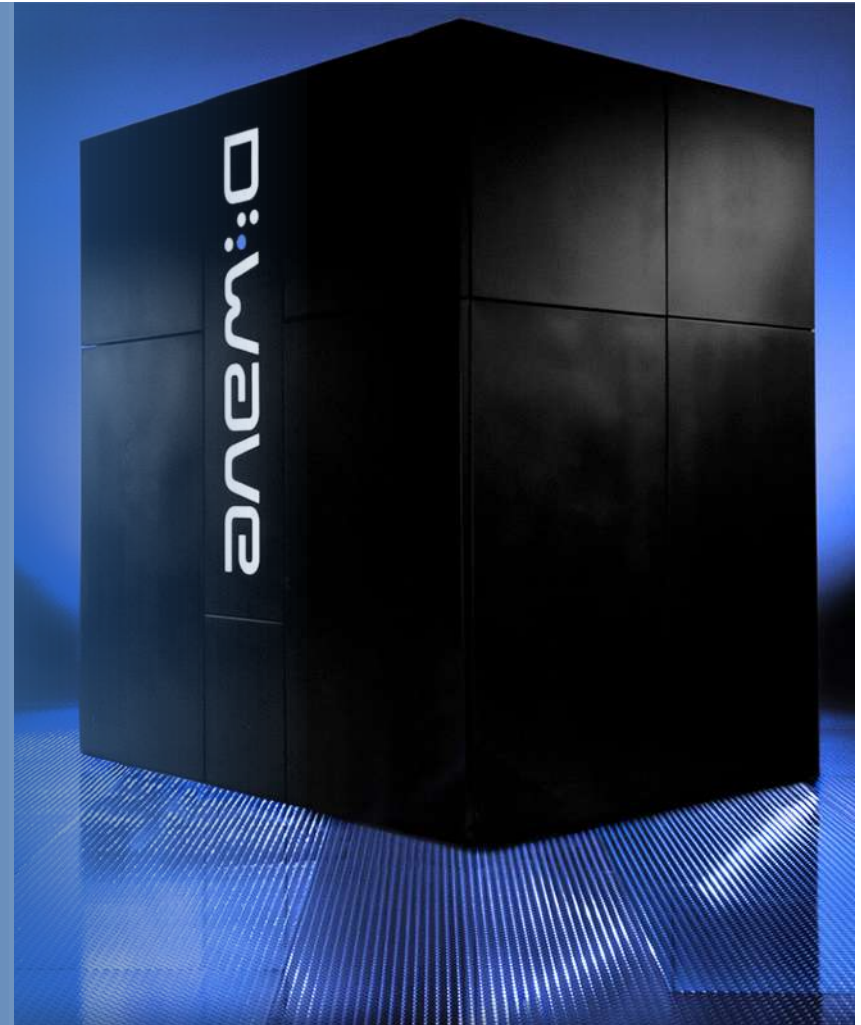# D-Wave Background

- 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
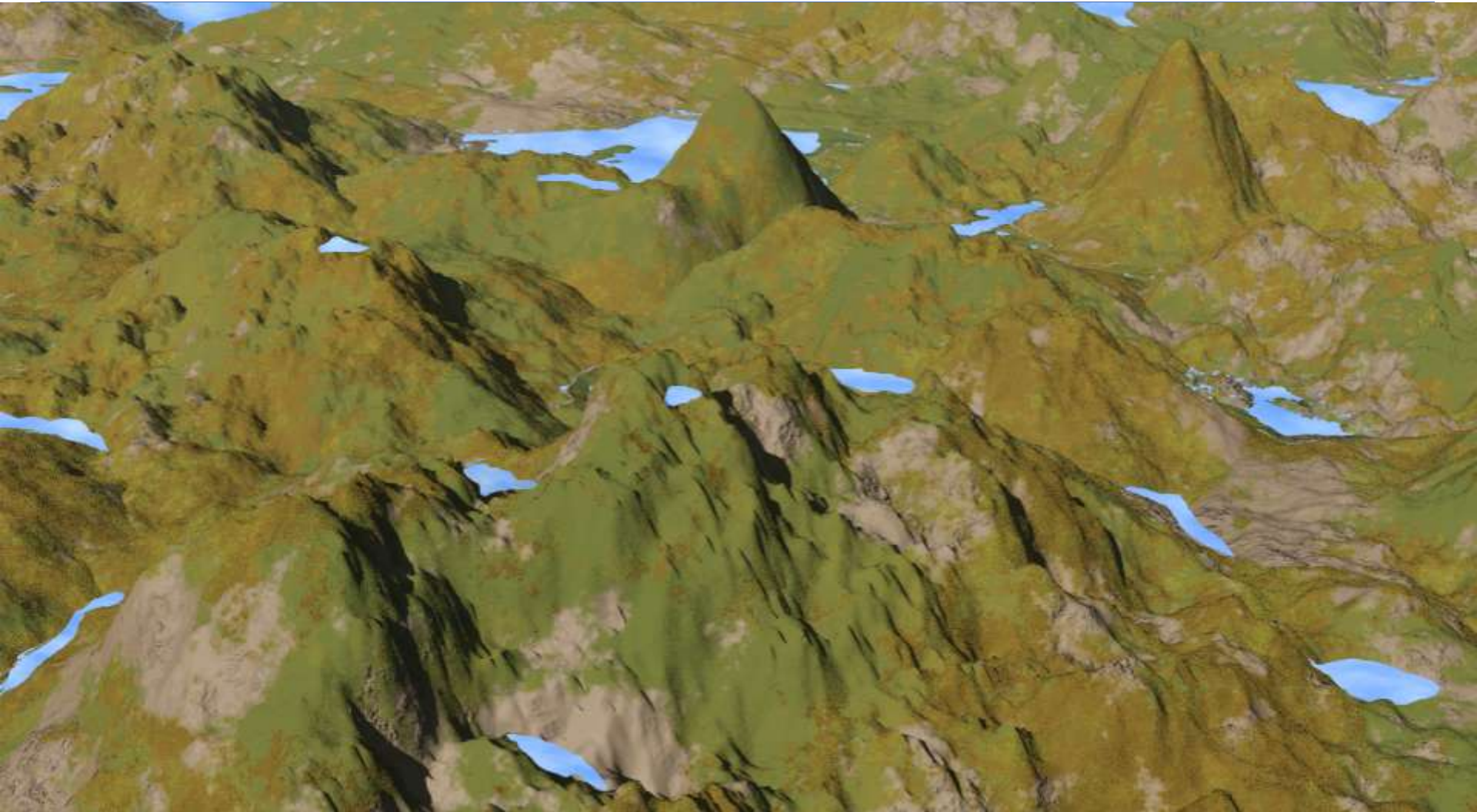
- 100 U.S. patents

- $130M raised

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Mission

To help solve the most challenging problems in the multiverse:

- **Optimization**

- **Machine Learning**

- **Monte Carlo/Sampling**

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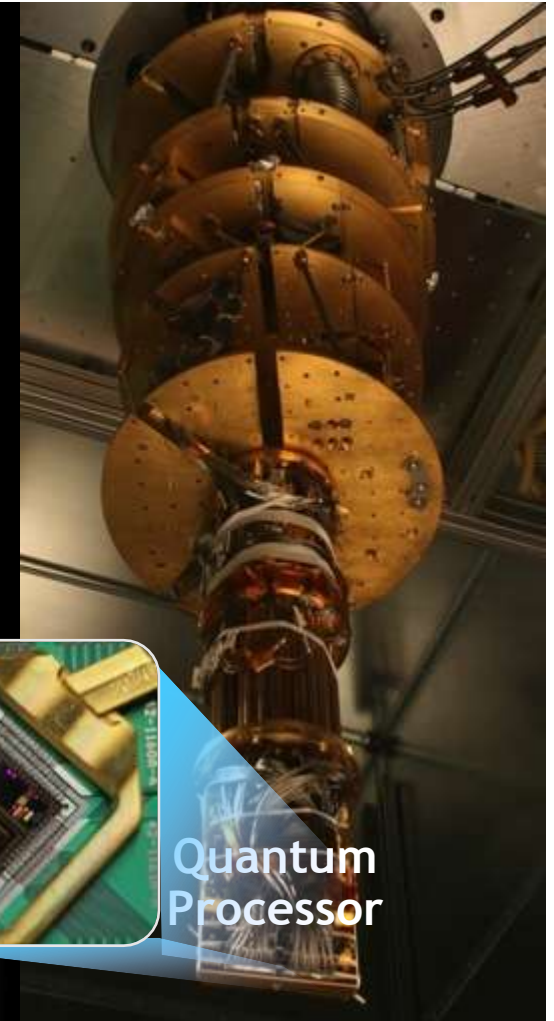The Quantum Computing Company™

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

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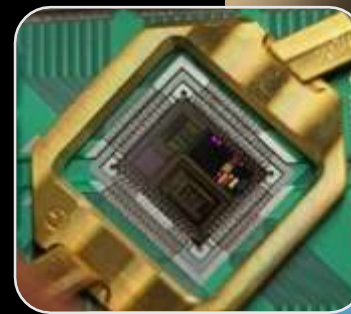
# What It Looks Like – Chip in a Cool SCIF

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

77K
4K
1K
300mK
20mK
Processor

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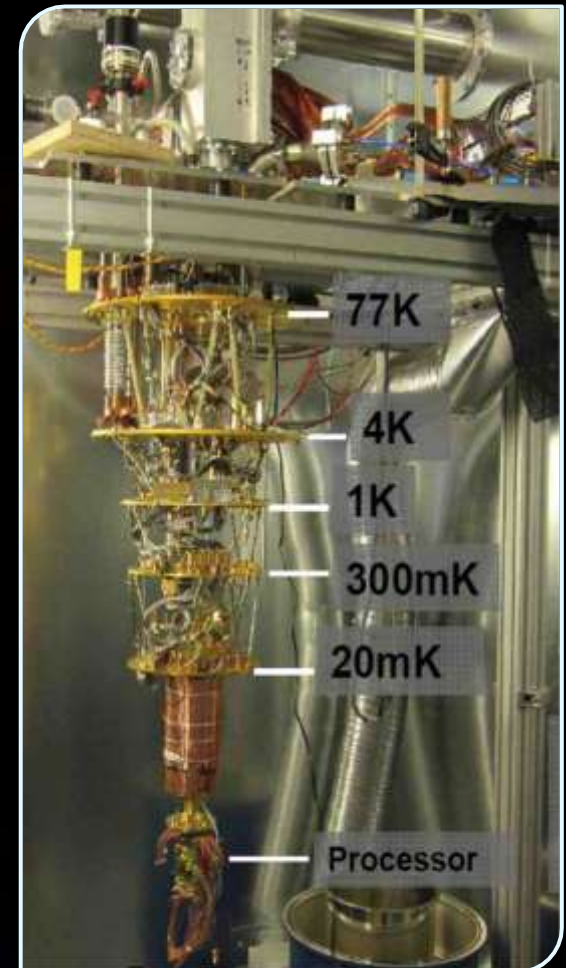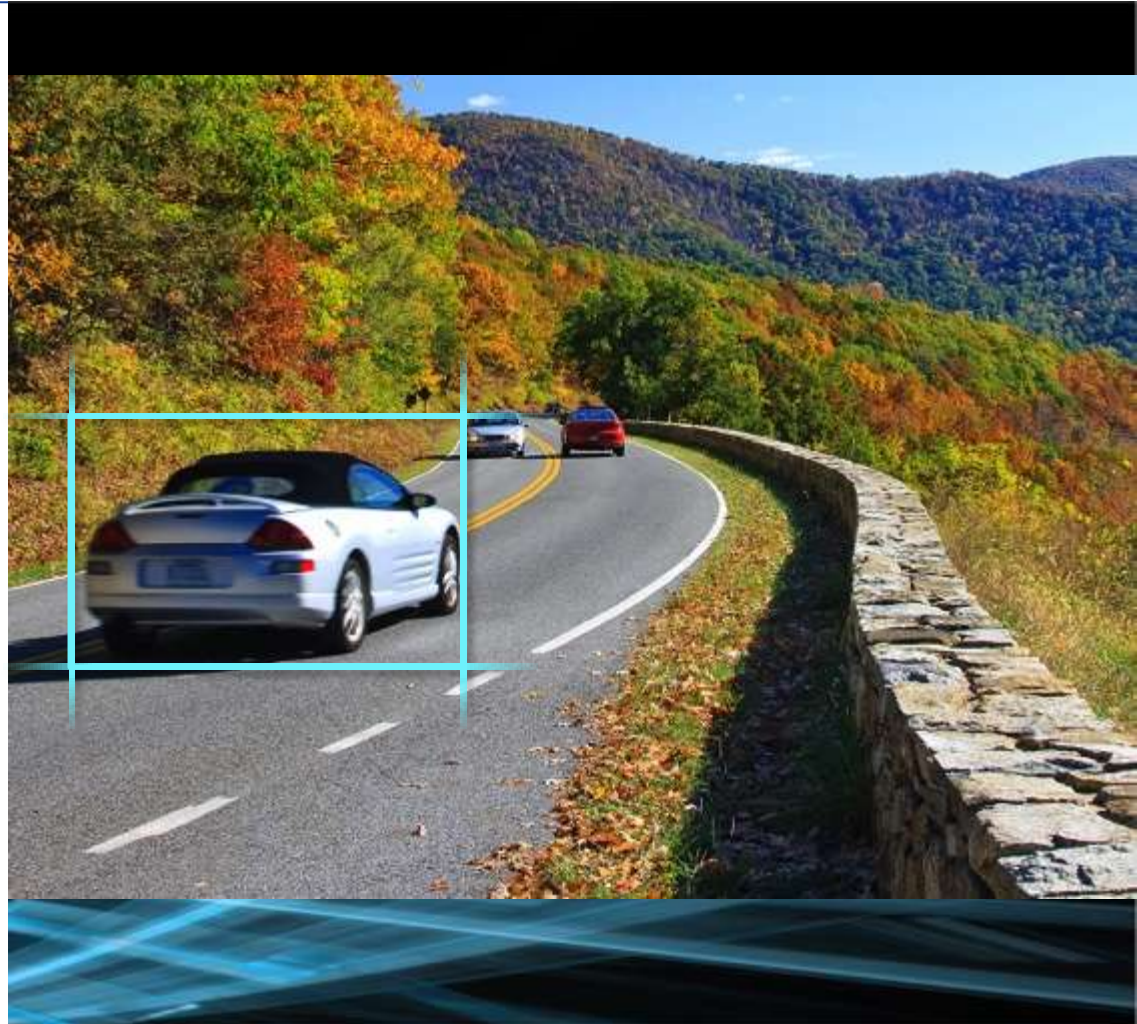
A D-Wave Two Quantum Processor
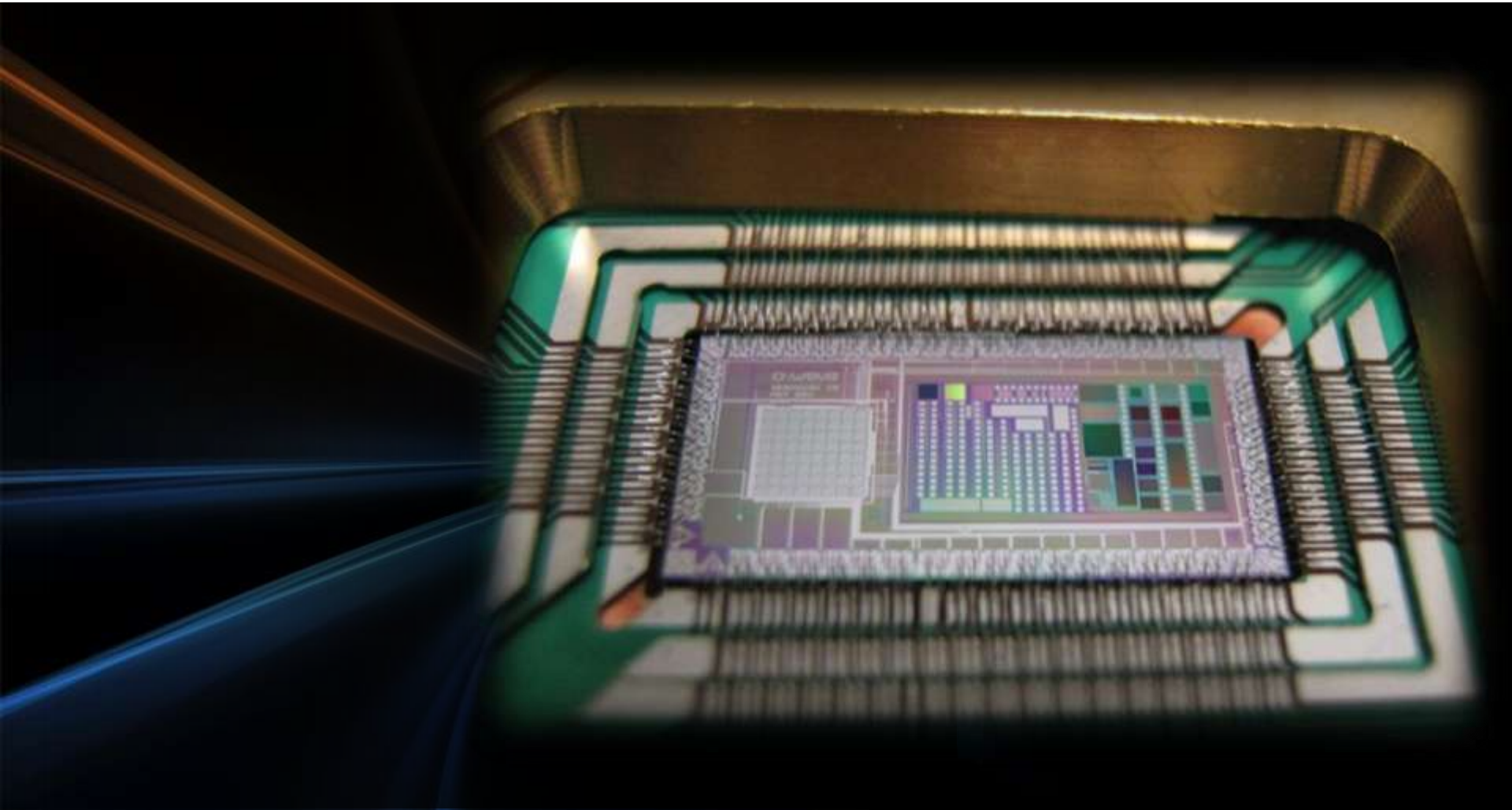
Programming Environment

- 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
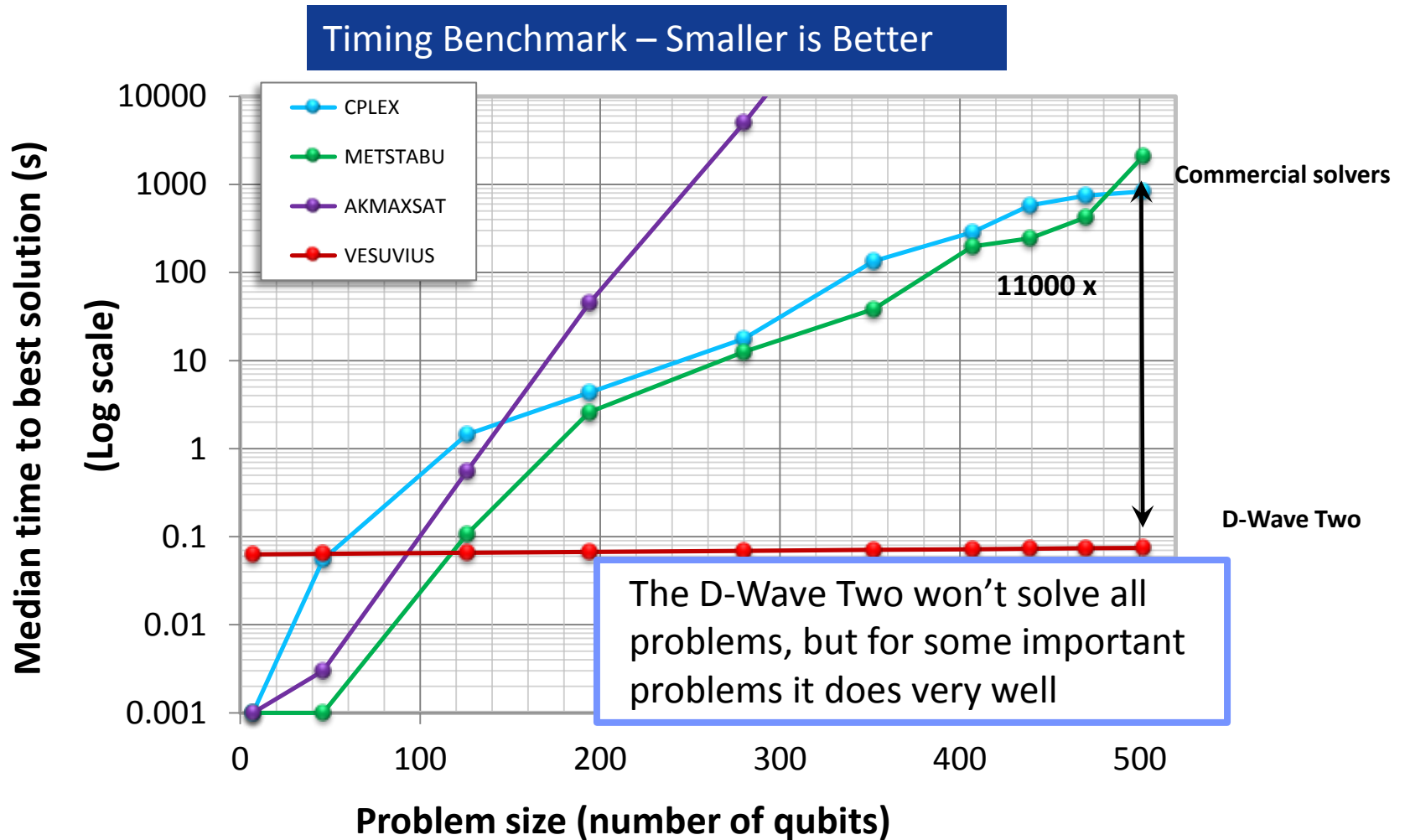   - QSage
    - *ToQ, Deqo*

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)!
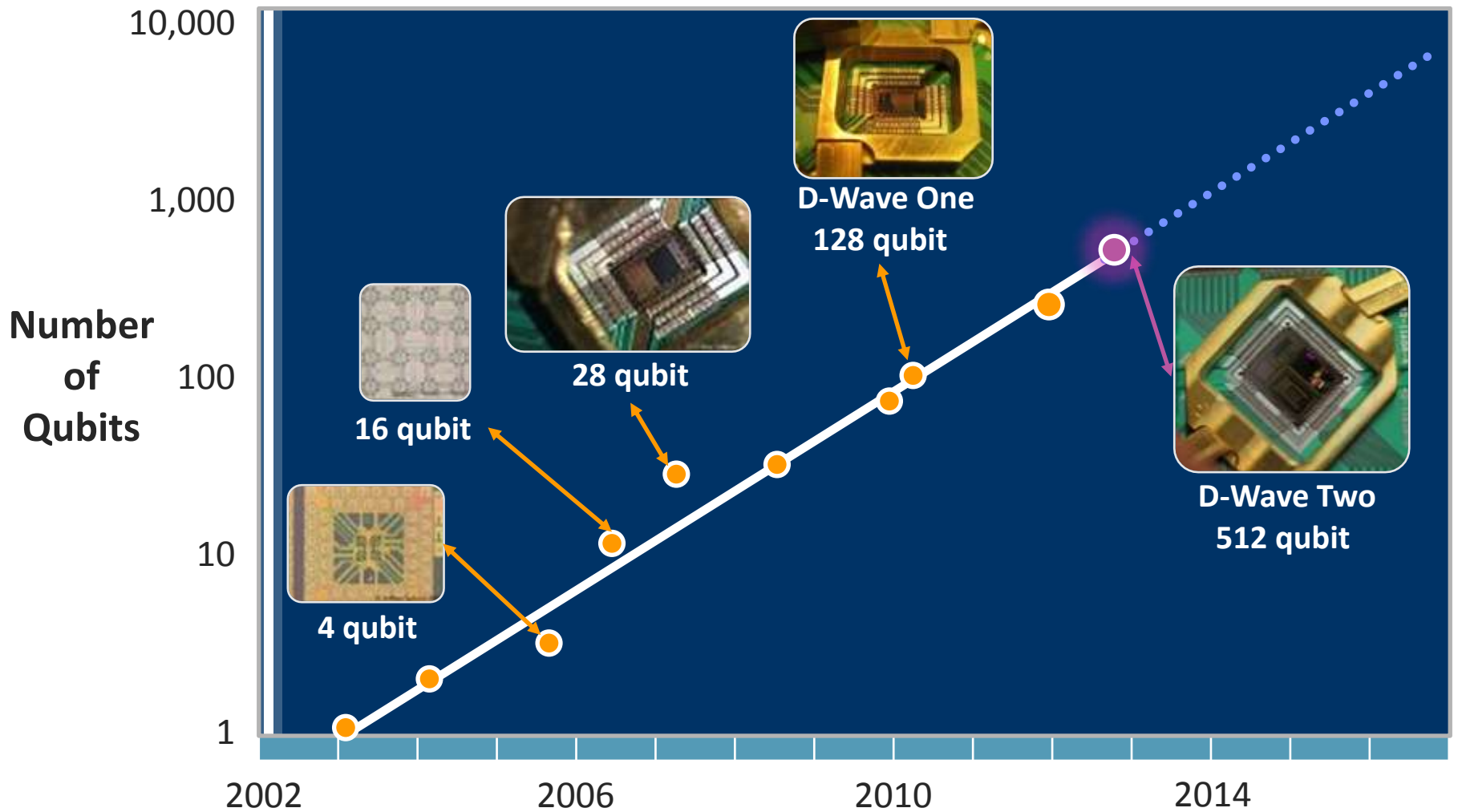
Discrete Combinatorial Optimization Benchmarks
Median Time to Find Best Solution

Timing Benchmark – Smaller is Better

The D-Wave Two won't solve all problems, but for some important problems it does very well

The New Law – Double #Qubits ~ Every Year

Number of Qubits (y-axis, logarithmic): 1, 10, 100, 1,000, 10,000

Years (x-axis): 2002, 2006, 2010, 2014

4 qubit
16 qubit
28 qubit
D-Wave One 128 qubit
D-Wave Two 512 qubit

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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 …

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