

E2E QUANTUM COMMUNICATION AND SYNCHRONIZATION TESTBED

Thales Alenia Space Italia



Date :

Ref :

Rif. Modulo : 83230347-DOC-TAS-IT-010

PROPRIETARY INFORMATION

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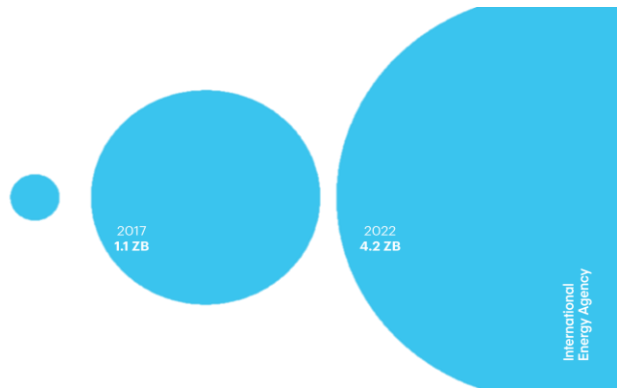
A "SECURELY" GLOBALLY INTERCONNECTED WORLD

The number of connections grows day by day...



- Local fiber network
- Global fiber network
- Free space RF links
- Satellite-to-ground links
- ...

...as well as the amount of exchanged information



- Voice call
- Video call
- Sensitive data
- Military communication
- ...

A non negotiable property in communication protocols is

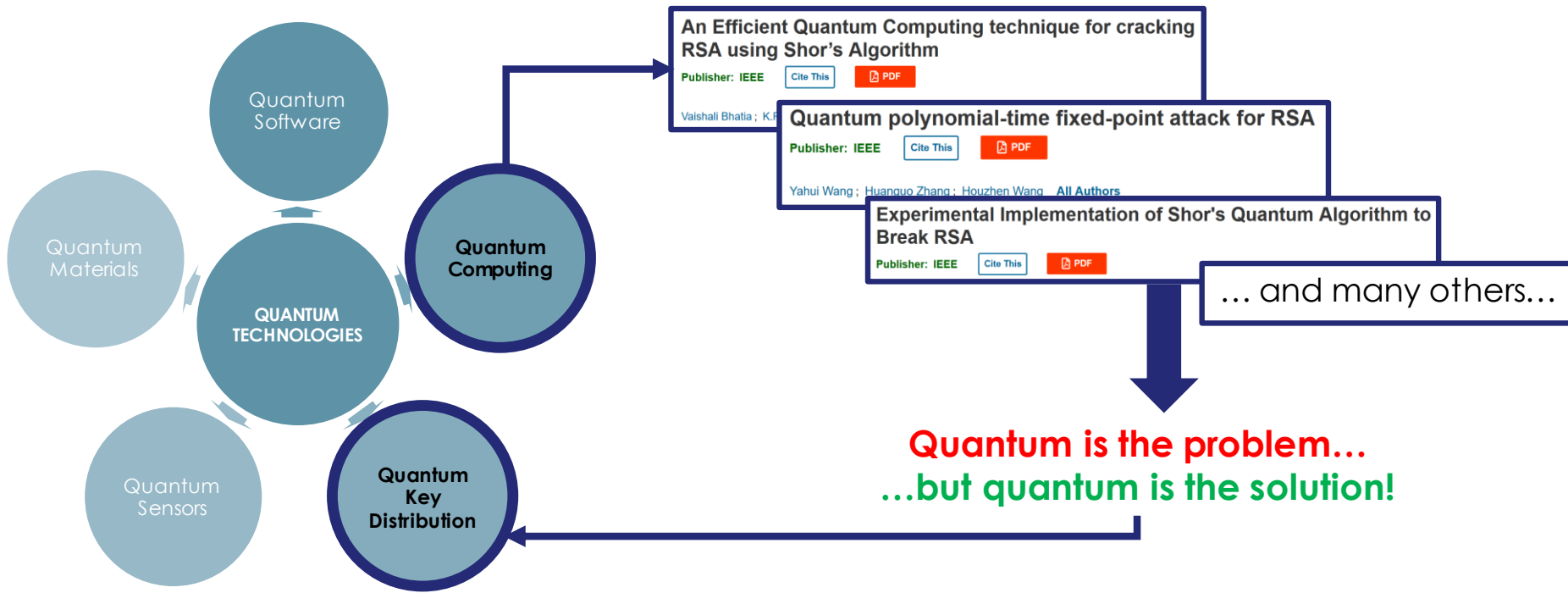
SECURITY



How do we grant it?

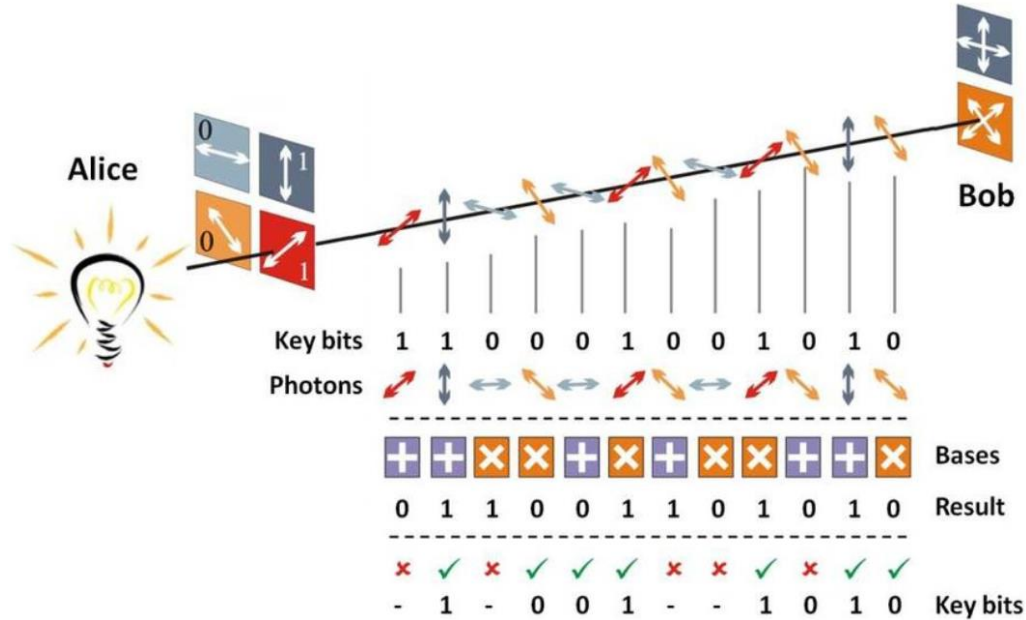
HOW TO SOLVE SECURITY ISSUES?

The quantum revolution is creating a completely new types of security threats...



QKD EXAMPLE – BB84 PROTOCOL

A Crypto-Key Exchange system intrinsically free from unwanted detection and/or recognition is the winning factor of a truly secure data exchange via a Telecom system against state-of-the-art and future threats



Carrasco-Casado, Alberto & Marmol, Veronica & Denisenko, Natalia. (2016). Free-Space Quantum Key Distribution. 10.1007/978-3-319-30201-0_27.

THE NETWORK

13km Fiber Link with INRIM station



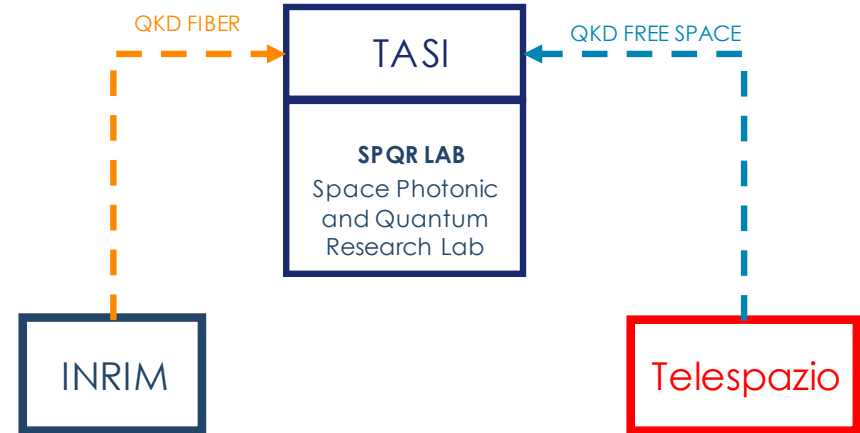
3km Free Space Optics link with Telespazio



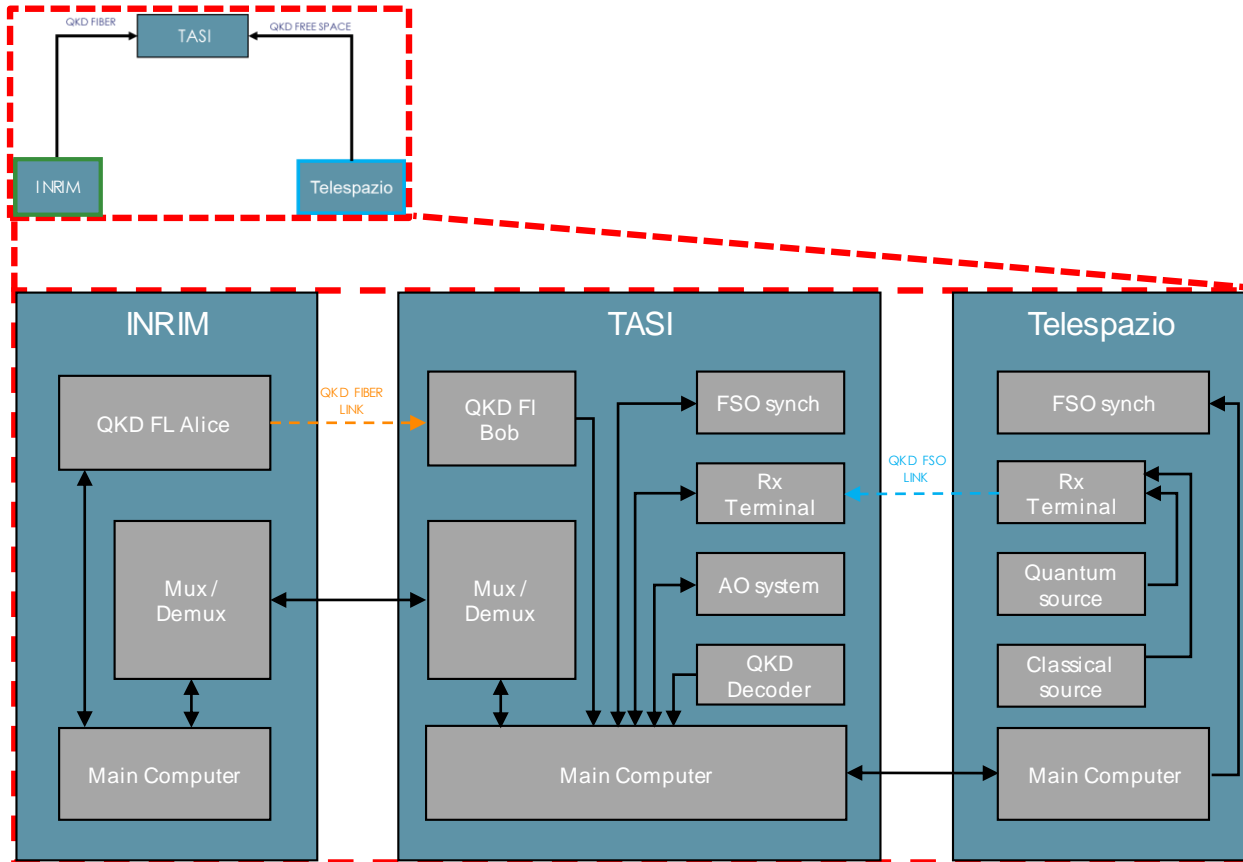
- TASI: trusted node for INRIM and SAPIENZA
- INRIM: performs a QKD session with TASI
- Telespazio: performs a QKD session with TASI



Thales Alenia Space will act as a trusted node to allow quantum secure communication between INRIM and Telespazio



THE NETWORK ARCHITECTURE



Modular approach philosophy

Each node is built following a building-block, modular approach.



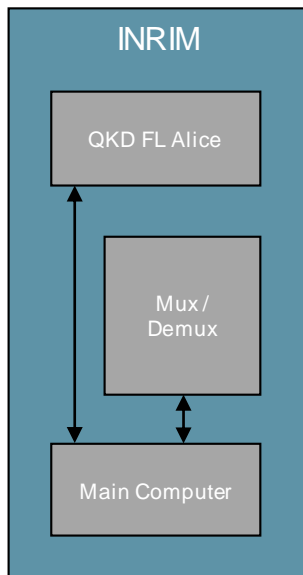
The modular approach allows to easily exchange different realizations of a given building block



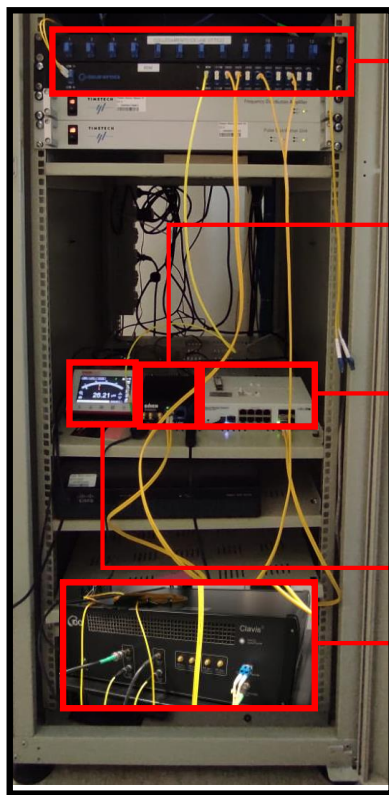
Different technologies can be tested with small modification of the setup!

FIBER LINK SETUP - TRANSMITTER

The fiber link has already been installed and successfully tested



- /// **Mux / Demux:** Passive element for beam managing
- /// **QKD Alice:** QKD module for quantum state exchange
- /// **Main computer:** to organize the complete set of action required by the protocol



MUX/DEMUX: passive optical device used to manage different wavelengths on the same fiber

White Rabbit switch: module for White Rabbit synchronization protocol implementation

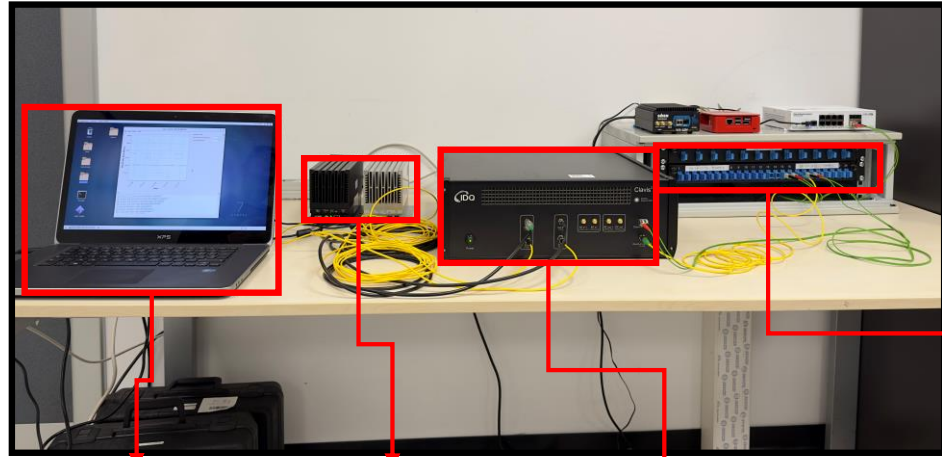
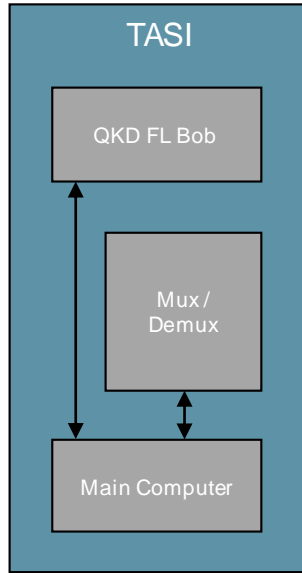
LAN switch: optical transceiver for classical communication over single mode fiber

Power meter: passive optical device used to monitor input and output laser communication power

CLAVIS QKD Alice: QKD device for Alice node. It sends quantum states to the correspondent Bob QKD device

FIBER LINK SETUP - RECEIVER

The fiber link has already been installed and successfully tested



Main computer:
classical computer for postprocessing tasks

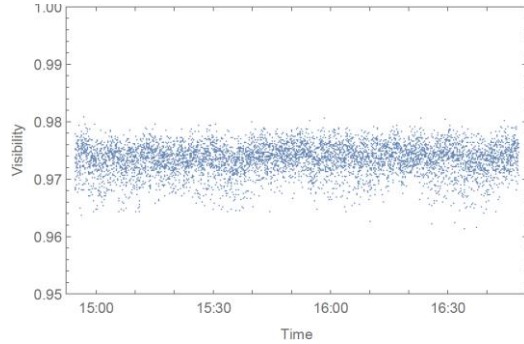
Single Photon Detectors:
InGaAs/InP avalanche photodiodes for single photon detection

CLAVIS Bob:
QKD device for Bob node. It receives quantum states from the correspondent Alice QKD device

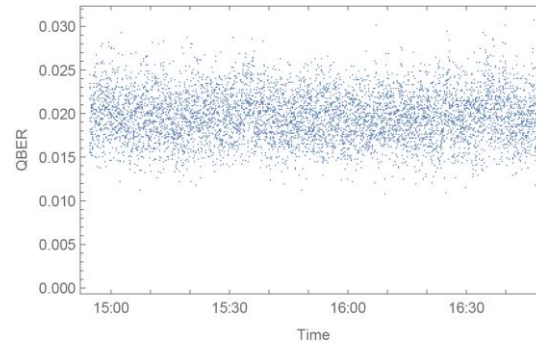
MUX/DEMUX:
passive optical device used to manage different wavelengths on the same fiber

- /// **Mux / Demux:** Passive element for beam managing
- /// **QKD Bob:** QKD module for quantum state exchange
- /// **Main computer:** to organize the complete set of action required by the protocol

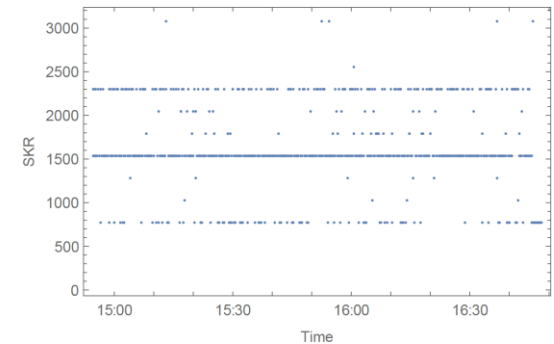
FIBER LINK – RESULTS



Visibility estimation: The visibility of the receiver setup is estimated and the optimal values of the parameters are found



QBER minimization: the QBER minimization step allows to optimize the internal settings of the QKD system internal components



Key exchange: The key exchange procedure is performed after the previous steps are completed

FREE SPACE LINK – LINE OF SIGHT

To establish a free space optical link a line of sight shall exist



TPZ from TASI

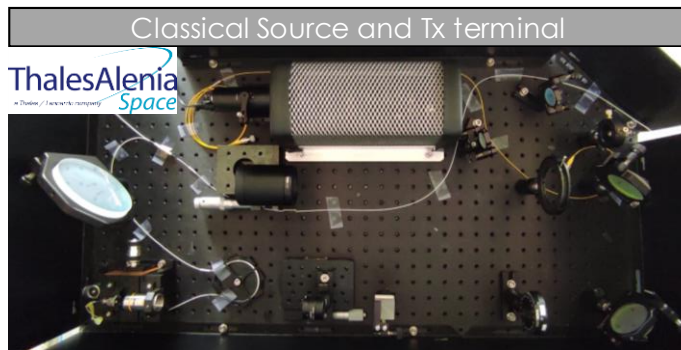
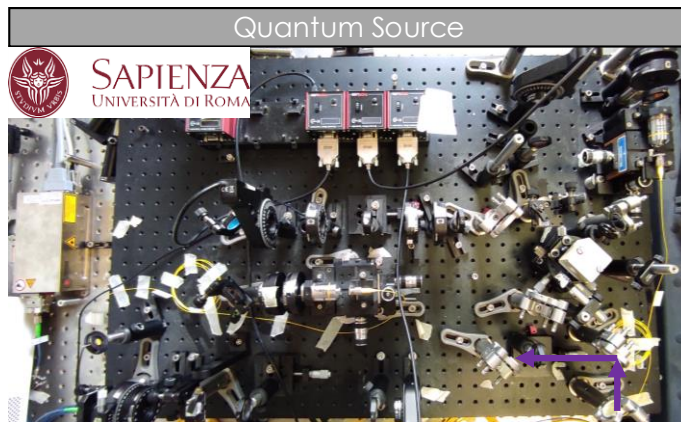
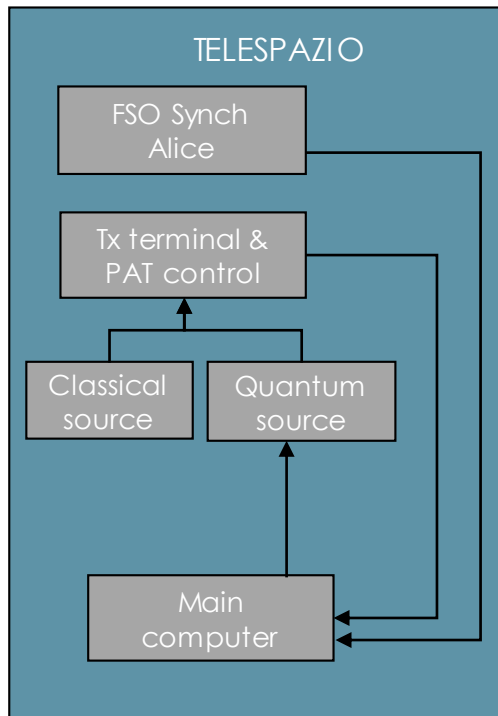
Along the 3km length optical path, the turbulence effects are clearly visible



TASI from TPZ

The LOS is assured thanks to a raised platform (~2m high) despite a quite tall building is present

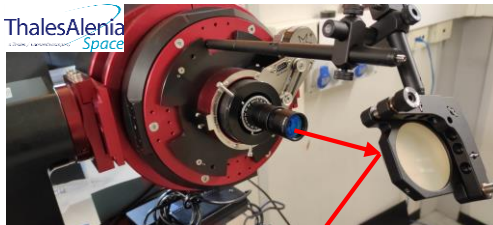
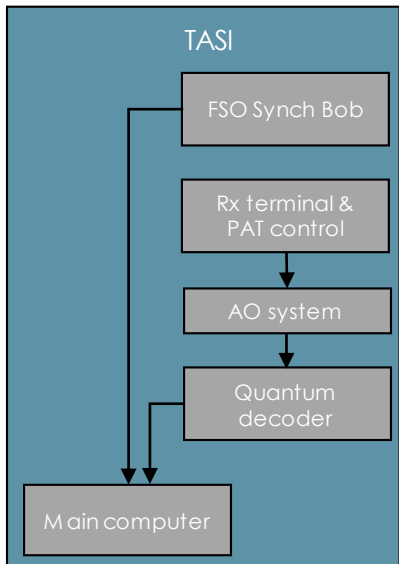
FREE SPACE LINK - TRANSMITTER



- High stability thanks to the Sagnac configuration
- Highly customizable: both EB and PM protocols can be implemented
- Modularity: the source can be easily substituted with PM only

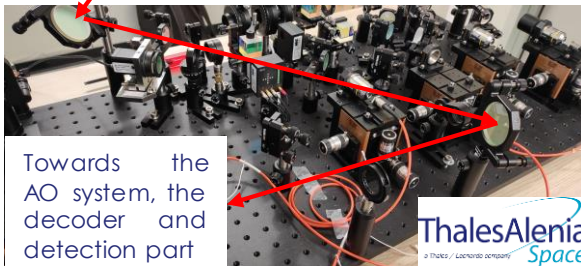
- Highly customizable
- Suitable to test different PAT techniques
- Lightweight and simple design

FREE SPACE LINK - RECEIVER



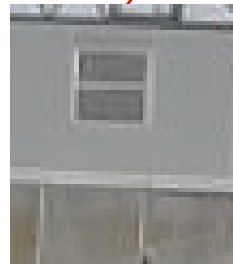
Rx antenna detail. The flipped mirror allows to interface the antenna and the decoder

Decoder detail. The decoder shall be correctly aligned in order to detect the single photons received by the antenna.



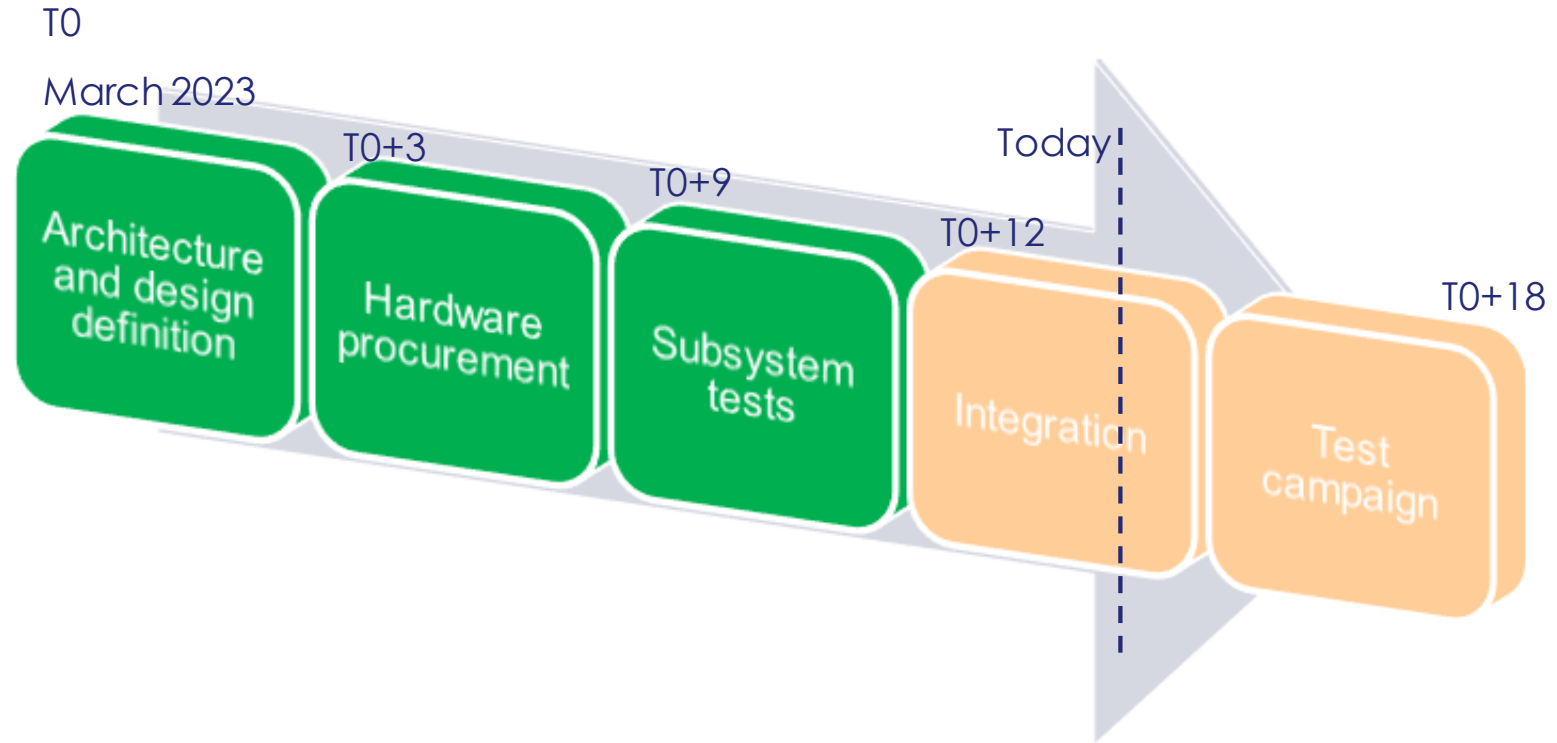
Towards the AO system, the decoder and detection part

Preliminary tests are ongoing on the Thales Alenia Space Italy roof, with a link of ~100m. The overall system will be tested to minimize risk when the longer link will be realized



Despite the short distance, the pointing shall be very accurate in order to correctly align the transmitter and the receiver.

PROJECT STATUS



BACKUP SLIDES

Date : 29/07/2021

Ref : Not referenced

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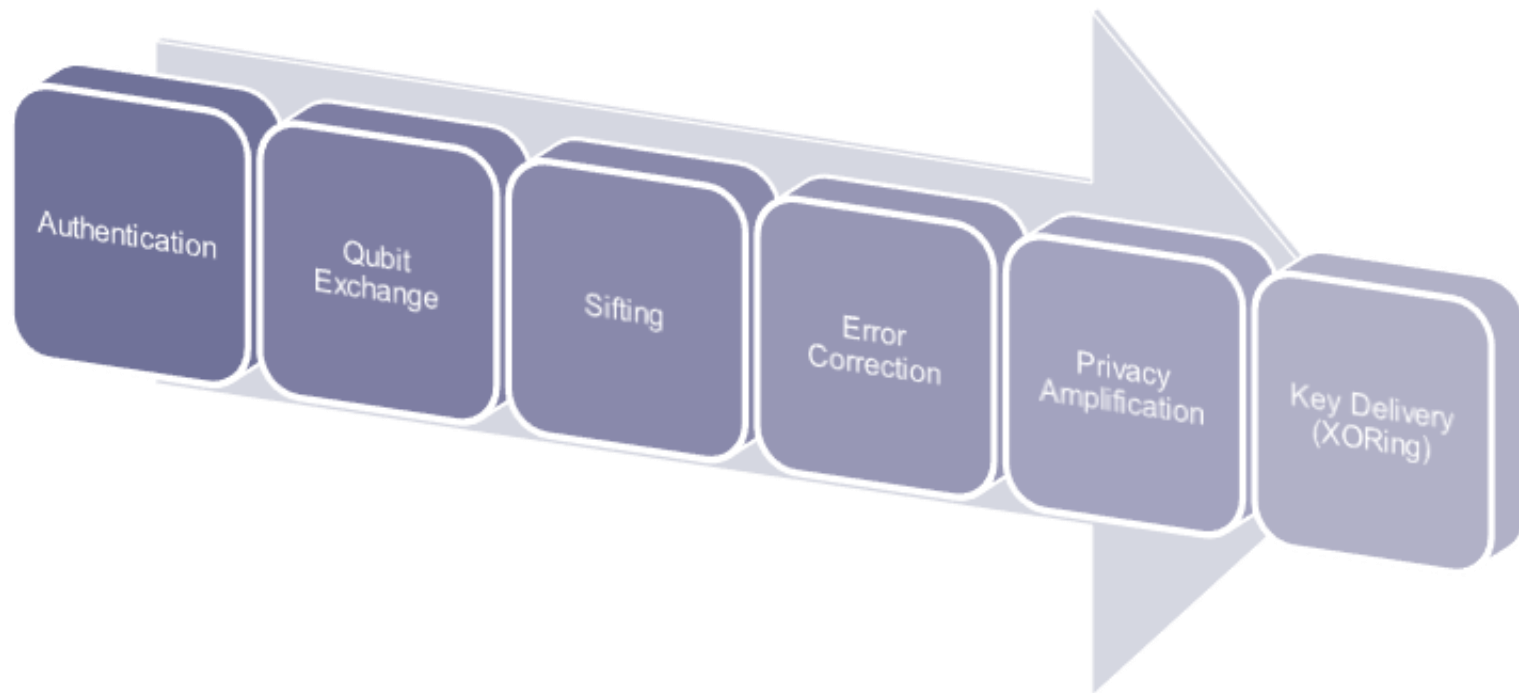
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QKD PROTOCOL

QKD Protocol Operations



SPQR-LAB 1.0 - FIBER LINK DESIGN

