Half Life of ^{101}Mo and ^{101}Tc β^--decay

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Abstract. In this work, the half-life of the ^{155}Sm β^- decay was determined using enriched ^{154}Sm samples submitted *to* irradiation in the IEA-R1 reactor of IPEN; the activity of the samples were followed for 4-5 consecutive half lives using a 198cm^3 HPGe detector. The data was corrected using a non paralizable dead time correction and fitted to an exponential decay function using a non linear fitting procedure developed on the MatLab platform. The resulting value - $T_{1/2}$=22.180(26) min - was compatible to the one found in the literature, with a lower uncertainty.

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INTRODUCTION

The half-lives of some nuclides are of high importance, especially for calculations regarding the nuclear fallout in nuclear accidents. Rare-earth elements, like Eu and Ce, in the form of oxides dissolved in irradiated nuclear fuel are non-volatile and released with difficulty during an accident, making their isotopes important in the investigation of radioecologycal studies [1]. There are many codes to calculate these radioisotopes activities in nuclear reactors, but to make these inventories, all the feeding chain must be known. Particularly, ^{155}Eu is formed by direct fission process, neutron capture of ^{154}Eu and beta decay of ^{155}Sm. The last process has a short half life and the correct value is an important information for the activity calculation.

In this work, the half-life of the ^{155}Sm β^- decay was determined using gamma spectroscopy with a HPGe detector and neutron irradiated samples of enriched ^{154}Sm. The data was corrected before the fit by non paralizable dead time correction [2].

The resulting value was compatible to the one found in the literature, with a lower uncertainty.

EXPERIMENTAL PROCEDURE

In the present experiment, the ^{155}Sm radioactive source was produced by neutron irradiation in the pneumatic station of the IEA-R1 nuclear reactor under a thermal

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neutron flux of ~5x10^{12}cm^{-2}s^{-1}. For each source was used 5mg of enriched ^{154}Sm (the isotopic abundance is 22.8 %) and the irradiation lasted for 5 minutes. A total of 52 radioactive samples were produced.

The data was taken using a gamma ray spectrometer with a 60% HPGe detector with low background shield coupled to a conventional energy electronics (linear amplifier in inhibit mode with a 4096-channel MCA). Each sample was counted for approximately 90 minutes separate consecutive 7.5 minute acquisitions in order to allow for the decay analysis. A total of 52 sources were produced yielding 624 spectra with 7.5 minute each.

After the irradiation process, the ^{155}Sm sources were transported in less than 2 minutes to the acquisition system; at the end of each measurement day the background spectra was taken in the same way as the Sm spectra for a period of 1.5 hour.

DATA ANALYSIS

Transition choice

To determine the half life were chosen the two more intense transitions of ^{155}Eu from the ^{155}Sm beta decay, the 104.3 keV (Iγ=74.6%) and 245.7 keV (Iγ=3.7%)

The first transition is the most intense of the spectrum and therefore has secondary detection effects, mainly the step below the photopeak, that does not always permit an accurate determination of the photopeak are and the higher pile up effects in the beginning of the data acquisition when the sample is very active. Moreover, despite the transition from being close to 245 other photons provides much better results. The counts of these gamma-ray photopeaks were obtained by IdeFix gamma analysis software [3].

Fitting function

One of the goals of ^{155}Sm decay measurements was to get nuclear data on the gamma transitions, leading to irradiation conditions that were not optimized for the most intense peaks. As a consequence, the first spectra presented up to 12 % dead time and therefore, one had to include the non-paralizable dead time correction [2] in the exponential decay function, as presented in Eq. 1.

$$f(t) = A_1 e^{-\frac{\log(2).\lambda t}{A_2}} . \left[\frac{ e^{A_3\left(A_1 e^{-\frac{\log(2).\lambda t}{A_2}} \right)} }{ 1 + A_3\left(A_1 e^{-\frac{\log(2).\lambda t}{A_2}} \right) } \right] \qquad (1)$$

To check the correction, the final half-life value was obtained in two ways. In the first the weighted average of the 52 different values for the half-life (one for each source produced) was calculated; in the second, a single fit with data from all 52 sources was done fitting also a "coupling parameter" for each sample so that all samples behave as if they were the same sample. In Fig. 1, this fit is shown and the 52 sources are sequentially sorted as a single measurement but one can see the decay of each source. To fit the functions a covariant Gauss-Marquardt routine [4] implemented in MatLab® environment was used.

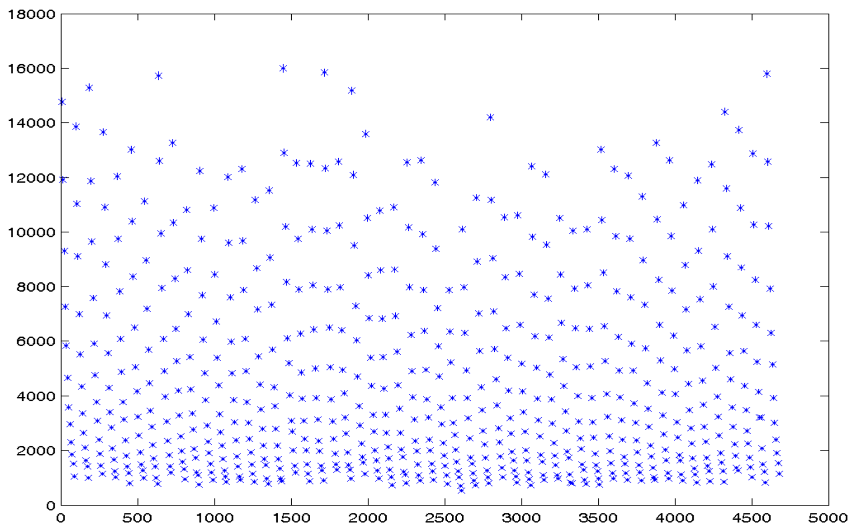

FIGURE 1. All sources in a single fit.

RESULTS

The weighted average of the 52 individual fits for ^{155}Sm resulted in 22.169 (26) min with χ^2=1.2, while the result of the single fit was 22.180(26) min; both values are compatible and with uncertainty significantly smaller than the tabulated result of 22.3 (2) minutes [5]. The non-paralizable dead time correction was not negligible and the single fit shown that the secondary effects were not relevant, yielding consistent results.

REFERENCES

1. P. Jaracz *et al*., *J. J. Environ. Radioactivity* , **26**, 83-97 (1995).
2. G. F. Knoll, *Radiation detection and Measurements*, John Wiley & Sons, New York, 2000, p.119-122.
3. P**.** Gouffon**,** *Manual do programa IdeFix*. (Instituto de Física da Universidade de São Paulo, Laboratório do Acelerador Linear, São Paulo, 1982.
4. P. R. Bevington, *Data Reduction and Error Analysis for the Physical Science*, McGraw-Hill New York, 1969, p. 237-239.
5 C. W. Reich, *Nucl. Data Sheets,* v.71, p.737-762, 1994.