# QIS Workshop: Welcome

## Argonne PSE/CELS QIS Working Group

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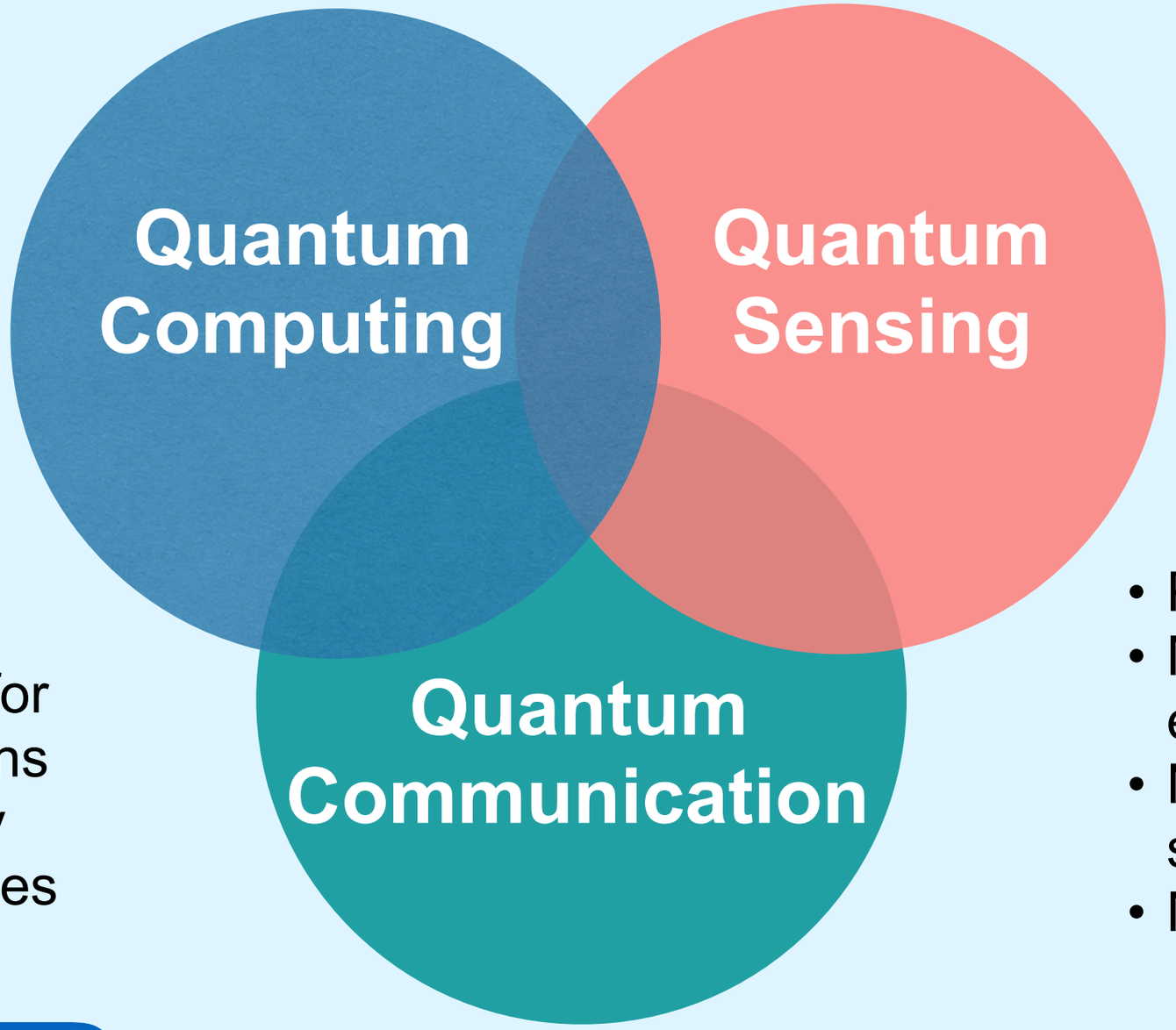
**CPS/HEP Divisions**
**September 23, 2019**




- Algorithms
- Hybrid computing
- Compilers
- Error correction
- Optimization
- QC architectures for science applications
- Device technology
- Materials challenges

- Precision metrology
- Measurement efficiency/sensitivity
- New detectors for sensing/imaging
- Materials challenges

- Flying Qbits/quantum networks
- Teleportation
- Realistic QC architectures
- Quantum memory

**Conference Support:**
**Becky Rank (PSE)**
**Samantha Tezak (CPS)**

# Workshop Goals

- **Snapshot of the state-of-the-art**
  - **Talks covering the frontier of current R&D boundaries**
  - **Forward-looking ideas in both "small" and "big" science**
  - **Discussions around new QIS topics and R&D directions**

- **Identification of possible collaborations**
  - **Talks covering a number of Argonne QIS activities**
  - **Enough time in discussion and poster sessions to explore topics of mutual interest**
  - **Develop informal and formal collaborations**

https://indico.fnal.gov/event/21552/overview

- **Argonne Info**
  - **First National Lab in the US** — (July 1, 1946), broad science reach, basic to applied
  - **Basic science —** materials science, physics, chemistry, biology, high-energy physics, nuclear physics, mathematics and computer science, high-performance computing
  - **Applied science and engineering** — energy resources, environmental management, and national security
  - **Major facilities** — Advanced Photon Source (APS) , Argonne Leadership Computing Facility (ALCF), Argonne Tandem Linear Accelerator System (ATLAS), Center for Nanoscale Materials (CNM)

# QIS: Engagement Drivers for Argonne

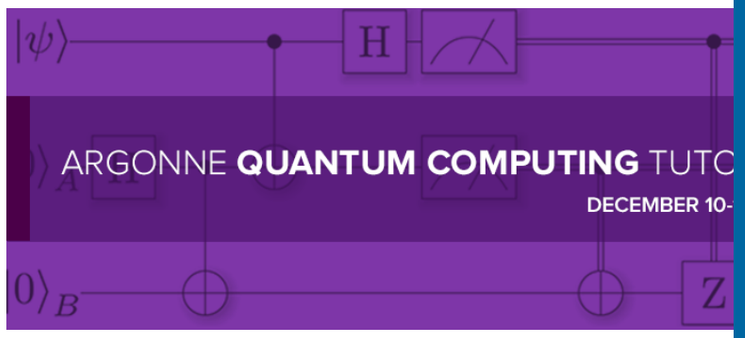
- **Placing QIS in the Argonne Context**
  - What can QIS do for Argonne? Key Issues:
    - **Argonne mission space** axes best aligned to QIS-based technologies
    - QIS projects that **strongly impact** Argonne's strategic R&D mission
    - **Timescales** for development and adoption of QIS-based approaches
  - What can Argonne do for QIS?
    - **Argonne R&D capabilities** that can nucleate new QIS directions/technologies and/or accelerate development of known techniques
    - **Internal and external collaborations** to best achieve connectivity with other efforts

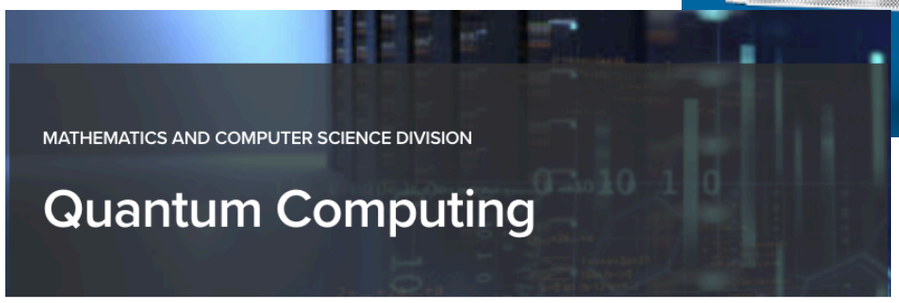
- **Institutional (PSE/CELS) QIS Working Group**
  - Ground-up effort to develop and focus QIS activities
    - coordinate collaborations and responses to proposals
    - organization of seminars/visitors/workshops
    - membership of ~100 Argonne scientists

**POCs:**
Salman Habib (CPS/HEP), habib@anl.gov
Stephen Gray (NST), gray@anl.gov

# QIS: Current Argonne Interests

- **Three Overlapping Categories**
  - **Theory**
    - Quantum computing, simulation, sensing, or other modeling related topics, substantial interest in near-term possibilities/applications
  - **Quantum Materials**
    - Experimentalists interested in “quantum materials” and oriented more towards fab/ characterization/probes
  - **Quantum Devices/Sensors**
    - Experimentalists more interested in technology realizations of quantum devices (includes qubits) and sensors (superconducting technologies)

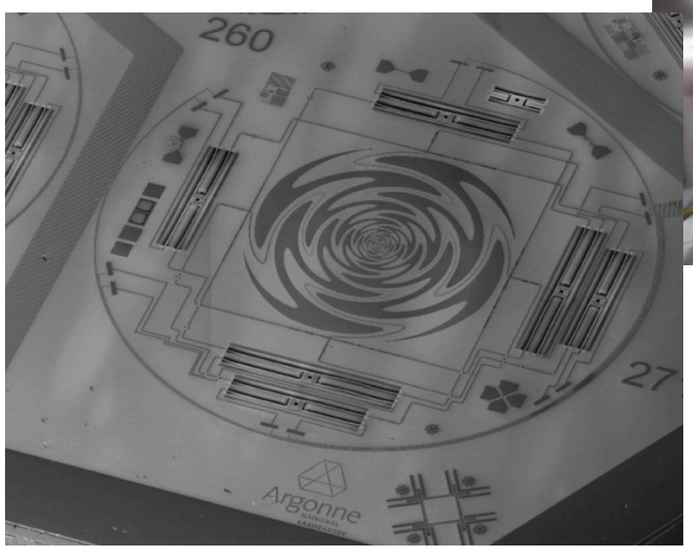





Offering the opportunity to revolutionize scientific computing

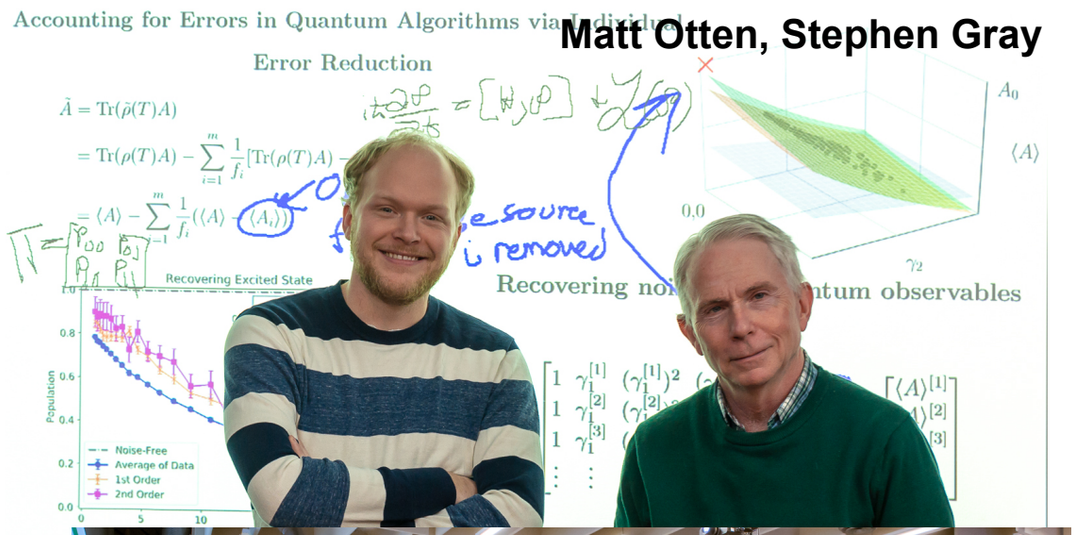
## Quantum Computing at Argonne

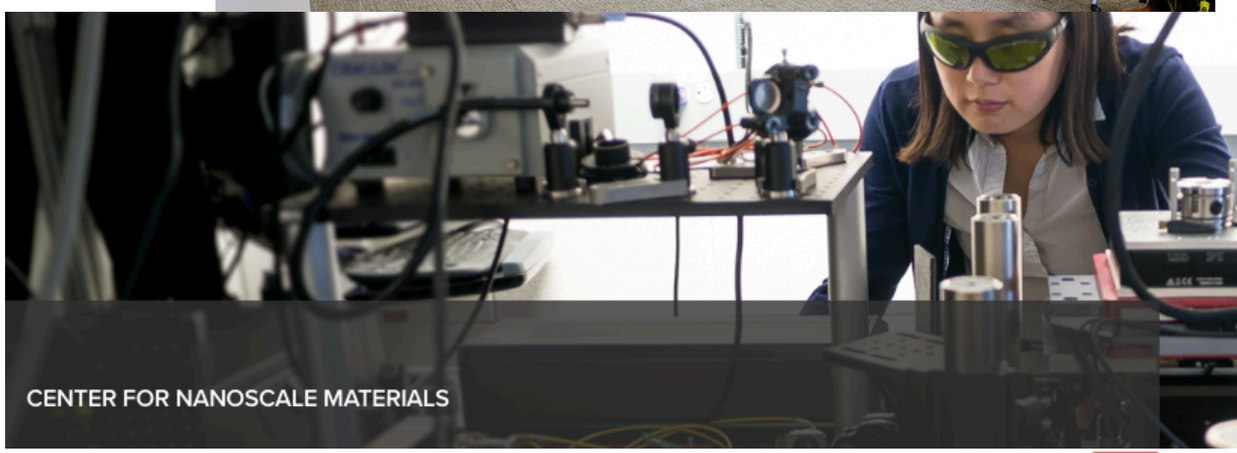
The quantum computing research group at Argonne Nationa
traditional strengths of the laboratory in classical supercompu



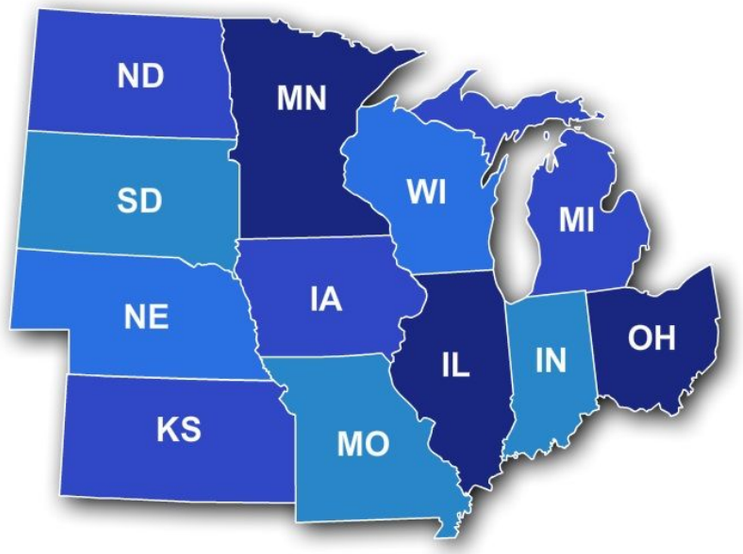
# QIS at Argonne

- **Argonne Context**
  - Leverage traditional strengths in supercomputing systems and applications
    - HPC quantum simulators (50+ qubits, Argonne supercomputers, IBM, Atos, —)
    - New NISQ system algorithms, parameter optimizers for variational algorithms
    - Error models and error correction tailored to hardware
  - Quantum technology leveraging science domain interests and materials and fab/ characterization expertise
    - Low-mass dark matter detection (w/ NIST)
    - Single photon sensing (SNSPD)
    - Entangled photon sources
    - New QIS materials
    - Transition-edge sensor development





# Quantum Information Science in the Midwest




## Universities with QIS Programs:

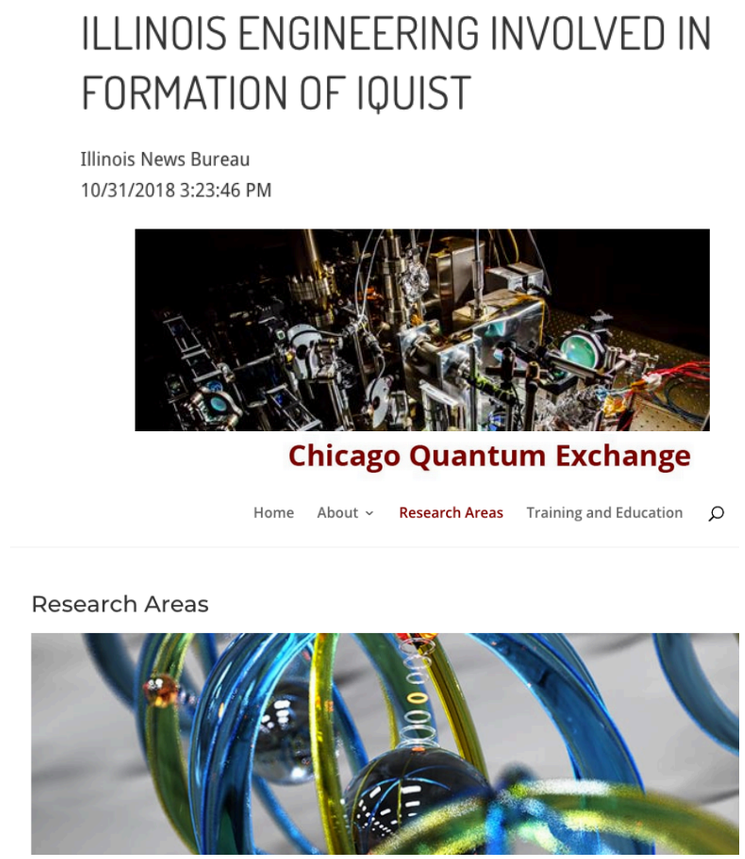
**University of Nebraska**
**University of Kansas**
**University of Minnesota**
**University of Iowa**
**Washington University in St. Louis**
**University of Wisconsin**
**University of Illinois**
**University of Chicago**
**Southern Illinois University**
**Northwestern University**
**Purdue University**
**Indiana University**
**University of Michigan**
**Michigan State University**
**Ohio State University —**

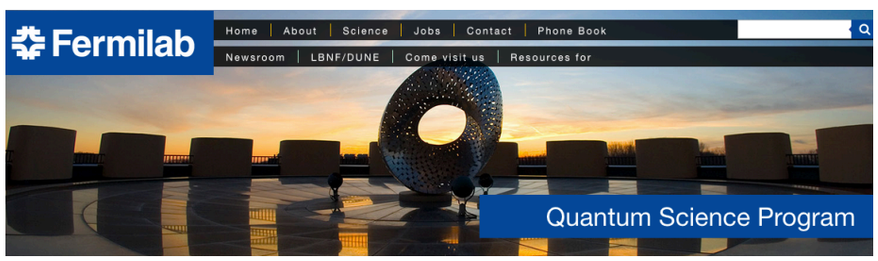
## DOE Laboratories:

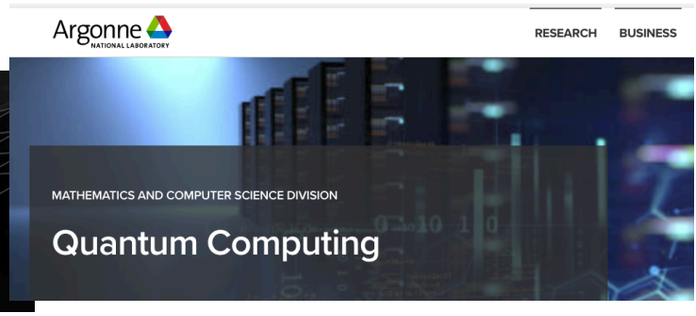
**Ames Laboratory**
**Argonne National Laboratory**
**Fermi National Accelerator Laboratory**

## Industry:

**Honeywell Quantum Solutions**
**EeroQ**
**Microsoft Quantum**



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