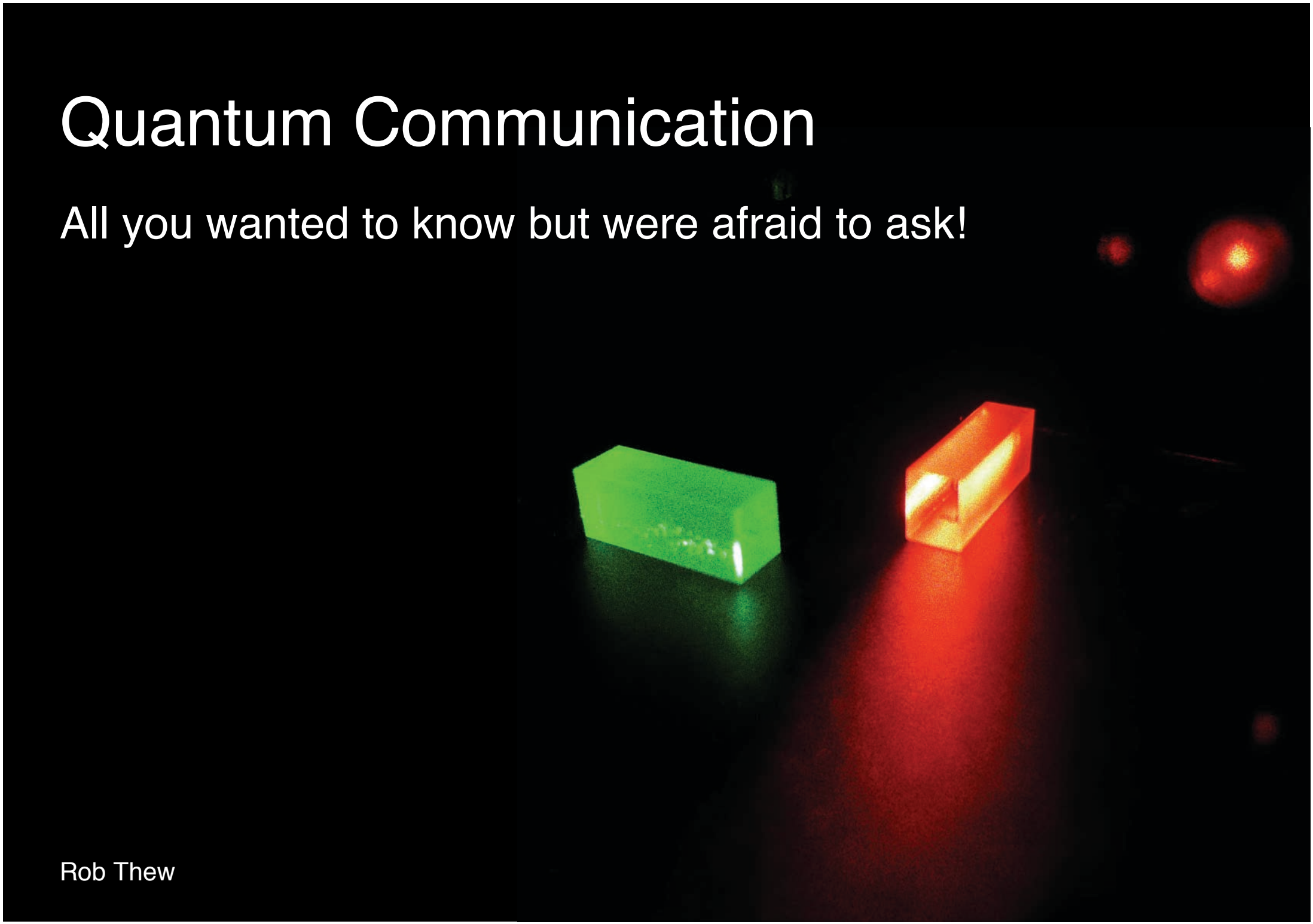
Quantum Communication

All you wanted to know but were afraid to ask!



Rob Thew

What is Quantum Communication?

Playing with quantum particles to improve today's communication technologies.

What is Quantum Key Distribution or Quantum Cryptography?

Securing communication – like your credit card details.

What is the challenge?

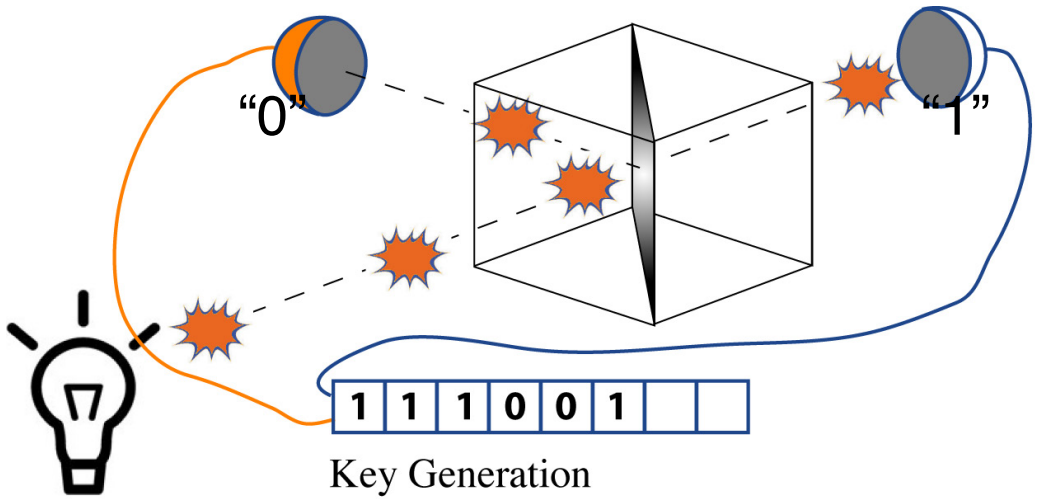
Private and secure communication on a global scale.

What do we need?

The generation of truly random numbers.

Quantum Random Number Generation (QRNG).

Randomness guaranteed by Nature!



Commercially available for almost 10 years.

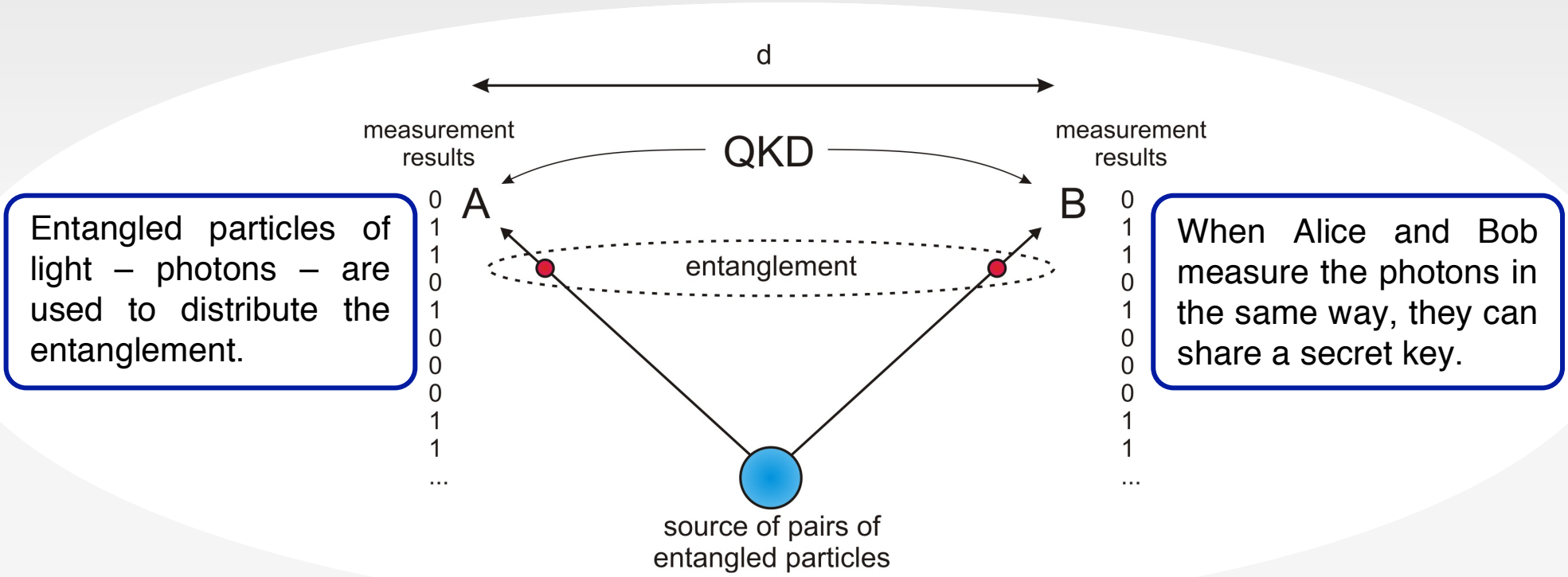
Randomness guaranteed by Nature? Like light hitting the surface of a lake - each photon randomly chooses to be reflected or transmitted at the water surface of a lake, or in our case, a glass.

…and then?

It is not enough to just generate random numbers.
You want to share the same set of random numbers, for example, with your bank.

Quantum Key Distribution (QKD)

The Distribution of “shared” private and secret randomness – a secret key!



Entangled particles of light – photons – are used to distribute the entanglement.

When Alice and Bob measure the photons in the same way, they can share a secret key.

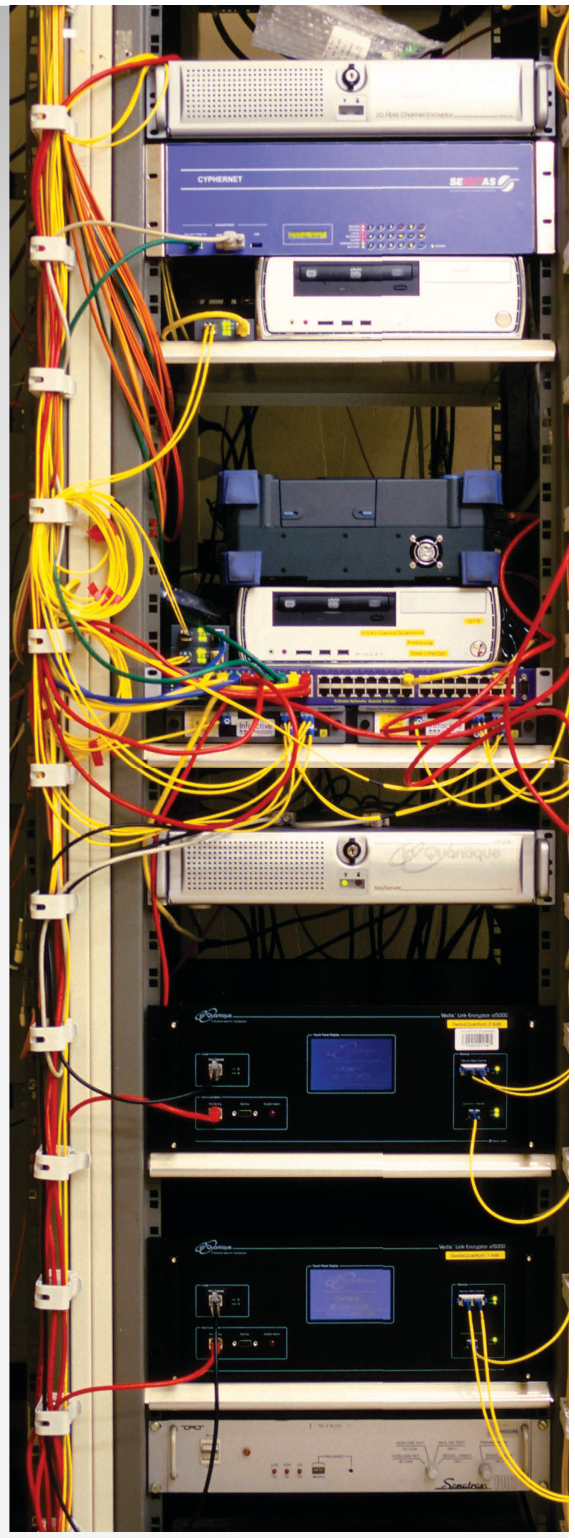
Entanglement can exists, in principle, independent of the distance.
If a spy tries to measure it, the entanglement is destroyed, revealing their presence, and ensuring the security of the communication channel.

QKD systems in a typical telecommunication rack.

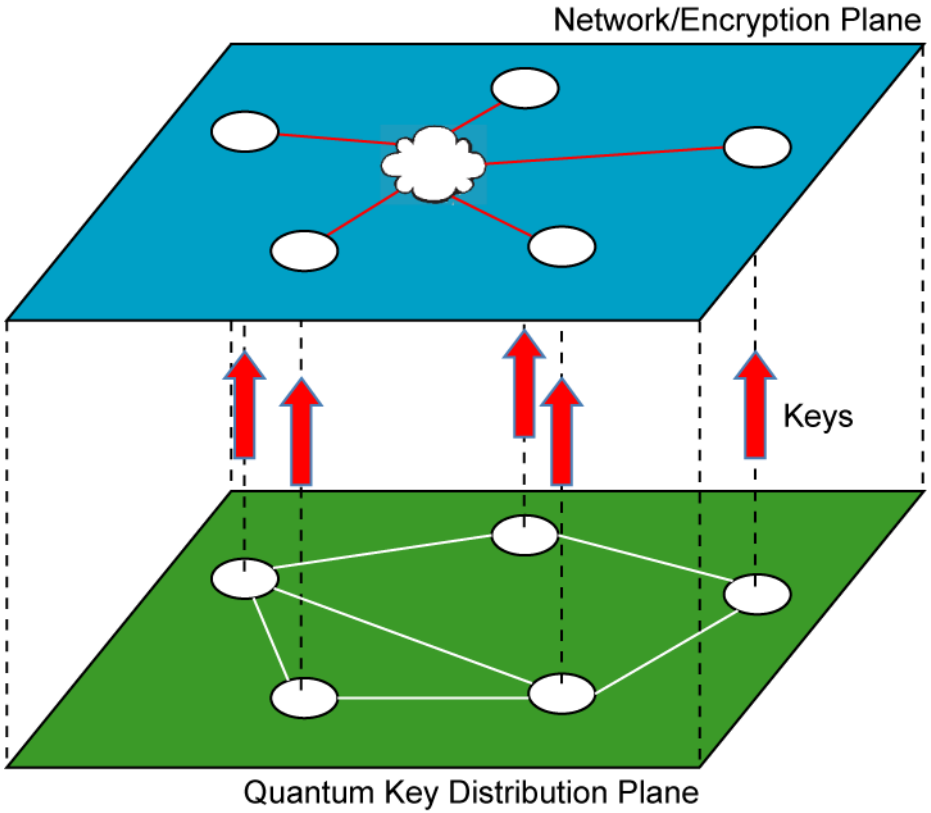
From the SwissQuantum demonstration system.

swissquantum.idquantique.com

The SwissQuantum network linked CERN, the University of Geneva and the Engineering school in a triangular network in the Swiss city of Geneva.
It ran continuously for nearly two years: 2009 - 2011.



The technology goes straight into your local telecommunication network



QKD allows secure transmission of secret keys, which are then used by cryptographic applications like encryption.

Commercial systems are currently installed and running
24 hours a day, every day of the year in countries all around the world.

What about long distance communication?

Loss is a problem …

Optical signals – both classic and quantum - travelling through fibre optic cables are absorbed, or scattered, like light travelling through water.

In normal networks, optical amplifiers are used to “boost” the signal, but for quantum systems this is not possible – in fact it is a point that is critical to the security of QKD.

Current commercial QKD systems are limited to < 100km

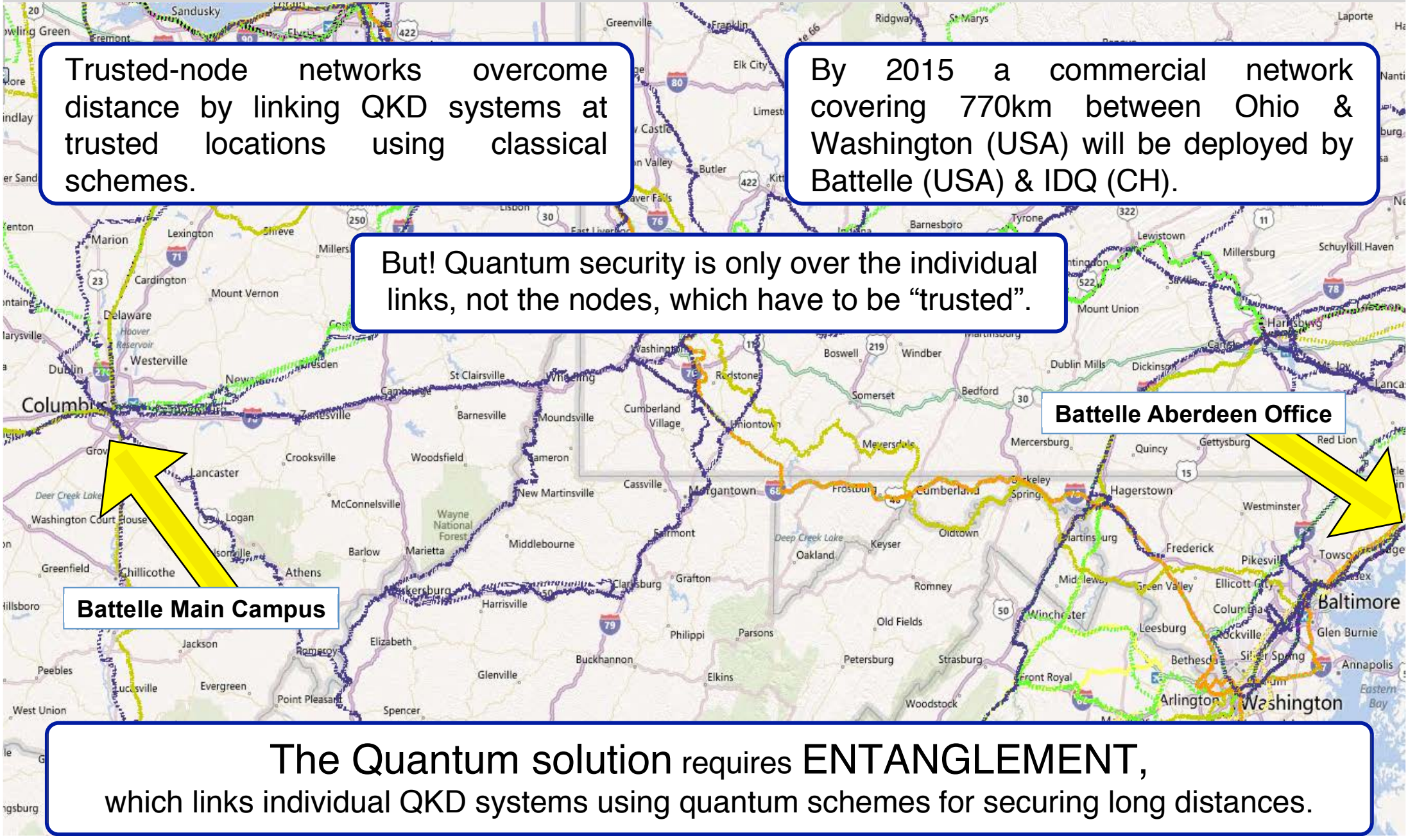
Experimental demonstrations have shown up to 200-250km

Trusted-Node Networks

Trusted-node networks overcome distance by linking QKD systems at trusted locations using classical schemes.

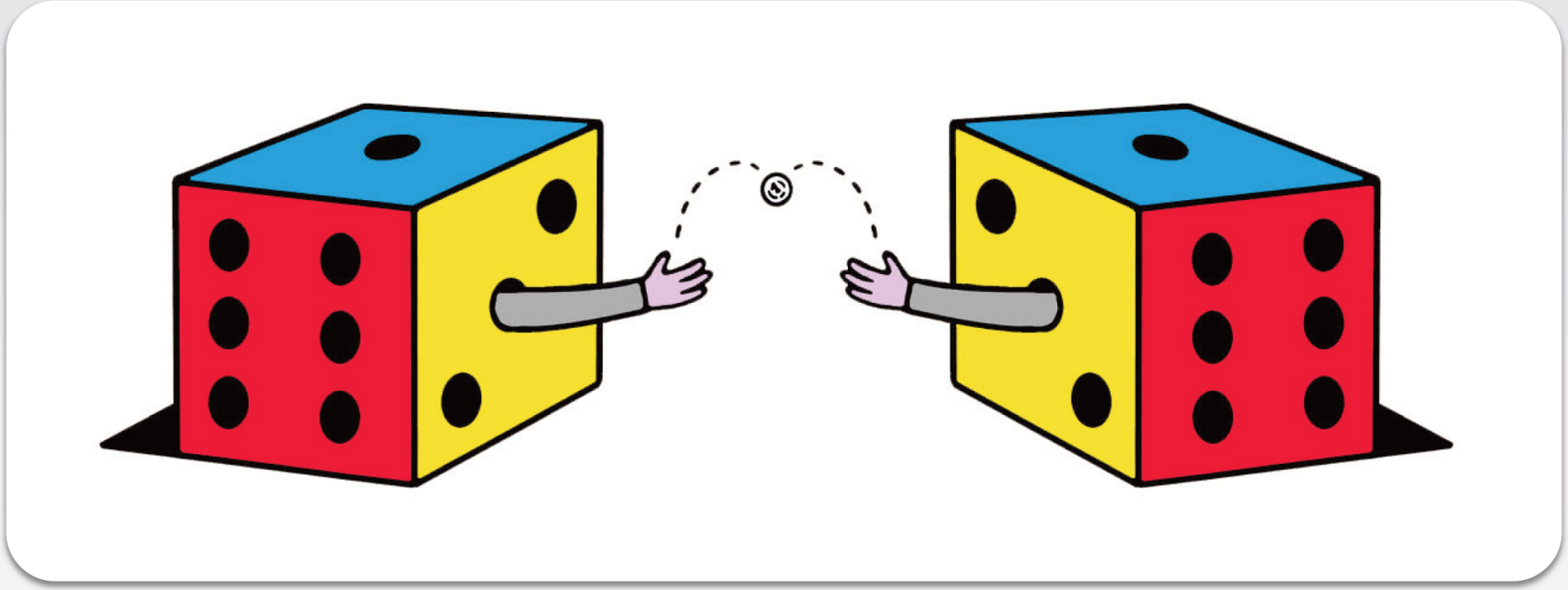
By 2015 a commercial network covering 770km between Ohio & Washington (USA) will be deployed by Battelle (USA) & IDQ (CH).

But! Quantum security is only over the individual links, not the nodes, which have to be “trusted”.



The Quantum solution requires ENTANGLEMENT,
which links individual QKD systems using quantum schemes for securing long distances.

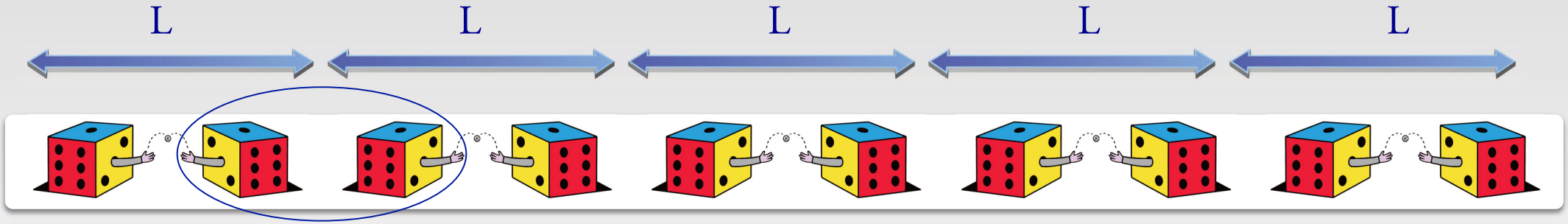
ENTANGLEMENT is like two people tossing a coin at distant locations…



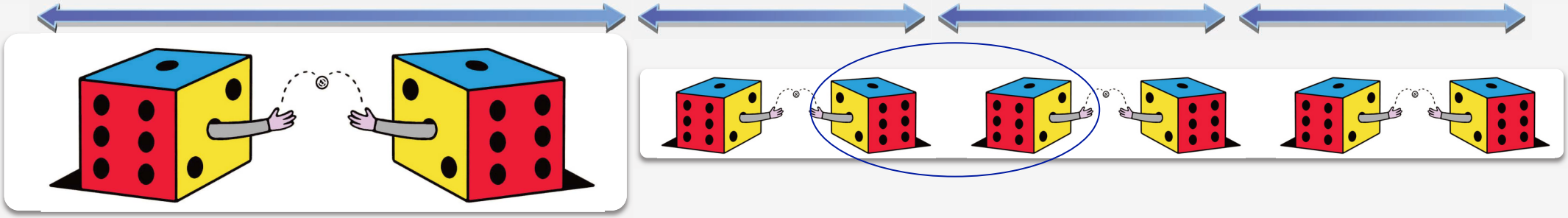
The outcome is completely random, but it is the same outcome in both locations!

Quantum Repeaters

Making a chain of quantum links to extend the distribution range of entanglement.

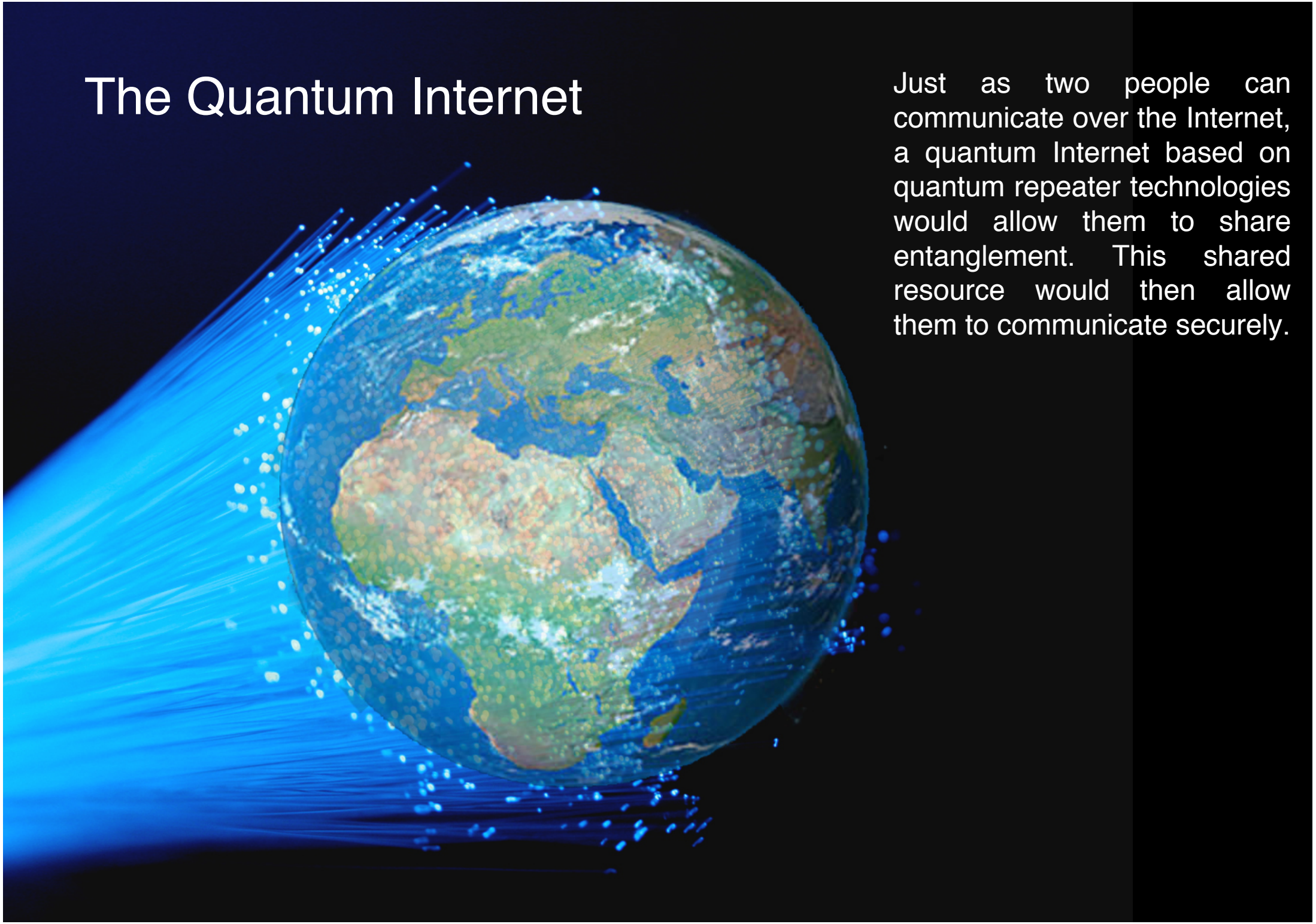


A measurement between two adjacent links, joins them and extends the distance.



Shared & secret randomness for security over long distances.

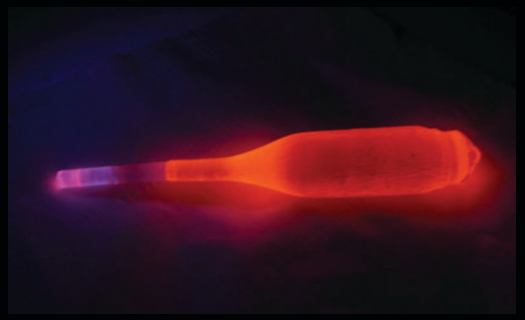
The Quantum Internet



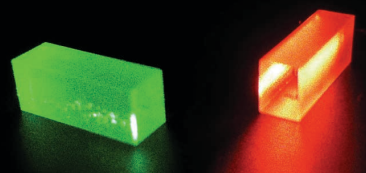
Just as two people can communicate over the Internet, a quantum Internet based on quantum repeater technologies would allow them to share entanglement. This shared resource would then allow them to communicate securely.

Quantum memories

First we grow the crystals!

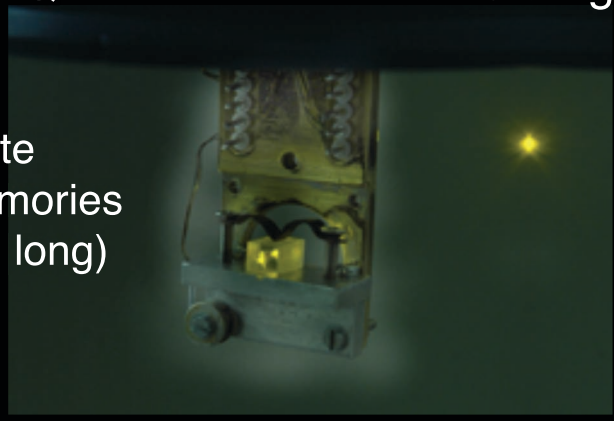


Then cut & polish the crystals.



Solid state
Quantum memories
(around 1cm long)

Quantum information storage.

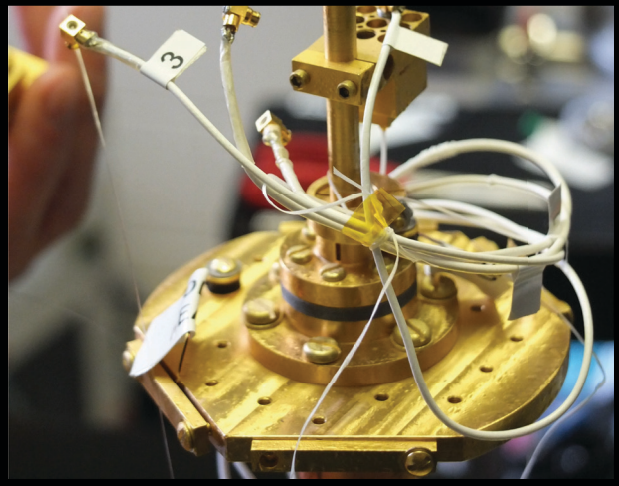


To build a Quantum Internet…

Entanglement

Efficient and compact photon sources.

Measurement



Capable of detecting single photons

For more info on Quantum Repeaters and Quantum Communication:

QuantumRepeaters.eu

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QuReP

Quantum Repeaters for Long Distance Fibre-Based Quantum Communication

SEVENTH FRAMEWORK PROGRAMME