

γ -ray spectroscopy of fission fragments from the cold-neutron ^{235}U induced fission with EXILL

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Abstract. A cold neutron induced fission experiment recently took place at the Institute Laue-Langevin (ILL) in Grenoble. The neutron beam was provided by the nuclear reactor facility at ILL and the detector setup that was used for the γ -spectroscopy of the fission products consisted mainly of the detectors of the EXOGAM array [1], thereby the name of the campaign is EXILL. The main purpose of our measurement was to investigate the nuclei in the region with $N = 50$ close to ^{78}Ni as well as the nuclei close to the $N = 82$ shell closure. In this paper, the motivation of the experiment is described as well as the experimental setup and the status of the ongoing data analysis.

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1. Motivation

Although the magic numbers have been well established for stable nuclei, the question still remains for nuclei far from stability. Particularly in question is the $N = 50$ neutron gap at $Z = 28$ since there are controversial evidences for either the support of the doubly magic nature of ^{78}Ni [2] or its weakening for nuclei beyond $N = 50$ [3]. The γ -ray spectroscopy of nuclei in the vicinity of ^{78}Ni could shed some light to this ambiguity by providing matrix elements involved in the residual proton-neutron interactions. Also of interest are the nuclei around the $N = 82$ shell closure. Through the experimental study of their metastable states, the intensity of the pairing correlations and the residual interactions in states of different seniority can be estimated by comparison to theoretical calculations.

2. Experimental setup

The cold-neutron ^{235}U induced fission mechanism can yield enough statistics for nuclei in both regions of interest mentioned above. For that purpose, such an experiment was performed at ILL using the EXOGAM array at the PF1B line of the laboratory.

The neutron beam is produced by the nuclear reactor of the Institut Laue-Langevin with an intensity of 10^8 n/s/cm^2 . After being well collimated, it impinges on a $\sim 600 \mu\text{g/cm}^2$ UO_2 target enriched by 99.7% in ^{235}U . The targets were put between dense backings in order to stop the fission fragments thus avoiding the Doppler shift of the peaks. Around the target an array of 16 HPGe detectors is placed consisting of ten four-segmented detectors (clovers) and six single crystal ones. Eight of the clovers and all the single crystal ones were surrounded by BGO crystals for Compton suppression. The detectors were arranged in three rings at 45° , 90° and 135° (see Fig.1). With $\sim 10^5$ fissions/s and 23 days of measurement enough statistics were acquired in order to construct the γ - γ -coincidence cube needed to analyze fission data.

3. Ongoing data analysis

The raw data are sorted using the “Ist2root” code provided by ILL through which the events are built each of which has a certain multiplicity of γ -rays which is dependent on the coincident time window set

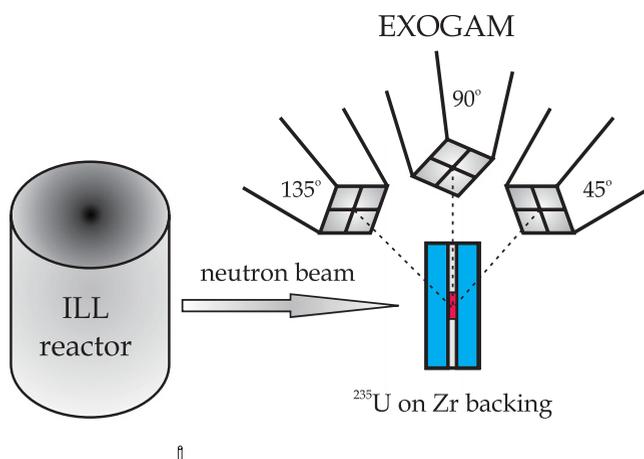


Figure 1. The experimental setup used for the experiment. The neutron beam coming from the reactor, is well collimated and it impinges on the ^{235}U thus causing the fission. With an array of 16 detectors the γ -rays of the fission products are detected.

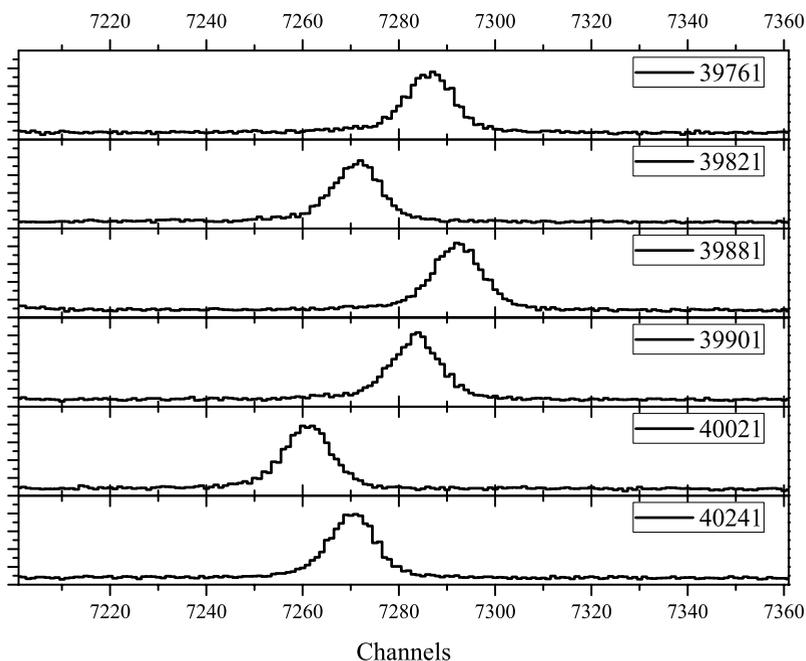


Figure 2. Due to the continuous gainshift of some of the detectors a thorough calibration procedure is necessary.

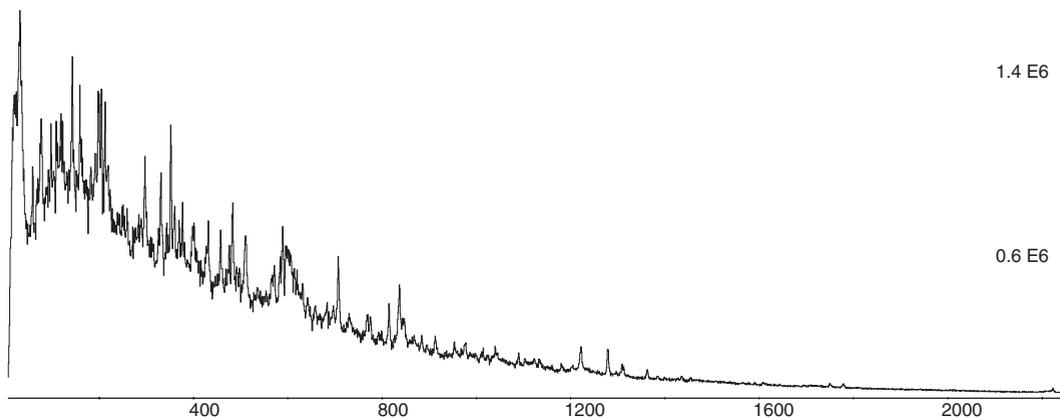


Figure 3. A total projection of a γ - γ - γ -coincidence cube from the ^{235}U fission data.

by the user. Within ROOT the energy calibration and the addback correction for the clover detectors is performed.

Special attention must be given to the energy calibration as it will strongly affect the energy resolution of the cube. A test was performed to check whether it would be better to use a quadratic calibration but it proved that this is not necessary up to ~ 3 MeV at least.

Also, a significant and continuous gainshift was observed for some of the detectors (see Fig. 2), therefore separate calibration parameters were extracted for each run. After the energy calibration and the addback correction a γ - γ - γ -coincidence cube was created for part of the data in the projection of which peaks of known fission products have already been identified (see Fig. 3). The analysis is ongoing.

References

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