Analysis of γ ray spectra with MCA

PH3105

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Debayan Sarkar
22MS002

Diptanuj Sarkar
22MS038

Sabarno Saha
22MS037

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I. Introduction

In this experiment, we perform γ ray epectroscopy using a scintillation detector and then measure the pulse heights using a multi channel analyser. In the previous experiment we used a single channel analyser by varying the window and baseline to measure pulses within the window. The Multi Channel Analyser(MCA) measures all the pulses in all the windows at the same time.

II. Theory

We lay out, in brief, the theory behind the decay of the radioactive sources that produce the γ rays in our interaction, and the Multi Channel analyser.

II.1. Decay Scheme of $^{137}_{55}$Cs and $^{137}_{55}$Co

We detail the γ ray decay scheme of the $^{137}_{55}$Cs and $^{60}_{27}$Co, both of which we will use in the experiment.

II.1.A. Decay scheme for $^{137}_{55}$Cs

Caesium-137 ($^{137}_{55}$Cs) or radiocaesium, is a radioactive isotope of caesium that is formed as one of the more common fission products by the nuclear fission of uranium-235. The decay scheme for the $^{137}_{55}$Cs is given in the schema below.

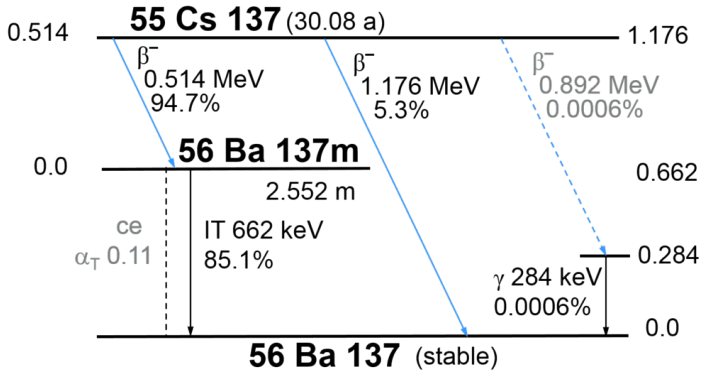

Figure 1 :: Decay scheme of $^{137}_{55}$Cs into $^{137}_{56}$Ba (Source: The Internet)

There are three decay schemes for $^{137}_{55}$Cs decaying into $^{137}_{56}$Ba. The most observed ones are the β decay into $^{137m}_{56}$Ba and then γ decay into $^{137}_{56}$Ba, and the direct β decay into $^{137}_{56}$Ba. We are observing the γ ray spectrum for the γ ray emitted on transition from $^{137m}_{56}$Ba to $^{137}_{56}$Ba. The 'm' in $^{137m}_{56}$Ba stands for metastable or unstable. The third decay scheme occurs only 0.0006% of the time, so, we can safely ignore that.

The decay leaves 94.7% of the parent Caesium nuclei into the metastable $^{137m}_{56}$Ba nucleus via a β^- ray interaction and the release of an anti-neutrino. Then a γ ray decay of energy 662 keV converts the metastable nuclei into the the ground state $^{137}_{56}$Ba. The nuclear reactions are written below.

$$^{137}_{55}\text{Cs} \longrightarrow {}^{137m}_{56}\text{Ba} + e^- + \overline{\nu}_e \longrightarrow {}^{137}_{56}\text{Ba} + e^- + \overline{\nu}_e + \gamma(661.65keV) \qquad [1]$$

II.1.B. Decay scheme for $^{60}_{27}$Co

Cobalt-60 ($^{60}_{27}$Co) is a synthetic radioactive isotope of cobalt with a half-life of 5.2714 years. It is produced artificially in nuclear reactors.

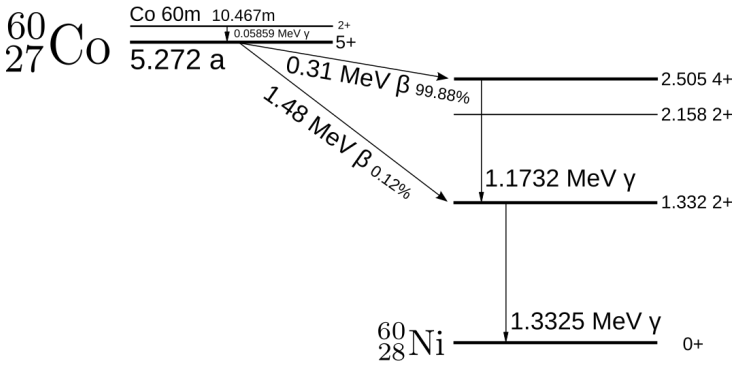

Figure 2 :: Decay scheme of $^{60}_{27}$Co into $^{60}_{28}$Ni (Source: The Internet)

This is produced on activation of $^{59}_{27}$Co via neutron activation. The dominant interaction here is a β^- decay to a intermediate state and then two consecutive γ ray decays to get to $^{60}_{28}$Ni. Then we get a multistep decay from $^{59}_{27}$Co to $^{60}_{28}$Ni. We observe a multistep decay due to some selection rules that do not allow transitions to certain states to take place. We thus get the following decay processes

$$^{59}_{27}\mathrm{Co} + n \longrightarrow {}^{60}_{27}\mathrm{Co} \quad [2]$$

$$^{60}_{27}\mathrm{Co} \longrightarrow {}^{60}_{28}\mathrm{Ni}^* + e^- + \overline{\nu}_e \longrightarrow {}^{60}_{28}\mathrm{Ni}^* + e^- + \overline{\nu}_e + \gamma(1.173MeV) + \gamma(1.333MeV) \quad [3]$$

II.2. Multi Channel Analyser

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