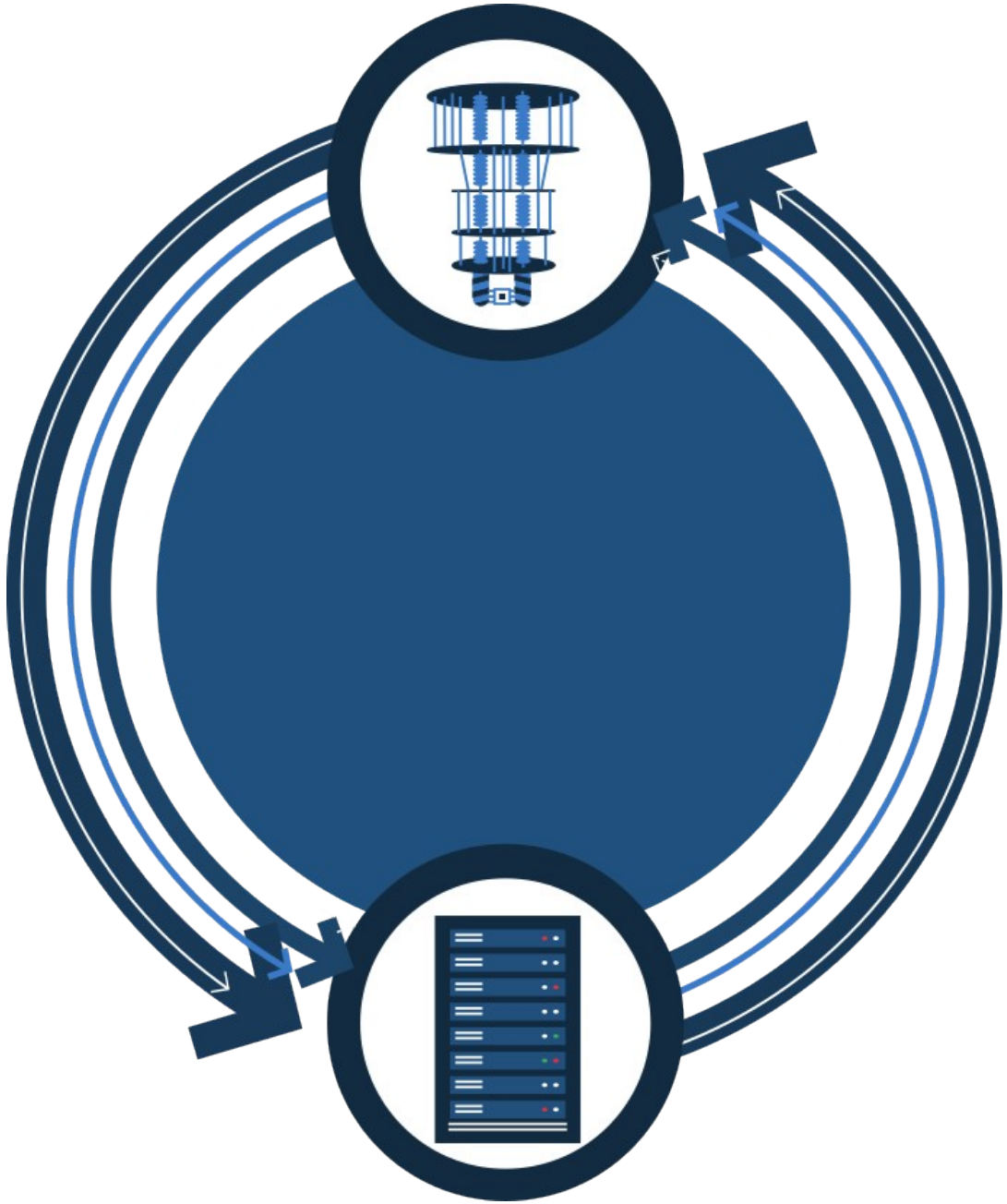
EuroSSQ-HPC:

Hybrid HPC-quantum computing



Ariana Torres Knoop

+100 institutions work together at SURF to develop ground-breaking ICT innovations for research and education.

→ SURF develops, implements and maintains the national research and education network (NREN) of the Netherlands

→ SURF provides IT infrastructure (network, data storage, data processing, etc)

→ SURF host and operates the National supercomputer Snellius

→ Soon to be host of a EuroHPC quantum computer

https://www.surf.nl/en

SURF and quantum

- **Drive innovation**
- **Provide a first class IT infrastructure to Research and Education (R&E)**
- **Facilitate adoption of quantum technologies**
- **Facilitate knowledge and expertise development around quantum technologies**

SURF and quantum

QUANTUM COMPUTING

Enable access and use of quantum infrastructure (emulators, simulators, computers)

Stimulate the development of quantum applications and use cases

Enable the implementation and execution of quantum applications

Support the integration of the quantum and classical IT ecosystems and infrastructure

QUANTUM COMMUNICATION

Understand how to build a reliable and specialized quantum enhanced network

Prepare for migration to quantum-safe infrastructure

Explore how quantum networks can support novel applications and workflows

Support ongoing research into next-generation quantum internet architectures

SURF

Why HPC-quantum computer at SURF?

EU positioning
Become a node in the European HPC-quantum infrastructure

Competitive advantage
Easy access for scientific users

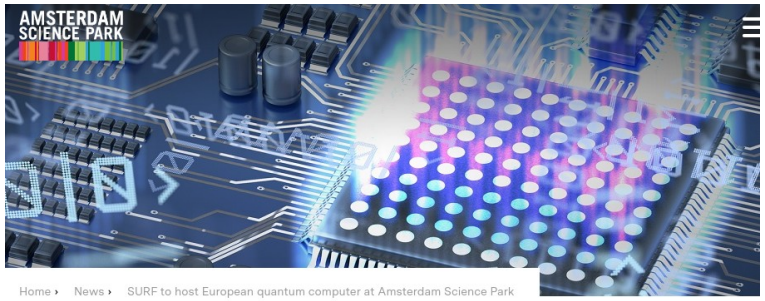
Capacity building
Development of experience with quantum technology

Extend and sustain a community of experts
Co-design the quantum infrastructure

Stay in the forefront
Leverage current position into European large-scale computing ecosystem

Prepare to take full-advantage
Opportunity to experiment, learn and develop expertise and capacity

SURF



Home › News › SURF to host European quantum computer at Amsterdam Science Park

October 23, 2024

SURF to host European quantum computer at Amsterdam Science Park

Deep Tech | Quantum technology and Quantum computing

SURF

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Nederland krijgt een grote Europese quantumcomputer

EMERCE TECH

Home/ Tech/ SURF gaat Europese kwantumcomputer in Amsterdam hosten

Nieuws - 23 oktober 2024 - 10:50

SURF gaat Europese kwantumcomputer in Amsterdam hosten

SURF gaat in Nederland een Europese kwantumcomputer hosten. De kwantumcomputer komt op Amsterdam Science Park te staan.

NOS Nieuws Sport Live Programma's

Voorpagina Amsterdam Verder in het nieuws Kunst & Media Uit in Amsterdam Log in

Nieuws

Amsterdam Science Park krijgt een van acht Europese quantumcomputers: 'Grote impuls voor de stad'

Amsterdam Science Park wordt de thuisbasis van een Europese quantumcomputer. Een grote stap, zowel voor de wetenschap als voor de stad, zegt hoofd *quantum* puting Ariana Torres-Knoop van Surf, een van de ren.

Het Parool

(N) nieuwsuur Vandaag in de uitzending

WOENSDAG

Nederland krijgt een van acht grote Europese quantumcomputers

fd. Mijn nieuws Net binnen Beurs Krant Podcasts FD Persoonlijk Abonneren

22 okt 12:01

Grote Europese kwantumcomputer komt naar Amsterdam

Jan Fred van Wijnen

Amsterdam is gekozen als locatie voor een van de kwantumcomputers die door heel Europa worde gebouwd. Brussel stimuleert de Europese ontwik

EuroHPC Joint Undertaking

Search

The European High Performance Computing Joint Undertaking (EuroHPC JU)

Home | About | Supercomputers | Access to Our Supercomputers | Research & Innovation | News & Events | Media | Documents | Contact

Home > New EuroHPC Quantum Computer to Be Hosted in the Netherlands

PRESS RELEASE | 22 October 2024 | European High-Performance Computing Joint Undertaking | 5 min read

New EuroHPC Quantum Computer to Be Hosted in the Netherlands

“The question is not longer only about theoretical capability but also practical applicability in real computing environments”

(HPCwire)

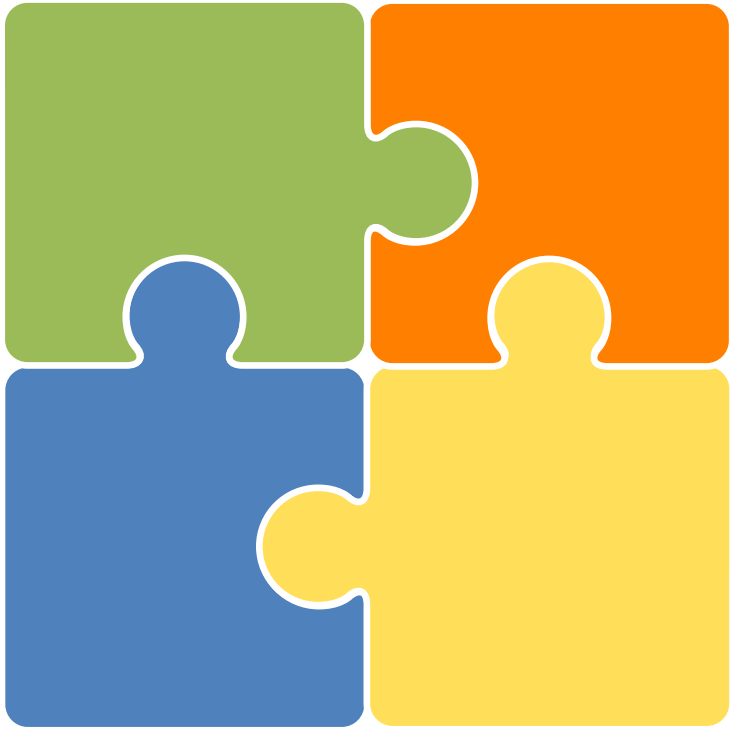
How do we get there? We need...

More and more robust qubits

Qubits are still very fragile

More algorithms

We need to continue develop fundamentally different algorithms for NISQ and FT



Robust software stack

We need to develop tools and libraries to enable the implementation of quantum algorithms

More applications

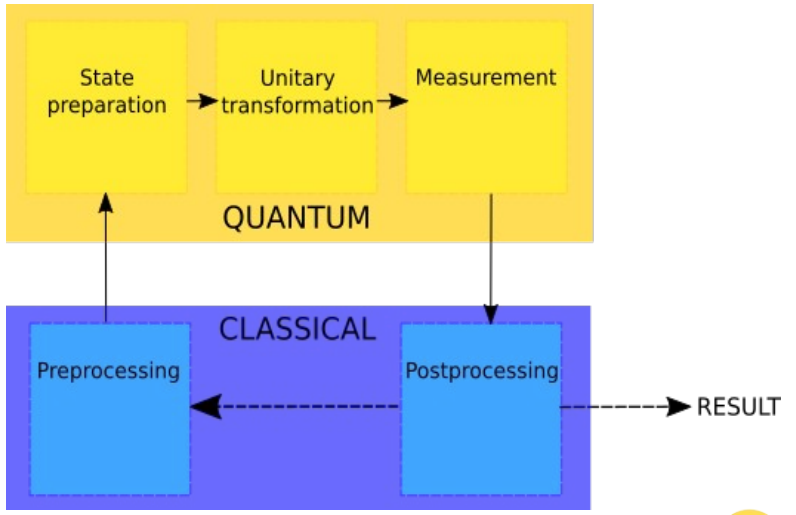
We need more applications to help guide the development of hardware and software

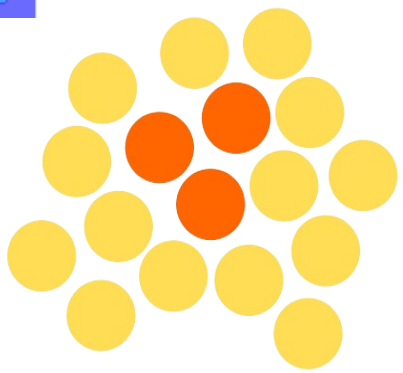
SURF

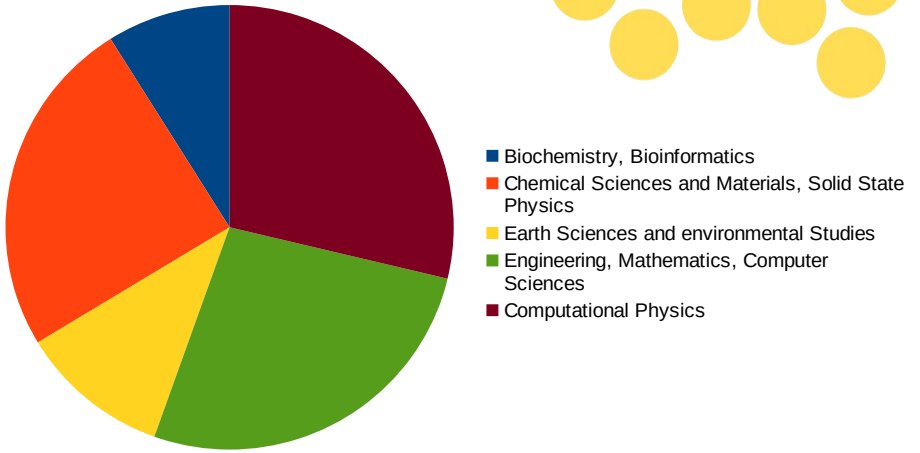
Integration to the existing classical ecosystem!
- Hardware, Facilities, Access, Software

Integration to classical ecosystem: HPC

- Hybrid quantum algorithms are currently the only way to exploit NISQ devices
- Quantum algorithms requires the support of classical resources
- The execution of quantum algorithms will most likely always be part of a larger hybrid workflow
- Many of the most promising applications of quantum computing overlap strongly with existing applications of HPC
- Simulation of quantum computers requires large computational resources
- User base and infrastructure







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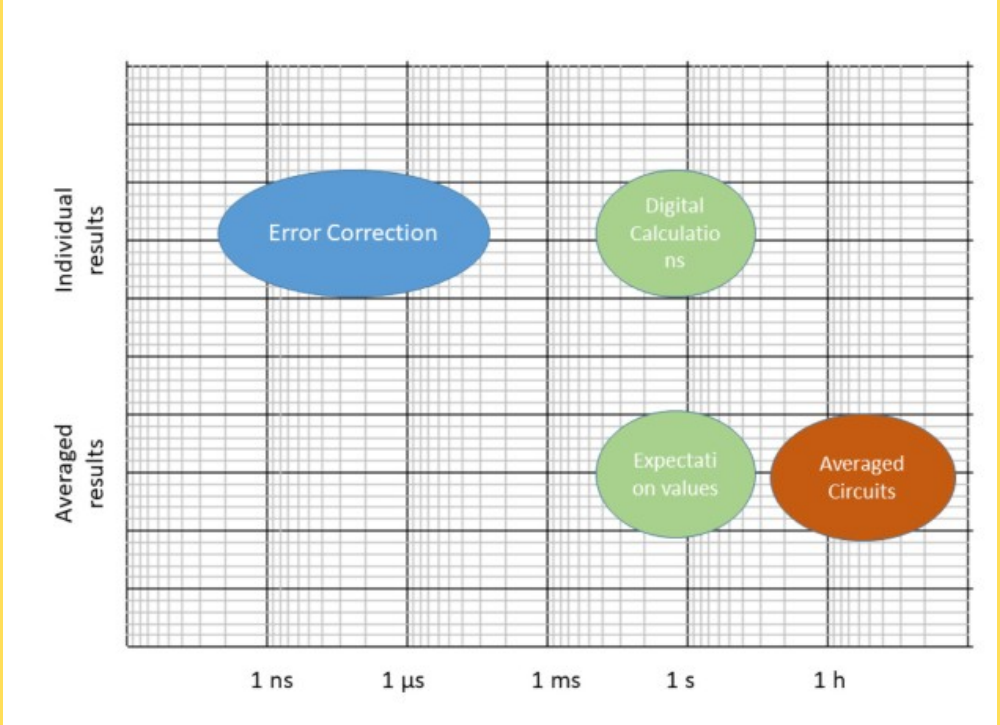
“Use of quantum computers to address existing computing challenges while leveraging the plethora of existing HPC tools, systems and workflows”

(2021 IEEE, Quantum Computers for High Performance Computing, Humble et al.)

SURF

Quantum for HPC, HPC for Quantum

- Usage of real quantum resources as accelerators: simulate quantum systems, optimizations, QML, CFD...
- Usage of classical resources to compute the theoretical output of a quantum algorithms
- Usage of classical resources for pre- post-processing (including error mitigation)
- Usage of classical resources for variational optimization
- Usage of classical resources for circuit cutting and knitting
- *Usage of classical resources for error correction (conditional preparation of quantum states based on intermediate measurements)*

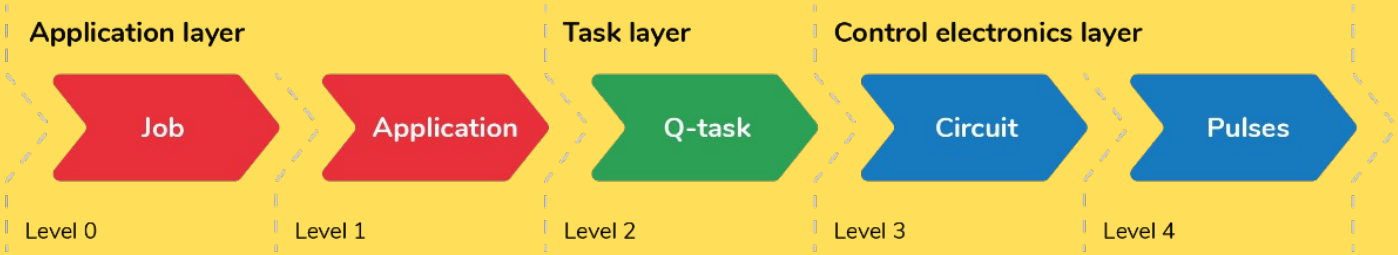


(2021 IEEE, Quantum Computers for High Performance Computing, Humble et al.)

What is the expected resource balance?
How tightly do the resources need to be coupled?
What is the latency needed?

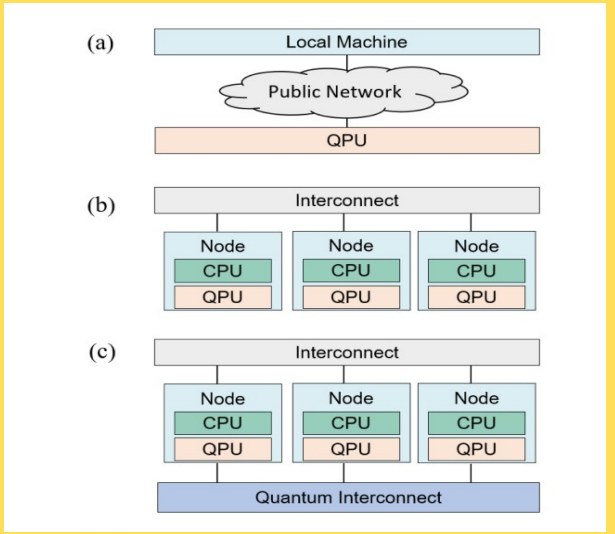
What is peculiar about Quantum?

- Tightly couple, unbalanced
- Scarce resource
- One user at the time
- Calibrations
- Non-homogeneous qubits
- …



→ More of a system-to-sytem integration

How should we schedule the jobs?
What needs to be optimized?
How do we share resources?
Access and authentication?
Resource monitoring?
How should the macro and micro architecture look like?



(2021 IEEE, Quantum Computers for High Performance Computing, Humble et al.)

EuroHPC quantum infrastructure

EuroQ-Exa, LRZ
Superconducting
+50 qubits, lattice,
IQM

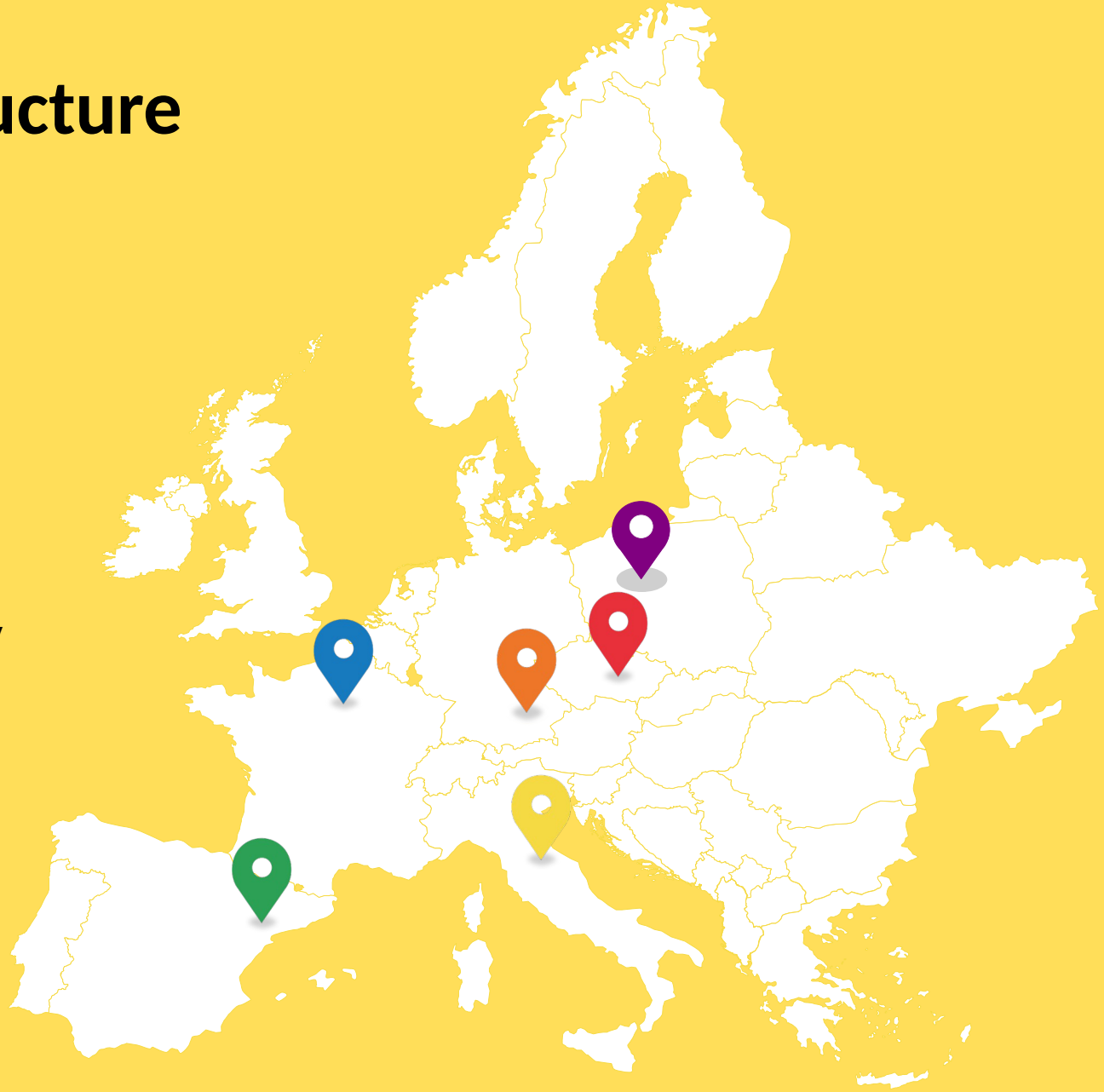
EuroQHPC-Spain,
BSC,
Superconducting
analogue

EuroQHPC-Italy,
CINECA
Neutral Atoms

EuroQHPC-Poland,
PSNC, Trapped ions

EuroQHPC-France,
GENCI, Photonics,
Quandela

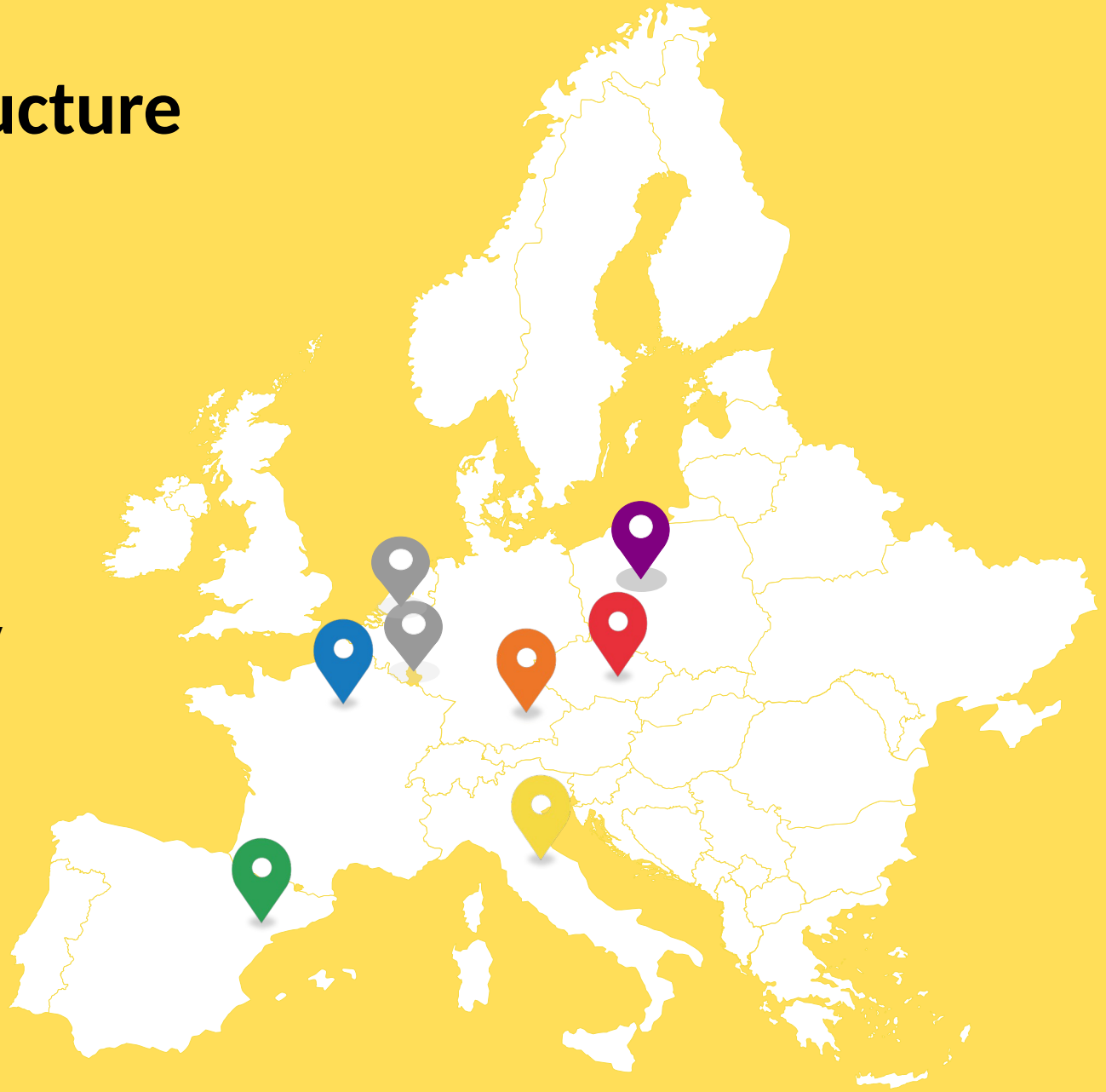
LUMI-Q, IT4I,
superconducting fully
connected (star-
shape), IQM



SURF

EuroHPC quantum infrastructure

- EuroQ-Exa, LRZ Superconducting +50 qubits, lattice, IQM
- EuroQHPC-Spain, BSC, Superconducting analogue
- EuroQHPC-Italy, CINECA Neutral Atoms
- EuroQHPC-Poland, PSNC, Trapped ions
- EuroQHPC-France, GENCI, Photonics, Quandela
- LUMI-Q, IT4I, superconducting fully connected (star-shape), IQM
- EuroSSQ-HPC, SURF, Spin Semiconducting
- MeluxinaQ, LuxProvide, Spin Semiconducting



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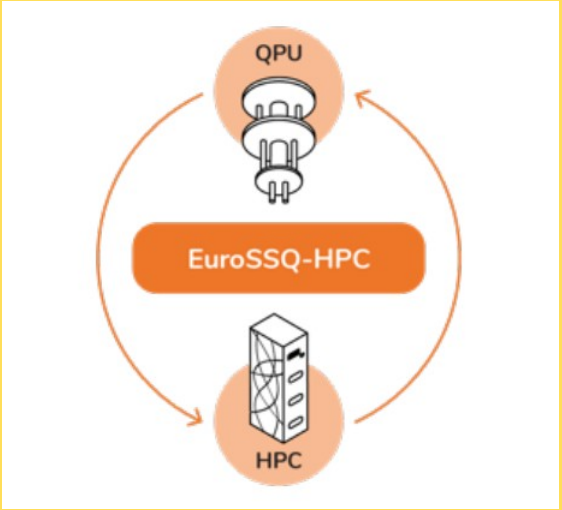
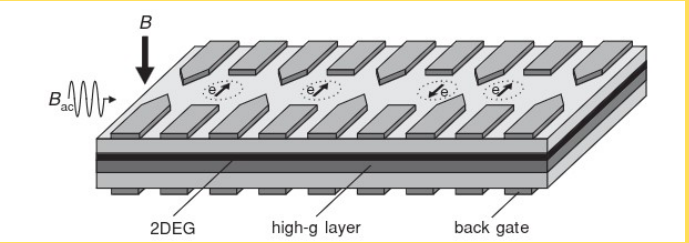
EuroSSQ-HPC



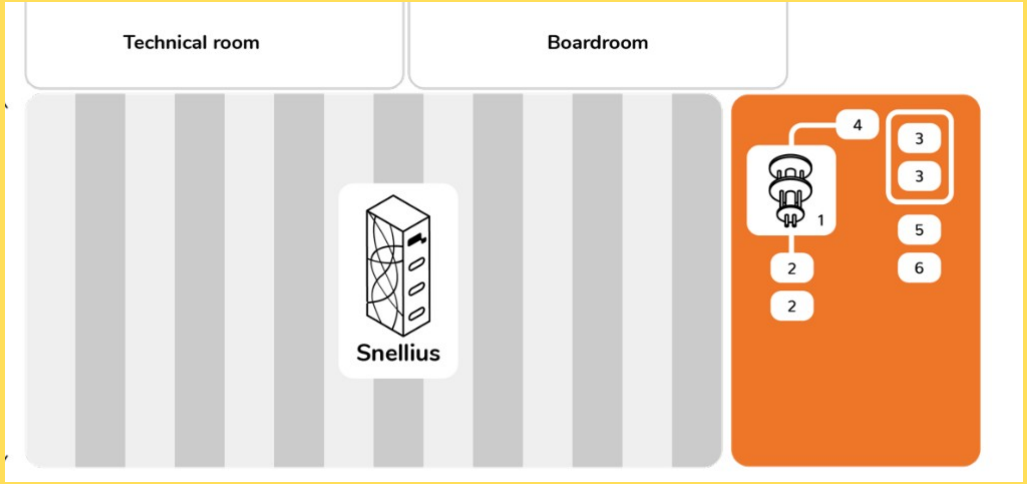


Semiconductor Few-Electron Quantum Dots
as Spin Qubits, J.M. Elzerman et al.

Consortium
University of Antwerpen (BE),
GENCI (FR),
NL eScience Center (NL),
Leiden University, aQa (NL),
Delft University of Technology (NL),
National Institute of Subatomic Physics, UM (NL)
SURF (NL)

System
Spin Semiconducting qubits (+16)

Location
Amsterdam Science Park, DigitalRealty Data Center



SURF

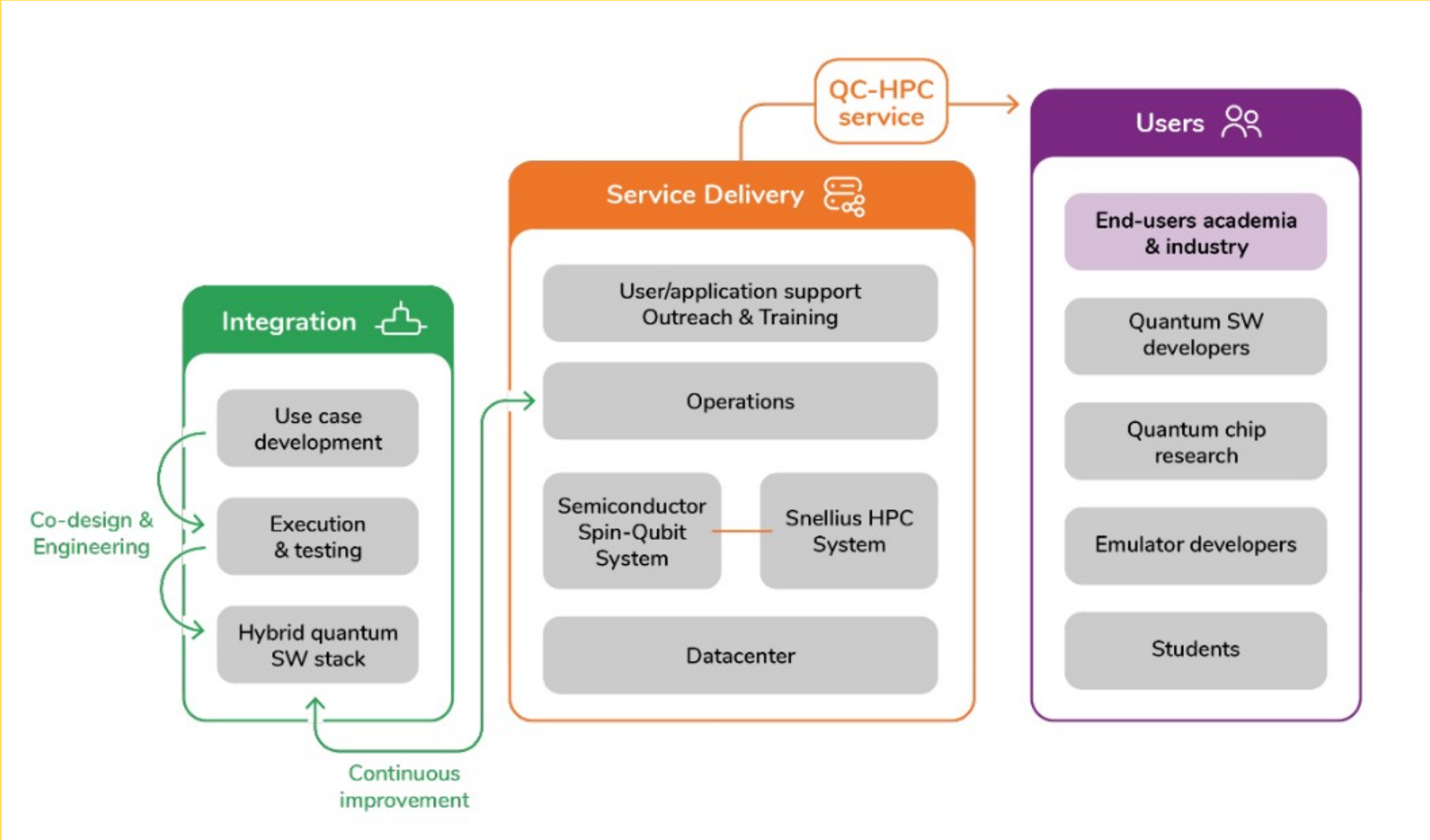
Spin Semiconducting qubits

- **Si or Si/Ge**
- Fast gates → allow for longer circuits
- Relatively long coherence times
- Small qubits → millions in one chip
- Compatible with current semicon technology and industry
- Potentially can operate at relatively high temperature (4K)
- Greater controls due to isolation of individual electrons

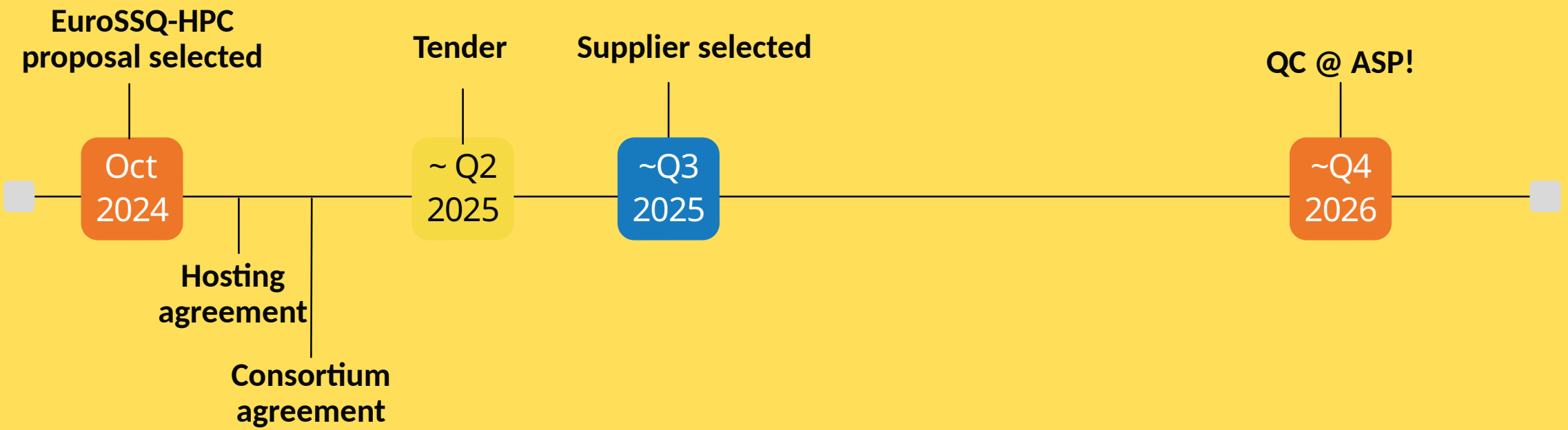
https://www.youtube.com/watch?v=y9dt5uTvsEM
https://www.youtube.com/watch?v=fBnKec6uI0U
https://www.youtube.com/watch?v=Re4l22ycc-k
https://www.youtube.com/watch?v=lPqd7A8mAzg
https://www.youtube.com/watch?v=SI4gQ-kYXLI

SURF

Our approach



Timeline


EuroSSQ-HPC proposal selected
Oct 2024
Hosting agreement
Consortium agreement
Tender
~ Q2 2025
Supplier selected
~Q3 2025
QC @ ASP!
~Q4 2026