EXPERIMENT 5

Beta and Conversion Electron Measurements with Solid State Detectors

Scope

In this experiment, calibration of a surface barrier detector with the known energies of the conversion electrons from ^{137}Cs will be done. This calibration will be done with a precision pulse generator that is normalized to the 620 keV line from ^{137}Cs. The next part of the experiment will be to determine the precise energies of the conversion lines from several other isotopes. The beta end point energy of ^{204}Tl will then be determined with this calibration and a Kurie plot.

Discussion

Beta emission is perhaps one of the most important decay mechanisms that will be studied in this manual. It has been through the measurement of Beta end point energies that many of the nuclear levels listed in the Table of the Isotopes have been determined. One of the main reasons for this, is that many of the isotopes that can be studied are produced in a reactor by the so called (n, γ) reaction. These reactions will be studied in detail in a later experiment. In producing these isotopes, the material to be studied is placed in the thermal neutron flux of the reactor. The material that is to be irradiated will produce the following reactions:

$$ {}^{m}_{z}A_1 + n \rightarrow {}^{m+1}_{\ z}A_1^* + \gamma \qquad (1)$$

The γ is prompt and will leave the sample in a time of the order of 10^{-15} seconds. The remaining nucleus ${}^{m+1}_{\ z}A_1^*$ is, in general, radioactive and will decay to an energetically more stable nucleus. A typical decay scheme for ${}^{m+1}_{z+1}A_1^*$ is shown in fig. 5.1.

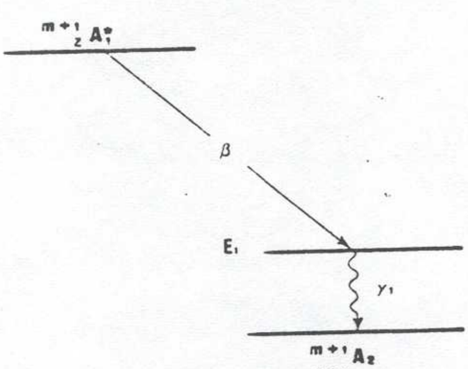

Figure 5.1. Typical Decay Scheme for a Beta Emitting Isotope.

The nucleus ${}^{m+1}_{\ z}A_1^*$ is neutron rich. In other words, the absorption of the neutron in eq. (1) has produced an excess of neutrons in the nucleus for stability. In order to reach a more stable configuration, one of the neutrons in the nucleus is converted to a proton by the following reaction:

$$ n \rightarrow p + \beta^- + \text{neutrino} \qquad (2)$$

Neither the proton, β^-, or neutrino from (2) can exist in the nucleus prior to the decay. The energy from the decay will be kinematically shared between the three products on the right of eq. (2).

From these Kinematic laws of conservation of energy and momentum, it can be shown that the proton receives very little of the energy that is available. The energy is therefore shared by the β^- and the neutrino. Since the neutrino can't be detected with this laboratory equipment, only the β^-'s can be measured. There are three nuclear particles on the right hand side of eq. (2) and therefore the β's that are measured will not have discrete energy. If the energy available during the decay is E_1, any combination of sharing this energy between the β's and the neutrino is possible. Figure 5.2 shows a picture of what the β spectrum for the decay of ${}^{m+1}_{\ z}A_1^*$ might show:

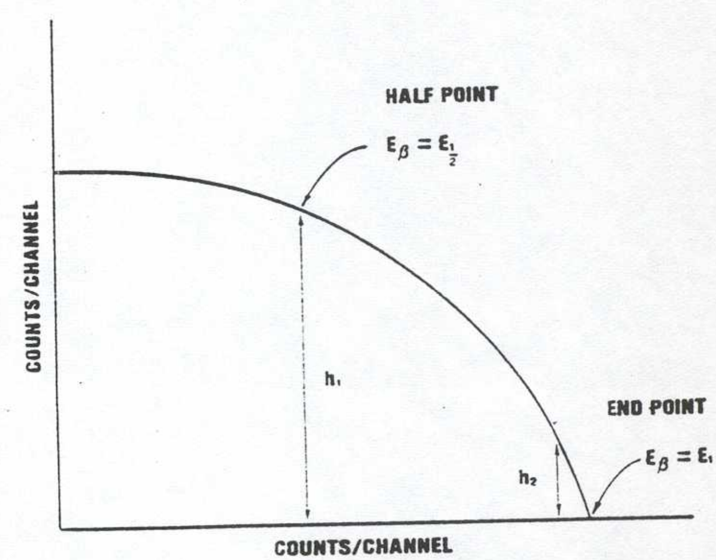

Figure 5.2. Typical Beta Spectrum showing the Continuous Distribution of Beta Energies up to the $E\beta_{max}$ End Point Energy.