Scintillation detectors

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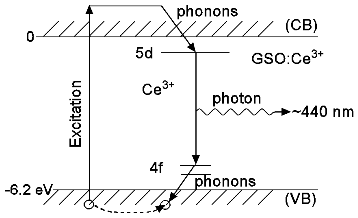
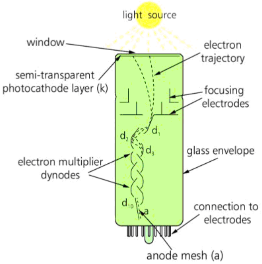
Principles of operation

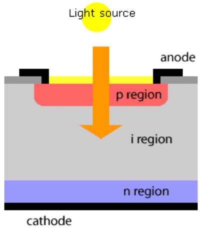
- Charged particles produce “excitons” – quanta of excitation
  - Part of excitation energy can be released as optical photons
- Popular organic scintillators: NE-102
  - scintillation occurs due to transition between molecular energy levels
  - typically involves π electrons ($2p$ electrons of C atoms in benzene rings)
- Popular inorganic scintillators: NaI, BGO ($Bi_4Ge_3O_{12}$)
  - radiation creates unbound electron-hole pairs which travel for a while before they recombine and emit photons
- Neutrons don’t produce ionization but can lead to recoil reactions (n,p) – works best in organic scintillators rich in hydrogen



Scintillating detector components

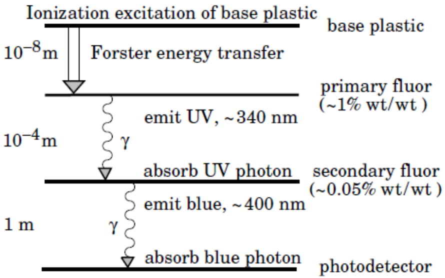
- Each scintillation detector consists of two components: scintillator itself and the photodetector
- Photodetectors: vacuum – PMT (photo multiplier tubes) and solid state – photodiodes
- PMT issues:
  - require high voltage
  - vacuum degrades over time
  - delicate, can be easily destroyed mechanically or by excessive light





Self-absorption and wavelength shifters

- Many scintillators can easily absorb their own scintillation
  - in other words, they are not transparent to the scintillation light
- This can be fixed by adding "wavelength shifters" – materials that absorb scintillation photons and emit photons of a different wavelength



Scintillator characteristics

- Light wavelength: has to match peak of sensitivity of photodetectors
- Density (the more the better)
- Time characteristics
  - typically there are two components: fast (important for timing) and slow (defines dead time before the detector is ready again for the operation)
  - BaF_2 has a fast component < 1 ns (fastest known scintillator) but its slow component is 630 ns
- other properties, e.g. hygroscopicity

DØ Fiber tracker

- 77k channels, readout: Visible Light Photon Counters
- Azimuthal spatial resolution 100 μm
- Approximate longitudinal resolution by measuring light arrival time on both sides of the fiber
- Huge problem: occupancy