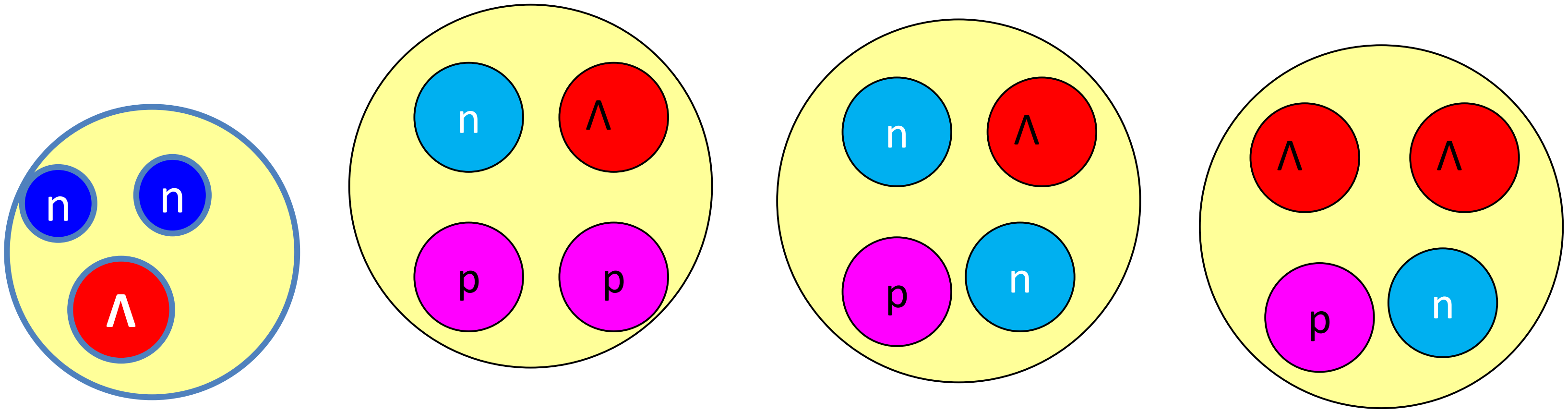
Light hypernuclei and ΛN-ΣN coupling

E. Hiyama (RIKEN)

One of the important and interesting subjects :
to study three- and four-baryon systems



${}^{3}_{\Lambda}n$ ${}^{4}_{\Lambda}He$ ${}^{4}_{\Lambda}H$ ${}^{4}_{\Lambda\Lambda}H$

C. Rappold et al.,
HypHI collaboration
Phys. Rev. C 88,
041001 (R) (2013)

A. Esser, PRL114,
232501(2015)

(1) Why is it important to study these three-and four-body systems?

(2) What kind of new understandings do we obtain by solving these systems as three- and four-body problems?

Our few-body caluclational method

Gaussian Expansion Method (GEM) , since 1987 ,

▪A variational method using Gaussian basis functions

▪Take all the sets of Jacobi coordinates

Developed by Kyushu Univ. Group, Kamimura and his collaborators.

Review article :
E. Hiyama, M. Kamimura and Y. Kino,
Prog. Part. Nucl. Phys. 51 (2003), 223.

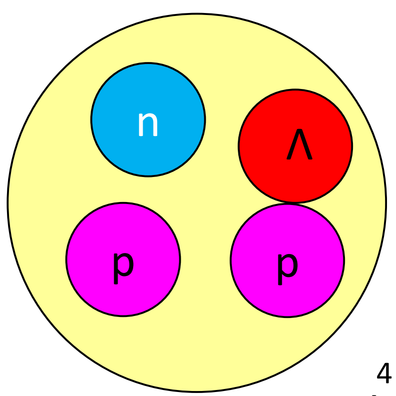
High-precision calculations of various 3- and 4-body systems:

Exsotic atoms / molecules , Light hypernuclei,
3- and 4-nucleon systems, 3-quark systems,
multi-cluster structure of light nuclei,

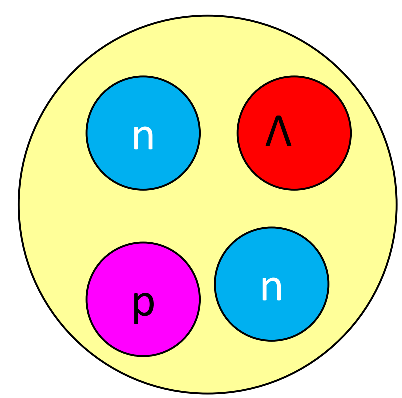
An example of the accuracy of the method:

Section 1

four-body calculation of $^{4}_{\Lambda}$H and $^{4}_{\Lambda}$He



$^{4}_{\Lambda}$He

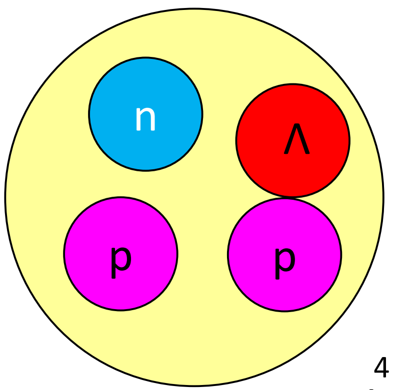


$^{4}_{\Lambda}$H

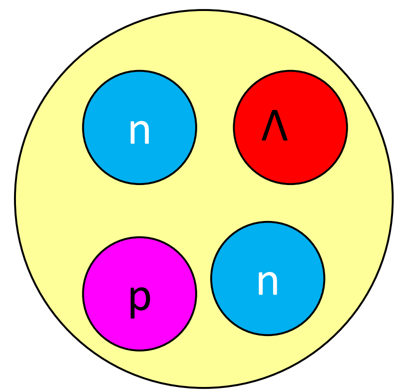
In S= -1 sector,
important subjects to extract information on YN interaction:

(1) Charge symmetry breaking

(2) ΛN－ΣN coupling



$^{4}_{\Lambda}$He



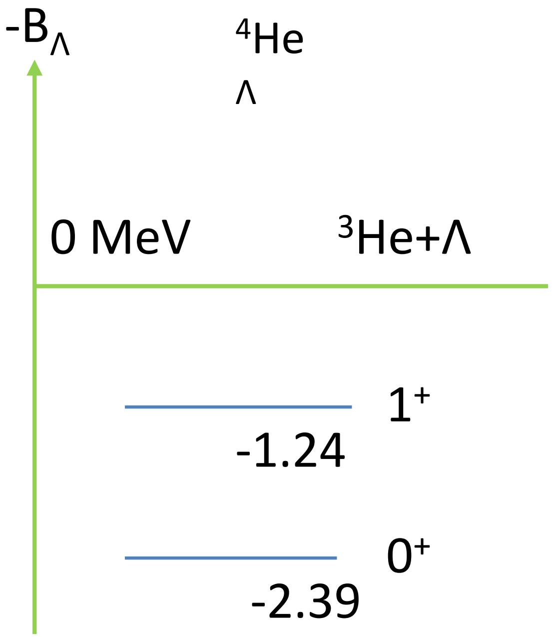
$^{4}_{\Lambda}$H

Interesting Issues for the ΛN-ΣN particle conversion in hypernuclei

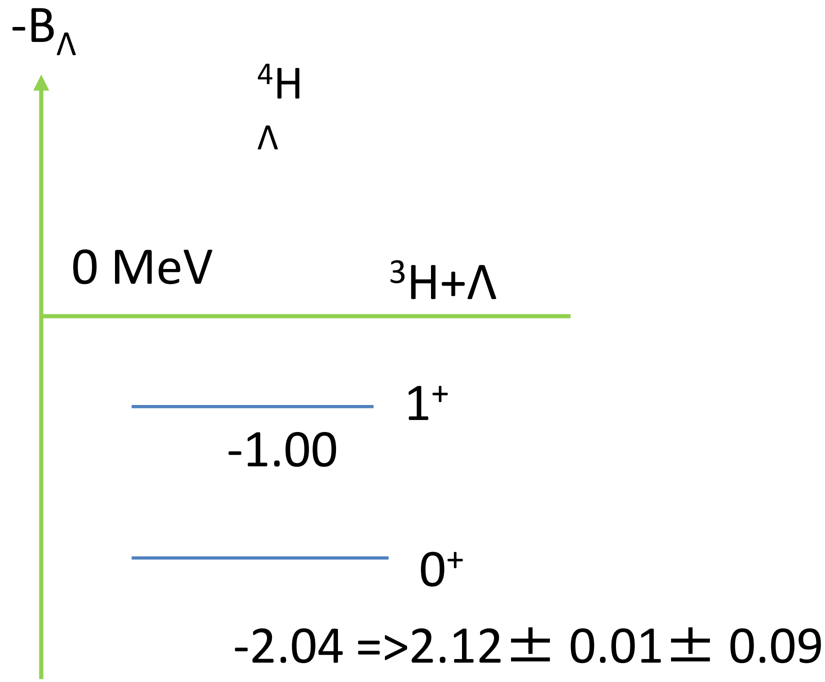
(1) How large is the mixing probability of the Σ particle in the hypernuclei?

(2) How important is the ΛN—ΣN coupling in the binding energy of the Λ hypernuclei?

(3) How large is the Σ-excitation as effective three-body ΛNN force?

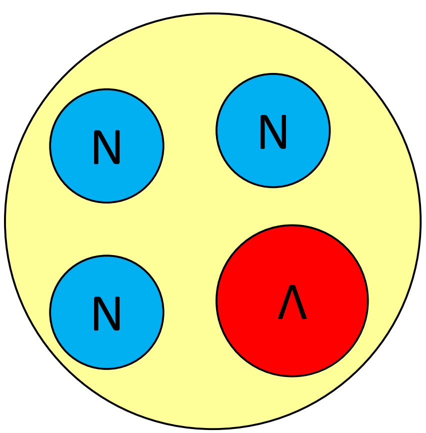


Exp.



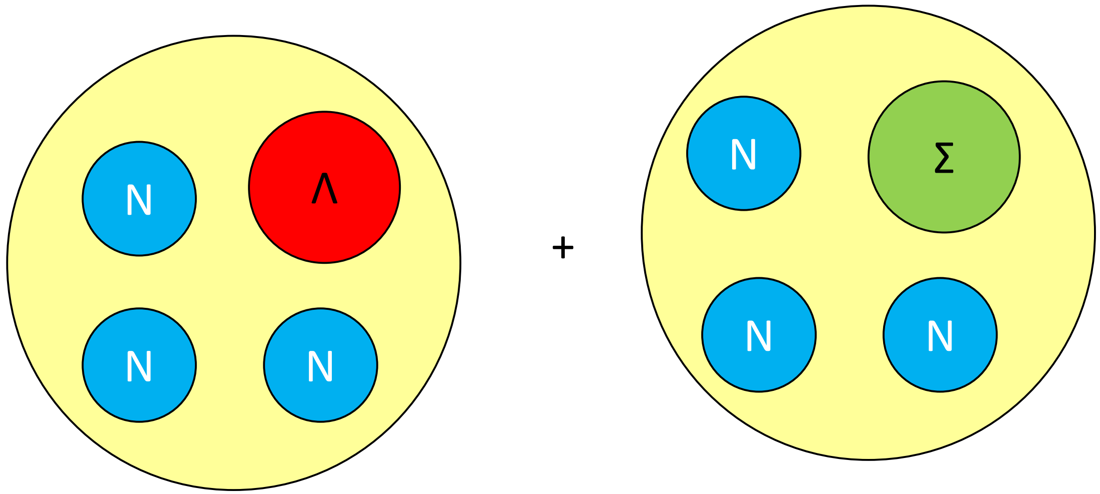
Exp.

A. Esser, PRL114, 232501(2015)



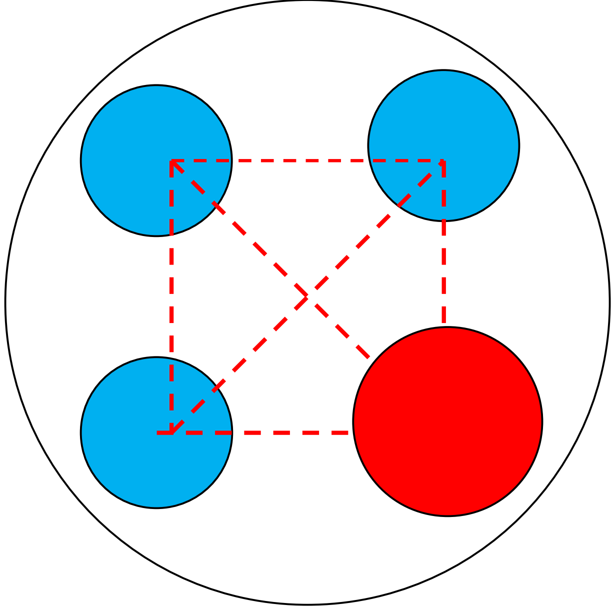
${}^{4}_{\Lambda}\mathrm{He}$

${}^{4}_{\Lambda}\mathrm{H}$



NNNΛ + NNNΣ

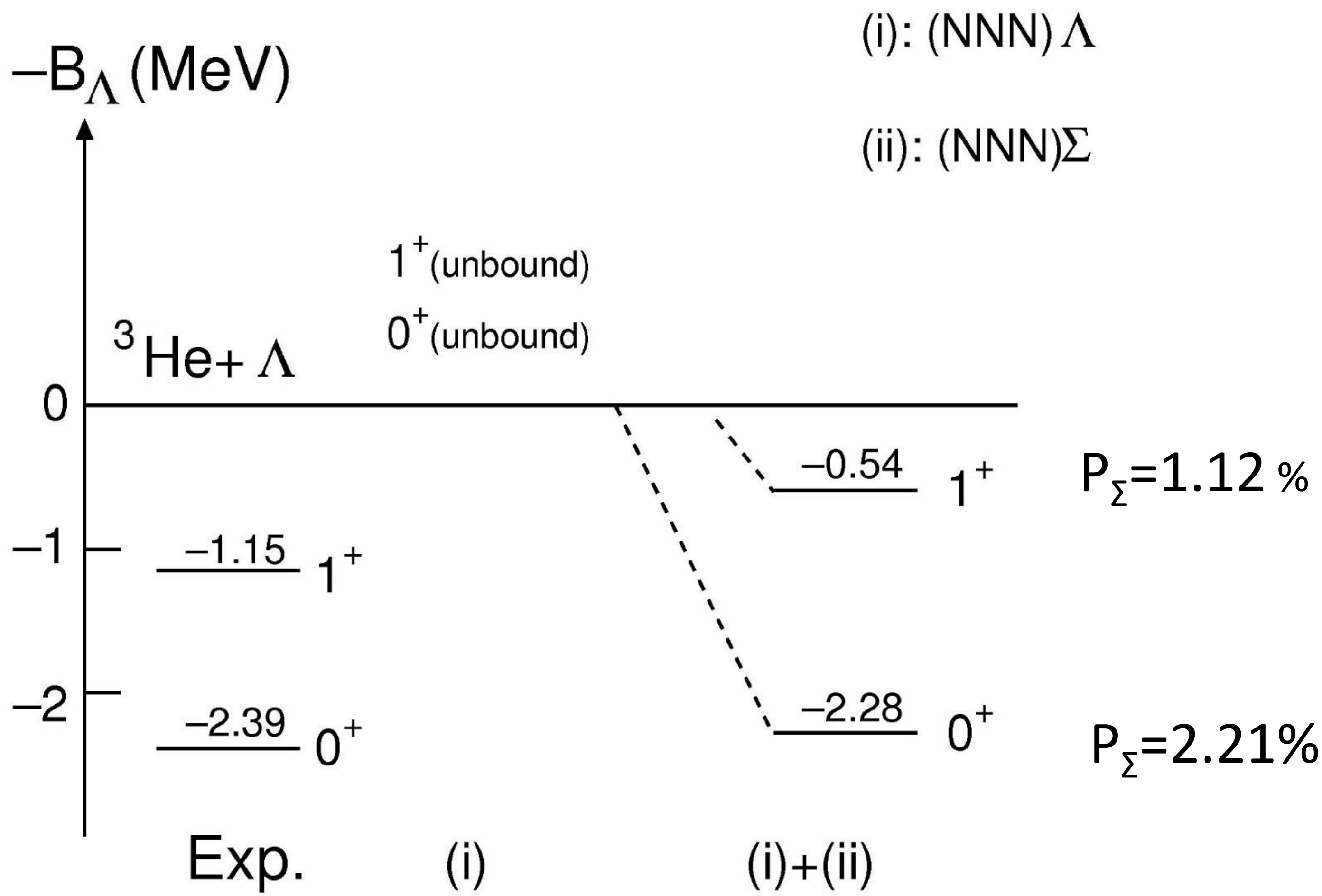
E. Hiyama et al., Phys. Rev. C65, 011301 (R) (2001).
H. Nemura et al., Phys. Rev. Lett. 89, 142502 (2002).
A. Nogga et al., Phys. Rev. Lett. 88, 172501 (2002).



${}^{4}_{\Lambda}\mathrm{He}$, ${}^{4}_{\Lambda}\mathrm{H}$

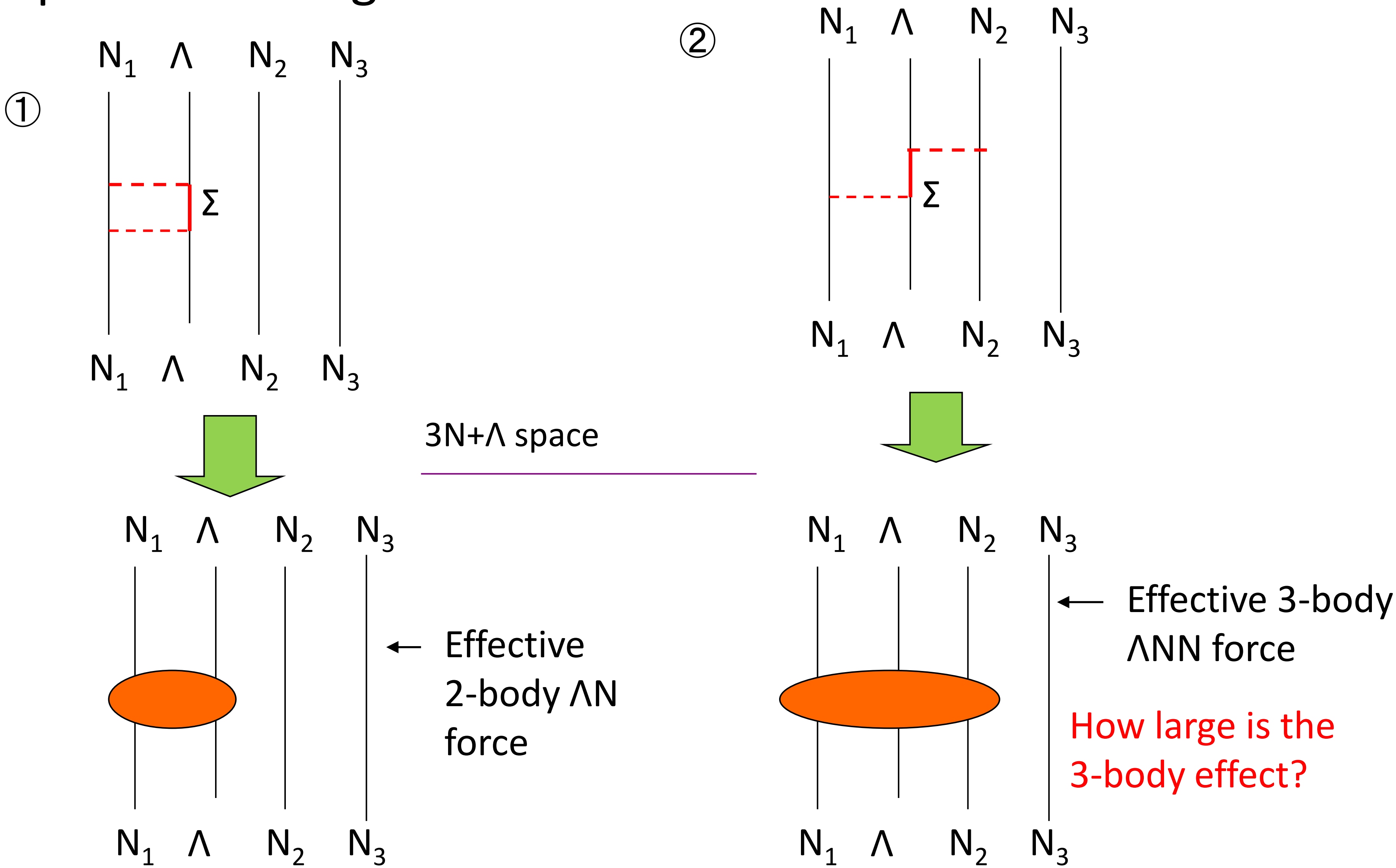
V_{NN} : AV8 potential

V_{YN} : Nijmegen soft-core ’97f potential

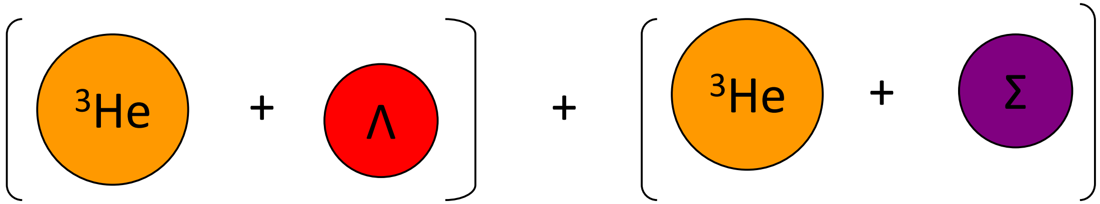


$^{4}_{\Lambda}\mathrm{He}$

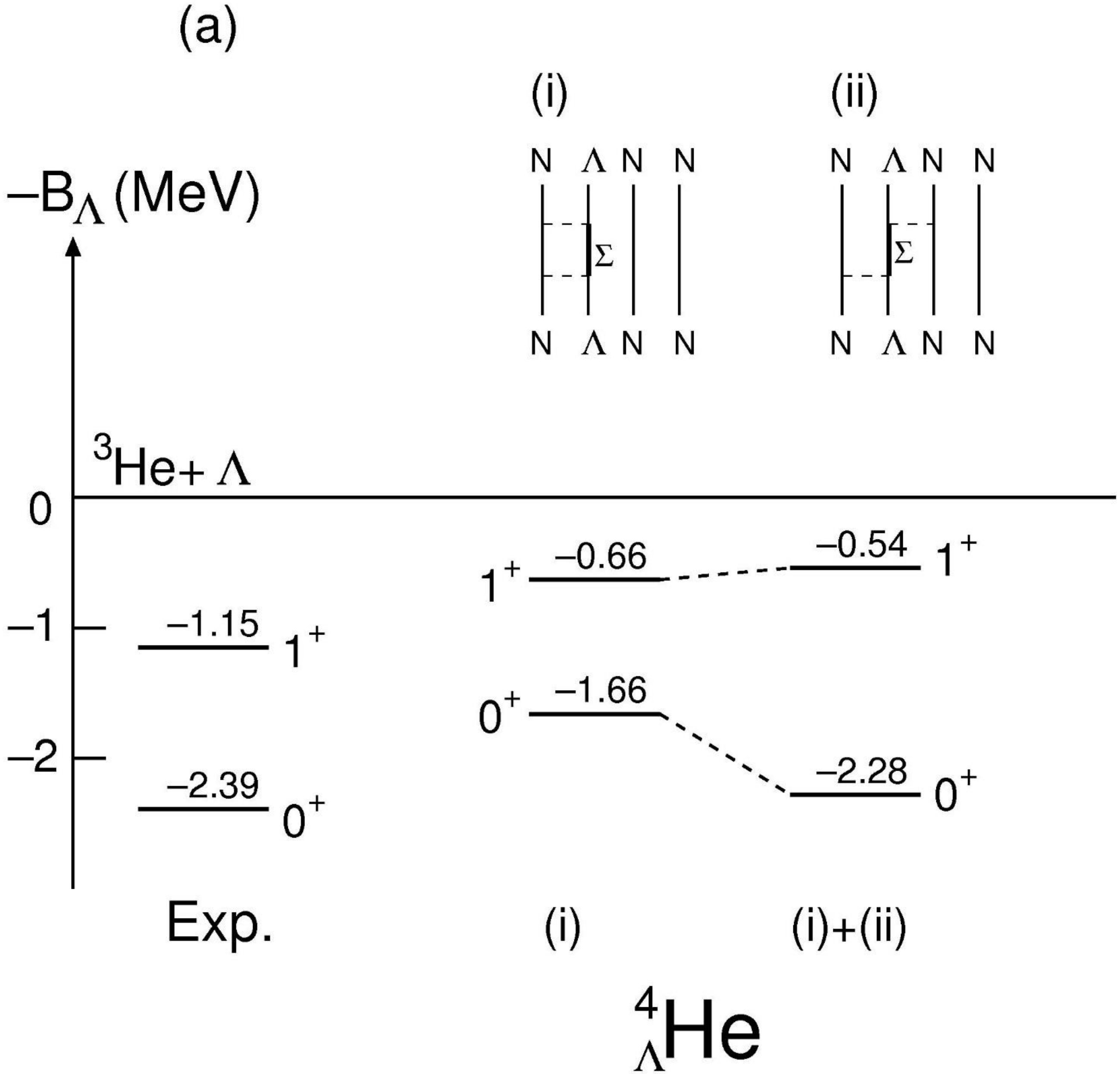
Another interesting role of Σ-particle in hypernuciei, namely effective ΛNN 3-body force generated by the Σ-particle mixing.



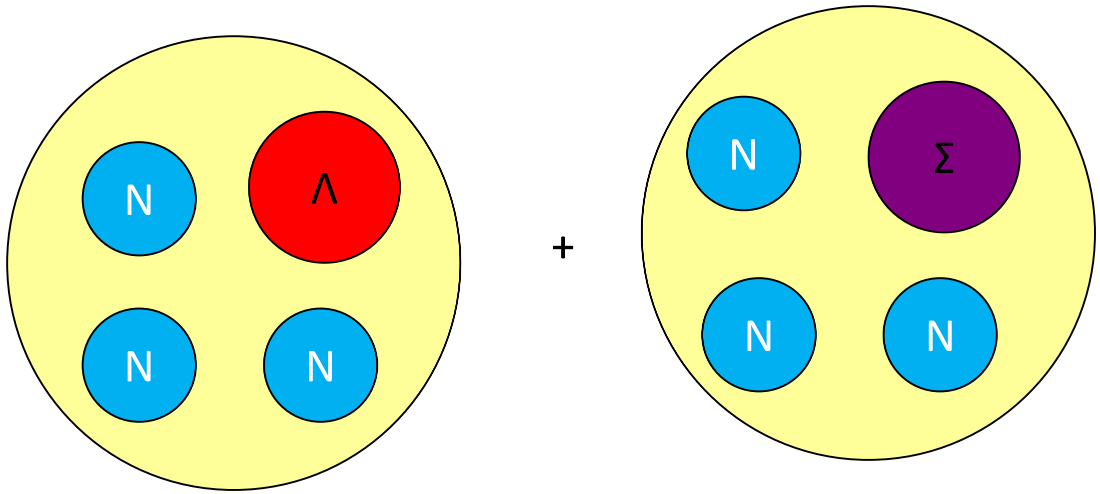
Y. Akaishi, T. Harada, S. Shinmura and Khin Swe Myint,
Phys. Rev. Lett. 84, 3539 (2000).



They already pointed out that three-body force effect is
Important within the framework of (^{3}He+Λ)+(^{3}He+Σ).


(a)
(i)
(ii)
N Λ N N
Σ
N Λ N N
N Λ N N
Σ
N Λ N N
$-B_\Lambda$ (MeV)
^{3}He+ Λ
0
−1
−2
−0.66
1^+
−0.54
1^+
−1.15
1^+
−1.66
0^+
−2.28
0^+
−2.39
0^+
Exp.
(i)
(i)+(ii)
$^4_\Lambda$He

To summarize the part of A=4 hypernuclei



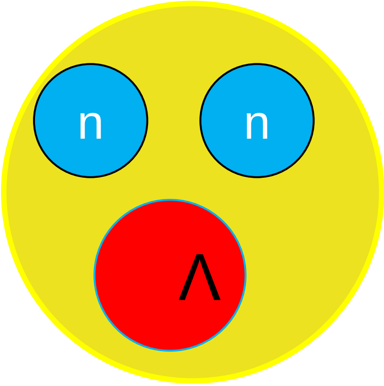
NNNΛ + NNNΣ

(1)NNNΣchannel is essentially important to make A=4 hypernuclei.

(2)ΛN-ΣN coupling as a three-body force is important in 0^+ state.

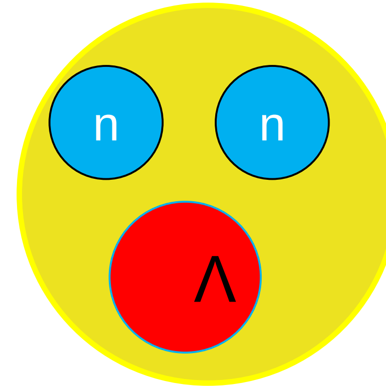
Section 2

three-body calculation of $^{3}_{\Lambda}n$



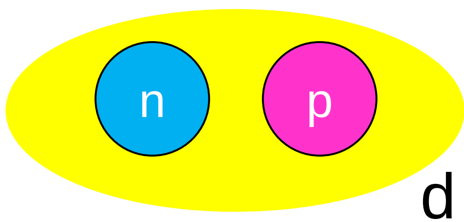
E. Hiyama, S. Ohnishi,
B.F. Gibson, and T. A. Rijken,
PRC89, 061302(R) (2014).

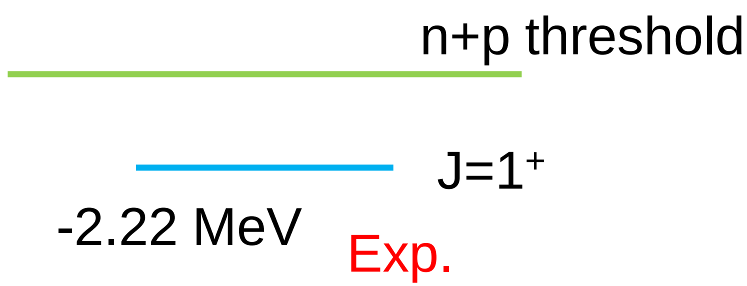
What is interesting to study nnΛ system?



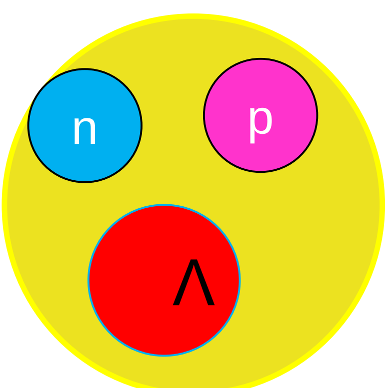
$\boxed{S=0}$

The lightest nucleus to have a bound state is deuteron.



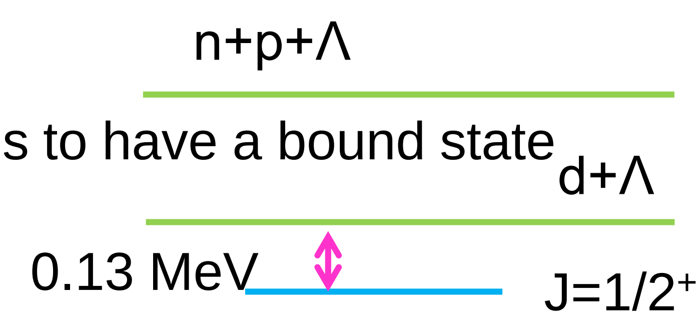


$\boxed{S=-1}$ (Λ hypernucear sector)



Lightest hypernucleus to have a bound state

$^{3}_{\Lambda}$H (hyper-triton)



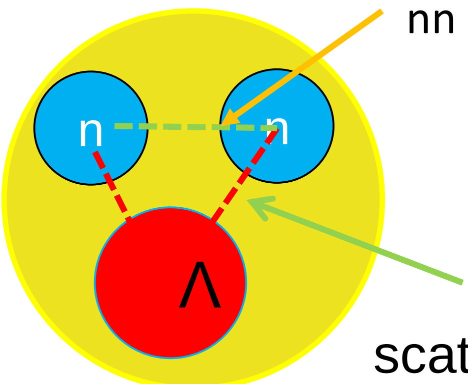
Exp.

PHYSICAL REVIEW C 88, 041001(R) (2013)

Search for evidence of ${}^{3}_{\Lambda}n$ by observing $d + \pi^-$ and $t + \pi^-$ final states in the reaction of ${}^{6}\mathrm{Li} + {}^{12}\mathrm{C}$ at $2A$ GeV

C. Rappold,[1,2,*] E. Kim,[1,3] T. R. Saito,[1,4,5,†] O. Bertini,[1,4] S. Bianchin,[1] V. Bozkurt,[1,6] M. Kavatsyuk,[7] Y. Ma,[1,4] F. Maas,[1,4,5] S. Minami,[1] D. Nakajima,[1,8] B. Özel-Tashenov,[1] K. Yoshida,[1,5,9] P. Achenbach,[4] S. Ajimura,[10] T. Aumann,[1,11] C. Ayerbe Gayoso,[4] H. C. Bhang,[3] C. Caesar,[1,11] S. Erturk,[6] T. Fukuda,[12] B. Göküzüm,[1,6] E. Guliev,[7] J. Hoffmann,[1] G. Ickert,[1] Z. S. Ketenci,[6] D. Khaneft,[1,4] M. Kim,[3] S. Kim,[3] K. Koch,[1] N. Kurz,[1] A. Le Fèvre,[1,13] Y. Mizoi,[12] L. Nungesser,[4] W. Ott,[1] J. Pochodzalla,[4] A. Sakaguchi,[9] C. J. Schmidt,[1] M. Sekimoto,[14] H. Simon,[1] T. Takahashi,[14] G. J. Tambave,[7] H. Tamura,[15] W. Trautmann,[1] S. Voltz,[1] and C. J. Yoon[3]
(HypHI Collaboration)

nn unbound



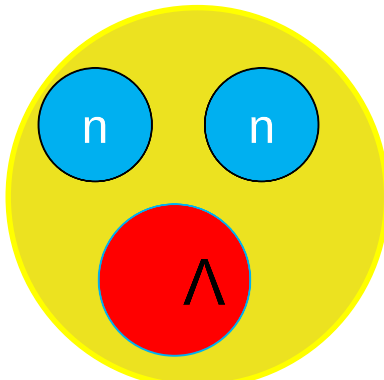
scattering length:-2.68fm

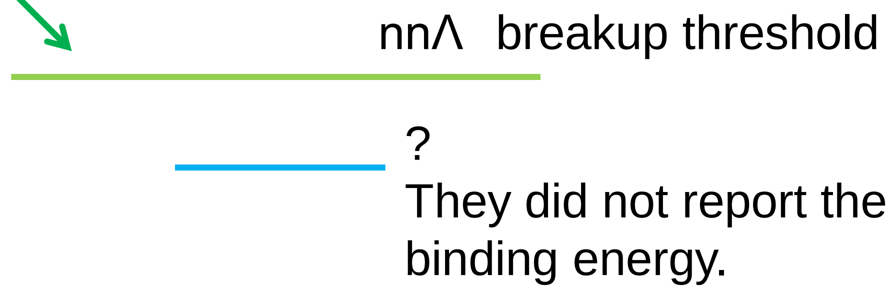
nnΛ breakup threshold

?
They did not report the binding energy.

Observation of nnΛ system (2013)
Lightest hypernucleus to have a bound state
Any two-body systems are unbound.=>nnΛ system is bound.
Lightest Borromean system.

Theoretical important issue:
Do we have bound state for nnΛ system?
If we have a bound state for this system, how much is binding energy?



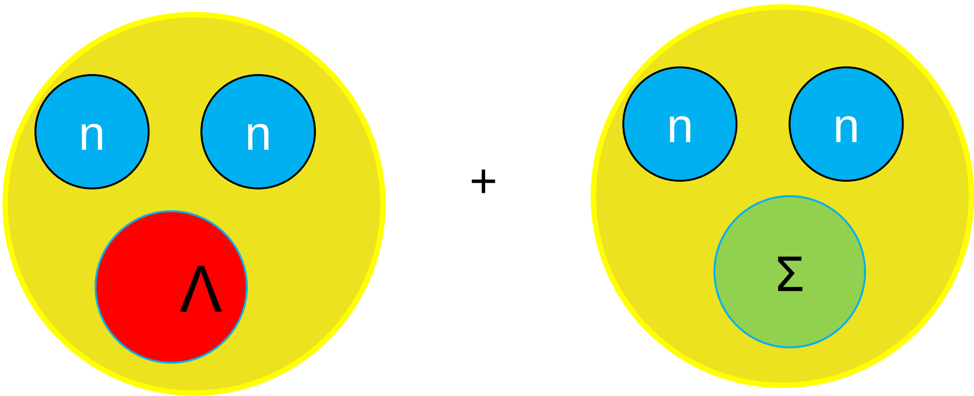


NN interaction : to reproduce the observed binding energies of ^{3}H and ^{3}He

NN: AV8 potential
We do not include 3-body force for nuclear sector.

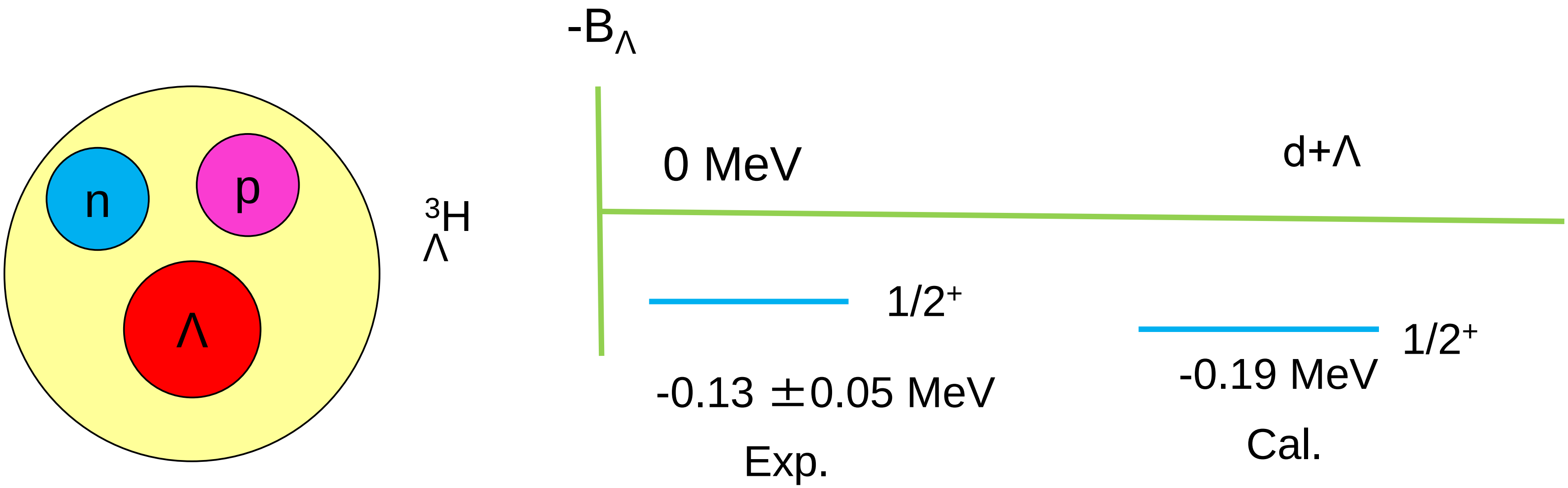
How about YN interaction?

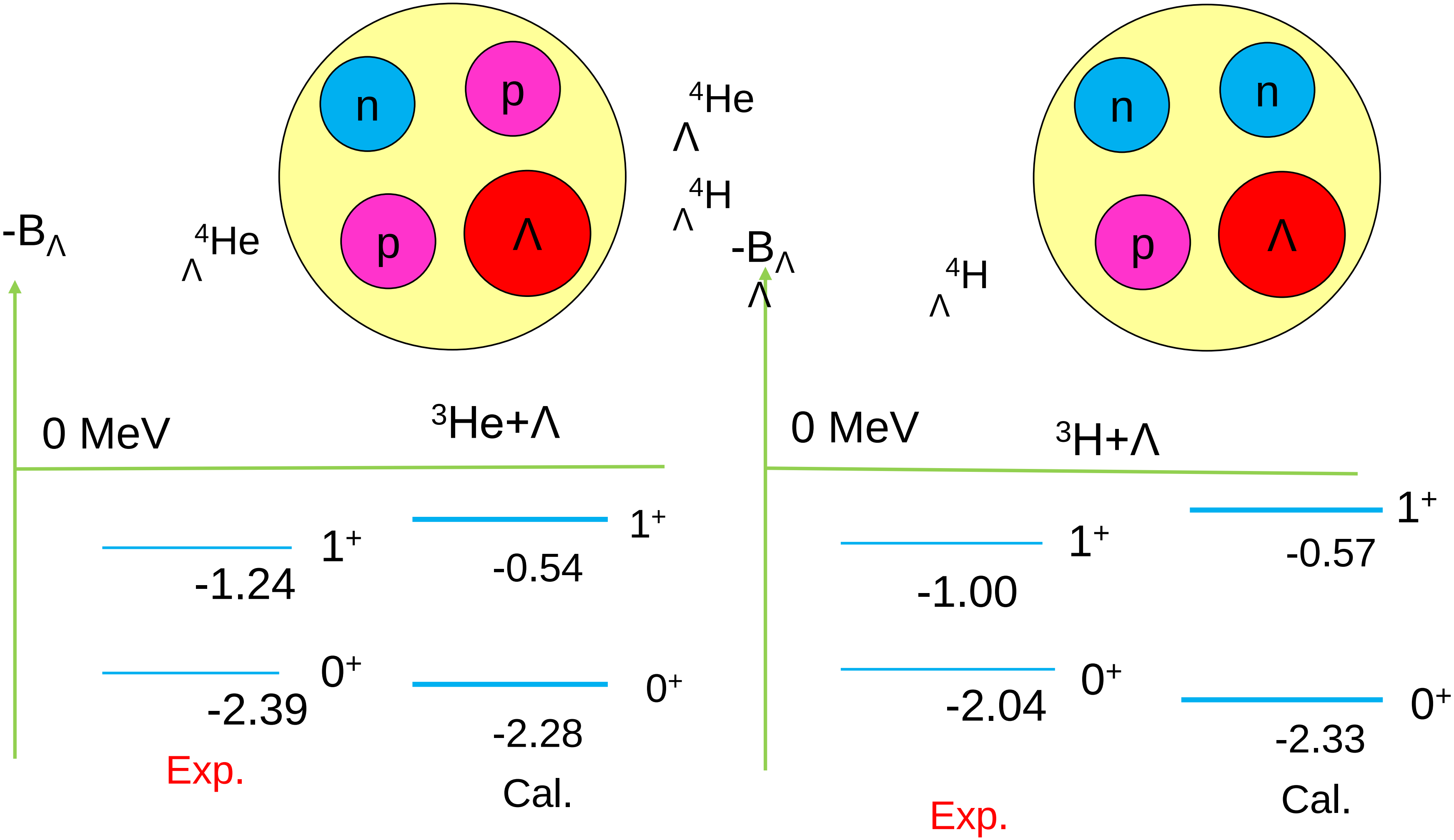
To take into account of Λ particle to be converted into Σ particle, we should perform below calculation using realistic hyperon(Y)-nucleon(N) interaction.



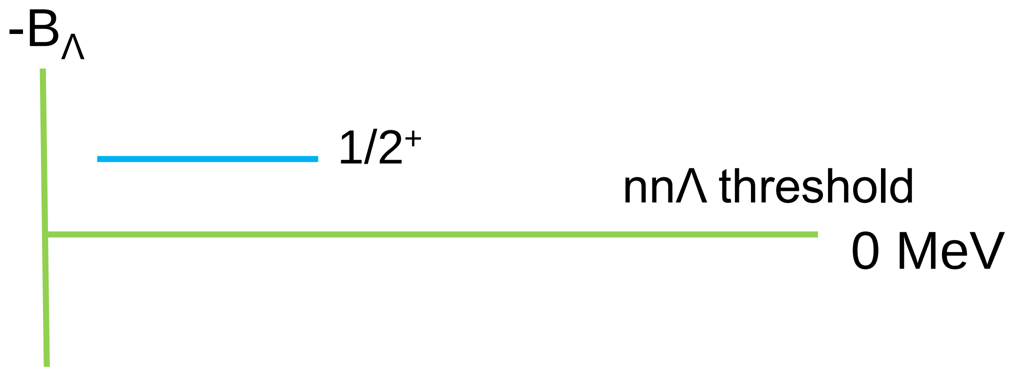
YN interaction: Nijmegen soft core '97f potential (NSC97f) proposed by Nijmegen group

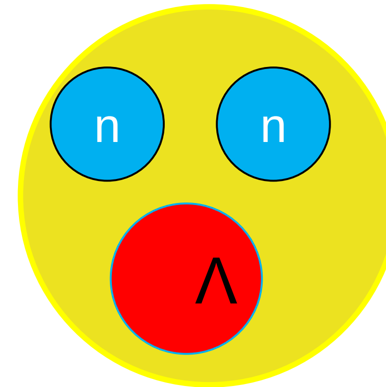
reproduce the observed binding energies of ${}^{3}_{\Lambda}H$, ${}^{4}_{\Lambda}H$ and ${}^{4}_{\Lambda}He$


n
p
Λ
$^3_\Lambda H$
$-B_\Lambda$
0 MeV
d+Λ
1/2$^+$
-0.13 ±0.05 MeV
Exp.
1/2$^+$
-0.19 MeV
Cal.



What is binding energy of nnΛ?





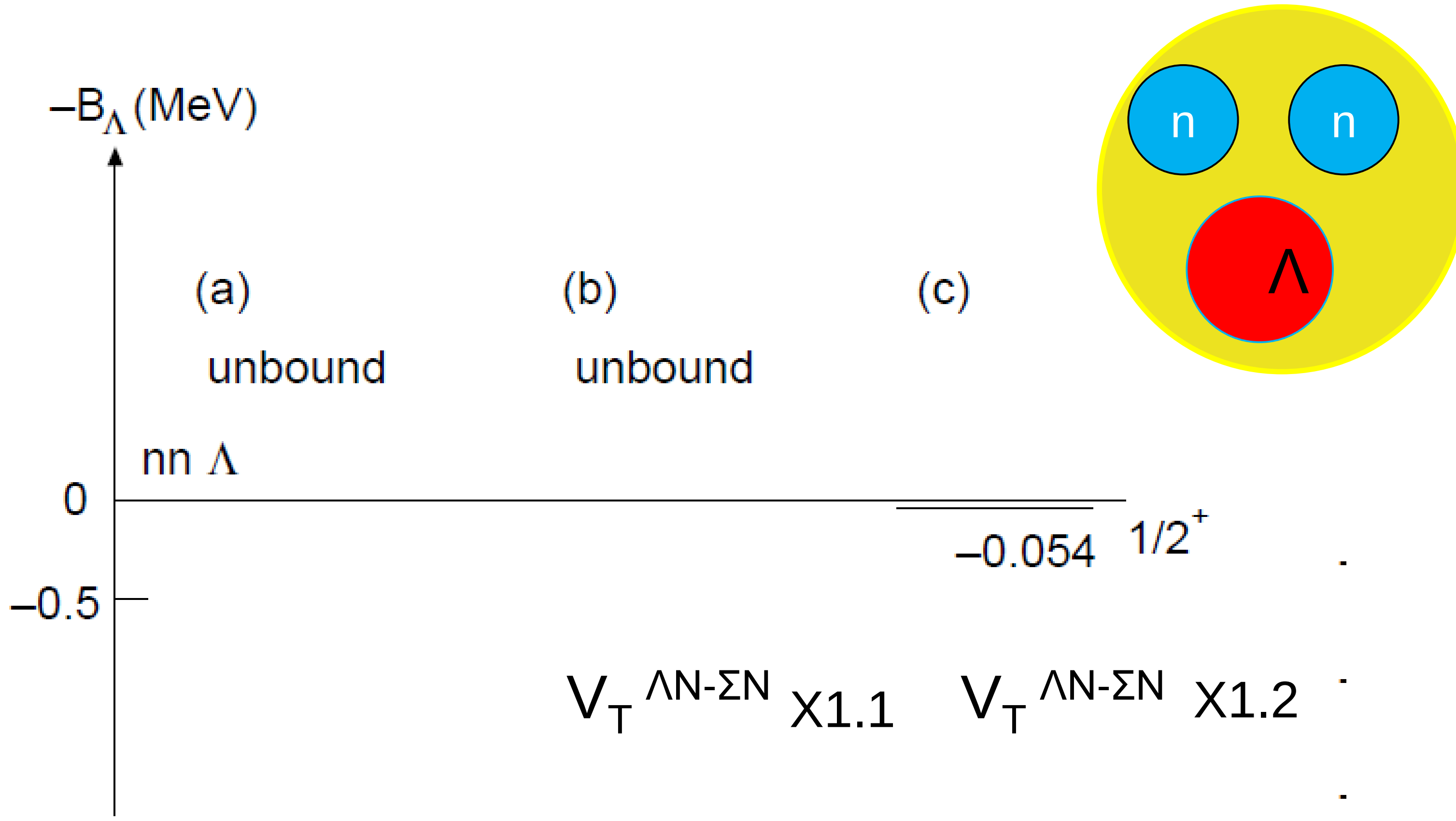
We have no bound state in nnΛ system.
This is inconsistent with the data.

Now, we have a question.

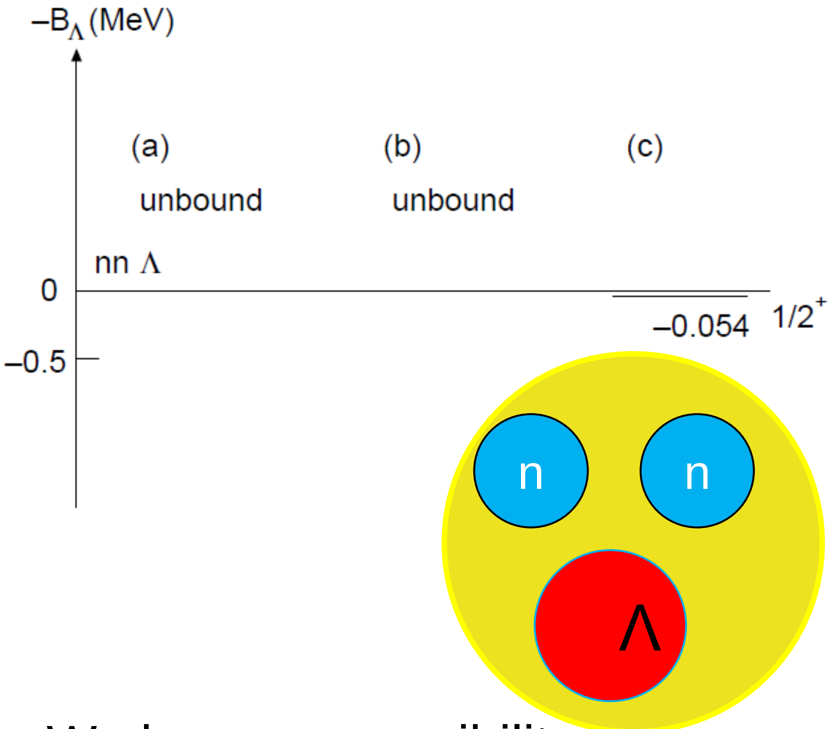
Do we have a possibility to have a bound state in nnΛ system tuning strength of YN potential ?

It should be noted to maintain consistency with the binding energies of ${}^{3}_{\Lambda}$H and ${}^{4}_{\Lambda}$H and ${}^{4}_{\Lambda}$He.

$V_T^{\Lambda N-\Sigma N}$ X1.1, 1.2



When we have a bound state in nnΛ system, what are binding energies of ${}^{3}_{\Lambda}$H and A=4 hypernuclei?



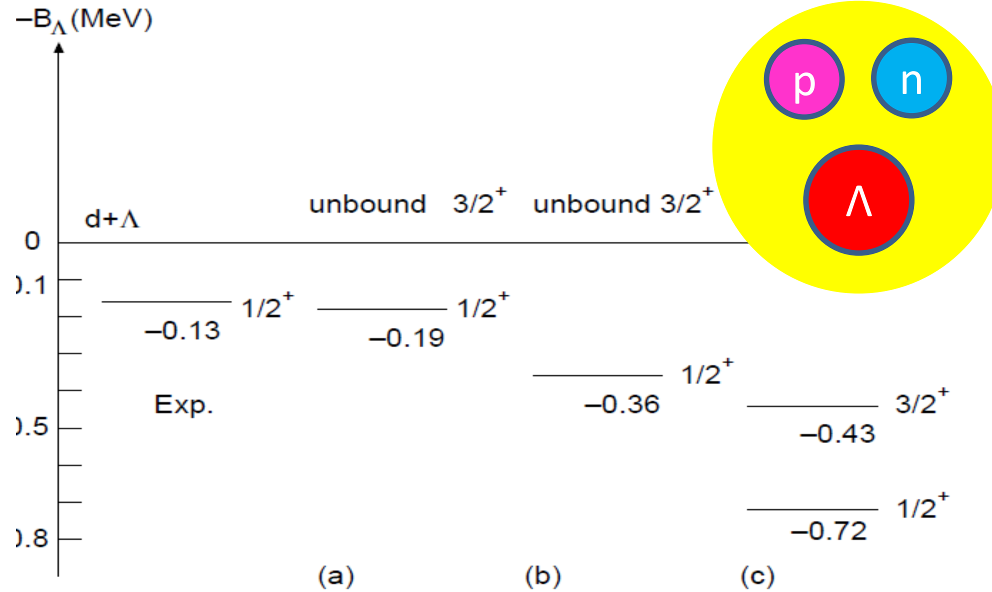
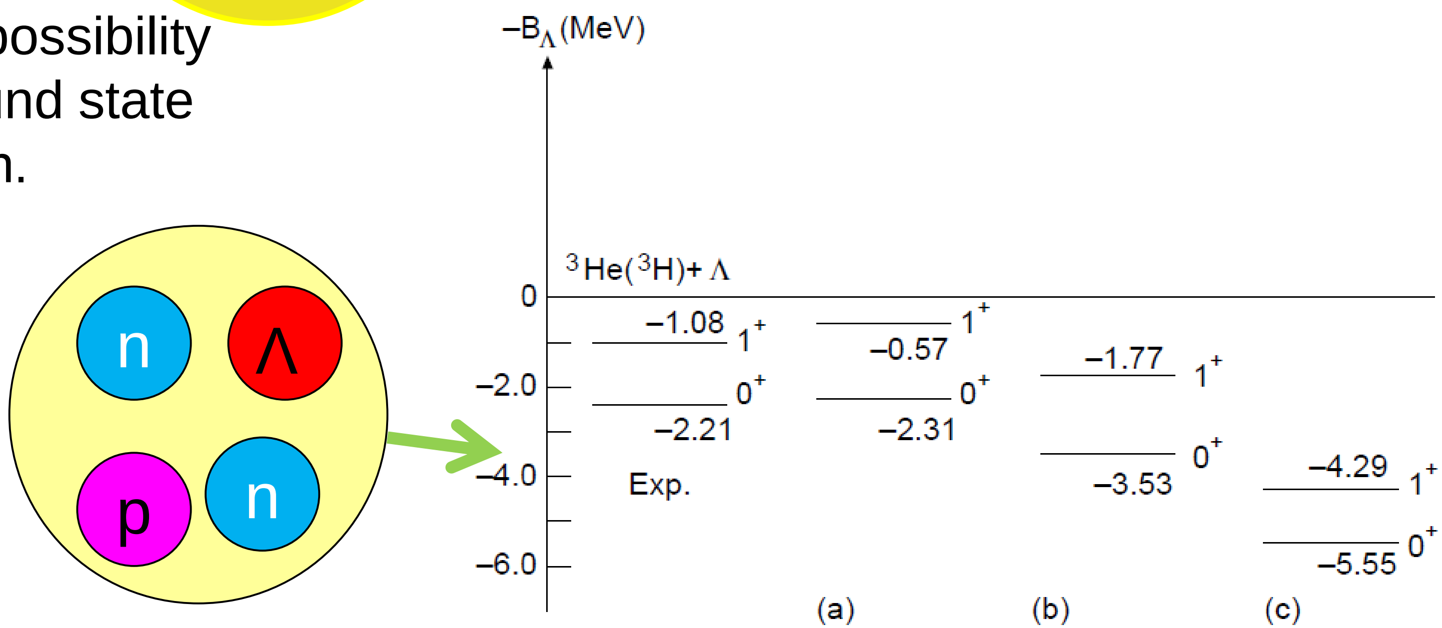


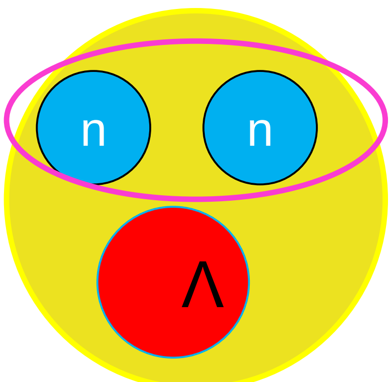
FIG. 3: Calculated Λ-separation energy for $^{3}_{\Lambda}$H with (a) $^{3}V^{T}_{N\Lambda-N\Sigma}$ × 1.00, (b) $^{3}V^{T}_{N\Lambda-N\Sigma}$ × 1.10, and (c) $^{3}V^{T}_{N\Lambda-N\Sigma}$ ×

We have no possibility to have a bound state in nnΛ system.



Question: If we tune $^1S_0$ state of nn interaction,
Do we have a possibility to have a bound state in nnΛ?
In this case, the binding energies of ^{3}H and ^{3}He reproduce the observed data?

Some authors pointed out to have dineutron bound state in nn system. Ex. H. Witala and W. Gloeckle, Phys. Rev. C85, 064003 (2012).



T=1, $^1S_0$ state
I multiply component of $^1S_0$ state by 1.13 and 1.35. What is the binding energies of nnΛ ?

PHYSICAL REVIEW C **85**, 064003 (2012)

Di-neutron and the three-nucleon continuum observables

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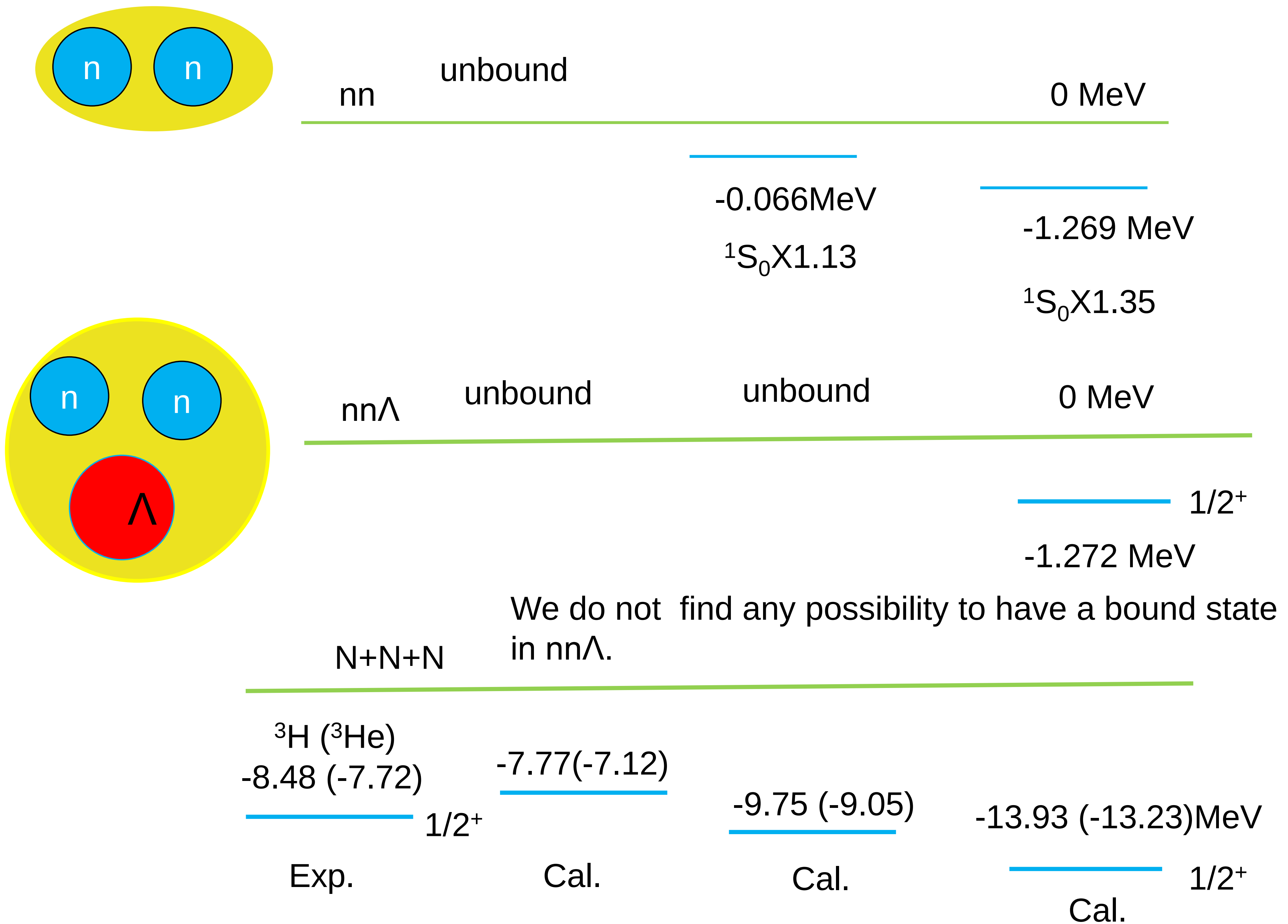
(Received 24 April 2012; published 25 June 2012)

We investigate how strongly a hypothetical $^1S_0$ bound state of two neutrons would affect observables in neutron-deuteron reactions. To that aim we extend our momentum-space scheme of solving the three-nucleon Faddeev equations and incorporate in addition to the deuteron also a $^1S_0$ di-neutron bound state. We discuss effects induced by a di-neutron on the angular distributions of the neutron-deuteron elastic scattering and deuteron breakup cross sections. A comparison to the available data for the neutron-deuteron total cross section and elastic scattering angular distributions cannot decisively exclude the possibility that two neutrons can form a $^1S_0$ bound state. However, strong modifications of the final-state-interaction peaks in the neutron-deuteron breakup reaction seem to disallow the existence of a di-neutron.

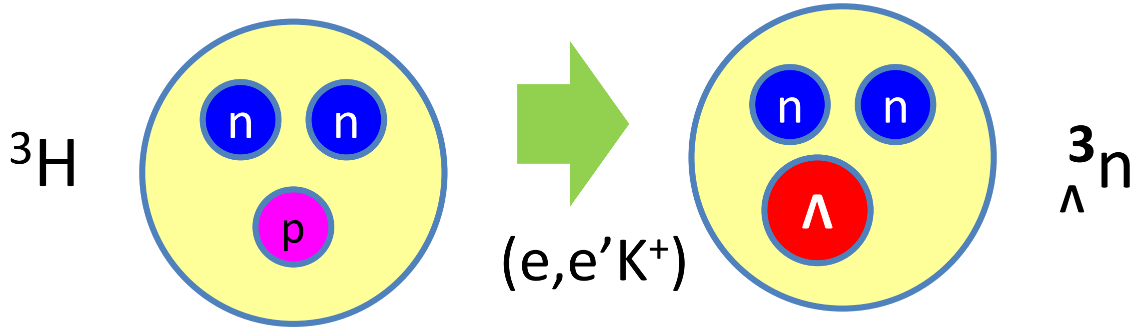


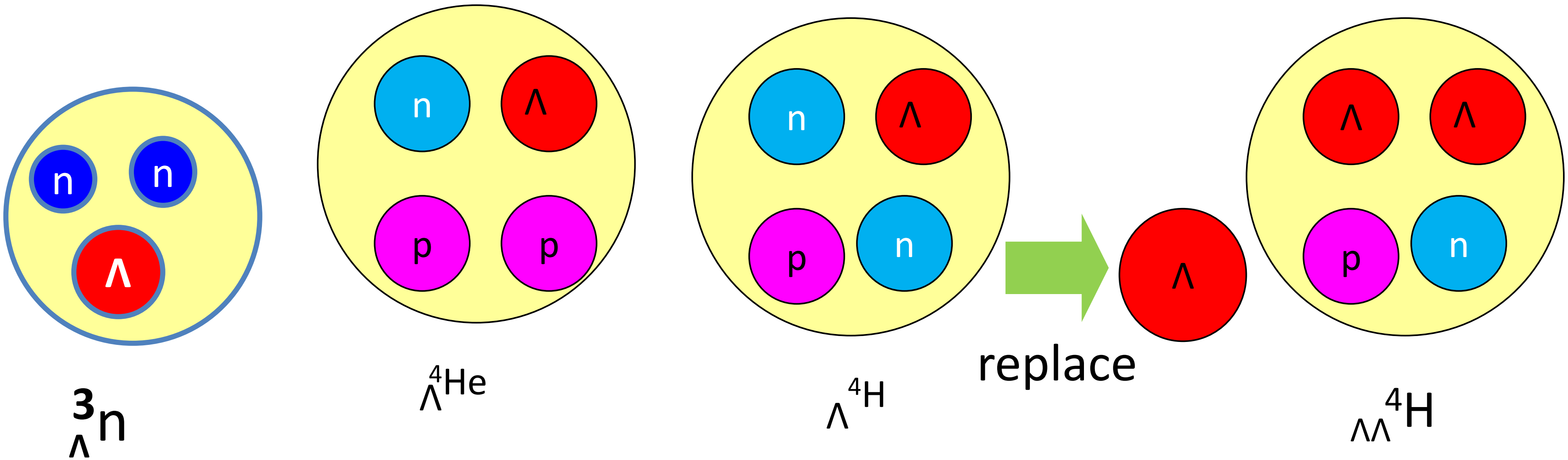
n
n
nn
unbound
0 MeV
-0.066MeV
1S0X1.13
-1.269 MeV
1S0X1.35
n
n
Λ
nnΛ
unbound
unbound
0 MeV
1/2+
-1.272 MeV
We do not find any possibility to have a bound state in nnΛ.
N+N+N
3H (3He)
-8.48 (-7.72)
1/2+
-7.77(-7.12)
-9.75 (-9.05)
-13.93 (-13.23)MeV
1/2+
Exp.
Cal.
Cal.
Cal.

Summary of nnΛ system:

Motivated by the reported observation of data suggesting a bound state nnΛ, we have calculated the binding energy of this hyperucleus taking into account ΛN-ΣN explicitly. We did not find any possibility to have a bound state in this system. However, the experimentally they reported evidence for a bound state. As long as we believe the data, we should consider additional missing elements in the present calculation. I need more data for nnΛ system. For this purpose, I am waiting for ALICE data.

It is planned to perform search experiment of nnΛ system at JLab to conclude whether or not the system exists as bound state experimentally. Also, it is planned to perform search experiment of nnΛ system at HypHI collaboration+Super FRS in 2018.



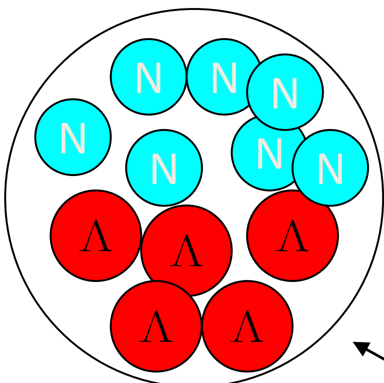


Interesting issue:

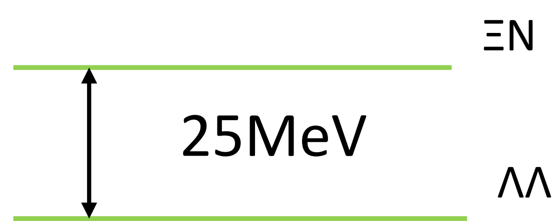
ΛΛ—ΞN coupling

ΛΛ-ΞN coupling

One of the major goals in hypernuclear physics
To study structure of multi-strangeness systems
(extreme limit : neutron star)



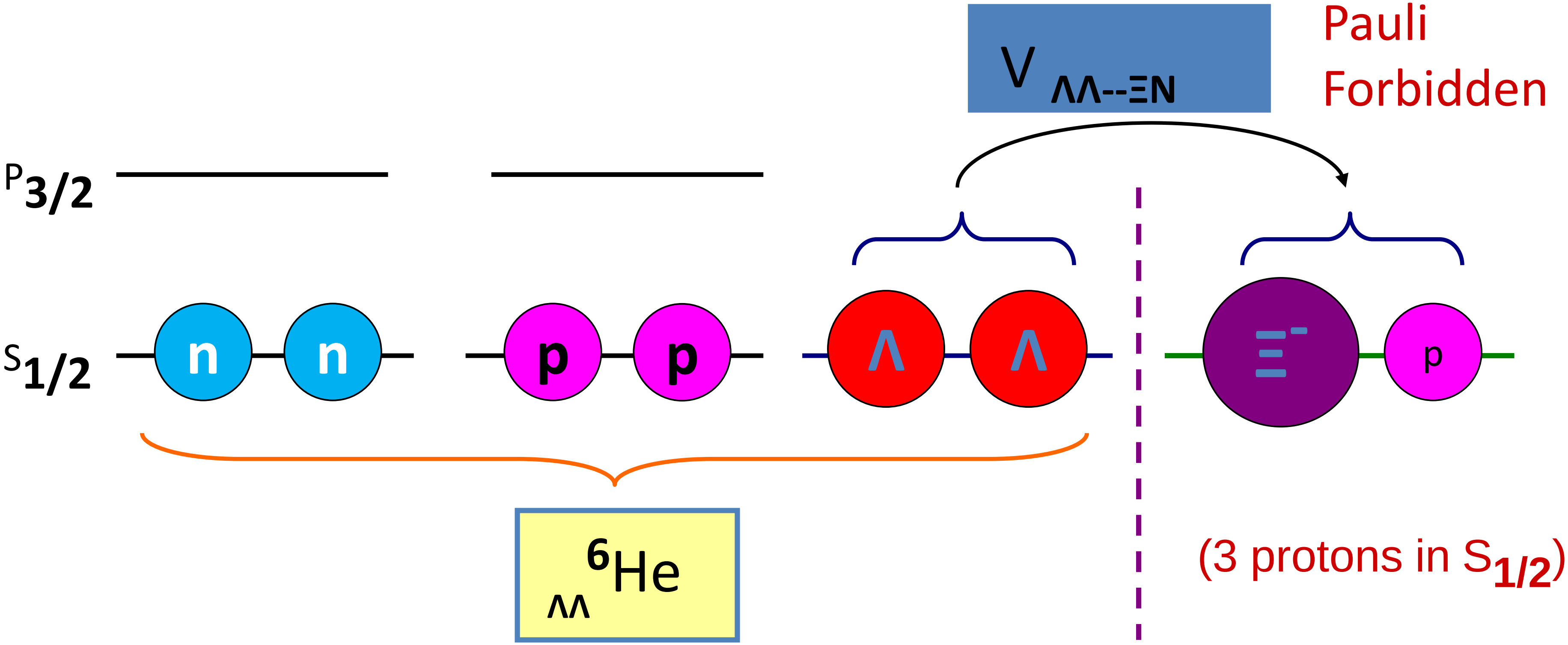
Multi-strangeness systems



threshold energy difference is very small!

It is considered that
ΛΛ→ΞN particle conversion
is strong in multi-strangeness system.

Effect of ΛΛ—ΞN coupling is small in $_{\Lambda\Lambda}{}^{6}$He which was observed as NAGARA event.

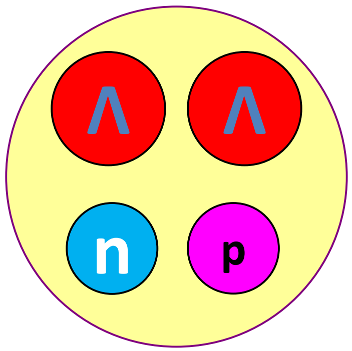


- I.R. Afnan and B.F. Gibson, Phys. Rev. C67, 017001 (2003).
- Khin Swe Myint, S. Shinmura and Y. Akaishi, nucl-th/029090.
- T. Yamada and C. Nakamoto, Phys. Rev.C62, 034319 (2000).

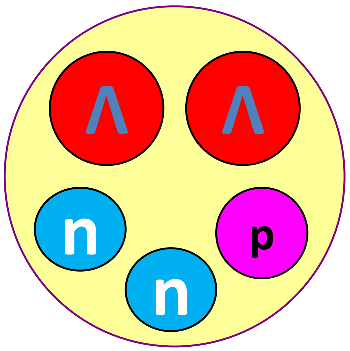
For the study of **ΛΛ**－ΞN coupling interaction,

s-shell double **Λ** hypernuclei such as

${}^{4}_{\Lambda\Lambda}\mathrm{H}$ and ${}^{5}_{\Lambda\Lambda}\mathrm{H}$ (${}^{5}_{\Lambda\Lambda}\mathrm{He}$) are very suitable.

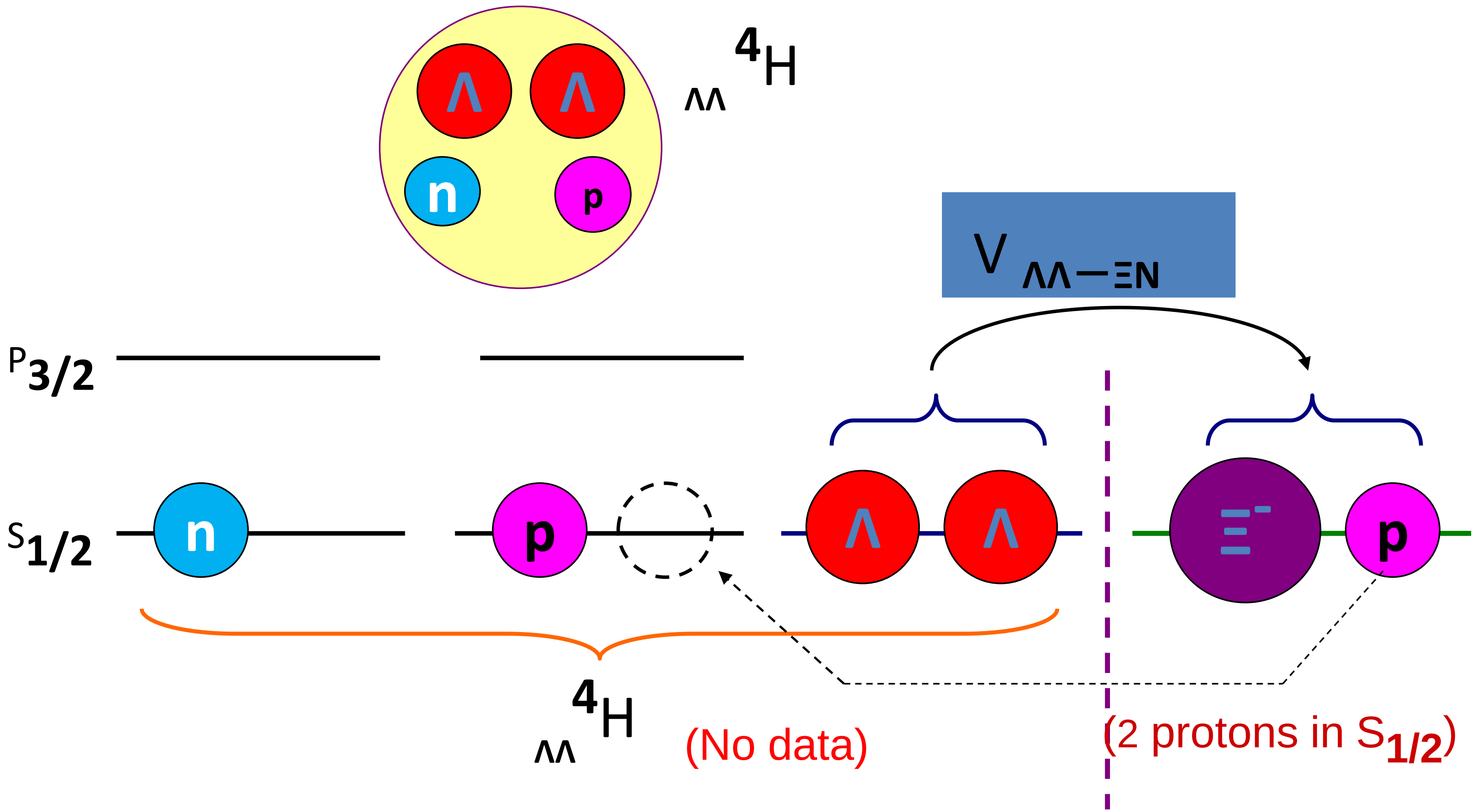


${}^{4}_{\Lambda\Lambda}\mathrm{H}$



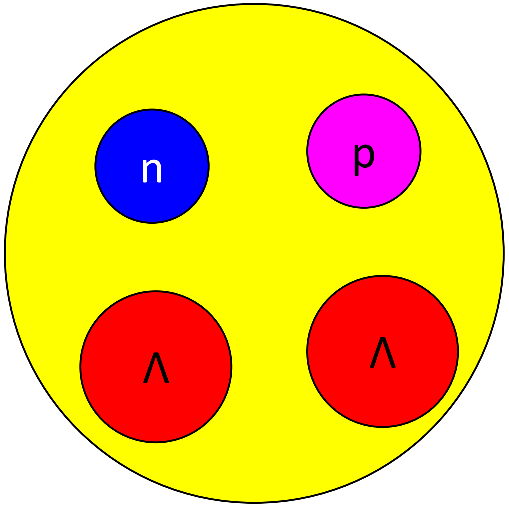
${}^{5}_{\Lambda\Lambda}\mathrm{H}$ $({}^{5}_{\Lambda\Lambda}\mathrm{He})$

- I.N. Filikhin and A. Gal, Phys. Rev. Lett. 89, 172502 (2002)
- Khin Swe Myint, S. Shinmura and Y. Akaishi, Eur. Phys. J. A16, 21 (2003).
- D. E. Lanscoy and Y. Yamamoto, Phys. Rev. C69, 014303 (2004).
- H. Nemura, S. Shinmura, Y. Akaishi and Khin Swe Myint,
  Phys. Rev. Lett. 94, 202502 (2005).



Due to NO Pauli plocking, the **ΛΛ—ΞN** coupling can be large in $^{4}_{\Lambda\Lambda}$H

B.F. Gibson, I.R. Afnan, J.A.Carlson and D.R.Lehman, Prog. Theor. Phys. Suppl. 117, 339 (1994).

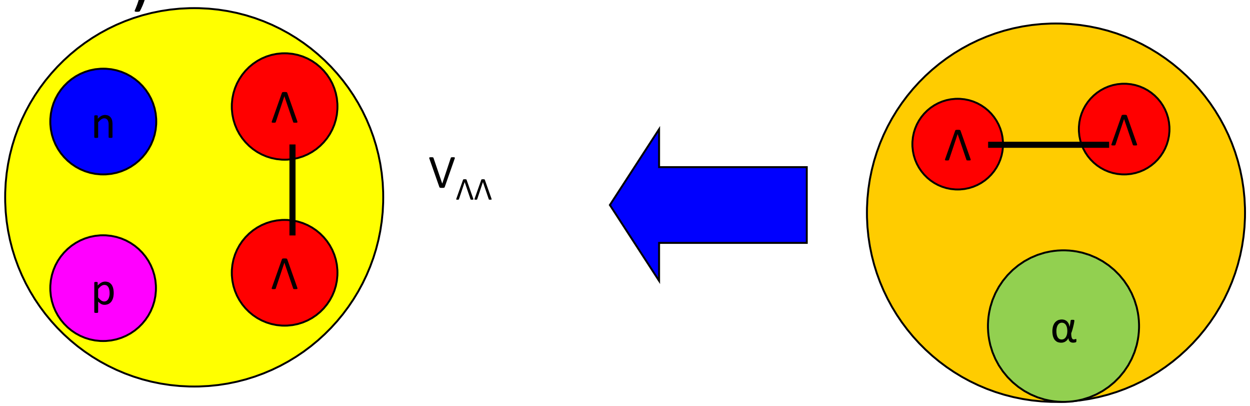


$^{4}_{\Lambda\Lambda}H$

The important issue:
Does the YY interaction which designed to reproduce the binding energy of $^{6}_{\Lambda\Lambda}He$ make $^{4}_{\Lambda\Lambda}H$ bound?
And how does the effect of ΛΛ—ΞN coupling play important role in the binding energy of $^{6}_{\Lambda\Lambda}He$ and $^{4}_{\Lambda\Lambda}H$?

1)I.N. Filikhin and A. Gal, Phys. Rev. Lett. 89, 172502 (2002)

2)H. Nemura, Y. Akaishi et al., Phys. Rev. C67, 051001 (2002)

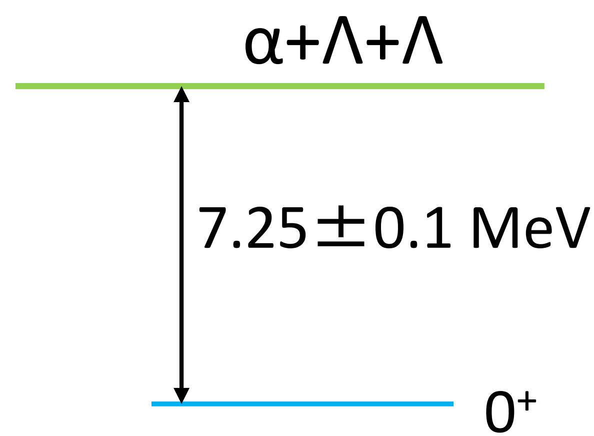


$^{6}_{\Lambda\Lambda}\mathrm{He}$

NAGARA event

NOT BOUND !

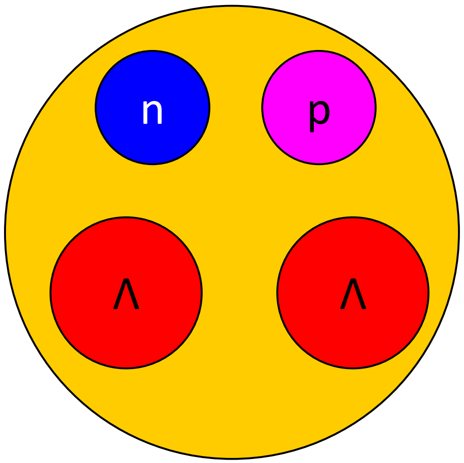
$^{4}_{\Lambda\Lambda}\mathrm{H}$



Did not include ΛΛ-ΞN coupling

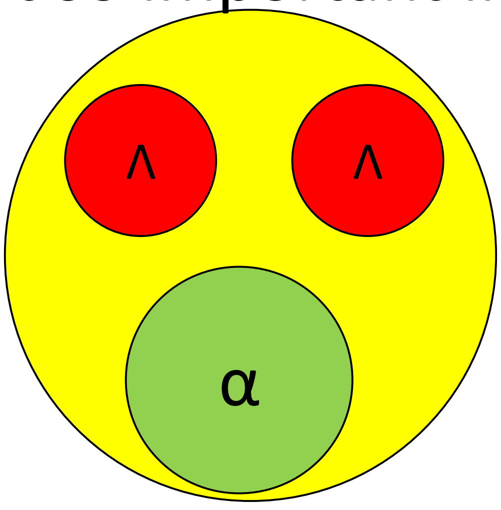
ΛΛ-ΞN coupling =>

- significant in ${}_{\Lambda\Lambda}^{4}\mathrm{H}$

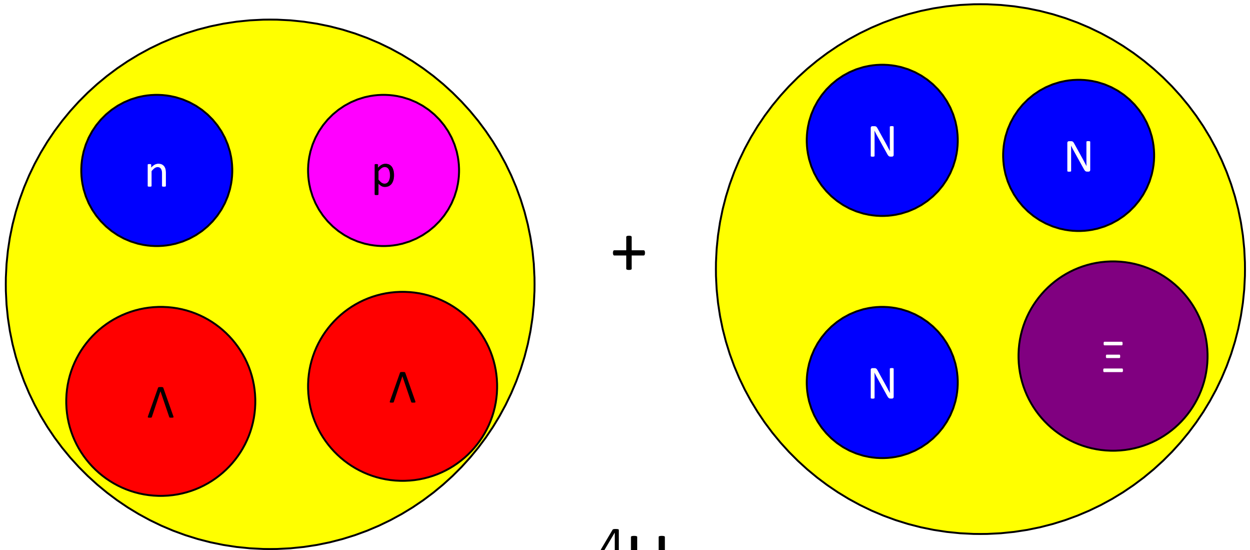


${}_{\Lambda\Lambda}^{4}\mathrm{H}$

- Not so important in ${}_{\Lambda\Lambda}^{6}\mathrm{He}$

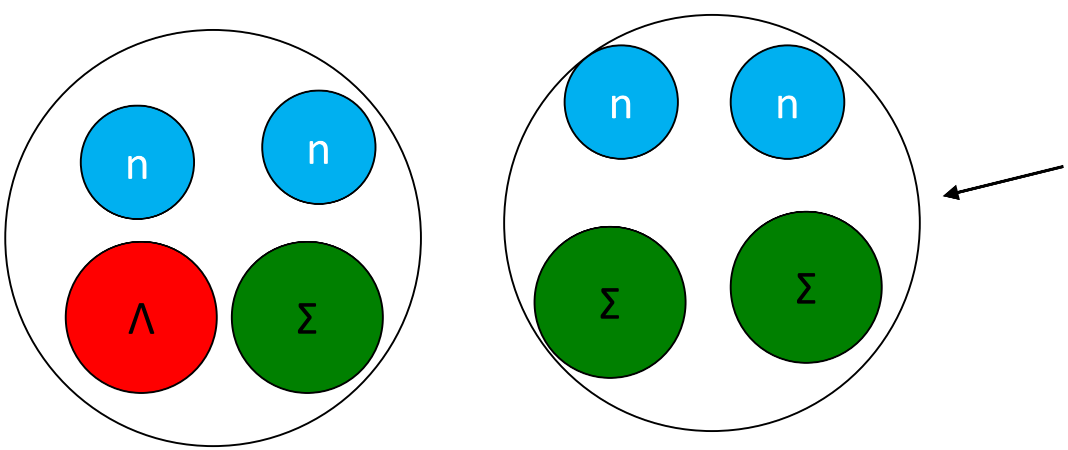


${}_{\Lambda\Lambda}^{6}\mathrm{He}$

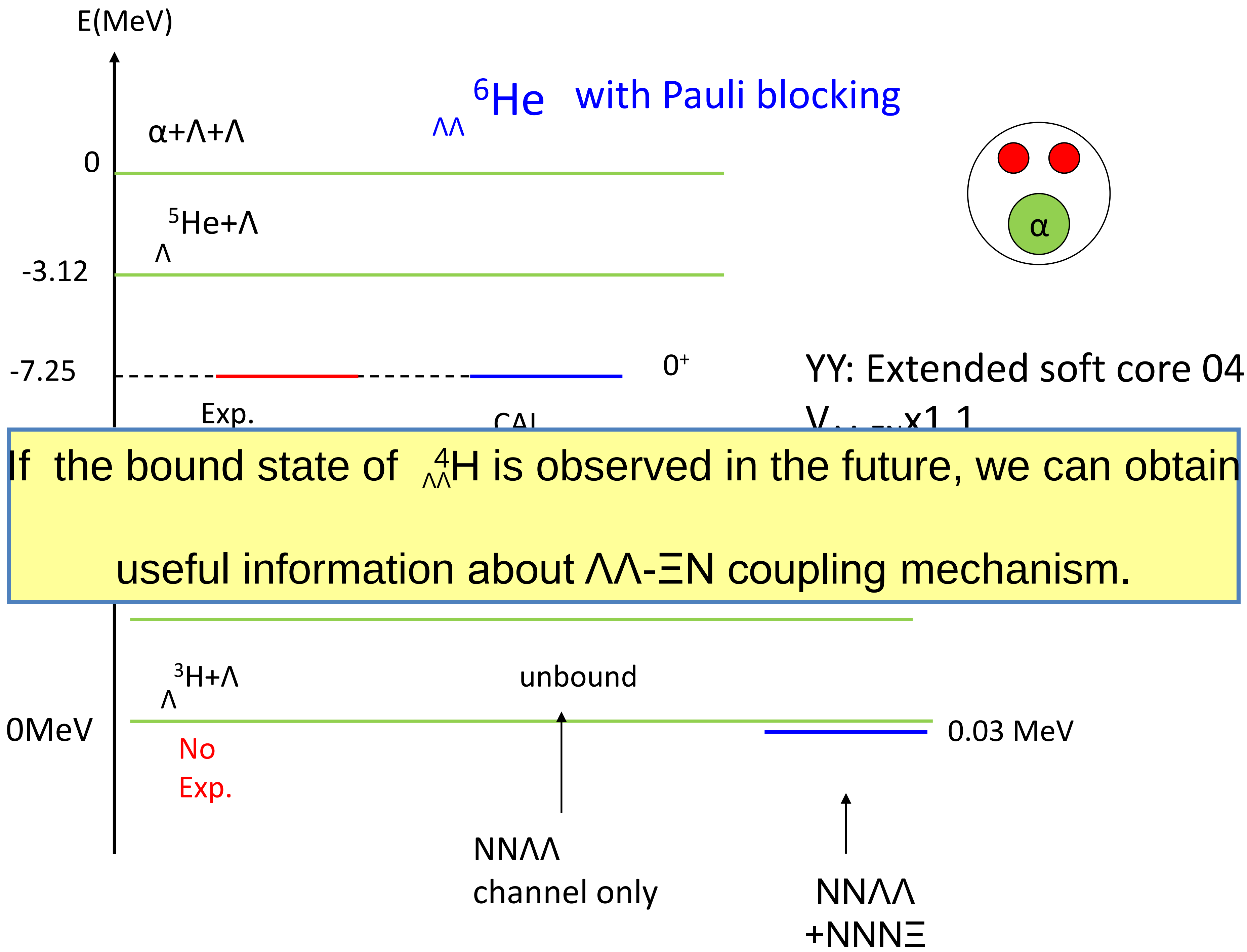


$^{4}_{\Lambda\Lambda}\mathrm{H}$

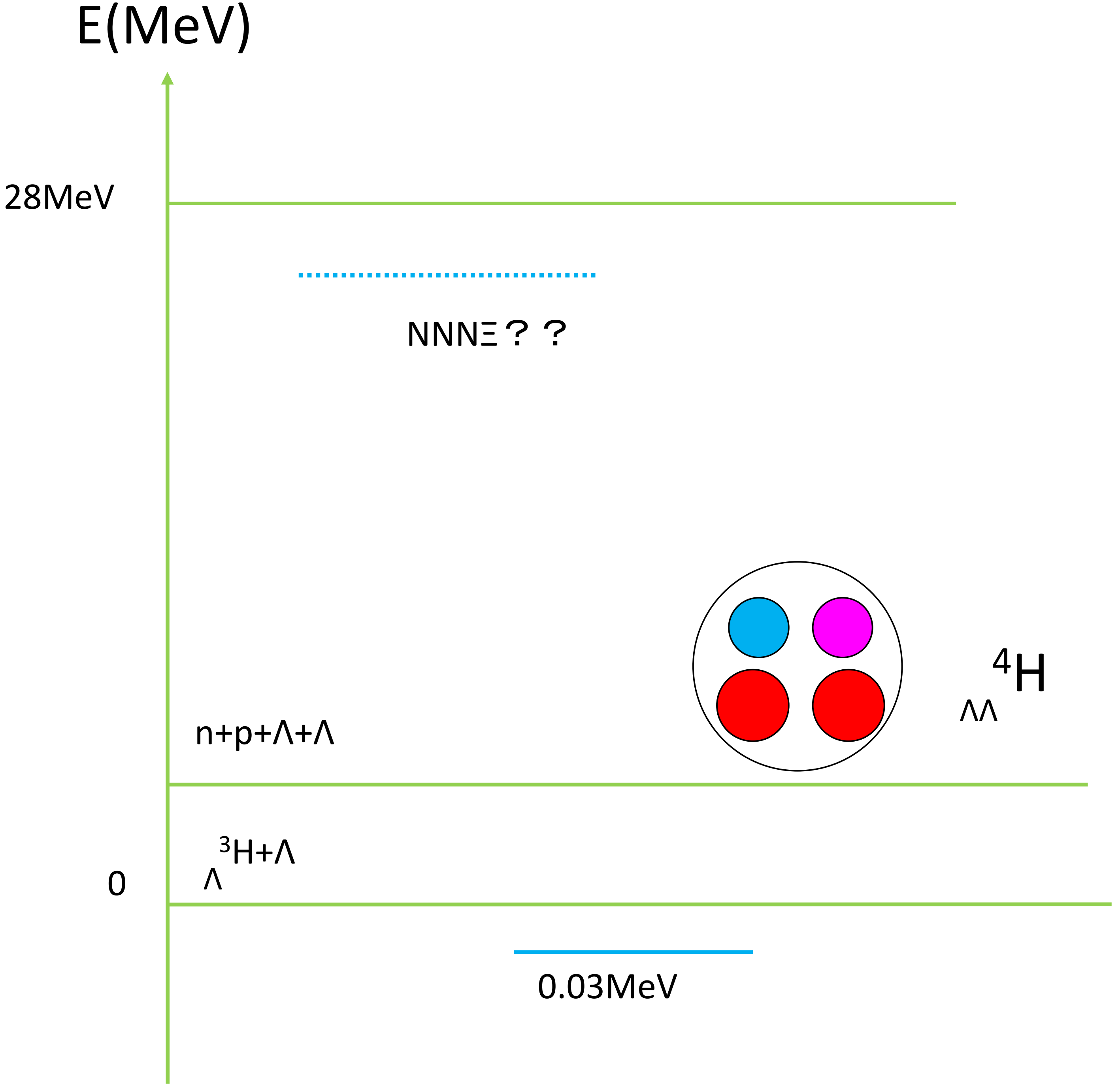
One of the most numerically difficult 4-body problem



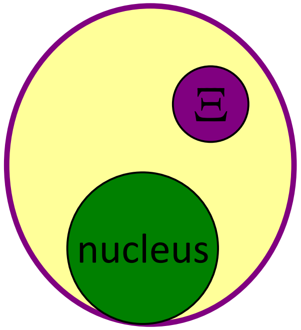
E. Hiyama
Dr. Nemura



If the bound state of $_{\Lambda\Lambda}{}^{4}$H is observed in the future, we can obtain useful information about ΛΛ-ΞN coupling mechanism.


E(MeV)
28MeV
NNNΞ？？
$^{4}_{\Lambda\Lambda}$H
n+p+Λ+Λ
$^{3}_{\Lambda}$H+Λ
0
0.03MeV

ΞN -ΞN interaction



Ξ hypernucleus

For the study of ΞN interaction, it is important to study the structure of Ξ hypernuclei.
Then, it is important to predict theoretically what kinds of Ξ hypernuclei will exist as bound states.

Important issue:

What kind of ΞN interaction should we employ?

Since there is no information about ΞN interaction, we cannot use phenomenological ΞN interaction.

We have realistic interactions although with large ambiguity.

- Nijmegen group
- Ehime group
- Kyoto-Niigata group

BNL-E885

PHYSICAL REVIEW C 61 054603

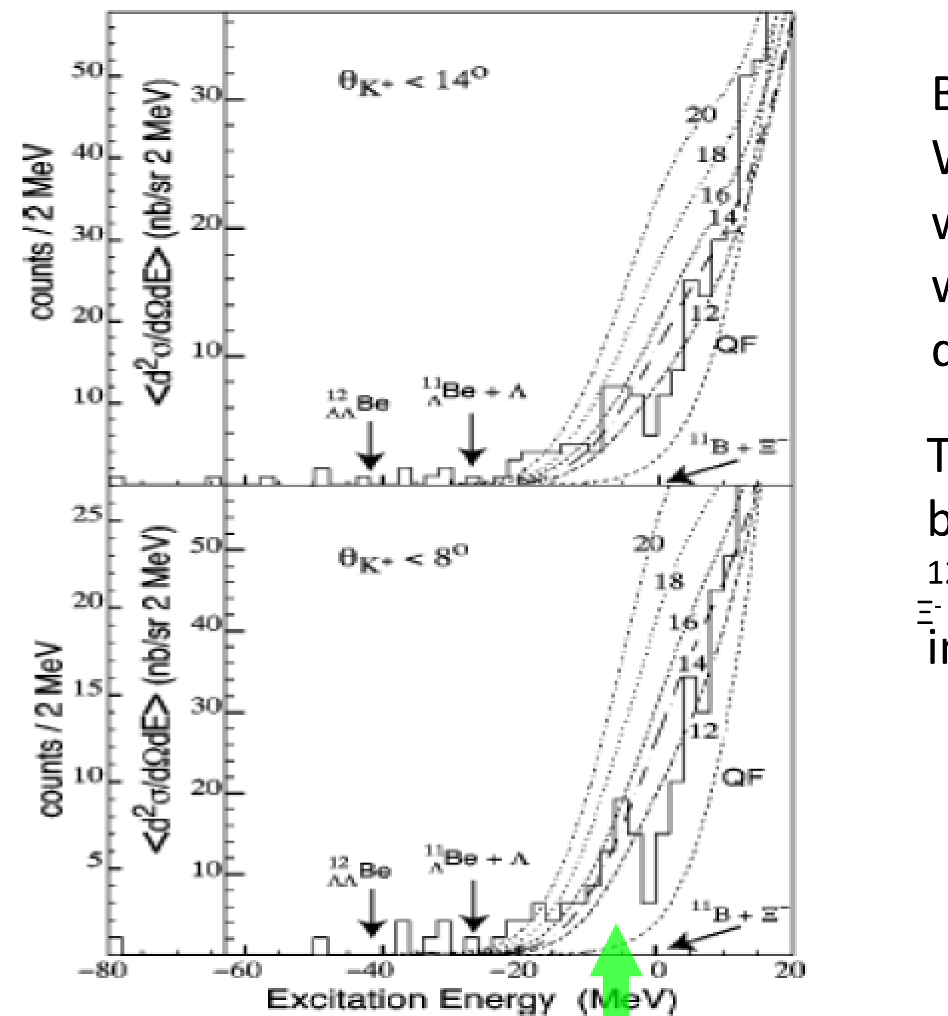
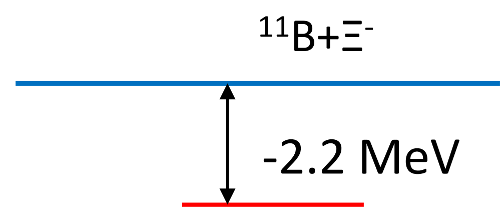


FIG. 6. Excitation-energy spectra from E885 for $^{12}C(K^-,K^+)X$

Only experimental data

By assuming a Ξ-nucleus Woods-Saxon potential with a depth of ～-14 MeV, we reproduce the experimental data.

This WS potential leads to be bound by -2.2 MeV in $^{12}_{\Xi^-}$Be when the Coulomb interaction is switched off.



We use this information.

The ΞN interaction to reproduce the data

- Extended soft core 04d (ESC04d)

  Th. A. Rijken, and Y. Yamamoto, Phys. Rev. C73, 044008(2006).

Extended soft core '08(ESC08)

Three- and four-body calculation using this potential is in progress.

TABLE I. Partial-wave contributions to $U_{\Xi}(\rho_0)$. In the case of ESC04d, the medium-induced repulsion is included by taking $\alpha_V = 0.18$. In the case of ND, the hard-core radii are taken as $r_c = 0.52$ and 0.45 fm in the ${}^{11}S_0$ and the other states, respectively.

Model	T	${}^1S_0$	${}^3S_1$	${}^1P_1$	${}^3P_0$	${}^3P_1$	${}^3P_2$	U_{Ξ}	Γ_{Ξ}
ESC04d	0	6.3	−18.4	1.2	1.5	−1.3	−1.9		
	1	7.2	−1.7	−0.8	−0.5	−1.2	−2.5	−12.1	12.7
ND	0	−3.0	−0.5	−2.1	−0.2	−0.7	−1.9		
	1	−4.1	−4.2	−3.0	−0.0	−3.1	−6.5	−29.5	0.8

ND : all parts of ΞN interaction are weakly attractive.

strength of ΛΛ—ΞN—ΣΣ is small.

The characteristic property of ESC04 potential

V(T=0,S=1): strongly attractive

-0.60MeV

V(T=0,S=0),V(T=1,S=0),V(T=1,S=1)

Not so strong attractive or weak repulsive

T=0, L=0,2 ,S=1,J=1^+

-1.60MeV

attractive Coulomb force

Ξ^- :1321.3MeV

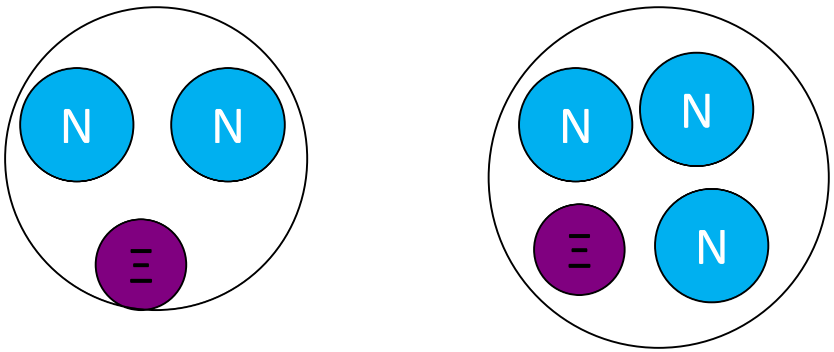
Ξ^0:1314.9MeV

T=0, L=0,2 ,S=1,J=1^+

U_Ξ=-12.1 MeV

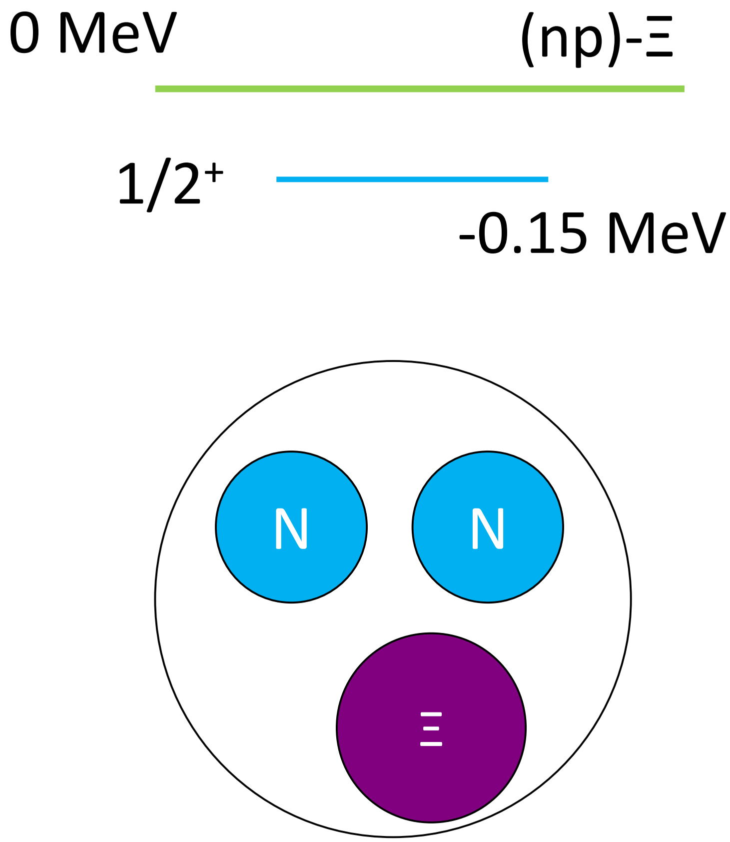
strength of ΛΛ—ΞN—ΣΣ is large.

ESC potential leads to give bound states in s-shell Ξ hypernuclei such as NNΞ and NNNΞ.

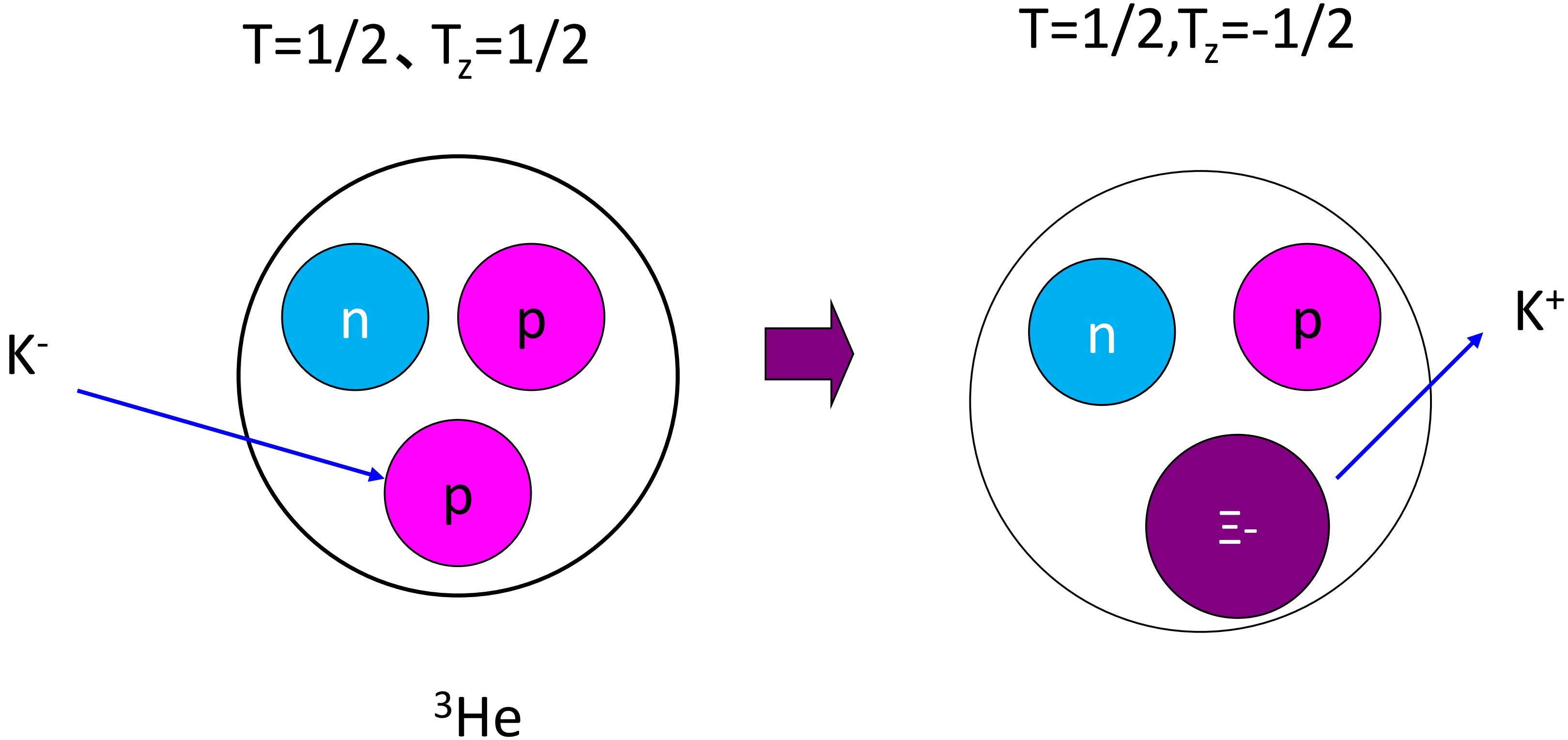


Results

ESC04

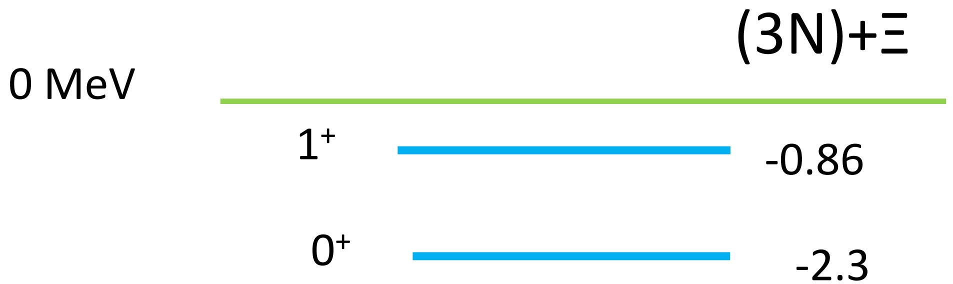


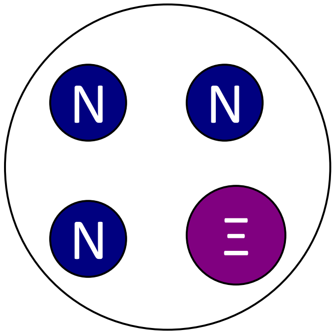
NNΞ



Using ^3He target, it might be produced this Ξ hypernucleus.
If this Ξ hypernucleus exist as bound state, what is isotope of this Ξ hypernucleus?

Results ESC04





T,S   repulsive   strongly attractive

$$1^+: [12V(1,1)+V(1,0)+10V(0,1)+3V(0,0)]/26$$

$$0^+: [V(1,0)+V(0,1)]/2$$

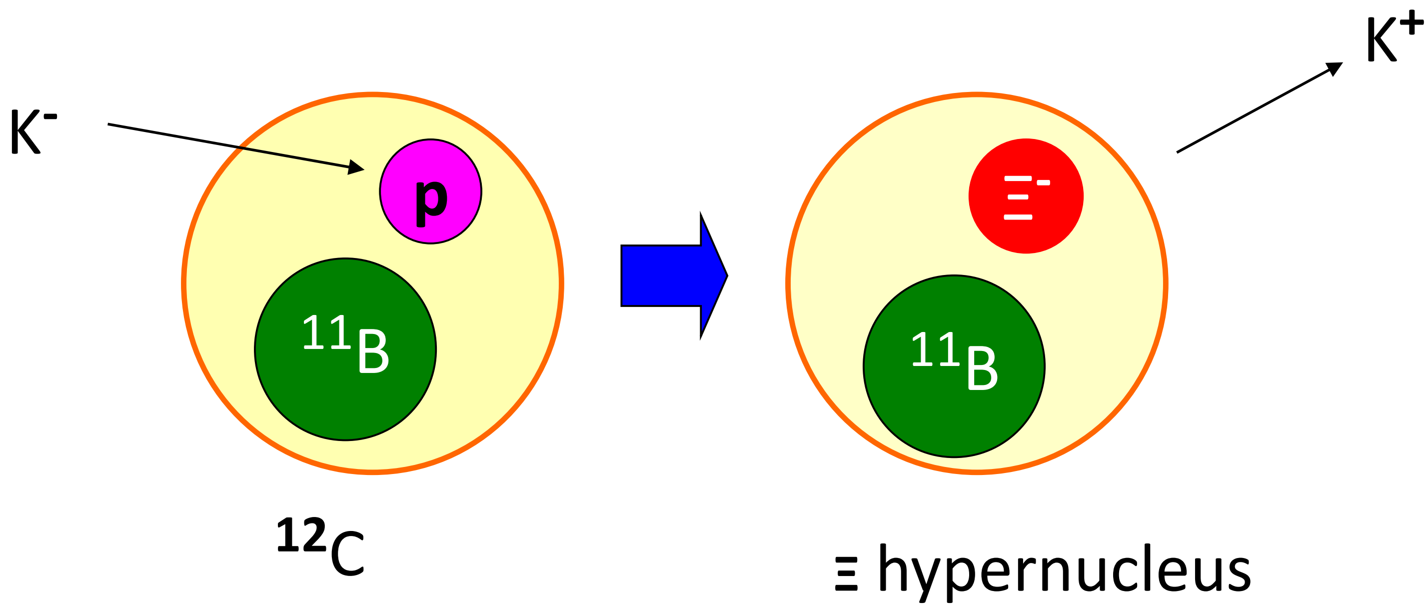
repulsive

weakly repulsive   strongly attractive

For the study of ΞN interaction, it is important to study the structure of Ξ hypernuclei.

Approved proposal at J-PARC : Day-1 experiment

- E05 “Spectroscopic study of Ξ-Hypernucleus, $^{12}_{\Xi^-}$Be, via the ^{12}C(K^-,K^+) Reaction” by Nagae and his collaborators



This will be the first observation of Ξ hypernucleus

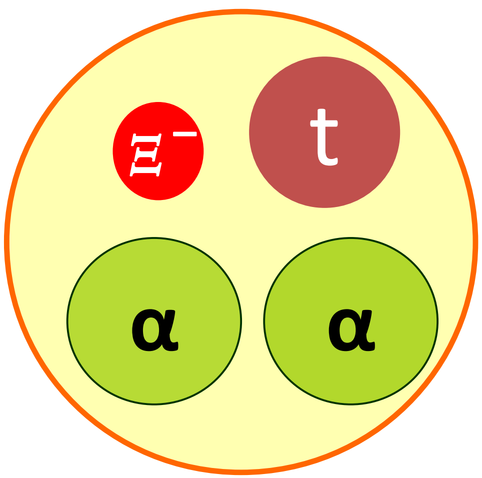
$^{12}C(K^-, K^+)\ ^{12}Be$ Day-1 experiment at J-PARC

Ξ^-

What part's information of the ΞN interaction do we extract?

$$V_{\Xi N} = V_0 + \boxed{\boldsymbol{\sigma}\cdot\boldsymbol{\sigma}}\, V_{\sigma\cdot\sigma} + \boldsymbol{\tau}\cdot\boldsymbol{\tau}\, V_{\tau\cdot\tau} + (\boldsymbol{\sigma}\cdot\boldsymbol{\sigma})(\boldsymbol{\tau}\cdot\boldsymbol{\tau})\, V_{\sigma\cdot\sigma\ \tau\cdot\tau}$$

All of the terms contribute to binding energy of ^{12}Be (^{11}B is not spin-, isospin- saturated).



Ξ^-

Then, even if we observe this system as a bound state, we shall get only information that $V_{\Xi N}$ itself is attractive.

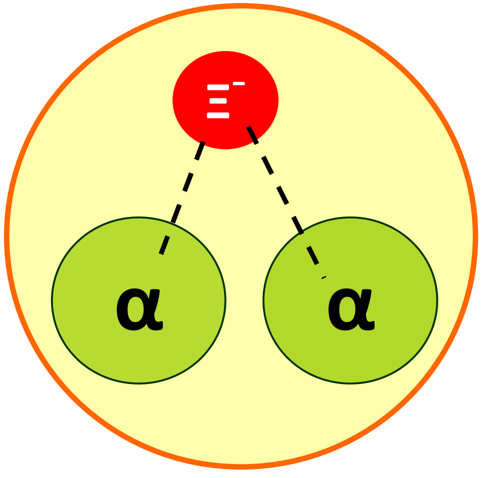
^{12}Be
Ξ^-
($T=1$, $J=1^-$)

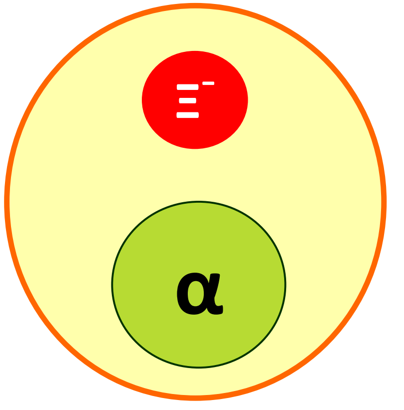
Therefore, after the Day-1 experiment, next, we want to know desirable strength of V_0, the spin-,isospin-independent term.

$$V_{\Xi N} = V_0 + \boldsymbol{\sigma}\cdot\boldsymbol{\sigma}\, V_{\sigma\cdot\sigma} + \boldsymbol{\tau}\cdot\boldsymbol{\tau}\, V_{\tau\cdot\tau} + (\boldsymbol{\sigma}\cdot\boldsymbol{\sigma})(\boldsymbol{\tau}\cdot\boldsymbol{\tau})\, V_{\sigma\cdot\sigma\ \tau\cdot\tau}$$

In order to obtain useful information about V_0,
the following systems are suited, because

the **($\sigma\cdot\sigma$)**, **($\tau\cdot\tau$)** and **($\sigma\cdot\sigma$) ($\tau\cdot\tau$)** terms of $V_{\Xi N}$ vanish by folding them into the **α**-cluster wave function that are spin-, isospin-satulated.





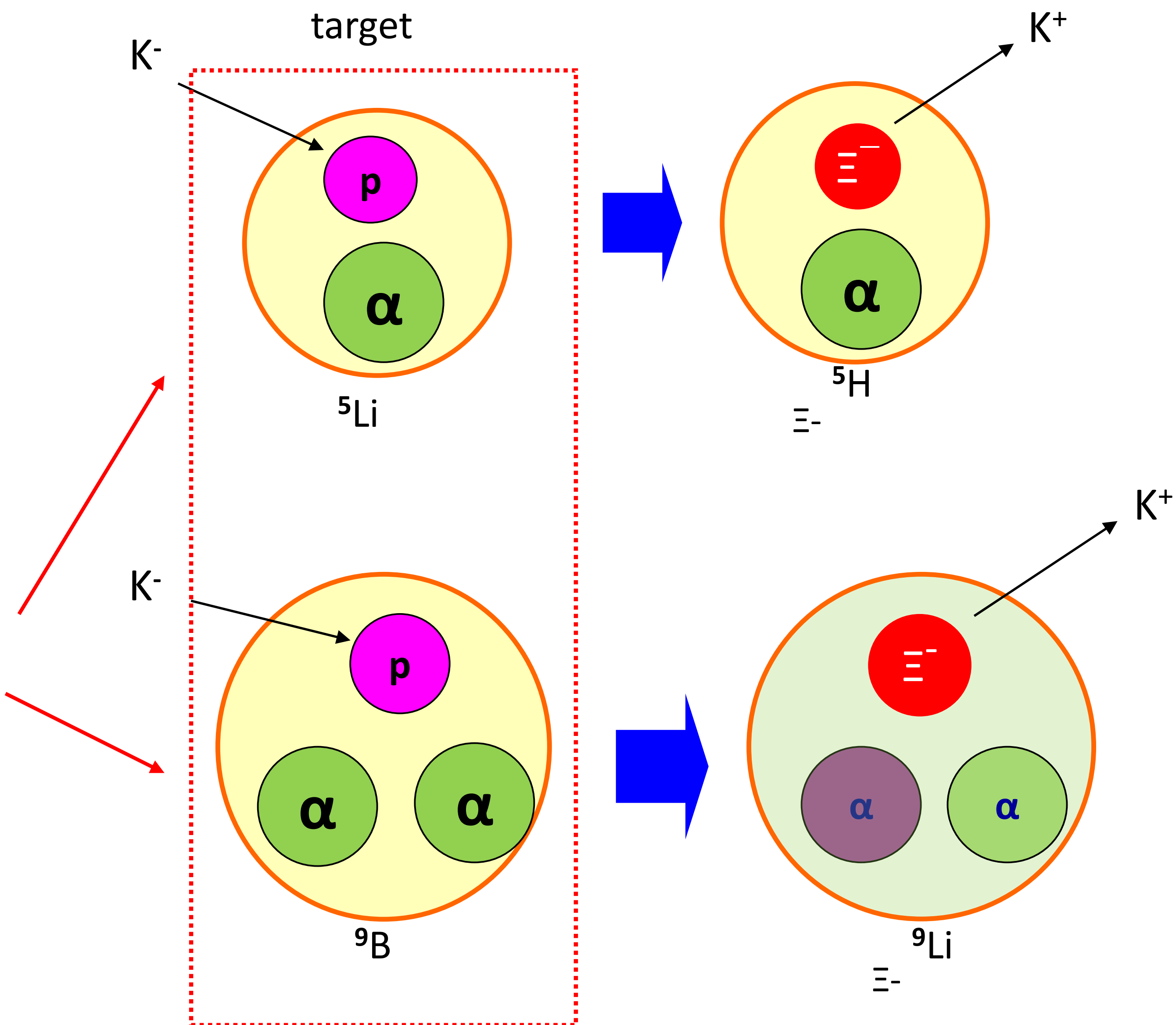
problem : there is NO target to produce them
by the (K^-, K^+) experiment .

Because, ･･･

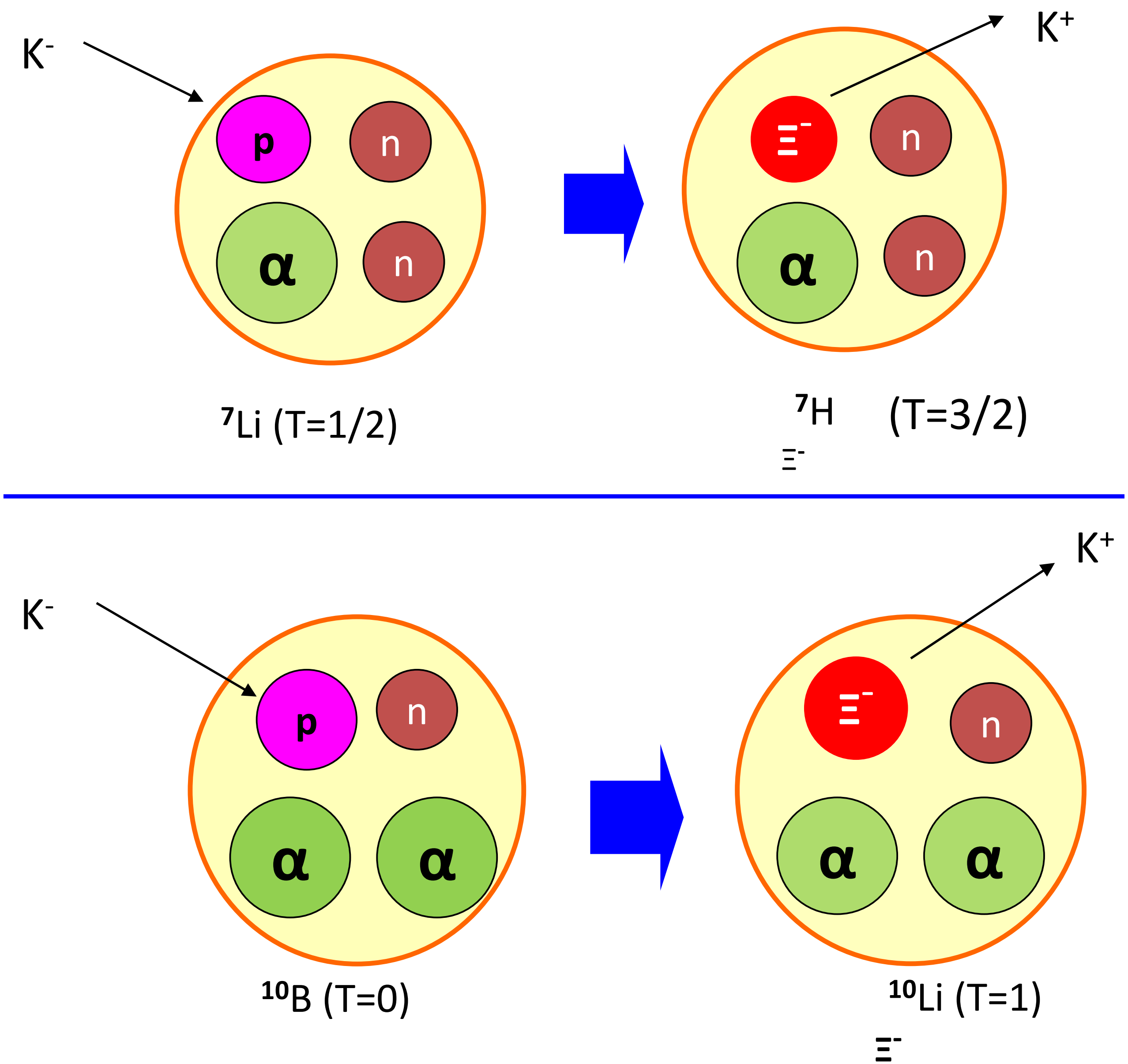
To produce **αΞ⁻** and **ααΞ⁻** systems by (K^-, K^+) reaction,

These systems are unbound.

Then, we cannot use them as targets.

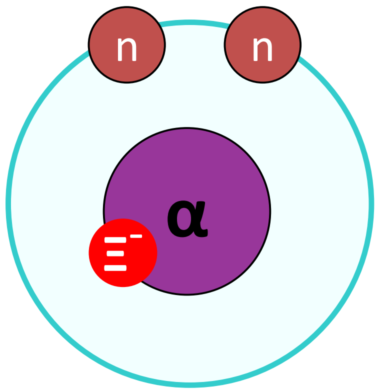


As the second best candidates to extract information about the spin-, isospin-independent term V_0, we propose to perform…

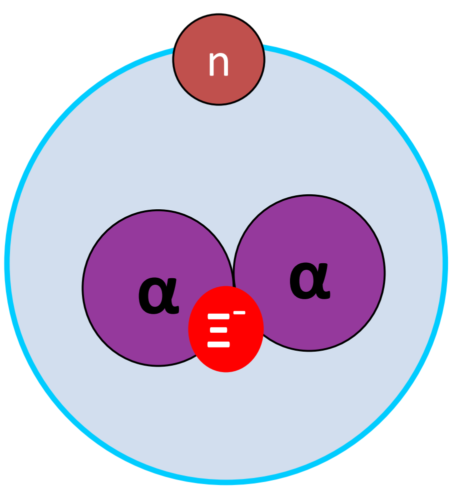


Why they are suited for investigating V_0?

(more realistic illustration)



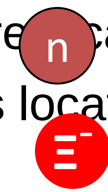
$^{7}_{\Xi^-}\mathrm{H}$ (T=3/2)



$^{10}_{\Xi^-}\mathrm{Li}$ (T=1)

Core nucleus ^{6}He is known to be halo nucleus. Then, valence neutrons are located far away from α particle.

Valence neutrons are located in p-orbit, whereas Ξ particle is located in 0s-orbit.



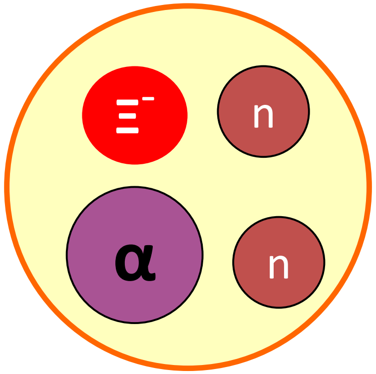
Then, distance between Ξ and **n** is much larger than the interaction range of Ξ and **n**.

Then, αΞ potential, in which only V_0 term works, plays a dominant role in the binding energies of these system.

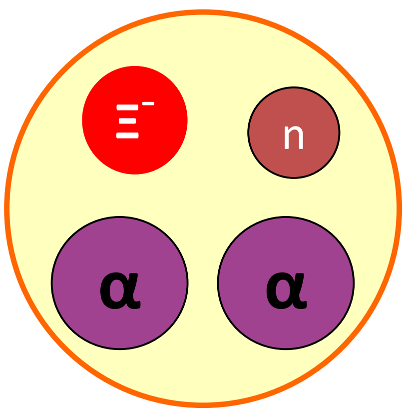
Before the experiments will be done,
we should predict whether these
hypernuclei will be observed as
bound states or not.

Ξ^-

Namely, we calculate the binding energies
of these hypernuclei.



$^{7}_{\Xi^-}H$ (T=3/2)



$^{10}_{\Xi^-}Li$ (T=1)

ΞN interaction

Only one experimental information about ΞN interaction

Y. Yamamoto, Gensikaku kenkyu 39, 23 (1996),

T. Fukuda *et al*. Phys. Rev. C58, 1306, (1998);

P.Khaustov *et al*., Phys. Rev. C61, 054603 (2000).

Well-depth of the potential between Ξ and ^{11}B: -14 MeV

Among all of the Nijmegen model,

ESC04 (Nijmegen soft core) and ND (Nijmegen Model D)

reproduce the experimental value.

OtherΞN interaction are repulsive or weak attractive.

We employ ESC04 and ND.

The properties of ESC04 and ND are quite different from each other.

Property of the spin- and isospin-components of ESC04 and ND

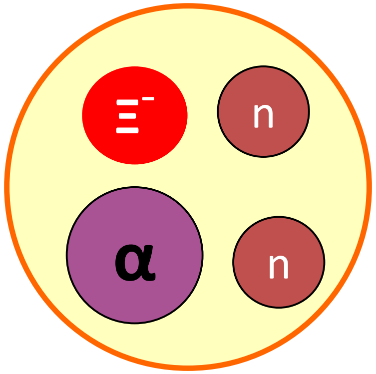
V(T,S)	ESC04	ND
T=0, S=1	strongly attractive (a bound state)	weakly attractive
T=0, S=0	weakly repulsive	
T=1, S=1	weakly attractive	
T=1, S=0	weakly repulsive	

Although the spin- and isospin-components of these two models are very different between them (due to the different meson contributions),

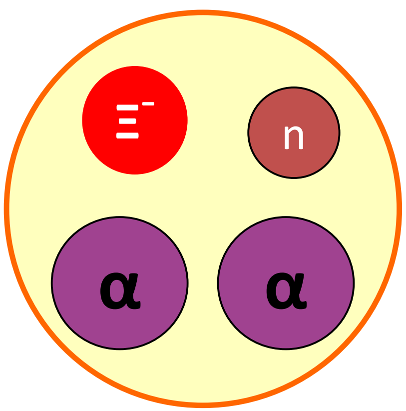
we find that the spin- and isospin-averaged property,

$$V_0 = [\,V(0,0) + 3V(0,1) + 3V(1,0) + 9V(1,1)\,] / 16,$$

namely, strength of the V_0- term is similar to each other.



${}^{7}_{\Xi^-}\mathrm{H}$ (T=3/2)



${}^{10}_{\Xi^-}\mathrm{Li}$ (T=1)

As mentioned before,

$\alpha\Xi$ potential, in which only **V_0** term works,

plays a dominant role in the binding

energies of these system.

Therefore, interestingly,

we may expect to have similar binding energies between

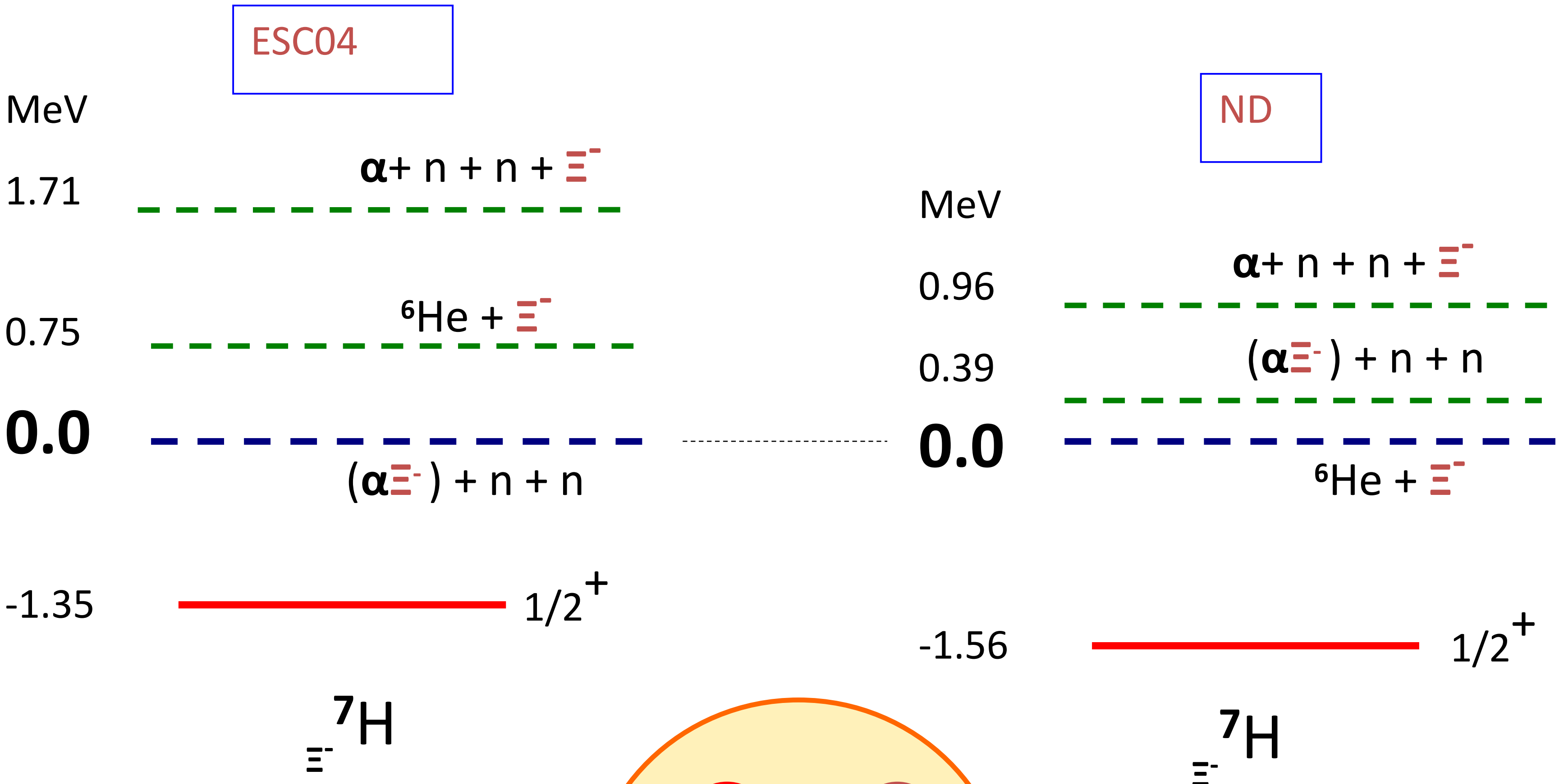
ESC04 and ND,

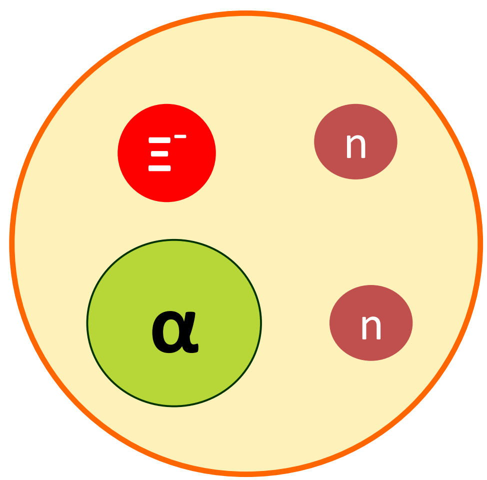
although the spin- and isospin-components are very different

between the two.

4-body calculation of $^{7}_{\Xi^-}\mathrm{H}$

E. Hiyama et al., PRC**78** (2008) 054316





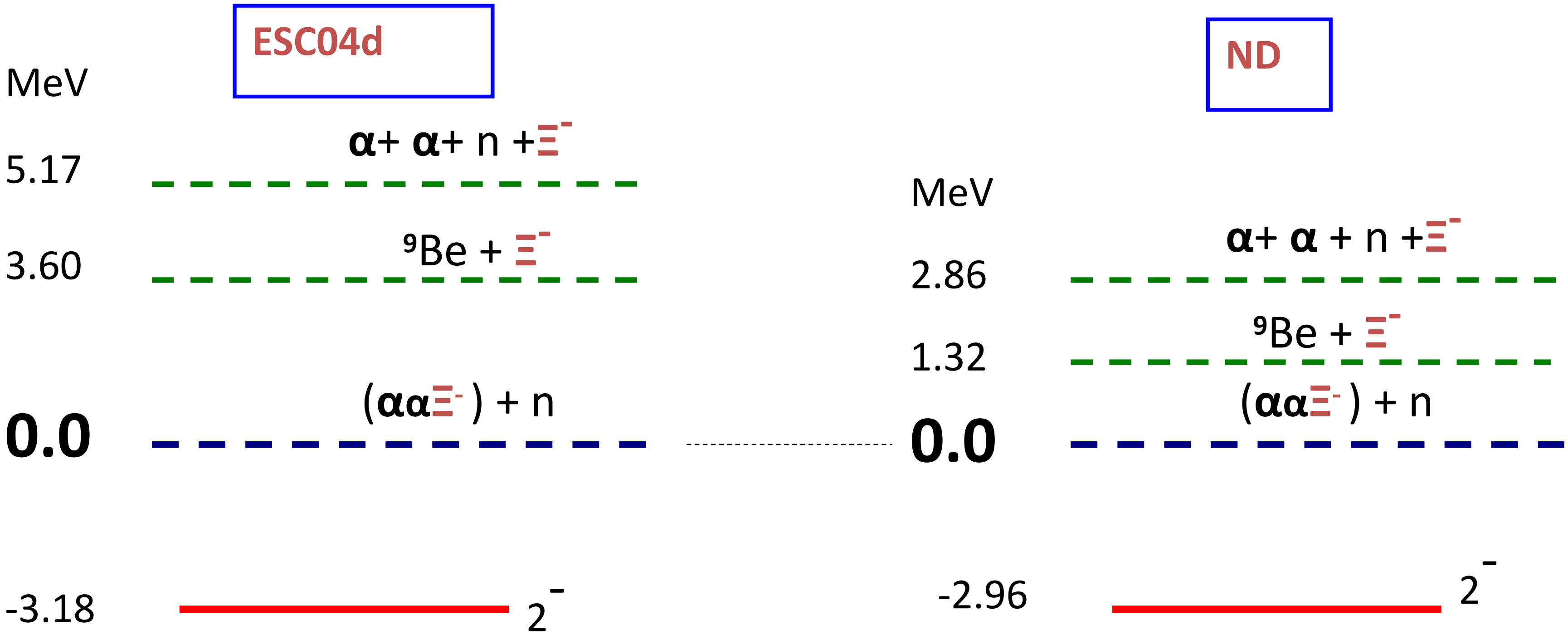
In experiments, we can expect a bound state.

Similar binding energies using ND and ESC04.

Independent on employed ΞN potential

4-body calculation of $^{10}_{\Xi^-}\mathrm{Li}$

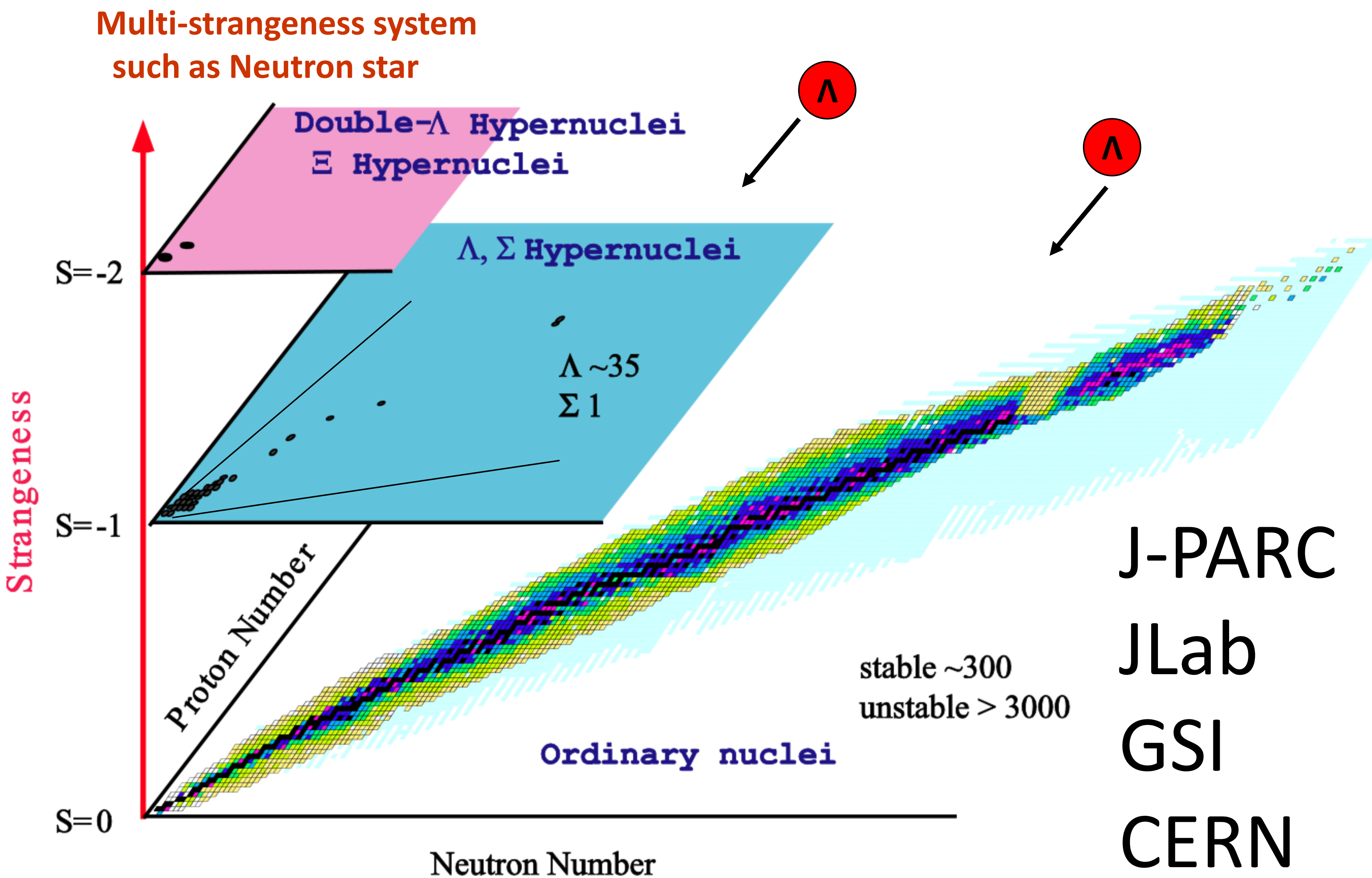
E. Hiyama et al.,
PRC**78** (2008) 054316



In this way, the binding energies of Ξ hypernuclei with A=7 and 10 are dominated by **αΞ** potential, namely, spin-, and iso-spin independent ΞN interaction (V_0).

Then, to get information about this part, we propose to perform the (K^-,K^+) experiment by using ^{7}Li and ^{10}B targets at J-PARC after the Day-1 experiment with ^{12}C target.

Nuclear chart with strangeness



J-PARC
JLab
GSI
CERN

Thank you!