$S = -1$ BARYONIC INTERACTION STUDY THROUGH HYPERNUCLER SPECTROSCOPY AT JLAB

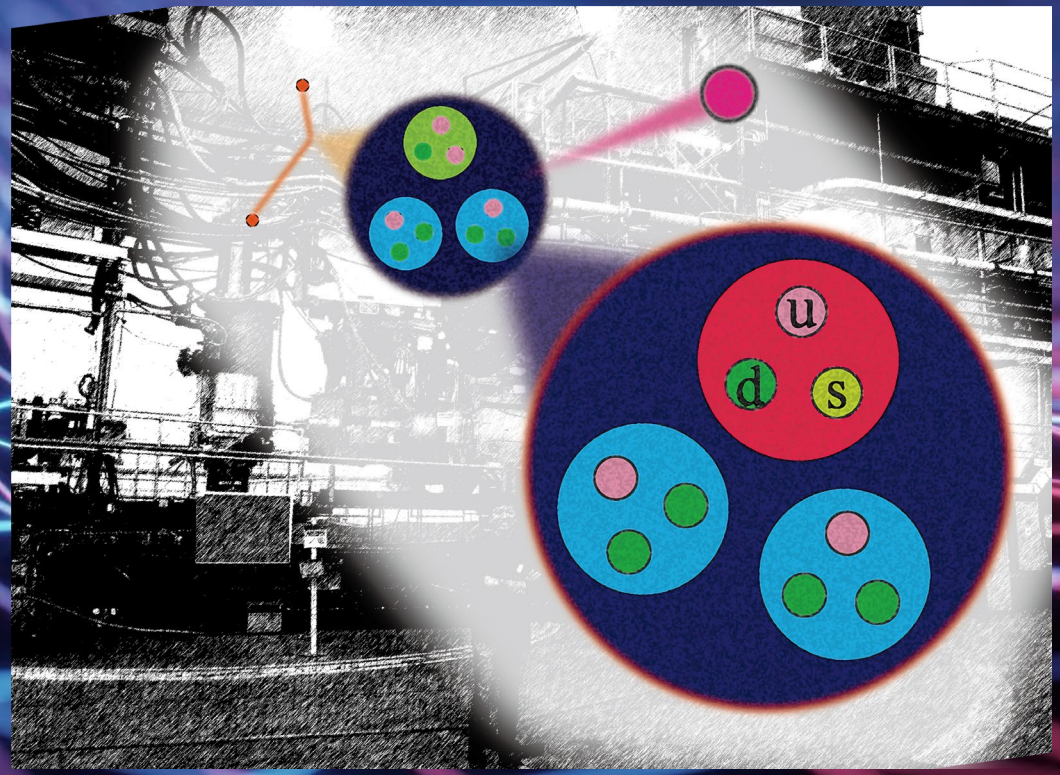
TOSHIYUKI GOGAMI (KYOTO UNIV.)

MAR 22, 2022

京都大学　理学研究科・理学部
GRADUATE SCHOOL OF FACULTY OF SCIENCE
KYOTO UNIVERSITY

PTEP Progress of Theoretical and Experimental Physics JPS
K.N. Suzuki et al., PTEP 2022 (1) 013D01 (2022)

https://www.kyoto-u.ac.jp/en/research-news/2022-03-16
→ https://www.nationaltribune.com.au/elusive-strange-nucleus-is-free-of-charge/

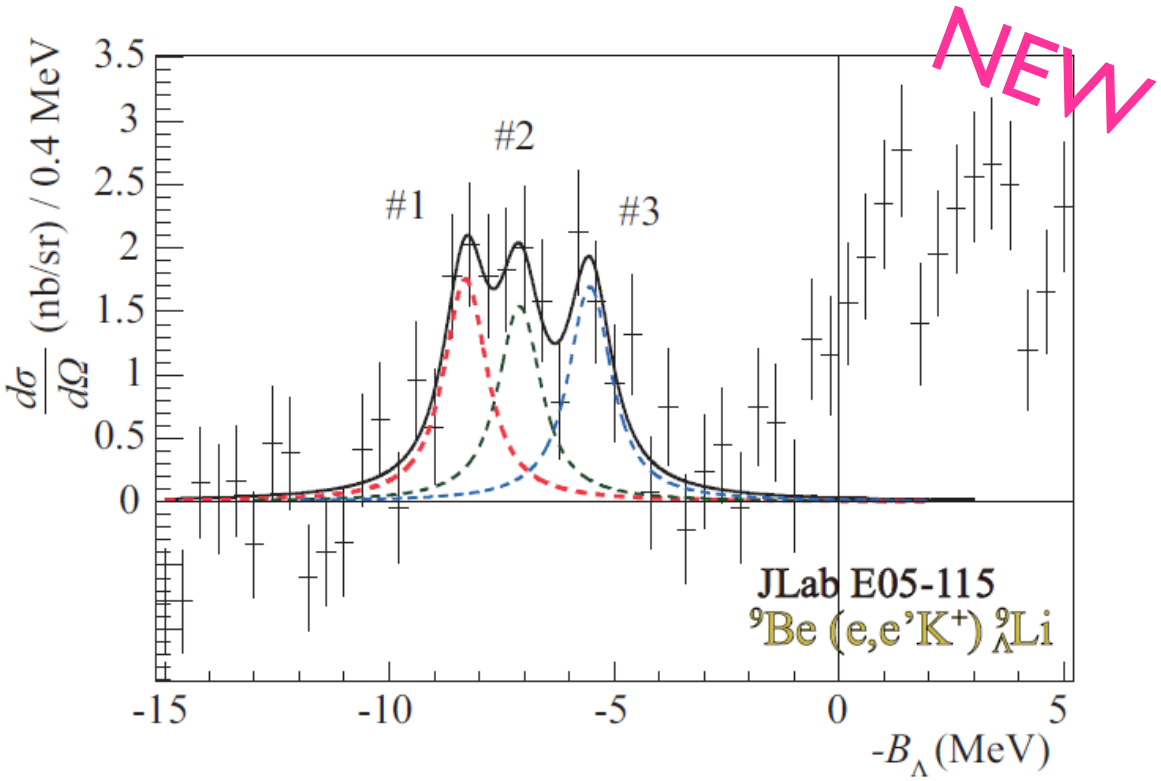


Press release (Kyoto Univ.):
https://www.kyoto-u.ac.jp/ja/research-news/2022-03-08

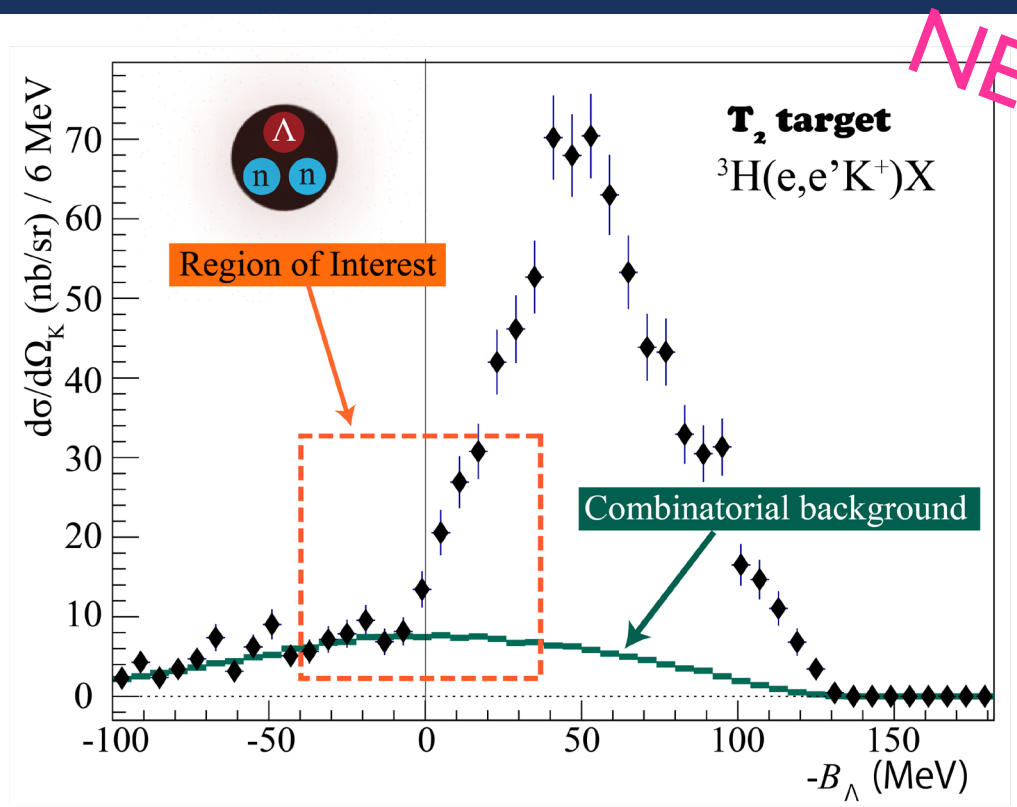
Press release (Tohoku Univ.):
https://www.tohoku.ac.jp/japanese/2022/03/press20220308-02-measurement.html
https://www.sci.tohoku.ac.jp/news/20220308-11965.html

SPIRITS
SUPPORTING PROGRAM FOR INTERACTION-BASED INITIATIVE TEAM STUDIES
科研費 KAKENHI

UPDATES FROM JLAB (APR 2021-)



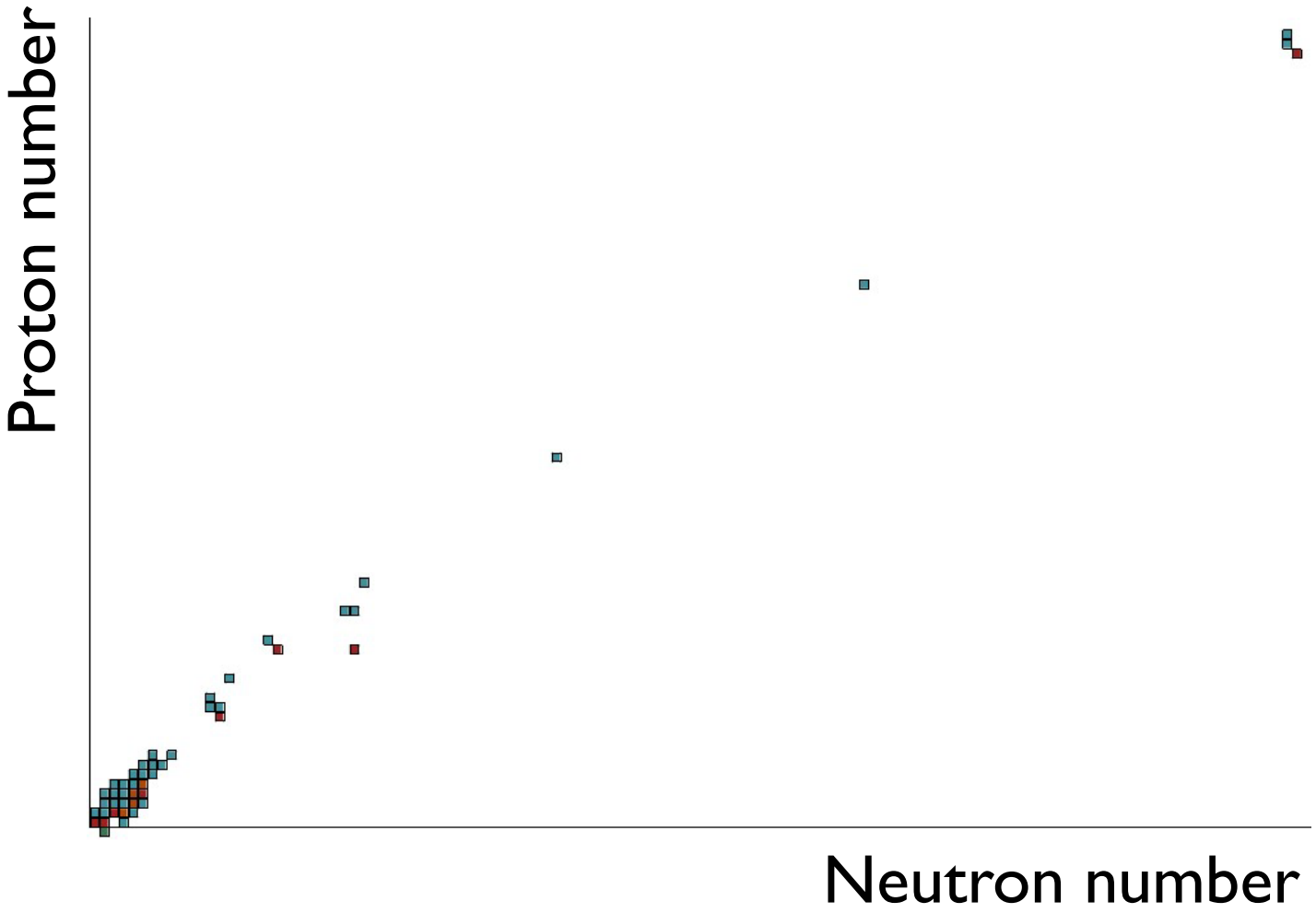
TG et al., PRC 103, L041301 (2021)
(DOI: 10.1103/PhysRevC.103.L041301)



K.N. Suzuki et al., PTEP 2022 (1) 013D01 (2022)
(DOI: 10.1093/ptep/ptab158)

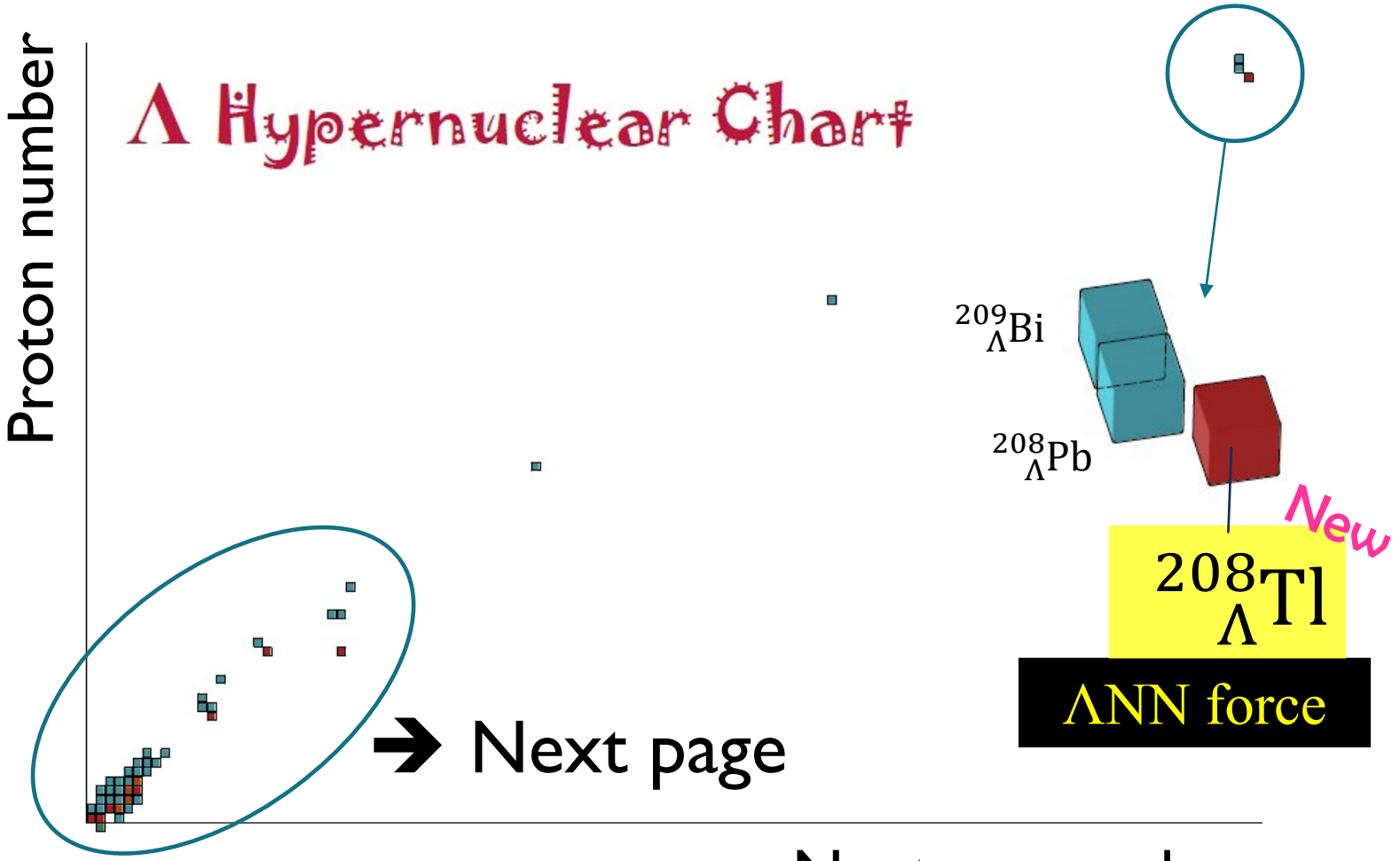
+ Kosuke (Tohoku Univ.) + Bishnu (Hampton Univ.)

NEXT EXPERIMENTS; LIGHT TO HEAVY



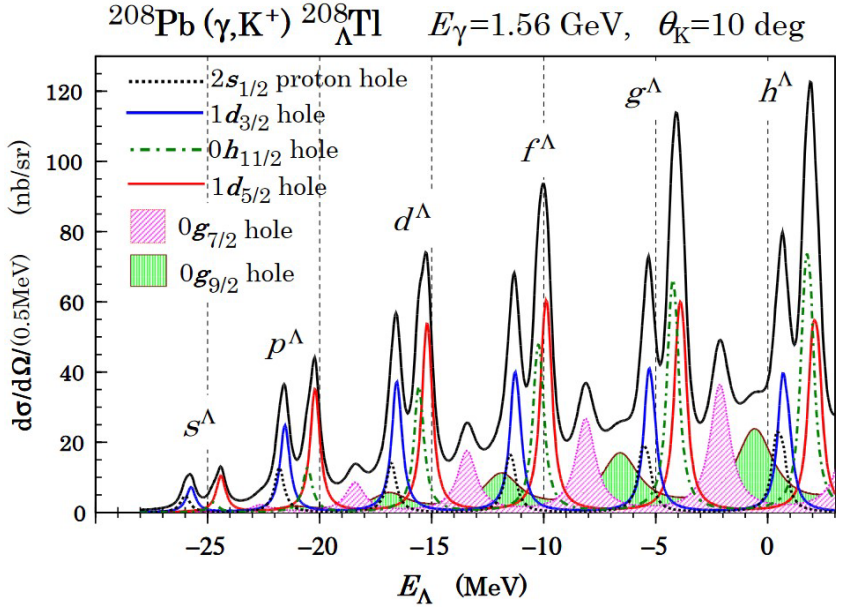
Very few…

NEXT EXPERIMENTS; LIGHT TO HEAVY



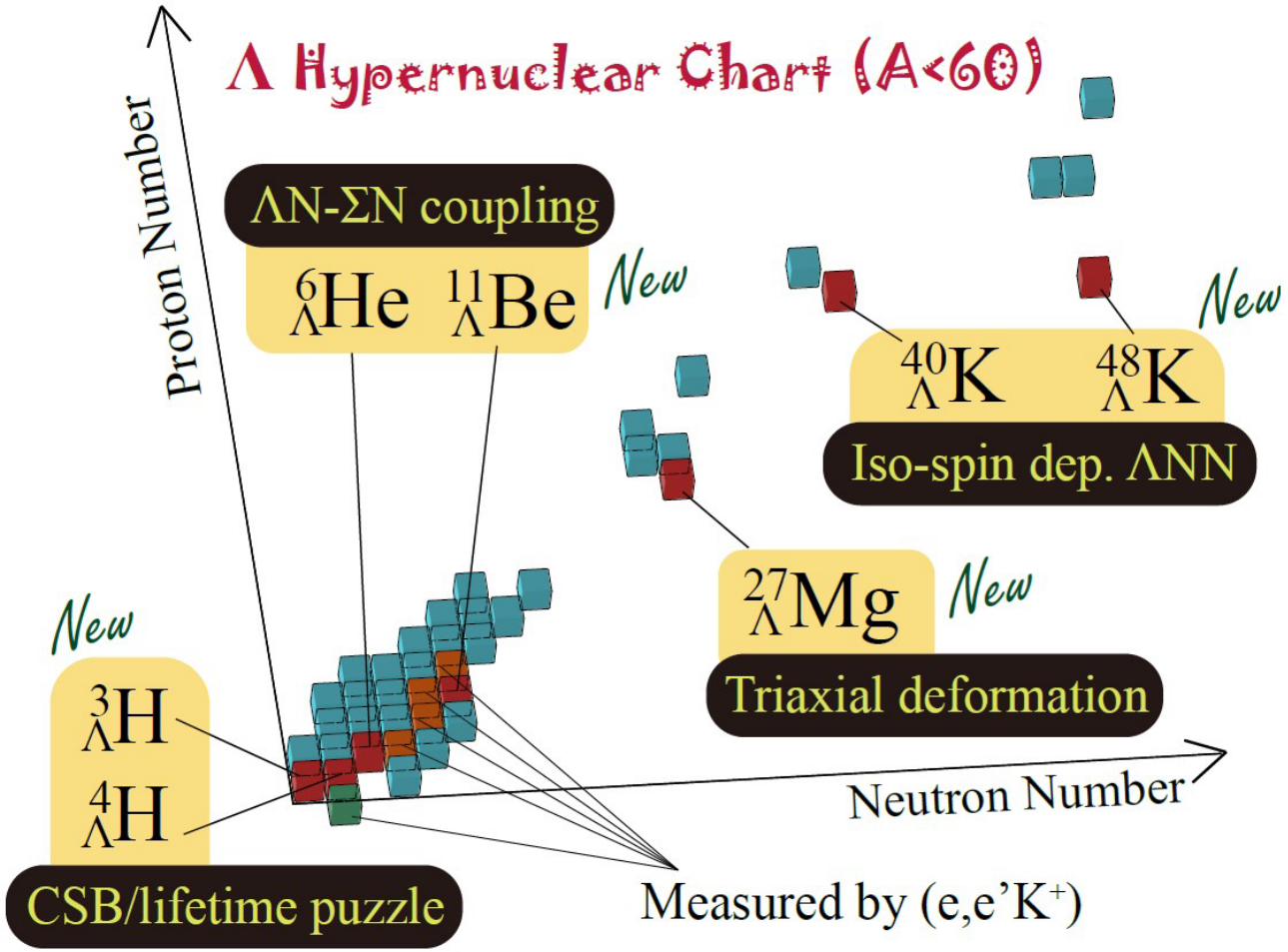
➔ Next page

T. Motoba, JPS Conf. Proc. 17, 011003 (2017)



➔ JLab E12-20-013

NEXT EXPERIMENTS; LIGHT TO HEAVY



➔ JLab E12-15-008
JLab E12-19-002

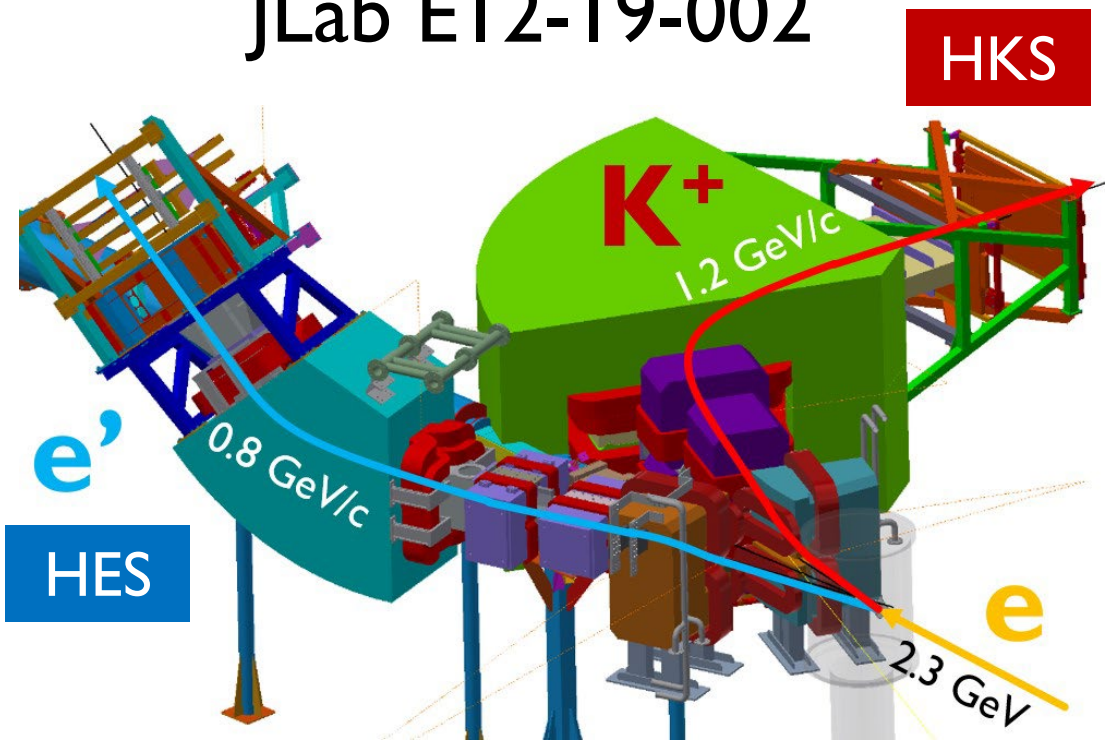


Figure from Sho

Time line ($^{3,4}_{\Lambda}$H, $^{6}_{\Lambda}$He, $^{11}_{\Lambda}$Be, $^{40,48}_{\Lambda}$K, $^{208}_{\Lambda}$Tl)

2022 2023 2024 …

Magnets — ERR (Experimental Readiness Review) → **Ready**

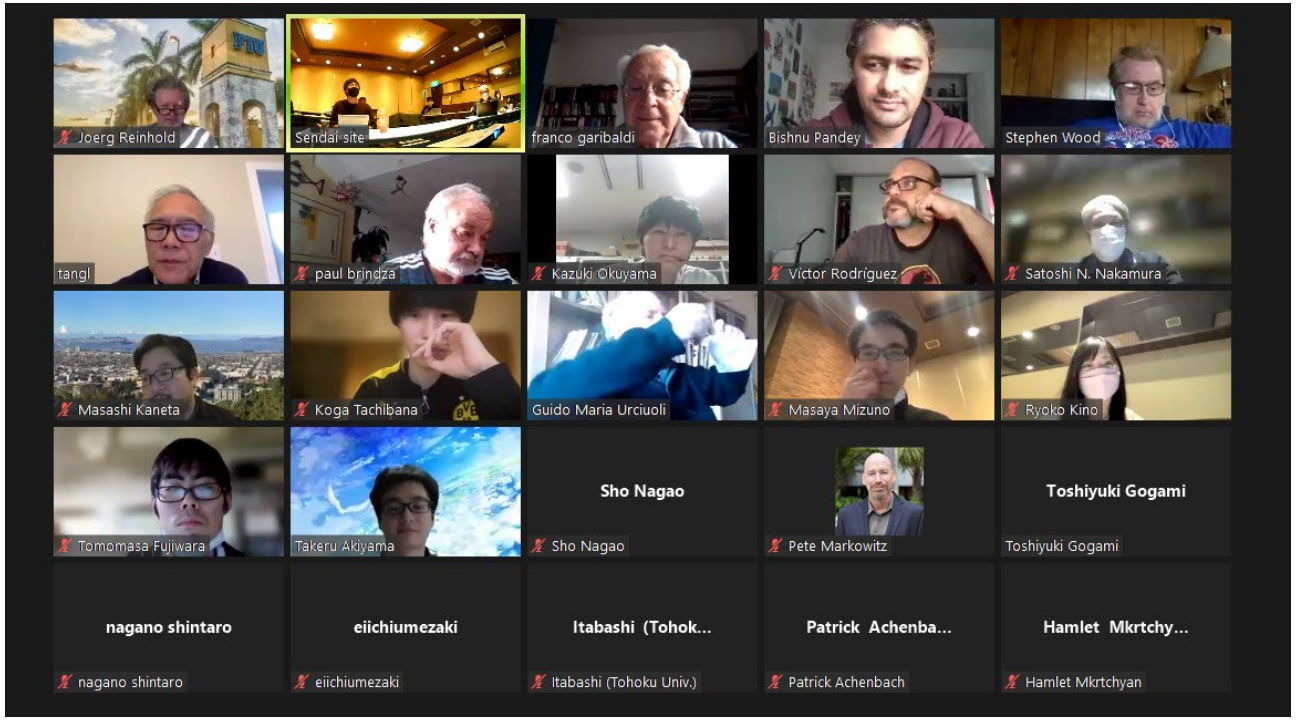
Detectors → **Ready**

Target — ERR → **Ready**

Installation

EXPERIMENT

COLLABORATION MEETING (DEC 7—9, 2021)



Discussions have been made to share the latest information with the collaborators

https://wiki.jlab.org/tegwiki/index.php/Hypernuclear_CollaborationMeeting_2021Dec

JLab Hypernuclear Collaboration (Experimentalists)

Spokespeople (7)

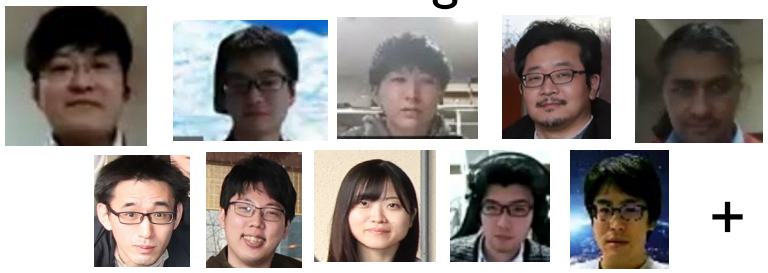
Core members
(~20)

Collaborators
(~ 50—100)

→ Univ. Tokyo

Directing the team
Communicating with JLab

Detector development / test / commissioning
Simulation
Data analysis
Leading the collaborators



+ …

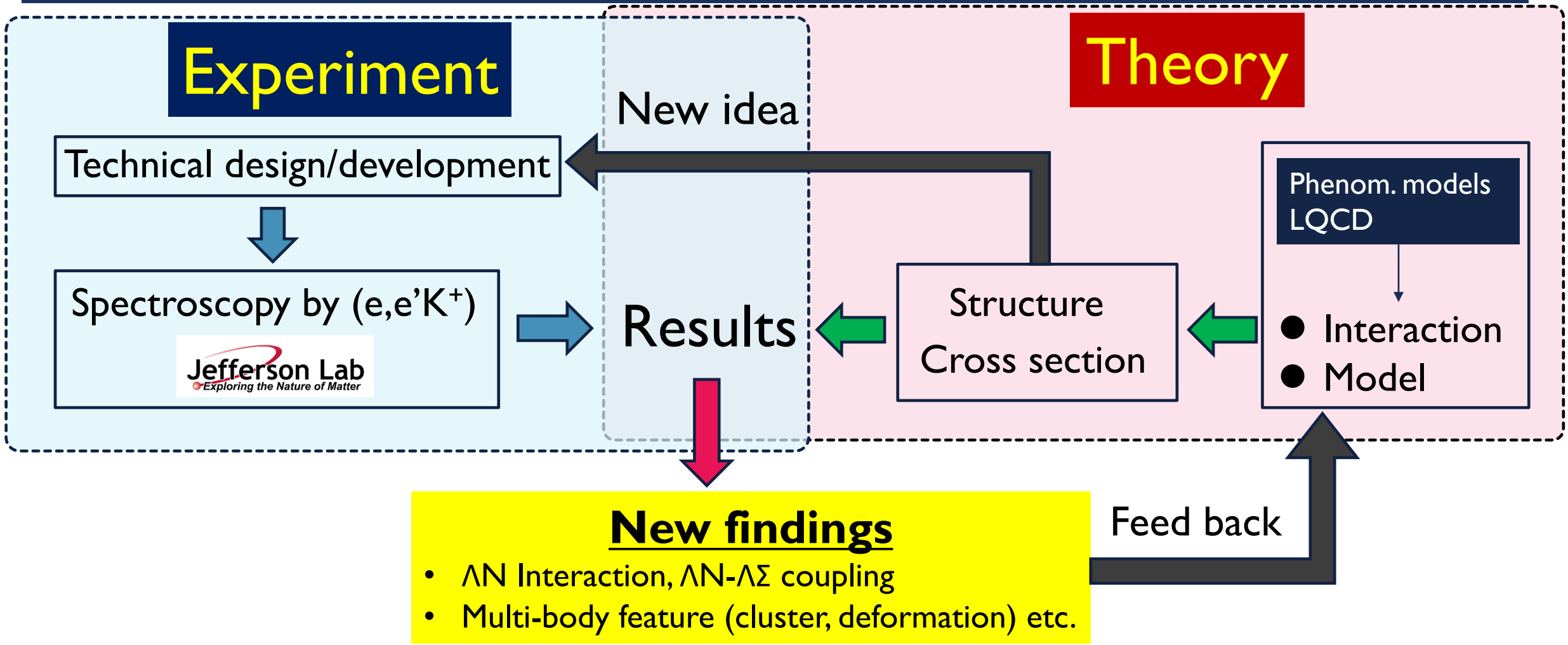
Preparation / conduction of the experiment
Shift taking

Engaging between theoretical and experimental work

Reaction	State etc.	Structure (calc.)	Cross section (calc.)	Experiment
$^{3}\mathrm{H}(e,e'K^{+})nn\Lambda$	nnΛ / FSI	○ / ?	×/ ×	○ / in progress
$^{3}\mathrm{He}(e,e'K^{+})^{3}_{\Lambda}\mathrm{H}$	$1/2^{+}$/ $3/2^{+}$,T=1	○ / ?	○ / × (T. Mart et al., PRC 78, 01004 (2008))	Next (E12-19-002)
$^{4}\mathrm{He}(e,e'K^{+})^{4}_{\Lambda}\mathrm{H}$	1^{+}	○ (Motoba, JPS Conf. Proc. 17, 011003 (2017))	○ (Motoba, JPS Conf. Proc. 17, 011003 (2017))	Next (E12-19-002)
$^{6}\mathrm{Li}(e,e'K^{+})^{6}_{\Lambda}\mathrm{He}$		○ (E. Hiayama et al., PRC 53, 5, 2075 (1996))	×	Next (E12-15-008)
$^{9}\mathrm{Be}(e,e'K^{+})^{9}_{\Lambda}\mathrm{Li}$		○ (Motoba et al., PTPS 185 (2010))	○ (Motoba et al., PTPS 185 (2010))	○ (Halls A and C)
$^{11}\mathrm{B}(e,e'K^{+})^{11}_{\Lambda}\mathrm{Be}$		○ (Umeya, Talk in JPS meeting 2022)	○ (Umeya, Talk in JPS meeting 2022)	Next (E12-15-008)
$^{27}\mathrm{Al}(e,e'K^{+})^{27}_{\Lambda}\mathrm{Mg}$		○ (Isaka, talk in PPPY-Λ2021)	×	Next (E12-19-002)
$^{40}\mathrm{Ca}(e,e'K^{+})^{40}_{\Lambda}\mathrm{K}$		○ (Motoba et al., PTPS 185 (2010))	○ (Motoba et al., PTPS 185 (2010))	Next (E12-15-008)
$^{48}\mathrm{Ca}(e,e'K^{+})^{48}_{\Lambda}\mathrm{K}$		○ (Umeya, talk in WEPH2021)	○ (Umeya, talk in WEPH2021)	Next (E12-15-008)
$^{208}\mathrm{Pb}(e,e'K^{+})^{208}_{\Lambda}\mathrm{Tl}$		○ (Motoba, JPS Conf. Proc. 17, 011003 (2017))	○ (Motoba, JPS Conf. Proc. 17, 011003 (2017))	Next (E12-20-013)

⇨ Calculations by different frameworks are necessary for data analysis & discussion

COLLABORATION WORK



COLLABORATION WORK

Experiment

Theory

New idea

Technical design/development

Spectroscopy

Cross section

Interaction

Model

I would like to start discussing

Next after next

- Isotope targets → isospin dep.
- Isobaric targets → delta dep. with the same A
- $pp(e,e'\pi^+K^+)n\Lambda$ → More n rich?
- $p(e,e'K^+K^+)\Xi^-$ → Ξ hypernuclei?
- etc.

New findings

- ΛN Interaction, ΛN-ΣΛ coupling
- Multi-body feature (cluster deformation) etc.

Feed back

Let’s continue close discussions!

2020

- **W**orkshop on **E**lectro- and **P**hoto-Production of **H**ypernuclei 2020
  http://physics.daliborskoupil.cz/workshop2020.html (Feb)

WEPH 2020

- **W**orkshop on **E**lectro- and **P**hotoproduction of **H**ypernuclei and **Re**lated Topics 2020
  http://physics.daliborskoupil.cz/onlineWS2020/ (Dec)

WEPH RE: 2020

2021

- **W**orkshop on **E**lectro- and **P**hotoproduction of **H**ypernuclei and **Re**lated Topics 2021
  http://physics.daliborskoupil.cz/rezWS2021/ (Sep)

WEPH RE: 2021

2022

This WS

比叡
HIEI 2022

- **H**ypernuclear **I**nvestigation with **E**lectromagnetic **I**nteraction (HIEI2022)
  https://wiki.jlab.org/tegwiki/index.php/HIEI2022_20220316 (Mar)
- **W**orkshop on **E**lectro- and **P**hotoproduction of **H**ypernuclei and **Re**lated Topics 2022 (Sep?)

WEPH RE: 2022

We are

Multi-body (strangeness) system bound by the **strong** interaction

WEPH 2020

Czech Republic, Feb 2020

PPPY-Λ 2021 (web page)

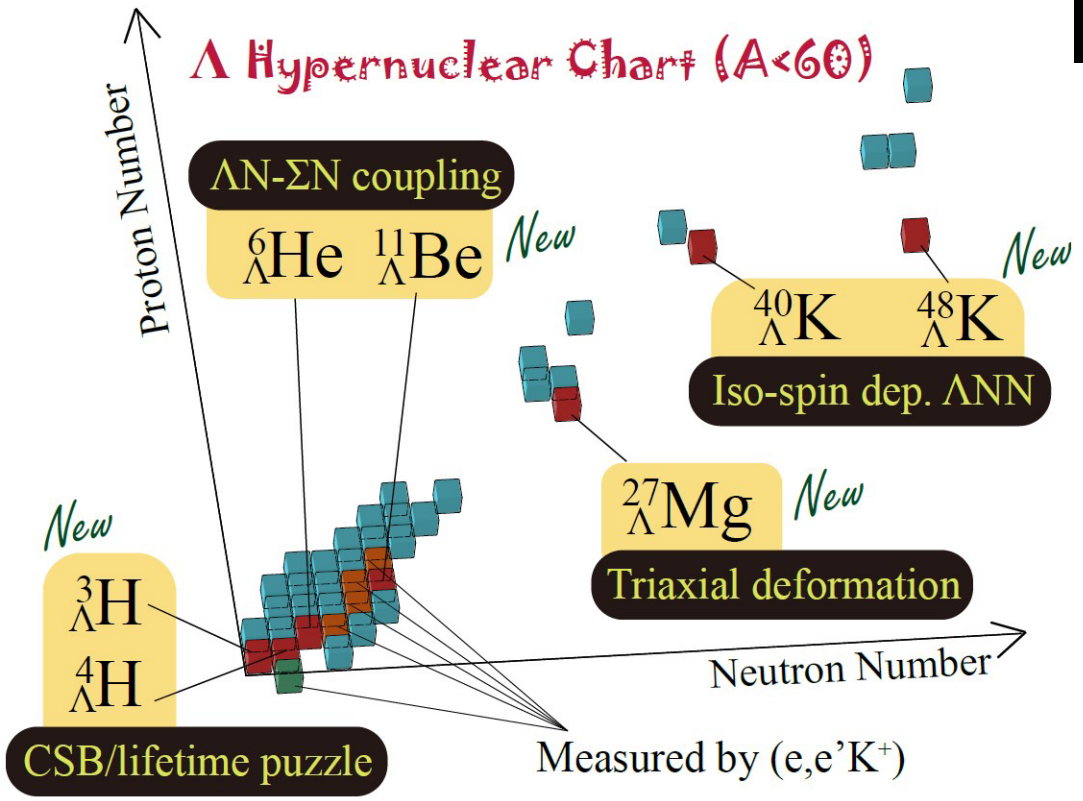
Sendai, Japan, Dec 2021

SUMMARY

New

$^{208}_{\Lambda}$Tl

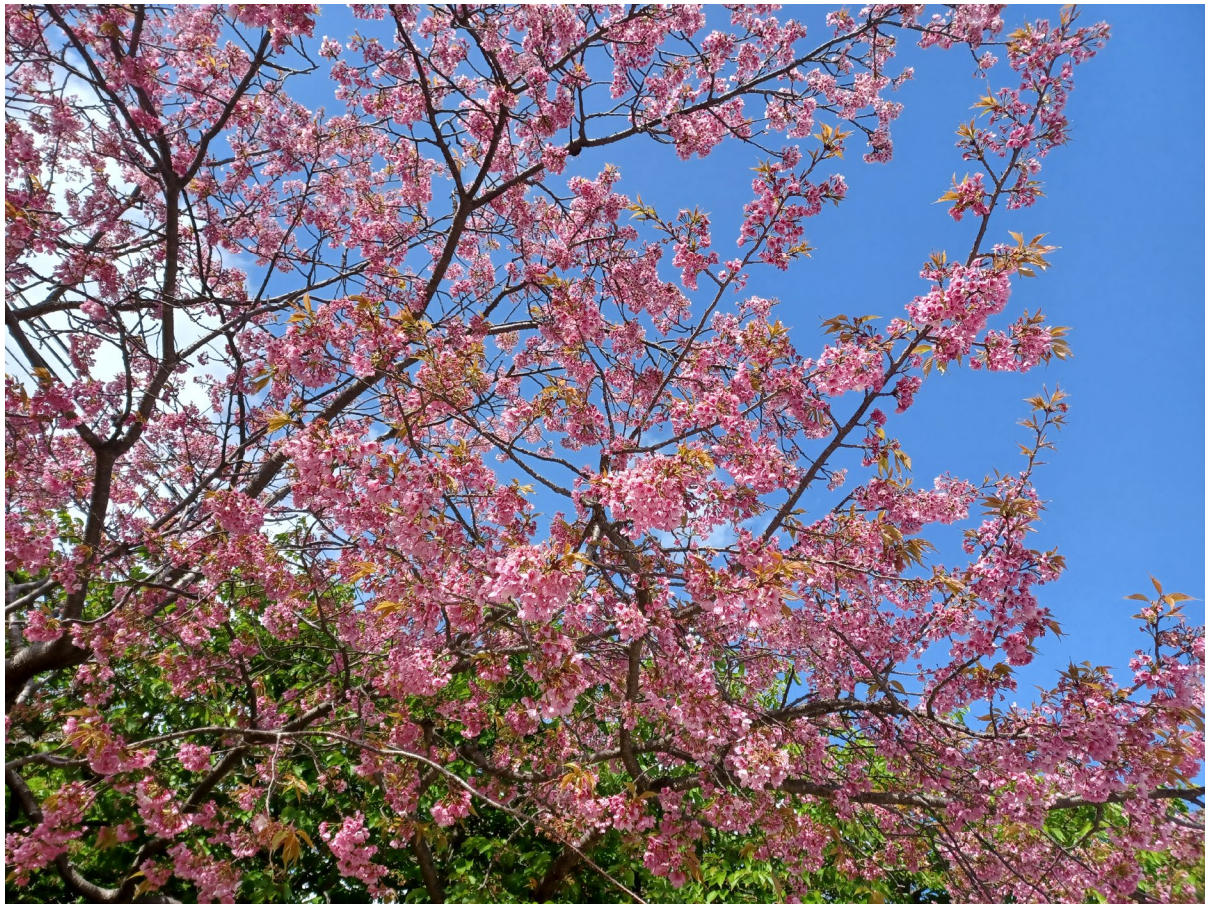
ΛNN force



What's next?

- Isotope targets → isospin dep.
- Isobaric targets → delta dep. with the same A
- pp(e,e'π^+K^+)nΛ → More n rich?
- p(e,e'K^+K^+)Ξ^- → Ξ hypernuclei?
- eta'
- etc.

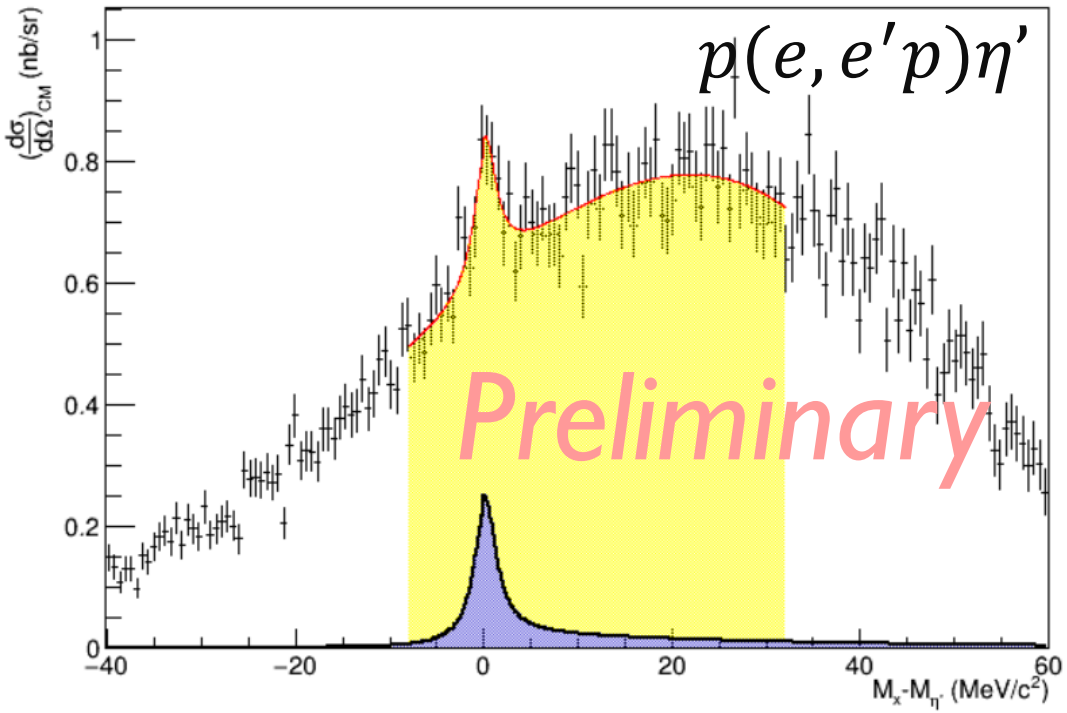
Jefferson Lab
Thomas Jefferson National Accelerator Facility



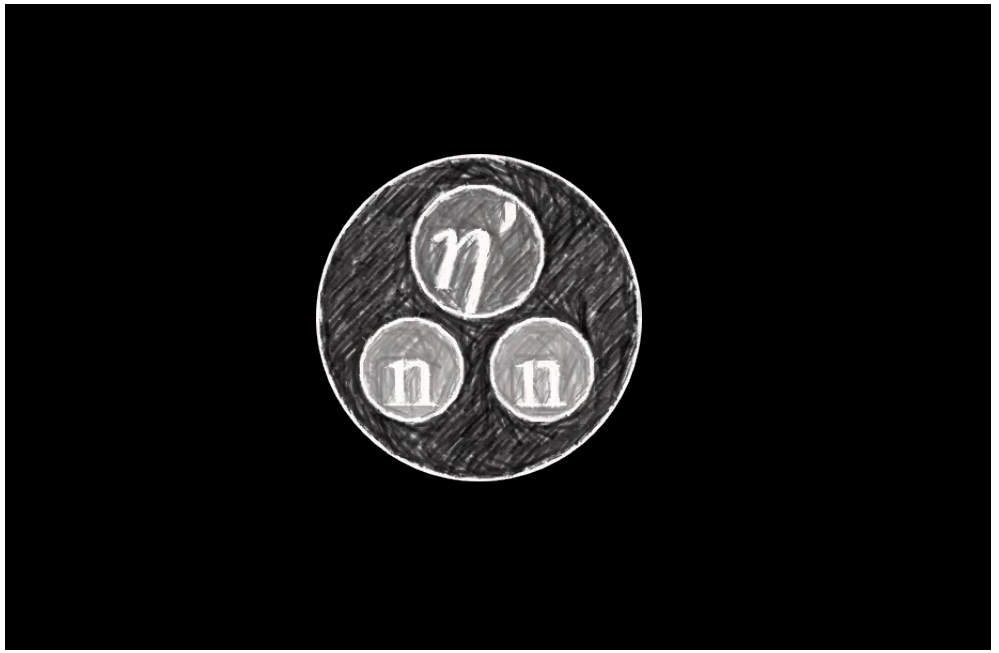
BACKUP

ETA'

Jefferson Lab
Thomas Jefferson National Accelerator Facility

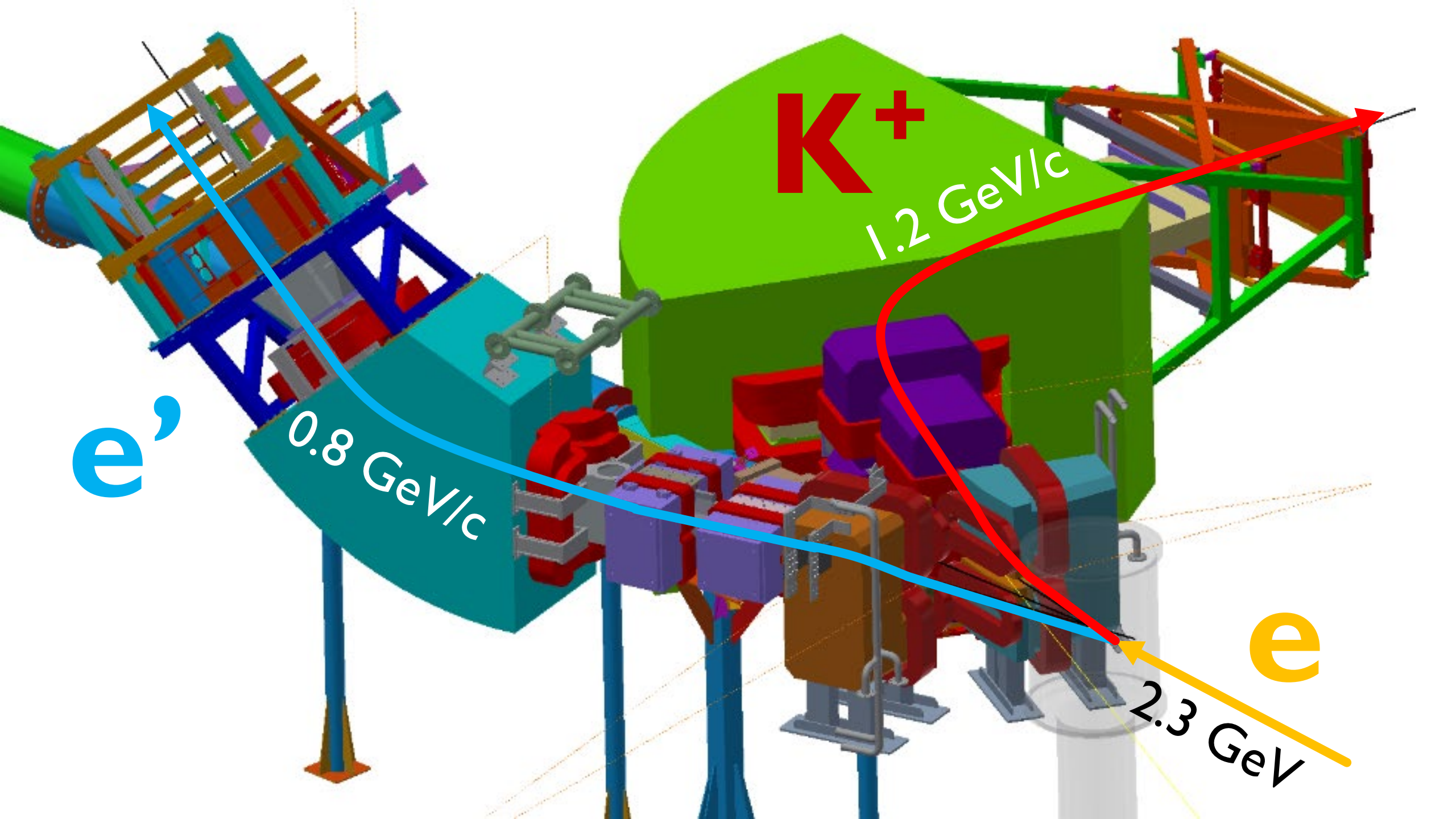


Proton target



Tritium target

Data exist already (← E12-17-003)


K+
1.2 GeV/c
e'
0.8 GeV/c
e
2.3 GeV

Isobaric hypernuclei

- $^{48}\mathrm{Ti}(e,e'K^+)^{48}_{\Lambda}\mathrm{Sc}$
  - (Z, N) = $^{48}_{\Lambda}$Sc (21, 26) vs. $^{48}_{\Lambda}$K (19, 28)
  - → the same mass number, but the different δ
- $^{40}\mathrm{Ar}(e,e'K^+)^{40}_{\Lambda}\mathrm{Cl}$ vs. $^{40}\mathrm{Ca}(e,e'K^+)^{40}_{\Lambda}\mathrm{K}$
- $^{46}\mathrm{Ca}(e,e'K^+)^{46}_{\Lambda}\mathrm{K}$ vs. $^{46}\mathrm{Ti}(e,e'K^+)^{46}_{\Lambda}\mathrm{Sc}$
- $^{48}\mathrm{Ca}(e,e'K^+)^{48}_{\Lambda}\mathrm{K}$ vs. $^{48}\mathrm{Ti}(e,e'K^+)^{48}_{\Lambda}\mathrm{Sc}$
- $^{50}\mathrm{Ti}(e,e'K^+)^{50}_{\Lambda}\mathrm{Sc}$ vs. $^{50}\mathrm{V}(e,e'K^+)^{50}_{\Lambda}\mathrm{Ti}$ vs. $^{50}\mathrm{Cr}(e,e'K^+)^{50}_{\Lambda}\mathrm{V}$
- $^{54}\mathrm{Cr}(e,e'K^+)^{54}_{\Lambda}\mathrm{V}$ vs. $^{54}\mathrm{Fe}(e,e'K^+)^{54}_{\Lambda}\mathrm{Mn}$

58: Fe, Ni
64: Ni, Zn
70: Zn, Ge
74: Ge, Se
76: Ge, Se
78: Se, Kr
… a lot

- $^{13}\mathrm{C}(e,e'K^+)^{13}_{\Lambda}\mathrm{B}$
- $^{14}\mathrm{N}(e,e'K^+)^{14}_{\Lambda}\mathrm{C}$