Quantum Computing Roadmap of the Jülich Supercomputing Centre

Discussion JSC – ParTec – Wigner Data Center Budapest | December 6, 2023 | KRISTEL MICHIELSEN

Member of the Helmholtz Association

JÜLICH
Forschungszentrum

JSC's Quantum Computing Strategy

Four Pillars

I. Modeling and emulation (since 2004)

II. Provision of QC systems (since 2016)

III. HPC-QC integration (since 2017)

IV. Creation of a quantum computing user infrastructure (since 2016)

JSC — Jülich Supercomputing Centre (JSC)

Quantum Computing user infrastructure (JUNIQ)

High Performance Computing (HPC) user infrastructure

JUNIQ – Jülich UNified Infrastructure for Quantum computing

JSC's Quantum Computing Strategy
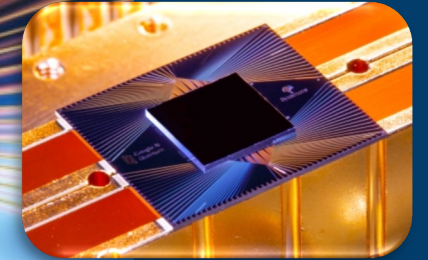
Pillar I: Modeling and emulation

Development of software to

▶ **validate** designs of quantum processors

▶ **investigate the performance of quantum algorithms**

Our emulator JUQCS

"Jülich Universal Quantum Computer Simulator"

WORLD RECORD

Benchmarking Google's quantum processor Sycamore

F. Arute et al., *Quantum supremacy using a programmable superconducting processor*, Nature 574, 505-510 (2019)

JSC's Quantum Computing Strategy

Pillar II: Provision strategy

Quantum annealer

Analog quantum computer with superconducting qubits

Hosting since 2021

Quantum simulator / computer

Analog /digital quantum computer with neutral atom qubits

Hosting planned for December 2023

Quantum computer

Digital quantum computer with trapped ion qubits

Hosting planned for 2024

or superconducting qubits, ...

Cloud access planned for 2023 - 2026

Co-evolution

Diversity of QC systems is in the interest of users and reduces risk.
Users acquire expertise and contribute to the co-design feedback loop.

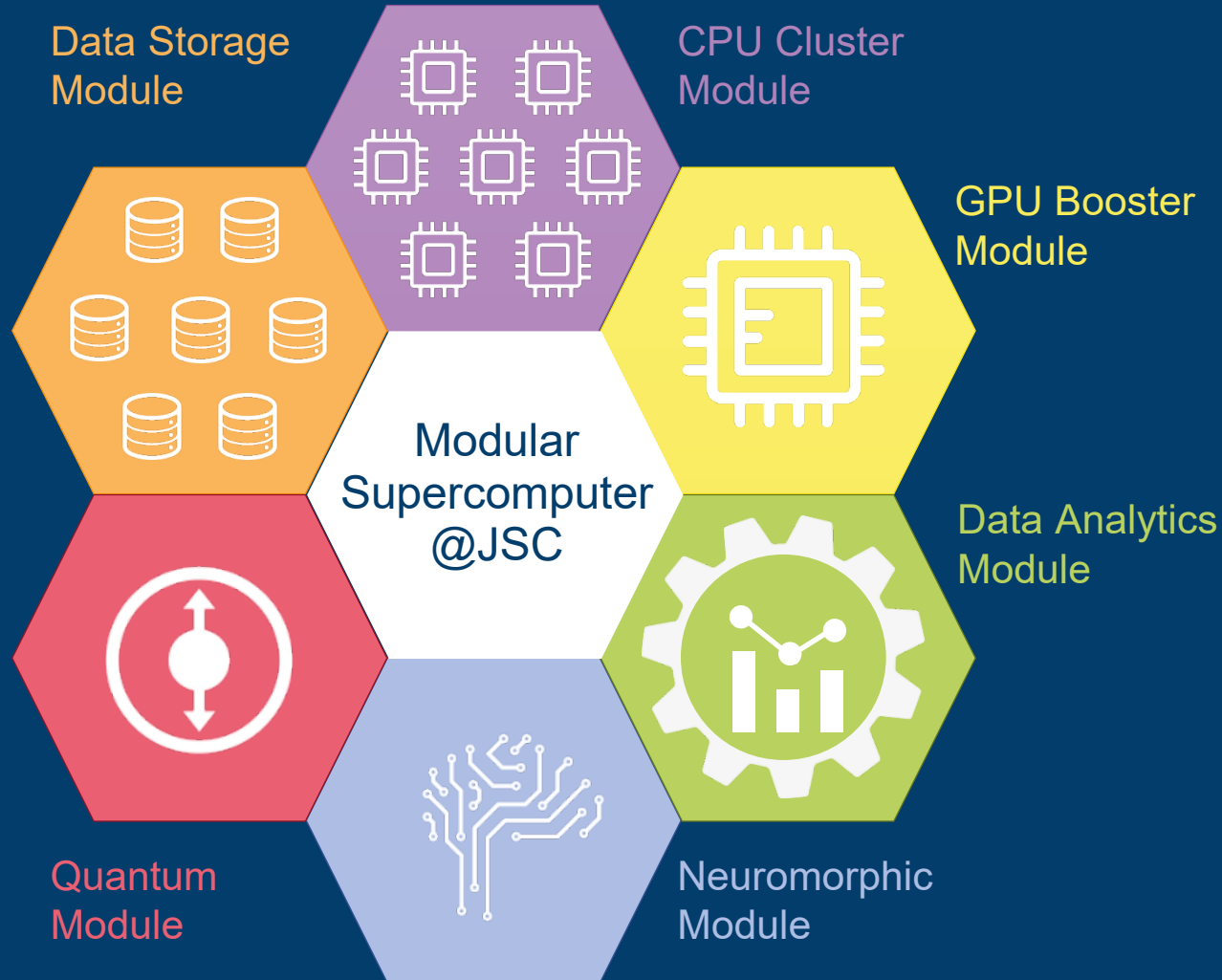# JSC's Quantum Computing Strategy

Pillar III: HPC-QC integration

For practical quantum computing …

the best of both computer technologies must be combined

JSC's Quantum Computing Strategy

Pillar III: HPC-QC integration

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

HELMHOLTZ QUANTUM

Data Storage Module

CPU Cluster Module

GPU Booster Module

Modular Supercomputer @JSC

Data Analytics Module

Quantum Module

Neuromorphic Module

▶ Pushing for the tightest possible integration of quantum computers into the HPC environment

▶ Modular supercomputing architecture is ideal for integrating quantum computing capabilities into HPC workflows

JÜLICH Forschungszentrum | JUNIQ QUANTUM USER FACILITY

JSC's Quantum Computing Strategy

Pillar IV: Creation of a quantum computing user infrastructure - JUNIQ

1. QC user facility for science and industry

2. Installation, operation and provision of QCs

3. Unified portal for access to QC emulators and to QC devices at different levels of technological maturity (QC-PaaS)

4. Development of algorithms and prototype applications

5. Services, training and user support

6. Modular quantum-HPC hybrid computing

Rolling call for peer-reviewed access:

https://www.fz-juelich.de/ias/jsc/juniq

JUNIQ Building

Built 2020 - 2021

2021   2024

JUNIQ - Jülich UNified Infrastructure for Quantum computing

High Performance Computer and Quantum Simulator hybrid

High Performance Computer and Quantum Simulator hybrid
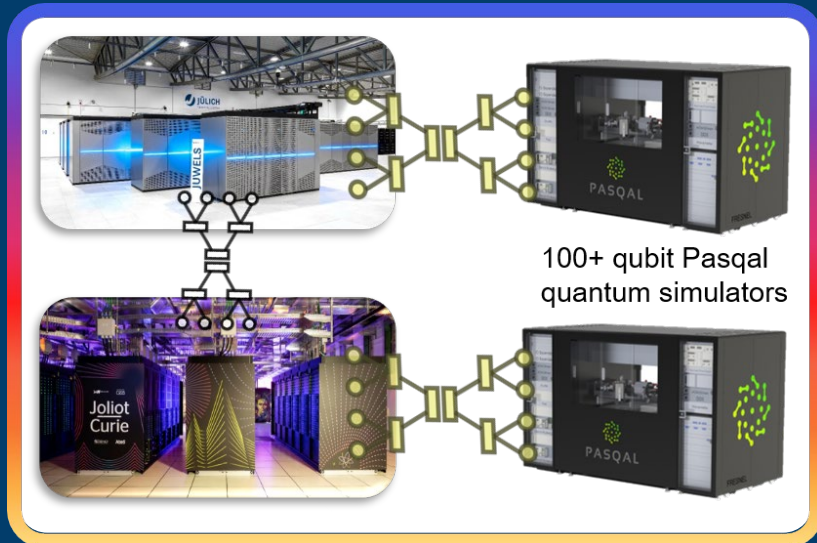
Integration of HPC and QC

⟨HPC|ₒS⟩   EuroHPC Joint Undertaking

Duration and Partners

▶ December 1st, 2021 - November 30th, 2025

▶ Coordinator: Forschungszentrum Jülich GmbH

▶ 5 partners + 3 linked 3rd parties from 6 countries

Project Aim

100+ qubit Pasqal quantum simulators

JÜLICH Forschungszentrum
GENCI
AtoS
cea
cnrs
ICHEC Irish Centre for High-end Computing
universität innsbruck
EURICE European Research and Project Office GmbH
Consiglio Nazionale delle Ricerche
FLYSIGHT
parityqc
Inría
BSC Barcelona Supercomputing Center Centro Nacional de Supercomputación
CINECA
Fraunhofer IAF

ParTec Modular Supercomputing
SORBONNE UNIVERSITÉ
CentraleSupélec

JÜLICH Forschungszentrum | JUNIQ QUANTUM USER FACILITY

European Federated Hybrid HPC/QC Infrastructure
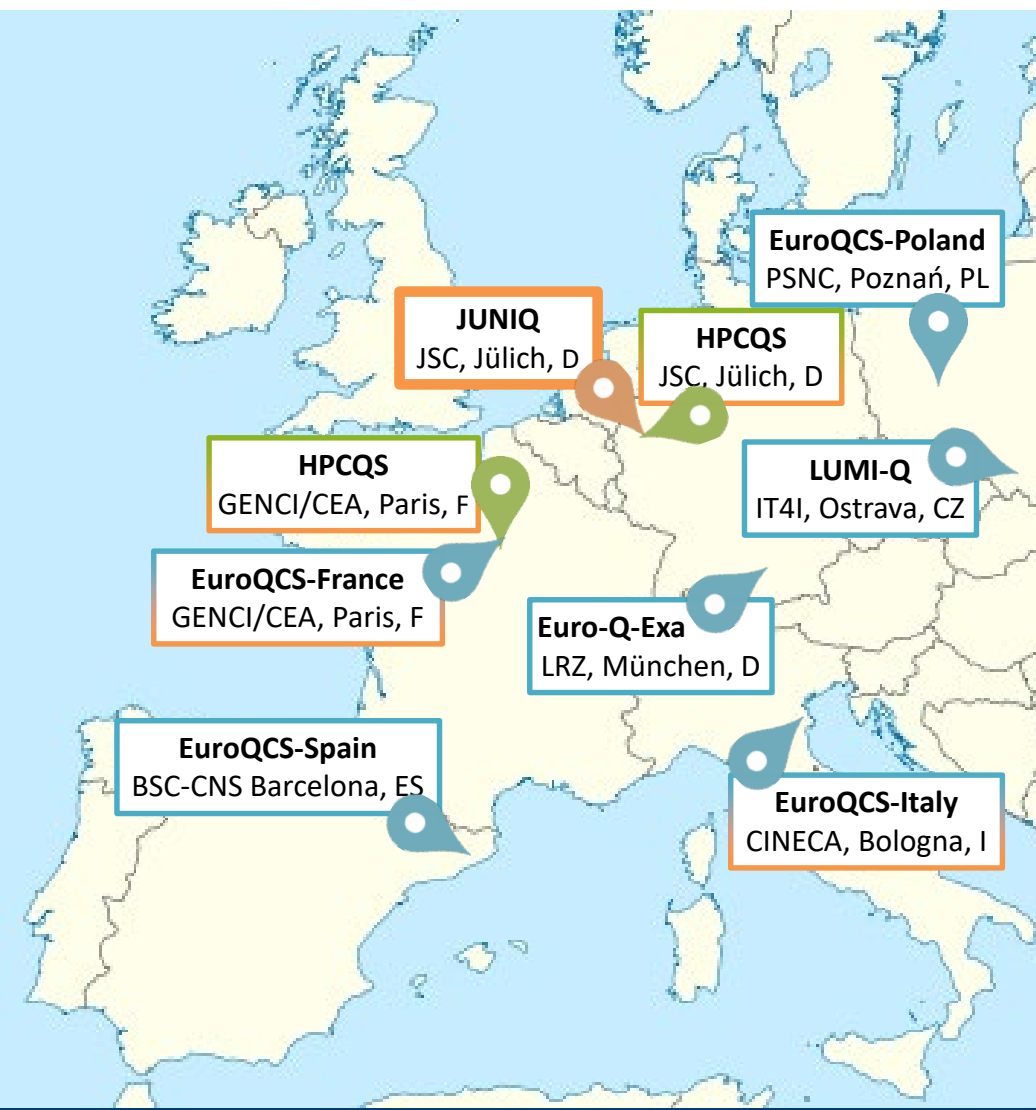
Perspective: European Federated Hybrid HPC/QC Infrastructure

When and for whom?