National Quantum Computing Centre

Annual Report **2025**

> "We are delighted to be one of the first UKRI centres to receive a 10-year commitment from government to our ambitious programme in pursuit of large-scale fault tolerant quantum computing."

International Year of Quantum:
breakthroughs, investments and celebration

As we reach the conclusion of 2025 – the International Year of Quantum – I was delighted to see the Nobel Prize in Physics awarded to John Clarke, John Martinis, and Michel Devoret for their pioneering work on energy quantisation and macroscopic quantum tunnelling. Their groundbreaking research in refining, controlling, and exploring the quantisation of energy states within superconducting electrical circuits sparked a global effort to develop quantum information processing as we know it today.

Recent advances in quantum error correction across trapped ions, superconducting circuits, and neutral atoms – along with record two-qubit gate fidelities, scalable qubit arrays, and demonstrations of verifiable quantum advantage – illustrate both the remarkable progress achieved and the innovation still required to realise fault-tolerant, large-scale quantum computing.

In 2025, private investment in quantum computing reached unprecedented levels, with $7.84 billion raised through venture capital since January – over $1 billion more than the previous decade combined – building on strong global government commitments. Yet, despite these resources and accomplishments, it is increasingly evident that no single corporation or country will achieve scalable fault tolerance alone.

At the NQCC, we continue to collaborate across the UK ecosystem to define the critical steps toward fault tolerance and to convene industry, government, and academia in partnership – core to our mission. Over the past year, we have expanded international collaboration, signing a memorandum of understanding with Japan's AIST and strengthening ties through the US-UK Tech Partnership announced during the September State Visit. We are also developing new European partnerships through projects on transduction and multiplexing.

This year marked the completion of the deployment phase of our quantum computing testbed initiative, with all seven commercial partners now operational. Together with the Quantum Software Lab at the University of Edinburgh, we have entered the technical test and evaluation phase, developing verification protocols to assess performance at component, system and application levels.

Beyond technology, we are scaling the user community through our **SparQ** readiness programme. Our 2025 initiatives include publications on quantum computing for healthcare, energy, and fintech, alongside case studies, hackathons, and workforce development through skills programmes, PhDs, and secondments.

2025 has been a pivotal year for quantum computing – one of extraordinary achievement and momentum as we enter the second century of quantum discovery.

Dr Michael Cuthbert
Director, NQCC

The **NQCC**

> The National Quantum Computing Centre (NQCC) facility, which opened on the Harwell Campus in 2024, is a focal point for quantum computing in the UK. The landmark building is providing a world-class research centre that attracts collaboration and engagement from across the UK and internationally.

Programme highlights:

60
Scientific publications, pre-prints, technical reports, and white papers

£8.6m
Leveraged funding secured by businesses on the back of initial funding from NQCC

6
Policy reports

3
Successful externally funded project applications with NQCC as technical partner.

77+
Highly skilled jobs

27+
Highly skilled jobs created in external organisations

133+
Organisations partnered with NQCC

Business impact:
Inward investments, co-location and industrial value creation

Our journey

2020

- NQCC Strategic Intent released
- Official launch of NQCC as an UKRI centre
- Leadership Team appointed; Governance structure established
- NQCC programme setup completed
- Internal technology roadmap developed

2021

- Internal development of Trapped Ion Quantum Computing initiated
- MOUs signed with QCS Hub and Oxford Quantum Circuits
- First NQCC 'Proof of Concept' projects awarded to explore applications of QC
- Internal software and control architecture project initiated to develop standards, benchmarking suite, algorithms and QuEST simulator

2022

- Internal development of Superconducting Circuits begins
- Launch of NQCC **SparQ** – quantum readiness programme
- Three NQCC-funded Fellowships delivered through EPSRC
- Two quantum courses launched in partnership with University of Bristol
- First NQCC Quantum Hackathon held to bring together coders and industry mentors to tackle practical challenges using QC
- £41M uplift to NQCC funding through Technology Mission Fund and Quantum Strategy

2023

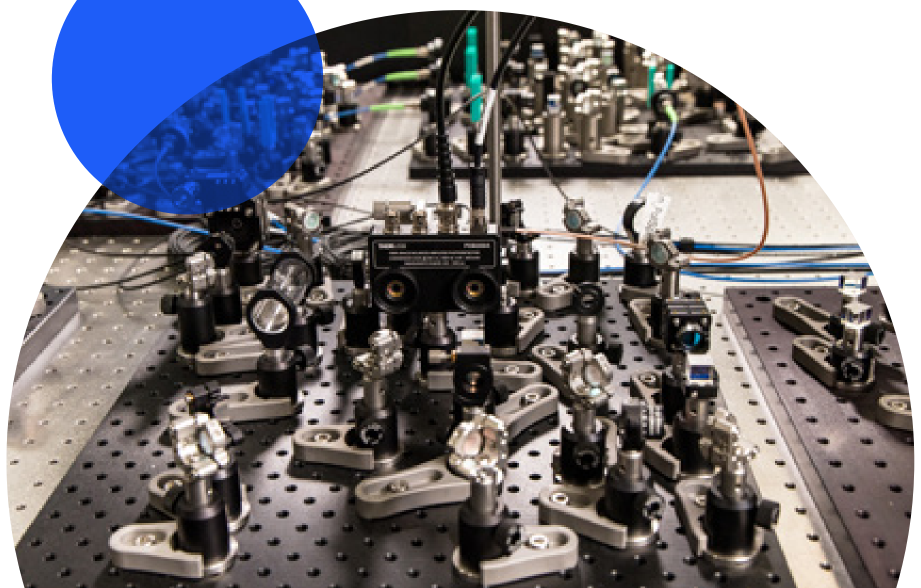
- MOU signed with the National Physical Laboratory
- Online quantum skills course launched using Q-CTRL's Black Opal
- 18 projects for feasibility studies in QC applications awarded (£5.65M total funding)
- Quantum Software Lab established through a strategic partnership with University of Edinburgh
- NQCC Innovation Hub opened at Harwell Campus as a dedicated collaborative R&D facility
- Contracts signed for cloud access to QC platform including with IBM

2024

- Internal development of Neutral Atom Quantum Computing begins
- £30M awarded to 7 companies to develop quantum testbeds, delivered through Innovate UK
- NQCC develops STATES principle for responsible and ethical development and use of QC and launches Responsible Quantum Industry Forum (RQIF)
- NQCC facility becomes fully operational
- NQCC Doctoral Studentship Scheme launched
- NQCC Quantum Computing Access Programme launched for access to cloud QC resources
- First superconducting qubit demonstrated by the NQCC internal team
- NQCC achieved a 'green' rating in the Gateway 4 review, confirming strong delivery confidence and implementation approach.

2025

- Seven quantum testbeds successfully delivered, and the technical test and evaluation commences
- High-Performance Computing (HPC) deployed at the NQCC
- NQCC Insights Paper on the convergence of quantum computing with healthcare and pharmaceuticals published
- NQCC launched a wide range of initiatives during the International Year of Quantum including: 2-month long Quantum Fringe festival at Edinburgh, NQCC's first work experience placement programme, and participated in several outreach and industry events
- Neutral Atom Quantum Computing Laboratory established
- NQCC Quantum Computing Use Case Compendium published highlighting 19 collaborative R&D use cases
- NQCC internal development results in a publication "A comparison of calcium sources for ion-trap loading via laser ablation"
- NQCC's governance evolves to suit operational 'Business as Usual' phase of NQCC
- NQCC becomes one of the first organisations to receive a 10-year funding commitment from the UK government
- NQCC launches new 'Quantum Advantage Objectives' for the next 5 years to scale ambition for the centre



Technology development highlights

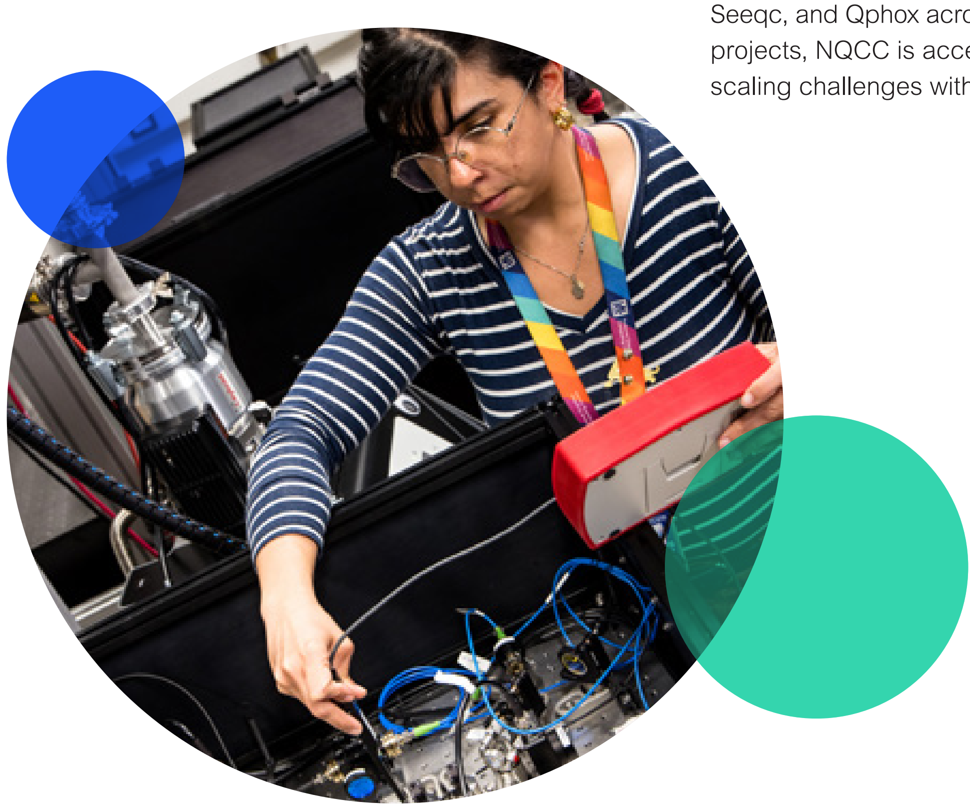
> Bringing together hardware and software innovators to advance testing and benchmarking, and apply quantum computing technologies for today and tomorrow

NQCC workstreams: from **qubits** to **quantum applications**

The NQCC is driven by the UK's ambition to become a global leader in quantum computing. By building the sovereign capabilities needed to develop quantum technologies, NQCC is enabling the UK to address complex challenges in transformative new ways. Since its launch, NQCC has been a key contributor to the UK's quantum strategy, and has played an integral role in its delivery.

Hardware: Building the quantum core

To accelerate the development and scaling of quantum computers, NQCC has adopted a strategic two-pronged approach. First, we have developed deep expertise and sovereign capabilities through R&D within the NQCC, enabling both technological independence and collaboration with the wider research community. Second, we have partnered with industry to de-risk development and provide dedicated testbeds for deploying and evaluating quantum computers at the NQCC facilities, helping to support the growth of the quantum ecosystem.



NQCC has accelerated development efforts in superconducting circuits, ion traps and neutral atoms, the current three most promising modalities to deliver quantum computing, and has built expertise in systems design, with a view towards scaling. The NQCC's ion trap lab focuses on modular systems, high fidelity gate control and scaling, and has benefitted from key partnerships with Nu Quantum, the University of Oxford and the National Physical Laboratory. One key advancement is the development of modular laser systems, which can be mounted in a standard rack, to enable more flexibility during the assembly.

Funding secured to progress scaling of superconducting quantum computing

The NQCC has completed the set-up of three dilution refrigerators, which are now operational in its superconducting circuits quantum computing lab. NQCC researchers have tested multiple uncoupled and coupled multi-qubit devices, and are building in-house capability and expertise in the process. In addition, by partnering with Rigetti, Seeqc, and Qphox across three Innovate UK funded projects, NQCC is accelerating development on scaling challenges within quantum computing.

Accelerating **ion-trap quantum computing** through technology transfer and capability development

Organisations involved:
NPL; NQCC

Through a strategic partnership with NPL, the NQCC has been able to accelerate its research on ion-trap quantum computers. Funding secured through a joint application to the Government Office for Technology Transfer (GOTT) enabled us to transfer an NPL-developed ion microtrap to the NQCC.

Ion trap researchers at the NQCC benefitted from two knowledge transfer secondments, which helped them to set up the device and trap the first ions, demonstrating the successful running of the platform. Continuing research at the NQCC will focus on harnessing the unique properties of strontium atoms to advance the capabilities for qubit storage; in particular, how multiple qubits might be stored within a single strontium atom to increase the information density for more scalable quantum computing.

> **"NPL has spent nearly 20 years developing this ion trap design. It is a precision engineered, microfabricated device the size of a computer chip, mounted in secure packaging, a vacuum chamber, and positioned within a set of lasers and mirrors. The species we're dealing with, strontium, offers three different ways to envision a qubit in the atomic level structure and NQCC is keen to investigate whether they can combine these three approaches. That could make running some quantum algorithms much more efficient"**
>
> **Dr Alastair Sinclair**
> Principal Scientist, NPL

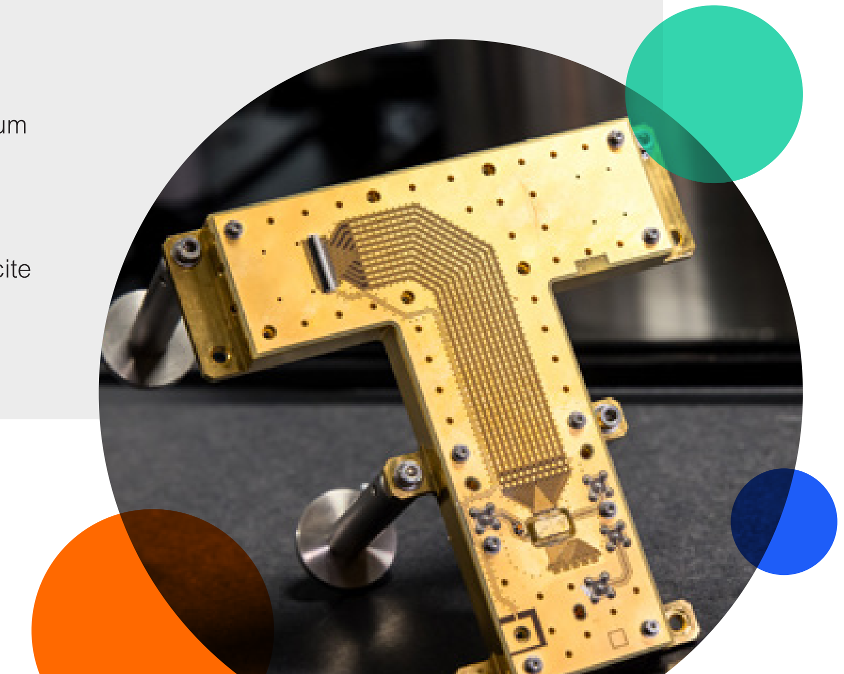
A comparison of calcium sources for ion-trap loading via laser ablation

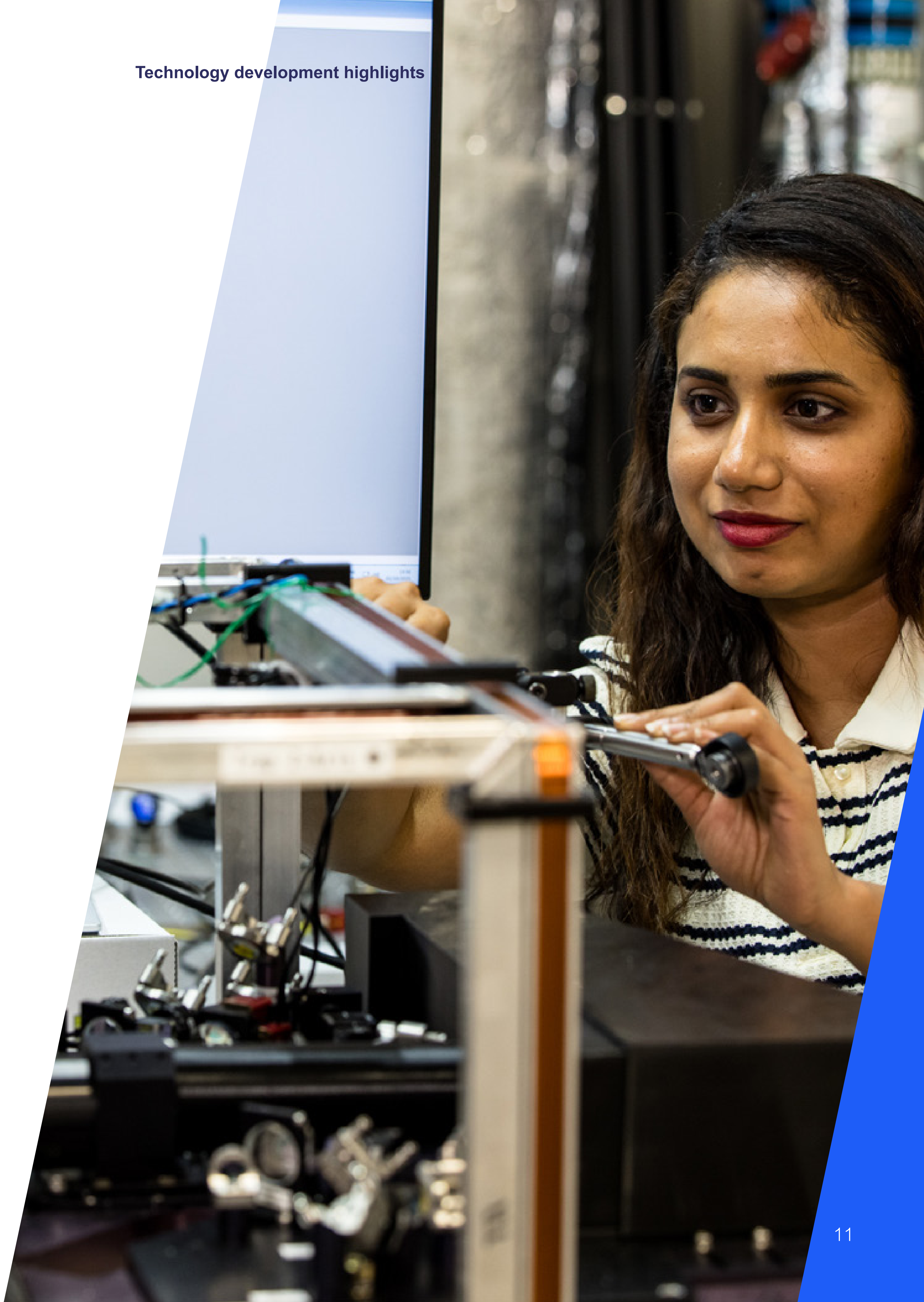
Research and development work by the NQCC's ion trap researchers was published in Applied Physics B. This study compares six calcium sources for ion-trap loading via laser ablation, evaluating the yield, temperature, and ease of use. Pure calcium and black calcite provided the highest yields, while white calcite and pure calcium produced the lowest plume temperatures.

For surface traps, white calcite and pure calcium yielded the most trappable atoms, with white calcite powder is recommended for its practicality and stability. For 3D traps, pure calcium and black calcite were optimal.

These findings are relevant not only for calcium but also for other fast-oxidising metals like strontium and barium, particularly when using expensive isotopically enriched targets.

https://doi.org/10.1007/s00340-025-08521-z





Novel approaches to overcoming **scaling challenges** through collaboration

Organisations involved:
Rigetti UK; QphoX; NQCC

A QuantEra collaborative project funded via Innovate UK and involving NQCC aims to demonstrate a viable path to scalable quantum computing by integrating optical readout into superconducting platforms.

To solve problems that are beyond the reach of today's supercomputers, it is essential to develop quantum processors at the scale of 1,000 qubits or more. Achieving this scale with sufficient gate fidelity is critical for testing prototype quantum error correction schemes, which are foundational to building fault-tolerant quantum systems. At this level of complexity, quantum algorithms can no longer be simulated on classical computers, marking a transition point where quantum processors begin to demonstrate truly useful computation.

For superconducting quantum processors, one of the most pressing technical challenges is integrating such large-scale systems within commercially available dilution refrigerators. New large-format fridges, such as the Oxford Instruments QX and Bluefors KIDE systems, offer promising platforms, but they impose strict constraints on thermal budgets. A major contributor to thermal load is the readout circuitry, which typically relies on numerous semiconductor amplifiers. These components generate heat and require extensive cabling, making it impractical to scale to 1000 qubits within current cryogenic infrastructure.

To address this bottleneck, a novel approach is proposed: replacing traditional readout mechanisms with an optical readout system. By converting microwave signals to the optical regime using a transducer, the quantum information can be transmitted via optical fibre out of the cryostat. This method eliminates the need for active amplifiers and coaxial cables inside the fridge, significantly reducing thermal conductivity and heat generation. The result is a more scalable and thermally efficient architecture for large-scale quantum processors.

This project has established a unique collaboration between the NQCC and two commercial organisations: QphoX, a Netherlands-based startup developing cutting-edge microwave-to-optical transduction technology, and Rigetti UK, a company specialising in the development of superconducting quantum computers.

Effort to remove bottlenecks in **error correction** through superconducting quantum computing

Organisations involved:
SEEQC UK; Cambridge Consultants; NQCC; Oxford Instruments; Rigetti UK; University of Edinburgh

This collaborative project, funded by Innovate UK through the Quantum Missions pilot: Quantum Computing and Quantum Networks call, is working towards an efficient methodology for quantum error correction (QEC).

To meet the UK Government's ambitious target of achieving a quantum computer capable of 1 million quantum operations by 2028, and to enable further scaling to 1 trillion quantum operations by 2035, quantum computers must be equipped with highly efficient protocols for QEC. QEC is essential for maintaining the integrity of quantum information, which is inherently fragile and prone to rapid decoherence. It works by continuously monitoring and correcting errors through the readout of 'syndrome qubits'. The speed and fidelity of this readout process are critical, since any delay or inaccuracy can allow errors to accumulate, and ultimately compromise the computation. This challenge is universal across all qubit modalities and represents a key bottleneck in scaling quantum systems.

The project addresses this bottleneck by integrating SEEQC's scalable readout technology with Rigetti UK's superconducting quantum computing platform. The result is a full-stack QEC readout testbed system designed to demonstrate a clear upgrade path for qubit readout performance. By enhancing the speed and quality of error detection and correction, the system lays the groundwork for scalable quantum computing architectures. This collaboration advances the technical readiness of UK quantum infrastructure.

> **"Developing high-performance quantum error correction is critical to achieving fault-tolerant quantum computing, and this project provides an ideal environment to advance those capabilities.**
>
> **By integrating our QEC stack with Rigetti and Seeqc technology, we aim to achieve measurable improvements in key performance metrics, including throughput, latency, and decoding accuracy, which are essential for real-time error correction. We look forward to making significant progress through this collaboration."**
>
> **Dr Steve Brierley OBE**
> CEO & Founder, Riverlane

Scaling the performance of **neutral atom quantum computing**

Partners:
Infleqtion, Fraunhofer Centre for Applied Photonics, NPL, University of Strathclyde, QSL

After the successful deployment of the quantum computing testbed at the NQCC, Infleqtion has been awarded a second UK government grant to enhance the performance of its SQALE neutral atom quantum computing platform. The £2.2 million project, named SQALE2, focuses on increasing gate processing rates by a factor of 10–100 through the development of advanced optical and control technologies. These improvements are intended to support faster and more efficient execution of quantum circuits, contributing to the scalability of neutral atom systems.

The 12-month programme is being delivered in collaboration with UK research institutions. The key technical focus will be to enable quantum gates to be executed in parallel, which is expected to improve both circuit speed and fidelity.

Infleqtion's platform exploits arrays of laser-controlled neutral atoms, offering advantages in stability, flexibility, and scalability compared to solid-state qubits. Independent benchmarking and verification of performance improvements will be carried out by partner institutions using both standard and custom-developed tools. This project supports the UK's broader strategy to develop scalable, application-ready quantum technologies.

> **"Neutral atom systems have long demonstrated compelling architectural advantages. This project shows that performance and speed can scale too, thanks to the strength of the UK's collaborative innovation ecosystem."**
>
> **Dr Ryan Hanley**
> General Manager, Infleqtion UK

Software and **control systems**

The NQCC's Software and Control Systems group aims to produce high quality solutions across different quantum systems with secure and scalable integration of third party modules when needed. The focus is on providing an easy-to-use library of software, control systems and flexible modules, with significant progress made towards developing a robust and scalable software infrastructure.

Central to this progress is the development of Kwon, a modular and extensible framework designed to integrate a wide range of quantum technologies and streamline the deployment of quantum applications. Key progress includes:

Framework development: The team has delivered a foundational "skeleton system" that supports both in-house and third-party components. This architecture enables seamless integration across a wide range of quantum hardware and software platforms.

Technology integration: Kwon now supports multiple programming languages (including Python, C++, Rust, and C#) and interfaces with leading quantum toolkits such as Qiskit, Pennylane, and TKET. It also includes a user-friendly web portal for job configuration, execution, and results analysis.

Application enablement: The system supports a growing suite of quantum applications, including execution of quantum circuits using Open Quantum Assembly Language, Shor's algorithm, and benchmarking tools. Emulation support includes Quantum Exact Simulation Toolkit (QuEST) and Qiskit AER, with future plans for advanced algorithms like QAOA and analogue computing.

Hardware compatibility: Kwon is being actively tested with a range of quantum computing testbeds, including systems from Aegiq, ORCA, Oxford Ionics, Rigetti, and others. It also integrates with open-source control systems such as Advanced Real-Time Infrastructure for Quantum physics (Artiq) and Quantum Universal Baseband Integrated Controller (QubiC).

Quantum Computing as a Service (QCaaS): Kwon supports the QCaaS platform, including IBM and Infleqtion, enabling remote access to quantum resources and expanding deployment options.

Scalability and extensibility: Designed with scalability in mind, Kwon leverages open-source technologies and standardised extension points to ensure long-term adaptability. This positions the platform to support real-world quantum applications and future quantum modalities.

Algorithms and **applications:** investigating challenges using quantum algorithms

The NQCC's focus on scaling encompasses both technology development and growing the user community for quantum computing.

Building expertise in application discovery and developing a strong user base in the UK are the core objectives of the **SparQ** programme. Through projects and strategic engagements with targeted sectors, NQCC has been identifying use cases to demonstrate the value of quantum computing.

> **"With internal air temperatures reaching 2000C, beyond the melting point of the materials we use, jet engines are a hostile environment for its components. Our current state-of-the-art materials have taken many years to develop, and we continually seek improvements in their properties to deliver more efficient engines. Quantum computing has the potential to revolutionise our ability to understand and design new materials."**
>
> **Professor Leigh Lapworth**
> Fellow in Computational Sciences, Rolls-Royce

A technical review of quantum computing use cases for finance and economics

Organisation: NQCC

Quantum computing is increasingly viewed as a promising tool for solving complex, high-dimensional problems in finance and economics, where classical methods often face scalability and efficiency limits. This review surveys quantum algorithms and maps them to practical use-cases across banking, investment, risk management, and macroeconomic forecasting, with a focus on identifying pathways toward Practical Quantum Advantage (PQA).

The review presents a structured analysis of quantum algorithms, including simulation, optimization, machine learning, and cryptography, and connects them to sector-specific applications such as option pricing, portfolio optimisation, credit risk analysis, and fraud detection. The review also explores emerging concepts like quantum assets and quantum money, suggesting future financial instruments native to quantum systems.

While current limitations in hardware, data access, and benchmarking remain, the document outlines a roadmap for interdisciplinary collaboration and highlights areas where early gains may be achievable as quantum technologies mature.

Awaiting upload to arxiv

High performance computing at the NQCC

A major deliverable this year was to tender, procure and install a high performance compute (HPC) system at the NQCC. Providing local high-bandwidth, low latency computing capability, this in-house cluster enables NQCC developers and partners to use dedicated HPC alongside on-site quantum computing resources.

A shared storage system supports high-speed data access from the HPC, ensuring consistent and efficient data handling across research and operational environments. These systems are housed in the NQCC's Business IT Suite, a resilient data centre with redundant power and cooling, and infrastructure to recover and reuse heat from the HPC. A robust network infrastructure underpins the HPC, storage, laboratories, and testbeds, enabling secure access and collaboration.

Digital quantum-classical interface achieves 1,000× data efficiency in quantum error correction

SEEQC, NQCC, and NVIDIA have demonstrated a first-of-its-kind digital interface system that connects SEEQC's quantum hardware directly with NQCC's high-performance computing infrastructure. This marks a major milestone in enabling scalable quantum error correction. The system integrates SEEQC's fully digital quantum–classical interface with GPU-accelerated decoders from NVIDIA's CUDA-Q platform, achieving real-time, ultra-low latency error correction with data throughput of up to 1,000 times greater than analogue systems.

By hosting the system at NQCC, it benefits from co-location with cutting-edge HPC resources, showcasing the UK's leadership in quantum-HPC integration and paving the way for energy-efficient, scalable quantum computing as well as quantum-enhanced AI.

> **"This all-digital integration will take advantage of each system for a low-latency interface while maintaining the highest possible bandwidth performance from each individual system. The development we're taking on with NVIDIA represents the best of breed in both quantum and classical; and, together, both core technologies create unprecedented compute power."**
>
> **Dr John Levy**
> CEO and co-founder, SEEQC

Accelerating quantum computing **research** through **cloud access** to quantum computing platforms

The NQCC's Quantum Access Programme (QCAP) provides access to assured quantum compute services to grow the UK's user community for quantum computing, and is an integral part of the NQCC's SparQ programme. SparQ seeks to support quantum readiness by facilitating access to a range of quantum platforms.

Users in the UK can apply to use both quantum hardware and simulators from leading technology providers, including IBM, Rigetti, IonQ and D-Wave. Access is available to UK universities engaged in quantum research, and partners involved in industry-led collaborative projects under the NQCC's **SparQ** use case discovery initiatives.

18
Number of academic institutions

60
Number of academic projects

96
Number of users

Real-Time Scattering on Quantum Computers via Hamiltonian Truncation

Organisations: Durham University and University of Cambridge

Cloud access provided by NQCC: IonQ quantum computing platform through AWS cloud

This paper presents a quantum computational framework for simulating real-time scattering processes in 1+1-dimensional scalar ϕ^4 quantum field theory using the Hamiltonian Truncation (HT) method. HT approximates the Hilbert space by truncating the energy eigenbasis of a solvable reference Hamiltonian, enabling simulations with significantly fewer qubits compared to traditional lattice-based approaches.

The authors develop and validate a quantum algorithm for preparing initial wavepacket states via adiabatic evolution from the free theory to the interacting regime.

Simulations performed on both quantum emulators and the IonQ Aria 1 trapped-ion quantum computer demonstrate the ability to capture wavepacket dynamics, interference patterns, and particle production following collisions.

The HT method shows strong qubit efficiency, reducing requirements by up to a factor of 40 for equivalent energy scales or precision, while circuit depth scales less favourably due to the non-local structure of the truncated Hamiltonian. Nonetheless, the sparsity of HT Hamiltonians opens the door to alternative simulation algorithms that may mitigate depth scaling in future implementations.

Overall, the study highlights HT as a promising approach for quantum field theory simulations on near-term quantum devices, with clear pathways for improvement through hardware advances and algorithmic innovation.

https://doi.org/10.48550/arXiv.2505.03878

Successful **deployment of seven quantum computing testbeds** at NQCC, move to technical test and evaluation

The NQCC funded seven quantum computing testbeds through a £30 million investment via Innovate UK, which have now been deployed at the NQCC.

The primary objective was to develop prototype quantum computing platforms for benchmarking, verification, and exploratory applications development. These systems establish five of the most promising quantum computing modalities at the NQCC, allowing the testbed companies to demonstrate and validate their technologies.

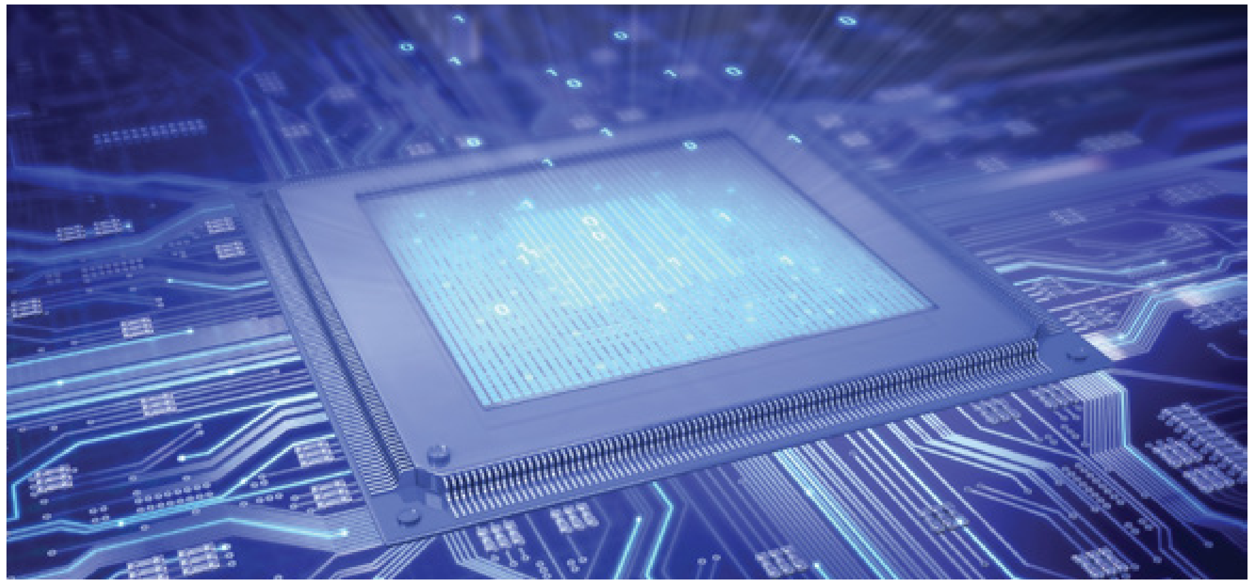
The successful deployment of the seven prototype systems to the NQCC is a result of the considerable effort of the teams within those organisations, alongside dedicated project oversight and facilities provision by the NQCC.

Within the funding process the NQCC has undertaken the role of an alpha customer, working with the testbed companies to address challenges and assure the technical quality and feasibility of the deliverables, providing expert oversight and guidance throughout the development process.

NQCC teams, in collaboration with colleagues from the Quantum Software Lab at the University of Edinburgh, are now preparing to test and evaluate these platforms for real-world applications.

This initiative has significantly advanced the development of quantum computing capability in the UK by supporting the deployment of systems at a third-party location and enabling early-stage testing. While it is still early for the broader impacts of the programme to fully materialise, the testbeds are already showing positive effects on the quantum ecosystem. These include accelerated product development, faster routes to market, increased turnover, high-value job creation, cost savings, and the attracting securing an additional £4.6 million in follow-on funding.

Notably, the initiative has been cited as a factor in the decision by QuEra, a US-based quantum computing company, deciding to establish a UK presence. While companies attract investment for a variety of reasons, the cumulative $715 million raised by testbed participants in 2025 reflects growing investor confidence – driven by the assurance that hardware developers can effectively deploy and demonstrate their technologies in a trusted, independent environment.



Testbed providers:	Modalities:
Inflegtion; QuEra	Neutral atom
Aegiq; ORCA Computing	Photonic
Oxford Ionics, an IonQ company	Trapped ions
Rigetti Computing	Superconducting circuits
Quantum Motion	Silicon spin (Quantum dots)

“By partnering with NQCC, the Quantum Software Lab (QSL) is accelerating the journey towards practical quantum advantage through integrated research, strategic partnerships and international collaboration. We aim to bring our benchmarking and verification expertise to enhance the Testbed Technical Test and Evaluation of the seven hardware platforms at Harwell.”

Professor Elham Kashefi
Chief Scientist, NQCC and Director, QSL

£30m
NQCC investment via Innovate UK

7
Testbeds across 5 technology modalities

Key **collaborations** and **partnerships**

> Accelerating quantum innovtion through strategic partnerships to drive progress in application development pipeline

Quantum Software Lab (QSL)

Launched in April 2023 and led by Professor Elham Kashefi, the NQCC's Chief Scientist, the QSL is a strategic partnership between the NQCC and the University of Edinburgh. It plays a central role in co-designing quantum software, with a core focus on practical applications, verification, and benchmarking.

QSL contributes to **SparQ**, the NQCC's user engagement programme that supports applications discovery, skills development, and provides opportunities for networking across the ecosystem, and to the NQCC's testbed initiative. The QSL lead and the NQCC co-lead the Quantum Advantage Pathfinder (QAP), advancing work in quantum-safe authentication, photonic processors, hybrid quantum-AI workflows, and quantum simulations. Joint projects have progressed from design to benchmarking, including entropy-density benchmarking, logical accreditation for fault-tolerant quantum computing, the Quantum Threat Tracker (QTT), and blind verification for trust in early quantum devices.

Partnership with QCi3 Hub

NQCC's strategic partnership with the former Quantum Computing and Simulation (QCS) Hub continues with signing of a memorandum of understanding with the new QCi3 Hub.

Both the QCi3 Hub and the NQCC are part of the National Quantum Technologies Programme (NQTP). Hence, the synergies within core areas of work will help accelerate development and performance of UK quantum computing efforts.

50+
Quantum researchers

137
QSL publications

Localized statistics decoding for quantum low-density parity-check codes

Quantum low-density parity-check (QLDPC) codes offer a promising route to fault-tolerant quantum computing with a lower overhead than surface codes. However, their practical use has been limited by the lack of efficient decoding algorithms. This work introduces Localized Statistics Decoding (LSD), a new decoder designed to address the computational bottlenecks of existing methods like BP+OSD, particularly in real-time applications.

LSD leverages the observation that, below the error threshold, faults tend to form small, disconnected clusters on the decoding graph. Instead of inverting large matrices, LSD performs local inversions on these clusters independently and in parallel. A key technical contribution is the on-the-fly elimination routine, which enables efficient matrix factorization during cluster growth without recomputing previous steps. Numerical simulations across several QLDPC code families including surface codes, hypergraph product codes, and bivariate bicycle codes demonstrate that LSD achieves decoding performance comparable to BP+OSD, while significantly reducing runtime and resource requirements. The algorithm is well-suited for implementation on parallel hardware and shows potential for real-time decoding of experimental syndrome data.

This approach improves the practicality of QLDPC codes and contributes to scalable strategies for quantum error correction.

https://doi.org/10.1038/s41467-025-63214-7

Advancing benchmarking and standards with **NPL**

Partners:
NQCC, NPL

A strategic partnership between the NQCC and NPL, formalised through a Memorandum of Understanding (MoU) that was signed in 2023, has enabled the two organisations to share a role in shaping standards, verification, and benchmarking for quantum computers. NPL is leading the Quantum Standards Network Pilot, which, in partnership with the NQCC, is helping to establish measurement protocols and international standards for emerging quantum technologies. As part of this activity, the NQCC led an initiative to define and consolidate a comprehensive suite of quantum performance metrics and benchmarks.

This work culminated in two publications and the launch of QCMet, an open-source benchmarking repository.

The NQCC and NPL have also concluded a Government Office for Technology Transfer (GOTT) project that has transferred an ion-microtrap system, originally developed at NPL, to the NQCC's lab for ion-trap quantum computing.

These activities lay the foundation for continued collaboration between the UK's national laboratories under Quantum Mission 1.

A review and collection of metrics and benchmarks for quantum computers: definitions, methodologies and software

Partners: NPL, QSL, Newcastle University, Durham University, Phasecraft Ltd, Sorbonne Université, University of Strathclyde, University of Warwick, NQCC, Royal Holloway – University of London

This paper presents a comprehensive framework for benchmarking quantum computers, developed collaboratively by the NQCC and the NPL. It addresses the challenge of objectively comparing quantum computing platforms, both gate-based and non-gate-based, by defining a structured set of performance metrics, methodologies, and reproducible software tools.

The framework categorises the metrics into ten groups, covering hardware architecture, qubit and gate quality, circuit and task execution, speed, stability, and metrics specific to quantum annealers, boson sampling devices, and neutral atom systems. Each metric is defined with a clear methodology, assumptions and limitations, and is supported by open-source implementations via the QCMet repository (qcmet.npl.co.uk).

Key benchmarking techniques include gate-set tomography, randomized benchmarking, cycle benchmarking, volumetric benchmarking, and algorithmic task evaluation. Noise modelling is addressed using density matrix formalism and Kraus operators, with provisions for both Markovian and non-Markovian noise.

The paper identifies a subset of mature metrics suitable for standardization, and proposes five areas for international coordination, including inter-laboratory comparisons and transparency in metric reporting. It also outlines the need for platform-specific benchmarks for non-gate-based systems and emerging fault-tolerant architectures.

The benchmarking framework provides a foundation for consistent and objective evaluation of quantum computing performance. It supports hardware developers, software engineers, and end-users in guiding system improvements, and also informs standardization efforts. As quantum technologies progress toward fault tolerance and practical advantage, the framework is designed to evolve, incorporating new metrics and methodologies to remain relevant and inclusive.

https://doi.org/10.48550/arXiv.2502.06717

Partnerships with **STFC** and **Harwell** to drive commercialisation and innovation

The NQCC has been partnering with STFC and Harwell on two initiatives that aim to accelerate innovation in quantum computing and to drive its commercial adoption.

Quantum Business Incubation Centre (QuBic)

A partnership between NQCC and STFC aims to support businesses in developing innovative products or services that exploit quantum technologies. QuBic provides cash funding, innovation vouchers and expert commercial coaching to provide structured support to start-up companies. Businesses supported through this initiative include Finchetto, Applied Quantum Computing, TreQ, Quantopticon, Qoro, AmorphiQ, Curenetics, Fabio Rovai and Qascade.

Quantum Cluster

The Quantum Cluster, sits under Harwell Campus Joint venture, a private-public partnership between STFC, UKAEA and Brookfield Asset Management. It has been launched to stimulate innovation and business growth in quantum technologies. It aims to leverage the presence of the NQCC and its key partners, bringing together experts from industry, academia, and government to address the challenge of scaling quantum technologies.

The Cluster has strong links to the University of Oxford and the local supply chain, including Oxford Instruments and ICEoxford. It will support collaborative R&D, promote ethical quantum development, and provide early access to quantum testbeds and computing platforms.

It will also serve as a focal point for building international partnerships with global clusters, including those in Europe, Canada, the United States, and Japan.

Harwell Quantum Cluster goals over the next decade:

1,000+
To create over 1,000 skilled jobs

£1bn
To attract over £1 billion in public and private investment

100+
To grow to over 100 quantum-focused companies

Partnerships through collaborative projects and funding

Advances in quantum machine learning and embedding techniques

Partners: Zaiku Group Ltd., Tecacet Inc., NQCC

Reverse map projections as equivariant quantum embeddings

Quantum computers process data differently from classical computers, and one of the first steps in quantum machine learning is converting classical data into quantum states. This paper presents a new family of data embedding methods inspired by cartographic map projections, which are used used to flatten the Earth's surface onto a map.

These new embeddings, called reverse map projections, preserve more information about the data than standard methods and can be tailored to respect symmetries in the data. This makes them particularly useful for improving the performance of models for quantum machine learning.

The paper defines a novel class of classical-to-quantum data embeddings that are based on reverse map projections from spheres to tangent planes. These embeddings address a key limitation of amplitude embedding, which loses information about the norm of input vectors, and allow symmetries in the data in the data to be preserved when used with appropriately designed quantum circuits. The authors prove that the embeddings are equivariant, and provide methods for using these embedding to construct equivariant quantum circuits.

The results demonstrate that embedding choice and circuit design are critical to quantum machine learning performance, especially in the noisy intermediate-scale quantum (NISQ) era. Future work will explore optimal embedding selection for different datasets and investigate the resilience of these embeddings to quantum noise.

https://doi.org/10.48550/arXiv.2407.19906

*Lead and partner organisations on projects. Does not include organisations from hackathon and engagement events

Building an **optically connected, multi-node distributed** quantum computing system

Organisations: NU Quantum, NQCC

Project IDRA, a partnership between NQCC and Nu Quantum, is specifically targeted at networking multiple quantum processors together to achieve scalable fault-tolerant quantum computing within a quantum data centre.

Scaling quantum computers to commercial utility requires billions of coherent operations across millions of qubits, while individual quantum cores (QPUs) may soon offer thousands of qubits per device. Project IDRA is exploring the most promising route to achieve further scaling by networking multiple QPUs together, which will be achieved by creating entanglement between two qubits inside different QPUs.

The project was initially awarded funding for the first two years of a four-year programme. At the end of the two years, the project team has successfully delivered the expected outcomes, particularly in de-risking the business and technical development.

The Technology Readiness Level (TRL) has increased from 1 to 2, indicating the successful transition from a conceptual entanglement scheme to the completion of a feasibility study, and laying the foundation for the next phase of the project. Based on these outcomes, Nu Quantum has secured follow-on funding for the remaining years with an award of £2 million.

> **"The UK continues to lead in the field of quantum computing, which is set to be truly transformational for our society and the planet. We're proud to be building on that base by collaborating with the NQCC to accelerate the usability and commercialisation of quantum computers, and to work together to build pioneering companies for a better future."**
>
> **Dr Carmen Palacios-Berraquero**
> Co-founder and CEO, Nu Quantum

User engagement, skills, learning and outreach

> Accelerating quantum readiness through engagement with a range of organisations and individuals from across industry, academia, government and beyond

SparQ quantum readiness programme

SparQ is the NQCC's flagship quantum readiness programme, which drives applications discovery, assists with responsible adoption, supports skills development, and provides opportunities for networking and collaboration..

SparQ aims to support the pathway to quantum readiness by building knowledge and expertise in applications discovery and developing the UK quantum computing user community.

The programme is aimed at current and future professionals in industry, business and academia, and enables technical users to gain knowledge and hands-on experience of working with quantum algorithms and real quantum processors.

28*
Number of companies collaborating across 12 proof of concept projects

>£3.6m
Leveraged private investment across NQCC-led applications challenges

Quantum Computing Use Case Compendium

This Compendium highlights the areas where we at the NQCC have been working with colleagues across government, academia and industry to investigate some of the most pressing computational challenges of our time, from advancing clean energy and sustainable manufacturing, to accelerating pharmaceutical discovery, optimising complex logistics, and underpinning resilient financial systems.

These challenges align not only with the technical frontiers of quantum computing, but also with the UK's National Missions on Net Zero, Health, Digital and Data, and the Future of Transport. Find more information on the 12 Proof of Concept projects from 2024/25, featured in the Quantum Computing Use Case Compendium on our website.

https://www.nqcc.ac.uk/wp-content/uploads/2025/06/NQCC-Quantum-Computing-Use-Case-Compendium-web.pdf

"We are delighted to have had the opportunity to work on such a potentially impactful quantum project, where the prize is to advance the effectiveness of cancer diagnostic techniques with possible future benefits in terms of earlier cancer detection and improved patient treatment."

Tim Thomas
CEO, Applied Quantum Computing

*As per the Quantum Computing Use Case Compendium, published in June 2025

Sectoral engagement for a quantum-ready economy

Sectors: Finance, Healthcare, Pharmaceuticals, Energy

The NQCC has been engaging with end users in major sectors of the UK's economy to raise awareness of the technology, build a knowledge base, and understand the opportunities and challenges of using quantum computing to address key industrial challenges.

In-depth workshops and networking events have so far focused on financial services, healthcare, pharmaceuticals, and energy, with particular application domains including optimisation, machine learning, simulation and cybersecurity. To support the development of a quantum-ready economy, the aim is to identify the most promising market opportunities, address any barriers to adoption, and understand the potential for developing cross-sector solutions.

Exploring quantum computing's potential in healthcare and pharmaceuticals

Insights Paper

This work has led to the release of the NQCC's first Insights Paper, entitled "The convergence of healthcare and pharmaceuticals with quantum computing: a new frontier in medicine".

Drawn from extensive sector engagement and contributions from the NQCC's workshop on Quantum Computing for Healthcare and Pharma (QCHP), this paper analyses the potential of quantum computing to enable more effective disease detection, improve the efficiency of healthcare services, and aid the development of novel treatment modalities. It provides key insights that will help organisations to prepare for the future deployment of quantum computing, and identifies five key priorities for accelerating adoption within the sector.

https://www.nqcc.ac.uk/insights-paper-the-convergence-of-healthcare-and-pharmaceuticals-with-quantum-computing/

Scalability Conference 2025

Technical Conference

The NQCC's second Quantum Computing Scalability Conference took place in April 2025 at Keble College, Oxford. The event is dedicated to tackling the key scalability issues across quantum platforms, from engineering challenges to advances in quantum physics. This 2025 conference brought together 250 experts from diverse quantum computing fields, fostering cross-disciplinary insights and enabling honest scalability assessments.

As the premier research-focused event hosted by the NQCC, the conference features in-depth technical talks, panel discussions, and a poster session for the first time this year. This new addition provides a platform for early-career researchers to showcase their work and contribute to the conversation.

Quantum computing for energy

Workshop

The NQCC hosted the Quantum Computing for Energy workshop to initiate collaboration, discussion, and discovery.

Bringing together voices from government, industry, and academia, the workshop explored how quantum computing could unlock new opportunities in the energy sector, while also tackling the technical and practical challenges that lie ahead. The workshop featured:

- Strategic insights from government stakeholders
- Real-world use cases from industry leaders
- Sector perspectives from across the energy ecosystem
- Interactive breakout sessions to foster open dialogue and idea-sharing

The level of engagement created a rich, cross-sector dialogue on the path to quantum adoption in energy. We're excited to keep the momentum going and continue working with the energy sector to explore and accelerate the practical adoption of quantum technologies.

Workforce, skills and outreach

The NQCC supports a range of activities to help build a quantum workforce, from outreach and schools engagement through to supporting PhD training and professional development.

Celebrating the IYQ 2025 at the NQCC

2025, marking 100 years of quantum mechanics, was declared the International Year of Quantum Science and Technology. The NQCC supported this through public engagement, including a major exhibit at the Royal Society's Summer Science Exhibition, promoting ethical, sustainable, and socially beneficial quantum computing aligned with the UN Sustainable Development Goals.

> **"The International Year of Quantum Science and Technology (IYQ) has ignited a remarkable wave of global activities to celebrate a century of quantum mechanics. In the UK, initiatives such as the UK Quantum Hackathon organised by the NQCC and the Quantum Software Lab (QSL) exemplify how the power of collaboration is unlocking the promise of quantum computing for society."**
>
> **Sir Peter Knight**
> Co-Chair, IYQ Steering Committee

The Quantum Fringe and UK Quantum Hackathon 2025

Held in collaboration with the Quantum Software Lab, the Quantum Fringe brought together students, the public, researchers, and industry experts to explore quantum computing. Central to the programme was the NQCC's UK Quantum Hackathon, now in its fourth year, where 15 teams developed quantum solutions to real-world problems with mentor support. Aligned with the UN Sustainable Development Goals, projects addressed societal challenges such as tumour prediction, fuel-cell optimisation, and accessible navigation. The winning team devised a quantum-powered road maintenance scheduler.

Overall, the Quantum Fringe strengthened collaboration and advanced the UK's quantum computing ecosystem through innovation and community engagement.

Outreach and public engagement in 2025

The NQCC's outreach and public engagement activities encompass a wide spectrum of audiences, extending the reach of quantum computing to schools, universities, and the wider public across the UK. These initiatives aim to foster greater understanding of quantum technologies and their societal applications, promote inclusivity, and cultivate the next generation of skilled quantum professionals.

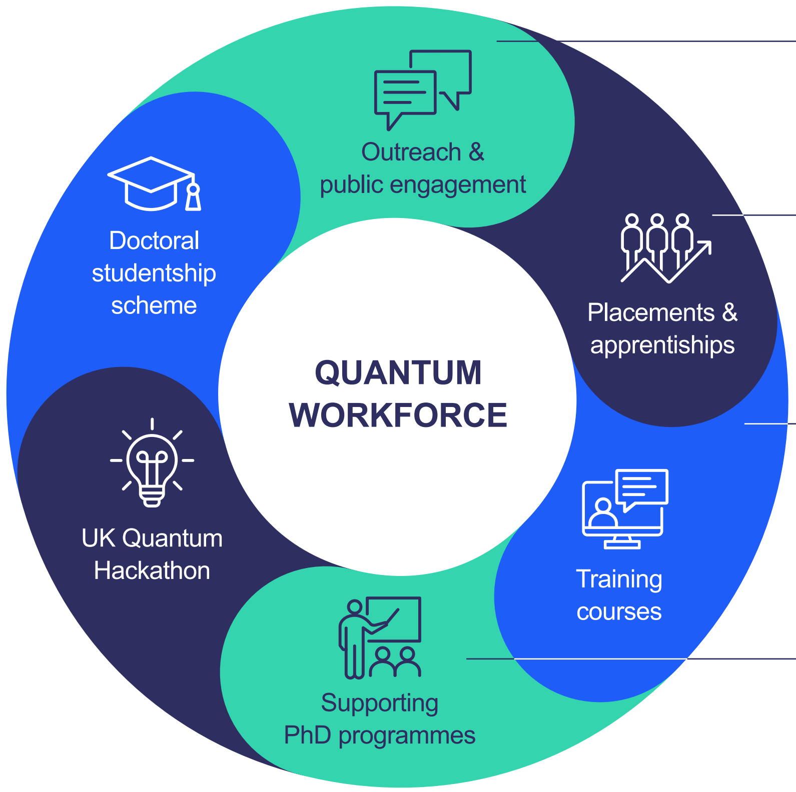
Early Careers

The NQCC continues to nurture aspiring and early-career quantum professionals through a range of placements and development opportunities. In 2025, we hosted our first work experience students – two A-level students who joined for two weeks in June – and welcomed our first master's-level placement. We also maintained our commitment to on-the-job learning through summer, industrial, and graduate placements, as well as apprenticeships.

The Quantum Zone: a collaborative public engagement exhibit

To mark the International Year of Quantum Science and Technology, the NQCC coordinated 'The Quantum Zone' exhibit at the Royal Society's Summer Science Exhibition. In collaboration with 11 partners across academia, government, and industry, the exhibit showcased quantum science through interactive demonstrations and activities grouped into three themes: quantum building blocks, building quantum technologies, and quantum in the real world.

Over six days, more than 140 trained volunteers engaged with around 7,800 visitors, helping to highlight the breadth and societal relevance of quantum technologies.



9,516
Meaningful interactions through outreach activities in 2025

13
Student placements and apprenticeships across NQCC in 2025

193
Q-Ctrl licences for online quantum skills course and 19 trained through the University of Bristol course in 2025

4
Key activities supporting PhD programmes (leading to funding 6 PhDs) in 2025

Doctoral studentship scheme

In collaboration with the EPSRC, the NQCC has established the Doctoral Studentship Scheme. Thirty students over five annual cohorts will work on cutting-edge collaborative projects co-developed by the NQCC and University partners to advance the development of quantum computing across the technology stack.

Doctoral studentship scheme (cohort 1)

The first cohort of 6 studentships were awarded to:

- Dr Gabriel Araneda and Professor David Lucas at the University of Oxford
- Dr Oliver Thomson Brown and Dr Joschka Roffe at the University of Edinburgh
- Professor Animesh Datta and Professor Tom Goffrey at the University of Warwick
- Dr Mario Gely and Professor David Lucas at the University of Oxford
- Dr Dominik Leichtle and Professor Elham Kashefi at the University of Edinburgh
- Professor Martin Weides, University of Glasgow

Doctoral studentship scheme (cohort 2)

We received over 60 project ideas for our second cohort of studentships through our expressions of interest call in June, from 30 universities across the UK, which represents a 50% increase compared to last year.

CDT and PhD training engagement

Five new Centres for Doctoral Training (CDT) for quantum were announced in March 2024, with three starting in autumn 2024 and two starting in autumn 2025. The NQCC has been engaging with these new quantum CDTs through a range of different activities, including training workshops, for example, on quantum programming and public engagement, technical lectures, visits to the NQCC, supervising literature reviews and collaborating on events.

Quantum Programming Residency 2025

A key highlight was our Quantum Programming Residency hosted at the NQCC in March 2025. We welcomed students from the Quantum Informatics Doctoral Training Programme at the University of Edinburgh for a month-long hackathon-style residency. Students gained hands-on experience in quantum programming, tackled industrially relevant use cases under the guidance of our senior quantum applications engineers, and had the chance to run their solutions on real quantum hardware.

> **"Building a skilled quantum workforce is essential to realising the full potential of quantum computing and securing the UK's leadership in this transformative field. The NQCC is committed to empowering the next generation of researchers through a range of training and development opportunities, enabling early-career scientists to tackle major challenges and advance the nation's wealth, health and security through quantum technlogy."**
>
> **Professor Gerard Milburn**
> Quantum Fellow, NQCC

Responsible and **Ethical Quantum Computing (REQC)**

One year on from the publication of the NQCC's Quantum STATES principles, we continue to progress our efforts towards enabling the responsible development and use of quantum computing.

Since launching the principles in August last year, our focus has shifted to putting them into practice. To this end, last year we delivered two series of workshops with all NQCC teams: building awareness and skills on responsible and ethical quantum computing (REQC), and identifying actions for embedding the STATES principles across our activities. The output from these workshops is now shaping an overarching REQC Action Plan, building our accountability and providing thought leadership on how to operationalise REQC.

As well as our internal efforts, we have also been working to enable responsible innovation across the wider quantum computing landscape. Last year, we established the Responsible Quantum Industry Forum (RQIF), along with industry co-chairs UKQuantum and techUK: a venue for exchanging best practices and lessons learnt in operationalising responsible innovation, building on shared principles.

This initiative has been recognised in national and international policy discussions, including in the UK government response on regulating quantum technologies, and at the launch event of the International Year of Quantum in Paris.

We also continue to place importance on training the next generation of quantum to innovate responsibly. At the UK Quantum Hackathon, REQC continues to be a core aspect, with participants asked to consider the wider implications of their use case, and build ethical considerations into their approach. REQC is also a key element of the NQCC's Quantum Programming Residency, enabled by workshops on responsible innovation.

Finally, our research on responsible and ethical quantum computing continue to progress. Drawing on lessons from our own efforts, we are developing and sharing best practices for operationalising responsible innovation, including at this years' Scalability Conference. Leveraging internal expertise, we are building knowledge on technical aspects of quantum computing ethics. Our aim is that this research will shape a future where quantum computing is developed and used responsibly, and benefits everyone.

Equality, Diversity and **Inclusion** at the NQCC

We are proud to celebrate the diversity within our staff and the inclusive practices that are becoming embedded across the organisation.

Now in its third year, the NQCC's ED&I working group continues to lead by example – championing inclusive best practices and working to break down barriers to access across the quantum ecosystem. Over the past year, the working group has launched several new initiatives designed to foster a more inclusive culture and broaden participation in the quantum industry.

New initiatives (2024–2025)

Awareness campaigns:
A series of LinkedIn posts were published to raise awareness of ED&I-related events and to showcase the positive work being undertaken across the NQCC.

Staff training and development:
All staff participated in an interactive ED&I workshop at our away day, covering key topics such as inclusive recruitment practices and cultural awareness.

Broadening access to quantum careers:
We supported a range of entry points into quantum technologies, including apprenticeships, internships, graduate roles, and summer student placements.

Cultural sensitivity guidance:
Developed internal guidance on cultural awareness during the winter holiday period to help teams plan activities and communications that are inclusive.

Event planning best practices:
We created a best practice guide for both internal and external events, covering inclusive scheduling, accessible venue requirements, diverse speaker representation, and catering considerations. This ensures events are welcoming and accessible to all.

Ongoing initiatives

Inclusive communications review:
We continue to assess our communications materials to ensure that our external presence reflects the diversity of our team and our inclusive values.

Open dialogue and support:
Regular drop-in sessions provide staff with the opportunity to raise suggestions, ask questions, and access support or signposting on ED&I-related matters.

Through the work of its ED&I Working Group, the NQCC initiates activities that raise awareness, embed inclusive practices, and ensure these values are integrated into all projects and activities.

A key outcome is the ED&I Guidance for Event Planning by Julimar Romero, an ED&I advocate and the current Chair of the ED&I Working group, developed from lessons learned to make NQCC events accessible, inclusive, and welcoming. The guide offers practical recommendations on logistics, inclusive language, accessibility, and speaker selection, and has been successfully implemented in programmes such as the quantum computing testbeds Technical Test and Evaluation workshops. In July 2025. the UKRI Project Profession awarded Juli with the Diversity and Inclusion Award, in recognition of her exceptional contributions driving excellence in project delivery across the organisation.

Leadership Team

With extensive experience of the UK's quantum technologies sector, the NQCC's Leadership Team is responsible for delivering the centre's wide-ranging programme of technology development and community engagement.

"We are delighted to be one of the first UKRI centres to receive a 10-year commitment from government to our ambitious programme in pursuit of large-scale fault tolerant quantum computing."

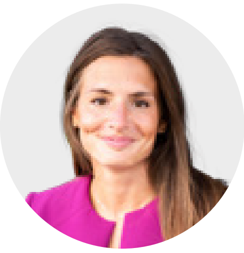
Michael Cuthbert Director

"The NQCC is committed to driving adoption of quantum computing, offering a clear analysis of the opportunities, challenges, and actions required to harness the full benefits in healthcare and pharmaceuticals, finance, energy, transportation and other sectors, as innovation continues at pace."

Simon Plant Deputy Director for Innovation

"The Quantum Software Lab is at the heart of our mission – advancing pioneering research, collaborating with industry, and training the next generation to harness quantum computing's potential in solving real-world scientific and technological challenges."

Elham Kashefi Chief Scientist



"The initial five-year programme to establish the NQCC successfully concluded in March 2025. Our latest Government-led audit concluded that 'the value and capability of the NQCC is already unequivocally clear'. The NQCC has now transitioned to a new governance structure, cementing our role as the UK's trusted authority in quantum computing."

Anne-Claire Blet Deputy Director for Programme Delivery

"As custodians of the UK's quantum computing roadmap, the NQCC is driving research priorities that will guide our journey from today's NISQ technologies toward achieving universal, fault-tolerant quantum computing."

Jonathan Burnett Deputy Director for Research

Our governance

Delivery of the NQCC's programme is overseen by the Programme Oversight Board, Strategic Advisory Committee and a Technical Advisory Group. Governance for the initial five-year programme to establish the centre was provided by the Programme Delivery Board (PDB), Programme Advisory Committee (PAC), and Technical Advisory Group (TAG).

The NQCC extends its sincere thanks to all those involved for their support, expertise, and commitment, which were instrumental in ensuring the programme's success. Their insight and guidance have been invaluable in shaping the NQCC's foundations.

In 2025, the NQCC transitioned to a new governance structure to reflect the organisation's move into a business-as-usual phase. The newly established POB and SAC, along with a reconstituted TAG, now provide governance for the centre. This structure ensures robust monitoring, oversight, challenge, and support for all NQCC activities.

Programme Oversight Board

The Programme Oversight Board (POB) oversees the NQCC's programme and activities. Chaired by EPSRC's Deputy Director for Future Communications and Quantum Technologies, Derek Craig, it includes senior sponsors from EPSRC and STFC. The POB takes a strategic role in supporting programme delivery, managing risks, and ensuring alignment with wider research council and UK National Quantum Technologies Programme activities. It usually meets quarterly, aligned with key programme milestones.

Strategic Advisory Committee

The Strategic Advisory Committee (SAC) advises and challenges the NQCC on its activities and programme. Comprising experts in quantum technologies, innovation, defence, and government, it provides informed guidance to the NQCC leadership. Meeting twice a year, the SAC supports links with the UK's National Quantum Technologies Programme, helps manage external risks, and engages with senior sponsors and stakeholders across academia, government, and industry.

Chair: Professor Ian Walmsley CBE FRS
Members: Dr Angeli Moeller; Professor Dominic O'Brien; Professor Gerald Buller; Mr Jonathan Legh-Smith MBE; Professor Julia Sutcliffe; Professor Sadie Creese; Mr Simon Andrews.

Technical Advisory Group

The Technical Advisory Group (TAG) offers independent expertise to guide the NQCC's technical roadmap and programme delivery. Comprising experts in quantum computing and related fields, it provides insight on progress at the NQCC and globally. Working with the Senior Leadership Team, the TAG reviews and updates the roadmap, advises on technical initiatives and quality criteria, and ensures the programme's technical integrity. It meets annually in line with the technical programme's approval cycle.

Chair: Professor Elham Kashefi
Members: Professor Mag. Dr Barbara Kraus; Dr Donatella Cassettari; Professor Gerard Milburn; Professor Martin Dawson; Dr Tobias Lindstrom; Professor Viv Kendon.

21
individuals provide governance

15
different organisations represented

Our **people**

> At the NQCC, people are at the heart of innovation. It's a place to connect, learn, and collaborate with experts and partners from across the globe, making the centre a thriving community for anyone passionate about advancing quantum computing.

Working at the NQCC

Working at the NQCC is deeply rewarding, offering opportunities to collaborate with diverse partners around the world while contributing to a vibrant, innovative community that is shaping the future of quantum computing research and development. The centre provides a stimulating environment that attracts global interest, making the NQCC the leading destination for quantum computing.

> **“Working at the NQCC is incredibly exciting – I get to collaborate with experts, contribute to cutting-edge quantum projects, and be part of an innovative team shaping the future of computing.”**
>
> **Caitlin O’Toole**
> Cybersecurity Apprentice, NQCC

Away Days

Collaboration

Every year, the NQCC members come together to review our progress and discuss future plans. As our organisation continues to grow rapidly, it’s important to dedicate time to strengthening our relationships and enhancing soft skills like communication and teamwork, that encourage collaboration across different teams.

NQCC Awards

Celebration

In 2025, the NQCC proudly launched the Values Awards – a fresh and inspiring initiative designed to celebrate colleagues, who truly embody our core values and help foster a vibrant, inclusive culture across the organisation. Through peer nominations, five outstanding individuals were recognised for their exceptional commitment to Objectivity, Agility, Collaboration, Innovation, and Leadership. In addition, the Team Award was introduced to honour cross-functional teams, that exemplify unity and collaboration.

Rounders’ Club

Well-being

The NQCC rounder’s team, Qubats, competed in the Harwell Campus summer rounders tournament for the third year, getting through to the finals! The team is open to all who work at the NQCC, with no previous experience of this rather niche British sport necessary! The team is led by Emma Athawes, Georgina Croft and Yashna Lekhai. This is a great way to develop working relationships across NQCC teams and meet others from the campus.

Tuesday Cake Club

Social

Each week we take a brief break to unwind and socialise over a sweet treat. Many have embraced the challenge of home baking, with fantastic results, and some have used the opportunity to share dishes from their own cultures. As we grow, fostering social cohesion remains important to us. These moments allow us all to connect on a personal level and chat.

Quantum Hourglass

Technical

The Quantum Hourglass is a new seminar series established to share and highlight the diverse work taking place across the NQCC and around the quantum ecosystem.

Featuring a range of speakers from both technical and non-technical backgrounds, the series provides a platform for all staff to share the essential work enabling quantum computing to thrive at the centre. Its goal is to make the science and daily operations of quantum computing accessible to everyone, fostering a broader understanding of the NQCC’s mission. By promoting collaboration and simplifying complex topics, the series keeps all staff engaged with the cutting edge of quantum technology.

Looking **ahead**

> By 2035, there will be accessible, UK-based quantum computers capable of running 1 trillion operations and supporting applications that provide benefits well in excess of classical supercomputers across key sectors of the economy.

In pursuit of **Quantum Advantage**

In June, the UK government published its Industrial Strategy along with a Digital and Technologies Sector Plan. As part of this, a £670m investment was announced, including a 10-year funding settlement for the NQCC to accelerate the impact of quantum computing. The 10-year commitment to the NQCC included the expectation for the NQCC to expand our work on quantum computing development, readiness and adoption.

Aligned to this expectation and in support of National Quantum Mission 1 (Computing) we have developed ongoing work plans across five programmatic themes, each with detailed metrics tracking progress, indicating technology maturity, investment, outcomes and impact.

Interwoven with the delivery of Quantum Mission 1 are many of the NQCC's ongoing programmes: specifically, the quantum computing testbed initiative, our industry facing **SparQ** programme, our skills programme and our quantum computing access programme.

Expanding the NQCC Programme

As we extend the testbed initiative from the deployment phase, we are now making each platform accessible to our in-house applications team and our collaboration partners at Quantum Software Lab, University of Edinburgh. In collaboration, the team have built a comprehensive technical test and evaluation protocol at device, system and application level. We see an opportunity to extend this work, providing independent third party evaluation of commercially available quantum processors as well as extend the hardware deployment, bringing new players into the testbed initiative as well as upgrading existing platforms as the technology progresses.

We will extend the **SparQ** programme to bring new industrial players into quantum computing, large and small, as well as explore new industrial sectors identifying use cases and opportunities for economic and societal impact.

Aligning this effort to each of the high value sectors identified in the Industrial Strategy extends the work we have in progress and gives us new target sectors to examine.

In collaboration with EPSRC, we will continue to support our early cohorts of Industrial Doctorate Landscape Awards sponsored PhDs and new cohorts of continuous professional training candidates, as well as work experience students, apprenticeships and graduate placements as partners in the STFC Skills Centre.

Through our QCAP programme, we are seeking to continue to grow user adoption with institutional partnering for researchers, as well as new rounds of industry-led proof of concept projects. Building longer term collaborations on applications and algorithms is a key element to be developed in the coming year.

MegaQuOp and beyond

As we embark on our 10-year vision towards large-scale fault tolerant quantum computing we will continue to drive our technical programmes, identifying technical bottlenecks, market and supply chain failures as well as implementation of error correction, benchmarking and verification techniques across the stack.

> **"The Digital and Technologies Sector Plan provides real focus for the UK quantum computing industry. It is a powerful signal of government ambition to make quantum computing a critical technology of the future and for the UK to be a key international player in its development and explotation."**
>
> **Dr Michael Cuthbert**
> Director, NQCC

Publications

Learning Quantum Processes with Quantum Statistical Queries
Chirag Wadhwa and Mina Doosti (2025)
https://doi.org/10.22331/q-2025-05-12-1739

A Practical Cross-Platform, Multi-Algorithm Study of Quantum Optimisation for Configurational Analysis of Materials
Kieran McDowall, Theodoros Kapourniotis, Christopher Oliver, Phalgun Lolur, and Konstantinos Georgopoulos (2025)
https://doi.org/10.48550/arXiv.2504.06885

A Technical Review of Quantum Computing: Use-Cases for Finance and Economics
MQ Hlatshwayo, Manav Babel, Dalila Islas-Sanchez, Konstantinos Georgopoulos (2025)
awaiting upload to arXiv

Real-Time Scattering on Quantum Computers via Hamiltonian Truncation
James Ingoldby, Michael Spannowsky, Timur Sypchenko, Simon Williams, Matthew Wingate (2025)
https://doi.org/10.48550/arXiv.2505.03878

A Review and Collection of Metrics and Benchmarks for Quantum Computers: definitions, methodologies and software
Deep Lall et.al. (2025)
https://doi.org/10.48550/arXiv.2502.06717

Localized statistics decoding for quantum low-density parity-check codes
Timo Hillmann, Lucas Berent, Armanda O. Quintavalle, Jens Eisert, Robert Wille & Joschka Roffe (2025)
https://doi.org/10.1038/s41467-025-63214-7

A comparison of calcium sources for ion-trap loading via laser ablation
Daisy R. H. Smith, Silpa Muralidharan, Roland Hablützel, Georgina Croft, Klara Theophilo, Alexander Owens, Yashna N. D. Lekhai, Scott J. Thomas & Cameron Deans (2025)
https://doi.org/10.1007/s00340-025-08521-z

Heuristic-free Verification-inspired Quantum Benchmarking
Johannes Frank, Elham Kashefi, Dominik Leichtle, Michael de Oliveira (2025)
https://doi.org/10.1088/2058-9565/adc298

Heuristic Time Complexity of NISQ Shortest-Vector-Problem Solvers
Miloš Prokop, Petros Wallden (2025)
https://doi.org/10.48550/arXiv.2502.05284

Adiabatic quantum unstructured search in parallel
Sean A. Adamson, Petros Wallden (2025)
https://doi.org/10.48550/arXiv.2502.08594

Quantum algorithms and lower bounds for eccentricity, radius, and diameter in undirected graphs
Adam Wesołowski, Jinge Bao (2025)
https://doi.org/10.48550/arXiv.2502.20148

Synthesis of Quantum Simulators by Compilation
M Tarabkhah, M Delavar, M Doosti, A Shaikhha (2025)
https://doi.org/10.1145/3696443.3708949

A note on quantum divide and conquer for minimal string rotation
Qisheng Wang (2025)
https://doi.org/10.1016/j.tcs.2025.115120

Selectively Blind Quantum Computation
Abbas Poshtvan, Oleksandra Lapiha, Mina Doosti, Dominik Leichtle, Luka Music, Elham Kashefi (2025)
https://doi.org/10.48550/arXiv.2504.17612

Hybrid Authentication Protocols for Advanced Quantum Networks
Suchetana Goswami, Mina Doosti, Elham Kashefi (2025)
https://doi.org/10.48550/arXiv.2504.11552

Simultaneous Estimation of Nonlinear Functionals of a Quantum State
Kean Chen, Qisheng Wang, Zhan Yu, Zhicheng Zhang (2025)
https://doi.org/10.48550/arXiv.2505.16715

Improved Sample Upper and Lower Bounds for Trace Estimation of Quantum State Powers
Kean Chen, Qisheng Wang (2025)
https://doi.org/10.48550/arXiv.2505.09563

Experimental Verifiable Multiclient Blind Quantum Computing on a Qline Architecture
B Polacchi, D Leichtle, G Carvacho, G Milani, N Spagnolo, M Kaplan (2025)
https://doi.org/10.1103/PhysRevLett.134.200603

Engineering CSS surgery: compiling any CNOT in any code
Clément Poirson, Joschka Roffe, Robert I. Booth (2025)
https://doi.org/10.48550/arXiv.2505.01370

Logical accreditation: a framework for efficient certification of fault-tolerant computations
James Mills, Adithya Sireesh, Dominik Leichtle, Joschka Roffe, Elham Kashefi (2025)
https://doi.org/10.48550/arXiv.2508.05523

Long-Range Entangling Operations via Josephson Junction Metasurfaces
Bakr, Mustafa (2025)
https://doi.org/10.48550/arxiv.2506.14958

Multiplexed readout of superconducting qubits using a three-dimensional reentrant-cavity filter
Bakr, Mustafa; Fasciati, Simone D.; Cao, Shuxiang; Campanaro, Giulio; Wills, James; Alghadeer, Mohammed; Piscitelli, Michele; Shteynas, Boris; Chidambaram, Vivek; Leek, Peter J. (2025)
https://doi.org/10.1103/physrevapplied.23.054089

Characterization of Nanostructural Imperfections in Superconducting Quantum Circuits
Alghadeer, Mohammed; Fasciati, Simone D; Cao, Shuxiang; Piscitelli, Michele; Spink, Matthew C.; Hopkinson, David G.; Danaie, Mohsen; Speller, Susannah C.; Leek, Peter J.; Bakr, Mustafa (2025)
https://doi.org/10.48550/arxiv.2501.15059

Dynamic Josephson Junction Metasurfaces for Multiplexed Control of Superconducting Qubits
Bakr, Mustafa (2025)
https://doi.org/10.48550/arxiv.2411.01345

Low Crosstalk in a Scalable Superconducting Quantum Lattice
Alghadeer, Mohammed; Cao, Shuxiang; Fasciati, Simone D; Piscitelli, Michele; Gow, Paul C.; Gates, James C.; Bakr, Mustafa; Leek, Peter J. (2025)
https://doi.org/10.48550/arxiv.2505.22276

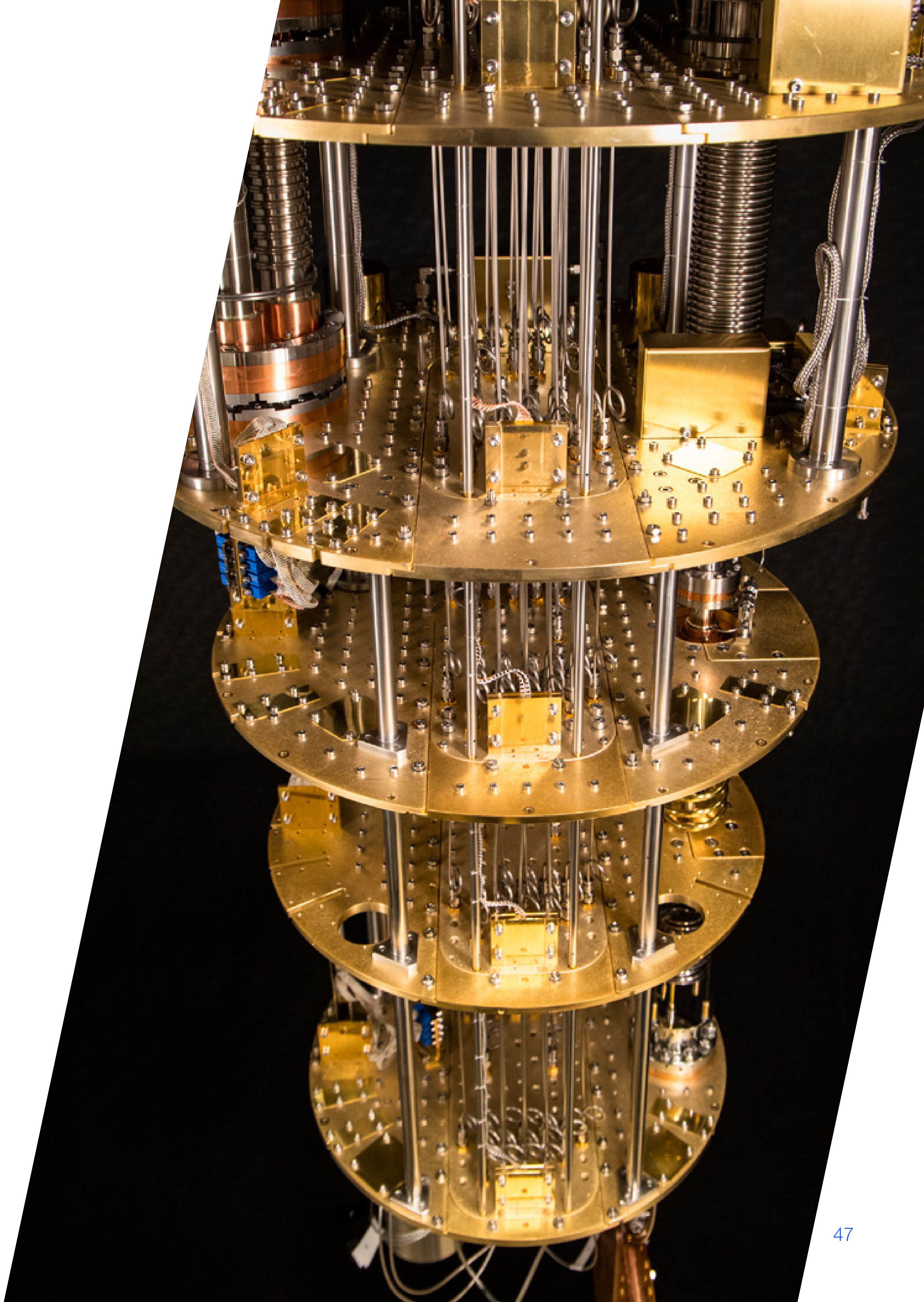
Automating quantum computing laboratory experiments with an agent-based AI framework
Cao, Shuxiang; Zhang, Zijian; Alghadeer, Mohammed; Fasciati, Simone D.; Piscitelli, Michele; Bakr, Mustafa; Leek, Peter; Aspuru-Guzik, Aln (2025)
https://doi.org/10.1016/j.patter.2025.101372

Intrinsic Multi-Mode Interference for Passive Suppression of Purcell Decay in Superconducting Circuits
Bakr, Mustafa; Alghadeer, Mohammed; Fors, Simon Pettersson; Fasciati, Simone D.; Cao, Shuxiang; Mahajan, Atharv; Amari, Smain; Kockum, Anton Frisk; Leek, Peter (2025)
https://doi.org/10.48550/arxiv.2507.09715

Agents for self-driving laboratories applied to quantum computing
Cao, Shuxiang; Zhang, Zijian; Alghadeer, Mohammed; Fasciati, Simone D; Piscitelli, Michele; Bakr, Mustafa; Leek, Peter; Aspuru-Guzik, Aln (2025)
https://doi.org/10.48550/arxiv.2412.07978

Quantum Theory of Distributed-Feedback Parametric Amplifiers and Oscillators
Davis, Alex O. C.; Flint, Alex I. (2025)
https://doi.org/10.48550/arxiv.2509.05752

Improved Classical and Quantum Algorithms for the Shortest Vector Problem via Bounded Distance Decoding
Divesh Aggarwal, Yanlin Chen, Rajendra Kumar, Yixin Shen (2025)
https://doi.org/10.1137/22M1486959



National Quantum Computing Centre

Disclaimer

NQCC advises that the information contained in this publication comprises general statements based on scientific research and stakeholder consultation. The reader is advised and needs to be aware that such information may be incomplete and will be superseded as research progress is made.

To the extent permitted by law, NQCC excludes all liability to any person for any consequences, including but not limited to all losses, damages, costs, expenses and any other compensation, arising directly or indirectly from using this publication (in part or in whole) and any information or material contained in it.

National Quantum Computing Centre
Rutherford Appleton Laboratory
Harwell Campus, Didcot, Oxfordshire, OX11 0QX

Email: **nqccinfo@nqcc.ac.uk**
Website: **www.nqcc.ac.uk**
Follow us: **linkedin.com/company/nqcc/**

Released on 6 November 2025