On-Chip Verified Quantum Computation: ocvqc-py

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LIP6

QUANTINUUM

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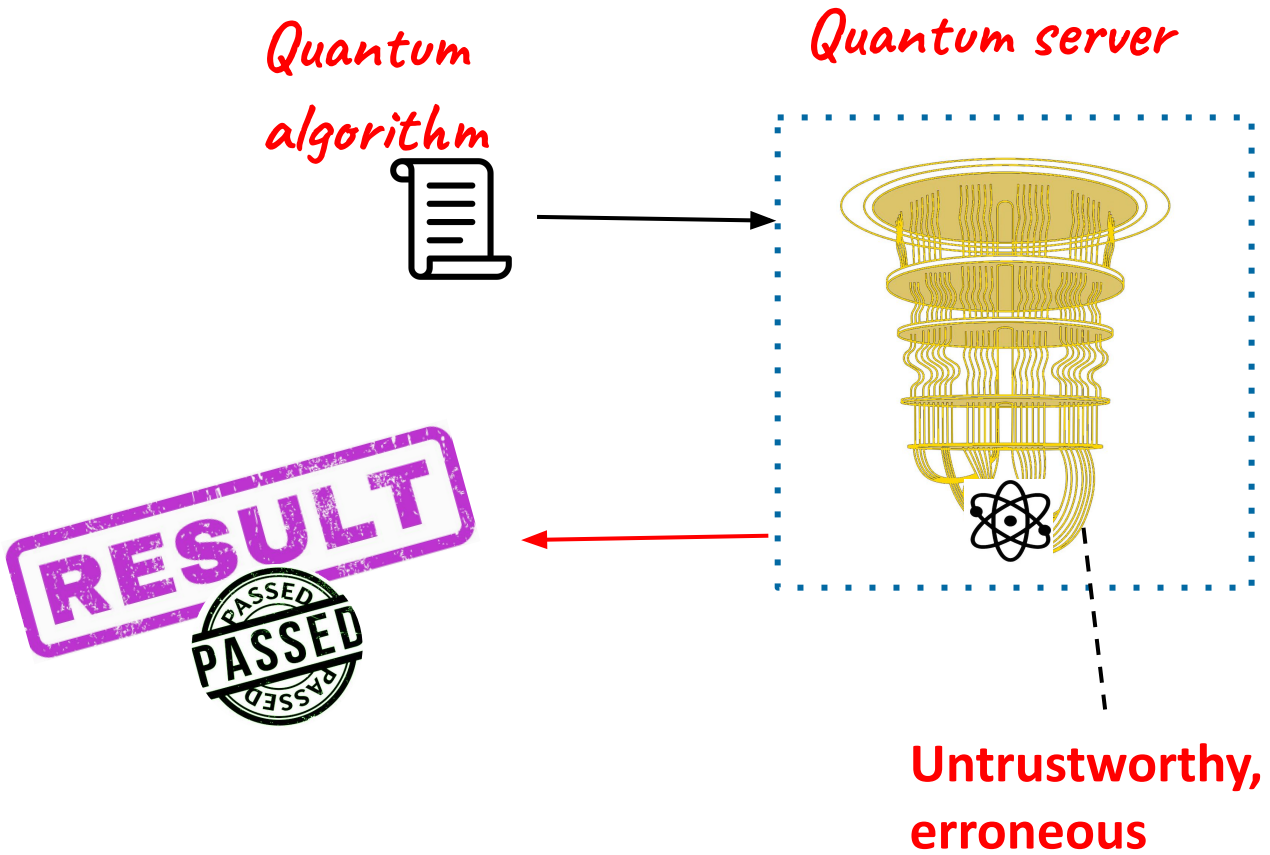
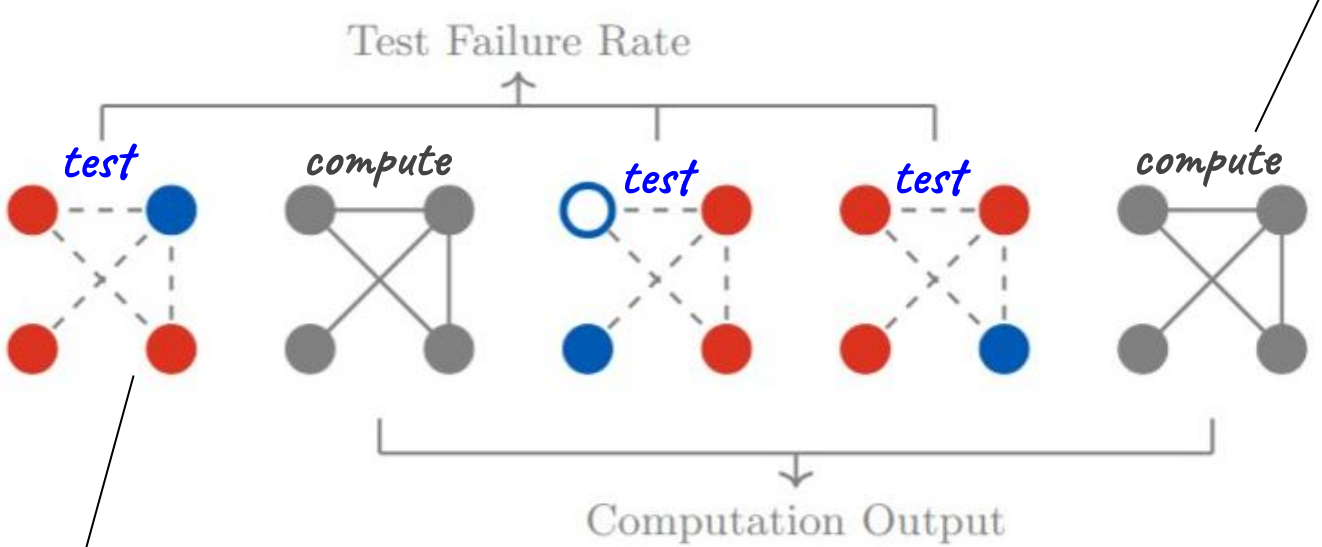
"on chip" Verification



On-chip verification protocol

Measurement-Based Quantum Computation (MBQC)

PASS / FAIL

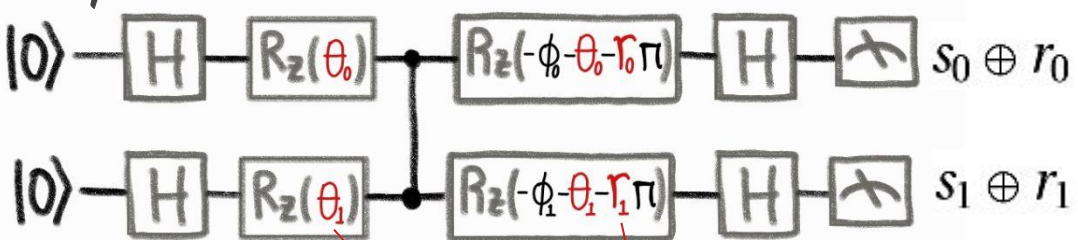


one measurement shot

RESULT

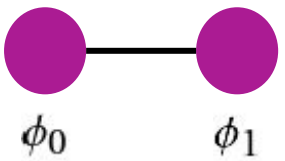
Verified MBQC in the gate model

compute

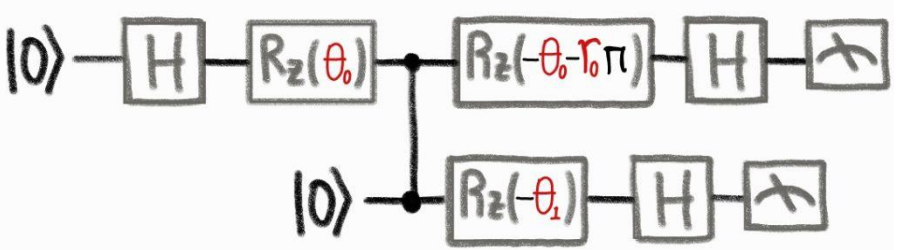


Random numbers per shot, per node

MBQC



test



0: pass

1: fail

Single shot!

Randomness per measurement shot

1. To decide: compute or test
2. Which coloring if test
3. Random θ for each node
4. Randomize bit r for each node

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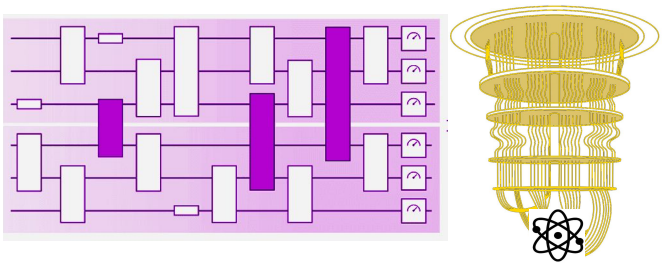
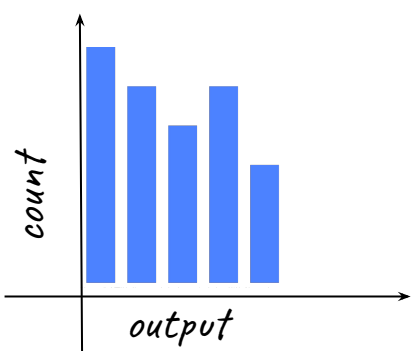
common setups in quantum software stack

>Run the same circuit multiple times

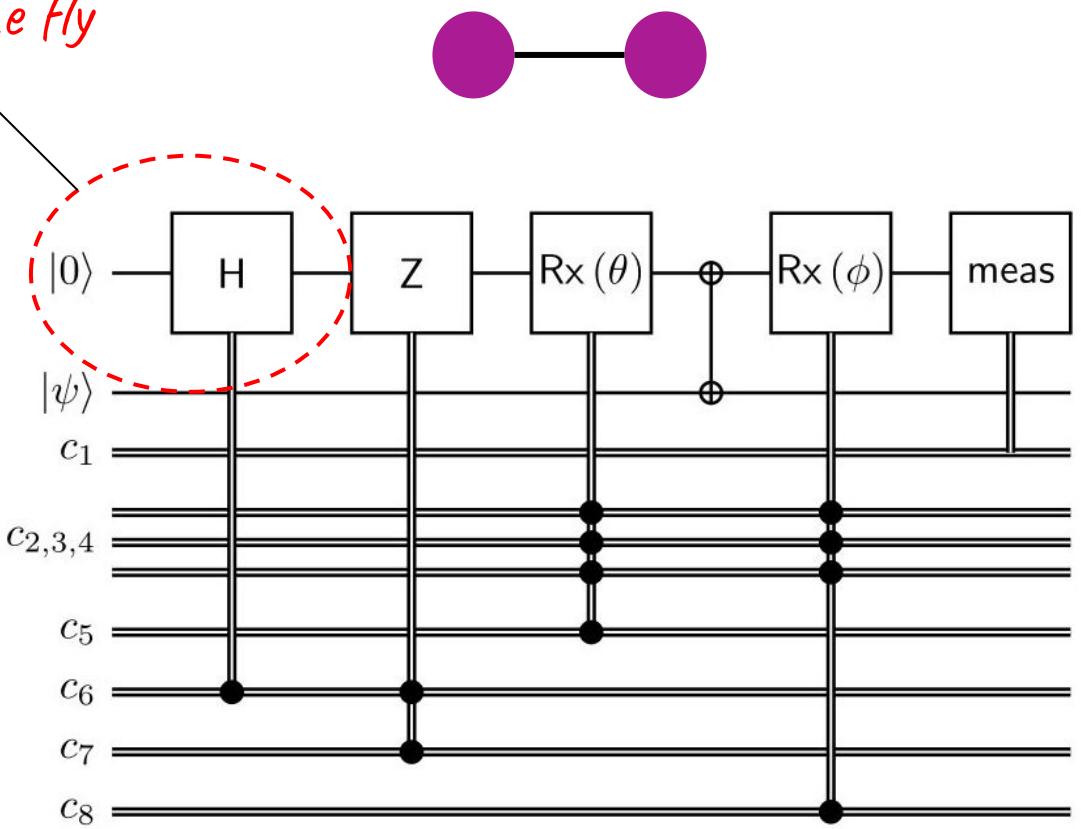
>No RNG





ocvqc-py: *possible to run on the common framework*

Create randomness on the fly



Capability requirements:

> Mid-circuit measurement

> classically-controlled rotations

Verified Z operation

```python
from ocvqc_py import GraphCircuit

graph_circuit = GraphCircuit(
    n_physical_qubits=2,
    n_logical_qubits=3,
    vertex_is_dummy_list=[
        [True, False, True],
        [False, True, False],
    ],
)

vertex_one = graph_circuit.add_graph_vertex(measurement_order=0)
vertex_two = graph_circuit.add_graph_vertex(measurement_order=1)

graph_circuit.add_edge(vertex_one, vertex_two)
graph_circuit.corrected_measure(vertex=vertex_one, t_multiple=4)

vertex_three = graph_circuit.add_graph_vertex(measurement_order=None)
graph_circuit.add_edge(vertex_two, vertex_three)
graph_circuit.corrected_measure(vertex=vertex_two, t_multiple=0)

graph_circuit.corrected_measure(vertex=vertex_three, t_multiple=0)
```

pyTKET Circuit

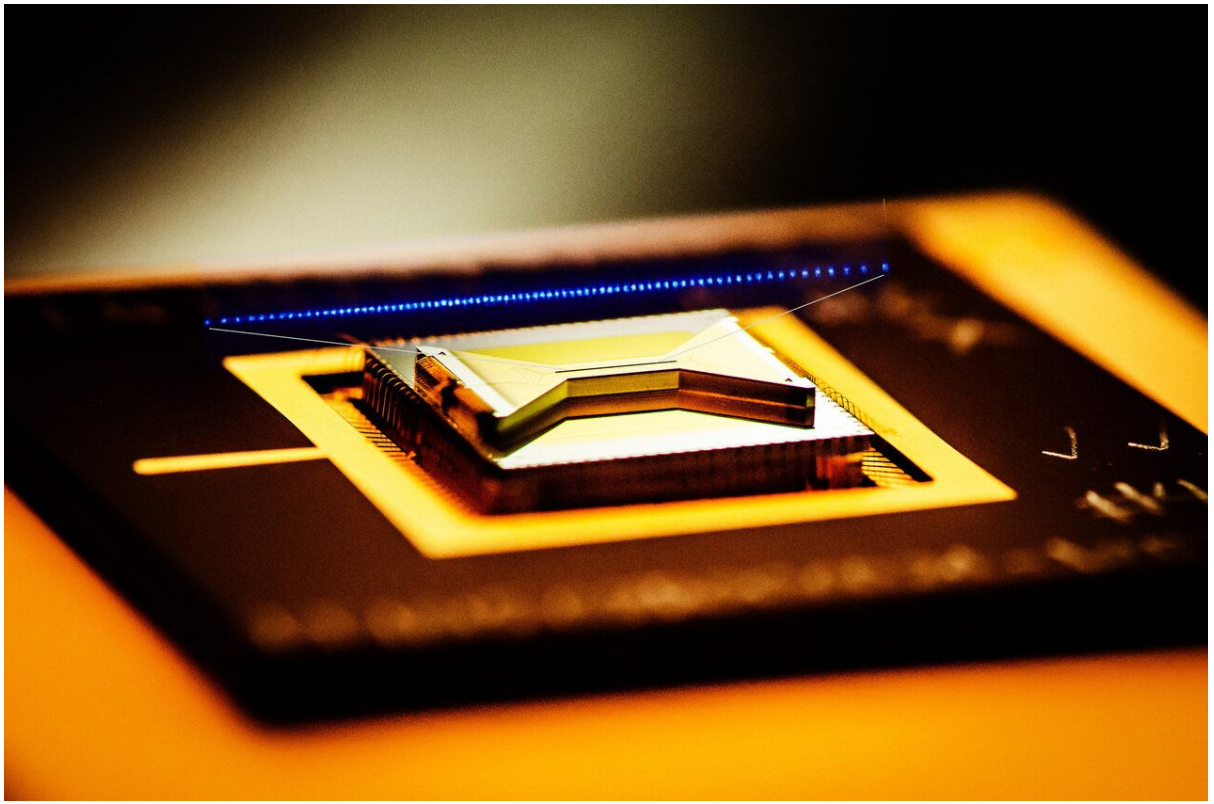
Compile to various quantum Computer backends: IBM, IonQ, Honeywell, ...

Ordering follows measurement pattern

Compiled operations of verified Z

Demonstrated on ion traps: 20 qubits

QUANTINUUM



Credit: Duke University, staq.pratt.duke.edu/

Verified Grover quantum search algorithm

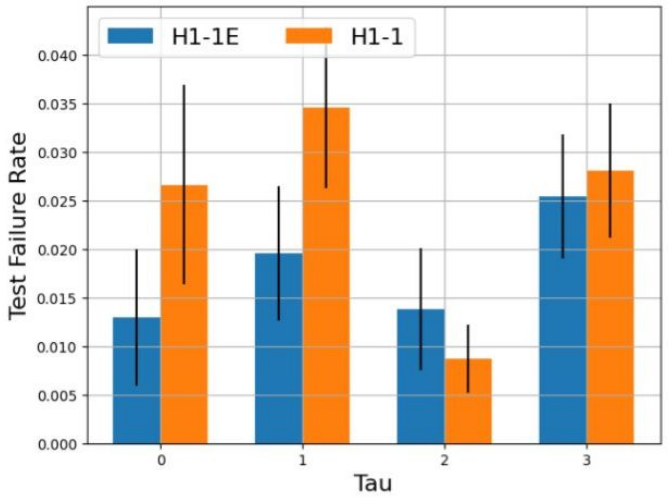
param	angle
ϕ_1	0
ϕ_2	0
ϕ_5	0
ϕ_6	0
ϕ_8	π
ϕ_7	π

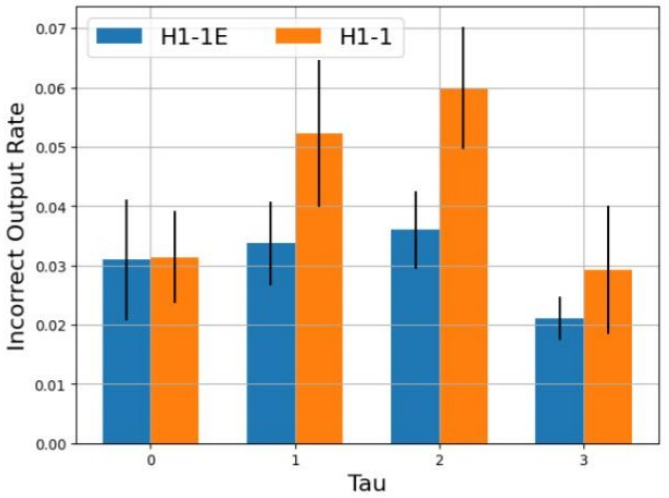
$\tau = 0$	
ϕ_3	π
ϕ_4	π

$\tau = 1$	
ϕ_3	π
ϕ_4	0

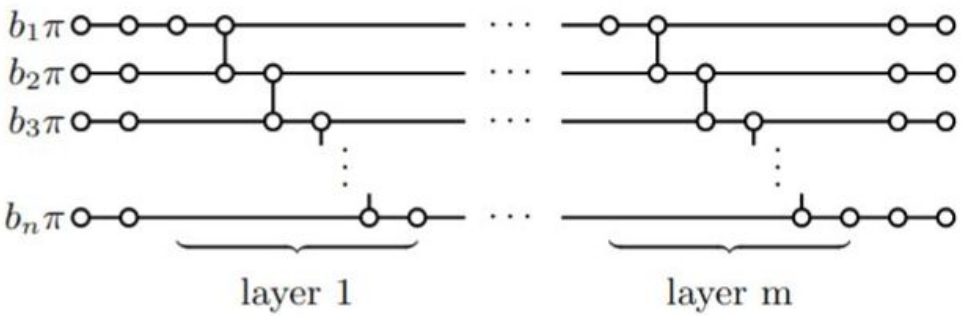
$\tau = 2$	
ϕ_3	0
ϕ_4	π

$\tau = 3$	
ϕ_3	0
ϕ_4	0



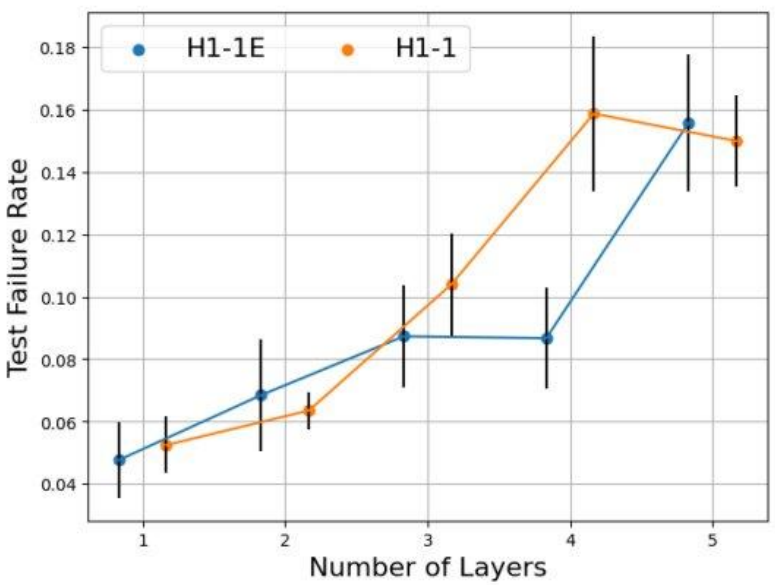


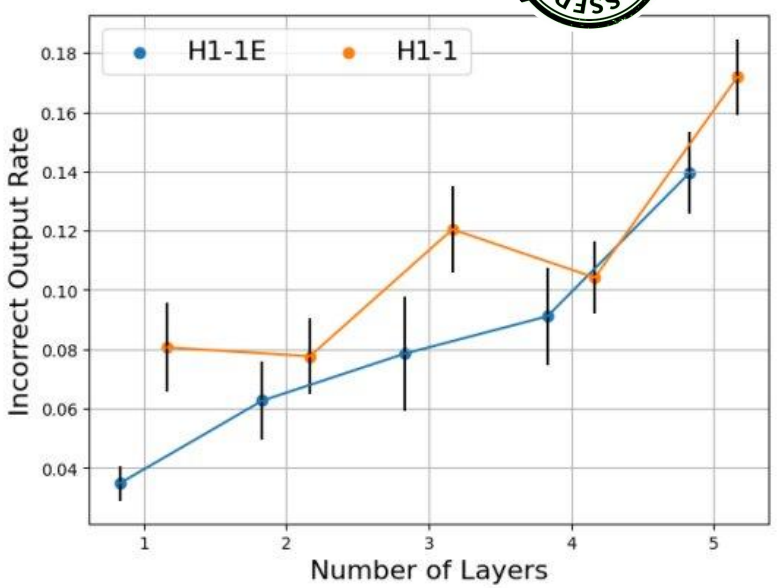
Verified 52-node MBQC: Largest to date!



RESULT

PASSED





Thank you for listening!