Fragment production in the spallation reaction of 500 *A* MeV ^{136}Xe with ^{1}H

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The complete understanding and modelling of proton-induced spallation reactions is a major goal both for fundamental research and technical applications. The spallation reactions have attracted interest to develop intense neutrons sources needed for accelerator-driven systems (ADS) for incineration of nuclear waste [1,2], material physics and biology [3] and also to produce high-intensity radioactive beams [4]. In addition, spallation reactions are a subject of interest in astrophysics to understand the origin of cosmic rays and their reactions with the hydrogen and helium nuclei in the interstellar medium [5]. All these perspectives have triggered a long-range research program [6] at GSI, devoted to reach a full comprehension of the proton and deuteron-induced spallation reactions by measurements of evaporation residues and fission fragments. To complete the study on the energy dependence of the spallation process, the spallation reactions of ^{136}Xe on protons at 500 *A* MeV and 1000 *A* MeV [7] were performed at GSI. The new data will help to develop improved models with better predictive power for spallation reactions involving nuclei spanning a wide mass range. In this paper, we will describe the experimental technique and the results obtained for the spallation of ^{136}Xe on protons at 500 *A* MeV.

Experiment and data analysis

The experiment was performed at the Fragment Separator (FRS) at GSI. Deflection of ions in the dipoles of the FRS, and the energy loss in two ionization chambers were used to identify in mass and atomic number every residue of the reaction. The achieved resolution in atomic number amount to $\Delta Z \approx 0.4$, and in mass $A/\Delta A \approx 400$. Moreover, high-precision information on the kinematical properties of each residue has also been obtained. Measured yields were corrected for the transmission losses, for the losses due to the secondary reactions in different layers of matter, and for the losses due to the dead-time of the data acquisition system. The production cross sections were obtained after normalizing these yields to the number of atoms in the liquid hydrogen target and to the number of impinging beam particles.

Results

The measured cross sections of the isotopes of the elements between Z = 33 and Z = 56 produced in the ^{136}Xe + ^{1}H spallation reaction at 500 *A* MeV are presented on Fig. 1 as a cluster plot on the chart of nuclides. The results of the experiments showed that the nuclide cross sections strongly decrease below Z = 40 and fall below the detection limit of the experimental set-up (~ 3 μb) for elements below Z = 33. The measurement covers a range in cross section of more than 4 orders of magnitude between 70mb and 3 μb. The single and double charge-pickup channels were also observed.

With data previously measured, these data will improve the present knowledge on spallation process, especially in its dependence on mass or on energy of the system.

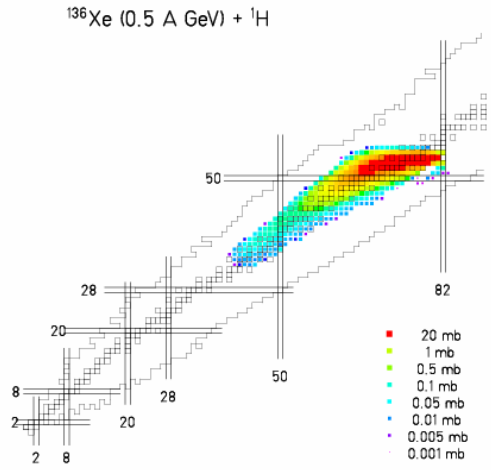

Fig. 1 Residual nuclide cross sections measured in the spallation reaction of ^{136}Xe + ^{1}H at 500 *A* MeV.

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