Measurement of mass and TKE dependent prompt fission γ-rays in ^{6}Li + ^{232}Th reaction

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Introduction

Understanding of Prompt Fission Gamma spectra (PFGS) and its multiplicity distribution is critical for the development of advanced GEN-IV nuclear fission reactors, Fusion reactors. It is also important for the shielding design and decay heat estimation. The contribution of gamma rays in total heat generation in a non-fuel region of a thermal reactor can be upto 90%. Generally, the PFGS is observed to extend beyond 10 MeV, where the high energy part is useful for the detection of special nuclear materials[1]. Recently, the study of PFGS has also shown to be important for understanding of the fusion-fission dynamics relevant to synthesis of super heavy nuclei [2]. Moreover, studies of the properties of the PFGS are important to improve models involving nuclear fission and compound nuclear evaporation. Therefore, in this scenario, the prompt fission gamma ray along with mass and total kinetic energy (TKE) distributions of fission fragments in the ^{6}Li + ^{232}Th reaction have been measured in the present work. Also, dependency of PFGS on mass and TKE of fission fragments, if any, have been investigated.

Experimental Details

The measurement has been carried out using ^{6}Li pulsed beam (E_{beam} =40 MeV) obtained from the BARC-TIFR Pelletron Linac Facility, Mumbai, bombarding on ^{232}Th target having thickness ≈400 μg/cm^2. As shown in Fig. 1, both the fission fragments are detected using two position-sensitive multi-wired proportional counters (MWPCs) having active area of 12.5 cm × 7.5 cm [3], placed at +50 ° and -120 ° angles, at a distance of 28 cm from the target centre. To measure the prompt fission gamma rays, two LaBr3(Ce) detectors having 4 inches diameter are mounted inside the thin stainless steel cups placed at angles 120 ° and 150 °. The distance of each LaBr3 detector from the target centre was 69 cm and 16.5 cm respectively. One monitor detector was also used for the measurement of the beam flux. The position calibrations of the MWPC detectors were performed using a mask of known dimensions, whereas time calibration was performed using a time calibrator module. The energy calibrations of LaBr3 detectors were performed using stan-

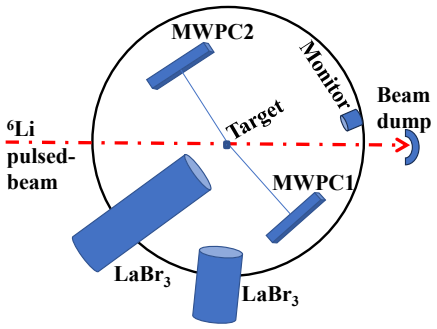

FIG. 1: Schematic diagram of the set up.

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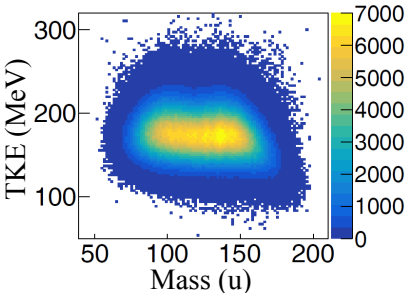

FIG. 2: Experimental mass-TKE correlation plot.

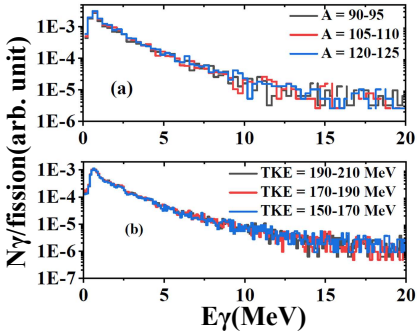

FIG. 3: PFGS for different FFs mass and TKE bins.

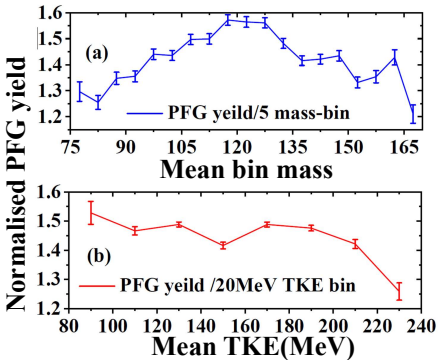

FIG. 4: PFG yield for different FFs mass and TKE bins.

dard gamma sources. The master gate of the VME based data acquisition system was generated with 'OR' of two anode signals after filtering with RF signal. The LaBr3 detectors are kept in 'SLAVE' mode, however its timing spectra were recorded using a TDC. A sharp peak (FWHM = 8ns) in the above TDC spectra have been observed (not shown here) and used as a gate to obtain the PFGS.

Results and Discussions

Following the analysis method given in Ref.[4], the masses and kinetic energies of the fragments have been determined on event by event basis. The correlation plot of the preliminary mass and TKE distributions have been shown in Fig.2, which is nearly consistent with the ones shown in Ref.[5] for the same system. Now the PFGS (efficiency uncorrected) obtained from $LaBr_3$1 detector have been shown for different mass and TKE gates. Typical normalized gamma ray spectra for three different mass cuts (A=90-95,105-110, 120-125) and for three different TKE cuts (TKE=140-160,160-180,180-200) are shown in Fig.3 (a) and (b) respectively. It is interesting to observe that the shape of PFGS extending upto ≈20 MeV look almost similar for all the applied mass and TKE cuts.

Further, corresponding to a specific mass/TKE cuts, the ratio of detected prompt gamma rays detected in $LaBr_3$1 to total fission counts detected in the fission detectors has been obtained and displayed in fig. 4. It is very interesting to observe that the ratio is found to be maximum for symmetric mass split (see Fig. 4(a)), whereas a weak decreasing trend of the ratio with the increasing TKE has been observed (see Fig. 4(b)). Further investigation is in progress.

Acknowledgments

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