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Quantum Technologies in High Energy Physics. The CERN Quantum Technology Initiative input to the European Strategy for Particle Physics

Quantum technology has the potential to revolutionize High Energy Physics (HEP), thanks to its disruptive nature. Quantum hardware could be employed to conceive novel detector technologies. Quantum software could speed up computing-demanding tasks in the next or next-to-next generation of particle physics experiments. Several national initiatives, across CERN Member States and beyond, are investigating various directions on R&D, coordinated through initiatives such as QC4HEP and DRD5.

The CERN Quantum Technology Initiative (QTI) has played a crucial role in consolidating quantum-related activities, serving as a European hub as well as carrying out its own R&D projects. Launched in 2020, QTI focuses on three main areas: hybrid quantum computing, quantum sensing, and quantum communication. These efforts aim to enhance the practical applicability of quantum technologies in HEP, fostering innovation and cross-disciplinary collaboration.

This document reviews the achievements of CERN QTI, highlighting its role in developing quantum algorithms, exploring novel detector technologies and fostering international collaborations. It provides a series of concrete recommendation to the European Strategy for Particle Physics group, advocating for a long-term investment in quantum technologies.

The recommendations are grounded in the lessons learned from QTI's initial phases, emphasizing the importance of realistic expectations, interdisciplinary collaboration, and the integration of quantum technologies in existing research frameworks. By aligning with the priorities of the HEP community and leveraging CERN's unique position, QTI is ideally situated to drive the next generation advancements of quantum technologies for HEP.

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