



Science and
Technology
Facilities Council



UK XFEL

London Townhall

Life Science and Bio Medicine
Hosted by Diamond Light Source

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What is an XFEL?

X-ray free-electron lasers are effectively large microscopes, which allow scientists to spot the tiny movements of molecules capturing their motion in snapshots then stringing these individual images into videos with attosecond frame rates.

Why are we here?

UK XFEL Conceptual Design and Options Analysis (CDOA) Project

2016



FELs

Strategic Review

Not a facility design but highlighted a SwissFEL-like option + increased international engagement

2018



Eu-XFEL + UK

UK becomes a member of Eu-XFEL

2020



UK XFEL

Science Case

Soft x-rays @ 1 MHz
Hard x-rays @ 1 kHz to 1 MHz

The Science Case for UK XFEL 2019-2020

In the last decade XFELs have had an impressive scientific impact, but there is clearly scope to do much, much more.

Taking a long view we looked at what kind of science we will do with an advanced XFEL operating from mid 2030's. Extrapolating current technology advances to frame what will be possible.

Science Case Objectives:

- To demonstrate scientific need
- To define a next generation XFEL capability
- To inform the technology that must be developed

Authored by an expert Science Team

Published in 2020 – available online at xfel.ac.uk



UK XFEL Science Case



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CDOA Objectives

By October 2025 we will have:

- mapped out how best to deliver advanced XFEL capabilities identified in the Science Case
- explored a Conceptual Design for a unique new machine that can fulfil all required capabilities
- examined other investment options and collaborations in existing XFELs
- updated the Science Case to feed into the process and inform future decisions
- held multiple Townhall Meetings around UK engaging with the user community (like this one)
- investigated the socioeconomic impact of a next generation XFEL

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Proposal and Aims of the CDOA

How best to deliver access to a Next Generation XFEL?

Evaluate five different options

including their feasibility, costs, benefits, risks and sustainability.

1. UK Facility in the UK
2. UK Facility in the UK with International partnerships
3. Invest in an International facility within Europe
4. Invest in an International facility internationally
5. No further investment

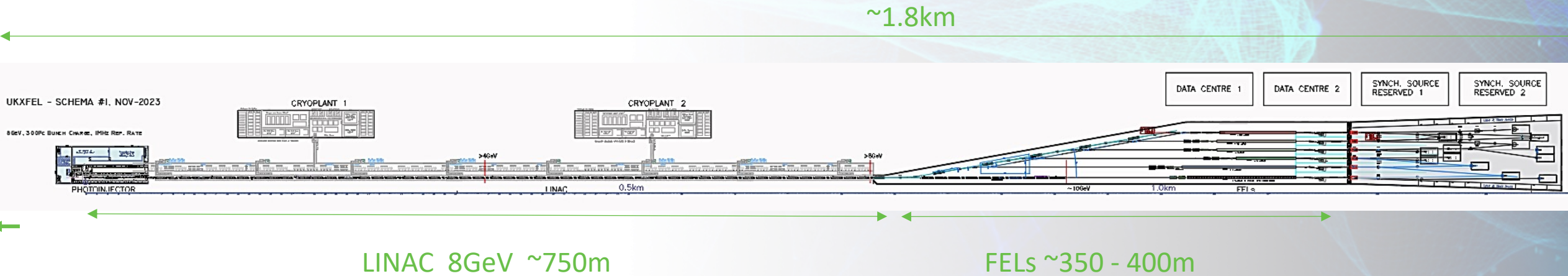
The **science case will also undergo a refresh** during this period along with research and development into new technologies required to deliver a **sustainable** next generation XFEL.

£3.2 million over the next three years, Project timescale **Oct 2022 to Oct 2025**.

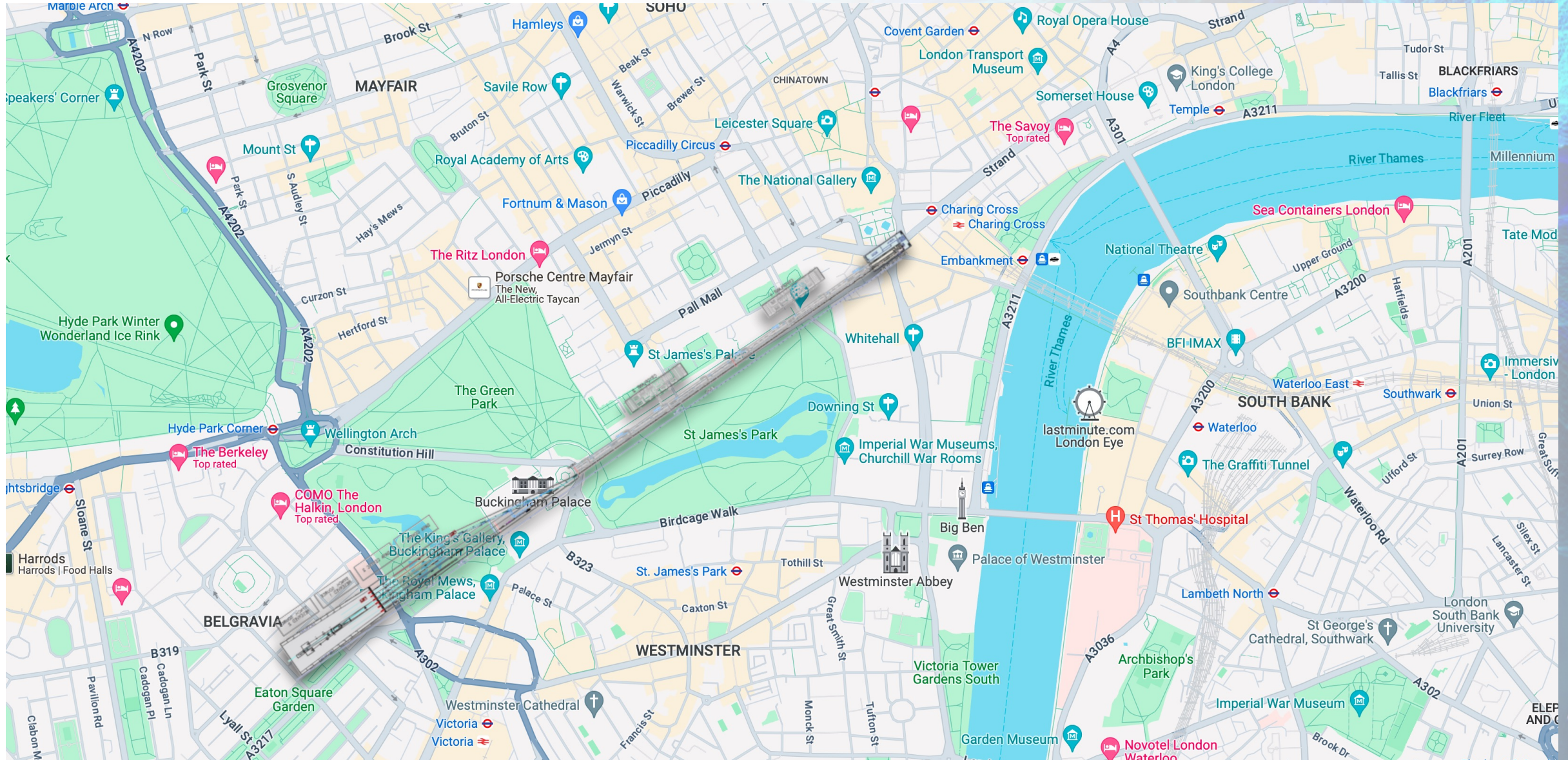
Design Philosophy

To develop a next-generation XFEL concept, we initially **assume a new-build facility at an international scale**, without constraints from location or from upgrading an existing machine.

Aspects of this design will later be mapped onto and compared against the different options (i.e UK-based/international investments).

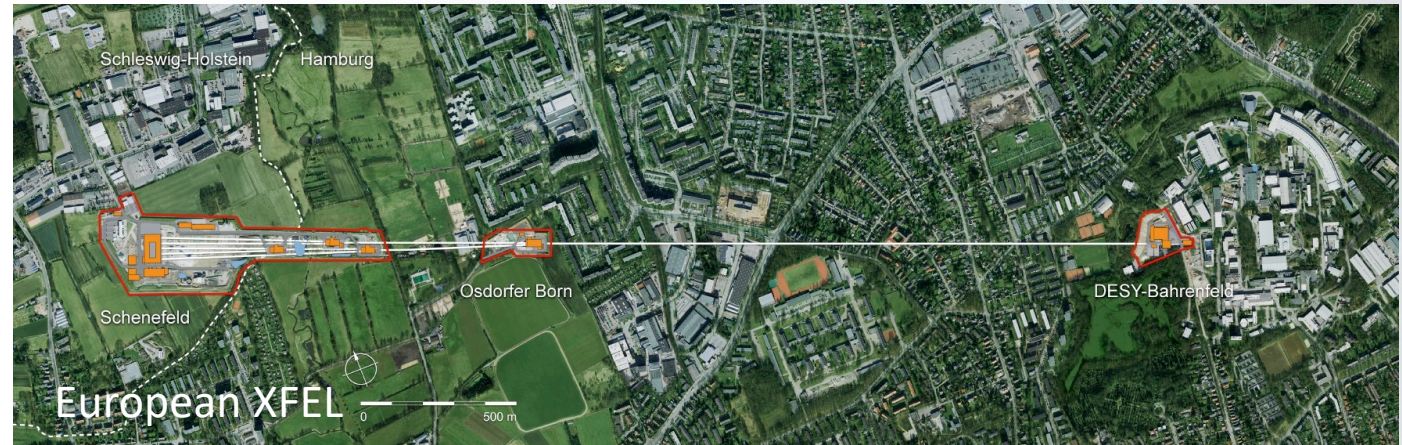


Cost and Location



Cost and Location

- For the UK based option the CDOA project will not take any account of the possible facility location. The conceptual design will assume a green field site.
- For an idea of the scale of the facility cost and physical layout we can refer to existing XFELs:
 - SwissFEL cost ~275 MCHF (2013) and is ~750m long and ~15m wide
 - European XFEL cost ~1220 Meuro (2005) and is ~3.4km long

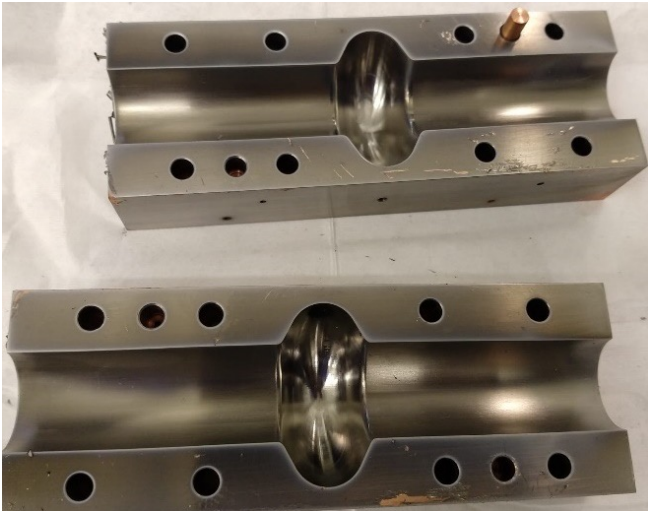


Sustainability

The UK accelerator community is already very active in developing more sustainable technologies, Using permanent magnets instead of electromagnets.

- Making use of different superconducting materials and **coatings** for RF cavities so that they can operate at 4K instead of 2K.
- Developing more efficient RF power sources and much faster RF cavity tuners.

In addition we are assessing accelerators more broadly in terms of carbon footprint throughout the full project life cycles. This analysis will continue and feed directly into the CDOA project.



ASTEC-SATF-0001 v0.1

28 November 2022

ben.shepherd@stfc.ac.uk

An Analysis of Sustainable Practice in Particle Accelerator Infrastructures

Ben Shepherd, Louise Cowie, Anthony Gleeson, Gary Hughes, Storm Mathisen, Katherine Morrow, Hywel Owen, Andrew Vick
STFC Daresbury Laboratory
Warrington WA4 4AD, United Kingdom

Keywords: particle, accelerator, sustainability, carbon

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Science Engagement

LEDS Workshop

PhotonMEADOW

International Workshop on AMO Science @ X-ray Free Electron Laser

EAAC23

IPAC '24

Particle Accelerators and Beams 2024

Science@FELs 2024 and Satellite Workshop

UK/Japan Symposium on Frontiers of Structural Biology

Harwell Open Day

FEL 2024

Specialist Workshops

Monthly feedback loop with the design team.

Townhalls

xfel.ac.uk/events





University of
Sheffield





UK XFEL

The role of magnetic fields in turbulent high-energy-density plasmas

Broader engagement

UK RI UK Research and Innovation

Science and Technology Facilities Council

UK XFEL

The UK enjoys world leader in established manufacturing such as aerospace, pharmaceuticals, electronics design and photonics technologies.

Materials research is highly pervasive in its impact and ability to contribute to socioeconomic challenges.

xfel.ac.uk

UK RI UK Research and Innovation

Using cutting edge equipment, scientists can investigate a wide range of material properties and characteristics.

Versarien

Communications

- Website refreshed, and updated – xfel.ac.uk
- Community slides updated for use by anyone
- Social media presence via twitter and linkedin
- Two blogs written for Medium [\[1\]](#) [\[2\]](#)
- Update in FELs of Europe Newsletter
- Videos produced for [YouTube](#)

- Mailing list now over 360 people

- Engaging with the likes of IoP, BBC and TEDx for public talks and engagement

- Improved internal team comms



Proposal and Aims

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Eu-XFEL



- Multiple Eu-XFEL/DESY
- A list of prioritised topics was agreed included Synchronisation, Injector and few topics in beam dynamics
- Monthly seminars on each topics with collaborative ideas take place
- Regular meetings continue on a quarterly basis
- Plan to discuss SRF and FELs as UK XFEL design progresses
- Aim to implement specific MoU
- Proposing a face to face meeting of few key people in DESY this Autumn.

LCLS



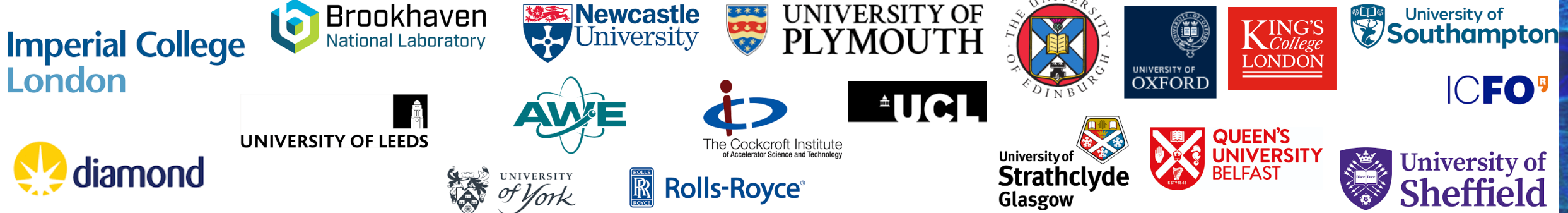
- Team visited LCLS in Nov 23
- Senior STFC Staff have visited LCLS
 - Alan Partridge
 - Mark Thomson
- Multiple 'touch base' meeting
- Second in person meeting planned for Sept
- STFC would also like to engage with SLAC on ultrafast electron diffraction (UED) for the RUEDI project.
- Aim to formalise collaboration agreement

Who are we?

UK XFEL



Science Team



UK Research Councils & Government



Other XFELs



The Design Team

WPO - Management

Science Lead
- Jon Marangos

Technical Led
- Jim Clarke

Sponsor
- John Collier

Project Manager – Paul Aden

Chief Engineer –
Barry Fell

Champion lead – Jim Clarke

International
– Ed Snedden

UK-XFEL
– Dave Dunning

European
– Deepa Angal-Kalinin

Machine Design team:

WP3. Low Energy Beam

WP4. High Energy Beam

WP5. FELs & Undulators

WP6. Photon Beams

WP7. Data & ML

WP8. Synchronous Sources

WP9. End Stations

WP10. Synchronization

WP11. Project Delivery

WP12. Detector Systems

- Boris Militsyn

- Peter Williams

- Neil Thompson

- Mark Roper

- Storm Mathisen

- Dave Walsh

- James Green

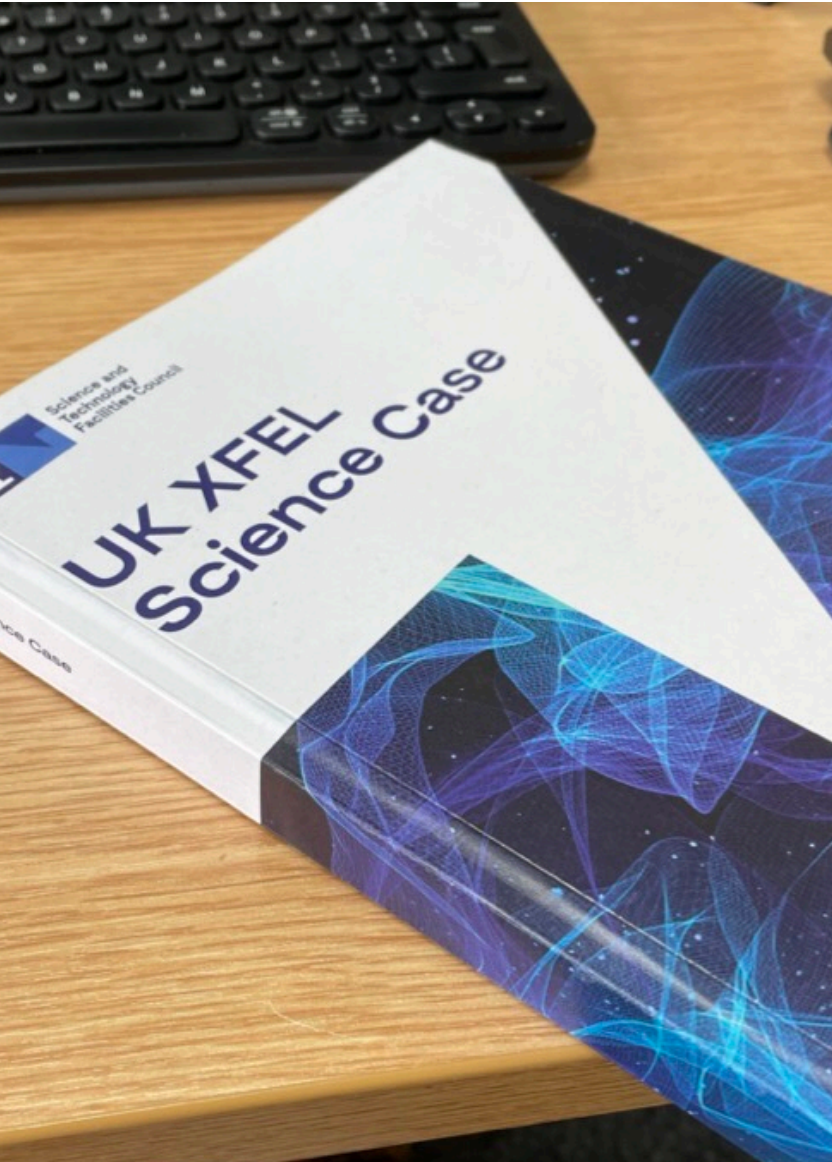
- James Henderson

- Barry Fell

- Matt Wilson

WP13 -Socioeconomic

Expert Science Team



Matter in extreme conditions

Andy Higginbotham (York), Andy Comley (AWE), Emma McBride (QUB), Sam Vinko (Oxford), Marco Borghesi (QUB), Malcolm McMahon (Edinburgh), Justin Wark (Oxford)

Nano/Quantum materials

Anna Regoutz (UCL), Marcus Newton (Soton), Ian Robinson (UCL/Brookhaven), Mark Dean (Brookhaven), Awan Shakil (Plymouth), Paolo Raedelli (Oxford), Simon Wall (Aarhus), Sarnjeet Dhesi (Diamond),*

Engineering/Materials/Applications

*David Rugg (RR), Sven Schroeder (Leeds), David Dye (IC) Dan Eakins (Oxford), Mike Fitzpatrick (Coventry) +**

Life sciences:

Allen Orville (Diamond), Jasper van Thor (IC), Xiaodong Zhang (IC), Shakil Awan (Plymouth), Adrian Mancuso# (Diamond), Tian Geng (Heptares)*

Chemical sciences:

Julia Weinstein (Sheffield), Russell Minns (Soton), Sofia Diaz-Moreno (Diamond), Alex Baidak (Manchester), Andrew Burnett (Leeds), Tom Penfold (Newcastle), Rebecca Ingle (UCL), Mark Brouard, Claire Vallance (Oxford)*

Physical sciences:

Amelle Zair (KCL), Adam Kirrander (Edinburgh), Jason Greenwood (QUB), Jon Marangos (IC), Elaine Seddon (Cockcroft) + #

+ around 100 additional experts from around the world contributing to Science Case

Next Steps

Overview

We are presently 8 months into the project. The Year 1 activities below are largely complete – the focus is on developing the conceptual design and making progress towards the Year 2 activities.

Year 1

- Project launch event
January 2023
- Initial conceptual
design and layout
- Preliminary
engagement with
overseas XFEL
facilities
- Survey of the science
team, workshops and
town halls meetings
begin

Year 2

- R&D targeting gaps in
key physics and
technology areas
- Collaborative activities
and working groups
with overseas XFEL
facilities
- Workshops and town
hall meetings continue

Year 3

- Summary of R&D
activities
- Preferred options
identified, socio-
economic analysis
- Revision to science
case published
- CDOA phase
completed September
2025

Expected timelines

Evaluate

2019 to 2020 Science Case – Completed

Design

Currently here



Oct 2022 to Oct 2025

Conceptual Design and Options Analysis

Funding bid ongoing

Oct 2025 to ~2029

Technical Design Review

Construction

~2029 onwards

Civil Construction work

~2030 onwards

Accelerator Construction work



Thank You!



Continue the discussion, xfel.ac.uk ukxfel@stfc.ac.uk

Electronics, photonics and quantum technologies
8-9th August 2024, Royce Institute, Manchester



HENRY
ROYCE
INSTITUTE

Advanced materials and manufacturing
17-18th September 2024, Cardiff University, Wales





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Thank You

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