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Strongly Curved Super-Conducting Magnets: Beam Optics Modeling and Field Quality

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Superconducting dipoles with a strong curvature (radius smaller than 2 meters, for an aperture of about 100 mm and a length of 1-3 meters) are required for applications where compactness is key, such as the synchrotron and gantry for Carbon-ion therapy developed within the European program HITRIplus.
Such magnets challenge several assumptions in the field description and put to the test the range of validity of beam optics codes. In particular, the equivalence that holds for the straight magnets between the transverse multipoles description obtained from the Fourier analysis (used for magnet design and measurements) and the Taylor expansion of the vertical field component along the horizontal axis (used in beam optics) is not valid any longer. A proper fringe field modelling also becomes important, due to the curved geometry and the aperture being large compared to the magnetic length.
We explore the feasibility and the limits of modeling such magnets with optics elements (such as sector bends and multipoles), which allows parametric optics studies for optimization, field quality definition and fast long-term multi-pass tracking.

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