Operation of Pelletron tandem accelerator

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The Pelletron tandem accelerator (5SDH-2), which is registered as a joint-use equipment (ID: WE0429)[1] at the Wako campus, provides ion beams accelerated by up to 1.7 MV for sample surface modification, material analysis, and developments of detectors used in RIBF. The maintenance, operation, and updates of beam lines are managed by the Detector Team of RNC. Figure 1 shows the configuration of the accelerator part, two ion sources, four beam lines, and storage tanks of SF_6 insulator gas. The Alphatross is a source of the RF charge-exchange type to generate He^- ions. Almost all other negative ions are generated via the Source of Negative Ions by Cesium Sputtering (SNICS). 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. For example, the energies of He^{2+} and $^{12}C^{6+}$ are 5.1 and 11.9 MeV, respectively, upon the application of 1.7 MV. The ion sources, accelerator, beam transport consisting of a quadrupole magnet, an analyzing switching magnet, and BL-E15 including a sample chamber were provided from National Electrostatics Corp. (NEC) in USA.

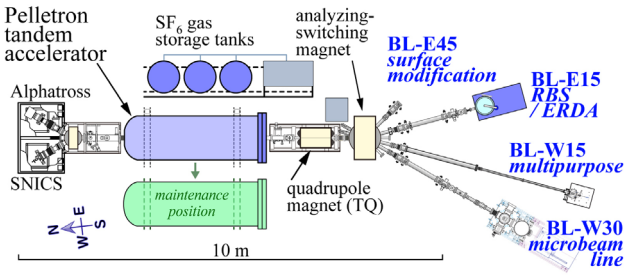

Fig. 1. Pelletron tandem accelerator and beam lines at Nishina R&D Building.

BL-E45 is dedicated to a sub-mm sized beam irradiation for samples in liquid.[2] BL-E15 is used for material science or device engineering to perform Rutherford backscattering (RBS) spectrometry analysis[3,4] and elastic recoil detection analysis (ERDA). Further, BL-W15 is employed as a multipurpose line. Test systems have been constructed for profile measurements of ion microbeam produced by glass capillary[5,6] and microbeam irradiation to induce damage in DNA of mammalian cells.[7] Production of γ rays based on proton-induced resonance reactions is available for a cross-section measurement in an international summer school, Nishina School (Fig. 2),[8] and for calibration of

Fig. 2. Nishina School participants at an experiment performed by volunteer young researchers in 2023.[8]

Ge detectors using high energy γ rays up to 10.8 MeV though the 992-keV proton resonance in the reaction of $^{27}Al(p,\gamma)^{28}Si$.[9,10] A reaction of $^{56}Fe(p,p'\gamma)$ to generate partially polarized 847-keV γ rays was used for a polarization measurement using a Compton Camera.[11] BL-W30 was previously used for detector calibration;[12] however, since 2020, it is dedicated to a new cell irradiation port equipped with a glass capillary microbeam generator[13–15] to irradiate living cells in liquid medium with a short ion range (<100 μm) and a large stopping power (>200 keV/μm), which is sufficiently high to induce double strand breaks of DNA in cell nucleus.

The total machine time from January 1 to December 31, 2023, was 16 days, which can be seen from Table 1. The conditioning of the ion sources is not included.

Table 1. Beam conditions.

Ion	Energy [MeV]	Beam current [particle nA]	Experiment	Operation time [days]
$^1H^+$	1.6–3.4	0.003–710	Irradiation	14
$^4He^{2+}$	2.28	5–15	RBS	2

Experiments performed in this facility are listed below.

(1) Microbeam performance study with H ions using glass capillaries at BL-W15 and -W30 (11 days)
(2) RBS/ERDA experiments at BL-E15 (2 days)
(3) Educational experiment of proton capture by carbon/boron-nucleus for the Nishina School (3 days)

References

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