TRAPPED ION QUANTUM COMPUTING AT QUANTINUUM

PRESENTED BY:

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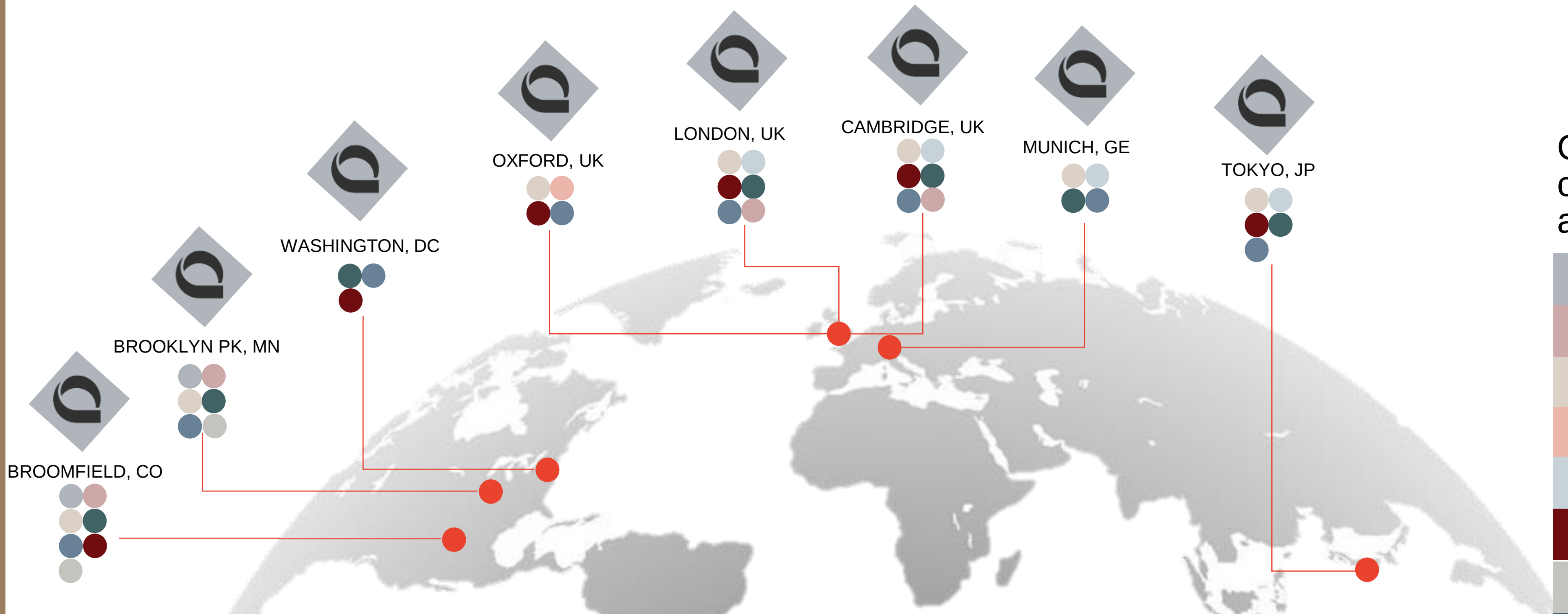
Commercial Operations Team

Quantum Computing Bootcamp
Thomas Jefferson National Accelerator Facility
June 30, 2023

QUANTINUUM

WHO WE ARE



Our people are clustered by specialty and science domain

- Ion trapping
- Engineering
- Quantum algorithms
- Quantum foundations
- Quantum chemistry
- Quantum cryptography
- Integrated Supply Chain
- HR, finance, IT, legal
- Biz dev, comms

Cambridge Quantum

Leader in Quantum Computing Software

Honeywell Quantum Solutions

Leading Quantum Computing Hardware

AN INTEGRATED APPROACH

Industrial Collaborators

Telcom, Finance, Pharma, Automotive, Manufacturing, Transport, Chemicals….

Cybersecurity

Quantum Origin: quantum computing-enabled cryptographic keys

Quantum Chemistry

InQuanto: State-of-the-art chemistry platform for quantum computers

AI & ML

Including open-source QNLP Toolkit and Library '**LAMBEQ**'

TKET

Open-source quantum software development platform

Third Party Platforms

Quantum Hardware, Simulators and Cloud Providers

H-Series

Quantum Computers

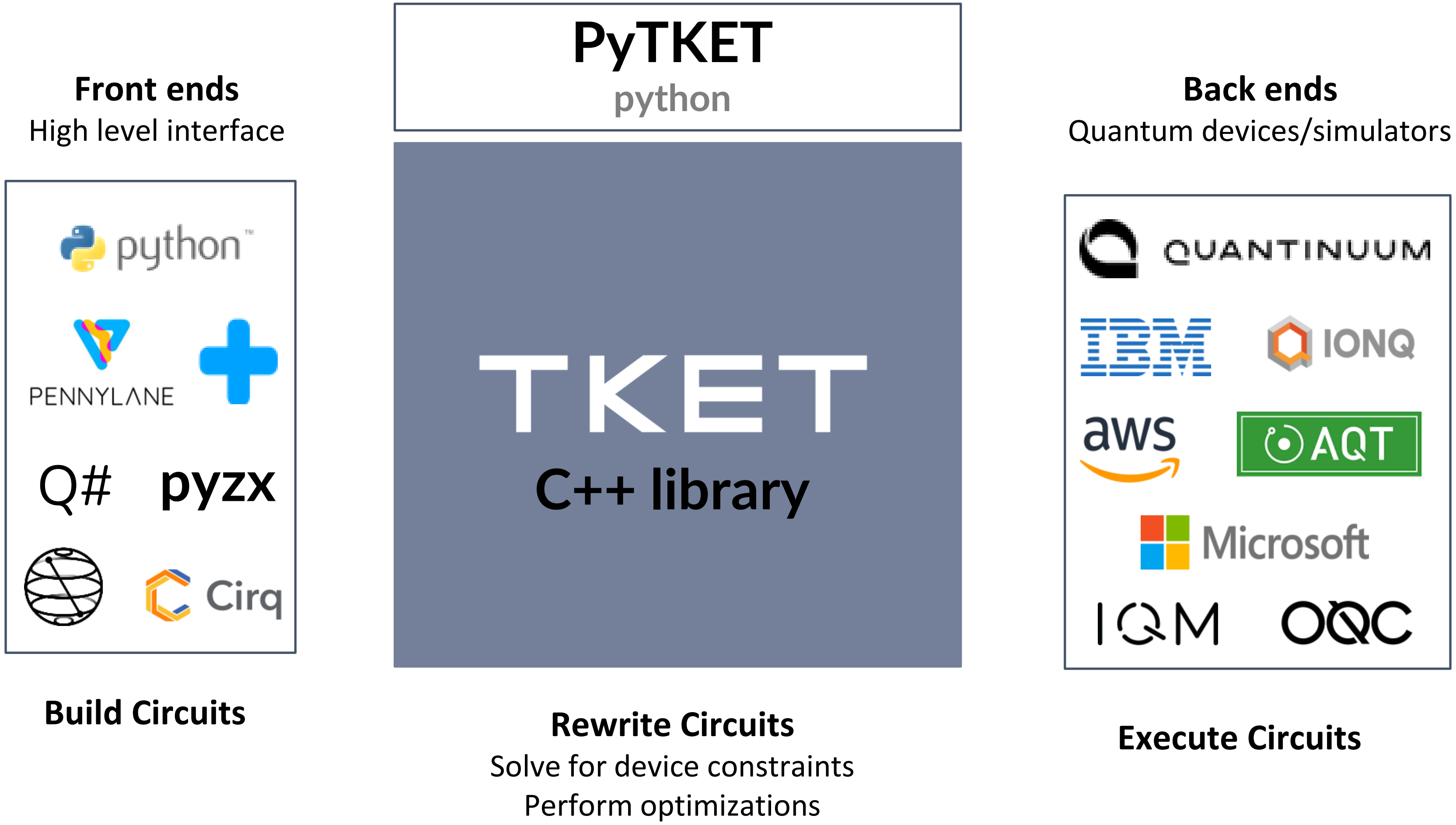
Powered by **Honeywell**

■ Quantinuum Products □ Partner / Ecosystem Products

TKET as a universal software development kit

TKET optimizes quantum circuits, reducing the number of required operations – essential
for NISQ devices.

941,952 downloads as of June 21, 2023



Front ends
High level interface

Build Circuits

PyTKET
python

TKET
C++ library

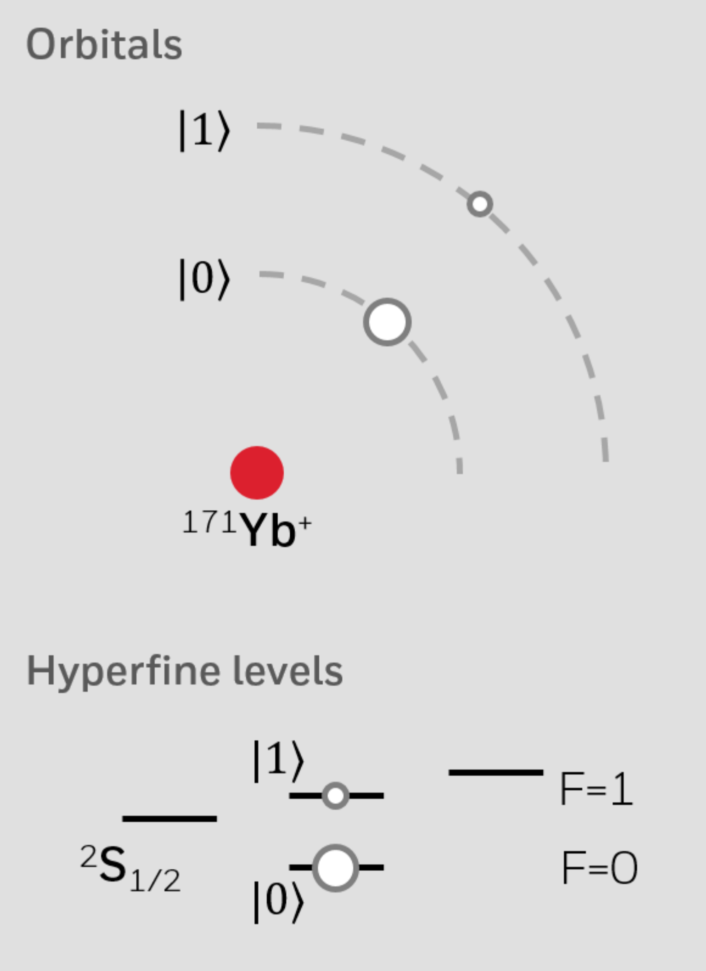
Rewrite Circuits
Solve for device constraints
Perform optimizations

Back ends
Quantum devices/simulators

Execute Circuits

TRAPPED ION QUANTUM COMPUTER

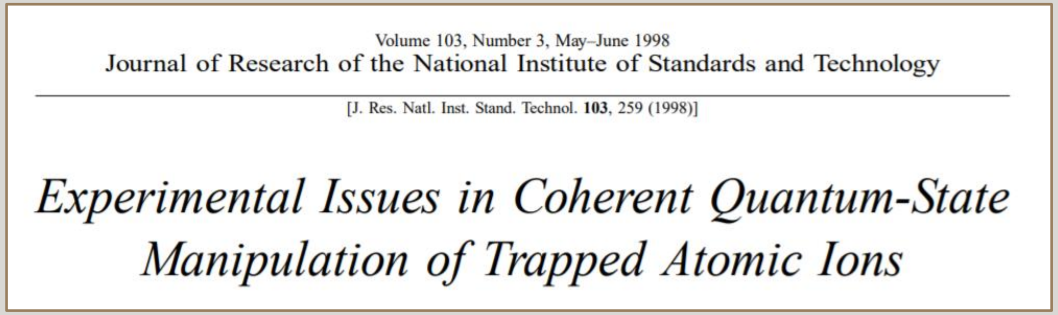
PERFECT QUBITS FROM YTTERBIUM IONS



- Each ion is identical, each qubit is identical
- Quantum information is stored in hyperfine energy levels
- Lasers are used to address, entangle, and measure qubits
- Errors are fundamentally understood
- The secret is to precisely capture, control, and manipulate ions for quantum operations

QCCD ARCHITECTURE – PROPOSED IN 1998

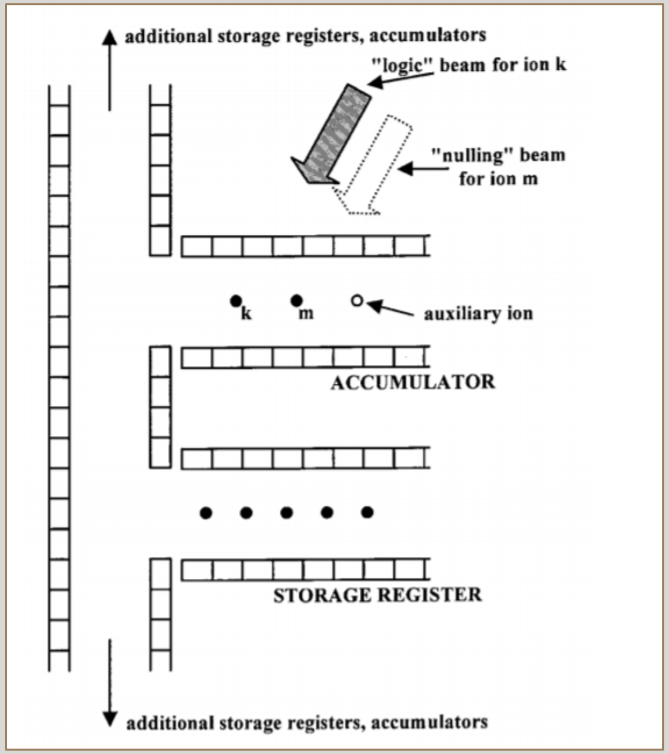
QUANTUM CHARGE-COUPLED DEVICE PROPOSAL BY NIST ION STORAGE GROUP (1998)



Volume 103, Number 3, May–June 1998
Journal of Research of the National Institute of Standards and Technology

[J. Res. Natl. Inst. Stand. Technol. **103**, 259 (1998)]

Experimental Issues in Coherent Quantum-State Manipulation of Trapped Atomic Ions



KEY CONCEPTS

Qubits through ions

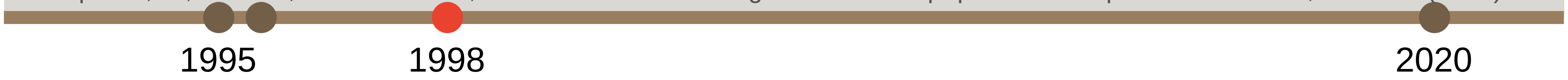
Connectivity by physical transport

High-fidelity gates via lasers on short ion chains

Dedicated zones for logic / initialization / measure

Scalability enabled by microfabricated traps

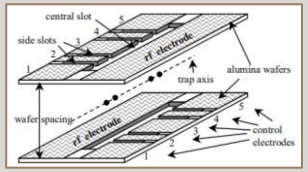
Additional reference:
Kielpinski, D., Monroe, C. & Wineland, D. Architecture for a large-scale ion-trap quantum computer. Nature 417, 709–711 (2002).

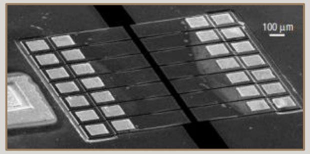


ION TRAPS & ION TRANSPORT RESEARCH

EARLY TRAPS AND TRANSPORT

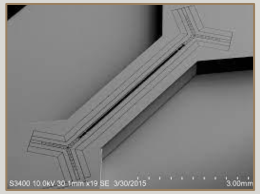
- M. Rowe et al., Transport of Quantum States and Separation of Ions in a Dual RF Ion Trap, Quantum Inf. & Comp. 2, 257 (2002).
- D. Stick et al., Ion trap in a semiconductor chip. Nature Physics 2, 36 (2006).

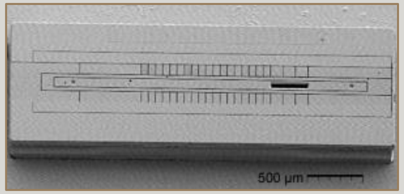




SURFACE TRAPS

- N. Guise et al., Ball-grid array architecture for microfabricated ion traps, Journal of Applied Physics 117, 174901 (2015).
- Sandia HOA



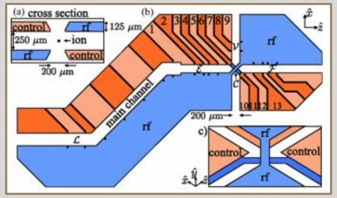


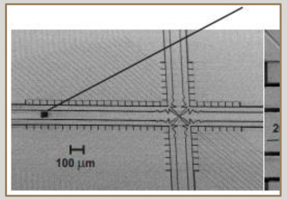
FAST LINEAR TRANSPORT

- Bowler, R. et al. Coherent diabatic ion transport and separation in a multizone trap array. Phys. Rev. Lett. 109, 080502 (2012).
- A. Walther et al., Controlling Fast Transport of Cold Trapped Ions. Phys. Rev. Lett 109, 080501 (2012)

2D ARRAYS

- R. B. Blakestad et al., Near-ground-state transport of trapped-ion qubits through a multidimensional array. Phys. Rev. A 84, 032314 (2011).
- K. Wright et al., Reliable transport through a microfabricated x-junction surface-electrode ion trap. New Journal of Physics 15, 033004 (2013)



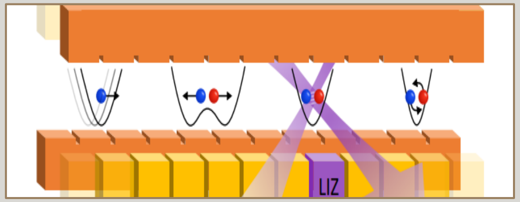


MIXED SPECIES TRANSPORT

- Palmero, M., Bowler, R., Gaebler, J. P., Leibfried, D. & Muga, J. G. Fast transport of mixed-species ion chains within a paul trap. Phys. Rev. A 90, 053408 (2014).

QCCD OPERATIONS

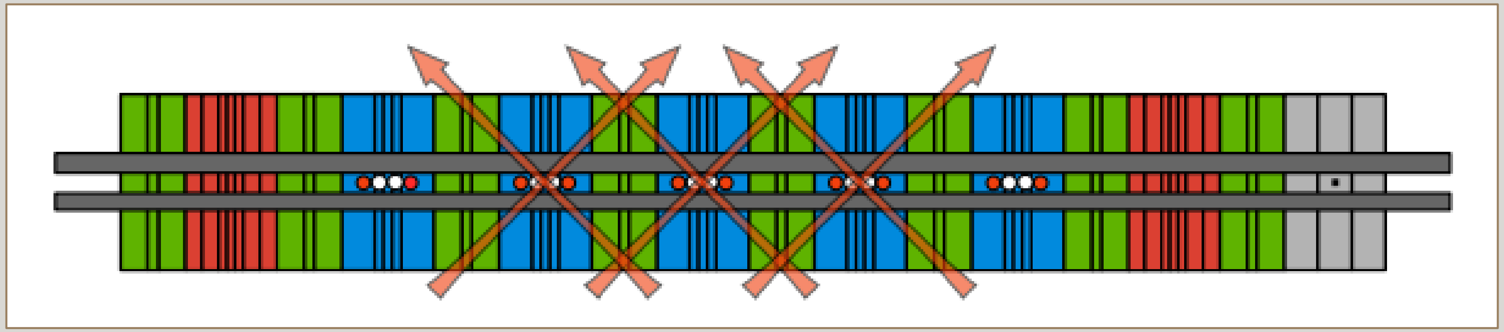
- Kaushal, V. et al. Shuttling-based trapped-ion quantum information processing. AVS Quantum Science 2, 014101 (2020).

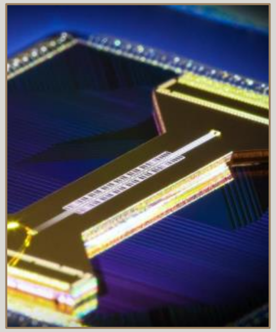


QCCD ARCHITECTURE – REALIZED IN 2020

QUANTUM CHARGE-COUPLED DEVICE DEMONSTRATED BY QUANTINUUM (2020)

ION TRAP ARCHITECTURE

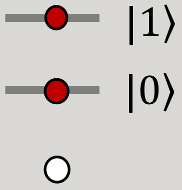




ARCHITECTURE FEATURES

- Identical, high-quality qubits
- Dedicated interaction zones
- Short ion chains
- High fidelity quantum gates
- Ions transport from zone to zone

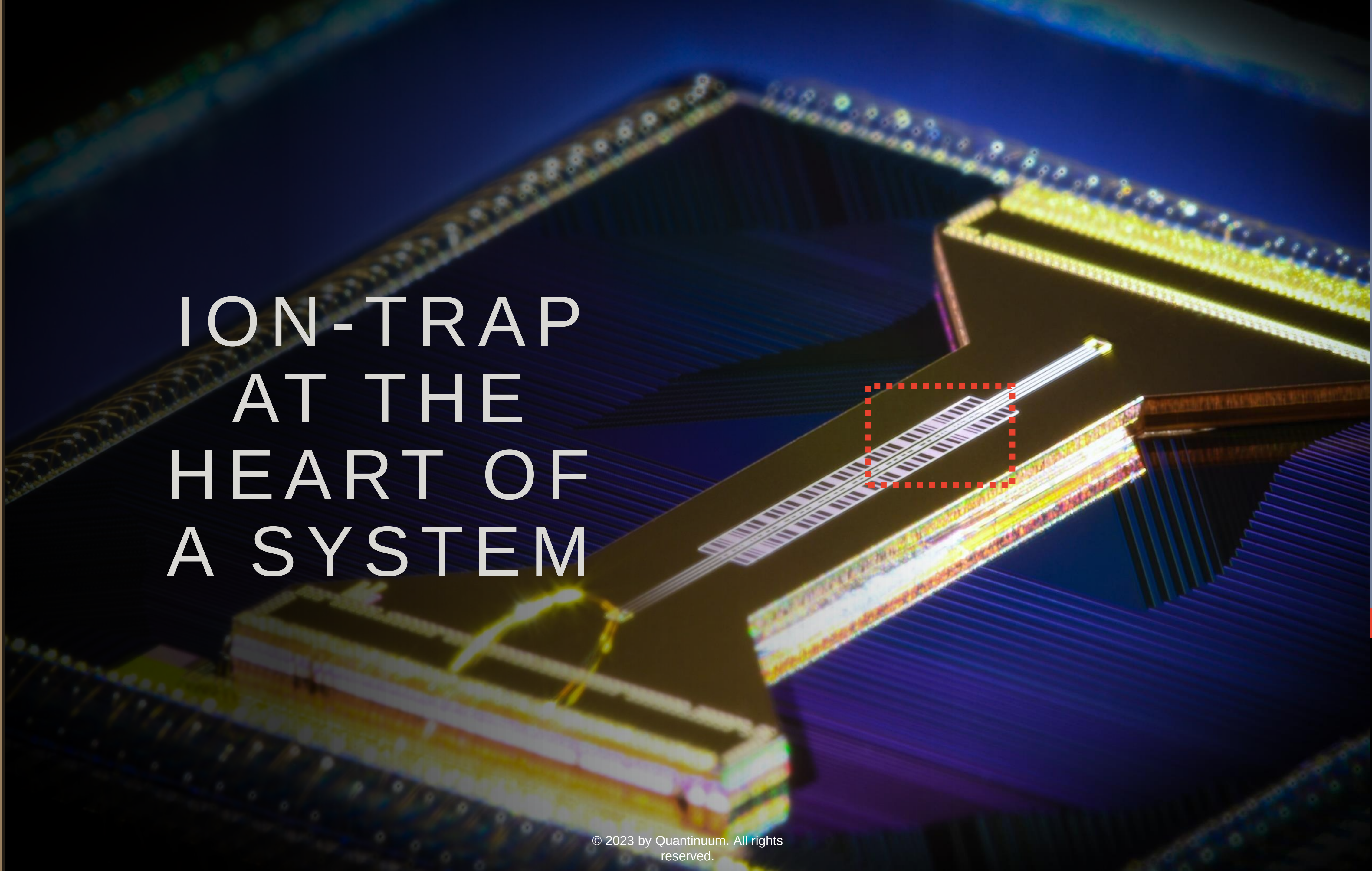
Quantum bits (qubits) are stored in the electronic states of Yb⁺ ions



$^{171}\text{Yb}^+$ $|1\rangle$ $|0\rangle$ HYPERFINE QUBIT

$^{138}\text{Ba}^+$ COOLING ION

Pino, J.M., Dreiling, J.M., Figgatt, C. *et al.* Demonstration of the trapped-ion quantum CCD computer architecture. *Nature* **592,** 209–213 (2021).



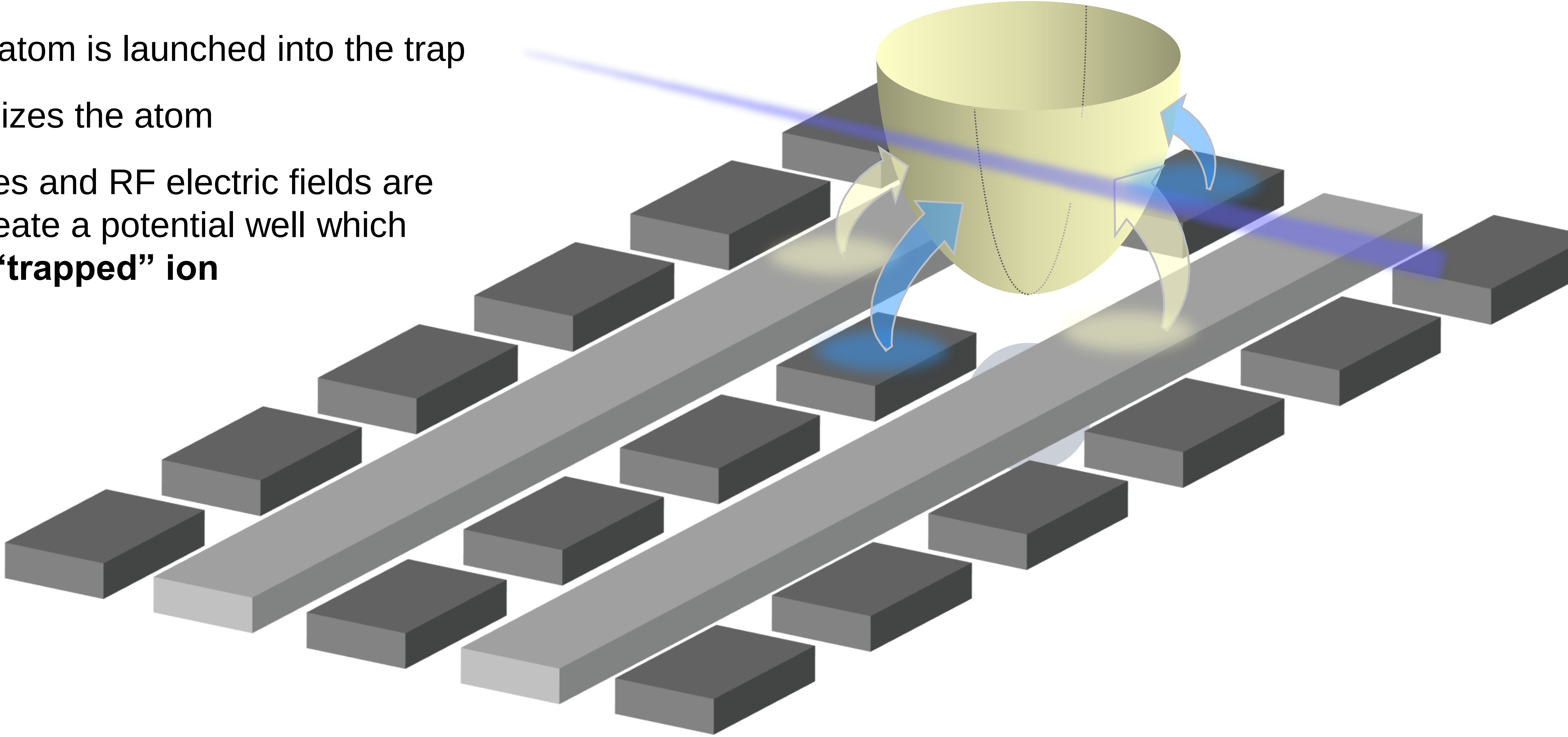
ION-TRAP AT THE HEART OF A SYSTEM

LOADING IONS

Ytterbium atom is launched into the trap

A laser ionizes the atom

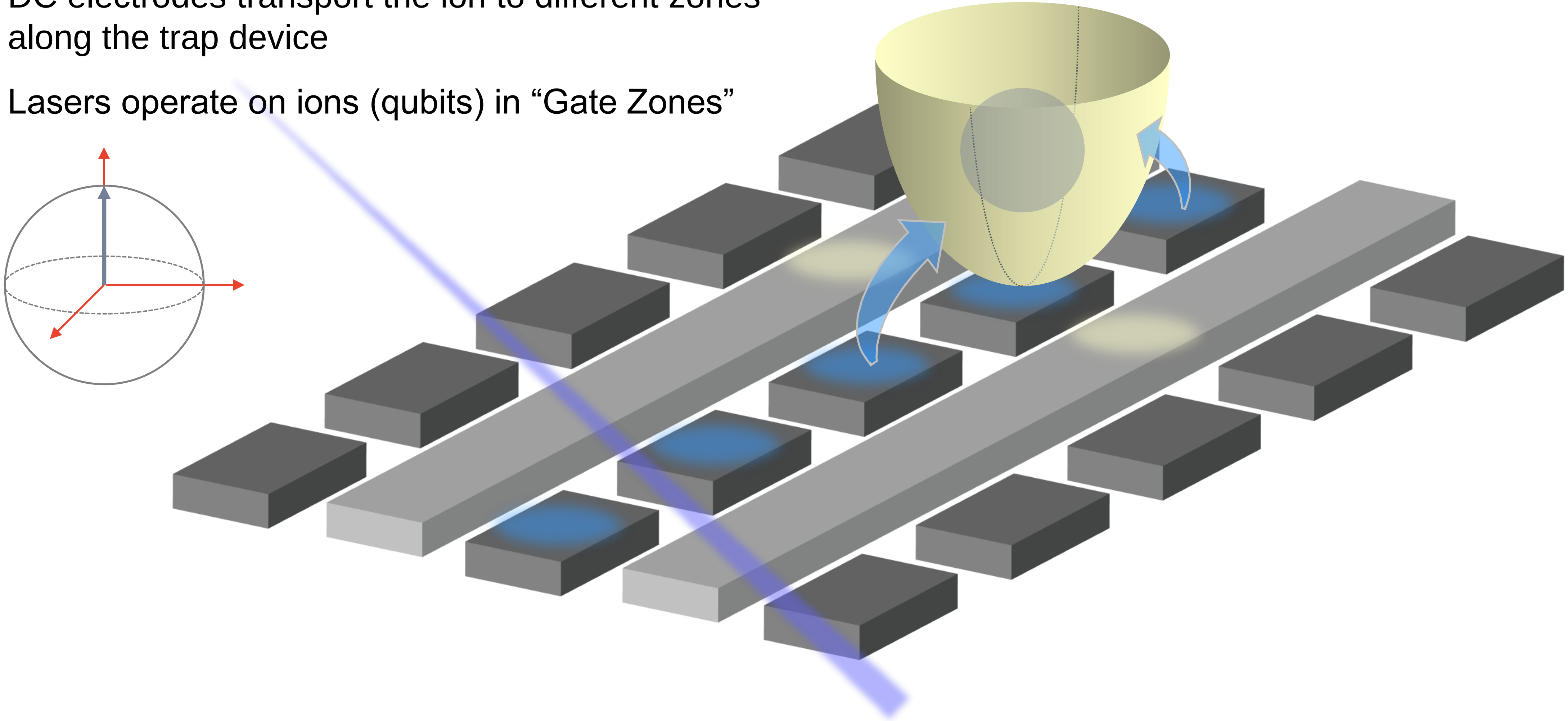
DC voltages and RF electric fields are used to create a potential well which holds the **“trapped” ion**



TRANSPORT AND GATE

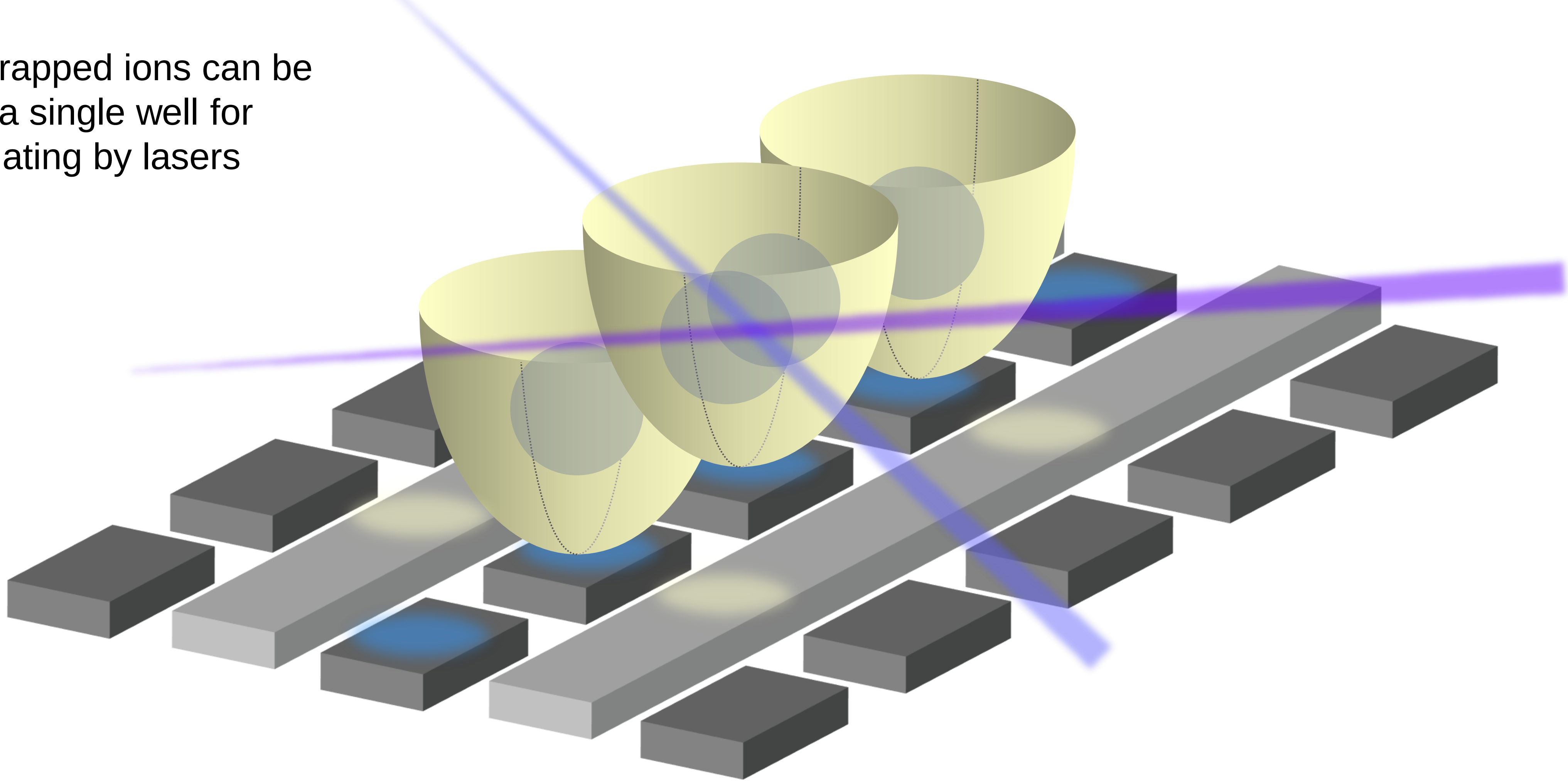
DC electrodes transport the ion to different zones along the trap device

Lasers operate on ions (qubits) in "Gate Zones"



MERGE AND ENTANGLEMENT

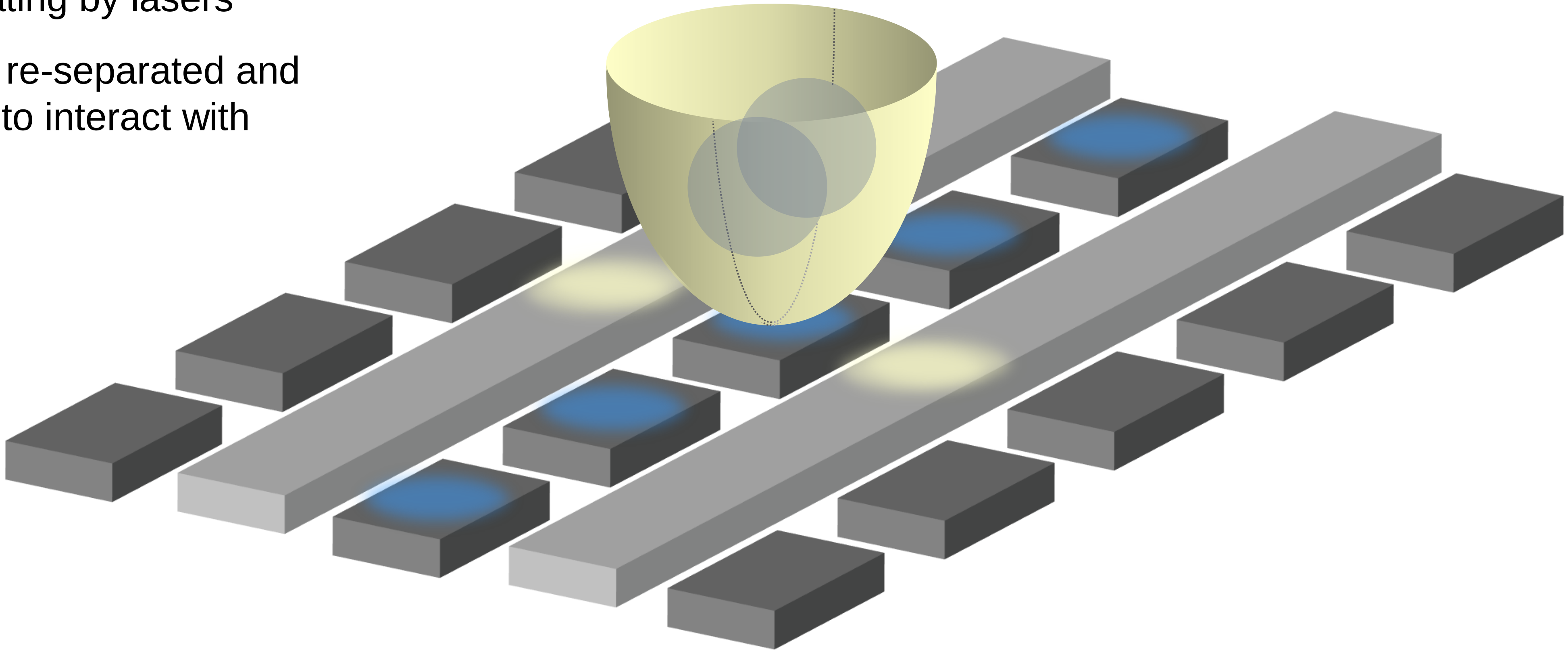
Individual trapped ions can be merged to a single well for two-qubit gating by lasers



MERGE AND ENTANGLEMENT

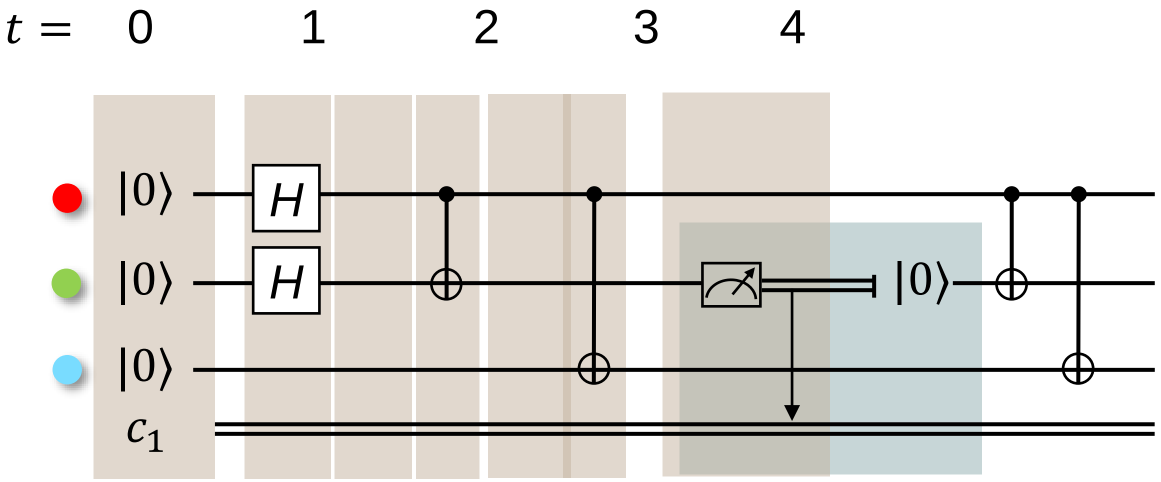
Individual trapped ions can be merged to a single well for two-qubit gating by lasers

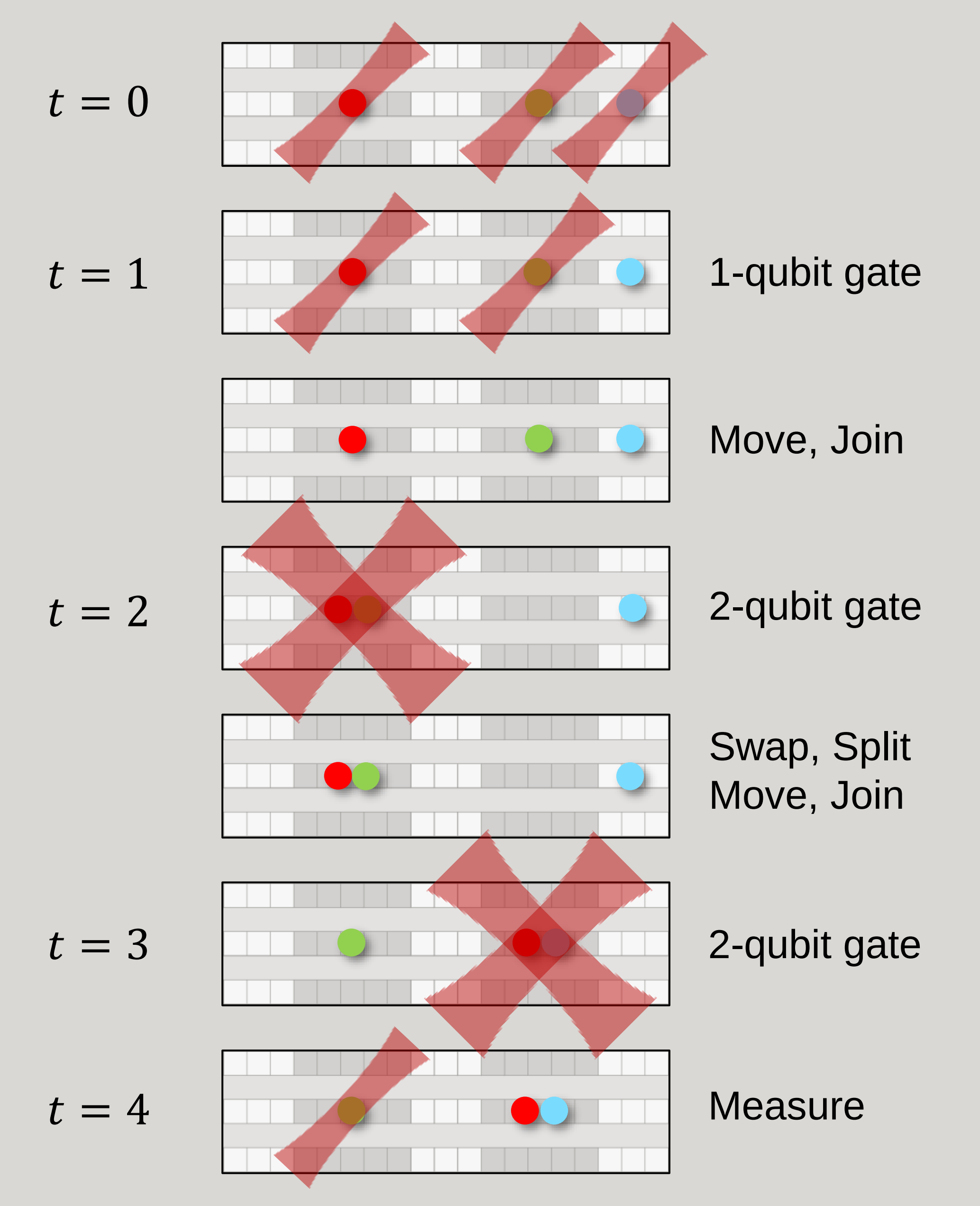
Ions can be re-separated and transported to interact with other ions



PHYSICAL IMPLEMENTATION

Quantum Circuit





REAL-WORLD VIEW

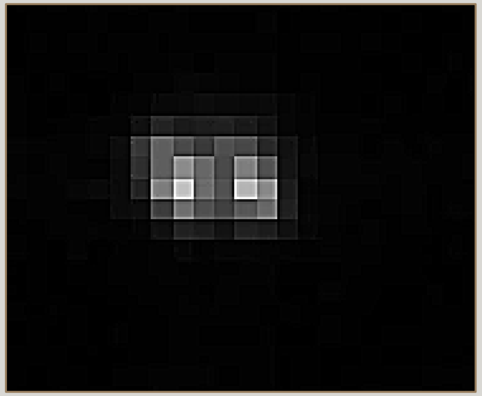
SPLIT AND COMBINE

Ion is transported into the same zone

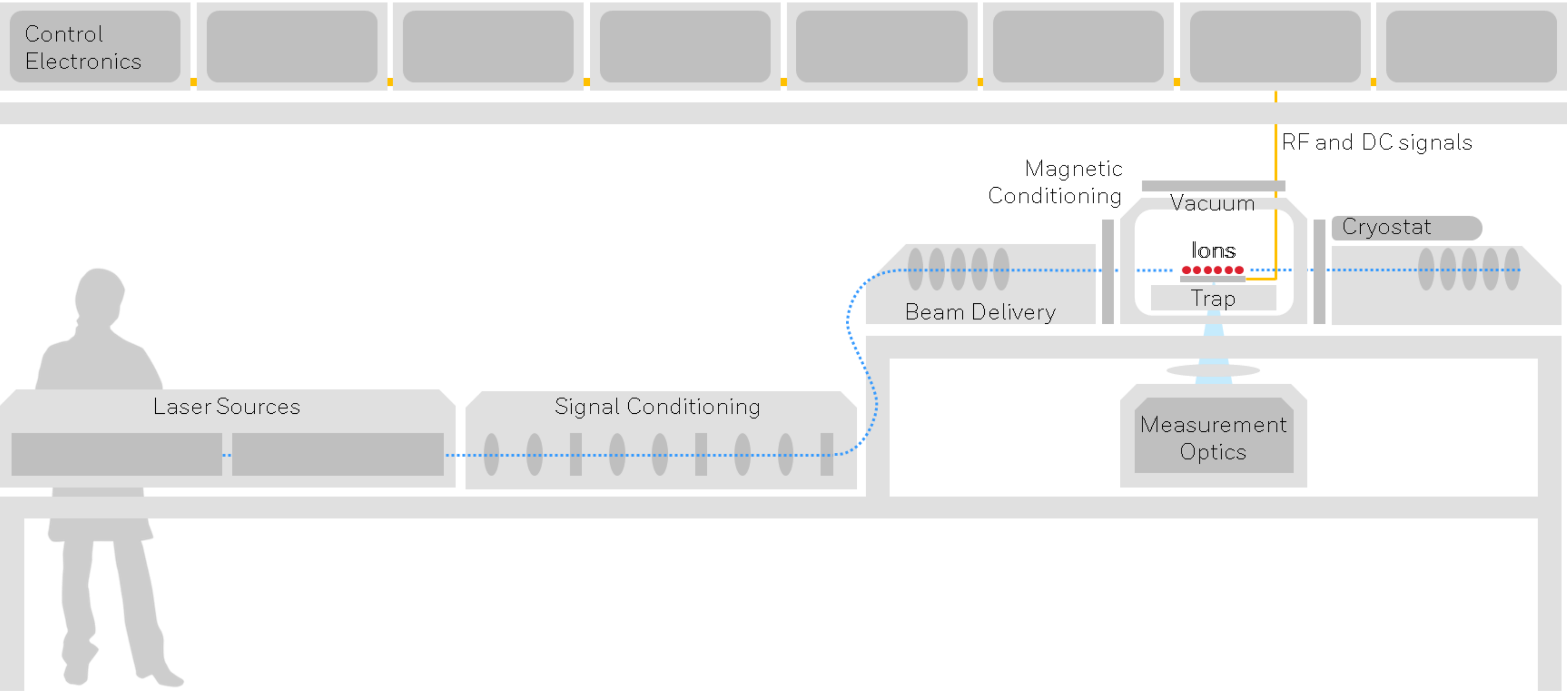
Ions are combined into a single potential well and then re-separated

SWAP

Ions are carefully manipulated to reorder positions

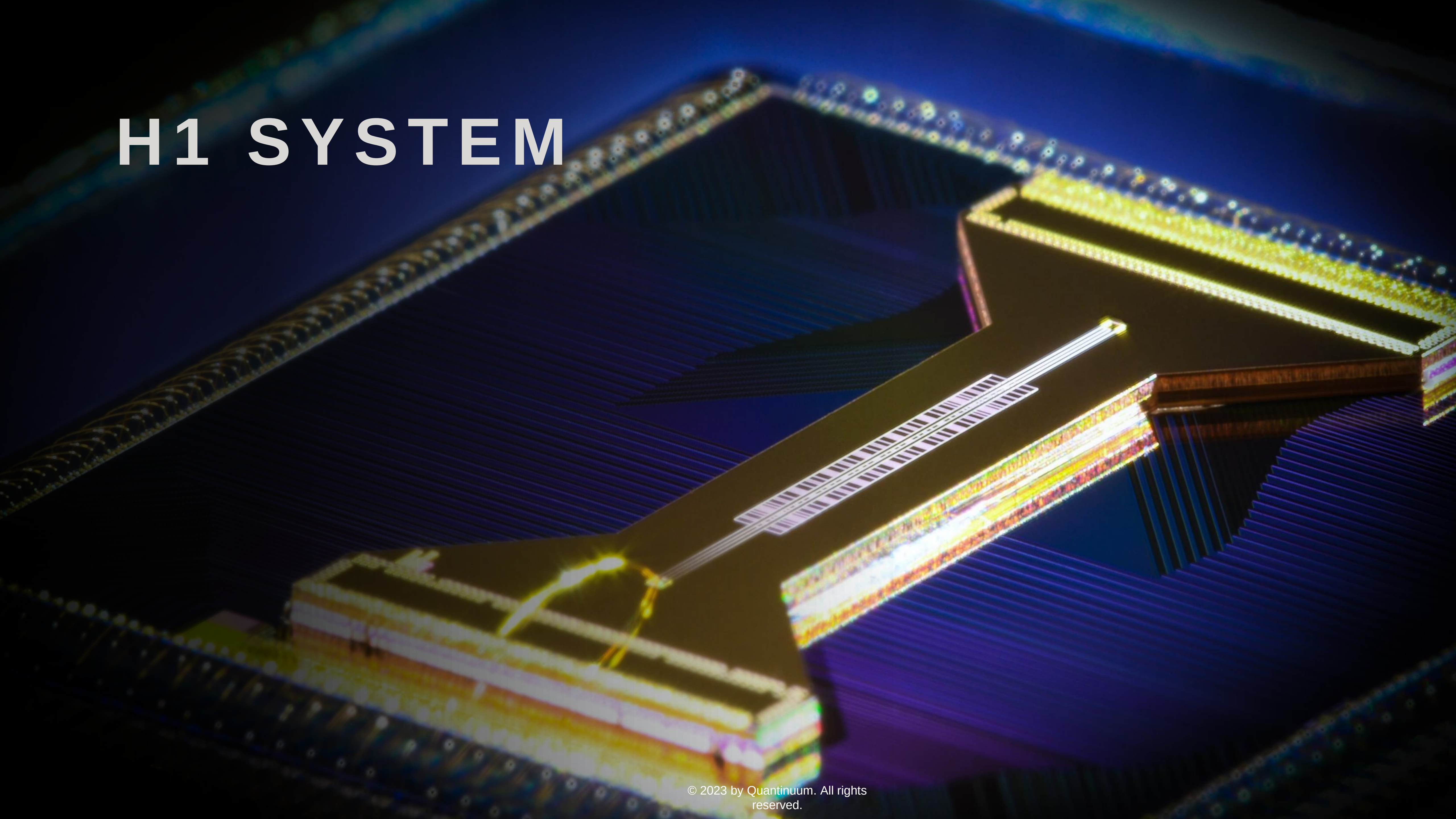


TRAPPED-ION QUANTUM COMPUTER



OUR COMMERCIAL QUANTUM COMPUTERS

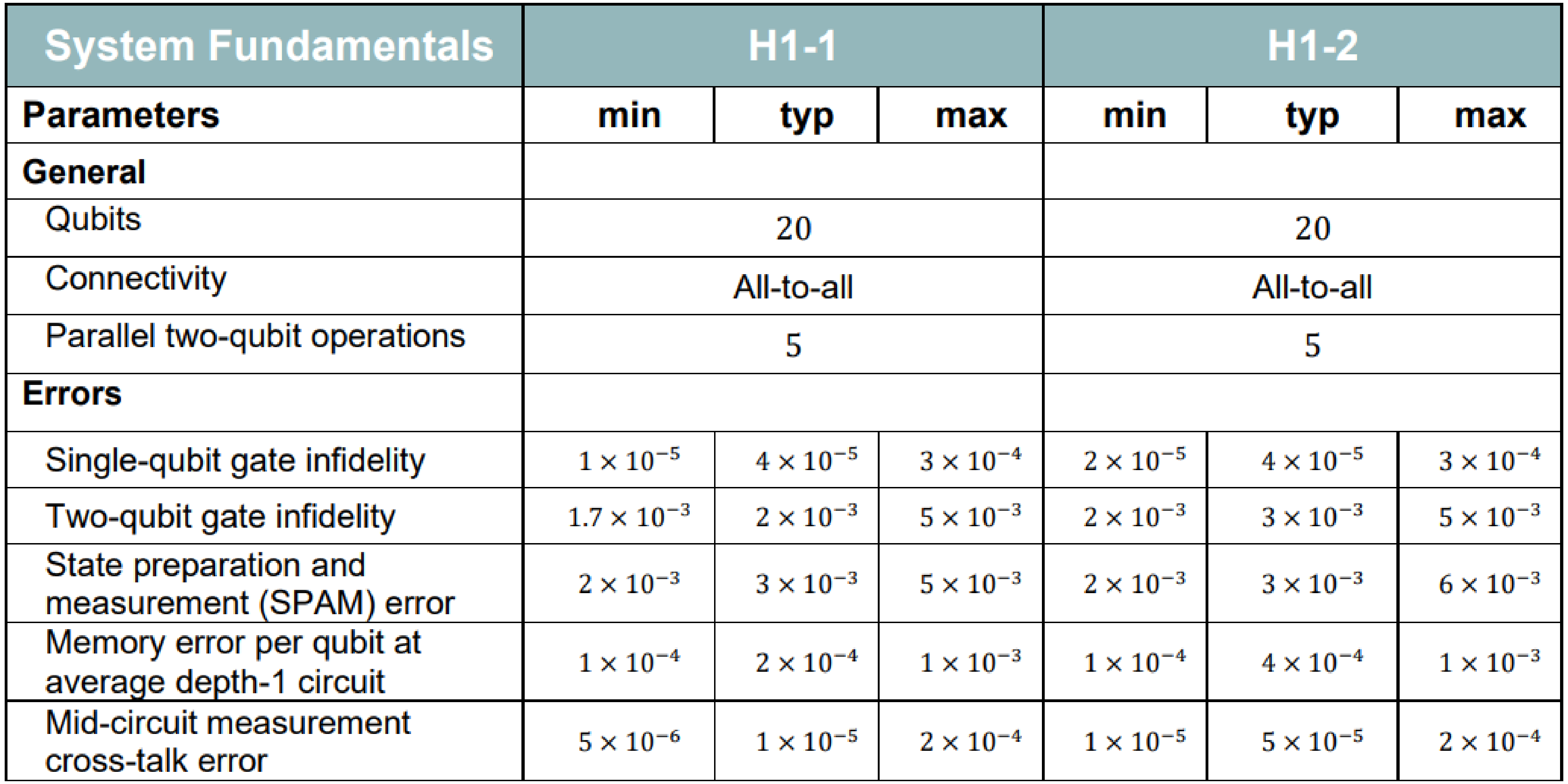
H1 SYSTEM



MEASURED PERFOMANCE OF H1-1 & H1-2

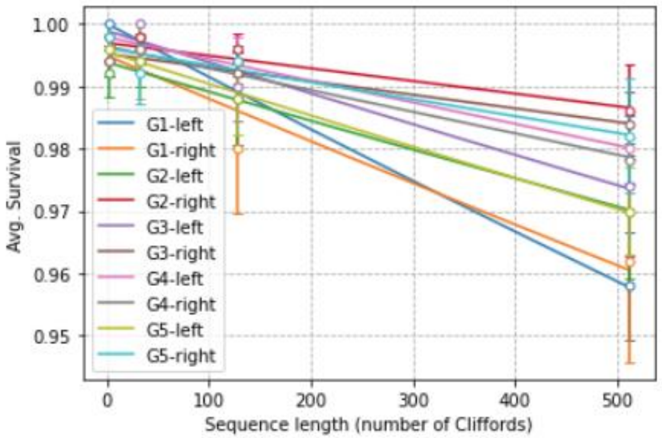
Fidelity = 1 - Infidelity

Table 1 Quantinuum H-Series Specifications

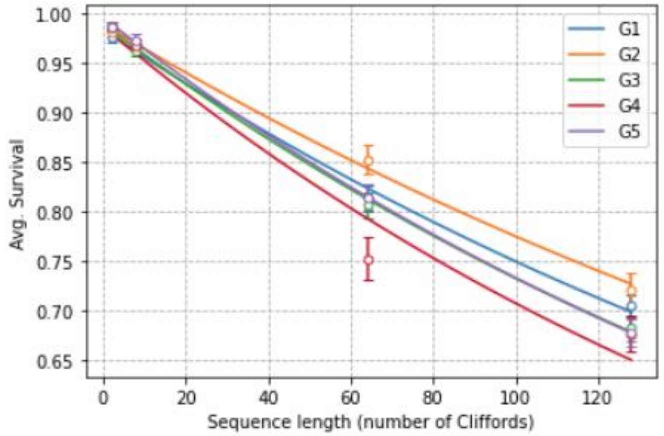


System Fundamentals	H1-1			H1-2		
Parameters	**min**	**typ**	**max**	**min**	**typ**	**max**
General						
Qubits	20			20		
Connectivity	All-to-all			All-to-all		
Parallel two-qubit operations	5			5		
Errors						
Single-qubit gate infidelity	1×10^{-5}	4×10^{-5}	3×10^{-4}	2×10^{-5}	4×10^{-5}	3×10^{-4}
Two-qubit gate infidelity	1.7×10^{-3}	2×10^{-3}	5×10^{-3}	2×10^{-3}	3×10^{-3}	5×10^{-3}
State preparation and measurement (SPAM) error	2×10^{-3}	3×10^{-3}	5×10^{-3}	2×10^{-3}	3×10^{-3}	6×10^{-3}
Memory error per qubit at average depth-1 circuit	1×10^{-4}	2×10^{-4}	1×10^{-3}	1×10^{-4}	4×10^{-4}	1×10^{-3}
Mid-circuit measurement cross-talk error	5×10^{-6}	1×10^{-5}	2×10^{-4}	1×10^{-5}	5×10^{-5}	2×10^{-4}

Single Qubit Randomized Benchmarking



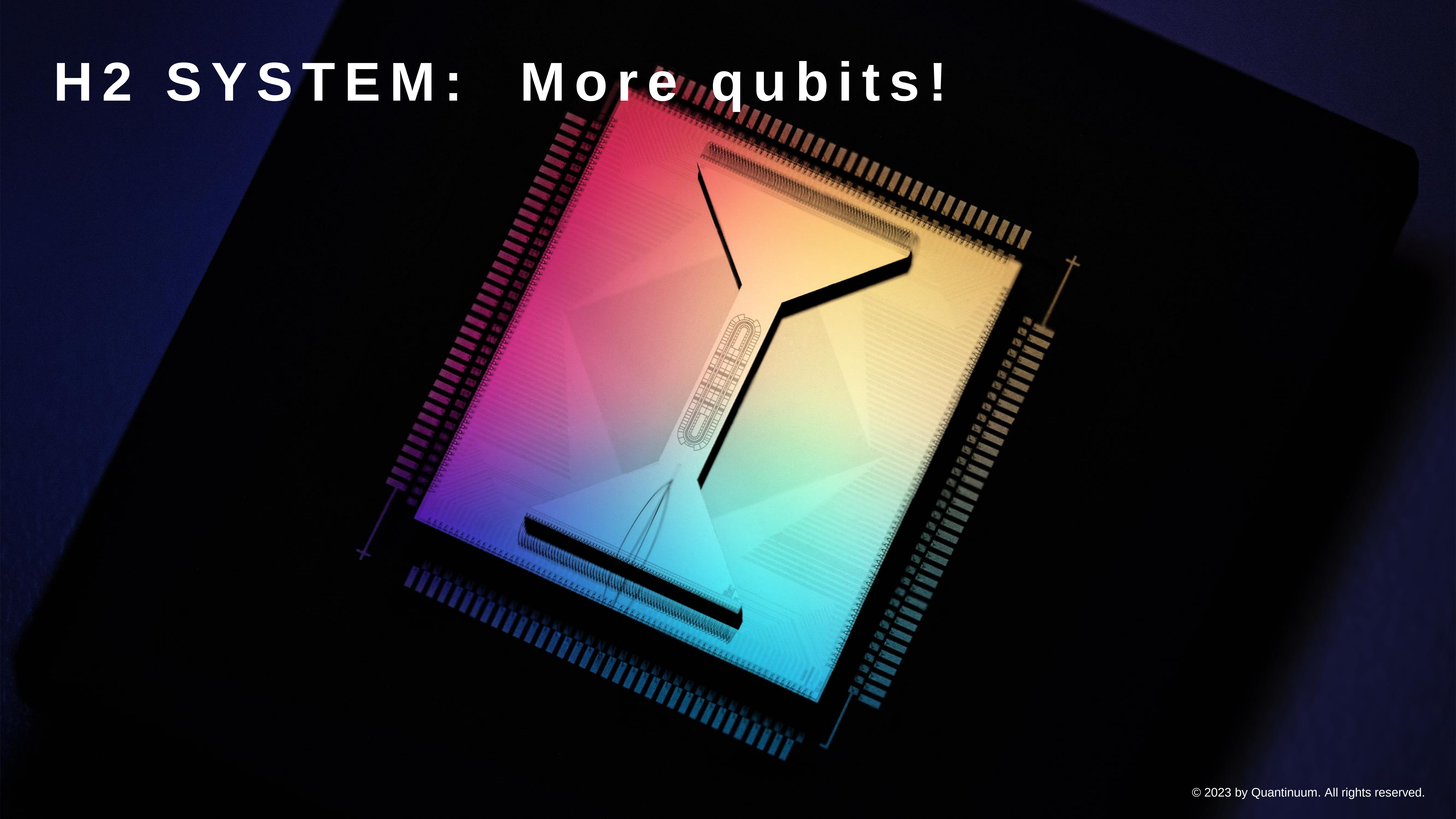
Parallel Two Qubit Randomized Benchmarking

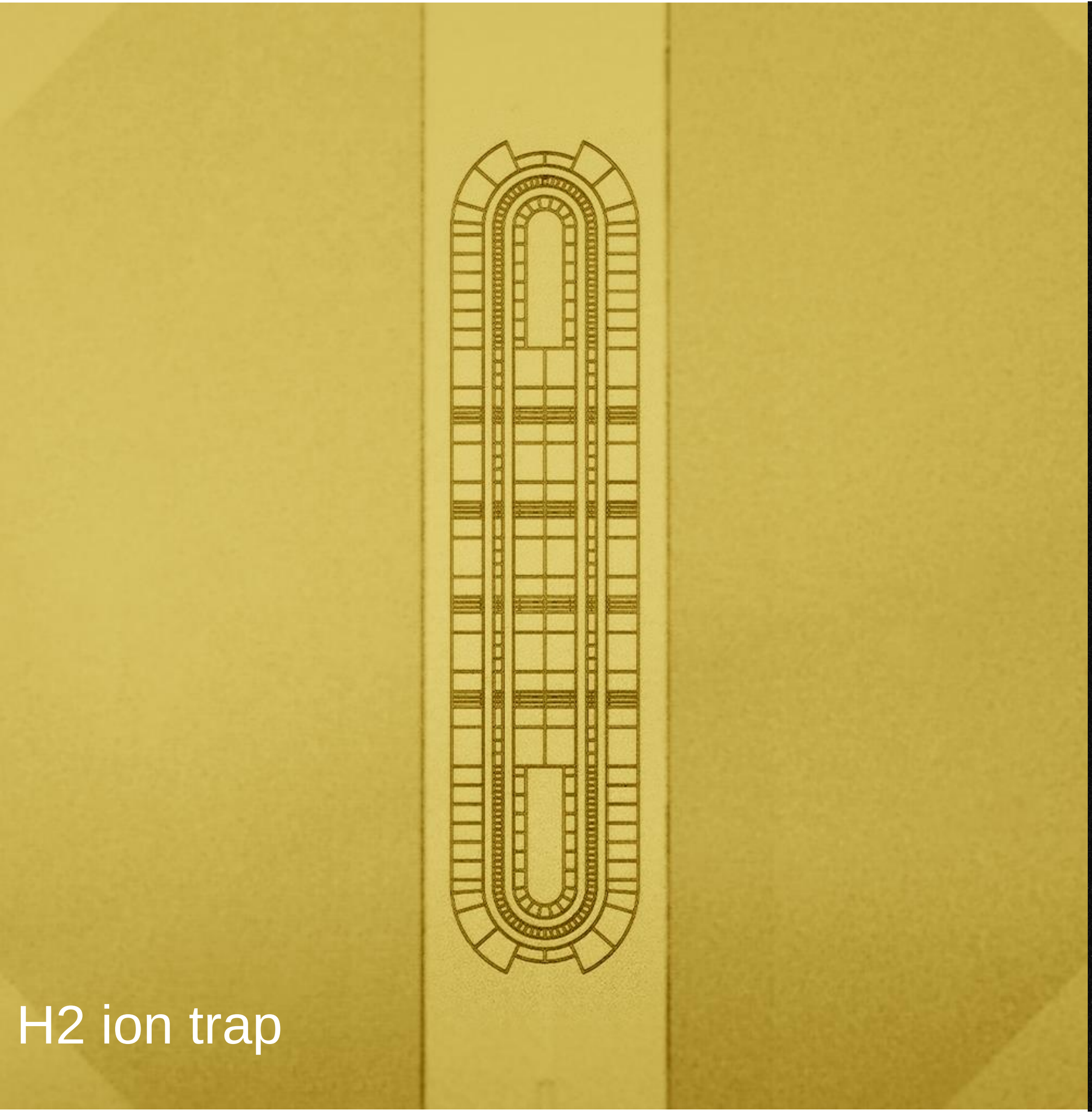


Raw data and analysis code available at:

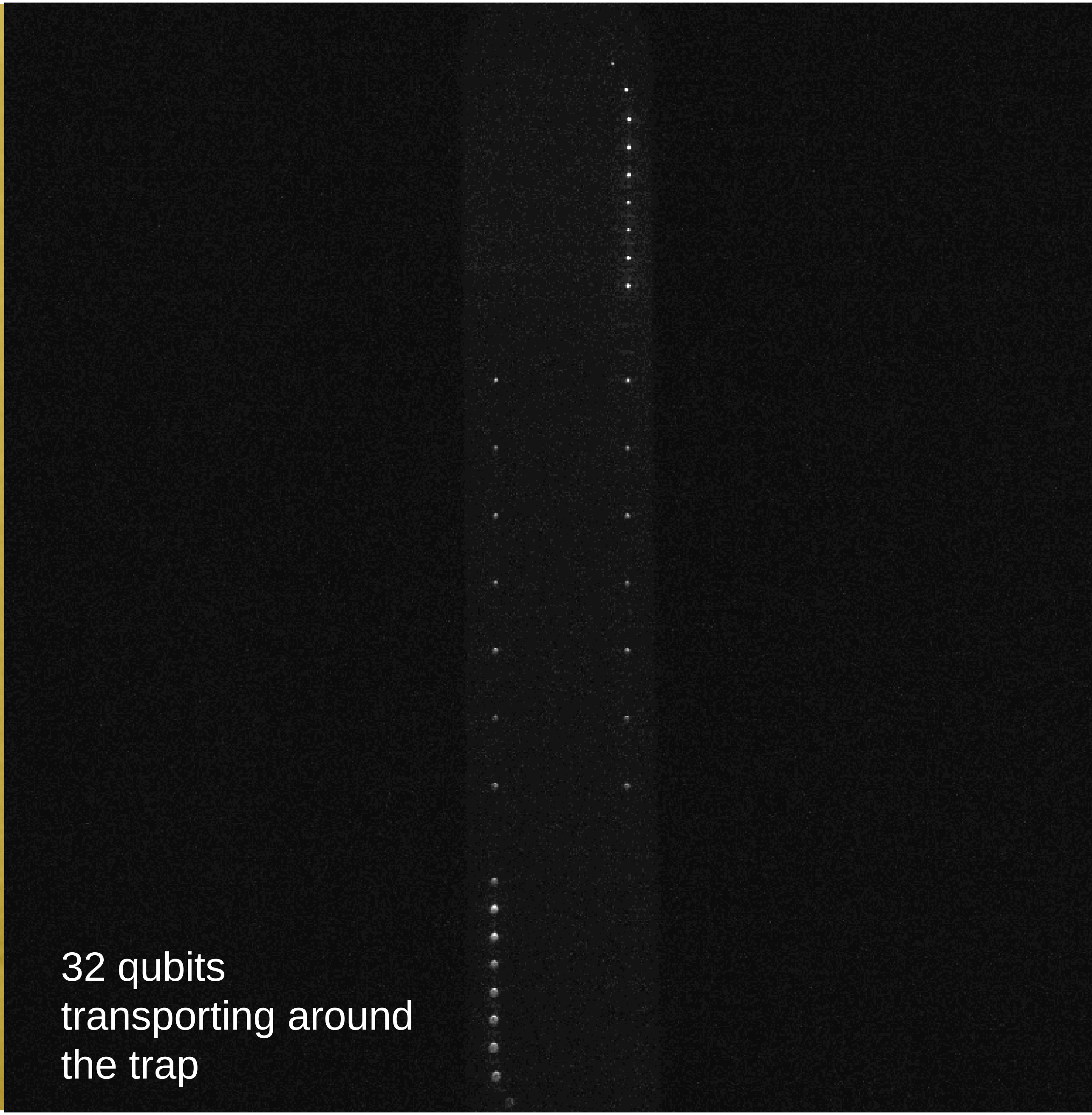
https://github.com/CQCL/quantinuum-hardware-specifications

H2 SYSTEM: More qubits!





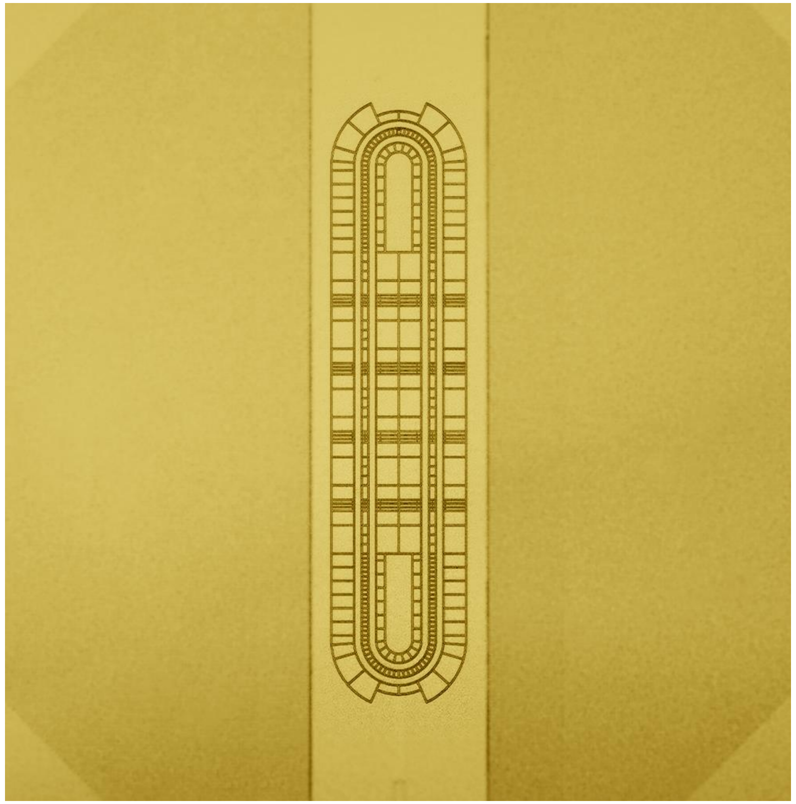
H2 ion trap

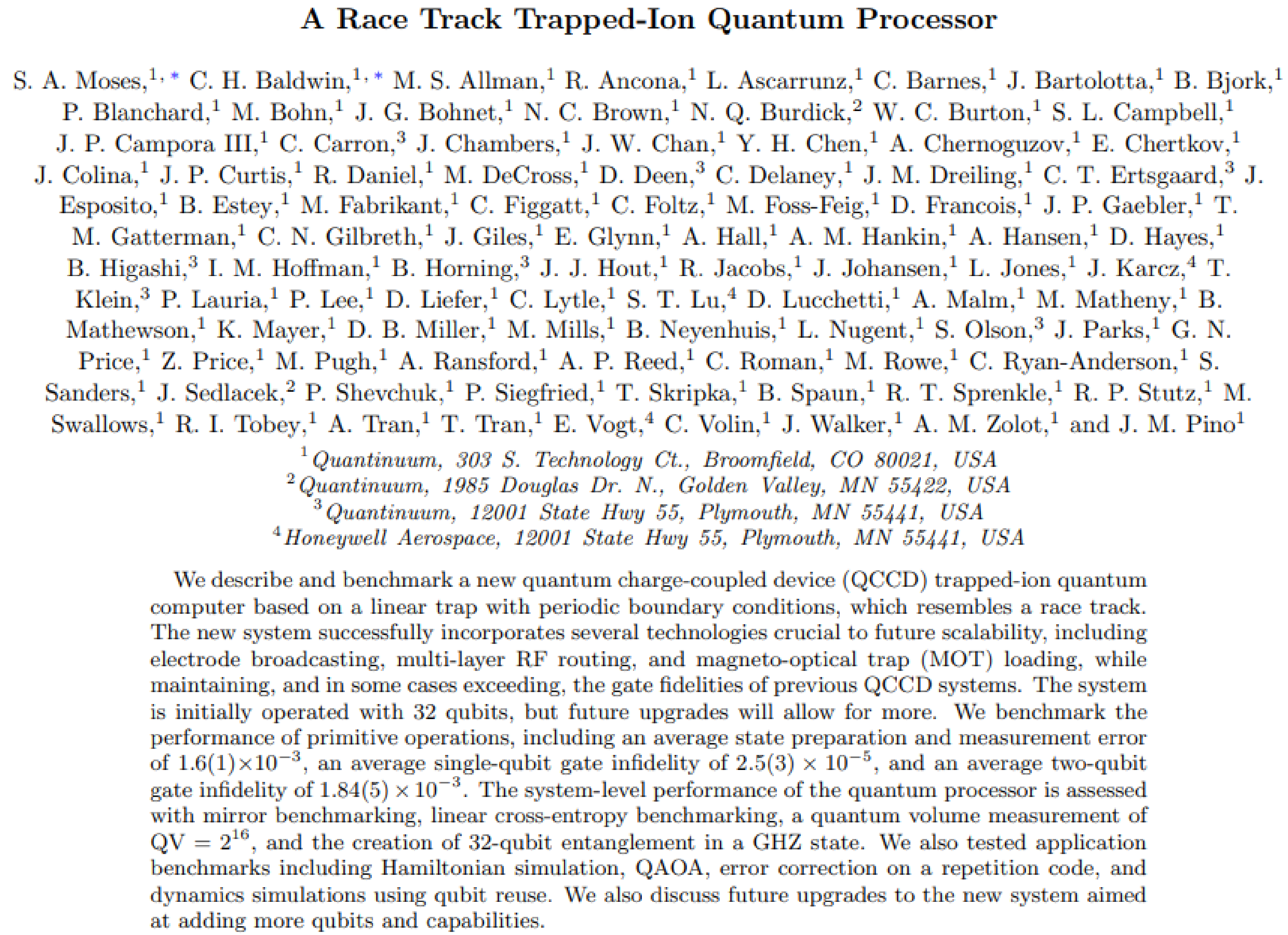


32 qubits transporting around the trap

SCALING **HIGH QUALITY** QUBITS

- H2: Industry Leading Performance
  - **32 Qubits – globally entangled at high fidelity**
  - 1Q Fidelity 99.998%
  - 2Q Fidelity 99.8%
  - SPAM 99.8%
  - Memory Fidelity 99.98%
  - Measurement cross-talk error 0.0005%
  - All-to-all connectivity
  - Mid-circuit measurement with conditional logic
  - Qubit reuse
  - Parametrized angle 2Q gate included in native set





A Race Track Trapped-Ion Quantum Processor

S. A. Moses,[1,*] C. H. Baldwin,[1,*] M. S. Allman,[1] R. Ancona,[1] L. Ascarrunz,[1] C. Barnes,[1] J. Bartolotta,[1] B. Bjork,[1] P. Blanchard,[1] M. Bohn,[1] J. G. Bohnet,[1] N. C. Brown,[1] N. Q. Burdick,[2] W. C. Burton,[1] S. L. Campbell,[1] J. P. Campora III,[1] C. Carron,[3] J. Chambers,[1] J. W. Chan,[1] Y. H. Chen,[1] A. Chernoguzov,[1] E. Chertkov,[1] J. Colina,[1] J. P. Curtis,[1] R. Daniel,[1] M. DeCross,[1] D. Deen,[3] C. Delaney,[1] J. M. Dreiling,[1] C. T. Ertsgaard,[3] J. Esposito,[1] B. Estey,[1] M. Fabrikant,[1] C. Figgatt,[1] C. Foltz,[1] M. Foss-Feig,[1] D. Francois,[1] J. P. Gaebler,[1] T. M. Gatterman,[1] C. N. Gilbreth,[1] J. Giles,[1] E. Glynn,[1] A. Hall,[1] A. M. Hankin,[1] A. Hansen,[1] D. Hayes,[1] B. Higashi,[3] I. M. Hoffman,[1] B. Horning,[3] J. J. Hout,[1] R. Jacobs,[1] J. Johansen,[1] L. Jones,[1] J. Karcz,[4] T. Klein,[3] P. Lauria,[1] P. Lee,[1] D. Liefer,[1] C. Lytle,[1] S. T. Lu,[4] D. Lucchetti,[1] A. Malm,[1] M. Matheny,[1] B. Mathewson,[1] K. Mayer,[1] D. B. Miller,[1] M. Mills,[1] B. Neyenhuis,[1] L. Nugent,[1] S. Olson,[3] J. Parks,[1] G. N. Price,[1] Z. Price,[1] M. Pugh,[1] A. Ransford,[1] A. P. Reed,[1] C. Roman,[1] M. Rowe,[1] C. Ryan-Anderson,[1] S. Sanders,[1] J. Sedlacek,[2] P. Shevchuk,[1] P. Siegfried,[1] T. Skripka,[1] B. Spaun,[1] R. T. Sprenkle,[1] R. P. Stutz,[1] M. Swallows,[1] R. I. Tobey,[1] A. Tran,[1] T. Tran,[1] E. Vogt,[4] C. Volin,[1] J. Walker,[1] A. M. Zolot,[1] and J. M. Pino[1]

[1] *Quantinuum, 303 S. Technology Ct., Broomfield, CO 80021, USA*
[2] *Quantinuum, 1985 Douglas Dr. N., Golden Valley, MN 55422, USA*
[3] *Quantinuum, 12001 State Hwy 55, Plymouth, MN 55441, USA*
[4] *Honeywell Aerospace, 12001 State Hwy 55, Plymouth, MN 55441, USA*

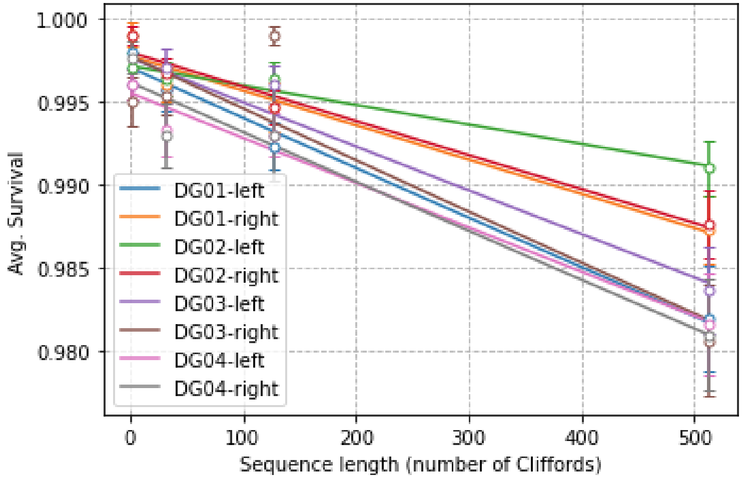
We describe and benchmark a new quantum charge-coupled device (QCCD) trapped-ion quantum computer based on a linear trap with periodic boundary conditions, which resembles a race track. The new system successfully incorporates several technologies crucial to future scalability, including electrode broadcasting, multi-layer RF routing, and magneto-optical trap (MOT) loading, while maintaining, and in some cases exceeding, the gate fidelities of previous QCCD systems. The system is initially operated with 32 qubits, but future upgrades will allow for more. We benchmark the performance of primitive operations, including an average state preparation and measurement error of $1.6(1)\times10^{-3}$, an average single-qubit gate infidelity of $2.5(3)\times10^{-5}$, and an average two-qubit gate infidelity of $1.84(5)\times10^{-3}$. The system-level performance of the quantum processor is assessed with mirror benchmarking, linear cross-entropy benchmarking, a quantum volume measurement of $\mathrm{QV} = 2^{16}$, and the creation of 32-qubit entanglement in a GHZ state. We also tested application benchmarks including Hamiltonian simulation, QAOA, error correction on a repetition code, and dynamics simulations using qubit reuse. We also discuss future upgrades to the new system aimed at adding more qubits and capabilities.

https://arxiv.org/abs/2305.03828

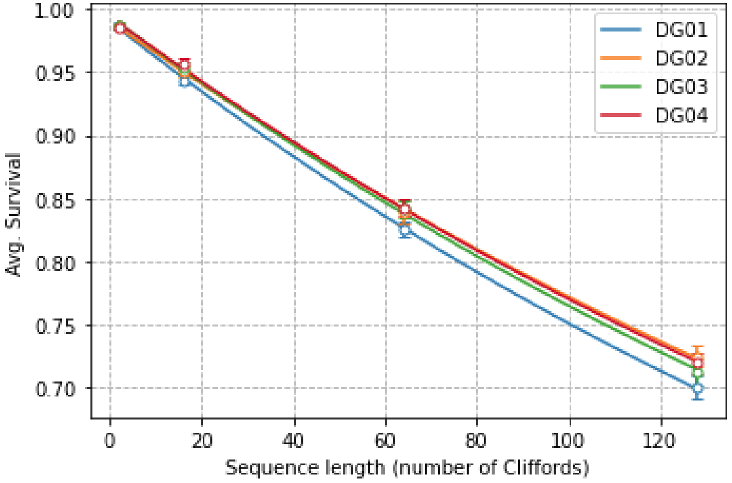
MEASURED H2-1 PERFORMANCE

Raw data and analysis code available at: https://github.com/CQCL/quantinuum-hardware-specifications

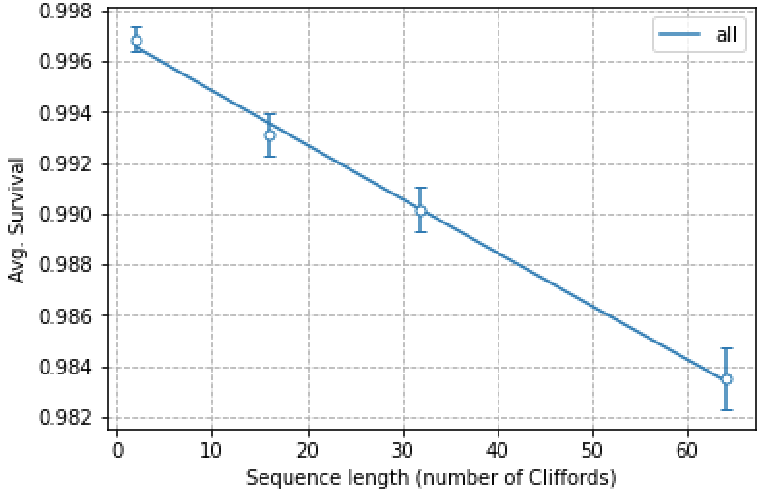
Single Qubit Randomized Benchmarking



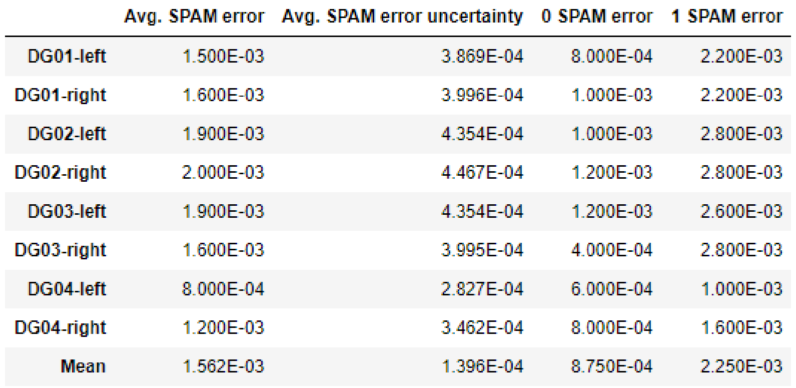
Parallel Two Qubit Randomized Benchmarking



Memory Randomized Benchmarking

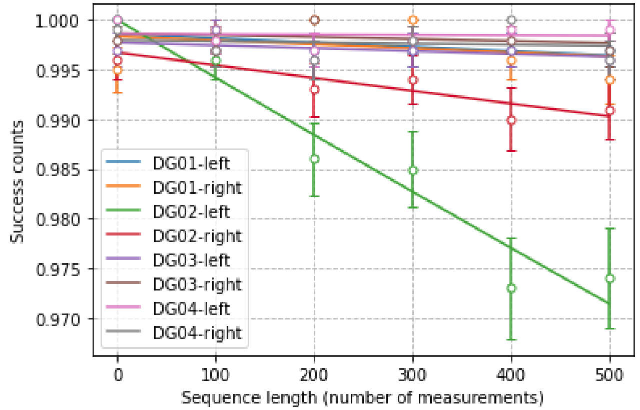


SPAM



	Avg. SPAM error	Avg. SPAM error uncertainty	0 SPAM error	1 SPAM error
DG01-left	1.500E-03	3.869E-04	8.000E-04	2.200E-03
DG01-right	1.600E-03	3.996E-04	1.000E-03	2.200E-03
DG02-left	1.900E-03	4.354E-04	1.000E-03	2.800E-03
DG02-right	2.000E-03	4.467E-04	1.200E-03	2.800E-03
DG03-left	1.900E-03	4.354E-04	1.200E-03	2.600E-03
DG03-right	1.600E-03	3.995E-04	4.000E-04	2.800E-03
DG04-left	8.000E-04	2.827E-04	6.000E-04	1.000E-03
DG04-right	1.200E-03	3.462E-04	8.000E-04	1.600E-03
Mean	1.562E-03	1.396E-04	8.750E-04	2.250E-03

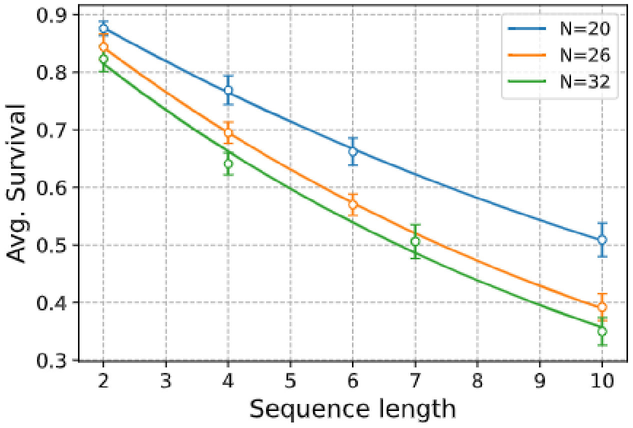
Measurement Crosstalk



SQRB	2.5(3) x 10^{-5}
TQRB	1.8(4) x 10^{-3}
Memory RB	2.2(3) x 10^{-4}
SPAM	1.6(1) x 10^{-3}
Measurement Crosstalk	4.5(6) x 10^{-6}

H2 SYSTEM LEVEL PERFORMANCE

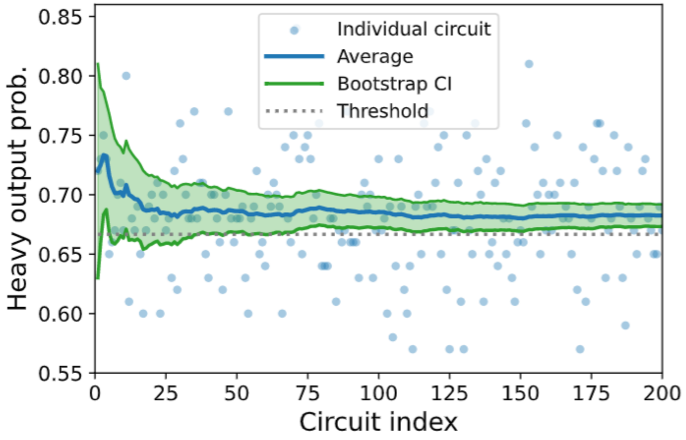
Mirror benchmarking



Introduced by Sandia National labs

Industry First

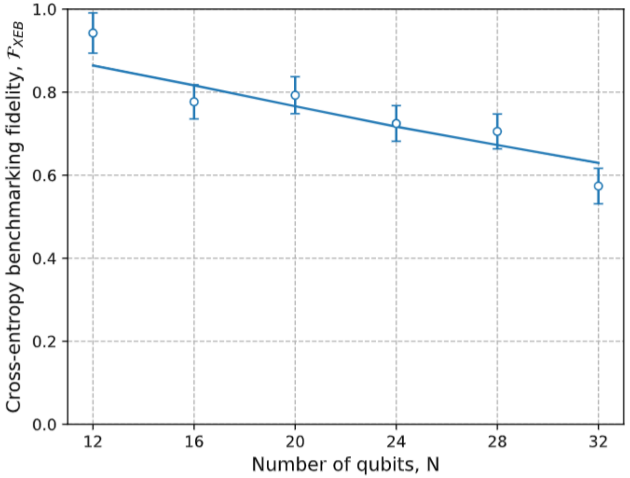
Quantum volume



Introduced by IBM

World Record

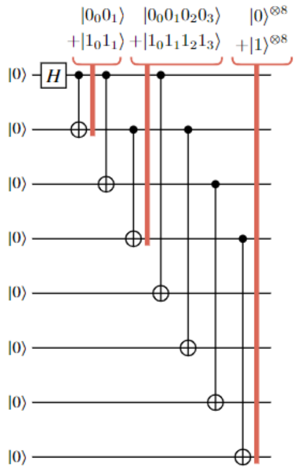
Random circuit sampling



Introduced by Google

Best performance at N=32 (8x)

32 qubit GHZ state



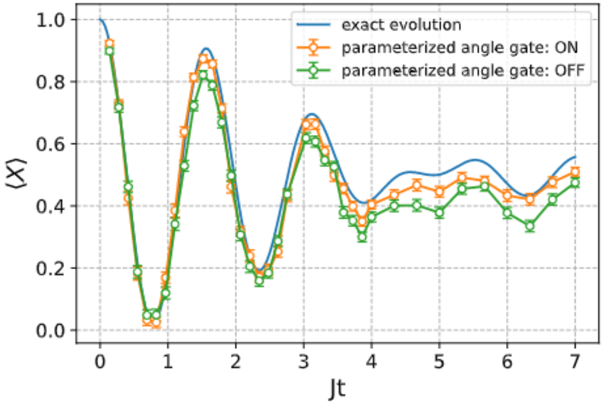
Common in industry and academia

World Record

QUANTINUUM

H2 APPLICATION BENCHMARKS

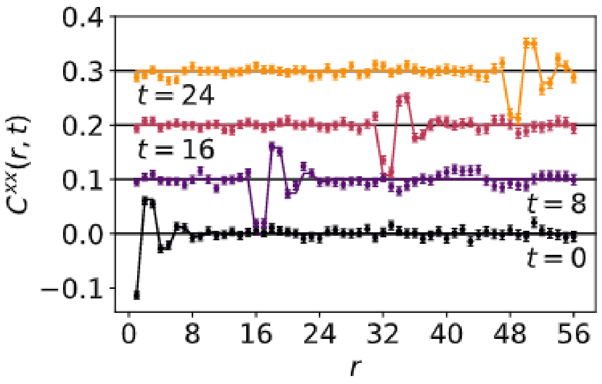
Hamiltonian simulation



Likely near-term application

Data shows benefits of programmable gate parameters

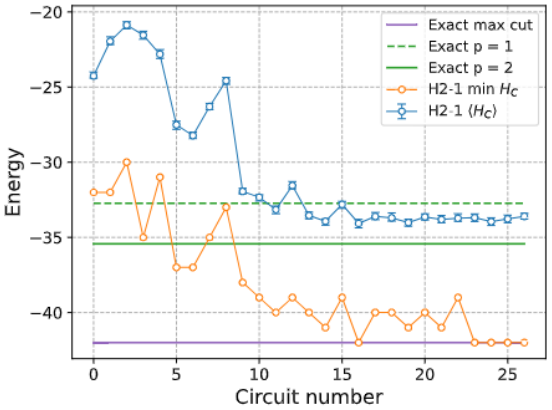
Quantum dynamics



Simulates how information propagates in quantum systems

Demonstrates low measurement crosstalk

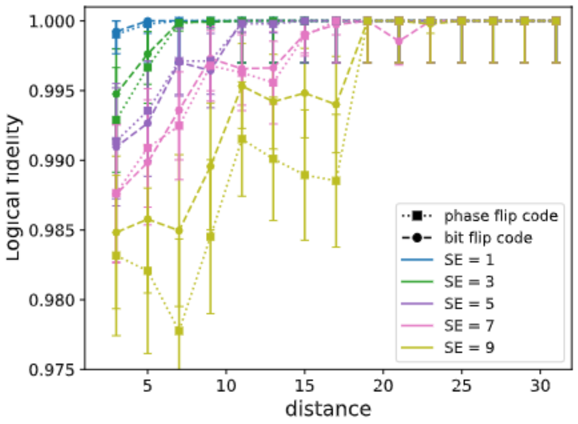
QAOA



One of the largest optimization problems solved on a quantum computer

High connectivity

Error correction

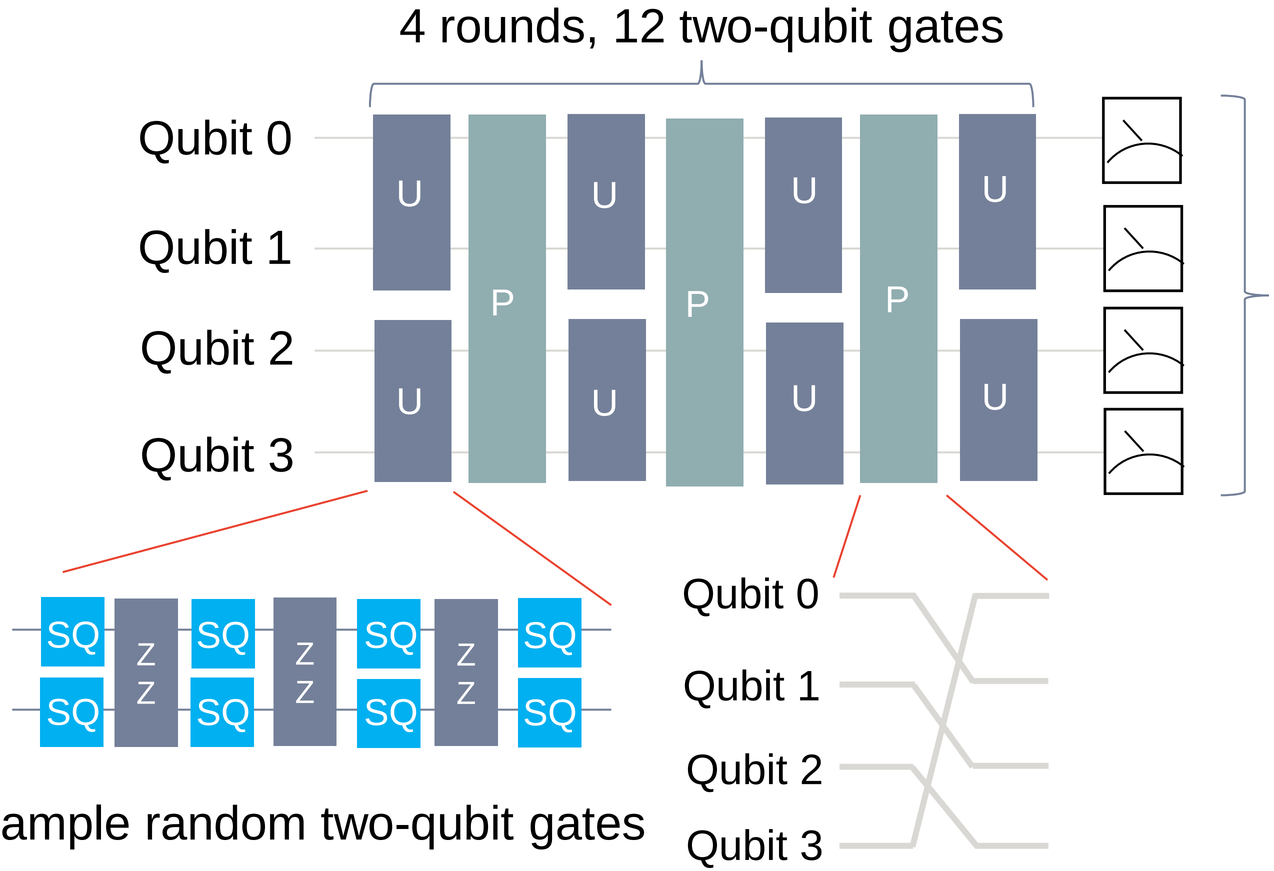


Classical (not Quantum) error correction

Qubit reuse advantage
QPU-CPU interaction

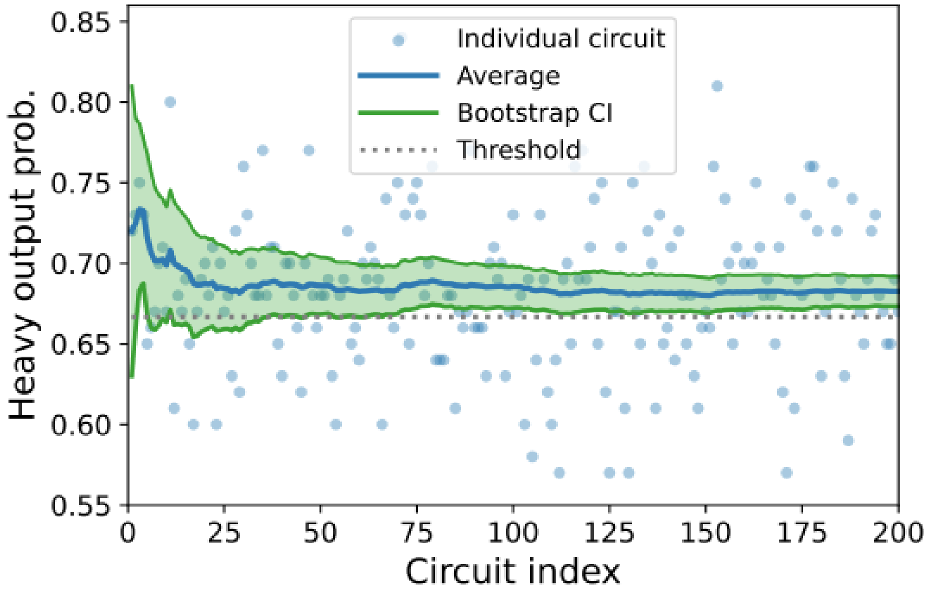
HOLISTIC BENCHMARKS - QUANTUM VOLUME

Quantum volume is a measure of the largest circuit that can successfully be run with depth = qubit number. QV = $2^{\min(\text{depth, qubit number})}$



Example random two-qubit gates

Random permutation of qubits

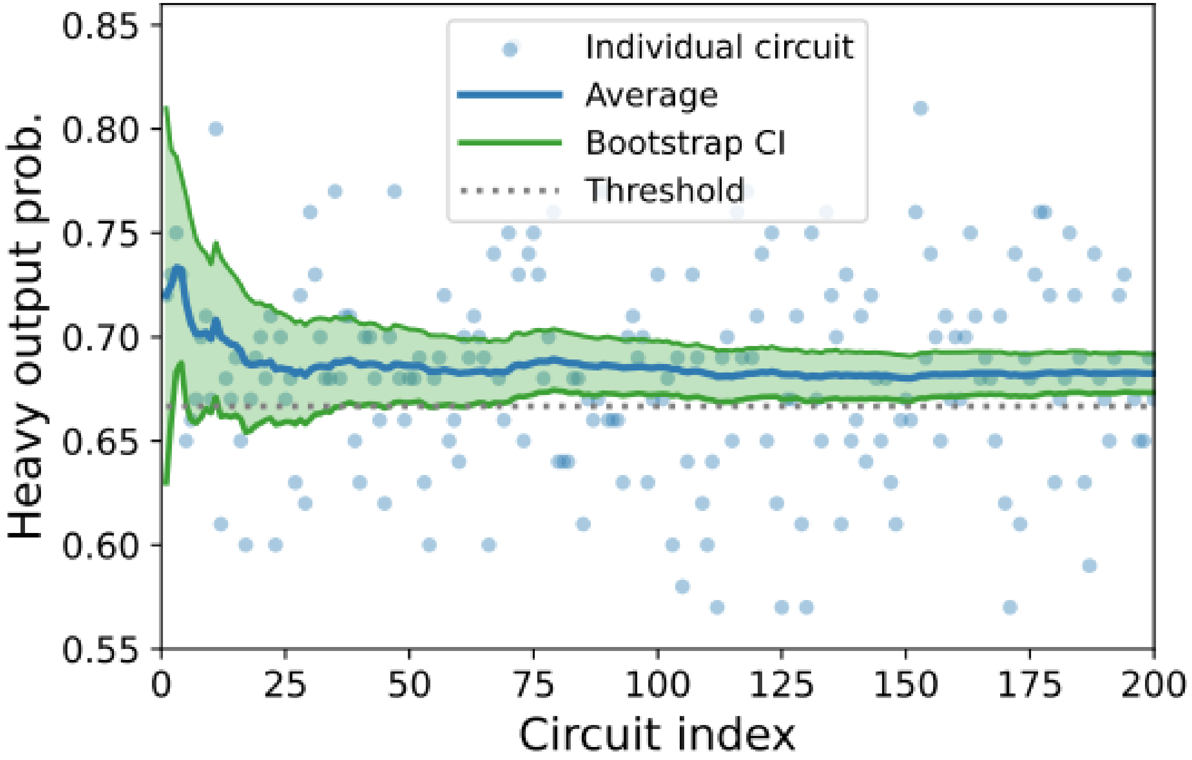


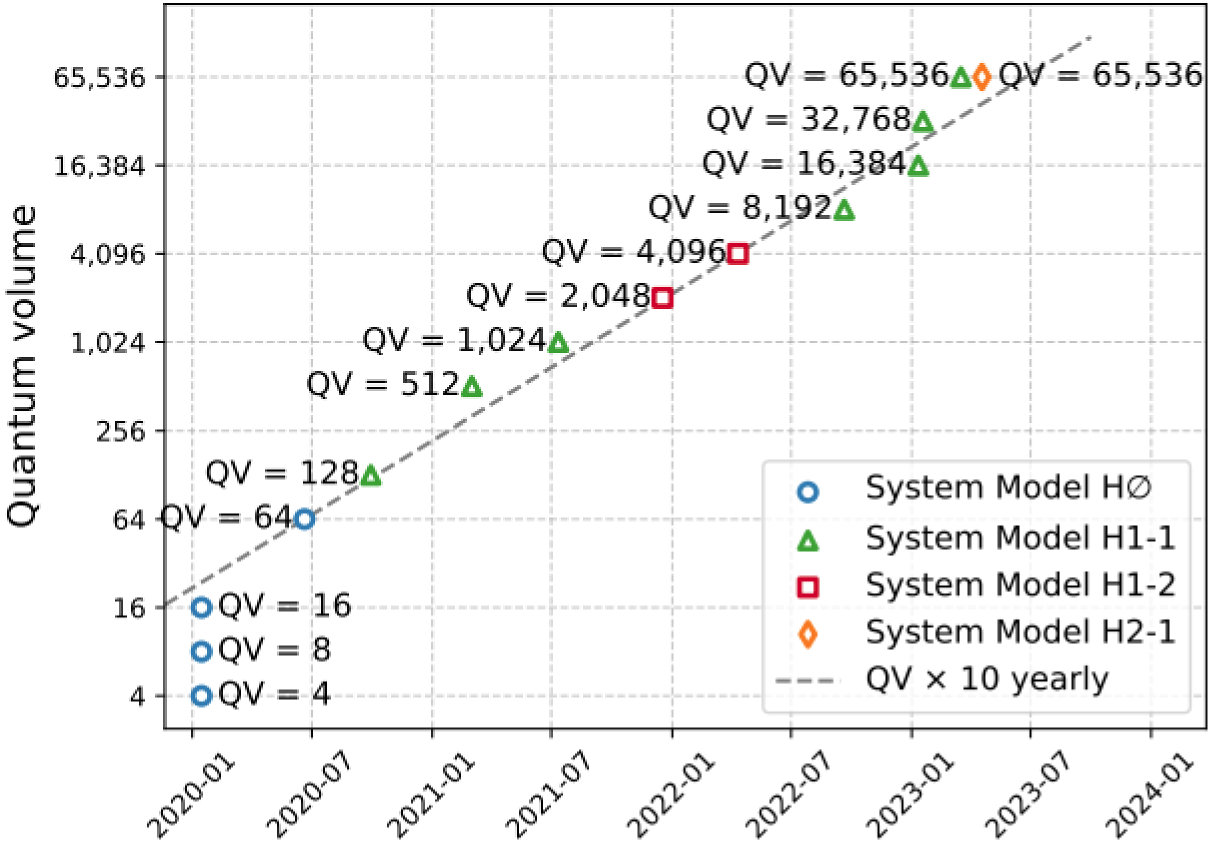
Experimental result must match simulation >2/3rd time, with 2σ confidence

A. W. Cross, L. S. Bishop, S. Sheldon, P. D. Nation, and J. M. Gambetta .Phys. Rev. A **100**, 032328 (2019)

C. H. Baldwin, K. Mayer, N. C. Brown, C. Ryan-Anderson, D. Hayes, Quantum 6, 707 (2023)

HOLISTIC BENCHMARKS - QUANTUM VOLUME 2^{16} = 65,536





“Re-examining the quantum volume test: Ideal distributions, compiler optimizations, confidence intervals, and scalable resource estimations” Charles H. Baldwin, Karl Mayer, Natalie C. Brown, Ciarán Ryan-Anderson, David Hayes, Quantum 6, 707 (2023)

OUR TECH ROADMAP

TRAP SCALING ROADMAP

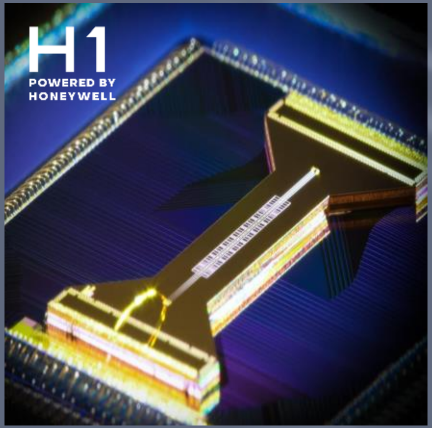
LINEAR

PARALLEL
GATE ZONES

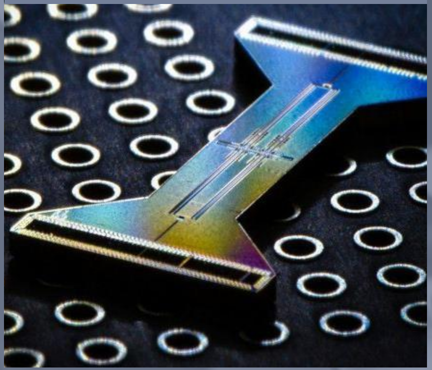
GRID

INTEGRATED OPTICS

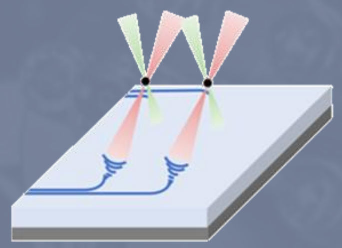
LARGE SCALE



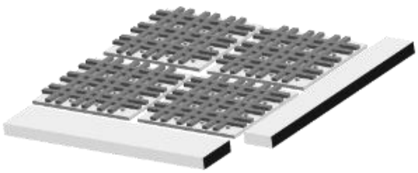
Grid Trap Prototype



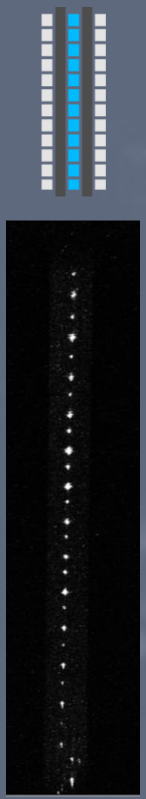
Photonic Waveguides
& Couplers



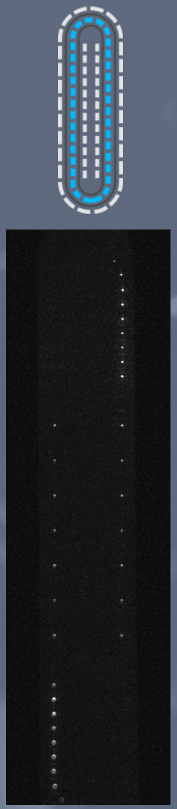
Modular, Tiled Traps



TRAP SCALING PROGRESS

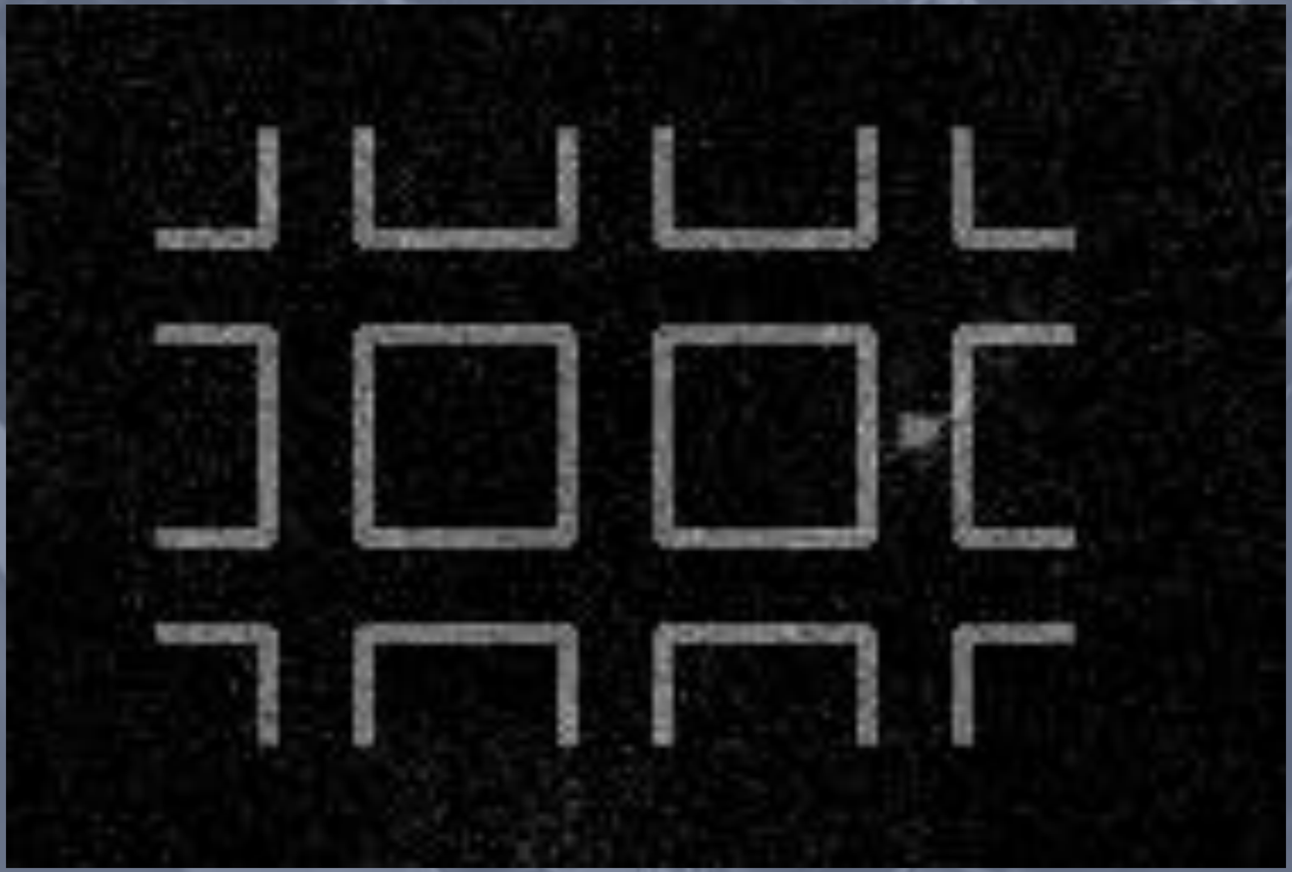


H1



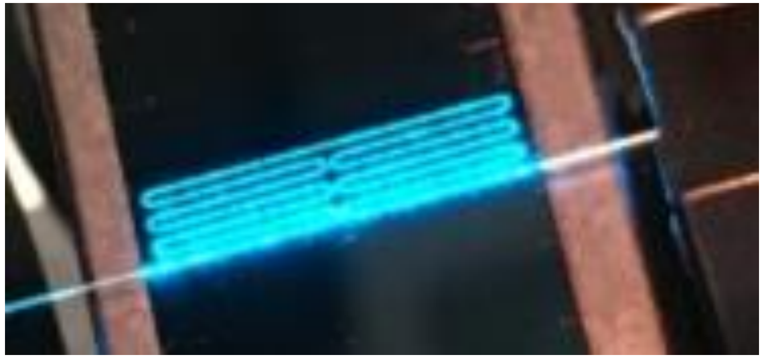
H2

Grid

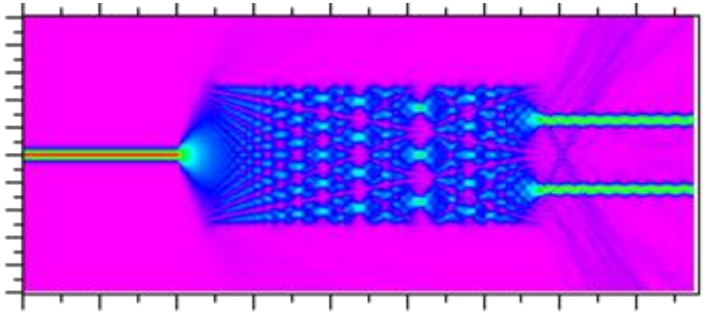


Grid-trap prototype

FUNCTIONALITY ON A CHIP

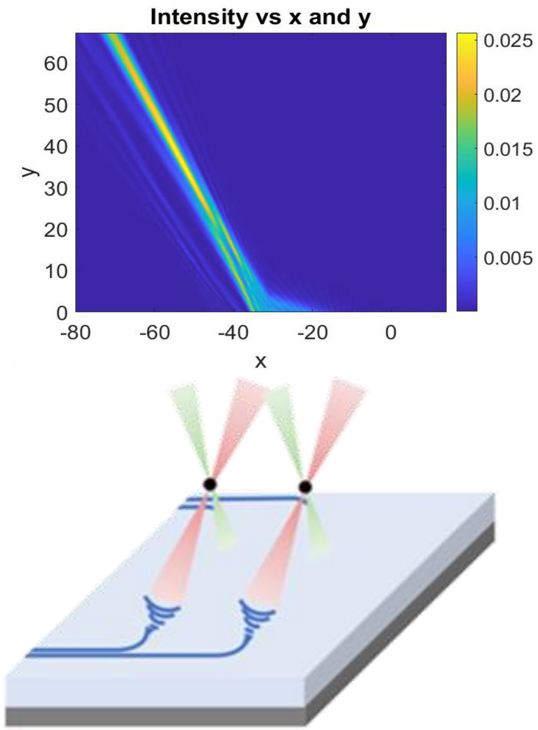


Guiding light on a chip



Power-splitting light on a chip

Developing these with industry-leading groups at national labs, universities, and commercial photonics foundries.



Guiding light from chip to ion

ACCESSING OUR QUANTUM COMPUTERS

QUANTINUUM
ACCELERATING QUANTUM COMPUTING

PROVIDING ACCESS
FOR QC RESEARCH:

- **Quantum Computing User Program** from Oak Ridge National Laboratory

  https://www.olcf.ornl.gov/olcf-resources/compute-systems/quantum-computing-user-program/

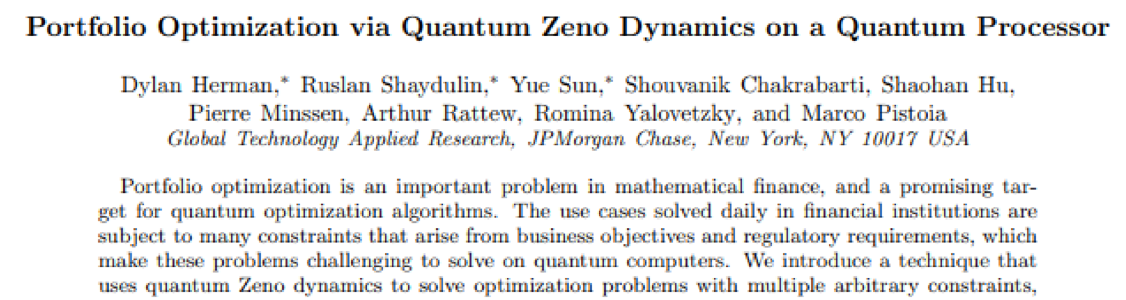
- **Azure Quantum Credits Program** from Microsoft

  https://aka.ms/aq/credits

Reach out to learn more:

https://www.Quantinuum.com

H-SERIES USER PUBLICATIONS



Portfolio Optimization via Quantum Zeno Dynamics on a Quantum Processor

Dylan Herman,* Ruslan Shaydulin,* Yue Sun,* Shouvanik Chakrabarti, Shaohan Hu,
Pierre Minssen, Arthur Rattew, Romina Yalovetzky, and Marco Pistoia
Global Technology Applied Research, JPMorgan Chase, New York, NY 10017 USA

Portfolio optimization is an important problem in mathematical finance, and a promising target for quantum optimization algorithms. The use cases solved daily in financial institutions are subject to many constraints that arise from business objectives and regulatory requirements, which make these problems challenging to solve on quantum computers. We introduce a technique that uses quantum Zeno dynamics to solve optimization problems with multiple arbitrary constraints,

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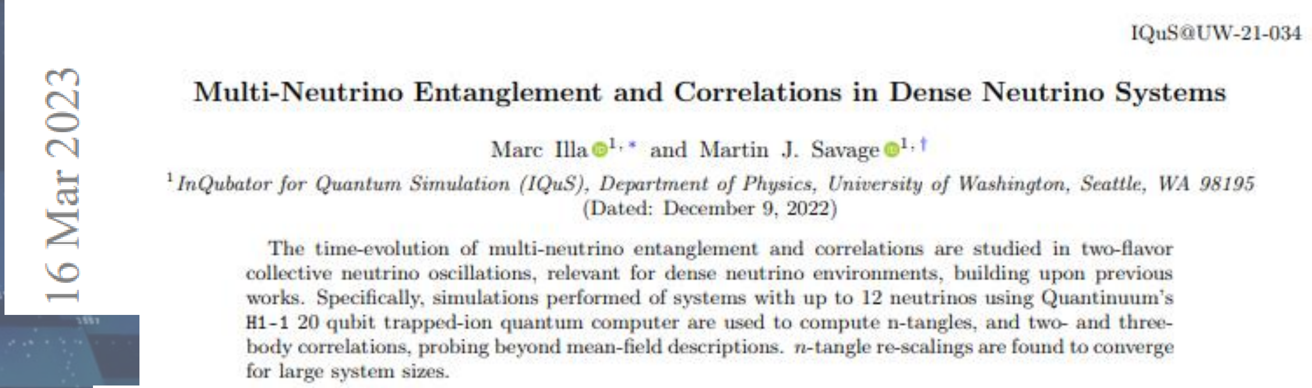


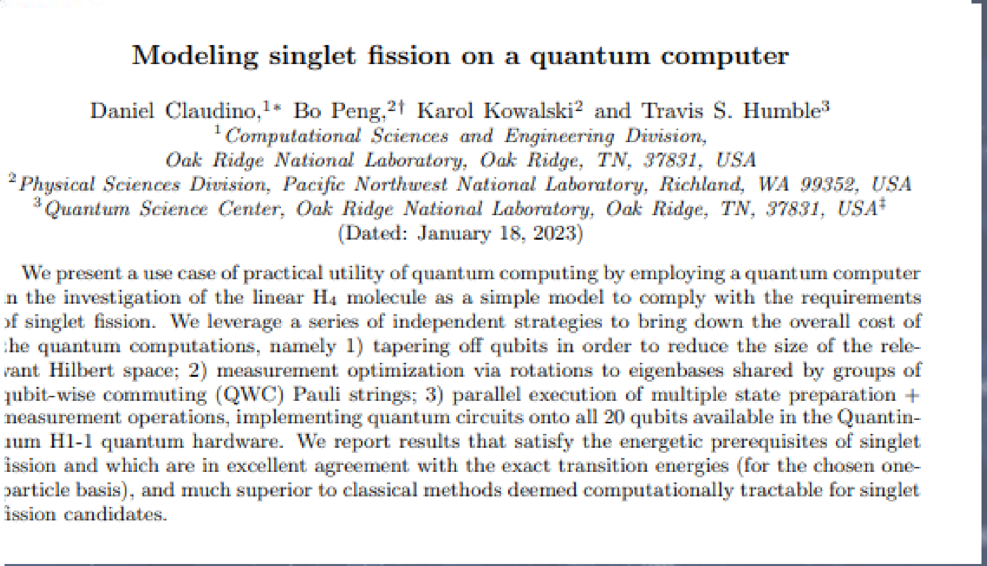
IQuS@UW-21-034

16 Mar 2023

Multi-Neutrino Entanglement and Correlations in Dense Neutrino Systems

Marc Illa[1,*] and Martin J. Savage[1,†]
[1] *InQubator for Quantum Simulation (IQuS), Department of Physics, University of Washington, Seattle, WA 98195*
(Dated: December 9, 2022)

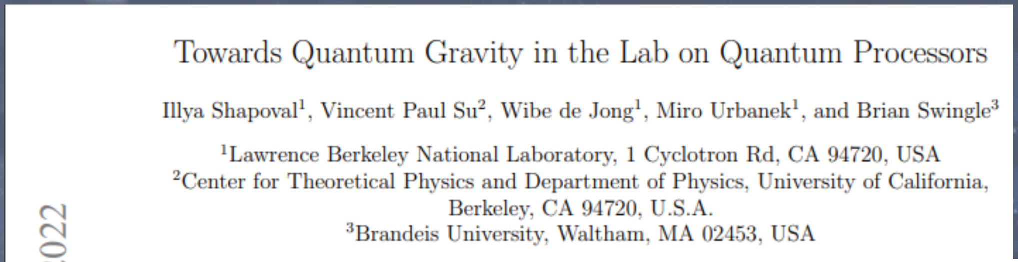
The time-evolution of multi-neutrino entanglement and correlations are studied in two-flavor collective neutrino oscillations, relevant for dense neutrino environments, building upon previous works. Specifically, simulations performed of systems with up to 12 neutrinos using Quantinuum's `H1-1` 20 qubit trapped-ion quantum computer are used to compute n-tangles, and two- and three-body correlations, probing beyond mean-field descriptions. n-tangle re-scalings are found to converge for large system sizes.



Modeling singlet fission on a quantum computer

Daniel Claudino,[1*] Bo Peng,[2†] Karol Kowalski[2] and Travis S. Humble[3]
[1] *Computational Sciences and Engineering Division, Oak Ridge National Laboratory, Oak Ridge, TN, 37831, USA*
[2] *Physical Sciences Division, Pacific Northwest National Laboratory, Richland, WA 99352, USA*
[3] *Quantum Science Center, Oak Ridge National Laboratory, Oak Ridge, TN, 37831, USA‡*
(Dated: January 18, 2023)

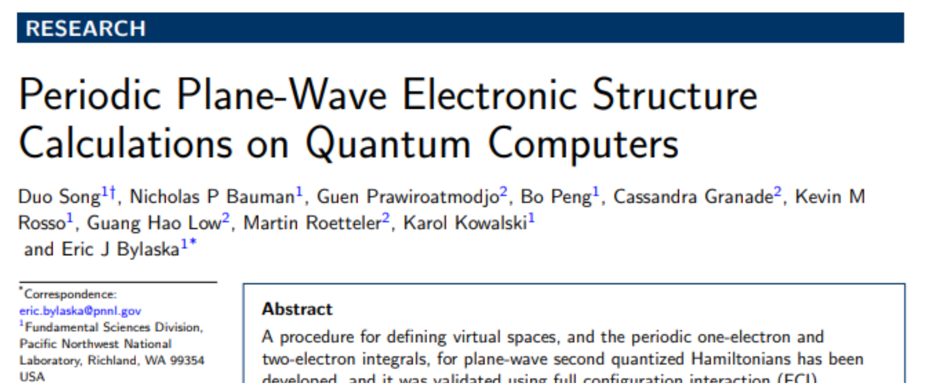
We present a use case of practical utility of quantum computing by employing a quantum computer n the investigation of the linear H_4 molecule as a simple model to comply with the requirements of singlet fission. We leverage a series of independent strategies to bring down the overall cost of he quantum computations, namely 1) tapering off qubits in order to reduce the size of the relevant Hilbert space; 2) measurement optimization via rotations to eigenbases shared by groups of ubit-wise commuting (QWC) Pauli strings; 3) parallel execution of multiple state preparation + neasurement operations, implementing quantum circuits onto all 20 qubits available in the Quantinuum H1-1 quantum hardware. We report results that satisfy the energetic prerequisites of singlet ission and which are in excellent agreement with the exact transition energies (for the chosen one-article basis), and much superior to classical methods deemed computationally tractable for singlet ission candidates.



14081v1 [quant-ph] 27 May 2022

Towards Quantum Gravity in the Lab on Quantum Processors

Illya Shapoval[1], Vincent Paul Su[2], Wibe de Jong[1], Miro Urbanek[1], and Brian Swingle[3]
[1]Lawrence Berkeley National Laboratory, 1 Cyclotron Rd, CA 94720, USA
[2]Center for Theoretical Physics and Department of Physics, University of California, Berkeley, CA 94720, U.S.A.
[3]Brandeis University, Waltham, MA 02453, USA



RESEARCH

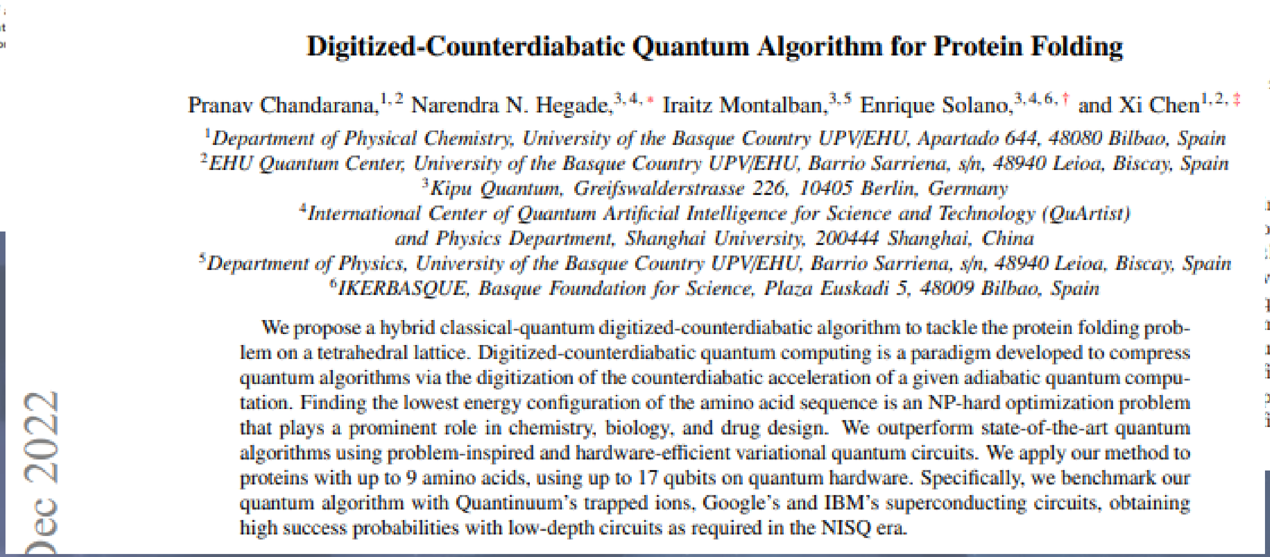
Periodic Plane-Wave Electronic Structure Calculations on Quantum Computers

Duo Song[1†], Nicholas P Bauman[1], Guen Prawiroatmodjo[2], Bo Peng[1], Cassandra Granade[2], Kevin M Rosso[1], Guang Hao Low[2], Martin Roetteler[2], Karol Kowalski[1] and Eric J Bylaska[1*]

*Correspondence: eric.bylaska@pnnl.gov
[1]Fundamental Sciences Division, Pacific Northwest National Laboratory, Richland, WA 99354 USA
Full list of
available at
†*Correspo

Abstract

A procedure for defining virtual spaces, and the periodic one-electron and two-electron integrals, for plane-wave second quantized Hamiltonians has been developed, and it was validated using full configuration interaction (FCI)



Digitized-Counterdiabatic Quantum Algorithm for Protein Folding

Pranav Chandarana,[1,2] Narendra N. Hegade,[3,4,*] Iraitz Montalban,[3,5] Enrique Solano,[3,4,6,†] and Xi Chen[1,2,‡]
[1]*Department of Physical Chemistry, University of the Basque Country UPV/EHU, Apartado 644, 48080 Bilbao, Spain*
[2]*EHU Quantum Center, University of the Basque Country UPV/EHU, Barrio Sarriena, s/n, 48940 Leioa, Biscay, Spain*
[3]*Kipu Quantum, Greifswalderstrasse 226, 10405 Berlin, Germany*
[4]*International Center of Quantum Artificial Intelligence for Science and Technology (QuArtist) and Physics Department, Shanghai University, 200444 Shanghai, China*
[5]*Department of Physics, University of the Basque Country UPV/EHU, Barrio Sarriena, s/n, 48940 Leioa, Biscay, Spain*
[6]*IKERBASQUE, Basque Foundation for Science, Plaza Euskadi 5, 48009 Bilbao, Spain*

We propose a hybrid classical-quantum digitized-counterdiabatic algorithm to tackle the protein folding problem on a tetrahedral lattice. Digitized-counterdiabatic quantum computing is a paradigm developed to compress quantum algorithms via the digitization of the counterdiabatic acceleration of a given adiabatic quantum computation. Finding the lowest energy configuration of the amino acid sequence is an NP-hard optimization problem that plays a prominent role in chemistry, biology, and drug design. We outperform state-of-the-art quantum algorithms using problem-inspired and hardware-efficient variational quantum circuits. We apply our method to proteins with up to 9 amino acids, using up to 17 qubits on quantum hardware. Specifically, we benchmark our quantum algorithm with Quantinuum's trapped ions, Google's and IBM's superconducting circuits, obtaining high success probabilities with low-depth circuits as required in the NISQ era.

Dec 2022

THANK YOU!

- Questions?