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Background reduction in long CsI(Tl) crystals

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Abstract

A simple method to reduce the background from secondary reactions in telescopes composed of long CsI(Tl) crystals is presented. The method has been developed for the KRATTA [1] modules.

1 Introduction

A major factor limiting the telescope identification method to relatively low energies is the increasing probability of secondary reactions in the detector material. These reactions deteriorate the identification of energetic reaction products and produce a substantial amount of background. Application of digitizers to register and store the whole waveforms for the off-line treatment allows to take into account many new degrees of freedom in the data analysis and to device new methods of the data reduction.

2 Telescope module

The presented results have been obtained using the KRATTA data from the ASY-EOS experiment [2] carried out at GSI. Each KRATTA module

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consists of two CsI(Tl) crystals read out by large area photodiodes. Figure 1 presents a schematic view of the active elements of the module.

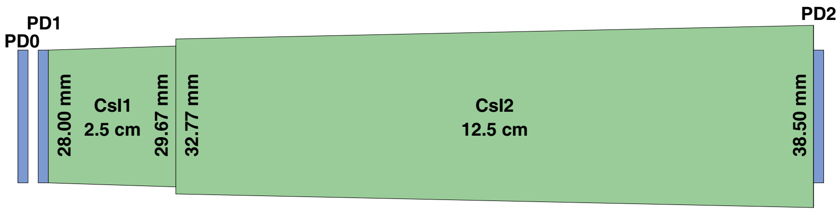

Figure 1: Schematic layout of the active elements of the module.

The crystals are altogether 15 cm long, which implies about 30-40% probability of secondary reactions/scatterings for particles penetrating the full length.

3 Method and results

Figure 2 presents an identification map showing the logarithm of the amplitude from the thin crystal as a function of the ratio of the Slow over Fast amplitudes in the thick crystal.

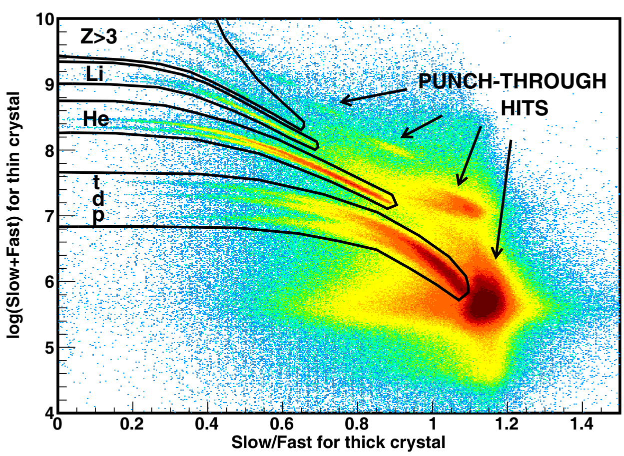

Figure 2: Logarithm of the total light in the thin crystal vs Slow over Fast component of light in the thick crystal. The lines define borders of the regions of well identified particles (inside the cuts).

In this representation the punch through segments as well as a substantial amount of secondary reactions and γ-ray hits can be isolated from the well defined hits of particles stopped in the thick crystal (located inside the specified graphical cuts). The left panel of Fig. 3 shows a standard $\Delta E - E$ telescope identification map. For long crystals this representation suffers from a huge background and from punch through segments that back-bend and overlay with the identification lines of the lower lying isotopes. This effect is especially harmful for hydrogen isotopes. The lines correspond to protons, deuterons, tritons, ^{3}He, alphas, ^{6}He (immersed in the background), ^{6,7,8}Li, etc, from bottom to top, respectively. The right panel of Fig. 3 shows the same map but for hits lying inside the graphical cuts specified in Fig. 2.

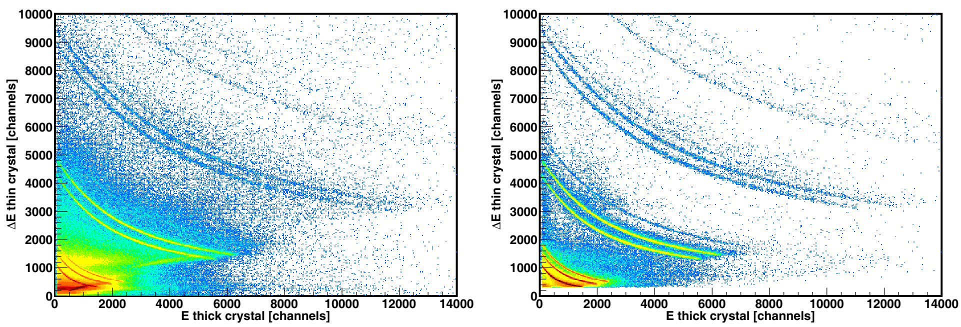

Figure 3: Left: Raw $\Delta E - E$ identification map. Right: Same but for hits inside cuts from Fig. 2.

Reduction of the background is substantial, also the punch through segments get removed in a relatively clean way. The effect of the applied cuts is spectacular for the ^{6}He isotope whose line emerges from the background. The left panel of Fig. 4 presents the mass distribution of helium isotopes before and after background subtraction. The method allows to recognize the secondary reaction events and reduce the background by more than 80%.

4 Discussion

Using the least-squares approach one can demonstrate that the ratio of the Slow over Fast components increases monotonically with the effective fall time of the CsI(Tl) fluorescence. Thus, the observed separation between the well identified and punching-through or scattered particles can be possibly interpreted by taking into account the relation between the effective fall time of the pulse and the ionization density [3] in the crystal (see right panel of

Fig. 4). For particles escaping from the crystal, one can expect that the high ionization density part of the track (near the Bragg peak) contributes less to the fluorescence signal than in the case of stopped particles.

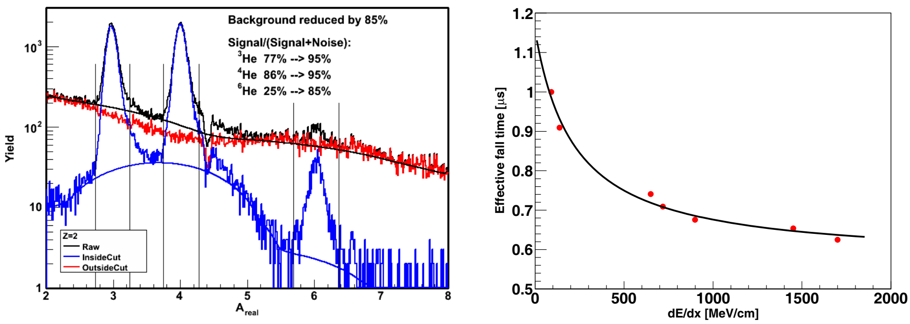

Figure 4: Left: Mass spectrum for Z=2 particles, before (black) and after (blue) background reduction. Red histogram corresponds to the background. Right: CsI fall time vs dE/dx (after T. Masuda et al. [3]).

Thus, the light signal is mainly due to the low ionization density part of the track which is characterized by a longer effective fall time and, consequently, by a larger Slow over Fast ratio.

Acknowledgment

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References

[1] J. Lukasik et al., Nucl. Instr. Meth. 709 (2013) 120128

[2] P. Russotto et al., J. Phys. Conf. Ser., 420. 5 (2013)

[3] T. Masuda et al., Nucl. Instr. Meth. A 322 (1992) 135.