**Slide 1: Quantum vs classical computers**

Classical computers are programmed with bits as data units (which can be either zeros or ones). Quantum computers use so-called qubits, which can be overlays of zeros and ones (meaning part zero and part one at the same time).

**Qubits do not exist in isolation but instead become entangled and act as a group**. These two properties enable qubits to achieve an exponentially higher information density than classical computers. Note that this interaction is at the heart of what we will discuss later.

The limitation of bits comes into play when classical computers face a problem with multiple variables. In these scenarios, computers must conduct a new calculation every time a variable is changed. Each calculation is a single path to a single result. On a large-scale problem this could take millions of years

Quantum computers, on the other hand, have an exponentially larger working space, thanks to the nature of qubits. They can find all possible variants at the same time, which is what gives quantum computers the potential to be so much faster. They deliver multiple results in a tight range, getting you closer to the answer far faster than classical computers can.

**Slide 2: Quantum vs classical computers**

In [quantum computing](https://en.wikipedia.org/wiki/Quantum_computing), quantum supremacy or quantum advantage is the goal of demonstrating that a programmable quantum device can solve a problem that no classical computer can solve in any feasible amount of time

While quantum computers cannot solve any problems that classical computers cannot already solve, it is suspected that they can solve certain problems faster than classical computers. For instance, it is known that quantum computers can efficiently [factor integers](https://en.wikipedia.org/wiki/Integer_factorization), while this is not believed to be the case for classical computers

On September 20, 2019, the [Financial Times](https://en.wikipedia.org/wiki/Financial_Times) reported that "Google claims to have reached quantum supremacy with an array of 54 qubits out of which 53 were functional, which were used to perform a series of operations in 200 seconds that would take a supercomputer about 10,000 years to complete".[[34]](https://en.wikipedia.org/wiki/Quantum_supremacy#cite_note-34)[[35]](https://en.wikipedia.org/wiki/Quantum_supremacy#cite_note-35) On October 23, Google officially confirmed the claims

Example: In December 2020, a group based in [USTC](https://en.wikipedia.org/wiki/University_of_Science_and_Technology_of_China) reached quantum supremacy by implementing a type of [Boson sampling](https://en.wikipedia.org/wiki/Boson_sampling) on 76 photons with their [photonic quantum computer](https://en.wikipedia.org/wiki/Linear_optical_quantum_computing) [Jiuzhang](https://en.wikipedia.org/wiki/Jiuzhang_(quantum_computer)).[[41]](https://en.wikipedia.org/wiki/Quantum_supremacy#cite_note-41)[[42]](https://en.wikipedia.org/wiki/Quantum_supremacy#cite_note-42)[[43]](https://en.wikipedia.org/wiki/Quantum_supremacy#cite_note-43) The paper states that to generate the number of samples the quantum computer generates in 20 seconds, a classical supercomputer would require 600 million years of computation

**Slide 3: Quantum computers will not replace classical computers**

Even though, quantum computers can solve some problems faster than classical computer, they will not replace them.

It is due to the fact that quantum computers don’t deliver one clear answer. Instead, users get a narrowed range of possible answers.

In fact, they may find themselves conducting multiple runs of calculations to narrow the range even more, a process that can significantly lessen the speed gains of doing multiple calculations at once.

Getting a range rather than a single answer makes quantum computers sound less precise than today’s computers. That’s true for calculations that are limited in scope, which is one reason quantum computers won’t replace today’s systems.

Instead, quantum computers will be used for different kinds of problems, incredibly complex ones in which eliminating an enormous range of possibilities will save an enormous amount of time.

In the 2020s, we expect many multivariable problems to be solved through a combination of quantum and classical computing. For instance, by using nascent quantum computers to narrow the range of possible solutions to a finance or logistics problem, a company might reach the optimal solution 10 percent faster.

**Slide 4: Main obstacle to quantum computing**

One of the greatest challenges involved with constructing quantum computers is controlling or removing [quantum decoherence](https://en.wikipedia.org/wiki/Quantum_decoherence). This usually means isolating the system from its environment as interactions with the external world cause the system to decohere.

Due to decoherence qubits are extremely fragile and their ability to stay in superposition and or entangle is severely jeopardized..

Which basically means if we don’t factor in the precautions for completely eliminating decoherence then there is no quantum system.

There is a limit to how long qubits can retain their quantum properties before errors falter the computational mechanism. This is called Coherence Length. Time-consuming tasks may render some quantum algorithms inoperable, as maintaining the state of qubits for a long enough duration will eventually corrupt the superpositions

**Slide 5: Quantum error correction**

To increase coherence length and build fault-tolerant quantum computers we must introduce the idea of Quantum Error Correction.

QEC is a theory loosely built on conventional error correction where information is copied and encoded into multiple bits. This helps to deal with any errors that disrupt information and change their state from 0 to 1. In order to have error corrected qubit, possibly 1,000 error-correcting qubits would be needed for each calculating qubit. This implies that the next five to ten years of development will probably take place without error correction.