

# Hybridization & Going Commercial

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# Troubles merging quantum with classical

## Hardware

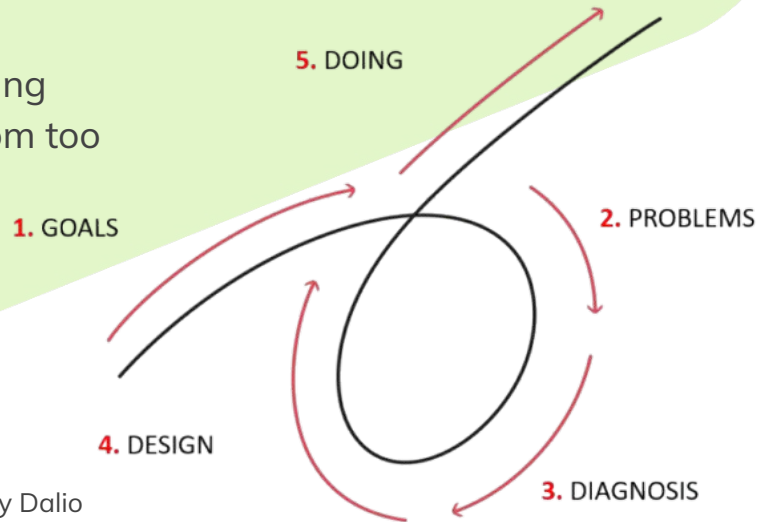
- We remain at peak potential → always 5 years away
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## Software

- Error correction improvement and better adoption
- Integration → scheduling, interpretation,
- Simulations lack memory for large qubit counts

## What's the plan?

- Still in NISQ, not yet [Fault-Tolerant Quantum Computing \(FTQC\)](#)
  - Microsoft just released their [roadmap](#) to FTQC for topological quantum computer
  - IQM has their [roadmap](#) with superconducting qubits (40k qubits by 2030)
  - QuEra has [theirs](#) for neutral atoms (100 logical qubits by 2026)
- The world is jumping on the band wagon
  - # ArXiv 'quantum physics' papers per year is doubling
  - Investors rich off AI boom want in on Quantum boom too



# Troubles merging industry & academia

## [Bridging the quantum divide \(2025\) - Zappin et al.](#)

- Hot potato & short lifespan of OS repositories
  - 91% of repos dead or docile
- Bugs appear with no bug spray in sight
  - Dead repo, tough integration & compatibility, platform islands → 39% report issues
  - 17% of repos have open issues regarding hybridization
- Academia & Industry don't have the same bug climate
  - Academia focuses quantum bugs, while industry faces classical bugs
  - Entanglement, qubit ordering **VS** library compatibilities, API changes, struggling support

# Quantum platforms

- Qiskit dominant
- PennyLane & Strawberry Fields part of Xanadu ecosystem
- Azure QML integrates with the rest of Microsoft Azure cloud computing
- D-Wave has monopoly on annealing
- TFQ is TensorFlow Quantum, by Google

[Credit: Tomar, Tripathi, Kumar](#)

Framework	Key Focus	Strengths	Typical Use Cases	Limitations
<b>TFQ (TFQ)</b>	Hybrid quantum-classical algorithms, QML	Integration with TensorFlow, Supports deep quantum circuits, Scalable	QML, optimization, chemistry simulations	Limited quantum hardware support, High learning curve
<b>PennyLane</b>	Hybrid quantum-classical computation	Supports multiple quantum devices, Strong in QNN	QML, optimization, quantum chemistry, RL	May have integration challenges with some quantum devices
<b>Qiskit</b>	Quantum circuit design, quantum algorithm execution	Wide device compatibility, Open source, large community support	QC, quantum simulation, optimization, QML	Limited scalability for larger systems
<b>Amazon Braket</b>	Quantum algorithms on cloud, Hybrid quantum-classical	Cloud-based, multi-platform support (IONQ, D-Wave, Rigetti)	Quantum optimization, chemistry simulations, ML	Limited quantum hardware variety for some algorithms
<b>Azure QML</b>	Quantum programming, Hybrid quantum-classical	Supports various quantum processors, Cloud-based, Integration with ML	Quantum optimization, quantum chemistry, QML, finance	Can be complex to integrate with existing systems
<b>D-Wave</b>	Quantum annealing, Optimization algorithms	Best suited for quantum annealing, Fast optimization solutions	Optimization problems, ML, QML, logistics	Only supports quantum annealing, not suitable for general QC
<b>Google Cirq</b>	Quantum circuit design, QC with Python	Well-integrated with Google hardware, Focus on near-term quantum devices	Quantum simulations, optimization, QML	Limited to specific hardware, Lack of flexibility for large-scale systems
<b>Orquestra</b>	Quantum software development platform	Integrates with multiple quantum frameworks, Focus on software lifecycle	Hybrid quantum-classical algorithms, neural networks, QML	Complex setup, Requires strong understanding of quantum systems
<b>Strawberry Fields</b>	Photonic QC, Quantum circuits	Strong in photonic quantum systems, High-	Quantum photonic computing, optimization, QML	Limited to photonic quantum systems, not widely compatible

## More quantum software

- [Qulacs](#) and [Yao](#): Fast simulators in Python and Julia
- [qBraid](#)
  - Extensions for Jupyter lab and VSCode, CLI, learning suite, own SDK
- [MIMIQ-Circ](#) by QPerfect
  - Uses Matrix Product States (MPS) and can simulate 100s of qubits
- [CUDA-Q](#) by Nvidia
  - Integrates [cuQuantum SDK](#) into the rest of CUDA
- [Classiq](#): Great algorithm design with large algorithm ensemble
- [Fire Opal](#) by Q-CTRL
  - Impressive error suppression, integrated to qBraid, Classiq and others



# Quantum landscape

- Largest focus on general hardware and software
- Lots more out there
- ...and everyone wants the Father of Quantum Mechanics' name
  - Planqc
  - PlanQK (Acquired by Kipu Quantum)
  - Max Planck Institute
- Checkout [Dealroom](#) for broad investor sentiment

Credit: Apex Ventures / Dealroom



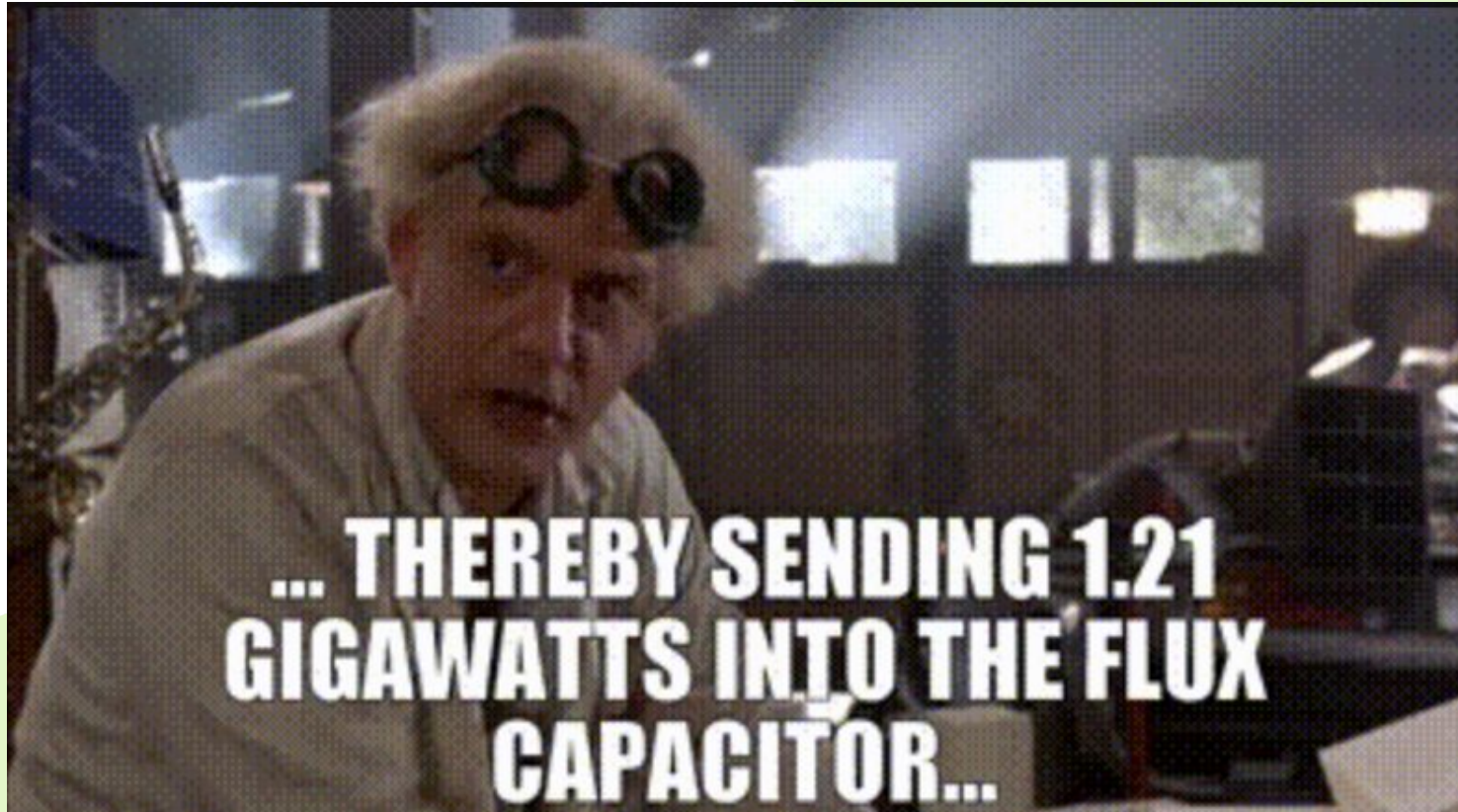
## Tech developments

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- [Record fidelity in superconducting qubit \(2025\)](#)
- MIT Quantum Research
- 99.998% fidelity!
- Uses a 'fluxonium' (what?)
  - Superconducting qubit made of:
    - Capacitor
    - Josephson junction
    - A large "superinductor"
- Less environment noise → higher coherence
- Fastest (superconducting) gate in town



## My thoughts on that...



## Tech developments

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- [World's first open-source, full stack quantum computer \(early 2026\)](#)
  - Open Quantum Design non-profit
  - Partnered with Xanadu, Haiqu, Unitary Foundation & Waterloo University
  - Ion-trap quantum computer, unknown qubits plan
  - Started 2024, launches 2026
  - Tools already online at [Github](#)
    - Atomic emulator
    - Analog emulator
    - Cloud server
    - Compiler infrastructure



## Tech developments

- [6100 neutral atoms trapped in tweezers](#) Dec 2024
  - Also record coherence time of 12.6 seconds
  - 12 000 sites for qubits
  - Caltech
- [5000+ two-qubit gate depth in superconducting](#) Nov 2024
  - IBM Quantum Heron R2 quantum processor with 156 qubits
  - Took 2.2 hours on another 2880 gate benchmark
- [Willow quantum processor does great error correction](#) Nov 2024
  - Don't need to describe, Google probably told you already
- [Certified randomness - Quantinuum 56 qubit trapped-ion](#) Mar 2025
  - Things are definitely random this time (jury, lottery, security)
- [Simulate QSVM with 784 qubits on 1 GPU!!](#) Jan 2025
  - [cuTN-QSVM](#) built on cuQuantum, plus MPI-enabled

# Industry expectations

2021

“While impact in the next 5 years is low, several high-impact use cases have been identified”

Challenge	Problem Domain	Company	Use Case	Impact
Engineering & Design	Machine Learning	AIRBUS	QC for Surrogate Modeling of Partial Differential Equations	High
		AIRBUS	Wingbox Design Optimization	High
	Optimization	Bosch	Software Testing and Correctness Proving	Medium
		Bosch	Design Optimizations for Electric Drives Using Numerical Simulation and Finite Element Methods	Medium
		Merck	Identification and control of Actionable Parameters for Disease Spread Control	Unknown
Material Science	Optimization	Boehringer Ingelheim	Optimized Imaging – Quantum-Inspired Imaging Techniques	Medium
	Simulation	BASF	Quantum Chemistry – Prediction of Chemical Reactivity in Molecular Quantum Chemistry	High
		Boehringer Ingelheim	Molecular Dynamics – Simulation of the Dynamics of Molecules	High
		Merck	Development of Materials and Drugs Using Quantum Simulations	Medium
		Munich Re	Battery Cover – Performance Guarantees for eVehicle Batteries	Medium
		VW	Chemistry Calculation for Battery Research	High
Production & Logistics	Machine Learning	Siemens	QaRL – Quantum-assisted Reinforcement Learning – Applicable to many Industrial Use Cases	Medium
	Optimization	BASF	Fleet Management – On-site Truck and Machine Deployment and Routing	Medium
		BMW	Robot Production Planning – Robot path Optimization for Production Robots (e.g., PVC sealing robot)	Medium
		BMW	Vehicle Feature Testing – Optimizing Test Vehicle Option Configuration	Medium
		BMW	Shift Scheduling – Optimizing Labour Shift Assignments	Medium
		Infineon	Demand Capacity Match in Supply Chain – Decide on a Production Plan given Predicted Customer Demand	Medium
		Infineon	Using Infineon Sensors and Actuators to Optimize Supply Chain Processes on the Customer Side	Medium
		Munich Re	Transportation Cover – Insurance of Time-Critical Freight	Medium
		SAP	Logistics – Truck Loading	Medium
		SAP	Supply Chain Planning – Improved and Accelerated Sizing of Orders (Lot Sizing)	High
		Siemens	QoMP – Quantum-optimized Matrix Production – Realtime Shop Floor Optimization	Medium
		VW	Vehicle Routing Problem – Optimize Vehicle Utilization in a Transport Network	High
Post-Quantum Security	Cryptography	Munich Re	IoT Cyber Cover – Insurance of Post Quantum Cryptography	Medium

## Industry developments

- Waste management 2021
  - [Tokyo reduces CO2 emissions by 57% with D-Wave annealing](#)
- Portfolio optimization 2021
  - [60% Return On Investment \(ROI\) on real datasets with D-Wave](#)
- Battery design 2024
  - [Improved ground state energy computations - Volkswagen & IQM](#)
- Quantum communication 2024
  - [NASA wants to connect quantum systems globally from space](#)
- Medical 2024
  - [Practical diamond quantum magnetometer for brain scanning](#)

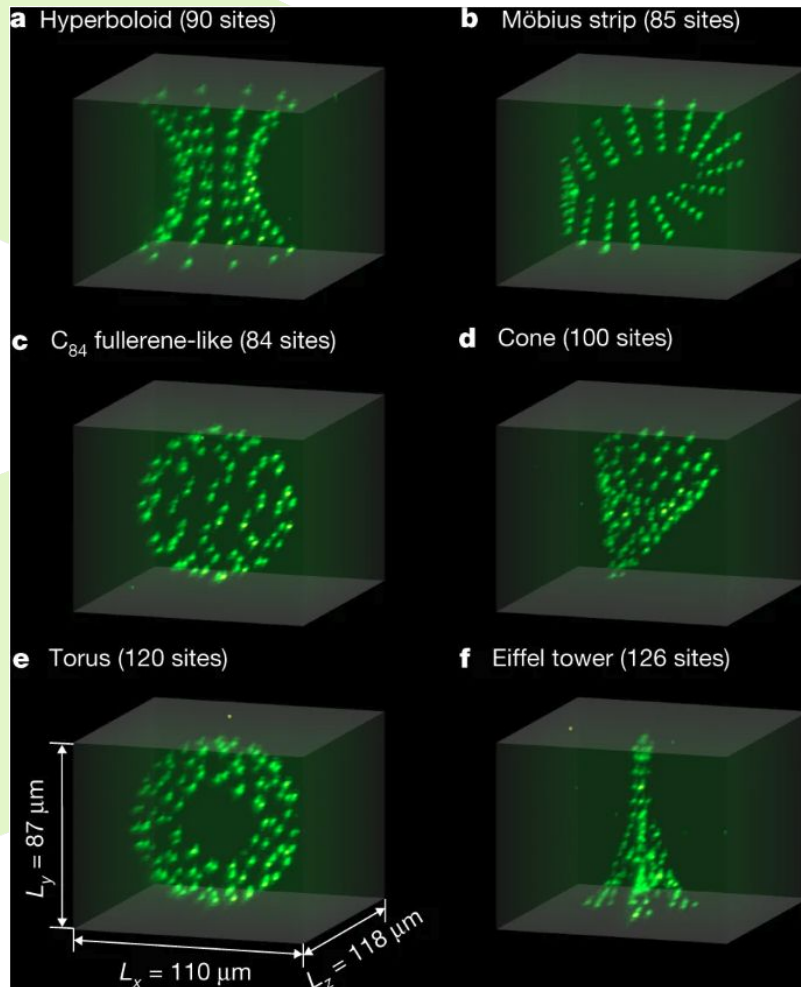
## Favorite media highlight

- [Jensen Chuang \(Nvidia CEO\) says quantum is decades away](#) (Jan 8)
  - Quantum stocks crash
- [Alan Baratz \(D-Wave CEO\) slams back with practical applications](#) (Jan 9)
  - Tries to dampen the fire
- [Nvidia has Quantum Day at GTC](#) (Mar 20)
  - Jensen admits he was wrong
  - “This whole session is going to be like a therapy session for me” - Jensen
  - Announces development of NVIDIA Accelerated Quantum Research Center (NVAQC)
  - All the big players involved
  - Double down on CUDA-Q

## Neutral atoms

### 3D neutral atom arrangement (2018)

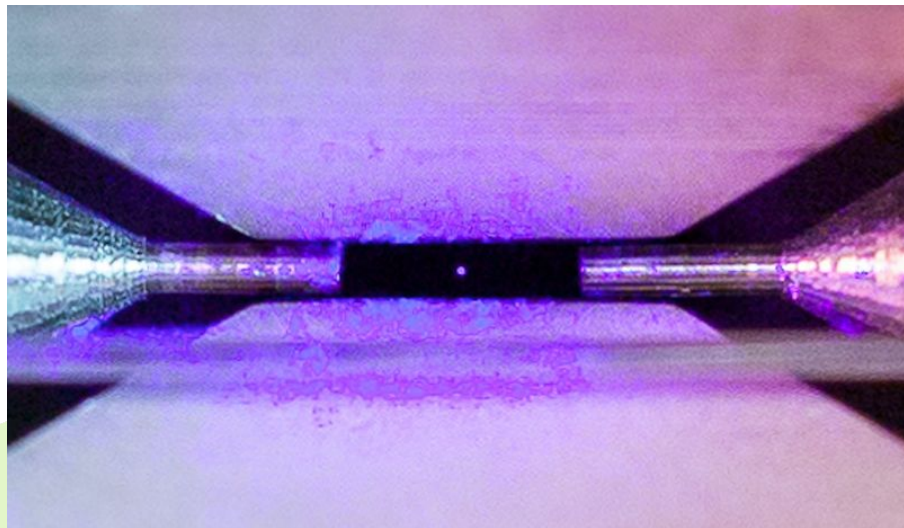
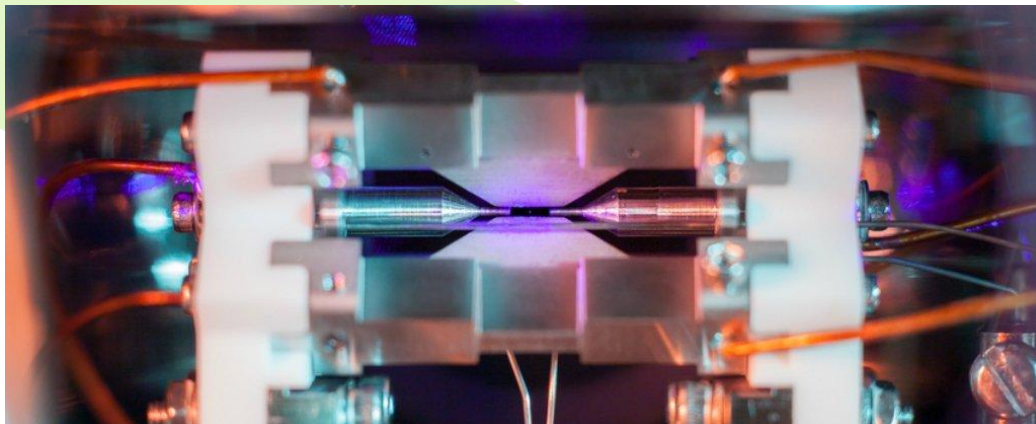
- Up to 72 atoms (could be qubits)
- Any shape you wish
- Imagine e.g. strength testing applied...
- ISC24 and SC24: panelists had the most intrigue towards neutral atoms
- Global leader: QuEra





## Atom to the naked eye

Strontium atom in ion trap,  
re-emitting color from laser in  
long exposure photo



David Nadlinger [wins photography competition at EPSRC in 2018](#)

## Grand thoughts

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### Next generation ideas for quantum to solve:

- Simulate every tissue molecule in humans
- Unlock Artificial General Intelligence (AGI) via quantum
- A greener world via QRAM
- Unhackable everything
- Your GPS doesn't lead you into the lake (optimal routing)

## **Acknowledgement**

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**Credit to Qureca for news in quantum**



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