MEASURING FUSION EXCITATION FUNCTIONS WITH RIBS AND STACKED TARGETS: HOW TO DEAL WITH THE LARGE BEAM ENERGY DISPERSIONS?

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The study of fusion reactions involving halo or, more in general, weakly bound nuclei at energies around the Coulomb barrier had considerable interest in the last decade due to the effects of the weakly bound projectile structure on the reaction dynamics (see e.g. [1] for a recent review). Fusion reactions induced by low intensity RIBs have been studied by irradiating stacks of several targets and measuring off-line the radiation emitted in the decay of the evaporation residues [e.g. 2-7]. Such a technique offers the considerable advantage that several reaction energies may be simultaneously measured. However, its main drawback is the degradation of the beam quality as it passes through the stack due to statistical nature of energy loss processes and any non-uniformity of the stacked targets.

Indeed, due to the large number of used foils and/or their non-uniformities and/or the quality of RIBs used, in many experiments targets were irradiated by beams having large energy dispersions (e.g. up to ~2 MeV FWHM in [2,3] and up to ~ 6 MeV FWHM in [4,5]). If not taken properly into account, this degradation can lead to ambiguities of associating effective beam energies to reaction product yields in a target within the stack and thus, to a wrong determination of the fusion excitation functions. In general, up to now, for these multiple thick target experiments very limited account has been devoted to the study how these factors could influence the deduced excitation functions. In this contribution the results of a thorough investigation of this problem will be discussed.

In particular, it will be shown that, in general, the traditional way to represent the fusion cross section as function of the energy in the middle of the target, or as a function of an effective energy based on a weighted average which takes into account both the beam energy distribution and the energy dependence of the cross section, leads to a wrong determination of the fusion excitation function. A new method, based on an unfolding procedure of the data, will be proposed.

Considering typical target/degrader combinations different simulations will be presented in order to show the considerable effects of beam degradation on the extraction of the fusion excitation functions. Possible consequences of the discussed effects on existing data will be evaluated.

To properly take into account the discussed effects target surface morphology has to be correctly considered and a method to characterise the target thickness distribution will be presented.

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