Ion-beam-profile monitor using MCP at the SCRIT electron scattering facility

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At the SCRIT electron scattering facility,[1)] ion-beam-profile monitors[2)] are installed in the ion-beam transport line for injecting low-energy (∼10 keV) ions into the SCRIT device.[1)] They are composed of a meshed Faraday cup, a CsI(Tl) scintillator, an optical prism, and a network-based CCD camera. Using these monitors, ion-beam tuning is performed in real time. However, it is difficult to apply them to a low-rate ion beam, such as a continuous beam with 10^7 ions/s or a pulsed beam with 10^6 ions/pulse, because the number of produced photons is considerably less than the expected value calculated using the conversion factor, 2×10^4 photons/MeV. One of the reasons for this suppression is that the low-energy ions stop near the surface of a CsI(Tl) scintillator and the number of involved CsI molecules is insufficient. Thus, a new ion-beam-profile monitor is required for real-time beam tuning with low-energy RI beams. This year, we tested a new monitor using a micro channel plate (MCP) and report out first results in this paper.

Figure 1 presents a schematic view and photograph of an ion-beam-profile monitor using an MCP. This monitor consists of two MCPs equipped with a phosphor screen (HAMAMATSU F2806 with P46), an optical prism, and a network-based CCD camera (Basler scA640-70gc). The horizontal and vertical dimensions of the effective area of the MCP are 45 mm and 35 mm, respectively. A collimator, which has a 28-mm diameter hole, is installed in front of the optical prism to define the effective detection area because the effective area of the MCP is larger than the entrance size of the optical prism, 30 mm^2. In the present setting, ion beams are directly observed with MCPs. The applied voltages of MCP-in, MCP-out, and Phos-in, which are electrodes shown in Fig. 1, are 0, 2, and 6 kV, respectively. The extracted electron cloud resulting from the beam encountering the MCP surface is converted to photons in the phosphor screen, which are transported to the CCD camera through the collimator and the optical prism. The exposure time of the CCD camera is set to 500 μs. Data from the CCD camera are monitored through a network in real time. With a pulsed beam, the trigger of the CCD camera is synchronized with the injection timing.

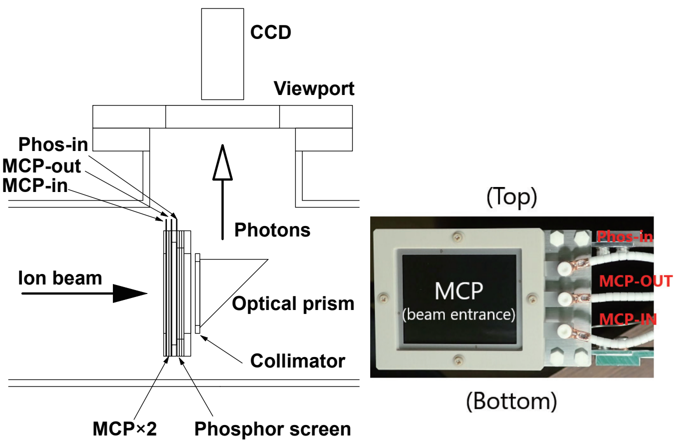

Fig. 1. Schematic view and photograph of the ion-beam-profile monitor. MCP-IN, MCP-OUT, and Phos-in represent electrodes of the monitor.

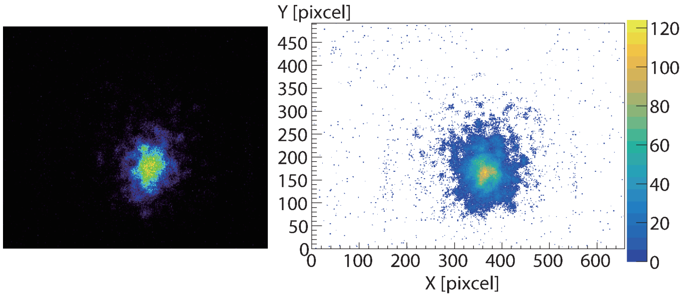

Fig. 2. Beam profile of 1 pulse with a 10^4 ions/pulse beam. Left figure is the image of the beam profile and right figure is its digital number distribution.

The commissioning of the new ion-beam-profile monitor was performed using a ^{138}Ba-ion beam of 6 keV. Figure 2 shows the measured beam profile of only 1 pulse using a 1-Hz pulsed beam with 10^4 ions/pulse. The number of ions with a low-intensity pulsed beam was estimated with the current of a continuous beam, 13 pA, measured at the Faraday cup installed in front of the ion-beam-profile monitor. Calibration was performed using a 0.3-nA continuous beam and a pulsed beam with $5{\times}10^5$ ions/pulse. Figure 2 shows an image of the beam profile (left) and its digital number distribution (right). More detailed analysis is being performed to estimate the number of injected ions using only the digital number distribution.

We tested the new ion-beam-profile monitor using an MCP with a low-intensity pulsed ion beam. The beam profile of a low-intensity pulsed ion beam was successfully measured in real time. In the case of RI beams using the present monitor, electrons corresponding to the decay of the RIs can cause background events. To avoid this problem, a thin foil is installed in front of the MCPs to stop RI beams, and electrons produced during the decay of RIs are used as an MCP signal. Next year, we will test a new setup using RI beams and evaluate its applicability considering the efficiency and position resolution.

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References
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