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The Laser-hybrid Accelerator for Radiobiological Applications (LhARA)

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Particle beam therapy (PBT) today is delivered at low dose rates ($< 10\,\mathrm{Gy/min}$) within restricted beam characteristics by employing a small number of temporal schemes and spatial distributions. The damage to the healthy tissue limits the dose delivered and, thus, constraints the clinical efficacy. Exciting evidence of enhanced therapeutic benefit has been recently found with the use of novel beams with strikingly different characteristics, e.g. very high dose per fraction, very high dose rate ($> 40\,\mathrm{Gy/s}$, "FLASH"), and spatially fractionated dose from "mini-beams" (MBRT). The exploration of new regimens of PBT now provides the impetus for a radical transformation of PBT.

LhARA is proposed as a novel facility with the potential to deliver high-intensity proton and ion beams to serve a systematic research programme in completely new regimes of radiobiology. The ambition of the multidisciplinary collaboration is that the technologies demonstrated in LhARA will be transformative in the delivery of ion beam therapy (IBT). The laser-hybrid approach offers enormous potential by providing more flexible, compact, and cost-effective high energy particle sources.

As LhARA will be developed in two stages, the first stage will serve a programme of *in-vitro* experiments. A high-power laser is utilized to produce ultrashort proton and light-ion bunches of energies up to 15 MeV from a tape target. The particles are captured close to the source and focused using electron plasma lenses while evading the space-charge limitations of current sources. The ultra-high instantaneous dose rates and the short bunch duration will enable studies of the FLASH regime and beyond. The second stage will accelerate protons up to 127 MeV in an FFA ring that was designed to make use of the flexibility of the source and deliver a wide variety of time structures and spatial configurations of the dose to either an *in vivo* or a second *in vitro* end station.

The LhARA facility has been simulated using a variety of codes. We outline here the motivation of the LhARA collaboration and present the conceptual design of the LhARA facility as well as the most recent progress toward the technical design of the accelerator.