Contribution ID: **85** Type: **Poster (In person)**

Probing residual nuclei production to optimize ISRS performance

Wednesday 27 November 2024 18:30 (1 minute)

One main objective of the ISRS project is to investigate residual nuclei production to enhance the ISRS performance and, thereby, guide more precise experimental designs for future research. The analysis in this area has been initiated using different computational codes, namely EMPIRE and PACE4 [1-2]. Our initial examination involves reactions on a CD_2 target induced by a neutron-rich ^{68}Ni beam at a center-of-mass energy of 19.4 MeV. The modified version of the EMPIRE used in our study integrates the post-form distorted wave Born expression of the Ichimura-Austern-Vincent approach (DWBA-IAV) [3-6] for the elastic breakup and nonelastic breakup predictions, as well as the exciton and statistical Hauser-Feshbach models accounting for preequilibrium and compound-nucleus processes. This framework enables precise incorporation of key mechanisms, leading to a reliable estimation of the yields of the residual nuclei produced in the nuclear reaction. The results from EMPIRE were compared with those obtained from PACE4, revealing that EMPIRE predicts a broader range of residual nuclei and a larger total cross section in this reaction. In addition to general computational differences, the main discrepancy in the predictions arises from the fact that PACE4 focuses on projectile absorption, while EMPIRE incorporates all key processes and predicts the formation of different types of pre-compound/compound nuclei in the reaction, making it a more comprehensive tool for examining the reaction mechanisms and residual nuclei.

In addition to the production yields, we investigated the angular distributions of the residual nuclei using the Monte-Carlo simulation code PACE4. These distributions showed that the yields of nearly all residual nuclei were produced at forward angles of less than 2 degrees. We scaled the cross sections obtained from EMPIRE based on the angular distribution patterns observed in the PACE4 results, ensuring consistency in the cross sections across different angular ranges for each nucleus. Subsequently, using the distributions obtained, precise Gaussian fits were found for each residual nucleus, which will be used in beam dynamic simulations to optimize the design of ISRS.

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Session Classification: Poster session