Isotopic production cross sections of fragmentation residues in reactions induced by $^{238}U(1A \cdot GeV)$ in deuterium

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The production cross sections of more than 500 fragmentation residues produced in the interaction of $^{238}U(1\ A \cdot GeV)$ with deuterium have been measured [1] within an European collaboration at GSI started in 1996. The aim of this work is to provide fundamental data for spallation sources (e.g. accelerator-driven systems). These data are also relevant to investigate the production of radioactive nuclear beams. The goal of this experimental program is to provide a large benchmark data collection which will help to better understand the reaction mechanisms involved in the residue production in spallation reactions. In this program, the spallation of ^{197}Au [2,3], ^{208}Pb [4], and ^{238}U [5,1] has been measured so far. The quality and quantity of the data now available, allow to study the differences among the reactions investigated.

The present experiment was performed by shooting a U-beam accelerated in the SIS synchrotron, into a cryogenic liquid-deuterium target. The use of *inverse kinematics* allows to investigate the produced residual nuclei in mass and atomic numbers while flying forward, using the **FRS** as an achromatic energy-loss spectrometer. Only a few extremely short-lived alpha-emitters with 128 neutrons, having half-lives around 100 ns, partly decayed inside the spectrometer. For all other nuclides, the production cross sections were determined prior to their radioactive decay. With this procedure we demonstrated that the isotopic identification is unambiguous, a challenge for nuclides with Z above 70 at this energy. To define the cross sections we had to correct the counting rates for the effects inherent to our method. The resulting uncertainty of the cross-section values was 12-19%, higher for lower masses.

In Fig. 1 we show the cross-section values measured in the ^{238}U induced reactions on proton [4] (upper panel) and deuteron [5] (lower panel), plotted in grey-scale on top of a chart of nuclides. We can see that the length of the fragmentation corridor is larger in the case of the deuteron. This effect is due to the additional available excitation energy in the system, just after the collision. The deexcitation can proceed further, reaching lighter residues. We also observed that the production of heavy residues in the reactions induced by protons and deuterons are rather similar. The heaviest residues result from the most peripheral collisions. Due to the large spatial distribution of the deuteron, many of the impacts involve a single nucleon. Thus both reactions, with deuteron and proton, result in the same production. No differences between neutron and proton impacts were found. We also compared the productions of residues in the reactions induced by ^{208}Pb and ^{238}U on deuteron. As known from other reactions [4], the results are expected to be similar, just scaled by the ratio of the total reaction cross sections. However large differences in the production of heavy residues were observed, due to the fission channel. This channel largely dominates the reaction mechanism in the neighborhood of the projectile ^{238}U, populating medium-mass residues.

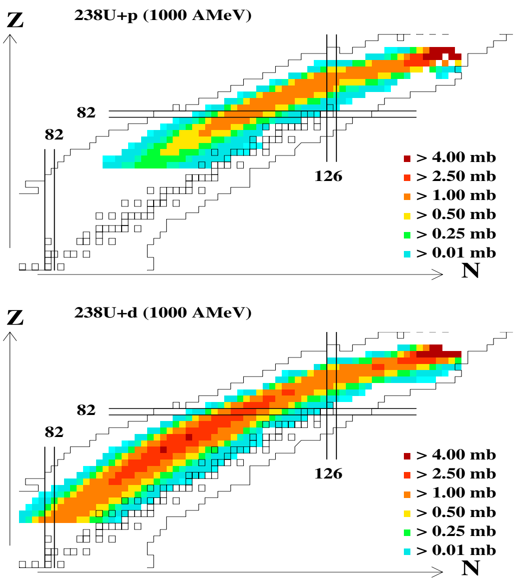

Figure 1: Production cross-sections measured in the ^{238}U induced reactions on proton (upper panel) and deuteron (lower panel) at $1A \cdot GeV$, plotted in grey-scale on top of a chart of nuclides.

The comparison of the results from proton and deuteron induced reactions will allow to improve the description of the impact of several nucleons, since the deuteron is the simplest extension after the collision of a single nucleon. The difference in energy deposition between nucleon and ion collisions can also be investigated [6]. The comparisons of reactions involving ions with very different fissilities, help to determine the accuracy of the description of the fission to particle-emission competition. All these results are essential in order to improve the models that describe the reactions mechanisms.

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