A Study of the Decay Scheme of ^{244}Cm by an Alpha X-Ray Coincidence Experiment

EQUIPMENT NEEDED FROM EG&G ORTEC

113 Scintillation Preamplifier
142A Preamplifier
266 Photomultiplier Tube Base
Bin and Power Supply
408A Biased Amplifier
428 Detector Bias Supply
556 High Voltage Power Supply
480 Pulser
Two 575A Amplifiers
551 Timing Single Channel Analyzer
427A Delay Amplifier
Surface Barrier Detector R-017-050-100
ACE-2K MCA System including suitable IBM PC (other EG&G ORTEC MCAs may be used)
Oscilloscope
1 μCi ^{244}Cm
905-1B Thin-Window NaI(Tl) Detector with PM Tube
Mechanical Vacuum Pump
305 Vacuum Can with Thin Plastic Window
Source Kit SK-1X
Source Kit SK-1A
ORC-20 Cable Set

Purpose

This experiment demonstrates the technique of measuring the coincidence between alpha particles and x rays and verifies the alpha particle branching as indicated in ref. 4 for ^{244}Cm.

Introduction

Coincidence events such as (γ,γ) have been studied in previous experiments. The decay scheme of ^{244}Cm given in Fig. 20.1 shows that two alpha particle energies are present in the charged-particle spectrum. The energies are 5.806 MeV and 5.763 MeV. Figure 20.2 is a typical alpha spectrum of ^{244}Cm obtained with a surface barrier detector.

The details of making measurements with surface barrier detectors are covered in Experiment 4. The 43-keV level in Fig. 20.1 de-excites most of the time by internal conversion. The e_L/γ for this level is 760, which means there will be 760 conversion electrons for each 43-keV gamma. The internal conversion process has to be with the L or M electrons, since the binding energy of the K electron is 121.81 keV for ^{240}Pu. Therefore most of the time α_1 will be in coincidence with the L x rays resulting from the internal conversion process. This experiment will show that α_1 and only α_1 is coincident with the conversion electron x rays from this state.

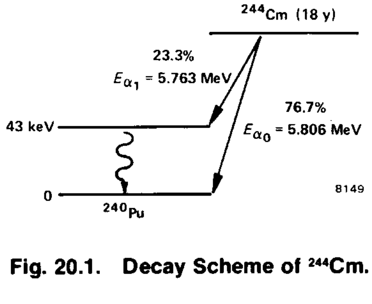

Fig. 20.1. Decay Scheme of ^{244}Cm.

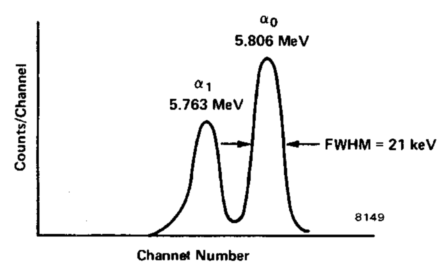

Fig. 20.2. Alpha Spectrum of ^{244}Cm.

Procedure

1. Connect the system as shown in Fig. 20.3. Connect the output of the 575A Amplifier on the NaI(Tl) detector side of the circuit to the MCA as shown by the broken line in the figure. Set the MCA Gate toggle switch at Off.

2. Adjust the 556 High Voltage as required for the thin-window NaI(Tl) detector and phototube.

3. Adjust the gain of the 575A Amplifier in the NaI(Tl) circuit so that the output will provide the spectrum on the MCA as shown in Fig. 20.4.

Note that the calibration points have been taken with the 6.4- and 14.4-keV lines from ^{57}Co and with the 32.2-keV x ray from ^{137}Cs. The x rays observed in Fig. 20.4 are the L conversion x rays resulting from the internal conversion of the 43-keV level in ^{240}Pu.

4. Set the 551 Timing Single Channel Analyzer for minimum delay of 0.1 μs. Adjust its window so that it brackets the 14.2- and 18.2-keV x-ray lines of Fig. 20.4. Use a calibrated 480 Pulser to aid in this adjustment.

5. Move the input connection for the MCA to the output of the 408A Biased Amplifier as shown by the solid line in Fig. 20.3. Leave the MCA Gate toggle switch at Off to permit calibration of the surface barrier detector side of the circuit.

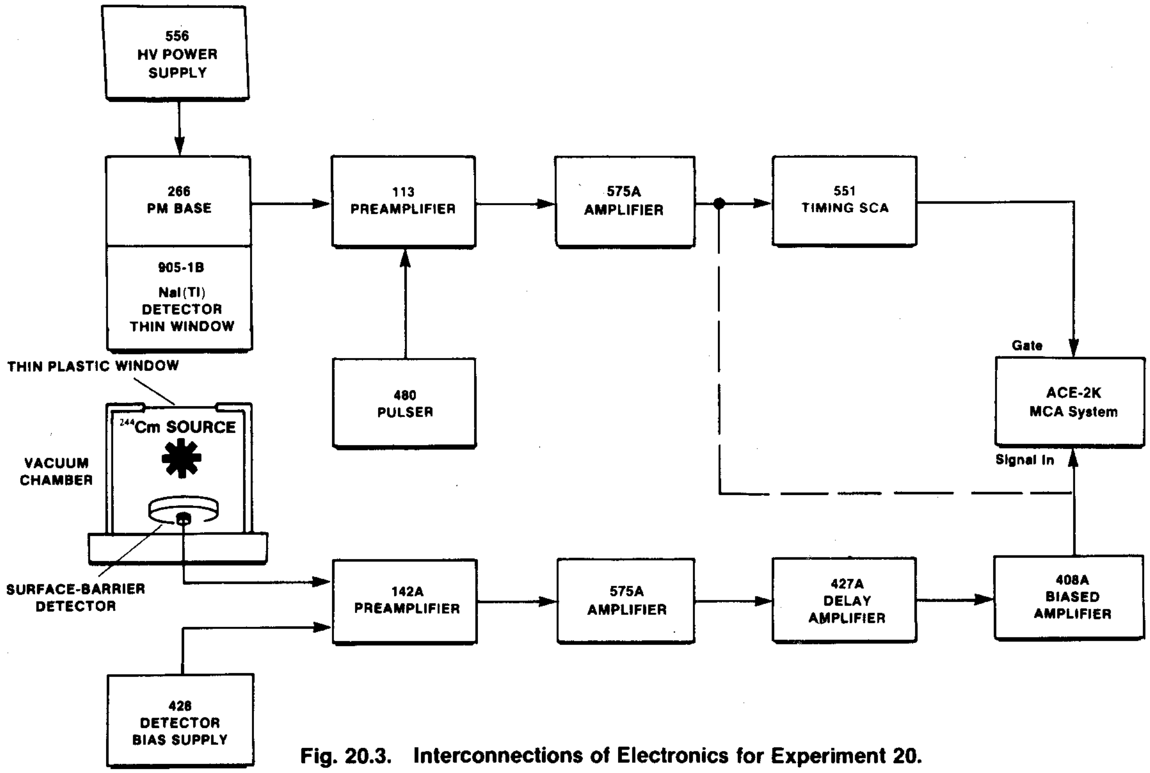

Fig. 20.3. Interconnections of Electronics for Experiment 20.

Remove the coincidence gate Input to the MCA as shown in Fig. 20.3. This allows for calibration of the surface barrier detector with the ^{244}Cm lines.

6. Increase the 428 level slowly to the bias that is required for the surface barrier detector. Adjust the gain of the 575 Amplifier and the 408A Biased Amplifier on the surface barrier detector side of the circuit to obtain the alpha spectrum, similar to Fig. 20.2, in the MCA.

7. Reconnect the coincidence gate Input to the MCA.

8. Accumulate a spectrum on the MCA long enough to clearly see that the 5.806-MeV alpha is no longer present in the spectrum. The resulting spectrum should resemble Fig. 20.5 because the 5.763-MeV alphas are in coincidence with the x rays and will be present in the spectrum but the 5.806-MeV alphas are not in coincidence with the x rays and are therefore not present in the spectrum.

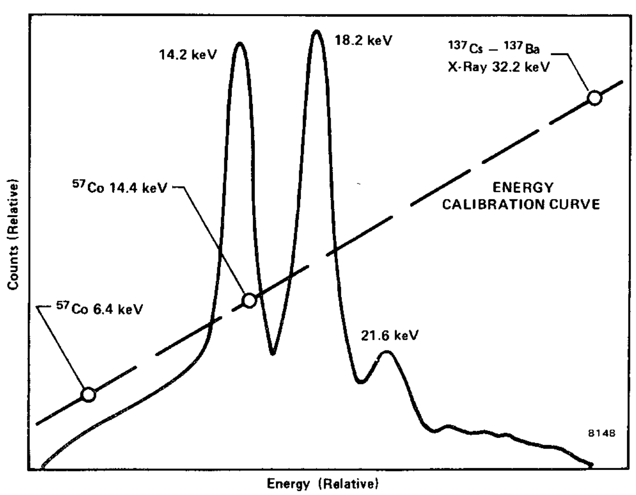

Fig. 20.4. Thin-Window NaI(Tl) Spectrum of ^{244}Cm.

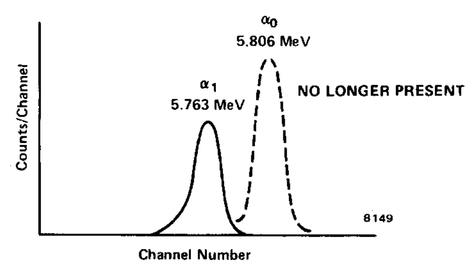

Fig. 20.5. Alpha Spectrum for ^{244}Cm with X-Ray Coincidence Requirement.

References

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