Building a quantum router

for discrete photons using linear optics

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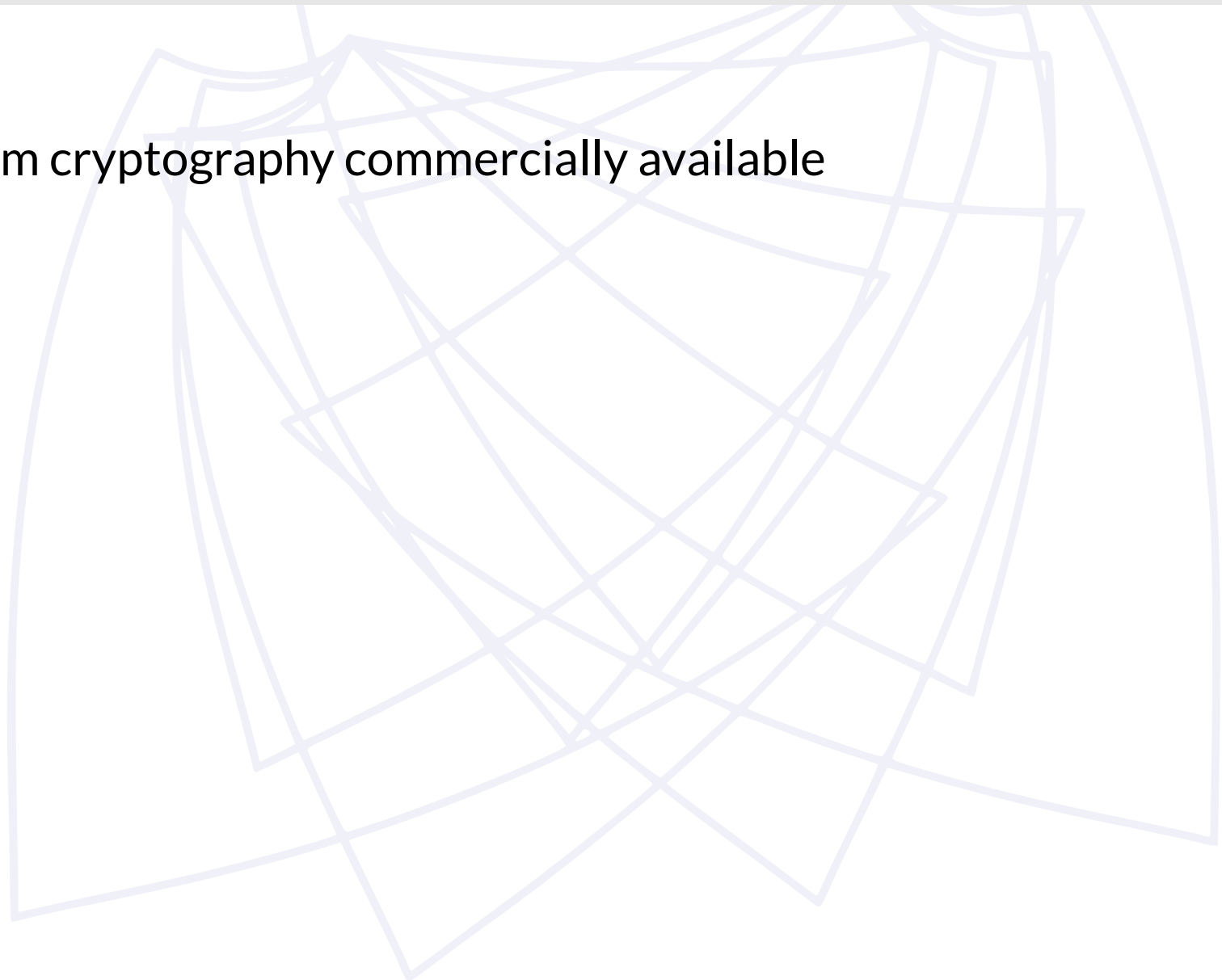
Quantum networks – on the brink of feasibility



- ✓ quantum cryptography commercially available

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← idQuantique (Switzerland)

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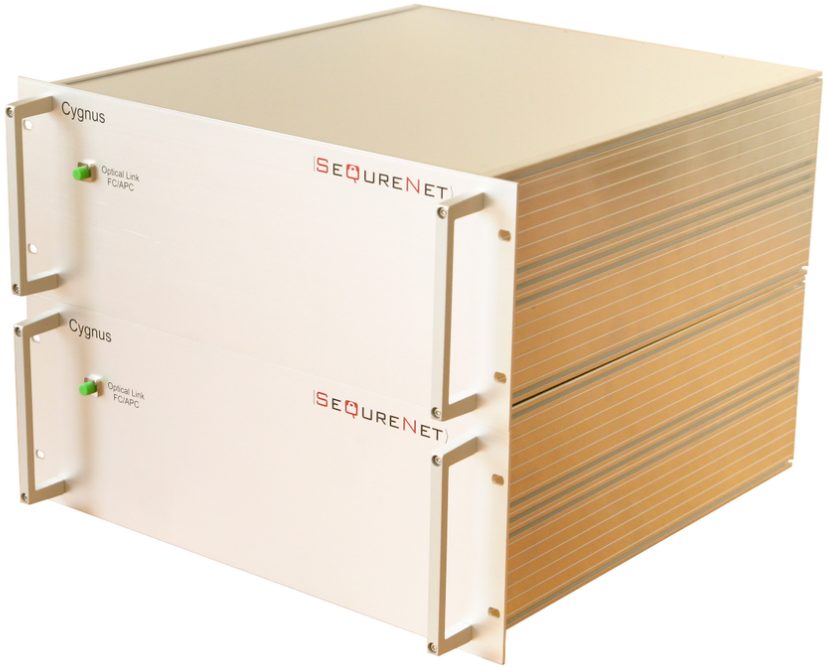

← SeQureNet (France)

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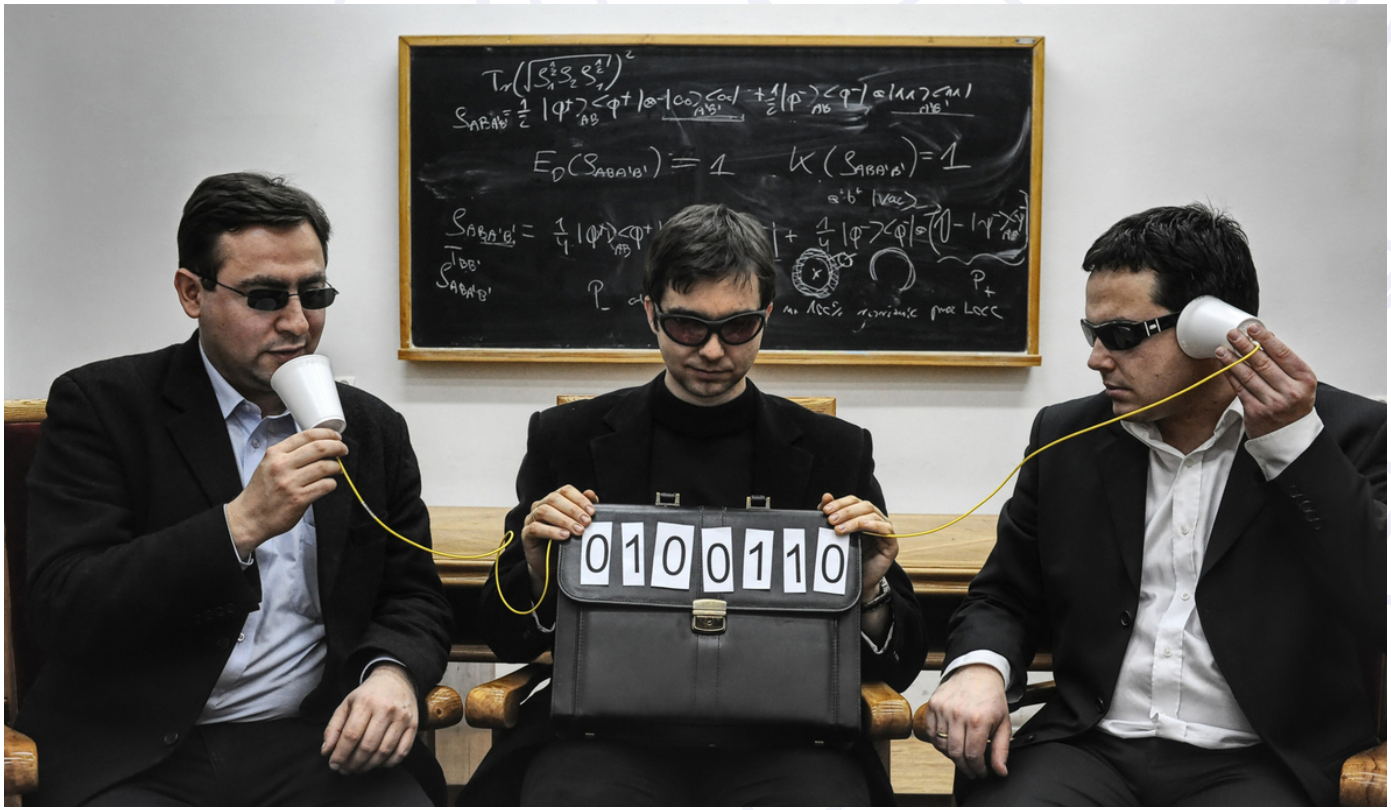

Paweł Horodecki TM (Poland)

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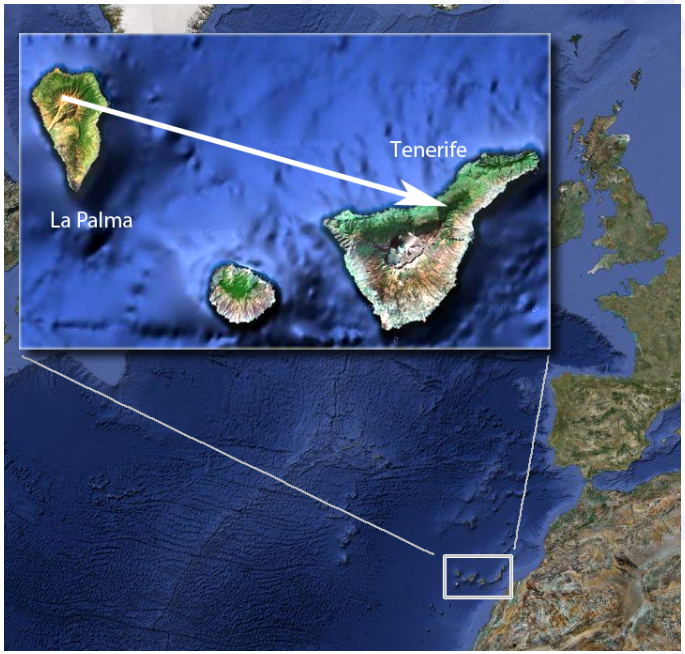

← Nature **489**, 269 (2012)

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← Nat. Photon. **10**, 671 (2016)

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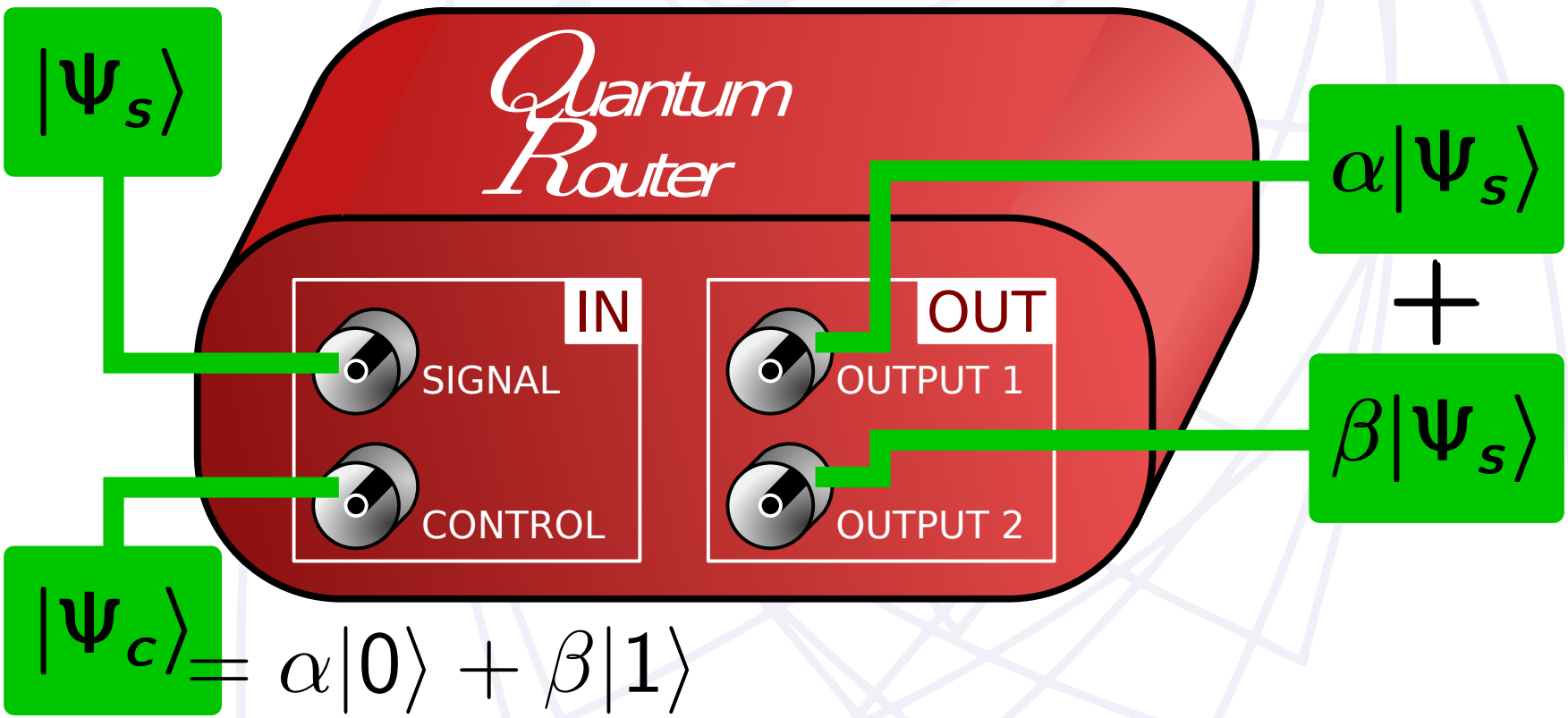
→ **solution: quantum routers**
(joining multiple users and routing quantum information from source to destination)

Quantum router – general concept

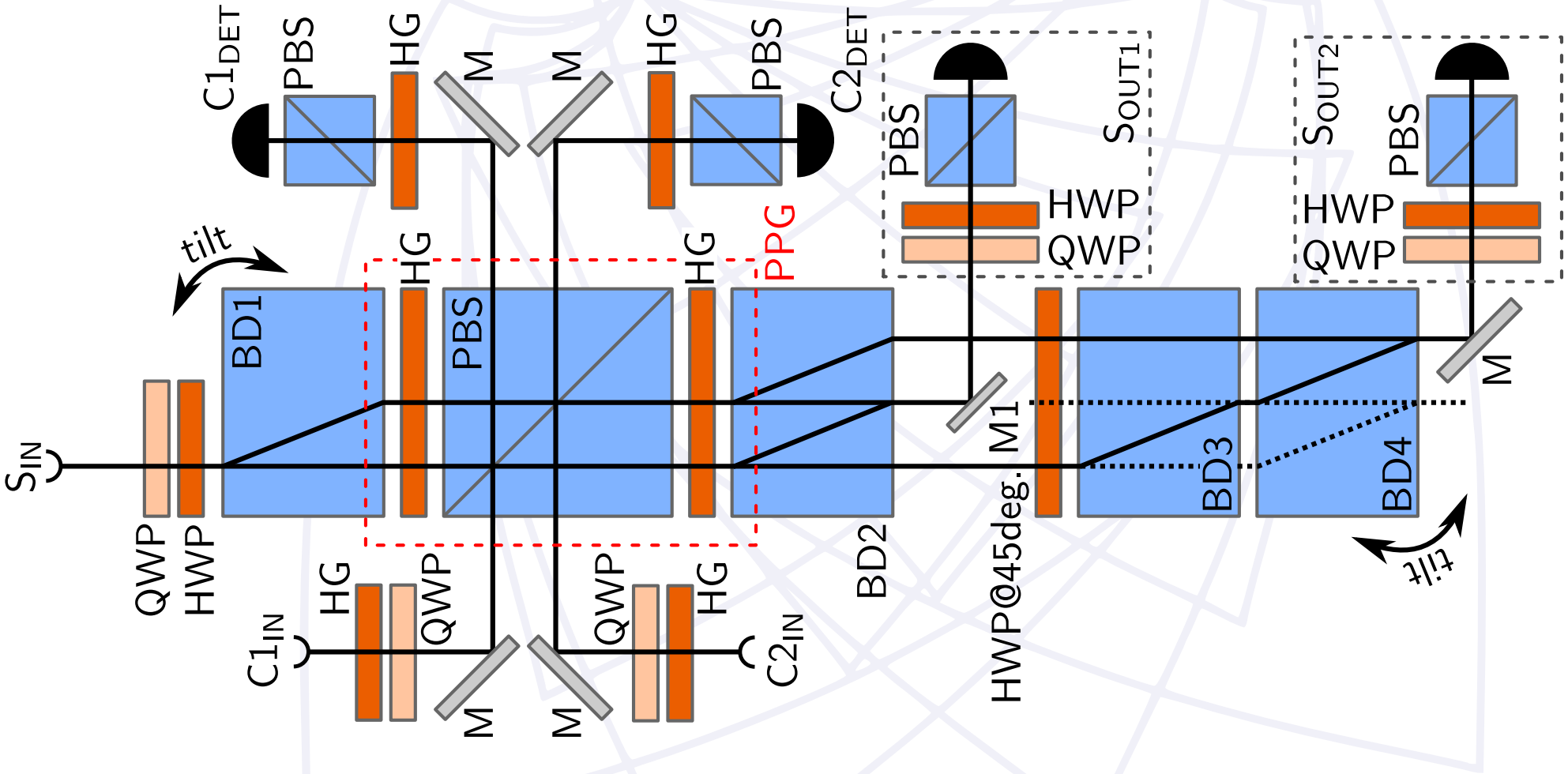


- coherently routes signal qubit into two (or more) spatial modes depending on the control qubit

Previous implementations & proposals

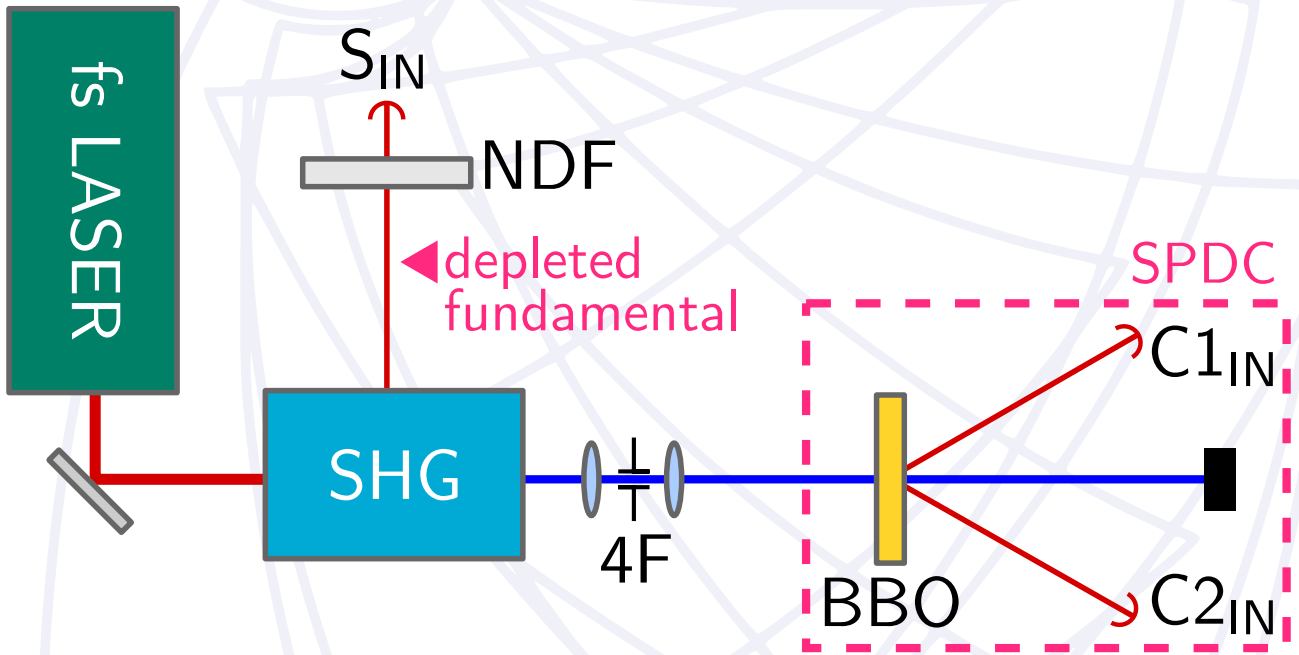
Platform	Implementations	Note
light-atoms	Zueco *et al.*, PRA **80**, 042303 (2009). Aoki *et al.*, PRL **102**, 083601 (2009). Hoi *et al.*, PRL **107**, 073601 (2011). Zhan *et al.*, PRA **90** 012331 (2014).	experimentally demanding
light beams	Hall *et al.*, PRL **106**, 053901 (2011).	classical control
nonlinear	Chen, Lin, Sci. Chin. Inf. **57**, 1 (2014).	strong Kerr
linear opt.	Zhan *et al.*, PRA **90** 012331 (2014). Vitelli *et al.*, Nat. Phot. **7** 521 (2013).	classical signal $P_{succ.} = 1/8$

Our implementation



- 2 control qubits, only real output superpositions, $P_{succ.} = 1/4$

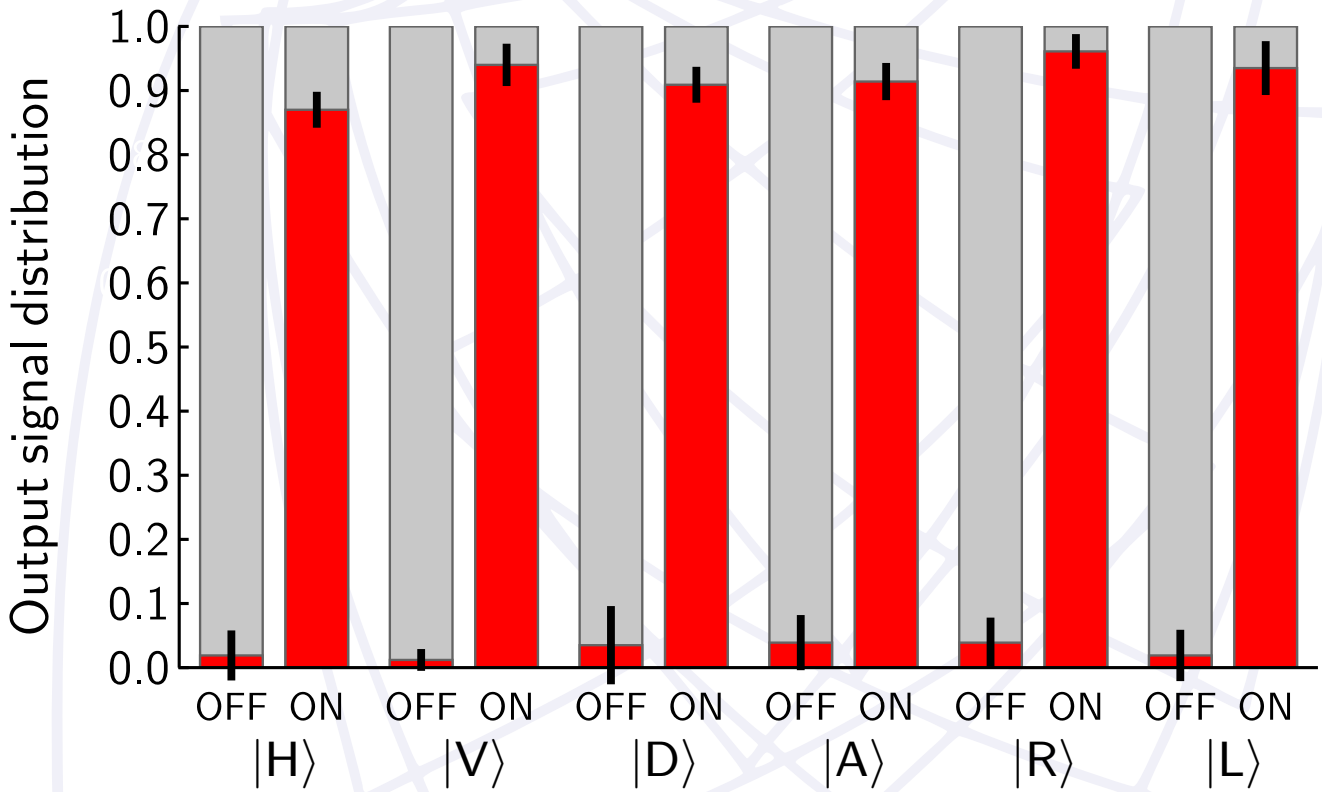
Three-photon source



- control photons: Type I SPDC
- signal photon: attenuated depleted fundamental beam
- imperfection: parasitic coincidences (e.g. two photons in S_{IN})

Testing the router

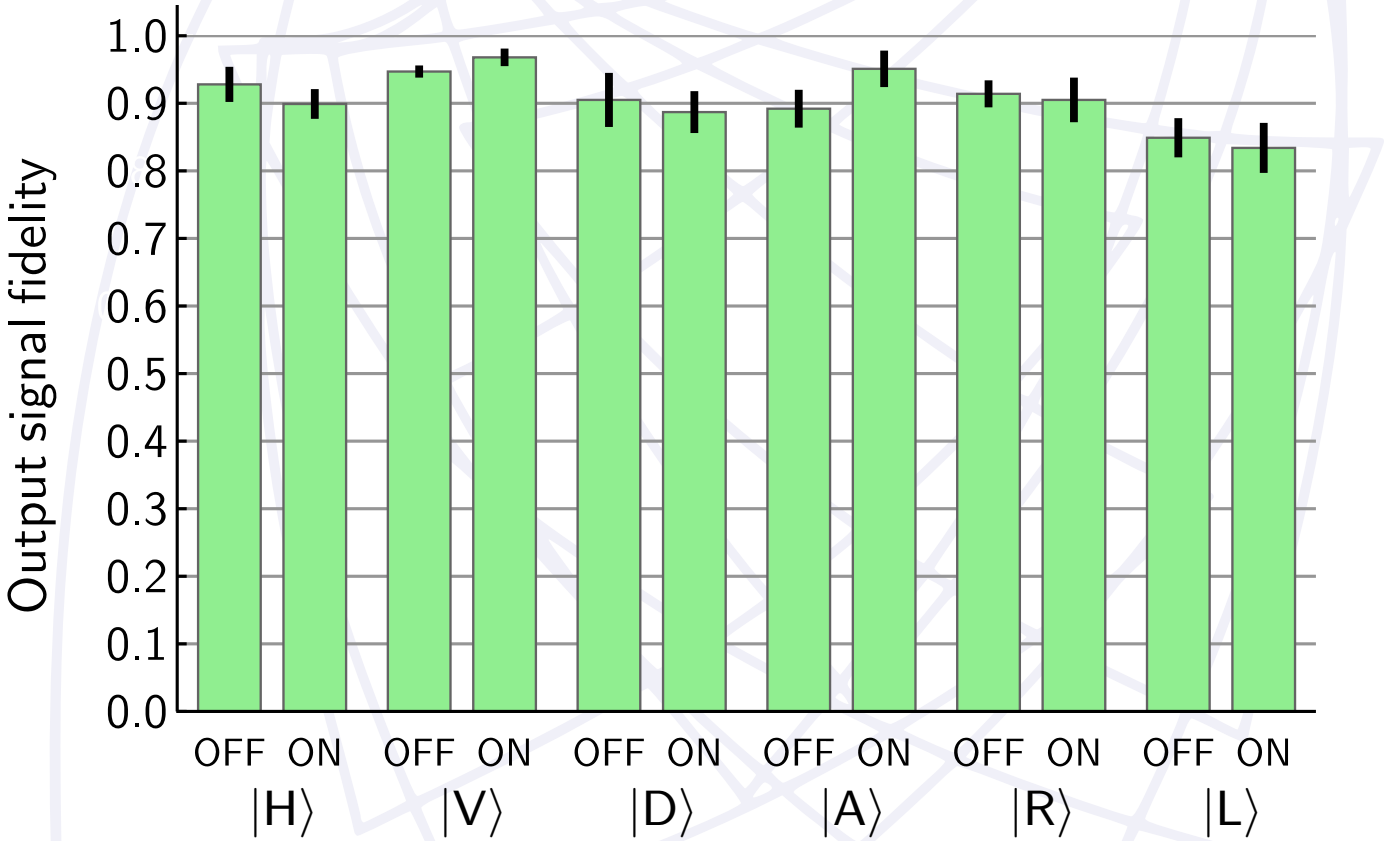
(phase I) routing ON/OFF



- six input signal states: H,V,D,A,R,L & control qubits set to $|0\rangle$, $|1\rangle$.
- probability of observing the signal in output ports 1 and 2

Testing the router

(phase II) routing fidelity

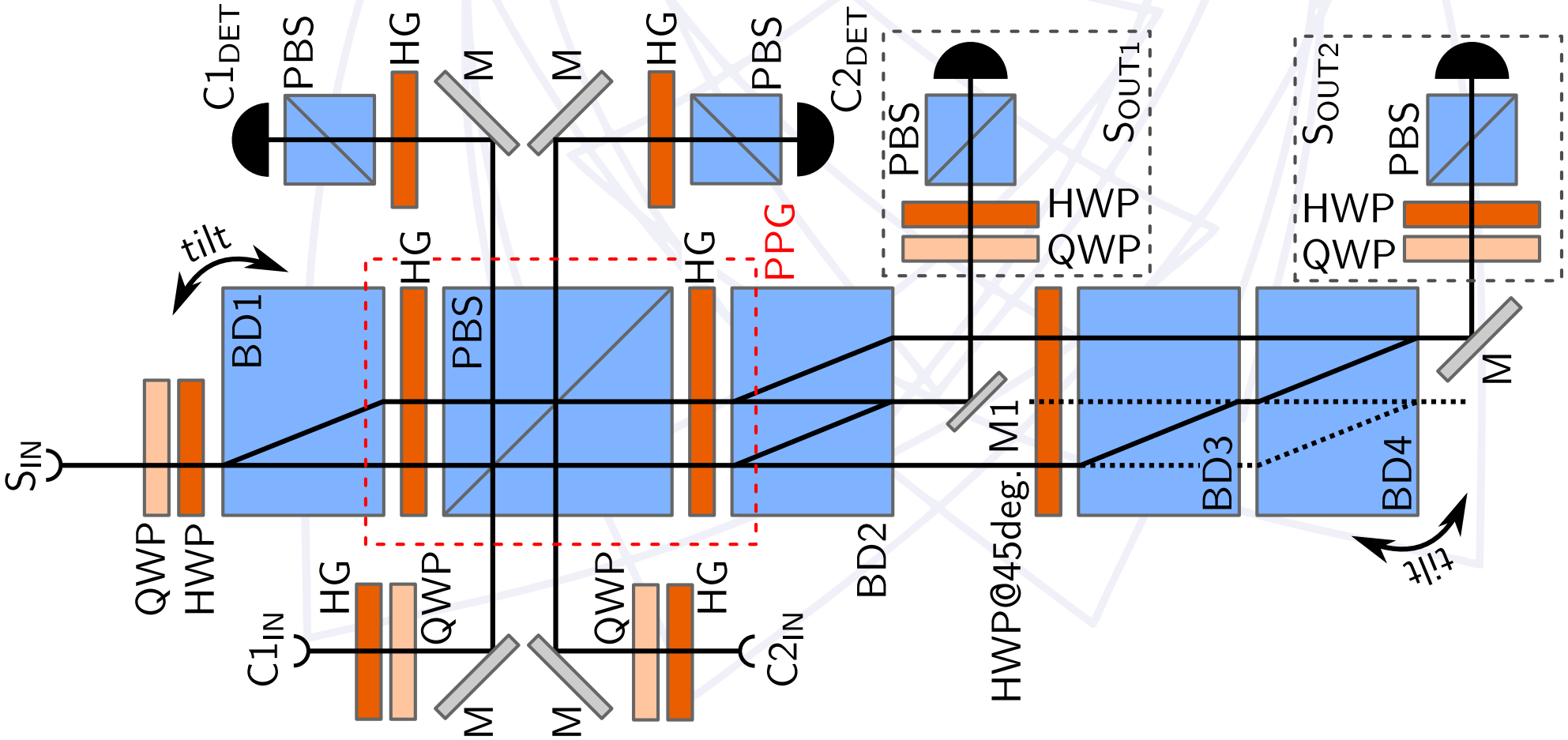


- six input signal states: H,V,D,A,R,L & control qubits set to $|0\rangle$, $|1\rangle$.
- measuring fidelity of the output state

Testing the router

(phase III) routing coherence

- tested for H signal state
- removing M1 and BD3 (dotted beam path), tilting BD4



Testing the router

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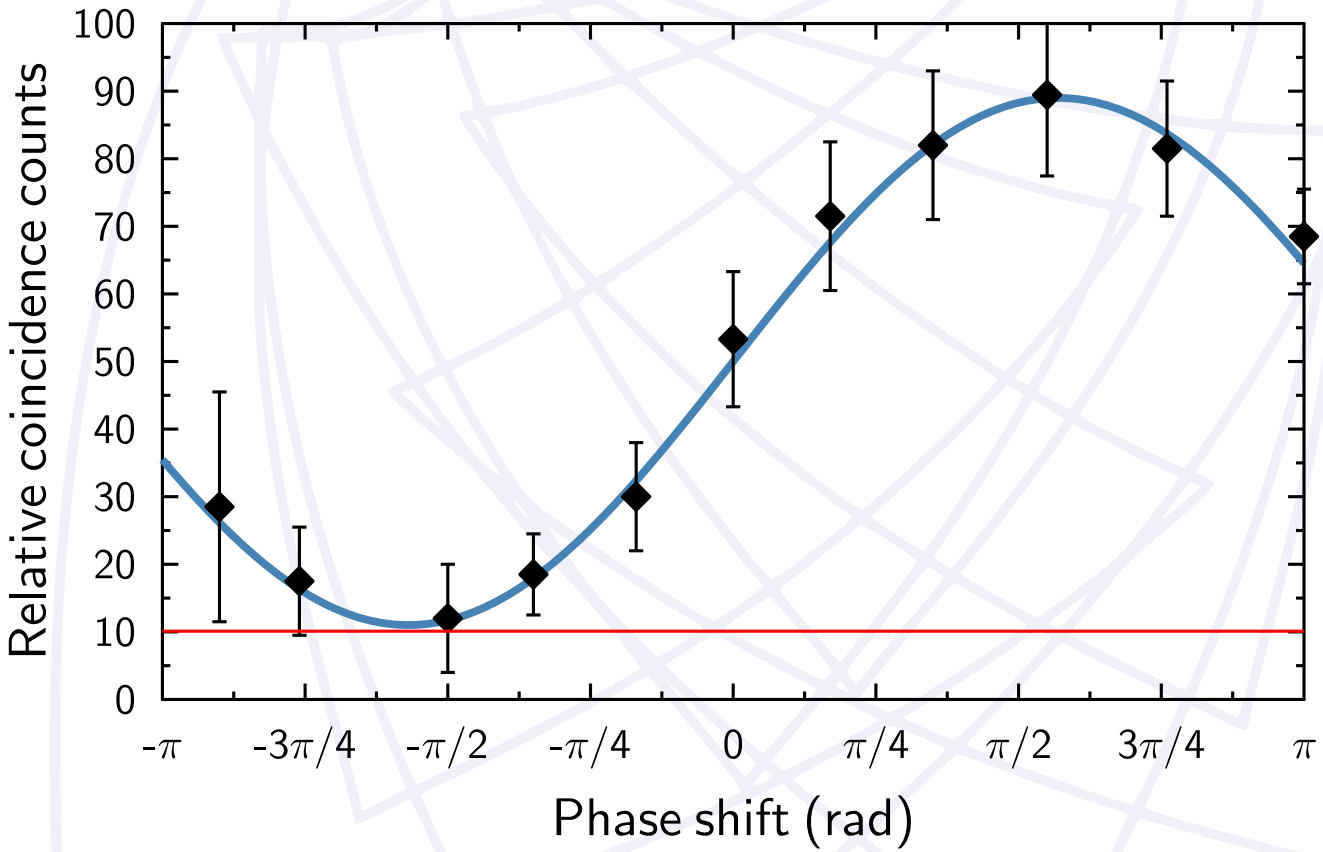
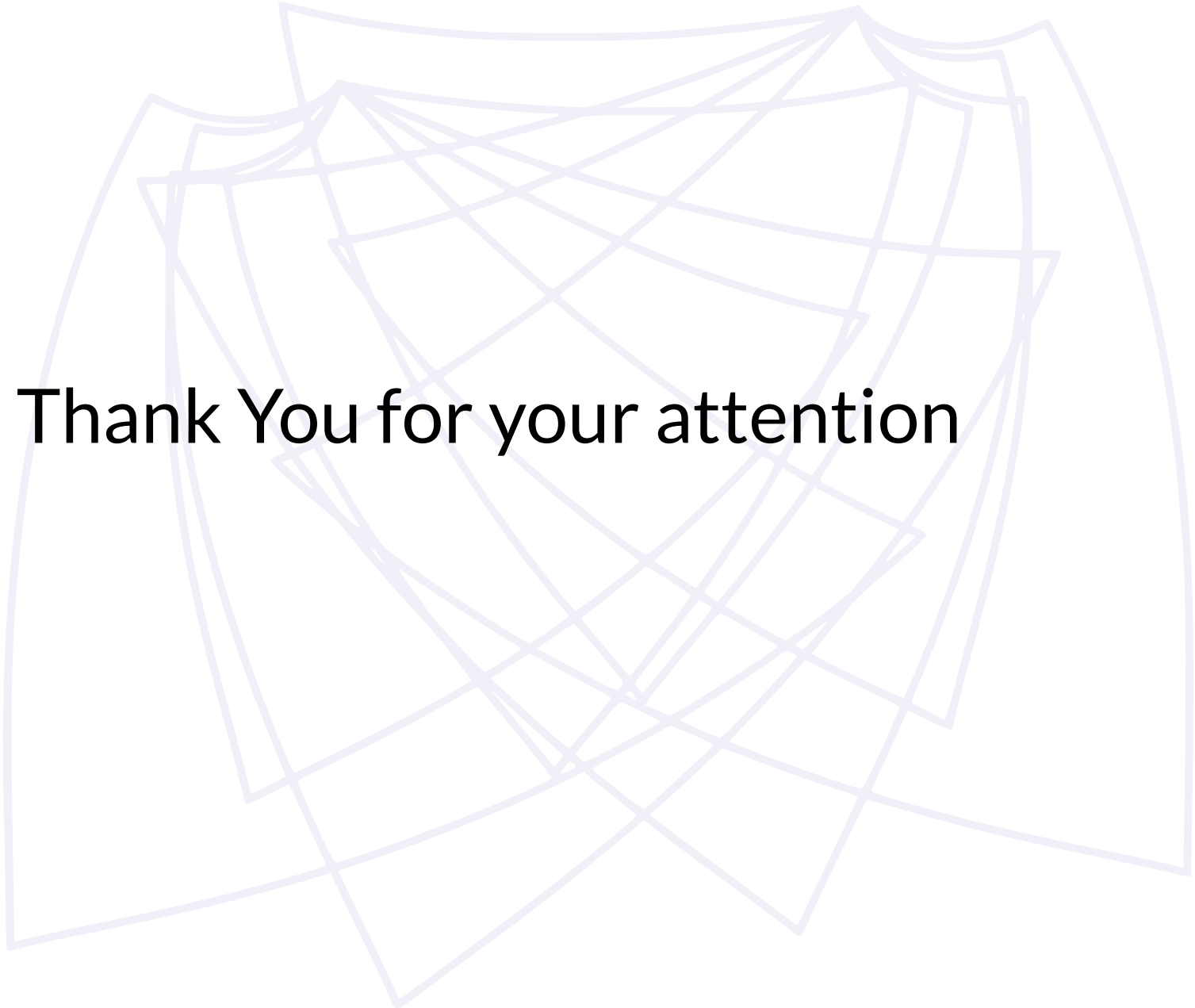


- red line – parasitic coincidences level
- corrected visibility $97.7 \pm 0.3\,\%$



Thank You for your attention