TARGET/HEAT-SINK DESIGN AND THERMAL ANALYSIS STUDIES

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During this reporting period, we have continued to use the FEA analysis code ANSYS[2] in modeling the transport of primary-beam-deposited heat from fibrous and composite targets to the H_2O cooled target/heat-sink system, described in the last Annual Progress Report. The code, along with its fluid-flow complement, FLOTRAN,[3] was used for computing the heat transfer across the heat-sink/H_2O boundary in arriving at the steady-state solutions to the various target scenarios considered in these studies. The target matrix is in good thermal contact with a carbon beam stop, of sufficient length to stop the unimpeded primary beam, which is attached to the water cooled Cu-heat-sink. The target/heat-sink system consists of fibrous materials (e.g., Al_2O_3, SiO_2, Y_2O_3, ZrO_2, HfO_2, Ta_2O_5, rare-earth oxides, UC_2, etc.) or target materials plated onto vitreous-carbon-fiber (SiC, Ni, ZrC, NbC, Mo, Ta, W, Ir, Re, UC_2) to form high permeability composite targets. Refractory-oxide fibrous target materials are preferred for generation of $^{17,18}F$ for the HRIBF astrophysics research program. Since the thermal conductivity of fibrous Al_2O_3 is especially poor, efforts were made to improve the heat removal properties of targets made from these materials. Two examples of analyses of target designs for this application are shown in Figs. 1 and 2. In the scenario displayed in Fig. 1, a 1 mm thick fibrous Al_2O_3 (fiber diameter: 5-10 µm) mat is spiral rolled with a 25 µm Ir foil, attached directly to the C-beam-stop. The heat generated by the primary ion beam is radially transferred to the Ir foil then longitudinally transferred to the C-beam-stop heat-sink system. In the scenario illustrated in Fig. 2, the heat generated by the primary ion beam is transferred laterally to the surrounding Ta tube through Mo-mesh disks, spaced 3 mm apart; the Ta tube is attached directly to the C-beam-stop heat-sink system. Both techniques permit higher beam intensities to be used for production of these isotopes than without these additional heat transport media. As a further example of these studies, the temperature distribution in a composite target of UC_2 is shown in Fig. 3.

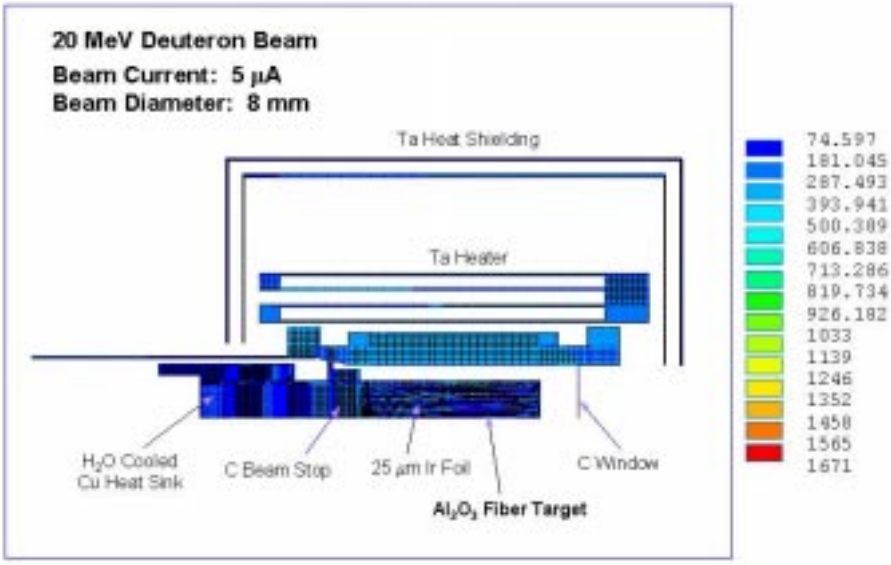

Fig. 1. ANSYS simulation of the temperature distribution generated by primary-beam-deposited heat in a fibrous Al_2O_3 target/heat-sink system designed with Ir spiral. Target diameter: 11.2 mm; target length: 24.6 mm.

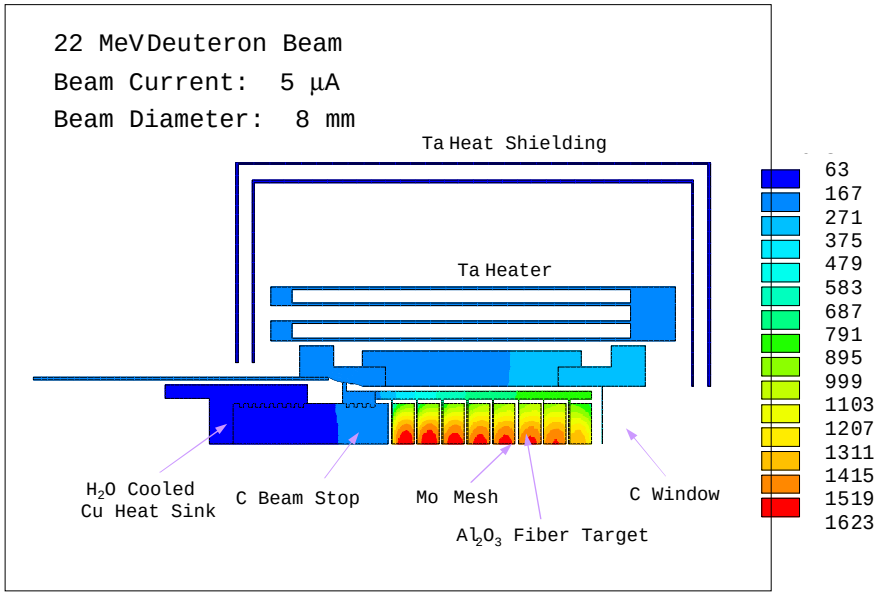

Fig. 2. ANSYS simulation of the temperature distribution generated by primary-beam-deposited heat in a fibrous Al_2O_3 target/heat-sink system with Mo mesh. Target diameter: 11.2 mm; target length: 24.6 mm.

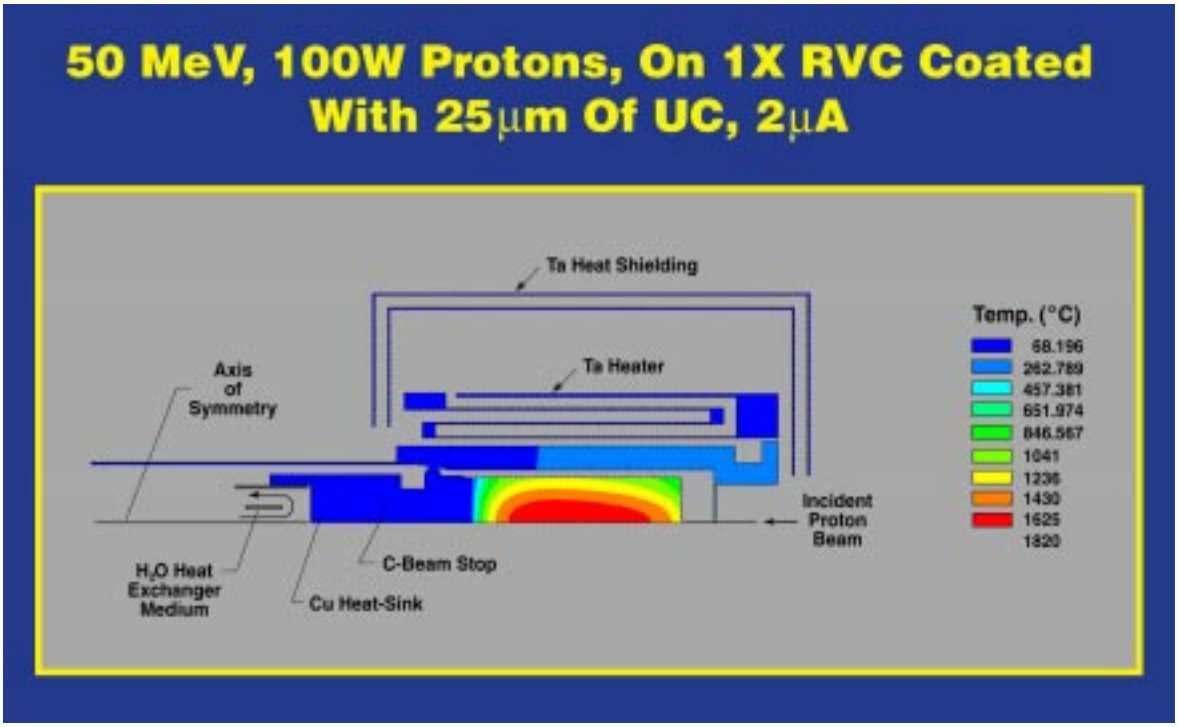

Fig. 3. ANSYS simulation of the temperature distribution generated by primary beam deposited heat in a 12 μm thick deposit of UC_2 on RVCF to form a composite target/heat-sink system designed for the production of fission fragments. (The upper temperature limit that UC_2 can be heated during production is ~ 2100 ^{o}C.) Target diameter: 16 mm; target length: 38 mm.

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[2] ANSYS is a finite element computer code that is designed to solve thermal transport as well as thermal and mechanical engineering problems and is a product of Swanson Analysis Systems, Inc., Houston, PA.

[3] FLOTRAN is a finite element computer code that is designed to calculate heat-transfer coefficients between media as well as other fluid transport engineering problems and is a product of Swanson Analysis Systems, Inc., Houston, PA.