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CHARACTERISTICS OF SEGMENTED SUPER CLOVER DETECTOR IN CLOSE GEOMETRY DECAY MEASUREMENTS*

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Characteristics of the segmented Super Clover germanium detector response in close geometries have been studied. Results obtained with localising hit pattern recognition are compared with results from add-back and individual crystal analysis. The detector has been used at the focal plane of a gas filled recoil separator to detect isomeric gamma-rays from the nuclei produced in the ^{150}Sm(^{42}Ca,4n)^{188}Pb reaction. Coincidence data from the detector was analysed and the level scheme below the 1.2 μs isomeric state in ^{188}Pb could be deduced.

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1. Introduction

Composite germanium detectors typically have a large active volume [1,2], thus they are very efficient and suitable for off-beam gamma-ray spectroscopy in close geometries. Segmentation of composite detectors [3–5] can be advantageous also in off-beam spectroscopy. Position sensitivity of the

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segmented composite detector allows the localisation of detected gamma-rays within the detector to be determined. It is also possible to separate coincident gamma-rays. The GSI Super Clover detector [6, 7] consists of four large n-type HPGe crystals, each of 6 cm diameter and 14 cm length before shaping. The crystals are electrically segmented into four quadrants on their outer contact (figure 1(a)). The resulting 16 separate sub-volumes are coupled into nine signals (figure 1(b)). The four center contacts have good energy and timing resolution while the outer segmented contacts with lower signal quality are used for localisation. The detector was surrounded by an 8 element suppression shield (figure 1(b)).

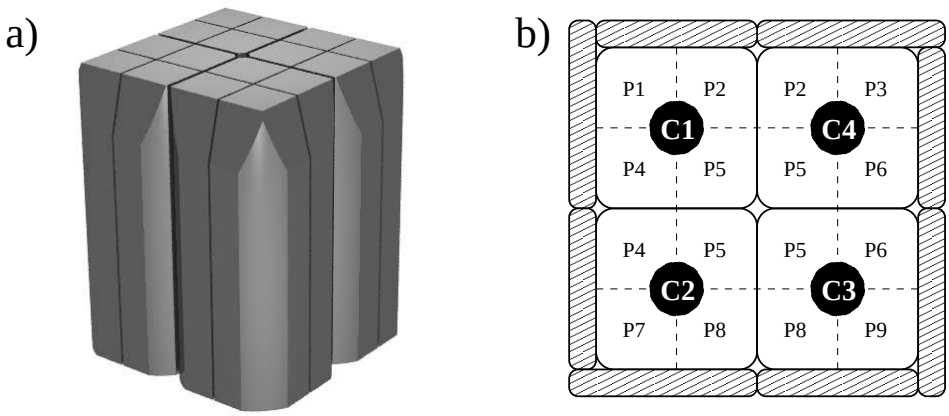

Fig. 1. (a) Illustration of the Super Clover crystals. (b) Schematic drawing of the 9-fold segmentation scheme and the BGO shield. The center contacts (C1-C4) have good energy and time resolution while the position signals (P1-P9) are used to localise the gamma-rays. The elements of the BGO shield are indicated using hatching.

2. Analysis modes and detector characteristics

Data from the detector were analysed using three different methods: *(i)* in total add-back mode, *(ii)* as four individual crystals and *(iii)* using a hit pattern recognition algorithm developed for segmented clover detectors. In the algorithm the 16-fold segment hit pattern is recovered using both crystal and position signals. The pattern is searched for isolated hits of a single or adjacent double or triple segments. The energy and time of the

incident gamma-rays are then calculated from the energy and time signals of the inner contacts overlapping the pattern found. No checks of crystal or position energies are done, which makes the method simple and independent of the quality of the position signals but at the same time some sensitivity is lost. Characteristics of the detector were measured with radioactive sources placed on the axis of the detector 2.5 cm from the detector face. Absolute efficiencies deduced from the ^{60}Co data show that the individual crystal mode is the most efficient of the three at this distance, having a photopeak efficiency of approximately 5.5% at 1332 keV. For both total add-back and the hit pattern recognition, the add-back factor drops below 1.0 from typical values of 1.5 and 1.2 measured at the standard 25 cm source-detector distance. In the case of total add-back this reflects the large probability of coincidence summing as the solid angle subtended by the whole detector is nearly 30% at 2.5 cm. Hit pattern recognition is less affected by the coicidence summing but the coupling of the segments makes the recovery of some scattering paths (for example C1P5-C2P4) impossible using the simple hit pattern recognition alone. In the latest segmented clover detectors with 16-fold uncoupled segmentation the performance of the hit pattern recognition algorithm should be better. The BGO shield was used in three different configurations in which a crystal was vetoed with (all) eight, four or two closest elements. Whole shield suppression was found to give optimum performance.

3. Isomer spectroscopy of ^{188}Pb

The detector was subsequently placed at the focal plane of the RITU [8] gas filled recoil separator.

The recoiling nuclei produced in the ^{150}Sm(^{42}Ca,4n)^{188}Pb reaction were separated from beam particles and fission products by the separator and implanted into a position sensitive silicon strip detector (PSSD). Delayed γ–γ events detected in the clover detector placed at 2.5 cm from the PSSD were sorted into matrices using individual crystal analysis mode. Transitions de-exciting the 1.2 μs isomeric state at an excitation energy of 2576 keV in ^{188}Pb were identified using an additional condition that the gamma-rays must have been detected within 3 μs after the recoil implantation (figure 2). The data are in agreement with those proposed by Heese *et al.* [9] and Dracoulis *et al.* [10] and show that the detector can be used to detect coincident events in such experiments.

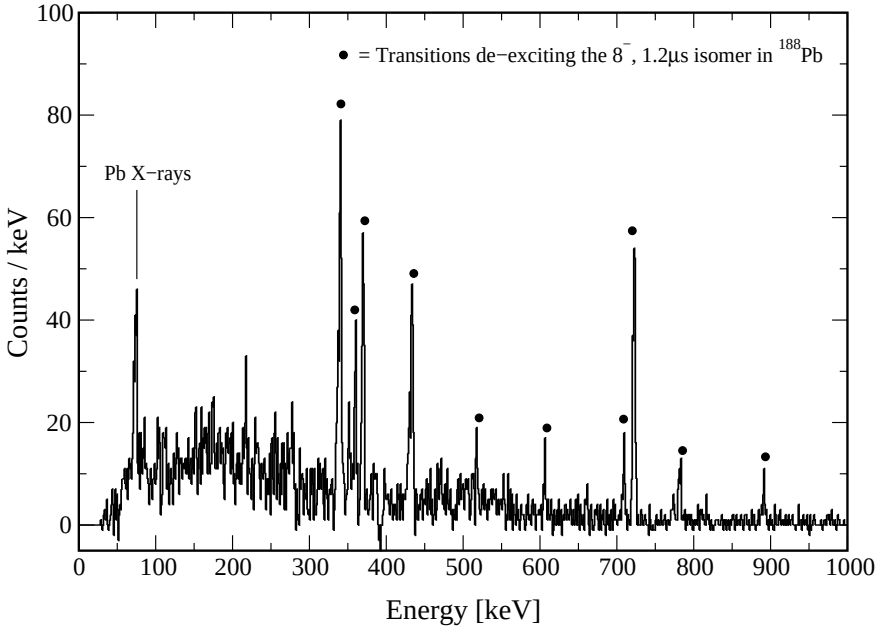

Fig. 2. Energy spectrum of coincident gamma rays observed 3 μs after the recoil implantation and gated by the 723, 340 and 370 keV transitions.

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REFERENCES

[1] P.J. Nolan *et al.*, *Annu. Rev. Nucl. Part. Sci* **30**, 561 (1994).
[2] C.W. Beausang *et al.*, *J. Phys.* **G22**, 527 (1996).
[3] S.L. Shepherd *et al.*, *Nucl. Instrum. Methods Phys. Res.* **A434**, 373 (1999).
[4] S. Bouneau *et al.*, *Nucl. Instrum. Methods Phys. Res.* **A443**, 287 (2000).
[5] P. Jones *et al.*, *Acta Phys. Pol.* **B30**, 671 (1999).
[6] J. Gerl *et al.*, GSI Scientific report, 271 (1994).
[7] M. Kaspar *et al.*, GSI Scientific report, 195 (1997).
[8] M. Leino *et al.*, *Nucl. Instrum. Methods Phys. Res.* **B99**, 653 (1995).
[9] J. Heese *et al.*, *Phys. Lett.* **B302**, 390 (1993).
[10] G.D. Dracoulis *et al.*, *Phys. Lett.* **B432**, 37 (1998).