Background reduction in long CsI(Tl) crystals

J. Lukasik\textsuperscript{1}, P. Pawlowski\textsuperscript{1}, B. Czech\textsuperscript{1}, I. Skwirczyńska\textsuperscript{1}, J. Brzychczyk\textsuperscript{2}, M. Adamczyk\textsuperscript{2}, S. Kupny\textsuperscript{2}, P. Lasko\textsuperscript{2}, Z. Sosin\textsuperscript{2}, A. Wieloch\textsuperscript{2}, M. Kiš\textsuperscript{3}, Y. Leifels\textsuperscript{3}, W. Trautmann\textsuperscript{3} and the ASY-EOS Collaboration

\textsuperscript{1} Institute of Nuclear Physics, IFJ-PAN, 31-342 Kraków, Poland
\textsuperscript{2} Institute of Physics, Jagiellonian University, 30-059 Kraków, Poland
\textsuperscript{3} GSI, D-64291 Darmstadt, Germany

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 \cite{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 to device new methods of the data reduction.

Telescope Module

The presented results have been obtained using the KRATTA data from the ASY-EOS experiment \cite{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.](image)

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

**Method and Results**

Figure 2 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.

![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).](image)

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 (dying 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 seg-
ments 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.
Left panel of Fig. 4 presents the mass distribution of helium isotopes be-
fore and after background subtraction. The method allows to recognize the
secondary reaction events and reduce the background by more than 80%.

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 (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.

![Mass spectrum and CsI fall time vs dE/dx graph]

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.

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**References**

