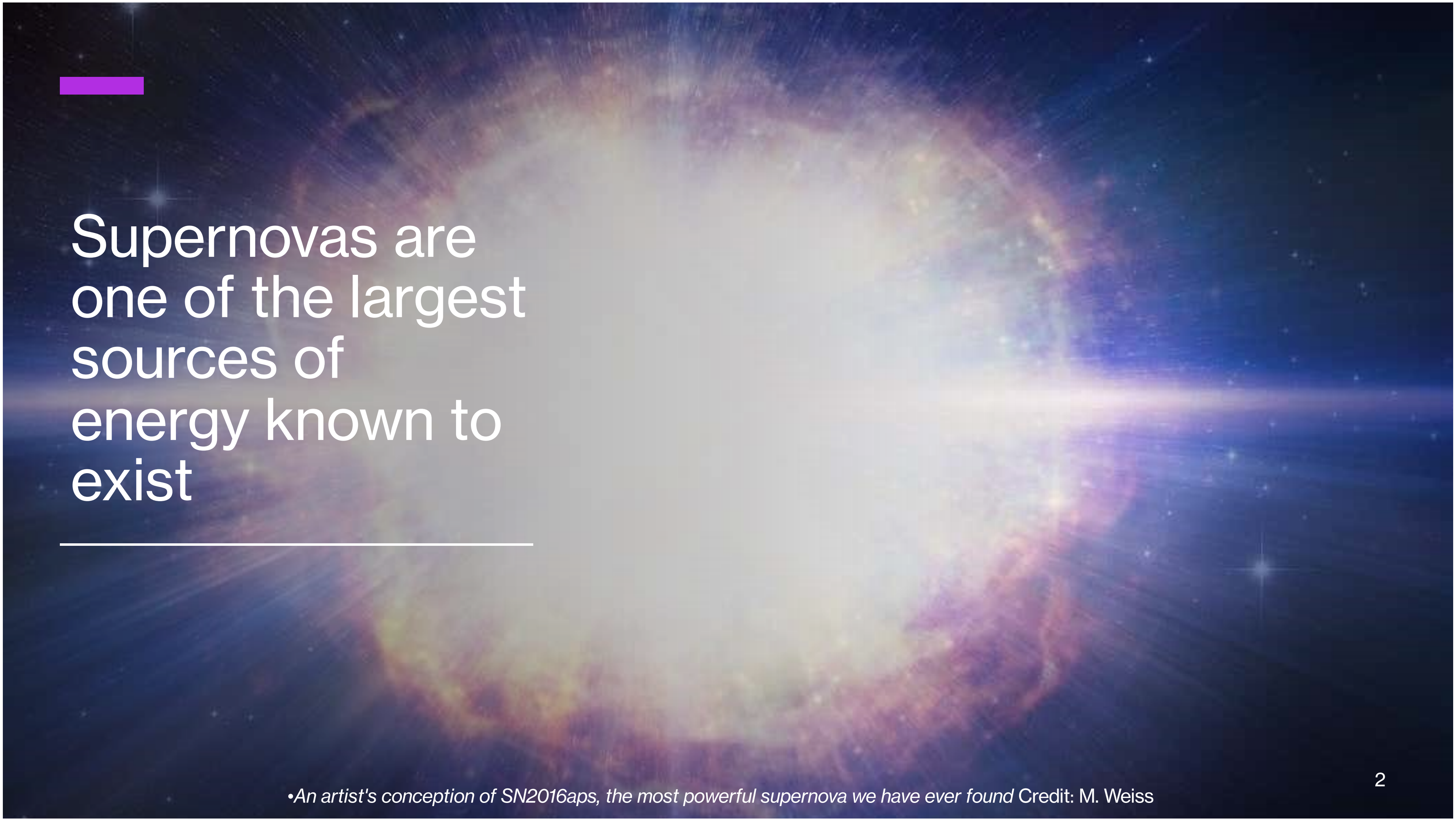
Pulse-level quantum computing of collective neutrino oscillations

Presented by Kaytlin Harrison

In close collaboration with;

Pooja Siwach, Baha Balantekin, Peter Zlatev, Anna Suliga,

Daniel Heimsoth, Caroline Laber-Smith



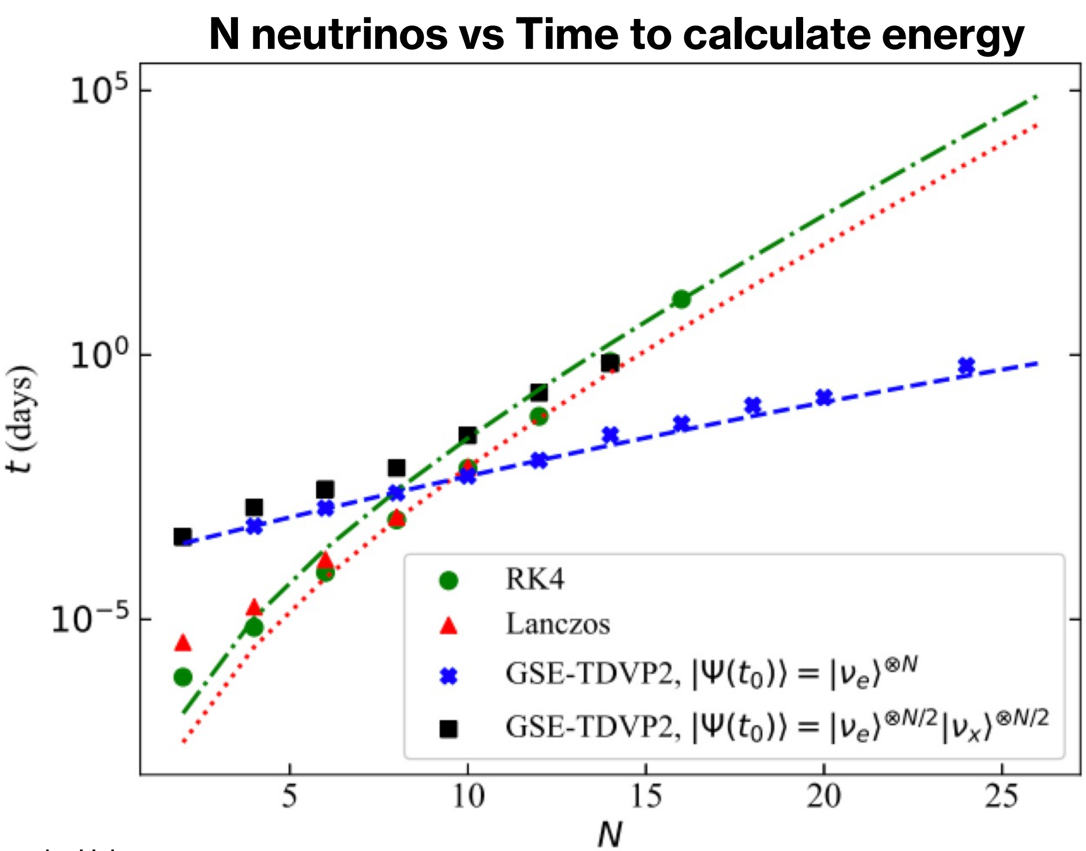
•*An artist's conception of SN2016aps, the most powerful supernova we have ever found* Credit: M. Weiss

Neutrinos describe supernovas

- Supernova
- Neutrinos
- Hamiltonian
- Quantum

Neutrino-Neutrino interactions are a challenge to study

Quantum computing can help!



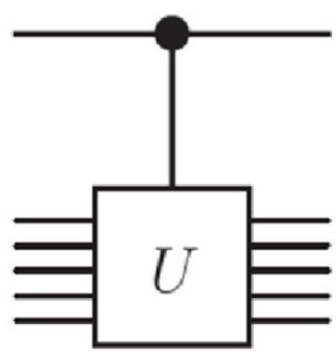
[1] Cervia, Michael, et al. "Collective Neutrino Oscillations with Tensor Networks Using a Time-Dependent Variational Principle." *ArXiv.org*, American Physical Society (APS), arxiv.org/abs/2202.01865.

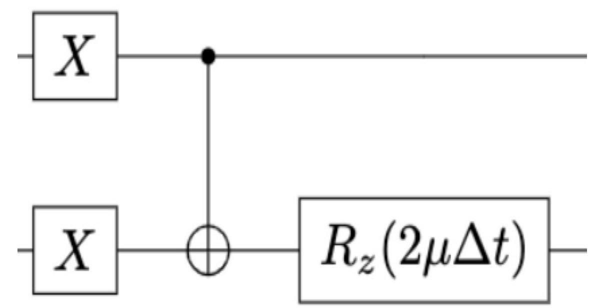
Where Quantum comes in

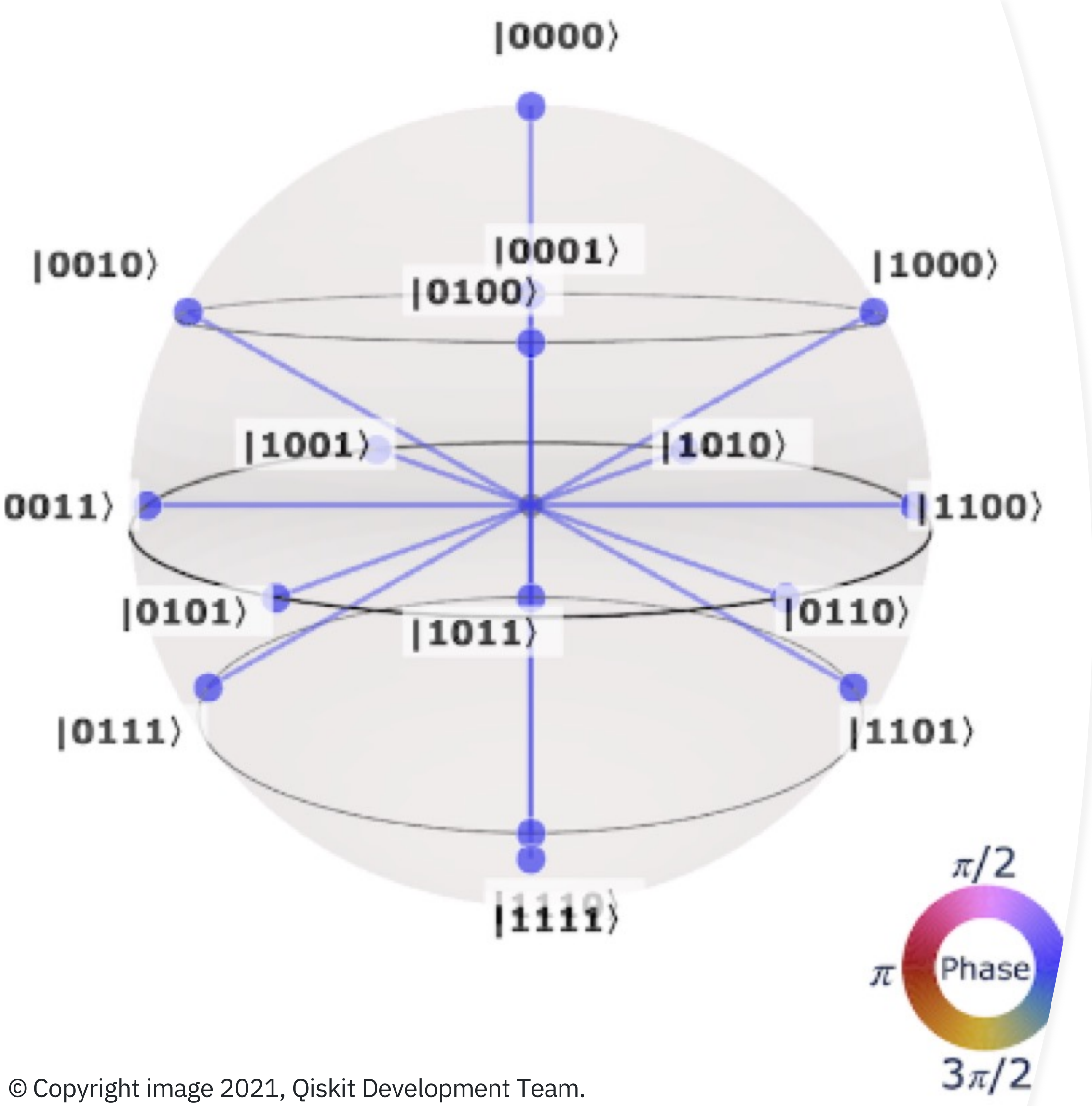
Quantum computing uses trotterization to effectively model the time evolution of neutrinos

Hamiltonian → Unitary matrix form → Trotterize into gates

$\mathbf{H}$







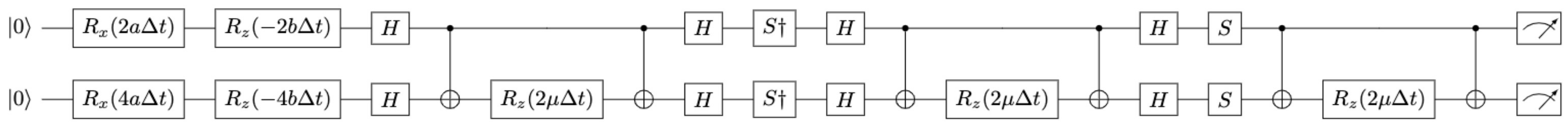
Current quantum computers are error prone

Methods of error correction considered in tandem as a means of decreasing noise in our quantum circuit.

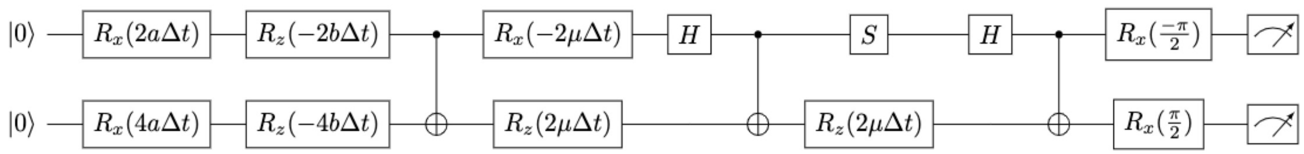
- Gate Reduction
- Pulse-level quantum

Reducing the number of gates reduces the amount of error in quantum computers

- **Standard method**

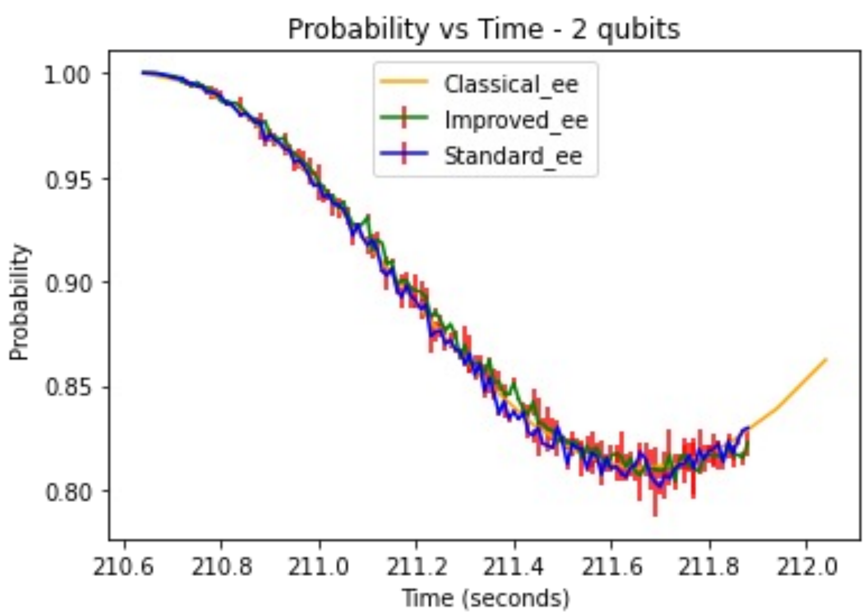


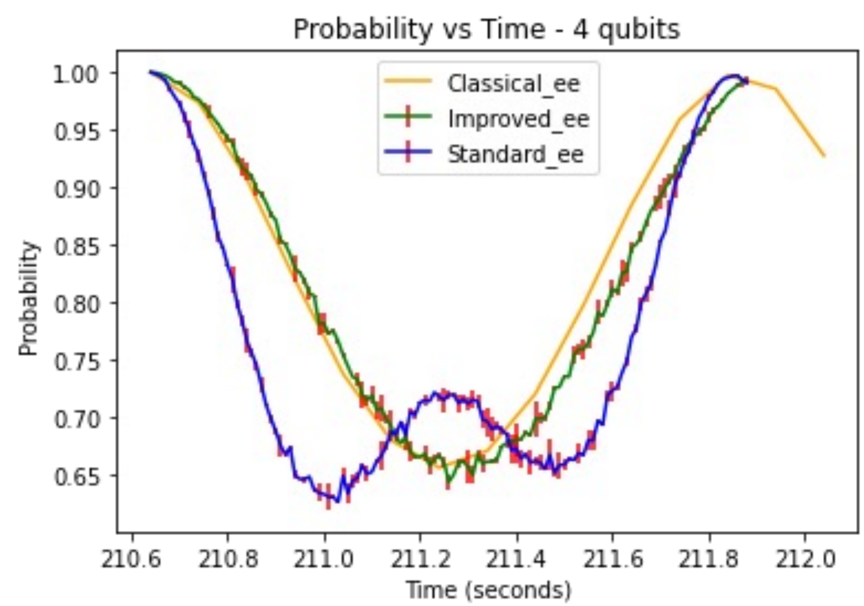
- **Improved method** [2]



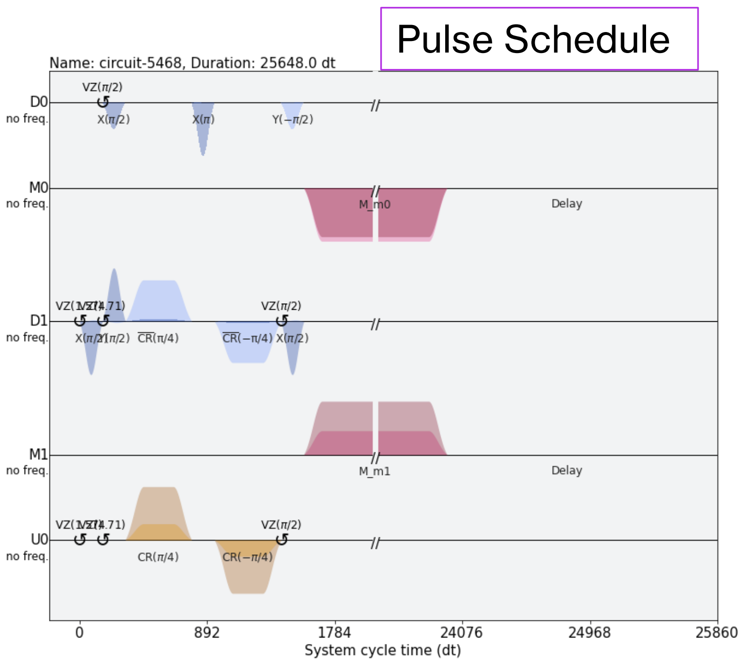
[2] Vidal, G, and C.M. Dawson. "Universal Quantum Circuit for Two-Qubit Transformations with Three Controlled-NOT Gates." American Physical Society, link.aps.org/doi/10.1103/PhysRevA.69.010301.

Simulated probability all neutrinos remain electron-neutrinos



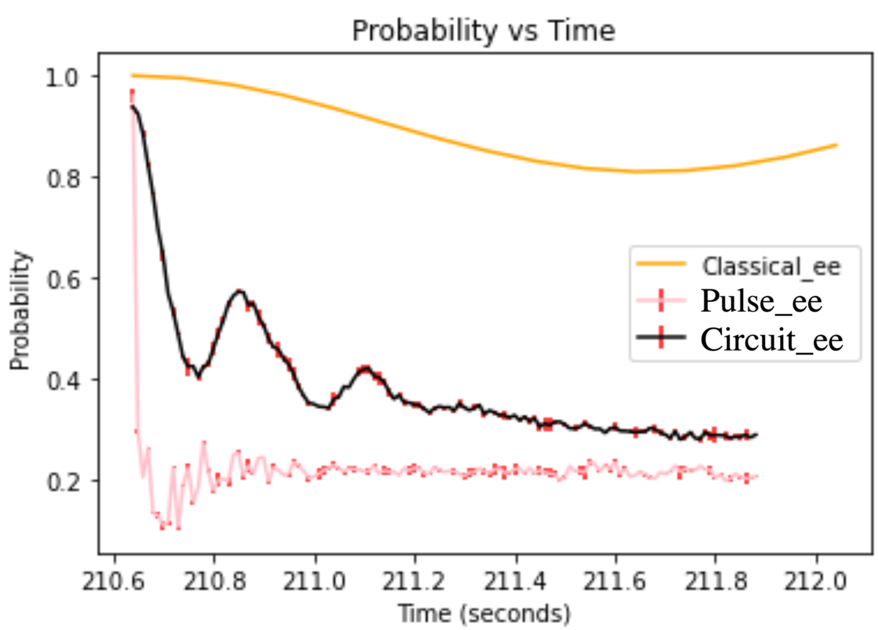


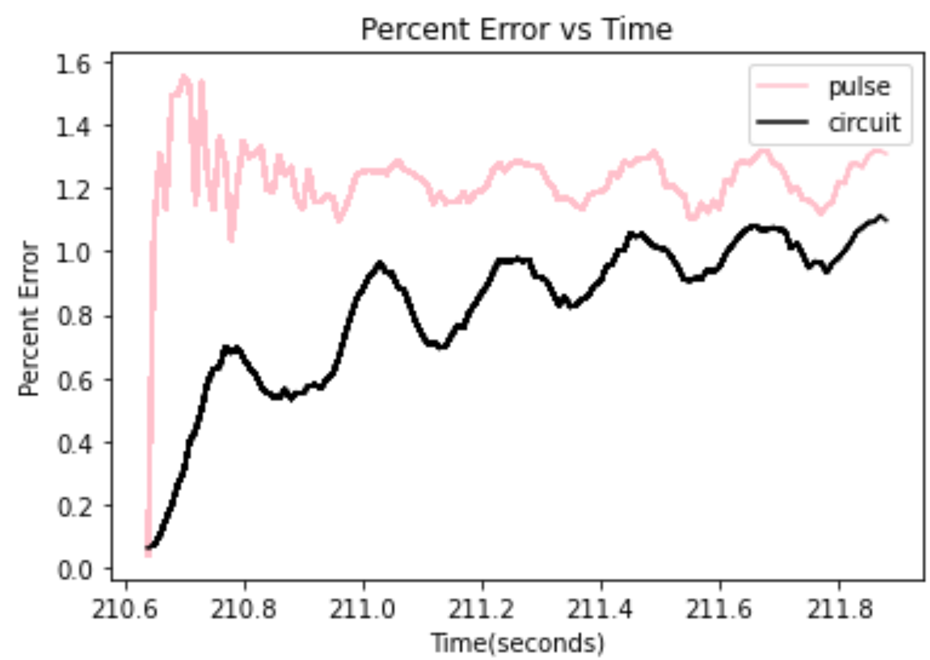
Pulse-level quantum has potential to reduce error in quantum computers



From a Circuit of Gates, to a Schedule of Pulses

Comparison of **Real** pulse and circuit quantum computers to known probability achieved by a classical computer





Future Goals

Incorporate	Compare	Consider	Expand
Error Mitigation	Additional methods of Gate evolution	Cancelation pulses	Model to three flavors

Thank you for your time and special thanks to the following for their support!

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