Improving SPDC single-photon sources via spectral filtering and feed-forward control

Marcello Massaro[1], *Evan Meyer-Scott*[1], *Nicola Montaut*[1], *Harald Herrmann*[1], *Christine Silberhorn*[1]

[1]*Integrated Quantum Optics, University of Paderborn, Germany*

Generation of pure single-photon states at high rates is fundamental to modern quantum technologies and applications. Current methods for single-photon generation include parametric downconversion (PDC) processes in non-linear crystals, four-wave mixing (FWM) in photonic-crystal fibers, quantum dots and nitrogen-vacancy (NV) centers in diamonds.

One of the most promising platforms for heralded single-photons is PDC from periodically-poled LiNbO3 waveguides, which offer high non-linearity and integration capabilities [1]. However, one of the main drawbacks of such sources is their spectral multimode nature, which reduces the purity of the heralded photons. This problem can be addressed with different methods, such as source engineering [2], and/or spectral filtering. Spectral filtering is typically achieved by heralding one of the two photons after its transmission through a spectral filter such as a grating. However, spectral filtering comes at the cost of reduced source brightness [3]. In principle it is possible to overcome this by increasing the pump power. However, this increases the probability of generating unwanted multiple pairs of photons at a time. If two pairs are generated, one of them being outside the filter bandwidth, a false-positive will occur, compromising the fidelity of the output photon state with the single photon state.

We propose a scheme (Figure 1) to mitigate this problem by monitoring both the transmitted and reflected ports of the spectral filter. In doing so, events involving multiple downconversions can be seen though the simultaneous detection of photons in both of the ports. If multiple photons are detected, the heralded photon is discarded using a fast electro-optical switch in a feed-forward scheme. This results in an improvement of the heralded $g^{(2)}(0)$ function, compared to the case of heralding the presence of a photon by only using the transmission port of the filter.

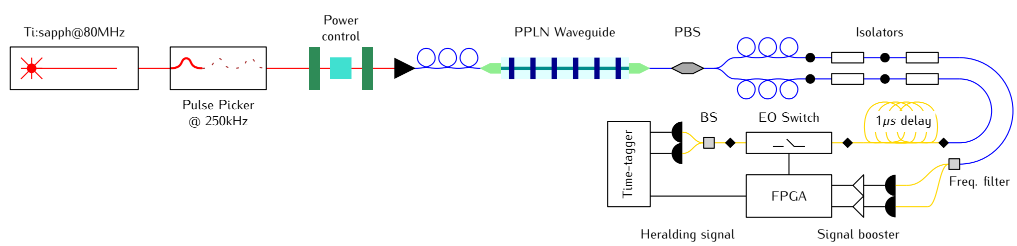

Figure 1: Experimental setup.

Better performances can be achieved by using multiplexed schemes [4 – 6], but these generally require a considerable resources overhead compared to the presented method, which can be easily applied to existing setups.

References

[1] Nicola Montaut *et al.*“High-Efficiency Plug-and-Play Source of Heralded Single Photons”, Physical Review Applied **8** (2017).

[2] Peter J. Mosley *et al.*, “Heralded Generation of Ultrafast Single Photons in Pure Quantum States”, Physical Review Letters **100** (2008).

[3] Evan Meyer-Scott, *et al.*, “Limits on the heralding efficiencies an spectral purities of spectrally filtered single photons from photon-pair sources”, Physical Review A **95** (2017).

[4] Grimau Puigibert, “Heralded Single Photons Based on Spectral Multiplexing and Feed-Forward Control”, Physical Review Letters **119** (2017).

[5] Fumihiro Kaneda *et al.*, “Time-multiplexed heralded single-photon source”, Optica **2** (2015).

[6] Thomas Meany *et al.*, “Hybrid photonic circuit for multiplexed heralded single photons: Hybrid photonic circuit for multiplexed heralded single photons”, Laser & Photonics Reviews **8** (2014).