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Three-Stage Simulation for the Development of an Ion-Acoustic Dose-Deposition Mapping System for LhARA

Sunday, 7 May 2023 16:00 (2 hours)

LhARA, the Laser-hybrid Accelerator for Radiobiological Applications, is a proposed facility for the study of proton and ion radiation biology. The accelerator is designed to deliver a variety of ion species over a wide range of spatial and temporal profiles at ultra-high dose rates. The facility requires that the deposited dose distribution be measured in real-time. For this purpose, an ion-acoustic dose mapping system has been developed that, exploits the ultrasound waves generated by the ion beam*. The feasibility of this approach is being evaluated using a two-stage simulation.

A water phantom modelled in Geant4 with beam energies up to 250 MeV is used to calculate the energy deposited by the beam as a function of position and time. The time-dependent 3D energy distribution is then used as the source in k-Wave to simulate the ion energy generation of acoustic (pressure) waves and their propagation in the three-dimensional space. A hemispherical acoustic sensor array is also simulated and its ability to reconstruct the generated pressure distribution is evaluated.

The results show that the 3D deposited-energy distribution can be reconstructed with sub-millimetre accuracy and suggest, that further development of the system can lead to real-time, non-invasive Bragg peak localization and dose deposition profile measurement during ion-beam therapy.

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Footnotes

- Aymar G. et al. Front Phys. 2020;0:432. ** Haffa D. et al. Sci Rep. 2019;9(1):6714. *** Allison J. et al. Nucl. Instrum. Meth. A. 2016;835:186-225. **** Treeby BE, Cox BT. J. Biomed. Opt. 2010;15(2):021314.

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Yes

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