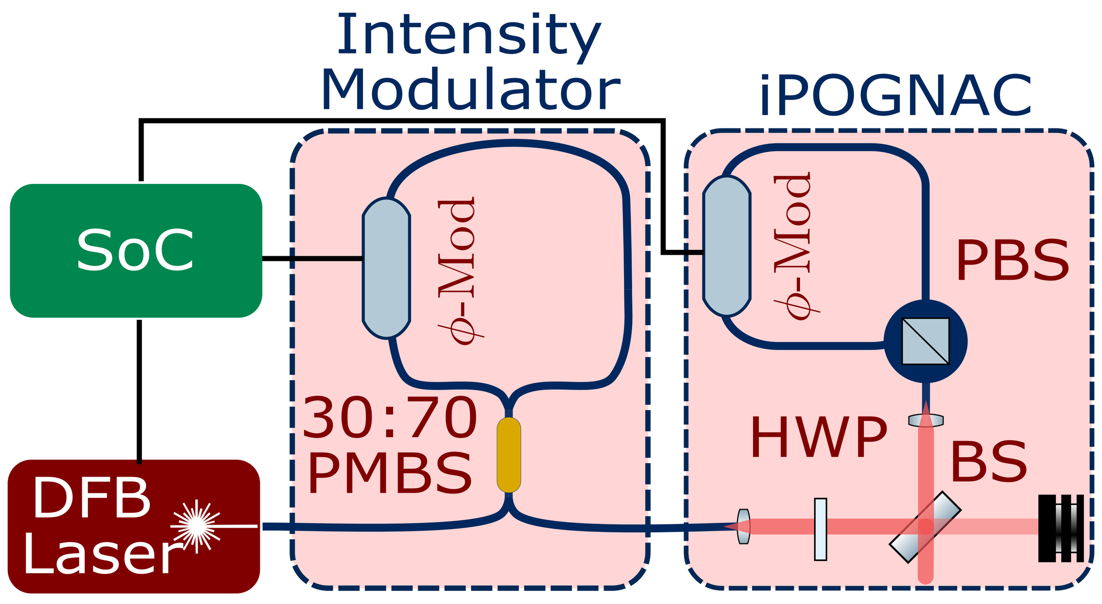
DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

Self-compensating source at 800 nm for satellite quantum key distribution

F. Berra, C. Agnesi, S. Cocchi, A. Stanco, M. Avesani, P. Villoresi and G. Vallone
Department of Information Engineering, University of Padova, 35131 Padova, Italy

Free-space transmitter and receiver

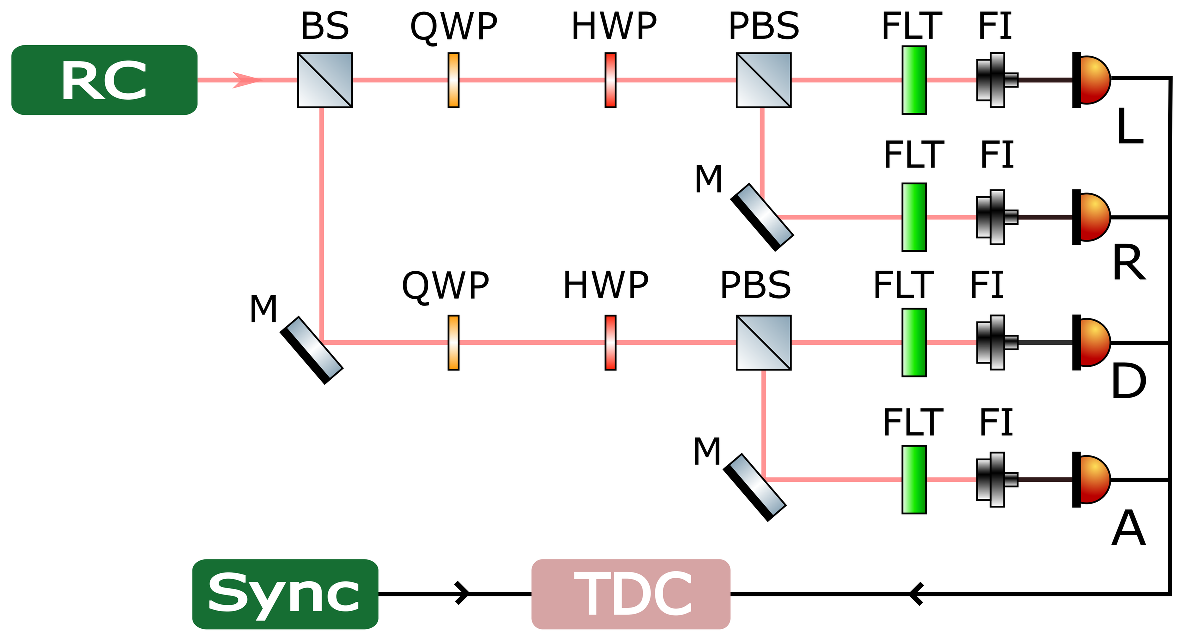
Transmitter



Features:

- **Intensity modulator**[1] attenuates the pulses at single photon level $\mu_1 \approx 0.58$ and $\mu_2 \approx 0.16$
- **Polarization modulator**[2] generates 3-polarization states: L, R, D
- The source output is already in free-space excellent for satellite communications

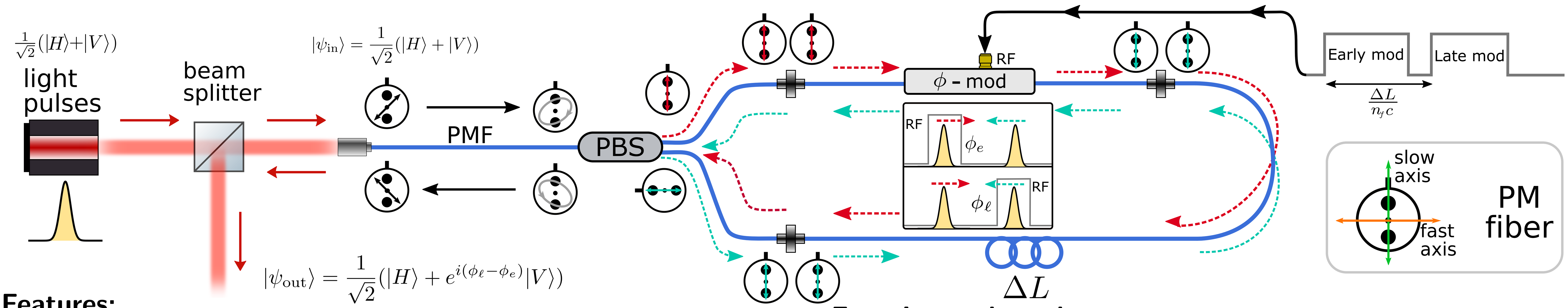
Receiver



Features:

- A beam-splitter randomly projects the incoming qubits into two basis X, Y
- Each bases measures two orthogonal states $X = \{D, A\}$ and $Y = \{L, R\}$
- The arrival time of qubits is then synchronized with an external source for post-processing

iPOGNAC technology



Features:

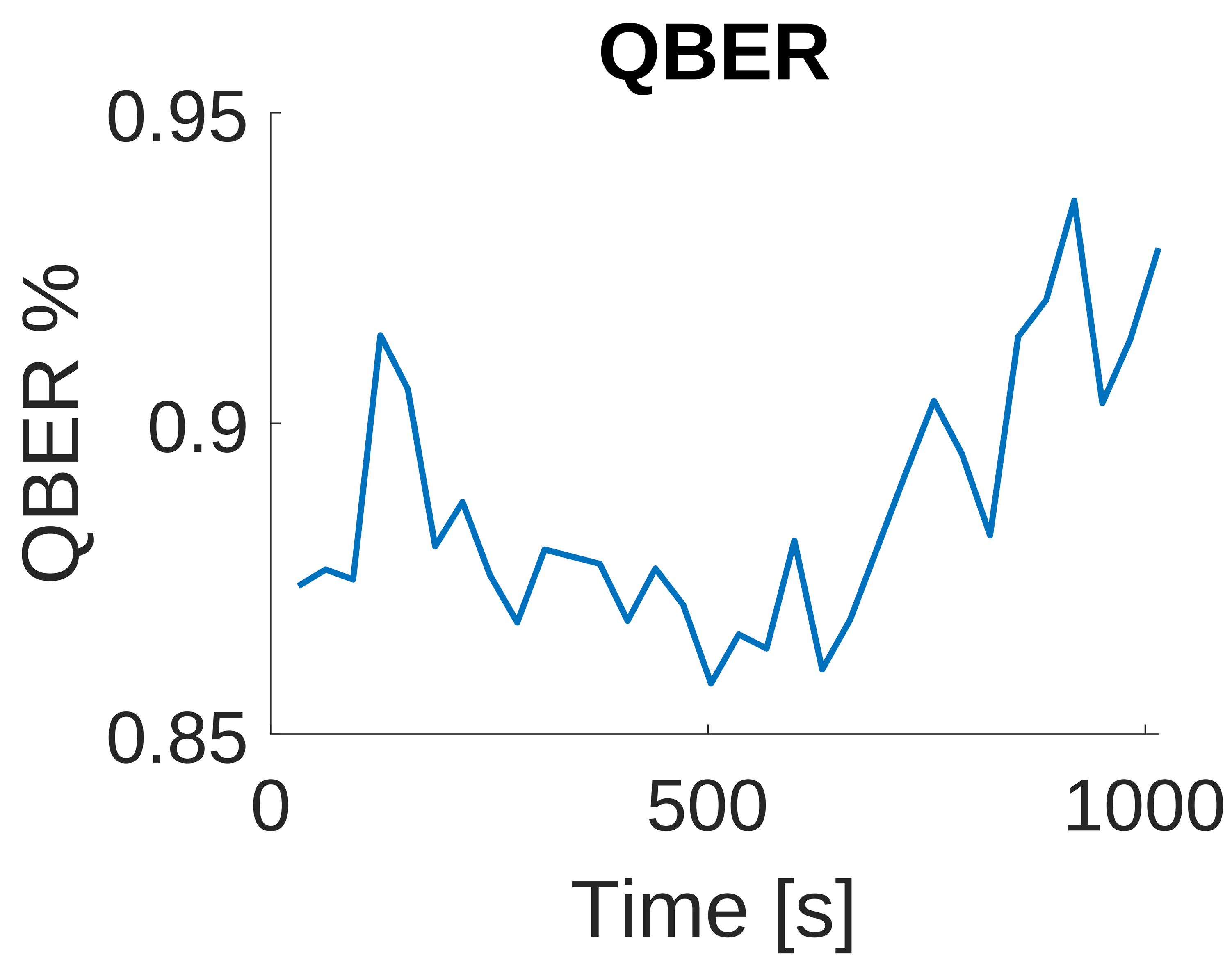
- **Long term stability**: Thermal and mechanical phase drifts are automatically compensated
- Phase modulator needs to support **only one polarization**
- **Low** V_π: no need to modulate the relative phase

Working principle:

- The qubits enter with $|D\rangle$ state into a polarization maintaining (PM) fiber where it get an elliptical phase δ
- A fiber Polarization Beam Splitter (PBS) **splits** the light into two **orthogonal polarizations**, guided by PM fibers
- Both beams are **aligned to the slow axis** of the PM fiber. The polarization degree of freedom is mapped to the optical path of the photons. From now, **only one polarization travels in the loop**.
- The phase modulator, placed **asymmetrically**, can add a ϕ_e to the **Clockwise** pulse and a ϕ_ℓ shift to the **Counter-clockwise** pulse.
- At the PBS the pulses are recombined
- The qubits entering again in the polarization maintaining (PM) fiber with swapped H, V components getting an elliptical phase $-\delta$
- The final state is $|\psi_{\text{out}}\rangle = \frac{1}{\sqrt{2}}\left[|H\rangle + e^{i(\phi_e - \phi_\ell)}|V\rangle\right]$

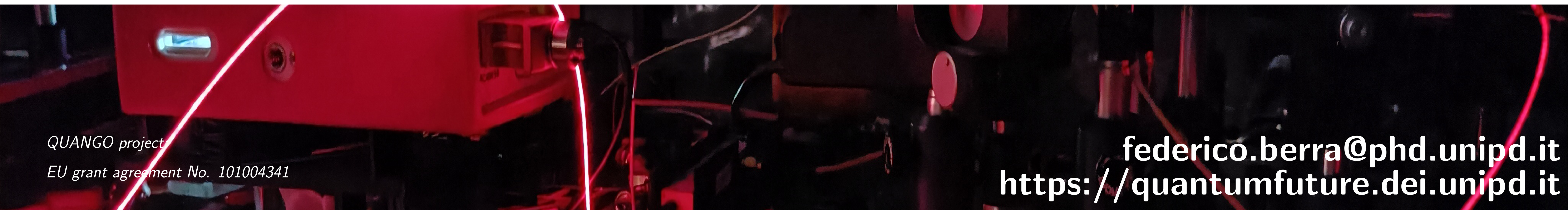
Experimental results:

- Implemented at **795 nm** with only COTS components
- Repetition rate 50 MHz
- **Low QBER:** $\leq 1\%$ with Si SPAD at 800nm



References

1. G. Roberts *et al.* *Patterning-effect mitigating intensity modulator for secure decoy-state quantum key distribution*, Opt. Lett. **43** (20), 5110 (2018).
2. M. Avesani *et al.* *Stable, low-error, and calibration-free polarization encoder for free-space quantum communication*, Opt. Lett. **45** (17), 4706 (2020).



QUANGO project
EU grant agreement No. 101004341

federico.berra@phd.unipd.it
https://quantumfuture.dei.unipd.it