

CERN QTI: An Overview

Alberto Di Meglio, MEng, PhD

Head CERN openlab

Coordinator CERN Quantum Technology Initiative



QUANTUM
TECHNOLOGY
INITIATIVE

CERN

“Science for peace”

- International organisation close to Geneva, straddling Swiss-French border, founded 1954
- Facilities for fundamental research in particle physics
- 23 member states, 1.2 B CHF budget
- ~3'200 staff, fellows, trainees, ...
- >13'000 associates



1954: 12 Member States

Members: Austria, Belgium, Bulgaria, Czech republic, Denmark, Finland, France, Germany, Greece, Hungary, Israel, Italy, Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom

Candidate for membership: Cyprus, Estonia, Slovenia

Associate members: Croatia, India, Lithuania, Pakistan, Turkey, Ukraine

Observers: EC, Japan, JINR, Russia, UNESCO, United States of America

Numerous **non-member states with collaboration agreements**

>2'500 staff members, 645 fellows, 21 trainees

7'000 member states, 1'800 USA, 900 Russia, 270 Japan, ...

CERN

1 PB/sec

CMS



CMS

ALICE



ALICE



ATLAS

ATLAS

LHCb



LHCb

LAST DATA UPDATE

9.7 MB Downloaded Wednesday, 11 September 2019 14:05:12
Last transfer was on : Monday, 29 July 2019 08:00:00

LOADING

100 %

VOLUME TRANSFERS

VOLUME FILES

VOLUME DATA

The Worldwide LHC Computing Grid (WLCG)

About 1 million processing cores

170 data centres in 42 countries

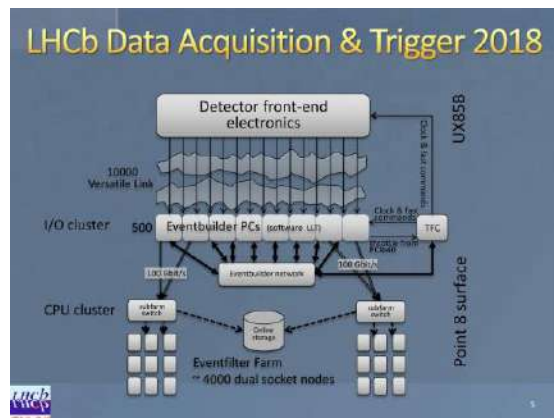
>1000 Petabytes of CERN data stored worldwide

DATA TRANSFER CONSOLE

405647605 From Ufanda-HPC To Ufanda-HEP Monday 29 July 2019 04:04:50
0 From USCOT2 To INFN-T1 Monday 29 July 2019 04:05:40
0 From Vanderbilt To Nebraska Monday 29 July 2019 04:06:06
5667223 From INFN-CC To INFN-BARI Monday 29 July 2019 04:07:31
4934033 From L-JHP-T2 To CERN-PROD Monday 29 July 2019 04:08:20
163581055 From INFN-T1 To GLOW Monday 29 July 2019 04:09:35
13229123125 From INDACMS-TIFR To pcc Monday 29 July 2019 04:08:43
16279251793667 From CERN-PROD To INFN-KNU-T3 Monday 29 July 2019 04:09:29
1674048 From MIT-CMS To FIJHP-T2 Monday 29 July 2019 04:09:54
50209650 From INFN-T1 To CIT-CMS-T2 Monday 29 July 2019 04:10:11
254420 From CERN-PROD To INFN Monday 29 July 2019 04:10:41
0 From UK-SOUTHERD-HARP To GLOW Monday 29 July 2019 04:12:05
56639772 From INFN-T1 To JINR-T1 Monday 29 July 2019 04:12:10
12957706763333 From CSCS-LCD2 To INFN-LNL-2 Monday 29 July 2019 04:12:10
2905786385 From SPRACE To JINR-T1 Monday 29 July 2019 04:12:20
0 From INFN-LNL-2 To CSCS-LCD2 Monday 29 July 2019 04:12:25
2244329565568 From INFN-CC To prague2 Monday 29 July 2019 04:13:03
43819226355667 From UK-SOUTHERD-HARP To CERN-PROD Monday 29 July 2019 04:13:11
0 From BELGIUM-UGL To CIT-CMS-T2 Monday 29 July 2019 04:14:30
0 From Vanderbilt To USCOT2 Monday 29 July 2019 04:14:57
33866768370214 From RU-Protvino-HEP To CERN-PROD Monday 29 July 2019 04:15:10
169449714 From CSCS-LCD2 To RU-Protvino-HEP Monday 29 July 2019 04:15:45

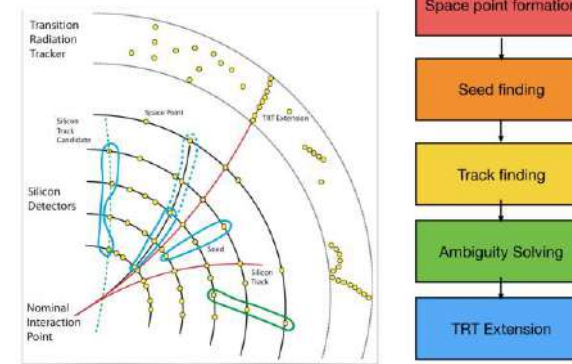
LHC Experiments Computing Workloads

© Niko Neufeld - LHCb

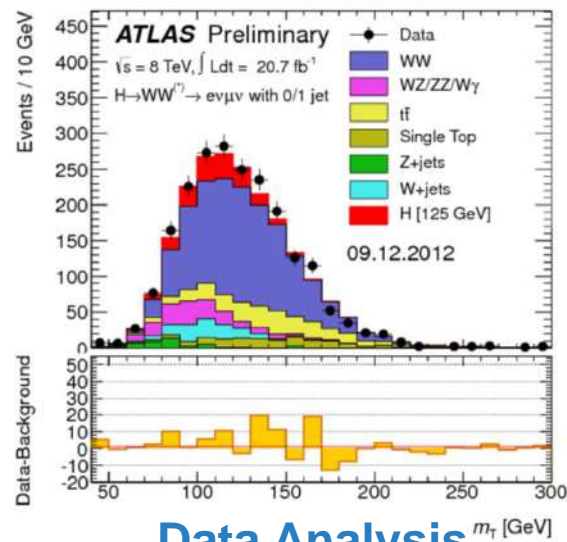


Data Acquisition

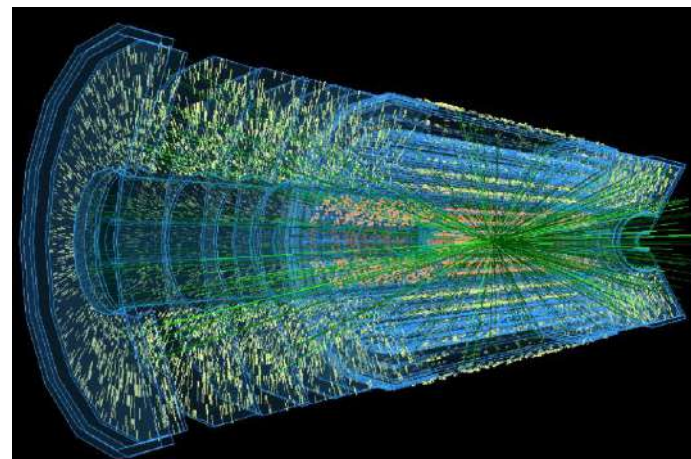
Multi-step iterative Kalman filter approach



Track Reconstruction

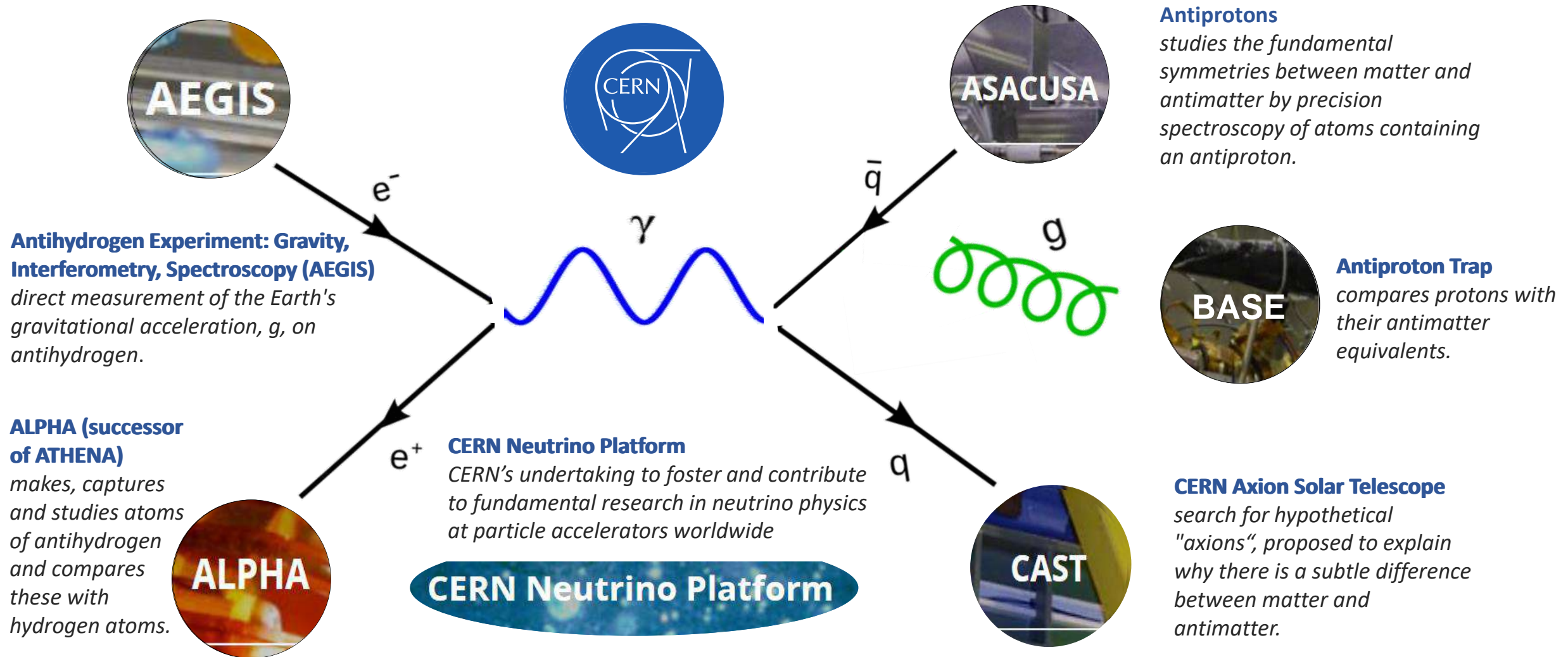


Data Analysis m_T [GeV]



Simulation

Non-LHC Experiments



Quantum Theory

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

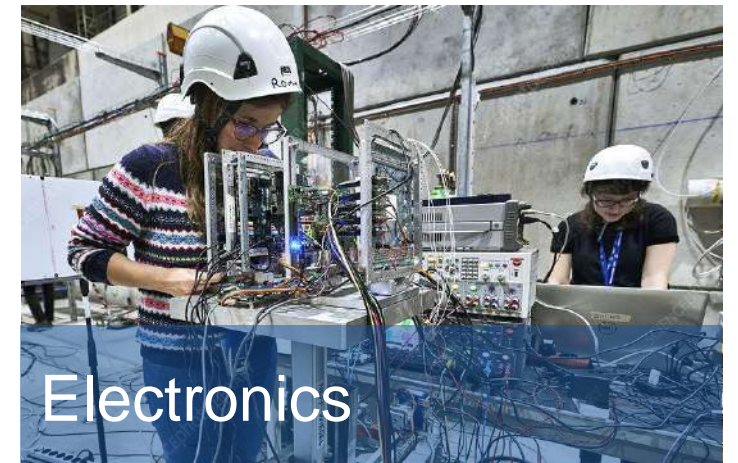
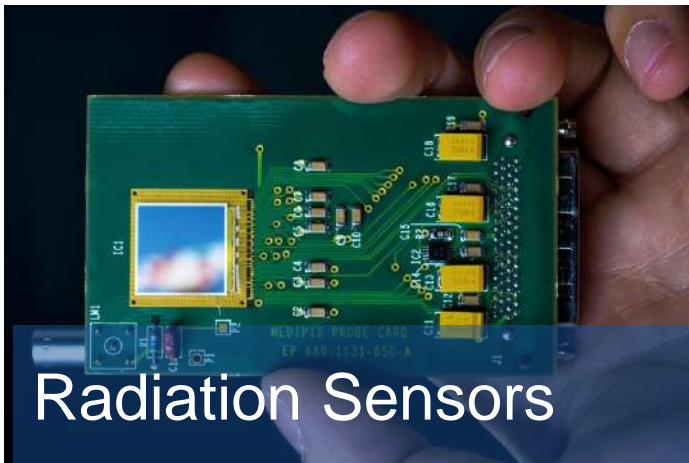
Lattice — theory inputs for nuclear and particle physics, first principle calculations of the low energy aspects of QCD, lattice as a formal tool for understanding QFTs

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

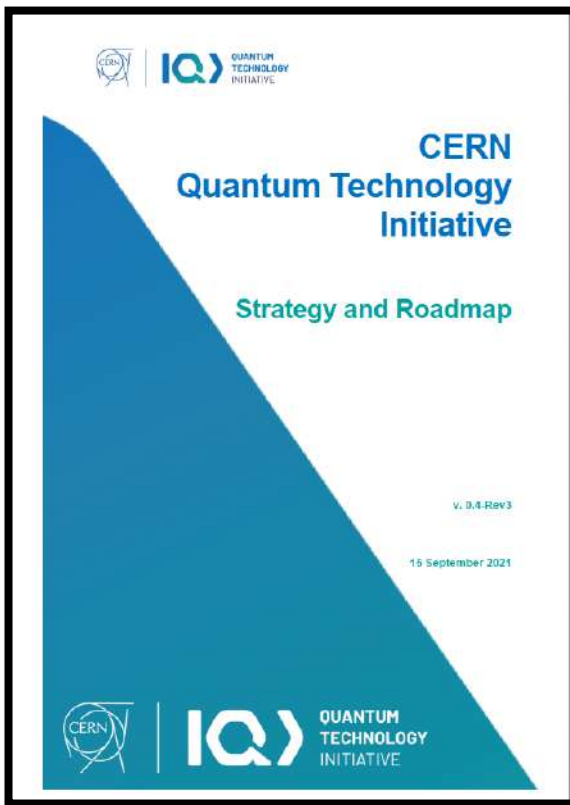
Cosmo/AstroParticle — properties and evolution of the early universe, large scale structure, dark sectors, neutrinos, gravitational waves, CMB

Engineering



CERN Quantum Technology Initiative

The Quantum Technology Initiative started in 2020 to coordinate the activities at CERN on quantum technologies in the four areas of **Quantum Computing and Algorithms, Quantum Simulation and Theory, Quantum Sensing and Materials, Quantum Communications and Networks**



T1 - Scientific and Technical
Development and Capacity
Building

T3 - Community Building

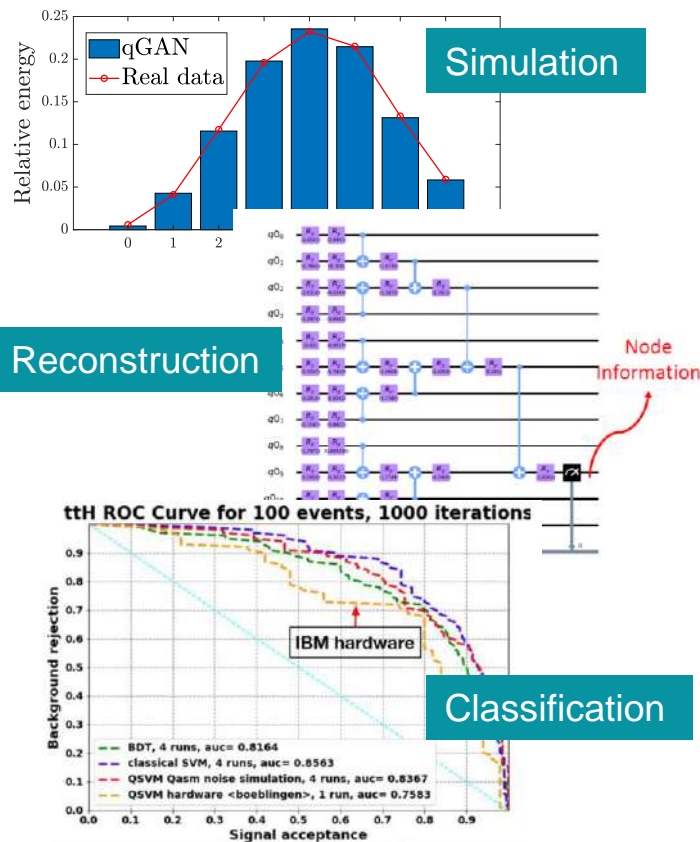
T2 - Co-development

T4 - Integration with national and
international initiatives and
programmes

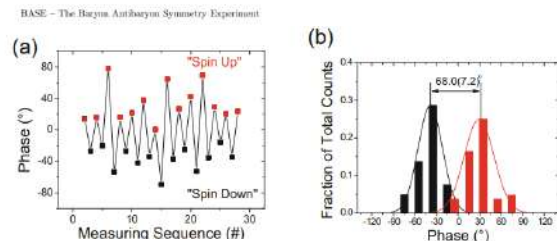
<https://doi.org/10.5281/zenodo.5553774>

R&D Projects

Computing



Sensing



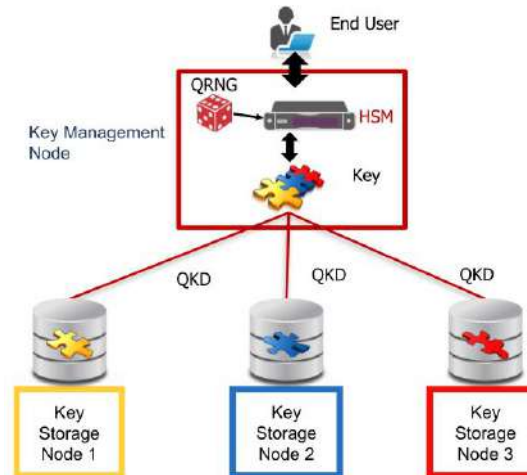
<https://doi.org/10.1140/epjst/e2015-02607-4>

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



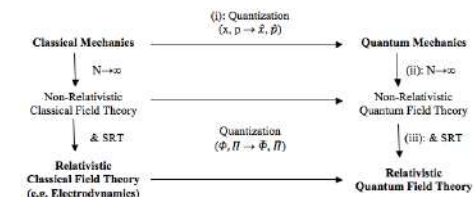
Future HEP Detectors

Communications

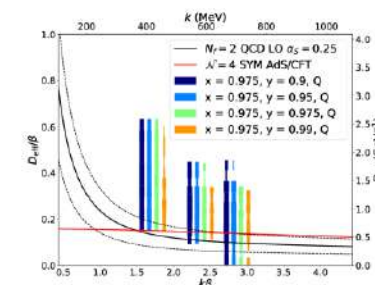


QKD
infrastructures
Quantum Internet

Theory



Quantum Field Theory



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

Lattice QCD

Many pilot projects already started as part of the **CERN openlab quantum** programme (<https://openlab.cern/quantum>)

Research Collaborations

Organizations and Projects



Academia, Research Labs and Agencies

Knowledge Transfer Opportunities

The screenshot shows the CERN Knowledge Transfer website. At the top, the CERN logo and tagline 'Accelerating science' are visible. Below this, a navigation bar includes 'ABOUT US', 'ACTIVITIES & SERVICES', 'TECHNOLOGIES', 'COMPETENCES', 'APPLICATIONS', and 'WHO ARE YOU?'. The main heading is 'CERN tech for Quantum Systems'. To the left is a large, abstract image of a particle detector. To the right, there are two sections: 'GET INVOLVED' with three bullet points: 'Industry? Collaborate with us.', 'Work for CERN? Collaborate with us.', and 'HEP Academic? Collaborate with us.'; and 'CONTACT PERSON' featuring a photo of Benjamin Frisch, Knowledge Transfer Officer, with his email 'benjamin.frisch@cern.ch' and phone number '+41 22 76 64 576'.

- Measurement & control of quantum-scale systems
- Particle traps technologies
- Excited atoms, ions
- Picosecond synchronisation
- FPGAs for quantum simulators
- 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>



Home

CERN Quantum Technology Initiative

Accelerating Quantum Technology Research and Applications

<https://quantum.cern>

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**