Welcome to the conference

Quantum Technology for High-Energy Physics 2022

Alberto Di Meglio
Head of Innovation – IT Department Coordinator CERN QTI
CERN openlab organised a kick-off event of its Quantum Computing initiative on **November 5th-6th, 2018**

- [https://indico.cern.ch/event/719844/](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**

**This event was a first step into the investigation of Quantum Technologies, from there we started looking more broadly at how CERN could contribute to the development and use of technologies**
HEP Experiments Computing Workloads

Data Acquisition

Track Reconstruction

Data Analysis

Simulation

Multi-step iterative Kalman filter approach

Space point formation

Seed finding

Track finding

Ambiguity Solving

TRT Extension
Low-Energy Experiments

Antiproton Trap compares protons with their antimatter equivalents.

CERN Axion Solar Telescope search for hypothetical “axions”, proposed to explain why there is a subtle difference between matter and antimatter.

Atomic Spectroscopy And Collisions Using Slow Antiprotons studies the fundamental symmetries between matter and antimatter by precision spectroscopy of atoms containing an antiproton.

CERN Neutrino Platform
CERN's undertaking to foster and contribute to fundamental research in neutrino physics at particle accelerators worldwide.

ALPHA (successor of ATHENA) makes, captures and studies atoms of antihydrogen and compares these with hydrogen atoms.

Antihydrogen Experiment: Gravity, Interferometry, Spectroscopy (AEGIS) direct measurement of the Earth's gravitational acceleration, $g$, on antihydrogen.

ALPHA

CERN Neutrino Platform

1 November 2022
Welcome - QT4HEP22
Quantum Theory and Simulation

- **pQCD and Standard Model** — collider physics, parton showers, theory input for precision electroweak, interpretation of data from collision experiments
- **Heavy Ion** — effective descriptions of quark gluon plasma, jets in heavy ion collisions, hydrodynamics of strongly coupled systems
- **Lattice** — theory inputs for nuclear and particle physics, first principle calculations of the low energy aspects of QCD, lattice as a formal tool for understanding QFT
- **Cosmo/AstroParticle** — properties and evolution of the early universe, large scale structure, dark sectors, neutrinos, gravitational waves, CMB
- **Strings/QFT** — quantum gravity, string theory, conformal bootstrap, AdS/CFT correspondence, information paradox
- **BSM** — collider searches for BSM, dark matter model building, experimental signatures of dark matter, model building of new physics, BSM explanation of experimental anomalies
Engineering

Cryogenics
Vacuum
Mechanical Eng. Material Science
Radiation Sensors
Lasers
Electronics
Discussions about a Quantum Technology Initiative took place in 2020 with representatives of quantum initiatives in the CERN Member States, the CERN community, the Worldwide LHC Computing Grid, the CERN Scientific Computing Forum, with LHC experiments and the HEP Software Foundation.
R&D Activities

Computing
- qGAN
- Real data

Simulation
- Node
- Information

Reconstruction
- Classification

Sensing
- Low-energy experiments, quantum states measurements, nanotechnologies
- https://doi.org/10.1140/epjst/e2015-02607-4

Communications
- QKD infrastructures
- Quantum Internet
- Future HEP Detectors

Theory
- Quantum Field Theory
- https://cds.cern.ch/record/2703396

Quantum Field

Lattice QCD
CERN IBM Quantum Hub

Since 2021 CERN is a “Hub Member” in the IBM Quantum Network and has welcomed two new members in 2022.

A project-based hub dedicated to quantum computing applications to fundamental physics research, computational chemistry, computational biology, and related fields.
Co-Development and Knowledge Transfer

- Measurement & control of quantum-scale systems
- Particle traps technologies
- Excited atoms, ions
- Picosecond Synchronisation
- FPGAs for fast inference
- Digital Low-Level Radio Frequency (LLRF) control systems
- Cryogenic system design, measurement & control
- Vacuum system design & control (HV, UHV, XHV)
- Thin film coatings for high-performance applications
- Laser devices

https://kt.cern/competences/cern-tech-quantum-systems
Education Programme

Fundamental component to prepare the community for future applications of quantum technology

› Lectures and seminars with field experts (in collaboration with the CERN Academic Training Lectures)

› Training courses (in collaboration with academic and industry experts)

› Colloquia and specialistic seminars (https://indico.cern.ch/category/14580/)

› Hackathons

› Summer Students Programmes
This event comes at the end of the second year of the CERN QTI.

It’s a way for us to talk about our collaborations and achievements

But, this is definitely not just about the CERN QTI, of course. A lot more is happening around us.

So this is also our way to concretely work on the mission of creating bridges between different communities, sharing knowledge, getting input, and providing opportunities beyond CERN

Registration deadline extended until Friday, 28 October for the International Conference on Quantum Technologies 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 recent developments in the quantum science field and keep looking for activities within HEP — and beyond — that can benefit from the application of quantum technologies.
In collaboration with the QTI Advisory Board and the International Programme Committee, we have strived to provide you with a programme covering a broad range of scientific, technological, and societal topics.

The first two days are dedicated to the four typical areas of quantum technologies (theory and simulation, sensing, computing, and communication).

Thursday is mostly dedicated to industrial co-development.

We will finish the day with a brief foray into the very important aspects of education, awareness, and societal impact.

Friday is dedicated to hands-on sessions with three different quantum computing providers.
Student Grants and Poster Session

We have tried our best to facilitate participation and engagement for students

In collaboration with the event sponsors, we have been able to provide travel and participation grants to students selected through the submission of motivation letters

We have organised a poster session on Wednesday night during the networking cocktail with a final prize ceremony before the event closing on Thursday

You can vote for the best three posters at any time during the event until Thursday afternoon at:

https://indico.cern.ch/event/1190278/surveys/3738
Sponsors

Google

“Future Lights” Sponsor for sponsoring the student grants

Alexander Del Toro Barba
Google Python/Cirq-based quantum computer simulator in CoLab
Friday at 13:00
Sponsors

“Conference Connector” and “Hub” Sponsor for sponsoring networking events and the Hub workshop

Jay Gambetta, IBM Fellow and Vice President, IBM Quantum
Charting a continuous path to Quantum Advantage
Wednesday at 18:00

Elisa Bäumer
IBM Qiskit Hands-on
Friday 09:00
Sponsors

“Conference Connector” Sponsor for sponsoring networking events

Gian Giacomo Guerreschi, Senior Research Scientist, Intel Labs
Intel Quantum SDK: A Platform for Efficient Execution of Variational Algorithms
Thursday at 14:20
Clarke’s Three Laws

1 – “When a distinguished but elderly scientist states that something is possible, they are almost certainly right. When they state that something is impossible, they are very probably wrong.”

2 – “The only way of discovering the limits of the possible is to venture a little way past them into the impossible.”

3 – “Any sufficiently advanced technology is indistinguishable from magic.”

Quantum technology is an emerging field of physics and engineering that has 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 (QT) 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.

LATEST NEWS