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Multiphysics Modeling and Simulation for the Development of a Nanofiber Target Concept

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The High Power Targetry Research and Development (HPT R&D) Group at Fermi National Accelerator Laboratory (FNAL) has been investigating a novel target concept which has the potential to withstand high intensity primary beams: a target consisting of electrospun ceramic nanofibers. If successful, these exciting new targets could support the next generation of neutrino facilities, and could have separate applications in medical isotope production as well.

Thermal shock experiments performed by the HPT R&D Group on nanofiber target samples at CERN's HiRadMat facility revealed that the survivability of the nanofiber targets has a strong dependence on the manufacturing parameters of the nanofiber mat, particularly the packing density of the fibers, as samples with a lower packing density showed no damage after beam exposure whereas samples with a higher packing density developed holes at the beam center and became brittle. In order to optimize the performance of these nanofiber targets, the dependency of the targets' performance on their construction parameters must be understood. These nanofiber targets gain advantages due to their nanostructure, such as the ability to be actively cooled by forcing gas through the pores formed by the layered fibers, but this same structure raises challenges to predicting their performance accurately.

In this talk we share some of the multiphysics modeling and simulation work we have pursued in order to support the development of the HPT R&D Group's nanofiber target concept. To this end, we discuss porous media models and how they translate nanoscale effects to the macroscale, thus allowing us to perform multiphysics simulations of how these nanofiber targets respond to a high intensity particle beam. Using this simulation infrastructure, we return to the motivating problem of the HiRadMat tests and identify potential causes for the difference in the samples' performance.

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