QuiX QUANTUM

CINECA HPC WORKSHOP

Caterina Taballione, Commercial & Partnership Lead
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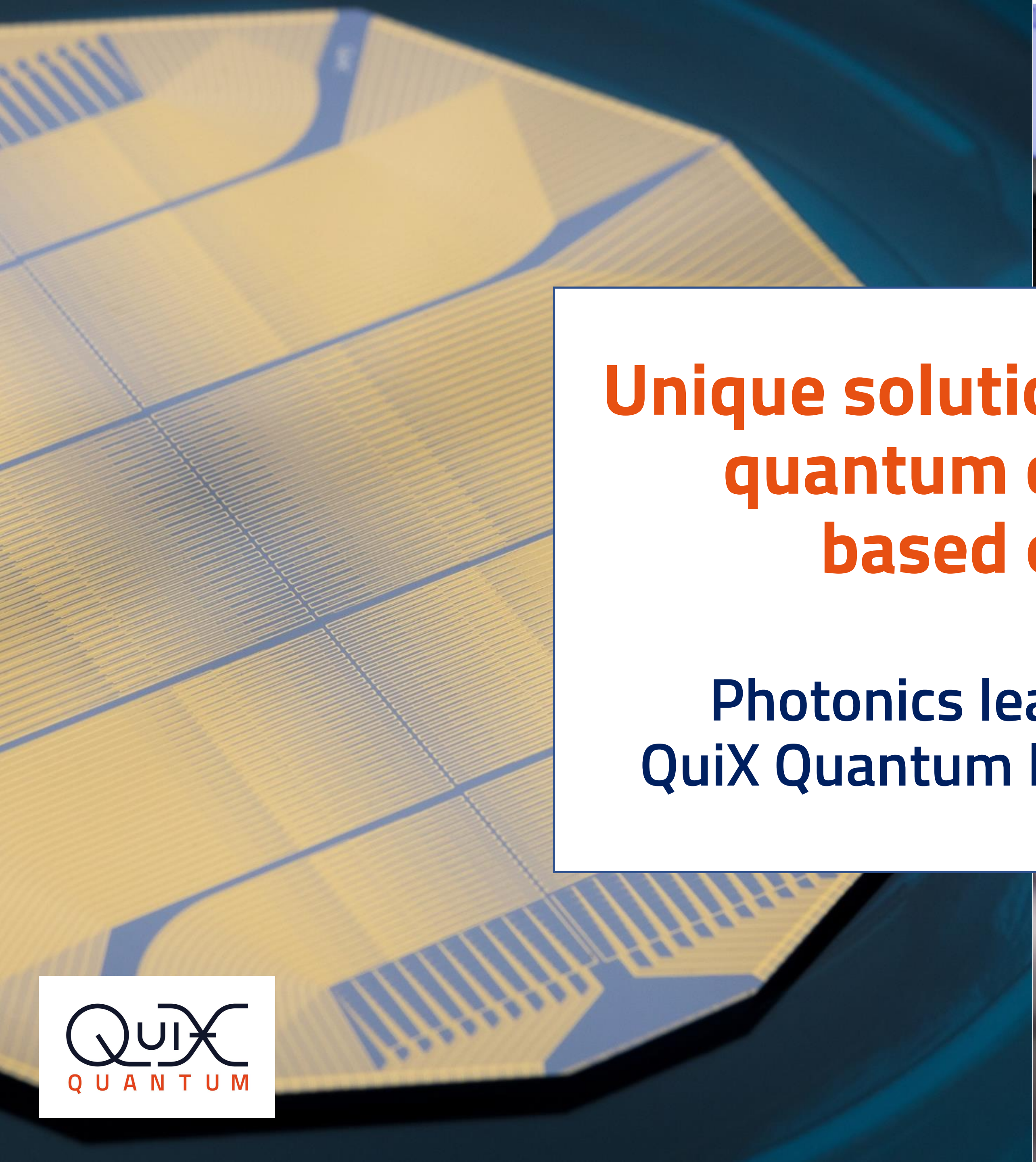

Unique solution for scalable quantum computing based on light

Photonics leads quantum,
QuiX Quantum leads photonics!

Making the impossible, possible

Healthcare

- Drug discovery
- Personalized medicine

Finance

- Optimization trading
- Fraud detection

Climate

- Agriculture, green fertilizers
- Energy, new catalysts

Supply Chain

- Storage and distribution
- Logistics

High Tech

- AI, image recognition
- Machine Learning, self-driving cars

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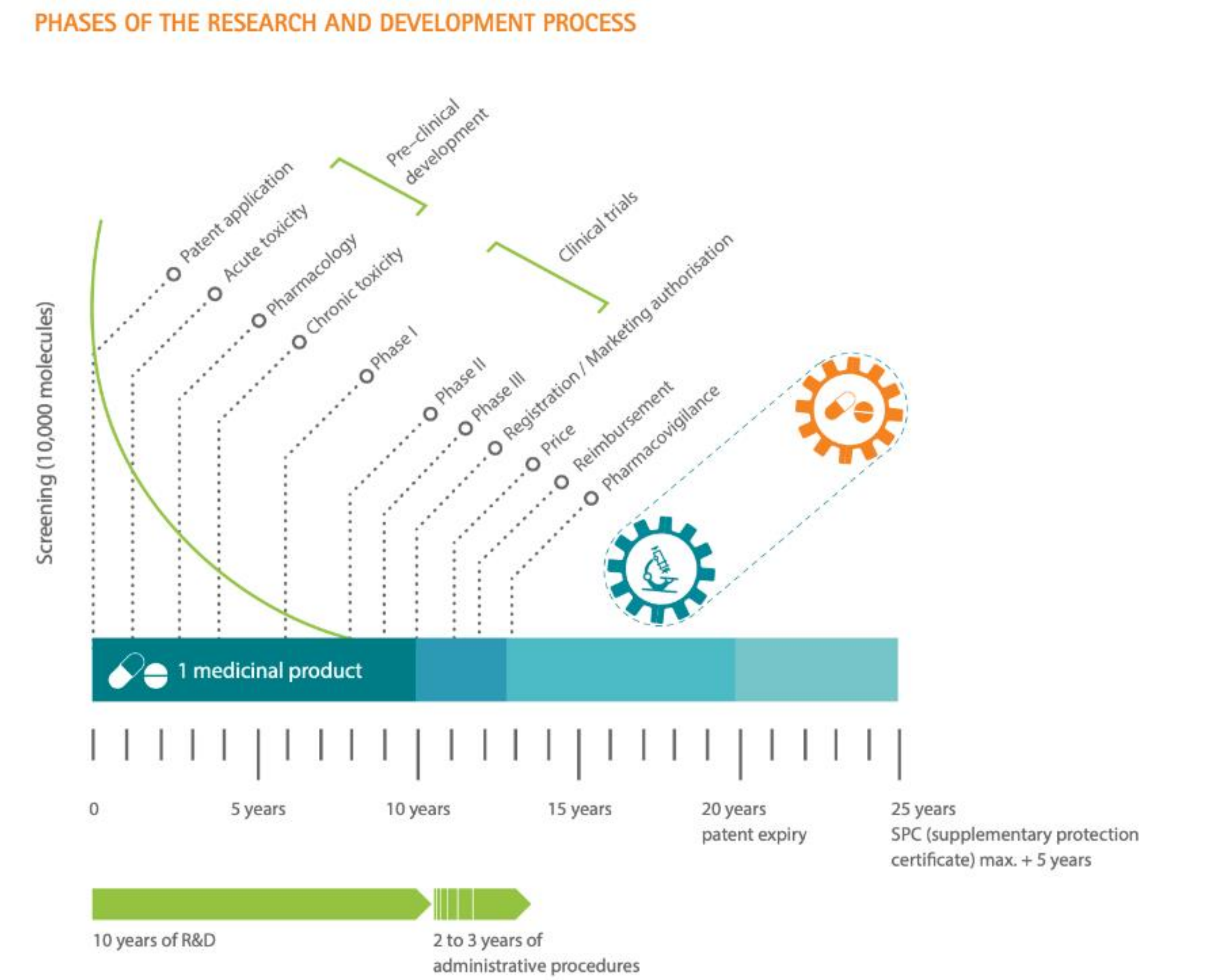
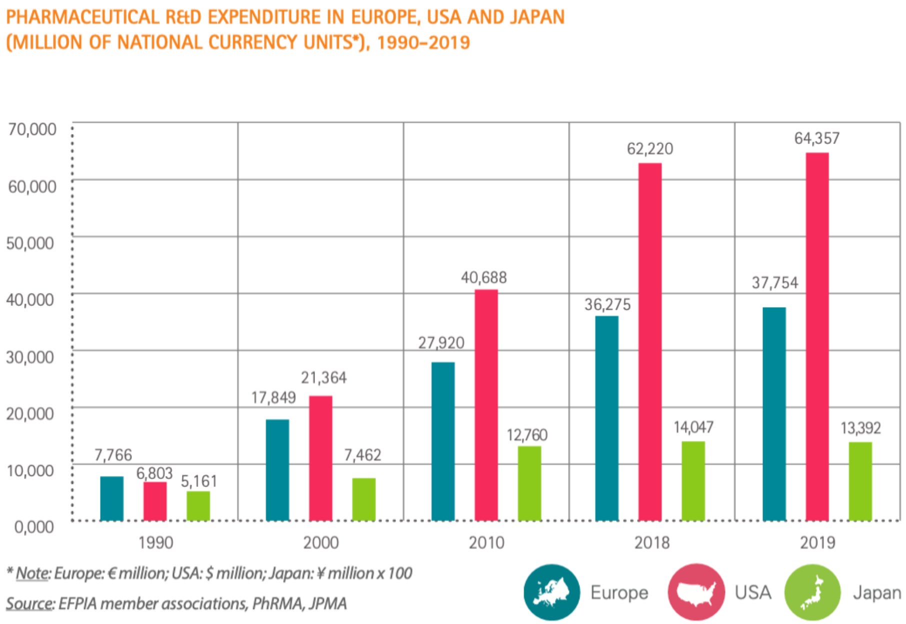
Expected quantum computing market = $1 Trillion by 2035
McKinsey

Speeding up healthcare

Enormous pharmaceutical R&D expenditure

- 12-13 years time-to-market
- 1,926 Million Euro Development costs in 2013
- 1/10,000 chance of success





Source: EFPIA - European Federation of Pharmaceutical Industries and Associations

Speeding up healthcare

Enormous pharma [partly obscured] e

- 12-1[partly obscured]
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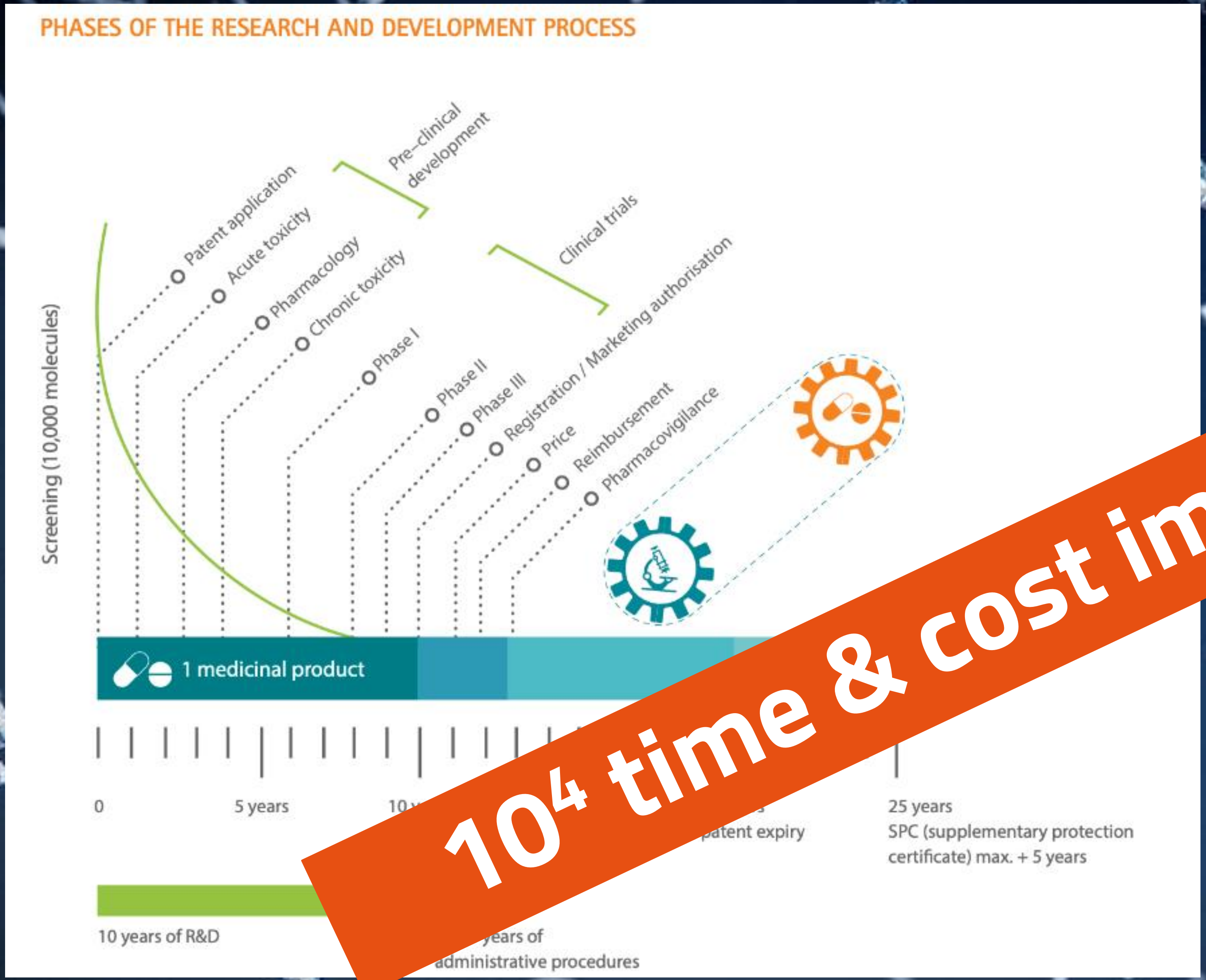
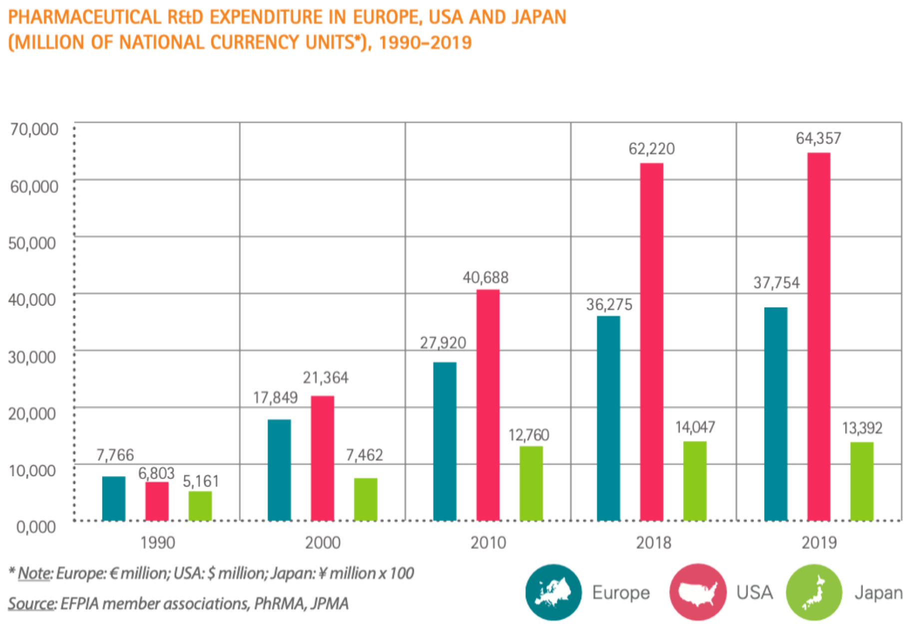
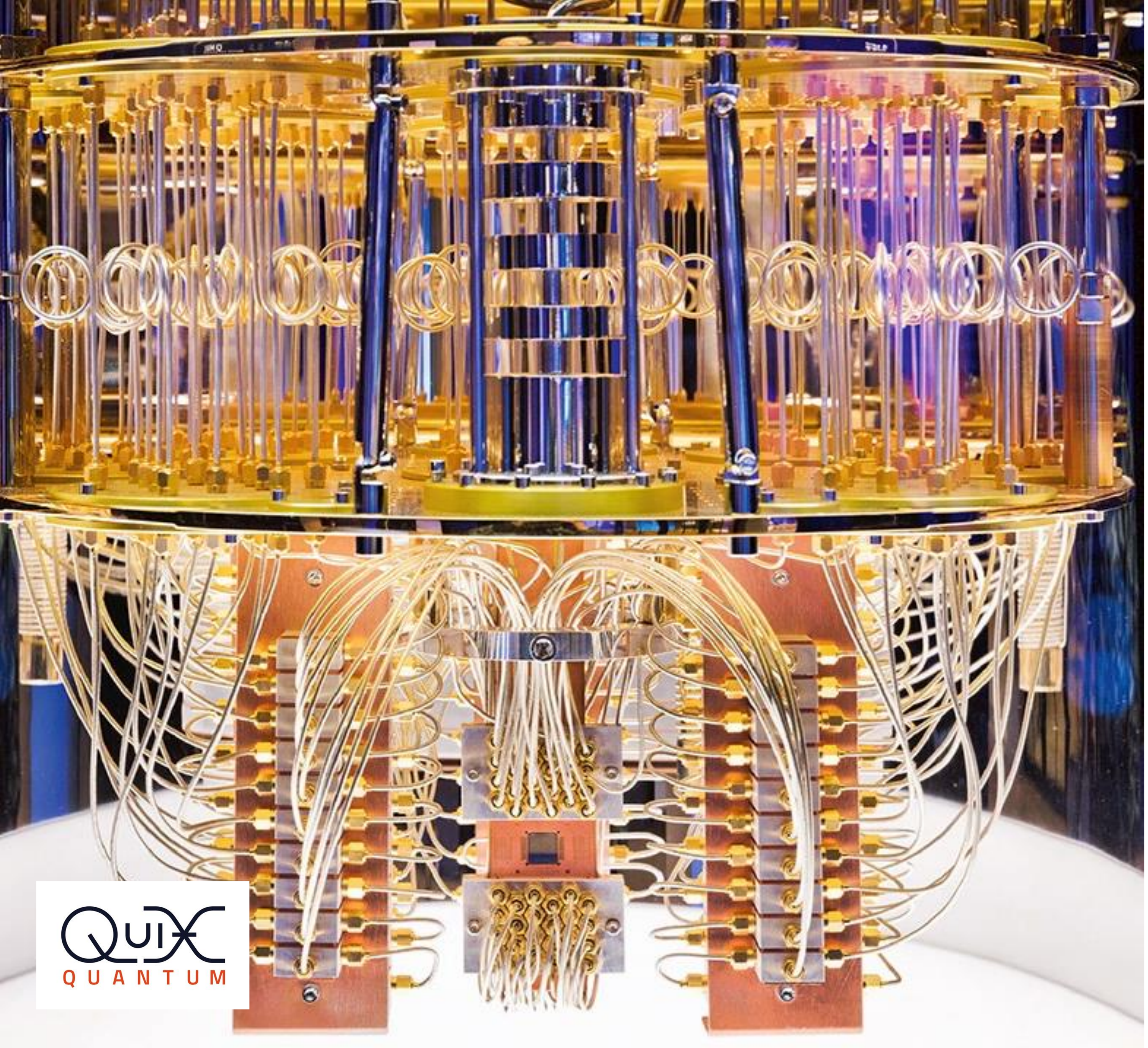
- [partly obscured] 00 chance of success



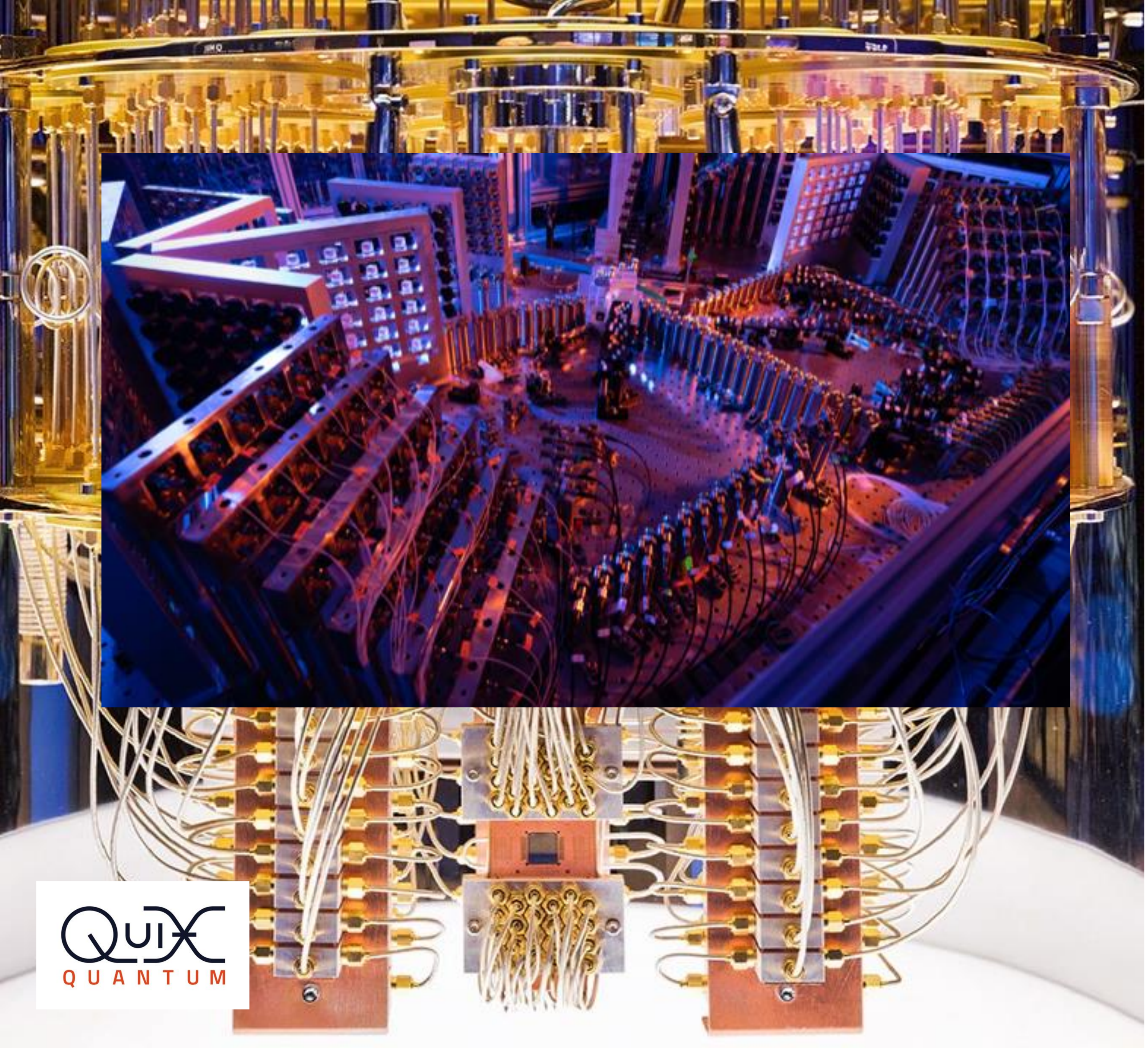


10^4 time & cost improvement!

Source: EFPIA - European Federation of Pharmaceutical Industries and Associations

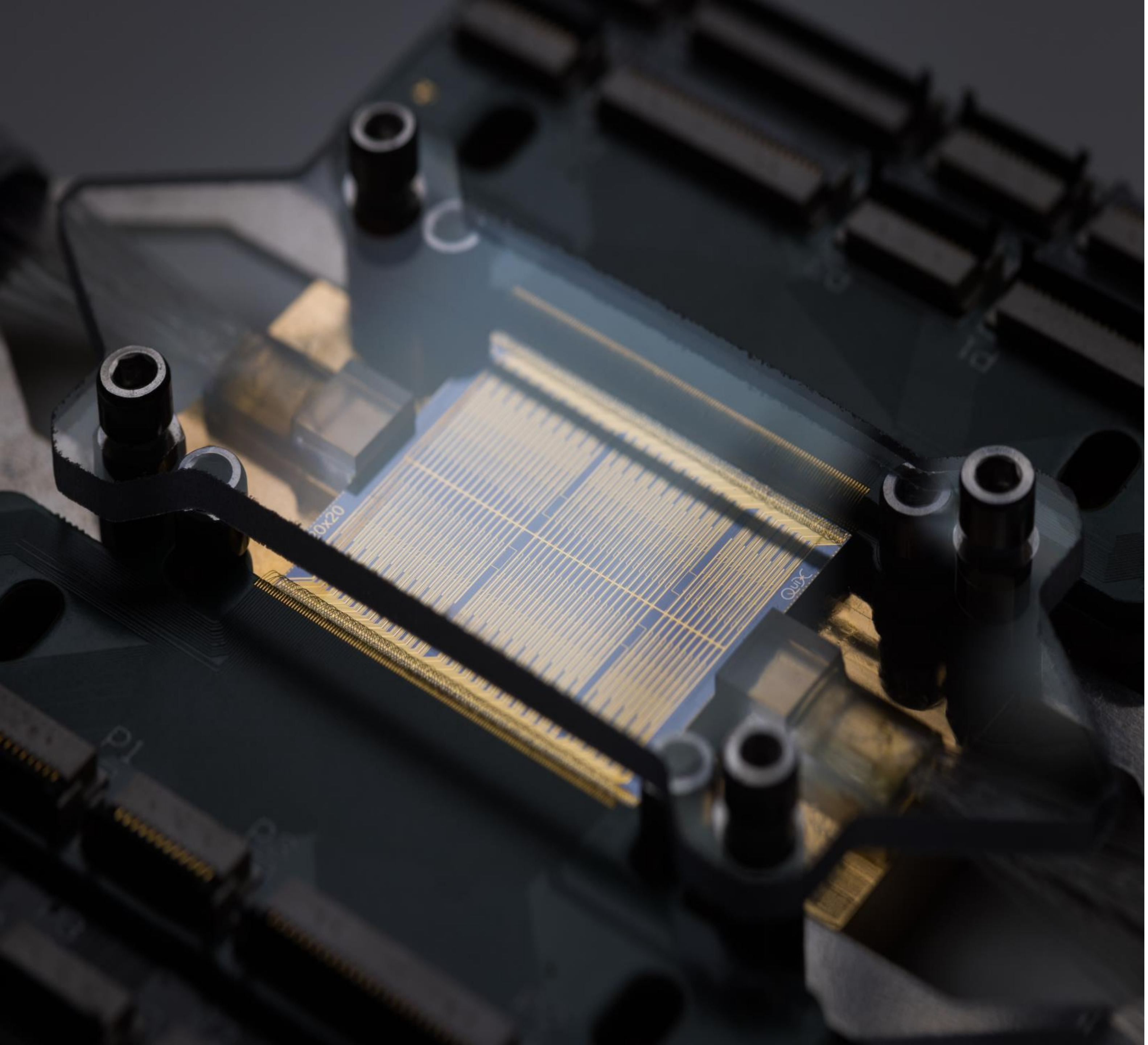


Quantum Computing



Quantum Computing

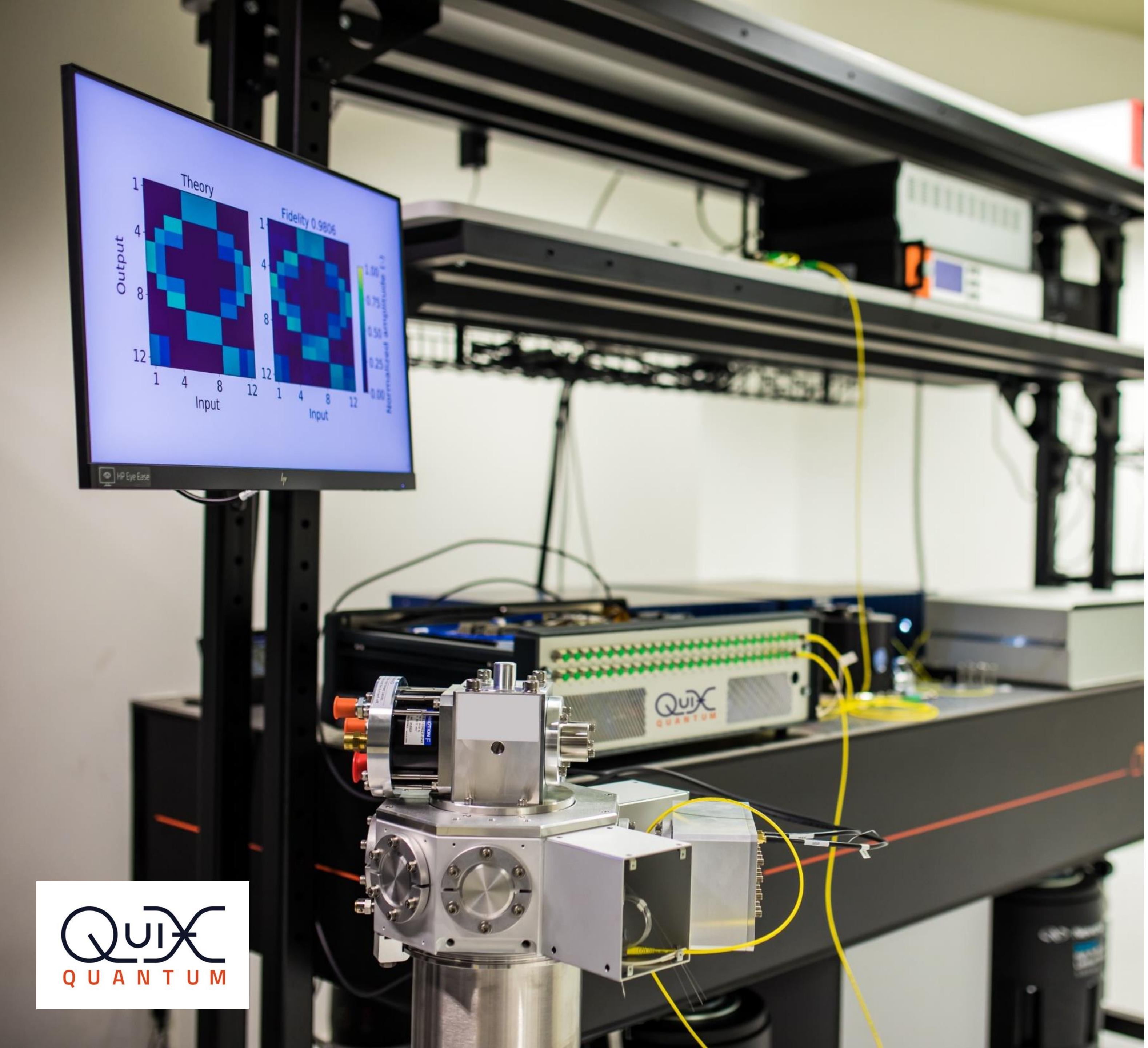
based on photonics



Quantum Computing

based on photonics

with QuiX Quantum



Quantum Computing

based on photonics

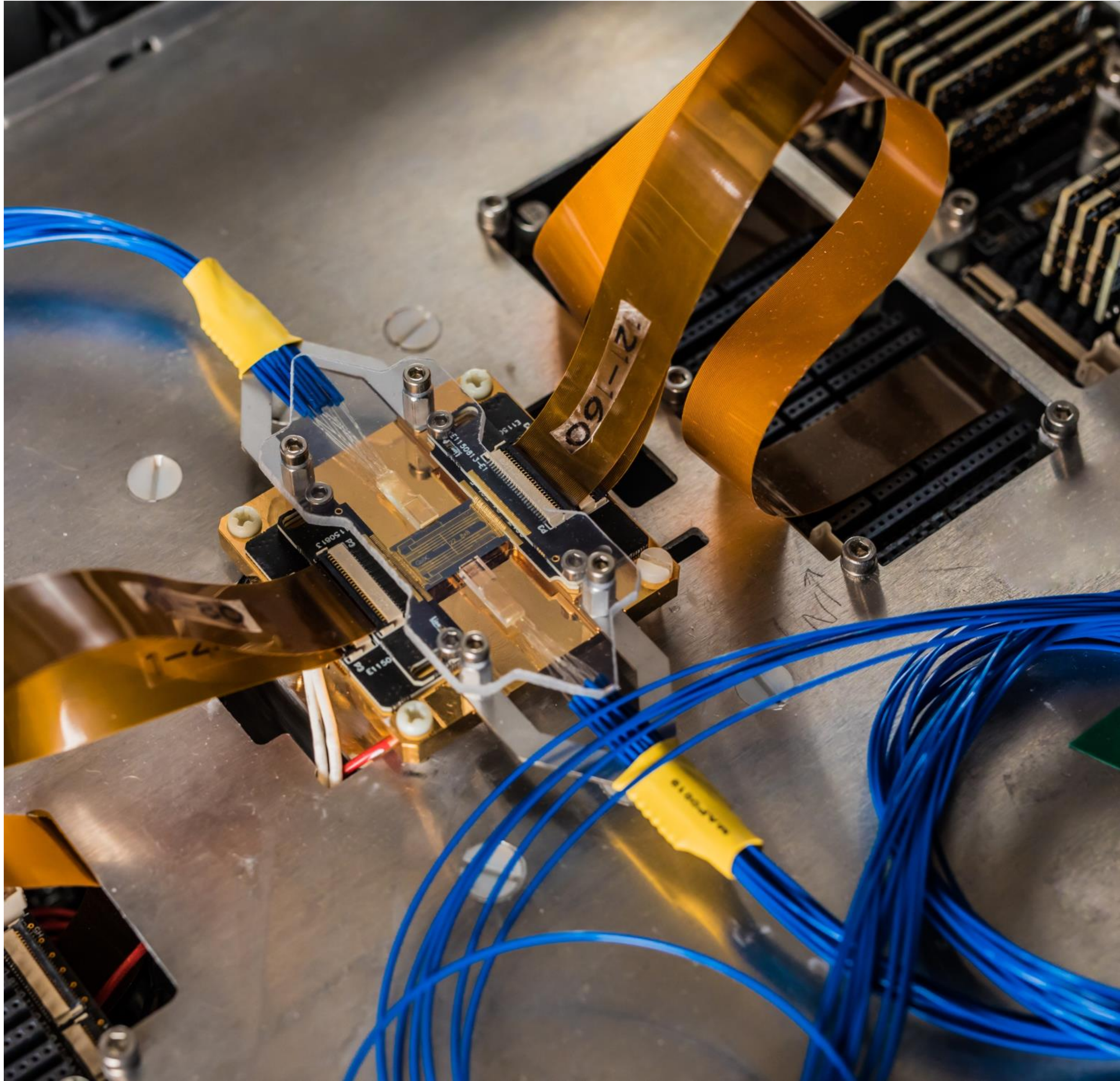
with QuiX Quantum

Cloud access coming soon!

In the core:
Quantum Photonic Processor

The market leading technology made by
QuiX Quantum

Qubits	→	Photons
Manipulation	→	Interference
Computation	→	Measurement



Technical challenges, our solutions

in developing a universal quantum computer

Challenge	Solution
1. ERRORS	LOW-LOSS
2. SCALABILITY	MODULARITY
3. CONNECTIVITY	QUANTUM PHOTONICS LINKS
4. COOLING POWER	ROOM TEMPERATURE

TriPleX^{TM} Waveguide platform

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Product Portfolio

2020

2023

2027

	Processors	Quantum Computer	Universal Quantum Computer
Solutions for	R&D, quantum computing	Optimization, simulation	All industry sectors
Customers	Researchers, QC companies	Healthcare, finance, logistics	Full industry
Cloud access	No	Yes	Yes

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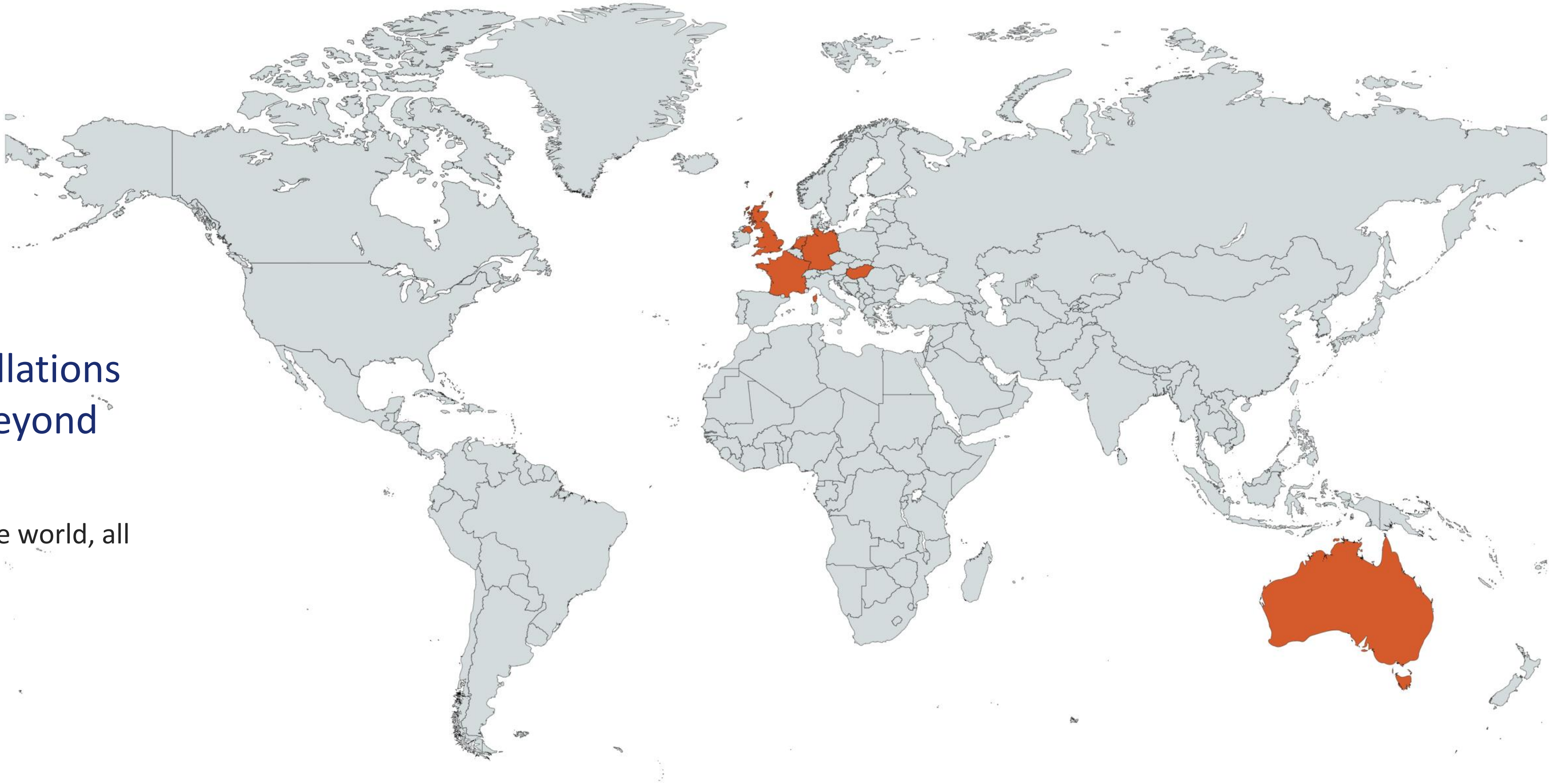
QuiX Quantum Processors out in the world



Remote installations Production beyond prototypes

6 systems out in the world, all working reliably

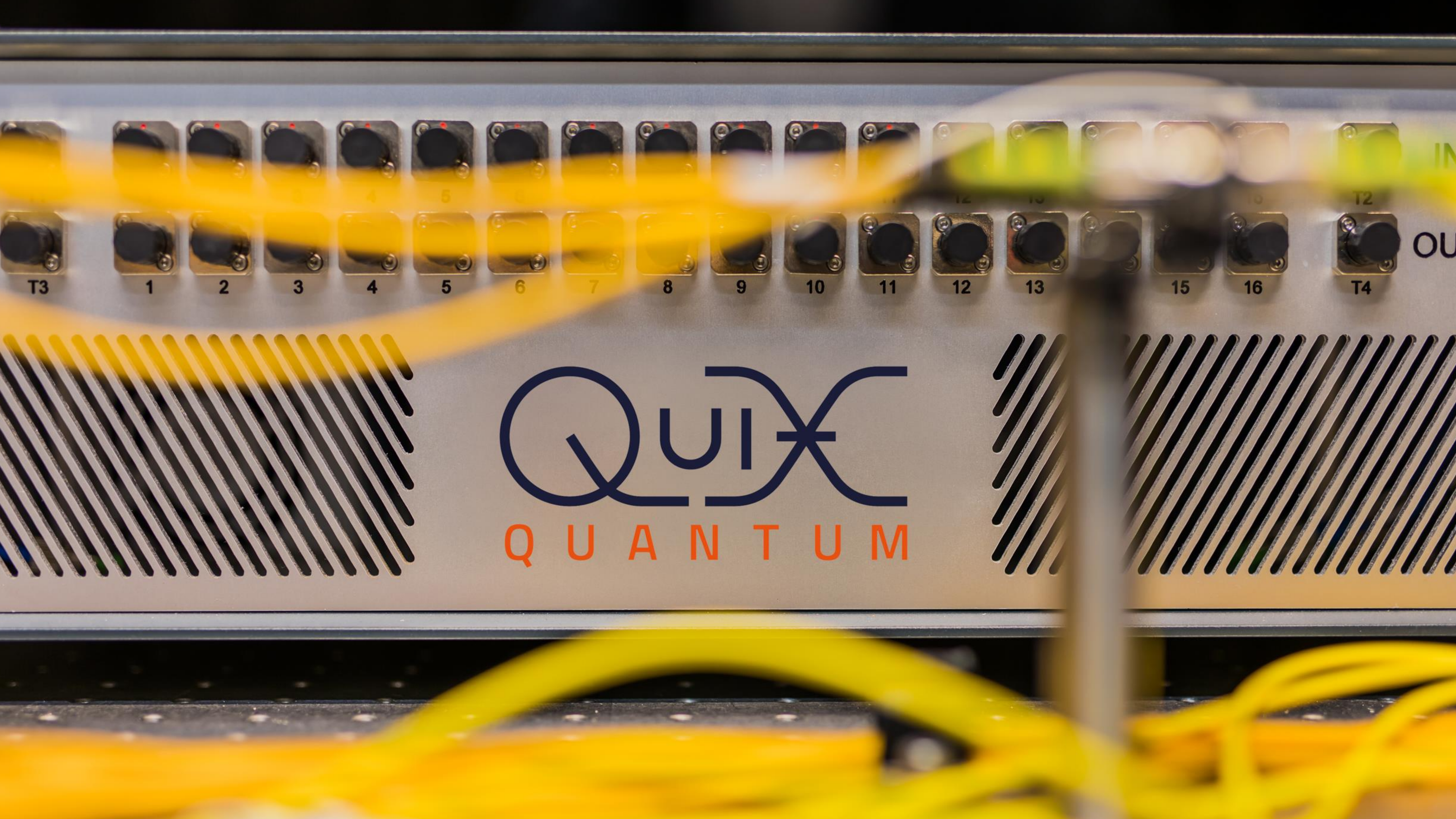
QUIX QUANTUM

QuiX Quantum Processors out in the world

Remote installations Production beyond prototypes

6 systems out in the world, all working reliably

We don’t make promises, we deliver them!


T2
T3 1 2 3 4 5 6 7 8 9 10 11 12 13 15 16 T4
QuiX
QUANTUM

File Edit Selection View Go Run Terminal Help

tutorial.py

tutorial.py > ...

Run Cell | Run Below | Debug Cell | Go to [1]

```python
#%%
import dogwood
import numpy as np
import matplotlib.pyplot as plt
```

Run Cell | Run Above | Debug Cell

```python
#%%
p = dogwood.PhotonicProcessor(port="COM3",
                              test_mode=True)
print(p.get_temp(), p.get_current())
```

Run Cell | Run Above | Debug Cell | Go to [3]

```python
#%%
# Set matrix
matrix = np.identity(12)
p.set_unitary(matrix)

# Perform measurement
plt.imshow(np.abs(p.matrix), clim=[0, 1])
```

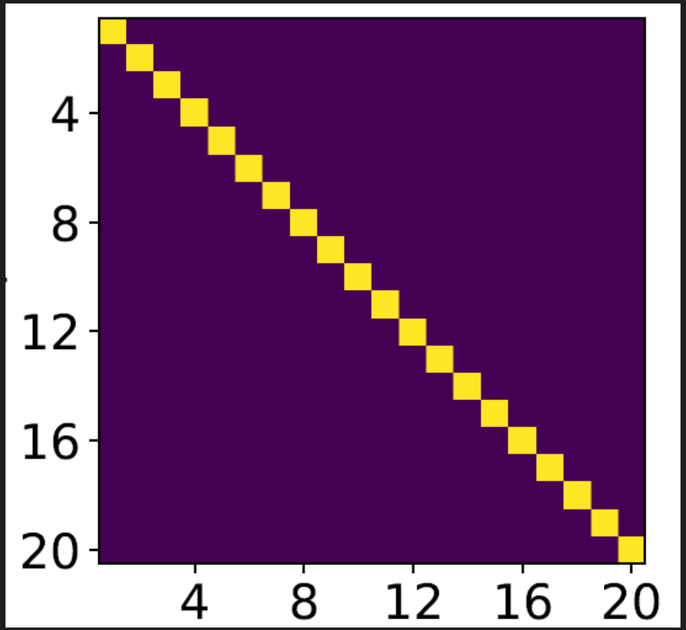
Interactive-1

Clear All Restart Interrupt env (Python 3.9.5)

```
28 0.0
```

```
# Set matrix ...
```

```
<matplotlib.image.AxesImage at 0x1d62b8cfe20>
```



Type code here and press Shift+Enter to run

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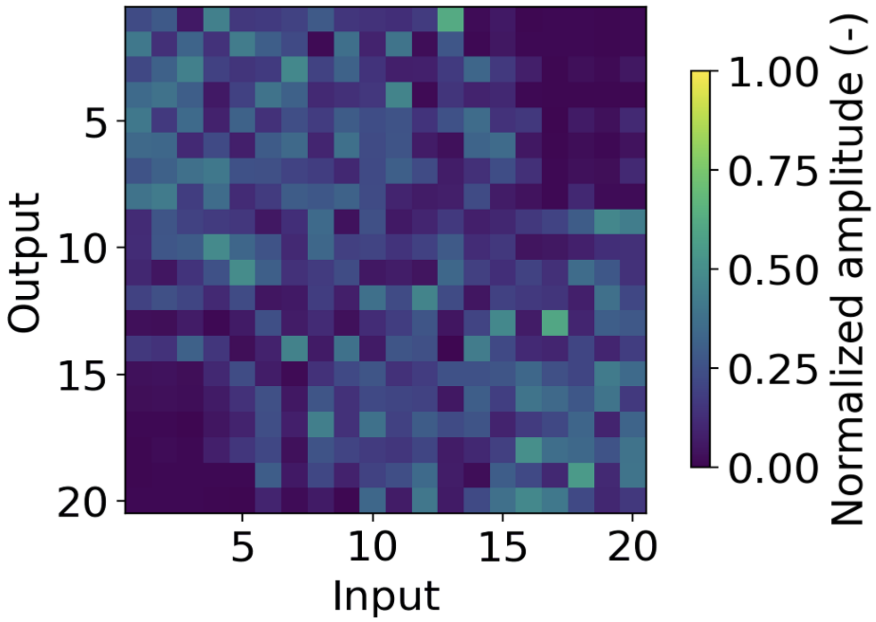
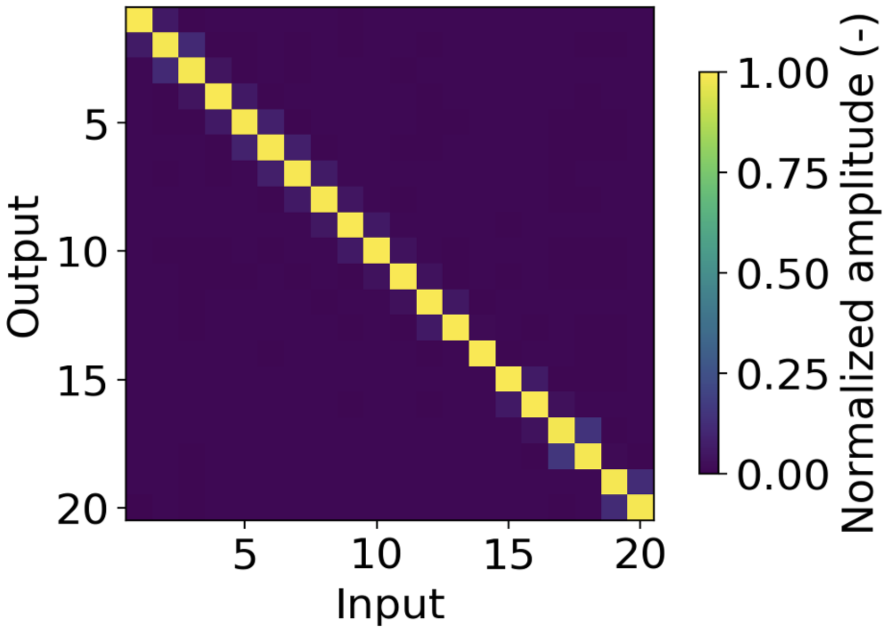
0 0   Ln 8, Col 30   Spaces: 4   Python   3.9.5 ('env': venv)   Spell

Programmability

How well can we control the quantum photonic processor?





High-Fidelity (~99.9%)

Quantum Interference (~98%)

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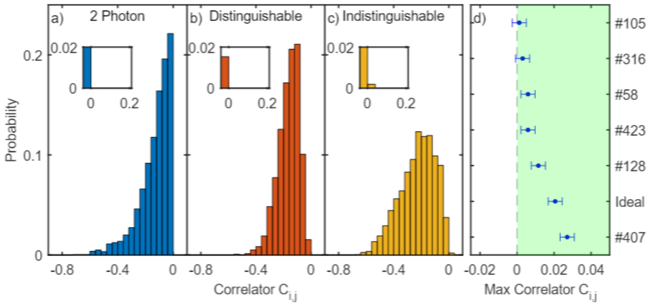
arXiv:2203.01801v2

What can you do with QuiX Quantum Processors?

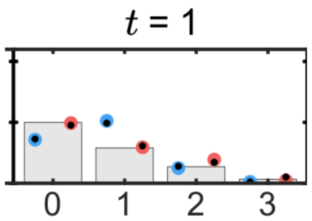
From our collaborators on a 12-mode processor

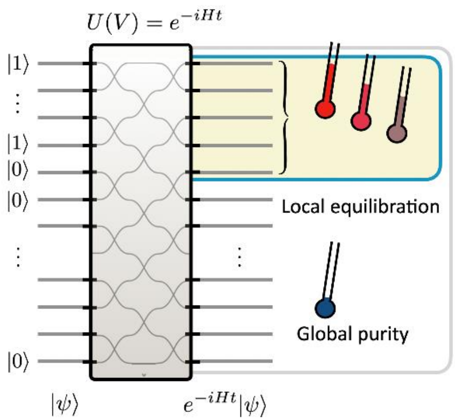
Entanglement witness
arXiv: 2112.00067



Quant Quantum Nanotechnology Twente

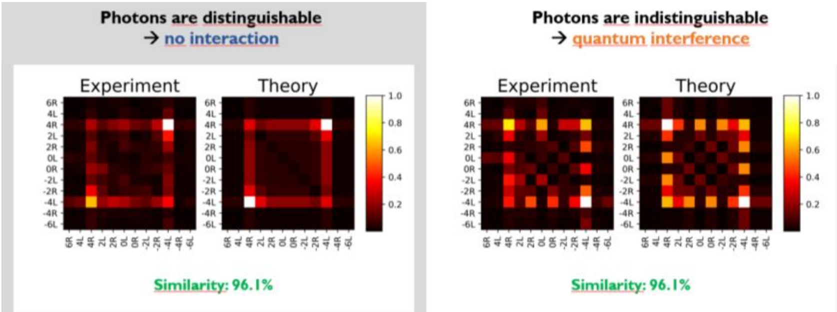
Quantum thermodynamics
arXiv: 2201.00049





UNIVERSITÄT PADERBORN
Die Universität der Informationsgesellschaft

Two-photon Hadamard quantum walk



Measurement time: **< hours**

Conventional approach (no processor): **days**

CONFIDENTIAL

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The progress so far

- Market leader in photonic quantum computing hardware
- 10+ processors sold worldwide
- Record breaking devices made
- € 9M investment
- **Sale of universal photonic quantum computer to German governmental organization**

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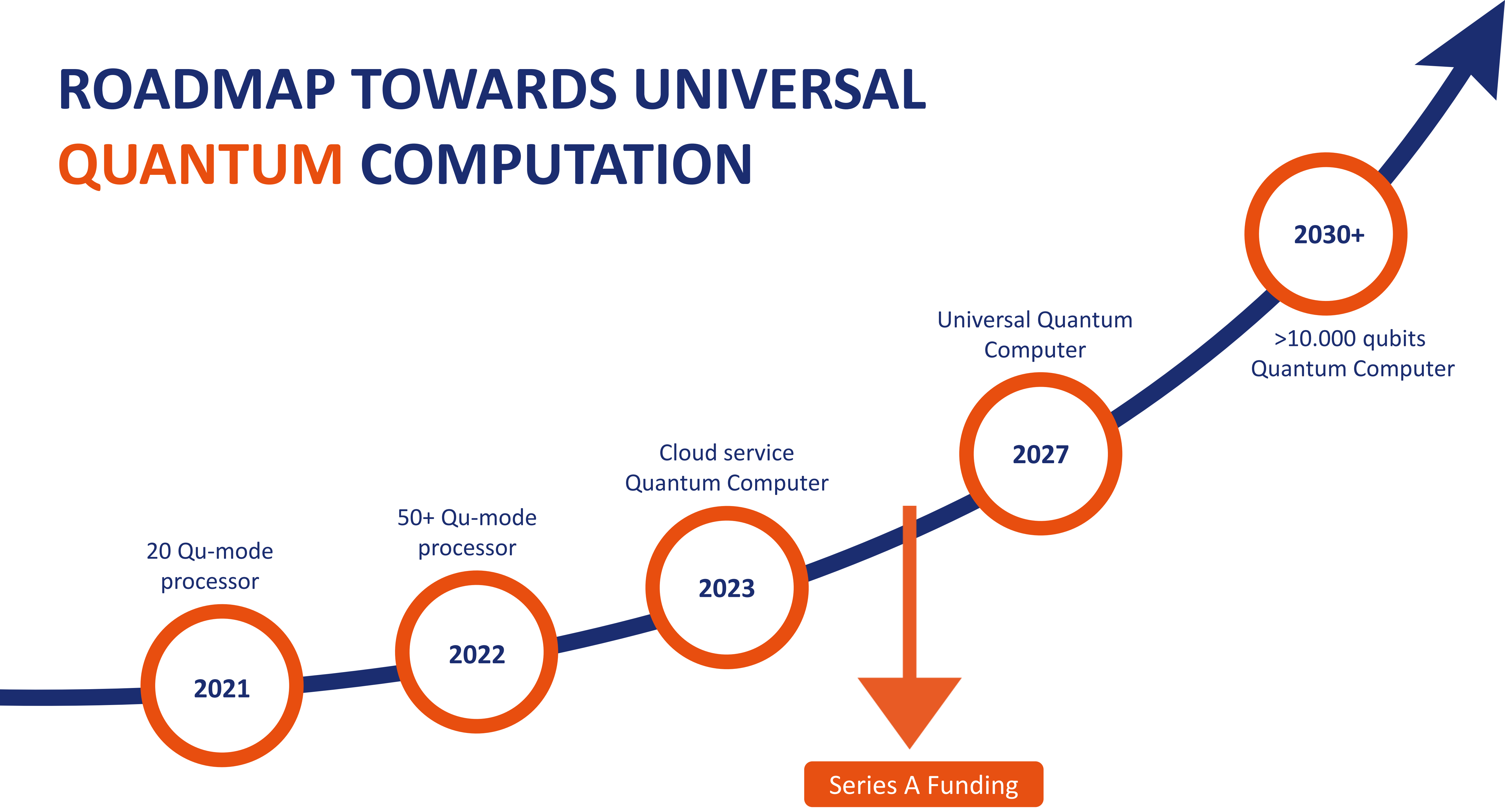
ROADMAP TOWARDS UNIVERSAL QUANTUM COMPUTATION



Partners & collaborators

PhotonDelta

QuIC European Quantum Industry Consortium

QPhot innovation network

EPIC European Photonics Industry Consortium

LioniX INTERNATIONAL

phix

Qu & Co

kvantify

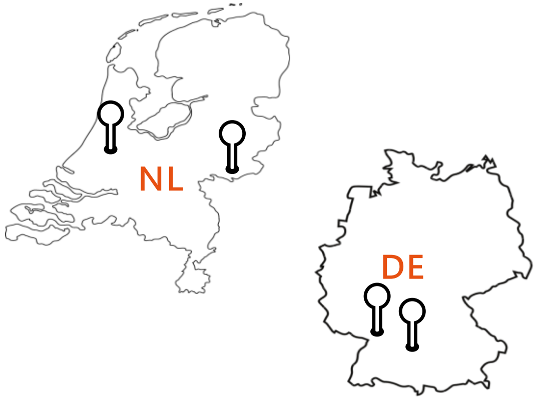
UNIVERSITY OF TWENTE.

QuiX QUANTUM

The Team

+10

And we're growing!



Interested?

Apply now!

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Photonics leads Quantum,

QUIX QUANTUM leads Photonics!

Let's connect!

Caterina Taballione, Commercial & Partnerships Lead
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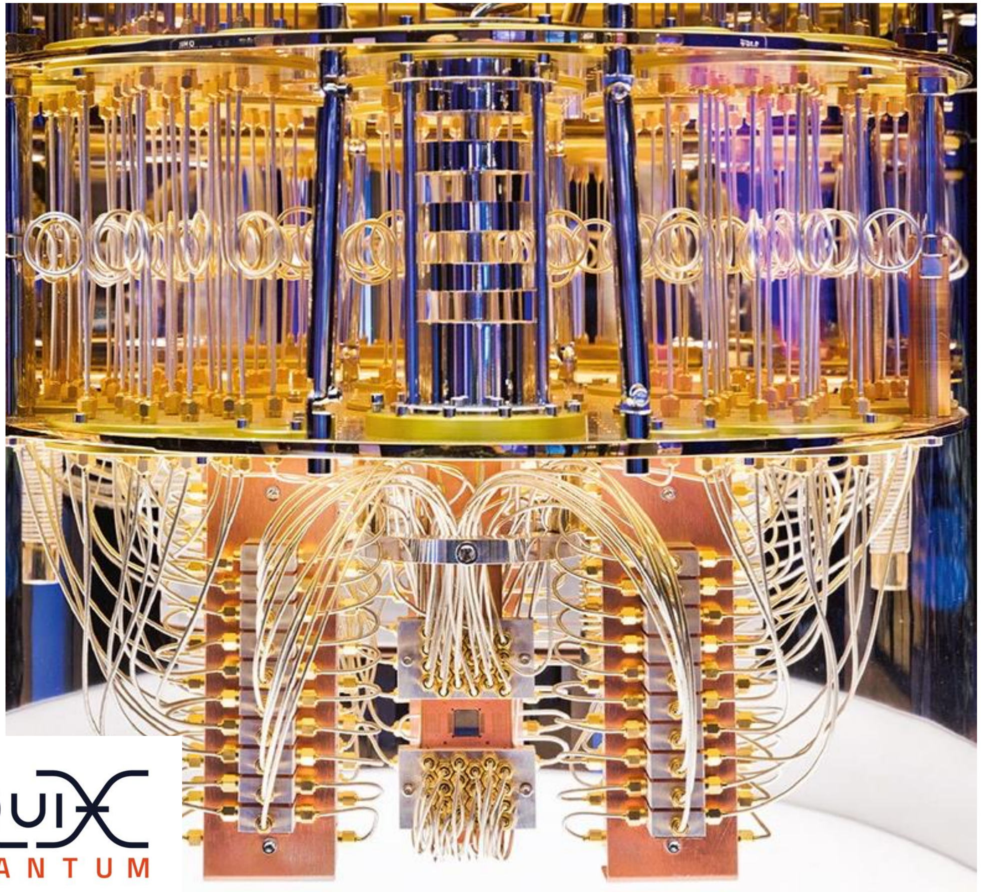
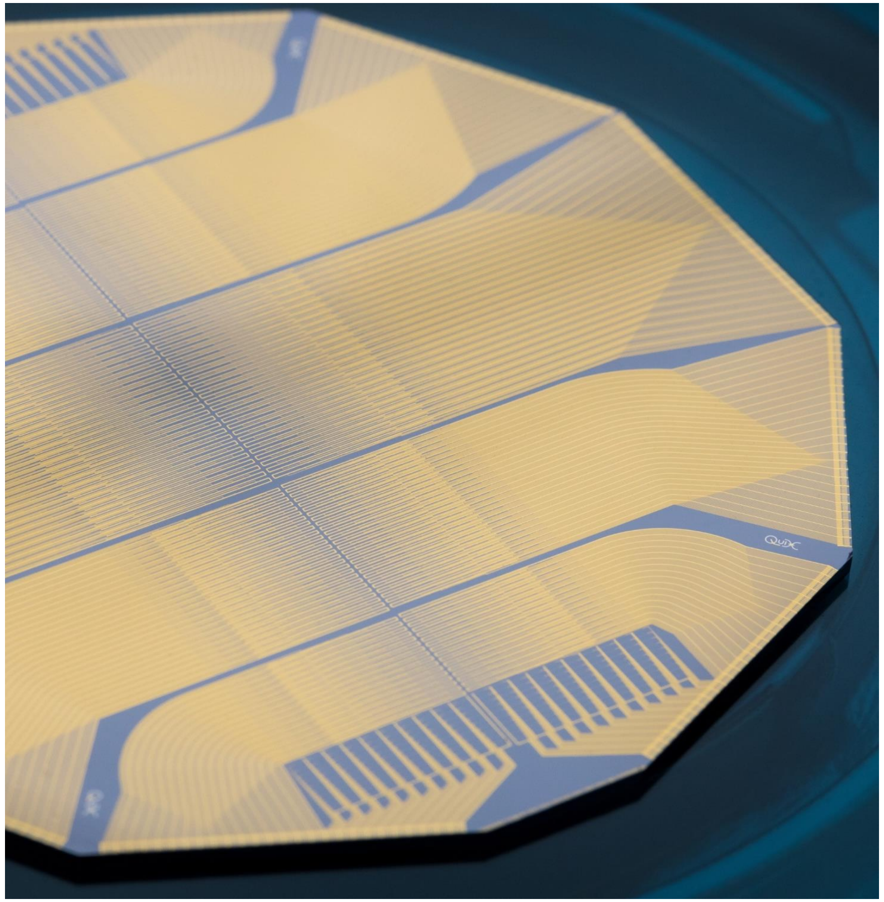
Measurement-based Quantum Computing

How does it differ from the most common approach?

Circuit model (Gate model)	Measurement-based Quantum Computing
	

QuiX QUANTUM

Measurement-based Quantum Computing

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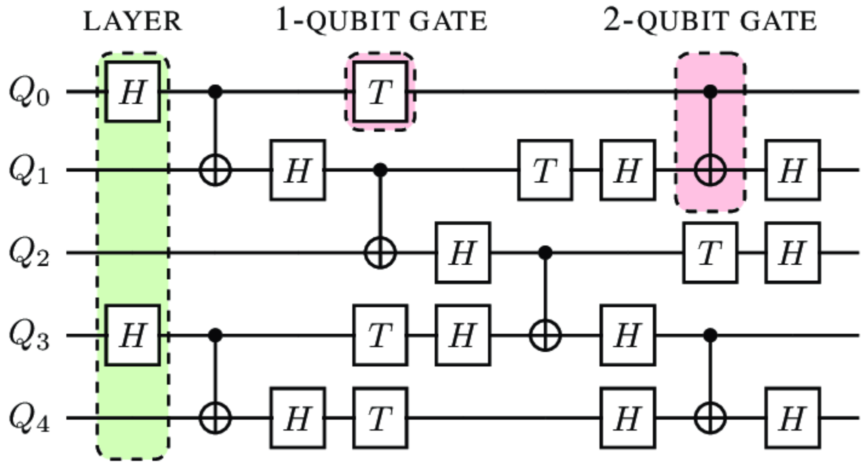

- Sup. & Ent: built during computation
- Steps: quantum gates
- Single- & 2-qubit gates
- End: Measure (Project) 1 or more qubits

Measurement-based Quantum Computing

QUiX QUANTUM

Measurement-based Quantum Computing

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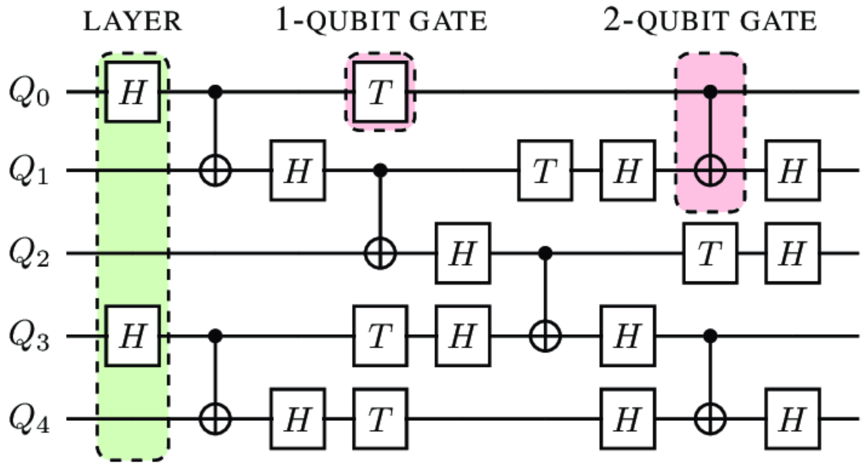

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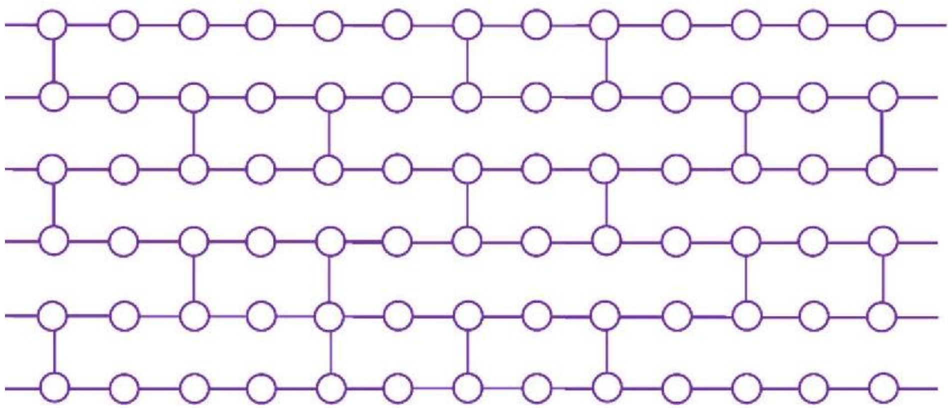
Measurement-based Quantum Computing



- Sup. & Ent: **prepared offline as resource**
- Steps: measure state in different basis
- **Only Single-qubit gates**
- End: Measure (Project) of the state + feedforward

QUIX QUANTUM

Measurement-based Quantum Computing

How does it differ from the most common approach?

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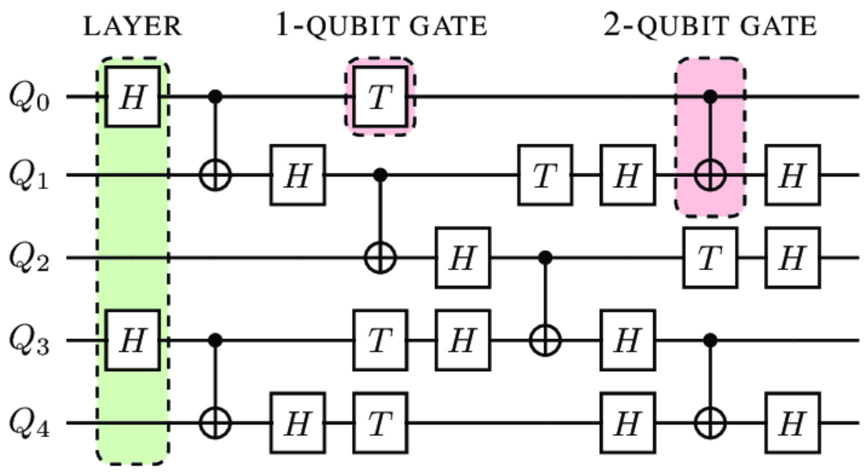

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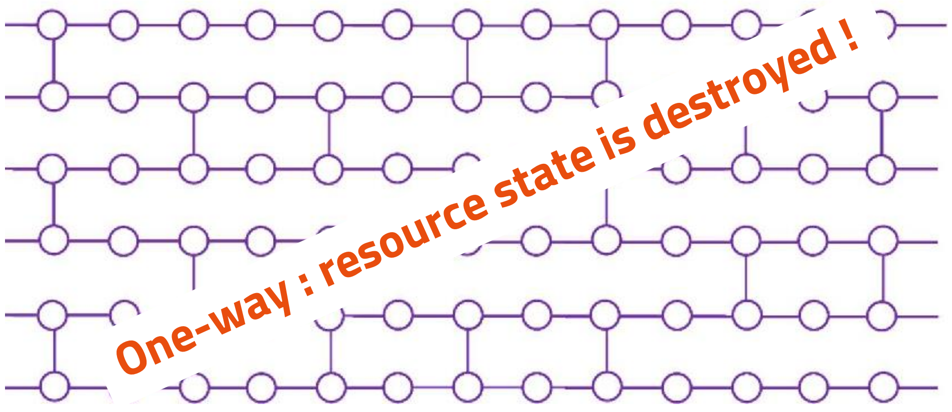
Measurement-based Quantum Computing



- Sup. & Ent: **prepared offline as resource**
- Steps: measure state in different basis
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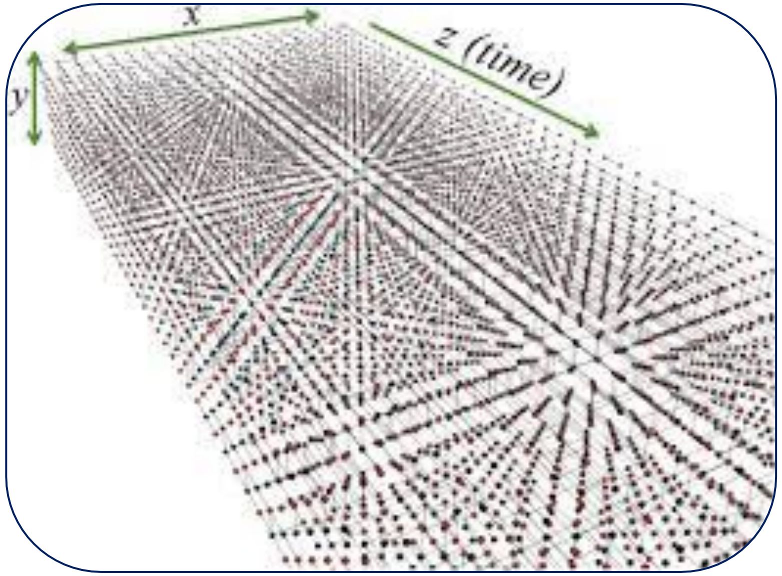
Advantages of Measurement-Based Quantum Computing



1. **Smaller** overhead
2. **Flexibility** in computation

No need to **maintain** the entire train track, only use the part when the train is riding. This **simplifies** the enormous engineering challenge!

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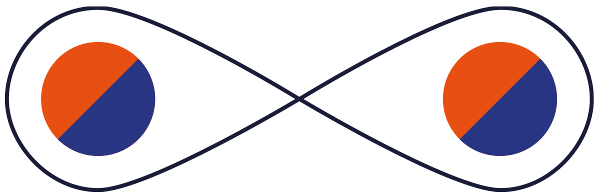
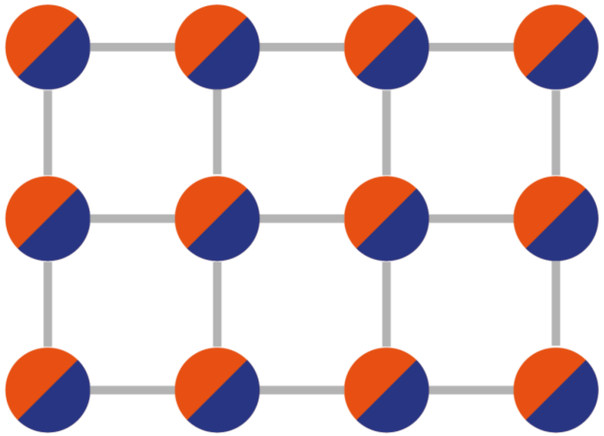
What is the entangled resource state?

Cluster state

Cluster state within it are the main ingredients for quantum computing

Entanglement bonds

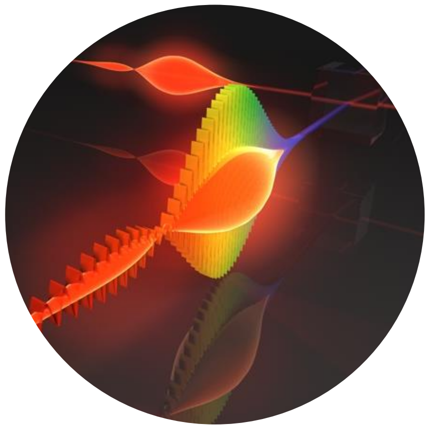




$$|+\rangle = \frac{1}{\sqrt{2}}(|0\rangle + |1\rangle)$$

Encoding element of light (squeezed state, single photon) as a qubit.

Qubit in Superposition



Behind the artistic picture is a simple and beautiful mathematical framework:

$$|C\rangle = \prod_{k\in n(1)} CZ_{1k}\, |+\rangle |\psi\rangle_{2,...,N}$$

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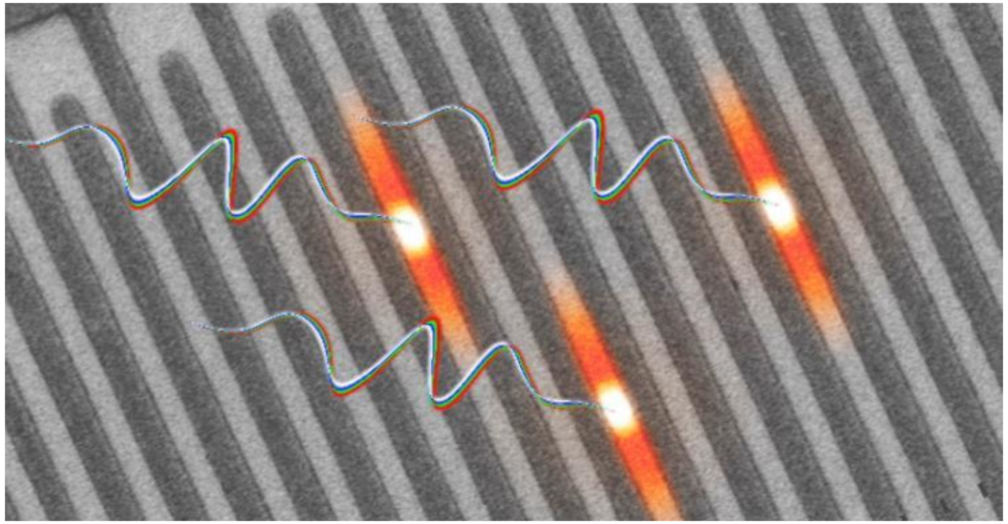
How to encode a qubit in photonics!

Discrete variable (DV) quantum computing
Use particle properties of light

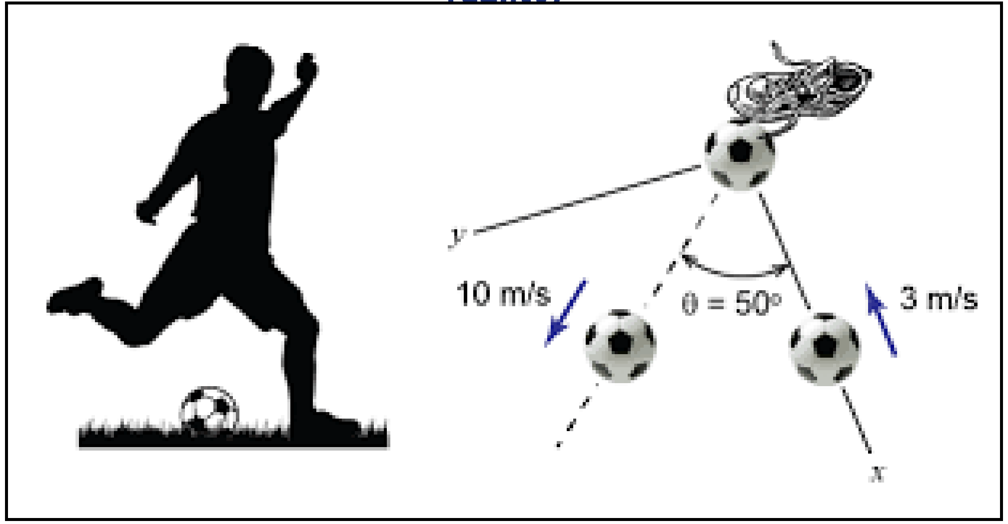
Encoding: Single light quanta (single photon).
(Dual-rail encoding)



Detection of single light quanta (photons).
The detector either observer the light or not (discrete)

Continuous variable (CV) quantum computing
Use wave properties of light

Encoding: The position and Momentum quadrature of light (squeezed state). (Electrical field – vector potential in reality)



One can shoot in all direction with certain speed
(no discrete values)

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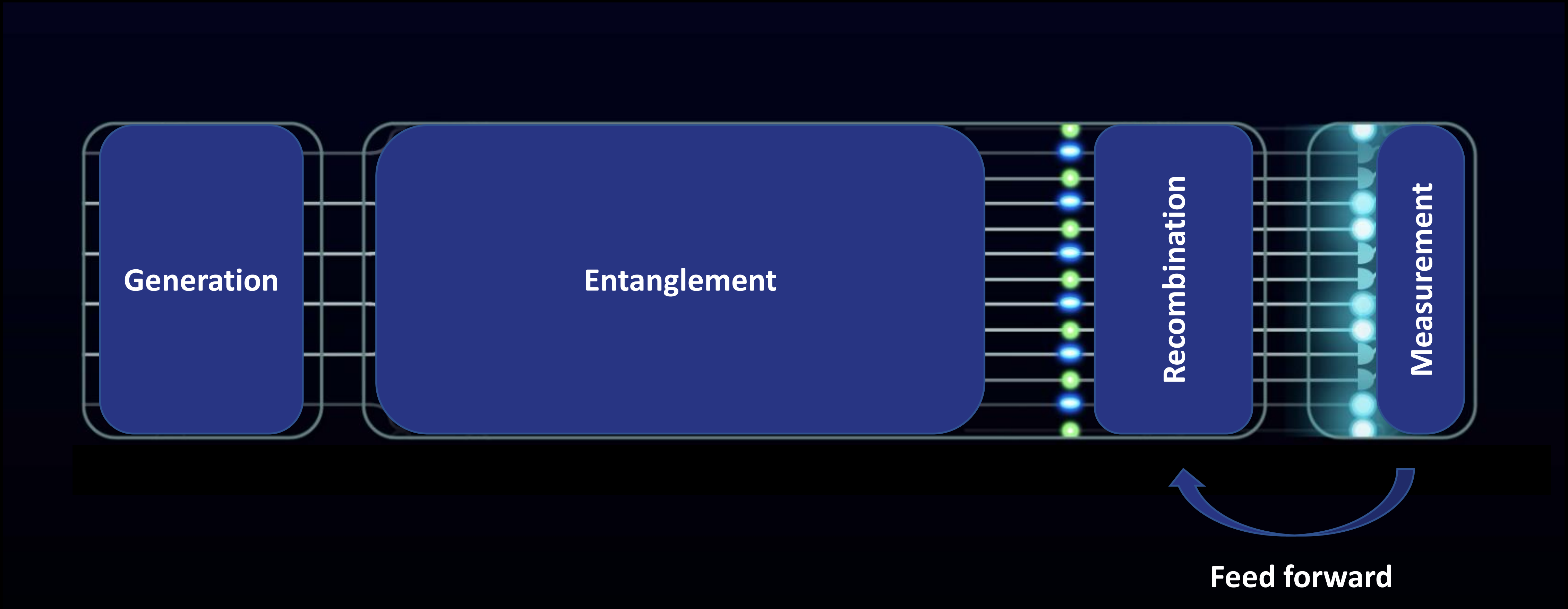
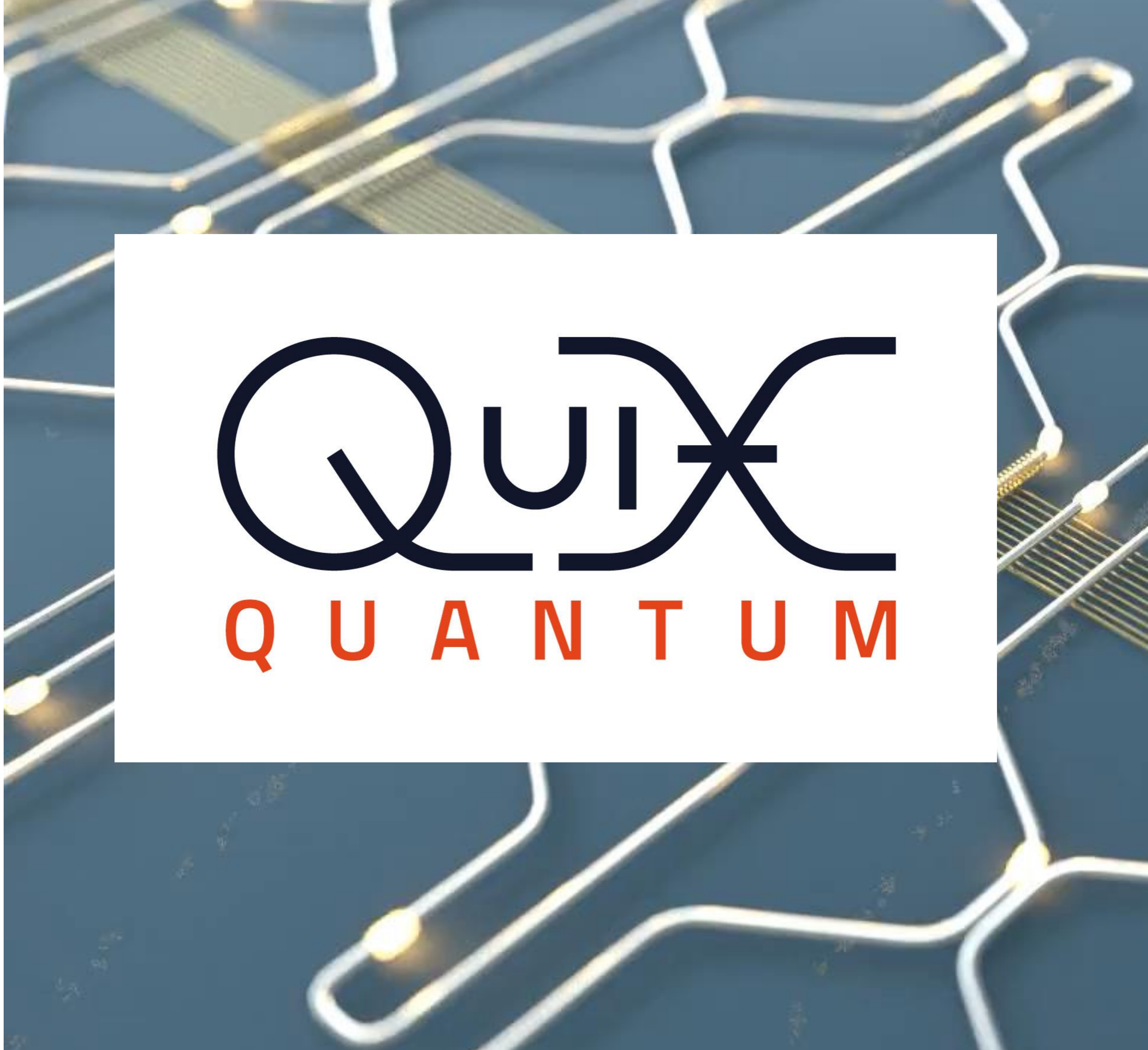
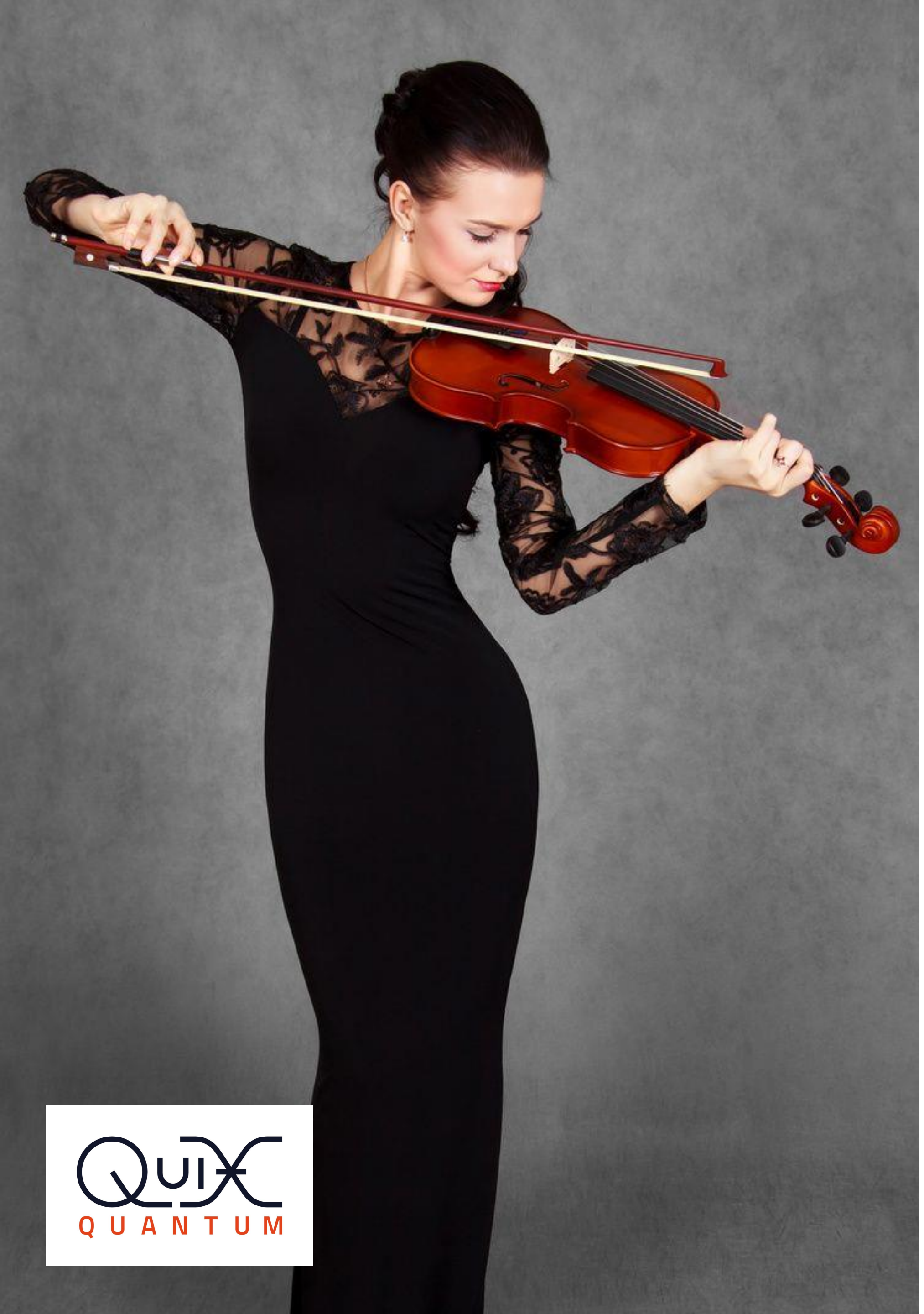
Our solution for universal quantum computing using light



Working at





What's it like to work at

QuiX
QUANTUM

Work at the cutting edge of quantum photonics

Committed to the development, growth, and well-being of our employees

Flexible and adaptive working conditions, excellent employee benefits

Excellent colleagues!

Our typical Mondays look like…

- **Meeting day!**
- Online meetings via Teams

And then our Fridays look like...

- Friday drinks!
- A pinball competition!
- Foosball game!