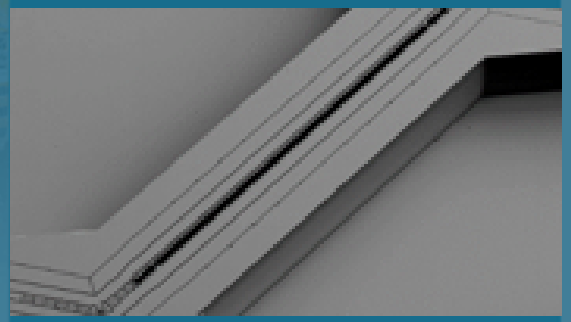
SAND2022-0306C

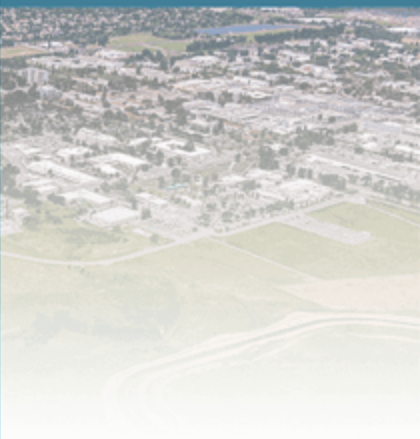
Sandia National Laboratories

Quantum Systems Accelerator



Rick Muller
Senior Manager, Quantum and Advanced Microsystems, Sandia National Labs
Deputy Director, Quantum Systems Accelerator

PQE Conference, Snowbird, UT, 1/13/2022



U.S. DEPARTMENT OF ENERGY | NNSA

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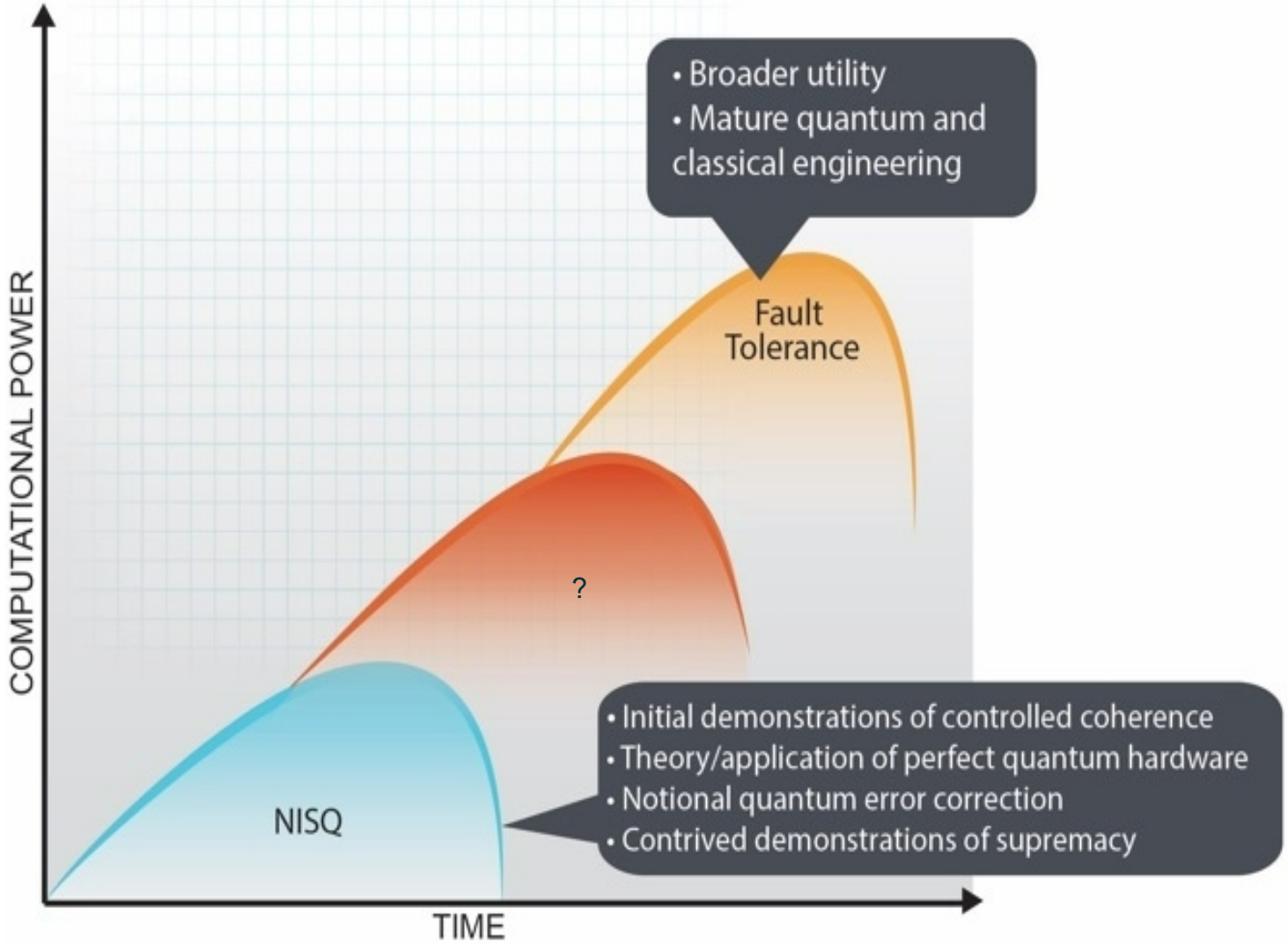
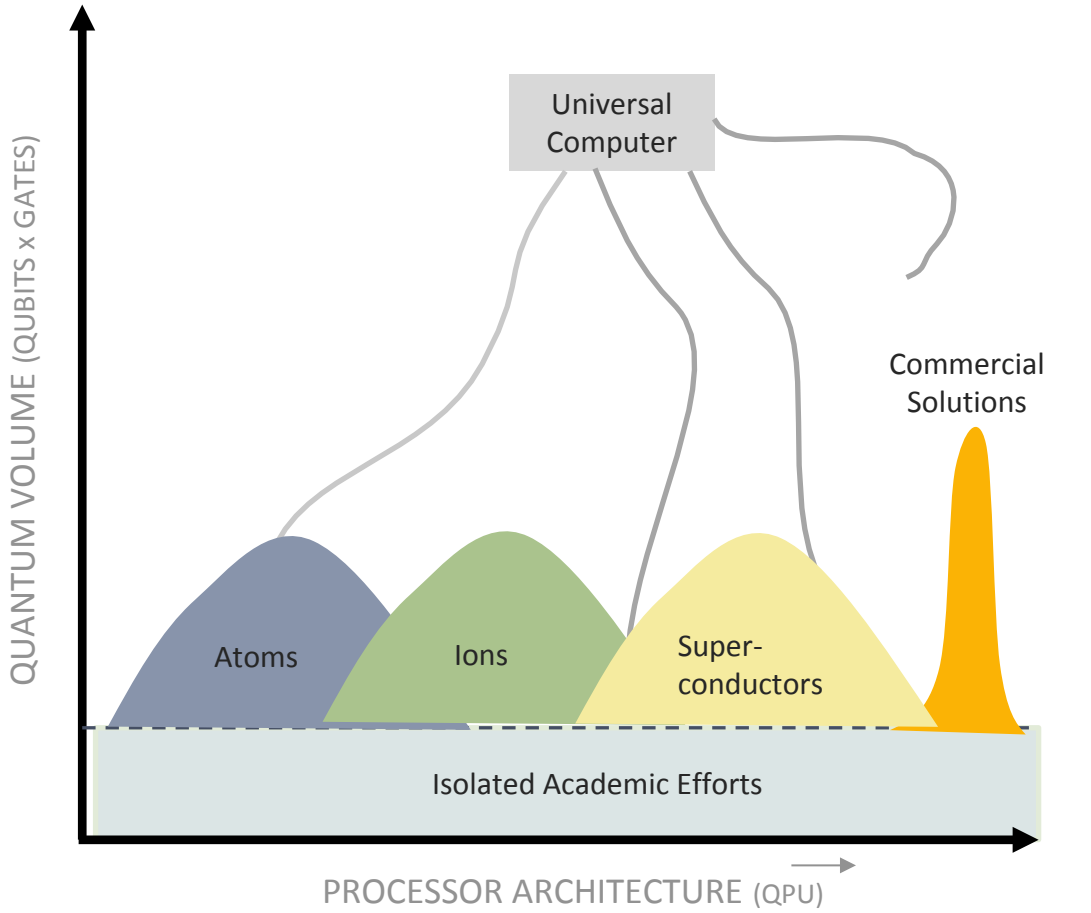
Where are we in QIS? Where are we going?



Quantum Systems Address Major Challenges in QIS



Open/closed q. system

Graph coordination

Algorithm type

. . .

. . .

QSA Approach

Obstacle 1: Errors and coherence issues.

- Systems-level materials optimization
- Noise resilient encodings & Active error suppression

Obstacle 2: Non-extensible controls

- Integrated optical/microwave control: CW & pulsed
- Cost-effective modularization

Obstacle 3: Unexplored domain of meaningful applications

- Platform-aware simulation/emulation/optimization
- Robust vs. complexity tradeoffs

Obstacle 4: Lack of benchmarking protocols for NISQ

- Scalable quantum benchmarks / supremacy
- Comparison of algorithm type for exact models

QSA Addresses the Scientific Foundations for Quantum Computation

QUANTUM SYSTEMS ACCELERATOR

Catalyzing the Quantum Ecosystem

Catalyzing **national leadership** in quantum information science to co-design the algorithms, quantum devices, and engineering solutions needed to deliver certified quantum advantage in Department of Energy scientific applications.

QSA Approach: Co-Design Across the Stack

APPLICATIONS

INTERFACE

SYSTEMS

CONTROLS

QUBITS

MATERIALS

Algorithms & Applications

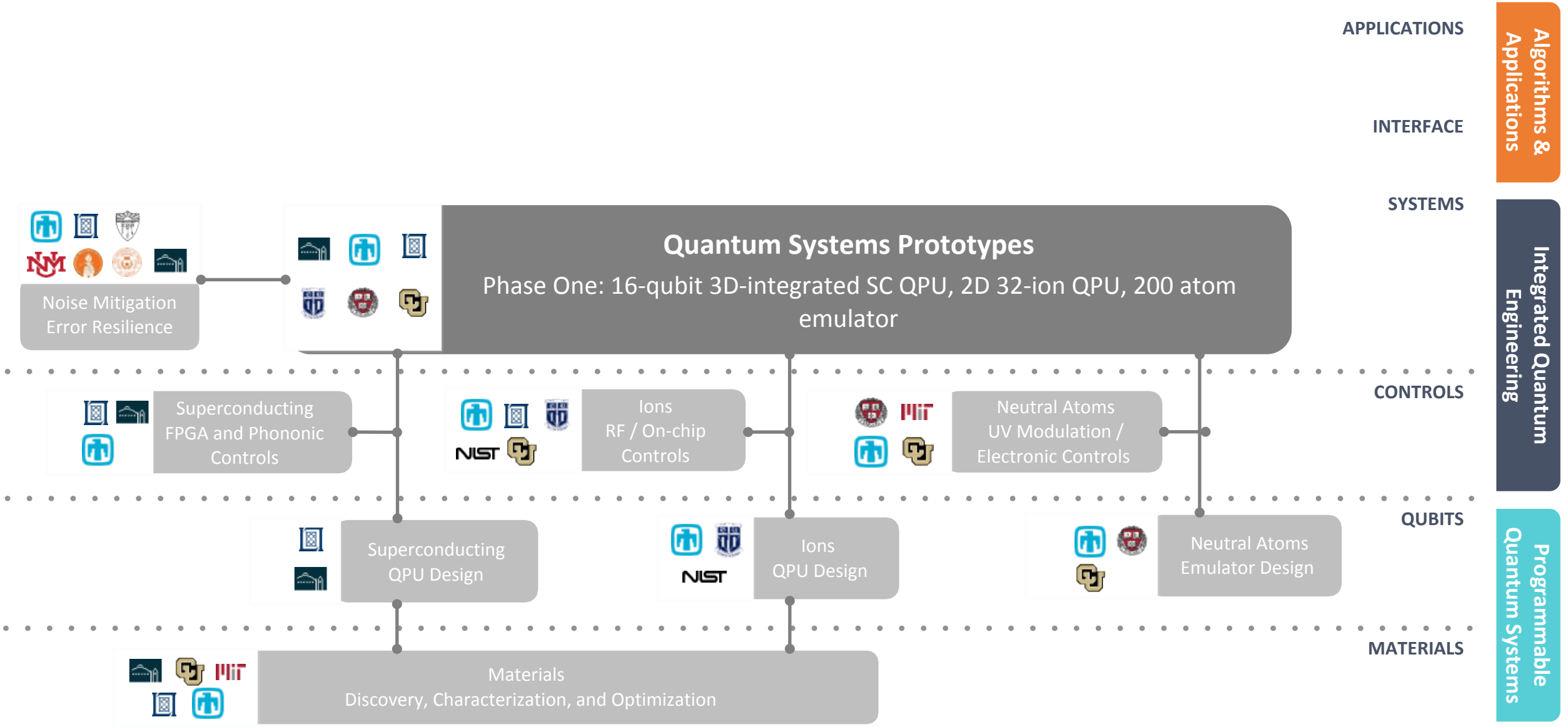
Integrated Quantum Engineering

Programmable Quantum Systems

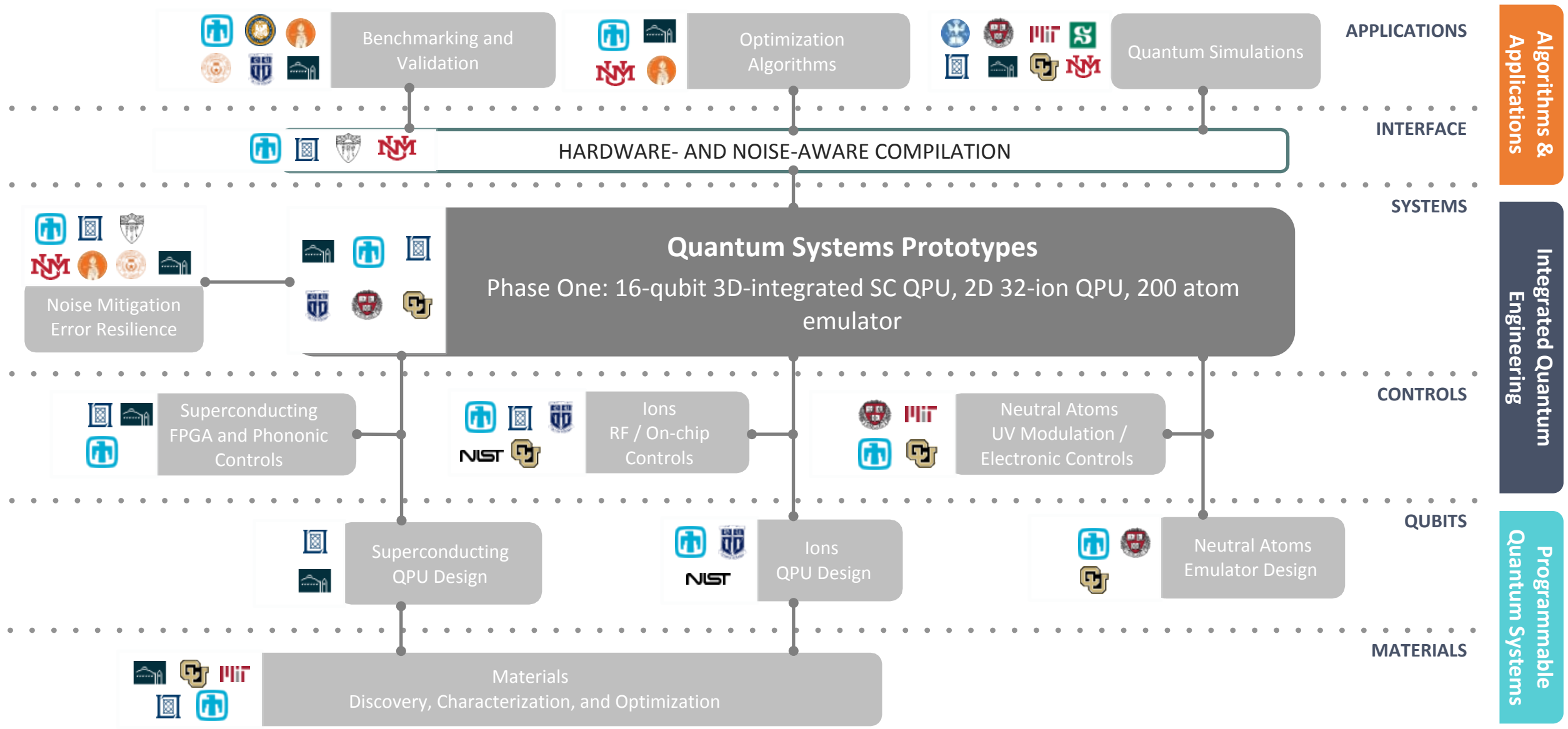
Quantum Systems Prototypes

Phase One: 16-qubit 3D-integrated SC QPU, 2D 32-ion QPU, 200 atom emulator

QSA Approach: Co-Design Across the Stack

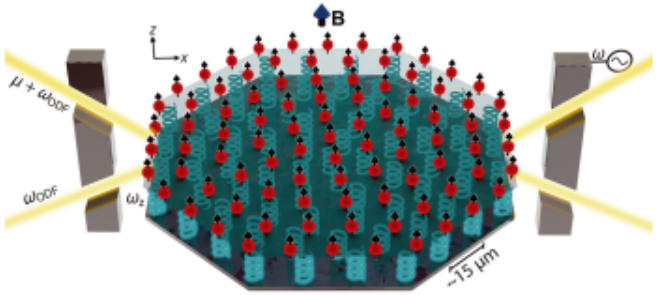


QSA Approach: Co-Design Across the Stack



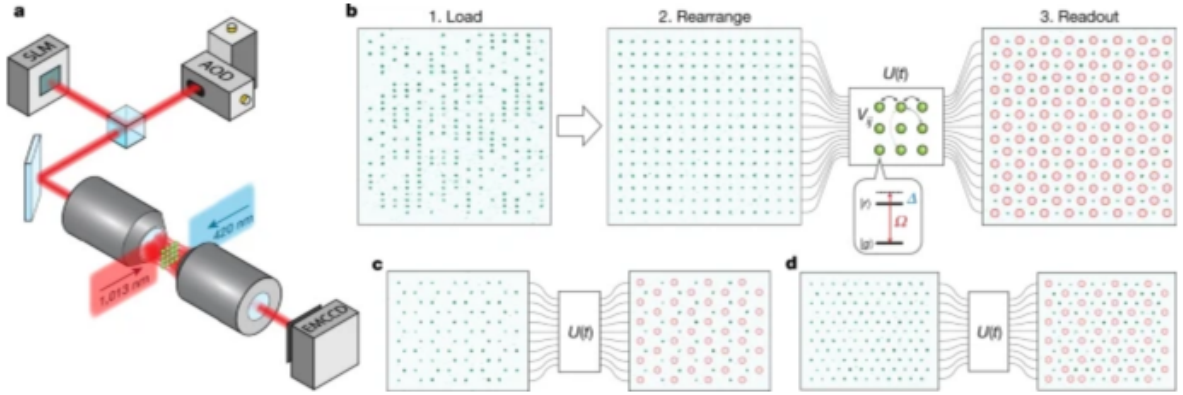
Science Emerging from the QSA

Quantum-enhanced sensing of displacements and electric fields with two-dimensional trapped-ion crystals



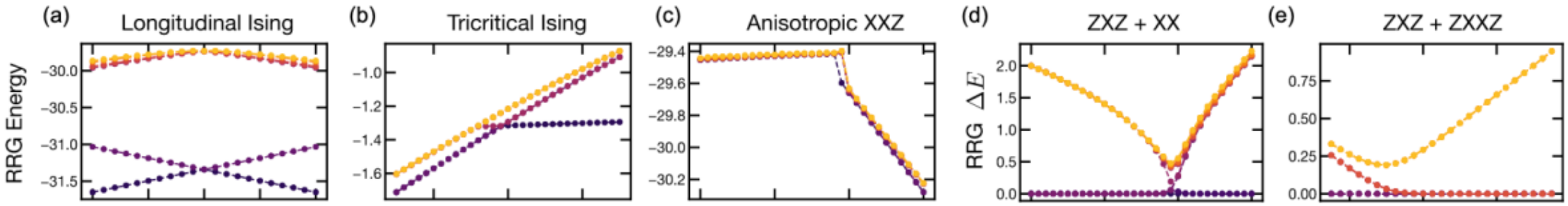
Gilmore *et al.,* Science 373, 6555

Quantum phases of matter on a 256-atom programmable quantum simulator



Ebadi *et al.,* Nature 595, 227–232

Performance of the rigorous renormalization group for first-order phase transitions and topological phases



Block *et al.,* Phys. Rev. B 103, 195122

This is a photonics meeting. How Does Photonics Fit In?

- Obviously
  - Optical control for AMO systems
  - Ryan Camacho's "Optical Backplane"
  - Quantum networks of heterogeneous hardware
- Less obviously
  - Photonic quantum computing and its implications:
  - If we're going to use photonics technology to network heterogeneous hardware together, why not integrate photonic computation as well?
  - If photonic quantum computing is integrated into a heterogeneous quantum environment, what is the proper role for it to play?