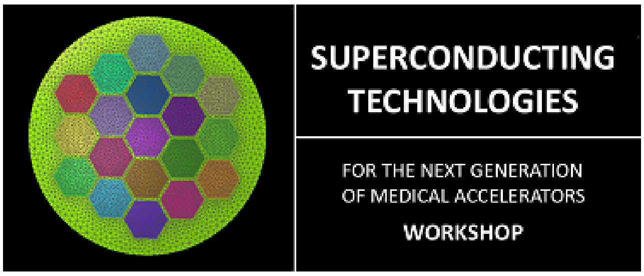
Academia-Industry Matching Event on Superconductivity for Accelerators for Medical Applications



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Superconducting magnets for Ultra-Light and magnetically shielded, compact cyclotrons for medical applications

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Superconducting cyclotrons are increasingly employed for proton beam radiotherapy treatment (PBRT). The use of superconductivity in a cyclotron design can reduce its mass an order of magnitude, yielding significant reduction in overall cost of the device, the accelerator vault and its infrastructure, as well as operating costs. Despite several decades of design effort, the magnetic configuration for superconducting cyclotrons remains relatively unchanged from that proposed by Lawrence over 80 years ago for resistive-magnet-based cyclotrons. The basic configuration still consists of a single, split pair solenoid embedded in a relatively massive iron return yoke, with the radial magnetic field profile in the acceleration region produced by a pair of magnetically saturated iron poles. The use of a warm iron yoke also requires the transmission of substantial electromagnetic loads across the cryostat boundary; these loads must be accommodated in the cryogenic design of the magnet vessel.

At MIT, we previously developed a design for a very high field superconducting synchrocyclotron (9 T at the pole face) that results in a compact device that is small enough and light enough to mount directly on the beam delivery gantry, entirely eliminating the beam delivery system. As a next step for advancing superconducting cyclotron technology we are developing a method to design a compact superconducting synchrocyclotron that demonstrates the possibility to reduce its weight significantly by eliminating all iron from the design. Implementation of this proposed design benefits from several significant advances in superconducting magnet technology pioneered in the magnetic resonance imaging (MRI) industry during the past 20 years, such as active magnetic shielding.

In addition to the prospect of reduced weight, smaller accelerator vault volume, enhanced magnetic shielding, and structural efficiency, the linear relationship between operating current and field magnitude facilitates the development of iron-free synchrocyclotrons with the capability for beam energy variation without a degrader. Reliance on an energy degrader comes at the cost of undesirable production of secondary radiation that markedly increases the amount of radiation shielding required. Simultaneous with this beam energy degradation is another negative consequence, reduction of the beam current. Additionally this concept could potentially be used for acceleration of a variety of ion species in a single device.

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