A QCCD trapped-ion quantum computer: the early days

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The quantum charge coupled device (QCCD) architecture is the foundational concept behind a scalable quantum computer based on mobile trapped-ions [1]. The architecture posits that by using ion transport, large-scale devices can be realized while maintaining the high-fidelity primitive operations achieved in ideal environments. The crucial technical ingredients include a scalable trap fabrication concept (Fig. 1), fine-grained control of the electromagnetic trapping fields to collect and isolate ions, the ability to remove mechanical energy from the system without disturbing stored quantum information, and localized regions used for quantum operations. Once these ingredients are combined, this system is fully-connected and can execute high-fidelity dynamic quantum circuits while minimizing any circuit overhead [2].

The Quantinuum system model H1 quantum computer is available to outside users through cloud access. In this talk, I'll present our latest internal benchmarking at both the individual component and the holistic levels. Component benchmarking includes variants of randomized benchmarking of single-qubit and two-qubit gate operations [2], mid-circuit measurements, and transport characterization. System level benchmarking includes crosstalk characterization of gates and mid-circuit measurements [3], quantum volume measurements [4](Fig. 2), and tests of chief algorithms such as quantum simulation [5] and quantum error correction [6].

Finally, I will report on recent advancements that should enable performance enhancements in future systems.

References

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[3] Gaebler, J. P., PRA, 104 (2021) 062440
[4] Baldwin, C.H., arXiv:2110.14808 (2021)
[5] Foss-Feig, M., PRL, 128 (2022) 150504
[6] Ryan-Anderson, C., PRX, 11 (2021) 041058

Figures

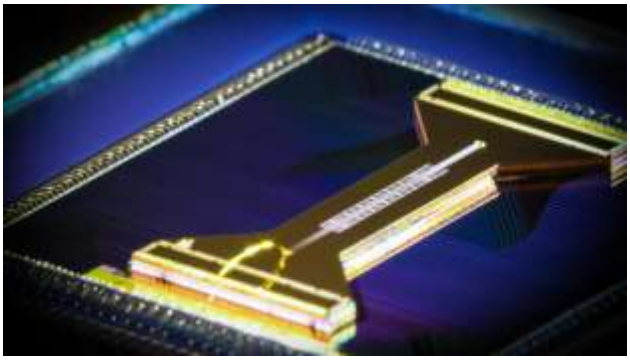

Figure 1: The trap fabricated by Honeywell that serves as the heart of Quantinuum's system model H1 quantum computer.

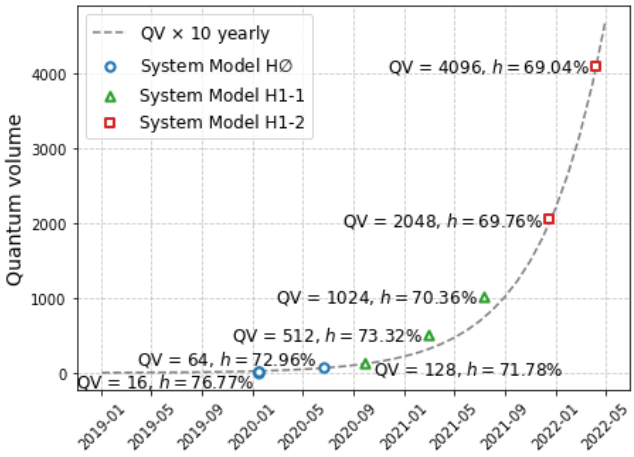

Figure 2: Quantum volume measurements on Quantinuum H-series quantum computers.