THAT IS WHY WE GO INTO THE COLD

JSC END-OF-THE-YEAR COLLOQUIUM

DECEMBER 5, 2023 I KRISTEL MICHIELSEN

ENERGY COSTS – WE MUST RISE TO THE CHALLENGE

- **Energy crisis:** most threatening challenge for large-scale digital research today
- **Computing** and **digitalization** in general are **energy-intensive activities**
- **Prominent example: simulation and AI**
  - On all scales from the **desktop to exascale**
  - **Rise of energy prices** for research might level off at **+50 % in 2025**
  - Measures to achieve **scalability** and **sustainability?**

- **Communication** in general is **extremely energy demanding**
  - **Growing amounts of data** demands a continuous increase in communication
- A **reduction of energy consumption** is absolutely **mandatory**
  - We need to contribute
    - by **improvement** of current technology through **intensive R&D**
    - by invoking **new** and potentially **disruptive computing paradigms**

THE ENERGY CHALLENGE IN COMPUTING

Disruptive answers are required

- Transition to **energy efficient GPUs** is in full swing, still needs strong push
- **For simulations and AI, novel energy-efficient hardware technologies** such as ARM or RISC-V-based CPUs are investigated
- **Novel computing paradigms** need to be introduced and explored ASAP
  - Quantum computing;
  - Neuromorphic computing;
  - Cryo-computing;
  - Mixed-precision computing …
- **Need to stimulate energy-awareness**
  - New data center monitoring and steering
  - Green coding

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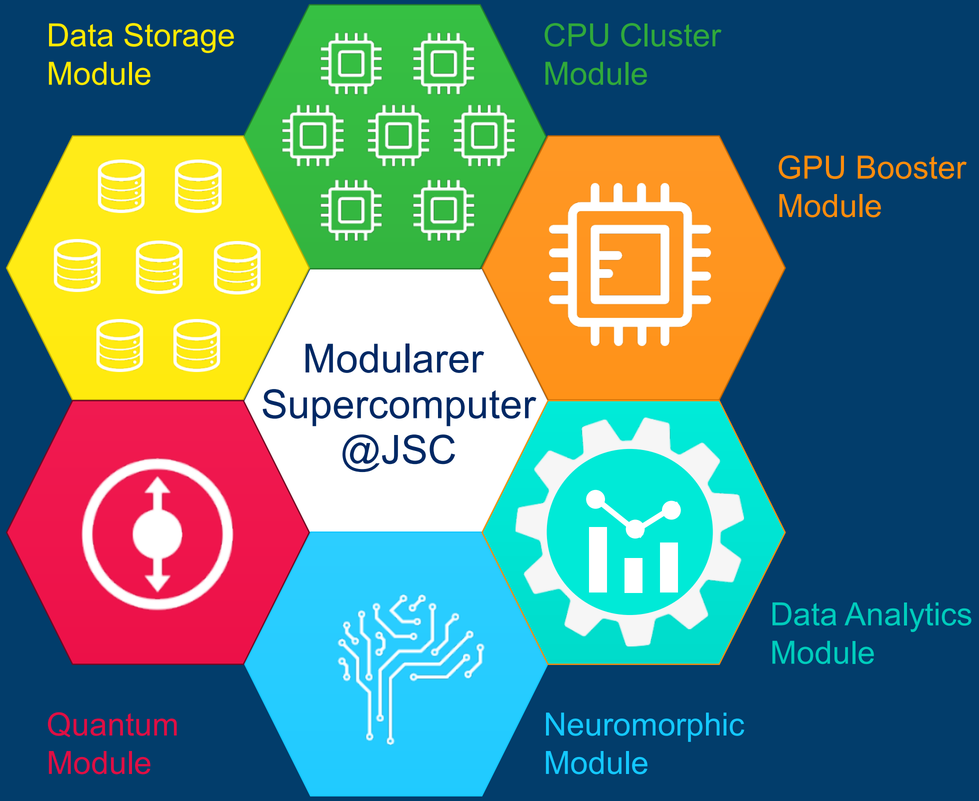
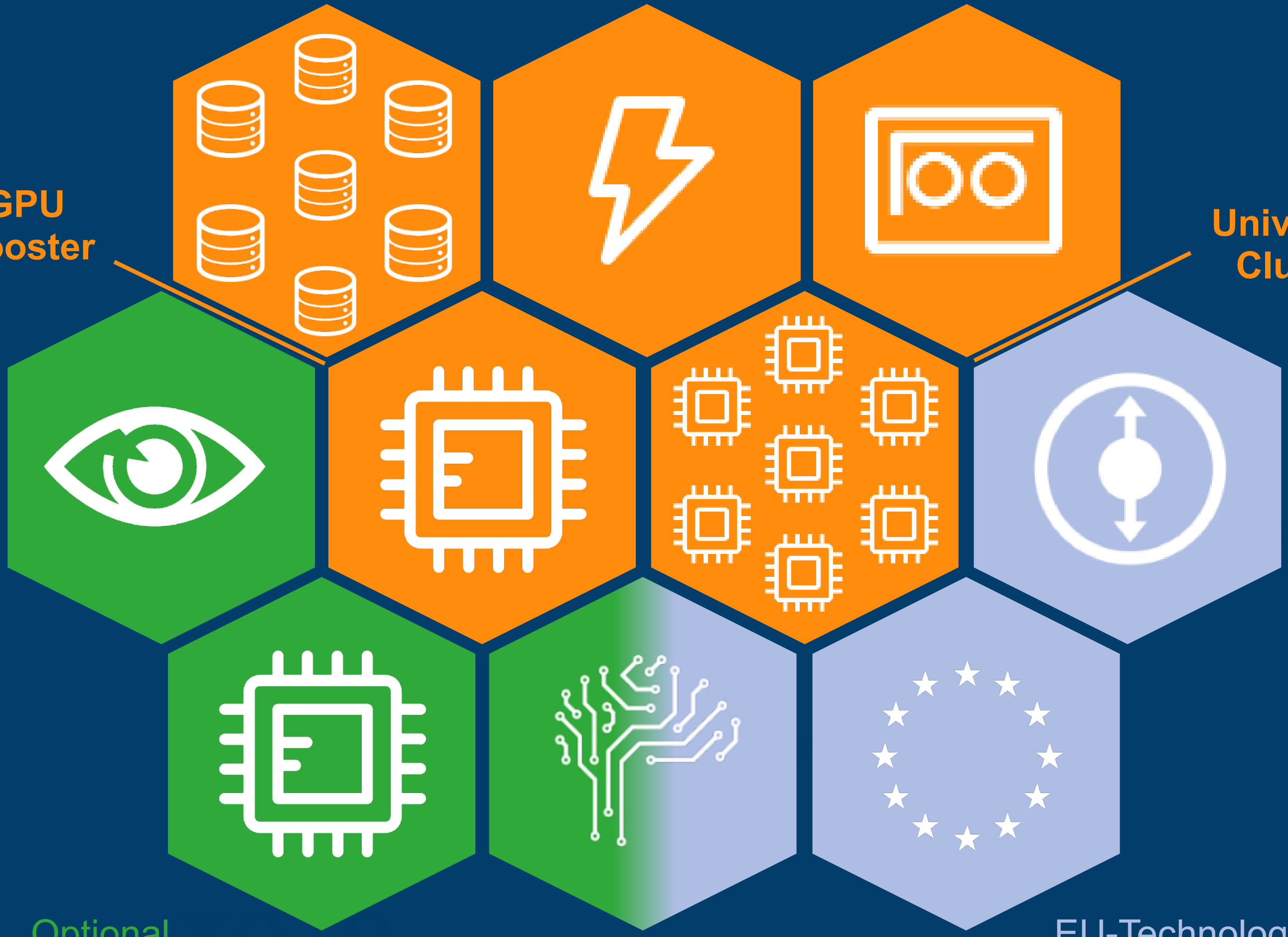
A HARDWARE SOLUTION – GO MODULAR

- How to keep **power consumption** under control?
  - Use power-hungry, general purpose computing **CPUs only where absolutely necessary**
  - Exploit energy efficient highly parallel elements by default
  - Take recourse primarily to device-internal memory
- **Modular supercomputer architecture (MSA)**
  - allows to realize most energy-efficient computing
  - can be formulated theoretically as optimization
    - → exploit most energy efficient algorithms and data-flows
    - → exploit mixed-precision algorithms on MSA
    - → optimize on energy or other criteria



EXASCALE COMPUTING – GO MODULAR



Basis configuration
Optional modules
Future technology modules

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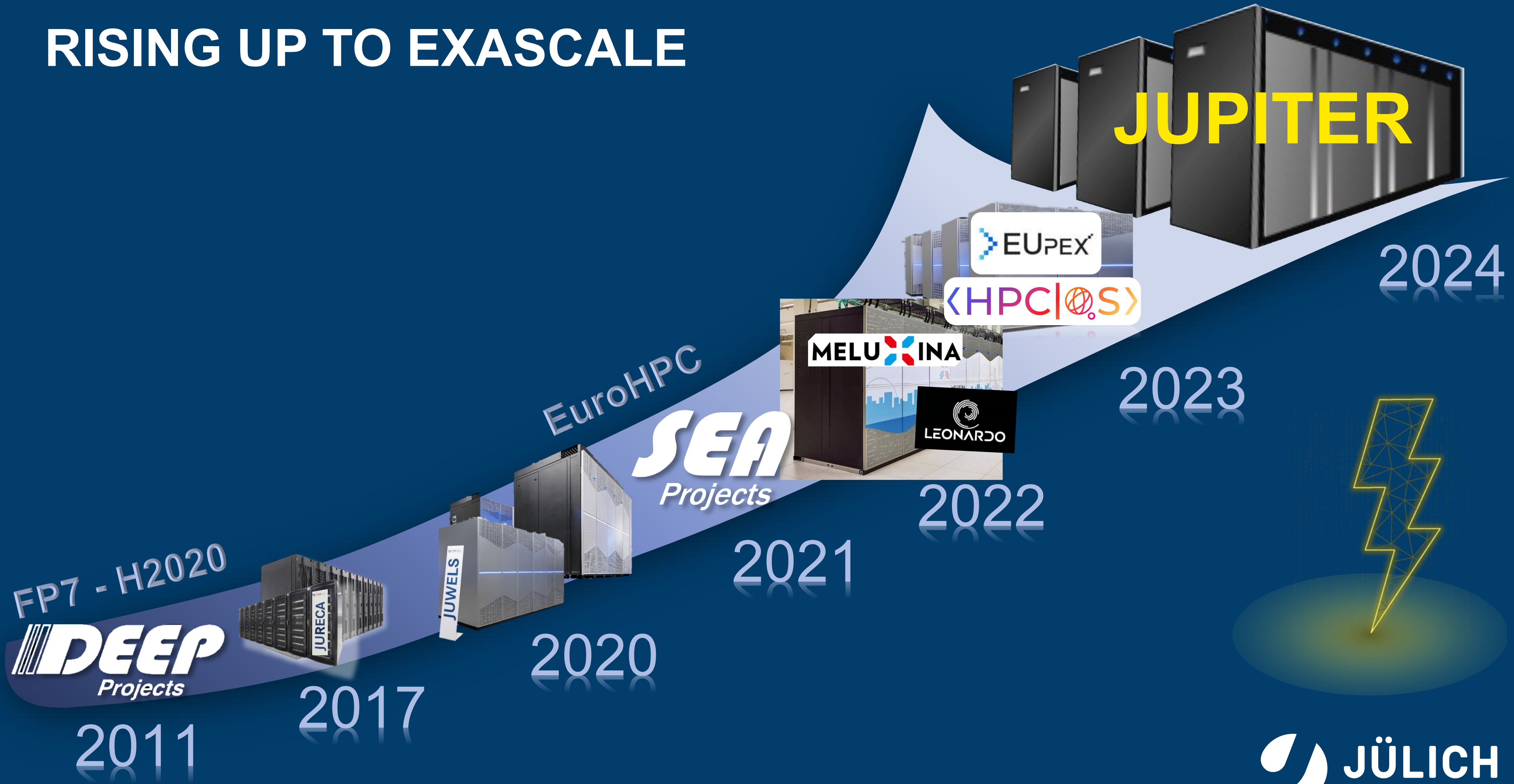
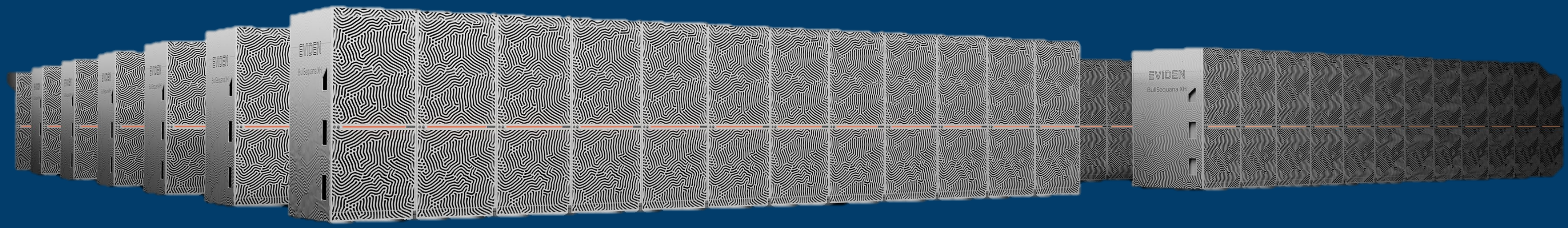
RISING UP TO EXASCALE



EXASCALE COMPUTING – JUPITER (BOOSTER)

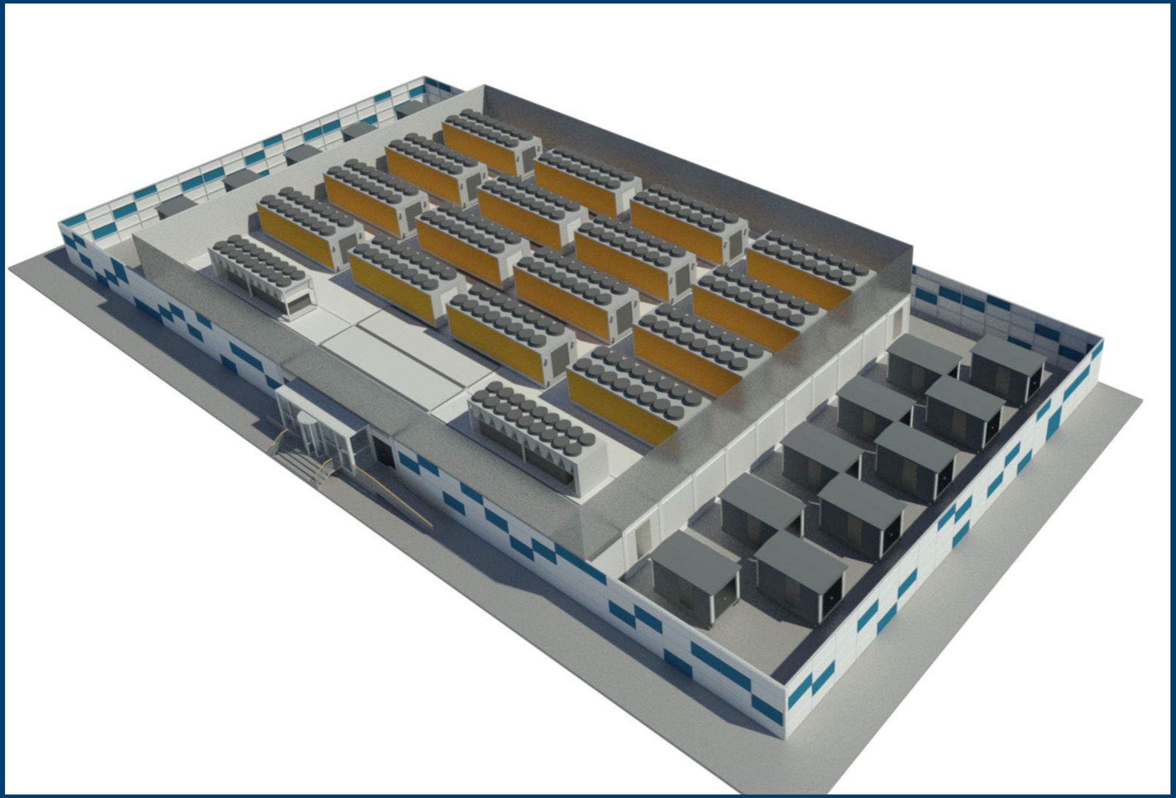
93 ExaFLOPS of AI | 1.0 ExaFLOPS for HPC | 24,000 GH200

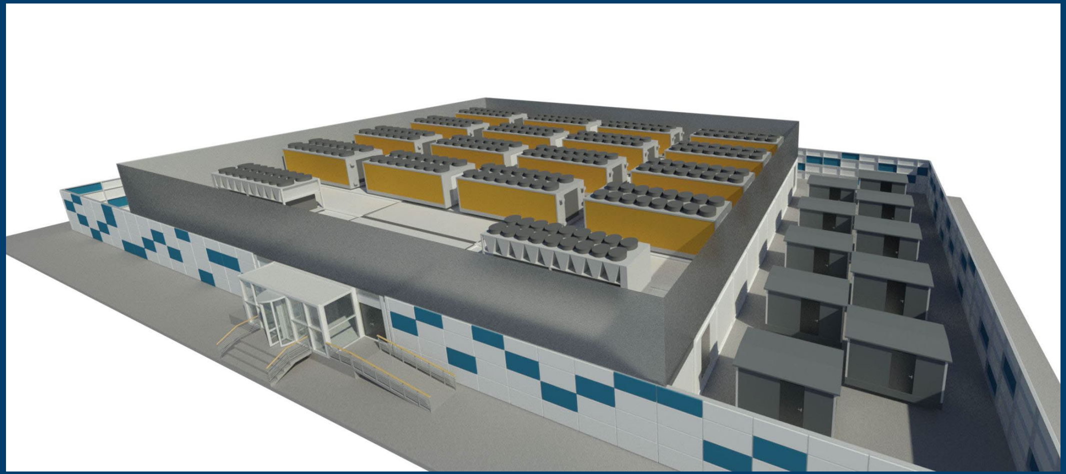
Power consumption: 18.2 megawatts (expectation for normal operation: 12 megawatts)



EuroHPC Joint Undertaking | EVIDEN an atos business | JÜLICH Forschungszentrum | NVIDIA | ParTec MODULAR SUPERCOMPUTING

DATA CENTRE – GO MODULAR





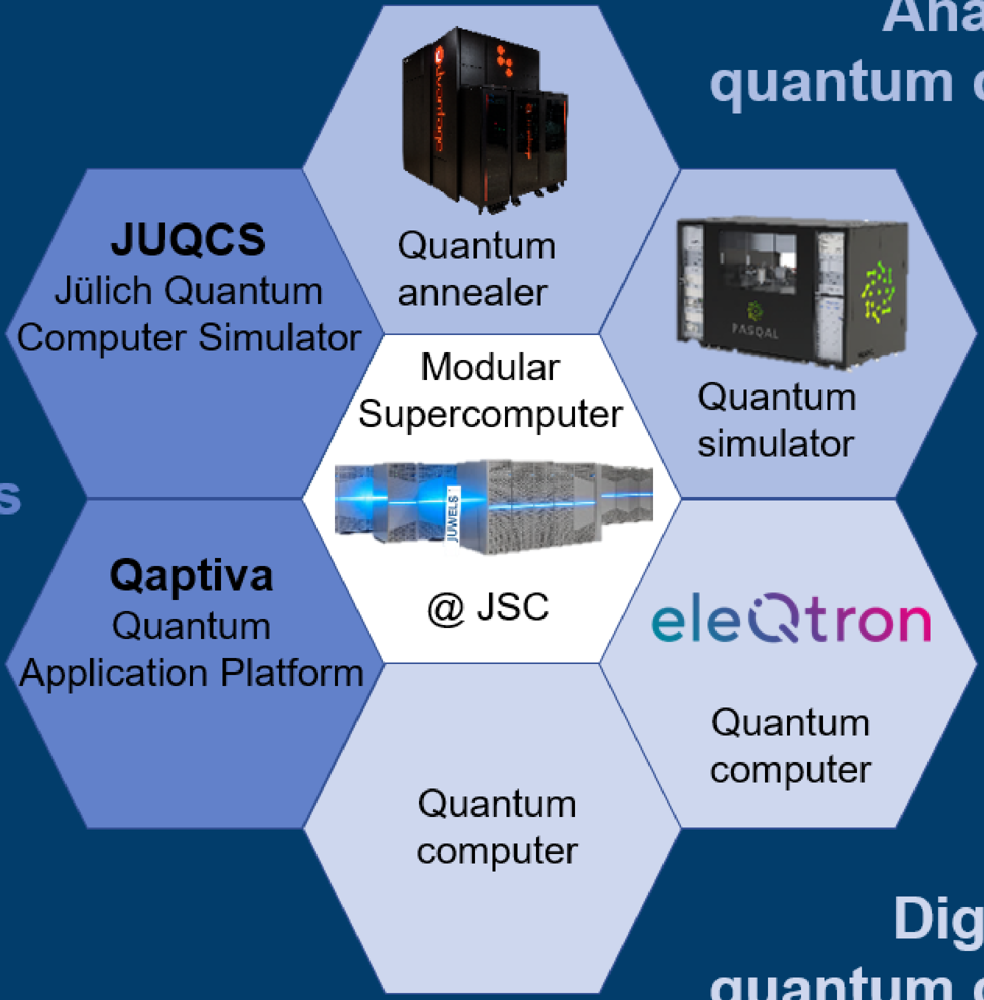
QUANTUM COMPUTING – GO MODULAR

Jülich UNified Infrastructue for Quantum Computing - JUNIQ

Hosting

Analog quantum computers

Emulators



Digital quantum computers

Cloud access

DAQC

SOLID

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D-WAVE QUANTUM ANNEALER JUPSI

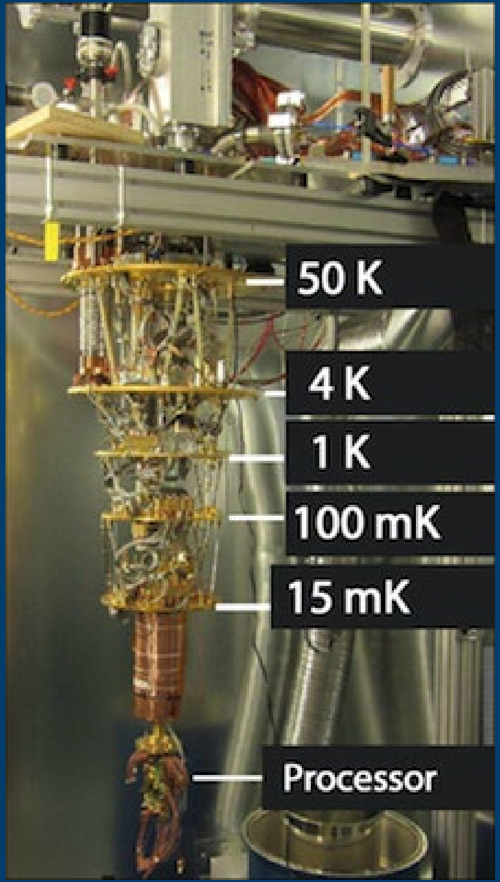
Deployed by JUNIQ since 2021

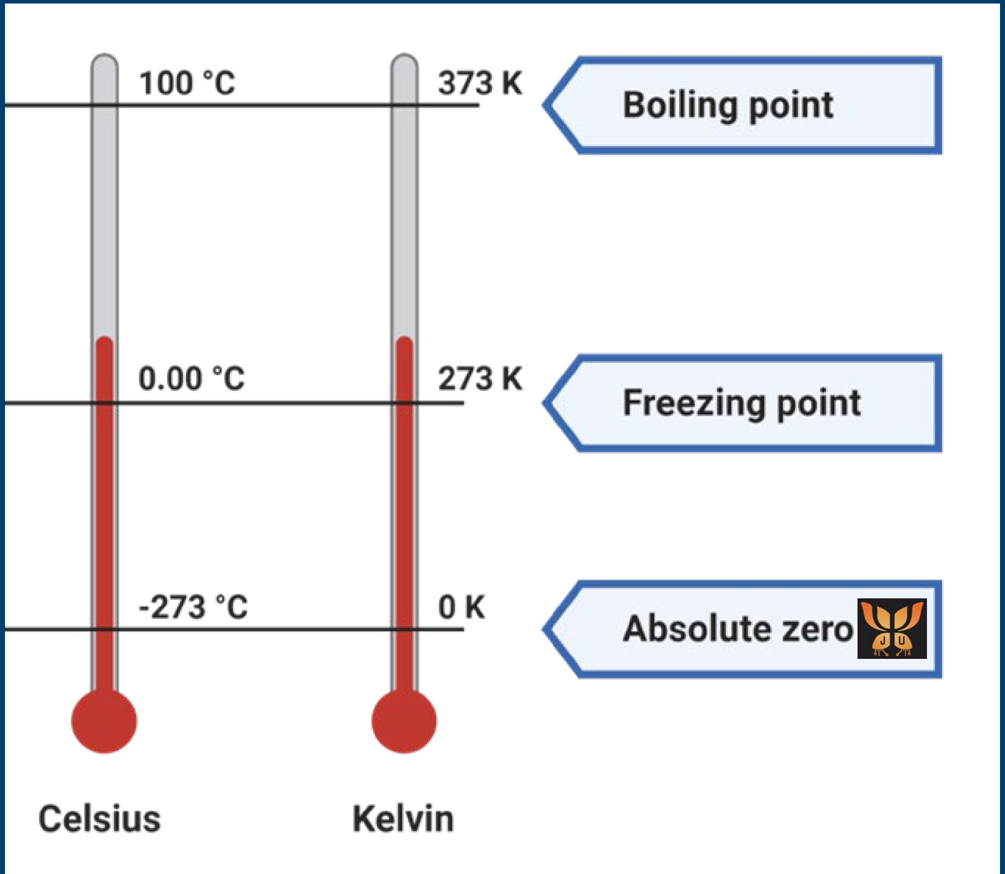
5000+
superconducting qubits

Power consumption:
25 kilowatts

D-WAVE QUANTUM ANNEALER

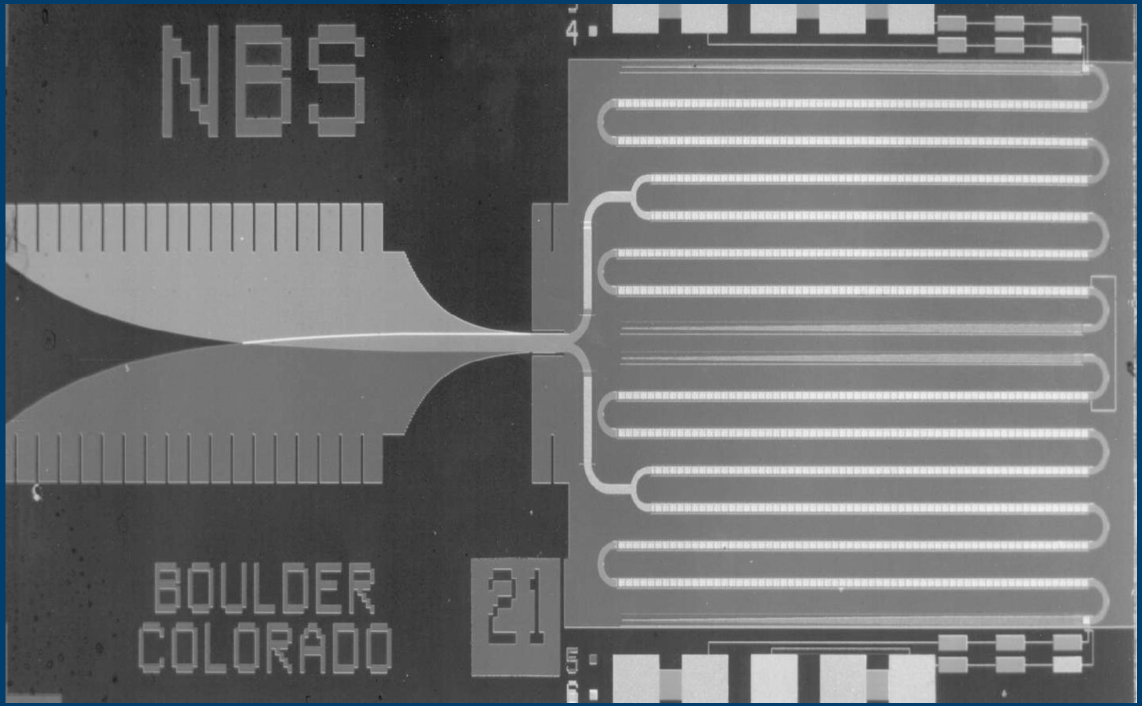
Cryogenic dilution refrigerator system



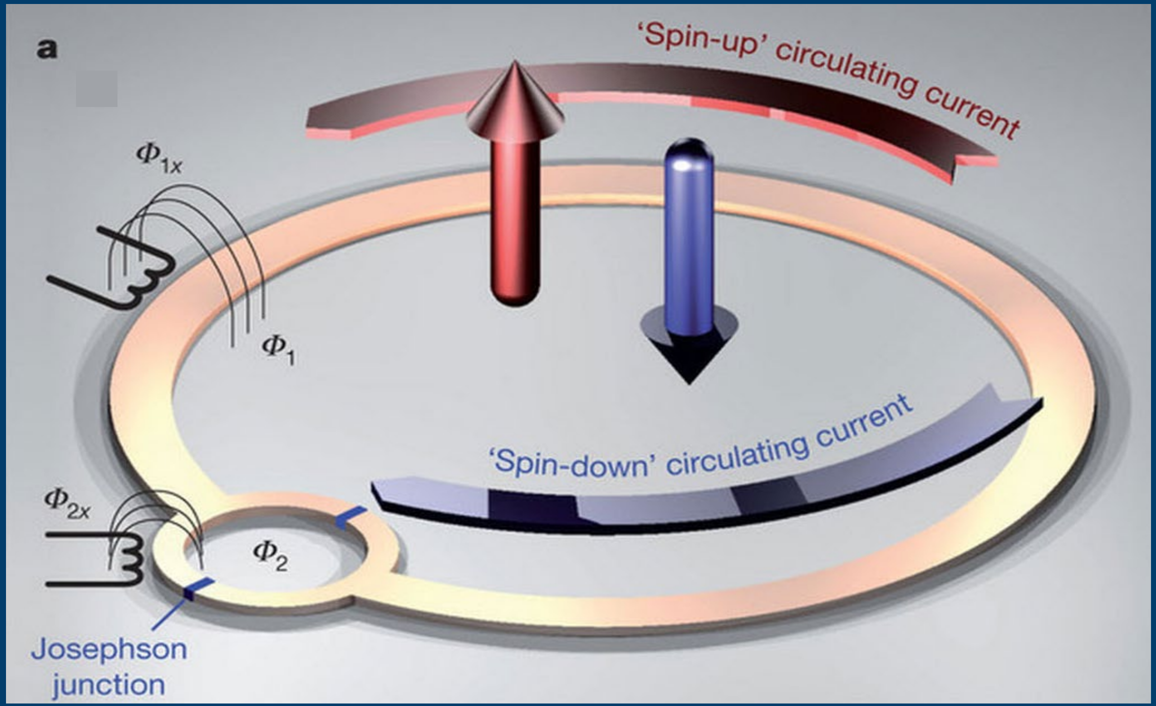


D-WAVE QUANTUM ANNEALER

Superconducting qubits



A Josephson junction



A Superconducting Quantum Interference Device (SQUID)

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CRYOCOMPUTING

Superconducting technology for post-exascale computing

- Potential of **single-flux quantum (SFQ) circuits**
  - **Three orders of magnitude reduction in electrical power**
  - **One order of magnitude of higher compute speed**
- Target clock frequency of superconducting electronic circuits: > 100 GHz for operating temperature < 4K
- Application, e.g., all-atom molecular dynamics simulations of small biological systems
  - Target performance: 500 GF/s per scalar core
  - Target data rate: 0.5 to 1 byte / flop (optical interconnects)
  - On-chip superconducting memory
- Post-exascale computing
  - Extension of superfast scalar nodes to superconducting vector units achieving 50 TF/s thereby boosting the memory access
  - Parallelization: place 1000 cores in one cryostat

SUSTAINABLE CHRISTMAS TREE – GO MODULAR


Thank you