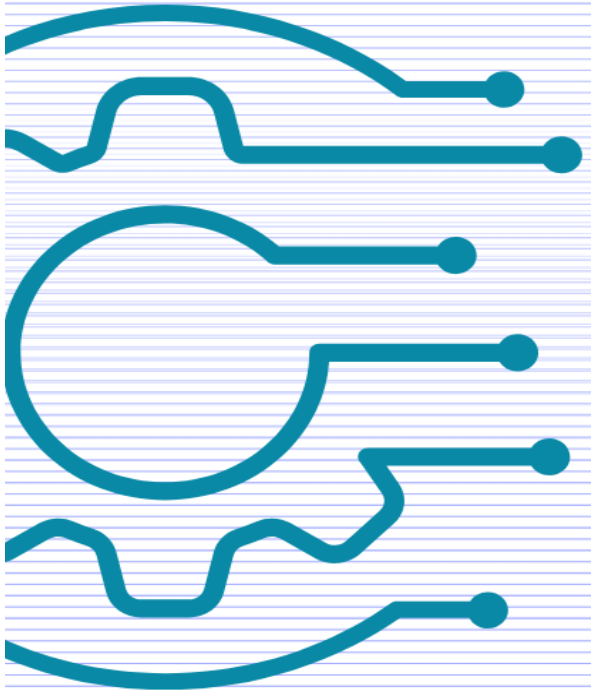
QUANTUM TECHNOLOGY INITIATIVE

CERN Main Auditorium



QUANTUM TECHNOLOGY CONFERENCE

QT4HEP

20-24 January 2025

QUANTUM TECHNOLOGY INITIATIVE

WELCOME TO CERN!

«..a Swiss winter day..»
25 January 2005
cds.cern.ch

Build expertise through collaborations

Evaluate impact of QT on CERN scientific program

Identify CERN technologies that can contribute to QT development

Quantum Technology Initiative: Origins

2018

Openlab Workshop on Quantum Computing

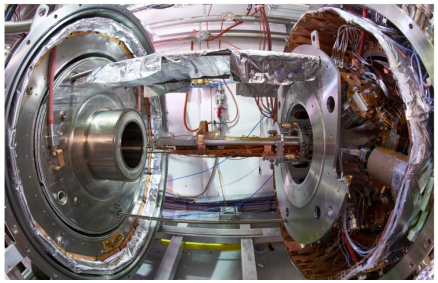
2020

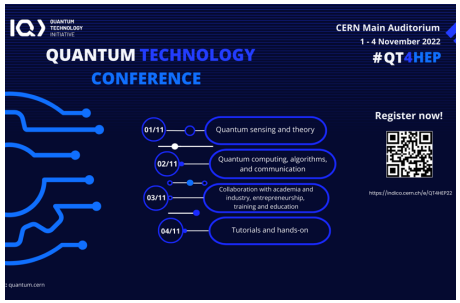
Quantum Technology Initiative is approved

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

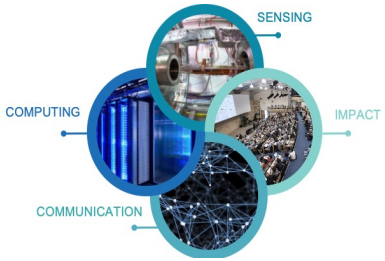
30 SEPTEMBER, 2020 | By Matthew Chalmers





2022

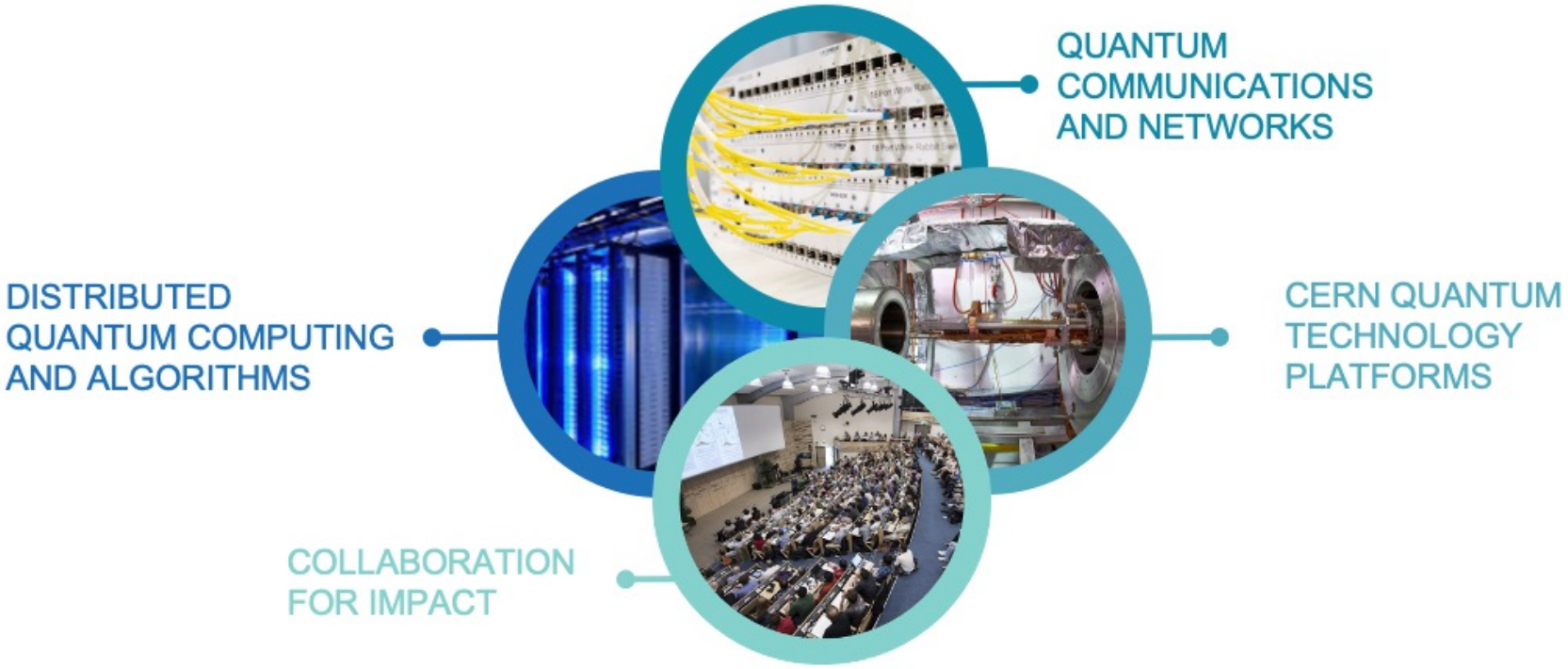
First edition of QT4HEP



2024

QTI Phase 2 starts!

Quantum Technology Initiative: Today

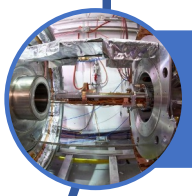


Our Goal: Design a **coherent research** plan that can evolve into a long term strategy on quantum technologies, aligned with CERN's traditional values of innovation, collaboration, and advancing knowledge for the benefit of humanity.

QTI Objectives

Integrate quantum computers within HEP computing model

Make CERN a node of the future European network infrastructure



Lead development of next generation detectors for fundamental physics

Join the broader quantum ecosystem to multiply impact

Actions:

Develop hybrid algorithms for realistic applications;

Contribute to infrastructure development

Design Quantum Network demonstrators incorporating White Rabbit for time synchronization;

Characterize performance of communication protocols in realistic use cases

Develop superconducting RF cavities for sensing and computing applications;

Significant contribution to ECFA DRD5 program

Setup co-development partnerships with companies, institutes and other entities.

QTI Research contributes to CERN program

QTI Areas

CERN Program

Major QTI results

QTI Research contributes to CERN program

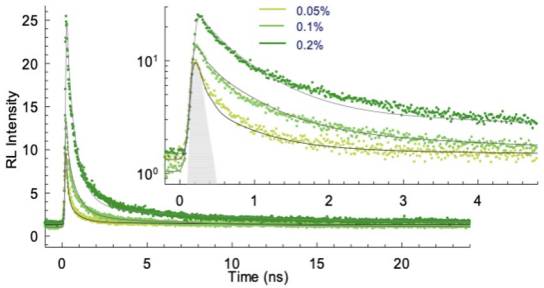
QTI Areas

Quantum Sensing

CERN Program

Accelerators
Technologies and
Future Detectors
R&D

Major QTI results



Frank, I. J. C. **Investigation of Nanocomposite Scintillators and New Detector Concepts for High Energy Physics**, *doi: 10.1109/NSSMICRTSD49126.2023.10337902.*

QTI Research contributes to CERN program

QTI Areas

Quantum Sensing

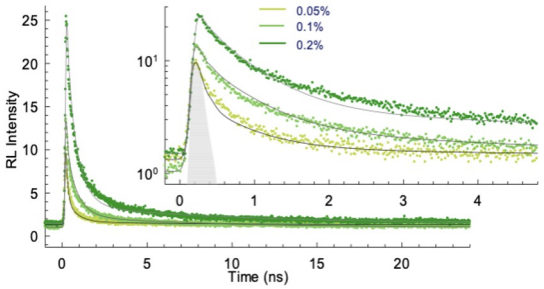
Quantum Simulation

CERN Program

Accelerators Technologies and **Future Detectors** R&D

Theory, **Physics Beyond Colliders**

Major QTI results



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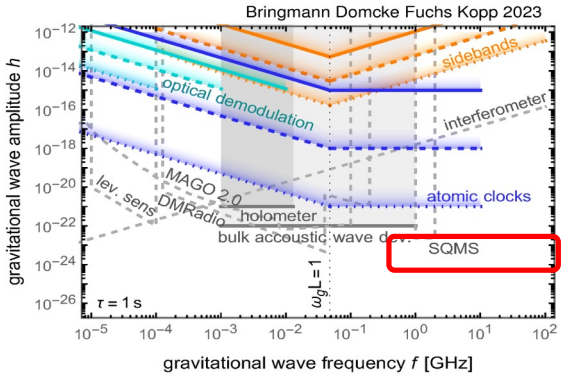
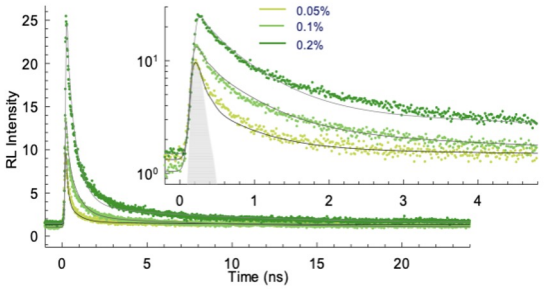


QTI Research contributes to CERN program

QTI Areas		**CERN** Program
Quantum Sensing	⟷	**Accelerators** Technologies and **Future Detectors** R&D
Quantum Simulation	⟷	Theory, **Physics Beyond Colliders**
Quantum Computing	⟷	**Scientific Computing**: Algorithms, Distributed Computing
Quantum Communication	⟷	

Major QTI results



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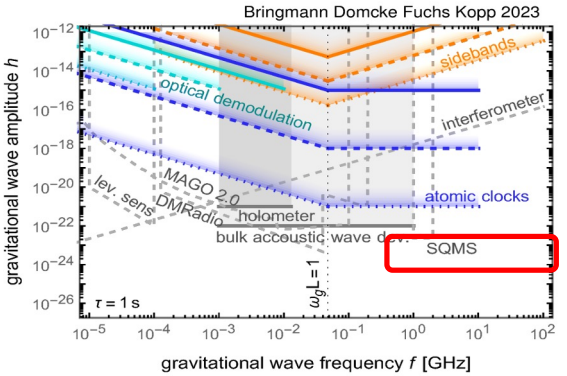

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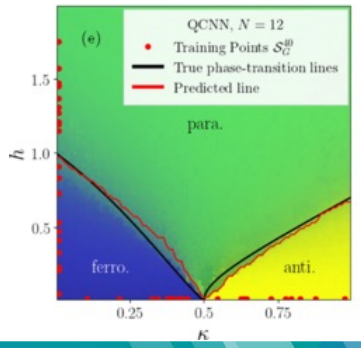


Monaco, S. et al. "**Quantum phase detection generalization from marginal quantum neural network models.**" *Physical Review B* 107.8 (2023): L081105.

QTI Research contributes to CERN program

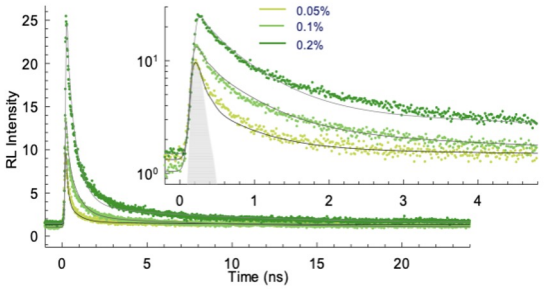
QTI Areas

- Quantum Sensing
- Quantum Simulation
- Quantum Computing
- Quantum Communication

CERN Program

- **Accelerators** Technologies and **Future Detectors** R&D
- Theory, **Physics Beyond Colliders**
- **Scientific Computing**: Algorithms, Distributed Computing

Major QTI results



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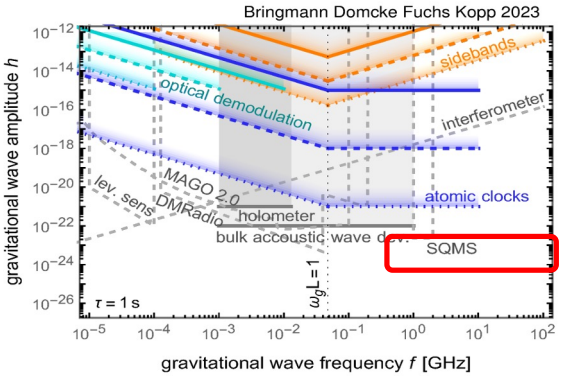

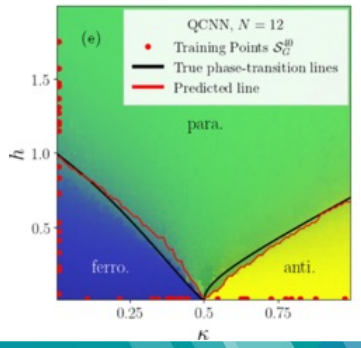

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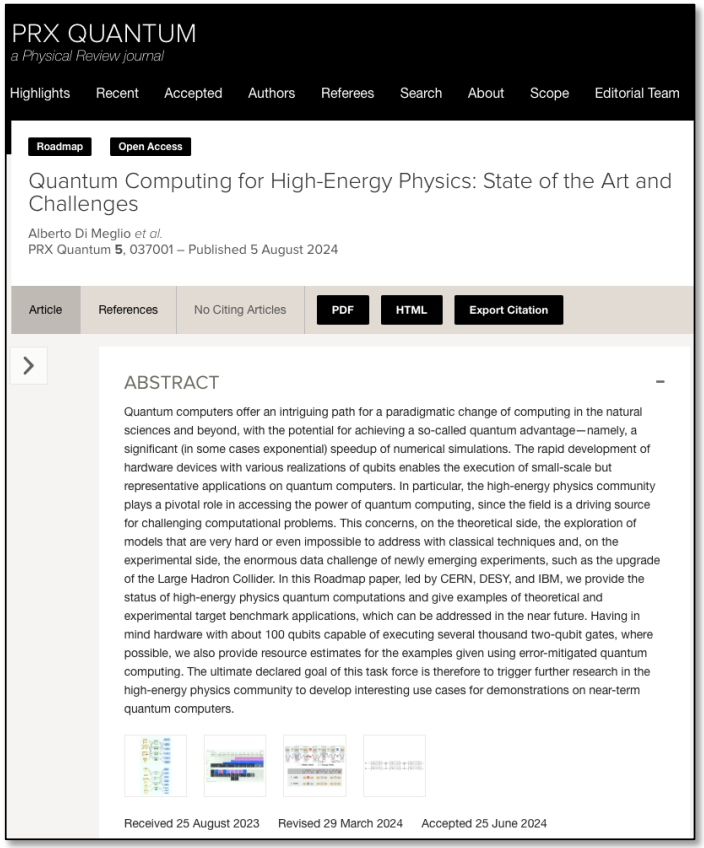
Foster a expert community studying usability of Quantum Computing for HEP

- Lead the creation of a new community of experts from the Member States and beyond
- Focus on concrete challenges of QC for HEP
- White Paper on a realistic roadmap in experimental and theoretical physics → a seminal paper!

QC4HEP ANNUAL MEETING on FRIDAY (https://indico.cern.ch/event/1484549/)



Di Meglio, A. , *et al*. **Quantum Computing for High-Energy Physics: State of the Art and Challenges**. *PRX Quantum* 5.3 (2024): 037001.

Open Quantum Institute (OQI)

TALK ON TUESDAY!

The Open Quantum Institute at CERN

- Driving values of **inclusivity, global scope, openness, focus on impact**, and fostering collaborations
- Leveraging **QTI's mission to explore the full potential of quantum technologies** and maximise their societal impact
- Strengthening CERN's profile as a scientific institution **addressing society's pressing challenges**

The work of OQI

- Accelerating applications for humanity
- Access for all
- Advancing capacity building
- Activating multilateral governance

https://open-quantum-institute.cern

https://indico.cern.ch/event/1433194

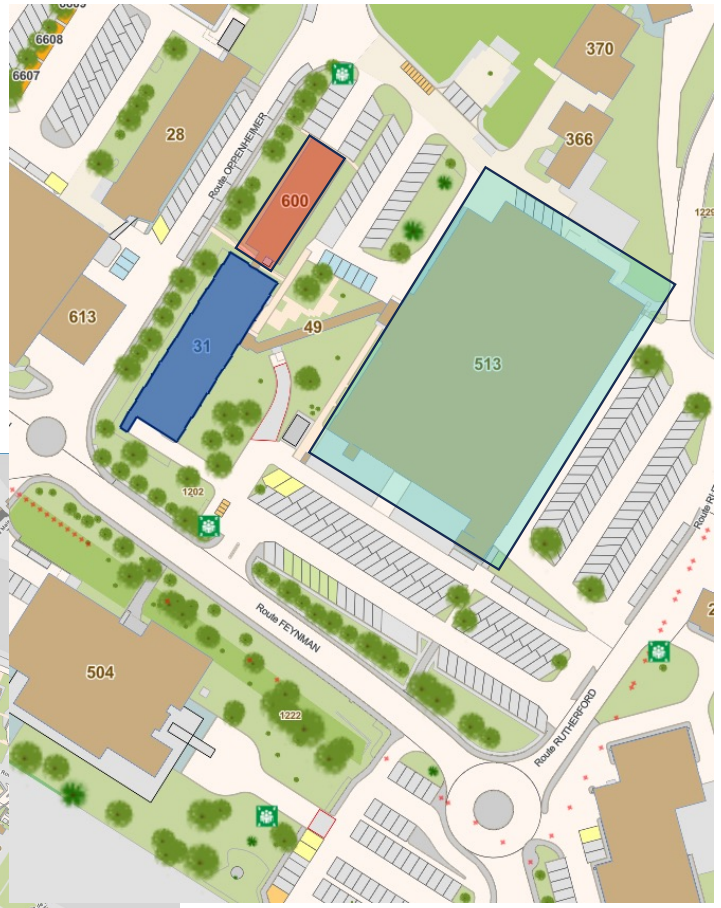
DAY1: COMMUNICATION
Welcome introduction
500/1-001 - Main Auditorium, CERN
CERN QTI2
500/1-001 - Main Auditorium, CERN
The European Commission Joint Research Centre's contribution to quantum and pre
Petra Scudo
Coffee break
500/1-001 - Main Auditorium, CERN
High-speed SNSPDs for clock-rate scaling in quantum networks
500/1-001 - Main Auditorium, CERN
Photon-number-resolving SNSPDs and their applications for quantum networks and
[IDQuantique]
Félix Bussières
Metropolitan-scale entanglement generation between quantum processors: from the
Arian Stolk
Lunch
500/1-001 - Main Auditorium, CERN
The Entanglement Fabric: enabling distributed quantum computing with quantum ne
Simone Zaffiro Barker
Entanglement Networking Hardware: Driving Real-World Applications Beyond QKD
500/1-001 - Main Auditorium, CERN
The Road to a Quantum-Connected World: Insights from Deutsche Telekom's Activiti
500/1-001 - Main Auditorium, CERN
Building physics-centric Quantum Networks [Stony Brook University]
500/1-001 - Main Auditorium, CERN
Coffee break
500/1-001 - Main Auditorium, CERN
Open discussion session on synchronisation for quantum communication
500/1-001 - Main Auditorium, CERN
DAY2: COLLOQUIA COMPUTING POSTERS
Quantum network technology – the second life of rare-earth crystals [Univers
81/R-003C - Science Gateway Auditorium C, CERN
Quantum computing roadmaps toward fault-tolerance
81/R-003C - Science Gateway Auditorium C, CERN
Coffee
81/R-003C - Science Gateway Auditorium C, CERN
The Quantum Internet: Applications, Challenges and Opportunities
81/R-003C - Science Gateway Auditorium C, CERN
The Open Quantum Institute (OQI)
81/R-003C - Science Gateway Auditorium C, CERN
Conference Photo
500/1-001 - Main Auditorium, CERN
Lunch
81/R-003C - Science Gateway Auditorium C, CERN
Efficient Use of Quantum Computers for Collider Physics
81/R-003C - Science Gateway Auditorium C, CERN
Quantum Machine Learning with Physics-Informed and Symmetry-Aware Mod
81/R-003C - Science Gateway Auditorium C, CERN
Prof. Fabio Maltoni - Quantum Observables in HEP
81/R-003C - Science Gateway Auditorium C, CERN
Coffee break
81/R-003C - Science Gateway Auditorium C, CERN
Jad Halimeh - quantum simulation in lattice gauge theories and long-range qu
81/R-003C - Science Gateway Auditorium C, CERN
The quantum life of a Feynman propagator as a qubit
81/R-003C - Science Gateway Auditorium C, CERN
DAY3: SENSING COMPUTING
Overview Quantum Sensors for particle physics
500/1-001 - Main Auditorium, CERN
Atom Interferometry
500/1-001 - Main Auditorium, CERN
High Tc superconducting particle detectors
500/1-001 - Main Auditorium, CERN
Coffee Break
500/1-001 - Main Auditorium, CERN
Superconducting Calorimeters
500/1-001 - Main Auditorium, CERN
Chromatic calorimetry (quantum dots)
500/1-001 - Main Auditorium, CERN
Nuclear clocks for fundamental and particle physics
500/1-001 - Main Auditorium, CERN
SRF / heterodyne cavity applications for axion searches
500/1-001 - Main Auditorium, CERN
Lunch
500/1-001 - Main Auditorium, CERN
QSNET: network of
500/1-001 - Main Auditorium, CERN
Superconducting Qubits as P
500/1-001 - Main Auditorium, CERN
High-Q cavity coupled to high permittivity dielectric resonator for sensing applications
Antonio Cassin
500/1-001 - Main Auditorium, CERN
Magnetic techniques for quantum sensing using single molecule magnets in the NAMASSTE experimen
Giuseppe Latino
Towards realization of long-lived chains of circular Rydberg atoms for quantum simulatio
500/1-001 - Main Auditorium, CERN
Characterization of a Rubidium based Four Way Mixing Entangled Photon Pair Source with SNSPDs
Federica Facchin
Highly Sensitive Optical Quantum Sensors
500/1-001 - Main Auditorium, CERN
Coffee break
500/1-001 - Main Auditorium, CERN
On multivariate polynomials achievable with quantum signal processing
81/R-003C - Science Gateway Auditorium C, CERN
Complementary polynomials in quantum signal processing
81/R-003C - Science Gateway Auditorium C, CERN
Estimates of loss function concentration in noisy parametrized quantum circuits
81/R-003C - Science Gateway Auditorium C, CERN
Break
81/R-003C - Science Gateway Auditorium C, CERN
Guarantees for smart initializations in variational quantum computing
81/R-003C - Science Gateway Auditorium C, CERN
Neural quantum states for lattice field theory
81/R-003C - Science Gateway Auditorium C, CERN
Prospects for the quantum simulation of quark-gluon plasma
81/R-003C - Science Gateway Auditorium C, CERN
DAY4: COMPUTING
Some recent progress in the description of atomic nuclei using qua
500/1-001 - Main Auditorium, CERN
Engineering periodic boundary conditions with circuit cutting for hi
500/1-001 - Main Auditorium, CERN
Efficient Encoding of Quantum States for Hamiltonian Simulation of
Relta Maeno
Enhancing quantum field theory simulations on NISQ devices with H
JAMES,ALLAN INGOLDBY
Projected Entangled Pair States for Lattice Gauge Theories with Dyn
500/1-001 - Main Auditorium, CERN
Fault-tolerant simulation of Lattice Gauge Theories with gauge cova
500/1-001 - Main Auditorium, CERN
Coffee break
500/1-001 - Main Auditorium, CERN
Building quantum event generators through parton-based formulat
500/1-001 - Main Auditorium, CERN
Quantum Chebyshev Generator Model for Fragmentation Functions
500/1-001 - Main Auditorium, CERN
Efficient calculation of Green's functions on quantum computers via
Francesco Tacchino
Learning to generate high-dimensional distributions with low-dimen
Cenk Tüysüz
Towards quantum advantage with photonic state injection
500/1-001 - Main Auditorium, CERN
Closing
500/1-001 - Main Auditorium, CERN
Lunch
500/1-001 - Main Auditorium, CERN

Quantum Computing Hackathon

Please note different location on Friday:

https://indico.cern.ch/event/1433194/timetable/#20250124.detailed

- IT Auditorium for the challenge presentation
- Breakout rooms in the IT Department



https://aqora.io/events/
cern-hep-challenge-2025

Some Practical Info

Mon-Wed-Thu in the Main Auditorium

- Coffee breaks served just outside
- Lunch tickets for the main cafeteria (R1)

(16 CHF value, you should cover additional costs)

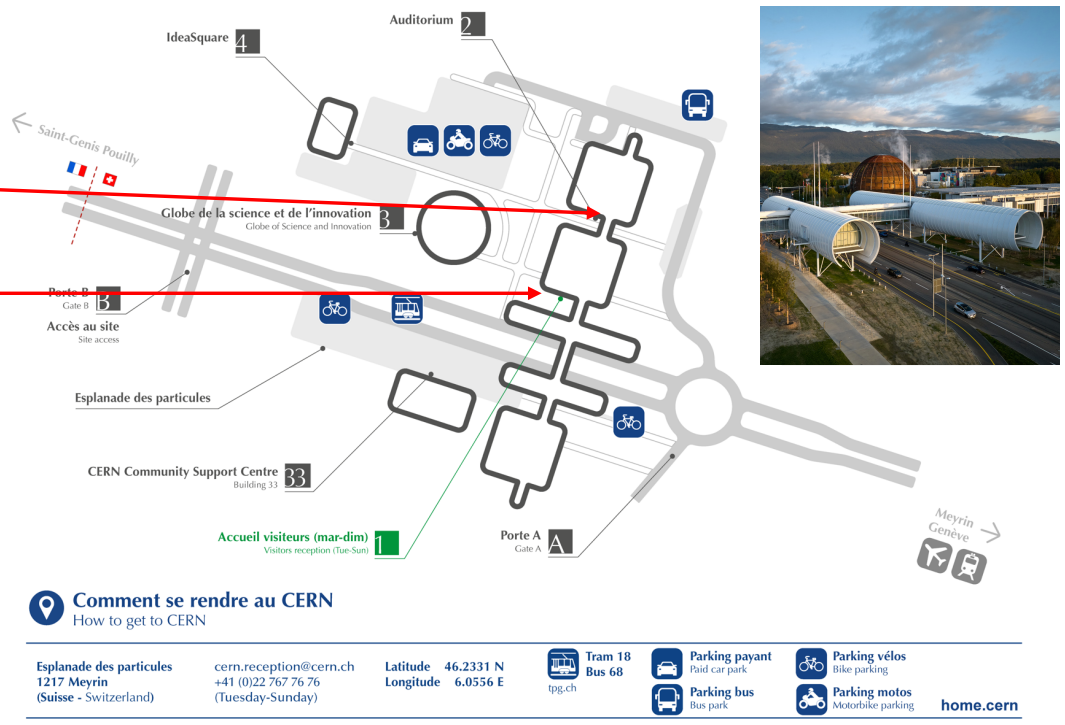
Tuesday we are at the Science Gateway

- Lunch is served there
- To visit the exhibitions use the public entrance.
- Conference badge will get you 10% discount at the CERN store

Conference Photo Tuesday before lunch

Poster Session and Conference Cocktail on Tuesday at the Science Gateway

- Don’t forget to bring your poster there!



Thank you

Enjoy the conference!