Quantum Technology in Finland

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31 August 2023

Building on a strong research tradition…

1965 – Low Temperature Laboratory

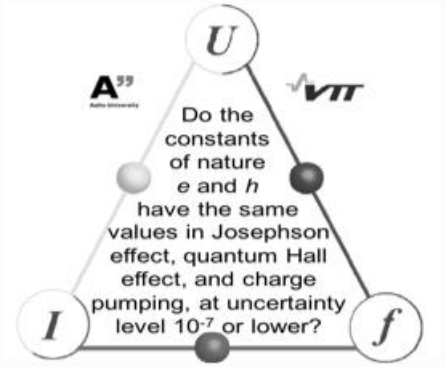
1994 – European research infrastructure collaboration

1995 – Centre of Excellence

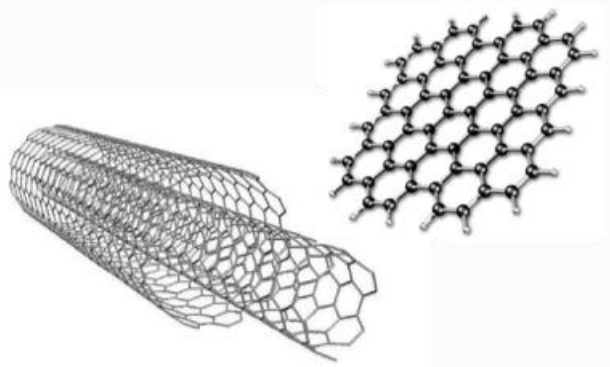
2009 – National research infrastructure

… from ultra-low temperature physics, to nano electronics and quantum technology

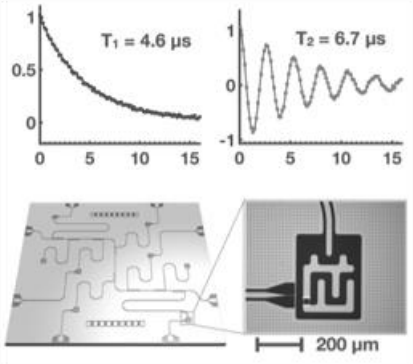
CRYOGENIC TECHNIQUES



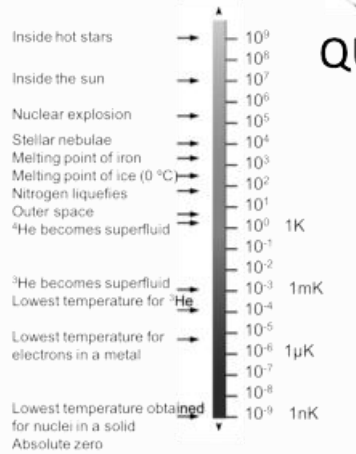
QUANTUM METROLOGY



GRAPHENE, NANOTUBES, 2D MATERIALS

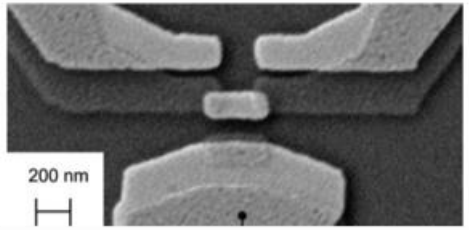


SUPERCONDUCTING CIRCUITS



SUPERCONDUCTIVITY AND SUPERFLUIDITY

MAGNETOENCE-PHALOGRAPHY



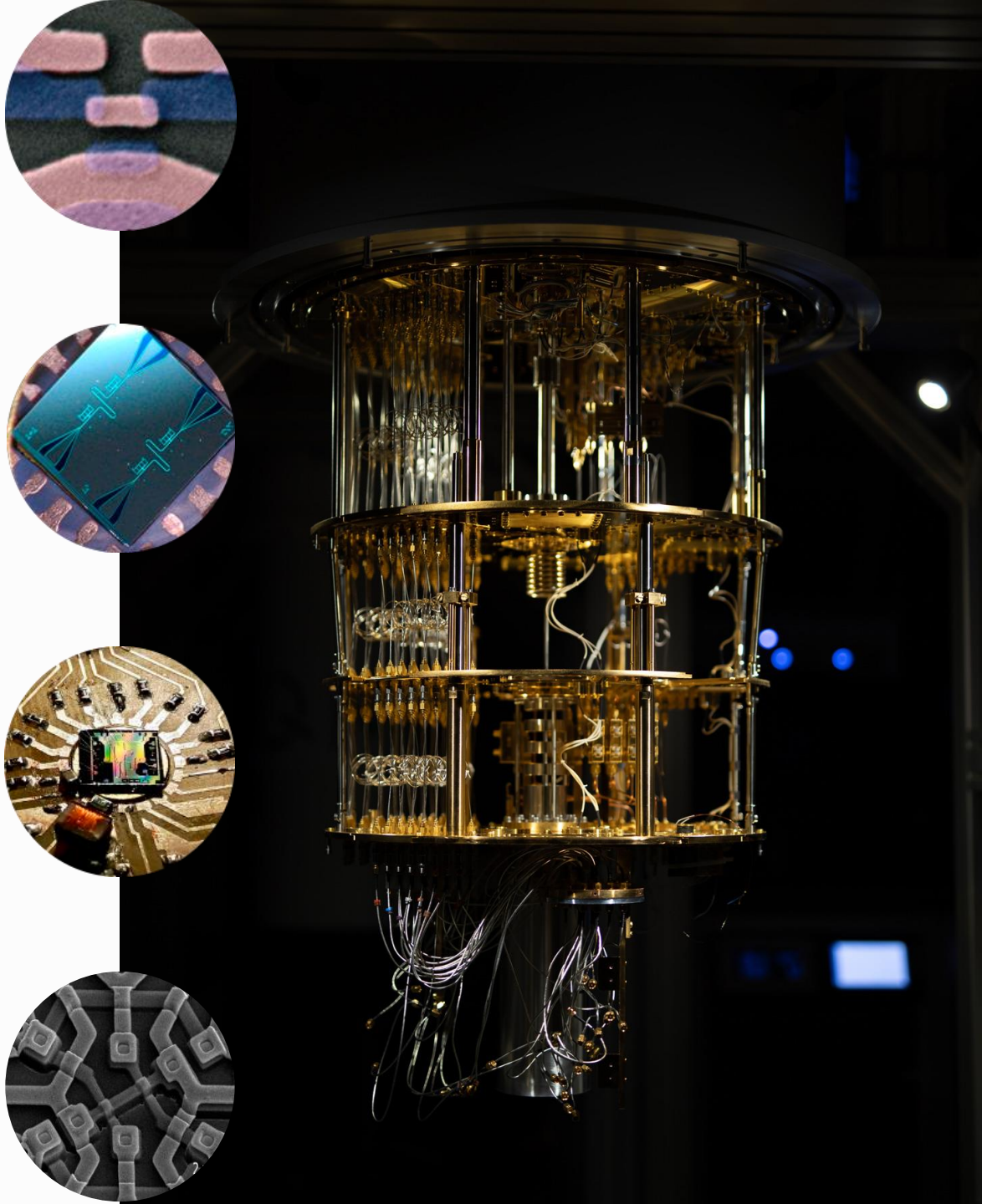
NANOELECTRONICS

Quantum Technology Finland

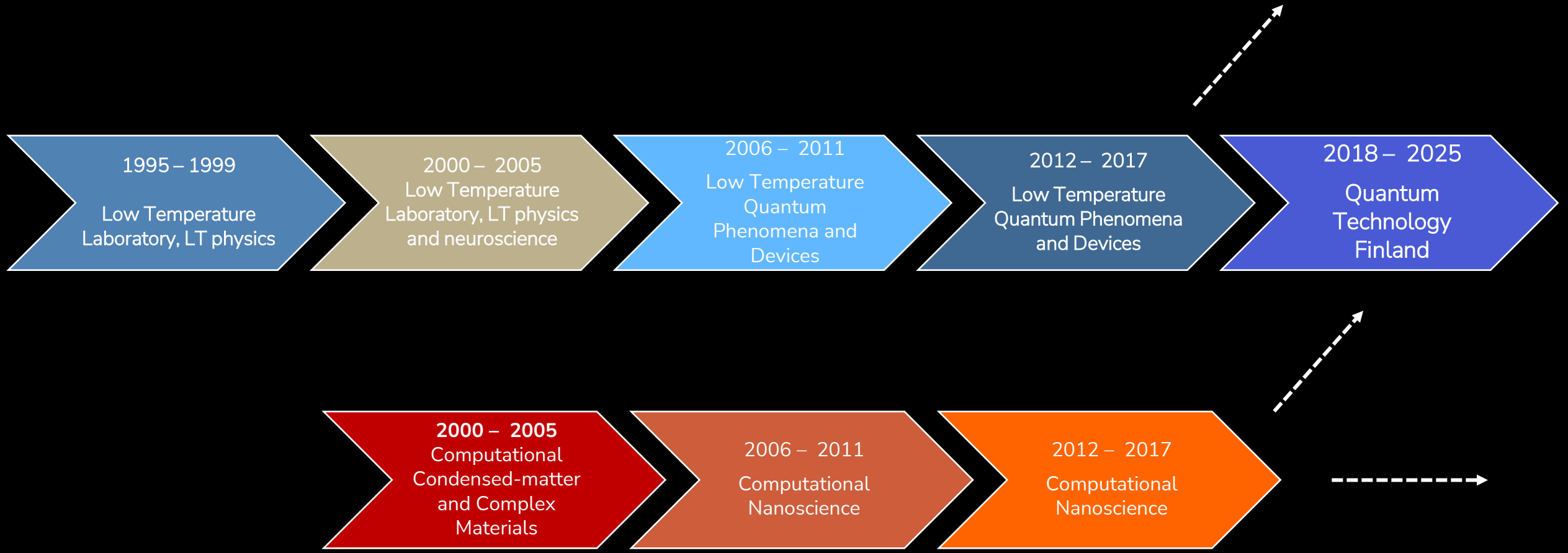
Centre of Excellence

2018–2025

Developing quantum technologies aimed at **controlling**, **transmitting**, and **measuring** photons, electrons, and phonons at the quantum level, and relevant to engineering applications.



National Centres of Excellence in research



Evolving ecosystem

1972
Instruments for Technology Oy Ab

1978 PICOWATT
instruments for thermometry at ultralow temperatures

1989 Mustekala ky
Functional neuroimaging (currently global business area of York Instruments Ltd)
YORK INSTRUMENTS

2005 Nanoway cryoelectronics
CBT thermometers

2006 aivon
cryogenic sensors, lab electronics

2008 BLUEFORS
cryogenic cooling systems

2013 ASQELLA
passive sub-mm-wave technology for security applications

2015 BEAT2PHONE
(VitalSignum Oy)
mobile health technology sensor applications

2016 Eigenco Oy
microwave measurement techniques

2018 IQM
superconducting quantum computing

2020 Algorithmiq
quantum-enhanced solutions to complex problems

2021 QUANSCIENT
quantum simulation-as-a-service platform

2023 SemiQon
silicon based quantum processors

1995 – 1999
Low Temperature Laboratory, LT physics

2000 – 2005
Low Temperature Laboratory, LT physics and neuroscience

2006 – 2011
Low Temperature Quantum Phenomena and Devices

2012 – 2017
Low Temperature Quantum Phenomena and Devices

2018 – 2025
Quantum Technology Finland

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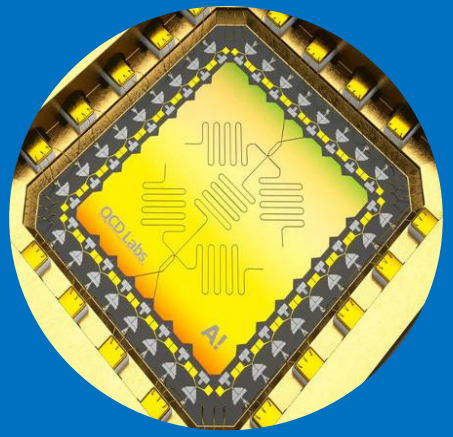
National open access research infrastructure

PICTURE: AALTO UNIVERSITY / N.D.

- Sub mK facilities
  - 3 nuclear demagnetization cryostats
- Sub 1K facilities
  - 18 dilution refrigerators (8-30 mK base temperature)
- Facilities at liquid He temperatures
  - cryostats between 4.2-1.2 K
- Room temperature facilities
  - incl. microRaman setup and AFM
- OtaNano micro -and nanofabrication facilities
  - 2600 m^2 cleanrooms, ISO 4–ISO 6
- Service for industry
- Cryogenic and nanofabrication training

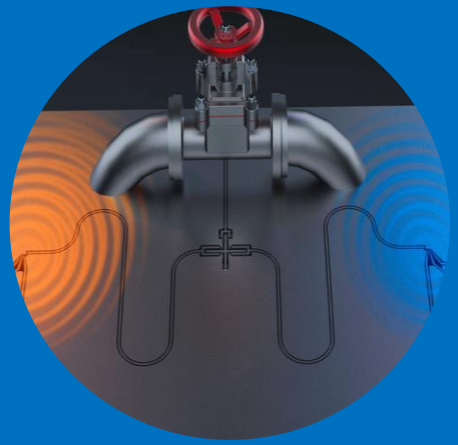
otanano

Quantum highlights



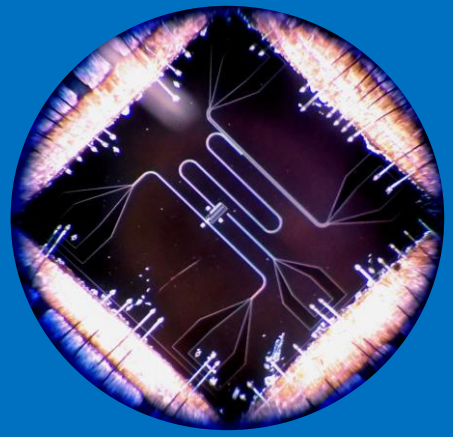
Faster detectors to read quantum memory –

speeding up getting data from a quantum computer.



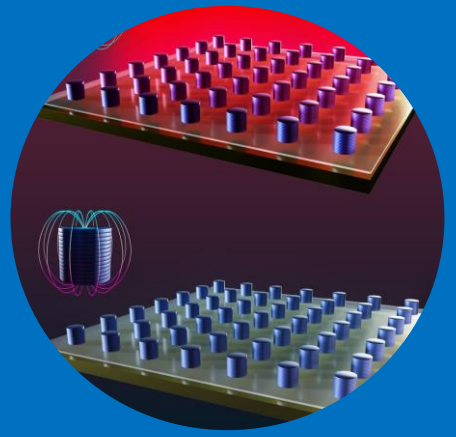
Realization of a miniature heat valve –

a major step towards quantum refrigerators and heat engines.



Quantum control of high speed energy transfers –

paving the way towards quantum simulation and computing applications.



Magnetic switching of nanolasers –

novel control mechanism for topologically protected lasing and robust signal processing.

Macroscopic quantun entanglement –

new tools for probing quantum/ classical domains, quantum sensing, and network nodes.

Example of recent progress: Finnish quantum computer

2017
Quantum computer development starts at Aalto and VTT

2018
IQM established

2019
IQM secures VC funding

2020
VTT and IQM to build quantum computer

2021 – 2024
Finnish quantum computing infrastructure on the new national roadmap

2022
first 5 QPU device connected to LUMI super-computer

2024
20 QPU ready

...

QCD Labs

SUPPORTING

Quantum Technology Finland

otanano

FIQCI
National Quantum Computing Infrastructure

- Building the Finnish quantum super computing environment
- Combining high performance computing with quantum computing (HPC-QC)
- Future: computing time and training

PICTURE: SHUTTERSTOCK

Aalto key expertise in quantum technology

Materials

superconducting materials

2D materials, heterostructures, topological materials

designer nanosystems, entangled quantum matter

quantum magnetism, spintronics, magnon-phonon/magnon-photon coupling

integrated quantum photonics

Devices

superconducting circuits, qubits, bolometers

open quantum systems

control of heat, correlations and decoherence in quantum circuits

nanoscale components, sensors, detectors

mechanical quantum devices, cavity optomechanics, qubit-acoustic hybrids

hybrid devices

Computing

superconducting platforms

quantum simulations and NIQS

AI and machine learning, quantum machine learning

market emergence

Algorithms and software

quantum error correction

fault-tolerant quantum computing, compilers, and decoders

Communication

quantum key distribution

quantum microwave communications and quantum covert communications

combinatorics and algebraic geometry

quantum private information retrieval

post-quantum cryptography

quantum information processing

PICTURE: AALTO UNIVERSITY / N.D.

Institute

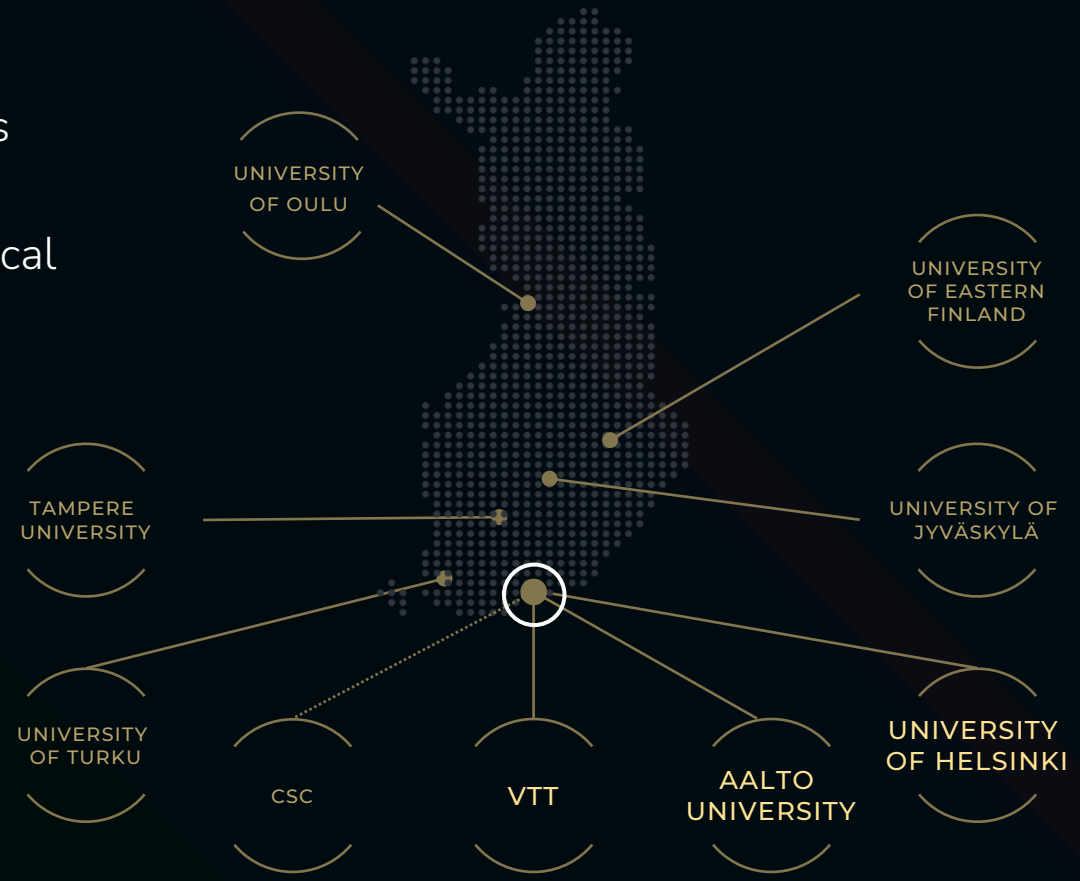
The Finnish Quantum Institute

1st stage: 50+ groups joining forces for QST in Finland

PARTICIPATING GROUPS FROM:

- physics
- chemistry
- mathematics and statistics
- computer science
- neuroscience and biomedical engineering
- electronics and nanoengineering
- communications and networking
- management
- philosophy

Annual volume of operations:
> **EUR 40 million**



EXPERTISE IN

- quantum materials,
- superconducting and semiconducting technologies,
- optics,
- theory,
- device applications,
- scale-up, device integration, and interfacing,
- software and algorithms,
- IT solutions and interfaces for national quantum computing resources,
- commercialization,
- education

Mission

Our goal at InstituteQ is to raise the readiness of Finnish society for the potential and implications quantum technologies will have for society and the economy at large.

Vision

By teaming up our expertise and resources, we aim to carry, implement, and mutually benefit from front line research, education, innovations, and infrastructures, that form the competitive edge for our community in the quantum era.

BusinessQ Nurturing quantum industry

- broadening the impact of quantum technology in industry and business in Finland
- new business creation and adaptation of quantum technologies through industrial collaboration in national and European level
- quantum-ready and quantum-safe Finland

AND GROWING...

Quantum technology expertise in Finland

InstituteQ members

Tampere University
Novel quantum materials and metamaterials Quantum emitters and lasers Quantum photonics

CSC
National access to quantum computing resources Deployment of QKD in Finland

University of Turku
Quantum foundations Optical methods

Aalto University
Superconducting technologies Quantum materials Integrated quantum photonics Sensing applications Quantum computers Algorithms and software Quantum communications engineering Quantum foundations Market emergence

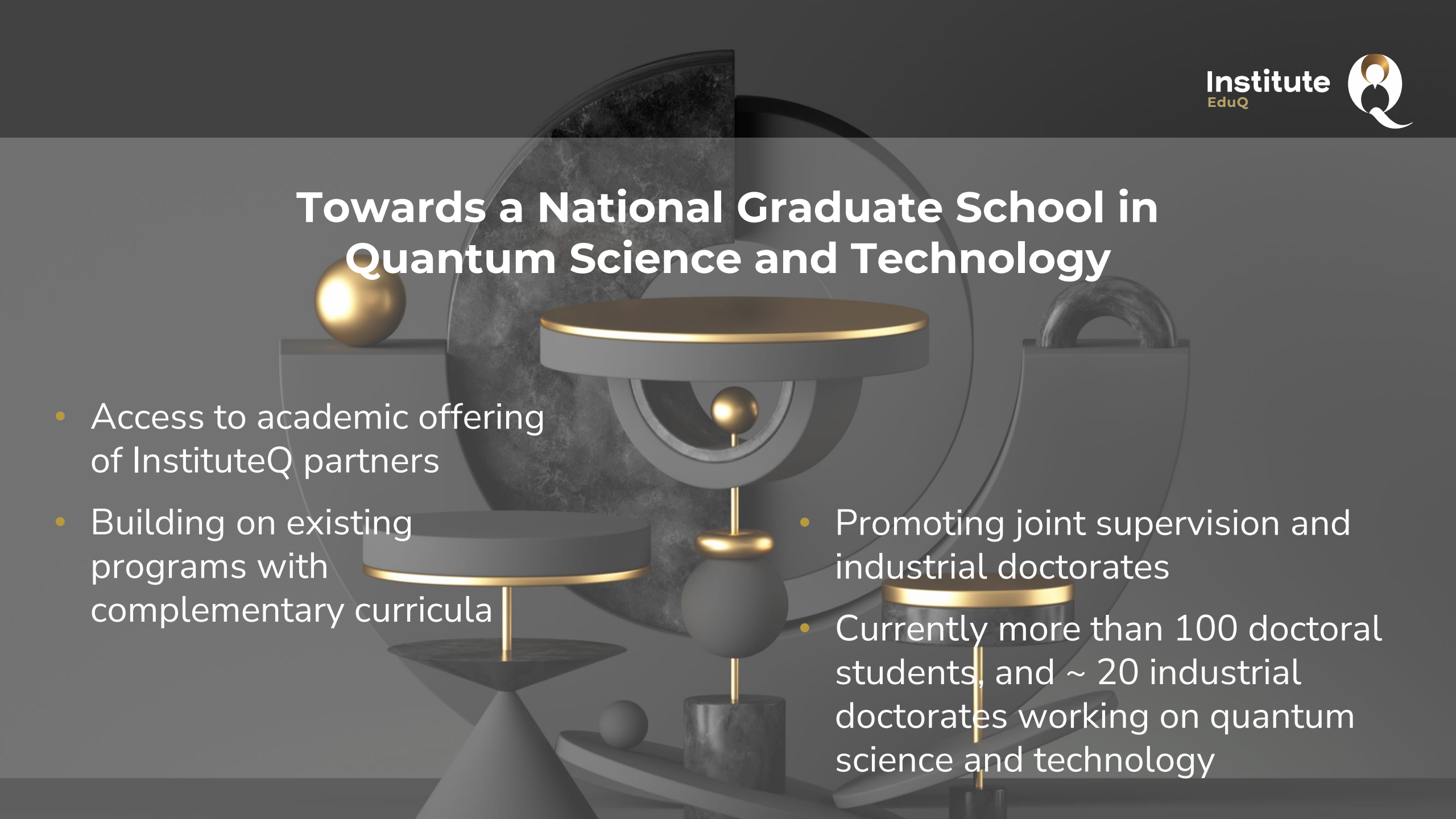
University of Oulu
Theory of quantum devices Quantum error correction

University of Jyväskylä
Superconducting circuits Quantum materials Radiation sensors Quantum algorithms and software Precision measurements Atomic clocks

University of Eastern Finland
Micro- and nanodiamond synthesis Quantum-enhanced electromagnetic measurements

University of Helsinki
Quantum algorithms and software Quantum simulations and NISQ Quantum information and foundations Quantum education research Quantum philosophy

VTT
Microsystems design and fabrication Quantum components and architectures System integration Quantum computers Quantum standards, and atomic clocks Deployment of QKD in Finland

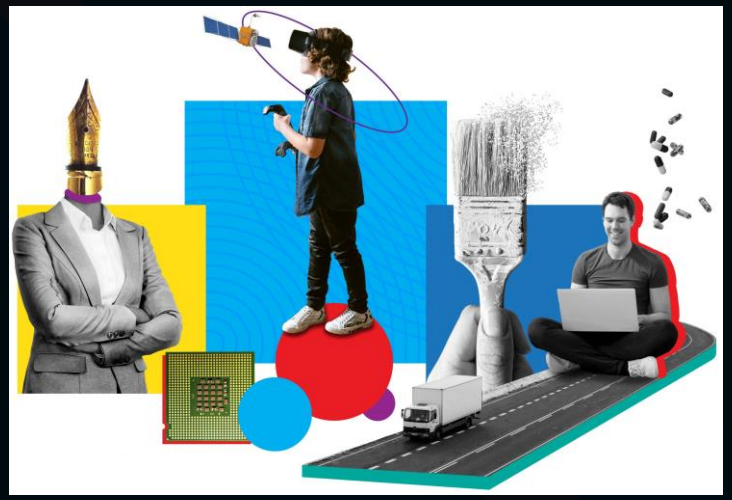


Towards a National Graduate School in Quantum Science and Technology

- Access to academic offering of InstituteQ partners
- Building on existing programs with complementary curricula
- Promoting joint supervision and industrial doctorates
- Currently more than 100 doctoral students, and ~ 20 industrial doctorates working on quantum science and technology

Institute

Learning is possible for everyone.



qplaylearn

https://qplaylearn.com

Institute
EduQ

People in charge of EduQ operations

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University of Helsinki

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Tapio Rasa
University of Helsinki

EDUQ COORDINATION,
(Doctoral level & Aalto University)
Jani-Petri Martikainen

EDUQ COORDINATION,
Master's level & University of Helsinki
Paolo Muratore-Ginanneschi

OUTREACH AND
EUROPEAN PILOTS
Caterina Foti,
Aalto University

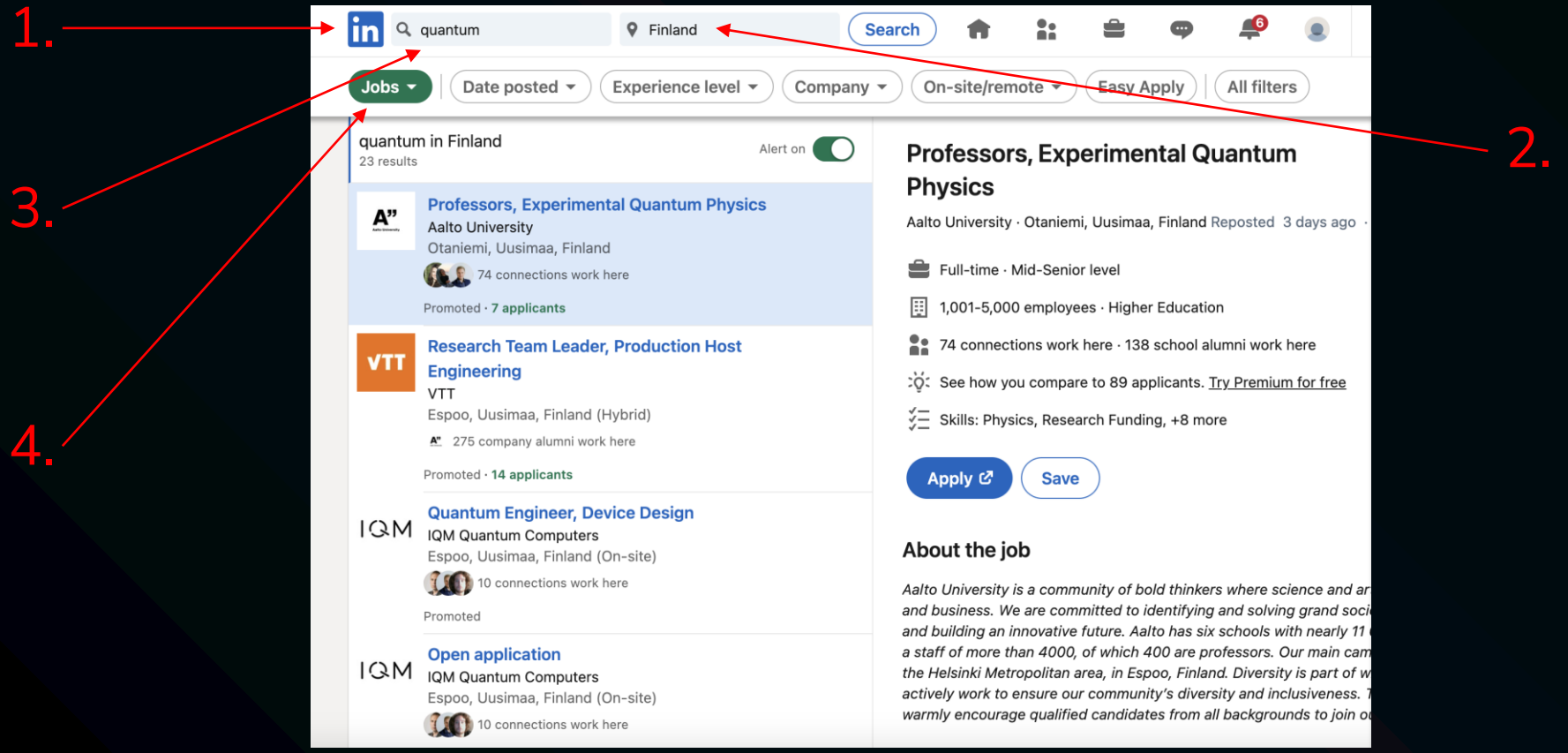
For postdoc opportunities

Institute ResQ

1. Contact the PI you wish to work with: https://instituteq.fi/about/#participating-groups
2. For Aalto, contact the Grant Writer or Research Liaison Officer of the school where your supervisor works: https://www.aalto.fi/en/services/research-and-innovation-services
3. If you are hesitant of whom to contact, reach out to ResQ coordinators at each organization: https://instituteq.fi/research/
4. InstituteQ general contacts: https://instituteq.fi/contact-us/

Institute

Fast access to all academic and industry QUANTUM positions in Finland?



More questions?

Institute Q

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