Operation of the Pelletron tandem accelerator

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The tandem accelerator (Pelletron 5SDH-2, 1.7 MV max.) in Nishina R&D Building (Fig. 1) has been managed by the Detector Team, RNC since April 1st, 2016. The accelerator has three beam lines for (1) RBS (Rutherford backscattering) spectrometry/ERDA (elastic recoil detection analysis), (2) microbeam port, and (3) multi-purpose use. So far, the ion species of H, He, Li, B, C, N, O, Si, Ti, Ni, Cu, and Au have been accelerated.

The total machine time including sample irradiation was 37 days during the annual reporting period from Jan. 1 to Dec. 31, 2016, excluding repair of the high-voltage system. In addition, a precise alignment of the beam elements as well as the ion source was performed. The experiments in machine time and details of the maintenance are described in this report.

Fig. 1. Pelletron tandem accelerator and beamline.

The ion species accelerated in this year were H^+, B^{3+}, and Au^{6+}, with energies ranging from 1.0 to 10.5 MeV, as summarized in Table 1.

Experimental studies including a machine study on the following subjects were performed. (Machine studies without beam delivery to beam ports are not counted.)

(1) Performance test of a thin Si detector (11 days)
(2) Educational experiment of proton capture by carbon nucleus for Nishina School (Fig. 2) (5 days)
(3) Metallic nanoparticle formation by ion irradiation in liquid (5 days)
(4) Microbeam irradiation to single cells (6 days)
(5) Machine study of proton microbeam using tapered glass capillaries (10 days)
(6) Analyses using elastic scattering (RBS/ERDA) as Wako joint-use equipment (0 days = no user)

In April, the stability over 700 s of the acceleration voltage was examined, as shown in Fig. 3(a). The horizontal axis shows the monitored voltage, which is proportional to the acceleration voltage (5.95 V corresponding to 1.5 MV). The fluctuation σ (standard deviation of the data) was found to be more than 0.3%, which was worse than the specification of 0.1% guaranteed by the manufacturer. After a maintenance overhaul (cleaning in the acceleration tank to avoid discharge and replacing a broken ground level shaft with a new one), it improved, as shown in Fig. 3(b), for a 9,000-s operation. In December, the locations of all beam elements (ion source, triplet-Q, dipole magnet, and beam ducts) were measured precisely. Because of the position adjustment of the ion source, the beam intensity at the irradiation port improved by two orders of magnitude.

Table 1 Beam conditions and experiments conducted in the tandem accelerator (*experiments that used more than one ion species per day.)

Ion	Energy [MeV]	Beam current [nA]	Experiment	Operation time [days]
$^{1}H^{+}$	1.0–3.0	0.01–50	Irradiation	37
$^{4}B^{3+}$	1.5–2.3	0.01–1	Irradiation	*3
$^{197}Au^{6+}$	7.0–0.5	0.01–1	Irradiation	*2

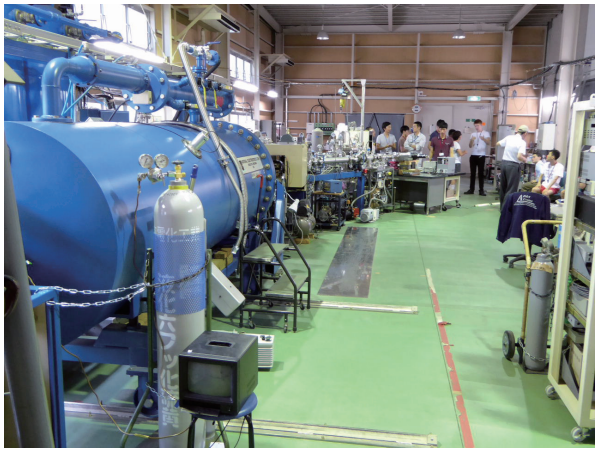

Fig. 2. Educational experiment for Nishina School.

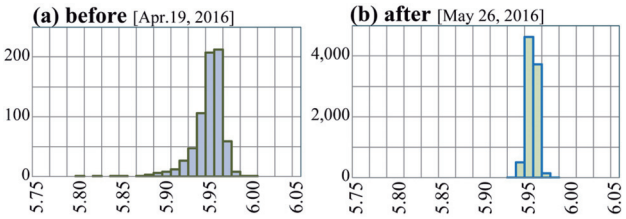

Fig. 3. Acceleration voltage monitoring results (a) before and (b) after the repair. Fluctuation σ improved from (a) σ = 0.312% to (b) 0.095%.

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