Advancing the Frontiers of Quantum Computing

(and Other Exciting Science) with Low Temperature Probe Stations and milliKelvin Research Cryostats

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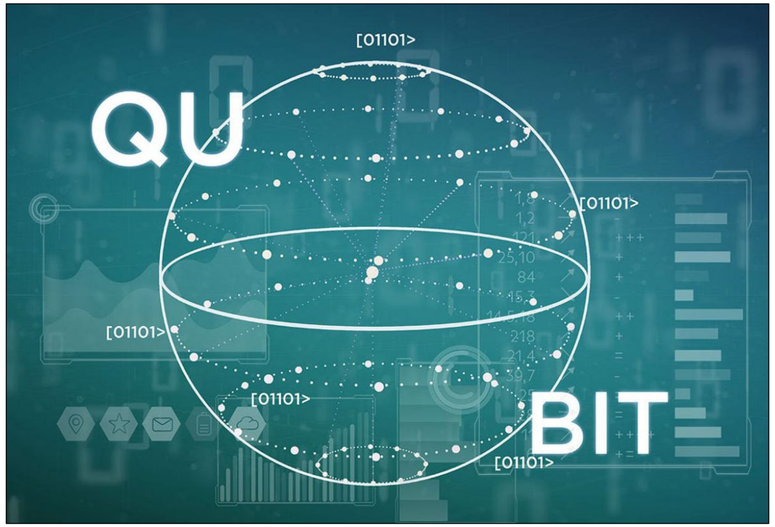
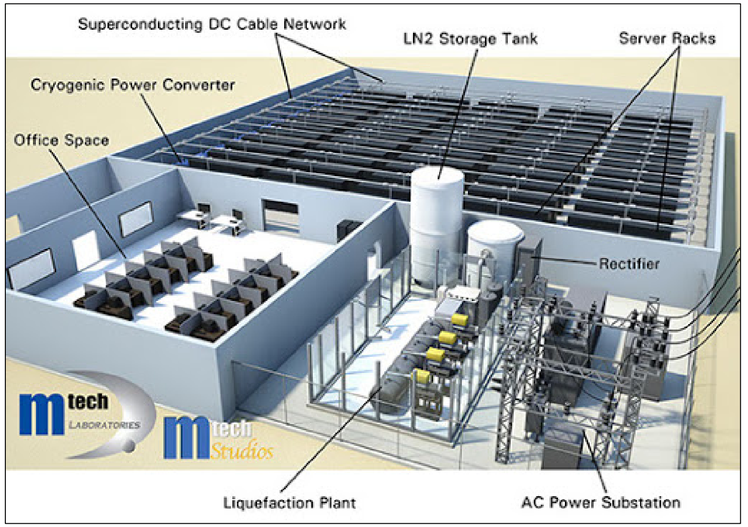
November 17, 2020

What science is happening at ~4 K and below?

- Quantum Computing
- Superconducting Computing
- Astronomy
- Nuclear forensics

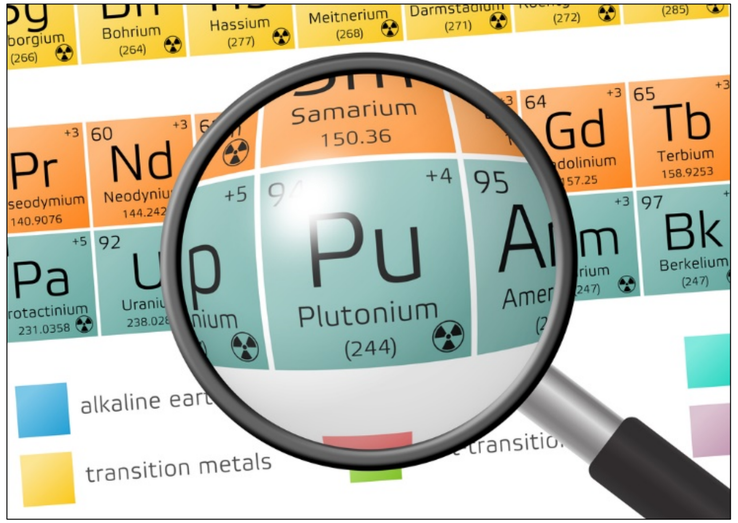


Quantum Computing



Superconducting Computing

Astronomy

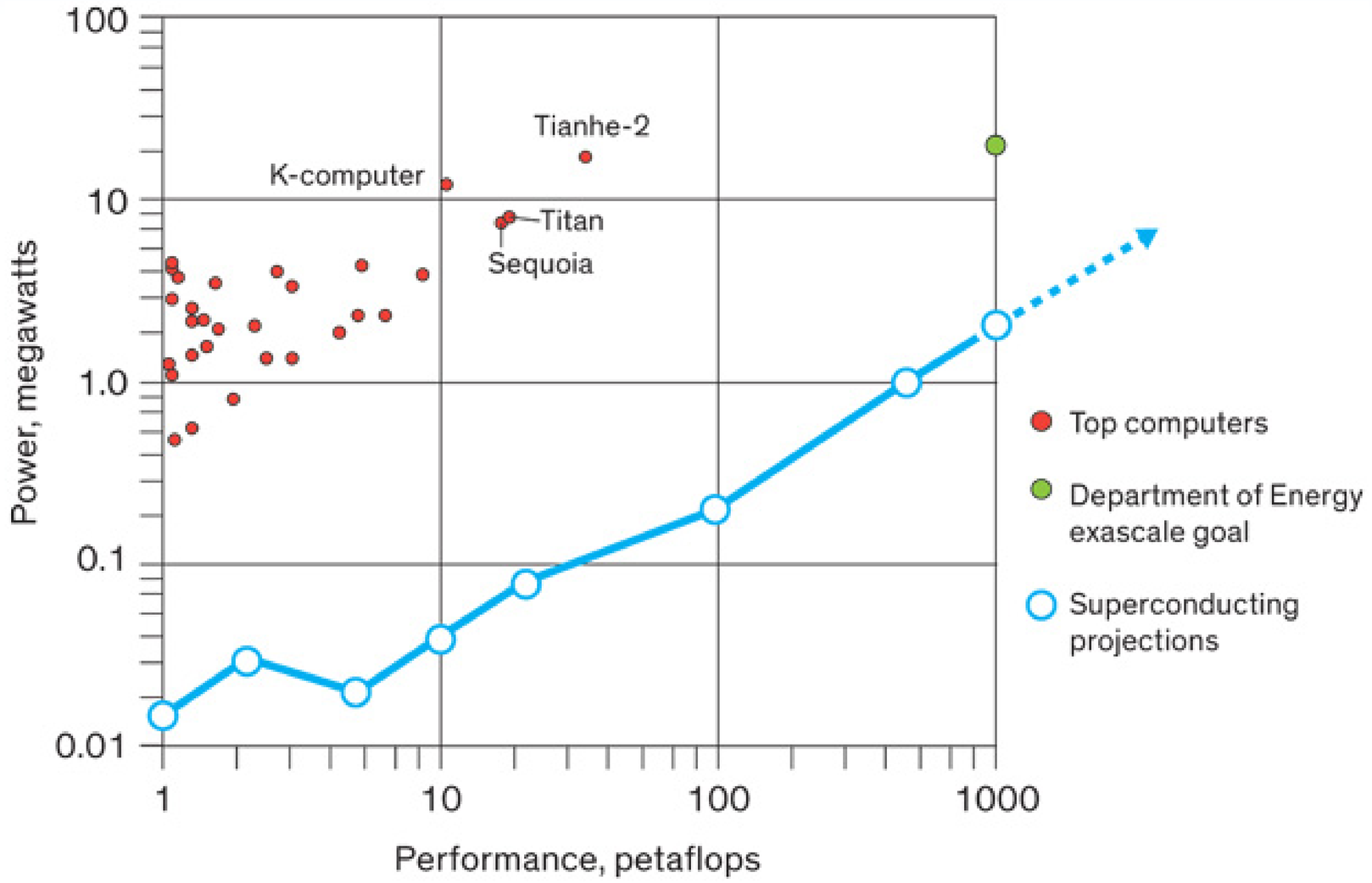


Nuclear Forensics

What's science is happening at ~4 K and below?

Superconducting computing

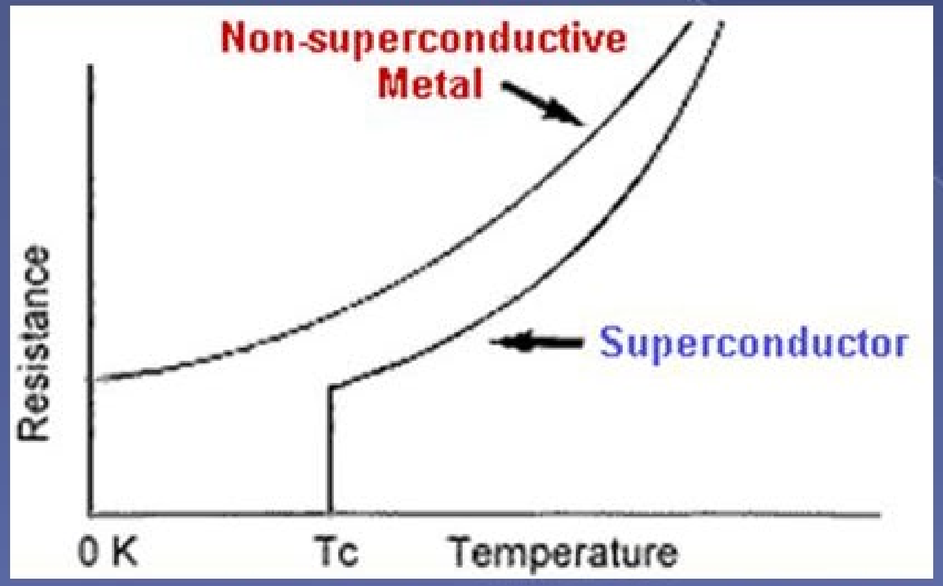
Addressing unsustainable trends in cooling power projections.



How Superconductivity makes it all possible

WHAT IS SUPERCONDUCTIVITY??

For some materials, the resistivity vanishes at some low temperature: they become *superconducting*.



Superconductivity is the ability of certain materials to conduct electrical current with no resistance. Thus, superconductors can carry large amounts of current with little or no loss of energy.

- **Superconductivity was discovered in 1911 by Heike Kammerlingh Onnes**

How does superconductivity enable awesome science?

- Achieve sensitivities impossible by any other means
- Appreciate efficiencies that greatly increase data processing rates
- How about an analogy to explain superconductivity in layman terms?

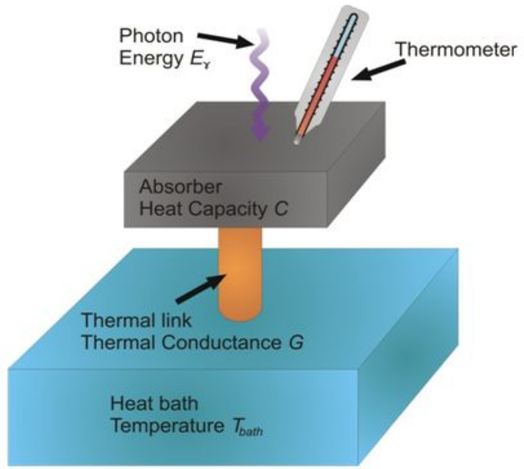
Transition Edge Sensors (TES)

One example of the increased sensitivity is the TES

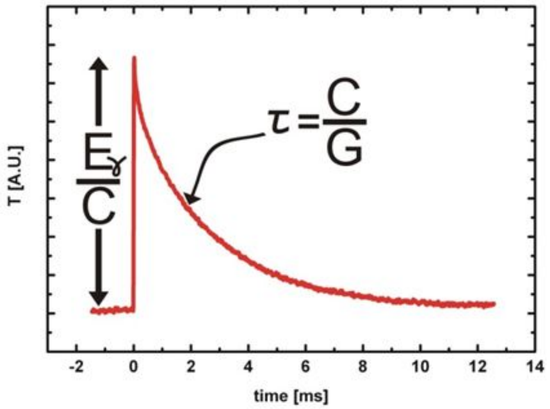
Transition-Edge Sensor (TES)

UNIVERSITY OF JYVÄSKYLÄ

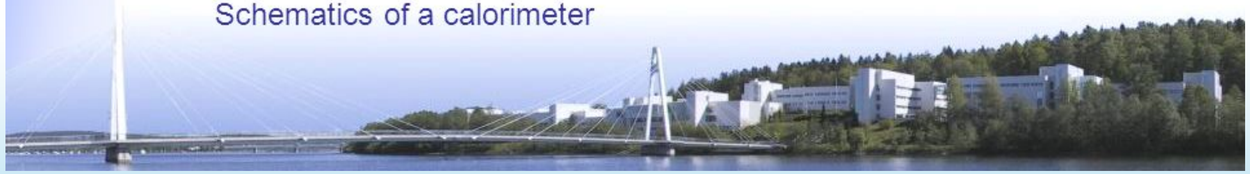
- TES as a calorimeter
  - Measures the energy of incident radiation

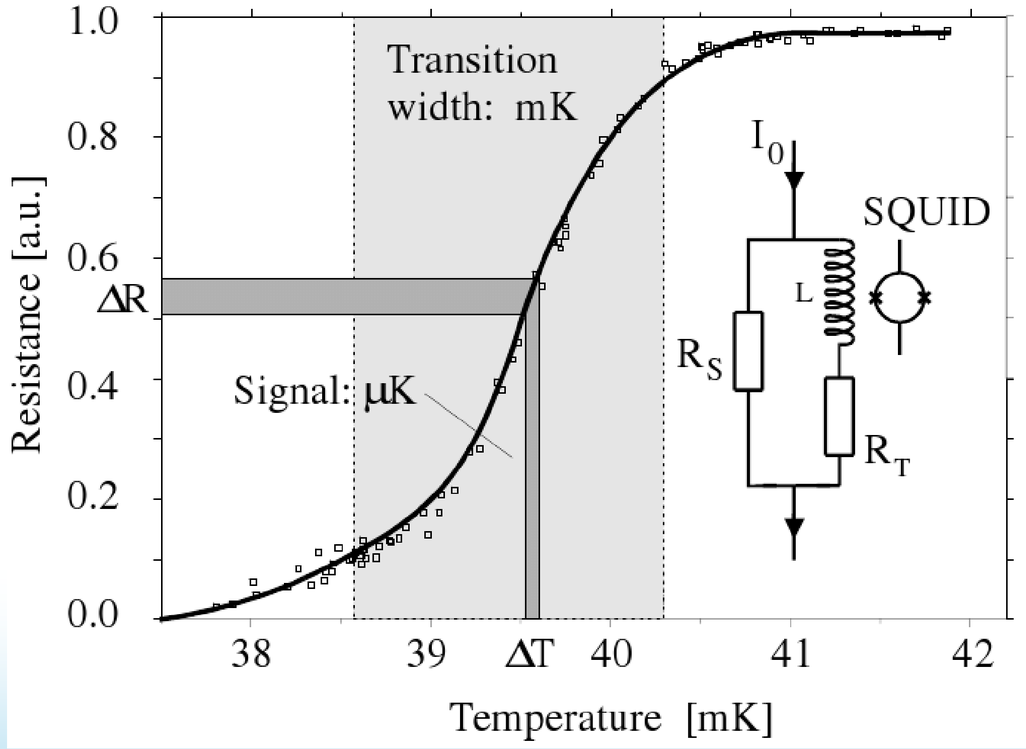


Schematics of a calorimeter



Typical pulse from a calorimeter



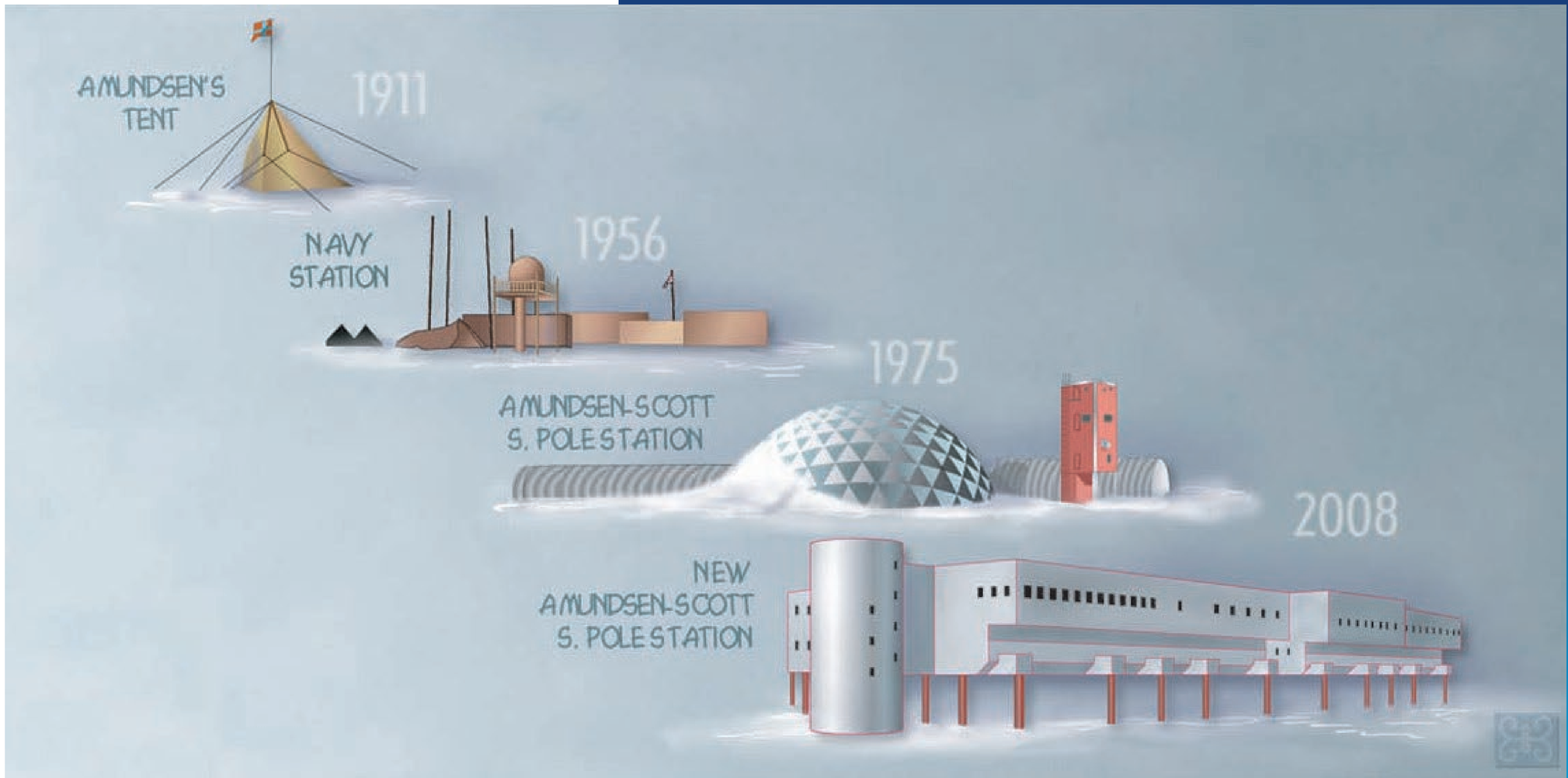


BICEP and South Pole Telescopes

Located at the bottom of the world, in desolation, is one of the most useful and productive observatories on earth.

BICEP and South Pole Telescopes

How things have evolved over the last century at the South Pole



BICEP and South Pole Telescopes

BICEP – Background Imaging of Cosmic Extragalactic Polarization

- Purpose is to measure the B-modes of the polarization of the Cosmic Microwave Background – the oldest light in the universe
- Located at Amundsen-Scott South Pole Station

Photo credit: John Kovac

BICEP and South Pole Telescopes

Last flight out of South Pole before winter, February 15, 2017

Photo credit: NOAA

BICEP and South Pole Telescopes

What's so special about the South Pole?

After the sun goes down…for six months:

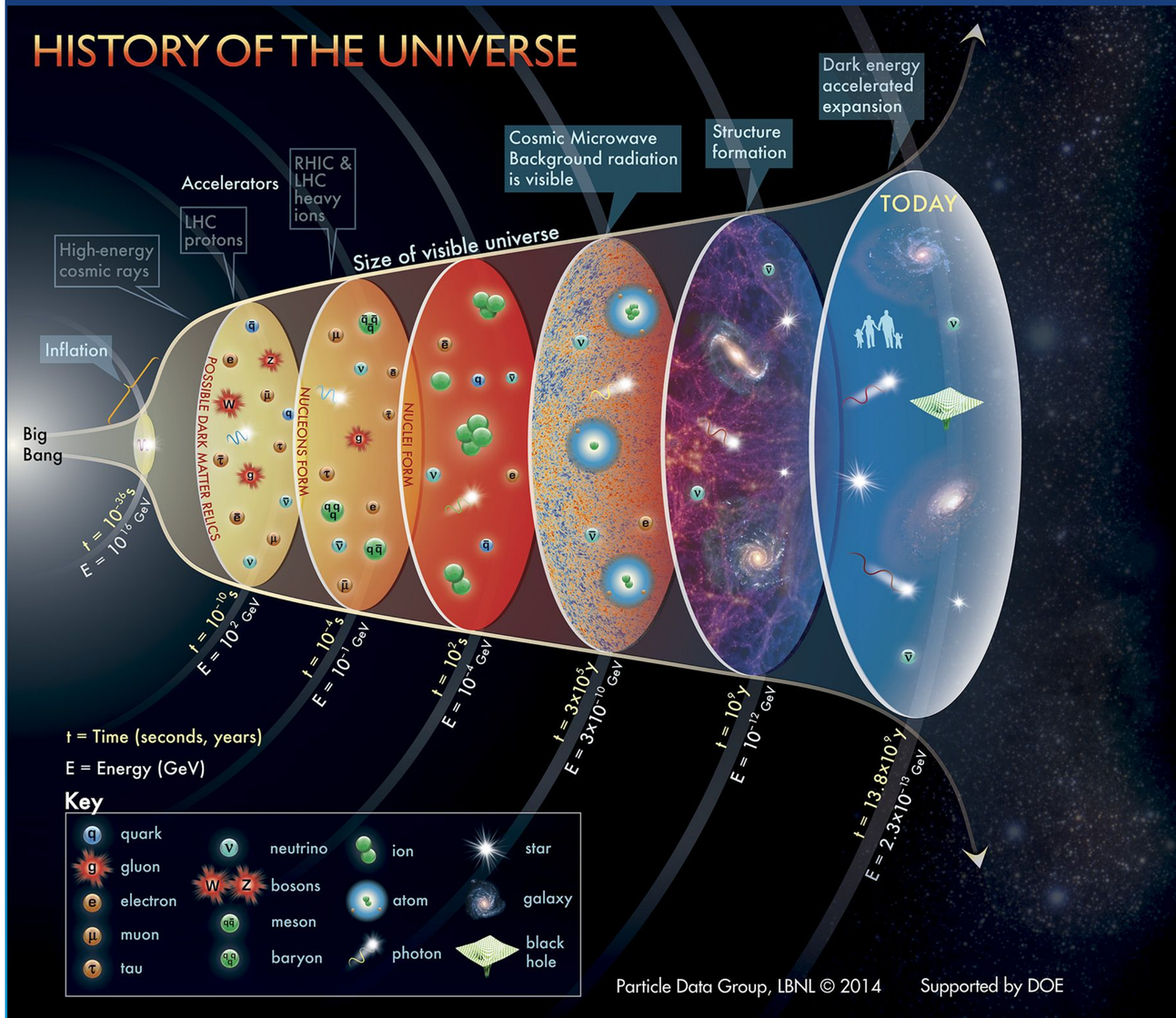
- Driest location on earth
- No alternating day and night, providing stable air
- High elevation, further reducing water vapor in the air

Photo credit: Keith Vanderlinde

BICEP and South Pole Telescopes

What can we learn by studying the CMB?

- Age of universe
- Rate of expansion
- How celestial bodies formed



BICEP and South Pole Telescopes

University of Toronto – Keith Vanderlinde's group

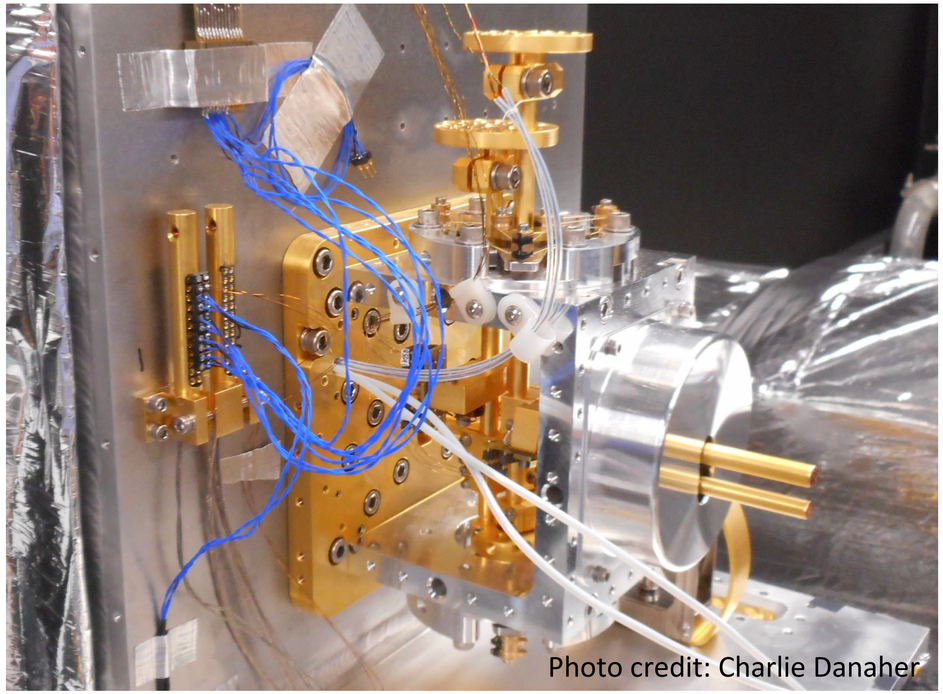
- Installing detector array into HPD Model 104 ADR Cryostat
- Characterizing detector arrays in advance of deployment to observatories

Photo credit: University of Toronto

Other Astronomy Research

Ben Mazin’s UCSB Laboratory

- Using HPD Model 155 ADR Insert, incorporated into observatory detector assembly



Quantum Computing

What is Quantum Computing?

- Whereas classical computers operate on the basis of 1 or 0, a quantum computer can operate on a 1 or 0, or a superposition of the two.
- Entanglement

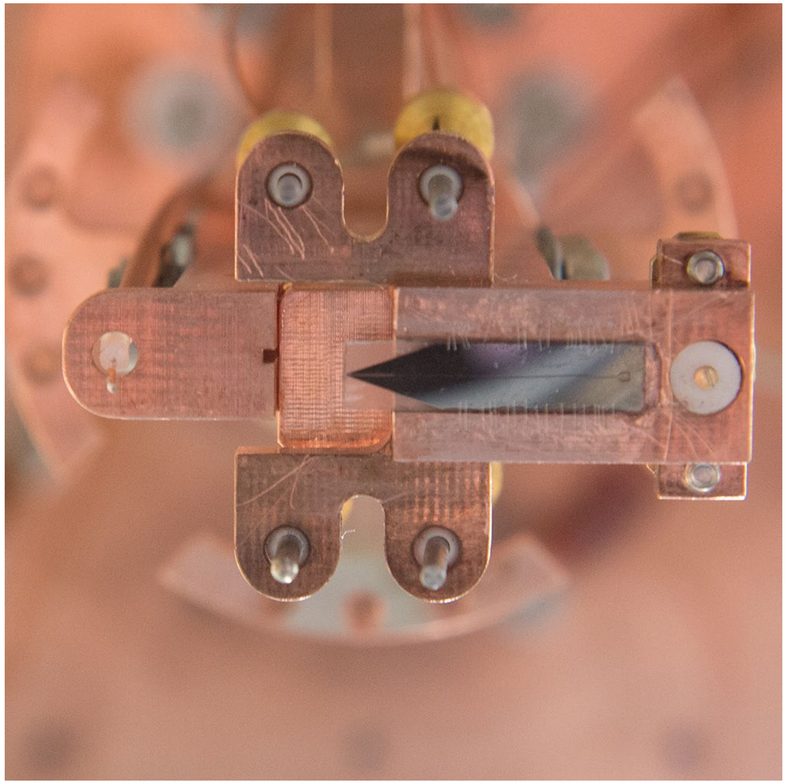
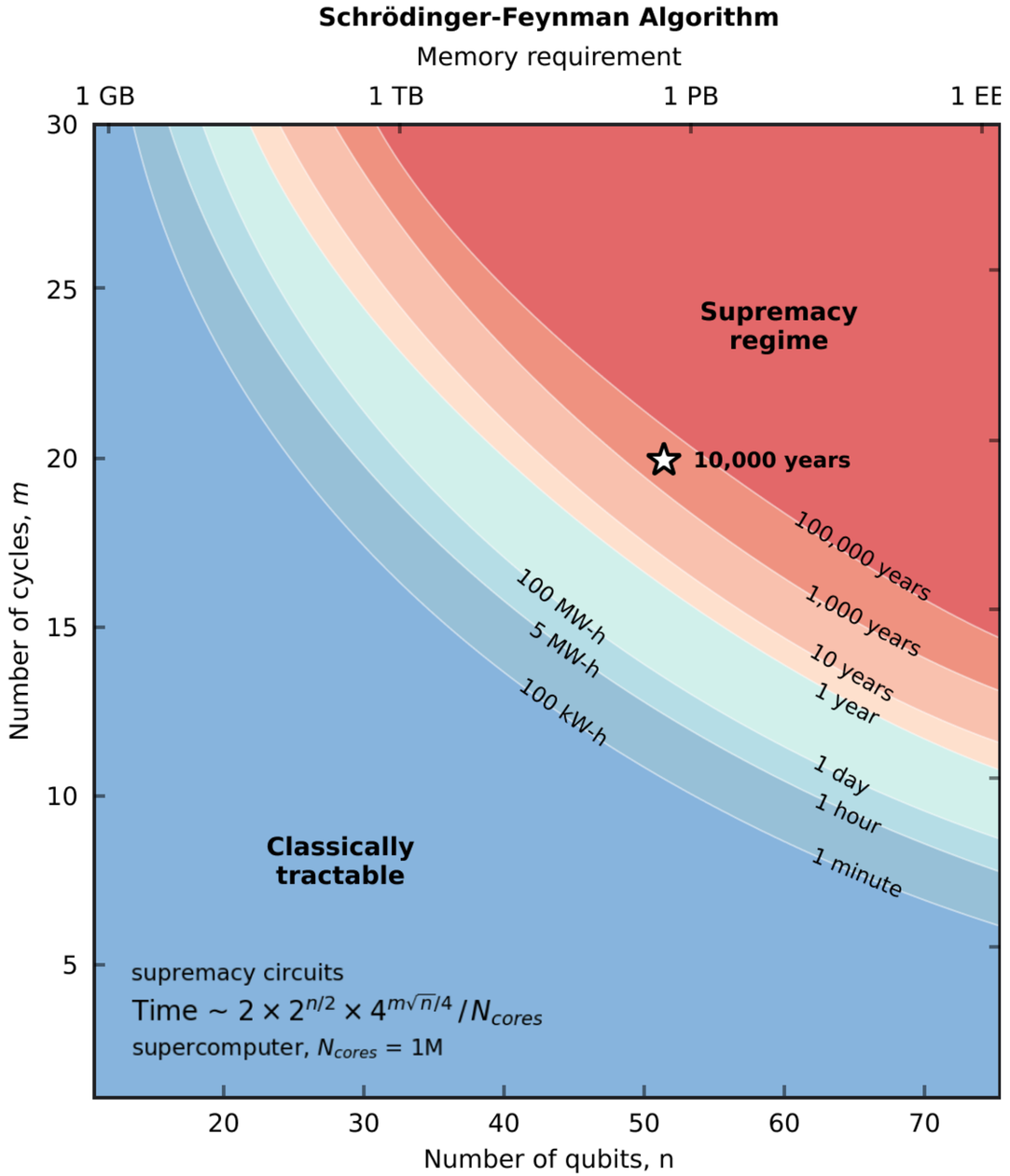


Photo credit: Syracuse University

Quantum Computing

What can Quantum Computing do for us?

- Solve equations otherwise impossible or impractical to solve
- Help optimize systems to provide greater efficiencies, and performances
- Such challenges as finance, intelligence, drug design, utilities, artificial intelligence
- What is Quantum Supremacy?



Quantum Computing

Quantum work performed at UCSB on HPD Model 101 Dilution Refrigerator Cryostat

- Initial experiment was to perform the factoring of 15.
- Proving the ability of factoring is fundamental to more complicated problem solving

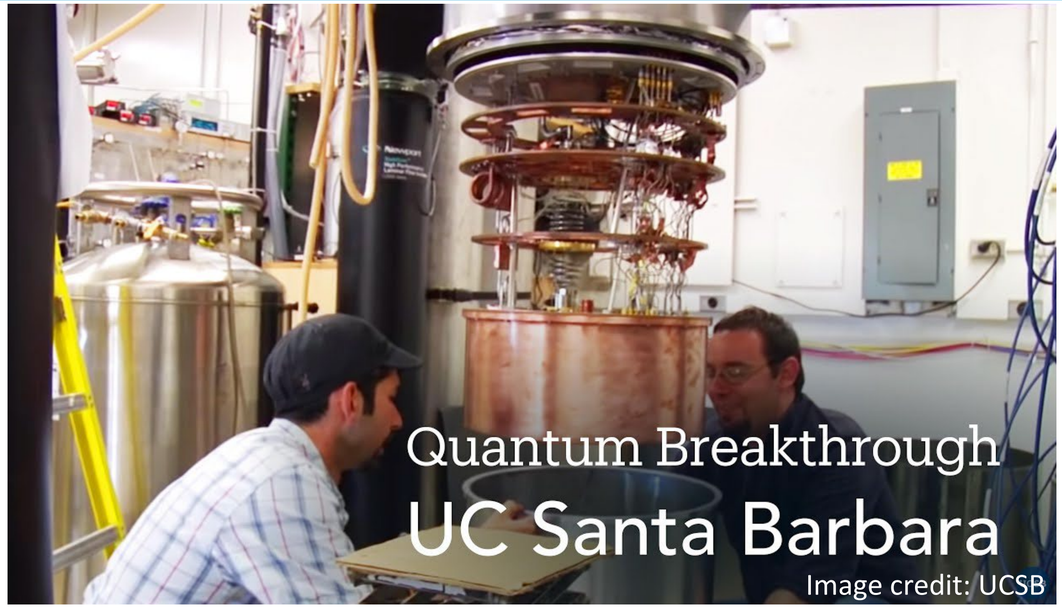


Image credit: UCSB

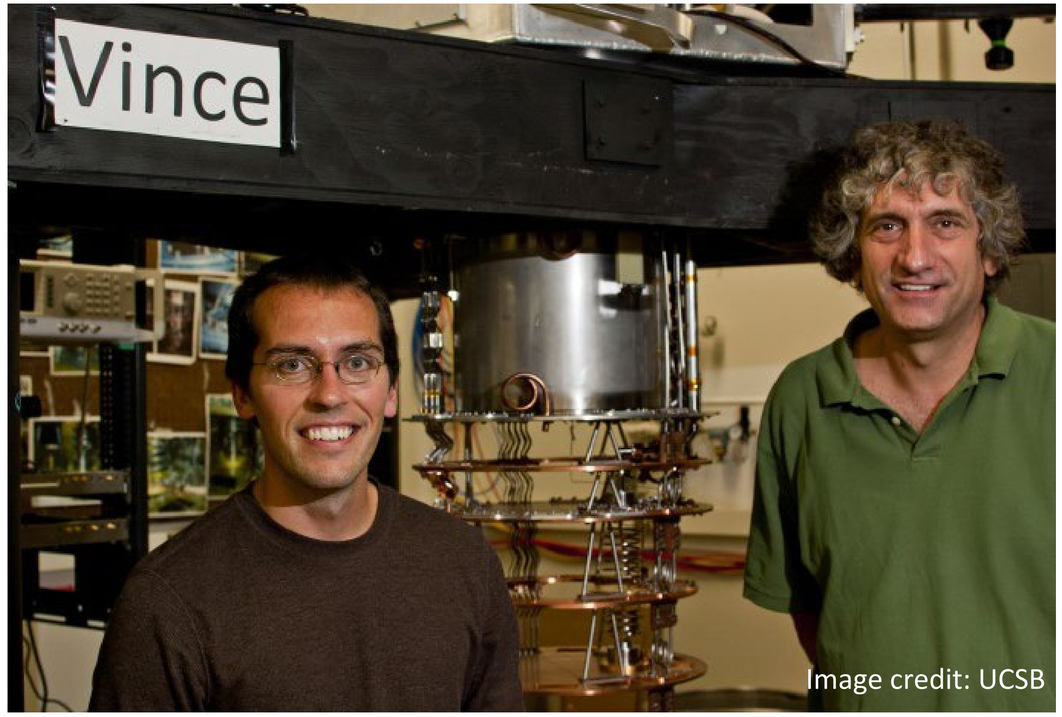


Image credit: UCSB

THANK YOU