Photofission of ^{232}Th and ^{238}U with Bremsstrahlung Photons below 20 MeV: Measurements and Model Predictions of Delayed Neutron Yields and Spectra

D. Ridikas[1*], J-C. David[1], D. Doré[1], M-L. Giacri[1], J-M. Laborie[2], X. Ledoux[2], A. Van Lauwe[1]

1) DSM/DAPNIA/SPhN, CEA/Saclay, 91191 Gif-sur-Yvette, France

2) DAM/DPTA/SPN, CEA/DIF, 91680 Bruyères-le-Châtel, France

Recently a particular attention is paid to the non-destructive characterization of waste containers and detection of nuclear materials, both based on photo-fission process and the associated delayed neutron (DN) emission. Indeed, interrogation by photons with energies above ~6 MeV can be used to localize small amount of fissile nuclei inside various surrounding materials, where the measurement of DNs emitted by fission products brings unique information for their quantification. Good quality DN time spectra also could be used for isotopic identification of actinides present in the waste barrels or cargo containers.

Unfortunately, available DN data from photo-fission are scarce, incomplete and in some cases even contradictory. Therefore, a new experimental program has been undertaken in order to provide the good quality photofission DN data being the essential information for the above applications (including the need of DN data for the evaluated nuclear data files (ENDF)) in the energy range of the endpoint Bremsstrahlung photons from 6 MeV to 19 MeV, i.e. covering the entire Giant Dipole Resonance (GDR) region. The experiments were performed using the ELSA electron accelerator at CEA/DAM of Bruyères-le-Châtel (France).

In this paper the experimental photo-fission DN yields for ^{238}U and ^{232}Th are presented. For both of these nuclei at 12 and 15 MeV our experimental DN values have improved the accuracy obtained previously nearly by a factor of two. In addition, our measurements were extended to higher energies (up to 18 MeV), where no DN data existed at all. These new results allowed us to examine in more detail the 2nd chance fission and its influence for the total delayed neutron yield as a function of excitation energy. As long as the DN 6-group parameters are concerned, our results permitted us to clarify the situation for the 4th and 6th group constants in particular compared to the contradictory old data. Finally, the DN decay curve measurements performed with the "mixed" ^{238}U and ^{232}Th sample has proven that the isotopic separation of actinides is possible if good quality single isotope data is available.

In parallel to the experimental program, systematic calculations were performed with the GSI fission-evaporation code ABLA+PROFI in order to compare with experimental mass distributions of photo-fission fragments and newly measured DN data. We show that the DN parameters for ^{238}U are well reproduced by the code predictions, while for ^{232}Th some model improvements are still necessary.

Our efforts both in experimental and theoretical work will continue in the near future with the major goal to provide the ENDF data files with consistent photo-fission DN data for strategically important actinides as ^{235}U and ^{239}Pu in addition to ^{238}U and ^{232}Th to be presented in this paper.

* E-mail: ridikas@cea.fr