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Use of Gamma Rays from the Decay of 13.8-sec ^{11}Be to Calibrate a Germanium Gamma Ray Detector for Measurements up to 8 MeV

Y. IKEDA¹, F. MAEKAWA¹, Y. UNO¹, Y. KASUGAI¹, K. KAWADE², D. SMITH³

¹ JAERI, Tokai, Japan, ² Nagoya University, Nagoya, Japan, ³ ANL, Argonne, USA

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Gamma rays from the β^- decay of 13.8-sec ^{11}Be can be used for Ge photon detector efficiency calibration at energies $> 2\text{-}3\text{ MeV}$ that are not accessible using more conventional gamma-ray sources. ^{11}Be is generated by the $^{11}\text{B}(\text{n},\text{p})^{11}\text{Be}$ reaction using a boron oxide sample and 14-MeV neutrons from a neutron generator. The short-lived activity is carried to the detector using a pneumatic transport system. This paper describes the experimental method used and provides an example of a Ge detector efficiency calibration curve augmented by this technique.

1 Introduction

Calibration procedures for Ge detectors are described in an ANSI standard [1] and various other literature sources (*e.g.*, refs. 2-3). Spectra are usually generated using radioactive sources (*e.g.*, ^{60}Co , ^{22}Na , ^{137}Cs , $^{152,154}\text{Eu}$) which emit gamma rays that have known intensities (either absolute or relative). Efficiencies are then deduced from the recorded full-energy-peak yields. For convenience these data can be fitted with smooth empirical or semi-empirical formulas (*e.g.*, ref. 4). However, using this approach it is difficult to obtain a calibration $> 2\text{-}3\text{ MeV}$ due to the scarcity of gamma-ray sources covering this energy range. Higher-energy gamma rays can be generated by (n,γ) or (p,γ) reactions (*e.g.*, refs. 5-6) using an accelerator or reactor neutron or proton radiation source. ^{11}Be is an attractive auxiliary calibration source if a neutron generator and rapid sample transport apparatus are available. It can be produced by the $^{11}\text{B}(\text{n},\text{p})^{11}\text{Be}$ reaction. The reaction Q value is -10.724 MeV and the cross section is 5.5 millibarn at 14 MeV [7]. ^{11}Be decays by β^- emission (100%) with a 13.8-sec half life, and the decay gamma branching is adequately known [8]. Gamma rays in the range 478-7975 keV are generated by this source (see Table 1). Although some of these gamma rays are relatively weak, it is still possible to obtain adequate yield in the full-energy-peak lines of a recorded spectrum by resorting to cyclic activation, *i.e.*, by repeatedly alternating irradiations and counts of a sample containing a boron compound. This paper describes the technique briefly, provides a diagram of the apparatus used in a demonstration experiment performed at the FNS accelerator facility, JAERI, Tokai, Japan, and shows a sample Ge detector efficiency calibration curve which was extended to higher energies by using gamma rays from ^{11}Be decay.

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Table 1: Gamma rays from the β^- decay of 13.8-sec ^{11}Be [8]

E_γ (keV)	I_γ (%) ^a	E_γ (keV)	I_γ (%) ^a	E_γ (keV)	I_γ (%) ^a
478	0.39 ₄	2895	0.081 ₃	5852	2.13 ₉
692	0.0344 ₁₁	4444	0.054 ₃	6790	4.48 ₂₂
1771	0.263 ₁₄	4666	1.82 ₅	7975	1.90 ₁₄
2124	35.5	5019	0.467 ₁₆		

^a The notation 0.39 ₄ indicates that 0.39 ± 0.04 out of 100 decays of ^{11}Be produce the 478-keV gamma ray. The systematic uncertainty for the gamma-ray yields per decay is 5.1%.

2 Experiment and data analysis

The experimental setup is shown in Fig. 1. A several-gram boron oxide (B_2O_3) sample was placed in a plastic capsule and carried by a pneumatic transport device to a position near the

Figure 1: Schematic diagram of the apparatus used in a demonstration experiment

target of the FNS D-T 14-MeV neutron generator for irradiation [9]. After ≈ 30 sec the sample was retrieved to a remote, shielded location and counted with a Ge detector for ≈ 30 sec. This procedure was repeated many times until adequate statistical precision was achieved. A Ge detector calibration < 2 MeV was generated first using several conventional radioactive sources [1]. Full-energy-peak counts for the ^{11}Be gamma rays were then divided by the relative intensities given in Table 1 and sum-coincidence corrections were applied. This yielded relative efficiencies from 500-8000 keV thus extending the original calibration curve to higher energies.

3 Results

A Ge detector efficiency curve generated by this approach is shown in Fig. 2. This result demonstrates that ^{11}Be is a worthy calibration source when it can be produced and used easily.

Figure 2: Efficiency calibration for a Ge detector, based in part on ^{11}Be decay gamma rays

References

- [1] ANSI Standard N42.14-1978 (Reaffirmed 1985), American National Standards Institute, Institute of Electrical and Electronics Engineers, 345 E. 47th St., New York, NY, USA.
- [2] B.P. Singh and H.C. Evans, *Nuclear Instruments and Methods* **97**, 475 (1971).
- [3] L.A. McNelles and J.L. Campbell, *Nuclear Instruments and Methods* **109**, 241 (1973).
- [4] P.W. Gray and A. Ahmad, *Nucl. Instr. and Meth. in Phys. Research* **A237**, 577 (1985).
- [5] M.L. Stelts and R.E. Chrien, *Nuclear Instruments and Methods* **155**, 253 (1978).
- [6] D.L. Smith, J.W. Meadows and J.F. Whalen, *Nucl. Sci. and Engineering* **77**, 256 (1981).
- [7] Evaluated Nuclear Data File, ENDF/B-VI, Brookhaven National Laboratory (1991).
- [8] E. Browne and R.B. Firestone, *Table of Radioactive Isotopes*, J. Wiley, New York (1985).
- [9] T. Nakamura et al., *Proc. 4th Symp. on Accel. Sci. and Technol.*, Riken, Japan (1982)