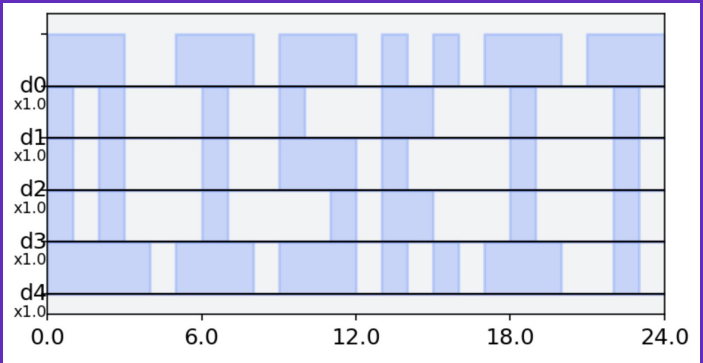
Qiskit Advocate Mentorship Program

#2 — Upgrade Qiskit Textbook pulse section



Mentor:

Naoki Kanazawa

Mentees:

Farai Mazhandu

Spencer Churchill

Kazumasa Umezawa

Soyoung Shin

Syntax Updating

```
schedule = pulse.Schedule(name='Frequency sweep')
schedule += Play(drive_pulse, drive_chan)
# The left shift `<<` is special syntax meaning to shift the start time of the schedul
schedule += measure << schedule.duration

# Create the frequency settings for the sweep (MUST BE IN HZ)
frequencies_Hz = frequencies_GHz*GHz
schedule_frequencies = [{drive_chan: freq} for freq in frequencies_Hz]
```

```
freq = Parameter('freq')

with pulse.build(backend) as parametrized_sched:
    with pulse.align_sequential():
        pulse.set_frequency(freq, pulse.drive_channel(qubit))
        pulse.play(pulse.Gaussian(duration=16 * int(pulse.seconds_to_samples(drive_duration_sec) / 16),
                                  amp=drive_amp,
                                  sigma=pulse.seconds_to_samples(drive_sigma_sec),
                                  name='spect_pulse'),
                   pulse.drive_channel(qubit))
        pulse.measure(qubits=[qubit], registers=[pulse.MemorySlot(mem_slot)])
```

```
# Drive pulse samples
drive_pulse = pulse_lib.gaussian(duration=drive_samples,
                                 sigma=drive_sigma,
                                 amp=drive_amp,
                                 name='freq_sweep_excitation_pulse')
```

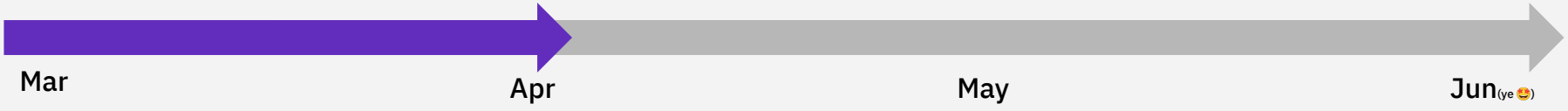
```
# Drive pulse samples
from qiskit.pulse.library import Gaussian
drive_pulse = Gaussian(duration=drive_samples,
                       sigma=drive_sigma,
                       amp=drive_amp,
                       name='freq_sweep_excitation_pulse')
```

```
schedule.draw(channels=[drive_chan, meas_chan, acq_chan], label=True, scaling=1.0)
```

```
schedule.draw(backend=backend) # extra space for screenshot :P
```

The code above shows a few examples of syntax we're updating. In addition to these general improvements, we all have lab-specific improvements.

Current Progress



Mar 4: Kick-off

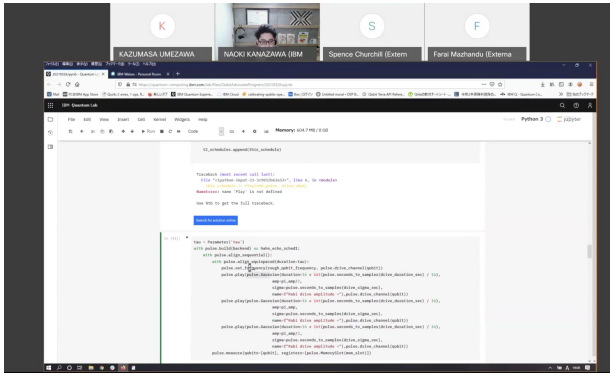
Mar 11: Group study on Qubit calibration with Pulse Builder

Mar 18: Divide duties and start working

Mar 25: Group meetup with lecture from mentor about

dispersive readout and QND measurement /

Kazumasa's work review



21.03.25 meetup

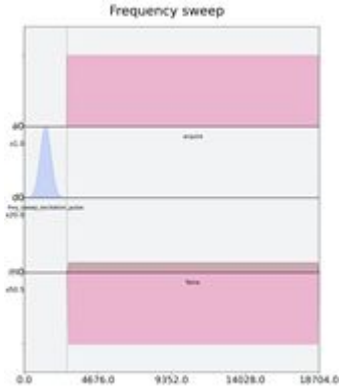
Timeline

	Title	Assignee	Apr	May
Qiskit textbook — Pulse part	Calibrating Qubits with Qiskit Pulse			
	Accessing Higher Energy States			
	Exploring the Jaynes-Cummings Hamiltonian with Qiskit Pulse			
	Measuring the Qubit ac-Stark Shift			
	Hamiltonian Tomography			

Mentee modified contents
Proofread
Pull Request

Calibrating Qubits with Qiskit Pulse

Kazumasa Umezawa



To rewrite the source code of this chapture into Builder syntax …

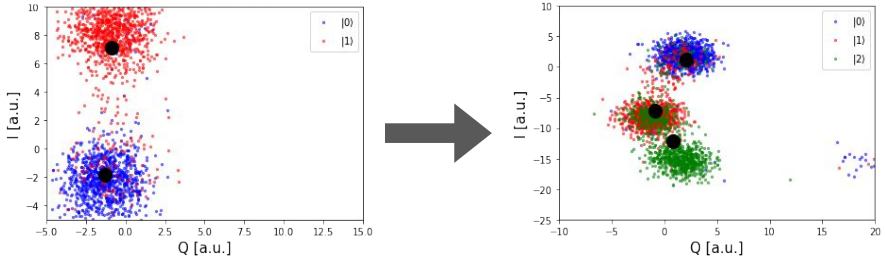
1.Studying builder syntax
2.Sharing what I have learned with team members

What to do for the rest of the time …

1.Rewrite the code and send PR
2.In Japan, the recognition of Qiksit pulse is low, so in order to improve it, I will summarize how to use the pulse and a collection of samples in a Japanese blog.

Accessing Higher Energy States

Spencer Churchill



1. Saves bandwidth

```
# Create schedule
rabi_01_schedules = []
# loop over all drive amplitudes
for ii, drive_amp in enumerate(drive_amps):
    # drive pulse
    rabi_01_pulse = Gaussian(duration=drive_samples,
                             amp=drive_amp,
                             sigma=drive_sigma,
                             name='rabi_01_pulse_%d' % ii)

    # add commands to schedule
    with pulse.build(name='Rabi Experiment at drive amp = %s' % drive_amp) as schedule:
        pulse.play(rabi_01_pulse, drive_chan)

    schedule.insert(schedule.duration, measure, inplace=True) # shift measurement to after drive pulse
    rabi_01_schedules.append(schedule)
```

2. Utilizes new syntax

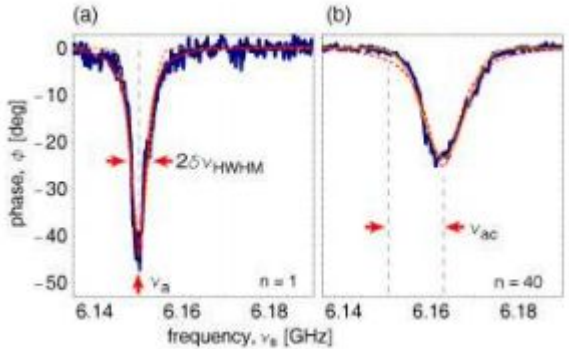
```
# draw a schedule
display(schedules[-1].draw(backend=backend))
```

3. Formatted Pulse drawer

4. Testing and validation (TODO 🤩)

Measuring the Qubit ac-Stark Shift

Farai Mazhandu



AC-Stark Shift and Dephasing of a Superconducting Qubit Strongly Coupled to a Cavity Field by D. I. Schuster et al

- A superconducting quantum two-level system can be strongly coupled to a single microwave photon
- Spectroscopic measurements induce energy level shifts in qubit
- Number of photons used in measurement system causes qubit energy level shifts by 0.6MHz - AC Stark Shift
- Makes it difficult to reference qubit energy levels (dephasing)

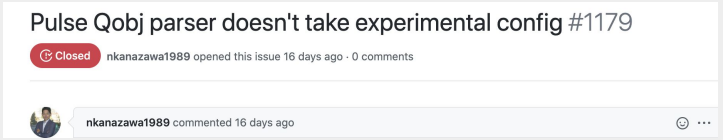

```
Traceback (most recent call last):
  File "<ipython-input-75-88cb6b5e5ecd>", line 14, in <module>
    pulse.play(temp_resonator_tone, meas_chan)
NameError: name 'temp_resonator_tone' is not defined

Use %tb to get the full traceback.
```

Hamiltonian Tomography

Soyoung Shin

Done:

Try to use pulse simulator for qubit frequency sweep experiment → we found small bug and reported



To do:

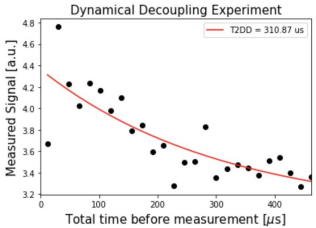
Syntax modification on Hamiltonian tomography part in i) using pulse.measure ii) Modify code in a way that allows maximum flexibility of builder

Try to build faster calculation

Future plan

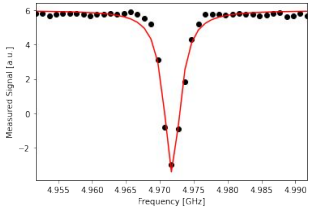
Extra activity

- doing interesting experiments like dynamic decoupling.



From:https://qiskit.org/textbook/ch-quantum-hardware/cQED-JC-SW.html#6.-The-Cross-Resonance-Entangling-Gate-

- making some packages for optimizing pulses to maximize gate fidelity on different hardware.



From:https://qiskit.org/textbook/ch-quantum-hardware/calibrating-qubits-pulse.html

More Contribution

- Introducing Qiskit Pulse to Local Qiskit Community — ex: Korea, Japan, Zimbabwe and Africa
- Making other interesting community tutorials — if possible
- Use Qiskit Metal together with Qiskit Pulse for hardware design and testing - if possible