Measurements and PHITS Monte Carlo estimations of residual activities in the injection area at J-PARC RCS ring

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At the injection area of the RCS ring in the J-PARC, several rectangular ceramics ducts are installed in the beam injection shift bump magnets. Residual gamma dose at the ceramic ducts, especially immediately downstream of the charge-exchanged foil, has increased with the output beam power. In order to investigate the cause of high residual activities at the ceramic ducts in the injection area, residual gamma dose and radioactive sources produced at the exterior surface of the ducts have been measured by a GM survey meter and a handy type of Germanium (Ge) semiconductor detector with 181 MeV injected proton beam energy. Moreover, the copper stripes attached on the exterior surfaces of the ceramic ducts have been removed to estimate the distribution of produced radioactive sources with a stationary type of Ge semiconductor detector. With these measurements, radioactive sources have been specified with materials in the ceramic ducts. In addition, residual gamma dose and radioactive nuclei at the inner side of the exterior surface of the ceramic ducts was much higher than at the other exterior surfaces of the ceramic ducts due to the magnetic configuration of shift-bump magnets.

For a better understanding of phenomena in the injection area, simulation has been done with the PHITS Monte Carlo code. The distribution of radioactive sources and residual gamma dose rate obtained by the calculations are consistent with the measurement results. With this consistency, secondary neutrons and protons derived from nuclear reactions at the charge-exchanged foil are the dominant cause to high residual gamma dose at the ceramic ducts in the injection area of RCS ring. These measurements and calculations are unique approaches to reveal the cause of high residual dose around the foil. This study is essential for the future of high-intensity proton accelerators using a stripping foil.

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