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An Evaluation of the Various Aspects of the Progress in Clinical Applications of Laser Driven Ionizing Radiation

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There has been a vast development of laser driven particle acceleration (LDPA) using high power lasers. This has driven by the radiation oncology community to use the dose distribution and biological advantages of proton/heavy ion therapy in cancer treatment with a much greater accessibilty than currently possible with cyclotron/synchrotron acceleration. Up to now, preclinical experiments have only been performed at a few LDPA facilities; technical solutions for clinical LDPA have been theoretically developed but there is still a long way to go for the clinical introduction of LDPA.

Therefore, it is highly important to evaluate the alternative particle acceleration approaches and to explore the further potential bio-medical advantages of LDPA. The main characteristics of LDPA are the ultra-high beam intensity, the flexibility in beam size reduction and the potential particle and energy range selection whilst conventional accelerators generate single particle, quasi mono-energetic beams. There is a growing number of studies on the potential advantages and applications of Energy Modulated X-ray Radiotherapy (EMXRT) in the range of 2-10 MV with relative fast energy switching of the new generation linacs due to the lack of appropriate technology to modulate photon energy. Furthermore the ultrahigh space and/or time resolution of super-intense beams are under intensive investigation at synchrotrons with growing evidence of significant improvement of the therapeutic index. These promising, innovative approaches for cancer therapy present a huge challenges for dose calculation, dosimetry and for investigation of the biological effects. The biomedical application group at ELI-ALPS is preparing biological systems and endpoints (cell cultures, zebrafish embryos and small animals) for the comparison of the effect of LDPA with using conventional photon and electron beams techniques. Current model development for in vitro and in vivo preclinical research on both healthy tissues and diverse tumors will address the key biological questions concerning the LDPA with large variety of particles, energies and intensity. As well as secondary ionizing beams, tertiary particles (compton/thomson photons by electrons, neutrons by protons) could be generated which could be beneficial for special forms of radiotherapy. The planned LDPA (photons, very high energy electrons, protons, carbon ions) at ELI facilities have the unique property of ultra-high dose rate (>Gy/s^-10), short pulses, and at ELI-ALPS high repetition rate, have the potential to develop and establish encouraging novel methods working towards compact hospital-based clinical applications.

Summary

Clinical aspects of potential multiparticle, flexible, compact, energy and intensity modulated laser driven ionizing particle beams with ultrahigh space and time resolution will be presented.

Primary authors: Mrs UGHY, Bettina (ELI-ALPS Nonprofit LTD.); Mrs SZABÓ, Emilia Rita (ELI-ALPS Nonprofit LTD.); Dr HIDEGHÉTY, Katalin (ELI_ALPS Nonprofit LTD.); Mr POLANEK, Róbert (ELI-ALPS Nonprofit LTD.); Mrs TŐKÉS, Tünde (ELI-ALPS Nonprofit LTD.)

Presenter: Dr HIDEGHETY, K. (ELI-ALPS)

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