Identification of a Low-Energy Beta Emitter by HRGS

1 Introduction

Unknown beta source. Characterisation via high resolution gamma spectrometry (HRGS). MCNP calibration of HRGS measurement. Activity assessment for disposal.

2 Objectives

To identify an unknown low-energy beta source (Fig 1) and estimate the amount of activity present to allow disposal in-line with regulatory requirements.

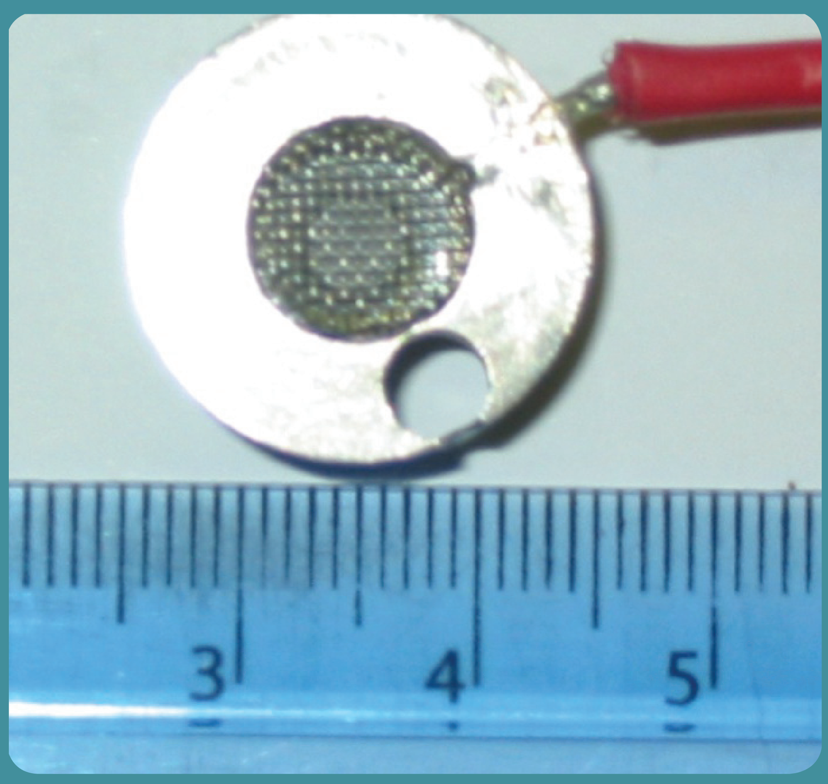

Fig 1: The source

Fig 2: The HRGS system (shielding open)

3 Method

Bremsstrahlung x-rays have a continuous energy spectrum up to a maximum which is equal to the maximum kinetic energy of the betas.

Thus the Bremsstrahlung emission spectrum for the unknown source would be similar to its beta spectrum, but modified by absorption as the x-rays pass through the materials surrounding the sensitive detector volume.

Measurements with conventional health physics monitoring equipment suggested that the source was emitting betas with Emax < 156 keV and x-rays < 50 keV. This implied Ni-63 (E_{MAX} = 66 keV) could be a strong candidate. Two calculations were performed with MCNP.

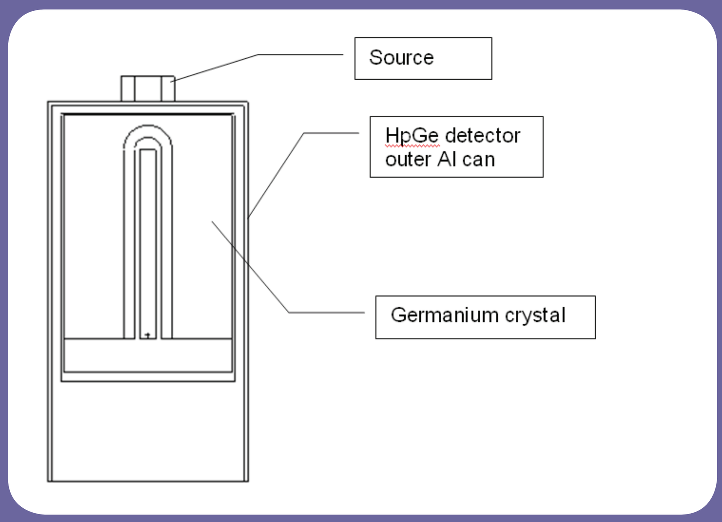

Fig 3: Sketch of the HpGe Detector System as Modelled

Firstly, the anticipated spectrum from Ni-63 was generated using appropriate emission data (JAERI). Secondly, an efficiency calibration was performed for the detector to enable an activity estimation to be made.

4 Results and Discussion

The unknown source was placed on a HRGS and the measured spectrum compared to that from a known Am-241 source (Fig 2). The unknown source spectrum is the curved line, which meets the background just above the 59.5 keV peak from Americium-241.

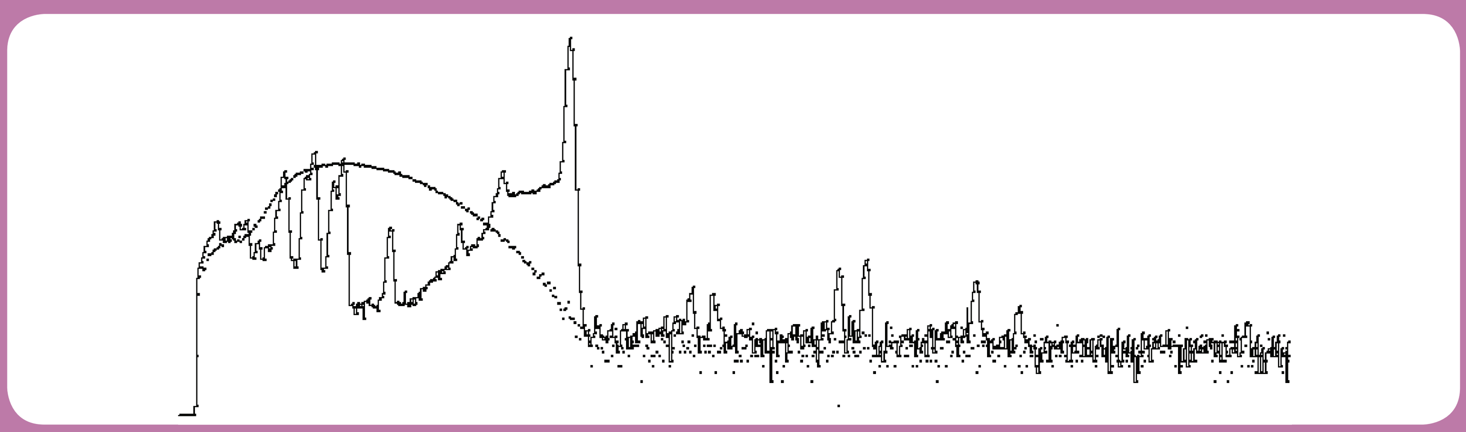

Fig 4: Comparison of Unknown Source Spectrum and Americium-241 Spectrum

The maximum energy of a Ni-63 beta particle is 66 keV, which was in good agreement with the maximum energy of the source spectrum measured. Pb-210, Zr-93 and Sn-125 also have a beta emission at around 60 keV but were discounted due to differences in spectrum shape or the absence of other photon emissions that should have been present.
Although it was difficult to determine the precise end-point energy of the measured spectrum due to the background continuum, the spectrum shape was very similar to the predicted spectrum and the end-point energies for both plots were about 65 keV (Fig 3).

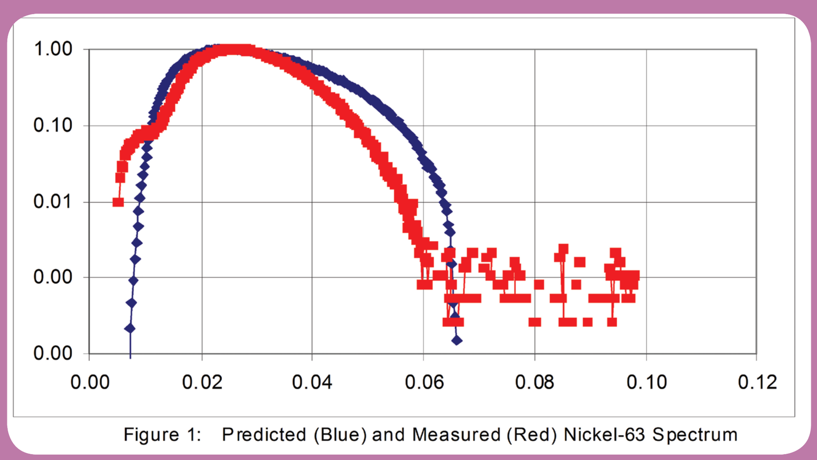

Fig 5: Predicted (Blue) and Measured (Red) Nickel-63 Spectrum

The system efficiency for a Ni-63 source was calculated and the activity of the source estimated to be around 1 GBq.

5 Summary

A combination of screening the unknown source with a range of conventional Health Physics instrumentation, MCNP modelling and HRGS measurements enabled identification of the radionuclide present (Ni-63) and also a reasonable assessment of the total activity (1 GBq ± 10%), thus ensuring that the source could be disposed of in accordance with regulatory requirements.

Note:
It should be noted that the measurement of low-energy emissions i.e. less than 60 keV is an unusual application of HpGe detectors of this type. The derivation of the predicted spectra will be subject to a number of uncertainties including the thickness of absorbing material (in this instance the aluminium can and dead layers within the Germanium crystal), nuclear decay data and cross section data. It was considered that the principle source of uncertainty was due to the unknown thickness of the absorbing layers and although AMEC endeavoured to quantify these at low energies (59.5 keV) it was estimated that the uncertainty introduced was about a factor of two.

6 Further Information

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