# QC – From Lab to Business

… and a Selection of Current Challenges

ARIC Brown Bag Session

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11/25/2025

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# Index

# Why Quantum Advantage?

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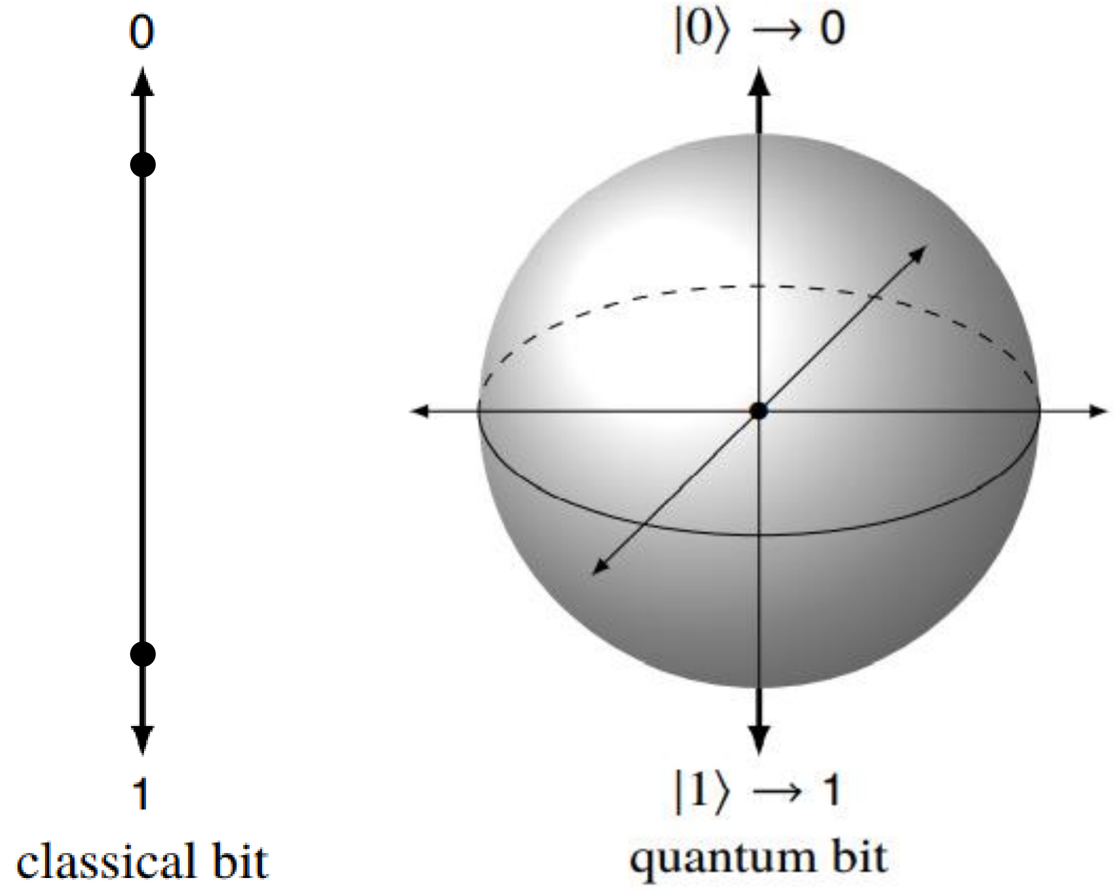
11/25/2025

# Classical versus Quantum Information




Superposition is creating a quantum state that is a combination of |0> and |1>.

Measurement is an action that forces a qubit to either |0> or |1> based on probability.

Entanglement strongly connects two or more qubits so that their quantum states are no longer independent.

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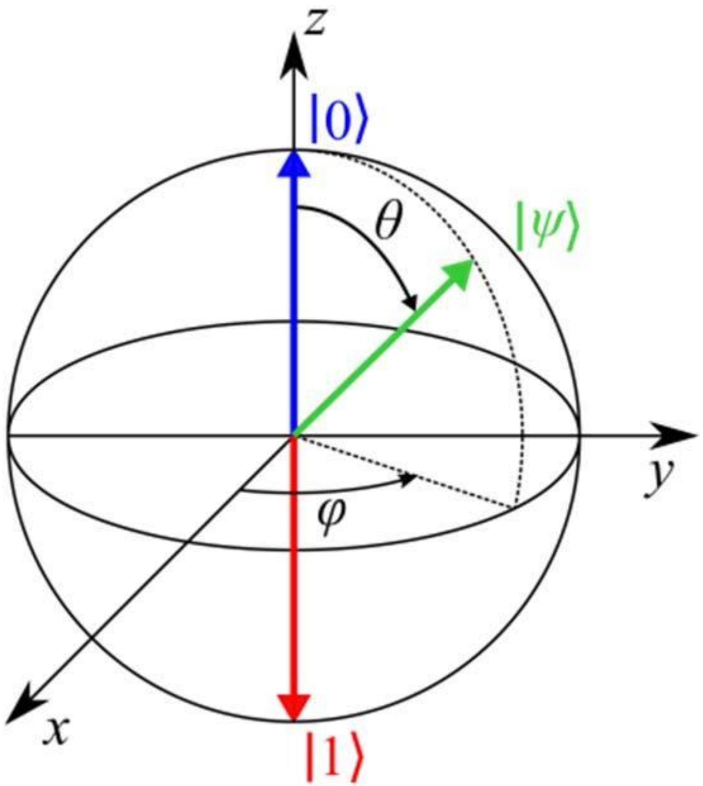
# Linking angles and vector

**Bloch sphere**




author: Fabio Sebastiano

$$|\psi\rangle = \alpha\,|0\rangle + \beta\,|1\rangle$$

$$|\alpha|^2 + |\beta|^2 = 1$$

$$|\psi\rangle = \begin{pmatrix} \alpha \\ \beta \end{pmatrix}$$

$$\alpha \rightarrow \cos\left(\frac{\theta}{2}\right) \qquad \beta \rightarrow e^{i\varphi}\sin\left(\frac{\theta}{2}\right)$$

$$e^{i\varphi} = \cos(\varphi) + i\sin(\varphi)$$

$$0 \le \theta \le \pi \qquad 0 \le \varphi < 2\pi$$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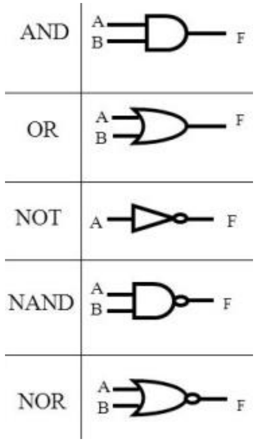
# Classical and Quantum Computing

## Classical Computer

**bits (0,1)**



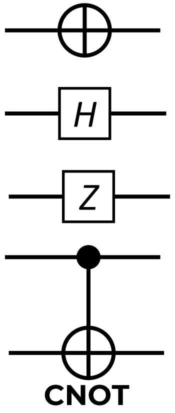

Logic, ***boolean operators***,

to represent ***boolean gates***

Output

01011010001...

## Quantum Computer




**quantum bits : qubits (|0⟩ and |1⟩)**

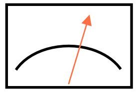
**qubit is a quantum system with 2 states**

Linear algebra, vectors and matrices

to represent ***quantum gates***

(e.g; NOT, Hadamard, phase shift, CNOT)

Measurement





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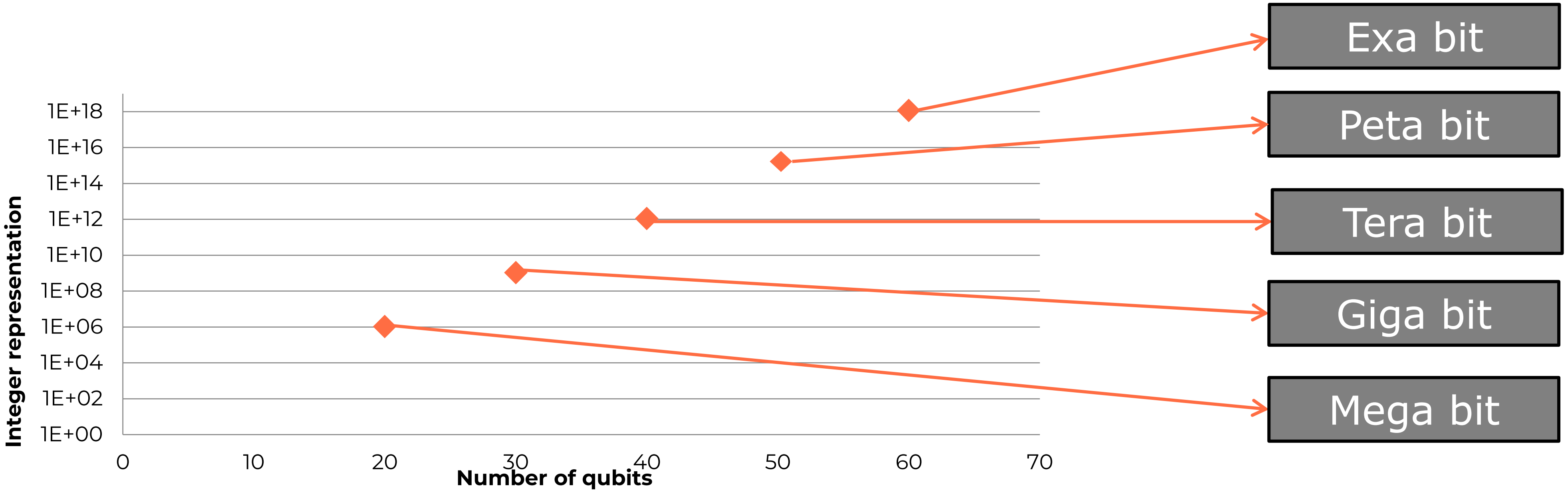
# Scalability

▸ With N qubits, you can handle **$2^N$ states**

**Scale**




$2^{50}$ 1.125.899.906.842.624 (one million billion )

$2^{200}$ 6070840288205403346623318458823496583257521372037936003911913780434075891266276556 8
(more basis states than there are atoms in the observable universe )

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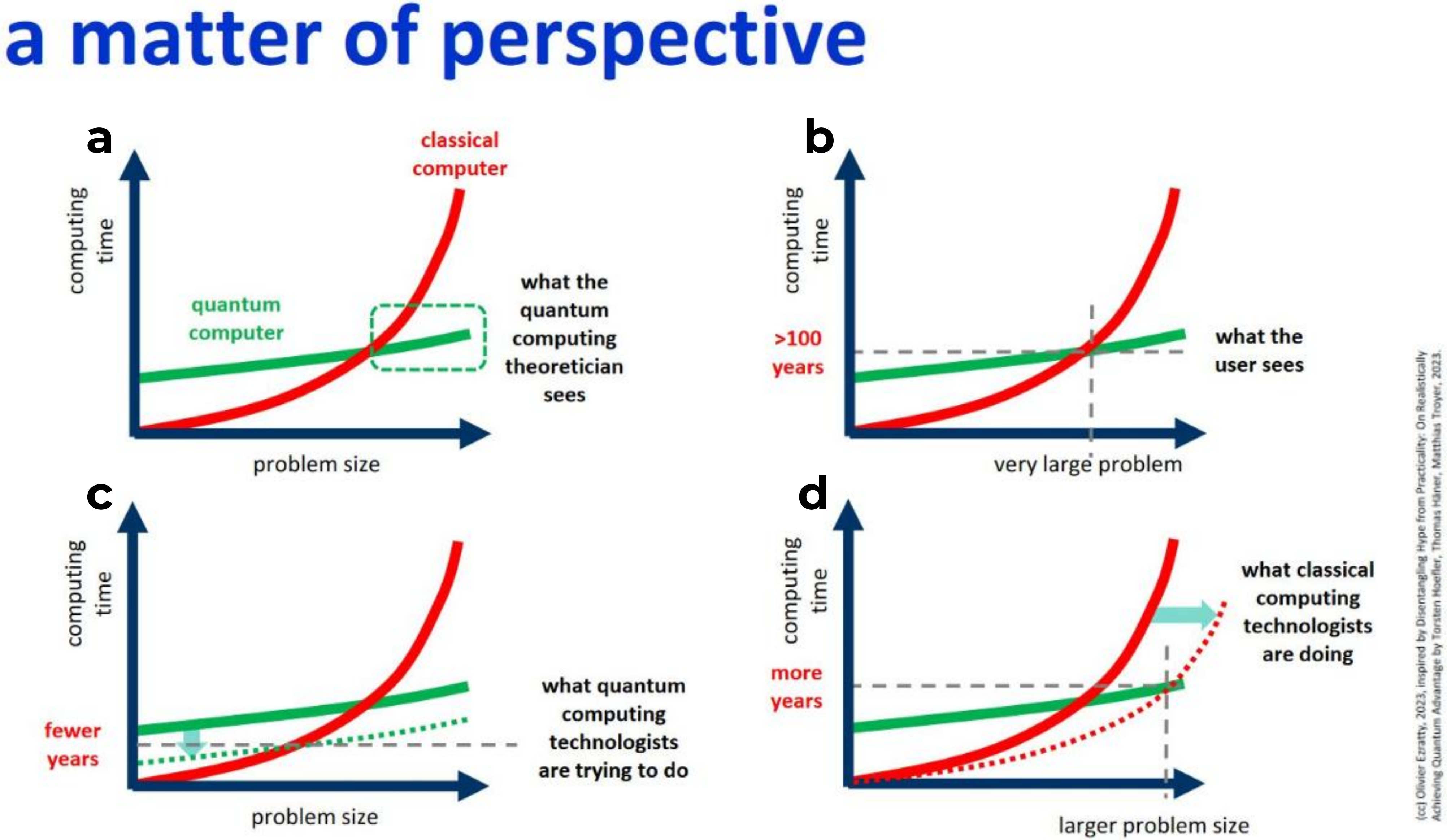
# Quantum Advantage



# Quantum Computing has the potential to revolutionize every industry

| Finance & Insurance | Energy & Utilities | Manufacturing | Public Sector & Defense | Healthcare & Lifesciences | Telco & Media |
|---|---|---|---|---|---|
| Portfolio optimization | Decarbonization | Supply chain | Academic Research | Genomics | Content |
| Risk assessment | Network Infrastructure | Software validation | Cryptanalysis | Virtual screening | Antenna location |
| Credit scoring | Facility location | Material science | Material science | Protein folding | Chip layout optimization |
| Fraud detection | Logistics scheduling | Product development | Nanotechnology | Drug discovery | Predictive maintenance |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# Market Overview & Roadmaps

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11/25/2025

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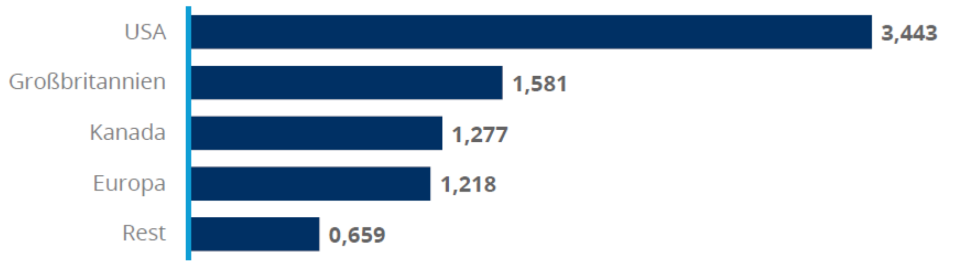
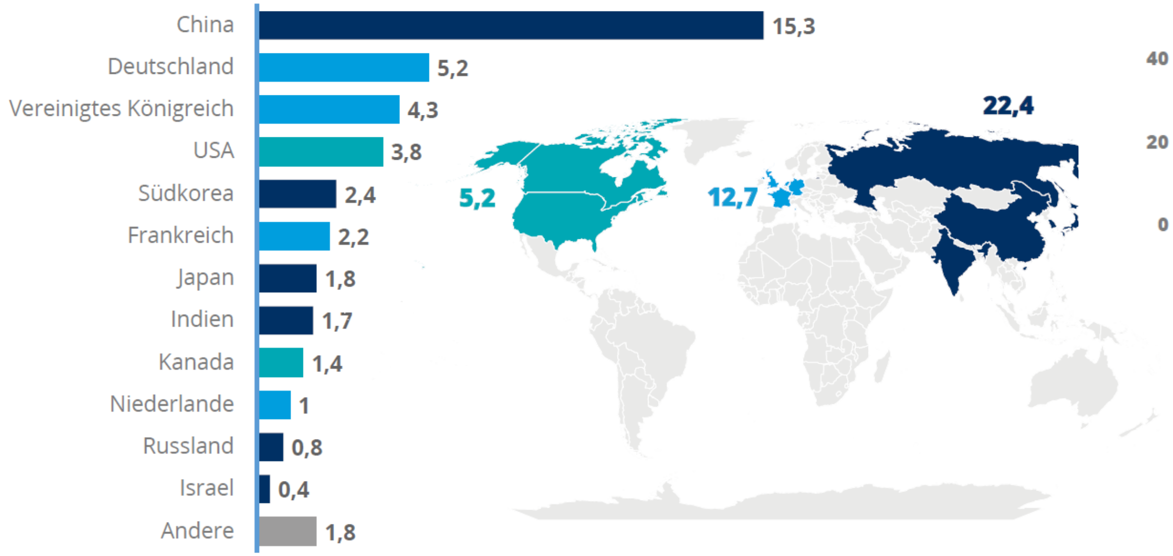
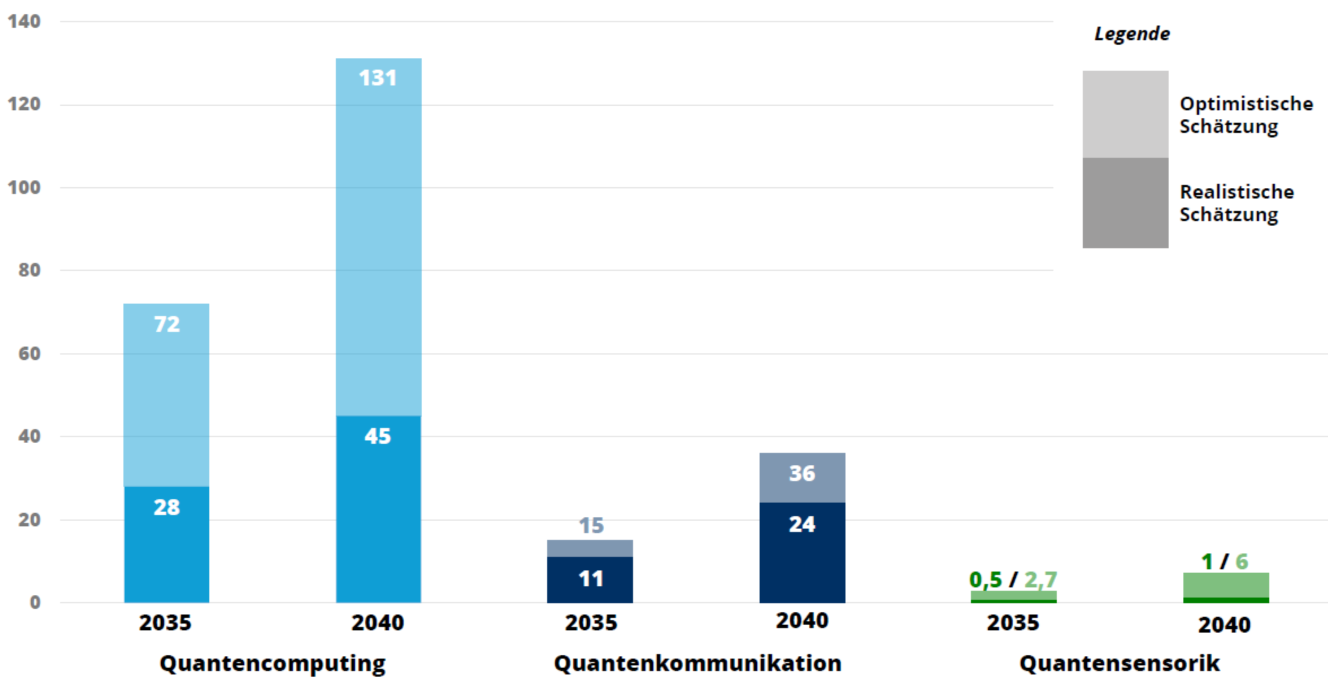
# Market Overview & Forecast

## Worldwide Effort, Investment & Public Procurement

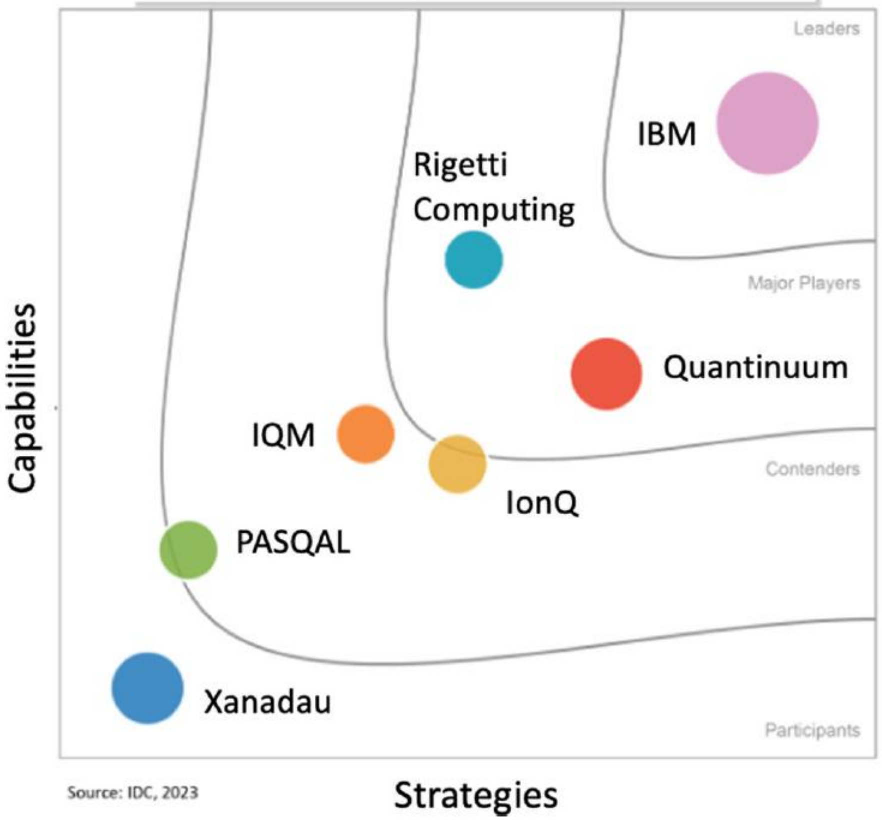



[Positionspapier NRW – EIN Quantum NRW]

## Example Market Leader - IBM




# IBM to invest $150bn in US manufacturing over next five years

Computer business is latest example of a US technology group boosting its home investment since President Trump's punitive global tariffs were unveiled

In a statement released Monday, April 28, the chipmaker announced plans to invest more than $150 billion over the next five years in new facilities and projects related to quantum computing production.

- Revenue to this point: ~1 Bn
- Invest planned: ~150 Bn

Pfaendler *et a.l.*
Advancements in Quantum Computing—Viewpoint: Building Adoption and Competency in Industry | Datenbank-Spektrum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# Quantum Ecosystem KPIs – EU Commission

[KPIs for Quantum Technologies in Europe - 2023 Values | Quantum Flagship (qt.eu)]

## KPIs Ecosystem

### 1. Investment

Total amount of EC investment in the form of venture capital (EU quantum start-ups), corporate seed-funding (EU incubators & accelerators), and EU public investment (EU public-private ventures).

| | |
|---|---|
| *2021 value* | 344 M€ |
| *2022 value* | 408 M€ |
| *2023 value* | 551 M€ |
| *progression/year* | +90 M€ |
| *2030 target* | 1000 M€ |

### 2. Lab-to-market

Number of quantum start-ups, spinoffs, incubators, accelerators, as well as public private joint ventures in Europe (given for all pillars, including established EU companies that enter the field).

| | |
|---|---|
| *2021 value* | 79 |
| *2022 value* | 95 |
| *2023 value* | 99 |
| *progression/year* | +20 |
| *2030 target* | 250 |

### 3. "Lab-to-fab" infrastructure and value chains

Number of EU research institutions offering open application labs, testbeds, production cleanrooms, with testing, prototyping and calibration service facilities accessible to European SMEs, covering TRL 2-6.

| | |
|---|---|
| *2021 value* | 1 |
| *2022 value* | 9 |
| *2023 value* | 22 |
| *progression/year* | - |
| *2030 target* | 60 |

### 4. Job creation

Number of jobs in quantum technologies.

| | |
|---|---|
| *2021 value* | n/a |
| *2022 value* | n/a |
| *2023 value* | 3850 |
| *progression/year* | +15% |
| *2030 target* | 10000 |

**Remark**: Data obtained by surveying QuIC members (industry sector jobs).

### 5. Patent creation and IP retention

Quantum-related European patents granted versus distribution of granted patents globally.

| | |
|---|---|
| *2021 value* | n/a |
| *2022 value* | n/a |
| *2023 value* | Top 2 globally |
| *progression/year* | - |
| *2030 target* | Top 2 globally |

**Remark**: Relative rank in international patent families by country of origin.

### 6. Supply chain and strategic autonomy

Number of components (supply chain) of quantum technologies which were formerly imported to EU and are now produced in EU that are of strategic importance and needed for self-sufficiency.

| | |
|---|---|
| *2021 value* | 0 |
| *2022 value* | 35 |
| *2023 value* | 44 |
| *progression/year* | +3 |
| *2030 target* | 60 |

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# From Lab to Business

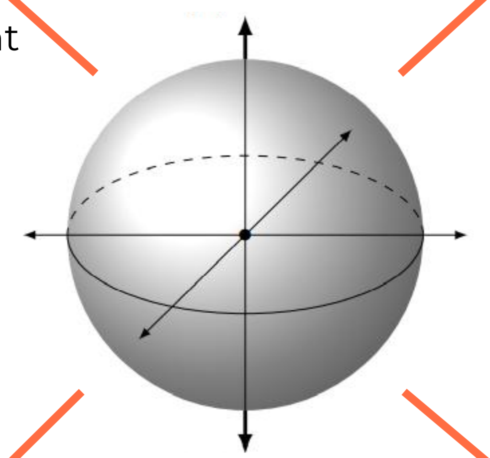
## What do we need?

### Mature Technology

- ✓ Hardware Evolution
- ✓ Algorithm Development
- ✓ Stability
- ✓ Standardization

### Ecosystem

- ✓ Cloud Access
- ✓ Platforms
- ✓ Industry/Academia/Public collabs
- ✓ Talent Development



### Application & Use Cases

- ✓ Beyond PoC
- ✓ Industry-relevant
- ✓ Short-term: NISQ
- ✓ Mid-term/long-term: EFT/FTQC

### Business Integration & Commercialization

- ✓ "Quantum-Readiness"
- ✓ Easy Access
- ✓ Integration into existing systems
- ✓ Use Case to Business Case

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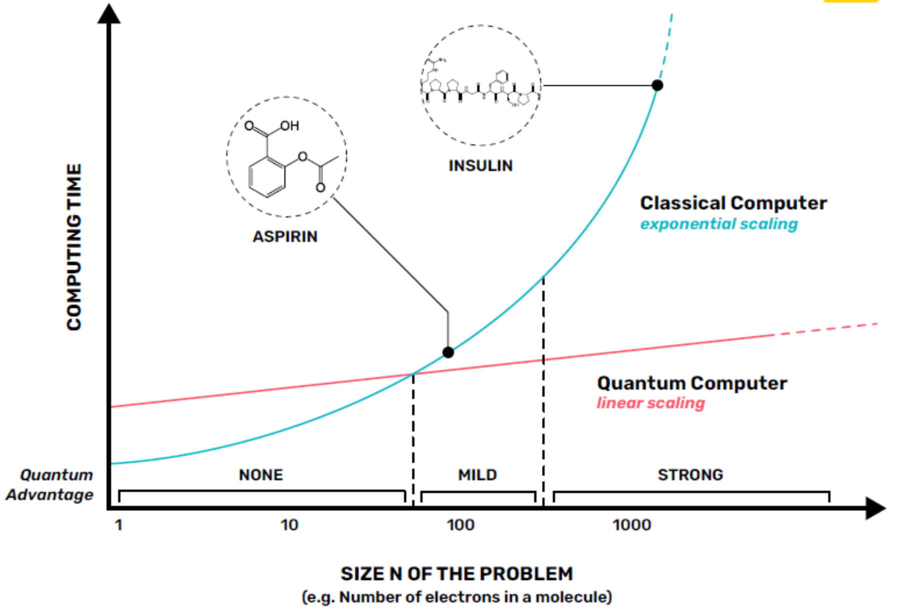
# Quantum Computing

**QUANTUM ADVANTAGE DEPENDS ON THE PROBLEM SIZE**




**RSA-248 bit:** $n \approx 2^{248} \approx 4.3 \times 10^{74}$

[Think-Inside-The-Box Alice & Bob Whitepaper]

**OVERVIEW OF QUANTUM ALGORITHMS AND USE CASES**

SHORTER TERM ⟷ LONGER TERM

| | Molecular simulation | Quantum optimization | Quantum Monte Carlo | Machine learning | HHL | Decryption[1] |
|---|---|---|---|---|---|---|
| **Life sciences** | Calculating a drug's binding affinity | Optimizing the location of clinical trial sites | Predicting the spread of disease in epidemics | Improving image classification in diagnostics | Modelling forces for protein-folding simulations | Protecting patient data privacy |
| **Chemicals** | Simulating the reaction pathway in synthesis | Optimizing the production process of chemicals | Simulating meso-scale reactor processes | Predicting the properties of new chemicals | Solving fluid dynamics in reaction vessels | Protecting data related to IP and trade secrets |
| **Energy** | Designing new materials for carbon capture | Optimizing power dispatching in an electric grid | Forecasting energy prices in the market | Predicting energy production from weather patterns | Solving DC power flow calculations in electrical grids | Protecting access to data on grid infrastructure |
| **Telecom** | Designing new semiconductor materials | Optimizing antenna placement | Stress-testing network resilience | Improving customer segmentation | Solving EM-field calculations in antenna design | Protecting the data exchanged over a network |
| **Advanced manufacturing industries** | Designing new batteries for electric vehicles | Optimizing the step sequence in car production | Improving the resilience of the supply chain | Improving fault detection in chip manufacturing | Solving aerodynamics simulations | Protecting communication connections |
| **Logistics** | N/A | Optimizing the route of a delivery service | Stress-testing logistic schedules for disruptions | Predicting maintenance needs in a fleet | Improving inventory management | Protecting personalized customer data |
| **Finance** | N/A | Optimizing the value of an asset portfolio | Modelling credit value at risk in capital allocation | Improving the detection of fraud in transactions | Estimating risk for the future value of an asset | Protecting customer transaction data |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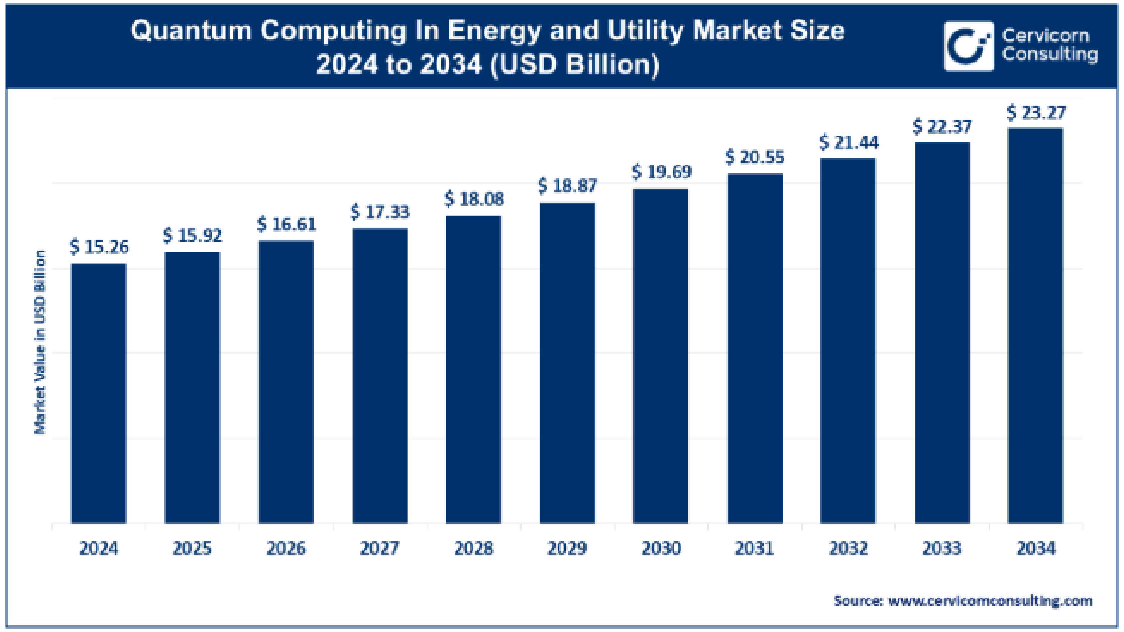
# Quantum to Business

## Focus on Benefits

Focus on financial advantages, increase of revenue and cost savings

- ✓ Costs **500 k€** to do a physical test on a car crash but only **100 €** to simulate it
- ✓ Simulating cheaper than physical tests, logistics improvements potentially save billions




# Example: Energy Market

- **Net Optimization**: Efficient Steering of Energy Systems.
  - ✓ Planning of **Production, Distribution and Storage** gets increasingly difficult
  - ✓ Has to be adapted to changes on **short notice**
  - ✓ Maintaining a **constant, balanced relationship** between electricity supply and consumption is essential, minimizing risk for large-scale power outages
- **Renewable Energies**: Better integration and management of solar/wind energy
- **Storage**: Optimization of battery cells and storage systems
- **Simulations**: Development of new materials for energy systems
- **Risk management**: Better predictions and hedging of fluctuations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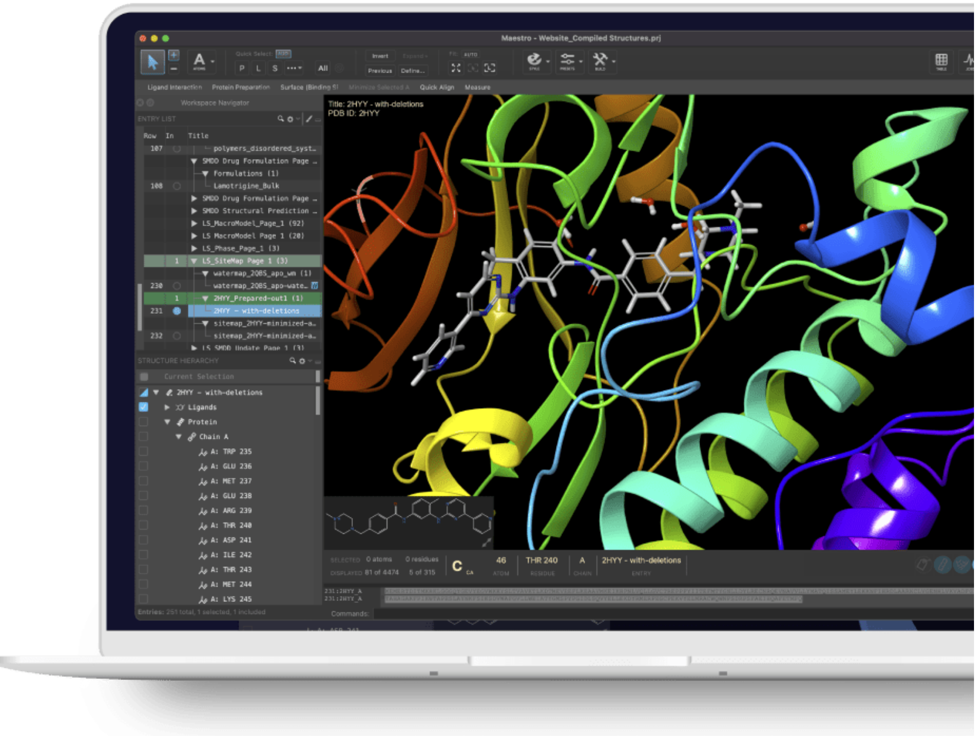
# Potential in Pharmaceutical Research



## Simulation of complex molecules

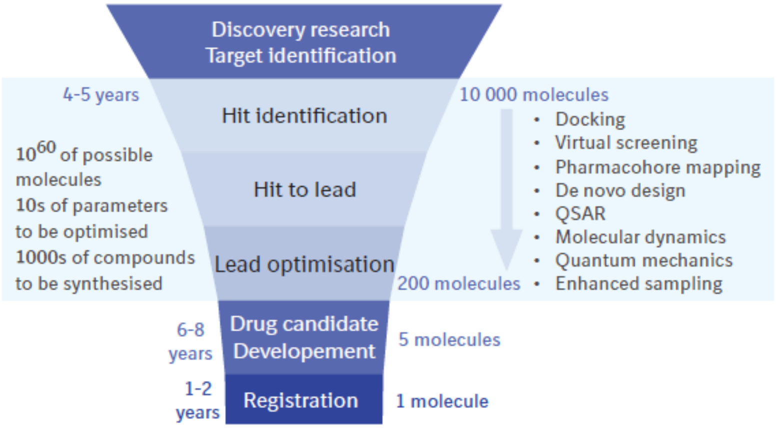
The simulation of complex molecules enables a deeper understanding of biochemical processes for innovative medical solutions.

## Classic computing power requirements

Simulations involving large molecules are extremely complex, and individual simulations can take weeks.

## Potential of quantum computing

The use of special algorithms such as VQE and other quantum optimization algorithms can potentially reduce throughput time significantly.




**Drug design on quantum computers**


Raffaele Santagati,[1,*] Alan Aspuru-Guzik,[2] Ryan Babbush,[3] Matthias Degroote,[1] Leticia González,[4] Elica Kyoseva,[1,†] Nikolaj Moll,[1] Markus Oppel,[4] Robert M. Parrish,[5] Nicholas C. Rubin,[3] Michael Streif,[1] Christofer S. Tautermann,[6,7] Horst Weiss,[8] Nathan Wiebe,[2] and Clemens Utschig-Utschig[1]


https://www.nature.com/articles/s41567-024-02411-5

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# Current Challenges
# #1 Error Correction

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# Principle of QEC

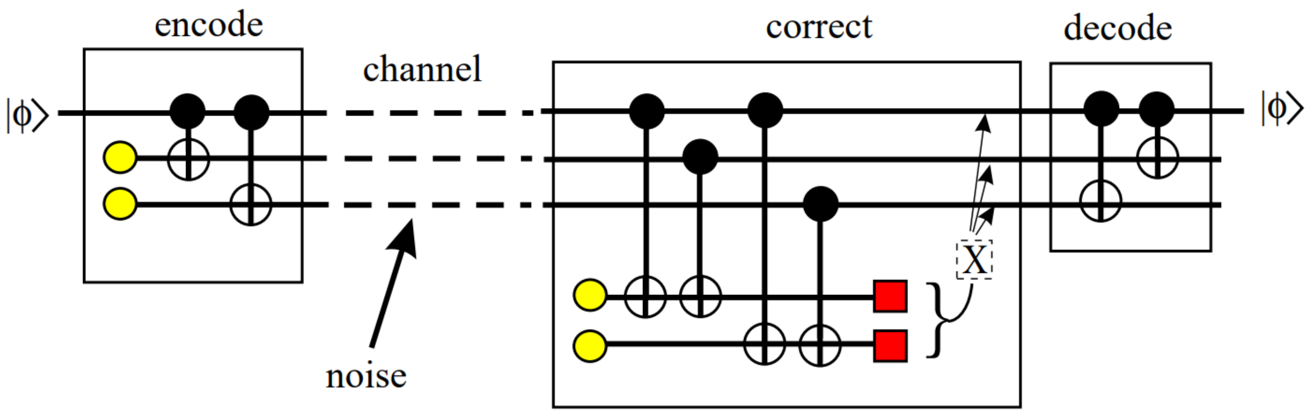


**Figure 1.** Simple example illustrating the principles of quantum error correction. Alice wishes to transmit a single-qubit state $|\phi\rangle = a|0\rangle + b|1\rangle$ to Bob through a channel which introduces $\sigma_x$ errors ($|0\rangle \leftrightarrow |1\rangle$) randomly. Alice prepares two further qubits in the state $|0\rangle$, represented by a small circle. She then *encodes* her single qubit into a joint state of three qubits, by two controlled-NOT operations. These three qubits are sent to Bob. At the receiving end, Bob *recovers* the joint state by extracting a syndrome, and correcting on the basis of this syndrome. The correction is a $\sigma_x$ operation applied to one (or none) of the qubits. Finally, a *decoding* operation disentangles one qubit from the others, giving Bob a single qubit in the state $|\phi\rangle$ with probability $1 - O(p^2)$.

A Tutorial on Quantum Error Correction, by Andrew M.

- Encoding **Logical** into **Redundant Physical** Qubits
  - ✓ Redundancy allows the system to detect and correct w/o directly measuring the quantum info
- Use **ancilla qubits** so the encoded logical state doesn‘t collapse
- **Different types** of QEC (bit flip, phase flip, combined)
- **Classical Decoder** determines the error and **recovers** to **restore the logical state**
- **Fault-tolerant implementation**
  - ✓ Prevent errors from spreading: single physical error doesn‘t cascade to multiple logicals
  - ✓ How much noise is tolerated before QEC fails?


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# From NISQ to EFT era

## NISQ Era (now)

- ✓ 50 – 1000 physical Qubits
- ✓ High error rates, low coherence times
- ✓ Goal: Improve stability
- ✓ Research, Benchmarking, Demos, Variational Methods (hybrid quantum-classical)

## Transition Phase (‘25 – ’30)

- ✓ Error mitigation techniques
- ✓ First practical quantum advantages
- ✓ Better gate fidelities
- ✓ Hybrid quantum-classical approaches
- ✓ Codesign: Algorithms tailored to topology, gate sets and noise

## EFT: Scaling & Error correction (2030+)

- ✓ Logical qubits through error correction
- ✓ Stable, scalable platforms with 1000+ logical qubits
- ✓ Transition to fault-tolerant computing

## FTQC (?)

- ✓ Millions of logical qubits
- ✓ Fully fault-tolerant quantum algorithms
- ✓ Universal applications
- ✓ Commercial and scientific usage on industrial level


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# Quantum Error Correction

## On the Road from NISQ to EFT

**Mind the gaps: The fraught road to quantum advantage**

Jens Eisert[1,2,3] and John Preskill[4,5]

https://arxiv.org/abs/2510.19928

The path from NISQ to FASQ is likely to be arduous, expensive, and prolonged.

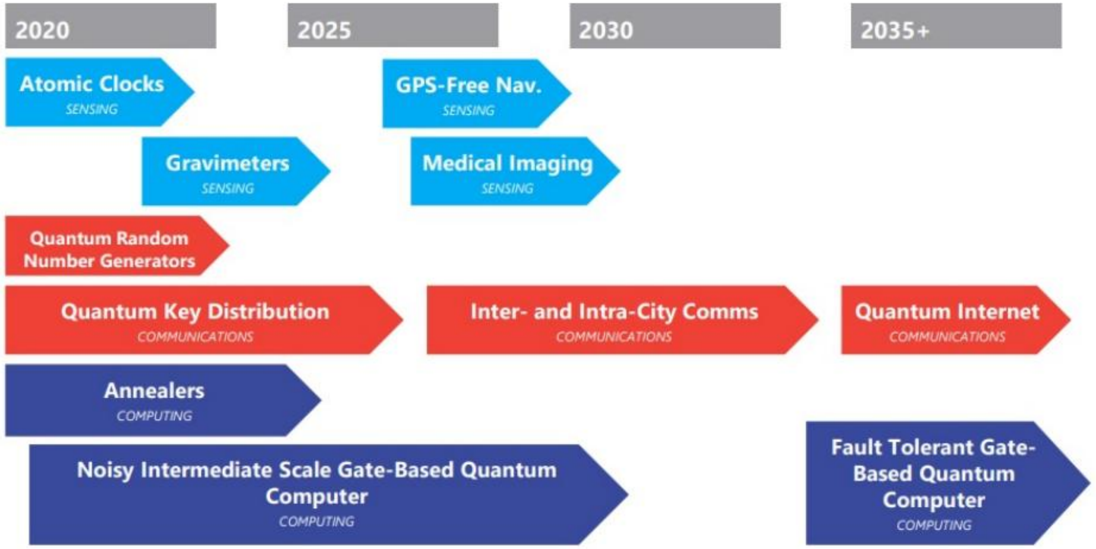
Quantum random circuit sampling experiments demonstrate that today's NISQ quantum processors can perform some tasks that are beyond the reach of today's classical supercomputers; this is a notable milestone but not of great practical interest.

Quantum error mitigation boosts substantially the circuit volume that can be executed accurately. However, due to a sampling overhead cost that scales exponentially with circuit volume, this method fails for very large circuits.

An imperfect quantum computing device can accurately simulate an ideal computation with $L$ logical gates using $O(L \text{ polylog } L)$ physical gates, if the noise is sufficiently weak and not too strongly correlated.

Quantum advantage in variational quantum algorithms has not been firmly established, and potential obstructions have been identified.

Thanks to the substantial boost in circuit volume attainable via quantum error mitigation, NISQ machines with sufficiently low gate error rates might achieve marginally useful quantum advantage.




| **TRL** | TRL 1–3 | TRL 4–6 | TRL 7–9 |
|---|---|---|---|
| **QC technologies** | Prototype quantum computers | QC demonstrators | Deployed quantum computers, e.g. quantum annealers |
| **Road to 2035: proposed standardisation activities** | • Roadmaps<br>• Terminology<br>• Use cases<br>• Measurements<br>• Testing/benchmarking | • Functionality tests<br>• Guidelines<br>• Quality metrics | • Interoperability<br>• Exchange protocols<br>• Certification |

https://www.euroquic.org/wp-content/uploads/2024/02/PUBLIC-version-Strategic-Industry-Roadmap-2024.pdf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# Variational Quantum Algorithms on the decline?

Scalability Challenges in Variational Quantum Optimization under Stochastic Noise

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[2]Physics Department, Technical University of Munich, Garching, Germany
[3]Faculty of Physics, Ludwig-Maximilians-University Munich, Munich, Germany

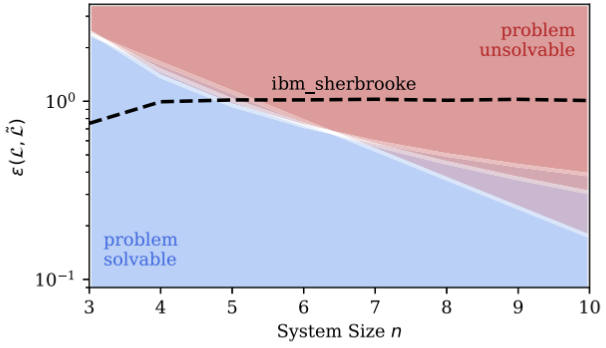


FIG. 9. Exemplary hardware error and problem solvability regions. The three possible separation lines represent the three fitted functions (cf. Fig. 8) of the critical noise threshold $\sigma^*$ for the most noise-resilient optimizer, NGD, converted into the RAE metric $\epsilon^*$ (35) based on measurements from Sec. IV B. Above these lines, the probability of finding the optimal solution becomes negligible or effectively zero. The dashed line shows the empirically measured hardware error obtained using the ibm_sherbrooke[1] backend model.

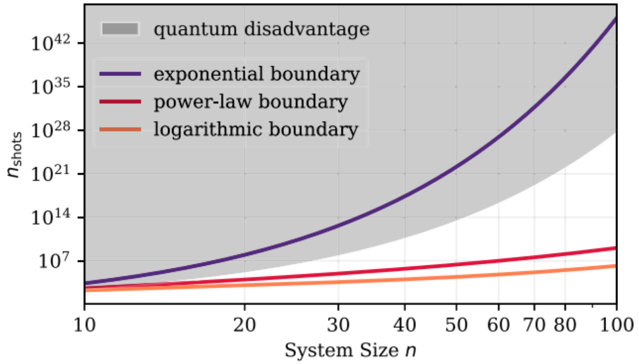


FIG. 11. Required shots $n_{\text{shots}}$ for solving a random QUBO problem of size $n$. The minimum number of shots required by the most noise resilient optimizer, NGD, to reach three specified noise thresholds is shown as solid lines. For any value above these theoretical curves, solving a QUBO problem of size $n$ using the BENQO algorithm becomes feasible. The shaded region represents the regime where the number of required quantum circuit executions surpasses the number of classical brute-force trials, rendering the quantum algorithm less efficient than the worst classical solver.

https://journals.aps.org/pra/abstract/10.1103/rgyh-8xw8

- How do VQAs scale under stochastic noise?
- Focus on QUBO problems
- Key Finding: Threshold beyond which the probability if finding the solution drops drastically
- This threshold drops rapidly as *n* grows
- Translation into measurement shots: Achieving the desired precision becomes impractical for moderate size problems (poor scaling)
- Can current VQAs deliver **"practical" quantum advantage** at all (large enough instances)?


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# Recent Work

## Simulation and Benchmarking of Real Quantum Hardware

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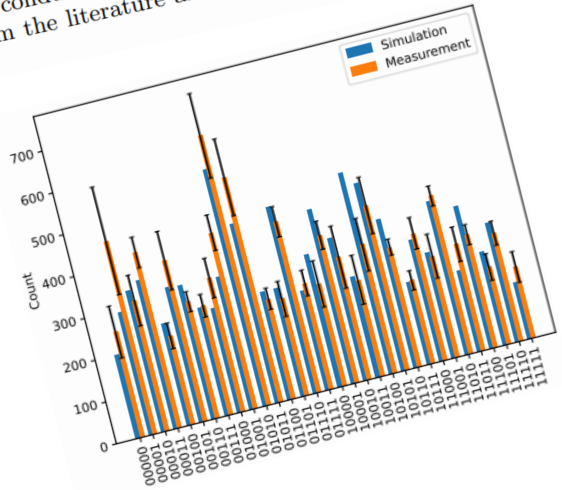
The effects of noise are one of the most important factors to consider when it comes to quantum computing in the noisy intermediate-scale quantum computing (NISQ) era that we are currently in. Therefore, it is important not only to gain more knowledge about the noise sources appearing in current quantum computing hardware in order to suppress and mitigate their contributions, but also to evaluate whether a given quantum algorithm can achieve reasonable results on a given hardware. To accomplish this, we need noise models that can describe the real hardware with sufficient accuracy. Here, we present a noise model that has been evaluated on superconducting hardware platforms and could be adapted to other common architectures such as trapped-ion or neutral atom devices. We then benchmark our model by simulating a 20-qubit superconducting quantum computer, and compare the accuracy of our model to similar approaches from the literature and demonstrate an improvement in the overall prediction accuracy.




## Make Some Noise! Measuring Noise Model Quality in Real-World Quantum Software

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***Abstract*—Noise and imperfections are among the prevalent challenges in quantum software engineering for current NISQ systems. They will remain important in the post-NISQ area, as logical, error-corrected qubits will be based on software mechanisms. As real quantum hardware is still limited in size and accessibility, noise models for classical simulation—that in some cases can exceed dimensions of actual systems—play a critical role in obtaining insights into quantum algorithm performance, and the properties of mechanisms for error correction and mitigation.**

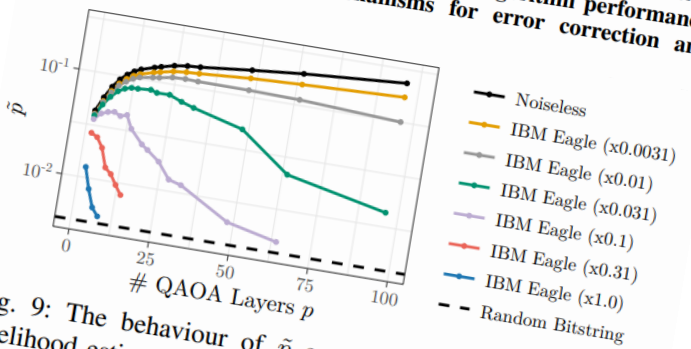


Fig. 9: The behaviour of $\tilde{p}$ as obtained from a maximum likelihood estimation, as a function of the QAOA depth. The different lines correspond to different gate error rates, with the blue line corresponding to the median error rate of a current IBM Eagle processor.

# Quantum Computing Landscape – 2025 Overview

| Company | Quantum Computer | Qubit Type | # Physical Qubits | # Logical Qubits | Technology | Key Feature / Notes |
|---|---|---|---|---|---|---|
| **IBM** | Condor | Superconducting | 1,121 | ~0 (experimental) | Gate-based | Largest superconducting QPU |
| **Google** | Willow | Superconducting | 105 | ~0 (experimental) | Gate-based | Solved problem in 5 mins vs 10 septillion years |
| **Atom Computing** | Unnamed System | Neutral Atoms | 1,180 | 28 | Gate-based | Commercial system with entangled logical qubits |
| **Microsoft** | Azure Quantum + Atom | Neutral Atoms + Virtualization | N/A | 24–28 | Logical Qubit Platform | Qubit virtualization + error correction |
| **D-Wave** | Advantage2 | Quantum Annealing | 5,000+ | N/A | Annealing | Optimization-focused, not gate-based |
| **Alice & Bob** | Helium / Boson / Lithium Series | Cat Qubits (Bosonic) | ~16 per logical qubit | 1 (2025), 100 (by 2030) | Fault-tolerant, bosonic codes | Longest-lived qubits (7+ mins), efficient error correction |
| **IQM** | Spark, Radiance, Resonance | Superconducting | 150 | 4-36 | NISC to QEC Fault-tolerant | Fast Gate speeds |
| **Eviden** | Qaptiva | Emulator | N/A | Qaptiva QLM >40 | Emulated | Hardware-agnostic |

**Understanding Physical vs Logical Qubits**

- **Physical Qubits**: The actual quantum hardware (e.g., superconducting circuits, trapped ions, neutral atoms). They are fragile and error-prone.
- **Logical Qubits**: Encoded across many physical qubits using **quantum error correction**. They are more stable and usable for real computation.

Typical ratios:

- **Surface Code (Google, IBM)**: ~1 logical qubit per 49–288 physical qubits
- **Cat Qubits (Alice & Bob)**: ~1 logical qubit per 16 physical qubits (targeting 15:1 ratio)


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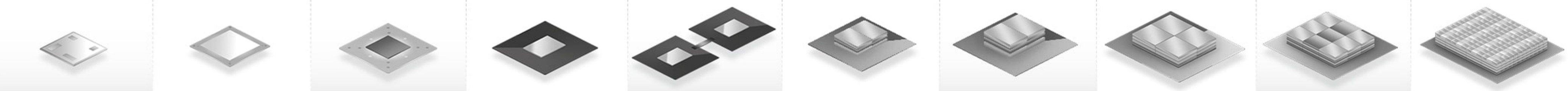
# Roadmap IQM

| | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2030 | 2031 | 2033+ |
|---|---|---|---|---|---|---|---|---|---|---|
| | Foundation | | | | Quantum Utility | | | Quantum Advantage | | |
| **Simulation** $28bn value in 2030 | System benchmarking, noise characterisation | Short to medium-sized molecular simulations (e.g., H2O, LiH, BeH2) and simulations of Ising and fermion models<br>Proof of concept: simulation of battery electrolytes | | | Medium size molecular simulations and new quantum materials for battery optimization and carbon capture | | | Drug discovery, catalyst and fertilizers design, carbon capture<br>Development of novel quantum materials, battery materials and energy storage | | |
| **Optimization** $18bn value in 2030 | | Proof of concept: power plant maintenance scheduling, Product portfolio optimization, train scheduling | | | Medium size problems: portfolio optimization, traveling salesperson and graph coloring problems | | | Advanced logistics and routing, energy grid optimization, risk management, infrastructure planning, telecom and data center management | | Global supply chain and transport, global energy systems |
| **Quantum Machine Learning** $26bn value in 2030 | | Proof of concept: predicting chemical reaction behaviour, fraud detection | | | Anomaly detection, feature selection, quantum data encoding, drug discovery, image generation | | | Bio data generation for training, drug-discovery, personalized medicine, complex market dynamics modelling, optimizing trading strategies, smart cities and autonomous systems | | |
| **Software Platform** | Stand-alone algorithm execution | | Loose HPC integration<br>Pulse-level access | HPC integration guidebook<br>Open architecture and programming framework for developers and partners | Tight HPC integration | | Realtime encoding of QLDPC code | | | |

**Processor Layout**

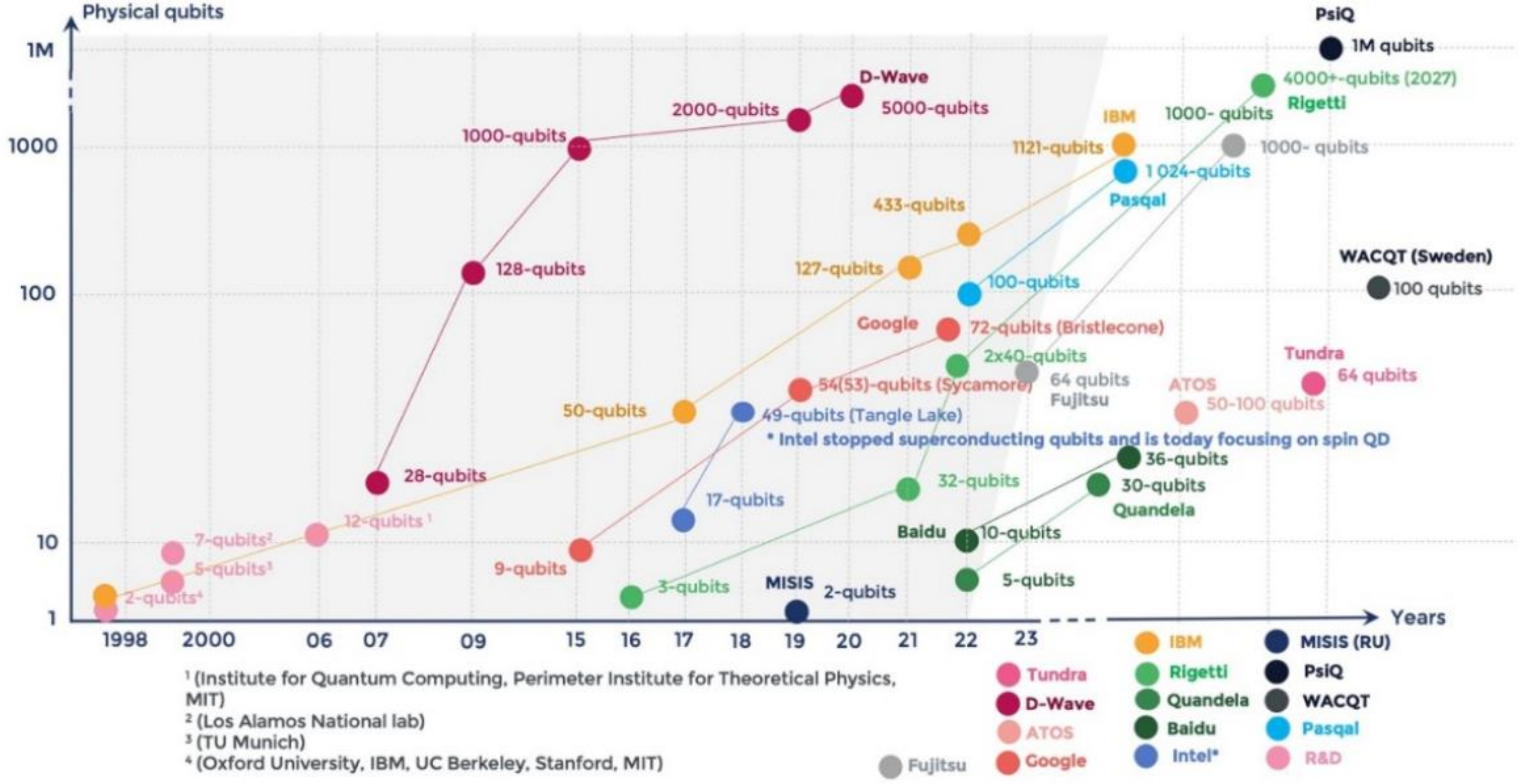


| | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2030 | 2031 | 2033+ |
|---|---|---|---|---|---|---|---|---|---|---|
| | NISQ | | | | | QEC Demonstrators | | Fault Tolerance | | |
| **Performance** | 99.8% | 99.8% | 99.9% | 99.92% | 99.94% | $10^{-5}$ | $10^{-6}$ | $10^{-7}$ | $10^{-8}$ | $10^{-9}$ |
| | | | Two-qubit gate fidelity | | | | | Logical error rate | | |
| **Qubit count** – Crystal Topology | 5 | 20 | 54 | 150 | 300 (150 × 2) | 1k | 5k | 40k | 100k | 1M |
| **Qubit count** – Star Topology | | | 6 | 24, 46 | 150 | | | | | |
| **Logical qubits** | Testbeds for 1-2 logical qubits | | | | | 4-36 | 60-180 | 240-720 | 600-1800 | 2400-7200 |



[Roadmap - IQM Quantum Computers]

# How close are we?

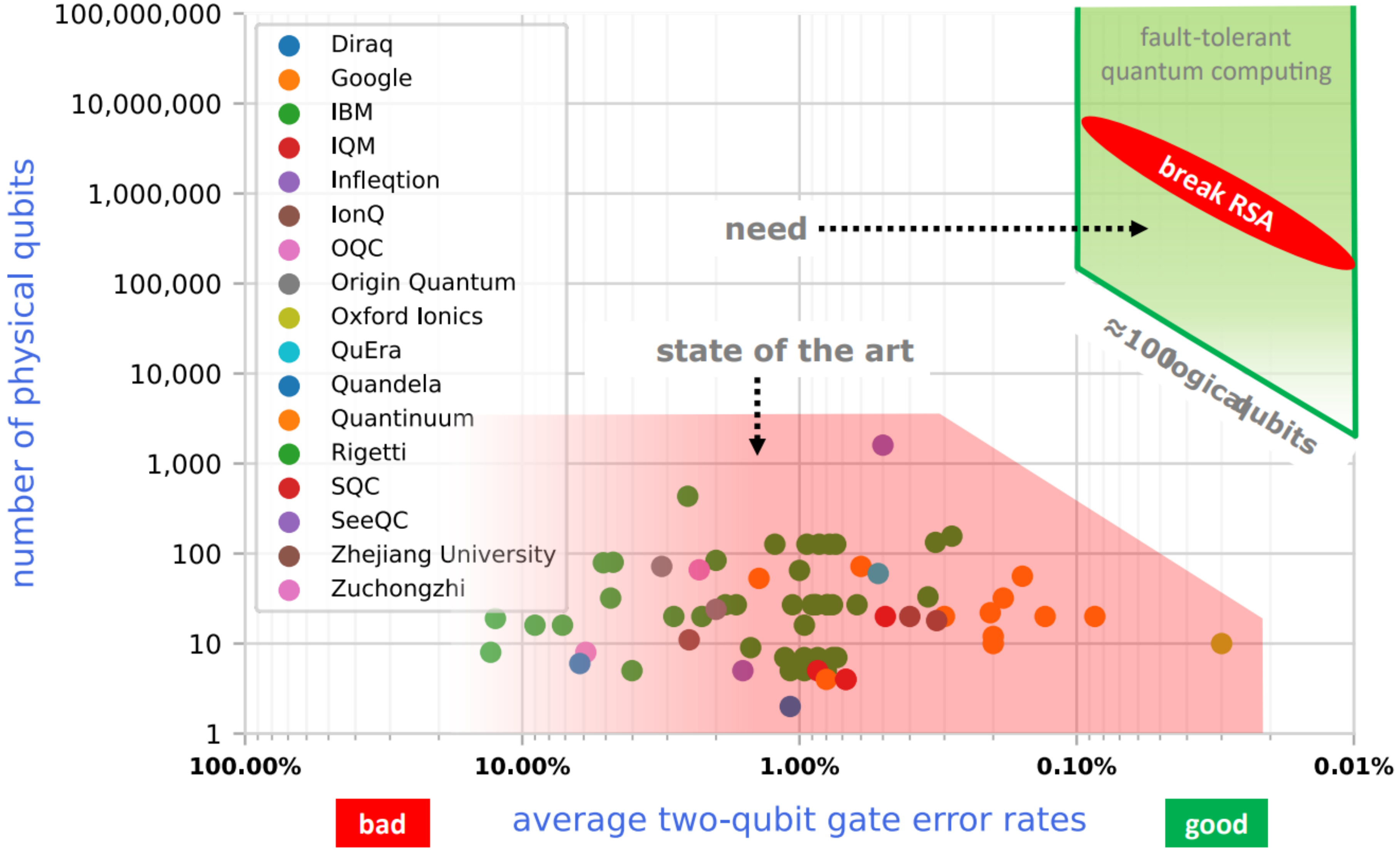



[1] (Institute for Quantum Computing, Perimeter Institute for Theoretical Physics, MIT)
[2] (Los Alamos National lab)
[3] (TU Munich)
[4] (Oxford University, IBM, UC Berkeley, Stanford, MIT)

YOLE Intelligence

www.yolegroup.com | ©Yole Intelligence 2023

# How close are we?

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https://arxiv.org/pdf/2111.15352

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# Our Qaptiva Solutions

Dr. Erik Schulze
Senior Presales Consultant
11/25/2025

an atos business

# Quantum Computing has the potential to revolutionize every industry

**Finance & Insurance**
- Portfolio optimization
- Risk assessment
- Credit scoring
- Fraud detection

**Energy & Utilities**
- Decarbonization
- Network Infrastructure
- Facility location
- Logistics scheduling

**Manufacturing**
- Supply chain
- Software validation
- Material science
- Product development

**Public Sector & Defense**
- Academic Research
- Cryptanalysis
- Material science
- Nanotechnology

**Healthcare & Lifesciences**
- Genomics
- Virtual screening
- Protein folding
- Drug discovery

**Telco & Media**
- Content
- Antenna location
- Chip layout optimization
- Predictive maintenance

**Cybersecurity – Post-Quantum Cryptography**


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# Adopting QC technology comes with its own set of challenges that need to be addressed

What is the best technology that will help to achieve my goal?

What issues can QC technology help me solve?

How can Quantum computing speed up HPC?


Why should we adopt QC now?

Do I need a Quantum emulator and QPU?

Do I have the people, tools, and expertise to program, optimize, and develop quantum algorithms?

How can researchers and industries cost-effectively leverage QC?

How can I ensure sovereignty?

Is it necessary for me to have access to all the technologies available in the market?

How can I future-proof my investment?

How can I train my people?


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# Qaptiva™ ID card

Pioneering since 2016

+83 patents
#1 in France #2 in Europe

+15 international research projects


Quantum emulation on noisy and noiseless qubits

Emulation of quantum annealing up to 50000 spins & hundreds of Qubits

Quantum Computing as a Service
or
On-premises

Leaders in HPC & Quantum hybridization

Use-case specific quantum libraries

Access to physical QPUs

Leaders' quadrant according to Technology Business Research TBR

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# Eviden Qaptiva positioning

## A hardware-agnostic approach to Quantum Computing

**Quantum Emulator**

| Quantum Annealing | Super-conducting | Trapped ions | Topological qubits | Photons | Silicon qubits | Misc. |
|---|---|---|---|---|---|---|
| D-Wave The Quantum Computing Company™ | IBM | IONQ | Microsoft | Hewlett Packard Enterprise | intel | QDTI Quantum Diamond Technologies |
| *Limited to optimization algorithms* | intel | AQT | NOKIA | XANADU | cea | PASQAL |
| | Google | universität innsbruck | QuTech | UNIVERSITY OF OXFORD | NOKIA | |
| | rigetti | Honeywell | Technische Universiteit Delft | ORCA Computing | NTT | |
| | QCI | | | | | |
| | OQC | | | | | |
| | QuTech | | | | | |
| | UCSB | | | | | |
| | IQM | | | | | |



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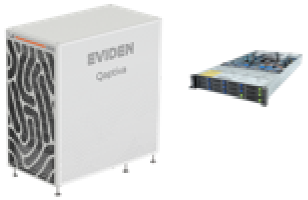
# Qaptiva

## Scalable solutions for quantum computing programming, emulation, simulation, and hybridization.

### Consulting & Training

### Appliances & Servers



- Qaptiva™ 800
- Qaptiva™ Access

### QC as a Service

### Python Package myQLM

Welcome page — myQLM documentation documentation

### Software Enablers

- 3rd party libraries
- Emulation on HPC
- HPC Hybridization
- Qaptiva™ Q-Pragma

### Strong Partnerships

- QPU Makers
- Industry-specific Software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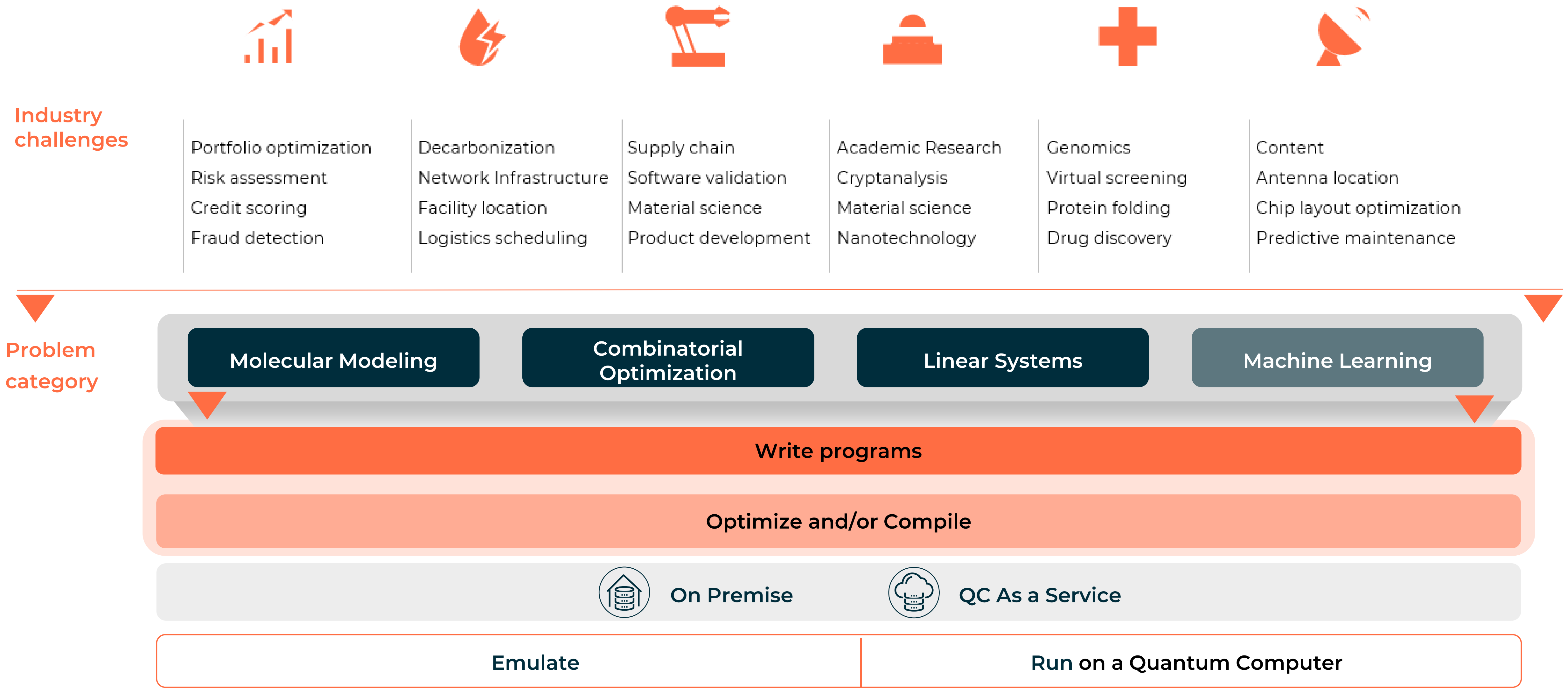
# With Qaptiva™, we support our customers at every stage of their journey

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# Qaptiva Application Platform

myQLM Python free package

-Development tools

**Programming: AQASM, pyAQASM, CIRC and QLIB**

**Libraries (Fermion, Eviden's proprietary libraries, Partners' libraries) and Notebooks**

**Universal / Gates**

**Full Vector:** Linear algebra emulator, noisy/noiseless emulator.

**Tensor Networks:** MPS/MPO, compressors.

**Others:** Feyman Path, BDD and more

**Annealing**

Simulated Quantum Annealing (SQA) emulator

**Analog**

Hamiltonian schedules

Analog QPU emulator

**Optimize and/or Compile**

Topological optimizer
Pattern circuit optimizer
Noise models and density matrices

Quantum tomography
Scheduler & Resource manager
Batch generators

**On Premise**

**QC As a Service**

Interface with other languages

**Emulate** | **Run on a Quantum Computer**

# Emulators included in the Qaptiva portfolio

| Paradigm | Model | Noiseless / Noisy | Qaptiva 800s Appliance | Qaptiva HPC | myQLM |
|---|---|---|---|---|---|
| Gate | Linear algebraic | Noiseless | LinAlg (GPUs supported) | CLinAlg<br>PyLinAlg<br>D-LinAlg (Distributed + GPUs mono-node) | CLinAlg<br>PyLinalg |
| | Linear algebraic | Noisy | NoisyQProc (Deterministic and Stochastic, GPUs supported) | D-Noisy (Deterministic)<br>(Distributed + GPUs mono-node) | |
| | Matrix Product | Noiseless | Matrix Product States (MPS)<br>QPEG | Matrix Product States (MPS) | |
| | Matrix Product | Noisy | Matrix Product Operator (MPO) | Matrix Product Operator (MPO) | |
| | Sparse Linear | Noiseless | Feynman | | |
| | Quantum Multi-valued Decision Diagram | Noiseless | Bdd | | |
| Analog<br>(Qubit simulation) | Matrix Product | Noiseless* | MPSTraj | D-MPSTraj<br>(Distributed) | |
| | Matrix Product | Noisy* | MPSTraj (Stochastic) | D-MPSTraj<br>(Distributed Stochastic) | |
| | Linear algebraic | Noiseless* | QutipQPU<br>AnalogQPU | | QutipQPU |
| | Linear algebraic | Noisy* | QutipQPU (Deterministic and Stochastic)<br>AnalogQPU (Deterministic and Stochastic, GPUs supported) | | QutipQPU<br>(Deterministic and Stochastic) |
| Analog<br>(Bosonic simulation) | Linear algebraic | Noiseless* | QutipQPU (Bosonic) | | QutipQPU<br>(Bosonic) |
| Analog<br>(Fermionic simulation) | Linear algebraic | Noiseless* | QutipQPU (Fermionic) | | QutipQPU<br>(Fermionic) |
| Annealing | N/A | Noiseless | SQA QPU | | Simulated Annealing (SA) |

* An analog QPU is inherently noisy because it is based on a hardware model: the *noiseless* version corresponds to the basic model with its inherent noise, while the *noisy* version adds pre-processing to reproduce additional noise sources.

# Current Challenges
# #2 HPC Integration

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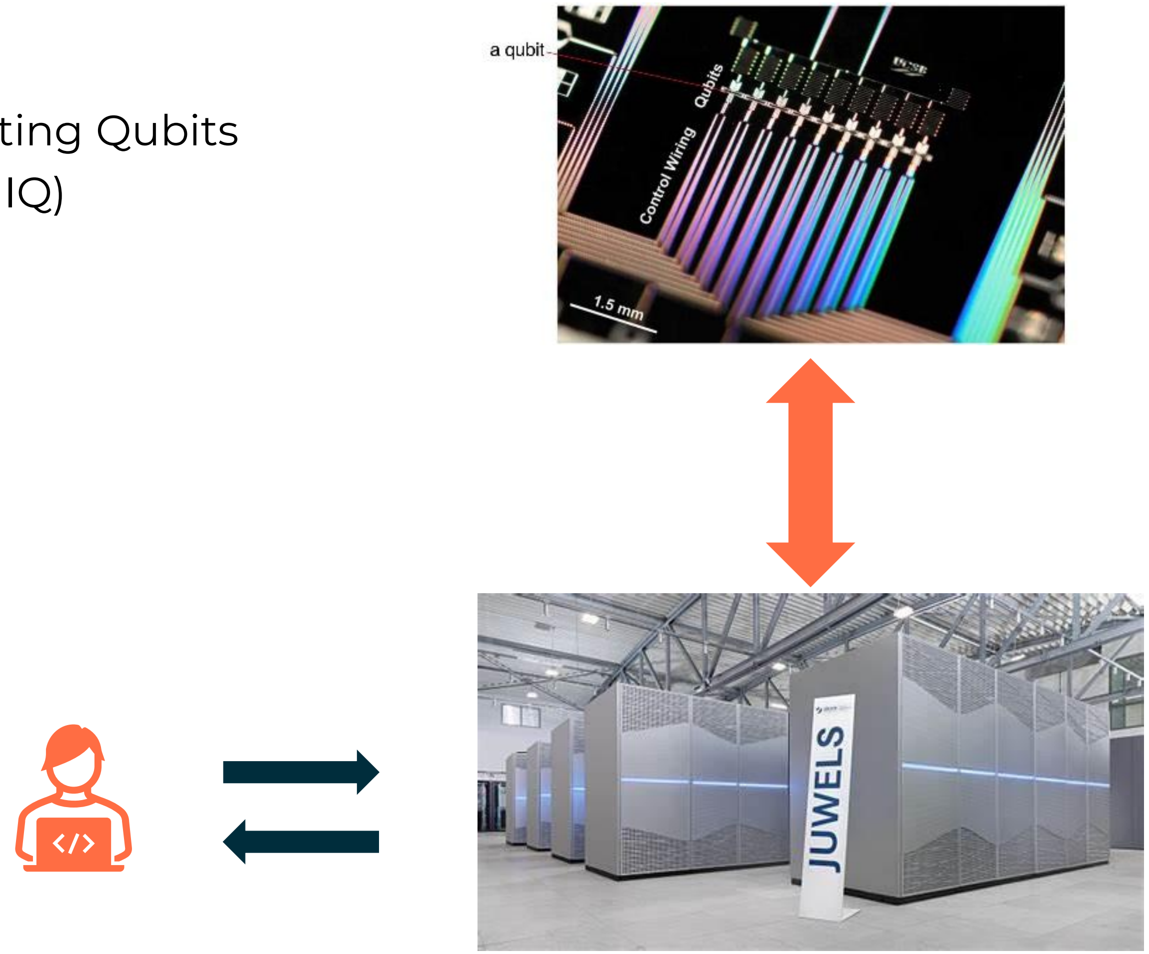
# Q-Solid

## Quantum Computer in the Solid State

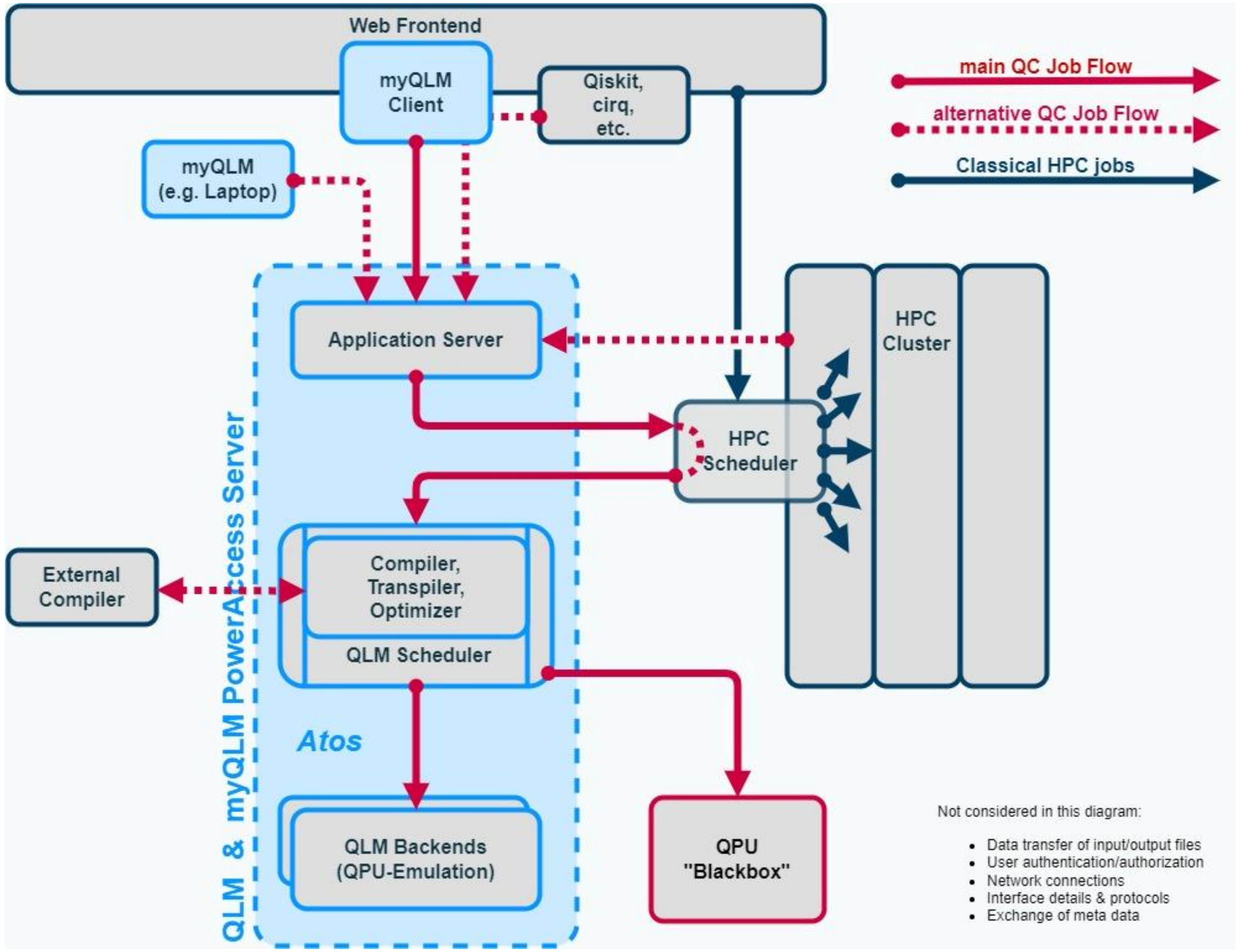
- Overall Project Goal:
  - ✓ Build a 30 Qubit QPU @FZ Jülich based on superconducting Qubits
  - ✓ Integration of QPU into existing HPC-Infrastructure (JUNIQ)
    → External may run qantum algorithms
  - ✓ Development of a QPU to reach „beyond-classical“ limits
- Run Time:
  - ✓ January 2022 – December 2026 (5 y)
- Project Partner (almost 30):
  - ✓ FZJ
  - ✓ HQS Quantum Simulations
  - ✓ ParityQC
  - ✓ ParTec
  - ✓ Qruise
  - ✓ IQM
  - ✓ etc.



# Eviden and Qaptiva in QSolid

## Qaptiva as central Middleware for HPC-Integration

➢ **Qaptiva as central part for the Integration of the QPU into existing HPC-Infrastructure**





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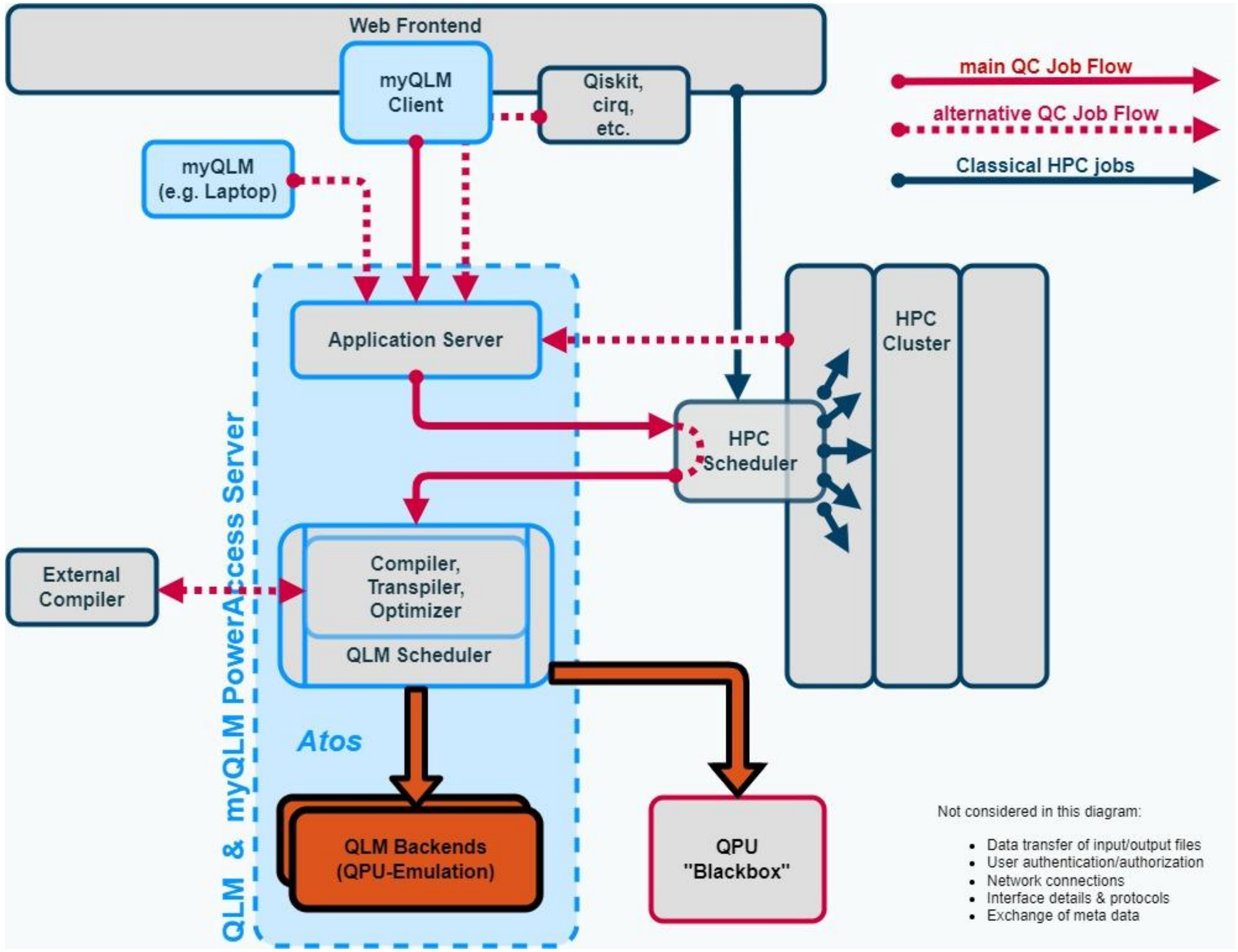
# Eviden and Qaptiva in QSolid

## Qaptiva as central Middleware for HPC-Integration

- **Qaptiva as QPU-Emulator and interface to the real QPU:**
  - ➢ Develop and test quantum algorithms and HPC integration workflows with Qaptiva before „real quantum hardware“ is ready
  - ➢ User may address Emulator and QPU in the same way





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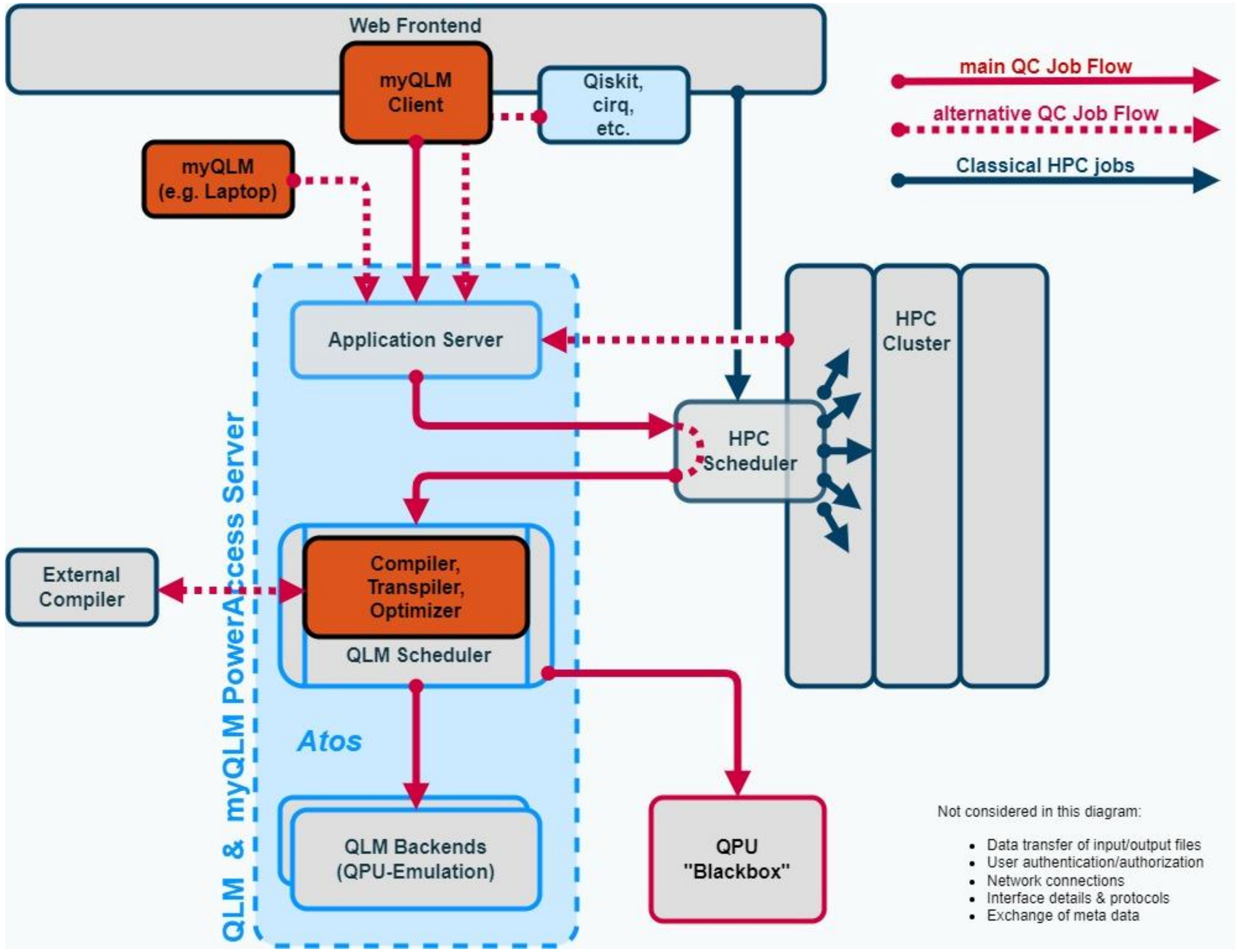
# Eviden and Qaptiva in QSolid

## Qaptiva as central Middleware for HPC-Integration

- **QLM-Framework as programming environment for quantum algorithms:**

  ➢ User may develop quantum algorithms independent of the details of the QPU („hardware agnostic“)

  ➢ Qaptiva adapts the quantum algorithm to the real hardware:
  - ✓ Topology
  - ✓ Transpilation
  - ✓ Circuit-Optimization
  - ✓ etc.





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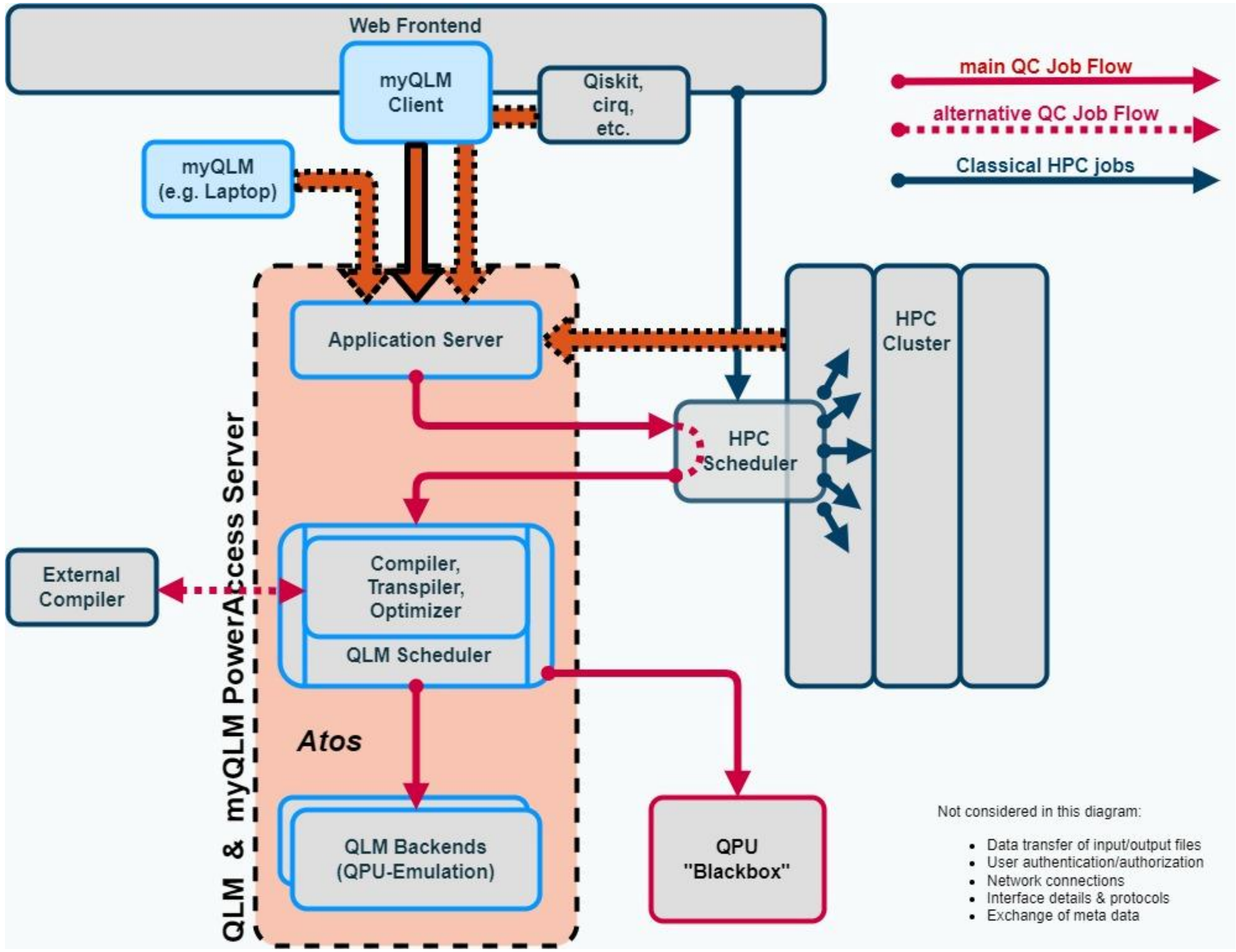
# Eviden and Qaptiva in QSolid

## Qaptiva as central Middleware for HPC-Integration

- **myQLM PowerAccess:**
  - ➢ Easy and secure remote multi-user access
  - ➢ User may write quantum algorithms on their laptop and run it on real or emulated QPU via Power Access





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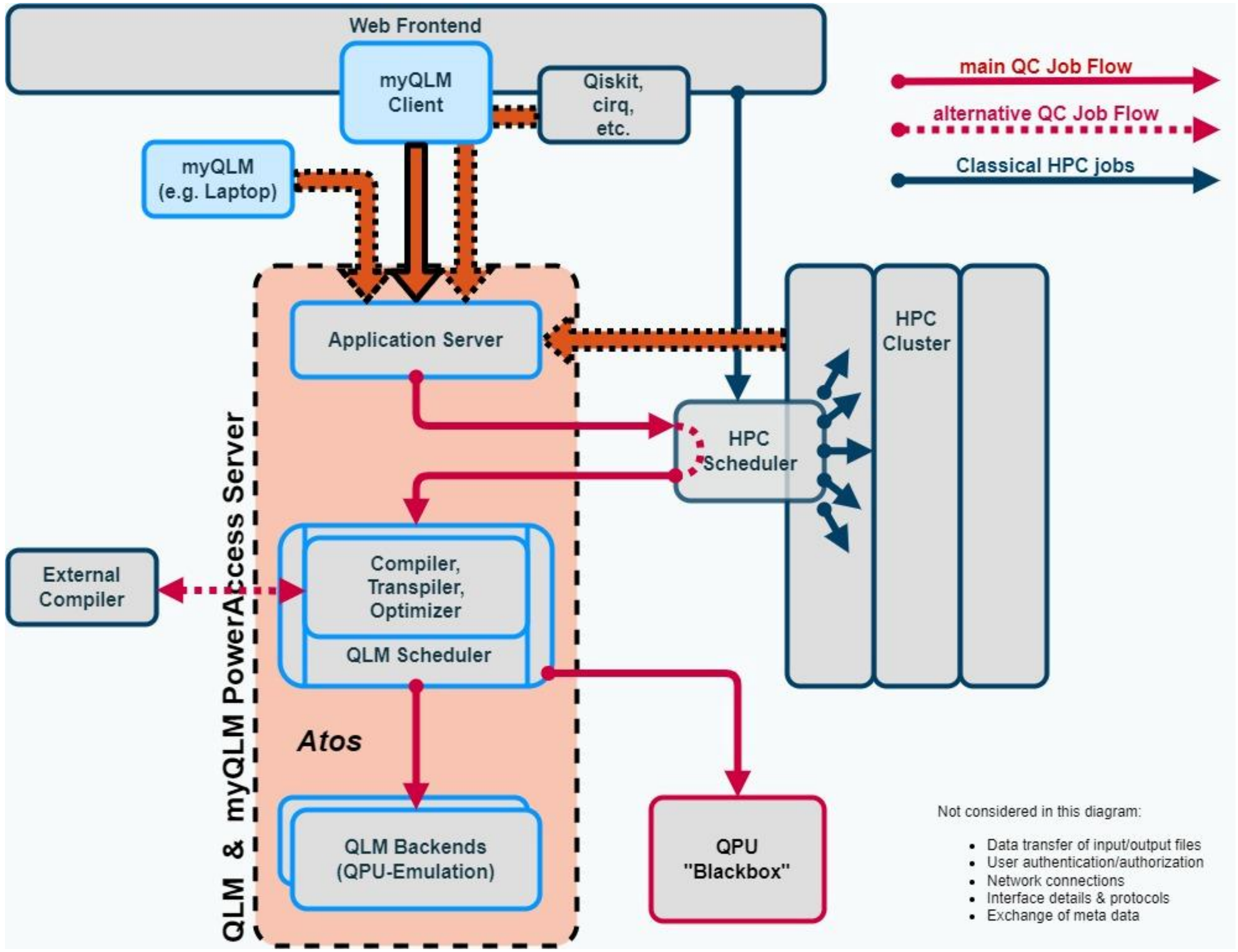
# Eviden and Qaptiva in QSolid

## Qaptiva as central Middleware for HPC-Integration

- **Flexibility of Qaptiva:**
  - ➢ Qaptiva serves as a middleware between user, HPC cluster and QPU
  - ➢ Additional quantum software is integrated as Plugin
  - ➢ Internal Scheduler orchestrates the distribution of pure and hybrid quantum tasks



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# Quantum Partner Network & Customer Success

Dr. Erik Schulze
Senior Presales Consultant
11/12/2025

an atos business

# Qaptiva™ Partner Ecosystem

## Software & Consulting Partners

Aerospace

Finance

Automotive

Healthcare

Defense

Logistics

## QPU Makers

With its strong partnerships and joint go-to-market strategies, Eviden is realizing its commitment to offering end-to-end solutions.

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# Qaptiva™ Partner Ecosystem

## Expanding offerings and capabilities to deliver more value

QUANDELA

### Photonics

2 to 12 optical qubits

Co-design approach or ready-made hardware

**Available now on Qaptiva™ as a Service**

- Hosted by Quandela
- VQE example
- 10000 shots - 20 seconds execution – few euros to run

IQM

### Superconducting

Gate-based paradigm

World-class error rates

Co-design approach or ready-made hardware

Use-case-specific hardware design

- As a Service in 2024
- Plan to be hosted by Eviden
- 5 qubits capabilities

PASQAL

### Neutral atoms

Analog and gate-based computing paradigm

Up to 200 qubits

Deep integration with myQLM tools

ALICE & BOB

### CAT Qubits

Innovative hardware-efficient design will reduce the hardware requirements for a fault-tolerant quantum computer


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# Eviden Quantum Customers

CSC
World Wide Technology
BMW GROUP
Argonne NATIONAL LABORATORY
Stanford University
OAK RIDGE National Laboratory
CERN
CESGA Centro de Supercomputación de Galicia
ICHEC
Hartree Centre Science & Technology Facilities Council

TotalEnergies
BAYER
SENAI CIMATEC SISTEMA FIEB
JÜLICH Forschungszentrum
cea
eDF
Université de Reims Champagne-Ardenne
lrz
सीडैक CDAC
INTELLIGENT WAVE INC.


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# Thank you!

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Erik.Schulze@eviden.com

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