Studying the impact of deuteron non-elastic breakup on ^{93}Zr + d reaction cross sections measured at 28 MeV/nucleon[†]

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Owing to the deuteron's low binding energy it is easily broken apart by the Coulomb and nuclear fields of a target nucleus. This non-elastic breakup enhances deuteron-induced reaction cross sections above 50 MeV/nucleon,[1,2] where comparisons between measured data and statistical model outputs (*i.e.* DEURACS and TALYS) help improve our understanding of the underlying breakup mechanisms. However, there remains a lack of data at energies below 30 MeV/nucleon for long-lived fission product ^{93}Zr. To address this, in 2017 the optimized energy degrading optics[3] (OEDO) system was used to measure ^{93}Zr + d reaction cross sections at 27.7 MeV/nucleon, the lowest energy to date. This report summarises the recently published letter presenting the final results.

The ^{93}Zr secondary beam was produced in the BigRIPS separator from in-flight fission of 345 MeV/nucleon ^{238}U with a ^{9}Be 5 mm thick target. The beam was transported through the OEDO beamline, where it was used to bombard a cryogenically-cooled deuterium gas target. Reaction products from the D_2 target were collected and momentum-analyzed by the SHARAQ spectrometer operating in QQD mode.[4] Tracking and timing information from parallel plate avalanche counters were used to calculate the products' mass-to-charge (A/Q). The beam and products were stopped in an ionization chamber, and their Bragg curves were fitted to extract mass (A) and atomic numbers (Z). Consequently, individual fragments were identified using their A, Z, and A/Q information, and their production cross-sections were calculated.

The ^{93}Zr + d cross sections as a function of incident deuteron energy are shown in Fig. 1. Measured data from this study are plotted at 55.8 MeV, where the hatched band represents the energy range covered in the D_2 target. The data of previous studies[5,6] are plotted at higher energies. The solid lines represent the DEURACS calculations, and dotted/dashed lines represent the TALYS calculations considering different deuteron breakup models.

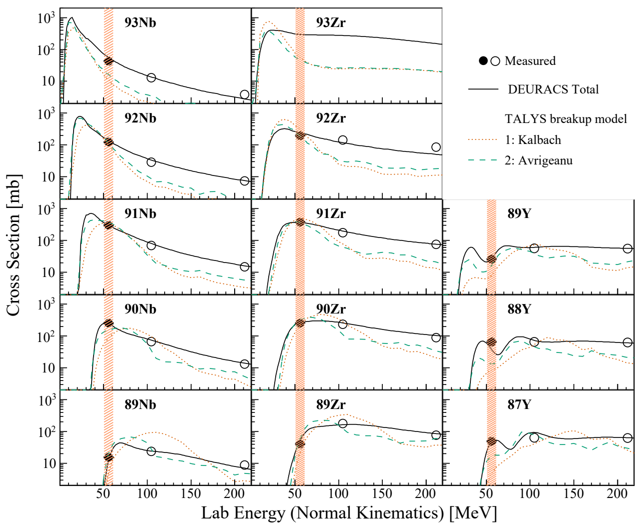

Fig. 1. ^{93}Zr + d cross sections, see text for details.

Our data was in quantitative agreement with the output of DEURACS and TALYS. The present data helps constrain models of deuteron-breakup on reaction cross sections and may assist accelerator-driven transmutation systems in their efforts to treat ^{93}Zr in nuclear waste. In future, coincidence measurements detecting evaporated light particles and γ-ray emissions alongside the heavy residual particles would be helpful.

References

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