

We are

**EVIDEN**

**Quantum Computing  
The Simulation Approach**

# Introduction

1931

Since the very beginning of the “Computer Era”



2014

Worldwide Digital Leader

**111,000** employees

69 countries

Olympic & Paralympic Games  
Worldwide Partner

2,400 member of Atos Expert  
Community



2023

Expanding possibilities

57,000 researchers, engineers and  
problem-solvers in 45 countries.

Worldwide #1 in managed security  
services

**European #1** high-performance  
computing

**Visionary** In public cloud

**Leader** in data & analytics

Deep expertise in technology and  
data value chains: **2,100 patents,**  
**50,000+ certifications**



Our Mission

We fully commit to your  
industry business success

We provide a unique alliance of  
services and trusted data  
intelligence technologies

We completely master the  
data value chain

We develop a “Customer for Life”  
agile co-innovation approach

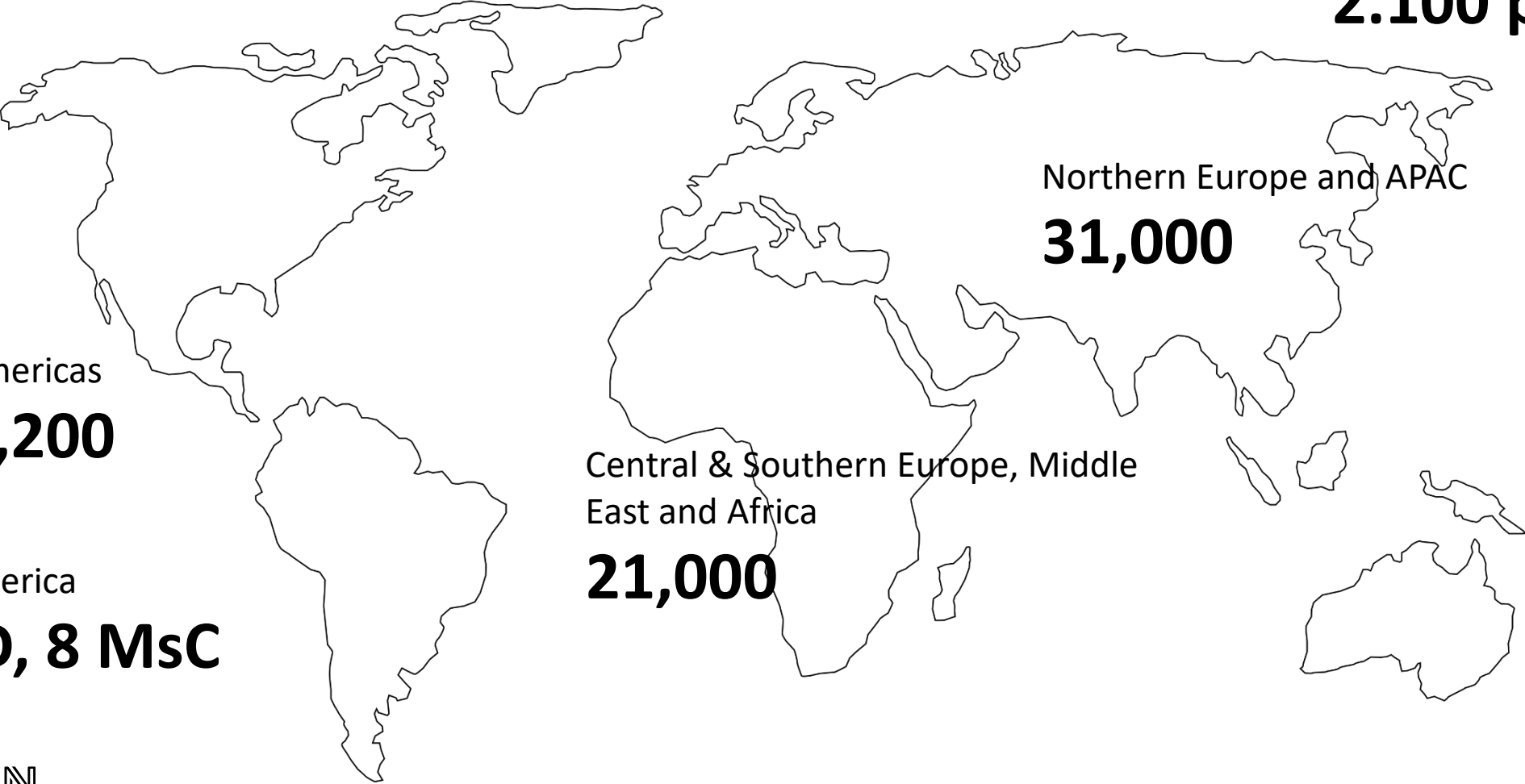
#GrowTogether  
#DareToTry  
#DoTheRightThing  
#StayCurious

# Where the people are

**57,000** researchers, engineers and problem-solvers in **45 countries.**

Worldwide

**2.100 patents**



Worldwide we hold over 2100 patents and invest 250 million euros in R&D annually.

In Brazil, we have centers of excellence in HPC, Advanced Computing, Big Data, and Artificial Intelligence, with a long-term partnership with two relevant research centers:



Salvador, BA

Centro de pesquisa no Senai  
CIMATEC

AI and BigData Competence Center  
Quantum Computing Center



Laboratório  
Nacional de  
Computação  
Científica

Petrópolis, RJ

Supercomputador Santos  
Dummont no LNCC


# ... Research centers in Computer Vision, Quantum Computing, Artificial Intelligence and HPC

**Centro de Pesquisa Aplicada em Inteligência Artificial**  
**Brazilian AI Network - Reference Center for the Industry**

**Brazilian Universities:**


- SENAI CIMATEC - Leader
- ISI Embedded Systems (IS)
- ISI Metalmeccânica (RS)
- ISI Virtual Systems (RJ)
- UERJ (RJ)
- USP ICMC (SP)
- IFBA, BA
- Universidade Federal da Bahia (UFBA, BA)
- Instituto Tecnológico da Aeronáutica (ITA, SP)

**Engaged Companies:**



**International Partners:**

- Harvard University (EUA)
- University of California San Diego (UCSD, EUA)
- German Research Center for Artificial Intelligence (DFKI, Alemanha)
- Guangzhou University (China)
- University of Quebec (Canadá)
- Polytechnique Montréal (Canadá)
- Coventry University (Inglaterra)
- Middlesex University (Inglaterra)
- Systems Research Institute (Polônia)
- University of Granada (Espanha)



**Atos**

## SENAI CIMATEC e Atos lançam o primeiro centro de computação quântica no Brasil

COMPARTILHE:  
 f in G+

o centro será o primeiro dedicado a tecnologia de computação quântica aplicada ao setor empresarial do Brasil

o SENAI CIMATEC, instituição referência em educação, pesquisa e inovação, e a Atos, líder global em transformação digital, estão lançando o primeiro centro de computação quântica no Brasil. O Latin America Quantum Computer Center (LAQCC) será apresentado no dia 05 de maio, às 9h, em uma cerimônia realizada ao vivo pelo YouTube do SENAI CIMATEC e da Atos, diretamente de Salvador, Bahia.

o LAQCC visa disseminar a tecnologia quântica no país, impulsionar a capacitação de mão de obra e incentivar



# HPC Leadership in South America

## Petrobras

Pégaso 19 PFlops

Dragão 9 PFlops

Atlas 4,4 PFlops

Fenix 3,2 PFlops

LNCC - Santos Dummont



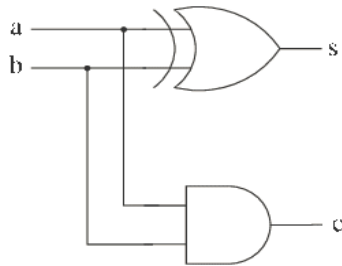
SENAI CIMATEC - Ogbon



# What is Quantum Computing?

**Classical Computing:** *The World as we know*

classical bits ou "bits": **1|0**



Boolean gates  
Boolean circuit

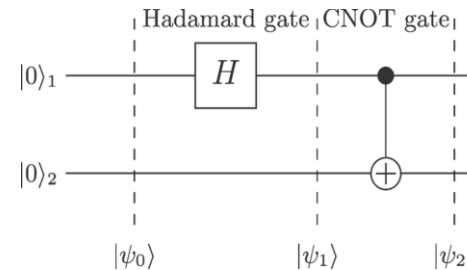
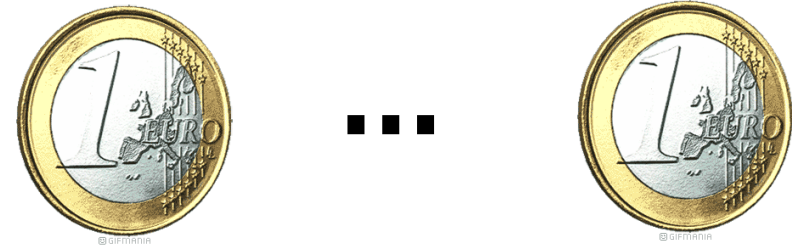
Serial logic

$$\Psi_n = 0000\dots000|0000\dots001|\dots|1111\dots111$$

Informação: **n bits**  $\rightarrow$  **n bit values**

**Quantum Computing:** *A New Paradigm*

quantum bits ou "qubits": **a. $|1\rangle$ +b. $|0\rangle$**



Quantum gates  
Quantum circuit

Parallel logic

$$|\Psi_n\rangle = a_1 |0000\dots000\rangle + a_2 |0000\dots001\rangle + \dots + a_{2^n} |1111\dots111\rangle$$

Informação:  **$2^n$  states**  $\rightarrow$   **$2^n$  amplitudes!**

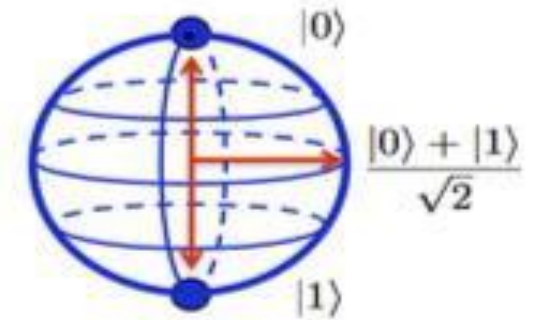
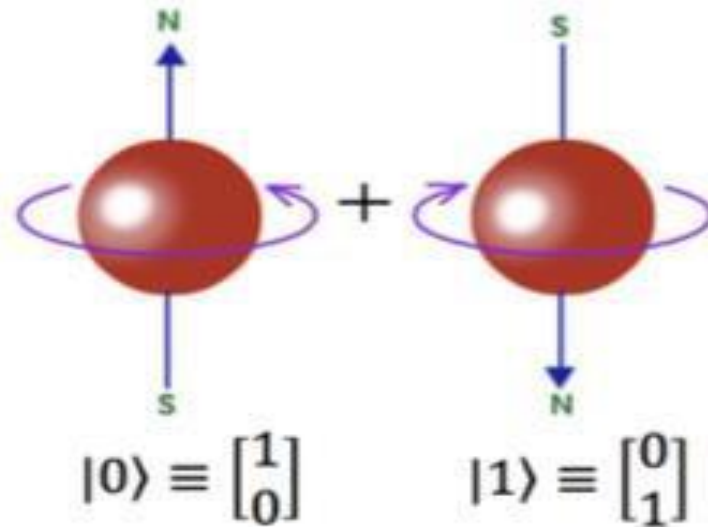
# Quantum Computing → Analog Computing

Arithmetic

Probabilistic

Classical bit

Quantum bit



Classical Bit

Qubit

$$\psi = \alpha|0\rangle + \beta|1\rangle \text{ with } |\alpha|^2 + |\beta|^2 = 1$$

- $|\alpha|^2$  probability to get  $\alpha$ ,  $|\beta|^2$  probability to get  $\beta$



# Bits (Clássicos)



# Bits (Clássicos)



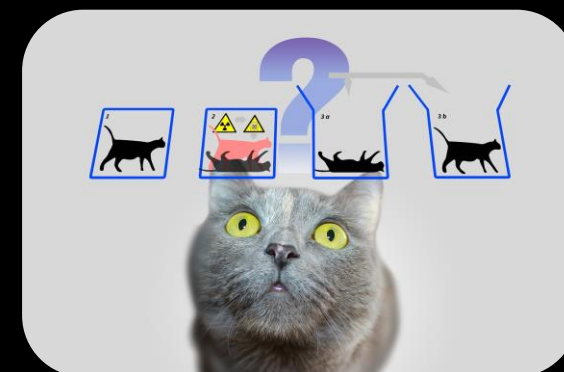
# Bits (Clássicos)



# Qubits: Bits Quânticos



## Superposition



Experiment known  
as Schrödinger's cat.

# Bits vs Qubits: Simplificado



*Classical Bit*

EVIDEN



# Bits vs Qubits: Simplificado



*Classical Bit*

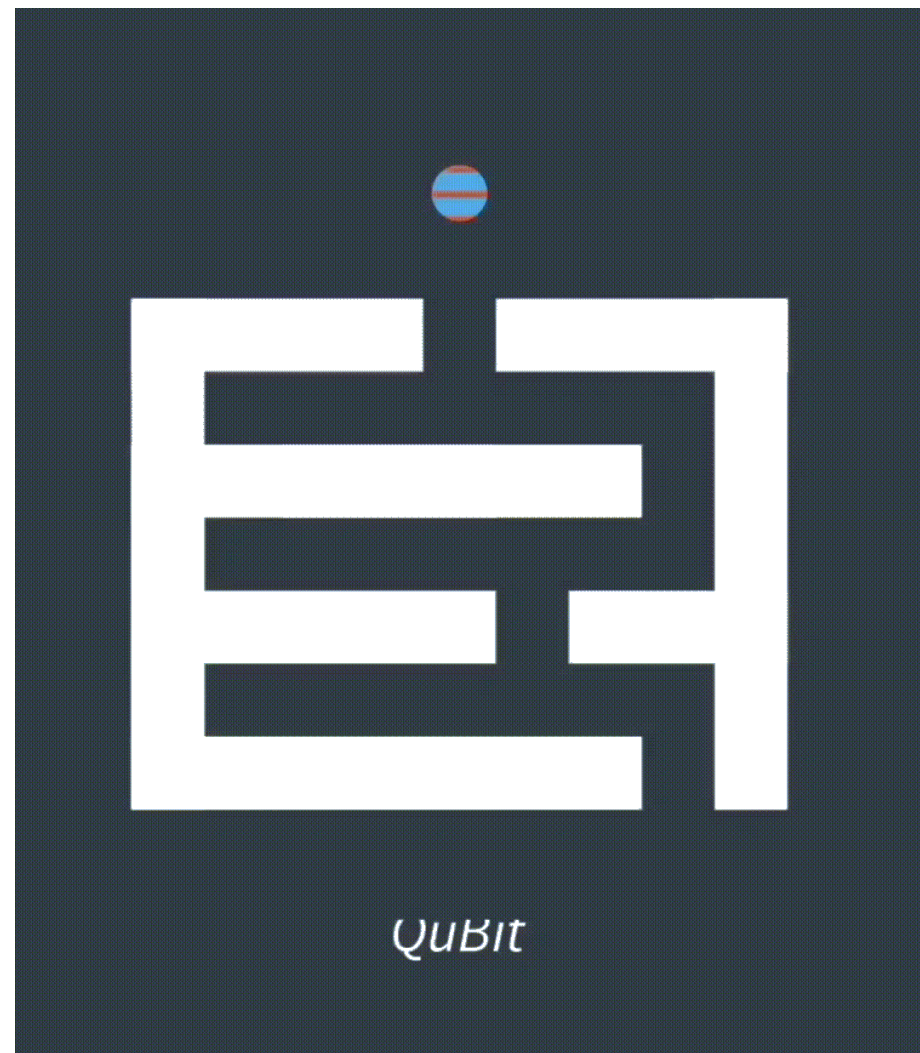
EVIDEN



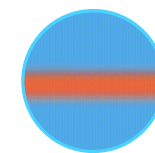
# Bits vs Qubits: Simplificado



Classical Bit



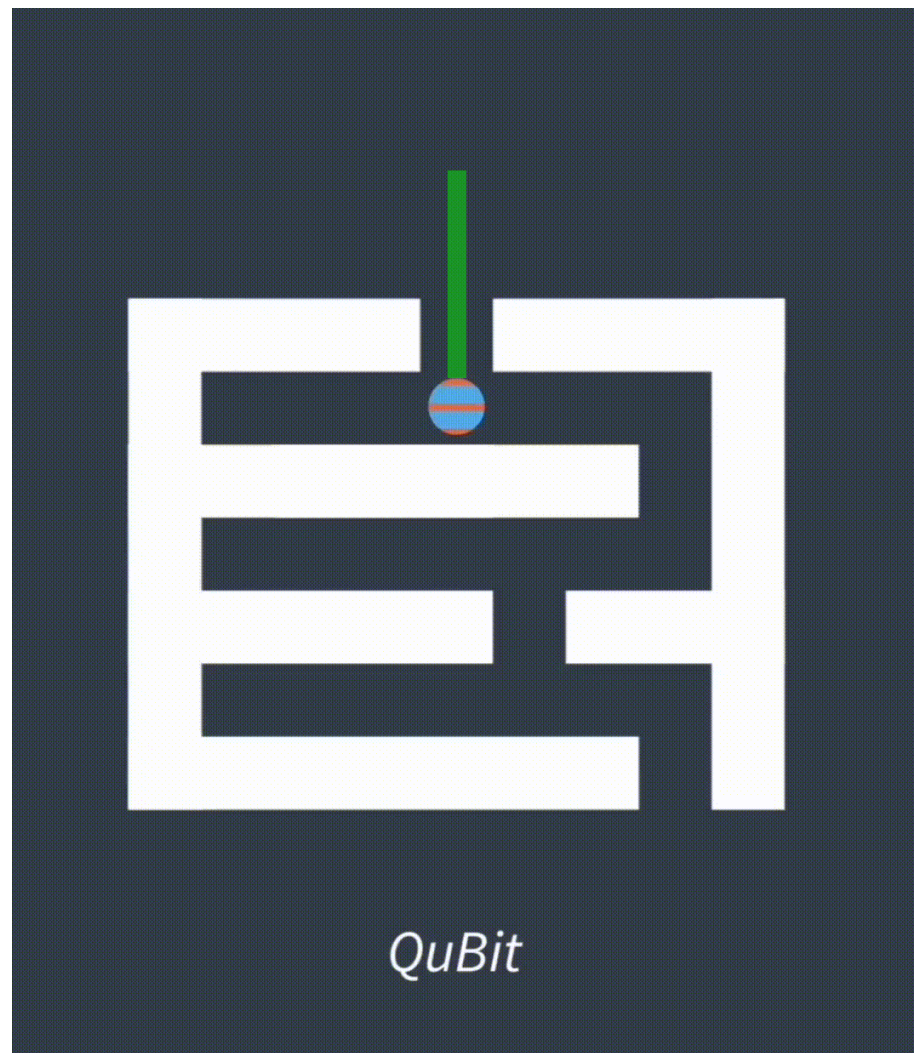
QUBIT



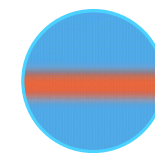
# Bits vs Qubits: Simplificado



Classical Bit



QuBit



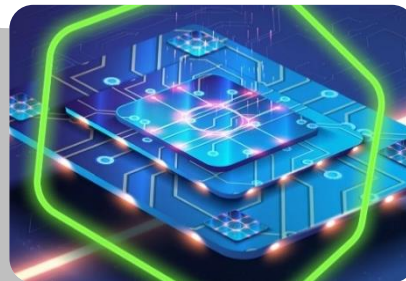


# Quantum Technology

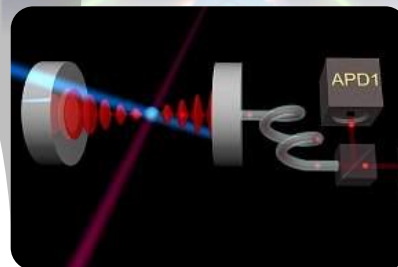


Quantum Mechanics &  
Quantum Information

Hardware  
Quantum



Quantum  
Computing



Sensors  
Quantum



Communication and  
Quantum Cryptography



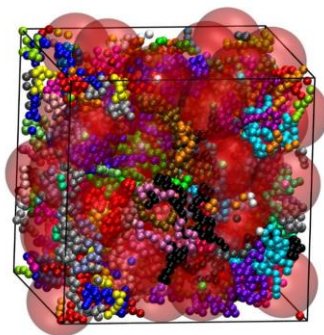
Technological Disruption



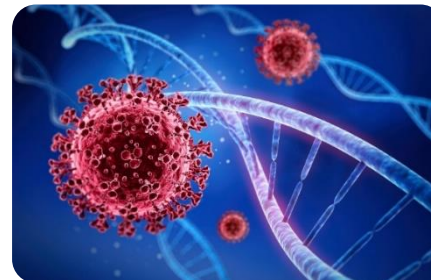
# Quantum Technologies: Applications and Benefits



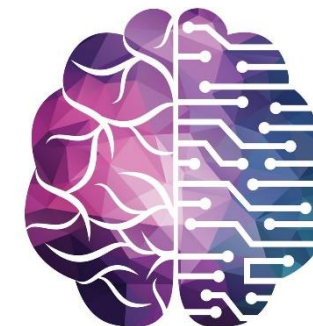
New Energy Sources



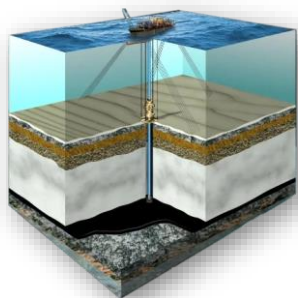
Nanotechnologies



Synthesis of New Drugs



Computational Intelligence



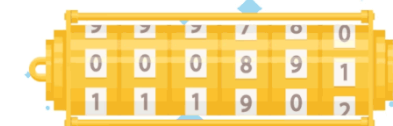
Oil Exploration



Decarbonization



Climate Change



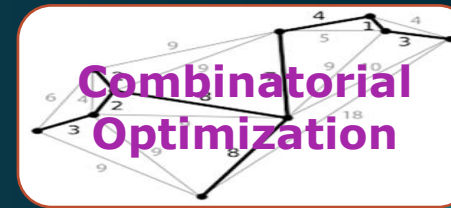
Cyber Security

# Why do we need quantum computing?

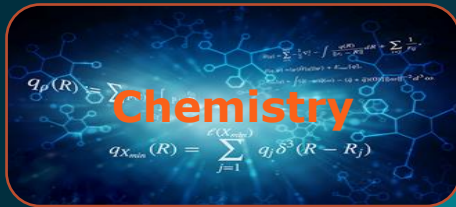
## Several typical applications



Factoring products of prime numbers with poly. complexity  
Shor's algorithm



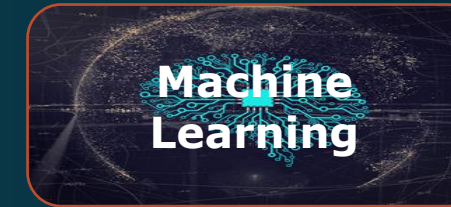
Travelling salesman problem solved with exp. speedup  
QAOA



Expected to compute the exact energies of large molecules  
Variational Quantum algorithms



Speedups theoretically proven for Monte Carlo models



Exp. speedup in key applications  
Train neural networks of higher complexity



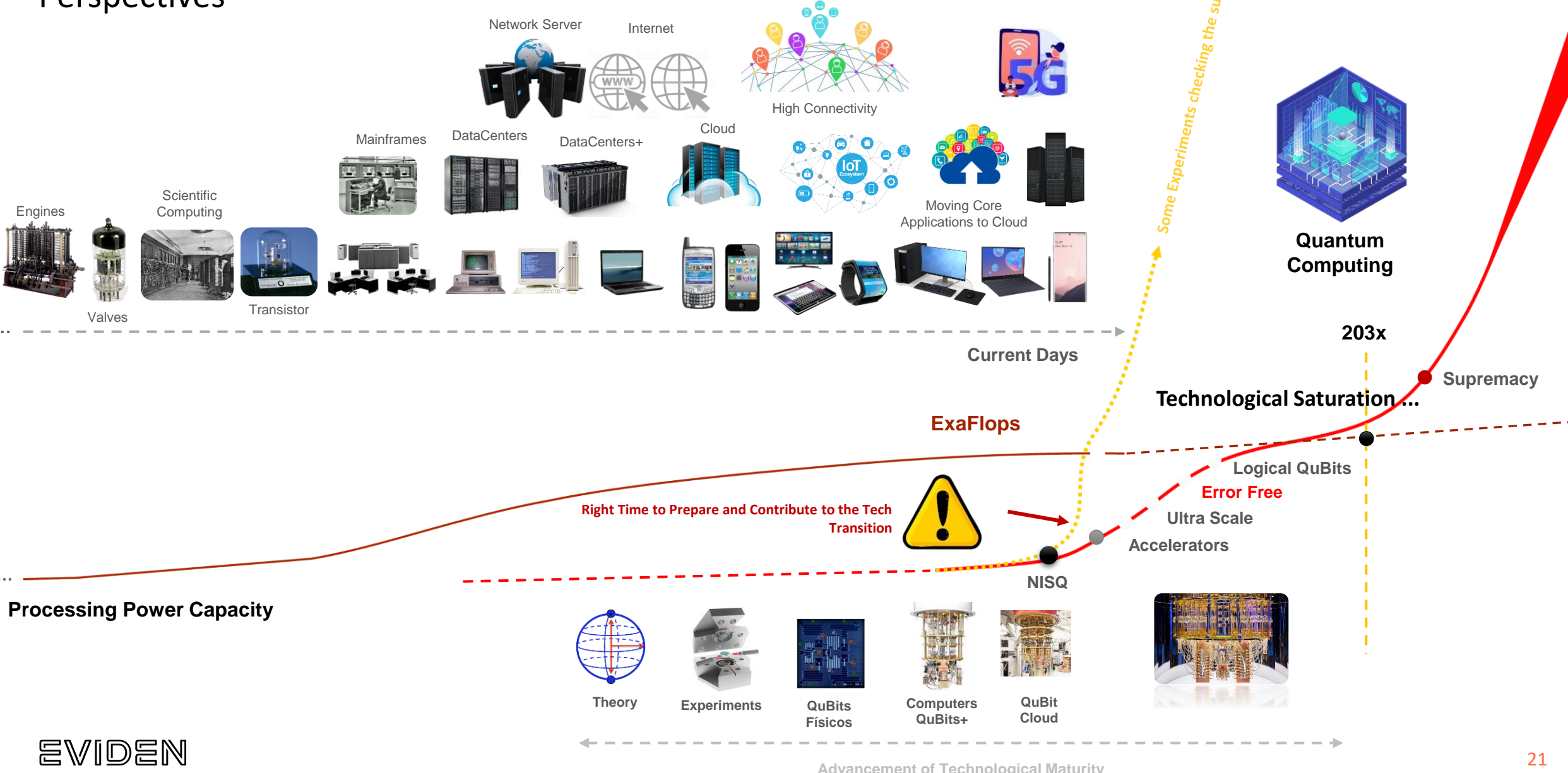
Expected to allow the exact simulation of protein folding



Partial Differential Equations solved with exp. speedup  
HHL

## Much more are expected in the next few years...

# Perspectives



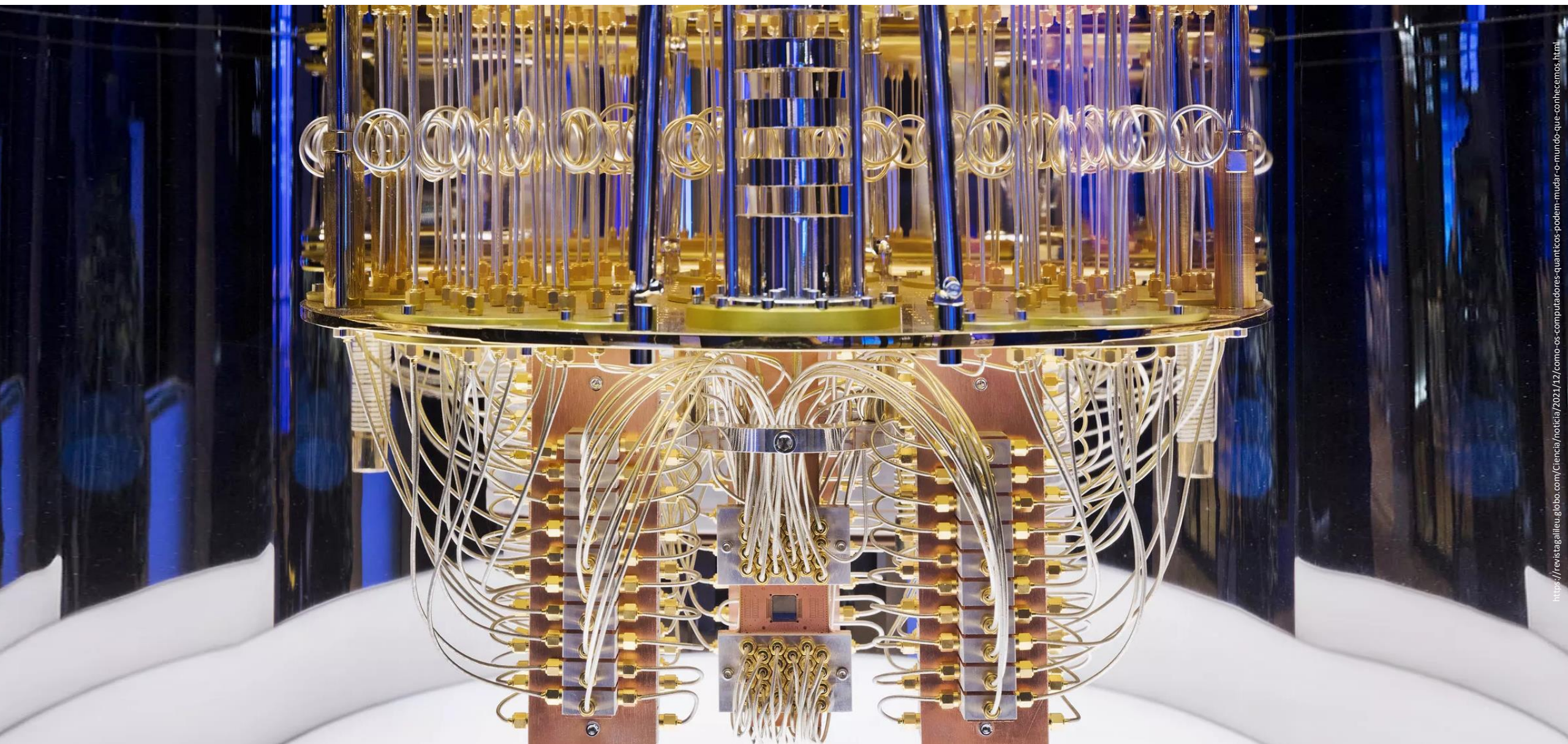
Processing Power Capacity

EVIDEN

NISQ - Noisy Intermediate-Scale Quantum Technology

Advancement of Technological Maturity

# Technology Race: Quantum Computer



# World Market Outlook

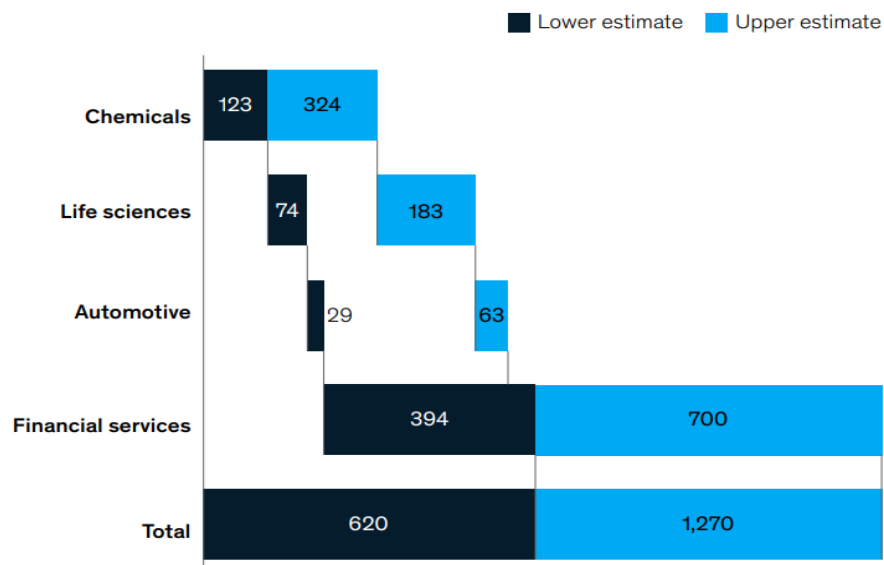
The estimated value at stake for QC in the four industries most likely to see impact first has now reached nearly \$1.3 trillion.

Economic value + Incremental ++ Significant +++ Disruptive

Industry	Key segment for QC	2025–30	2030–35
Global energy and materials	Oil and gas	+	++
	Sustainable energy	+	+++
	Chemicals	++	+++
Life sciences	Pharmaceuticals	++	+++
Advanced industries	Automotive	++	++
	Aerospace and defense	+	++
	Advanced electronics	+	++
	Semiconductors	+	++
Finance	Financial services	++	+++
Telecom, media, and technology	Telecom	+	++
	Media	+	+
Travel, transport, and logistics	Logistics	+	++
Insurance	Insurance	+	+

## Four industries expected to see first impact

Value at stake with incremental impact of QC by 2035, \$ billion



Quantum Technology Monitor – Mckinsey Abril 2023



What Applications  
 Will they benefit?

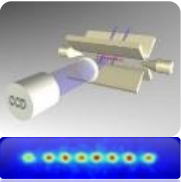


Breaking paradigms!  
 The conversion to QC  
 It won't be straightforward!

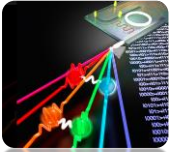
# Kinds of Quantum Computers



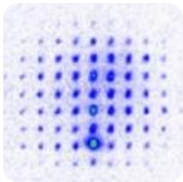
Quantum Chip = Multi-Phenomena



Ionic



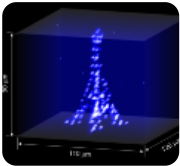
Photon



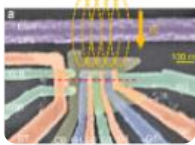
Topological



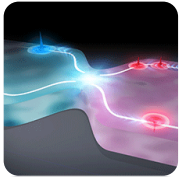
Annealing



Neutral Atoms



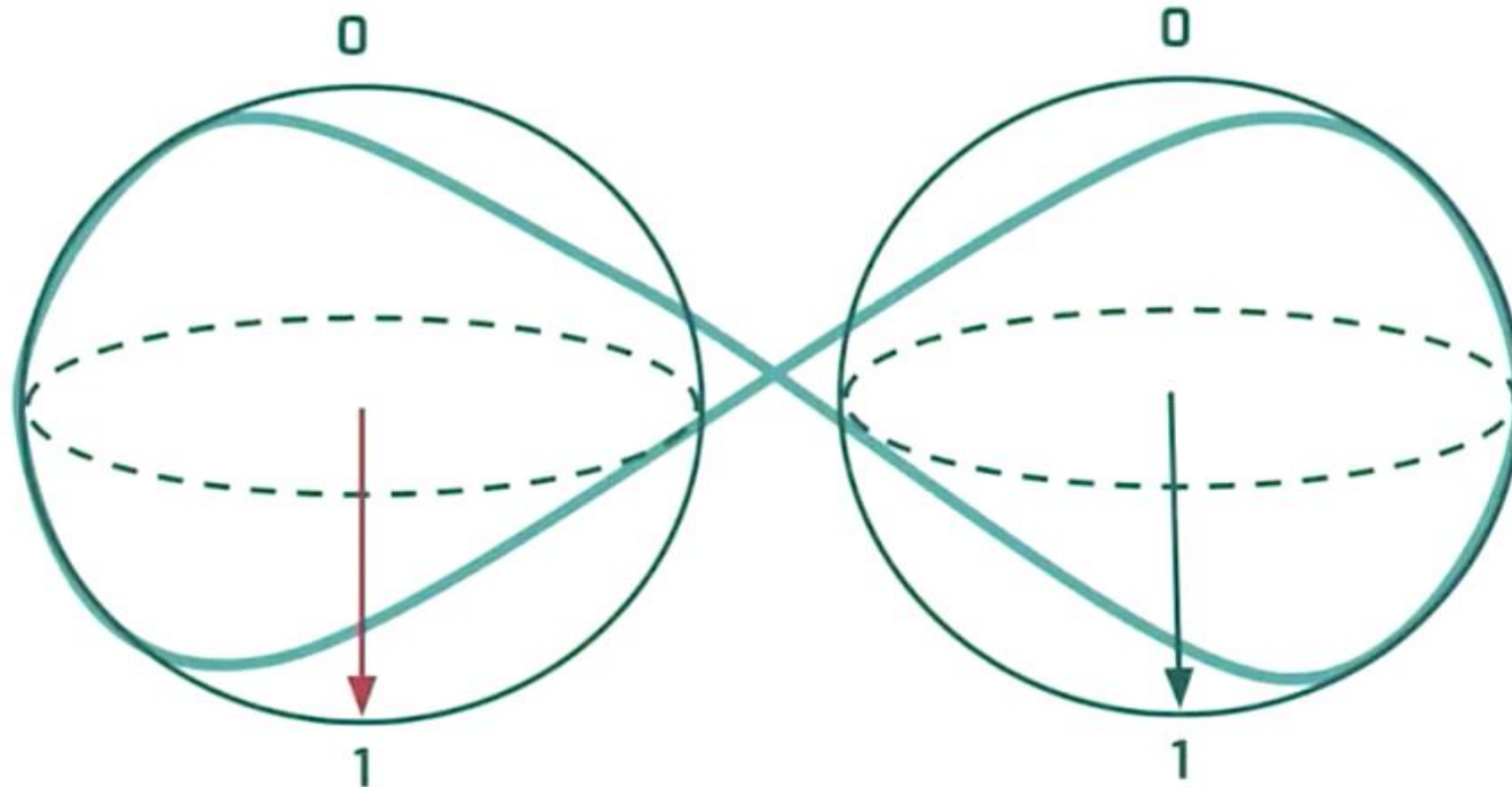
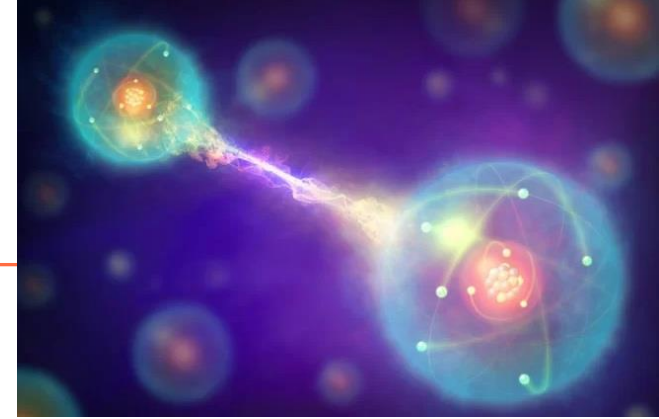
Semiconductor



Superconductor

...

# Quantum Entanglement

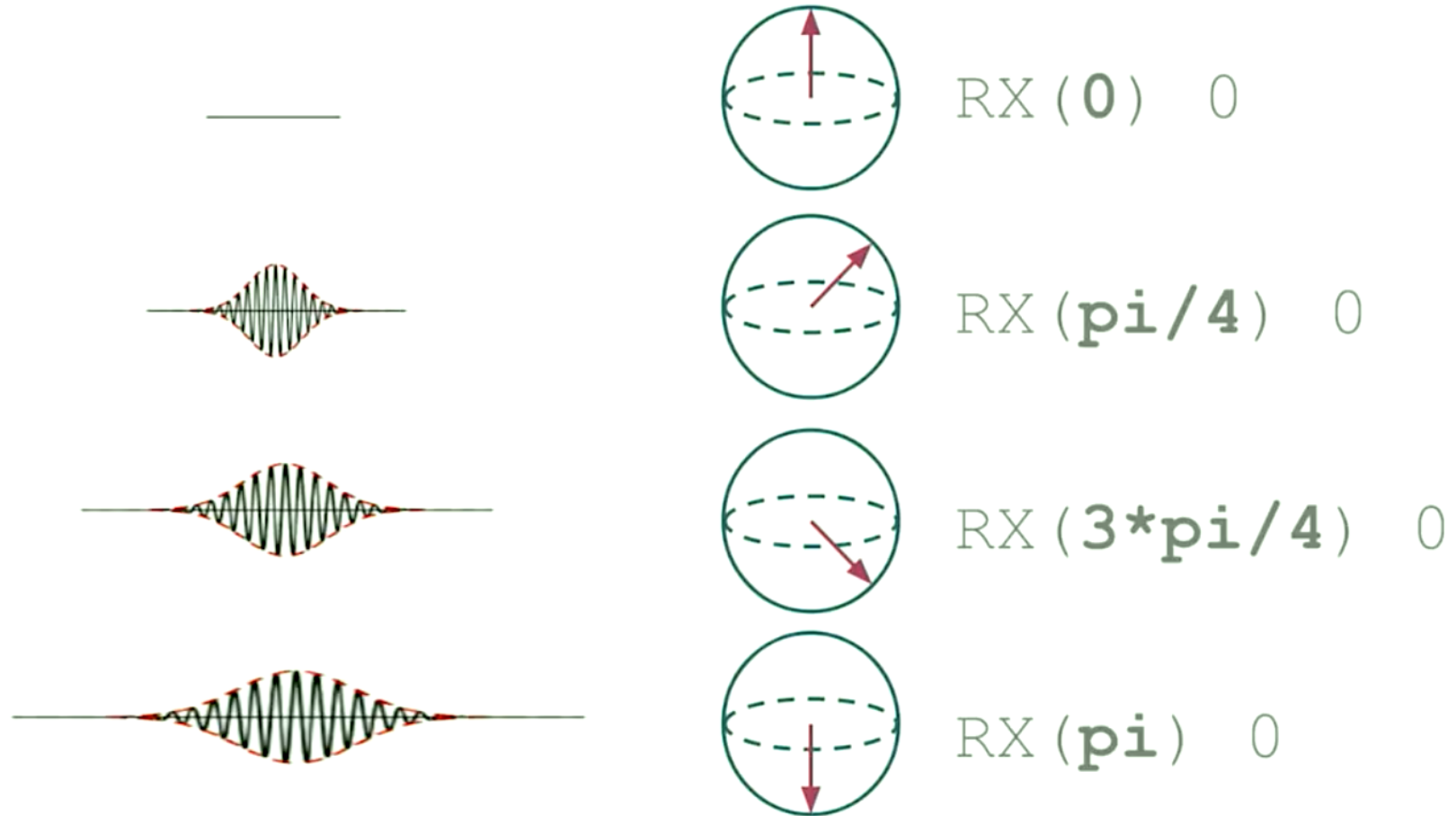


Despite being thousands of miles (or even light years) apart, it's been proven that if you measure an entangled qubit, you will know instantly the state (synched) of its partner.

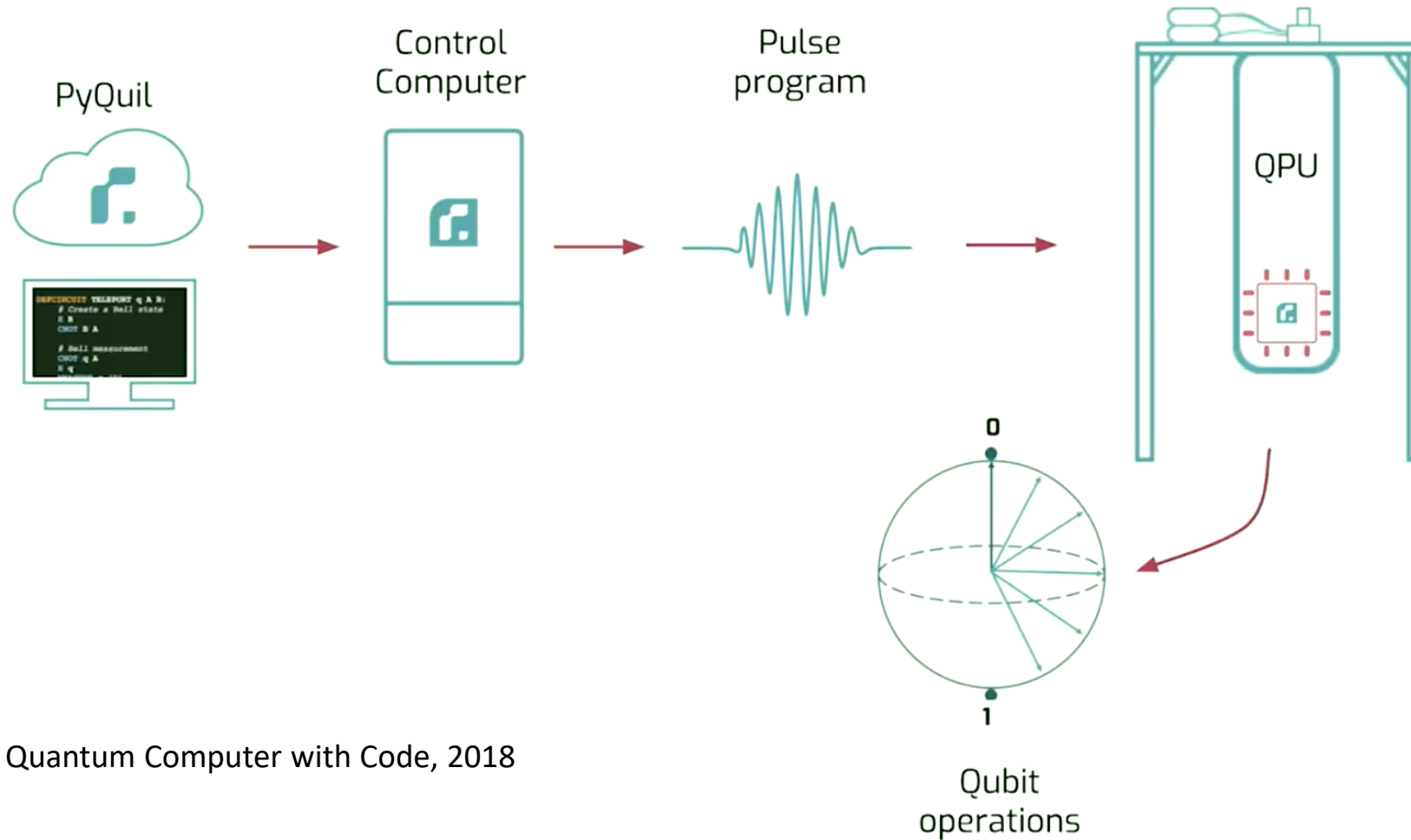
Source: Controlling a Quantum Computer with Code, 2018



# Programming using 'Pulses'

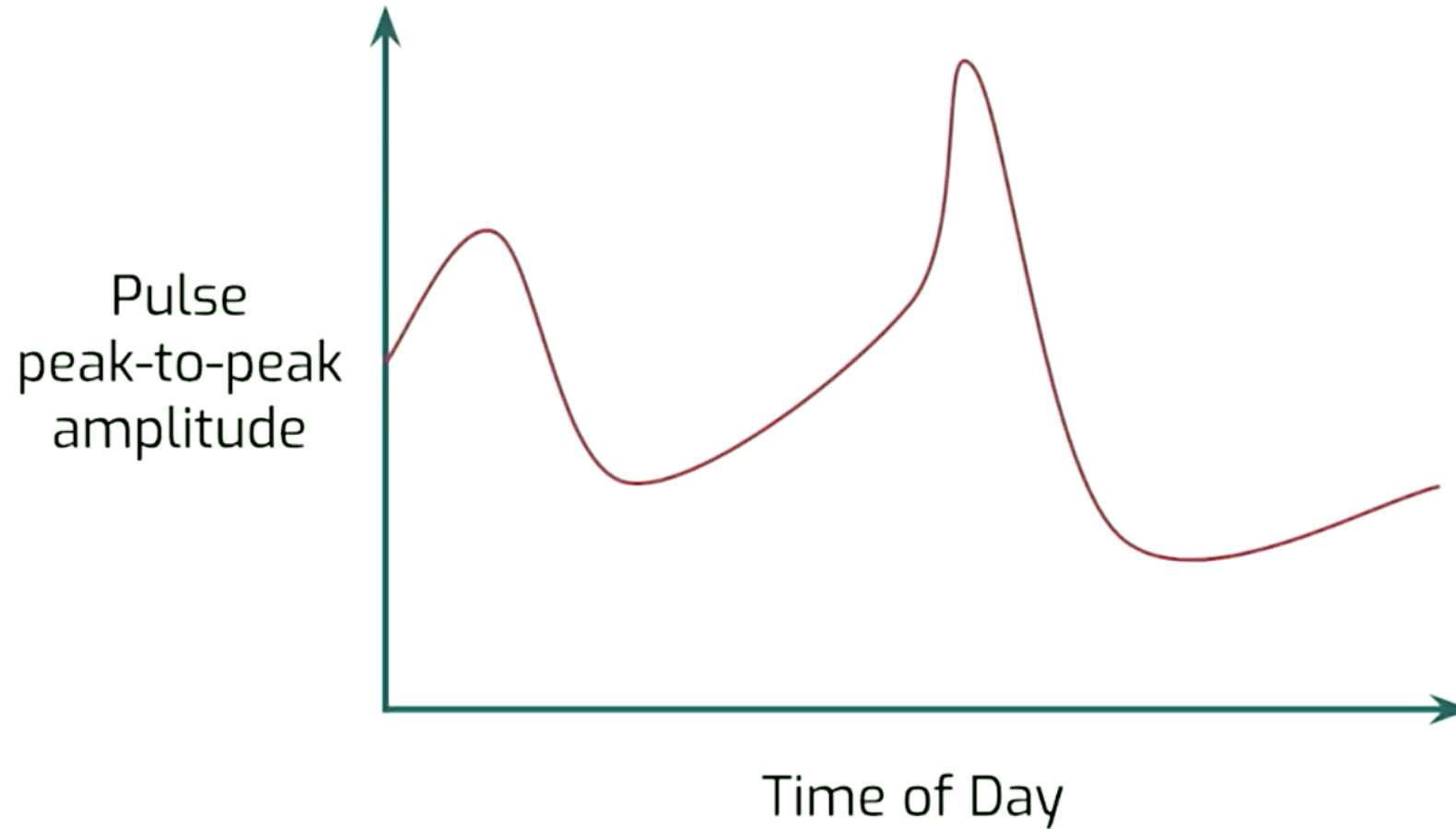


# Programming with 'Pulses'



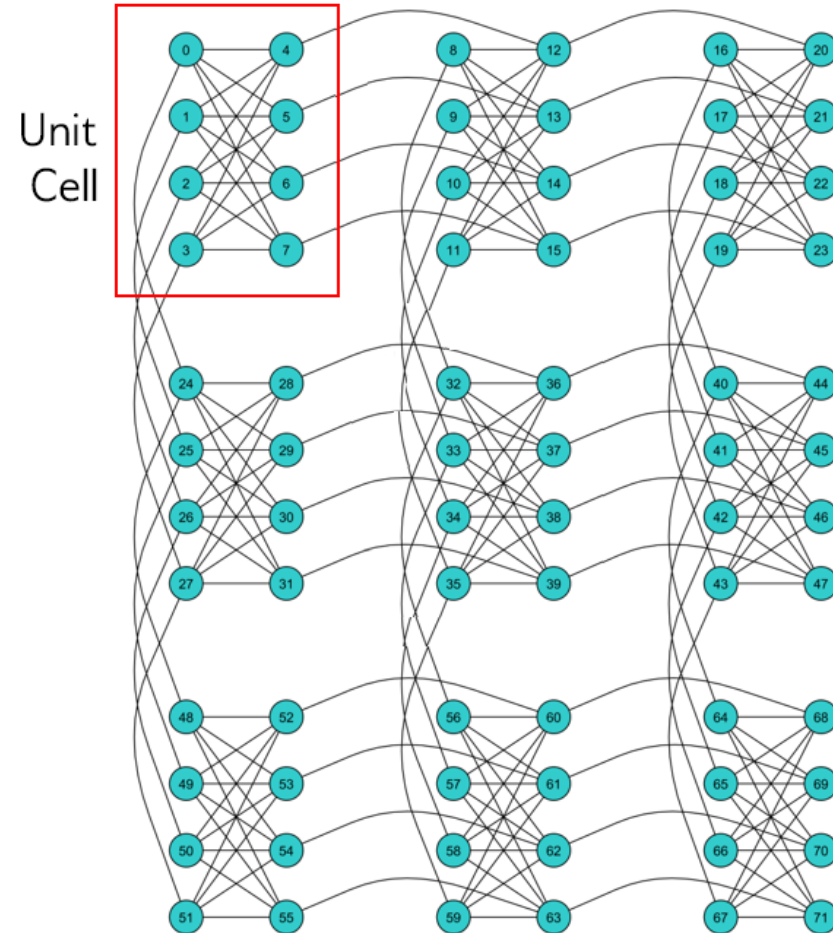
Source: Controlling a Quantum Computer with Code, 2018

## Need for constant calibration of pulses

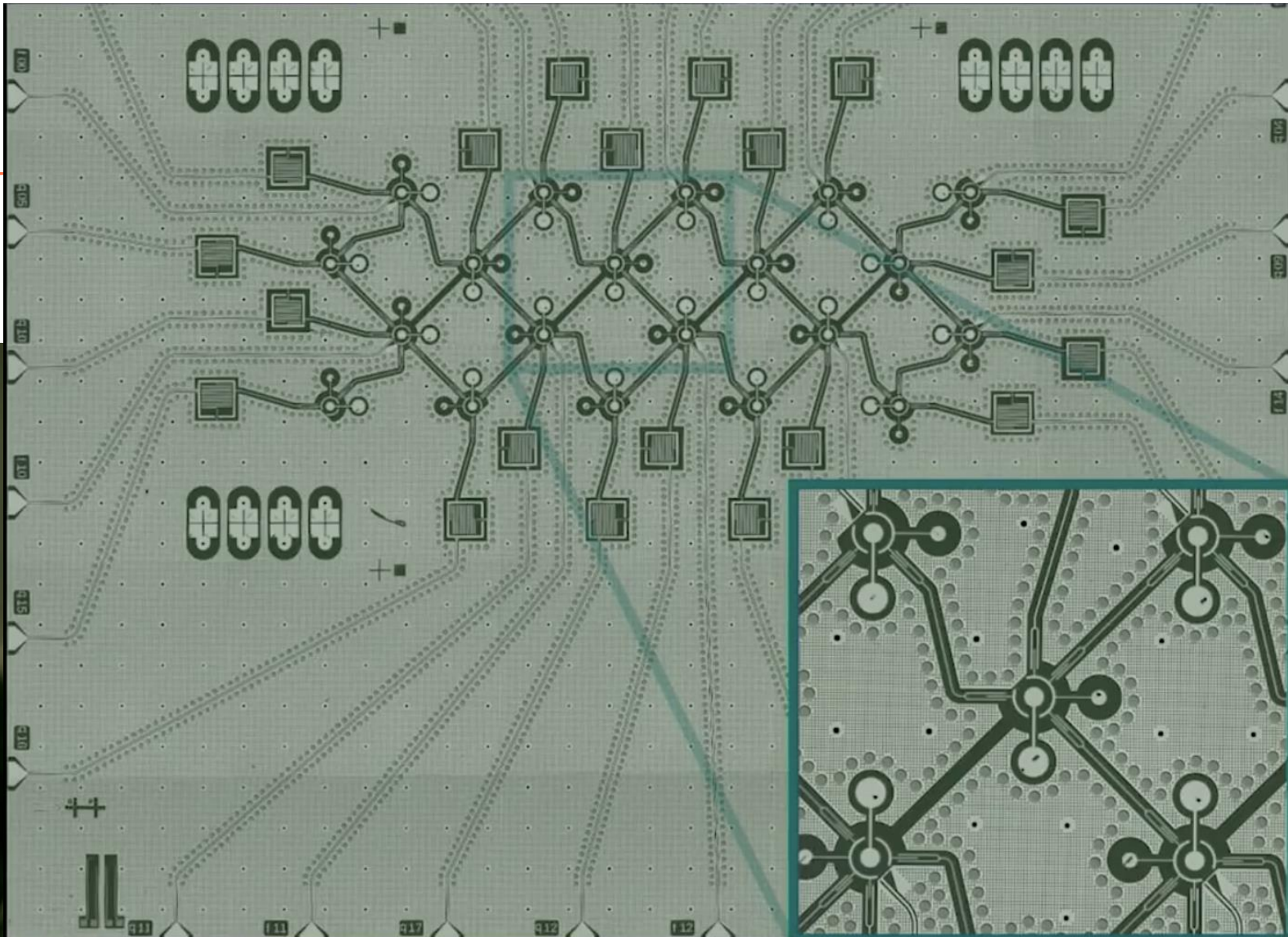
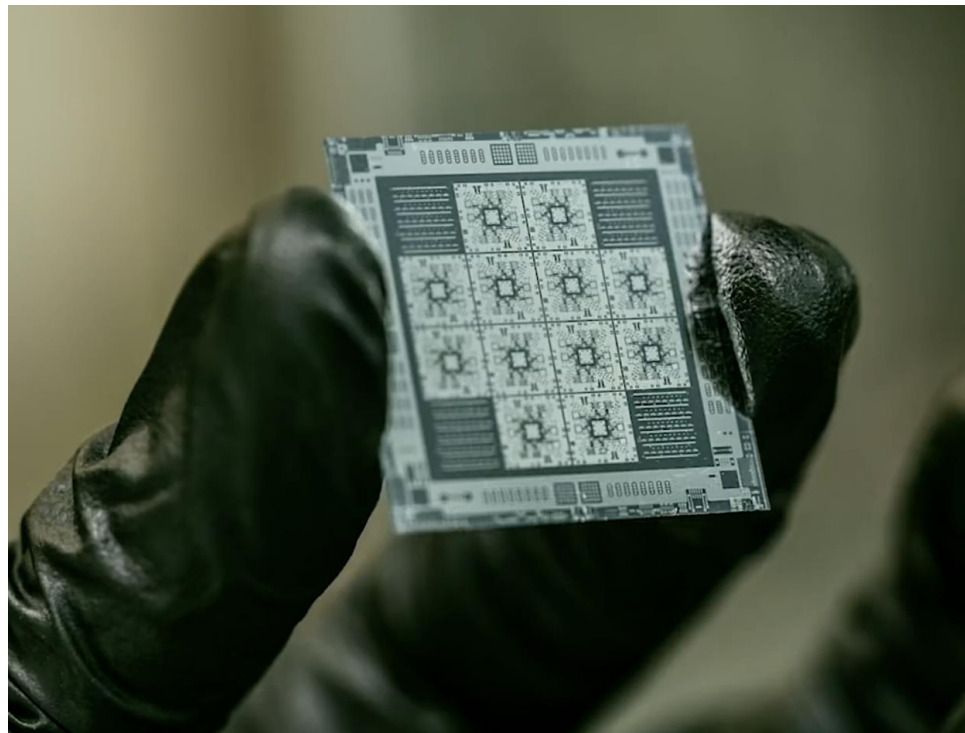


## Open problems in the field

- There is no off-the-shelf hardware products
- The output has noise (error)
- Constant calibration
- Time of Coherence / de-coherence
- Ion traps  $\rightarrow \sim 20s$
- Electron spin  $\rightarrow \sim 30\mu s$
- Qubits as a connected graph
  - but...
- We expect an accelerator in 2 years

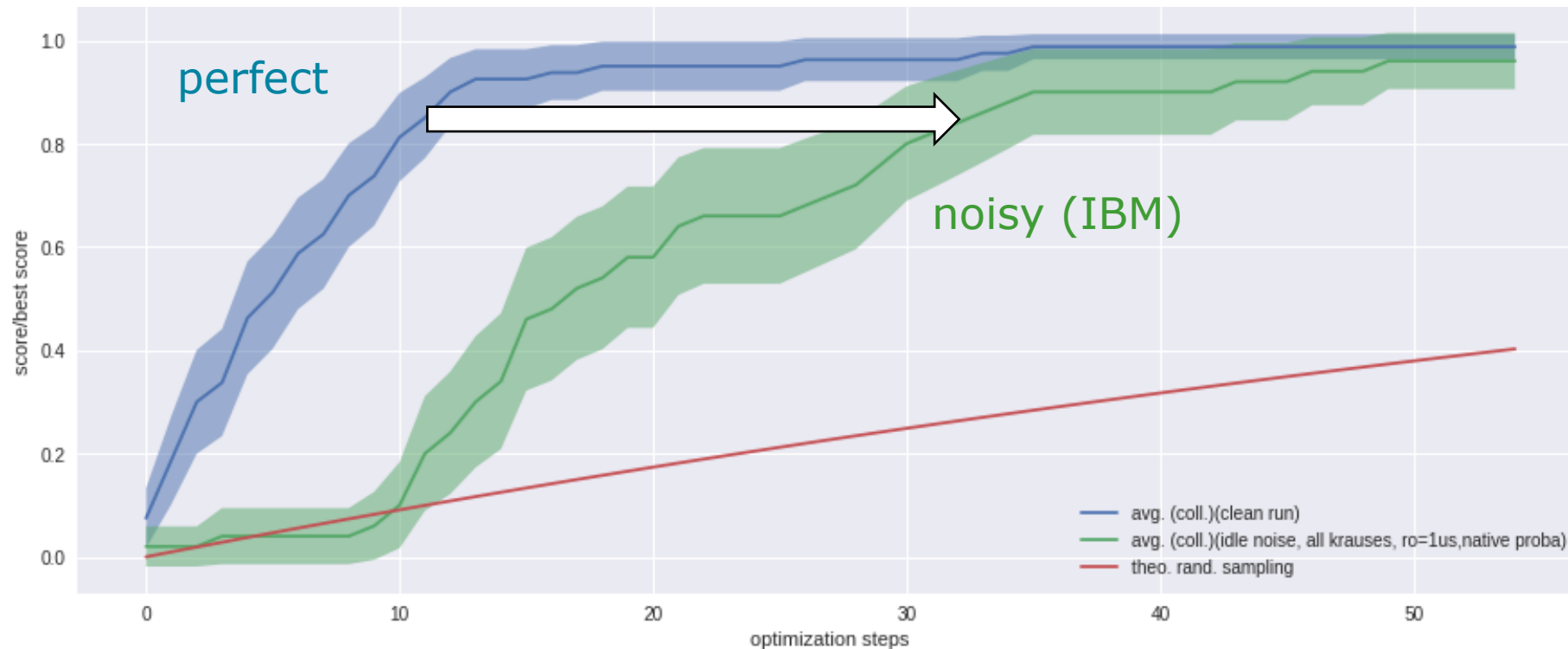


# Rigetti



# Noise tolerance (sensitivity)

- No Error-Free System Before 2025-2030
- Meanwhile: we must develop algorithms for imperfect qubits

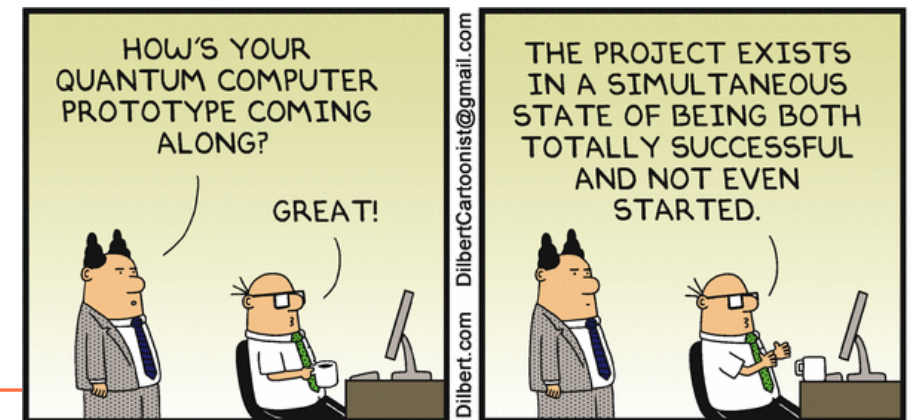


## Misconceptions about quantum computing

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- Quantum computing is good for BigData
- Quantum computing is good for everything
- Software will be smoothly migrated to quantum computing
- Quantum computers will replace classical computer

<https://dilbert.com/stip/2012-04-17>



EVIDEN

# Eviden Qaptiva™ : The simulation approach



# EVIDEN

Help people **learn, experiment** with quantum computers, **develop** applications and algorithms, without the need to wait for quantum machines to be physically available...



## Qaptiva Quantum program

1

Quantum  
Programming  
Platform

Complete programming and simulation environment for quantum software/hardware developers and for education/training

2

Quantum Expert  
Consulting Services

Assisting our customers in discovering Quantum Computing, detecting relevant use cases, assessing quantum implementation benefits on the QLM simulator

3

New Generation  
Architectures

Designing the new quantum-powered accelerators for supercomputers or hybrid systems

4

Quantum  
Algorithms

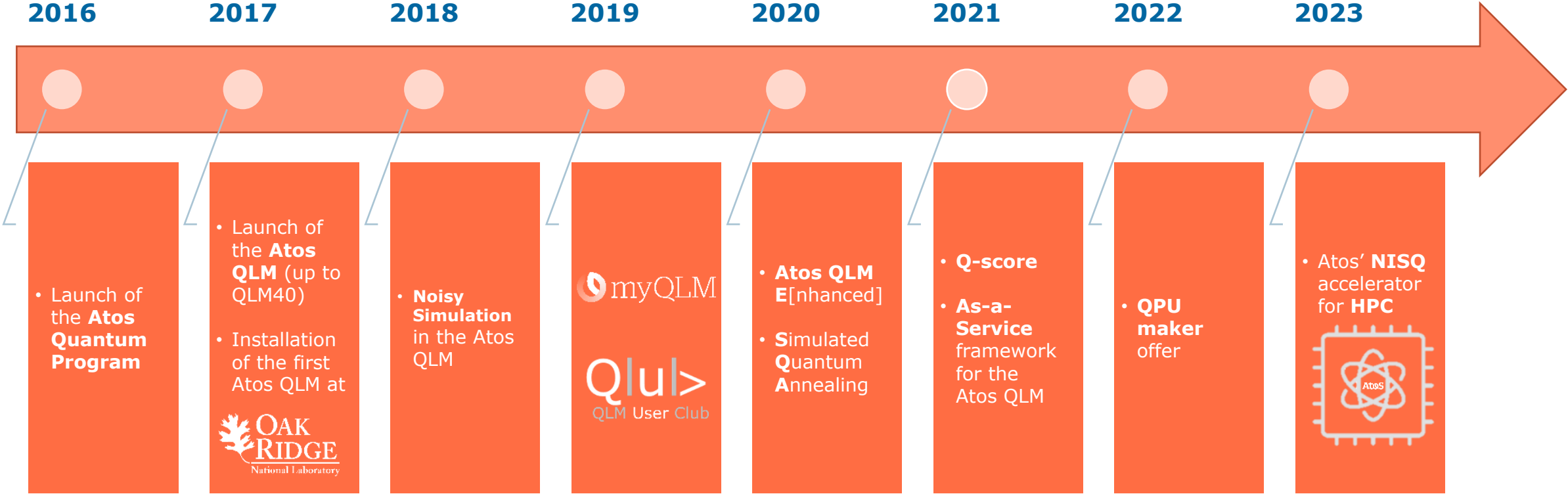
Atos' own research, focused on Variational Algorithms, one of the most promising application areas for NISQ (Noisy Intermediate-Scale Quantum) computing

5

Quantum Safe  
Cryptography

Preparing the cryptographies and hardware security modules, resistant to quantum computer attacks

# The road to quantum-accelerated HPC



# Qaptiva™ solutions

**Enabling end-users preparing themselves now for the arrival of the first generation of GPQPU**

**Allowing quantum algorithms development without quantum hardware constraints**

**Offering a unique software environment for users without having to modify quantum algo. when real GPQPU available**



# What is the Qaptiva™ Plataform ?

A complete programming environment and a quantum processor emulator

## PROGRAMMING

### AQASM

Assembly language to build quantum circuits

### pyAQASM

Python extension to AQASM

### CIRC

Binary format of quantum circuits

### QLIB

AQASM & pyAQASM libraries

### QUANTUM ALGORITHMS

QML, VQE, Shor, Grover's search, QAOA...

### INTEROP.

Connectors with other frameworks

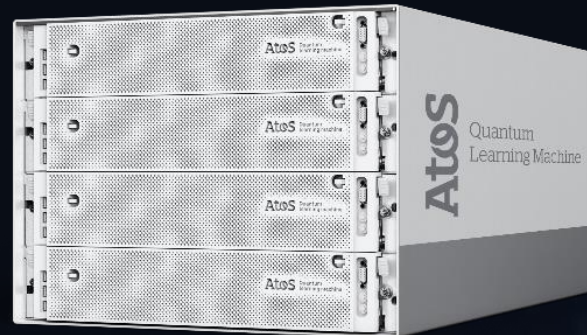
ProjectQ  
rigetti



Cirq



Qiskit



## OPTIMIZATION

### PBO

Pattern based optimizer

### NNIZER

Topology constraint solver

### Circuit Optimizer

Generic circuit optimizer

## SIMULATION

### SIMULATORS

Simulation modules

### PHYSICS

Physical Noise models

# Qaptiva™ ID card

Pioneering since 2016

+15 international research projects

+83 patents

Quantum emulation on noisy and noiseless qubits

Emulation of quantum annealing up to 50000 spins

Quantum Computing

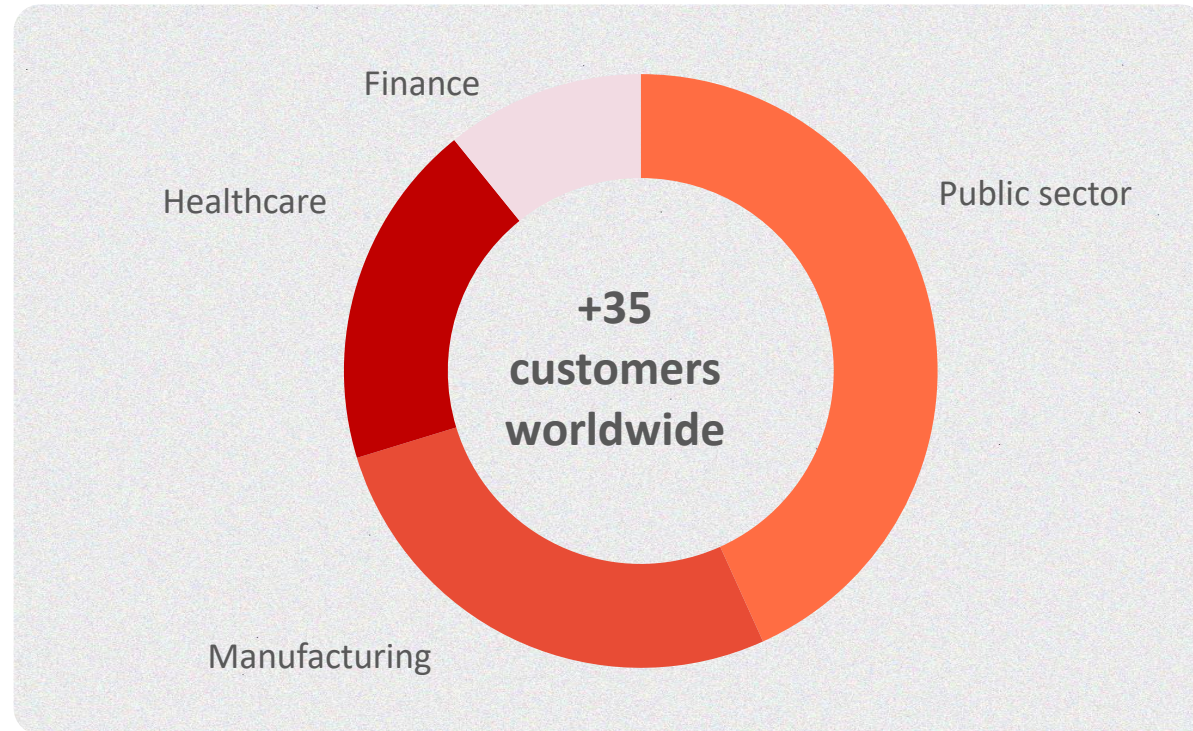
As a Service or On-premises

Leaders in HPC & Quantum hybridization

Use-case specific quantum libraries

Access to physical QPUs

Leaders' quadrant according to Technology Business Research TBR



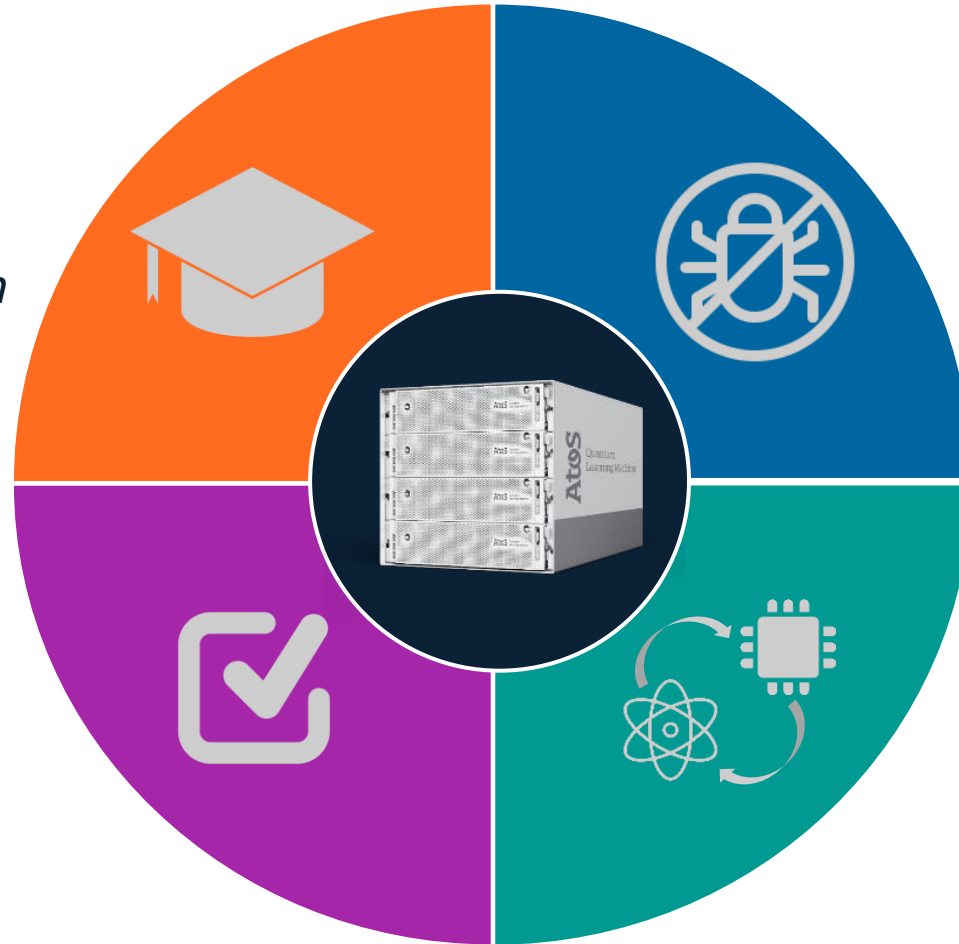
What are the possible ways to use the Qaptiva™ ?

## LEARN

*Get acquainted with quantum computing*

## OPTIMIZE

*Select the best quantum technology to solve your problem*



## TEST

*Conceive new programs ...  
... and debug them*

## RUN HYBRID CODE

*Off-load the quantum-acceleratable parts to the simulated QPU*

# Operation Model: Applications



## Quantum Simulator

Quantum Annealing	Super-conducting	Trapped ions	Topological qubits	Photons	Silicon qubits	Misc.
 D:WAVE The Quantum Computing Company™ <i>Limited to optimization algorithms</i>						

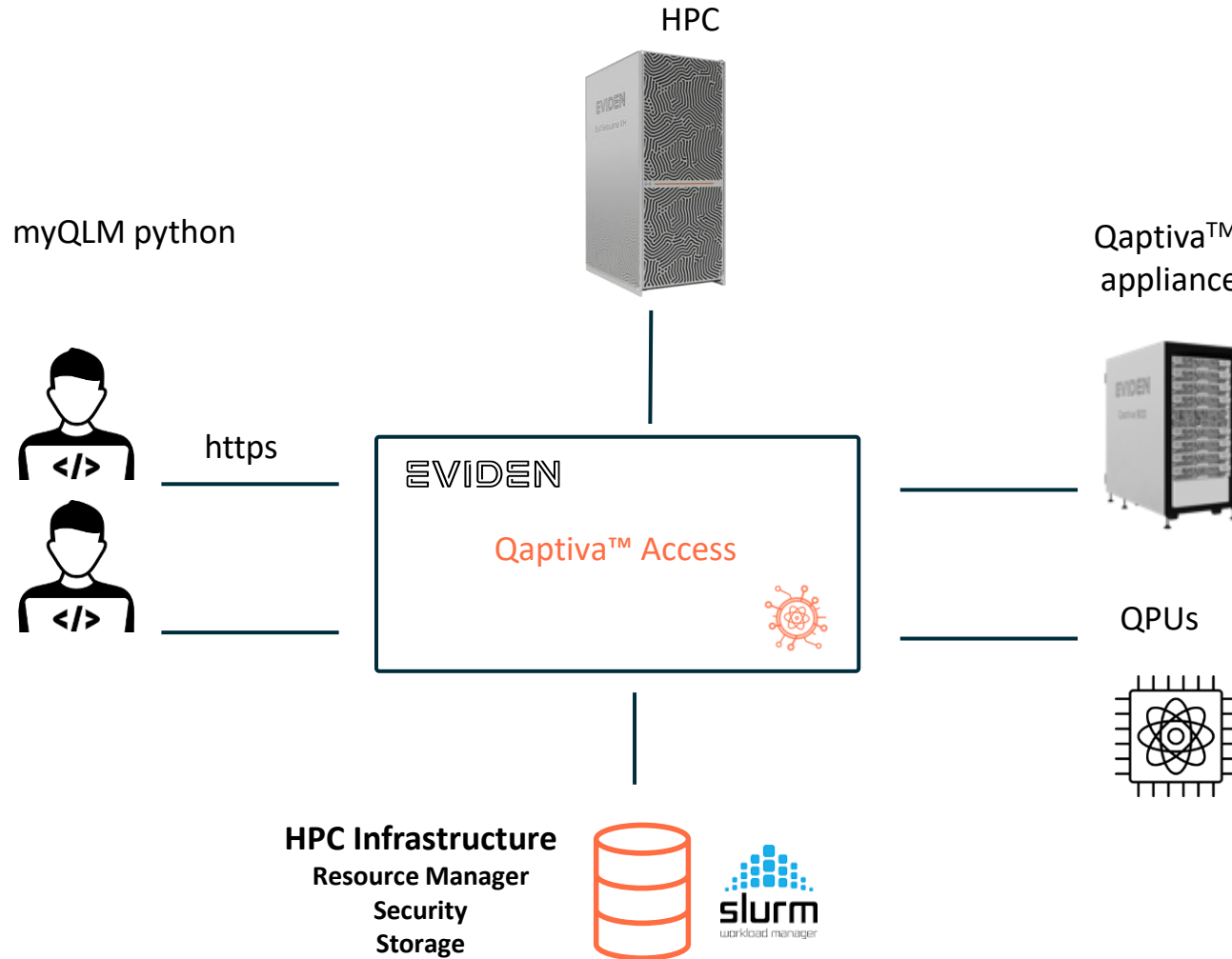


**Intellectual Properties and Assets**



# Qaptiva™ Access (1/2)

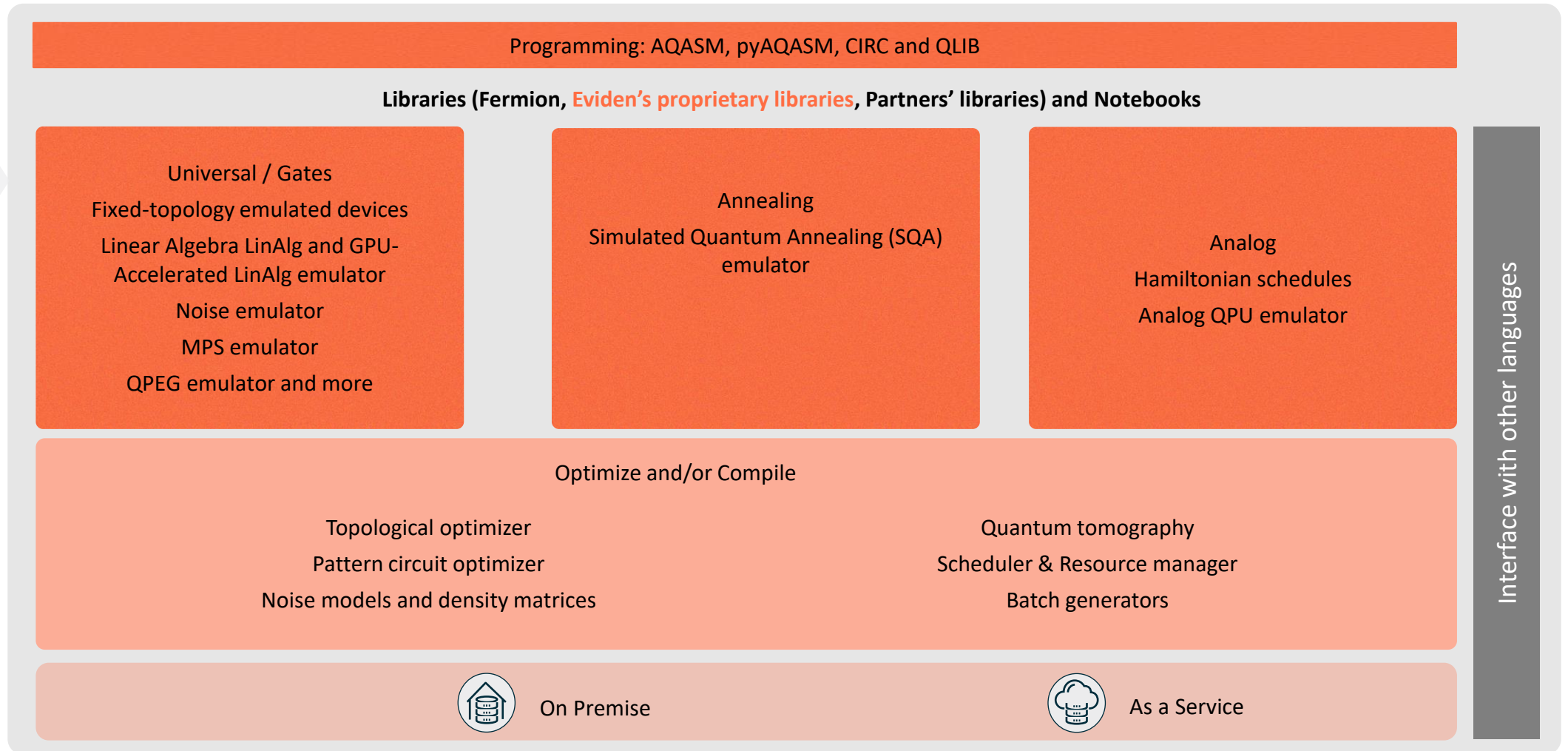
HPC & Quantum hybridization



This feature enables the integration of any quantum processing unit (QPU) and emulator into the high-performance computing (HPC) infrastructure.

- Real scheduling of QPUs with SLURM
- Scale-out numerical simulation (MPI + GPU)
- Used in several HPC-QC pilots:
  - HPC-QS (EuroHPC)
  - HQI (France)
  - QSolid (GER)

# Qaptiva™ Application platform (2/2)



**Emulate** (Qaptiva™ 800, Power Access, classical resources)

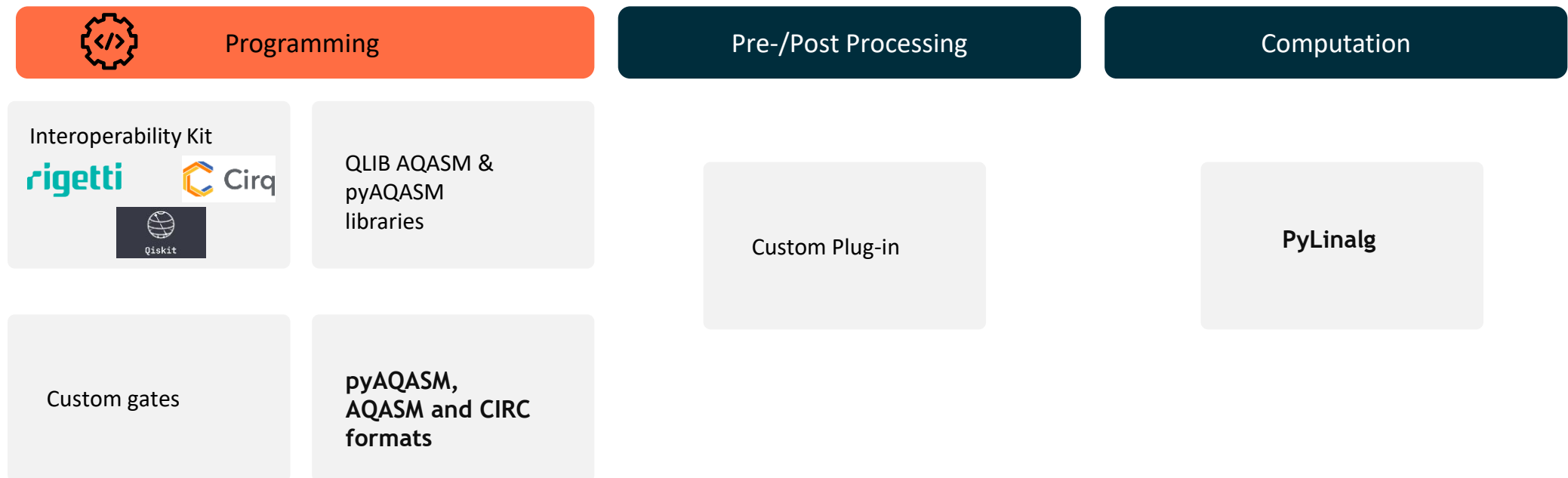
**Run on a Quantum Computer**

# Qaptiva™ Freeware - myQLM

Test and develop quantum algorithms on any device

<https://myqlm.github.io/>

- Freeware Python package with interoperability connectors that provides basic programming features, and serves as a rich client to Qaptiva™ access
- It allows for easy integration and collaboration with other tools and systems, making it a versatile and accessible solution for working with quantum computing applications.
- [Available for download](#)



# Eviden Quantum Computing

Client success



**+35**  
Appliance customers

An orange rectangular box containing the text '+35 Appliance customers' and a small icon of a person standing next to a bar chart.

EVIDEN

Thank You!

GUSTAVO VILLELA

[gustavo.villela@eviden.com](mailto:gustavo.villela@eviden.com)

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