Digital Gamma-ray Spectroscopy with High Purity Germanium Detectors

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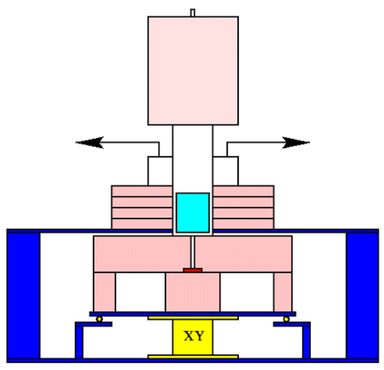
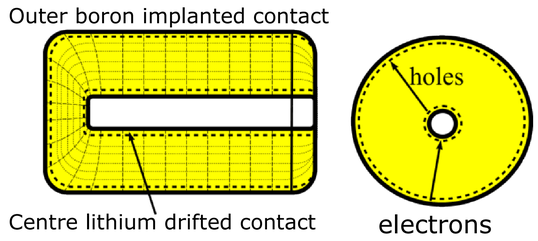
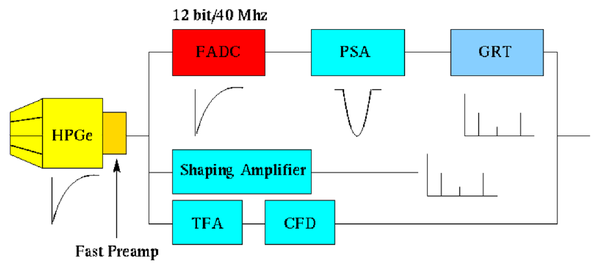
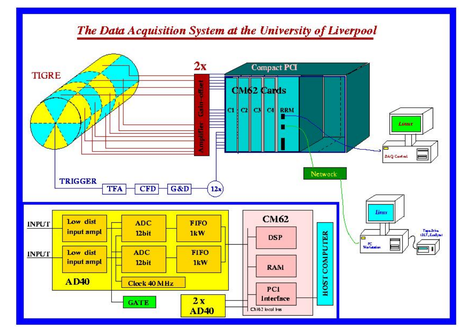
The Background

In nuclear physics we require precise knowledge of the energy and time of the interaction of a gamma-ray photon in a High-Purity Germanium (HPGe) detector. Position information has been limited to the solid angle (and hence size) subtended by the detector in question. With the use of digital Pulse Shape Analysis (PSA) it is theoretically possible to indentify the interaction position inside a HPGe crystal to high precision.





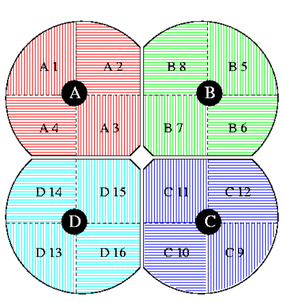


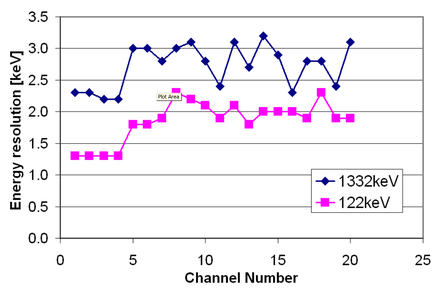


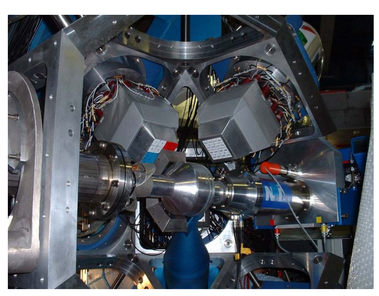
A detector scanning apparatus has been assembled at the University of Liverpool in order to facilitate a study of the response function of HPGe detectors to gamma-ray interactions at differing positions in the crystal volume. The fully automated system is based on two Parker linear positioning tables. A 25MBq radioactive source, collimated using a 2mm diameter tungsten/lead collimator is positioned in 2mm steps across the front face of a detector. The response function of the detector preamplifiers is recorded to a RAID disk storage array for offline analysis.

EXOGAM Detector

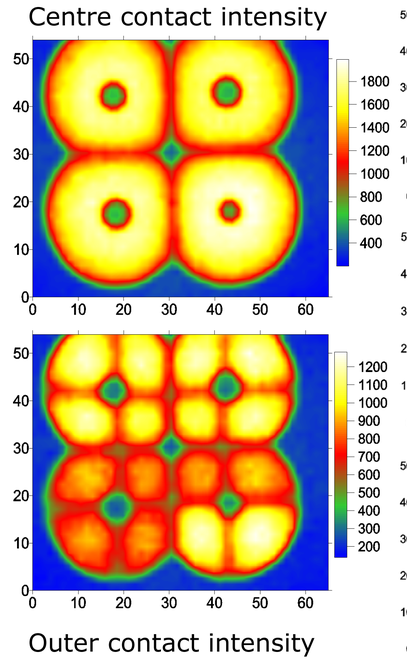
The EXOGAM detector array is currently being commissioned at GANIL in France. The array is designed for use on the SPIRAL radioactive ion-beam facility. The design of the array is for maximum efficiency (~20% photopeak) at low to moderate multiplicity. The EXOGAM detectors will be furnished with both analogue and digital electronics. The performance of an Ortec EXOGAM Clover detector has been characterised. Preliminary selected results are presented here.
The EXOGAM detector consists of four n-type HPGe crystals mounted in one cryostat. Each crystal is electrically segemented into four segments.
The effectiveness of the segmentation and the risetime characteristics of a detector are illustrated here (preliminary).



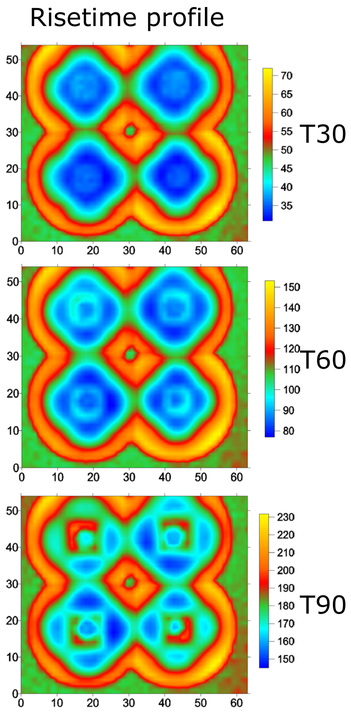


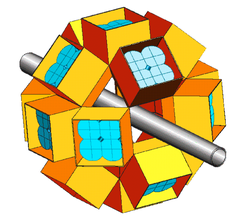


Centre contact intensity

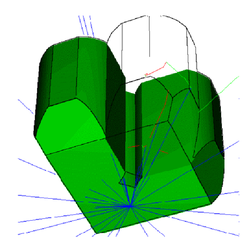


Risetime profile





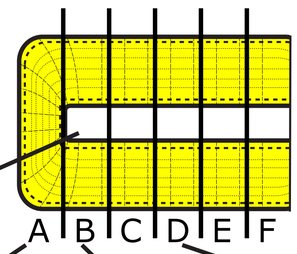
The exogam detector specification required that the crystal lattice orientation on the four crystals was the same.



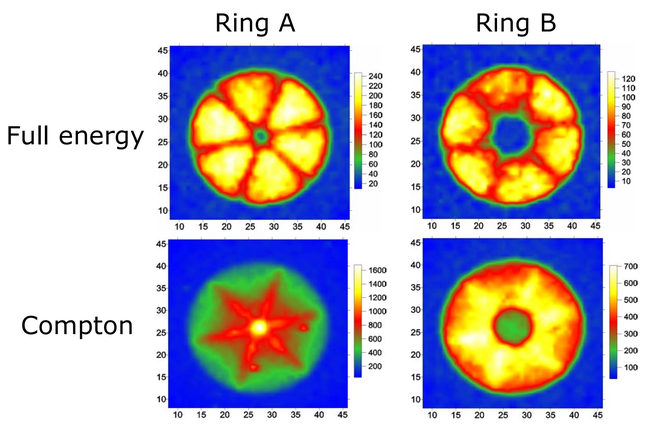
MCNP simulation

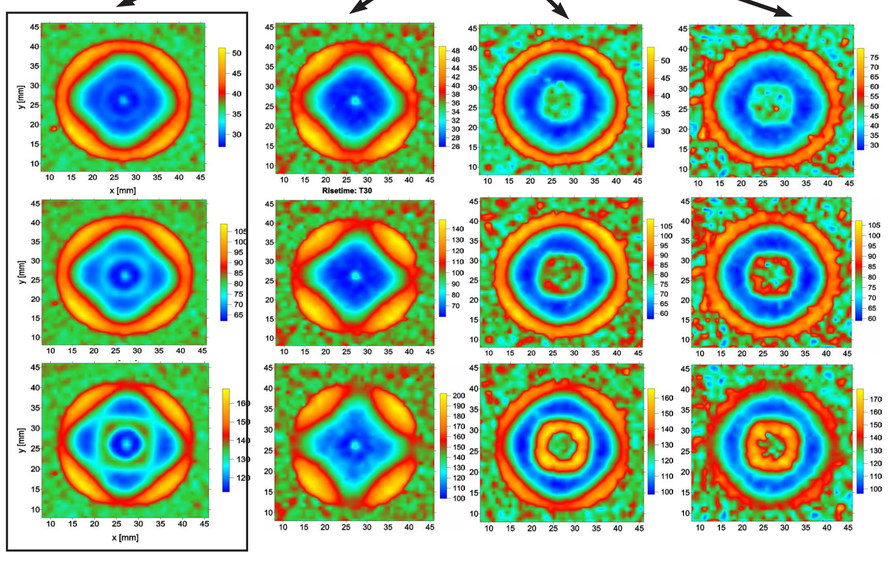
36 Fold Detector

A highly segmented germanium detector manufactured by Eurisys Mesures has been scanned. The detector consists of an n-type HPGe crystal, 60mm in diameter and 90mm in length, with 36-fold segmentation of the outer boron implanted contact. The detector has equally spaced z-segmentation of 1.5cm. Each contact is furnished with a fast preamplifier fitted with warm FETs. Typical outer contact energy resolutions are 2.1-2.5 keV measured for 1332keV ^{60}Co.



The number of counts as a function of position for rings A and B, the front two rings are shown. The plots require that 662 keV is deposited on the centre contact.





The plots show the pulseshape risetime profile as a function of depth in the detector. A 662keV photon is required to be deposited in each ring. The risetime is measured on the centre contact from T10 to 30, 60 or 90% of the maximum of the charge pulse.
The complex structure of the E-field in the front segment is clearly manifest.

The Future

As part of the UK gamma-ray tracking project, a new VME based DAQ card has been developed at Daresbury Laboratory. The card consists of a 4 channel VME board mounted with 4 80Mhz 14bit FADCs. The processing and data buffering is performed by two dedicated Xilinx Spartan 2 FPGAs per channel. The card can operate in a differentiated or non-differentiated configuration. The card is design to facilitate real data rate operation through use of the FPGA to perform PSA.
The University of Liverpool will begin commissioning the new VME base DAQ with 40 channels of the new digital electronics along with 60 channels of Silena ADCs at the end of August 2002. In beam tests of the 24-fold Ortec (TIGRE) detector and 36-fold Eurisys detector are planned for December 2002.