Operation of Pelletron tandem accelerator

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The Pelletron tandem accelerator (5SDH-2) managed by the Detector Team of RNC provides ion beams accelerated by up to 1.7 MV. This accelerator is also registered as a joint-use equipment at the Wako campus for material analysis. As shown in the configuration of the accelerator and the beam lines (Fig. 1), two ion sources are available. One is the RF charge-exchange ion source, called Alphatross, which is employed for experiments using He ion beams. The other is the Source of Negative Ions by Cesium Sputtering (SNICS), which can generate almost all other ions. Thus far, ion species of H, He, B, C, O, and Au have been mainly accelerated in the range of 0.5–1.7 MV.

The maximum energies of different accelerated ions are listed in Table 1. Since 2019, the regulation of the maximum energy of carbon ions was changed from 7.2 MeV to 11.9 MeV, where $^{12}C^{6+}$ is accelerated with the full voltage of 1.7 MV. However, owing to aged deterioration (more than 30 years), acceleration voltages of less than 1.4 MV have been used in recent years.

A unique feature of this facility is the ability to irradiate samples in liquid with a microbeam produced by glass capillary optics at some beam lines.[1] There are four beam lines named BL-E/W*nn* (*nn* denotes the bending angle of the east or west beam line). BL-E45 is dedicated to microbeam irradiation for samples in liquid.[2] BL-E15 is used by user groups in the field of material science to perform Rutherford backscattering (RBS) spectrometry analysis.[3] The RBS apparatus (Charles Evans and Associates Model RBS-400) consists of a goniometer to rotate a sample and a particle detector at 165° to the incident beam direction to measure the back scattered ion energies. Both are inside a vacuum chamber with a vacuum level of the order of 10^{-4} Pa. The intensity of the input He^{2+} beam of 2.28 MeV is approximately 10 nA when the beam size is collimated to 5 mm in diameter. On the west side, BL-W15 was previously used for channeling experiments;[4] however, since 2016, it is employed as a multipurpose line for various equipment. Some examples are a profile measurement system

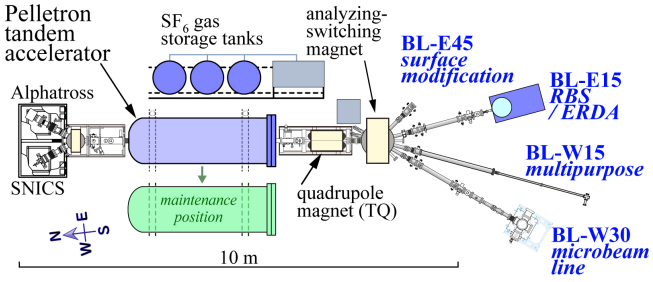

Fig. 1. Pelletron tandem accelerator and beam lines at Nishina R&D Building.

Table 1. Approved conditions at 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: 6.3×10^{12} ions / s (1 pμA)

for an ion microbeam produced by glass capillary,[5] microbeam irradiation tool to induce damage in DNA of mammalian cells,[6] cross-section measurement setup for an international summer school, Nishina School, and detector calibration system based on proton-induced resonance reactions to produce γ rays of up to 10.8 MeV[7] BL-W30 was previously used for detector calibration;[8] however, since 2020, it is dedicated to a new microbeam irradiation port equipped with an Olympus research microscope.

The total machine time (MT) from January 1 to December 31, 2021, was 27 days, which can be seen from Table 2. The MT included a machine study on acceleration, whereas excluded the conditioning of the ion sources. One team used both H and He ion beams in one MT.

Table 2. Beam conditions employed in accelerator.

Ion	Energy [MeV]	Beam current [pnA]	Experiment	Operation time [days]
$^{1}H^{+}$	1.0–2.8	0.3–450	Irradiation	20
$^{4}He^{2+}$	2.28	0.015–12.5	RBS	7

Points 1–5 below list the studies that used the beam lines, along with the number of days of MT. The Nishina School experiment was not performed in 2021.

(1) Microbeam performance study with H ions using glass capillaries at BL-W15 (10 days)
(2) Microbeam (H/He ion) irradiation for single cells at BL-W30 (4 days without samples)
(3) RBS experiments (8 days)
(4) Educational experiment of proton capture by carbon/boron-nucleus for the Nishina School (0 days)
(5) Development of a charged-particle/γ-ray detector to be used for RIBF experiments (5 days)

References

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