QUANDELA

Enabling organizations to achieve their quantum transformation

Niccolo Somaschi
CEO

Introducing Quandela

More than 70 people dedicated to Quantum

Semiconductors,
Optical technologies,
Mathematics
Algorithms, AI,
Computer science

Founded in 2017

- Paris-Saclay
- Munich
- Cambridge

Paris-Saclay

R&D Centers

Production Centers

LA FRENCH TECH 2030

Gartner

2023 Quantum Cool Vendor

Our Mission

‘Build the first useful quantum computer and enable organizations to achieve their **Quantum Transformation** anywhere in the world’.

Quandela: commited and recognized for real delivery

Photonic is the **best** platform for QC

Manufacturing	Photonic core components manufactured using mature semiconductor fabs
Cooling	Photons do not feel heat and can operate at ambient temperature in traditional data centers.
Connectivity	Interconnects can be achieved using conventional optical fiber.
Control	Thermal and EM insensitivity permits colocation of complex control electronics.
Photons emission	Quandela is world leading manufacturer of solid-state quantum light emitters

Quantum offers tailored to your needs

Quandela

Quantum Acceleration Program (QAP)

Strategic client program focused on enabling and accelerqting clients along their framing to scaling quantum journey

Program fee

EDF · MBDA MISSILE SYSTEMS · ONERA THE FRENCH AEROSPACE LAB · SAFRAN · AIRFRANCE

Quantum Computing-as-a-Service (MosaiQ on the Cloud)

Pay-for-usage access to a full stack photonic quantum computer to develop and run applications

Usage-based fee (€/qubit second[1])

THALES EDF · MBDA · Alysophil

Quandela's Cloud

Quantum Computing System Sale (MosaiQ)

Sale of full-stack quantum computer to research and industrial customers as well as state agencies

One-time product and service fee (€/unit sold) + recurring annual maintenance fee (€/unit sold/year)[2]

CINECA · OVHcloud · Leibniz-Rechenzentrum der Bayerischen Akademie der Wissenschaften · FRANCE HYBRID HPCQUANTUM INITIATIVE

On-premise

Example of impact of future Quantum Computer

Applications of Fourier Transform

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Classical

Complexity ~ $n.2^n$

Quantum

Complexity ~ n^2

Our quantum bits

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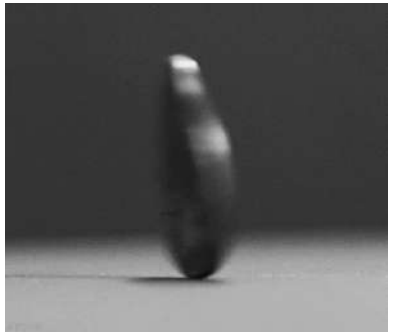
1 What is a qubit ?

- 1
- 0

Classical

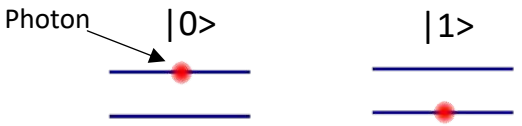


2 Photonic Qubits

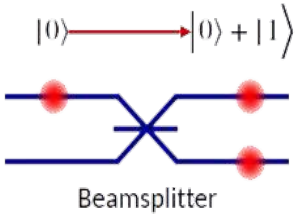
Photons are Flying Qubits → moving through the QPU and optical fibers

The QPU chip is classical and not functional without photons in input: it ACTS on the qubits

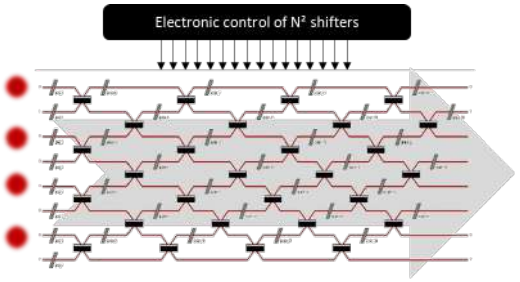
1 PHOTON IN SPATIAL MODES (DUAL RAIL ENCODING)



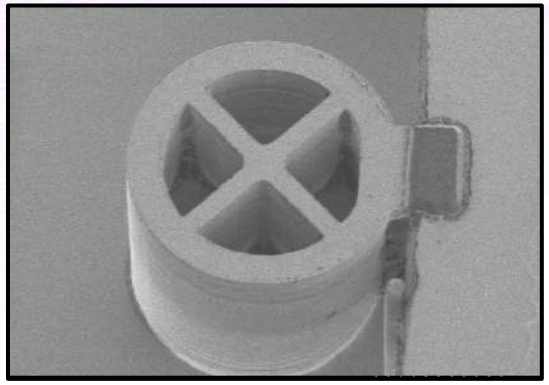
ONE-QUBIT GATE

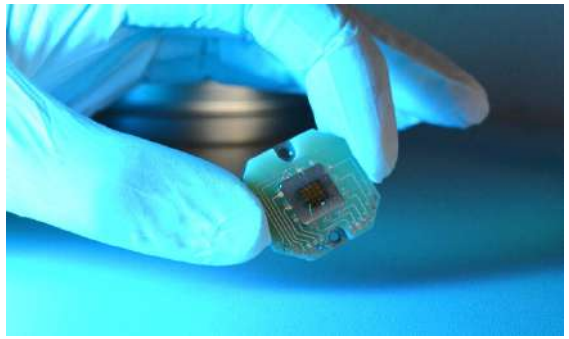


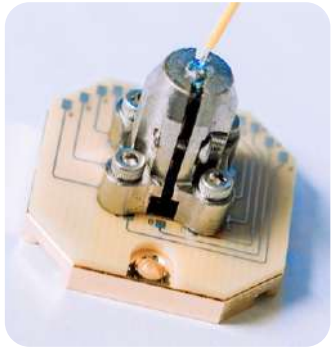
SEQUENCE OF N-QUBIT GATES

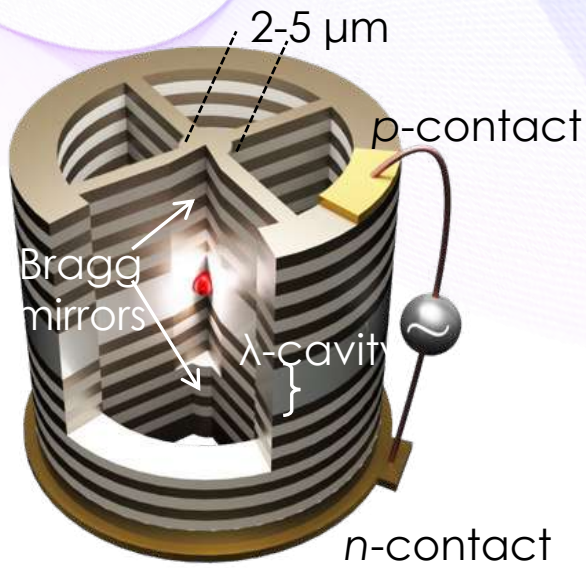


Qubit Generation – World best emission of photons









First Quandela product, sold around the world since 2018

C2N

cnrs

université PARIS-SACLAY

Developed in the group of Pascale Senellart at the Center for Nanoscience and Nanotechnology

00:00:00

QUANDELA

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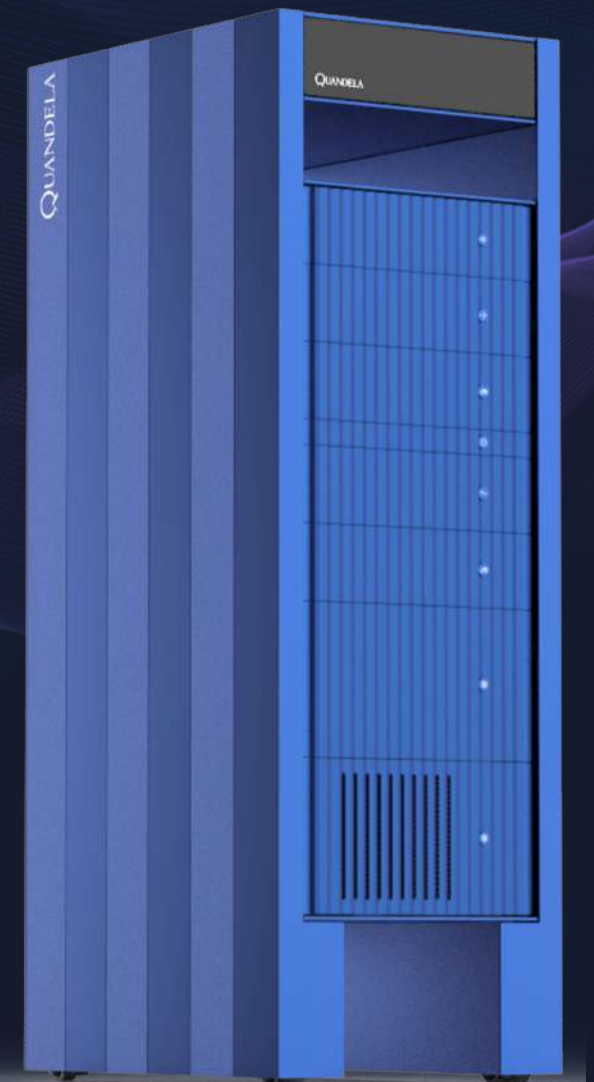
How to start using Quandela Quantum computers

Quandela is the first European provider of QC based on light



MosaiQ

- Computing Framework & Simulator
- Compilation
- Optics / PICs / Electronics
- Semi-conductor

Cloud service

Perceval
Open-source programming framework

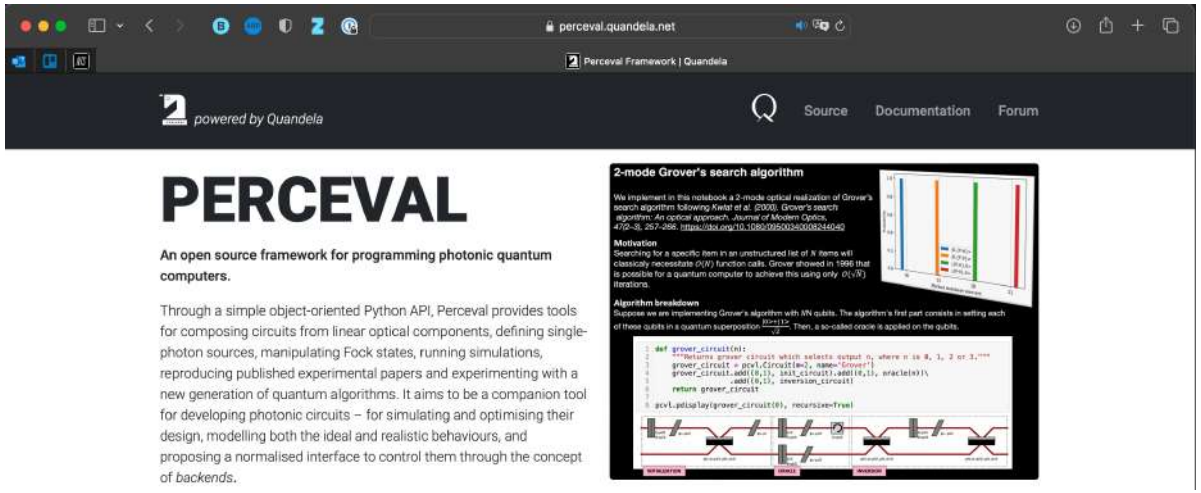
Algorithm toolbox
Solutions for Industry applications

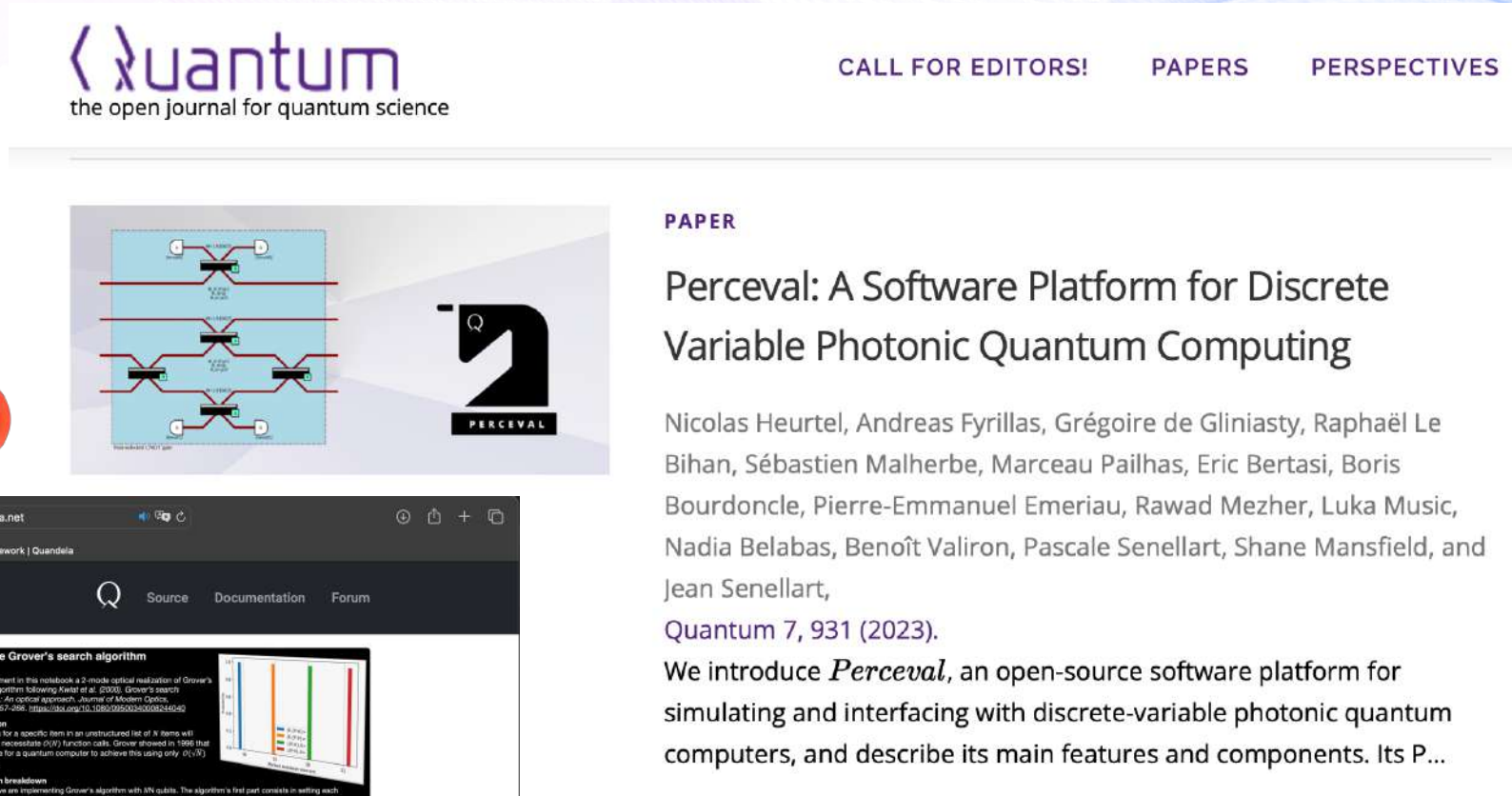
MosaiQ QPU
Server rack size systems

Perceval

Open-Source Framework for Photonic Quantum Computing

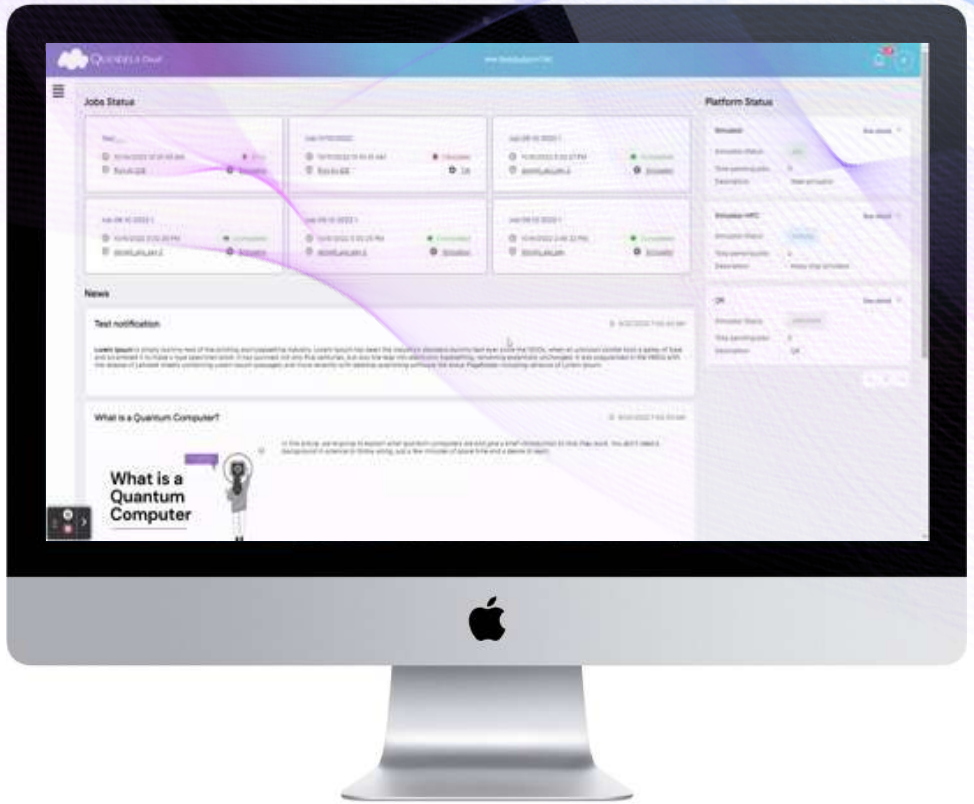
- Photon-specific
- Fully compatible with *myQLM*
- Connectors to run gate-based circuit directly in myQLM





Convivial and accessible interface

- Get access to powerful simulators (up to 15-20 photons) and real quantum processing units.
- Generate and manage your tokens and keep track of your projects.
- Manage your company account and follow the activities of your collaborators
- Intuitive Interface with extensive documentation



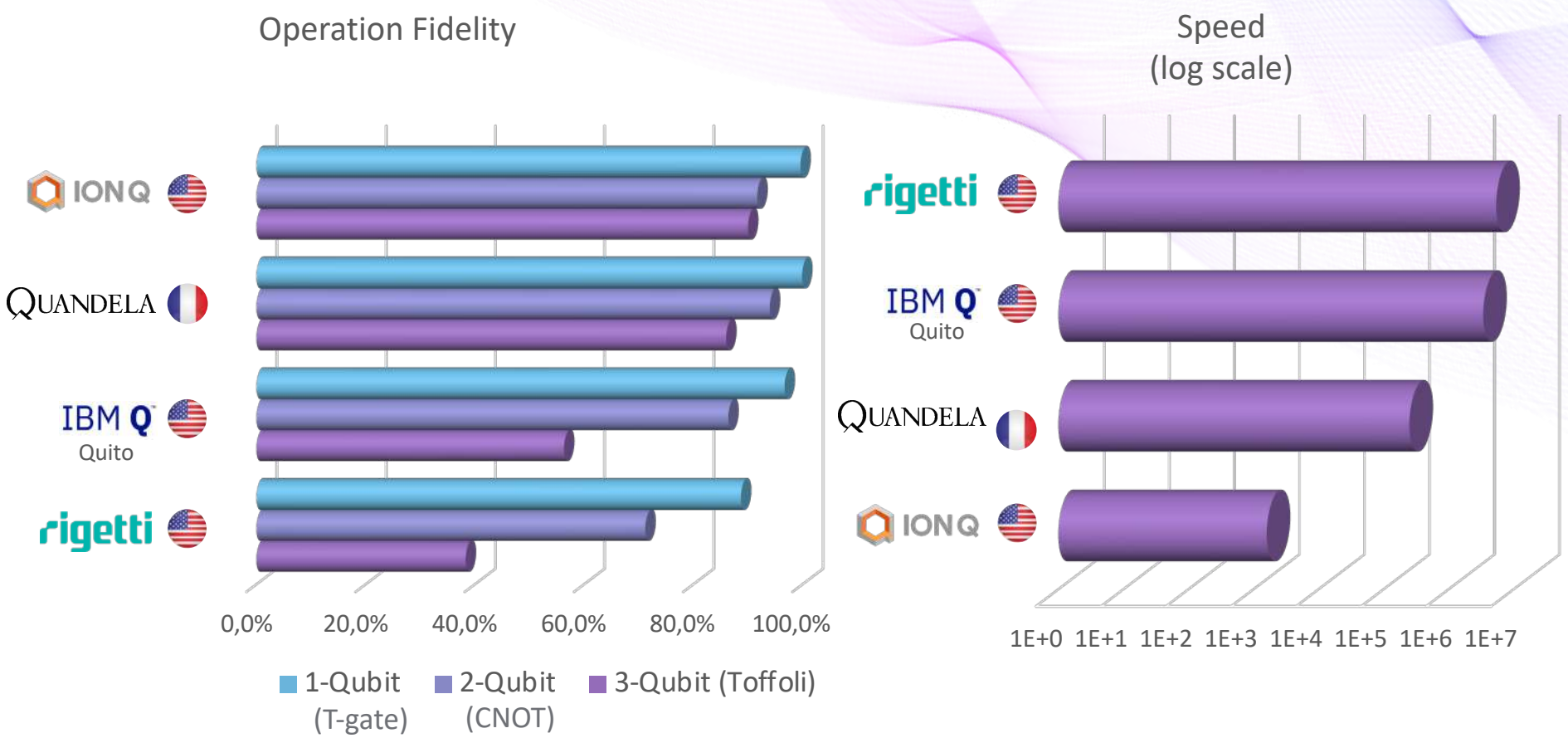
Get started for free
https://cloud.quandela.com

Benchmark with other platforms available in the cloud

Quandela takes advantage of semiconductor technologies and its photonic platform to provide the fastest and most reliable quantum computers

Benchmarking with other online platforms

1. Combines fidelity and speed — QUANDELA
2. Good fidelity but slow — IONQ
3. Good speed but lower fidelity — IBM Q rigetti



Create value for the users in a “ready-to-operate” QC platform

Quantum devices are available on https://cloud.quandela.com

Users

THALES LEONARDO EDF MBDA MISSILE SYSTEMS CRÉDIT AGRICOLE CORPORATE & INVESTMENT BANK

Quantum Application Toolbox

- $\frac{df}{dx}$ Partial Differential Equations solver
- 010001 1001010 0111101 Entropy (QRNG)
- QUBO Quantum Optimizer
- Graph problem
- Quantum Machine Learning

Programming

Perceval – Programming Framework
https://perceval.quandela.net

Available Quantum Hardware

- Noisy Simulator (< 15-20 qubits)
- Archernar, Ascella, Altair Quantum Processor Units https://cloud.quandela.com

Quandela's ongoing industrial applications

Cybersecurity

How:
Using quantum certified randomness to generate spy-proof hash keys

Applications:
- Developing next generation post-quantum cryptography algorithms

Pharmaceuticals & Chemistry

How:
Using Variational Quantum Eigensolver (VQE) to resolve 3D-molecular molecule configuration

Applications:
- Proteins folding modelling
- Modelling how drug candidates interact with biologically relevant proteins
- Faster and safer clinical trials

Logistics

How:
Using state superposition to simultaneously explore a large number of paths to research solutions for NP-hard problems

Applications:
- Drone cohort flight planning
- Gate-Scheduling Optimization
- Cargo Optimization

Finance

How:
Using quantum forward propagation to detect weak signals in long time series

Applications:
- Enhanced simulation of financial markets (option pricing, portfolio risk management)
- Portfolio optimization /diversification or issuance of auctions
- Fraud detection & money – laundering prevention

Certified Randomness

Tools at the core of cryptography and security systems

Toolbox

010001
1001010
0111101

Entropy (QRNG)

Generating secure and certified random numbers

Patented

Use cases

Implemented today:

Encryption/decryption

OVHCloud recently purchased MOSAIQ-entropy (2-qubit QPU) to enhance the security of its data-center encryption protocol via certified random numbers. Entropy leverages quantum advantage for randomness generation [2].

OVHcloud

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algorithm toolbox

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Primitives

Quadratic Unconstrained Binary Optimization solver

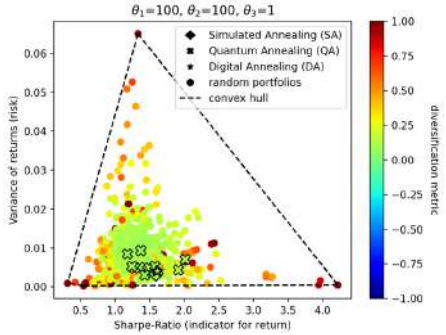
Use cases

For finance:

Phrase the problem in QUBO form :

$$\theta_1 \sum_i [-\alpha_i E(R_i)] + \theta_2 \sum_{i,j} \alpha_i \alpha_j Cov(R_i, R_j) + \theta_3 (\sum \alpha_i A_i - B)^2$$

To solve portfolio optimization problem [3]:



Implemented use-cases:

Drones will make the management of the air space highly complex. Therefore, Thales and Quandela have teamed up to solve shortest-path problems using a QUBO approach on Quandela's photonic quantum computer.

THALES

REPLY SIGMA

[3] Portfolio Optimization: Applications in Quantum Computing Michael Marzec, https://doi.org/10.1002/9781118593486.ch4

Engineering using Quantum Computers

Toolbox or « Optimization & Material Design »

Toolbox

$\frac{df}{dx}$ Partial Differential Equations solver

Generic Partial Equation Differential solver primitive

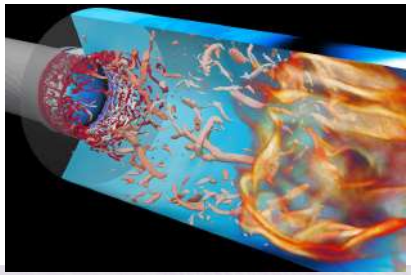
Use cases

Computational Fluid Dynamics

Quandela collaborates with ONERA and MBDA to solve the PDE that governs the behavior of a combustion reaction in a heat engine. This is a central task for ONERA as it consumes up to 95% of ONERA's computational resources).

ONERA THE FRENCH AEROSPACE LAB

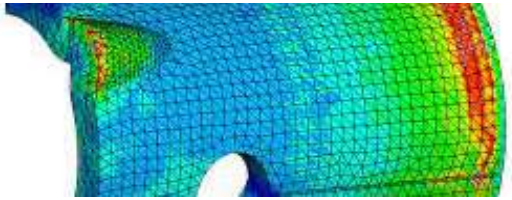
MBDA MISSILE SYSTEMS

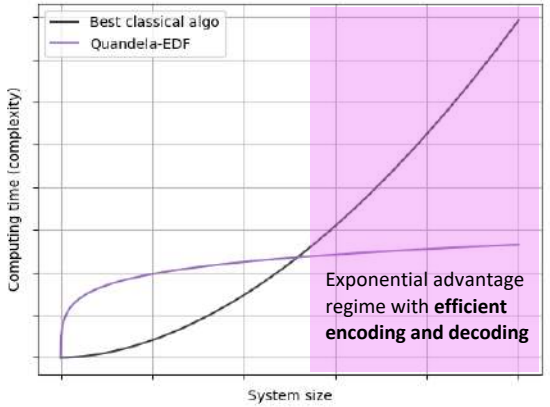


Materials and Structural Design

Quandela and EDF developed a VQ circuit to solve PDE, predicting the behavior of a dam. The number of resources scales logarithmically with the problem size which may lead to an exponential advantage. This algorithm will improve the safety of hydroelectric dams and nuclear plant pipes.

EDF

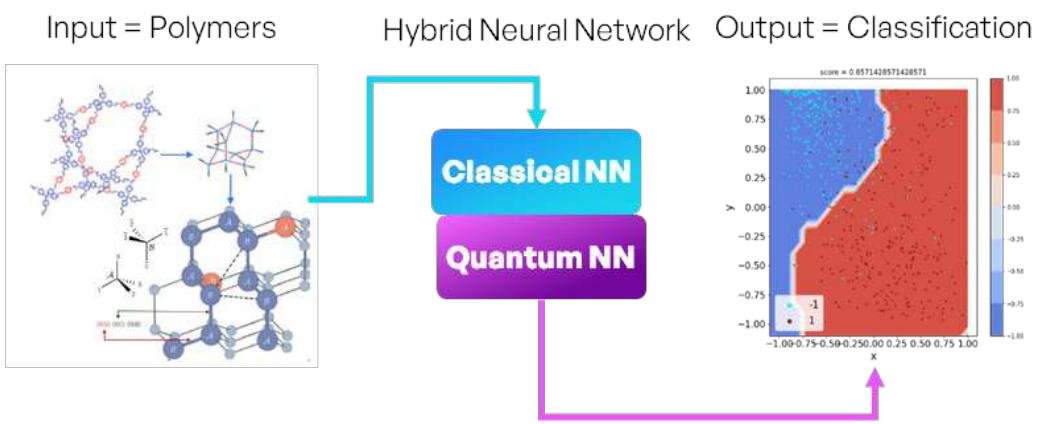




Impact on chemical industry

Quandela deploys a true expertise to design new materials

Use-case example



Quandela and Alysophil used a **pre-trained classical network** to **extract the essential features** which describe the existing database about polymers. These features are **analyzed by a quantum neural network which classifies the polymers**. This is a transfer learning process which uses a hybrid quantum-classical to **predict polymers properties**.

With clients & prospects in various industries:

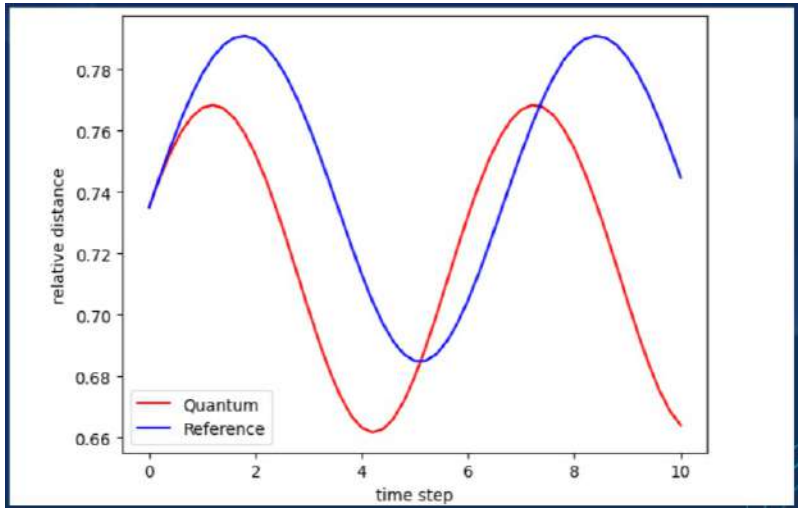
MBDA MISSILE SYSTEMS

TotalEnergies

Impact on chemical & cosmetic industries

Applications in Pharmaceutical Industry

At BCG Quantum Hackathon, a team studied a Quantum approach to enhance molecular dynamics simulation on Photonic QPU in collaboration with Boehringer Ingelheim



Other Collaborations:

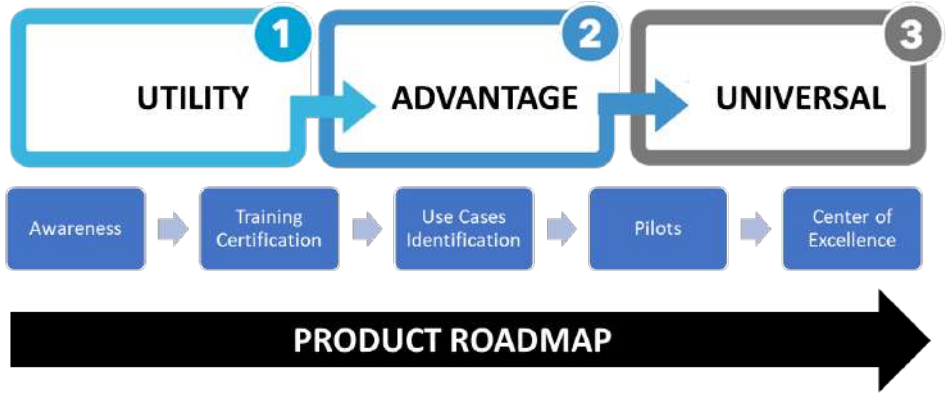
Boehringer Ingelheim

The full cycle to develop a new drug lasts 10–15 years and costs $ 1 – 2 billion !

Quantum could accelerate the discovery and optimization of lead compounds

Quantum Acceleration Program (QAP)

Quantum Transformation is initiated with a QAP. Quandela's team will support your organization through multiple quantum journeys, every step of the way with **products and solutions tailored to your needs.**



- Generate awareness in the organization
- Identify possible use cases with end users
- Consult with quantum scientist about best approach
- Develop model and test performance, scalability on simulators
- Benchmark on real QPUs and GPUs

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Enabling organizations to achieve their quantum transformation

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algorithm toolbox

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Primitives

$\frac{df}{dx}$ PDE solver

Generic Partial Equation Differential solver primitive

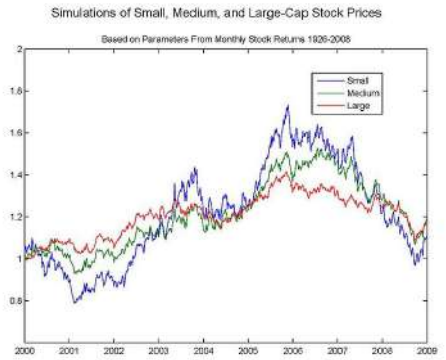
Use cases

For finance:

Applied to Black-Scholes equation :

$$\frac{\partial V}{\partial t} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 V}{\partial^2 S} + rS\frac{\partial V}{\partial S} - rV = 0$$

For options pricing:



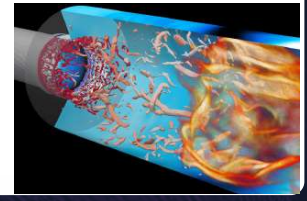
Credits to Robert Croce

Implemented today:

Quandela collaborates with ONERA and MBDA to solve the PDE that governs the behavior of a combustion reaction in a heat engine. This is a central task for ONERA as it consumes up to 95% of ONERA's computational resources).

ONERA THE FRENCH AEROSPACE LAB

MBDA MISSILE SYSTEMS



EDF

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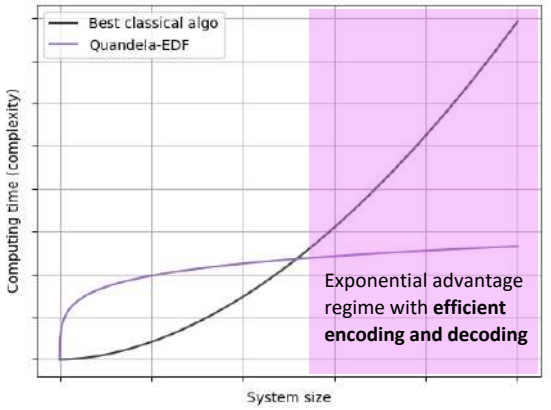

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Primitives

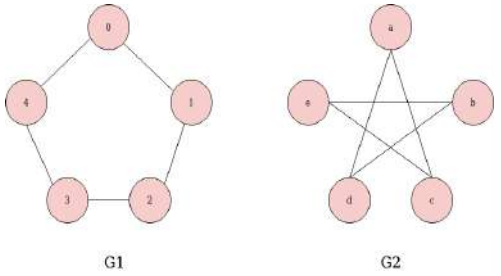
SCAN ME

Graph problem

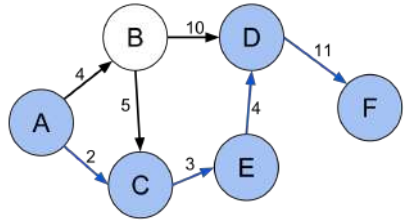
Generic graph problem approach that finds:
- Graph isomorphism
- Dense subgraphs
- Shortest paths
- Perfect matchings

Patented

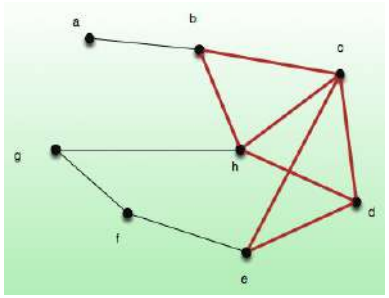
Graph isomorphisms:



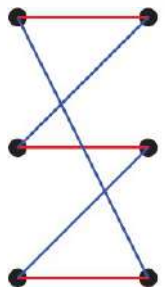
Shortest paths :



Dense subgraphs :



Perfect matchings:



Use cases

For finance:

Detecting fraud as fraudulent agents are densely connected on transactions graph [4]

Narrowing a many-to-many match to a one-to-one match in Loan Matching [5]

[4] "HiDDen: Hierarchical Dense Subgraph Detection with Application to Financial Fraud Detection " Si Zhang et al.
[5] Cohen, Gregory J et al.," Finance and Economics Discussion Series 2018-085. Washington: Board of Governors of the Federal Reserve System
[6] Quandela's scientific article under preparation

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algorithm toolbox

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Primitives

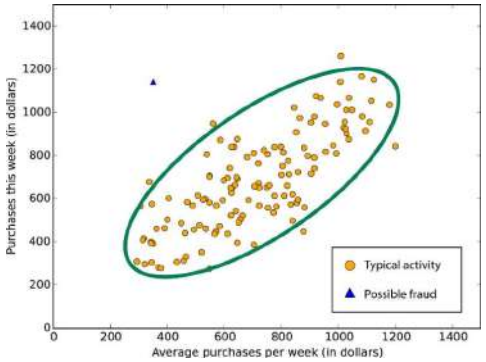
QML primitive

Quantum Machine learning technique using variational quantum algorithm native to photonics

Use cases

For finance:

For fraud detection [7] :



For risk-adjusted portfolio construction [8] :

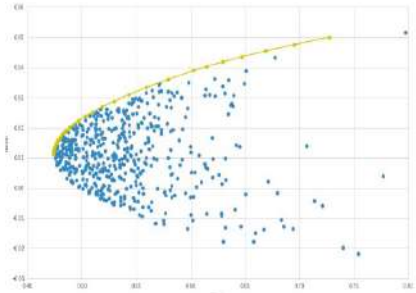


Figure 1: Optimized Markovitz portfolios.

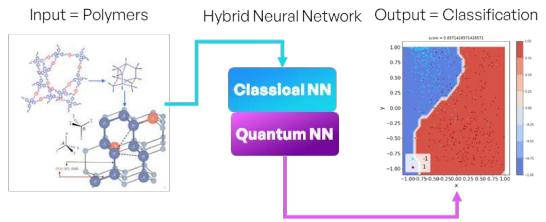
Other sectors:

Using parametrized photonic chip to enhance training complexity, expressivity and prediction performances to predict time-series [9]

Implemented use-cases:

Quandela and Alysophil use a **pre-trained classical network** to **extract the essential features** which describe the data. These features are **analyzed by a quantum neural network which classifies the polymers.** This is a transfer learning process which uses a hybrid quantum-classical to **predict polymers properties** [6]

SCAN ME



[6] "Photonic Quantum Computing For Polymer Classification" Alexandrina Stoyanova, Taha Hammadia, Arno Ricou, Bogdan Penkovsky, arXiv:2211.12207

[7] Pattern Recognition "Anomaly Detection Challenges" Nadim S. Hmeidat, DOI: 10.13140/RG.2.2.31798.60480

[8] Clustering algorithms for Risk-Adjusted Portfolio Construction Diego Leon et al, https://doi.org/10.1016/j.procs.2017.05.185

[9] Quantum Machine Learning for Finance, Pistoia et al. , ICCAD

Quandela Partnership Program

- **Create the first useful Quantum computer**
- Enable organizations to achieve their **Quantum Transformation** anywhere in the world.
- Focus on **3 Industries**: Finance, Energy, Pharma/Health
- **Scope:** Hardware / Software / Applications
- Execute **Quantum Acceleration Program**
  - Access to tools, Technical expertise, Enablement
  - Industry problems to solve
  - Ecosytem alignment
  - Quantum journeys / product roadmap
- Define and Optimize Resource Model
- Growth Accelerator: Quandela Rev Year 1: $2M per Partnership