Consider what nuclear information can be determined from the decay scheme in fig. 5.1 and the measured β spectrum in fig. 5.2. From the calibration and measured end point energy in fig. 5.2, the energy difference between ${}^{m+1}_{z}A_1$ and E_1 the first excited state can be determined. As mentioned in Experiment #2, the energy of level E_1 can be established by simply measuring γ_1. Furthermore, if ${}^{m+1}_{z}A_1$ also decayed directly to the ground state of ${}^{m+1}_{z+1}A_2$ that β^- end point energy could be measured and directly establish the energy difference between the ground state of ${}^{m+1}_{z+1}A_2$ and ${}^{m+1}_{z}A_1$. In a later experiment, the principle of coincidence measurements will be illustrated. In the example, γ_1 would be in coincidence with the β particle shown in fig. 5.1.

Before leaving this discussion, the topic of Internal Conversion electrons should be discussed since these discrete lines for energy calibration will be used.

Internal electron conversion is a decay process that is in direct competition with gamma emission. In fig. 5.1, ${}^{m+1}_{z}A_1$ decays by β^- emission to the first excited state E_1 of the nucleus ${}^{m+1}_{z+1}A_2$. In an earlier example, the state E_1 decayed to the ground state by the emission of γ_1. For some nuclei, it is possible for this energy of excitation to be given directly to an orbiting electron in the daughter nucleus ${}^{m+1}_{z+1}A_2$. This usually happens to the K, L, or M electrons. If this energy of excitation is large enough to remove the K shell electron, it will be knocked out of its orbit with an energy given by:

$$(E_0) = E_i - K_{ab} \qquad (3)$$

where K_{ab} is the binding energy of the K shell electron of the daughter nucleus. Some smaller fraction of these conversions will occur to the L shell electrons. When this happens, the energy of L conversion electron is given by:

$$(E_0) + E_1 - L_{ab} \qquad (4)$$

Since eq. (3) and (4) give discrete energies, they can be used to calibrate the system. Figure 5.3 shows a spectrum of conversion lines from the decay of

Thus, by the use of conversion electron spectra, the system can be accurately calibrated and the β end point energy for an isotope can be measured. As pointed out earlier, β spectroscopy has given much of the valuable nuclear information that is tabulated in the Table of the Isotopes. This is, therefore, one of the most important experiments in this manual.

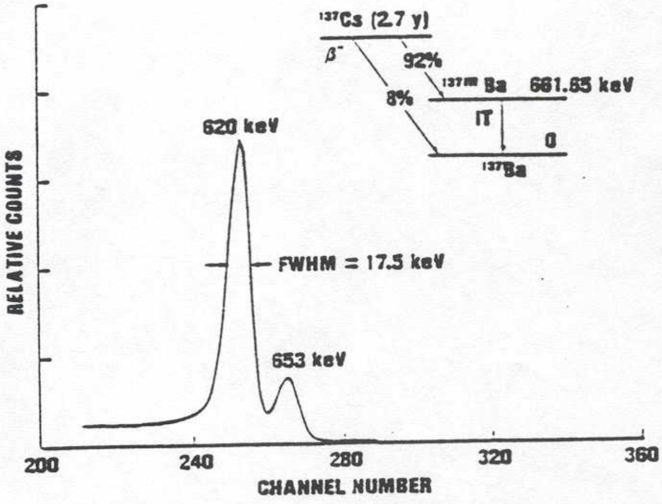

Figure 5.3. Internal Conversion Spectrum for ^{137}Cs.

EXPERIMENT 5.1

Energy Calibration for Beta Spectroscopy

Experimental Procedure

1. Set up the electronics as shown in fig. 5.4. Note this is exactly the same arrangement used for the last two experiments. Please take all of the precautions that were used in these earlier experiments. Place the ^{137}Cs source 2 cm from the face of the detector. Pump the system down and set the bias voltage for the surface barrier detector.

2. Adjust the gain of the amplifier so that the 620 keV conversion line from ^{137}Cs is at approximately channel 250.

3. Record the exact channel of the 620 keV line. Remember, for some analyzers and PCA's, a centroid finding program can be used to determine this value. Turn on the pulser and adjust the pulse height dial to 620/1000. Use the attenuation switches and the calibrate adjustment to set the pulser peak in the same channel as the 620 keV conversion electron line. The pulser is now calibrated so that each division on it corresponds to 1 keV. Set the pulser at 1000/1000 and record the position of the peak. Fill in the rest of the calibration data points in Table 5.1. Plot a calibration curve, and calculate the slope of the curve in keV/ch. From the slope of the calibration curve, calculate the resolution of all of the lines from the pulser and the ^{137}Cs Conversion Spectrum.