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Sub-barrier fusion induced by neutron-rich radioactive ^{132}Sn

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Abstract. Evaporation residue cross-sections measured with short-lived ^{132}Sn on ^{64}Ni at energies near and below the Coulomb barrier were found to be enhanced as compared to those measured with stable Sn isotopes on ^{64}Ni. Subsequent measurements of fission following fusion of ^{132}Sn with ^{64}Ni and extending the measurement of evaporation residues to higher energies were carried out.

PACS. 25.60.-t Reactions induced by unstable nuclei – 25.60.Pj Fusion reactions – 25.70.-z Low and intermediate energy heavy-ion reactions – 25.70.Jj Fusion and fusion-fission reactions

1 Introduction

Study of fusion induced by radioactive nuclei is a topic of current interest [1]. We have measured evaporation residue cross-sections using neutron-rich radioactive ^{132}Sn beams incident on a ^{64}Ni target in the vicinity of the Coulomb barrier. This is the first experiment using accelerated ^{132}Sn beams to study nuclear reaction mechanisms. The average beam intensity was 2×10^4 particles per second and the smallest cross-section measured was less than 5 mb. A large sub-barrier fusion enhancement was observed compared to evaporation residue cross-sections for ^{64}Ni on stable even Sn isotopes [2]. The enhancement cannot be accounted for by a simple barrier shift due to the change in nuclear sizes [3]. Coupled-channels calculations including inelastic excitation and neutron transfer with input parameters obtained from stable Sn and Ni reactions underpredicted the measured cross-sections at low energies where the evaporation residue cross-sections were taken as fusion cross-sections [4].

In the previous measurement, the compound nucleus decays by particle evaporation at energies below the barrier. At energies near the barrier fission starts to compete with particle evaporation. In order to study fusion it is important to measure fission cross-sections.

2 Experimental method

The measurement was carried out at the Holifield Radioactive Ion Beam Facility at the Oak Ridge National Laboratory. The secondary ^{132}Sn was produced by the ISOL technique and accelerated to energies from 530 to 620 MeV to bombard a ^{64}Ni target. The evaporation residues were detected in the apparatus described in ref. [5]. The fission fragments were detected in a large area annular Si strip detector. The detector has 48 annular strips and 16 radial sectors which cover an angular range of 15° to 40°. Figure 1 presents the setup of the measurement.

3 Data reduction

The procedures for obtaining the evaporation residue cross-sections are described in ref. [3,5]. The fission fragments were identified by requiring a coincidence hit on the Si strip detector and from the kinematics. Figure 2 displays the calculated energy as a function of scattering

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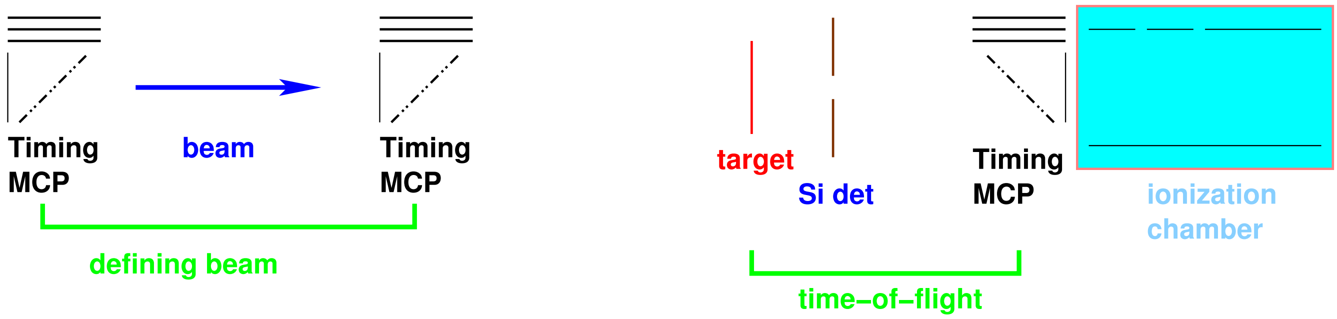

Fig. 1. Apparatus for measuring evaporation residues and fission fragments (not drawn in scale).

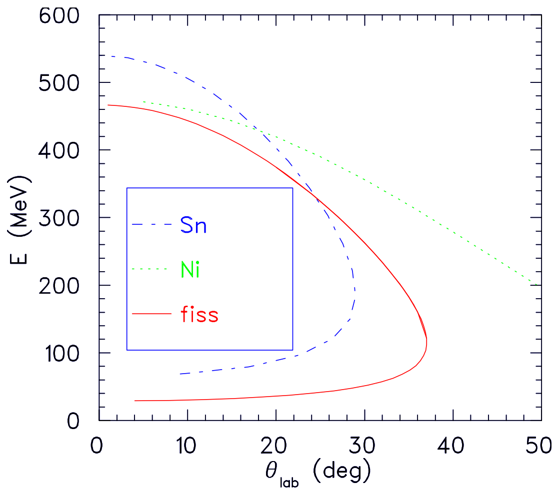

Fig. 2. Calculated particle energy as a function of angle in 560 MeV ^{132}Sn on ^{64}Ni. The elastically scattered Sn and Ni are shown by dashed and dotted curves, respectively, and the fission fragments are shown by the solid curve.

angle for fission fragments and elastically scattered particles. This can be compared with the coincidence data taken by the strip detector at 560 MeV as shown in the bottom panel of fig. 3. The top panel of fig. 3 presents results of Monte Carlo simulations for coincident events in the strip detector from the same reaction. The fission fragments are located in the marked regions and the elastically scattered Ni and Sn events are shown by the labels. As can be seen, the fission fragments can be distinguished from particles originated from other reactions. Detailed analysis of the data is underway.

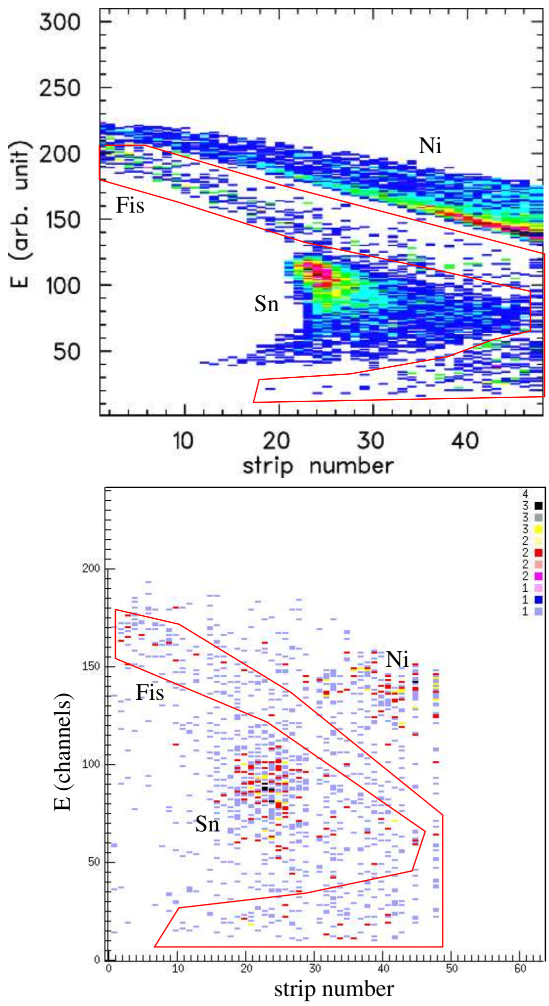

Fig. 3. Top panel: results of Monte Carlo simulation for particles from 560 MeV ^{132}Sn on ^{64}Ni detected in coincidence in the strip detector. Bottom panel: coincidence data from the same reaction measured by the strip detector. The fission fragments are shown in the marked area.

References

1. W. Loveland, these proceedings.
2. W.S. Freeman *et al.*, Phys. Rev. Lett. **50**, 1563 (1983).
3. J.F. Liang *et al.*, Phys. Rev. Lett. **91**, 152701 (2003).
4. J.F. Liang *et al.*, Prog. Theor. Phys. Supp. **154**, 106 (2004).
5. D. Shapira *et al.*, these proceedings.