

Table 1 Beam Dynamics Parameters.

Input parameters	
Bunch charge/nC	0.5
Bunch radius/mm	1
Half width of Gaussian/(°)	1.5
Injection phase/(°)	vary from 22 to 25
Average field of RF Gun/(MV/m)	100
Parameters after optimization	
Multi of B_{solenoid}	1.033
Center position of B_{solenoid} /cm	23.37
Injection phase/(°)	22.2
position of entering the booster & Z_{min} of $[X_{\text{rms}}]$ /cm	127.87
Beam RMS size/mm	0.54
Horizontal Emittance/(mm·mrad)	1.07
Beam energy/MeV	80.30

6 - 22 Radiation Safety Report of HIRFL in 2014

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The total operation time of HIRFL is 7 272 h in 2014, and the user beam time is about 4 964.5 h (from 21st Dec. 2013 to 21st Dec. 2014). 3 749 h for physics experiment, 332 h for life science research, 883.5 h for material science and single particle effect research, and 235 h for machine research. There are 24 heavy ions beams were provided by HIRFL in 2014. The highest ions energy provided is 487 MeV/u, and the maximum accumulated ion intensity is 1 000 μA .

Environment radiation level was measured with TLDs which were placed in the yard 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 2014. Environmental radiation dose of neutron and γ ray had been measured with portable dose meter four times a year. The measured results show no difference with background (Table 1).

Table 1 Environment dose surrounding HIRFL.

Location	Direction	Distance/m	Neutron dose rate/(nSv/h)	γ dose rate/(nSv/h)
Experimental hall door	South	10	23.1	88
The north gate of IMP	South	50	7.05	103
2# building	East	5	29.2	85
6# building	Northwest	5	13.3	90
	West	5	20.5	81
	Southwest	10	10.1	74
	Northeast	5	920.0	176

Measuring time: March 26th, 2014; beam: 70MeV/u⁴⁰Ar⁸⁺ at RIBLL1; survey: FHT762 neutron dosimeter, BH-3013B γ dosimeter.

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 2014 is 4 mSv/h on the SFC deflector surface. To reduce the external dose of workers, adequate cooling time, and reducing the operating time is essential.

291 persons accepted individual dose monitoring in 2014, and the results are shown in Table 2. The annual collective effective dose was 34.92 mSv. 35 of them are less than 0.1 mSv. The highest individual dose was about 1.49 mSv, which was under the dose limit (20 mSv) of national standard.

Table 2 Individual dose monitoring results in 2014.

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
2014	291	34.92	0.12	35	252	4(1.49 mSv)	0	0	0

Table 3 Total α , β radioactivity of the environmental samples in 2014.

Site	Water/(Bq/L)		Site	Soil/(Bq/kg)		Plant/(Bq/kg)	
	α	β		α	β	α	β
Huanghe new bridge	0.9	0.14	North of CSRe	591.3	731.3	13.1	107.9
Sangyuanzi bridge	0.13	0.17	South of the institute	726.6	860.2	22.4	155.1
Tap water	0.093	0.06	North of 6# building	494.8	850.9	13.8	120.7
Waste water	0.1	0.14	West of 6#building	555.4	888.1	14.9	97.0
			North of RWS	594.1	959.0	20.9	173.0
			West of RWS	698.8	858.5	23.0	129.0
			East of RWS	744.3	842.4	23.1	152.6
			South of RWS	565.1	725.1	14.0	172.7

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 Measuring Instrument, the results are shown in Table 3, and compared with the background level of China^[2].

Radiation safety license of IMP which was awarded by Ministry of Environmental Protection was renewed in 2015, furthermore, several radiation facilities were list in the permit, which means all of these radiation facilities running in IMP yard were permitted by law.

References

- [1] Chunting Liu, Shuming Bai, Xiuying Ren, et al., Radiation Protection, 16(1996)121.
- [2] The investigation group of national environmental natural radioactivity level, Radiation Protection, 12(1996)122.

6 - 23 Comparison Results of National Individual Dose of IMP in 2014

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IMP participated in the comparison of national individual dose which was organized by National Institute for Radiological Protection, China CDC, and the comparison results were corrected and was granted with certificate. In the comparison, RGD-3B reader, LiF(Mg,Cu,P)detectors, FJ411B annealing furnace and TLD400 detector box were used. The RGD-3B measuring system and LiF(Mg,Cu,P) thermoluminescence detectors were calibrated in 2014. Five groups dosimeters marked number 1 to number 5 which used for routine monitor were selected to the comparison, each group with ten detectors. The first five groups were bland samples. Group 6 was standby sample and group 7 was for background dose monitor. The first 5 groups were exposed by the organizer in a standard flat water phantom in unknown direction with X or γ rays (according to ISO spectrum norm) with five different unknown individual dose equivalent values $H_p(10)$. The measured values were obtained according to calibration factors, readout values, and the corresponding background values.

The relative error of each group in the comparison can be calculated as follows:

$$P_i = [H'_i - H_i]/H_i, \quad (1)$$

where H'_i is measured value, H_i is the exposed value which we don't know in advance, P_i is the relative error. If $|P_i| \leq 0.4$ ^[1], P_i of all the five groups is within 0.4, the results were considered to be credible.