Experimental report

25/01/2024

Proposal:	**3-01-708**	**Council:**	10/2022

Title: Measurement of 153Eu cumulative yield from 239Pu(nth,f) with the LOHENGRIN spectrometer

Research area: Nuclear and Particle Physics

This proposal is a new proposal

Main proposer: **David BERNARD**

Experimental team:
Abdelhazize CHEBBOUBI
Gregoire KESSEDJIAN
David BERNARD
Adrien VIEVILLE
Olivier GUILLAUDIN
Olivier MEPLAN
Mourad RAMDHANE
Christophe SAGE

Local contacts:
Ulli KOESTER
Jean Michel DAUGAS

Samples:

Instrument	Requested days	Allocated days	From	To
PN1	7	7	06/11/2023	13/11/2023

Abstract:

The nuclear industry has to provide accurate reactor physics calculations to provide safety margins for cycle follow-up. It was shown that the LWRs critical letdown boron curves are not enough accurately calculated: their interpretation showed a slight over prediction of the reactivity loss versus burnup by using JEFF-3.1.1 evaluation files leading to a shorter cycle length with calculations compare to available measurements.
Recent evaluations files (JEFF-3.3) showed a worth performance partly due to the huge increase of the 153Eu cumulative fission yield from 239Pu+nth.

Experimental report on: Measurement of ^{153}Eu cumulative yield from ^{239}Pu(n_{th},f) with the LOHENGRIN spectrometer (3-01-708)

The purpose of this work was to measure the A = 153 mass yield for the ^{239}Pu(n_{th},f) reaction. This mass is of particular interest for nuclear industry applications. Indeed, the current nuclear data evaluations predict a shorter time before reloading the fuel in commercial light water reactor, in comparison with available measurements. This is likely related to the build-up of neutron poisons, e.g. ^{153}Sm and its daughter nuclide ^{153}Eu. Hence, the accurate fission yield of this mass has an important impact on this calculation.

In November 2023, during one week we have used a ^{239}Pu target of 53 μg/cm^2 thickness covered by 0.25 μm Ni foil. Prior to the experiment, we have conducted different tests in order to study the stability of the regulation of the main magnet of the LOHENGRIN spectrometer (see report 3-01-705). The conclusion was to make two consecutive measurements for the same setting. This solution allowed to identify the abnormal points, but did not drastically improve the reproducibility of the spectrometer settings. In addition, the frequent variation of the reactor power implied new challenges that should be taken into account in the analysis. Figure 1 shows the variation of the target burnup as a function of time, along the variation of the reactor power.

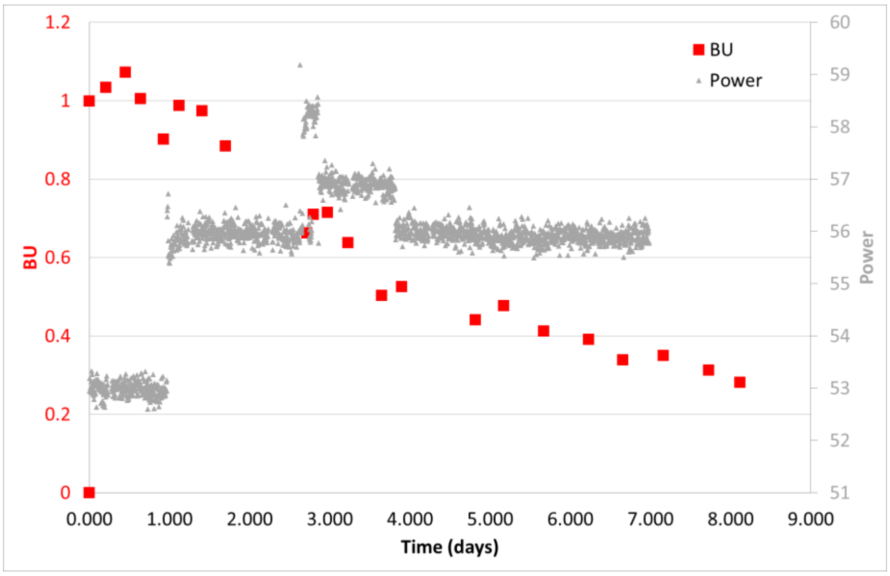

Figure 1: Target evolution for the November 2023 campaign.

After few days, the power supply of the main magnet had a breakdown and was replaced by a backup supply. Now, the stability of the spectrometer was improved, however the connection between NOMAD (which controls the instrument settings) and the power supply was often lost and, after detection of the problem, had each time to be reset manually. Finally, while the target quality was excellent at the beginning, it degraded after few days as can be seen on figure 2.

Nevertheless, even if such conditions were not compatible to provide mass yield measurements with an accuracy of about 1%, we may have enough precision (about 5%) to disentangle the different nuclear data library and provide the first measurement of the ^{153}Eu cumulative yield. More than 2400 files were recorded in order to measure the mass yield of mass A=153 with respect to reference masses A=133, 134, 135, 136, 137, 138 and 148.

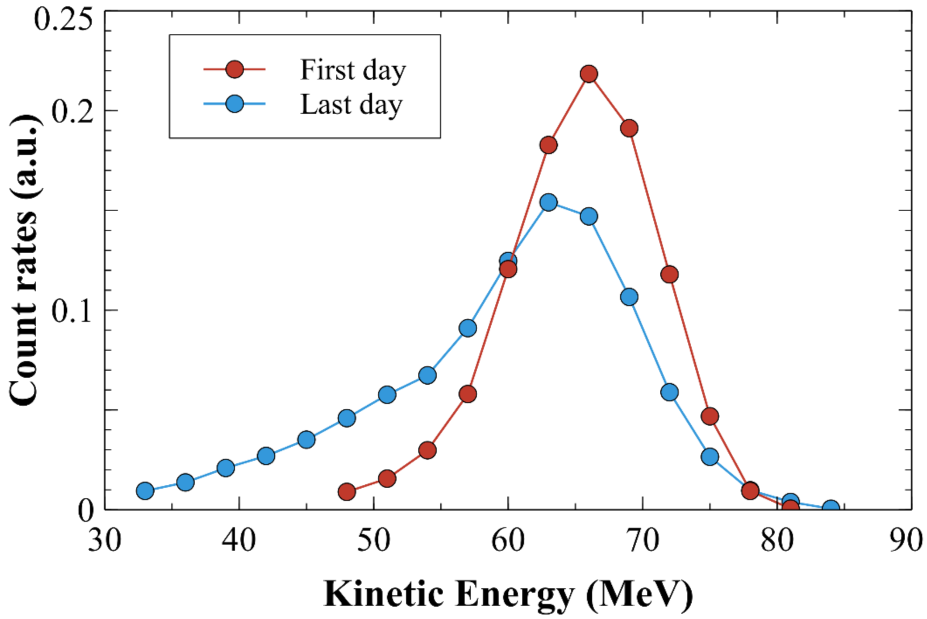

Figure 2: Evolution of the kinetic energy distribution of the triplet A/q/E = 137/21/E between the first day and the last day of the experiment.