Towards a hybrid quantum operating system

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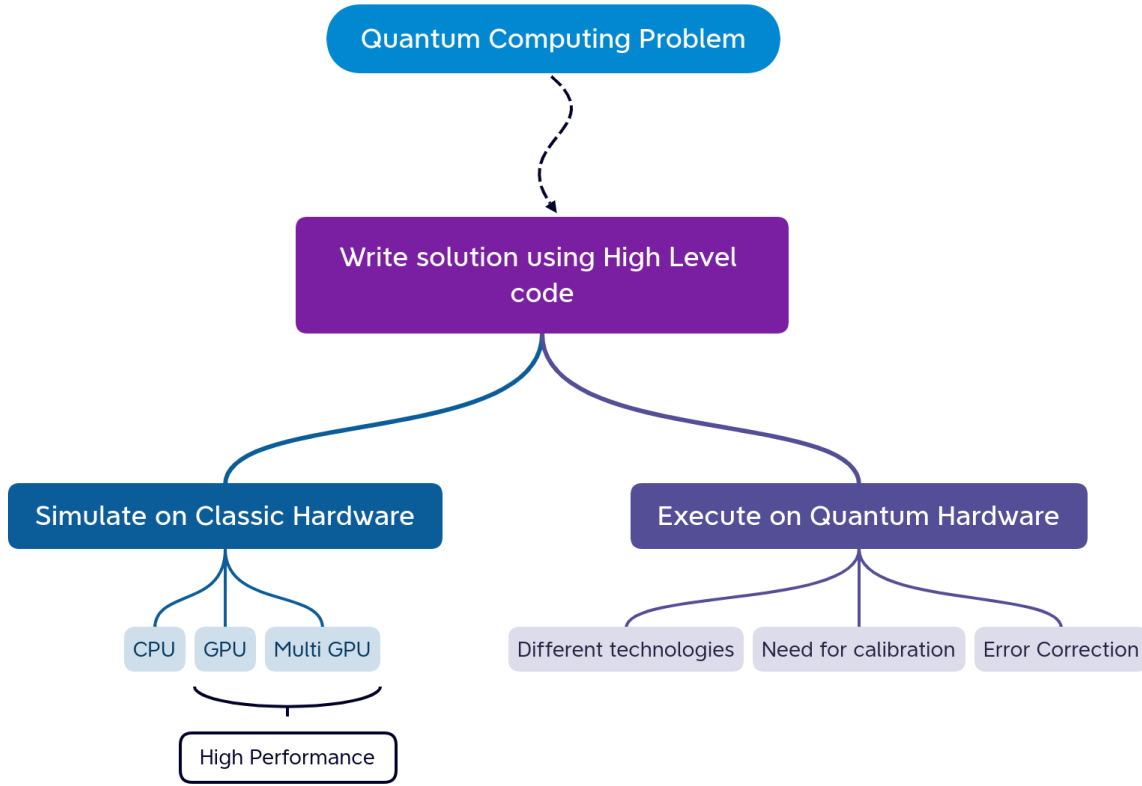
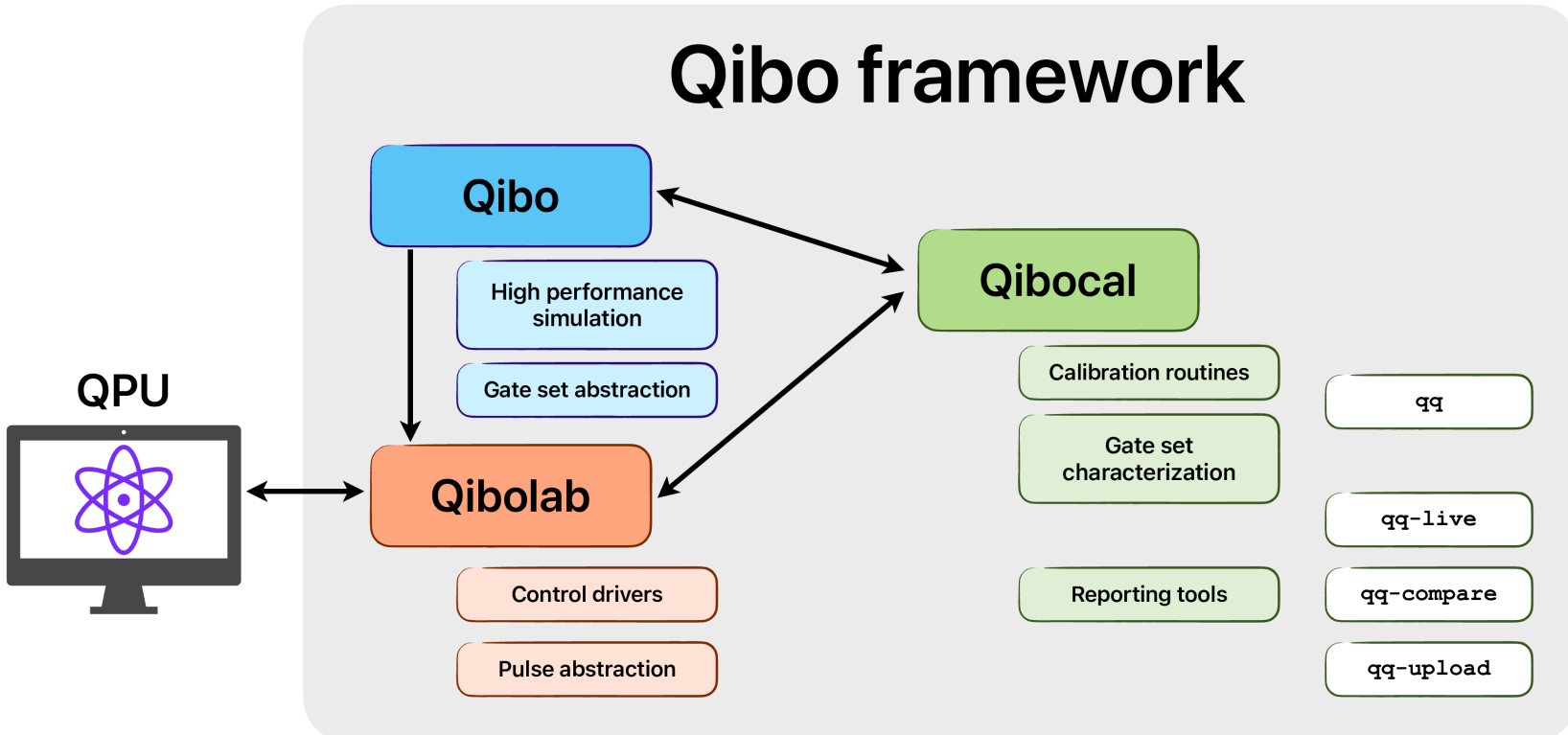
What is the challenge?



Is it possible to create from scratch a framework for all of this?

Introducing Qibo

Open-source full stack API for quantum simulation, hardware control and calibration


Qibo framework
Qibo
High performance simulation
Gate set abstraction
Qibocal
Calibration routines
Gate set characterization
Reporting tools
qq
qq-live
qq-compare
qq-upload
QPU
Qibolab
Control drivers
Pulse abstraction

High performance simulation

Gate set abstraction

```python
import numpy as np
from qibo.models import Circuit
from qibo import gates, set_backend

# Set driver engine
set_backend("numpy")

c = Circuit(2)
c.add(gates.X(0))

# Add a measurement register on both qubits
c.add(gates.M(0, 1))

# Execute the circuit with the default initial state |00>.
result = c(nshots=100)
```

```python
# Change backend
set_backend("qibojit")

# Circuit execution with new driver
result = c(nshots=100)
```

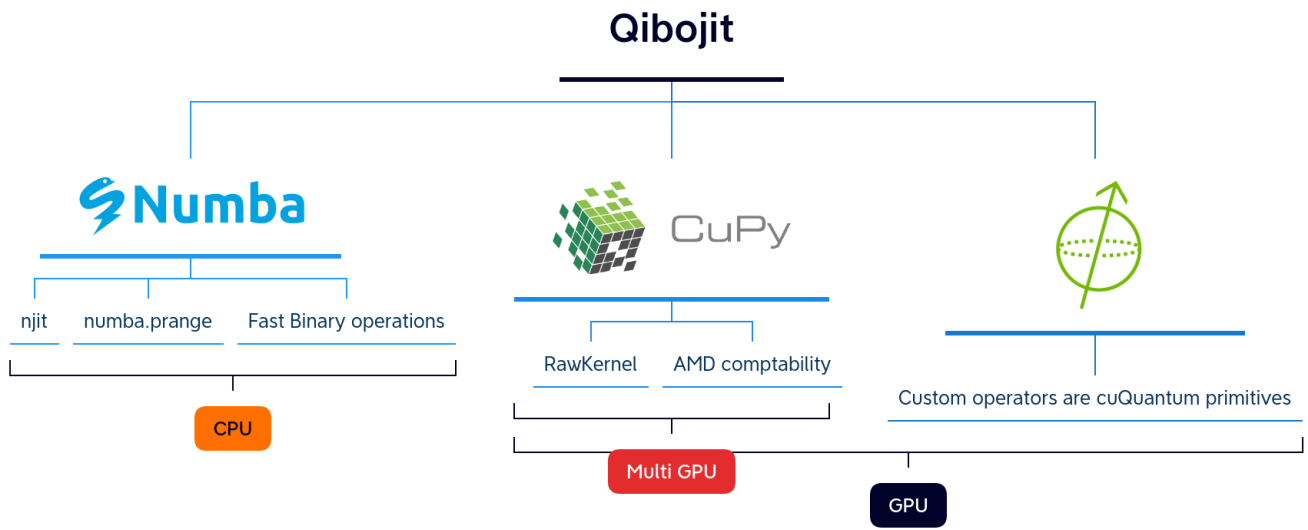
Qibo features

- Definition of a standard language for the construction and execution of quantum circuits with device agnostic approach to simulation and quantum hardware control based on plug and play backend drivers.
- A continuously growing code-base of quantum algorithms applications presented with examples and tutorials.
- Efficient simulation backends with GPU, multi-GPU and CPU with multi-threading support.
- A Simple mechanism for the implementation of new simulation and hardware backend drivers.

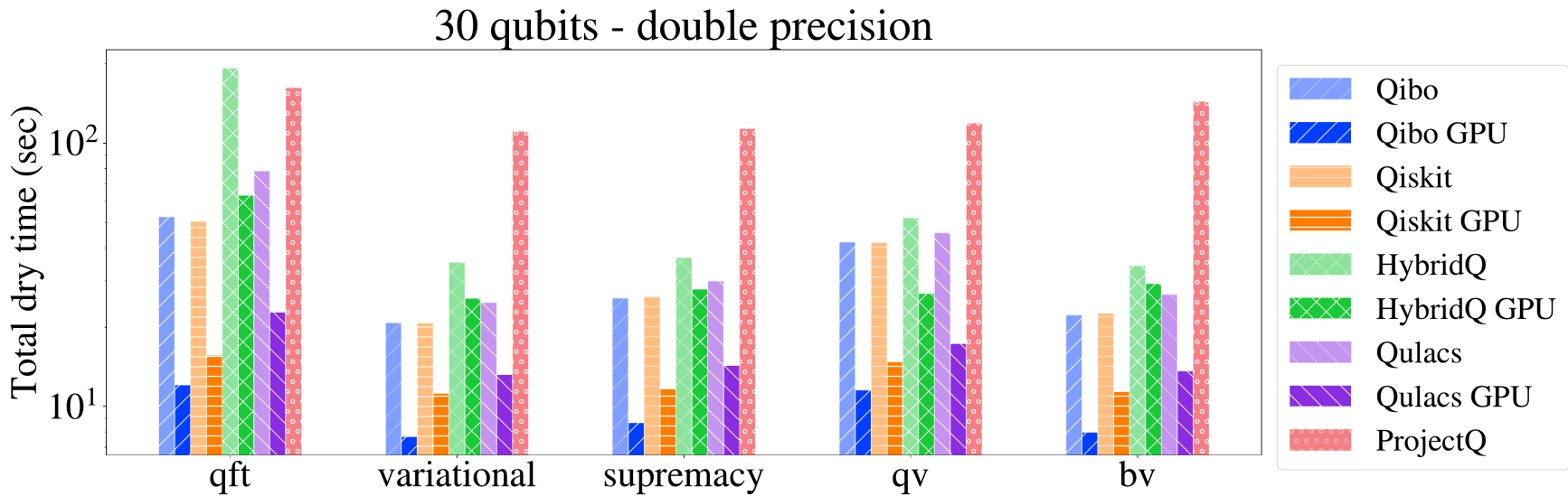
High performance simulation

❌ Long computational times using naive approach (`Numpy` or `TensorFlow`) for circuits with large number of qubits.

✅ We need more sophisticated tools to be able to simulate a quantum circuits with more qubits!



BENCHMARK



All the benchmarks are available in qibojit-benchmarks.

Hardware Control using Qibo

How are gates implemented on a Quantum Computer?

↓

By sending microwave pulses.

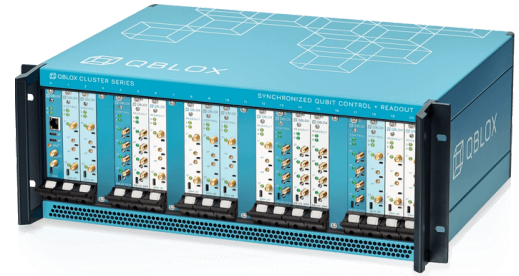
↓

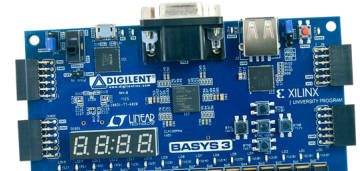
How do we control them?

↓

Using FPGAs

→ We need a Pulse API + Drivers for different electronics.





Introducing Qibolab

Automatic deployment of quantum circuits on quantum hardware

What is Qibolab?

Introducing Qibocal

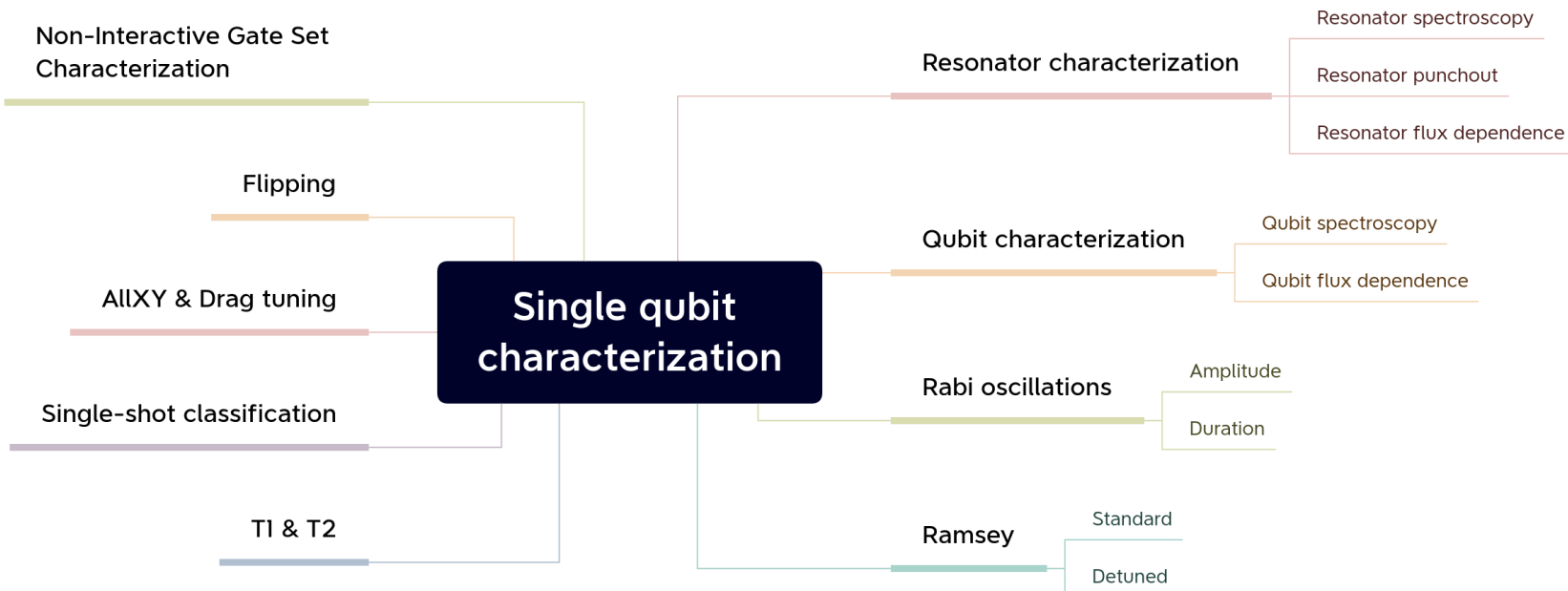
A reporting tool for calibration using Qibo

Motivation

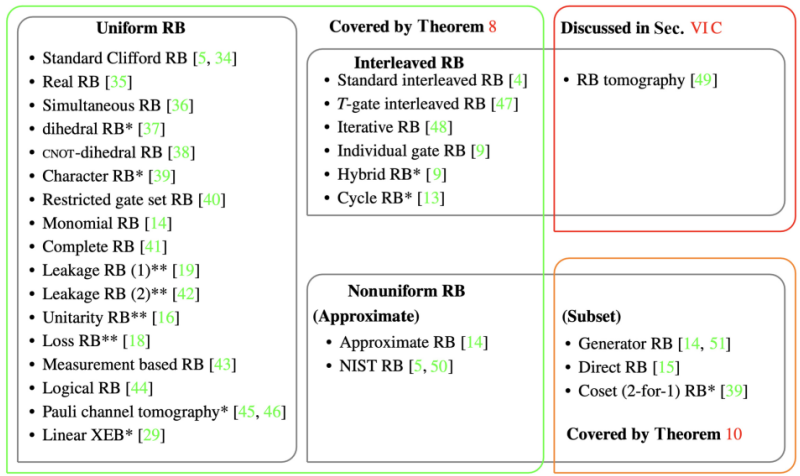
Suppose that we have assembled a quantum computer and we have a way to send pulses to the chip... are we done? NO

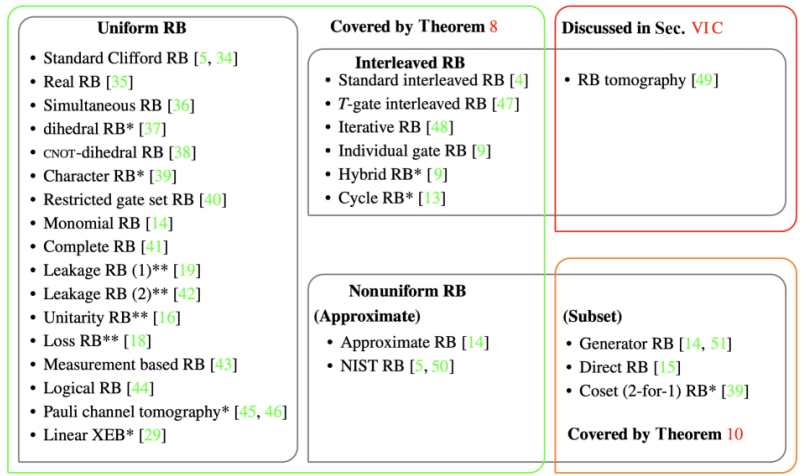
We need to characterize, validate and verificate our qubits.

Single Qubit Characterization: Pulse Level



Single Qubit Characterization: Circuit Level

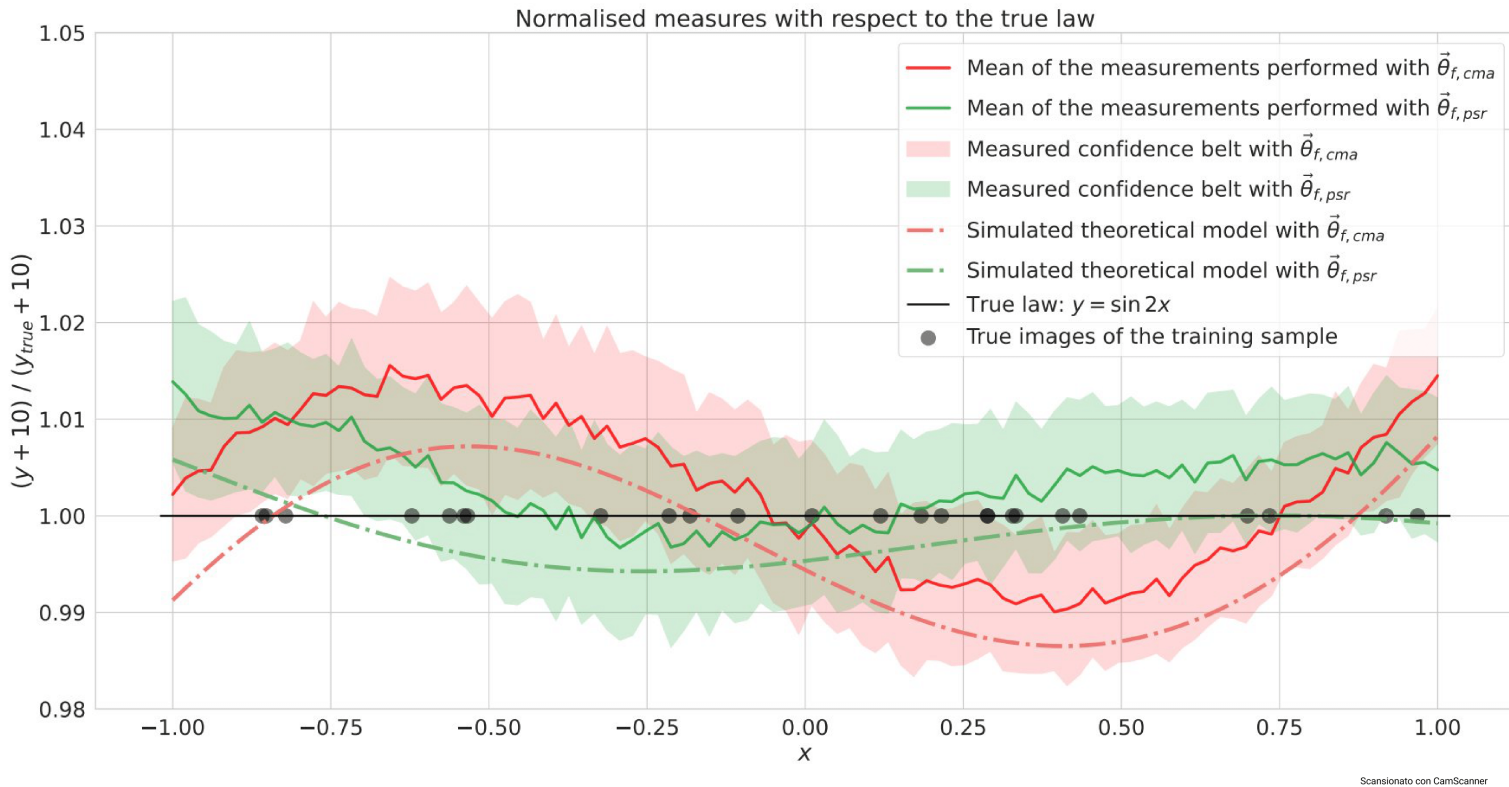




Applications

What can we achieve using `Qibo` + `Qibolab` + `Qibocal`?

Successfully performed a gradient descent on a QPU with a single using Parameter Shift Rule algorithm.



Outlook

Qibo is growing to accomodate different tasks:

- High performance quantum simulation: qibojit
- Hardware control: qibolab
- Hardware calibration: qibocal

What makes Qibo different from the other libraries:

- Publicly available as an open source project
- Modular layout design with the possibility of adding
    - new backends for simulation
    - new backends for hardware control
- Community driven effort

Thanks for listening!