

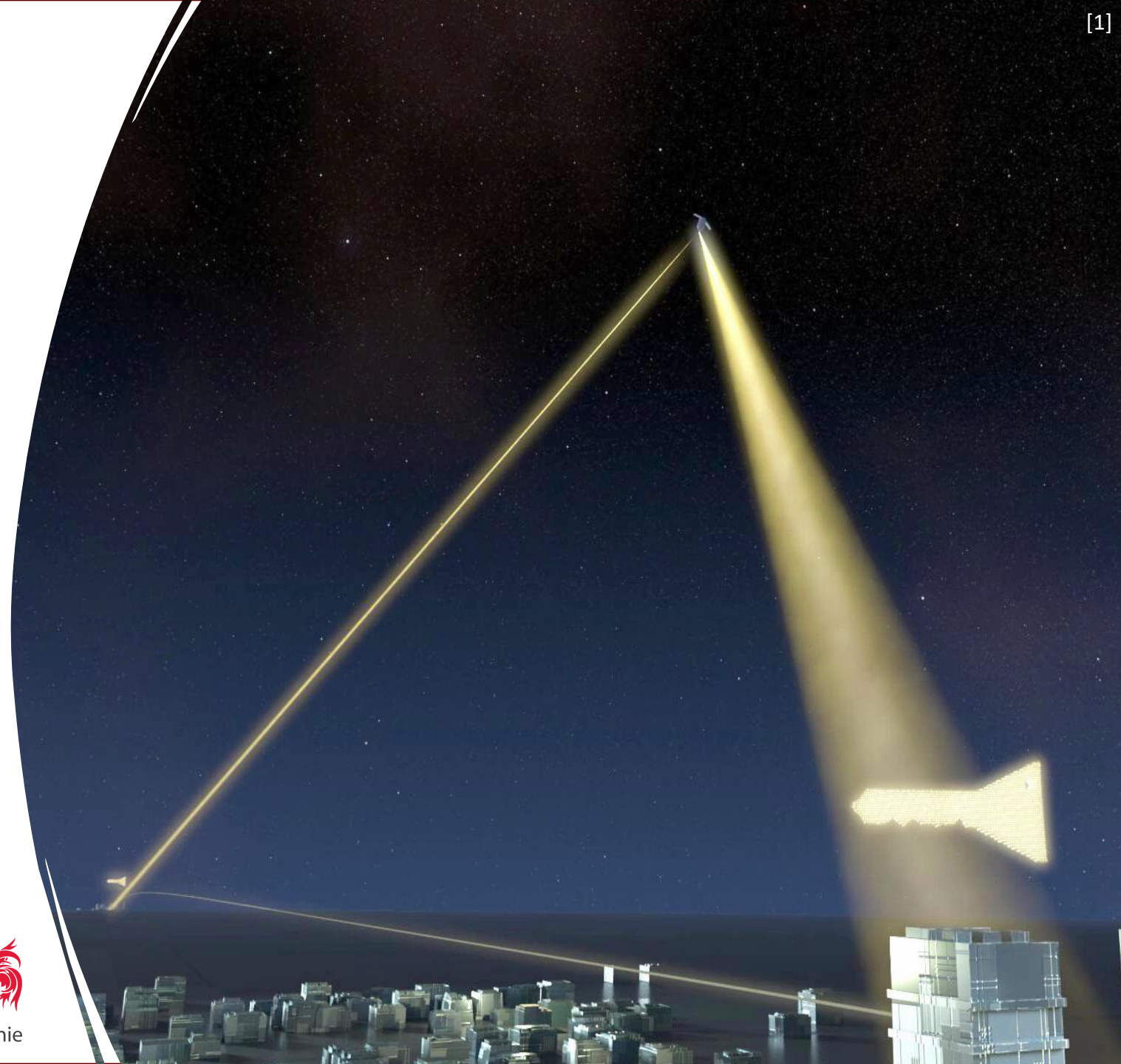
Development of Single-Photon Sources for Space Quantum Key Distribution

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Supervisor: Serge HABRAKEN

Co-supervisor: Yves HERNANDEZ

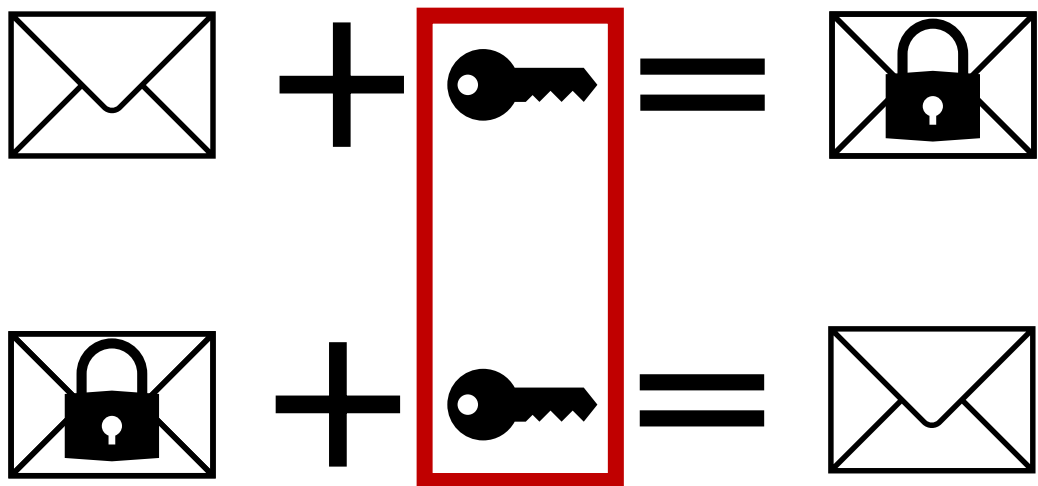
25 November 2025



Quantum Key Distribution Principles

Context

Cryptography



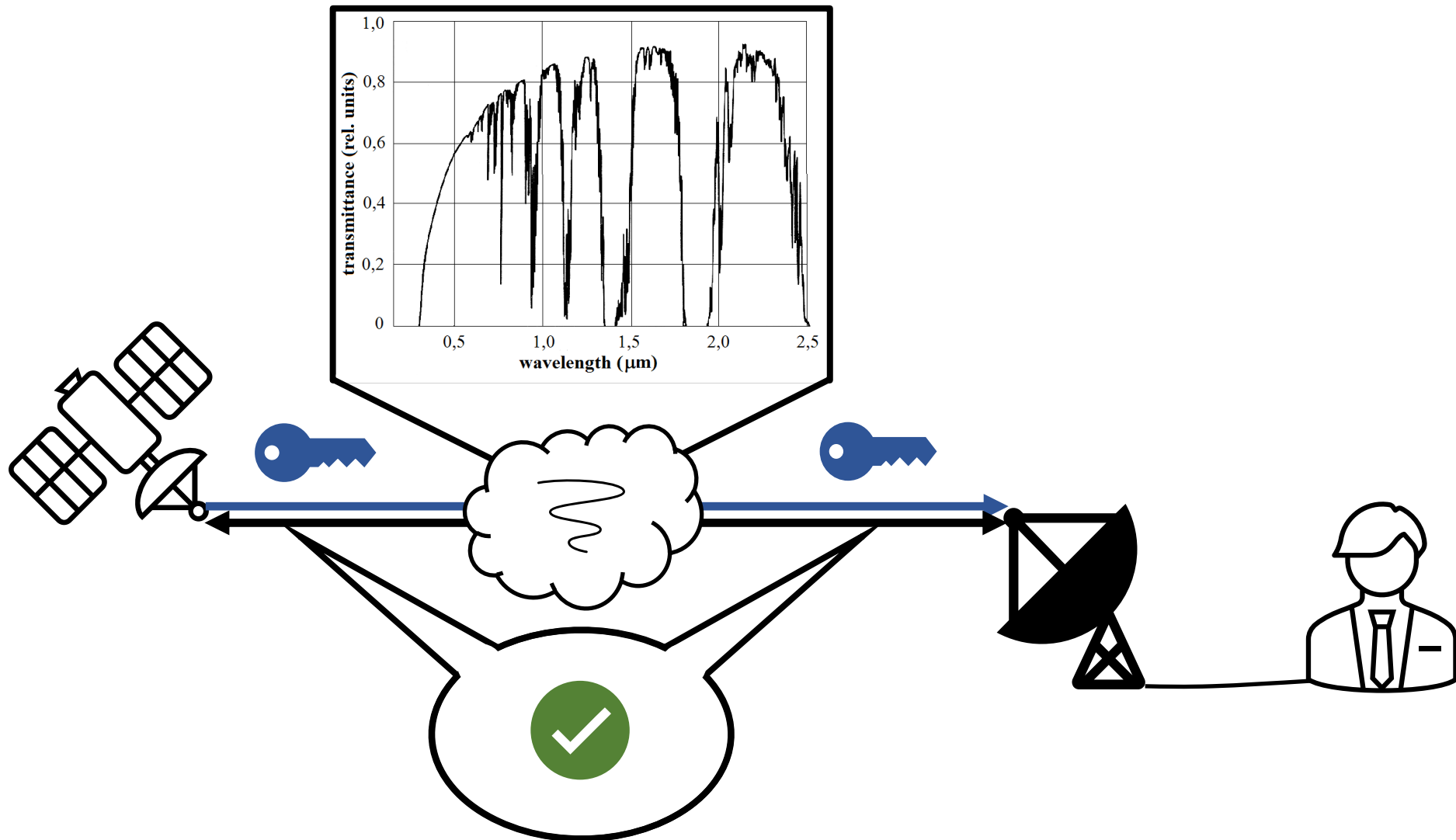
Threat



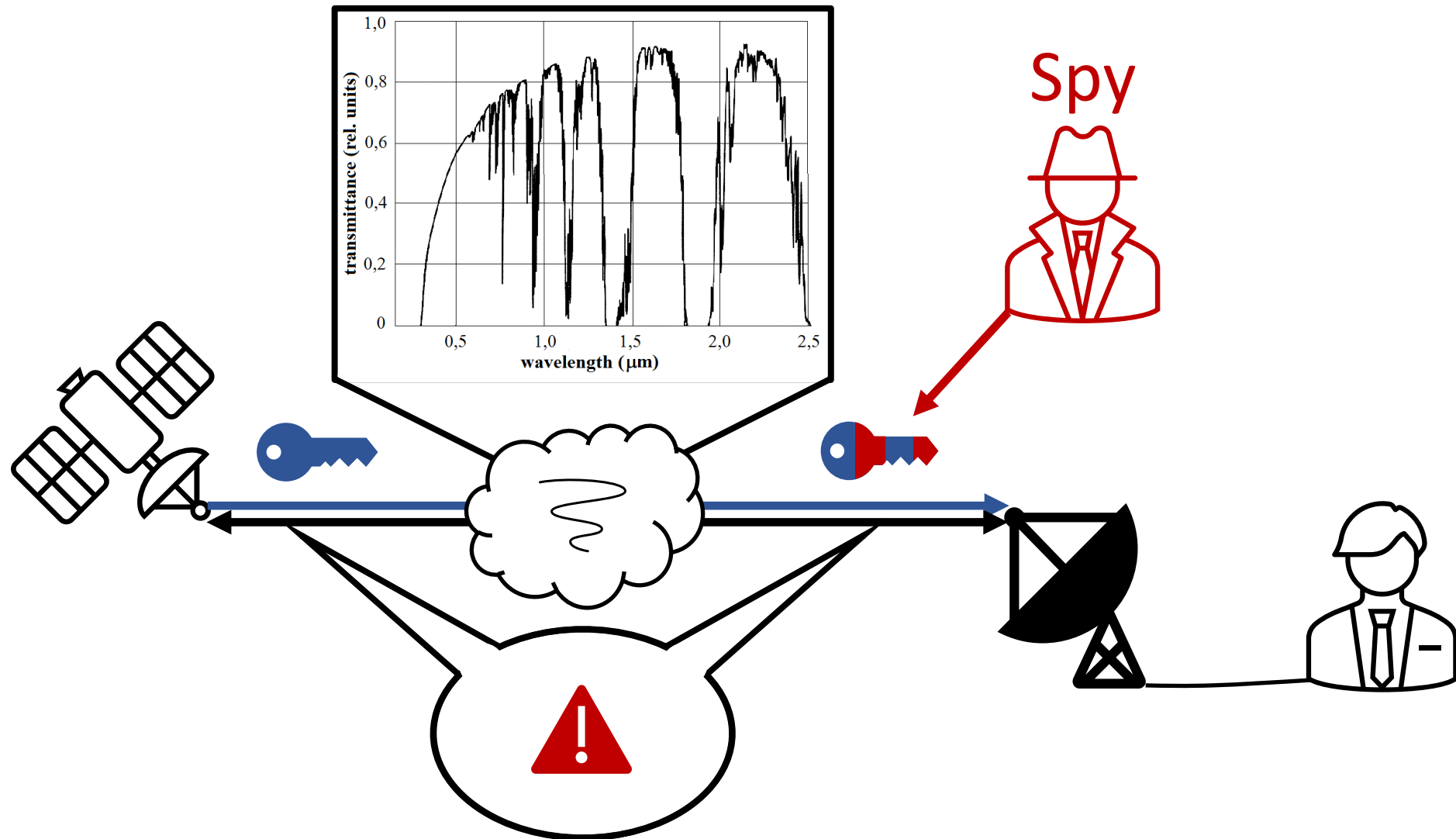
Quantum computers

[2]

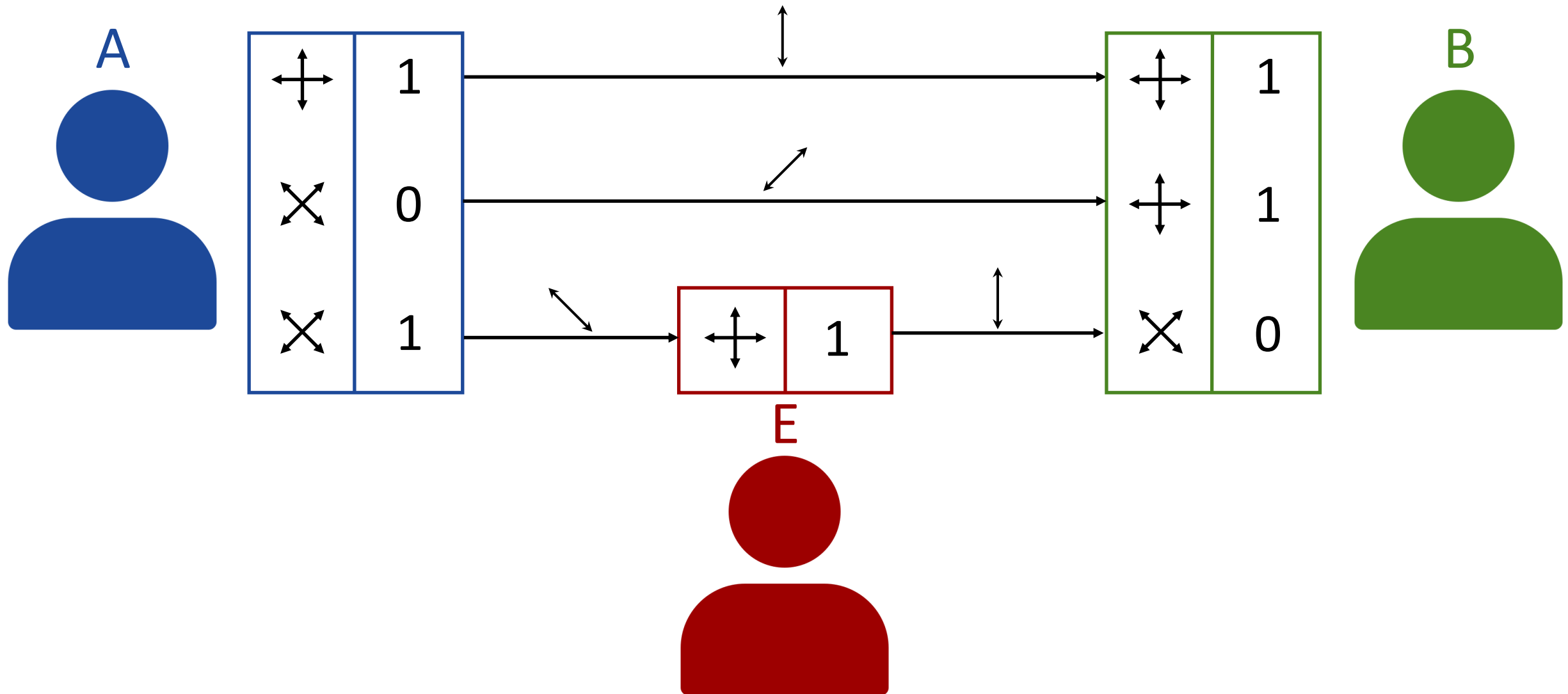
Quantum Key Distribution (QKD)



Quantum Key Distribution (QKD)



The BB84 Protocol



Heralded Single-Photon Source



Attenuated laser

Laser

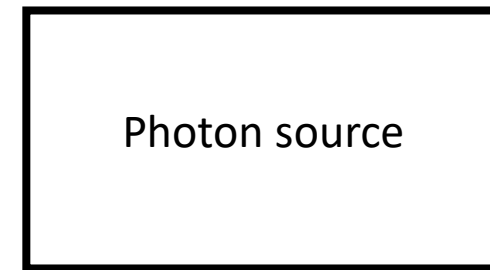
Attenuator



How many photons ?



Heralded single-photon source



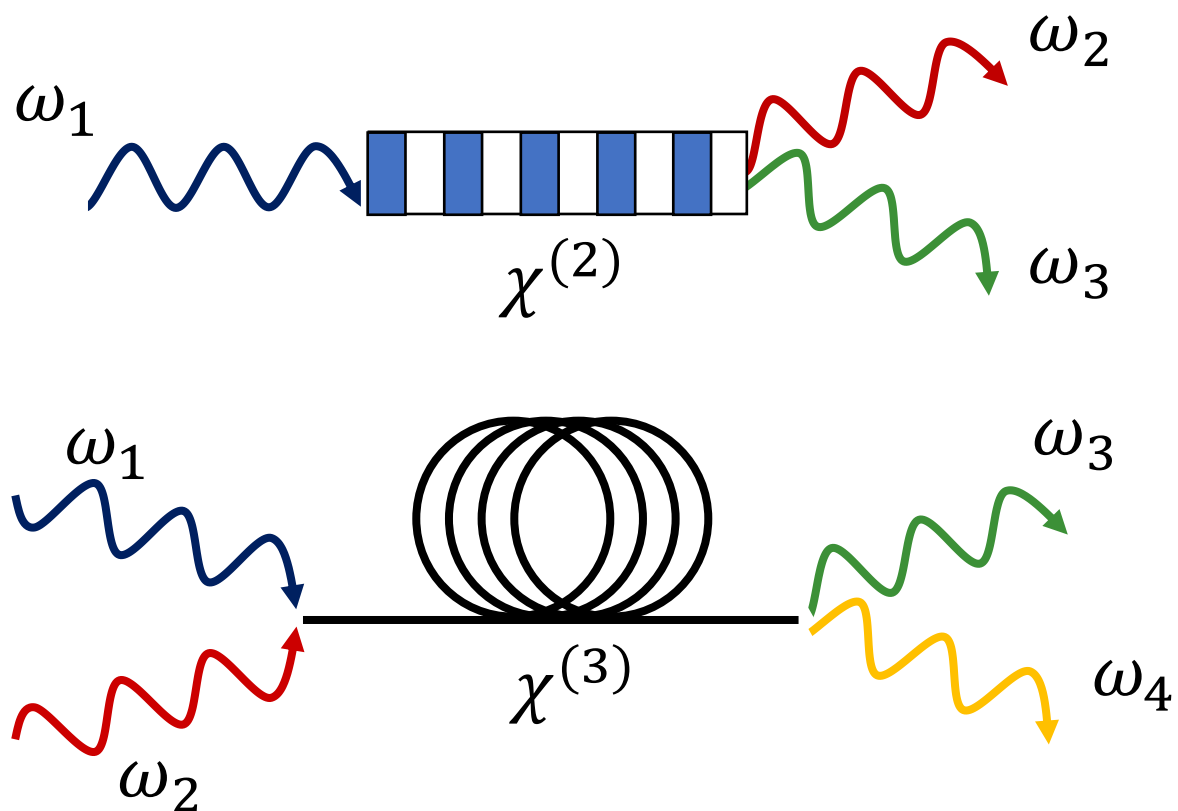
Detector



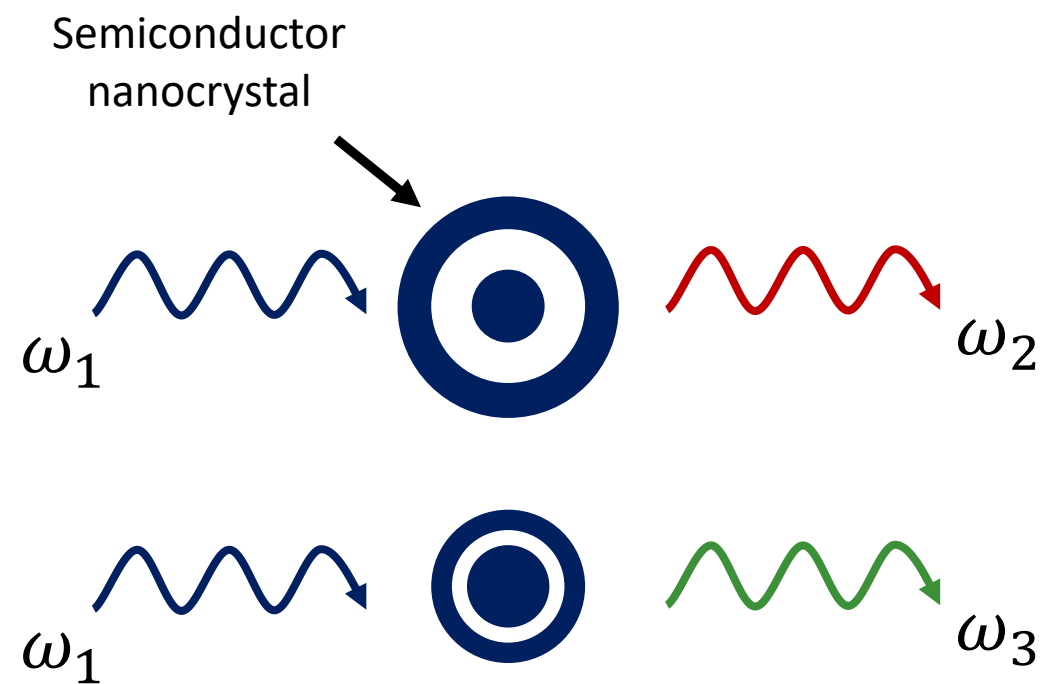
Estimate thanks to the second photon

Two Approaches

Nonlinear optics

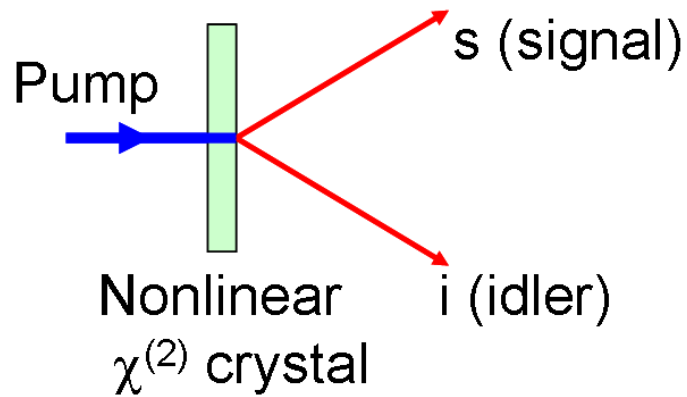


Quantum dots

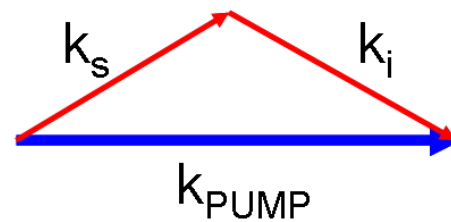


Spontaneous Parametric Down-conversion (SPDC)

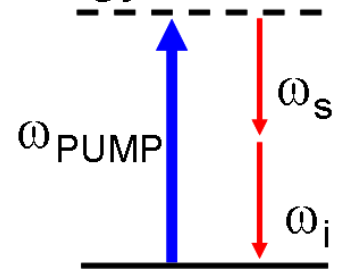
Spontaneous
Parametric
Downconversion



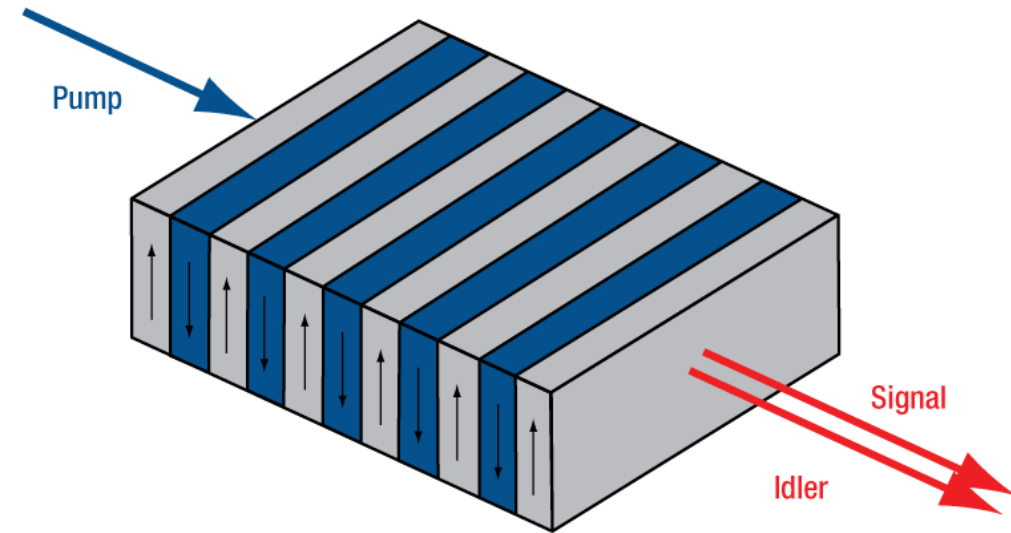
Momentum Conservation ^[4]



Energy conservation

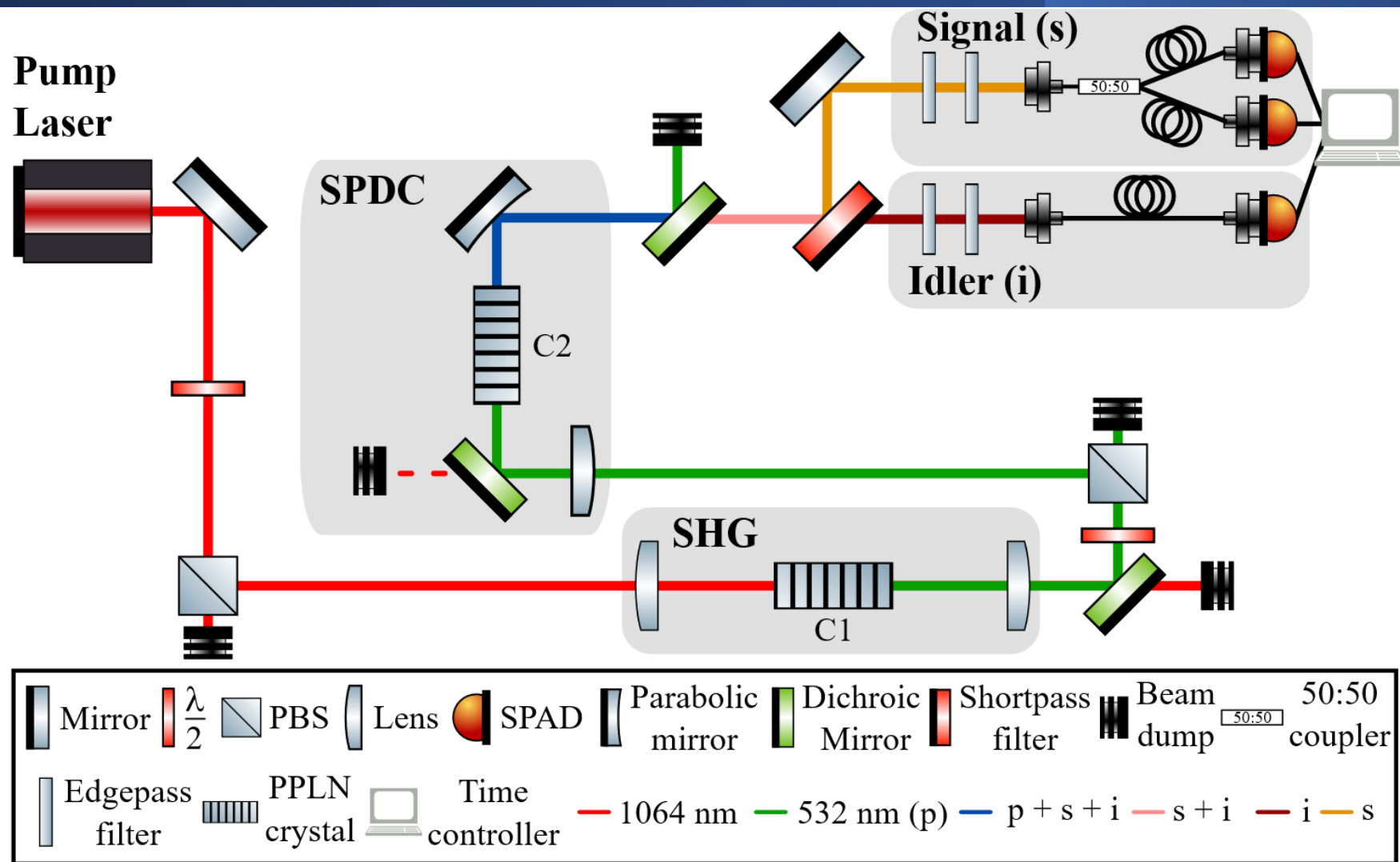


$$\varphi_{\text{PUMP}} = \varphi_s + \varphi_i$$

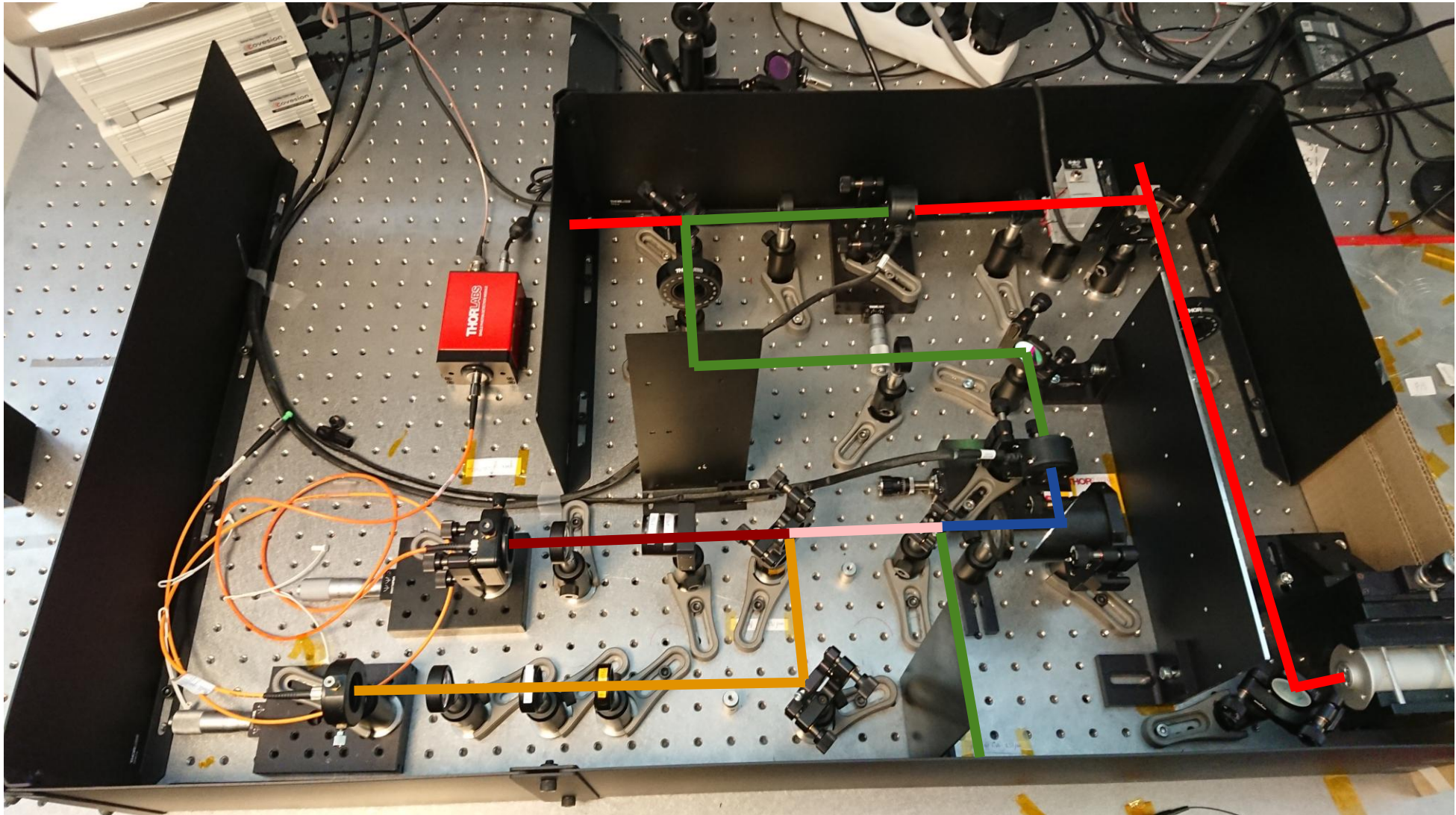


Progress of the Experimental Set-up

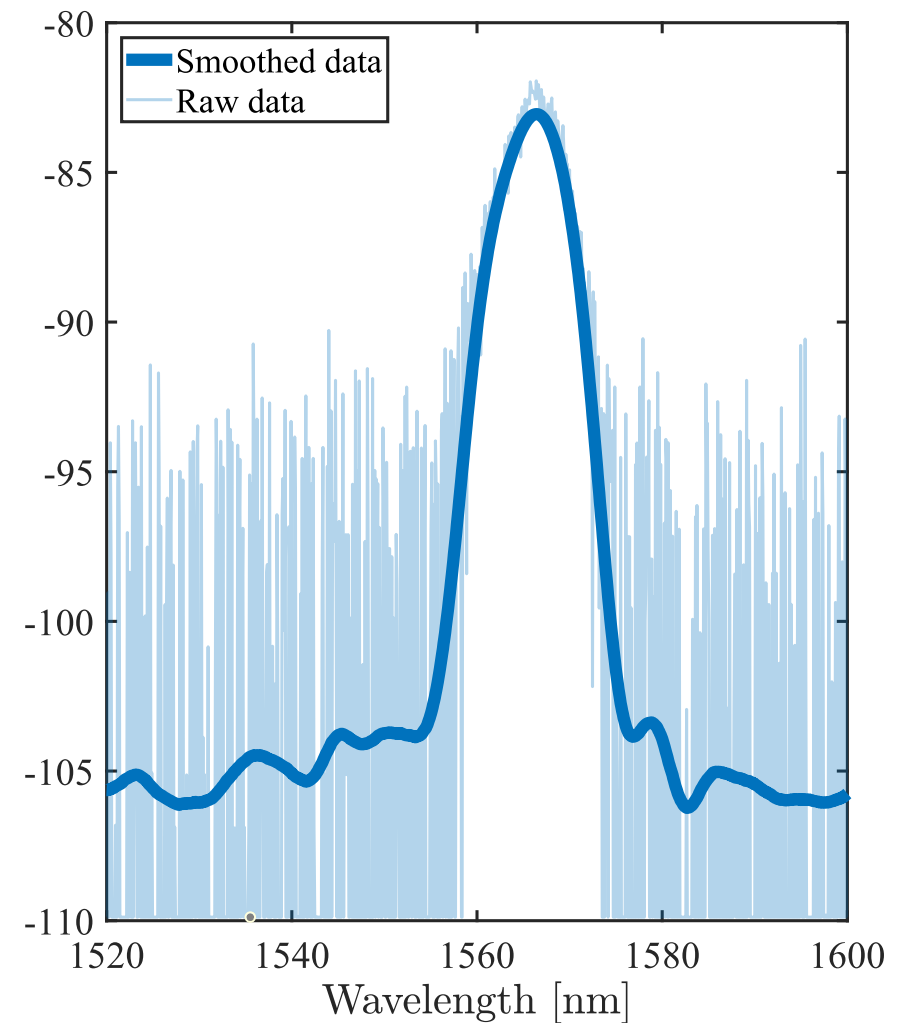
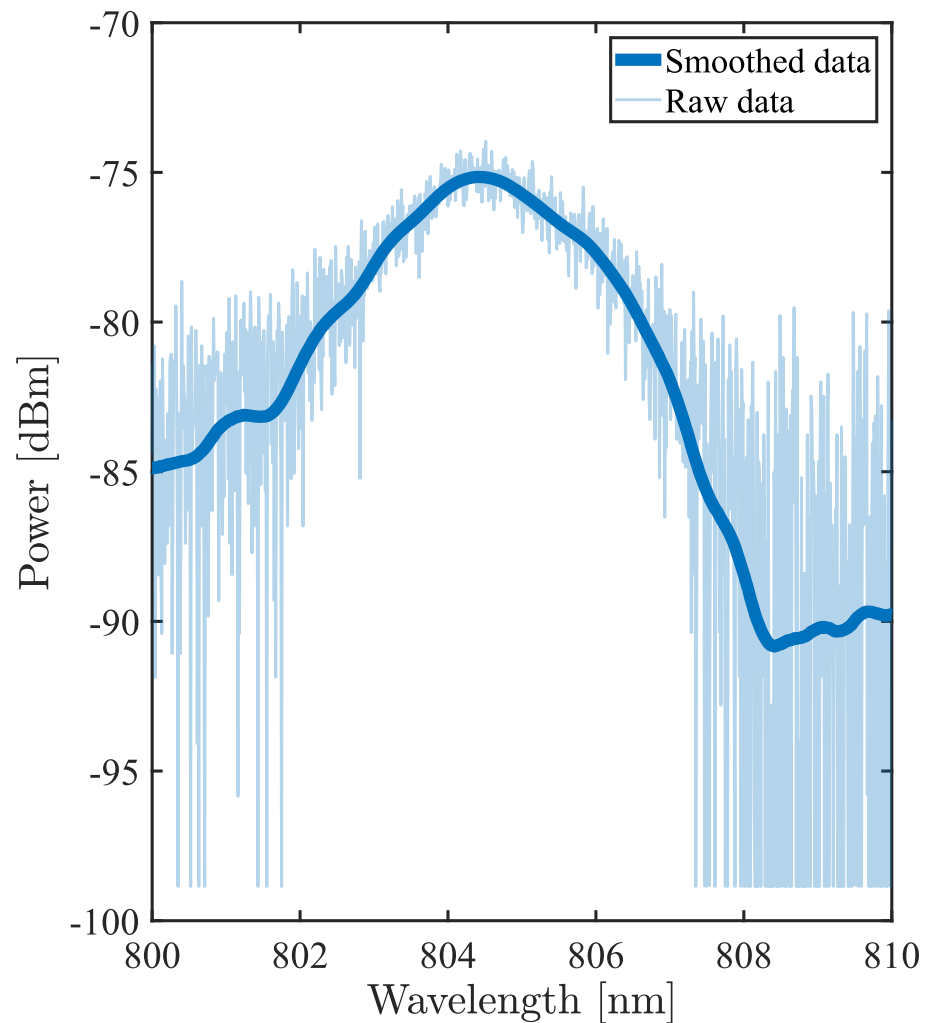
Experiment



Experiment

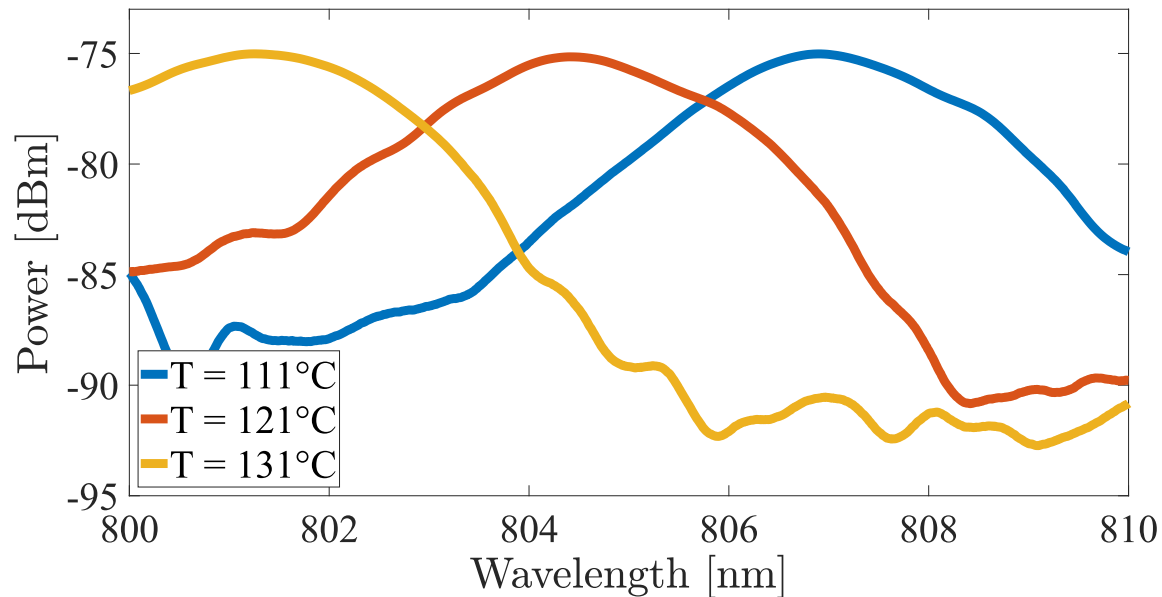


Photon Pair Generation

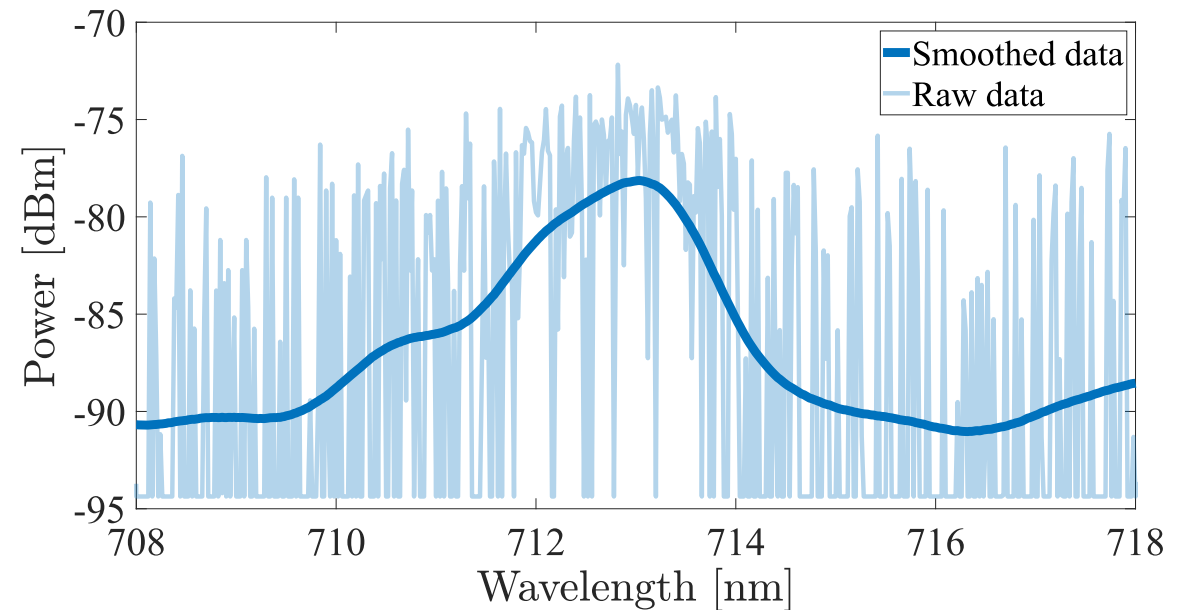


Wavelength Tunability

Temperature variation



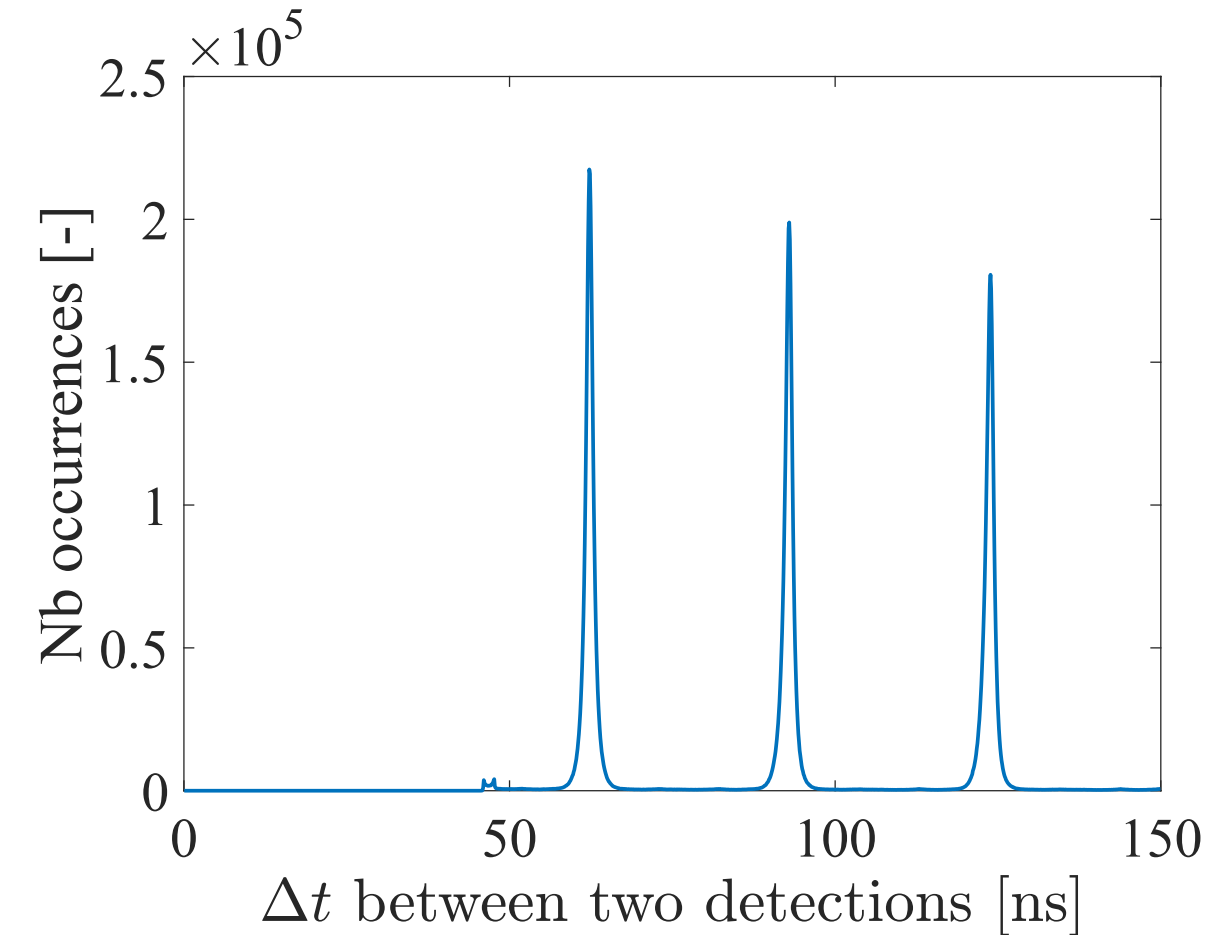
Launching in another channel



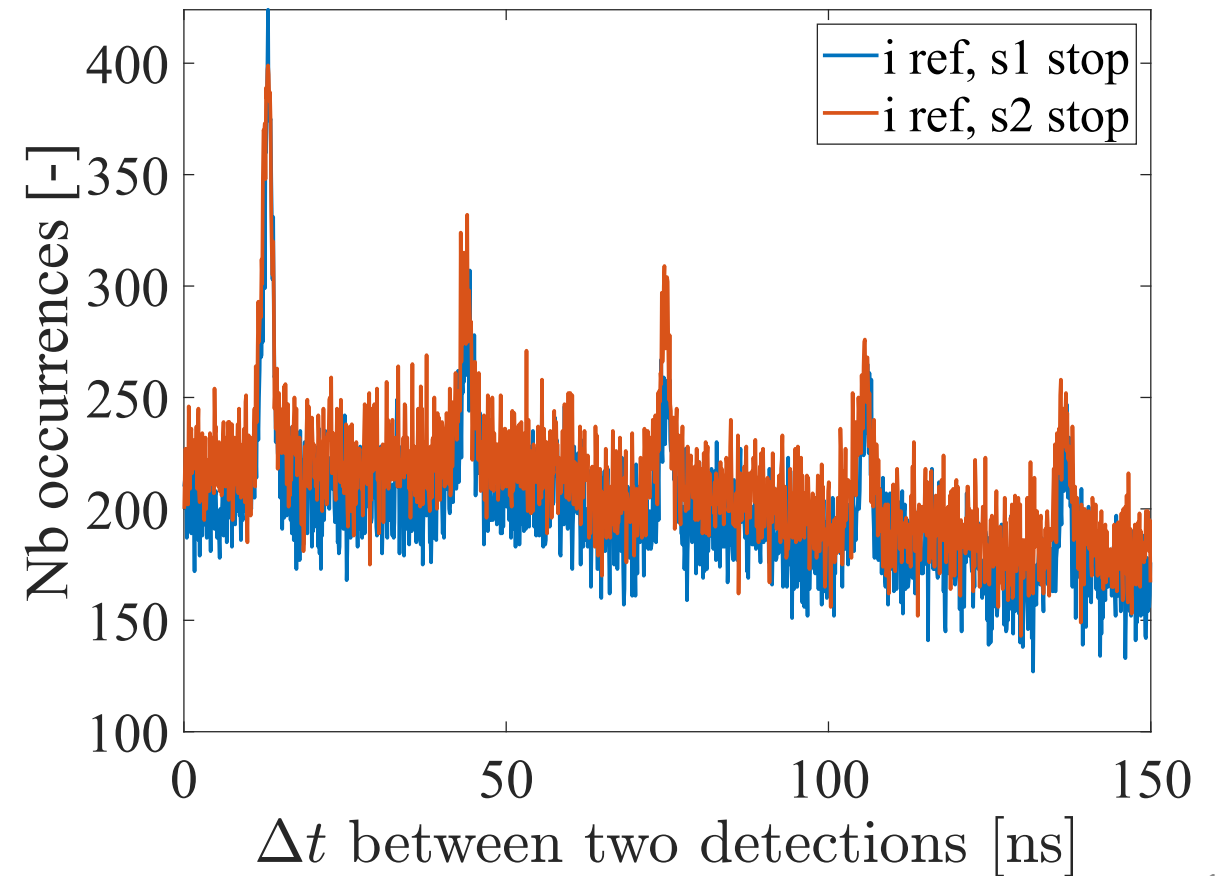
Ability to generate signal photons
from 1064 nm to 2200 nm

Correlation Measurements

Idler ref, idler stop



Idler ref, signal stop



Conclusions

Conclusions and Perspectives

1) Single photon regime

- Gating of the infrared detectors
- Characterisation of the multi photon emissions

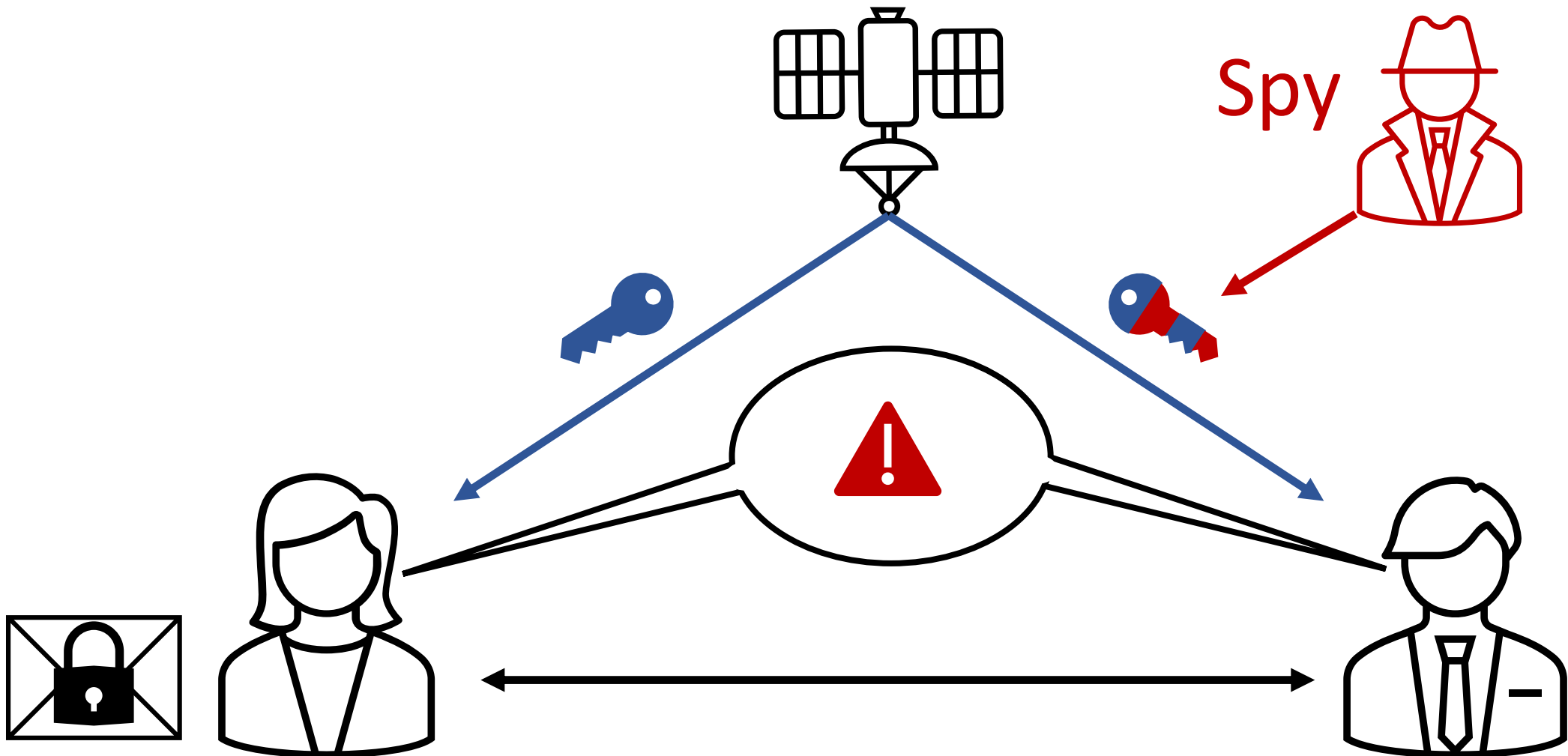
2) Characterisation at other wavelengths

- Correlations, single photon regime...

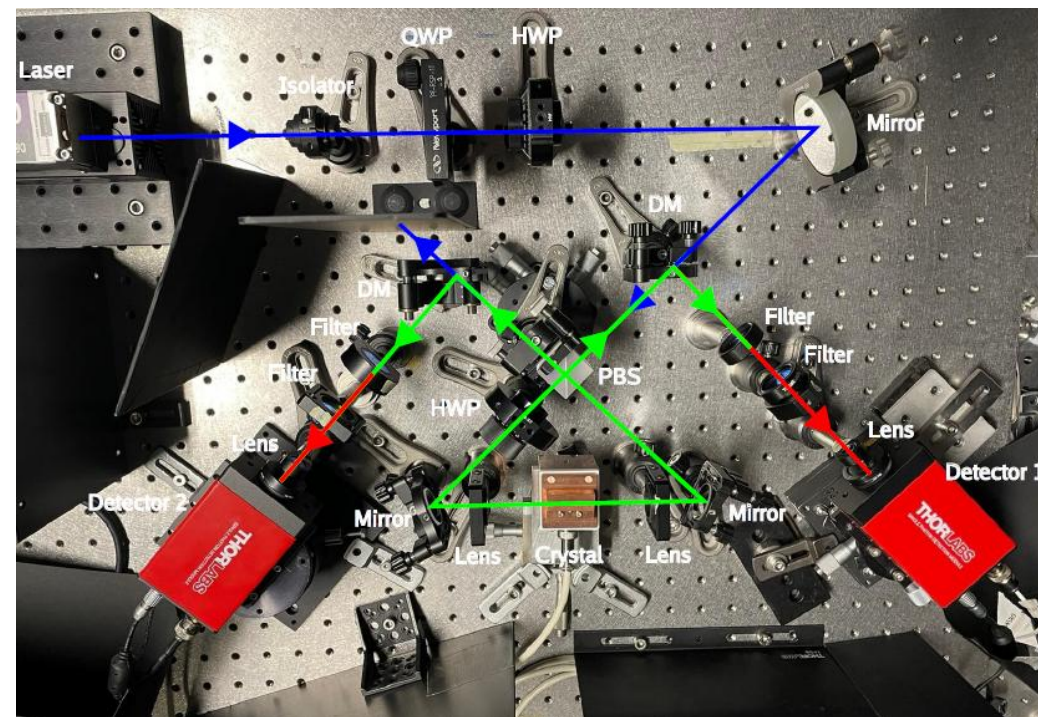
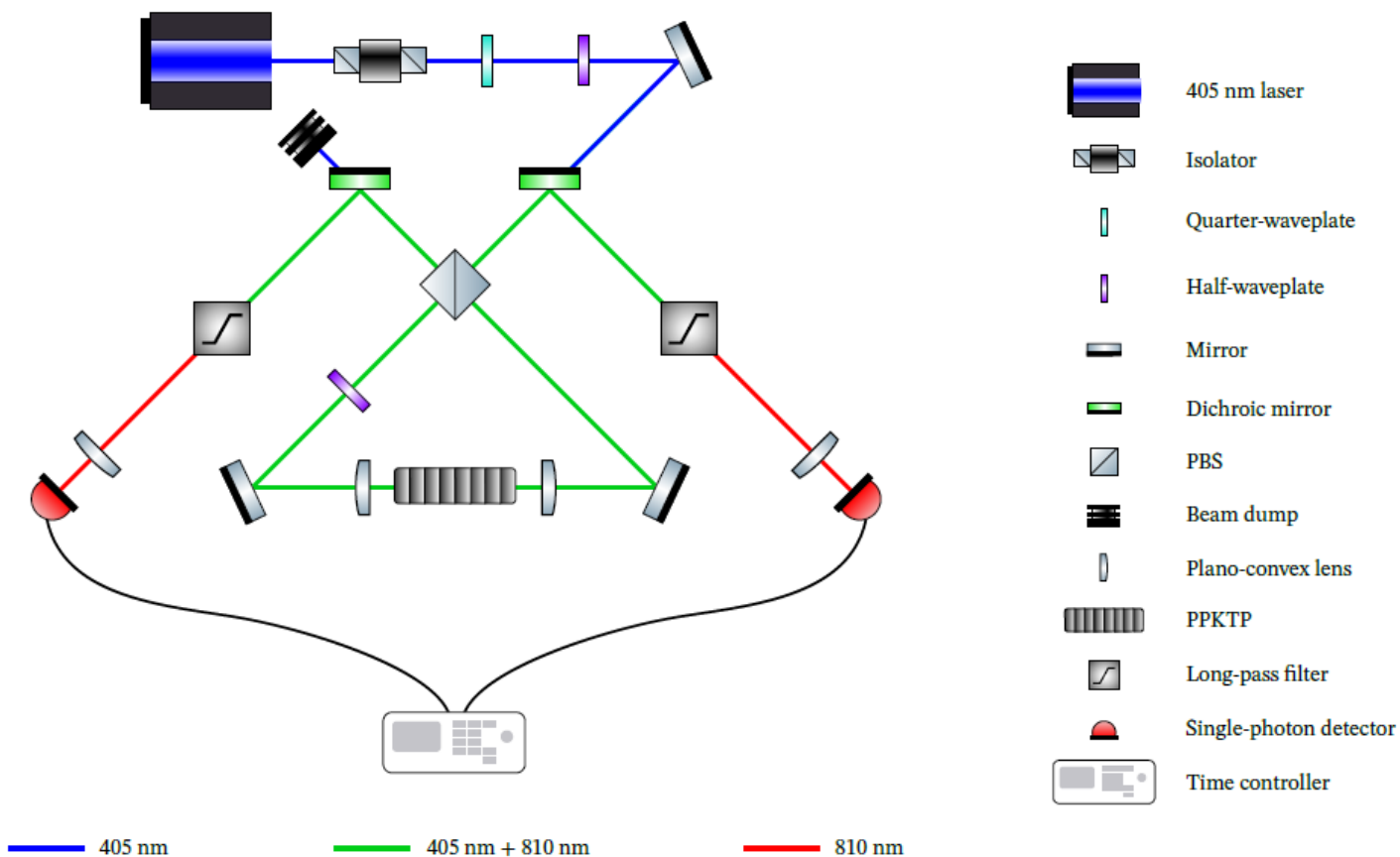
3) Going towards entanglement-based protocols

- Other architecture

Entanglement



Experiment in CSL



[6]

Special Thanks



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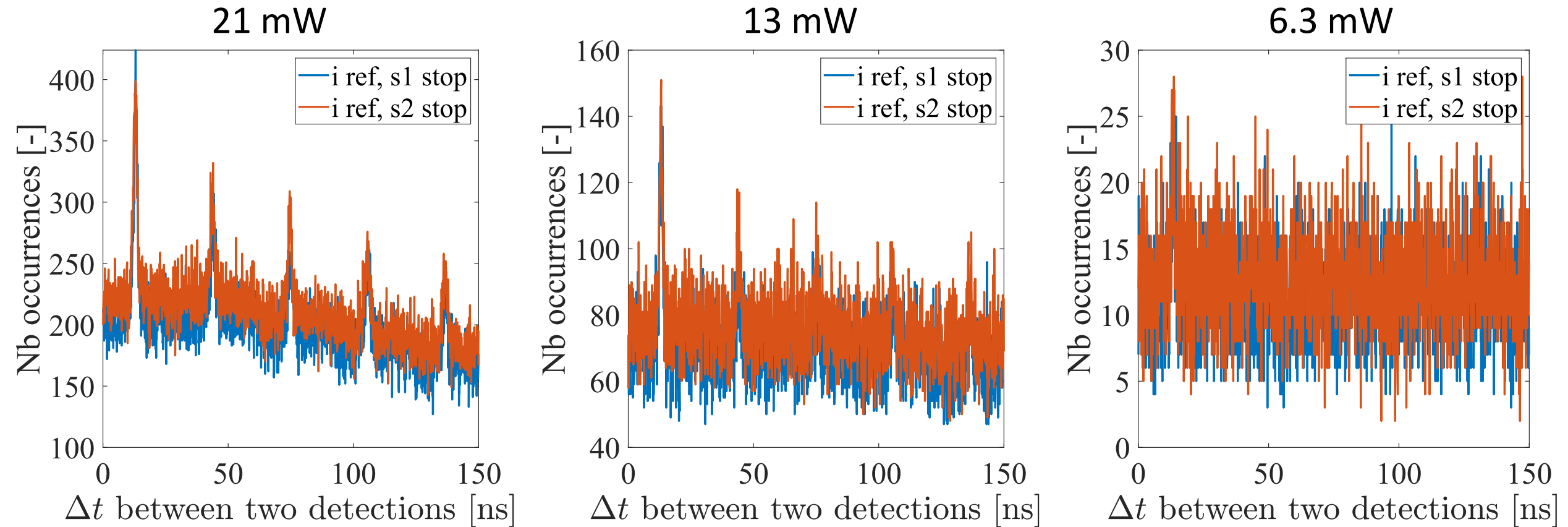
Image references

- [1] https://www.esa.int/Applications/Connectivity_and_Secure_Communications/Secure_communication_via_quantum_cryptography
- [2] Wikipedia : [https://commons.wikimedia.org/wiki/File:IBM_Q_system_\(Fraunhofer_2\).jpg](https://commons.wikimedia.org/wiki/File:IBM_Q_system_(Fraunhofer_2).jpg)
- [3] Edinburgh Instruments: what is antibunching ? Accessed: Nov. 25, 2025. [Online]. Available: <https://www.edinst.com/resource/what-is-antibunching/>
- [4] 'Spontaneous_Parametric_Downconversion.png (PNG Image, 1277 × 752 pixels)'. Accessed: Jun. 16, 2024. [Online]. Available: https://upload.wikimedia.org/wikipedia/commons/7/74/Spontaneous_Parametric_Downconversion.png
- [5] 'Correlated Photon-Pair Sources'. Accessed: Jun. 16, 2024. [Online]. Available: <https://www.thorlabs.com>
- [6] 'Development of a Laser Source of Entangled Photons for Space Quantum Key Distribution', Marine Adam

Thank you for your attention!

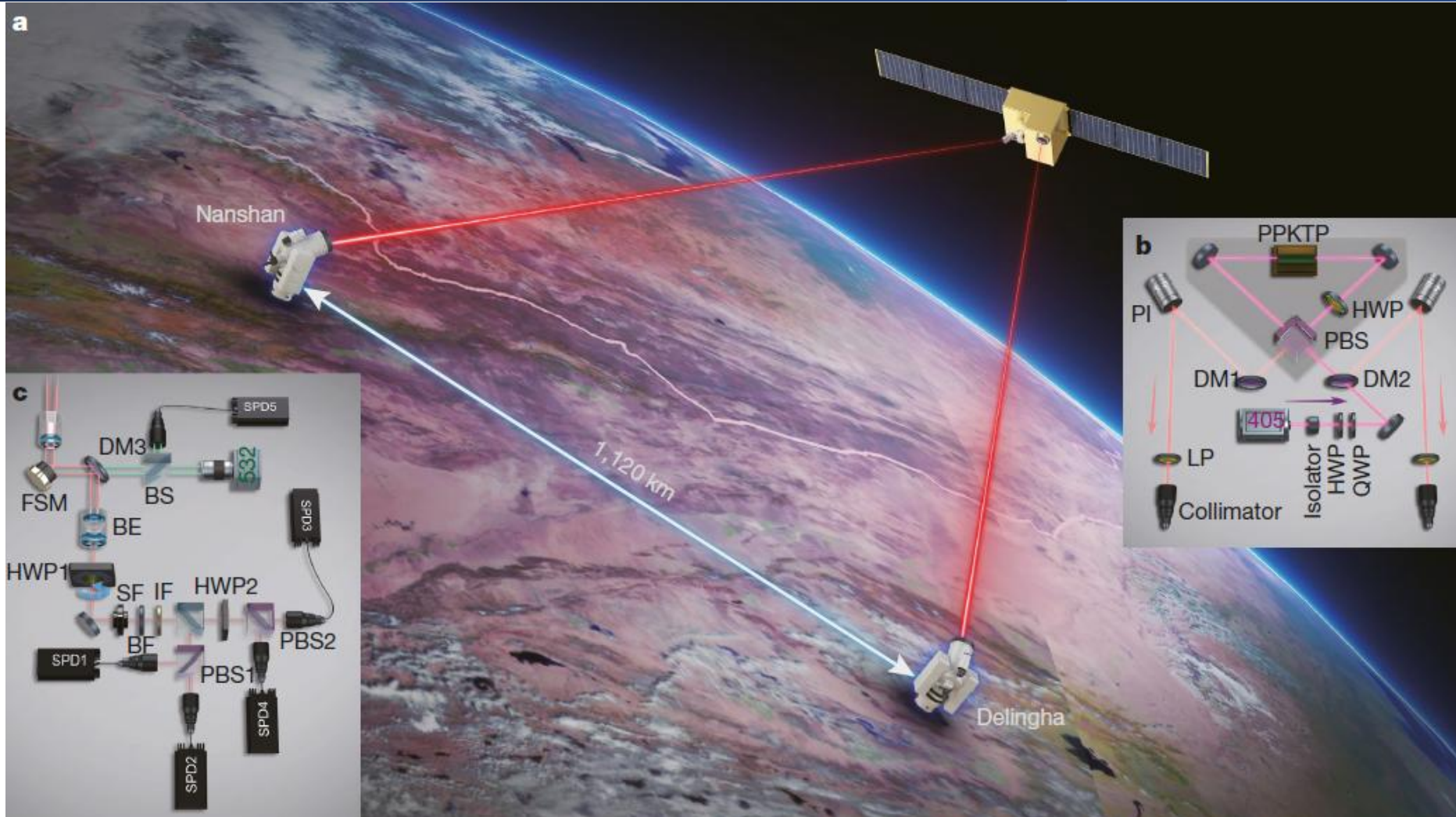
Annexes

Influence of the Incident Optical Power



Micius (2017)

Receiver

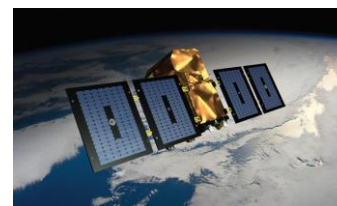


Transmitter

European initiatives



Advanced Research in
Telecommunications
Systems (ARTES)



Four-wave mixing

