

Quantum Computer Simulation on Intel KNL

Thomas Häner, Damian Steiger

For more details

0.5 Petabyte Simulation of a 45-Qubit Quantum Circuit

Thomas Häner*, Damian S. Steiger*

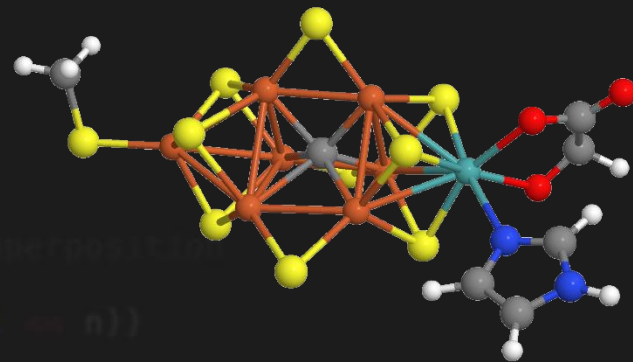
**Institute for Theoretical Physics, ETH Zurich, 8093 Zurich, Switzerland*

Wednesday 2:30pm in room 301-302-303

Our paper on arXiv 1704.01127

Simulating quantum computers

✓ or ✗



Debugging new algorithms

Determine time step sizes, ...

Simulation is important BUT...

Quantum Simulator

Qubits	Memory	Time for one gate
10	16 kByte	microseconds on a smart watch

Quantum Simulator

Qubits	Memory	Time for one gate
10	16 kByte	microseconds on a smart watch
20	16 MByte	milliseconds on a smartphone

Quantum Simulator

Qubits	Memory	Time for one gate
10	16 kByte	microseconds on a smart watch
20	16 MByte	milliseconds on a smartphone
30	16 GByte	seconds on a laptop

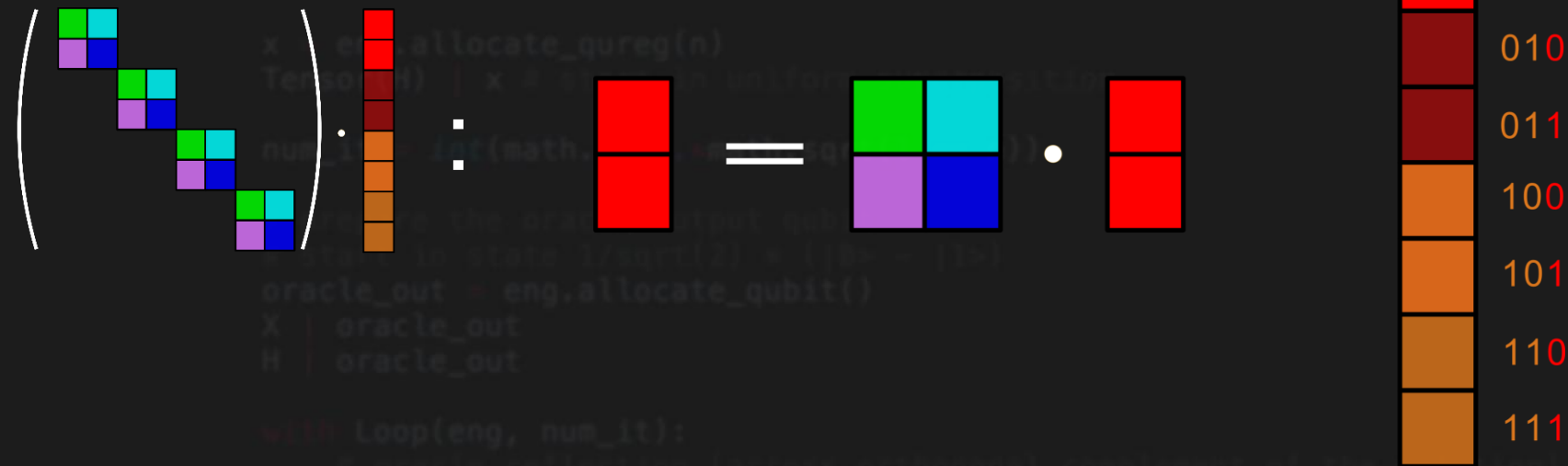
Quantum Simulator

Qubits	Memory	Time for one gate
10	16 kByte	microseconds on a smart watch
20	16 MByte	milliseconds on a smartphone
30	16 GByte	seconds on a laptop
40	16 TByte	minutes on a supercomputer

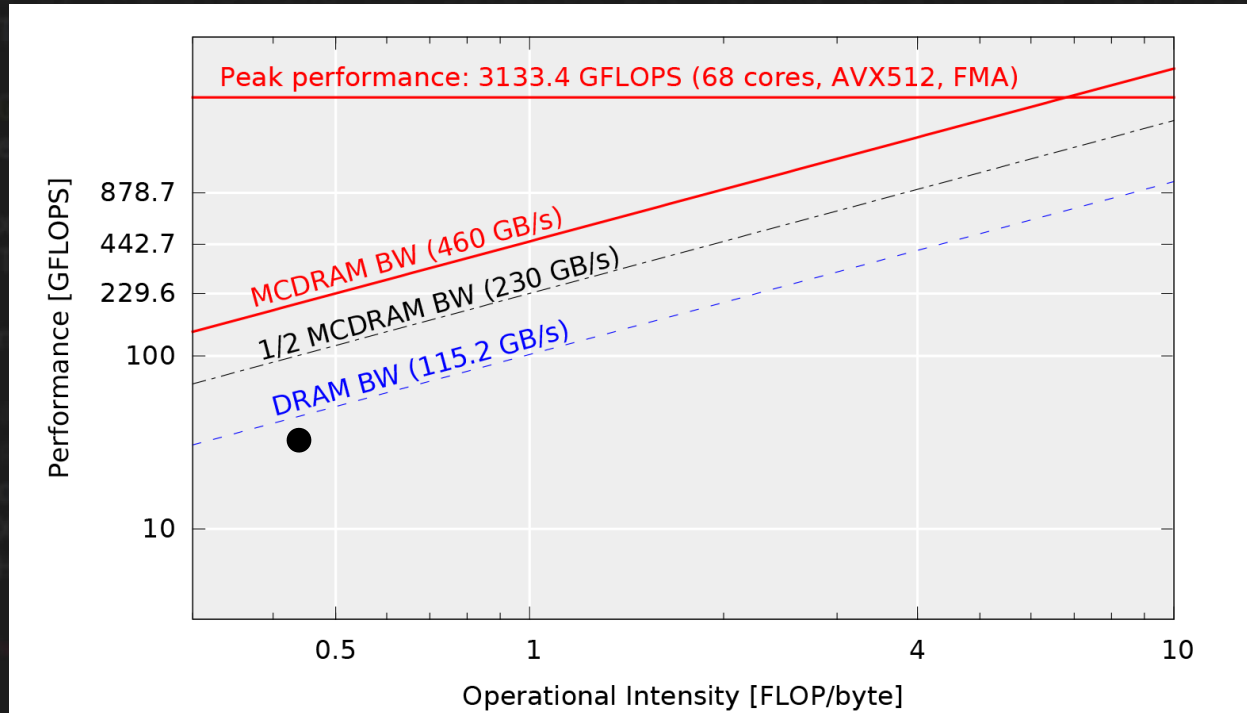
Quantum Simulator

Qubits	Memory	Time for one gate
10	16 kByte	microseconds on a smart watch
20	16 MByte	milliseconds on a smartphone
30	16 GByte	seconds on a laptop
40	16 TByte	minutes on a supercomputer
260	each particle of visible universe	age of universe

Quantum Gate Kernel

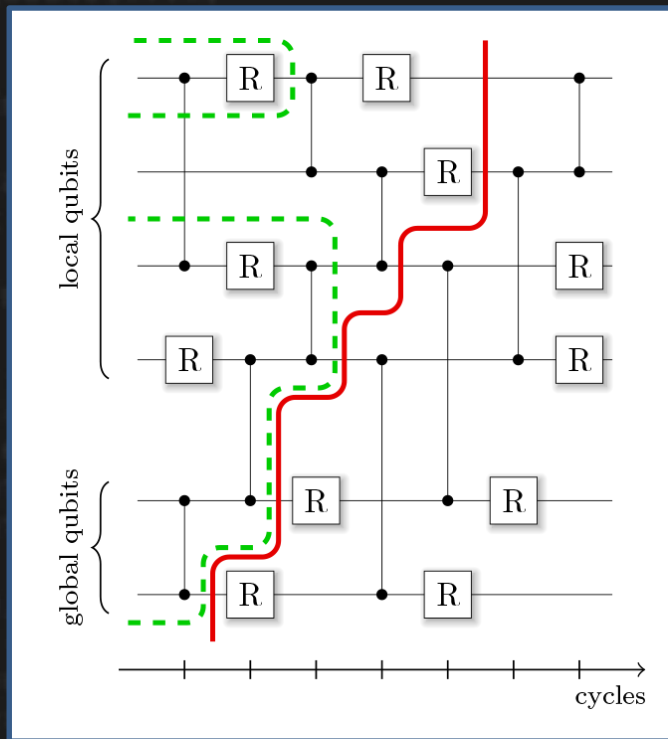


Roofline performance

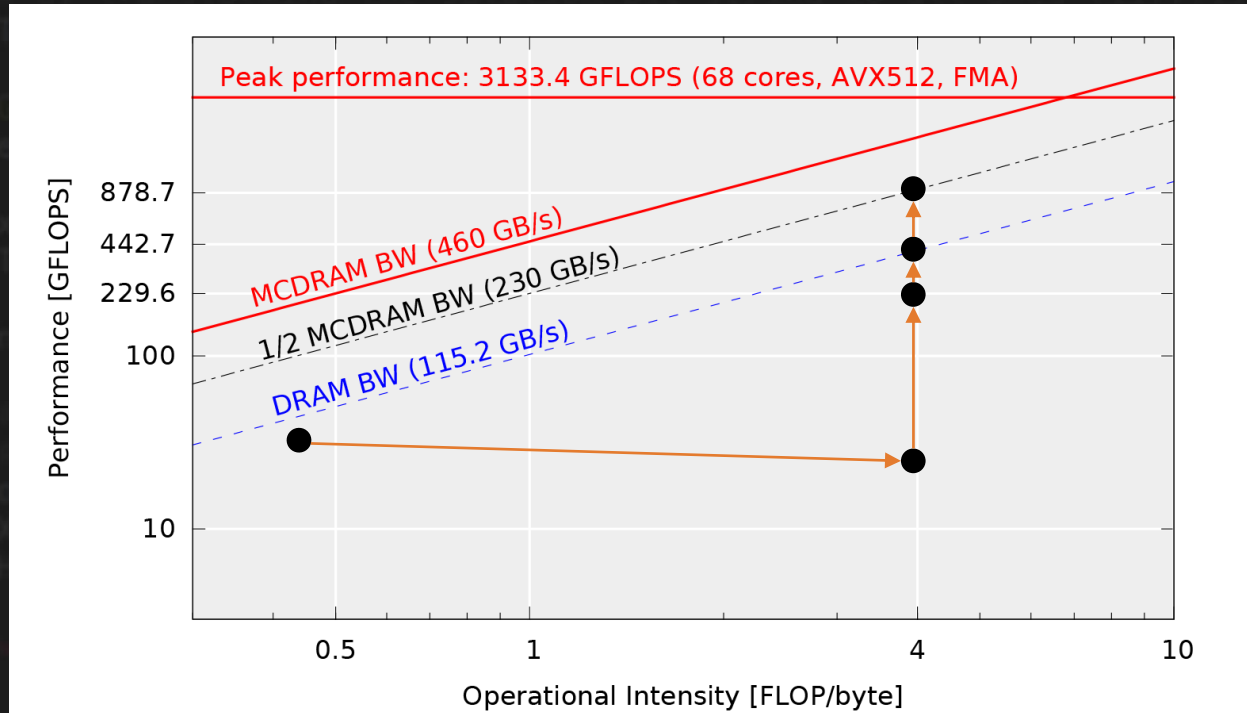


Intel Xeon Phi (KNL) 7250

Gate scheduling and specialization

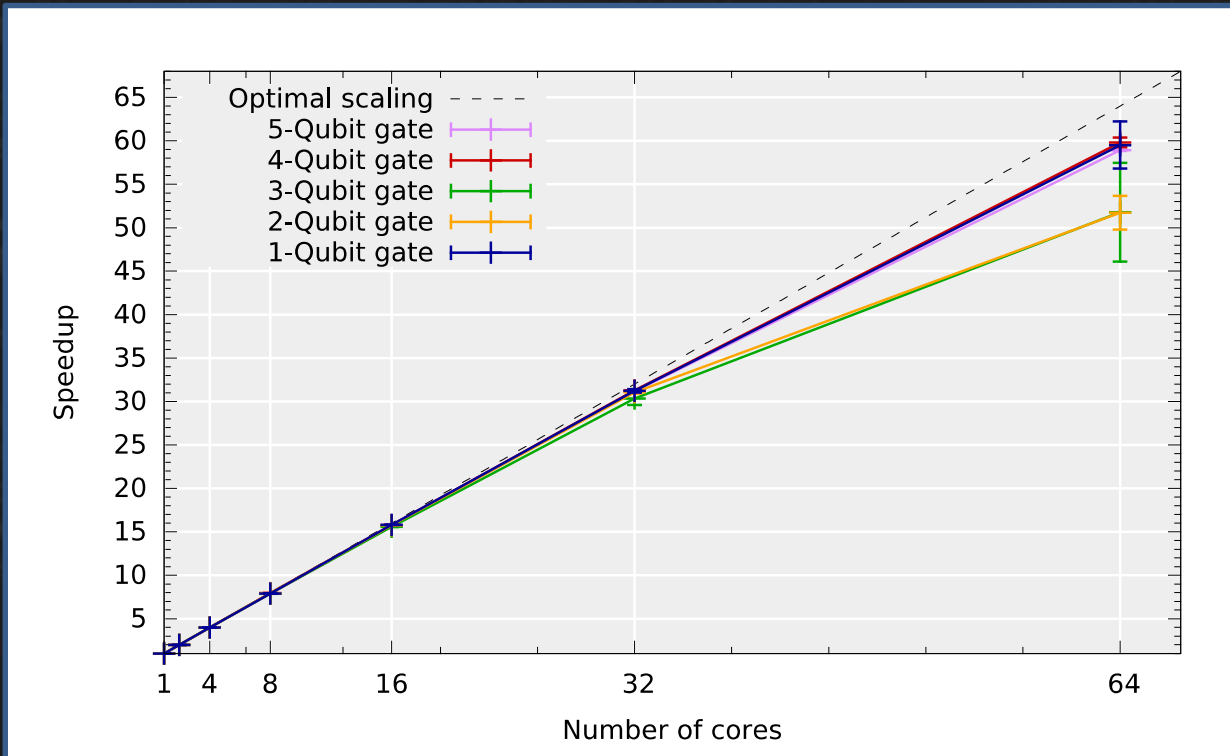


Roofline performance

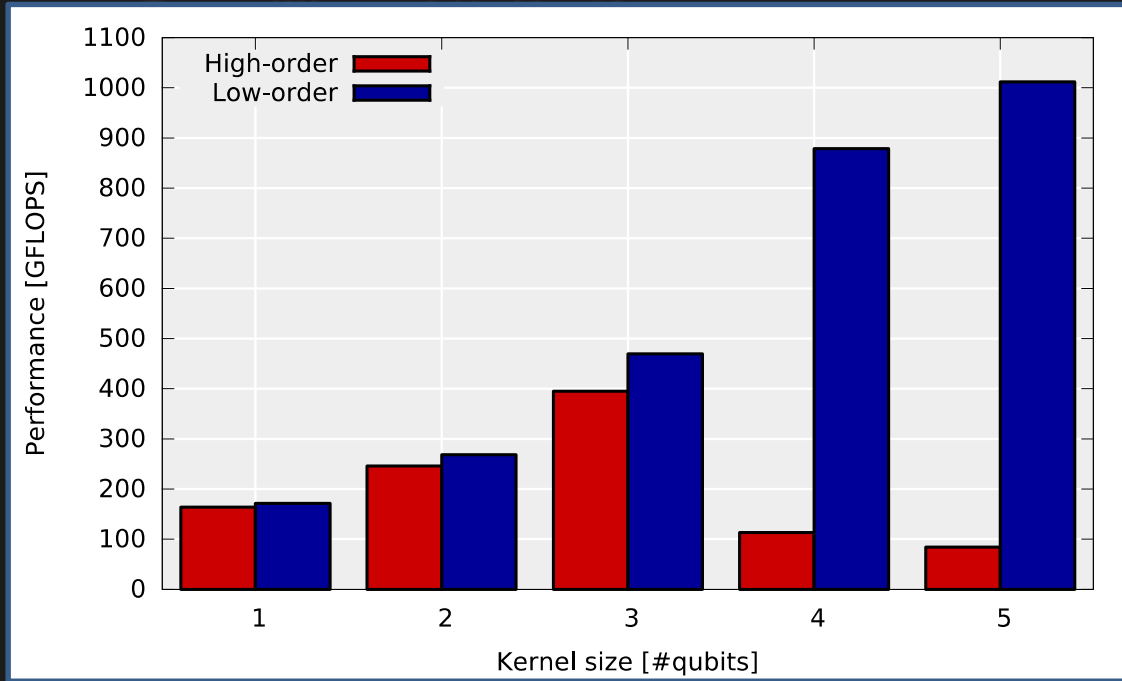


Intel Xeon Phi (KNL) 7250

Strong scaling KNL node



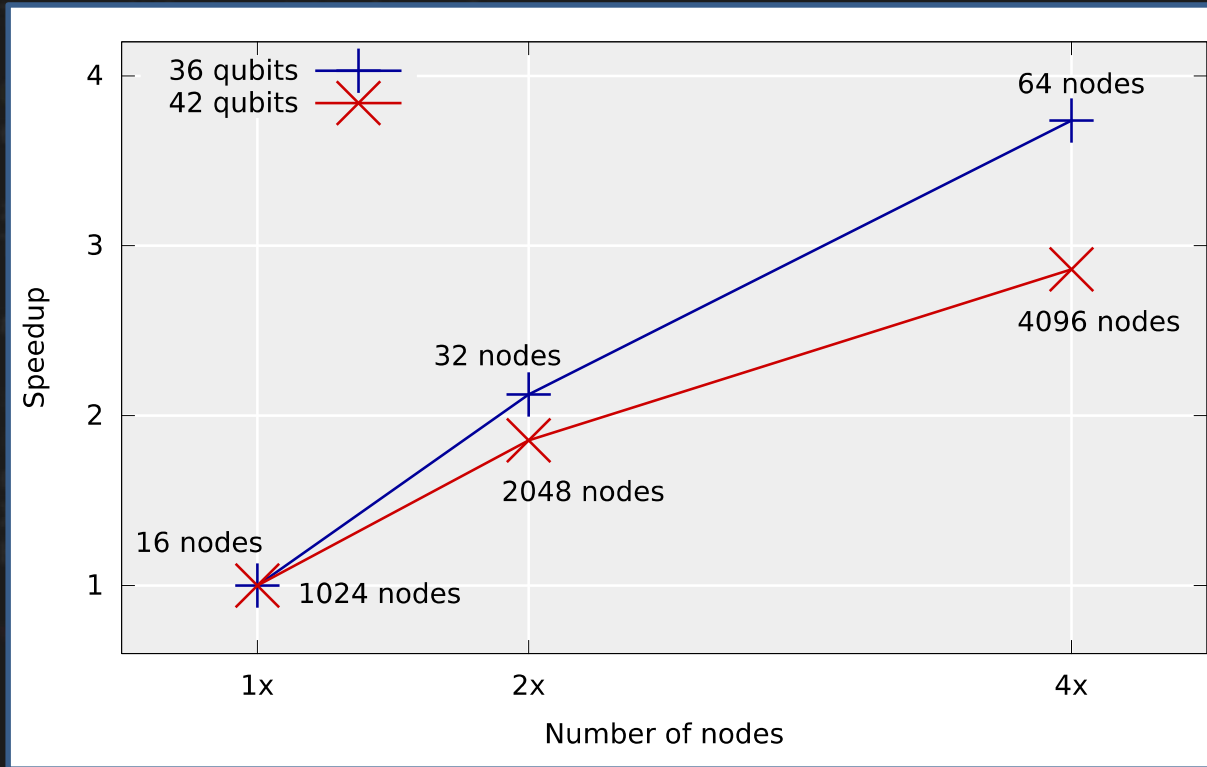
Performance drop



For a 3 qubit gate on qubit 0, 3, and 7:

```
V[***0***0**0]
V[***0***0**1]
V[***0***1**0]
V[***0***1**1]
V[***1***0**0]
V[***1***0**1]
V[***1***1**0]
V[***1***1**1]
```

Multi-node strong scaling



Summary

- Optimizations at all levels
 - Circuit-level
 - Cluster-level (MPI)
 - Node-level (OpenMP, vectorization, blocking, ...)
- > 10x improvement at all scales (on KNL)

For more details

0.5 Petabyte Simulation of a 45-Qubit Quantum Circuit

Thomas Häner*, Damian S. Steiger*

**Institute for Theoretical Physics, ETH Zurich, 8093 Zurich, Switzerland*

Wednesday 2:30pm in room 301-302-303

Our paper on arXiv 1704.01127

Thanks for your attention!