Study of barrier distribution in the reaction $^{48}Ca,^{50}Ti+^{208}Pb$ and $^{48}Ca+^{248}Cm$ at RIKEN-GARIS

T. Tanaka,[*1,*2] Y. Narikiyo,[*1,*2] K. Morita,[*1,*2] K. Fujita,[*1,*2] D. Kaji,[*1] K. Morimoto,[*1] S. Yamaki,[*1,*3] Y. Wakabayashi,[*1] K. Tanaka,[*1,*4] M. Takeyama,[*1,*5] A. Yoneda,[*1] H. Haba,[*1] K. Komori,[*1] S. Yanou,[*1] B. JP. Gall,[*1,*6] Z. Asfari,[*1,*6] H. Faure,[*1,*6] H. Hasebe,[*1] M. Huang,[*1] J. Kanaya,[*1] M. Murakami,[*1,*7] A. Yoshida,[*1] T. Yamaguchi,[*3] F. Tokanai,[*1,*5] T. Yoshida,[*1,*5] S. Yamamoto,[*1,*2] Y. Yamano,[*1,*2] K. Watanabe,[*1,*2] S. Ishizawa,[*1,*5] M. Asai,[*8] R. Aono,[*7] S. Goto,[*7] K. Katori,[*1] and K. Hagino[*9]

In order to study the nucleus-nucleus interaction for the synthesis of superheavy elements,[1)] we measured excitation functions for the quasielastic scattering of $^{48}Ca,^{50}Ti+^{208}Pb$ and $^{48}Ca+^{248}Cm$. The quasielastic scattering events were clearly separated from background events by using the gas-fillled recoil ion separator GARIS and guided to focal-plane detectors.

The barrier distributions were derived by taking the first energy derivative of the excitation function. The experimental results were well reproduced by coupled-channel calculations[2)] taking account of vibrational and/or rotational excitations of nuclei and neutron transfer before the capture process (Figs. 1 and 2).

The centroids of the barrier distributions are shown to coincide with the peak of evaporation residue cross sections for the reaction $^{48}Ca,^{50}Ti+^{208}Pb$.[3–6)] This implies that, for these Pb-based cold fusion reactions, the peak of the cross section is in good agreement with that of the barrier distributions after one takes into account several experimental conditions such as measured energy step, which is typically 2.0 MeV, and energy coverage region, which is typically 1.0 MeV, of the target thickness.

In contrast, for the hot fusion reaction $^{48}Ca+^{248}Cm$, the peak of the cross section[7,8)] is shifted to the above barrier region. The barrier distribution of the above barrier region corresponds to side-by-side collision. In the compound nucleus (CN) formation process, the probability of CN formation is increased by side-by-side collision because the probability depends on the distance to the center of nuclei. It is therefore important to combine the barrier distribution study with studies on quasi-fission and evaporation processes in order to predict the optimum incident energy for a search of undiscovered superheavy elements by the hot fusion reaction.

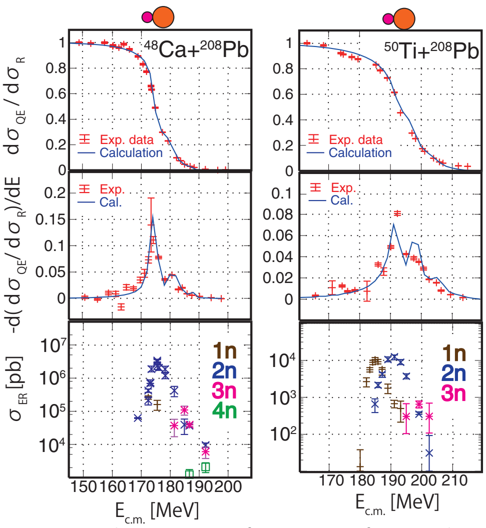

Fig. 1. Measured excitation functions of quasielastic scattering cross section relative to Rutherford cross section (upper panels) and the barrier distributions (middle panels). The lower panels show the evaporation residue cross sections for these reactions.

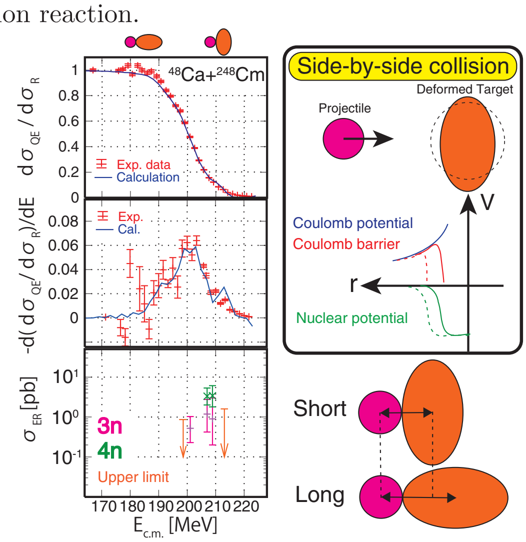

Fig. 2. Left side panels show same as Fig. 1. Right side panels show the explanation of Side-by-side collision.

*1 RIKEN Nishina Center
*2 Kyushu University
*3 Saitama University
*4 Tokyo University of Science
*5 Yamagata University
*6 IPHC-DRS/Université de Strasbourg
*7 Niigata University
*8 Advanced Science Research Center, JAEA
*9 Tohoku University

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