Signal Processing for GRETA - a Progress Report

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One crucial ingredient in the concept of GRETA and γ-ray tracking is the determination of the energies and the positions of individual interactions of γ-rays in the Ge crystals. GRETA - as it is proposed so far - will consist of a closed 4π arrangement of segmented coaxial Ge detectors. Germanium is still the best available material with regard to energy resolution and efficiency for γ-ray spectroscopy (100 keV$\leq$E$_\gamma$ $\leq$10 MeV).

To determine the interaction position, the outside contact of each Ge detector will be segmented longitudinally and azimuthally. The radius, as the third dimension, will be extracted by pulse-shape analysis, in a similar way as the drift time analysis in a TPC. However, to reduce the number of segments, pulse-shape analysis can also be employed to improve the longitudinal and azimuthal resolution beyond the size of the segments. This can be done by analyzing the pulse-shapes of transient induced signals in segments adjacent to that containing the interaction. Generally, in a segmented detector, all signals will depend on the distance of the interaction to the segment boundaries, whether the segment contains interactions or not.

During the last year we performed measurements to study the feasibility of such an approach and found that previous calculations give the correct sensitivity to induced signals with regard to position resolution. This included comparisons between measured and calculated signal shapes as well as comparisons of parameters such as the amplitude of the induced signal as a function of distance from the boundary. The measurements were performed with a 12 fold segmented Ge-detector (described in the 1996-97 NSD annual report). Fig. 1 demonstrates the observed position sensitivity for induced signals. Shown on the right are maximum amplitudes of transient induced charge signals obtained with a collimated ^{241}Am source (E$_\gamma$=60 keV) at the indicated positions at the left. From this analysis we obtain a position sensitivity of 1-3 mm - dependent on the noise level - up to a distance of about 1.2 cm from each boundary. This implies that a segment size of about 2$\times$2 cm^2 is sufficient to extract the positions of the interactions to an accuracy of a few millimeters. To obtain a comparable position resolution by segmentation only would require several thousands of channels, while by using the induced signals only $\sim$40 channels are needed.

A 36 fold segmented Ge detector has been ordered as a final prototype to confirm this signal decomposition. A drawback in using larger segment sizes is the possibility of having several interactions in one segment. To decompose multiple interactions in one or adjacent segments an algorithm has been developed which will be tested and applied to the new Ge detector.

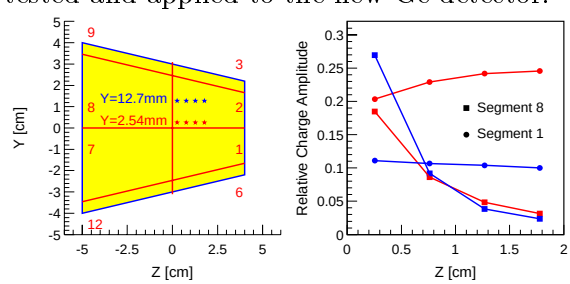

Figure 1: Measured amplitudes of induced signals in the 12 fold segmented GRETA prototype detector.