Beam delivery for laser-driven proton radiotherapy

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Abstract:

Radiation therapy is an important modality in cancer treatment. Ion beams due to their superior dose profile over widely applied photons and electrons, may provide higher dose-conformity and healthy tissue sparing. But due to high costs and huge size of existing facilities, ion beam therapy is limited to few, large centers. Ion acceleration, on micrometer scale by ultra-intense lasers, promises compact accelerators and beam delivery systems. However, in contrast to narrow, monoenergetic, and (quasi) continuous beams from conventional accelerators, laser-driven ion beams are characterized by ultra-short pulses of very high particle flux, low repetition frequency, broad energy spectrum, large divergence and significant pulse-to-pulse fluctuation. In addition to laser particle accelerator development for generating therapeutically applicable ion beams, the distinct features of these beams demand new solutions for efficient beam transport via 360 degrees rotatable gantry systems and safe treatment dose delivery.

Over the last years, we designed a compact proton gantry system based on pulsed magnets, with integrated laser-particle acceleration chamber, novel beam capturing and energy selection system. This is an achromatic 360 degrees isocentric design and is approximately 2.5 times smaller than conventional gantries. Also, a scanning system for wide beams with broad energy distribution was designed for irradiations with clinical accuracy and is capable of dispersion-free scanning through 20x20 cm^2 field size. For the gantry realization, light-weight iron-less high-field pulsed magnets are being developed. We report on the design and test of the different types of pulsed magnets like solenoid for particle capturing and focusing, sector magnet for beam bending and quadrupole for beam shaping.

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Reference:

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