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Superconducting Qubits as Particle Detectors

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Recent years have seen growing concerns in the scientific community about the sensitivity of superconducting qubits to ionizing radiation. Particle interactions in the chip substrate produce phonons that reach the superconductor and break Cooper pairs, producing quasiparticles that can cause a drop in the decay time of the qubit.
Previous studies have already proven that radioactivity affect the performance of superconducting quantum circuits [1], will be a limit for the energy-relaxation time of next-generation qubits [2] and induce correlated errors in multi-qubit chips that could make present-day error correction algorithms fail [3, 4].
Despite being a concern for quantum computing experiments, the sensitivity of superconducting qubits to radioactivity is also an opportunity for the development of a novel particle detector. I will present the research activity carried out at the Gran Sasso National Laboratory (LNGS), Italy, where for the first time a superconducting qubit has been used for the detection of MeV-scale gamma particles [5]. To better disentangle ionizing radiation from other decay mechanisms, measurements were done in a deep-underground facility in the Hall C of LNGS underground laboratory. The facility is surrounded by 1.4 km of rock that acts as a natural shield for cosmic rays, and we implemented a lead and copper shield for suppressing the flux of environmental gammas. This configuration allowed us to characterize the qubit in an unprecedented low-radioactivity environment. We then exposed the qubit to Th sources with different activities and compared the results.
We observed that when the qubit was exposed to the Th sources, sudden increases in their decay rate would occur. Each of these events lasted a few milliseconds, and their rate increased linearly with the activity of the sources, confirming that they are radiation-induced.

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