Conceptual design of new high-power beam dump for BigRIPS

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A new high-power beam dump situated at the exit of the first dipole magnet (D1) in the BigRIPS separator has been designed to absorb a 2 particle μA ^{238}U beam at 345 MeV/nucleon. The BigRIPS separator is equipped with beam dumps located both inside and at the exit of the D1 magnet to intercept unreacted beams resulting from primary beam + production target reactions at the focal plane F0. In the near future, the RIBF intends to utilize a 2 particle μA ^{238}U primary beam, which is 30 times more intense than the current ^{238}U beam, in order to produce a greater variety of exotic nuclei. However, the existing beam dump at the exit of the D1 magnet (hereafter referred to as the exit-beam dump) is incapable of safely absorbing such an intense beam due to insufficient cooling power. For performing experiments with 2 particle μA ^{238}U beam, a new high-power exit-beam dump, that utilizes a rotating water-cooled copper drum, has been designed.

The schematic depiction of the newly proposed exit-beam dump is illustrated in Fig. 1. The drum-shaped beam dump, measuring 300 mm in diameter and 350 mm in depth, rotates about its central axis to distribute heat and improve radiation damage resulting from the intense beam. The dump is made of a copper alloy, specifically Cu-Cr-Zr, and is equipped with 72 screw tubes (M8 tapped) to serve as water-cooling channels.[1)] The water flowed in the cooling channels is pressurized at 1 MPa and runs at a velocity of 10 m/s, ensuring a high rate of heat transfer between the cooling water and the copper alloy. This M8 tapped cooling channels have already been equipped for the present exit beam dump.[2)] The distance from the surface of the dump to the center of each cooling channel is 14 mm, and the pitch of the cooling channels is 12.2 mm. The rotational frequency of the dump is assumed to be sufficient to achieve a uniform temperature distribution along the circumference of the dump.

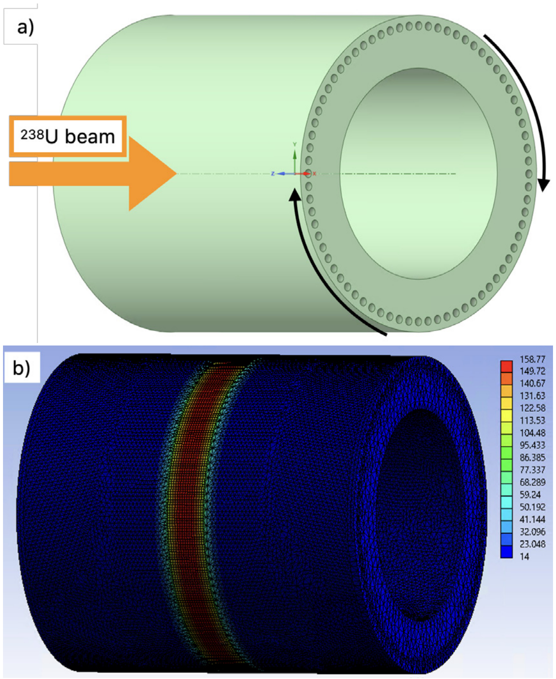

Fig. 1. a) Schematic view of the new exit beam dump. b) Caluculated temperature distribution on the surface of dump impinged by a 2 particle μA ^{238}U primary beam.

The cooling capacity of the dump is evaluated through finite element method simulation utilizing the ANSYS code. The results of the simulation are appraised against the following criteria:[2)] the maximum temperature of the dump should be less than 350°C to maintain the radiation hardness of the dump, and the heat flux at the surface of the cooling channels must be less than the critical heat flux (55 MW/m^2) for stable cooling of the dump. It is known that copper alloy keeps good radiation hardness at temperatures below 400°C. Above the critical heat flux, the heat transfer rate at the cooling channel abruptly decreases as the surface of the cooling channel becomes covered with vapor generated by vigorously boiling cooling water. In the simulation, it is assumed that a 2 particle μA ^{238}U beam ($Q = 86^+$) at 345 MeV/nucleon is directly impinged on the dump as illustrated in Fig. 1a). The beam spot on the dump is of an elliptical shape due to overfocus by the D1 magnet. The ratio of magnetic rigidities between the ^{238}U beam and a beam following the central trajectory of the D1 magnet is assumed to be 0.85. The range of the 345 MeV/nucleon ^{238}U beam in copper alloy is 3.2 mm.

Figure 1b) illustrates the calculated temperature distribution on the surface of the dump upon the impingement of the 2 particle μA ^{238}U beam. The maximum temperature of the dump is 159°C and the maximum heat flux at the surface of the cooling channel is 5.4 MW/m^2. These values are below the allowable temperature and the critical heat flux, indicating that the new dump can safely absorb the 2 particle μA ^{238}U beam. The detailed design of the new exit beam dump is currently underway.

References
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