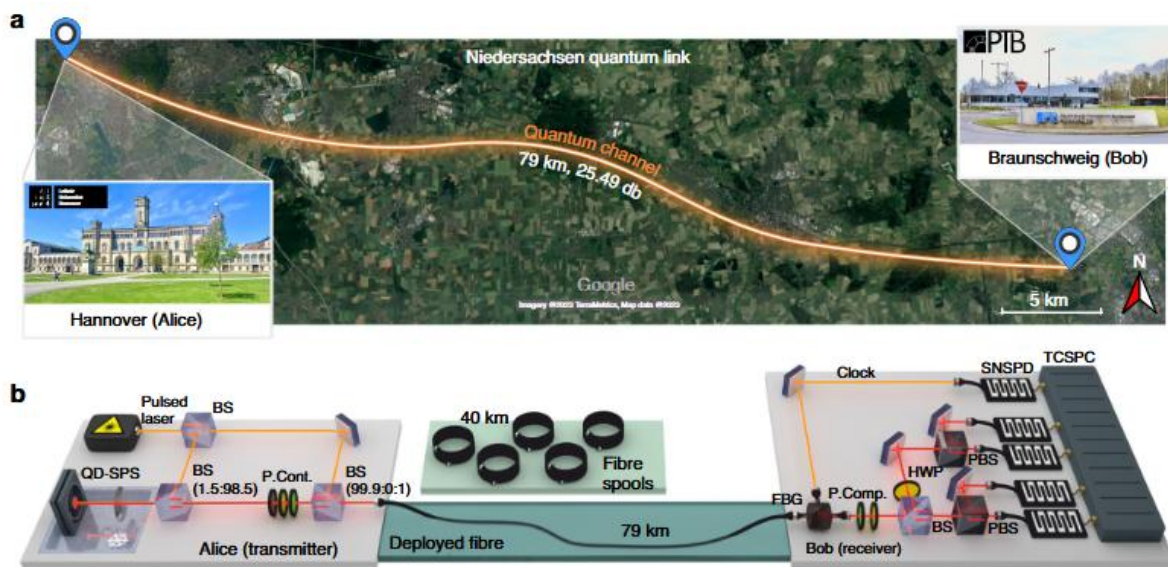


## Niedersachsen Quantum Link / PTB Time & Frequency Link



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

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

### B: Technical Information

<b>Type of Transmission</b>	dark fiber
<b>Length [km]</b>	78
<b>Losses [dB]</b>	22 (quantum signals), 26 (T & F signals)

<sup>1</sup> Demonstration achieved through the collaborative project involving LUH, the University of Stuttgart and PTB

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

### C: Additional information

<b>Linked Projects</b>	<ul style="list-style-type: none"> <li>• QR.X: <a href="https://quantenrepeater.link/">https://quantenrepeater.link/</a></li> <li>• QR.N: <a href="https://www.forschung-it-sicherheit-kommunikationssysteme.de/projekte/quantenrepeater-net-qr.n">https://www.forschung-it-sicherheit-kommunikationssysteme.de/projekte/quantenrepeater-net-qr.n</a></li> <li>• Q.Link.X: <a href="https://www.forschung-it-sicherheit-kommunikationssysteme.de/projekte/q-link.x">https://www.forschung-it-sicherheit-kommunikationssysteme.de/projekte/q-link.x</a></li> <li>• InterSync: <a href="https://gepris.dfg.de/gepris/projekt/491585234?context=projekt&amp;id=491585234&amp;task=showDetail&amp;utm">https://gepris.dfg.de/gepris/projekt/491585234?context=projekt&amp;id=491585234&amp;task=showDetail&amp;utm</a></li> <li>• DE-QOR: <a href="https://www.forschung-it-sicherheit-kommunikationssysteme.de/projekte/de-qor">https://www.forschung-it-sicherheit-kommunikationssysteme.de/projekte/de-qor</a></li> </ul>
<b>Press Release and Publications</b>	<ul style="list-style-type: none"> <li>• <a href="#">Niedersachsen quantum communications testbed, 05.2025</a></li> <li>• <a href="#">Paving the way for secure quantum communication networks</a></li> </ul>

	<ul style="list-style-type: none"><li>• <a href="#">Quantum leap: Breakthrough for secure communication with “artificial atoms”, 2024</a></li><li>• <a href="#">High-rate intercity quantum key distribution with a semiconductor single-photon source, 07.2024</a></li><li>• <a href="#">Quantum Dots Power Secure Intercity Communication, 12.2024</a></li><li>• <a href="#">Phase-coherent comparison of two optical frequency standards over 146 km using a telecommunication fiber link, 2009</a></li></ul>
<b>Demonstrated Milestone</b>	<ul style="list-style-type: none"><li>• characterization of polarization, phase fluctuations, loss and reflections profile of the quantum link.</li><li>• calibration of the fiber link stability between LUH and PTB (loss, polarization, and length fluctuation)</li><li>• quantum key distribution with entangled photon source over 90 km fiber spool</li><li>• time and Frequency distribution at minimal intensity over 100 km fiber spool (important with respect of getting T&amp;F and QKD on the same fiber)</li><li>• 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 <math>\approx 18\pm 90</math> ps.</li></ul>
<b>Outlook</b>	<ul style="list-style-type: none"><li>• demonstration of quantum communication over PTB-LUH link with single and entangled photon sources</li><li>• time- and frequency synchronized quantum communication over PTB-LUH link with single and entangled photon sources</li><li>• multiplexing of quantum signals and time/frequency signals on same fiber</li><li>• testing, development and optimization of entangled photon sources</li></ul>
<b>Suggested Use Cases</b>	<ul style="list-style-type: none"><li>• component characterization at QKD fiber testbed</li><li>• test of QKD transmitters and receivers</li></ul>



Video: Quantum Key Distribution using quantum dots light Animation<sup>1</sup>



Figure 1: Time Tagger

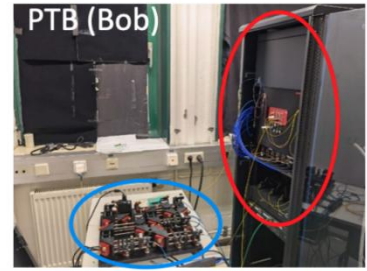
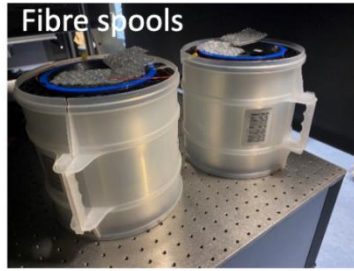
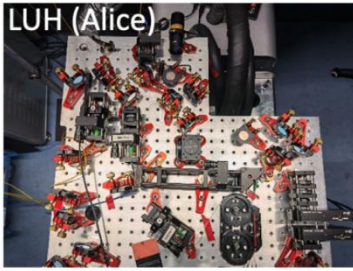


Figure 2: Laser



Figure 3: SNSPD

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j. yang, et al., Light Sci & Applications. 13. 150 (2024)

Figure 4: QKD BB84