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OPERATION STATUS OF CSNS/RCS TRANSVERSE COLLIMATION SYSTEM*

J. B. Yu[1,2†], S. Y. Xu[1], Q. B. Wu[1], J. X. Chen[1], G. Y. Wang[1], X. J. Nie[1],
C. J. Ning[1], A. X. Wang[1], J. S. Zhang[1], L. Liu[1], L. Kang[1]
Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China
[1]also at Spallation Neutron Source Science Center, Dongguan, China
[2]also at University of Chinese Academy of Science, Beijing, China

Abstract

In order to meet the requirements of daily maintenance of CSNS/RCS, the transverse collimation system was designed to concentrate the uncontrollable beam loss in this region. Based on physical parameters, considering the processing technology, the area was rationally arranged. At present, the beam collimation system has been running with no mechanical failure for nearly three years, and it plays an active role in beam power boost and beam loss control, which proves that the structural design of the system is reasonable.

LAYOUT OF THE TRANSVERSE COLLIMATION SYSTEM

The design of the CSNS/RCS transverse collimation system adopts a secondary collimation system which include one primary collimator and four secondary collimators [1, 2].

As the only "hot" point of RCS, the beam loss in the transverse beam collimation region is particularly large. According to the physical design requirements, the primary collimator will be replaced at the upgrade program, now it was designed with a beam loss energy of 100 MeV and a power of 624 W, while the four secondary collimators won't be replaced at the upgrade program, so they were designed with a beam loss energy of 400 MeV and a total power of 8 kW. The average was about 2 kW each. According to the requirements of radiation protection, under the premise of ensuring the mechanical structure and equipment installation permit, increase the local concrete shielding as much as possible. Figure 1 shows the residual dose of the collimator system after 100 days operating. The lateral shielding of the primary collimator is 50 cm iron + 20 cm concrete, and the lateral shielding of the secondary collimator is 60 cm iron + 65 cm concrete [3].

According to the overall mechanical layout, the transverse beam collimation area includes 3 ion pumps, 4 beam loss monitoring probes, 1 primary collimator and 4 secondary collimators, and all the scrapers and absorbers are movable. Considering the design and processing technology issues, the four secondary collimators are designed into two structures. Among them, the secondary collimator 1 is one structure, and the following three secondary collimators use the same structure, and the middle area uses vacuum Pipe connection. In order to reduce the possibility of system maintenance as much as possible, it is necessary to place vulnerable components such as motors, encoders, ion pumps and other components on the outside of the shielding wall. Among them, the moving parts such as motors and mobile platforms are selected from radiation resistant products, and the displacement sensor LVDT is selected for transmission. The cable is an ordinary sensor with a radiation-resistant cable. Figure 2 shows the layout of transverse collimation system.

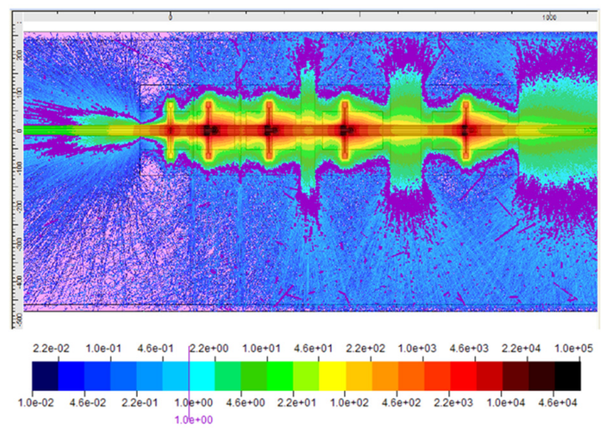

Figure 1: Residual dose of the collimator system which had been operating 100 days after 4 hours shutdown.

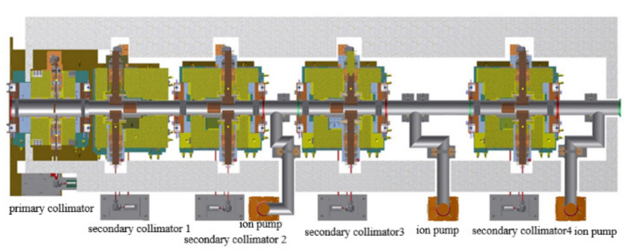

Figure 2: Overall layout of transverse collimation system.

OPERATION STATUS OF THE TRANSVERSE COLLIMATION SYSTEM

The effect of the transverse beam collimation system in controlling beam loss was not obvious in the initial stage of beam adjustment, therefore, the system was not used. It was used till December 2018 as shown in Fig. 3. According to the physical condition of beam adjustment, the beam loss was mainly concentrated on the primary collimator,

* Work supported by Natural Science Foundation of Guangdong Province 2018A030313959
† yujb@ihep.ac.cn

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the secondary collimator 1 and the secondary collimator 2. Figure 4 shows the secondary collimator 1 and the secondary collimator 2. The monitoring results of all the stop temperature sensors. Figure 5 shows the monitoring results of the dose rate in the collimator area after the collimator has been shut down since its use.

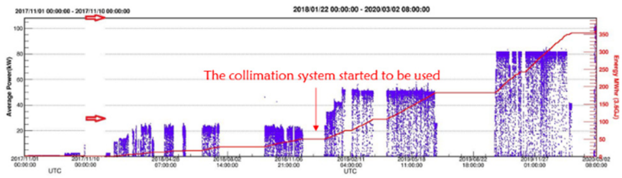

Figure 3: Record of CSNS beam power increasing process.

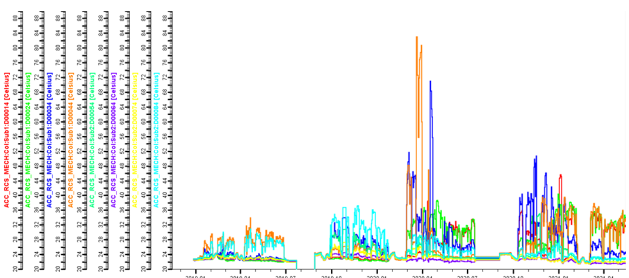

Figure 4: Temperature record of first two secondary collimators' absorbers.

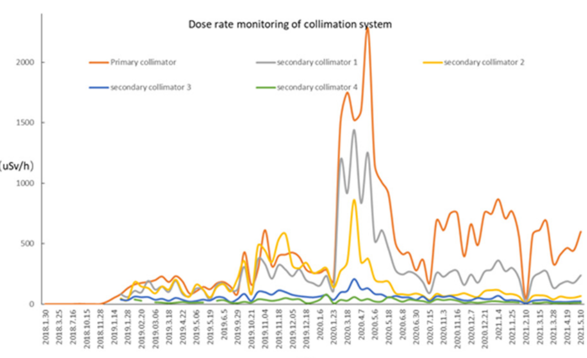

Figure 5: Dose rate distribution of collimation system after CSNS shutdown.

In the initial stage of the use of the collimator, the induced radioactivity generated in the area after the CSNS shutdown gradually increased with the beam power increase. In March 2020, the CSNS beam power reached 100 kW, and the maximum dose rate of the induced radioactivity in the local area exceeds 2 mSv/h. Through optimization of the magnet and collimators, and also narrowed the holes for the motor transmission shaft in the concrete shield of the collimators as shown in Fig. 6, at present, the induced radioactivity generated in this area is less than 1 mSv/h. Because the current shielding thickness of the primary collimator is smaller than that of other areas, the measured value of the induced radioactive dose rate after shutdown is higher than that of other areas.

Figure 6: Change the holes of concrete shielding before (left) and after (right).

During the use of the transverse beam collimation system, the displacement sensor in the secondary collimator failed one after another. First, the sensor of the secondary collimator 1 failed, followed by the next two secondary collimators, Fig. 7 shows comparison of rotary encoder and displacement sensor of partial absorbers. Combining the different power deposition conditions on the different collimator stoppers during the beam adjustment process, it is determined that the main reason for the damage of the sensor is the radiation caused by the particles outside the predetermined track deposited on the absorbers. For the displacement sensors are inside the concrete shielding, they were difficult to be changed, the state of the absorbers will be monitored only by rotary encoders which installed after the motors.

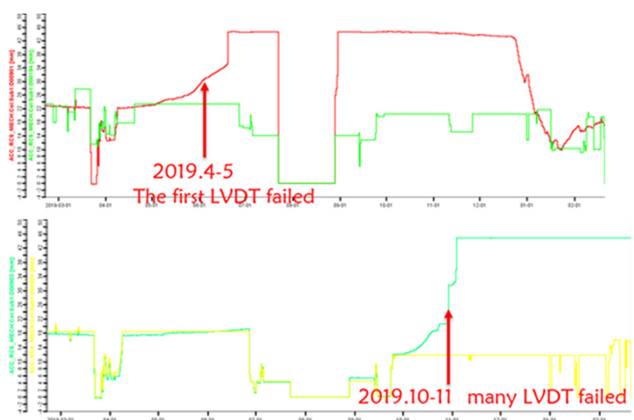

Figure 7: Comparison of rotary encoder and displacement sensor of partial absorbers.

THERMAL ANALYSIS OF THE SECONDARY COLLIMATOR'S ABSORBER

According to the difference of temperature sensors of different blocks in the process of beam adjustment, the temperature distribution of the blocks under different power loads has been analysed, Fig. 8 shows the temperature of the absorbers with different beam power deposition. The analysis results can provide a theoretical reference for beam adjustment.

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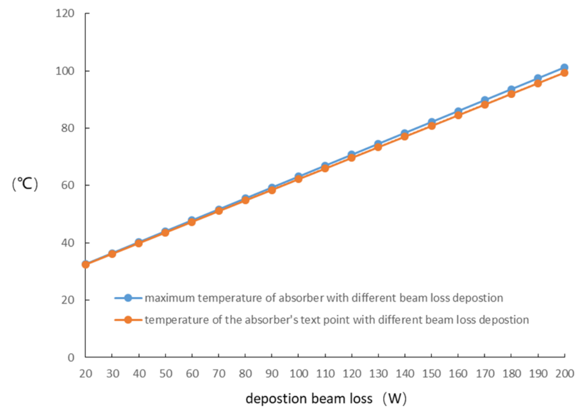

Figure 8: Temperature of the absorbers with different beam power deposition.

CONCLUSION

The transverse collimation system is now under stable operation status, and it should be monitored for a long period.

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