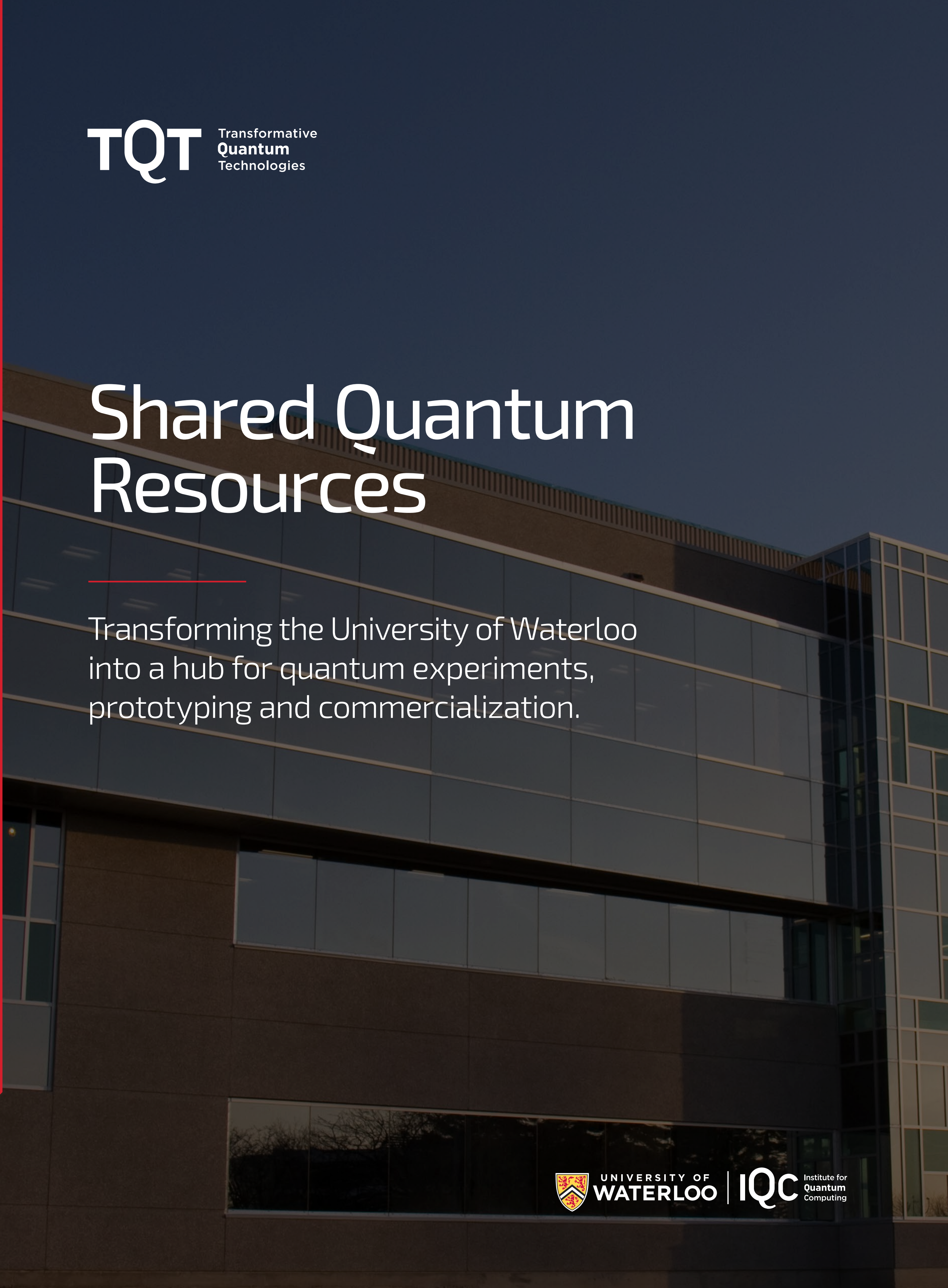
TQT Transformative Quantum Technologies

Shared Quantum Resources

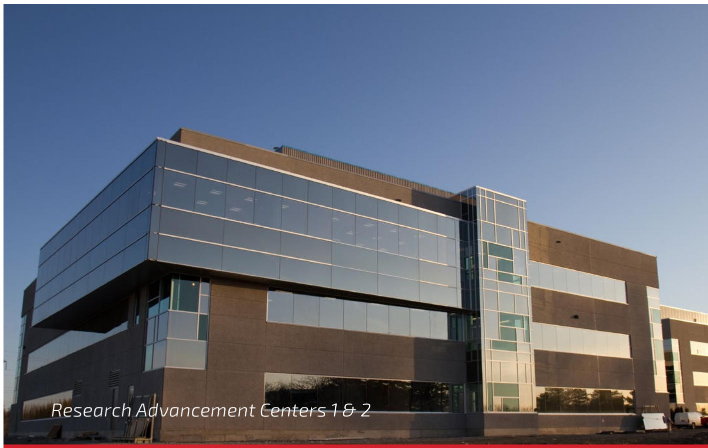
Transforming the University of Waterloo into a hub for quantum experiments, prototyping and commercialization.



University of Waterloo | IQC Institute for Quantum Computing

From Quantum Science to Quantum Innovation

Waterloo's quantum ecosystem — a community of researchers dedicated to advancing quantum science, technology, and innovation.



Research Advancement Centers 1 & 2

Academic, commercial and collaboration space. Infrastructure developed by TQT and QVI.

The Institute for Quantum Computing and the Quantum-Nano Fabrication & Characterization Center (QNFCF).

Mike and Ophelia Lazaridis Quantum-Nano Centre

Quantum Innovation Cycle (QuIC)

QuIC is a complete technology development resource enabling quantum exploration and development. Capabilities are open to all quantum researchers.

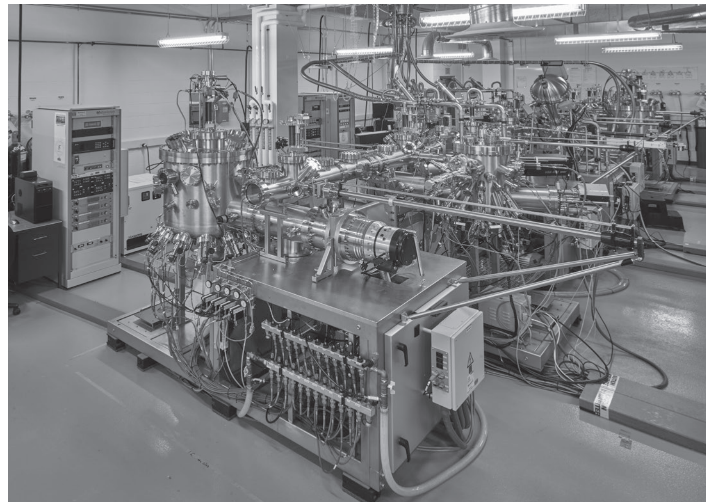
KEY QUANTUM LABS

- QNFCF
- Growth Labs @ TQT
- Characterization Labs @ TQT
- Quantum Simulation @ TQT

Quantum Matter

Quantum devices demand extraordinarily clean and defect free materials.

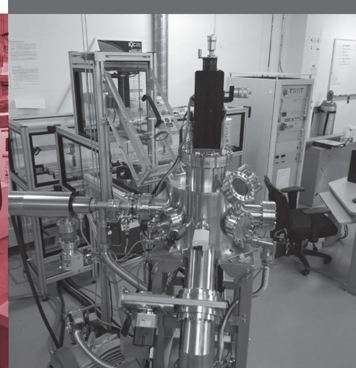
There are a variety of specialized facilities at UW to support the growth or deposition of quantum materials.



7 Chamber UHV Molecular Beam Epitaxy for Superconductors & Topological Insulators

Silicon CVD

Pulsed Laser Deposition for Metal Oxides, including YBCO



Graphene CVD

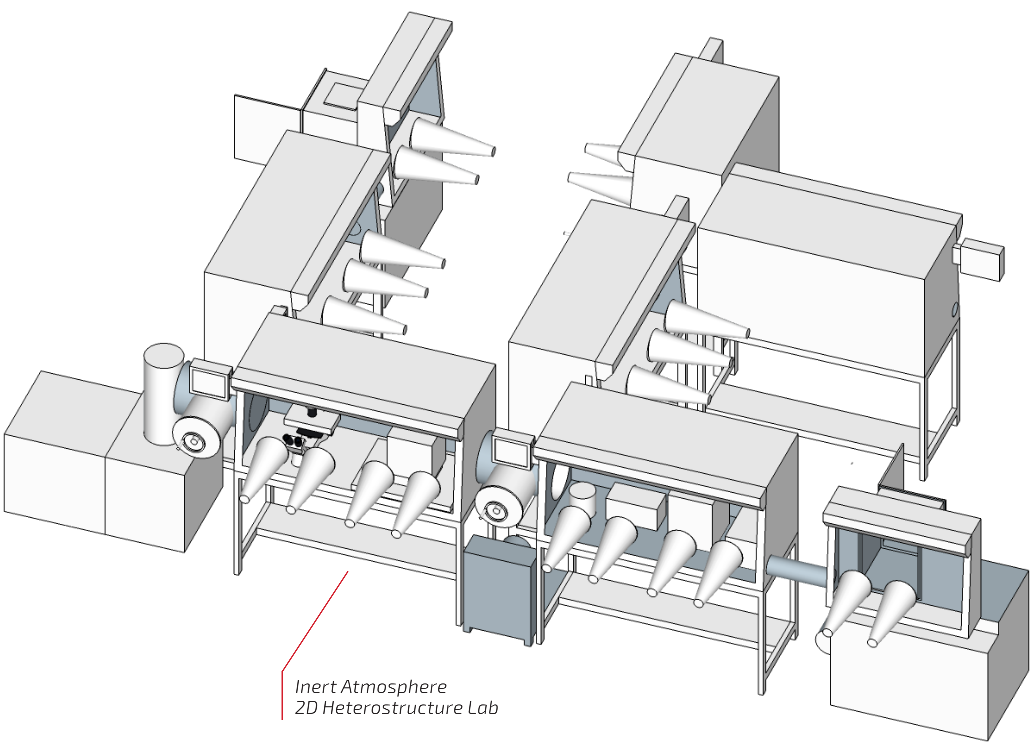
Diamond CVD

Quantum Matter

Under development: a complete fabrication system for 2D Heterostructure devices, where all activities, from exfoliation to device testing, can be performed in an inert atmosphere.

CAPABILITIES UNDER INERT ATMOSPHERE

- Metallization
- Atomic Force Microprobe (AFM)
- Scanning Electron Microscope (SEM)
- Electron Beam Lithography (EBL)
- Rapid Thermal Annealing (RTA)
- Reactive Ion Etching (RIE)
- Spin Coating
- Develop/Strip

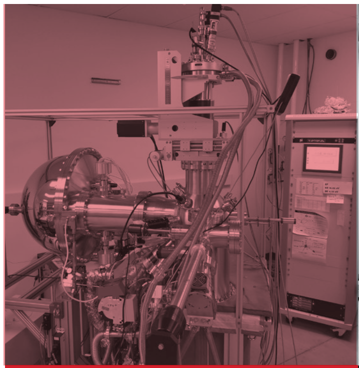


Materials Characterization

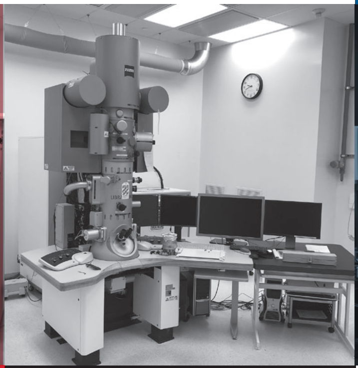
Characterizing and improving material properties are essential components of QuIC. For some materials characterization, we have developed unique quantum tools.

Vibrating Sample Magnetometer (VSM)

Fast-Scan Atomic Force Microprobe (AFM)

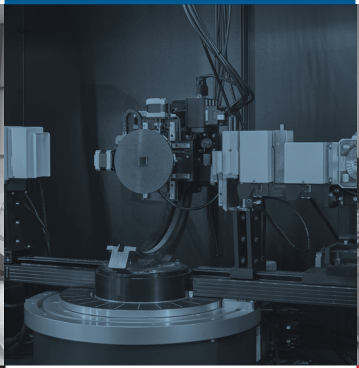


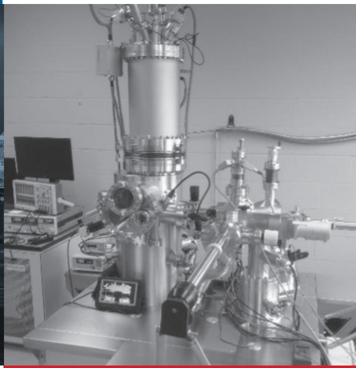
Angle-Resolved Photo Electron Spectroscopy (ARPES)



Transmission Electron Miscroscopy (TEM) (Currently being upgraded)

X-Ray Diffraction (XRD)





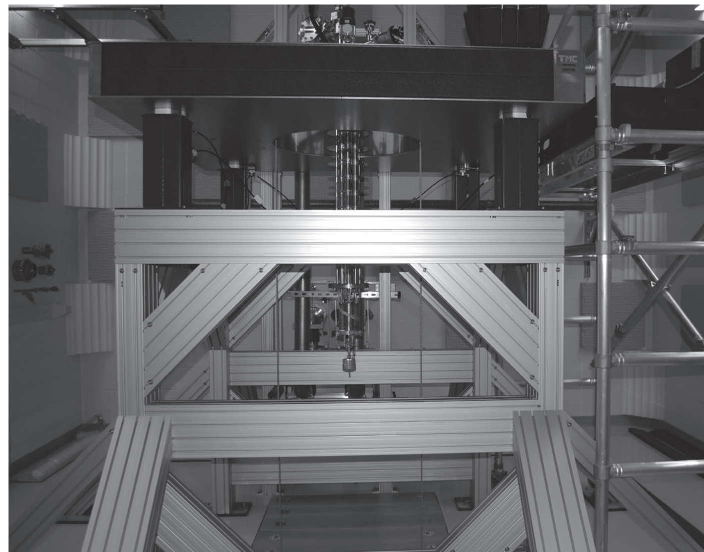
Low Temperature Scanning-Tunneling Electron Microscope (LT-STM)

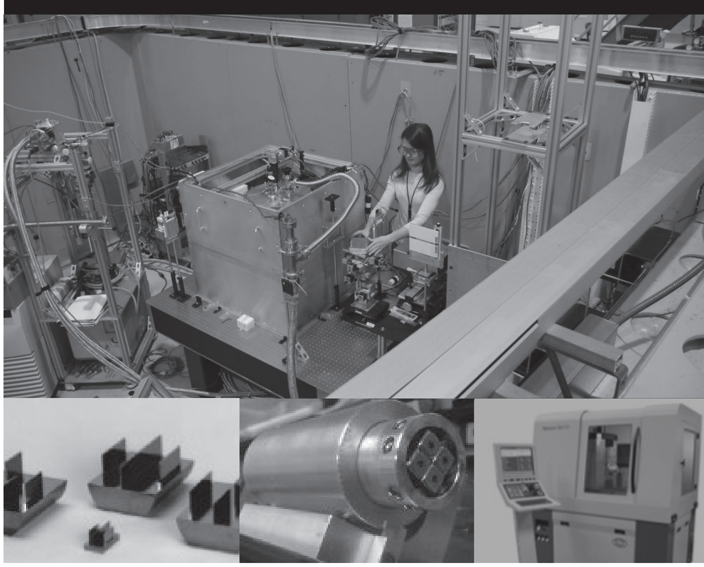
Custom Quantum Devices for Characterization

MAGNETIC RESONANCE FORCE MICROSCOPY (MRFM)
MRFM allows atomic resolution subsurface structure determination with applications to structural biology and quantum matter.

MAGNETISM & COMPOSITION
Using a novel quantum sensor provides extraordinary increases in signal to noise ratio (SNR) for electron spin resonance (ESR).

NEUTRONS
In a collaboration with NIST, we have extended neutron interferometry to characterizing the internal fields of quantum materials.


MRFM

Neutrons



Quantum probes for ESR

Device Fabrication

The QNFCF provides a complete suite of fabrication tools including e-beam lithography.

Electron Beam Lithography (EBL) and Maskless Photo-lithography

Maskless aligner for rapid device fabrication

Custom space for clean assembly of optics, trapped ions, superconductors, LT physics, and other fabrication.

Device Testing

Testing device performance, from measuring relaxation times to bench marking coherent control, are enabled by shared control systems and low temperature (LT) systems.

Dilution Refrigerators

Flow Cryostat in 2T Magnet

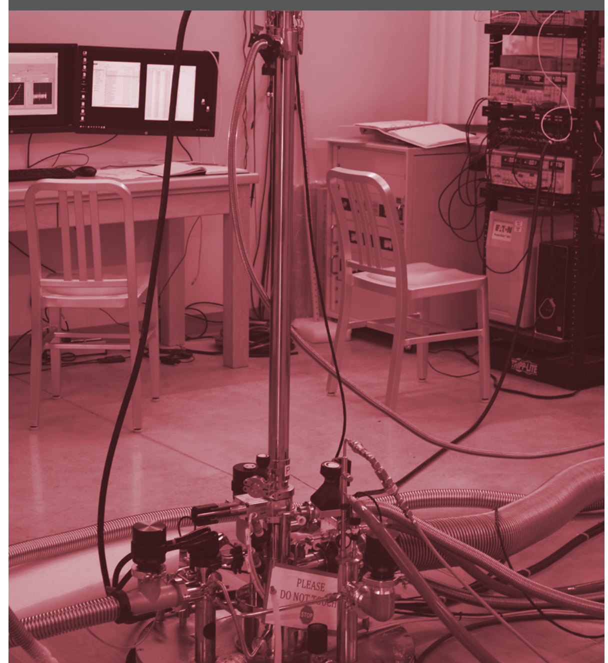
Dilution Refrigerator
in Low Vibration Space

Device Testing
Low Temperature, High Field

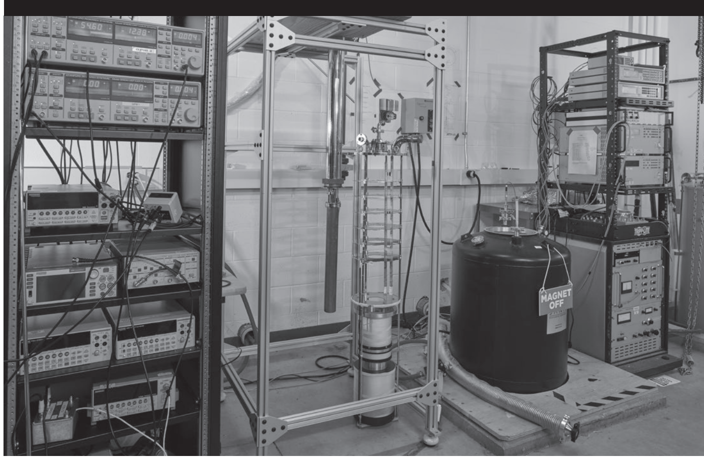
A range of options are available for testing samples at low temperatures and high magnetic fields:

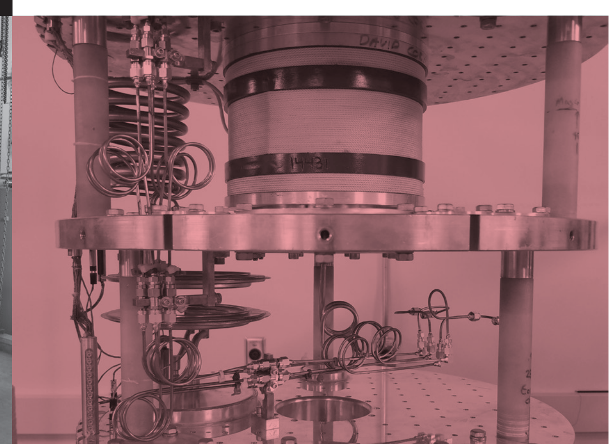
- Flow cryostats below 3K and up to 1T fields
- ^{3}He refrigerator (350 mK) or Variable Temperature Insert (VTI) (1.5-300 K) in a 12T magnet
- Dilution refrigerator (10 mK, 400 μW) in a 20T magnet

Dilution Refrigerator with 20T Magnet



^{3}He or VTI in 12T Magnet





High and Low Field Dilution Cryostat Platform

Quantum Applications

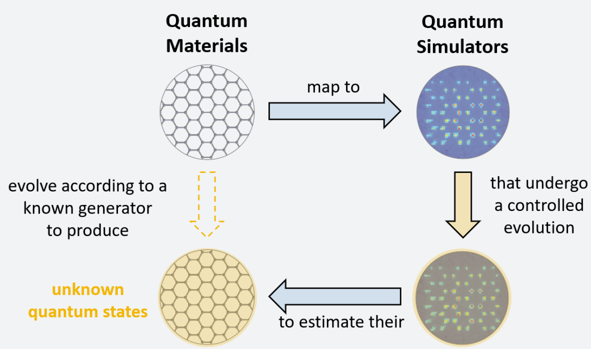
Quantum simulation is the key activity that closes the QuIC. Using programmable simulators, we can model materials and devices, developing new targets for materials growth and fabrication.

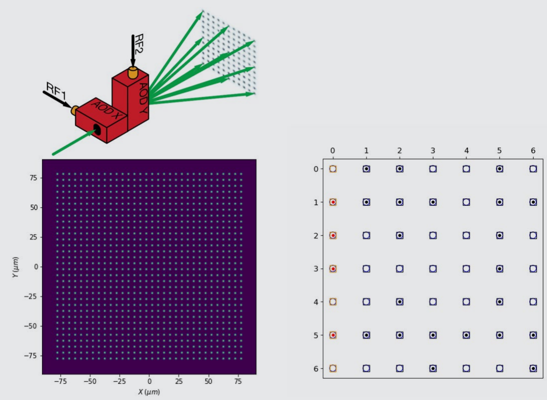
The general scheme of quantum simulation, a controllable quantum system is used to model one that we do not have experimental access to.

With either approach to quantum simulation, each spatially localized atom acts as a qubit. The interactions between qubits are fully programmable and the state of any individual qubit can be read out.

Trapped Ions in a 2-D Simulator

Quantum Simulation





Rydberg Atoms in a 2-D Simulator

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