Principles of Spectrometry

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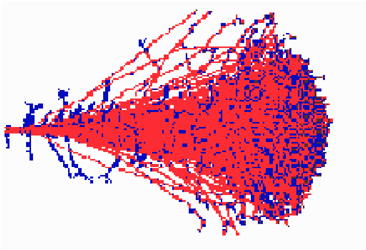
- Radiation detection requires that radiation interacts with detector material.
- Energy deposition (not all detectors…!).
- Charged particles **continuously** transfer their energy to the medium.

http://www.srim.org

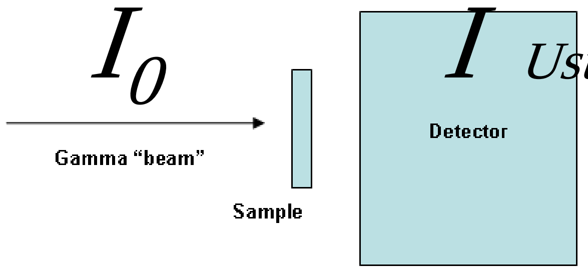


Energy Loss: Electronic or nuclear

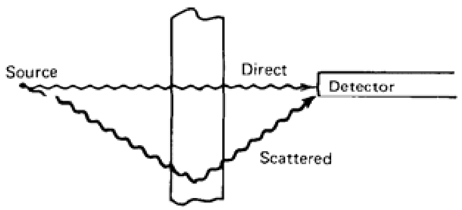
- Gammas and X-rays interact (if they do) **catastrophically.**

http://physics.nist.gov/PhysRefData/Xcom/Text/XCOM.html

Attenuation: Absorption or scattering



Usually corresponds to net area under the full energy peak.



If not, then build-up. Good or bad geometry.

- Photon interactions produce secondary electrons.
- Neutron interactions produce secondary heavy charged particles.
  Could be secondary gamma (Shielding).

Collimation.

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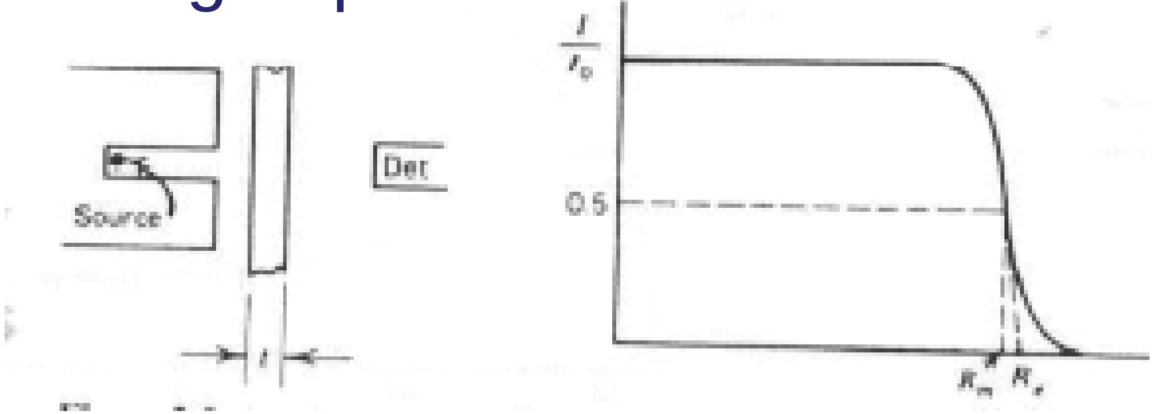
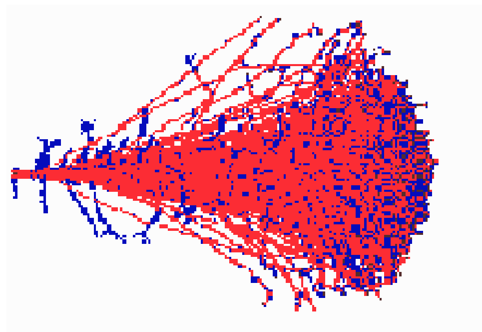
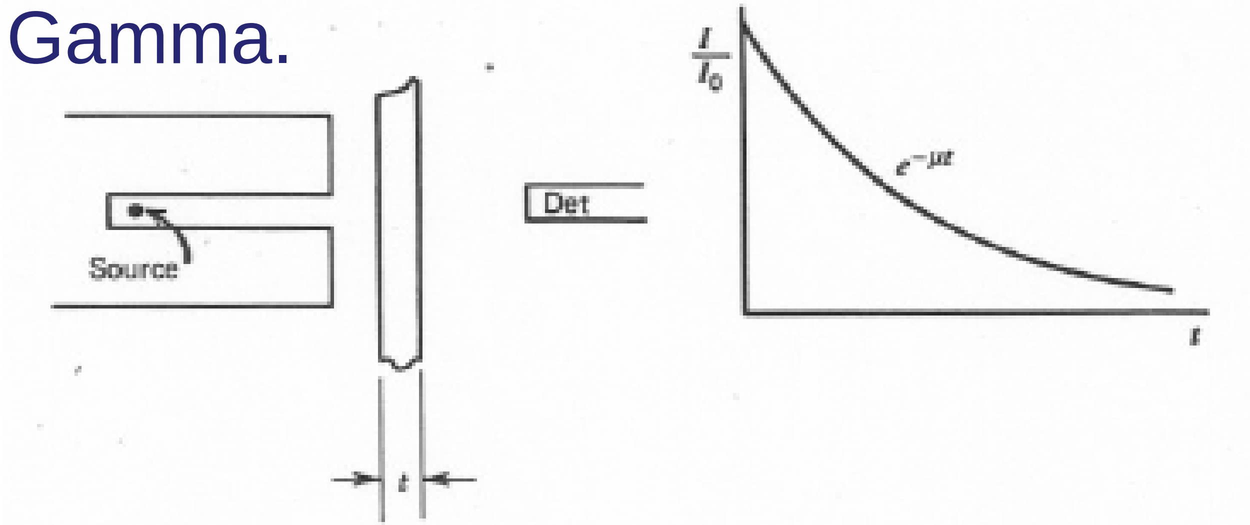
Charged particles.





Gamma.

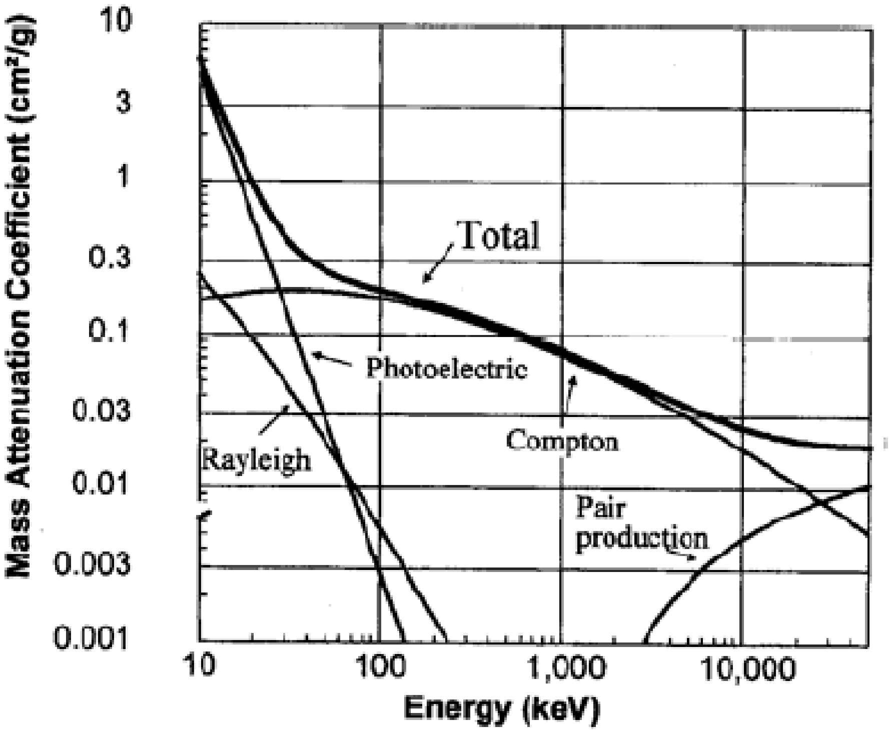


Principles of Spectrometry

Interaction of gammas

- Partial or complete transfer of photon energy to electrons.
- Many types of interactions, but three (**or four**) are important.

Mass Attenuation Coefficients for Soft Tissue



Buildup Factor

$$I = I_0 e^{-\mu x}$$

- **Attenuation coefficient and mass attenuation coefficient.**
- **Compare to macroscopic cross section Σ for neutrons.**

$$I(X) = I_0 e^{-\Sigma_t X}$$

HW 2 What is coherent scattering.

$$P_{no-interaction}(X) = e^{-\Sigma_t X}$$

$$P_{interaction}(X) = 1 - e^{-\Sigma_t X}$$

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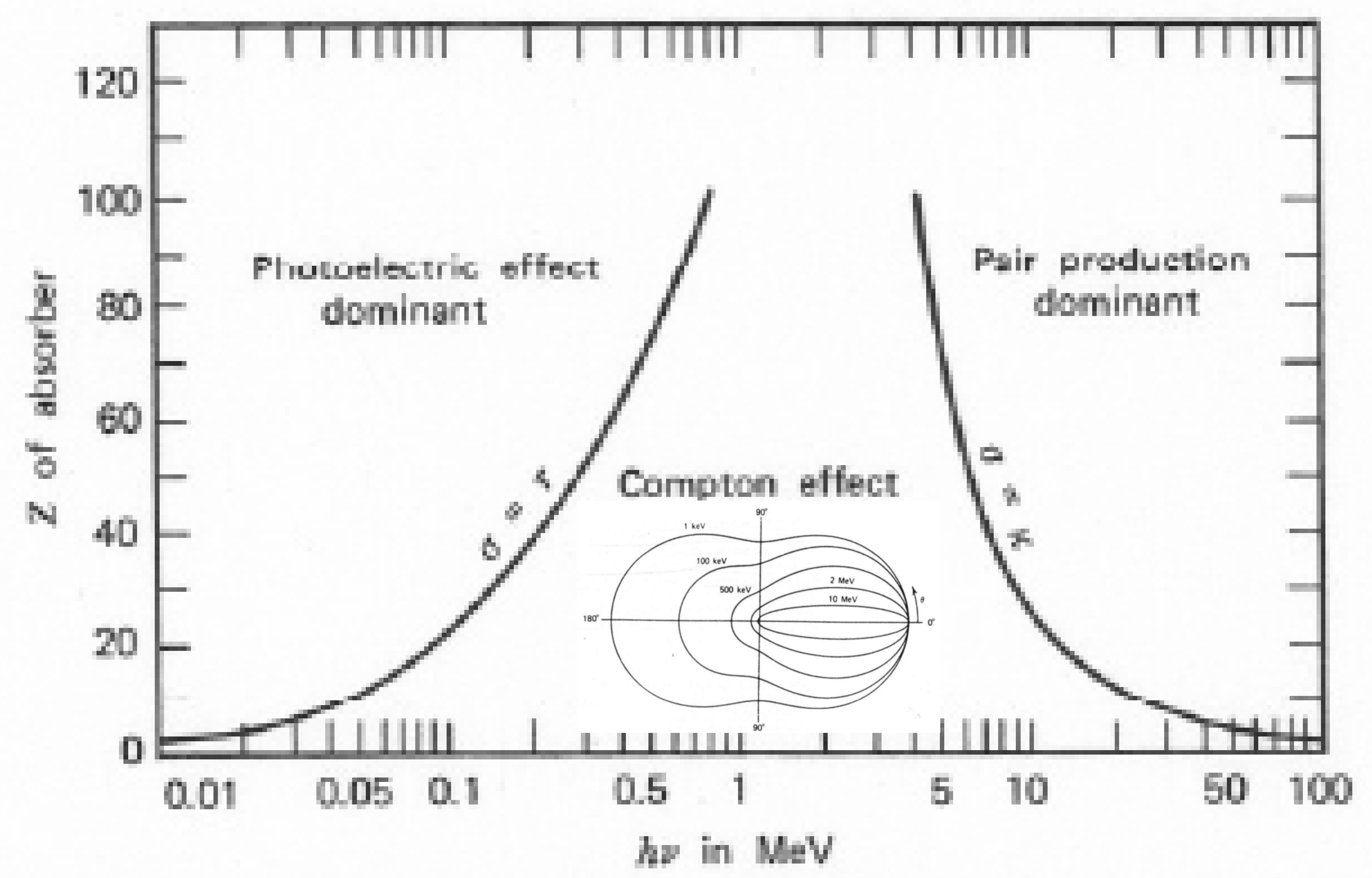
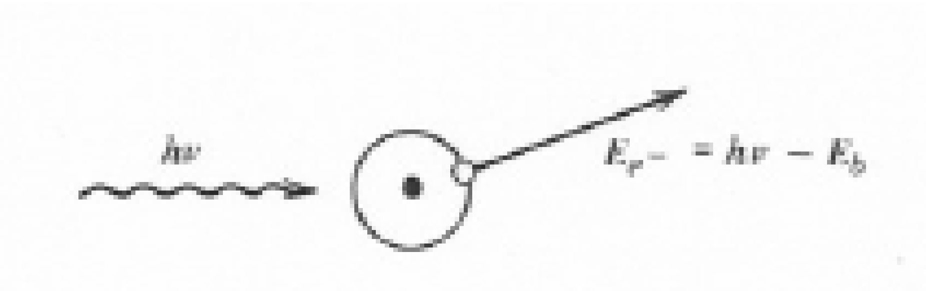
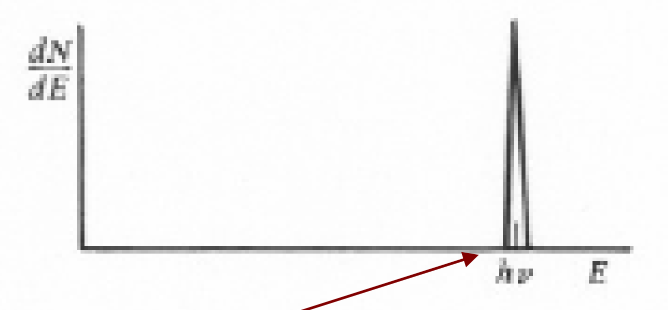


Principles of Spectrometry

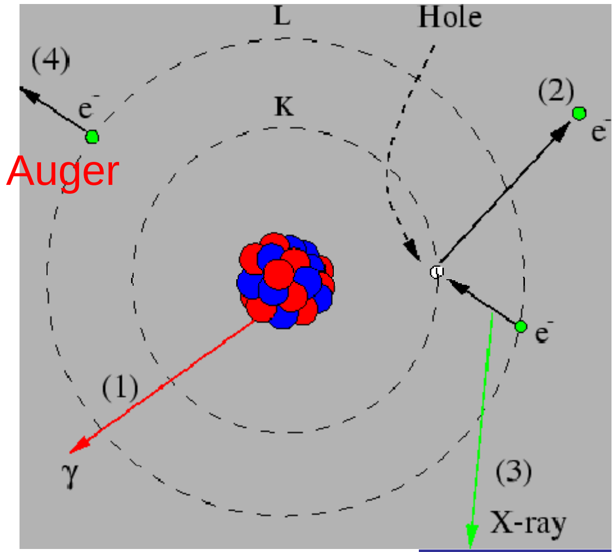
Photoelectric Absorption.

(**with atoms, why??**)





Spectrum if all energy is captured in detector.
Allows identification of gamma energy.



- **Large Detector (in depth?!).**
- **Photo Peak or Full Energy Peak…?**
- **Doppler.**
- **Cost.**
- **Crystal growth.**

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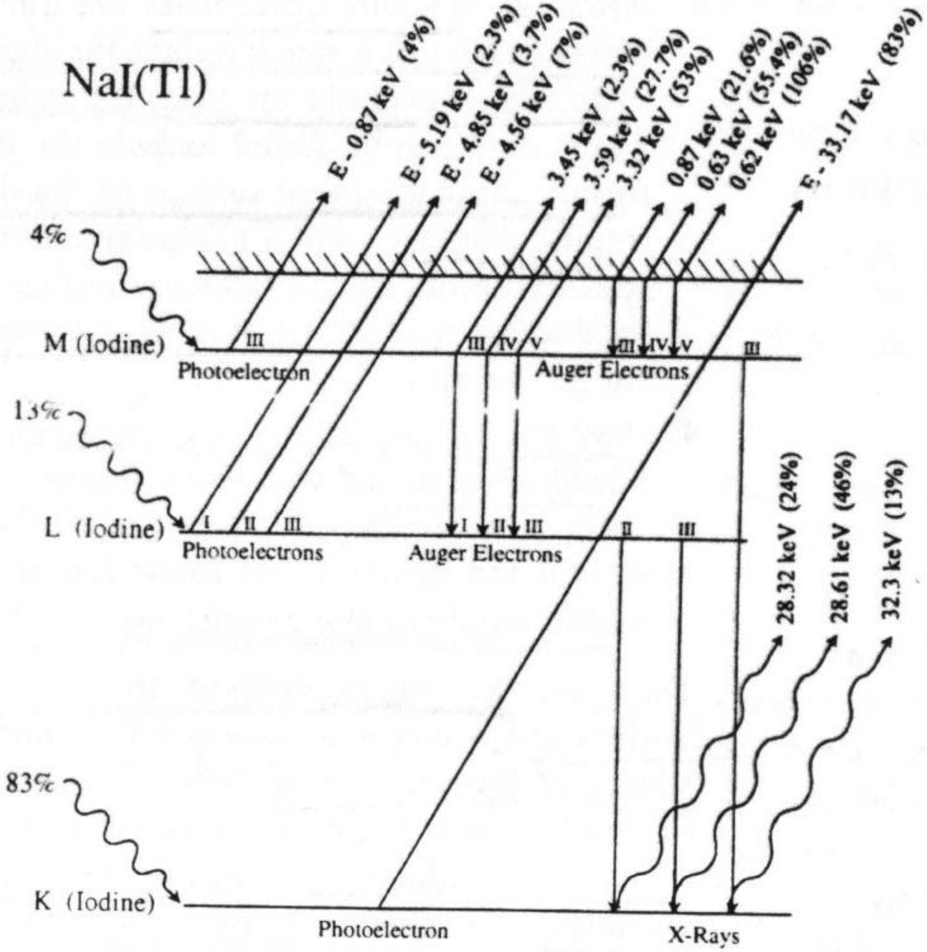
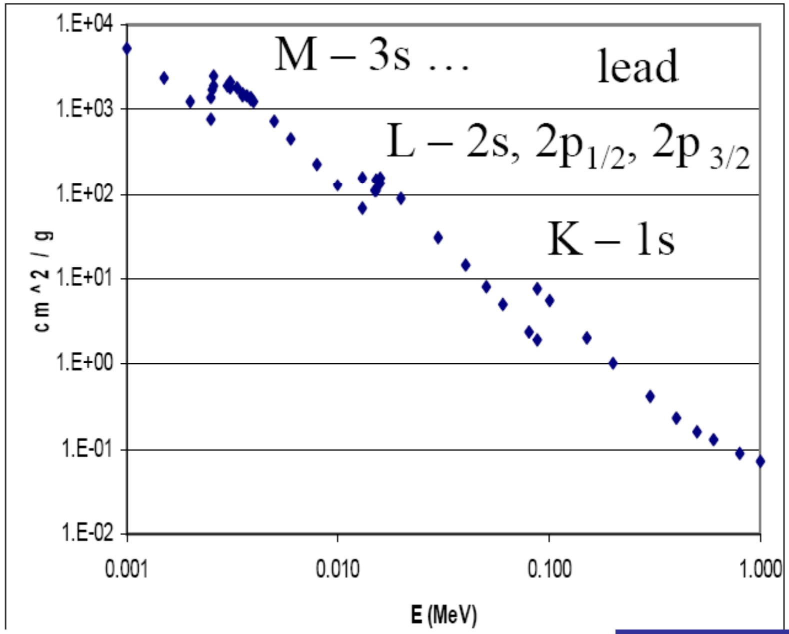
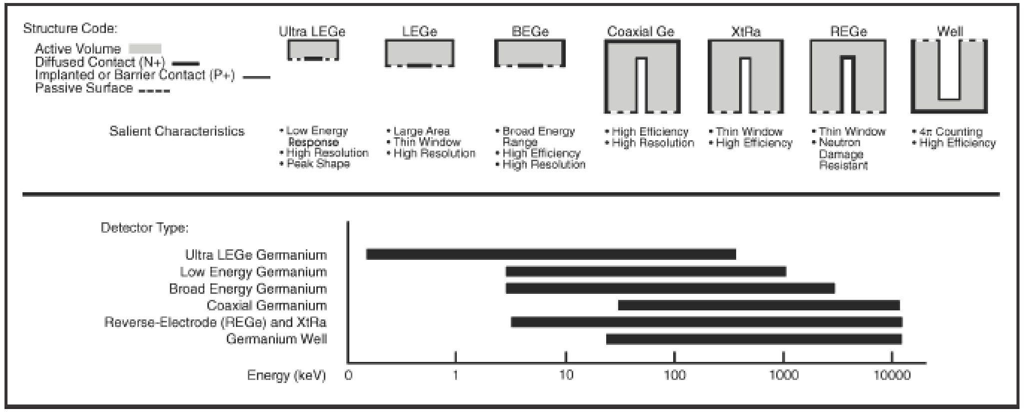


- Spectroscopy, energy deposition.
- Consider what might escape.
- Size and material of detector.
- Shield lining.

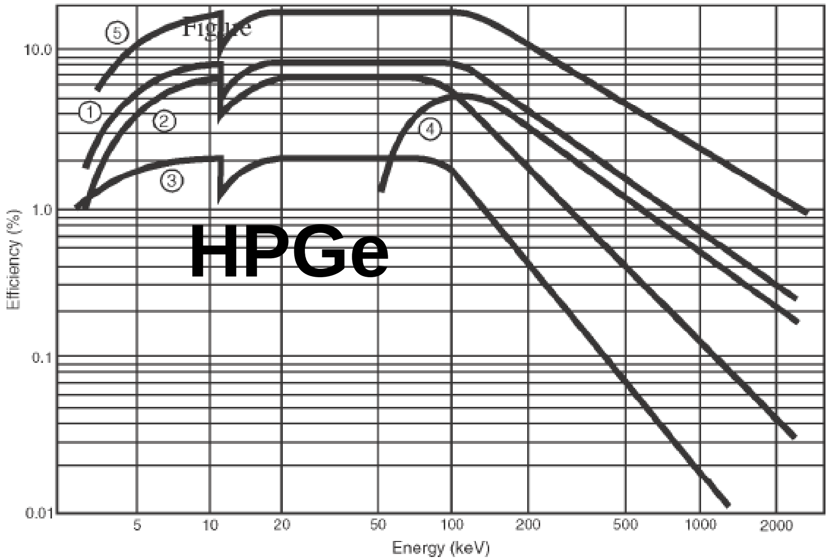


Considerations for
shields and detectors?

Principles of Spectrometry



HW 3



Principles of Spectrometry

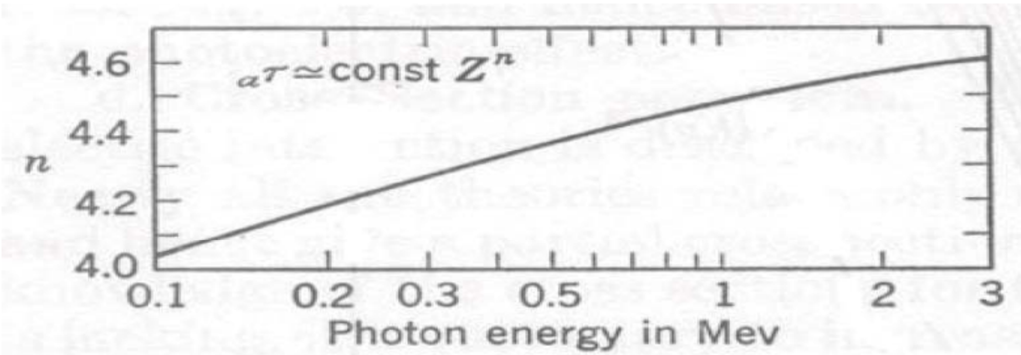
- "Probability" for **photoelectric** absorption:

Theoretical

$$\sigma_\tau = \int d\Omega \frac{d\sigma_\tau}{d\Omega} = 4\sqrt{2}\sigma^o \frac{Z^5}{(137)^4}\left(\frac{m_e c^2}{\hbar\omega}\right)^{7/2}$$

Practical

$$\tau \propto \begin{cases} \dfrac{Z^4}{(h\nu)^{3.5}} & low\ energy \\ \dfrac{Z^5}{(h\nu)^{3.5}} & high\ energy \end{cases}$$



- Strong *Z* dependence.
- Considerations for **shields and detectors**.

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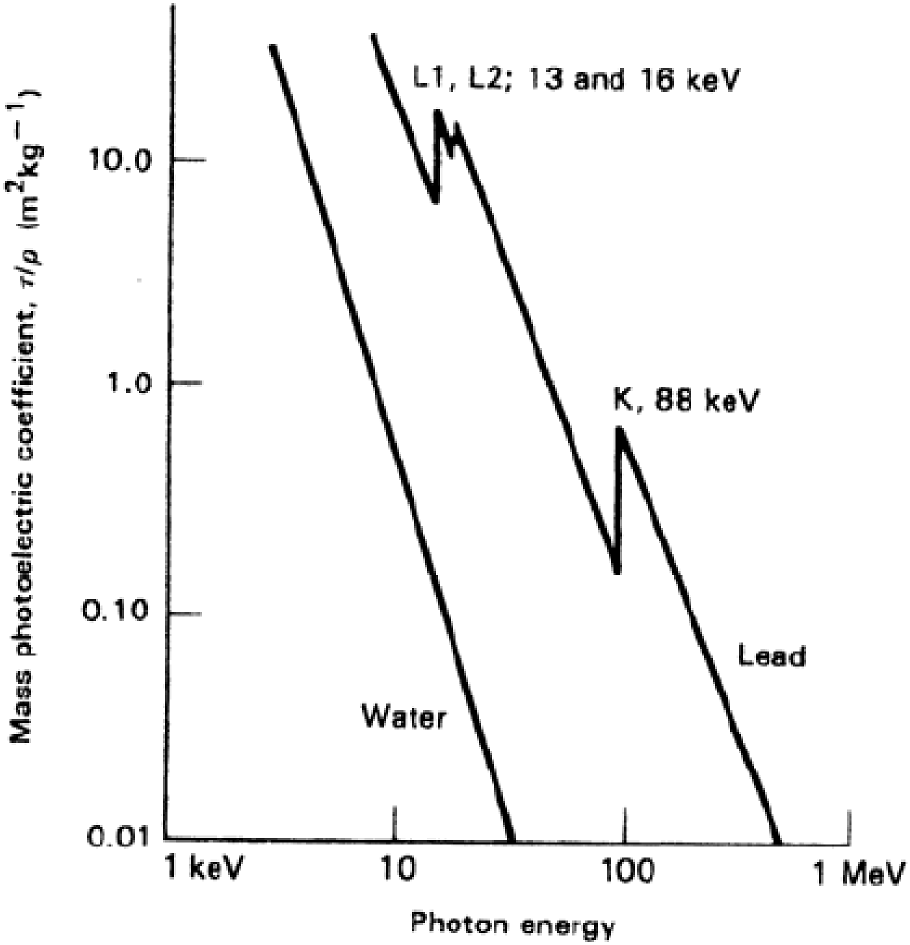
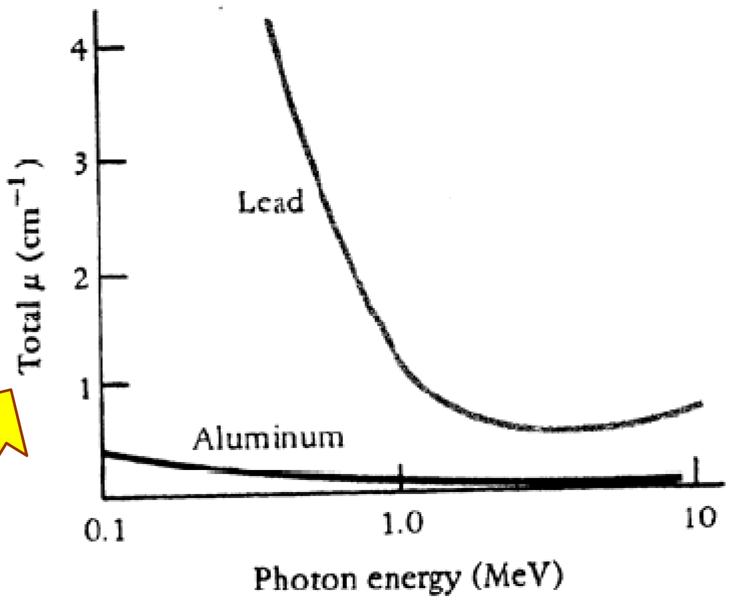
Efficiency considerations.





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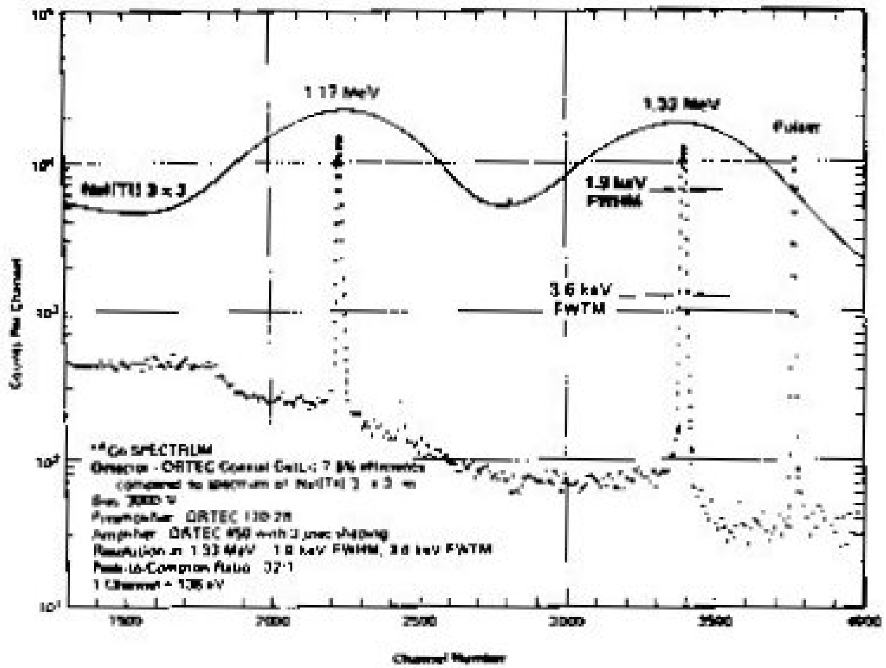
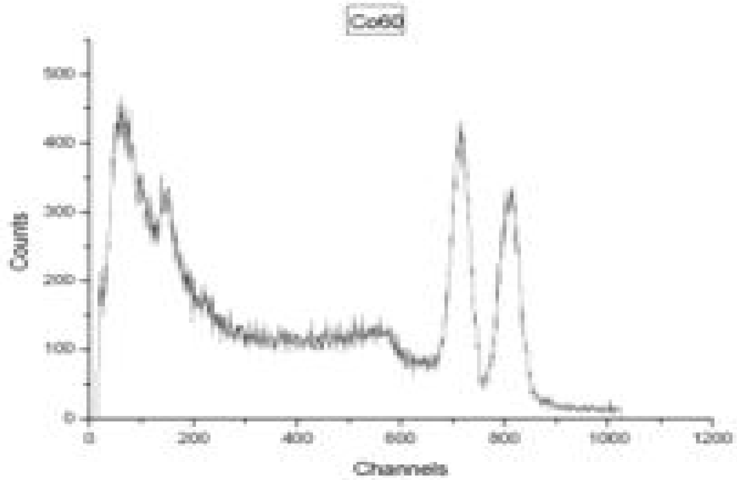
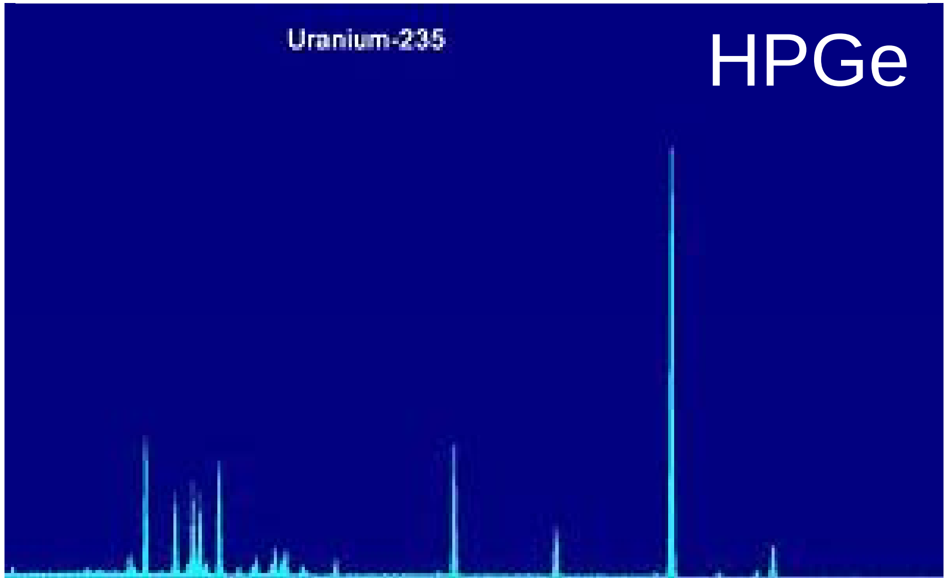
Efficiency vs. Resolution



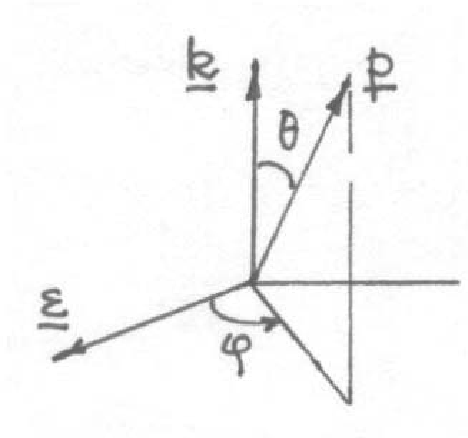
NaI or BGO





Principles of Spectrometry

$$\frac{d\sigma_\tau}{d\Omega} = 4\sqrt{2}\,\frac{r_e^2 Z^5}{(137)^4}\left(\frac{m_e c^2}{\hbar\omega}\right)^{7/2}\frac{\sin^2\theta\cos^2\varphi}{\left(1-\frac{v}{c}\cos\theta\right)^4}$$



Considerations for **shields and detectors?**