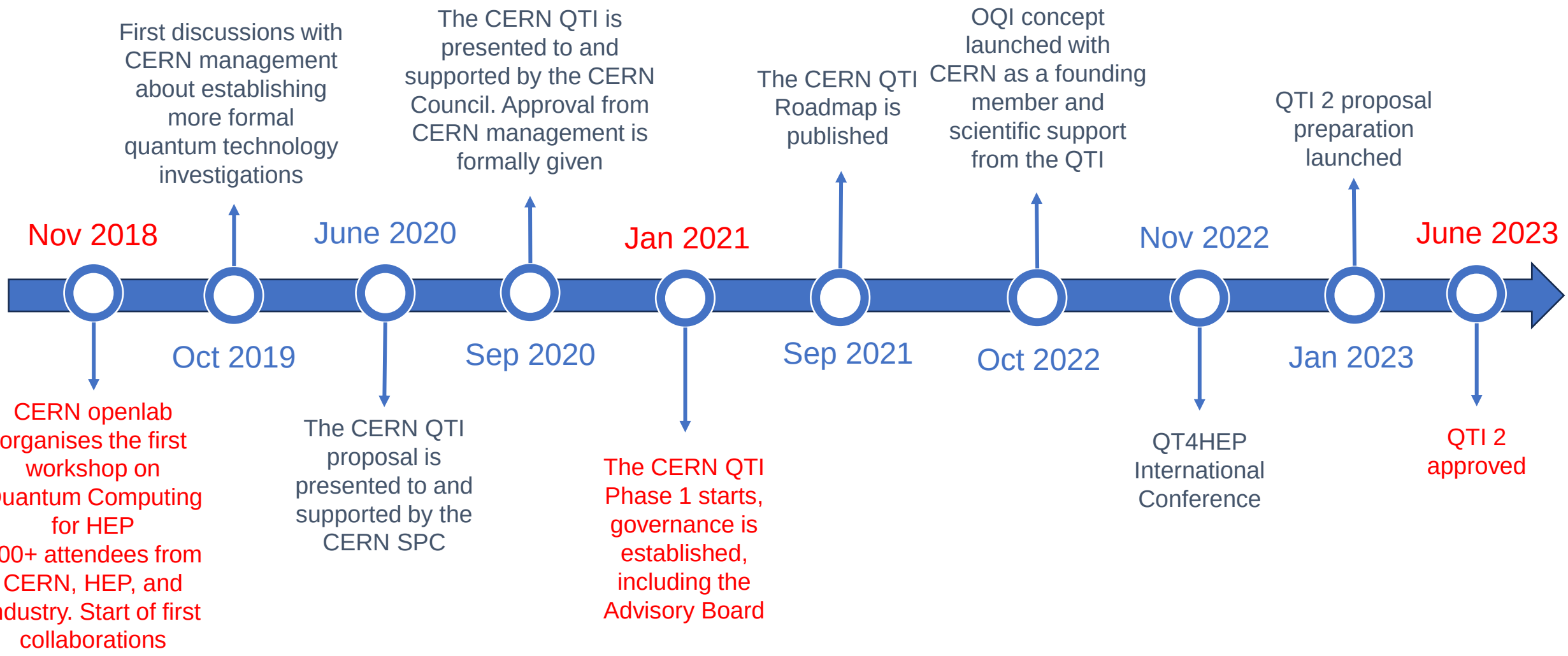
Welcome to QTML

from the CERN QTI

Alberto Di Meglio
CERN QTI Phase 1 Coordinator

CERN | QUANTUM TECHNOLOGY INITIATIVE

CERN and Quantum Technologies



CERN QTI Phase 1

Main objectives

- **Identify** areas of knowledge and technology where CERN can make an impact on the development of quantum technologies
- Conduct a scientific **investigation** of the potential impact of quantum technology on CERN and related physics programmes implemented as a set of joint projects
- **Align and collaborate** with quantum initiatives in the CERN Member States to support the development of quantum capacity
- **Facilitate** the collaboration across the HEP community and between HEP and quantum technology experts outside HEP

CERN QTI Strategy and Roadmap

Developed at the beginning of the QTI Phase 1 with the CERN community and international experts. Reviewed and endorsed by the QTI AB Members and announced at the SPC and Council in September 2021. Formally published in September 2021 (https://zenodo.org/record/5846455#.ZFEwU4JBy4Q)

Four main high-level objectives covering science, technology, and collaboration, with detailed sub-goals

T1 - Scientific and Technical Development and Capacity Building

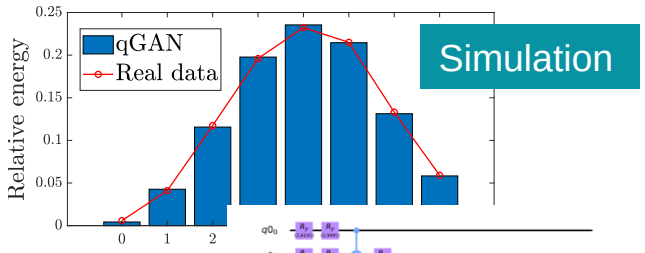
T3 - Community Building

T2 - Co-development

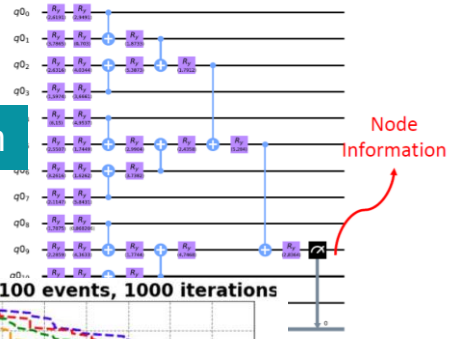
T4 - Integration with national and international initiatives and programmes

R&D Interests

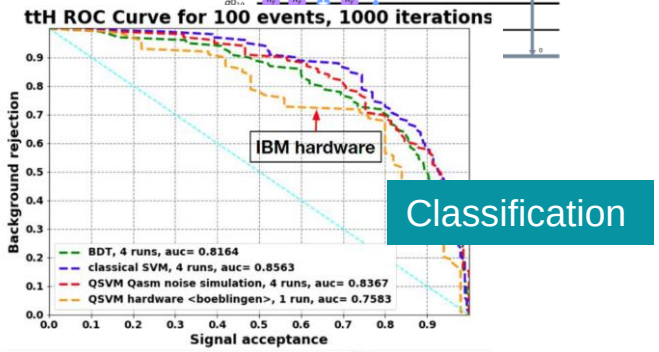
Computing



Simulation

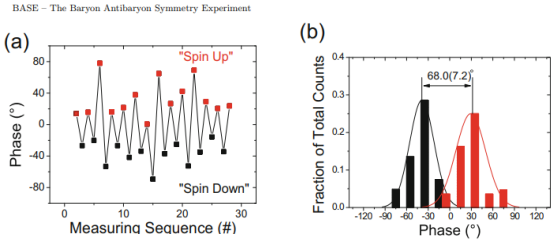


Reconstruction



Classification

Sensing

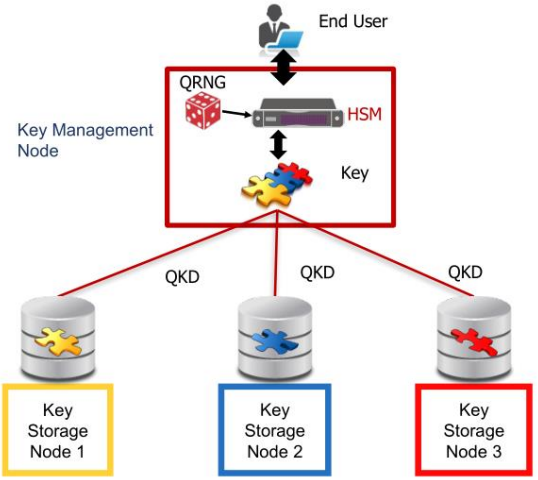


https://doi.org/10.1140/epjst/e2015-02607-4

Low-energy experiments, quantum states measurements, nano-technologies

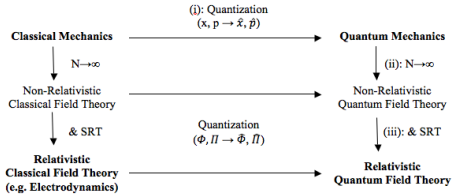
Future HEP Detectors

Communications

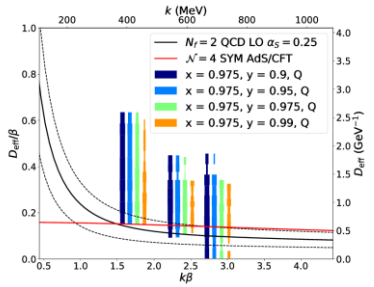


QKD infrastructures Quantum Internet

Theory



Quantum Field Theory

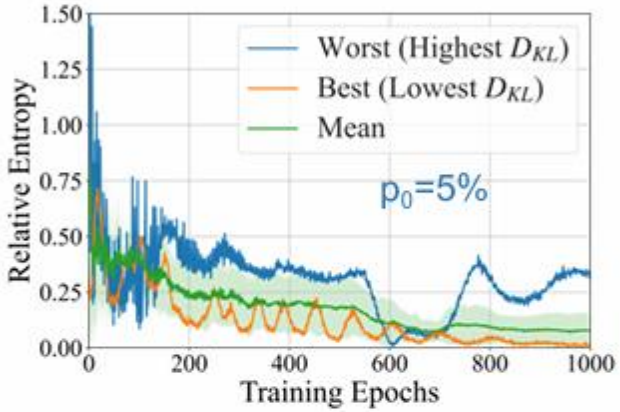


https://cds.cern.ch/record/2703396

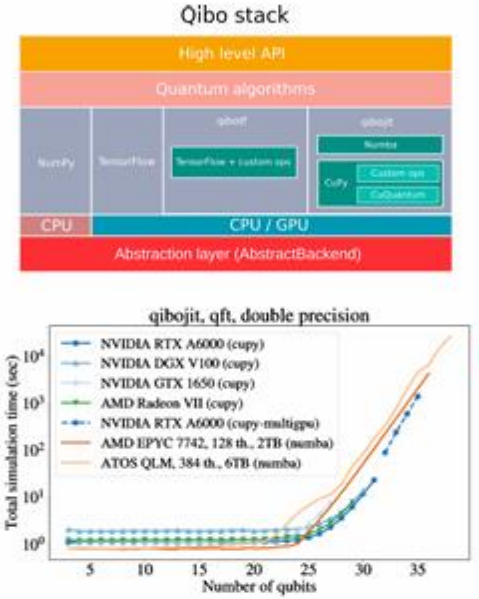
Lattice QCD

QC @ CERN

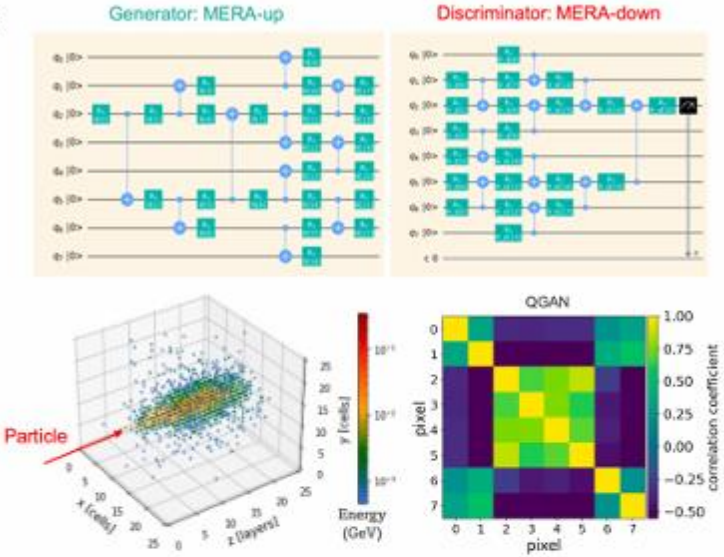
Borras, Kerstin, et al. "**Impact of quantum noise on the training of quantum Generative Adversarial Networks.**" *arXiv preprint arXiv:2203.01007* (2022).



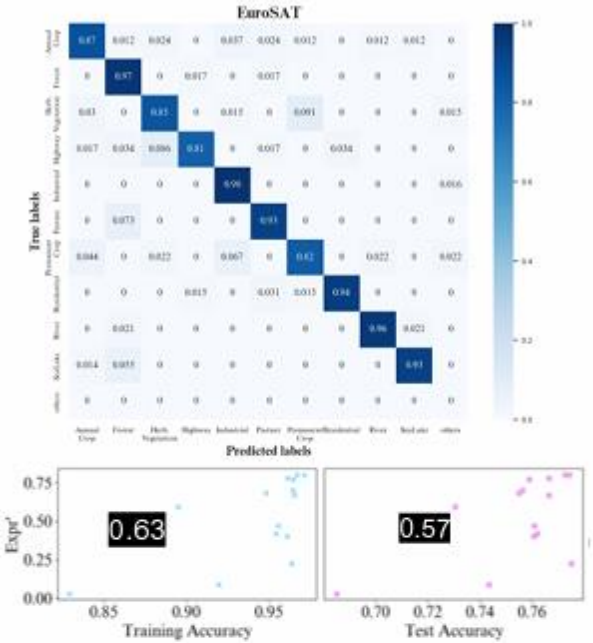
E.Stavros et all., **Quantum simulation with just-in-time compilation,** Quantum 2022



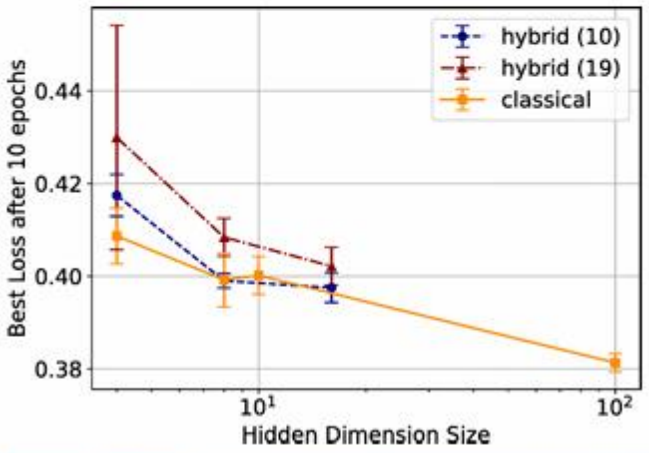
F.Rehm, **Full Quantum GAN Model for HEP Detector Simulations,** ACAT22



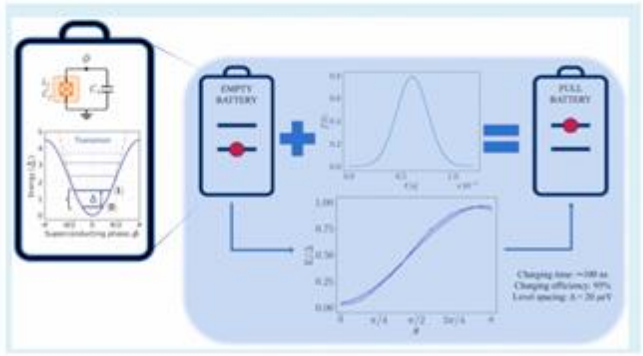
S.Chang, et all, **Hybrid Quantum-Classical Networks for Reconstruction and Classification of Earth Observation Images,** ACAT22



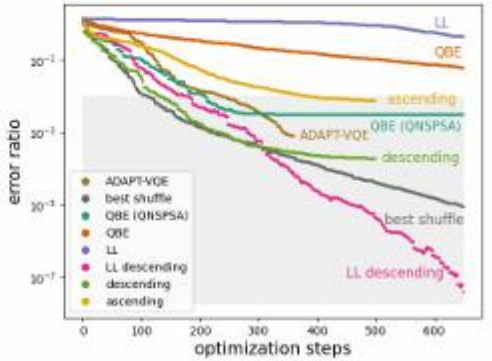
Tüysüz, Cenk, et al. "**Hybrid quantum classical graph neural networks for particle track reconstruction.**" *Quantum Machine Intelligence* 3.2 (2021): 1-20.



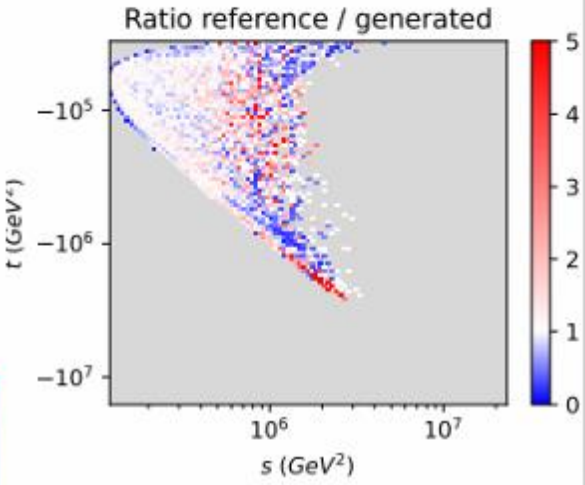
G. Gemme, M. Grossi et al, **IBM Quantum Platforms: A Quantum Battery Perspective**, *Batteries* ***8****, 43 (2022)*



O. Kiss, **Quantum computing of the 6Li nucleus via ordered unitary coupled cluster,** 10.1103/PhysRevC.106.034325



Bravo-Prieto, Carlos, et al. "**Style-based quantum generative adversarial networks for Monte Carlo events.**" *Quantum 2022*



QT4HEP Conference

RESEARCH

Quantum Computing for High-Energy Physics State of the Art and Challenges Summary of the QC4HEP Working Group

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Abstract

Quantum computers offer a fascinating path for a paradigmatic change of computing in the natural sciences and beyond, with the potential of achieving a so-called quantum advantage, namely a significant (in same cases exponential) speed-up of numerical simulations. The rapid development of hardware devices with various realizations of qubits allows already now to execute small scale but representative applications on quantum computers. In particular, the High Energy Physics community plays a pivotal role in accessing the power of quantum computing, since the field is a driving source for challenging computational problem. This concerns, on the theoretical side, the exploration of models which are very hard or even impossible to address with classical techniques and, on the experimental side, the enormous data challenge of newly emerging experiments,

Successful QT4HEP Conference in November 2022, more than 250 attendees. A **working group on Quantum Computing for HEP has been formed** with participation from HEP Institutes in EU, US, Japan and other countries showing the impact that CERN is having in the field via the QTI activities.

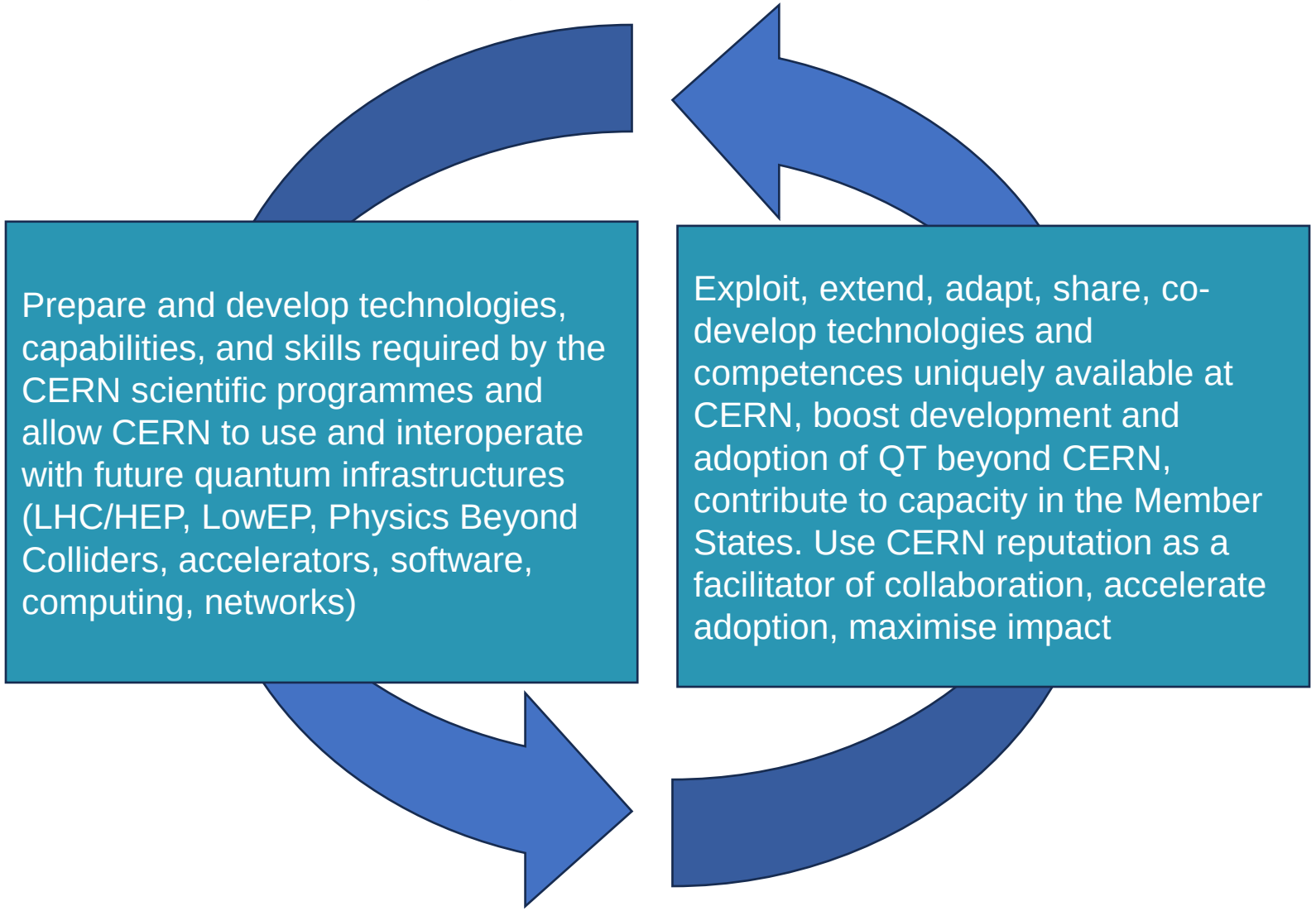
A joint paper across the HEP community published in Spring 2023. 48 contributors from HEP institutes in EU, US, and Japan

https://arxiv.org/abs/2307.03236

Why CERN should engage in Quantum Technologies?

QT4HEP

Can CERN stay out of quantum technologies?



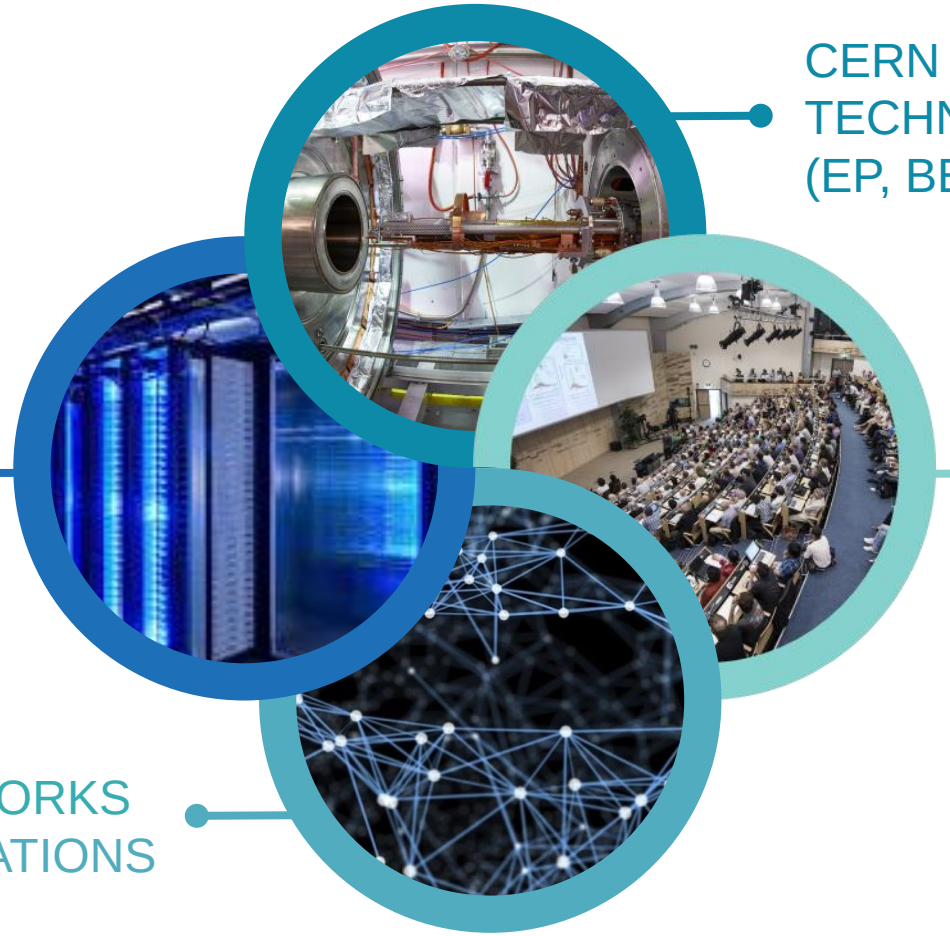
HEP4QT

How can CERN contribute to quantum technologies?

CERN QTI Phase 2 – 4 Centres of Competence

CERN QUANTUM TECHNOLOGY PLATFORMS (EP, BE, TE, SY)

HYBRID QUANTUM COMPUTING AND ALGORITHMS (**IT**, TH, EP)



COLLABORATION FOR IMPACT (**IT**, IPT, IR)

QUANTUM NETWORKS AND COMMUNICATIONS (**IT**, BE)

CERN | QUANTUM TECHNOLOGY INITIATIVE

An initiative hosted by CERN, born at GESDA, supported by UBS

THE OPEN QUANTUM INSTITUTE

https://oqi.gesda.global

gesda

Use the future to build the present

The Open Quantum Institute

What is it and what does it propose?

gesda
GESDA Initiatives
27Oct2023

The Open Quantum Institute (OQI) seeks to inclusively unleash the powers of **quantum computing** to ensure that the whole world contributes to and benefits from quantum computing.

The OQI has four core objectives, which we call the "4A's"

ACCELERATING APPLICATIONS FOR HUMANITY

Realising the full potential of quantum computing by accelerating the use cases geared towards achieving the SDGs, thanks to the combined forces of researchers and developers, entrepreneurs, the United Nations, and large NGOs.

ACCESS FOR ALL

Providing global, inclusive and equitable access to a pool of public and private quantum computers and simulators available via the cloud.

ADVANCING CAPACITY BUILDING

Developing educational tools to enable everyone around the world to contribute to the development of quantum computing and make the most of the technology.

ACTIVATING MULTILATERAL GOVERNANCE FOR THE SDGS

Providing a neutral forum to help shape multilateral governance of quantum computing for the SDGs.

The OQI has the potential to be the first truly multilateral effort to accelerate applications of quantum computing for the SDGs.

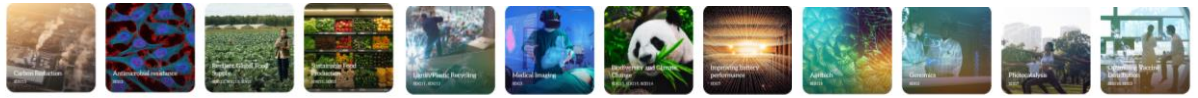
The Open Quantum Institute

SDG Use Cases for Quantum – bridging science and diplomacy stakeholders

gesda
GESDA Initiatives
27Oct2023

→ articulation of SDG use cases
→ real-world implementation
→ scientific review

→ E.g.: Food production, Anti-microbial resistance and carbon reduction. More at https://oqi.gesda.global/applications/



Bespoke methodology

Phase 0 Themes	Phase 01 Outline	Phase 02 Full Proposal	Phase 03 Proof of Concept/ Simulation	Phase 04 Proof of Concept/ Quantum Processor	Phase 05 Real World Implementation
Submit themes for SDG use cases	Outline the project 3-5 pages (Letter of Intent/Abstract)	Describe the methodology to develop quantum algorithm	Develop proof of concept implemented on quantum simulator	Develop proof of concept implemented on quantum processor	

Partners

Permanent representations in Geneva that have participated in the informal discussions on multilateral governance of quantum computing are: Australia, Austria, Brazil, Chile, Czech Republic, Egypt, France, India, Israel, Italy, Japan, Malta, Mexico, Morocco, the Netherlands, Pakistan, Singapore, Slovenia, Switzerland, the United Kingdom, and the United States.

Intergovernmental Organizations and NGOs have been actively helping in defining possible Quantum for SDG use cases.

CERN and the QTML 2023

We believe that Quantum Computing and Quantum Technologies in Machine Learning will have a disruptive effect on science and research in the years to come

However, the road ahead is still steep and largely unchartered

Collaboration across disciplines and events like the QTML are the most effective ways of accelerating discoveries and applications and CERN is proud to host this year event and promote the work done by a very committed and enthusiastic community

Thanks for your contributions and enjoy the event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