Radiation transport calculation of BigRIPS separator

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Radiation transport calculations of the BigRIPS separator from the production target (F0) to the final focus (F7) have been conducted to investigate the origin of the neutron radiations in the BigRIPS room. During the BigRIPS operation, the power supplies and the control panel of the superconducting quadrupole magnets (STQs) in the BigRIPS room freeze occasionally owing to the neutron radiations. To prevent these problems, radiation shielding is necessary. In designing an efficient radiation shield, knowing the origin of neutrons is important.

Thus far, radiation transport calculations of the BigRIPS separator have been conducted from F0 to the first focus (F1) region[1–3)] using the particle and heavy-ion transport code system (PHITS).[4)] In the present study, we extended such a calculation to cover the entire BigRIPS region from F0 to F7. The previous geometry model was extended to include all magnets, beam ducts, chambers, and slits of the BigRIPS separator. The building walls and radiation shielding blocks in the BigRIPS room were also included in the model. Calculations were performed with PHITS ver. 3.24 code installed in the HOKUSAI BW supercomputer at RIKEN. Hybrid-parallel computing, with 128 parallel processes of 10 threads, was used to conduct the calculations. The calculations were performed under various conditions that replicated the experiments performed at the Radioactive Isotope Beam Factory. In a calculation, 100 million events were generated for all incident beams except ^{238}U. The event number was reduced to 30 million for the ^{238}U beam, because the calculations needed a longer CPU time. A total CPU time (CPU time summed over 1280 arithmetic cores) of 40–50 million seconds was used for one calculation.

Figure 1 shows the neutron dose distribution in the BigRIPS room for the ^{238}U beam at 345 MeV/nucleon impinging to a 5-millimeter-thick Be target. The BigRIPS separator was tuned for ^{79}Ni beam production. In this setting, the ^{238}U beam was stopped at the inner-side of the exit beam dump, which was located at the exit of the first dipole magnet. High doses were observed at the target (F0) and the beam dump (BD in Fig. 1) regions where the ^{238}U beam decreased their energies. The neutron dose gradually decreased with the distance from F2 in the F3-F7 region, whereas it was slightly high around F5.

The calculated neutron doses were compared with experimental measurements. Two neutron survey meter (TPS-451, manufactured by ALOKA Co., Ltd.) were placed at the power supply and the control panel of the STQs and used for neutron measurements. The observed doses were $\sim$1.8 μSv/h at the power supply and 0.8 μSv/h at the control panel with a 70-particle nA (pnA) ^{238}U beam; normalized to a 100-particle nA beam intensity, they were $\sim$2.5 μSv/h and $\sim$1.1 μSv/h, respectively. The calculated neutron doses were $\sim$8 μSv/h and $\sim$2 μSv/h for a 100-particle nA beam. Thus, the calculations reproduced the experimental observations by a factor 2–3. Based on the calculations, the design of the shielding blocks is undergoing.

References

1) T. Ohnishi *et al.*, RIKEN Accel. Prog. Rep. **44**, 129 (2011).
2) K. Tanaka *et al.*, RIKEN Accel. Prog. Rep. **44**, 132 (2011).
3) K. Tanaka *et al.*, Prog. Nucl. Sci. Technol. **4**, 201 (2014).
4) T. Sato *et al.*, J. Nucl. Sci. Technol. **55**, 684 (2018).

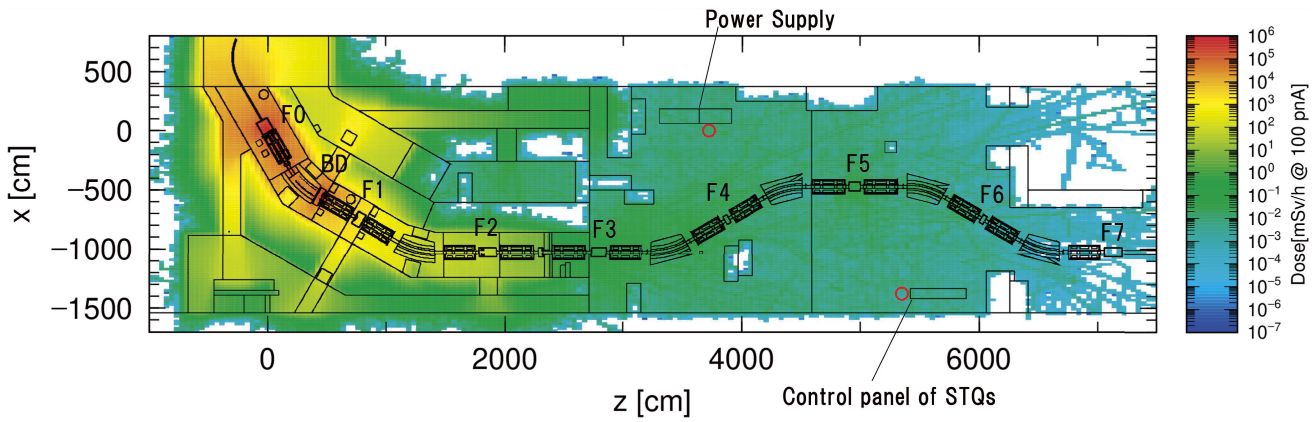

Fig. 1. Neutron dose distribution in BigRIPS room for ^{238}U beam impinged on 5-mm-thick Be target. Red circles represent positions of neutron survey meters that are used for neutron measurements.

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