SUPER LOW ENERGY GAMMA RADIATION DETECTION

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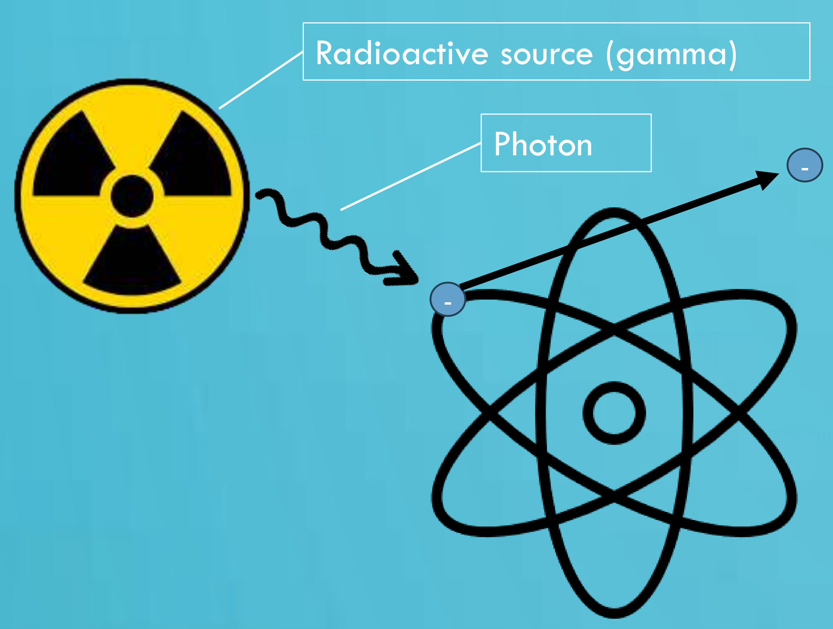
GAMMA RADIATION INTERACTIONS WITH MATTER.

For gamma detection there are two main interactions to consider for energys below 5 MeV, the photoelectric effect and the Compton effect.

PHOTOELECTRIC EFFECT



The photoelectric effect happens when a photon interacts with an electron and transfer **ALL** of its energy to the electron, ejecting it from the atom it was bond with. The photon energy is transformed into kinetic energy of the electron, but not all of it, a part of the energy is used to remove the electron from the atom, this energy is equivalente to the work function of the material, which is basically the bonding energy of the electron with the nucleus.

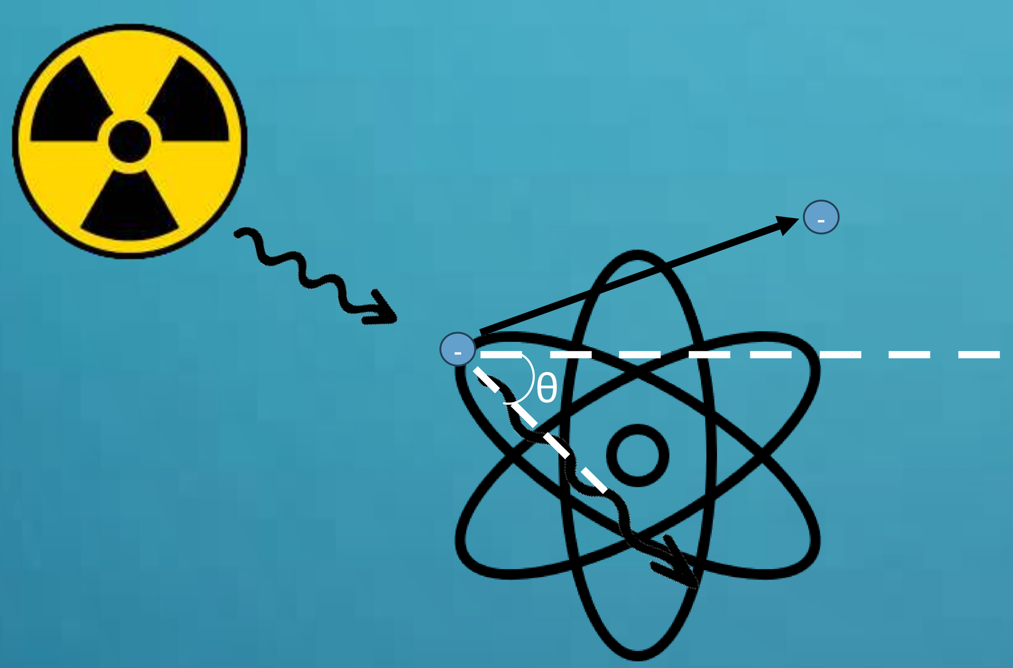
$E_p = h \cdot f$

E_p = Photon energy
h = Planck constant
f = Photon frequency

$KE_e = E_p - \Phi$

KE_e = Kinetic energy of the eletron
Φ = Work function of material

COMPTTON EFFECT



The Compton effect happens when the photon doesn't deposit all of its energy in the electron, only a part of it and get scattered. The scattered photon can Interact again and generate more photonelectrons. We will see why this is a big problem especially for low energy gamma radiation detection ahead.

PAIR PRODUCTION

As it can be seen on graph 2, pair production is more dominat above 5 MeV, that is many orders of magnitude above low energy, which is below 100 keV.

DETECTION

The best suited detectors for really low gamma radiation detection are semiconductors. Semiconductors are materials that have electrons in its valence band that need very little energy to jump to the conductance band. That way very low energy photons are enought to move the electron to the conductance band and we can collect this charge to measure the radiation.

Window: A barrier used to absorb unwanted radiation that could damage the detector, mostly beta and alpha particles.

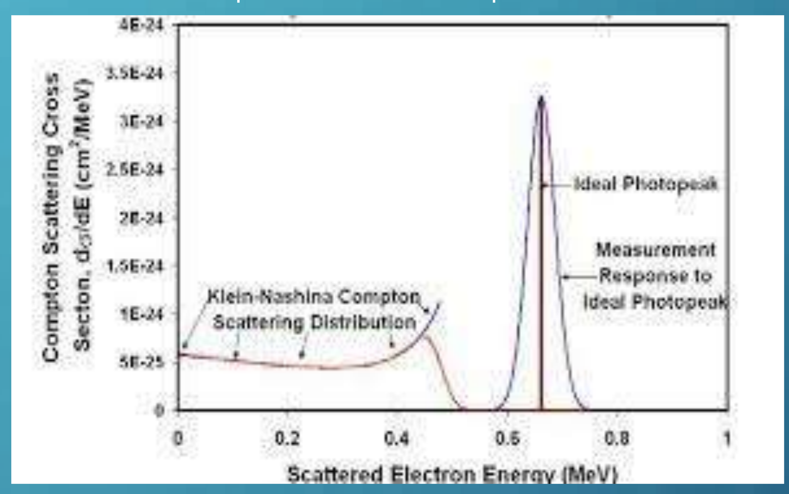
Germanium crystal: The size of the crystal is important to maximize the detector efficience. Higher crystal volume means there are a higher chance of interaction.

Diodes: After the charge is generated in the crystal the diodes collect the charges to transform it in na logical output signal. Using diodes around and in the center of the crystal enhances the charge collecting velocity.

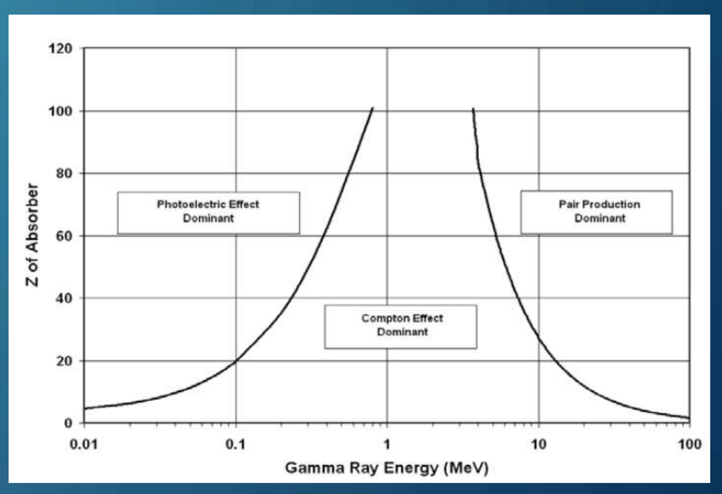
WHY LOW ENERGY IS HARD TO MEASURE

The first thing we need to have in mind is that radioactive materials are usually emiting radiation on a wide range of energys, any energy above the one we want to measure will leave a trail (Compton effect) as can be seen on graph 1.The Compton effect will build a background on the low energy ranges that will most likely cover the low energy peak.

Graph 1: Theoredical Compton effect.



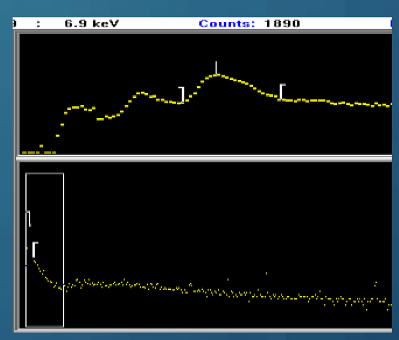
Graph 2: Gamma ray most dominant interaction with matter as a function of energy

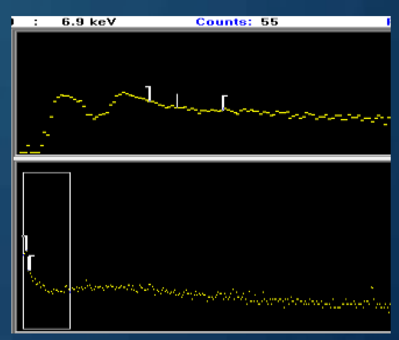


SOLUTION

To measure the low energy radiation you can't have other emitions on your source, so it's necessary to isolate the exact radioisotope that emits the low energy from every other source of radiation. This is done by shielding the detector from outside radiation, and by radiochemical separation.

EXPERIMENTAL SPECTRUM OF ^{59}NI DETERMINATION (6,9 keV)





IF YOU ARE INTERESTED

The information in the poster is very superficial, if you are interested in learning more please contact me by email or, if you're reading this in na event, I'm probably around, look for me!