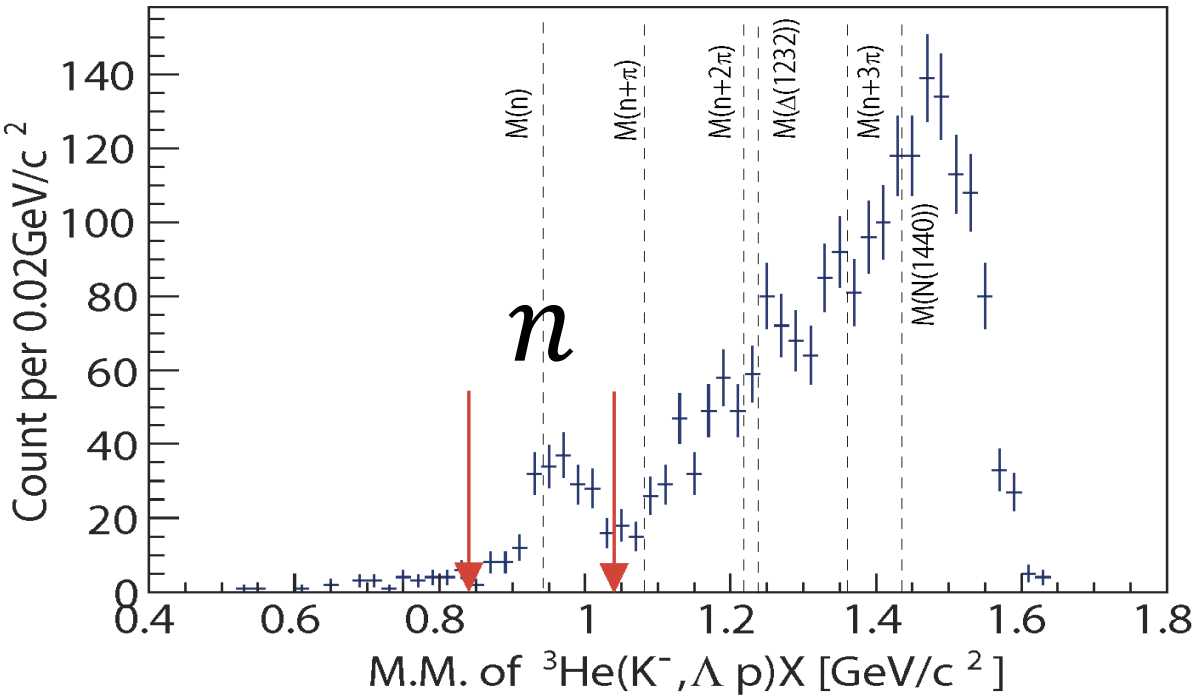
Decay: K-pp->Λp

- The Upper limit is much smaller than the cross section of quasi-elastic ~14 mb/sr

Exclusive $^3He(K^-, \Lambda p)n$

Search for K-pp→ Λp→pπ⁻p

$^3He(K^-, \Lambda p)X$ missing mass

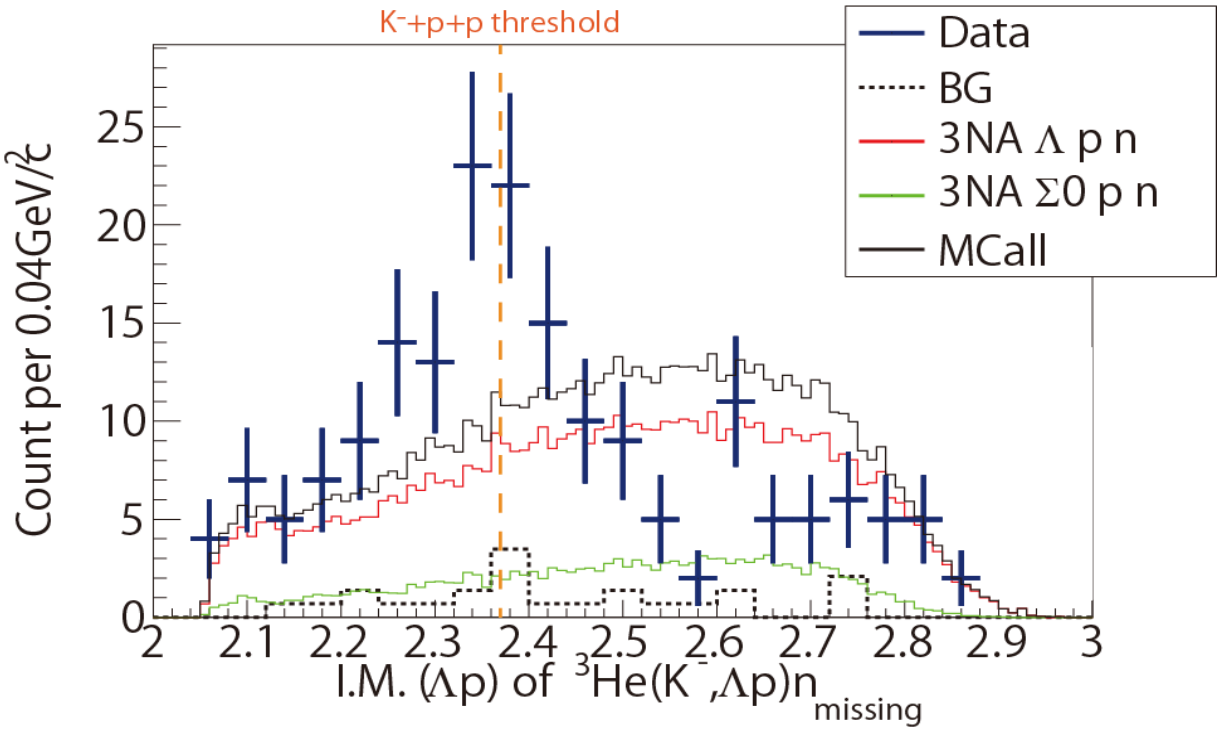


Missing neutron peak can be seen.

Λpn final state can be identified.

Invariant mass Λp

$^3He(K^-, \Lambda p)n$



- Simulated distribution from 3NA process is overlaid
- The shape cannot be explained by 3NA

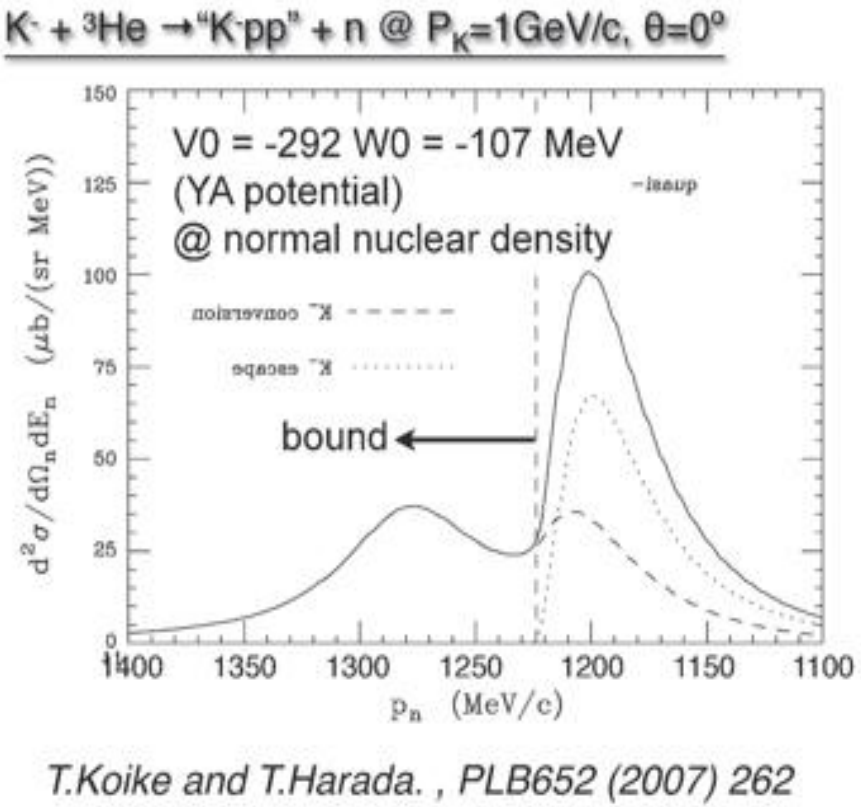
- Statistics are not enough → We require 2nd physics run 10 times as data as 1st

Summary

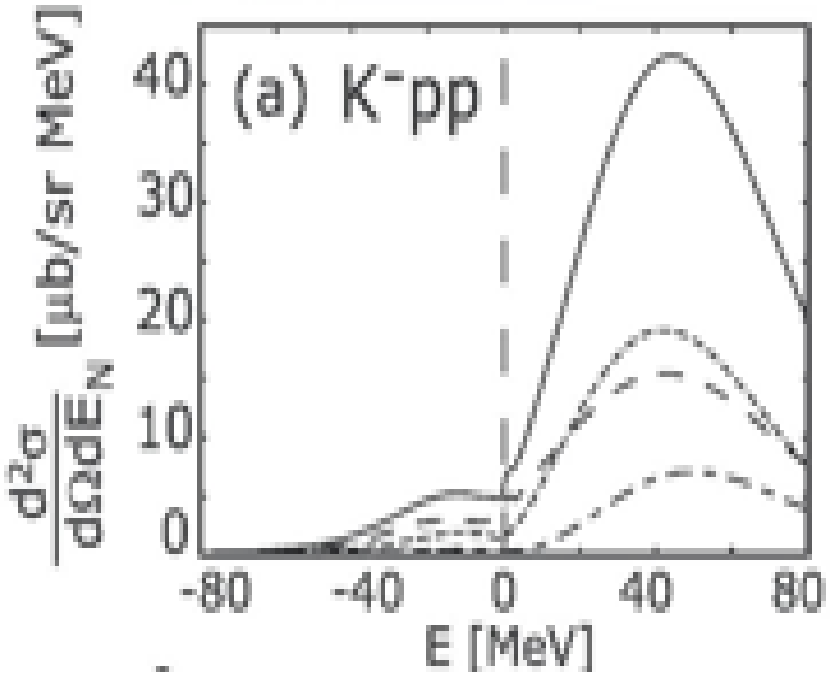
- The Preliminary result of the E15 1st physics run data is presented.
- Inclusive $^3He(K^-, n)$
  - No significant peak structure is observed in the deeply bound region.
    → Mass-dependent upper limit of K-pp->Λp cross section
  - The Upper limit is much smaller than σ(KN→KN) ~14 mb/sr
- Exclusive $^3He(K^-, \Lambda p)$n
  - Λp invariant mass spectrum is obtained.
  - The spectrum shape is hardly explained by 3NA.
- 2nd run will be allocated.
  - 10 times more data

Back Up

Comparison with theoretical calculation for around the threshold



T.Koike and T.Harada. , PLB652 (2007) 262



Cross section in all bound region ~mb/sr

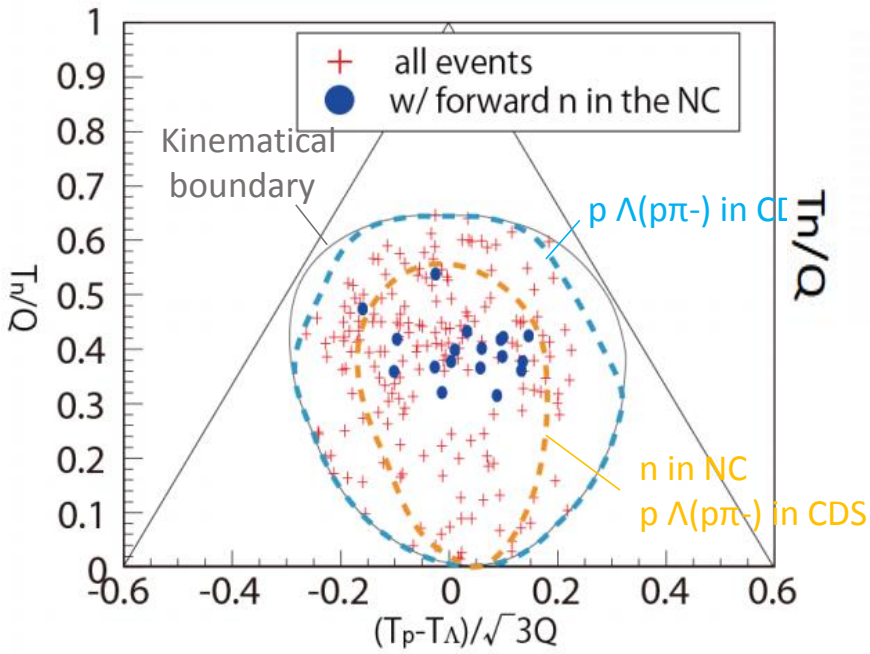
→ Similar to the all excess of the data

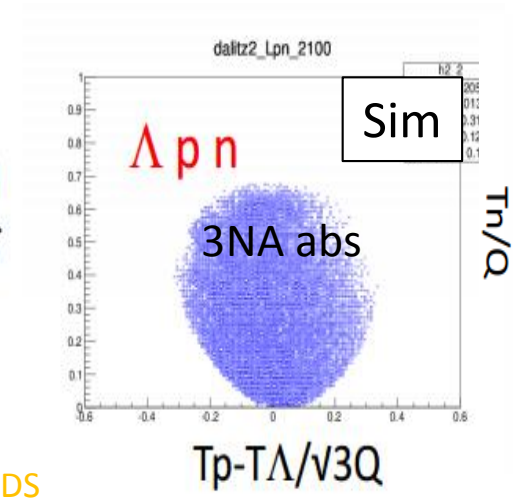
Cross section in the deeply bound region ~mb/sr

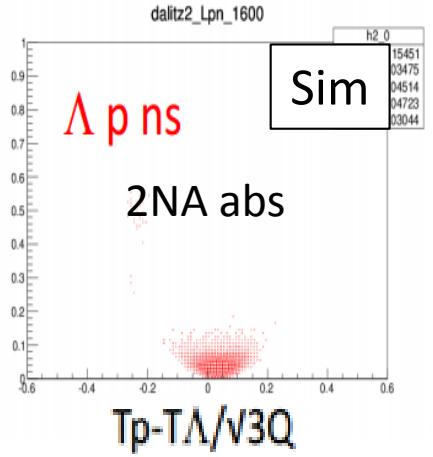
→ One order larger than upper limit

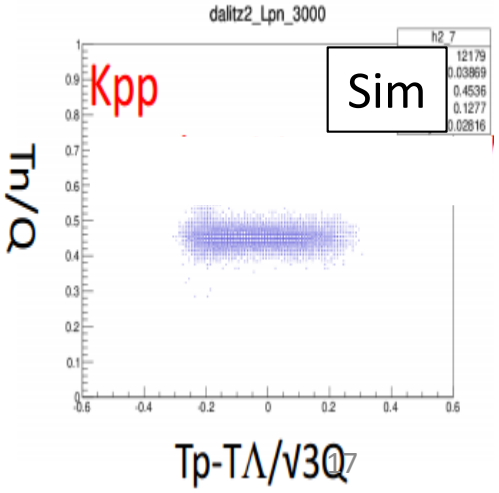
Search for K-pp in Λ+p+n final state

Dalitz plot





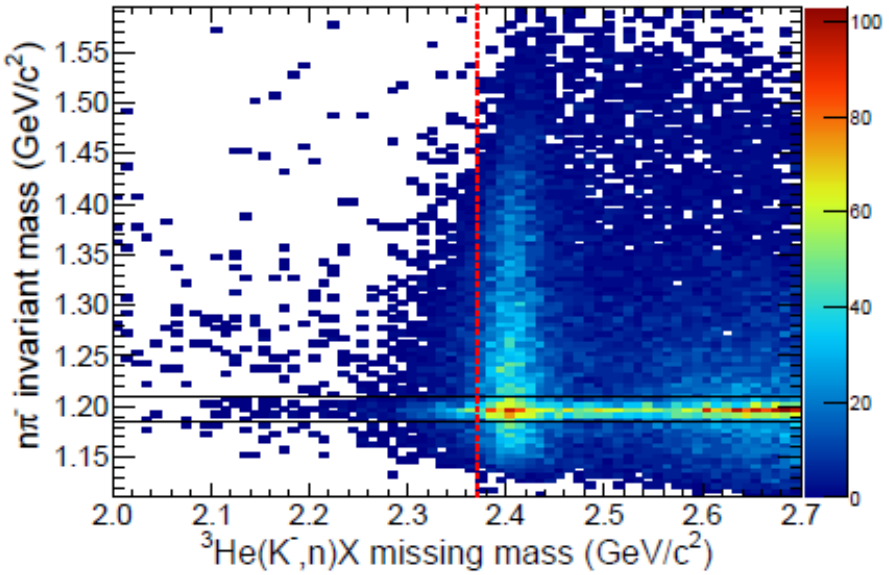




- Energy correlation in Dalit plot can separate K-pp and 2NA .
- The data plots seem scattered in allowed region almost uniformly.

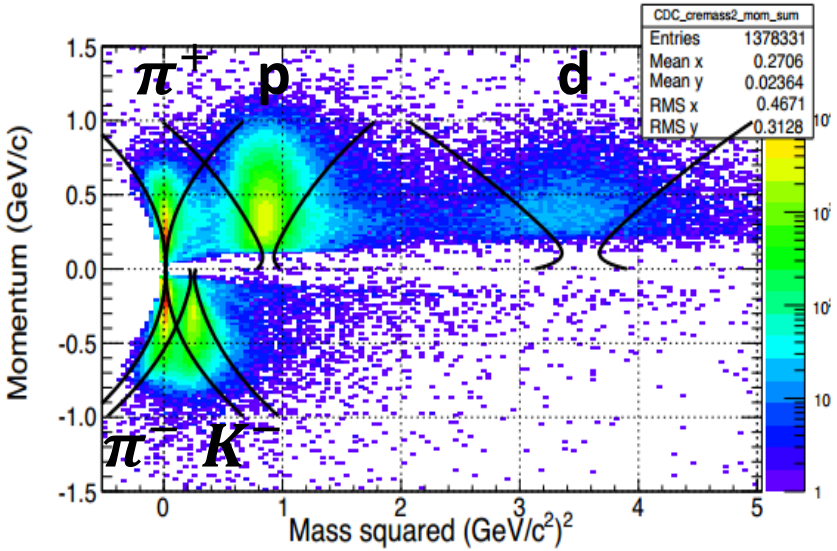
→3NA is dominant.

→2NA is hardly reflected

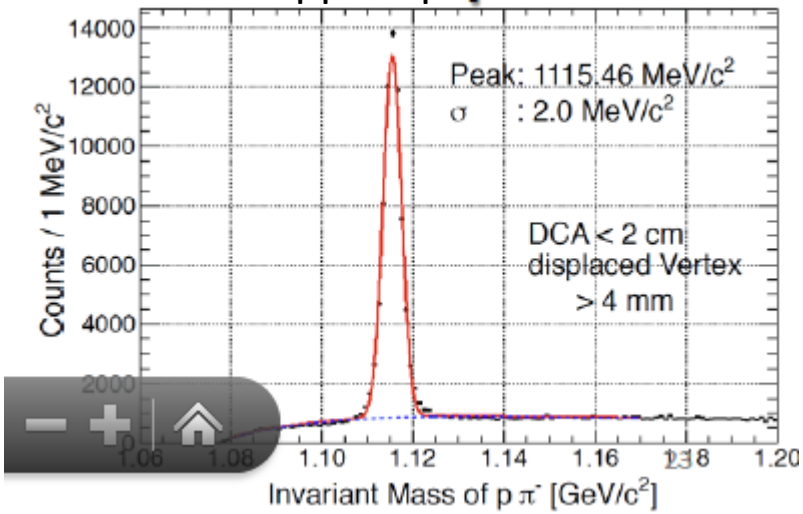


Cross section of K-pp → Λp, Σ^0p, $(\pi\Sigma)^0$p ~1mb/sr

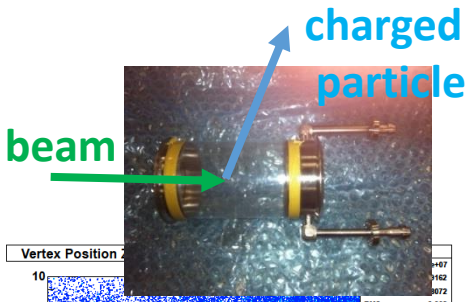
Decay charged particles Identification in CDS

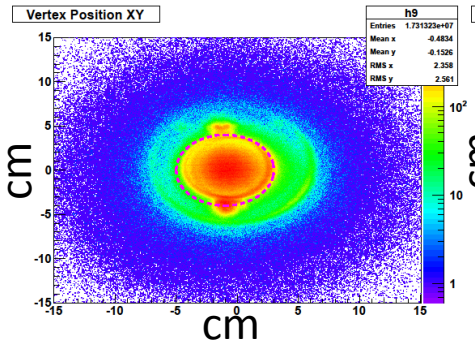


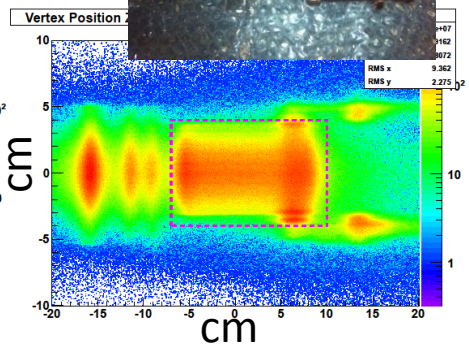
Reconstruction $\Lambda \rightarrow p\pi^-$ for K-pp→**Λ**p



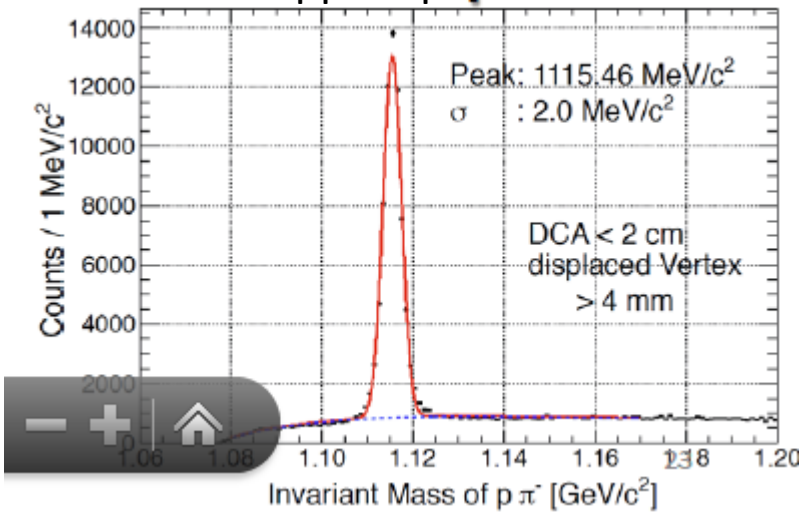
Target Image







Reconstruction $\Lambda \rightarrow p\pi^-$
for K-pp→**Λ**p



- CDS has no acceptance to π^- in

$K^-n \rightarrow \pi^-\Lambda$

$\Lambda \rightarrow \pi^0 n_{Forward}$

- Many theories predicted the K-pp bound state with various B.E and Γ.
- Few experiments claimed observation the K-pp state.
- We need more experiment data in another way to distinguish all background process.

J-PARC E15 experiment