
Oishi T., Sanami T.*, Hagiwara M., Itoga T., Yamauchi I., and Baba M.
Cyclotron and Radioisotope Center, Tohoku University
High energy accelerator research organization

Introduction
In recent years, progress of a digital storage oscilloscope (DSO) enables raw waveform acquisition from a radiation detector. In this method digital storage oscilloscope is connected just after a radiation detector, a raw signal data is saved in it as digital waveform outs. By using this method, there are many advantage compared with the method using electronic circuits as follows,

• Because the whole raw data is saved, a complicated and flexible analysis is possible such as smoothing and noise reduction.
• Fine parameter adjustment in signal processing
• Easy to setup

On the other hand, there are some disadvantages to overcome.

In this study, the method was adopted to the measurement of secondary fragments from neutron induced reaction for Bragg carve spectrometer (BCS)

Application
Figure 1 shows a schematic view of the BCS which is a cylindrical gridded ionization chamber. A target was mounted on cathode plate and irradiation by neutron. Fragment from the target produced by neutron induced reaction ionize the gas in the BCS. Electrons drift toward the anode by the electric field keeping a shape of ionization distribution Bragg curve. Therefore, the time distribution of the anode signal is just to the reversed. Thus, the fast part of anode signal is proportional to the Bragg peak that provides the information on the atomic number of the fragment. The integration of the whole anode signal represents the total charge that is proportional to the fragment energy.
By using anode signal, we distinguish the energy and the charge of fragments event by event.

Signals from the BCS were digitized by a Lecroy WAVEPRO7000 digital oscilloscope with a sampling frequency of 100 MHz after charge-sensitive preamplifier. Digitized signals were transmitted to a personal computer by Ethernet.

Figure 2 shows one of a transmitted signal which is integrated Bragg curve by a preamplifier. The pulse height is equal to particle energy and the maximum differentiation value, (the steepest slope), corresponding to Bragg peak. When we determine the steepest slope, there was a problem of high frequency noise, however, pulse height was obtained exactly. In the noise elimination process, Fourier analysis was adopted to determine frequency of signals originated fragments. The components with other frequencies were remove as noise components by “the finite impulse response (FIR) filter”. FIR filter is one of the frequency selective digital filters. Figure 3 shows example of the suppression of high frequency noise component.

After the procedure, pulse height and the steepest slope were obtained for each waveform. Figure 4 shows scatter plot of pulse height and the steepest slope. A result by analog electronic circuit is also shown in Figure 5. “H”, ”He”, and ”Li” denote the hydrogen, helium, and lithium particle respectively. In order to show the ability of particle discrimination quantitatively, the portion except the former was projected on the vertical axis. Figure 6 and figure 7 show Bragg peak pulse height spectra by the digital waveform analysis and the analog electronic circuit, respectively. It was observed that the result by the digital waveform analysis had the better ability of particle discrimination than by the analog electronic circuit.

This method has much possibility. Application and improvement of this technique for various detectors is in progress.

References

2) Hagiwara M. et al., CYRIC annual report 2003, to be published.
Ar+10% CH4 gas 200 Torr

Field shape rings
Produce drift E field

Grid : shield anode
from E field of cathod-grid

0.15 V/cm/Torr

Drift to anode by E field

Fig. 1. Schematic view of the Bragg curve spectrometer.

Max differentiation value = Bragg peak

Pulse height = Particle energy

Fig. 2. One of raw data

Before

After

Fig. 3. Suppression of high frequency.
Fig. 4. Scatter plot by digital waveform analysis.

Fig. 5. Scatter plot by analog electronic circuit.
Fig. 6. Bragg peak pulse height spectra by digital waveform analysis.

Fig. 7. Bragg peak pulse height spectra by analog electronic circuit.