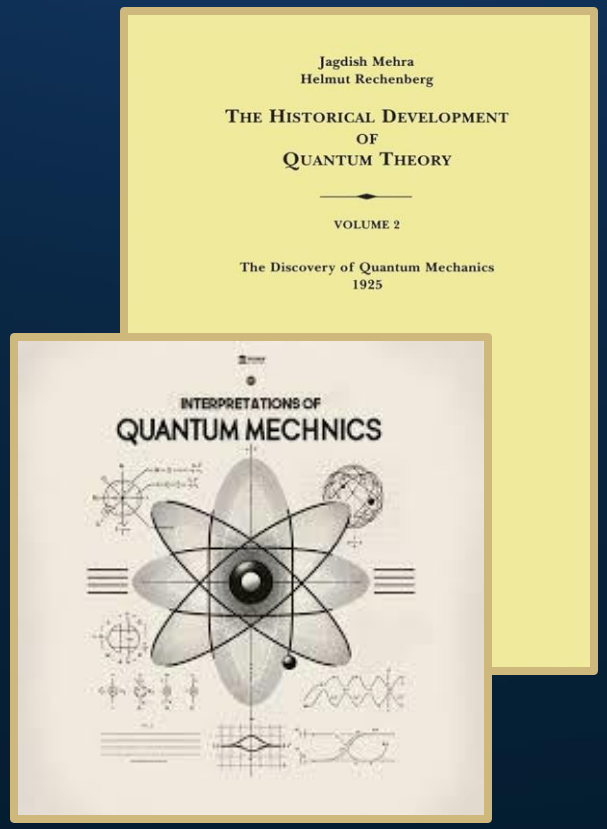
# From JILA to Elevate Quantum

A Perspective on Quantum Technology in the Colorado Front Range

CUbit QUANTUM INITIATIVE

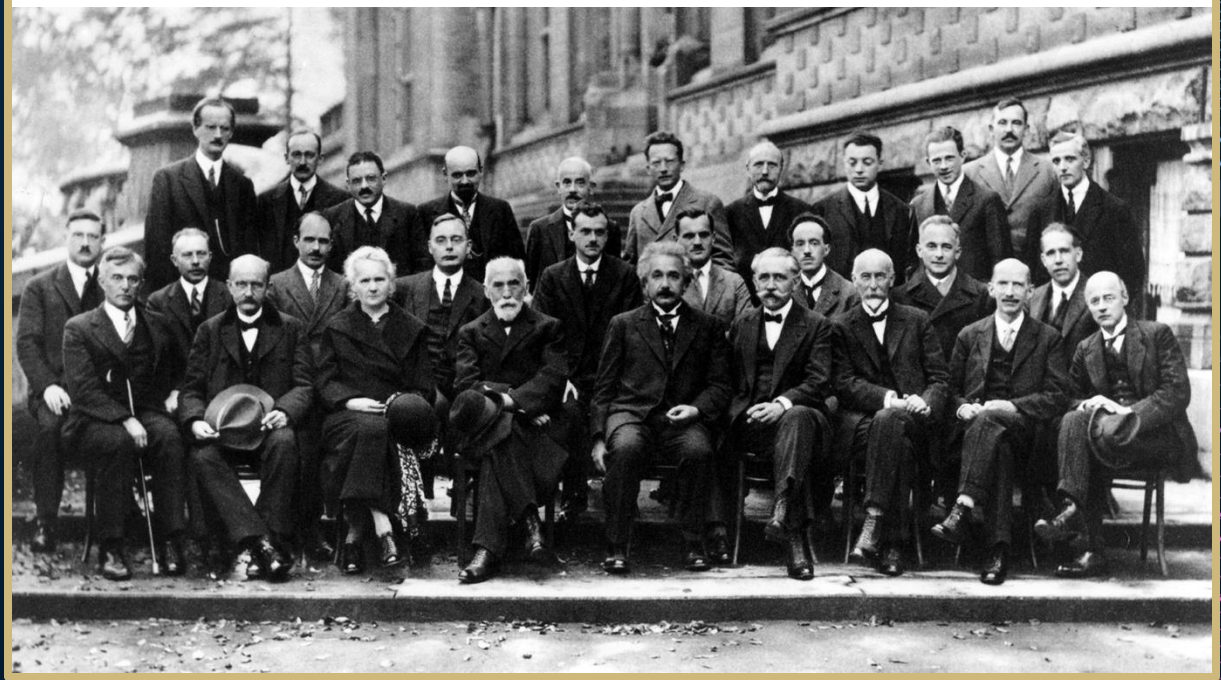
University of Colorado Boulder

# Quantum mechanics: A new way of looking at the world...




This subtle idea separates the quantum world – one of small things and small energies – from the larger objects of our normal, or classical world

The 1927 Solvay International Conference on Electrons and Photons was attended by many of the 20th century's greatest minds in physics



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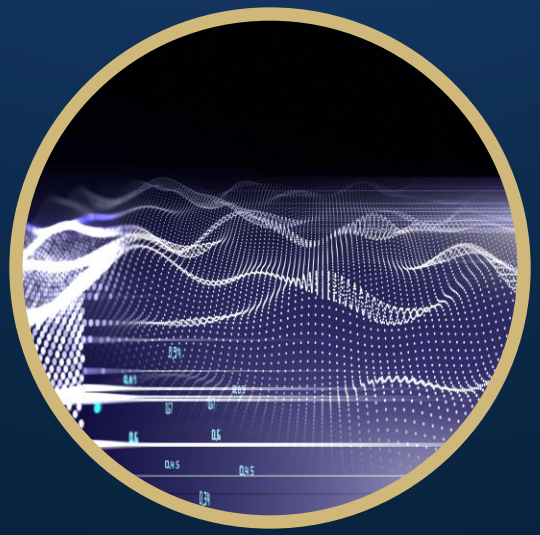
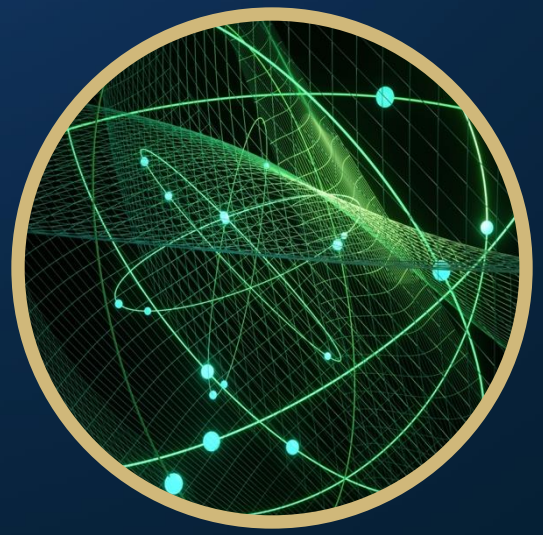
# From quantum theory to implications



**Quantum sensing** will improve observations of fundamental physical quantities



**Quantum networks** will make data and communications more secure

**Quantum computing** will enable the solution of large, complex problems

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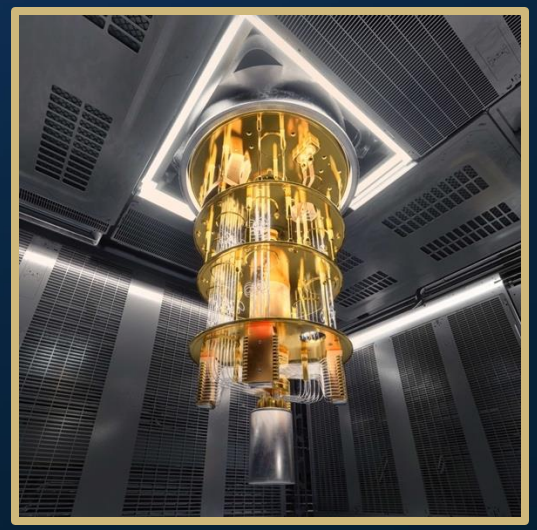
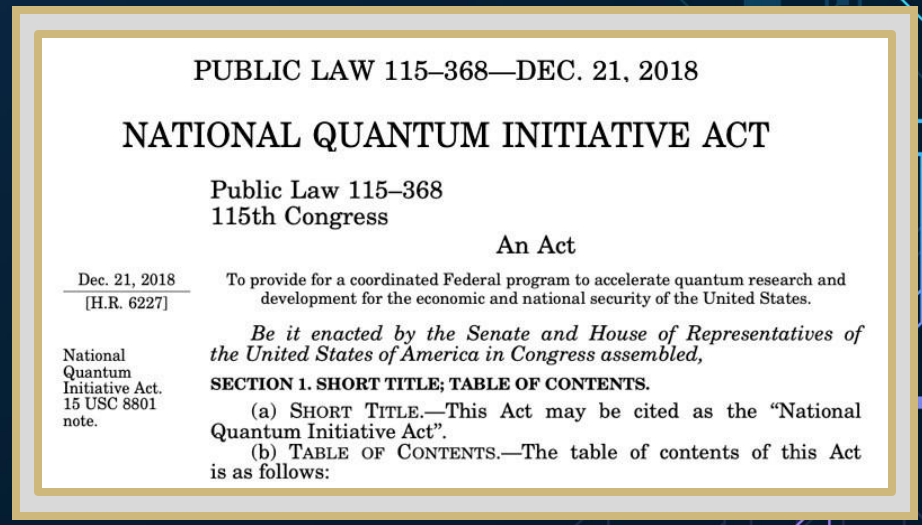
# Quantum is a race

**The race for quantum leadership is accelerating, fueled by substantial investments from federal, regional and private sectors aimed at mastering quantum technology**

We are on the brink of a quantum revolution



The implications of quantum advancements are vast



PUBLIC LAW 115–368—DEC. 21, 2018

NATIONAL QUANTUM INITIATIVE ACT

Public Law 115–368
115th Congress

An Act

Dec. 21, 2018
[H.R. 6227]

To provide for a coordinated Federal program to accelerate quantum research and development for the economic and national security of the United States.

National Quantum Initiative Act.
15 USC 8801 note.

*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,*

**SECTION 1. SHORT TITLE; TABLE OF CONTENTS.**

(a) SHORT TITLE.—This Act may be cited as the "National Quantum Initiative Act".

(b) TABLE OF CONTENTS.—The table of contents of this Act is as follows:

Quantum is a national and international priority

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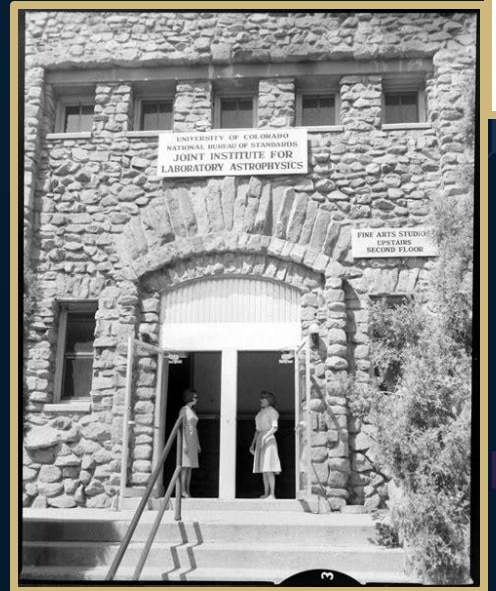
# Formation of JILA

JILA was established as a collaboration between the **University of Colorado Boulder** and the **National Institute of Standards and Technology (NIST)**, formerly known as the National Bureau of Standards (NBS)

JILA




NIST
National Institute of Standards and Technology

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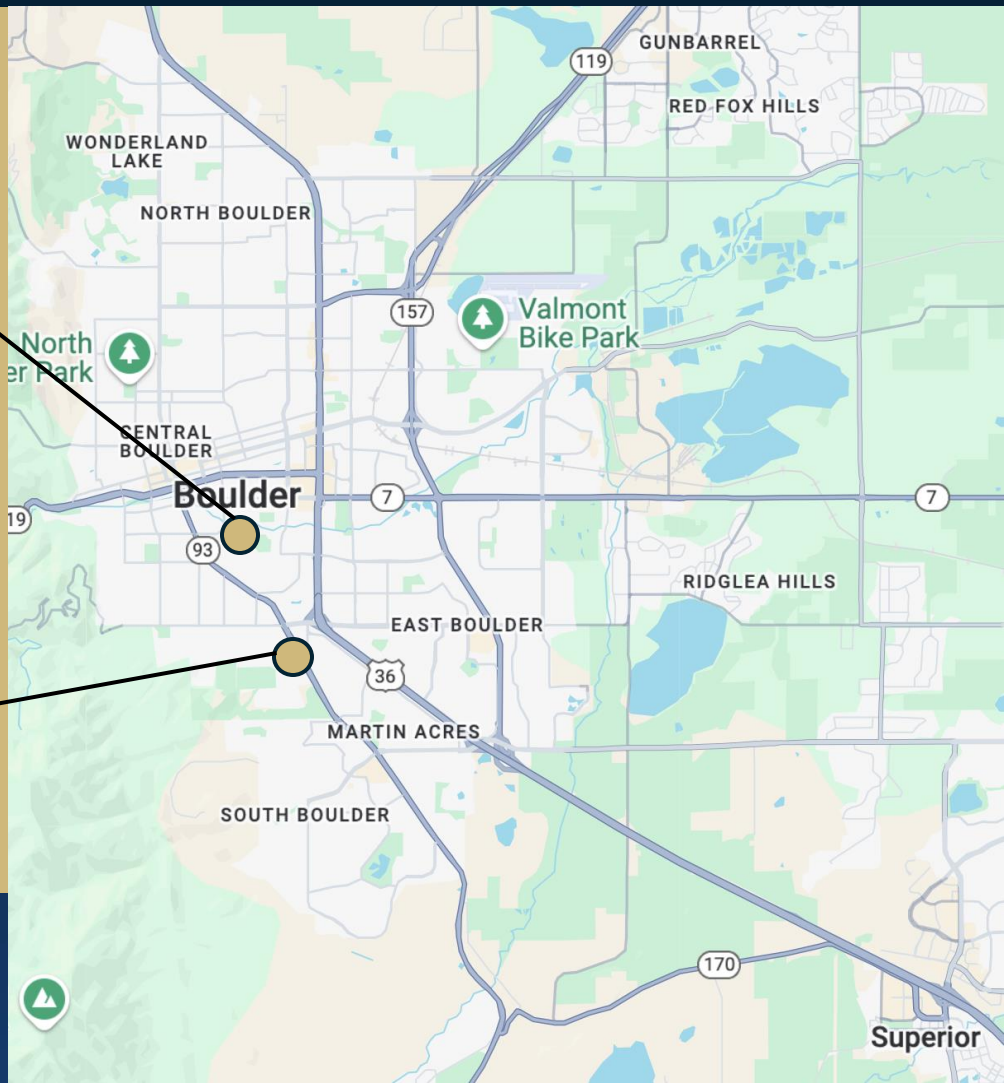
# Front Range Quantum Ecosystem:
## Research institutions / Federal Labs

JILA

NIST

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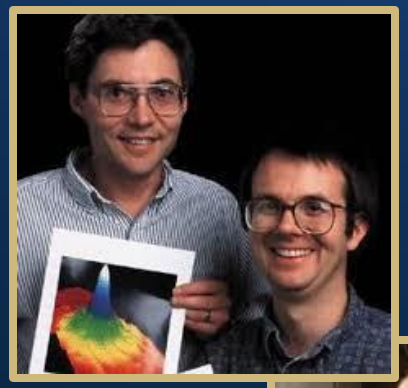
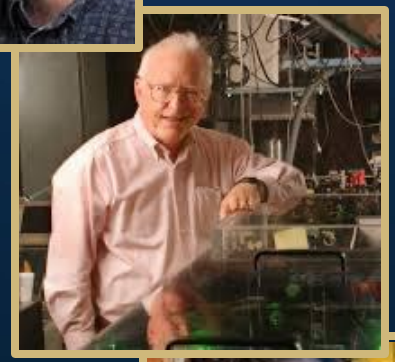
# 4 Nobel Prizes in quantum physics



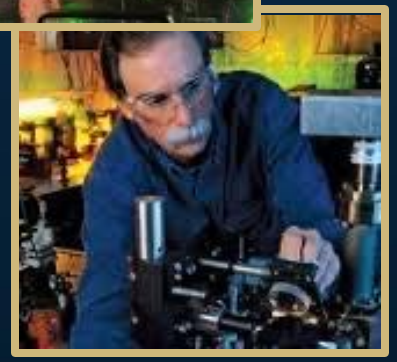
**Eric A. Cornell and Carl E. Wieman**
**The Nobel Prize in Physics 2001**

For the achievement of Bose-Einstein condensation in dilute gases of alkali atoms, and for early fundamental studies of the properties of the condensates



**John L. Hall**
**The Nobel Prize in Physics 2005**

For contributions to the development of laser-based precision spectroscopy, including the optical frequency comb technique



**David J. Wineland**
**The Nobel Prize in Physics 2012**

For ground-breaking experimental methods that enable measuring and manipulation of individual quantum systems

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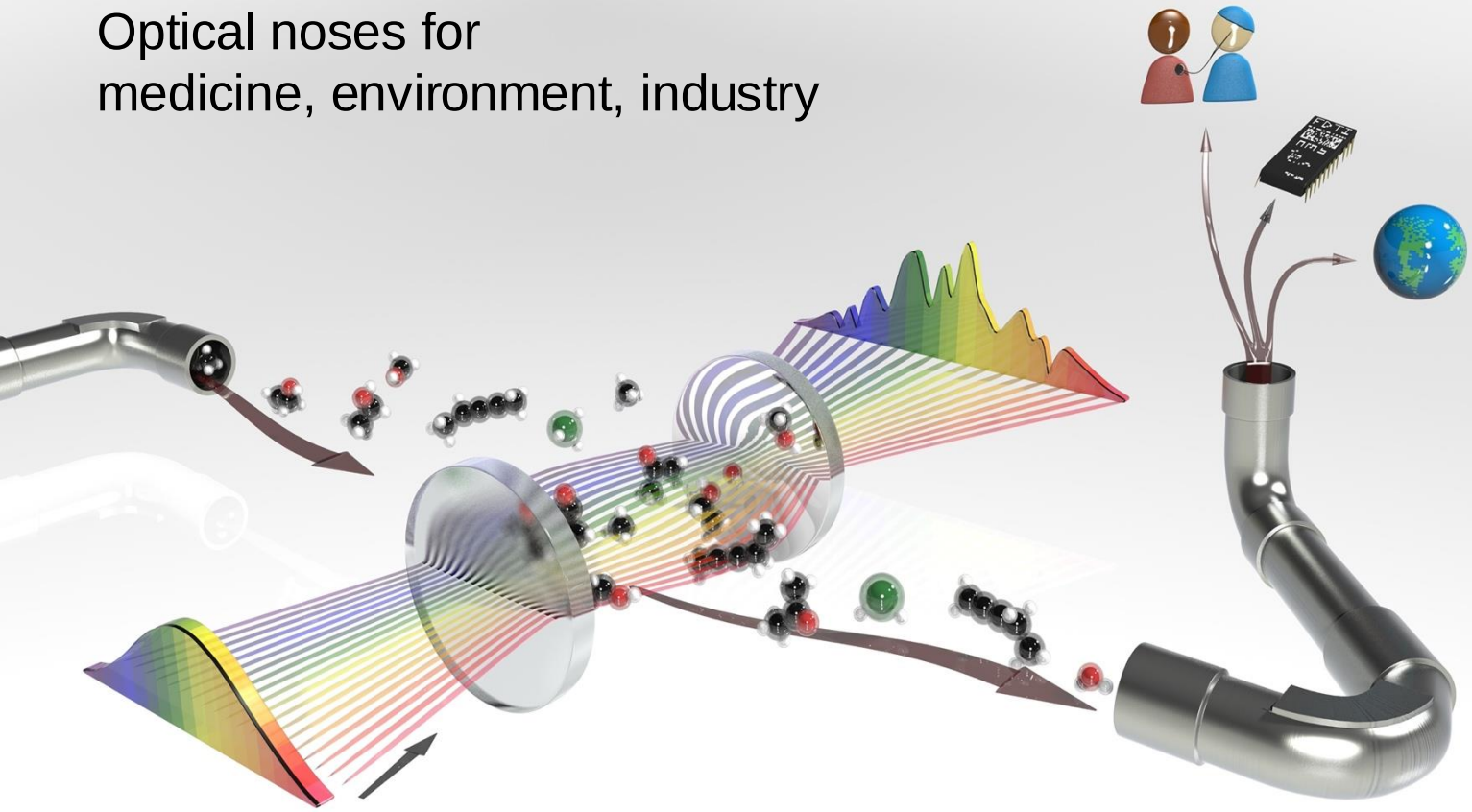
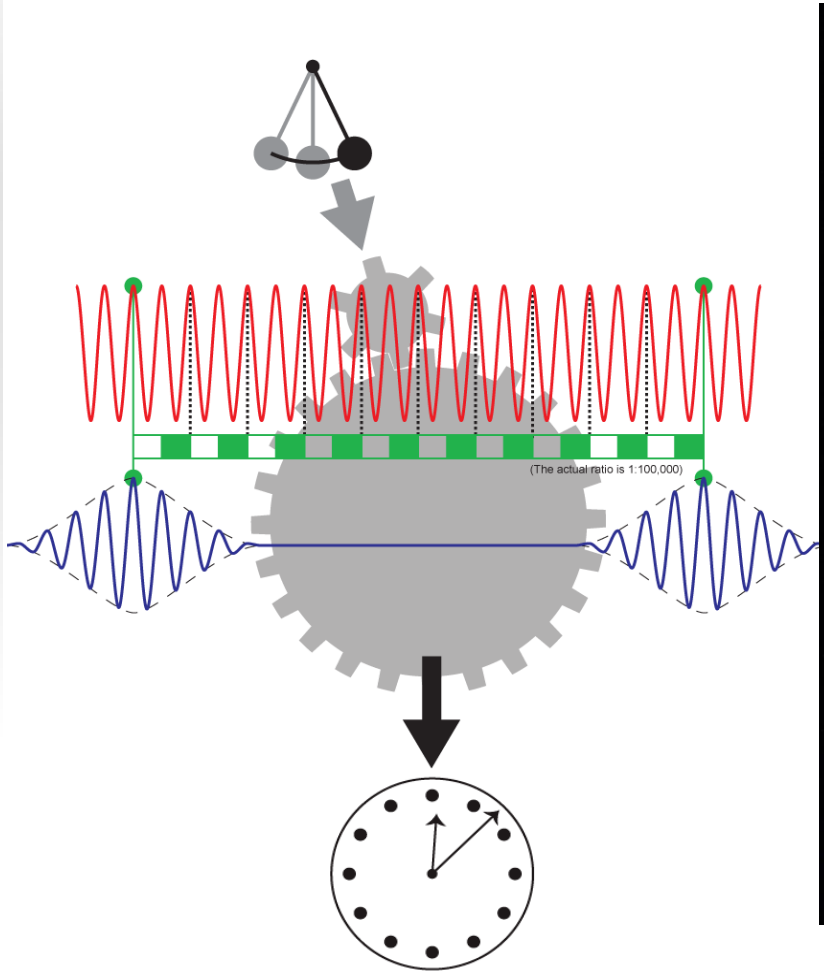
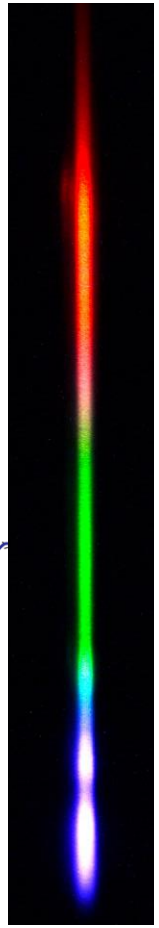
# Curiosity opens new windows & dreams

Optical noses for
medicine, environment, industry





# Leading the charge

**60+ years of scientific discovery and rapidly expanding**

## Renowned Faculty

- 4 Nobel Laureates
- 4 MacArthur Genius Fellows
- 11 National Academy Members

## Top Education Programs

- BA in Physics
- BS in Engineering Physics
- MS in Physics
- PhD in Physics
- Minor in Quantum Engineering
- Quantum Forge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## The university's comprehensive research environment:

- ✓ Accelerates fundamental advances
- ✓ Develops engineering and technical expertise
- ✓ Engages state and national leaders to cultivate a next-generation economy and workforce
- ✓ Turns groundbreaking lab discoveries into real-world impact

CUbit QUANTUM INITIATIVE

The **CUbit Quantum Initiative** is an interdisciplinary hub that works to **convene**, **coordinate** and **catalyze** quantum activities at CU Boulder.

**colorado.edu/cubit**

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# Quantum Science and Technology Centers

## Quantum Systems through Entangled Science and Engineering (Q-SEnSE)

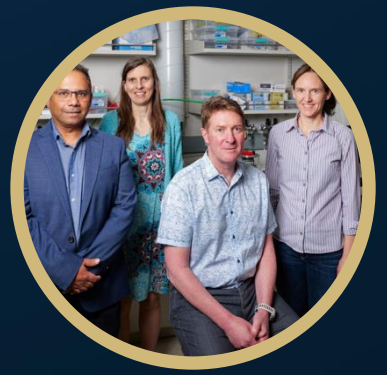
An NSF Quantum Leap Challenge Institute where collaborators explore how to advance quantum sensing

## Quantum Systems Accelerator (QSA)

A DOE-funded multiorganization initiative established to design and deliver scalable quantum computers within five years

## Quantum Engineering Initiative (QEI)

An initiative involving faculty from the College of Engineering & Applied Science and scientific staff from NIST Boulder Labs



## National Quantum Nanofab (NQN)

An open-access facility for the co-design and development of atomic-photonic devices for quantum computers, networks, atomic clocks and advanced sensors

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# Front Range Quantum Ecosystem:
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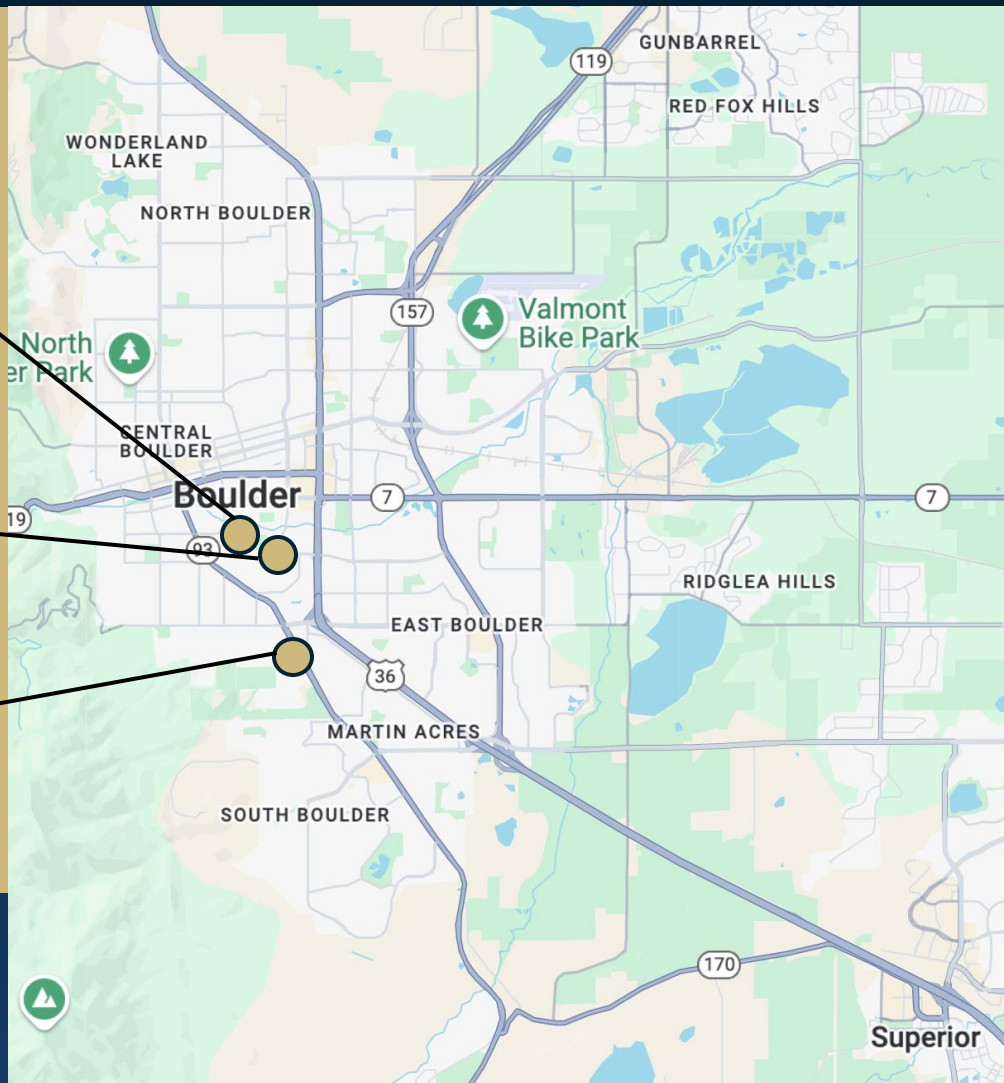
JILA

QUANTUM ENGINEERING INITIATIVE

NIST

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QUANTUM ENGINEERING INITIATIVE

## Goals:

- Creating impact for quantum science through translational research
- Building a quantum engineering workforce
- Strengthening connections to local and regional partners

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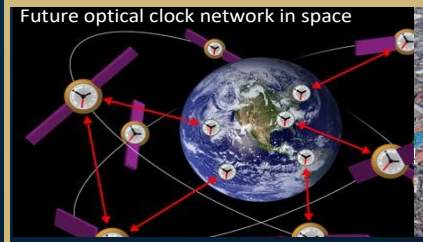
## New Facilities:

3000+ sq. ft. of remodeled lab space

## New Faculty & Collaborations:

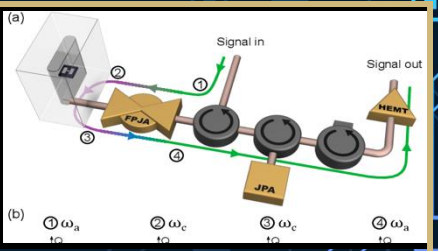
- 3 recent hires in quantum + new endowed chair
- 5 adjoint faculty appointments for NIST researchers in ECEE and other CEAS departments

## New Research:




Quantum Sensing

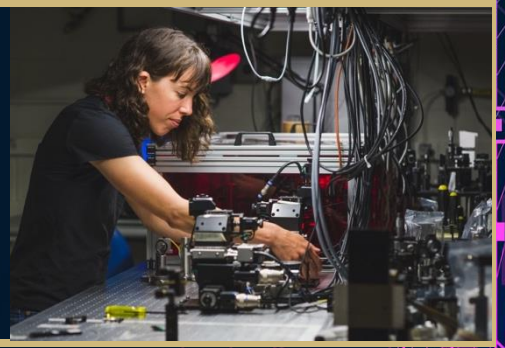

Quantum Networks




Quantum Computing

## New Curriculum:

- Quantum engineering minor
- Quantum engineering MS (coming soon)
- Connections to our quantum industry



# NSF-funded National Quantum NanoFab facility

- ✓ “Quantum machine shop” of the 21st century
- ✓ $20 million/5-year NSF grant
- ✓ 2,900 sq ft  expansion of the existing cleanroom and characterization facilities
- ✓ Quantum specialists can design and build new quantum devices
- ✓ Will transform quantum discoveries into technologies that will positively impact society, boost Colorado’s economy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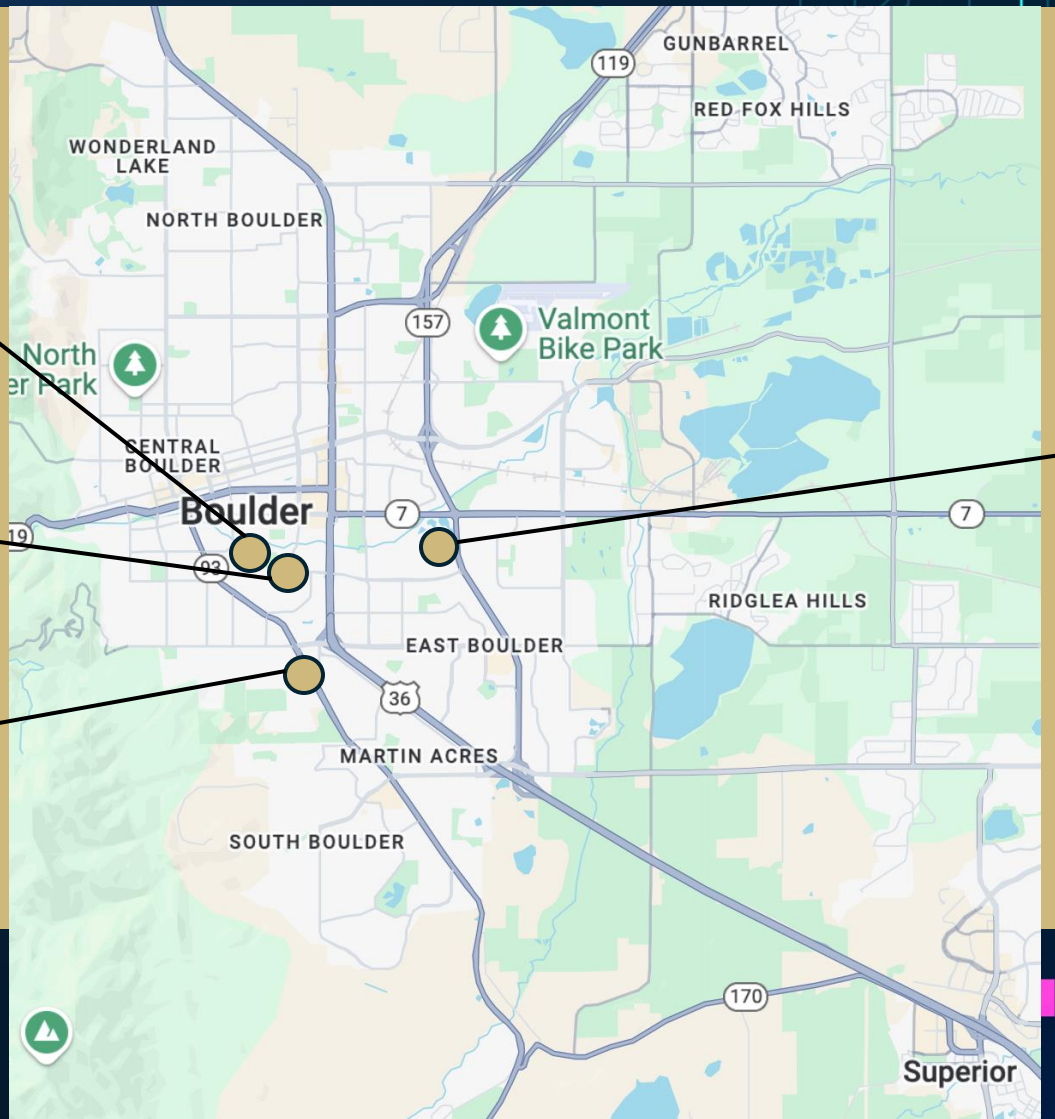


National Quantum Nanofab

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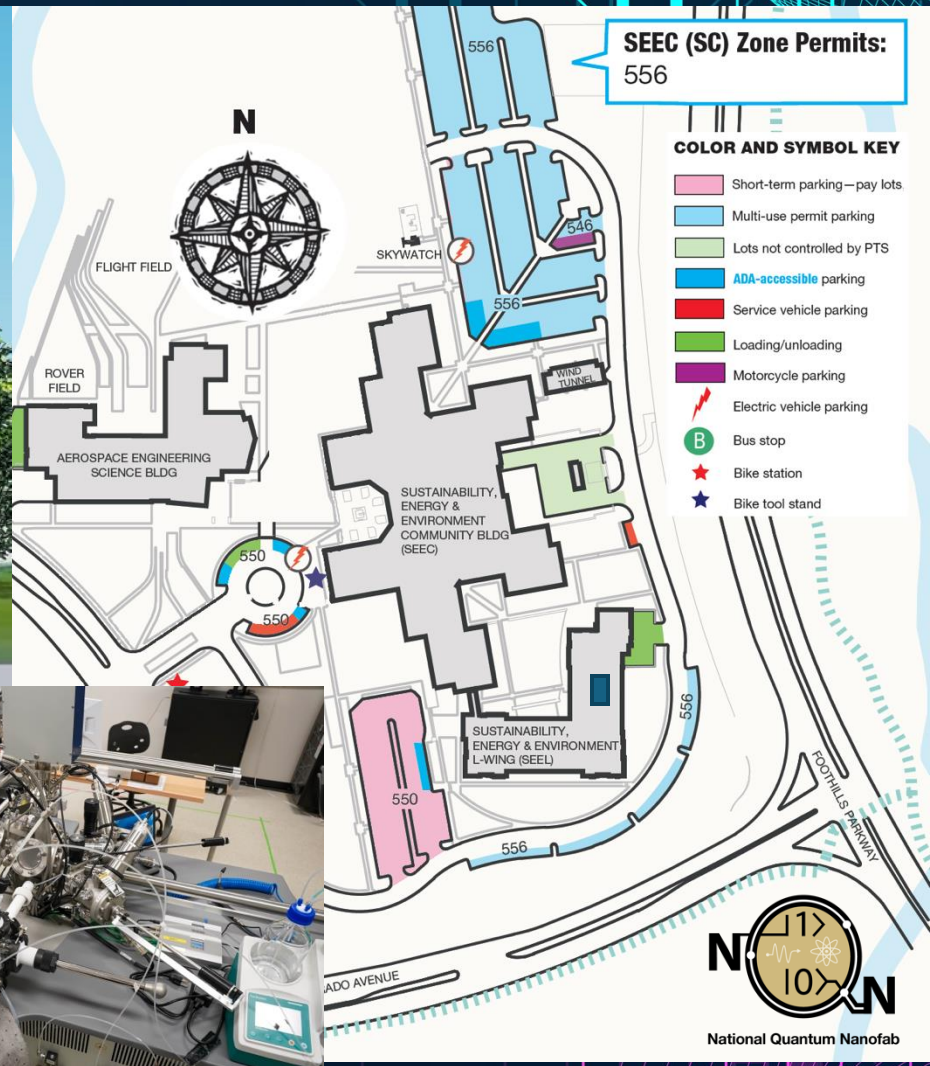
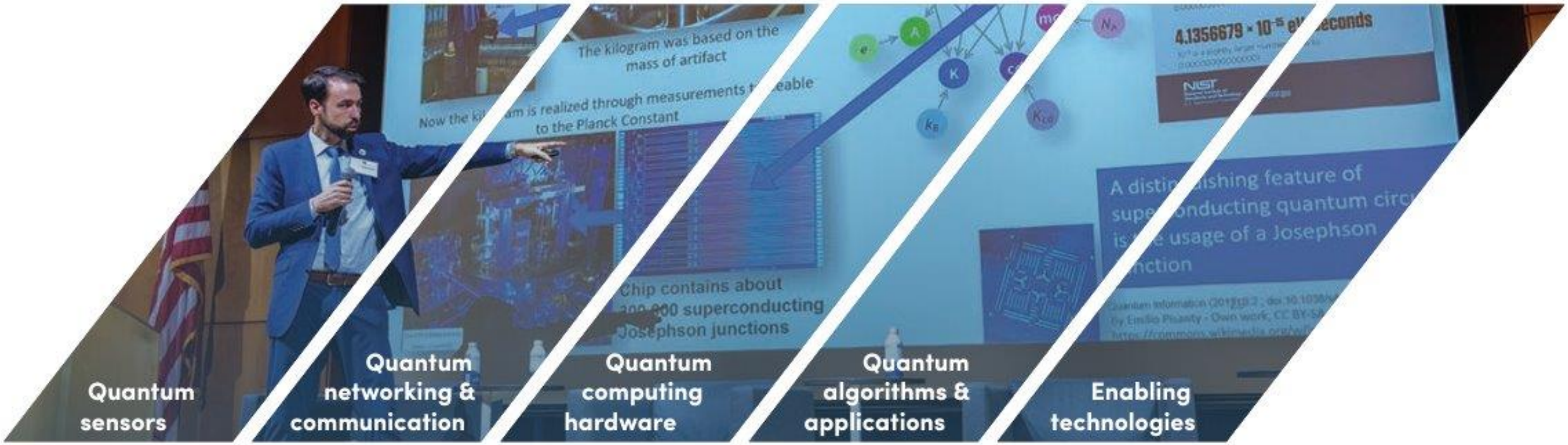
# National Quantum NanoFab location


# The quantum industry is maturing




/ OCTOBER 2023 QUANTUM WORKFORCE DEVELOPMENT CONVENING

# Front Range quantum companies

atom computing

Danaher Cryo
Pursue the near impossible

Stable Laser Systems

oxford ionics

FieldLine

Boulder

Flari Tech Inc.

mesa quantum

FormFactor™

LONGPATH TECHNOLOGIES

ICARUS QUANTUM

IQM

KMLABS inc.
LEADING IN ULTRAFAST

Infleqtion

Louisville

OCTAVE PHOTONICS

Lafayette

Xairos

Broomfield

QUANTINUUM

VEXLUM

Denver

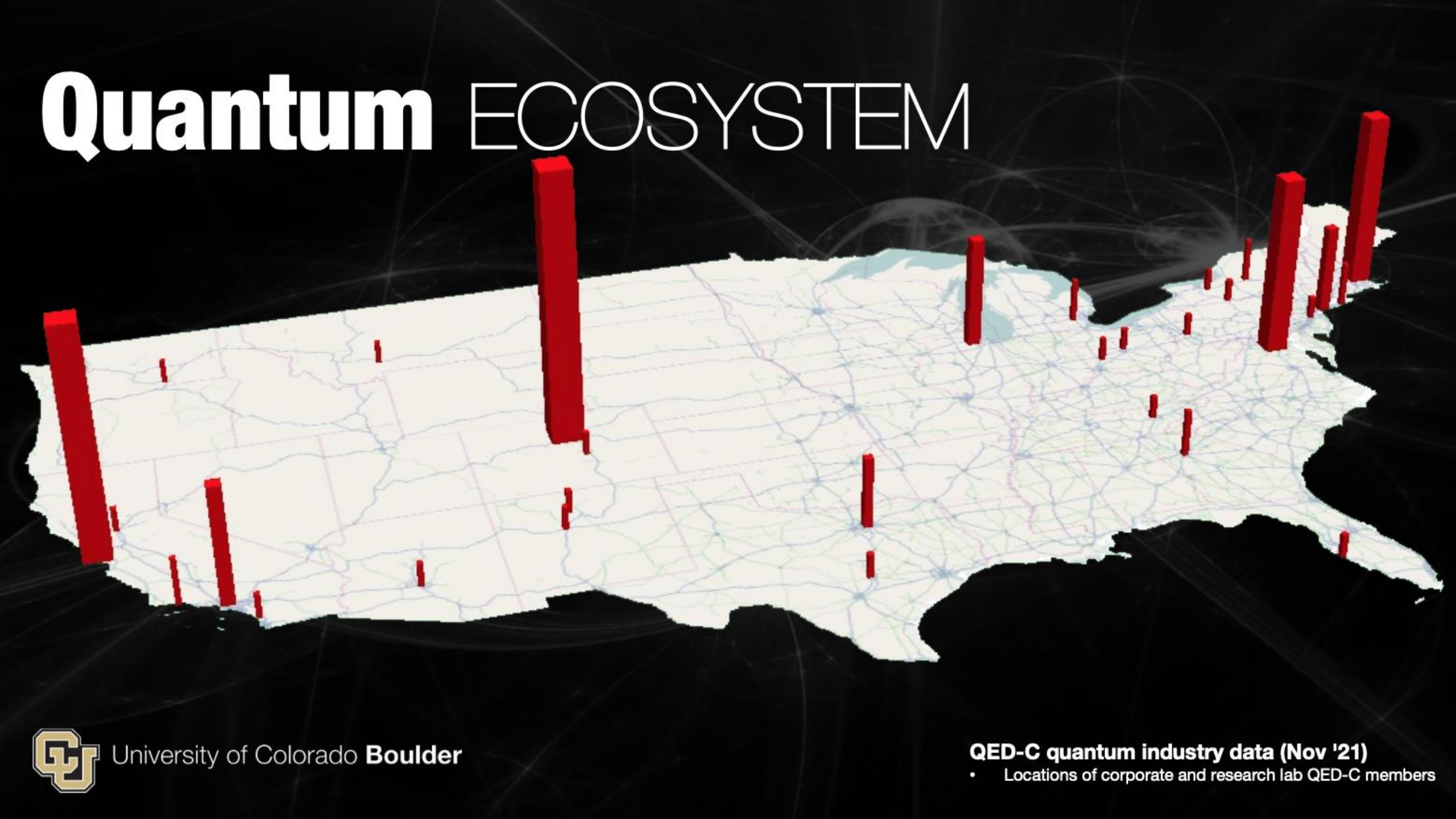
Maybell

RESILIENT ENTANGLEMENT
QUANTUM.AI.SMARTGRID

Golden

VESCENT

# **Quantum** ECOSYSTEM



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**QED-C quantum industry data (Nov '21)**

- Locations of corporate and research lab QED-C members



**An ambitious 10-year plan calls for …**

**50** launched quantum startups

**10K+** new quantum jobs

**30K+** workers trained in quantum tech

**$2B+** quantum startup funding

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# Quantum Tech Hub

Elevate Quantum

**Tech Hub Phase 2** implementation award from the Department of Commerce

**Establishes Mountain West as a global leader** for quantum innovation

Unlocks **more than $127 million** in new federal and state funding

The **Elevate Quantum consortium** brings together partners from industry, academia and federal labs

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# Colorado: The Future of Quantum is Here

- **CU Boulder, Elevate Quantum partners garner a $127M regional quantum boost**
  - ✓$40.5M TechHub EDA
  - ✓$30M State of CO Loan Guarantee (HB1325)
  - ✓$44M State of CO Tax Credits (HB1325)
  - ✓$3M State of CO Matching
  - ✓$10M State of NM


Governor Polis signs HB1325 bill strengthening quantum in Colorado at JILA

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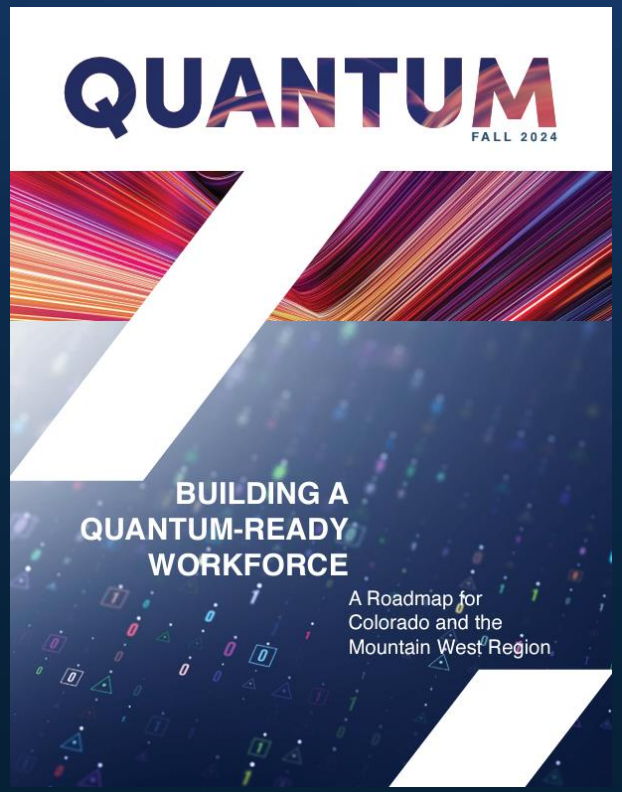
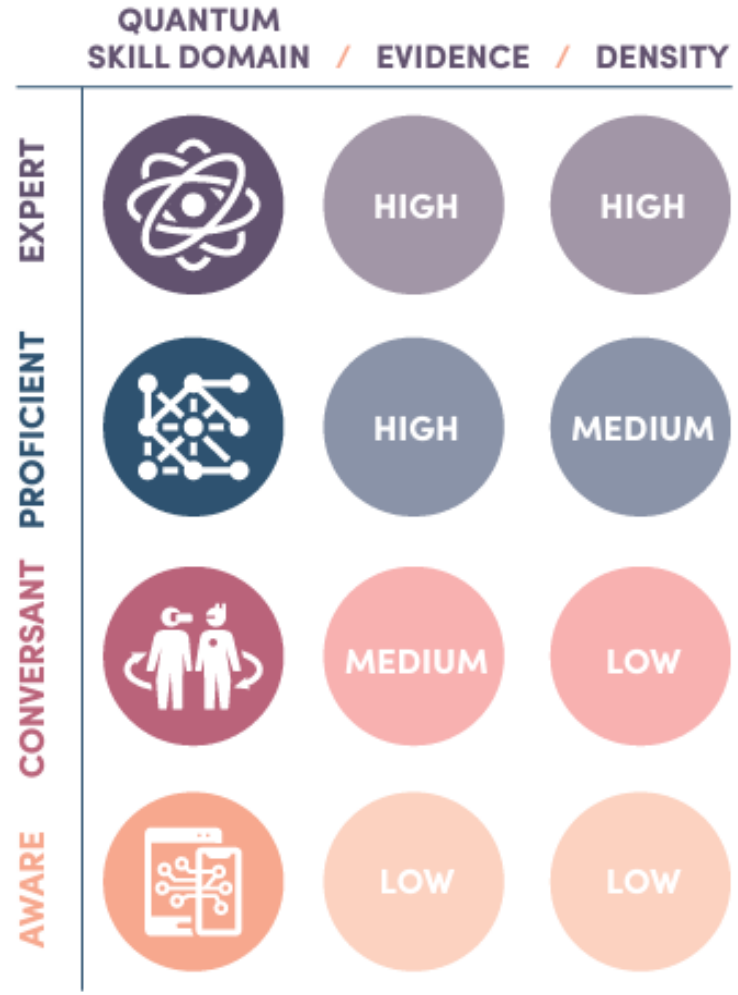
# Building a Quantum-Ready Workforce




## Ecosystem Signatories

Boulder Valley School District
Colorado Community College System
Colorado Mesa University
Colorado School of Mines
Colorado State University
Fort Lewis College
Front Range Community College
Infleqtion
Quantinuum
University of Colorado Anschutz
University of Colorado Boulder
University of Colorado Colorado Springs
University of Colorado Denver
University of Colorado System
University of Northern Colorado

**A robust quantum-ready workforce includes the following skill domains:**

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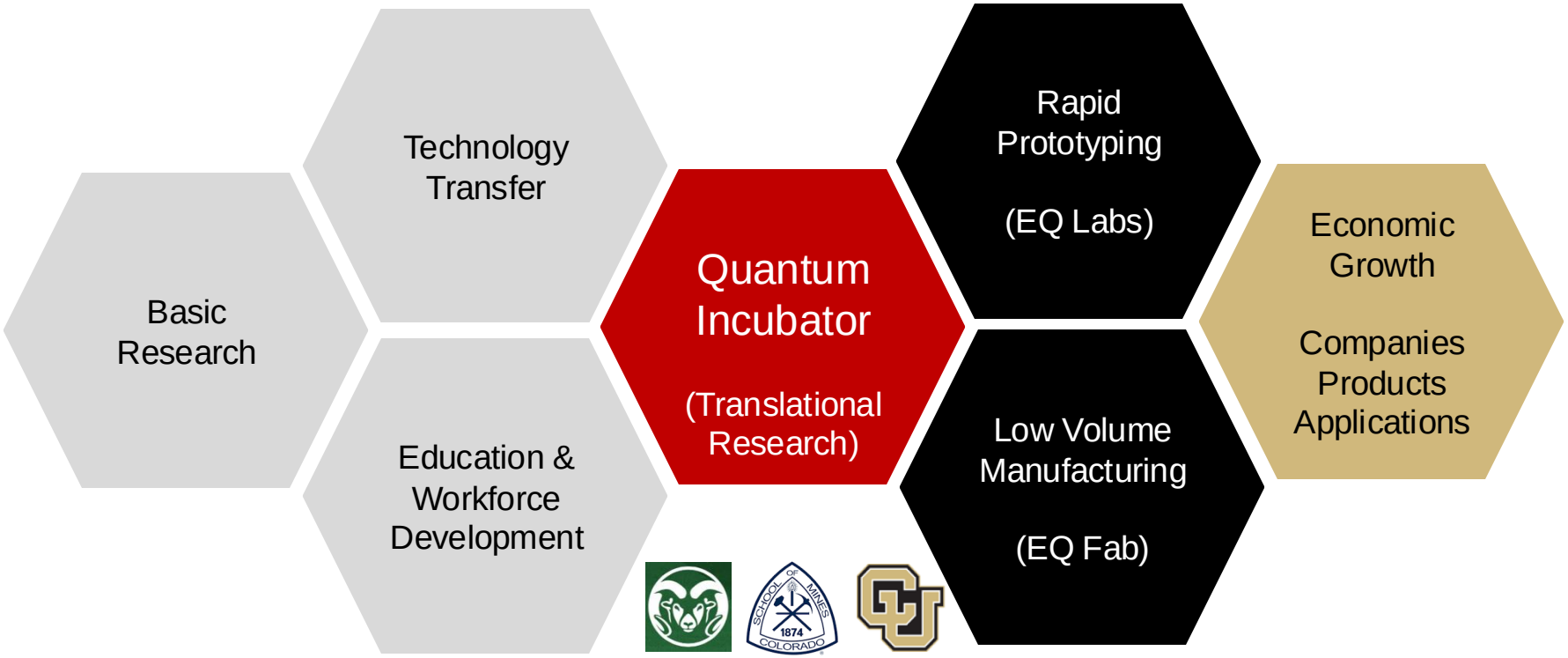
# Continuum of Quantum Assets

Elevate Quantum

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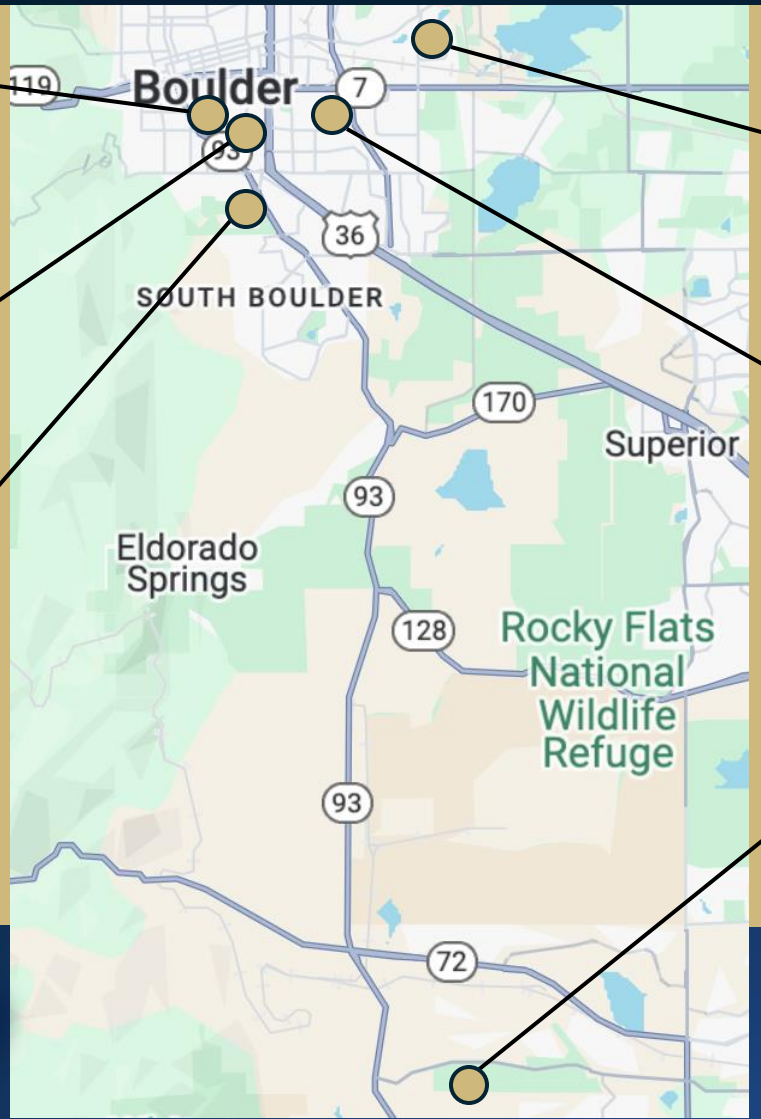


Quantum Incubator

National Quantum Nanofab

Quantum Commons @ Arvada

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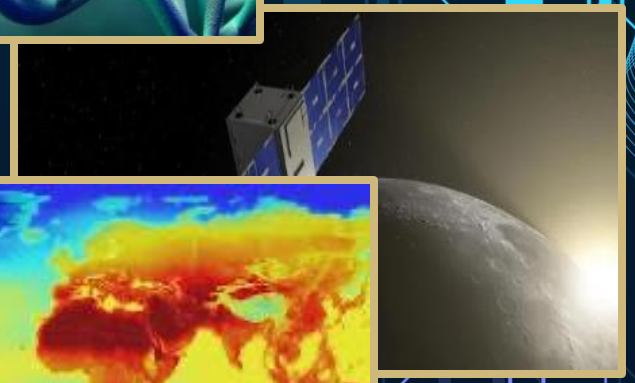
# Quantum for societal impact

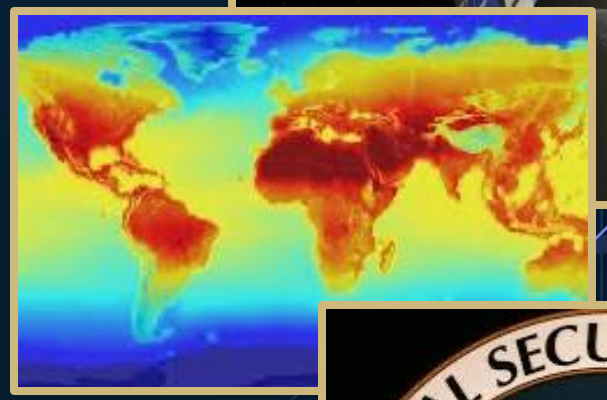
- ✓ **Biosciences & Human Health**—Disease states and diagnoses, treatment strategies, understanding healthy human and animal systems

- ✓ **Aerospace**—Astrodynamics, autonomous systems, bioastronautics, fluids/structures and materials, remote sensing, earth and space science

- ✓ **Climate and Sustainability**—The dynamical, physical and chemical processes that occur in the atmosphere and oceans

- ✓ **National Security**—Secure communications, protecting privacy; position, navigation and timing



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# Thank You!

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