Accelerating cryogenic testing and characterization of quantum materials and devices with fast and easy-to-use cryostats

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The wide-scale application of quantum computing demands significant advancements in qubit performance, including reduced error rates, extended coherence times, and enhanced gate fidelity. Achieving these goals requires extensive testing and characterization of quantum materials, devices, and fabrication techniques at ultra-low temperatures (mK range). However, traditional cryogenic solutions are slow and costly, due to long cooldown times, reliance on specialized operators, and dependence on helium-3, an increasingly scarce and costly resource.

We present novel cryostats[1] developed for the characterization and operation of quantum materials and devices at sub-Kelvin temperatures, based on adiabatic demagnetization refrigeration. We describe how continuous sub-Kelvin cooling and wide-range temperature control can be achieved by combining multiple ADR units and mechanical thermal switches.

We also present a novel sample loader mechanism[2] that allows cooling samples from room temperature to below 100 mK in less than 3 hours, in a fully automated way. Finally, we show how this novel cryostat can be used to study low-temperature characteristics of superconducting films, resonators, and even qubits, with extremely fast turnaround time, allowing multiple measurement runs per day.

[1] Regnat et al. (2018) Cryogen-free cooling apparatus (EP 3163222). European Patent Office.
[2] Spallek et al. (2022) System and method for inserting a sample into a chamber (EP 3632560). European Patent Office.

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Figures

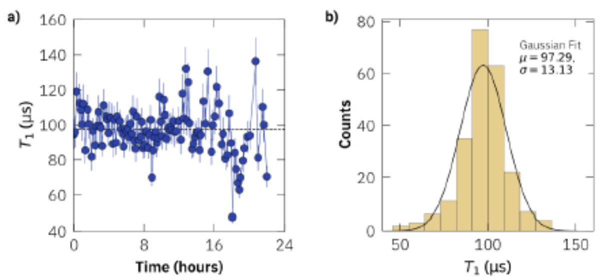

Figure 1: Long-term study of *T1* for a transmon qubit in a kiutra L-Type Rapid (LTR).
a) *T1* measurements as a function of time.
b) Histogram of the *T1* measurements. The data shows a gaussian distribution around an average *T1* of 94 μs.