DNA Repair Dynamics Following Laser-Ion Irradiation at Ultra-high Dose Rates

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The limitations of conventional X-ray radiotherapy are overcome by the use of proton and carbon ion beams which deliver the dose with superior precision, owing to their finite range and maximum energy deposition in the Bragg peak.

More than 90,000 patients have been treated worldwide with protons from synchrotrons, cyclotrons and linear accelerators. This number could be considerably higher, but the overall size and cost of this type of facility is well outside the scope of a typical hospital. The proposed solution is to base future facilities on laser-driven accelerators, reducing both the cost and complexity. One of the characteristics of laser-driven ion beams is their ultra-short duration, as the ions are emitted in bursts of picosecond duration at the source. From here, the beam pulse will lengthen in time, resulting in a pulse of nanosecond duration. A pulse of protons depositing their energy on this very short time frame coupled with the inherent high flux correlates into an ultra-high dose rate of $>10^9$ Gys^{-1}. Their therapeutic use may result in dose rates as many as 8 orders of magnitude higher than those normally used with conventionally accelerated protons. However, the biological effects of ions at these ultra-high dose rates are virtually unknown and cannot be put to any medical use until they have been carefully assessed.

An investigation into DNA repair dynamics in human fibroblast cells (AGO1522) by means of the 53BP1 Immunofluorescence assay, following irradiation with proton and carbon ion beams of multi MeV/nucleon energies and respective dose rates of 10^{10} and 10^9 Gys^{-1} produced through laser-ion acceleration, was carried out at the Astra-Gemini laser system at the Rutherford Appleton Laboratory.