## Science and Technology Facilities Council
## Statement of Interest/Outline Proposal

Before filling in this pro forma or writing your Scientific Justification, please ensure that you have fully read the SOI guidance.

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| **Project Title** | Laser-hybrid Accelerator for Radiobiological Application (LhARA) CDR |
| **Contact Person** | K. Long |
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| **Proposers** | **Institute** |
|---|---|
| 1. Zulfikar Najmudin | Imperial College London/JAI |
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| 3. Juergen Pozimski | Imperial College London/STFC |

(additional names may be included on separate sheet if necessary)

**Brief Project Outline**

We propose to develop the conceptual design report (CDR) for the 'Laser-hybrid Accelerator for Radiobiology' (LhARA). LhARA exploits laser interactions to create a large flux of protons or light ions which are captured and formed into a beam by novel, strong-focusing plasma (Gabor) lenses. The ions are captured at high energy (~15 MeV), thereby avoiding the space-charge flux-limit of present-day ion sources. Post acceleration is provided by a Fixed Field Accelerator (FFA) with large dynamic aperture. The hybrid approach proposed here will create a uniquely flexible facility for radiobiology in which ion species from proton to carbon are delivered in ultra-short pulses over the range of energies and instantaneous dose-rates required to support a systematic study of hadron-beam radiobiology that includes the ultra-high dose rates required in FLASH radiotherapy. The technologies developed for, and demonstrated in, LhARA have the potential to be used in a new generation of similarly flexible hadron-beam therapy facilities.

With this Statement of Interest we seek the resources to recruit a post-doctoral researcher for two years and a post-graduate student. Together, the two early-career researchers will leverage the effort of experienced personnel from the participating institutes (proto-coalition, see below) to deliver the CDR. During the preparation of the CDR we shall engage with stakeholders from the clinical, radiobiological, academic, and industrial communities to build the coalition of clinicians, researchers, facility-providers and industrialists necessary to propose and execute the staged development of LhARA.

The programme initiated by the investment proposed here has the potential to prove the principle of the laser-hybrid technique, deliver a uniquely flexible facility for the systematic study of radiobiology, and place the UK at the forefront of the development of the next generation of accelerators for scientific and clinical application.

**Fit to STFC Strategic Priorities**

Our vision is that the modest resources requested here will initiate a national/international programme that has the potential to prove the laser-hybrid technique in a 'production-ready' facility. The techniques developed will have general applicability in facilities that require:

- Proton or light-ion fluxes that exceed those that can be produced by present-day ion sources; and/or
- Rapid acceleration of proton or ion beams with intensities large enough to require accelerators with large dynamic aperture, such as the FFA, to manage space-charge forces.

We therefore believe that the proposed seminal investment in two early-career researchers to deliver the LhARA CDR is an excellent fit to the STFC Strategic Priorities laid out in the '*2017 Accelerator Strategic Review Report*', and in particular to the report's recommendations:

1. "*Expeditious investment in novel acceleration over a 5—10 year timescale is recommended to support accelerator applications development in collaboration with industry*":
   As outlined above and in the Scientific Justification, during the preparation of the CDR we shall engage with stakeholders, including those from the industrial community, to build on the 'proto-coalition' defined below and to establish the robust, multi-disciplinary coalition required to propose and execute the staged development of the facility.
7. "*The UK national laboratories should be charged with the co-ordination of research and development activities across stakeholders in development of future neutron and x-ray sources.*"; and
8. "*Enable implementation of a range of ISIS II upgrade options. …*":
   Aspects of the programme outlined above and described in the accompanying Scientific Justification have been developed in close collaboration with ISIS Department.

The work proposed here will contribute to the development of the pool of experienced scientific and technical talent required to exploit the paradigm-shifting resource that laser-accelerator technology is likely to provide.

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Our vision is also well aligned with the mission of 'UK Research and Innovation' (UKRI) that includes the strategic development of research programmes that require the exploitation of cross-cutting, multi-disciplinary approaches. Through the CCAP at Imperial and the 'proto-coalition' supporting this proposal we have established the multi-disciplinary team required to support the two early career researchers requested here in the specification and delivery of the LhARA CDR. We propose to continue to forge links across academic disciplines and technical specialities through the development of the robust coalition required to deliver a paradigm shift in the delivery of proton and light-ion beams for science and innovation.

**Timing** (e.g. expected project start date, duration, longer-term commitment implications/future decision points)

We propose that the two-year programme to deliver the LhARA CDR start in October 2019. This early start is designed to leverage the enthusiasm generated through the establishment of the multi-disciplinary collaboration that is the CCAP and the capability contained within the proto-coalition of institutes that support the present proposal.

**Estimate of cost to STFC (including manpower).** Please give details in Scientific Justification

| *Year 1 £k* | *Year 2 £k* | *Year 3 £k* | *Year 4 £k* | *Total £k* |
|---|---|---|---|---|
| ***134.17*** | ***136.17*** | ***21.34*** | ***10.67*** | ***302.35*** |

**Related projects (and previous investment)**

This project has common themes with numerous national and international programmes. On a national scale, the availability of radiation sources for advanced radiotherapy studies ties in well with the thrust in hadron therapy in the UK with the facilities at Christies (Manchester) and UCH (London) about to come into operation. The use of laser-plasma accelerators as a source of radiation relates well to the initiative made by the EPSRC-funded ASAIL consortium (QUB, Strath, ICL, RAL) that seeks to use all-optical techniques to deliver beams of 200 MeV/u. The increasing use of accelerators for medical applications is an active area of study within the Accelerator Institutes (Cockcroft and John Adams) and is a major component of their on-going Institute grants. Finally, the medical use of accelerators has also been outlined in the justification of numerous novel accelerator facilities, many based on state-of-the-art laser technology, such as the ELI facilities under development through the auspices of the EU. An international consortium, ELIMED, has been established to forward the use of laser driven sources for medical applications.

**Main funding sources (and any financial liabilities)**

The development of an initial concept for LhARA is being carried out using resources presently available to CCAP at Imperial and the collaborating institutes. Presently there are no financial liabilities.

**Principal partners/collaborators (and level of commitment)**

The two early career researchers that will be recruited through the present proposal will join the CCAP LhARA design team to leverage the work of the experienced researchers at Imperial and within the CCAP. Personnel from the 'proto-coalition' support the work proposed here. The early career researchers will be able to call on advice from personnel within the institutes that form the proto-coalition.


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**Estimates of key risks associated with the project**

The principal risk will be incurred through delay to the seminal investment proposed here. It is that the enthusiastic, multi-disciplinary collaboration that is the CCAP will not be able to leverage the expertise of the members of the proto-consortium to deliver the conceptual design for LhARA. The lack of investment will result in a reduced probability that the UK can take a position of international leadership in the development of novel beams for radiobiological applications.

Conversely, the investment proposed here will mitigate this risk by creating the conceptual design for LhARA and the robust, multi-disciplinary coalition necessary to propose and execute its staged implementation. The investment proposed here therefore has the potential to establish the UK as a key player in the field and allow members of the UK community to forge partnerships with collaborators in Europe, Asia and The Americas.

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