**Developing the institute**

**BioPhysicsX**

**Purpose**

The institute creates an environment for ground-breaking research to study the effects of different types of potential radiobiology cancer treatments. It will investigate how the DNA in cells react to different types of charged beams and treatment regimes. The step change in understanding at the gene level that is developed will lead to improved treatments and better clinical systems to deliver them resulting in improved outcomes for patients.

The co-location of experts from different disciplines within the institute, coupled with an interdisciplinary leadership team and governance structure, will produce highly productive conditions for novel research that will rapidly drive the field of radiobiology in particular forward. The innovative setting will enhance skills and knowledge development at all levels from student to expert developing a coherent multidisciplinary community that will include academics, clinicians and industry.

A flexible system for beam delivery lies at the heart of the institute. Innovative physics techniques are being developed to firstly build a research tool for in-vivo experiments using lasers to create the beams that are rapidly accelerated opening up new radiobiology research areas. These advances will pave the way for a radical redesign of therapy machines, for example removing the need for gantries, and the interdisciplinary activities of the institute will enable further development into a patient treatment machine.

**Research**

Research will initially be focused on two strands, the development and construction of the Laser-hybrid Accelerator for Radiobiological Applications (LhARA) and radiobiology research that will later use LhARA as its research base.

LhARA is an ion beam accelerator that can deliver a variety of ion species at ultra-high dose rate in different spatial-, temporal, and spectral fractions. It brings together components used in other physics research fields to create a compact system with numerous advantages to the benefit of the life science and medical fields;

* The laser system creates a large flux of protons or light ions that can be triggered in nano second pulses which allows accurate targeting of the beam that can be coupled to an interactive feedback system to reposition the beam
* The Gabor lens is a strong focusing plasma that can capture protons and ions at higher energies than conventional systems removing limitations on the instantaneous dose rate and at a fraction of the cost of conventional systems.
* The fixed field alternating (FFA) gradient accelerator provides an efficient system that maintains the structure of the beam. This advanced technique of capturing the beam would mark an engineering breakthrough making LhARA a unique research tool for physicists including medical physicists as well as adding value to a variety of physics disciplines.
* Ion-acoustic dose profile measurement will allow the real-time measurement of the dose and its distribution. This will be fully automated so that it can be tailored to meet individual needs and pulse to pulse adaptations as the beam is moved

Combining these elements creates a highly flexible tool with a stable and easily accessible beam that offers researchers a wealth of R&D opportunities in all the associated fields. Even at the early stages the development possibilities in instrumentation and computing techniques will be of benefit to medical physics field and the potential to be spun out into treatment planning.

Initial extensive use of computer simulation techniques is being used to optimise design and enhance prototyping of the components and systems. Construction will follow this phase bringing in state-of-the-art instrumentation prior to development of a therapy machine.

The current funding for the 2-year preliminary phase is enabling R&D and initial prototyping for the conceptual design report.

The radiobiology research will examine the relative biological effectiveness of different ions and effectiveness of beam delivery systems leading to an understanding of the interaction of different charged beams at high repetition rates on living cells and the biological mechanisms involved in breaking DNA strands. This insight will pave the way to improve clinical therapy and its delivery. Current research aims to provide the basis for comparison between conventional and novel beams developing the techniques that will maximise the scientific benefits of LhARA when access becomes available.

**Industry**

The institute environment embeds constructive interaction and collaboration benefitting different aspects of industrial partnership. This would range from research projects at PhD or shorter collaboration level, which would give sponsoring organisations insight into emerging technology and data as well as training, to more extensive, focused partnerships through to incubation spin-out companies. An example of this is the links made through a UKRI funded Future Leadership Fellow at LEO Cancer Care, a company that is developing upright radiation therapy solutions.

**Skills and training**

The institute will bring together currently fragmented research strands into a coherent and holistic view quickly creating synergies that are likely to produce a step change in capability. It will offer substantial research opportunities and under- and post-graduate level in research areas including those not currently accommodated.

**Structure**

At present the development of the research strategies is through institutional collaboration. A step change in focus will come through the creation and funding of the institute’s senior leadership team (CEO, director of physics, director of radiobiology), which will enhance the interdisciplinary aspects of skills and training and help drive forward engagement with potential industry and international partners.