Low-Resource Challenges and Opportunities in Quantum Computing

Tobias Hartung

Northeastern University - London

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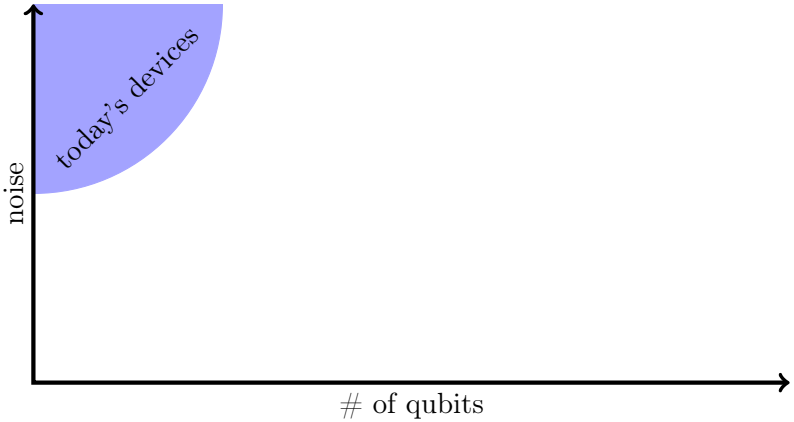
./me

- Associate Professor in Computer Science at Northeastern University London

- mathematician
- work a lot with high energy physicists
- quantum computing and quantum algorithm research since 2018

Current Quantum Computers



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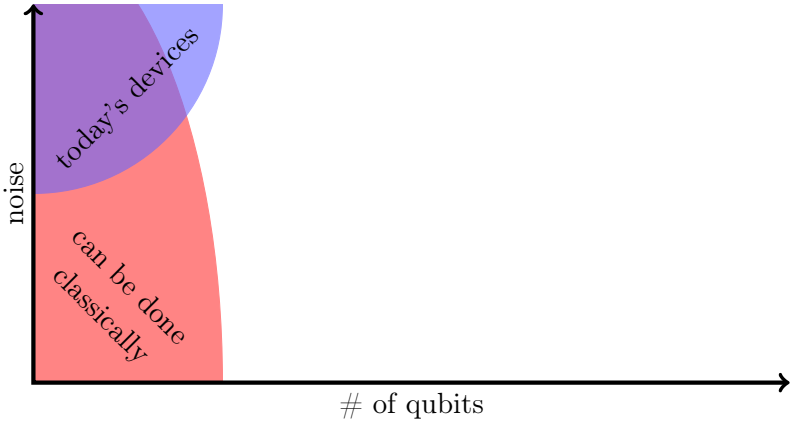

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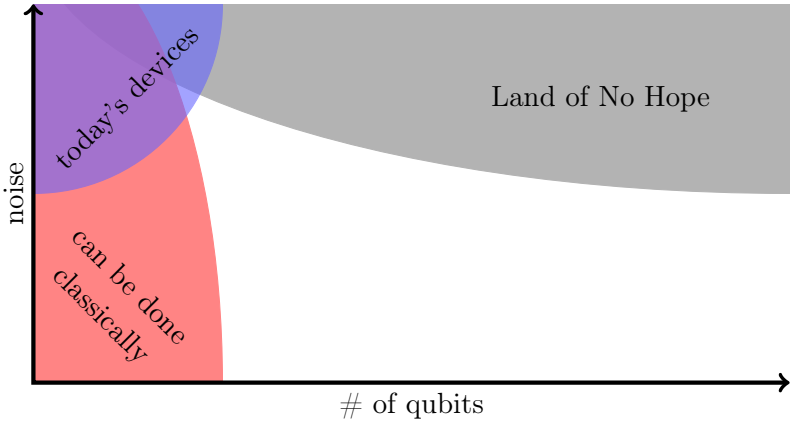

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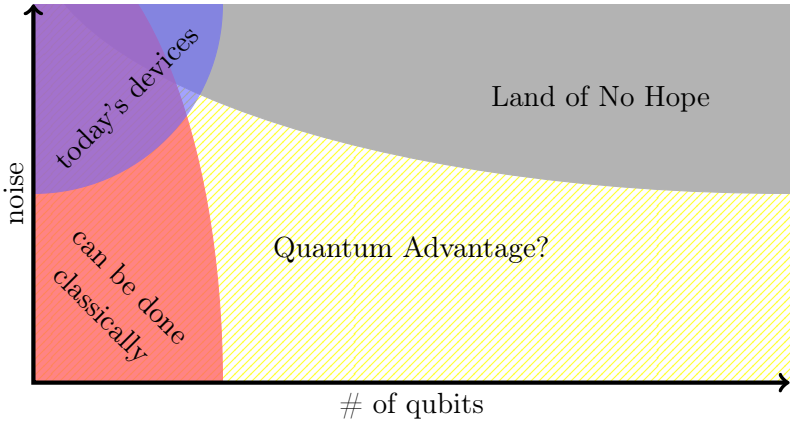

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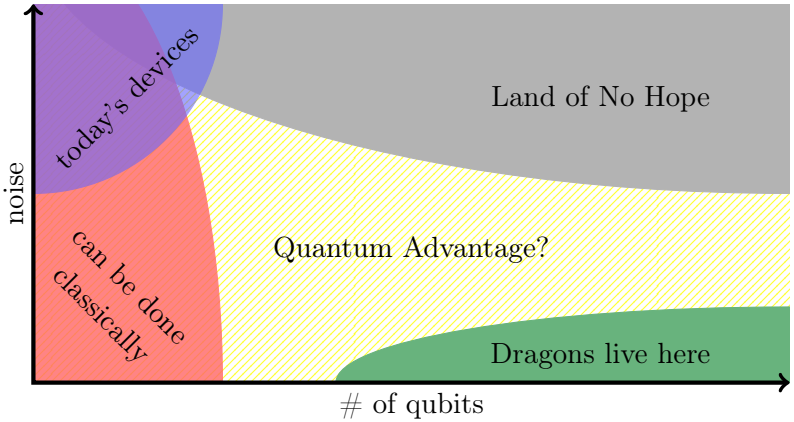

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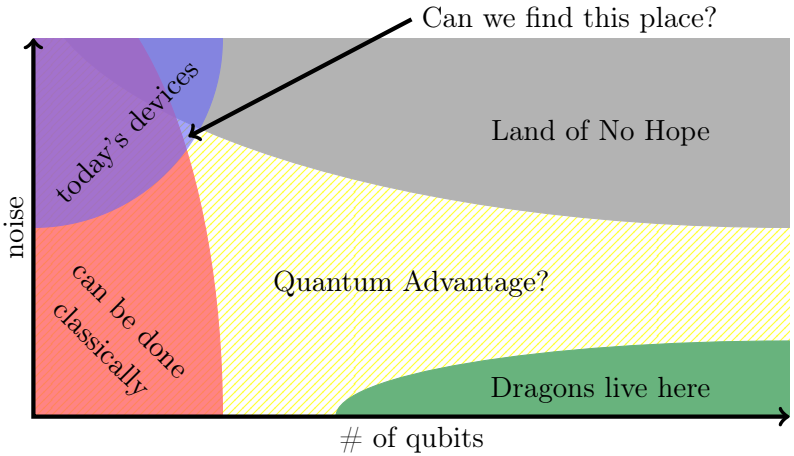
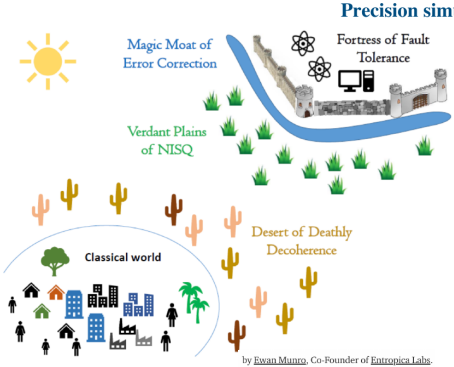
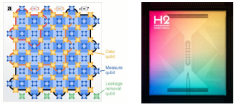
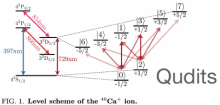


How to find dragons when not in Wales?







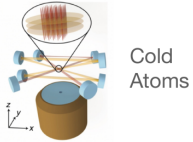


image credit: Martin Savage @U Washington

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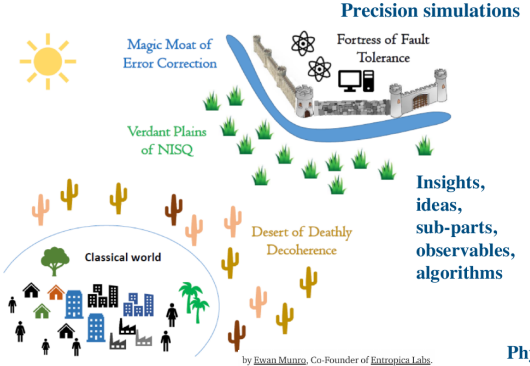

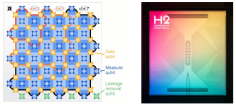

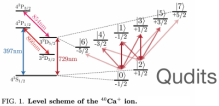

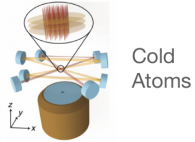

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What to do from an algorithms perspective?

Task

Find *applications and algorithms* that

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Low-Resource Challenge

- fit on current or near-future devices
- be cheaper than classical alternatives
- (be significantly better than any classical alternative)

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- Challenges
  - Quantum operations are unitary » public key cryptography severely restricted
  - Distributed computing with limited knowledge
  - Fast and cryptographically secure

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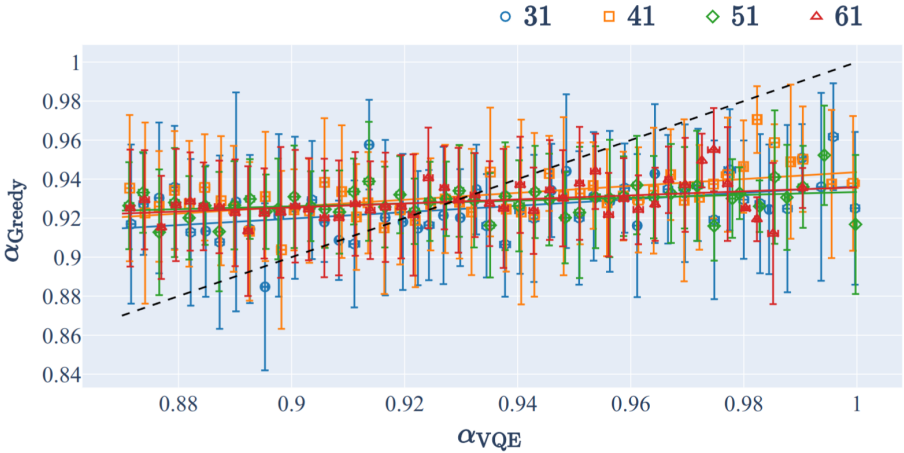
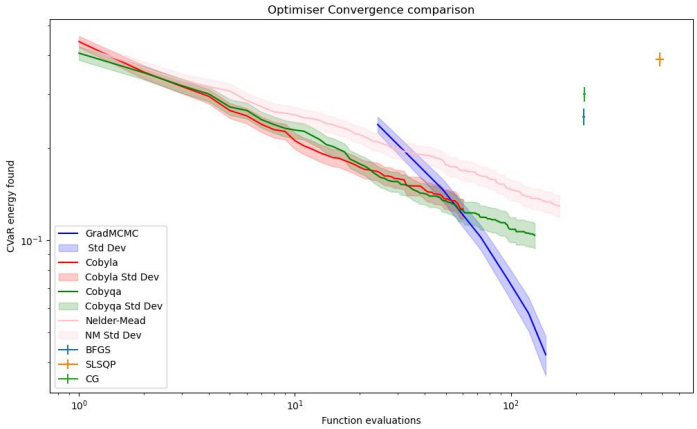
- needs quantum magic
  - describes resources needed to beyond what is classically efficient (stabilizer states)
  - otherwise just use tensor networks

Benchmarking [arXiv:2408.03073]

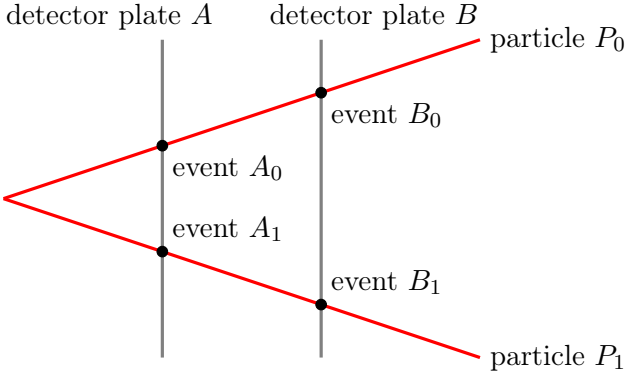


Circuit and Optimizer Design

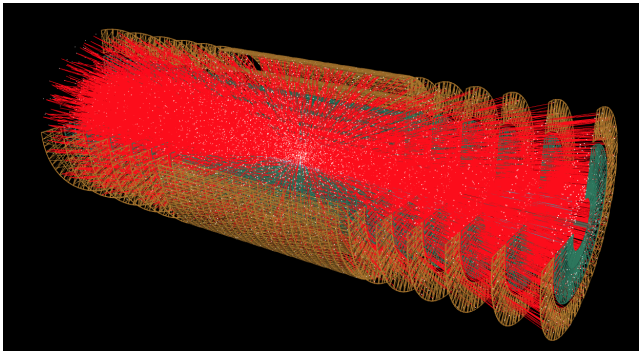


Particle track reconstruction - simplified

Two particles moving through two detector plates, being observed in detector events.



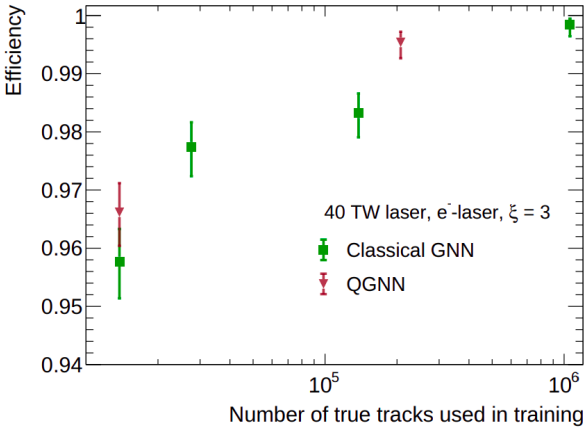
Particle tracking - how hard can it be?



Credit: Atlas Experiment > News > Track ML Challenge
https://atlas.cern/updates/news/trackml-challenge

Big Data: Particle Track Reconstruction [arXiv:2304.01690]

- 1% efficiency boost in low resource application



Conclusion

State of the Art

- classical computing is great, but has impactful limitation
- quantum computing offers to overcome some limitations of classical computing
- current quantum devices are small and noisy
  - practical quantum advantage is still elusive
  - near-term viability characterized by low-resource constraints

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My work

- algorithm design
  - What can be done today?
  - When will we be able to solve relevant problems?
- circuit design and analysis
  - How do we best use the hardware available to us?