QUANDELA

Single-Photon based Quantum Computers available in the cloud

Metrics and Benchmarks

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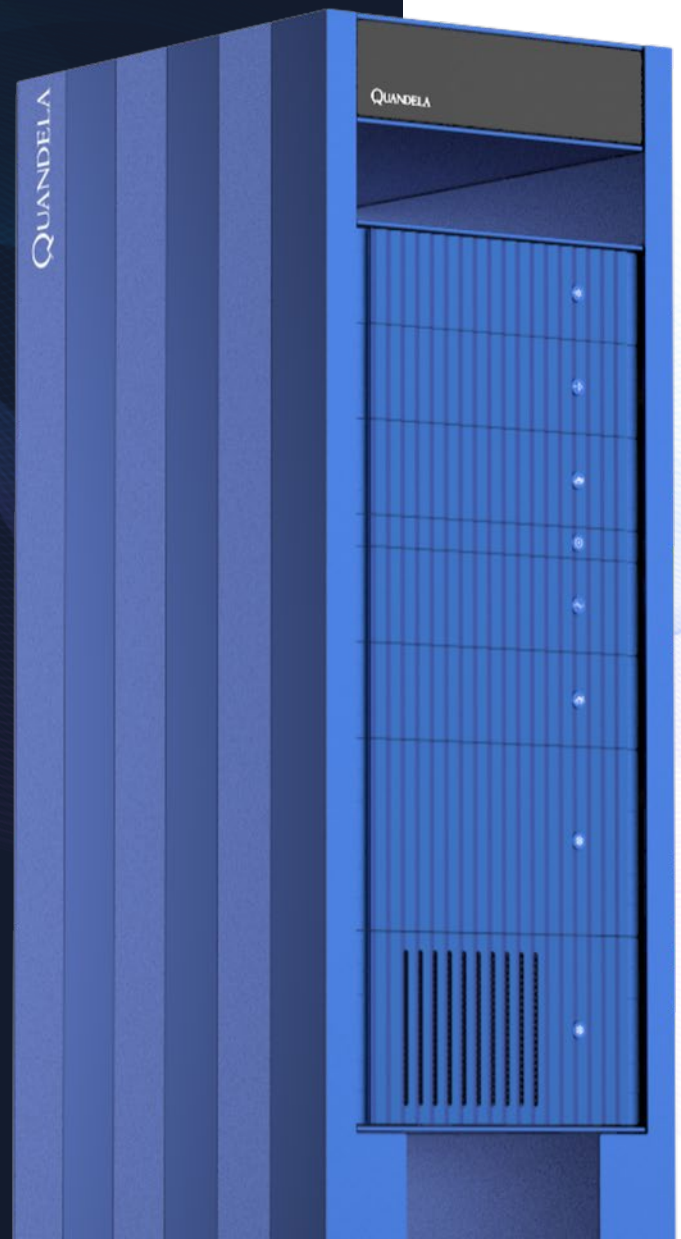
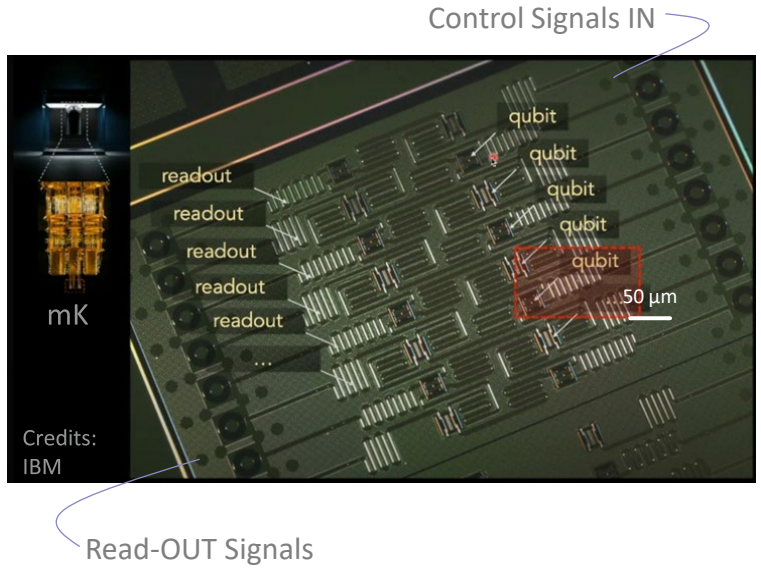


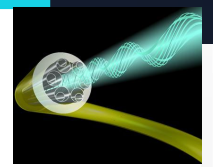
Digital Approaches to Quantum Computing

1 Matter Qubits: Ions, Superconductors, Cold Atoms, etc

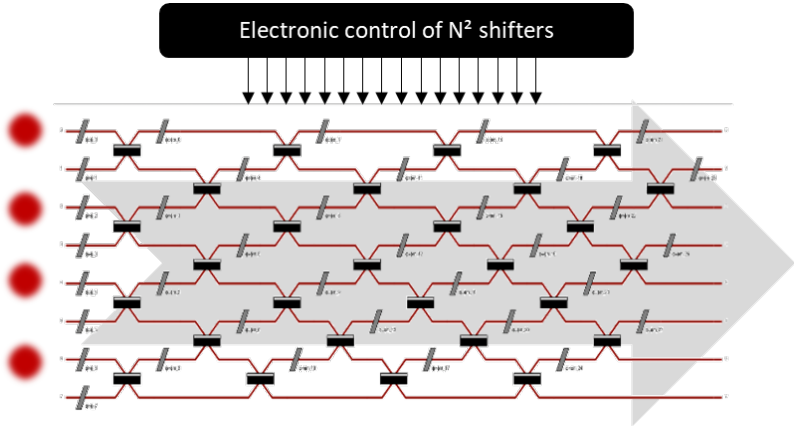
- Static qubits
- Objects located on a QPU



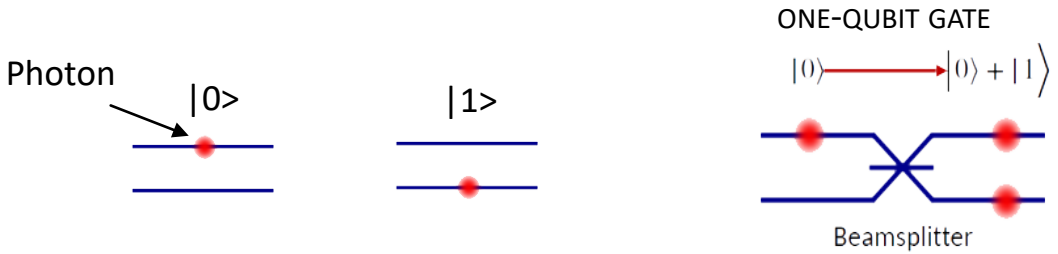
2 Photonic Qubits



- ‘Flying’ qubits
- Passing through a QPU
- Optical fibres, integrated linear optical circuits



1 qubit (dual-rail encoding):



Photons and Qubits

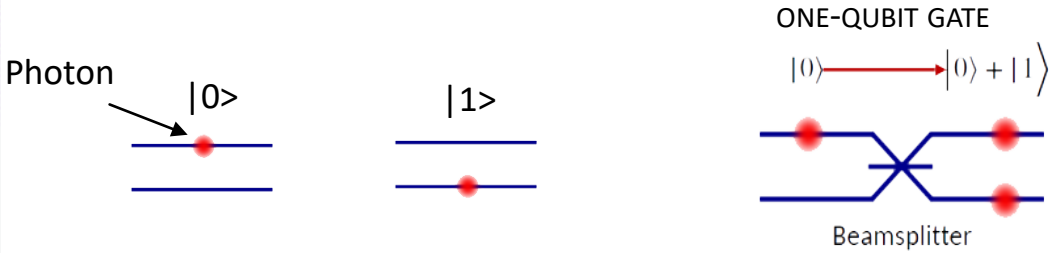
Encoded qubits

Photons

- More degrees of freedom than a qubit
- More computational states:
  - $\binom{n-1}{m-1}$ states of n photons in m modes
  - 2^n sates of n qubits
- Photonic quantum algorithms can exploit this
- Why demonstrations of quantum advantage to date are either photonic or have a strong photonic flavour
- This also means there are many ways to **encode qubits into photons!**

Photonic Qubits

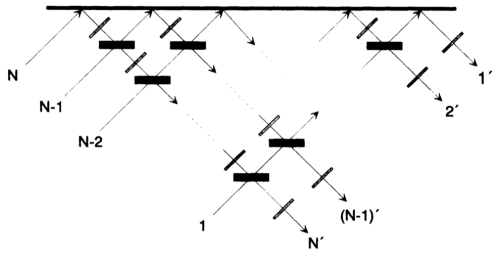
Ex 1: Dual-rail Encoding



Ex 2:

Reck–Zeilinger–Bernstein–Bertani (RZBB) Decomposition

- Any *qubit circuit* can be described by a *unitary matrix*
- Any *unitary matrix* can be constructed as a *linear optical circuit*



Universal Chip Design

Ascella – A General Purpose QPU

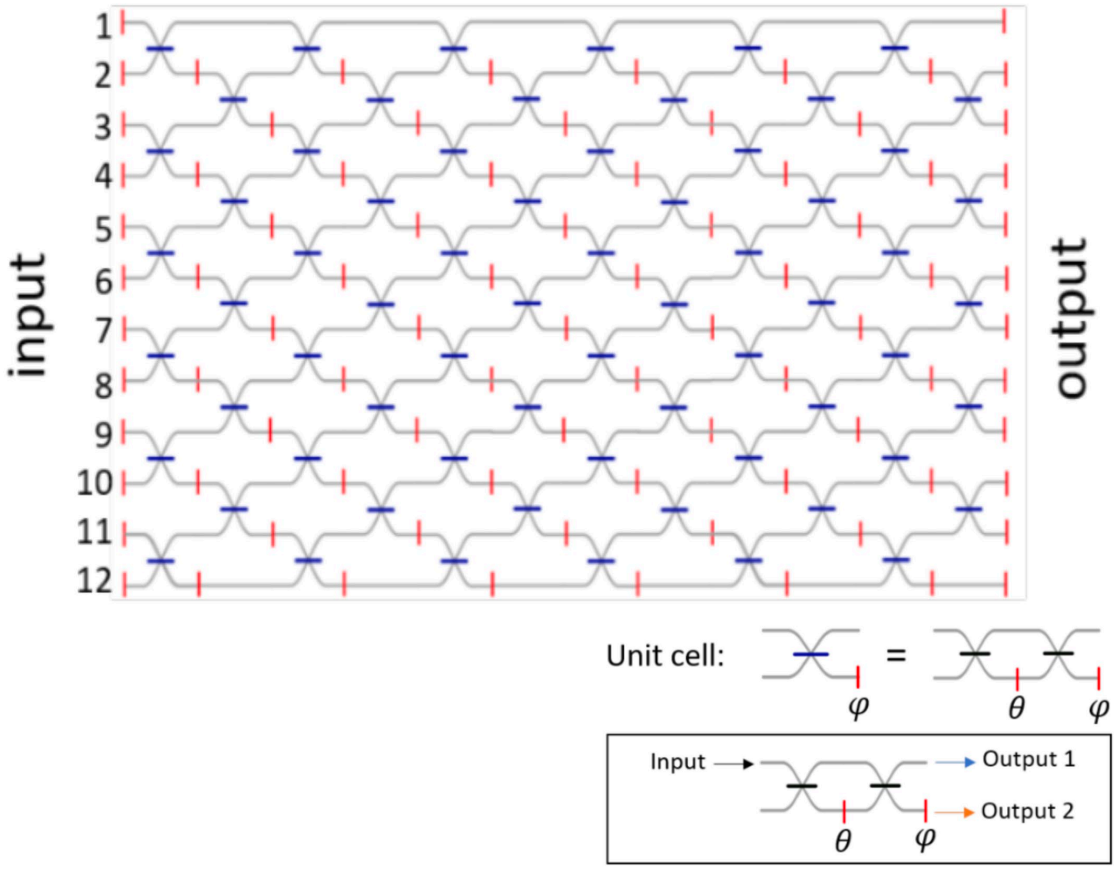
Running Computations

- Chip is designed to have a “universal” architecture
- Similar to the RZBB decomposition

- Can run **photon-native algorithms**
- Quandela’s Differential Equation Solver, or Boson Sampling

- Can also run general **qubit circuits**
- *Perceval* software will automatically translate qubit circuits or *Qiskit* code to run on our chip

12 modes – up to 6 photons – 126 parameters

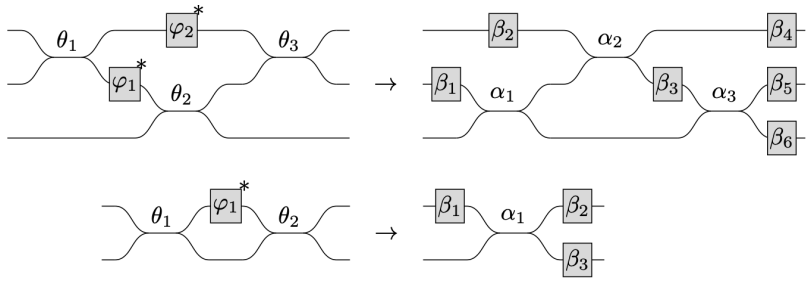


Specialized Chip Design

Altair - A Machine Learning QPU

Application Specific Integrated Circuits

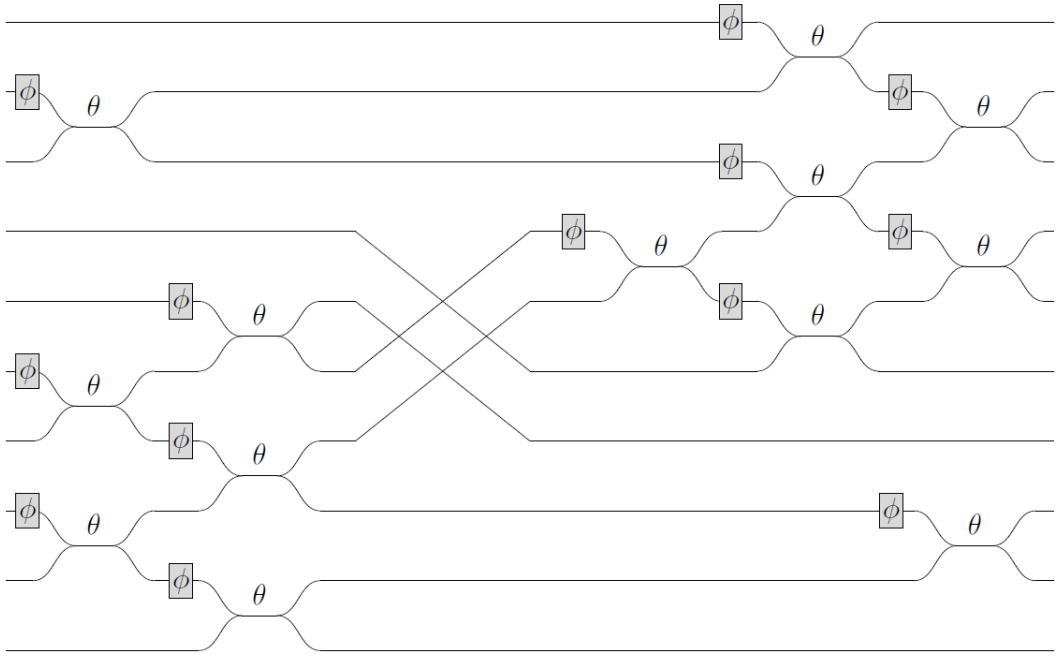
- Accelerated performance with QPUs that are **optimized to specific tasks**
- **Reduced parameters** compared to "universal" architecture
- Powerful design tools such as the **LOv-calculus**



Examples:

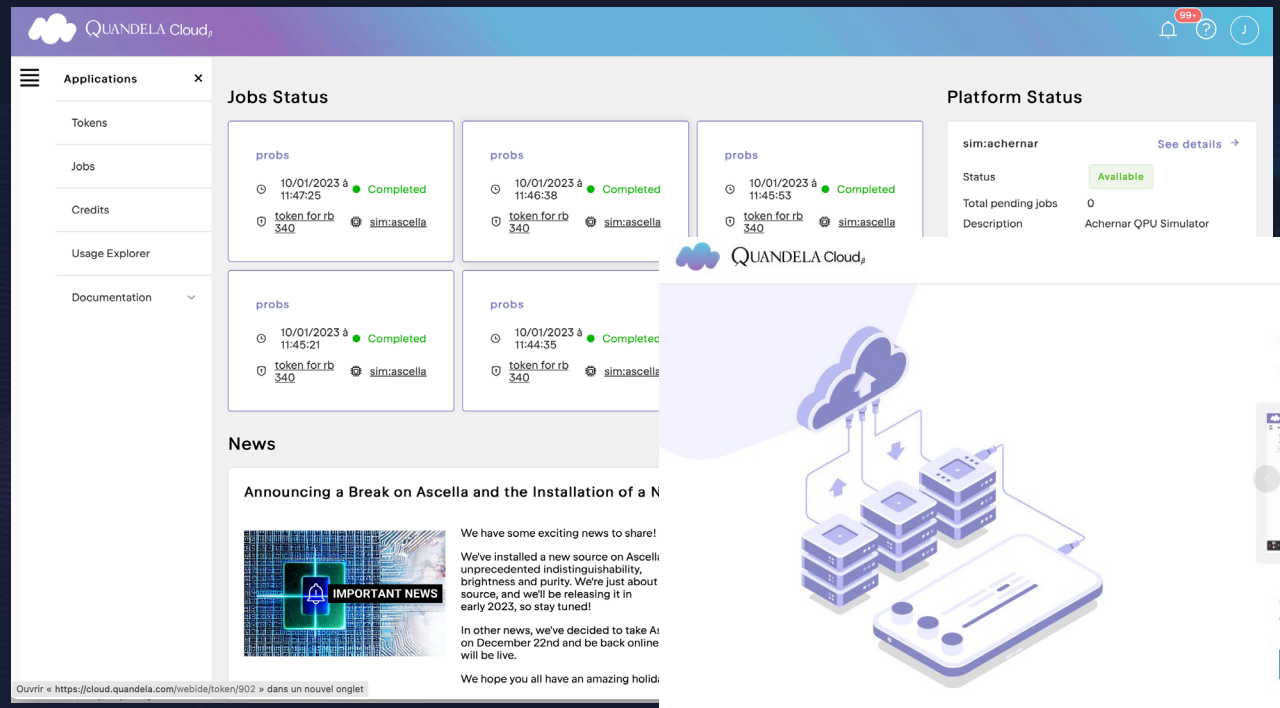
- *Altair* is optimized for ansatz circuit generation
- Quandela's *Entropy* device contains circuits optimized for certified random number generation

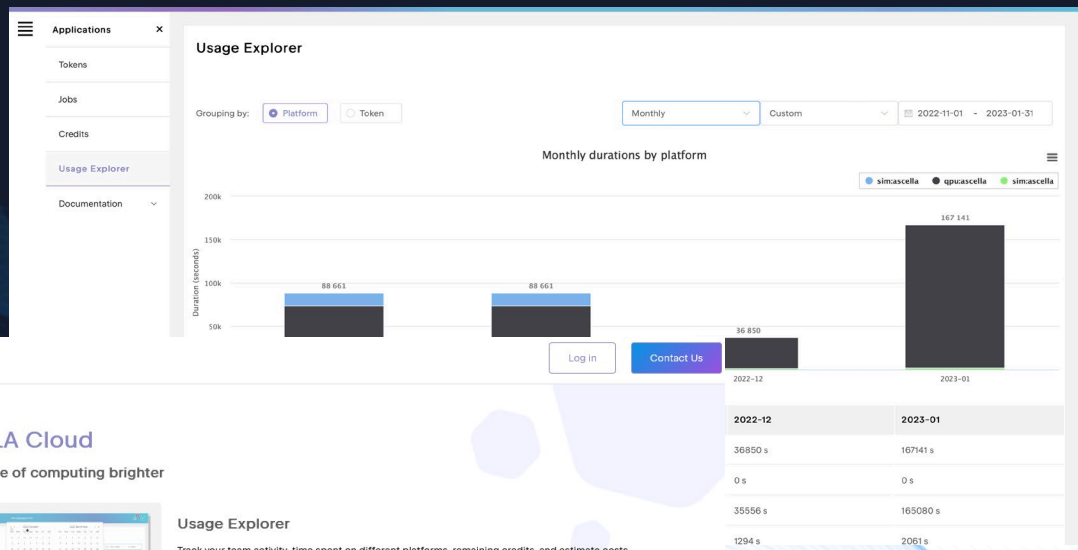
10 modes – 3 photons – 26 parameters

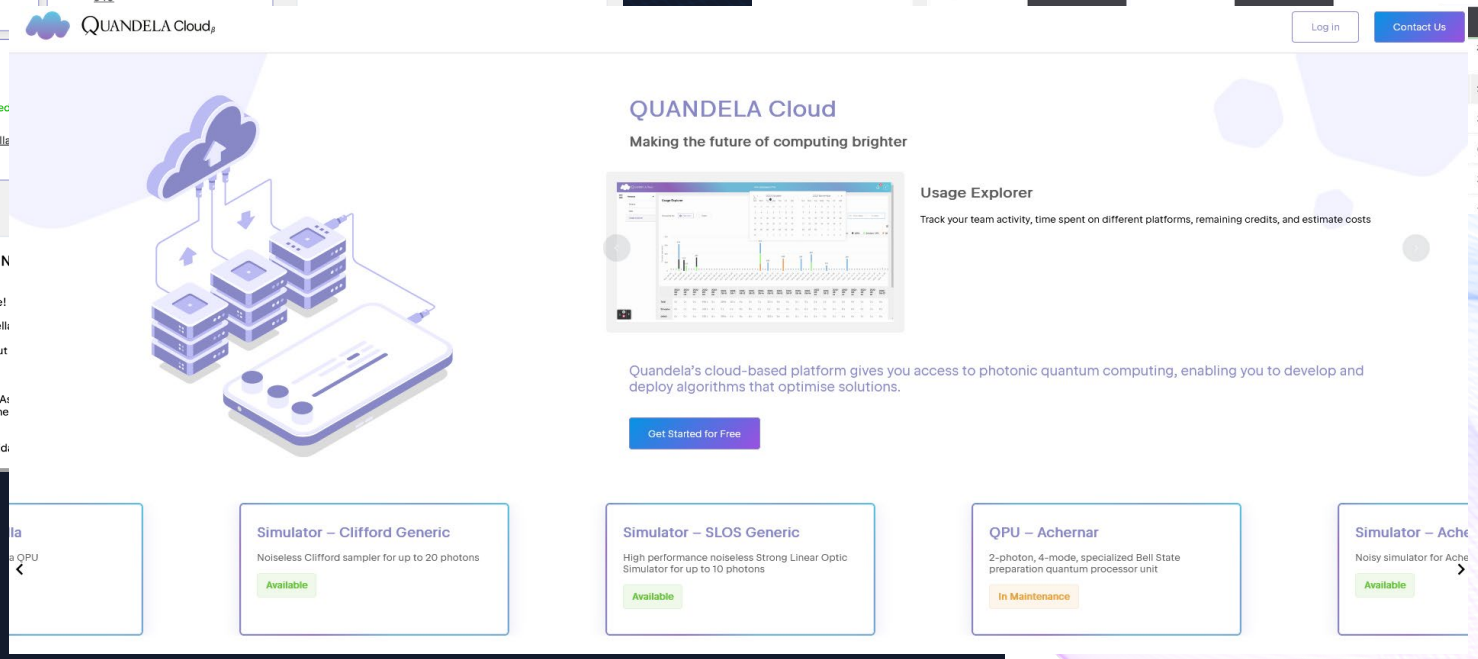


Quandela: the first European QPU provider in the cloud

Open to all

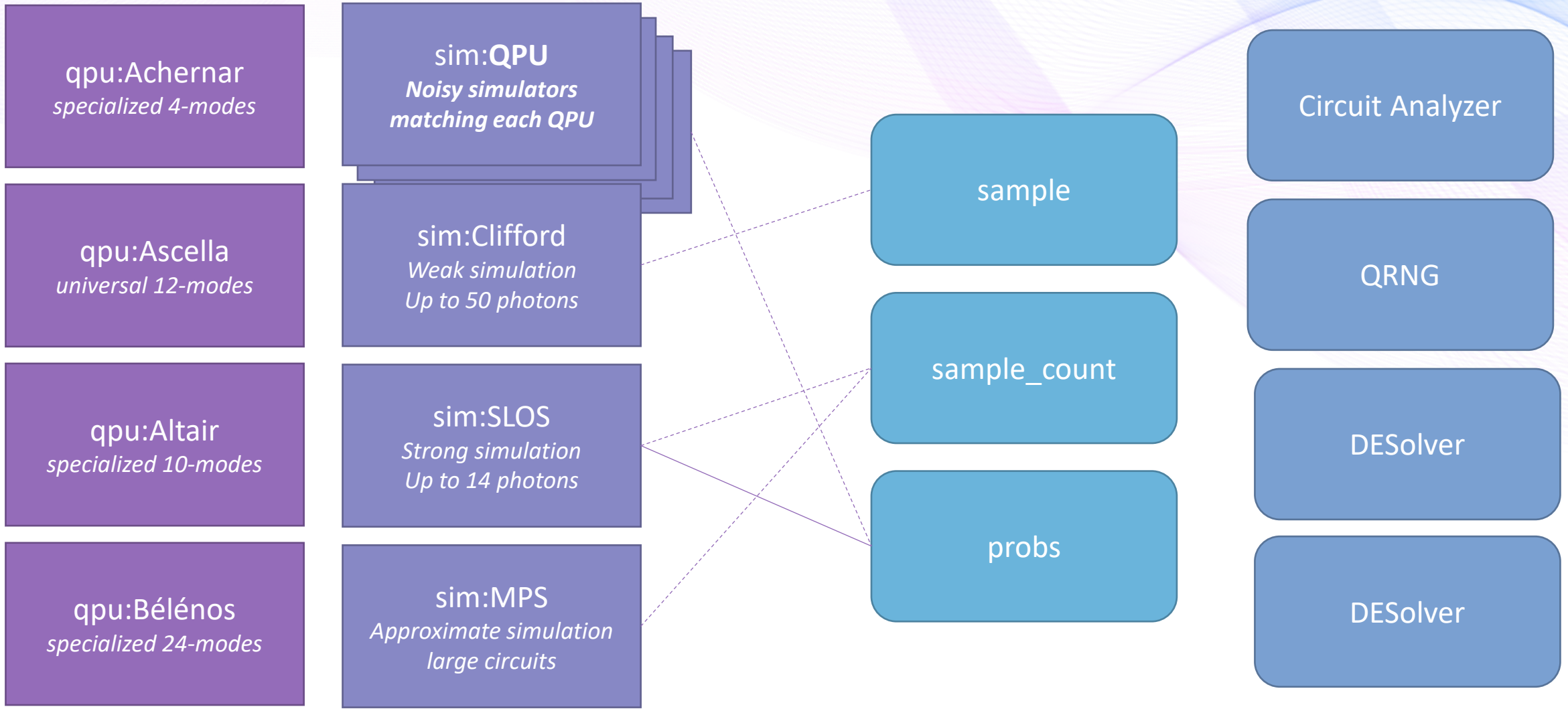






Test our QPUs available in the cloud
https://cloud.quandela.com

Available Processors and Primitives

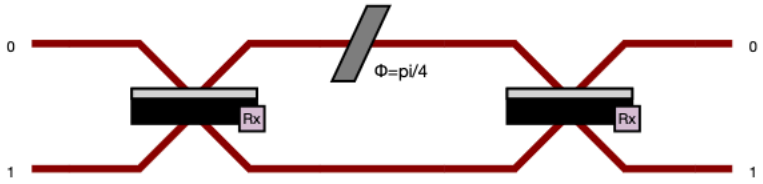


Running a quantum program on the cloud

A sample program on a photonic processor !

```
import perceval as pcvl
from perceval.algorithm import Sampler
```

```
input_state = pcvl.BasicState([1, 1])

c = pcvl.Circuit(2)
c.add(0, pcvl.BS())
c.add(0, pcvl.PS(phi = np.pi/4))
c.add(0, pcvl.BS())

pcvl.pdisplay(c)
```




```
# Use your key here to let the system know who you are
token_qcloud = 'MY_SECRET_KEY'
remote_qpu = pcvl.RemoteProcessor("qpu:ascella", token_qcloud)
```

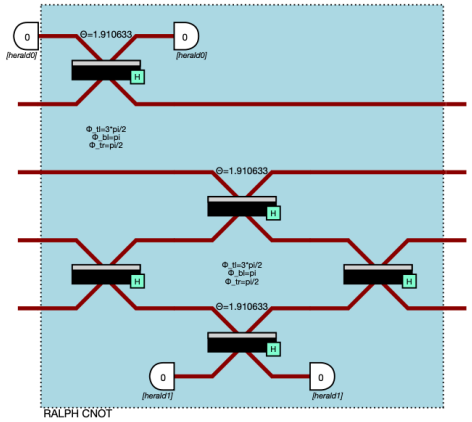
```
remote_qpu = pcvl.RemoteProcessor("qpu:ascella", token_qcloud)
remote_qpu.set_circuit(c)
remote_qpu.with_input(input_state)
remote_qpu.mode_post_selection(1)

sampler_on_qpu = Sampler(remote_qpu)

nsample = 10000
job = sampler_on_qpu.sample_count(nsample)
```

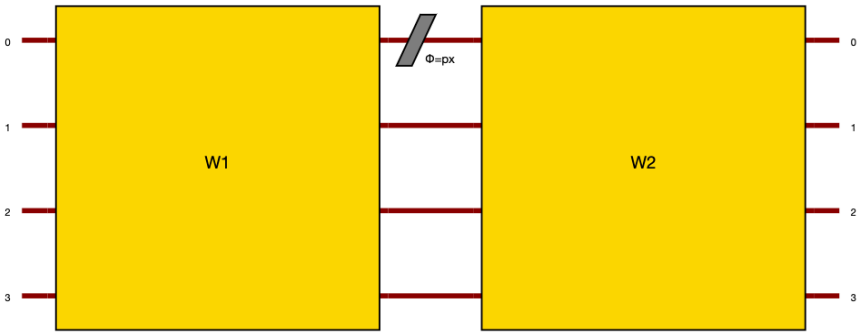
```
results = job.get_results()
print(results['results'])
```

```
{
  |0,1>: 13979
  |1,0>: 9627
  |1,1>: 51
}
```

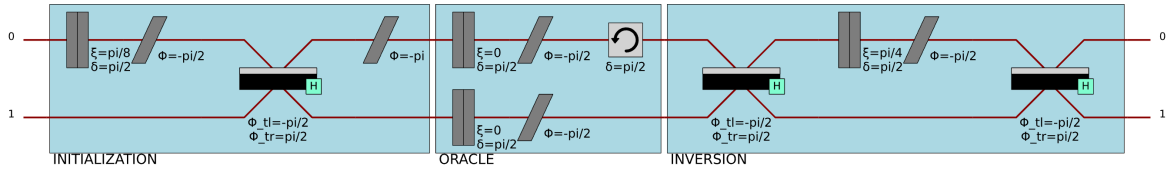
Example Circuits

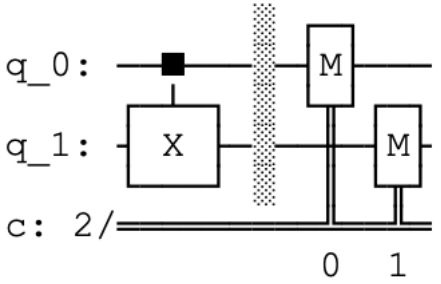
Native Photonic Circuit

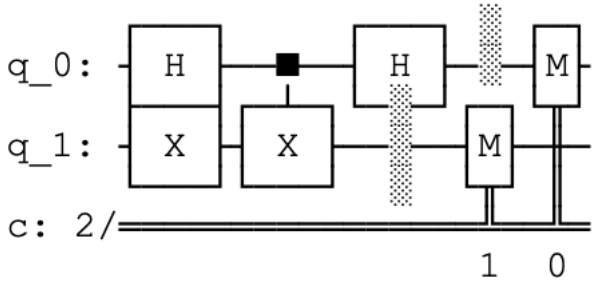




Other Supported circuit

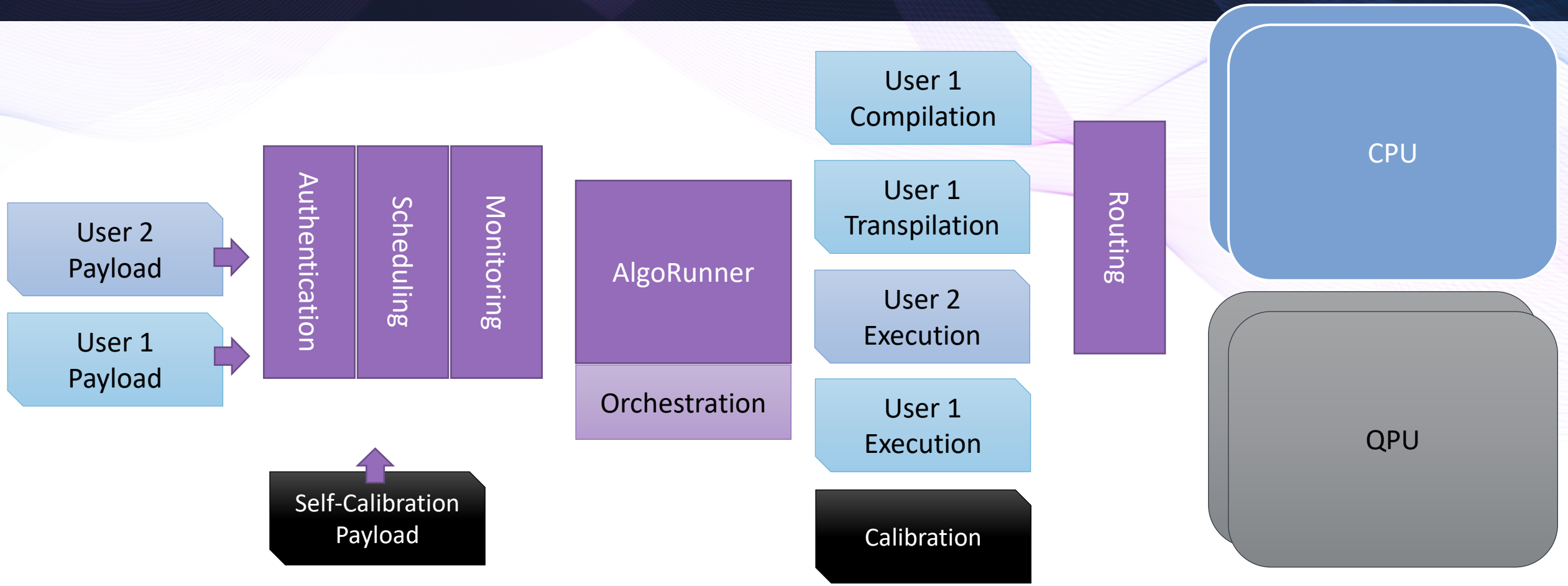






Behind the scene

Step-by-Step request processing



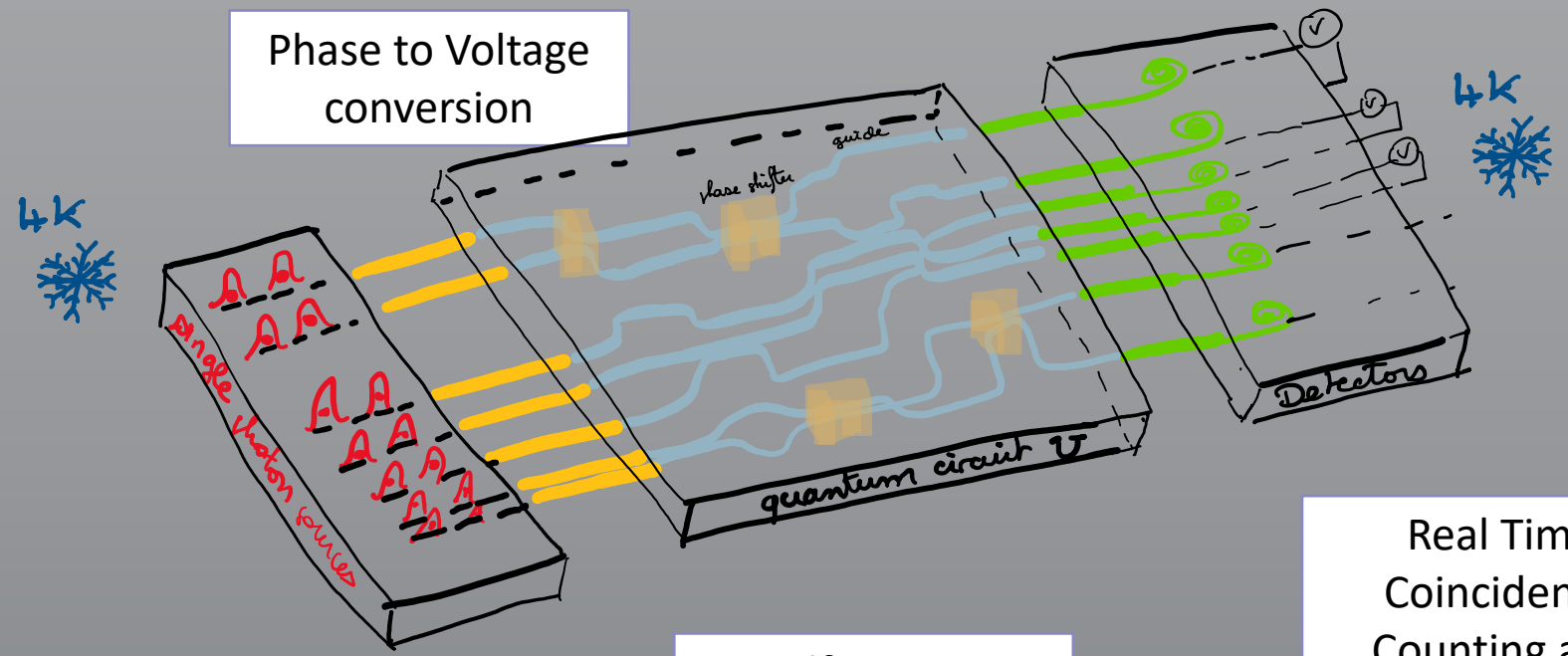
Full complementarity between classical and quantum algorithms

Behind the scene

Step-by-Step request processing

QPU

Phase to Voltage conversion



User 2 Execution

Circuit Input State

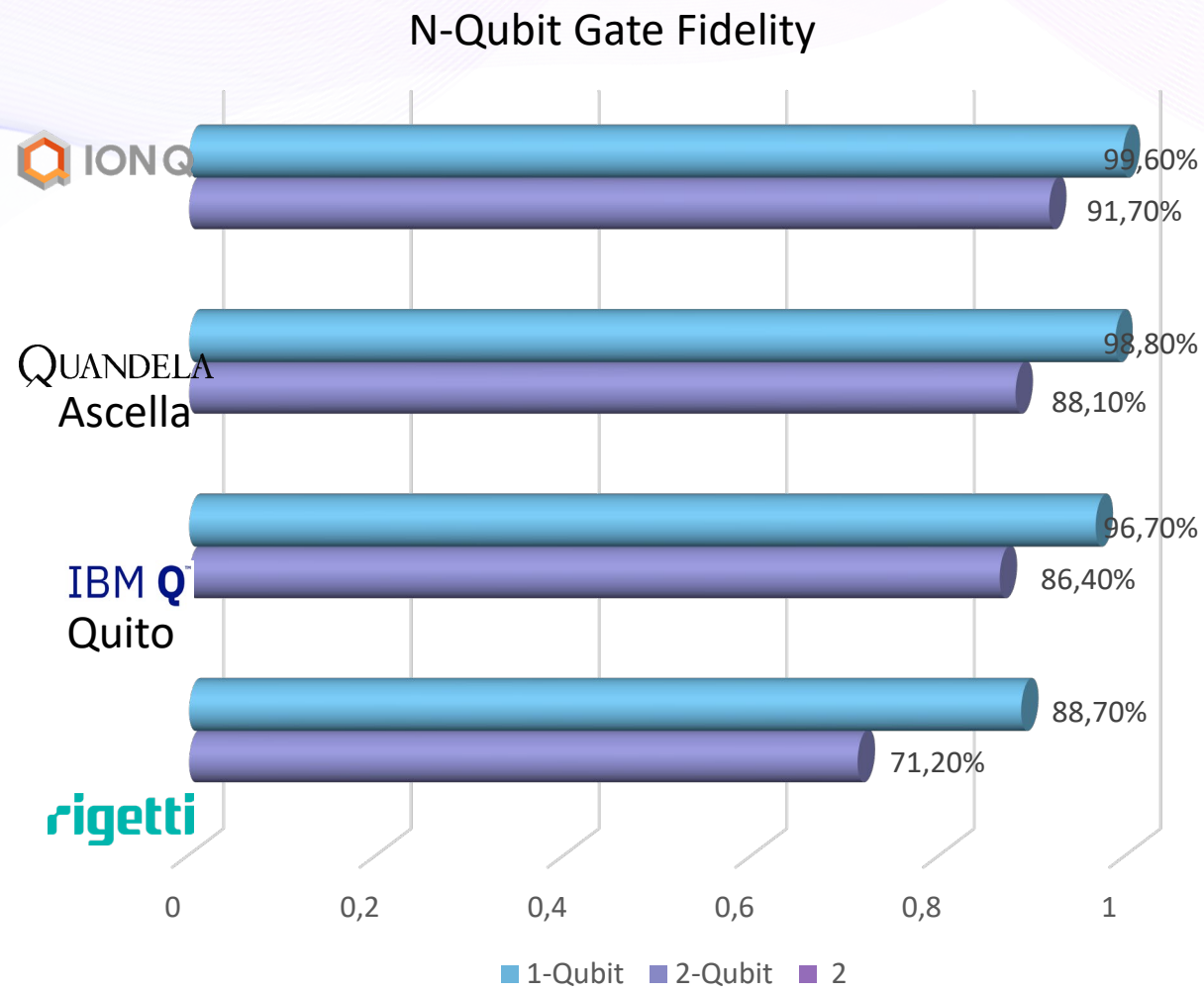
Photon Routing Control

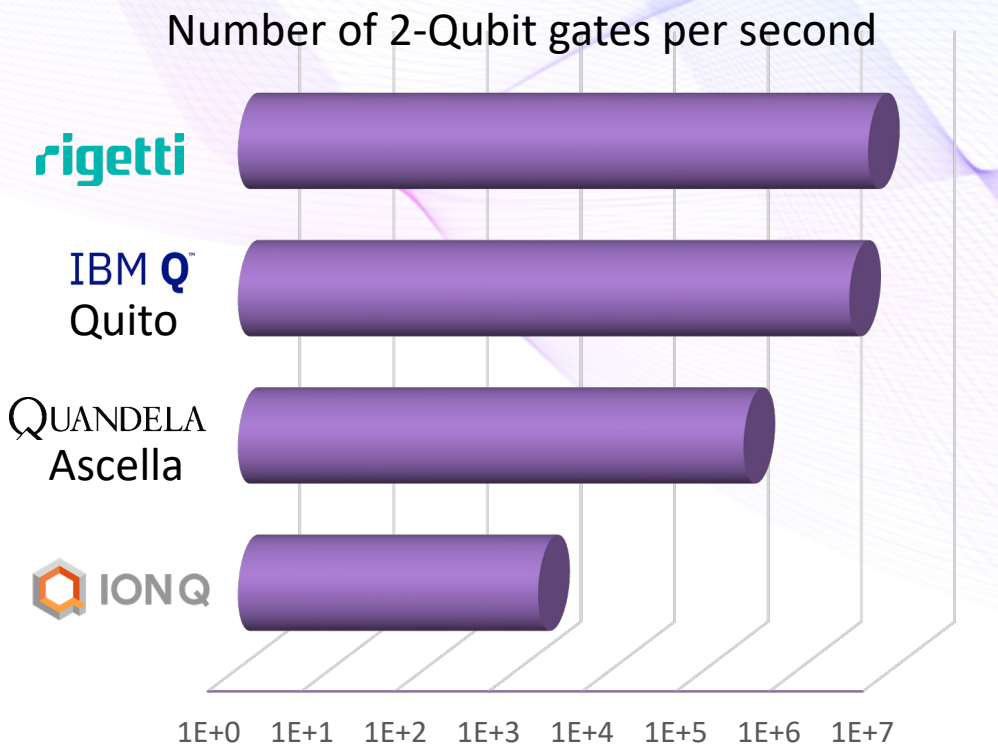
Self-System Monitoring

Real Time Coincidence Counting and Aggregation

Full complementarity between classical and quantum algorithms

Benchmarking with other online platforms





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Merci !

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