

11th May 2020

**JLab Hypernuclear Workshop
(Blue Jeans)**



Hypernuclear Physics at JLab in the 12GeV era

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Current problems on Λ hypernuclei

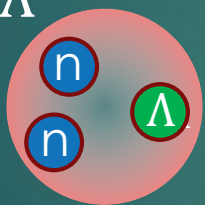
Hypertriton Puzzle

Shallow bound
Short lifetime

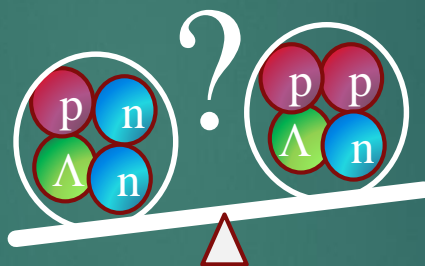


Λ^3n Puzzle

Bound?
Resonance?
Not Exist?



CSB of Λ Hypernuclei



Hyperon Puzzle



Why massive
NS exists?

$A=3$
 10^{-15} m



$A \sim 10^{57}$
 10^4 m

Current problems on Λ hypernuclei

Hypertriton Puzzle

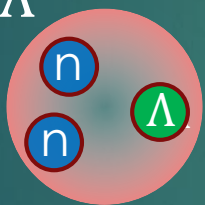
C12-19-002

Shallow bound
Short lifetime



${}^3_\Lambda n$ Puzzle

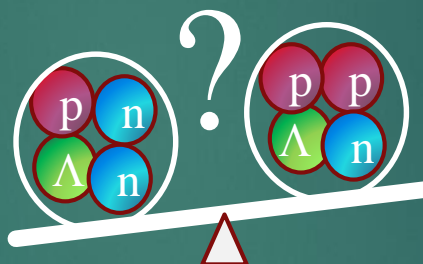
Bound?
Resonance?
Not Exist?



E12-17-003

CSB of Λ Hypernuclei

E12-15-008



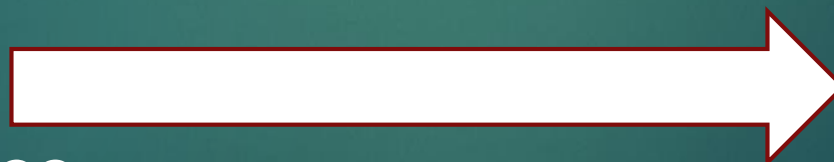
Hyperon Puzzle



Why massive
NS exists?

P12-18-004

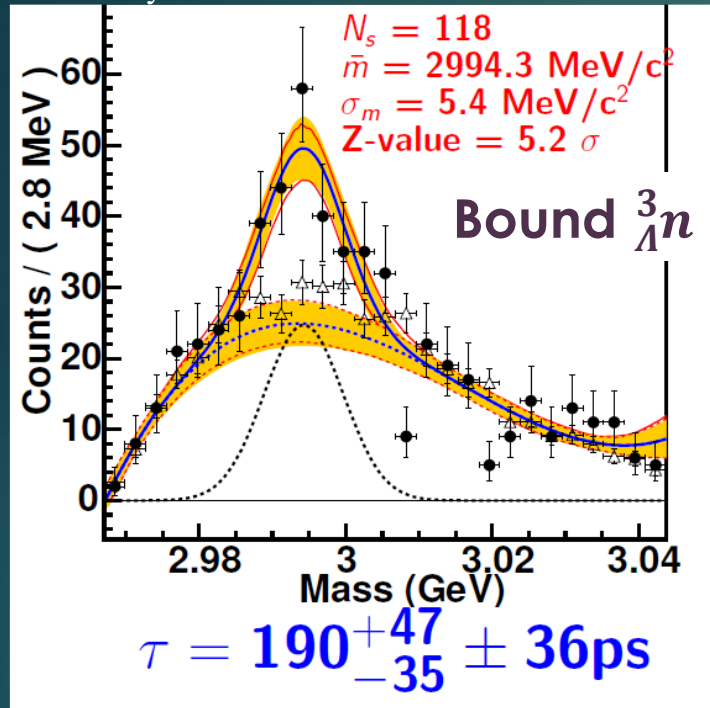
$A=3$
 10^{-15} m



$A \sim 10^{57}$
 10^4 m

$nn\Lambda$ state exists?

C. Rappold et al. (HypHI Collaboration),
Phys. Rev. C 88, 041001(R) (2013).
Talk by C.R. at EMMI2

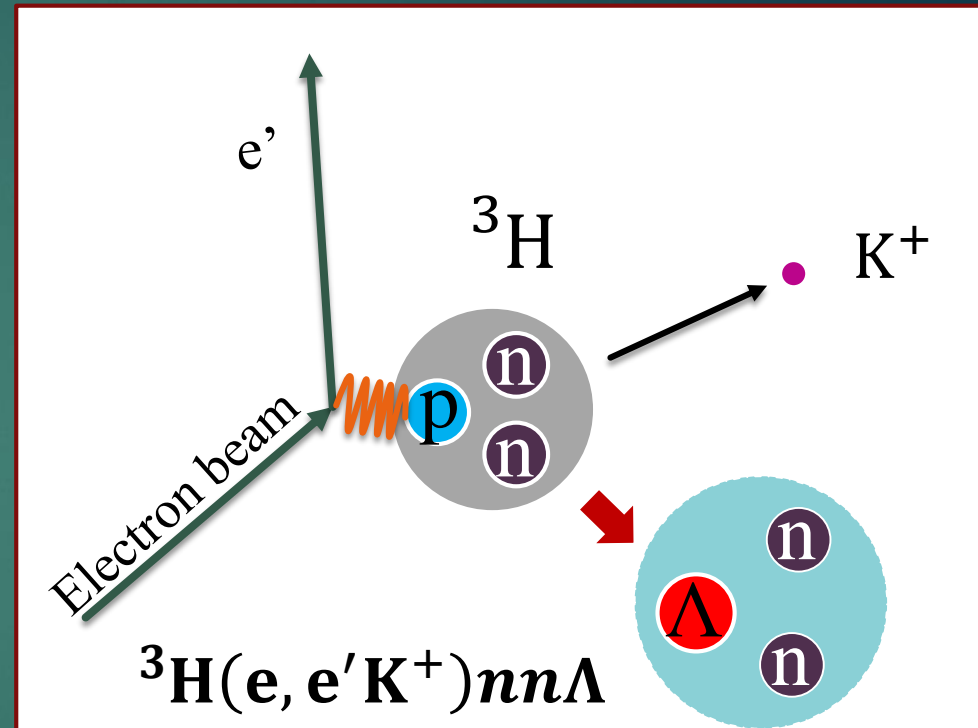


Resonance $nn\Lambda$ may exist:

I.R.Afnan et al., PRC 92, 054608 (2015)

H. Kamada et al., EPJ Web Conf. 113, 07004 (2016)

I.Filikhin et al., EPJ Web Conf. 113, 08006 (2016).



Bound $3\Lambda n$ cannot be reproduced:

E. Hiyama et al., Phys. Rev. C 89, 061302(R) (2014)

A. Gal et al., Phys. Lett. B 736, 93–97 (2014)

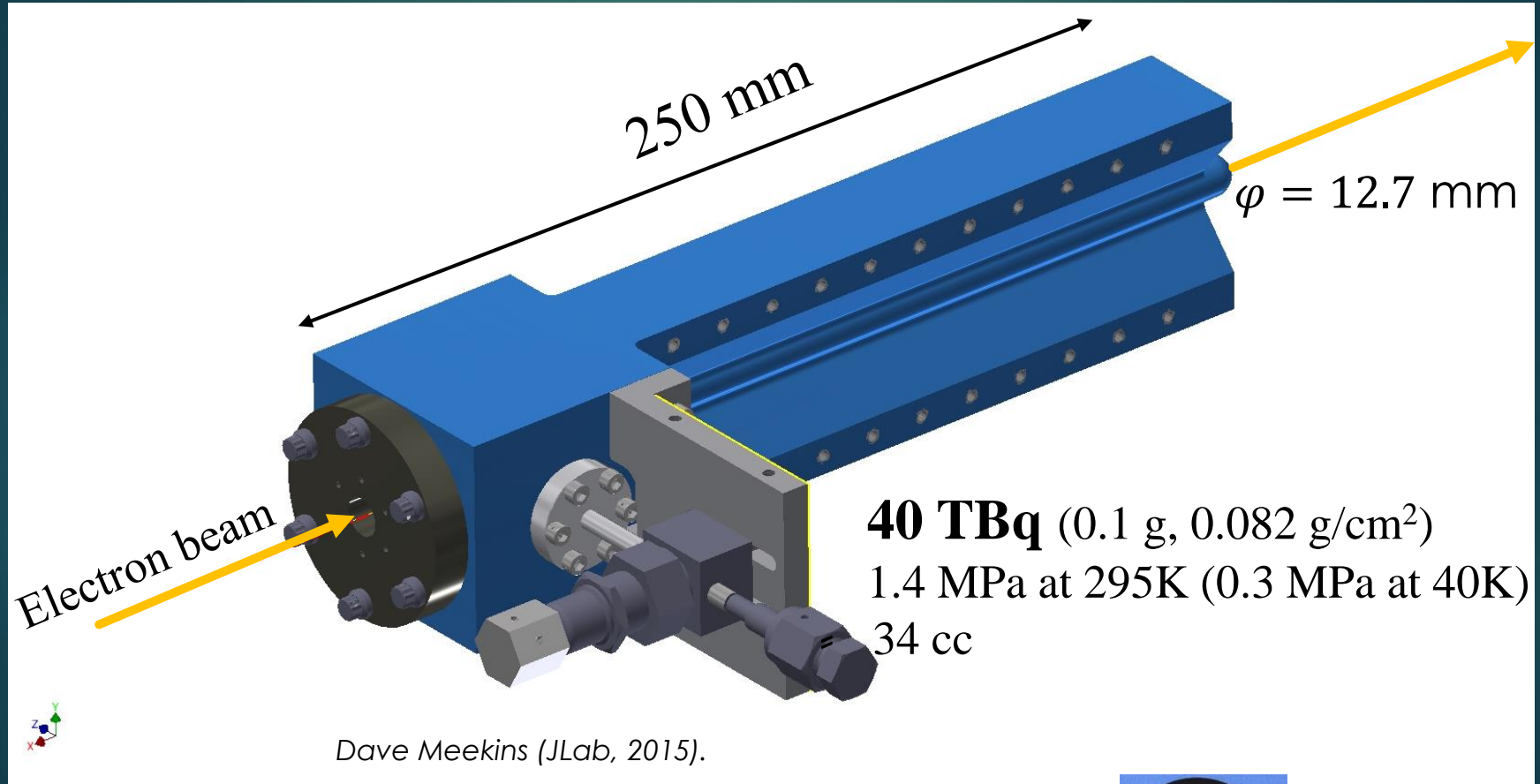
Detectable both bound and resonance states

E12-17-003 : Exp. Performed in 2018

${}^3T(e, e' K^+) nn\Lambda$

Target cell of tritium gas

Cell material:
Al alloy (ASTM B209 AL 7075-T651)



Typical Checking Source for Detector Test :
3.7 MBq

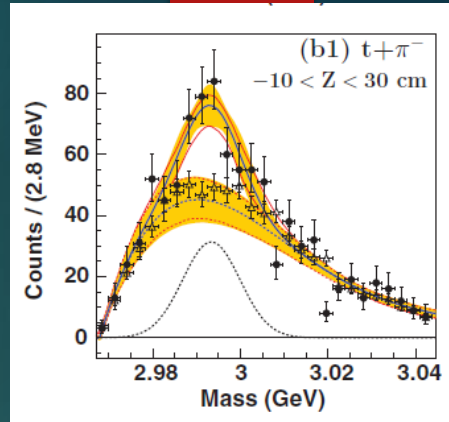


$\times 10^7$

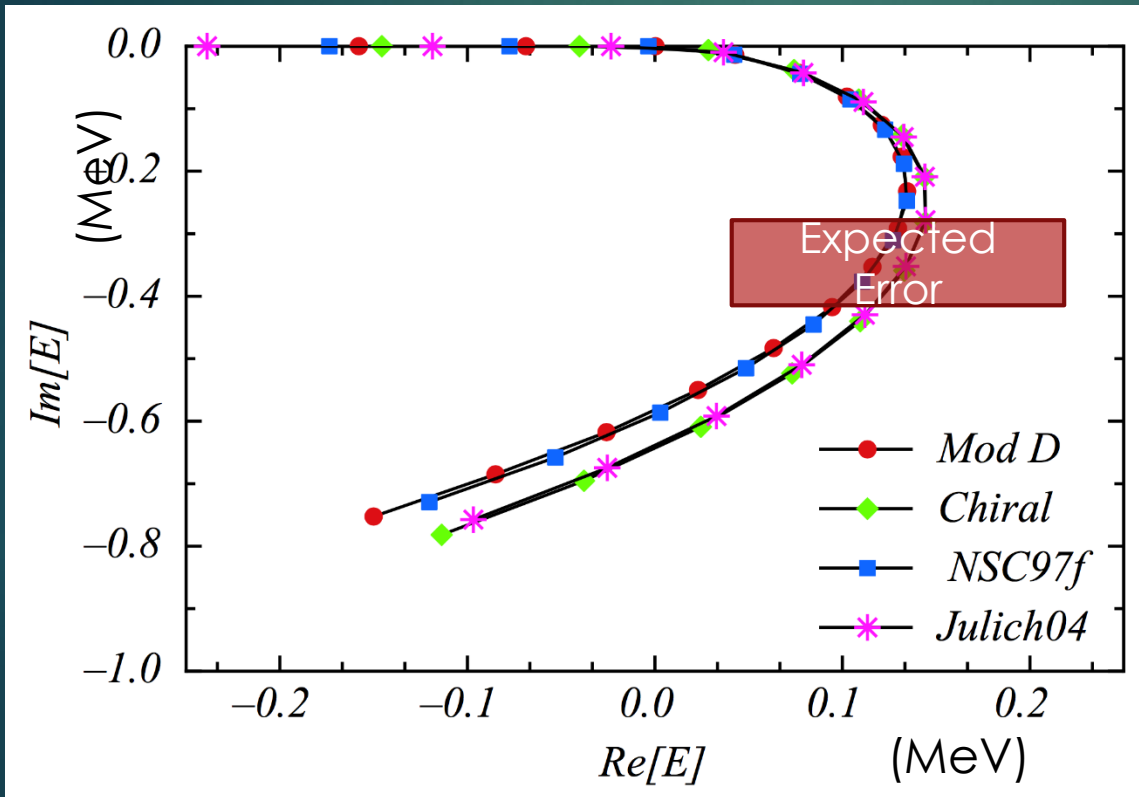
JLab E12-17-003

An interaction study
by investigation of Λ_{nn} resonance

Jlab PAC45 approved
as "High-Impact" exp.
(June 2017)



C.Rappold et al.
PRC 88041001(R) (2013)



${}^3T(e, e' K^+) nn\Lambda$

Beamtime finished
Nov.- Dec. 2018.

Analysis is in progress.

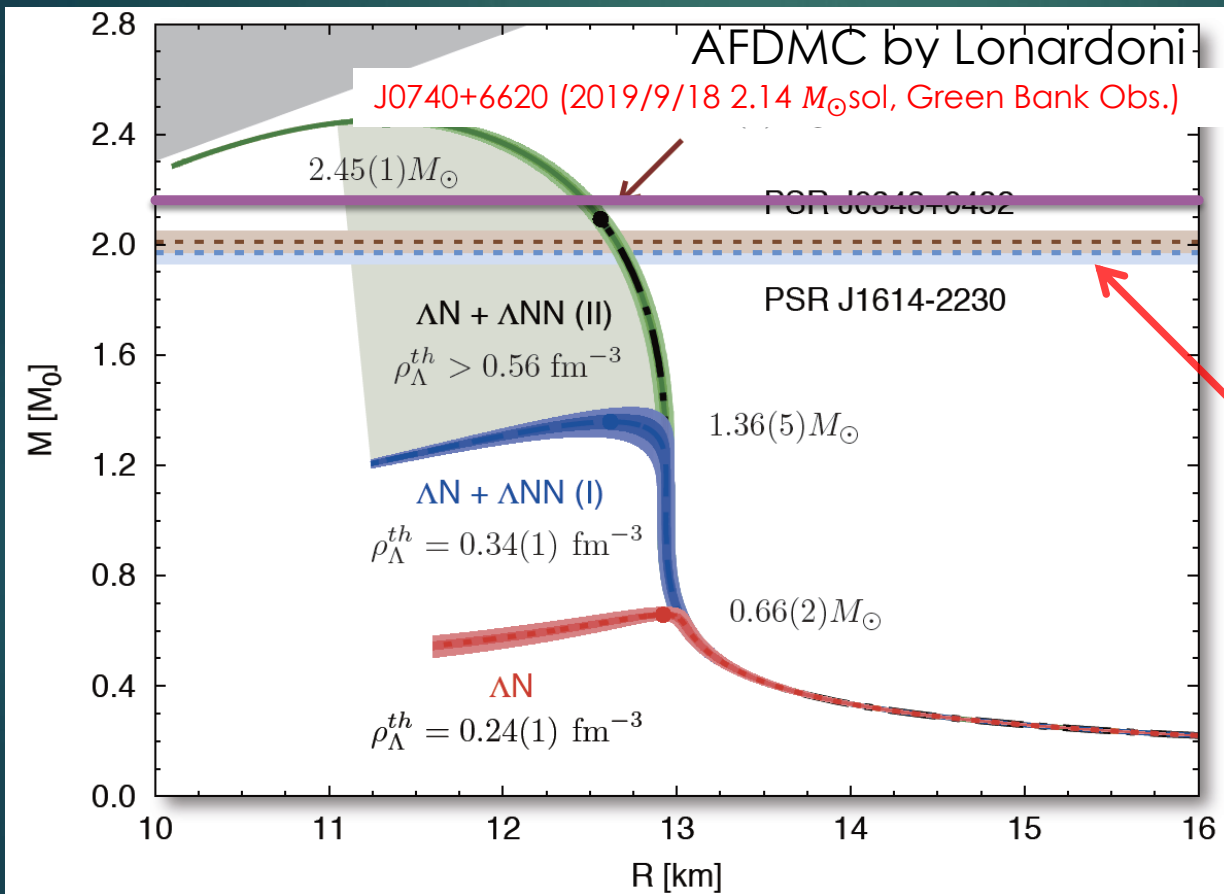
I.R.Afnan and B.F.Gibson, PRC 92, 054608 (2015)

Existing potential models allow $E \sim$ a few 100 keV resonance state.

Hyperon Puzzle

Based on our knowledge on Baryonic Force:

Hyperon naturally appear at high density ($\rho = 2 \sim 3\rho_0$)



Too Soft EOS

**Contradict
to
observation**

2 M_\odot Neutron Stars

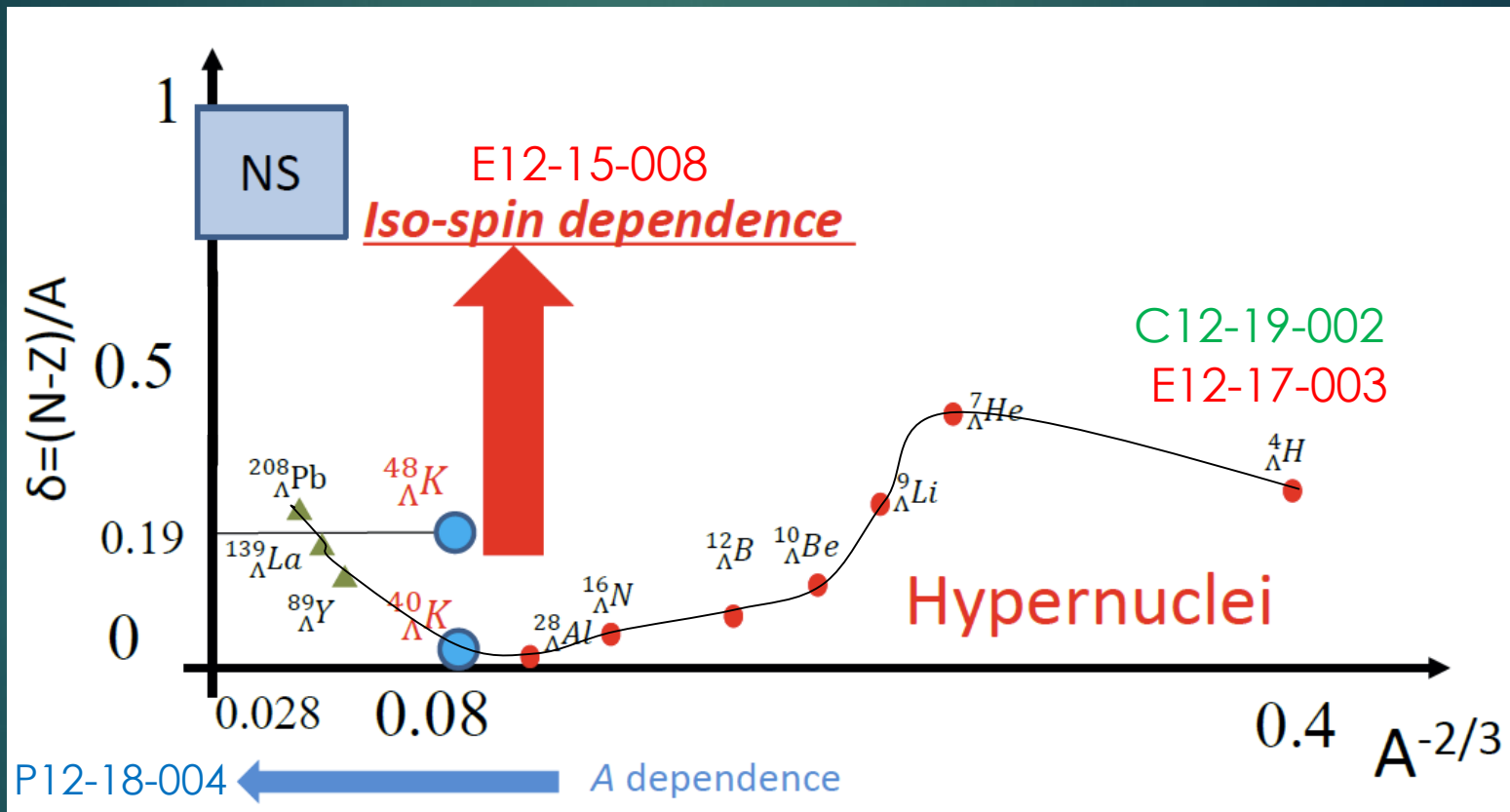
Additional Force
to make EOS stiff

AFDMC by Lonardoni et al. PRL114 (2015) 092301, updated (2016)

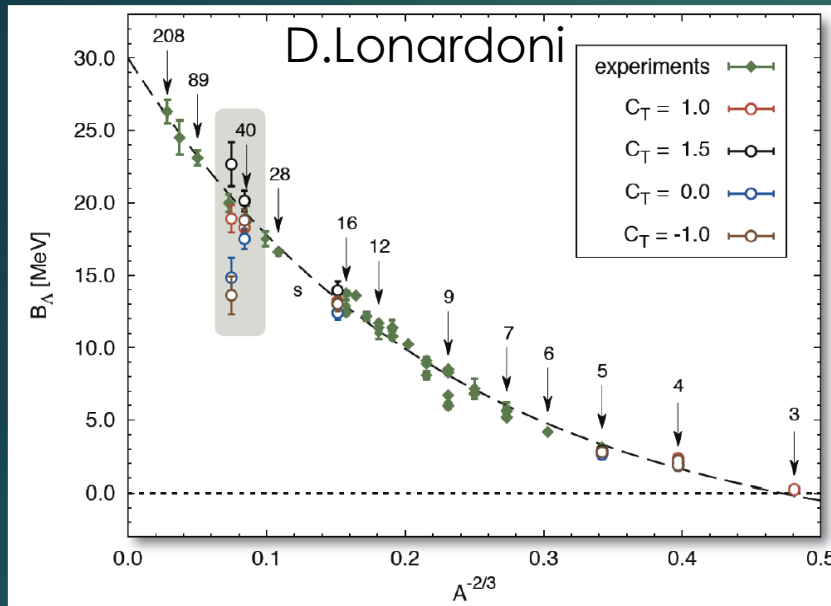
ESC08c + 3B/4B RF : G-Matrix Calc. by Yamamoto et al., PRC 90 (2014) 045805.

Variational Meth. + AV18+UIX by Togashi et al., PRC 93 (2016) 035808

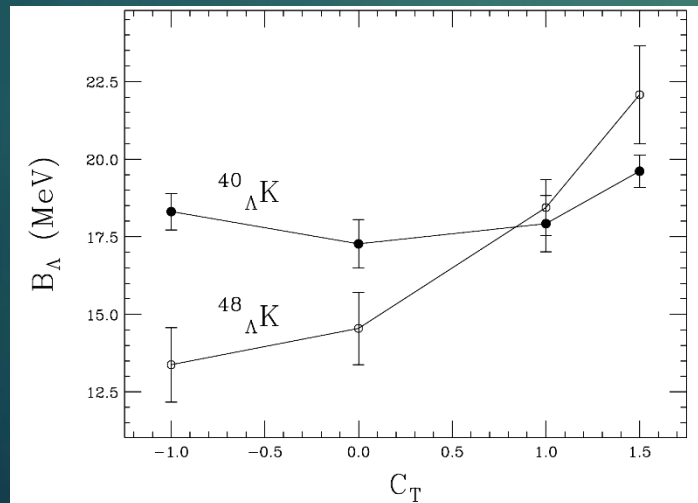
From Hypernuclei to NS



Phenomenological 3 BRF+AFDMC



C_T : Parameter to gauge Λ nn contribution in Λ NN potential

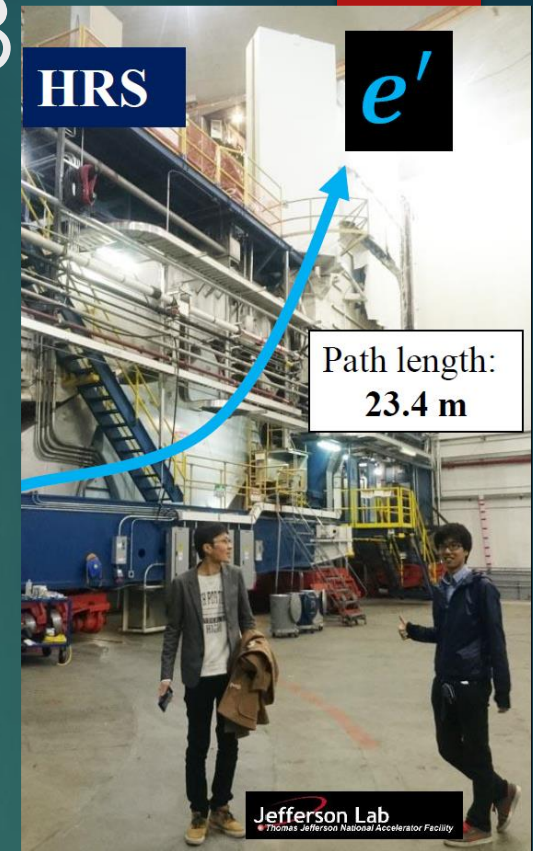
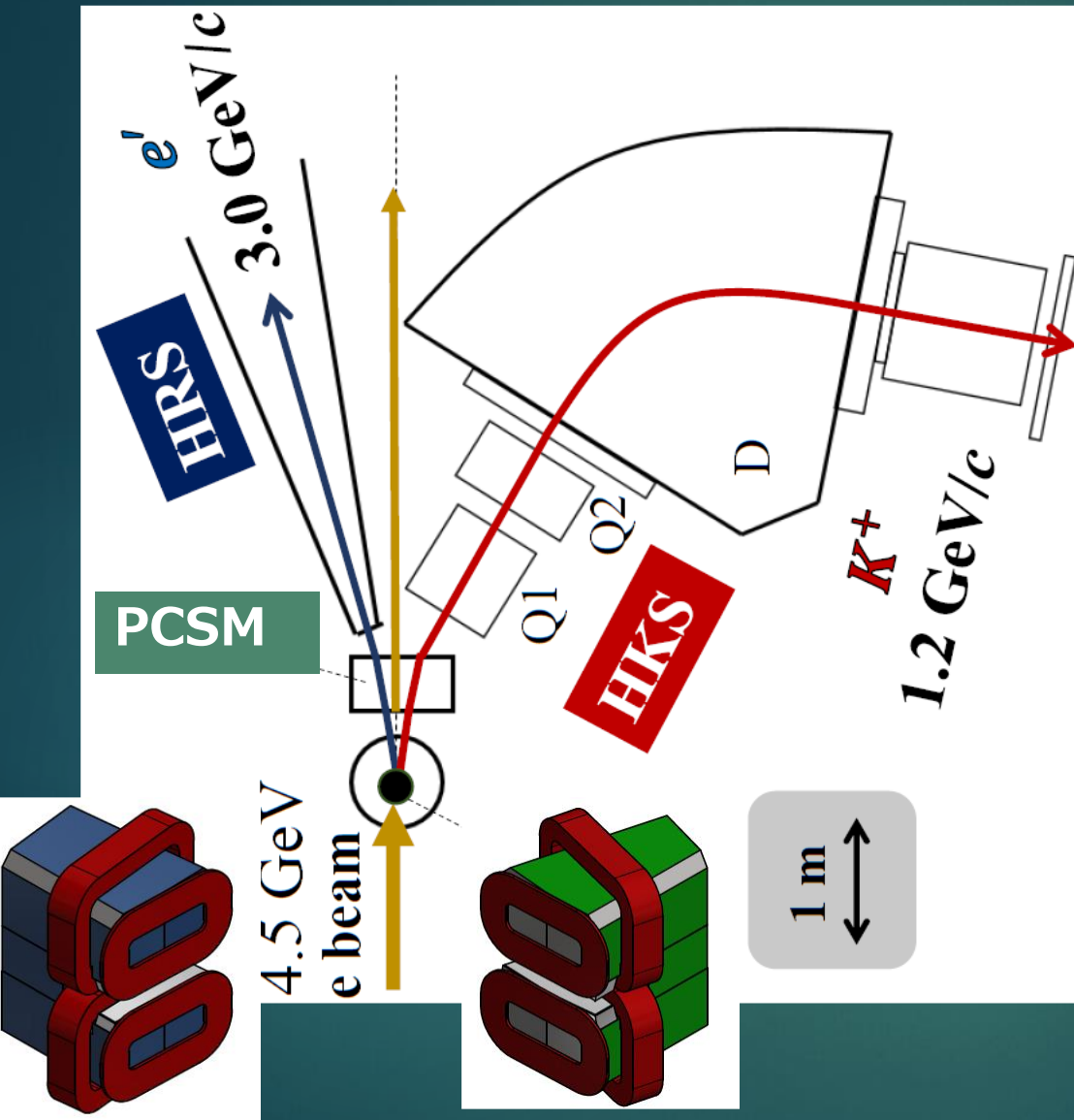


$^{40}\text{Ca}(e, e'K^+)^{40}_\Lambda K$ and $^{48}\text{Ca}(e, e'K^+)^{48}_\Lambda K$

E12-15-008
accepted with GRADE A.

Other calculations are important to analyze new data.

New setup for E12-15-008



New Pair Charge Sep. Mag.
 $^{40,48}\text{Ca}$ targets

prepared and
already in hand.

To be done before E12-15-008 beamtime

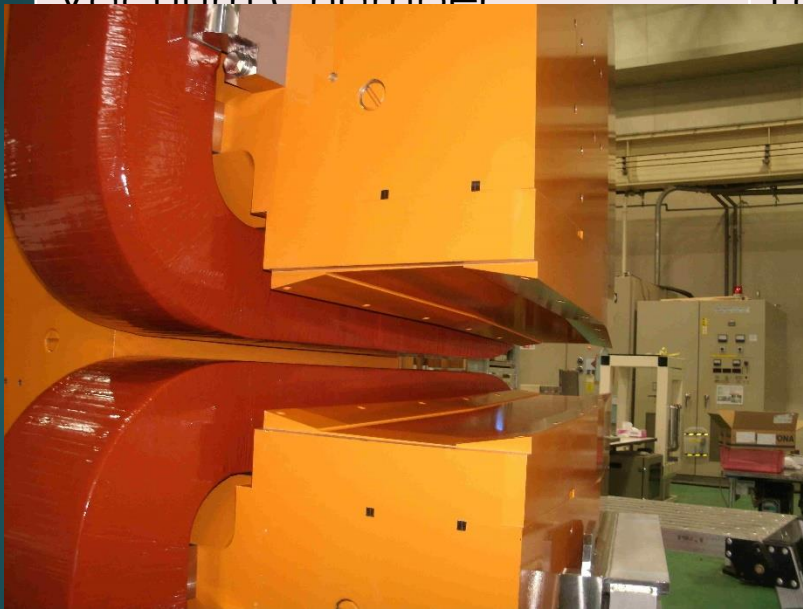


| Item | Status | Schedule |
|-----------------------------|---------------------|------------------|
| Pair of Charge Sep. Magnets | Completed | Ready for ship |
| Vacuum Chamber | For Solid targets | Und. Design |
| | For Cryo. targets | Depends on PAC48 |
| Targets | $^{40,48}\text{Ca}$ | Ready in hand |
| HKS Water Cerenkov | Prototype ready | Spring 2020 |
| Stand for HKS | | |
| Sieve slits, collimators | | |
| Analysis/Simulation codes | Under develop. | In 2020 |

Ready for Beam in 2021

To be done before E12-15-008 beamtime

| Item | Status | Schedule |
|-----------------------------|-----------|----------------|
| Pair of Charge Sep. Magnets | Completed | Ready for ship |
| Vacuum Chamber | For Solid | Unit D |



Ready for Beam in 2021

Summary

Hypertriton Puzzle

C12-19-002 : Updated Proposal
Other exp. at ELPH, J-PARC, Mainz

$^3_{\Lambda}n$ Puzzle

E12-17-003 : Data taken. Analysis in progress
GSI new experiment

CSB of Λ Hypernuclei

E12-15-008 : New Magnets Completed
Preparing for Exp. Readiness Review
Ready for beam in 2021

Hyperon Puzzle

P12-18-004 : Proposal will be prepared