

Quantum Computing at CERN



QUANTUM
TECHNOLOGY
INITIATIVE

Sofia Vallecorsa

AI & Quantum Research - CERN IT

The CERN Quantum Technology Initiative

CERN established the QTI in 2020

- Roadmap in 2021
- Publicly available on Zenodo

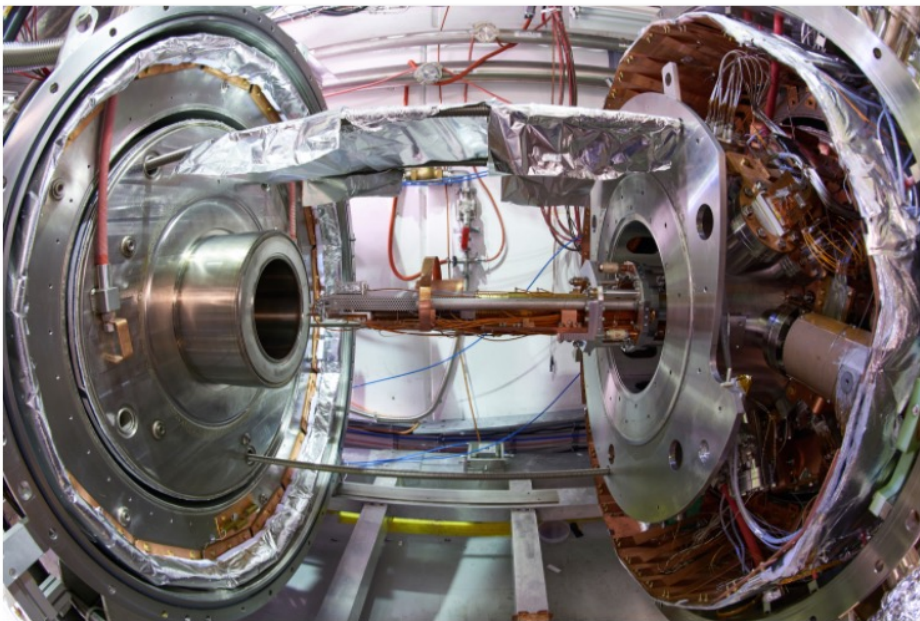
<https://doi.org/10.5281/zenodo.5553774>

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CERN meets quantum technology

The CERN Quantum Technology Initiative will explore the potential of devices harnessing perplexing quantum phenomena such as entanglement to enrich and expand its challenging research programme

30 SEPTEMBER, 2020 | By Matthew Chalmers



The AEGIS 1T antimatter trap stack. CERN's AEGIS experiment is able to explore the multi-particle entangled nature of photons from positronium annihilation, and is one of several examples of existing CERN research with relevance to quantum technologies. (Image: CERN)

T1 - Scientific and Technical Development and Capacity Building

T2 - Co-development



T3 - Community Building

T4 - Integration with national and international initiatives and programmes

Scientific Objectives



- Assess the **areas of potential quantum advantage** in HEP (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 computing and sensing approaches by providing **theoretical foundations** to the identifications of the areas of interest

Simulation & Theory



- Develop and promote **expertise in quantum sensing** in low- and high-energy physics applications
- Develop quantum sensing approaches with emphasis on **low-energy 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

Quantum Computing Objectives at CERN



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Computing & Algorithms

Set baseline for **prioritisation** and **systematisation**

- **Quantum Machine Learning**
 - Relatively loose definition
 - Variational approach / Robustness to noise
- **Algorithms beyond QML**

Formal approach to algorithms, methods, error characterisation and correction

Test different hardware

- Semi-conductors, ions, ... (IBM, Rigetti, IonQ,...)
- Photonic (Xanadu), Annealer (D-Wave)
- Quantum-inspired (Fujitsu digital, Toshiba SBM)

International Conference on Quantum Technologies for High-Energy Physics (QT4HEP22)

1–4 Nov 2022

CERN

Europe/Zurich timezone

There is a [live webcast](#) for this event.



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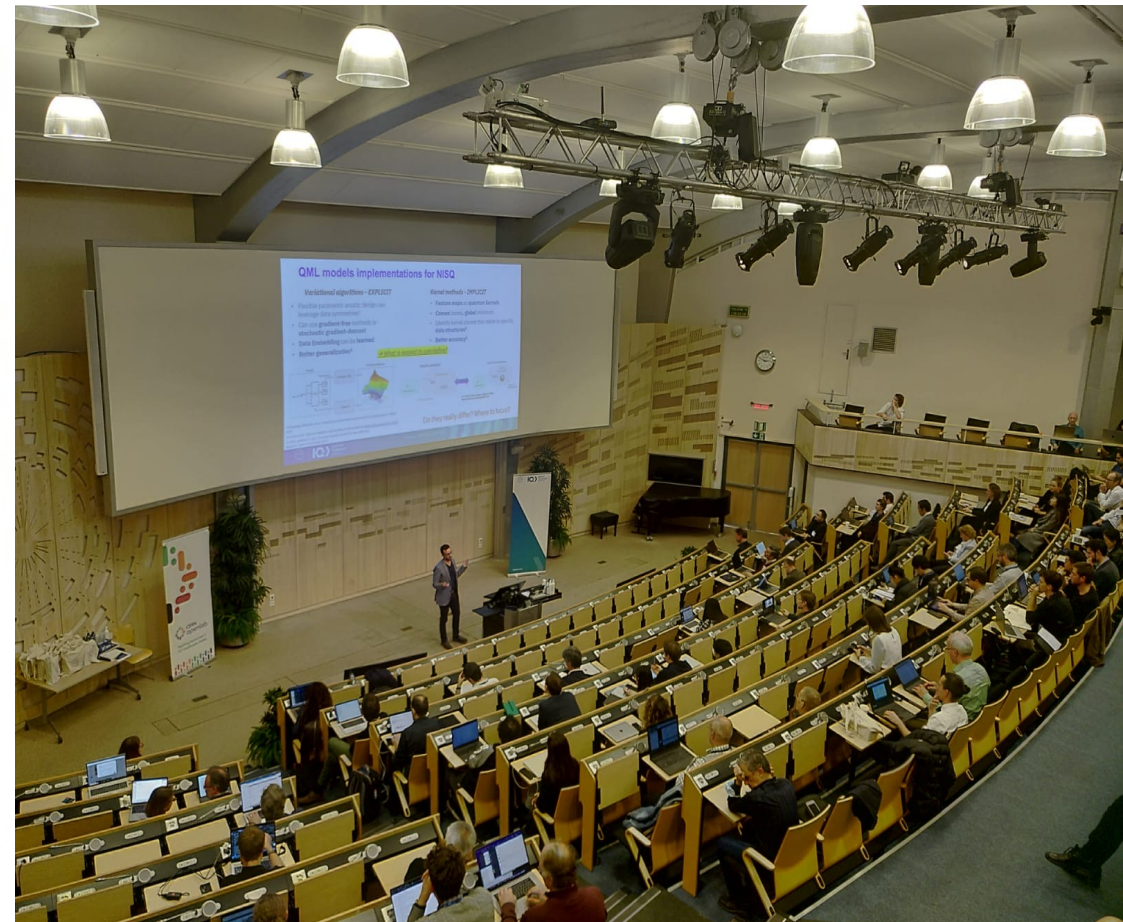
✉ QT4HEP-conference@c...



Registration deadline extended until Friday, 28 October for the International Conference on Quantum Technology for High-Energy Physics, which will be hosted at CERN on 1–4 November 2022.

Following [CERN's successful workshop on quantum computing in 2018](#), this is the first edition of the #QT4HEP conference taking place to further investigate the nascent quantum technology and its great promise to support scientific research.

Bringing the whole community together, we aim to foster common activities and knowledge sharing, discuss the recent developments in the quantum science field and keep looking for activities within HEP — and beyond — that can most benefit from the application of quantum technologies.



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Collaboration ecosystem

Organizations and Projects



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FLAGSHIP



QuantHEP



esa



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IBM

Cambridge
Quantum
Computing

Industry

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intel

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Academia, Research Labs and Agencies



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The ESA-CERN Cooperation Agreement

- ESA and CERN have in place a Collaboration Agreement since 2014 to explore common technologies and interests, such as hardware radiation hardening for particle detectors and spacecraft instruments
- Experiments like CLOUD are bridging the communities
- Cold Atom Technologies (CAT) are proposed as promising solutions for the Voyage 2050 programme
- **A collaboration on Artificial Intelligence and Quantum Computing has started in 2020**
- An initial programme of co-funded PhD-level research is in place since January 2021