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Next-generation quantum computer system with long chains of trapped ions

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Trapped ions are a leading platform for quantum computers, with their high level of programmability and lack of idle decoherence mechanisms. Here, we present progress on building a state-of-the-art quantum computer with full control of up to 32 $^{171}Yb^{+}$ ion qubits on a Sandia Phoenix ion trap chip. We measure the heating rate as a function of trap axial frequency and manage sources of electric field noise that affect entangling fidelity. We measure a hyperfine qubit coherence time of >2 seconds, which is mainly limited by magnetic field noise from Helmholtz coils. We measure the chamber pressure to be $1.3(2)\times10^{-11}$ Torr from the switching of an ion in a weak double well potential. We use 355-nm individually addressed Raman beams to implement unitary rotations, and characterize SPAM errors and motional coherence from Raman operations. The hardware upgrades compared to previous systems should lead to better fidelity gates and expand the complexity of physics and quantum circuits that can be run on the quantum processor.

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