



HQI: HPC & QC integrated platform

A HYBRID HPC-QC APPROACH

Coupling supercomputers with QPUs

- Quantum computing is **an accelerator** pour for targeted **HPC/AI** applications and algorithms that will be **offloaded to the QPU**
- A **workload evaluation** that must be adapted on existing middleware environments
- A **well-known access procedure**



A **central platform** to build programming environments, develop and provide access to scalable and interconnected quantum computers as well as applications.









GENCI's Joliot-Curie supercomputer
operated at TGCC/CEA

A **production hybrid HPC-QC platform**
and

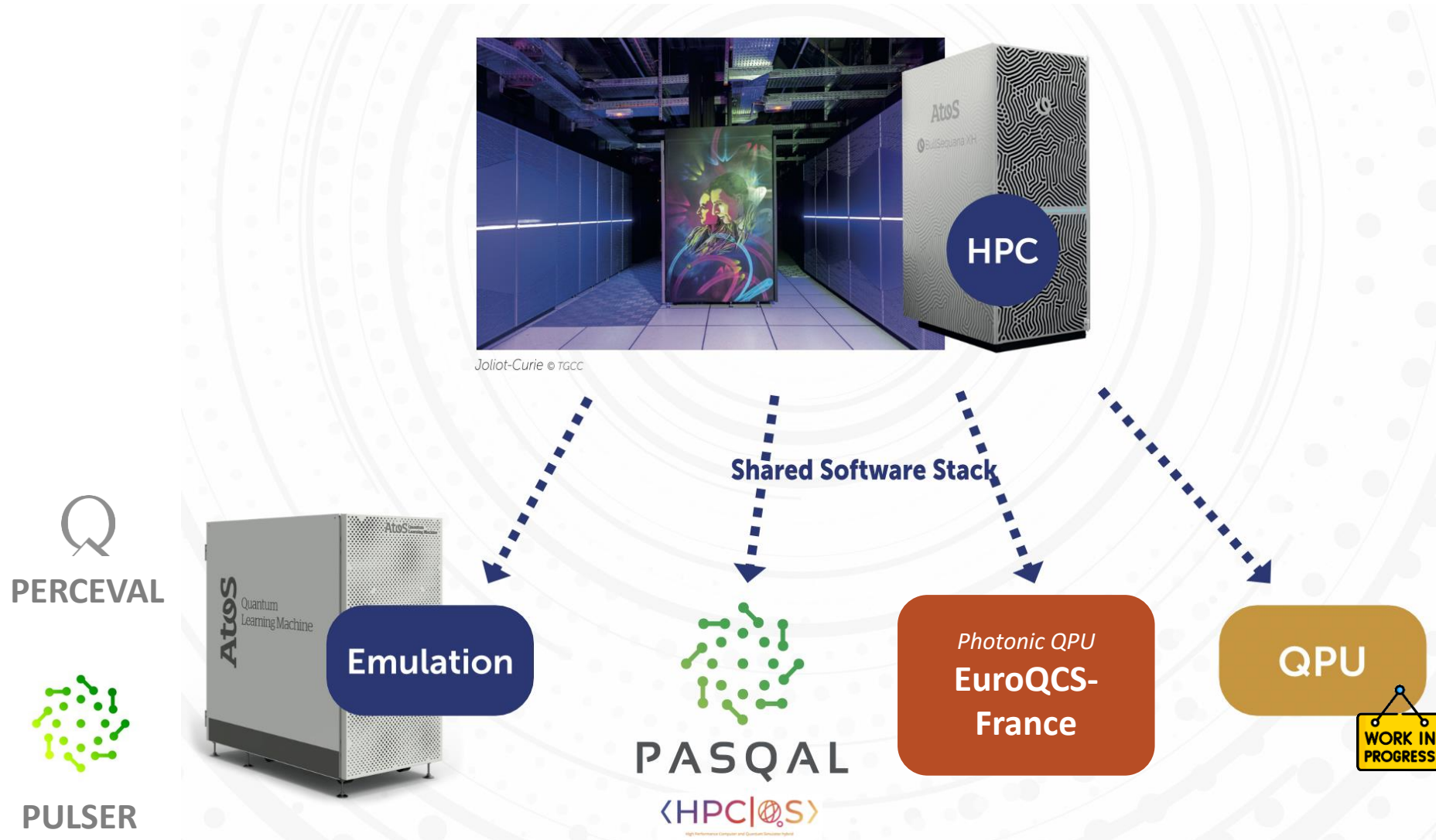
An **academic and industrial research programme**

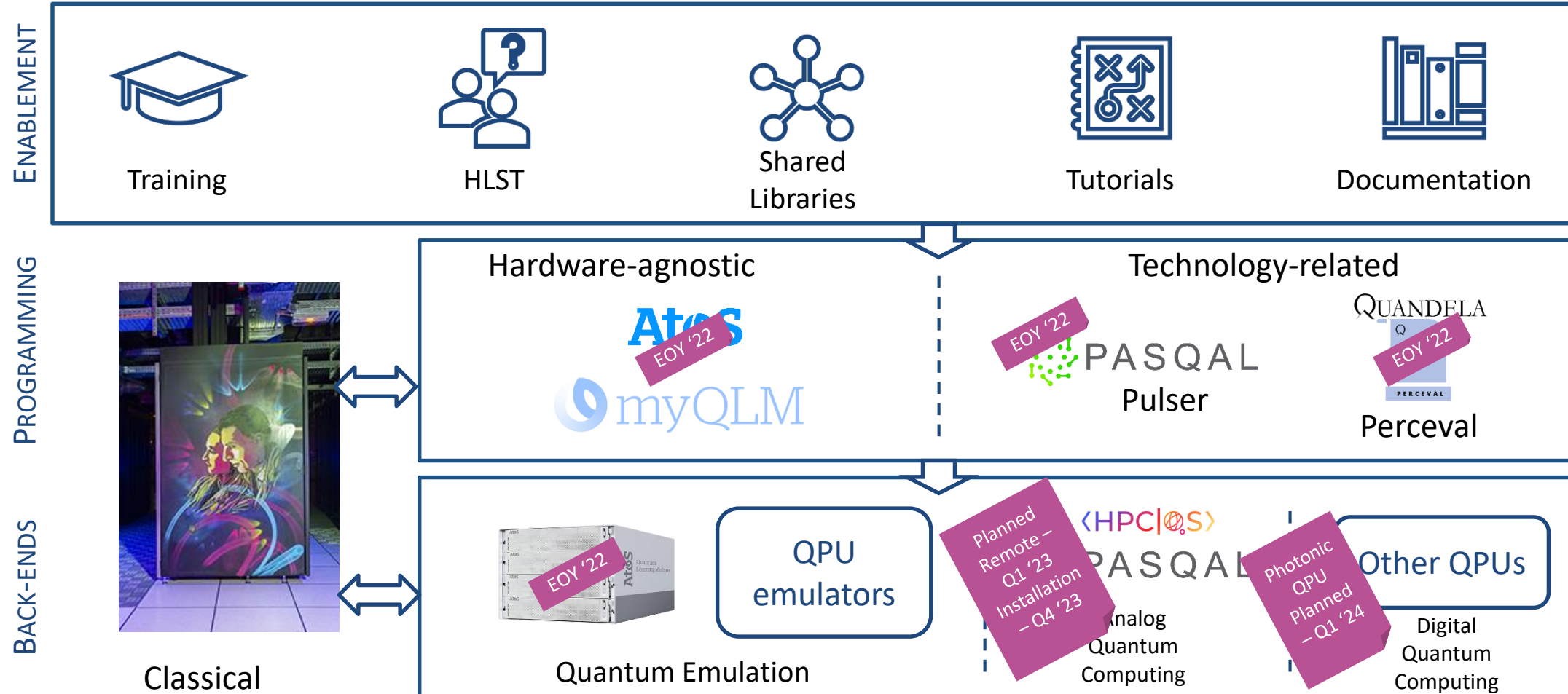


Procurement and deployment of QC platforms	 GENCI (36.3 M€) <small>Le calcul intensif au service de la connaissance</small>	
Academic research	 (36,0 M€)	  
Industrial research		 
Dissemination and end-user community support		

HQI: PROCUREMENT AND DEPLOYMENT OF QC PLATFORMS

A scalable and open platform





Main stack is based on Atos/QLM software

- To work on **quantum algorithms** (HQI integration)
 - myQLM runs on supercomputer
 - Offload quantum runtime to QLM appliance to QPUs or to QPUs directly
 - Jupyter notebooks or command line interface
 - QPU emulators run on supercomputer
- To work on **hybrid computing** in applications (HQI R&D)
 - Integration of quantum runtime in HPC environment
 - Use of API or compiler directive

Direct access to vendor stack is available

- Allow low level interaction with QPUs
- For advance R&D purpose

Three levels of integration

Weak coupling

- A step within a processing workflow or an simulation/data analysis run
- Uses the computing centre network
- Requires ability to share the QPU between runs (QPUs do not use time sharing)
- Only solution if the QPU is very expensive

Medium coupling

- A step within a processing workflow or an simulation/data analysis run
- A new supercomputer local resource
- Uses the supercomputer network
- Allow allocation of a group of QPUs to classic processing

Strong coupling

- Like GPU-type accelerators, can by used in each compute loop
- Uses either compute node buses or the supercomputer network
- Requires high density, low cost QPUs
- Need to put CPU in cryostat?

QC are separate systems

HQI initial setup

QC are racks in a supercomputer

HQI target

QC are cards on mother boards

HQI dream

Quantum Computers are simple to integrate but bring new constraints

- (+) Few electrical power (hundreds of kW)
- (+) Few cooling (cryostat are embedded)
- (-) Qubit quantum state need to be protected
 - Required few dust
 - Required few vibrations
 - Required few electromagnetic radiations
 - Required clean/stable electrical power

Classical Computer

- Room air cooling systems generate a lot of dust
- Cooling systems generate a lot of vibrations (pumps, fans)
- Computer power supply supports noisy current
- Large computers with CPU/GPU generate electrical variation (visible on led lighting)

CEA/TGCC strategy is to setup a dedicated computer room in existing facility

- Close to main computer room
- Compatible with short term usage (weak connection)

Pilot design and implementation



- Design and realized a converged hybrid Classic/Quantum computer
 - Based on Atos QLM and Atos XH3000 SuperComputer
 - Emulators
 - LSQ Distributed Heterogeneous Programming
- Improve the software-programming environment (tools for developers)

Applications



- Algorithms for Optimization, Machine Learning, Cryptanalysis
- Quantum simulation of nuclear many-body systems, Quantum computing applied to theoretical and quantum chemistry, Quantum many-body dynamics and entanglement, Quantum simulations of strongly correlated materials, Partial Differential Equation

Exploration



- Noise characterization and mitigation
- Quantum links for computing

HQI: DISSEMINATION AND END-USER COMMUNITY SUPPORT

Helping communities get their hands on the platform



Choice of a sovereign Cloud Services Provider to provide access to the platform



Community platforms - websites, wiki, Slack forum



Organization of dissemination **events**



Development of **International relationships**

Hands-on training for end-users



Setting up an HQI platform end-user **high-level support team**



Development of **use cases** through national and international extensions of the Quantum Pack initiative



Creation of a network of excellence centers: **Houses of Quantum**





HQI France



@HQI_France

Thank you

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