Beam Energy and Longitudinal Beam Profile Measurement System at the RIBF†

T. Watanabe,[*1] M. Fujimaki,[*1] N. Fukunishi,[*1] H. Imao,[*1] O. Kamigaito,[*1] M. Kase,[*1] M. Komiyama,[*1] N. Sakamoto,[*1] K. Suda,[*1] M. Wakasugi,[*1] and K. Yamada[*1]

Monitors with plastic scintillators as sensors (scintillation monitors) were fabricated to measure the energy and longitudinal profiles of heavy-ion beams at the RIKEN RI beam factory (RIBF). Six pairs of two scintillation monitors installed in the transport lines were used to measure the particle time-of-flight (TOF) between the paired monitors to determine the acceleration energy of the heavy-ion beams. The energy of the beam can be calculated from the measured TOF. In addition, five scintillation monitors were installed to measure the longitudinal profiles of the heavy-ion beams. Longitudinal beam profiles were obtained by using a time-to-digital converter (TDC), which digitizes the detected signals from the scintillator and the RF clock signal. Recently, to help users operate the system more easily, a new embedded processor with a higher-performance CPU has been introduced, and a new user interface has been constructed using the LabVIEW program.

For data acquisition and control of the scintillation monitors, we developed a ccompactPCI system that uses a Windows-based PC[1]. Signals from the detectors are amplified and converted to logic pulses by a constant-fraction discriminator. The TDC digitizes this pulse along with the RF clock and stores the events into the memory of the TDC. The TDC (TC890) has two memory banks based on a so-called ping-pong memory architecture that enables data readout while the module continues to acquire events. When a bank is ready to be read, an interrupt is generated, and the readout starts in the direct memory access mode.

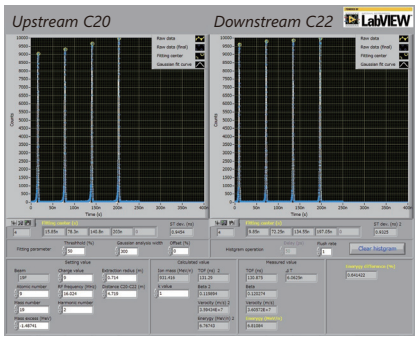

Fig. 1. Longitudinal profiles the $^{19}F^{9+}$ beam measured at C20 (upstream) and C22 (downstream) in the AVF cyclotron beam transport line as displayed on the graphical user interface.

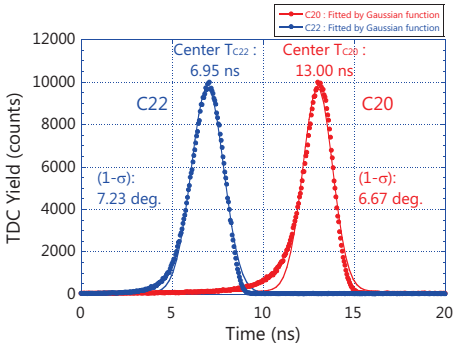

Fig. 2. Gaussian functions fit to the rightmost beam profiles at C20 and C22 in Fig. 1.

The programs for the data acquisition, control, and for showing results are written in LabVIEW (Windows7). The PCs are connected to a laptop in the main control room located 100 m from the Riken ring cyclotron (RRC) hall via Ethernet and remote desktop connection. The EPICS system controls insertion of the monitor into the beam line or its retraction from the beam line and it monitors these statuses.

We measured the energy of a $^{19}F^{9+}$ beam accelerated by the AVF cyclotron by using the TOF method. The $^{19}F^{7+}$ beam was used to produce element 105, ^{262}Db from a target of ^{248}Cm[2]. Because the sequential double pulse resolution was 15 ns, the $^{19}F^{9+}$ beam was attenuated to be under 1 M s^{-1} using beam attenuators. The longitudinal profile of the $^{19}F^{9+}$ beam was measured at C20 (upstream) and C22 (downstream) in the AVF cyclotron beam transport line were displayed on the graphical user interface as shown in Fig. 1. The rightmost longitudinal profiles obtained at C20 and C22 in Fig. 1 are expanded and plotted in Fig. 2. By fitting the profiles in Fig. 2 with Gaussian functions, we determined the center times T_{C20} and T_{C22} of the profiles and the longitudinal phase widths (1-σ), as shown in Fig. 2. The beam kinetic energy (T_{TOF}) obtained by measuring the TOF was 6.81 MeV/u. In addition, the beam kinetic energy ($T_{B\rho}$) can be determined by the magnetic field of the bending magnet that bends the $^{19}F^{9+}$ beam because the field was already known as a function of the exciting current. In this measurement, the hysteresis effect was not taken into account. The kinematic energy $T_{B\rho}$ was determined to be 6.80 MeV/u. These energies are in good agreement, with a difference between T_{TOF} and $T_{B\rho}$ of 0.1%.

† Condensed from the proceedings in 5th International Particle Accelerator Conference (IPAC'14)

*1 RIKEN Nishina Center

References

1) T. Watanabe et al.: RIKEN Accel. Rep. **43**, 135 (2010).
2) M. Murakami et al.: RIKEN Accel. Rep. **47**, 265 (2014).