aws

SUMMIT ONLINE

LX06

Quantum computing here and now with Amazon Braket

Jacky Ko

Professional Services Cloud Architect
Amazon Web Services

aws SUMMIT ONLINE

Agenda

What is quantum computing?

Why is quantum computing useful?

Quantum bit (qubit) and how they compute

Amazon Braket – your development environment for quantum algorithms

Demo

What is quantum computing?

AWS News Blog

Introducing QC2 – the Quantum Compute Cloud

by Jeff Barr | on 01 APR 2010 | in Amazon EC2, Compute | Permalink | Share

Jeff Barr, VP and Chief Evangelist, AWS

https://aws.amazon.com/blogs/aws/introducing-qc2-the-quantum-compute-cloud/

“I think I can safely say that nobody understands quantum mechanics.”

Richard P. Feynman

American theoretical physicist
who first conceived the
quantum computer in the 80s

aws SUMMIT ONLINE

"If you are not completely confused by quantum mechanics, you do not understand it."

John A. Wheeler

American theoretical physicist
who first used the term "black hole" in 1967

aws SUMMIT ONLINE

"A quantum computer is any device for computation that makes direct use of distinctively quantum mechanical phenomena, such as superposition and entanglement, to perform operations on data."

ScienceDaily

https://www.sciencedaily.com/terms/quantum_computer.htm

aws SUMMIT ONLINE

Quantum computing in a nutshell

Basic concepts of quantum computing and the road ahead

A quantum bit (qubit) can be 0 and 1 *simultaneously*

The states of 0 and 1 in a qubit operate in parallel with a probability distribution.
Like music: Superposition – multiple notes at the same time; entanglement – chords, not notes

Quantum computation is to manipulate qubits to give probable outcomes

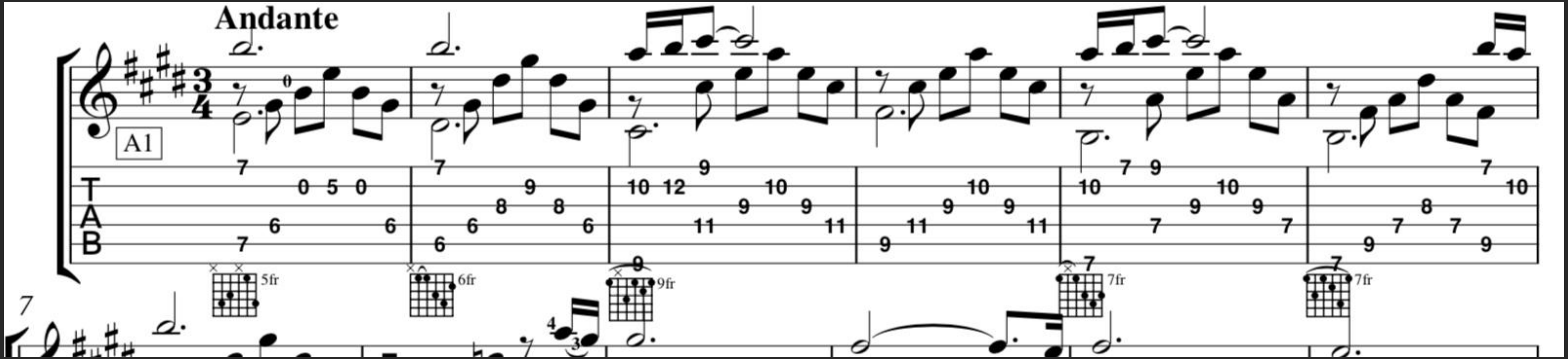
Multiple states exist; a quantum algorithm is to maximize the chance of giving the right outcome

Some challenges of quantum computing: noise and scale

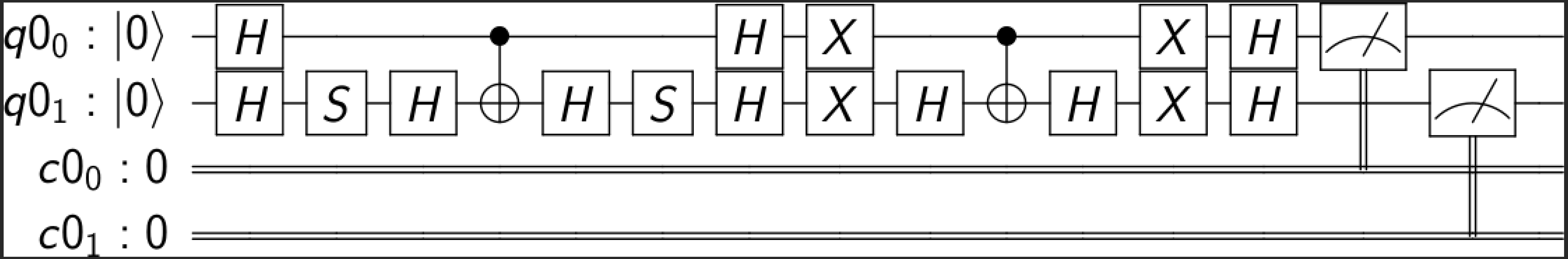
Qubits are fragile and noise can destroy its “music” (decoherence problem)

Building a large-scale quantum computer that outruns classical computers is a great challenge

Music to your ears



Cavatina – guitar arrangement



Grover’s algorithm – 2-qubit 4-item search

Why is quantum computing useful?

Potential applications of quantum computing

Some use cases in which quantum computing can deliver business outcome

Machine learning

Speeding up the training process in machine learning – Quantum Neural Network

Drug development

Simulating the chemistry of molecules to accelerate development of new drugs

Financial modeling

Modeling the financial market to gauge probability of outcomes and risks

Traffic optimisation

Finding the optimal path under a given condition and streamlining traffic flows

Quantum bits (qubits) and how they compute

aws SUMMIT ONLINE

“Quantum computers work by manipulating the amplitudes of the state vector.

“To program a quantum computer, you figure out how many qubits you need, wire them together into a quantum circuit, and run the circuit.

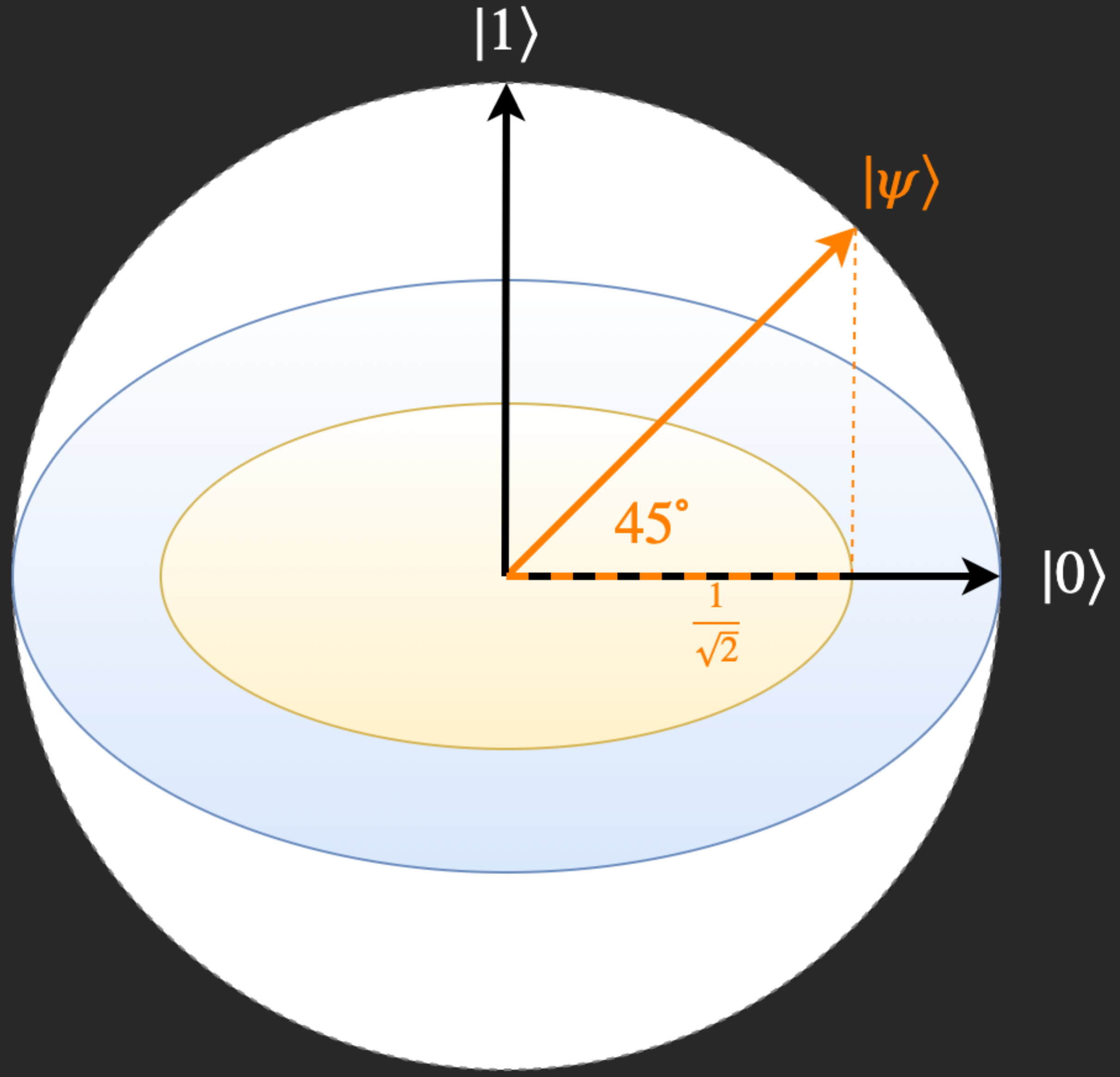
“When you build the circuit, you set it up so that the correct answer is the most probable one, and all the rest are highly improbable.”

Jeff Barr, VP and Chief Evangelist, AWS

https://aws.amazon.com/blogs/aws/amazon-braket-get-started-with-quantum-computing/

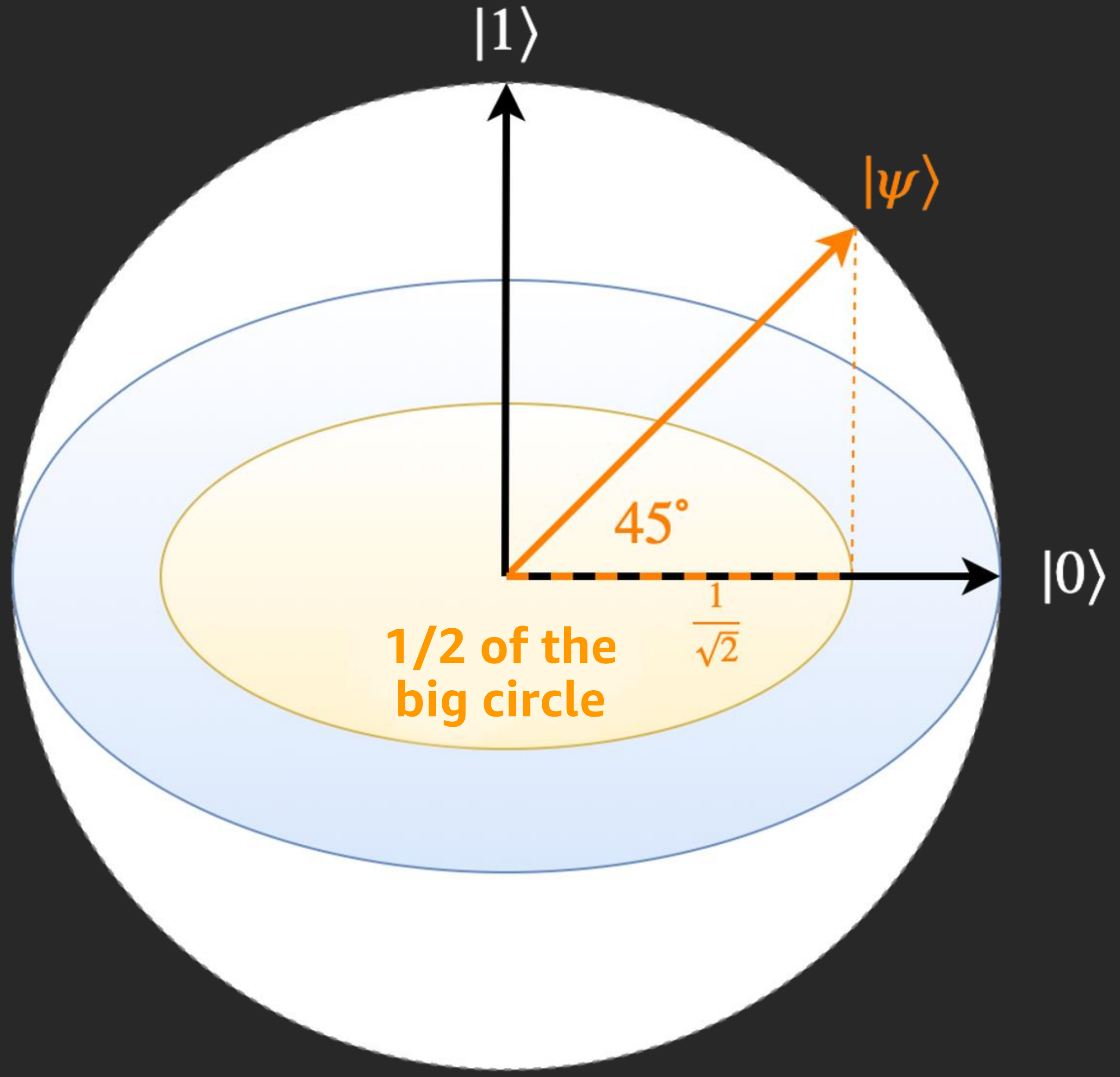
A quantum bit

A simplified model



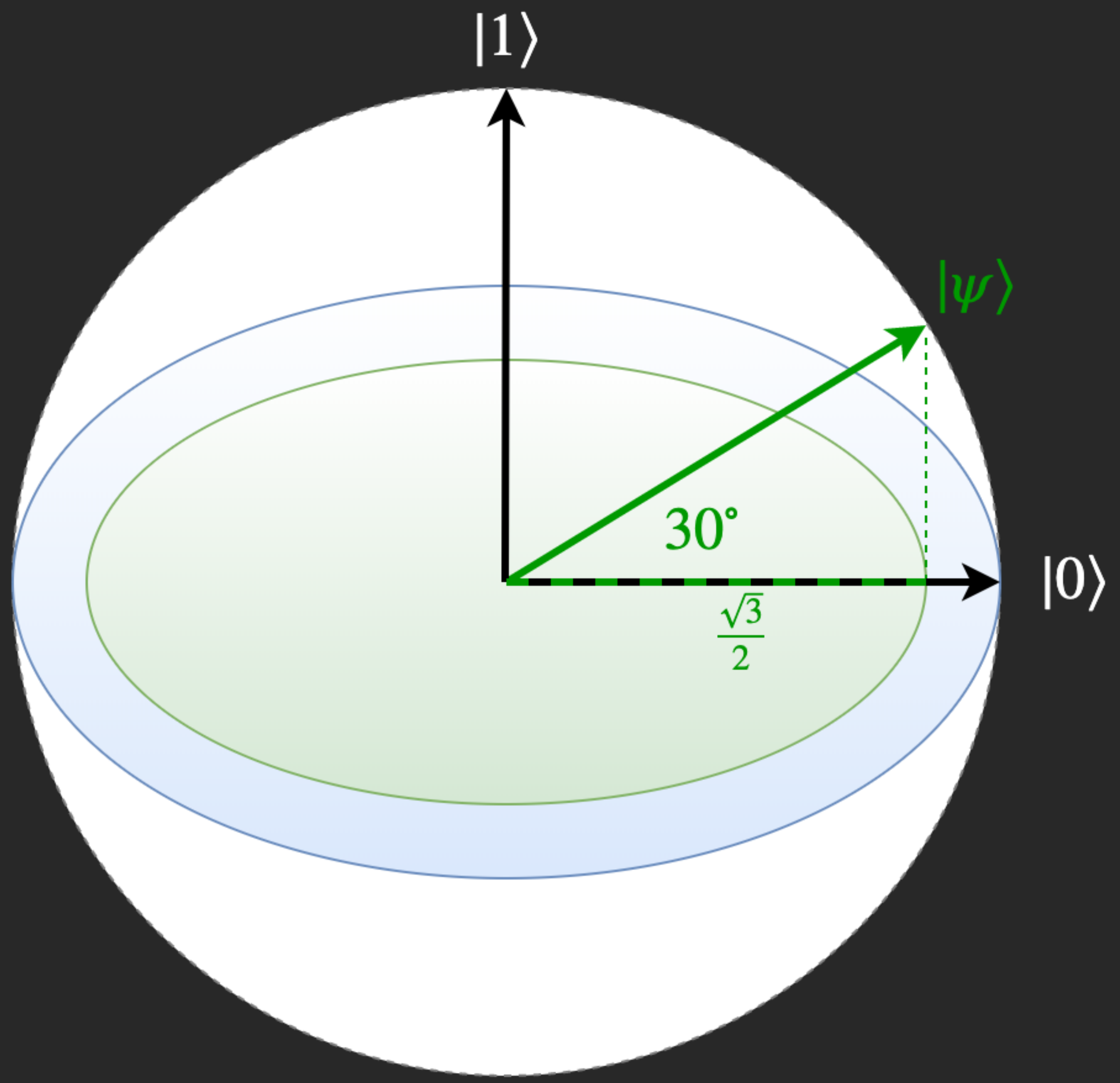
A quantum bit

A simplified model



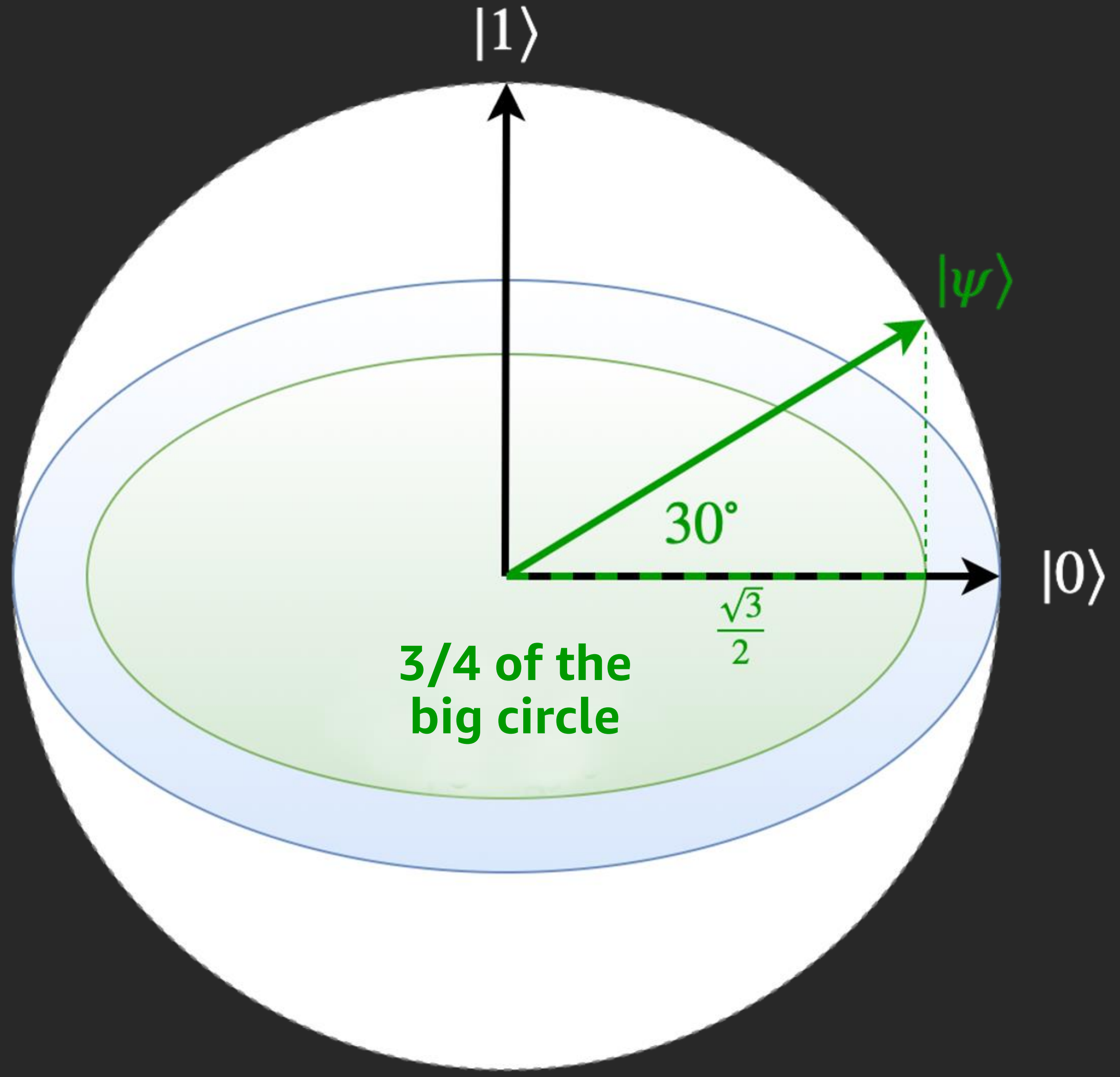
A quantum bit

A simplified model



A quantum bit

A simplified model



Amazon Braket

AWS SUMMIT ONLINE

Amazon Braket $\langle Bra \mid Ket \rangle$

Your development environment for quantum algorithms

Quantum algorithm development environment notebooks style

Developers, researchers, & scientists to explore, evaluate, & experiment with quantum computing

Access to real quantum computers of different technologies

Including Rigetti (superconductor), IonQ (ion trap), and D-Wave (annealing superconductor)

Amazon Quantum Solutions Lab

Collaborative research program to help you accelerate new quantum application development

Demo

aws SUMMIT ONLINE

Amazon Braket SDK

An example of Bell Pair

https://aws.amazon.com/braket/

```
bell = Circuit().h(0).cnot(0, 1)
print(bell)
print(f"\nserialized_circuit: {bell.to_ir().json()}")

result = simulator.run(bell, s3_destination_folder).result()
print(f"measurement_counts: {result.measurement_counts}")
print(f"measurement_probabilities: {result.measurement_probabilities}")

data = ["".join([str(bit for bit in shot]) for shot in result.measurements]
plot = plt.hist(data)
```

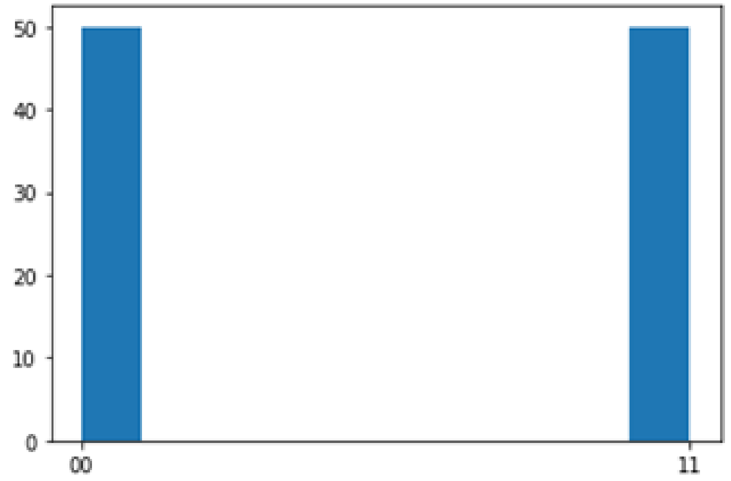
```
measurement_counts: ({'00': 50, '11: 50'})
measurement_probabilities: ({'00': 0.5, '11': 0.5})
```

Amazon Braket SDK

An example of Bell Pair

https://aws.amazon.com/braket/

```
 'ZZ']

In [3]: bell = Circuit().h(0).cnot(0, 1)
        print(bell)
        print(f"\nserialized_circuit: {bell.to_ir().json()}")

T  : |0|1|

q0 : -H-C-
        |
q1 : ---X-

T  : |0|1|

serialized_circuit: {"instructions": [{"target": 0, "type": "h"}, {"control": 0, "target": 1, "type": "cnot"}]}

In [4]: result = simulator.run(bell, s3_destination_folder).result()
        print(f"measurement_counts: {result.measurement_counts}")
        print(f"measurement_probabilities: {result.measurement_probabilities}")

        data = ["".join([str(bit) for bit in shot]) for shot in result.measurements]
        plot = plt.hist(data)

measurement_counts: Counter({'00': 50, '11': 50})
measurement_probabilities: {'00': 0.5, '11': 0.5}
```




```
In [5]: # QFT example. Encode a circuit with phase frequency of 2. Run QFT and get back a value of 2.
```

Thank you!

Jacky Ko

kjacky@amazon.com

AWS SUMMIT ONLINE