Compton Scattering.

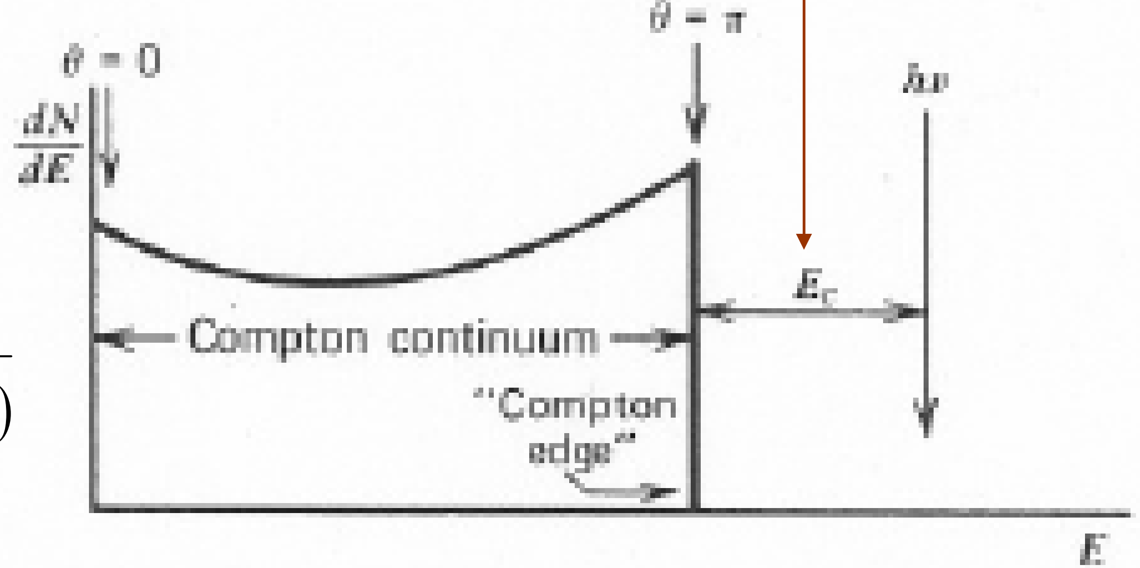
$$h\nu' = \frac{h\nu}{1 + \frac{h\nu}{m_0 c^2}\left(1 - \cos\theta\right)}$$

In the figure:

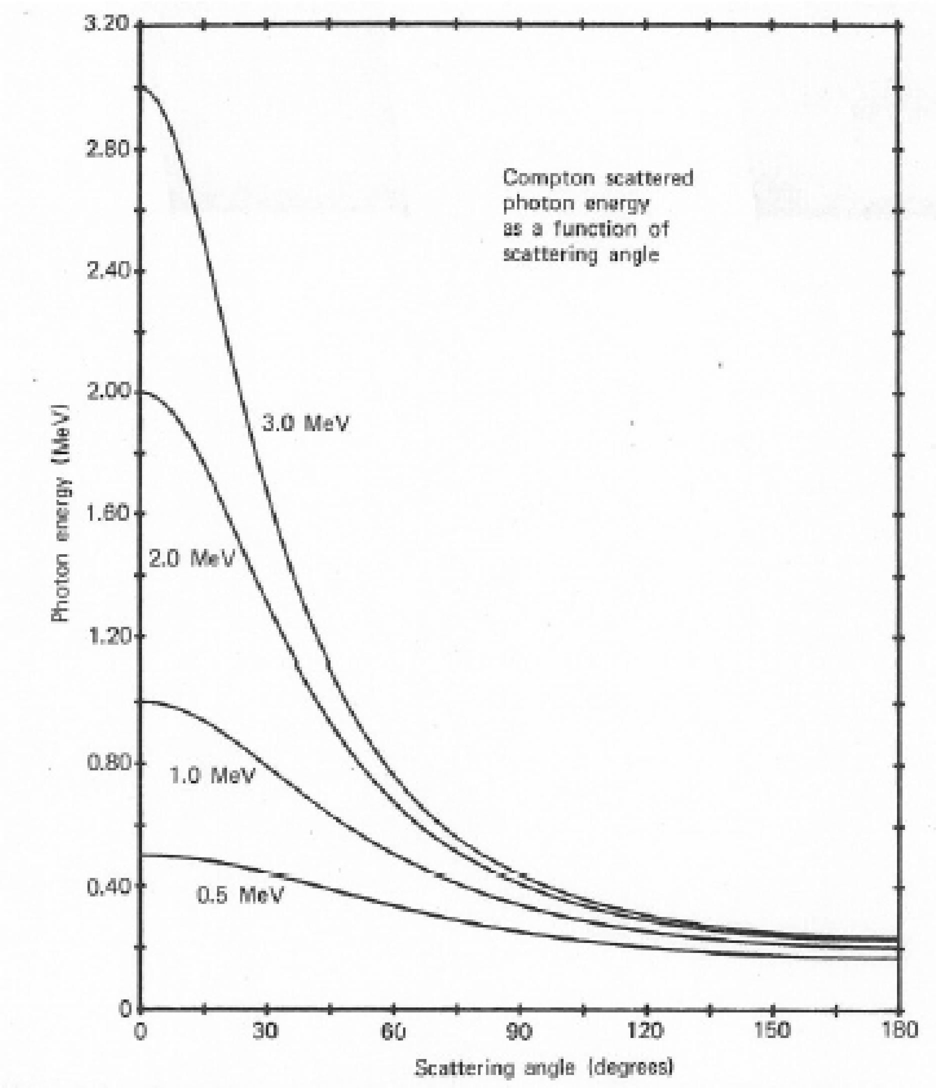
- **Photoelectric suppressed.**
- **Single Compton** (effect of crystal dimensions).
- **Below 1.022 MeV.**

$$E_c = \frac{h\nu}{1 + 2\frac{h\nu}{m_0 c^2}}$$

$$E_e = h\nu - h\nu' = h\nu \frac{\frac{h\nu}{m_0 c^2}\left(1 - \cos\theta\right)}{1 + \frac{h\nu}{m_0 c^2}\left(1 - \cos\theta\right)}$$



Principles of Spectrometry



Reproduce the graph.

$$h\nu' = \frac{h\nu}{1+\frac{h\nu}{m_0c^2}\left(1-\cos\theta\right)}$$

Principles of Spectrometry

- Compton scattering is predominant for energies typical of radioisotope sources.

HW 4

Let the recoil electron be emitted at an angle φ, calculate *cot(*φ*)* as a function of *tan(*θ*/2).*

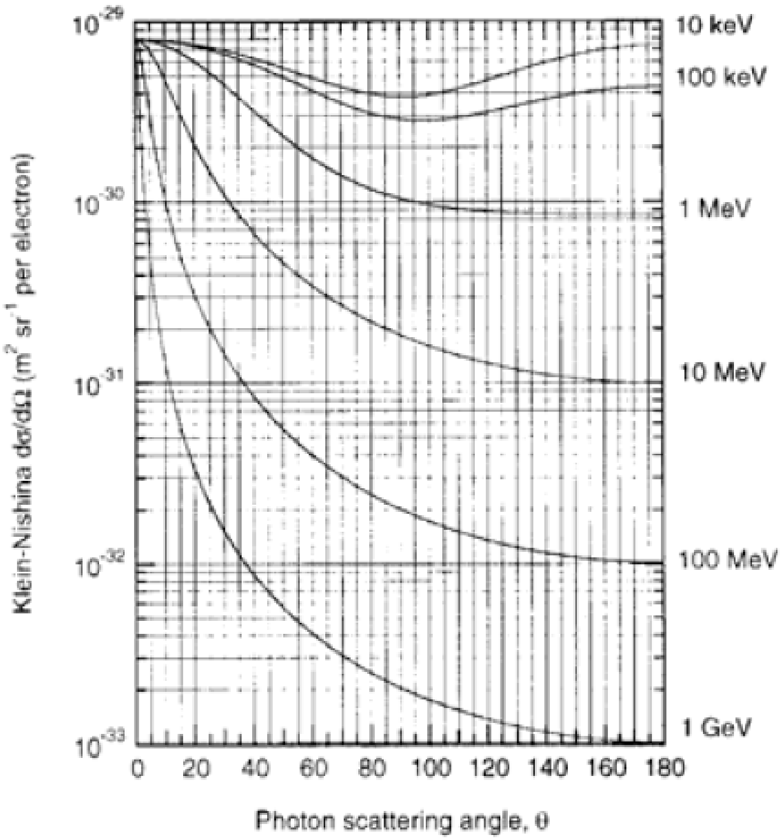
- "Probability" per **atom** increases linearly with Z (Why).
- Electron density.
- Effect of binding energy.
- Effect of polarized photons.
- Compton fraction.

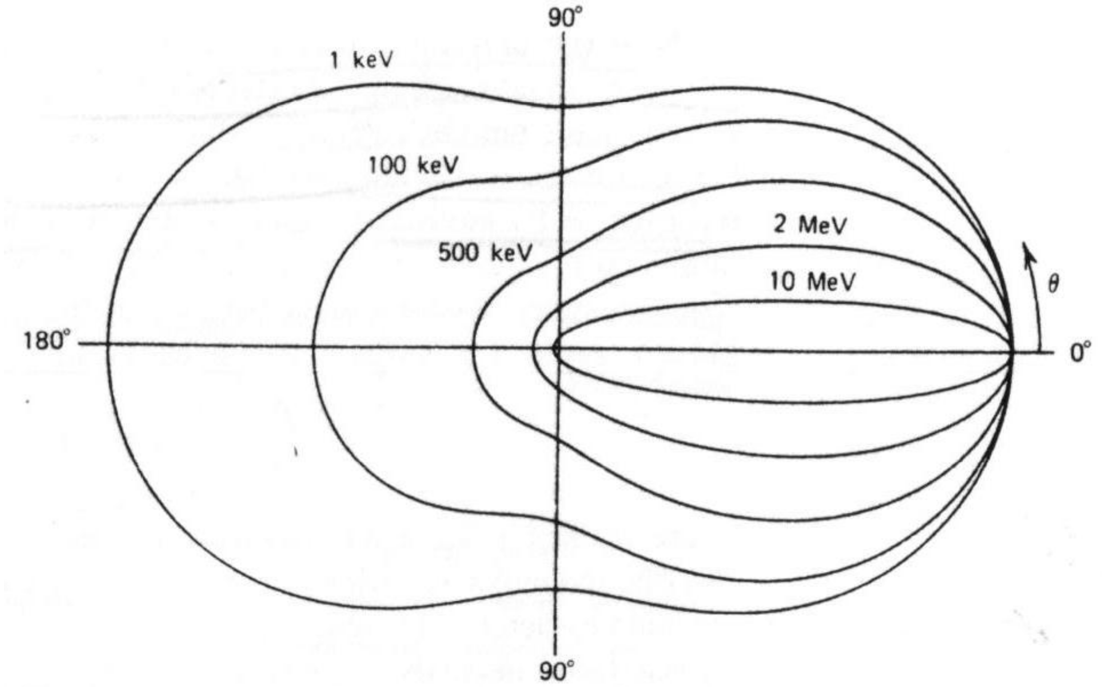
Klein-Nishina formula

$$\frac{d\sigma}{d\Omega} = Zr_0^2\left(\frac{1}{1+\alpha(1-\cos\theta)}\right)^2\left(\frac{1+\cos^2\theta}{2}\right)\left(1+\frac{\alpha^2(1-\cos\theta)^2}{(1+\cos^2\theta)[1+\alpha(1-\cos\theta)]}\right)$$

$$\alpha = \frac{h\nu}{m_0c^2}$$

HW 5 What is Thomson scattering.



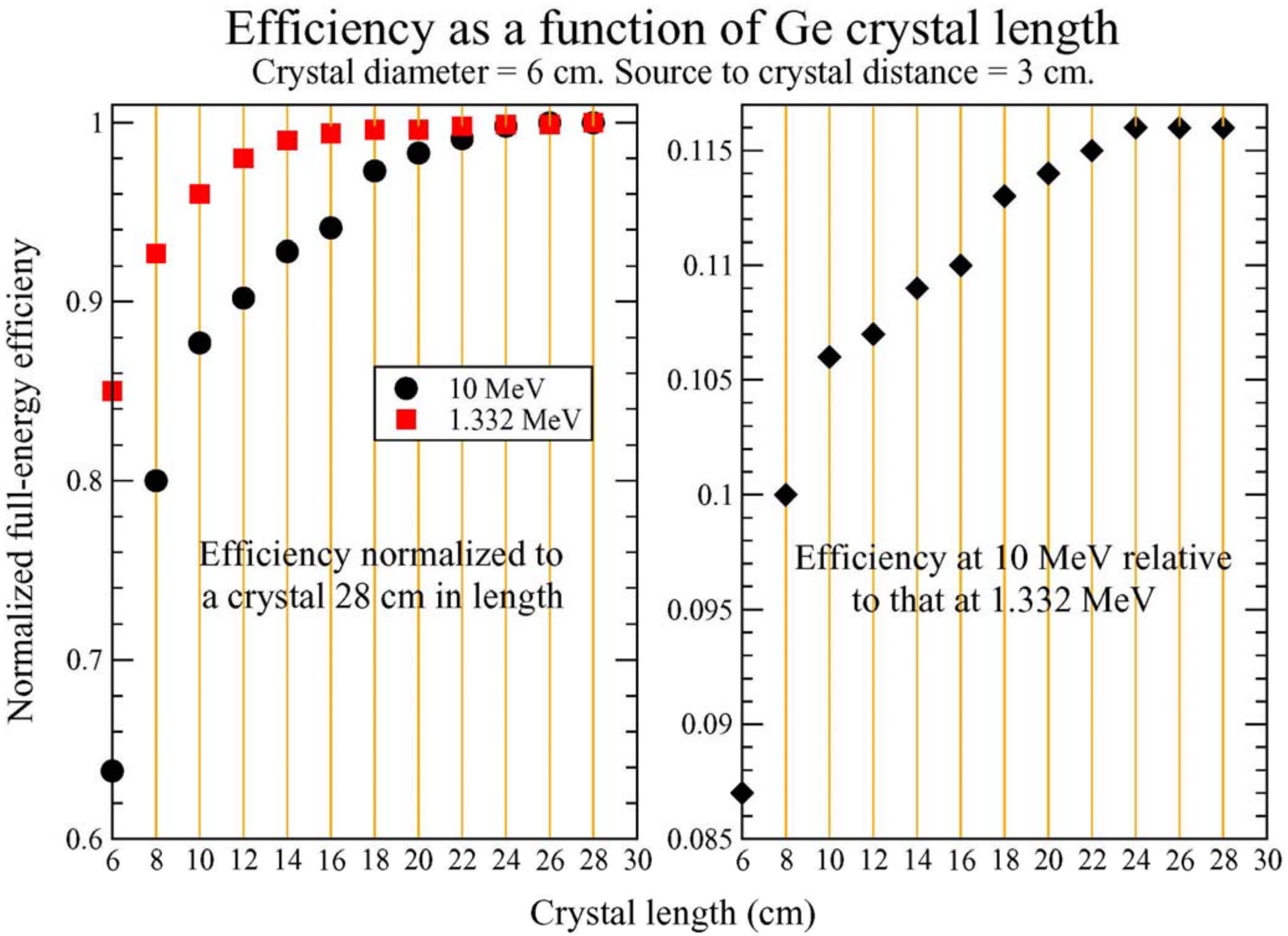


Note tendency for forward scattering at high energies.

Considerations for **shields and detectors? Sources vs. accelerators???**

Principles of Spectrometry

If you need to measure gamma ray yield from nuclear reactions (<u>using particle accelerators</u>), the photon energies could be as high as 10 MeV. What is the typical Ge detector to be used?



Prepared with Monte Carlo simulations.

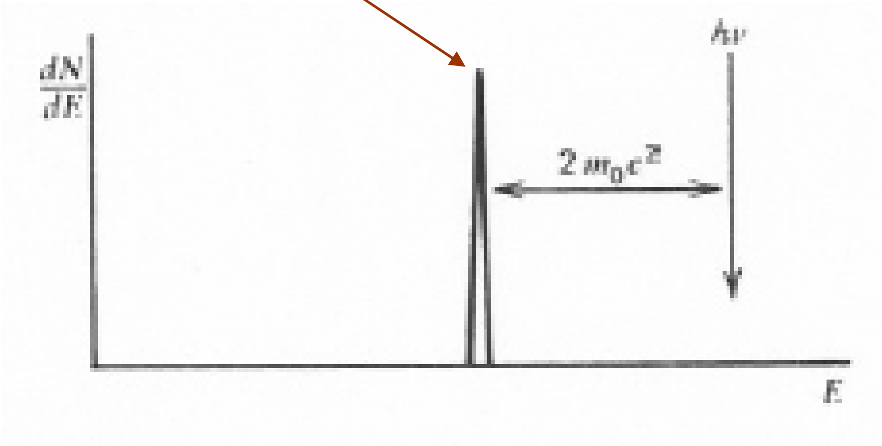
Principles of Spectrometry

Pair Production.

$$E_{e^-} + E_{e^+} = h\nu - 2m_0c^2$$

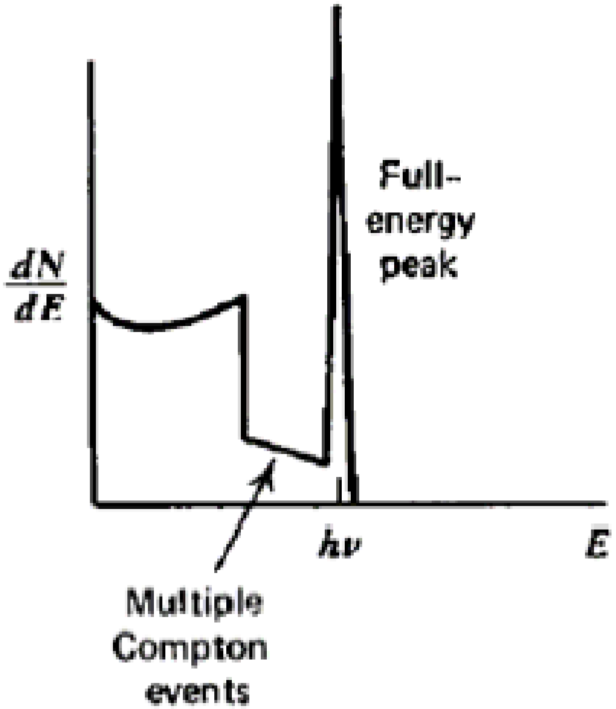
Rest mass of electron and positron. Gamma must have 1.022 MeV minimum energy for PP to occur.

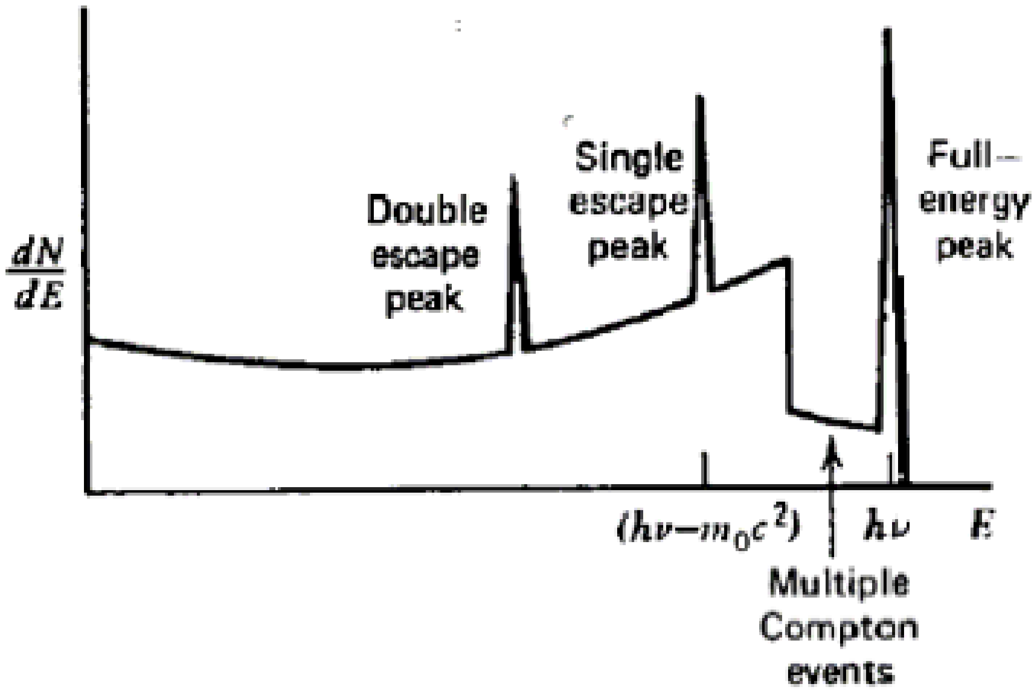
Single peak if electron and positron "kinetic" energies are captured by the detector. But annihilation!



Two annihilation photons are then created when positron recombines with an electron. These photons may or may not be captured, causing single and double escape peaks in the spectrum (effect of crystal dimensions).

Principles of Spectrometry





Low-energy gamma. **High-energy gamma.**

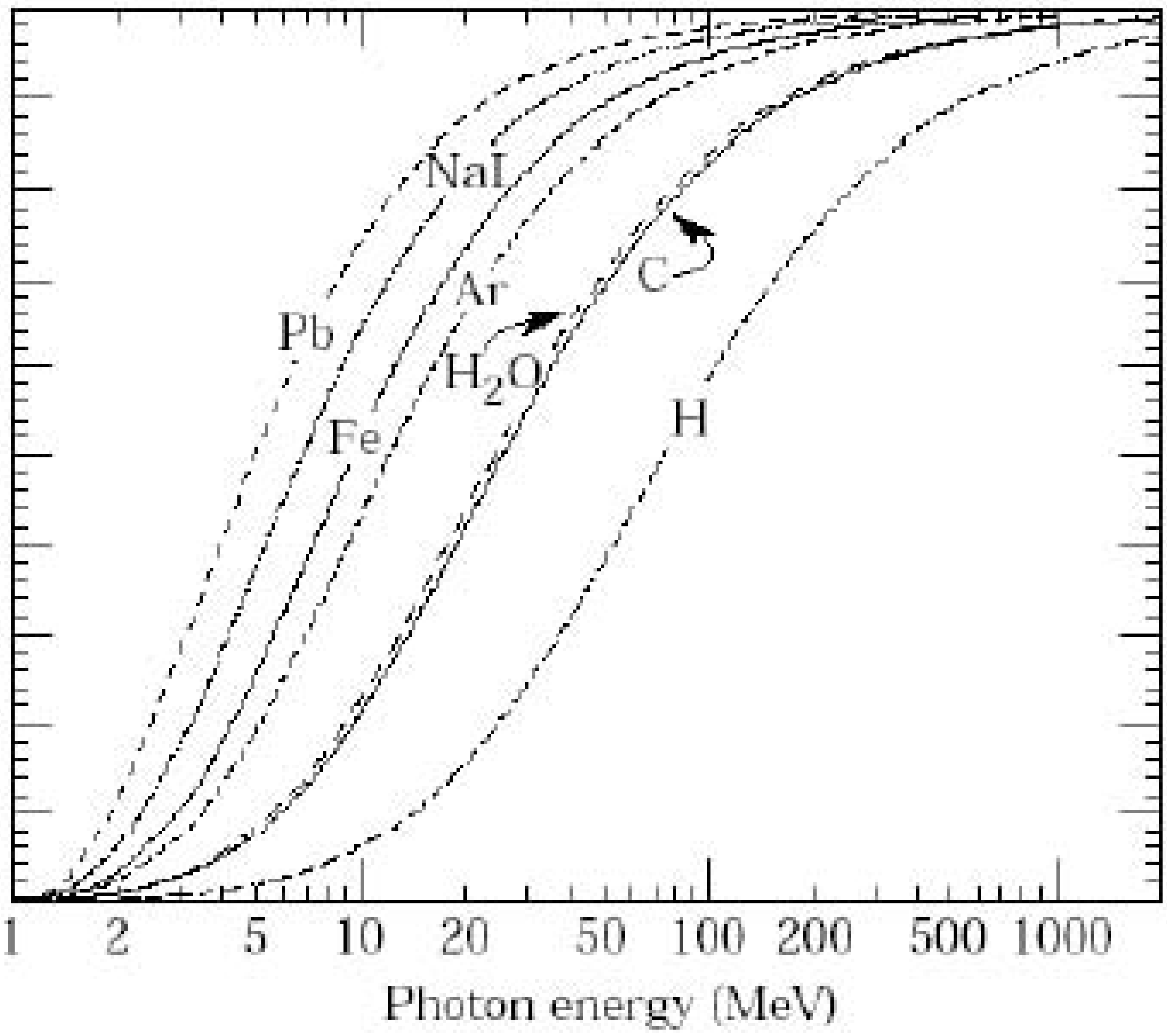
Principles of Spectrometry

Probability of pair production.
Dependence on Z?

HW 6

Recoil nucleus,
Why?

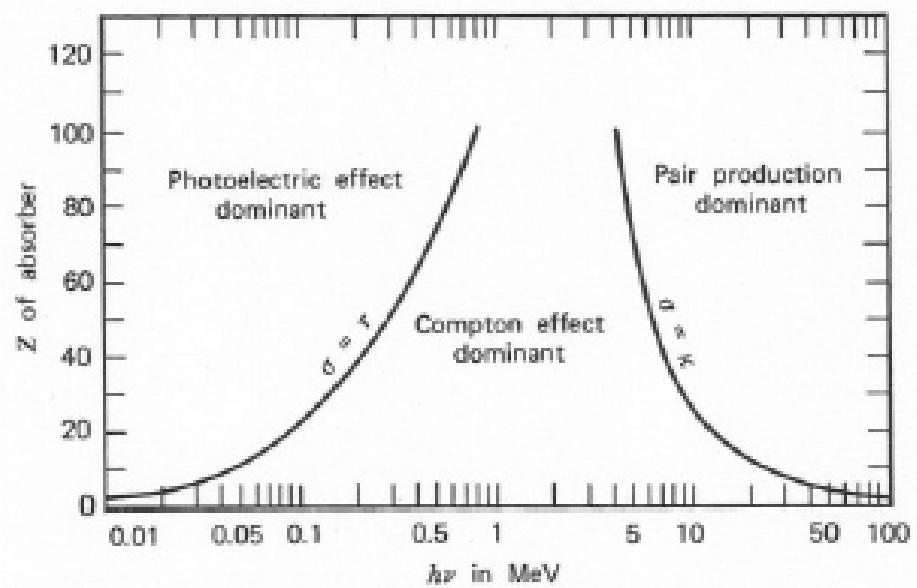
Effect of screening?



Principles of Spectrometry

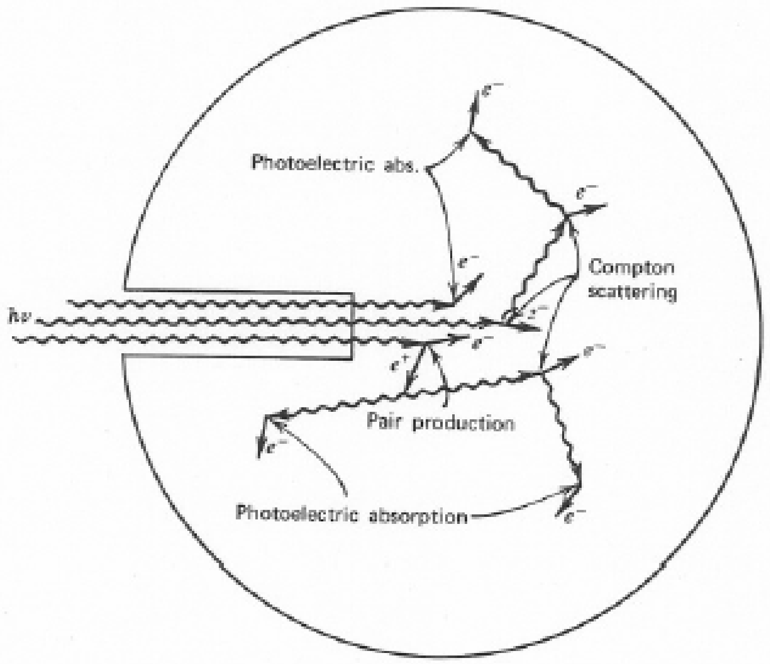
Type of interaction / Interaction with:	Absorption	Scattering: Elastic (Coherent)	Scattering: Inelastic (Incoherent)
Atomic electrons	**Photoelectric effect** $\sigma_{pe} \begin{cases} \sim Z^4 (L.E.) \\ \sim Z^5 (H.E.) \end{cases}$	Rayleigh scattering $\sigma_R \sim Z^2$ $(L.E.)$	**Compton scattering** $\sigma_C \sim Z$
Nucleus	Photonuclear reactions $(\gamma,n),(\gamma,p)$, photofission, etc. $\sigma_{ph.n.} \sim Z$ $(h\nu \geq 10MeV)$	Elastic nuclear scattering $(\gamma,\gamma) \sim Z^2$	Inelastic nuclear scattering (γ,γ')
Electric field surrounding charged particles	**Electron-positron pair production in field of nucleus,** $\sigma_{pair} \sim Z^2$ **$(h\nu > 1.02MeV)$**	Delbrück scattering	
	Electron-positron pair production in electron field, $\sigma_{trip} \sim Z^2$ **$(h\nu \geq 2.04MeV)$**		
	Nucleon-antinucleon pair production $(h\nu \geq 3$ GeV$)$		
Mesons	Photomeson production, $(h\nu \geq 150$ MeV$)$	Modified (γ,γ)	

Importance in Linacs?

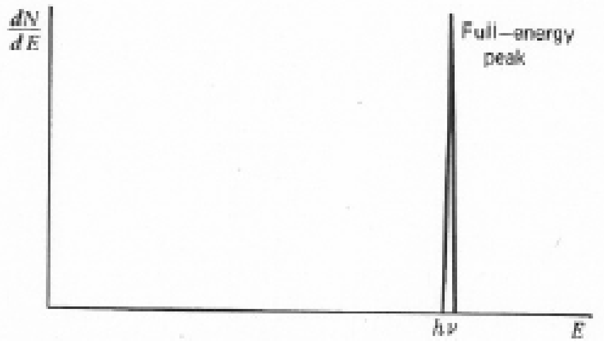


Principles of Spectrometry

Very large detector. All secondary radiation, including Compton scattered gamma rays, Bremsstrahlung, x-rays and annihilation photons, are captured in detector volume

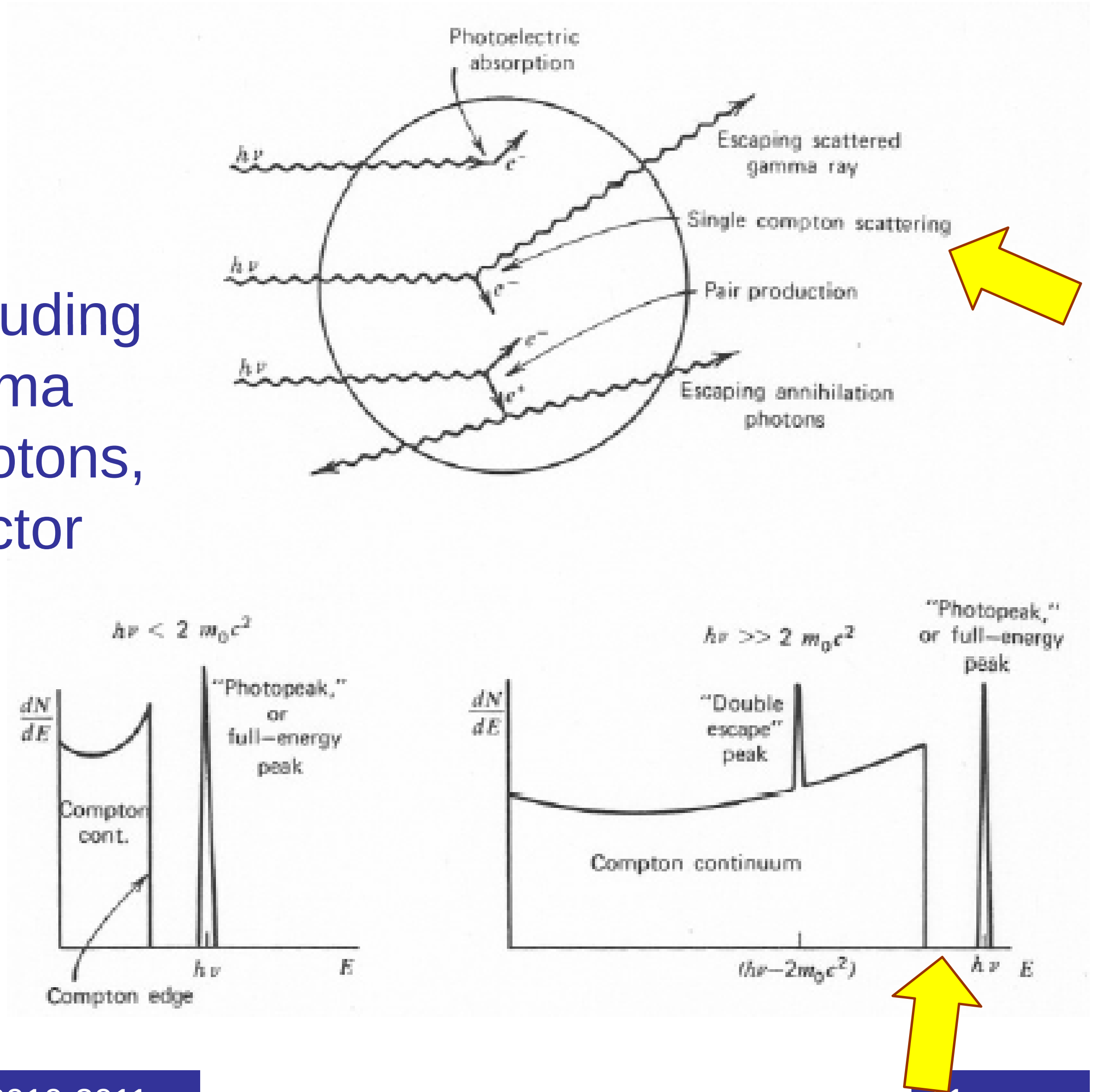


Large photofraction (fraction of full energy events) is desired in any detector



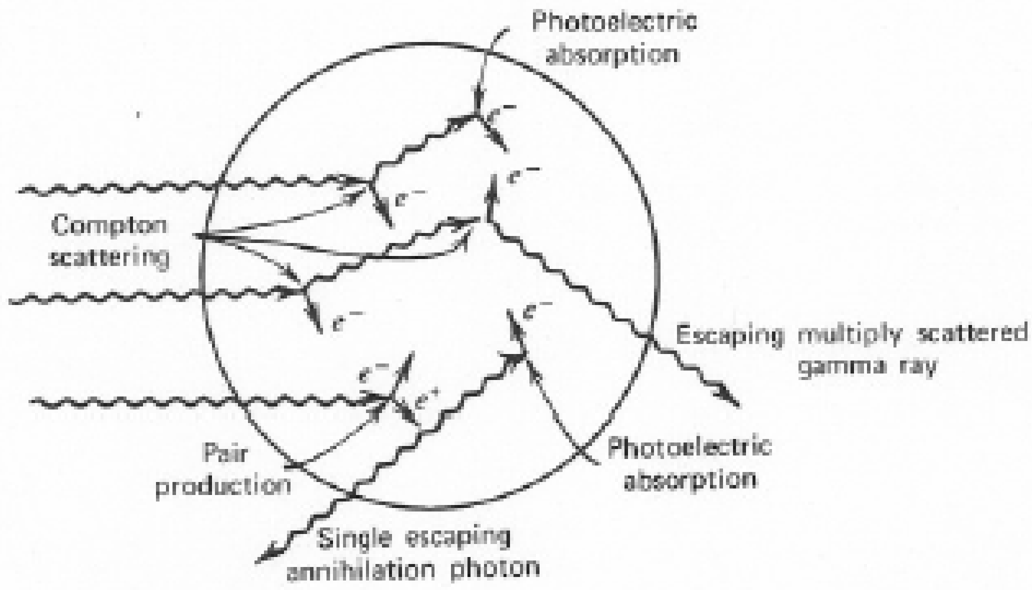
Principles of Spectrometry

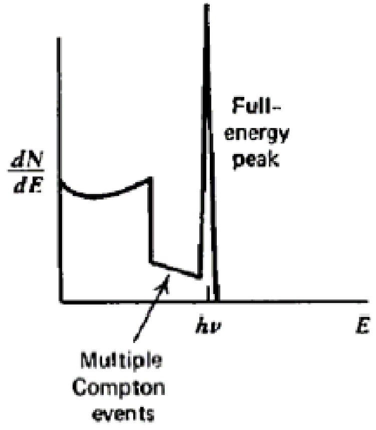
Very small detectors. All secondary radiation, including Compton scattered gamma rays and annihilation photons, are not captured in detector volume (escaping).

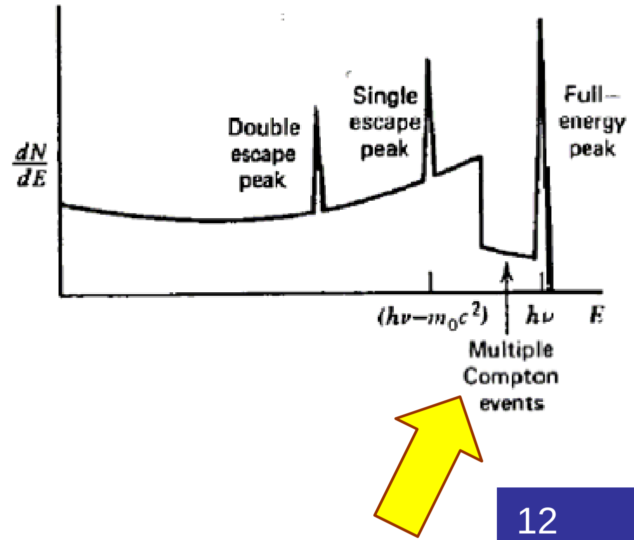


Principles of Spectrometry

A typical detector.



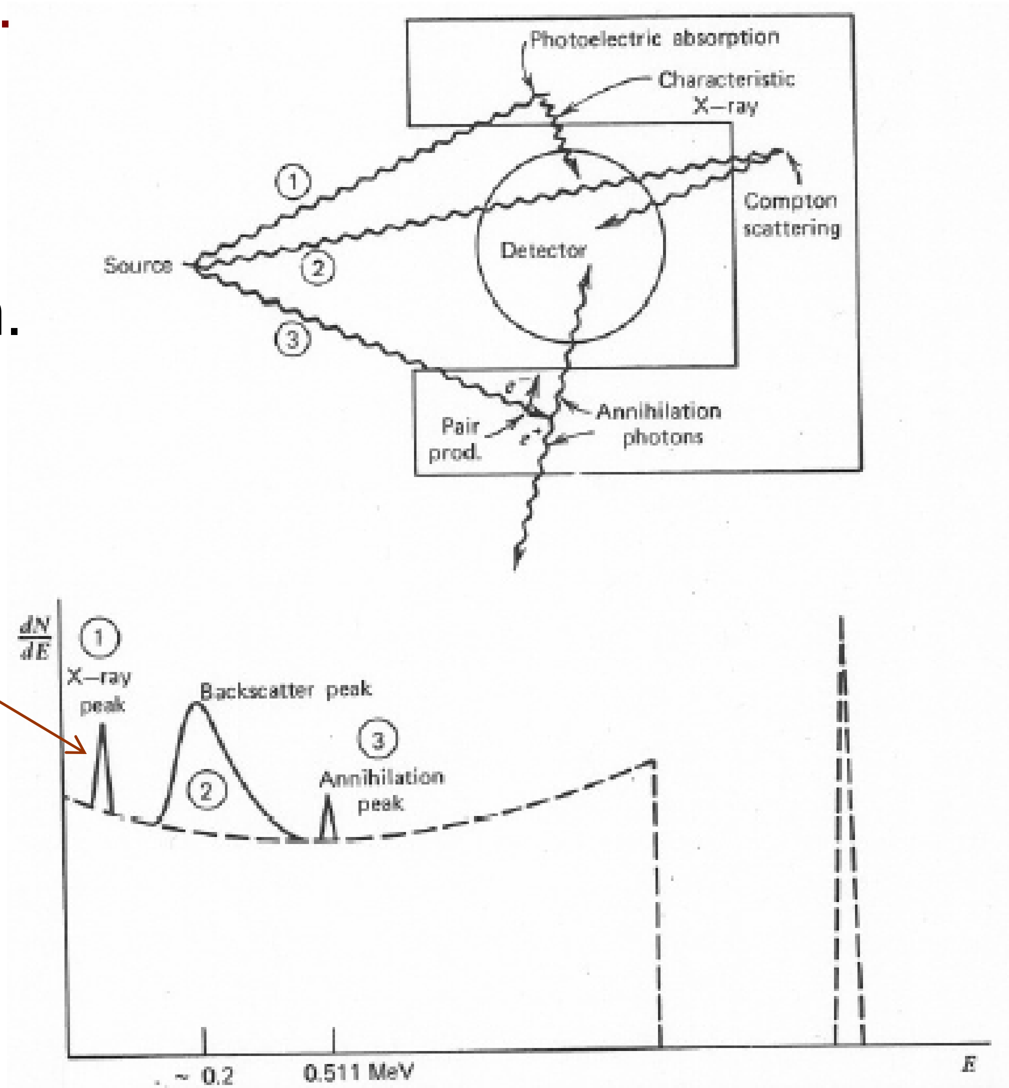




Principles of Spectrometry

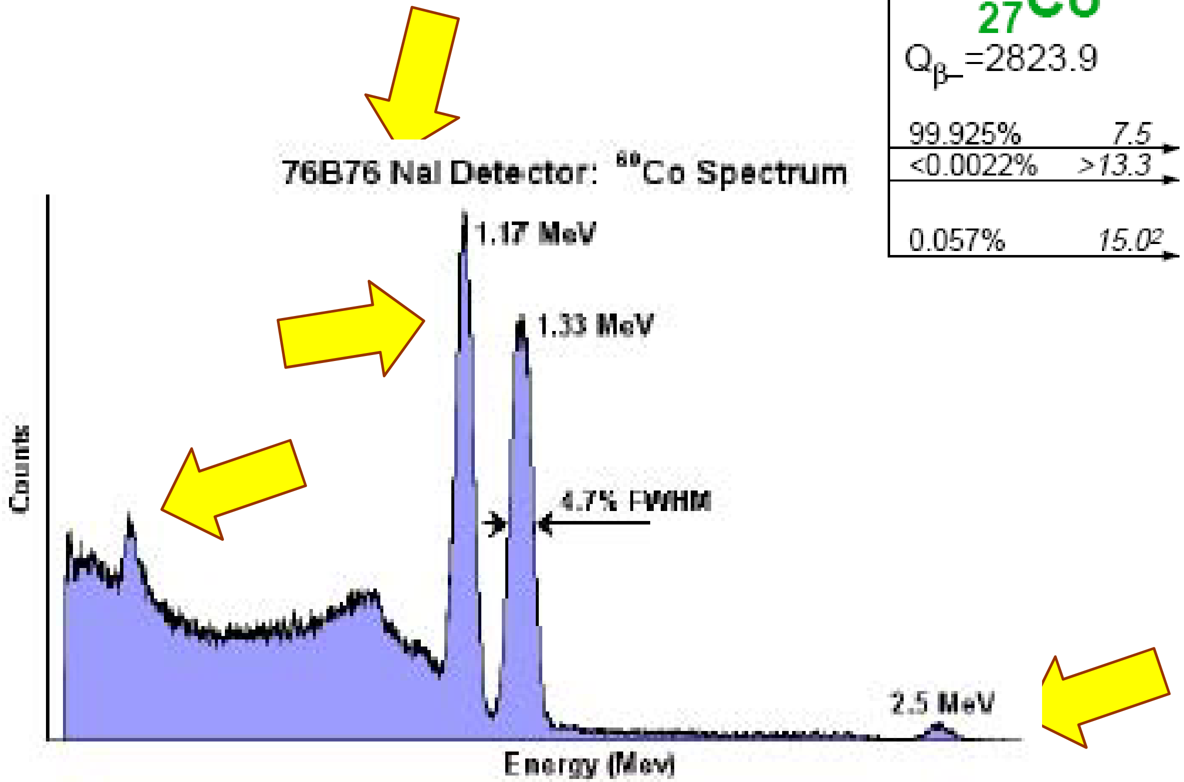
Effect of surrounding material. Detectors are normally shielded to minimize as much as possible the counting of ambient background radiation.

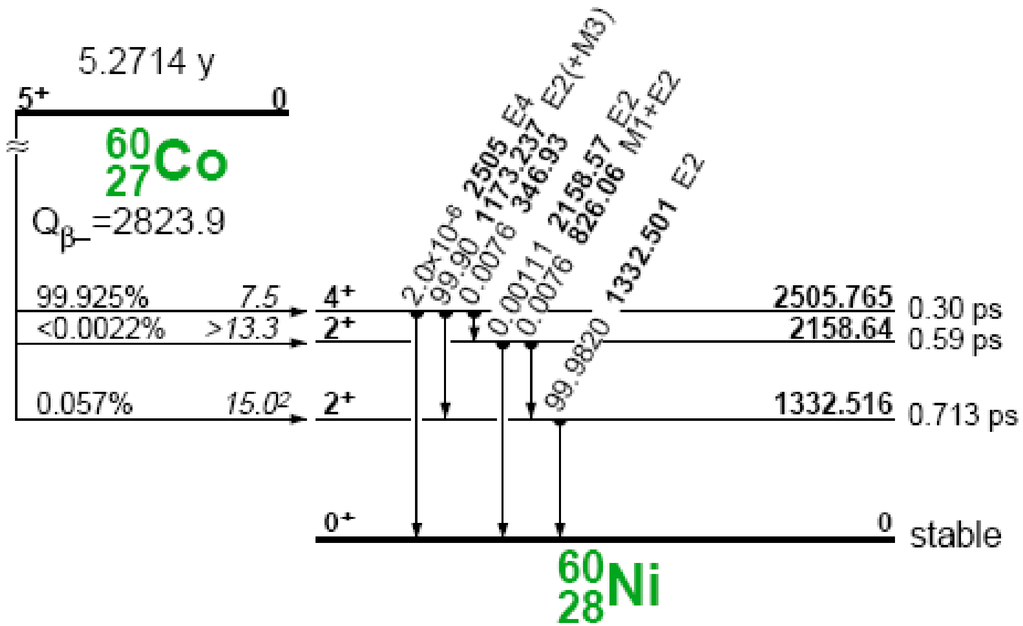
X-rays and lining.



Principles of Spectrometry

- Efficiency and resolution.
- Summing effects.





Principles of Spectrometry