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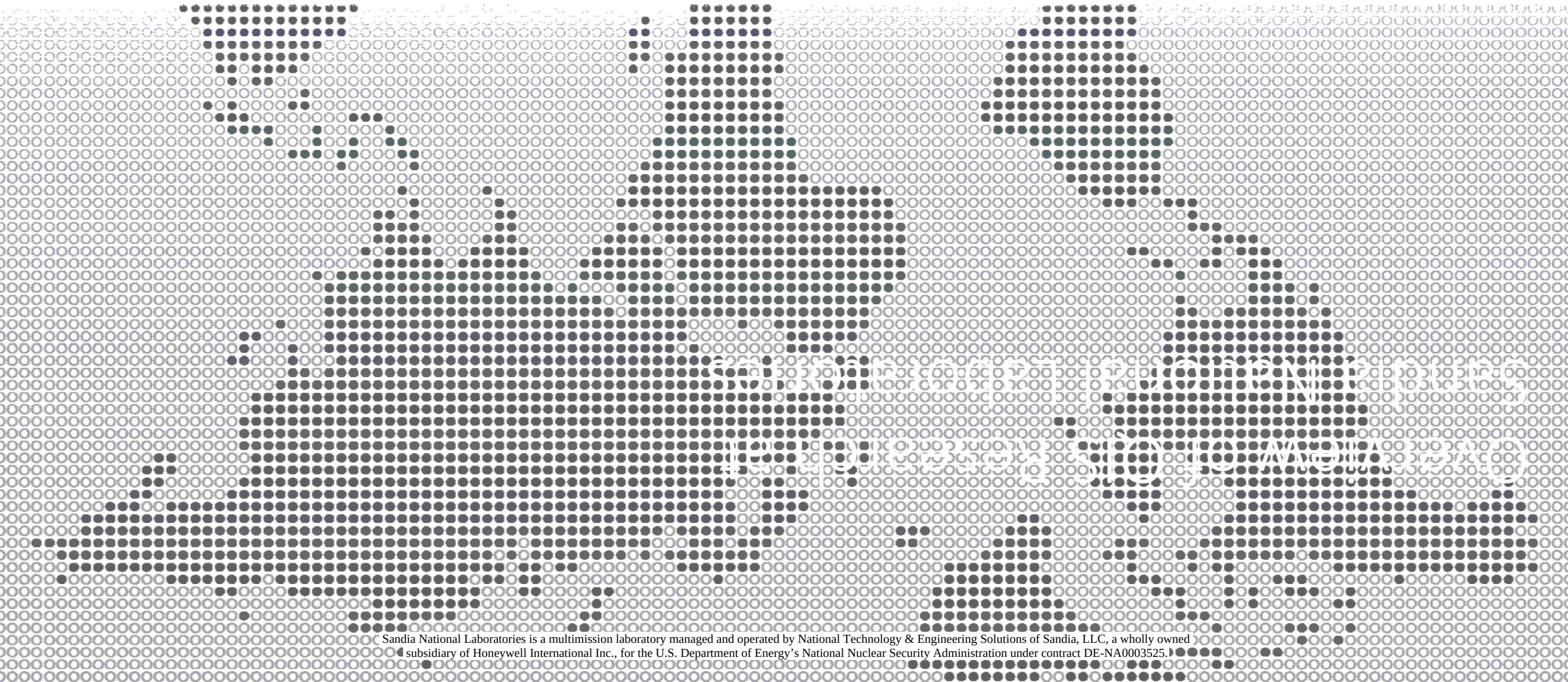

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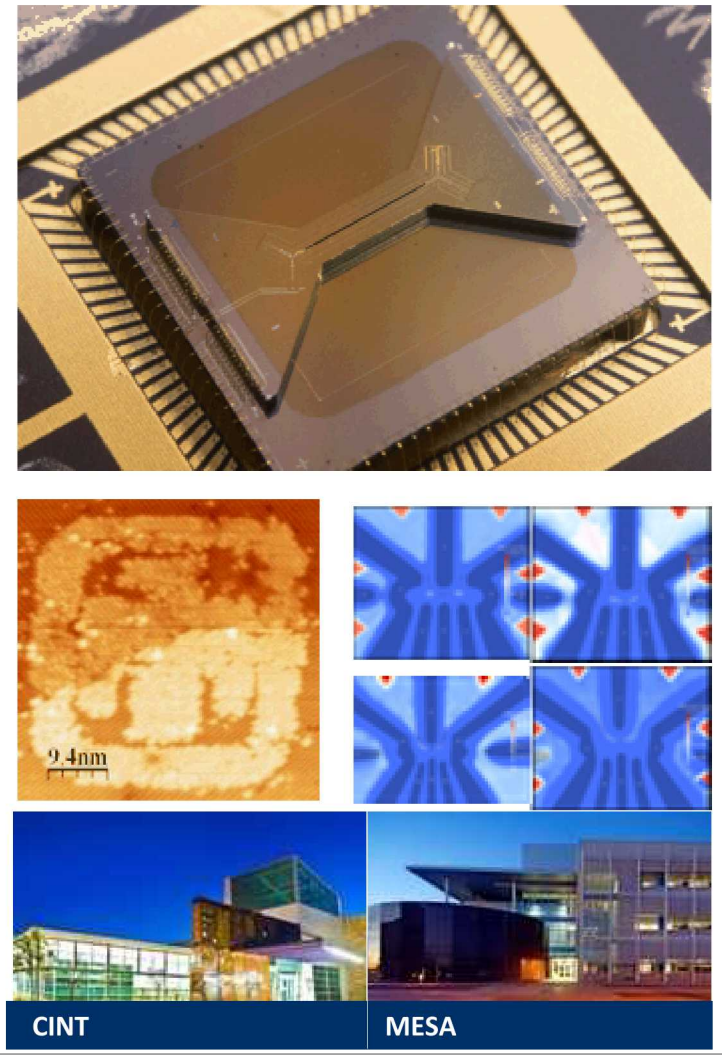
# Sandia Is a Leader in QIS

- Built on significant investments over 15 years
  - Over 70 different internally-funded projects
  - Matched by significant govt investment
- Unique, hard-to-replicate capabilities
  - Producing working quantum devices in multiple technologies
  - Deep understanding of how device architecture impacts quantum applications and algorithms
  - Strong cross-organizational team with deep quantum expertise and appropriate clearances
- Trusted advisor to USG
  - Decade of performance on government projects
  - Key agency rotations and workshop leadership



# Sandia QIS Capabilities Built on DOE Infrastructure

- MESA Silicon & Micro Fabs:
  - Design, build, test world-leading semiconductor and atomic qubits.
  - Capabilities for exotic materials, novel processing and fabrication
- Center for Integrated Nanotechnologies (CINT):
  - DOE/SC National User Facility - device testing, materials & devices characterization, Atomic Precision lithography
- Ion Beam Lab:
  - Phosphorous implantation for Donor & Donor-Dot qubits
- Extensive Computing Facilities:
  - Critical enabler for qubit design, physical modeling, testing, data analyses, and system evaluation
- Materials Science:
  - Synthesis, process prototyping, measurements, characterization, modeling

MESA

CINT

IBL

# Aggressive LDRD Investments Built Sandia QIS Foundations

*Internal investment anchored by five grand-challenge investments*

**FY08 – FY10**
*Si-based qubits*

- Silicon quantum dot qubits
- Architecture & logical qubit design

**FY11-FY13**
*Alt. Architecture*

- Adiabatic architecture assessment
- Atomic precision lithography development
- Neutral atom computation

**FY14-FY16**
*Comms/QKD*

- Quantum key distribution development
- Photonic communications/networking development

**FY18-FY20**
*Atom Interferometer*

- Develop deployable quantum devices
- Quantum sensing based location determination

# Current QIS LDRD Projects

NEW for FY19:

1. Leveraging Spin-Orbit Coupling in Ge/SiGe Heterostructures for Q. Info Transfer – D. Luhman, PI
   - A step in development of flying qubits
2. Enhance Coherence Time in Intensely Driven Quantum Systems – W. Pan, PI
3. A Quantum Analog Coprocessor for Correlated Electron Systems Simulation– A. Baczewski, PI
4. Characterization and Optimization of Building Blocks for Specialized Computing Platforms– T.S. Metodi, PI
5. Quantum Manifold Learning – M. Sarovar, PI
6. A Miniaturized Optical Atomic Clock for High Performance Navigation, Communication, and Radar Applications – P. Schwindt, PI
7. Quantum-Based Electron Spin Resonance Platform for Nanomaterials – M. Lilly, PI
8. Imaging Microwave Fields with Sub-Micron Resolution using Nitrogen-Vacancy Centers in Diamond – P. Kehayias, PI
9. Novel Optical Coupling For Heterogeneous Photonics – G. Vawter, PI
10. Integrated Photonics for Enhanced Dynamic Range Radio Frequency Systems – M. Gehl, PI

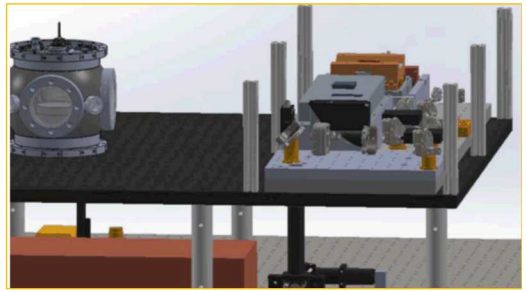
CONTINUING:

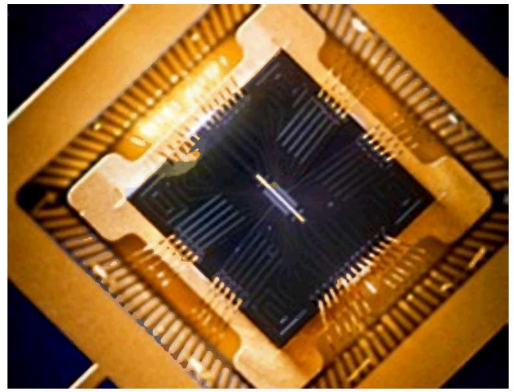
11. Topological Quantum Material for Quantum Computation – W. Pan, PI
12. Designer Quantum Materials – S. Misra, PI
13. Diagnosing and Destroying Non-Markovian Noise in Qubits – K. Young, PI
14. Efficient, Scalable Tomography of Many-Qubit Quantum Processors – E. Nielsen, PI
15. Demonstrating Robustness of Analogue Quantum Simulators – P. Maunz, PI
16. Magnetic Field Synthesis at the Nanoscale for Engineered Quantum Materials – T-M Lu, PI
17. Strategic Inertial Guidance using Matterwaves (SIGMA) – G. Biedermann, PI
    - Enable sub-100 ngal performance in a 1000x smaller package
18. Phonon Blockade of the Superconducting Transition – I. El-Kady, PI

**Brown entries:** Enabling technologies for QIS

# DOE:ASCR Research
## *Quantum Testbeds, Algorithms, and Performance Assessment*

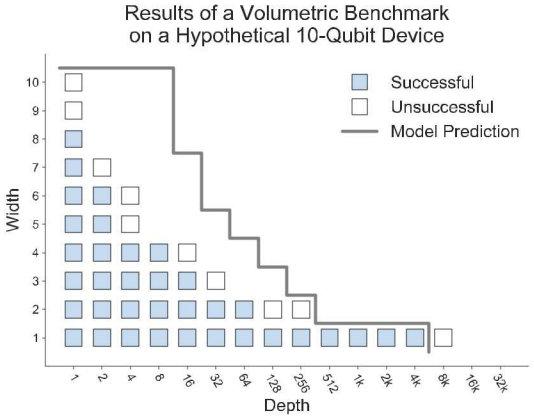
**QSCOUT:** Open quantum testbed facility to explore quantum algorithms for scientific computing problems. $25M/5 yrs



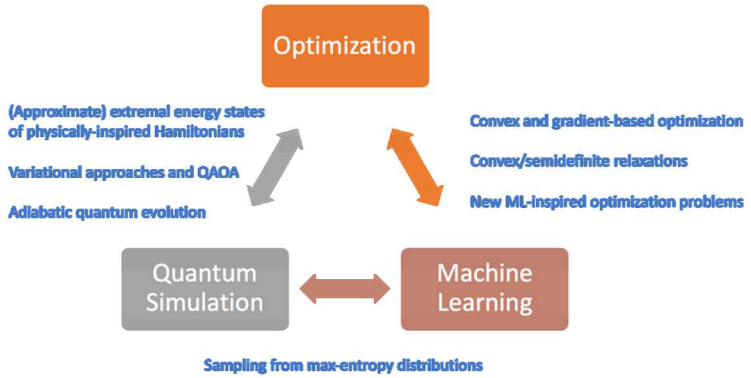


**QPERFORMANCE:** Cross-platform assessment of quantum processors' performance at meaningful tasks. $4M/5 yrs

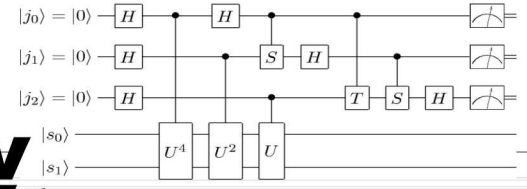
R. Blume-Kohout and K. Young, "*A volumetric framework for quantum computer benchmarks*" arXiv:1904.05546




**QOALAS:** Quantum Optimization and (machine) Learning and Simulation.
*Results include*: new rigorous approximations for physical ground states, new quantum algorithms for optimization and solving linear systems
*Project website*: https://qoalas.sandia.gov
$5M/3 yrs




**OVER-QC:** Optimization, verification, and engineered reliability of quantum computers. Produce software and analysis tools to verify the operation of near-term devices and to increase their reliability on real-world problem instances.
*Project website*: https://overqc.sandia.gov
$5M/3 yrs



ProveIt: http://pyproveit.org

New projects under ASCR Accelerated Research in Quantum Computing:
- **FAR-QC**: Fundamental Algorithmic Research for QC (Parekh, SNL, PI) $7M/5 yrs to SNL
- **AIDE-QC**: Advancing Integrated Development Environments for QC (Sarovar, SNL, CoPI) $4M/5 yrs to SNL