Absorption of beta particles & beta end point decay energy

Objective:

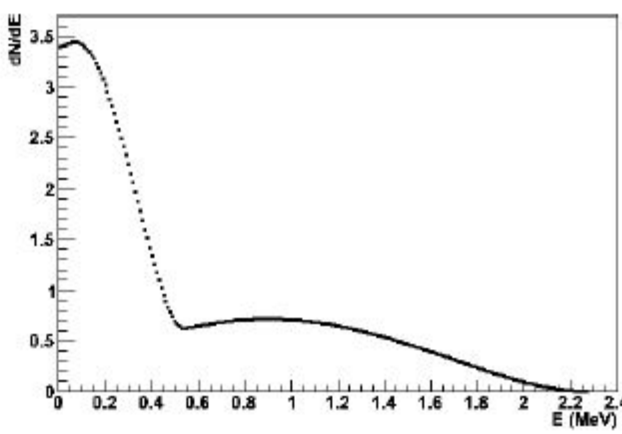
To investigate the absorption of beta particles and determine the maximum energy of decay of a beta particle.

Introduction:

Experiments have shown the beta particle to be identical to an electron except for its origin. An electron emitted from a nucleus is called a beta particle.
Typical neutron decay emits beta particle as follows:

$$n \rightarrow p + e^{-} + \bar{\nu}$$

Unlike alpha particles that are emitted from a source with the same energy (~ 5 MeV), beta particles are emitted with a range of energies, lying between zero MeV and the maximum energy for a given isotope. The velocity of a beta particle is dependent on its energy, and velocities range from zero to about 2.9×10^8 m/sec, nearly the speed of light.
Knowing the maximum energy of a beta particle is very important in that it helps in identifying the isotope.
Strontium-90, the source used in this experiment, is a pure Beta emitter. However unlike most Beta emitters it does not decay directly to the ground state but first into (Yttrium 90)*, and then to Yttrium 90, the ground state. Yttrium has a half- life of 64 hours. The endpoint energy for Strontium 90 is 0.456 MeV and for Yttrium 90 it is 2.27MeV. An energy spectrum for them is displayed to the right.



Through experimentation with our source ^{90}Sr the value that is obtain for the endpoint energy using the current techniques is approx. 0.85 MeV.

In this experiment, you will find a range of beta particles by measuring their attenuation with calibrated absorbers and extrapolating the absorption curve. The range, R, will then be substituted into the empirical formula

$$E_m = 1.84R + 0.212 \qquad [1]$$

where R is expressed in **g/cm²**. And E_m is the maximum energy of the beta particle emitted.

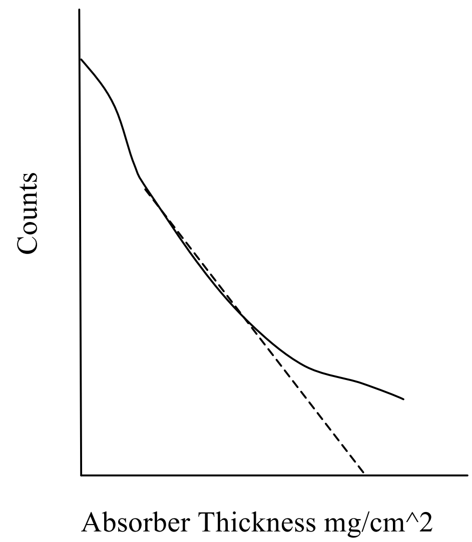
Range is the amount of absorption thickness material required to stop the maximum energy particle from exiting the material. While the absorption thickness would be a fixed value for a source the thickness require would vary upon the type of material used.

The count rate however may never be reduced to simple background counts.
The excited electrons interact with other electrons within the absorption material create Bremsstrahlung, or breaking radiation. This is an electromagnetic radiation produced by the deceleration of the fast electron. Additionally fast particles may also produce X-rays when passing through thicker materials. This can be characteristically seen by the existence of low energy peaks in a gamma energy spectrum.

As we are limited to a simple G-M counter determining the range R can be accomplished by measuring the count rate of a source as the radiation passes through different absorption thickness of a material.

The graph shown to the right represent a likely graph. If a straight line can be fitted through the linear portion of the graph and extrapolated down to pass through the x axis, then the x-intercept is the range, R, for the equation [1]. It should be noted that performing this physically on the graph by drawing a line may be the best method.

The absorber thickness of a material is a product of the materials density in mg/cm^3 and the thickness of the material in cm. The values are given on the box.



Procedure:

1. Using the ST 360 counter set it up for a nominal operating voltage and a counting time of 300 seconds.
2. Take a data run to determine a value for the background counts.
3. Obtain a Strontium-90 Beta source, this is a pure Beta source but has 2 beta emissions. Place the source in the 2^{nd} shelf of the counter with the paper side toward the G-M Tube.
4. Take a data run to determine a value for the source counts without any absorbers present.
5. Start with absorber G (located inside the wooden box) and place it in the tray above the source. Take a data run and record the counts. Also convert the absorption thickness to g/cm^2.
6. Determine the corrected count rate from the difference of the count rate and background counts
7. Repeat the process using the absorbers H - O.

8. Repeat using plastic (located inside the wooden box). You will have to combine multiple plastics sheets to get the desired absorption thicknesses.

You are to plot Counts vs. absorption thickness for each material. And then follow the guideline mentioned in the introduction to determine the maximum energy, E_m, of the emitted beta particle.

Background ______________

Absorber Letter	Absorber Thickness g/cm^2	Counts	Corrected Counts
none			
G			
H			
I			
J			
K			
L			
M			
N			
O			

Absorber Letter	Absorber Thickness g/cm^2	Counts	Corrected Counts
none			
E			
F			
E+F			
F+F			
E+F+F			
F+F+F			
F+F+F+E			