# $^{4}$He標的へのK$^{-}$ビーム照射による K$^{-}$ppn束縛状態探索

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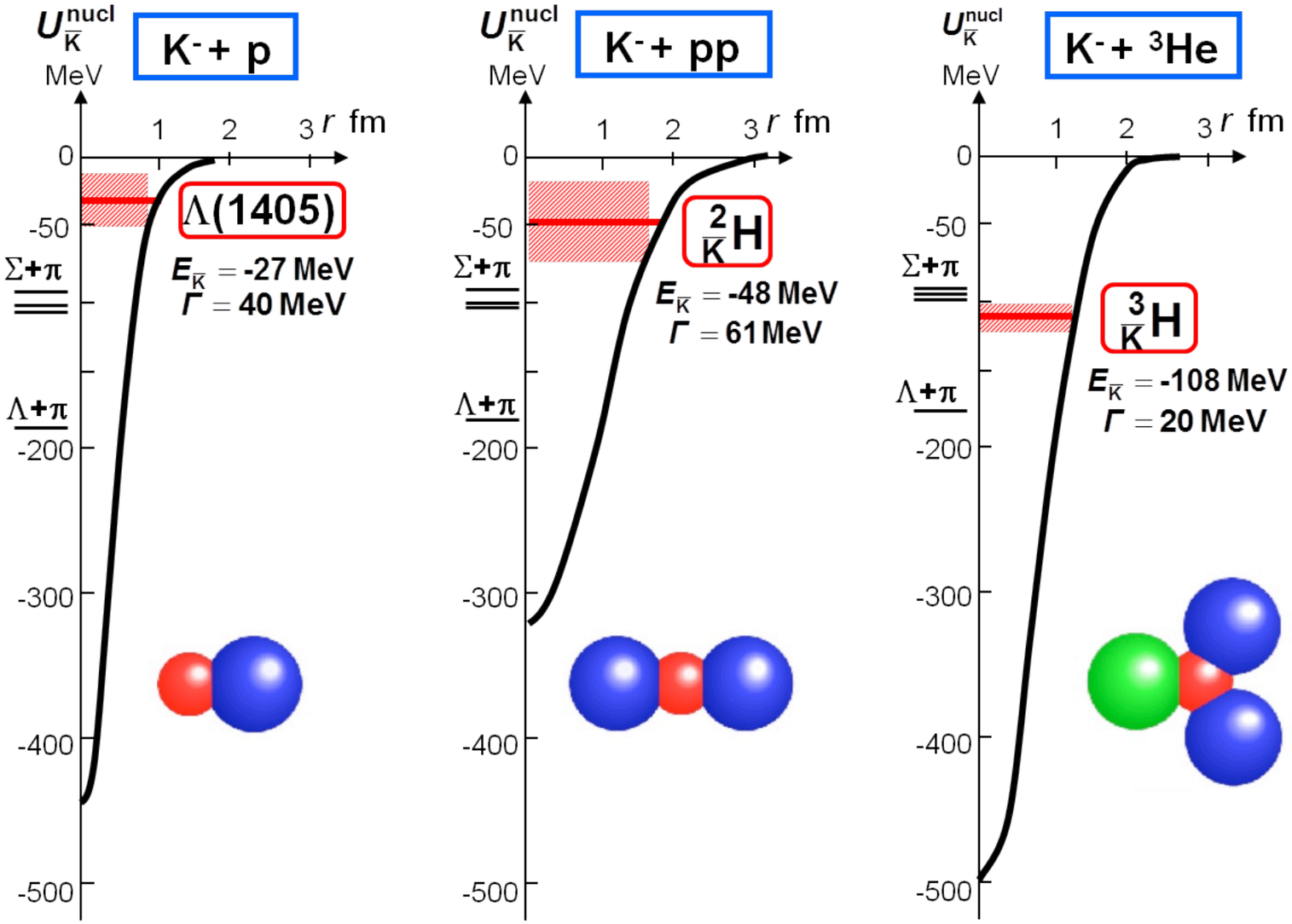
for the J-PARC E73/T77 collaboration

日本物理学会 第77回年次大会（2022年）講演番号17aA122-7

# Kaonic nuclei

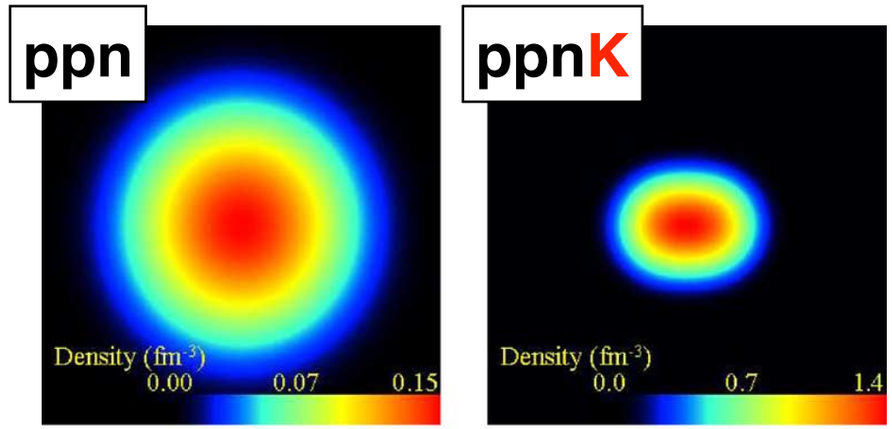
関連セッション: 17pA132　中間子原子・原子核

predicted from
attractive K$^{bar}$N interaction in I=0




1.Y. Akaishi and T. Yamazaki. *Phys. Rev. C* **65,** 044005 (2002).
2.T. Yamazaki and Y. Akaishi. *Physics Letters B* **535,** 70–76 (2002).

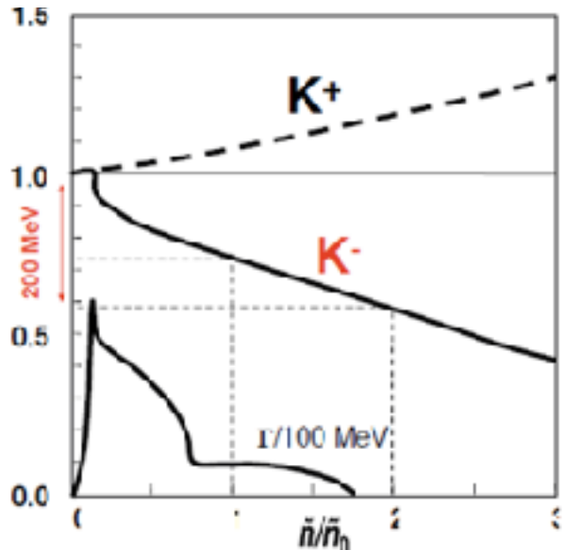
***dense nuclei are predicted***




(a) $^{3}$He　(b) $^{3}$He$K^{-}$

Phys. Lett. B 590 (2004) 51

***Kaon mass changes in nuclear medium?***

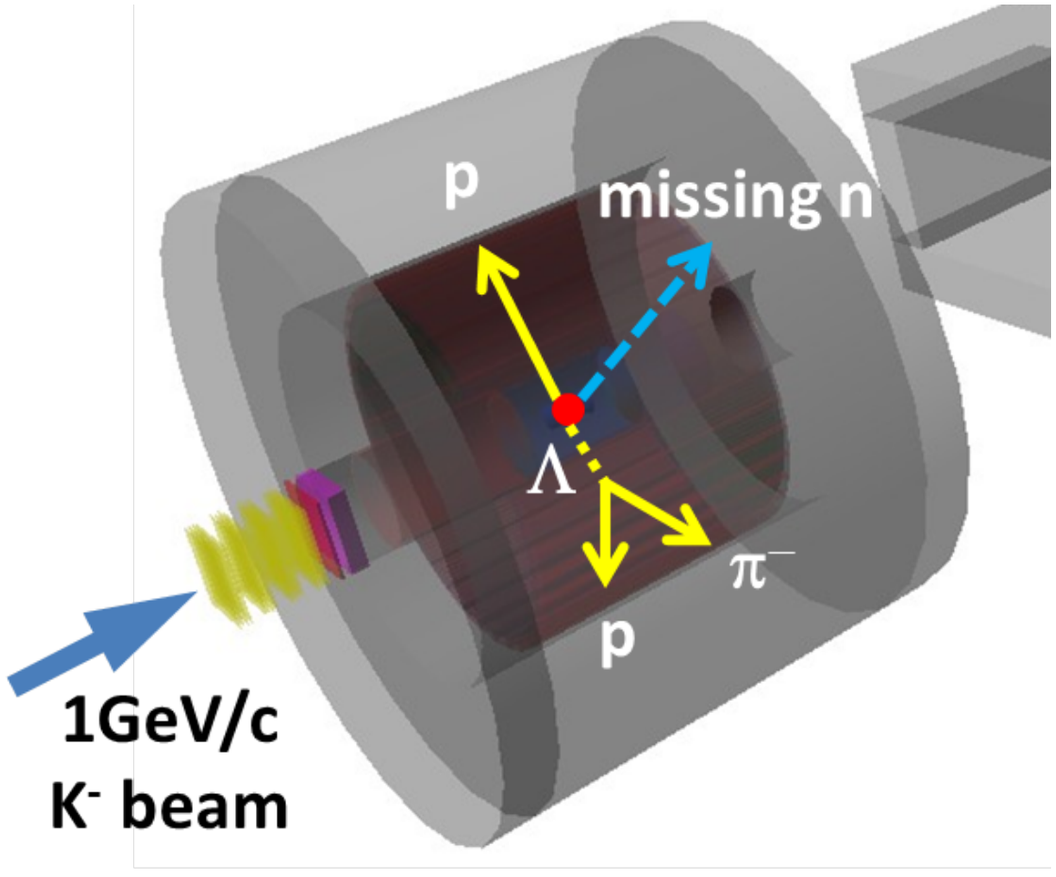


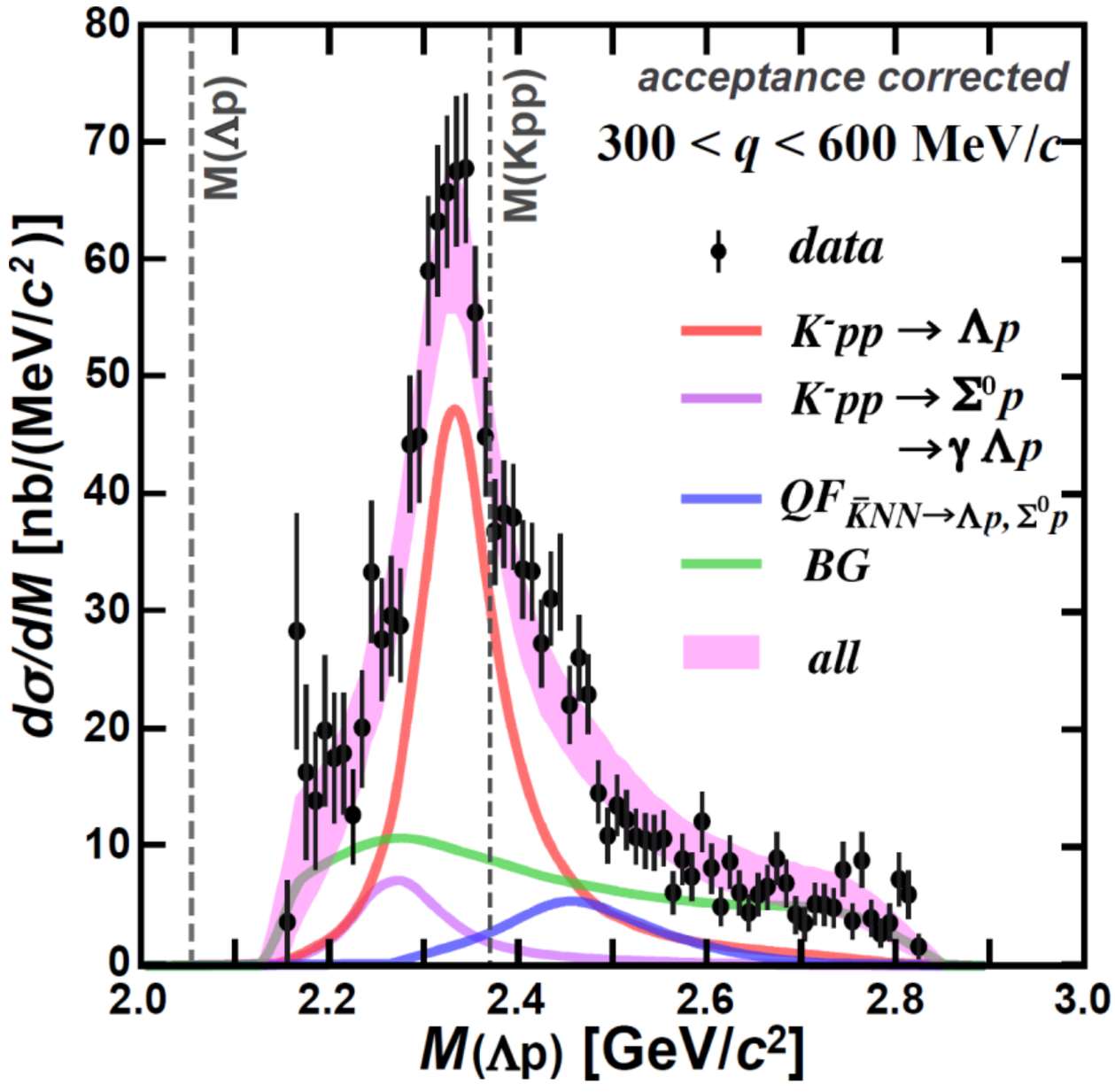

T. Waas, N. Kaiser & W. Weise, Phys. Lett. B379 (1996) 34.

**Anti-Kaon could be a unique probe for hadron/nuclear physics**

# “K⁻pp” in J-PARC E15

PLB789(2019)620., PRC102(2020)044002.

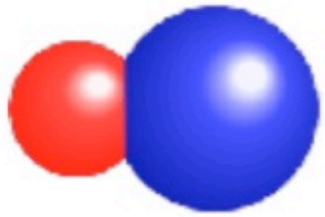



- Exclusive measurement of all the final state particles
- Most convincing data after a history of 20-year search

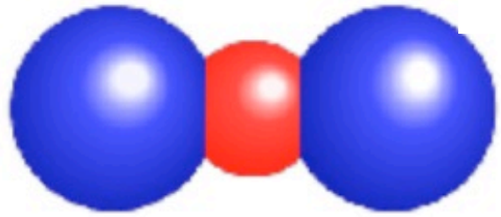
# What's next?

- Λ(1405)　(E31+)



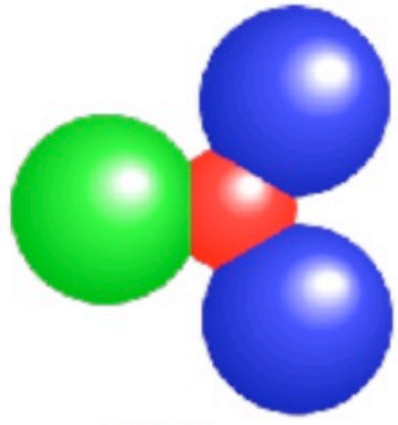
$K^-p$

- Details of the "$K^{bar}NN$" (P89)
  - spin-parity, isospin partner "$K^{0bar}nn$"



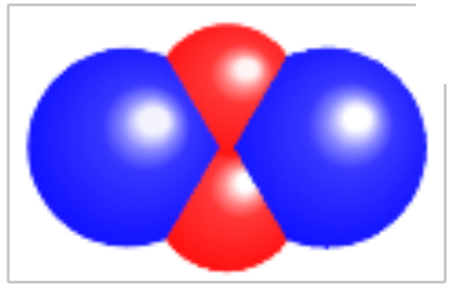
- **Heviear kaonic nuclei (E80)**

$K^-pp$



$K^-ppn$

- Double kaonic nuclei (LOI)

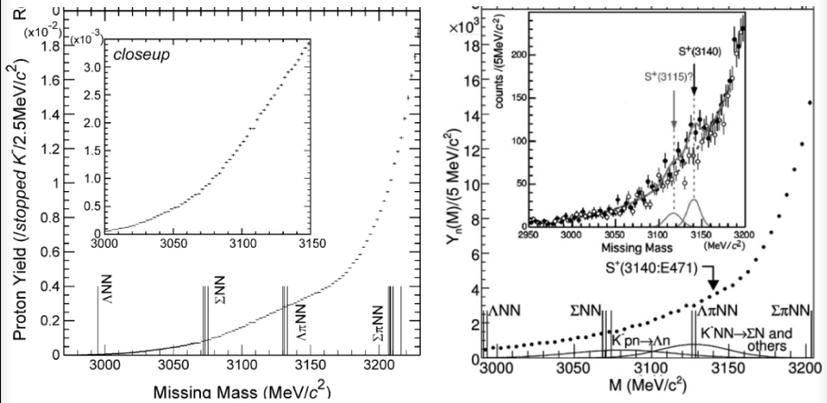


$K^-K^-pp$

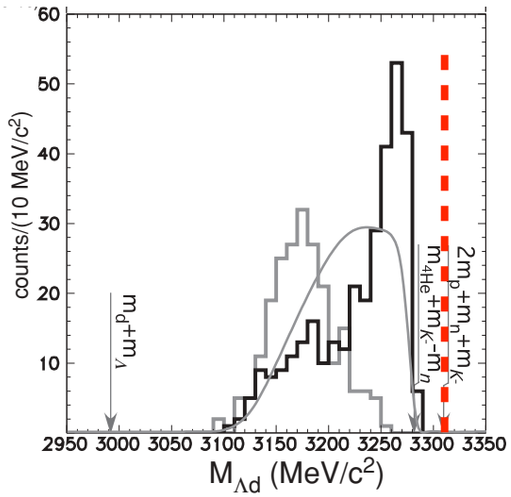
# “K-ppn”: Experimental situaion

## Stopped K⁻ on ⁴He

**E471/E549@KEK**



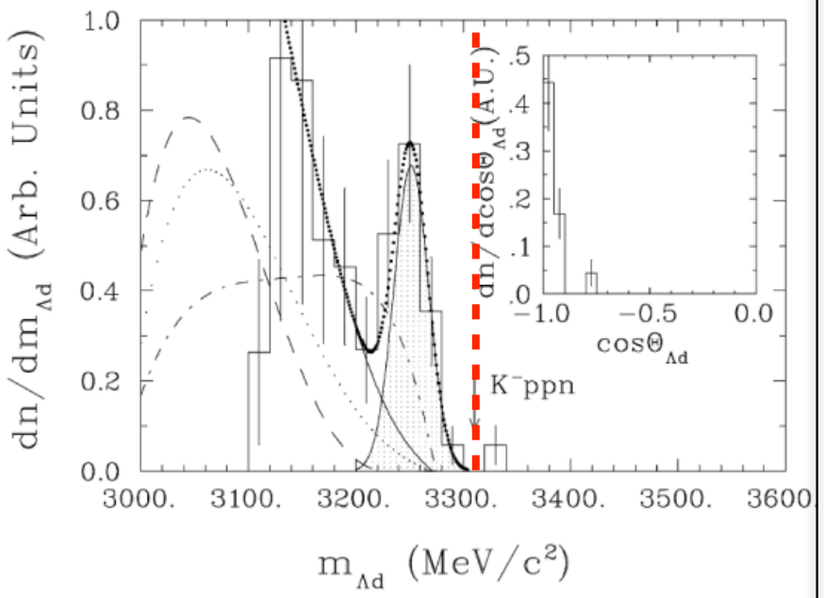

PLB659(2008)107, PLB688(2010)43




PRC76(2007)068202

## Stopped K⁻ on Li/C back-to-back Λd

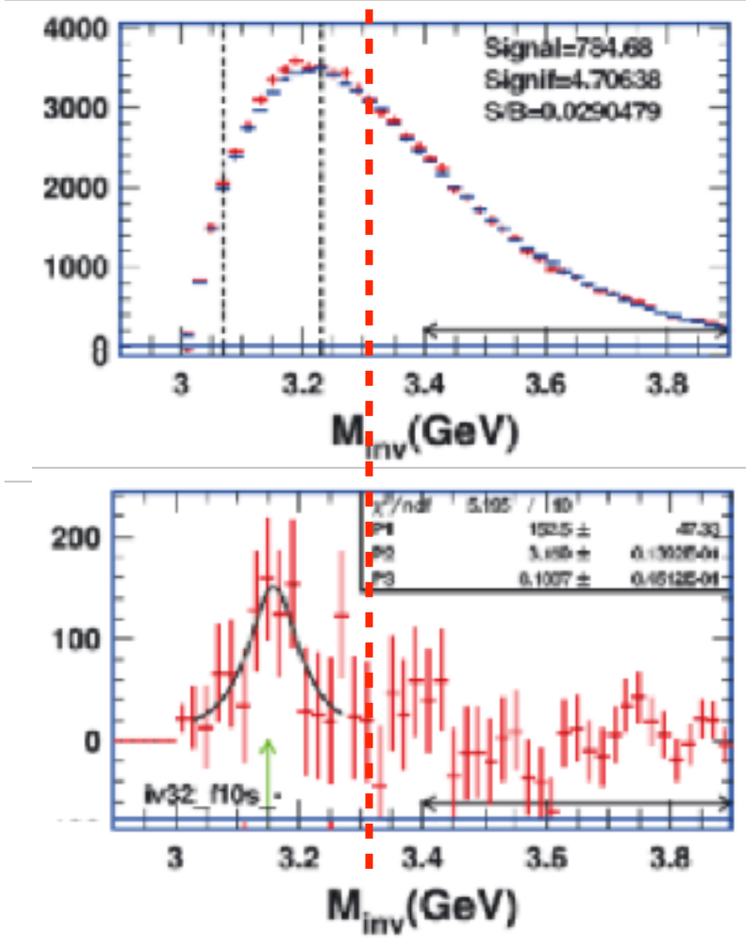
**FUNUDA@DAΦNE**




PLB654(2007)80

## Λd in Ni+Ni

**FOPI@GSI**

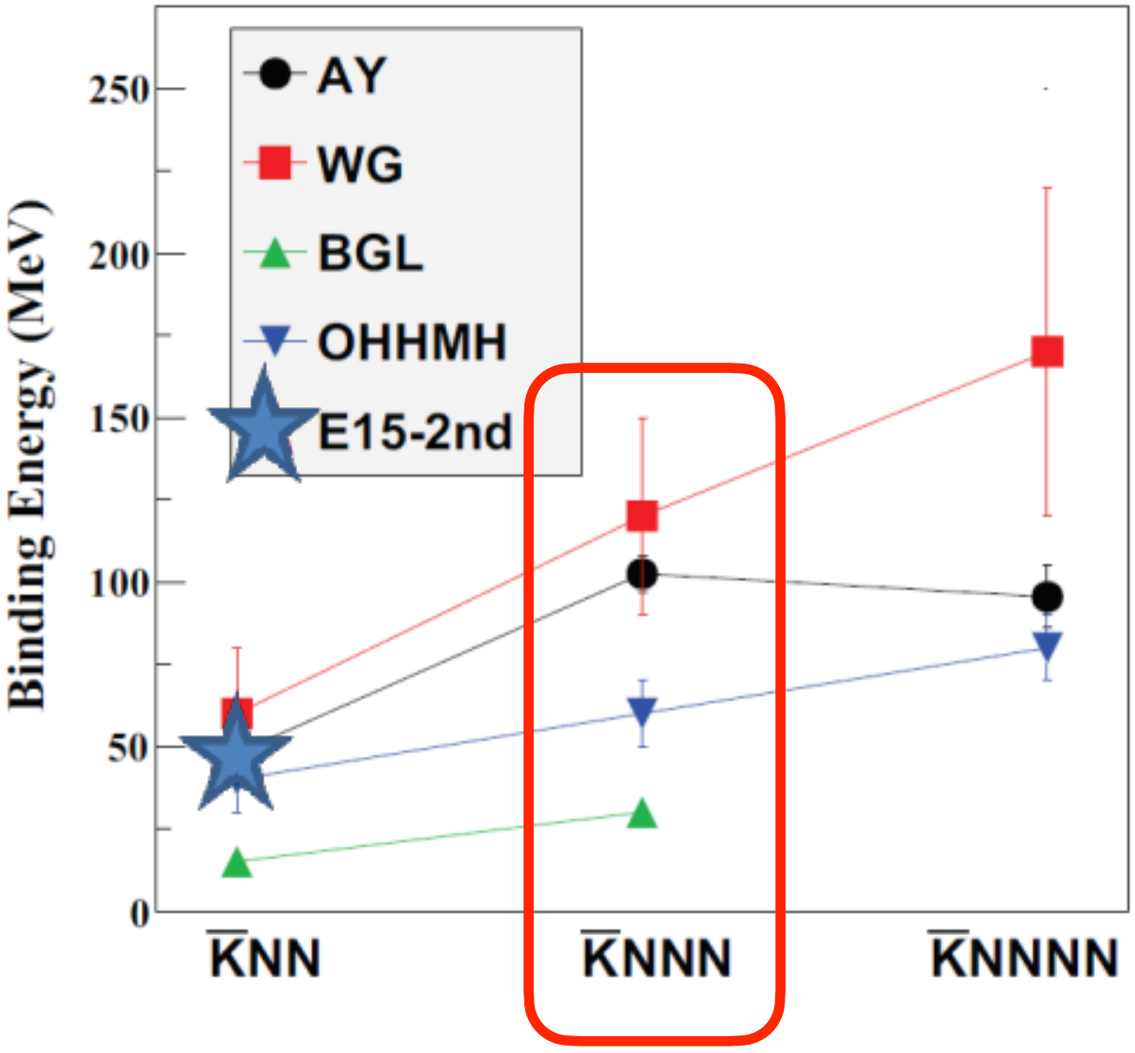



EXA05 Proceedings (2005)

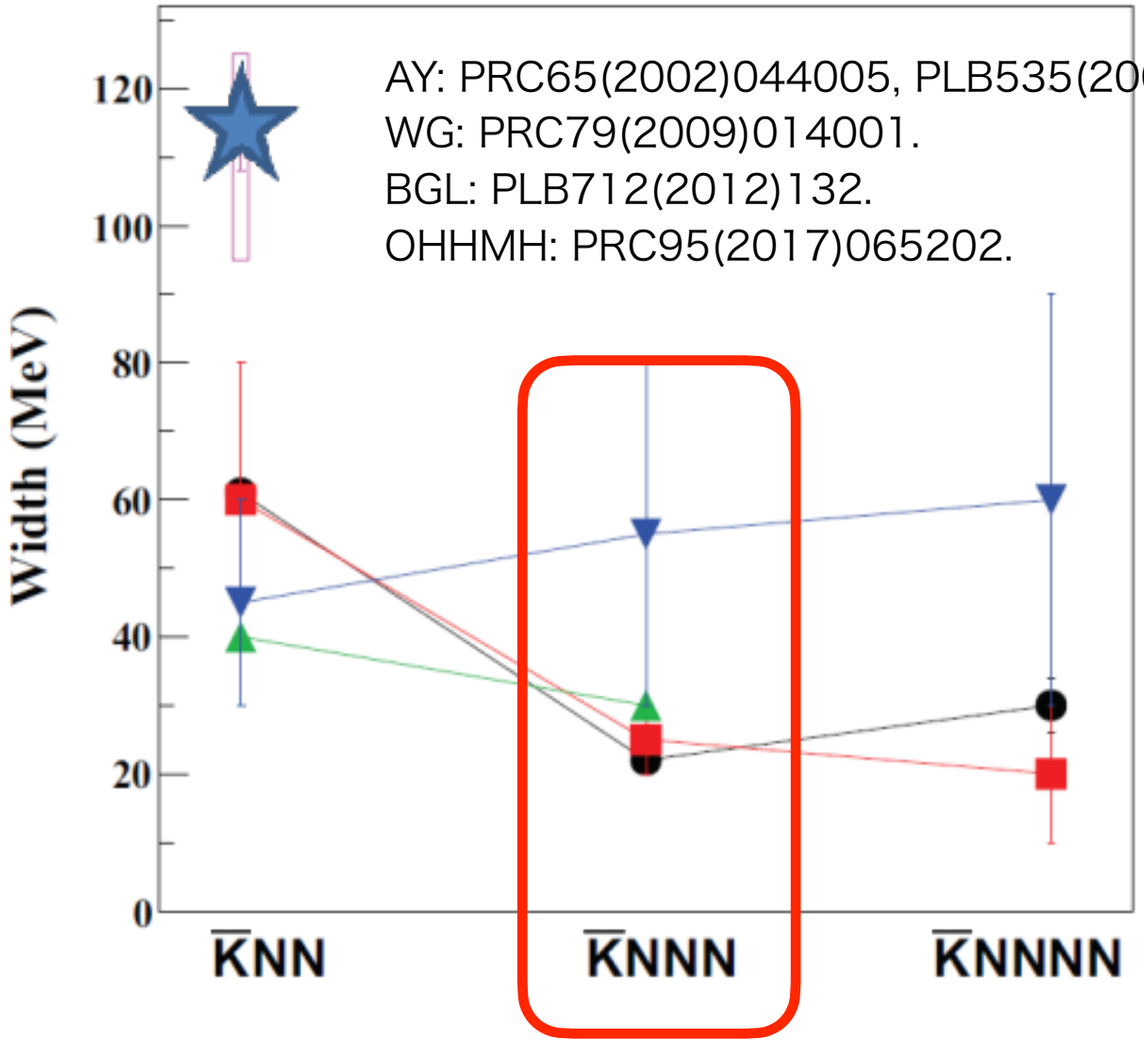
- Some experimental searches in 2000s. No conclusive result.

# “K-ppn”: Theoretical situaion

## Binding Energy

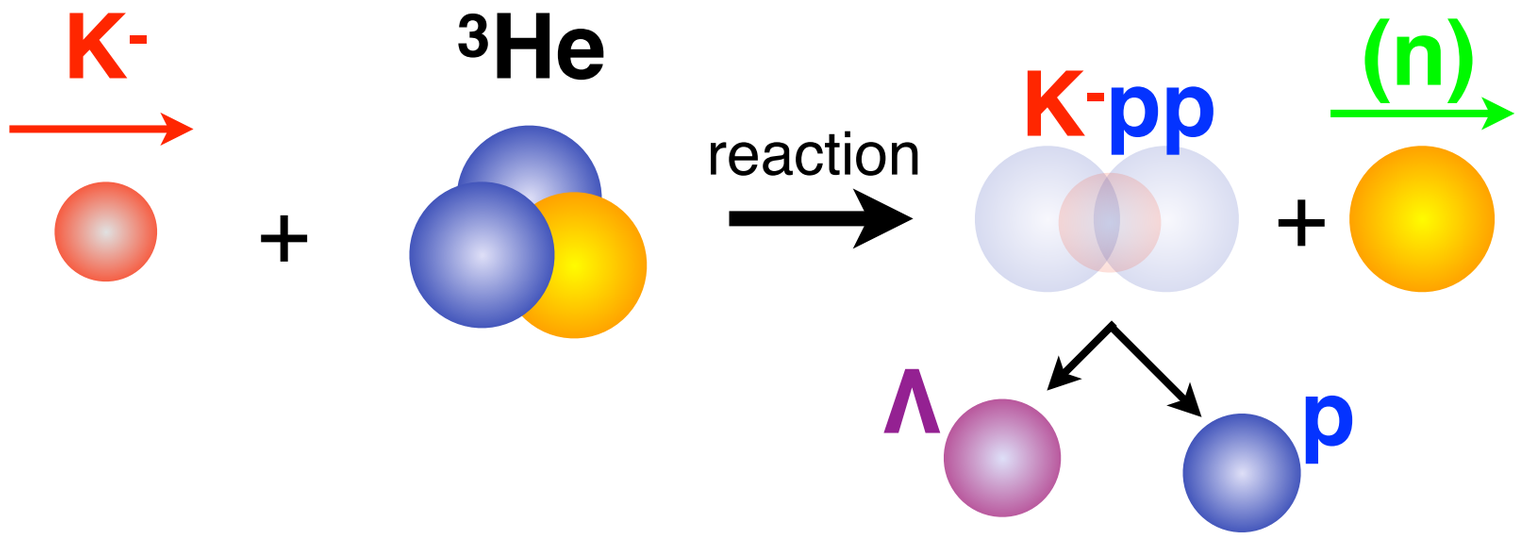



## Width (mesonic-only)



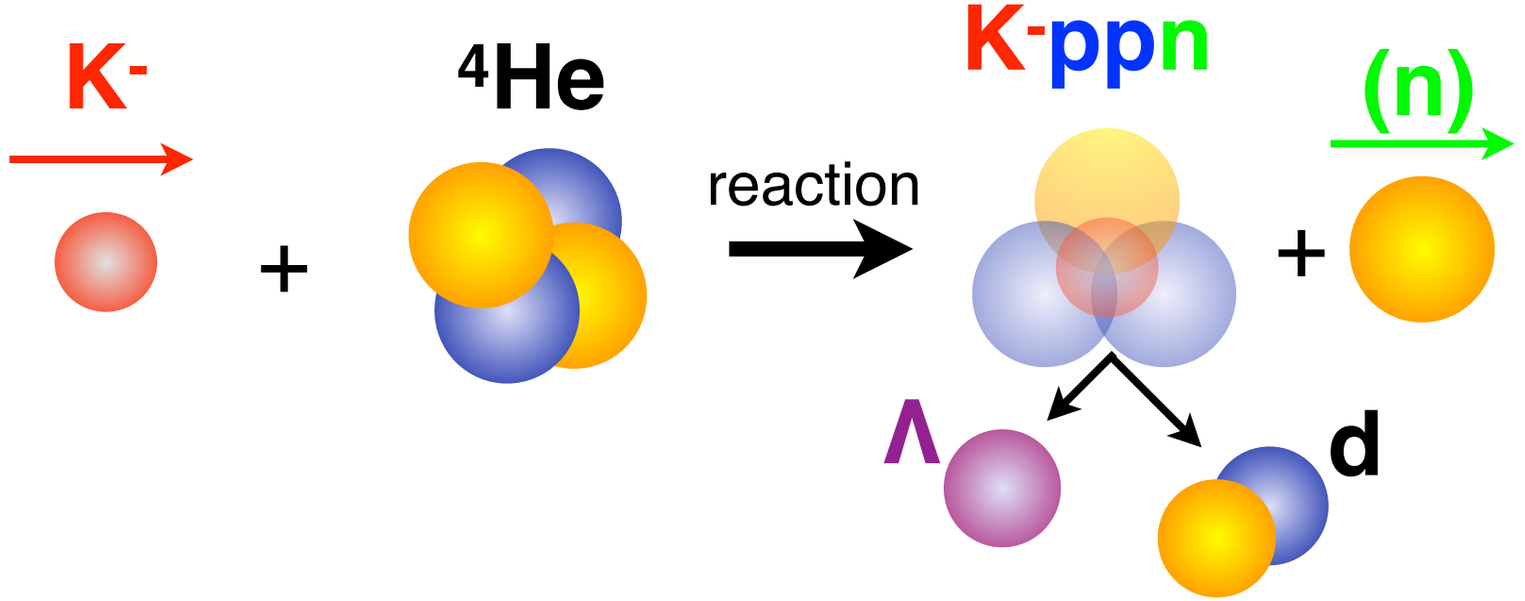

Larger binding than “K-pp” and similar width are predicted.

J-PARC E15




add one neutron

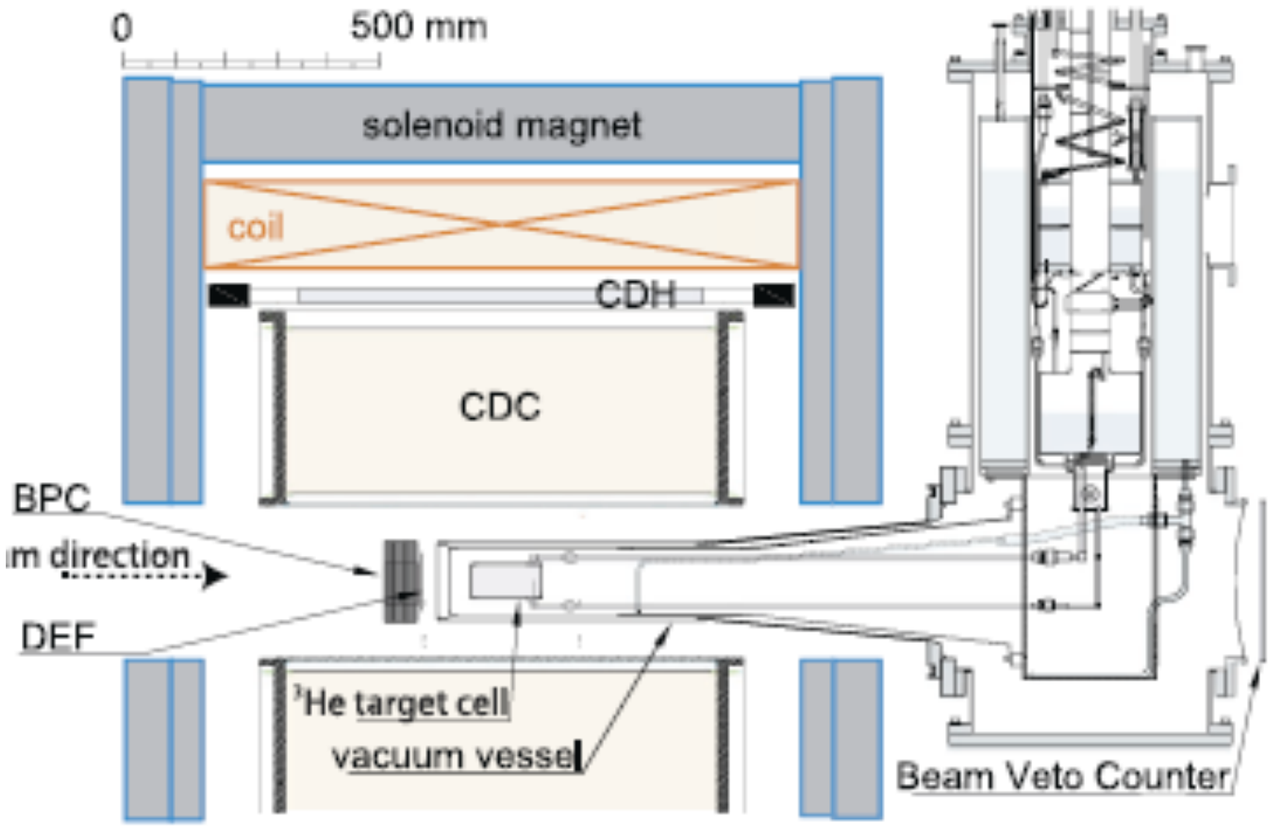
This talk



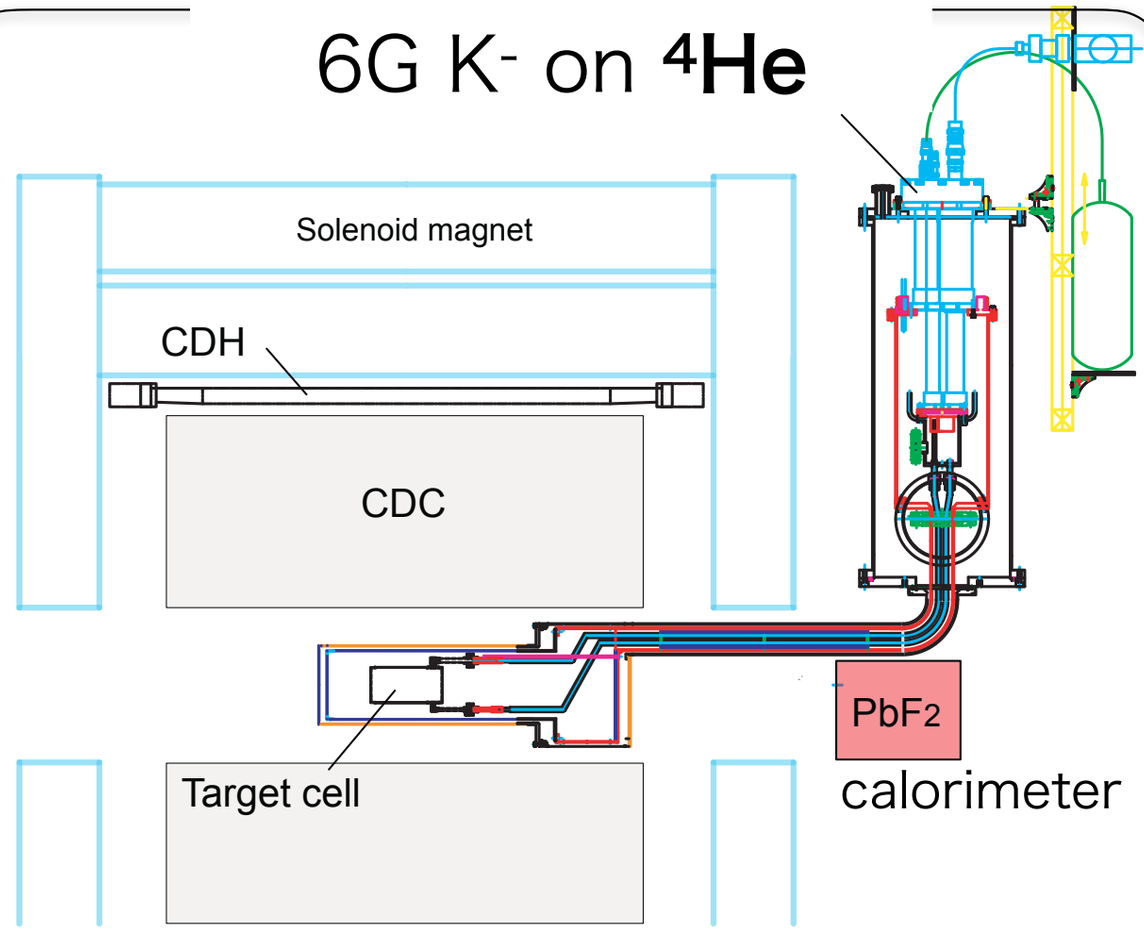

We have small dataset with $^4$He target
for the lifetime measurement of hypernuclei (J-PARC T77/E73)

# J-PARC E15 vs T77

## J-PARC E15@2015
### 42G K⁻ on $^3$He

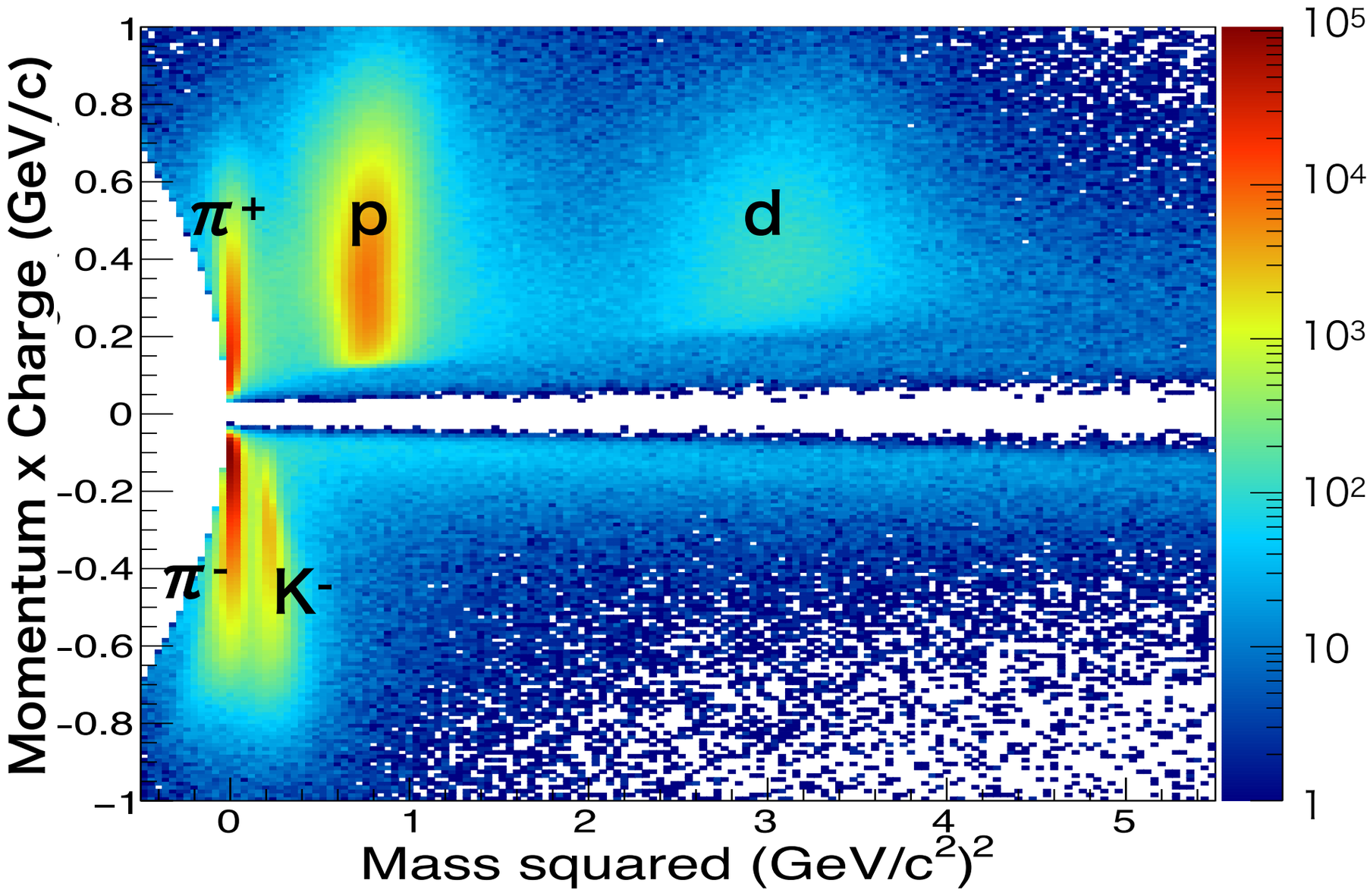



## J-PARC T77@2020
### 6G K⁻ on $^4$He




- The same cylindrical detector system
  + forward calorimeter for lifetime measurements of hypernuclei
- New cryogenic target system. **$^3$He** → **$^4$He**
- Improved DAQ efficiency. 80%@1k/spill → >90%@10k/spill

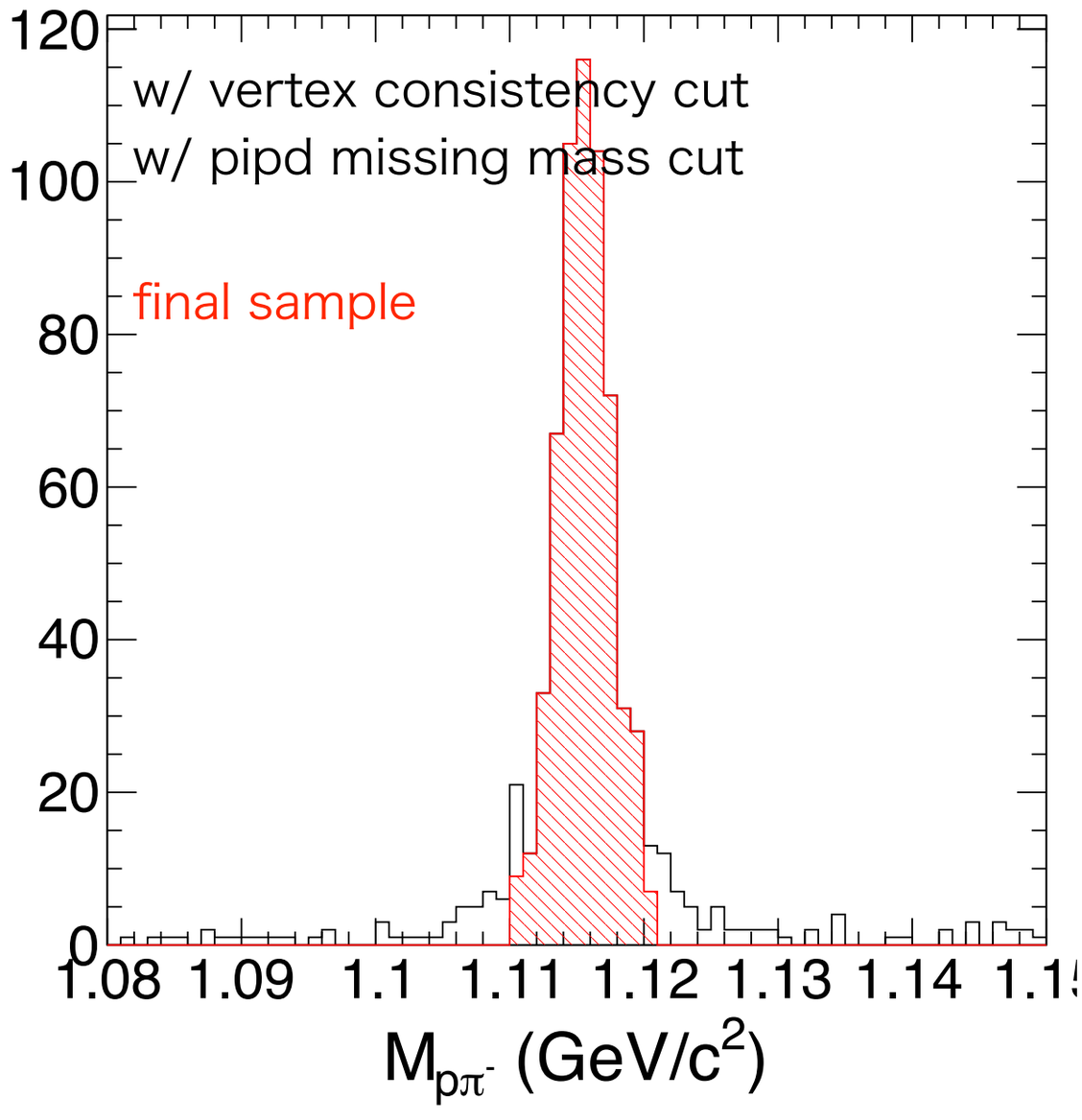
# Deuteron identification in CDS



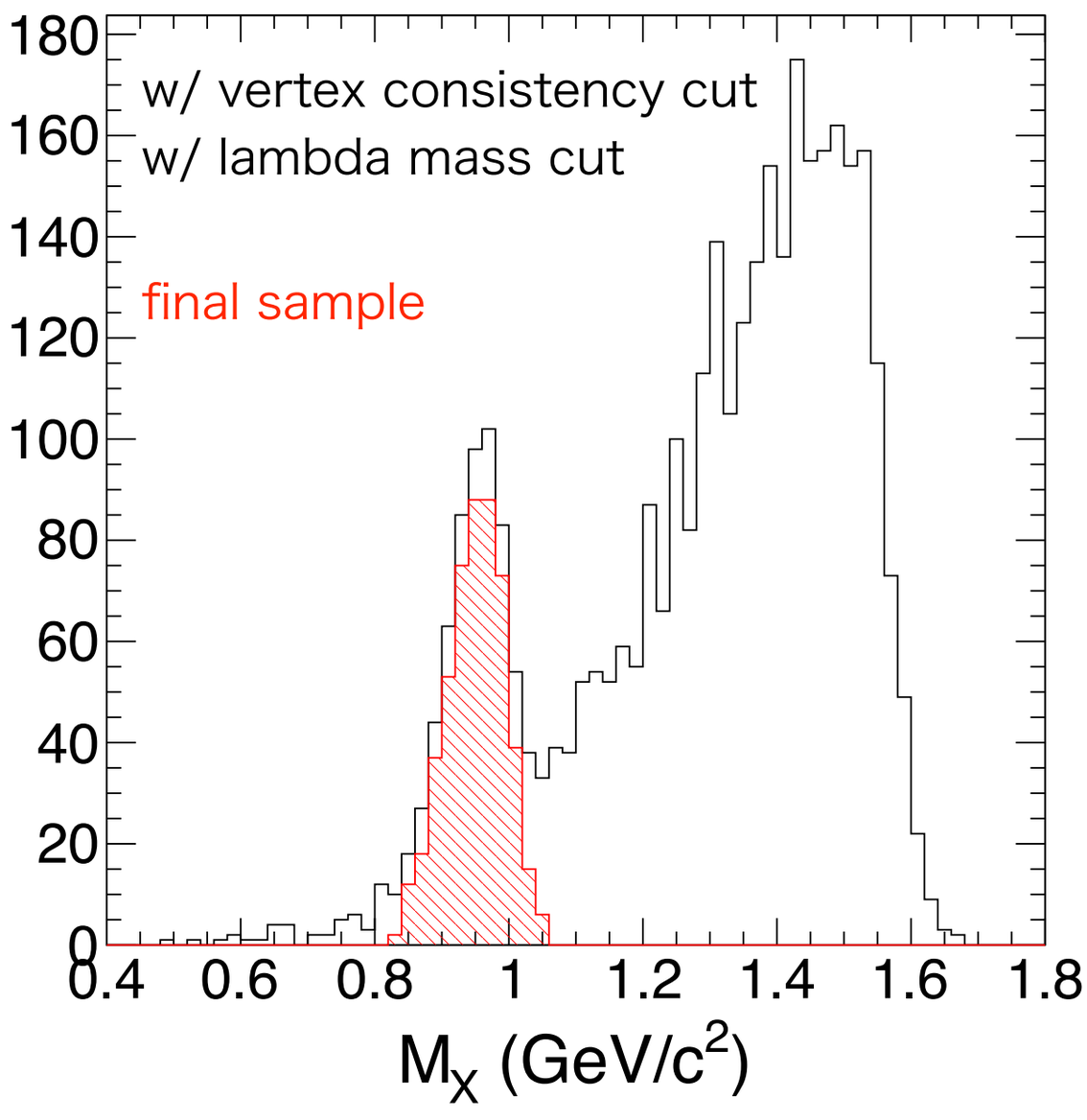

Deuterons are identified using the track curvature and TOF

# Λdn event selection

## Λ reconstruction




## Missing neutron ID



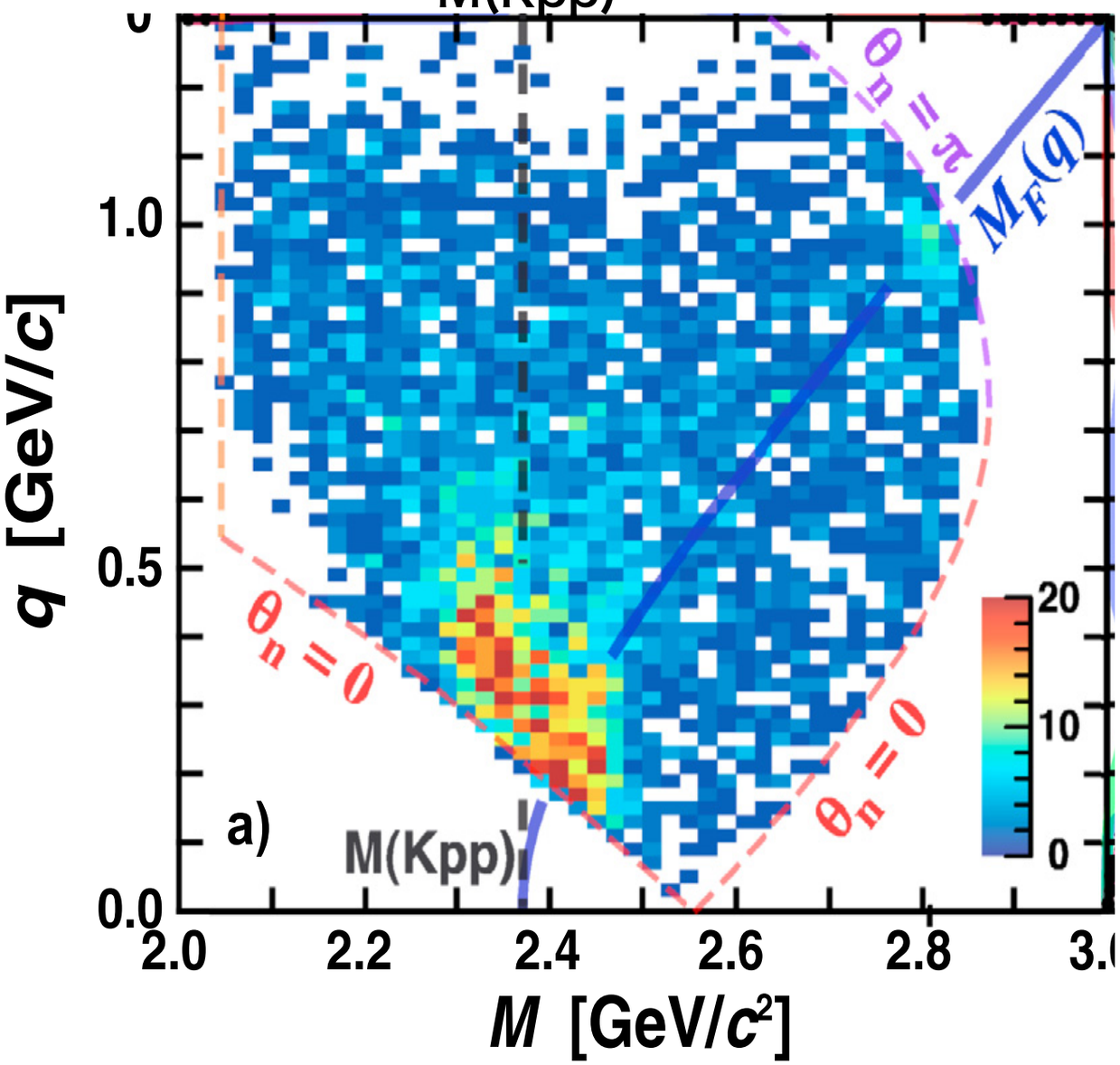

- Λdn final states are identified with a good purity
- ~20% contamination from $\Sigma^0$dn/$\Sigma^-$dp

# Preliminary result

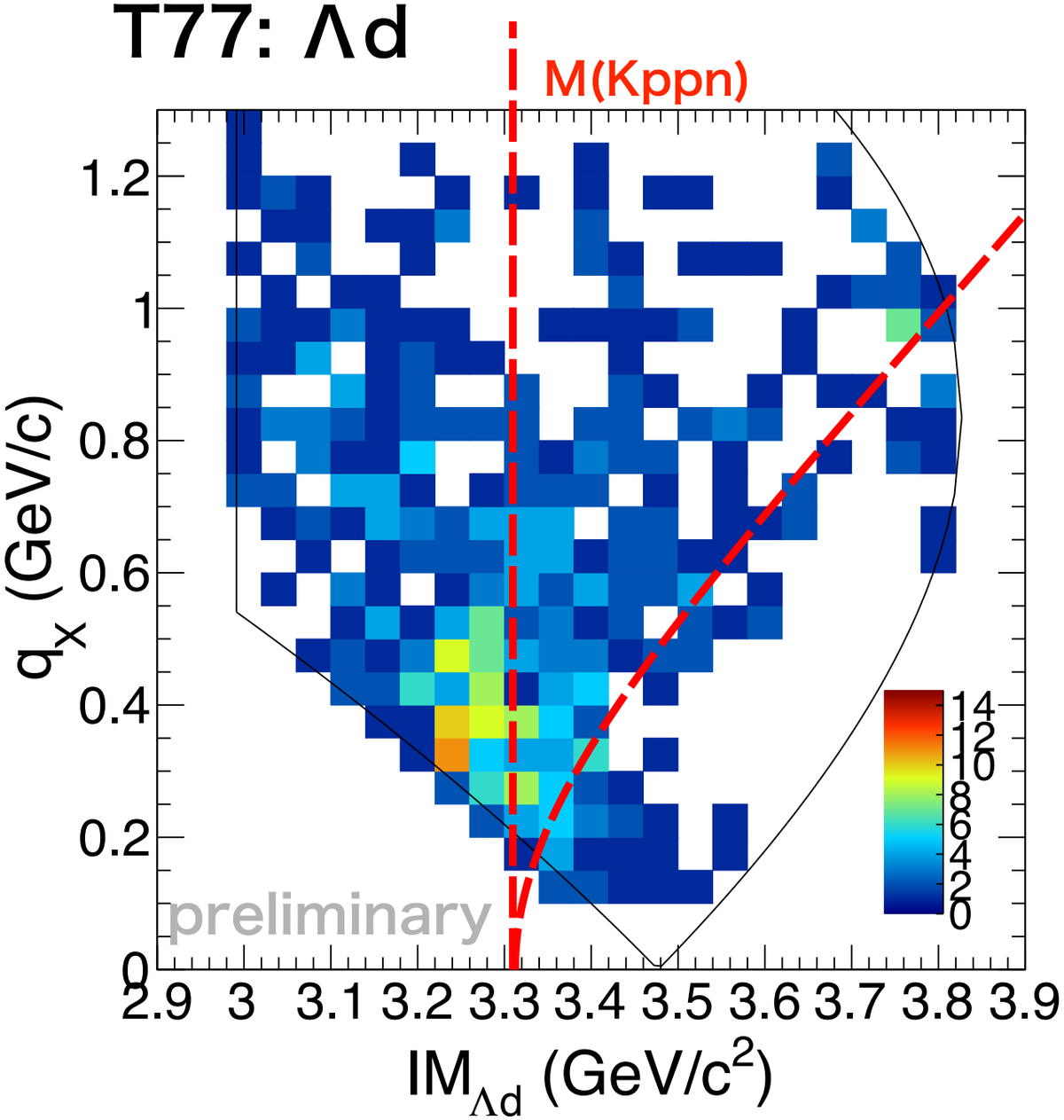
before acceptance correction

## E15: Λp

PLB789(2019)620




## T77: Λd




- Two disributions are quite similar
- CS x B.R. ~ 10 $\mu$b for “K-pp”, a few $\mu$b for “K-ppn”

# Summary & Outlook

- We observed **$^{4}$He($K^-$,$\Lambda$d)n** events as a by-product of J-PARC T77: Lifetime measurement of hypernuclei.

- The observed distribution is similar to that of $\Lambda$p in E15, and would be a signal of **“K$^-$ppn”**.
  → **First A-dependence data of Kaonic nuclei.**

- We are proposing to take **x10 data** with the present CDS to compare with “K$^-$pp” in detail. (**~ 2 week** beam time as P92)

- More complehensive study with a **neutron detection** capbility and **~4$\pi$ acceptance** can be done with a next-generation larger CDS in the not-so-distant future.

# J-PARC E73/T77 collaboration

T. Akaishi[1], H. Asano[2], X. Chen[5], A. Clozza[7], C. Curceanu[7], R. Del Grande[7], C. Guaraldo[7], C. Han[5], T. Hashimoto[4], M. Iliescu[7], K. Inoue[1], S. Ishimoto[3], K. Itahashi[2], M. Iwasaki[2], Y. Ma[2], M. Miliucci[7], R. Murayama[2], H. Noumi[1], H. Ohnishi[10] S. Okada[2], H. Outa[2], K. Piscicchia[7,9], A. Sakaguchi[1], F. Sakuma[2], M. Sato[3], A. Scordo[7], K. Shirotori[1], D. Sirghi[7,8], F. Sirghi[7,8], S. Suzuki[3] K. Tanida[4], T. Toda[1], M. Tokuda[1], T. Yamaga[2], X. Yuan[5], P. Zhang[5], Y. Zhang[5], H. Zhang[6]

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**Thank you for your attention!**