Agenda Booklet

Quantum Computing User Forum

August 12-15, 2024

Hosted by the Oak Ridge Leadership Computing Facility at Oak Ridge National Laboratory

Quantum Computing User Forum

The Quantum Computing User Forum brings together users to discuss common practices in the development of applications, software, and simulations for quantum computing devices and systems. The forum is hosted by the Quantum Computing Institute and the Oak Ridge Leadership Computing Facility at Oak Ridge National Laboratory. The forum highlights the results from a broad variety of projects supported by the Quantum Computing User Program which enables more than 400 users to access state-of-the-art quantum computing systems. This program is supported by the US Department of Energy, Office of Science, Advanced Scientific Computing Research program office.

The four-day meeting is scheduled for August 12-15, 2024, at Oak Ridge National Laboratory. The forum agenda includes 4 keynote presentations, 26 contributed talks, and 4 industry-driven workshops from leading researchers in the field of quantum computational science.

Keynote presentations will be provided by Dr. Brian Neyenhuis from Quantinuum, Dr. Antonio Mezzacapo from IBM, Dr. John Gamble from IonQ, and Dr. Josh Mutus from Rigetti.

In addition, four workshops led by Quantinuum, IBM, IonQ, and Amazon Braket will be co-located at ORNL during the forum and open to all forum attendees.

 Presentation and poster abstracts can be found [here](#).

Meeting Logistics

Location

- The meeting is located in the Conference Center, on the second floor of Building 5200, at Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Parking

- Park in the Conference Center Parking lot, located north of the traffic circle at the center of the Oak Ridge National Laboratory Campus.

Registration

- Registration is required to attend the meeting.
- Access to ORNL requires approval by the site security office.
- Follow directions in site access email, and pick up your badge at the conference center, follow signs at Building 5200.

Forum Agenda

- All times presented in the agenda reference Eastern Daylight Time (UTC-4).
- Sessions will adhere strictly to the scheduled timetable.

Forum Presentations

- The forum is scheduled as an in-person event only.
- Session chairs will moderate questions as time permits.

Workshop Agendas

- Participation in the workshops is included in registration for the forum.

Quantum Computing User Forum
& Workshops
AGENDA

August 12-15, 2024

All times are Eastern Daylight Time (EDT/GMT-4)

Hosted by the Quantum Computing Institute and Oak Ridge Leadership Computing Facility at Oak Ridge National Laboratory

The Quantum Computing User Forum brings together users to discuss common practices in the development of applications, software, and simulations for quantum computing devices and systems. Hosted by the Oak Ridge Leadership Computing Facility at Oak Ridge National Laboratory, the meeting includes invited presentations from leading researchers in the field of quantum computer science. This program is supported by the US Department of Energy, Office of Science, Advanced Scientific Computing Research program office.

This agenda contains the times for each presentation from the forum for the keynote talks, invited talks, and poster sessions to be presented August 12-15, as well as the dates and times for the four associated workshops. For more information about this event please visit: https://www.olcf.ornl.gov/calendar/quantum-computing-user-forum-2024/

QUICK LOOK: DAYS 1-4

EVENT	DAY	DATE	LOCATION
Quantinuum Workshop	1	8/12	Bldg 5200: Floor 2 Mezzanine and Tennessee Rooms
IBM Workshop	2	8/13	Bldg 5200: Floor 2 Mezzanine and Tennessee Rooms
Poster Session	2	8/13	Bldg 5200: Floor 2 Mezzanine
IonQ Workshop	3	8/14	Bldg 5200: Floor 2 Mezzanine and Tennessee Rooms
Amazon Braket Workshop	4	8/15	Bldg 5200: Floor 2 Mezzanine and Tennessee Rooms

OAK RIDGE
National Laboratory

DAY 1
Monday, August 12th

REGISTRATION

			ORNL Visitors Center Bldg 5200
MONDAY BADGING	7:30am	8:30am	
CHECK-IN & CONTINENTAL BREAKFAST	7:30am	8:30am	Bldg 5200: Floor 2 Mezzanine

WORKSHOP

Quantinuum Workshop	8:30am	12:00pm
H-Series Hardware: Hardware Overview, Quantinuum Nexus, Resource Visibility	8:30am	9:30am
Break	9:30am	9:40am
Maximizing H-Series Usage: H-Series Emulators, Mid-Circuit Measurement and Reset and Qubit Reuse, Arbirary Angle Gates	9:45am	10:45am
Break	10:45am	10:55am
Use Cases with H-Series: Quantum Error Correction, Quantum Dynamics, Q&A	10:55am	12:00pm

The H-Series workshop consists of three hand-on sessions that will provide participants with a comprehensive understanding of H-Series quantum hardware, user workflows to maximize machine time, and use cases explored on H-Series.

1. Hardware Overview & User Workflow: Understand the H-Series quantum architecture and tools to support the user development cycle, including the H-Series emulators.
2. Maximizing H-Series Usage: Understand how to use Qubit Reuse, including the qubit reuse package, discover techniques to maximize machine utilization, and utilizing H-Series native gates.
3. Use Cases: Walk through two use cases run on H-Series hardware, including a QEC use case example using the H-Series QEC Decoder toolkit.

Participants will leave this workshop equipped with practical knowledge to harness the power of H-Series quantum computing for various scientific and industrial applications.

DAY 1
Monday, August 12th

AFTERNOON SESSIONS

Lunch: Sponsored by Quantinuum	12:00pm	1:00pm	
Afternoon Session Opening	1:00pm	1:05pm	Travis Humble
Keynote: Quantinuum's Trapped-Ion Quantum Computers	1:05pm	2:00pm	Brian Neyenhuis (Quantinuum)
Afternoon Session 1	2:00pm	3:30pm	Moderator: In-Saeng Suh
Fault-Tolerant Quantum Criticality in Dynamically Generated Concatenated Codes	2:00pm	2:30pm	Grace Sommers (Princeton University)
Quantum Approximate Optimization	2:30pm	3:00pm	Phil Lotshaw (Oak Ridge National Laboratory)
Break	3:00pm	3:30pm	
Afternoon Session 2	3:30pm	5:00pm	Moderator: Titus Morris
Quantum Computation with Neutral Atoms: Key Outcomes from NERSC's First R&D Collaboration with QuEra Computing	3:30pm	4:00pm	Katie Klymko (Lawrence Berkeley National Laboratory)
Evaluating Non-Local Quantum Strategies on NISQ Hardware: Connecting Benchmarks to Performance	4:00pm	4:30pm	Jim Furches (Virginia Tech)
Approximate Computing for Noise Resilient Optimized Quantum Circuits	4:30pm	5:00pm	Himanshu Thapliyal (University of Tennessee - Knoxville)

DAY 2
Tuesday, August 13th

REGISTRATION

CHECK-IN & CONTINENTAL BREAKFAST	7:30am	8:30am	Bldg 5200: Floor 2 Mezzanine

WORKSHOP

IBM Workshop	8:30am	12:00pm
Quantum computing at scale: mapping problems to quantum hardware	8:30am	9:30am
Break	9:30am	9:45am
Quantum computational workload optimization and error mitigation	9:45am	10:45am
Break	10:45am	11:00am
Hands on example of a utility-scale workflow	11:00am	12:00pm

Addressing timely problems with quantum computers requires not only advanced hardware and software capabilities but also efficient and scalable frameworks that facilitate code reuse and simplification. In this session, we will introduce a utility-scale workflow based on Qiskit patterns, comprising a four-step process for running algorithms on a quantum computer. This process includes mapping significant problems onto quantum computers by integrating both the advantages and limitations of current technology into the problem definition phase, optimizing the quantum workload by transforming circuits to align with the system's constraints and native instructions, executing the circuits on real hardware through a co-located runtime environment with effective error mitigation techniques, and analyzing the results to validate outcomes at scale. Participants will gain insights into Qiskit's latest features, including Primitives V2 and runtime execution modes, as well as problem selection and mapping techniques through utility-scale examples. Additionally, they will learn about quantum workload optimization through state of the art circuit transpilation and hardware execution with Qiskit Runtime, combining error suppression methods like Dynamical Decoupling (DD) and Pauli Twirling (PT) alongside error mitigation techniques such as Twirled Readout Error Extinction (TREX) and Zero-Noise Extrapolation (ZNE). Each step will be covered in detail, with practical examples using Qiskit code to illustrate their application.

DAY 2
Tuesday, August 13th

AFTERNOON SESSIONS

Lunch: Sponsored by IBM	12:00pm	1:00pm	
Afternoon Session Opening	1:00pm	1:05pm	Claire Marvinney
Keynote: Chemistry Beyond the Reach of Exact Solutions of the Schroedinger Equation on a Quantum-centric Supercomputer	1:05pm	2:00pm	Antonio Mezzacapo (IBM)
Afternoon Session 1	2:00pm	3:30pm	Moderator: Alessandro Baroni
Computational Fluid Dynamics on Quantum Computers	2:00pm	2:30pm	Madhava Syamlal (QubitSolve)
Quantum Simulation of SU(3) Lattice Gauge Theory at Leading Order in Large N	2:30pm	3:00pm	Anthony Ciavarella (Lawrence Berkeley National Lab)
Break	3:00pm	3:30pm	
Afternoon Session 2	3:30pm	5:00pm	Moderator: Ryan Landfield
Multidimensional Quantum Convolution for Variational Quantum Algorithms	3:30pm	4:00pm	Esam El-Araby (The University of Kansas)
Quantum-HPC Hybrid Computing in Materials Discovery	4:00pm	4:30pm	In-Saeng Suh (Oak Ridge National Laboratory)
Classification of Non-Linearly Separable Datasets on NISQ Devices	4:30pm	5:00pm	Jan Balewski (NERSC/LBNL)
Recent Technology Development at IQM	5:00pm	5:10pm	IQM
Poster Session: Sponsored by D-Wave Systems	5:30pm	7:00pm	

DAY 3
Wednesday, August 14th

QUANTUM COMPUTING USER FORUM

REGISTRATION

			Bldg 5200: Floor 2 Mezzanine
CHECK-IN & CONTINENTAL BREAKFAST	7:30am	8:30am	

WORKSHOP

IonQ Workshop	8:30am	12:00pm
Native Gates and Virtual Z	8:30am	9:30am
Break	9:30am	9:45am
QAOA: Vanilla & Sideways	9:45am	10:45am
Break	10:45am	11:00am
Forte; Four Corners map coloring	11:00am	12:00pm

This workshop will introduce you to the native gates of IonQ's trapped ion quantum computers, including the virtual Z gate that provides extra efficiency for the circuit designer. With this foundation in place, we'll introduce the standard QAOA circuit as described by Farhin et al and tabulate the gates needed by the IonQ compiler. We then rotate the circuit on its side and compile it manually into native gates. Finally, we introduce the additional native gate of the Forte platform and show how it impacts this analysis. The Four Corners map coloring problem is a case study which illustrates the impact of different problem encodings. Each section is accompanied by exercises - some purely pencil and paper and others requiring a Python environment.

DAY 3
Wednesday, August 14th

AFTERNOON SESSIONS

Lunch: Sponsored by IonQ	12:00pm	1:00pm	
Afternoon Session Opening	1:00pm	1:05pm	Josh Cunningham
Keynote: Scalable Trapped-Ion Quantum Computing with Ionq	1:05pm	2:00pm	John Gamble (IonQ)
Afternoon Session 1	2:00pm	3:30pm	Moderator: Antonio Coello Perez
Research On Use of Quantum Computers in Power Grid	2:00pm	2:30pm	Suman Debnath (Oak Ridge National Laboratory)
High-Round QAOA for MAX k-SAT on Trapped Ion NISQ Devices	2:30pm	3:00pm	Elijah Pelofske (Los Alamos National Laboratory)
Break	3:00pm	3:30pm	
Afternoon Session 2	3:30pm	5:00pm	Moderator: Kathleen Hamilton
Quantum Error Mitigation and Correction Mediated by Yang-Baxter Equation and Artificial Neural Network	3:30pm	4:00pm	Sahil Gulania (Argonne National Laboratory)
Experimental Realization of Dynamically Corrected Gates on IBM hardware	4:00pm	4:30pm	Hisham Amer (Virginia Tech)
QDA: Quantum Design Automation of Dynamically Corrected Quantum Computing Circuits	4:30pm	5:00pm	Weiwen Jiang (George Mason University)

DAY 4
Thursday, August 15th
QUANTUM COMPUTING USER FORUM

			Bldg 5200:
CHECK-IN & CONTINENTAL BREAKFAST	7:30am	8:30am	Floor 2 Mezzanine

WORKSHOP

Amazon Braket Workshop	8:30am	12:00pm
What is Amazon Braket?	8:30am	8:45am
Get access to your AWS environments	8:45am	9:00am
How to run circuits on simulators and QPUs	9:00am	9:20am
Introduction to Amazon Braket Hybrid Jobs	9:20am	9:30am
Running your first hybrid algorithm on Amazon Braket	9:30am	9:55am
Q&A	9:55am	10:00am
Break	10:00am	10:10am
Deep Dive: Uncovering quantum phases of 2D spin systems with QuEra Aquila on Amazon Braket	10:10am	12:00pm
Quantum computing with neutral atoms in the cloud	10:10am	10:45am
Studying quantum phase transitions in Shastry-Sutherland model using neutral atoms	10:45am	11:15am
Simulating Shastry-Sutherland model on Amazon Braket	11:15am	11:55am
Wrap up and Q&A	11:55am	12:00pm

Join us for a hands-on exploration of Amazon Braket, the Amazon Web Services (AWS) quantum computing service. In the first half of the workshop, you will learn how to build, test, and run quantum and quantum-classical algorithms across various quantum processing units (QPUs) and classical simulators with Amazon Braket. We will introduce Amazon Braket software development kit that you can run locally on a laptop, or in Amazon Braket's fully managed Jupyter notebook environment. We will demonstrate how to use features like quantum task batching, Amazon Braket Hybrid Jobs, and simulator backends. In the second half of the workshop, you will learn how to use Amazon Braket for solving real-world quantum simulation problems. We will introduce a recent study of a quantum phase transition in 2D Shastry-Sutherland lattice spin systems done using QuEra's Aquila device, an analog Hamiltonian simulator available through Amazon Braket. In a hands-on session we will demonstrate how to build an Amazon Braket solution for the problem and test the solution using a simulator backend. No prior AWS experience is required to participate in the workshop. AWS will provide the participants with temporary accounts to experiment with Amazon Braket.

DAY 4
Thursday, August 15th

AFTERNOON SESSIONS

Lunch: Sponsored by QuEra & Amazon Braket	12:00pm	1:00pm	
Afternoon Session Opening	1:00pm	1:05pm	Travis Humble
Keynote: Distributed Quantum Computing, Tomorrow and Today	1:05pm	2:00pm	Josh Mutus (Rigetti)
Afternoon Session 1	2:00pm	3:30pm	Moderator: Daniel Claudino
Exploring and Benchmarking Prospects for HPC-Quantum Integration on a Leadership-Scale Computing Platform	2:00pm	2:30pm	Toño Coello Perez (Oak Ridge National Laboratory)
Quantum Computing and Simulations for Energy-related Applications	2:30pm	3:00pm	Yuhua Duan (National Energy Technology Laboratory)
Break	3:00pm	3:30pm	
Afternoon Session 2	3:30pm	5:00pm	Moderator: Andrea Delgado
Performance Analysis of QAOA for Metamaterial Design on HPC and Quantum Systems	3:30pm	4:00pm	Seongmin Kim (Oak Ridge National Laboratory)
Two-Nucleon Scattering on a Quantum Computer	4:00pm	4:30pm	Sanket Sharma (University of Tennessee - Knoxville)
A Cross Platform QIR Execution Engine	4:30pm	5:00pm	Elaine Wong (Oak Ridge National Laboratory)