Operation of the Pelletron tandem accelerator

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The tandem accelerator (Pelletron 5SDH-2, 1.7 MV max.) in the Nishina R&D Building, which is managed by the Detector Team of RNC, is joint-use equipment in Wako campus. Figure 1 shows the configuration of the beam elements. Two ion sources are employed. One is the RF charge-exchange ion source, called Alphatross, for experiments using He ion beams. The other is the Source of Negative Ions by Cesium Sputtering (SNICS), which is used for experiments with almost all other ions. Thus far, ion species of H, He, Li, B, C, N, O, Si, Ti, Ni, Cu, and Au have been accelerated at 0.5–1.7 MV.

The accelerator has four beam lines named BL-E/W*nn* (*nn* stands for the bending angle). BL-E45 is used for surface modification. BL-E15 is reserved for the analysis of Rutherford backscattering (RBS) spectrometry/elastic recoil detection analysis (ERDA). A micrometer-sized beam based on glass capillary optics with an end window is available at BL-W30 to irradiate the biological sample in air or solution.

During the annual reporting period from January 1 to December 31, 2019, the total machine time (MT) including a machine study was 20 days, where the condition test of the ion sources is not included. The ion species accelerated in 2019 were the light ions H^+, He^+ and He^{2+} with energies ranging from 1.0 to 4.8 MeV and Au ions with energies of 3 and 9 MeV, as summarized in Table 1. An experiment used both H and He ions on a day to compare the effects of different stopping powers. The topics (1–6) are listed with the number of days of machine time.

(1) Microbeam performance study with H ions using glass capillaries at BL-W30[1] (7 days)

(2) Microbeam (He ion) irradiation for single cells at BL-W30[2] (9 days including 1 day with He/H ions.)

(3) RBS/ERDA experiments using carbon ions (0 day)

(4) Educational experiment of proton capture by carbon/boron nucleus for Nishina School (2 days)

(5) Development of charged-particle/gamma-ray detector to be used for RIBF experiments (2 days)

(6) Other development using protons (0 day)

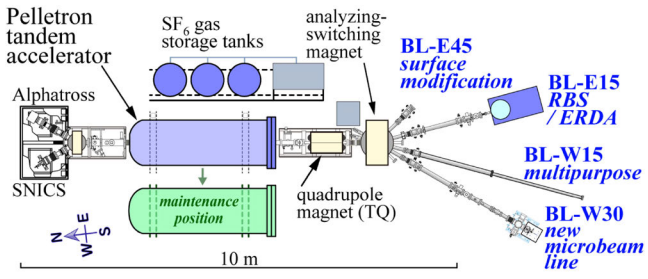

Fig. 1. Pelletron tandem accelerator and beamlines in the Nishina R&D Building.

Table 1. Beam conditions and experiments conducted in the tandem accelerator. A day for He^{2+} includes an MT for H^+.

Ion	Energy [MeV]	Beam current [pnA]	Experiment	Operation time [days]
$^{1}H^{+}$	1.0–3.0	0.001–160	Irradiation	8
$^{4}He^{+,2+}$	3.0–4.8	0.018–200	Irradiation	12
Au^{5+}	3.0–9.0	0.1	Irradiation	1

Table 2. Approved conditions at the RIKEN Pelletron.

Ion	Maximum Energy	Ion	Maximum Energy
H	3.4 MeV	B	10.2 MeV
He	5.1 MeV	C	12 MeV
Li / Be	6.8 MeV	other	0.6 MeV/u

* Z : 1 – 83 excluding deuterons

* Maximum intensity: 6.3 x 10^{12} ions / s (1 pμA)

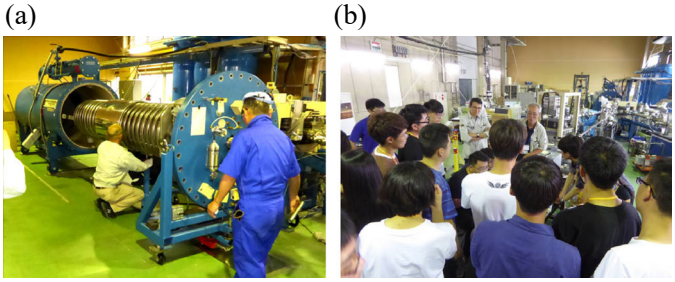

Fig. 2. (a) Overhaul of the Pelletron accelerator. (b) A school principal explaining the accelerator to students.

In this year, the regulation of the maximum energy of carbon ions was changed, as summarized in Table 2 with other ions. The charge state $^{12}C^{6+}$ is now available with the full acceleration voltage of 1.7 MV (E_{carbon} = 11.9 MeV). The approved maximum energy was 0.6 MeV/nucleon.

The acceleration tank was overhauled in May for the first time in 3 years (Fig. 2(a)). No serious deterioration was found at any essential parts for the operation. The pellet chains and inner wall of the tank were cleaned to avoid sudden voltage drops. In August, the experiment of the Nishina School was performed. 1- and 2-MeV protons were provided for the nuclear resonance reaction of $^{12}C(p,\gamma)^{13}N$, the reaction energies of which are 0.457 and 1.699 MeV, respectively. The energy spectra of the γ rays from the carbon and boron targets were obtained. Some known and unknown γ-ray peaks were discussed by the student participants.

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References

1) T. Ikeda *et al.*, Nucl. Instrum. Methods Phys. Res. B **470**, 42 (2020).
2) T. Ikeda *et al.*, in this report.