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**Industrial CASE and CASE Plus Studentship Competition 2018**

**Case for Support Form**

**Please ensure that you have read the Guidance for Applicants before completing the**

**form.**

**ACADEMIC RESEARCH ORGANISATION DETAILS**

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| Professor Kenneth Long  Imperial College London  Department of Physics |

**NON-ACADEMIC PARTNER/COMPANY NAME**

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| Maxeler |

1. **THE PROJECT**
   1. **Project Title**

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| Automating on-treatment image verification of cone beam CT for adaptive radiotherapy |

**1.2 Proposed Project Details** (Up to 3000 characters including spaces)

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| The aim of this PhD project is to demonstrate the capability of a high-bandwidth, high-performance FPGA-based processor to automate on-treatment verification of cone beam CT scans to facilitate fast and accurate adaptive radiotherapy. This demonstration will motivate the integration of image processing into the feedback-and-control systems of the next generation of clinical radiotherapy machines.  The 3.5-year PhD programme will be carried out within the Centre for the Clinical Application of Particles that has been established at Imperial as an interdisciplinary collaboration of particle, laser/plasma and medical physicists, clinical oncologists, and cancer researchers. Through the Centre, the student will have access to and be supported by world-leading experts in each discipline that underpins the execution of the project. After 6-months of general academic training at Imperial the project will be executed in three sections:  1. *Development of the CT-image-acquisition system, specification of feature-recognition and tissue-classification requirements, and development/benchmarking of image-processing algorithms* will take place at the Charing Cross Hospital. Supervision at the Hospital will be provided by Dr. D Gujral (Consultant Clinical Oncologist and Honorary Senior Clinical Lecturer) and Dr. C. Hardiman (Consultant Clinical Scientist and Head of Medical Physics). The development and benchmarking of image-processing and feature-recognition codes will be supported by Dr. S. Cooper (Lecturer in the Dyson School of Computing). It is anticipated that between 9 and 12 months will be required to deliver this section of the project. During this time, the student will be based at the Charing Cross Hospital, travelling to Imperial College and Maxeler as required to consult on the development of algorithms and their implementation;  2. *Implementation of image-processing algorithms on high-performance, FPGA-based processor exploiting Maxeler compiler and compute cluster* will take place at Maxeler. It is anticipated that code-development, the demonstration that the feature-recognition specifications have been met, and the benchmarking of the codes will take approximately 12 months. During this period the student will be based at Maxeler, travelling as necessary to Charing Cross Hospital and Imperial College London; and  3. *Integration of image-acquisition and image-processing systems, evaluation of performance and optimisation of algorithms and their implementation* will take place at the Charing Cross Hospital. It is expected that the integration, initial validation and subsequent performance evaluation will take between 6 and 9 months, leaving a three-month writing-up period. During this final portion of the PhD programme the student will once again be based at Charing Cross Hospital.  Risks to the completion of the project have been mitigated by breaking the project down into three quasi-self-contained sections. Should there prove to be insufficient time to complete section 3, a comprehensive thesis that contains original contributions to knowledge and technique can be written on sections 1 and 2.  ***3150 of 3000 characters.*** |

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**1.3 Impact Summary** (Up to 1500 characters including spaces)

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| Variation of the tumour position (due to breathing, changes of the filling of hollow organs, peristalsis, etc.) is a major challenge in RT. Image-guided radiotherapy (IGRT) detects the tumour position immediately prior to treatment and allows adaptation of RT if the target position differs from that assumed in planning. Present day systems are manually operated, slow and have limited precision. The demonstration of automatic on-treatment verification of cone beam CT scans using a high-bandwidth, high-performance FPGA-based processor will facilitate fast and accurate adaptive RT. The demonstration, combined with the existence-proof of an integrated image acquisition/processing system will have a profound impact on the development of future RT facilities. The CCAP will seek to take the programme initiated here forward through the collaborative development of automated RT facilities.  **<Impact from Maxeler perspective … 1500 – 898 characters.>** |

**2. ACADEMIC RESEARCH ENVIRONMENT, TRAINING AND SUPPORT** (Up to 1500 characters including spaces)

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| The student will be enrolled in the PhD programme in the Department of Physics at Imperial College London and will become a member of the CCAP. The PhD training programme run by the CCAP is based around the successful model established in the Physics Department. In the first six months the student will attend a comprehensive training programme delivered by the CCAP member institutes. The training programme will include academic courses on the medical, accelerator and detector physics relevant to the students programme. The student will also attend machine-learning and image-processing courses offered by the Department of Computing and the Dyson School. These courses will be supplemented by the transferrable-skills courses offered centrally by Imperial College.  Academic supervision will be provided jointly by Prof K. Long and Dr. D. Gujral, both of whom have successfully supervised numerous graduate students. In each section of the project, the student will work with an internationally-recognised expert in the field:   * **<List by project section, to be discussed.>** |

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**3. NON-ACADEMIC RESEARCH ENVIRONMENT, TRAINING AND SUPPORT** (Up to 1500 characters including spaces)

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| **<Support and training from Maxeler perspective … 1500 characters.>** |

1. **MANAGEMENT & MONITORING**

**4.1 Academic Supervisors**

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| Research Organisation | Supervisor | Main Supervisor? |
| Imperial College London | Prof Kenneth Long | YES |

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| Research Organisation | Supervisor | Main Supervisor? |
| Imperial College Healthcare NHS Trust | Dr Dorothy Gujral | YES |

**<Additional boxes by section; to be agreed.>**

**4.2 Non-Academic Partner Supervisors**

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| Partner Organisation | Supervisor | Main Supervisor |
|  |  | Please Select |

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| Partner Organisation | Supervisor | Main Supervisor |
| Maxeler | Title Name Surname | Please select |

**4.3 Management and monitoring** (Up to 2000 characters including spaces)

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| The academic co-supervisors D. Gujral and K. Long will be responsible for all aspects of the student’s academic training and for the successful execution of the project. D. Gujral **<… Dorothy, please provide some purple prose …>**. K. Long has extensive project-management experience that encompasses the development of equipment, software, data-processing, and data analysis. In line with the successful mentoring and pastoral-support structure in place in the Department of Physics an Academic Mentor will be appointed. In addition, the Department of Physics provides additional support where needed for PG students.  A project-management structure appropriate to the nature and scale of the project will be adopted. A monthly meeting will be convened of the Academic Supervisors and the three ‘lead-experts’ with whom the student will work in each section of the project. This regular meeting will address issues that arise in the execution of the project and identify and address interface issues to ensure the project proceeds smoothly from one section to the next.  The student would be subject to the same formal monitoring requirements as other STFC students. Progress will be assessed throughout the studentship: after nine months, the students produce a written report covering their progress and plans, followed by a viva examination by two members of staff, not associated with the project. This is the threshold to be fully registered for a PhD. Subsequently, there will be assessments to monitor progress towards thesis completion at approximately yearly intervals. These assessments will be based on an oral or written-report/viva format carried out by independent assessors. The student will also be strongly encouraged to present his/her work at CCAP plenary meetings and at national and international conferences. |

1. **THE COLLABORATION** (Up to 4000 characters including spaces)

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| A strong and mutually beneficial relationship has been established between Imperial College and Maxeler. Imperial HEP Group personnel have partnered with Maxeler to deliver a number of successful CASE PhD programmes. Maxeler also works closely with Imperial’s Department of Computing, the Quantum Optics Group and the Theoretical Chemistry Group. Maxeler has an established capability in image processing and is actively collaborating with the Department of Computing in the development of the necessary techniques.  To deliver the proof-of-principle of the automated on-treatement verification system successfully requires that an interdisciplinary approach is taken from the outset. The ‘Centre for the Clinical Application of Particles’ (the CCAP) is an interdisciplinary collaboration of personnel from the Imperial Department of Physics, the Imperial Faculty of Medicine, the Imperial Academic Health Science Centre, the Imperial CRUK Cancer Centre, the Institute of Cancer Research, the John Adams Institute and the Oxford Institute for Radiation Oncology with the mission to ‘Develop the technologies, systems, techniques and capabilities necessary to deliver a paradigm shift in the clinical exploitation of particles’. The academic co-supervisors Gujral and Long each hold senior positions in the management of the Centre and are therefore ideally placed to bring the diverse expertise of the Centre’s personnel to bear on the delivery of the research programme defined in this proposal.  Imperial College London, the Charing Cross Hospital and Maxeler’s UK office are located within 2.5 miles of each other. Excellent public transport links the three sites and, in addition, Imperial runs a shuttle-bus service between its South Kensington and Hammersmith sites. This makes it straightforward for a strong working relationship to be built up across the three sites. The ICR has offices in the Old Brompton Road (SW7), which is a short walk from Imperial, and at its Sutton campus, which is easy to reach by public transport. Since the OIRO and the JAI in Oxford are easily reached by public transport it will be straightforward to access the expertise that resides within the CCAP personnel.  The academic excellence of the principal partners in the project (the Physics Department at Imperial College London, the Charing Cross Hospital, and Maxeler technologies) combined with the wealth of expertise that resides with the CCAP and the Imperial Department of Computing will make provide an outstandingly dynamic, diverse interdisciplinary environment for the student. The CCAP has forged, or is building, collaborations with MedAustron, the Medical University of Vienna, CNAO and CERN, adding to the depth of expertise which can be brought to bear on the development of the project.  **<Maxeler paragraph>**  This project could not be completed successfully by either partner alone since it requires the application of clinical expertise, the application of techniques developed for the handling of data in particle physics, the application and development of image-processing and machine learning techniques, integrated through the high-performance computing hardware, compilers and software developed by Maxeler. |

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