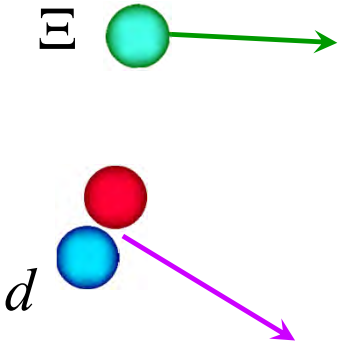
重陽子-Ξ相関関数に対する重陽子分解効果

Effect of deuteron breakup on the deuteron-Ξ correlation function

PRC **103**, 065205 (2021) [arXiv:2103.00100]

基研研究会「核力に基づいた原子核の構造と反応」



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in collaboration with

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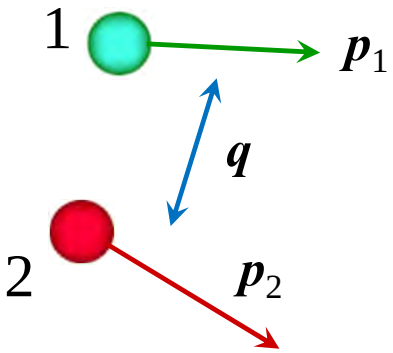
Correlation function (CF)

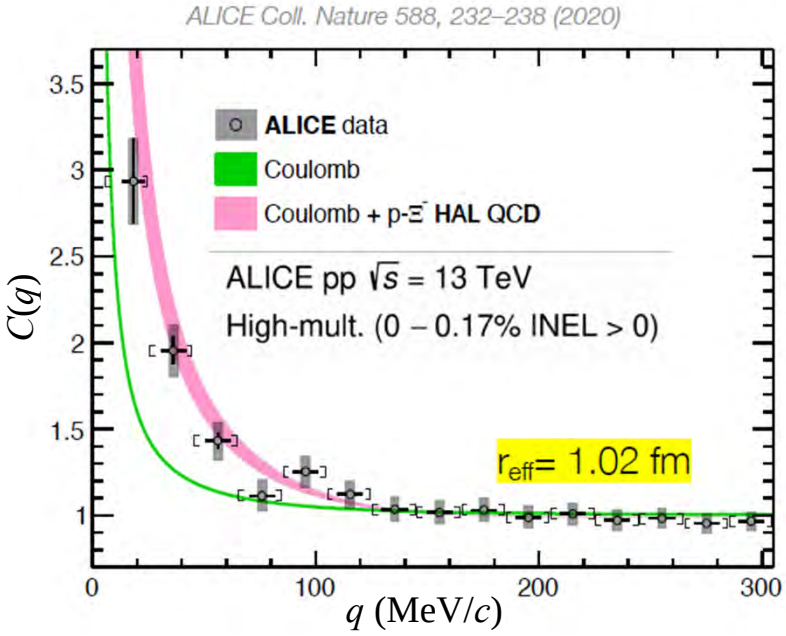


*S. E. Koonin, Phys. Lett. B **70**, 43 (1977); S. Pratt, Phys. Rev. D **33**, 1314 (1986).*

source function

$$C(\boldsymbol{p}_1, \boldsymbol{p}_2) = \frac{N_{12}(\boldsymbol{p}_1, \boldsymbol{p}_2)}{N_1(\boldsymbol{p}_1) N_2(\boldsymbol{p}_2)} \approx \int \mathcal{S}_{12}(\boldsymbol{R}) \left| \psi_{12}^{(-)}(\boldsymbol{R}) \right|^2 d\boldsymbol{R}$$

relative wave function

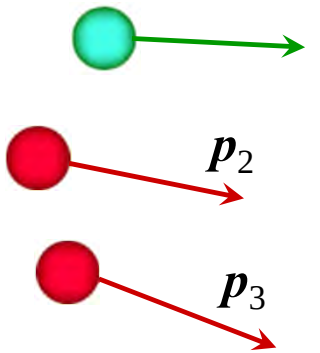


CF contains information on the

- interaction between 1 and 2
- source function created in (heavy-ion) collisions.

*K. Morita+, PRC **91**, 024916 (2015); A. Ohnishi+, NPA **954**, 294 (2016);*
*K. Morita+, PRC **94**, 031901 (2016); T. Hatsuda+, NPA **967**, 856 (2017);*
*D. L. Mihaylov+, EPJ C**78**, 394 (2018); J. Haidenbauer, NPA **981**, 1 (2019);*
*K. Morita+PRC 101, 015201 (2020); Y. Kamiya+, PRL **124**, 132501 (2020);*
Y. Kamiya+, arXiv2108.09644 [hep-ph].

Three-body correlation function (3bCF)

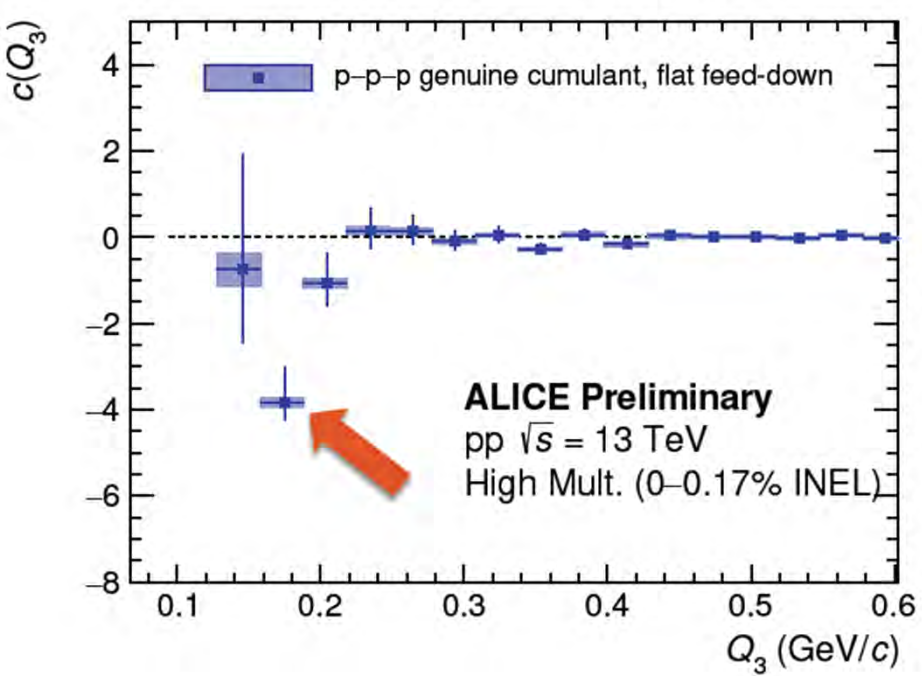


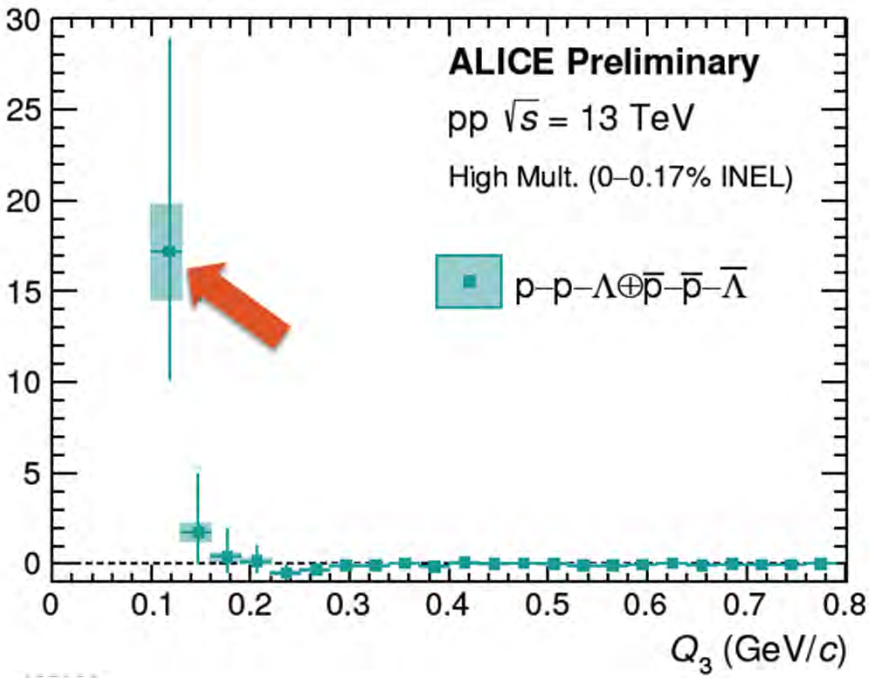
$$Q_3 = \sqrt{q_{12}^2 + q_{23}^2 + q_{31}^2}$$

3bCF will allow us to access

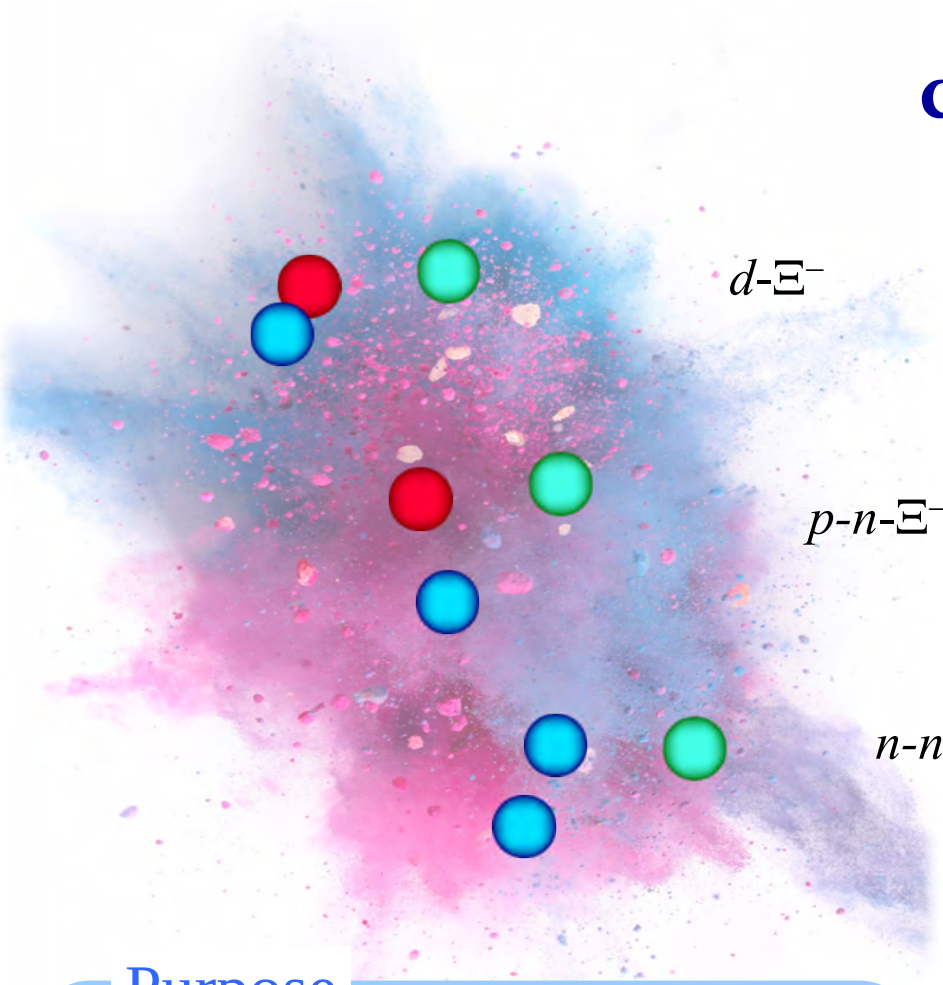
- 3b interactions
- triplets created in heavy-ion collisions.

Presentation by V. Mantovani Sarti (TUM) at Strangeness in Quark Matter Conf. 2021.





d-Ξ 3bCF

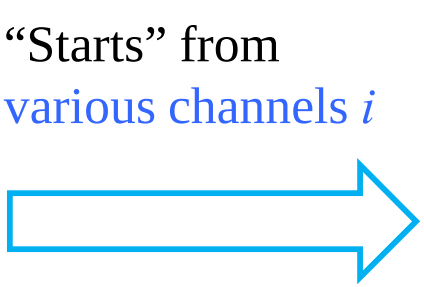


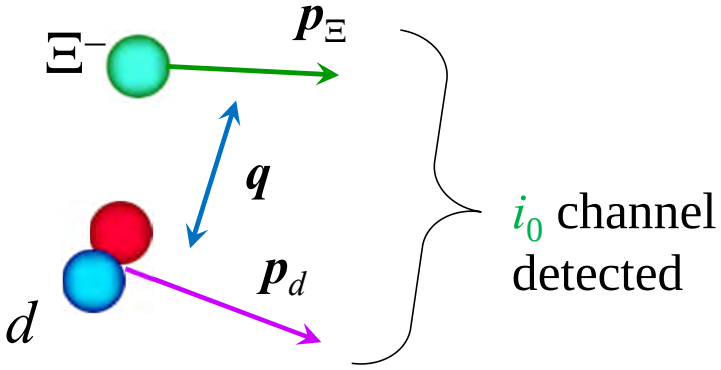
d-Ξ^-

p-n-Ξ^-

n-n-Ξ^0

"Starts" from
various channels i

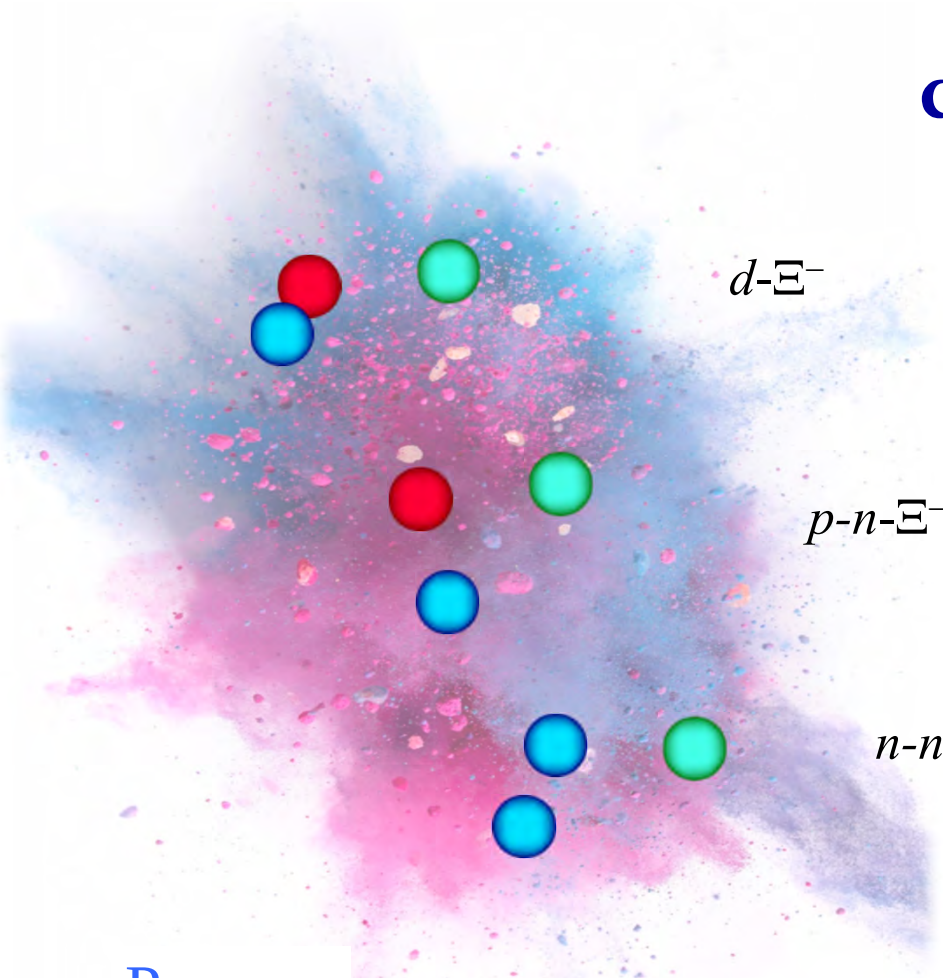




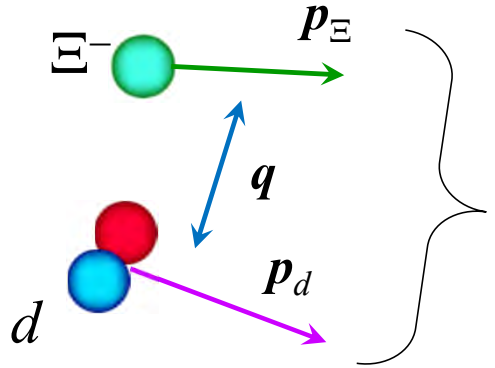
Purpose

Clarification of the CC (deuteron breakup) effect on the d-Ξ 3bCF

d-Ξ 3bCF



"Starts" from various channels i



$$\Psi_{i_0}^{(-)}(\boldsymbol{r},\boldsymbol{R}) = \sum_i \phi_i(\boldsymbol{r})\,\psi_{i,i_0}^{(-)}(\boldsymbol{R})$$

$$\psi_{i,i_0}^{(-)}(\boldsymbol{R}) \to \delta_{ii_0} e^{i\boldsymbol{K}\cdot\boldsymbol{R}} + \sum_i f_i^*(\Omega)\,\frac{e^{-iK_c R}}{R}$$

3bCF

$$C(\boldsymbol{q}) = \sum_i \int \mathcal{S}_i(\boldsymbol{R}) \left|\psi_{i,i_0}^{(-)}(\boldsymbol{R})\right|^2 d\boldsymbol{R}$$

In this work, $\mathcal{S}_i(\boldsymbol{R}) \to \mathcal{S}(\boldsymbol{R})$.

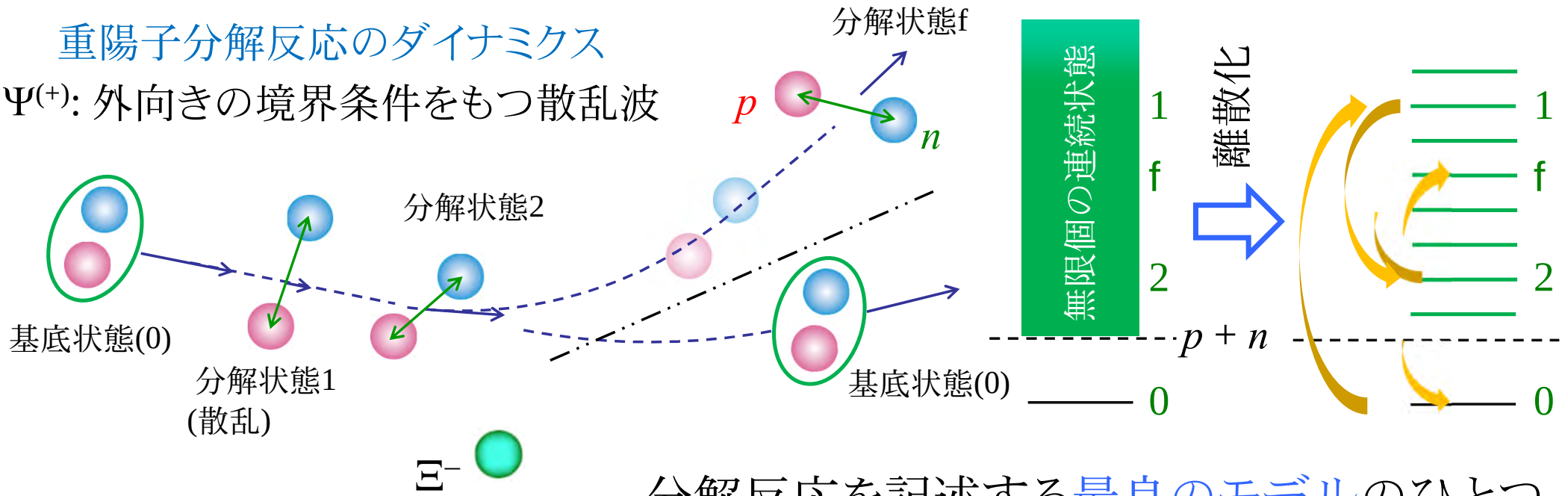
Purpose

Clarification of the CC (deuteron breakup) effect on the d-Ξ 3bCF

連続状態離散化チャネル結合法(CDCC)

重陽子分解反応のダイナミクス

$\Psi^{(+)}$: 外向きの境界条件をもつ散乱波



分解反応を記述する最良のモデルのひとつ

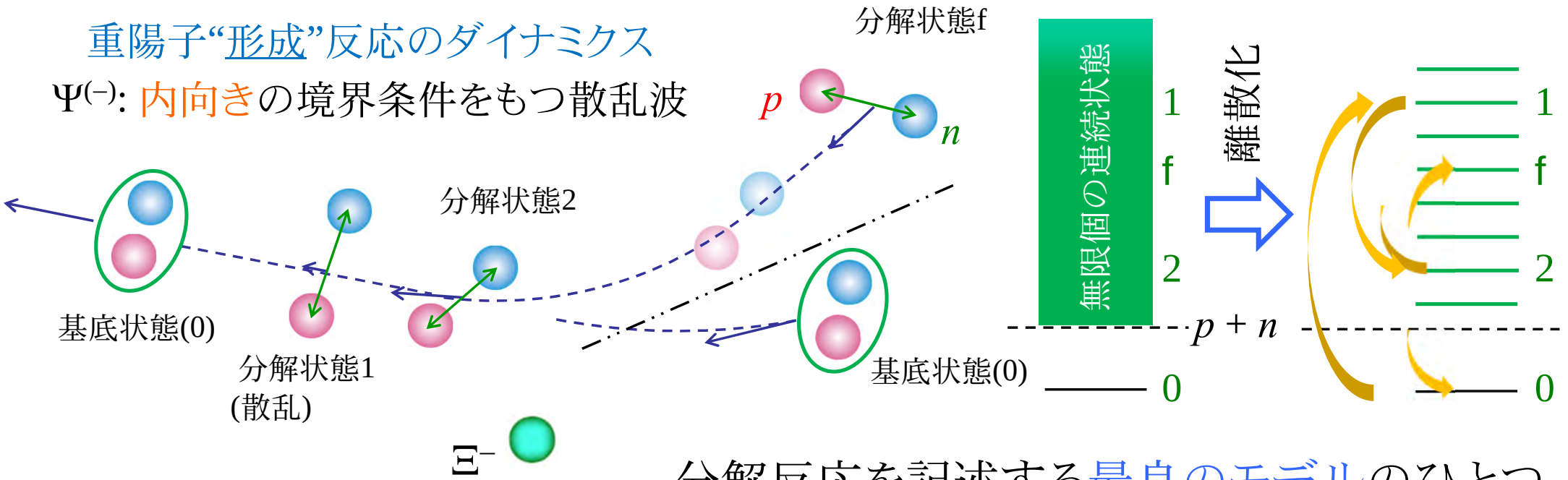
(精度と柔軟性の両立 ＝ 靭軟性)

cf. Kamimura, Yahiro, Iseri, Sakuragi, Kameyama, and Kawai, PTP Suppl. ***89****, 1 (1986);*
Austern, Iseri, Kamimura, Kawai, Rawitscher, and Yahiro, Phys. Rep. ***154*** *(1987) 126;*
Yahiro, Ogata, Matsumoto, and Minomo, PTEP ***2012****, 01A206 (2012).*

連続状態離散化チャネル結合法(CDCC)

重陽子“形成”反応のダイナミクス

$\Psi^{(-)}$: 内向きの境界条件をもつ散乱波



分解反応を記述する最良のモデルのひとつ

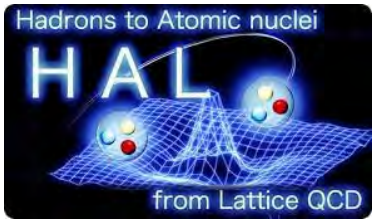
(精度と柔軟性の両立 ＝ 靭軟性)

CDCCで求めた$\Psi^{(-)}$には、観測された重陽子の素性の情報が含まれる。

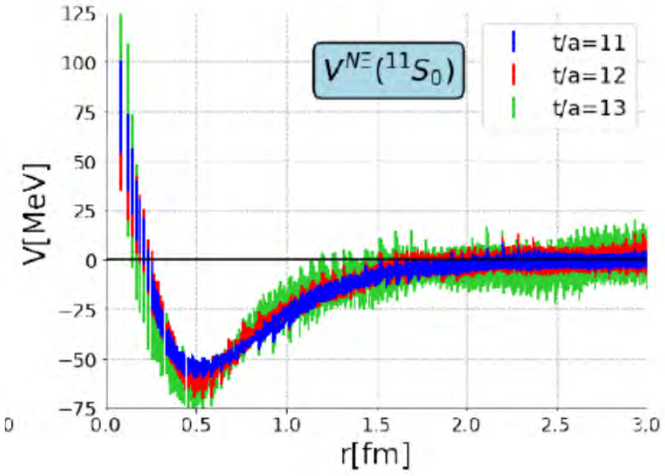
cf. Kamimura, Yahiro, Iseri, Sakuragi, Kameyama, and Kawai, PTP Suppl. ***89****, 1 (1986);*
Austern, Iseri, Kamimura, Kawai, Rawitscher, and Yahiro, Phys. Rep. ***154*** *(1987) 126;*
Yahiro, Ogata, Matsumoto, and Minomo, PTEP ***2012****, 01A206 (2012).*

CDCC + LQCD for the d-Ξ 3bCF

K. Sasaki+ (HAL-QCD), Nucl. Phys. A **998**, 121737 (2020).

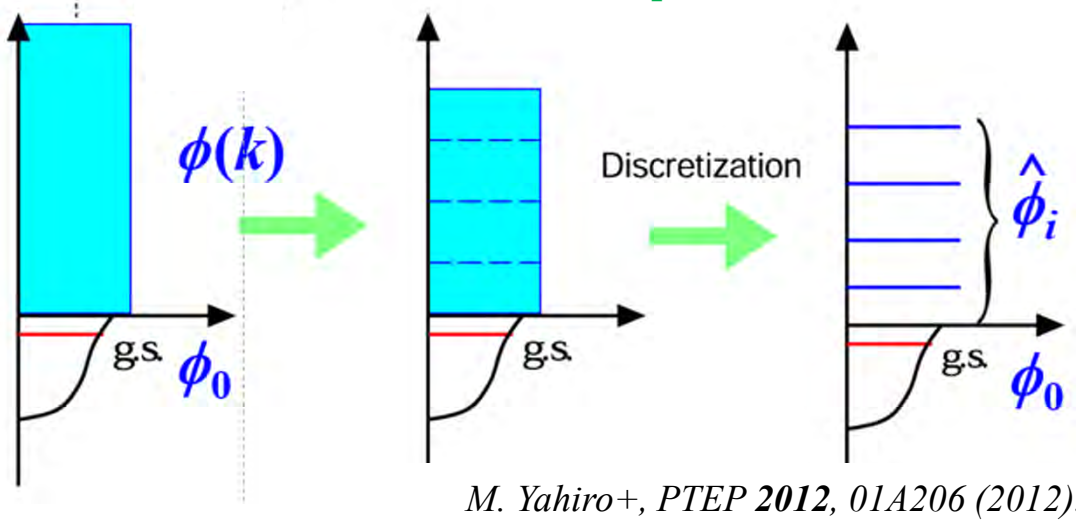


s-wave N-Ξ pot. by LQCD



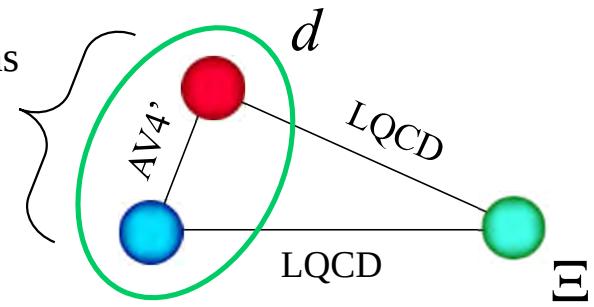
*KO, T. Fukui, Y. Kamiya, and A. Ohnishi, PRC **103**, 065205 (2021).*

Continuum-Discretized Coupled-Channels method



*M. Yahiro+, PTEP **2012**, 01A206 (2012).*

$^{13}S_1$ (*pn*): g.s. + 10 bins
$^{31}S_1$ (*nn*): 400 bins
(up to 166 MeV)
↓
411 channels

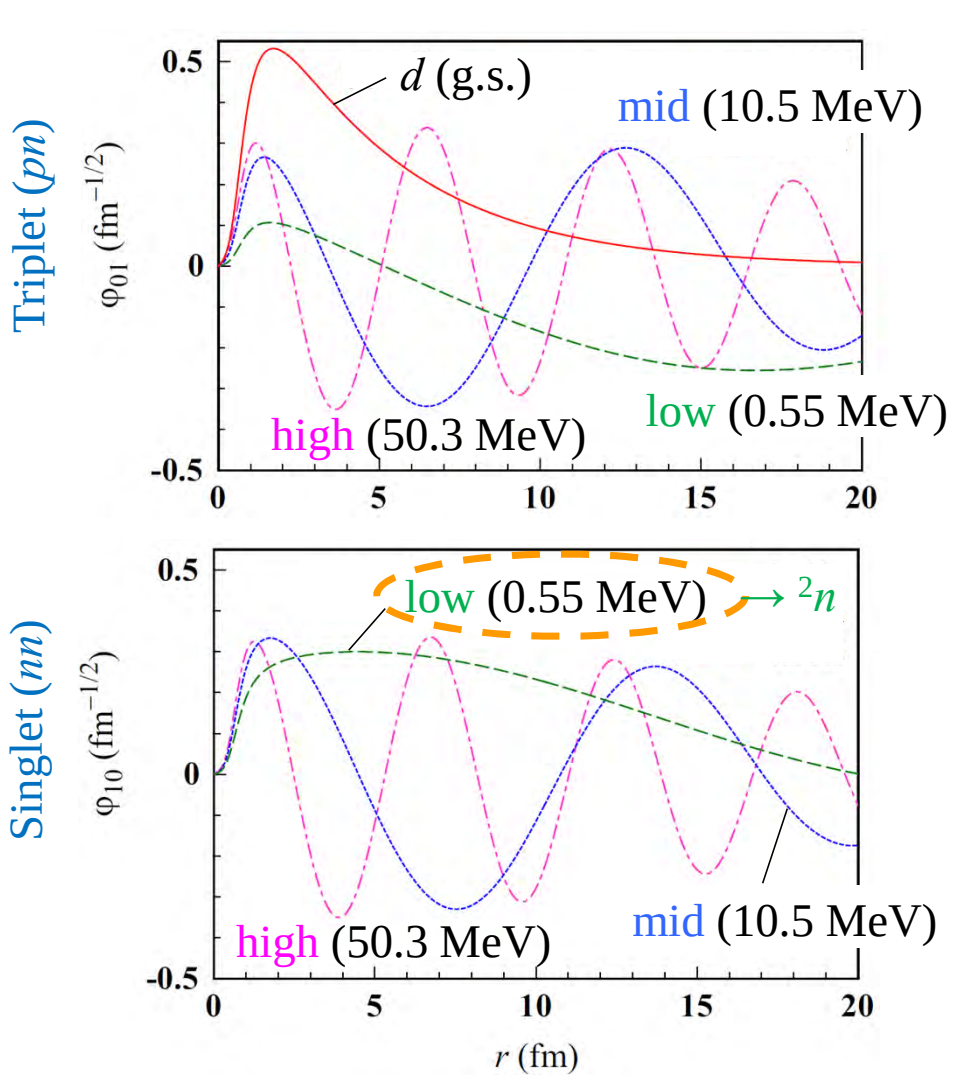


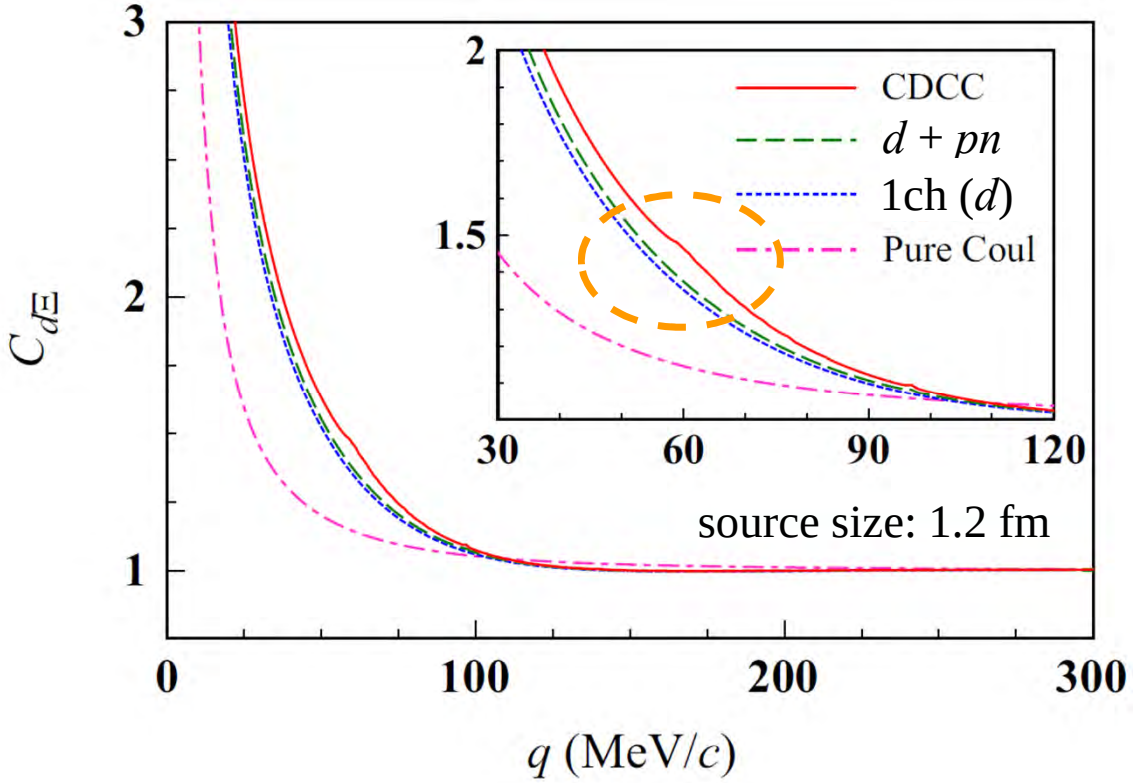
All interactions are isospin-spin dep.

Limitations

- Coulomb int. presents in all channels.
- Orbital ang. moms. are restricted to 0.
- Isospin dep. of masses of *N* and Ξ is ignored.
- Rearrangement channels are disregarded.

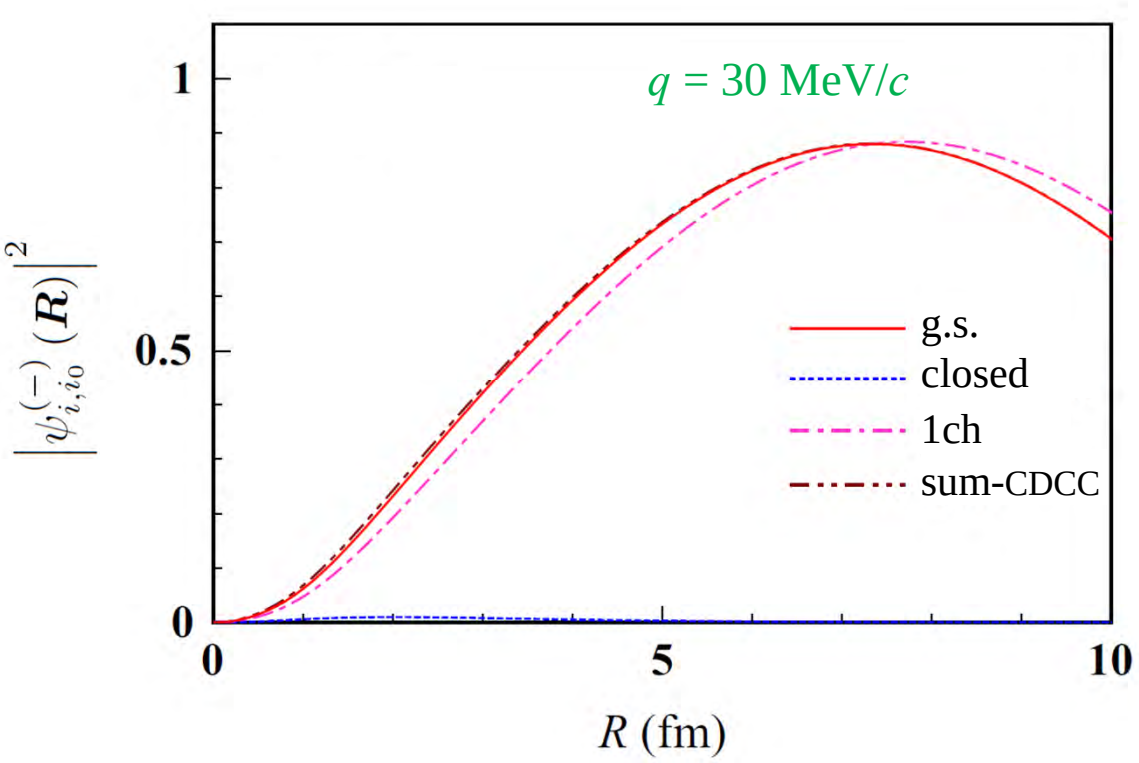
d-Ξ correlation function

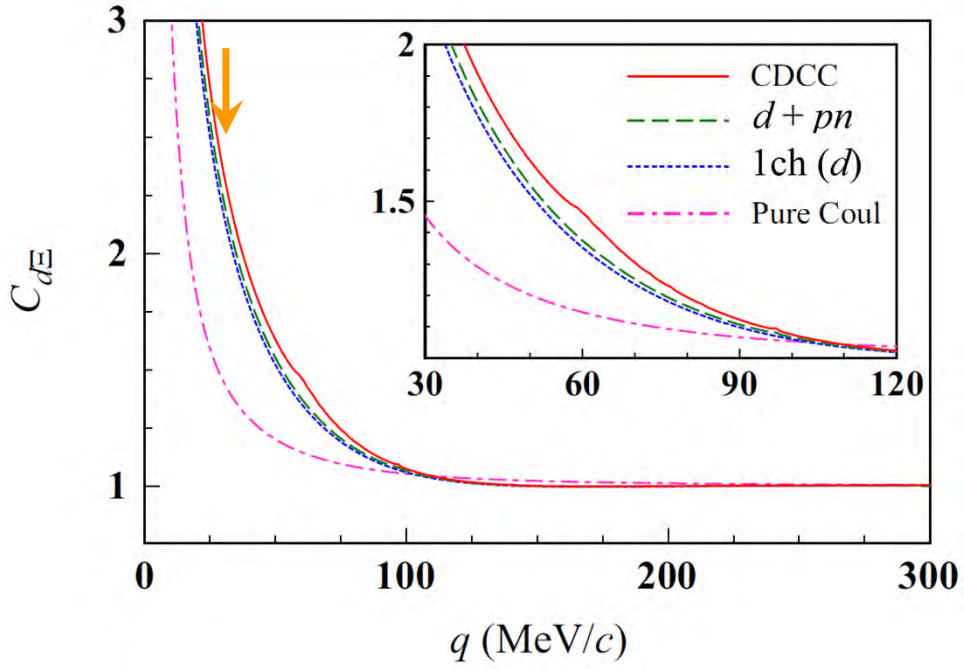




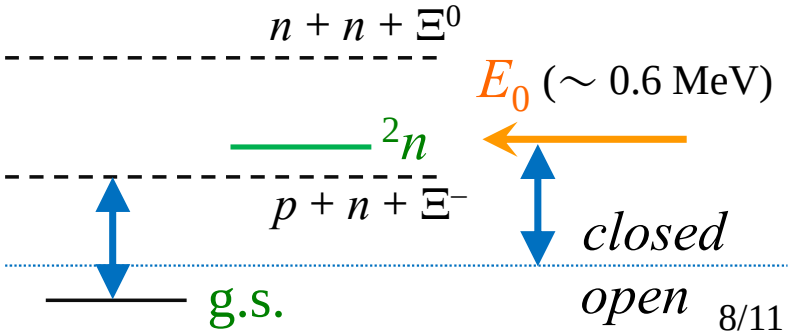
- Clear increase due to strong int. showing an attractive nature of the *d*-Ξ int. (no bound state, though)
- Slight enhancement due to the coupling with the low-lying *nn* (singlet-even) BU channel, the ^2n channel

NN-Ξ relative W.Fn.: below the nn-Ξ threshold

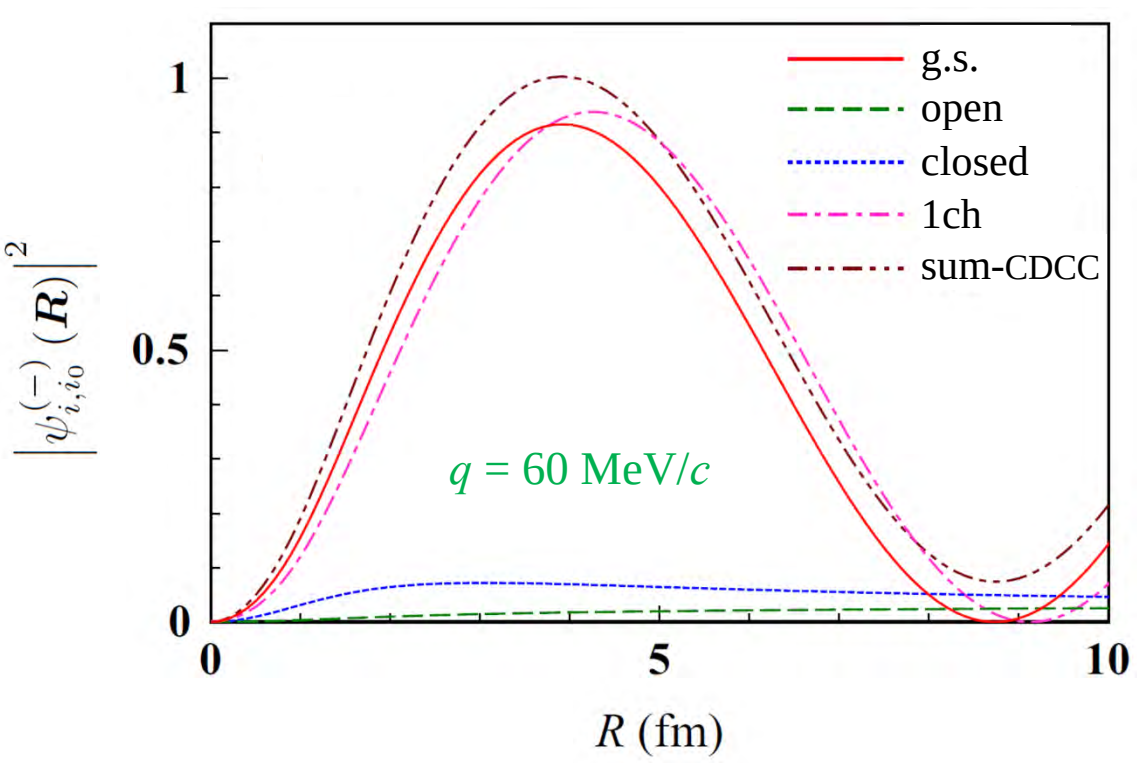


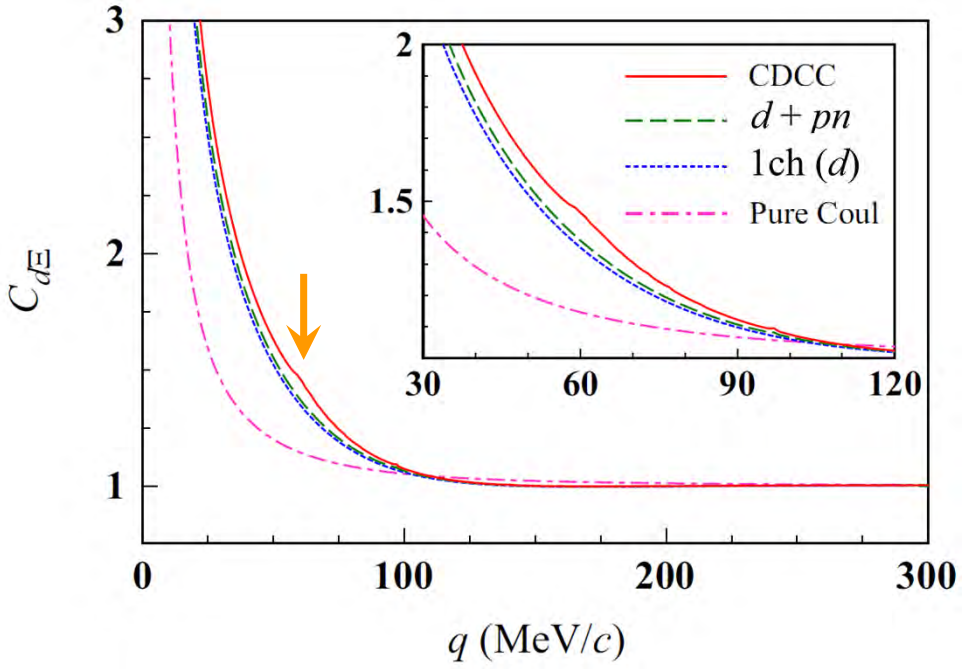


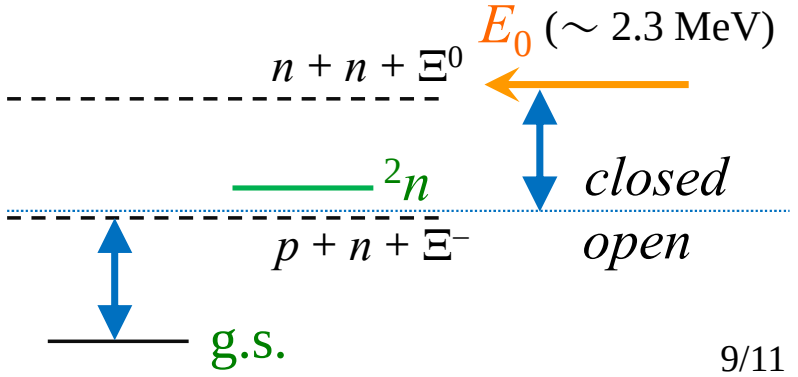
- ψ in the d-Ξ Ch. is slightly larger than that obtained with a 1ch calculation (Back-Coupling effect).
- Contributions from BU (closed) Chs. are negligibly small.



NN-Ξ relative W.Fn.: around the nn-Ξ threshold

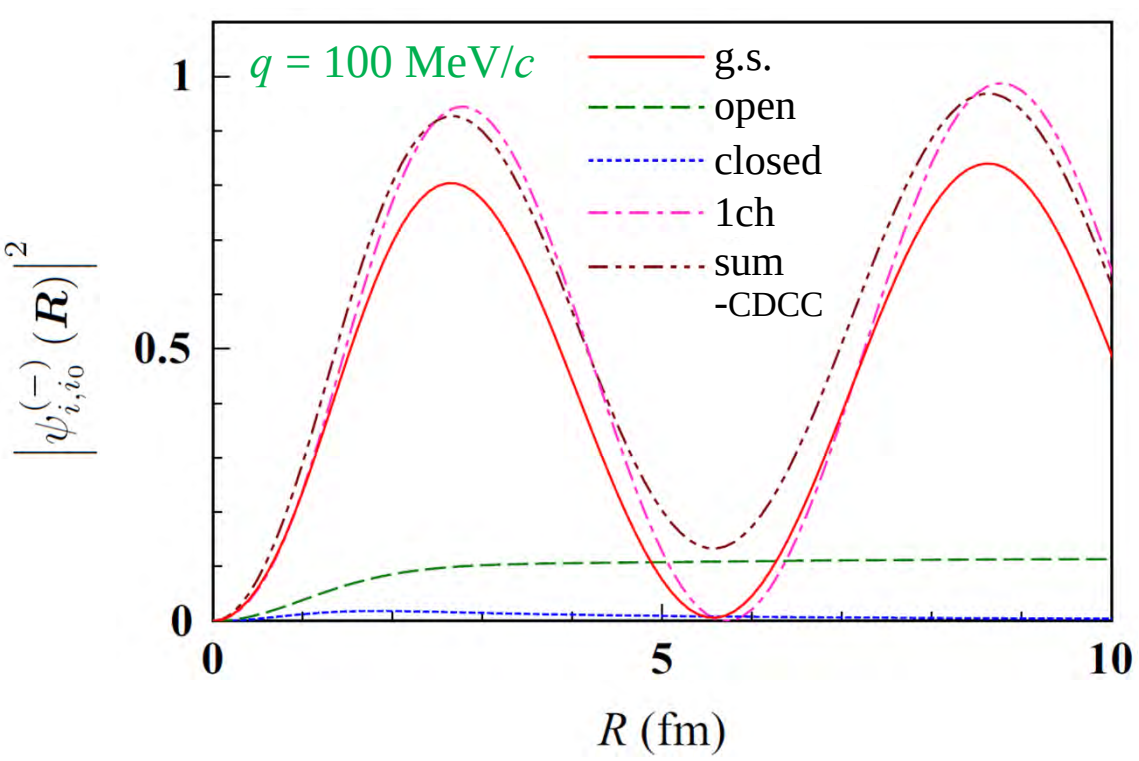


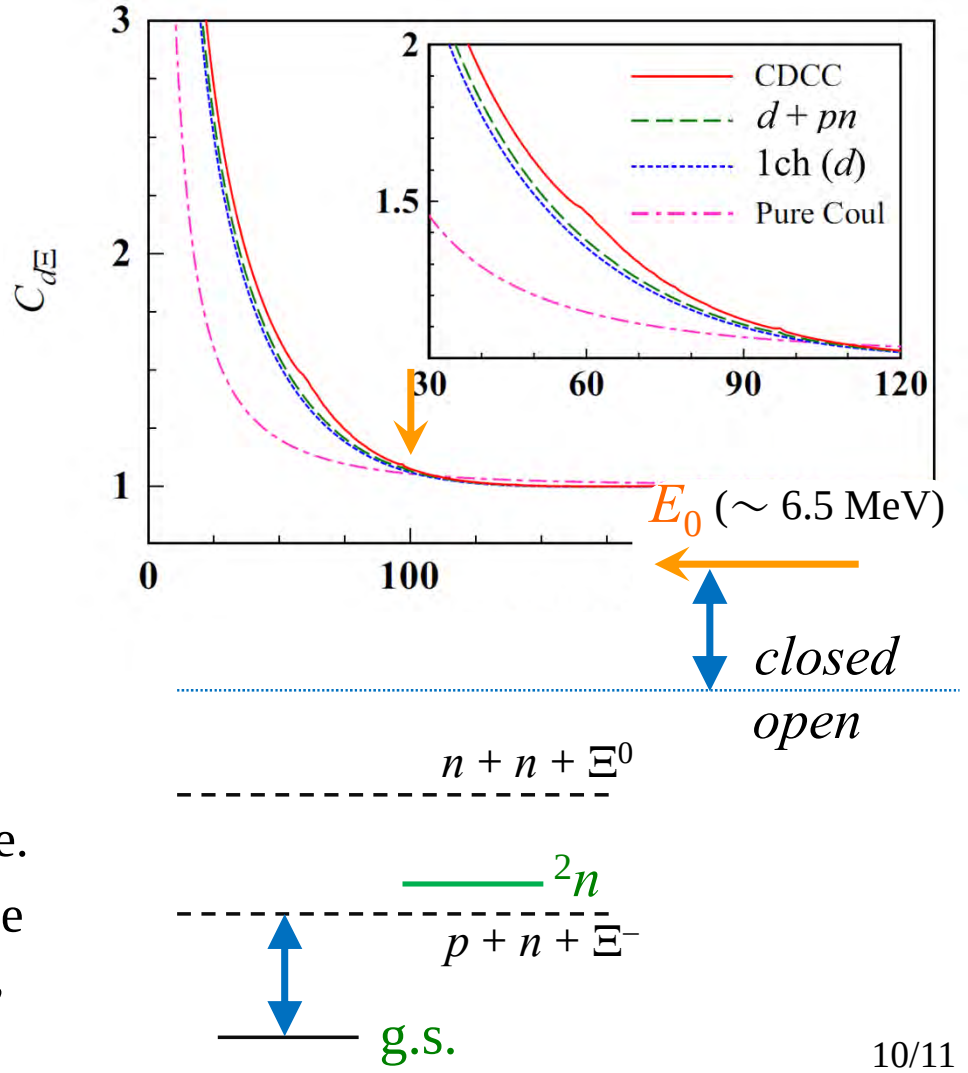




- The BC effect is the same as at q = 30 MeV/c.
- The contribution from the BU (closed) Ch is appreciable. This is due to the ^2n-Ξ channel located just below the nn-Ξ threshold.

NN-Ξ relative W.Fn.: above the nn-Ξ threshold





- The ^2n-Ξ Ch. becomes open, whose contribution is large.
- The summed result for the CC calc. is very similar to the result of the 1ch calc. because of the unitarity condition, which makes the net CC effect negligible.

Summary

- We have investigated the deuteron BU effect on the d-Ξ CF with CDCC adopting LQCD NΞ interactions.
  - ✓ The deuteron BU effect is found to be not very significant, giving an enhancement of the CF by 6-8 %.
  - ✓ The coupling with the ${}^2n$-Ξ channels is strong and dictates the BU effect on the CF.
  - ✓ Our result may justify a simple d + Ξ two-body model calculation for the CF.

*KO, T. Fukui, Y. Kamiya, and A. Ohnishi, PRC **103**, 065205 (2021) [arXiv:2103.00100].*

- The result of the present calculation may change if the isospin dependence of the particle masses, a proper treatment of Coulomb, and channel dep. of the source Fn. are considered.

cf. Y. Kamiya+, arXiv2108.09644 for $p\Xi^-$-$\Lambda\Lambda$ CF calculation.

- The framework proposed in this study will be applicable to ppX 3bCF (X ≠ nucleon), if rearrangement channels can be disregarded.