

Research paper

Advancing magnetic cooling for applied quantum technologies

Modern quantum technologies rely on cryogenic infrastructure, with many leading platforms requiring millikelvin temperatures. Today, these temperatures are almost exclusively generated using dilution refrigeration, which depends on the scarce and costly isotope helium-3. This reliance presents a challenge for the scalability and long-term sustainability of cryogenic systems needed for industrial quantum technologies. Alternative approaches that enable millikelvin cooling without helium-3 are therefore becoming increasingly important.

One such approach is adiabatic demagnetization refrigeration (ADR) – a magnetic cooling technology traditionally used in scientific instruments and detector applications. At kiutra, ADR has been advanced into a continuous cooling method (cADR) capable of delivering uninterrupted cooling in the millikelvin regime. Building on years of research, kiutra has developed the key technologies and components required for practical ADR-based cooling systems.

In a recent collaboration with Delft Circuits, we developed and built a compact cADR demonstrator integrating magnetic cooling with superconducting flexible RF wiring in a single rack-mounted platform. The system combines a four-stage continuous ADR with thermally optimized RF wiring and a radiation-shielded sample environment designed for superconducting quantum hardware. The demonstrator shows that kiutra's cADR technology can achieve millikelvin temperatures, continuous cooling power, and application-ready wiring configurations suitable for emerging quantum systems. These results demonstrate the feasibility of magnetic cooling platforms for small-scale quantum computing, sensing, and communication systems.

Full technical details of the demonstrator, including system layout, thermal modeling, and experimental performance, are presented in our recent publication: Schüßler et al., *Review of Scientific Instruments*, 97, 025214 (2026).

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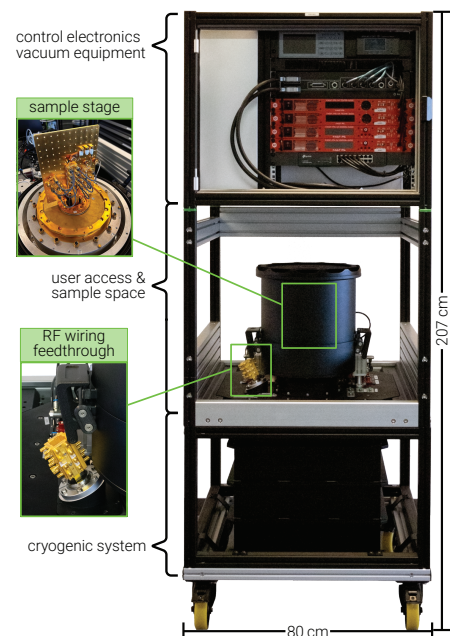


Figure 1: Photograph of the complete cryogenic system. All components are integrated into a single rack measuring 80 cm x 80 cm x 207 cm.

Beyond demonstrating feasibility, this work establishes the technological foundation for the next generation of magnetic cryogenic systems. Building on the results of the demonstrator, kiutra is developing the X-Type – the new modular cooling architecture designed for significantly higher cooling power and lower base temperatures, enabling an expandable cryogenic infrastructure for growing quantum systems.

