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Thu-Mo-Po.11-05: Conceptual design and preliminary experimental validation of a novel bi-directional scanning magnet with ceramic support bobbin for cooling

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Superconducting gantries are required to reduce the size and cost of proton or carbon beam delivery systems for cancer radiation treatment. To map out the whole volume of a tumor, a well-focused pencil beam is scanned over the tumor in the two transverse directions while beam penetration and energy deposition in the axial direction is achieved by adjusting the beam energy. To minimize the aperture of the superconducting gantry magnets, it is required to perform the beam scanning downstream of the gantry which requires strong normal conducting bending magnets which are pulsed at 100-200 Hz. To achieve the bending strength, large, pulsed excitation currents are needed which cause significant eddy currents and DC and AC losses in the coil windings. A novel coil configuration is presented which enables field uniformities below 0.1% despite the presence of eddy currents and the effect of the external field enhancing iron yoke. The demanding cooling requirements are met by using heat conducting ceramic bobbins as the coil support and immersing the whole winding in a fluor-inert liquid. With the novel cooling scheme, the large required current densities of about 60 A/mm2 in copper conductor can be achieved. The high cooling efficiency, possible with heat conducting ceramics, and the expected AC losses for the complete magnet has been analyzed with numerical multiphysics calculations. Total power loss has been measured for a prototype of this system at the Center for Advanced Power Systems (CAPS). These experimental results along with model predictions are presented.

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