Improved control over the source-detector distance in β-γ coincidence measurements

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The precision of branching ratios extracted from simultaneous measurements of *β-γ* coincidences and *β* singles depends most on how well the absolute efficiency of the *γ* detector is known. For a decay scheme like that of ^{34}Ar, in which each excited level populated in the *β*-decay daughter subsequently *γ* decays directly to the ground state, the branching ratio can be expressed to a first approximation as

$$BR_\gamma = \frac{N_{\beta-\gamma}}{N_\beta \times \varepsilon_\gamma} \qquad (1)$$

where $N_{\beta\text{-}\gamma}$ and N_β are the total numbers of observed *β-γ* coincidences and *β*-singles respectively, and ε_γ is the absolute efficiency for detection of the *γ* ray. We have already calibrated the absolute efficiency of our HPGe detector to a precision of 0.2% in the energy range 50 keV to 1800 keV and 0.5% up to 3.5 MeV using long-lived sources [1]. However, in the calibration measurements the source-to-detector distance could be controlled to ±0.1 mm, while in a real experiment the source is implanted in a mylar tape, which is positioned in front of the *β* and *γ* detectors by our fast tape-transport system (see, for example, ref. [2]). Being a mechanical system, the tape-transport system positions the activity to a lower accuracy. To overcome this limitation, we have upgraded our measurement system by adding a laser-based position sensor, *AccuRange 600-4* [3], which is able to determine a distance to ±0.1 mm for distances in the range from 9 to 19 cm. The distribution of the tape-to-detector distances as observed in our recent ^{34}Ar experiment [4] is given in Fig. 1. Before this upgrade we could use only the average source-detector

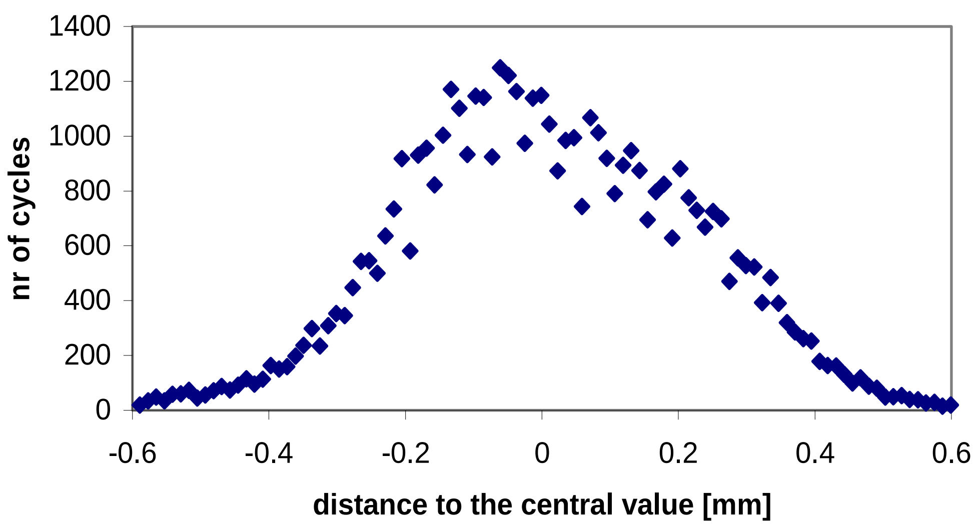

Figure 1. Distribution of the source-to-HPGe-detector distance relative to the central value (15.1 mm) as measured in the ^{34}Ar experiment [4].

distance, which we assumed – and have now verified – had an spread, FWHM, of 0.5 mm. Thus, the absolute efficiency, ε_γ, in equation (1) had to carry a higher uncertainty, which in turn increased the uncertainty in the extracted branching ratios. In the upgraded system, every detection cycle is now tagged with its own source-detector distance, accurate to 0.1 mm. This increases the precision we can achieve in a branching-ratio measurement to the limit defined by the precision of the absolute efficiency of the γ-ray detector.

[1] J. C. Hardy, *et al.*, Int. J. Appl. Radiat. Isot. **56**, 65 (2002), R. G. Helmer, *et al.*, Nucl. Instrum. Methods Phys. Res., **A511**, 360 (2003). R. G. Helmer, *et al.*, Int. J. Appl. Radiat. Isot. **60**, 173 (2004).

[2] V. E. Iacob, *et al.*, Phys. Rev. C **74**, 015501 (2006).

[3] http://www.acuityresearch.com/AR600/

[4] V. E. Iacob, *et al.*, *Progress in Research*, Cyclotron Institute, Texas A&M University (2007-2008), p. I-29.