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Simulation of radiation impact on qubits operated deep underground at SNOLAB

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Quantum technologies based on solid-state devices attract a growing interest in both academic and industrial research, which is why understanding their performance limitations and finding effective mitigation strategies is a key priority. Even though quantum coherence times of superconducting circuits have increased from nanoseconds to tens and hundreds of microseconds, further improvements are needed to reduce the hardware overhead of conventional quantum error correction schemes.

On a fundamental level, reaching this goal requires reducing the density of broken Cooper pairs (so-called quasiparticles) in the circuitry. One hypothesized source of non-equilibrium quasiparticles are interactions of ionizing radiation with the substrate of solid-state devices arising from environmental radioactivity and cosmic rays. A new collaboration between researchers from the Institute for Quantum Computing (IQC) at the University of Waterloo, the Sudbury Neutrino Observatory Laboratory (SNOLAB), Ontario, and Chalmers University of Technology in Sweden has been formed to investigate the impact of ionizing radiation and cosmic rays on quantum technologies. The goal is to perform an advanced characterization of superconducting transmon qubits by operating them deep underground in SNOLAB’s Cryogenic Underground TEst facility (CUTE) – coined the QUTEbits project.

This talk will briefly introduce the QUTEbits project at SNOLAB and summarize simulation studies performed with GEANT4 to characterize the expected backgrounds at CUTE. Additionally, first results of using the G4CMP condensed matter physics extension to GEANT4 will be shown to help evaluate the impact of radiation on qubit decoherence.

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Keyword-3

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