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.

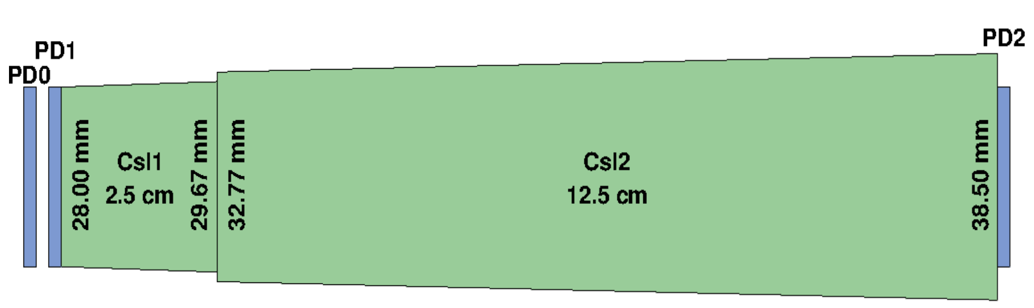
Introduction

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 device new methods.

Telescope Module

The presented results have been obtained using the experimental data from the ASY-EOS experiment [2] with the KRATTA detector, Each KRATTA module consists of two CsI(Tl) crystals read out by photodiodes:



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

Method and Results

Figure 1 presents an identification map of the logarithm of the amplitude from the thin crystal vs the ratio of the Slow over Fast amplitudes in the thick crystal.

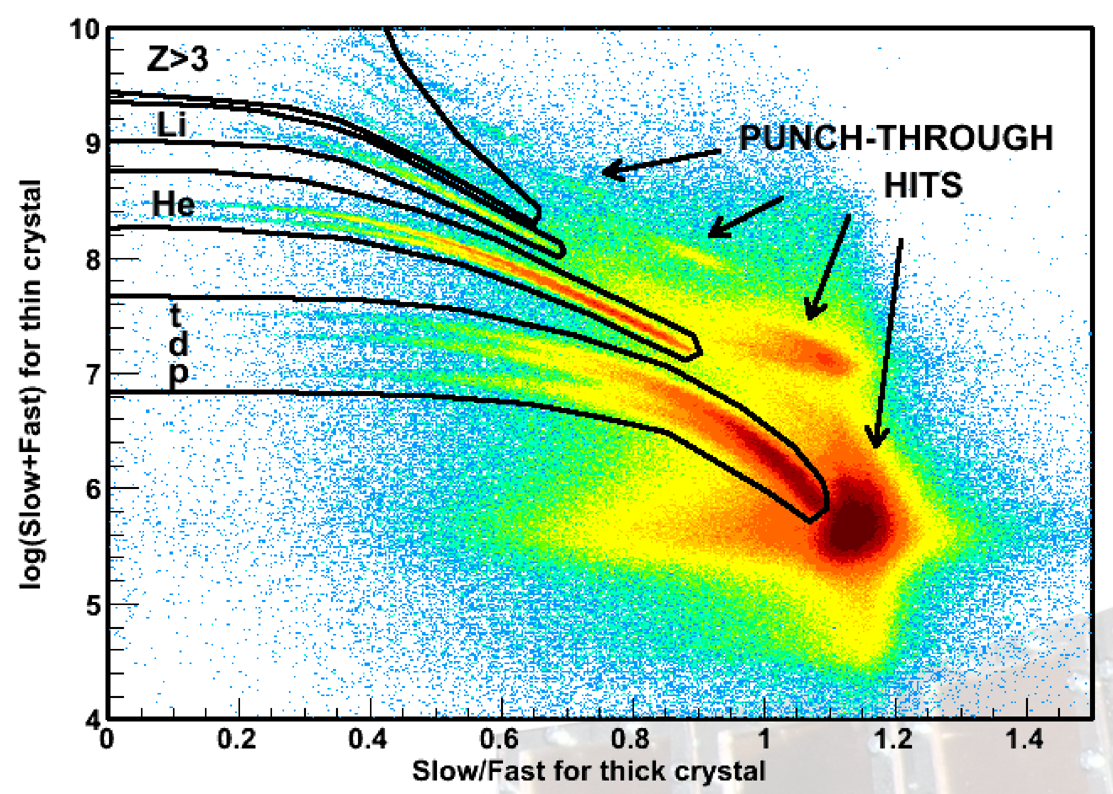


Fig. 1: Logarithm of the total light in the thin crystal vs Slow over Fast component of light in the thick crystal. The lines define borders of the regions of well identified particles (inside the cuts).

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 cuts).

Figure 2 shows a standard 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, 3He, alphas, 6He (dying in the background), 6,7,8 Li, etc, from bottom to top, respectively

Figure 3 shows the same map but for hits lying inside the cuts specified in Fig. 1.

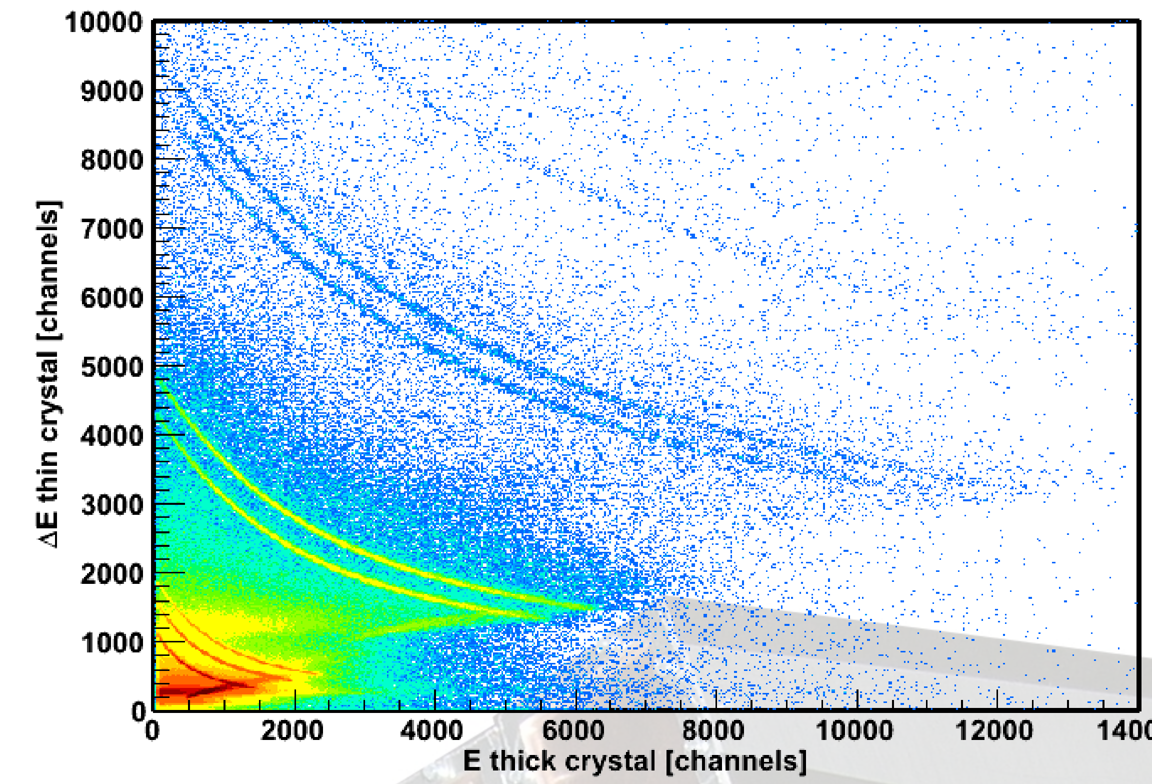


Fig. 2: Raw ΔE-E identification map

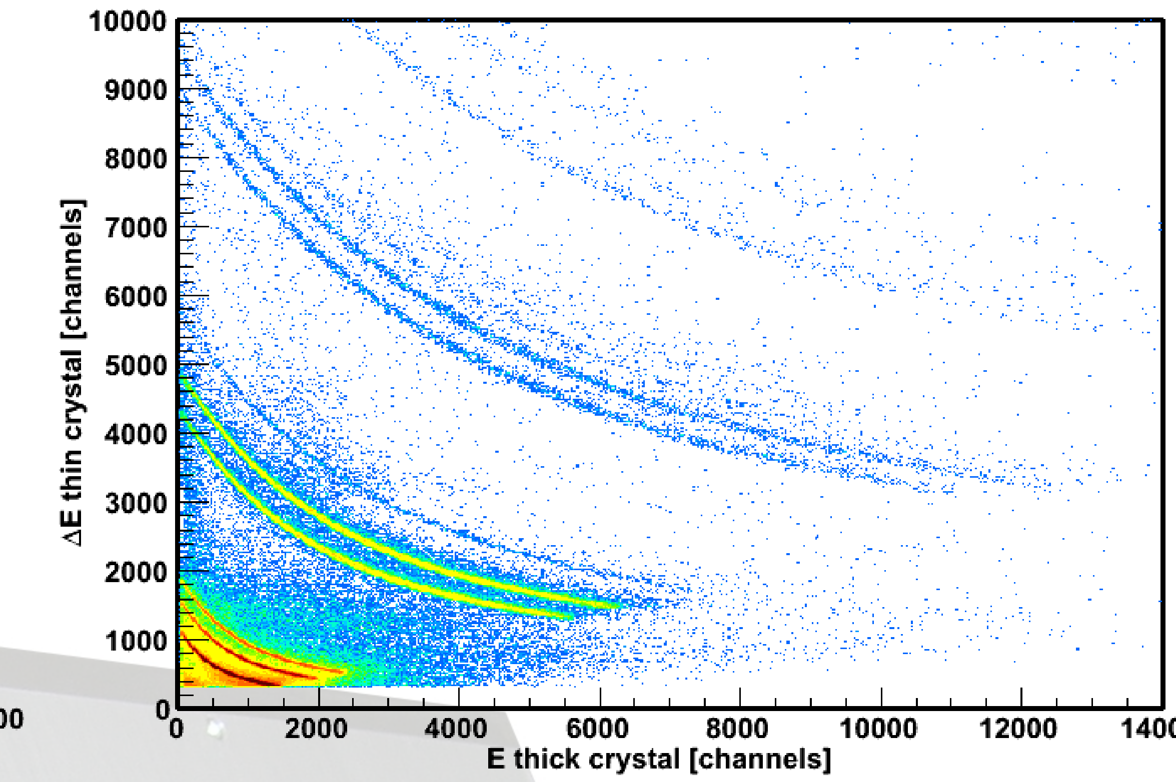


Fig. 3: Same as Fig. 2 but for hits inside cuts fom Fig. 1

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 6He isotope whose line emerges from the background in Fig. 3.

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%.

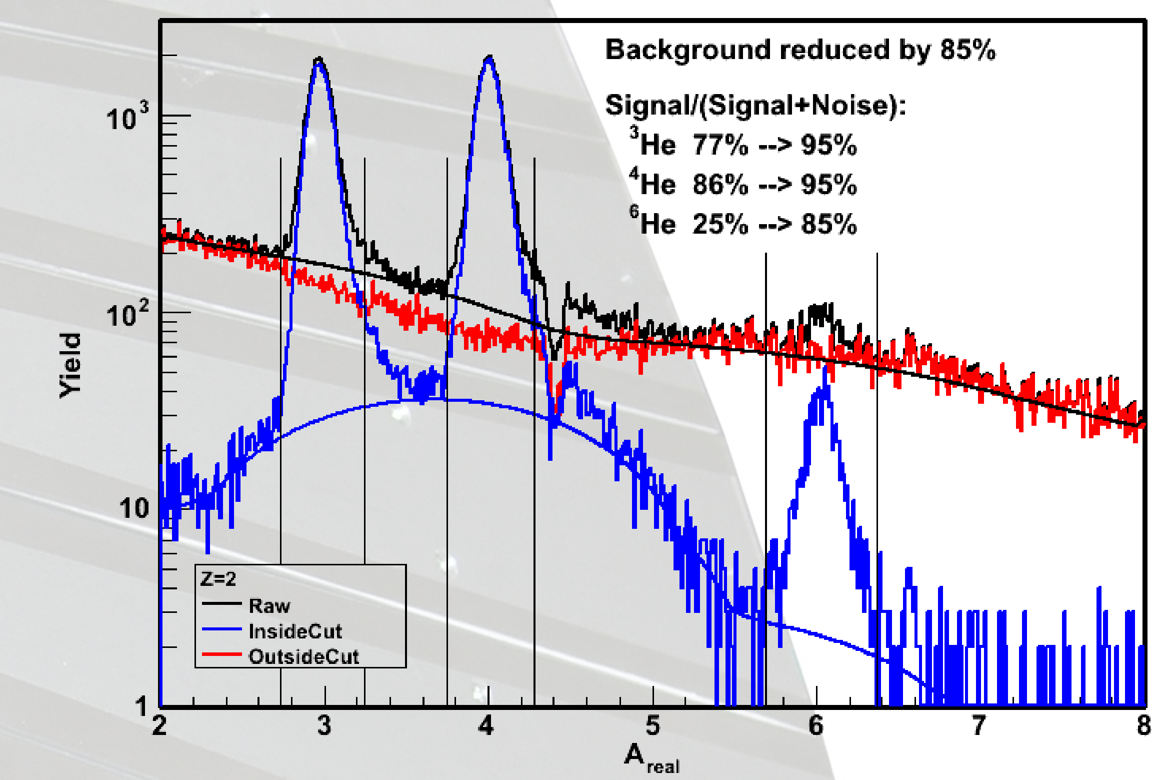


Fig. 4: Mass spectrum for Z=2 particles, before (black) and after (blue) background reduction. Red histogram corresponds to the background.

Discussion

Since the ratio of the Slow over Fast amplitudes increases monotonically, and is well correlated, with the fall time of the CsI(Tl) fluorescence, 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. 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.

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

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