Beam energy measurement system using electrostatic pickups at the RIBF

T. Watanabe,[*1] N. Fukunishi,[*1] M. Fujimaki,[*1] and R. Koyama[*2]

It is important to measure the beam energy of heavy-ion beams at the RIBF. Monitors with plastic scintillators as sensors (scintillation monitors) were used to measure the energy and longitudinal profiles of heavy-ion beams.[1] However, the beam cannot be used while it is being measured, and there is a danger of melting the scintillator. For the purpose of real-time measurement of the beam energy, electrostatic pickups were newly designed, fabricated, and installed in the beam transport line (C01, C02) in the AVF cyclotron.[2] Two electrostatic pickup monitors installed in the beam transport line are used to measure the particle time- of-flight (TOF) between the paired monitors. Researchers who conduct experiments can always watch the beam energy in real time with a web browser even if they are in an experiment room.

When a charged-particle beam passed along the axis of the electrostatic pickup, the image charge is electrostatically induced on the pickup. The beam signals are amplified and transmitted via coaxial cables with a length of 46 m directly to the DAQ stage outside the radiation protected area. Finally, a high-speed digitizer board digitizes the beam signals and sends the date to a controller PC. We chose this digitizer for the signal processing instead of a standard oscilloscope because it has high transfer rates and large-capacity onboard memory. The electrical specifications of the digitizer and amplifier are listed in Table 1. The program for the data acquisition of the digitizer and for displaying results is written in LabVIEW. Since the controller PC in the DAQ stage is connected to an EPICS Ethernet LAN, the measured results can be watched with a web browser on any PC, only users have permissions. The obtained data are stored in a

Table 1. Electrical specifications of digitizer and amplifier.

Digitizer	
Model No.	NI PXIe-5160 (National Instruments)
Bandwidth	DC - 500 MHz
Sampling rates	2.5 GS/s (1 ch), 1.25 GS/s (4 ch)
Memory	2GB
Resolution	10-bit
Channels	4
Transfer Rates	600 MB/s
Amplifier	
Model No.	ABL0300-00-3230 (Dynamic RF Inc.)
Bandwidth	9 kHz - 3.0 GHz
Noise Figure	2.5dB typical, 3.0 dB Max @25 °C
Gain	32 dB @25 °C

*1 RIKEN Nishina Center
*2 SHI Accelerator Service Ltd.

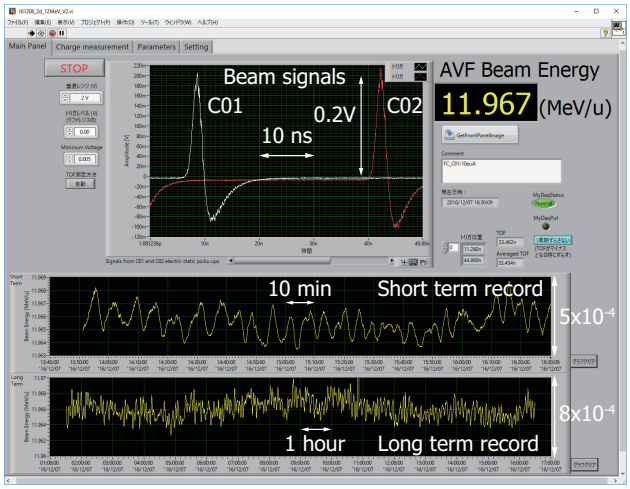

Fig. 1. Example of the measured results for the acceleration of a $^2H^+$ beam at an intensity of 10 μA.

MyDAC, which is a simple data-logging and display server. An example of the measured results for the acceleration of a $^2H^+$ (deuteron) beam with an intensity of 10 μA is shown in Fig. 1. In these results, the beam energy was found to be changed periodically with a period of about 6 min. This phenomenon was synchronized with a temperature change of cooling water, which was caused by a heat exchanger and temperature-control device. The temperature of cooling water was changed within ±0.4°C every 6 min. Although the investigation indicated that the beam-energy change might have been caused by the temperature change of the main coil of the cyclotron, more detailed investigation is necessary. The accuracy can reach better than 0.2% for the energy spread assuming precisions of the length ΔL = 1 mm and time Δt = 100 ps. The minimum detectable beam current with this system is approximately 50 nA.

In fiscal year 2016, we measured the beam energy 12 times for the cross section measurements for RI production experiments,[3–7] which typically lasted for 3 days. Those beam-energy measurements were performed using the scintillation monitors and electrostatic pickup monitors.

References

1) T. Watanabe et al.; Proc. IPAC'14 (2014), p. 3566.
2) T. Watanabe et al.; Proc. 12th Ann. Meet. of PASJ, (2015), p. 1198.
3) S. Takács et al., NIM B **383**, 213 (2016).
4) F. Ditrói et al., NIM B **385**, 1 (2016).
5) S. Takács et al., NIM B **397**, 33 (2017).
6) A. Usman et al. NIM B **399**, 34 (2017).
7) A. Saito et al., ARI **125**, 23 (2017).