Please join us for…

QSC Cryogenic Engineering and Quantum Sensing Training 2022

September 15-16, 2022

In-person @ FNAL **WH 7 (Racetrack)**

Registration Needed

https://indico.fnal.gov/e/QSCtraining2022

WELCOME

to

QSC Cryogenic Engineering and Quantum Sensing 2022

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Illinois Institute of technology

&

Fermilab

September 15-16

Quantum Science Center

- One of the 5 DOE Quantum Science Centers funded under National Quantum Initiative act (passed by congress in 2018).
- The National Quantum Initiative Act provides for the continued leadership of the United States in QIS and its technology applications. It calls for a coordinated Federal program to accelerate quantum research and development for the economic and national security of the United States.

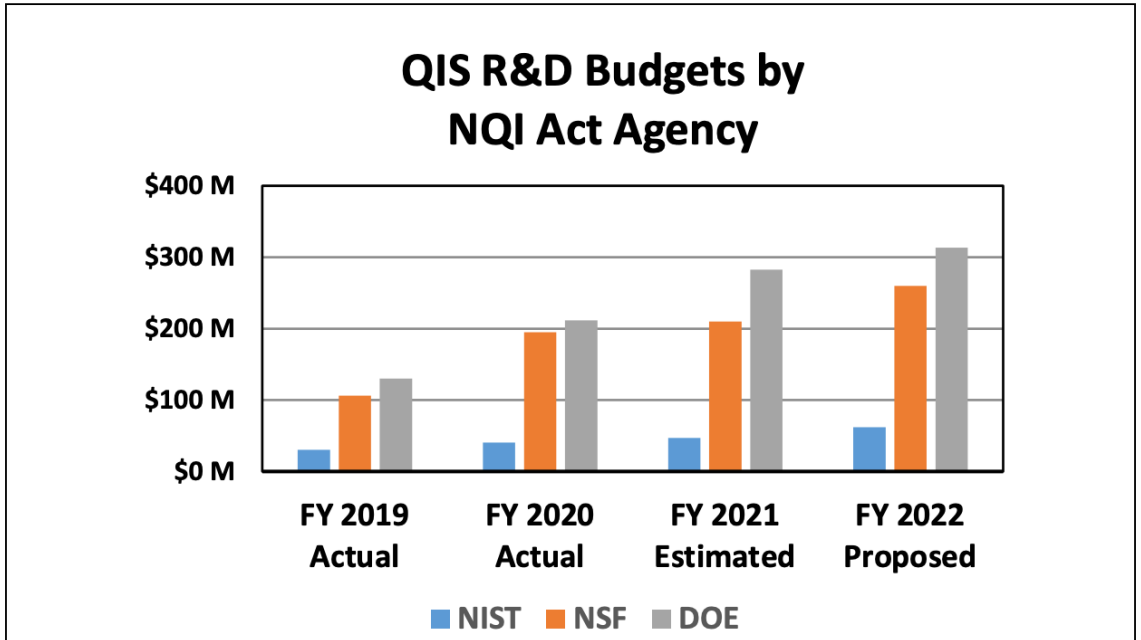


Figure 2.3: QIS R&D Budgets for three Agencies identified in the NQI Act, showing FY 2019 & FY 2020 actual expenditures, FY 2021 estimated expenditures, and FY 2022 requested budgets.

NQI Program Component Areas

- **Quantum Sensing and Metrology (QSENS)** refers to the use of quantum mechanics to enhance sensors and measurement science. This can include uses of superposition and entanglement, non-classical states of light, new metrology regimes or modalities, and advances in accuracy and precision enabled by quantum control, for example with atomic clocks.
- **Quantum Computing (QCOMP)** activities include the development of quantum bits (qubits) and entangling gates, quantum algorithms and software, digital and analog quantum simulators using programmable quantum devices, quantum computers and prototypes, and hybrid digital plus analog, as well as quantum plus classical computing systems.
- **Quantum Networking (QNET)** includes efforts to create and use entangled quantum states, distributed over distances and shared by multiple parties, for new information technology applications and fundamental science; for example, networking of intermediate scale quantum computers (modules) for enhanced beyond-classical computing capabilities.
- **QIS for Advancing Fundamental Science (QADV)** includes foundational efforts to invoke quantum devices and QIS theory to expand fundamental knowledge in other disciplines; for example, to improve understanding of biology, chemistry, computation, cosmology, energy science, engineering, materials, nuclear matter, and other aspects of fundamental science.
- **Quantum Technology (QT)** catalogues several topics: work with end-users to deploy quantum technologies in the field and develop use cases; basic R&D on supporting technology for quantum information science and engineering, e.g., infrastructure and manufacturing techniques for electronics, photonics, and cryogenics; and efforts to understand and mitigate risks raised by quantum technologies, e.g., post-quantum cryptography (see Box 4.1).

Quantum Science Center

- Quantum Science Center (QSC) Led by Oak Ridge National Lab
- ***Bringing together unique capabilities of National labs, Universities and Industries to advance science of quantum materials, sensors and algorithms.***
- Thrusts:

1) Quantum Materials Discovery and Development
2) Quantum Algorithms and Simulation
3) Quantum Devices and Sensors for Discovery Science

Led by Aaron Chou -- FNAL

Subgroup : Quantum Sensor for Dark Matter

Led by Lauren Hsu -- FNAL

QSC at FNAL

- 3 projects under Thrust 3, Quantum Devices and Sensors for Discovery Science (Led by **Farah Fahim, Dan Baxter and myself**)
- Other FNAL members might be involved in other projects in different capacities
- **Gustavo Cancelo and team (Chris, Sho, Leo and Sara)** at the center of these projects with their RFSoC based Quantum Toolkit (QICK) + RF board for qubit control and readout.
- Thrust 4: Codesign thrust: Several different projects

  -- Project "Quantum Sensing for Real World Applications" led by

  Daniel Bowring
- Cryogenic Engineering led by **Matt Hollister**
- Collaborate with local Dark Matter **(Tali, Northwestern)** and **Quantum (Alex Ruchio Ma, Leonid and Yong, Purdue)** experts.

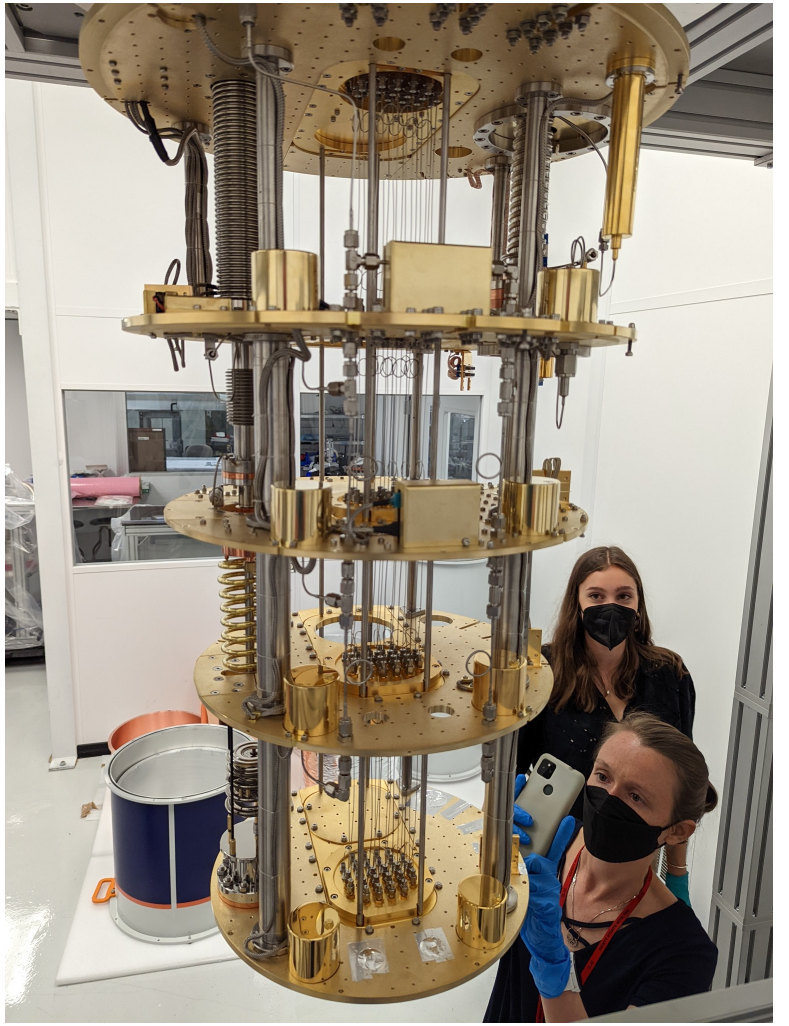
Why are we here?

We are building program in the following areas:

1) Types of quantum devices and sensors that fill in the gap in the current Dark Matter search regime particularly in the sub-GeV to μeV Ultralight Dark Mass regime. With utilization of low bandgap energy devices and exotic materials.
2) Development and readout of highly sensitive quantum sensors and technology in general useful for HEP applications and quantum computing.
3) Large array of qubits and quantum devices control and readout technology development utilizing ***RFSoC (RF System-on-Chip) FPGA toolkit (Quantum Instrumentation Control Kit: QICK) and RF companion board*** developed by Gustavo.
4) Exploration of novel materials like Topological Insulators and work with quantum materials community in utilizing and designing novel materials for HEP science.

We are developing workforce





Structure of the program

- In person and zoom talks
- Demo

Covers the topics in:

-- Cryogenic engineering and filtering,

-- Cryogenic electronics and quantum amplifier

-- RFSoC+RF boards

-- Quantum Instrumentation Control Toolkit (QICK) for qubit control and readout

Lunches and coffee are provided both days

Dinner social in Fermilab Pub on Friday after the program

Indico: https://indico.fnal.gov/event/56046/

- Thank you for joining us

Acknowledgement

DOE-OHEP-QuantiSED

Fermilab

This material is based upon work supported by the U.S. Department of Energy, Office of Science, National Quantum Information Science Research Centers, Quantum Science Center.

- This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.