Experimental report

18/12/2019

Proposal: 3-07-385 **Council:** 10/2018

Title: Absolute yield and kinetic parameters of delayed neutrons from the neutron-induced fission of Pu-239

Research area: Nuclear and Particle Physics

This proposal is a continuation of 3-07-380

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Instrument	Requested days	Allocated days	From	To
PF1B	18	14	20/06/2019	28/06/2019
			28/06/2019	01/07/2019

Abstract:

There is currently a strong request, supported by IAEA/Coordinated Research Program, to provide new high quality data of delayed neutron (DN) yield and group constants for nuclear reactor and criticality/safety applications, as well as to validate fission models with calculations like FIFRELIN or GEF.

In this proposal, the PF1B instrument is requested to deliver a collimated cold neutron beam to an active target of Pu-239 enclosed in a flat miniature fission chamber. The latter is surrounded by a neutron long counter. A fast shutter (<10ms) will be placed prior to this device, in order to drive repeated cycles of irradation and decay phases. The DN emission will be recorded as well the prompt neutron emission, in parallel with the monitoring of the fission events from the target.

This proposal is focused on irradiating a new Pu-239 miniature fission chamber. in addition, a U-235 detector will also be irradiated in the same setup for comparison with results obtained in experiment 3-07-380.

This proposal is part of a PhD work by D. Foligno (2016-2019). A financial support was obtained by EDF and FRAMATOME, as well as from the NEEDS/NACRE collaborative program hosted by CNRS.

Experiment 3-07-385 (20/06 – 28/06): Preliminary Report

Context

The ALDEN (Average Lifetime of DElayed Neutrons) project aims at providing measurements of the decay of delayed neutron (DN) precursors induced by thermal fission of major actinides. The project, partly funded by the "Defi NEEDS", is organized within a large collaboration (CEA/DEN, CEA/DRF, IRSN, CNRS/LPSC, CNRS/CENBG, CNRS/LPC Caen and Caen University).

This experiment is a follow up of Experiment 3-07-380, during which the experimental setup (LOENIEv2) was tested and optimized. It is based on 16 He^3 proportional counters arranged in a polyethylene matrix, in such a manner that the detector efficiency is nearly flat on DN energy range (0.1 – 1 MeV). Background noise from scattered neutrons is reduced as low as possible thanks to adequate boreflex shielding. The central cavity accommodates a vacuum container in which a fission chamber containing the target material can be placed and connected to a BNC feedthrough. A fast beam shutter (FS) allow controlling the irradiation time: it is a rotating device, motioned by a brushless motor, with two vertical B4C/Cd screens.

The experimental program was initially to irradiate a plutonium target, as well as acquire additional measurements with a uranium target (the same as the one used in September 2018). Finally, it was only possible to irradiate the uranium target. For that reason, the vacuum container was used in fact used at standard pressure.

Experimental campaign

The experiments were conducted as follows:

1. from 18/06 to 20/06: LOENIEv2 outside of the irradiation area, tests and setting up of the acquisition system using a neutron source,
2. from 20/06 to 22/06: setting up in the irradiation area of PF1B, irradiation of a Gd film for checking the beam position on the target, estimation of dead time correction,
3. from 22/06 to 27/06: experiments on dead time corrections (by changing gradually the FS position), dosimetry using gold foil, irradiation of the uranium target with various settings of irradiation vs. decay time,
4. from 27/06 to 28/06: test of fission chamber energy spectrum for fission rate calibration purposes, additional dead time tests for various discrimination thresholds.
5. from 28/06 to 01/07 : irradiation of the factice target for background estimation.

It was intended to use a digital pulser in order to monitor and correct the dead time, but we were unable to correctly add the pulser signal to the one of a He3 tube without altering it dramatically. So, the option was abandoned and instead additional dead time tests were performed (by changing the flux intensity and assessing the linearity of the counting rate)

Preliminary results

Several DN decay curves are displayed on Figure 2, which were obtained for various irradiation settings (5s, 15s, 50s and 100s of irradiation time). The curves are yet to be analyzed by applying to each the same analytical model but with parameters adapted to the case. The CEA-developped CONRAD fitting software will be used for that purpose.

A specific experiment, with very short decay time (0.5s) was used to estimate the delayed neutron multiplicity. By using calculated calibration coefficients for delayed and prompt neutrons (same values as used for the first experimental campaign), the delayed neutron multiplicity is: ν_d = 1.638% ± 0.011%. This is in perfect agreement with the previous value of 1.631% ± 0.02% as well as the recommended value issued by OECD/NEA.

Preliminary conclusions: The early results of the experimental campaign show that the data quality is very satisfactory. The experiment schedule was followed and it has been possible to acquire several types of DN decay curves. This will allow an optimal estimation of the DN parameters of ^{235}U.

The estimation of the DN multiplicity confirms the value obtained by the first experiment, with a final uncertainty improved by a factor of two.

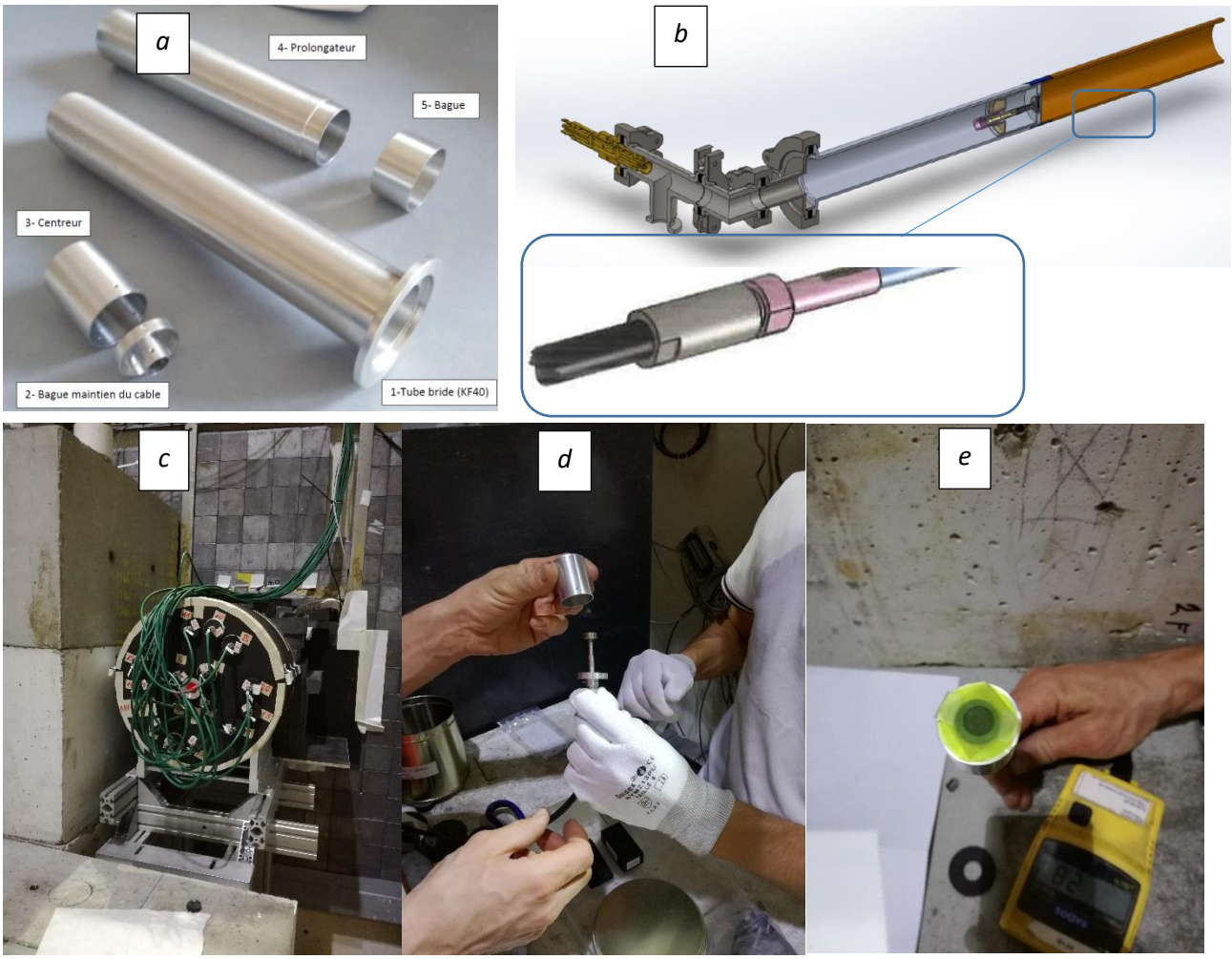

Figure 1 : Parts of the aluminum fixture (a); Drawing on the setup showing the target mounted (b); LOENIEv2 device installed in the irradiation area (c); fission chamber connected to the coxial cable (d); test irradiation to check the neutron beam (e).

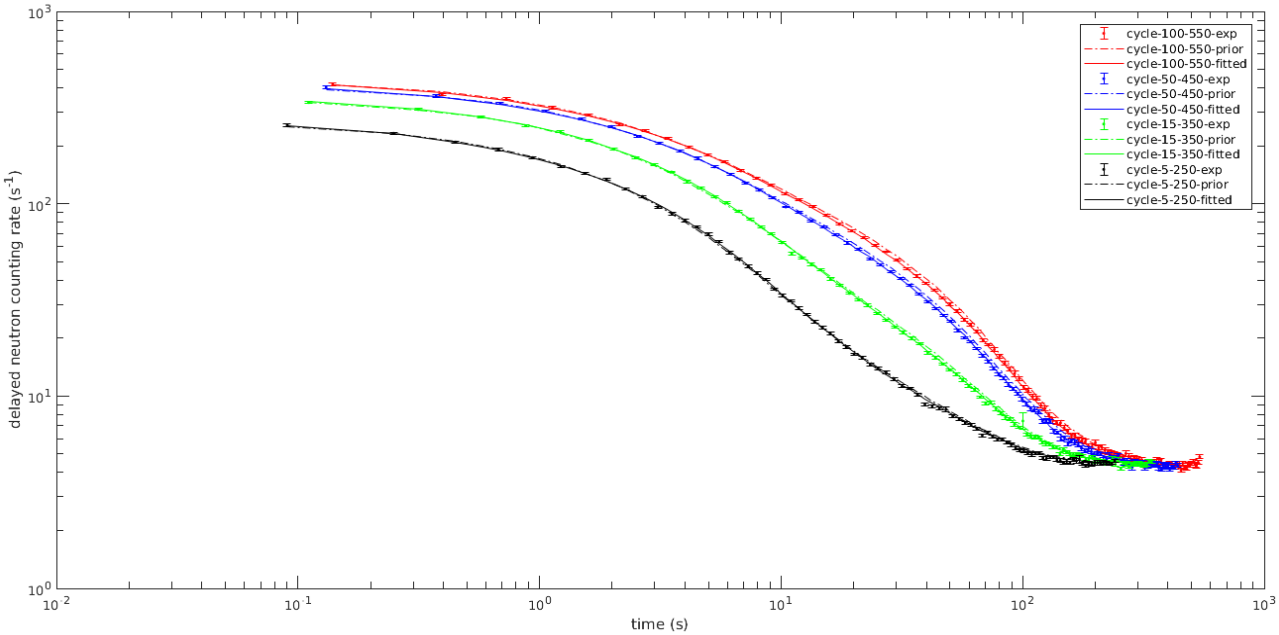

Figure 2 : Experiments (dots + error bars) and fitted curves (solid and dotted lines) obtained for several irradiation parameters (5/150s, 15/250s, 50s/450s, 100s/550s)