TeleQuant

Telecom-wavelength quantum communication with on-demand quantum light sources

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VTT: George Thomas, Kalle Hanhijärvi

Aalto: Mikko Möttönen

Quantum 2.0

- ➢**Quantum computing** brings an exponential increase of efficiency in solving complex problems
- ➢**Current data encryption** can be cracked by a quantum processor
  - →Need for resilient quantum-secure data communication – Quantum Key Distribution (QKD)
- ➢**Quantum Internet** – connecting remote quantum processors to operate together in a distributed manner

- ➢**Deploying quantum communication is crucial**
  - ▪ **Resilience, security, and self-sufficiency**
- ➢**Quantum communication market expectation** (Precedence Research)
  - ▪2025: USD 1.41 billion
  - ▪2034: USD 13.12 billion

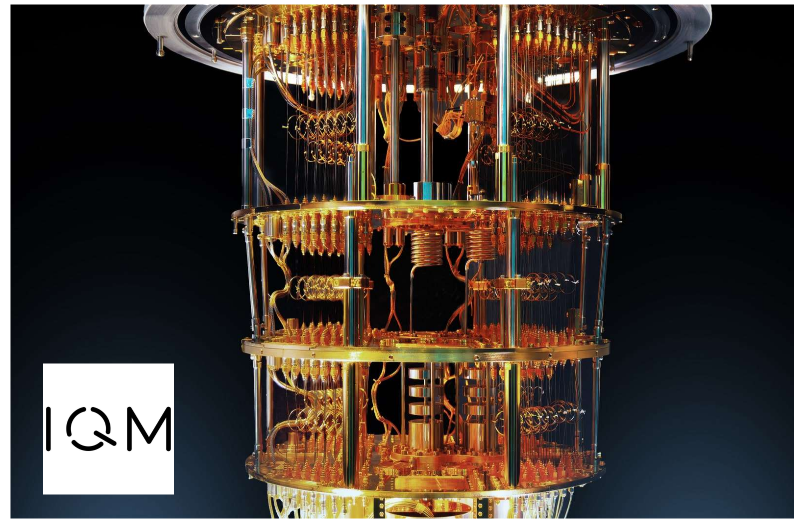
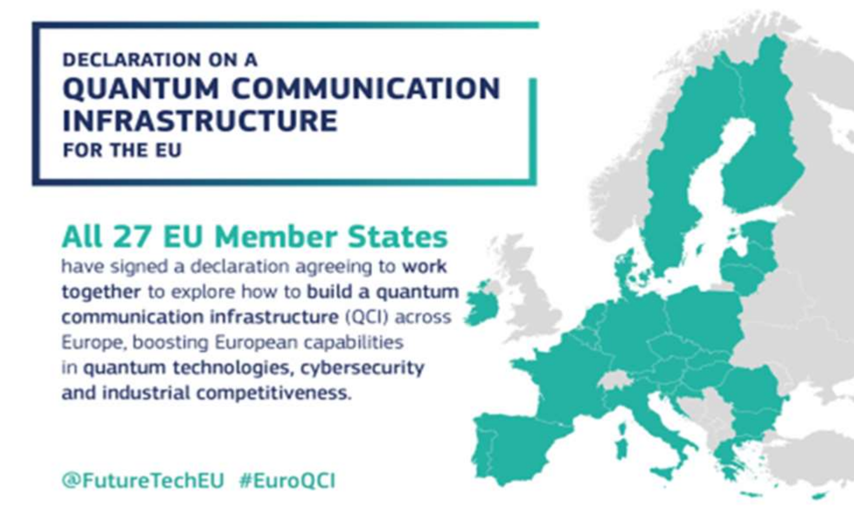


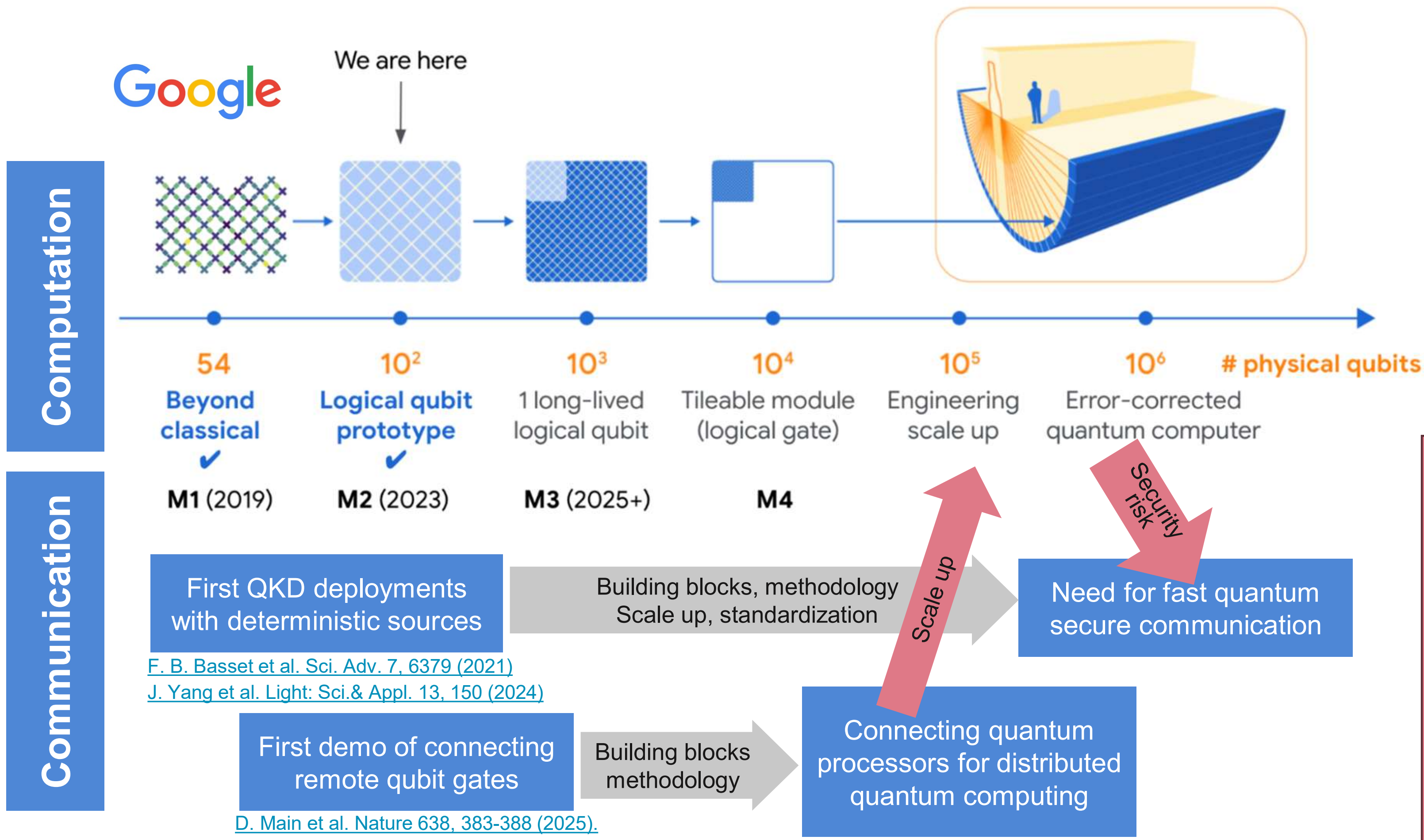
Image: Nature

Quantum communication in Finland

- Finland included in European Quantum Internet Alliance and Quantum Secure Communication Partnership
- Finland has technology foundation for key QKD components enabling quantum internet
    - Finnish Quantum Flagship
    - Photonics flagship PREIN
- TeleQuant is the first national level initiative to leverage the Finnish key competence at building block level and elevate it to system level



Technology drive



F. B. Basset et al. Sci. Adv. 7, 6379 (2021)
J. Yang et al. Light: Sci.& Appl. 13, 150 (2024)
D. Main et al. Nature 638, 383-388 (2025).

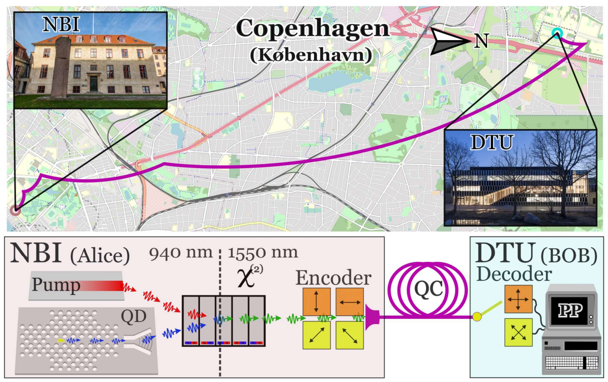
TeleQuant:
- Key building building blocks enabling differentiation at system level
- Application ecosystem in development

Novelty and differentiation:

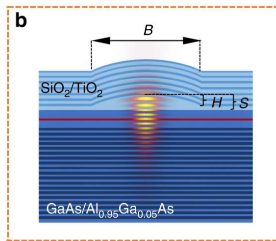
Fiber-compatible on-demand quantum light sources

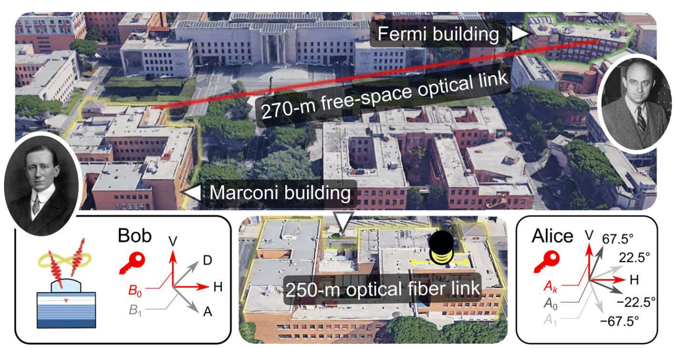
Best QDs: 900nm InGaAs and 780nm GaAs

– high transmission losses in fibers and air



M. Zahidy et al. npj Quantum Information 10, 2 (2024).

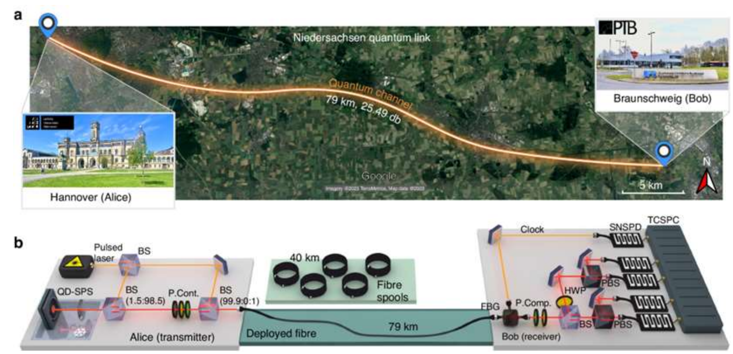




F. B. Basset et al. Sci. Adv. 7, 6379 (2021)

Fiber-compatible: 1550 nm InGaAs QDs

– current QKD SoA with 4.8×10^{-5} key bits/pulse

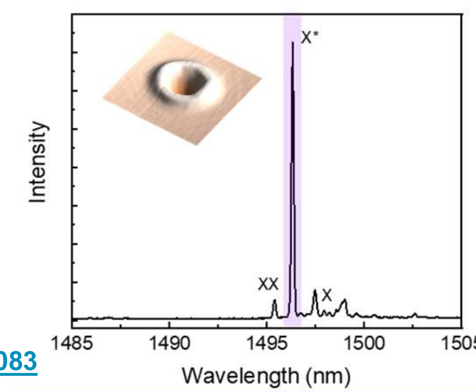


J. Yang et al. Light: Sci.& Appl. 13, 150 (2024)

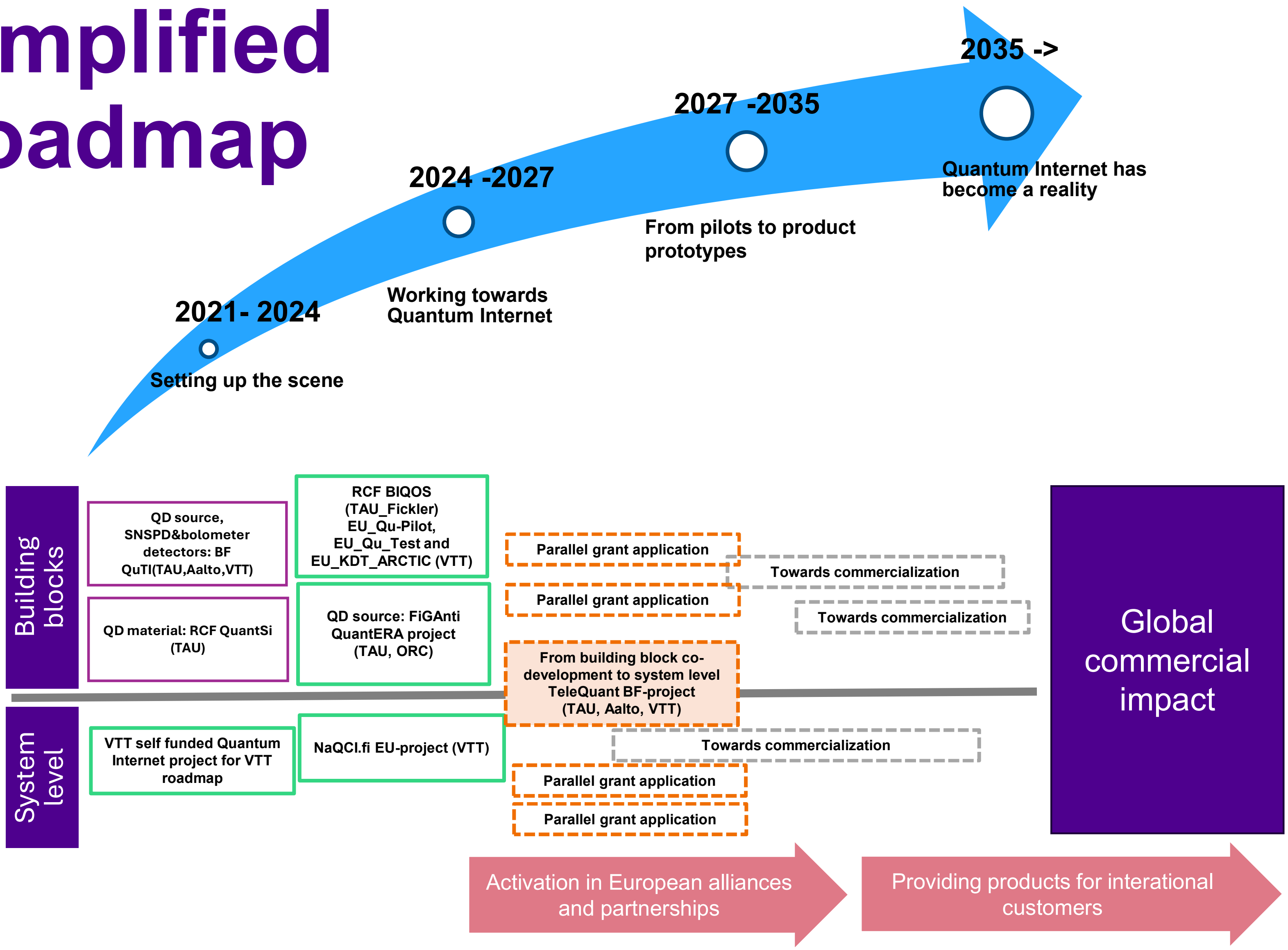
Our Telecom GaSb QDs

- ➢ Properties matching the best short wavelength QD materials
- ➢ But at fiber-compatible wavelength

T. Hakkarainen et al. https://arxiv.org/abs/2404.06083



Simplified roadmap



General goals and differentiation path

Goal 1: Development of quantum key distribution (QKD) building blocks with fiber-compatible 1.5 µm emitting on-demand single-photon sources. Construction of a proof-of-concept testbed exceeding the current SoA. Field-deployment in the final phase of the project.

→ Ensures Quantum-secure communication capabilities and hardware self-sufficiency for Finland

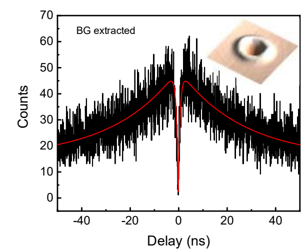
Goal 2: Development of 1.5 µm on-demand quantum sources, quantum memories, protocols, and detectors for applications beyond current QKD approaches.

→General quantum communication networks beyond the short-term data security needs

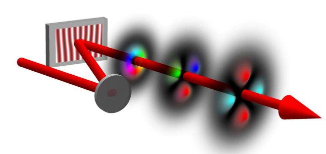
Consortium and synergy

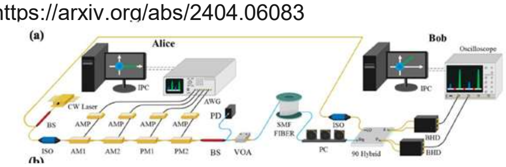
	Key people	Source	Processes	Memory	Detectors	PoC
TAU	Teemu Hakkarainen, Mircea Guina, Robert Fickler	x	x			x
VTT	George Thomas, Kalle Hanhijärvi		x	x	x	x
Aalto	Mikko Möttönen		x		x	x

	Technology building block	Project background
TAU	Unique 1.47-1.55µm emitting GaSb quantum dot single photon sources (ORC)	RCF QuantSi, BF QuTI, **QuantERA FiGAnti, RCF PoC IntegrateQT**
TAU	Encoding, manipulation, and decoding of photonic quantum states. Fundamentals of quantum cryptography (Exp. Quantum Optics)	>10 research articles on quantum communication **RCF BIQOS**
VTT	SNSPD single-photon detectors	BF QuTI **EU_Qupilot, EU_Arctic, EU_NaQCI.fi**
VTT	BB84 DV-QKD demo with probabilistic sources	**EU: NaQCI.fi & Qu-Test, internally funded**
Aalto	Superconducting bolometer photon counters, energy&number resolving	BF QuTI

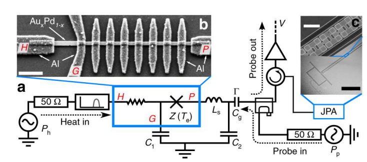


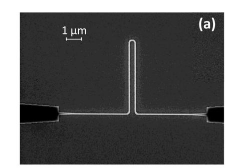
T. Hakkarainen et al.
https://arxiv.org/abs/2404.06083


F. Bouchard, R. Fickler et al. Quantum 2, 111 (2018).



VTT QKD demonstration


R. Kokkoniemi...M. Möttönen Comm. Physics 2, 124 (2019).



M. Cherchi et al. Adv.Phot. Nexus 2, 024002 (2023).

Technical goals

Path to Goal 1: Quantum key distribution

KPI	Technology	Goal
1 (D1.1)	Source	**Source KPI**
2 (D3.2)	Detector	**Detector KPI**
3 (D4.3)	QKD system	**Projected proof-of-concept QKD testbed performance**

Path to Goal 2: Quantum internet

KPI	Technology	Goal
4 (D1.2)	Source	**Source KPI**
5 (D3.4)	Detector	**Detector KPI**
3 (D4.3)	Memory	**Memory KPI**

Technical goals for the first 2 years

- Measurable goal for each building block technolology
- Bar set up to a highly ambitious level

Impact

Creating a vertically integrated value chain for quantum communication systems

Companies/Organizations	Group	Impact
Electricity and water supply facilities, Stock market, Defence forces, Healthcare	End users	Quantum secure digital systems, self-sufficiency, resilience
Telecom operators, Erillisverkot, Defence Forces, CSC, Cinia	Primary users / Service providers	Quantum secure digital systems, operational reliability, security
Nokia, Qmill, INSTA	Software companies	New products and services: Data architecture, operating systems
Nokia, Bittium, Savox, INSTA, **spinoff potential**	Telecom hardware companies	New products and services: Quantum light sources, detectors, repeaters, and memories.

Spinoff background in the QT field

Key strengths of the proposal

- **Topic aligning with the aim of the call and global technology trends**
  - Timeliness for national need
  - Global market potential
  - Existing state-of-the-art building blocks

- **Clear vision of the timeline and required actions**
  - Technology positioning
  - Development roadmap

- **Strong research team**
  - Strong track record in semiconductor, superconductor, and photonic technologies – from science to startups
  - Existing underlying technology for the building blocks – each approaching breakthrough level
  - Unique vision for combining building blocks for system level implementation

Thank you