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Radiation Sensing with Superconducting Transmon Qubits

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Superconducting transmon qubits play a pivotal role in contemporary superconducting quantum computing systems. These nonlinear devices are typically composed of a Josephson junction shunted by a large capacitor and the bottom two energy eigenstates serve as qubits. When a qubit is placed in its excited state, it decays to its ground state with a relaxation timescale T_1. However, recent studies have suggested that cosmic rays or ambient gamma radiation could significantly degrade the relaxation times of transmon qubits, leading to detrimental correlated errors that impede quantum error correction processes [1,2]. In this study, we explore the potential of utilizing transmon qubits as radiation detectors by investigating the impact of radioactivity on transmons fabricated at the Superconducting Quantum Materials and Systems (SQMS) center, Fermilab. We develop a fast detection protocol based on rapid projective measurements and active reset to perform detection with milli-second time resolution. We utilize the underground facility at INFN-Gran Sasso and controlled radioactive sources (such as Thorium) to validate our scheme. Additionally, we investigate the possibility of enhancing detection efficiency by evaluating transmons fabricated with various superconducting materials and improved signal analysis schemes.

[1] Matt McEwen et al., Nature Physics18, 107–111 (2022)
[2] C.D. Wilen et al., Nature 594, 369–373 (2021)

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Plenary (Invited talks only)

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