Alpha Particle Measurements with Surface Barrier Detectors

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Study of the Energy Loss of Alpha Particles in Matter

Discussion

This experiment is designed to show the student how to use surface barrier detectors to study the properties of alpha emitting isotopes. In Experiment #4 which follows this experiment, the energy loss of alphas in thin foils will be studied. The electronic configuration for the two experiments is the same.

Silicon Surface Barrier Charged Particle Detectors

The first thing that the student will realize is that these detectors are extremely easy to use. Tennelec makes detectors that range in size from 25 mm^2 to 2000 mm^2 active area. These detectors are 100% efficient over their active area and can be used to measure a wide range of charged particles. This range includes protons and electrons as low as 20 keV up to fission fragments of energy over 100 MeV. Figure 3.1 shows a pulse height spectrum of scattered protons at 150 keV. On the other hand, fig. 3.2 shows a fission fragment spectrum from ^{252}Cf. The light fission fragment group (the one on the right) has an energy of 103 MeV while the heavy group is 70 MeV. The data analysis with these detectors is extremely simple since they are 100% efficient. For example, in fig. 3.1, if one wished to know the number of scattered protons for the data in the figure, it would only be necessary to integrate under the peak and subtract the estimated background from the sum. These detectors can be thought of as a solid state ionization detector. When a charged particle enters the depletion region of the detector, it loses its energy primarily by making electron hole pairs in the silicon.

For each electron hole pair that is made, the initial charged particle must lose 3.6 eV. In this experiment we will be measuring alpha particles that have an energy of 5.305 MeV. When these alphas enter the detector, 1.47 x 10^6 electron-hole pairs will be produced. The detector is reverse biased and these electron-hole pairs are collected to produce the output pulse of the detector. Since there are a large number of charge carriers produced, the statistical variation in the number collected is small and hence very good resolution is possible. Tennelec can provide detectors with resolutions as low as 12 keV for alphas for the PP series premium partially depleted detectors. The detector recommended for this experiment is a PD series Partially Depleted Detector with 15 keV resolution. This detector is cheaper and is quite adequate for the experiment.

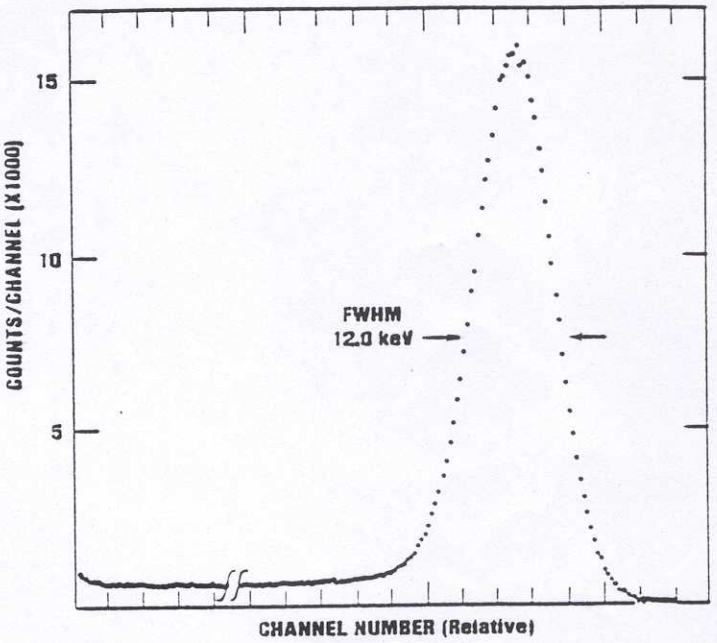

Figure 3.1. Silicon Surface Barrier Detector pulse height spectrum of 150 keV scattered protons from the ^{12}C (p,p) ^{12}C reaction at 30°.

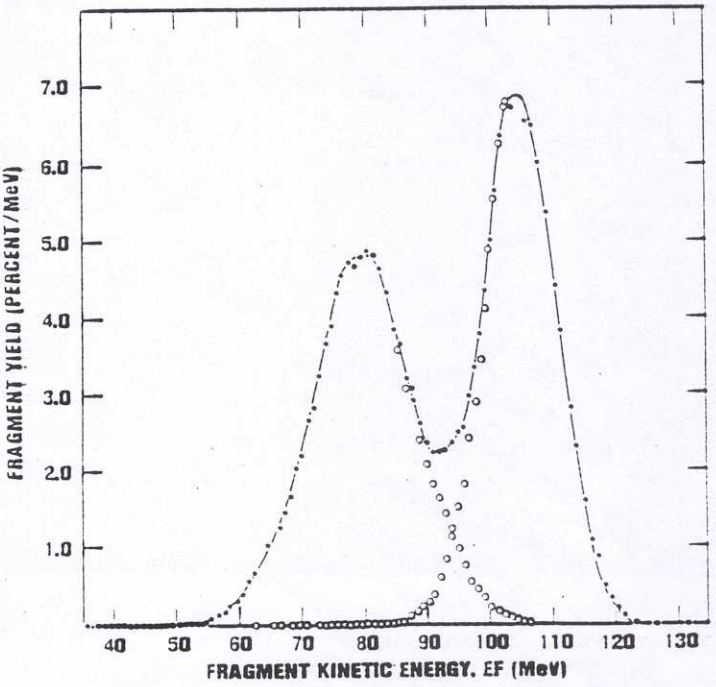

Figure 3.2. Surface Barrier Detector Fission Fragment Spectra from ^{252}Cf (courtesy of Stan Whetstone and the Physical Review Reference 1).