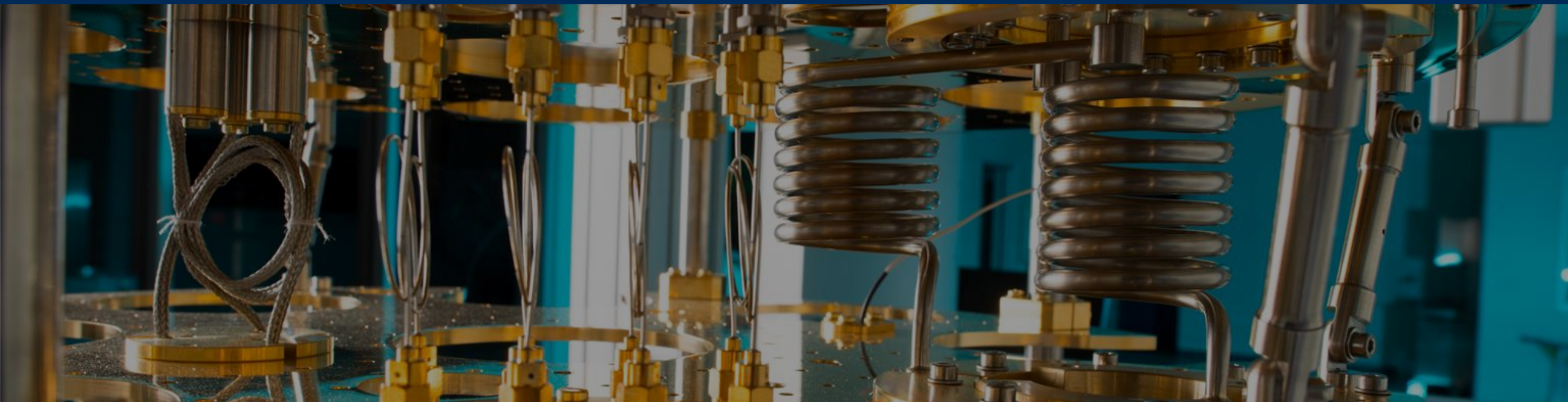


The U.S. Department of Energy National Quantum Information Science Research Centers: Mission and Activities

Directors of the National QIS Research Centers

Feb. 23, 2024

Who we are

C²QA Co-design Center for Quantum Advantage

Andrew Houck, Director

Lead lab: Brookhaven

QUANTUM SCIENCE CENTER

Travis Humble, Director

Lead lab: Oak Ridge

SQMS SUPERCONDUCTING QUANTUM MATERIALS & SYSTEMS CENTER

Anna Grassellino, Director

Lead lab: Fermilab

Q-NEXT NEXT GENERATION QUANTUM SCIENCE AND ENGINEERING

David Awschalom, Director

Lead lab: Argonne

QUANTUM SYSTEMS ACCELERATOR Catalyzing the Quantum Ecosystem

Bert de Jong, Director

Lead lab: Berkeley

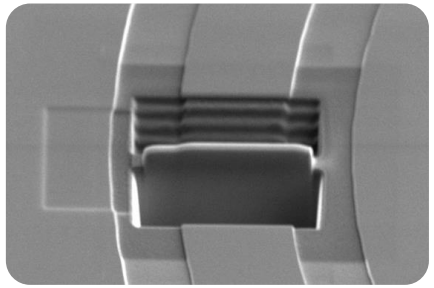
Complementary science, broad impact

Each center tackles major scientific and technological challenges in quantum information science in unique ways using complementary approaches. Together, we advance quantum computing, communication, networking, sensing, and materials in ways that will have impacts in science, energy, security, communication, medicine, finance, and logistics.

Quantum Systems Accelerator

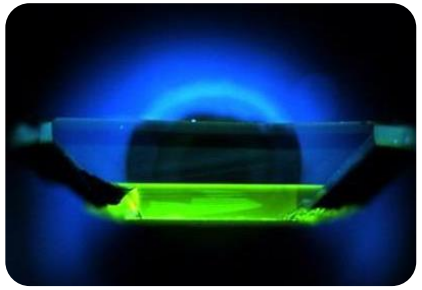
- Co-designing powerful programmable quantum prototypes with algorithms that maximize performance of hardware in three technologies: neutral atoms, trapped ions, and superconducting circuits
- Demonstrating optimal applications in computing, materials science, and fundamental physics

SQMS



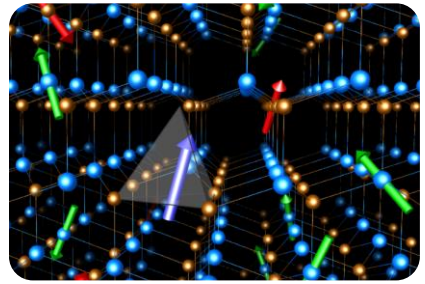
- Identifying and mitigating loss channels in superconducting quantum devices
- Designing and building prototypes of quantum computers and sensors for scientific discovery

C²QA



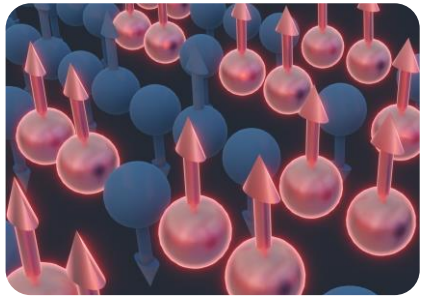
- Overcoming the current limits of quantum computing systems to achieve quantum advantage
- Developing quantum co-design principles to target software and algorithms, devices, and materials

Q-NEXT



- Developing the technology to store, control and distribute entangled states of matter
- Delivering quantum communications links, networks of ultraprecise sensors, and novel demonstration test beds

Quantum Science Center



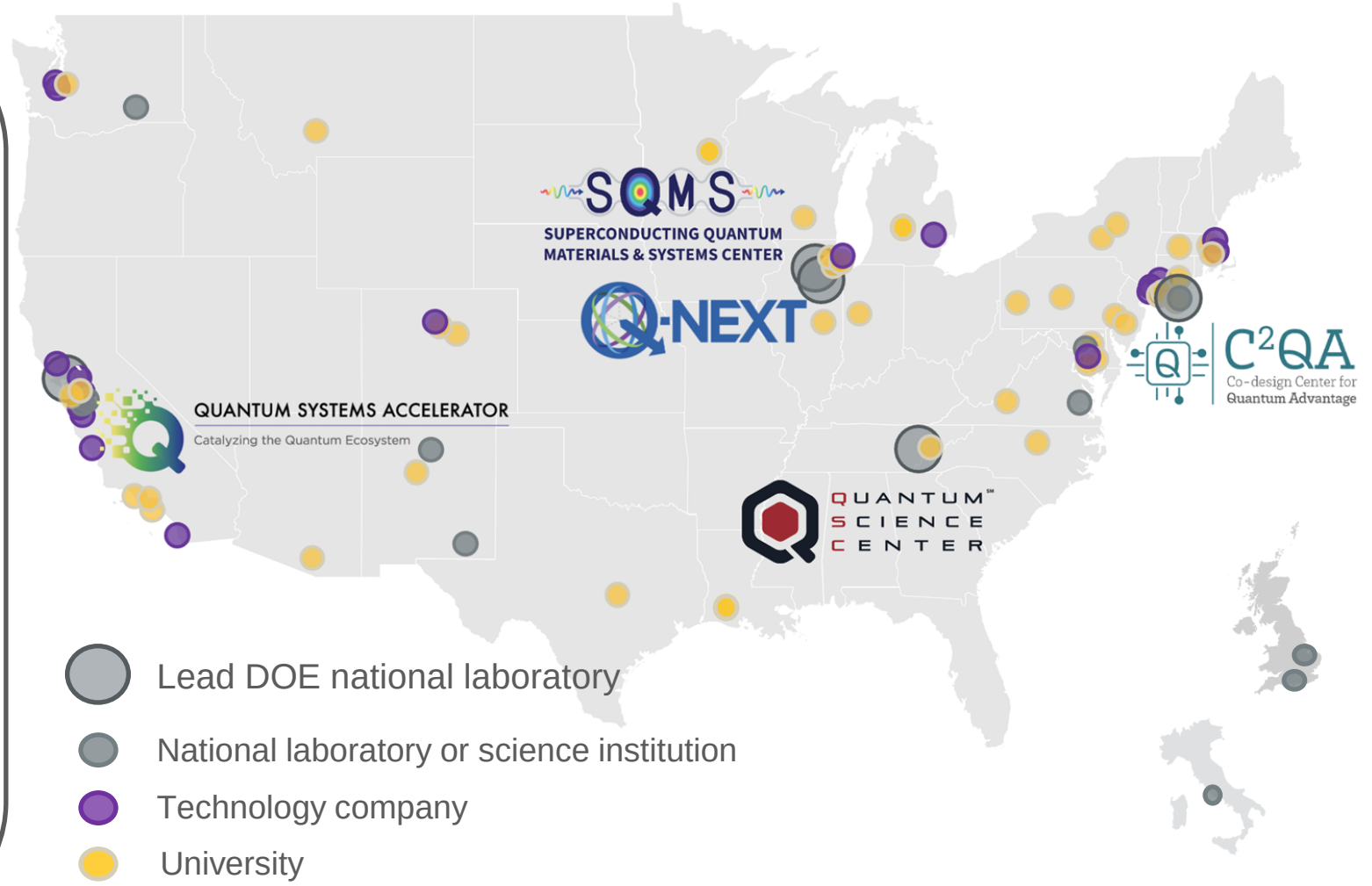
- Designing quantum materials, algorithms to enable more precise manipulation of quantum information
- Implementing new quantum devices and sensors to characterize topological states, detect dark matter

Partnerships across academia, industry and national labs

The centers bring together multidisciplinary collaborations of more than **1,500** experts, including **600** students and postdocs, across over **115** academic, industry and national science institutions in more than **22** states and DC.

Through institutional partnerships, the centers unite unique capabilities, expertise and facilities.

- Solving key challenges in QIS thanks to the unique strength of multi-institutional and multidisciplinary collaborations
- Leveraging DOE user facilities for advanced materials analysis and device fabrication
- Collaborating across industry, academia and national labs to deploy new quantum facilities, foundries and test beds for the centers and the national ecosystem.
- Training a new and diverse quantum workforce
- Technology transfer – rapid cycle from discovery to commercialization
- Developing national standards and roadmaps for quantum technology that incorporate processes, metrology and testing data



Four years of achievements: science and technology

In the first four years, the five centers facilitated scientific and technological breakthroughs.

Science and technology

Built a 256-qubit programmable quantum simulator and used it to observe new states of quantum matter.

Built an underground cryogenic test stand to evaluate the influence of atmospheric radiation on quantum technologies.

Co-developed with industry the first superconducting commercial quantum processor to be installed and operated at a DOE national laboratory.

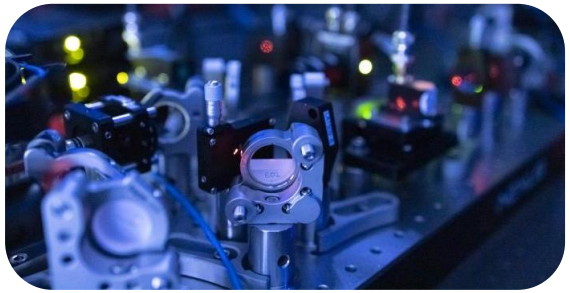
Demonstrated scalable material fabrication techniques for storing quantum information and developed quantum sensing platforms based on defects in portable diamond films.

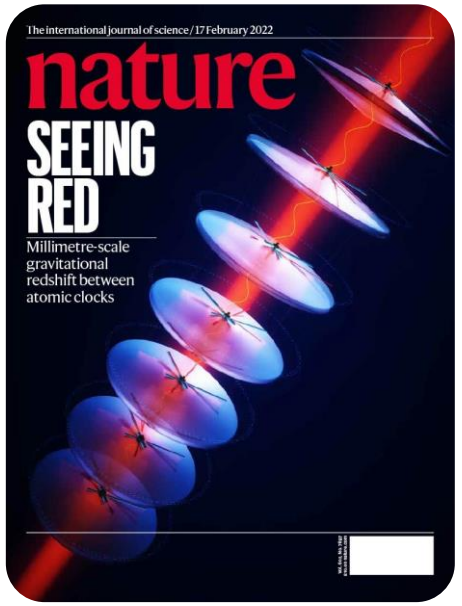
New tools and databases

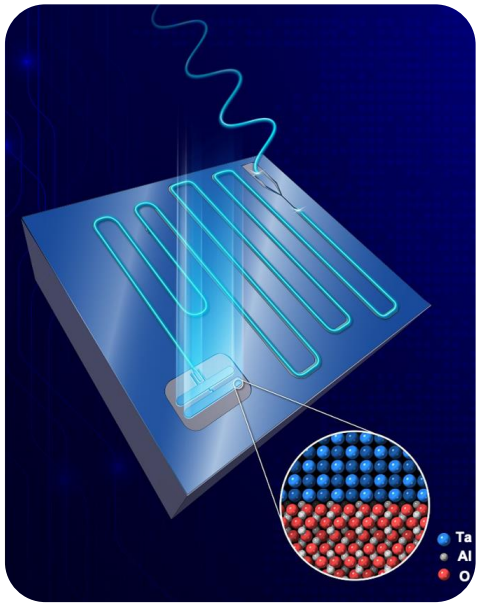
Officially opened the Argonne Quantum Foundry, which meets a critical need for quantum science by providing a robust supply chain of materials for semiconducting quantum devices and systems.

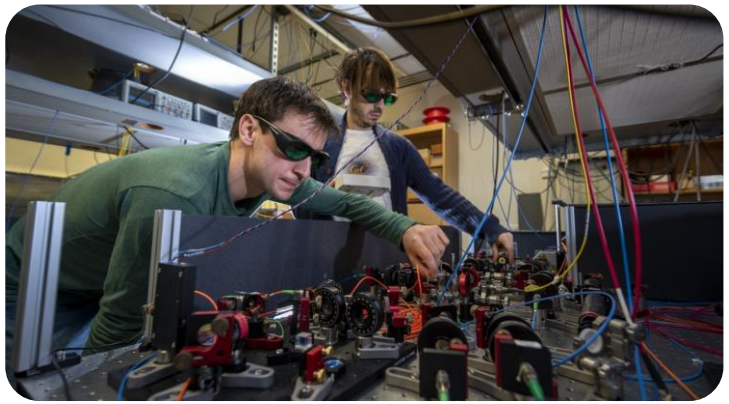
Established a national-scale task force to evaluate qubit performance, build devices, and develop standards for next-generation, consistently high-performance qubits.

Commissioned The Quantum Garage, a new 6,000-square-foot quantum laboratory at Fermilab, featuring six new dilution refrigerators, operating commercial quantum processors, materials testbeds and quantum sensors for fundamental physics.









C²QA Q-NEXT QUANTUM SCIENCE CENTER QUANTUM SYSTEMS ACCELERATOR Catalyzing the Quantum Ecosystem SQMS

Four years of achievements: ecosystem and workforce

During the first four years, the five centers worked together to promote cooperation in quantum information science R&D and raise awareness of opportunities in the field.

Workforce development

Trained hundreds of young researchers through summer schools, internships, fellowships and workshops to help students at all education levels.

Organized the U.S. Quantum Information Science School, the largest in-person federally funded school focused on quantum information science and technology. Over 200 participants and instructors attended. The second annual USQIS will be hosted at QSC in July 2024.

Hosted faculty development programs aimed at partnerships with minority serving institutions.

Hosted QCaMP, teaching high school teachers and students in New Mexico, Colorado, California and Chicago basics in quantum information science

Hosted annual virtual Quantum Information Science Career Fairs with nearly 1,000 registrants each.

Partnerships and ecosystem

Held collaboration annual meetings and workshops with hundreds of experts from the national and int'l ecosystems, including industry partners, to discuss and advance key QIS goals.

Organized and led scientific sessions at events such as AAAS, IEEE, APS March, international scientific conferences and more.

Published “A Roadmap for Quantum Interconnects,” which details key imperatives for quantum interconnects research to have future impact. Thirty-nine experts, including 10 from seven leading U.S. companies, contributed.

Experts from across the five centers have contributed to National Quantum Initiative and cross-agency coordination groups.

Future developments

The upcoming year promises important advances in quantum science and technology and the quantum ecosystem from the five National QIS Research Centers.

In year 5 and beyond, we plan to:

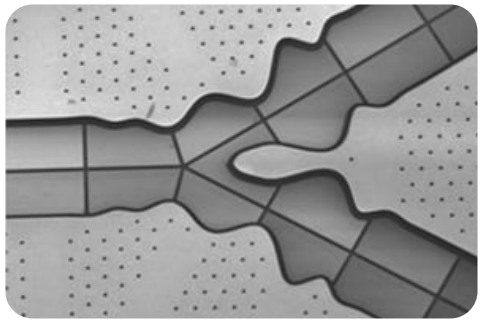
C²QA: Demonstrate measurable improvements in qubit materials, device performance and software requirements for useful quantum computing.

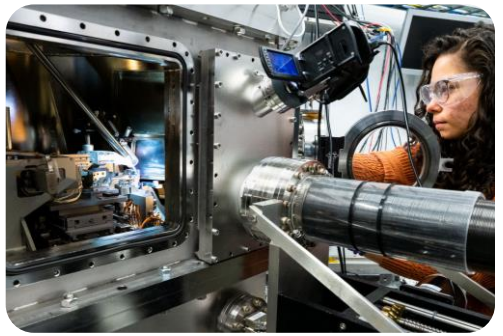
Q-NEXT: Achieve fully operational quantum foundries at Argonne and SLAC to reinforce domestic supply chain for quantum materials research.

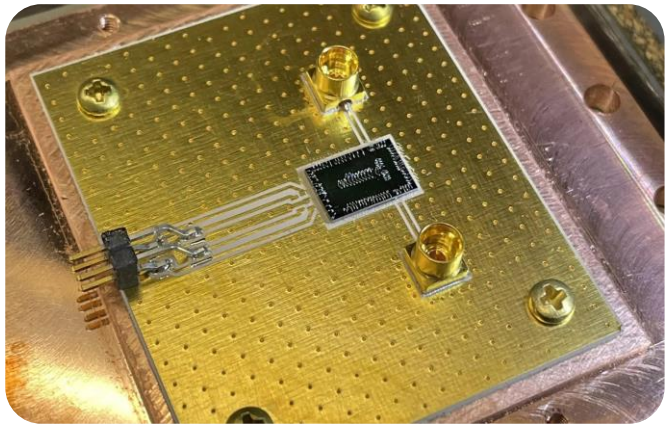
QSA: Deliver critical advances in QSA's neutral atom, trapped ion and superconducting quantum platforms for demonstrating meaningful quantum advantage.

QSC: Demonstrate advances in quantum simulation and sensing for materials, chemistry, nuclear physics, and artificial intelligence.

SQMS: Deploy the first SQMS-developed quantum computing and sensing prototypes demonstrating impactful applications in the newly commissioned 6,000 sq. ft quantum computing lab at Fermilab.







AT A GLANCE

DOE NATIONAL QUANTUM INFORMATION SCIENCE RESEARCH CENTERS

BY THE NUMBERS

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
- DEMONSTRATE TRANSFORMATIONAL BREAKTHROUGHS IN 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
- DEVELOP NEW MATERIALS TO OVERCOME THE FRAGILITY OF QUANTUM STATES

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

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

MORE THAN **1000** EXTERNAL STUDENTS TRAINED THROUGH SCHOOLS AND INTERNSHIPS

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

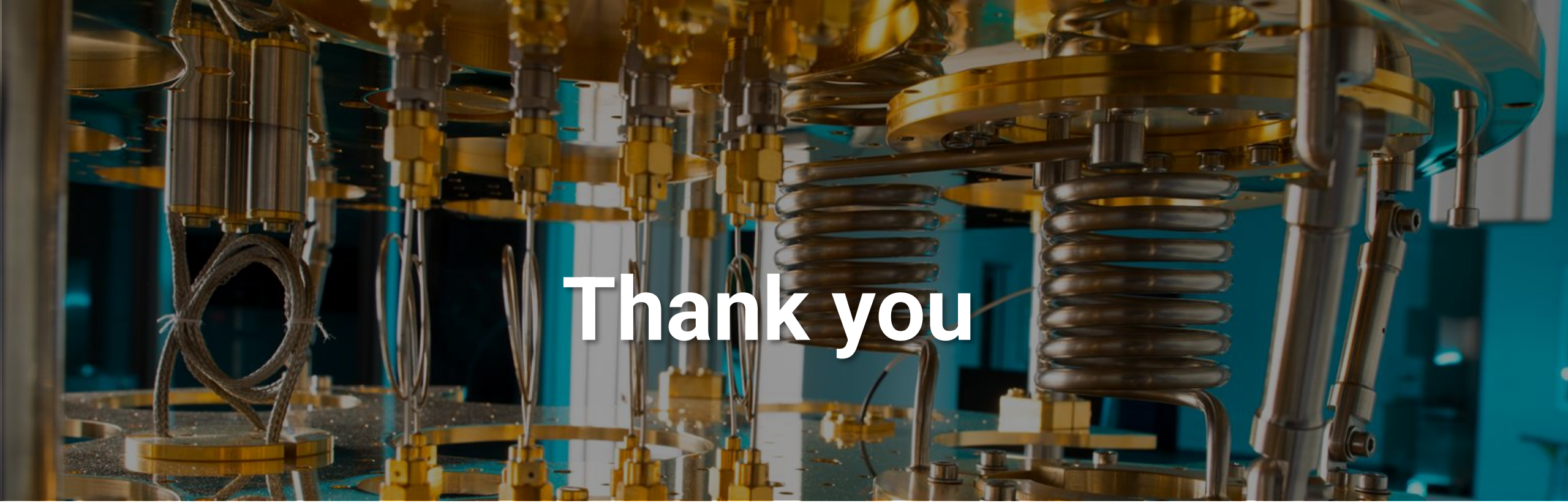
OVER **500** EXPERIMENTS OR INITIATIVES TO ADVANCE QUANTUM RESEARCH

> 1100 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



Thank you

C²QA Co-design Center for Quantum Advantage

Q-NEXT NEXT GENERATION QUANTUM SCIENCE AND ENGINEERING

QUANTUM SCIENCE CENTER℠

QUANTUM SYSTEMS ACCELERATOR
Catalyzing the Quantum Ecosystem

SQMS SUPERCONDUCTING QUANTUM MATERIALS & SYSTEMS CENTER