Abstract

The AGATA demonstrator consists of five AGATA Triple Cluster (ATC) detectors. Each triple cluster detector contains three asymmetric, 36-fold segmented, encapsulated high purity germanium detectors. The purpose of the demonstrator is to show the feasibility of position-dependent γ-ray detection by means of γ-ray tracking, which is based on pulse shape analysis. The thesis describes the first optimization procedure of the first triple cluster detectors. Here, a high signal quality is mandatory for the energy resolution and the pulse shape analysis. The signal quality was optimized and the energy resolution was improved through the modification of the electronic properties, of the grounding scheme of the detector in particular.

The first part of the work was the successful installation of the first four triple cluster detectors at INFN (National Institute of Nuclear Physics) in Legnaro, Italy, in the demonstrator frame prior to the AGATA commissioning experiments and the first physics campaign. The four ATC detectors combine 444 high resolution spectroscopy channels. This number combined with a high density were achieved for the first time for in-beam γ-ray spectroscopy experiments. The high quality of the ATC detectors is characterized by the average energy resolutions achieved for the segments of each crystal in the range of 1.943 and $2.131\,\mathrm{keV}$ at a γ-ray energy of $1.33\,\mathrm{MeV}$ for the first 12 crystals. The crosstalk level between individual detectors in the ATC is negligible. The crosstalk within one crystal is at a level of 10^{-3}.

In the second part of the work new methods for enhanced energy resolution in highly segmented and position sensitive detectors were developed. The signal-to-noise ratio was improved through averaging of the core and the segment signals, which led to an improvement of the energy resolution of $21\,\%$ for γ-energies of $60\,\mathrm{keV}$ to a FWHM of $870\,\mathrm{eV}$. In combination with crosstalk correction, a clearly improved energy resolution was achieved for events of each hit-segment multiplicity. For γ-ray energies of $1.33\,\mathrm{MeV}$, an improvement of $20\,\%$ was achieved.

The study of electron trapping using a new position-sensitive correction method for the energy measurement was completed. The correction of electron trapping resulted in an additional improvement of the full width at half maximum of the peaks of the γ-spectra. A total energy resolution of $2.01\,\mathrm{keV}$ at $1.33\,\mathrm{MeV}$ was achieved with a segmented, large volume germanium detector. The position-sensitive operation enabled calculating the Fano factor, which resulted in $F = 0.095 \pm 0.005$. Eventually, a significant improvement of the energy resolution was achieved. Consequently,

the novel segmented high-purity germanium AGATA detectors are operated at significantly improved conditions superior to the common Ge detectors in energy and position resolution. The essential improvement arises from the redundant energy measurement of independent core and segment electrodes and from the correction of the position-dependent trapping effects.