

QUICFIRE - Quantum Internet Components in Fibre-Integrated Realisation for Low-Loss Entanglement Distribution

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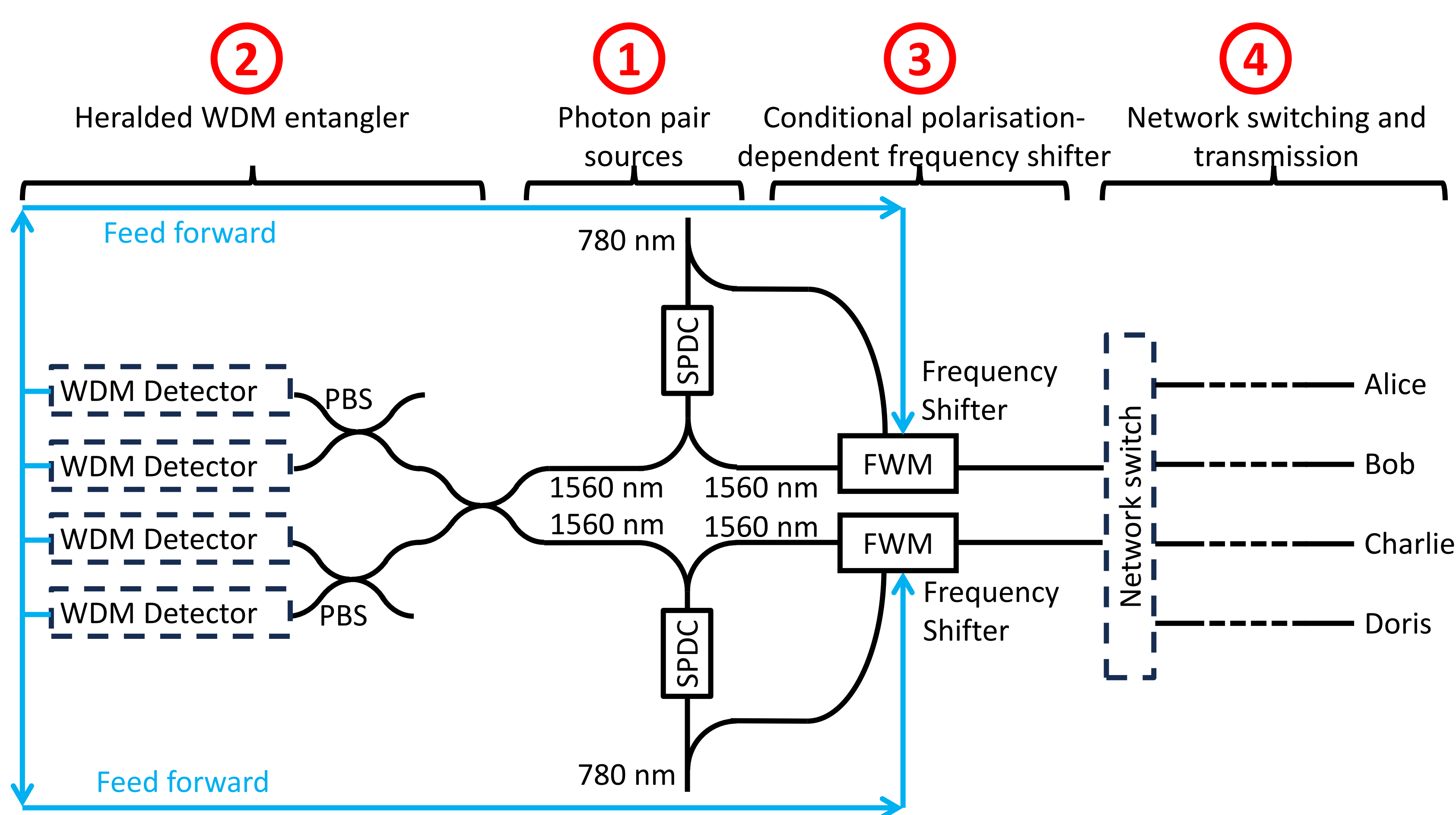
We will develop and demonstrate a new architecture for high-fidelity quantum entanglement distribution at high repetition rate over fibre networks. The scheme exploits fast, efficient, and fibre-integrated heralded sources of entangled photon pairs, fast and low-loss fibre switches, and a novel architecture for single-photon frequency-multiplexing.

Brief technical summary

Spontaneous down conversion is an established method for the generation of entangled photon pairs. However, the achievable bit rate is generally low because most time bins are empty to avoid sending multiple photons. Frequency multiplexing can mitigate this and allow much higher pump powers and thus higher photon pair creation rates in a scheme called ZALM (zero-added loss multiplexing) [1-3]. QUICFIRE will implement ZALM with a much more hardware-efficient embodiment and a simplified network structure than proposed in [1-2].

Objectives

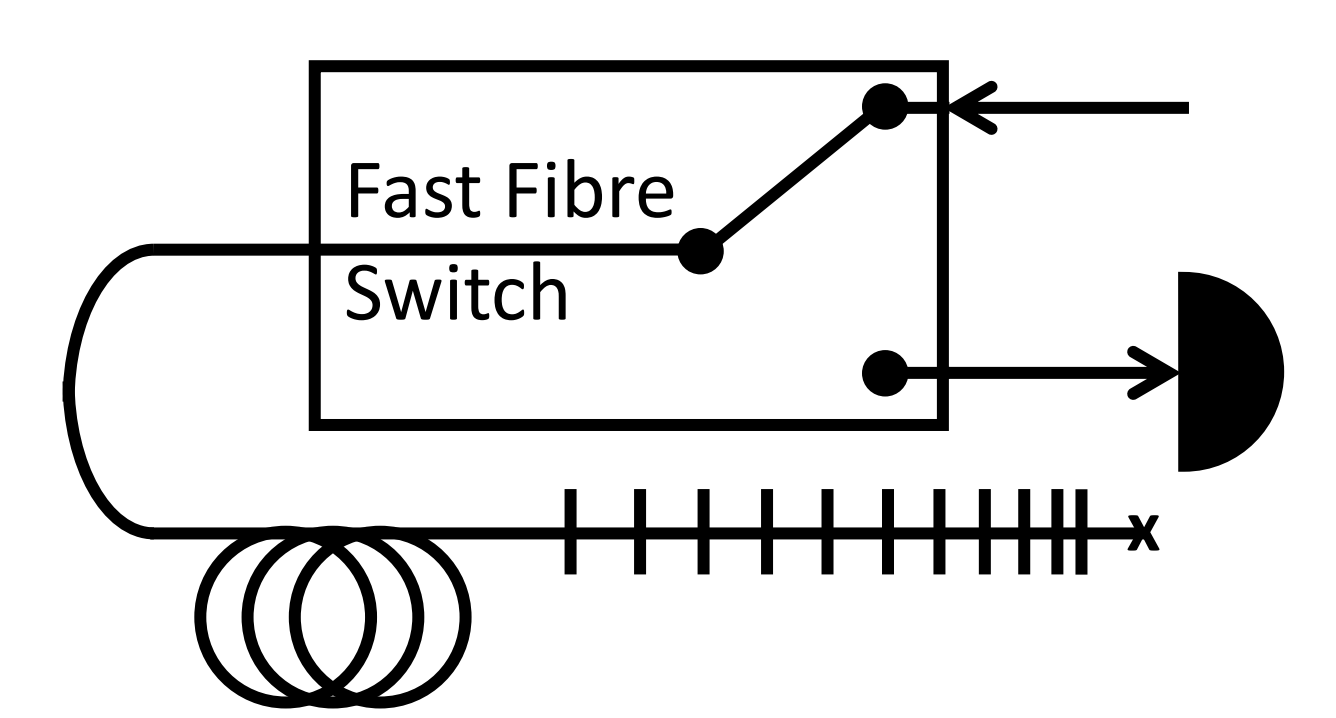
- Fast polarisation-entangled photon pair sources with fiberised frequency-resolved heralding.
- Low-loss all-fibre switches, with modulation times in the 10s of nanoseconds.
- Switchable all-fibre single photon frequency conversion at the sender.
- First experimental demonstration of such a fast entanglement distribution scheme.
- Full theoretical and numerical modelling of the system for performance optimisation.
- Industry-led feasibility evaluation and roadmap to future commercial use.



1 Photon pair sources: High repetition rate short-pulse 780 nm source generates broadband polarisation-entangled photon pairs at 1560 nm.

2 Heralded WDM entangler: Bell-measurement on the two idler photons entangles the output signal photons. Chirped fibre Bragg gratings perform frequency-to-time mapping [4], time-resolved single photon detection thus leads to frequency multiplexing.

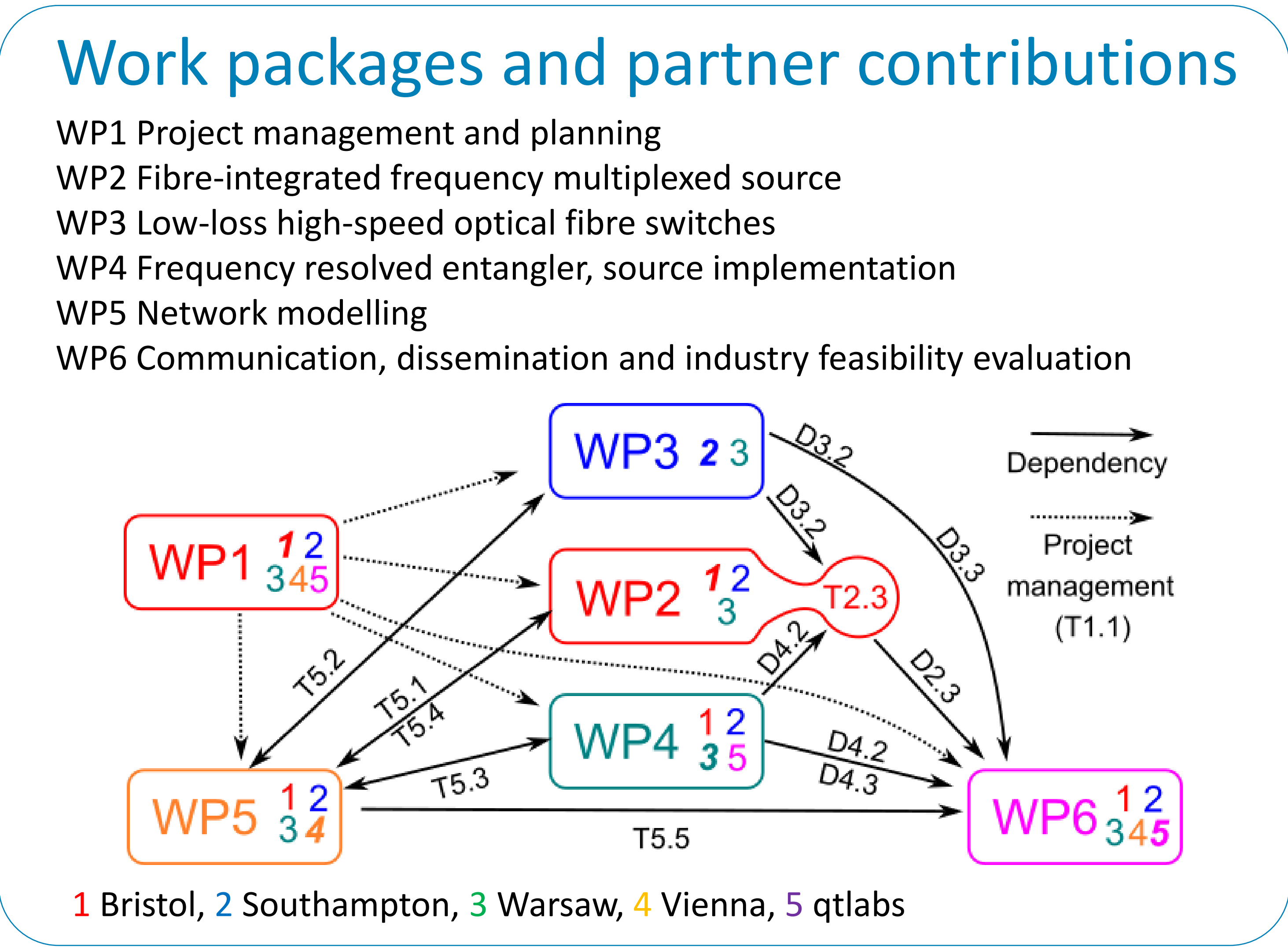
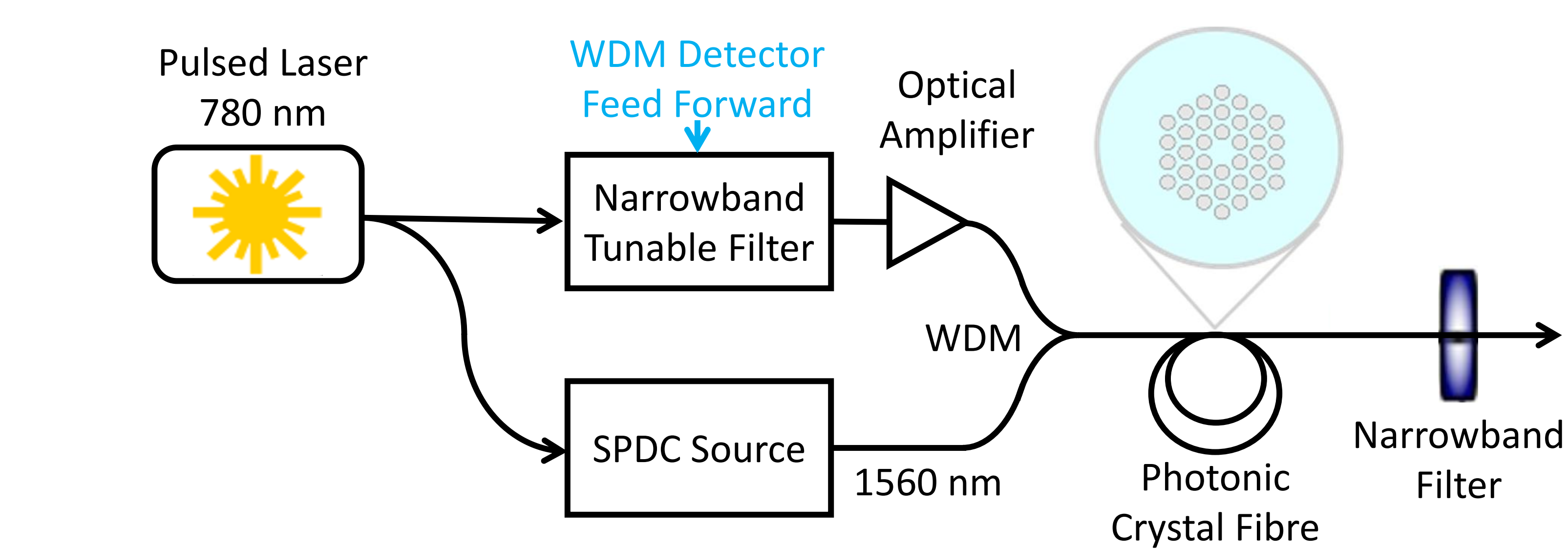
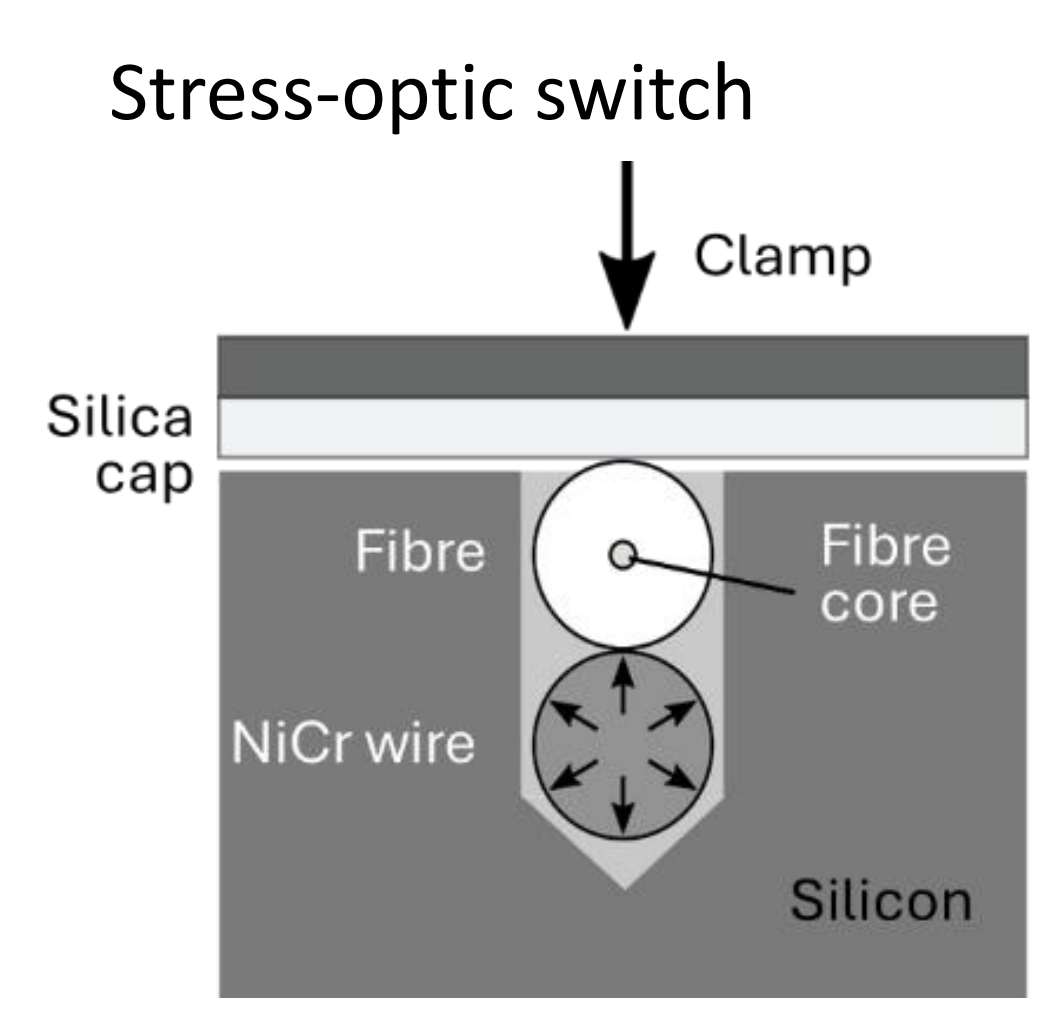
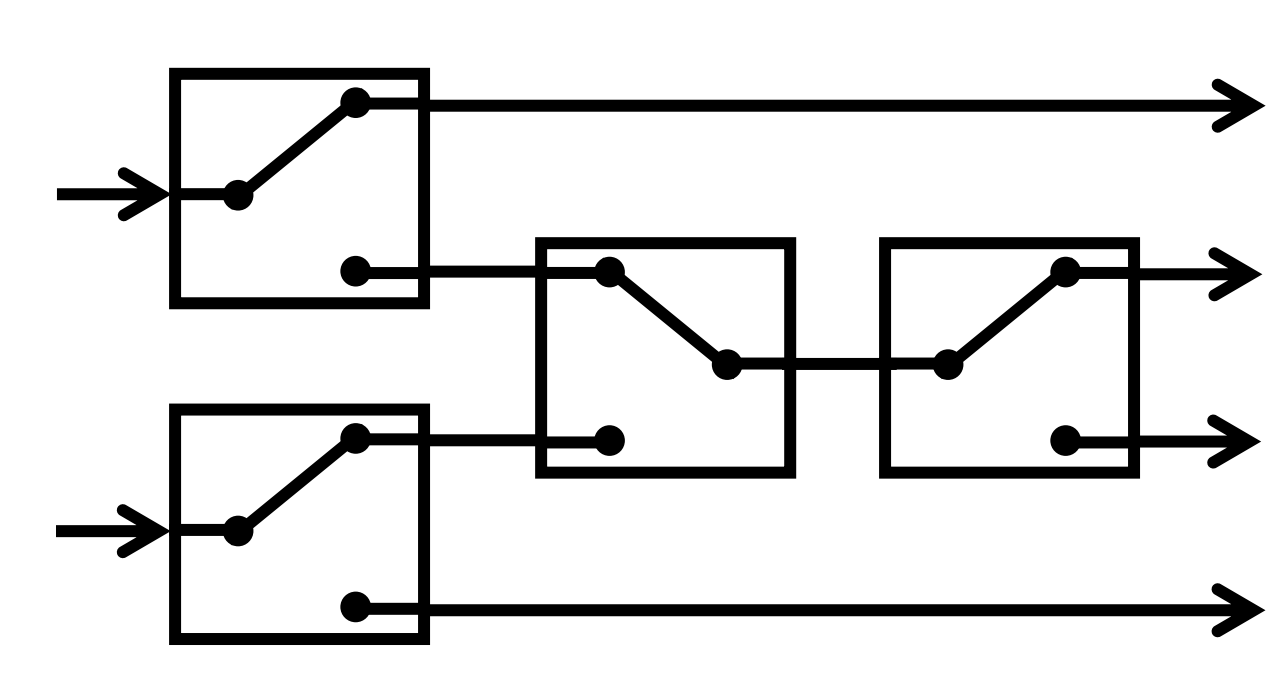
WDM Detector



3 Conditional polarisation-dependent frequency shifter: Based on the frequency measurement of (2), the H and V polarised components of the signal photons are frequency shifted such that all output photons are always at the same wavelength.

4 Network switching and transmission: The signal photons are routed to a pair of end users A-D by fast low-loss fiberised stress-optic switches [5].

Network switch



Impact

- Robust and reliable all-fibre technology** allows for seamless integration with existing fibre networks and future low-loss hollow-core fibres. Robustness of devices also crucial for satellite-base quantum technology.
- Realisation of factor 10** [1] or even orders of magnitude [3] improvement in entanglement distribution rates compared to current record of 9 bit/s over 248 km [6].
- First demonstration** of ZALM scheme, ensuring European leadership in this crucial network infrastructure of the future.
- Low-loss fibre switches** reducing the loss per switch from current 0.4 dB to 0.1 dB, implying a loss reduction by 50% for 10 switching actions and by a factor of 1000 for a network including 100 switches.
- Fibre-based wavelength conversion technology** can also be exploited for interfacing different quantum architectures, e.g., telecommunication wavelength photons (1550 nm), NV centres in diamond (637 nm), neutral atoms (Rb: 780 nm), ions (Ca: 397nm, 854nm) etc.