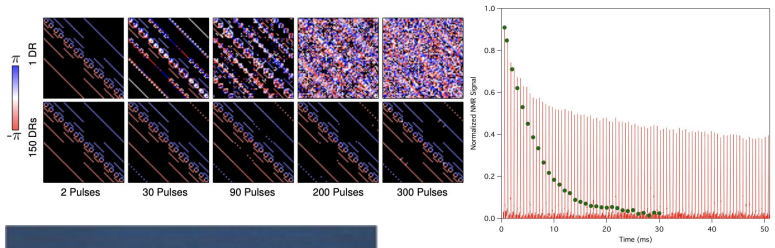
Dale Li

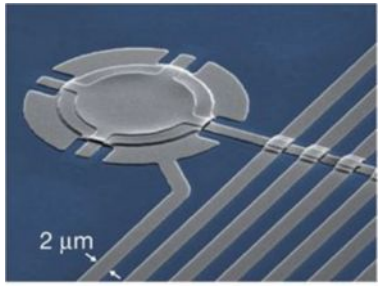
- Quantum decoherence in a many spin system

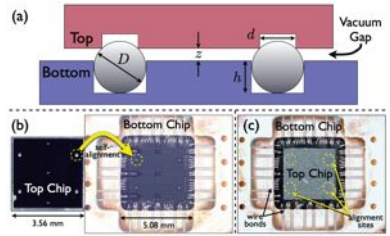
- Superconducting qubits
- Cooling of micromechanical oscillators
- SQUID flip-chip testing for advanced qubits

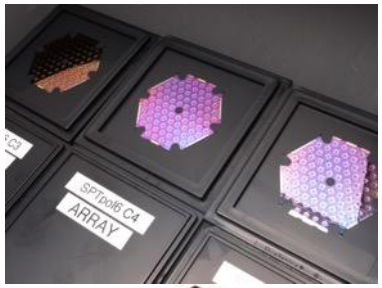
- Design and Fabrication of detector arrays for CMB

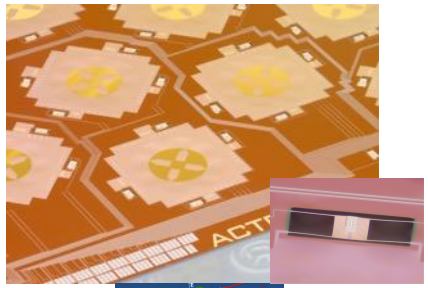
- TES spectrometer for SSRL, LCLS-II
- DM Radio
- Quantum sensors for wave-like DM detection
- DMF superconducting cleanroom

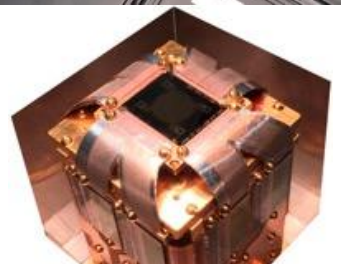


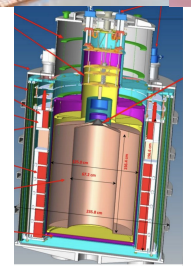












Quantum 1.0 Technology Growth

Superconducting Quantum Interference Devices (SQUIDs)
- Magnetometry – geology, medical imaging, fundamental science
- Detector multiplexing & readout
- NMR spin sensing

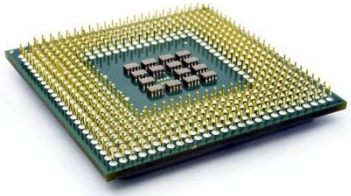
Superconducting Transition-Edge Sensors (TES)
- Dark-matter detection
- CMB cosmology
- X-ray spectroscopy
- Forensics and nuclear safeguards

Microwave Kinetic Inductance Devices (MKIDs)
- Dark-matter detection
- CMB cosmology
- Forensics

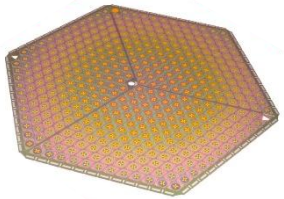
1. Does not require detailed control and manipulation of coherent quantum states *(*which would be Quantum 2.0).
2. Limited by the Heisenberg Uncertainty Principle to the Standard Quantum Limit (SQL) (evading the SQL would be Quantum 2.0).

Technological Vision for Superconducting Fab

Develop superconducting device fabrication (both Quantum 1.0 and Quantum 2.0) to the maturity level required for DOE science applications



"Easy": semiconductor processing, after decades of multi-billion-dollar industrial investment.



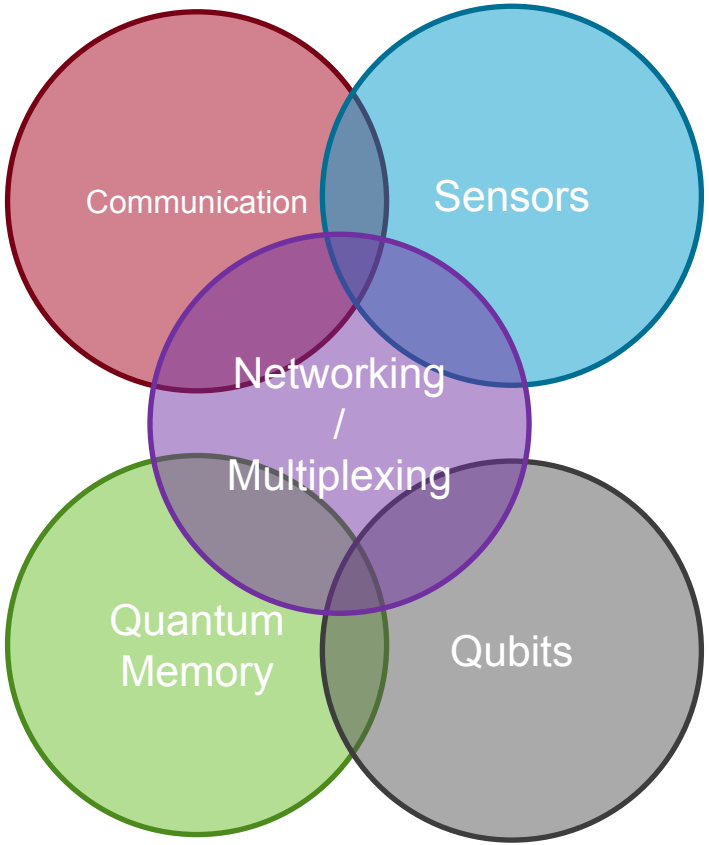
Hard: superconductor processing. Will always be an art; the market is too small for industrial "skin in the game". Requires lab-scale effort and high level of metrology to maintain.

DMF technical goals:

- Dedicated Tools: Uniformity, Control, Contaminant-Free
- Development of customized metrology for specific scientific yield
- Training of a new quantum device workforce

Diverse Challenges in Superconducting Fabrication

Fabrication for superconducting quantum devices



- Wide range of applications and fabrication challenges.
- Many fabrication challenges (e.g. decoherence) are unique to this field.
- Future scientific goals of DOE-SC will hinge upon successful maturation of this technology.
- We need a process to solve these challenges.

Different Testing Types and Needs