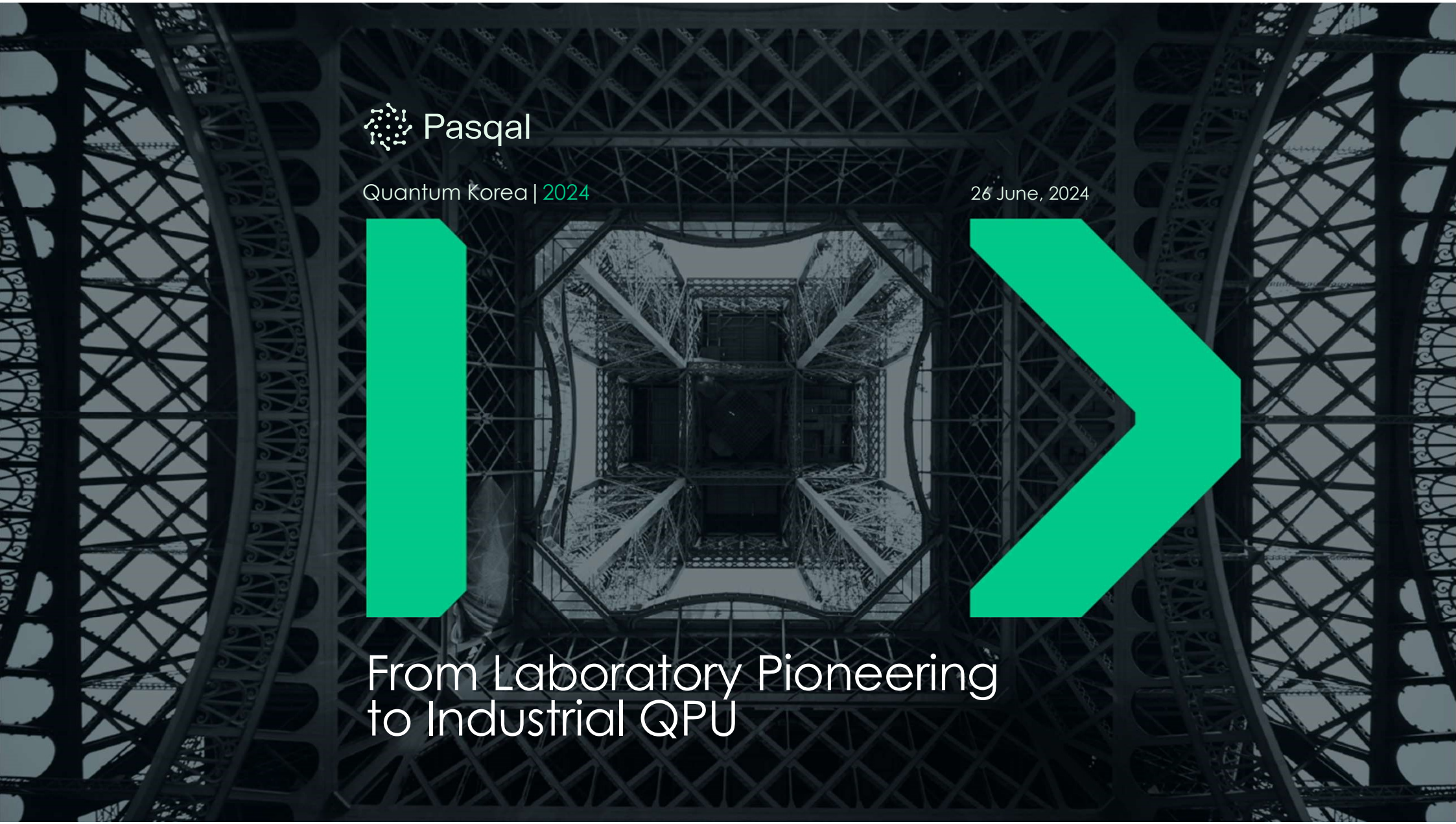

Pasqal
Quantum Korea | 2024
26 June, 2024
From Laboratory Pioneering
to Industrial QPU

PASQAL is a Unique Mix of Science and Engineering

Pasqal

> When there are no fundamental limitations, engineers find a path.
>
> — Prof. Alain Aspect

Georges-Olivier Reymond

Co-founder & CEO

16 years in bringing new tech on the market

Prof. Alain Aspect

Co-founder & Scientific Advisor

2022 Nobel Prize Laureate in Physics

Prof. Antoine Browaeys

Co-founder & Scientific Lead

2022 Solvay conference attendee, Nature 2021 & 2023

From Laboratory Pioneering to Industrial QPU

Pasqal

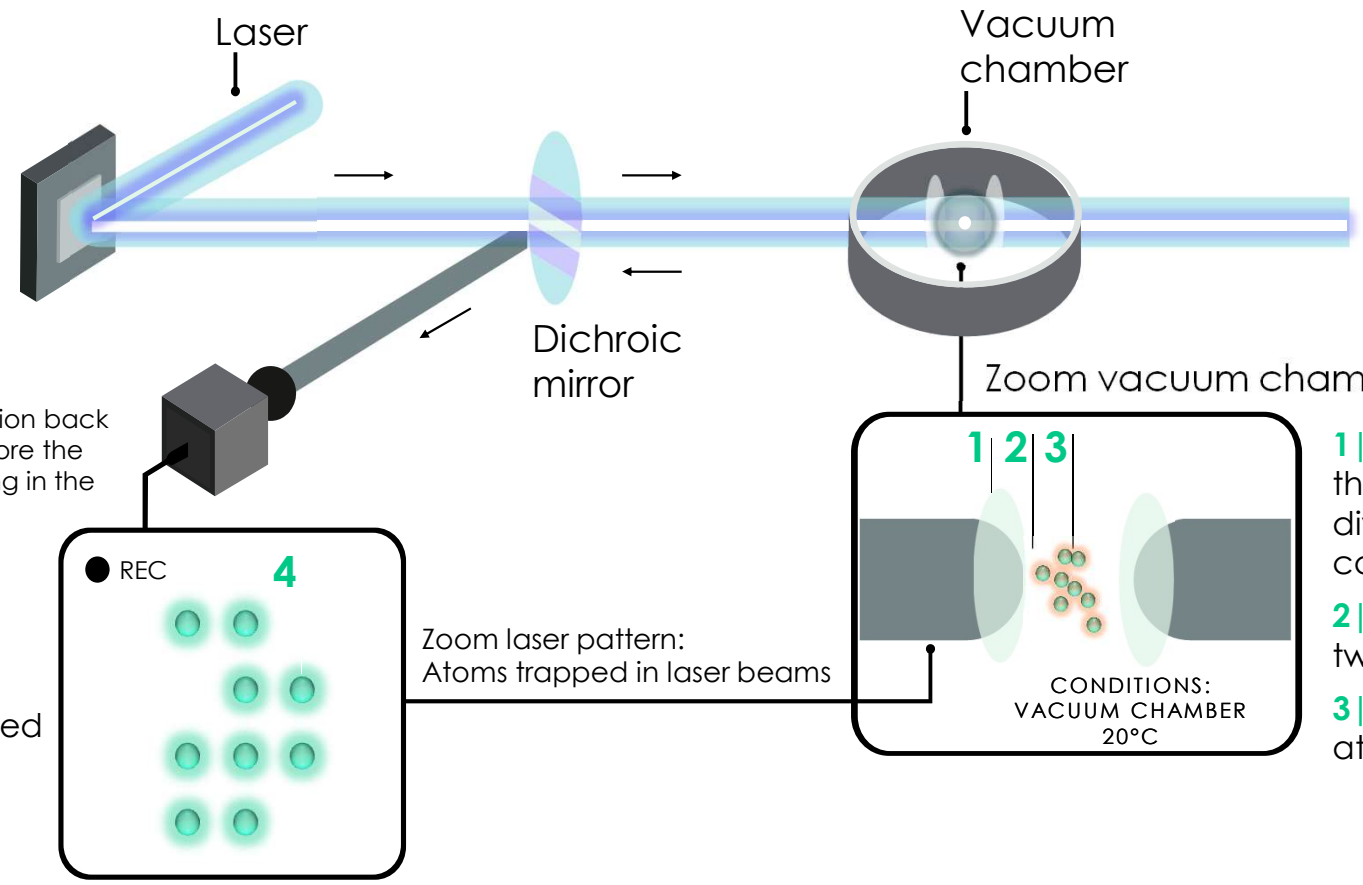
1

PASQAL: from lab to integrated Product ecosystem


PASQAL

Neutral Atoms Drive Our Quantum Technology

Pasqal



Camera
The mirror sends the reflection back to the camera, and therefore the image of what is happening in the vacuum chamber

4 | The light points come from photons emitted by the trapped atoms

1 | Optical system allows the laser beam to be divided into several beams called "optical tweezers"

2 | Multiple optical tweezers

3 | Trapped rubidium atoms (1 atom = 1 qubit)

Source: Quantum computing with neutral atoms, Quantum 4, 327 (2020)

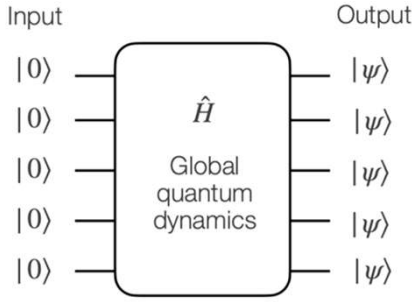
Neutral Atom QPUs can implement Algorithm with High Number of Equivalent Gates

Pasqal

Analog Control

Programming a Hamiltonian sequence

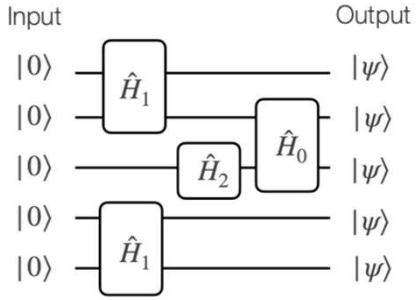
The Hamiltonian faithfully describes the dynamics of a physical quantum system or a reformulation of an operational case. Parameters can be tuned continuously.

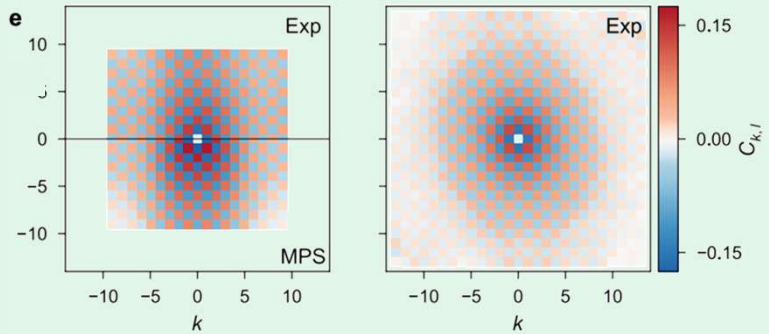


Digital Control

Programming a quantum circuit with digital quantum gates

Elementary operations are discrete digital quantum gates, that can act either on individual qubits, or on several qubits at the same time.





Staggered magnetisation histograms for 10 × 10 and 14 × 14 arrays, with MPS shown on the lower part of the 10 × 10 array (14 days for simulation with TeNPy) [1].

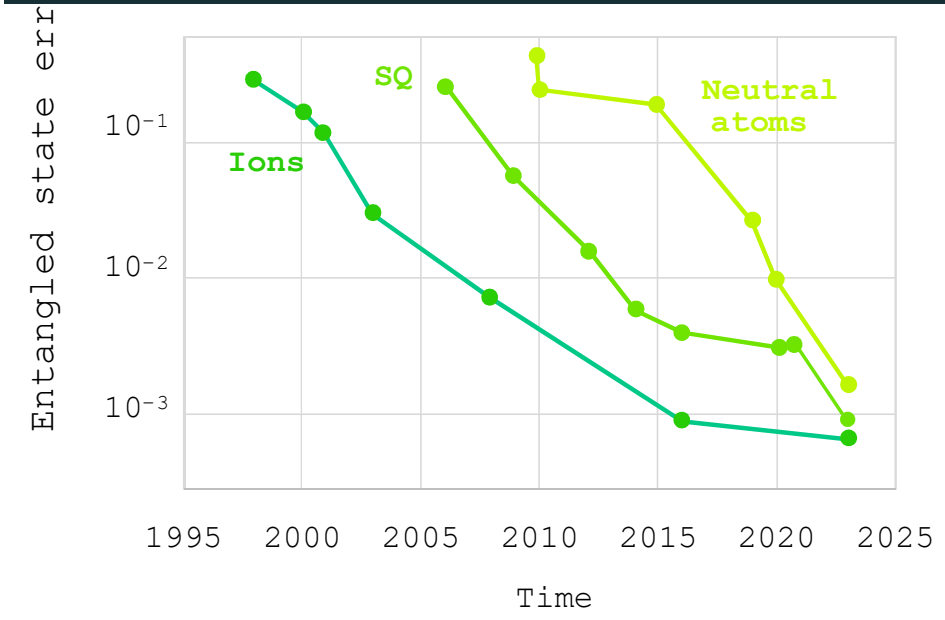
With typical error level of 1% of the analog mode, 10^6 gates are required with 1-F < 10^{-6} to simulate the same quantum dynamics of a 10x10 2D Ising-like model system[2].

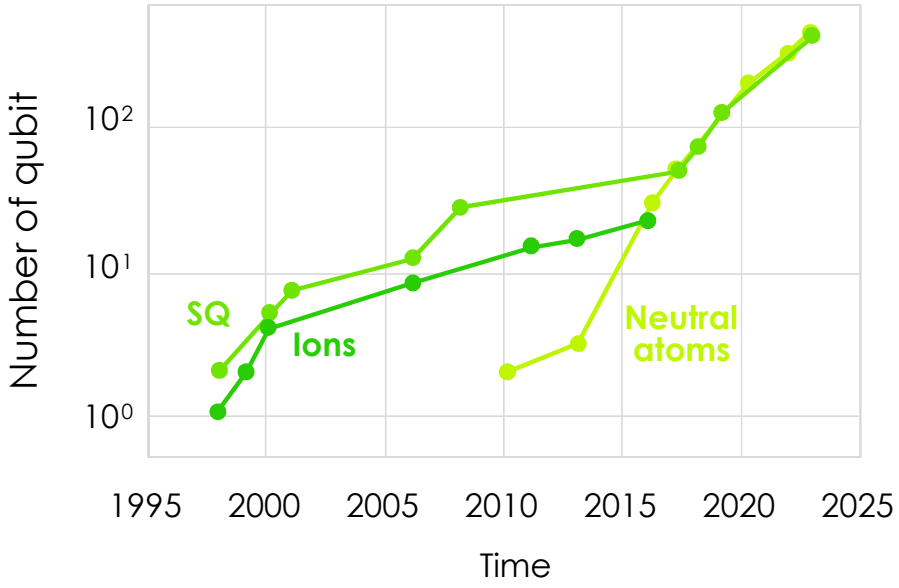
[1] Scholl, et al., Nature 595 (2021)
[2] Flannigan, Pearson, Low, Buyskikh, Kokail, Bloch, Zoller, Troyer, Daley (Nature 2022, Q Sci. Technol. 2022)

QEC: strong momentum for Neutral atoms

Pasqal

Neutral Atoms Compared to Other Platforms



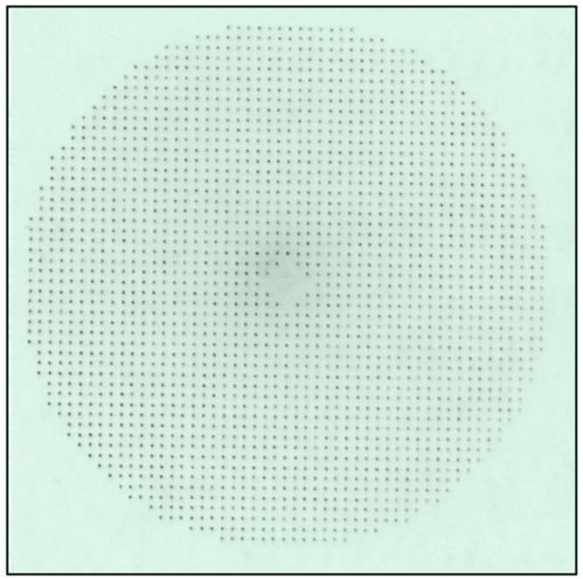


- Gate error approaching below 1E-3
- Qubit number moving towards 1000

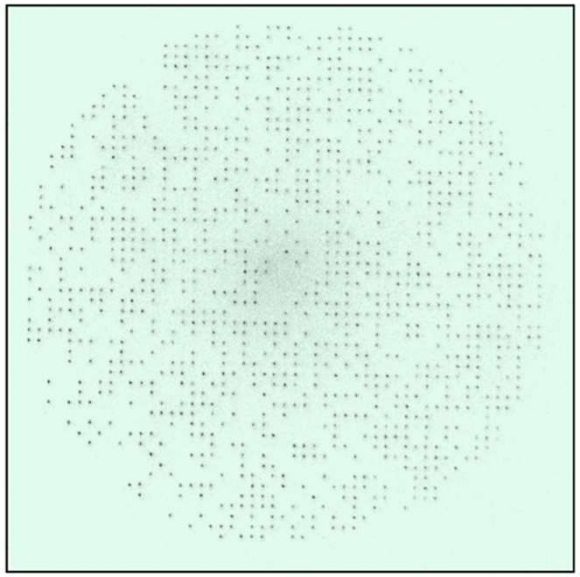
- Fault tolerant quantum computing is getting closer

Innovation on Common Platform to Boost qubits Scaling

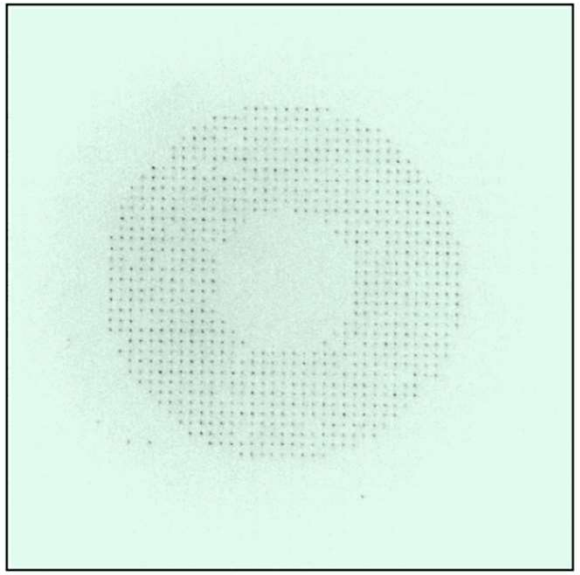
Pasqal



40x40 maximum fluorescence atom array [1]



Single shot 1100+ atoms[1]



Rearrangement with a target array of 828 atoms selected (95% occupancy) [1]

[1] G. Pichard, D. Lim, E. Bloch, J. Vaneecloo, L. Bourachot, G.-J. Both, G. Meriaux, S. Dutartre, R. Hostein, J. Paris, B. Ximenez, A. Signoles, A. Browaeys, T. Lahaye, D. Dreon, https://arxiv.org/abs/2405.19503 (2024)

Engineering Approach

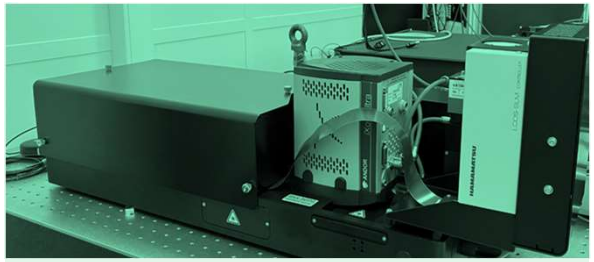
Pasqal

Higher Stability and Uptime, Repeatability

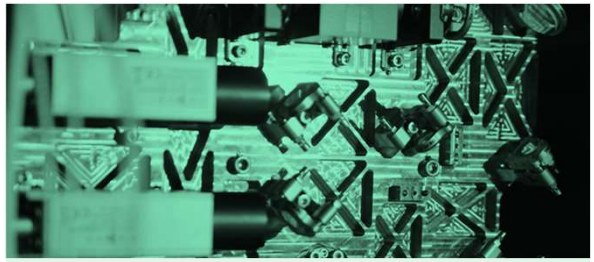
Improve modular design, sub-modules with well-defined interfaces

Stability, ease of maintenance & development

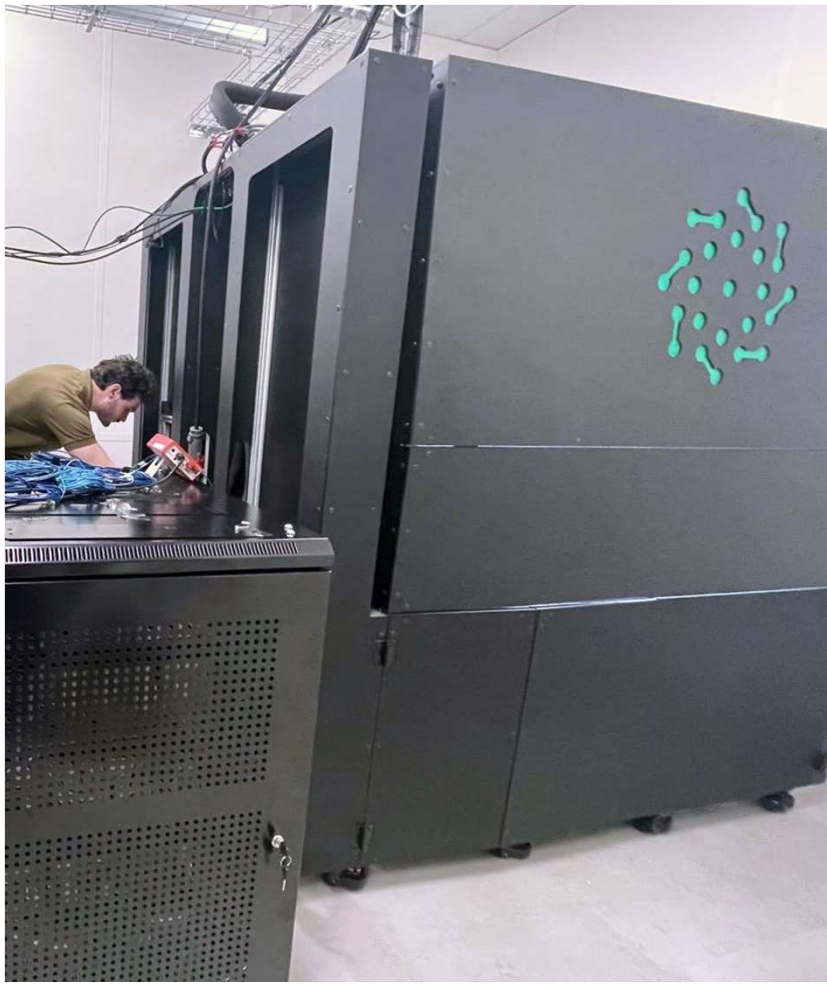
Continuous improvement while keeping compatibility with interfaces



Opto-mechanical bench for atomic array creation and re-arrangement, very compact and optimized design to implement functionnality



Engineered laser lock system to precisely control laser frequency



Orion Alpha first generation of QPU, already provides opportunities for concrete use cases

Orion Alpha

✔Custom:

- Mechanical Design for Stable Structure
- Electronics
- Optical Setups to Ensure Stability
- Software to Automatize the QPU

Devices already operational	• High uptime during production period • Suitable for a Wide Range of Applications
Solutions co-developed with Partners	• World-class experts & Relevant Solutions • Hybrid Quantum-classical Algorithms Considering Existing HPC Environment
Algorithms Running Now	• Truly Benchmark our Algorithms • Fueling co-design Hardware development

Many use cases have been implemented on Orion Alpha

Orion Alpha

✔Custom:

- Mechanical Design for Stable Structure
- Electronics
- Optical Setups to Ensure Stability
- Software to Automatize the QPU

	ALGORITHM/PRIMITIVE	USE CASE DESCRIPTION
PASQAL	Graph Machine Learning	Toxicity Screening & Molecular structure
Qubit Pharmaceuticals	Optimization	Protein Hydration
CINECA Links	Optimization	Graph coloring for telco networks
JÜLICH Forschungszentrum / HPC|QS	Quantum Materials	Dynamics of Ising model
CINECA	Optimization	Analog QAOA
Multiverse Computing / CA	Optimization	Credit risk analysis
EDF	Optimization	Smart charging of electric vehicles
PASQAL	Quantum Simulation	Variational algorithm
THALES Building a future we can all trust	Graph Optimization	Mission planning for satellites

Recognition by major players in the global industry

Pasqal

aramco

HPC|QS

IBM

May 20th, 2024

Aramco Signs Agreement With Pasqal To Deploy First Quantum Computer (200 qubits) In The Kingdom Of Saudi Arabia by end of 2025

May 30th, 2024

CEA HPCQS welcomed the delivery of the first Orion QPU (100 qubits), which will be connected to the Joliot Curie supercomputer

June 6th, 2024

IBM and Pasqal Initiate Collaboration to Define Classical-Quantum Integration for Quantum-Centric Supercomputers

Pasqal

2

PASQAL Full-Stack Roadmap towards Quantum Readiness

PASQAL, the First Company Pushing Engineering for Neutral Atoms QPU

Pasqal

Engineering

A choice that enables us both to boost our technologies and develop products that can be used by the community

Boosting performance

NEAR-TERM QC

Qubit scaling +

Increase # of qubits in same QPU

Addressability +

Run and parallelize multiple qubit ops

Repetition rate

Increase the max # of calculations per second

+

ERROR CORRECTED QC

Error Correction +

Implement active error correction on logical qubits

Interconnect

Increase logical computational power

Mature Products & Community-driven application development

QPU generations +

Increasing hours of QPU for users +

Collaborative platform +

Open-source software stack

Our Roadmap

Pasqal

		2022 - 2023	2024 - 2025	2026 - 2027	2028+
Technology					
PASQAL & affiliated ecosystem					
HARDWARE PLATFORM	Max qubits	200	1,000	10,000	
	Addressability	Z add	Z+X add	Addressable 1Q and 2Q gates	
	Base repetition rate	1 Hz	3 Hz	10 Hz	100 Hz
	FTQC Program		Atom shuttling; Ultra High-Fidelity Gates	Scalable logical qubits architecture	
HARDWARE ACCELERATED LIBRARIES	Quantum Matter & Quantum AI	Algorithm Blueprint	Algorithm Development	Production	
Products					
QUANTUM PROCESSORS	Generation	**Orion Alpha** ~3M gates	**Orion Beta** ~5M gates On premise delivery	**Orion Gamma** ~10M gates On premise delivery; **Vela** ~40M gates	**Pegasus** ~200M gates; **Centaurus FTQC QPU** 128+ Logical qubits 200M+ gates
	Total hours of QPU for users	500	5-10,000	20-30,000; 60-70,000	200-250,000; 500-550,000
	Factories	France	Canada	Factory 3	
COMMUNITY	Platform		Learn	Interact; Collaborate	
	Open-source Software Stack	Pulser	Qadence	Solvers & Emulators	

ity


Pasqal