QUANTUM NEW MEXICO

New Mexico is a quantum state

NM Legislative Finance Committee: Quantum Ecosystem Overview

Presented By: Dr. Ivan Deutsch, University of New Mexico
Mr. Jake Douglass, Sandia National Labs
Dr. Michael W. Rabin, Los Alamos National Lab

July 16, 2024

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NM will be tomorrow's quantum hotbed

THE QUANTUM INSIDER

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Tomorrow's quantum hotbeds? 7 U.S. cities that could incubate the next great quantum technology ecosystem

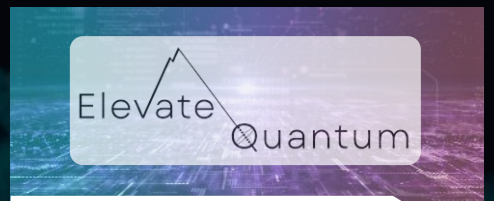
Link

Why?

- World Class Research Institutions
- Entrepreneurial Ecosystems
- Pro-Innovation Government
- Quantum Solutions for NM priorities

JANUARY, 2024

The University of New Mexico launches the Quantum New Mexico Institute



MARCH, 2024

Governor Polis and Governor Lujan Grisham urge the Department Of Commerce to fund the Regional Quantum Partnership

CNM
Central New Mexico Community College

MAY, 2024

New Mexico Community College receives federal funding to launch rare quantum learning lab and training program

July, 2024

EDA announces $504 million in funding to 12 designated tech hubs across America

What is Quantum Information Science (QIS)?

- Emerging technology that will revolutionize computing, communication and sensing:
  - Quantum computers to **solve previously unsolvable problems**
  - Break otherwise **unbreakable** cryptography and enable **provably** secure communications
  - Dramatically improve **sensing** and **detection**

The convergence two of the great scientific pillars of the 20th Century

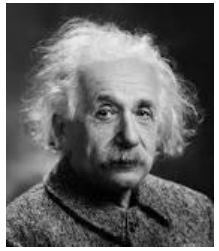
Quantum Mechanics:

The physics of the microscopic world

atom

electron

photon



Albert Einstein

QIS

Information Science:

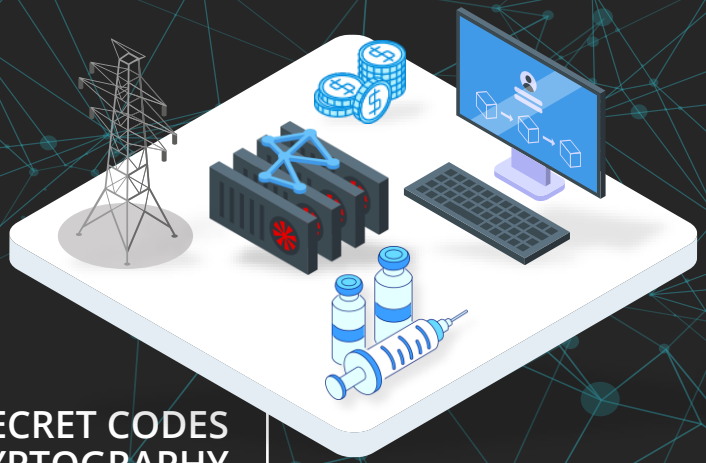
Computers & communications

Claude Shannon

Quantum will supercharge the information economy

Quantum Computing

A new computing paradigm that will help us solve problems in completely new ways



- BREAK SECRET CODES OR CRYPTOGRAPHY
- DRUG DESIGN
- OPTIMIZE THE ENERGY GRID
- FRAUD DETECTION IN FINANCIAL MARKETS

Quantum Sensing

Atomic level sensors that will greatly enhance sensing capabilities

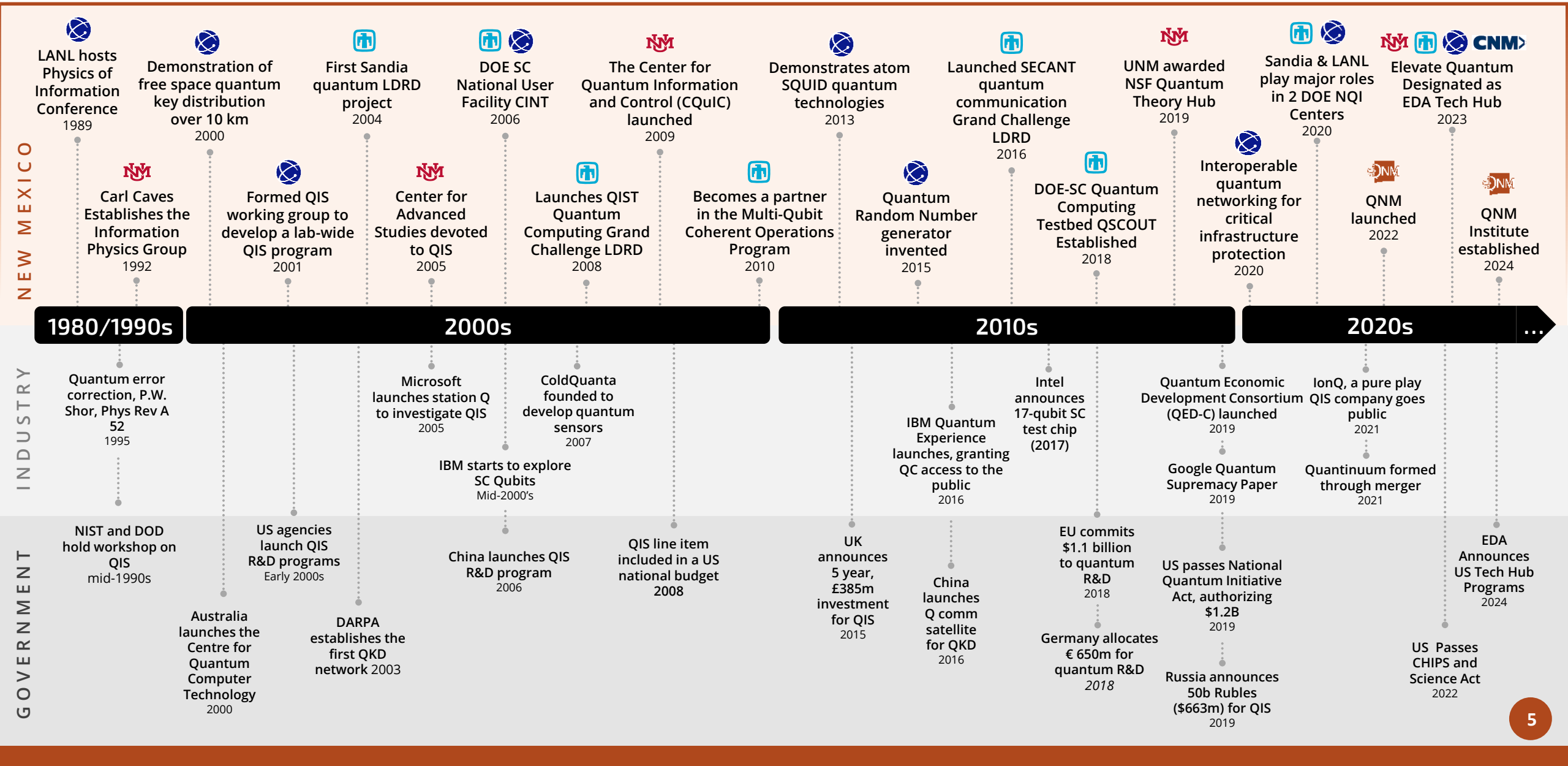
- GPS DENIED NAVIGATION
- ENHANCED BIOLOGICAL SENSORS
- MINERAL AND OIL EXPLORATION

Quantum Communication

Provable secure communication and new communication protocols

- THE QUANTUM INTERNET
- ULTRA-SECURE COMMUNICATIONS
- ENERGY EFFICIENT COMMUNICATIONS

NM has been a leader in QIS technologies for decades



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QUANTUM NEW MEXICO

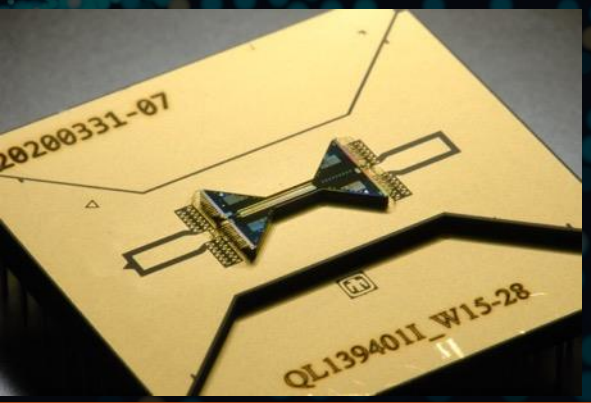
OBJECTIVE:

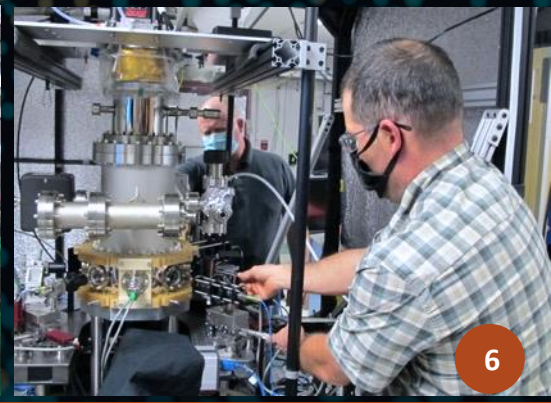
Make New Mexico a world-class quantum ecosystem by building on our historical strengths and expanding the impact of quantum technologies across the State:

- Science & Engineering R&D
- QIS Education & Workforce Development
- Industry Engagement and Entrepreneurial Support

WHY:

To create a vibrant ecosystem and cement NM as a Quantum powerhouse in this critical emerging technology area





The QNM-Institute will strengthen NM's role as a premier R&D ecosystem

QNM-I is a research & education center that will make transformative, long-lasting quantum breakthroughs through the efforts of QNM scientists, engineers, and business professionals

- Established January 2024 as a Category-III university-wide institute at UNM.
- Planned joint institute between UNM, Sandia, and LANL
- Sustain innovation cycle in R&D to catalyze and grow New Mexico's quantum economy.
- Broaden participation with new opportunities for New Mexicans across the State

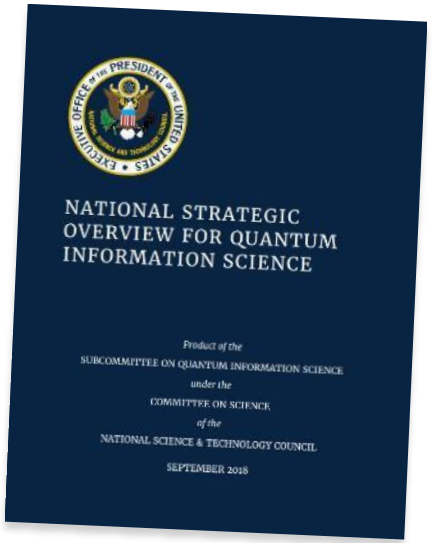
Quantum is one of the top emerging technologies in the world

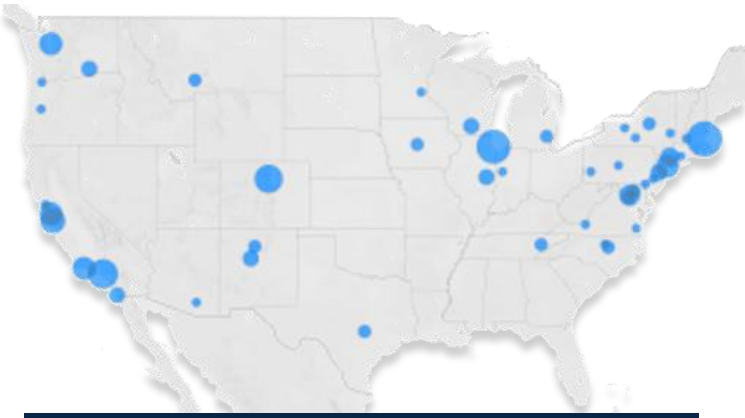
Federal legislation

- **National Quantum Initiative (NQI):** Passed in 2018, authorized $1.15B in funding to support an all of government approach to sustain national and economic security in quantum.
- **National Defense Authorization Act (NDAA):** Passed in 2019 and 2020, legislate DOD to carry out and support quantum R&D
- **CHIPS and Science Act:** Passed in 2021, authorized additional funding for quantum infrastructure, R&D, and workforce development programs

Federally supported quantum programs

- **National Science Foundation**
  - Quantum-Leap Challenge Institutes* (NM)
  - Technology, Innovation and Partnerships
- **Department of Energy**
  - NQI Science and Research Centers* (NM)
  - Office of Science - Reaching a New Energy Sciences Workforce (NM)
- **Department of Defense**
  - NDAA QIS Research Centers*
  - Defense Advanced Research Projects Agency (NM)

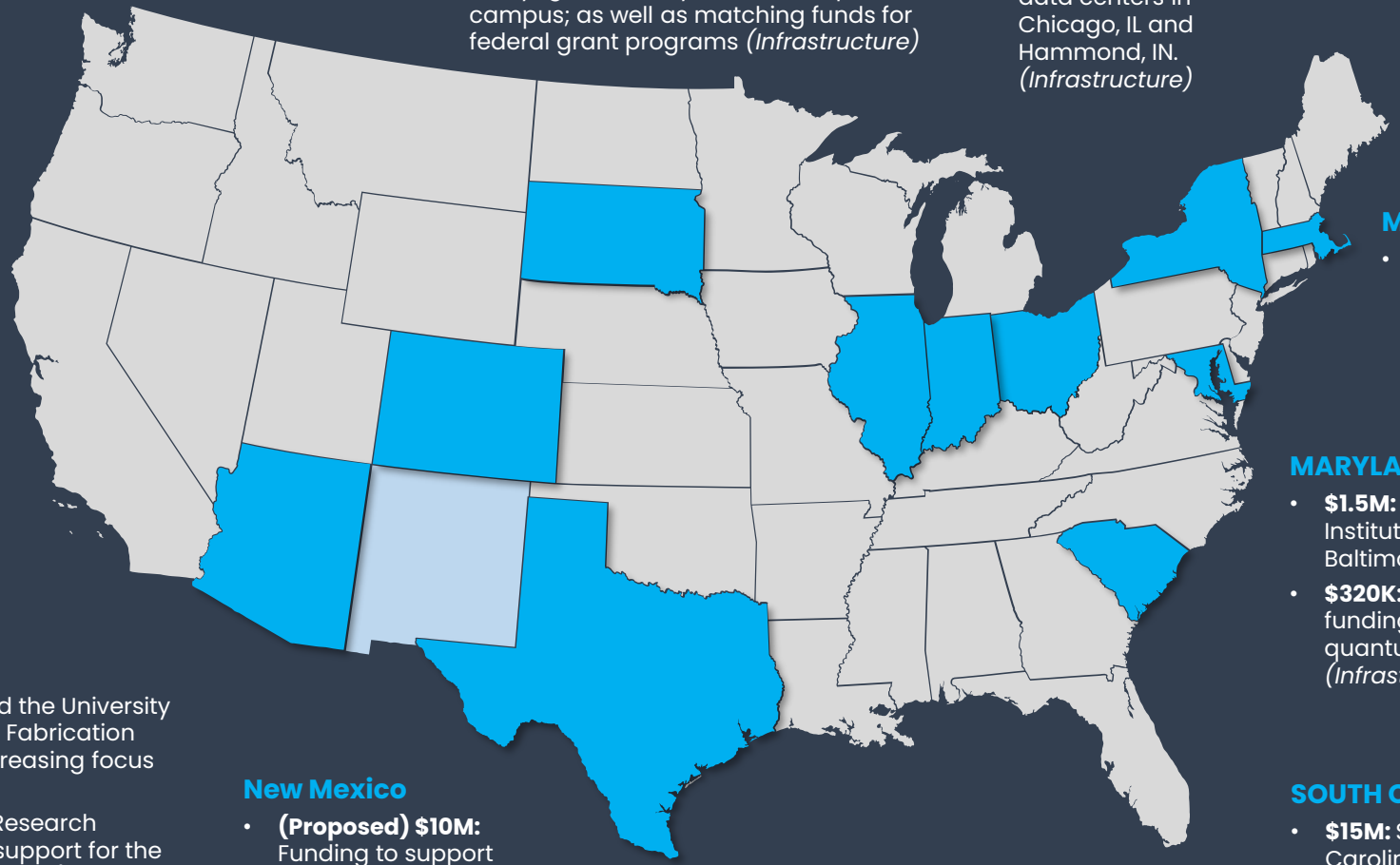




The 13 major NQI research centers and their affiliates (quantum.gov)

***Blue dots on the map correspond to "Federal Quantum Programs"**

Quantum-Specific Investments by State Governments



SOUTH DAKOTA

- **$3M:** Establishes a Center for Quantum Information Science and Technology (C-QIST) as a partnership between Dakota State University and South Dakota School of Mines and Technology *(R&D, Education, Infrastructure/Resources)*

ILLINOIS**

- **$200M:** Support for Chicago Quantum Exchange including the development of new quantum facilities at institutions in Illinois *(Infrastructure/Resources, Education)*
- **(Proposed) $500M: F**or the development of cryogenic facility and a new quantum campus; as well as matching funds for federal grant programs *(Infrastructure)*

INDIANA

- **$4M:** Grant to expand the Quantum Corridor fiber network across the state, connecting data centers in Chicago, IL and Hammond, IN. *(Infrastructure)*

OHIO

- **$7M:** Funds projects with Ohio-based partners to collaborate on a project titled "Quantum Sensor System using Rydberg Atoms" *(R&D)*
- **$750K:** Funding to build long-distance quantum networks *(Infrastructure)*

NEW YORK**

- **$6.5M** from the Long Island Investment Fund to construct a Quantum Internet Test Bed at Stony Brook U. *(R&D, Infrastructure)*

MASSACHUSETTS

- **$1M:** Supports access to the University of Mass. Boston and Western New England University to help tech companies test their quantum computer components in cryogenic test facilities *(Resources)*

COLORADO**

- **$74M** incentive package to support Economic Development Administration Tech Hub (Workforce, Economic Development)
- **$3M** in earmarked funds to support Tech Hub grant winners
- **$1.5M** for the CUbit Quantum Initiative *(Workforce)*

MARYLAND**

- **$1.5M:** Seed funding for a Quantum Science Institute at the University of Maryland, Baltimore County *(R&D, Education)*
- **$320K:** Build Our Future Grant Pilot Program funding small-scale efforts to expand quantum facilities and education efforts *(Infrastructure, Education)*

ARIZONA**

- **$36M:** Funding to expand the University of Arizona's Micro/Nano Fabrication Center which has an increasing focus on quantum *(R&D)*
- State of AZ Technology Research Initiative Fund provides support for the ASU Quantum Collaborative *(R&D, Education, Economic Development)*

New Mexico

- **(Proposed) $10M:** Funding to support Economic Development Administration Tech Hub (Workforce, Economic Development)

TEXAS**

- **$200M:** The Texas CHIPS Act will provide Texas A&M University $200M to build fabs for quantum and AI chip fabrication *(Infrastructure)*

SOUTH CAROLINA

- **$15M:** Support for the South Carolina Quantum Association to bolster quantum education *(Education)*

****Integrated with and supported by an ecosystem of local players and investments**

Private investment in quantum tech has been significant over the past 5 years

- Quantum market is estimated to be ~$106B by 2040*
- Economic impact of quantum is projected to exceed $1.3T by 2035 *

- In 2022, **$2.35B** was raised for quantum technology startups
- With economic changes there was a downshift in 2023, but there are still strong trends for the QIS industry overall

Quantum computing
- 261 start-ups
- $6.7 billion investment

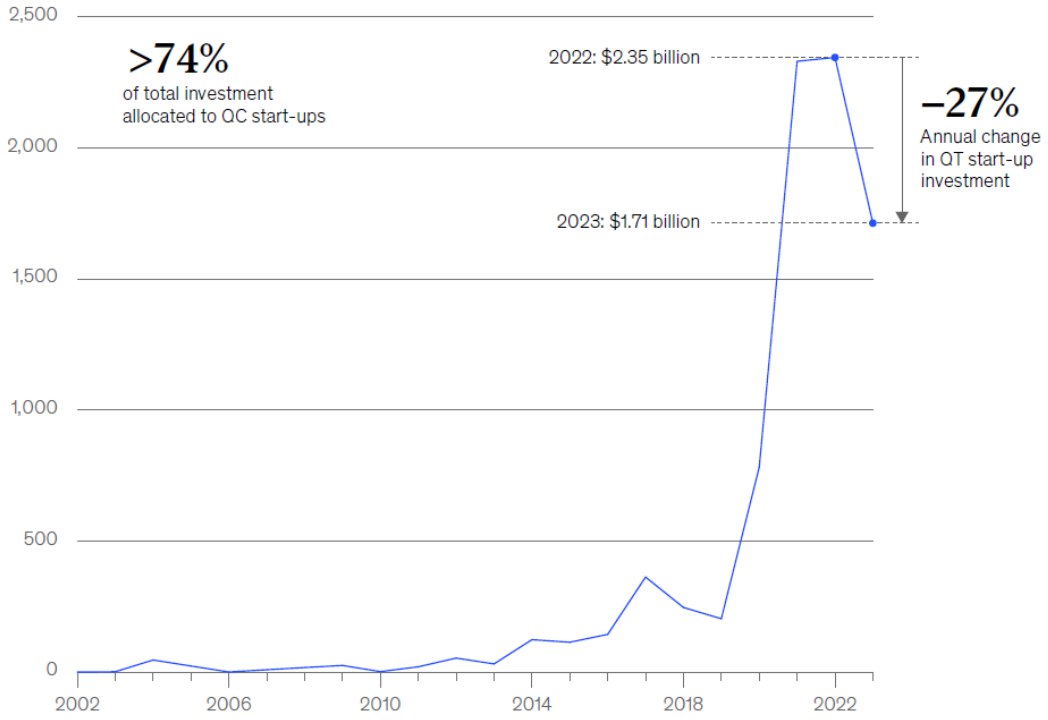
Quantum communication
- 96 start-ups
- $1.2 billion investment

Quantum sensing
- 48 start-ups
- $0.7 billion investment

Companies pursuing two or more quantum technologies simultaneously: 38

Private investments in quantum technology*

Annual raised start-up investment,[1] $ million



[1]Based on public investment data recorded in PitchBook; actual investment is likely higher.
Source: PitchBook

Information reported in McKinsey Digital titled "Steady progress in approaching the quantum advantage", April 2024.

QIS workforce demand is high

- There are significant workforce growth opportunities in the region across multiple disciplines and from diverse backgrounds
  - Currently there is only one qualified candidate for every three quantum job openings
  - Today, half of quantum jobs don't require an advanced degree

- **Future outlook**
  - Jobs in the Mountain West are projected to grow significantly by 2035*
  - Additional jobs will emerge that we didn't expect across the full quantum stack
  - Continued shift towards the ability to enter the field without an advanced degree
  - Expanding need for business acumen and support for QIS industry

Source: Delivery Associates, Lightcast, Quantum Computing Report, Expert Interviews.

NM QIS workforce development across the spectrum

- QCaMP has introduced quantum to hundreds of high school teachers and students
- Launching a **first of its kind** quantum technician training program led by CNM
- Summer schools and internships have engaged hundreds of undergrad & graduate students

***Traditional higher education pathways**: UNM, NMSU, NMT, CNM*

Highschool | Associates & Certificates | Bachelors | Graduate | Postdoc

Additional QIS workforce opportunities

QU-REACH
Quantum Undergraduate Research Experience At CHTM

QPAQT
Quantum Photonics and Quantum Tech Graduate program

QNM Quantum Fellowships

Gil Herrera Postdoctoral Fellowship in QIS

Qu-Drive: Quantum material summer program

Quantum Computing Summer School Fellowships

QIS Internship Programs

QCaMP High school teacher & student camps

Quantum Learning Lab (QuLL)
Hands on training for NM students

Elevate Quantum Workforce Collaborative (EQWC) - Full spectrum workforce collaborative

Industry engagement is critical for QNM

- Drive economic development by supporting **entrepreneurs** and through **strategic industry partnerships**
- Expand capacity by supporting large-scale **quantum infrastructure** initiatives and projects
- Ensure **equitable access** to information and new technologies through intentional community engagement and outreach
- Capitalize on the **Elevate Quantum** Economic Development Administration (EDA) Tech Hub funding to establish a quantum industry anchor tenant in NM for a potential **multitrillion-dollar** industry

"As the established leader in quantum computing, Quantinuum finds a perfect match in New Mexico. The state offers a vibrant technology ecosystem and a talented workforce that fits naturally with our needs," said Dr Rajeeb Hazra, CEO of Quantinuum. "New Mexico is a key collaborator and leader in developing integrated photonics for ion traps, with a community that is among the most advanced in quantum algorithms development and error correction techniques. The partnership between Quantinuum and New Mexico will further strengthen the Mountain West's position as a leader of this revolutionary technology."

Elevate Quantum EDA Tech Hub

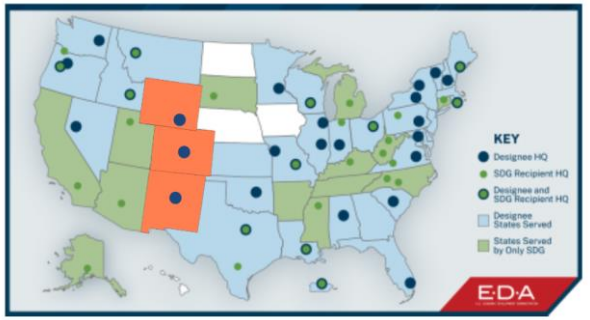
Keep the Mountain West on top for the quantum century

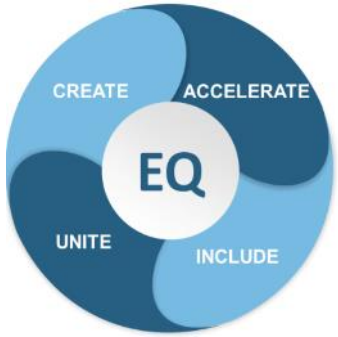
- **An EDA Technology and Innovation Hub**
  - Elevate Quantum is a Mountain West regional tech hub led by Colorado and made up of 120+ partners focused on advancing Quantum Technologies
- **Selected as 1 of 12 Phase 2 participants, unlocking $127M of funding for the region:**
  - $40.5M in EDA funding, $10M from State of NM*, and $76M in State of CO State incentives
- **Established the Mountain West as THE Quantum Tech Hub for the United States**
  - We beat out Chicago despite the $500M investment by IL
  - May unlock future funding opportunities from EDA
- **NM will play key roles across the project**
  - NM will establish a lab/fab aimed at accelerating quantum tech commercialization
  - NM will co-lead workforce development programming
- **Wouldn't have been possible without support from the State of NM**

**Subject to appropriation and approval*

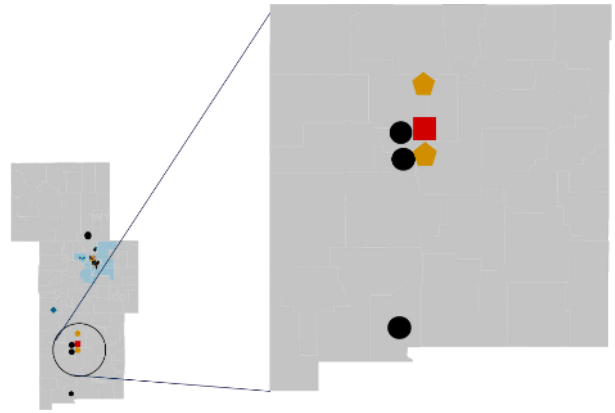
Elevate Quantum

Designated Tech Hubs Map





EQ Partners	
Category	No.
Industry	24
Higher Education	32
Economic Development	25
Labor, workforce training	17
State, local, tribal gov	10
Federal Labs	5
Other	3
Total	116



Los Alamos National Laboratory EST. 1943 · Sandia National Laboratories · New Mexico EPSCoR · iexplora! · NMSU · CNM Central New Mexico Community College · NM STATE · STAR CRYOELECTRONICS · EDD Economic Development Department

The time is now to establish a NM Quantum Campus

We have the opportunity to capitalize on the momentum of recent success, establish a new high value sector for NM, and create a competitive advantage that unlocks future funding streams

Why is this critical for our success ?

Complete the NM translational ecosystem

- House the **QNM Institute**
- Serve as the convener for **quantum ecosystem development** across NM
- Provide **high value jobs** for communities across NM

Unified location for QIS workforce programming

- Leverage **leading edge** quantum education programs pioneered in NM
- Home to **advanced facilities** for hands on workforce development programs across the educational spectrum

Sustainable global competitive advantage

- Expands access to the **massive national security markets** and customers in NM
- Unlocks world leading expertise and capabilities in **packaging and heterogeneous integrations**

Enables entrepreneurial and industry growth

- **Pathfinding QIS user facility** for NM will lower barriers of entry to QIS and help de-risk QIS technologies
- Provide a platform to **deploy entrepreneurial programs**
- Build a robust **industry presence** in NM

What is next for QNM?

Launch the QNM Institute

- Finalize partnerships and realize the QNM Institute vision
- Chart a pathway to establish a NM Quantum Campus

Expand the industrial base in NM

- Bring the community together to create a supportive ecosystem for industrial partners
- Expand the industry base in the state through targeted engagements

Build a diverse and inclusive local quantum workforce

- Scale our current programs and expand partnerships
- Support new job creation and training programs for communities across NM

Establish NM as a leader in QIS across the world

- Deliver on the Elevate Quantum EDA Tech Hub commitments
- Pursue additional opportunities through the NSF Regional Innovation Engines

Capitalize on our foundation and realize New Mexico's potential as an economic leader in quantum technology for decades to come

QUANTUM NEW MEXICO

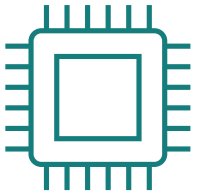
New Mexico is a Quantum State


QNM
QUANTUM NEW MEXICO
APPENDICES

We are exploring what quantum can do

Energy

Mineral & oil exploration, oil well optimization, energy distribution, battery & solar cell design

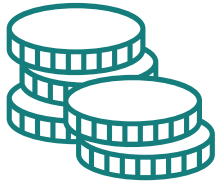


Information Technology

Cybersecurity, machine learning, AI, search, software verification & validation

Chemistry & Pharma

Catalyst & enzyme design, drug discovery, bioinformatics, genomics, patent diagnosis, improved MRI



Finance

Portfolio optimization, asset pricing, risk analysis, trading strategies, fraud detection, market simulation

Defense

Inertial guidance, radar, imaging, cyber, autonomy, command & control

Other Industry

Materials, OLEDs, composites, logistics, scheduling, semiconductor device design, chip layout

Quantum technologies are still under development, but some applications are here now

Quantum New Mexico

Bringing stakeholders together to build the QIS ecosystem in NM

QNM THRUST AREAS	Science & Engineering R&D	QIS Education & Workforce	Economic Development
FOCUS AREAS	▪ Broaden basic and applied research programs ▪ Support QNM partner R&D priorities and strategies ▪ Partner to advance QIS technology advancement	▪ Develop new QIS pathways across all education levels ▪ Support growing QIS academic programs ▪ Identify opportunities for Internships, fellowships, and apprenticeships	▪ Build QIS Infrastructure ▪ Support QIS industry engagements in NM ▪ Establish unified economic development strategy ▪ Create resource for QIS business & policy coordination
STATEWIDE IMPACT	• Support quantum program development at UNM, NMSU, NMT, NTU, CNM & More • Maximize program impact at Sandia, LANL, and AFRL • Expand QIS R&D to new partners in the ecosystem	• Support university capacity building efforts • Expand K-career workforce development programs • Expand QIS jobs via expanding partnerships with industry and national lab partners	• Collaborate with quantum computing and industry partners • Work with NMEDD on statewide QIS coordination • Work with tech transfer offices to use state of NM and lab-led partnership programs including NMSBA and TRGR

Quantum, Computing, Mathematics, & Physics Summer Camp

WHAT IS QCaMP?

- Summer camps that introduce high school teachers and students to quantum technologies

2024 Camps

Teachers: June 10-12, 2024

Students: July 1–26, 2024

QCaMP GOALS AND GUIDING PRINCIPLES

Goal: Serve as a launching point for communities to get engaged in quantum

Goal: Break down barriers. Stipends for all. No prerequisites. Hands-on activities throughout.

Goal: Give teachers tools to introduce quantum topics to their students, allowing us to **reach more students from underrepresented communities**.

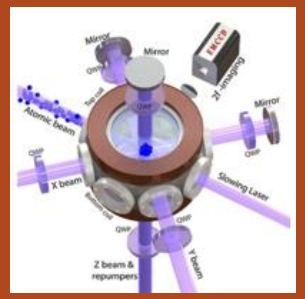
Goal: Provide exposure to and get students excited about a career in quantum

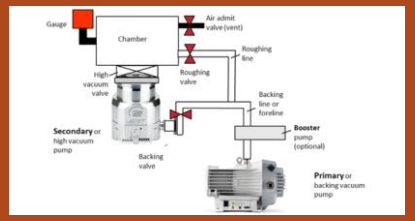
- Sandia & LBNL participate in ORISE's JSTI program (2021) 10 Students
- QCaMP team creates virtual pilot program (2022) 32 Students & 20 Teachers
- QCaMP team expands to a hybrid program (2023) 42 Students & 16 Teachers
- 2024 Teacher QCaMP expands to other regions 83 teachers & participants
- 2024 Student QCaMP expands to 4 weeks with DOE grant 43 Students

2021: 10 Participants (cumulative) → **2024: 200+ Participants (cumulative)**

Quantum Learning Lab (QuLL)

- Led by CNM and Sandia National Labs
- Training lab for Quantum Workforce Development located at the FUSE Makerspace in downtown ABQ
- Provide hands-on quantum experience for University and Community College students across the state
- Enhance knowledge of early-stage researchers and entrepreneurs





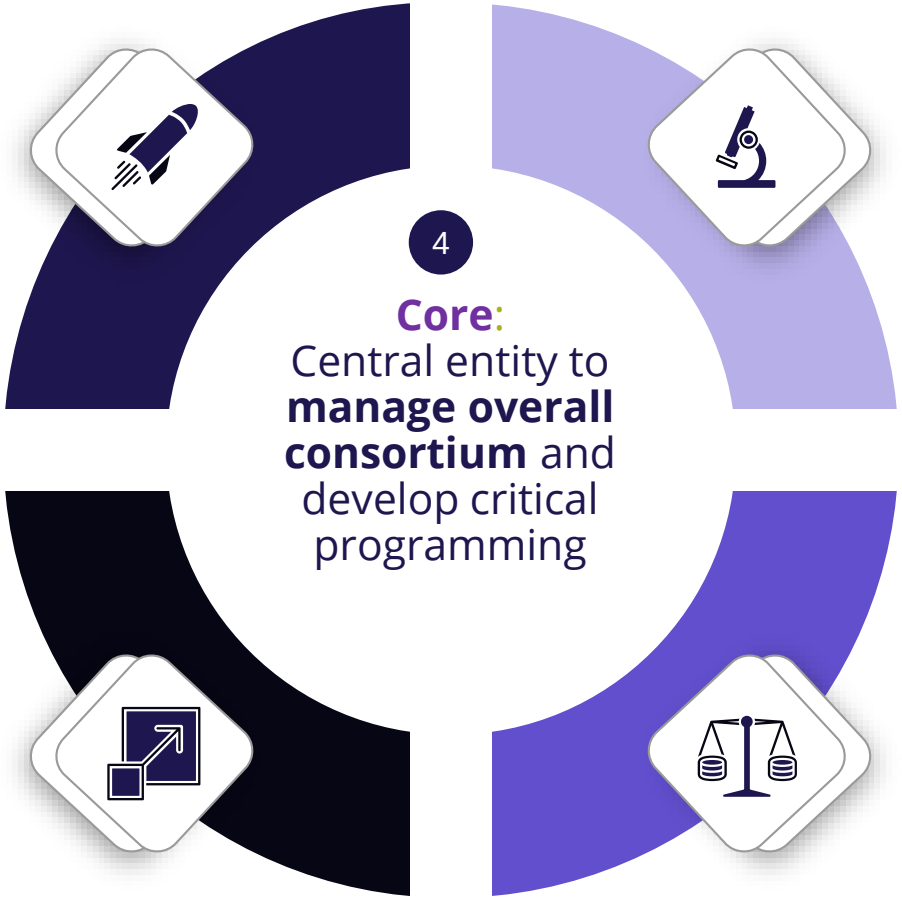
- Immersive Hands-On Workforce Training (10-weeks)
  - Built on the success of CNM Ingenuity's Deep Dive Bootcamps
  - No prior math/science needed
- Focus
  - Optics and Photonics
  - Ultra-High Vacuum Systems
  - Quantum Phenomenon
  - Problem Solving, Documentation, Math, Statistics

DEEP DIVE
powered by CNM Ingenuity

- Skills applicable to adjacent industries
  - Semiconductor, Solar Cell, Opto-Electronic Manufacturing

Elevate Quantum focused on four key projects to support a highly integrated ecosystem

1 **Create:** An **open-access commercial quantum fab/lab** providing outreach and access to hardware, software, compute, and expertise



2a **ACCELERATE (Launch):** A E2E set of **accelerator programs from TTO, studio, and accelerator** designed to commercialize technology and form new successful quantum businesses in CO

3 **Include:** An **industry-informed, accessible, skilled, and inclusive quantum innovation and education ecosystem** that prioritizes activated diversity and equity within the quantum workforce

2b **ACCELERATE (Scale):** A program to facilitate scaleups by offering **loan guarantees and multi-dimensional support** to grow partners