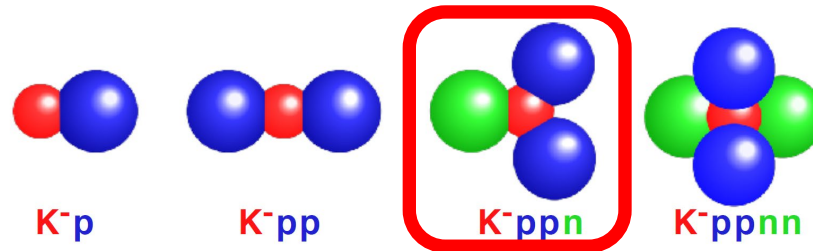


Proposal for
the E80 Phase-I Experiment:

***Investigation of the $\bar{K}NNN$ Bound State
Focusing on the Λ_d Decay
[P92 Experiment]***



F. Sakuma, RIKEN



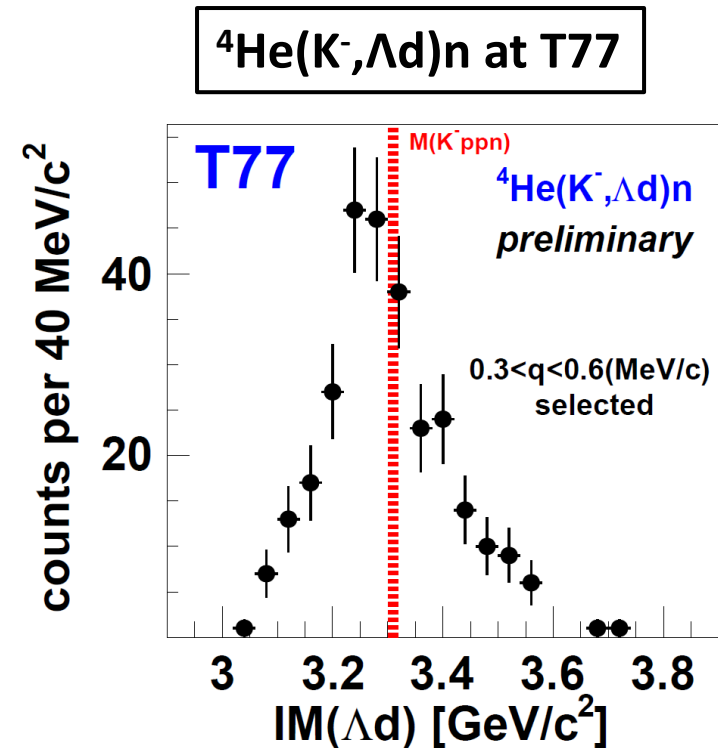
on behalf of

the J-PARC E80/P92 collaboration

Executive Summary

- We observed a peak structure below $M(K^-ppn)$ via ${}^4\text{He}(K^-, \Lambda d)n$ using T77 data
 - K^-ppn bound state signal was detected
- P92 with the **present setup** urgently provides physical information on $K^-ppn \rightarrow \Lambda d$ at sufficient statistics comparable to E15 data
 - Λdn final state: $\sim 6,000$ events
 - All apparatus is ready @ K1.8BR

P92 Beam-Time Request	
Beam power	90kW
Duration	14 days



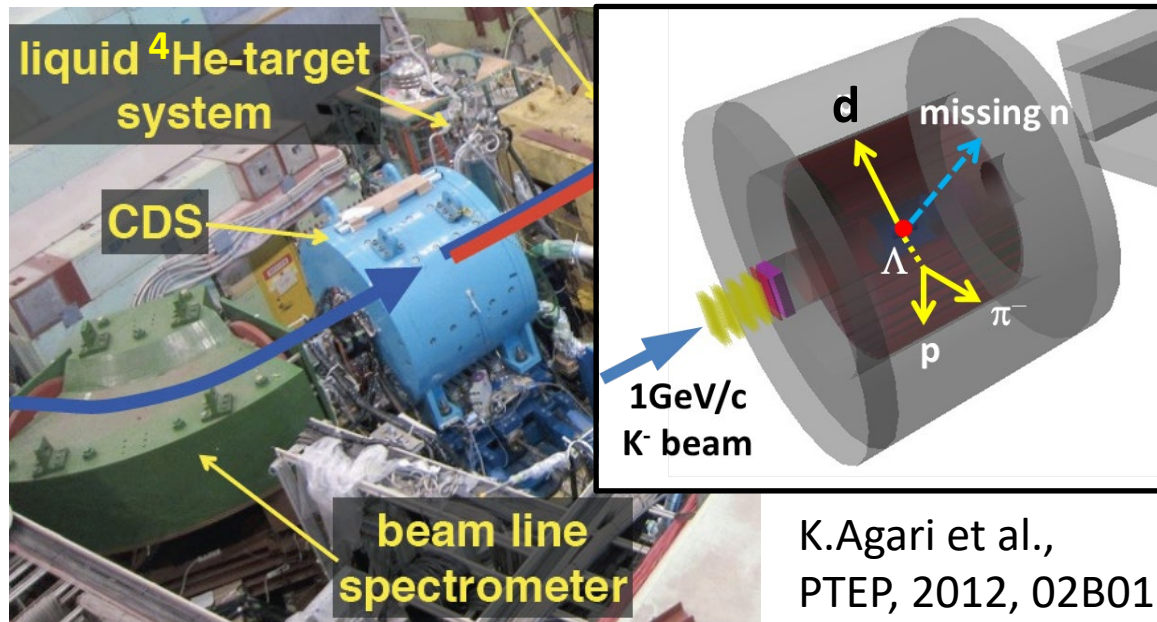
We request for urgent approval of the $K^-ppn \rightarrow \Lambda d$ study with the present K1.8BR setup

$K^- {}^4\text{He} \rightarrow \Lambda dn$ ***using the T77 data***

T77: lifetime measurement of ${}^4_{\Lambda}\text{H}$ conducted in 2020

Analysis of $K^{-4}\text{He} \rightarrow \Lambda dn$ at T77

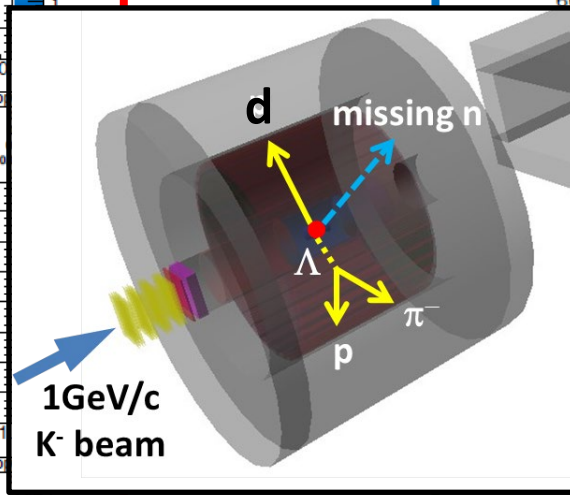
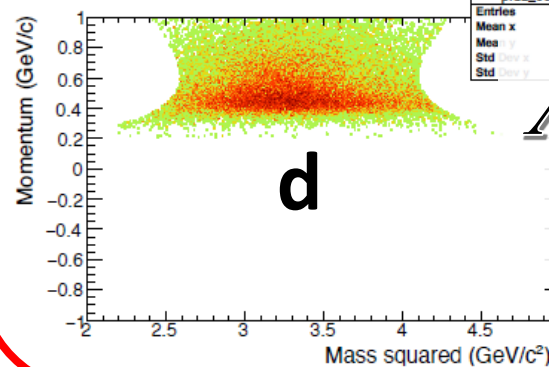
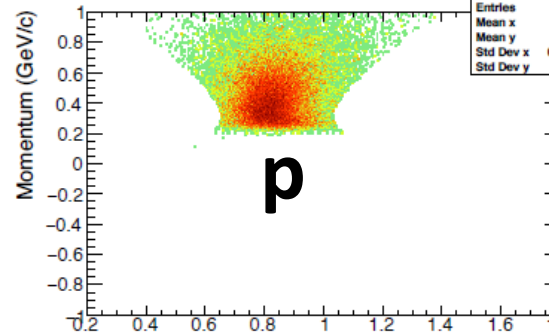
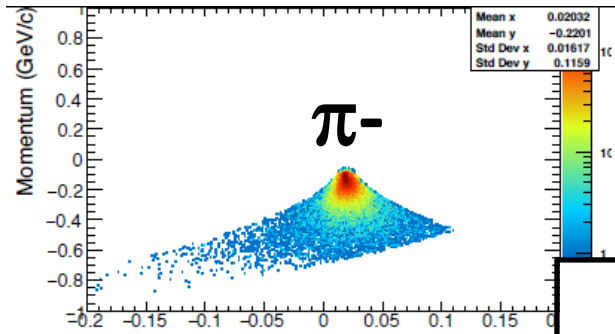
- We have conducted a prompt analysis on Λdn final state of $K^{-4}\text{He}$ reaction at **1 GeV/c**
 - 66 hours under 51 kW corresponding to **140 kW*days**
- T77 experiment used the **present CDS** (Cylindrical Detector System)



K.Agari et al.,
PTEP, 2012, 02B011

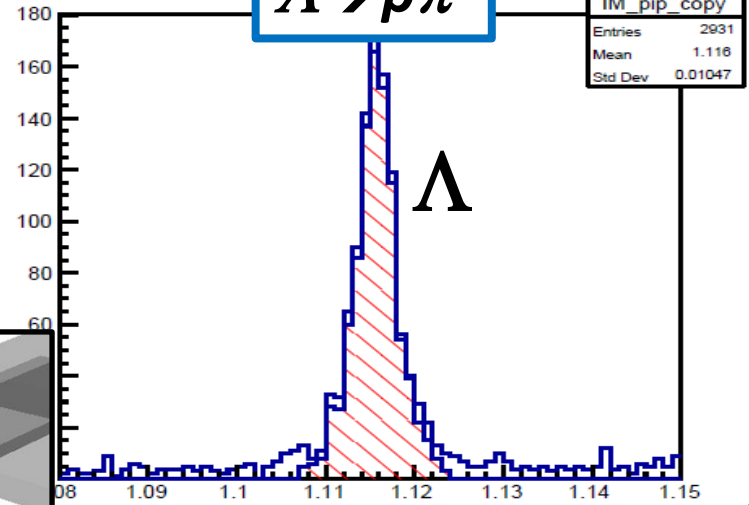
Event Selection

PID with CDS

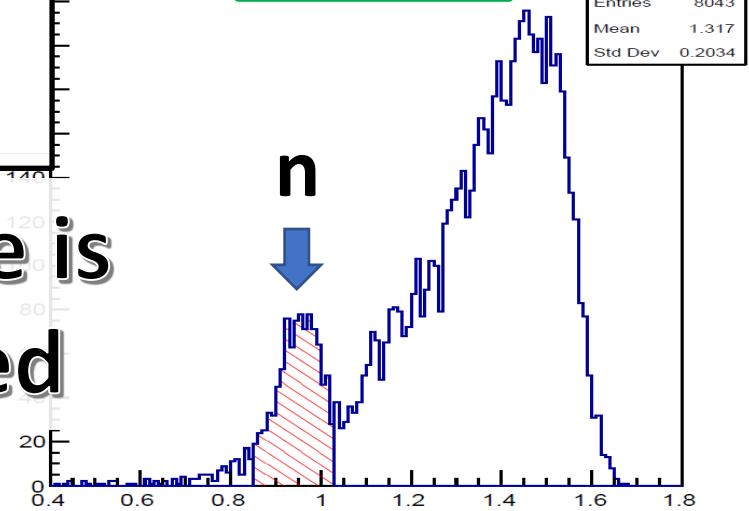


Λdn final state is well identified

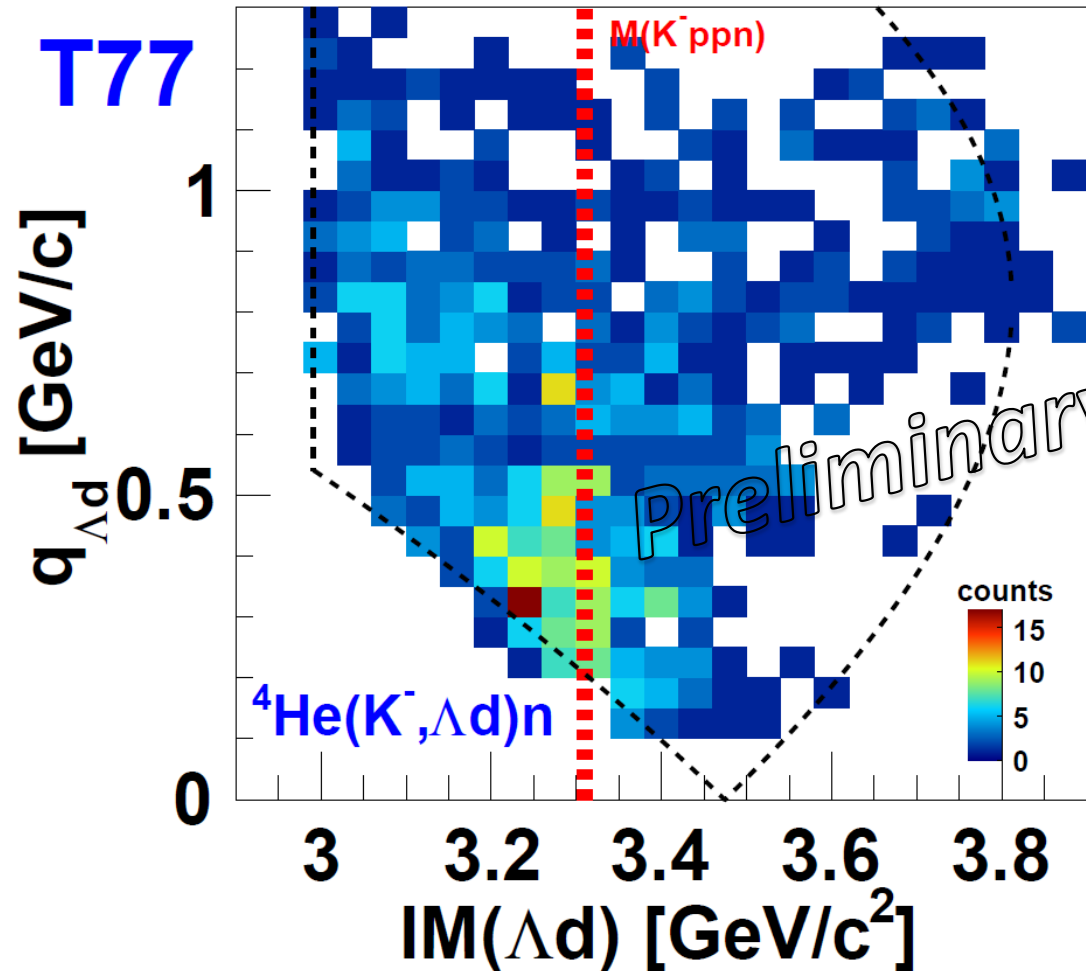
$\Lambda \rightarrow p \pi^-$



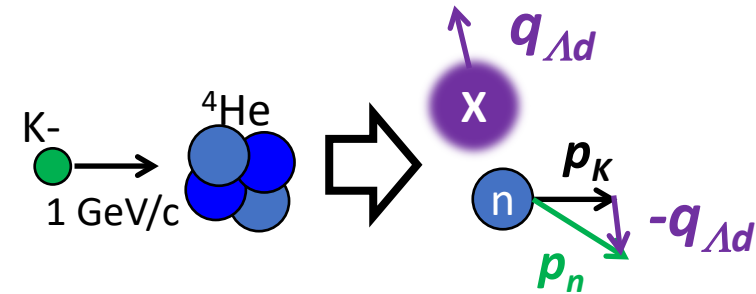
MM(Λd)



Λn Final State



$q_{\Lambda d}$: momentum transfer to Λd



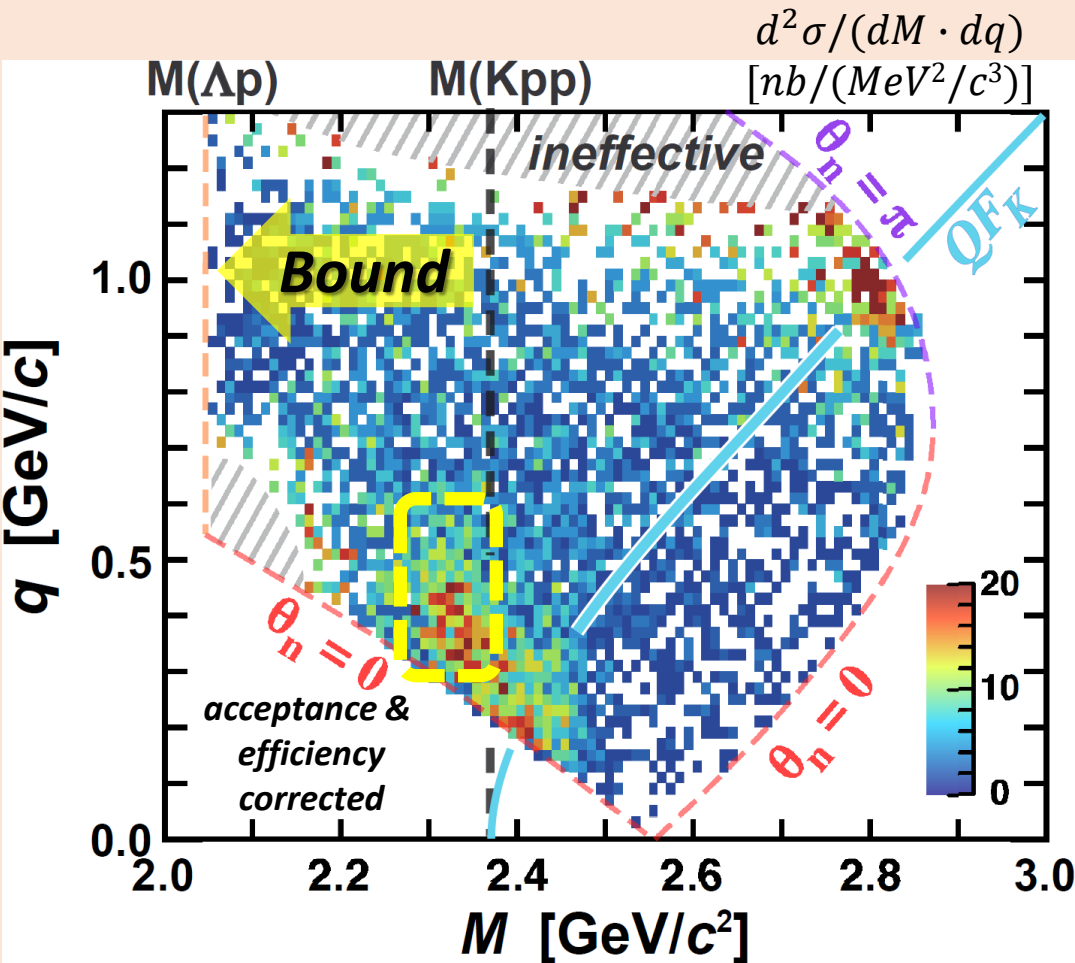
In the Λn final state,
we observed:

- ✓ event concentration
below $M(K^- p p n)$
- ✓ located at lower q

**→ Both specific features exactly represent
the production and decay of the kaonic nuclei**

c.f. $\bar{K}NN$ in Λpn @ E15

T.Yamaga et. al., PRC102(2020)044002.



q : momentum transfer to Λp system

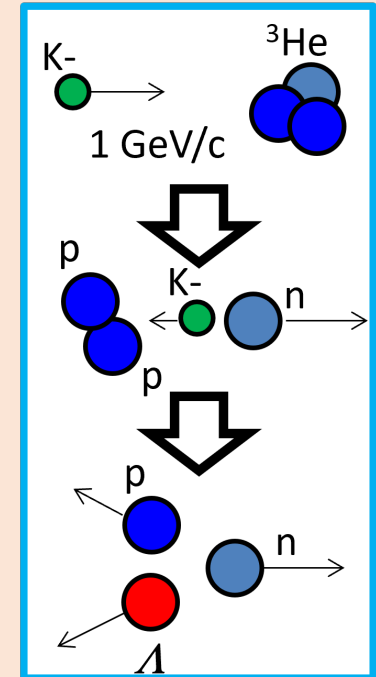
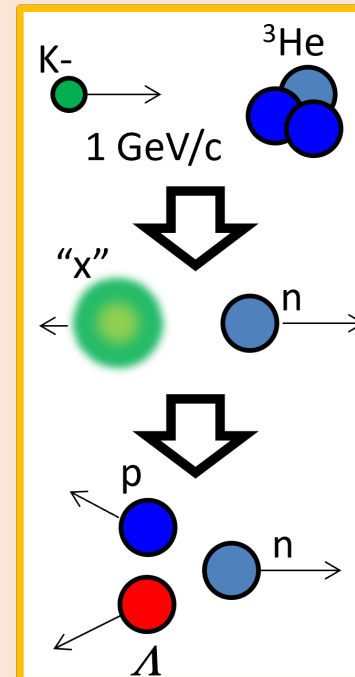
M : invariant mass of Λp

• K^-pp bound state

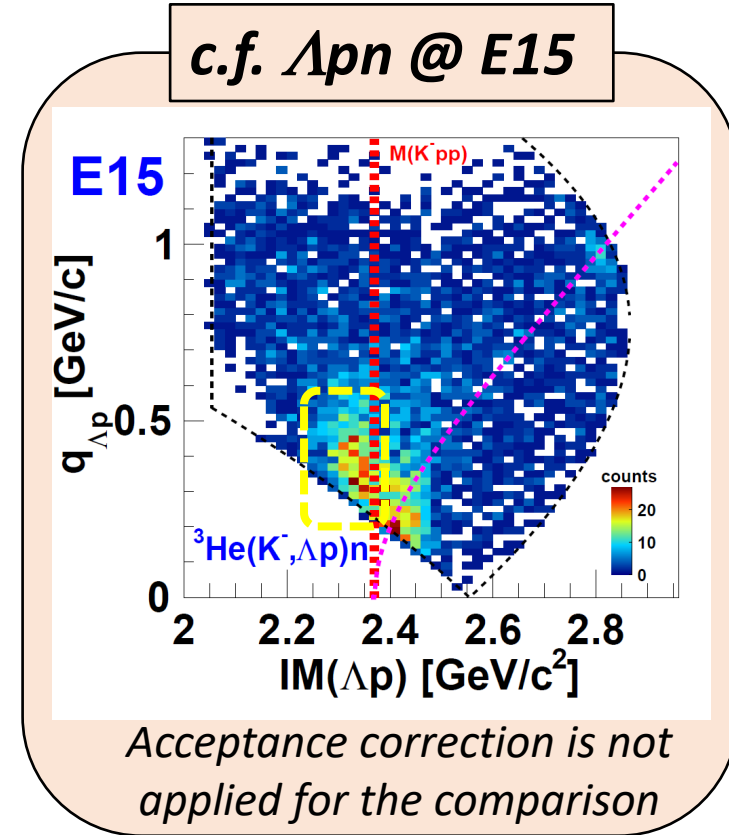
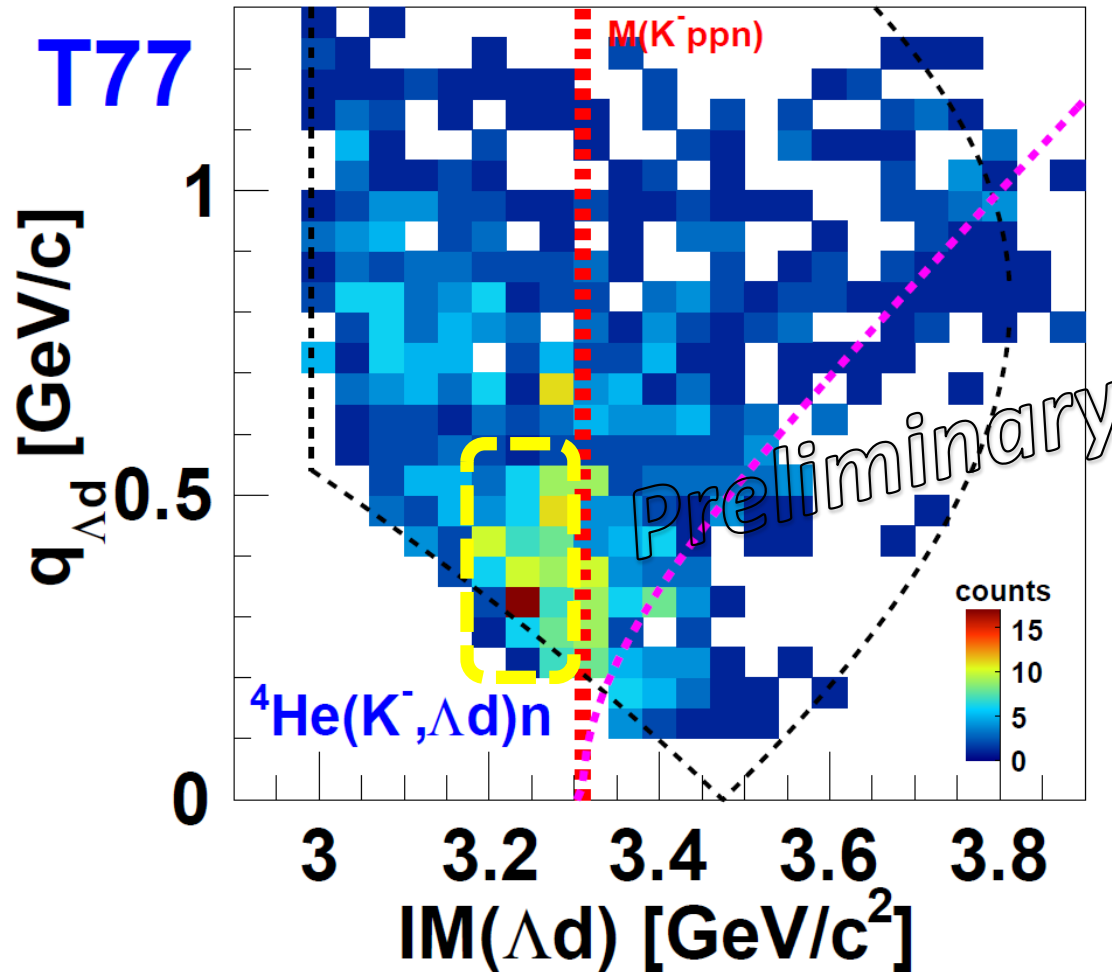
✓ q -independent

• QF followed by 2NA

✓ q -dependent

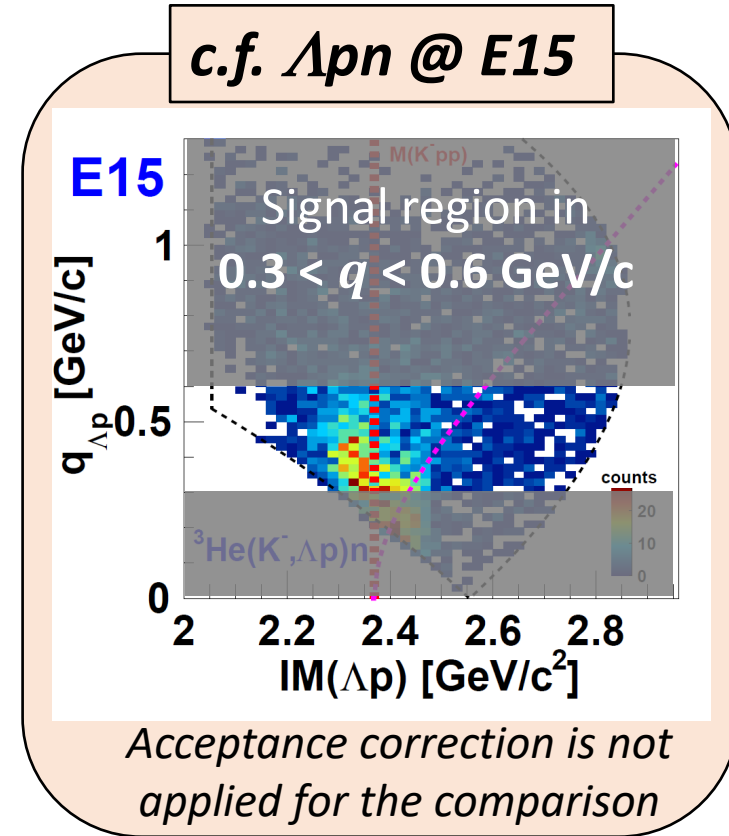
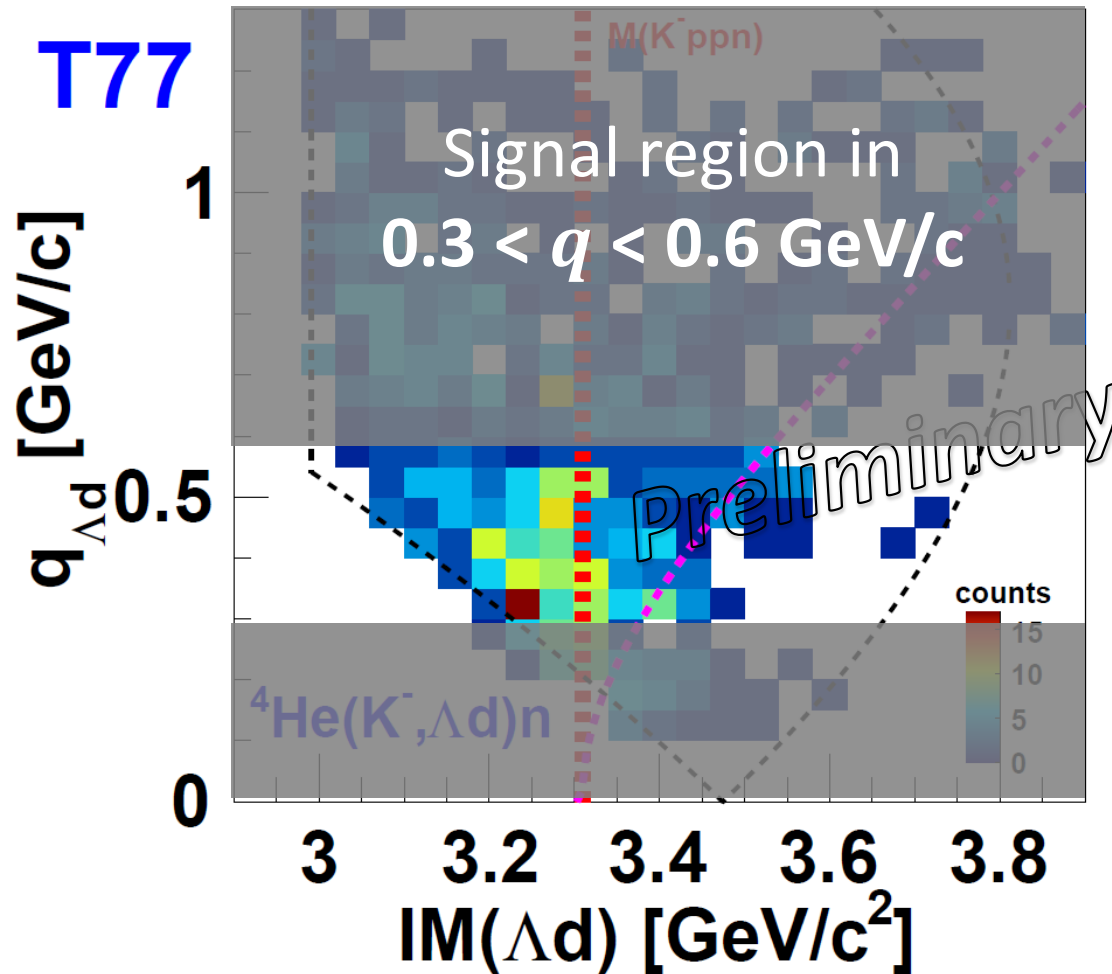


Λn Final State



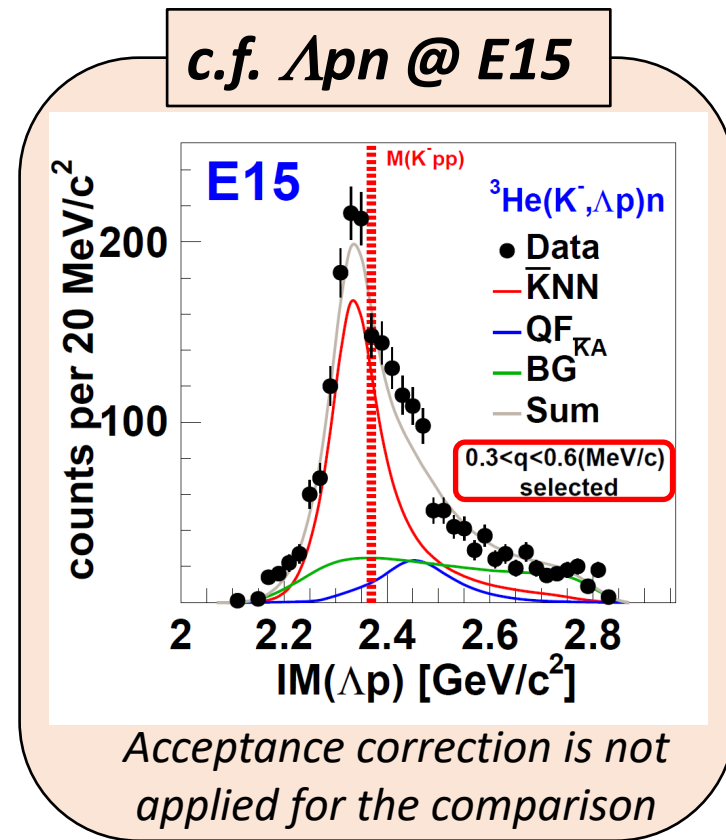
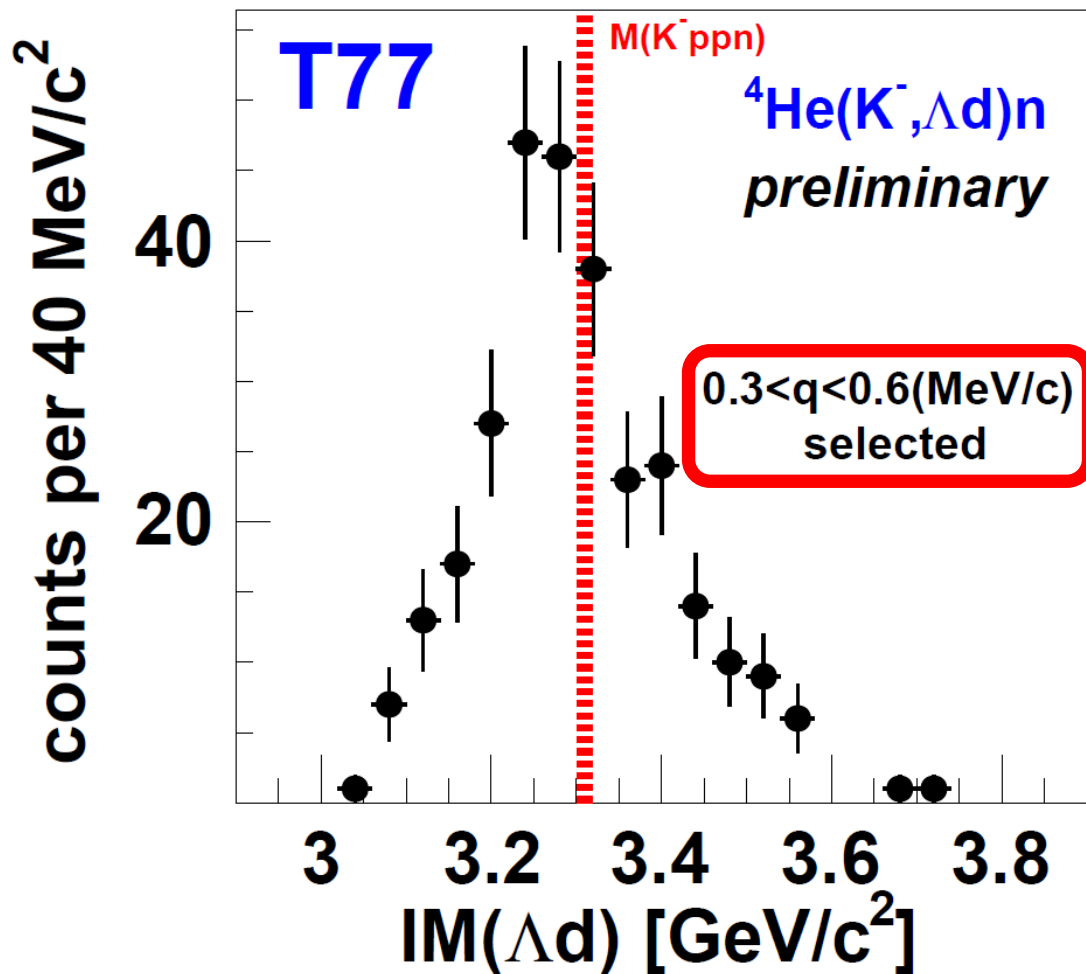
similar to the Λn final state in the $K^-{}^4\text{He}$ reaction
(mass shifted by one nucleon, accordingly)

Λ dn Final State



Same event window on momentum transfer q
to reduce background

Λ dn Final State



A peak structure below $M(K^-ppn)$ was observed
→ the K^-ppn bound state signal was detected

What the experiment can provide

- The $K^-ppn \rightarrow \Lambda d$ decay mode is unique evidence that the isospin of the K^-ppn bound state is 0
 - $I(J^P) : \Lambda = 0(1/2^+), d = 0(1^+), K^- = 1/2(0^-), {}^3\text{He} = 1/2(1/2^+)$
 - If the K^-ppn state is $0(1/2^-)$ as theoretically predicted, $K^-ppn \rightarrow \Lambda d$ should be P-wave decay *← will be studied in future with the newly constructed CDS*
- Systematic measurement of mass-number dependence will disentangle the $\bar{K}N$ interaction and short-range NN repulsion *← will be deduced by collaborating with theoretical groups*
 - binding energy, width, and system size
 - further confirmation is desirable by tighter selection on higher statistics
 - need sufficient statistics comparable to E15 (K^-pp) data
→ P92 Experiment

P92 experiment

performs more data taking of $K^{-4}\text{He}$
with the **present setup**

Beam-Time Request for P92

- As we established the K^-pp at E15, we need **$\sim 6,000 \Lambda dn$** events to provide physical information on the K^-ppn

	# of Λdn	Int. beam power
T77	~ 800	140 kW*days
P92	$\sim 6,000$	1,050 kW*days

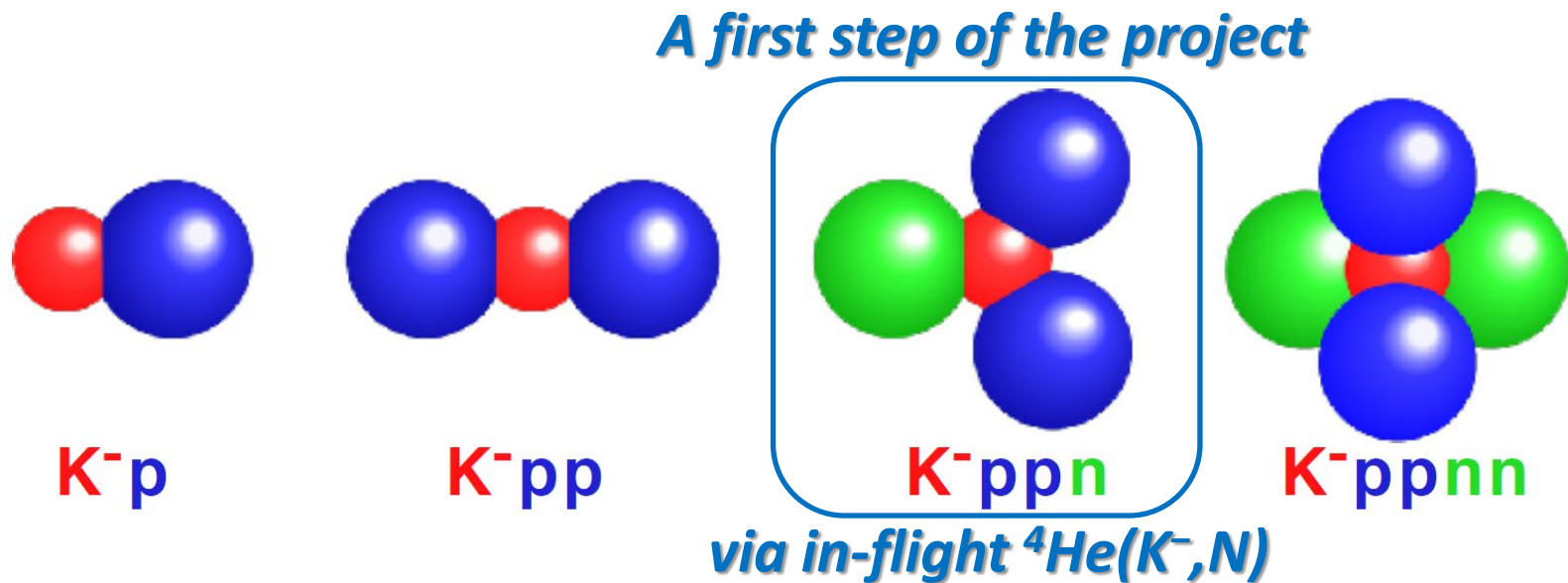
- We request **1,050 kW*days** beam time with **L^4He** target
 - corresponding to 13 days under 90 kW with 90% machine up-time
- We will also perform H_2 run for **a day** with **LH_2** target
 - To confirm the spectrometer performance under the high-intensity operation around 90 kW

Summary

- We detected the ***K^-ppn bound state*** signal via ***$^4\text{He}(K^-, \Lambda d)n$*** using T77 data
- **P92** with the **present setup** urgently provides physical information on the ***$K^-ppn \rightarrow \Lambda d$***
- **We request for urgent approval of P92**
 - All apparatus have already worked well in a safe manner

P92 Beam-Time Request	
Beam power	90kW
^4He Run	13 days
H_2 Run	1 day

Thank you for your attention!



Collaboration of E80/P92



I. Asano K. Itahashi, M. Iwasaki, Y. Ma, R. Murayama, H. Outa, F. Sakuma^{*},
T. Yamaga

RIKEN Cluster for Pioneering Research, RIKEN, Saitama, 351-0198, Japan

K. Inoue, S. Kawasaki, H. Noumi, K. Shiotori

Research Center for Nuclear Physics (RCNP), Osaka University, Osaka, 567-0047, Japan

H. Ohnishi, Y. Sada, C. Yoshida

*Research Center for Electron Photon Science (ELPH), Tohoku University, Sendai,
982-0826, Japan*



T. Hashimoto

Japan Atomic Energy Agency (JAEA), Ibaraki 319-1195, Japan



M. Iio, S. Ishimoto, K. Ozawa, S. Suzuki

High Energy Accelerator Research Organization (KEK), Ibaraki, 305-0801, Japan



T. Akaishi

Department of Physics, Osaka University, Osaka, 560-0043, Japan

T. Nagae

Department of Physics, Kyoto University, Kyoto, 606-8502, Japan



H. Fujioka

Department of Physics, Tokyo Institute of Technology, Tokyo, 152-8551, Japan



M. Bazzi, A. Clozza, C. Curceanu, C. Guaraldo, M. Iliescu, M. Miliucci, A. Scordo,
D. Sirghi, F. Sirghi

Laboratori Nazionali di Frascati dell' INFN, I-00044 Frascati, Italy



P. Buehler, E. Widmann, J. Zmeskal

Stefan-Meyer-Institut für subatomare Physik, A-1090 Vienna, Austria

