The novel Laser-hybrid Accelerator for Radiobiological Applications

Elisabetta Boella[1,2]

[1] *Lancaster University, Lancaster LA1 4YW (UK)*
[2] *The Cockcroft Institute, Warrington WA4 4AD (UK)*

e.boella@lancaster.ac.uk

Despite the advantages of using protons and ions for radiobiological applications and cancer treatments were first highlighted in 1946 [1], the impact of these ionising radiations on living tissues is still characterised by significant biological uncertainties. An example regards the value of their relative biological effectiveness, which is critical for accurate treatment planning [2]. In addition, even if there are indications of the therapeutic benefits of ultra-high dose rates (the so-called FLASH effect) [3] and spatially fractioned doses from mini-beams [4], thresholds and underpinning radiobiology of these novel regimes are still open questions. The Laser-hybrid Accelerator for Radiobiological Applications (LhARA) has been conceived as a flexible and innovative radiobiology research facility that will provide definite answers to these compelling questions [5].

In this presentation, I will illustrate the key technologies of LhARA. LhARA will leverage Target Normal Sheath Acceleration to produce a large flux of protons and carbon ions. Gabor lenses will be employed to capture the particles and shape them into a beam with an average energy of 15 MeV in the case of protons or 4 MeV/nucleon in the case of carbon ions. In a first phase, the bunches will be transported to an *in vitro* end station. In a second phase, particles will be post-accelerated in a fixed-field alternating gradient accelerator and delivered to a high-energy *in vitro* or an *in vivo* station.

By using three-dimensional Particle-In-Cell (PIC) simulations performed under realistic LhARA conditions, I will discuss the features of the proton source. I will then show the results of Monte Carlo particle tracking simulations carried out to explore the proton transport from the source to the low energy *in vitro* station. These simulations use the output of the PIC simulations as input and demonstrate that TNSA divergent protons can be shaped into a well collimated beam with a transverse size < 1 cm (RMS) and 2% energy spread.

Acknowledgments

The LhARA collaboration.

References

[1] R. R. Wilson, Radiology **47**, 487 (1946)
[2] H. Paganetti and P. van Luijk, Seminars in Radiation Oncology **23**, 77 (2013)
[3] V. Favaudon et al., Science Translational Medicine **6**, 245ra93 (2014)
[4] Y. Prezado et al., Scientific Reports 7, 14403 (2017)
[5] G. Aymar et al., Frontiers in Physics **8**, 567738 (2020)