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Detection Efficiency of Ge detectors For Radioactive Cylindrical Samples

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Abstract

In order to calculate the efficiency of a cylindrical sample, it can be divided into disks parallel to the face of the detector and the activities of all disks can be integrated according to their distance from the detector face.

Two factors lead to the decreasing contribution of the disk as it's distance from the detector face increases, i.e. the absorption of the gamma photons in the sample and the decrease of the angle of the detector with increase of the distance.

As a first step the dependence of the efficiency for a radioactive disk was studies in order to eliminate the absorption factor and single out the geometric one. It was found experimentally that high volume Ge detectors can be taken as an average effective plate detector with an efficiency function.

$$\varepsilon = \frac{\varepsilon_0 \cdot h_0^2}{(h + h_0)^2} \qquad (1)$$

Where ε is the fraction of emitted photons causing a photo peak signal in the detector and h is effective plate depth, which assume that all the detector is concentrated the distance of the disk from the detector cap. ε_0 and h_0 are linearization parameters, where h_0 is called the in an effective plate in a distance h_0 from the detector. ε_0 is the efficiency of a thin disk on the detector cap (h=0). The effective depth h_0 is changing very little with the

energy, in contrast to the findings for a point source, however it increases with the disk radius.

It can be shown that for photons with energy above ~ 200 keV the geometric factor is much larger than the absorption factor. Thus a reasonable approximation for cylindrical samples will be to ignore completely the absorption phenomenon and assume decrease of the disk efficiency only due to increasing h. Integration of equation 1 leads for a cylinder of height h to the equation.

$$\text{(2)} \qquad \varepsilon_h = \frac{\varepsilon_0 \cdot h_0}{h + h_0}$$

It was shown experimentally that equation (2) is applicable for γ energies from 40 to 2600 keV.

Using the radial dependence for a radioactive disk on the detector cap.

$$\text{(3)} \qquad \varepsilon_0 = \alpha\,(1 - \beta R^2)$$

It can be shown that the optimal radius of a cylinder for measurement of a volume V is given by the equation:

$$R = \sqrt[4]{\frac{2\,V}{\pi\beta\,h_0}}$$