Scintillation Detectors
Uses of Scintillation Detectors

- Gamma rays/x-rays
- Neutrons
- Charged Particles
Operation

1. Gamma rays interact (photoelectric, Compton, pair production)
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4. De-exciting atoms produce visible light
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Ionization/excitation \( \propto \) energy of electron
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For photoelectric effect, $K_e = E_\gamma$

Thus, number of light photons $\propto E_\gamma$
Photomultiplier
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Bialkali Photocathode (Sb-Rb-Cs, Sb-K-Cs)
Scintillator & Photomultiplier

- Incident photon
- Scintillator
- Light photon
- Photocathode
- Electrons
- Focusing electrode
- Dynode
- Anode
- Electrical connectors
- Photomultiplier tube (PMT)
Spectrum Interpretation

- Photoelectric effect: \( K_e = E_\gamma \)

- Compton effect:

\[
E_\gamma' = \frac{E_\gamma}{1 + \frac{E_\gamma}{mc^2}(1 - \cos \theta)}
\]

\[
K_e = E_\gamma - E_\gamma'
\]
Spectrum Interpretation

• Compton effect:

\[
E_\gamma'(\text{min}) = \frac{E_\gamma}{1 + \frac{E_\gamma}{mc^2}(1 - (-1))}
\]

\[
K_e(\text{max}) = E_\gamma - E_\gamma'(\text{min})
\]

For \(^{137}\text{Cs}, \ E_\gamma = 662\text{ keV}, \ E_\gamma'(\text{min}) = 184\text{ keV}

\[
K_e(\text{max}) = 478\text{ keV}
\]
NaI(Tl) vs HPGE
NaI(Tl) Detector in Nuclear Medicine

Attenuation coefficient at 150 keV

\[ \mu(\text{PE}) = 1.68 \text{ cm}^{-1} \]
\[ \mu(\text{C}) = 0.39 \text{ cm}^{-1} \]
\[ \mu(\text{total}) = 2.07 \text{ cm}^{-1} \]

For \( x = 0.5 \) in (1.27 cm),

\[ \frac{l}{l_0} = 0.07 \]
Other Scintillation Detectors

- CsI(Tl)
- BGO (bismuth germanate)
- BrilLanCe (cerium doped lanthanum bromide)
- Plastic
- Organic liquids
Neutron Detection

- Plastic or organic liquid scintillators
- Recoil proton from n-p scattering
- Pulse-shape discrimination