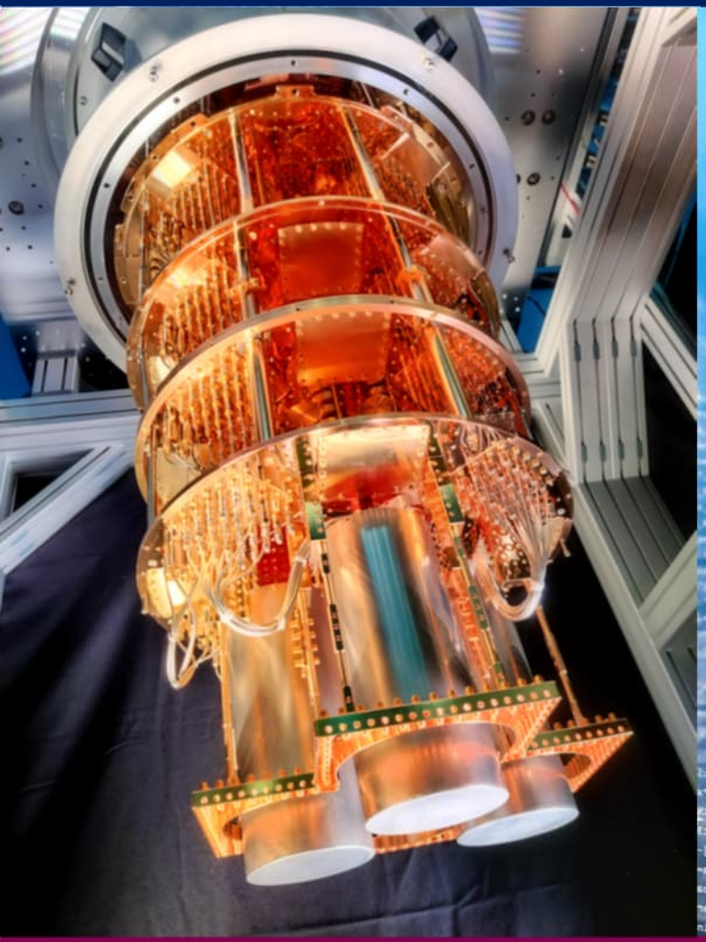
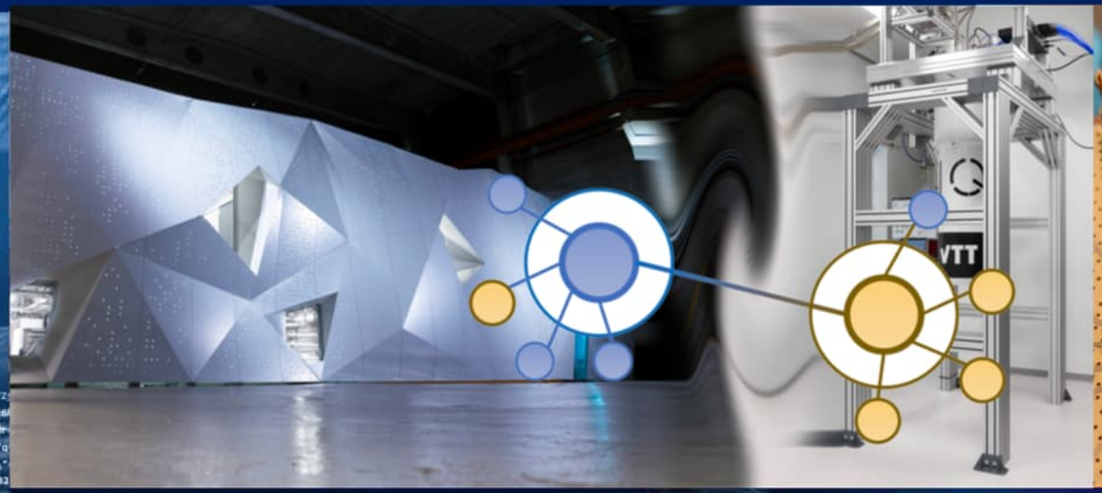
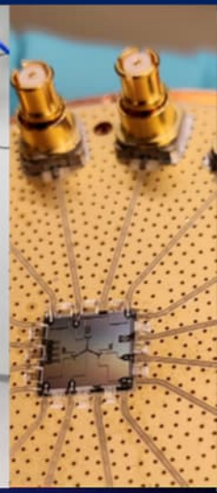
The Finnish Quantum-Computing Infrastructure FiQCI

Summer School on New Directions in Quantum 22 Aug 2025 / Mikael Johansson







Non-profit owned by Finnish state and higher-ed institutions

Providing HPC services for **50+** years

Univac 1108

Carbon negative data centre in Kajaani, Finland

Support in all phases of research:
training*, *planning*, *executing,
analysing, storing, sharing, ...

700+
employees

Why are we (as an HPC centre) interested in quantum computing?

Quantum computers will not replace supercomputers

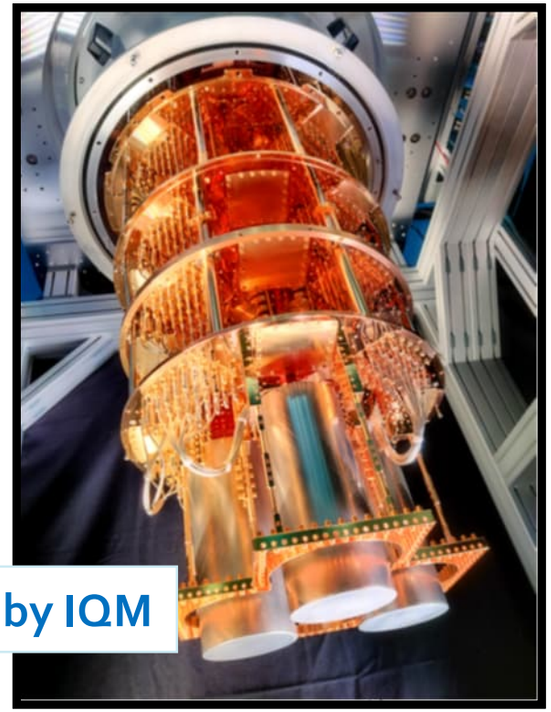
- Instead, the two will merge
- Important to stimulate **co-creation** between the HPC and QC communities

Our end-users will need early-access to HPC+QC in order to make their workflows quantum-ready

- The **transition from classical CPUs/GPUs to quantum QPUs** requires fundamental rethinking of problems and algorithms
- Requires time, resources, and support

HPC centres serve as natural starting points

- All the necessary basic services already in place:
    - User authentication and administration
    - Resource allocation and control
    - Storage, high-speed network, classical resources, …
- **End-users!**



Quantum computer by IQM

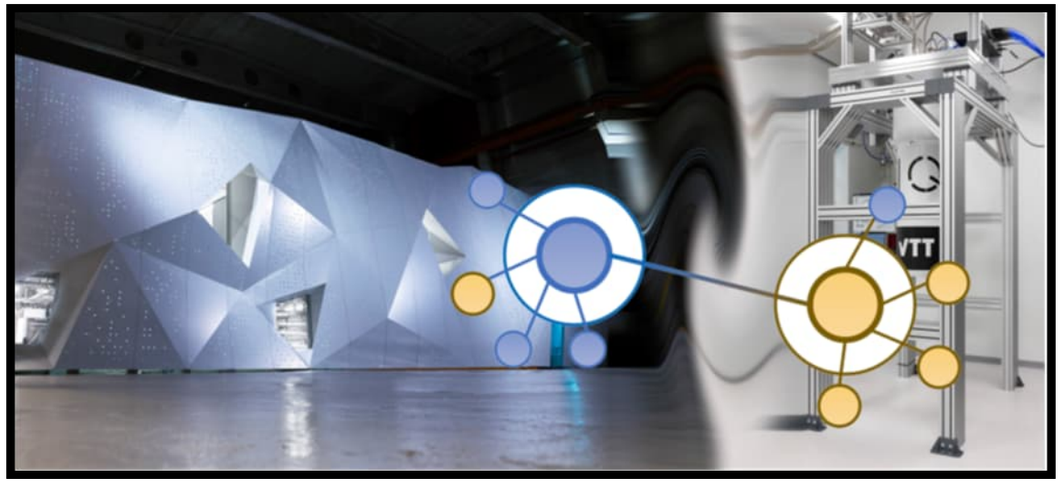
Connecting supercomputers with quantum computers

High-Performance Computing + Quantum Computing (HPC+QC)

LUMI

Quantum acceleration

- Quantum computers are performing computations in a completely different manner
- **For some types of calculations**, QC can potentially speed up calculations significantly
- **For most types of calculations**, QC provides *no* advantage over classical computing



LUMI and Helmi

→ **Hybrid HPC+QC is the future!**

- Quantum computers will merge with supercomputers, both need each other

- Finland is at the global forefront in developing HPC+QC
- LUMI connected to the Finnish quantum computers
  - 5 qubit Helmi, 53 qubit VTT Q50
  - Academic use through CSC
  - Commercial use through VTT


The Register

Tiny quantum computer plugs into top Euro supercomputer – because why not?

It's not how many qubits you've got, it's how you use them

Tobias Mann

Wed 2 Nov 2022 // 06:20 UTC

What is needed for quantum advantage

- **Deep understanding of the problem at hand:** classical modelling algorithms have been developed for a hundred years!
  - Need to know what the *actual* bottlenecks for present and future classical methods are and will be!
- **Deep understanding of the possible quantum solution at hand**
- **Understanding how to exploit "classical support software"**
  - **Pre- and postprocessing**
  - Compiling and transpiling quantum algorithms
  - Machine learning for creating quantum algorithms?
  - Error mitigation of the results, enhancing "signal to noise ratio"
- **Access to HPC+QC infrastructure**

Quantum computers are different

- From classical supercomputers
- **From each other**

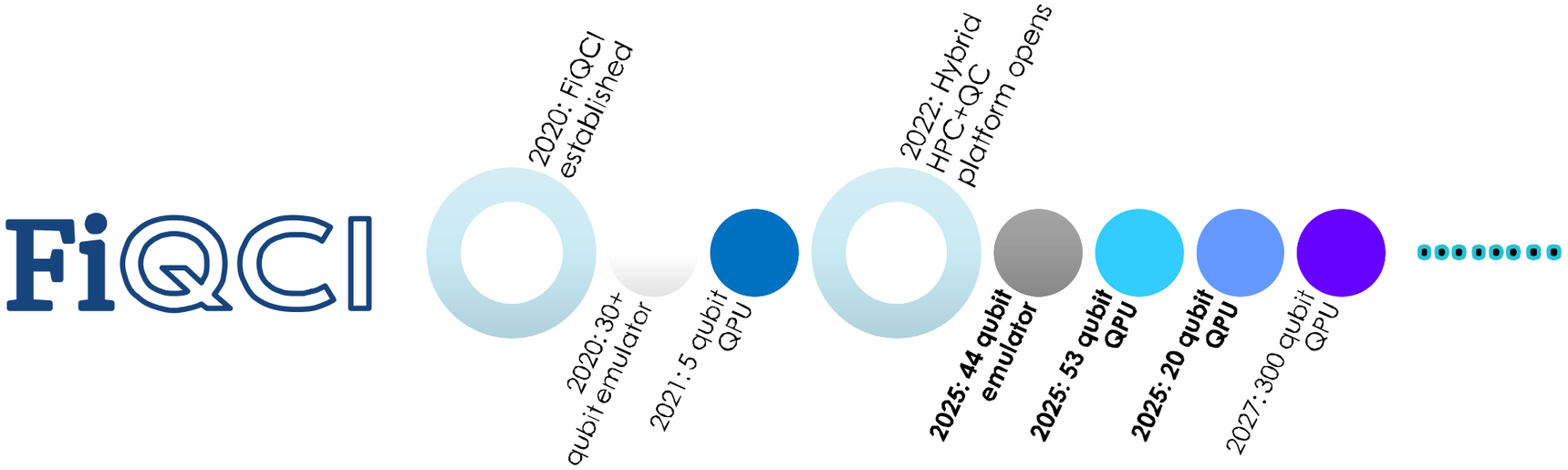
Users need access to several different quantum computers

CSC

The Finnish Quantum-Computing Infrastructure

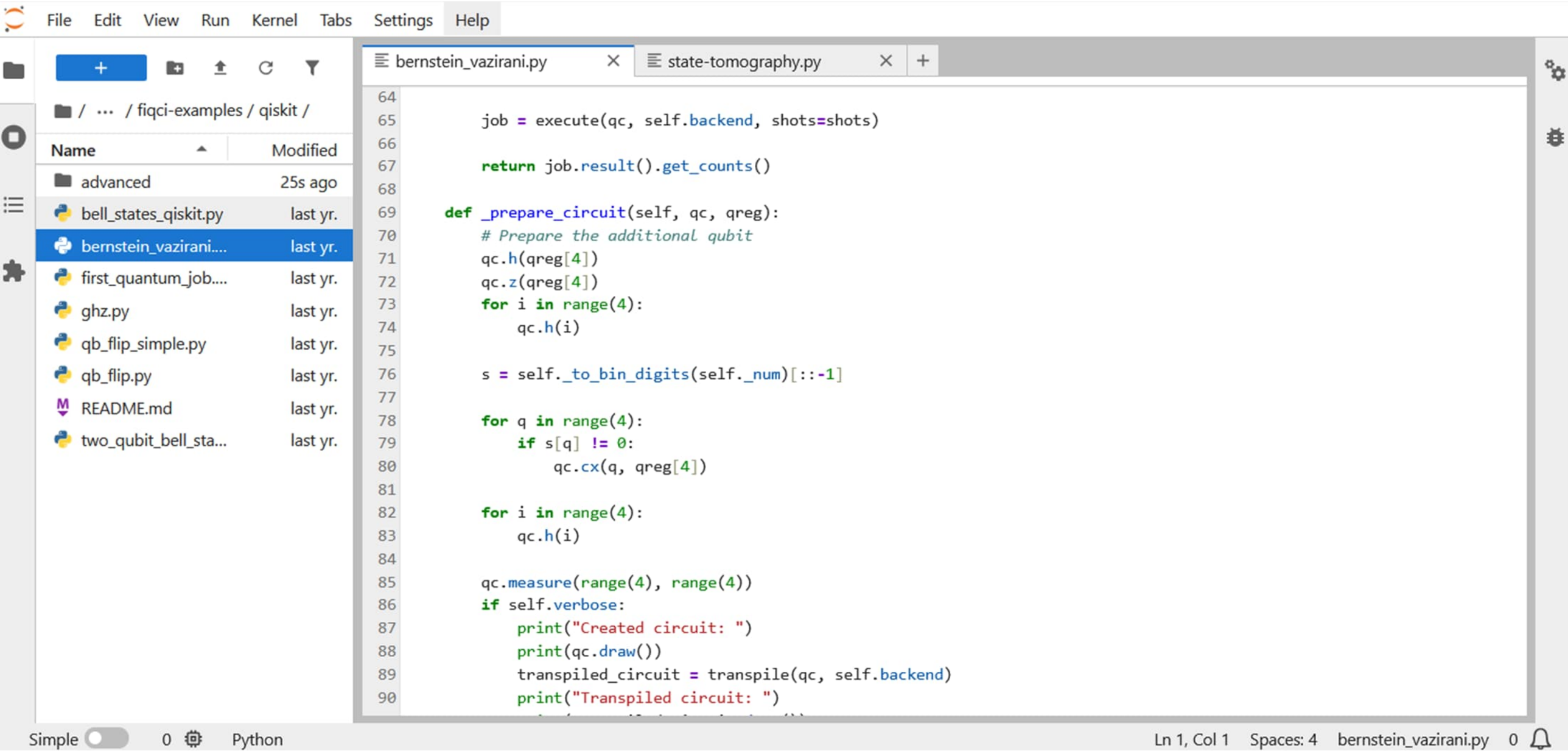
Founded by **VTT, Aalto University**, and **CSC** in 2020

- "The mission of FiQCI is to provide state-of-the-art quantum-computing services such as computing time and training"



- Access to Helmi through LUMI opened November 2022
- Access to VTT Q50 through LUMI opened July 2025

Access FiQCI HPC+QC from your browser: *www.lumi.csc.fi*



In Focus

28.5.2025
LUMI AI Factory

Latest news and articles

25.7.2025
Podcasts for summer

22.7.2025
ELLIOT project launches to build more responsible AI in Europe

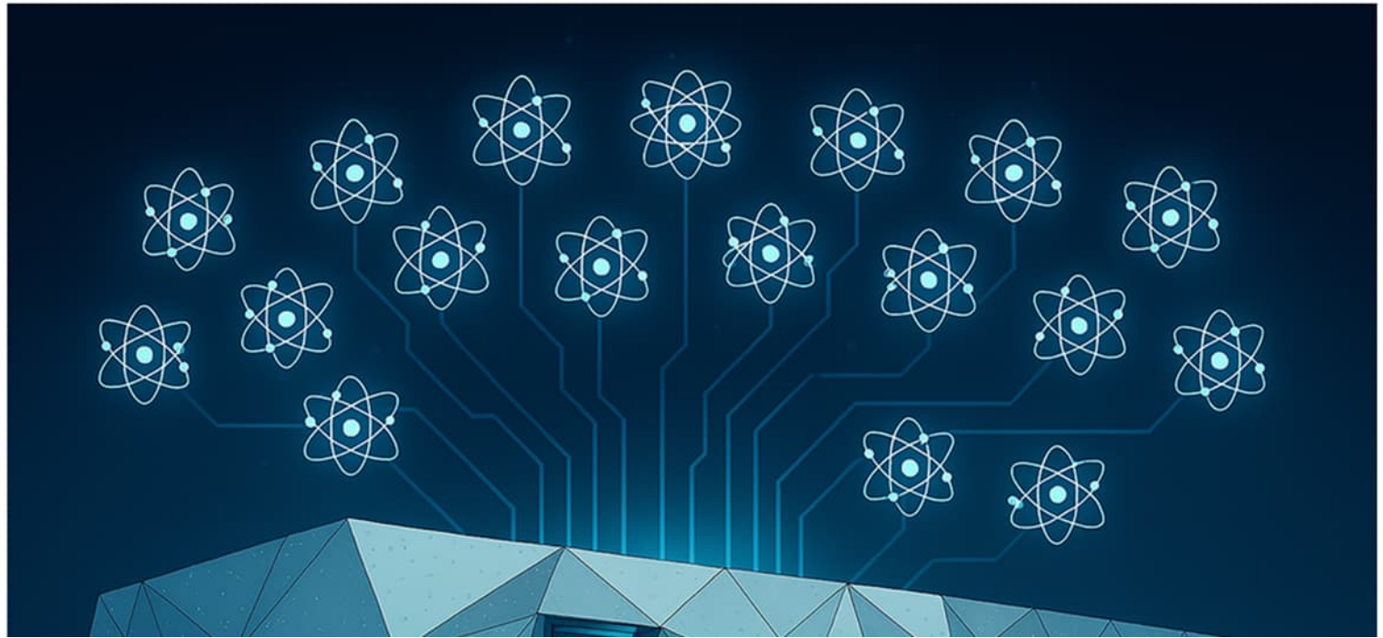
22.7.2025
Current open calls for LUMI resources

18.7.2025
LUMI supercomputer powers IQM's quantum processors optimisation

LUMI enables simulations of large-scale algorithms for quantum advantage

14.4.2025

Quantum computing holds the promise of revolutionising computational modelling. Recent progress in constructing quantum computers has been rapid – already now, science that previously was impossible can be performed on real quantum devices. What we still need, is a larger selection of quantum algorithms and software to drive quantum-accelerated supercomputing further. For this, tools for simulating the behaviour and performance of quantum algorithms on classical computers are crucial. Now, full simulation of quantum algorithms utilising up to 44 qubits can routinely be explored on the LUMI supercomputer, pushing the frontiers for the next generation of science and discovery.



Blog

Meeri Mäkitalo

Junior Application Specialist at CSC, Quantum Technologies

Q50 Dark matter Quantum sensing

Blog | Aug 21, 2025

Dark Matter Detection with Qubits

"What is dark matter?" is a question that as been asked by scientists for many years. Recently an interest has spiked on using qubits as sensors for finding dark matter. Superconducting qubits are used for searching for a specific type of dark matter particle, an axion. Axions are light particles that do not interact with "ordinary" matter easily. However, they can cause additional electrical currents while coupling to photons which could be sensed by a qubit. These signals are very weak and it has been proposed that the sensitivity of the qubit sensor system could be increased with a quantum circuit. In this blog post, an introduction to the basics of using qubits as sensors and an introduction to axion dark matter is given. The use of superconducting qubits for axion dark matter detection is also motivated and the circuit for the sensitivity enhancement is presented. The code for this circuit is also available so that anyone can run it on the VTT Q50 quantum computer.

Qubits as sensors

Read next:

Quantum Circuit-Knitting on FiQCI

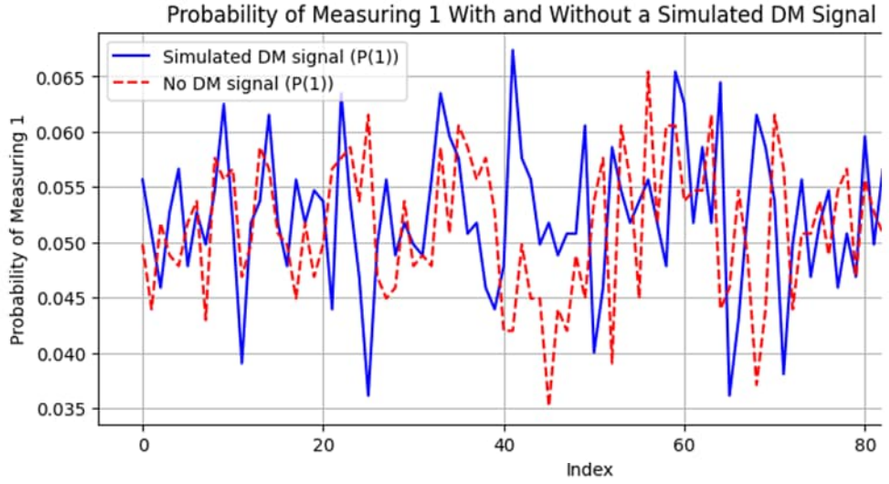
Blog | 27.8.2024

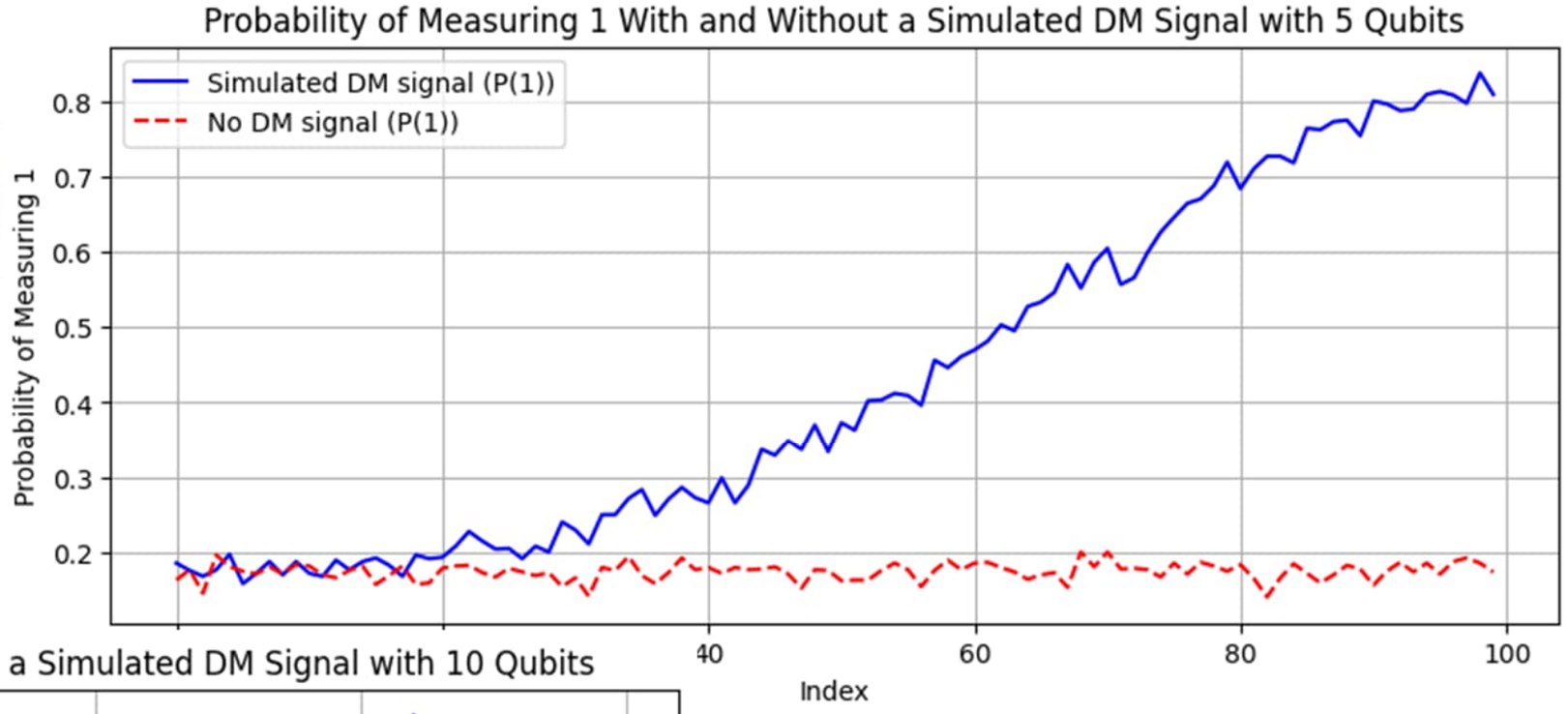
Why Qubit Layout Should Be Considered when Designing Quantum Circuits

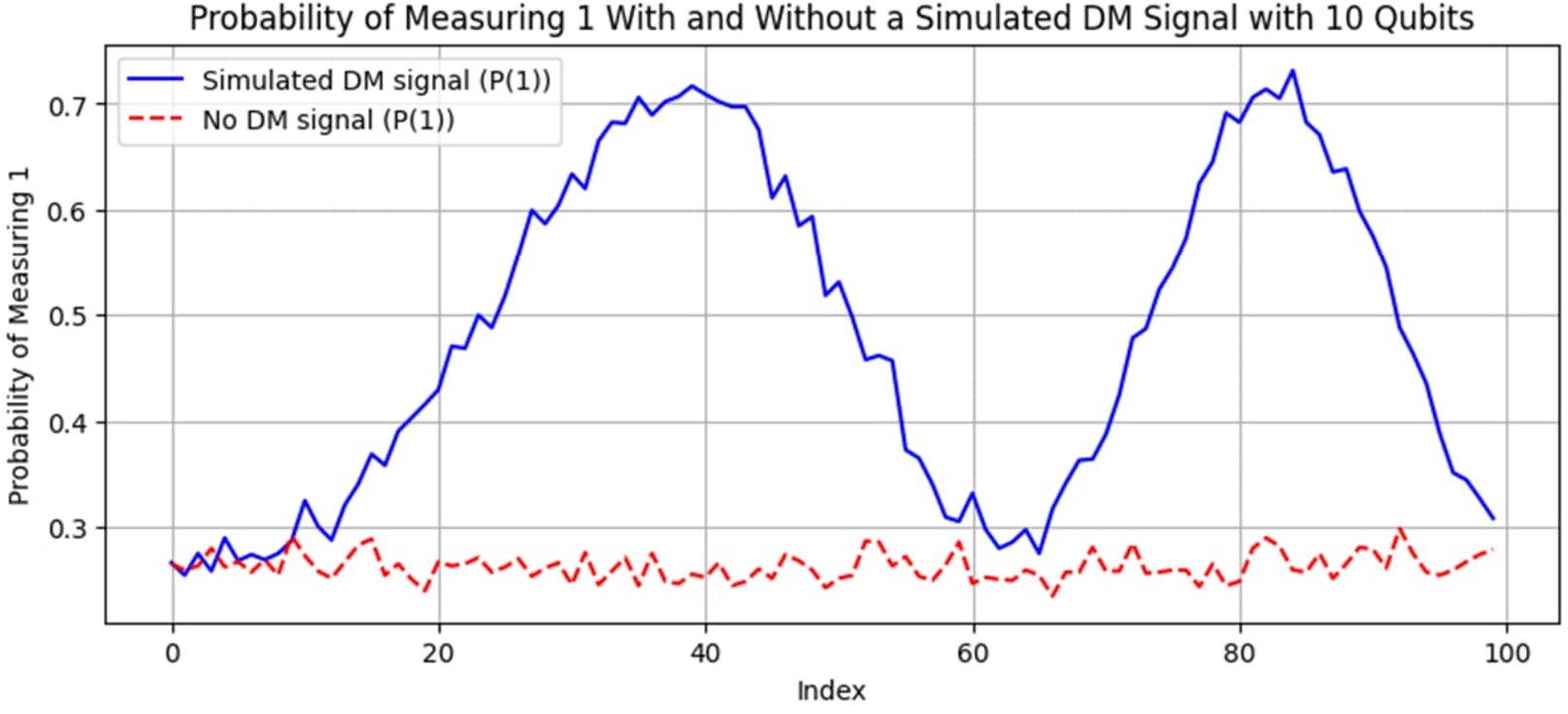
Blog | 29.8.2024

Open Call 1/2025 for Academic Projects for the VTT Q50 Quantum Computer

News | 4.3.2025


Probability of Measuring 1 With and Without a Simulated DM Signal
Simulated DM signal (P(1))
No DM signal (P(1))
Probability of Measuring 1
Index

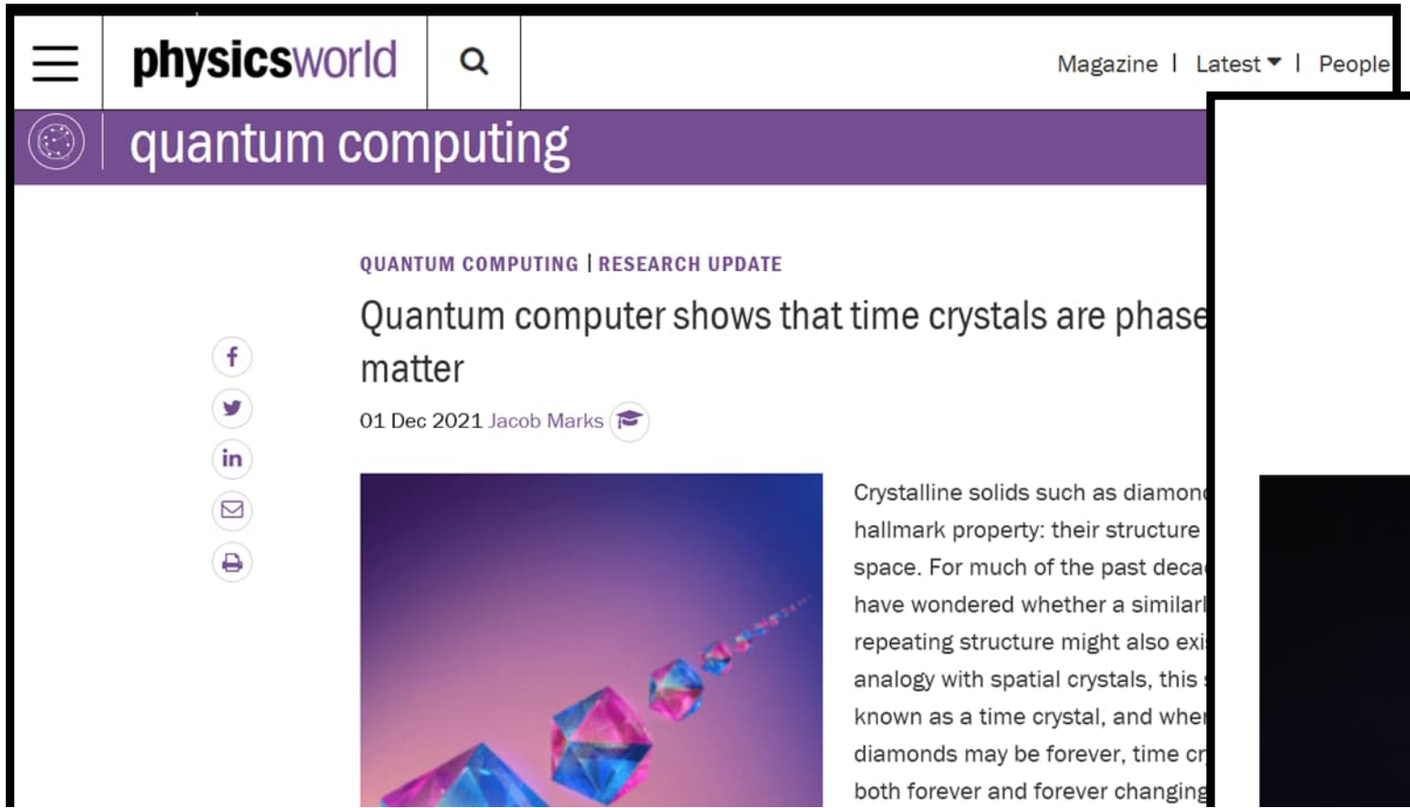

Probability of Measuring 1 With and Without a Simulated DM Signal with 5 Qubits
Simulated DM signal (P(1))
No DM signal (P(1))
Probability of Measuring 1
Index

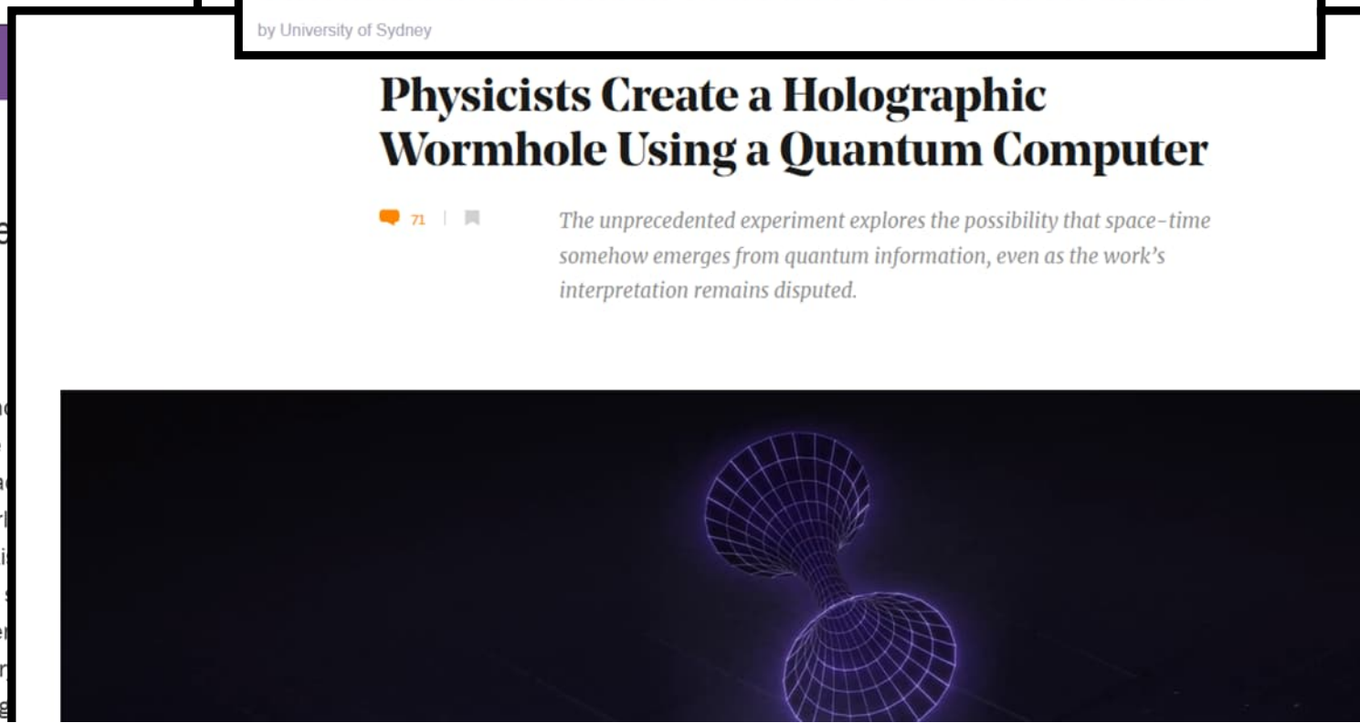

Probability of Measuring 1 With and Without a Simulated DM Signal with 10 Qubits
Simulated DM signal (P(1))
No DM signal (P(1))
Probability of Measuring 1
Index

Non-computing applications

Quantum computers are already providing quantum advantage

- **Enabling new type of quantum *experiments***
- Instead of using the computer to solve an algorithm, use the fine control for manipulating quantum states on the quantum processing unit (QPU)



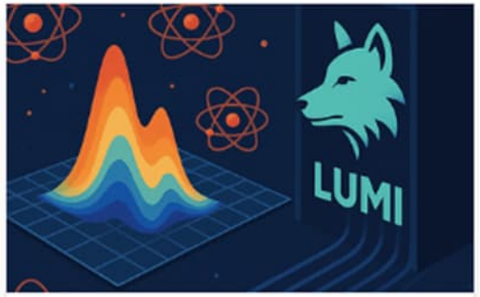


Dark Matter Detection with Qubits

Blog | 21.8.2025

Open Call 2/2025 for Academic Projects for the VTT Q50 Quantum Computer

News | 2.7.2025

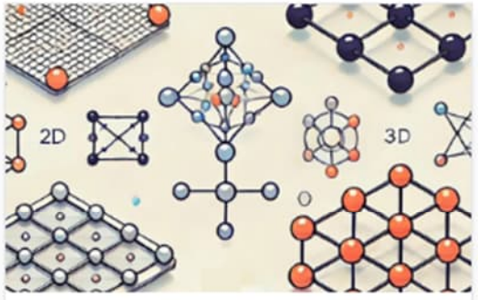


Breaking New Ground: Simulating Quantum Algorithms Up to 44 Qubits on LUMI

Blog | 1.4.2025

Open Call 1/2025 for Academic Projects for the VTT Q50 Quantum Computer

News | 4.3.2025



Why Qubit Layout Should Be Considered when Designing Quantum Circuits

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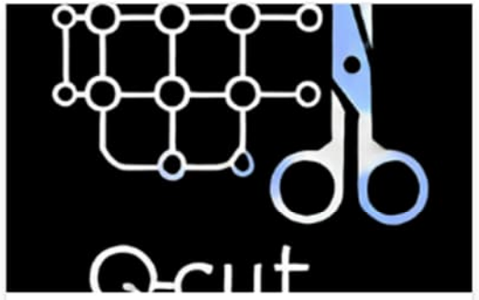
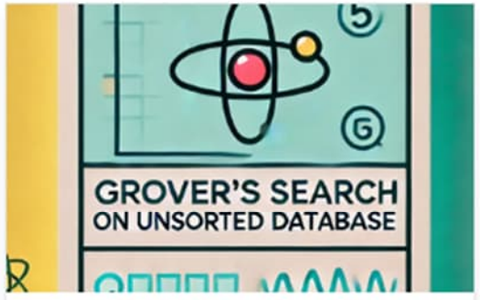


Quantum Circuit-Knitting on FiQCI

Blog | 27.8.2024



Quadratic Speedup Search Algorithm with [[4, 2, 2]] Quantum Error Detecting Code

Blog | 26.8.2024

Getting started with Helmi through LUMI web interface

Instructions | 23.8.2024

LUMI-Q

LUMI-Q consortium
LUMI consortium
LUMI-Q quantum computer
quantum computer
supercomputer

Inclusive

- Builds on the 11-country pan-European LUMI consortium

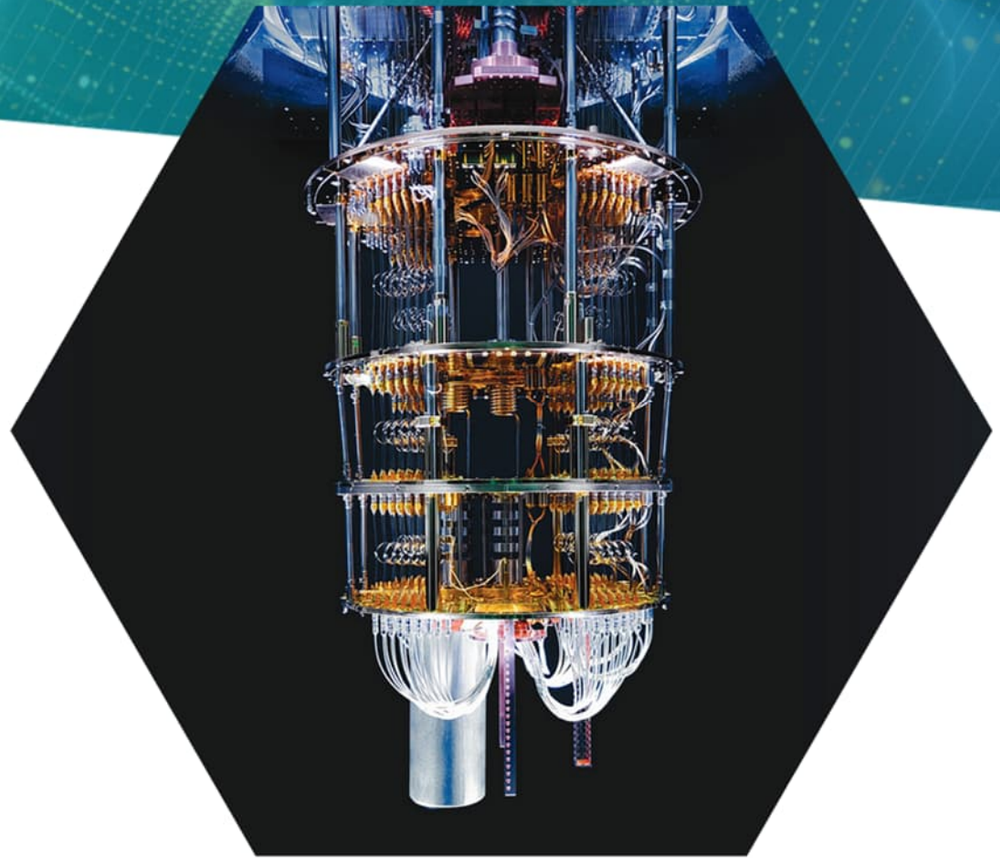
Diverse

- Getting several QCs to the fingertips of researchers and developers is crucial for catalysing software development.
- Different problems will fit different architectures **and software stack infrastructure** better

Accessible

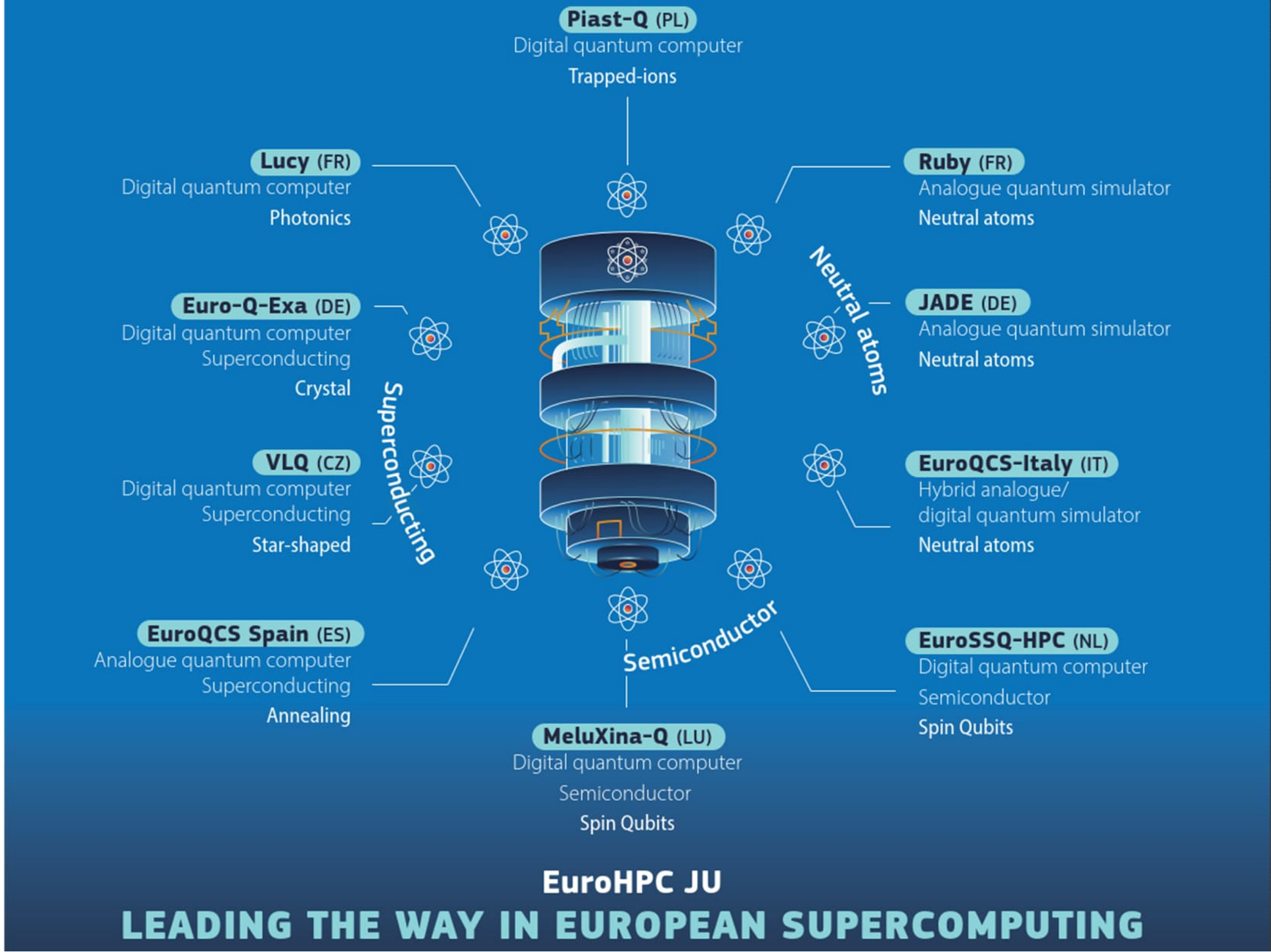
- By being available through several platforms distributed throughout Europe, LUMI-Q provides a familiar interface to a uniquely large user base

LUMI-Q CONSORTIUM: QUANTUM COMPUTER



VLQ, the quantum computer of the LUMI-Q consortium, will provide a European-wide quantum computing environment **integrated with the EuroHPC infrastructure**. VLQ will allow the integration of the targeted EuroHPC quantum computer into EuroHPC supercomputer KAROLINA in Czechia, LUMI in Finland, and EHPCPL in Poland.

The full EuroHPC QC family will be available to European users soon!



LUMI AI Factory

Vision

LUMI AI Factory

LUMI AI Factory

- The three pillars of LUMI AI Factory
  - AI-optimised supercomputer **LUMI-AI**
  - AI Factory **Service Center**
  - Experimental quantum-computing platform **LUMI-IQ**
- CSC (Finland) coordinates consortium with participation from Czechia, Denmark, Estonia, Norway and Poland
  - Other Finnish partners are FCAI (Aalto University, University of Helsinki) and AI Finland (Technology industries)
- Total budget over 612 million euros
  - EU 306.4 M€, FI 250 M€, CZ 11 M€, DK 10 M€, EE 5 M€, NO 20.4 M€, PL 10 M€
  - largest public computing ecosystem investment in Finland, among the largest in Europe
  - largest EuroHPC AI Factory investment
- Significant investment in talent and competence development

LUMI-IQ

Advanced AI-Optimised
Experimental Platform

LUMI-IQ: Quantum-enhanced AI within the LUMI-AI Factory

Set up a world-leading HPC+AI+QC infrastructure

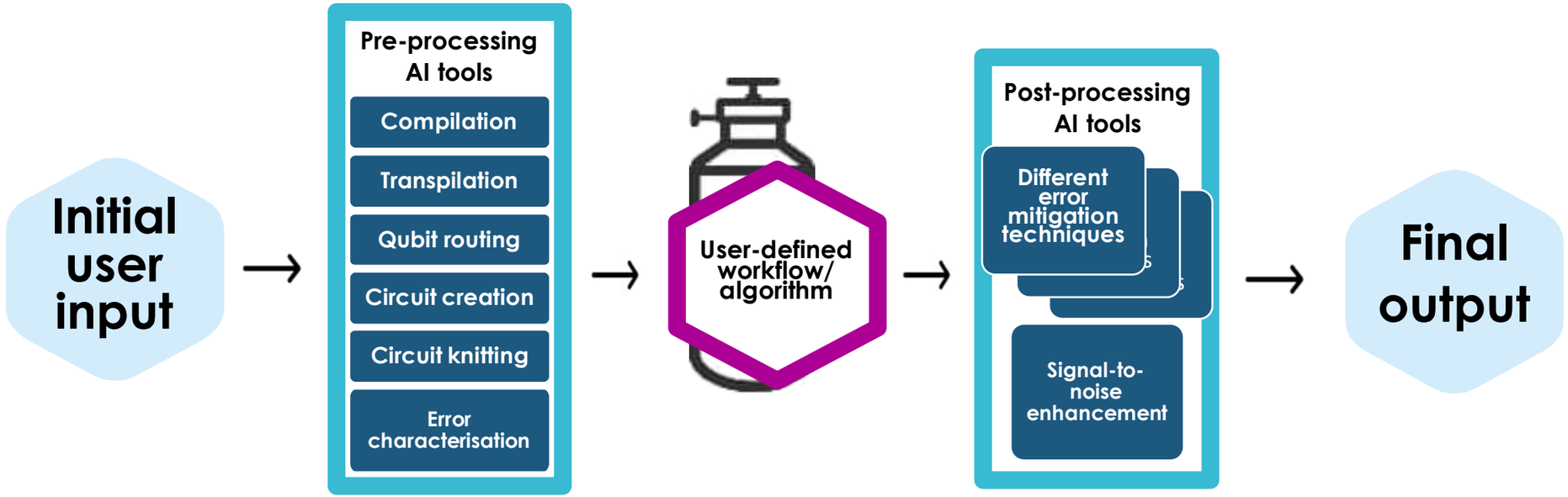
Accelerate AI development	Quantum AI software development and classical AI software development for quantum computing enhancement will get a significant boost from gaining **access to world-class HPC+AI+QC infrastructure.**
Establish new high-value commercial activities	The LUMI-IQ infrastructure, including user support and vetted use case libraries, will **aid industry in adopting quantum-accelerated AI** solutions in their service delivery, research, development, and innovation activities.

Accelerate development and uptake of useful QML and Quantum AI methodology, such as:

- Quantum Neural Networks (QNNs)
- Quantum Reinforcement Learning (QRL)
- **Quantum Reservoir Computing (QRC)**
- …

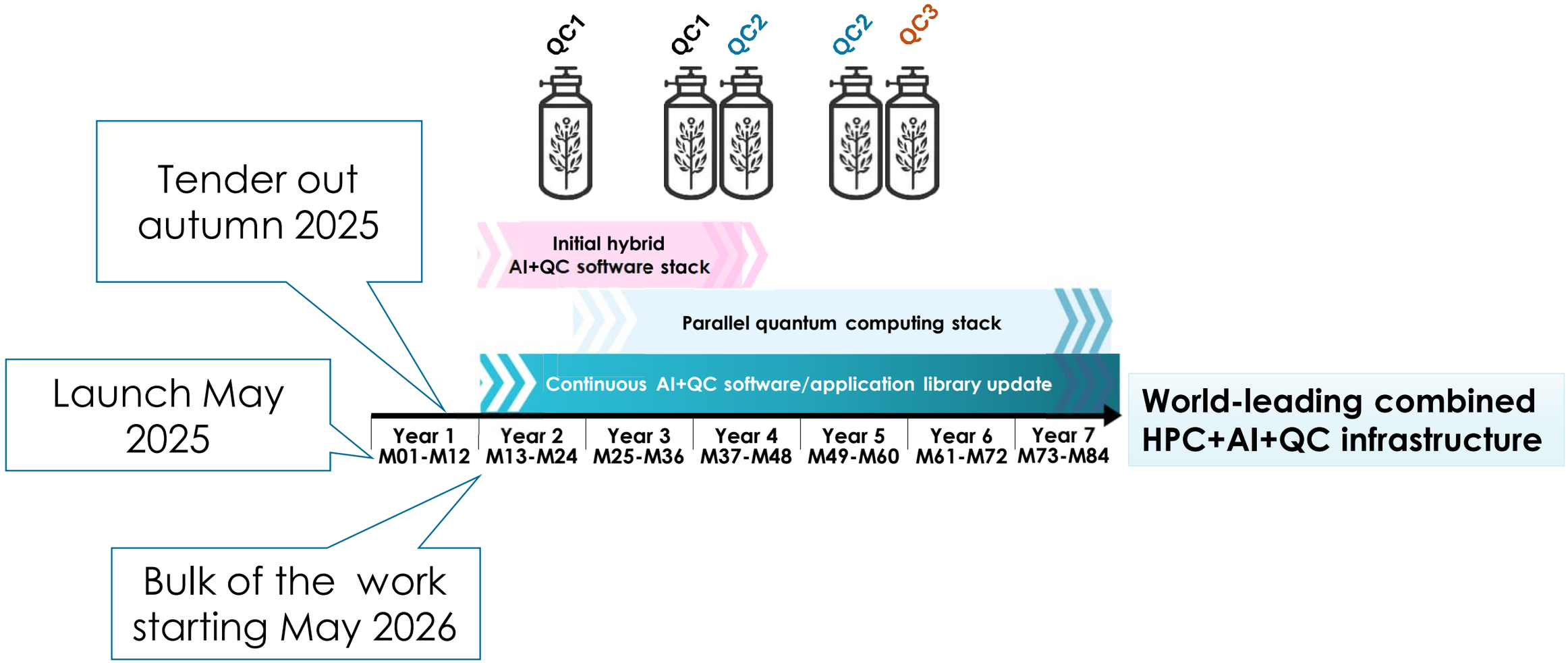
AI for QC

Goal: Set up a comprehensive supporting-software framework for quantum computing



- Default set of tools available and in use
- User configurable: on/off/replacement

Timeline for the LUMI-IQ Experimental Platform



Summary and Conclusions

Setting up the FiQCI HPC+QC infrastructure has been an exciting journey

Main lessons learned

- Need to be open-minded and actively think out of the proverbial box
  - QC is a completely different way of computing, counterproductive to try to replicate established classical implementations
- QC brings a completely new group of users to HPC centres
  - Need to be flexible and agile when setting up an appropriate service
  - Actively seek for feedback and development ideas from (potential) end-users
- To get the most utility out of quantum computing infrastructure, user support and training is crucial

Future

- Build up an HPC+QC infrastructure that matches end-user needs
  - **Including proactively creating services that our customers might not know they want, yet!**

Feedback

- We welcome feedback and comments! *fiqci-feedback@postit.csc.fi*
- *https://fiqci.fi*

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