Vortrag fuer Gamma Spektroskopie

Lektuere:

dieses buch

Germaniumdetektor Versuch 🡪 denk an p-n dotierung nicht so wie es scheint (mail von jens)

* Photons enter matter and interacts with free or bonded (bound) electrons, nuclei or electric fields.
* Interaction processes depending on photon energy, Z of absorber atom
* Interactions important for gamma spectroscopy:
* inner photoeffect, Compton effect, pair production/annihilation
* photon loses energy while traversing through a medium (intensity = photons / (time and area) gets lower)
* intensity loss prop. Thickness, number of electrons and cross section (sigma)
* extinction coefficient mu = (sigma \* Z \* N\_L \* rho) / (A)
* N\_L = loschmidt’sche zahl
* 1/mu = mean distance of a photon in a medium with a proton number Z, cross section sigma and density rho and atom weight A

1. PHOTO EFFECT:

* Photon with E > E\_bind of K schale electron interacts with huellen electron
* Electron leaves the atom and has the remaining photon energy as kinetic energy
* Gamma + atom -> atom^+ + electron
* E(electron) = E(photon) – E(bind)
* „loch“ is filled in from electrons from higher orbitals recursively.
* The energy difference between orbitals are characteristic and the photons released are x-rays
* Rarely: the photons leave the absorber. Often excite other electrons inside the absorber and redo the process above
* Absorptionskante: unstetige aenderung des WQ

1. COMPTON EFFECT:

* Interaction of a photon with free pointlike electron
* Inelastic scattering of a photon at an electron “in ruhe”
* Photon transfers some of its energy to the electron and keeps remaining E; electron now moving
* E\_l = E\_photon \* (e \* [1 – cos phi] ) / (1 + e \* [1 – cos phi])
* E\_l = E electron after scattering
* e = E\_gamma / m\_0 \* c^2, m\_0 = electron mass
* E\_(l,max) = E\_gamma \* (2e / 1 + 2e) for phi = 180 deg (rueckstreuung)
* -> bad to have: only a fraction of E measured, cannot view full spectrum
* Non-isotropic angular distribution
* For small e (feasible since keV) thomson’sche streuquerschnitt sigma\_th = 8/3 \* pi \* r\_e^2 (r\_e = classic electronradius)
* d(sigma) / dE = … (show plot)

1. PAIR PRODUCTION:

* If E\_gamma > 2 \* m\_0 c^2 (photon can produce two leptons with electron mass -> electron positron pair)
* Pair production can only occur in the proximity of a nucleus or any other scattering partner to take the momentum from the gamma
* Why? Look at restframe photon mass = 0, 2e mass > 0 therefore created in nucleus
* Also possible if photon scatters at an electron -> need 4 m\_0 c^2
* Cross section depends on where pair production happens (K schale much coulomb field rejection, outer: other shielding effects)
* Low photon energy around core (coulomb case) 10 to 25 MeV photon energy:
* Sigma = alpha \* r\_e^2 \* z^2 (28/9 \* ln(2e) – 218/27)
* Full shielding out oft the electron huelle with E\_photon > 500 MeV
* Sigma = const1 \* (const2 \* ln(183/cuberoot(z)) – 2/27), constants from sigma term above
* E\_photon line only when e+e- pair fully absorbed, possible that one or both escape
* Also lines at E\_photon – m\_0c^2 and E\_photon – 2 \* m\_0c^2
* Escaping leptons may do bremsstrahlung (accelerated particles emit radiation tangential to the acceleration)
* Annihilation peak = 511 keV (electron mass) or 1022 keV because of 2 electrons

1. How to detect gamma radiation? germanium detector

* Ge-detector is a semi-conductor
* Must have solid detector material since we want full radiation inside detector!
* Gas is bad since absorption not enough and photons or particles will escape with part of the energy
* Electron-hole pairs must be converted to electric signal -> supply electric field and sweep the particles out (only suitable if the material has electrical properties) that’s why semi-conductor
* Or use scintillators -> trap photons and use SiPMs

1. Band structure of solids (uff…)

* Electrons are in discrete/precise energy bands, each with fixed number of electrons
* Valence band: most outer band, for chemical reactions, most inhibited
* Electrons must move between bands to migrate inside the material

Insulator: full valence band, huge forbidden region (band gap E\_g 10 eV) to conduction band, no electrical current possible because electrons are immobile

Conductor: valence band not full, continuous with conduction band which is never empty, electrical field causes current to flow

Semiconductor: similar to insulator but band gap much smaller (roughly 1 eV), small amount of electrons in conduction band, limited conductivity. Electron migrating to conduction band goes up with Temperature T rising, down when cooled -> p(T) approx.. T^(3/2) \* exp(-E\_g/2 \* k\_b \* T)

Creating of charged carriers by gamma radiation