RADIATION DOSE LEVEL IN THE SSRF DURING THE NORMAL OPERATION

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Abstract

Shanghai Synchrotron Radiation Facility (SSRF) has been commissioned since December 2007, and has been formally operated since May 2009. In order to ensure the radiation safety for staff members and publics, the radiation levels of the workplace, the environment and the staff are monitored through a real-time network of gamma and neutron monitors as well as through TLD passive dosimeters. This paper reports the results of the radiation monitoring. From these results, we found that the annual dose equivalents were good to meet the management values of SSRF.

INTRODUCTION

The SSRF is a third generation light source aiming at providing powerful X-rays to the Synchrotron Radiation users in a variety of research fields. It includes a 150 MeV electron Linac, a 3.5GeV Booster, a 3.5GeV Storage Ring and a number of experimental beam lines utilizing synchrotron radiation.

When the electrons are accelerated along accelerator orbit, the beam loss is unavoidable. The losing high energy electrons will produce electromagnetic cascades after colliding with the material. Significant amount of bremsstrahlung and neutrons will be produced. So the accelerator radiation measurements and radiation protection are necessary.

The radiation measurements outside the accelerator tunnels in SSRF are performed through a real-time radiation monitoring system, survey monitoring instruments as well as through TLD passive dosimeters. The real-time monitoring system includes an area monitoring system and an environment monitoring system; there are 46 monitoring points in the radiation control area in SSRF workplace and 5 radiation monitoring points in environmental area inside the site. A neutron detector and a photon detector are mounted side-by-side at each monitoring point. The layout of the real-time area monitoring system outside the accelerator tunnel is shown in Figure 1. The layout of the real-time environmental monitoring system is shown in Figure 2. Each circle in green colour in the figure is a monitoring point.

A neutron meter composed of a BF_3 proportional counter surrounded by moderating and absorbing layers is adopted as the area neutron monitor and a cylindrical high pressure argon filled ionization chamber is adopted as area gamma monitors. A BF_3 proportional counter surrounded by a polyethylene moderator is adopted for the environmental neutron monitor. The spherical high-pressure argon filled ionization chamber is adopted for the environmental gamma monitor. The radiation detectors for gamma and neutron are equipped with a local display with audible and visual warning functions.

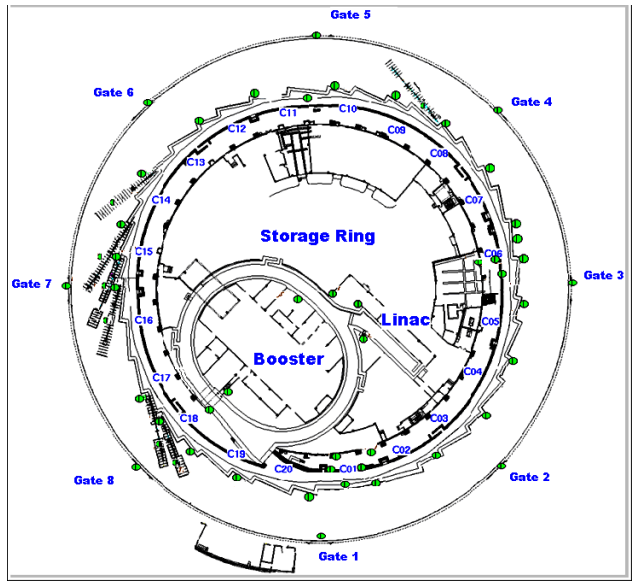

Figure 1: Layout of the real-time area radiation monitoring system.

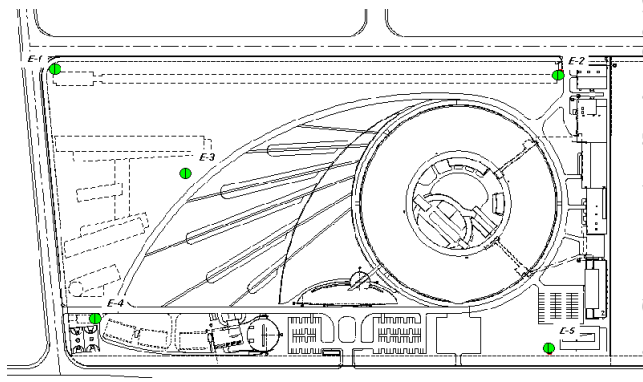

Figure 2: Layout of the real-time environmental radiation monitoring system.

DOSE LIMIT

The SSRF dose limit is based on the legal documents:"Basic standards for protection against ionizing radiation and for the safety of radiation sources GB18871-2002" published by Chinese government in 2002. It demands the basic occupational exposure limit is 20 mSv per year, and the actual or potential basic doses to any member of the public should not exceed 1 mSv per year. According to the ALARA principle, the dose limit objectives for SSRF should be below regulatory dose limits:

- The annual integrated effective dose equivalent received by an occupational individual does not exceed 5 mSv per year.
- The average dose equivalent for public does not exceed 0.1 mSv per year.

The low dose limit is based on the good shielding design of accelerator and beam lines in SSRF.

RADIATION MEASUREMENT

SSRF radiation measurement plan has been performed early from the accelerator commission since 2007. When the Storage Ring operated at December 2008, the radiation measurements for safety are performed every day. The important locations with many beam losses are concerned carefully. They are the beam injection area and RF cavity area. The first 7 beam lines area is also concerned carefully because of the radiation safety for the experiment users. The real-time radiation dose rates are measured with the real-time area monitoring system, and the accumulated doses are analyzed and reported. The regular survey monitoring with portable instruments or mobile monitoring instruments are also carried out around the control area of Linac, Booster, Storage Ring and beam lines.

The Area Radiation Monitoring

The area radiation monitoring points are selected at the easily beam loss points. The real-time monitoring results of two points are shown in Figure 3. The peaks come from the suddenly lost of the storied beam.

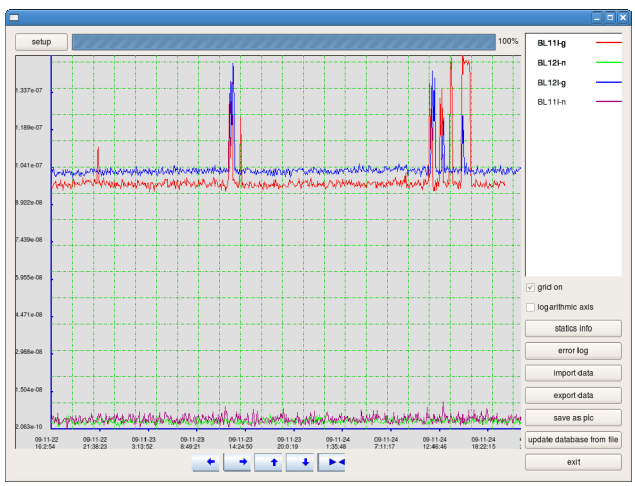

Figure 3: The real-time monitoring results under normal operation.

The integrated doses are also gathered weekly with the real-time monitoring system. The weekly integrated doses (from 2011.3.14 to 3.21) are shown in Figure 4.

The Annual Doses at some monitoring locations are shown in Figure 5. The highest annual dose point located at downstream of the Linac accelerator. The annual doses at the Storage Ring injection area (INJECTION ROOF, BL01B) are not high because of the local shielding inside the injection tunnel. The annual dose equivalents are below the 2mSv without exceeding the 5 mSv dose limits. The annual dose equivalents were good to meet the management values of SSRF.

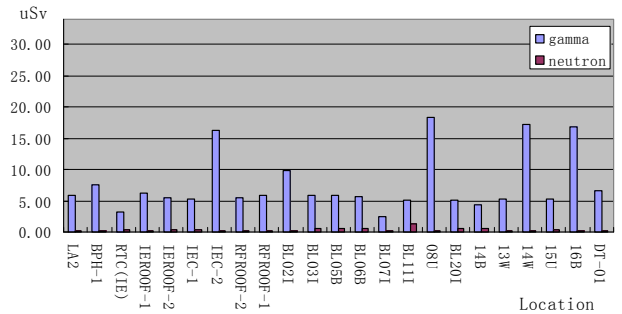

Figure 4: The weekly integrated doses under normal operation.

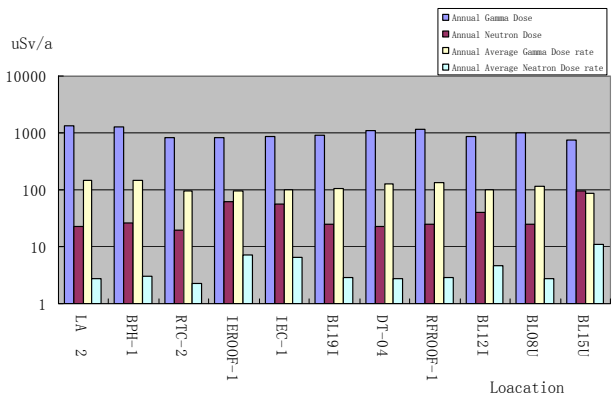

Figure 5: The Annual Dose at some Locations.

Figure 6 shows the radiation dose rate monitoring results outside the Storage Ring ratchet wall by the mobile monitoring instruments during accelerator operate in decay mode (3.5GeV, 210mA).The horizontal axis is the monitoring positions around the Storage Ring ratchet wall, 1.3m above the hall surrounding. In decay mode. It is obviously that the whole radiation level in SSRF is very low.

TLD detectors are also used in area radiation measurement in SSRF. They are placed on the Storage Ring ratchet wall at the height equivalent to beam obit (130cm) and the beam lines, The annual accumulate results from TLD does not exceed 1mSv.

The Environmental Radiation Monitoring

The environmental radiation in SSRF comes from the skyshine. It is formed by the high-energy gamma and neutron escaping through the roofs of the shielding of the accelerator tunnel. Five environmental stations near the site boundary are established for the environmental dose measurement. There are high-sensitive gamma and

neutron monitors equipped for each station to measure the small changes of the natural background.

The annual measurement results for 2010 shows that the annual environmental average gamma and neutron dose rates in SSRF are from 74.7 nSv/h to 91.4 nSv/h. According to the survey by the authority Organization in Shanghai, the values of the environmental radiation dose rate is 40 to 113nGy/h . So the environmental impacts from SSRF is very small. The operation of SSRF is safe to public.

Personal Dose Measurement

In order to ensure the radiation safety for staff members, publics and users, the TLD passive dosimeters are used in personal dose measurement. Each staffs and users in SSRF must wear the TLDs, the radiation dose values of the TLDs must be read out every three months for staff and several weeks for users. The results must be kept and stored for full lifetime. The annual measurement records of the TLDs from the commission on December 2007 to normal operation now do not exceed 2 mSv/person. The annual doses for staff are all less than 1mSv in 2010.

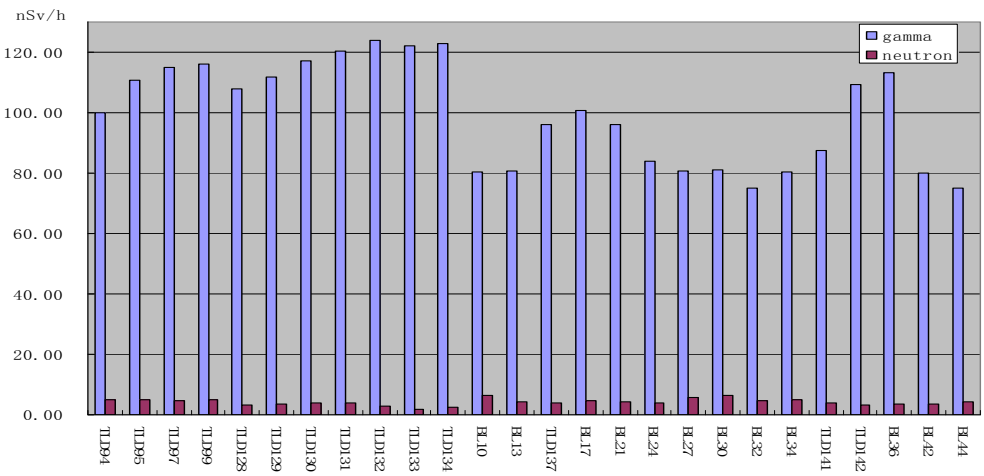

Figure 6: Dose rate Outside the Storage Ring Ratchet Wall at decay mode (3.5GeV, 210mA)

CONCLUSION

- The radiation levels in SSRF have been measured by three kinds of methods. We found that the annual dose equivalents at workplace and environment were good to meet the management values of SSRF.
- The annual doses received by staff are all less than 2mSv every year. It is safe enough to work during the normal operation in SSRF.

REFERENCES

[1] Basic standards for protection against ionizing radiation and for the safety of radiation sources, GB18871-2002.
[2] K. M. Fang, X. J. Xu, J. H. Cai, Radiation Measurements 41(2007), S256-S259.
[3] X. J. Xu, J. H. Cai, K. M. Fang, Radsynch'04, Spring-8, November 2004, p. 84(2004).
[4] Y. Liu, X. M. Xi, Radiation Protection Bulletin, 22(2002) 5.