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Feasibility Study of GaToroid Gantries for Carbon Ions

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The use of carbon ions in particle therapy can enhance the treatment quality, introducing higher biological effectiveness compared to photons and protons.
Rotating gantries are nowadays used to deliver particle beams from different directions to obtain precise conformal dose mapping at the tumour location. The mechanical stability requirements during the rotation usually require heavy structures.
Superconducting magnets can be used to reduce size and weight of the machine, but complex cryogenics systems are needed to maintain superconductivity during the gantry rotation.
The seek of novel gantry configurations for carbon ions is one of the greatest challenges that need to be tackled to widen the accessibility of hadron therapy to a larger number of patients.
The concept of GaToroid, a steady-state toroidal gantry implemented with superconducting magnets, can be used to deliver the beam from different directions without the rotation of neither the structure nor the patient.
In this work, we present the magnetic design of two GaToroid solutions for Carbon ions, conceived to operate with Nb-Ti cables in the range of 6-7 Tesla. The first solution was designed with 20 pairs of coils, to maximize the flexibility of the treatment, and with an internal diameter of 3.5 meters, to allow a complete couch rotation on the plane.
The second option, based on a more conservative design with an internal diameter of 2.3 meters and 8 couples of coils, aims to be a compromise between the complexity and cost of the machine, and the flexibility of the treatments.
For both configurations, the coil geometry and current distribution were optimized to maximize the carbon ion momentum acceptance for complete coverage of the treatment range without variation of the toroidal magnetic field.
The studies here presented can be considered as the first milestone toward the design of toroidal gantries for heavy ions.

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