Fission fragment mass distribution in thermal neutron induced fission of ^{235}U

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Introduction

Nuclear fission is a complex process that involves large scale collective rearrangement of nuclear matter in a short time scale. The excited fission fragments emit prompt neutrons and γ-rays which carry information on their structural properties as well as the dynamics of the fission process. The understanding of the dynamical aspects of the fission process requires a detailed information of various experimental observables measured with improved experimental techniques. The fission fragment mass and charge distributions are decided during saddle to scission transition and are related to the scission configuration, providing valuable information on the dynamical evolution of the shape of the fissioning nucleus. The shape of the fissioning nucleus evolves in the multidimensional space of relative separation, neck opening, mass asymmetry, and deformation of the fragments. Various theoretical models have been put forward to describe the complex shape evolution of deformed nuclei [1]. In heavy-ion induced fission, the fragment mass distribution have a strong influence of the nuclear shell closures of the fragment nuclei [2] even at high excitation energy of the fissioning compound nucleus. Recently, we have reported the results on the fission fragment yields from thermal neutron induced fission of ^{235}U in CIRUS reactor facility, BARC [3]. For low excitation fission, the asymmetric mass distribution of the fission fragments have been well known for long time and more precise measurement will enrich nuclear data to understand the nuclear fission process.

The prompt γ-γ coincidence technique provides fission fragment mass identification uniquely. Here we report the results on the mass distribution measurement from the ^{235}U(n$_{th}$, f) reaction performed at the EXILL campaign [4] at ILL, Grenoble, employing the above-mentioned technique.

Experimental Details

The experiment was performed at the PF1B line of the high-flux reactor facility at the Institut Laue-Langevin (ILL), Grenoble, France. UO_2 with a thickness of $\sim$600 μg/cm^2 and 99.7% ^{235}U enrichment was taken as target. This target was bombarded with a collimated neutron beam flux of the order of 10^8 n. s^{-1} cm^{-2} for the production of fission fragment nuclei. The produced fission fragment nuclei were stopped in a thick backing. An efficient array of Ge detectors which comprised of eight EXOGAM large clovers, six single-crystal coaxial Ge detectors from GASP and two clover detectors from ILL was used in the measurement. The EXOGAM and GASP detectors were mounted with their anti-compton shields. The eight EXOGAM clovers were mounted in

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a 90° ring around the target position. The other detectors were positioned in the two rings with angles of 45° and 135°. The photopeak efficiency of the full-array was about 6%. A trigger-less digital data acquisition system based on 14 bit 100 MHz CAEN digitizers were used.

Result and Discussion

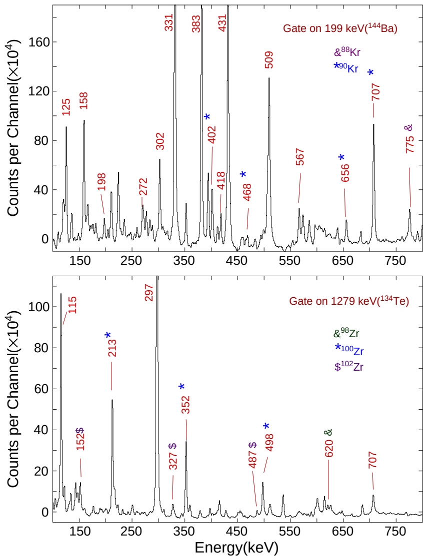

FIG. 1: Representative gated spectra of ^{144}Ba and ^{134}Te. The known strong transitions of these nuclei and their complementary fragments are labeled.

In the Fig. 1, representative spectra of ^{144}Ba (upper panel) and ^{134}Te (lower panel) are shown with gate on $4^+ \rightarrow 2^+$ transition. Several γ transitions corresponding to ^{144}Ba, ^{134}Te and their complementary fragments are clearly visible in the spectra in Fig. 1. A large number of fission fragment nuclei were identified in the data and the relative isotopic yield distribution of the even-even isotopes of complementry fragment pairs *viz.*, (Ru-Cd), (Mo-Sn), (Zr-Te), (Xe-Sr), (Kr-Ba) and (Se-Ce) have been obtained. The fission fragment mass distribution has been obtained by adding the isotopic yields of a particular mass as shown in Fig. 2. It is evident from Fig. 2

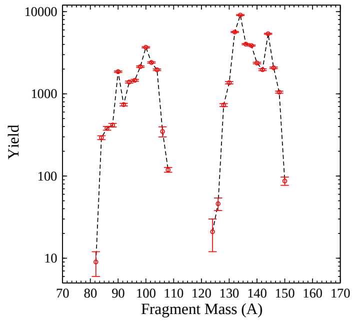

FIG. 2: Fission fragment mass distribution as observed in ^{235}U(n_{th}, f) reaction.

that the light fragment mass region extends from A=80 to A=110, whereas the heavy fragments are produced from A=125 to A=155. It is observed that there is a reduction of fission yield around A=140 and also at the complementary region around A=94. The reduction of the yield may be due to the inhibition of the nuclear shape around the neutron shell closure (N=82) similar to the earlier observation in nuclear fission at high excitation energy [2]. In the present work, coincidence rates of ^{90}Kr, ^{96}Sr, ^{100}Zr, ^{134}Te, ^{138}Xe and ^{144}Ba nuclei with their complementary fragment nuclei have also been measured. Results in detail will be presented during the symposium.

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