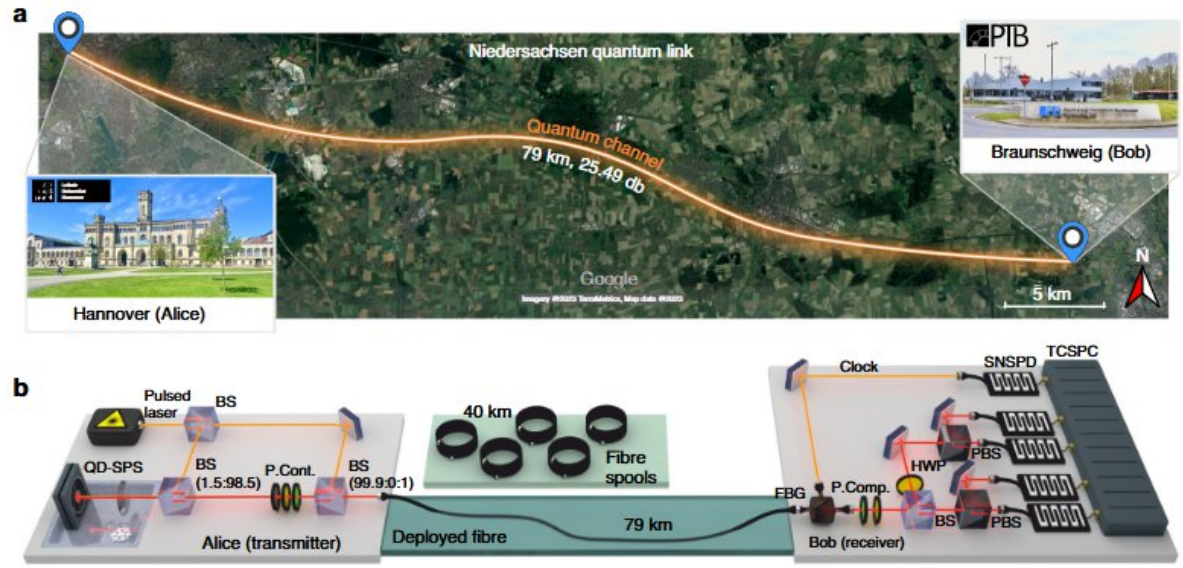
Niedersachsen Quantum Link / PTB Time & Frequency Link

This testbed consists of a 78 km long pair of dark fibers between the cities of Hannover and Braunschweig and is operated by the Physikalisch-Technische Bundesanstalt and the Leibniz Universität Hannover. One of the dark fibers (losses approx. 22 dB) is reserved for “quantum” applications, while the second fiber (losses approx. 26 dB) is dedicated to the dissemination of time and frequency reference signals as well as classical communication between two sites. This combination of dark “quantum” fiber and integrated time-frequency infrastructure is a unique feature of the Niedersachsen Quantum Link testbed.



A: Brief Information

Testbed Title	Niedersachsen Quantum Link / PTB Time & Frequency Link
Start Point	Leibniz University of Hanover
End point	Physikalisch-Technische Bundesanstalt (PTB)
Institution/ Organization	Physikalisch-Technische Bundesanstalt (PTB) Leibniz University of Hanover (LUH)
Contact	Prof. Dr. Stefan Kück: stefan.kueck@ptb.de
	Prof. Dr. Fei Ding: f.ding@fkp.uni-hannover.de
Status	active

B: Technical Information

Type of Transmission	dark fiber
Length [km]	78

1 Demonstration achieved through the collaborative project involving LUH, the University of Stuttgart and PTB

Losses [dB]	22 (quantum signals), 26 (T &F signals)
Supported Wavelengths [nm]	C-Band, CH44, O-band (1310 nm) to C-band (1565 nm)
Type of Fiber	single mode
Type of Deployment	underground
Polarization Stabilization	No
Quantum Communication Infrastructure	entangled photon source with center wavelength at 807 nm plus 1560 nm for quantum communication; Telecom C-band single photon sources, polarization detection and superconducting-nanowire single photon detectors (O-band to C-band)
Available Infrastructure for external Parties	time & frequency infrastructure (dark fiber) single and entangled photon sources & detectors Lasers, TCSPC, polarization en-/decoding. synchronization infrastructures: based on Electronically stabilized time and frequency (ELSTAB) and White Rabbit technologies are available and can be used for quantum communication. classical communications infrastructure: which includes separate VLANs for time-frequency and QKD devices management. A VLAN for the QKD user data traffic can also be configured. DWDM/CDWM infrastructure: for multiplexing/demultiplexing signals of different services. optical switching infrastructure: for flexible remote management of the transmission of QKD and Time-frequency signals.

C: Additional information

Linked Projects	• QR.X: https://quantenrepeater.link/ • QR.N: https://www.forschung-it-sicherheit-kommunikationssysteme.de/projekte/quantenrepeater-net-qr.n • Q.Link.X: https://www.forschung-it-sicherheit-kommunikationssysteme.de/projekte/q-link.x • InterSync: https://gepris.dfg.de/gepris/projekt/491585234?context=projekt&id=491585234&task=showDetail&utm • DE-QOR: https://www.forschung-it-sicherheit-kommunikationssysteme.de/projekte/de-qor
Press Release and Publications	• Niedersachsen quantum communications testbed, 05.2025 • Paving the way for secure quantum communication networks • Quantum leap: Breakthrough for secure communication with “artificial atoms”, 2024

	• High-rate intercity quantum key distribution with a semiconductor single-photon source, 07.2024 • Quantum Dots Power Secure Intercity Communication, 12.2024 • Phase-coherent comparison of two optical frequency standards over 146 km using a telecommunication fiber link, 2009
Demonstrated Milestone	• characterization of polarization, phase fluctuations, loss and reflections profile of the quantum link. • calibration of the fiber link stability between LUH and PTB (loss, polarization, and length fluctuation) • quantum key distribution with entangled photon source over 90 km fiber spool • time and Frequency distribution at minimal intensity over 100 km fiber spool (important with respect of getting T&F and QKD on the same fiber) • installation of multi-node time and frequency distribution system based on White Rabbit technology. The achieved time synchronization accuracy between PTB/Braunschweig and FKP/Hannover is ≈ 18±140 ps.
Outlook	• demonstration of quantum communication over PTB-LUH link with single and entangled photon sources • time- and frequency synchronized quantum communication over PTB-LUH link with single and entangled photon sources • multiplexing of quantum signals and time/frequency signals on same fiber • testing, development and optimization of entangled photon sources
Suggested Use Cases	• component characterization at QKD fiber testbed • test of QKD transmitters and receivers

Video: Quantum Key Distribution using quantum dots light Animation[1]

Figure 1: Time Tagger

Figure 2: Laser

Figure 3: SNSPD

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Figure 4: QKD BB84