What is quantum computing?

Dr. Geordie Rose
Founder and CTO, D-Wave
6:00PM Wednesday January 8th 2014
@ UBC

http://www.wired.com/wiredscience/2010/01/quantum-computer-hydrogen-simulation/

… quantum computers … can solve problems whose solution will never be feasible on a conventional computer.

Quantum computing for everyone
Michael Nielsen (2008)
http://michaelnielsen.org/blog/quantum-computing-for-everyone/

Image from http://www.longexposure.ca/2011/03/tedx-waterloo-the-uncharted/

…all the effects of nature are only the mathematical consequences of a small number of immutable laws.

A Philosophical Essay on Probabilities

Pierre-Simon Laplace (1795)

http://bayes.wustl.edu/Manual/laplace_A_philosophical_essay_on_probabilities.pdf

Image from http://en.wikipedia.org/wiki/Pierre-Simon_Laplace

The universe is but a watch on a larger scale.

Conversations on the Plurality of Worlds

Bernard de Fontenelle (1686)

http://www.amazon.ca/The-Clockwork-Universe-Newton-Society/dp/0061719528

Image from http://en.wikipedia.org/wiki/Bernard_Le_Bovier_de_Fontenelle

One by one, pillars of classical logic have fallen by the wayside… quantum mechanics… demonstrated that elementary particles and the atoms they form are doing a million seemingly impossible things at once.

A Universe Without Purpose, LA Times

Lawrence Krauss (2012)

http://articles.latimes.com/2012/apr/01/opinion/la-oe-krauss-cosmology-design-universe-20120401

Computers are physical objects, and computations are physical processes. What computers can or cannot compute is determined by the laws of physics alone, and not by pure mathematics.

The Fabric of Reality

David Deutsch (1997)

http://en.wikipedia.org/wiki/David_Deutsch

Classical computers

Classical physics

The universe is but a watch on a larger scale.

Classical computers

Quantum computers

Classical physics

Quantum physics

Nature isn't classical, dammit...

Good initial use targets …

- Number theory (crypto, bitcoin mining)
- Simulating chemistry (pharma & chemical)

→ ‘Drexlerian’ nanotechnology

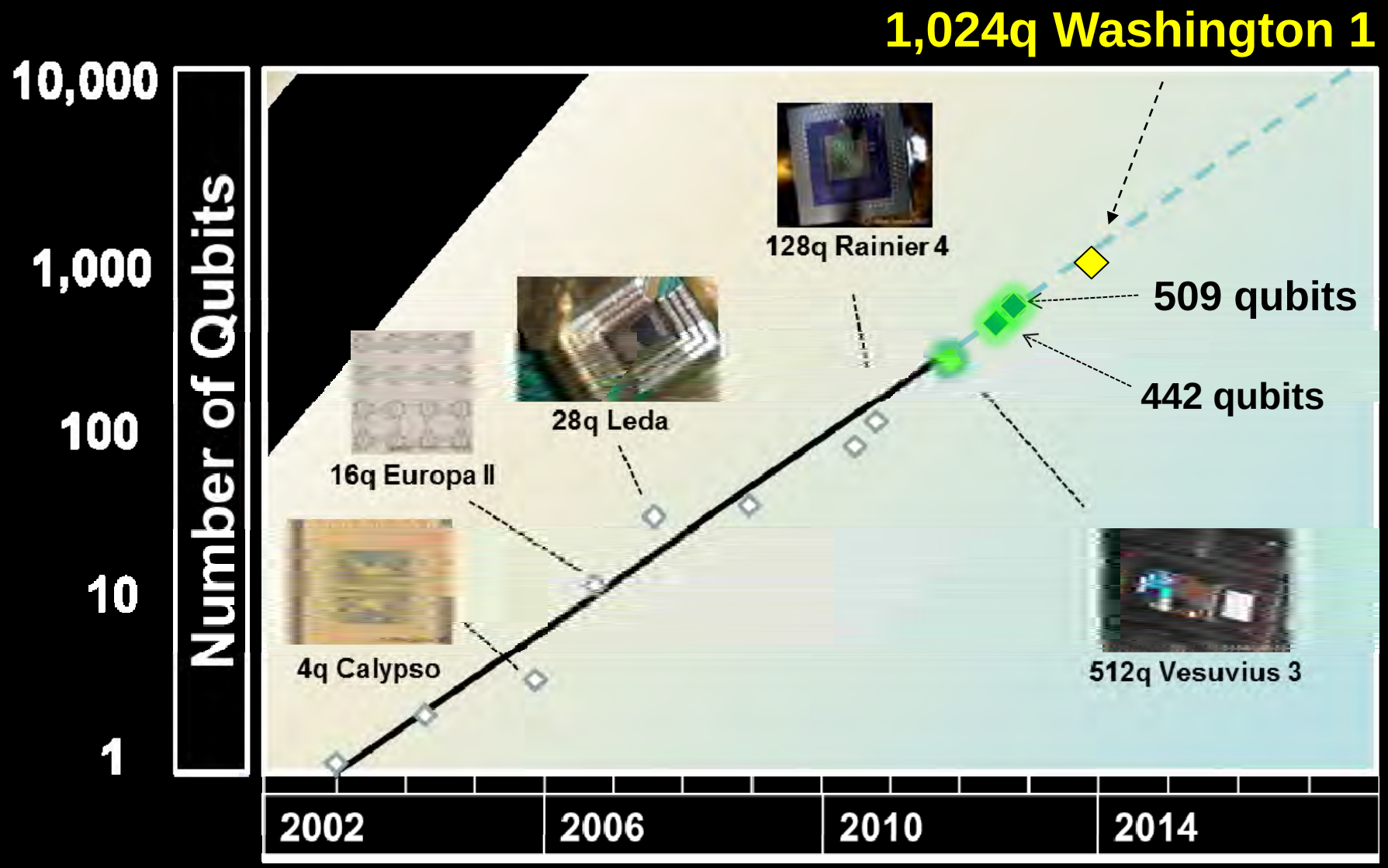
- **Optimization & probabilistic computing (machine learning, artificial intelligence, robotics, planning, logistics, etc…)**

→ **Augmenting machine intelligence**

Our approach to building QCs

Image from
http://www.nas.nasa.gov/quantum/quantumcomp.html

Evolve a new species of processor

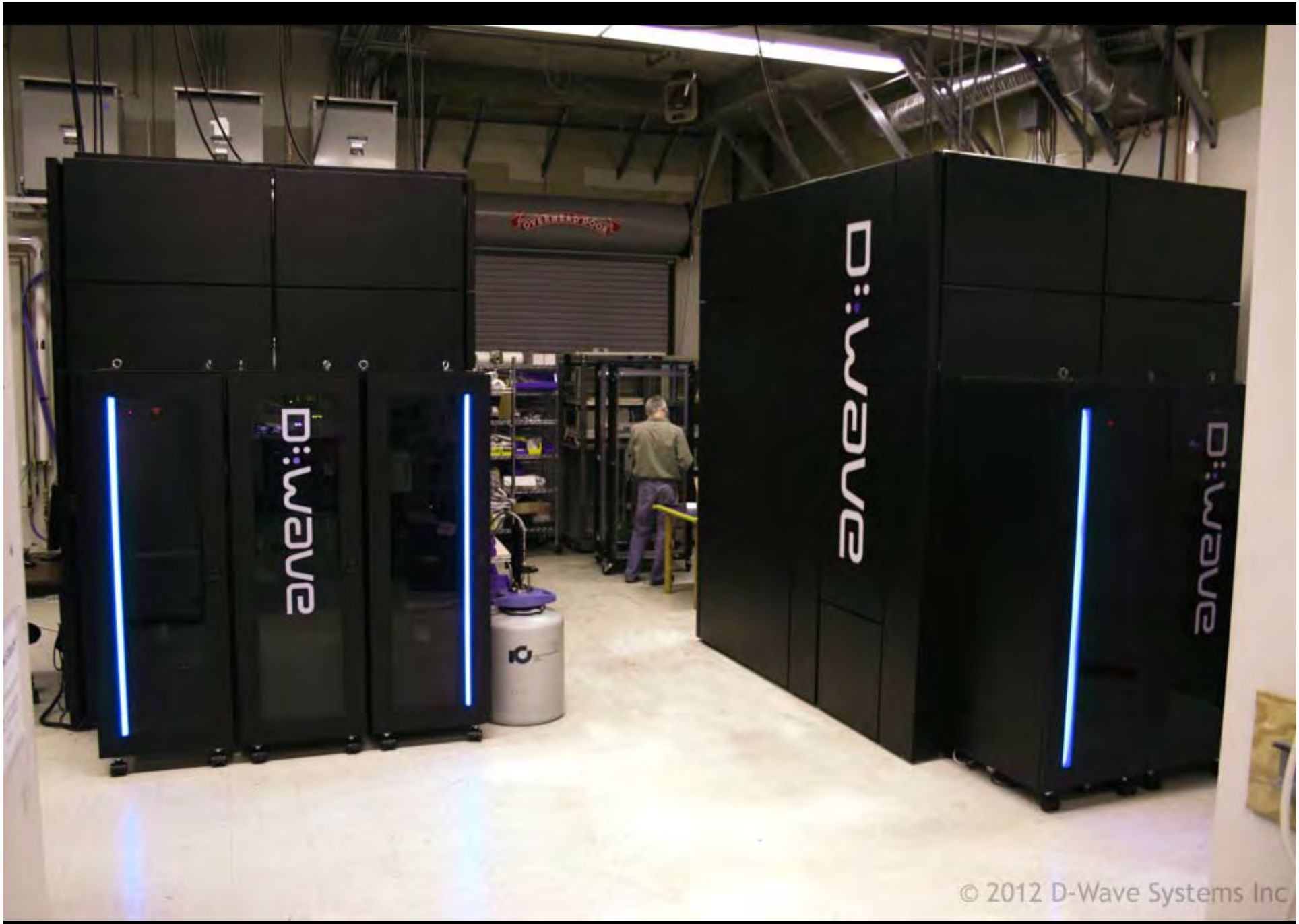


Processor evolution overview available at
http://www.youtube.com/watch?v=6VIAL8gQRTI

512 qubit Vesuvius [2012] is about 500,000 times faster than 128 qubit Rainier [2010]

Donkey: 1 mph

SR-71: 2,000 mph

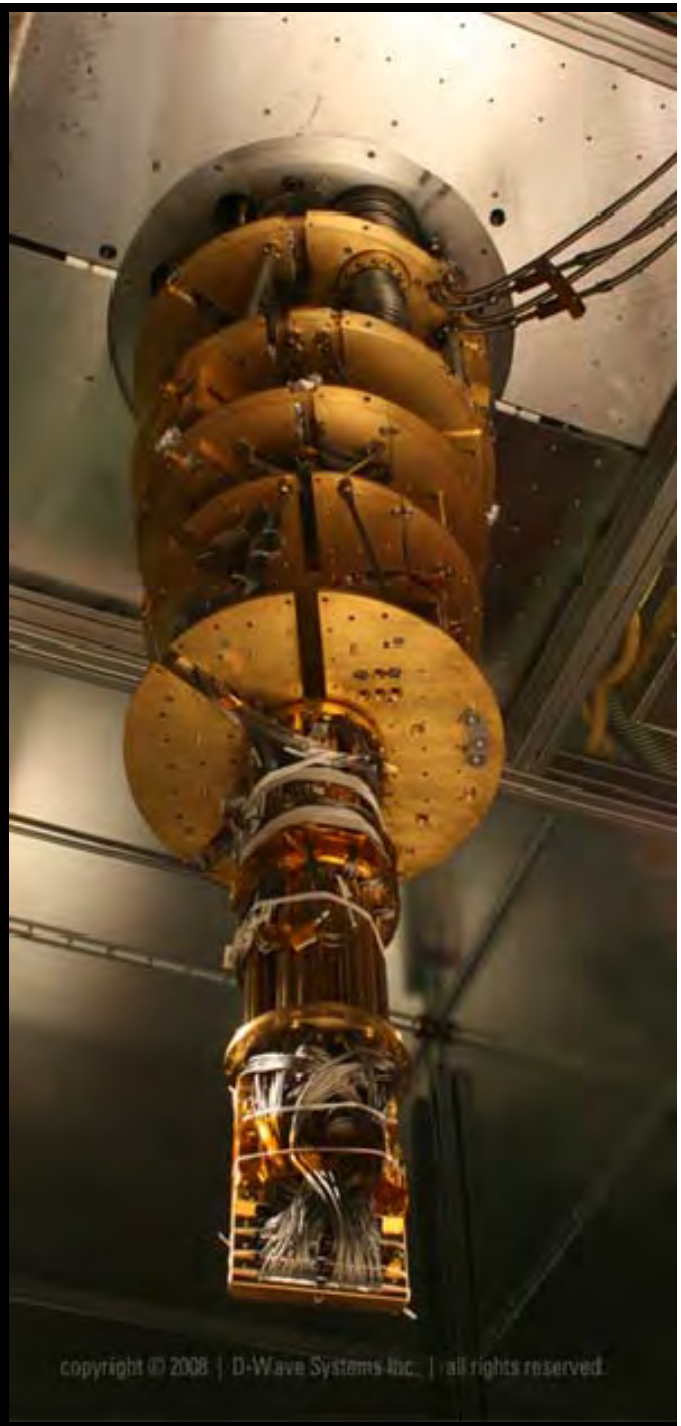


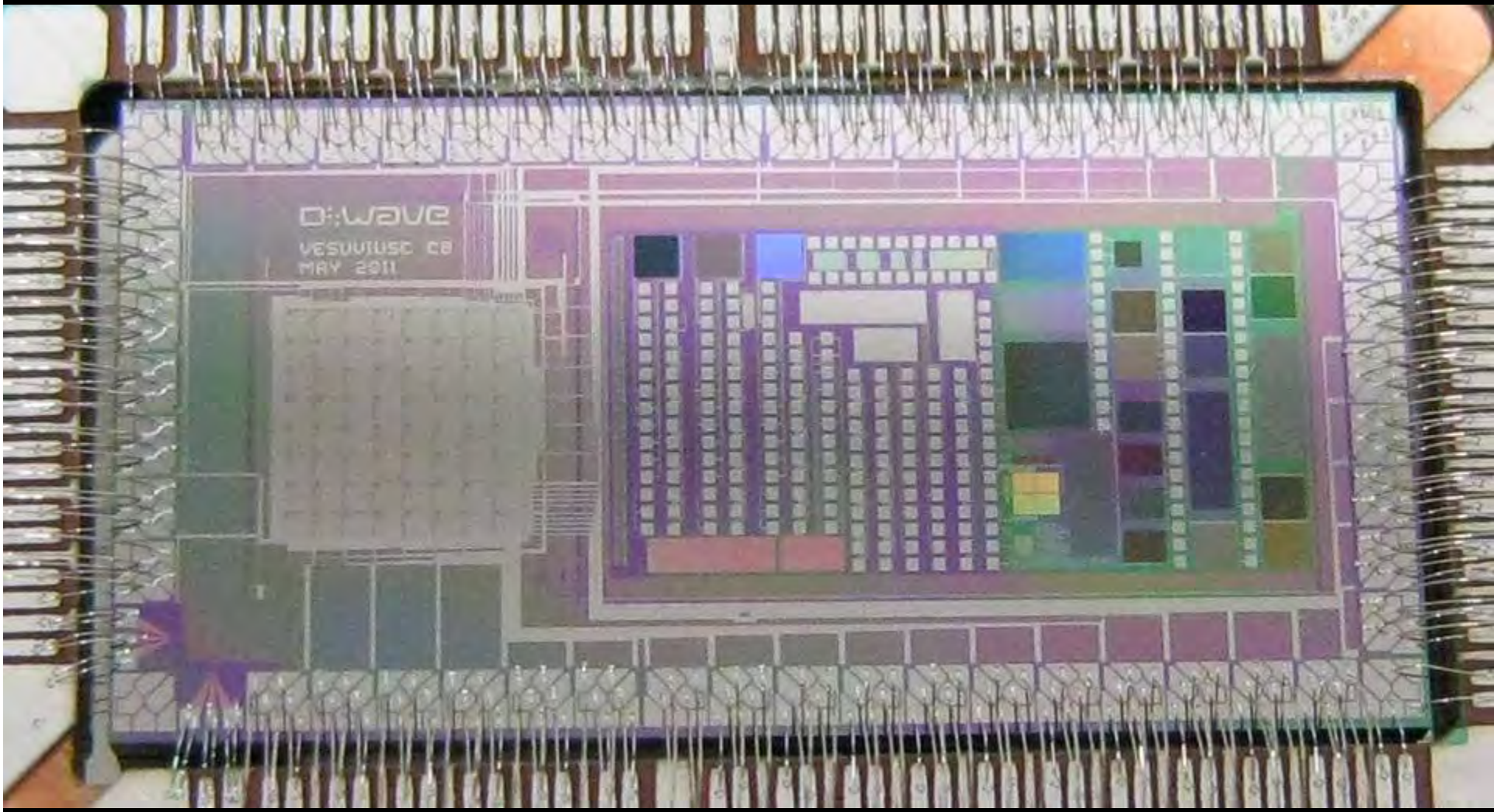
Footprint

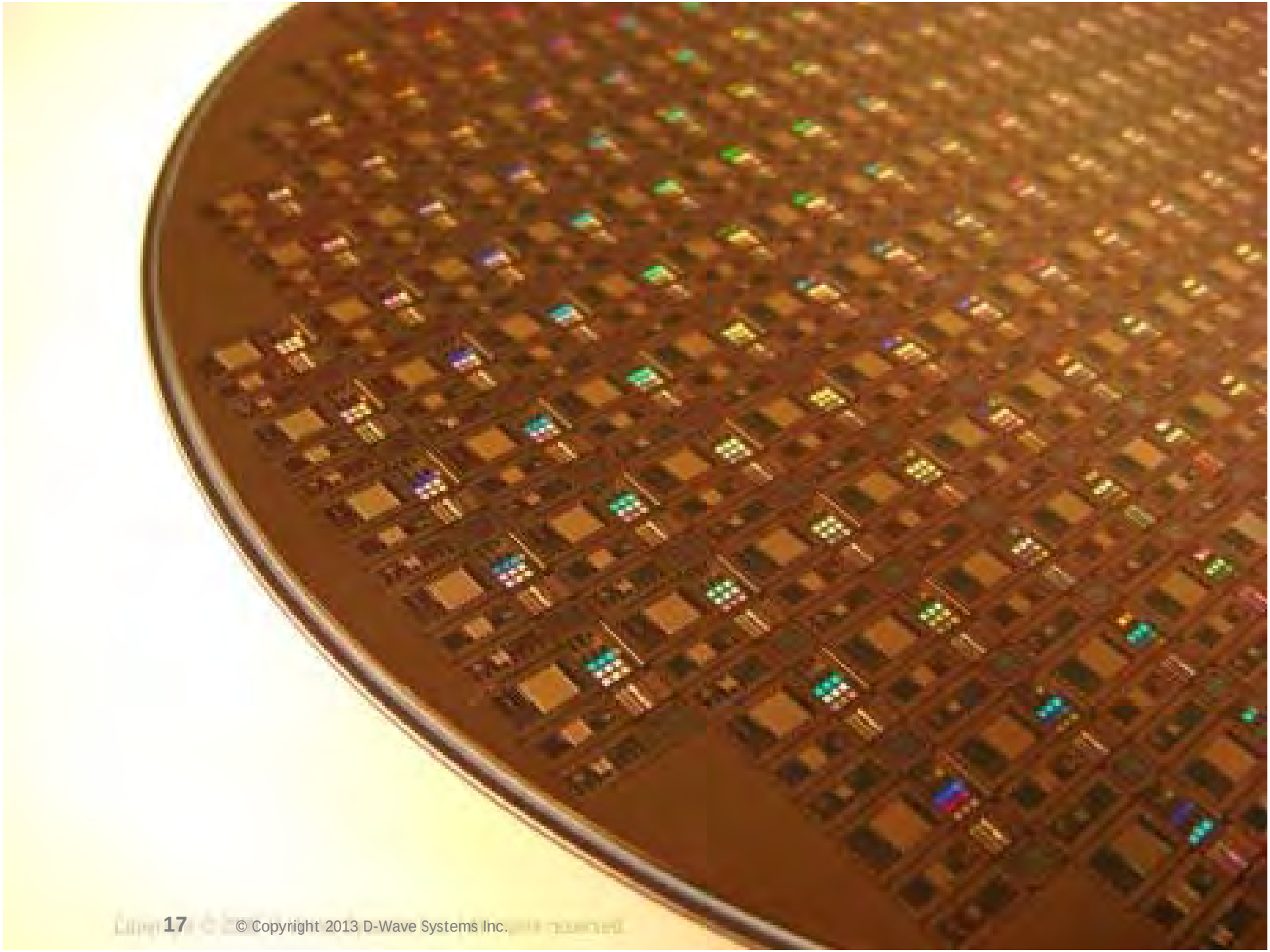
- ~ 200 square feet
- Closed cycle fridge
- Consumes ~ 15 kW

Processor environment

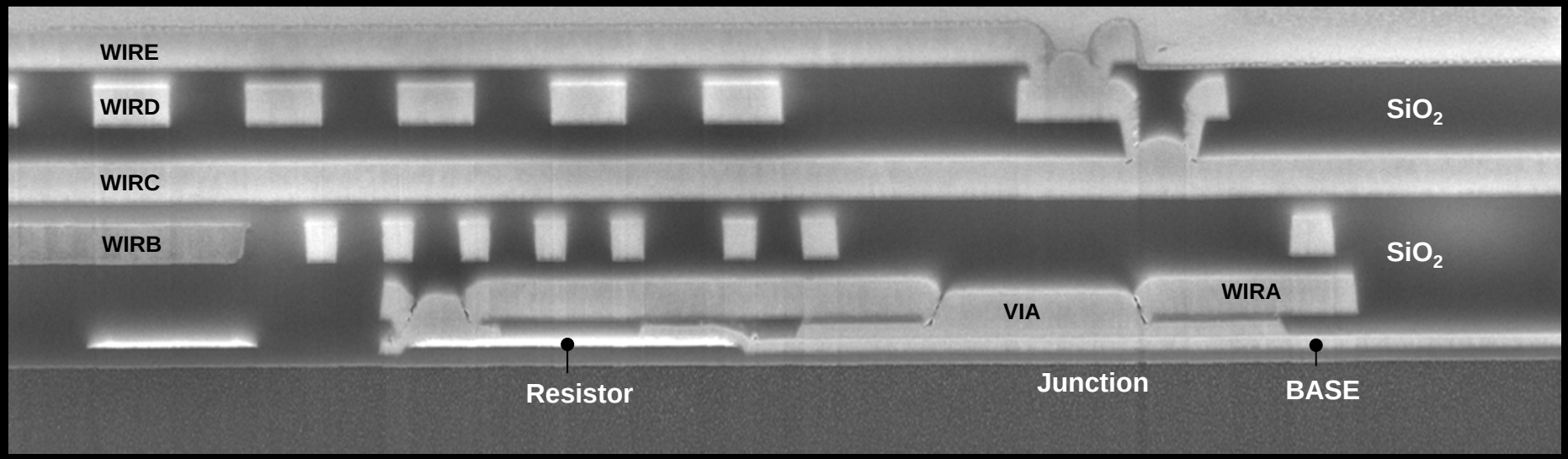
- 168 lines from room temperature to processor
- 10 kg of metal at 20 milliKelvin
- 1 nanoTesla in 3D across processor; 50,000x less than earth's magnetic field







Fabrication cross-section



One of very few processes in the world capable of fabricating VLSI superconducting processors

Some interesting uses

Supervised binary classification (2006 –)

Ongoing work with Google vision group

Use Case: Ultra compact classifiers for mobile devices

Case study: Wink detector for Google Glass

- D-Wave solution 3x less power draw and ½ false positive rate
- First retail use of quantum computation
- Based on 'TotalQBoost' algorithm developed by Google

Augmenting deep learning (2012 –)

- Work with Google, LMCO, US government, University of Florida, University of Montreal, UBC
- Very encouraging results – my unique current focus

There's a fascinating hypothesis that a lot of human perception … can be explained by a single learning algorithm.

Unsupervised Feature Learning and Deep Learning
Andrew Ng (2011)
http://www.youtube.com/watch?v=I56UugZ_8DI

Image from http://coursera.com

WIRED

Researcher Dreams Up Machines That Learn Without Humans

06.27.13

The New York Times

Scientists See Promise in Deep-Learning Programs

John Markoff

November 23, 2012

THE GLOBE AND MAIL

CANADA'S NATIONAL NEWSPAPER • FOUNDED 1844

Google taps U of T professor to teach context to computers

03.11.13

WIRED

The Man Behind the Google Brain: Andrew Ng and the Quest for the New AI

BY DANIELA HERNANDEZ 06.07.13 6:30 AM

The New York Tim

Monday, June 25, 2012 Last Update: 11:50 PM ET

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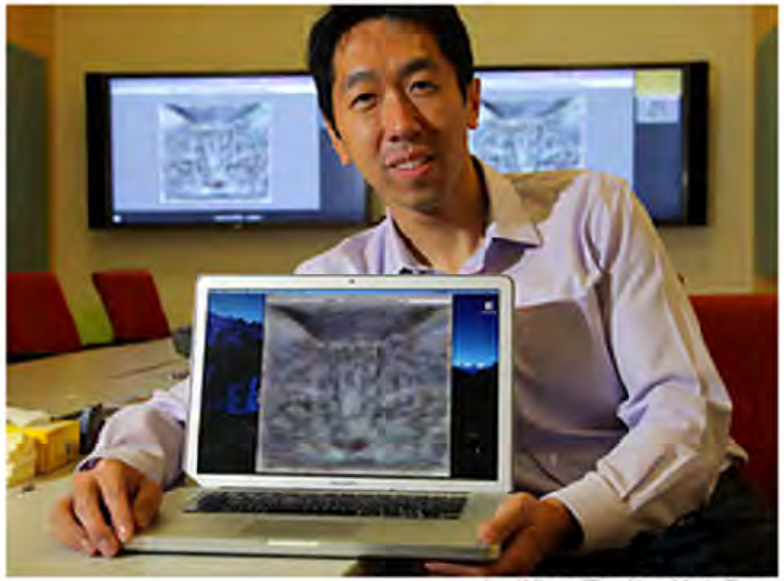


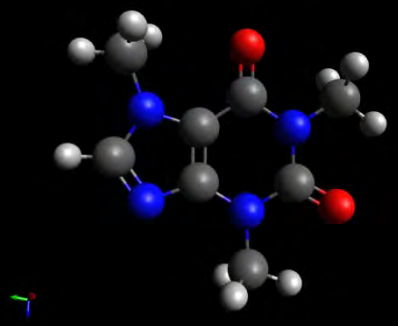
Jim Wilson/The New York Times

Despite Itself, a Simulated Brain Seeks Cats

By JOHN MARKOFF 12 min ago

A Google research team, led by Andrew Y. Ng, above, and Jeff Dean, created a neural network of 16,000 processors that reflected human obsession with Internet felines.

Use Case: Identifying pharmacogenomic markers in drug trials



ATTACCGGCTT

ATCACAGGATT

I visualize a time when we will be to robots what dogs are to humans, and I'm rooting for the machines.

Omni magazine

Claude Shannon (1987)

http://hplusmagazine.com/2012/09/14/friday-brain-food-claude-shannon-father-of-the-information-age/

Thanks!

rose@dwavesys.com