## BETA DECAY SPECTROMETER

**Purpose:**
We will measure electron energy spectrum for two radioactive beta emitters, Sr90 and Tl204. The average *Q* and endpoint energy will be observed. The spectrum is not monochromatic, but is characteristic of a 3-body decay where the beta may take on a spectrum of energies.

P -> D + e- + v          Parent --> Daughter + beta- + neutrino

The *Q*-value of the decay is the total kinetic energy available to the decay products.

$$Q = M(P) - M(D) - M(e) - M(v)$$

*Q* is shared equally amongst the three decay products, so

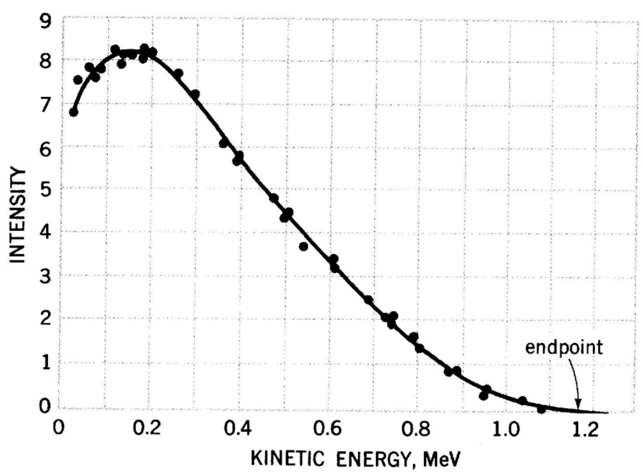
$$\langle Q \rangle \sim Q/3$$

The maximum Tmax a decay product may receive is *Q* !

$$Tmax = Q \quad \text{(endpoint)}$$

Thus by measuring the electron's kinetic energy spectrum of we can determine Tmax = *Q*.

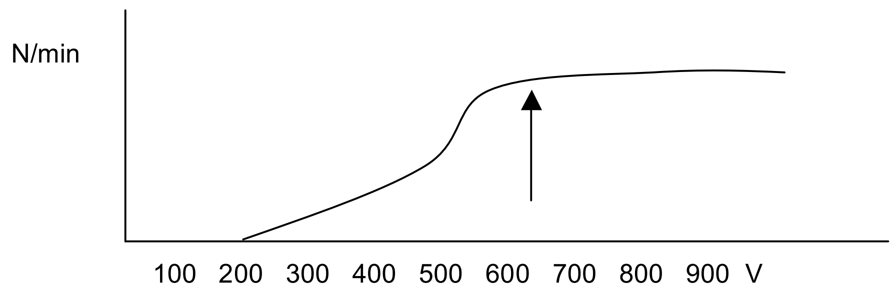
**FIGURE 11-1 Energy spectrum of electrons emitted in the beta decay of Bi$^{210}$.** [*From G. J. Neary, Proc. Phys. Soc. (London),* **A175: 71 (1940).**]



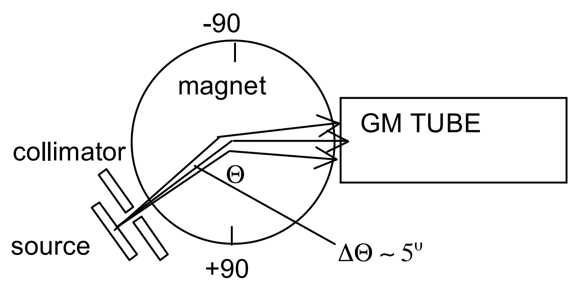

**(1) HV Plateau** Before using the beta spectrometer with the GM tube you should find the GM tube operating voltage by moving the source to the zero $+70^0$ position and record the number of counts per 10-minute interval, each 100V between 300 V and 800V.

Graph the result and identify the plateau region. The Geiger tube voltage should be set to a value about 20% past the onset of the plateau.

| V | 100 | 200 | 300 | 400 | 500 | 600 | 700 | 800 | 900 |
|---|---|---|---|---|---|---|---|---|---|
| N/min | | | | | | | | | |




**(2)** Take counts per 10 minute interval each 10 degrees (0 to + 90 degrees. ).




| Angle | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
|---|---|---|---|---|---|---|---|---|---|---|
| Counts/10m | | | | | | | | | | |

**(3)** Graph the number of counts above background per energy interval versus electron kinetic energy. *dN/dE vs T.*

$$\frac{dN}{dT} = \left(\frac{dN}{d\theta}\right)\left(\frac{d\theta}{dT}\right) \quad with \quad \left(\frac{d\theta}{dT}\right) \sim \left(\frac{\Delta\theta}{\Delta T}\right) = \left|\frac{5^O}{T(\theta + 2.5^O) - T(\theta - 2.5^O)}\right|$$

(See BetaCalculator.xls on web site. )

Determine the endpoint energy *Q* where the energy spectum merges in to the background.

**Derivation of Kinetic Energy Equation**

$$T = E - mc^2 \quad and \quad p = qBr = eBR/\tan\left(\theta/2\right)$$

$$T = \sqrt{p^2c^2 + m^2c^4} - mc^2 = mc^2\left\{\sqrt{\left(\frac{pc}{mc^2}\right)^2 + 1} - 1\right\} = mc^2\left\{\sqrt{\left(\frac{eBR}{mc}\frac{1}{\tan\left(\theta/2\right)}\right)^2 + 1} - 1\right\}$$

$$with \quad \left(\frac{eBR}{mc}\right) = 1.131$$

$$T = 0.511\left\{\sqrt{\left(\frac{1.131}{\tan\left(\theta/2\right)}\right)^2 + 1} - 1\right\} MeV$$