13th Dec. 2022

JLab Hypernuclear Collaboration Meeting

(zoom)

THE UNIVERSITY OF TOKYO

Opening + Introduction

SATOSHI N. NAKAMURA

THE UNIVERSITY OF TOKYO

JLab Hypernuclear Collaboration Meeting

- We are now recovering from COVID-19 pandemic.
- International Collaboration keeps activities.
  Frequent analysis meetings, Biweekly strategy meeting
- Redesign the experiment for Hall-C

Achievements during COVID-19 pandemic

- Analysis of E12-17-003 ($^{3}\mathrm{H}(e,e'K^{+})$) data taken at Hall-A in 2018

  Ph-D These B. Pandey (2021, Hampton)

  K.N. Suzuki (2022, Kyoto)

  K. Itabashi (2022, Tohoku)

  Master's these T. Akiyama (2021 Tohoku), K.Okuyama (2021 Tohoku),

  K. Katayama (2021 Kyoto), T.Toyoda (2021 Kyoto)

  Publications K.N.Suzuki et al., PTEP 2022 013D01.

  B. Pandey et al., PRC 105, L051001 (2022)

  Proceedings of International Conf. Many talks at HYP2022

  T. Gogami et al. (3,4-body Λ hypernuclei at JLab), F. Garibaldi et al. (^{208}Pb target HY study at JLab),

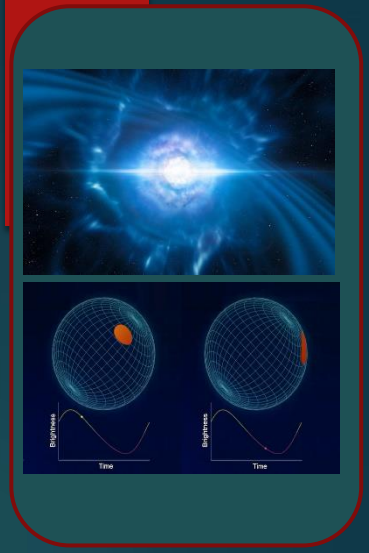
  T. Gogami et al. (nnΛ hcross section), K. Okuyama et al. (Λ/Σ^{0} electroproduction),

  K.Itabashi et al. (nΛ FSI), S.N.Nakamura et al. (Future projects)

- Analysis of E05-115 data taken in Hall-C in 2009

  T. Gogami et al., PRC 103, L041301 (2021) about $^{9}_{\Lambda}\mathrm{Li}$

Current problems of Λ hypernuclei



Recent astronomical observations

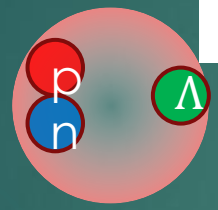
Hypertriton Puzzle

MAMI

Shallow bound
Short lifetime

J-PARC

ELPH

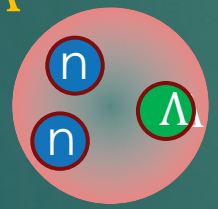


JLab E12-19-002

$^{3}_{\Lambda}n$ Puzzle

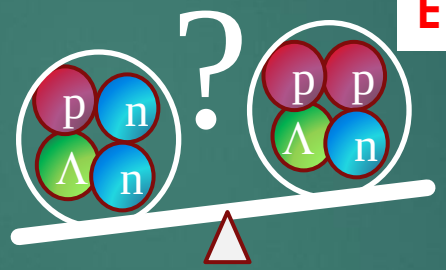
GSI

Bound?
Resonance?
Not Exist?



JLab E12-17-003

CSB of Λ Hypernuclei



JLab E12-15-008 E12-20-013

Hyperon Puzzle

Why massive NS exists?

$A=3$

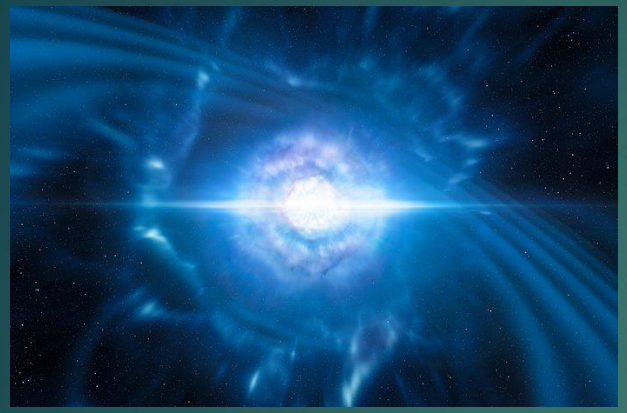
10^{-15} m

$A\sim10^{57}$

10^{4} m

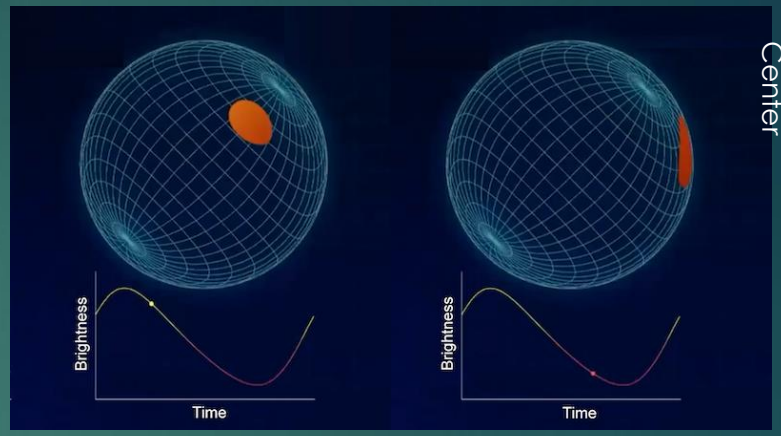
J-PARC HIHR

New Astronomical Observations of Neutron Stars



CC4.0 ESO/L. Calçada/M. Kornmesser

Gravitation Wave from neutron star mergers
LIGO/Virgo PRL **119**, 161101 (2017)



Goddard Space Flight Center

NICER ： NS x-ray hot spot measurement
Physics 14, 64 (Apr. 29, 2021)

Great progresses
Macroscopic features of NS

Microscopic understanding
becomes more important!

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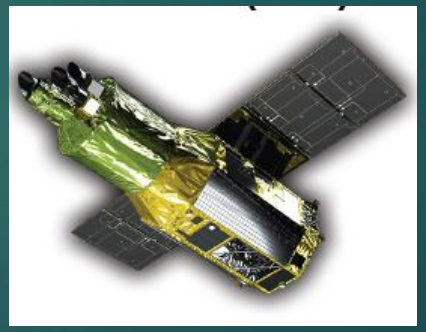
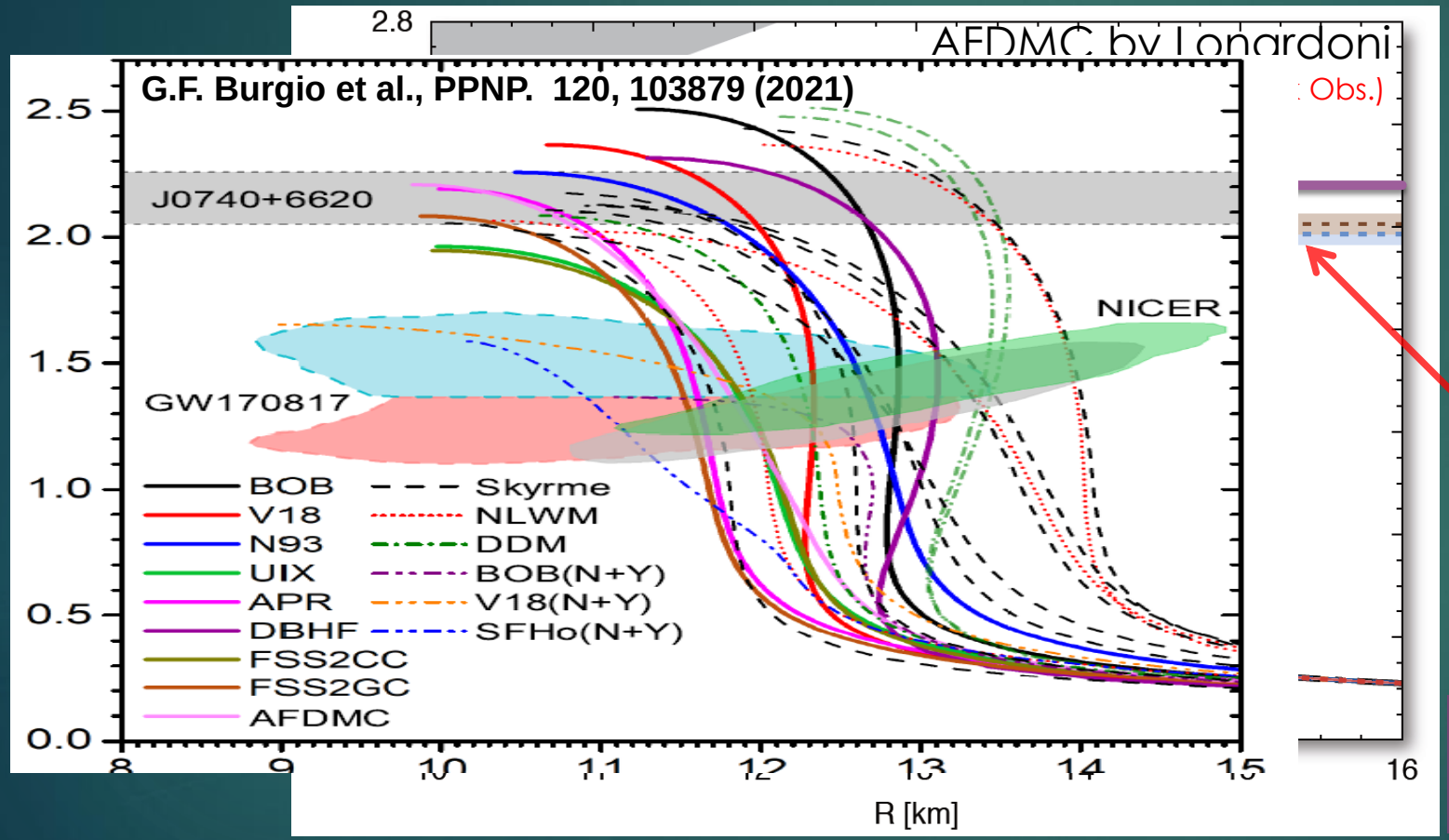


X-Ray Imaging and Spectroscopy Mission (XRISM) will launch in JFY 2022.

Hyperon Puzzle

Based on our knowledge on Baryonic Force:

Hyperon naturally appear at high density ($\rho=2\sim3\rho_0$)



Too Soft EOS

Contradict to observation

2 $M_\odot$ Neutron Stars

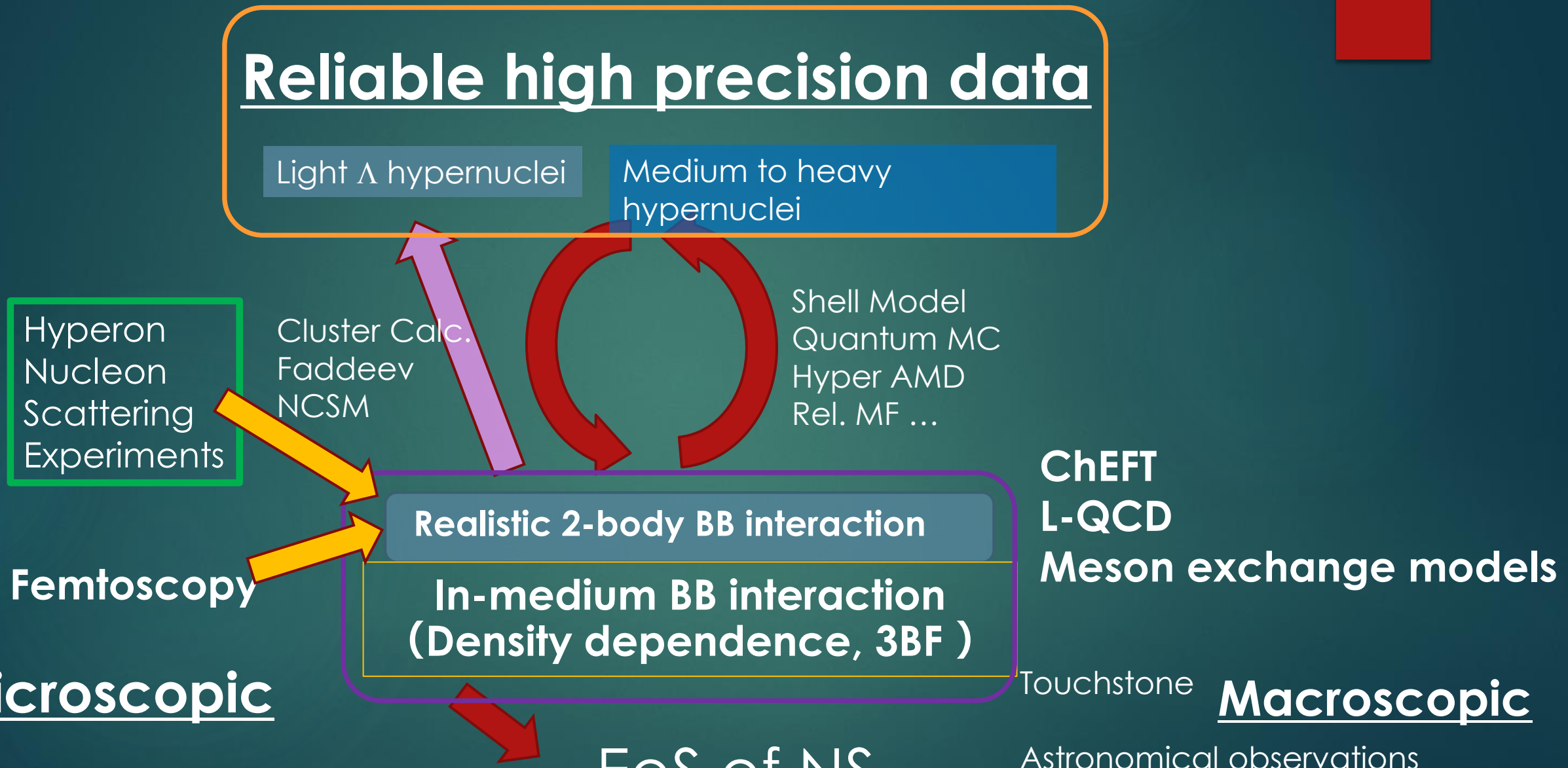
Additional Force to make EOS stiff

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

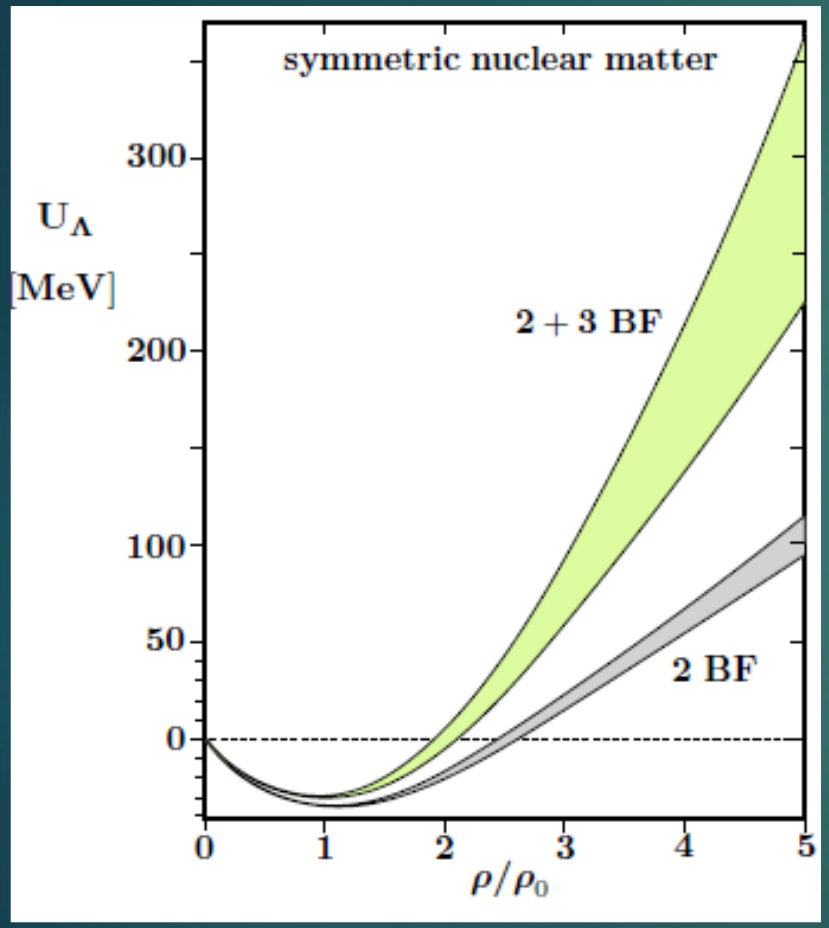
ESC08c + 3B/4B RF : G-Matrix Calc. by Yamamoto et al., PRC 90 (2014) 045805.

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

Strategy to solve the hyperon puzzle

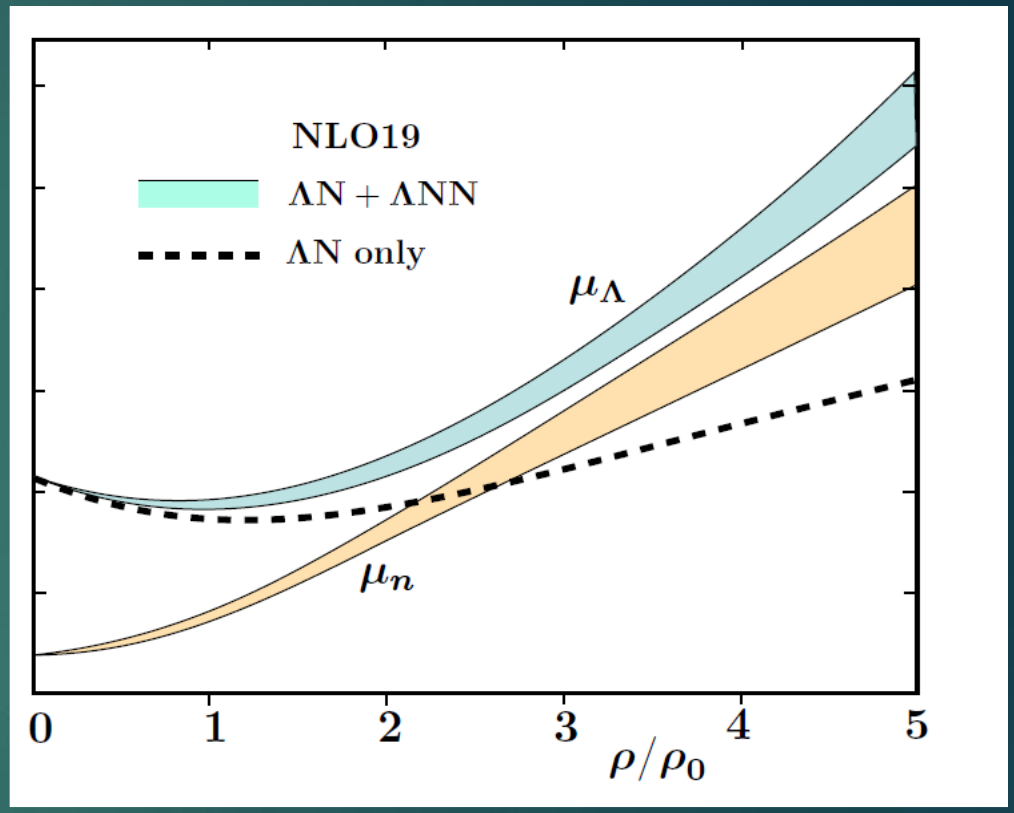


3BF recovers stiffness



With 3BRF
recover stiffness

With Hyperon
too Soft

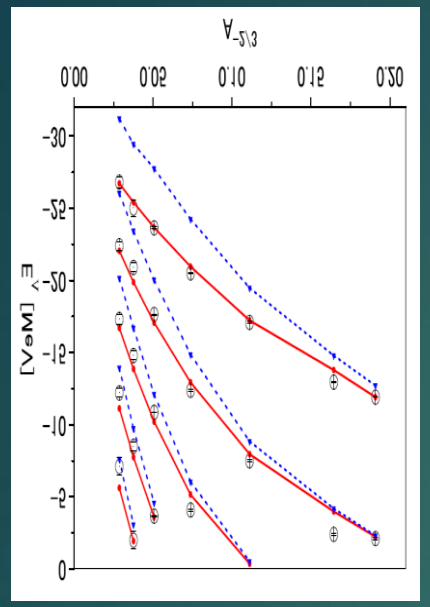


D.Gerstung et al., Eur. Phys. J. A (2020) 56:175; W. Weise EPJ Web. Of Conf. 271, 06003 (2022)

ChEFT(NLO: Saturation Decuplet)+Brueckner-Bethe-Goldstone eq.+ΛN-ΣN,ΛNN-ΣNN coupled channels

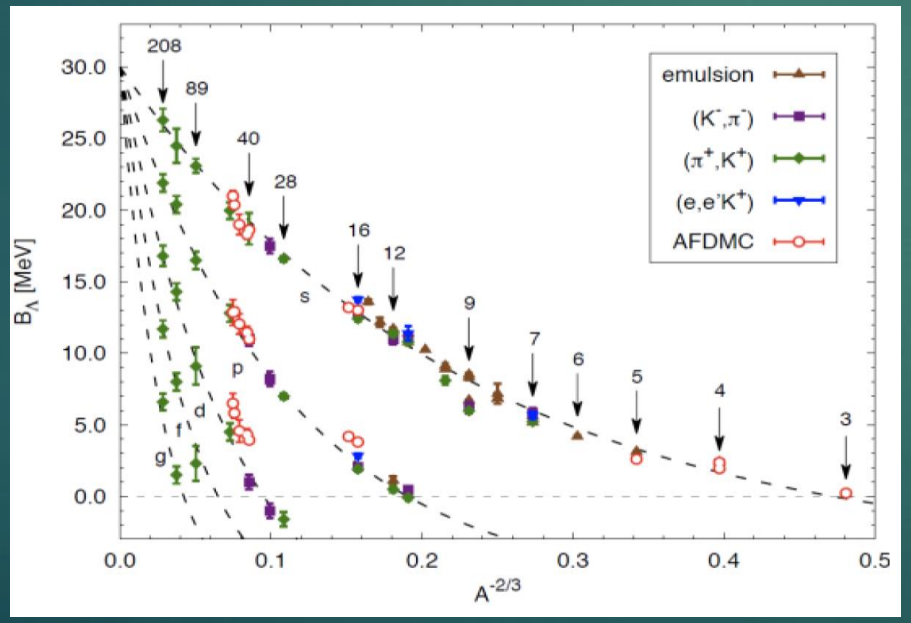
Λ Single Particle Energies of Λ Hypernuclei by Various Calculations

M.M. Nagels et al., PRC 99 (2019) 044003.

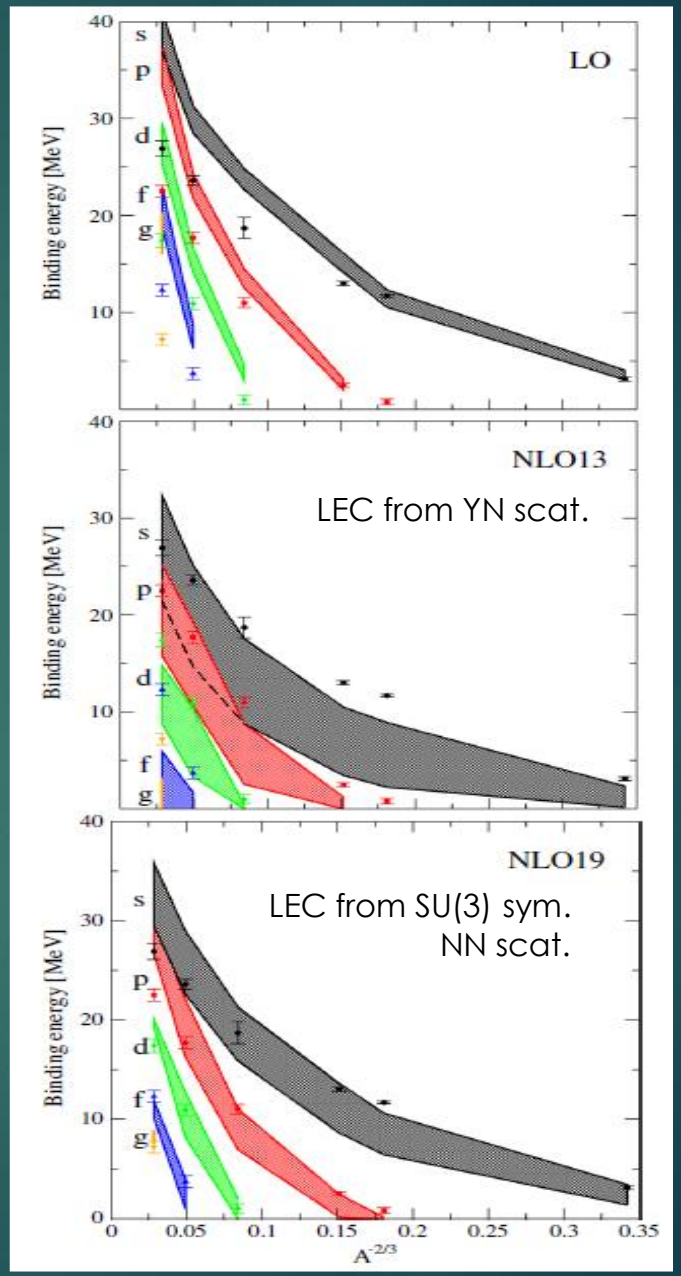


ESC16
ESC16+ (Inc. 3BF)
G-matrix

AFDMC



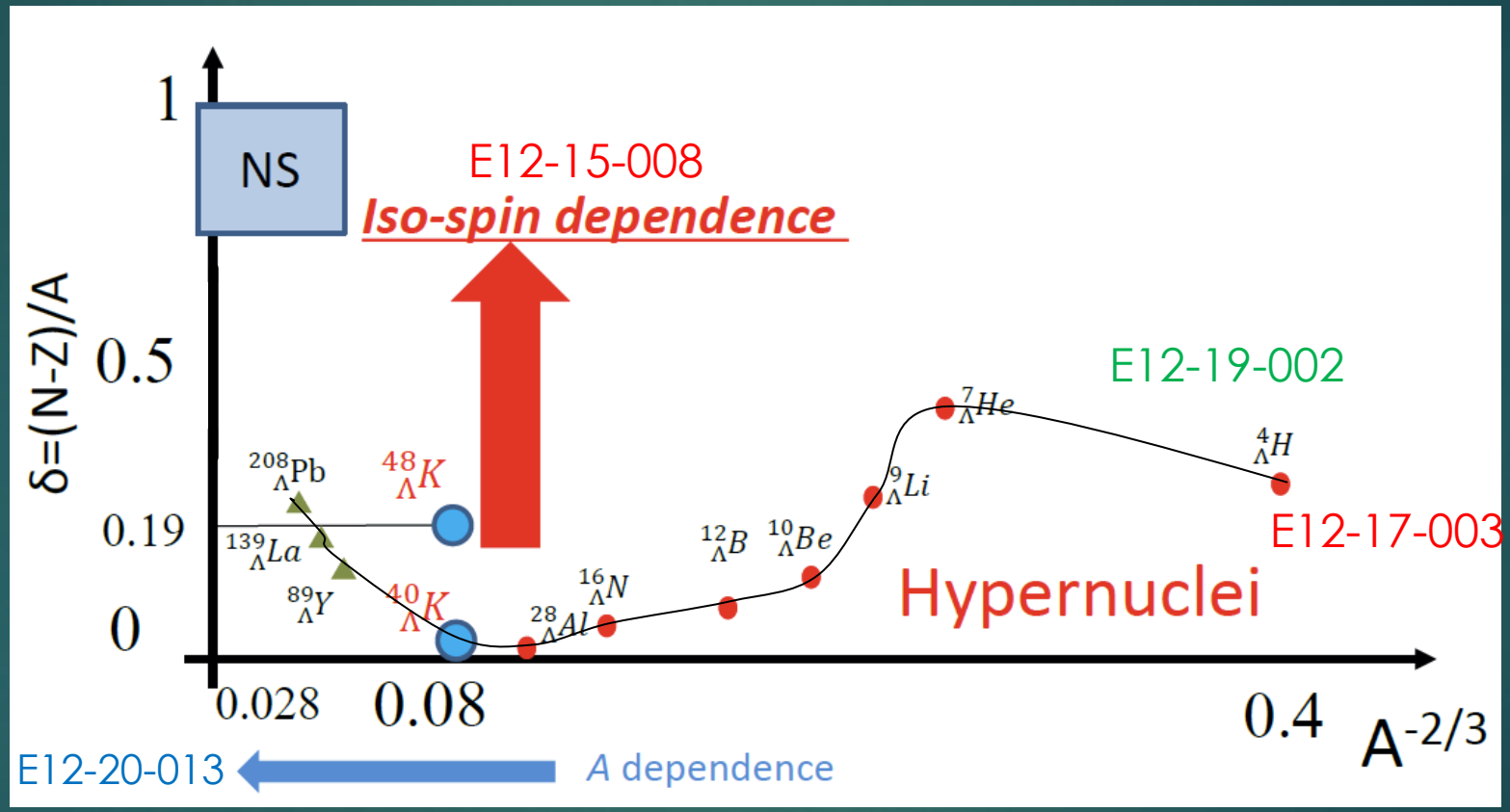
D.Lonardoni and F. Pederiva, arXiv:1711.07521.



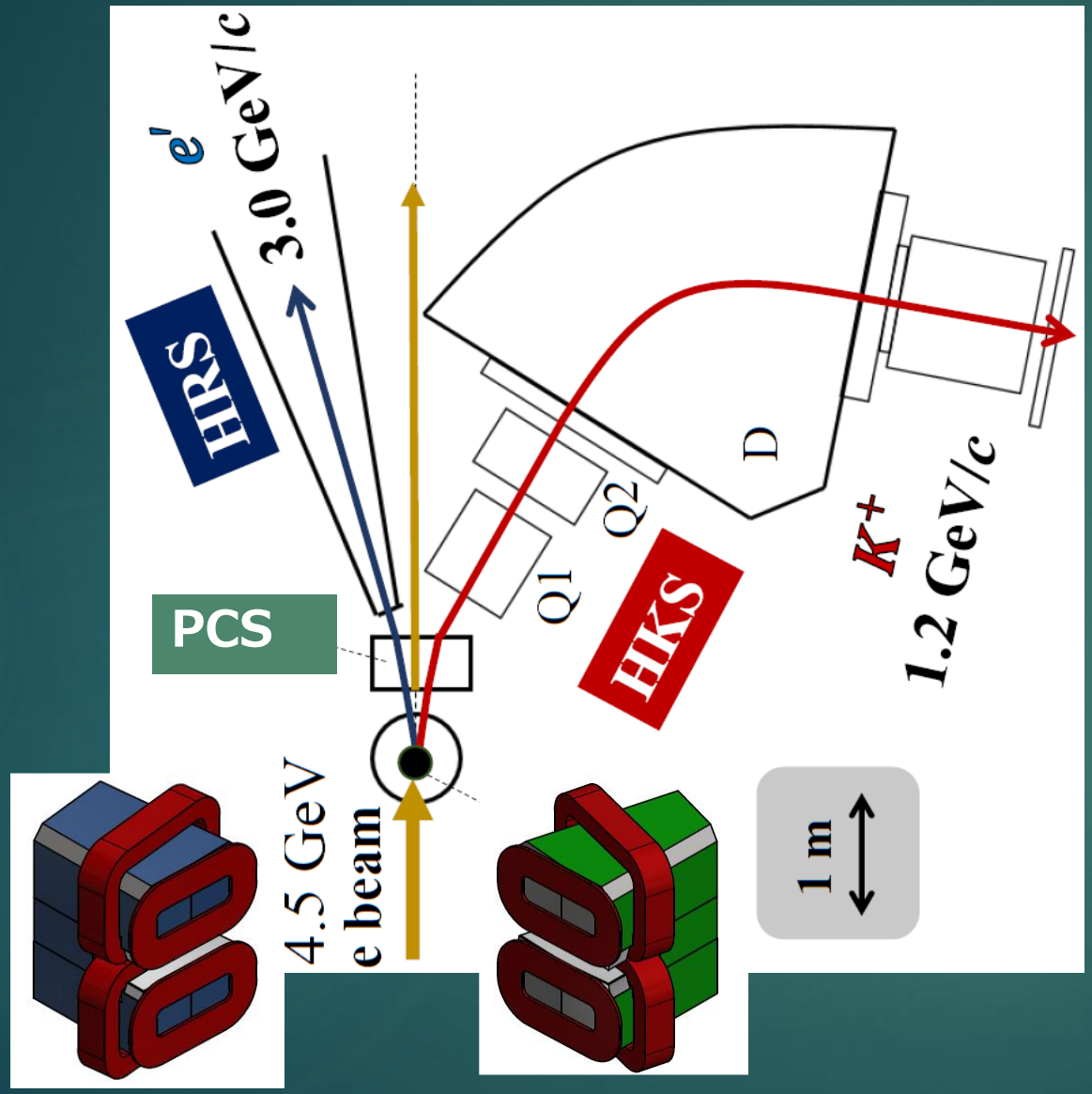
ChEFT

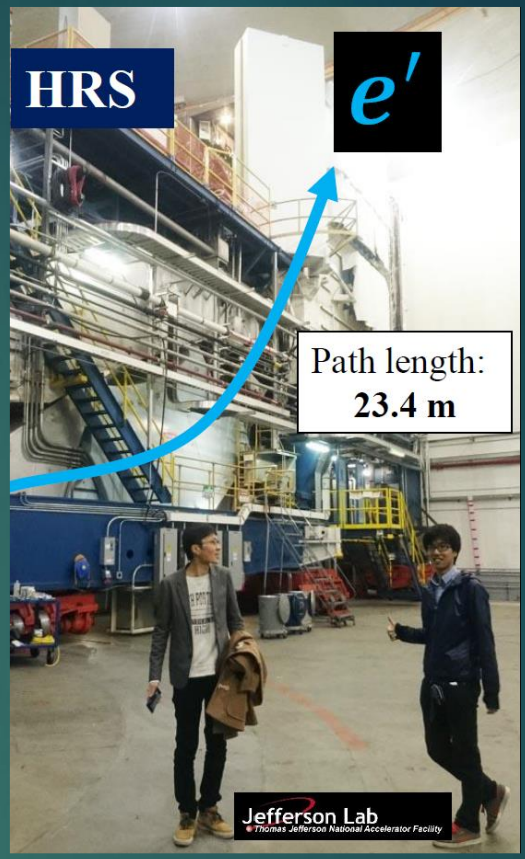
J.Haidenbauer, I.Vidana, EPJA (2020) 56:55.

From Hypernuclei to NS



Original setup in Hall-A



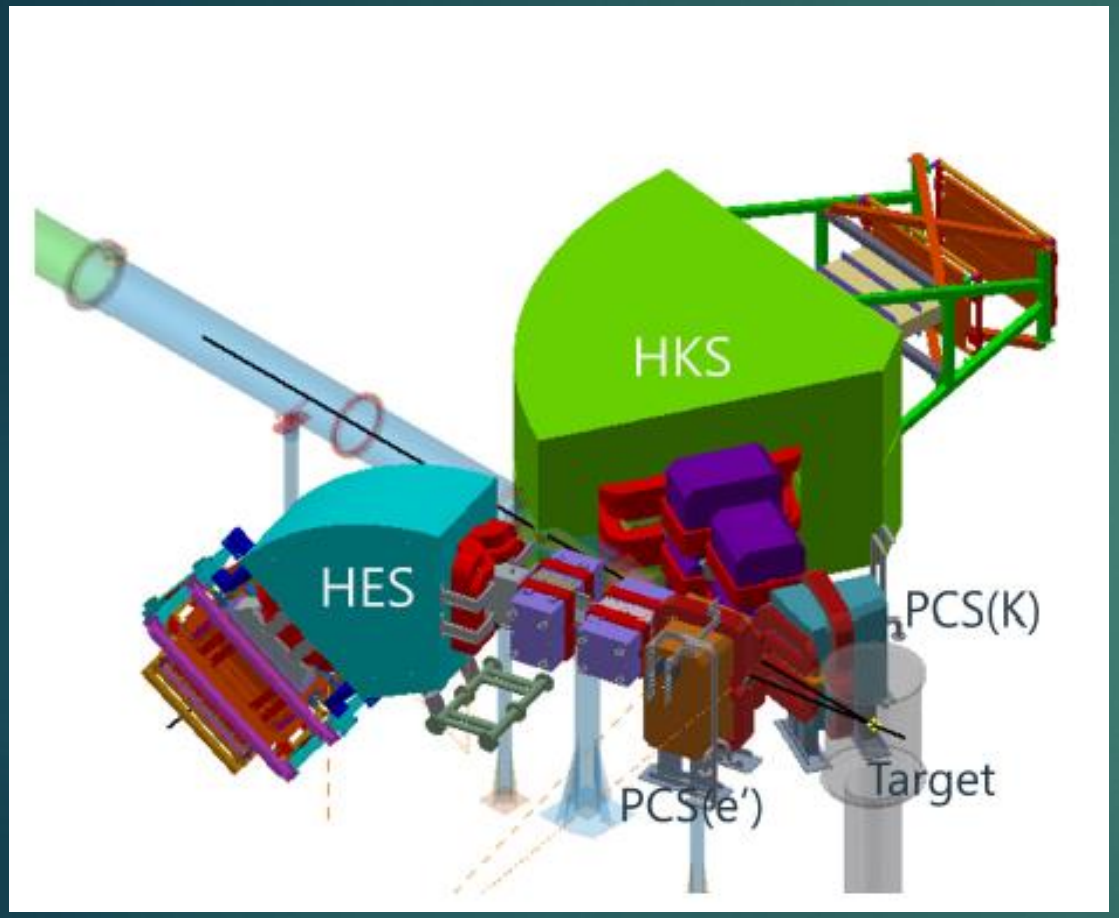


New Pair Charge Sep. Mag.
^{40,48}Ca, ^{208}Pb, Cryogenic-gas ^{3,4}He

Beam availability issue

Move to Hall-C

No Vertical-bending HRS in Hall-C



Investigation of the strangeness baryon interaction by Λ hypernuclear spectroscopy

A pre-document for the experimental readiness review of E12-15-008, E12-19-002, and E12-20-013.

by

F. Garibaldi, T. Gogami, P. Markowitz, S. Nagao,
S. N. Nakamura, J. Reinhold, L. Tang, G. M. Urciuoli

on behalf of JLab Hypernuclear Collaboration

This document is submitted to JLab for official request of supports
by the JLab Hypernuclear Collaboration
November 13, 2022

Hall-A vs Hall-C

	Hall-A	Hall-C	Comments
e' Spectrometer	HRS	HES (V) or SHMS	HES needs mod. to vertical
K Spectrometer	HKS	HKS (H or V)	1.2 GeV/c
Beam Energy	4.23 GeV	~~2.34~~ 2.24 GeV	
Resolution	○	◎ (HES) △ (SHMS)	
Yield	◎	○ (Vertical)	
S/N	◎	×	

Two days collaboration Meeting

December 13, 2022

Time Table (Dec 13, 2022). Chair = J. Reinhold (FIU)

Time (EST)	Time (CET)	Time (JST)	Speaker	Title
07:00-07:30	13:00-13:30	21:00-21:30	S.N. Nakamura (Univ. Tokyo)	Opening + Introduction
07:30-08:00	13:30-14:00	21:30-22:00	M. Jones (JLab)	Hall Status and Plan
08:00-08:20	14:00-14:20	22:00-22:20	T. Gogami (Kyoto Univ.)	Status / activity summary
08:20-08:40	14:20-14:40	22:20-22:40	S. Nagao (Univ. Tokyo)	Modification summary, Hall A to Hall C
08:40-09:00	14:40-15:00	22:40-23:00	S. Lassiter (JLab)	Hall design for hypernuclear experiment
09:00-09:30	15:00-15:30	23:00-23:30		Discussion

Information update
Current status
General Discussion

December 14, 2022

Time Table (Dec 14, 2022). Chair = P. Markowitz (FIU)

Time (EST)	Time (CET)	Time (JST)	Speaker	Title
07:00-07:20	13:00-13:20	21:00-21:20	Ishige (Tohoku Univ.)	MC simulation study for future experiment
07:20-07:40	13:20-13:40	21:20-21:40	G.M. Urciuoli (INFN)	Experiment for Pb target
07:40-08:00	13:40-14:00	21:40-22:00	B. Pandey (VMI)	Commissioning of aeregel Cherekov counters for HKS
08:00-08:20	14:00-14:20	22:00-22:20	Okuyama (Tohoku Univ.)	Λ and Σ^0 production (E12-17-003)
08:20-08:40	14:20-14:40	22:20-22:40	Akiyama (Tohoku Univ.)	η' production (E12-17-003)
08:40-09:00	14:40-15:00	22:40-23:00		Discussion
09:00-09:10	15:00-15:10	23:00-23:10		Summary and closing

Detailed discussion about detectors and analysis

Important steps

- Magnets, Sepectrometers

  Design of a new HES, PCS supports for vertical-bending.
  - Is modification of HES necessary?
  - PCS base
  - Beam pipes, sieve slits, vacuum
- Power supplies and cooling water
- Radiation budget calculation
- Target system
- Beamline and beam diagnose
- DAQ & Electronics
- Analysis

To be done before the beamtime

Item	Status	Schedule
Pair of Charge Sep. Magnets	Completed	Shipped to JLab
Vacuum Chamber	For Solid targets	Und. Design
	For Cryo. targets	
Targets	^{40,48}Ca	Ready in hand
HKS Water Cerenkov	Prototype ready	Mass production
Stand for HKS		
Sieve slits, collimators		
Analysis/Simulation codes	Under develop.	Modified to Hall-C

ERR in 2023, Ready for Beam in 2024-2025

Summary

Hypertriton Puzzle

$^{3}_{\Lambda}n$ Puzzle

CSB of Λ Hypernuclei

Hyperon Puzzle

E12-19-002 : Design cryo-gas target
Other exp. at ELPH, J-PARC, Mainz

E12-17-003 : 3 Ph-D these, 2 publications (+ 1)

E12-15-008 , E12-20-13 : PCS is ready
v-HES optics study was done

Modification of HES+Stand design are necessary