*21st Oct. 2020*

**THEIA-Strong, REIMEI seminar (zoom)**

# Short overview on planned hypernucleus activities at JLab


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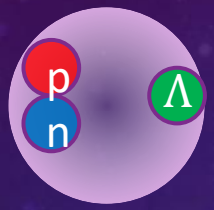
JSPS KAKENHI Grants No. 18H05459, 17H01121
Toward new frontiers : Encounter and synergy of state-of-the-art astronomical detectors and exotic quantum beams


Graduate Program on Physics for the Universe

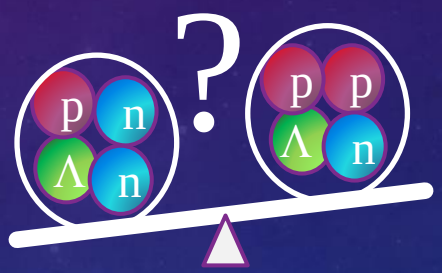
# CURRENT PROBLEMS ON Λ HYPERNUCLEI

## Hypertriton Puzzle

Shallow bound
Short lifetime




## CSB of Λ Hypernuclei

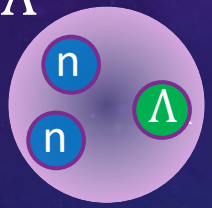



## Hyperon Puzzle

Why massive
NS exists?

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

Bound?
Resonance?
Not Exist?




$A$=3

$10^{-15}$ m

$A$~$10^{57}$

$10^{4}$ m

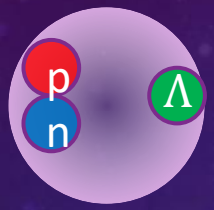
# CURRENT PROBLEMS ON Λ HYPERNUCLEI

T.Gogami will talk.

## Hypertriton Puzzle

***C12-19-002***

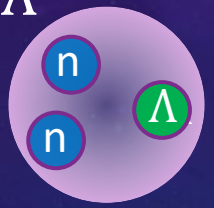
Shallow bound
Short lifetime




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

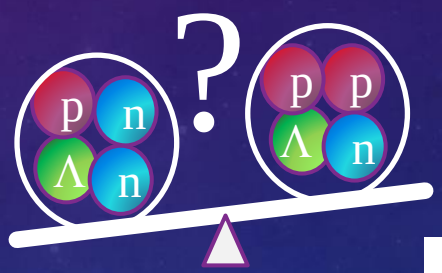
Bound?
Resonance?
Not Exist?

**E12-17-003**




## CSB of Λ Hypernuclei

**E12-15-008**




## Hyperon Puzzle

Why massive NS exists?

***E12-18-004***

F. Garibaldi will talk.

$A$=3

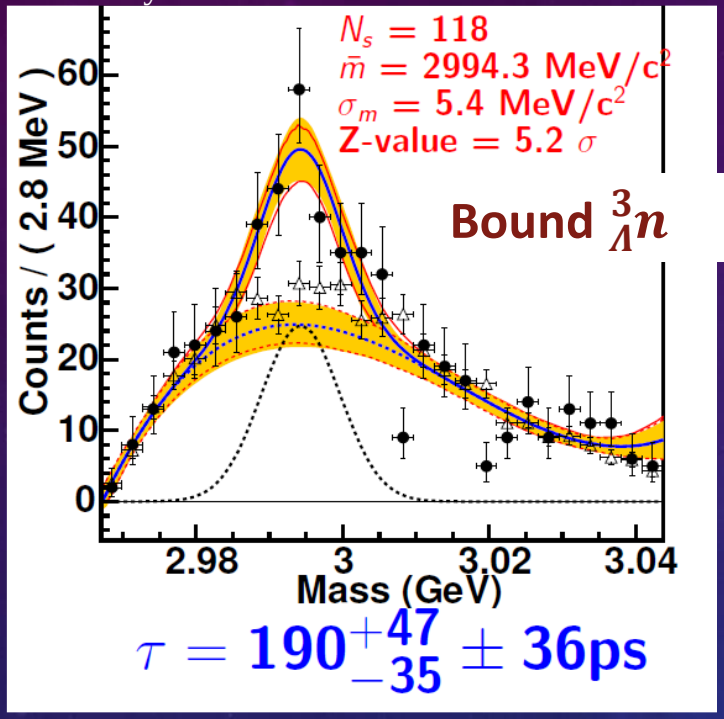
$10^{-15}$ m

$A$~$10^{57}$

$10^{4}$ m

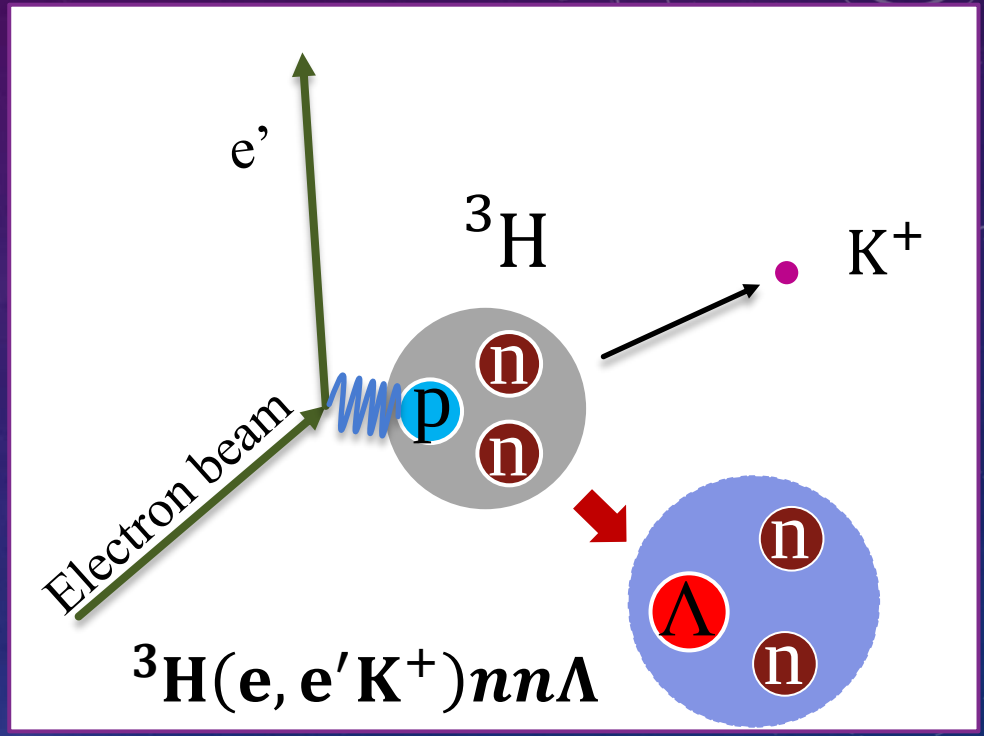
# $NN\Lambda$ STATE EXISTS?

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

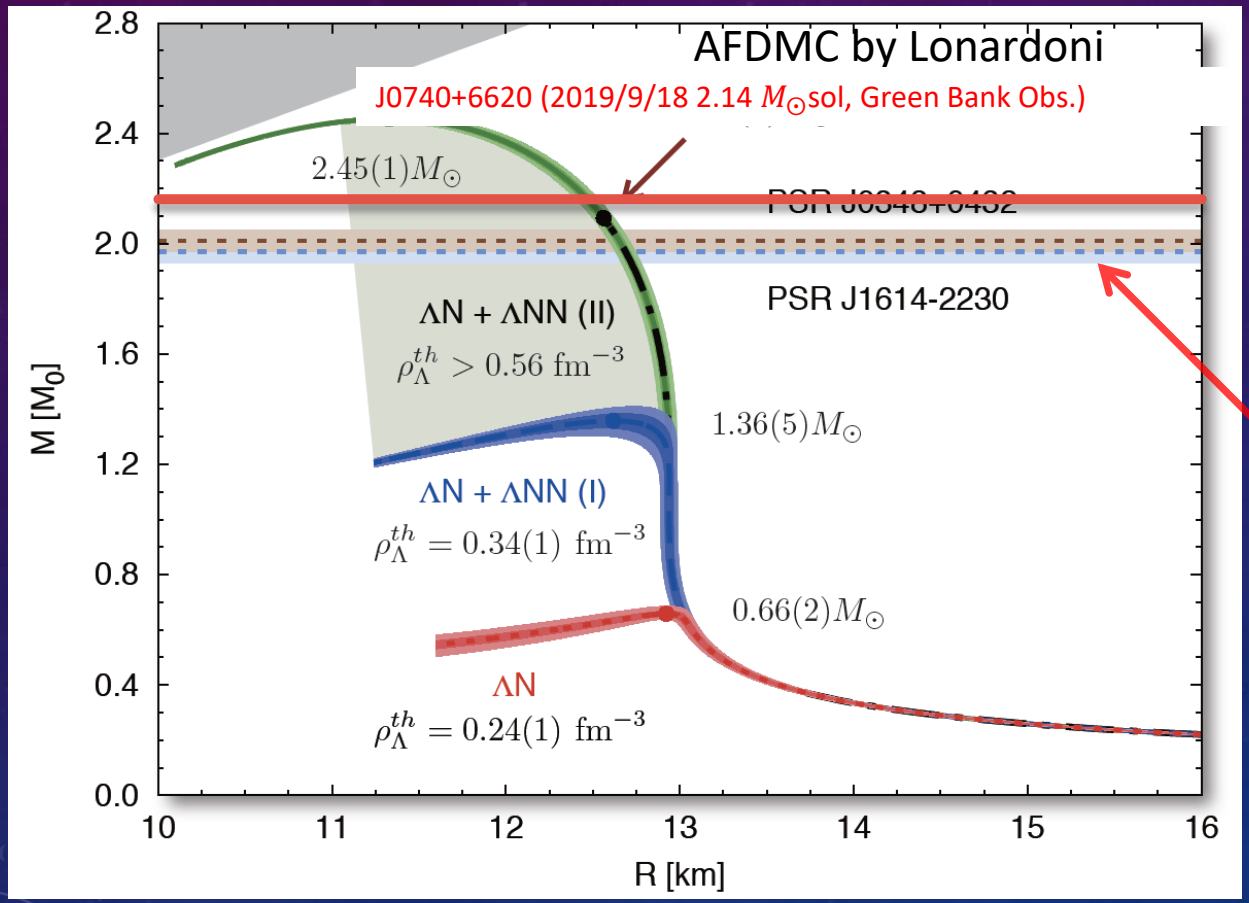
**E12-17-003 : Exp. Performed in 2018**

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

# HYPERON PUZZLE

Based on our knowledge on Baryonic Force:

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




Too Soft EOS

**Contradict to observation**

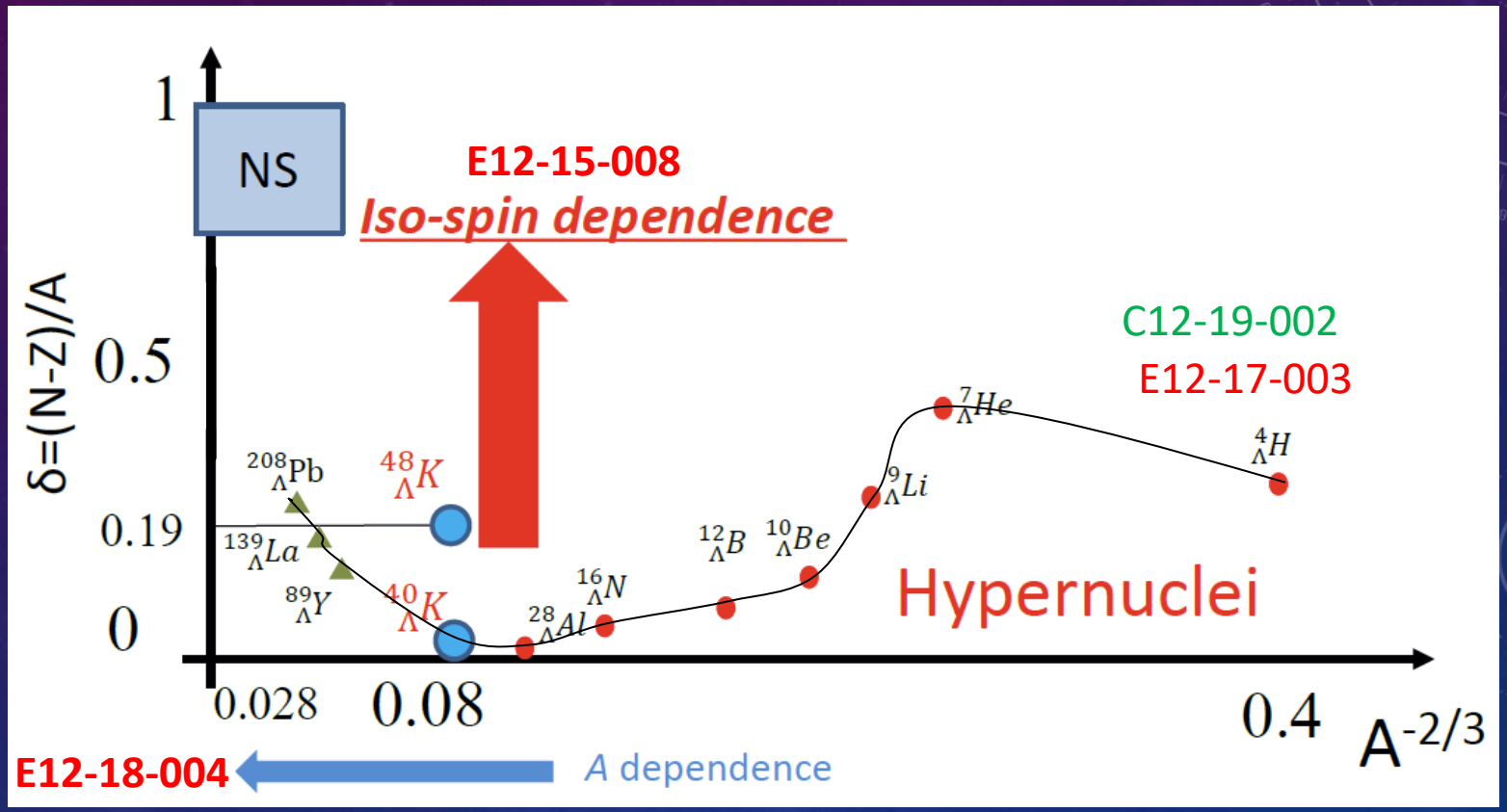
2 $M_\odot$ Neutron Stars

Additional Force to make EOS stiff

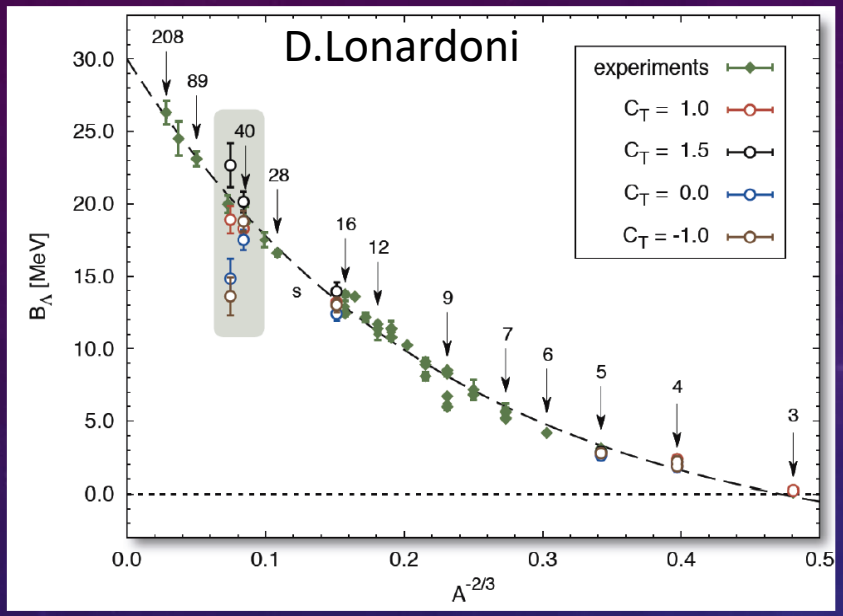
AFDMC by Lonardoni et al. PRL114 (2015) 092301, updated (2016)

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

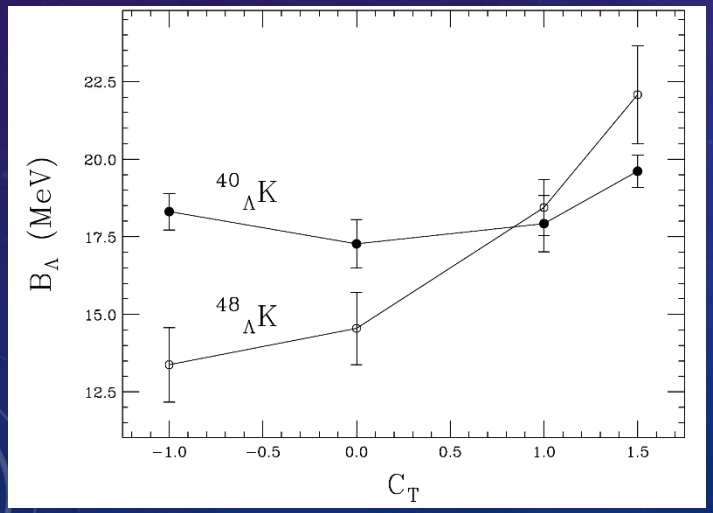
# From Hypernuclei to Neutron Stars



# PHENOMENOLOGICAL 3 BRF+AFDMC




$C_T$ :Parameter to gauge $\Lambda$nn contribution in $\Lambda$NN potential

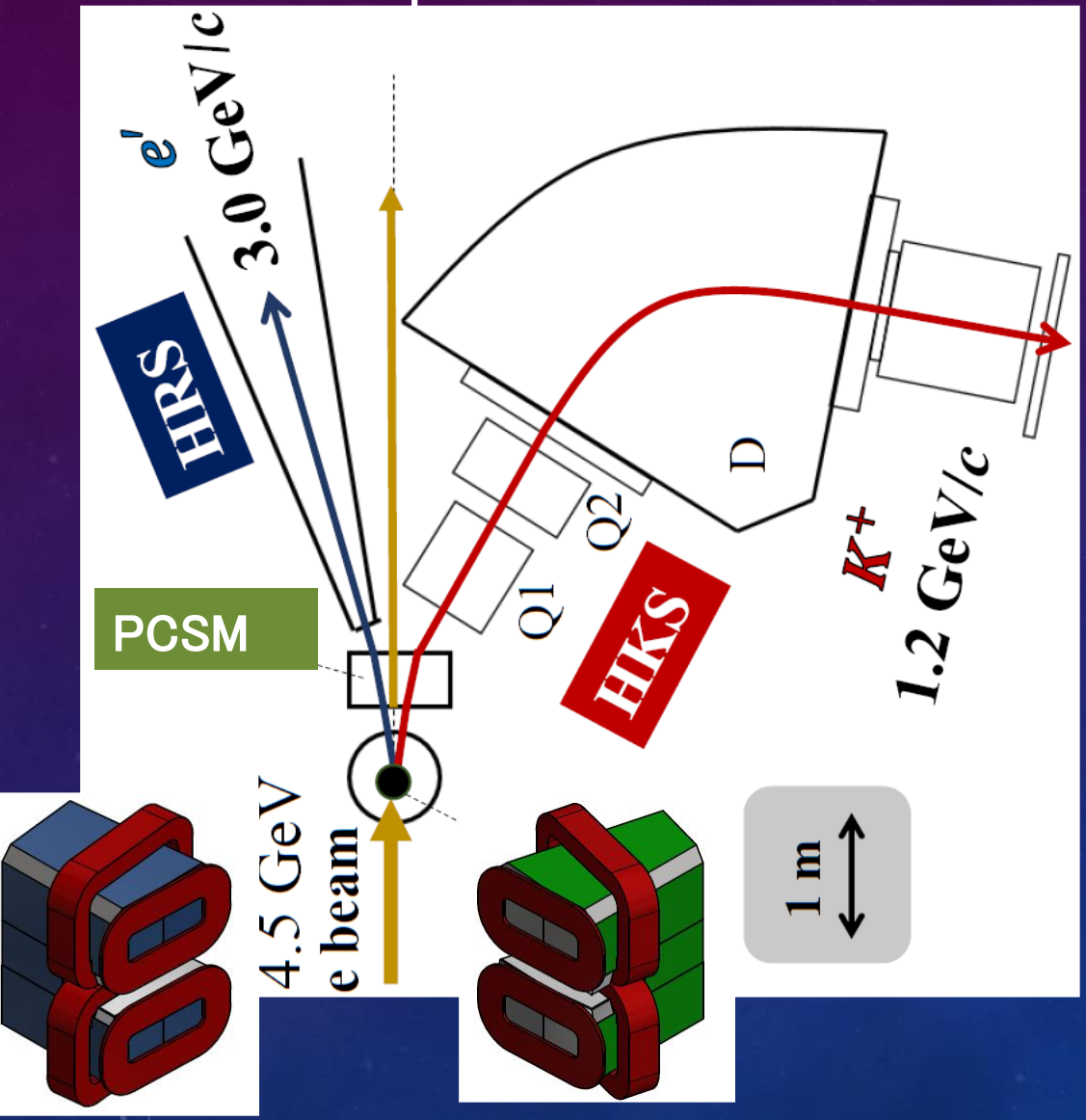



$^{40}$Ca(e ,e′K$^+$)$^{40}_{\Lambda}$K and , $^{48}$Ca(e, e′K$^+$)$^{48}_{\Lambda}$K

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.
$^{40,48}$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 | Concep. Design |
| Targets | $^{40,48}$Ca | Ready in hand |
| HKS Water Cerenkov | Prototype ready | Mass Production |
| Stand for HKS | | Und. Design |
| Sieve slits, collimators | | |
| Analysis/Simulation codes | Under develop. | In 2020~21 |

Ready for Beam in 2021

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| Item | Status | Schedule |
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| Pair of Charge Sep. Magnets | Completed | Ready for ship |
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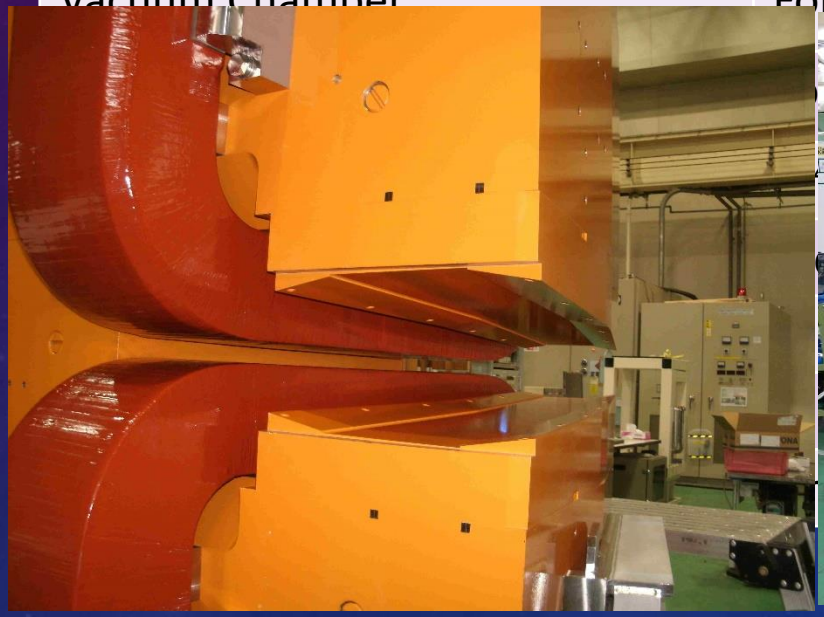

Ready for Beam in 2021

# SUMMARY

Hypertriton Puzzle

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

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

**E12-17-003 : Data taken, Analysis in progress**
**C12-20-003 : Additional Beam for more statistics**
**GSI new experiment**

CSB of $\Lambda$ Hypernuclei

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

Hyperon Puzzle

**E12-18-004 : Franco will talk.**