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Steps Toward Fault-Tolerant Quantum Computing with 2D and 3D Superconducting Qubits[1]

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Recent improvements in superconducting qubit coherence times, entangling gates, and measurement techniques have set the stage for high-fidelity demonstrations of multi-qubit operations needed for performing error correction in architectures such as the surface code. Using a planar network of transmon qubits and superconducting resonators, we benchmark a complete set of high-fidelity single- and two-qubit gates on a three-qubit sub-section of the surface code. Combining these gates with high-fidelity individual single-shot readouts, we deterministically entangle two non-nearest-neighbor qubits to implement a parity check operation, an essential component of surface code error correction. A complementary system consisting of three-dimensional cavities linked by individually placed transmon qubits provides an additional platform for the investigation of loss mechanisms and entangling schemes. Using this architecture, we demonstrate high-fidelity entanglement between arbitrary qubit pairs in a three-qubit, four-cavity network.

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