Radiation safety management at RIBF

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Since 1986, residual radioactivity at the deflectors of cyclotrons has been measured regularly just before maintenance work. The variations in the dose rates are shown in Fig. 1. New measurements in 2013 were conducted only at AVF and RRC owing to their maintenance work. The beam intensity of AVF has been increased since 2006 for the radioisotope production, and the dose rate has also increased. Because the high intense beam was not provided to RRC in 2013, there was a reduction in the dose rates as shown in Fig. 1. The change in the dose rate at RRC from 1990 to 2006 is not large, and the value is typically around 20 mSv/h. After 2006, large variations in the dose rate are observed. It depends on the beam intensity of RIBF and the cooling time. The dose rate of SRC increased in 2011, and the value became similar to those of AVF and RRC. The dose rates of IRC and fRC were measured in 2012 only.

The residual radioactivity was measured along the beam lines after almost every experiment. Points 1–26, marked with solid circles in Fig. 2, are the locations where high-residual dose rates were usually observed. Table 1 lists these dose rates and the measurement dates, beam conditions, and the decay periods after the end of operation. The maximum dose rate was found to be 7 mSv/h at point 25, which is below the beam dump chamber of BigRIPS. The dose rates on the site boundary in 2013 have been monitored to prevent it be over legal limit of 1 mSv/y.

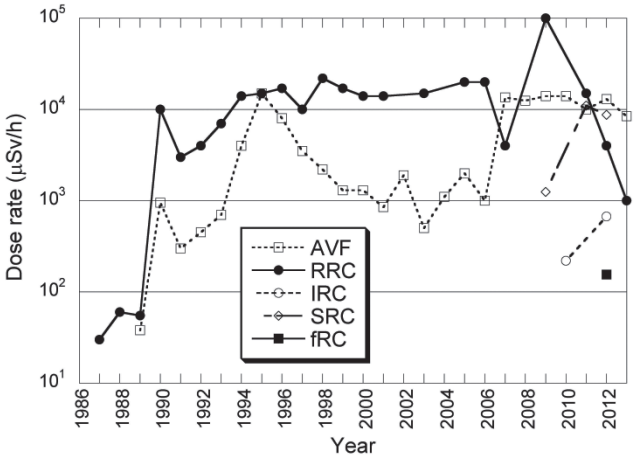

Fig. 1. Dose rates of residual radioactivity at the deflectors of 5 cyclotrons.

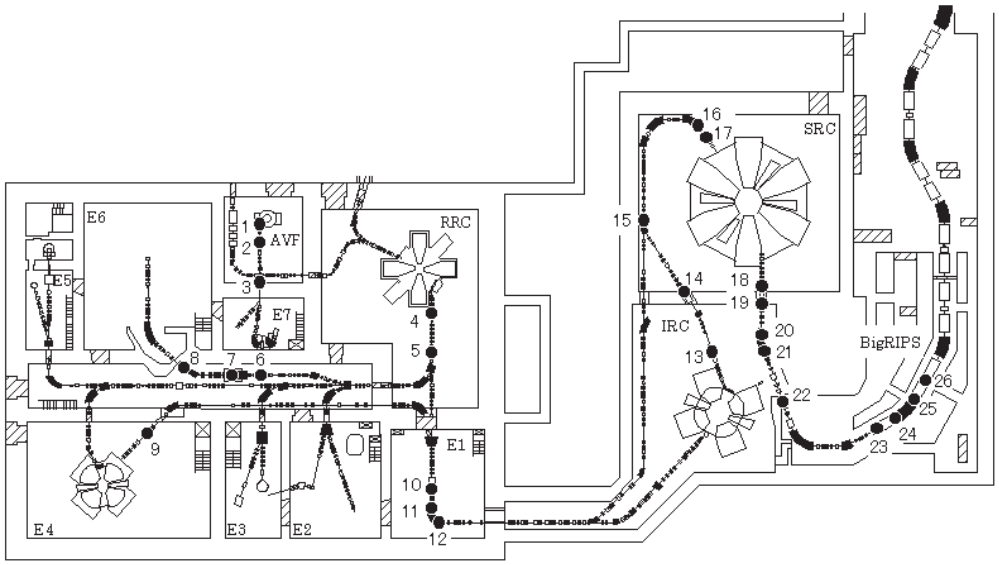

Fig. 2. Layout of beam lines at RIBF. Locations where high dose rates were observed are indicated by solid circles 1–26.

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Table 1. Dose rates measured at beam lines in 2013. Points 1−26 indicate the measured locations shown in Fig. 2.

Point	Dose rate (μSv/h)	Date (M/D)	Particle	Energy (MeV/u)	Intensity (pnA)	Decay period (h)
1	630	8/22	d	12	10000	414
2	300	8/22	d	12	10000	414
3	500	7/24	O-18	6.28	1000	50
4	110	12/24	Xe-124	10.75	1210	424
5	300	7/1	Xe-124	10.75	1300	1300
6	180	12/26	Xe-124	10.75	200	466
7	920	12/26	Xe-124	10.75	200	466
8	300	7/17	Rb-87	66	0.07	31
9	200	7/4	Xe-124	50	143	74
10	1300	7/4	Xe-124	50	143	74
11	1000	7/4	Xe-124	50	143	74
12	1300	7/4	Xe-124	50	143	74
13	80	7/4	Xe-124	114	51	74
14	80	7/4	Xe-124	345	36	75
15	160	7/4	Xe-124	345	36	75
16	143	4/19	O-18	250	200	2
17	260	7/4	Xe-124	345	36	75
18	230	4/19	O-18	250	200	2
19	6000	7/4	Xe-124	345	36	75
20	110	7/4	Xe-124	345	51	74
21	250	7/4	Xe-124	345	51	74
22	3000	7/4	Xe-124	345	36	75
23	400	7/4	Xe-124	345	36	75
24	1400	7/4	Xe-124	345	36	75
25	7000	7/4	Xe-124	345	36	75
26	250	7/4	Xe-124	345	36	75

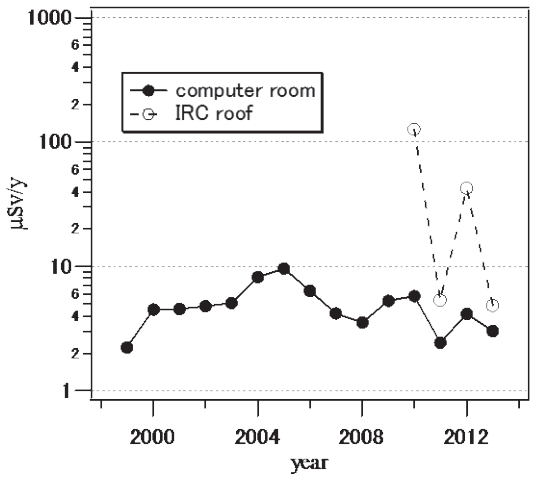

Fig. 3. Accumulated leakage radiation at the boundary of the radiation-controlled area.

We continuously monitor the radiation in and around the RIBF facility using neutron and gamma area monitors. The background dose rates were evaluated and the measured values were corrected. The background data have been acquired over a period of a month in August 2013 when all the accelerators were not in operation. The background of gamma-ray dose is currently about 2 times higher than the natural dose rate because of the fallout due to the accident at the Fukushima Dai-ichi power station. Before the accident, the natural background of the gamma-ray dose at the site boundary near the BSI East Bldg. was 0.039 μSv/h in January 2011. The background of gamma-ray dose in 2013 was 0.062 μSv/h. Just like before, all of the corrected dose rates monitored at 2013 were below the detection limit, corresponding to 2 μSv/y for neutrons and 8 μSv/y for gamma-rays. The total dose rate was less than 10 μSv/y and was considerably lower than the legal limit.

The radiation dose on the boundary of the radiation-controlled area have also been monitored. The monitors of gamma-rays and neutrons are placed at the three points on the boundary. One is in the computer room of the Nishina building, and the two other are on the roofs of the IRC and BigRIPS in the RIBF accelerator building. The highest value was observed on the IRC roof as a result of the beam loss at the transport line between SRC and BigRIPS. The annual neutron doses at these locations since 1999, which are sufficiently lower than the legal limit, are shown in Fig. 3. The value of the BigRIPS roof was similar to the background level and is not shown in Fig. 3. The legal limit of a boundary of a radiation-controlled area is 1.3 mSv/3month, and all the measured doses were low enough.