Quantum secured network across the french riviera

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Workshop sur le Temps-Fréquence et les Technologies Quantiques, 10 Novembre 2023

Why field-deployed ?

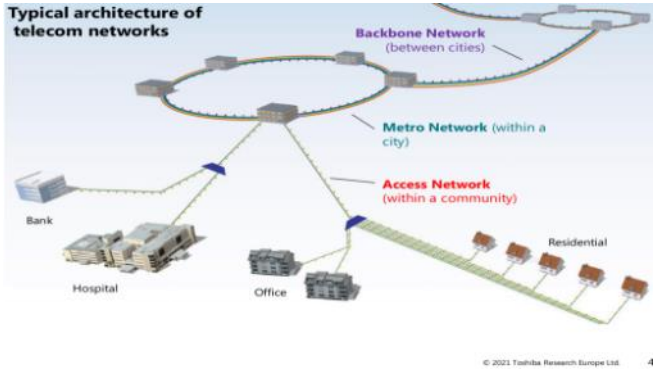
Distance
- Type of link (satellite or terrestrial)
- Protocols (BB84, BBM92,…)

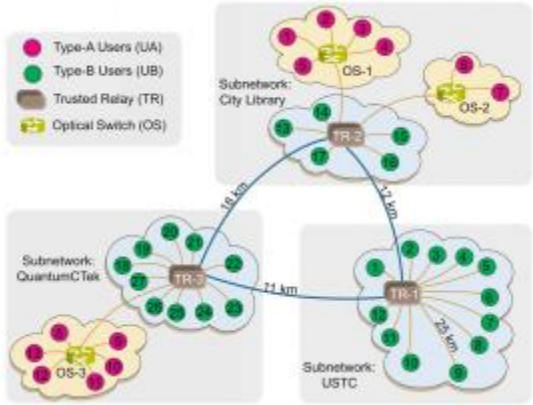
Network topology
- Multi-user design

Scalability
- Temporal synchronisation of users

Applications
- Integration with PQC
- Security assessment in real life

Cost
- Classical data transfer
- Integration with classical network





CLASSICAL NETWORK

QUANTUM NETWORK

SEAMLESS CLASS/QUANT NETWORK

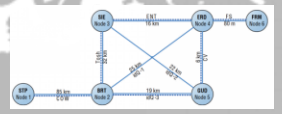
Quantum network initiatives

Boston 42km

New-York 20km

UK 400km

Austria 60km



Italy-Slovenia 200km

Geneva 35km

Nice / Paris 100km

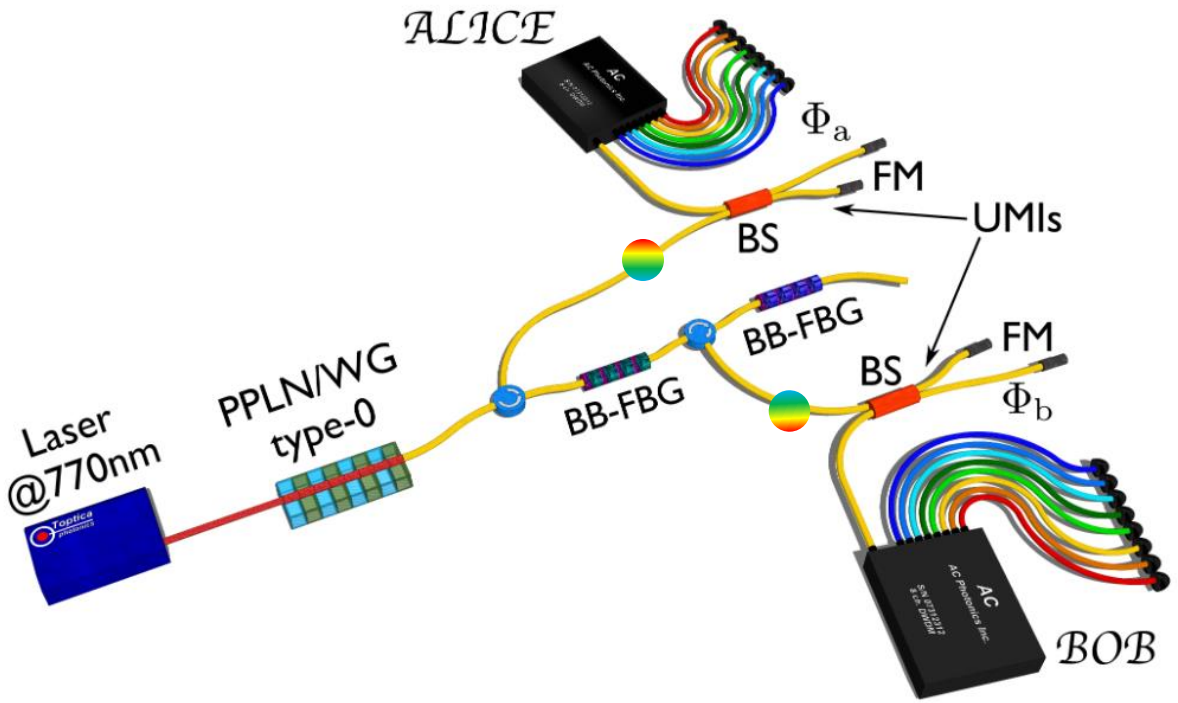
China 4600km

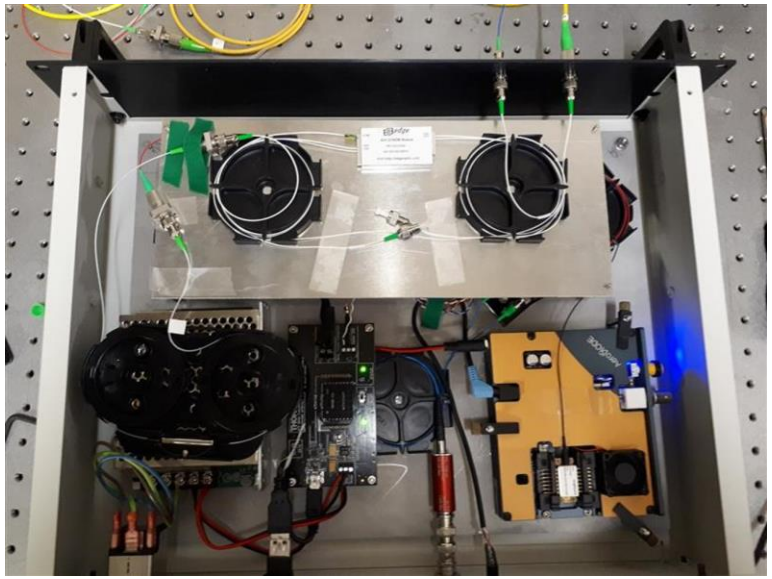
Japan 200km

Singapore 40km

Quantum Communication testbed on the French Riviera

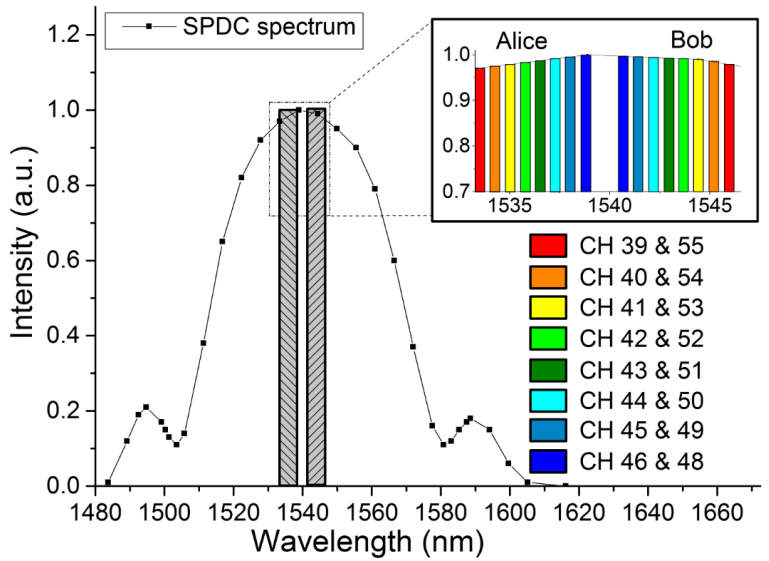
Energy-Time entanglement source





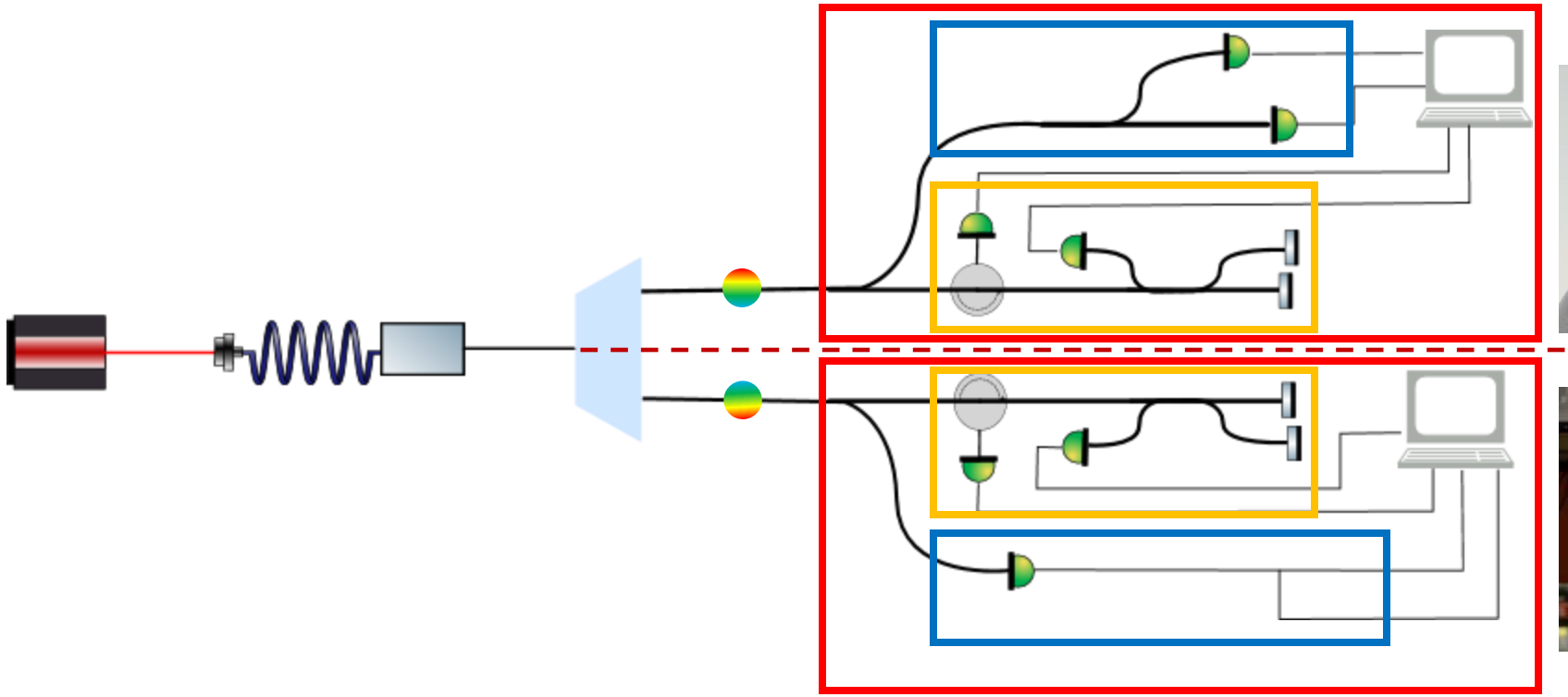
Energy-time entanglement

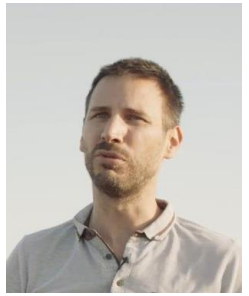
$$\frac{1}{\sqrt{2}}|t\rangle_s|t\rangle_i + e^{i(\phi_s+\phi_i)}|t'\rangle_s|t'\rangle_i \qquad \Delta(E_i+E_s)\Delta(t_i-t_s) \geq \frac{\hbar}{2}$$



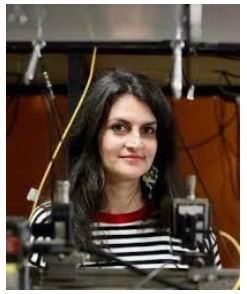
D. Aktas *et al. Laser & Photonics Reviews* 10.3 (2016): 451-457

From entanglement to QKD





Clément



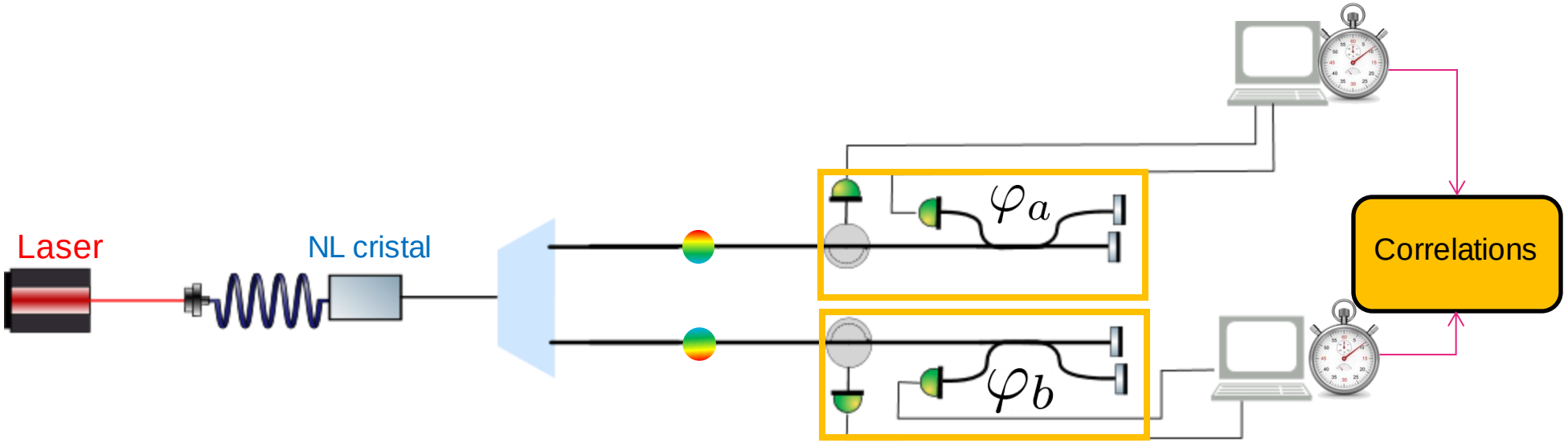
Virginia

Two complementary basis required for QKD with a passive choice:

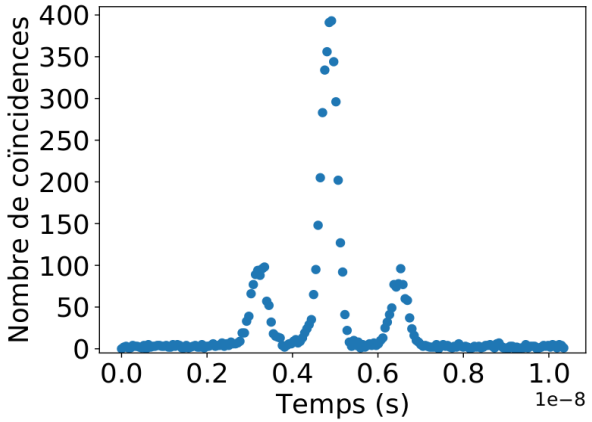
TIME basis : to generate and establish secret keys at remote locations (A & B)

ENERGY basis : to ensure and optimize the security of the link

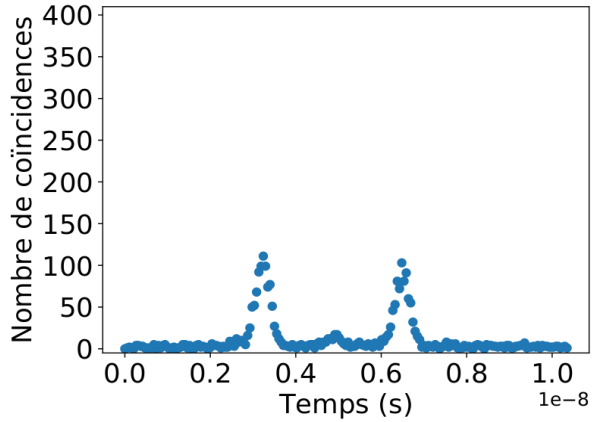
Time bin QKD analyser : ENERGY basis



2x temperature stabilized interferometers

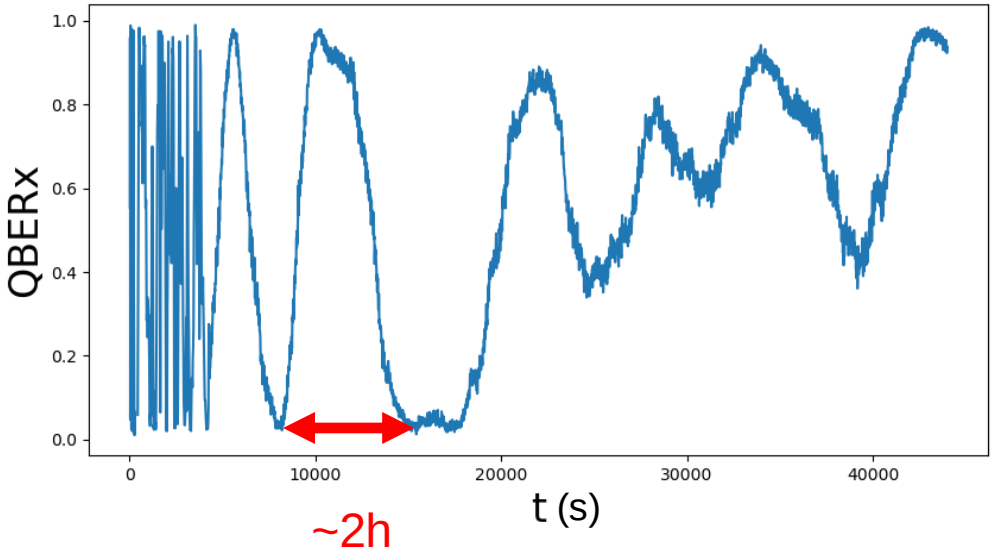


$\varphi_a + \varphi_b = 0$



$\varphi_a + \varphi_b = \pi$

Time bin QKD analyser : ENERGY basis



Entanglement raw vis 99% @0km

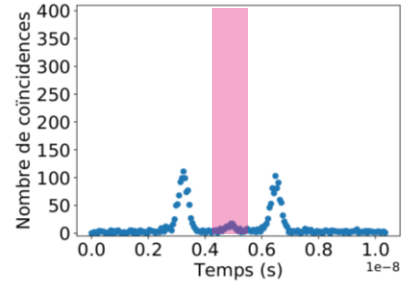
Thermal stabilization ~2h for 2π

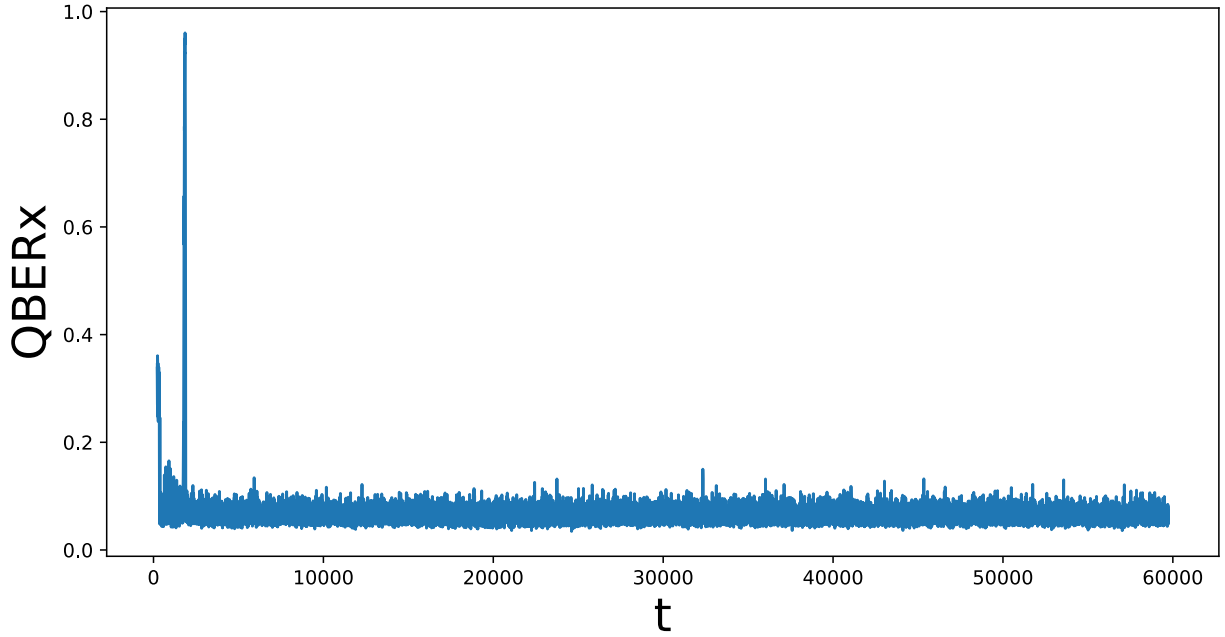
Active stab of interferometers

Piezo stabilization

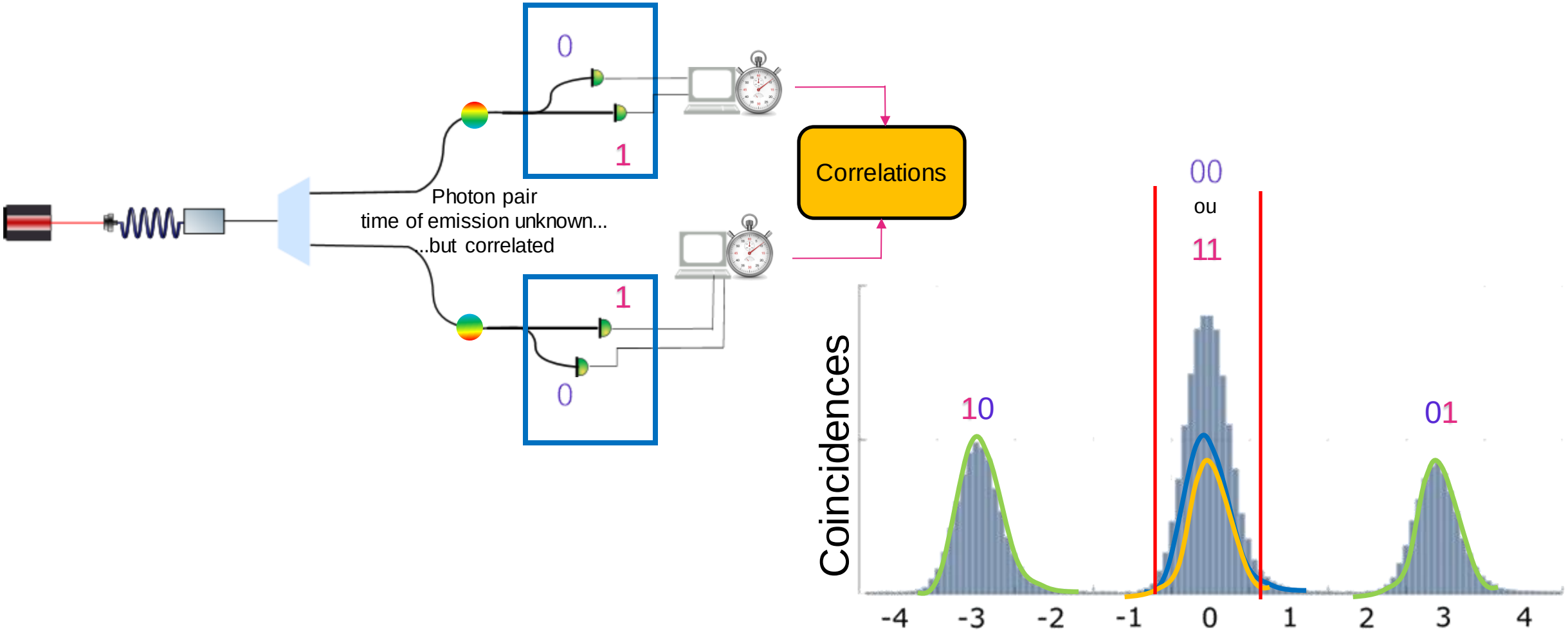
Feedback using QBERx

Average QBERx : 6.1%

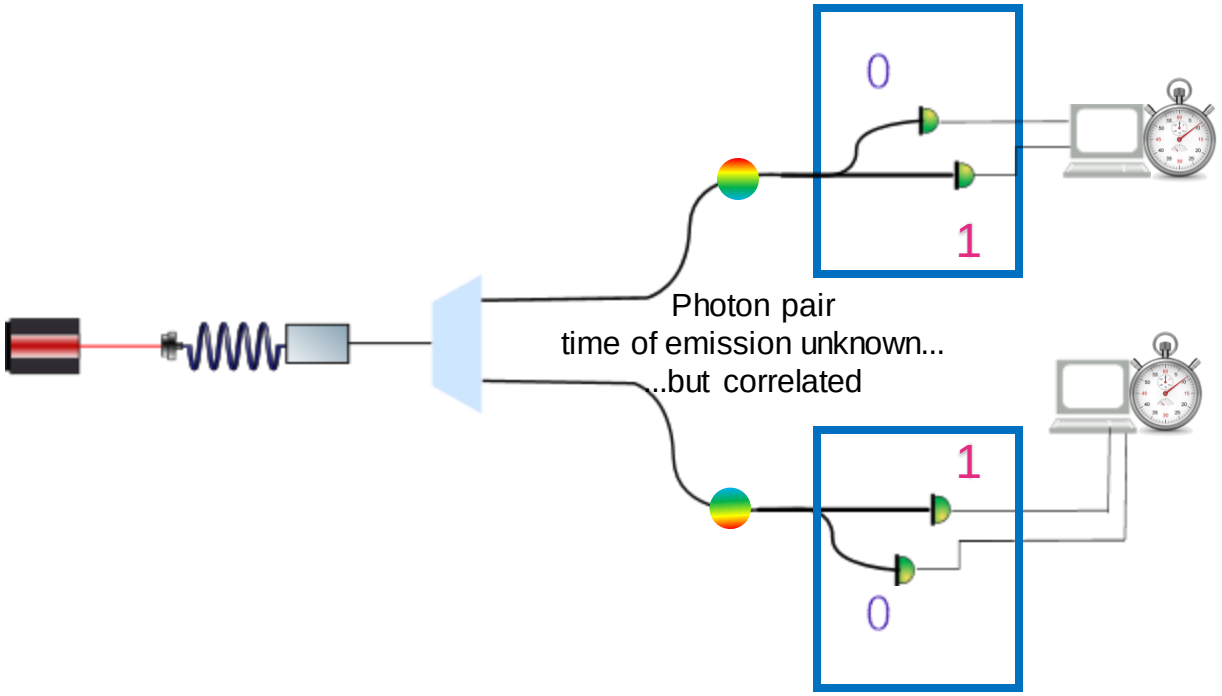


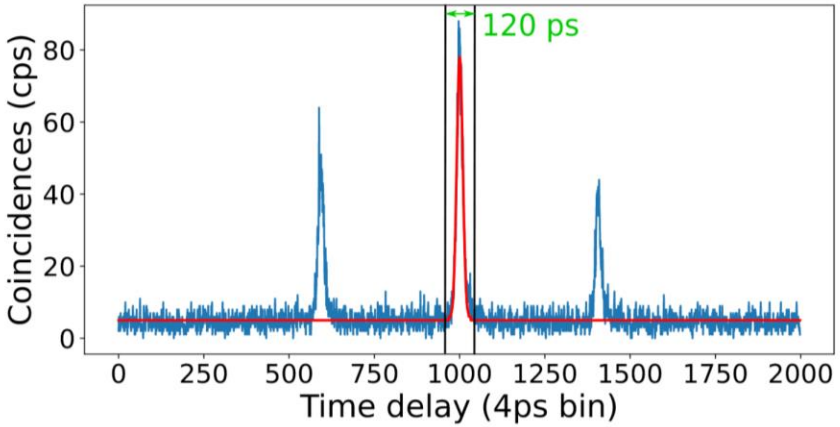


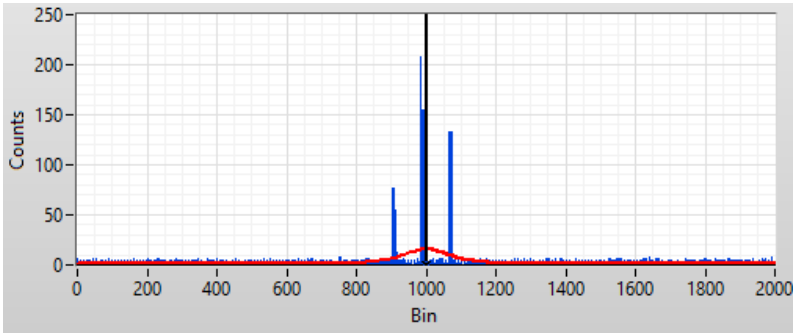
Time bin QKD analyser : TIME basis

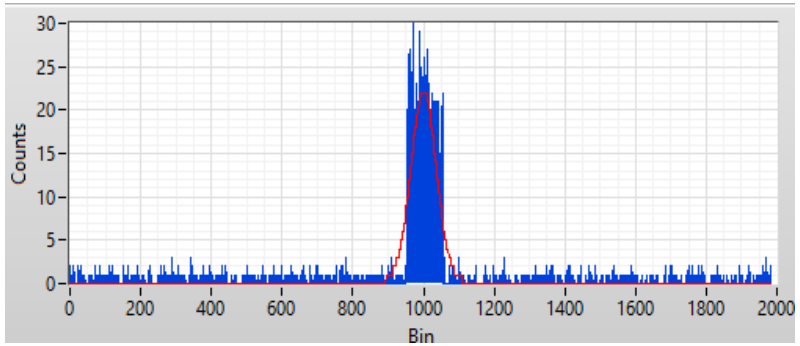


Time bin QKD analyser : TIME basis

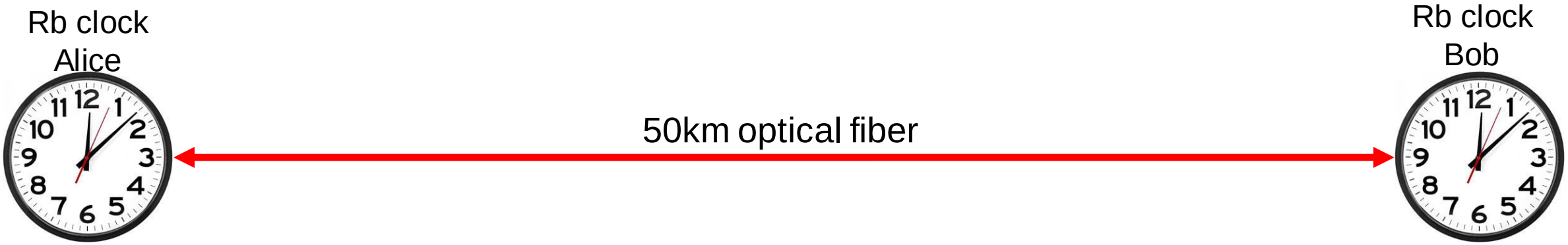


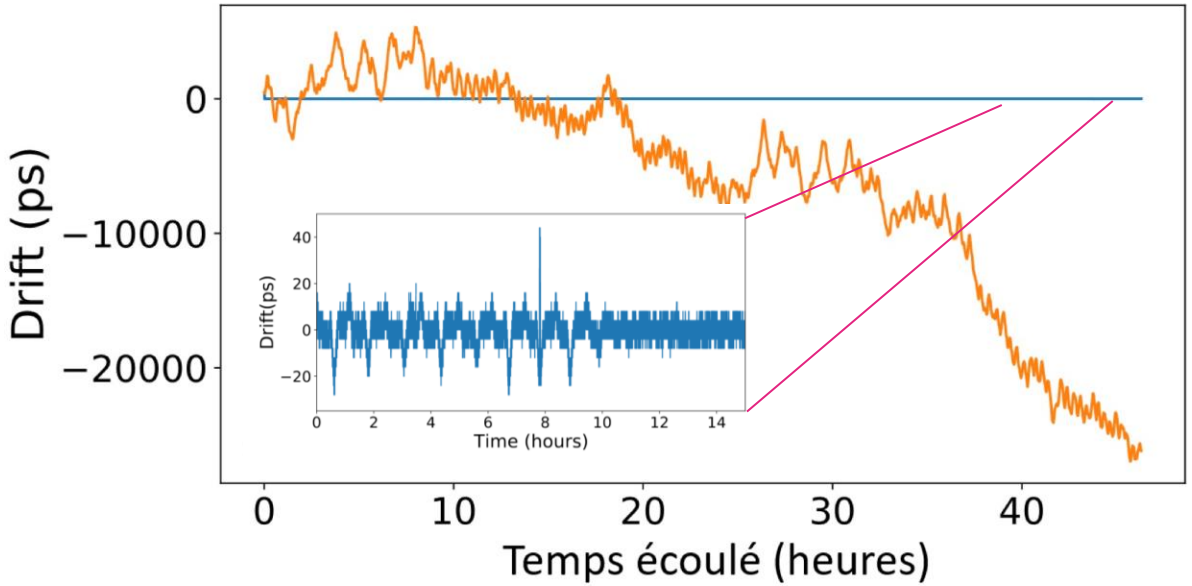






Time bin QKD analyser : TIME basis





Rb clock natural drift : 500ps / sec

- Active synchronization :
  - Tracking of the central peak
  - Feedback on the remote every few seconds

"Energy-time" Stabilization using quantum signals

Pro

- No additional resources required
- No crosstalk with classical signals
- Precision of tens of ps

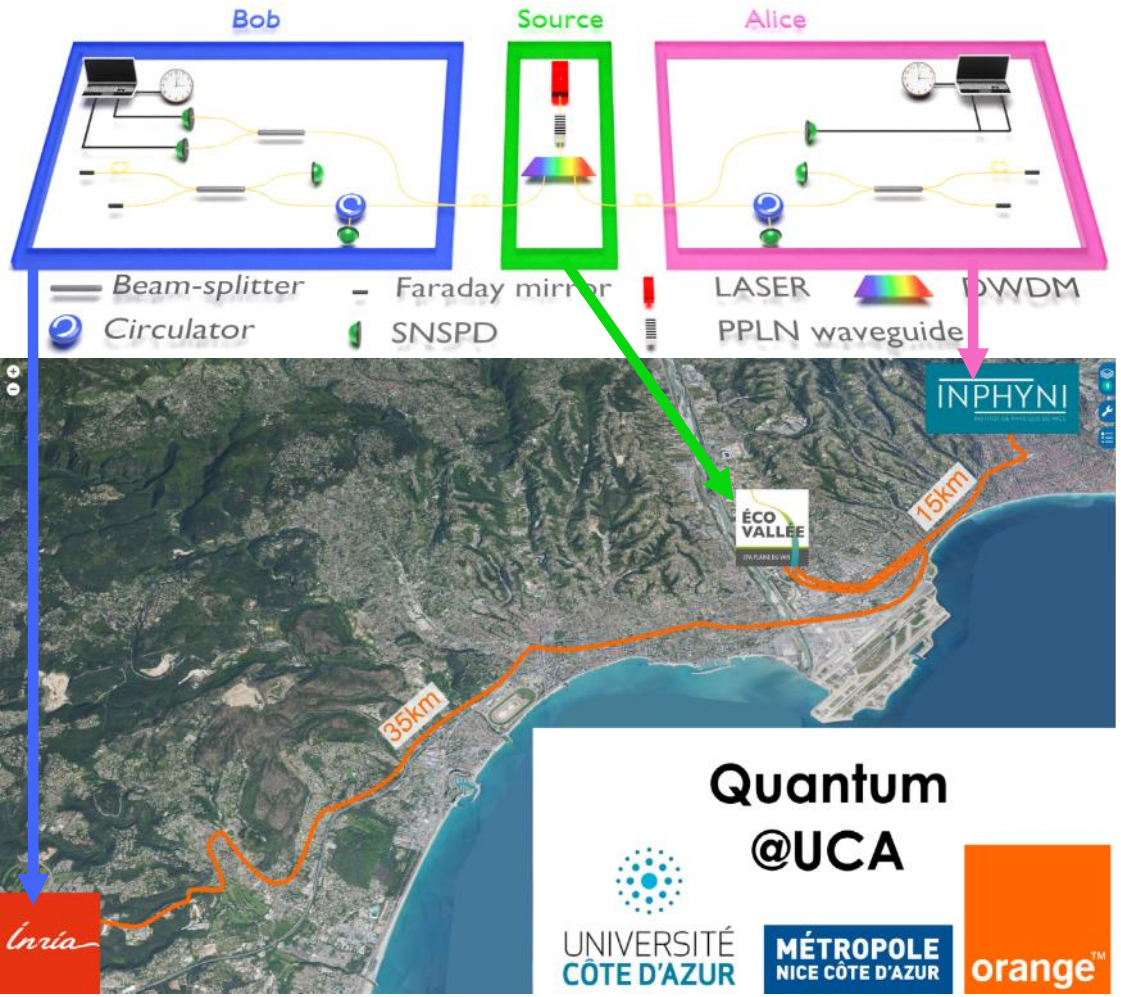
Cons

- Very sensitive to detection rate
- Computer CPU demanding (autocorrelation calc)
- Not 1PPS compatible

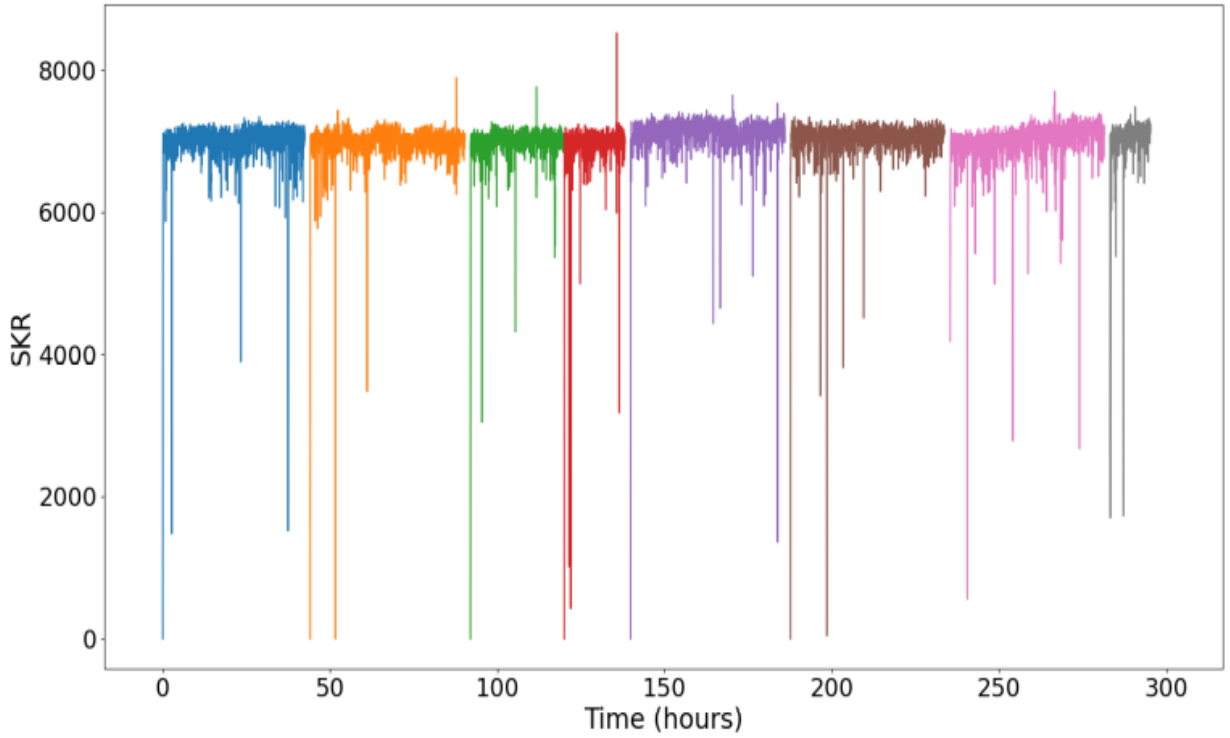
How to synchronize efficiently N users ?

Time-Frequency solutions for quantum app. ?

QKD on the French Riviera



- **Fully automated QKD operation**
- **Quantum time transfer**
- **Secret Key Rate : 7kbps over 300h**
- **Potential to operate for 40 users**



Toward space QKD

Test of free-space entanglement distribution

Investigation of turbulence impact and mitigation solution

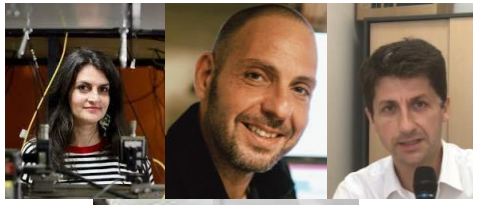
Frame reference distribution for polarization QKD

Toward Space QKD (Laurent de Forges de Parny's talk)

Quantum technologies on the French Riviera

Institut de Physique de Nice

- Quantum information
- Quantum photonics
- Nonlinear optics and interferometry

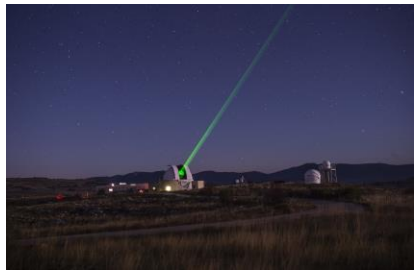


V. D'Auria, S. Tanzilli, L. Labonté
A. Martin, J. Etesse

CRHEA

- Semi-Conductor growth (GaN)
- Nanophotonics

J. Zuniga-Perez, P. Boucaud, J-Y Duboz



GéoAzur (OCA)

- Space communication
- Laser ranging
- Time transfer

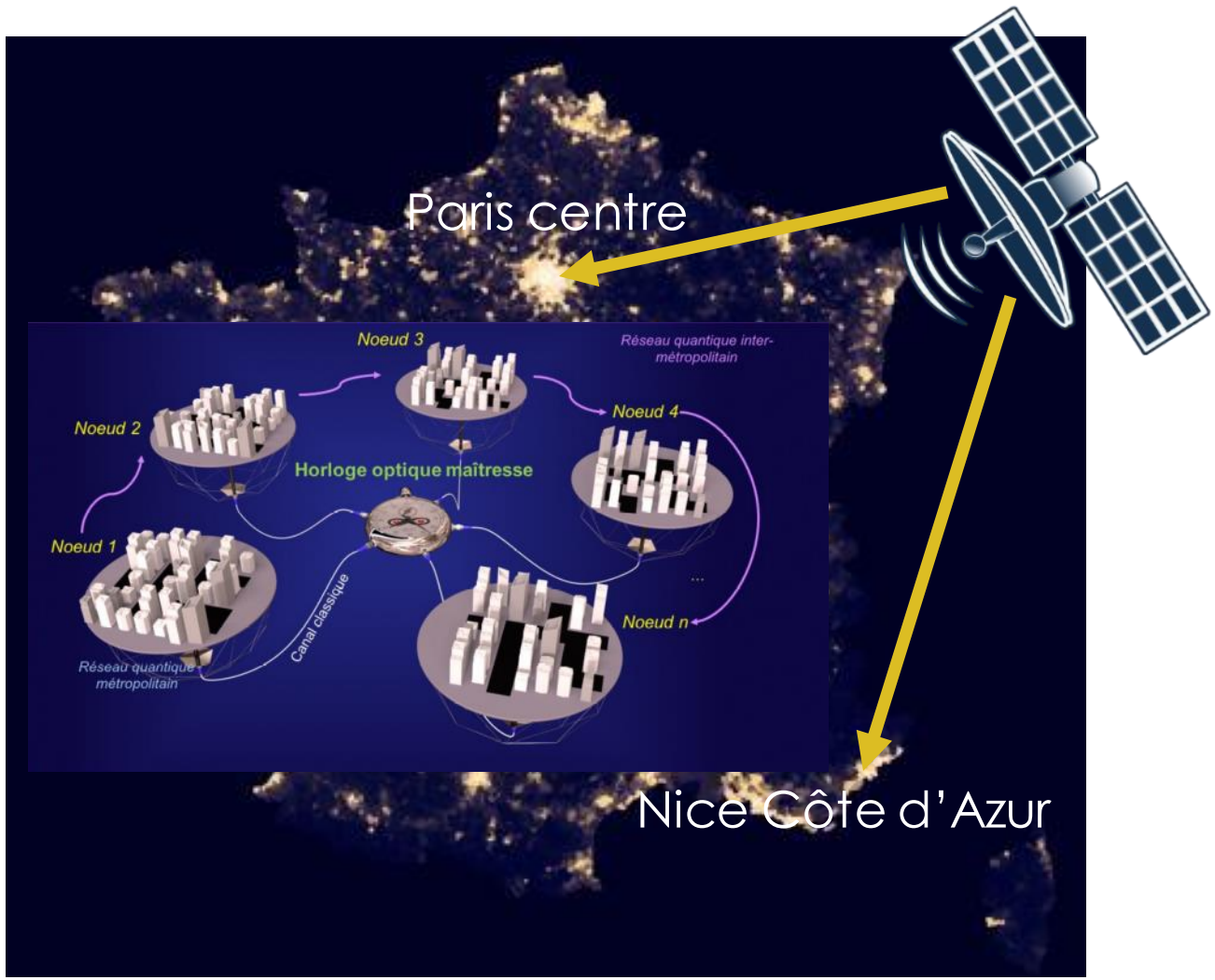
C. Courde, J. Chabé, D-H Phung

I3S

- Cyber-security
- Ciphering

B. Martin

Toward space QKD



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