

Swaption pricing with QML

QAA team – Hirmay, Sonya, Tommaso, Leonardo

PushQuantum Hackathon 2025 x
Quandela

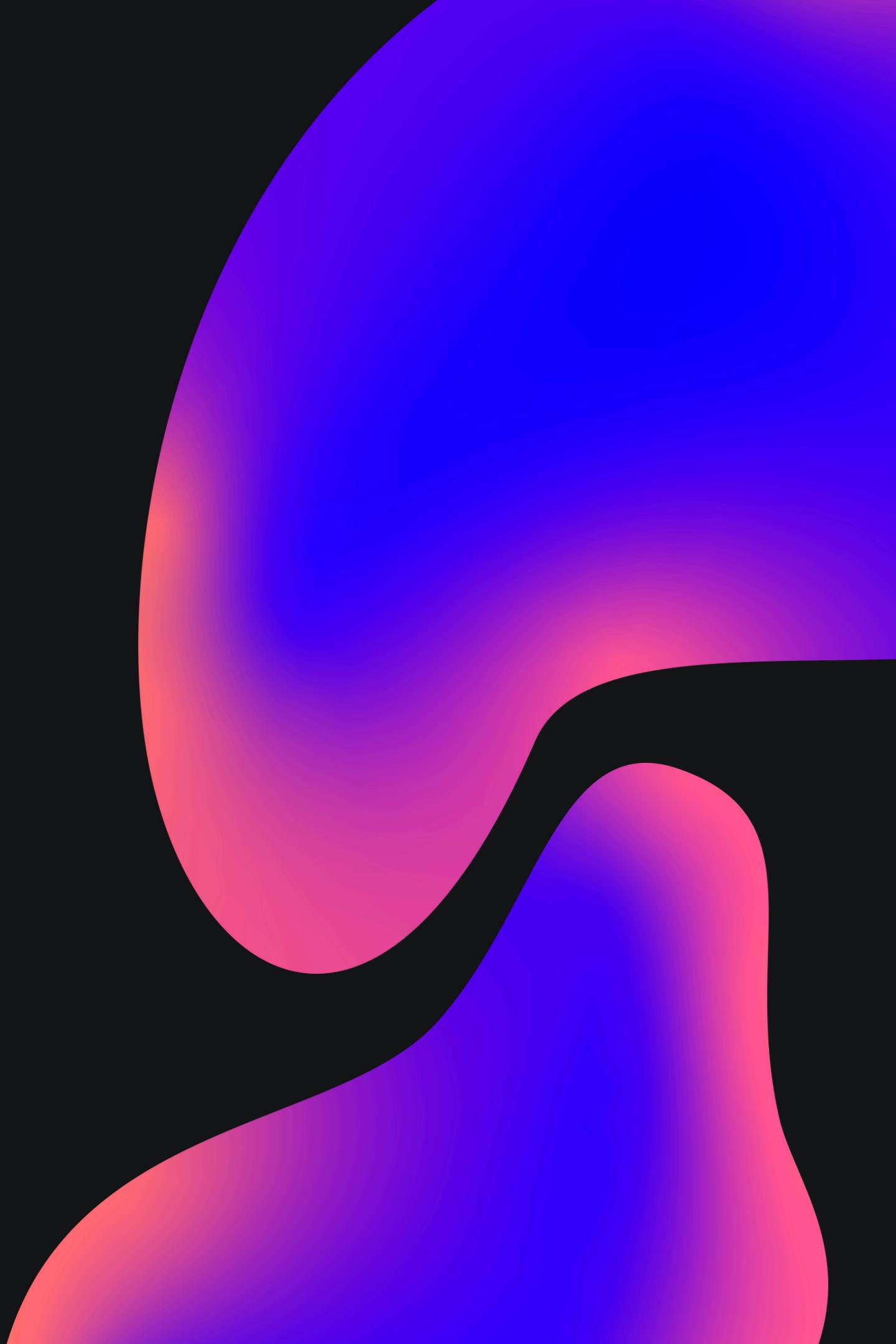
The Problem

Def.: **Swaption**

A **Swaption** is an option that grants the holder the right, but not the obligation, to enter into an interest rate swap at a specific future date and rate.

The Goal : Accurate, real-time pricing is critical for hedging risk and maintaining market liquidity.

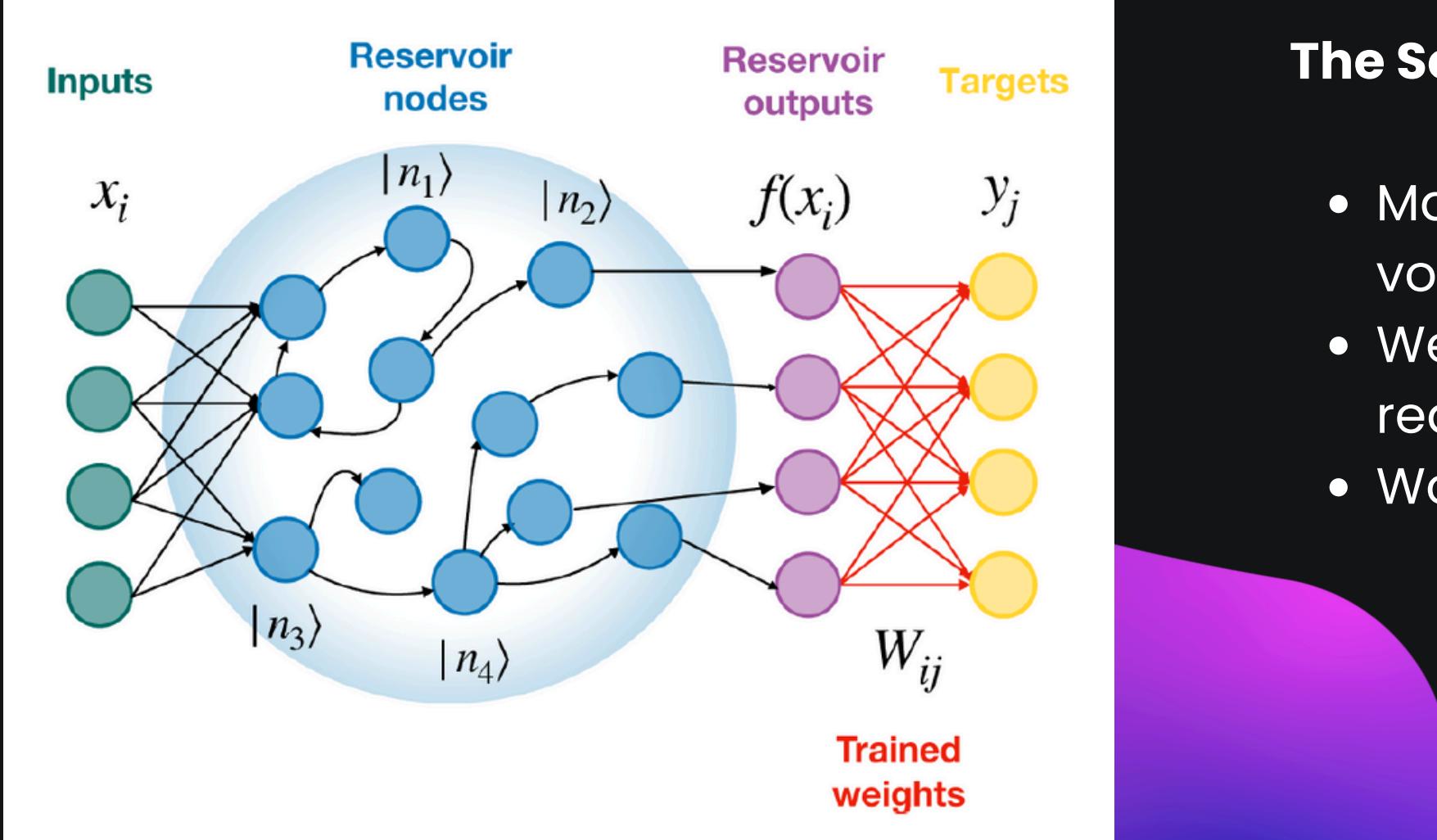
Classical AI training is computationally too intensive for real-time market adaptation.



Why QRC?

Classical Neural Networks (RNN/LSTM)

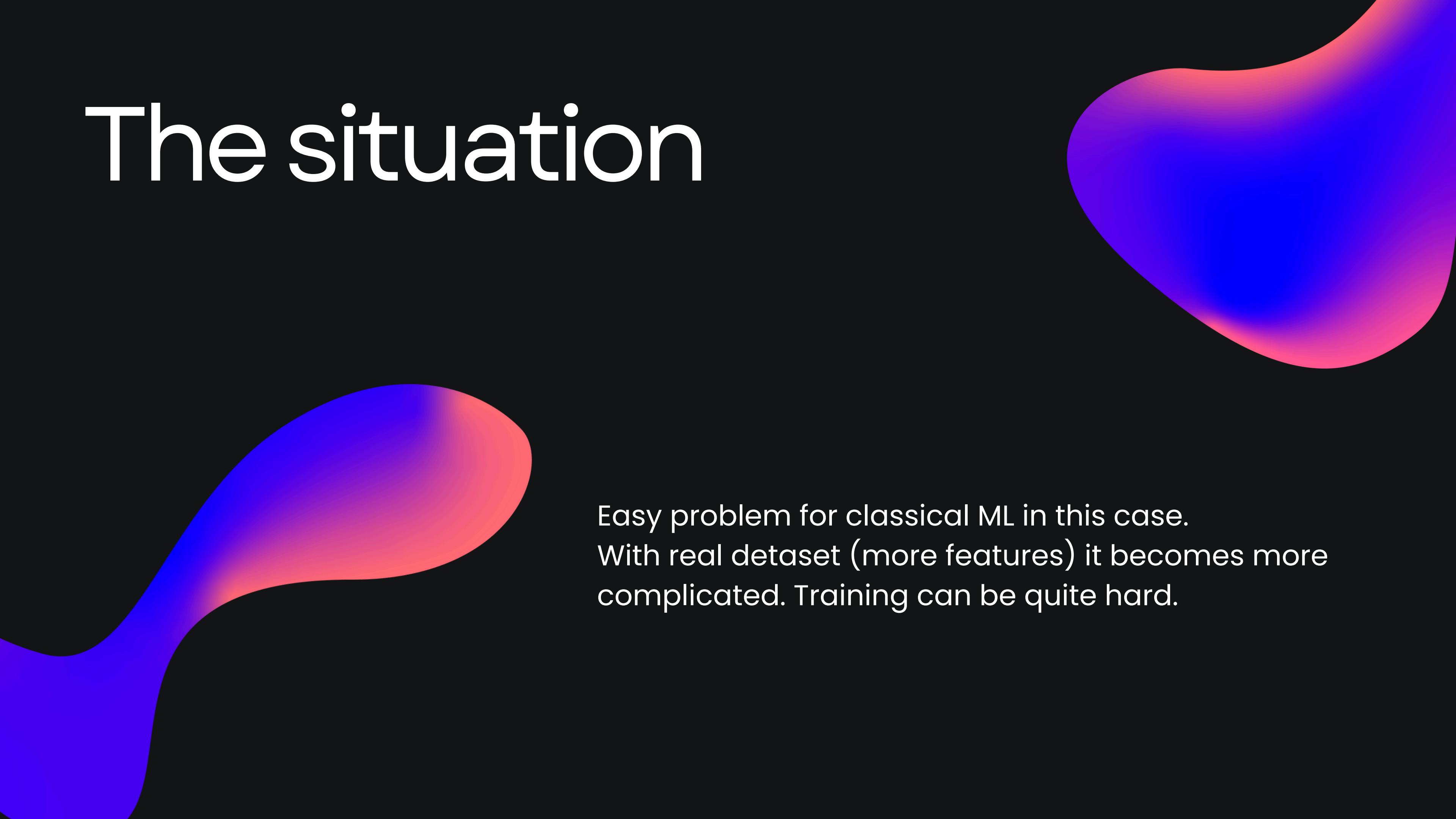
- Training Bottleneck: computationally heavy and slow
- Prone to overfitting when training data is limited
- Struggles to retain long-term dependencies in market trends



The Solution: Quantum Reservoir Computing (QRC)

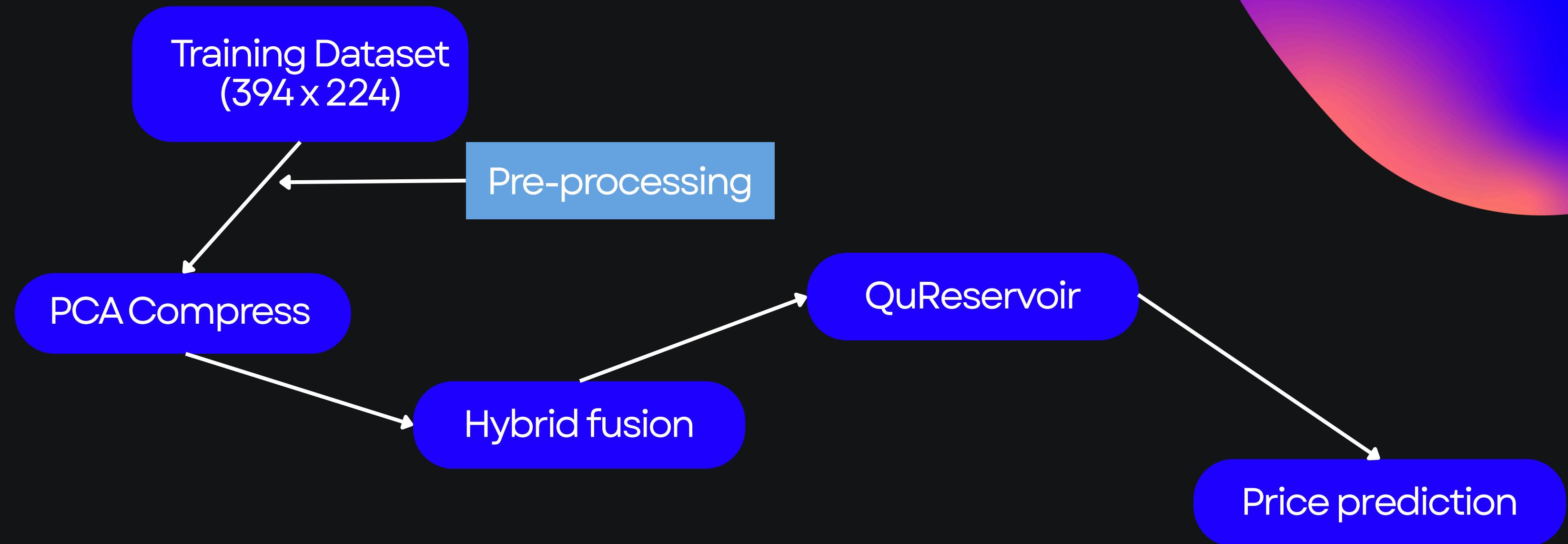
- Maps inputs to a huge Hilbert Space, capturing non-linear volatility patterns that classical nodes miss
- We do not train the quantum circuit. We only train the final linear readout.
- Works with device noise (NISQ), rather than failing because of it

The situation



Easy problem for classical ML in this case.
With real dataset (more features) it becomes more
complicated. Training can be quite hard.

Our Vision



Our Solution

Hybrid ML model:

- Linear Classical Layer to recognize the main trands

$$y_{lin} = Wx + b \quad x \in R^d$$

- Apply PCA to reduce dimensionality

$$z = PCA(x) \quad z \in R^k, k \ll d$$

- Use Quantum Layers to investigate non-linearity

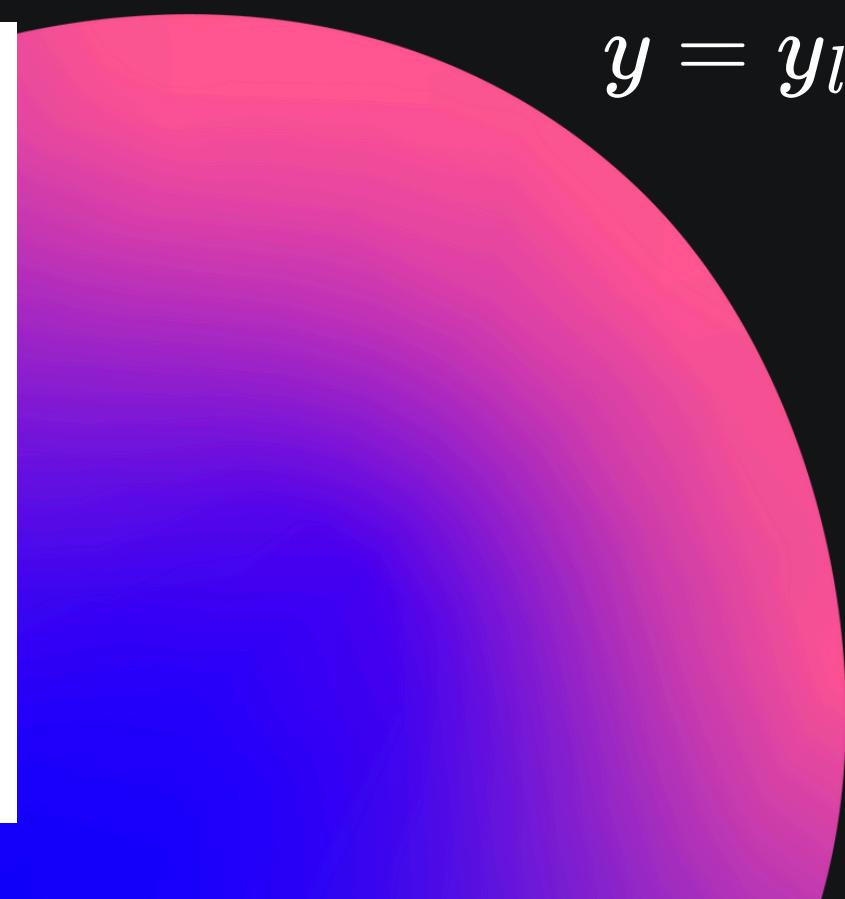
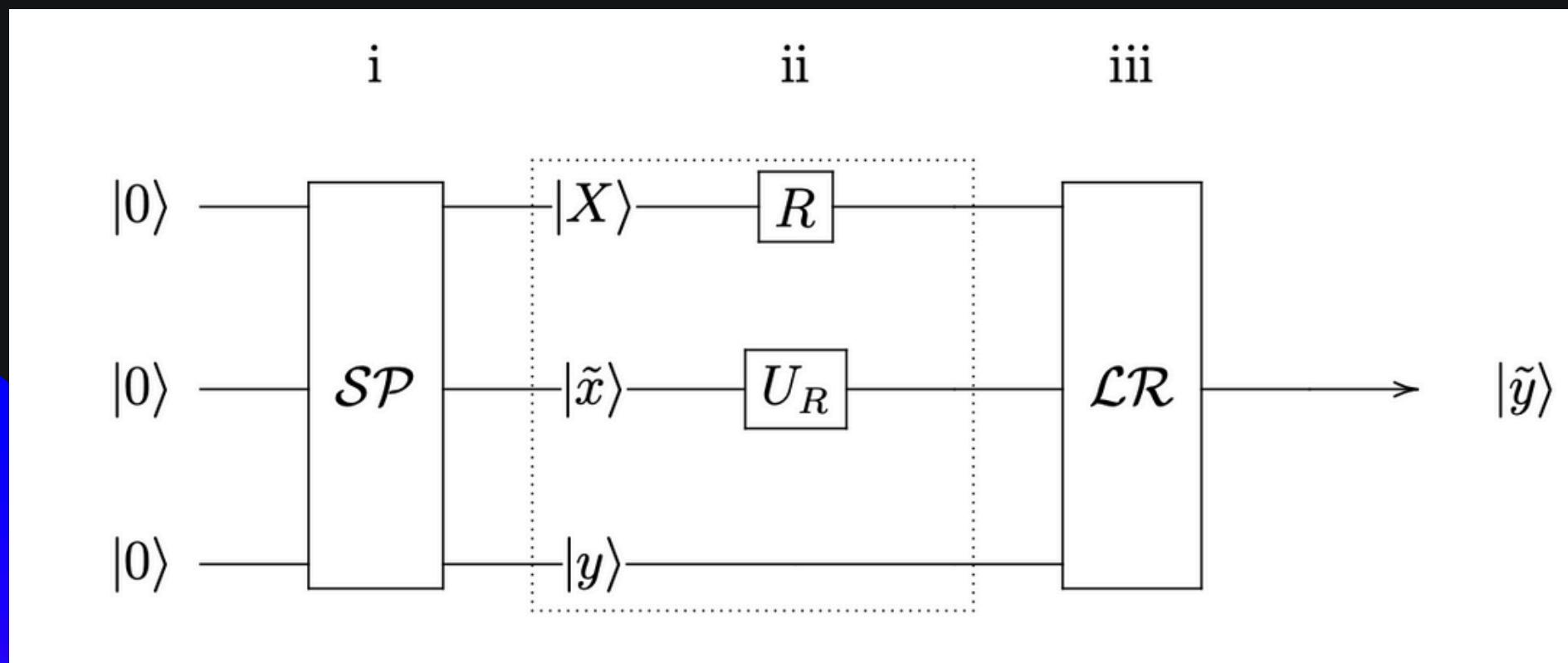
$$q = Q(z)$$

- Pass to another Linear Layer

$$y_{quantum} = W_q x + b_q$$

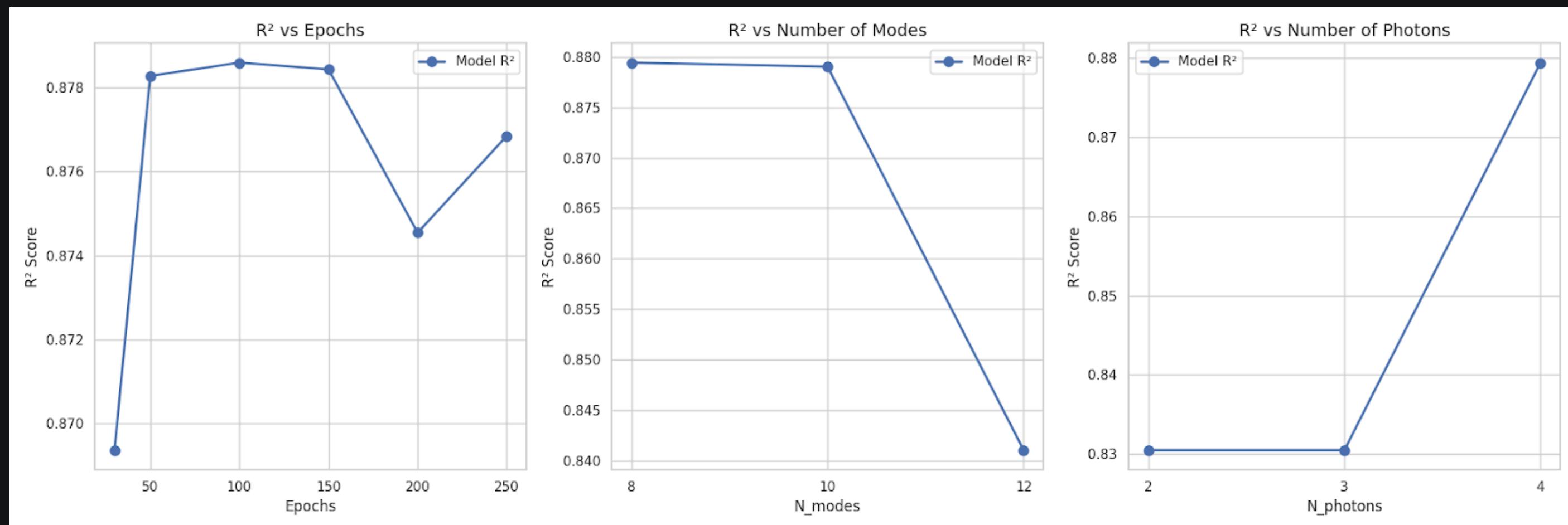
- Final prediction

$$y = y_{linear} + y_{quantum}$$

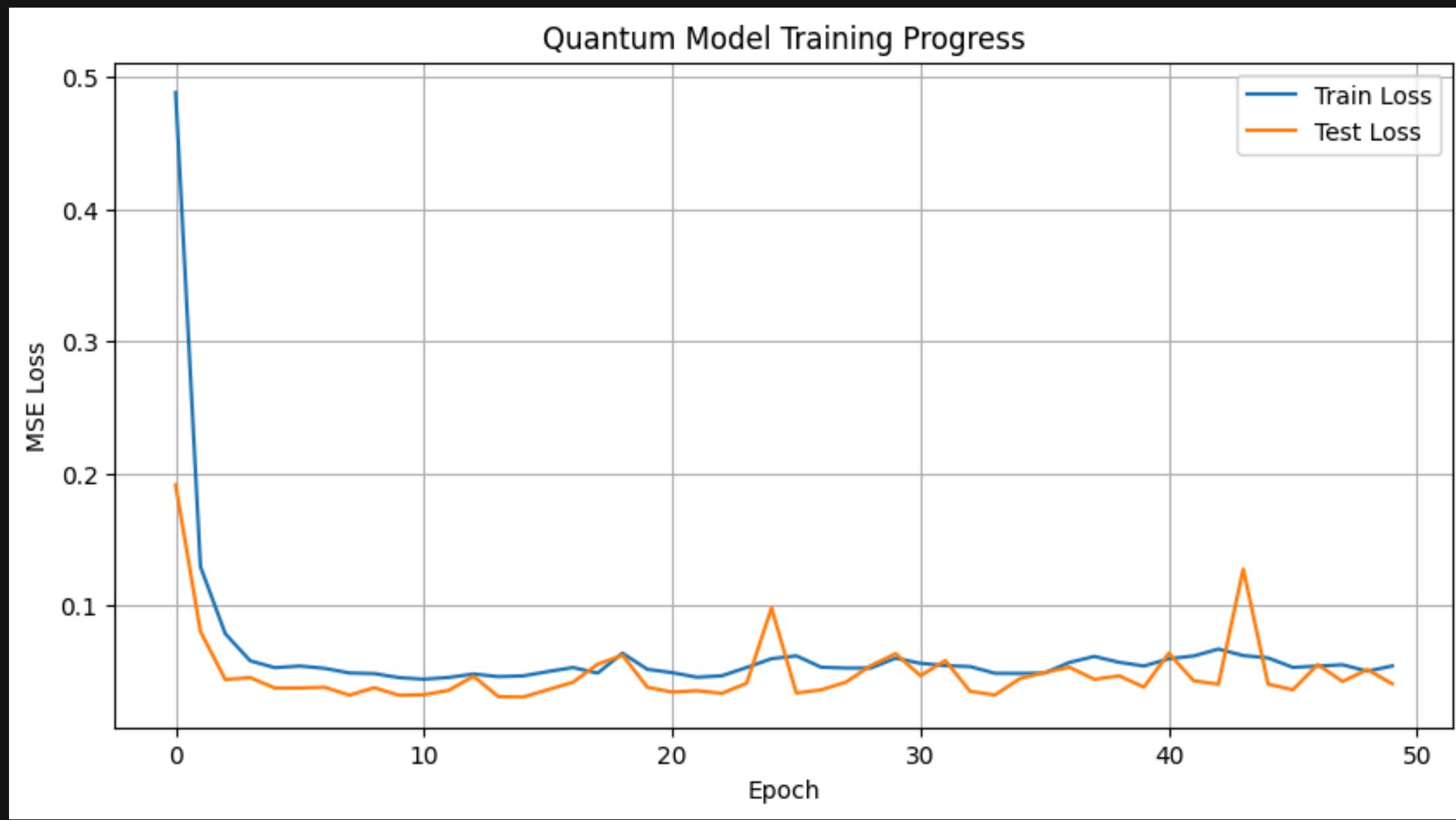


Hyperparameters

We ran simulations to find the optimal set of hyperparameters



Performance



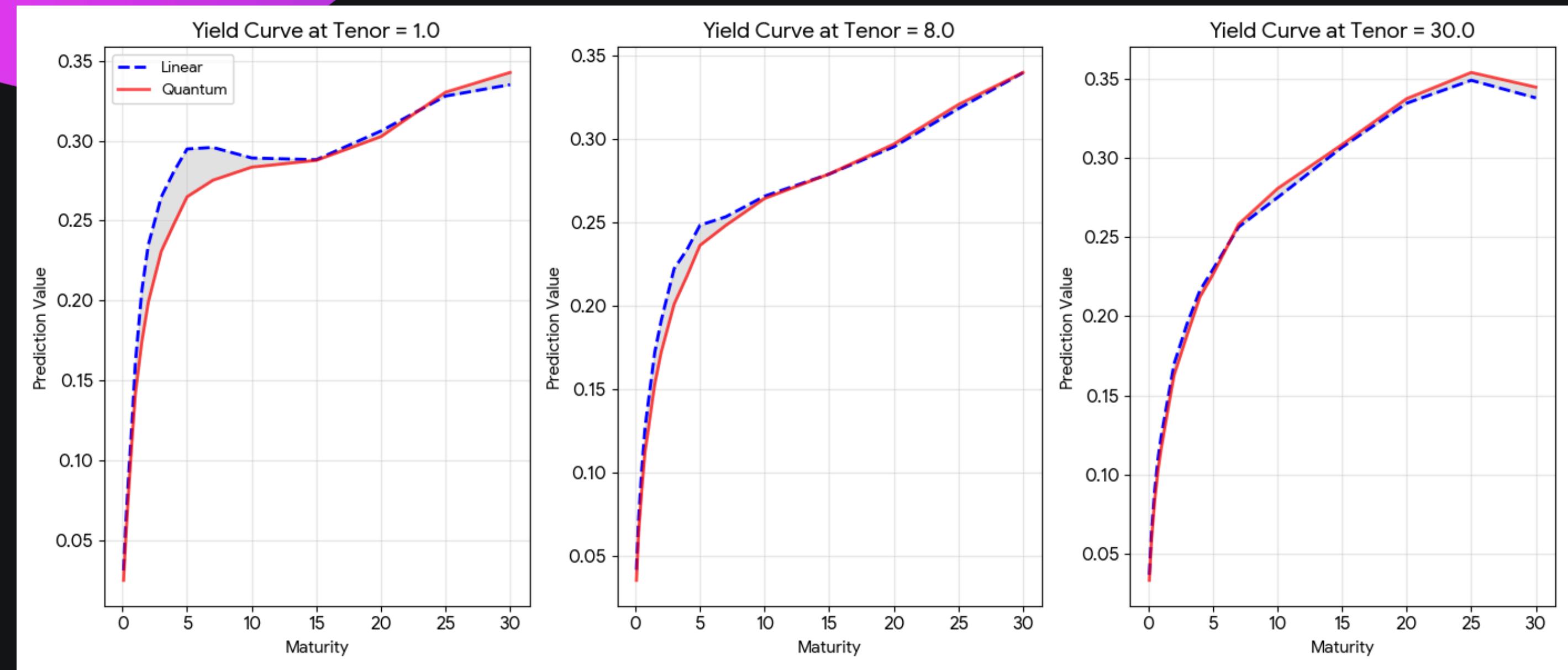
The optimized hyper-parameters:

- LR=0.00005
- N_MODES=8
- N_PHOTONS=4
- EPOCHS=50
- BATCH_SIZE=32

**MSE : 0.0014
RMSE : 0.0374
R² : 0.879**

Predictions

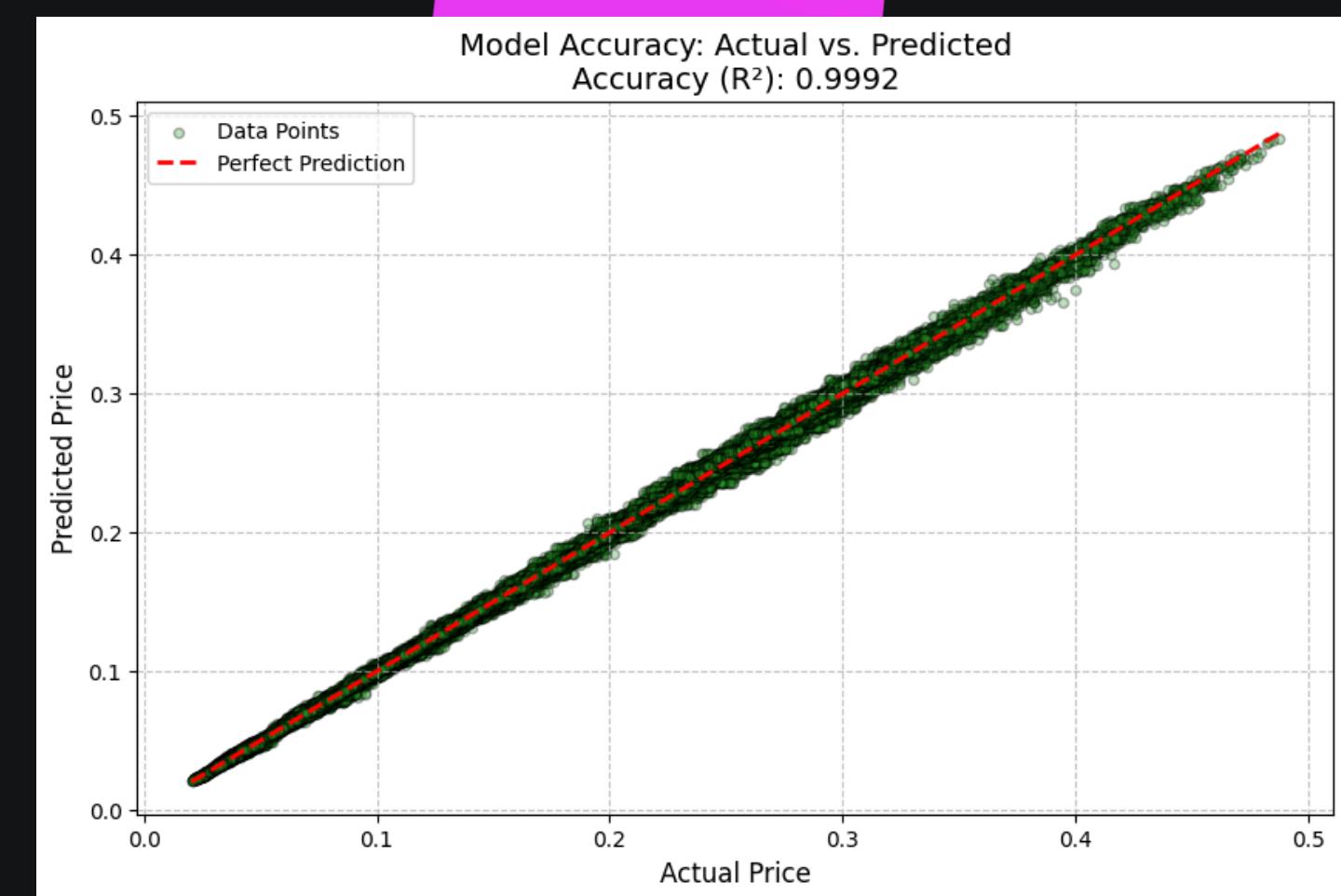
Linear Regression vs. Quantum Reservoir Models



Experimenting

We tried a number of experiments!

1. Running on Quandela cloud
2. Different circuit configurations
3. Quantum enhanced random forest
4. Implementing a feed forward layer
5. Running on digital quantum circuits (Qiskit)



Outlook and future directions

- More **complex** feedforward configurations
- Investigate **other QML models**
- Running the model on a **real Quandela quantum machine**

Our Team



Tommaso



Leonardo



Hirmay



Sonya

Thank You ❤

Your Quantum Anonymous Alcoholics team

(And our mascot)
(And thank you Arno)

