November 30, 2020

Nuclear medicine

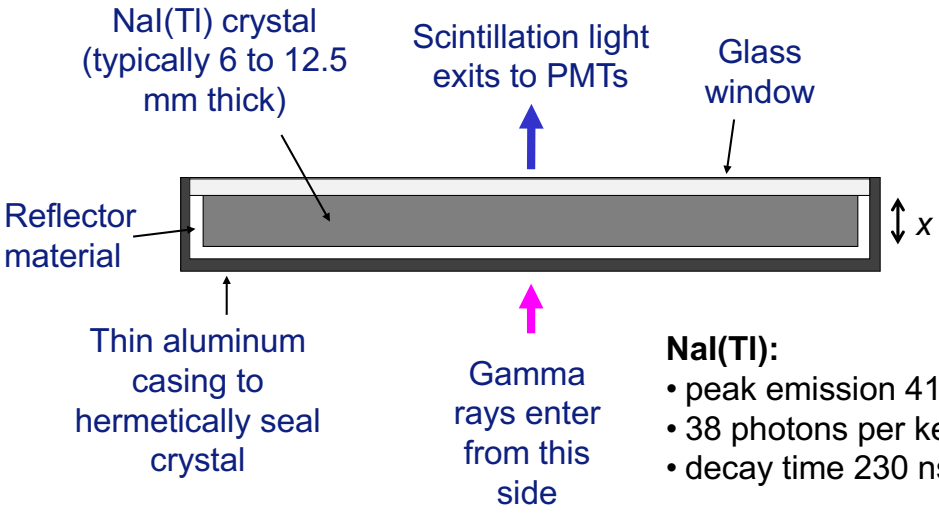
Week 1; Lecture 3; Section 4: Gamma camera: scintillator

K. Long (k.long@imperial.ac.uk)
Department of Physics, Imperial College London/STFC
R. McLauchlan (ruth.mclauchlan@nhs.net)
Radiation Physics & Radiobiology Department, Imperial College Healthcare NHS Trust

Section 4

Scintillator

Crystal assembly



NaI(Tl):

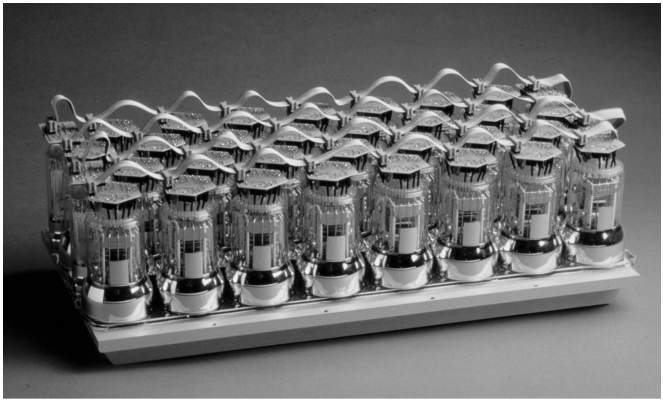
- peak emission 415 nm
- 38 photons per keV
- decay time 230 ns

Head

Area: typically $60 \times 40\,\mathrm{cm}^2$

PMT diameter: typically 50 mm

30–100 PMTs per head



Position reconstruction

In linear approximation:

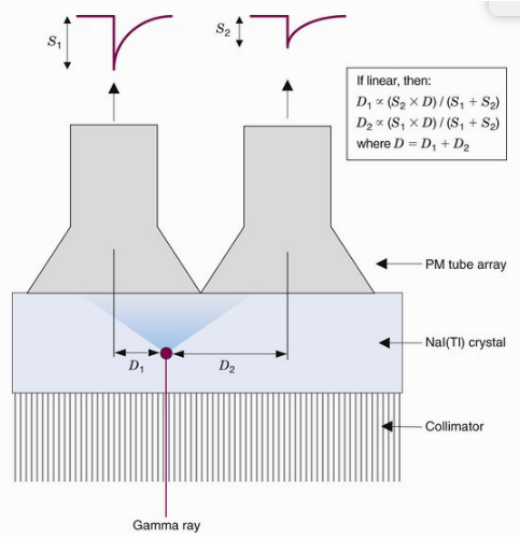
$$D_1 = \frac{S_2 \times D}{S_1 + S_2}$$

$$D_2 = \frac{S_1 \times D}{S_1 + S_2}$$

where $D = D_1 + D_2$

Event position is calculated as the centroid ("centre of mass") of the PMT signals

More complex algorithms that account for distortions are also employed



Detection efficiency

Can now define detection efficiency of the system:, $\mathcal{E}$:

$$\mathcal{E} = g\epsilon F_{\text{elec}}$$

where:

- g is the geometrical efficiency
- ϵ is the ratio of the number of γs recorded divided by the the number of γs incident:

$$\epsilon = 1 - \exp\left(-\mu_{\text{scint}} t_{\text{scint}}\right)$$

  where μ_{scint} is the linear attenuation coefficient of the scintillator and t_{scint} its thickness
- F_{elec} is the fraction of the γs accepted by the discriminators (front-end of the electronics)

Spatial resolution

Three major contributions to the spatial resolution:

- **Collimator resolution**, δr_{col}, defined above, usually dominates
- Intrinsic resolution, δr_{int} – ability of PMTs to localise event
- Residual impact of Compton scattering, δr_{Compt} in tissue resulting in non-colinearity of deetected γ with the γ that which left the decay site

System resolution is given by:

$$\delta r_{\text{sys}} = \left[\delta r_{\text{col}}^2 + \delta r_{\text{int}}^2 + \delta r_{\text{Compt}}^2\right]^{\frac{1}{2}}$$