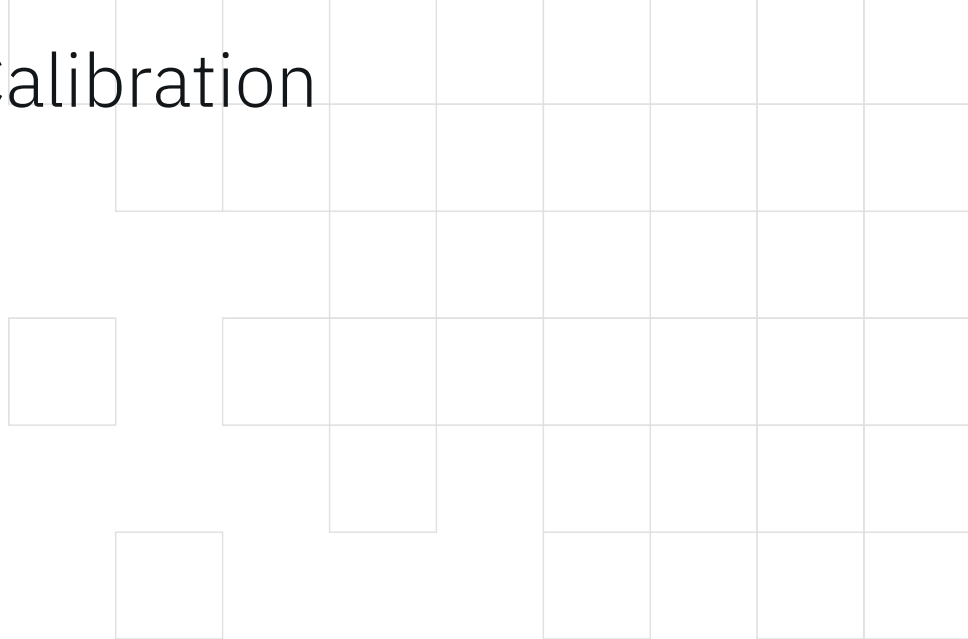


Benchmarking Crosspoint Calibration

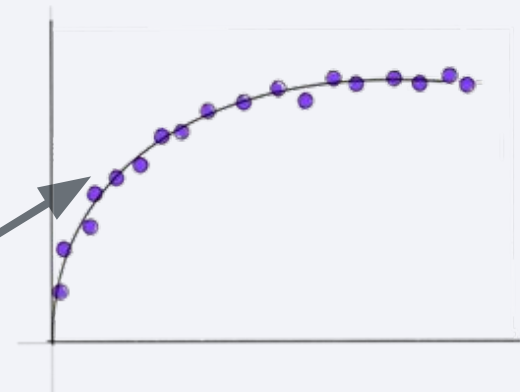
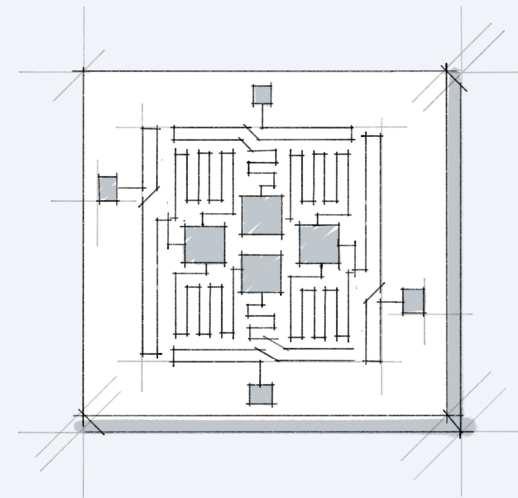
Mentee: Shota Nakasuji
Kathrin König

Mentor: Naoki Kanazawa



Introduction: Qubit Calibration

- **Ping-Pong calibration / Crosspoint calibration**
 - Techniques of qubit calibration
 - Conventional / Not implemented yet but promising
- **Qubit calibration**
 - High-fidelity control of qubits is essential for quantum computing
 - Qubits are controlled by microwave pulses
 - Pulse parameters have to be precisely tuned



With experiments(dots) and fitting(curve),
pulse parameters can be tuned

Calibration: Ping-pong vs. Crosspoint

Technique	Ping-Pong	Crosspoint
Error-to-Param Conversion	<p>△</p> <ul style="list-style-type: none">- Cannot be directly converted- Use an empirical method	<p>○ ?</p> <ul style="list-style-type: none">- The optimal parameters can be estimated directly
Precision	<p>△</p> <ul style="list-style-type: none">- Need to repeat experiments to achieve certain precision	<p>○ ?</p> <ul style="list-style-type: none">- Arbitrary precision without repeating experiments
Current Status	<ul style="list-style-type: none">- Currently in use	<ul style="list-style-type: none">- Not implemented yet

Expected, but not yet demonstrated



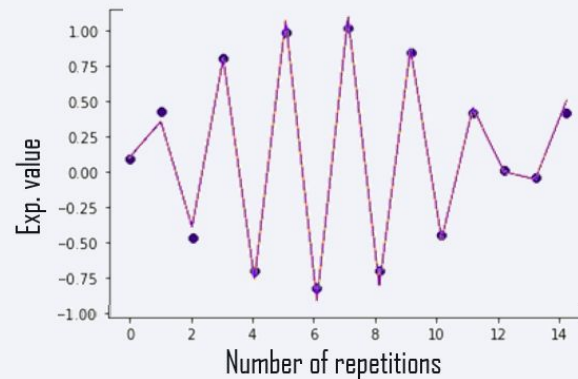
In this project, we will:

- **Benchmark this**
- **Deploy it if it's proven to be better**

Typical experimental data of Ping-Pong and Crosspoint Calibration

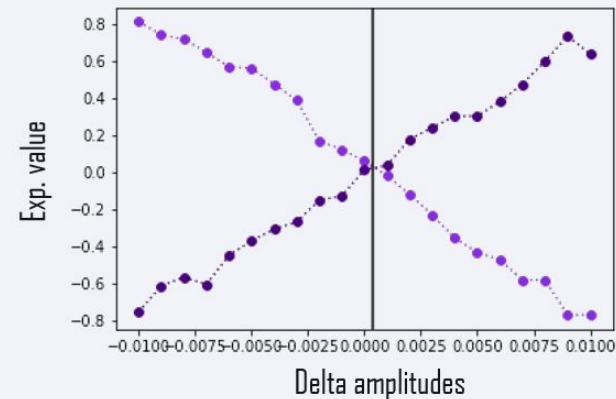
Ping-Pong

- Amplify rotation angle error
- Calculate π -amplitude from estimated rotation angle error



Cross-Point

- Amplify rotation angle error
 - Use pulse to rotate states clockwise and counter clockwise
- Find cross point of the two rotations



π -amplitudes of Ping-Pong and Crosspoint Calibration



Backend: ibmq_ehningen, shots: 256, puls parameter: amplitude

Further work (to do)

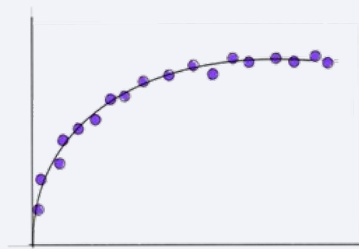
Calibration	Ping-Pong	Crosspoint
Number of Circuits	15	42
dt / t_{av}	1.19	1.04

Further work to do:

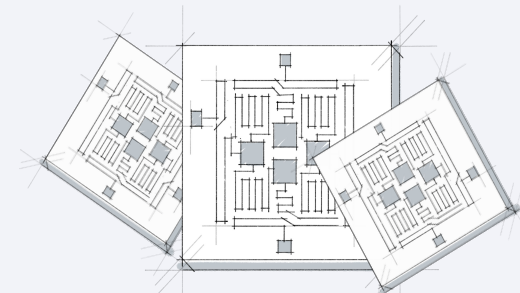
- Change pulse duration and number of shots
(test stability of calibration)
- Test calibration on several backends
- Generate data for statistical analysis



Variation of pulse duration



Generating data



Testing on several backends