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FRIB Linac Beam-Intercepting Device Material Challenges

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The Facility for Rare Isotope Beams (FRIB) is a heavy ion accelerator facility aiming to reach 400-kW primary beams, which will extend the heavy-ion accelerator power frontier by more than one order of magnitude. FRIB's superconducting radio frequency (SRF) continuous-wave heavy-ion linear accelerator can accelerate all the ions up to uranium to energies above 200 MeV/u. The design beam power of 400 kW requires an intense beam, 8 particle μA or 5 x 10^13 ions/s in the case of uranium.

FRIB's driver linac uses a charge stripper to remove electrons from the primary beam ions, which increases the energy gain of the beam being accelerated, by approximately a factor of two. The linac was designed to accelerate multiple charge states of the stripped beam. But the charge states beyond the acceptance of the linac are intercepted by a device called the charge selector. These are the two main beam-intercepting devices in the FRIB linac.

The major challenges in these devices are ultra-high volumetric heat density and intense radiation damage. To overcome these challenges, for high power and heavy ions FRIB's charge stripper uses a replenishing thin liquid lithium film, which is highly efficient in the heat removal and free from radiation damage. A rotating carbon foil is used for low power and light ions. The charge selector uses solid slits to stop and remove the unwanted charge states. The slits used currently are positional (to isolate charge states of interest), and static during intercept of beam. They are made of Glidcop and water cooled. This configuration however, has a limitation in acceptable beam power. We are exploring a new design that can support higher power operations. The design we are working on uses graphite wheels with a 150-mm or even larger diameter spinning at <1600 rotations per minute. This design is intended to distribute both thermal load and radiation damage. The greatest uncertainty in this design is the lifetime of the slits that we think is determined by the radiation damage. The radiation damage induced by heavy ions of the FRIB intensity is not well understood. The authors would like to discuss how we approach this challenge and receive valuable comments from experts in the field.

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