Compton Effect Calculations – Outline and Typical Results

(for 1.9 cm-length Al cylinder target)

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(See Melissinos and Napolitano table, and calculations, ch. 9.)

I. Decay rate R of ^{137}Cs source, at 16.5 years (for example) since May 1995 when it was $R_0 = 5.46$ mCi

$R(16.5\text{ yr}) = R_0\exp(-16.5/\lambda)$ (Half life $t_{1/2} \approx 30$ years → $\lambda = 43.28$ yr)3.

$R(16.5\text{ yr}) = 3.729$ mCi $= 13.797 \times 10^7$ disintegrations/s

II. Area of sphere at target distance from source (20 cm)

$4\pi(400) \approx 50 \times 10^3\ \text{cm}^2$

III. Incident γ intensity I_0 at target (# γ rays/(cm^2-s))

$I_0 = 13.797\times10^7/\text{s} / 50\times10^2\ (\text{cm}^2) = 2.759\times10^4/(\text{cm}^2\text{-s})$

IV. Number of electrons in 1.9 cm long by 1.9 cm diameter Al target cylinder

$N = \#\text{ moles Al (in target)} \times 6.023\times10^{23}\times13$ (electrons per Al atom)

$= (\text{target volume}\times\rho_{Al})\times6.023\times10^{23}\times13/27$ (g/mole)

Target volume $= \pi(1.9)^2(1.9)/4 = 5.387\ \text{cm}^3$

$N = 0.5387\times6.023\times10^{23}\times13 = 4.218\times10^{24}$ electrons (in 1.9 cm-length Al cylinder)

V. Solid angle of detector, seen from target (distance from center of target to detector front face ≈ 41.cm)

$d\Omega_{det} = \pi(2.3)^2/(41^2) \approx .010$ sr

VI. Cross section $d\sigma/d\Omega$

$d\sigma/d\Omega = \text{yield}/(d\Omega_{det}\times N\times I_0) = (\text{yield}/1.166)\times10^{-27}\ \text{cm}^2$

and peak to total ratio

VII. **Yield** = counts/s into the area of the Compton-shifted peak of the subtracted spectrum, corrected for detector efficiency. You cannot use regions of interest in the original target in/target out spectra to get this – you must do this after the spectrum subtraction, in Excel or Graphics Analysis. To get the total counts in the subtracted peak, fit the peak to a Gaussian (using Excel or GA) and integrate over the region corresponding to the peak's limits. (Note that Melissinos and Napolitano integrate the total counts in entire γ spectrum and multiply by the peak-to-total ratio, whose determination is not specified by them but representative values are given in the figure above the detector efficiency plot. This ratio can be estimated from your subtracted spectrum as well, by integration over the peak region only and division by the total γ count over the entire spectrum. In either approach you must fit the peak region alone to get its integral. If you do wish to calculate peak-to-total ratios in your spectra, you may find it