

3.1 Energy Resolution of Scintillation Detectors – New Observations*

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[VI.1]

According to present knowledge, the non-proportionality of the light yield of scintillators appears to be the fundamental limitation of energy resolution. However, several observations collected in the last 10 years on the influence of slow components of light pulses on energy resolution suggest more complex processes in the scintillators. Fig. 1 presents the energy spectrum of 662 keV γ -rays from a ^{137}Cs source measured with the small NaI coupled to the LAAPD [1]. It is worthwhile to stress a very good energy resolution of $3.8 \pm 0.1\%$, however, measured at 50 μs peaking time.

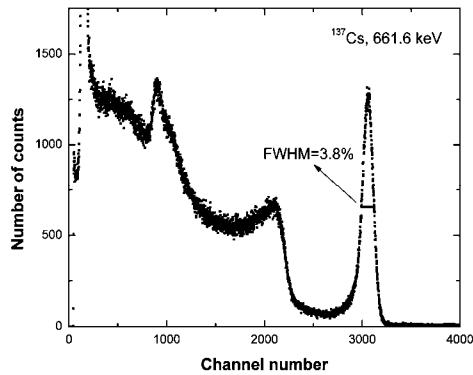


Fig. 1 Energy spectrum of a ^{137}Cs source measured with NaI at 50 μs peaking time in the gated integrator amplifier. Following [1].

Fig. 2 presents the dependence of the measured energy resolution, the statistical contribution and the calculated intrinsic resolution of NaI on the amplifier peaking time [1]. The corrections for the statistical contribution of the number of e-h pairs on the peaking time were introduced using data presented in the upper part of Fig. 2.

These results suggest that the observed performance is strongly related to the intrinsic resolution created in the NaI tested. A slow component with the total intensity of about 20% up to 50 μs peaking time, is clearly seen in the upper panel of Fig. 2. However, its contribution weakly affects the statistical error of the energy resolution, see the lower panel of Fig. 2. Note that the main component of the light pulse has decay time constant below 100 ns. Thus the measured energy resolution is mainly affected by the intrinsic resolution.

Similar effects were observed also with CsI(Tl) [2], ZnSe(Te) [3], and for NaI(Tl) [4] at temperatures reduced below 0 $^{\circ}\text{C}$. A common conclusion of these observations is the fact that the highest energy resolution, and particularly the intrinsic resolution measured with scintillators, characterized by two components of the light pulse decay, is obtainable when the spectrometry equipment integrates the whole light of both components. The simultaneous study of non-proportionality response of the crystals suggests

that it is correlated with the improved non-proportionality characteristics observed for the case of the integration of the whole light.

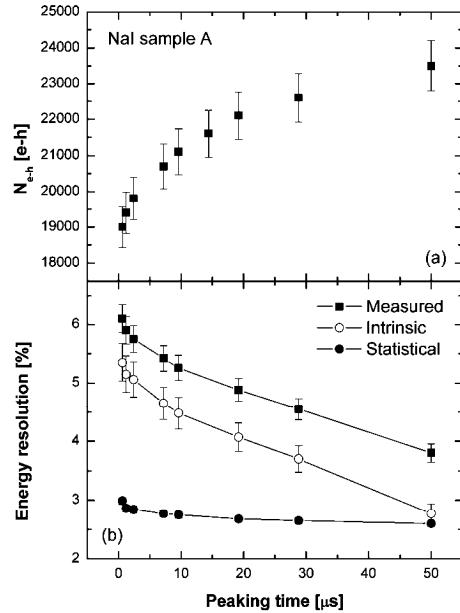


Fig. 2 The measured energy resolution, statistical contribution, and calculated intrinsic energy resolution of NaI for 662 keV γ -peak versus amplifier peaking time at liquid nitrogen temperature. Also shown the yield of primary e-h pairs (upper panel).

The independently observed correlation of the intrinsic energy resolution of the LGSO crystals and the intensity of their afterglow suggests that the energy resolution of scintillation detectors may be affected also by a strong afterglow of the crystals [5].

In the limiting case, the afterglow could be also considered, as a very slow component destroying the energy resolution. The aim of this work was to summarize all the above observations looking for their origin.

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- [2] A.Syntfeld, et al., IEEE Trans. Nucl. Sci., in press
- [3] M.Balcerzyk, et al., Nucl. Instrum. Meth., A 482 (2002) 720
- [4] Ł.Świderski, et al., IEEE Trans. Nucl. Sci., in press
- [5] M.Moszyński, et al., IEEE Trans. Nucl. Sci., in press

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