Inspection of exit-beam dump for BigRIPS

Y. Togano,[*1] N. Fukuda,[*1] N. Fukunishi,[*1] K. Kusaka,[*1] M. Ohtake,[*1] H. Suzuki,[*1] Y. Shimizu,[*1] H. Takeda,[*1] M. Yoshimoto,[*1] Y. Yanagisawa,[*1] K. Yoshida,[*1] and S. Michimasa[*1]

There are signs of melting at the exit-beam dump of BigRIPS,[1] caused by the use of a ^{70}Zn beam in the fall of 2022.[2] Thermal analysis of this melting event concluded that, assuming the exit-beam dump retained its original performance from the time of construction, melting would not occur unless the beam heat flux was 20% higher than estimated. This suggests either performance degradation of the beam dump or inaccuracies in the estimated beam heat flux. Despite the occurrence of melting, we intend to continue using this dump, necessitating tests to confirm its integrity and assess any performance degradation. For these tests, we irradiated the exit-beam dump with a ^{124}Xe beam.

The ^{124}Xe primary beam directly impinged on the low-momentum side of the exit-beam dump without the production target. The exit-beam dump is made of CuCrZr alloy and has M8 screw tubes 3 mm below the dump surface as cooling channels. The coolant is pressurized water with a temperature of 14°C and pressure of 1 MPa. The coolant water speed was 6 m/s, 8 m/s, or 10 m/s, depending on the measurements. The temperature was measured using a thermocouple (TC) located 76 mm from the inside edge of the dump and mounted 2 mm below the dump surface. The horizontal temperature was measured for different dump position. The vertical position of the beam was also varied by using a beam steerer before F0 to observe the effect of the beam vertical position on the temperature. The heat flux of the beam was enlarged by adjusting the magnetic field of the first superconducting quadrupole magnet STQ1 to have a similar heat flux to that of ^{70}Zn.

Because the beam heat flux depends on the beam spot size and beam intensity, we performed separate measurements for the beam spot size and beam intensity. The ^{124}Xe beam emittance was estimated to be 1.1π mm mrad (1σ) in the horizontal direction and 0.47π mm mrad (1σ) in the vertical direction by fitting 10 beam profiles between SRC and the BigRIPS F0. The beam spot size on the exit dump was estimated to be 2.1 mm (1σ) in the horizontal direction and 1.2 mm (1σ) in the vertical direction based on the matrix of the ion optics of BigRIPS. The uncertainty of the beam spot size was estimated to be 30%. To calibrate the beam intensity, the charge state distribution of the ^{124}Xe beam after passing through the 1-mm Be target was measured using BigRIPS. The measured charged state distribution was used to convert the ^{124}Xe^{50+} rate in BigRIPS to the total ^{124}Xe beam intensity. These data were also used to calibrate the current of the exit dump.

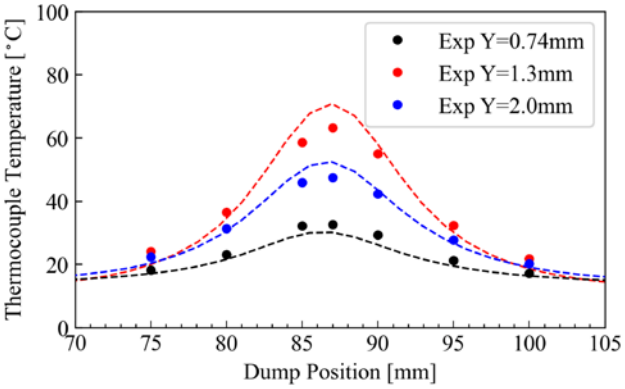

Fig. 1. Temperature distribution measured using a thermocouple on the dump for various beam vertical positions.

Figure 1 shows the TC temperature with respect to the horizontal dump postion and various beam vertical position on the dump. The cooling water speed was 8 m/s. The temperature peaked at a dump position of 87 mm, where the beam directly irradiated the TC position. The black, red, and blue circles correspond to the measured temperatures for the beam vertical positions of 0.74 mm, 1.3 mm, and 2.0 mm from the center of the beamline, respectively. The dashed curves in 3 different colors denote the calculation results for each set of conditions obtained via the finite element method using the ANSYS code.[3] The thermal conductivity of the dump was assumed to be 370 W/mK, and the heat transfer coefficient at the surface of the cooling water tube was presumed to be 70–110 kW/m^{2}K for the temperatures of 14–180°C. The calculation with these assumptions reproduced fairly well the temperature distribution for a ^{48}Ca beam measured in 2016.[4]

As shown in Fig. 1, the calculated temperature distributions for different vertical beam positions fairly well reproduced the measured values. This consistency between the values suggests that the present exit dump has kept the cooling capability as designed within a ∼30% error. The analysis for the different beam and exit dump settings is ongoing.

*1 RIKEN Nishina Center

DOI:10.34448/RIKEN.APR.58-037

References

1) K. Yoshida *et al.*, Nucl. Instrum. Methods Phys. Res. B **317**, 373 (2013).
2) Y. Togano *et al.*, RIKEN Accel. Prog. Rep. **57**, 95 (2024).
3) ANSYS Inc., Product Release 24.0 USA.
4) K. Yoshida *et al.*, RIKEN Accel. Prog. Rep. **49**, 159 (2016).