

*Welcome to the conference*

# Quantum Technology for High-Energy Physics 2022

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Coordinator CERN QTI*



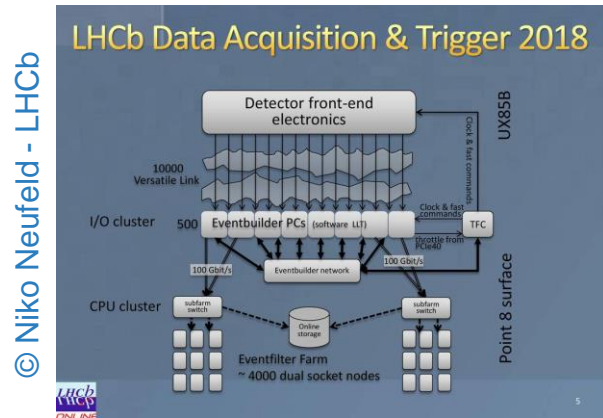
QUANTUM  
TECHNOLOGY  
INITIATIVE

# 1<sup>st</sup> CERN Quantum HEP Workshop



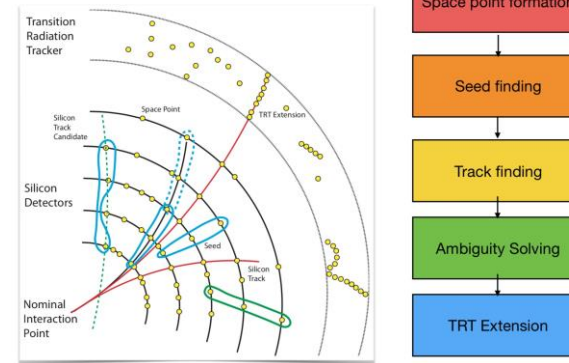
- CERN openlab organised a kick-off event of its Quantum Computing initiative on **November 5<sup>th</sup>-6<sup>th</sup>, 2018**
  - <https://indico.cern.ch/event/719844/>
  - > 400 registered participants from the HEP physics community, companies and worldwide research laboratories and beyond
- Goals:
  - 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**
- **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

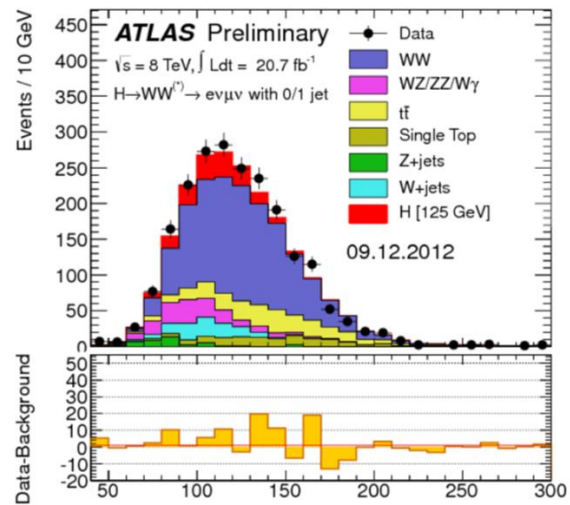


Data Acquisition

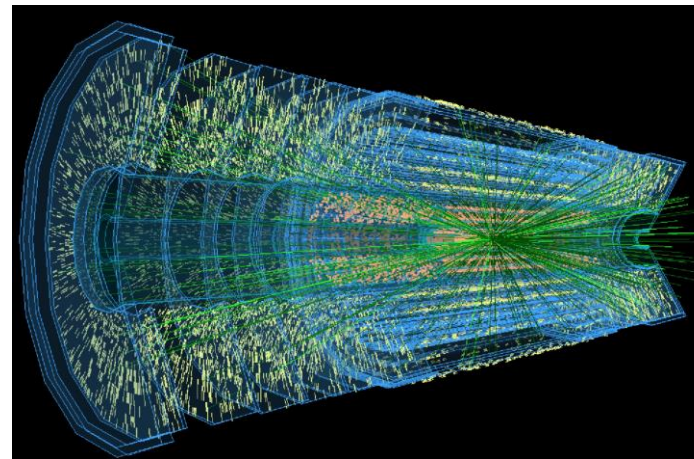
Multi-step iterative Kalman filter approach



Track Reconstruction

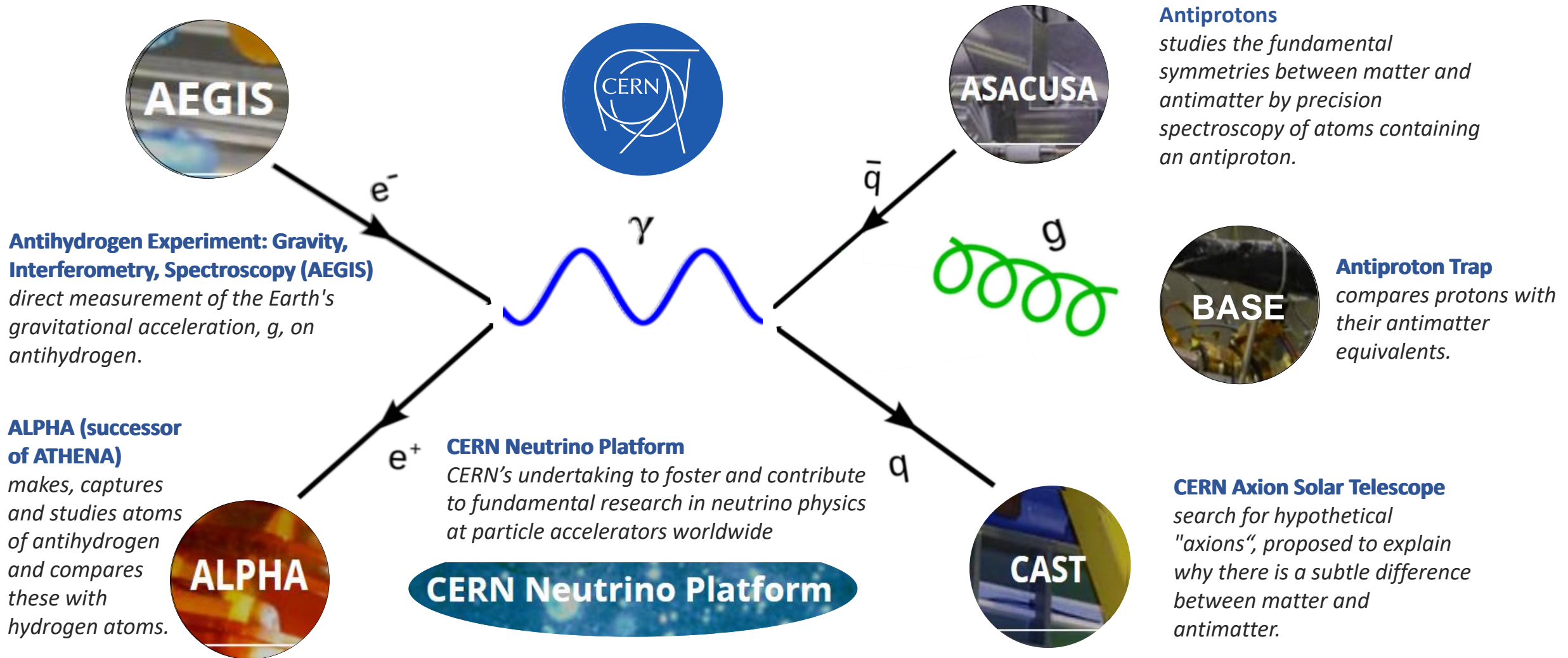


Data Analysis  $m_T$  [GeV]



Simulation

# Low-Energy Experiments





# 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 QFTS

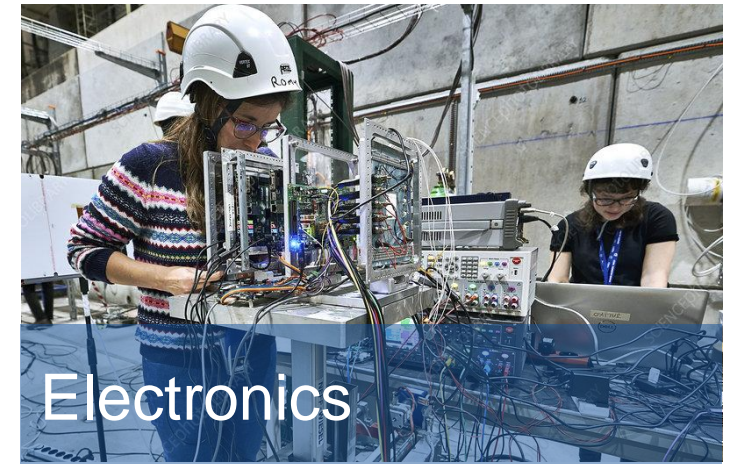
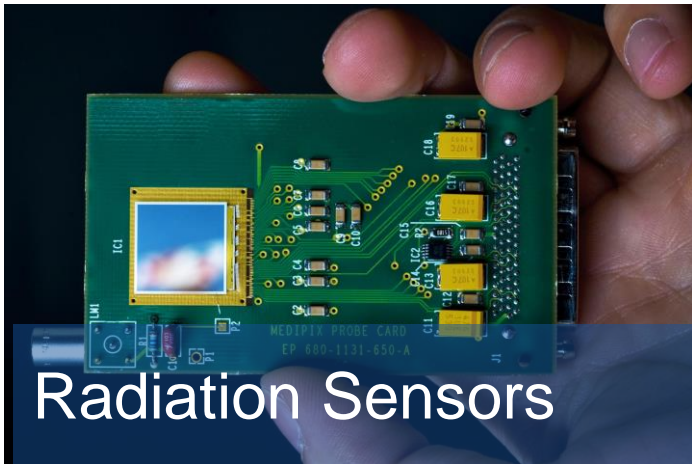
**BSM** — collider searches for BSM, dark matter model building, experimental signatures of dark matter, model building of new physics, BSM explanation of experimental anomalies

**Strings/QFT** — quantum gravity, string theory, conformal bootstrap, AdS/CFT correspondence, information paradox

**Cosmo/AstroParticle** — properties and evolution of the early universe, large scale structure, dark sectors, neutrinos, gravitational waves, CMB



# Engineering



# CERN Quantum Technology Initiative

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



T1 - Scientific and Technical Development and Capacity Building

T3 - Community Building

T2 - Co-development

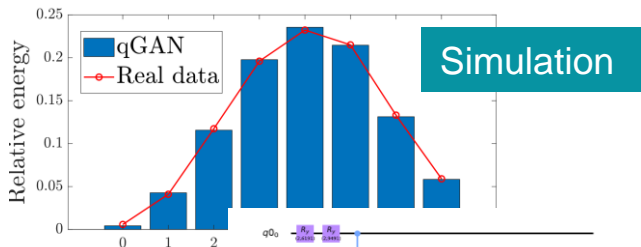
T4 - Integration with national and international initiatives and programmes

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

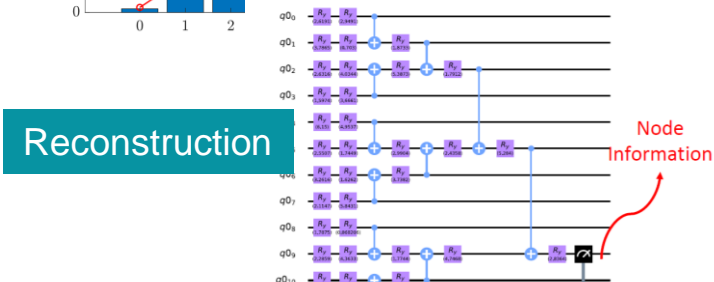


# R&D Activities

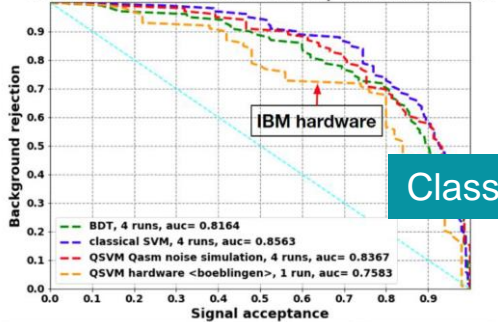
## Computing



## Reconstruction

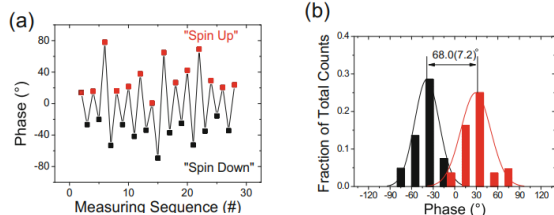


ttH ROC Curve for 100 events, 1000 iterations



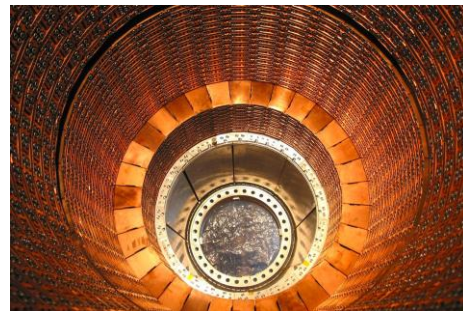
## Sensing

BASE - The Baryon Antibaryon Symmetry Experiment



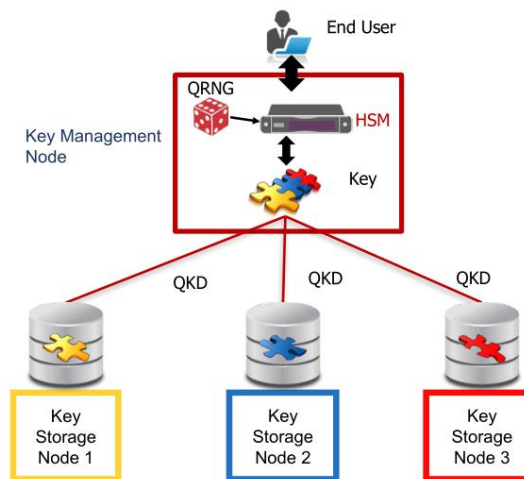
<https://doi.org/10.1140/epjst/e2015-02607-4>

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



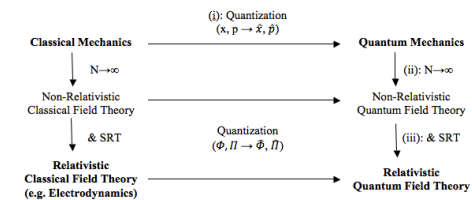
Future HEP Detectors

## Communications

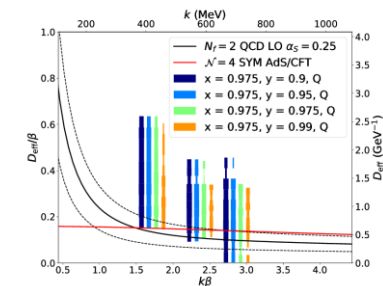


QKD  
infrastructures  
Quantum Internet

## Theory



## Quantum Field Theory

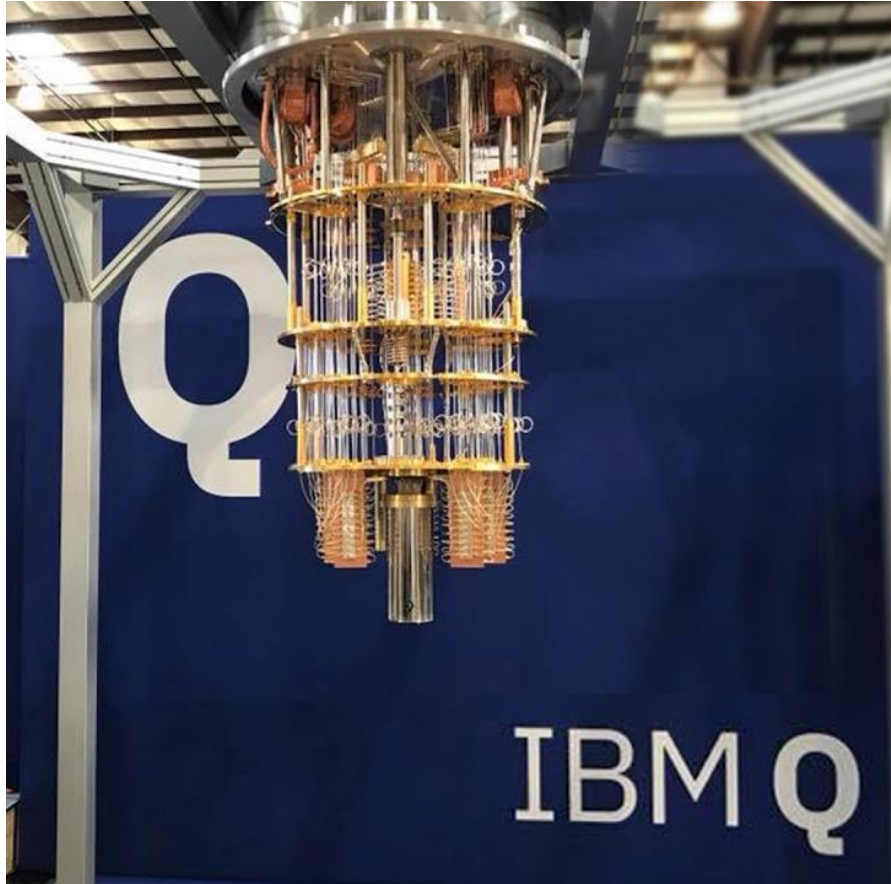


<https://cds.cern.ch/record/2703396>

## Lattice QCD



# CERN IBM Quantum Hub



Since 2021 CERN is a “Hub Member” in the IBM Quantum Network and has welcome 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

The screenshot shows the CERN Knowledge Transfer website. At the top, there is a navigation bar with the CERN logo and the text 'Knowledge Transfer Accelerating Innovation'. The main navigation menu includes 'ABOUT US', 'ACTIVITIES & SERVICES', 'TECHNOLOGIES', 'COMPETENCES', 'APPLICATIONS', and 'WHO'. The main content area is titled 'CERN tech for Quantum Systems' and features a large, abstract image of quantum systems with glowing particles and orbits. To the right of the image, there are two sections: 'GET INVOLVED' and 'CONTACT PERSON'. The 'GET INVOLVED' section lists three options: 'Industry? Collaborate with us.', 'Work for CERN? Collaborate with us.', and 'HEP Academic? Collaborate with us.'. The 'CONTACT PERSON' section features a circular profile picture of Benjamin Frisch, his name, title 'Knowledge Transfer Officer', and contact information: email 'benjamin.frisch@cern.ch' and phone '+41 22 76 64 576'.

- 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

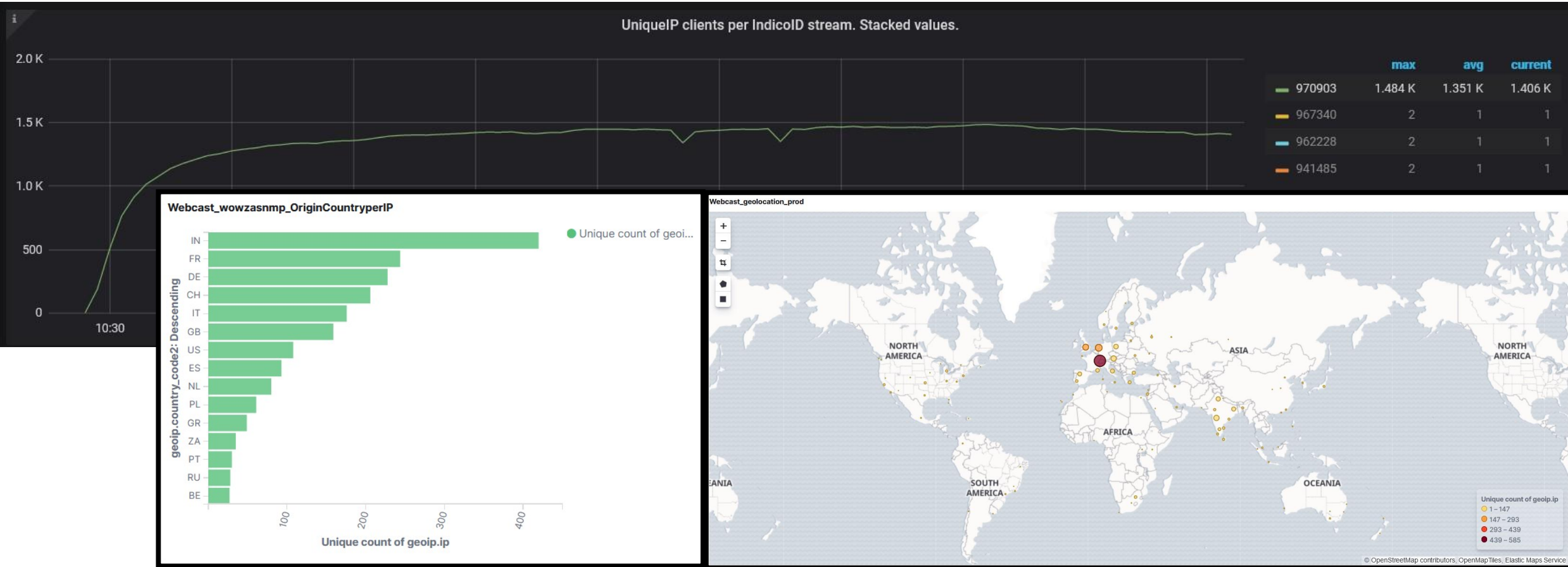
- › Lectures and seminars with field experts (in collaboration with the CERN Academic Training Lectures)
- › Training courses (in collaboration with academic and industry experts)
- › Colloquia and specialistic seminars (<https://indico.cern.ch/category/14580/>)
- › Hackathons
- › Summer Students Programmes





# “A Practical Introduction to Quantum Computing”

A 7-part lecture series by Prof. Elias Combarro, University of Oviedo, CERN Scientific Associate (06/11-18/12/2020)



# QT4HEP22

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

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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QUANTUM TECHNOLOGY CONFERENCE  
QT4HEP 1 - 4 November, 2022

CERN Main Auditorium

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.

# Conference Programme

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  QUANTUM TECHNOLOGY INITIATIVE

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

Overview

Poster session

Call for poster abstracts

Student grants

**Timetable**

My Conference

My Contributions

Registration

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Invitation letters for visa

How to get to CERN

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### Timetable

Tue 01/11 Wed 02/11 Thu 03/11 Fri 04/11 All days

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Tue 01/11

09:00	<b>Welcome address</b> 500/1-001 - Main Auditorium, CERN	Joachim Josef Mnich 09:00 - 09:10
	<b>Welcome: Welcome and Introduction</b> 500/1-001 - Main Auditorium, CERN	Alberto Di Meglio 09:10 - 09:30
	<b>Simulation &amp; Theory</b>	Elina Fuchs
10:00		
11:00		
12:00		



# 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**

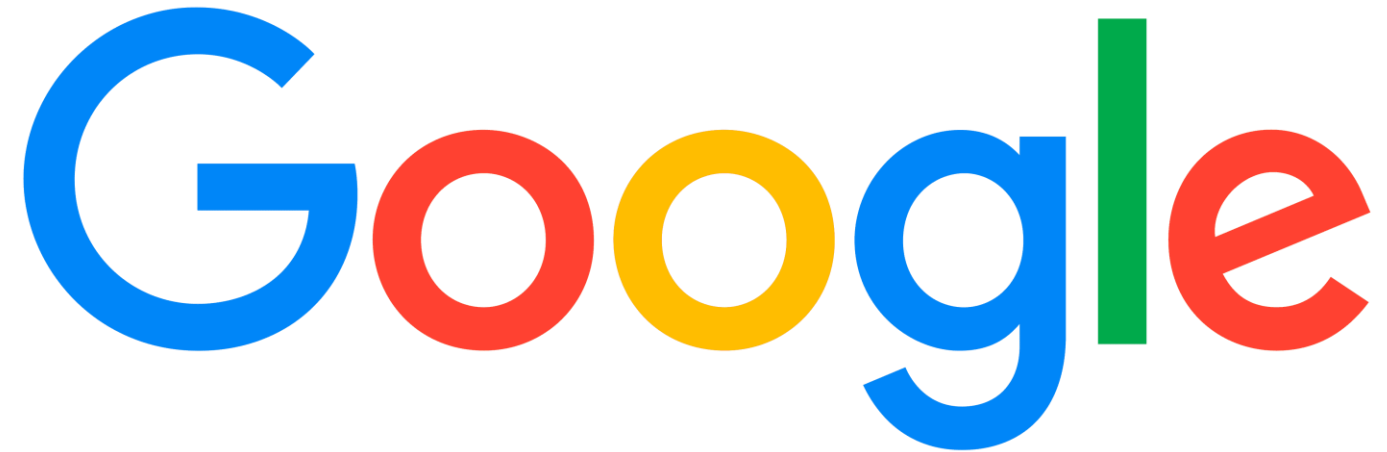
We have organised a **poster session on Wednesday night during the networking cocktail** with a **final prize ceremony** before the event closing on Thursday

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



**“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

# IBM Quantum

**“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**

# Parting thoughts

## 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.”

*Arthur C. Clarke, "Hazards of Prophecy: The Failure of Imagination" in the collection Profiles of the Future: An Enquiry into the Limits of the Possible (1962, rev. 1973)*



Home

# CERN Quantum Technology Initiative

## Accelerating Quantum Technology Research and Applications

<https://quantum.cern.ch>

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.

### LATEST NEWS







**QUANTUM  
TECHNOLOGY  
INITIATIVE**