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The Centre for the Clinical Application of Particles (CCAP): An interdisciplinary collaboration transforming personalised, precision particle-beam therapy of the future

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While external-beam radiotherapy (RT) is most often delivered using photons, there is increasing emphasis on particle-beam therapy (PBT) using proton and ion beams. In PBT, dose may be conformed precisely to the tumour, sparing healthy tissue and organs at risk, since the bulk of the beam energy is deposited in the Bragg peak. The importance of PBT is widely recognised in the UK and overseas.

The beam characteristics exploited in PBT today are restricted to low dose rates (< 10 Gy/min), a small number of temporal schemes, and a small number of spatial distributions. Clinical efficacy is dependent on the dose delivered which may be limited to minimise damage to the healthy tissues. The use of novel beams with strikingly different characteristics has led to exciting evidence of enhanced therapeutic benefit, e.g. therapy using very high dose per fraction, very high dose rate (> 40 Gy/s, "FLASH"), and "mini-beam" (MBRT) which, together with developments in our understanding of personalised medicine based on the biology of individual tumours, now provides the impetus for a radical transformation of PBT.

I will describe the "Laser-hybrid Accelerator for Radiobiological Applications", LhARA, a novel, uniquely flexible facility dedicated to the study of the biological impact of proton and ion beams. The technologies demonstrated in LhARA can be developed to provide a radical transformation of the clinical practice of PBT by creating a fully automated, highly flexible system to harness the unique properties of laser-driven ion beams to:

- Deliver PBT in completely new regimens by combining a variety of ion species in a single treatment fraction, exploiting ultra-high dose rates and novel temporal-, spatial- and spectral-fractionation schemes; and
- Make "best in class" treatments available to the many by integrating patient, soft-tissue, and dose-deposition imaging with real-time treatment planning in an automatic system that triggers the delivery of dose tailored in real time to the individual patient.

The system will reduce the capital cost by removing the requirement for a large gantry and increase patient throughput by reducing the time spent in treatment.

On behalf of the multi-disciplinary collaboration of clinical oncologists, medical, particle, plasma, laser, ultrasound, and optical physicists, accelerator, computer, and instrumentation scientists, radiobiologists, industrialists, and patient representatives, I will present our vision of a programme to deliver a transformative PBT system in the long term that is structured to maximise the breadth of the clinical impact it will generate in the R&D and proof-of-principle phases.