

Update on Education & Training and Public Engagement at JAI

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Imperial College
London



ROYAL
HOLLOWAY
UNIVERSITY
OF LONDON



UNIVERSITY OF
OXFORD

Introduction

- The JAI programme is organised around three pillars:
 - Research & development for advanced and novel accelerator technology.
 - **Training** of next generation of accelerator scientists in accelerator techniques.
 - Advanced accelerator applications in science & society, impact and **public engagement / outreach.**

EDUCATION AND TRAINING

Guiding Strategy

- Training in accelerator science & technology is **one of the pillars** of JAI mission and recognised by JAI Advisory Board to be **world-leading**.
- Objective is to **develop skills** of next generation accelerator scientists.
- JAI has provided **graduate & undergraduate training** in accelerator science & technology since first course delivered in 2005 (**for more than 20 academic years**).
- Students participate in **comprehensive core formal training** through **academic courses & projects** and 3 years of cutting-edge **research** at state-of-the-art facilities (national & international).
- Many JAI academic staff invited to give courses & lectures at **international accelerator schools**.

JAI Graduates & Careers

- JAI training is **well aligned with STFC strategic aims** to address national demand for **scientifically-skilled workforce** to sustain UK's world-leading position in research & technology and JAI's unique aspect of **academic training** for PhD students as addressed in ***2017 STFC Accelerator Strategy Review & 2019 Accelerator Programme Evaluation***.
- **PhD graduates total more than 120**; all obtained **fruitful employment**; about **20% female**.
 - Alumni consistently pursue **careers in science & technology**
 - Destinations include **research positions** in universities, ASTeC, BNL, CERN, CI, DESY, LBNL, LLNL, NPL, RAL, SLAC, PSI etc.
 - Some reached **full academic positions**; about **15% work in industry**.

Graduate Accelerator Physics Course

Term I October-December 2024

Lectures (24)

Types of Accelerators*

Applications of Accelerators*

Live Connection – LHC Control Centre*

Transverse Optics (2)

Longitudinal Dynamics

Momentum Effects

Lattice Design

Hamiltonian Dynamics (2)

Beams & Imperfections

Basic Plasma Physics Concepts for Plasma Accelerators

Plasma-based Electron Acceleration

Plasma-based Ion Acceleration

RF Cavities (4)

Beam Diagnostics & Instrumentation

Synchrotron Radiation

Wigglers & Undulators

Radiation Damping & Excitation (2)

Parameters for *HALHF* Student Project

Exercise Classes (6)

Introduction to Accelerators*

Transverse Dynamics

Longitudinal Dynamics

RF Cavities

Hamiltonian Dynamics

Synchrotron Radiation

** Combined Particle Physics &
Accelerator Physics cohort*

*Course carried out in hybrid format
(in person & Zoom)*

***NEW: Visit to ISIS Neutron & Muon Source
(Rutherford Appleton Laboratory)***

Graduate Accelerator Physics Course

Term II January-March 2025

Lectures (22)

Magnet Design (2)

Non-linear Dynamics (2)

Beam-beam Effects

Space Charge Tune Shift

Injection, Beam Transport and Extraction

Linear Colliders (4)

Instabilities (2)

Beamlines for Fixed-target Experiments

Cyclotrons for Various Applications

Particle Sources

Free Electron Lasers

Vacuum and Surface Science

Accelerator Science & Particle Therapy

Introduction to Radiobiology & its Applications to Accelerator Science

Particle Accelerator Sustainability*

Commercialisation of Accelerator Technologies*

Exercise Classes (2)

Magnet Design

Introduction to *HALHF* Student Project

Tutorials (6)

HALHF Student Project

JAI Seminar (1)

HALHF Student Project

*Course carried out in hybrid format
(in person & Zoom)*

*** As proposed by JAI AB**

Graduate Accelerator Physics Course 2024-2025

- Number of Students
 - **University of Oxford**
 - JAI Accelerator Physics (3)
 - Atomic & Laser Physics (Plasma Physics, 2)
 - Particle Physics* (10)
 - **Royal Holloway, University of London (1)**
 - **Imperial College London (3)**

* *Term 1: first three lectures, first tutorial & ISIS visit only*

Accelerator Design Project

- Accelerator Design Study for
 - ❑ **FCC-ee Positron Damping Ring: 2022-2023**
 - ❑ **LhARA Stage I: 2023-2024**
 - ❑ **HALHF: 2024-2025**
 - ❑ Design work consisted of study of the lattice, magnet systems and RF cavities.

“The design project significantly contributes to the value of a PhD at the JAI and is a very effective learning tool ... it played an essential role in helping me to find a postdoc.”

“To me, the design project was by far the best part of the course. It puts the material taught into context and bridges the gap between lectures ... and a DPhil project”



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JAI
John Adams Institute for Accelerator Science

Laser-hybrid Accelerator for
Radiobiological Applications
(LhARA)

John Adams Institute Accelerator Design Project 2024

M. Pereira, G. Passarelli
Royal Holloway, University of London

C. Jolly, S. Leadley, C. Lehmann, S. Preston
University of Oxford

G. Christian, L. Bradley, J. Hills, L. Kennedy
Imperial College London

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London



2023-2024: LhARA

Design Report published
on CDS ([10.17181/CERN.9K4Y.MM92](https://cds.cern.ch/record/10.17181/CERN.9K4Y.MM92)) and
students delivered JAI Seminar (March
2024) and visit to CERN (July 2024)

2024-2025: HALHF

Design Report to be published on CDS and students delivered JAI
Seminar on 13 March 2025; Visit to CERN planned for July 2025

Consolidated Accelerator Course

- Graduate lecture course includes **plasma research training**.
 - Lectures provided by ICL, as part of development of **integrated accelerator-laser-plasma training**,
 - Training in '**Centre for Postgraduate Training in Plasma Physics & High Energy Density Science**' – established in 2014 by ICL, Oxford, and Warwick.
 - **Plasma-related** lecture courses also provided in Oxford.
- Graduate students take **additional courses in related subjects** – statistics, EM, safety, particle physics and astrophysics.
- Universities offer **courses on transferable skills** – Research Management, Critical Thinking, Personal Effectiveness, Research Skills & Techniques, Written & Oral Communication, Team Working, Career Development, Entrepreneurship, Ethics, and Advanced IT.
- **Lecturers & Instructors**
 - **J. Bauche (CERN)**, M. Dosanjh (Oxford), M. Fraser (CERN), H. Garcia-Morales (Oxford/PickleTech), A. Gerbershagen (Groningen), D. Kelliher (RAL), **B. Kyle (RAL)**, S. Lawrie (RAL), S. Mangles (ICL), I. Martin (Diamond), Z. Najmudin (ICL), S. Patel (RAL), C. Plostinar (ESS), **D. Posthuma de Boer (RAL)**, M. Schippers (PSI), P. Tait (Oxford), F. Tecker (CERN), E. Tsesmelis (CERN/Oxford), H. Wakeling (Oxford), Rob Williamson (RAL)
 - Lecturers / instructors from **JAI universities** and from external institutes – **CERN, Uni. Groningen, DIAMOND, ESS, PSI, RAL.**

JAI Student Resources

- **Student Handbook** provides information to the students of the training programme in accelerator science at JAI.
 - Syllabus & course content, course resources, assessment, evaluation, recommended textbooks.
 - Supplementary information (public engagement, lecture series, summer student programme etc.)
- Dedicated site on **INDICO**
 - <https://indico.cern.ch/category/5869/>
 - Timetable, slides / documents, Zoom connection

John Adams Institute for Accelerator Science

Education & Training in Accelerator Science

Student Handbook
and Programme Syllabus

2024-2025

September 2024



John Adams Institute for Accelerator Science - Accelerator Physics Courses

The John Adams Institute for Accelerator Science (JAI) is a centre of excellence in the UK for advanced and novel accelerator technology, providing expertise, research, development and training in accelerator techniques, and promoting advanced accelerator applications in science and society. The JAI programme is organised around three pillars: research in accelerator science; training the next generation of accelerator scientists; and science outreach to industry and the public. The JAI is jointly hosted by the physics departments of the University of Oxford, Royal Holloway, University of London and Imperial College London.

As part of its training programme, the JAI provides courses in Accelerator Physics and related disciplines. Details of the courses are provided in the JAI Student Handbook 2024-2025.

January 2025

 Jan 23 - Mar 21 [Hilary Term 2025](#)

October 2024

 Oct 16 - Dec 05 [Michaelmas Term 2024](#)

January 2024

 Jan 18 - Mar 21 [Hilary Term 2024](#)

October 2023

 Oct 11 - Nov 30 [Michaelmas Term 2023](#)

New Graduate Students 2025-2026 Academic Year

■ Oxford

- Meg Savage: Beam-driven wakefield acceleration (R. d'Arcy); STFC & DESY funding
- Francesco Straniero: ISIS beam dynamics (A. Oeftiger); STFC & ISIS funding

■ RHUL

- N.N.: Optical beam diagnostics; STFC funding

■ ICL

- George Weis: Accelerating deuteron beams for laser-plasma interactions (Z. Najmudin); STFC funding

Process for graduate student selection on-going at all JAI universities

Matching funding and international fee waivers to support non-UK applicants for CERN Doctoral posts are increasingly difficult to obtain from UK universities. 12

Graduate Student Funding

- Since 2019, JAI included in **STFC quota** PhD studentships scheme receiving three studentships per year (exceptionally four in 2024).
- This **leverages additional funding sources** allowing JAI to recruit a few additional PhD students / year.
 - **Various funding sources** include most recently JAI universities, the Royal Society, EPSRC Industrial CASE & Centres for Doctoral Training, the CERN Doctoral Student programme, ISIS, Diamond Light Source, the Ada Lovelace Centre, and the Central Laser Facility.
 - Successful in collaborating with external universities through **cooperation agreements**, such as University of Oxford with Humboldt University, Berlin, whose students have attended the JAI course, and other non-UK sources.

Continue to explore wide range of possibilities for sustainable funding.

Undergraduate Accelerator Physics Courses

■ RHUL

- Short option course (12hr) for 3rd year students.
- Annual intercollegiate course for 4th year MSc students from the University of London and as well as BSc/MSc project students.

■ University of Oxford

- Undergraduate course is currently being revised and is expected to become available as of 2026-2027 academic year.
 - ‘Short option’ in Year 3, consisting of 12 lectures (6 detectors and 6 accelerators).
- 4th year undergraduate projects undertaken annually (e.g. plasma accelerators, medical accelerators).

Expect programmes to attract undergraduate students to accelerator science.

Undergraduate Accelerator Physics Summer Student Internships

- Oxford University
 - Internship Programme (CERN in July/August annually)
 - **Two or three students** join **CLEAR** accelerator project supervised by Oxford faculty & graduate students.
 - Participate in **CERN Summer Student** lecture series and in an accelerator project.
 - Sub-department of Particle Physics Internship Programme
 - **Three positions:** Sustainability (H. Wakeling), Beam-driven wake-field acceleration (R. d'Arcy), Metrology (A. Reichold)
- Imperial College
 - Around **4 students** appointed annually.
 - Spend 8 weeks working at **Imperial College & RAL**.
- RHUL
 - Around **2 students** appointed annually.
 - Carry out research work at **RHUL**.

Expect programmes to attract undergraduate students to accelerator science.

UK Accelerator Institutes Seminar Series

- JAI, together with ASTeC and the Cockcroft Institute, organise jointly the **UK Accelerator Institutes Seminar Series**
<https://indico.cern.ch/category/13863/>
 - Delivered by distinguished speakers from the participating institutes and from laboratories / universities world-wide.
- Seminars held in person and via videoconference and scheduled so that the graduate student body can attend.

Latest Session in January – March 2025

Title	Speaker
University Neutrons: The High-Flux Facility at Birmingham	Carl Wheldon (Uni. Of Birmingham)
The TWOCRIST Project at the CERN LHC	Pascal Hermes (CERN)
Development of HTS Trapped Field Magnets Using 2G HTS Coated Conductors	Hengpei Liao (Uni. Of Strathclyde)

External Training Commitments (Abridged)

- JAI academic staff invited to provide training & to contribute to various international forums:
 - EU Integrating Activity Projects on Training, Communications & Outreach in Accelerators – TIARA 2011-2014, ARIES 2017-2021, I.FAST 2021-2025 (P. Burrows serves as WP Leader). Will coordinate new European panel on education & training in accelerator science – IFAST2 - under TIARA auspices.
 - TIARA - Chair of Task Force on Training in Accelerator Science for Europe (P. Burrows).
 - CERN Accelerator School CAS (various JAI faculty and staff, P. Burrows serves on CAS AB).
 - Joint Universities Accelerator School (JAI is partner institute, P. Burrows serves on JUAS AB).
 - US Particle Accelerator School (USPAS, various JAI faculty and staff).
 - Cockcroft Institute graduate accelerator physics course (S. Gibson).
 - University of London intercollegiate undergraduate & graduate accelerator physics courses (S. Gibson, P. Karataev).
 - University of Melbourne Medical Accelerator Physics Programme (S. Sheehy).
 - Nanyang Technological University undergraduate lectures on accelerator physics (E. Tsesmelis).
 - Culham Summer School on Plasma Physics - Laser Wakefield Accelerators (S. Mangles)
 - EuPRAXIA-DN School on Plasma Accelerators, Introduction to Plasma Diagnostics, (Z. Najmudin)
 - Winter School on Intense Laser Science WiSILS 2024), Indian Institute of Technology (Z. Najmudin)
-
- Public IOP Evening Lecture on Sustainable Accelerators (H. Wakeling)

Future Programme - Training

Proposal & plan for the future education & training programme at JAI:

- Continue to **deliver an outstanding training programme** both within JAI and via our contributions to CAS, JUAS and other schools.
- Consolidate, strengthen and augment our programme by:
 - further **integrating lectures and seminars** across our three universities;
 - augmenting focus on **sustainability** in accelerator design and construction;
 - strengthening focus on **commercialisation and impact**;
 - linking to dedicated **training in AI/ML techniques** provided via our universities.
- Continue to promote a pipeline of graduate students via our **undergraduate portfolio** of courses, summer internship programmes and research projects.
- Aim to strengthen our collaboration on training with the **CI on advanced topics** and to continue support of the **UK Accelerator Institutes Seminar Series**.
- Continue to support student participation in relevant specialised **external training** courses (e.g. Advanced CAS) and presentation of their research work at **international conferences and workshops**.

PUBLIC ENGAGEMENT

Introduction

- JAI continues to develop its high-profile, in-person public engagement in post-Covid environment.
- Covid pandemic devastated in-person events, throwing them into online events.
- Greatly reduced activities and only now events have reached pre-pandemic levels.

APPEAL

- Re-start Accelerator and Particle Physics Education at A-Level (APPEAL) following pause due to Covid-19.
- Annual training event started in 2010.
- APPEAL-11 in June 2025

Accelerators for Particle Therapy in Medicine

APPEAL 11 - Accelerators for Particle Therapy in Medicine

In collaboration with CERN, the University of Oxford is organising a one-day school to give A-level teachers an opportunity to learn about particle accelerators and their applications in particle therapy. Particle accelerators, invented and used for pure research in fundamental physics have become important instruments in medicine, for both diagnosis and treatment of ailments such as cancer.

The school will also include lectures on admission to undergraduate studies in physics and a hands-on MasterClass on particle therapy.

The school will address questions that often fascinate students, such as "How does a particle accelerator work?" and "What are the applications of particle accelerators in our daily lives?".

Past APPEAL events were very successful and this event should be as interesting and thought-provoking event as ever.

The APPEAL-11 event will take place on **Saturday, 28 June 2025** at the **University of Oxford**.

To take part in this school please register [here](#) before the **Friday, 20 June 2025**.

There are **no registration fees** for the teachers to participate in the event. The organisers are grateful for the support received from the following organisations:



Consists of lectures and MasterClass

<https://indico.cern.ch/event/1539515/>

Public Engagement & Schools Outreach

‘Particle Accelerators: from Higgs Bosons to Curing Cancer’

Delivered 40 times in pre-pandemic decade

Continued in 2024 at nearby school: >100 attendees



Feedback from female GCSE student:

‘It meant a lot to me that you spent your time discussing my ambition to have a career in physics once I am older. I greatly appreciate that you talked with me and I thank you for the advice you gave me.

Our discussion really inspired me and I am more determined than ever, ... at the moment I am likely to be the only student at my school taking Physics and Further Maths A-Level, but this will not deter me.’

Phil Burrows

Public Engagement & Music



Brian Foster

- ***Oxford May Music Festival*** (May 2024, 15th season).
 - 4 days of events with a total attendance of around 1000.
- ***Einstein's Universe*** given over 100 times over almost 20 years to a live audience totalling more than 30,000

Public Engagement & Festivals



**Imperial College London
(September 2024)**



Great Exhibition Road Festival, London

- ❑ Celebrate how science and the arts help people, communities and nature to flourish, with a weekend of events for all ages.
- ❑ Stall on plasma accelerators by ICL in 2024.
- ❑ Preparation of LhARA VR activities by RHUL for Great Exhibition Road Festival (June 2025)



RHUL Science Festival (May 2024)

Public Engagement & Students

Make Science Count

Communicating Science in a complex environment

Hector Garcia Morales
Physics PhD and Science Communicator/Writer



Pilot initiative by
Suzie Sheehy & Hector Garcia Morales

In future, could collaborate with similar effort
of **Oxford Particle Physics**

Science Communication Lectures & Workshops for JAI DPhil Students

Underlined the importance of:

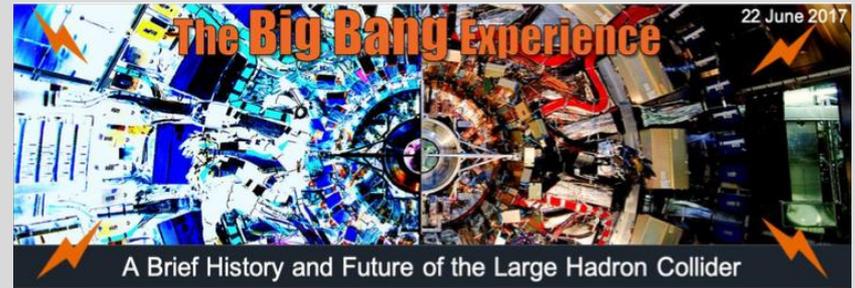
- ❑ **Communication skills** are essential.
- ❑ Use of Elements of **Storytelling**.
- ❑ Engage with **different audiences**.
- ❑ **Writing** is special.
- ❑ **Trust, ethics and uncertainty** in scientific narratives.

Public Engagement & The Big Bang Experience!

- Brief history and future of the LHC revealing wonders of the LHC at CERN and how it is unravelling mysteries of the universe.



- Big Bang Experience at **British Science Week** (March 2024)



Royal Holloway University London

Public Engagement & Literature



Popular science book
by Suzie Sheehy

Outreach events, interviews
and coverage in Australia, the
UK and the US reaching over
4000 people live.

Suzie awarded **Australian
Institute of Physics Prize for
Physics Communication** and
Finalist for the **Eureka Prize**
for Public Understanding of
Science.



Spin-off *Nature* article: 'The Woman Who Broke Parity' (January 2024).

Rosemary Fowler awarded honorary doctorate (Bristol) 75 years after her discovery of the kaon

Public Engagement & International Forums

- **IUPAP Working Group 14 Accelerators:**
 - Project to grow public engagement activities globally with accelerators and their applications (S. Sheehy).
- **SDG 3 – Good Health and Well-being (M. Dosanjh)**
 - Climate Change and Health Task Force Meeting (World Health Organization).
 - Member of Conference of Non-Governmental Organizations in Consultative Relationship with the United Nations (CoNGO) Board and Invited Speaker at WSIS 2022.
- **SDG 5 – Gender Equality (M. Dosanjh)**
 - Committee on Status of Women - Geneva (CSW-Geneva)
 - UK Civil Society Women’s Alliance (UKCSWA)



Proposal and Plan for Future

- JAI continues to be **leader in communicating accelerators & associated physics.**
- Activities for future include:
 - **Training days for teachers** (APPEAL – Accelerator and Particle Physics at A-Level) for science teachers.
 - Long-standing **schools programmes** – ‘Particle Accelerators: from Higgs Bosons to Curing Cancer’, ‘Einstein’s Universe’ and ‘Big Bang Experience’.
 - **High-profile collaborative public engagement** attracting new audience to science – Big Bang Fair, Oxford May Music, Great Exhibition Road Festival.

Summary

- JAI continues to deliver **world-class** accelerator science **education & training** and **public engagement** programmes.
 - Intense **accelerator physics course**.
 - Innovative and **educational accelerator design projects**.
 - **Successful placement of students** once they enter professional careers.
 - **Recognised and award-winning public engagement** activities with global reach - continue strengthening existing portfolio and encourage new & innovative ideas.