Barrier distribution measurement of the ^{51}V + ^{159}Tb system

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With the discovery of elements up to oganesson (Z = 118), all reactions based on the ^{48}Ca beam leading to a new element have already been performed. The next step forward to produce new element Z = 119 and beyond needs to rely on ^{50}Ti, ^{51}V, or ^{54}Cr beam on trans-actinium targets. However, in the super heavy mass region, the reactions using these beams have only been studied on spherical targets (^{208}Pb and ^{209}Bi). Thus, very little information regarding the reaction parameters on deform targets is currently available with these beams. Most of the information used by the predictions is extrapolated from the ^{48}Ca results. Systematic studies of reaction using these beams on deform targets are thus needed to improve the predictive power of the different models.

One of these important parameters is the beam energy selected for the search for new elements. The search of the element Z = 119 is currently ongoing at RIKEN using the ^{51}V + ^{248}Cm reaction. The optimal beam energy was selected by studying the barrier distribution of this reaction.[1)] We decided to begin the systematic measurement of the same parameters extracted in Refs. 1) and 2) with lighter deformed targets, starting with the ^{159}Tb. The relation between the maximum cross-section of production and the QuasiElastic (QE) barrier distribution is directly linked to the reaction dynamics.

The ^{51}V^{13+} beam was provided by the newly upgraded SRILAC accelerator.[3)] Similarly to the reports,[1,2)] we used the GARIS-III separator to transport the QE backscattering. These events correspond to the recoil of target-like events at 180° (or a beam-like event at 0°). Using the information from our detector array located at the end of GARIS-III,[3)] we can use the time-of-flight telescope to select the target-like recoil nuclei. Then, by using the dose estimated through elastic scattering of the ^{51}V beam onto the ^{159}Tb at the target position, we can extract the barrier distribution as shown in Fig. 1 (bottom panel). The top panel represents the reflection probability $R(E)$, which is the normalized ratio of target-like events detected at the focal plane to the number of elastic scatterings detected at the target position. The bottom panel represents the barrier distribution $D(E)$ defined as:

$$D(E) \equiv -dR/dE$$

The average barrier height is defined at the 0.5 crossing

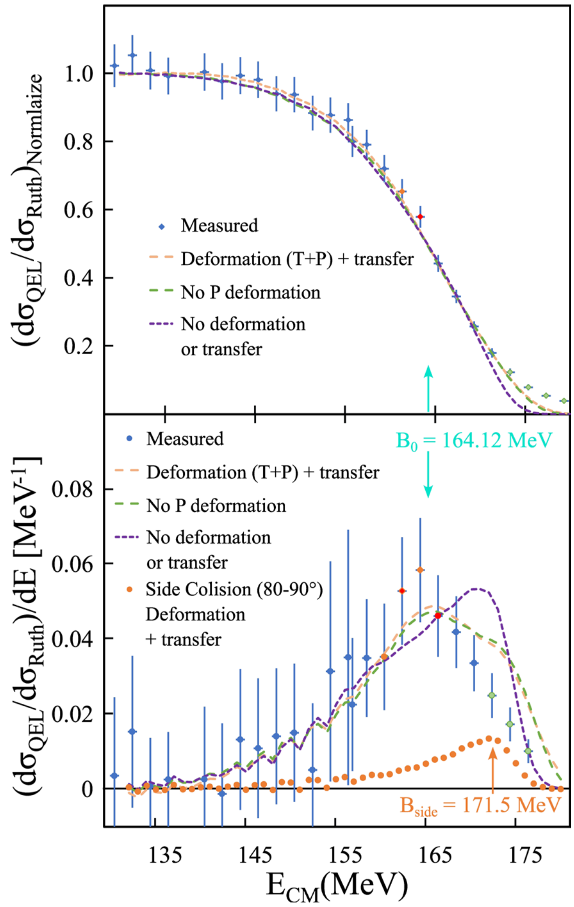

Fig. 1. Reflection probability (top panel) and barrier distribution (bottom panel) of the ^{51}V+^{159}Tb reaction. The points (blue, red/orange, and green) are the measured data and the several curves CCFULL calculations[4)] with different input parameters.

in the $R(E)$ distribution. It is determined as 164.12 ± 0.3 MeV (blue arrow in Fig. 1). This value is related to the maximum of the cross-section of production in the case of reaction on spherical targets. However, in the case of the deformed targets, the side collision energy is more important, as has been pointed out.[1,2)]

This side collision corresponds to the collision of the projectile and target at a 90° angle in a compact configuration. In order to extract this side collision energy, we need to perform the Coupled Channels calculation (CCFULL[4)]).

The dashed orange line in Fig. 1 represents the optimized CCFULL calculations,[4)] and the orange dots represent the contribution of the side collision to the

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overall barrier distribution. We optimized the parameters of the CCFULL calculation to reproduce both the reflection probability and the barrier distribution. We can then extract from these calculations the side collision energy as 171.5 ± 0.5 MeV (orange dot and arrow in Fig. 1 bottom panel). These results will be compared and correlated with the precise excitation function we simultaneously measured for this reaction.[5)]

References

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