ERC Advanced Grant 2020
Research proposal [Part B1][1]
(Part B1 is evaluated both in Step 1 and Step 2,
Part B2 is evaluated in Step 2 only)

Super-efficient ion capture to harness laser-hybrid accelerators for science, innovation, and society

CaptureLhARA

Cover Page:

- Name of the Principal Investigator (PI) : Kenneth Long
- Name of the PI's host institution for the project : Imperial College London
- Proposal duration in months : 60

Radiotherapy is central to cancer treatment and is most often delivered using X-rays using a source that rotates around the patient. The energy deposited by X-rays falls exponentially with depth, limiting the dose that may be delivered to a tumour without exposing healthy tissue to unacceptably high radiation levels.

Proton and ion beams overcome the fundamental limitation of X-rays because the bulk of the energy is deposited in the 'Bragg peak' that occurs as the beam comes to rest. This allows a large dose to be delivered to the tumour while sparing healthy tissue. **The maximum instantaneous dose that can be delivered today is limited at the ion source** because of the mutual repulsion of the low-energy ions (approximately 60 keV) of the ions produced. At such low energies the repulsion between the ions causes the beam to diverge rapidly and limits the capture efficiency. **I propose to overcome this fundamental limitation by using a laser to create ions with energies of up to ~15 MeV and capturing them using a strong-focusing plasma lens.**

I propose to develop a novel, as-yet unproven, source of proton and ion beams by exploiting state-of-the art technologies that to-date have only been demonstrated independently. The particle flux produced by a high-power short-pulse laser has a broad energy spectrum, is highly divergent, and contains a variety of particle species. **I will construct a highly efficient capture system that exploits novel electron-plasma lenses to turn the divergent laser-generated proton and ion flux into a beam.** To prove the principle of the technique, **I will use my system to initiate a programme of radiobiology exploiting the laser-hybrid technique.**

A system capable of delivering high instantaneous dose rate will have broad applicability. **The laser-hybrid technique will allow radiotherapy to be carried out in completely new regimes, exploiting a variety of ion species, energy spectra, time structures, and spatial configurations at ultra-high dose-rate.**

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Explain and justify the cross-panel or cross domain nature of your proposal, if a secondary panel is indicated in the online proposal submission forms. There is a limit of 1000 characters, spaces and line breaks included.