# THE NATIONAL QUANTUM INFORMATION SCIENCE RESEARCH CENTERS

## *Highlights*

U.S. DEPARTMENT of ENERGY | Office of Science

## C²QA — Co-design Center for Quantum Advantage

**Website**: https://www.bnl.gov/quantumcenter/

**Lead laboratory**: Brookhaven National Laboratory

The Co-design Center for Quantum Advantage (C2QA) aims to overcome the limitations of today's noisy intermediate scale quantum (NISQ) computer systems by applying quantum co-design principles. As materials scientists are uncovering the microscopic mechanisms behind quantum computational errors, other C2QA researchers are designing and optimizing devices to improve performance parameters, including the amount of time before errors overwhelm quantum computations and the distance over which quantum systems can communicate. Software and algorithms experts are simultaneously leveraging the latest hardware advances to achieve quantum advantage for scientific computations in high-energy, nuclear, chemical and condensed matter physics.

## Q-NEXT — Next Generation Quantum Science and Engineering

**Website**: https://q-next.org

**Lead laboratory**: Argonne National Laboratory

Q-NEXT brings together leading experts from national laboratories, academia and the private sector to develop the science and technology to control and distribute quantum information. The center develops technologies to enable secure communication over long distances using quantum repeaters, quantum sensors to achieve unprecedented sensitivities, and processing and test beds for quantum simulators and future full-stack universal quantum computers. Q-NEXT has launched two national foundries for quantum materials, is working to establish a National Quantum Devices Database for standardizing next-generation quantum devices, and is training the quantum workforce through innovative programs with industry, academia and government.

## Quantum Systems Accelerator — Catalyzing the Quantum Ecosystem

**Website**: https://quantumsystemsaccelerator.org

**Lead laboratory**: Lawrence Berkeley National Laboratory

The Quantum Systems Accelerator (QSA) catalyzes national leadership in quantum information science to co-design the algorithms, quantum devices, and engineering solutions needed to deliver certified quantum advantage in scientific applications. Led by Lawrence Berkeley National Laboratory with lead partner Sandia National Laboratories, the QSA brings together dozens of scientists who are pioneers of many of today's quantum capabilities from 15 institutions. The team pairs advanced quantum prototypes — based on neutral atoms, trapped ions, and superconducting circuits — with algorithms specifically designed for imperfect hardware to demonstrate optimal applications for each platform in scientific computing, materials science, and fundamental physics.

## Quantum Science Center

**Website**: https://www.qscience.org

**Lead laboratory**: Oak Ridge National Laboratory

The Quantum Science Center (QSC) performs cutting edge research at national laboratories, universities, and industry partners to overcome key roadblocks in quantum state resilience, controllability and ultimately the scalability of quantum technologies. QSC researchers are designing materials that enable topological quantum computing; implementing new quantum sensors to characterize topological states and detect dark matter; and designing quantum algorithms and simulations to provide a greater understanding of quantum materials, chemistry, and quantum field theories. These innovations enable the QSC, headquartered at ORNL, to accelerate information processing, explore the previously unmeasurable, and better predict quantum performance across technologies.

## SQMS — Superconducting Quantum Materials & Systems Center

**Website**: https://sqmscenter.fnal.gov

**Lead laboratory**: Fermi National Accelerator Laboratory

The Superconducting Quantum Materials and Systems Center (SQMS) brings together partners from more than 30 institutions to make revolutionary advances in QIS. A key SQMS goal is to extend the 'coherence time' — or lifetime — of quantum states. Building on a world-record coherence time, demonstrated at Fermilab in superconducting devices and drawing on expertise in materials science, condensed matter physics, particle physics and computational science, SQMS is building national QIS platforms for discovery. With experts from the U.S., U.K., Italy and Canada, SQMS has become one of the world's largest hubs for the advancement of quantum technologies.

The US Department of Energy's (DOE's) National Quantum Information Science Research Centers (NQISRCs) have advanced critical components of the national quantum science and technology ecosystem through integrated research campaigns that address major cross-cutting challenges. The centers have created new national quantum foundries, chip-scale quantum computers, molecular-scale quantum sensors, and long-range quantum networks. The following accomplishments emphasize the expertise, facilities, and cross-collaborative nature of the five centers.

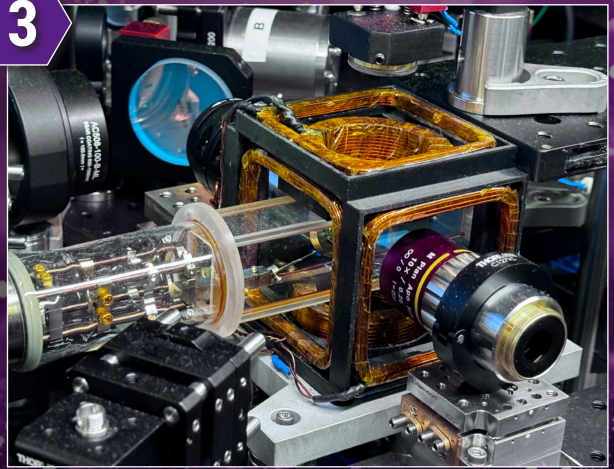
1

**Established multiple quantum foundries** that reinforce the US supply chain for critical materials, devices, and cryogenics used for quantum computing, sensing, and communication.

2

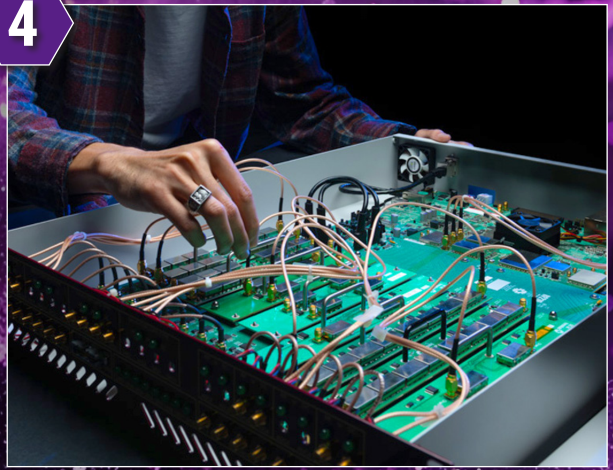

Built a national facility to test and evaluate quantum technologies underground with **200× greater sensitivity**.

3



Delivered new technologies for ion traps, superconducting platforms, and cryogenics, thereby enabling **quantum computing scale up by 100×**.

4



Established a national user community whose efforts created a **10× scale up in programming quantum computers** using open-source hardware.

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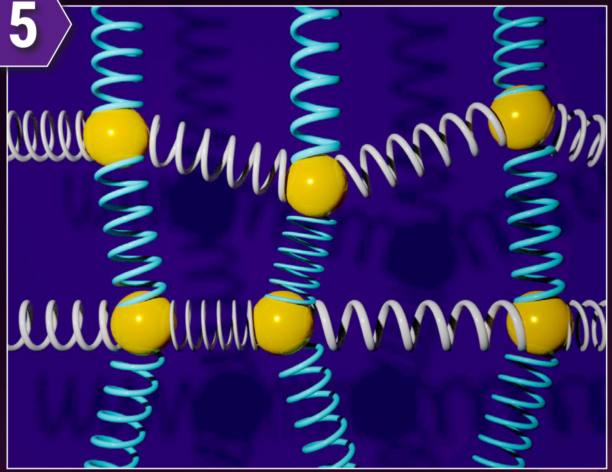

**Improved quantum computer program performance by 100×** for more accurate and sophisticated simulations.

6

Codesigned a new fabrication process with industry that more than **doubled the performance accuracy** for quantum computer chips.

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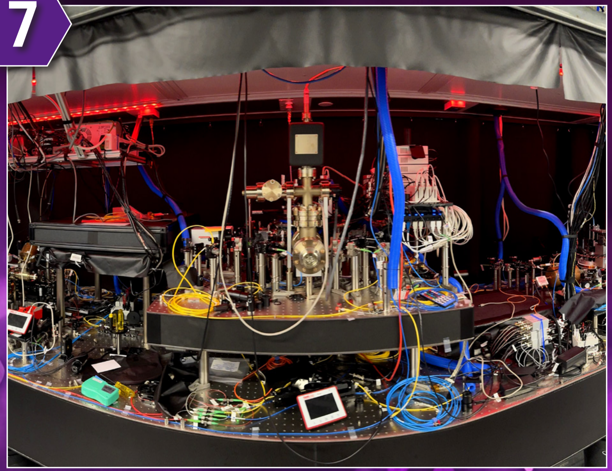
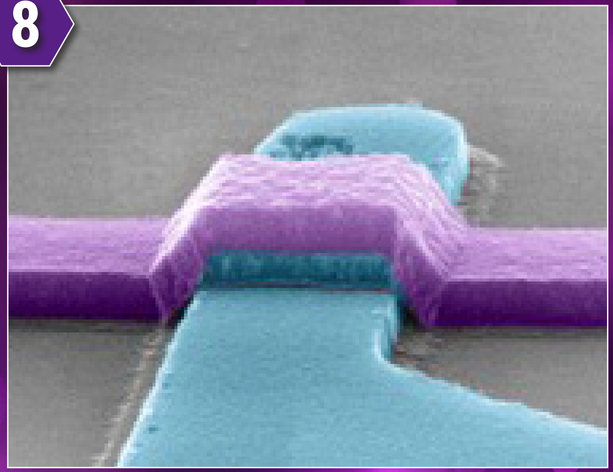


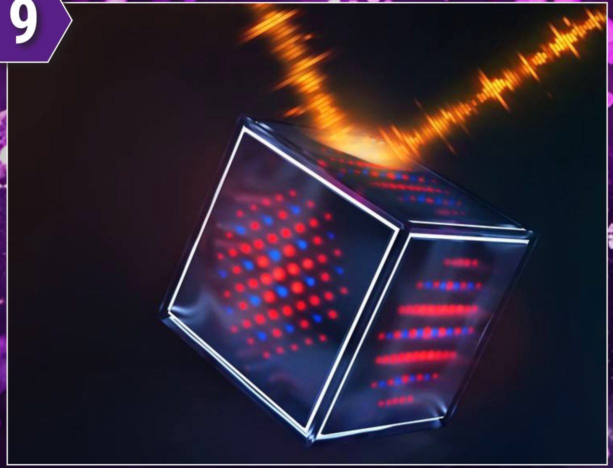
Connected two atom-based quantum computers with light to demonstrate a **path to scalable quantum technologies**.

8



Demonstrated new qubits that operate at **100×** higher temperatures and frequencies for improved performance.

9



Demonstrated the **first applications of quantum error correction**, which increased the accuracy of quantum computing systems and **reduced failure rates by up to 70×**.

10

**Trained over 1,000 students and teachers**, helping build quantum science and technology's next generation of experts and practitioners.

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