∃-(Angular Correlation Correction for High Precision Coincidence Measurements

J. Giovinazzo[a], J. C. Hardy, V. E. Iacob and M. Sanchez-Vega
[a] *Centre d'Etudes Nuctéaires de Bordeaux-Gradignan, IN2P3/CNRS, France*

There is no significant ∃-(angular correlation in strong allowed ∃ decays. However, a correlation may appear if the allowed matrix elements are suppressed and higher-order ones begin to play a role. This has been observed in the decay of some light nuclei [1, 2], where an asymmetry was found in the order of 10^{-3} to 10^{-4}.

The high precision ∃-(coincidence measurements currently being performed at the Cyclotron Institute [3] mainly focus on the branching ratios for superallowed Fermi transitions, which are not affected by angular correlations. However, the branching ratios for other transitions are also involved in these measurements and, in principal, some could exhibit angular-correlation effects. Since our goal is to reach a precision of 0.1%, we have examined whether angular correlations could affect our results at that level.

The angular asymmetry between the 3 particle and the (ray can be written in the form [1, 21

$$W(2) = 1 + A \cdot \cos^2 2_{∃(}$$

where A is the asymmetry parameter.

We have performed a Monte-Carlo simulation, adopting a detection geometry as close as possible to the one used for the actual measurements. The radioactive source is located 4 mm from the plastic scintillator (for ∃ detection) and about 15 cm from the 70% germanium detector (for (-ray detection). Since we are only interested in the relative effects of the ∃-(angular correlation, there is no need to incorporate a precise description of the detector response function. The most important factor is the size of the detectors, *i.e.* their geometrical efficiency. We then compare the coincidence detection efficiency for a symmetric case and for cases with asymmetry parameters spanning several orders of magnitude.

We consider a decay with asymmetry *A*, which yields *N*(*A*) observed coincident (-ray events, and compare it with one with no correlation, which yields N(0) events. The relative difference between them corresponds to the relative error one would make in ignoring the correlation when extracting a (-ray peak area. This relative error is then given by

$$E(A) = \frac{N_{tot}(A) - N_{tot}(0)}{N_{tot}(A)}$$

The results for 10^6 detected coincidence events are shown in figure 1 and table 1 for

Table 1: Relative error calculated with 10^6 events in the adopted geometry. The case with $A = 0$ is used as a reference for the relative error estimate. The uncertainties are due to statistical errors in the Monte-Carlo simulation.

A	N(A)/N(0)	E(A)in %
-0.1000	0.9906 (10)	0.80 (14)
-0.0100	0.9978 (10)	0.08 (14)
-0.0010	0.9985 (10)	0.01 (14)
0.0000	0.9986 (10)	—
+0.0010	0.9987 (10)	-0.01 (14)
+0.0100	0.9996 (10)	-0.10 (14)
+0.1000	1.0069 (10)	-0.83 (14)

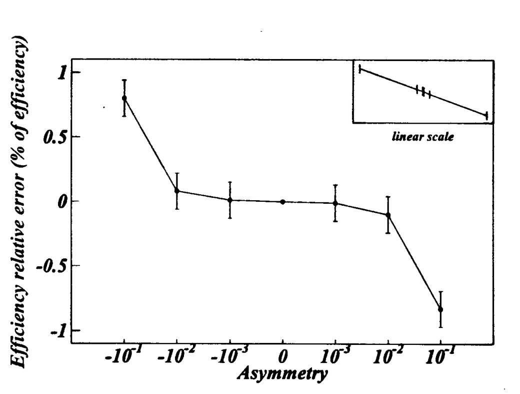

Figure 1: Relative error on (intensity as a function of the asymmetry parameter. The error bars have come from statistical uncertainties in the Monte Carlo calculations. Each point corresponds to 10^6 detected coincidence events. The inset shows the same data using a linear axis for asymmetry.

several orders of magnitude of the asymmetry parameter. Since the expected value for any asymmetry is expected to be less than a few parts in 10^4, the error incurred by ignoring ∃-(angular correlations when extracting (-ray intensities from measured spectra can be neglected. The error is certainly less than 10^{-4} of the observed intensity.

In conclusion, even if precision measurements depend upon the measurement of ∃ transitions for which the allowed matrix elements are suppressed, the possible effects of ∃-(angular correlations remain very small and may be neglected. With the experimental arrangement used at the Cyclotron Institute to study super-allowed ∃ decay, these effects are about one to two orders of magnitude lower than the uncertainties quoted for the efficiency calibration of the detector used [4].

References

[1] R. E. Tribble and D. P. May, Phys. Rev. C **18**, 2704 (1978).

[2] C. J. Bowers *et al.*, Phys. Rev. C **59**, 1113 (1999).

[3] J. C. Hardy *et al.*, *Progress in Research,* Cyclotron Institute, Texas A&M University (2000-2001), p. I-24.

[4] J. C. Hardy *et al., Progress in Research,* Cyclotron Institute, Texas A&M University (2000-2001), p. V-24; and Applied Radiation and Isotopes, to be published.