Measuring the orientation of the Ge Crystals of the iThemba LABS Segmented Clover Detector

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Abstract. The iThemba LABS segmented detector includes four Ge crystals in a clover configuration inside a single cryostat [1]. The orientation of the Ge crystals inside the cryostat needs to be measured. It plays a crucial role in the simulation of the charge collection in the detector and generating realistic pulse shapes. The rise times of the core signals corresponding to two arbitrary interaction points were measured. They show a distinct difference, indicating that the rise times of the segmented clover detector are sensitive to interaction position and can be used to determine the crystal orientation of the Ge crystals.

1. Introduction

One of the primary parameters to describe a Ge detector for pulse shape analysis is the orientation of the crystallographic axes of the cubic centered Ge crystal. The drift mobility for the electron-hole pairs in Ge depends on the orientation of the electrical field with respect to these axes and causes deviation in the collection times of up to 30% [2]. The intention of a team at iThemba LABS is to characterize the segmented iThemba LABS Ge detector, see Figure 1, and to develop a pulse shape analysis technique able to determine the position of each energy deposition caused by the interaction of a gamma-ray in the segmented Ge crystal [3]. This necessitates a measurement of the lattice orientation of the four crystals of the detector.

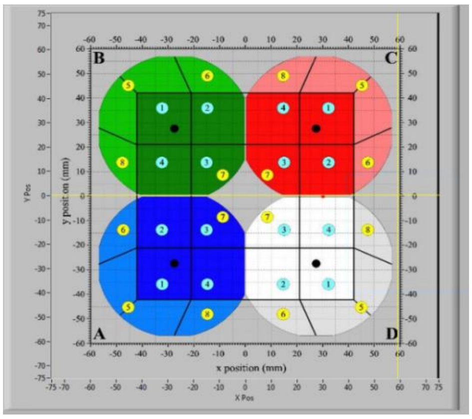

Figure 1. Schematic diagram of the HPGe crystals of the iThemba LABS segmented clover detector. The four crystals are labelled as A, B, C, D.

2. Method

To determine the orientation of a Ge crystal one has to scan the detector measuring its time response e.g. T10, T30, T60 and T90, which are the times for the pulse to rise to 10%, 30%, 60% and 90% of its maximum amplitude, respectively, on a grid with a small step. Examples for such measurements, performed at TRIUMF for a similar detector are shown [4]. Based on these measurements it was concluded that the lattice of crystal D of their detector is rotated by 5^o clockwise in the (x,y) plane [4]. To prepare for such measurements new sorting code was developed at iThemba LABS. To test the detector and the sorting code, initial measurements were done for two arbitrary positions with a collimated source placed on the scanning table. A ^{137}Cs source was installed underneath a collimator with an inner hole of 3 mm in diameter and 100 mm in length. Position (0,0) corresponds to the centre of the detector, see Figure 1. Two arbitrary locations, (-5,27) and (-23,27) in crystal B were measured with at least 10^3 counts in the 662 keV gamma-ray peak of ^{137}Cs. The measurements typically took 30 minutes per location. Both measurements were in front of segment 2 of crystal B, see Figure 1.

3. Results and Discussion

The events with energy of E = 662 keV registered on the core were selected and the corresponding traces are shown in Figures 2 and 3 for positions 1 and 2 respectively.

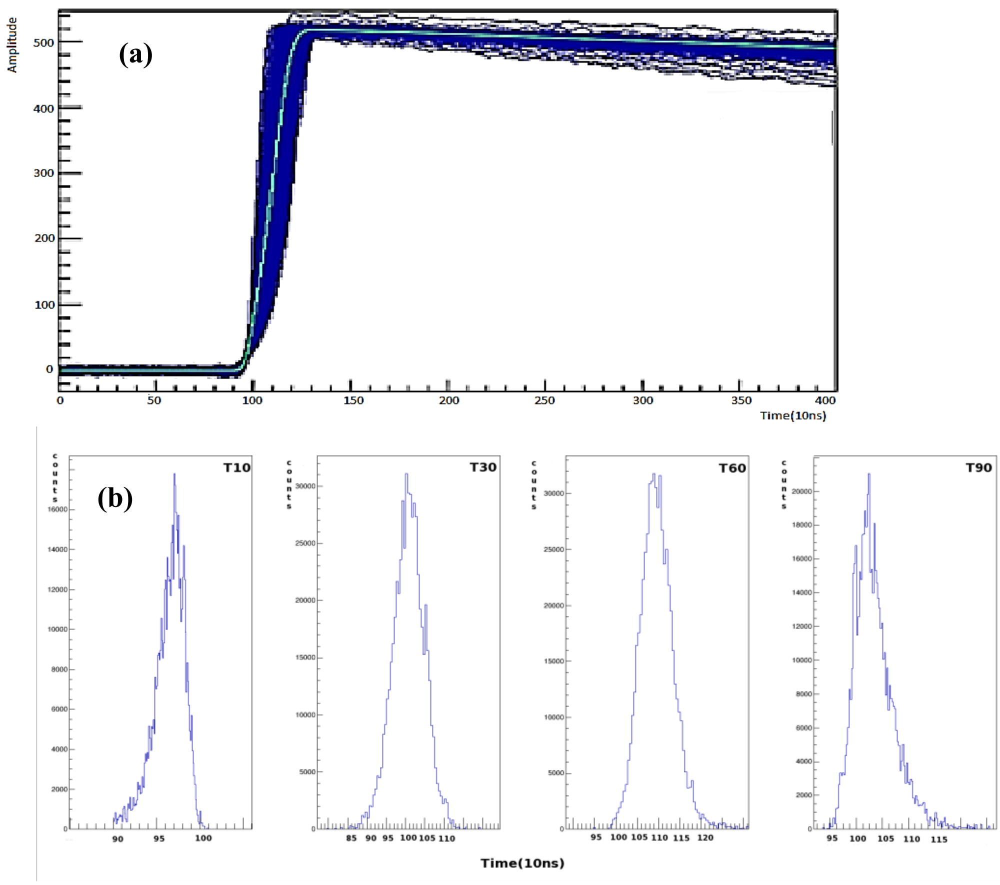

Figure 2. The average (green line) and the individual (blue lines) traces for position (-5, 27), which is near the surface of crystal B is shown in (a). The measured individual rise times are shown in (b).

The rise times T10, T30, T60 and T90 were determined on the average traces for these positions and are listed in table 1. In addition, the distributions of the time spectra T10, T30, T60 and T90 (10% to 90% of the amplitude) rise times were measured, by evaluating the rise times from each trace. They are shown in Figures 2 and 3. Note, that using a collimated source the x- and y-coordinates of the interaction sites are determined, while the depth (the z-coordinate) remains unrestricted.

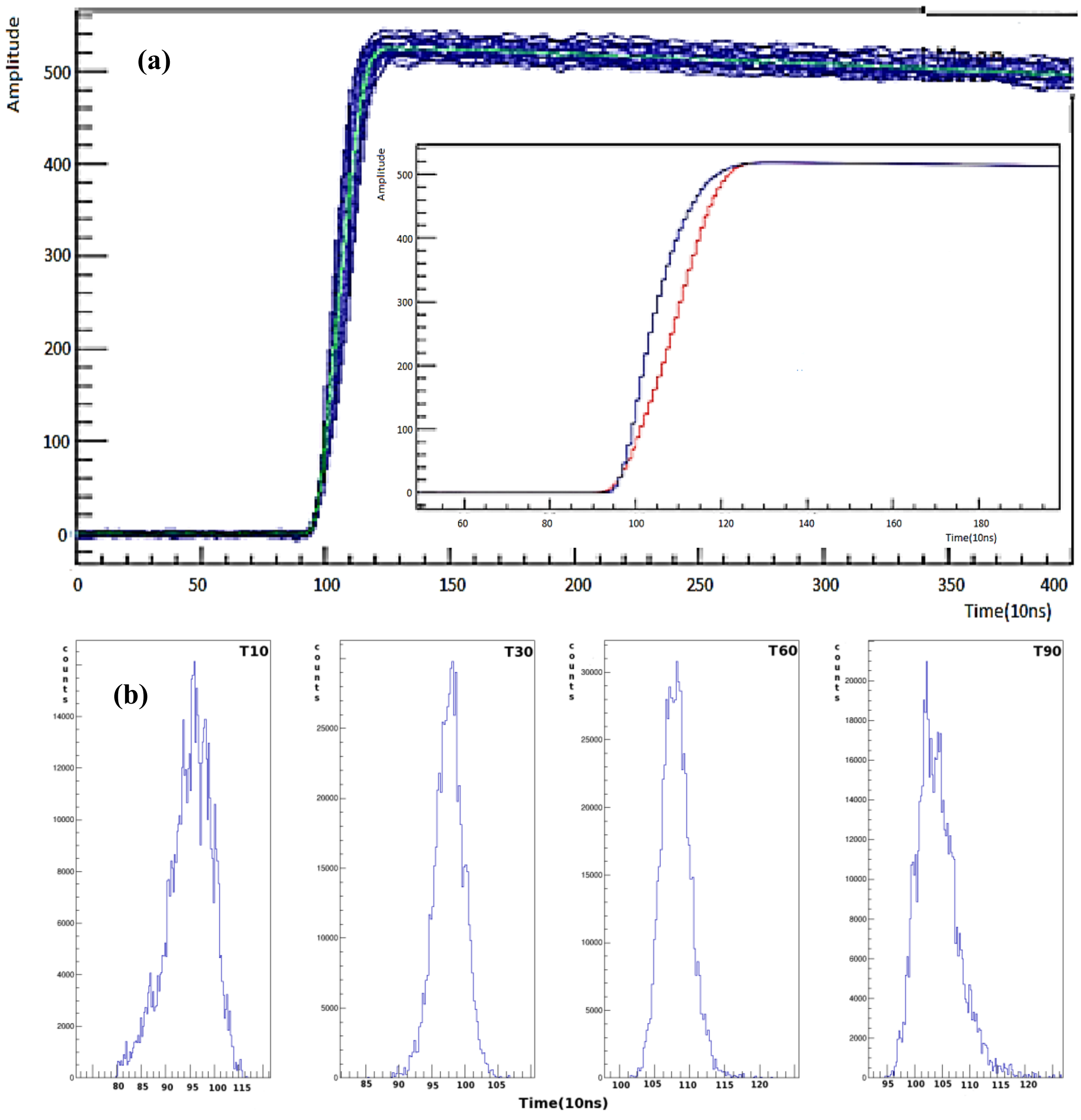

Figure 3. The average (green line) and the individual (blue lines) traces for position (-23, 27), which is near the core of crystal B are shown in (a). The insert shows the average traces for positions 1 (blue) and 2 (red) . The measured individual rise times for position 2 are shown in (b).

Table 1. Measured rise times in units of time clocks (10ns) for the average core signal registered for the two positions.

	T10	T30	T60	T90
Position 1	97	100	105	114
Position 2	97	103	110	117

The insert in Figure 3 shows the average traces for the two arbitrary positions 1 and 2. It is clear that the rise times are distinctly different. Thus the sorting software is completed. We were able to determine average traces and to extract the T30, T60 and T90 rise times. These rise times show a distinct difference for the two arbitrary interactions. As a next step a scan of the detector will be carried out in order to determine the rise times as a function of (x,y) coordinates of the interaction position. The results will be used to determine the lattice crystal orientation.

References

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