Imperial College London

CCAP

Novel techniques radiobiology and radiotherapy

Proton and light-ion beams have great potential in the treatment of cancer. To bring the benefits to a large fraction of the community requires the size of the facility, as well as its cost, to be reduced substantially and to do this requires novel accelerator systems. The accelerator research programme of Imperial's new 'Centre for the Clinical Application of Particles' (the CCAP[1]) is aimed at delivering a paradigm shift in the provision of hadron therapy.

The "relative biological effectiveness" (RBE) of proton/ion beams is defined with respect to the X-ray dose that must be delivered to achieve a particular biological effect. RBE is known to vary with beam energy, dose, dose-rate, tissue type, and ion species. Limitations in the present data and its interpretation have led to the use of a representative RBE value of 1.1 in treatment-planning systems. The CCAP has embarked on a programme of measurement and simulation to develop a detailed understanding of the proton-tissue and ion-tissue interaction.

To take its programme forward, the CCAP has established collaborations with CERN in Geneva and the GSI Helmholtzzentrum für Schwerionenforschung (GSI) in Darmstadt. A student entering the CCAP programme will have the opportunity of a long-term attachment at one of these laboratories. These opportunities are open to home, EU and overseas students.

Compact accelerator systems for radiobiology/radiotherapy in collaboration with CERN:

Our collaboration with CERN is focused on the development of compact linear or circular accelerators capable of delivering a variety of ion species. One of the most critical aspects of this facility is the low-energy portion that takes the ion beam from the source and accelerates it to $\sim 10\,\text{MeV}$.

The CCAP's concept for a Laser Accelerator for Radiobiological Applications, "LARA", exploits a laser-driven source to overcome the dose-rate limitations inherent in conventional sources. LARA requires the laser-generated ion beam be captured using novel strong focusing "plasma" lenses at an energy of $\sim 10\,\text{MeV}$.

A student joining this programme will contribute to the development of a novel concept for the ion-source/capture section and the first acceleration stage that takes the ion-energy to 10 MeV. While at CERN the student will have the opportunity to contribute to the ion-source characterisation programme and to the development of a detailed design for, and simulation of, the low-energy section of the multi-ion facility. The student will also contribute to the development of LARA and will be involved in the proof-of-principle experiments which we plan to execute on the Plasma Group's new laser facility.

Biophysics at GSI:

The CCAP has developed novel real-time dose-measurement concepts. A student joining this programme will continue the development of novel scintillating-fibre and/or silicon sensors and their exploitation in the radiobiology programme at GSI. The development of a detailed simulation of the beam-delivery system, the sensors themselves, and the beam's interaction with biological systems will also be part of the project.

[1] https://www.imperial.ac.uk/clinical-application-of-particles/

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Doctoral Programmes at CERN and GSI:

The CERN Doctoral Programme (`http://careers.cern/students`) provides a bursary for up to three years while the student is resident at CERN. Applications are accepted in two batches, with deadlines in the spring and autumn. We have identified co-supervisors at CERN and will support you in the preparation of a successful application for a position in the CERN Doctoral Student programme.

Student placements at GSI may be obtained by applying for Associate Scientist status. The Associate Scientist position provides a bursary and, depending on the requirements of the programme, may be extended for up to three years. We have agreed to collaborate with GSI and will support you in the preparation of a successful application for an Associate Scientist position at GSI.

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