11-1 DNA Double-Strand Breaks of Human Cancer Cells by Irradiation with Laser-Accelerated Protons
－Toward Cancer Therapy by Laser-Driven Accelerators－

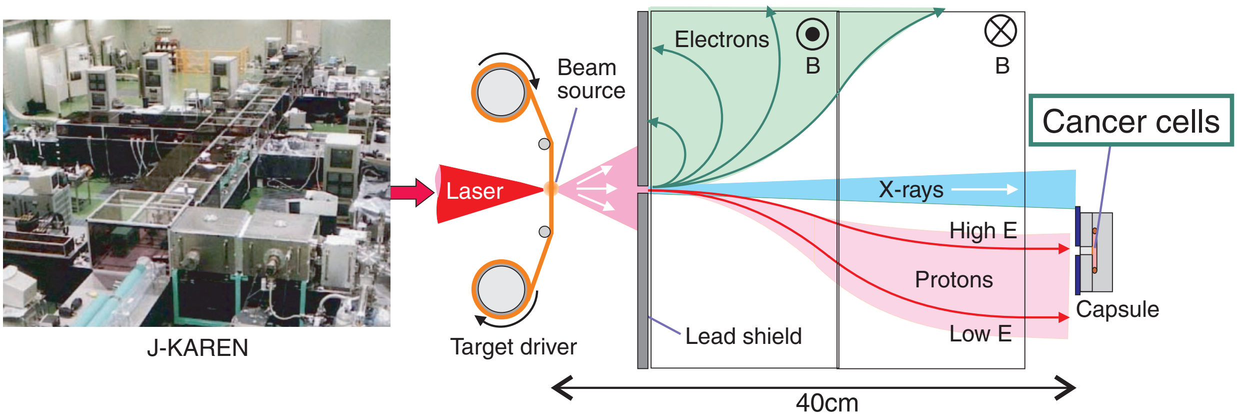

Fig.11-3 Newly-developed laser-driven proton irradiation system for radiobiological studies
High-intensity laser pulses are generated by J-KAREN laser system and focused onto thin plastic foil successively shifted by a target-driver. The laser focal spot is a “micron-sized” proton accelerator. The proton beams are separated by magnetic fields and irradiate cancer cells cultured in a capsule.

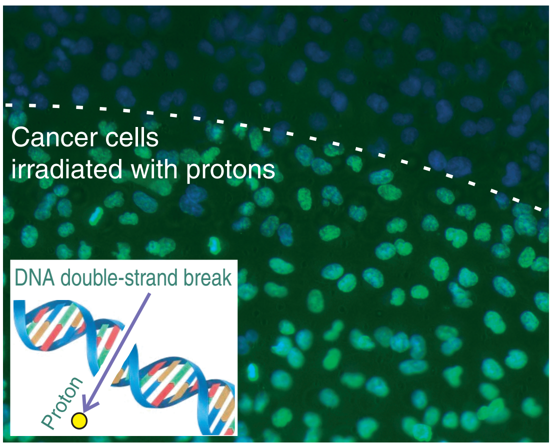

Fig.11-4 Result of laser-accelerated proton irradiation of in-vitro human lung cancer cells
Cancer cell nuclei irradiated with the protons are stained with green color indicating the generation of DNA double-strand breaks.

During these past several decades, high-frequency ion accelerators have been used for ion-beam cancer therapy. Recently, high-intensity lasers have been suggested as a potential cost-saving alternative to conventional ion accelerators for this radiotherapy. A unique feature of laser acceleration is the extremely high peak current given to a single proton bunch for a short duration. However, technical problems have prevented production of such high-current, short-duration laser-driven ion beams suited for investigating biological effects.

We have developed a laser-driven ion irradiation apparatus for biological studies that causes the desired fundamental interactions between laser-accelerated protons and human cancer cells in a vacuum (Fig.11-3). This apparatus delivers $\sim 2.5 \times 10^4$ laser-driven protons onto a $1 mm^2$ cultured (in-vitro) cell layer within a time interval of only 15ns. We estimated the proton flux to be $\sim 10^3 mm^{-2} ns^{-1}$. The peak current was seven times that in ion beam therapy by conventional accelerators. The DNA double-strand breaks of in-vitro human lung cancer cells (A549) are shown in Fig.11-4. These results indicate that laser-driven protons are applicable to ion-beam cancer therapy. This laser-driven table-top ion-irradiation apparatus will open a new field of radiobiological science, and many applications should be forthcoming.

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Reference
Yogo, A. et al., Application of Laser-Accelerated Protons to the Demonstration of DNA Double-Strand Breaks in Human Cancer Cells, Applied Physics Letters, vol.94, no.18, 2009, p.181502-1-181502-3.