CERN QTI

CERN openlab Technical Workshop 2022

Overview

QUANTUM TECHNOLOGY INITIATIVE

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CERN QTI Coordinator

1st CERN Quantum in HEP Workshop

- CERN openlab organized a kick-off event of its Quantum Computing initiative on **November 5th-6th , 2018**
  - https://indico.cern.ch/event/719844/
  - > 400 registered participants from the HEP physics community, companies and worldwide research laboratories and beyond
- Goals:
  - Create a database of QC projects to foster **collaborations** between interested **user groups, CERN openlab and industry**
  - Continue to seek **opportunities** to support QC projects
  - **Investigating ways of scaling up the QC activities**

The CERN Quantum Technology Initiative: Year 1

- The **QTI** was approved in September 2020, started in January 2021 and has now completed its first year of activities
- There were four main milestones to be achieved in year 1

✓ **Setting up the initiative and its governance**
- Coordination Task Force
- Advisory Board
- Web site, comms channels, branding, awareness

✓ **Projects and PhD programme**
- Research programme as part of CERN DOCT programme
- Research collaborations with institutes in the Member States and beyond (17 ongoing projects)

✓ **Infrastructure**
- Local **classic cluster** for quantum computing simulations, a **dedicated simulator**, and access to **quantum hardware** from different providers

✓ **Strategy and Roadmap**
- The Strategy and Roadmap has been formalized and discussed with the CERN community, the Advisory Board and experts from the HEP/quantum communities, **published in September 2021**

CERN QTI Strategy and Roadmap

The Strategy and Roadmap document has been published in September 2021 after a process of iterative consultations with CERN members, researchers in the HEP community, quantum technology experts and the QTI Advisory Board. The version publicly available in the Zenodo repository has been accessed more than 5,600 times

T1 - Scientific and Technical Development and Capacity Building

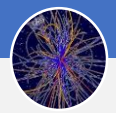
T3 - Community Building

T2 - Co-development

T4 - Integration with national and international initiatives and programmes

https://doi.org/10.5281/zenodo.5553774

Scientific Objectives



- Assess the **areas of potential quantum advantage** in HEP applications (QML, classification, anomaly detection, tracking)
- Develop **common libraries of algorithms, methods, tools**; benchmark as technology evolves
- Collaborate to the development of shared, **hybrid classic-quantum infrastructures**

Computing & Algorithms

- Identify and develop techniques for **quantum simulation** in collider physics, QCD, cosmology within and beyond the SM
- Co-develop quantum and sensing approaches by providing **theoretical foundations** to the identifications of the areas of interest

Simulation & Theory

CERN openlab

- Develop and promote **expertise in quantum sensing** in low- and high-energy physics applications
- Develop quantum sensing approaches [illegible] **particle physics measurements**
- Assess **novel technologies and materials** for HEP applications

Sensing, Metrology & Materials

- **Co-develop CERN technologies relevant to quantum infrastructures** (time synch, frequency distribution, lasers)
- Contribute to the **deployment and validation of quantum infrastructures**
- Assess requirements and **impact of quantum communication on computing applications** (security, privacy)

Communications & Networks

Research Collaborations (various stages of maturity)

Organizations and Projects

Industry

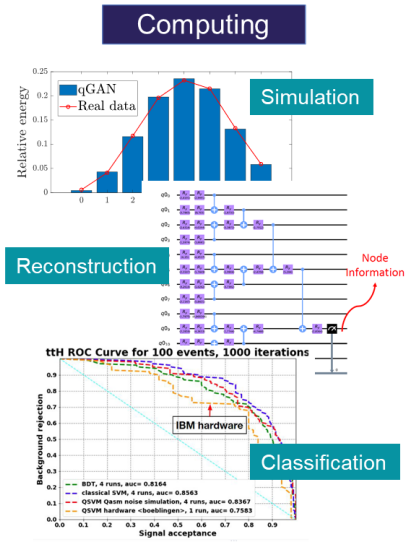
IBM Q-Net

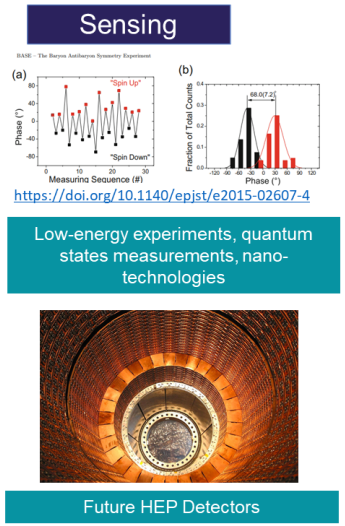
Xanadu

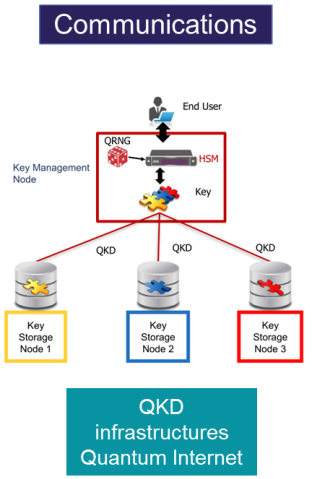
Academia, Research Labs and Agencies

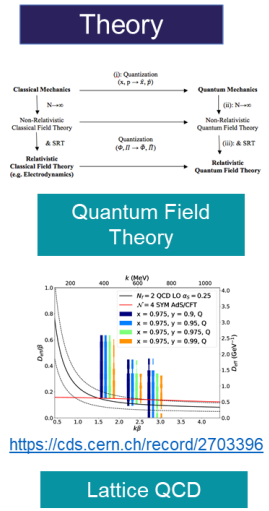
Scientific Production

- **More than 20 projects in all four quantum areas**
- **18 papers**
  - 8 on peer-reviewed journals
- **More than 20 talks and presentations at conferences and workshops**

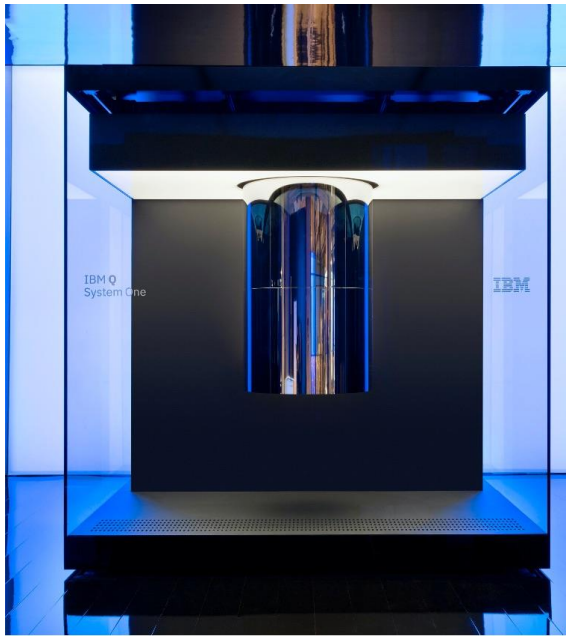








Quantum Computing Infrastructure and the Quantum Hub



A quantum computing simulation cluster with different simulators is available for initial investigations up to 20 qubits

A collaboration with Intel, TUM and the Munich Leibniz centre is being set up to investigate applications of quantum simulation on HPC

CERN has acquired an Atos QLM 34 simulation appliance for projects requiring more than 30 qubits

CERN is a Hub Member of the IBM Quantum Network with quota access to all IBM quantum computers up to the recently released 127-qubit system

Collaborations with cloud providers for access to different quantum hardware are being discussed

All hardware is available to projects proposed by CERN researchers

Quantum technology is an emerging field of physics and engineering that have the potential to revolutionise science and society in the next five to ten years. Knowledge in this rapidly evolving field has advanced considerably, yet still there are resources required that are not a mainstream today.

CERN can be at the forefront of this revolution. Given the broad range of specialised technical expertise found at CERN, the Laboratory is in a unique position today to take a leading role in the development of quantum technologies not only for its own programmes, but also as a general contribution to the advancement of science and technology.

The CERN Quantum Technology Initiative (QTI) will define a three-year roadmap and research programme in collaboration with the HEP and quantum-technology research communities. Together, we will establish joint research, educational and training activities, set up the supporting computing infrastructure, and provide dedicated mechanisms for exchange of both knowledge and technology.

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