

World Quantum Day

4/14/2023

$h=4.135667516 \times 10^{-15} \text{eV seconds}$

Update on EuroQCI Progress in Ireland

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IrelandQCI: Building a National Quantum Network for Ireland

IrelandQCI Team & Partners



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The University of Dublin






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University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath



IrelandQCI Roadmap towards EuroQCI

Use-case	QKD Encryption	City & National Quantum Network	Quantum Technology Laboratories & Testing Facilities
End-User	Government, cybersecurity, data centres	Government, standards, internet exchange, satellite industry	Academia, financial banking, photonics industries, high performance computing, quantum computing, simulators and emulators
Application	QKD as a service & data storage	Classical/quantum coexistence	Staging quantum internet, quantum interfaces & emitters, quantum PIC assembly & packaging
Software	QKD protocols & key management	System architecture, SDN, Protocols, security, standards	Quantum algorithms, quantum money schemes, quantum states, distributed quantum computing
Hardware	 <p>TRL 9</p>	 <p>TRL 7 EuroQCI Ready</p>	 <p>TRL 3 Quantum Internet Ready</p>
QI Stage	Prepare & Measure QKD	MDIQKD & Entanglement	Cryogenic Stations Interfaces Repeaters & Memories PIC Packaging
Month	M0 M3	M6 M9 M12	M15 M18 M21 M24 M27 M30

National Backbone Network

- M12: PM QKD
 - 3 End Nodes
 - 1 Trusted Node
- M18: PM + SNSPDs QKD
 - 3 End Nodes
 - 2 Bypass Nodes
- M20: MDI QKD
 - 4 End Nodes
 - 2 Core Nodes

Quantum Network Evolution

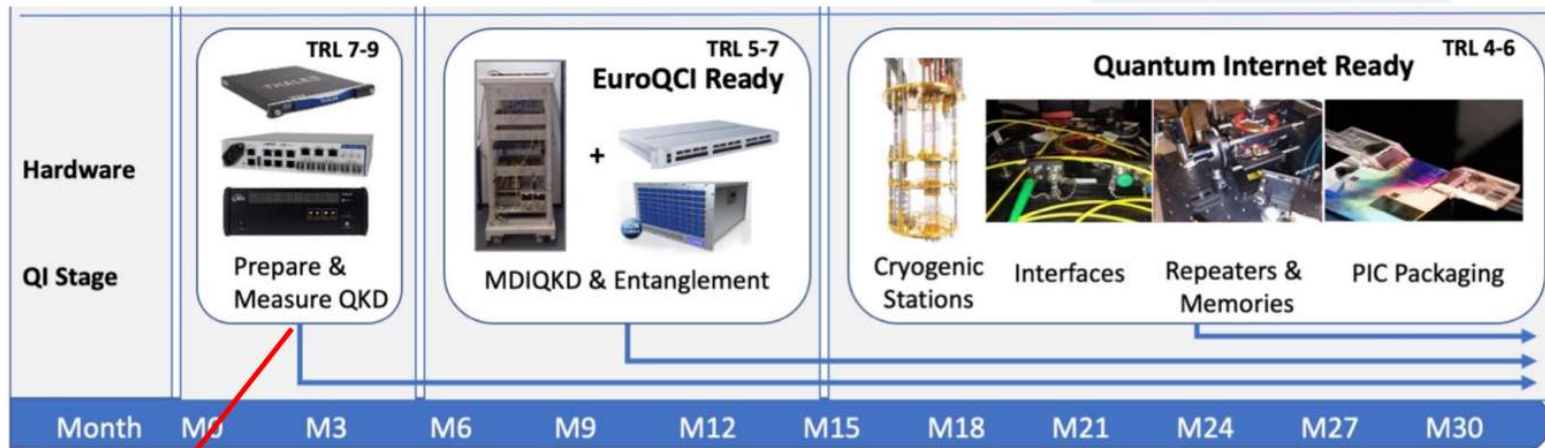


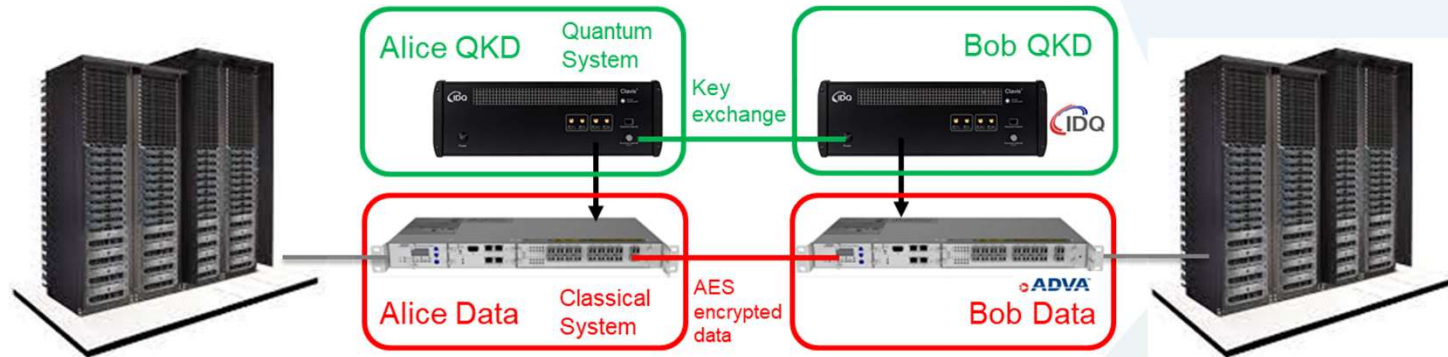
Fig. 2 IrelandQCI roadmap towards EuroQCI and the quantum internet

- Point-2-Point (P2P) QKD Links
- Off The Shelf (OTS) QKD devices at different DWDM wavelengths
- Create multiple topologies (P2P, Loop, Star)
- Integrate with OTS Encryption (transmission, IPsec, MACsec) and Key Management Devices

QKD with existing solutions



QKD – Data Centre Interconnect



Quantum Encryption

- IDQuantique Clavis³ QKD system:
 - 1.4 kbps, 12 dB loss ~100 km over standard telecoms
- ADVA FSP3000:
 - 100 Gbps, QKD-enabled WDM AES256 encryptors
- Compatible via the ETSI-QKD API

Quantum Network Evolution

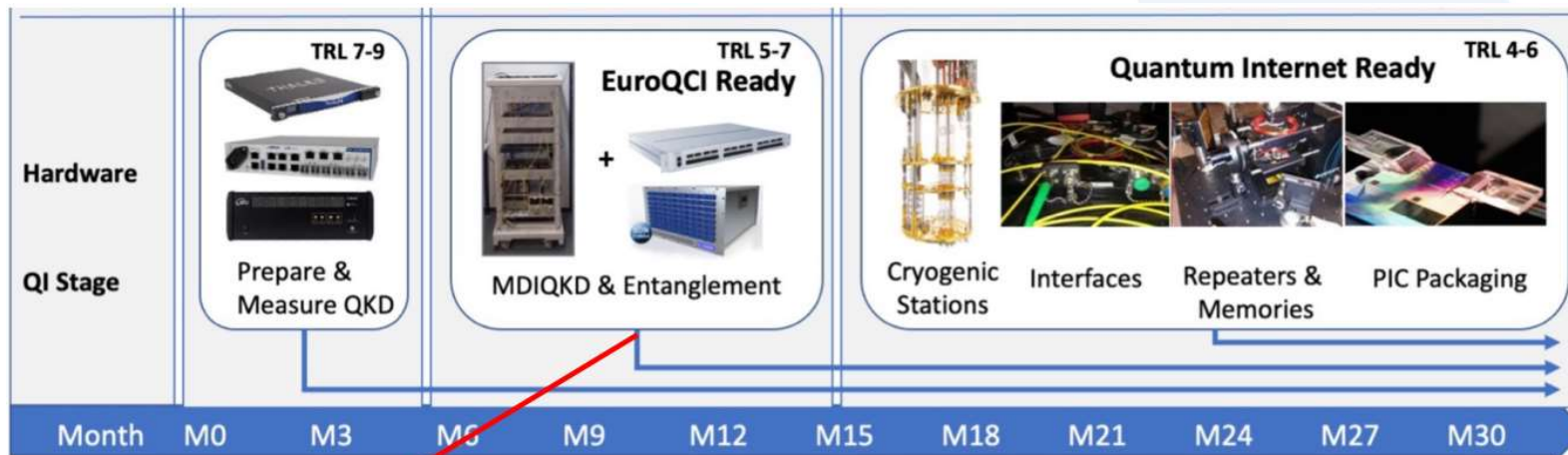


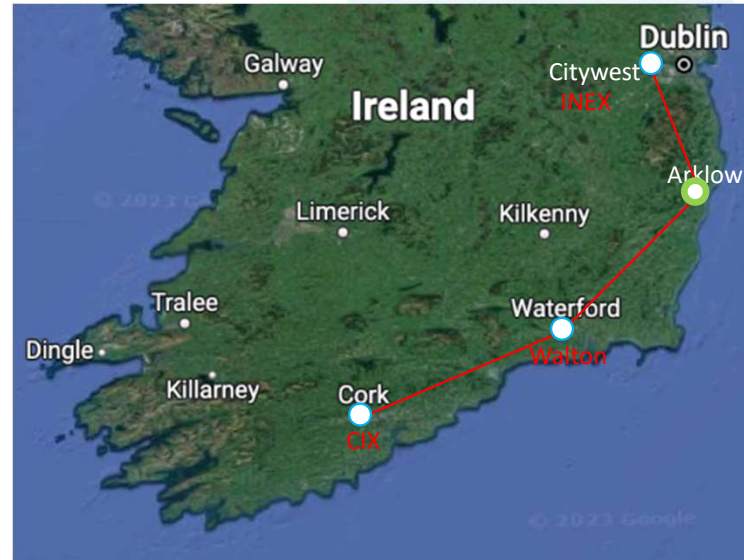
Fig. 2 IrelandQCI roadmap towards EuroQCI and the quantum internet

- External detectors added to extend practical range
- Prepare and Measure and superconducting nanowire single-photon detectors (SNSPD) QKD
- Multipoint-2-Multipoint (MP2MP) QKD Links
- Using Measurement Device Independent (MDI) QKD – with Core Nodes and End Nodes
- Bi-directional star topologies, with star to star connectivity
- Integrate with OTS Encryption (transmission, IPsec, MACsec) and Key Management Devices

Quantum Network Evolution

National Backbone Network

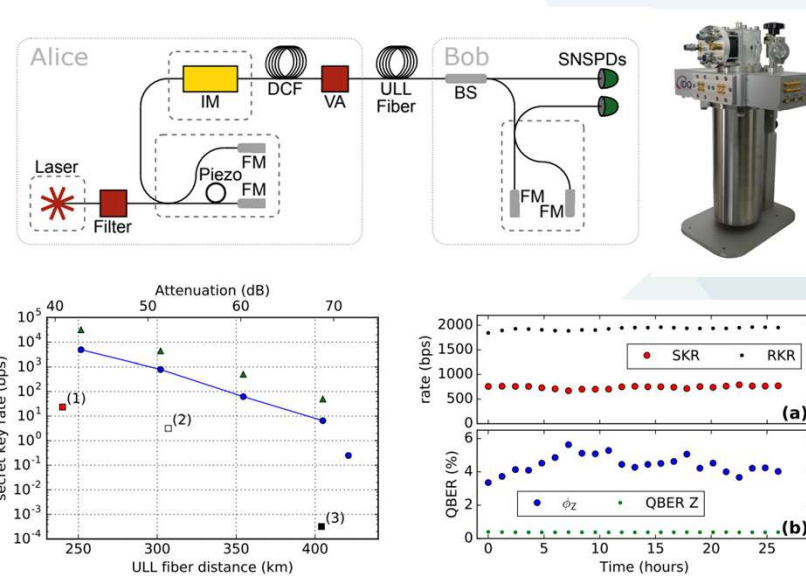
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Prepare and Measure SNSPD

Geneva (Laboratory)



- Phase-randomised pulsed laser diode 2.5 GHz
- 3 state time-bin, one decoy
- Modulating optical phase & intensity
- IDQuantique Quantis QRNG
- ULL single-mode fibre 0.16 dB/km loss
- SNSPDs @ 0.8 K
- Secure key rate 6.5 b/s over 405 km

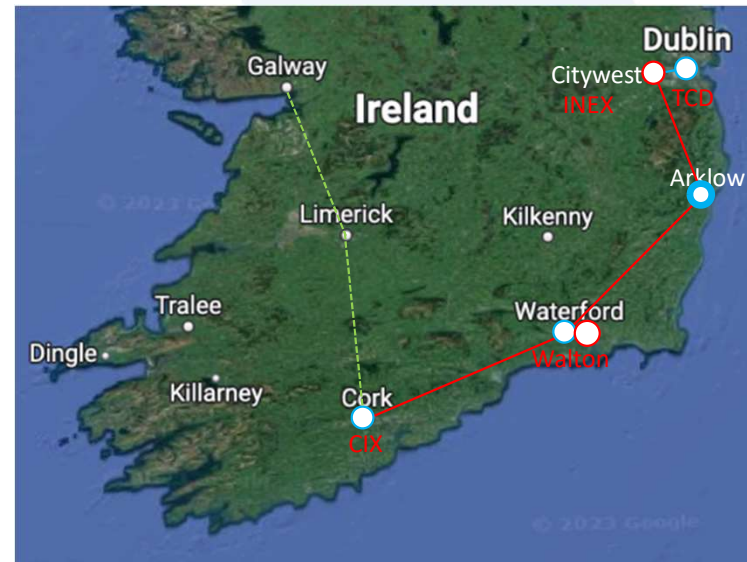


Boaron, A. *et al. Phys. Rev. Lett.* (2018)
[1807.03222.pdf \(arxiv.org\)](https://arxiv.org/abs/1807.03222)

Quantum Network Evolution

National Backbone Network

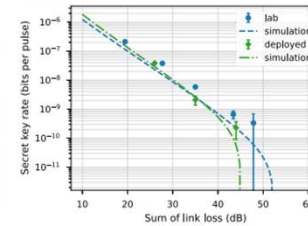
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Measurement Device Independent

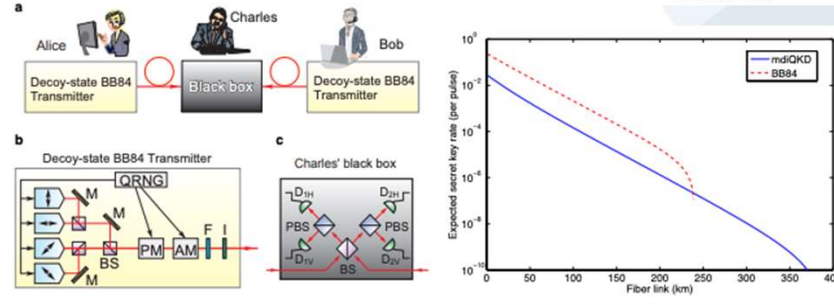
Netherlands

- End nodes (Alice, Bob)
- Centre node SNSPDs
- Decoy state BB84
- 10 Gb/s traffic over all links
- 50 dB attenuation,
- ~250 km spooled fiber



Network Performance

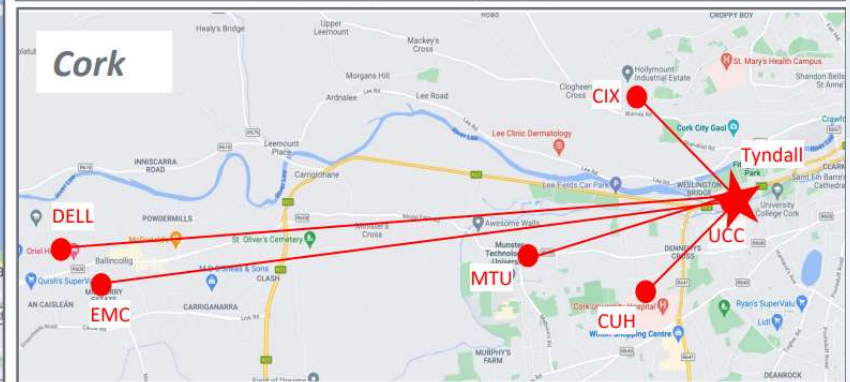
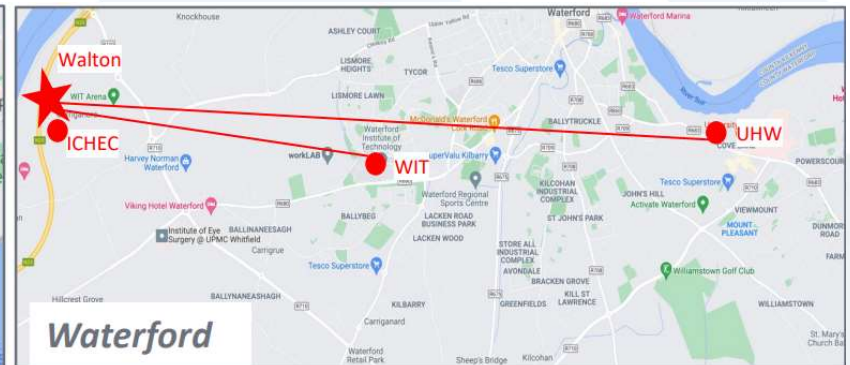
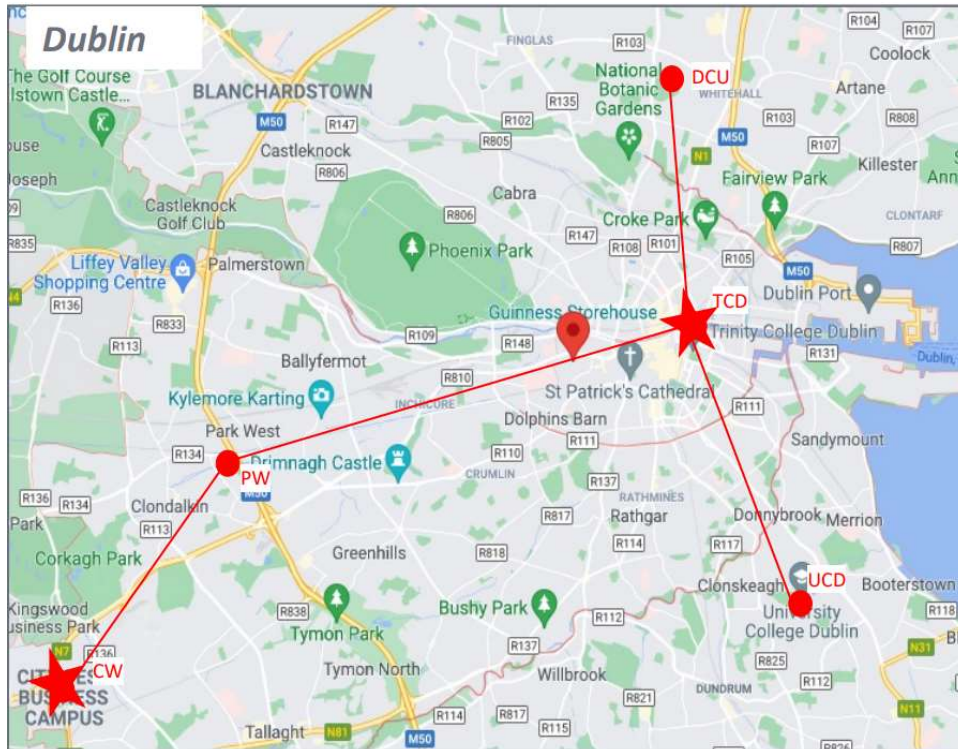
Number of nodes	3
Longest link (loss)	14.7 km (13 dB)
Operation Period	14 days
Data multiplexing	yes
Data bandwidth	10 Gbps



Lo, H. *et al. Nat. Photonics* (2014)
 Berrevoets, R. C. *et al. Commun. Phys.* (2022)



Metro MDI-QKD Pilots



MDI-QKD Star topology
Centre Node – Complex/Expensive hardware

Quantum Network Evolution

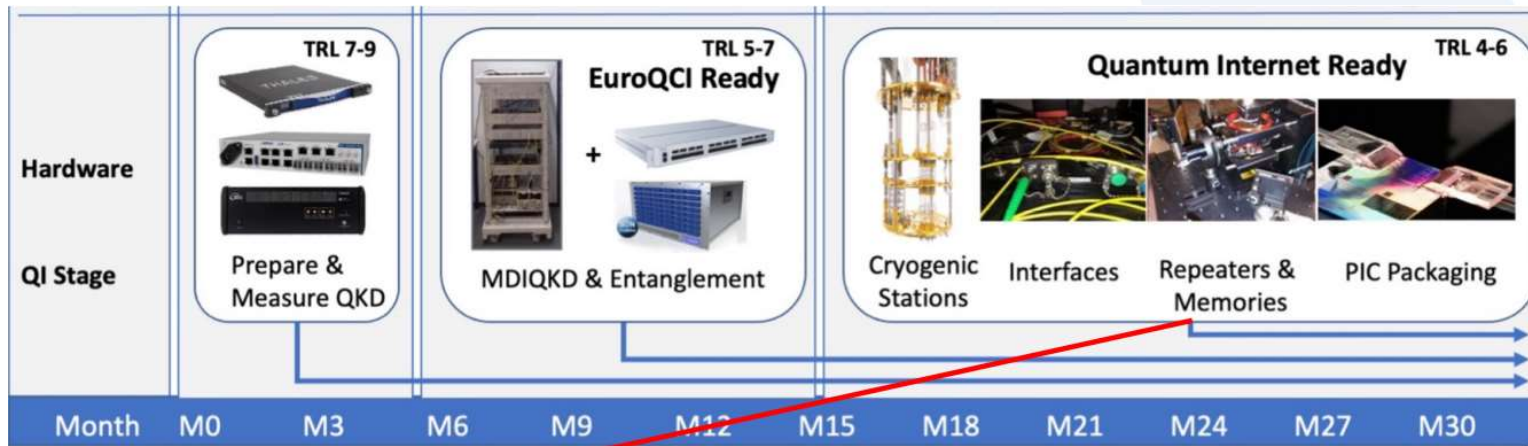


Fig. 2 IrelandQCI roadmap towards EuroQCI and the quantum internet

- Quantum Memories & Quantum Repeaters
- Interface with entanglement pair sources (EPS) and detectors in dilution refrigerators
- EPS to replace MDI End-Nodes
- MDI-QKD Core Nodes upgrade
- Quantum Packaging
- Create integrated quantum photonics that will be tested within the dilution refrigerators operated on the EuroQCI network



Thank you

Any questions?

