# Delving deep into the multi-faceted fission modes through fission fragment spectroscopy

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## Introduction

Nuclear fission is the process in which a heavy compound nucleus splits into two smaller primary fission fragments. During this splitting, the heavy nucleus has to overcome the fission barrier that develops in the Potential Energy Surface (PES) of the fissioning system due to the constant increase in elongation. This fission barrier of the system is found to be dependent on the various modes of fission. According to the Liquid Drop Model (LDM), the two smaller fission fragments produced after the rupture must be of equal size. But for heavy nucleus in the region of actinides, this split has been found to result in the production of two unequal size of fragments at low excitation energy [1]. This asymmetric division has been explained on the basis of influence of shell closure among the produced fission fragments [2]. In this mass region, the multichance fission also found to play a crucial role in enhancing the asymmetric mode of fission. Since this complex process involves large scale collective rearrangement of nuclear matter in a time scale of the order of $10^{20-22}$ seconds, development of a complete theoretical model of fission is still a gruelling challenge for the researchers.

Here we report the results obtained from the reaction, $^{232}$Th($\alpha$,f) that has been investigated using prompt $\gamma - \gamma$ coincidence measurement. This reaction of $\alpha$ induced fission of $^{232}$Th has already been studied using the radio-chemical analysis, and Time-of-Flight (TOF) measurement techniques. However, due to limitations of these techniques, a detailed yield distribution profile for this system is not available in the literature. Thus a detail investigation of secondary fission fragment yield distribution has been performed using prompt gamma spectroscopy. It is worth to mention that this system is an ideal surrogate reaction to that of the direct reaction of neutron induced fission of $^{235}$U. Hence, the data obtained from the present work will not only provide substantial inputs for the development of next generation Accelerator Driven Subcritical (ADS) reactors, but will also be beneficial for the development of fission models.

## Results and discussion

The relative isotopic yield distribution for nine pairs of complementary fission fragments

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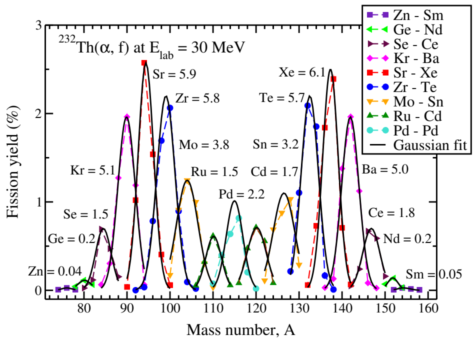


FIG. 1: Measured isotopic yield distribution for nine pairs of even-even fission fragments as obtained from the present work.

have been measured using prompt $\gamma$ spectroscopy technique [3]. The measured yields have been corrected for the contributions from the accompanying internal conversion and precursors beta decay process, following the prescription as given in Ref [4]. Since the present work has been primarily focused on even-even fragments, the raw yields are converted into fission yield (%) by using a scaling factor which makes the sum yields of all the light fragments and heavy fragments equal to 25% for each group. The obtained fission yield (%) distribution fitted with a Gaussian function (solid black line) has been shown in Fig. 1.

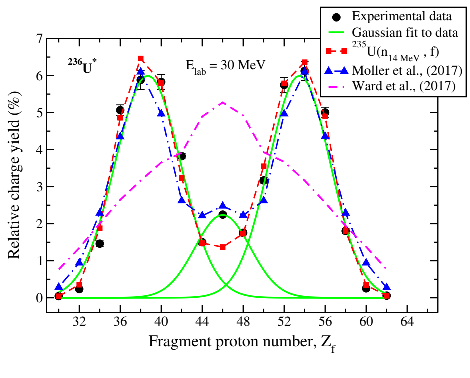


FIG. 2: Relative charge yield distribution (in %) of the even-Z, even-N fission fragments obtained from the present investigation.

The measured fission yield (%) distribution are further utilized to extract the relaive charge distribution. The charge distribution has been fitted with three Gaussian functions to extract the yields of different fission mode components. The two extreme peaks are produced from the asymmetric mode of fission, and the central third peak is due to symmetric mode of fission. In addition, the experimental yield distribution has been compared with two recent theoretical results on the same system at comparable excitation energy [5, 6]. Although both the calculations have considered shell effect, but only Moller *et al.*[6] have incorporated the effect of multichance fission. The comparison between the experimental and theoretical results provide clear evidences for competing influences of both shell effect and multichance fission on the concerned system at an $E_{ex} = 21.5$ MeV. Detailed results [7] on all these aforesaid aspects will be presented during the symposium.

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