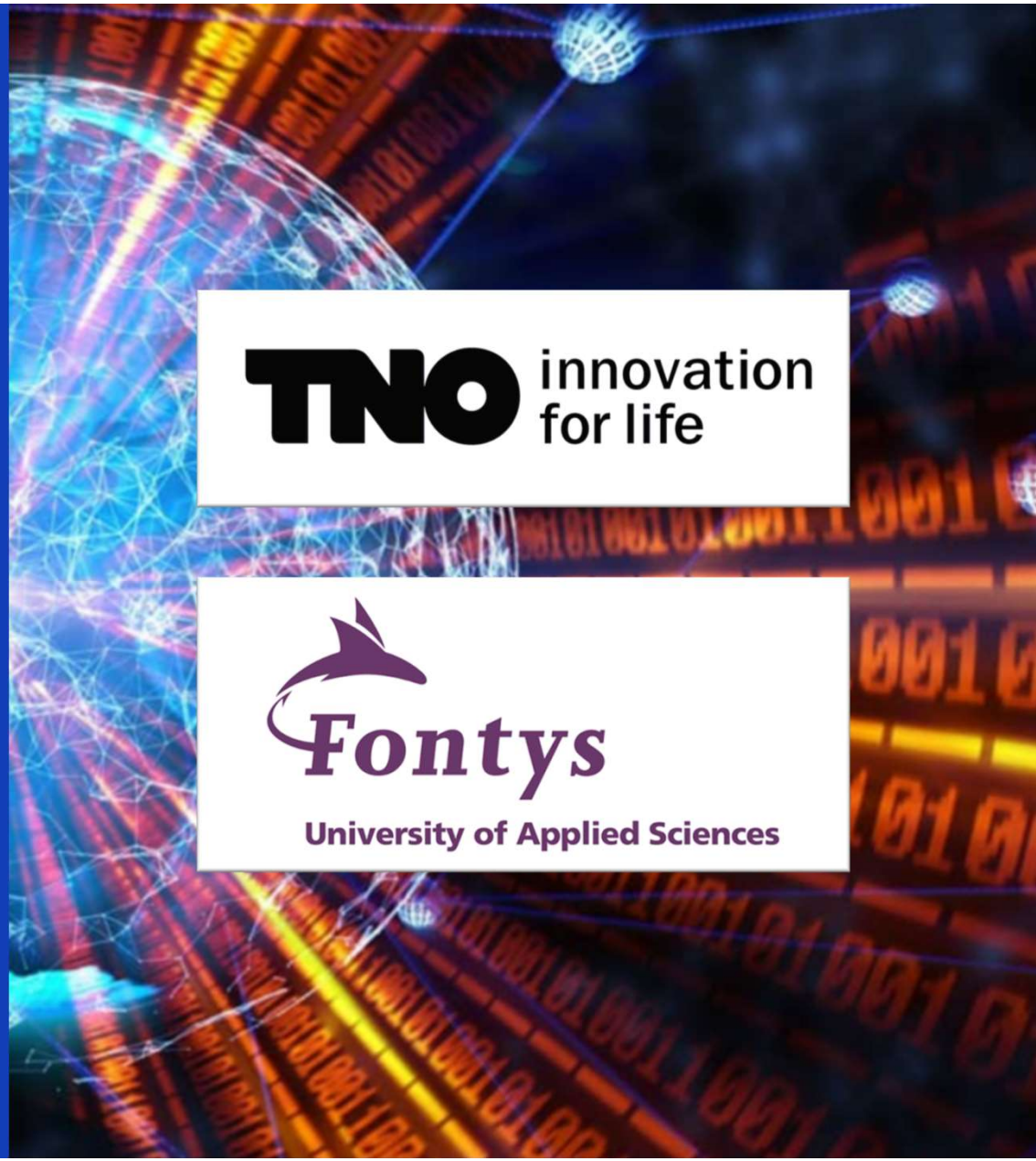
Evaluating Quantum Wire Cutting for QAOA

Performance Benchmarks in Ideal and Noisy Environments

Michel Meulen, Niels Neumann, Jasper Verbree

1 December 2025



TNO & Me

(EN) Dutch Organisation for Applied Scientific Research

(NL) Nederlandse Organisatie voor Toegepast-Natuurwetenschappelijk Onderzoek (TNO)

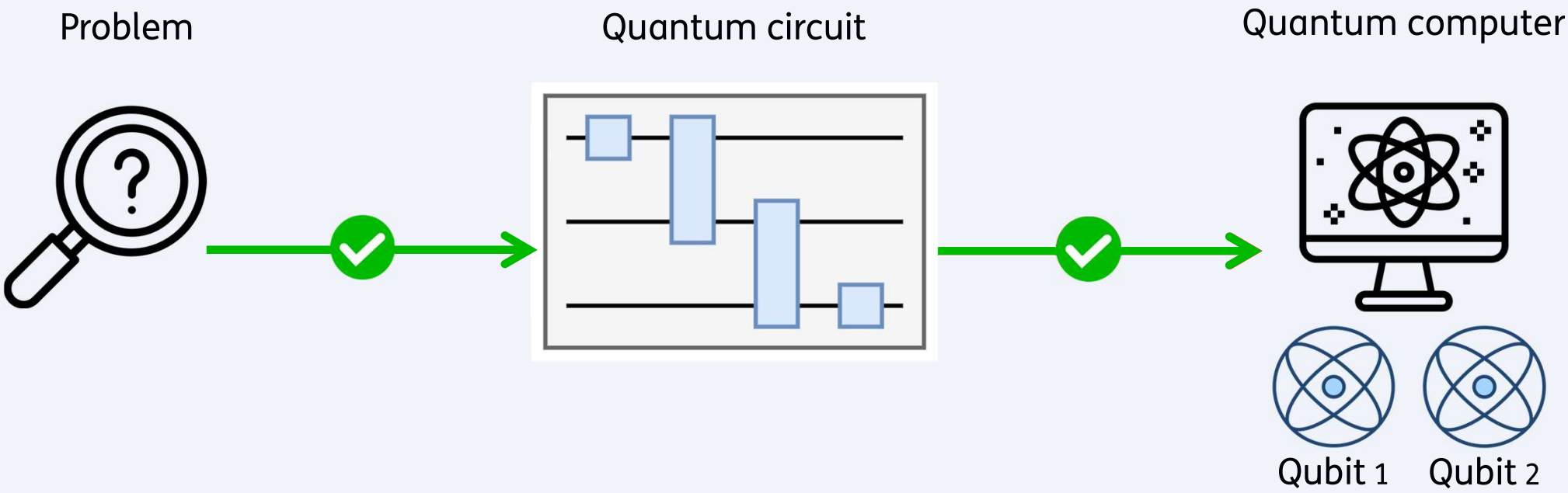
Working with industry, academia and government

Working on many topics e.g. quantum applications

Practical background in software engineering

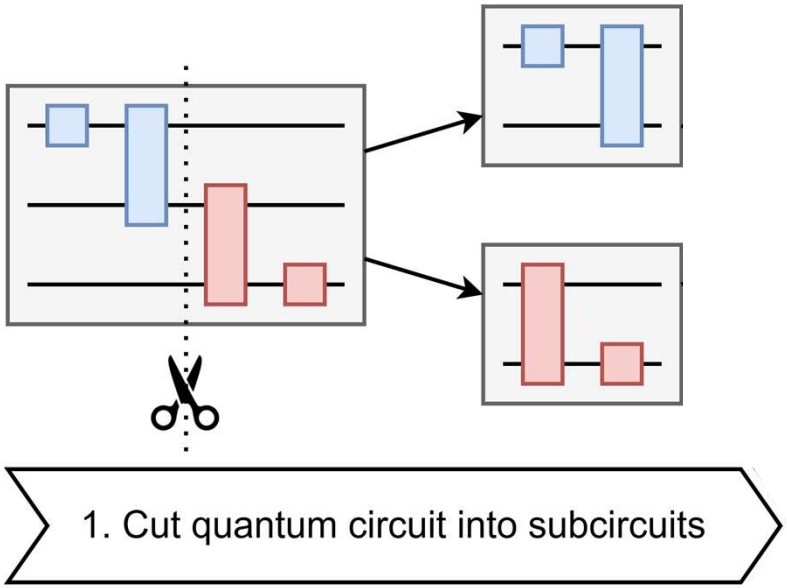
Main objective: Reducing the overhead generated by quantum wire cutting

Circuit cutting - Introduction



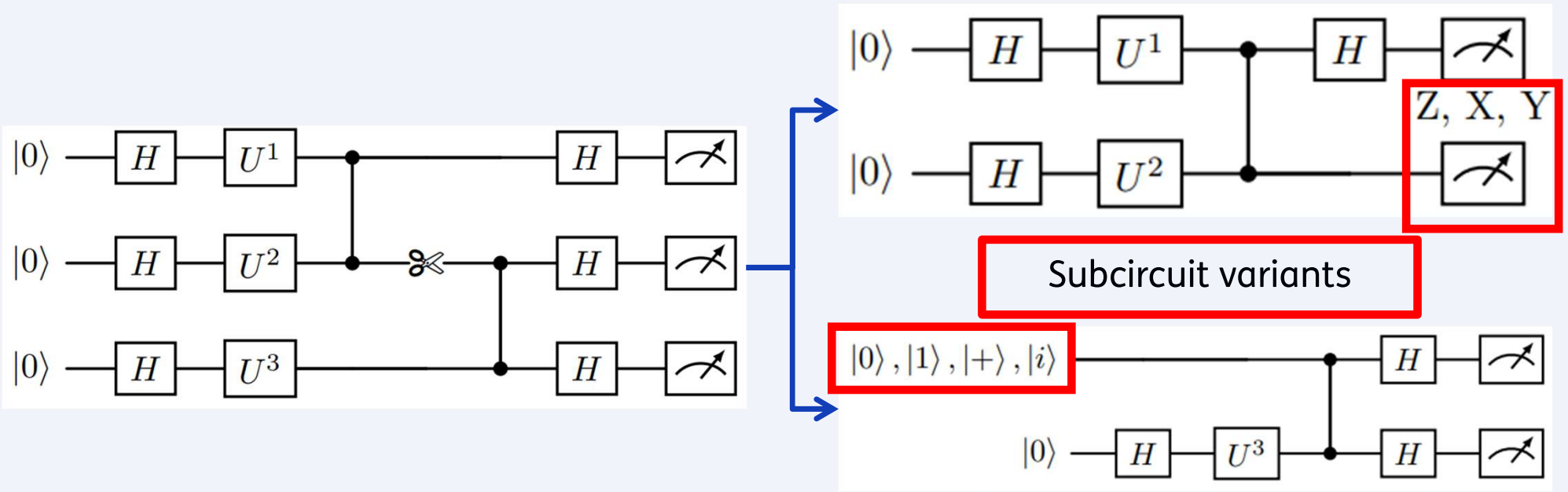
Pauli Wire Cutting - Overview

Based on: Peng et al. 2020



Pauli Wire Cutting - Example

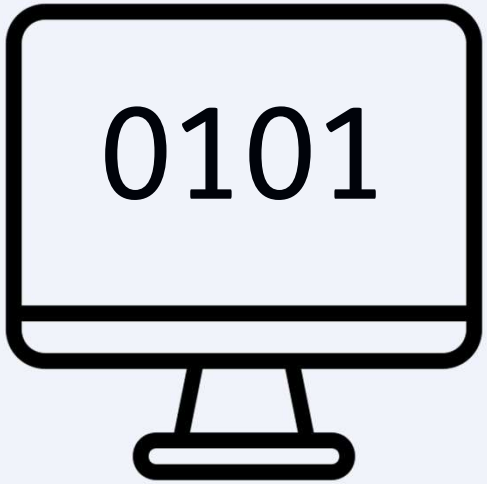
More circuits → More circuit evaluations



Pauli Wire Cutting – Classical Overhead

More wirecuts → More postprocessing

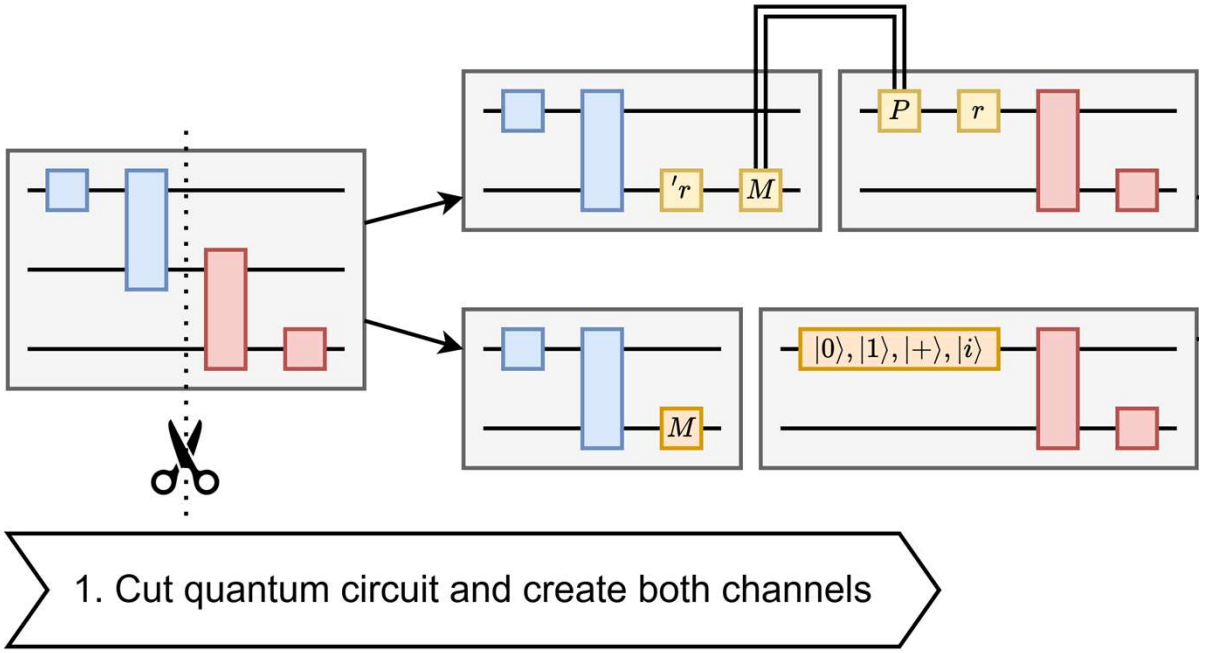
More qubits → More possible outcomes→ More postprocessing



How to reduce overhead from wirecutting?

Random Wire Cutting

Based on: Lowe et al. 2023



Wire Cutting Techniques

Pauli wire cutting

Random wire cutting
With Random Clifford

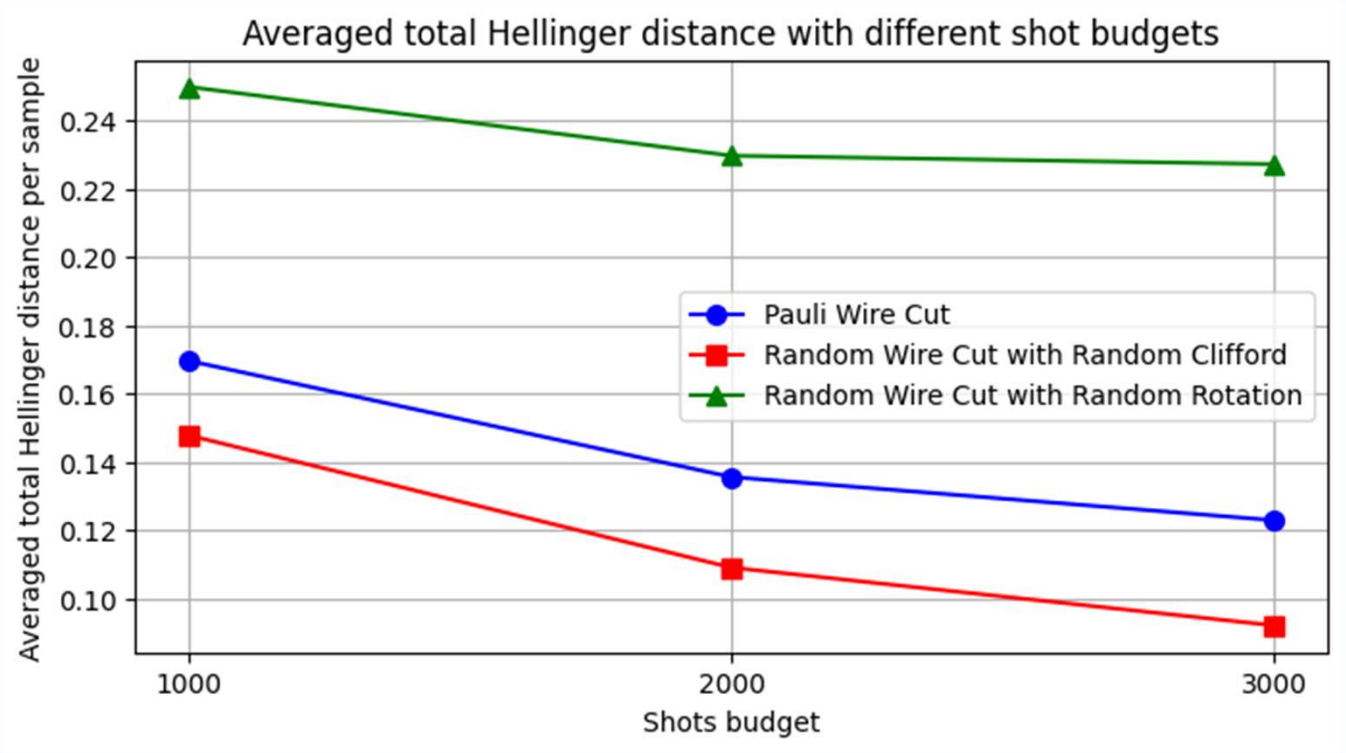
Random wire cutting
With Random Rotation

Comparison GHZ

Parameters:

- 5 qubit GHZ structured circuit
- Random rotation gates between Every CNOT gate
- 2 wirecuts
- 1000 samples

Hellinger distance (smaller is better)



Applying wire-cutting to a real problem?

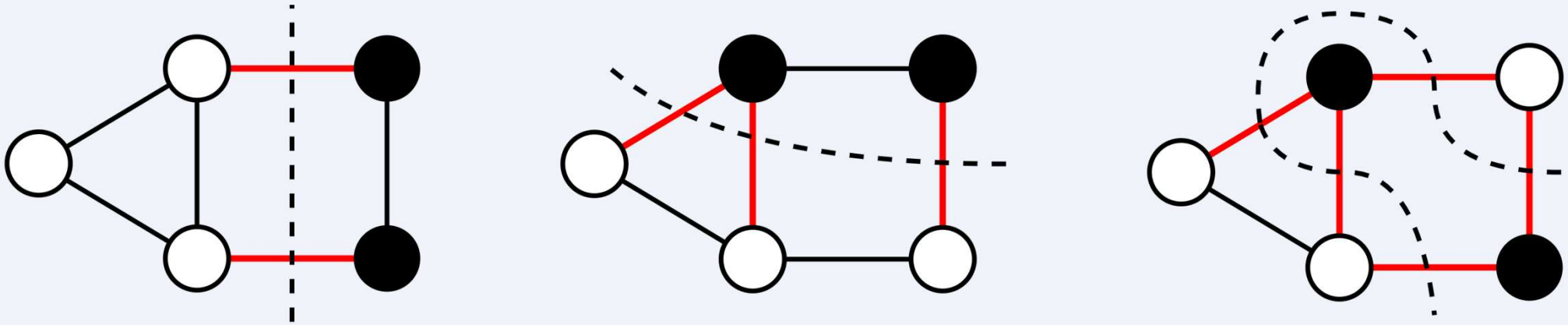
MAXCUT Problem

NP-complete optimization problem

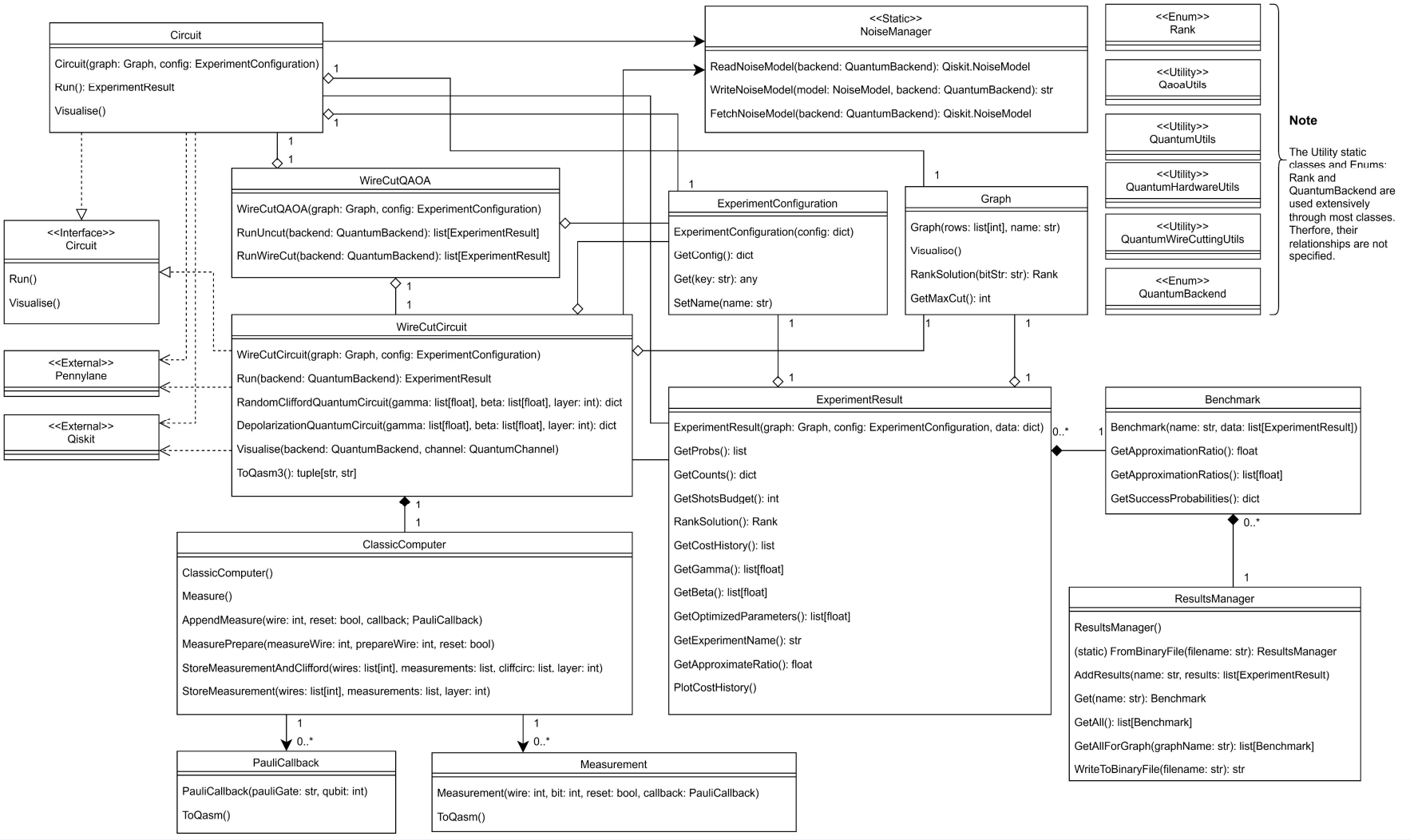
Seek two partitions where the number of edges connecting vertices in different subsets is maximized

Quantum Approximate Optimization Algorithm (QAOA)

- Classical optimization algorithm: Simultaneous Perturbation Stochastic Approximation (SPSA)
- Single QAOA layer ($p = 1$)

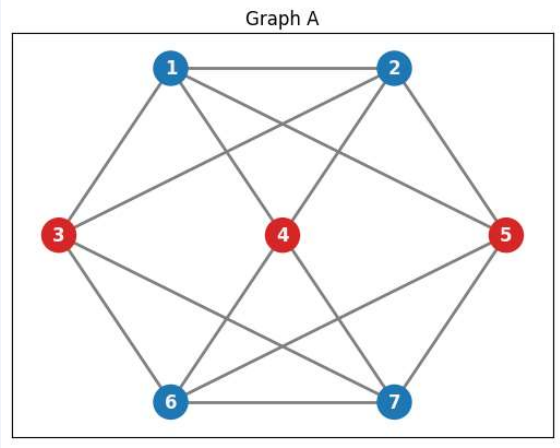


Software implementation

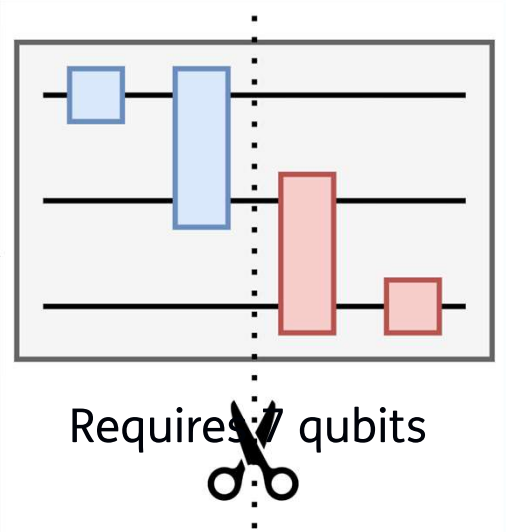


Wirecut-QAOA

MAXCUT problem

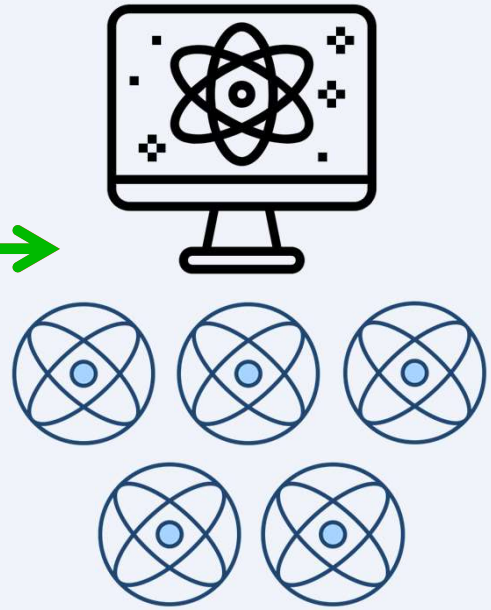


Quantum circuit



Requires ~~7~~ → 5 qubits

Quantum computer



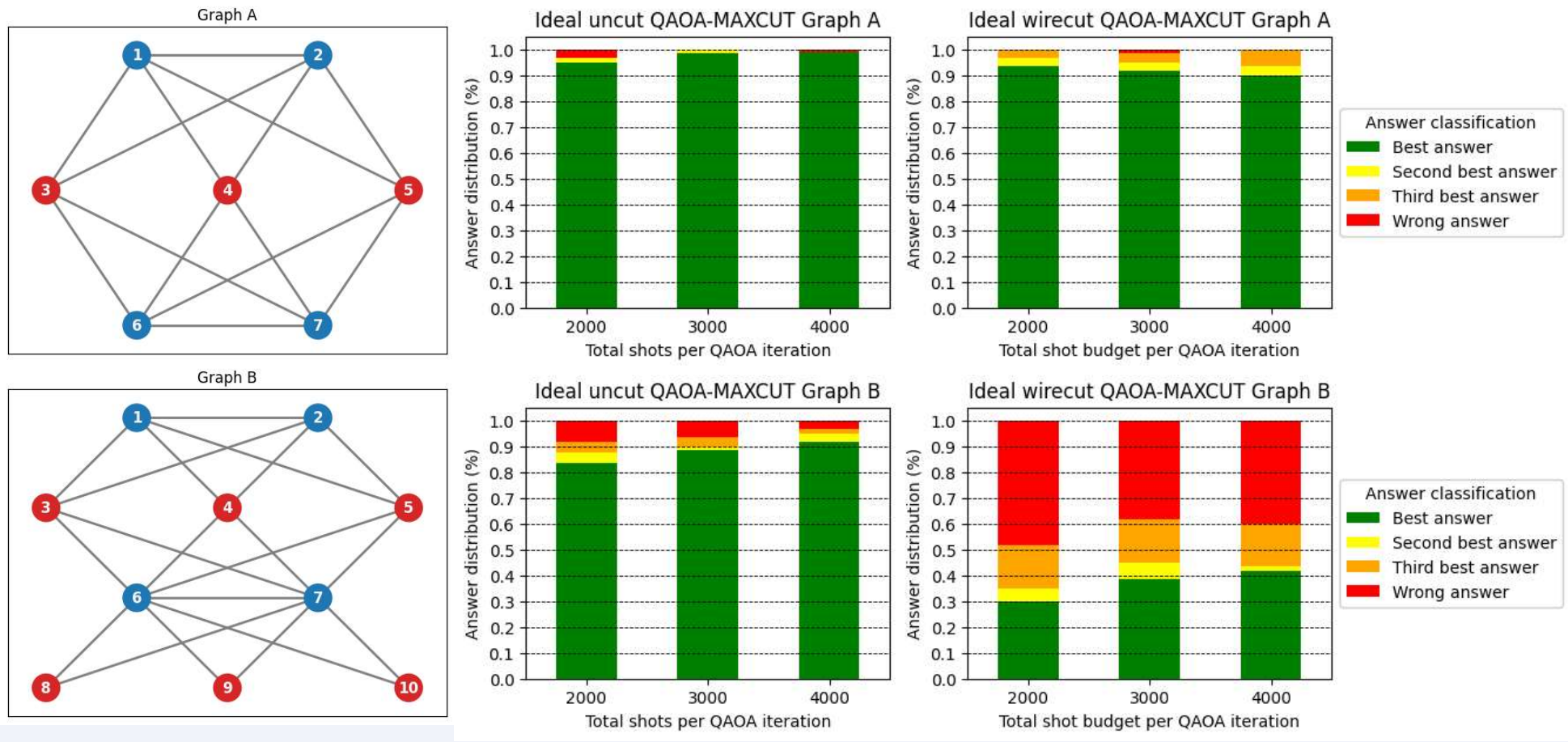
5 qubits

Wirecut-QAOA – Ideal simulation

Pennylane ideal simulations (sample size 120 and 60)

1 cut

2 cuts

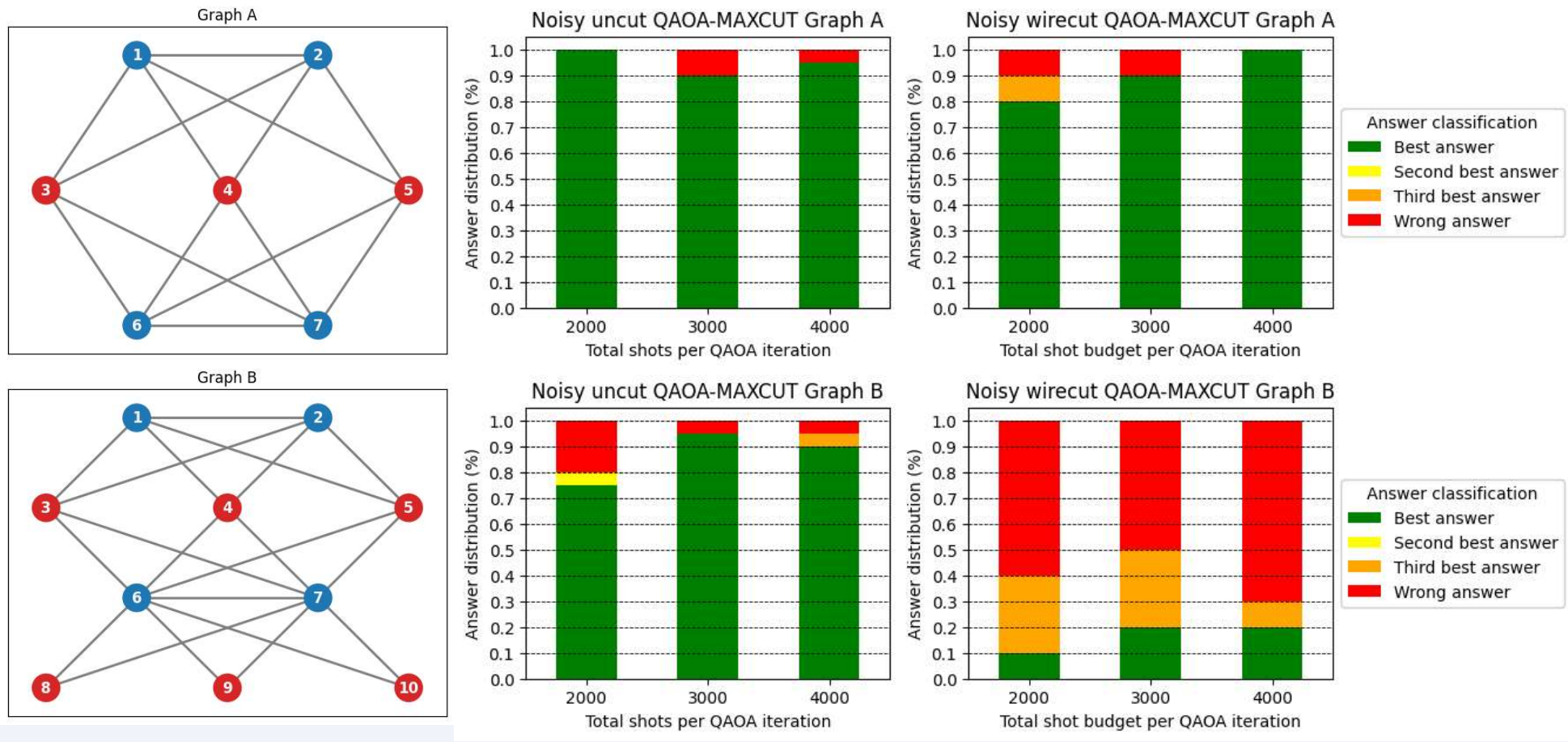


Wirecut-QAOA – Noisy simulation

Qiskit-aer simulations with the ibm_brisbane noise model (sample size 20 and 10)

1 cut

2 cuts



Limitations & Future Work

Limitations

- Simulation of noisy wirecut circuits is very computational heavy → Limited number of samples

Future work:

- More samples of noisy simulations
- Hardware validation
- Extending wire-cutting to other quantum algorithms

Conclusion

Random Wire Cut with Random Clifford is most accurate and efficient

Wire-cutting in QAOA lowers qubit needs but reduces accuracy

Accuracy loss can be mitigated by higher shot budgets

In this work:

In noisy simulations a practical problem can be solved with less qubits using wire-cutting

Thank you for your time and attention