

Q5992: Dear Sirs, I have downloaded the beta spectral data DEXRAX code as well as RADTOOLBOX provided by several Web sites. In these two codes it is possible to view beta spectrum frequencies with respect to predetermined energy grids. The codes quote that the spectrum is given in the form of E vs Y(E)dE and give the unit of N(E)/MeV/Bq s. I have determined efficiencies for commonly available beta sources carbon-14, cobalt-60, thallium-204, RaD+E (lead-210 plus bismuth-210), strontium-90/yttrium-90 with different thickness absorbers. Now I want to determine the efficiency of the counting system for various energy groups. Kindly let me know how to unfold the beta spectrum so that I can get N(E)/disintegration. I tried multiplying the difference of consecutive energy grid points, but when I sum the intensities together I always get 1.04 something instead of 1. I don't know where am making the mistake. Kindly guide me.

ANSWER: I took a look at some of the beta spectral data as given in the DEXRAX code. As you have noted the data are presented in two columns, the first representing energy and the second representing N(E), the fractional beta yield per MeV per disintegration. Thus, each energy point given in the first column has an associated N(E) value in the second column. The total fractional number of beta particles emitted per disintegration in an energy interval from E₁ to E₂ is obtained by integration:

$$T_f = \int_{E_1}^{E_2} N(E)dE . \quad (1)$$

If E₁ = 0 and E₂ = the maximum beta particle energy for a particular beta transition, then we would expect, for a radionuclide such as carbon-14, that exhibits a single beta transition, the integral value would be 1.00, as you have inferred. We cannot easily carry out the exact integration in equation 1 unless we have a suitable algebraic representation of the beta particle spectrum. In order to use the data as presented in DEXRAX we can approximate the integration by replacing the differential element dE term by a finite width element ΔE and performing a summation as follows:

$$T_f = \sum_{E_1}^{E_2} N(E')\Delta E \quad (2)$$

where ΔE represents the energy interval between two consecutive energies as given in the first column of the data in DEXRAX. If the energy bins are sufficiently narrow, the value of N(E') may be taken as the arithmetic average of the N(E) values given for the two consecutive energies being considered. As the data are presented in DEXRAX, the ΔE intervals separating consecutive energies are not all the same. As an example, if we take the last three data entries for ¹⁴C, we have:

E	N(E)
0.14000	0.4380
0.15000	0.07105
0.15648	0.000

If we calculate $N(E') \Delta E$ for the ΔE interval from 0.14000 to 0.15000 MeV, we have $\Delta E = 0.01000$ and $N(E') = 0.2545$ (arithmetic average of 0.4380 and 0.07105), and $N(E') \Delta E = 0.002545$. Similarly, for the ΔE interval from 0.15000 to 0.15648 we have $\Delta E = 0.00648$, $N(E') = 0.03553$, and $N(E') \Delta E = 0.0002302$. The summation from 0.14000 MeV to 0.15648 MeV is then $0.002545 + 0.0002302 = 0.002775$.

For the carbon-14 spectral data in DEXRAX there are a total of 89 E, N(E) data pairs. I carried out the summation as exemplified above, for all the data and obtained a fractional total value of 0.9995, sufficiently close to 1.0000 to satisfy me that the data are acceptable and the numerical summation method is adequate. If ΔE intervals are too wide a straight arithmetic average value of $N(E')$ may not be an adequate representation of the appropriate value because of curvature of the beta spectral shape in the interval, and more significant deviations of the summations from equation 2 compared to true values may prevail.

I hope this is helpful in your efforts in evaluating detection efficiencies. Good luck.

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