Welcome

Dave Newbold, Executive Director of National Laboratories, STFC

STFC's mission

Mission:

- Discovering the secrets of the Universe
- Developing advanced technologies
- Solving real world challenges

Responsibilities:

- Frontier research: particle physics, astronomy, nuclear physics and space science
- **Major UK multi-disciplinary facilities**
- **Stewardship of our R&I campuses**

Annual budget: ~£1.1b

UKRI Science and Technology Facilities Council

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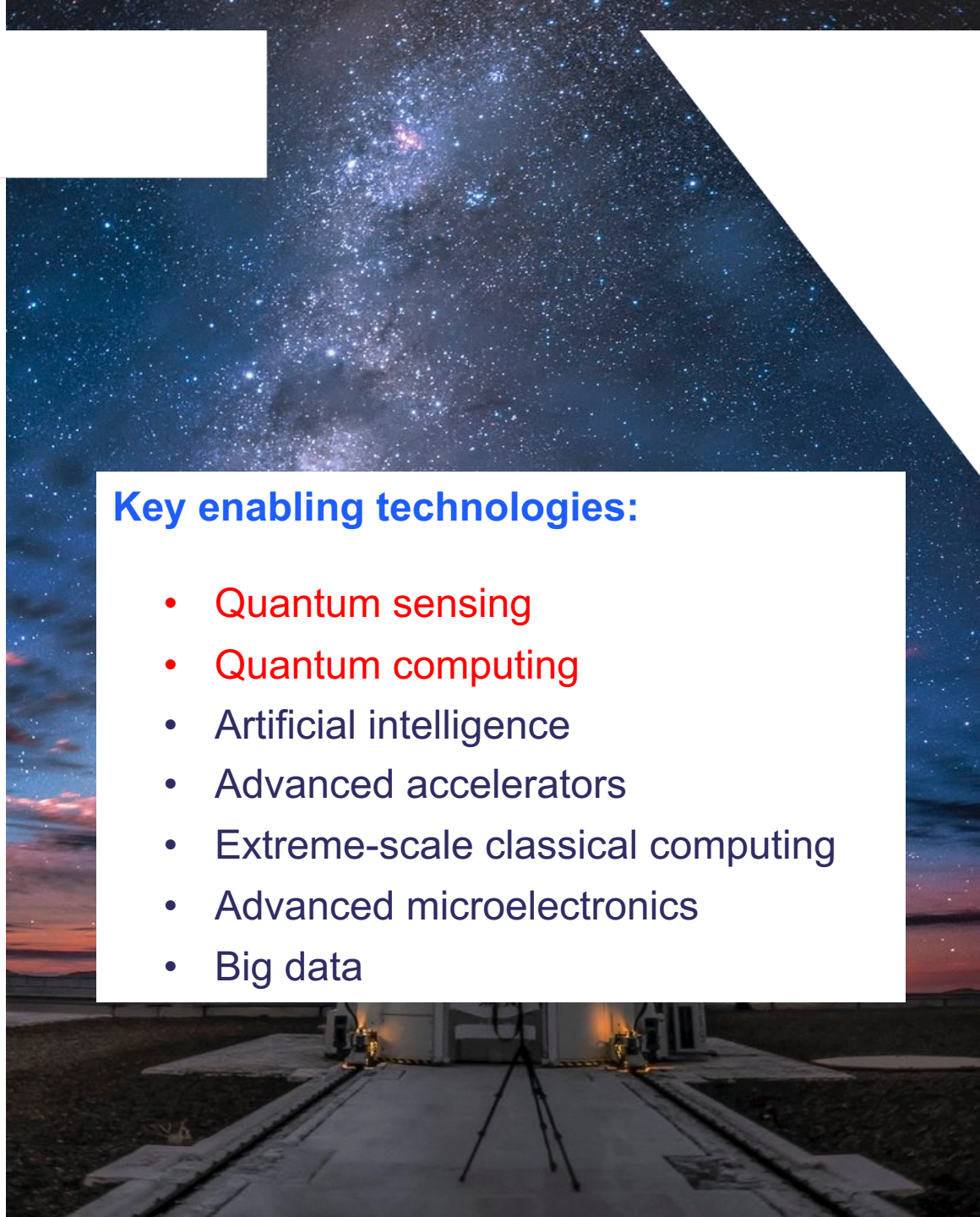


Key enabling technologies:

- Quantum sensing
- Quantum computing
- Artificial intelligence
- Advanced accelerators
- Extreme-scale classical computing
- Advanced microelectronics
- Big data

STFC's science base

Six sites across the UK + ING in La Palma

Around 3,000 staff

- approx. 30% of UKRI staff
- >85% are scientists, engineers and technicians
- **1660** at the Rutherford Appleton Lab

STFC National Laboratories

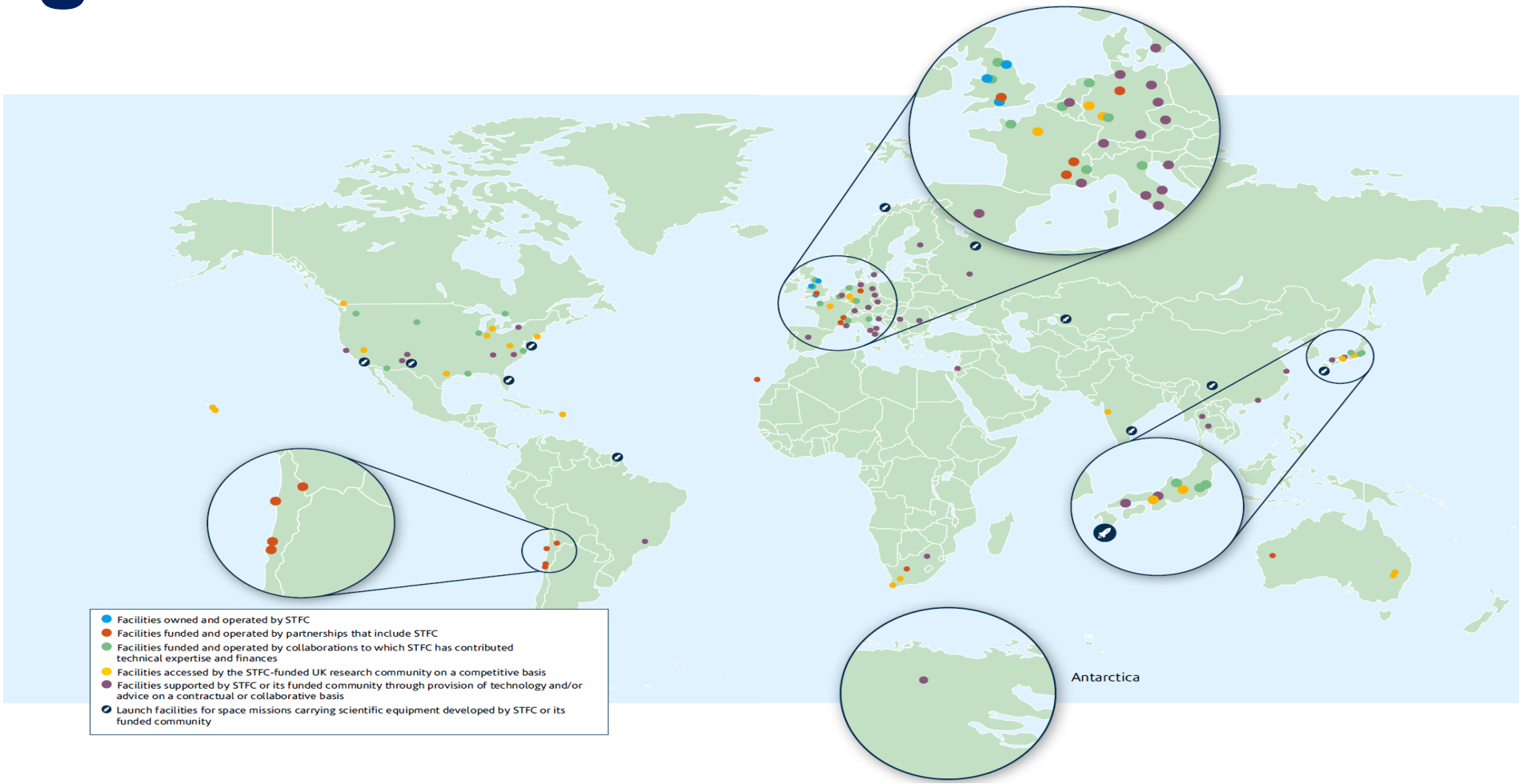
- STFC provides the necessary high-tech scientific and engineering support for >10,000 industrial and academic researchers from across all domains

Science and Technology Facilities Council

STFC's global reach

Includes:

- CERN
- Fermilab
- ESO
- ILL
- SKA
- ESRF
- XFEL
- ESS
- ESA
- ING
- …



Science and Technology Facilities Council

National Quantum Strategy

March 2023

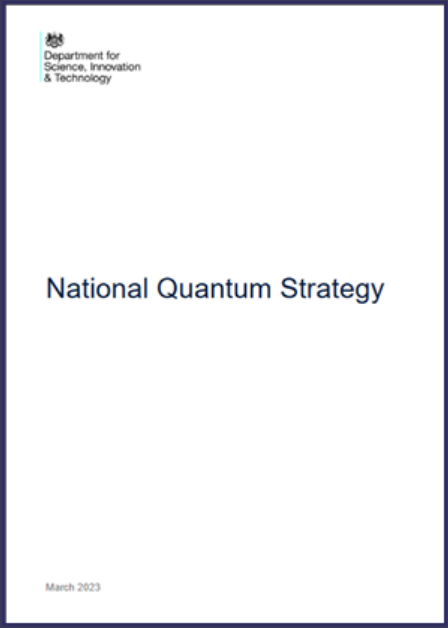
Our **ten-year vision** is for the UK to be a world leading **quantum-enabled economy**, building on scientific excellence and creating a thriving quantum sector to ensure that quantum technologies are an integral part of the UK's digital infrastructure and advanced manufacturing base, driving growth and helping to build a strong and resilient economy and society.

Ensure the UK is home to world-leading quantum science and engineering, growing UK knowledge and skills

Support business, making the UK the go-to place for quantum businesses and an integral part of the global supply chain, as well as a preferred location for investors and global talent

Drive the use of quantum technologies in the UK to deliver benefits for the economy, for society and for our national security

Create a national and international regulatory framework that supports innovation and the ethical use of quantum technologies, and protects UK capabilities and national security



UK NATIONAL QUANTUM TECHNOLOGIES PROGRAMME

Department for Science, Innovation & Technology

Ministry of Defence

[dstl] The Science Inside

NPL National Physical Laboratory

GCHQ

UK Research and Innovation

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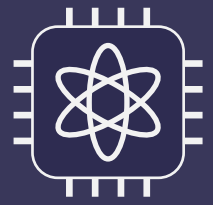

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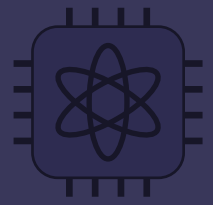

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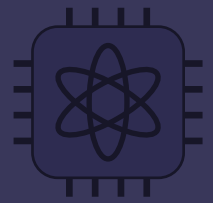

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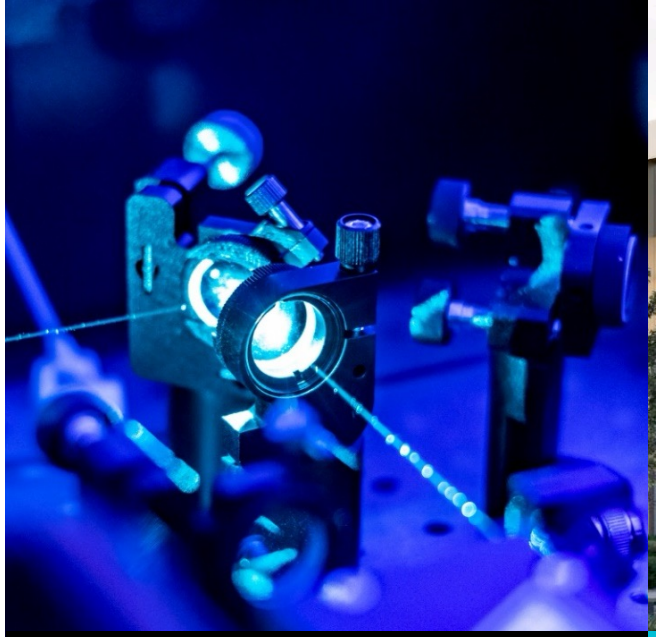
National Quantum Computing Centre

- Collaborative Programme: EPSRC and STFC
  - £100m initial 5 year investment (2020)
  - £50m programme acceleration (2023)
- Addressing the challenges of scaling quantum computing
  - Delivery through in-house development, UK and international collaborations and government procurement
  - Full stack architecture: hardware and software
  - Scalability: benchmarking, verification and error correction
  - Deployment: use-cases, algorithms and applications
  - Building and eco-system: Skills, training and engagement
- Driving user adoption and economic value through our Spar**Q** quantum readiness engagement programme



Technology

Infrastructure

Applications

Skills

National Quantum Computing Centre

Quantum Computing Testbeds

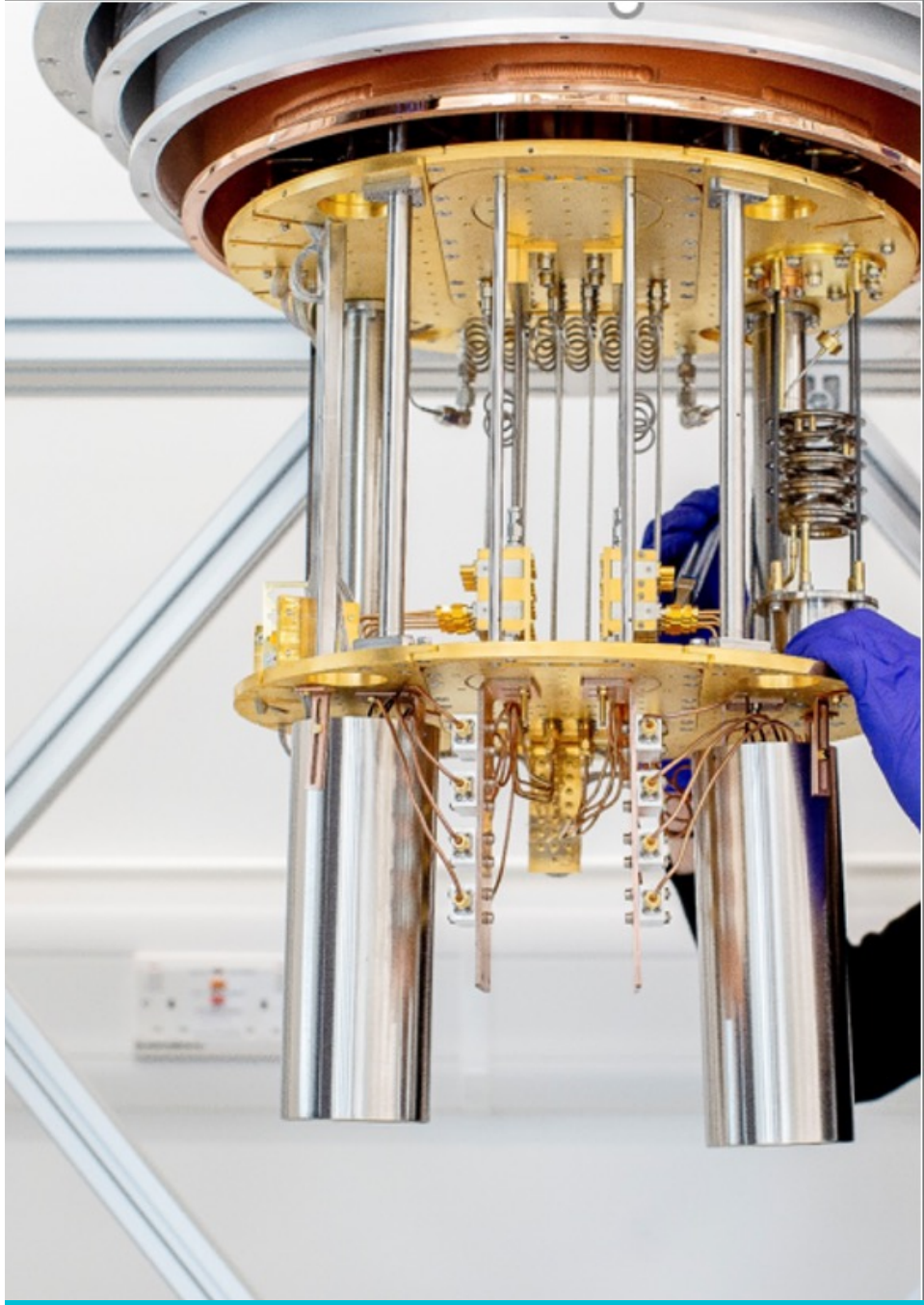
Strategic Intent:

- Gain access to a range of platforms enabling evaluation and benchmarking of performance
- Drive both in-house development and external platform evaluation
- Evaluate and de-risk deployment to help drive user-adoption
  - cost, time, performance …
- Accelerating UK Government as an informed customer and user

£35m investment

- 15 month deployment
- 24 month evaluation

Suppler	Platform Type
AEGIQ	Photonic
Cold Quanta UK	Cold Atom Tweezer Array
ORCA Computing	Photonic
Oxford Ionics	Trapped Ions
Quantum Motion	Si Quantum Dots
QuEra Computing	Cold Atom Tweezer Array
Rigetti UK	Superconducting



Infrastructure

Quantum Computing @ The Hartree Centre

PsiQuantum

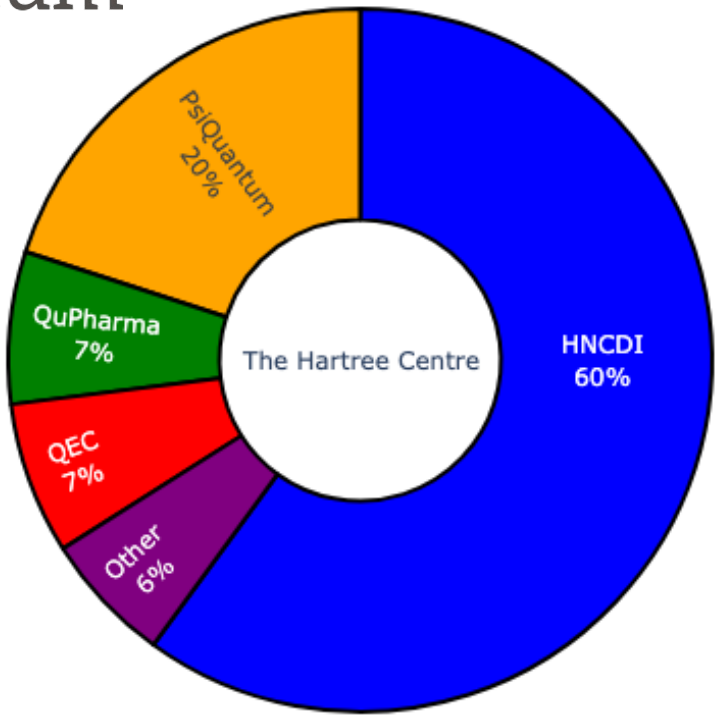
seeqc

QEC Project

QUANTUM BRILLIANCE

IONQ

D:wave
The Quantum Computing Company™



EMERGING TECHNOLOGY

IBM Quantum

algorithmiq

Plus Academic engagement
in the North-West

MANCHESTER 1824
The University of Manchester

UNIVERSITY OF LIVERPOOL

Lancaster University

History of QTFP

July 2018 Idea presented to STFC

October 2018 Opportunities grant: Quantum Sensors for Fundamental Physics (QSFP) and Society awarded

Oct 2018/Jan 2019 QSFP Community workshops

March 2019 Business case approved

May 2019 STFC Led Community workshop

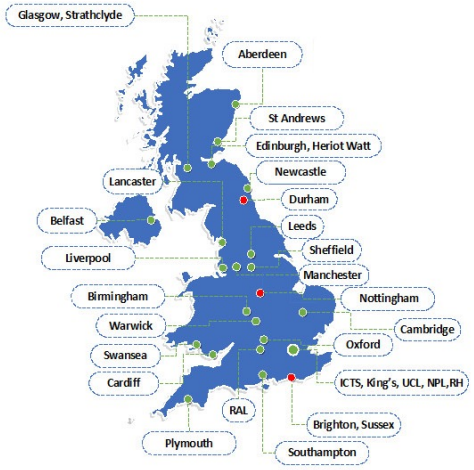
September 2019 First Call announced

January 2020 QSFP 1st School

January 2021 Successful proposals announced

November 2021 QTFP presence at NQTP Showcas

September 2022 Successful second call proposals announced

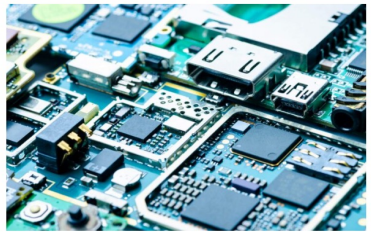


QSFP UK Institutions

The first Quantum Sensors for Fundamental Physics Community Workshop

Quantum projects launched to solve the universe's mysteries

£6 million to spur the UK's quantum leap

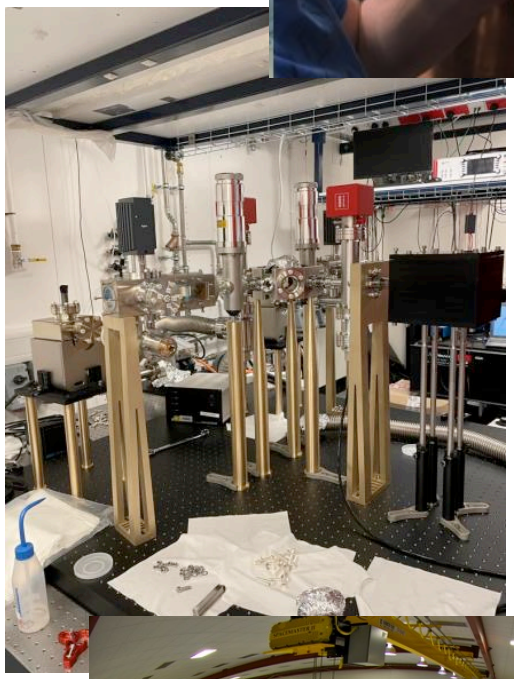


Engineering and Physical Sciences Research Council

Science and Technology Facilities Council

QTFP Objectives

- Establish a new community to exploit quantum technology for fundamental physics. Generating research outputs deemed excellent by international peer review
- Position the UK as a first rank nation in the scientific exploitation of quantum technology for physics applications
- Become an active player in the National Quantum Technology Programme (NQTP)
- Create the opportunity in the UK for new patents, new products and start-up companies as a result of developing new or improved equipment that will be needed to support the scientific work programme



UKRI Engineering and Physical Sciences Research Council

UKRI Science and Technology Facilities Council

QTFP Funding

The QTFP Programme has invested over £39m in 7 large consortia and 17 smaller projects.

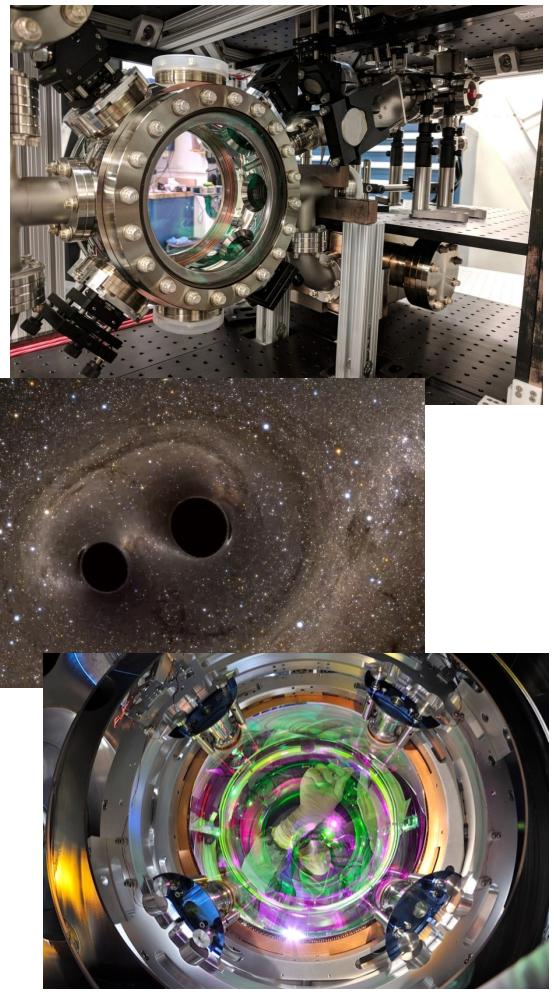
Large consortia

- AION: A UK Atom Interferometer Observatory and Network
- QI: Quantum-enhanced Interferometry for New Physics
- QUEST-DMC: Quantum Enhanced Superfluid Technologies for Dark Matter and Cosmology
- QSHS: Quantum Sensing for the Hidden Sector
- QSNET: A network of clocks for measuring the stability of fundamental constants
- QSimFP: Quantum Simulators for Fundamental Physics
- QTNM: Determination of Absolute Neutrino Mass Using Quantum Technologies

Examples of International Working

QTFP provides an opportunity for increasing international cooperation

- Atom Interferometry Observatory and Network – MAGIS (Fermilab)
- Determination of Absolute Neutrino Mass Using Quantum - Project 8 Collaboration
- Quantum Sensors for the Hidden Sector – ADMX
- Quantum Enhanced Interferometry for New Physics – Deutsches Elektronen-Synchrotron (DESY), Germany as well as collaborators across the US
- QSNET – Max-Planck Institute for Nuclear Physics, Germany
- Quantum Simulators for Fundamental Physics - project partners in Canada, Germany and Austria
- QUEST DMC – projects partners in US



Engineering and Physical Sciences Research Council

Science and Technology Facilities Council

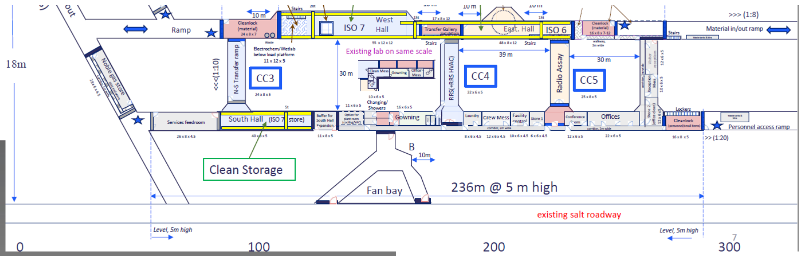
Images: Simulating eXtreme Spacetimes (SXS) Project; Stanford University; Project websites

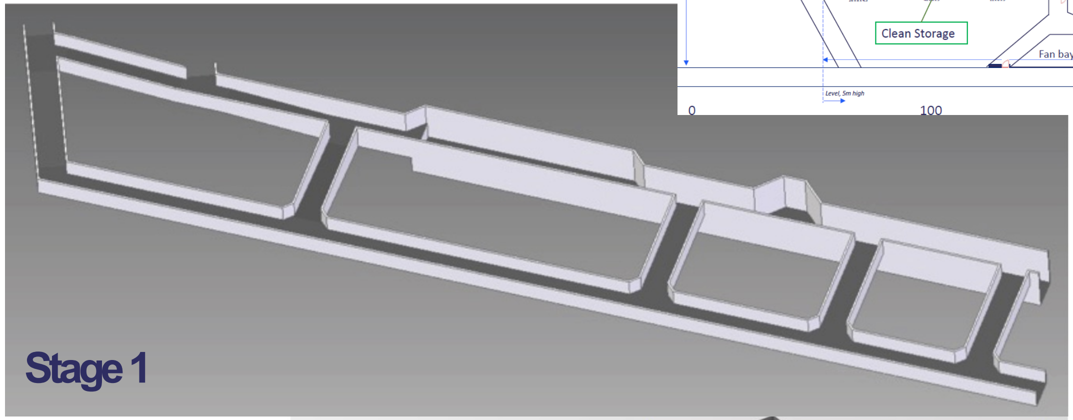
International Science Partnership Fund

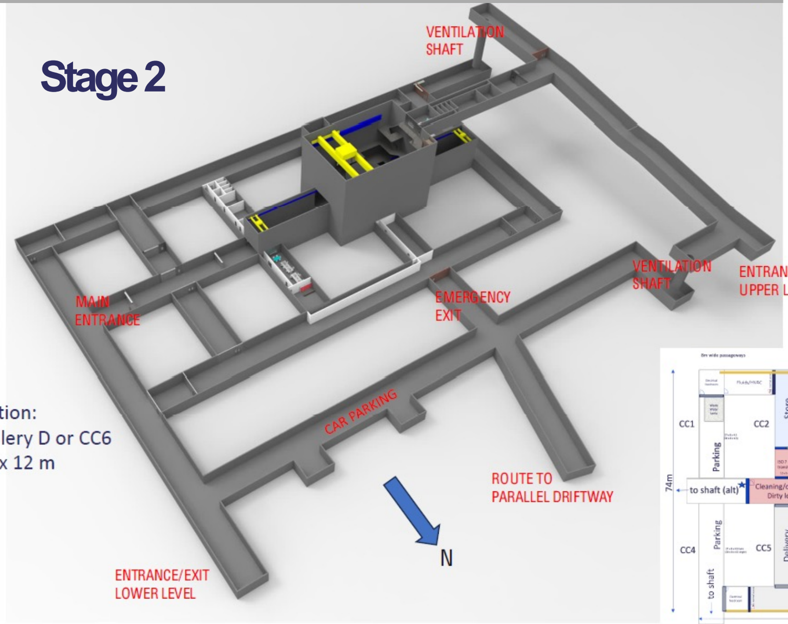
- QTFP related activities have been awarded through the International Science Partnerships Fund (ISPF) to support collaborations between UK researchers and innovators and their peers from around the world.
- Tranche 1 awards (£1.5m until FY 24/25):
  - **Quantum Software for a Digital Universe**: Collaboration between University of Edinburgh and UCSD to develop new quantum software to address fundamental physical questions.
  - **HiFAIS (High Flux Atom Interferometry Source):** Collaboration between RAL PPD/RAL Space and Stanford U. to develop new versions of a cold atom injector and quantum state preparation system.
- Tranche 3 awards (£4.55m until FY26/27):
  - 3-4 month **scientific exchange visits** awarded in FY 23/24. 14 grants awarded of which 10 are with the USA.
  - Pursuing discussions with Canada (NSERC, CFI) and USA (NSF, DOE) to fund collaborative activities starting in FY 24/25.

Boulby Development

New Facility







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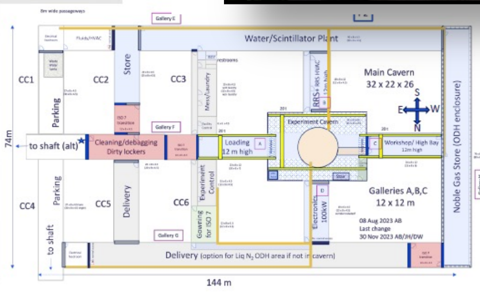

BUTTON
Technology Demonstrator

Nationa
Compu

Strategic Themes	Objectives	Deliverables	2035 Outcomes
Ecosystem	STFC will expand support for development of quantum technologies in the UK. New and existing STFC facilities will be made available to convene research communities collaborating through STFC centres of excellence, lab space, user resources, and test-beds.	• STFC expert network supports UK research excellence. • A suite of unique capabilities [SBRI @ NQCC, low-[illegible], cryo @ ASTeC etc.], driving international collaborations • A Q cluster, co-locating industrial researchers driving collaboration and accelerated discovery. • State-of-the-art Q & classical compute resources for academia and industry through on-prem and QCaaS. • Enabling the researcher community to deliver scientific excellence through QT.	• Trusted advisor to HMG on QT. • STFC integration supports UK QT pipeline. • Cutting edge, secure QT development. • 1000 Q engineers trained and accredited • 100 organisation Q cluster • On premises QC HW capable of 1m coherent operations with error correction. • STFC university researcher community becomes an expert user of QT
Science & Discovery	To stimulate and deliver quantum ideas and capabilities to advance fundamental physics, sensing beyond classical limitations and quantum computing, driving a *UK circular economy for QT*.	• Open access to QC test beds for scientific research. • Q Sensing for the very *small*, *large* or *difficult*. • Materials refinement through measurement & modelling. • Optical and satellite-based Q networking. • Support for in-orbit-demonstrations of QT. • Community of experts deploying QT for scientific challenge	• Next generation Q sensors for CERN and future particle detectors. • Improved capabilities for dark matter and gravitational wave detection. • Molecular modelling beyond current in-silico techniques. • Satellite-mediated UK Q network. • Higher yield QT fabrication through improved materials.
Applications & Engagement	To drive commercial impact and societal good through accelerated adoption of *trusted* high performance research products and services with STFC support.	• A research-oriented QC user community. • Supported industry adoption of QT. • Energy, Healthcare & Space partner advantage through early adoption of QT. • Acceleration of UKRI Net-Zero targets through the deployment of QT. • Support research council adoption of QT. • Integration of QC into UK HPC datacentres.	• 500 high impact research publications utilising STFC facilities, collaborations & partnerships. • Significant IP portfolio of high-TRL QT. • 75% UK user engagement across the 5 key industrial sectors served by QC. • BBSRC, NERC etc. are informed QT users. • UK quantum datacentres.
Fabrication & Materials	To provide nanofabrication and characterisation alongside process engineering, measurement and modelling capabilities for future impact, revolutionising materials and device deployment into quantum technologies.	• Diagnostic, test and characterisation of QT hardware. using state-of-the art equipment and techniques. • Nano-fabrication of novel materials and devices for QT. • Process engineering improving yield, quality and performance to scale QT hardware leveraging STFC strength in materials science.	• Clean-room facilities supporting semi-conductors, photonics, superconducting films • Metrology and QA supporting UK industry needs for quantum device production • Optimisation of classical technologies delivering quantum applications • Scaling QT through ASIC, control and systems integration.

Work in progress!

Some Reflections on TVLBAI

- The positive (and it's very positive)
  - Revolutionary technology for physics, astronomy, and beyond
  - Relatively low cost given the potential capabilities
  - An early and prominent example (?) of really large scale quantum technology
- The possibly less positive
  - It *is* going to take longer than we think (not technologically limited)
  - Will require significant accompanying investment in 'boring things'
    - Concrete, managers, that kind of stuff
  - In absolute terms, still expensive – so tensioning will be needed
  - QT has a tendency to break our nice system of funding silos

Some Reflections on TVLBAI

- Planning
  - Need a credible and agreed international science roadmap
  - Not all the science will come on day #1 – but incremental is good
  - What can we achieve on the way to the ‘big wins’?
- Essential that this be seen as a coherent international programme
  - Setting the context and justification for national investments

- Thanks for the invitation – I wish you a productive workshop
  - Great see a mixture of ages, disciplines, nationalities at this important event
  - The future looks bright – and dark 😀

Science and Technology Facilities Council