Update Qiskit-Experiment Tutorials

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Qiskit

Verification Experiments

StandardRB(qubits, lengths[, num_samples, ...])

InterleavedRB(interleaved_element, qubits, ...)

StateTomography(circuit[, ...])

ProcessTomography(circuit[, ...])

QuantumVolume(qubits[, trials, seed, ...])

Characterization Experiments

T1(qubit, delays[, unit])

T2Ramsey(qubit, delays[, unit, osc_freq, ...])

QubitSpectroscopy(qubit, frequencies[, ...])

EFSpectroscopy(qubit, frequencies[, unit, ...])

Calibration Experiments

DragCal(qubit)

Rabi(qubit)

EFRabi(qubit)

FineAmplitude(qubit)

FineXAmplitude(qubit)

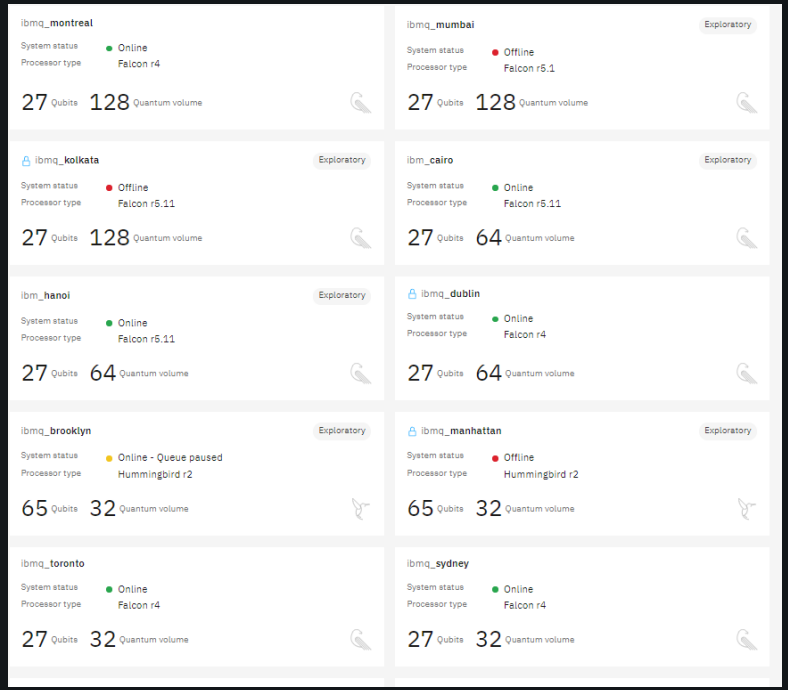
FineSXAmplitude(qubit)

Backends with different properties of qubits

- ✓ 23 backends in IBM Quantum Experiences
- ✓ All backends consists of different number of qubits with different properties
- ✓ Characterizing all the qubit at once.

Ibmq_lima (5

Qubit	T1 (us)	T2 (us)	Frequency (GHz)
Q0	90.9	116.85	5.03
Q1	98.64	132.95	5.128
Q2	74.26	83.94	5.247
Q3	12.44	16.36	5.302
Q4	20.86	17.35	5.092



Running Composite Experiment – Qubit Characterization Experiment

Qiskit

from qiskit_experiments.framework import ParallelExperiment

: combine separate component experiments as a single composite experiment

Parallel_exp=ParallelExperiment[exp1, exp2, exp3...]

Parallel_exp.run(backend).block_for_results()

from qiskit_experiments.library.characterization.qubit_spectroscopy import QubitSpectroscopy

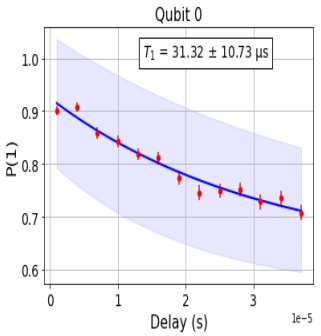
from qiskit_experiments.library import T1

from qiskit_experiments.library import T2Ramsey

Ibmq_lima : All T1 at once

Qiskit

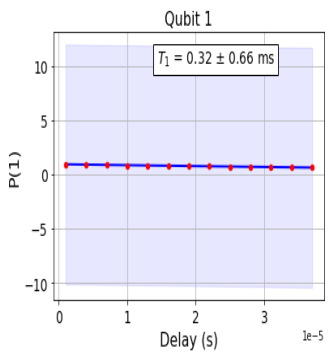
Component experiment 0



DbAnalysisResultV1
- name: T1
- value: 3.1319690748399380e-05 ± 1.0728597188103965e-05 s
- χ^2: 1.345035683005669
- quality: bad
- extra: <9 items>
- device_components: ['Q0']
- verified: False

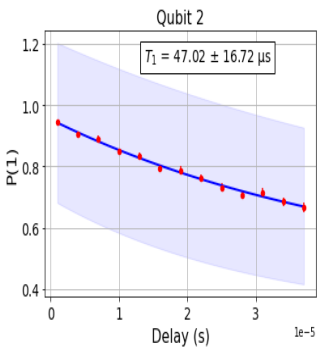
Component experiment 1

Component experiment 1



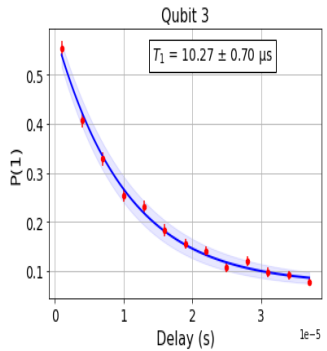
DbAnalysisResultV1
- name: T1
- value: 0.0003157812299232428 ± 0.0006563679516394252 s
- χ^2: 1.3085187627877553
- quality: bad
- extra: <9 items>
- device_components: ['Q1']
- verified: False

Component experiment 2



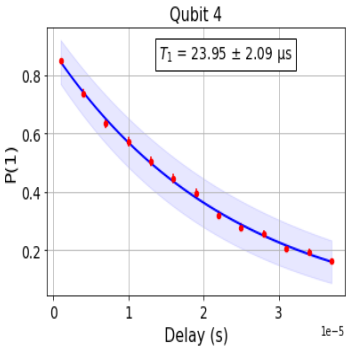
DbAnalysisResultV1
- name: T1
- value: 4.702469278204375e-05 ± 1.6720405410199527e-05 s
- χ^2: 0.47451121772118
- quality: bad
- extra: <9 items>
- device_components: ['Q2']
- verified: False

Component experiment 3



DbAnalysisResultV1
- name: T1
- value: 1.0272741740106604e-05 ± 7.007644304415822e-07 s
- χ^2: 0.7717121568549775
- quality: bad
- extra: <9 items>
- device_components: ['Q3']
- verified: False

Component experiment 4

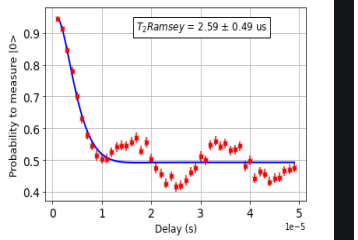


DbAnalysisResultV1
- name: T1
- value: 2.394760867005775e-05 ± 2.0910705276002416-06 s
- χ^2: 0.5168399892400787
- quality: good
- extra: <9 items>
- device_components: ['Q4']
- verified: False

Ibmq_lima :All T2 at once

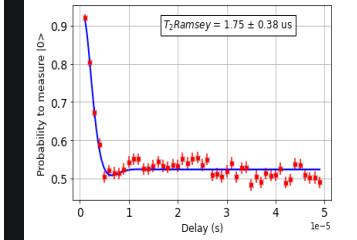
Qiskit

Component experiment 0



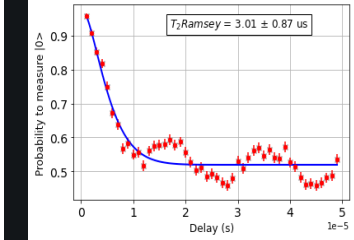
DbAnalysisResultV1
- name: T2star
- value: 2.587763066988959e-06 ± 4.861296393268532e-07 s
- χ^2: 7.841924707790944
- quality: bad
- extra: <10 items>
- device_components: ['Q0']
- verified: False
DbAnalysisResultV1
- name: Frequency
- value: 30330.46275201247 ± 7904.274066964896 Hz
- χ^2: 7.841924707790944
- quality: bad
- extra: <10 items>
- device_components: ['Q0']
- verified: False

Component experiment 1



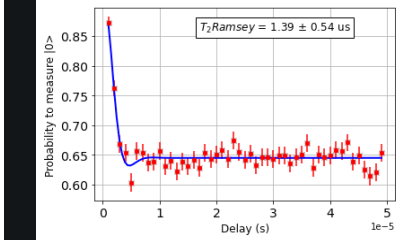
DbAnalysisResultV1
- name: T2star
- value: 1.7470931526852868e-06 ± 3.816208447724 9e-07 s
- χ^2: 1.5801497696665117
- quality: bad
- extra: <10 items>
- device_components: ['Q1']
- verified: False
DbAnalysisResultV1
- name: Frequency
- value: 87509.40178375931 ± 9363.388112560515 Hz
- χ^2: 1.5801497696665117
- quality: bad
- extra: <10 items>
- device_components: ['Q1']
- verified: False

Component experiment 2



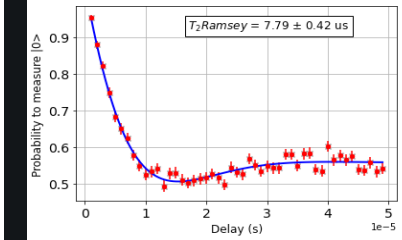
DbAnalysisResultV1
- name: T2star
- value: 3.0090031275429624e-06 ± 8.674760864900826e-07 s
- χ^2: 6.307788114318621
- quality: bad
- extra: <10 items>
- device_components: ['Q2']
- verified: False
DbAnalysisResultV1
- name: Frequency
- value: 17584.84594797173 ± 15178.10416541737 Hz
- χ^2: 6.307788114318621
- quality: bad
- extra: <10 items>
- device_components: ['Q2']
- verified: False

Component experiment 3



DbAnalysisResultV1
- name: T2star
- value: 1.391805624459046e-06 ± 5.448009693363144e-07 s
- χ^2: 0.885194809917762
- quality: bad
- extra: <10 items>
- device_components: ['Q3']
- verified: False
DbAnalysisResultV1
- name: Frequency
- value: 122951.77249368827 ± 35984.47441630337 Hz
- χ^2: 0.885194809917762
- quality: bad
- extra: <10 items>
- device_components: ['Q3']
- verified: False

Component experiment 4

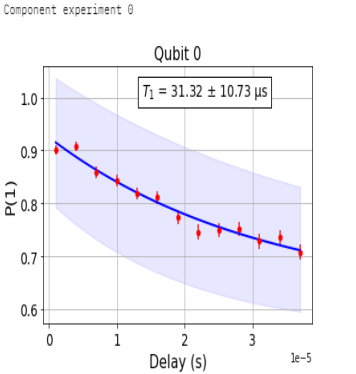


DbAnalysisResultV1
- name: T2star
- value: 7.791409584154377e-06 ± 4.248711860370 0023e-07 s
- χ^2: 1.259199150309948
- quality: bad
- extra: <10 items>
- device_components: ['Q4']
- verified: False
DbAnalysisResultV1
- name: Frequency
- value: 19769.341661810067 ± 2884.3416279155476 Hz
- χ^2: 1.259199150309948
- quality: bad
- extra: <10 items>
- device_components: ['Q4']
- verified: False

Verification of a backend with multiple qubits

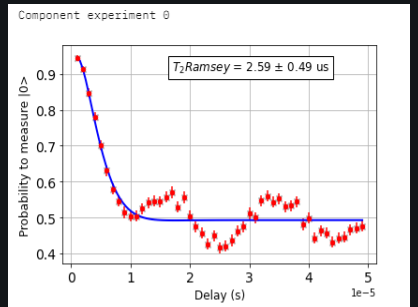
Qiskit

T1



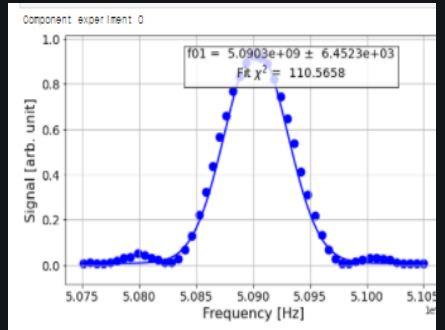
DbAnalysisResultV1
- name: T1
- value: 3.131969074839938e-05 ± 1.0728597188103965e-05 s
- χ^2: 1.3450356830056 69
- quality: bad
- extra: <9 items>
- device_components: ['Q0']
- verified: False
Component experiment 1

T2



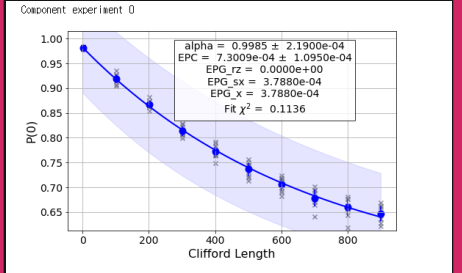
DbAnalysisResultV1
- name: T2star
- value: 2.587763066988959e-06 ± 4.861296393268532e-07 s
- χ^2: 7.841924707790944
- quality: bad
- extra: <10 items>
- device_components: ['Q0']
- verified: False
DbAnalysisResultV1
- name: Frequency
- value: 30330.46275201247 ± 7904.274066964896 Hz
- χ^2: 7.841924707790944
- quality: bad
- extra: <10 items>
- device_components: ['Q0']
- verified: False

Frequency



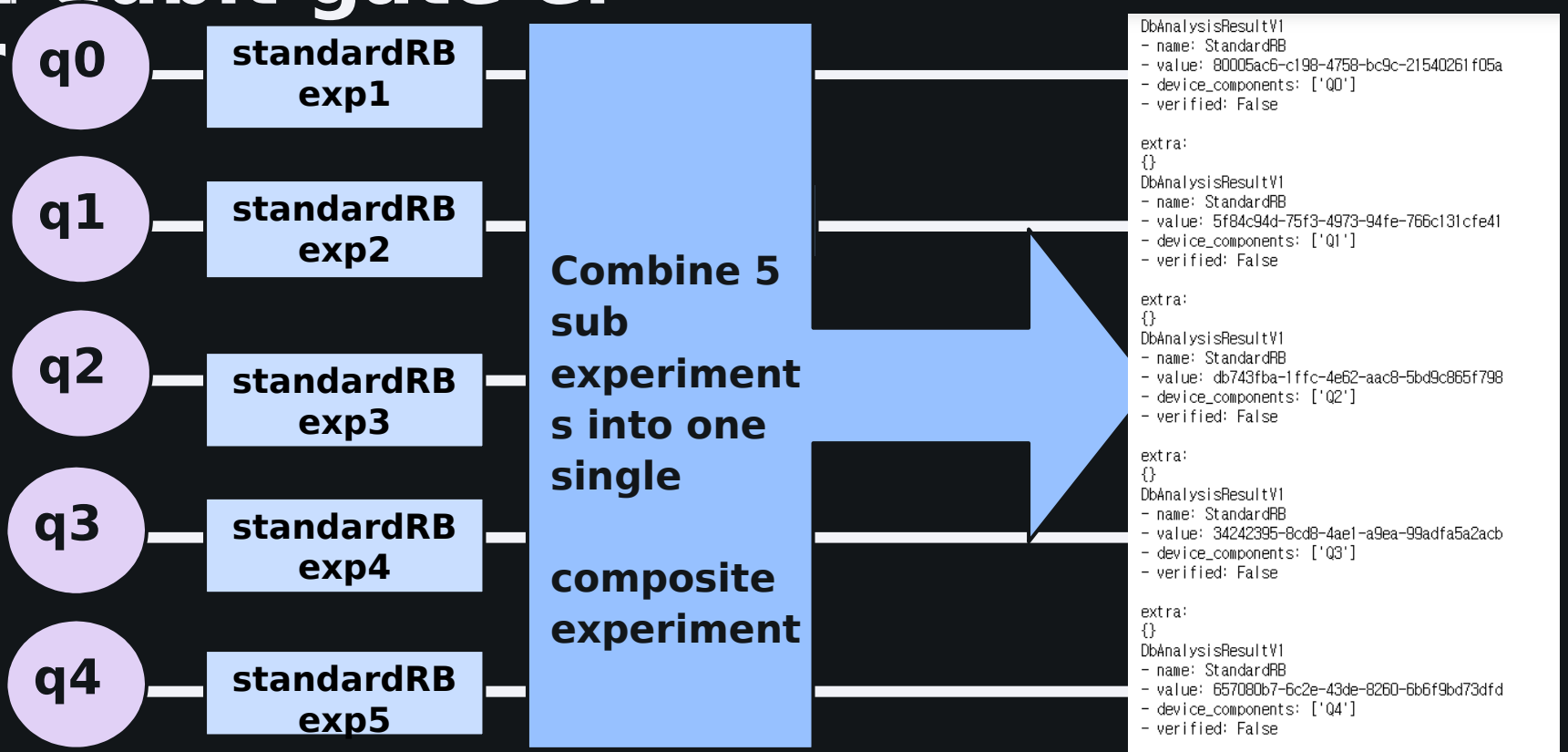
DbAnalysisResultV1
- name: @Parameters_ResonanceAnalysis
- value: [8.48266647e-01 2.77094145e+08 5.09026160e+09 8.90468229e-08] ± [
- χ^2 : 110.66677818698827
- quality: bad
- extra: <8 items>
- device_components: ['Q0']
- verified: False
DbAnalysisResultV1
- name: f01
- value: 5090281600.81627 ± 6462.262991940065 Hz
- χ^2 : 110.66677818698827
- quality: bad
- device_components: ['Q0']
- verified: False
Component experiment 1

1&2qubit gate errors

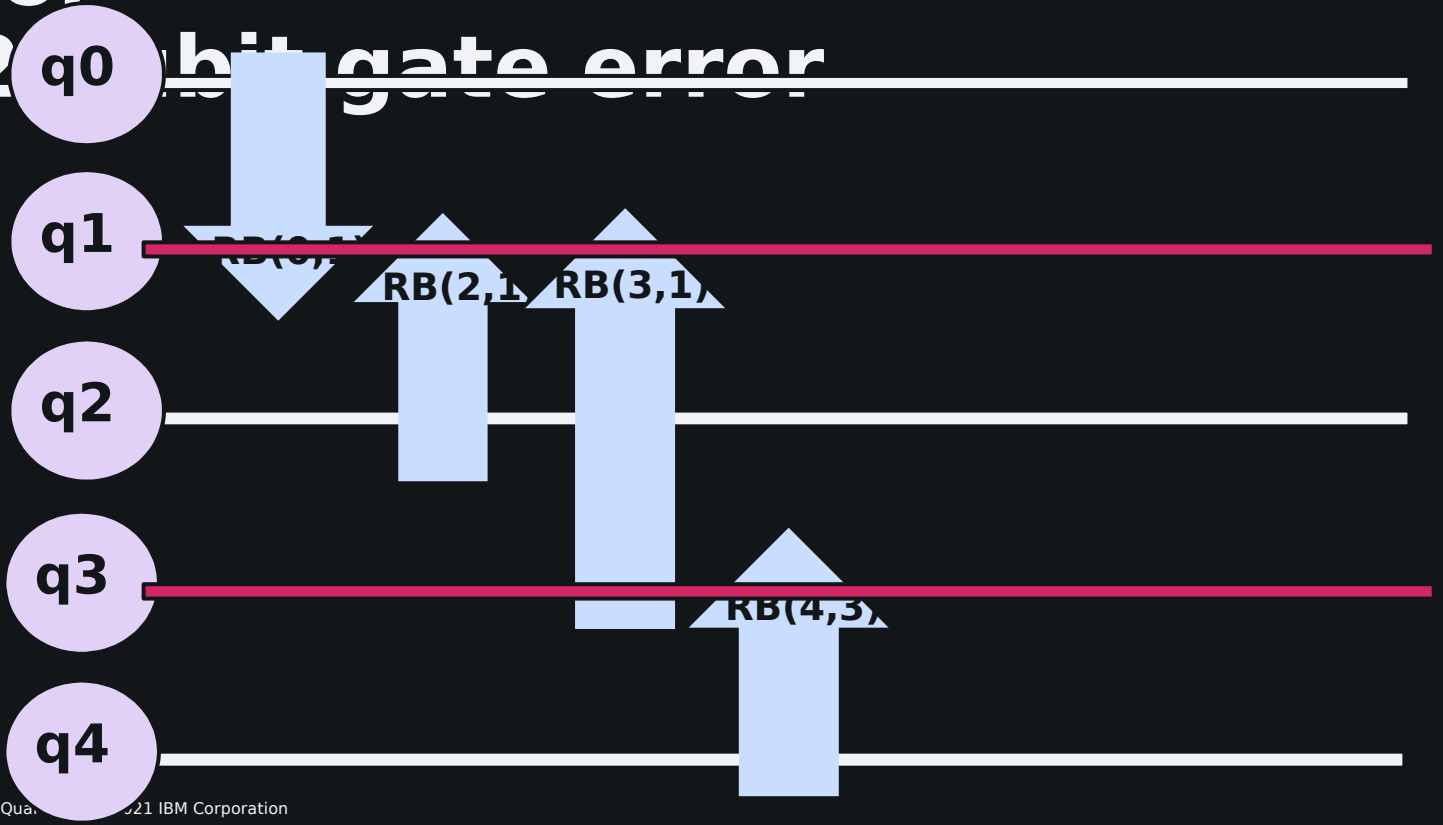


DbAnalysisResultV1
- name: @Parameters_RBAnalysis
- value: [0.46828341 0.99853983 0.51406031] ± [0.04557496 0.000219 0.04581386]
- χ^2 : 0.11362396283915219
- extra: <3 items>
- device_components: ['Q0']
- verified: False
DbAnalysisResultV1
- name: alpha
- value: 0.9985398294649062 ± 0.0002190041997 4582927
- χ^2 : 0.11362396283915219
- device_components: ['Q0']
- verified: False
DbAnalysisResultV1
- name: EPC
- value: 0.0007300852675469205 ± 0.0001095020998729 1464
- χ^2 : 0.11362396283915219
- device_components: ['Q0']
- verified: False
DbAnalysisResultV1
- name: EPG_rz
- value: 0.0
- χ^2 : 0.11362396283915219
- device_components: ['Q0']

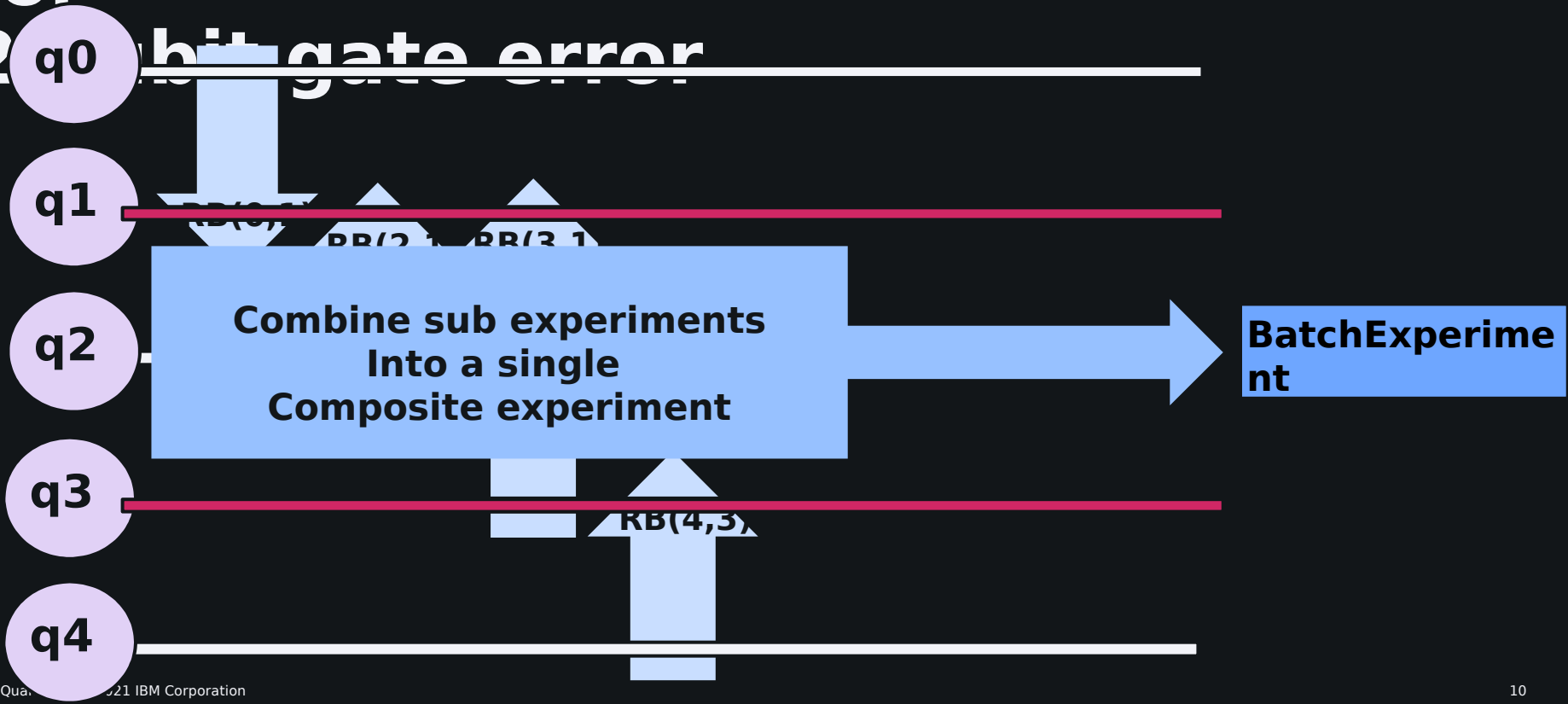
1 qubit RB for 1 qubit gate error



2qubit gate RB for 2qubit gate error



2qubit gate RB for 2qubit gate error



CNOT Direction

Qub	CNOT error	Gate time (ns)
Q0	0_1: 6.980e-3	0_1: 305.778
Q1	1_0: 6.980e-3 1_3: 1.488e-2 1_2: 5.477e-3	1_0: 341.333 1_3: 497.778 1_2: 334.222
Q2	2_1: 5.477e-3	2_1: 298.667
Q3	3_4: 1.613e-2 3_1: 1.488e-2	3_4: 519.111 3_1: 462.222
Q4	4_3: 1.613e-2	4_3: 483.556

Native direction : Gate time is shorter

```
coupled_qubit=config.coupling_map
def native_cnot(coupled_qubit):
    native_cnot=[]
    coupling_map=list(map(tuple, coupled_qubit))
    print(f'coupling_map={coupling_map}')
    print('₩n')

    for i in range(0, len(coupling_map)-1):
        for j in range(i+1, len(coupling_map)):
            if coupling_map[i][0]==coupling_map[j][1] and coupling_map[i][1]==coupling_map[j][0]:
                i_direction=backend.properties().gate_length('cx',(coupling_map[i][0],coupling_map[i][1]))
                j_direction=backend.properties().gate_length('cx',(coupling_map[j][0],coupling_map[j][1]))
                print(f'cx{coupling_map[i]} takes {i_direction}sec')
                print(f'cx{coupling_map[j]} takes {j_direction}sec')
                print('-----------------------------------------')
                if i_direction>j_direction:
                    native_cnot.append(coupling_map[j])
                else:
                    native_cnot.append(coupling_map[i])
    return native_cnot

native_cnot=native_cnot(coupled_qubit)

print(native_cnot)
```

```
coupling_map=[(0, 1), (1, 0), (1, 2), (1, 3), (2, 1), (3, 1), (3, 4), (4, 3)]


cx(0, 1) takes 3.0577777777777775e-07sec
cx(1, 0) takes 3.413333333333333e-07sec
-----------------------------------------
cx(1, 2) takes 3.34222222222222e-07sec
cx(2, 1) takes 2.9866666666666664e-07sec
-----------------------------------------
cx(1, 3) takes 4.977777777777778e-07sec
cx(3, 1) takes 4.622222222222222e-07sec
-----------------------------------------
cx(3, 4) takes 5.191111111111111e-07sec
cx(4, 3) takes 4.835555555555555e-07sec
-----------------------------------------
[(0, 1), (2, 1), (3, 1), (4, 3)]
```

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