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Abstract title: FOUR-STAGE SIMULATION FOR THE DEVELOPMENT OF AN ION-ACOUSTIC DOSE-DEPOSITION MAPPING SYSTEM FOR LHARA

Topic: Topic A: Radiation Modalities: A2. Quality assurance and real time dosimetry for FLASH RT measurement of FLASH doses, detector systems

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Background and Aims

LhARA, the Laser-hybrid Accelerator for Radiobiological Applications, is proposed as a facility for the study of radiation biology using proton and ion beams. 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, up to and beyond the FLASH regime.

The variable nature of the ion yield requires that the deposited dose distribution be measured in real-time. Due to the short pulses (10—40 ns) delivered by LhARA, the thermal expansion generated by the almost instantaneous energy deposition satisfies the stress confinement criterion necessary for the efficient generation of acoustic (pressure) waves.

Methods

An ion-acoustic dose mapping system has been developed and its feasibility has been evaluated in a four-stage simulation using BDSIM, Geant 4and k-Wave. The four stages include the generation and transport of the ions through the beamline, the generation of the beam-induced energy distribution in the medium, the acoustic wave generation, propagation and detection, and the dose-map reconstruction.

A water phantom modelled in Geant4, which acts as the propagating medium, was irradiated with the beam emerging from the BDSIM simulation of the beamline. The energy deposited was calculated as a function of position and time, and the 3D energy distribution was then used as the source in k-Wave to simulate the generation of acoustic waves and their propagation in the three-dimensional space. In addition, a hemispherical acoustic sensor array was simulated to evaluate the reconstruction of the pressure distribution using an iterative time-reversal algorithm. The acoustic signals of different body tissue and organs have also been investigated.

Results

The results show that the 3D deposited-dose distribution can be reconstructed with sub-millimetre accuracy.

Conclusion

This suggests that further development of the system can lead to an online, quantitative 4D dosimetry feedback system during ion-beam therapy.