PhD Position in Proton Beam Therapy

Modern cancer treatment is largely a combination of 3 techniques: surgery, chemotherapy and radiotherapy. Radiotherapy uses beams of X-rays to irradiate the tumour from many different directions. The effect is to kill the cancer by depositing as much radiation dose in the tumour as possible, whilst minimising the dose to the surrounding area to spare healthy tissue.

Proton therapy is a more precise form of radiotherapy that provides significant benefits over conventional X-ray radiotherapy. Protons lose energy - and therefore deposit their dose - in a much smaller region within the body, making the treatment much more precise: this leads to a more effective cancer treatment with a smaller chance of the cancer recurring. This is particularly important in the treatment of deep-lying tumours in the head, neck and central nervous system, particularly for children whose bodies are still developing and are particularly vulnerable to long-term radiation damage. The advantages of proton therapy, coupled to the reduced cost of the equipment, has led to a surge in interest in proton therapy treatment worldwide: in the UK, the NHS has funded 2 full-sized proton therapy centres - at University College Hospital in London and The Christie in Manchester - to operate alongside the eye treatment facility at the Clatterbridge Cancer Centre. These will provide treatment for a much wider range of cancers, allowing more patients to be treated closer to home.

Treating these cancers requires machinery that is significantly more complex than a conventional radiotherapy system. In order to ensure that treatment with such complex machinery is carried out safely, a range of quality assurance (QA) procedures are carried out each day before treatment starts. The majority of this time is spent verifying that the proton beam travels the correct depth and is carried out for several different energies: protons are counted at different depths in a plastic block that mimics human tissue. These QA measurements of the proton range take significant time to set up and adjust for different energies: the full procedure can take over an hour.

The focus of this project is to develop a detector that can make faster and more accurate measurements of the proton range than existing systems. The detector is built from layers of plastic scintillator that has the same density as water and resembles a sliced loaf of bread. Protons passing through this scintillator stack deposit energy in each layer which is converted into light: by recording the light from each layer, the amount of energy the protons deposit along their path can be measured. Such a system provides a direct measurement of the range of protons in tissue, since the absorption of the plastic is virtually identical to human tissue. As such, a measurement of the proton range for multiple energies would allow the complete morning energy QA procedure to be carried out in a few minutes, with an accuracy of less than a millimetre. At the two new NHS centres, this would translate into being able to treat an extra 12-18 patients every single day.

The PhD student will join the proton therapy group within High Energy Physics at UCL and contribute to the design, development and clinical implementation of the UCL proton range calorimeter. This will involve simulation work to optimise the geometry of the detector under development, the design of the front-end analogue electronics for scintillation light collection, FPGA programming to control the data acquisition and allow fast fitting of the resulting Bragg curves, development of the control GUI and beam tests at a number of clinical facilities around the world. All of this will be carried out as part of the existing proton therapy team. It is expected that the student will not only follow the High Energy Physics courses but also attend Medical Physics courses in order to learn the fundamentals of treatment with ionising radiation. It is also anticipated that time will be spent in both research and clinical environments to enable a proper understanding of the requirements of the system under development for regular clinical usage.