A versatile single mode photon source

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The generation of high-quality single photon states with controllable narrow spectral bandwidths and central wavelength is key to facilitate efficient coupling of any atomic system to non-classical light fields. Among others, such interaction is essential for applications in the fields of linear quantum computing and optical quantum networking. In order to be compatible with all of these experiments, a versatile single-photon source should allow for tuning of the spectral properties (wide wavelength range and narrow bandwidth), while retaining high efficiency.

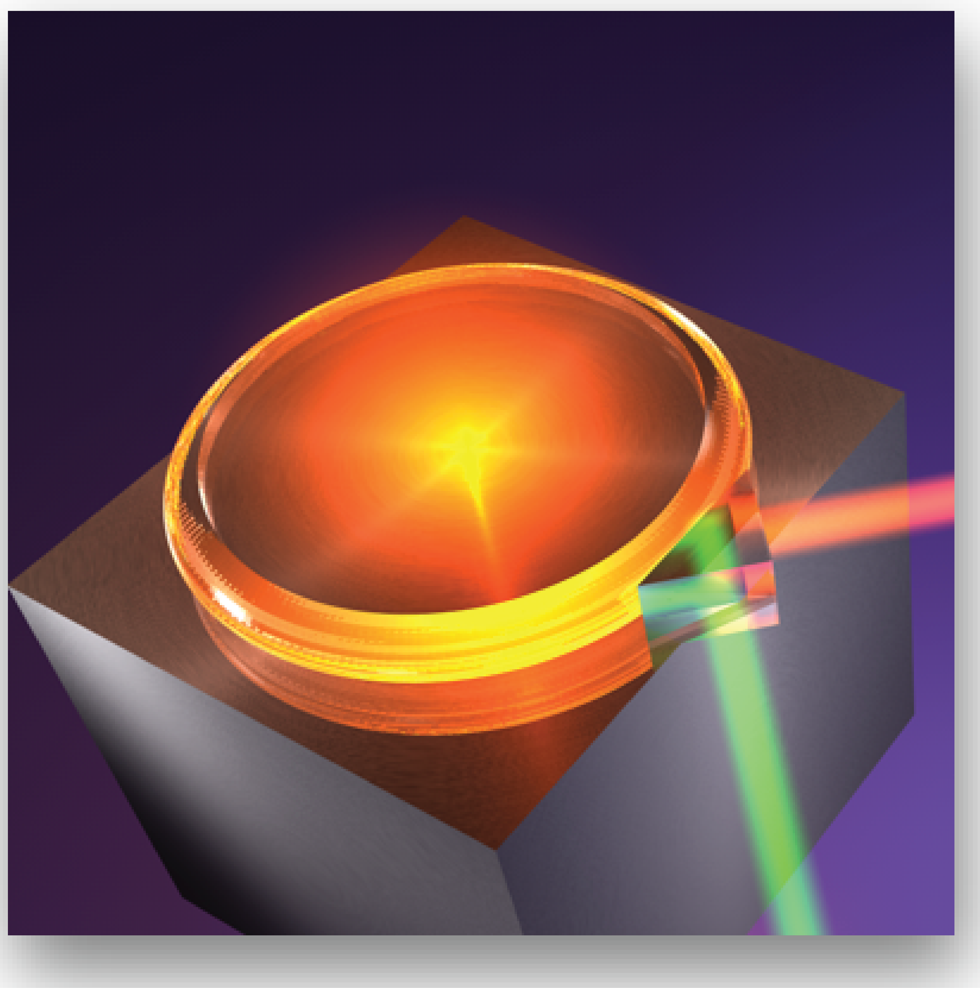
The Source

Crystalline Whispering Gallery Mode Resonator

- made from lithium niobate
- high Quality factor ($Q \approx 10^7$) [1]
- based on total internal reflection
- shows resonances within the whole transparency range of the material
- compact and stable

Prism coupling

- coupling via optical tunneling
- allows for tuning of the resonators bandwidth



Resonator assisted Spontaneous Parametric Down-Conversion

- one pump photon decays into two photons called signal and idler
- signal and idler preserve the energy and the momentum of the pump photon
- resonator assistance ensures narrow-band and efficient emission of signal and idler

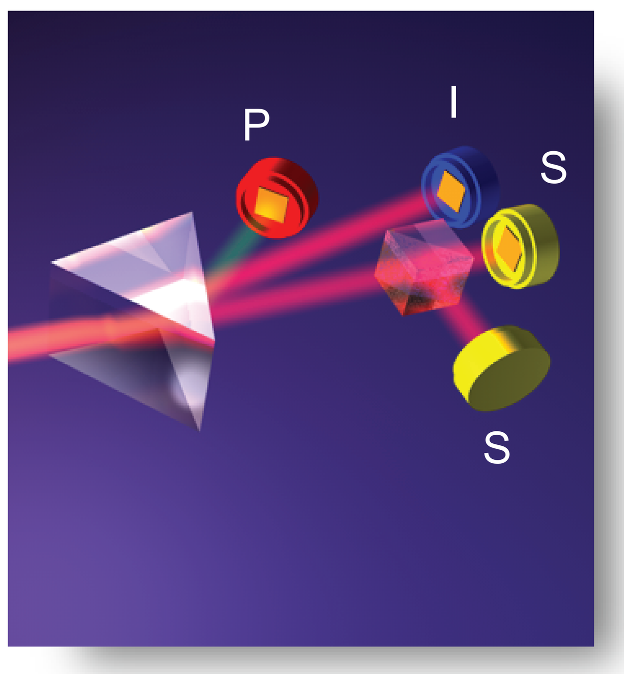
Natural Type-I Phasematching

- phasematching of the triply resonant cavity is controlled by temperature and voltage [2]

Setup

Photon Statistics

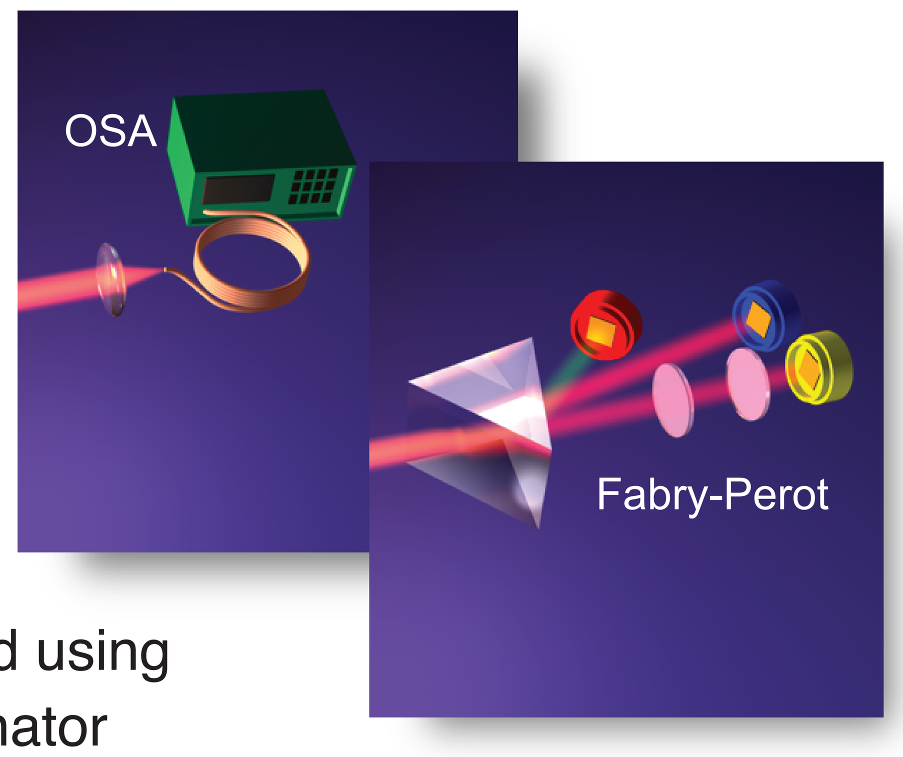
- the pump power (532 nm) is chosen to be far below threshold [2]
- the signal and the idler are separated by a dispersion prism
- the idler photons are detected with one avalanche photodiode (APD)
- the signal photons are the detected in a Hanbury Brown-Twiss setup
- the residual pump is monitored with a PIN diode



Wavelength tuning

- coarse (temperature based) wavelength tuning of the signal and the idler is investigated with an optical spectrum analyzer (OSA)

- fine (voltage based) wavelength tuning is analyzed using a scanning Fabry-Perot resonator

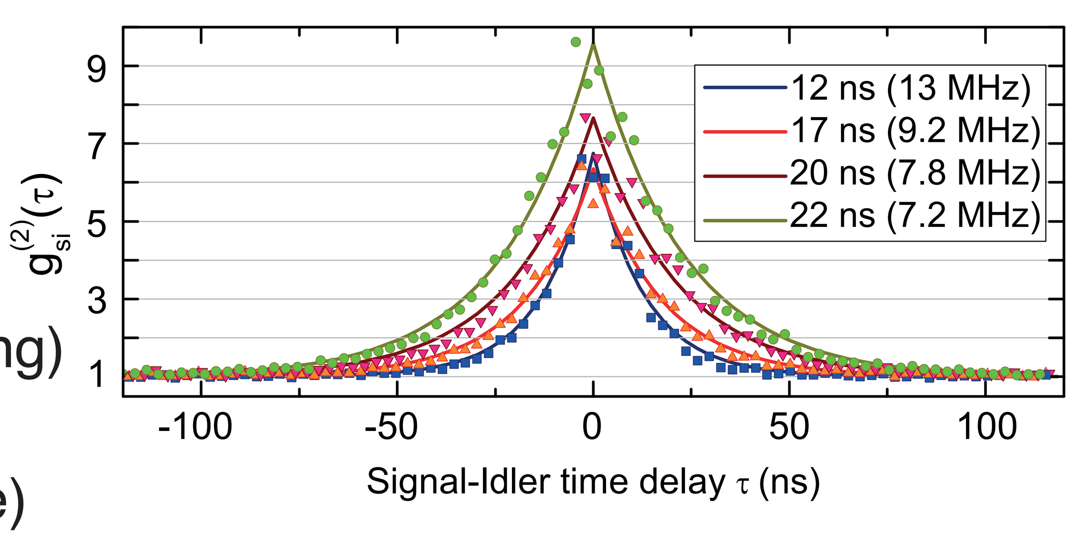


Results

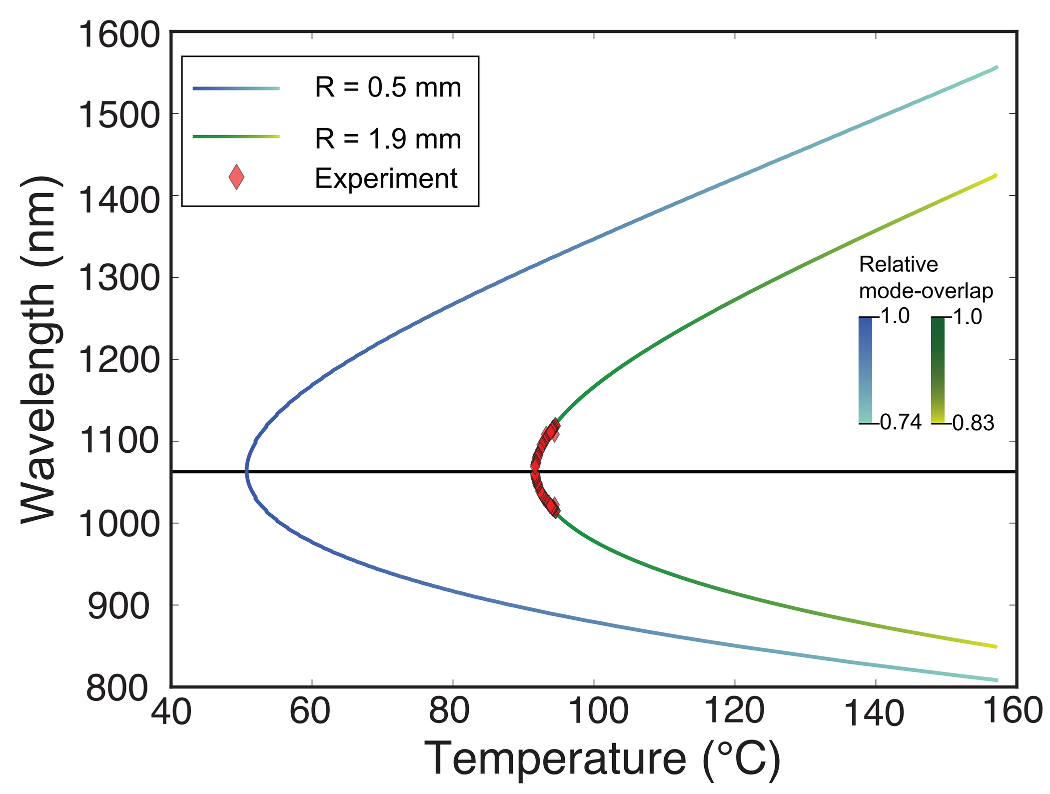
At a Glance [3,4]

- heralded single photons
- pair production rate: 0.97×10^7 pairs/(s mW 20 MHz)
- narrow bandwidth: 4.0 MHz
- tunable bandwidth: 4 MHz - 26 MHz
- true single mode emission (without narrow-band filtering)
- coarse wavelength tuning: > 500 nm
- fine wavelength tuning: up to 150 MHz (mode-hop free)

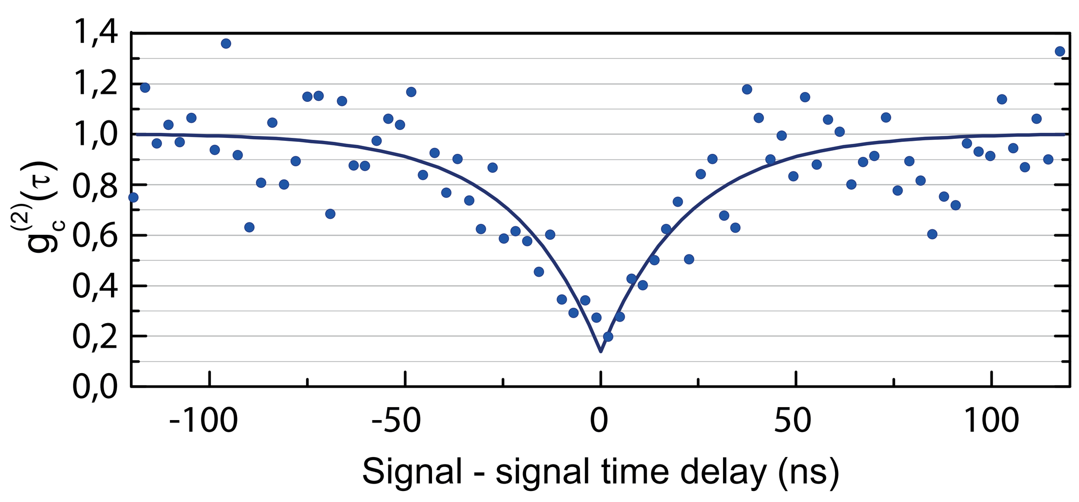
Cross-correlation function



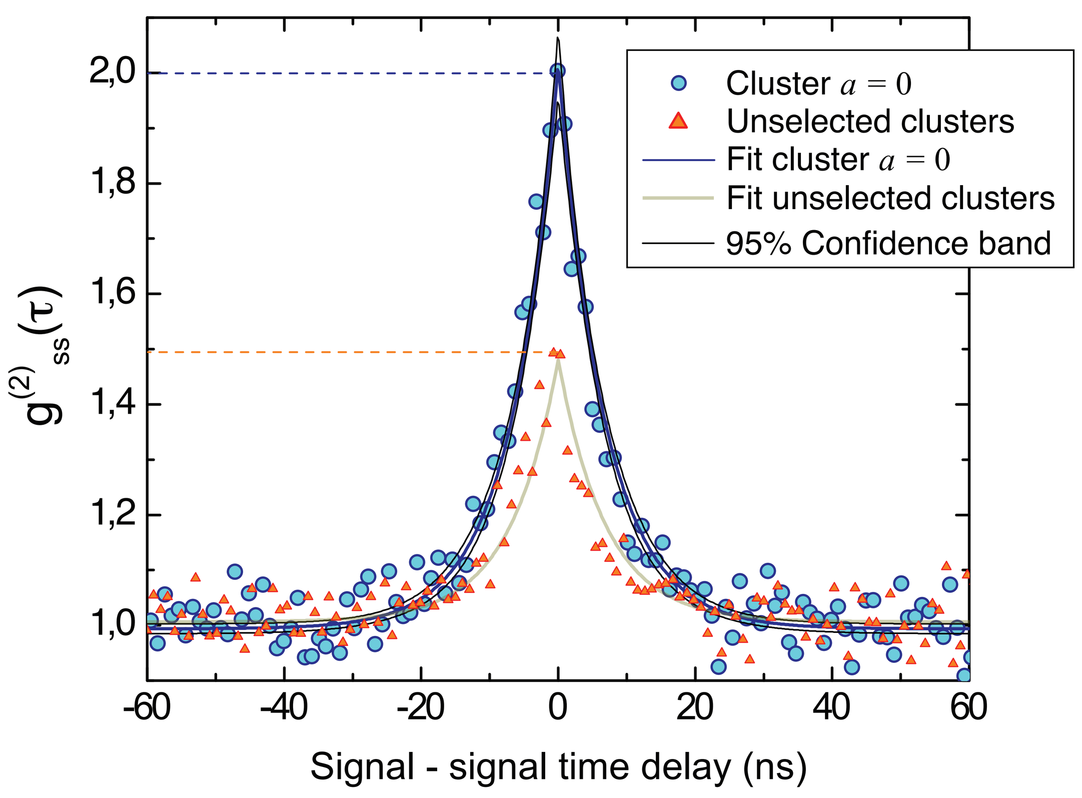
Wavelength tuning

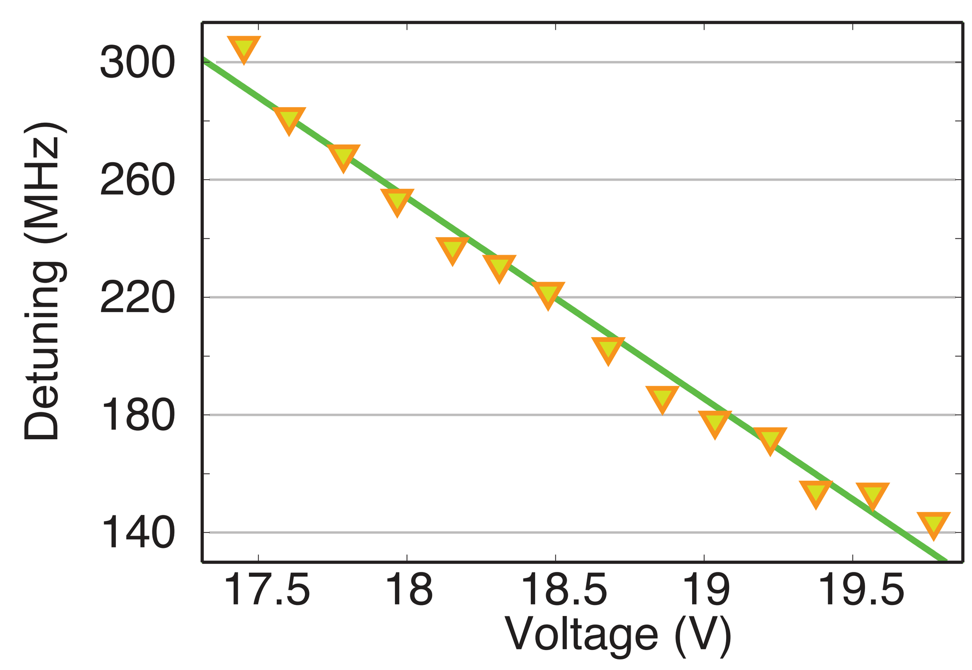


Heralded autocorrelation function



Autocorrelation function





Outlook

- couple single photons to atomic transitions
- study opto-mechanical properties
- combine nonlinear optics with opto-mechanic

[1] J. U. Fürst et al., Physical Review Letters 104,153901 (2010)
[2] J. U. Fürst et al., Physical Review Letters 105, 263904 (2010)
[3] M. Förtsch et al., Nature Communications 4, 1818 (2013)
[4] M. Förtsch et al., arXiv:1404.0593v1