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ELIMAIA-ELIMED beamline –a new opportunity for radiobiological research with laser-driven protons

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With the growing number of cancer patients requiring radiation treatment, advancements in accelerator technologies, proton-based in particular, are essential. The ELI Beamlines user facility is exploring laser-driven accelerators as an alternative type. The laser-driven proton beams (LDP) are produced with specific temporal and dose-rate characteristics that may potentially offer treatment benefits. The acceleration system is powered by the L3 HAPLS petawatt laser, integrated with the ELIMAIA (ELI Multidisciplinary Applications of laser-Ion Acceleration) laser-plasma accelerator and the ELIMED (ELI MEDical application) beam transport and dosimetry line, enabling multi-shot LDP irradiation.

During the first LDP biological experiment, human skin fibroblasts AG01522 were irradiated by protons with a mean energy ~23.5 MeV, fixed about 30 min post-irradiation, and assayed for DNA DSB assessment in the form of 53BP1 foci. The results suggest that the samples irradiated with multi-shot LDP exhibit a similar biological response to samples exposed to single-shot LDP assessed between 1- and 2-hours post-exposure. Considering the extended irradiation duration, cells likely initiated repair processes already during irradiation. Results for conventionally accelerated protons agree well with the corresponding single-shot LDP samples.

Another experiment focused on the irradiation of two cancer cell lines as 3D spheroids with LDP. This unique conformation is considered an intermediate step between in vitro and in vivo research, and in combination with LDP, provides rarely tested setup. LLC1 and HT-29 cell cultures are investigated for several biological endpoints, including survival, heat shock proteins 70 & 90 analysis, or RNA sequencing. Preliminary results will be discussed. These experiments provide an initial look at this user platform's potential for advanced research in the field of ultrafast radiation biology and open new opportunities for further experimental work.

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