The Quantum Industry Needs a Skilled Workforce – And Soon

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MNTeSIG
St Louis, MO
July 23, 2019

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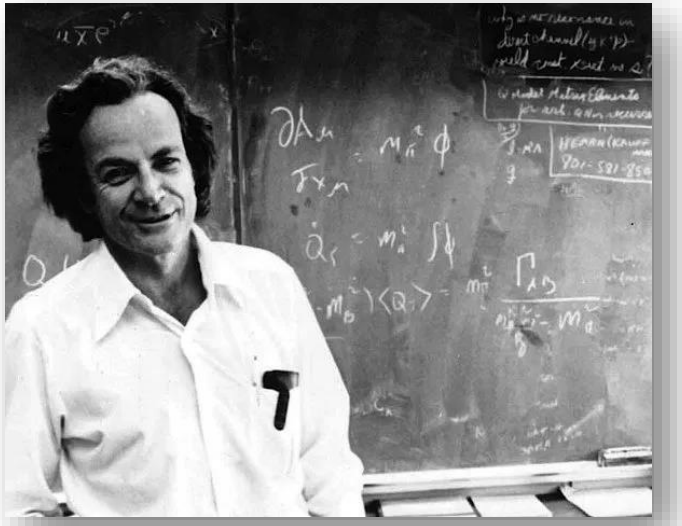
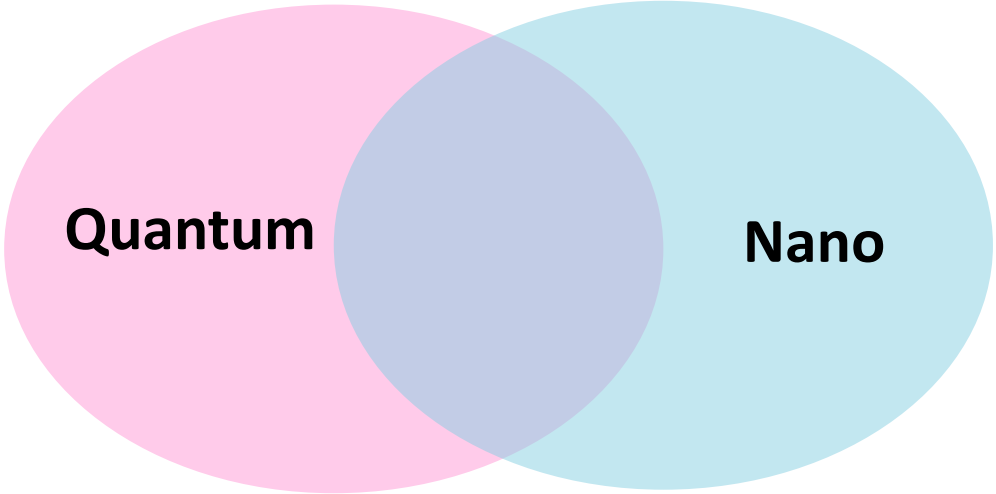
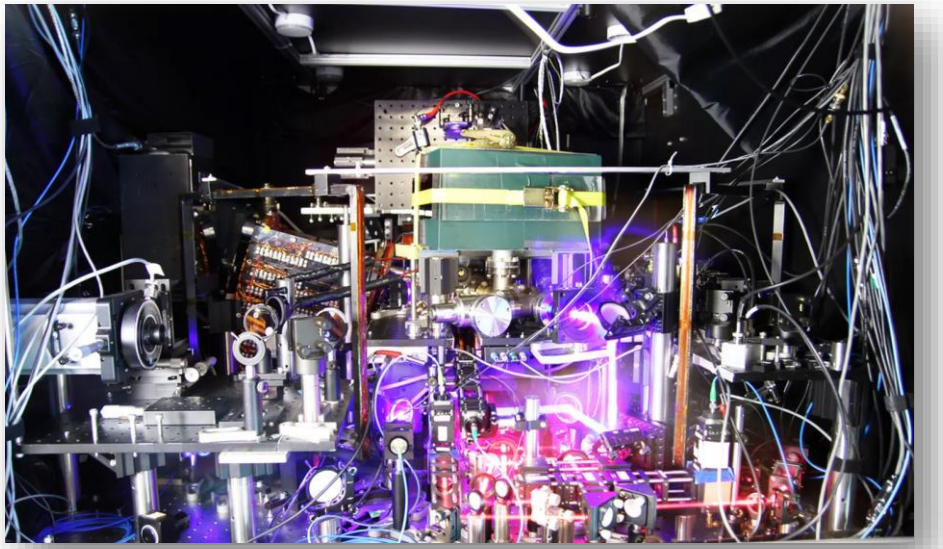
What is quantum technology?



- Based on “non-classical” phenomena that occur at small length scales
  - Quantized states
  - Tunneling
  - Particle-wave duality
  - Probability/uncertainty
  - Superposition
  - Entanglement



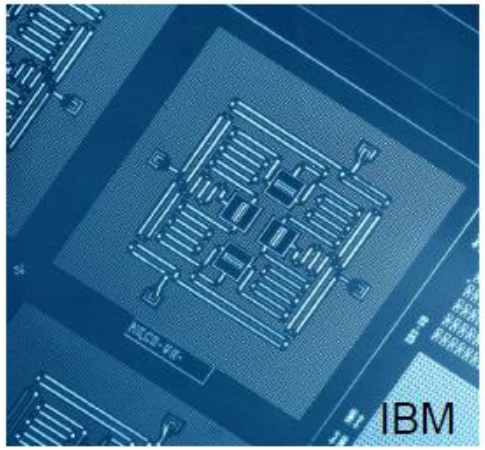
Some early quantum applications



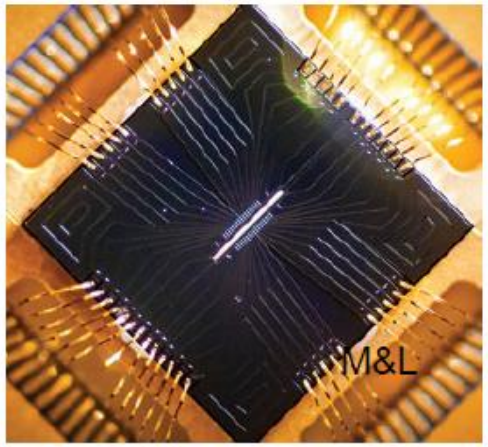
Potential quantum applications

- Exquisitely sensitive sensors/measurement technologies
- Truly secure communication networks
- Computers that can solve currently intractable problems

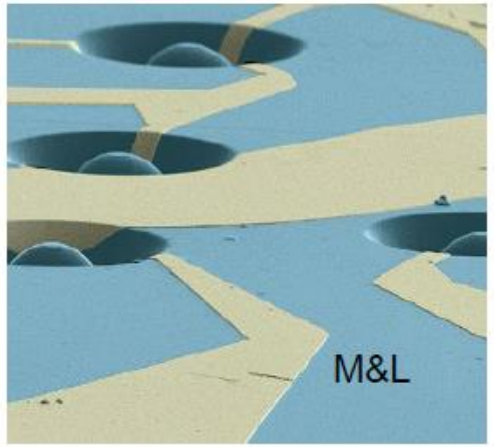
Quantum computing: It starts with the qubit



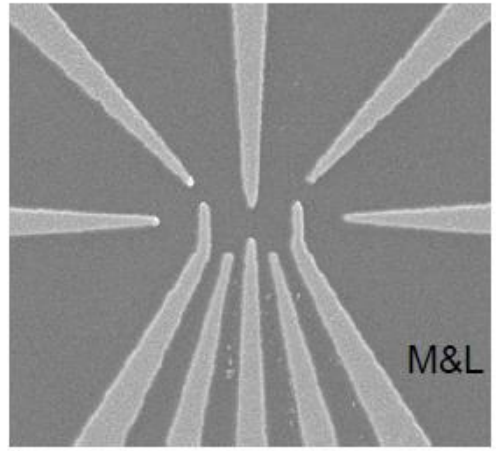
Superconducting Qubits



Trapped Ions



Engineered Defects



Quantum Dots or Spins

Sources: IBM and Morton and Lo, IEEE Spectrum, Aug 2014

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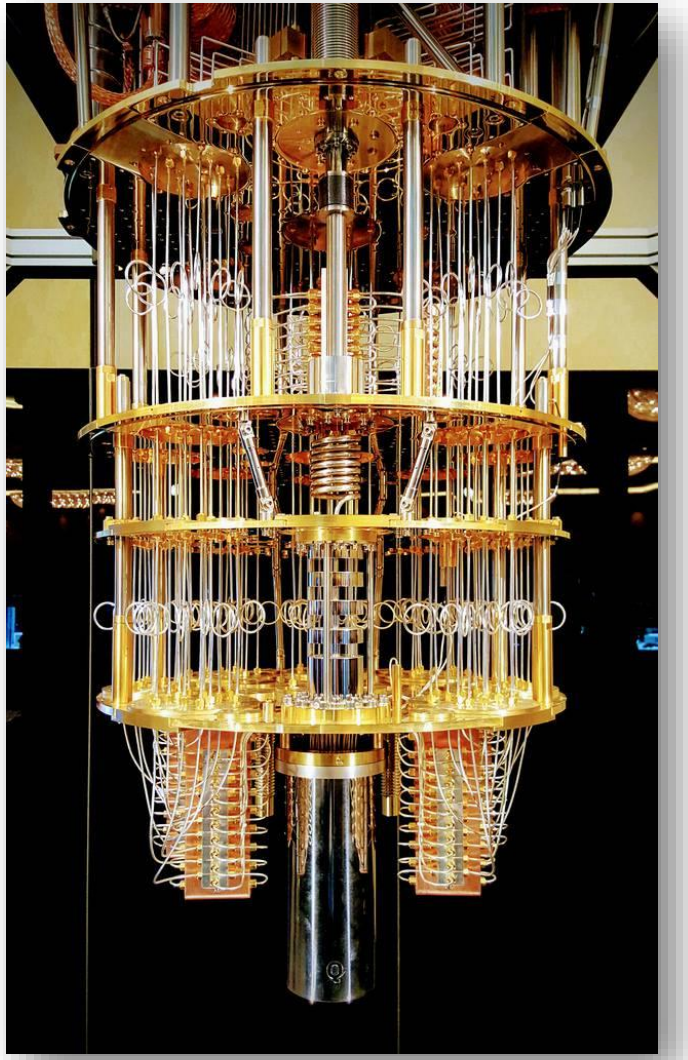
But there is a lot of engineering to be done

- Cryogenic technologies
- Control electronics
- Microwave generators
- Photonics
- Programming



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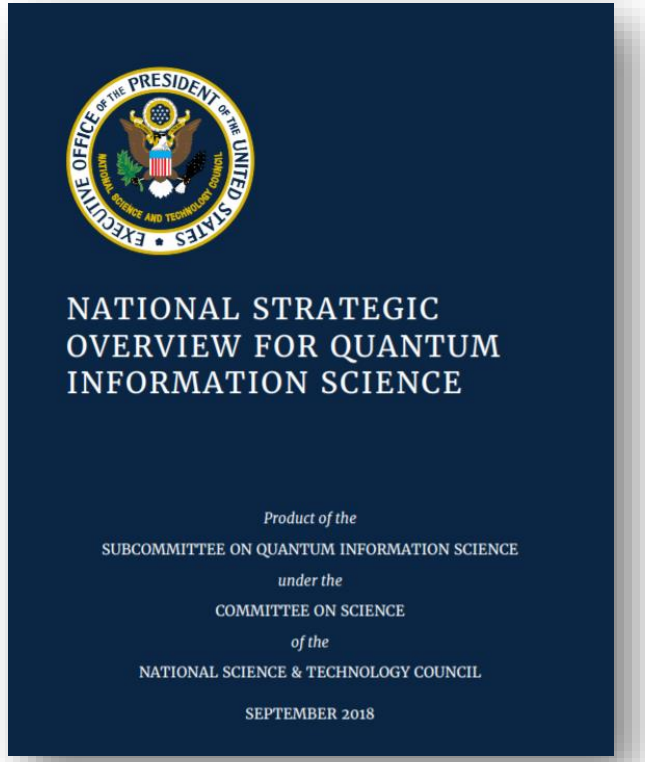
Estimated timing and size of market growth: Quantum Computing

Source: *Where Will Quantum Computers Create Value – And When?* Boston Consulting Group, 2019
https://www.bcg.com/publications/2019/quantum-computers-create-value-when.aspx

Government is ramping up

- NSF Big Ideas includes Quantum Leap (2016)
- Govt-wide research spending ~$200M-$250/yr (2017)
- National Strategic Overview for Quantum Information Science released (Sept 2018)
- National Quantum Initiative Act signed (Dec 2018)
- Solicitations released by multiple agencies
  - NSF Quantum Leap Challenge Institutes required to include industry collaboration and workforce development
- NIST launches industry consortium


NATIONAL STRATEGIC OVERVIEW FOR QUANTUM INFORMATION SCIENCE

Product of the

SUBCOMMITTEE ON QUANTUM INFORMATION SCIENCE

under the

COMMITTEE ON SCIENCE

of the

NATIONAL SCIENCE & TECHNOLOGY COUNCIL

SEPTEMBER 2018


One Hundred Fifteenth Congress
of the
United States of America

AT THE SECOND SESSION

Begun and held at the City of Washington on Wednesday, the third day of January, two thousand and eighteen

An Act

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

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 Economic Development Consortium (QED-C)

- An industry consortium with the mission to enable, accelerate, and strengthen the U.S. commercial quantum industry – with support of industry and government
- 60+ members from a broad cross-section of the quantum ecosystem
- QED-C purposes include:
  - Identify gaps that need to be filled to enable the robust U.S. quantum "ecosystem" that is necessary to realize the myriad benefits, including:
    - Enabling technologies
    - Standards and performance metrics
    - Workforce needs
  - Engage stakeholders to fill the gaps.
  - Provide a collective industry voice to guide R&D investment priorities, standards and regulation, and quantum workforce development

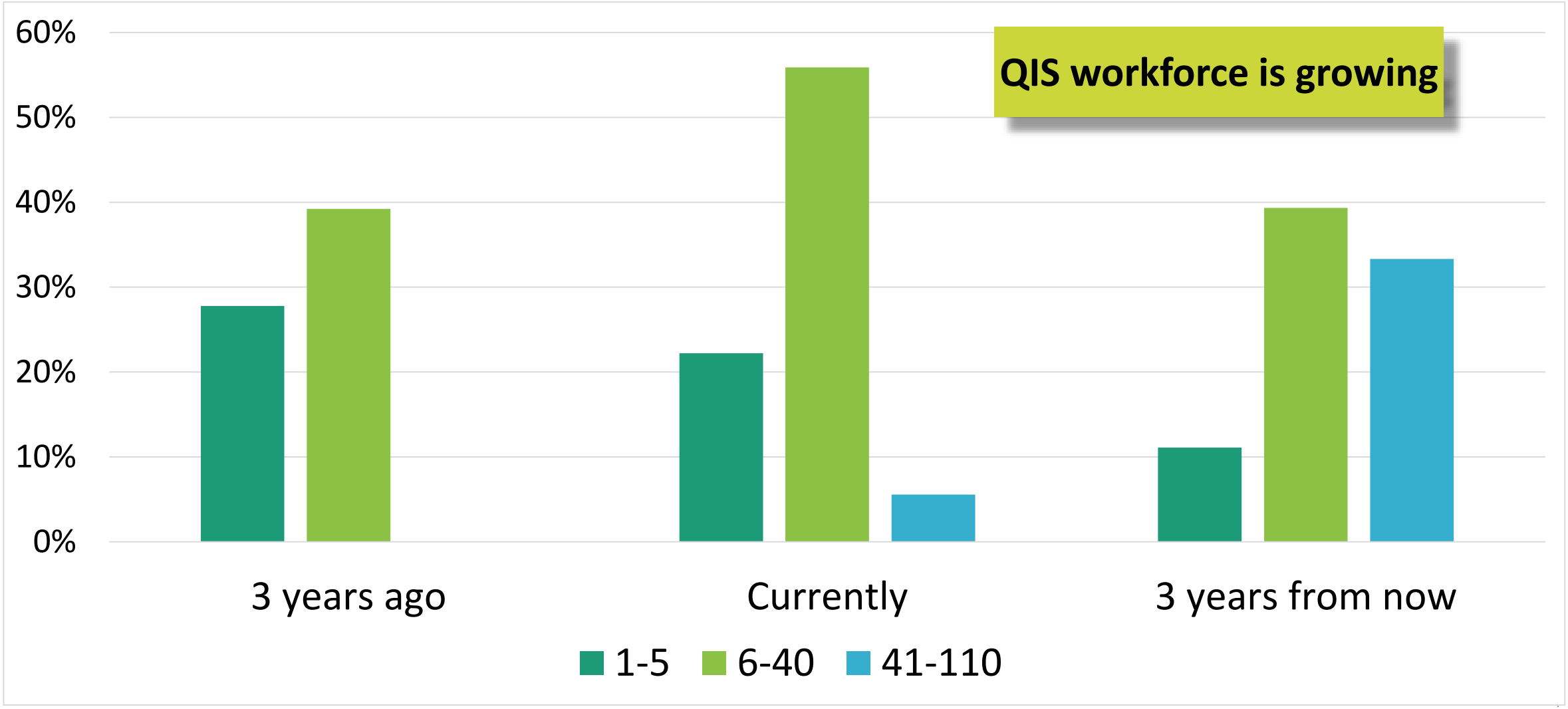
Step #1: Survey QED-C member companies

- **Motivation:**
  - **Get a snapshot** of QIS industry workforce trends and needs
  - **Inform discussions within the QED-C** on approaches to address members' workforce needs
  - **Provide QIS industry workforce needs to government** policy makers and program managers responsible for addressing this gap.
  - **Inform educational institutions** so they may adapt their programs at various levels and disciplines to meet industry needs.
- **Responses collected from QED-C member companies in Spring 2019**

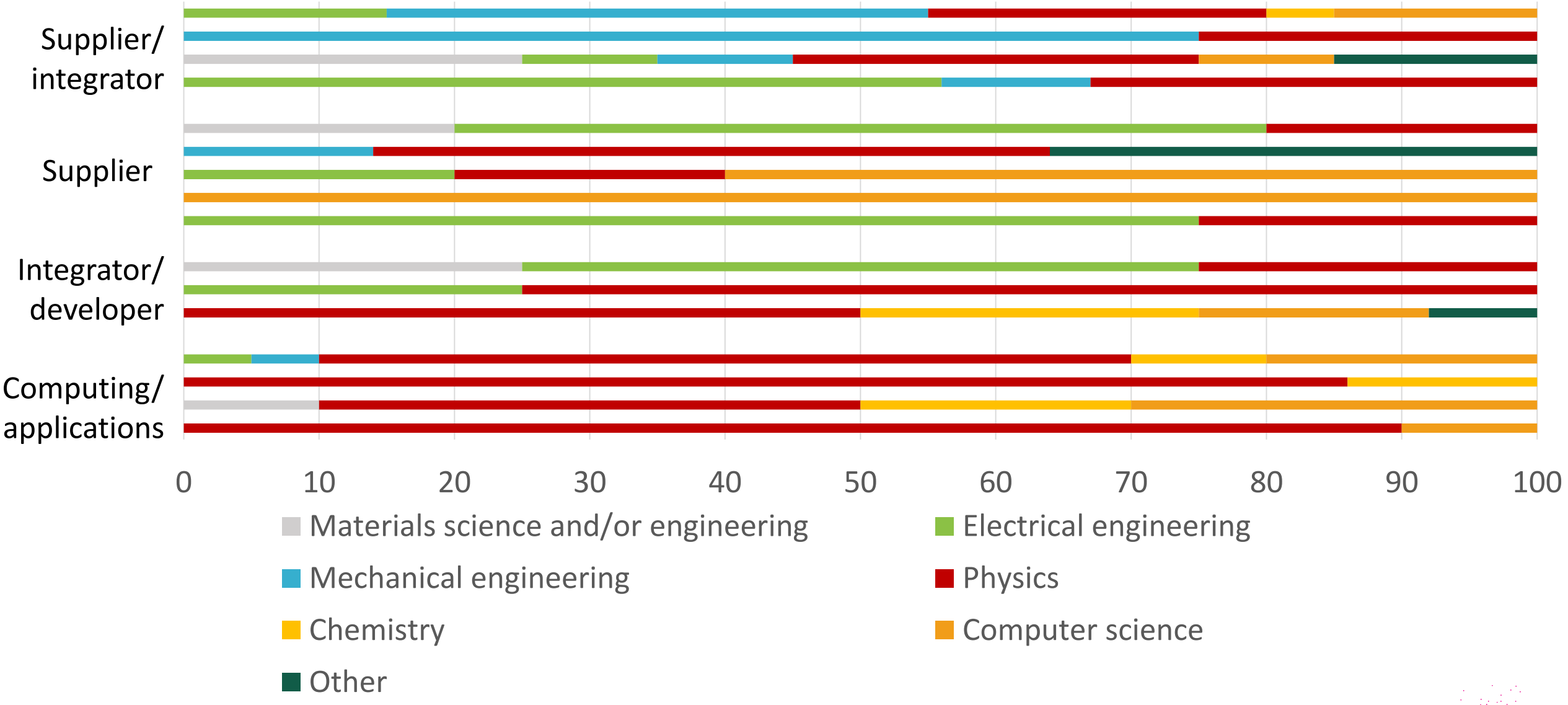
Survey topics

- Past, current and future workforce characteristics
  - Size
  - Degree level
  - Discipline
- Training needs

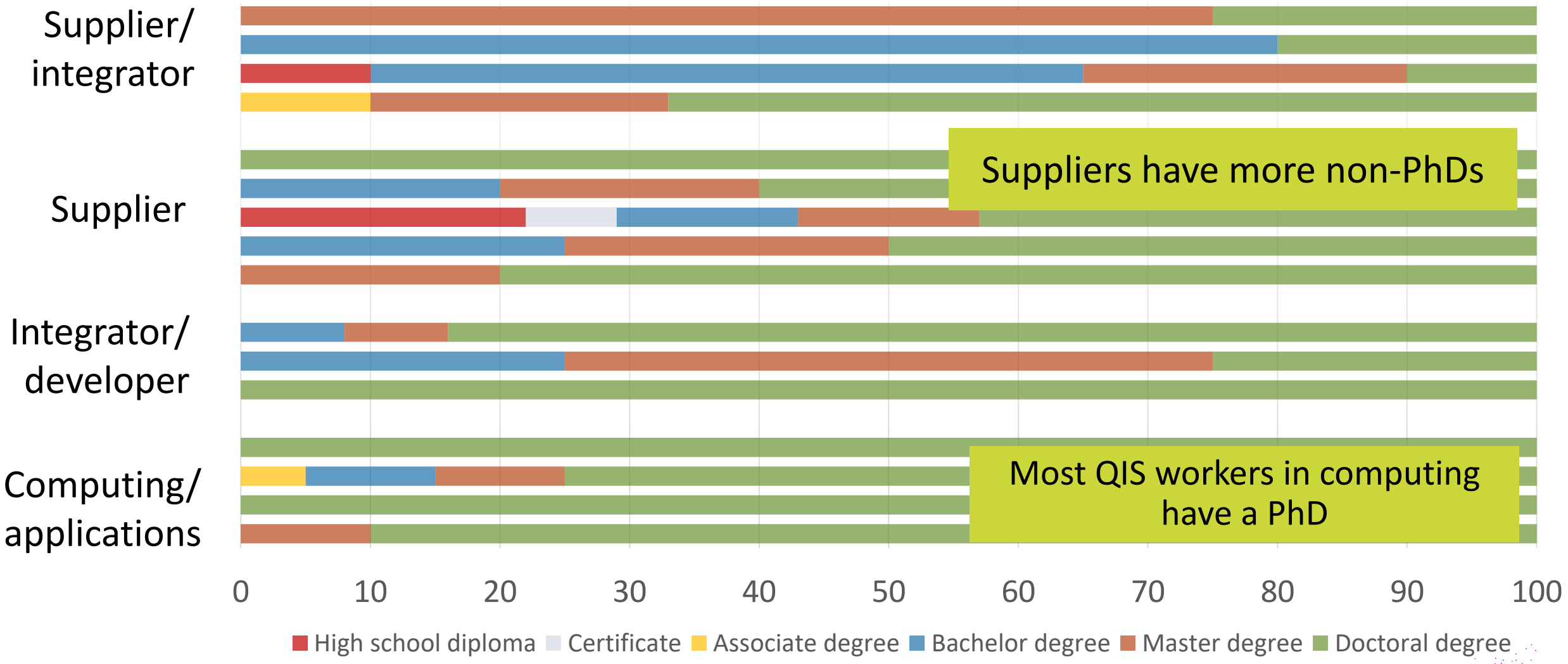
QIS workforce characteristics: # QIS workers over time



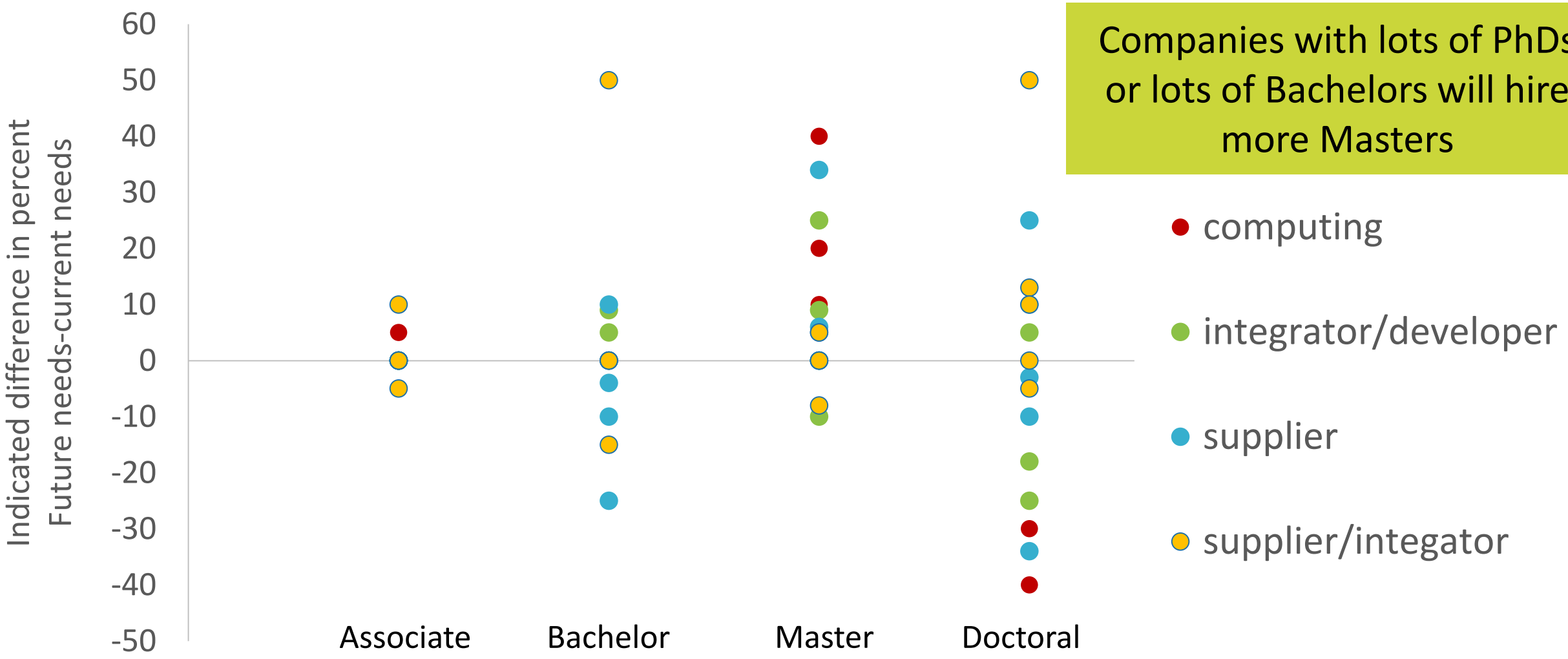
QIS workforce characteristics by current degrees



QIS Workforce Characteristics by highest credential



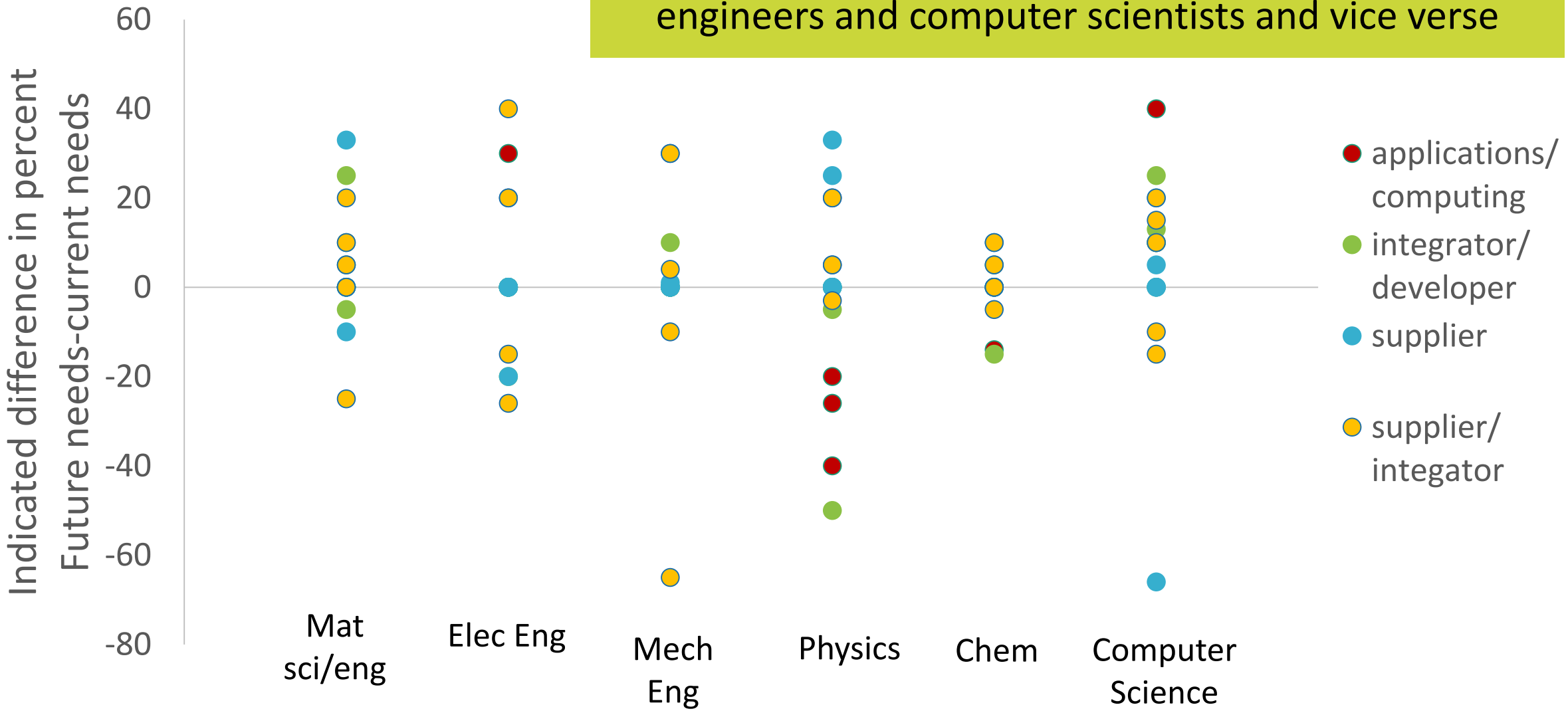
Fractional changes in degree levels (now vs. in 3 years)



Companies with lots of PhDs or lots of Bachelors will hire more Masters

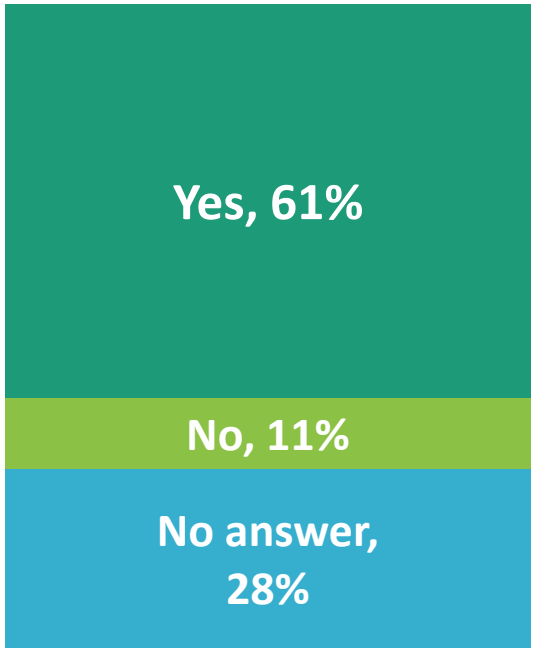
Changes in degree fields

Companies that have lots of physicists to hire more engineers and computer scientists and vice verse



Hiring issues

After hiring, do your QIS workers typically need additional training in fundamental QIS principles?



What knowledge or skills are missing from new graduates?

- Experimental skills, e.g. with lasers, nonlinear optics, and electronics
- Low-temperature training in theory, technologies, experimental techniques, and cryogenic device design and fabrication. Essentially the skills needed to be a "cryogenic engineer".
- Experience in building apparatus, designing for manufacturability, and manufacturing processing.

Key survey takeaways

- ✓ Quantum industry is expected to grow
- ✓ Multidisciplinary workforce needed
- ✓ Practical, hands-on experience is very much sought after
- ✓ ***The sample size is small***

Sample QIS Job Openings

- Assistant Scientist in Quantum Computing (Brookhaven National Lab)
- Associate Scientist, Quantum (Universities Space Research Association)
- Distinguished Staff Fellowships (ORNL)
- Calibration and Measurement Engineer, Quantum AI (Google)
- Engineer Quantum Test Lab (Northrop Grumman)
- Faculty Position in Computer Science (U Illinois Urbana-Champaign)
- Faculty Position in Electrical and Computer Engineering (U Illinois U-C)
- Faculty Position in Electrical and Computer Engineering (U Pittsburgh)
- Goodnight Distinguished Chair in Quantum Computing (NCSU)
- Industry Advisor, Research Directorate (NSA)
- Lead C++ Developer (HRL)
- Lead Python Developer (HRL)
- Multiple Open Positions (1Qbit)
- Multiple Open Positions (D-Wave)
- Multiple Open Positions (Honeywell)
- Multiple Open Positions (IBM Quantum Computing)
- Multiple Open Positions (IonQ)
- Multiple Open Positions (Microsoft)
- Multiple Open Positions (Qcrypt)
- Multiple Open Positions (Rigetti)
- Multiple Open Positions (Zapata Computing)
- Multiple Postdoctoral Positions (Virginia Tech)
- Physical Scientist (Battelle)
- Postdoctoral Appointee Quantum Computing (Argonne)
- Postdoctoral Employee (LBNL)
- Postdoctoral Research Scholar (NCSU)
- Postdoctoral Research Associate in Quantum Information Science (ORNL)
- Postdoctoral researcher Quantum optimization (IBM, Zurich)
- Postdoctoral Scholar in Quantum Computing (U Penn)
- Professor of Quantum Science And Engineering (Univ Wisconsin-Madison)
- Quantum Algorithms Post-Bachelor's Research Associate (ORNL)
- Quantum Computer Science Research Post-Bachelor's Research Assoc (ORNL)
- Quantum Computing Laboratory Specialist (Booz Allen Hamilton)
- Quantum Computing Postdoctoral Researcher (LLNL)
- Quantum Computing Software Engineer (ORNL)
- Quantum Electronics Test Engineer (Google)
- Quantum Engineer (Atom)
- Quantum Information Scientist (JHU-APL)
- Quantum Information Scientist (USC-ISI)
- Quantum Information Scientist (NIWC)
- Quantum Physicist / Photonics Engineer (Draper)
- Quantum Scientist, Error Correction (Alibaba Quantum Lab)
- Quantum Tools Engineer (Quantum Computing, Inc)
- Research Associate Quantum Computing (UNSW)
- Research Scientist in Quantum Algorithms (ORNL)
- Research Scientist in Quantum Communications (ORNL)
- Scientist IV Theoretical Quantum Information (HRL)
- Scientist IV Semiconductor Device Physics Theory (HRL)
- Scientist, Optical Engineering (Harris)
- Senior Research Scientist in Quantum Algorithms (ORNL)
- Scientist, Quantum (Universities Space Research Association)
- Staff Systems Engineer (Northrop Grumman)
- Technical Associate Staff Member- Quantum Information Science (ORNL)
- Tenure-Track Faculty Position in Physics (Stevens Institute)

Source: ORNL newsletter available at https://elist.ornl.gov/mailman/listinfo/qci-external

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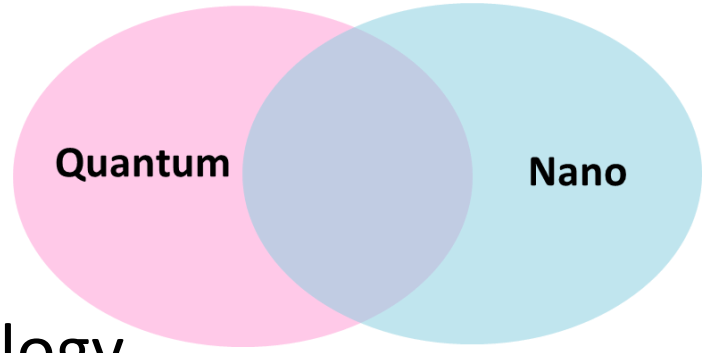
Concluding thoughts

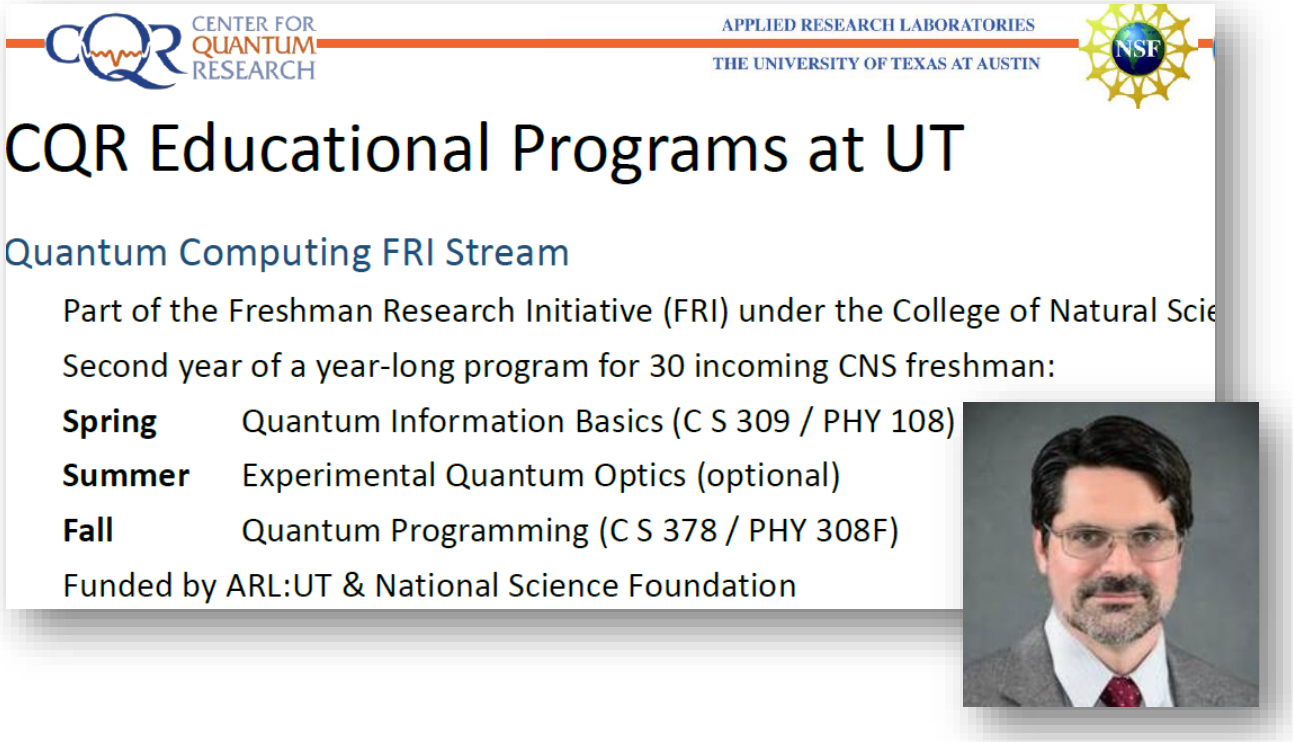


- Quantum technology shares a lot with nanotechnology
- Skills and knowledge needs are multidisciplinary and spread across many types of business
- Jobs are open now – and there will be more in the future
- There is a need to upskill existing workers
- Federal government recognizes the quantum workforce issues
  - The cross-NSF Quantum Leap is supporting research and education necessary to ensure the U.S. remains a leader
- QED-C is creating connections between industry and future workers

What you can do

- Incorporate (more) about quantum into nano courses
- Look at how your expertise relates to quantum challenges, e.g. materials synthesis and characterization
- Consider developing courses to upskill existing technical workforce

Example of course for first-year students at UT-Austin developed by Brian LaCour



THANK YOU

Celia.Merzbacher@sri.com

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QED-C LOI Signatories (as of 7/22/2019)

Corporate

- Advanced Research Systems (ARS)
- Amazon
- AO Sense
- ARM
- AT&T
- Atom Computing
- BAE Systems
- Boeing
- Boston Consulting Group
- Bra-Ket
- Citi
- ColdQuanta
- Corning
- D-Wave
- Entanglement Institute
- EZ Form Cable Corp.
- FieldLine
- FLIR
- GE Global Research
- General Dynamics Mission Systems
- Google
- Harris

Corporate

- Holzworth Industries
- Honeywell
- HPD
- Hyperion Research
- IBM
- Inside Quantum Technology
- Intel
- IonQ
- Janis Research
- Keysight
- KLA
- KMLabs
- Lake Shore Cryotronics
- Lockheed Martin
- Marki Microwave
- Microchip/Microsemi
- Montana Instruments
- NuCrypt
- Photodigm
- Photon Spot
- Psi Quantum
- QC Ware

Corporate

- QPRI
- Qrypt
- Quantum Circuits
- Quantum Xchange
- Qubitekk
- Raytheon
- Rigetti
- Riverside Research
- Rydberg Technologies
- SkyWater Technology Foundry
- Stable Laser Systems
- Strangeworks
- SRI International
- Toptica
- Twinleaf
- United Technologies Research Center
- Vescent Photonics
- Zapata Computing
- Zyvex Labs

Academic

- Caltech
- Colorado School of Mines
- George Mason University
- Georgia Institute of Tech.
- University of Colorado
- University of Maryland

Government

- DOD
- DOE
- NIST
- NSF

Other

- American Physical Society
- SEMI

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