Kinematical Simulation of In-Flight Alpha and Fission Decay of Heavy Nuclei in Super-Heavy Mass Region

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The production and detection of super-heavy nuclei has generated a lot of interest in recent years. Measurements of alpha decay and spontaneous fission decay has typically been used as tool to confirm the production of implanted super-heavy nuclei by the GSI and Dubna groups[1,2]. With the motivation of exploring detection systems for in-flight decay of super-heavy nuclei with Z about 120-125, we have carried out a preliminary simplified kinematical simulation of alpha and fission decay of heavy-nuclei, which are in motion with a velocities of 2-6 cm/ns. For the first simulation the half life of the heavy nucleus was assumed to be 1 ns. The half life gives information about the decay position relative to the target location. The alpha and fission half life have been assumed to be the same in the present simulation. However, any half life and exit channel can be kinematicaly simulated to have some preliminary ideas which will be helpful in deciding the experimental setup. A strip detector array is assumed to be symmetrically placed around the beam axis to detect alpha particles and fission fragments emitted by the in-flight heavy nuclei, the width of each silicon strip is 1 cm and its distance from the beam axis is 12.5 cm.

The energy and angular distributions of first chance alpha, first chance fission and fission of a daughter after alpha emission, have been simulated. The alpha energy chosen in the frame of the moving heavy nuclei is 20 MeV. The recoiling daughter produced by alpha emission decays via asymmetric fission. The first chance asymmetric fission decay of the in-flight heavy nuclei has also been simulated. The energies of the asymmetric fission fragments in their respective center-of-mass frames have been calculated by using the Viola's total kinetic energy systematic for asymmetric fission channels [3].

The mass and charge of the heavy nuclei was currently taken as 300 and 116 respectively, and the fission channels were assumed to be asymmetric with ^{132}Sn and ^{168}Dy in the first chance fission, and ^{132}Sn and ^{164}Gd in the fission of daughter. The characteristics of first chance fission and recoil fission of daughter are very similar since the heavy recoil velocity is almost negligible. The simulations have also been done in the presence of a blocker having an opening aperture which selects an initial angle of the heavy in-flight nuclei of 6-20 deg. In this case the yield distributions of alpha particles and fission products are shifted backward relative to the case where the in-flight nucleus was moving straight in the beam direction. The Fig. 1 shows the yield distributions in various strip detectors along the beam direction for the first chance alpha, first chance fission with both light and heavy fragments and recoil daughter fission with only light fragment. In the left side of the figure the in-flight heavy nucleus is moving in the beam direction, whereas in the right side of the figure the in-flight nucleus is moving at an opening angle of 6^0-20^0 with respect to the beam direction in the presence of a blocker.

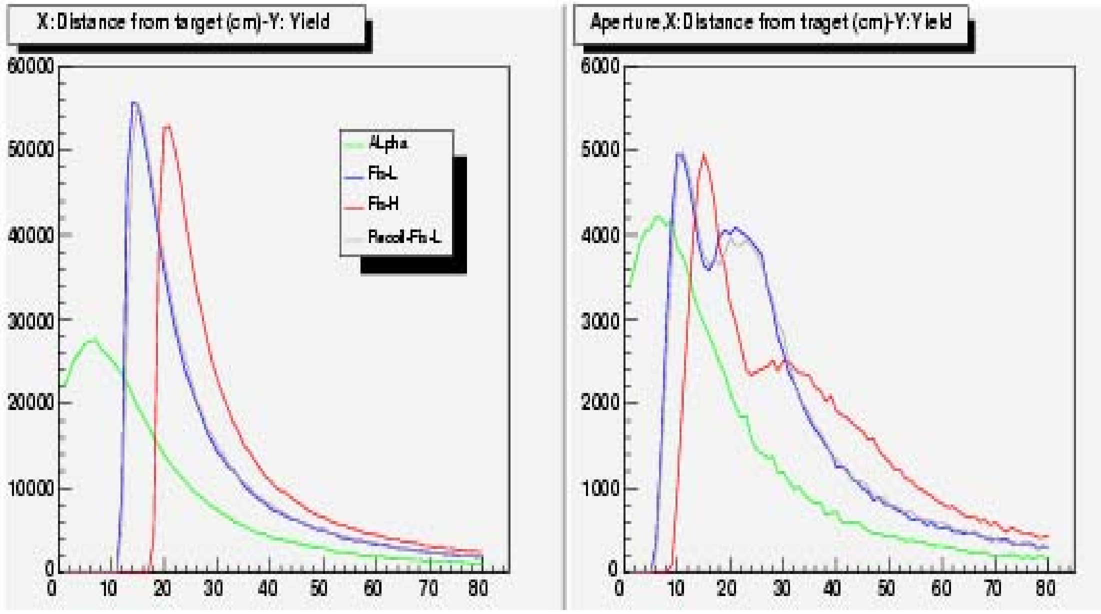

Figure 1. The yield distributions of alpha, fission (light and heavy marked by L and H) along the beam direction with and without blocker.

[1] S. Hofmann and G. Munzenberg, Rev. Mod. Phys. **72**, 733 (2000).

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[3] V.E. Viola, K. Kwiatkowski, and M. Walker, Phys. Rev. C **31**, 1550 (1985).