



The U.S. Department of Energy National Quantum Information Science Research Centers: Mission and Activities

Anna Grassellino

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The five DOE National QIS Centers



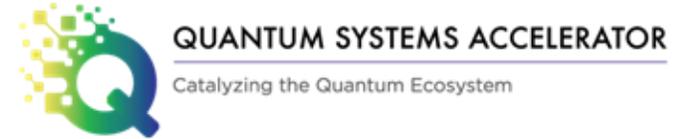
Chuck Black, Director
Lead lab: Brookhaven



Martin Holt, Director
Lead lab: Argonne



Travis Humble, Director
Lead lab: Oak Ridge



Bert de Jong, Director
Lead lab: Berkeley

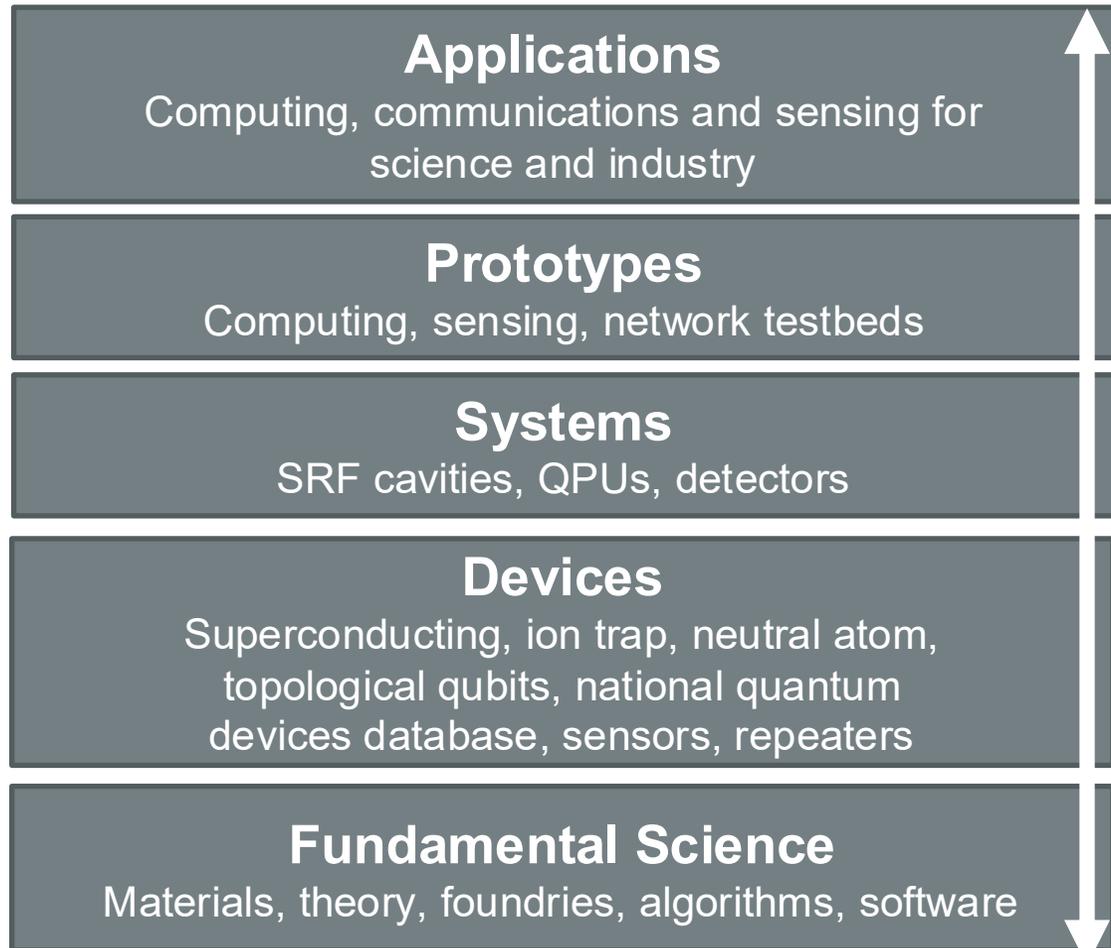


Anna Grassellino, Director
Lead lab: Fermilab

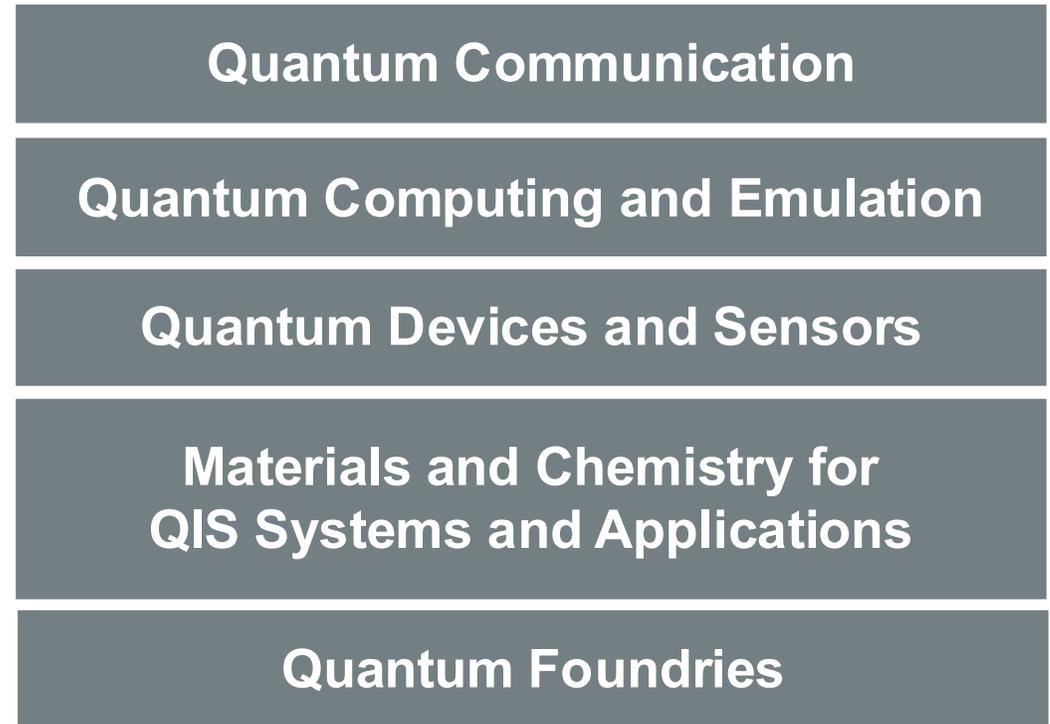


National QIS Research Centers: Essential Components

S&T Innovation Chain with Targets



Complementary Technical Areas of Interest



Science & Technology Innovation Chain

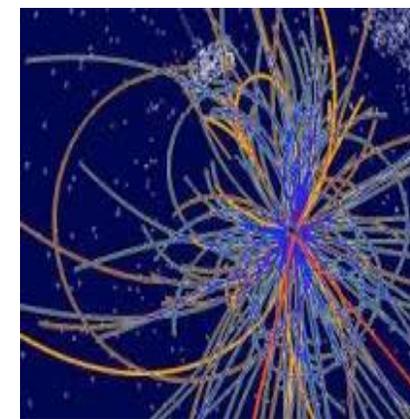
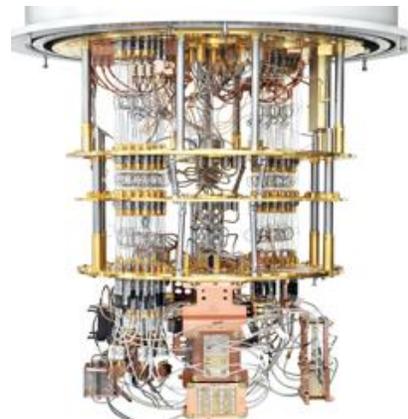
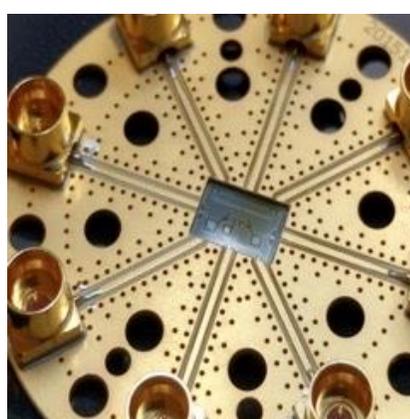
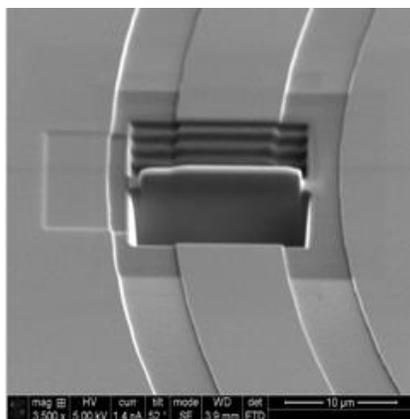
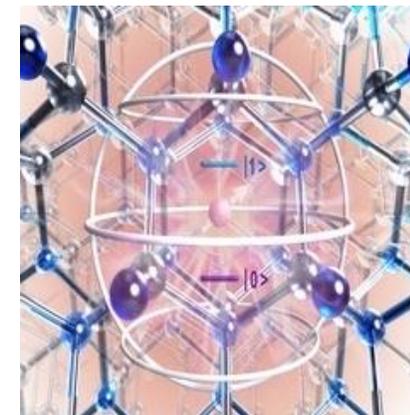
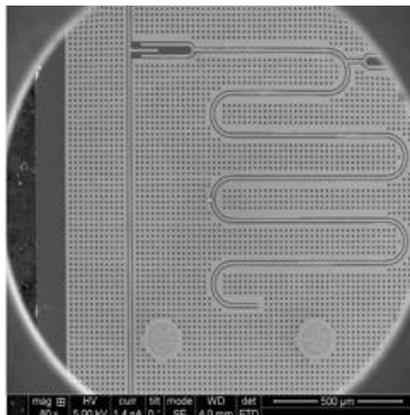
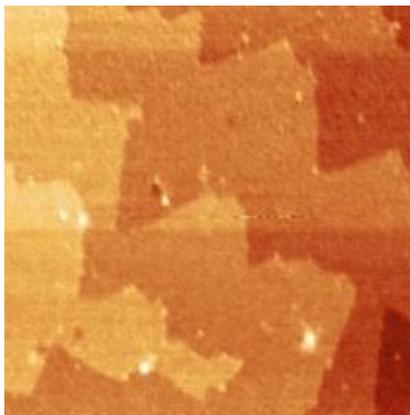
• Materials

High-coherence devices

Systems integration

New platforms for quantum computing & sensing

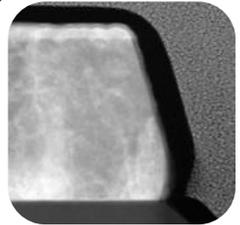
Quantum advantage



The Centers are addressing major cross-cutting challenges and moving through at least three levels of the chain combining the talent of **multi-institutional and multi-disciplinary teams**

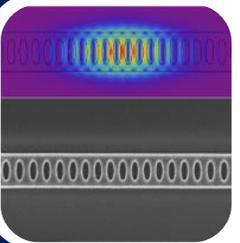
Five centers, one mission – achieve critical breakthroughs in quantum science, technology and engineering for scientific discovery

Addressing key roadblocks to quantum utility with unique solutions



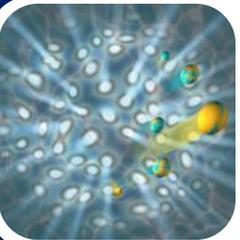
Overcoming errors

- Eliminating material decoherence
- Resource-efficient error correction
- Advanced cryogenics



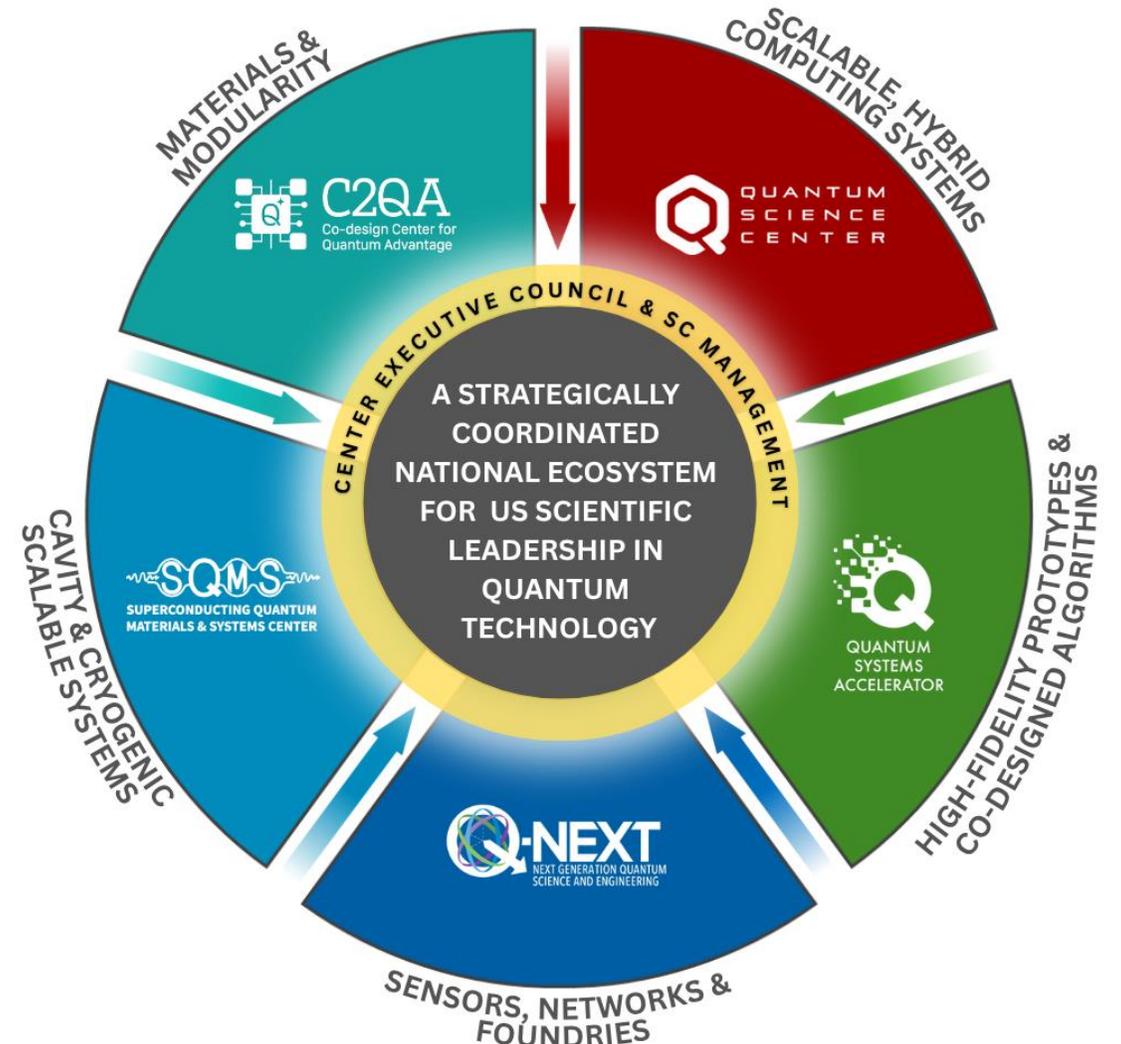
Unlocking scaling

- Distributed entanglement
- Cross-platform architectures
- Hybrid quantum-accelerated HPC

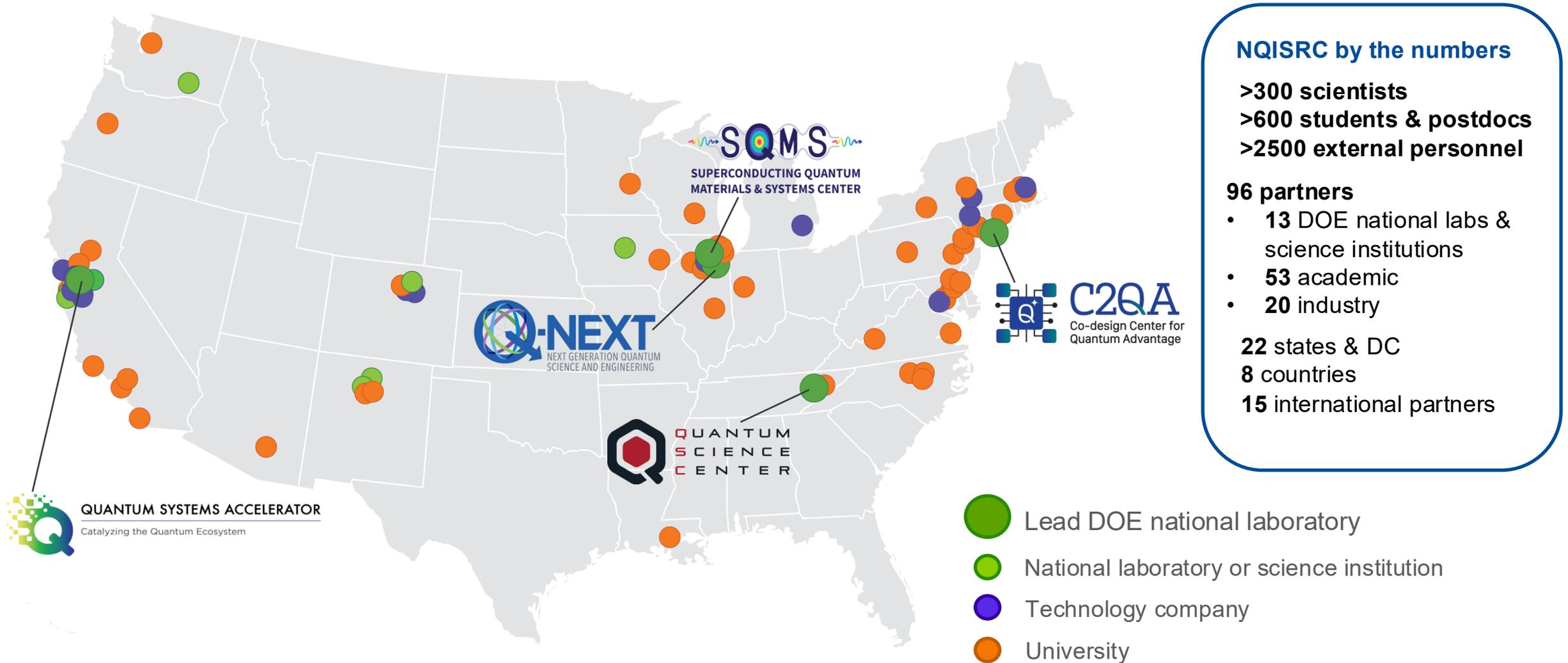


Enabling applications

- Quantum simulations of materials
- Interconnected quantum sensors
- New algorithms for scientific research



Partnerships across academia, industry, national labs



NQISRC by the numbers

- >300 scientists
- >600 students & postdocs
- >2500 external personnel

96 partners

- 13 DOE national labs & science institutions
- 53 academic
- 20 industry

22 states & DC
8 countries
15 international partners

NQISRCs: national labs, academia working hand in hand with industry

Science and Technology

- Developed first 256-atom programmable quantum simulator, building technologies enabling QuEra to commercialize quantum computing.
- Achieved world-leading performance in superconducting transmon qubits that could improve industry's best quantum processors by 1,000x.
- Co-developed with industry the first superconducting commercial quantum processor to be installed and operated at a DOE national laboratory.
- Developed a method for creating a core qubit component, a Josephson junction, from niobium that exhibit a 100-fold improvement in loss.
- Demonstrated first experimental validation of entanglement in quantum materials using neutron scattering

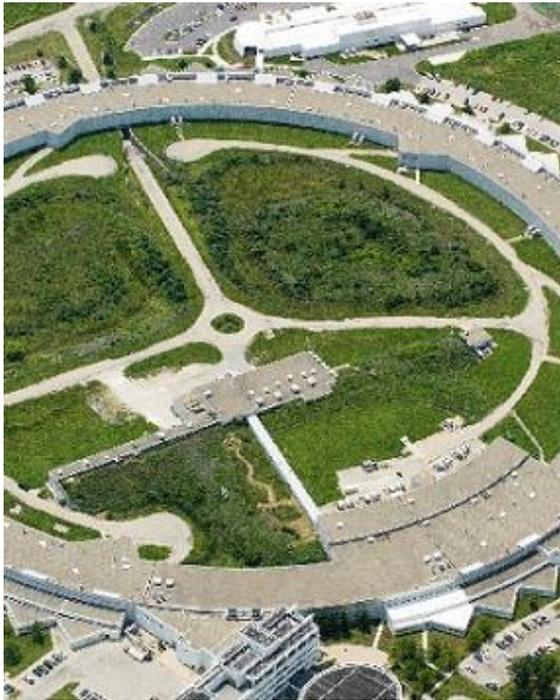
New Tools and Databases

- Partnered with Intel to operate a 12-qubit quantum dot device, combining industry manufacturing expertise with national-lab physics and characterization capabilities.
- Established a national-scale task force to evaluate qubit performance, build devices, and develop standards for next-generation, consistently high-performance qubits.
- Commissioned the new 6,000-square-foot quantum laboratory at Fermilab, featuring six new dilution refrigerators.
- Established the nation's first roadmap for quantum interconnects in 2022
- Invented and commercialized the QICK open-source electronic control system through partnerships with DOE and industry.

**22 industry partners across the 5 centers
11 are involved in multiple centers**



Role of DOE labs, skills and facilities needed to address key challenges



Light sources to investigate materials properties at the atomic scale



Supercomputing facilities



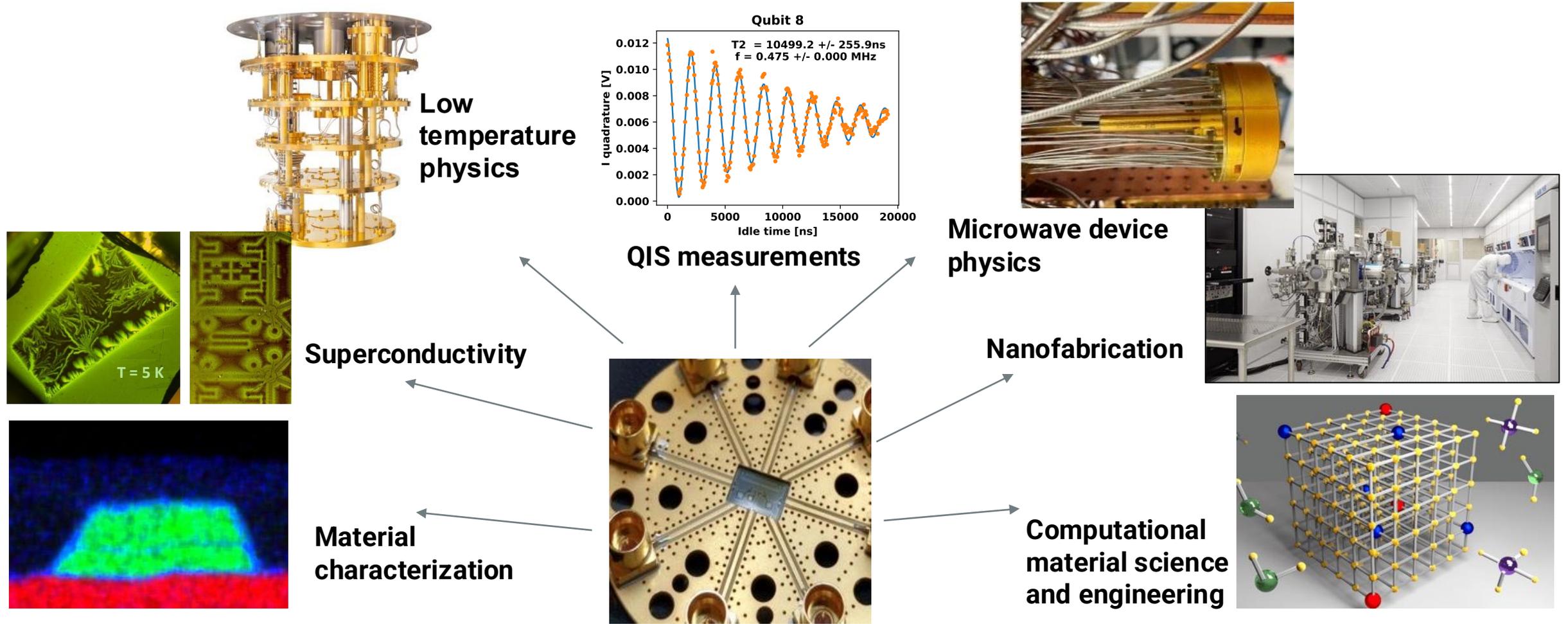
Superconducting microwave devices, microwave controls, systems integration



Large scale cryogenics, cryoplants, distribution systems

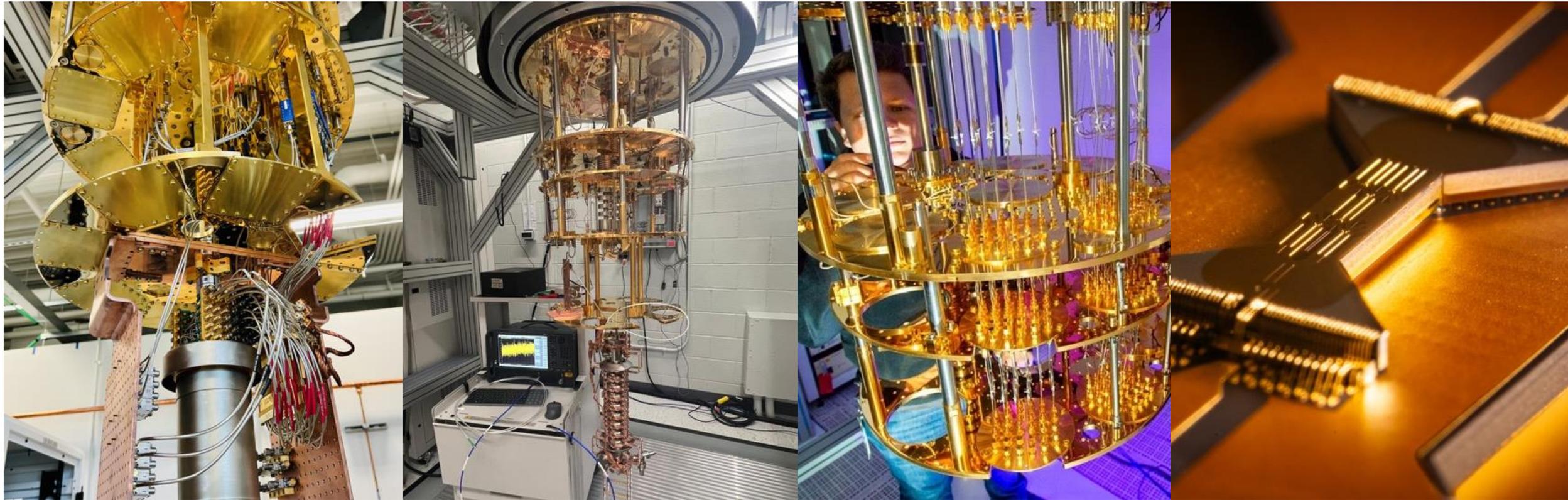
The NQISRCs are led by DOE national laboratories, bringing decades of investments in accelerator and computing facilities and technologies, scale-up and integration capabilities and the experience to lead large collaborations and projects

Example: multidisciplinary approach needed to attack key challenges



The DOE NQISRCs bring together large-scale multidisciplinary teams in **broad but focused, mission-driven** collaborations that attack QIS major challenges

Laying the foundation for quantum facilities at DOE labs



The NQISRCs are co-developing with industry quantum processors prototypes of different technological platforms at DOE national labs

Faces of NQISRCs: building a broad quantum community

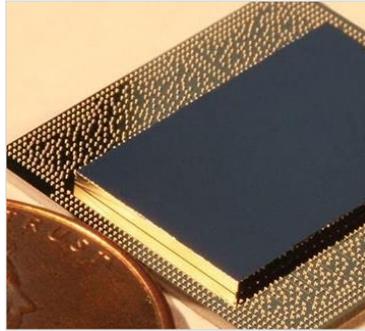


NQISRCs are accelerating the impact of quantum technology



COMPUTE

C2QA devices that are 10x better, 10x smaller than current.



STABILIZE

QSA's error-corrected prototype simulators maintain reliable computation while pursuing DOE relevant scientific discovery .



SCALE

SQMS's cavity-based interconnection units link processors together into a quantum data center.



TRANSMIT

Q-NEXT optical networks unite technologies within the quantum center and connect to a high-performance cluster at a National Lab.



APPLY

QSC's integration with HPC seamlessly applies quantum computers to breakthrough calculations in materials science, chemistry, or high energy physics.



Thank you

