

Position Reconstruction by Pulse Shape Analysis with the Ge-detector VEGA

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An optimum algorithm to find interaction positions of a γ -ray in a Ge-detector is being investigated by analyzing pulse shapes of the Ge-detector VEGA [1, 2]. The VEGA detector consists of four Ge crystals forming like a four leaf clover. Each crystal has four electric segmentations in radial quarters. A collection time of electron and hole (e-h) depends on their drift length, therefore the slope of the signal pulse depends on the distance of interaction position from the inner contact. For a segmented Ge-detector, an additional position information can be extracted by analyzing pulse shapes of neighboring segments. The drift of e-h affects the electric field in the neighboring segments and causes small transient pulses from image charges in the neighboring segments. The amplitude of the image charge signal depends on the position of the interaction in the irradiated segment. An analysis of pulse shapes gives more precise position information than a position sensitivity defined by the geometry of segments.

Signal pulses from the preamplifier of the VEGA detector (SSC No.2) were recorded by using a Flash ADC. A γ -ray source which was collimated to a 2 mm diameter beam was used to scan the detector surface by 4 mm steps. Details of the measurement have been reported [1]. An example of the pulse shapes is shown in fig. 1. For the radial

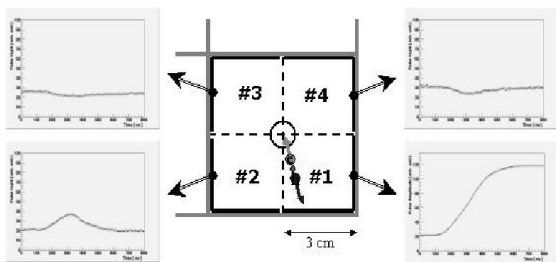


Figure 1: Typical pulse shapes for the irradiated segment (#1) and for the other segments (#2~4) in a crystal. The x-axis time range is $1\mu s$.

information preamplifier signals from the irradiated segment were converted to their first and second derivative to enhance their slopes [1]. Several parameters, time, height, and width of these pulses, were considered to extract pulse characteristics. The parameters show a radial dependence, however, in many cases they do not provide a unique solution to determine the interaction position. Amplitudes of image charge signals of the neighboring segments (#2 and 4) were also taken as parameters. The parameter has a maximum amplitude when the source position is close to the segment #2 with a distance of about 1cm from the crystal center, and it has a minimum when the source is close to the segment #2 but far from the crystal center. The image charge is not sensitive when the source position is far from the segment #2. The parameter for the segment #4 was obtained symmetrically to that for the seg-

ment #2. It means that the image charge of the segment #4 is position sensitive in a area where the image charge of the segment #2 is weak, and vice versa. By combining these two parameters a unique position information can be extracted.

Position reconstruction was performed by using these parameters. Results of Gaussian fitting on the parameters were taken as reference distributions for each source position, and mean and sigma values were stored in a look-up table. The data which was used to take the reference values had to be used, but the source position was kept as unknown. For each event a density of reference Gaussian at a parameter value in the event was taken for each parameter. The density was regarded as a probability to have the source position for the reference Gaussian. The probabilities were combined for different parameters and compared for all references. A source position can be determined according to the probabilities. An example of the position reconstruction for a 1.4 MeV γ -ray is shown in figure 2. The reconstructed position distributions have an

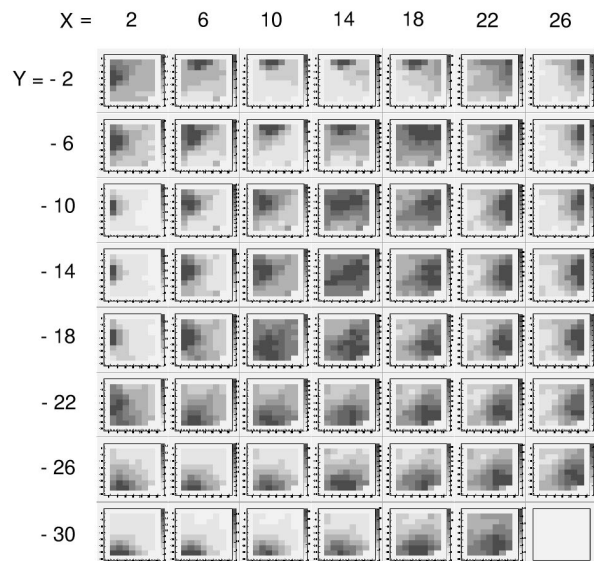


Figure 2: Each plot shows the reconstructed source position distribution in the segment #1 for a data set with a particular source position corresponding to the X,Y value.

resolution ranging from 7 to 9 mm in RMS. For the result shown in figure 2 two parameters, image charge amplitude for the segments #2 and 4, were used. The reconstruction is rather successful near the border comparing to that in the middle source position.

References

- [1] N. Saito, *et al.*, GSI sci. rep. 2002, 2003-1 (2003) 222
- [2] M.Kaspar, Ph.D. thesis, Frankfurt University (1999)