Operation of the Pelletron tandem accelerator

T. Ikeda,*[1] M. Hamagaki,*[2] and H. Sato*[1]

The tandem accelerator (Pelletron 5SDH-2, 1.7 MV max.) with two ion sources in the Nishina R&D Building (Fig. 1) is managed by the Detector Team of RNC. The accelerator has three beam lines for (1) Rutherford backscattering (RBS) spectrometry/elastic recoil detection analysis (ERDA), (2) a microbeam port, and (3) multi-purpose use. The RF charge-exchange ion source, called Alphatross, is mainly used for the extraction of He^- ions. Another source is the Source of Negative Ions by Cesium Sputtering (SNICS). Almost all other ions can be extracted from SNICS as negative ions, such as H^- and C^-. Thus far, ion species of H, He, Li, B, C, N, O, Si, Ti, Ni, Cu, and Au have been accelerated with the two ion sources. The range of the ion beams is several 10 μm at most for water (density = 1 g/cm^3). Only H^+ can have ranges greater than 100 μm for water. All experiments except for microbeam irradiation with tapered glass capillaries should be performed in vacuum chambers. However, heavy ions of several MeV, such as Au ions, can provide stopping powers greater than 200 keV/μm at only the surface layer of samples or detector-sensitive areas. Since the experimental area is approved as a second-class radiation-controlled area, users for all measurements can access their setup even during the beam irradiation time. The users are free from any setup for remote control utilities. These are advantages of the use of the Pelletron accelerator.

During the annual reporting period from Jan. 1 to Dec. 31, 2017, the total machine time including machine studies was 24 days, where the condition check of the ion sources is not counted. The experiments in the machine time and details of maintenance are described in this report.

The ion species accelerated in this year were H^+, He^+, He^{2+}, C^{2+}, C^{3+}, and C^{4+}, with energies ranging from 1.0 to 7.2 MeV, as summarized in Table 1. Experimental studies on the following subjects were performed.

(1) Ion irradiation on thin layers for the modification and creation of micro-particles (4 days)
(2) Machine study of a proton microbeam using tapered glass capillaries (6 days)
(3) Test of microbeam irradiation on single cells (8 days)
(4) ERDA experiments using carbon ions (3 days)
(5) Educational experiment of proton capture by a carbon nucleus for Nishina School (3 days)
(6) Analyses using elastic scattering (RBS/ERDA) as Wako joint-use equipment (0 days = no user)

In this year, the He ion source (Alphatross) was repaired because there was no machine time using the He ion beam owing to the extremely low intensity of He^- ions in the previous year. The reason for the low intensity was found to be the aged deterioration of the power supply for the confinement magnetic field and the RF supply tubes. Figure 2 shows the change of the He plasma densities between before and after the renewal (Left and Right, respectively). Precise alignment of the position of the source was also performed. The final intensity of the He^{2+} beam at an irradiation port was increased back to 50 particle nA.

For accurate positioning in the microbeam irradiation, a laser beam alignment system was tested at BL-E45. Glass capillary optics providing micrometer-sized ion beams needs axis orientation with respect to the initial beam with accuracy of the order of mrad. The alignment time was successfully reduced from a few hours down to a few minutes.

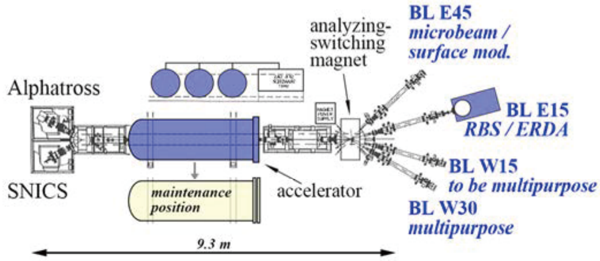

Fig. 1. Pelletron tandem accelerator and beamlines in the Nishina R&D Building. The tank colored blue is the position of operation, and the white one is for maintenance.

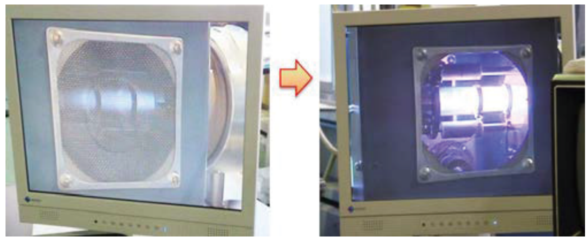

Fig. 2. Improvement of He plasma density to provide He ion beams with sufficient intensities.

Table 1. Beam conditions and experiments conducted in the tandem accelerator.

Ion	Energy [MeV]	Beam current [nA]	Experiment	Operation time [days]
$^{1}H^{+}$	1.0–3.0	0.01–50	Irradiation	9
$^{4}He^{+,2+}$	1.5–4.5	1–50 [pnA]	Irradiation	13
$^{12}C^{2,3,4+}$	up to 7.2	0.01–1	Irradiation	2

*1 RIKEN Nishina Center