$$N_2 = D \cdot G \cdot (\eta_2 - g \cdot \eta_{12}), \qquad (4)$$

these being the single-energy peaks corrected for counts lost in their sumpeak [Eqn (a)]. Equations (3), (4), and (a) then yield Eqn (2).

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Reply

The calculation of the activity of an I-125 source (*1*) from measurements of the pulse-height spectrum—in particular using the sum peak—was carried out using the classical coincidence-counting approach (*2*), since all observed photons are included in the photopeak and sum peak. The counting rates used were sufficiently low that random coincidences were negligible.

Let us consider $N_1 = A\epsilon_1$ (a), and $N_2 = A\epsilon_2$ (b), where A is activity, ϵ_1 and ϵ_2 are the probabilities of detecting an event following a disintegration, N_1 is the counting rate for one component of a coincident pair, and N_2 is the rate for the other. Let N_{12} be the coincidence rate. When the detection of two such coincident events is otherwise uncorrelated, the probability of detecting them in coincidence is the product of the individual detection probabilities. Thus, $N_{12} = A\epsilon_1\epsilon_2$ (c). Combining expressions (a), (b), and (c), $A = N_1N_2/N_{12}$ (d).

In the case of iodine-125, emission of the coincident photons is assumed to be isotropic without angular correlation, since the K-capture branch results completely from deexcitation of the atom, rather than directly from nuclear processes. Similarly, the events associated with the coincident decay from the 35-keV level ($T_{1/2} = 1.6$ ns), which follow the K capture, result in emissions that are 90.7% K fluorescent photons and 9.3% unconverted gammas. It appears impossible that any angular correlation could exist under such circumstances, and to the best of our knowledge, none has been reported.

In the spectrum of I-125 the single primary photopeak contains the K fluorescent photons resulting from K capture and those from internal conversion in the K shell following K and L capture, as well as the unconverted gamma photons. These are not resolvable with NaI(Tl). The sum-peak counting rate, N_{sum}, represents events in which two coincident photons are detected simultaneously, i.e., $N_{sum} \equiv N_{12}$. The total detection rate, N_T, is thus equal to the photopeak rate plus twice the sum-peak rate.

Let η_1 be the number of K x-rays emitted per disintegration, following K capture. This is the product of the K-capture fraction, 0.813 (*3*), and the fluorescence yield, 0.855 (*4*). Let η_2 be the number of photons emitted during the coincident γ decay. This is the product of the K-capture fraction, 0.813, the K-conversion fraction 0.80 (*5*), and the K fluorescence yield, 0.855 (*4*), plus the product of the K-capture fraction 0.813 and the unconverted gamma abundance 0.0666 (*6*). The total number of emitted K and γ photons per disintegration is $\eta_T = 1.4669$ (*5*). Thus,

$$N_1 = \frac{\eta_1}{\eta_T} N_T, \text{ and } N_2 = \frac{\eta_1}{\eta_T} N_T.$$

Substitution in Eqn (d) gives the activity at the point where the coincident branching occurs, i.e., the product of total activity and the K-capture fraction:

$$0.813\ A = \frac{\eta_1\eta_2}{\eta_T^2} \cdot \frac{N_T^2}{N_{sum}},$$

and

$$A = \frac{\left(\frac{N_2}{2.04}\right)^2}{N_{sum}},$$

as reported previously, with a slight correction introduced by the more recent abundance figures (*5*). Under the conditions of I-125 decay, the independent detection probability of the two coincident photons permits the statement, objected to by van Damme, that $\eta_{12} = \eta_1\eta_2$ (van Damme's notation). Measurements in a deep well crystal, where the geometry approaches 4π, would remove even this theoretical objection.

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