Radiation safety management at RIBF

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The results of radiation monitoring at RIBF, conducted at the border of the facility and the radiation-controlled area are reported. We also present the residual doses along the accelerator setups.

The dose rates at the boundary of the radiation-controlled area were monitored. Neutron and γ-ray monitors were used at three locations: roofs of the RRC, IRC, and BigRIPS. Figure 1 shows the annual neutron dose at these positions. Considering the thickness of the radiation shield at IRC roof was relatively small, the dose rate was high. At 2017, additional 1 m thick local-concrete shield was set on a beamline in IRC room. As the result, the dose was successfully reduced. The dose at IRC roof is sensitive to IRC and SRC operation time. In 2023, these have not been operated due to a failure of SRC. Therefore, the annual dose of IRC and BigRIPS roof was zero.

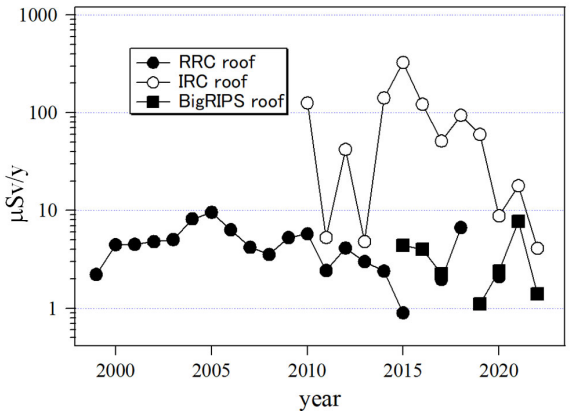

Fig. 1. Radiation dose at the boundary of the radiation-controlled area.

The dose rates at the site boundary with Wako city, where the legal limit is 1 mSv/y, were monitored by neutron and γ-ray monitors. The annual dose in 2023 was 12 μSv of neutron after the background correction. The annual dose of the γ-ray was under the background level. Therefore, the radiation dose rate was considerably lower than the legal limit.

The residual radioactivity at the deflectors of the cyclotrons was measured just before the maintenance work. The residual dose depends on factors such as the beam intensity, accelerator operation time, and cooling time. The data was taken at the cyclotrons maintenance works, when the deflectors were able to accessible.

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Therefore, the cooling times have not been constant. The dose rates from 1986 are shown in Fig. 2. The dose rates for FRC, IRC, and SRC are shown for years after 2006, when the RIBF operation started. For AVF, the dose rate increased in 2006 because the radioisotope production began, and the beam intensity increased. In 2023, dose rates only for AVF and IRC were measured. Dose rates for other cyclotrons were not measured because maintenance work have not performed in this year.

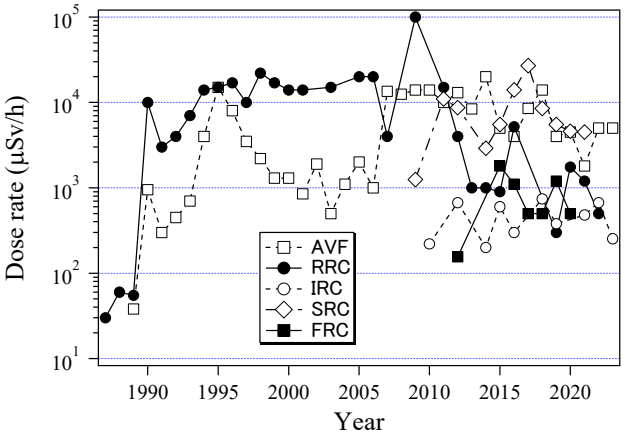

Fig. 2. Dose rates of residual radioactivity at the deflectors of 5 cyclotrons.

The residual radioactivity along the beam lines has been measured after almost every experiment. However, SRC have not operated in 2023 because of a failure. Therefore, the same measuring points as the previous report[1)] measured in June 2022 were adopted. Figure 3 shows the locations of measurement points where high residual-doses rates over 100 μSv/h were observed in 2022. Table 1 lists the dose rates, beam conditions, and cooling time at the measurement points. The maximum dose was 6.5 mSv/h at point 15, which is in the vicinity of the beam dump of BigRIPS. After the previous measurement in 2022, beam of 345 MeV/nucleon ^{70}Zn, whose maximum intensity was 1000 particle μA were provided less than 1 week only in December 2022. The measurements in 2023 were performed about 1 year after cooling time. Therefore, life of source nuclei of the residual dose downstream the SRC correspond to the points from 7 to 17 at Table 1 are expected to be over several months.

Although the water radioactivity in the closed cooling system at BigRIPS have been measure almost every year, it has not performed in 2023 owing to SRC failure.

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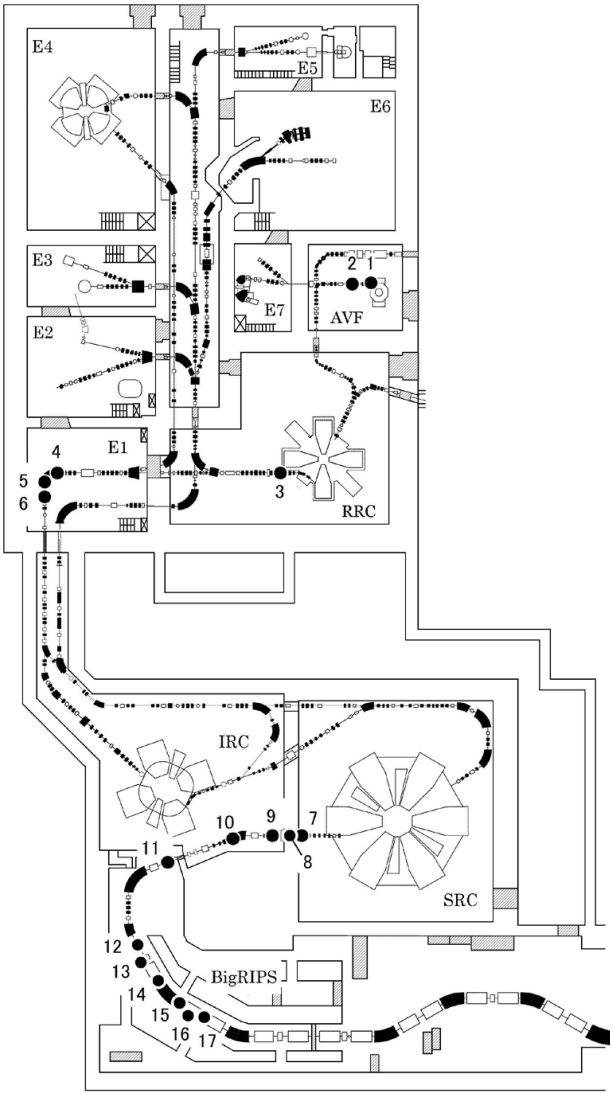

Fig. 3. Layout of the beam lines at RIBF. The measurement locations listed in Table 1 are indicated.

Table 1. Dose rates measured at beam lines in 2023. Points 1–17 indicate the locations where measurements were taken as shown in Fig. 3.

Point	Dose rate (μSv/h	Date (M/D)	Particle	Energy (MeV/u)	Intensity (pnA)	Decay period (h)
1	170	12/2	Xe-12	2.2	43	29
2	130	12/2	Xe-12	2.2	43	29
3	250	12/2	Xe-12	36.0	0.5	28
4	600	12/2	Ar-40	66	38	268
5	400	12/2	Ar-40	66	38	268
6	40	12/2	Ar-40	66	38	268
7	0	12/2	—	—	—	—
8	640	12/2	Zn-70	345	818	9114
9	60	12/2	Zn-70	345	818	9114
10	150	12/2	Zn-70	345	818	9114
11	45	12/2	Zn-70	345	818	9115
12	540	12/2	Zn-70	345	818	9115
13	500	12/2	Zn-70	345	818	9115
14	760	12/2	Zn-70	345	818	9115
15	6500	12/2	Zn-70	345	818	9115
16	130	12/2	Zn-70	345	818	9115
17	69	12/2	Zn-70	345	818	9115

The E-learning module, which can be accessed anytime and from anywhere (even from the outside RIKEN), has been used for the re-training to the radiation workers at RIBF. About 650 radiation workers have completed the training in 2023.

As described above, radiation management to comply with lows and to keep radiation level as low as usual has been carried out successfully.

Reference

1) K. Tanaka *et al.*, RIKEN Accel. Prog. Rep. **56**, 213 (2023).