

D-Wave Background

- Founded in 1999
- World's first commercial quantum computer
 - Two 512 qubit systems installed
Lockheed/USC
Google/NASA Ames
- We have demonstrated 10,000 – 100,000x speedups
- 100 U.S. patents
- \$130M raised

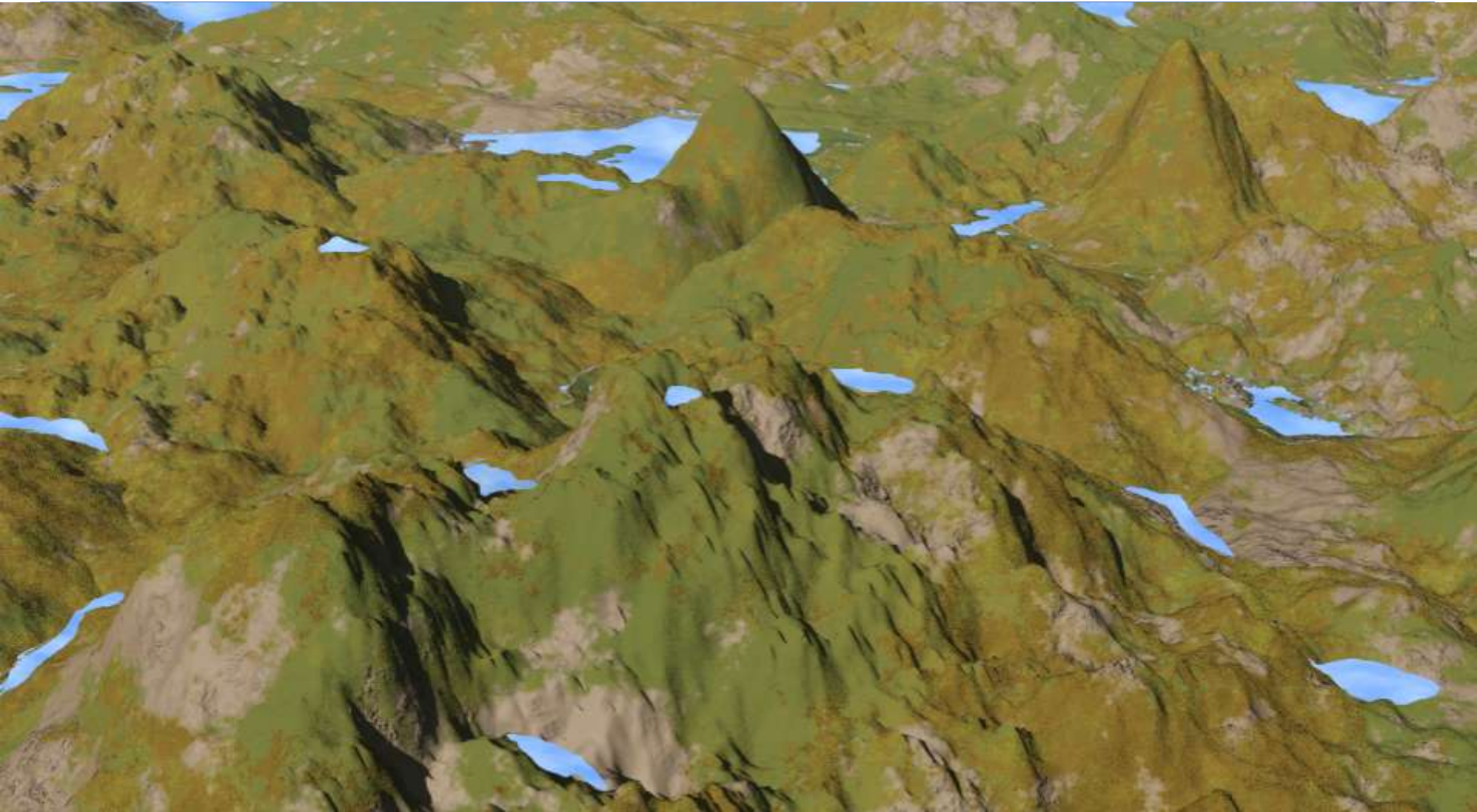


Mission

**To help solve the most challenging problems
in the multiverse:**

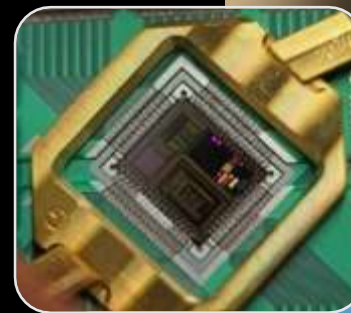
- **Optimization**
- **Machine Learning**
- **Monte Carlo/Sampling**

How it Works

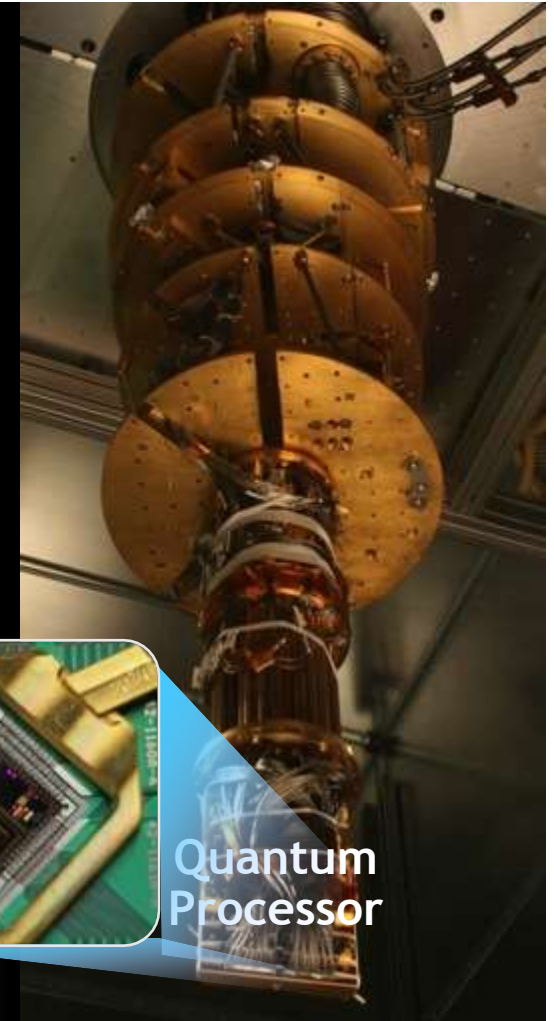


What is a Quantum Computer?

- Exploits **quantum mechanical** effects
- Built around “**qubits**” rather than “bits”
- Operates in an **extreme** environment
- Enables **quantum algorithms** to solve very hard problems

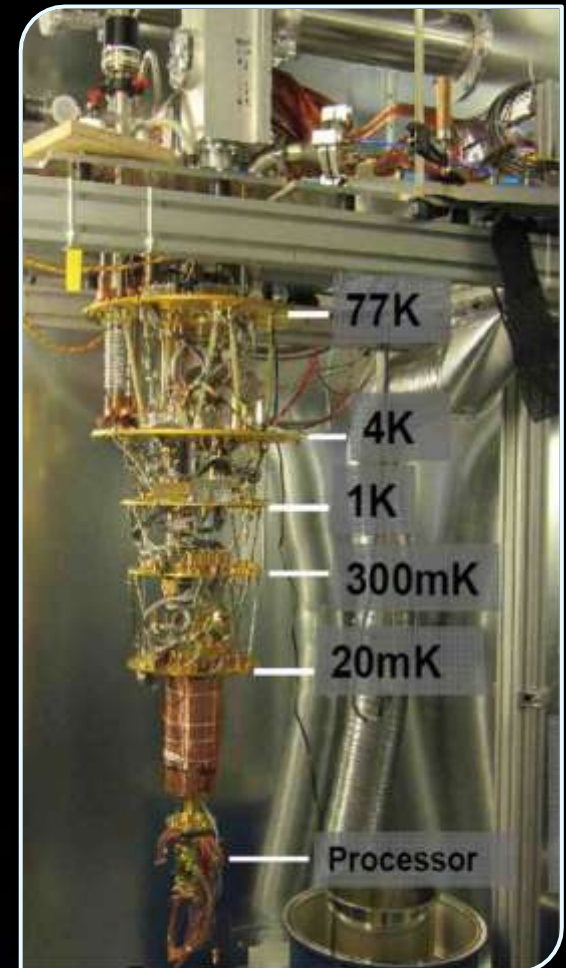


Quantum Processor



Environment Inside the Box

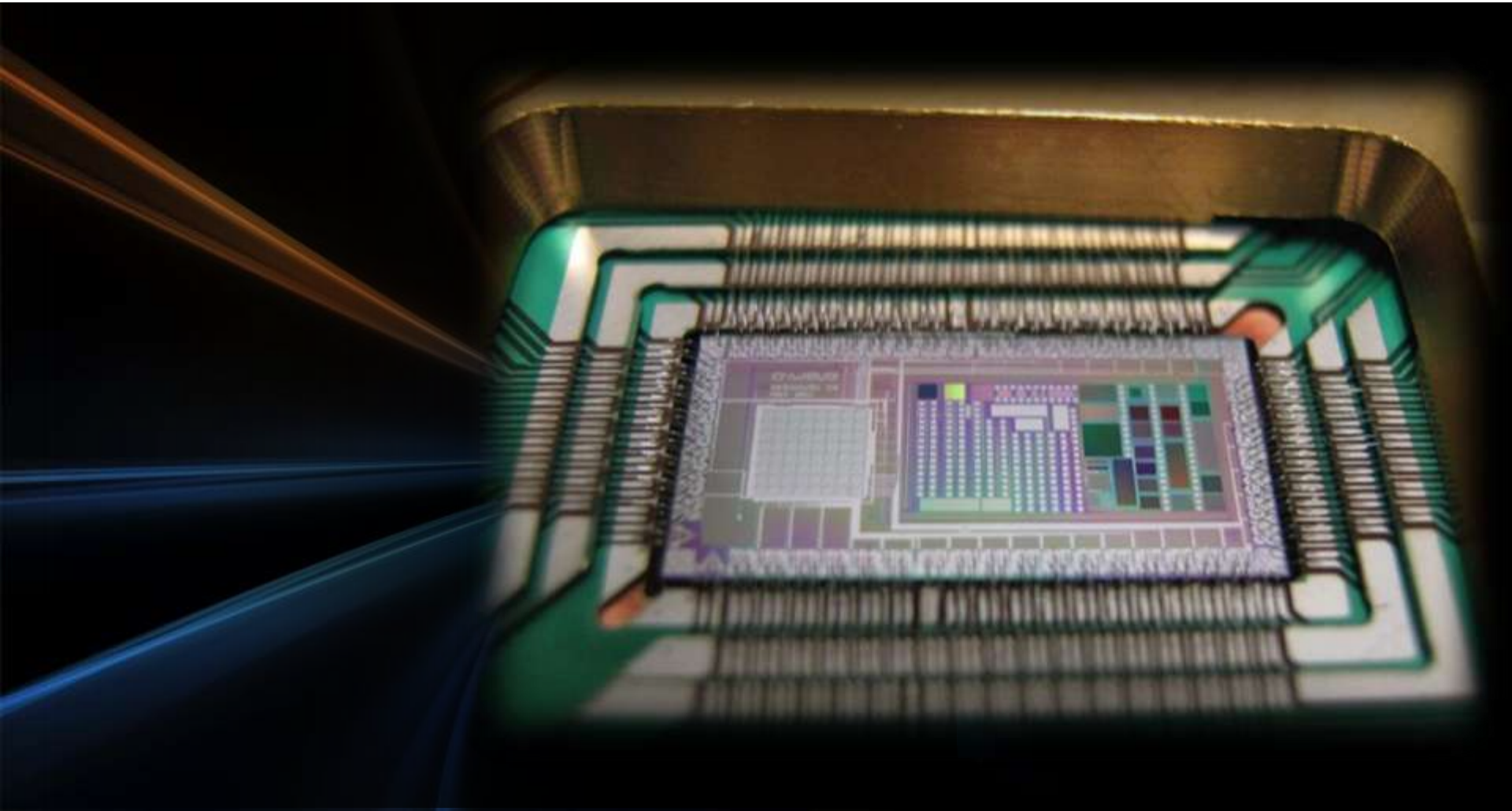
- Cooled to 0.02 Kelvin, 150x colder than interstellar space
- Shielded to 50,000× less than Earth's magnetic field
- In a high vacuum: pressure is 10 billion times lower than atmospheric pressure
- On low vibration floor
- Superconducting, power consumption is 15.5 kW



What It Looks Like – Chip in a Cool SCIF



A D-Wave Two Quantum Processor

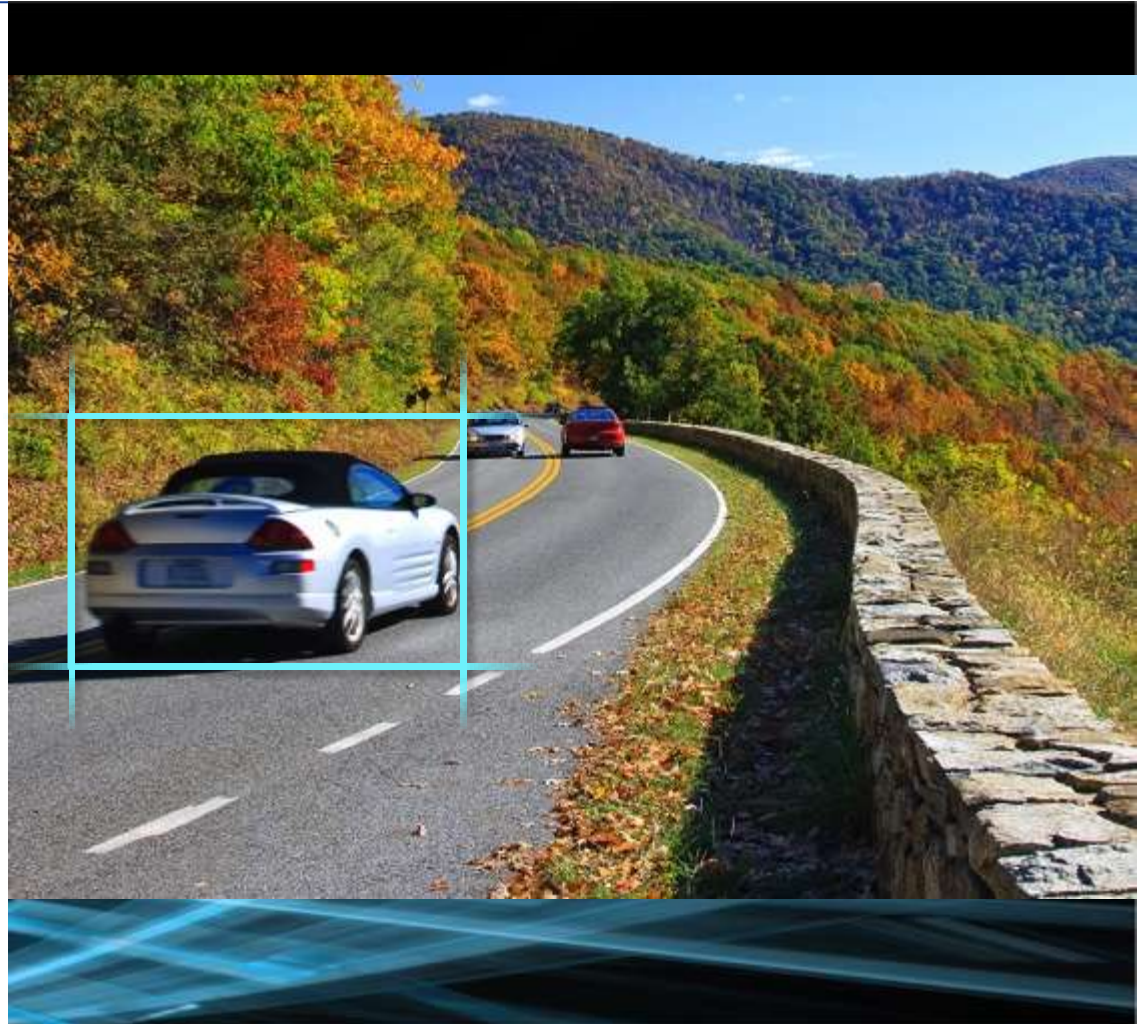


Programming Environment

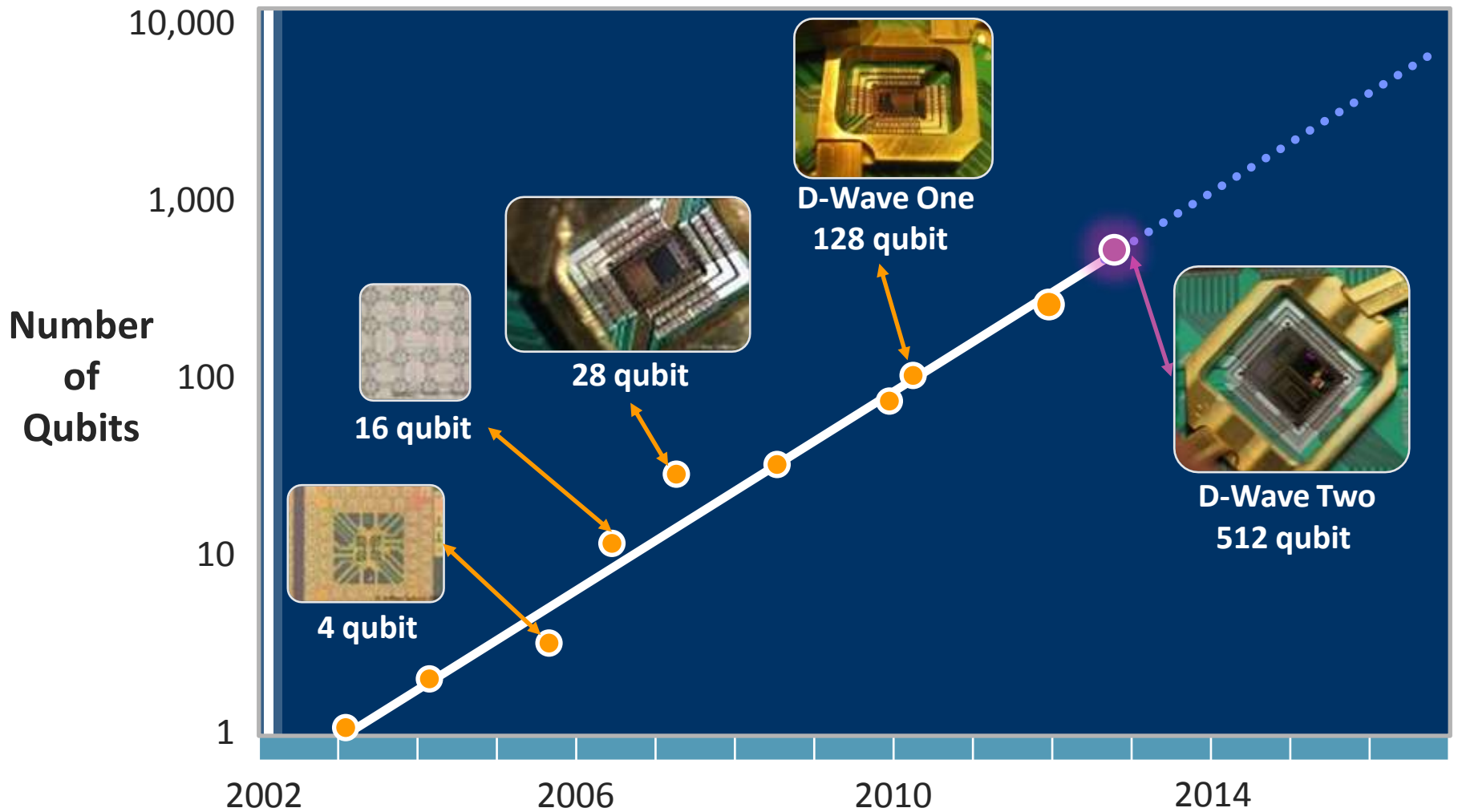
- Currently three programming methods:
 - Quantum Machine Language
 - Directly program the D-Wave system using its single machine instruction
 - Use a programming language or mathematical interpreter
 - Allows existing C, C++, Python, *Fortran*..programs to create and execute a quantum machine instruction
 - Use mathematical interpreter such as MATLAB to generate the quantum machine instruction
 - Software Tools
 - QSage
 - *ToQ, Deqo*

Machine Learning: Binary Classification

- Traditional algorithm recognized car about 84% of the time
- Google/D-Wave Qboost algorithm implemented to recognize a car (cars have big shadows!)
- “Quantum Classifier” was more accurate (94%) and more efficient
- Ported quantum classifier back to traditional computer, more accurate and fewer CPU cycles (less power)!



The New Law – Double #Qubits ~ Every Year



In Summary

Will QCs Make HPCs Obsolete?

- No
- They're suited to different tasks
 - **HPCs:** Computational fluid dynamics, molecular simulation, weather forecasting, nuclear weapons modeling, etc.
 - **QCs:** discrete combinatorial optimization, artificial intelligence, machine learning, sampling
- But **together** they can enhance each other ...