

# Quantum Information Science at the Office of Science

Tanner Crowder

Advanced Scientific Computing Research

Office of Science



U.S. DEPARTMENT  
*of* **ENERGY**

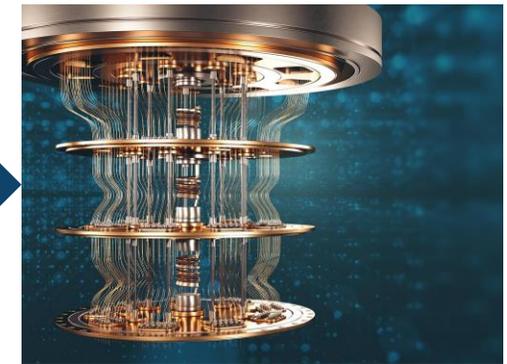
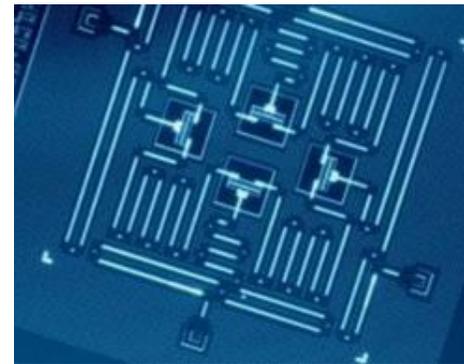
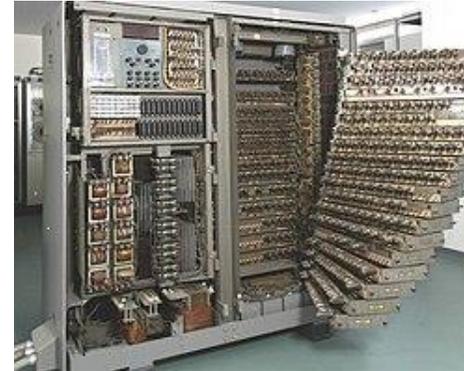
Office of  
Science

[Energy.gov/science](https://energy.gov/science)

# A Motivation for SC QIS Research

SC activities and efforts in QIS leverage its unique strengths to accelerate technology development and advance DOE-mission-focused applications. It is vital to sustain an open innovation ecosystem encouraged to take risks that can produce transformative discoveries.

- **Fundamental Science:** Supporting research with the potential to disrupt computing, simulation, networking, and sensing.
- **Unique Tools and Infrastructure:** Creating first-of-a-kind instruments and facilities to unlock new quantum capabilities.
- **Advancing Quantum Technologies:** Applying QIS solutions to the most pressing scientific challenges within the Office of Science.
- **Community and Workforce:** Building a thriving ecosystem through workforce development, educational opportunities, and strong partnerships.

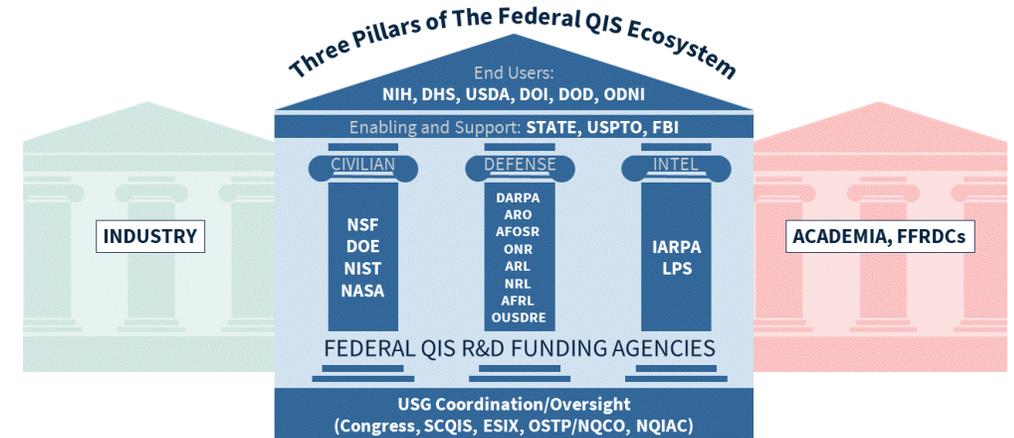
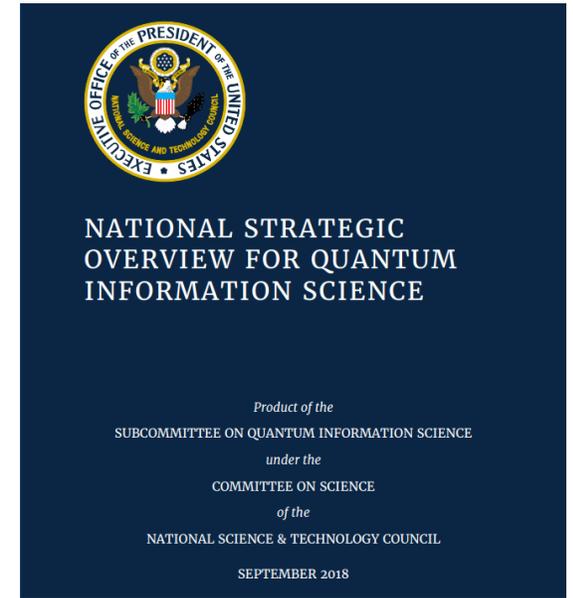


# The U.S. National Strategy for Global QIS Leadership

The U.S. National Strategy to ensure continued leadership in QIS, released in September 2018, continues to provide a strong framework to guide agency efforts in a highly collaborative and competitive international QIS ecosystem

- **Getting the science right** by understanding the applications and timelines by which quantum information science and technology will benefit our society, and roadblocks we must overcome to get there
- **Enhancing American competitiveness** by accelerating technology development toward useful economic and mission applications while also protecting national security
- **Enabling people** by building the necessary talent pipeline and ensuring that this field creates new opportunities for all Americans

The Department of Energy's Office of Science is a leader in this whole-of-government effort to maintain preeminence in quantum science and technology



# The Office of Science Investment in QIS Research

(dollars in thousands)

Quantum Information Science	FY 2022 Enacted	FY 2023 Enacted	FY 2024 Enacted	FY 2025 Enacted	FY 2026 Enacted
<b>Advanced Scientific Computing Research</b>	99,486	96,517	96,517	96,517	110,517
<b>Basic Energy Sciences</b>	102,357	102,000	92,000	92,000	98,500
<b>Biological and Environmental Research</b>	14,500	14,500	14,500	14,500	21,000
<b>Fusion Energy Sciences</b>	10,000	10,000	10,000	10,000	18,000
<b>High Energy Physics</b>	51,566	50,566	50,566	50,566	57,066
<b>Nuclear Physics</b>	10,866	10,866	10,866	10,866	17,366
<b>Isotope R&amp;D and Production</b>	4,300	4,300	4,300	4,300	6,300
<b>Total, SC Quantum Information Science</b>	293,075	288,749	278,749	278,749	<b>328,749</b>

# SC's QIS Portfolio Spans its Technical Breadth

Subatomic

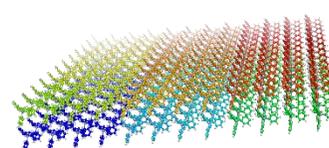
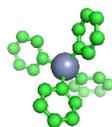
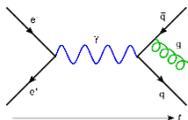
Nuclear

Molecular

Material

Quantum Device

Length Scale:



SC's portfolio of fundamental science and enabling capabilities and infrastructure for QIS spans its six core science programs and the Isotope Program.

ASCR	BES	FES	BER	HEP	NP	IP
Quantum Algorithms; Computer Science; Networking; Testbeds and HPC	New Quantum Phenomena; Quantum Computing for Materials and Chemistry; Infrastructure	Qubit Synthesis; Quantum Computing and Sensing for Fusion and Plasma Science	New Quantum-Enabled Methods for Bioimaging and Biosensing	Quantum Theory, Sensing, and Computing for Physics; Technology Development	Spin Qubits; Quantum Computing, Simulators and Sensors; Nuclear Clocks	Isotope Research, Production, and Distribution for QIS

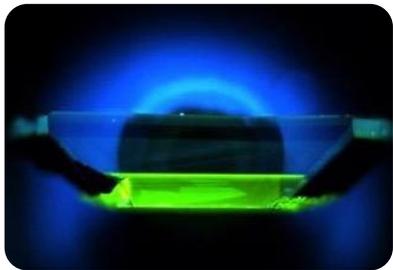
National QIS Research Centers | Q-NEXT, C<sup>2</sup>QA, SQMS, QSA, QSC

Enabling Infrastructure | X-ray light and neutron sources, NSRCs, Foundries, Quantum Testbeds, QC User Program, ...

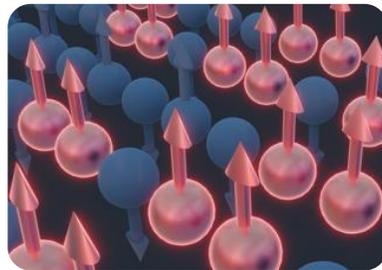


# The DOE NQISRCs: Complementary Science, Broad Impact

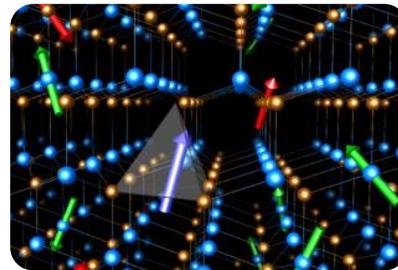
Each center tackles major scientific and technological challenges in QIS in unique ways using complementary approaches that leverage unique DOE investments. Together, the DOE Centers are strengthening the innovation ecosystem in QIS and establishing new, nationally impactful scientific infrastructure.



Bringing useful quantum computing within reach with disruptive technological advances



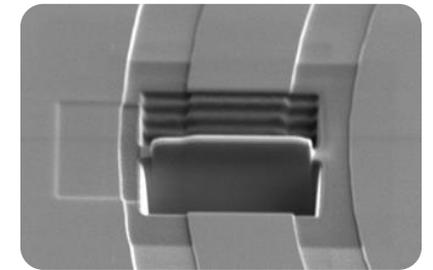
Creating scalable quantum-centric HPC systems and applications



Attacking the problem of scalable quantum entanglement



Realizing scalable, high-fidelity quantum technologies for quantum computing and sensing



Building on Fermilab's unique accelerator expertise and facilities to advance quantum S&T



# The DOE NQISRCs by the Numbers

Over nearly five years, the Centers have dramatically expanded the landscape of QIS research in the U.S. – new science, new capabilities, new ecosystems of discovery.

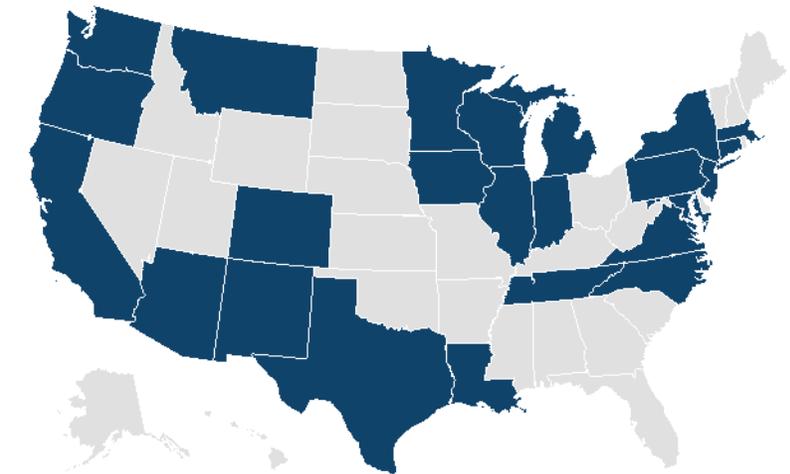
**RESEARCH SPANS** **>115** ACADEMIC, NATIONAL LABORATORY, AND INDUSTRIAL INSTITUTIONS

**MORE THAN 1500** COLLABORATORS ACROSS THE U.S. AND AROUND THE GLOBE



**5** CROSS CUTTING CHALLENGES

- UNDERSTAND AND ELIMINATE DECOHERENCE IN QUANTUM DEVICES TO ACHIEVE FAULT-TOLERANT QUANTUM COMPUTING
- DEVELOP TOPOLOGICAL MATERIALS TO OVERCOME THE FRAGILITY OF QUANTUM STATES
- DEMONSTRATE TRANSFORMATIONAL BREAKTHROUGHS IN THE CONTROL AND SCALABILITY OF COMPLEX QUANTUM SYSTEMS
- DEPLOY QUANTUM COMMUNICATION LINKS AND NETWORKS OF ULTRAPRECISE SENSORS
- ACHIEVE QUANTUM COMPUTING AND SENSING ADVANTAGE FOR PARTICLE, NUCLEAR PHYSICS, MATERIAL SCIENCE, CONDENSED MATTER PHYSICS AND SOCIETAL APPLICATIONS



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**> 300** NEW HIRES (TO-DATE, CENTER-WIDE)

OVER **600** STUDENTS & POSTDOCS ADVANCING CENTERS GOALS AND MISSION

MORE THAN **2500** EXTERNAL STUDENTS TRAINED THROUGH SCHOOLS AND INTERNSHIPS



DOE NATIONAL QUANTUM INFORMATION SCIENCE RESEARCH CENTERS  
**BY THE NUMBERS**

OVER **200** COMPANIES ENGAGED WITH THE CENTERS (MEMBERS + VENDORS)



OVER **500** EXPERIMENTS OR INITIATIVES TO ADVANCE QUANTUM RESEARCH



**> 2000** PUBLICATIONS (PEER-REVIEWED JOURNALS + ARXIV)



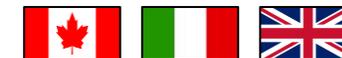
OVER **15** NEW QUANTUM FACILITIES, FOUNDRIES AND TESTBEDS



**\$575 million** U.S. FEDERAL FUNDING FOR RESEARCH OVER 5-YEAR PERIOD



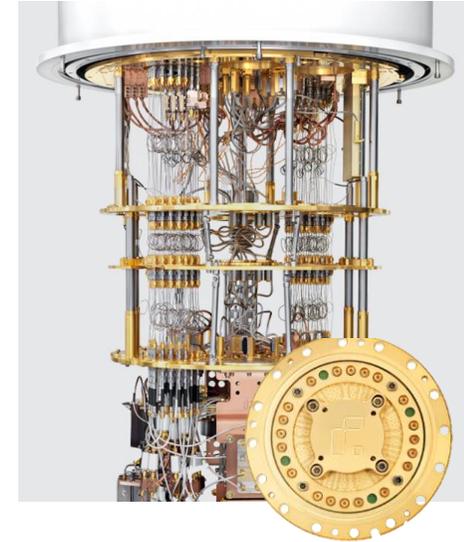
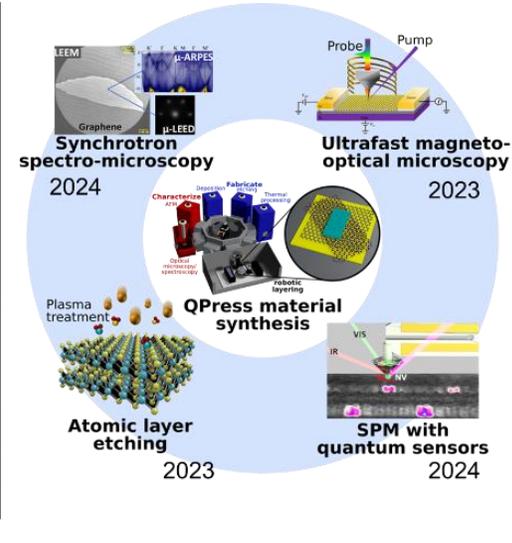
LEVERAGING OVER **20** DOE USER FACILITIES, UNIQUE CAPABILITIES, AND TECHNICAL INFRASTRUCTURE

As of Sep. 2024



# Leveraging World-Leading DOE Community Resources



5 light and 2 neutron sources to investigate quantum phenomena and materials properties at the atomic scale

3 of the world's most advanced super-computers, including 2 at the exascale, to accelerate system design and innovation.

QIST testbeds provide access to novel quantum computing hardware for QIS research

5 Nanoscale Science Research Centers with clean rooms, synthesis, and characterization tools for QIS systems

Quantum computing access programs a ORNL and NERSC provides access to industry quantum computing resources

# BACK UP

