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A Cryogenic Muon Tagging System for Error Mitigation in Superconducting Qubits

Superconducting quantum bits (qubits) are sensitive to ionizing radiation, including γ -rays from environmental radioactivity and cosmic-ray muons. These interactions produce quasiparticle bursts in the substrate, causing decoherence and correlated errors across multiple qubits—posing a critical challenge for fault-tolerant quantum computing. While passive shielding can suppress most radioactive backgrounds, cosmic-ray muons require either modifications to chip design or active mitigation strategies to ensure reliable above-ground operation.

We present the development and experimental validation of a muon tagging system based on a three-layer stack of Kinetic Inductance Detectors (KIDs) operating at millikelvin temperature and designed for integration with superconducting quantum processors. The first prototype, developed within the ACE-SuperQ project, achieved a muon tagging efficiency of $\sim 90\%$ and measured a coincidence rate of $(193 \pm 7) \times 10^{-3}$ events per seconds, in agreement with Monte Carlo predictions.

By detecting coincident signals in the KID array surrounding the quantum device, the system enables identification of muon interactions and rejection of operations affected by radiation-induced errors. This hybrid detection and mitigation approach improves the reliability of quantum processors in surface-level environments and provides a promising path toward scalable and resilient quantum computing platforms.

Topic

Cryogenics and quantum sensors

Title

A Cryogenic Muon Tagging System for Error Mitigation in Superconducting Qubits

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