

Submitting Qiskit jobs from the AI_INFEN platform

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Introduction

- Recently we obtained the access to **Lagrange**, a **5-qubit quantum computer installed in 2023 at Politecnico di Torino**
- This was possible thanks to an agreement between the INFN director of Firenze and the scientific director of INRiM (Istituto Nazionale di Ricerca Metrologica)
- We have received a single account, in order to test Lagrange for possible INFN applications
- **This is an exploratory phase, so we are not yet allowed to give accounts to other INFN users**, and all the resources are managed by INRiM

Lagrange

- **Lagrange** is a 5-qubit quantum computer installed in 2023 at **Politecnico di Torino** ([link](#))
- It has been provided by the company IQM Quantum Computers
- Its acquisition has been possible thanks to an agreement between Politecnico di Torino, Fondazione LINKS e Istituto Nazionale di Ricerca Metrologica (INRiM)

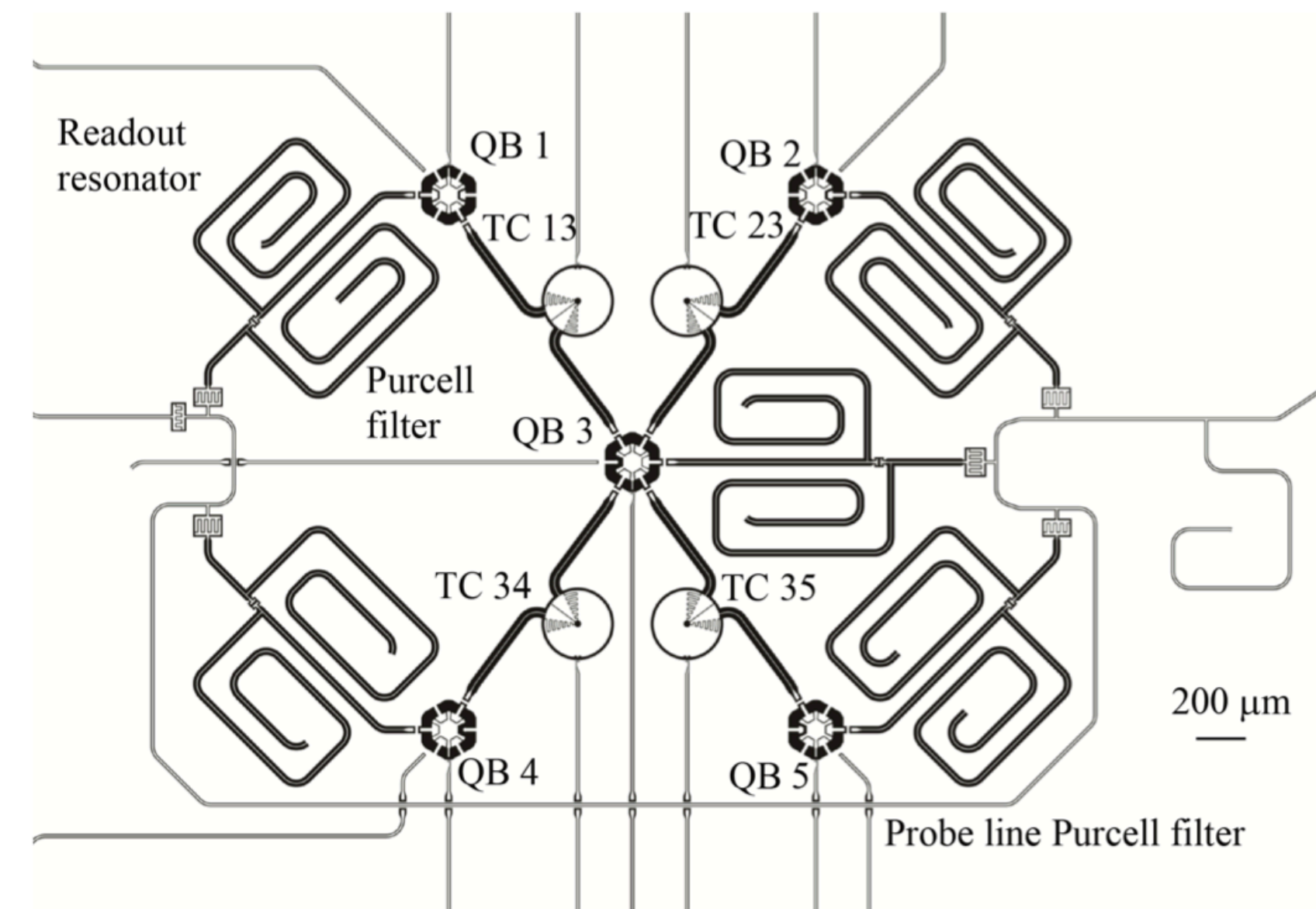


Fig. 1: Design of a 5-qubit superconducting quantum processing unit employed in this paper, showing 5 qubits (QB) connected by 4 tunable couplers (TC). Black, apart from explanatory text, indicates areas where superconducting film is etched exposing the substrate.

The story so far

- We have received a **personal account on the gitlab of the LINKS foundation, that manages the access to Lagrange**
- With this account we can log to the Lagrange dashboard, and we can create the token used for the job submission to Lagrange
- We have been assigned to the **project INRIM_INFN**, and a certain amount of **qpu time** has been allocated in the project (1 hour + 1 hour at the moment)
- We have prepared few Jupyter notebooks using **Qiskit** as main library
- We performed the installation of the software and the submission of the jobs both in my personal laptop and in **a AI_INFN virtual machine**

Installation

Installing necessary packages

Before we begin, you will need to install some prerequisites into your environment. This notebook can be executed as-is within google colab. Locally, it is necessary to create a conda environment as following

```
conda create -n iqm312 python=3.12 ipykernel jupyter
```

Run the cell below to complete the installations of the dependencies.

```
%pip install uv --quiet
!uv pip install "iqm-client[qiskit]==29.12" --quiet
!uv pip install matplotlib --quiet
!uv pip install lagrangeclient --index-url https://gitlab.linksfoundation.com/api/v4/projects/1709/packages/pypi/simple
```

Let's now get our token using the [authentication client](#).

```
!lagrangeclient

## On Windows use the following command instead:
# import sys
# !{sys.executable} -m lagrangeclient
```

Now, we can import the main iqm package

```
from iqm import qiskit_iqm
```

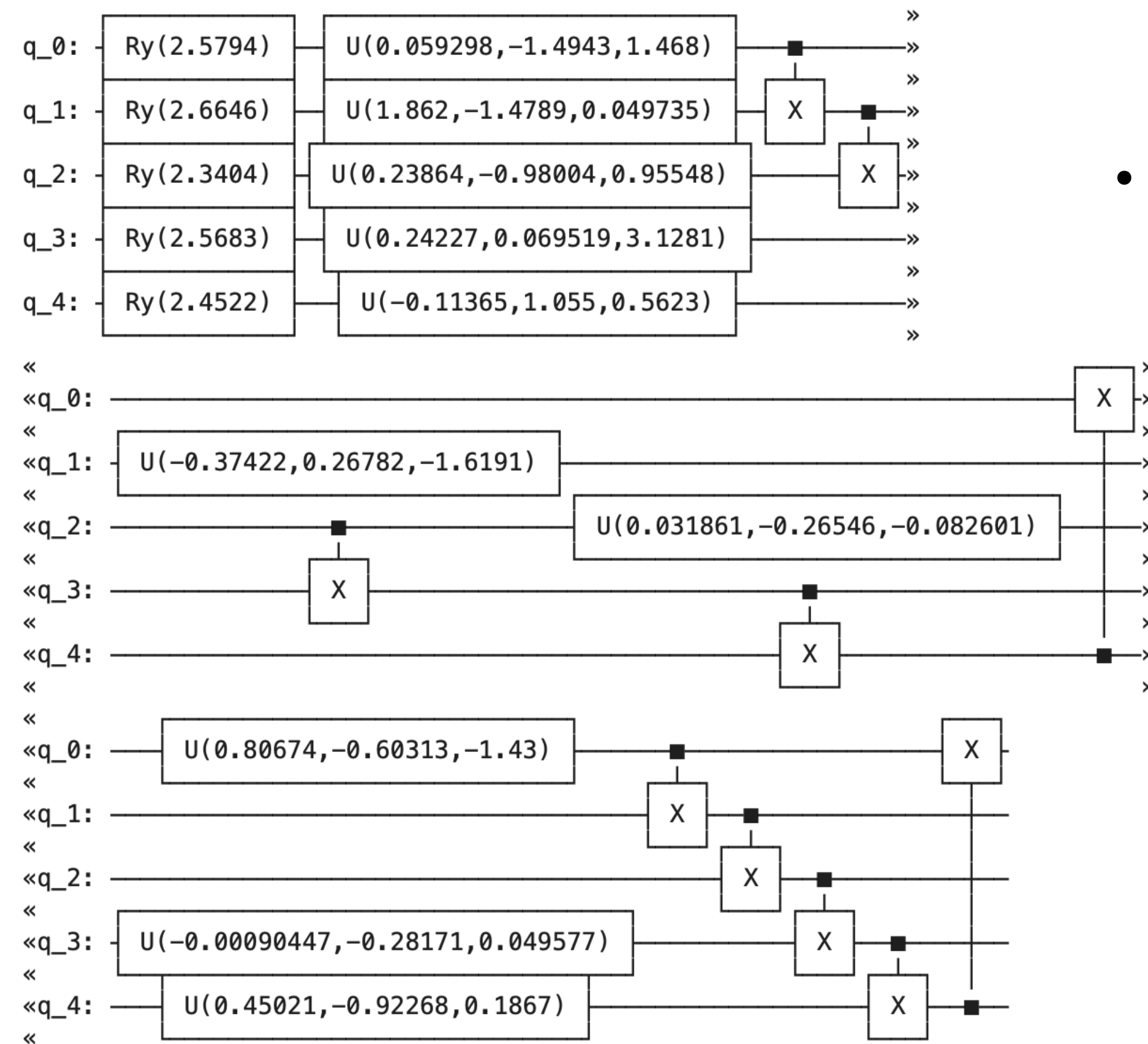
```
uv pip install \
    qiskit==1.4.2 \
    qiskit-machine-learning==0.8.4 \
    qiskit-ibm-runtime==0.43.1 \
```

Not all the up-to-date versions of qiskit libraries work in the framework: A bit of trial and error was necessary to identify the correct ones

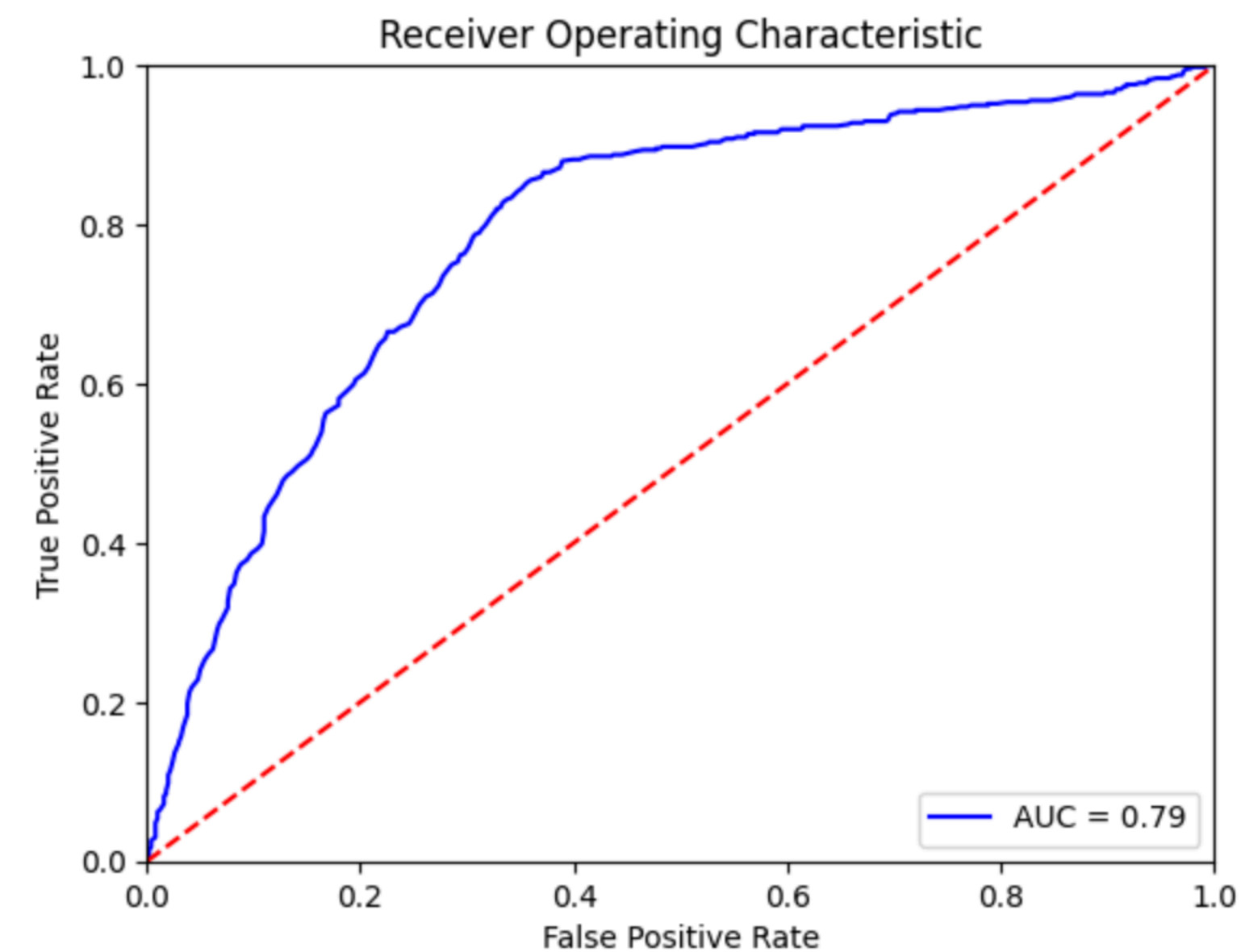
- **We have created the environment in the AI_INFN platform**, and we deployed it to CVMFS
- The full software stack can correctly run

Our application

Circuit (before transpiling)



- **Quantum Machine Learning** with variational quantum circuit
- Circuit pre-trained with simulator developed for the classification of b and c-hadron decay vertices at LHCb



- **ROC curve evaluated by processing the circuits on Lagrange**

Job submission

Then we can create an IQM backend connecting and authenticating to Lagrange

```
from iqm.qiskit_iqm import IQMProvider
from qiskit import transpile
from qiskit.visualization import plot_histogram
import os

os.environ["IQM_TOKENS_FILE"] = "./tokens.json"
iqm_url = "https://spark.quantum.linksfoundation.com/station"

provider = IQMProvider(iqm_url)
backend = provider.get_backend()
```

Finally, we can run the circuit on the machine

```
transpiled_circuit = transpile(circuit, backend=backend)
job = backend.run([transpiled_circuit], shots=1024)
counts = job.result().get_counts()
print(job.job_id())
print(counts)
plot_histogram(counts)
```

Running

Jobs

Dashboard

Jobs

EXPORT

Id ↑	Project	User	Jobid	Status	Execution start	Execution end	Submitted datetime	Submitted circuit	Results
64076	(Org 4) 2026_INRIM_INF	lorenzo.sestini@fi.infn.it	9bc8fae2-1986-4a33-8d21-a8dd91fc06b8	ready	27/01/2026, 11:52:44	27/01/2026, 11:52:45	27/01/2026, 11:52:44	link	link
64077	(Org 4) 2026_INRIM_INF	lorenzo.sestini@fi.infn.it	18b10015-1884-4fc6-bbef-b9883a762612	ready	27/01/2026, 11:52:46	27/01/2026, 11:52:47	27/01/2026, 11:52:46	link	link
64078	(Org 4) 2026_INRIM_INF	lorenzo.sestini@fi.infn.it	41cba87a-79da-401a-bda4-24efb7c0d50a	ready	27/01/2026, 11:52:49	27/01/2026, 11:52:49	27/01/2026, 11:52:48	link	link
64079	(Org 4) 2026_INRIM_INF	lorenzo.sestini@fi.infn.it	9c075673-1bdf-4c45-9dd1-6f1cd563b43d	ready	27/01/2026, 11:52:57	27/01/2026, 11:52:58	27/01/2026, 11:52:57	link	link
64080	(Org 4) 2026_INRIM_INF	lorenzo.sestini@fi.infn.it	51894780-db85-4b8c-b483-2bfa7ef5f533	ready	27/01/2026, 11:52:59	27/01/2026, 11:53:00	27/01/2026, 11:52:59	link	link
64081	(Org 4) 2026_INRIM_INF	lorenzo.sestini@fi.infn.it	e70b2020-cd29-4ba1-865a-6b8725a955fd	ready	27/01/2026, 11:53:05	27/01/2026, 11:53:06	27/01/2026, 11:53:05	link	link
64082	(Org 4) 2026_INRIM_INF	lorenzo.sestini@fi.infn.it	f65efa1f-4f5f-4ff1-8fd3-1faaa3966037	ready	27/01/2026, 11:53:08	27/01/2026, 11:53:09	27/01/2026, 11:53:08	link	link

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- Each job (single circuit evaluation) takes < 1 sec
- There is also the possibility to submit several circuits with the same job
- Sometimes (1 over 100) the job may fail for different reasons (e.g. on-going calibration of Lagrange)

Conclusions

- We tested the job submission to the **Lagrange 5-qubit quantum computer**
- The installation of the necessary libraries, based on **Qiskit**, was more or less straightforward
- **We succeeded in preparing the environment in the AI_INFN platform, and in submitting the job from it. The environment is also uploaded to CVMFS**
- The job running is pretty smooth, with a low rate of failed jobs
- The number of 5 qubit is pretty low for many applications
- Overall experience was pretty positive, also good support from the Politecnico di Torino
- The quantum computer that is being prepared at Cineca comes from the same company (IQM) and has 54 qubits. These tests with Lagrange can be considered as a gym for working with it