Ultra-bright photon-pair source based on MgO:LN waveguide chips for quantum fluorescence microscopy

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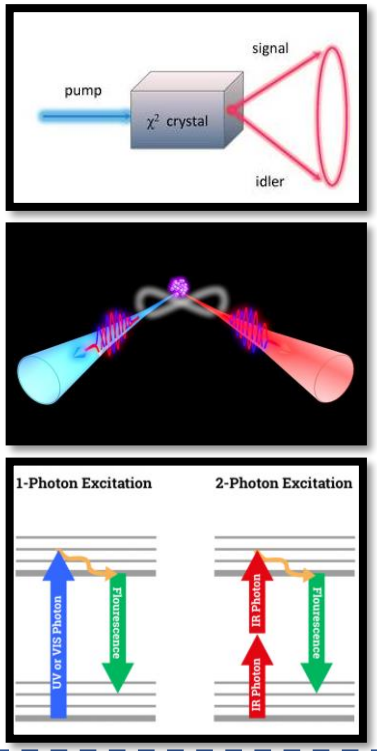
Theoretical Background

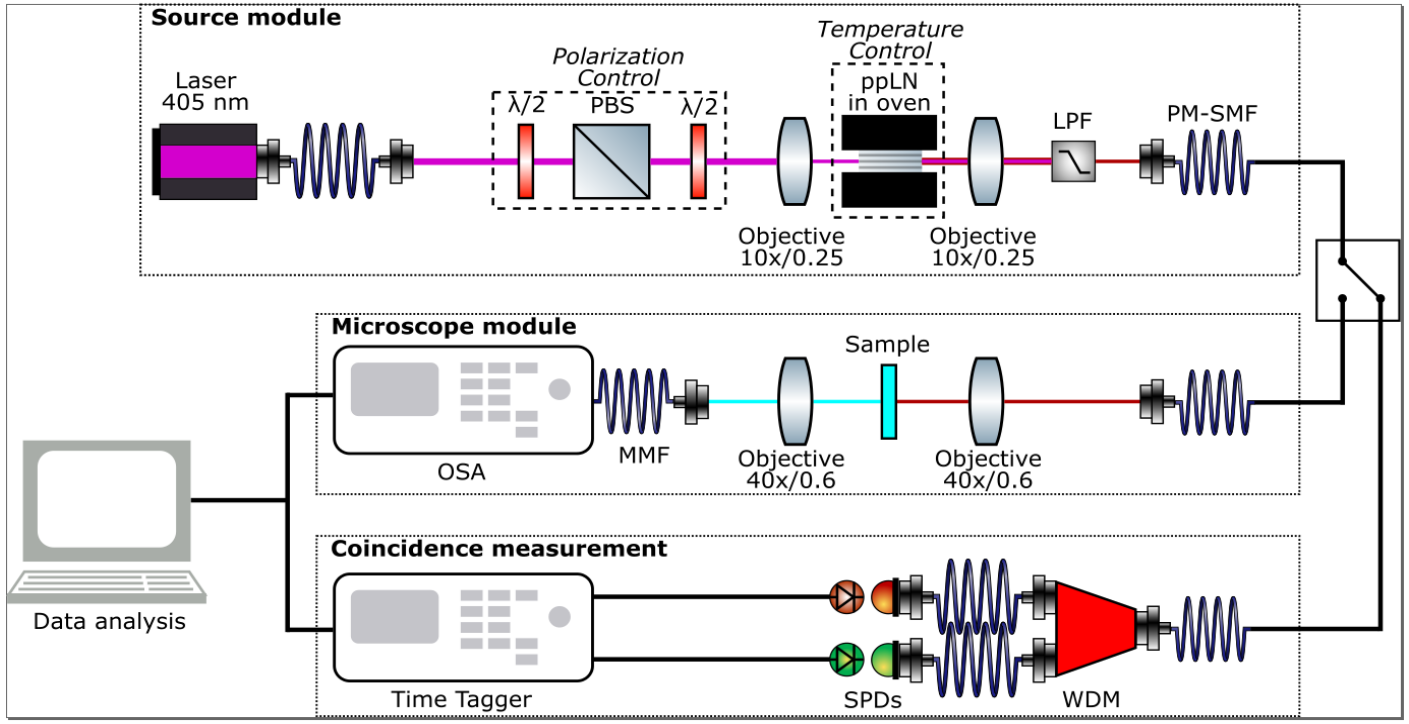


Photon-pair generation by spontaneous parametric down conversion (SPDC)

The twin photons share time-energy quantum correlations

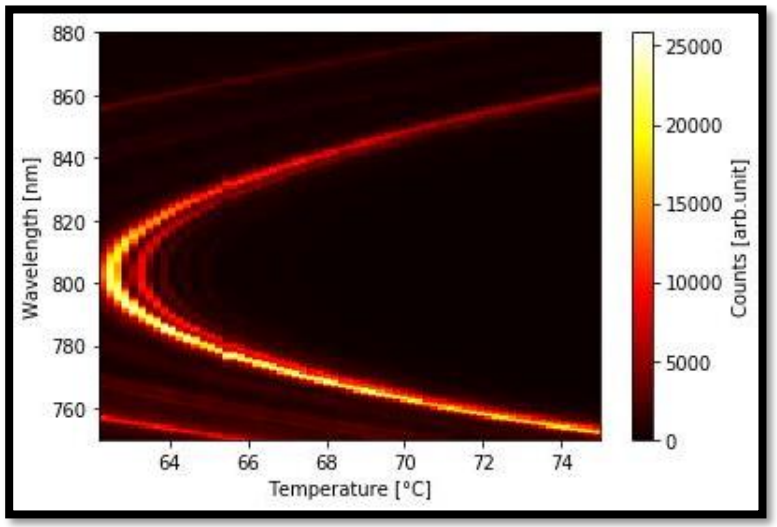
Time-energy quantum correlations boost the two-photon absorption (TPA)

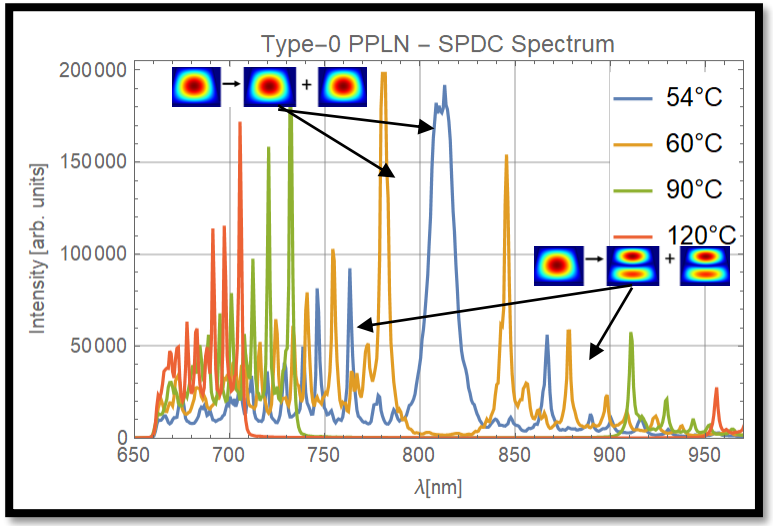
Experimental Set-up



Spectrum Characterization

From 62°C to 180°C the spectrum behaves as expected for a type-0 phase matched crystal. Degeneracy point at 810 nm





Multimodal behavior is present in the PPLN waveguide. Pump power is also distributed among the satellite peaks, decreasing the degenerate photon-pair flux at 810 nm

Photon-flux Characterization

$$dP_s^{(W)} = \frac{(2\pi)^4 \hbar c (d_{eff})^2 L_z^2}{\pi \epsilon_0 n_s n_i n_p \lambda_s^4 \lambda_i A_{over}} P \,\mathrm{sinc}^2\left(\frac{\Delta k L_z}{2}\right) d\lambda_s$$

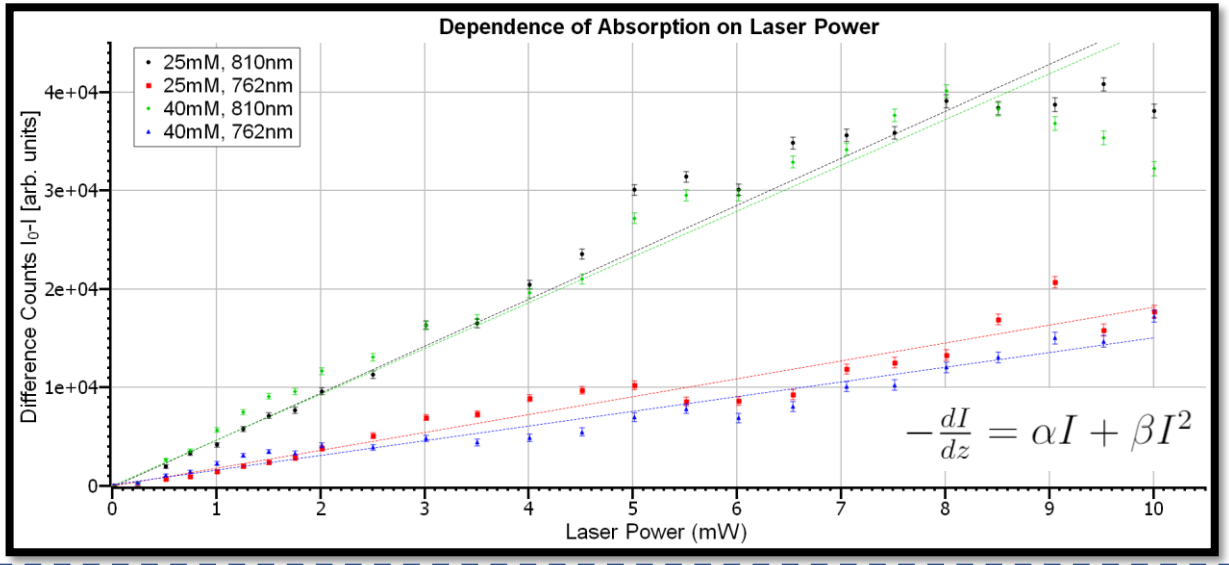
Measured photon-flux: 2.3 x 10^7 photon pairs/s/mW

Theoretical photon-flux (corrected for losses): 4.4 x 10^9 photon pairs/s/mW

Perfect phase-matching condition and single mode behavior were considered in the theoretical calculation

Linear absorption - ETPA

Time-energy quantum correlations allows the TPA on Rhodamine-101 to behave linearly with the pump power, similar to a single-photon absorption process (SPA)

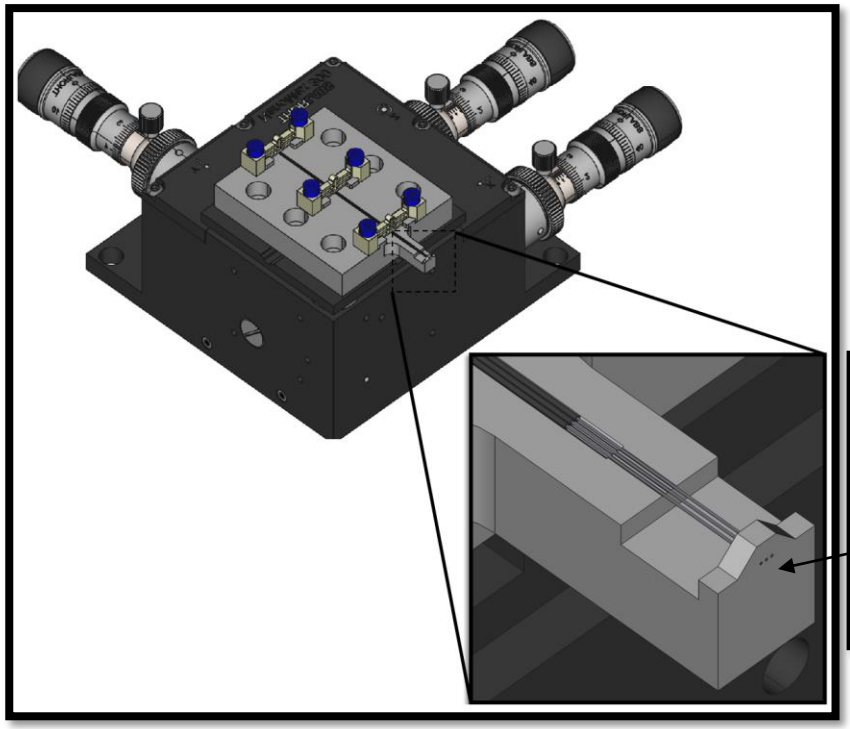


Spatial Multiplexing Scheme

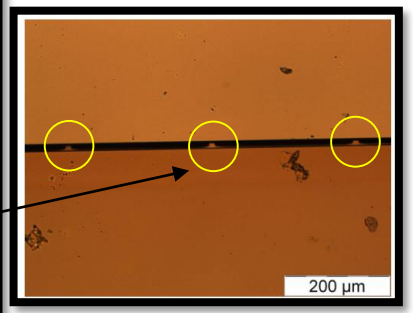
The photon-flux is enhanced by pumping multiple waveguides simultaneously with a V-Groove

The expected photon-flux is directly proportional to the number of waveguides pumped

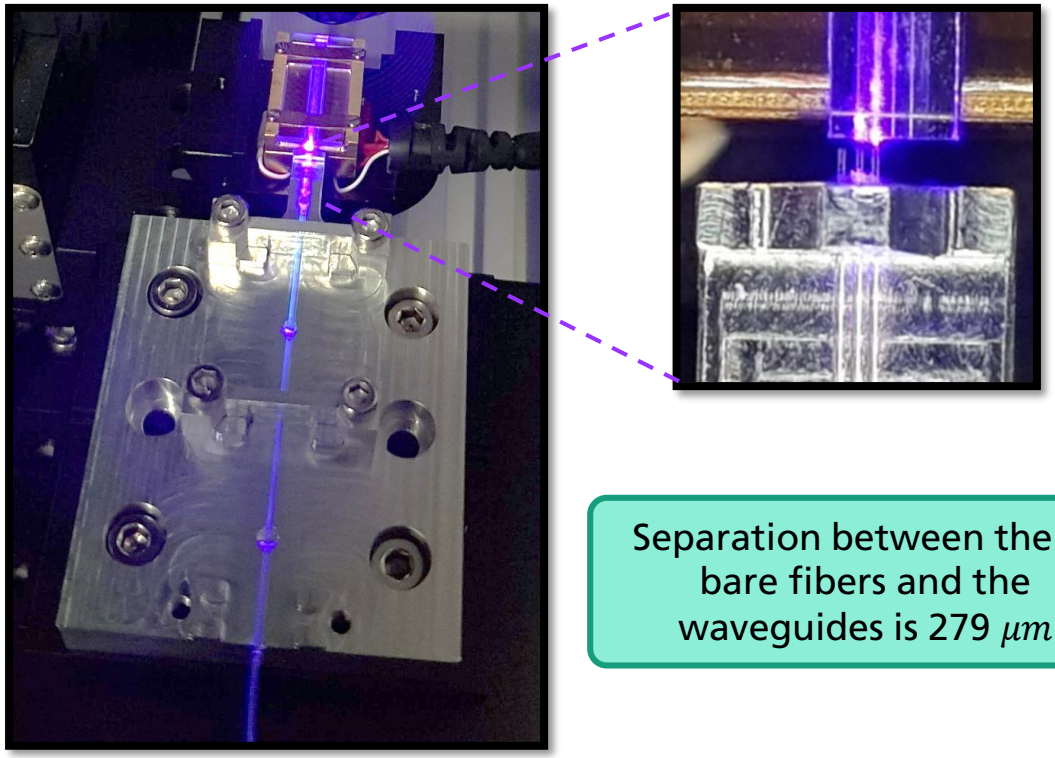
With the help of a nano-precision 3-axis stage bare fibers are placed in front the waveguides



SPDC photons are collected similarly by a V-Groove incoherently in one spatial mode



V-Groove set-up



Separation between the bare fibers and the waveguides is 279 μm

V-Groove holding the bare fibers and coupling the pump beam into one of the waveguides

The slow-axis of the bare fibers was oriented vertically in order to decrease the mechanical stress exerts by the glue