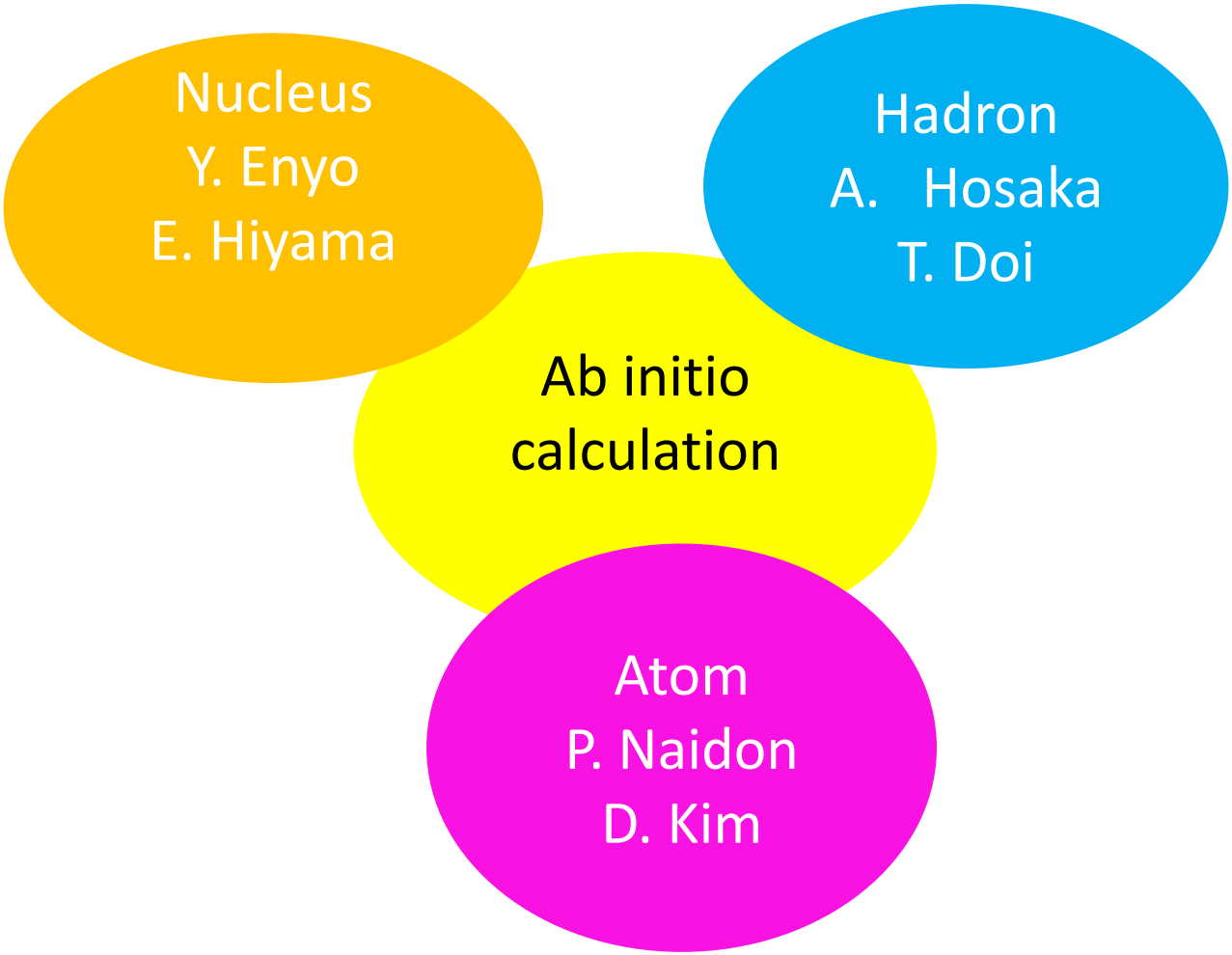
Few-body structure of neutron-rich nuclei and S=-2 hypernuclei

Emiko Hiyama (Kyushu Univ./RIKEN)


Nucleus
Y. Enyo
E. Hiyama
Hadron
A. Hosaka
T. Doi
Ab initio
calculation
Atom
P. Naidon
D. Kim

It is important to study baryon-baryon interaction.

Currently, S=-2 interaction especially important.

ΛΛ interaction: $^1S_0$

ΞN : repulsive ? Or attractive?

$^{14}N+\Xi$

-4.38 MeV～ -1.11 MeV

KISO event

In 2015, by observation of Kiso event, we found that nucleus-Ξ Interaction should be attractive.

Question: Next, what should we do for the study of ΞN interaction?

The experimental data of KISO event is enough?

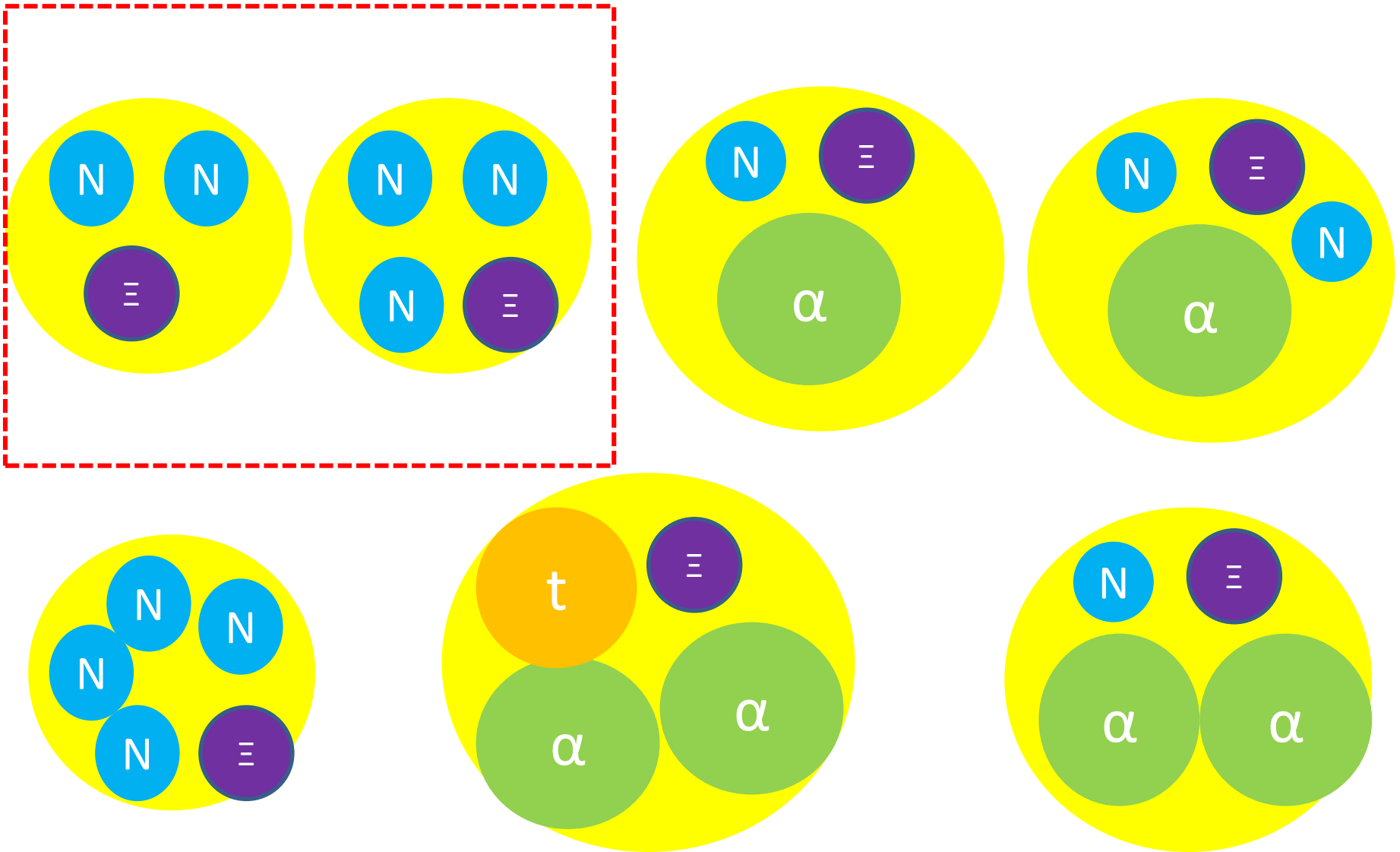
NO!

Collaboration meeting on 10th May in 2019 at RIKEN
物質階層構造を横断する会
Theme: double Λ hypernuclear fragment by Ξ absorption
Convener : H. Fujioka and E. Hiyama

Homework to Hiyama from T. Fukuka

I should calculate level structures of all of s- and p-shell Ξ Hypernuclei and explore what kinds of ΞN interaction could be obtained within one or two years.

My homework



Possible lightest Ξ Hypernucleus with Modern ΞN Interactions

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To be submitted in Phys. Rev. Lett.

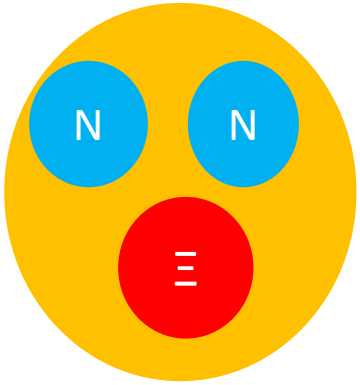
ΞN interaction: T=0, S=0
T=0, S=1
T=1, S=0
T=1, S=1

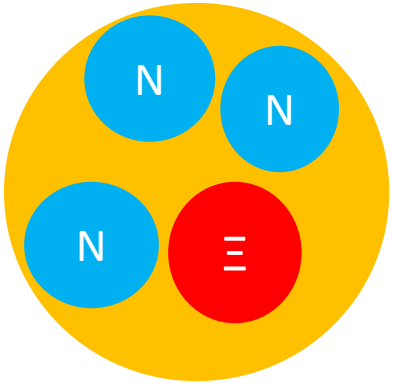
t=1/2
S=1/2

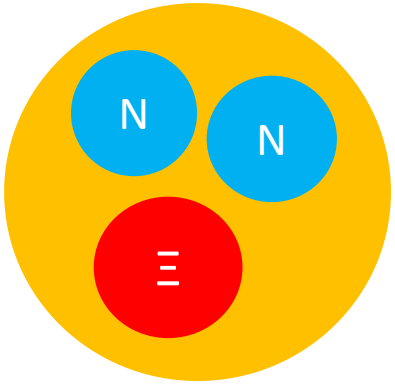
t=1/2
S=1/2

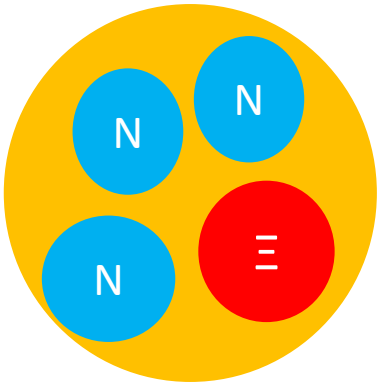
We want to know which partial wave is attractive or repulsive.
What is the lightest bound Ξ hypernuclei? ΞN? NNΞ? NNNΞ？

The suited systems to study are s-shell Ξ hypernuclei such as NNΞ and NNNΞ systems.









I show my new results of these light systems.

NN interaction: AV8 potential

ΞN interaction :

Nijimegen extended soft core potential (ESC08c)

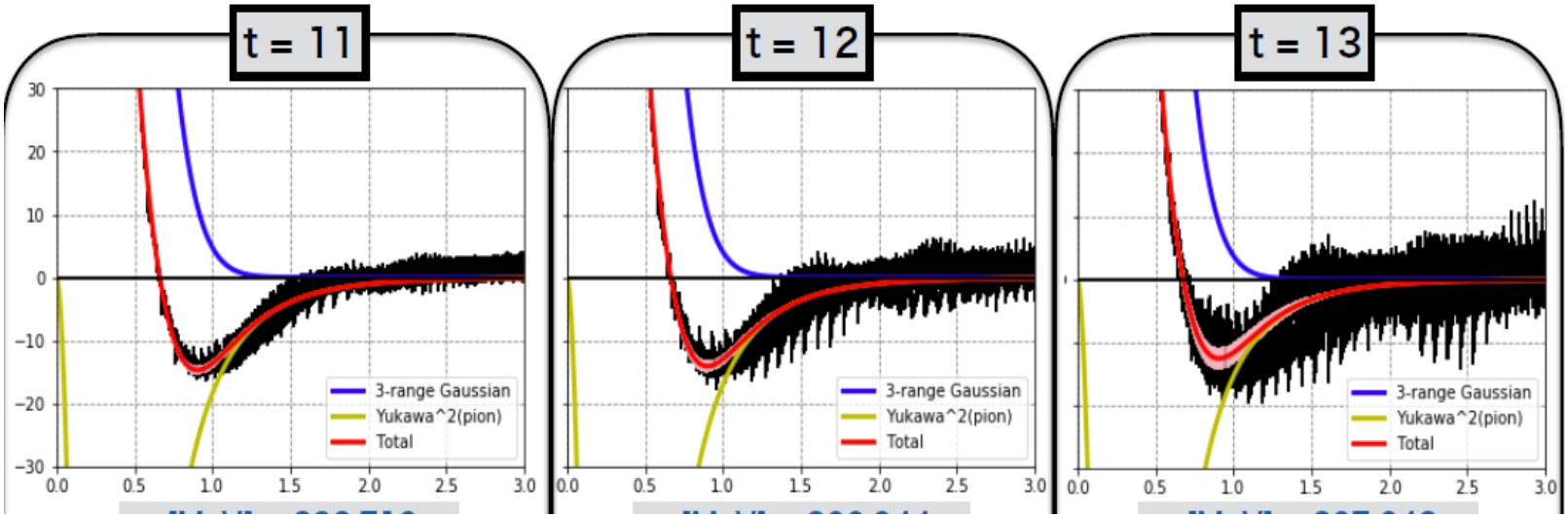
Realistic potential (only ΞN channel)

ΞN interaction by HAL collaboration (Lattice QCD calculation)

The potential was made by K. Sasaki, Miyamoto, Hatsuda and Aoki.

HAL potential

$V_{\Xi N}=V_0(r)+(\sigma_\Xi \cdot \sigma_N)V_s(r)+(\tau_\Xi \cdot \tau_N)V_t(r)+(\sigma_\Xi \cdot \sigma_N)(\tau_\Xi \cdot \tau_N)V_{ts}(r)$
All terms are central parts only.

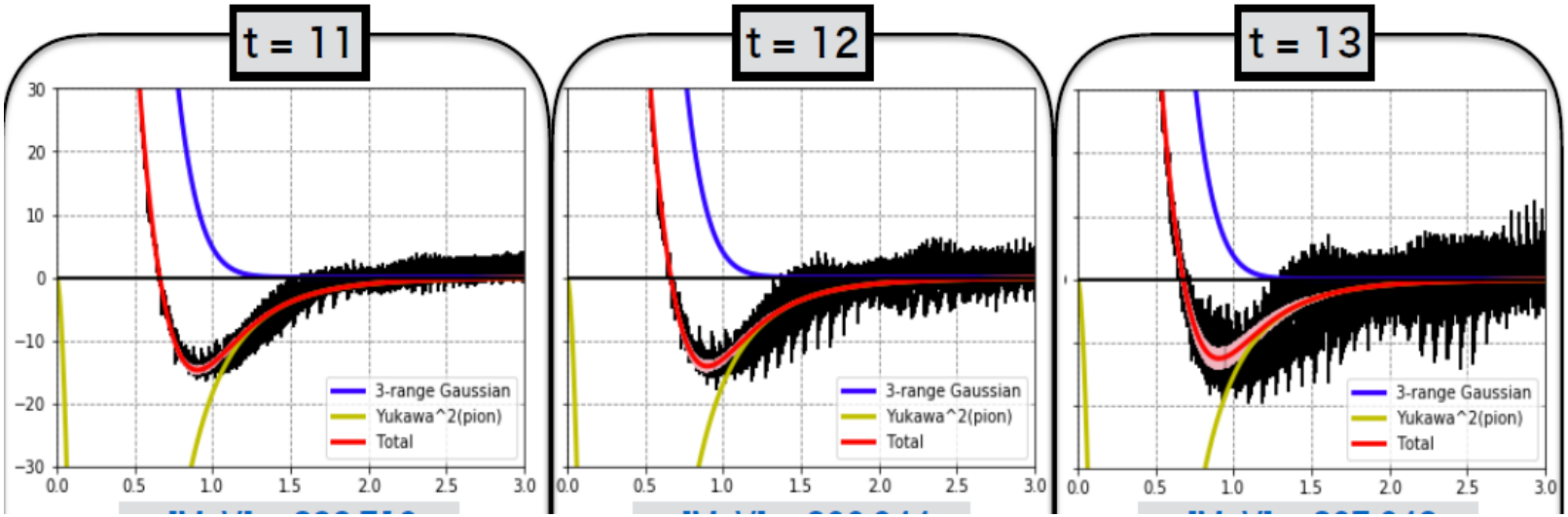


$V_0(r)$

In HAL potential , the statistical errors are NOT included.

HAL potential

$V_{\Xi N}=V_0(r)+(\sigma_\Xi \cdot \sigma_N)V_s(r)+(\tau_\Xi \cdot \tau_N)V_t(r)+(\sigma_\Xi \cdot \sigma_N)(\tau_\Xi \cdot \tau_N)V_{ts}(r)$
All terms are central parts only.



$V_0(r)$

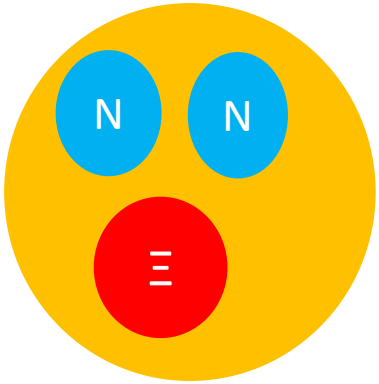
In HAL potential , the statistical errors are NOT included.

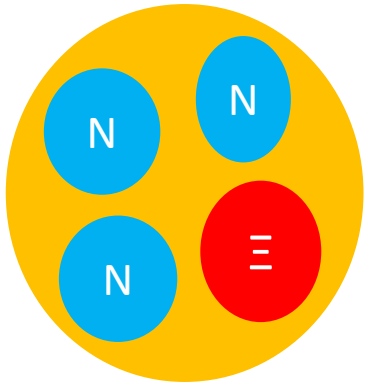
Property of the spin- and isospin-components of ESC08 and HAL

V(T,S)	ESC08c	HAL
T=0, S=1	strongly attractive	Weakly attractive
T=0, S=0	weakly repulsive	Strongly attractive
T=1, S=1	strong attractive	Weakly attractive
T=1, S=0	weakly repulsive	Weakly repulsive

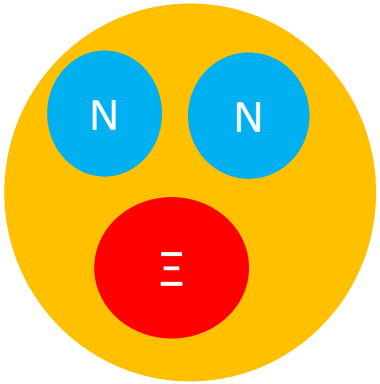
Although the spin- and isospin-components of these two models are very different between them.

It is interesting to see the difference in the energy spectra in s-shell Ξ hypernuclei.



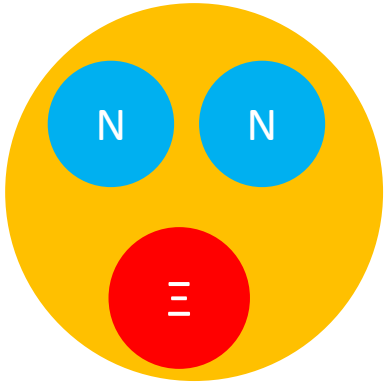


Question: do we have some bound states for these Three and four-body systems?



(NN) S=0, or 1

Ξ: ½ => J=1/2+ or 3/2+



$T=1/2$, $J=1/2^+$ and $J=3/2^+$

ESC08c

0 MeV

d+ Ξ

HAL potential

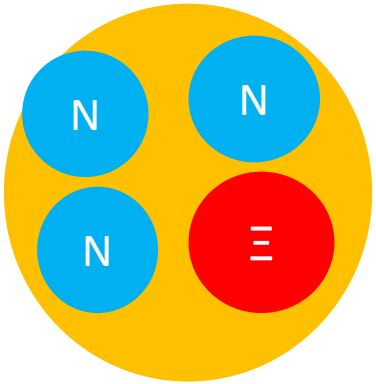
$J=3/2^+$

0 MeV

d+ Ξ

-7.20 MeV

$J=3/2^+$



$(3N)_{T=3/2}$ $+\Xi(t=1/2)$

Total isosipin T=1

T=1 state

0 MeV 3N+Ξ

0^+

-3.97 MeV

-13.07MeV

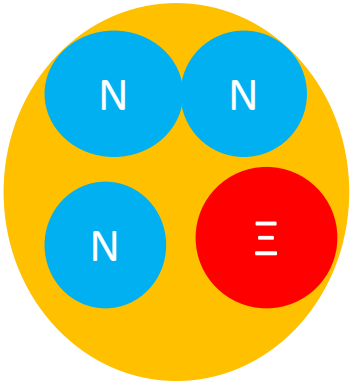
1^+

ESC08c

0 MeV 3N+Ξ

No bound state

HAL potential



$(3N)_{T=1/2}$ $+\Xi(t=1/2)$

T=0 state

0 MeV 3N+Ξ

-11.13 MeV 1^+

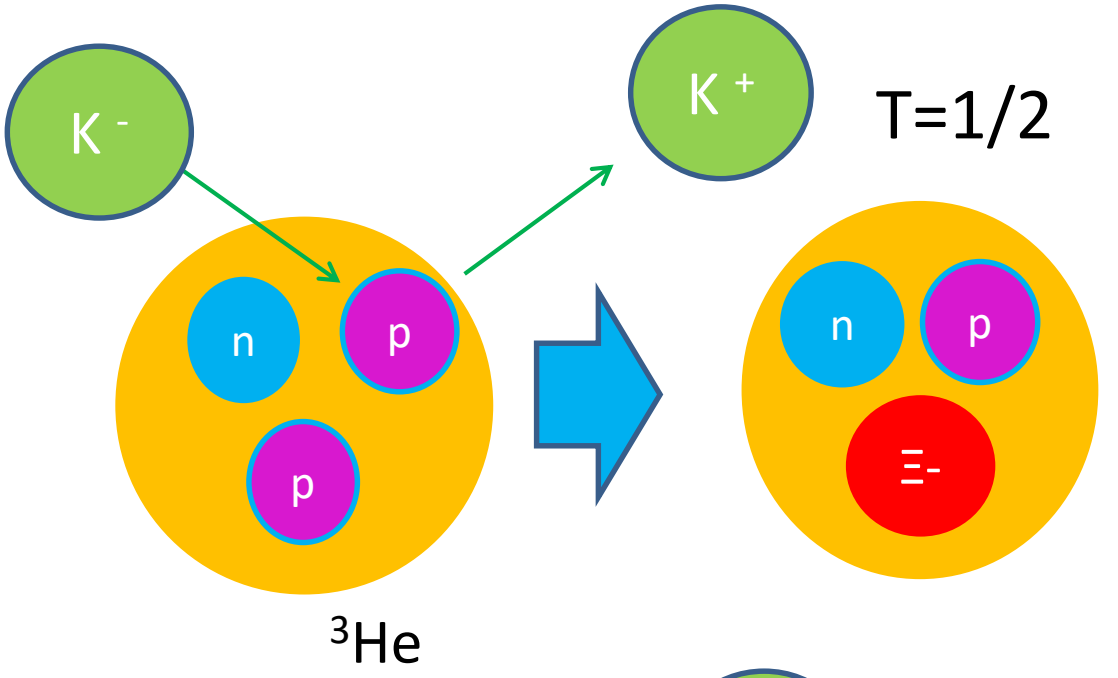
ESC08c

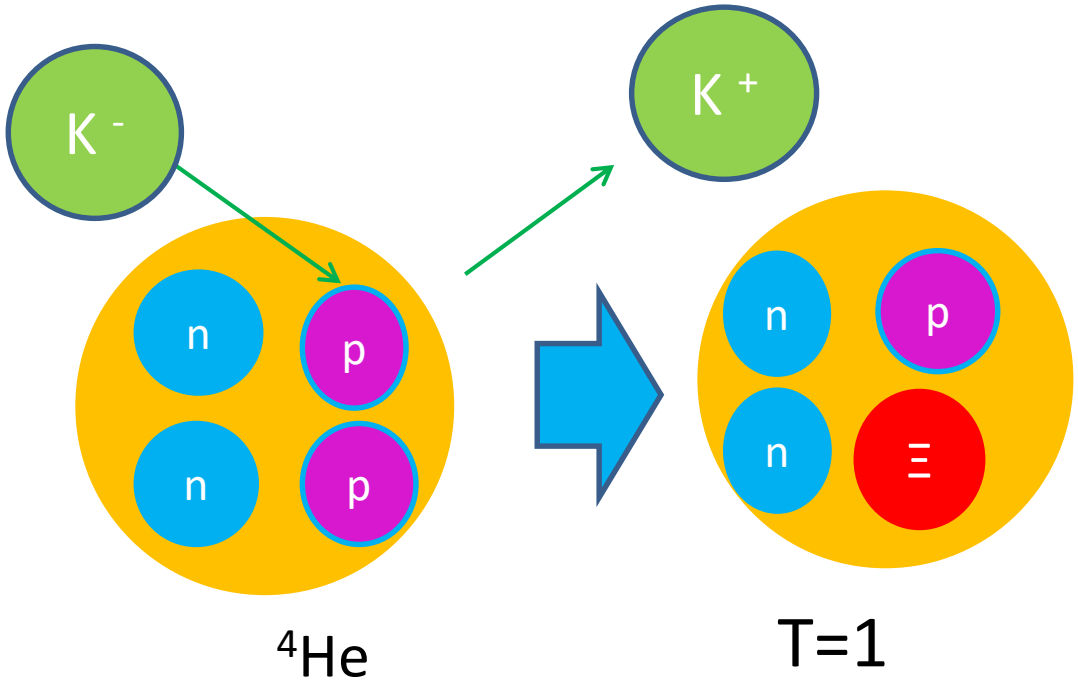
0 MeV 3N+Ξ

1^+

-0.05 ～ -0.67 MeV

HAL potential





Using 3He and 4He target,
It might be possible
to produce NNΞ and NNNΞ
systems by (K-,K+) reaction.

But, HAL potential does not
produce bound state in T=1
system,
But produce
a bound state for T=0 state.
How do we produce bound
state with
T=0?

Heavy ion collision might be one of useful tool.

conclusion

Using HAL potential, it is important to calculate these Ξ hypernuclei.