

# Update on the LhARA initiative

- **Strong support from STFC Council**
  - Added to that from STFC Executive, Science, and Tech. + Accel. Adv. Boards
- **Moving now to prepare proposal to:**
  - Infrastructure Advisory Board of UKRI
  - **Deadline: 17:00, Tuesday 15Jun21**
  - **Writing team:**
    - Massimo Noro, Jim Clarke, Hywel Owen, Charlotte Jamieson, Ken Long, Ailidh Woodcock, Rosanna Greenop

## Preliminary details and descriptions

<b>Name of project (and acronym or short name if relevant)</b>	Ion Therapy Research Facility (ITRF)
<b>Type of infrastructure project</b>	Establishment of new capability
<b>Submitting Council(s)/UKRI team(s)</b>	<input type="checkbox"/> AHRC <input type="checkbox"/> BBSRC <input type="checkbox"/> EPSRC <input type="checkbox"/> ESRC <input type="checkbox"/> Innovate UK <input type="checkbox"/> MRC <input type="checkbox"/> NERC <input type="checkbox"/> Research England <input checked="" type="checkbox"/> STFC <input type="checkbox"/> E-infrastructure Team <input type="checkbox"/> Large multidisciplinary facilities (STFC managed)
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<b>UKRI Contact(s) - Email address(es)</b>	Jim Clarke ( <a href="mailto:jim.clarke@stfc.ac.uk">jim.clarke@stfc.ac.uk</a> )
<b>Phone number(s)</b>	
<b>One-line description of the preliminary activity for use in summary tables to IAC, ExCo etc.</b> [22 words]	The ITRF will allow the biological impact of proton and ion beams to be elucidated using technologies that will transform clinical practice.
<b>Long description of the preliminary activity</b> [800 words, please continue to the next box when full - for IAC]	<p><b>Objectives:</b></p> <p>The Ion Therapy Research Facility will deliver the world-leading, multidisciplinary programme necessary to:</p> <ul style="list-style-type: none"> <li>Deliver the measurements required to elucidate the biological and biochemical mechanisms that underpin the clinical efficacy of proton- and ion-beam therapy.</li> <li>Demonstrate the disruptive accelerator, diagnostic, imaging, and computing technologies required to radically transform clinical practice in proton- and ion- (particle-) beam therapy (PBT) by creating a compact, fully automated, highly flexible system; and</li> <li>Create the capability to deliver proton- and ion-beam therapy in completely new regimens by combining a variety of ion species, from proton to neon, exploiting ultra-high dose rates and novel spectral-, spatial- and temporal-fractionation schemes.</li> </ul> <p>The novel beams that will be available at the ITRF promise a window on fundamentally new biological mechanisms of radiation cell-kill and immune response.</p> <p>The ITRF will place the UK at the forefront of the science and technology of particle therapy internationally, establish UK industry as a key player in the delivery of novel clinical equipment, and enable significantly enhanced access to state-of-the-art PBT across the UK. The ITRF will enhance the UK as the destination of choice for cutting-edge research.</p> <p><b>Transformative, multidisciplinary approach:</b></p> <p>Laser-driven proton and ion sources are disruptive and have the potential to transform the delivery of PBT by providing more flexible, compact and cost-effective, high energy particle sources. The international, multidisciplinary Laser-hybrid Accelerator for Radiobiological Applications (LhARA) collaboration has developed the concept for a facility that meets the objectives set for the ITRF using laser-hybrid system, in which novel strong-focusing electron-plasma (Gabor) lenses capture and focus the large flux of protons or ions created when a short pulse, high-power laser strikes a target, thereby delivering a wide variety of ion species in almost arbitrary time, spatial, and spectral structures.</p> <p>To realise the full potential of the ITRF requires that a multidisciplinary approach is taken from the outset. Therefore, by engaging with the LhARA collaboration of clinical oncologists, medical, particle, plasma, laser, ultrasound, and optical physicists, accelerator, computer, and instrumentation scientists, radiobiologists, industrialists, and patient representatives we have created the multidisciplinary team required successfully to deliver the ITRF.</p>

[344 words]

## The Preliminary Activity (PA):

We will develop the detailed specification and design of the ITRF, evaluate its cost, and elaborate the first phase of the ITRF research programme. The principal deliverable will be a full Conceptual Design Report (CDR). The PA will be executed in three work streams:

### 1. Detailed specification and staging plan

Led from the MRC Oxford Institute of Radiation Oncology (OIRO) and Liverpool University's Institute of Systems, Molecular and Integrative Biology, the biological-research capabilities of existing and planned proton- and ion-beam facilities will be reviewed and the biomedical research strategy for the ITRF will be developed. Detailed specifications of beam and end-station parameters will be derived along with a staging plan for the timely provision of *in-vitro* (Stage 1) and small-animal *in-vivo* (Stage 2) capabilities. Consideration will also be given to a Stage 3 programme of clinical trials to be initiated when the Stage 2 programme becomes established.

### 2. Conceptual Design Report, technology choice, technical-risk management

A conceptual design study will be carried out to produce a full project plan together with evaluations of operational arrangements, the national/international user community, and a detailed scientific, technological, economic, and societal impact assessment.

The expertise required to deliver the CDR resides within the LhARA collaboration. For example: the laser-driven source design will be led by Belfast, CLF, Imperial, and Strathclyde; the novel accelerator developments will be led by the Cockcroft and John Adams Institutes and ASTeC; the novel dosimetry, instrumentation, and diagnostic developments will be led by the National Physical Laboratory, the Institute for Cancer Research, Birmingham, Imperial, Liverpool, Manchester, PPD, UCL; and systems engineering/integration will be led from the national laboratories.

Effective tensioning of the benefits and costs of parameter trade-offs, technology choices, and implementation strategies will be carried out through 6-monthly reviews. Technology choices will be supported by appropriate prototype and test programmes that build on the technical-risk-management activities presently underway within the LhARA collaboration.

### 3. Impact co-creation

The implementation plan will be developed to maximise the impact of the programme in the following areas:

**Clinical:** Exploitation of *in vitro* and *in vivo* biological measurements to enhance the accuracy of treatment planning software. Exploitation of techniques developed for use experimental end-stations to enhance automated on-the-couch patient- and dose-imaging, and patient-positioning systems.

**Industrial:** Prototypes of the novel accelerator, imaging, and automated systems will be developed and produced in partnership with industrial members of the collaboration so positioning UK industry to take a leading role in the implementation phase.

**Scientific:** Impact will be generated in the fields of laser-driven acceleration, imaging, instrumentation, diagnostic-technology, and software-system development. Biological impact will be delivered throughout the ITRF programme. Key technologies developed and proved in operation can be spun-out to benefit accelerator-based science and innovation.

[451 words]

[Total: 797 words]

Circulated to ITRF Advisory Board & LhARA SG

# Imperial College London

Department of Physics  
Faculty of Medicine

**ICR** The Institute of Cancer Research

**UKRI** Medical Research Council  
Oxford Institute for Radiation Oncology

**UNIVERSITY OF OXFORD**

**JAI**  
John Adams Institute for Accelerator Science

**CCAP**  
Centre for the Clinical Application of Particles

**Imperial College Academic Health Science Centre**

**CANCER RESEARCH UK**

**IMPERIAL CENTRE**

**NHS**  
**Imperial College Healthcare**  
NHS Trust

**MANCHESTER**  
1824

The University of Manchester



**UNIVERSITY OF BIRMINGHAM**



**QUEEN'S UNIVERSITY BELFAST**



**UNIVERSITY OF LIVERPOOL**



DEPARTMENT OF PHYSICS

**UCL**  
MEDICAL PHYSICS & BIOMEDICAL ENGINEERING

**Lancaster University**

**ROYAL HOLLOWAY UNIVERSITY OF LONDON**



**NHS**  
**University Hospitals Birmingham**  
NHS Foundation Trust

**NHS**  
**The Clatterbridge Cancer Centre**  
NHS Foundation Trust

**institut Curie**

**UKRI** Science and Technology Facilities Council

**INFN**  
CATANIA

**ASTeC**  
**Particle Physics Department**  
**ISIS Neutron and Muon Source**



**Swansea University**  
Prifysgol Abertawe

**UNIVERSITY OF BIRMINGHAM**

**POSITRON IMAGING CENTRE**

**Corerain**  
鯤云科技

**The Rosalind Franklin Institute**

**NPL**  
National Physical Laboratory

**The Cockcroft Institute**  
of Accelerator Science and Technology

**UNIVERSITY OF BIRMINGHAM**

**CYCLOTRON FACILITY**

**LEO**  
Cancer Care

**MAXELLER**  
Technologies  
Maximum Performance Computing

**LhARA**  
Laser-hybrid Accelerator for Radiobiological Applications

# Goals for summer 2021

- **LhARA design revision paper:**
  - Significant progress reviewed today should be published
    - Preparation to start next month
- **White paper:**

P.Price, A.Giacca, J.Parsons, S.Green et al.

  - Review of biological understanding & LhARA's unique role
    - Specification document (PP) circulating; preparation to start soon
- **Proposal for 2—year programme**

[coincident with preliminary phase programme]

  - **Work packages:**
    1. Laser-driven proton and ion source
    2. Proton and ion capture
    3. Real-time dose-deposition imaging
    4. Novel, automated end-station development
    5. Facility design and integration
  - **Possible routes to submission:**
    - As a single, large, proposal
    - Coordinated submission of several self-contained proposals
    - As basis of Sol to (e.g.) STFC Science Board



# Initial discussion at LhARA half day, 10Jun21:

## LhARA half day meeting 10<sup>th</sup> June 2021; 09:30 -- 12:30 (13:30) BST

Presentations at the LhARA half day meeting will review the status of the LhARA initiative and identify the key development goals that will be taken forward of the summer. Talks in the half day will be organised in 7 "sessions".

Zoom link: <https://cern.zoom.us/j/61287769114?pwd=UkQ1b2N5S1hJcGZXM2xwZk0xUWJJEQT09>

1. 09:30--10:00: Introduction: aims and objectives: Conveners: K. Long, J. Parsons
  - Introduction (10+5): K. Long
  - Biology of ionising radiation; USPs for LhARA (10+5): J. Parsons
2. 10:00--10:50 Proton and ion source: Conveners: E. Boella, K. Long
  - Status of simulation of laser-target interaction (15+5): HT Lau
  - Progress towards 3D simulations of laser-target interactions (15+5): E. Boella
  - Towards the specification of a primary beam spectrometry experiment (7+3): K. Long

*Break to 11:15*

3. 11:15--12:00 Proton and ion capture: Conveners: C. Baker, C. Whyte
  - Understanding of first Gabor lens prototype (15+5): TS Dascalu
  - Development of electron plasma experimental programme at Swansea (15+5): C. Baker
  - The path to a second Gabor lens prototype (10+5): T.S. Dascalu
4. 12:00--12:20 Ion-acoustic imaging: Conveners: B. Cox
  - Ion-acoustic imaging; principle, status and plans (15+5): J. McGarrigle
5. 12:20--13:00 Vertical beam line for biological research on the Birmingham cyclotron: Conveners: J. Parsons, T. Price
  - Introduction and context (10+5): J. Parsons
  - Ideas for a vertical beam line for biological research on the Birmingham Cyclotron (20+5): T. Price
6. 13:00--13:30 Facility design and integration: J. Pasternak, W. Shields
  - Injection into FFA (10+5): W. Shields
  - FFA design update (10+5): J. Pasternak
7. 13:30 Close