The program MOCADI: application to fusion-evaporation studies

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Precise mass measurements are a basic method for understanding the strong interaction inside the atomic nucleus. Among the whole chart of nuclei, the mass region around ^{100}Sn is of particular interest due to several reasons related to both nuclear physics and nuclear astrophysics, namely: double shell closure $N = Z = 50$, proton drip-line, two-proton radioactivity, expected end of the *rp*-process, spontaneous emission of intermediate-mass fragments. Within this framework, we aim to perform this kind of measurements using the facilities SHIP [1] and SHIPTRAP [2] at GSI, Darmstadt (Germany). Fusion-evaporation reactions will be employed to produce these nuclei far from stability, since they allow for higher production rates than fragmentation or fission reactions. The evaporation residues will be subsequently separated from the primary beam by means of the velocity filter SHIP and stopped in a gas-cell. Precise mass measurements will be eventually performed with the SHIPTRAP Penning trap system.

Since the production cross sections of such exotic nuclei are in the μb-nb region, a detailed knowledge of the reaction kinematics as well as of the SHIP and SHIPTRAP efficiencies (including beam transport and focusing, atomic interaction in the target, in the degrader foils and in the gas-cell entrance window, ...) is required to optimize the transmission of the selected evaporation residues through the velocity filter and to provide a high background suppression. For this purpose we extended the Monte-Carlo code MOCADI [3] to fusion-evaporation reactions. The event generation has been carried out by using the code PACE2 [4], based on the statistical model, while the SHIP ion optics has been calculated with the code GICO. Reaction kinematics and ion optics have been combined into MOCADI in order to calculate the transmission through SHIP and to derive the stopping distribution inside the SHIPTRAP gas-cell. As an example, Fig. 1 shows the comparison between the calculated SHIP transmission for some reactions with the results of previous simulations [5] and with the available experimental values.

As a first application, the code has been employed during the last SHIPTRAP experiments (February 2006) to calculate the excitation functions of the evaporation residues for the reactions ^{58}Ni,^{50}Cr + ^{58}Ni. The relative yields for isotopic chains agree with the predicted values within one order of magnitude. Absolute transmission measurements for SHIP have been recently performed by studying the coincidences of γ-rays at the target position with evaporation residues detected at the SHIP focal plane detector. The data analysis is presently in progress.

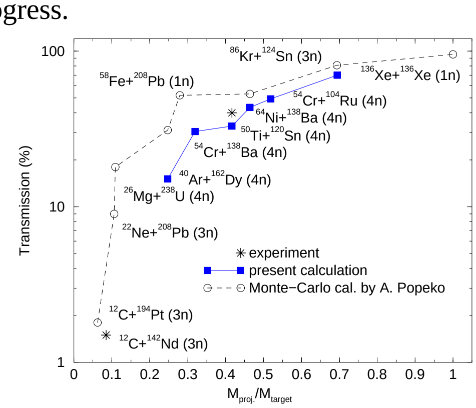

Figure 1: *Transmission of the velocity filter SHIP. Squares represent the results of the present simulations, stars experimental values and circles refer to previous calculations performed by A. Popeko[5].*

[1] G. Münzenberg et al., Nucl. Instrum. Methods 161, 65 (1979)
[2] M. Block et al., Eur. Phys. J. A 25, 49 (2005)
[3] N. Iwasa et al., Nucl. Instrum. and Meth. in Phys. Res. B 126, 284 (1997)
[4] A. Gavron, Phys. Rev. C 21, 230 (1980)
[5] A. Popeko, private communication