Verification of Near Term Quantum Computers

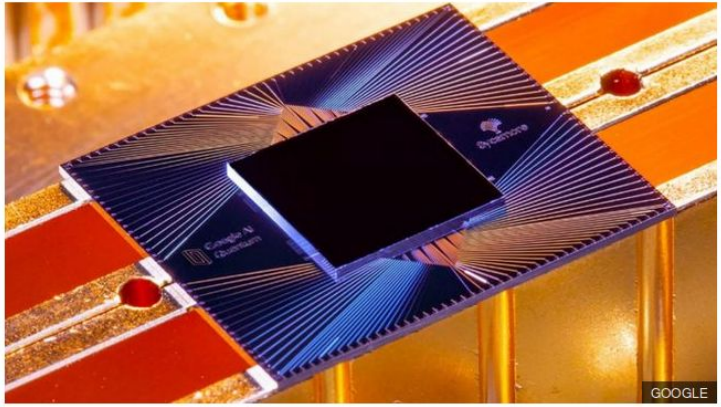
Daniel Mills

Science & Environment

Google claims 'quantum supremacy' for computer

By Paul Rincon
Science editor, BBC News website

23 October 2019 Share



Google says an advanced computer has achieved "quantum supremacy" for the first time, surpassing the performance of conventional devices.

The Internet Reacted With Some Excitement

Here's How Quantum Computer Supremacy Will Impact Self-Driving Cars

Lance Eliot Contributor ⓘ
Transportation

Quantum computers will impact self-driving cars, here's how. GETTY

Here's How Quantum Computer Supremacy Will Impact Self-Driving Cars

Lance Eliot Contributor ⓘ
Transportation

Quantum computers will impact self-driving cars, here's how. GETTY

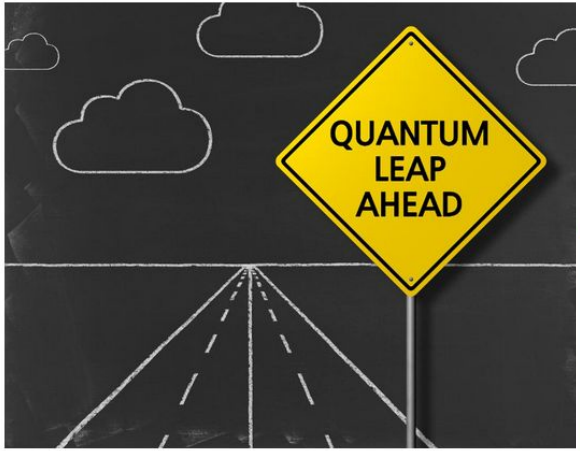
Google's Quantum Supremacy will mark the End of the Bitcoin in 2020

Ritika Sharma Monday, 13 January 2020, 03:49 EST Modified date: Monday, 13 January 2020, 05:00 EST Leave a comment

- Quantum computing can hit the most significant features of Blockchain like unchangeable data, unalterable, and security making it vulnerable.
- china Joined Google in the quantum supremacy Race and announced working on quantum technology.
- Quantum computing uses subatomic particles, which will be available in more than one state at one time.

Here's How Quantum Computer Supremacy Will Impact Self-Driving Cars

Lance Eliot Contributor ⓘ
Transportation

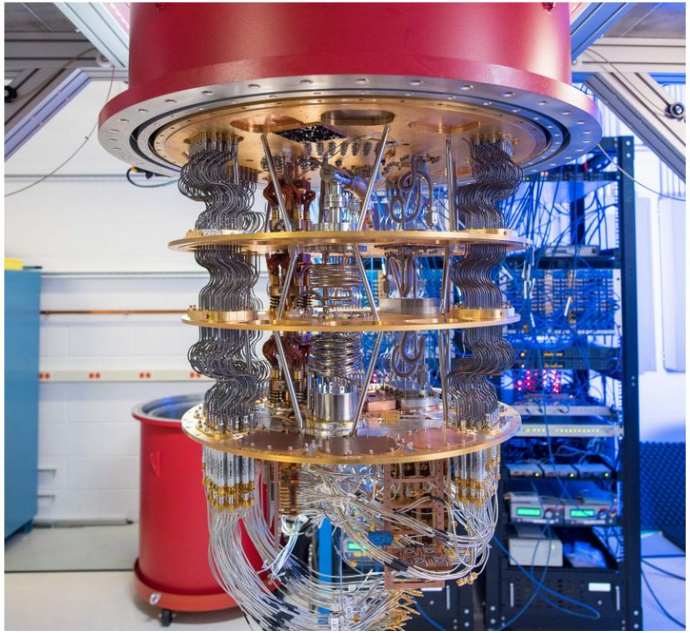


Quantum computers will impact self-driving cars, here's how. GETTY

Quantum computing could solve problems we don't even know we have

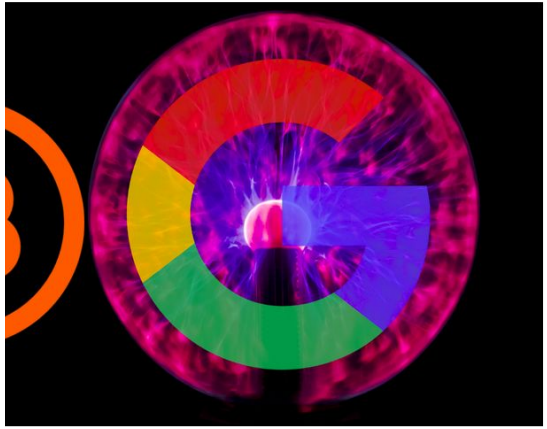
After decades of experimentation, billions of dollars in investment across the globe and gut-wrenching uncertainty about whether it was even physically possible, we've proven a quantum computer can work

by Alanna Mitchell Dec 27, 2019



Google's Quantum Supremacy will mark the End of the Bitcoin in

020, 03:49 EST Modified date: Monday, 13 January 2020, 05:00 EST Leave a comment



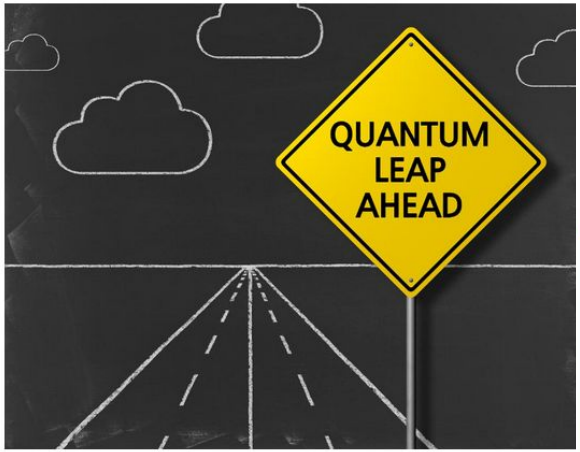
can hit the most significant features of Blockchain like unchangeable
ıd security making it vulnerable.

in the quantum supremacy Race and announced working on quantum

uses subatomic particles, which will be available in more than one

Here's How Quantum Computer Supremacy Will Impact Self-Driving Cars

Lance Eliot Contributor ⓘ
Transportation

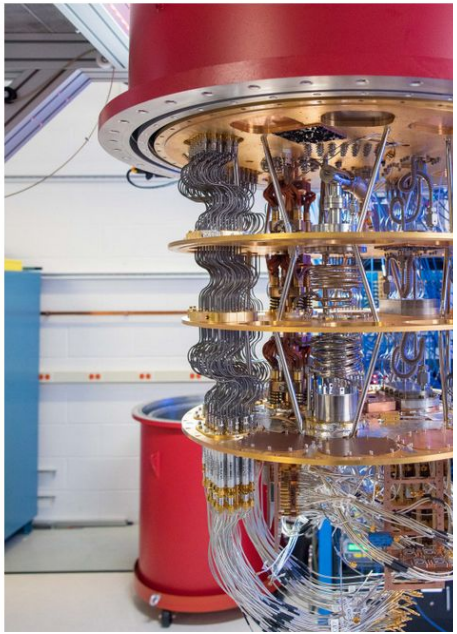


Quantum computers will impact self-driving cars, here's how. GETTY

Quantum computing could solve problems we don't even know we have

After decades of experimentation, billions of dollars in investment across the globe and gut-wrenching uncertainty about whether it was even physically possible, we've proven a quantum computer can work

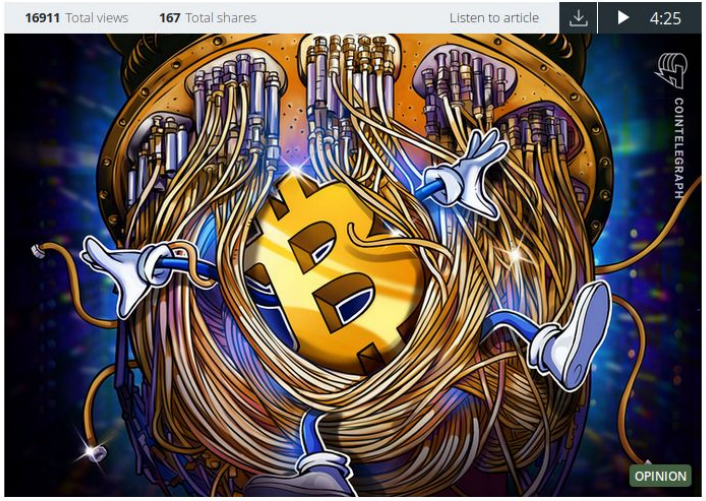
by Alanna Mitchell Dec 27, 2019



Google's Quantum Supremacy will mark the End of the Bitcoin in

020, 03:49 EST Modified date: Monday, 13 January 2020, 05:00 EST Leave a comment

Will Google's Quantum Supremacy Break Bitcoin in 2020?



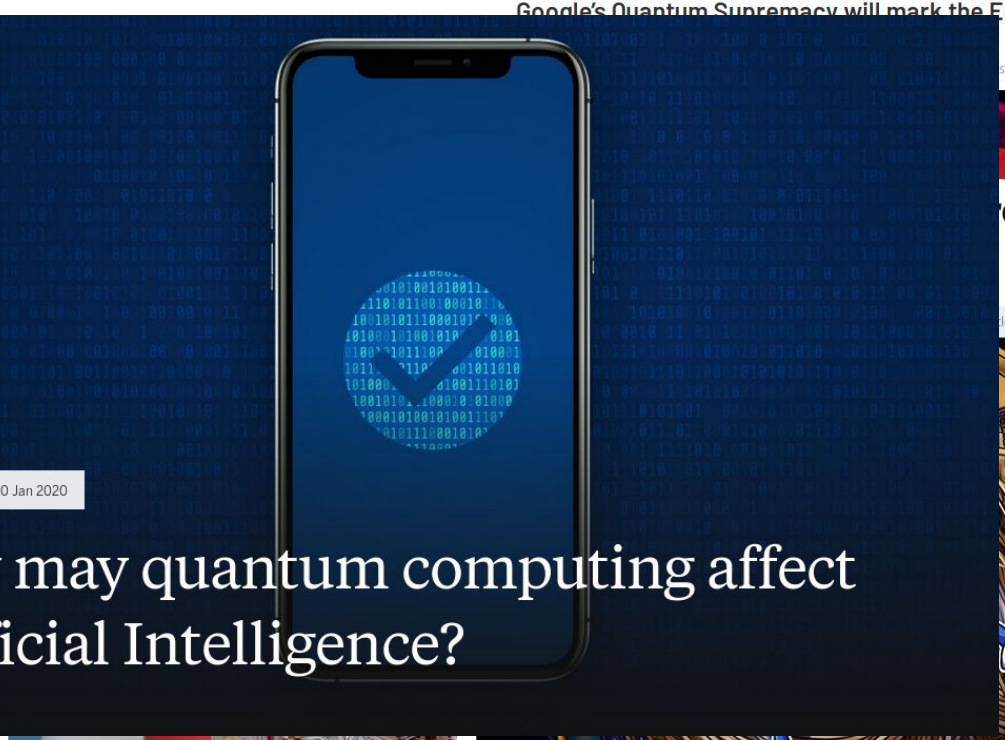
The topic of quantum computing has been steadily gaining interest within the cryptosphere, particularly so over the past 12 months. Given the heightened curiosity and concern, it is worth resolving some open questions around quantum supremacy for the crypto community, as there is a tremendous amount of misinformation circulating online.

Will our Bitcoin be stolen?

Here's How Quantum Computer Supremacy Impact Self-Driving

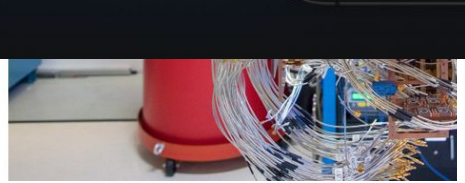
Lance Eliot Contributor
Transportation

Quantum computers will impact self-driving cars, here's how.



INNOVATION | 20 Jan 2020

How may quantum computing affect Artificial Intelligence?



Google's Quantum Supremacy will mark the End of the Bitcoin in

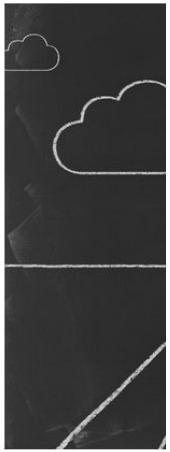
Leave a comment

The topic of quantum computing has been steadily gaining interest within the cryptosphere, particularly so over the past 12 months. Given the heightened curiosity and concern, it is worth resolving some open questions around quantum supremacy for the crypto community, as there is a tremendous amount of misinformation circulating online.

Will our Bitcoin be stolen?

Here's How Quantum Computer Supremacy Impact Self-Driving

Lance Elic
Transportat

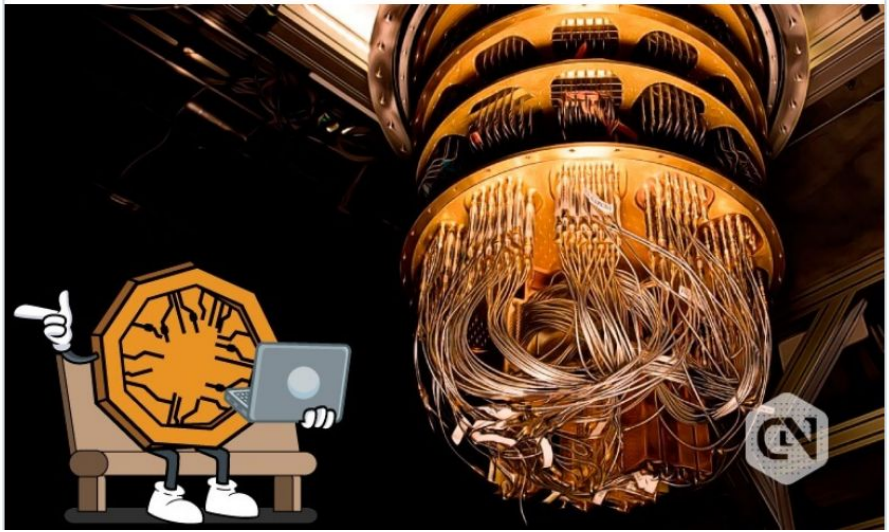


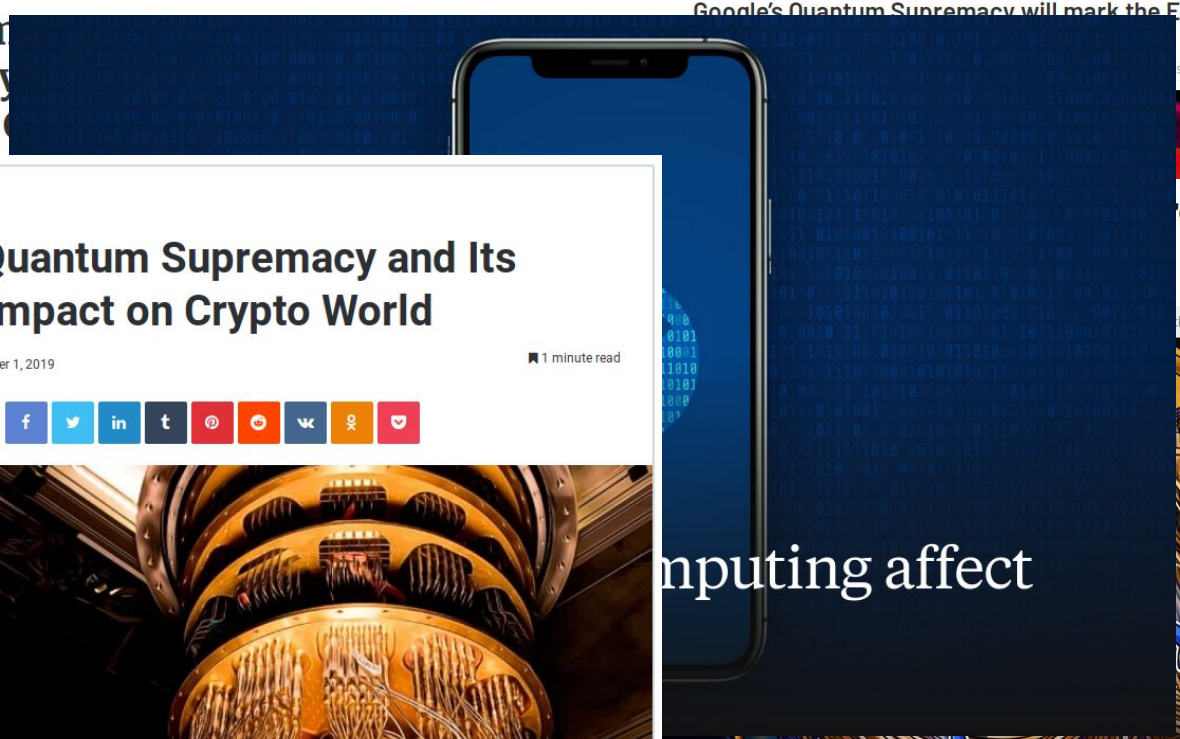
Quantum computers will

Cryptocurrency

Google's Quantum Supremacy and Its Possible Impact on Crypto World

Scott Cook · December 1, 2019 · 1 minute read





Google's Quantum Supremacy will mark the End of the Bitcoin in

Leave a comment

emacy

le

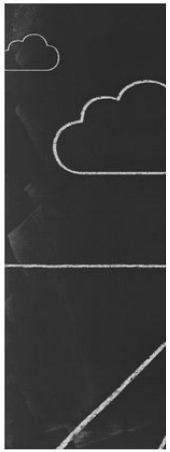
m

he topic of quantum computing has been steadily gaining interest within the ryptosphere, particularly so over the past 12 months. Given the heightened curiosity and oncern, it is worth resolving some open questions around quantum supremacy for the rypto community, as there is a tremendous amount of misinformation circulating online.

Will our Bitcoin be stolen?

Here's How Quantum Computer Supremacy Impact Self-Driving

Lance Elic
Transportat

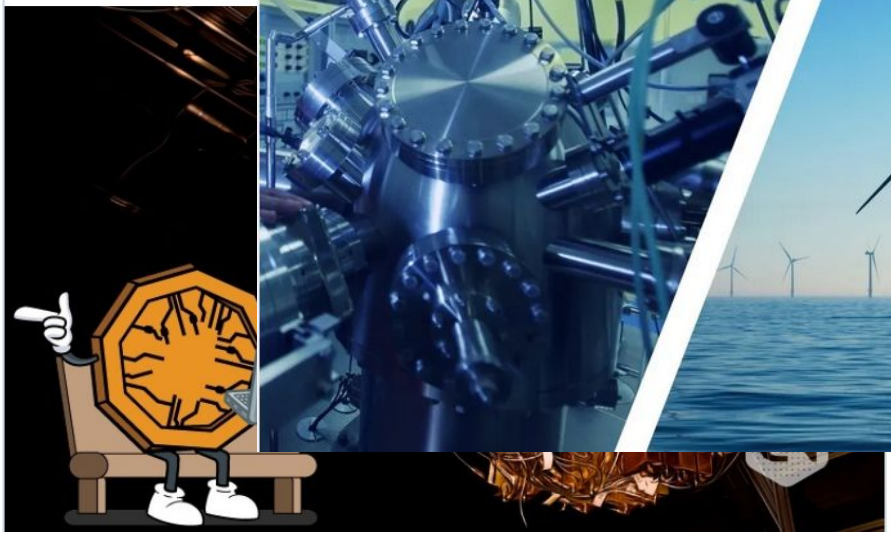


Quantum computers will

Cryptocurrency

Google's Qu Possible Im

Scott Cook · December 1,



3 ways quantum computing can help us fight climate change

There's a lot we can do with current technology to help stem the tide of climate change, but future technology may help even more.

MATT DAVIS 10 January, 2020

Google's Quantum Supremacy will mark the End of the Bitcoin in

Leave a comment

emacy

ily gaining interest within the
nths. Given the heightened curiosity and
ns around quantum supremacy for the
ypto community, as there is a tremendous amount of misinformation circulating online.

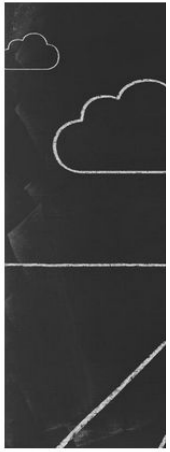
Will our Bitcoin be stolen?

le

m

Here's How Quantum
Computer Supremacy
Impact Self-Driving

Lance Elic
Transportat



Quantum computers will

Cryptocurrency

Google's Qu
Possible Im

Scott Cook · December 1,

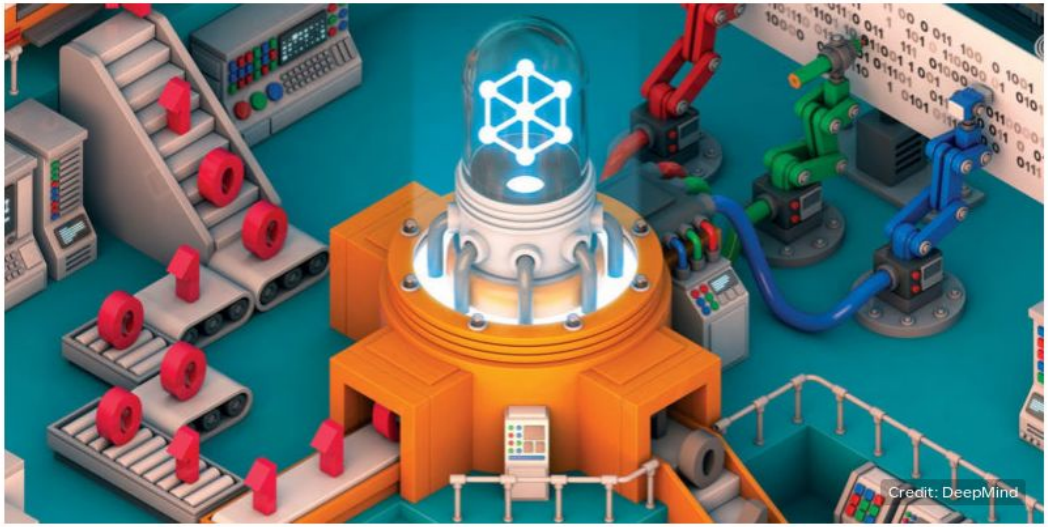
3 way
help u

There's a lot v
change, but f

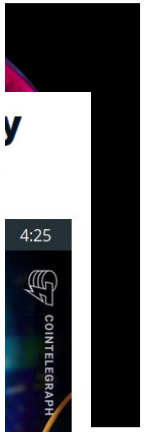
MATT DAVIS 10 J

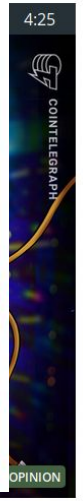
AlphaZero beat humans at Chess and StarCraft, now it's working with quantum computers

by TRISTAN GREENE — 5 days ago in ARTIFICIAL INTELLIGENCE



Bitcoin in





ily gaining interest within the
nths. Given the heightened curiosity and
ns around quantum supremacy for the
crypto community, as there is a tremendous amount of misinformation circulating online.

Will our Bitcoin be stolen?

Many People Become Involved

XANADU RECEIVES $4.4M INVESTMENT FROM SDTC TO ADVANCE ITS PHOTONIC QUANTUM COMPUTING TECHNOLOGY

Xanadu's unique photonic approach to quantum computing will be much more energy efficient than traditional computing methods, thereby saving energy and emissions from power generation.

Press release from Xanadu
January 16th 2020 | 1295 readers

Photo by Umberto on Unsplash

XANADU RECEIVES $4.4M INVESTMENT F... ADVANCE ITS PHOTONIC QUANTUM COM... TECHNOLOGY

Xanadu's unique photonic approach to quantum comput... energy efficient than traditional computing methods, th... emissions from power generation.

Press release from Xanadu
January 16th 2020 | 1295 readers

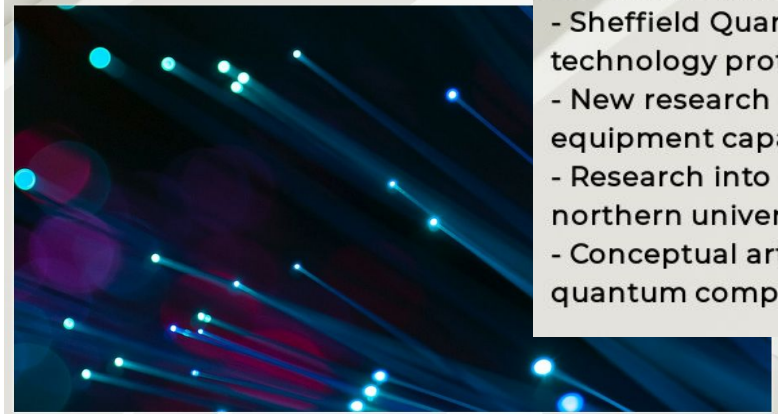


Photo by Umberto on Unsplash

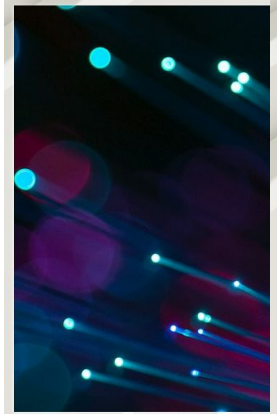
UNIVERSITY OF SHEFFIELD LAUNCHES QUANTUM CENTRE TO DEVELOP THE TECHNOLOGIES OF TOMORROW

- University of Sheffield launches new research centre to revolutionise computing, communication, sensing and imaging technologies
- Sheffield Quantum Centre will develop materials, devices and information technology protocols with unprecedented capabilities and performance
- New research centre will include £2.1 million Quantum Technology Capital equipment capable of growing state-of-the-art semiconductor materials
- Research into quantum technologies is a high priority area for the UK, with northern universities playing a significant role in their development
- Conceptual artwork representing how data may be controlled and stored in a quantum computer

XANADU RECEIVES $4.4M INVESTMENT FROM SDTC TO ADVANCE ITS PHOTONIC QUANTUM COM TECHNOLOGY

Xanadu's unique photonic a
energy efficient than traditi
emissions from power gene

Press release from Xanadu
January 16th 2020 | 1295 readers



FRANCE IS BEGINNING TO OUTLINE ITS QUANTUM STRATEGY, BUT DOES NOT GIVE DETAILS YET...

As quantum computing moves out of the research labs. Companies are starting to invest in it. But France publishes a report and sets up a working group. No concrete action is announced for the moment.

Philippe NIEUWBOURG
January 9th 2020 | 2376 readers

Photo Cédric O (via Twitter)

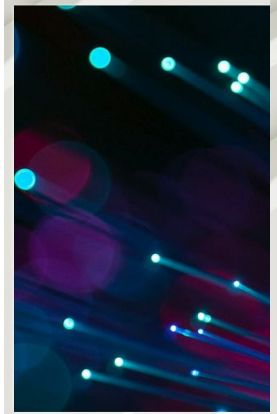
UNIVERSITY OF SHEFFIELD LAUNCHES QUANTUM CENTRE TO DEVELOP THE TECHNOLOGIES OF TOMORROW

esearch centre to revolutionise computing,
echnologies
o materials, devices and information
ted capabilities and performance
million Quantum Technology Capital
-the-art semiconductor materials
is a high priority area for the UK, with
ant role in their development
data may be controlled and stored in a

XANADU RECEIVES $4.4M INVESTMENT FROM SDTC TO ADVANCE ITS PHOTONIC QUANTUM COM TECHNOLOGY

Xanadu's unique photonic a
energy efficient than traditi
emissions from power gene

Press release from Xanadu
January 16th 2020 | 1295 readers



UNIVERSITY OF SHEFFIELD LAUNCHES QUANTUM CENTRE TO DEVELOP THE TECHNOLOGIES OF TOMORROW

esearch centre to revolutionise computing,
echnologies

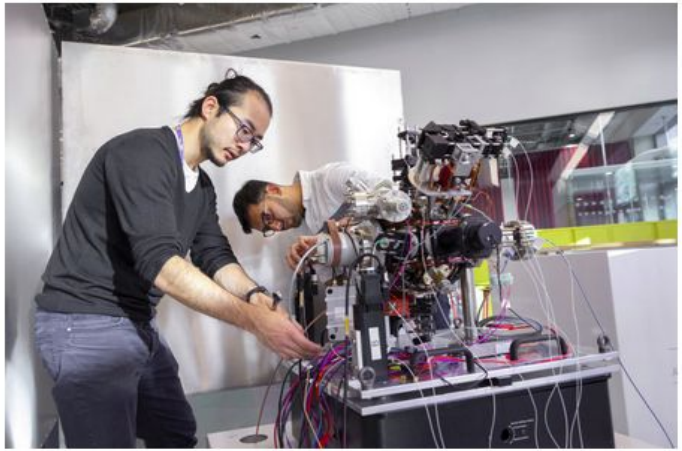
FRANCE IS BEGINNING TO OUTLINE ITS QUANTUM STRATEGY, BUT DOES NOT GIVE DETAILS YET...

As quantum computing moves out of the re
invest in it. But France publishes a report ar
concrete action is announced for the mome

Philippe NIEUWBOURG
January 9th 2020 | 2376 readers

Imperial in programme to push step change in UK quantum technology sector

by David Silverman
17 January 2020



Be the first to comment

Share this

Tweet this

Share on reddit

Share on LinkedIn

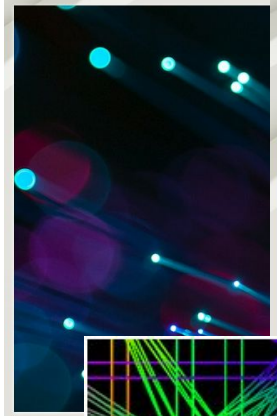
Print this story

ENTERPRISE AT IMPERIAL

XANADU RECEIVES $4.4M INVESTMENT FROM SPTC TO ADVANCE ITS PHOTONIC QUANTUM COM TECHNOLOGY

Xanadu's unique photonic a
energy efficient than traditi
emissions from power gene

Press release from Xanadu
January 16th 2020 | 1295 readers



UNIVERSITY OF SHEFFIELD LAUNCHES QUANTUM CENTRE TO DEVELOP THE TECHNOLOGIES OF TOMORROW

esearch centre to revolutionise computing,
echnologies

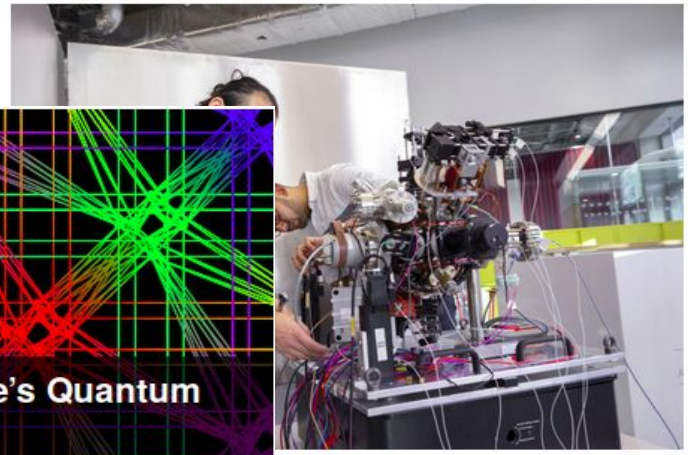
FRANCE IS BEGINNING TO OUTLINE ITS QUANTUM STRATEGY, BUT DOES NOT GIVE DETAILS YET...

As quantum computing moves out of the re
invest in it. But France publishes a report ar
concrete action is announced for the mome

Philippe NIEUWBOURG
January 9th 2020 | 2376 readers

Imperial in programme to push step change in UK quantum technology sector

by David Silverman
17 January 2020



Be the first to comment

Share this

Tweet this

Share on reddit

Share on LinkedIn

Print this story

ENTERPRISE AT IMPERIAL

XANADU RECEIVES $4.4M INVESTMENT FROM SDTC TO ADVANCE ITS PHOTONIC QUANTUM COM TECHNOLOGY

Xanadu's unique photonic a
energy efficient than traditi
emissions from power gene

Press release from Xanadu
January 16th 2020 | 1295 readers

UNIVERSITY OF SHEFFIELD LAUNCHES QUANTUM CENTRE TO DEVELOP THE TECHNOLOGIES OF TOMORROW

esearch centre to revolutionise computing,
echnologies

FRANCE IS BEGINNING TO OUTLINE ITS QUANTUM STRATEGY, BUT DOES NOT GIVE DETAILS YET...

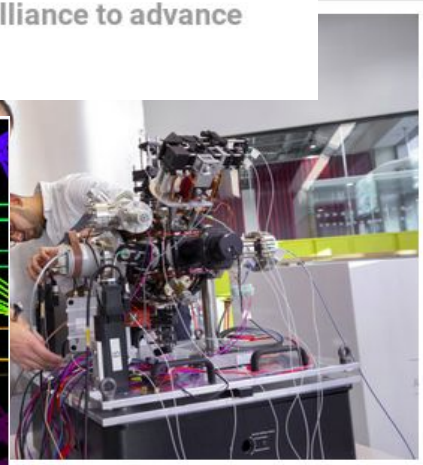
As quantum computing moves out of the re
invest in it. But France publishes a report ar
concrete action is announced for the mome

Philippe NIEUWBOURG
January 9th 2020 | 2376 readers

Imperial in programme to push step change in UK quantum technology sector

US alliance for quantum computing

The US has launched the Quantum Information Edge alliance to advance quantum computing.



Be the first to comment

Share this

Tweet this

Share on reddit

Share on LinkedIn

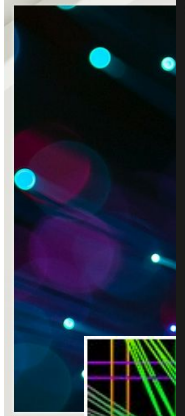
Print this story

ENTERPRISE AT IMPERIAL

XANADU RECEIVES $4.4M INVESTMENT FROM SPTC TO ADVANCE ITS PHOTONIC QUANTUM COM TECHNOLOGY

Xanadu's unique p energy efficient th emissions from pc

Press release from Xanadu
January 16th 2020 | 1295 rea



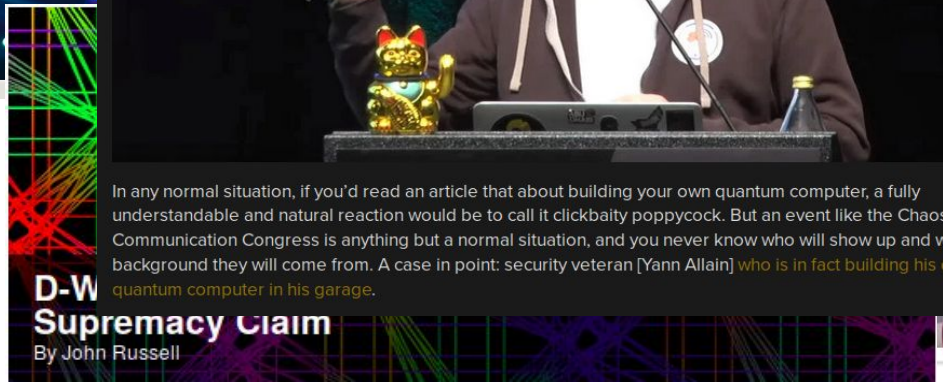
36C3: BUILD YOUR OWN QUANTUM COMPUTER AT HOME

by: Sven Gregori

20 Comments

December 30, 2019

In any normal situation, if you'd read an article that about building your own quantum computer, a fully understandable and natural reaction would be to call it clickbaity poppycock. But an event like the Chaos Communication Congress is anything but a normal situation, and you never know who will show up and what background they will come from. A case in point: security veteran [Yann Allain] who is in fact building his own quantum computer in his garage.



D-W
Supremacy Claim
By John Russell

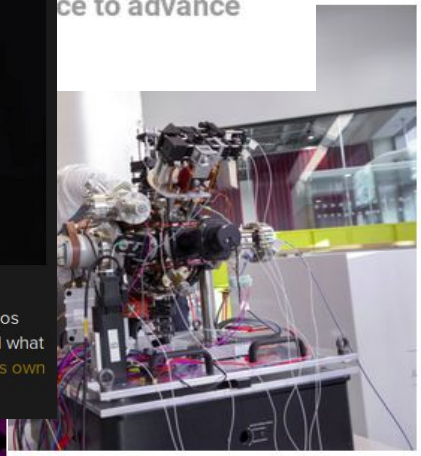
UNIVERSITY OF SHEFFIELD LAUNCHES QUANTUM CENTRE
OLOGIES OF TOMORROW

esearch centre to revolutionise computing,
echnologies

ramme to push step change in UK
logy sector

ting

ce to advance



Be the first to comment

Share this

Tweet this

Share on reddit

Share on LinkedIn

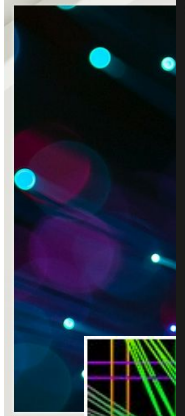
Print this story

ENTERPRISE AT IMPERIAL

XANADU RECEIVES $4.4
ADVANCE ITS PHOTONI
TECHNOLOGY

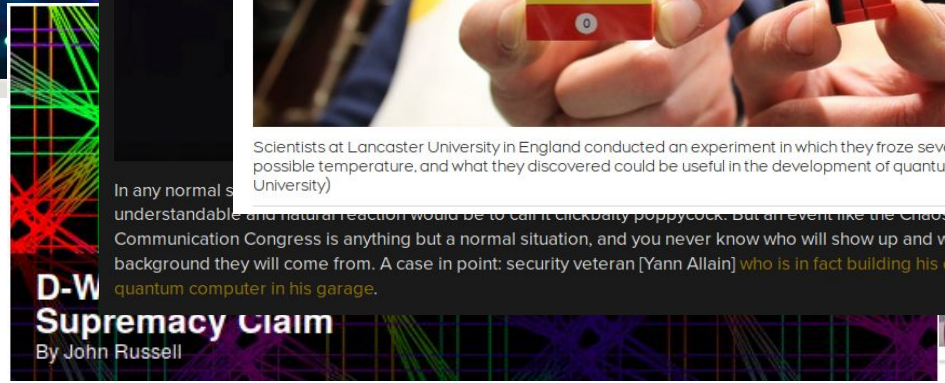
Xanadu's unique p
energy efficient th
emissions from pc

Press release from Xanadu
January 16th 2020 | 1295 rea



36C3
QUA

by: Sven Gre

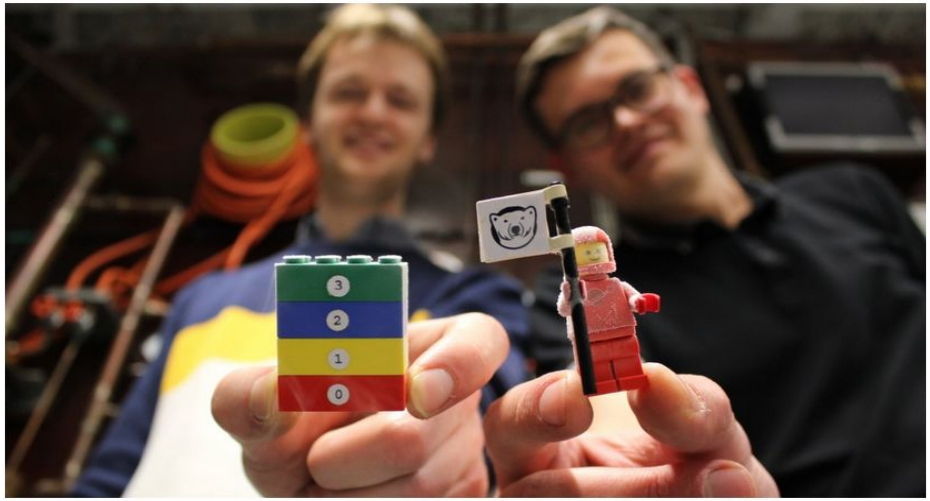


D-W
Supremacy Claim
By John Russell

World's 'coolest' Lego set could help develop quantum computing

Allen Kim
CNN

Published Friday, December 27, 2019 7:38AM EST
Last Updated Friday, December 27, 2019 9:24AM EST



Scientists at Lancaster University in England conducted an experiment in which they froze several Lego blocks to the lowest possible temperature, and what they discovered could be useful in the development of quantum computing. (Lancaster University)

In any normal s
understandable and natural reaction would be to call it clickbaity poppycock. But an event like the Chaos Communication Congress is anything but a normal situation, and you never know who will show up and what background they will come from. A case in point: security veteran [Yann Allain] who is in fact building his own quantum computer in his garage.

MOST READ

Iran MP offers US$3M 'to anyone who kills Trump': report

Print this story

ENTERPRISE AT IMPERIAL

NTRE

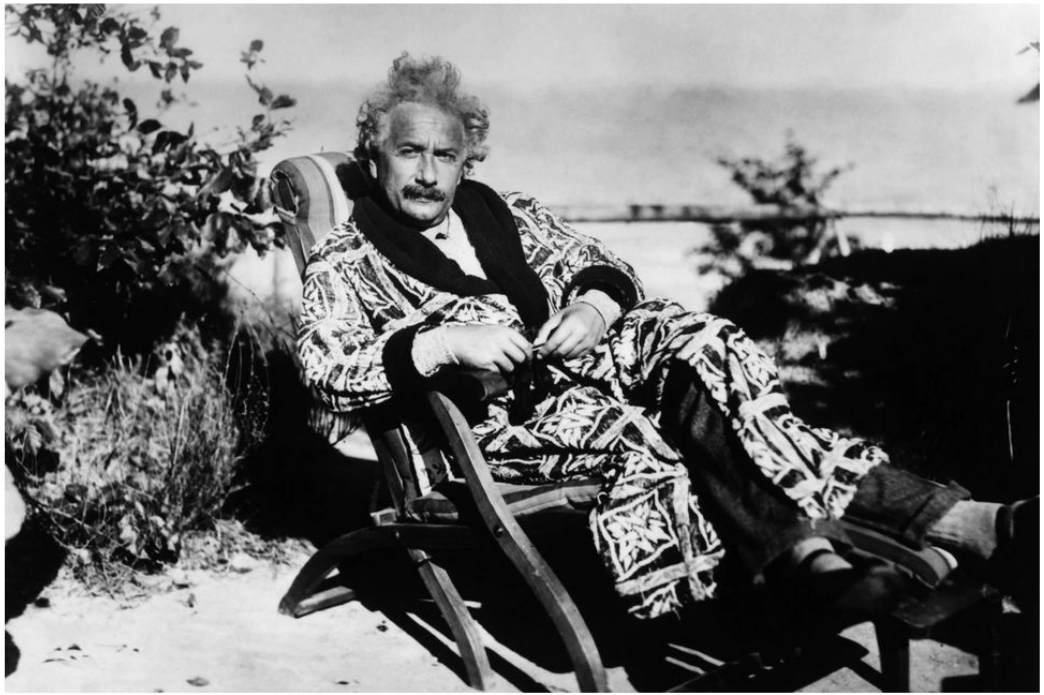
puting,

n UK

ment

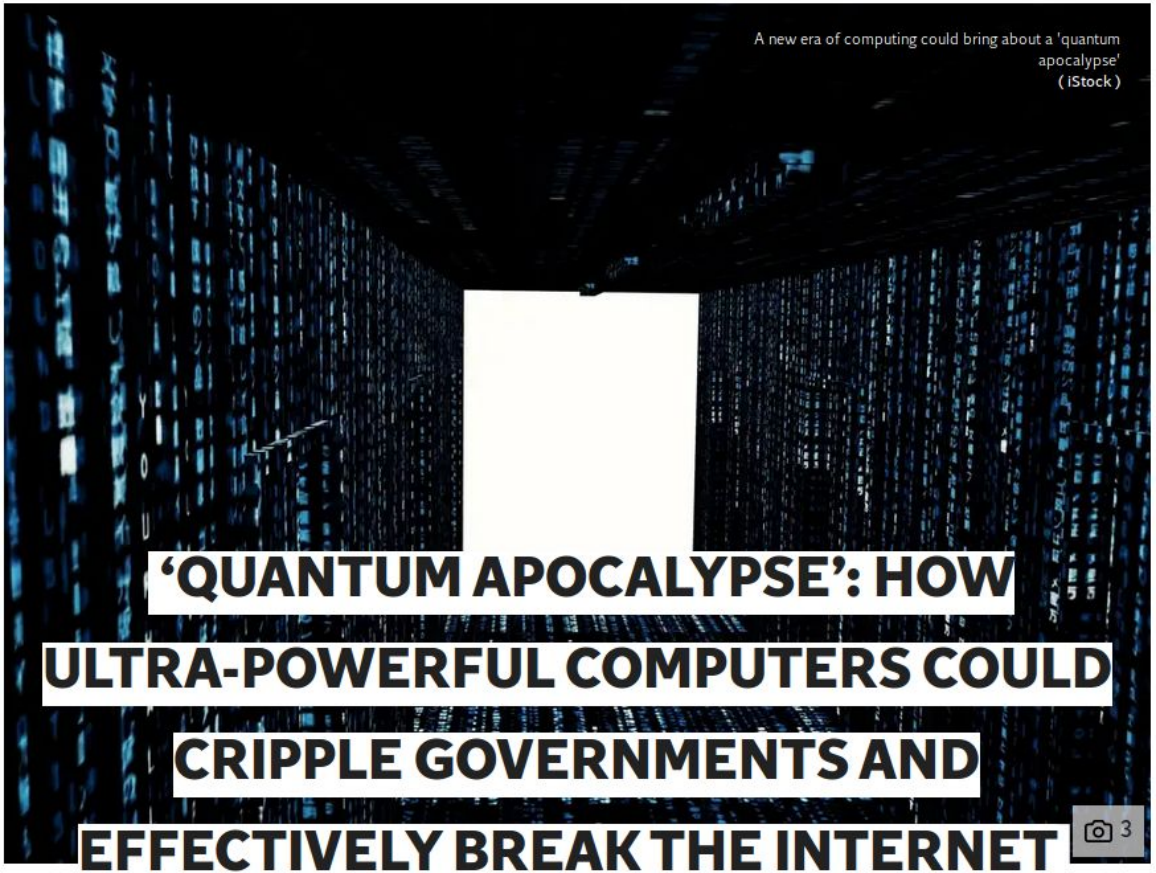
Revolt! Scientists Say They're Sick of Quantum Computing's Hype

A Twitter account called Quantum Bullshit Detector reflects some researchers' angst about overhyped claims and other troubling trends.



Revolt! ... **s Hype**

A Twitter accou ... ıds.



A new era of computing could bring about a 'quantum apocalypse'
(iStock)

‘QUANTUM APOCALYPSE’: HOW ULTRA-POWERFUL COMPUTERS COULD CRIPPLE GOVERNMENTS AND EFFECTIVELY BREAK THE INTERNET

3

'Our modern systems of finance, commerce, communication, transportation, manufacturing, energy, government, and healthcare will for all intents and purposes cease to function,' cyber security expert warns

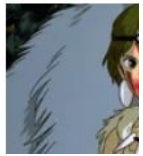
TL;DR

IBM puts its quantum computer to work in relaxing, nerdy ASMR video

Just listen to those qubits sing

By James Vincent | Jan 2, 2018, 9:56am EST

SHARE



Quantum Supremacy Through Overly Excited News Articles*

*Who even reads papers these days

MOTHERBOARD
TECH BY VICE

OK, WTF Is Quantum Teleportation?

Some quantum particles have soulmates, and scientists can use their "spooky" connections to send secret messages across the world, instantly.

By Carly Minsky

Jan 17 2020, 1:00pm

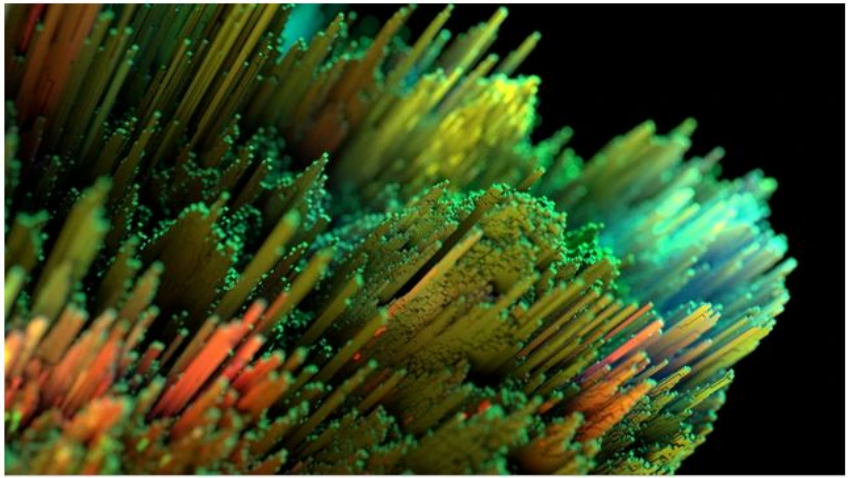
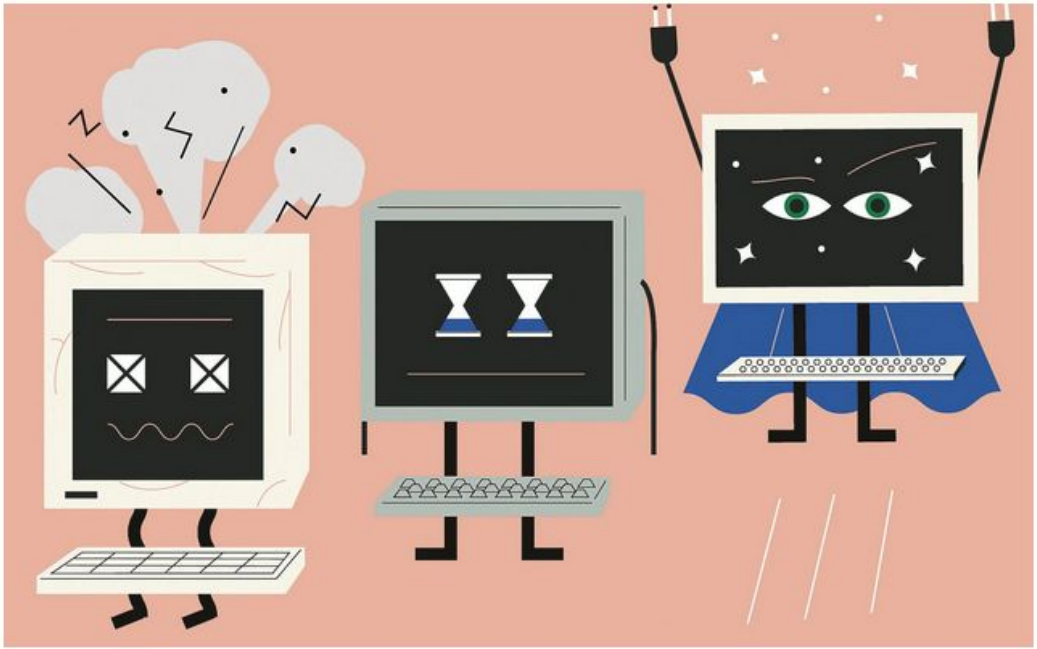


IMAGE: GETTY IMAGES

How the end of Moore's Law will usher in a new era in computing

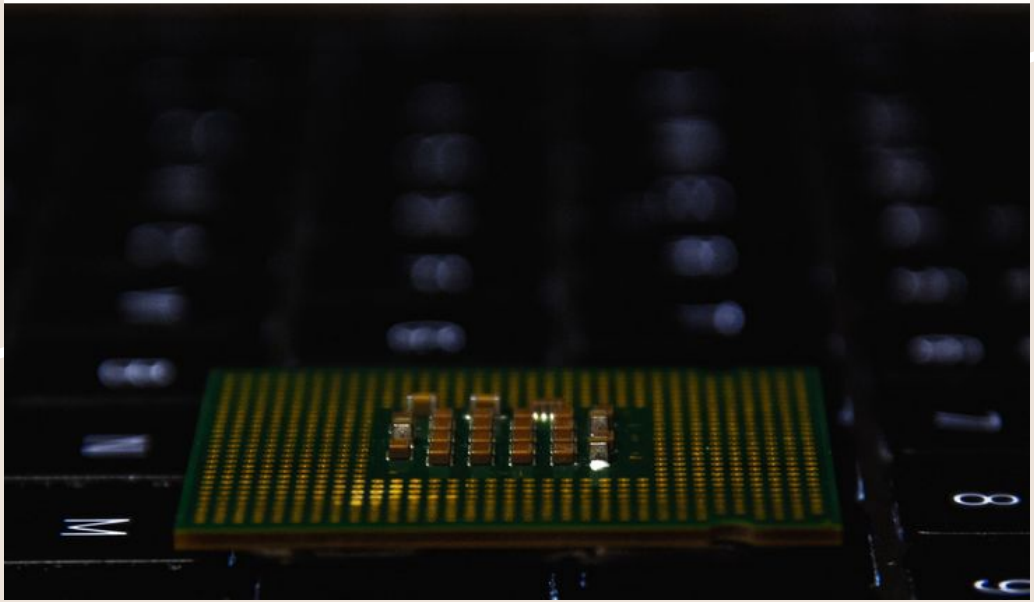


Will the next evolution of technology super power our computers? CREDIT: RUBY MARTIN

What Is Quantum Supremacy?

As the famous quote says 'If you can't win the game, change the rules'. Quantum Supremacy changes every fundamental rule of the computational game. Welcome and let's explore together.

Arun C Thomas Follow
Jan 20 · 5 min read ★



What is Quantum Supremacy?

Perform a task that could not be performed by a classical computer

What is Quantum Supremacy?

Perform a task that could not be performed by a classical computer

Perform a task **in a few minutes** that could not be performed by a classical computer **in 10,000 years**

What is Quantum Supremacy?

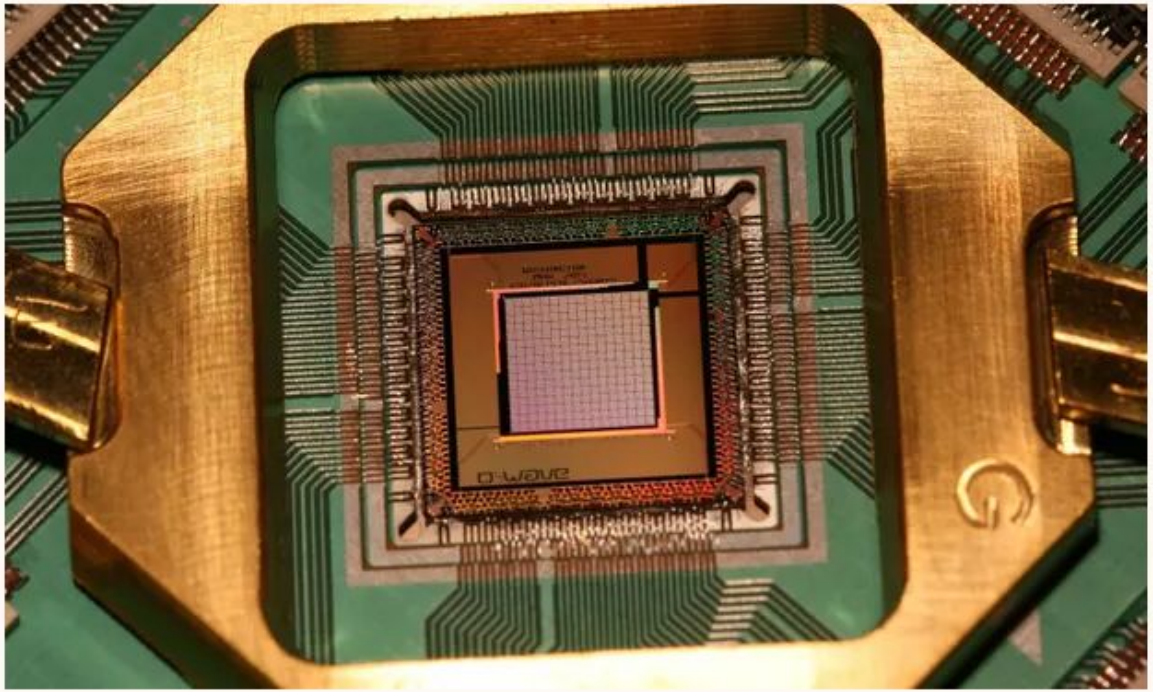
Perform a task that could not be performed by a classical computer

Perform a task **in a few minutes** that could not be performed by a classical computer **in 10,000 years**

Perform a task in a few minutes that could not be performed **by the most powerful supercomputer** in 10,000 years

Quantum supremacy is coming. It won't change the world

If quantum computers are to help solve humanity's problems, they will have to improve drastically



Why scientists are so excited about “quantum supremacy”

With a quantum computer, scientists are dipping into deeply weird physics to solve problems.

By Brian Resnick | @B_resnick | brian@vox.com | Oct 24, 2019, 3:30pm EDT

SHARE

Why are scientist so excited about “quantum supremacy”

Quantum supremacy:

- is achievable in real-world systems
- is not precluded by hidden physical laws
- heralds the era of Noisy Intermediate Scale Quantum (NISQ) technology

It’s a proof of principle!

Why are scientist so excited about “quantum supremacy”

Quantum supremacy:

- is achievable in real-world systems
- is not precluded by hidden physical laws
- heralds the era of Noisy Intermediate Scale Quantum (NISQ) technology

It’s a proof of principle!

Did Google demonstrate quantum supremacy?

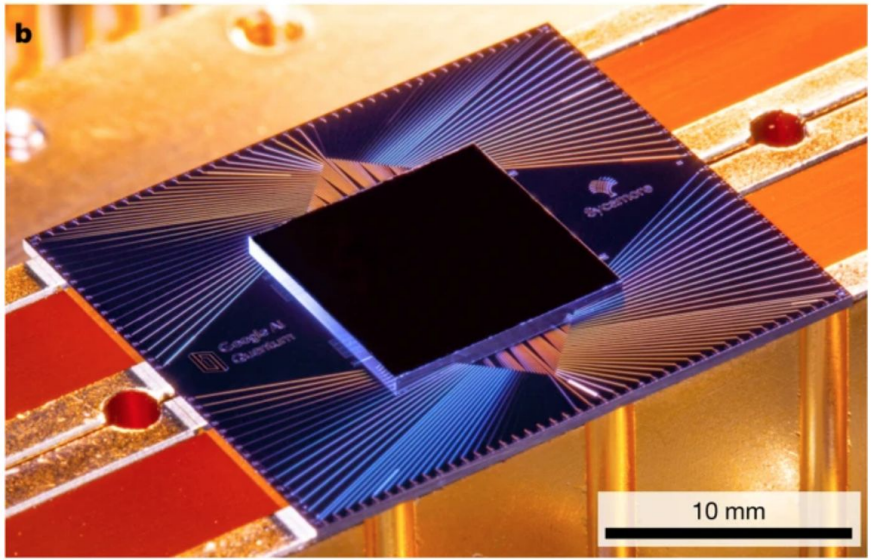
Google and IBM square off in Schrodinger's catfight over quantum supremacy

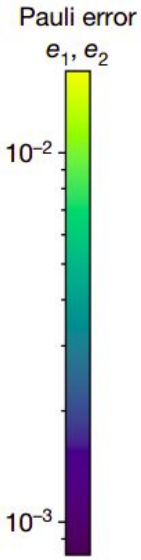
Should you believe the hype? Well, yes and no

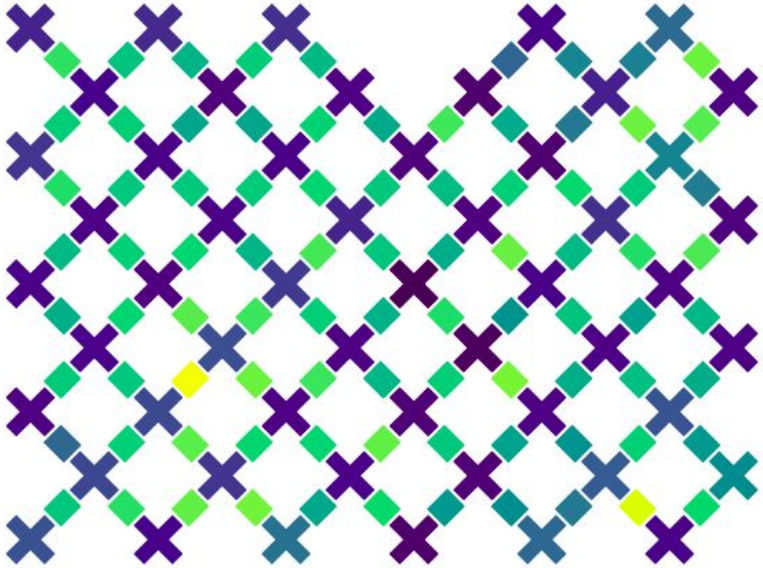
By Rupert Goodwins 9 Jan 2020 at 10:00 74 SHARE ▼

What Did Google Do?

The Device



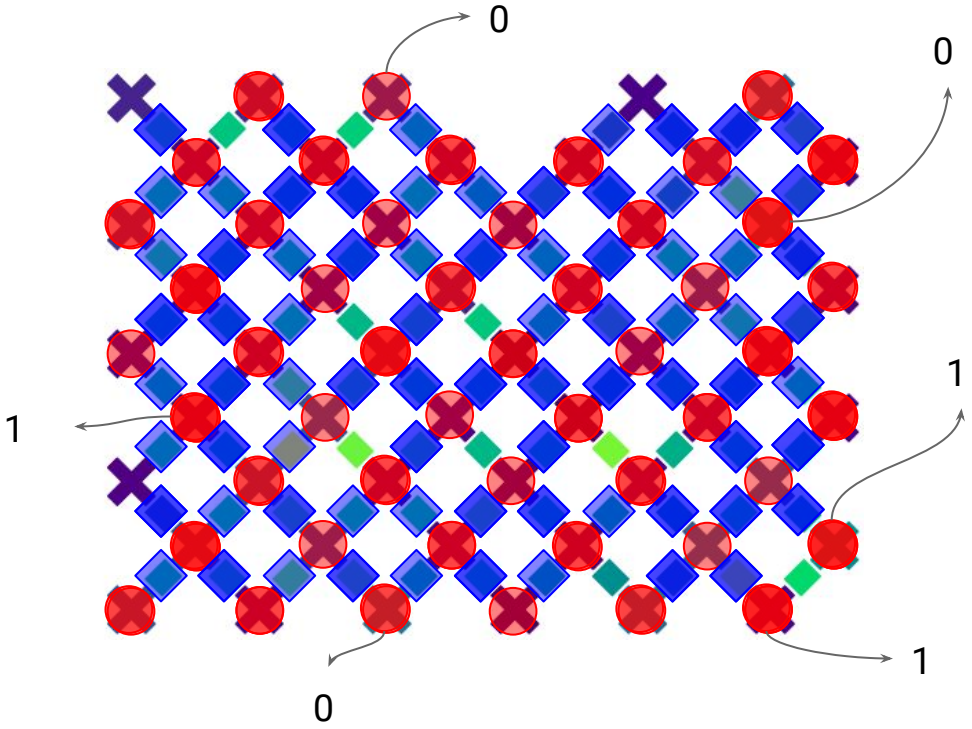




Random Circuit Sampling

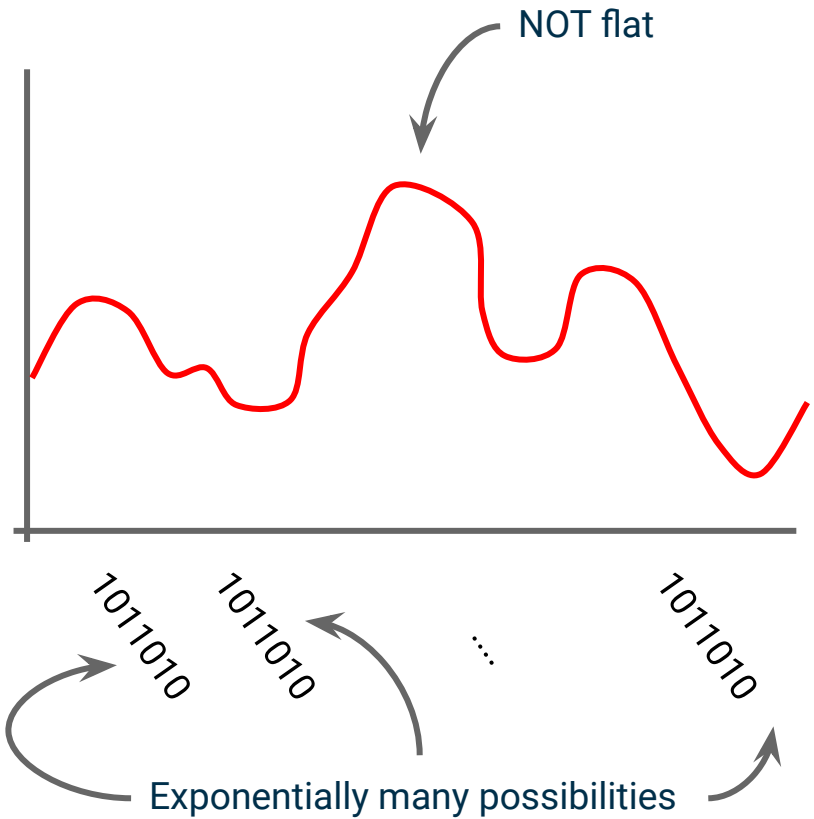
- Prepare qubits
- Perform random gates
- Measure qubits to get binary strings
- Repeat to gain collection of binary strings

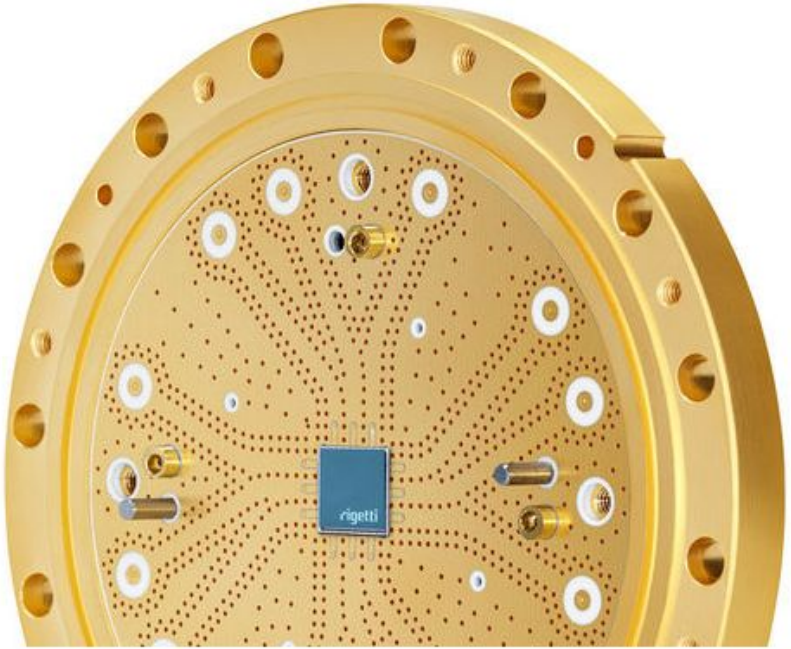
Random Circuit Sampling



(0011010101010101)
(0110100101010000)
...
(1101001010110101)

Very Hard Classically





Quantum computers rely on superconducting chips like this one from Rigetti Computing in Berkeley, California.
RIGETTI COMPUTING

How to evaluate computers that don't quite exist

By **Adrian Cho** | Jun. 26, 2019 , 8:00 AM

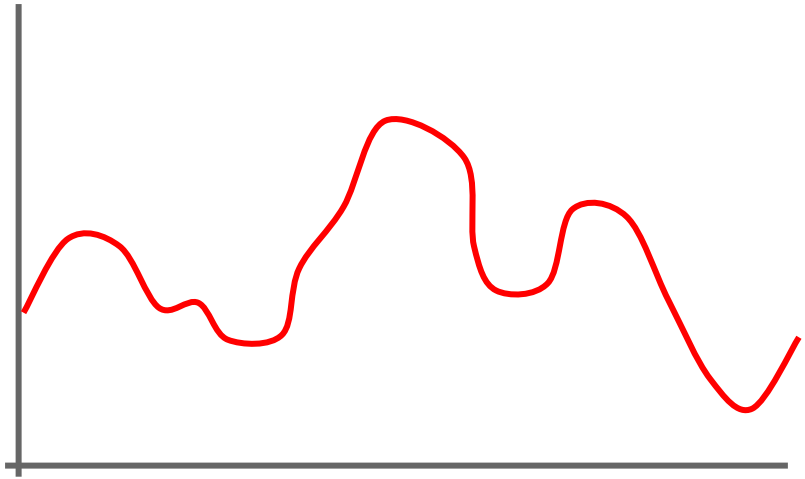
What does it mean to ‘not quite exist’

1. Very noisy device so cannot perform predictable computations
2. Cannot simulate classically by definition

Cross-Entropy Benchmarking

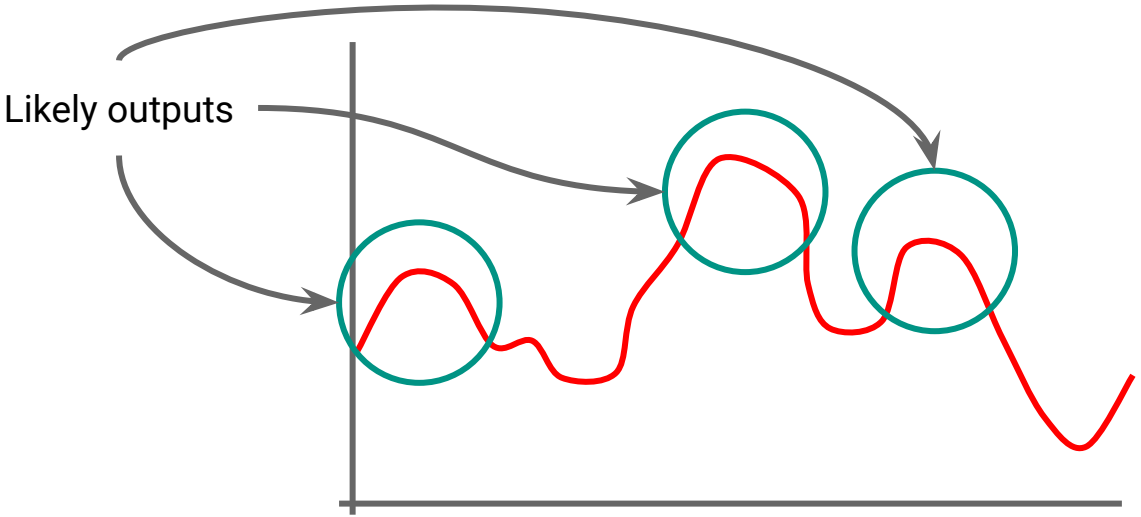
- Measures something like the mean of the probabilities of the bit strings measured

Cross-Entropy Benchmarking



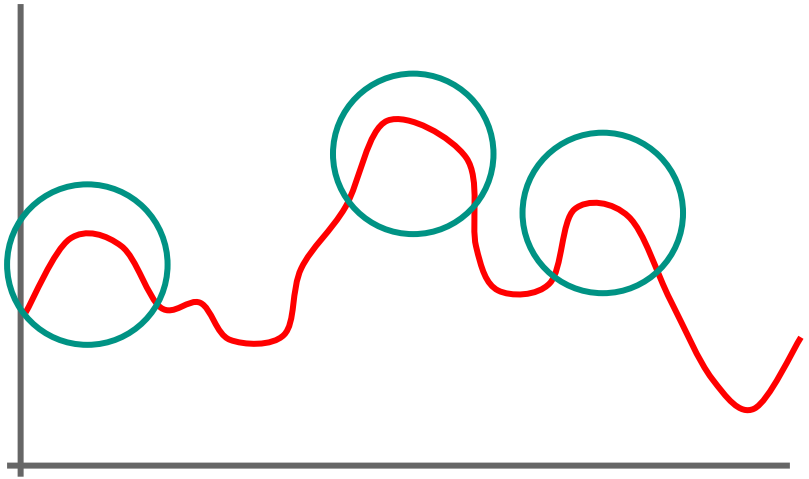
001010...1011011

Cross-Entropy Benchmarking



001010...1011011

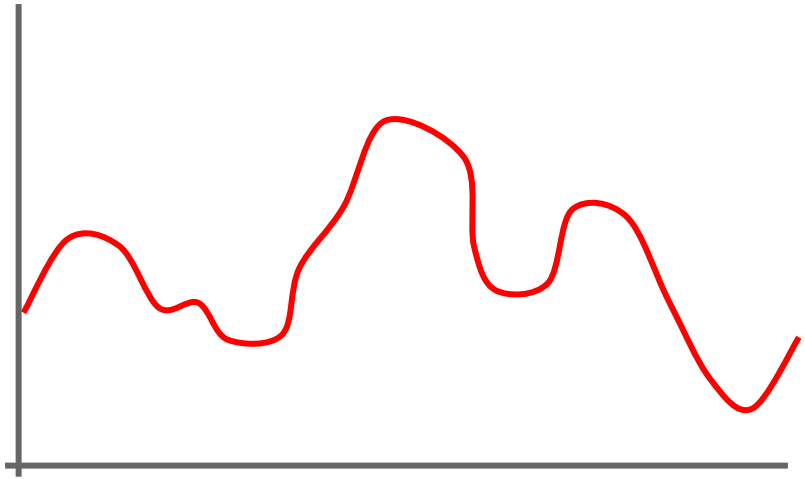
Cross-Entropy Benchmarking



001010...1011011

Mean probability of outputs sampled is **high**

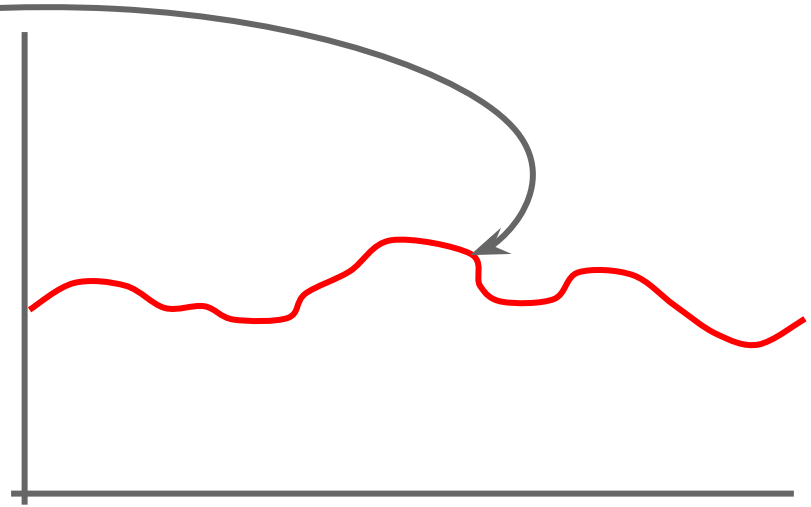
Cross-Entropy Benchmarking



001010...1011011

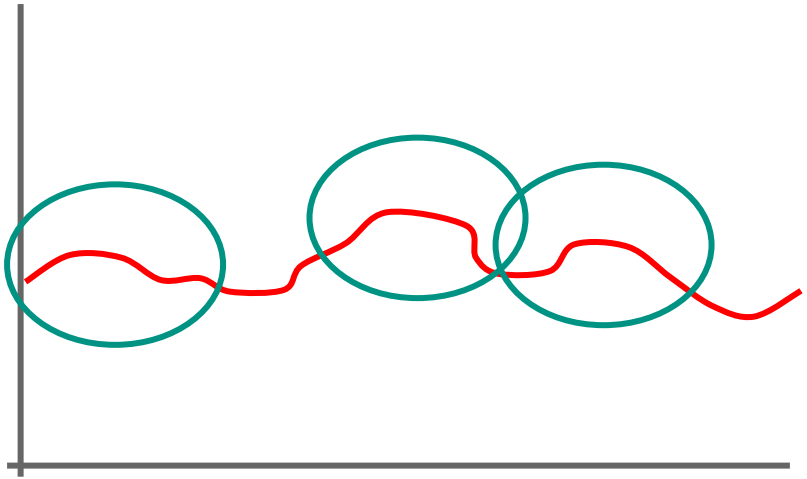
Cross-Entropy Benchmarking

Noisy distribution is flattened



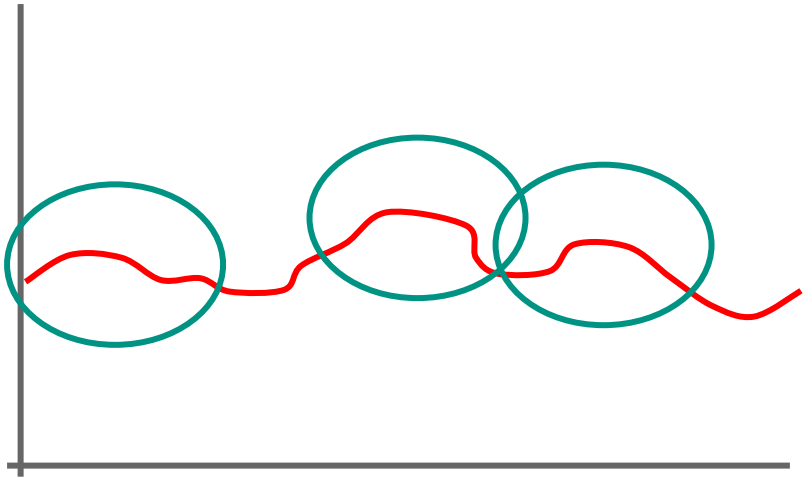
001010...1011011

Cross-Entropy Benchmarking



001010...1011011

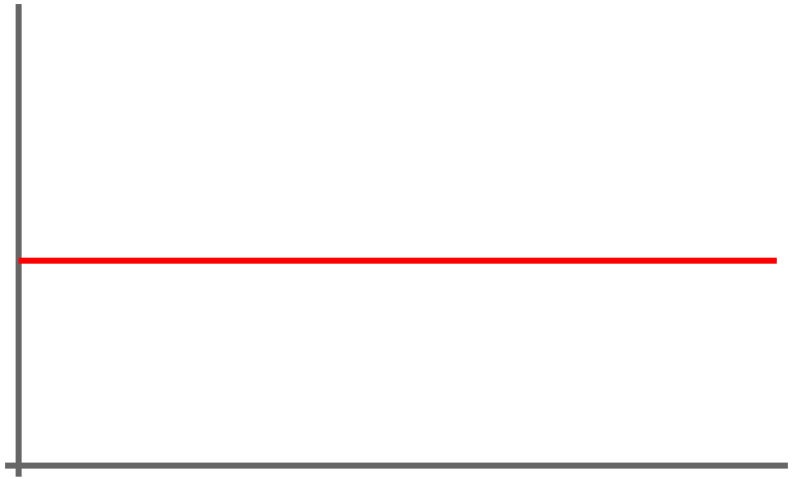
Cross-Entropy Benchmarking



001010...1011011

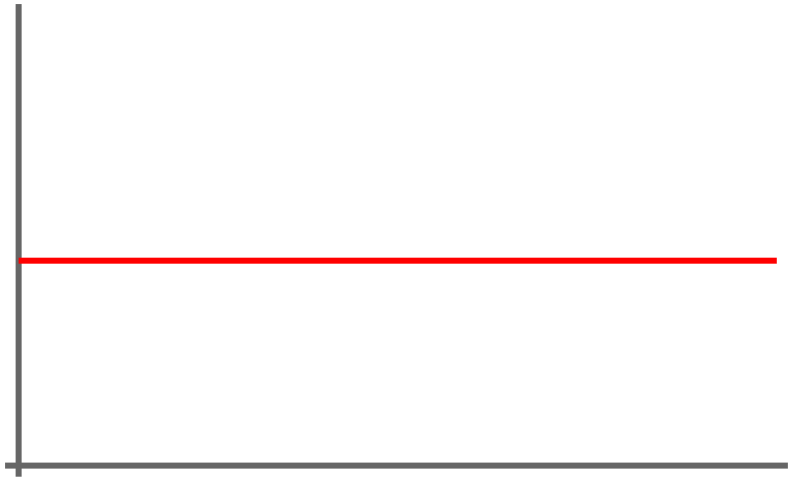
Mean probability of outputs sampled is **low**

Cross-Entropy Benchmarking



001010...1011011

Cross-Entropy Benchmarking



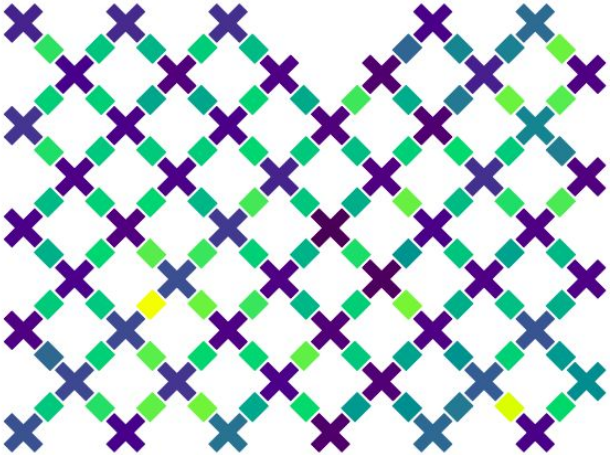
001010...1011011

Mean probability of outputs sampled is **very low**

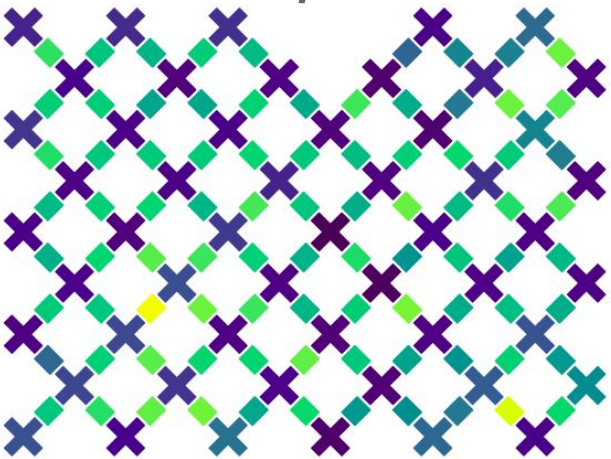
Cross-Entropy Benchmarking

- Measures something like the mean of the probabilities of the bit strings measured
- Would like a high cross-entropy

Cross-Entropy Benchmarking

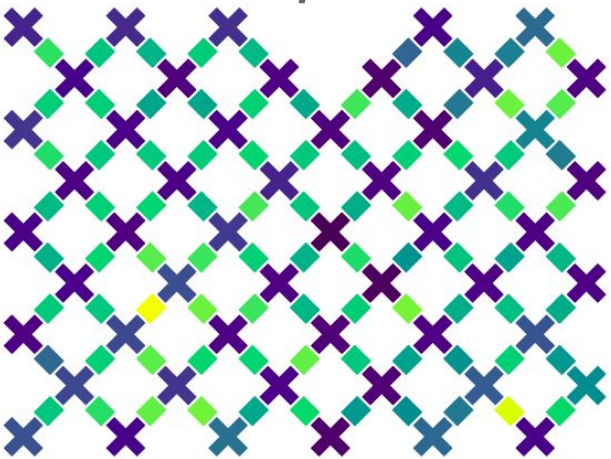


Cross-Entropy Benchmarking



(0011010101010101)
(0110100101010000)
...
(1101001010110101)

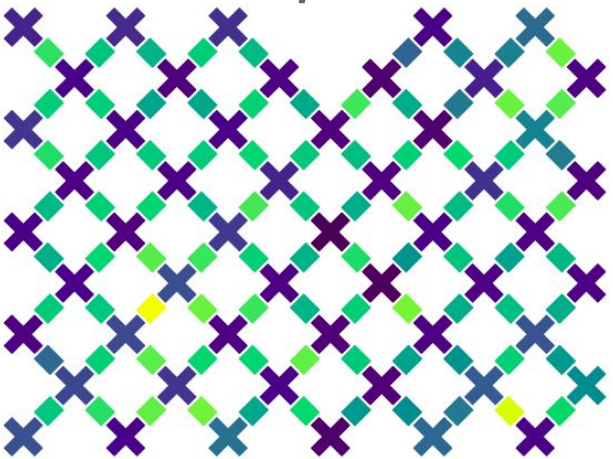
Cross-Entropy Benchmarking



(0011010101010101)
(0110100101010000)
...
(1101001010110101)

[P(x = 0011010101010101) +
P(x = 0110100101010000) +
...
P(x = 1101001010110101)] / m

Cross-Entropy Benchmarking

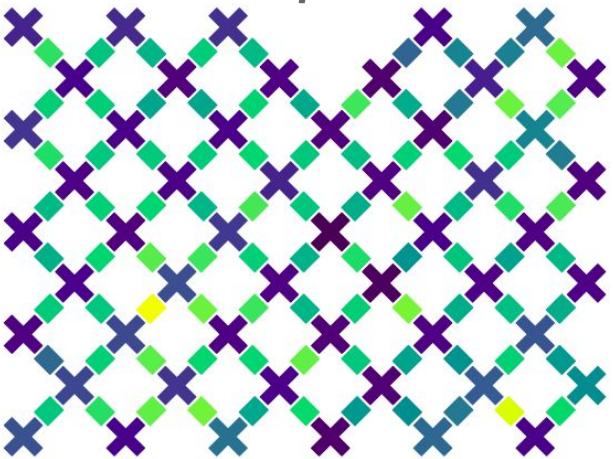


(0011010101010101)
(0110100101010000)
...
(1101001010110101)

[P(x = 0011010101010101) +
P(x = 0110100101010000) +
...
P(x = 1101001010110101)] / m

Cross-Entropy! :D

Cross-Entropy Benchmarking



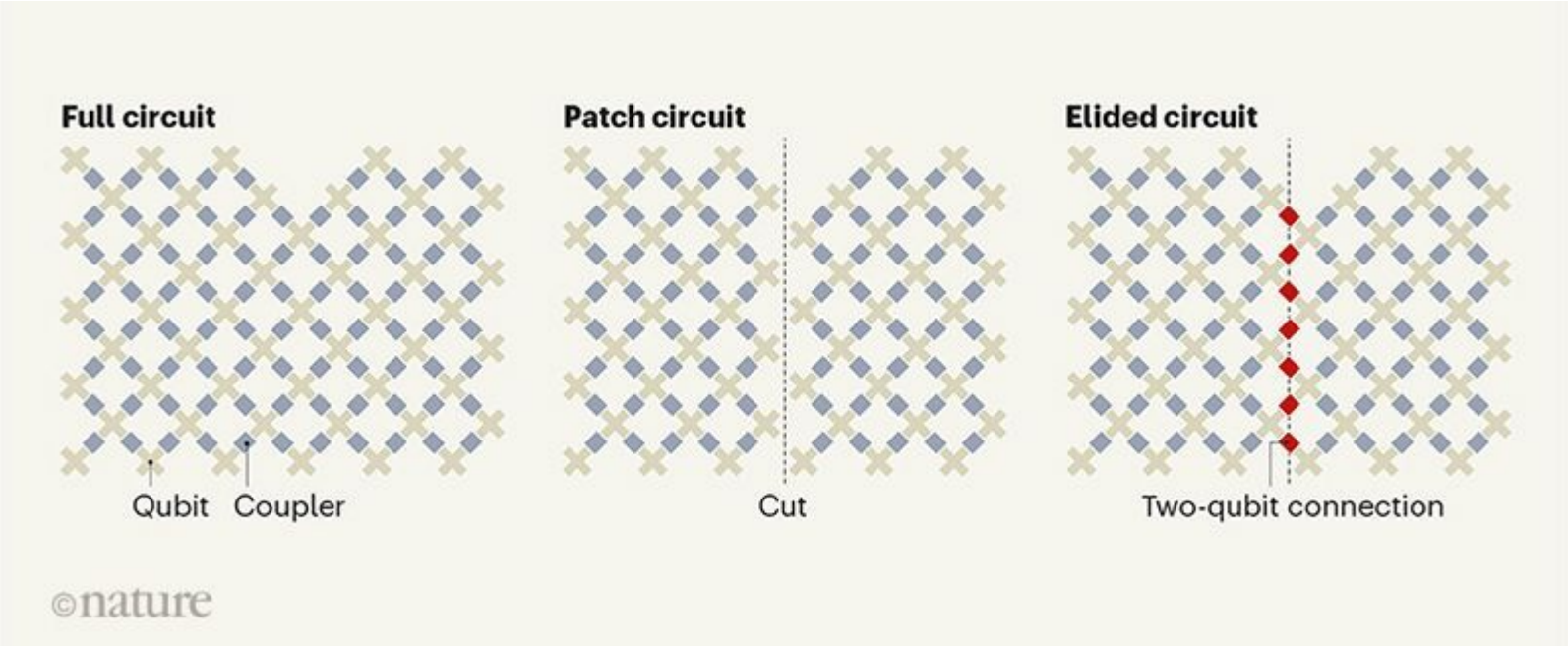
(0011010101010101)
(0110100101010000)
...
(1101001010110101)

[P(x = 0011010101010101) +
P(x = 0110100101010000) +
...
P(x = 1101001010110101)] / m

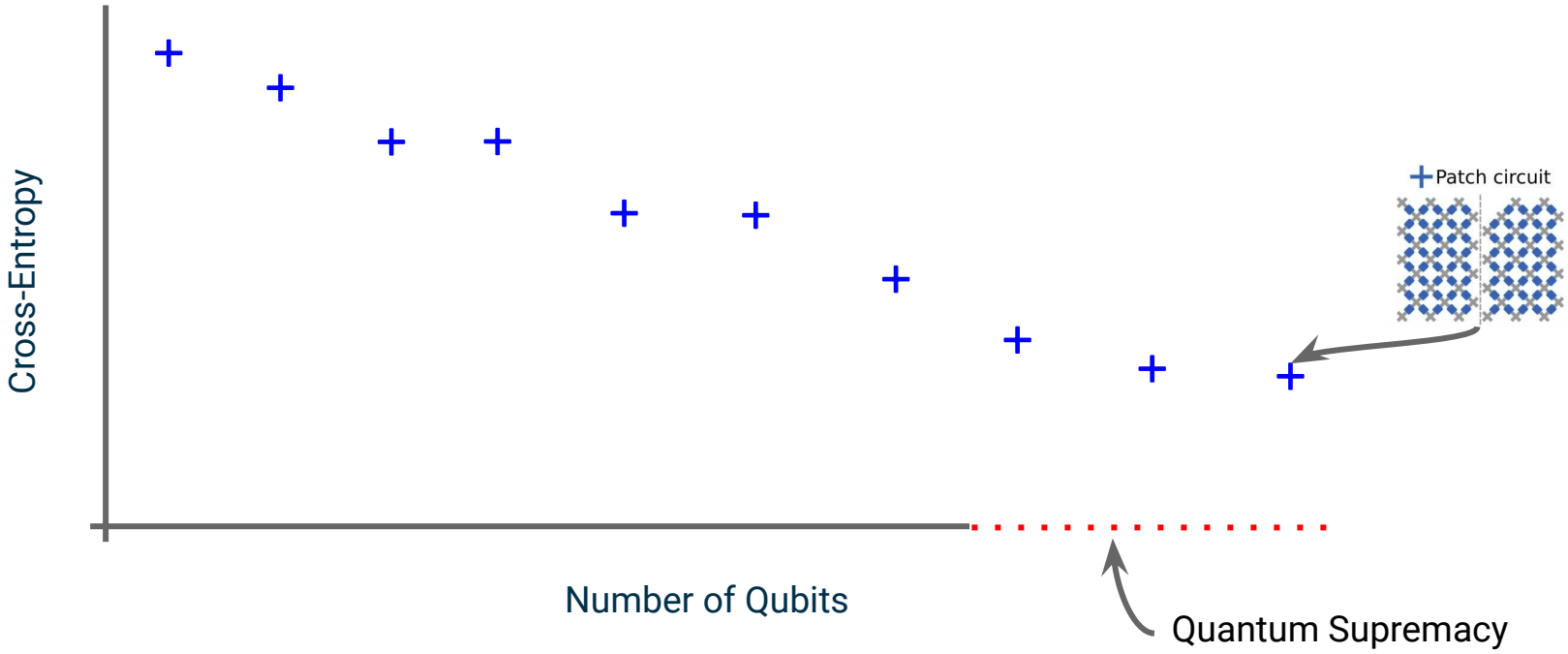
Cross-Entropy! :D

These take exponential time to compute! :(

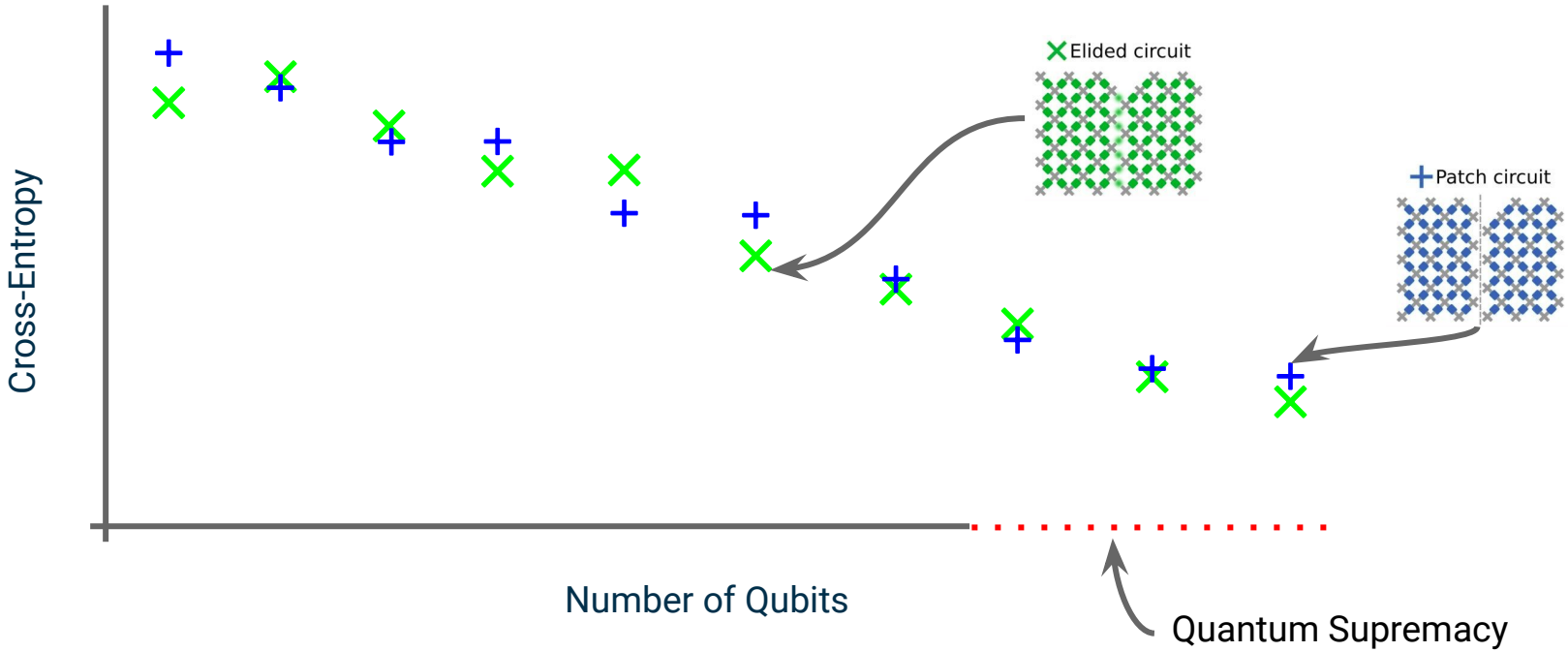
Cross-Entropy Benchmarking



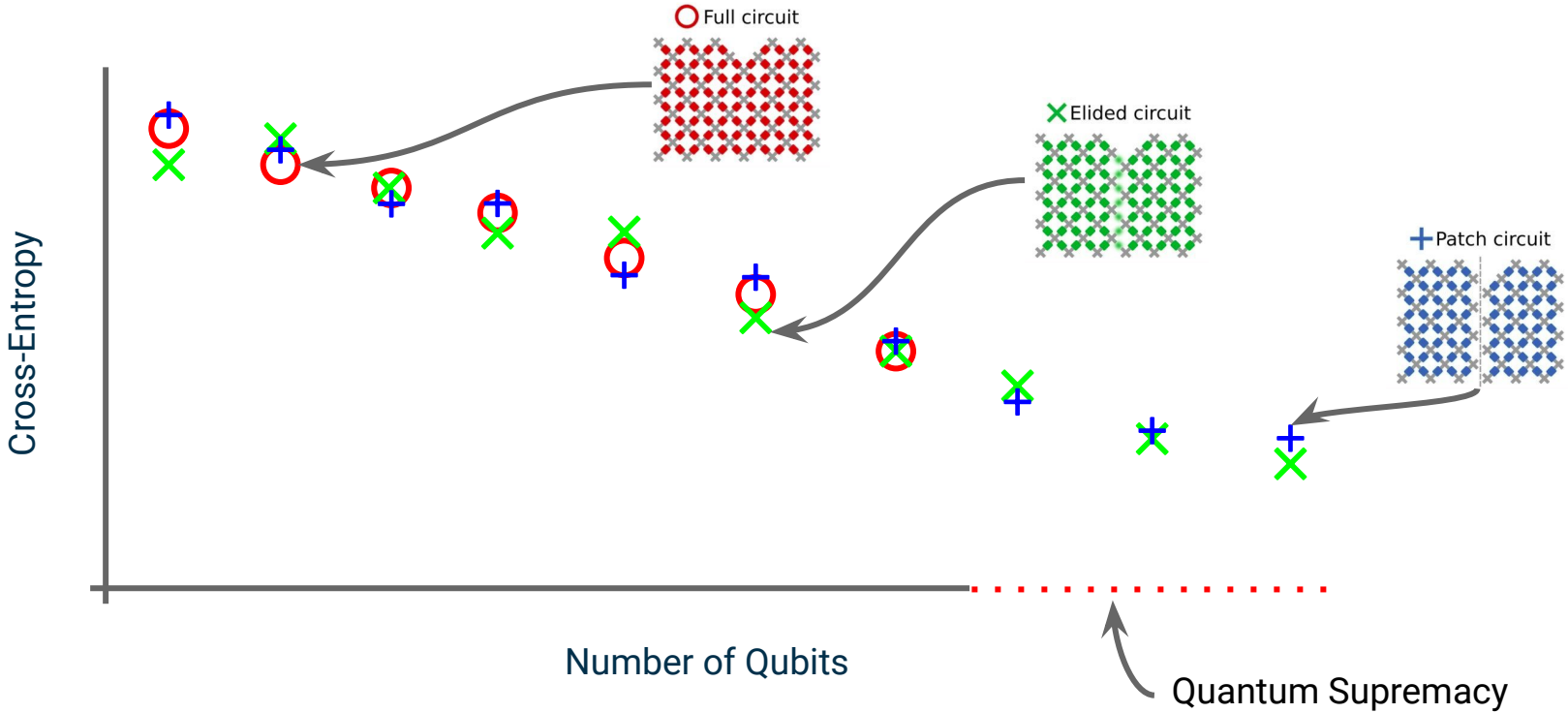
Cross-Entropy Benchmarking



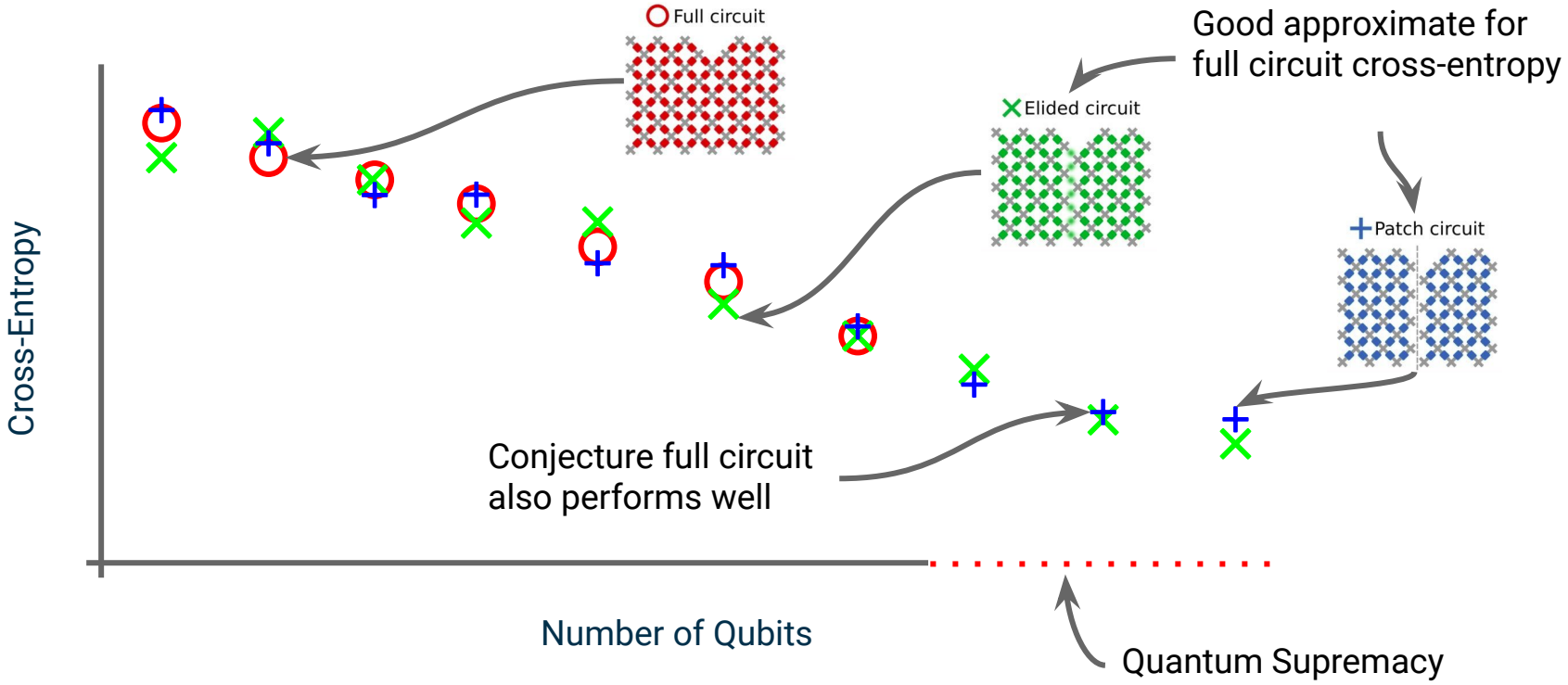
Cross-Entropy Benchmarking



Cross-Entropy Benchmarking



Cross-Entropy Benchmarking



Google's Quantum Computer Just Aced an 'Impossible' Test

By Tim Childers - Live Science Contributor October 24, 2019

Has Google achieved quantum supremacy?

Google and IBM square off in Schrodinger's catfight over quantum supremacy

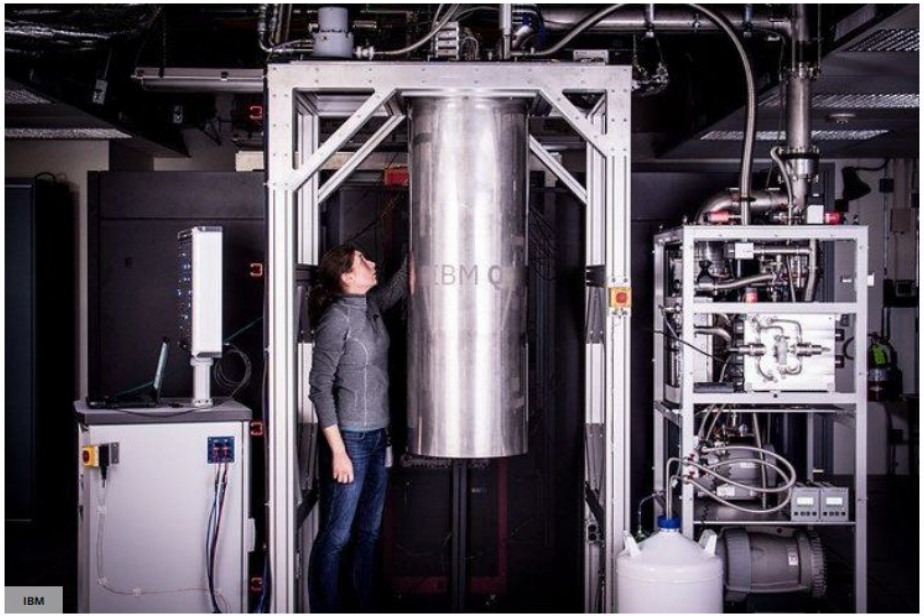
Should you believe the hype? Well, yes and no

By Rupert Goodwins 9 Jan 2020 at 10:00 74 SHARE ▼

IBM Unveils the Most Powerful Quantum Computer Yet

Big Blue is open for business.

By David Grossman Sep 19, 2019

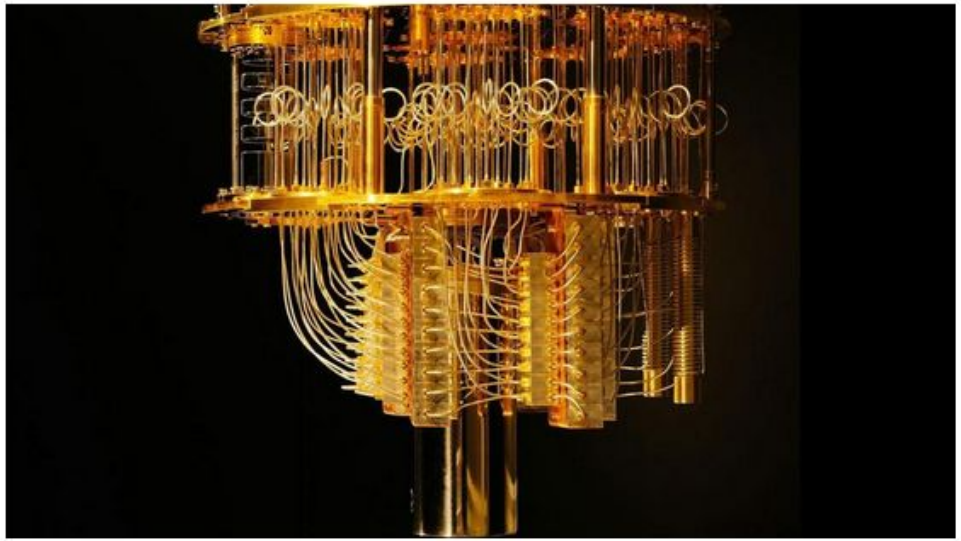


IBM

- IBM will be making a super-powerful quantum computer available for commercial use.
- Quantum computers operate on the atomic level, which allows them to process data at speeds unimaginable to classical computers like the one you're using to read this article.

Quantum Volume: A Yardstick To Measure The Performance Of Quantum Computers

Paul Smith-Goodson Contributor ⓘ
Cloud
Analyst-in-residence, Quantum Computing



IBM Quantum GRAHAM CARLOW

Disadvantage of Google Approach

- Gates are (kind of fixed) making other applications hard to implement
- Difficult to know how to improve device

Advantages of Quantum Volume

Uses very similar circuits but is agnostic to:

- connectivity of device
- gate set of device

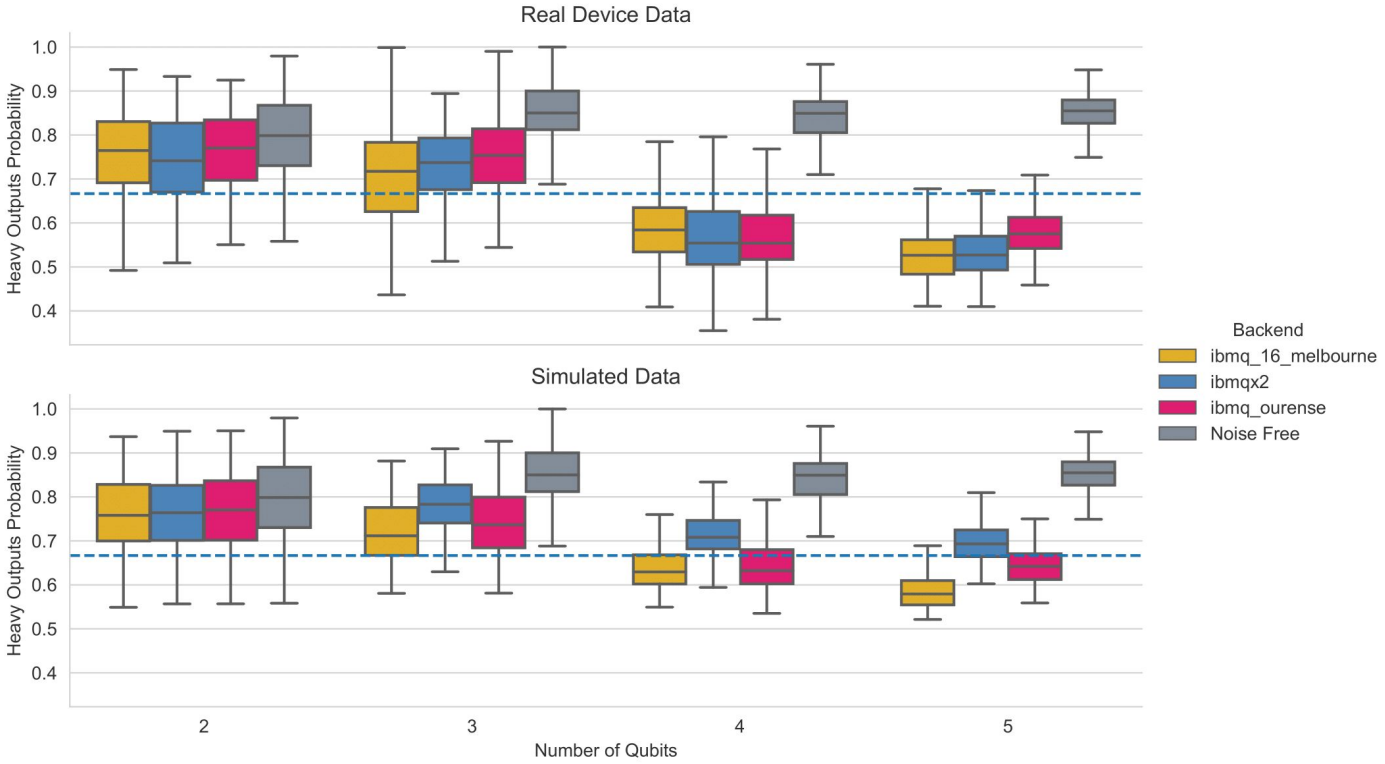
which allows one to compare devices.

Less specialised just for the demonstration of quantum supremacy and more of a benchmark

Comparison makes it possible to suggest improvement.

Still difficult to connect performance to applications.

Quantum Volume - Device Comparison

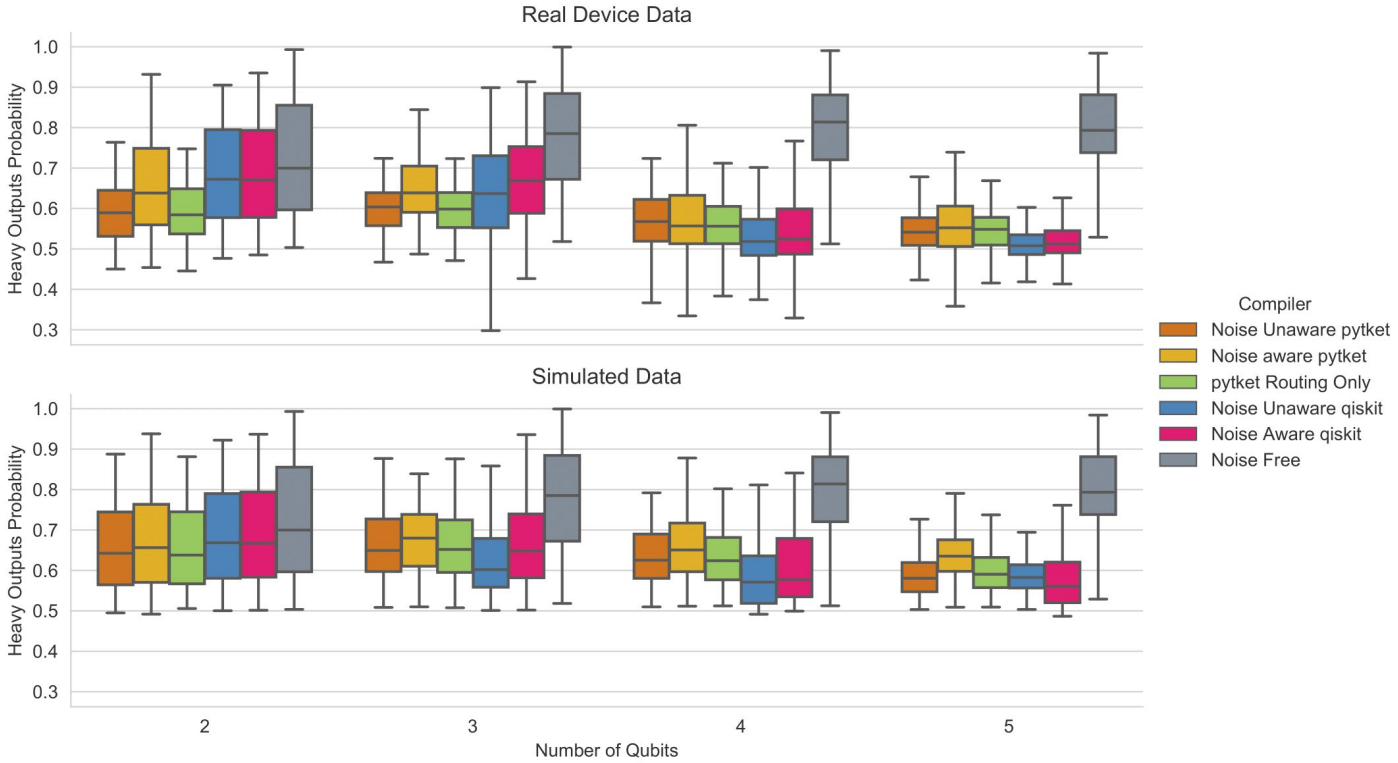


Let’s Take it One Step Further

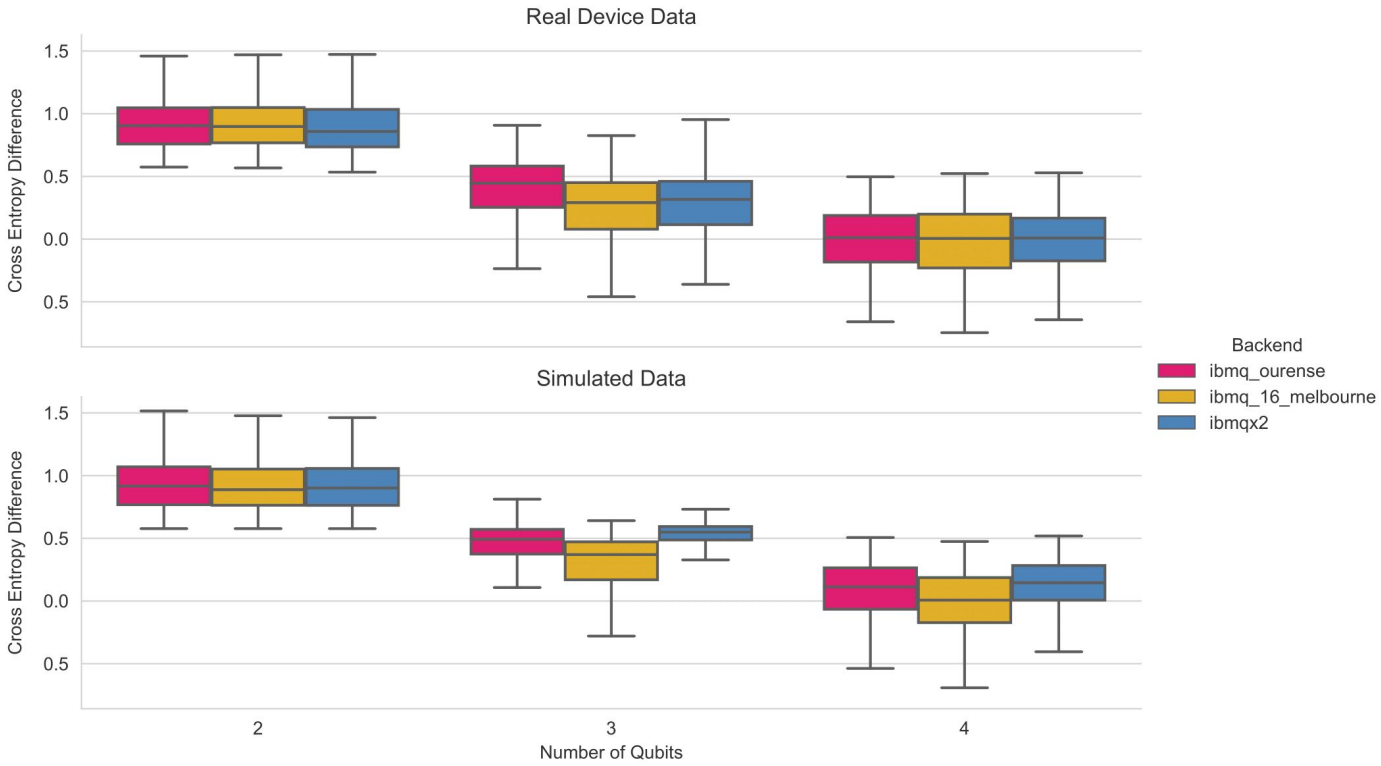
Incorporate:

- compiler to explore full stack
- application to be fairer to real world use

Quantum Volume - Compiler Comparison



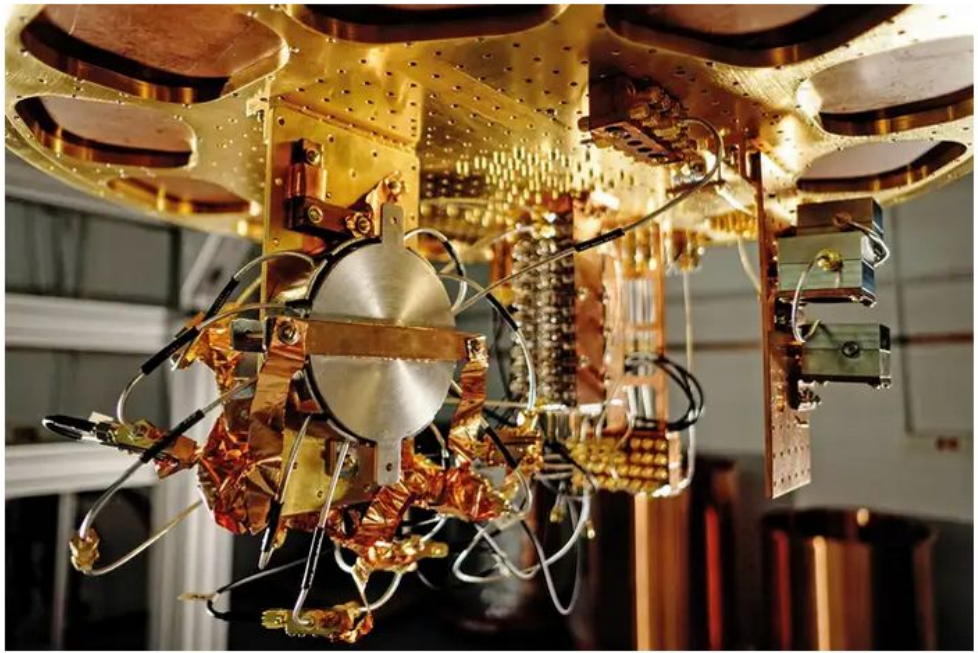
Quantum Volume - Application Aware



Google has reached quantum supremacy – here's what it should do next

TECHNOLOGY | ANALYSIS 26 September 2019

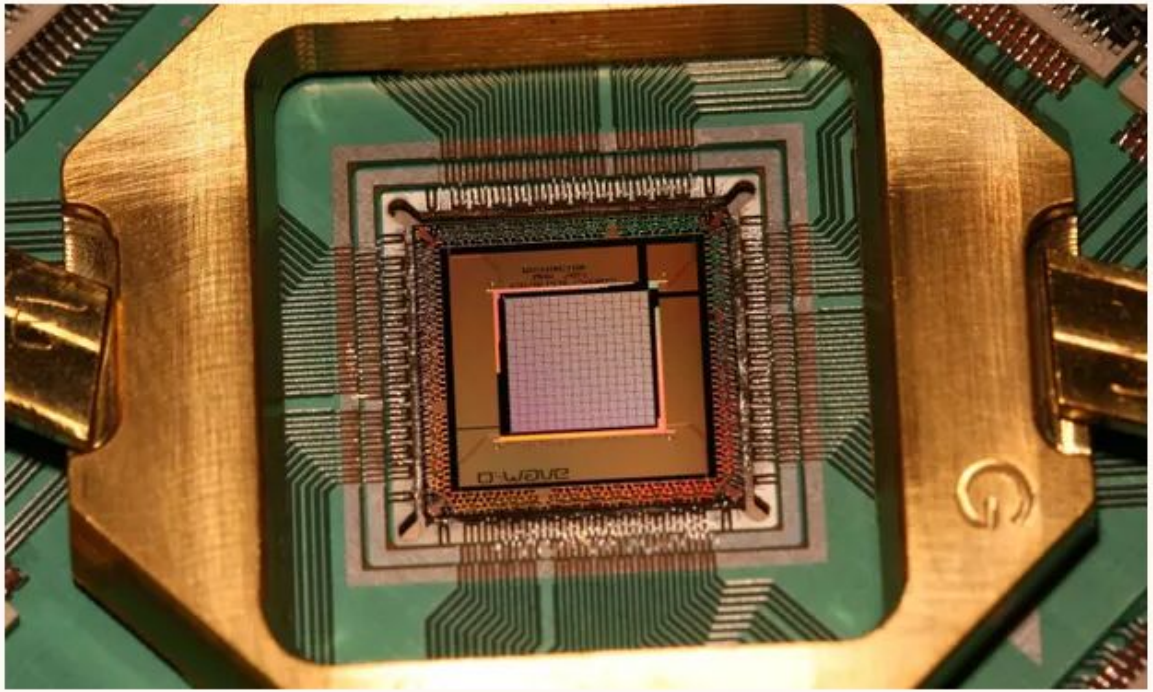
By Chelsea Whyte



Eric Lukero/Google

Quantum supremacy is coming. It won't change the world

If quantum computers are to help solve humanity's problems, they will have to improve drastically

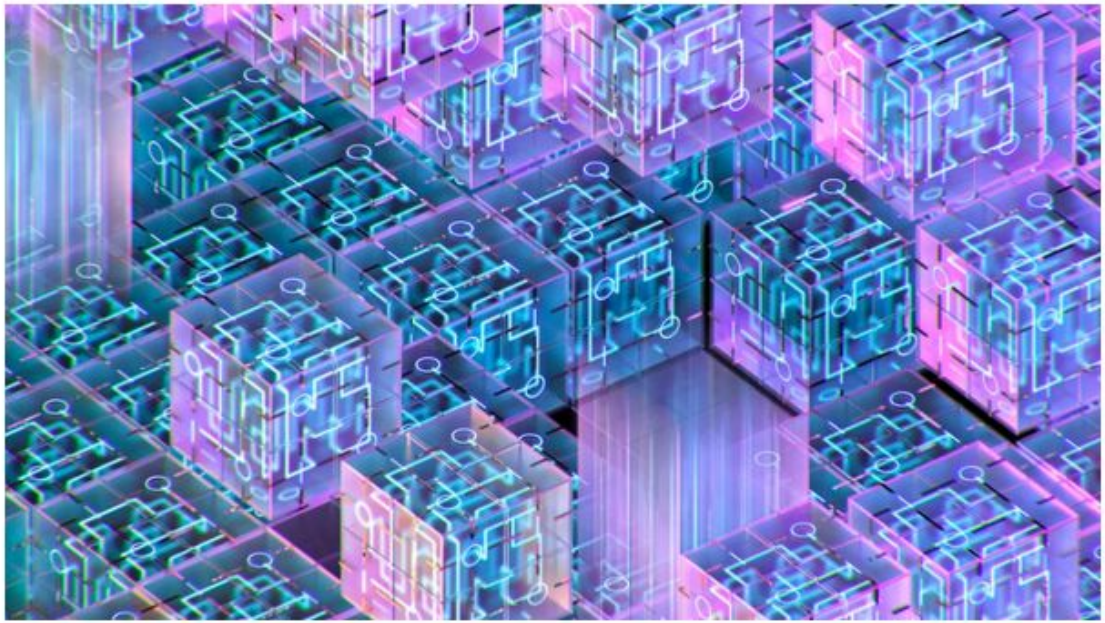


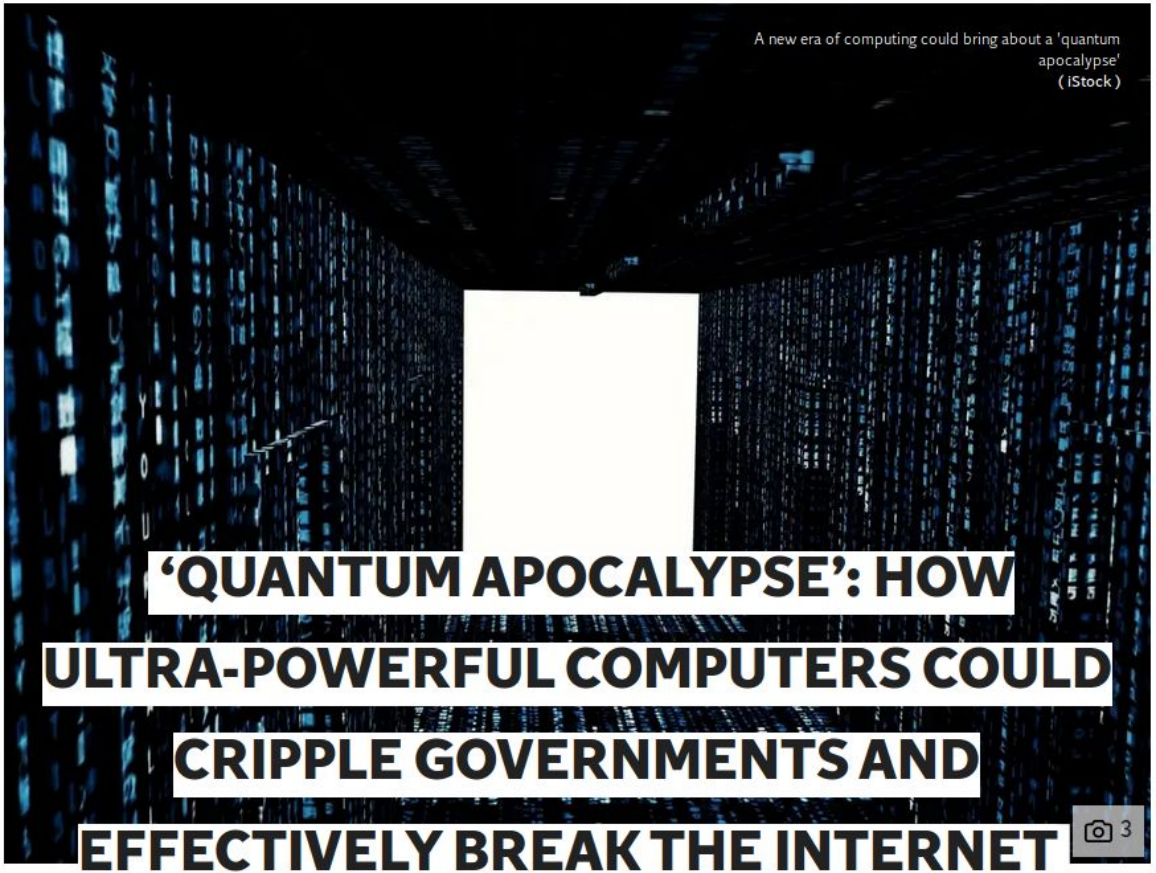
What should they do next?

- Clear up loopholes
- **Fault Tolerance!**

Forget Moore's Law — Quantum Computers Are Improving According to a Spooky 'Doubly Exponential Rate'

By Tia Ghose June 21, 2019





‘QUANTUM APOCALYPSE’: HOW ULTRA-POWERFUL COMPUTERS COULD CRIPPLE GOVERNMENTS AND EFFECTIVELY BREAK THE INTERNET

'Our modern systems of finance, commerce, communication, transportation, manufacturing, energy, government, and healthcare will for all intents and purposes cease to function,' cyber security expert warns