Gamma Gamma Coincidence

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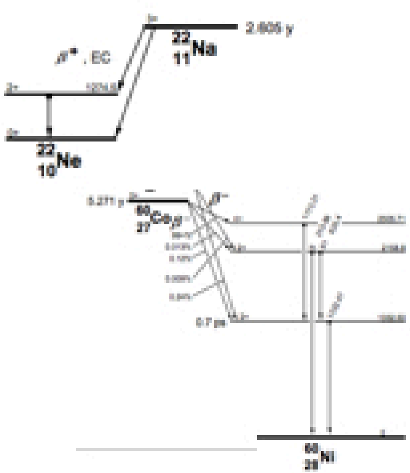
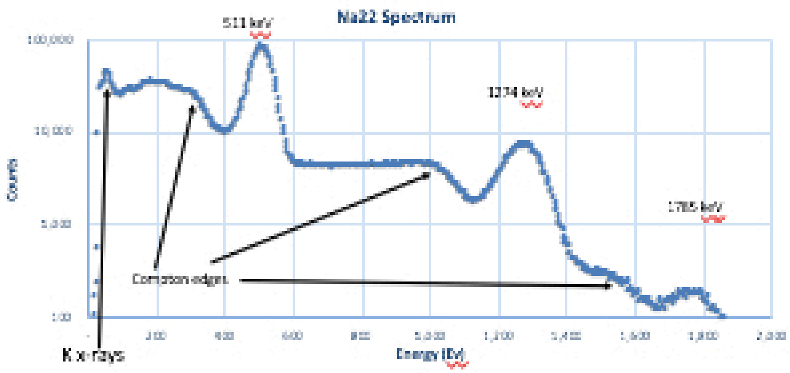
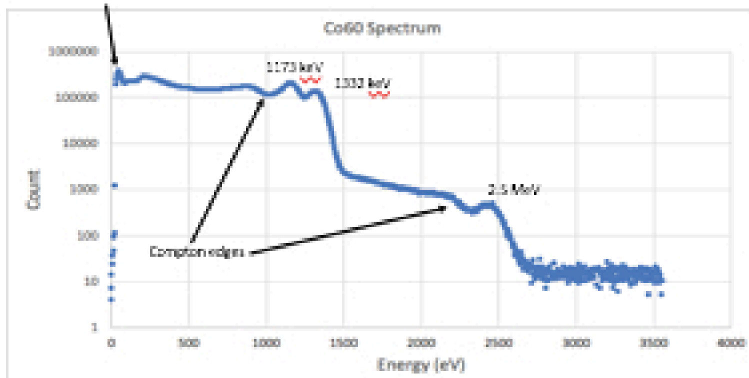
Production of Gammas

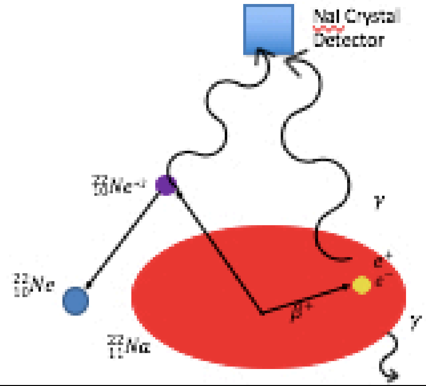
Gamma Gamma Coincidence is an unusual occurrence when two gamma rays with the same energy are detected at the same time. These gamma rays are produced in many different forms. Decay mechanisms from radioactive samples are a great way to produce a lot of gamma rays. These decay mechanisms include beta plus and minus decays, and gamma decay. Gamma rays can also come from electron-positron annihilation, electron capture, and Compton scattering. I detect these gammas from a NaI crystal detector which produces a spectrum of gammas.

Radioactive Decay Chains



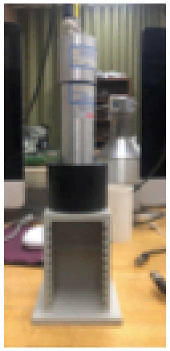




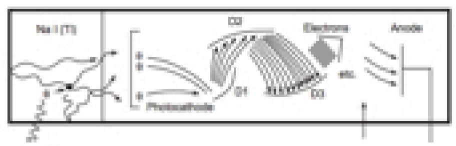


Detection

Above the radioactive sample is a sodium iodine crystal detector inside of a photomultiplier tube(PMT). All of which is inside aluminum reflectors to minimize leakage. Gamma rays come into the crystal after interactions with matter, like the photoelectric effect, Compton scattering, or pair production.

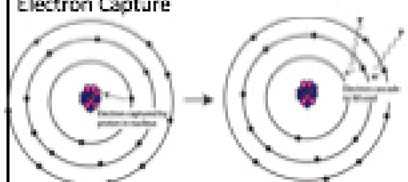


These gammas hit the photocathode in the PMT and are accelerated to charged dynodes in the PMT where they produce more and more photoelectrons. This process is called scintillation. All these photoelectrons are collected at the anode and produce an electric current that is measured and displayed on an energy spectrum.

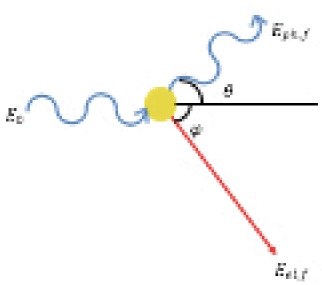


Gamma Production

Electron Capture



Compton scattering



Electron-Positron Annihilation:

Before:

After:

Results

Detecting these two gammas at the same time, within the time resolution of the detector, can be extremely helpful and can tell us a lot about the material. When talking about radioactive sources we always want to know the activity of a source. Finding the activity I used the follow equation:

$$A_s = A\frac{\pi r^2}{4\pi d^2}f_\gamma \varepsilon$$

Which uses the detector efficiency. Rather than finding the detector efficiency line for the NaI crystal for each energy, I can use the sum peak in my calculations to get rid of the detector efficiency in my calculations. I am able to use the sum peak to find the absolute activity of the gamma source, which I found to be 8.39 μCi.

References

Moura, [illegible]. "[illegible] Angular Correlation in $\gamma - \gamma$ Coincidence: A Quantitative Study" American Journal of Physics, [illegible]

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