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FEM modeling of superconducting whole body, actively shielded 7 T MRI magnets wound using Nb3Sn strands

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Nb3Sn strand was used to enable the development of short (1.4 m) segmented coil designs, as opposed to the nearly 2 m long compensated solenoid designs needed for NbTi machines. Using Nb3Sn strand will allow a conduction cooled design, if quench is properly managed. We modeled two designs with magnetic field homogeneity better than 10 ppm (part-per-million) within DSV (Diameter of Spherical Volume) of 45 cm. Several classes of Nb3Sn strand especially designed for MRI applications were considered as a possible candidate for winding such magnets. The magnets were assumed to achieve maximum on-axis magnetic field of 7 T. For this on-axis field a peak field inside the magnet windings was determined and parameters of the required Nb3Sn strands (such as critical current, engineering current density etc.) calculated. The coil load lines were compared to the critical currents of the Nb3Sn conductors and we find that such a segment coil design can be achieved with several classes of existing Nb3Sn conductor. Coil geometry, length of conductor, and overall magnetic performance, and current and thermal margins are discussed. This demonstrates that a viable compact 7 T whole body MRI is achievable using Nb3Sn conductor.
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