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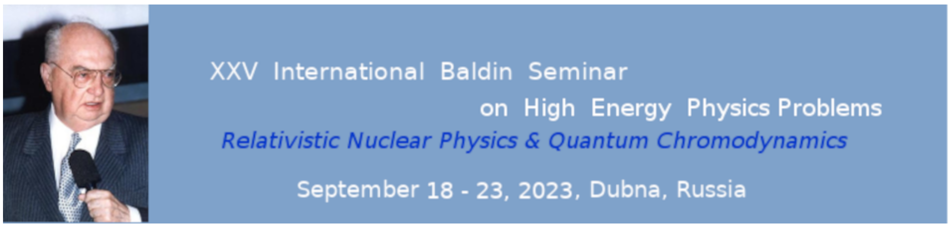
"Relativistic Nuclear Physics and Quantum Chromodynamics"



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Proton and carbon-ion minibeam therapy: from modeling to treatment

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More than 360 000 patients were treated at 100 proton and also at 8 heavy-ion cancer therapy facilities worldwide [1]. While beams of protons, ^{4}He and ^{12}C nuclei are very effective in killing deep-seated solid tumors, some damage to surrounding healthy tissues is unavoidable and must be reduced. It has been proposed [2,3] to use arrays of thin proton beams, spatially fractionated at the entrance to the patient's body. As shown in a preclinical study [4], this helps to spare normal tissues traversed by protons on their way to the target volume where the beams become wider and finally converge and overlap. The implementation of proton or heavy-ion minibeam radiation therapy (MBRT) is technically challenging in terms of precise shaping of sub-millimeter beams with grid collimators or by magnetic focusing [5]. A detailed modelling of minibeam propagation in tissue-like media is necessary to evaluate the peak-to-valley dose ratio (PVDR) and other parameters linked with the effectiveness of the minibeam therapy.

Using our experience with Geant4 [6] modeling of propagation of therapeutic proton and heavy-ion beams in tissue-like media [7], we simulate minibeams of protons and ^{12}C in water arranged as rectangular or hexagonal grids with different center-to-center distances and beam widths. Deep-seated target volumes to be irradiated with energetic protons and ^{12}C are considered because the sparing of a large volume of normal tissues is crucial in this case. The considered minibeam configurations are characterized by dose-volume histograms (DVH) in addition to commonly used PVDR. The results for minibeam configurations of the same geometry for proton and ^{12}C minibeams are compared for both rectangular and hexagonal grids. Due to the greater lateral divergence, the proton beams provide more uniform irradiation of the target volume compared to ^{12}C beams. However, further research is needed using radiation biology models to calculate cell survival rates to substantiate firm recommendations for minibeam configurations and choice of protons or ^{12}C as projectiles.

References

[1] Particle Therapy Co-Operative Group, https://www.ptcog.site/
[2] Y. Prezado, G.R. Fois, Med. Phys. 40, 031712 (2013)
[3] O. Zlobinskaya, S. Girst, C. Greubel et al., Radiat. Environ. Biophys. 52, 123 (2013)
[4] C. Lamirault, V. Doyère, M. Juchaux et al., Sci. Rep. 10, 13511 (2020)
[5] G. Datzmann, M. Sammer, S. Girst et al., Front. Phys. 8, 568206 (2020)
[6] J. Allison, K. Amako, J. Apostolakis et al., Nucl. Inst. Meth. A 835, 186 (2016)
[7] S. Dewey, L. Burigo, I. Pshenichnov et al., Phys. Med. Biol. 62, 5884 (2017)

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