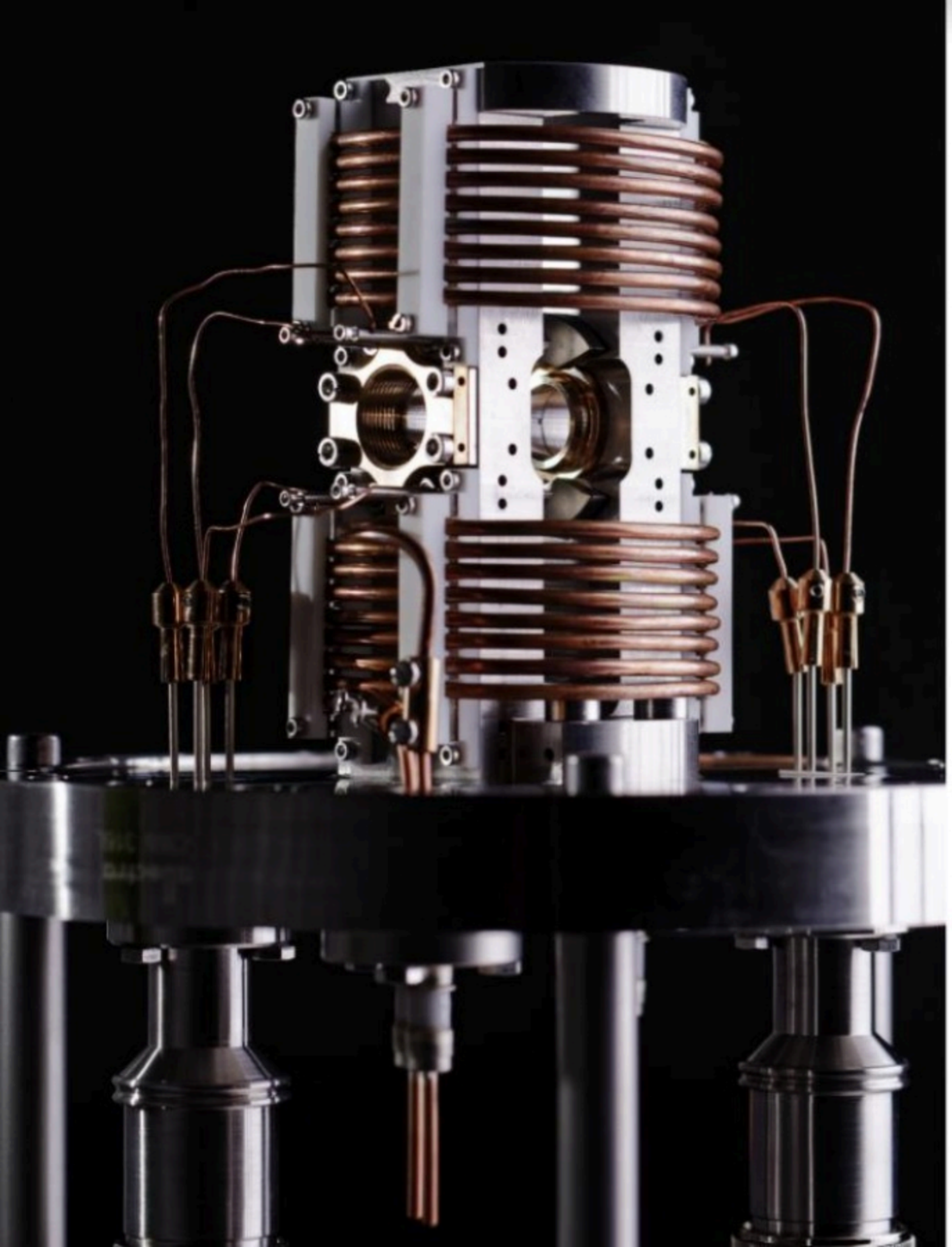


PASQAL

Quantum Advantage with Atoms Arrays

Investor day - Quantonation

Georges-Olivier Reymond –CEO-

May,2021

The Need for a Quantum Revolution

HPC technology is reaching its limits

Moore's law is slowing down and energy requirements for HPC centers are not sustainable.

Massive computational challenges ahead

QCs can be used to optimize complex networks, devise new materials, accelerate drug discovery…

Quantum computing is of strategic importance

It will contribute to driving future innovation and economic growth.

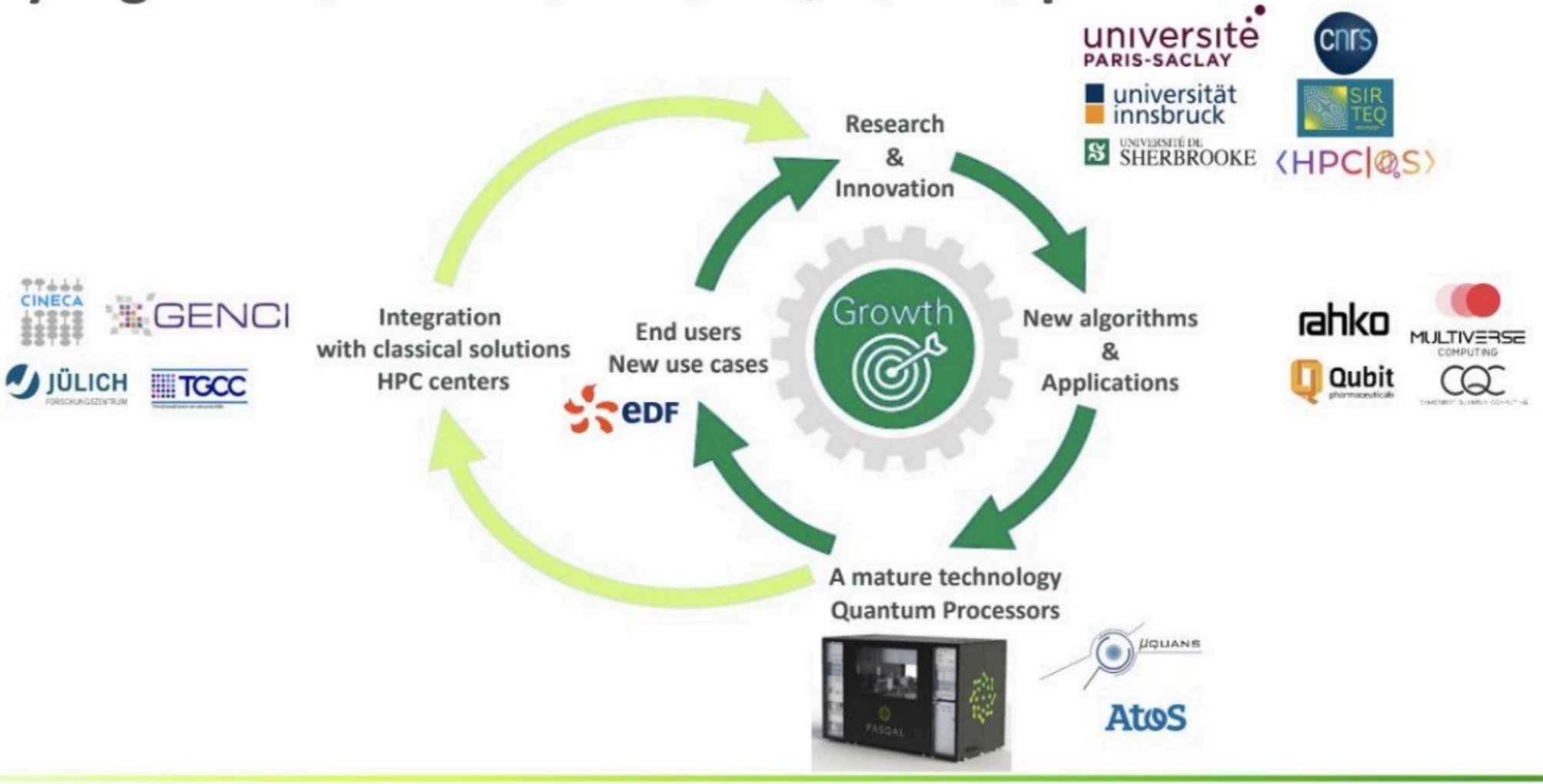
GREATEST CHALLENGE: To deliver the promise of QC, we need to SCALE UP the technology

Our mission: Reaching Quantum Advantage Faster

- **Our Legacy:**
  A word leading hub of Quantum science & Technology in Paris-Saclay
- **Our Solution:**
  Multi-purpose, flexible, 100 – 1000 qubit Quantum Processing Units (QPUs), built with neutral atoms
- **Our Strength:**
  QPUs with unrivalled performance(qubit number, connectivity, quantum volume) and full software stack, ready to be exploited on-premise or on the Cloud.

PASQAL is a leading European Quantum company, offering large qubit count, high performance and a maturity level allowing for practical use by both academics & corporates as of today

Key ingredients to unlock the Quantum potential



EMERGING TECHNOLOGY: To unlock the Quantum potential, we need to build a strong ecosystem

PASQAL's Offer : Bringing Quantum Advantage to End-Users

- **A roadmap allowing short-term access to the technology**
  - 100 qubits available end-2021 for PoCs
  - Cloud access end of Q1 2022
  - 1,000 qubit systems on the cloud end-2023
- **Two access modes:**
  - Directly, with QPUs installed in HPC Centers / at Clients' premises
  - Online, through a cloud infrastructure accessible to end-users and to partners
- **Partnerships for co-development of applicative use-cases**
  - Proofs of Concepts and joint studies
  - Involving PASQAL's engineers and partners (Qu&Co, Multiverse, Qubit Pharmaceuticals, Rahko…)

Co-Design Partnership Model

- **Initial exploration of topics of interest**
  - Objective: framing the case, inputs / ouputs
- **Algorithm development & emulation**
  - Development of quantum algorithm
  - Test and validation on PASQAL's emulator
- **Hardware implementation**
  - Implementation on a QPU
  - Analysis of results & iterations
- **Typical schedule :** 6 months / phase

We work with world-class HPC centers

GENCI – Le calcul intensif au service de la connaissance
JÜLICH FORSCHUNGSZENTRUM
CINECA

We will provide QCaaS to end users

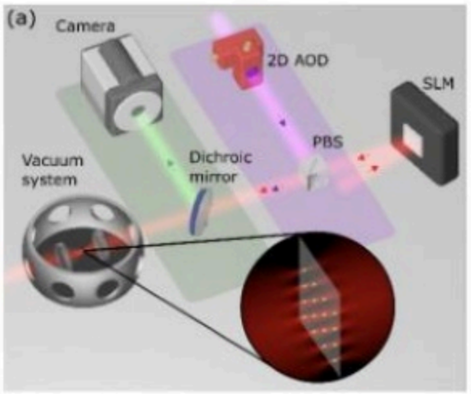
Qu & Co
MULTIVERSE COMPUTING
Qubit pharmaceuticals
EDF
rahko

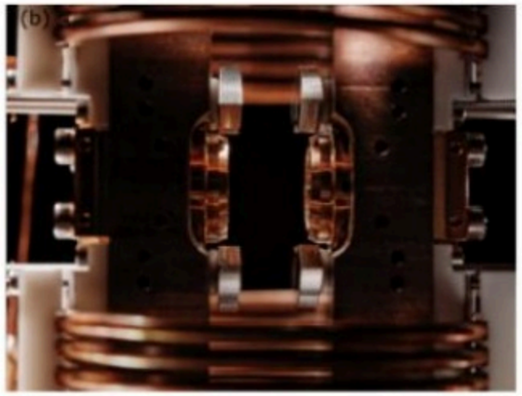
Bringing Quantum Advantage to End-Users

Our Technology

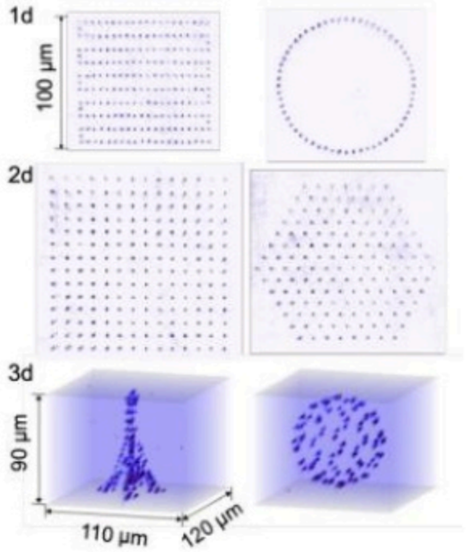
PASQAL's processor is designed to offer scalability for a wide range of algorithms

- **A unique scalability potential:**
  Trapped Rb atoms in an array of optical tweezers[1]

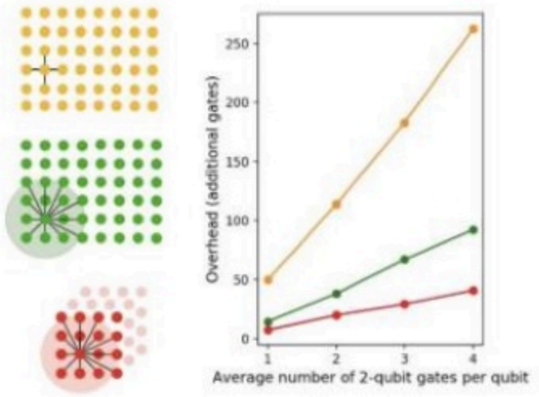




Quantum advantage demonstrated: P. Scholl *et al.* Programmable quantum simulation of 2D antiferromagnets with hundreds of Rydberg atoms, arXiv:2012.12268 (2020)



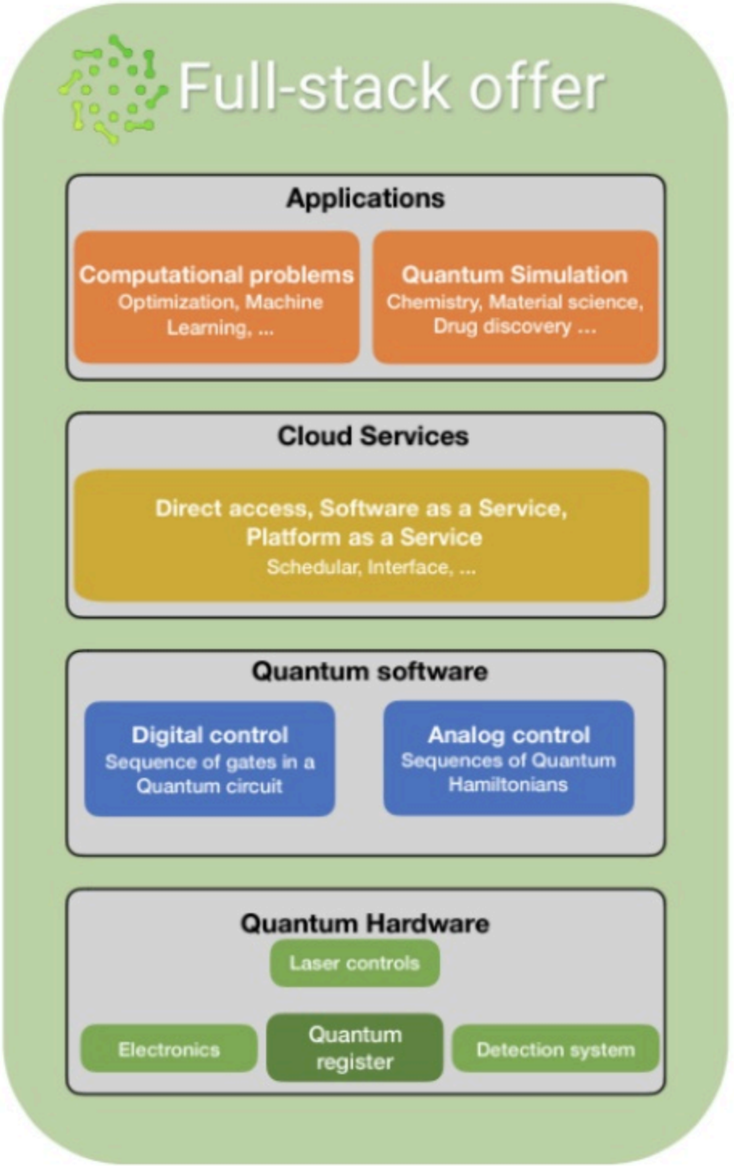
- **High flexibility of the platform:** different geometries in 1D, 2D or 3D



- **High connectivity**

[1]Quantum computing with neutral atoms, Quantum 4, 327 (2020)

PASQAL's Full-Stack Software Offer



- **Training and tutorials** are available to help users get started.
- Our Software & Applications team is **available to work jointly with you on quantum algorithm development**
- Checkout Pulser libraries, tutorials and article @

  https://github.com/pasqal-io/Pulser

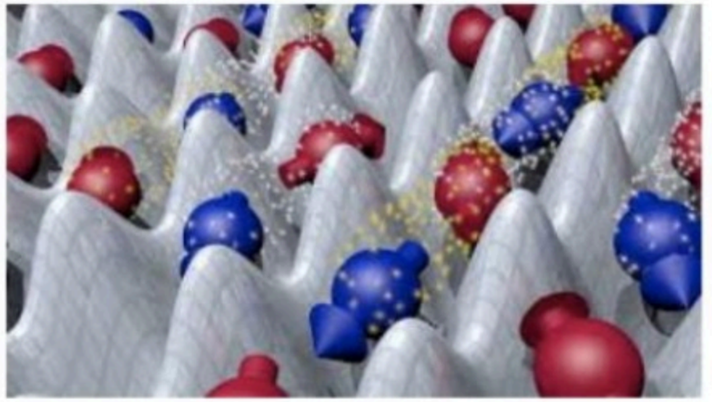
  https://pulser.readthedocs.io/

  https://arxiv.org/abs/2104.15044

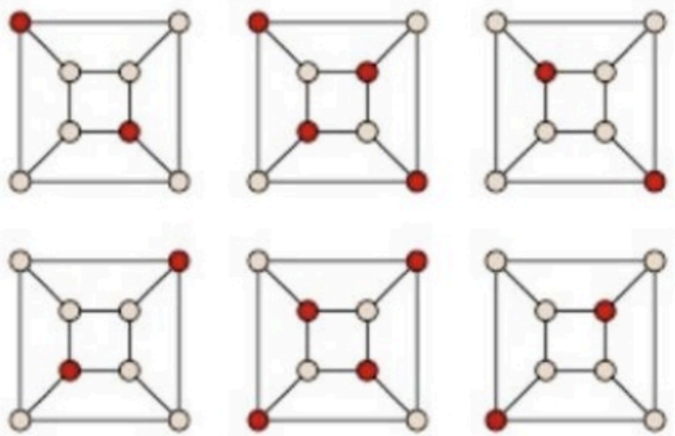
Applications

Applications

- Quantum Simulation[1] : artificially recreating in the experiment models of interest for scientific discovery
  - Many-body quantum physics
  - Material Science
  - Chemistry



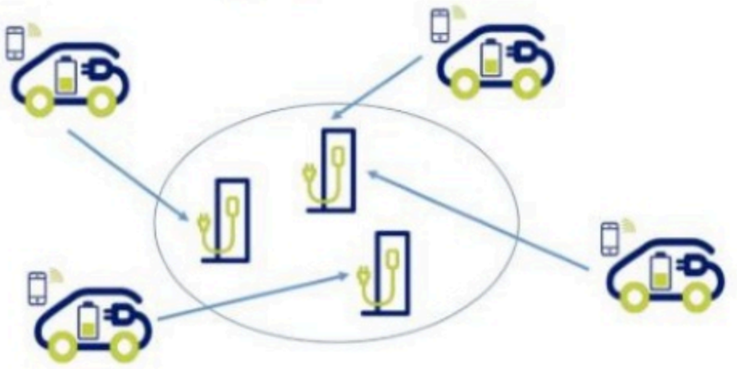
- Hard computational problems
  - Approximate optimization
  - Quantum-enhanced machine learning



[1] P. Scholl *et al.* arXiv:2012.12268 (2020)
S. Ebadi *et al.* arXiv:2012.12281 (2020)

An example of a use case: smart charging of EVs

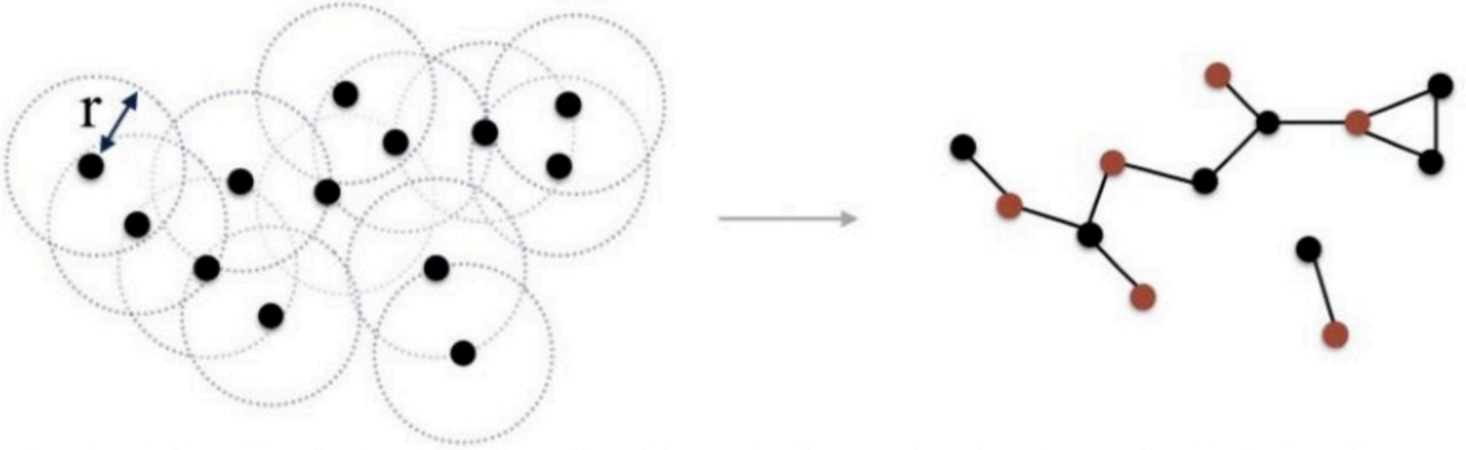
Ex: Smart-Charging of Electric Vehicles



Scheduling / decision problem:

many loads with incompatibilities.

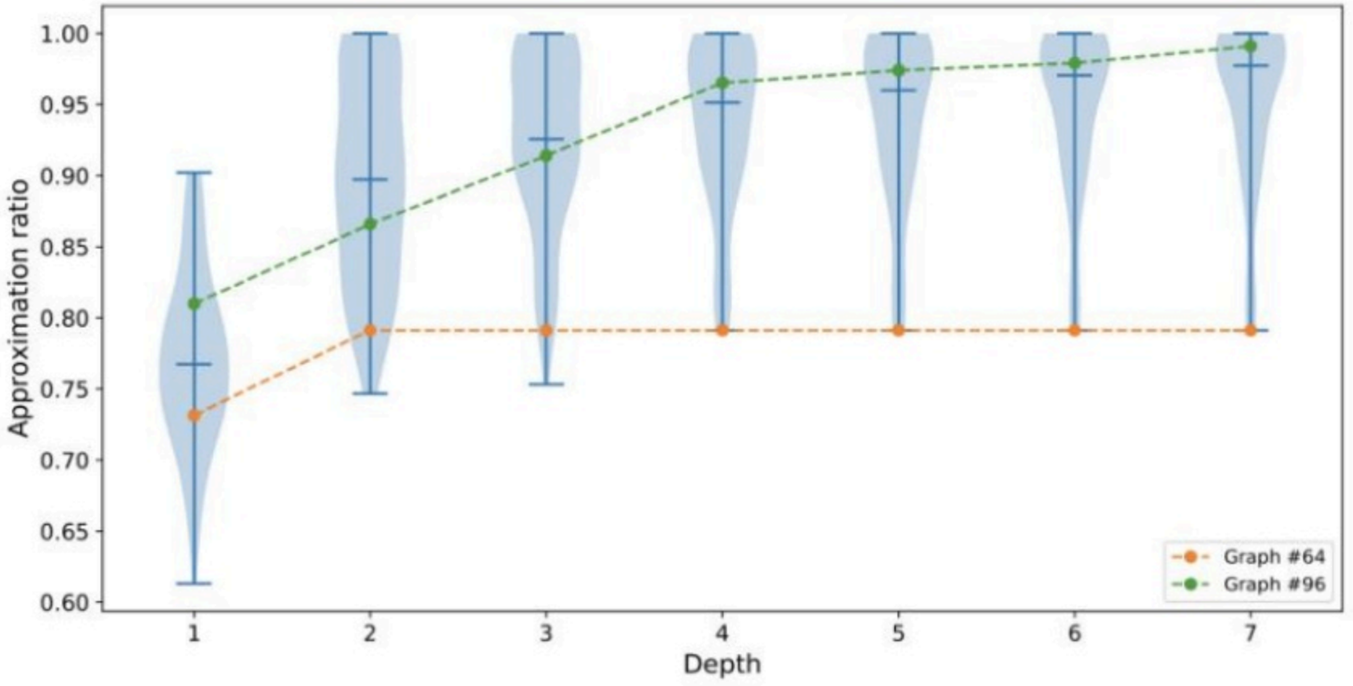
Under some conditions, the problem can be mapped onto a MIS problem. *This is an example of application for which a quantum advantage is reached with 1,000 qubits*[1].

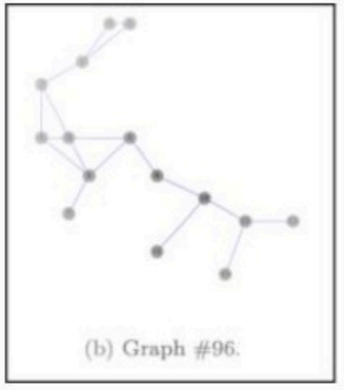


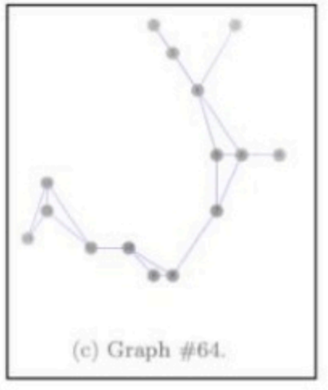
Practically, the positions of the atoms reproduce the 2D graph under consideration

[1] M. F. Serret *et al.* Phys. Rev. A **102**, 052617 – 23 November 2020

Solving MIS problem with a Quantum Approximate Optimization Algorithm (QAOA)




(b) Graph #96.


(c) Graph #64.

- **Promising early results:**
  A quick convergence towards large approximation ratios. The emulation was performed for 84 instances (real data provided by EDF) and 15 qubits.
- We observe some graphs resistant to the optimization process: to be investigated further.

C. Dalyac *et al., arXiv:2012.14859*

Conclusion & Outlook

- PASQAL has a **mature technology** available with unequalled number of qubits, and which will scale up quickly over the next years.
- Several collaborations have been established with partners to start working on use cases, as they will benefit from an early access to PASQAL's in-house 100 qubit prototype.
- The Cloud service will be available next year.
- On-premise QPUs will be available by early 2023 at two European HPC facilities: TGCC (France) and Jülich (Germany).