NQVL:QSTD:Pilot:

Erasure Qubits and Dynamic Circuits for Quantum Advantage (ERASE)

(U.S. National Science Foundation NQVL Award# 2435244)

Goal:

Build a Quantum Error Correction Testbed based on Dual-Resonator Erasure Flag Photonic Qubits

Begin to move out of the NISQ era.

Website:

https://erase.yale.edu

PI and co-PI's:

- Prof. Steven Girvin (PI, Yale)
- Prof. Michael Hatridge (co-PI, Yale)
- Prof. Margaret Martonosi (co-PI, Princeton)
- Prof. Steve Flammia (co-PI, Virginia Tech)
- Prof. Xiaodi Wu (co-PI, U. Maryland)

Disclosure: SMG and MH are consultants for, and equity holders in, Quantum Circuits, Inc.

Senior Personnel:

- Prof. Andrew Childs (U. Maryland)
- Prof. Yongshan Ding (Yale)
- Prof. Shruti Puri (Yale)
- Prof. Aleksander Kubica (Yale)
- **Dr. Ebad Jahangir (Project Manager, RTX)**
- Dr. Amit Surana (RTX)
- Prof. Raymond Samuel (Director of the NSF supported ExpandQISE Research Workforce Development Programs at North Carolina A&T State University).

Collaboration Letters from:

Quantum Circuits, Inc.

NVIDIA

JP Morgan & Chase (Shouvanik Chakrabarti)

Boehringer-Ingelheim (Nicolai Moll)

Quantinuum (Harry Buhrman)

AWS Quantum

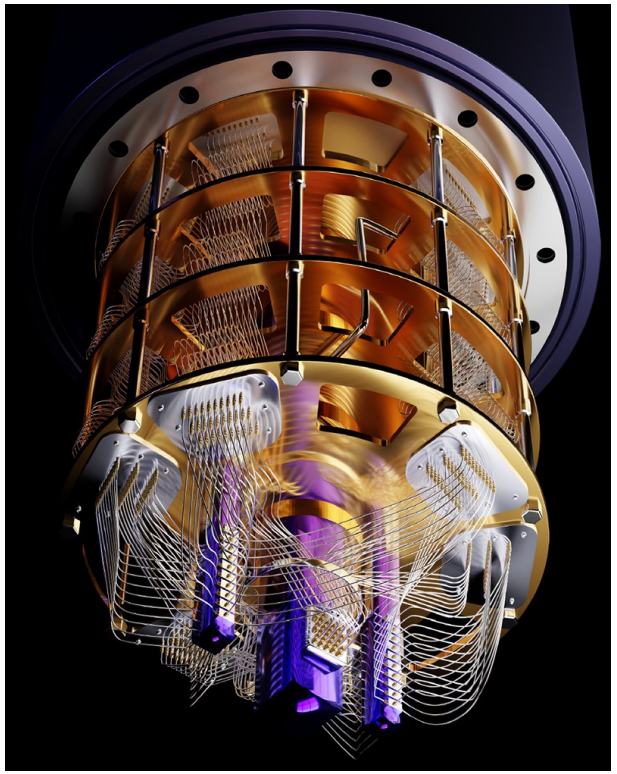
Quantum-CT (NSF Innovation Engine)

Nathan Wiebe (U. Toronto)

Ang Li (Pacific Northwest National Laboratory)

Industrial Partner: Quantum Circuits, Inc., [New Haven, CT]

Robert Schoelkopf (Founder & Chief Scientist; Not supported by this award.)
Andrei Petrenko (Head of Product)
Tom Lubinski (Head of Software)



Aqumen Seeker QPU

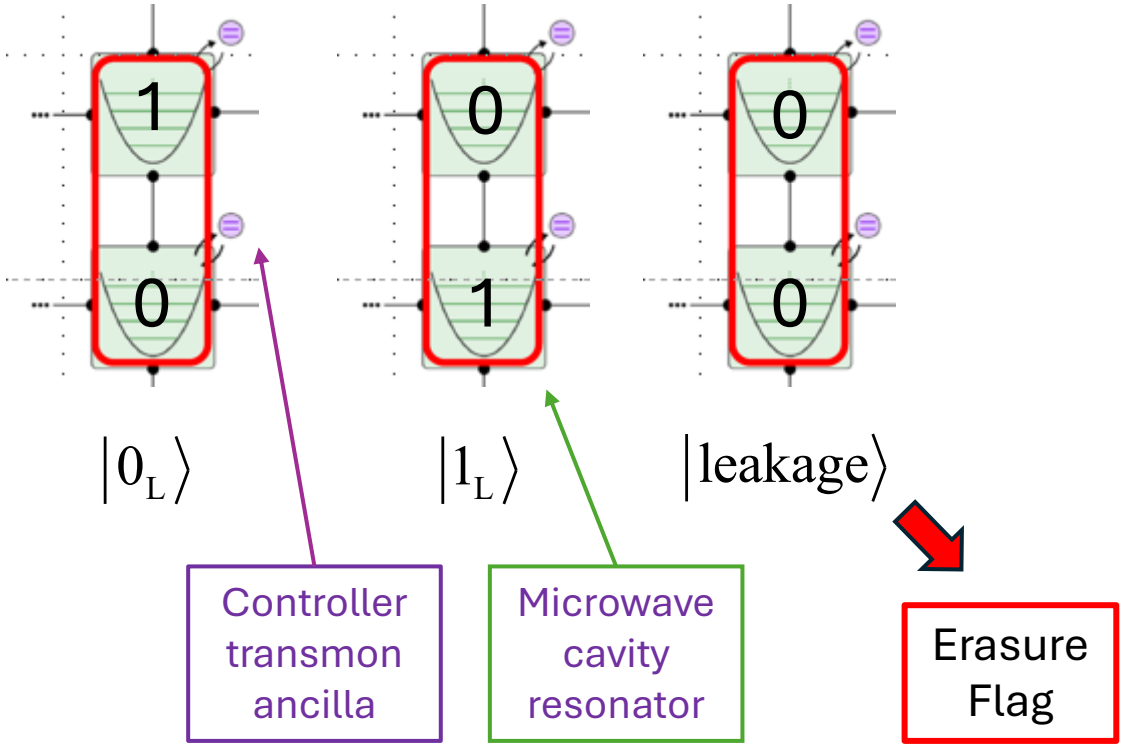
Real-Time Control Flow (RTCF)

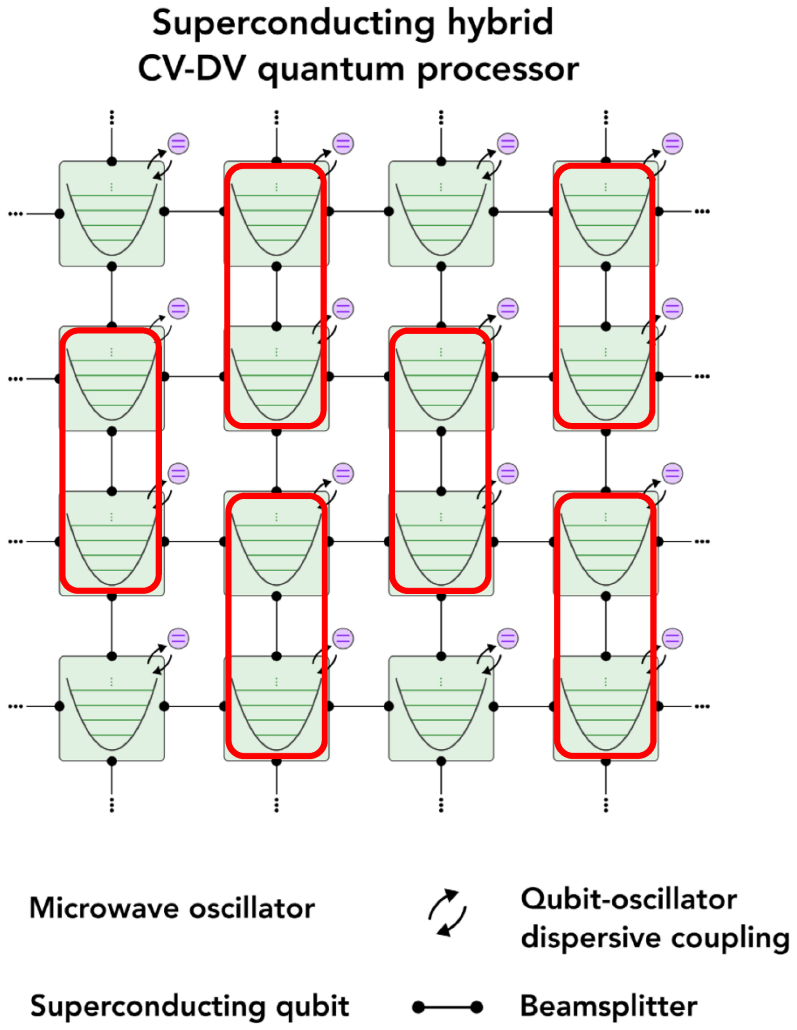
A toolkit to tightly couple classical-quantum programs:

- Measurement-based feedback
- Conditional branching
- Real-time qubit reset for reuse in calculation
- Arithmetic
- Dynamic gate parameterization
- Run-time looping

qci
Quantum Circuits, Inc.

Inner Code: Dual-Resonator Erasure Flag Qubits

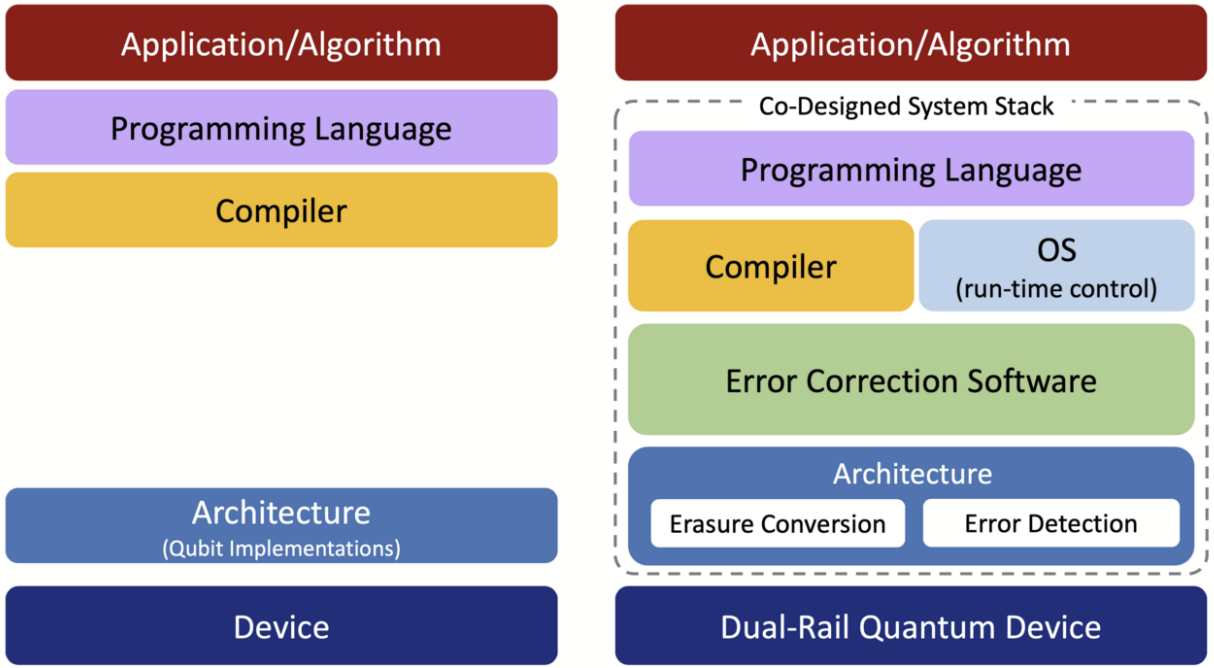




Outer Code: Surface, Color, QLDPC, etc.

Challenges and Opportunities:

Build a National Community to Help Optimize the Full Stack for a Quantum Error Correction Testbed based on Dual-Resonator Erasure Flag Photonic Qubits



- Development of new *robust* algorithms for our novel erasure flag error model
- Modern PL offering run-time control through API
- Run-time control for non-deterministic dynamic circuits (measurements and feedforward)
- Outer code residual error *correction*
- Hardware-level dominant error *detection and erasure conversion*
- Hardware-level dual-resonator photonic qubits

Note: Everything (including real-time control flow) above the low-level API will be open-source and available for experimentation by the community.

Today's Program: TUTORIALS ON DYNAMIC CIRCUITS (Mid-Circuit Measurements and Feedforward)

9:15 AM	Tutorial Introduction to Dynamics Circuits	Nathan Wiebe	U. Toronto
10:15 AM	Discussion		
10:30 AM	Introduction to the LAQCC Model and Recent Results	Yongshan Ding	Yale
11:30 AM	Discussion		
11:45 AM	LUNCH & Discussion (75 min) - YQI Seminar Room	YQI Seminar Room	
1:00 PM	Combining dynamic circuits and matrix product states for resource-efficient quantum simulation	Kevin Smith	IBM
2:00 PM	Discussion		
2:15 PM	AC/DC: Automated Compilation for Dynamic Circuits	Ed Younis	LBL
3:15 PM	Discussion		
3:30 PM	COFFEE BREAK (15 mins) - YQI Seminar Room	YQI Seminar Room	
3:45 PM	Qubit-reuse compilation with mid-circuit measurement and reset	Michael Foss-Feig	Quantinuum
4:45 PM	Discussion		
5:00 PM	ADJOURN		

Wednesday Morning Program: Quantum Circuits: Demo of QCDL Language

Quantum Circuits is planning to provide an overview of our erasure detection API. We will focus on using Qiskit, but users interested in leveraging advanced control flow techniques will also be able to try the Quantum Circuits API called QCDL.

To hit the ground running, participants are encouraged to have:

Some prior experience in Python, including basic scripting and usage of Jupyter notebooks.
Some prior experience with Qiskit, such as writing some basic circuits.

Documentation will be provided to aid participants through the workshop and several representatives from Quantum Circuits will be onsite to guide users along and answer any questions.

Non-industrial participants:
Agree to Quantum Circuits' Terms and Conditions, which should be carefully reviewed to understand limitations on using and sharing Quantum Circuits software and services.

Industrial participants: sign a Quantum Circuits NDA.

Questions?