Quantum Linear Optics Reservoir Computing

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Quantum Tide

FIRST qLinear Optics Reservoir

Presentation roadmap

1. The Challenge and Motivation
2. Reservoir Computing
3. Parameterized Beamsplitter Circuit
4. Injection Algorithm
5. Outlook

The Challenge

Provided by EDF

- Time series prediction of wind power production
- Use qLinear Optics to build qReservoir

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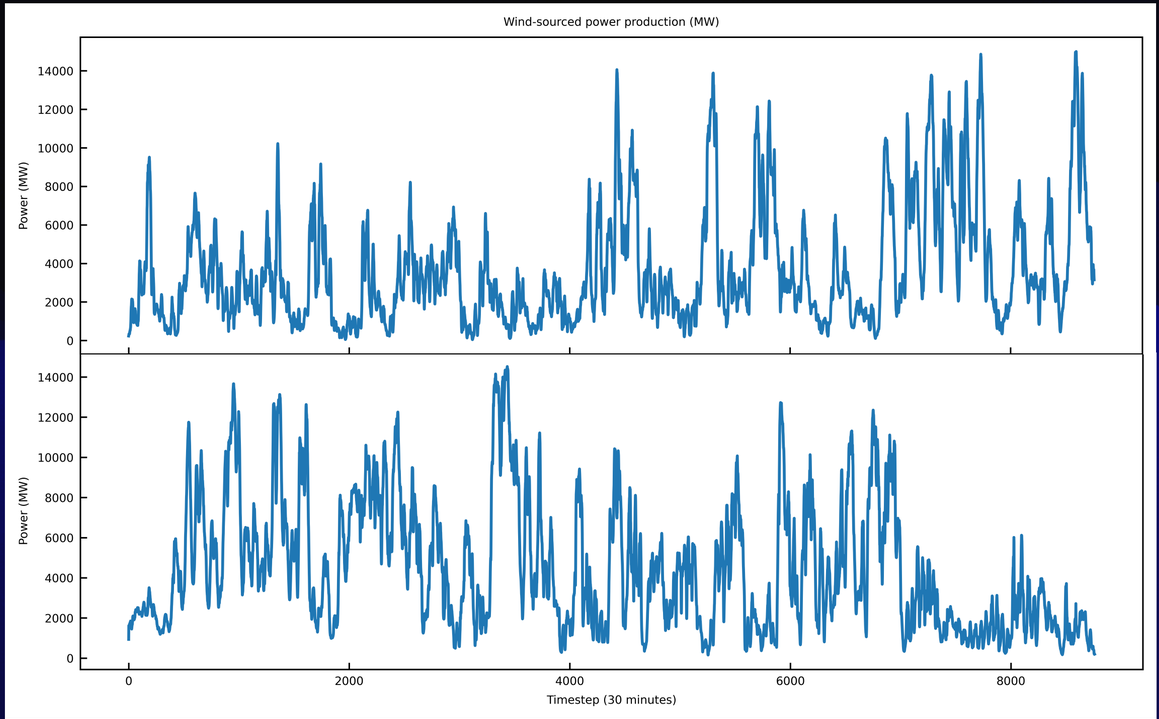


Fig. 2: Actual wind power prediction of EDF

Classical Reservoir

Soon to be a thing of the past

- Computationally expensive
- Use fixed connections and extract a hash

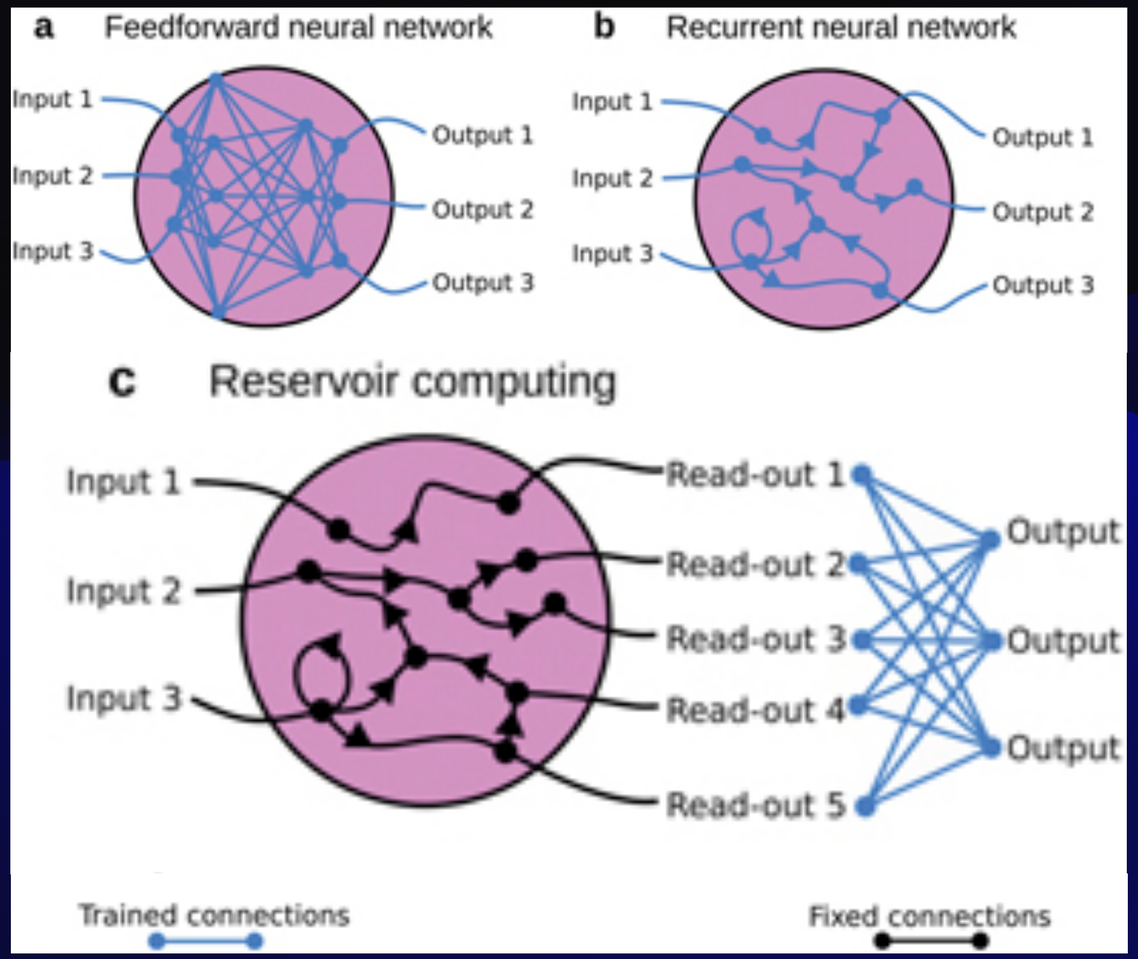


Fig. 3: Comparison of different prediction techniques

Quantum Reservoir (QR)

The potential future

- Leverage the intersection of classical and quantum computing
- Use qubit crosstalk
- Use quantum noise

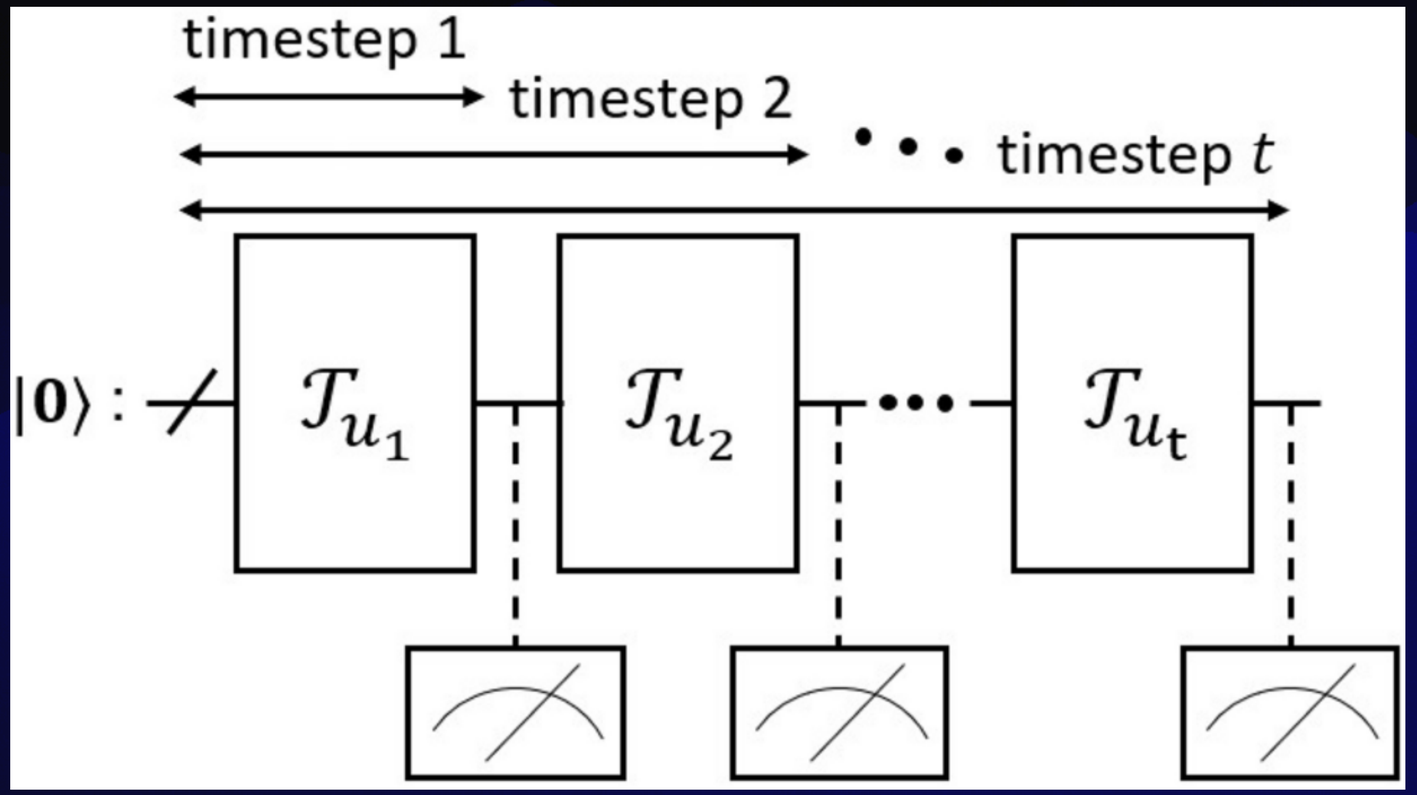


Fig. 3: Quantum Reservoir as proposed in Nature

QR with Linear Optics

The real future

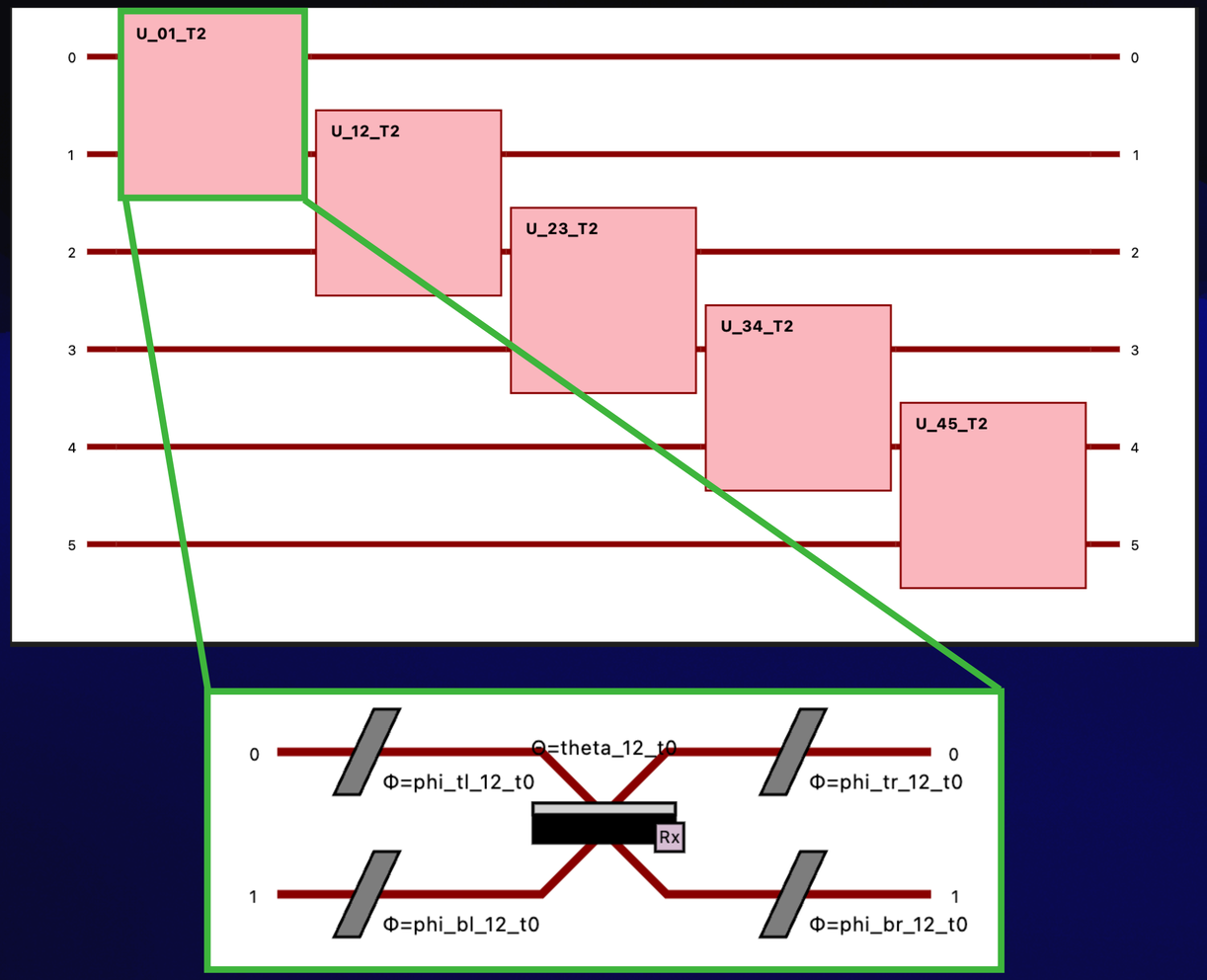
- This has NEVER been done before
- Uncharted territory

?

Parameterized Beamsplitter Circuit (PBC)

A simplified qReservoir approach

- Cascade of beamsplitters
- Parameterized with input data



Figs. 4 & 5: Circuit and single beamsplitter

Imagine you want to go surfing…

But the sea is flat when you get there

PBC Tide prediction

To catch the swell!

- Given: Data of previous two days
- Result: Can predict tidal peak with good accuracy

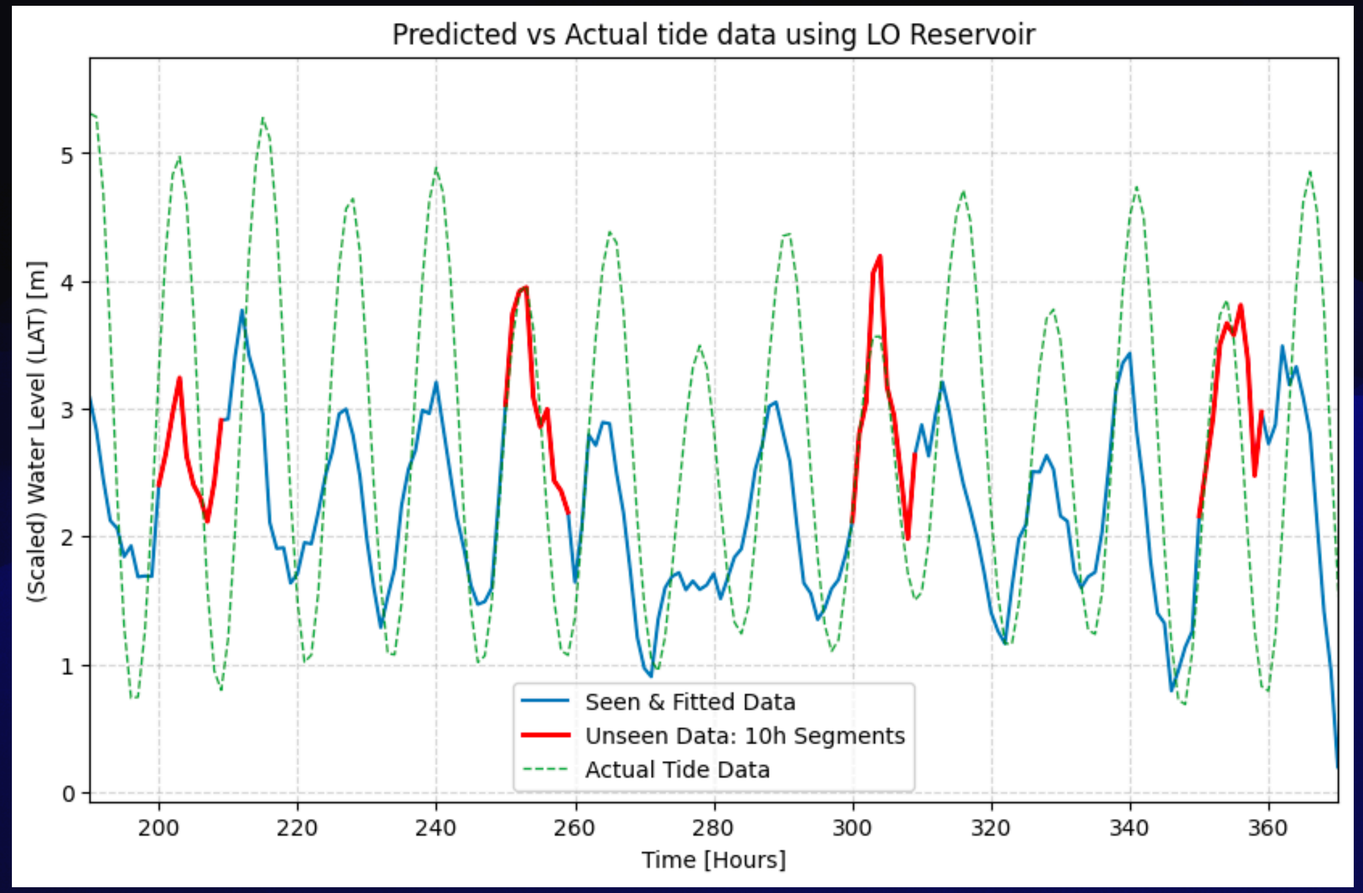


Fig. 8: Interleaved Tide Prediction using the PBC

PBC Tide prediction

To catch the swell!

- Given: Data of previous two days
- Result: Can predict tidal peak with good accuracy

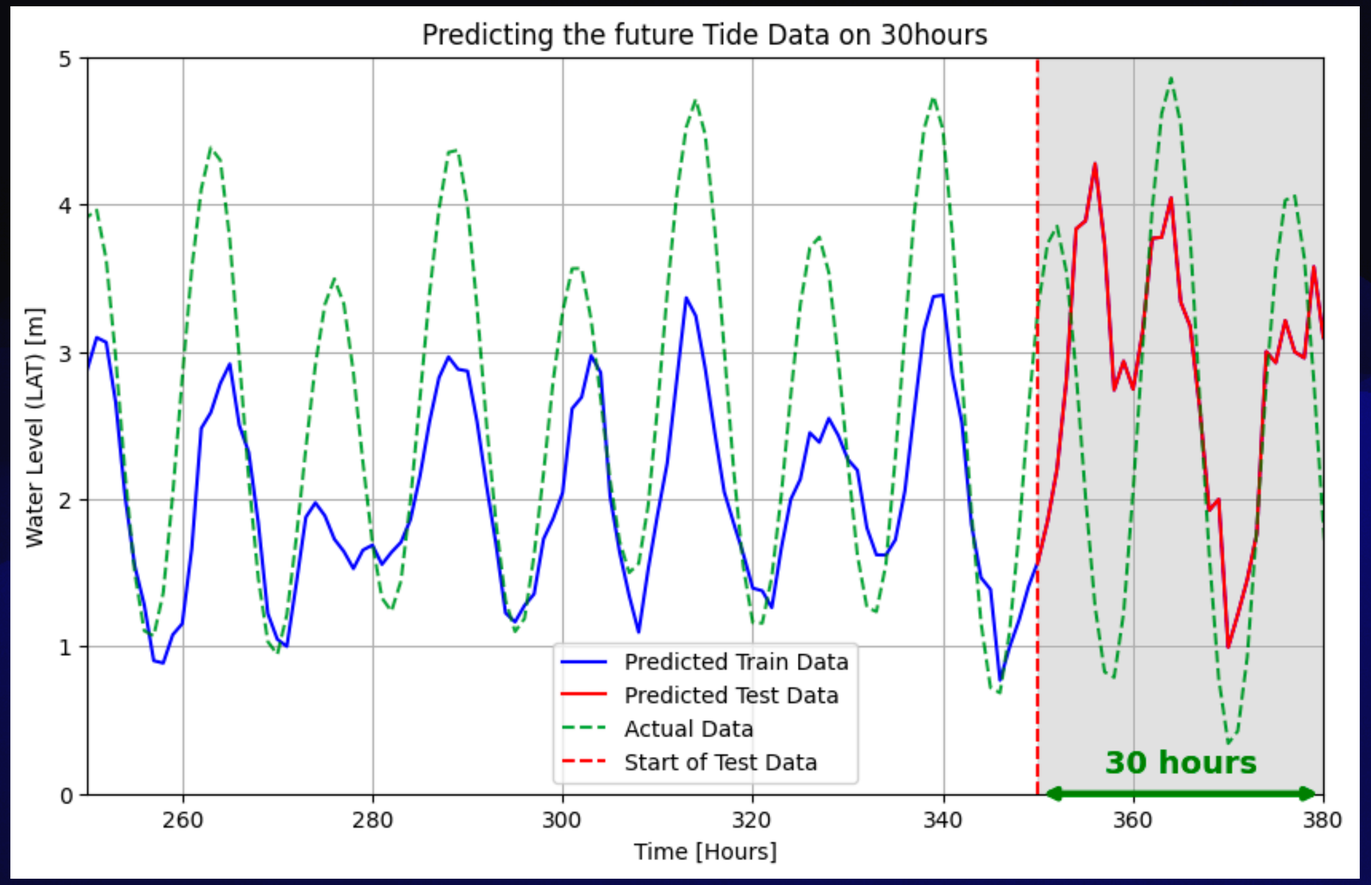


Fig. 9: Tide prediction

PBC NARMA prediction

THE time series benchmark

- NARMA is a hard test for time series prediction
- High accuracy on NARMA benchmark

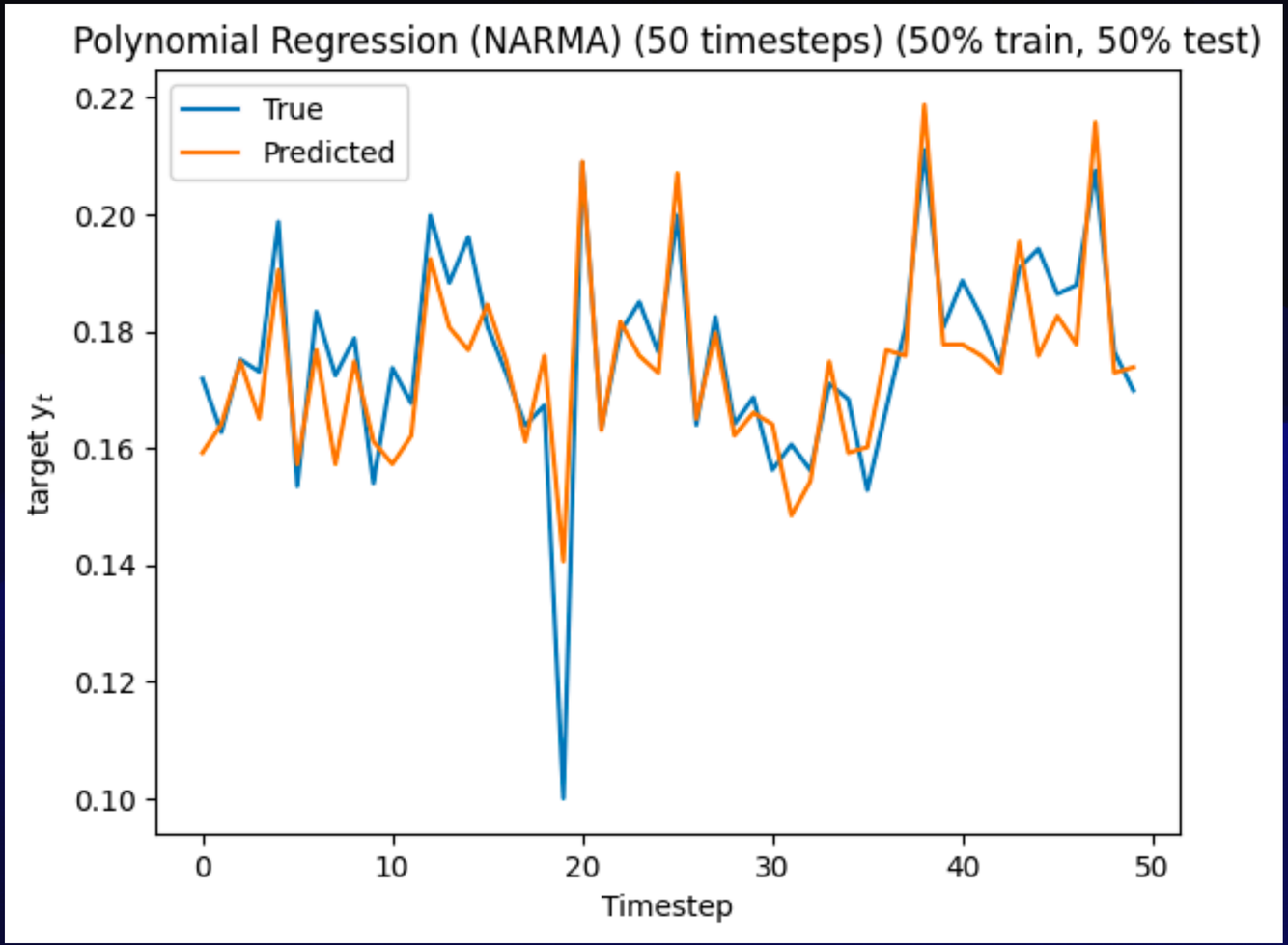


Fig. 11: NARMA Benchmark prediction

Now that you reconnected with nature, you want to use green energy

PBC EDF prediction

Tackling the challenge

- Accurate predictions for a day

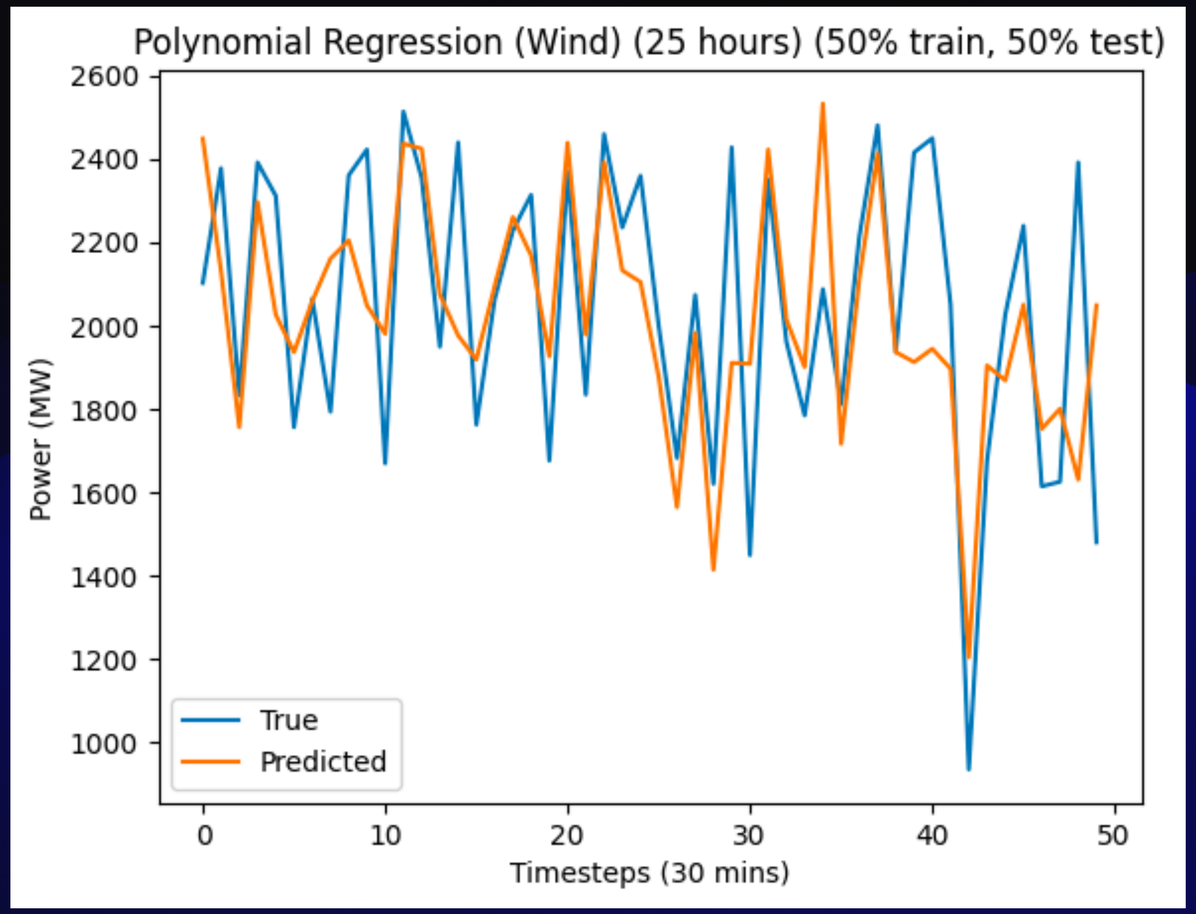


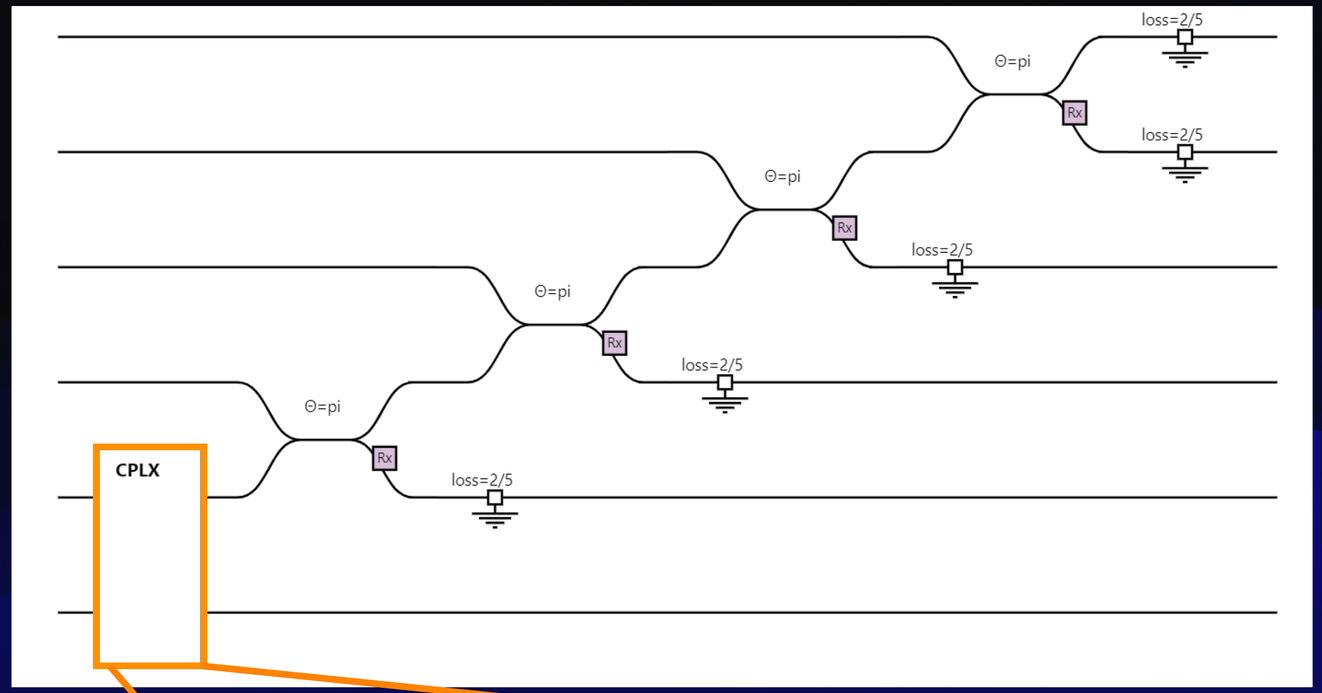
Fig. 13: EDF Wind Power Prediction

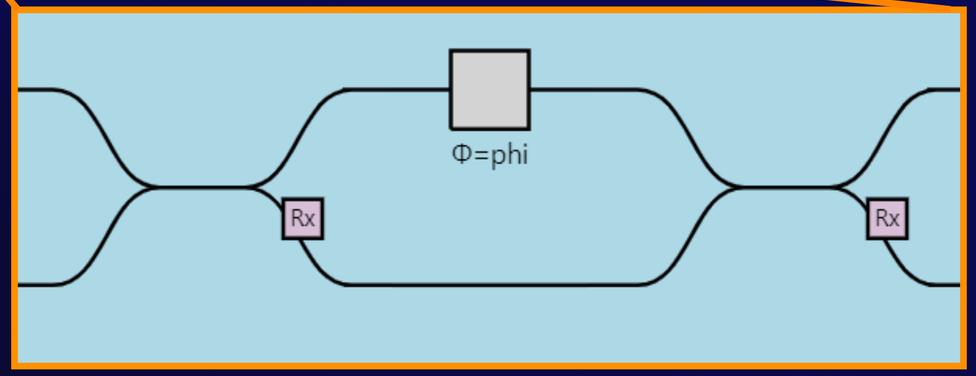
But is there more?

Injection Algorithm (IA)

An advanced approach

- Mach-Zehnder Interferometer (MZI) for ancilla injection
- Ancilla conditioned on data
- Beamsplitter cascade
- Employ photon loss





Figs. 14 & 15: Mach-Zehnder Interferometer

IA results

Tide prediction

- Continuous improvement over training data
- Very accurate prediction

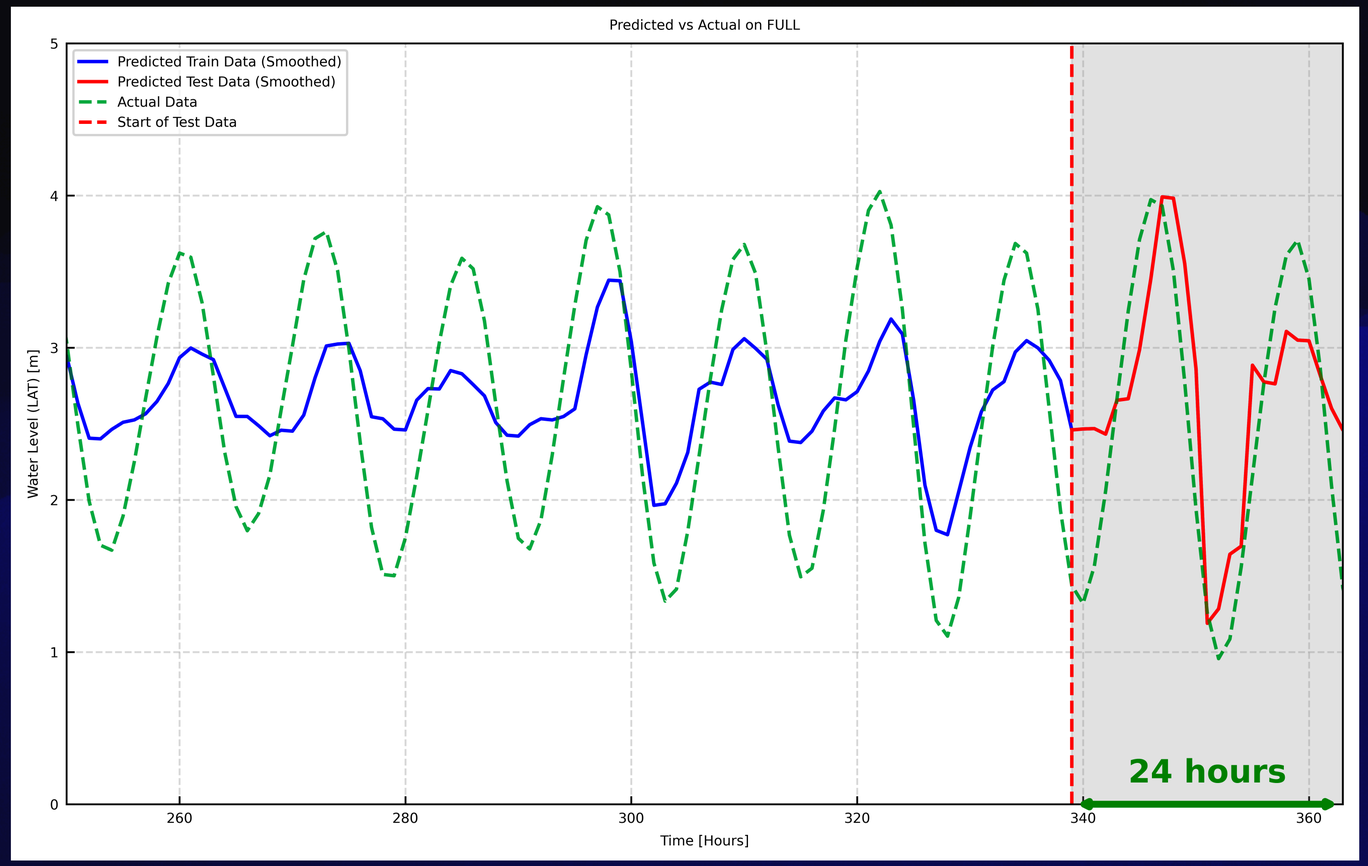


Fig. 16: Tide prediction for a whole day

“and do the other things, not because they are easy, but because they are hard”

John F. Kennedy

Roadmap for circuit improvement

If the LOQCathon would have lasted a week…

- Tweak the injection algorithm
- Adjust photon loss
- Optimize beamsplitter parameter setting

Outlook

What can be achieved with full quantum potential

- Predict stock market data
- Save energy and the World
- Get your surf session in with even more accurate predictions

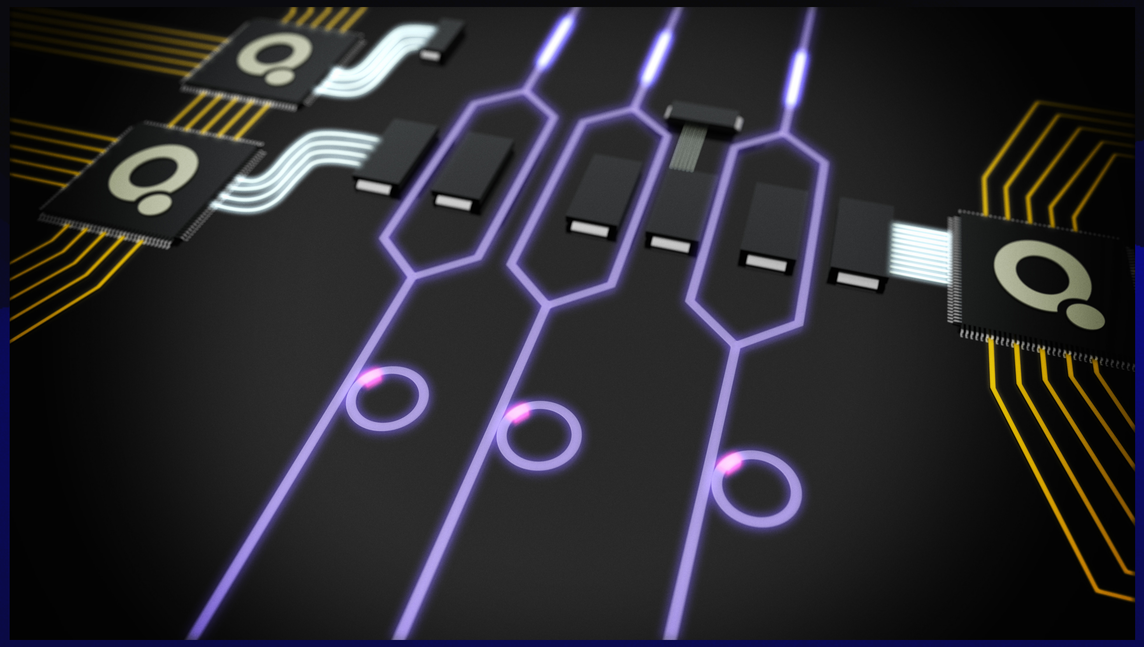


Fig. 17: Graphical representation of a photonic chip