6 - 43 Radiation Safety Report of HIRFL in 2016

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The total operation time of HIRFL is 7 488 h in 2016, the user beam time is about 5 547.5 h (from 21 Dec.2015 to 21 Dec. 2016). 3 178 h for physics experiment, 238.5 h for biological physics science research, 2 023 h for irradiation effect research, and 108 h for machine research. There are 26 heavy ions beams were provided by HIRFL in 2016. The highest ions energy provided is 7.9 MeV/u, the maximum accumulated ion intensity is 1 μA.

Environment radiation level was measured with TLDs which were placed in the yard of the institute around HIRFL, 15 sites of radiation level show no difference with environment background level of Gansu province[1]. Furthermore, environmental neutron and gamma dose was monitored by 3 environment radiation monitoring stations continuously, no abnormal data had been found in 2016. Environmental radiation dose of neutron and gamma ray had been measured with portable dose meter four times a year, the measured results show no difference with background see Table 1.

Table 1 Environment dose surrounding HIRFL.

Measuring time: August 31st, 2016; Beam: 60 MeV/u$^{12}C^{6+}$at SSC; Instruments: FHT762 neutron dosimeter, BH-3013B γ dosimeter				
Location	Direction	Distance/m	Neutron dose rate/(nSv/h)	γdose rate/(nSv/h)
Experimental hall door	South	1	19.1	91
		10	4.3	102
		20	6.7	83
		30	1.0	66
The north gate of IMP	north	50	1.0	69
2# building	East	5	19	539
		20	26	91
		30	6.8	80
6# building	Northwest	5	4.1	94
	West	5	2.4	102
	SSC north	5	231	124
	Northeast	5	680	176

The external dose received by workers mainly due to the residual radiation after the accelerator was shut down. Maximum surface dose rate had been measured in 2016 is 1.2 mSv/h on the SSC deflector surface. To reduce the external dose of workers, adequate cooling time, and reducing the operating time is essential.

352 persons accepted individual dose monitoring in 2016, and the results are shown in Table 2. The annual collective effective dose was 42.24 mSv. 45 are less than 0.1 mSv. The highest individual dose was about 1.26 mSv, which was under the dose limit (20 mSv) of national standard.

Table 2 Individual dose monitoring results in 2016.

Time	Number of monitored individuals	Annual collective effective dose/mSv	Average annual effective dose/mSv	Number of individuals with different annual effective dose/mSv					
				<0.1	0.1∼1	1∼5	5∼10	10∼20	≥20
2016	352	42.24	0.12	45	305	2(1.26 mSv)	0	0	0

Table 3 Total α, β radioactivity of the environmental samples in 2016.

Site	*Water (Bq/L)*		Site	*Soil(Bq/kg)*		*Plant(Bq/kg)*	
	α	β		α	β	α	β
Exhibition Center	0.175 0	0.315 8	North of CSRe	496.112 6	1 862.954 1	26.510 6	233.934 3
Sangyuanzi bridge	0.282 0	0.182 1	South of the institute	497.505 9	2 578.804 8	24.136 1	248.081 2
Tap water	0.135 7	0.438 4	North of 6# building	507.364	1 696.385 9	23.946 6	226.117 3
Waste water	0.210 2	0.402 1	West of 6#building	684.561 7	689.395 3	26.510 6	233.934 3
			North of RWS	651.709	2 256.824 5	24.64	345.327 9
			West of RWS	660.815 5	2 522.553 7	17.737 6	197.948 7
			East of RWS	706.27	642.55	24.478	302.516
			South of RWS	607.775 5	721.238 4	10.845	134.464

Total α,β radioactivity in soil, water, plant samples from environment around HIRFL and soil, plant samples from Radioactive Waste Storeroom (RWS) are measured with BH1216 low background α,β easuring instrument, the results are shown in Table 3, and compared with the background level of China[2].

References

[1] Chunting Liu, Shuming Bai, Xiuying Ren, et al., Radiation Protection, 1 (1996)121. (in Chinese)

[2] Lianmao Sha, Hennan Zhu, Shi Chen, Radiation Protection, 12(1996)122. (in Chinese)

6 - 44 Studying of Residual Activity Induced by 300 MeV/u Carbon Ion in Copper Target

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Activation of accelerator components due to beam losses is an important issue for a high-energy heavy ion accelerator. The induced components may become a main source of exposure to maintenance workers and a serious access-restriction for "hand-on" maintenance, and also have a certain radiation influence over the environment. In this work, experimental of residual activation induced by 300 MeV/u carbon ions was studied at the deep-therapy terminal of HIRFL.

Carbon ions with energy of 300 MeV/u were accelerated by HIRFL and delivered to the deep tumor therapy room, and the target was irradiated by 6.97×10^{10} carbon ions. The ion counts were measured by a plate ionization chamber which located behind the beam extraction windows. The ionization chamber is filled with the nitrogen gas with 1 atm pressure. The copper target consisted of 15 foils (7 thick targets and 8 thin target), and the thick and thin targets are alternating arranged. The overall thickness is 60 mm. The thin foil is a cylinder of 50 mm in diameter and 0.5 mm in thickness, used for gamma spectrum measurements to sample the depth-profiled of residual activity; and the thick foil is a cylinder of 50 mm in diameter and 8 mm in thickness, used for defining the distance between sampling-points. The configuration of the copper target is shown in Fig. 1. The experiment is carried out at the deep-therapy terminal of HIRFL, and the experimental layout as shown in Fig. 2.

Fig. 1 (color online) The copper target for experiment.

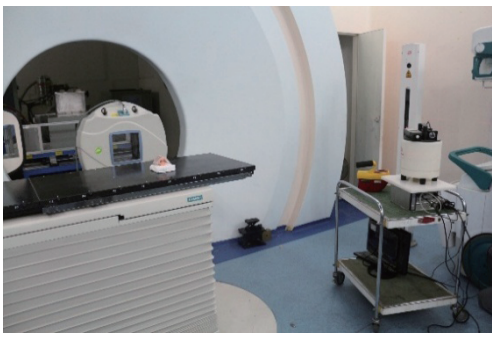

Fig. 2 (color online) The experiment layout.

The gamma-ray spectroscopy measurements were carried out with HPGe detector. Fig. 3 shows the time evolution of the total dose rate after the irradiation, it shows that the total activity will decrease rapidly just after the accelerator is shut down. The total dose rate in the copper target will reduce to about 54% of its original value after 11 min, and the dose rate reduce to about 39% of its original date after the accelerator shut down 30 min. As time goes on, total activity of the target decays more slowly. Table 1 shows the activity of the radionuclides in the first thin foil target. Fig. 4 shows the depth-profiling of the residual activity. It can be seen that the produced radionuclides have the largest activity at the end range of the carbon in copper target (the range of 300 MeV/u carbon ion in copper target is about 2.7 cm)，and there is also produced radionuclides in the target out of the carbon ion's range.。This is because a large number of carbon ions stopped near the end of range, and secondary particles have a larger range than the primary ions.