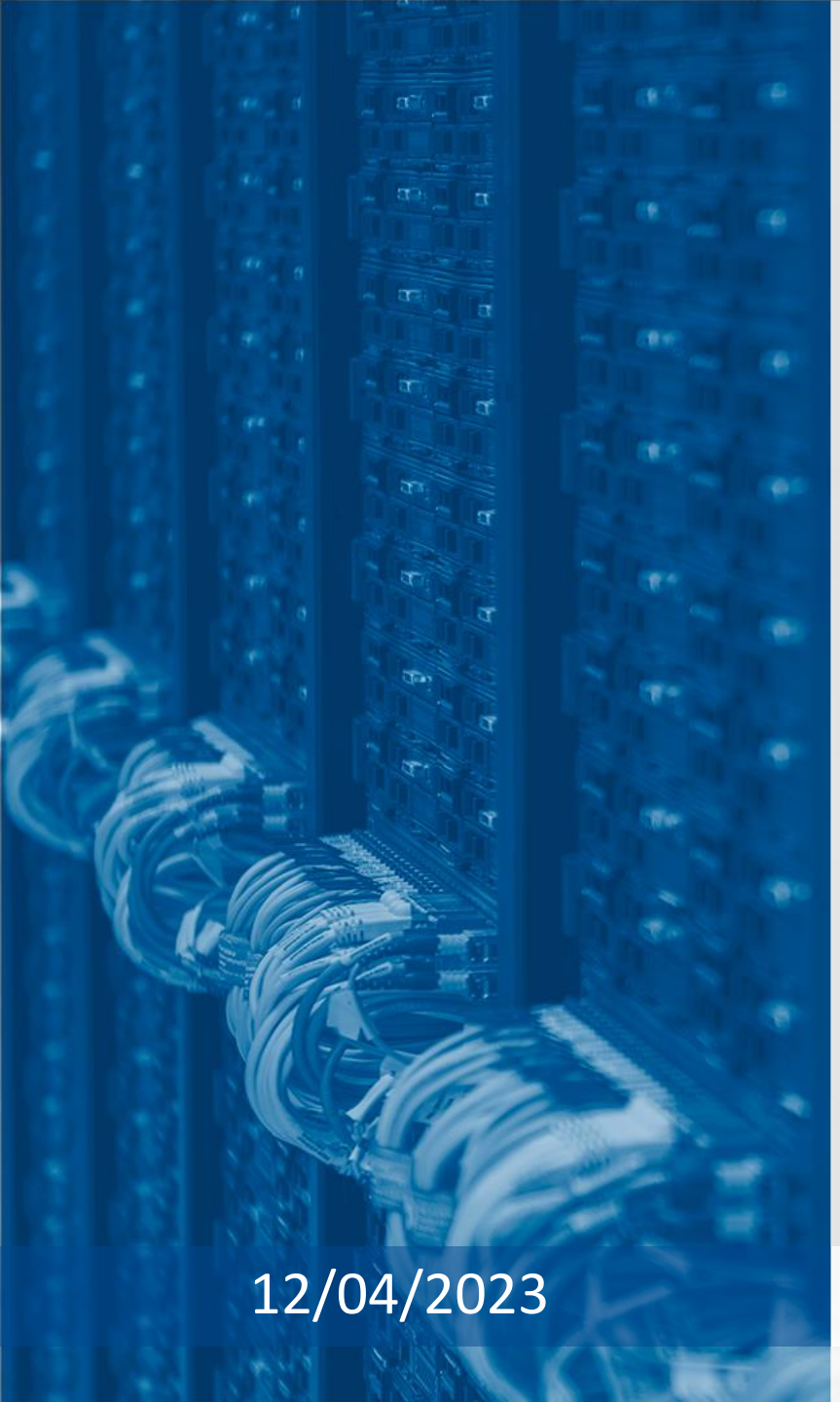

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Quantum Algorithms I and II

Alba Cervera Lierta

Senior researcher at BSC-CNS and Quantum Spain coordinator

12/04/2023

Sping School Superconducting Qubit Tech CCBPC

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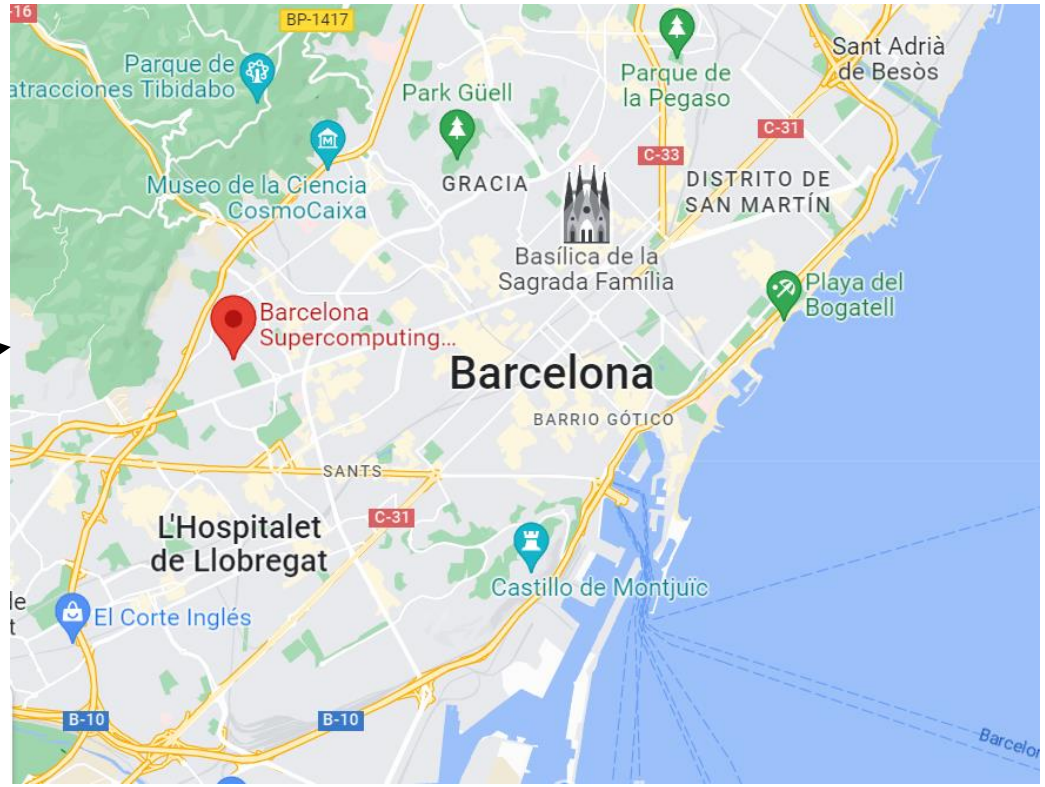

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Public research consortium:

GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA E INNOVACIÓN

Generalitat de Catalunya

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH

MareNostrum4 supercomputer

The general-purpose block has 48 racks with 3,456 nodes. Each node has two **Intel Xeon Platinum** chips, each with 24 processors, amounting to a total of 165,888 processors and a **main memory of 390 Terabytes**.
Its peak power is **11.15 Petaflops.**

+

Clusters of three different emerging technologies: IBM POWER9 processors and NVIDIA Volta GPUs (1,5 Pflops/s), AMD Rome processors and AMD Radeon Instinct MI50 (0,52 Pflops/s), 64 bit ARMv8 processors (0,65 Pflops/s)

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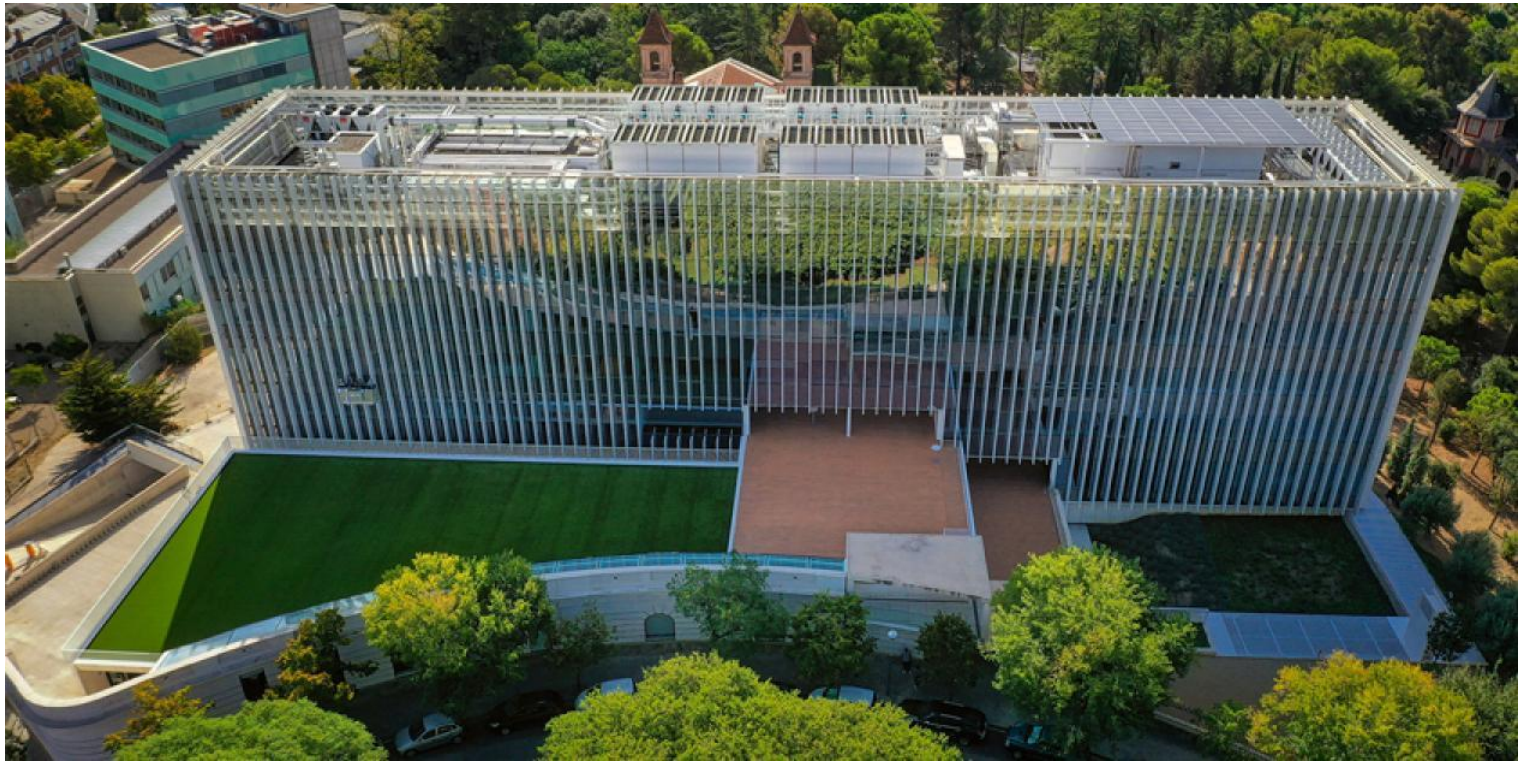
Next generation: MareNostrum5



Expected peak performance of 200 Pflops/s (pre-exascale supercomputer).

Initially two main partitions: general purpose and accelerators.

Starting on June 2023

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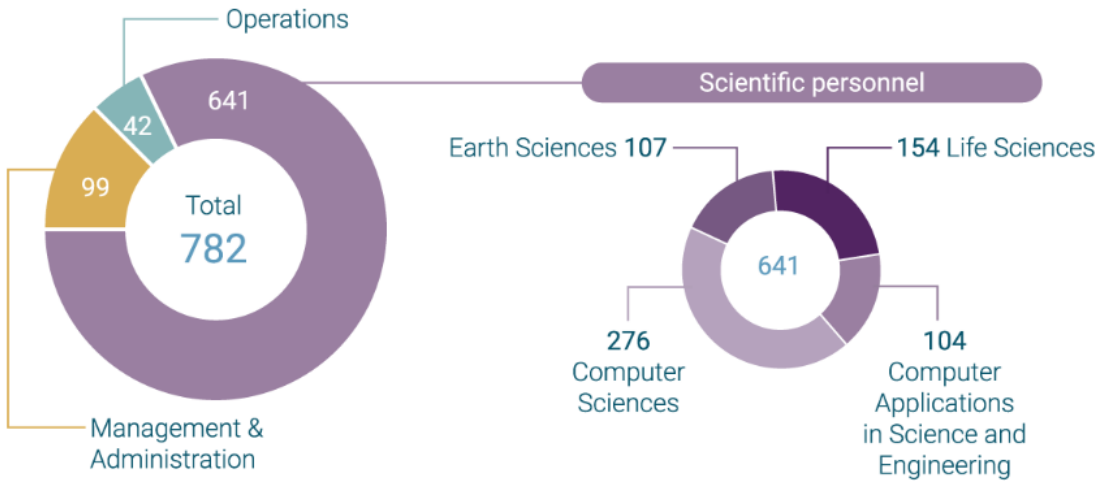
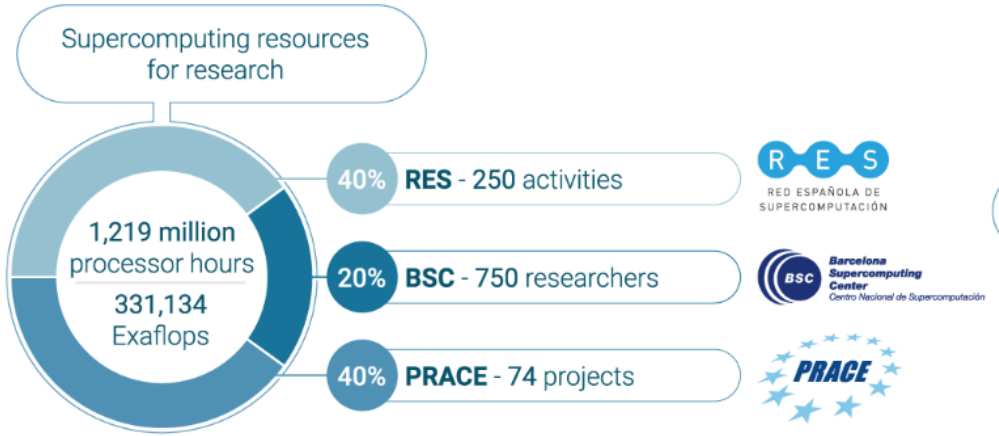
EuroHPC Joint Undertaking

Who are we and what do we do





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Quantum Computing Infrastructure at BSC-CNS

Two main projects:

Quantum SPAIN

Budget: 22 M€

Funding:

Plan de Recuperación, Transformación y Resiliencia

Financiado por la Unión Europea NextGenerationEU

España | digital 2026

Participants:

RES RED ESPAÑOLA DE SUPERCOMPUTACIÓN

Coordinator:

Barcelona Supercomputing Center Centro Nacional de Supercomputación

Goals:

1. Deploy a quantum computer at BSC-CNS
2. Deploy three quantum emulators (BSC, CESGA, SCAYLE)
3. Define user access to them
4. Develop novel quantum algorithms
5. Training

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EuroQCS - Spain

Budget: 12,5 M€

Funding:

EuroHPC Joint Undertaking

Plan de Recuperación, Transformación y Resiliencia

Financiado por la Unión Europea NextGenerationEU

España | digital 2026

FCT Fundação para a Ciência e a Tecnologia

Participants:

Barcelona Supercomputing Center Centro Nacional de Supercomputación

INL INTERNATIONAL IBERIAN NANOTECHNOLOGY LABORATORY

IFAE Institut de Física d'Altes Energies

Coordinator and host:

Barcelona Supercomputing Center Centro Nacional de Supercomputación

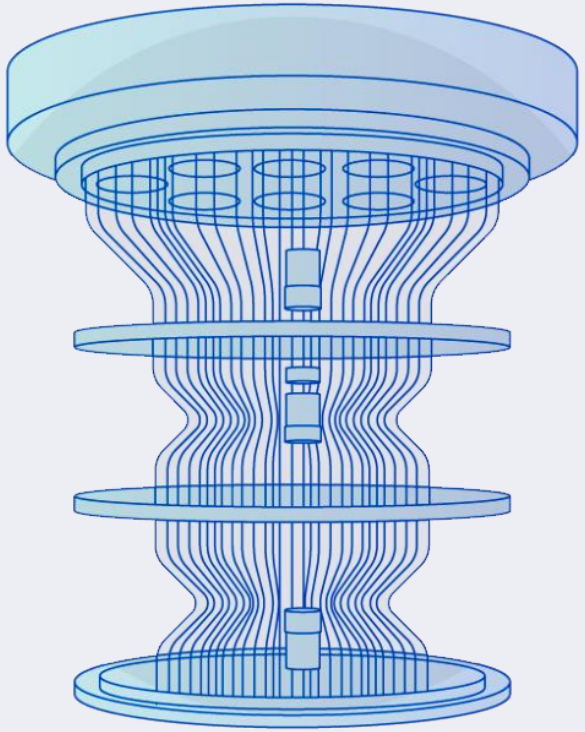
Goals:

1. Deploy a European quantum computer at BSC-CNS
2. Define user access to it
3. Integrate the QC with MareNostrum5 Supercomputer

Quantum Computer

Quantum SPAIN

Construction of a quantum computer in the Barcelona Supercomputing Center (BSC-CNS) based on superconducting qubits technology



Technology: Superconducting circuits.

Several generations of quantum chips with increasing capacities over time (number of qubits, connections, quality of operations, ...).

Public Access: Ensure that the greatest number of sectors experience and exploit this technology.

Operated by the BSC-CNS and technology **provided** by

QILIMANJARO QUANTUM·TECH

gmv INNOVATING SOLUTIONS

Also with IQM QUANTWARE QBLOX Leiden Cryogenics Leader in Low Temperature Techniques ...

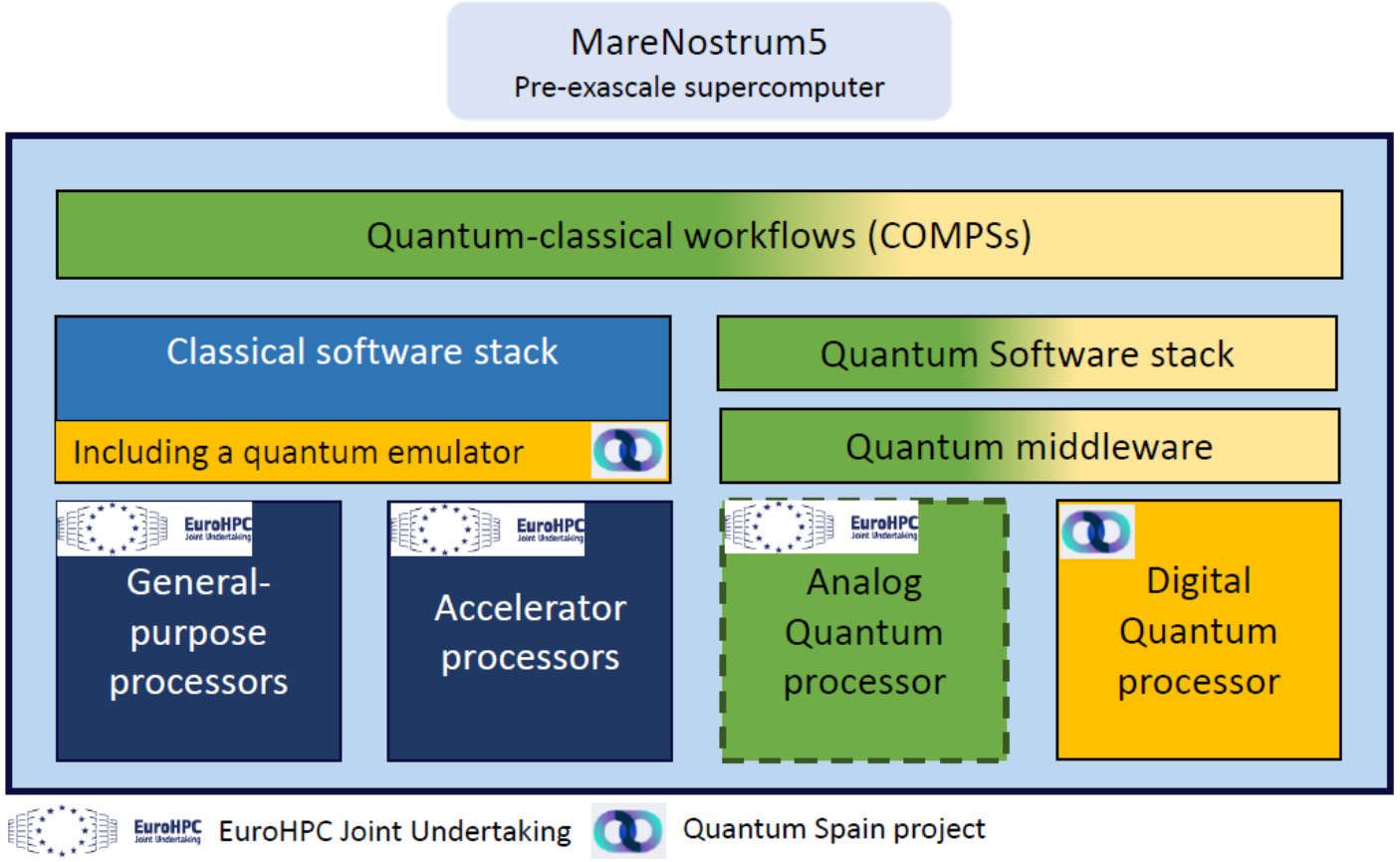
EuroQCS-Spain

One of the six selected projects

Hosting site and coordinator: Barcelona Supercomputing Center.

Consortium formed by the International Iberian Nanotechnology Laboratory (INL) from Portugal and the Institut de Física de Altes Energies (IFAE) from Spain.

Acquire a second quantum computer (an analog one) and integrate it into the MareNostrum5 supercomputer.



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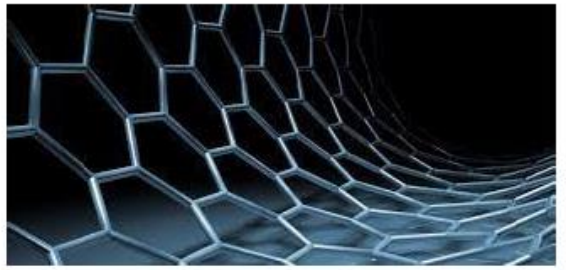
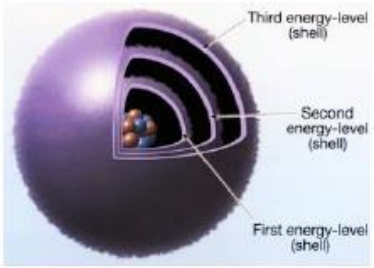
EuroQCS: European Quantum Computing & Simulation Infrastructure,
D. Binosi, T. Calarco, G. Colin de Verdière, S. Corni, A. Garcia-Saez, M.P. Johansson, V. Kannan, N. Katz, I. Kerenidis, J.I. Latorre, Th. Lippert, R. Mengoni, K. Michielsen, J.P. Nominé, Y. Omar, P. Öster, D. Ottaviani, M. Schulz, L. Tarruell.

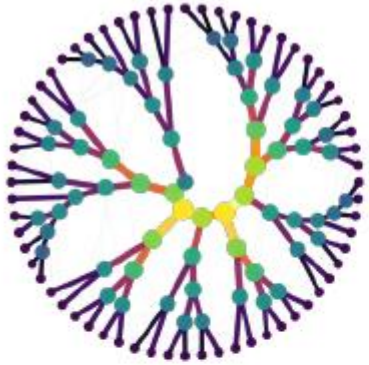
BSC Quantic group activities

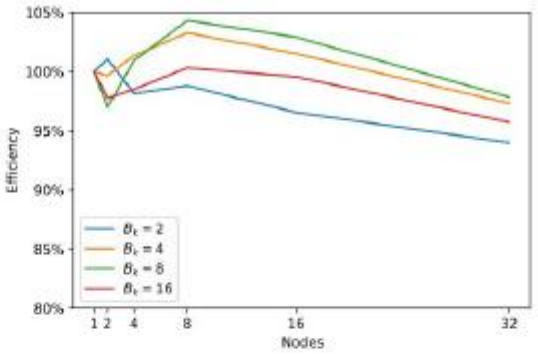
- A group of 10+ researchers in Physics and Computer Science

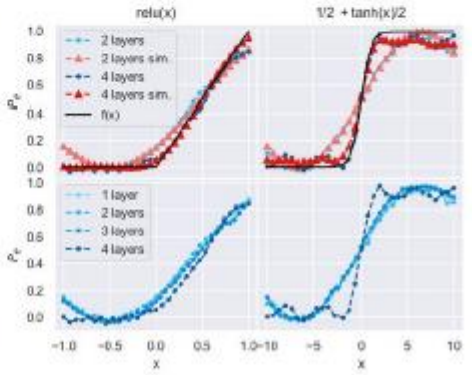
- Design of **applied Quantum algorithms**
  - A tool for advanced material science: Graphene
  - Nuclear Physics
  - Optimization
  - Particle physics analysis
  - Quantum Machine Learning
- Implementation of Quantum simulators on HPC systems
  - Development of advanced **Tensor Network** methods
    - Design for Exascale Systems
    - High efficiency algebra operations
    - Simulates 50+ qubits
    - Presentation and paper at SC21











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Outlook

Day 1: Blackboard

Why are we doing all of this? The power of quantum computation through basic algorithms (Grover, QFT and quantum simulation)

Day 2: Slides

What can we really do with current term devices? Variational Quantum Computing