Recent results of ^{45}Sc-induced fusion evaporation reactions on ^{158,160}Gd

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Recent superheavy element discoveries have benefitted from ^{48}Ca projectiles bombarding actinide targets. The possibilities for making new elements (Z > 118) in ^{48}Ca reactions have been exhausted and projectiles with higher Z such as ^{45}Sc, ^{50}Ti, etc. must be used instead.

Cross sections have been measured for the *4n* exit channel of the ^{45}Sc + $^{158,\,160}$Gd reactions. These complement previous bombardments of the lanthanide targets ^{159}Tb and ^{162}Dy with ^{45}Sc projectiles [1]. These systems allow for the study of projectile/target effects and the effects of the relative neutron content in the compound system on the *4n* cross sections. The evaporation residues (EVRs) were produced using beam from the K500 cyclotron. Unreacted beam and undesired reaction products were filtered using the spectrometer MARS [2]. The general experimental details are described in Ref. [3]. All data presented here are preliminary. The *4n* and *p3n* cross sections for the reactions of ^{45}Sc + ^{158,160}Gd, ^{159}Tb are plotted in Fig. 1 and Fig. 2, respectively. For the ^{45}Sc + ^{159}Tb reaction, the *p3n* exit channel cross section is significantly larger than the *4n* cross section. For the ^{45}Sc + ^{158,160}Gd reactions, sensitivity to the *p3n* product is limited by small alpha branches (~1-3%).

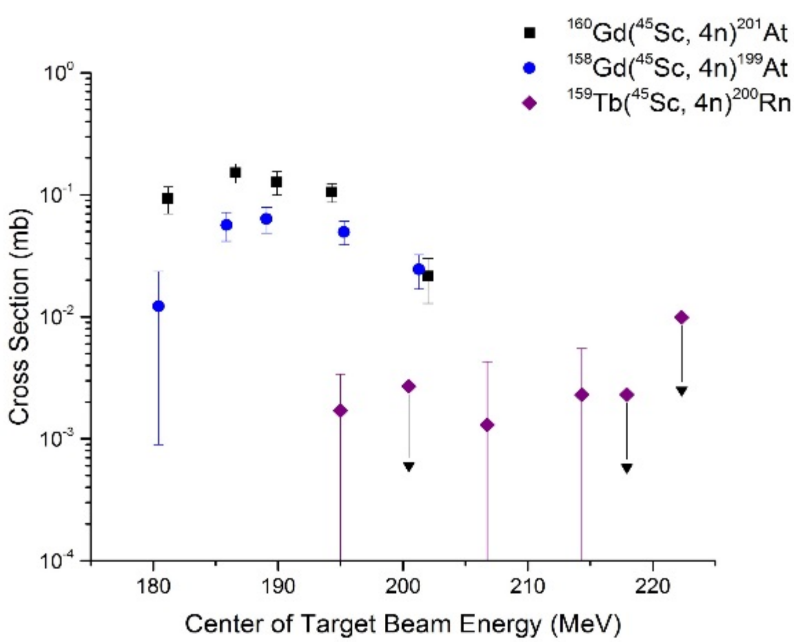

FIG. 1. Cross sections for the *4n* channels in the ^{45}Sc + ^{158,160}Gd (blue circles and black squares) and ^{45}Sc + ^{159}Tb (purple diamonds) reactions.

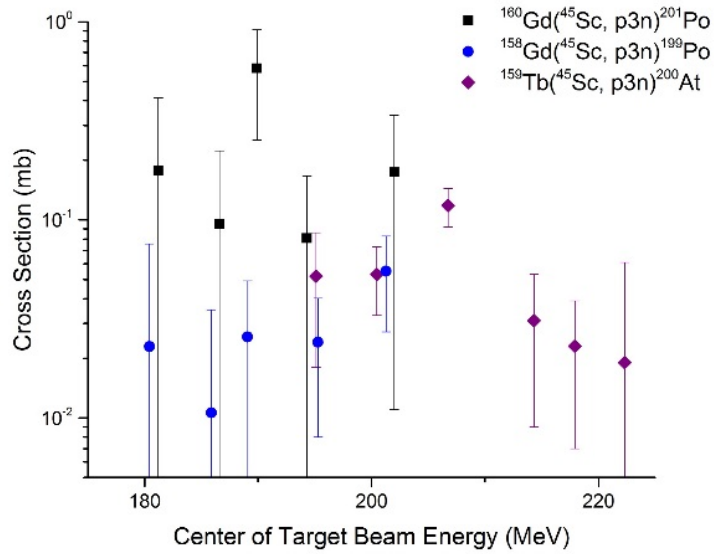

FIG. 2. Cross sections for the *p3n* channels in the ^{45}Sc + ^{158,160}Gd (blue circles and black squares) and ^{45}Sc + ^{159}Tb (purple diamonds) reactions.

These data were analyzed within a simple, three-step model of fusion evaporation reactions:

$$\sigma_{EVR} = \sigma_{capt} P_{CN} W_{sur},$$

where the fusion cross sections, σ_{capt}, were calculated using the coupled-channel code CCFULL[4]; compound nucleus formation probabilities, P_{CN} , were estimated using the functional form of the Fusion-by Diffusion [5] approach that is presented in Ref. [6], and survival probabilities, W_{sur}, were calculated using the standard transition state theory approach presented in Ref. [7]. The calculation of survival cannot be reduced to the well-known Vandenbosch and Huizenga formula [8] due to the large contribution of proton emission from the compound nucleus. The survival probabilities are shown to be the main force in driving down the *4n* cross sections in the ^{45}Sc + ^{159}Tb reaction. Calculations are still in progress and final results will be published in a future work.

[1] C.M. Folden III *et al.*, J. Phys. Conf. Ser. **420** 012007 (2013).
[2] R.E. Tribble *et al.*, Nucl. Instrum. Methods Phys. Res. A**285**, 441 (1989).
[3] C.M. Folden III *et al.*, Nucl. Instrum. Methods Phys. Res. A**678**, 1 (2012).
[4] K. Hagino *et al.*, Comp. Phys. Commun. **123**, 143 (1999).
[5] W.J. Świątecki *et al.*, Phys. Rev. C **71**, 014602 (2005).
[6] D. Mayorov *et al.*, Phys. Rev. C (submitted).
[7] K. Siwek-Wilczyńska *et al.*, Phys. Rev. C **72**, 034605 (2005).
[8] R. Vandenbosch and J.R. Huizenga, *Nuclear Fission* (Academic, New York, 1973), p. 232.