Pulse Backend in Qiskit Experiments

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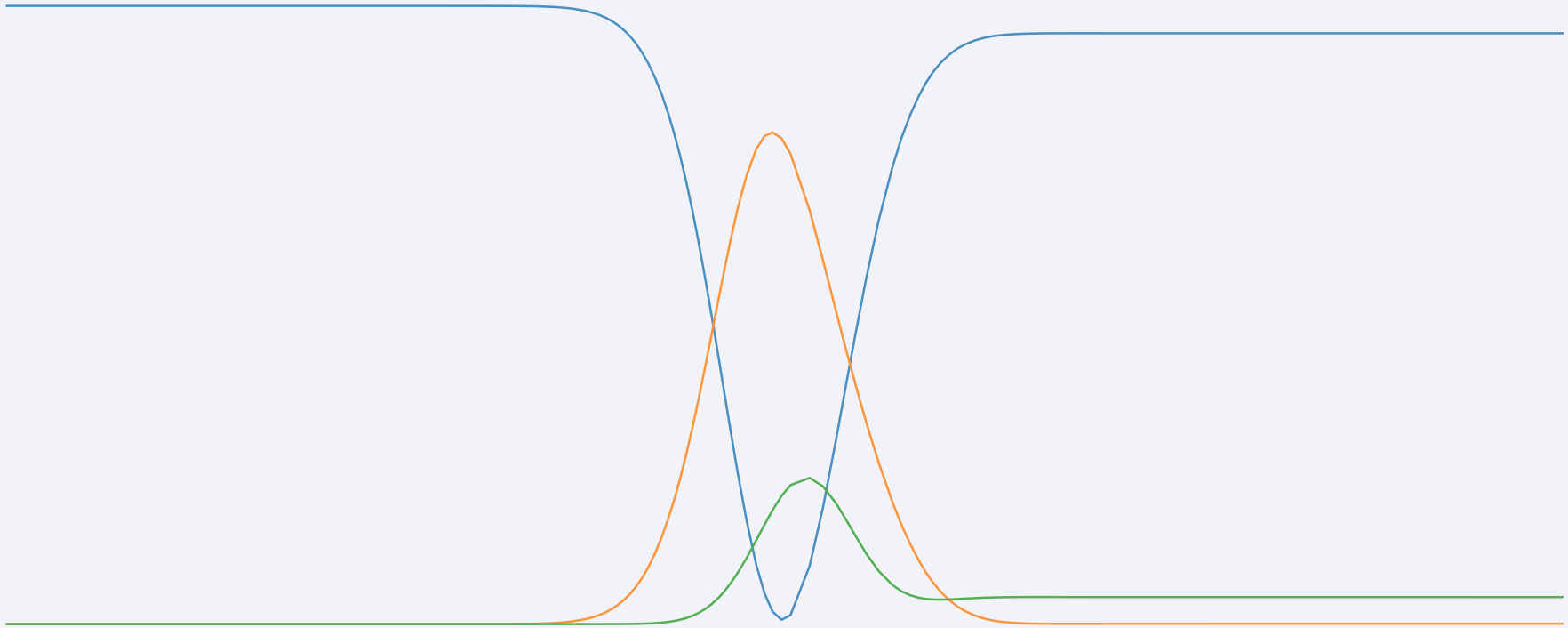


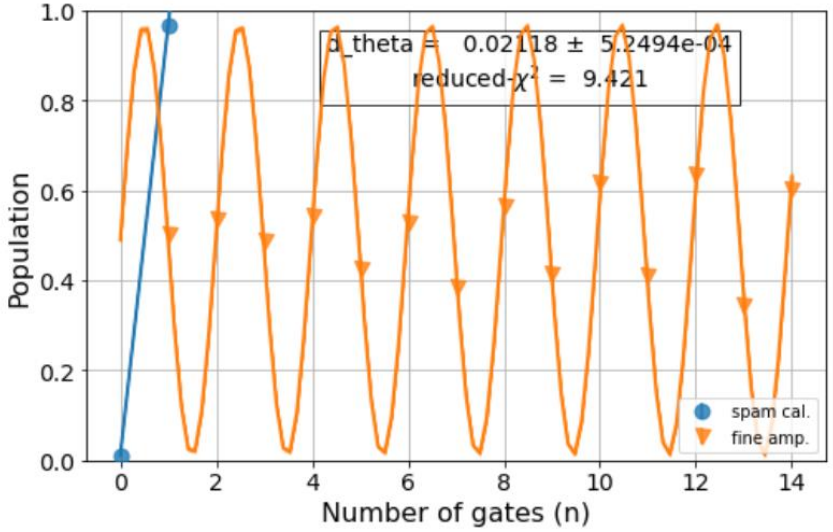
Introduction

Qiskit Experiments
a framework to

run a set of circuits
(experiment)

and

analyze the output
(analysis)



Currently

- Hard to test new experiments ⟹ simulate pulse schedules
- Tests hard-code the error patterns of many experiments

Goal

- *Realistic* backend
- *Efficient* tests based on pulse-level dynamics
- Tutorials without hardware backend

Hamiltonian Simulation

- We use a 3-level model for the qubit.
- This allows us to model leakage
- And perform DRAG experiments

- Parallel experiments are useful for calibrating multiple qubits in one job
- Hilbert space is given by sum rule

Single Transmon

$$H_s = \hbar \sum_{j=1,2} \omega_j \Pi_j + \varepsilon(t)\lambda_j \left(\sigma_j^+ + \sigma_j^-\right)$$

$$Model = Solver(H_0 = H_s, H' = H^{d_0})$$

Parallel Transmon

$$H_p = H_s \otimes I + I \otimes H_s$$

$$Model = Solver(H_0 = H_p, H' = (H^{d_0}, H^{d_1}))$$

Hamiltonian Simulation

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Parallel Transmon

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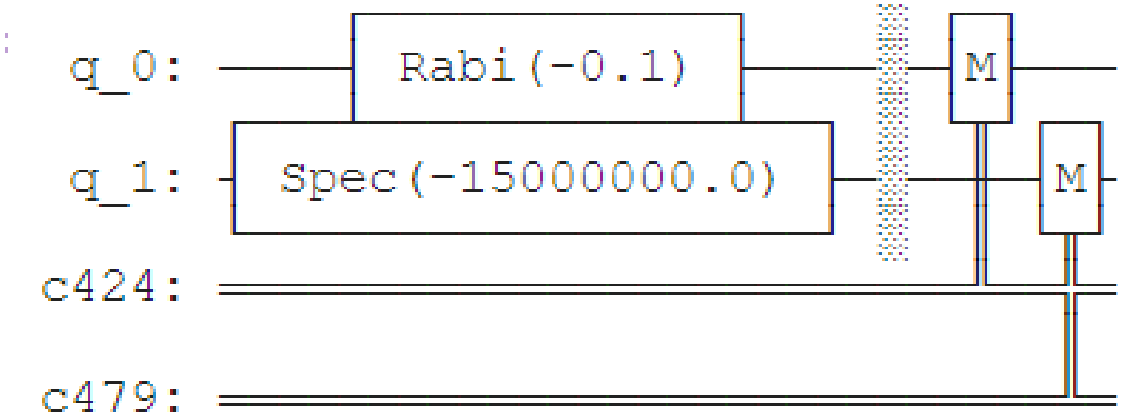
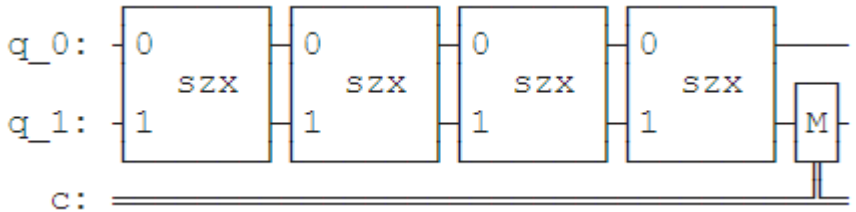
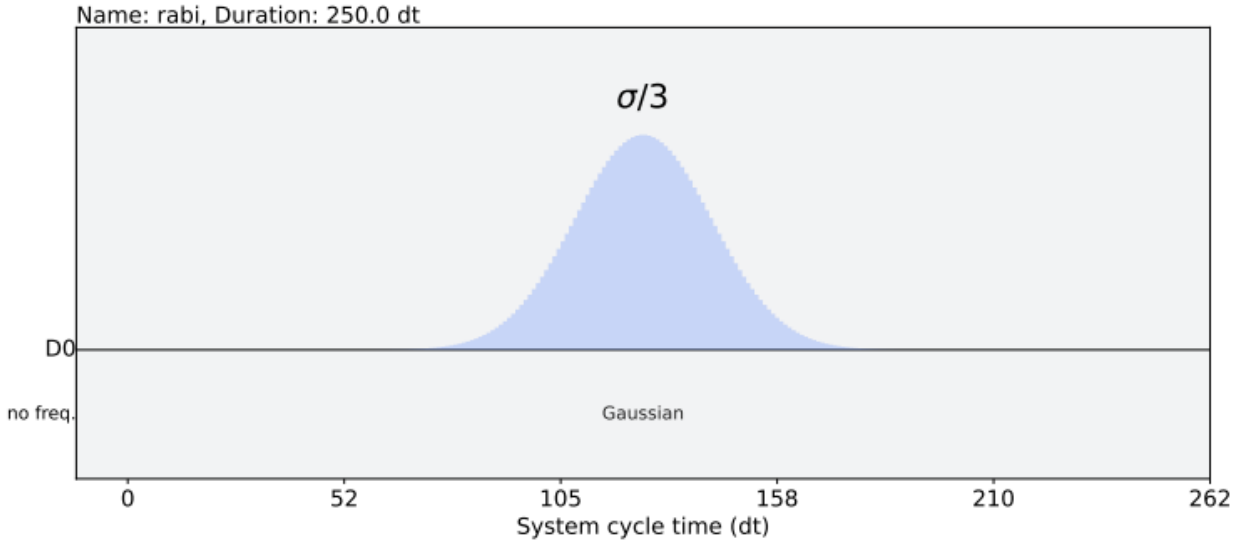


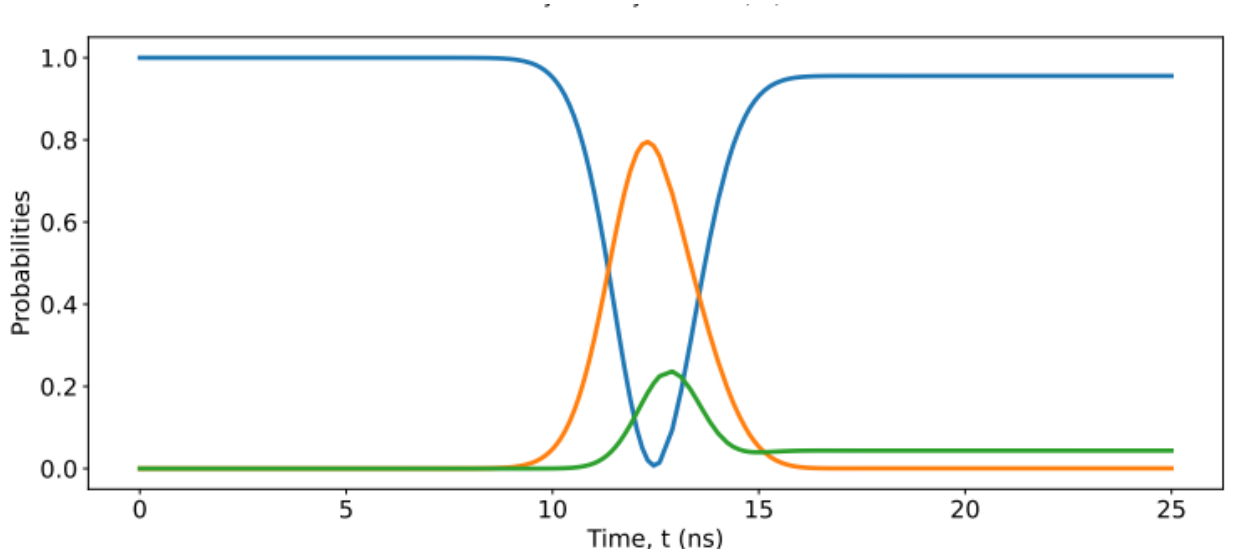
Two Qubit Transmon

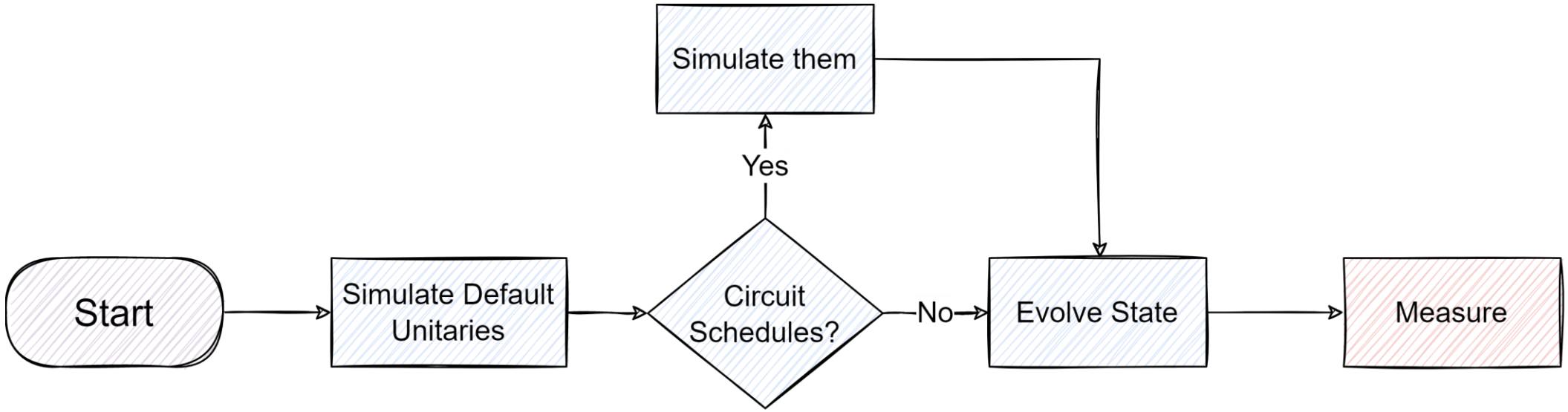


Framework

Qiskit

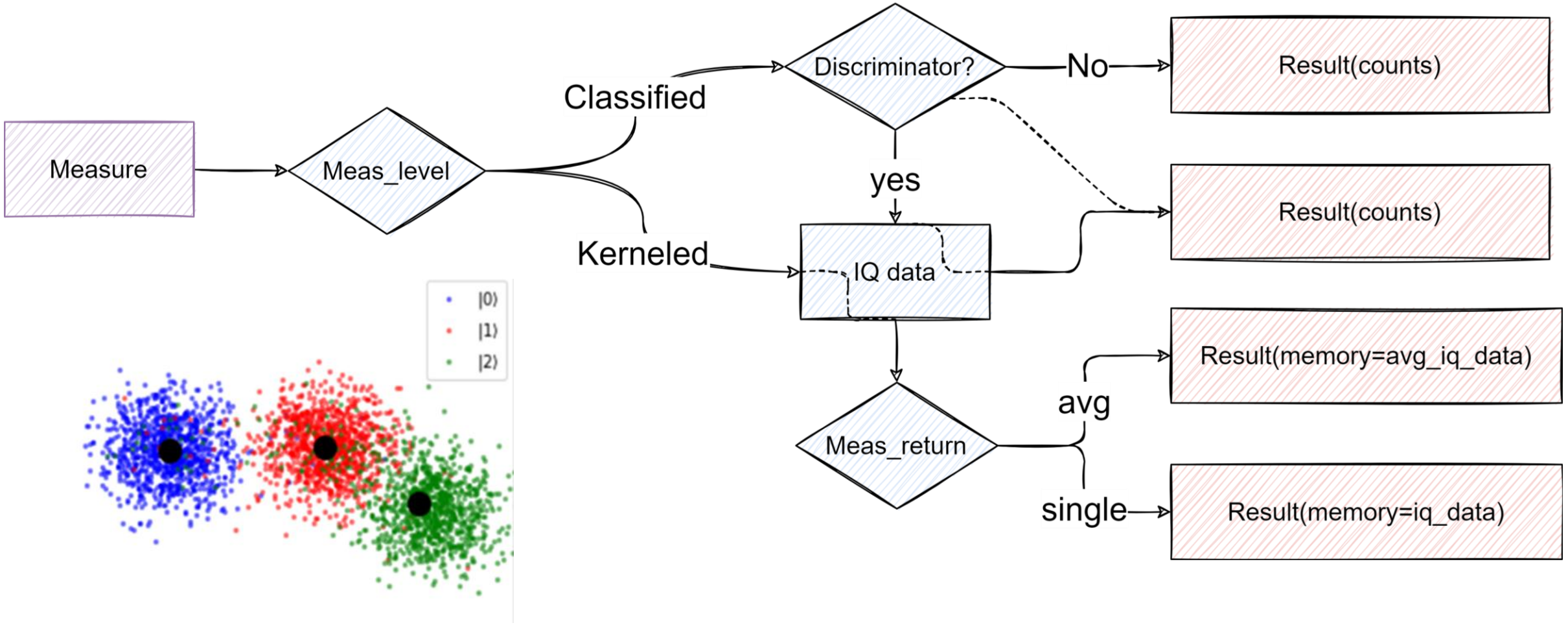






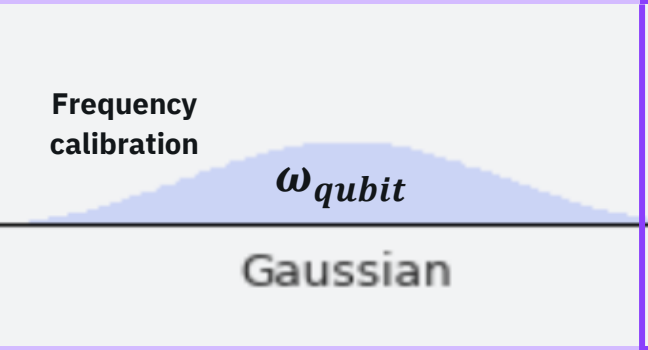
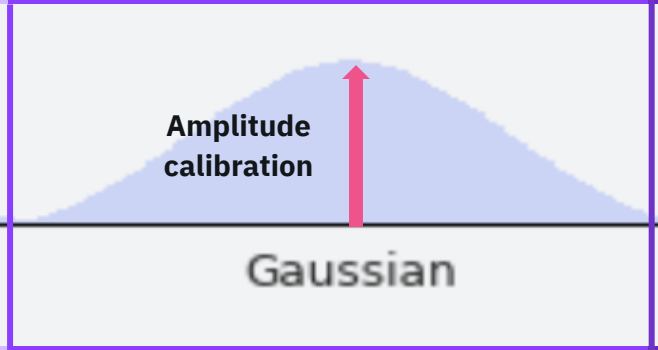
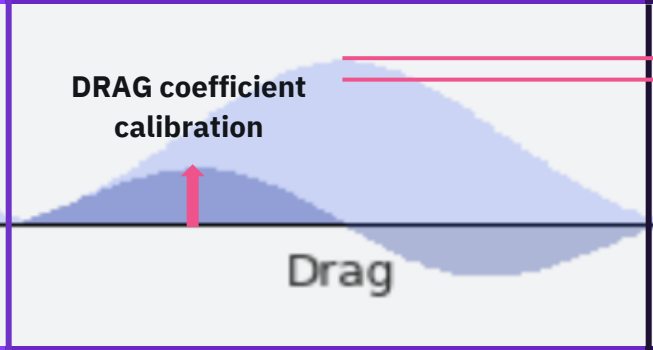
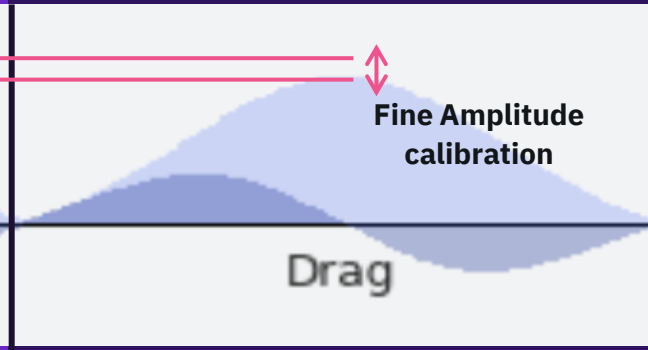
Framework

Qiskit



Calibrating a single-qubit gate on a pulse backend

Calibrating a gate is finding the optimal pulse parameters (frequency, amplitude, DRAG coefficient)

1. Spectroscopy	2. Rabi	3. DRAG	4. Fine amplitude
			
→Find qubit frequency	→Get π pulse amplitude $\Omega_x(t)$	→Get DRAG coefficient (correction amplitude β) $\Omega_x(t) + i\beta\partial_t\Omega_x(t)$	→Catch small over/under rotations errors

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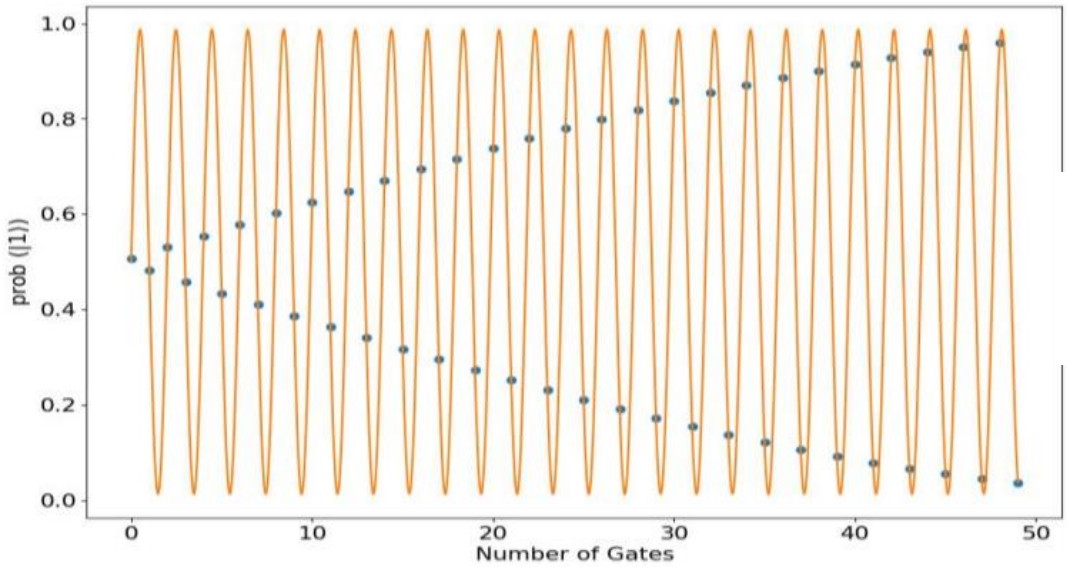
Write Tutorial

Qiskit

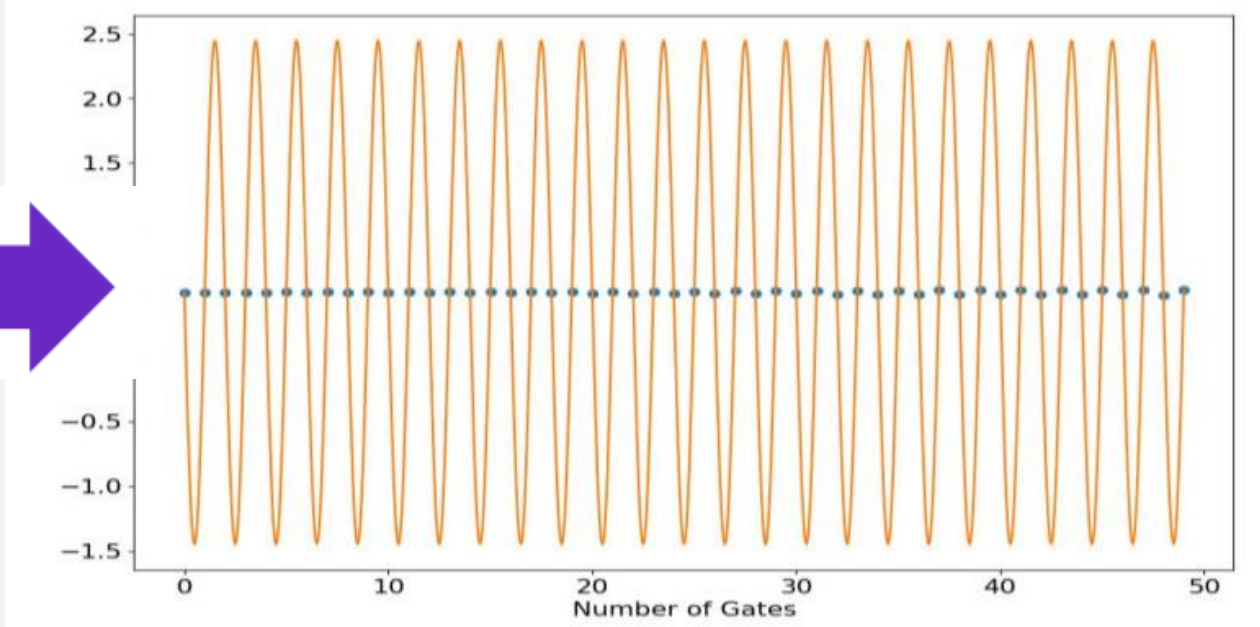
Tutorial : calibrating single-qubit gates on a pulse backend

Achievements & Future plan

- ✓ Single qubit pulse backend
- ✓ Two-qubit decoupled pulse backend
- ✓ Refactored test suite
- ✓ Wrote tutorials



- ✓ Coupled two-qubit pulse backend with the CR interaction
- ✓ Tutorials for the new backend



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backend
replies
thanks
pulse
need
think
tutorials
spectroscopy
experiment
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meeting
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characterization
https://github.com/rupeshknn/qiskit-experiments