Application of Digital Signal Processing to Bragg Curve Spectrometer Using Digital Storage Oscilloscope

III. 3. Application of Digital Signal Processing to Bragg Curve Spectrometer Using Digital Storage Oscilloscope

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Digital signal processing technique is a data handling method in which each signal waveform from a detector is acquired as digital data, and the information of the radiation, for example energy and time, can be derived through the analysis of the signal waveform using computers. Although this method has been carried out for more than ten years, it has not been always useful because of slow performance of ADCs and computers. Recently, the signal waveform acquisition becomes possible in a acceptable counting rate with a relatively simple way owing to the speedup of ADCs and computers. Therefore it becomes possible to apply the DSP technique to the practical radiation detection.

The most significant advantage of DSP technique is the possibility of flexible signal analysis which is difficult with the analog circuits. In this work, we intend to extract the fission fragment's events from signals overlapped with noise taking this advantage of the DSP technique. In addition, the DSP technique has more advantage for example, reduction of load for preparation of experiments owing to very few analog circuits required, and the possibility of high quality reanalysis owing to computing analysis.

In this study, this method was adopted to the measurement of fragments from neutron induced reaction for Bragg carve spectrometer (BCS). Figure 1 shows a schematic view of the BCS which is a cylindrical gridded ionization chamber[1,2]. A target was set up in the center of a scattering chamber and irradiated by protons. Fragments from the target produced by proton induced reaction enter the BCS through the window and 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 corresponds to just 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 the anode signal, we distinguish the energy and the charge of fragments event by event.

Signals from the BCS were digitized a Lecroy WAVEPRO7000 digital storage oscilloscope (DSO) with a sampling frequency of 100 MHz after charge sensitive preamplifier. Digitized signal data were stored in HDD of DSO and real time analysis was carried out by a computer with Ethernet connection.

Figure 2 (blue line) shows a typical signal data which is integrated Bragg curve by a preamplifier. Signal acquisition without preamplifier is difficult because of low SN ratio. In order to obtain the Bragg curve, it is needed to differentiate the signal. High frequency noise disturbs the differentiation. Accordingly, smoothing spline method was applied to suppress the noise, and signal waveform after applying shows in Fig. 2 (red line). The Bragg curve was obtained by differentiation of the applied signal waveform as shown in Fig. 3. Information of the Bragg peak, delta E and energy are obtained from Bragg curve. Bragg peak is defined as the peak of the Bragg curve and delta E is obtained from the Bragg curve's pulse height at constant time from particle injection. Energy is equal to pulse height of preamplifier out. Using this method, mass of fragments can be distinguished by delta E-E method with only one detector.

Figure 4 shows a scatter plot of Bragg peak and energy. Figure 5 shows a scatter plot of delta E and energy. In Fig. 4, we can recognize the separation of fragments in each atomic number, from bottom to top, helium, lithium, beryllium, boron, carbon. Moreover, it is clear that each mass is separated in Fig. 5.

In the future, proton induced reaction double differential fragment produce cross-section in each mass will be available using this method. DSP method has much possibility. Application and improvement of this technique for various detectors is in progress[3)].

References

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3) Oishi T., et al, J. Rad.. Prot. Bulletins (submitted).

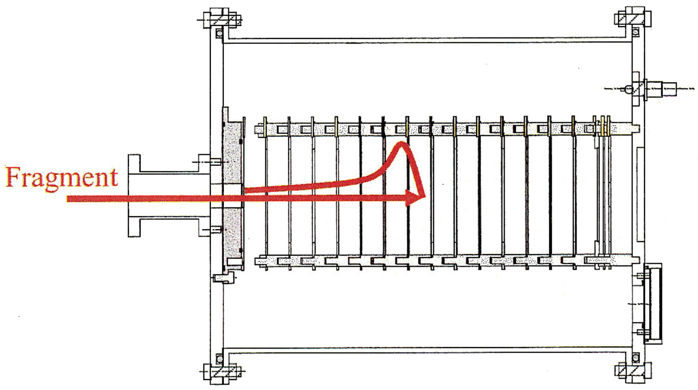

Fig. 1.　Schematic view of the Bragg curve spectrometer.

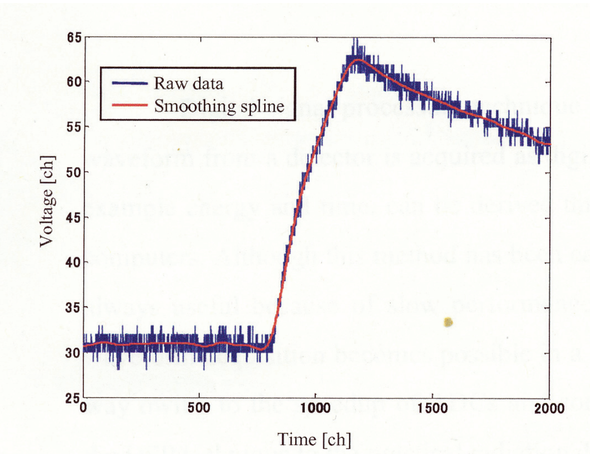

Fig. 2.　Typical signnal data and smoothing spline.

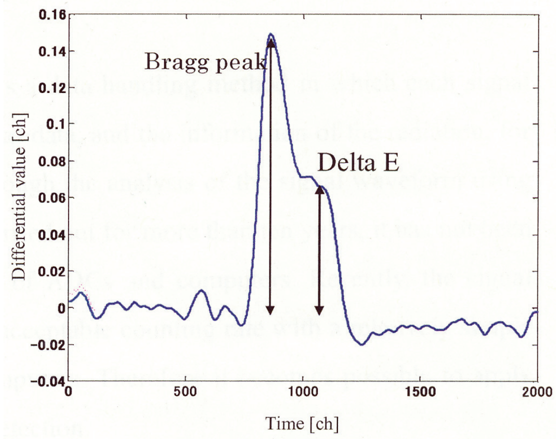

Fig. 3.　Bragg curve.

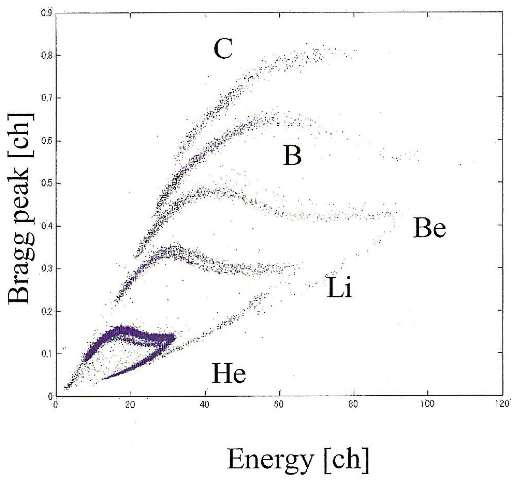

Fig. 4.　Bragg peak vs. Energy.

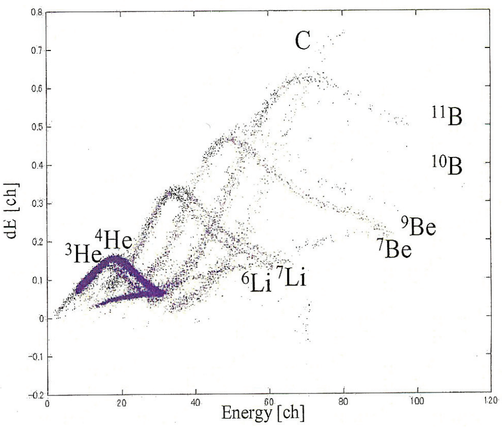

Fig. 5.　Delta E vs. Energy.