Master's Thesis Engineering Technology

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Study of parameters influencing the response of HPGe-detectors

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INTRODUCTION:
High Purity Germanium detectors (HPGe) have a superior resolution compared to other gamma-ray detectors. Today, many laboratories perform corrections for coincidence summing and efficiency transfer by using computer models of the detectors and samples. It is important that such models are as accurate as possible. Important parameters are e.g. the deadlayer thicknesses and they cannot be measured. Therefore, three goals were set:

1) To study the homogeneity of the top deadlayer of 3 detectors and use this for create a computer model for a detector of UHasselt.
2) Improve the computer model of detector T7(JRC) and investigate the influence of different parameters while doing this.
3) Compare two methods for deadlayer thickness calculations. These calculations give a deadlayer thickness that corresponds best to the results and not to the actual deadlayer thickness.

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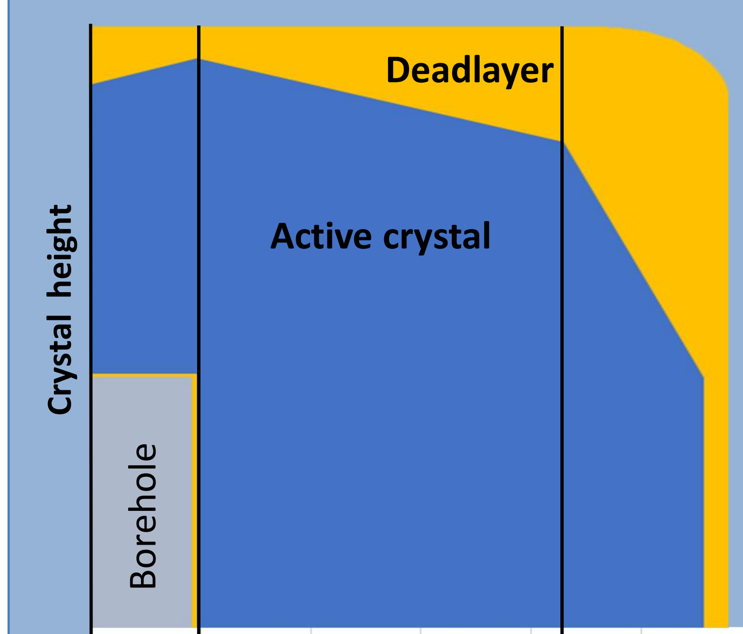
The homogeneity of the top deadlayer of three detectors, one for each of SCK•CEN, JRC and Uhasselt was studied. The deadlayers of the detectors from JRC and SCK•CEN were perfectly straight and homogeneous whilst the deadlayer of the UHasselt detector was not.



UHasselt detector (Fig. 1)

Å Deadlayer grew because of **Li-diffusion** at room-temperature (over **21 years**)

Å Good agreement scan and simulated scan → **R^2=0.988**

Å Drawing is **not** on scale. It serves to show the overal deadlayer shape

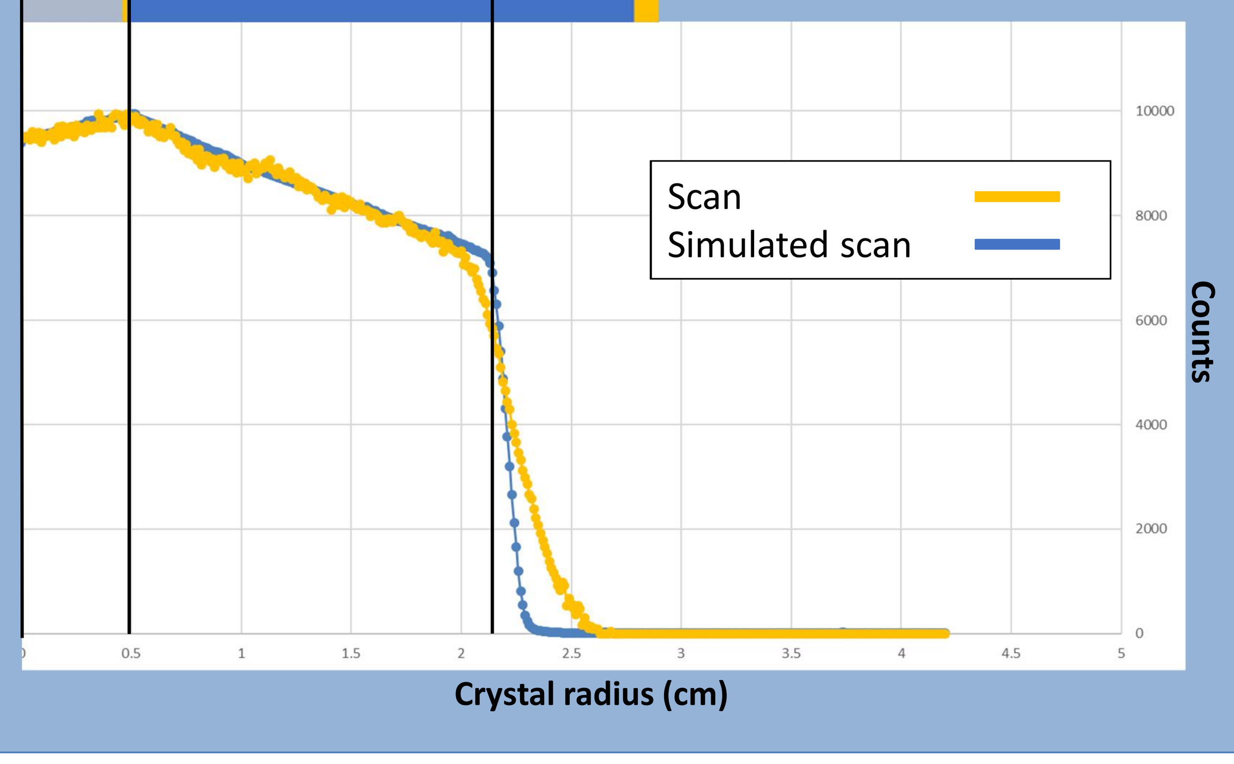


Figure 1: (upper) not on scale drawing of the detector of UHasselt, (below) comparison of the experimental scan and the calculated scan using the computer model.

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Å **Detector T7 (JRC)** needed a better computer model as the old one was not adequately fit for purpose

Å The 3 parameters that chielfy influenced the response of the detecor (in different energy-regions) were found to be:

- Å **Crystal-to-endcap distance**: Impact on all energies
- Å **Top deadlayer thickness**: great impact below 100 keV
- Å **Side deadlayer thickness**: Impact on all energies

Å The model was improved using an iterative procedure (Table 1) with the 7th model being adequately accurate.

Table 1: Influence of the change of multiple parameters of detector T7 based on the relative difference between the experimental and modelled Full Energy Peak efficiency.

Model number	Deadlayer thickness (mm)	Endcap to crystal distance (mm)	Side deadlayer thickness (mm)	Mean relative difference for low energy region (%)	Standard deviation on the relative difference for low energies(%)	Mean relative difference for high energy region (%)	Standard deviation on the relative difference for high energies(%)
1	0.0003	4	0.75	-6.22	3.60	-6.49	2.91
2	0.7330	4	0.75	122.72	155.90	-1.21	5.03
3	0.0100	4	0.75	2.59	6.30	-6.43	2.74
4	0.0100	8	0.75	12.50	7.18	2.37	3.14
5	0.0003	7	0.90	1.53	3.86	0.93	2.99
6	0.0003	7	1.00	1.63	4.02	1.46	3.07
7	0.0003	6	1.10	0.96	2.85	-0.23	1.81

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Quantitative determination of top deadlayer thickness

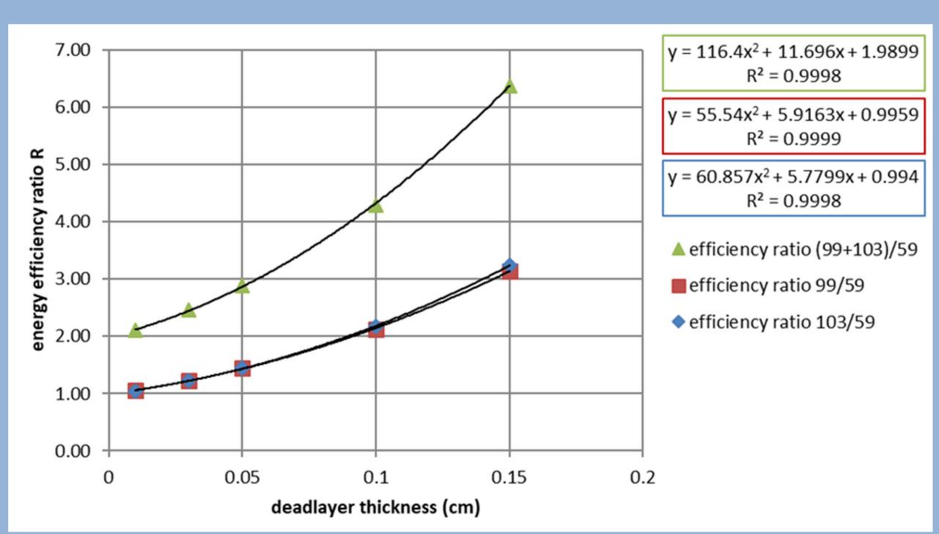

Figure 2: Graph that was used in to perform the method described in Budjas et al. [1] for detector T2 together with the trendline functions.

Å Two detectors used: T2 (JRC) and Ge-6 (JRC)

Å Two methods tested:

- Å (i) Based on difference in counting efficiency at 59.5 and 103 keV (Fig. 2), Budjas et al. [1] and
- Å (ii) Based on difference in attenuation coefficients at 59.5 and 103 keV (Fig. 3)

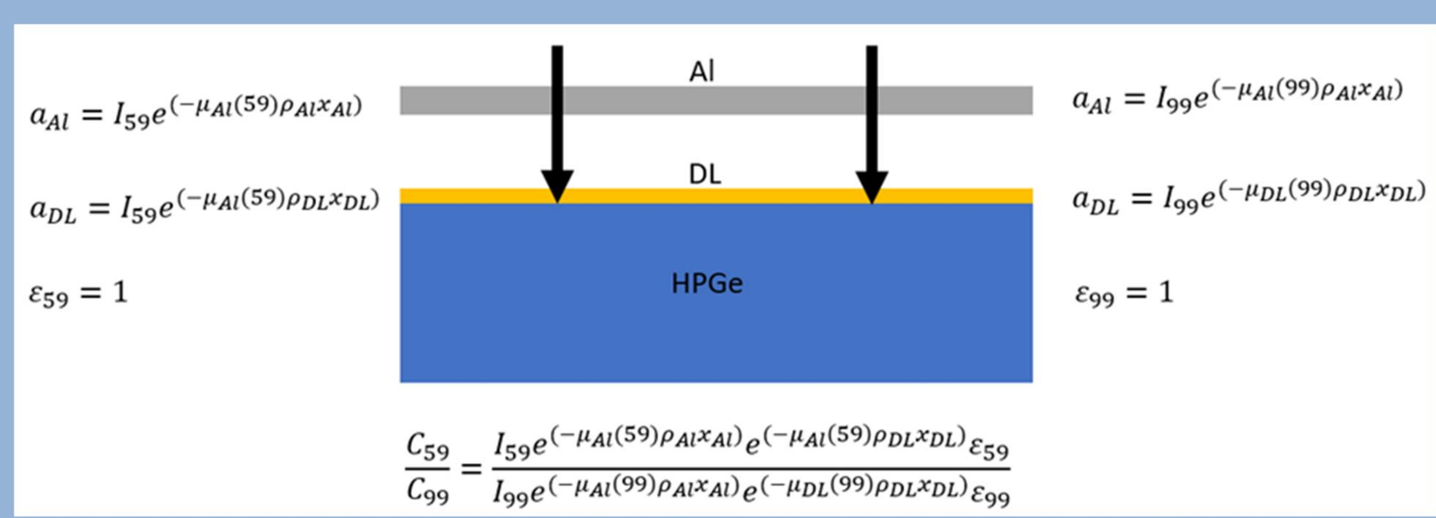

Figure 3: Explanatory image for the method based on the attenuation coefficients.

CONCLUSION:

1) A first model of the detector of UHasselt was created and a non-homogeneous top deadlayer was implemented based on data from a scan using a ^{241}Am-source.
2) A much improved computer model of JRC-detector T7 was created by iteratively varying the 3 parameters that were found to influence the response the most.
3) Two methods were tested to quantitatively determine the top deadlayer thickness. The two methods give similar results given that a non-collimated ^{241}Am source is used. It is also possible to use the 99 keV line instead of the 103 keV line.

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