**To:** N. Jennings (Vice Provost, Research and Enterprise) October 14, 2018
**From:** K. Long (Director, Centre for the Clinical Application of Particles)

# Centre for the Clinical Application of Partices; activity report October 2018

Over the reporting period (June 2018 to October 2018) the CCAP has held the first of its series of research seminars[1] and its second plenary meeting[2]. The Centre's web page on the College server has been established[3] and is being used to publicise news and events and, via a wiki[4], the web page is used as a tool to share information on the development of Centre's activities, in particular its research programme.

Three proposals have been submitted over the reporting period. Two (an application for an Imperial Research Fellowship led from Imperial Physics and an application for an STFC CASE award led jointly from Imperial Physics, the Charing Cross Hospital and Maxeler Technologies) are being evaluated. The third, a successful application to the STFC Impact Accelerator Account (IAA) raised £52.1k for the development of a scintillating-fibre based real-time dose-measurement of laser-driven ion beams.

The Centre is actively discussing the development of collaborative programmes in: the impact of electron (micro-) beams at high dose rate and high energy (Charing Cross Hospital, Department of Physics, Institute of Cancer Research); the development of a novel, real-time diagnostic and imaging systems (Charing Cross Hospital, Department of Physics); and the development of novel systems for radiobiology (Department of Physics and Institute of Cancer Research). A summary of two activities key to the development of the Centre's research portfolio follows.

## 1 Design of a novel Laser-driven Accelerator for Radiobiological Applications (LARA)

A strategic, long-term, priority for the CCAP is the implementation of a dedicated radiobiology facility at which the micro-biophysical processes that determine the efficacy of charged-particle beams (electrons, protons and ions from helium to carbon) can be studied precisely. Advances in accelerator technology, some of which have been spearheaded by Imperial personnel, make it possible to conceive of a laser-driven source coupled to a novel strong-focusing particle-collection system by which the dose-rate limitations of conventional source/accelerator technologies can be overcome. The technologies the Centre proposes to develop have the potential to be scaled up to serve the radiotherapy facilities of tomorrow.

Over the reporting period a first concept of an in-vitro facility was developed. Personnel from the Laser/Plasma and High Energy Physics Groups collaborated to produce the laser-driven accelerator concept. Personnel from the ICR advised on the specification of beam properties. The critical parameters of the biological end-station were specified by a radiobiologist from the Medical University of Vienna. To minimise the material in the path of the beam it was proposed that cells be grown on a membrane; the feasibility of this approach was proved at MedAustron.

Work now proceeds to develop a full conceptual design report for the 'Laser-driven Accelerator for Radiobiological Applications' (LARA). Initial simulations of the design will be presented at the end of October at 'The Third Geant4 International User Conference at the Physics-Medicine-Biology frontier' which will take place at the end of October 2018 in Bordeaux[5]. The conceptual design report will then be prepared for publication, if possible, by the end of 2018.

[1] S. Gruber (Medical University of Vienna), "*Radiobiology Research at MedAustron*", http://www3.imperial.ac.uk/newsandeventspggrp/imperialcollege/naturalsciences/physics/clinicalapplicationofparticles/eventssummary/event_16-7-2018-12-0-57.

[2] https://www.imperial.ac.uk/news/187188/2nd-plenary-meeting-centre-clinical-application/

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

[4] https://ccap.hep.ph.ic.ac.uk/trac

[5] http://geant4.in2p3.fr/2018/

## 2 Collaboration with MedAustron and the Medical University of Vienna

MedAustron is the Austrian centre for proton and carbon-ion radiotherapy and research. The MedAustron facility includes three patient-treatment rooms and a fourth end-station dedicated to research. MedAustron acts as a hub for Austrian university groups, such as the Medical University of Vienna (MUW) , to pursue research in various fields including radiobiology. By establishing a collaboration with MedAustron and the MUW we seek to bring radiobiological expertise into the CCAP and to become a contributor to cutting edge experimental proton and carbon-ion radiobiology.

A PhD student recruited into the CCAP programme has been resident at MedAustron since May 2018. He has contributed to the commissioning of the carbon-ion beam through simulation and the optimisation of magnet settings in the extracted beam lines. He has taken an active part in the data-taking programme. Having climbed the learning curve he is now providing valuable feedback to the commissioning team. For example, he introduced Geant-based tracking codes to the simulation of the MedAustron accelerator facility and, using the tools he introduced, contributed to the re-evaluation of the beam-properties in the synchrotron. He will now contribute to the optimisation of the transfer line through which particles are brought into the treatment rooms.

Building on our successful collaboration with MedAustron, we are working to establish a collaboration with the Medical University of Vienna to develop a 'SmartPhantom'. At present, the energy deposited in the cell cultures exposed to the beam in the non-clinical research room is inferred from simulations of the beam properties. These simulations are carried out using standard treatment-planning software. Using the scintillating-fibre real-time dose-measurement system being developed using the STFC IAA grant as a basis, we are working with the MUW to develop a design for a SmartPhantom in which the dose to the biological sample is measured in real time, shot-by-shot. Our intention is to bring forward a proposal for the resources to deliver the instrumentation for the SmartPhantom by the end of December 2018 so that the system can be in place when the carbon-ion beam becomes available in October 2019.