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 is being measured with a collimated source, where the axis of the collimator is perpendicular to the front face of the detector cryostat. This orientation plays a crucial role in the simulation of the charge collection in the detector and generating realistic pulse shapes.

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.

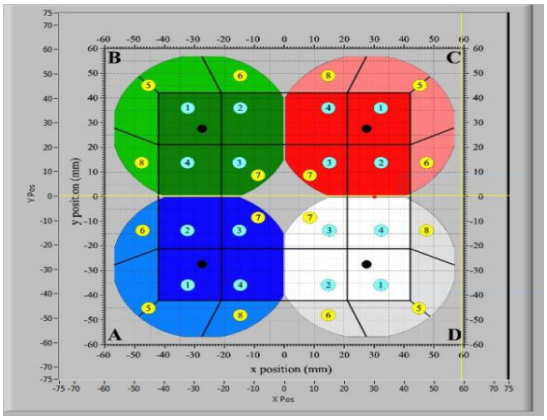

Figure 1. Schematic diagram of the HPGe crystals of the iThemba LABS segmented clover detector. The four crystals are labelled as A, B, C, D.

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 them 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 different 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 102 mm in length. Position (0,0) corresponds to the centre of the detector, see Figure 1. Two 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. 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 spectra of T10, T30, T60 and T90 rise times were measured on each trace and are shown in Figures 2 and 3.

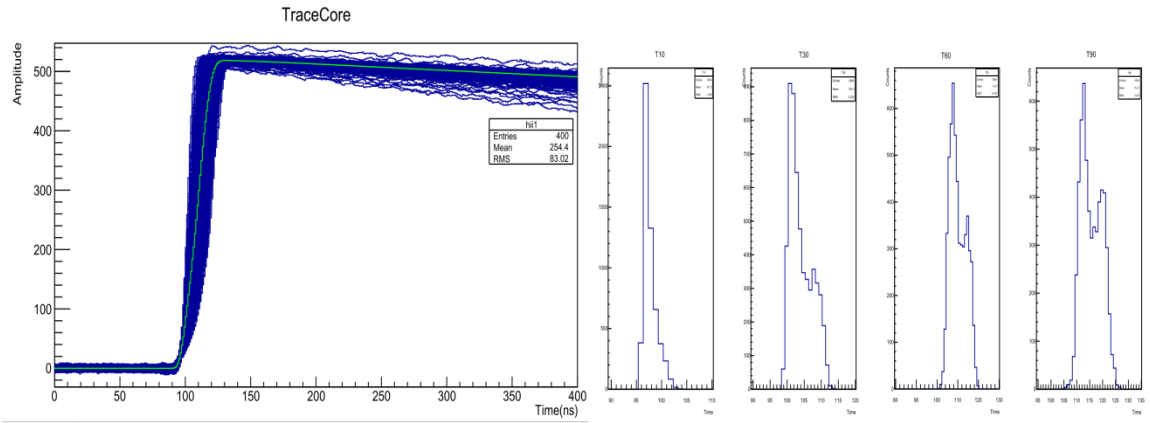

Figure 2. Left: The average (green line) and the individual (blue lines) traces for interaction 1, position (-5, 27), which is near the surface of crystal B. Right: The measured individual rise times for each trace for position 1.

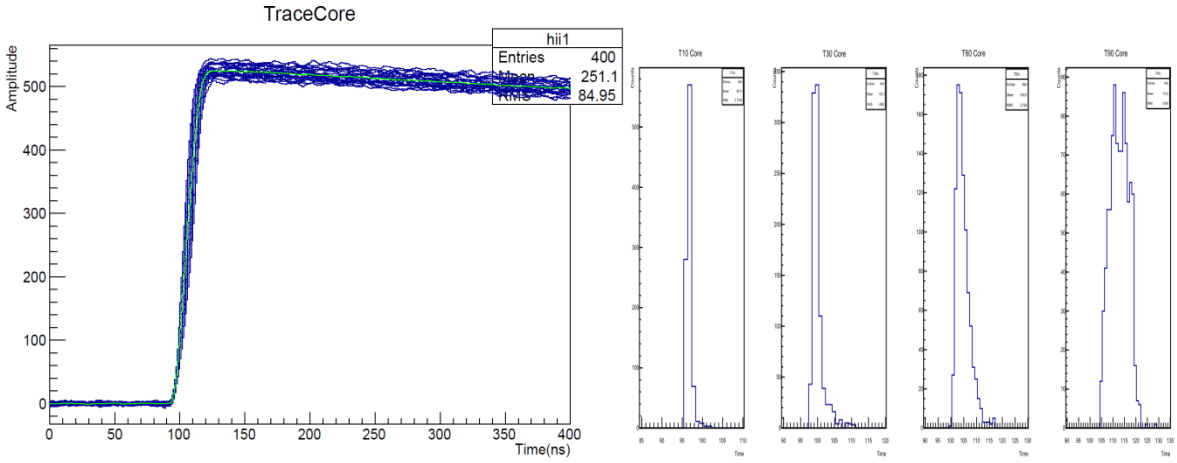

Figure 3. Left: The average (green line) and the individual (blue lines) traces for interaction 2, position (-23, 27), which is near the core of crystal B. Right: The measured individual rise times for position 2.

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**

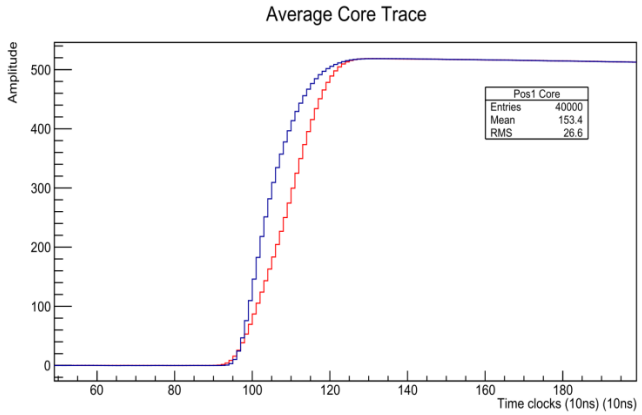

Figure 4. The average traces for positions 1 (blue) and 2 (red). The rise times for positions 1 and 2 show a clear difference.

Figure 4 shows the average traces for positions 1 and 2. It is clear that the rise times are distinctly different, thus a scan of the detector should yield information on the orientation of the Ge crystals. Such measurements are in progress.

References

[1] B. Bruyneel, et al., Nucl. Instr. And Meth., A569, 774 (2006)
[2] B. Bruyneel, et al., Nucl. Instr. And Meth., A569, 764 (2006)
[3] T. D. Bucher, et al., Progress Report (2014)
[4] H. C. Scraggs, et al., Nucl. Instr. And Meth., A543, 431-440 (2005)