Improved laser determination of source-detector distance for superallowed branching-ratio measurements

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The precision of branching ratios extracted from simultaneous measurements of β-γ coincidences and β singles is ultimately limited by how well the absolute efficiency of the γ-ray detector is known. For the decay scheme of a superallowed β emitter with (T, T_Z) = (1, -1), in which each excited level populated in the β-decay daughter subsequently γ decays 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-ray detectors by our fast tape-transport system. Being a mechanical system, the tape-transport positions the activity to a lower accuracy. To overcome this limitation, several years ago [2] we upgraded our measurement system by adding a laser-based position sensor, *AccuRange 600-4*, which was, in principal, capable of determining the distance to ± 0.1 mm for distances in the range from 9 to 19 cm. With the distance recorded for each counting cycle, the β-γ coincidence data could then be corrected off-line after the experiment was over.

Unfortunately the laser proved to be quite temperature dependent and its precision was only barely adequate for our branching-ratio measurements. Consequently, we have now installed an improved high-precision laser sensor, an *AccuRange 700* [3], which has 5-μm resolution. This laser sensor has a temperature dependence of only 10 μm per degree Celsius, but nonetheless we now also monitor and record the temperature with a resolution of 0.1 ^{o}C in the cave where the device is located. The laser sensor and temperature monitor are both connected to a PC via an RS232 interface, and during an experiment the position and temperature data can both be taken automatically for each tape cycle. Taking into account the mounting uncertainties and the temperature correction, a precision of 10 μm should be achievable for the tape-detector distance

[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, V.V. Golovko and J.C. Hardy, *Progress in Research*, Cyclotron Institute, Texas A&M University (2007-2008), p. V-19.

[3] www.acuitylaser.com/AR700