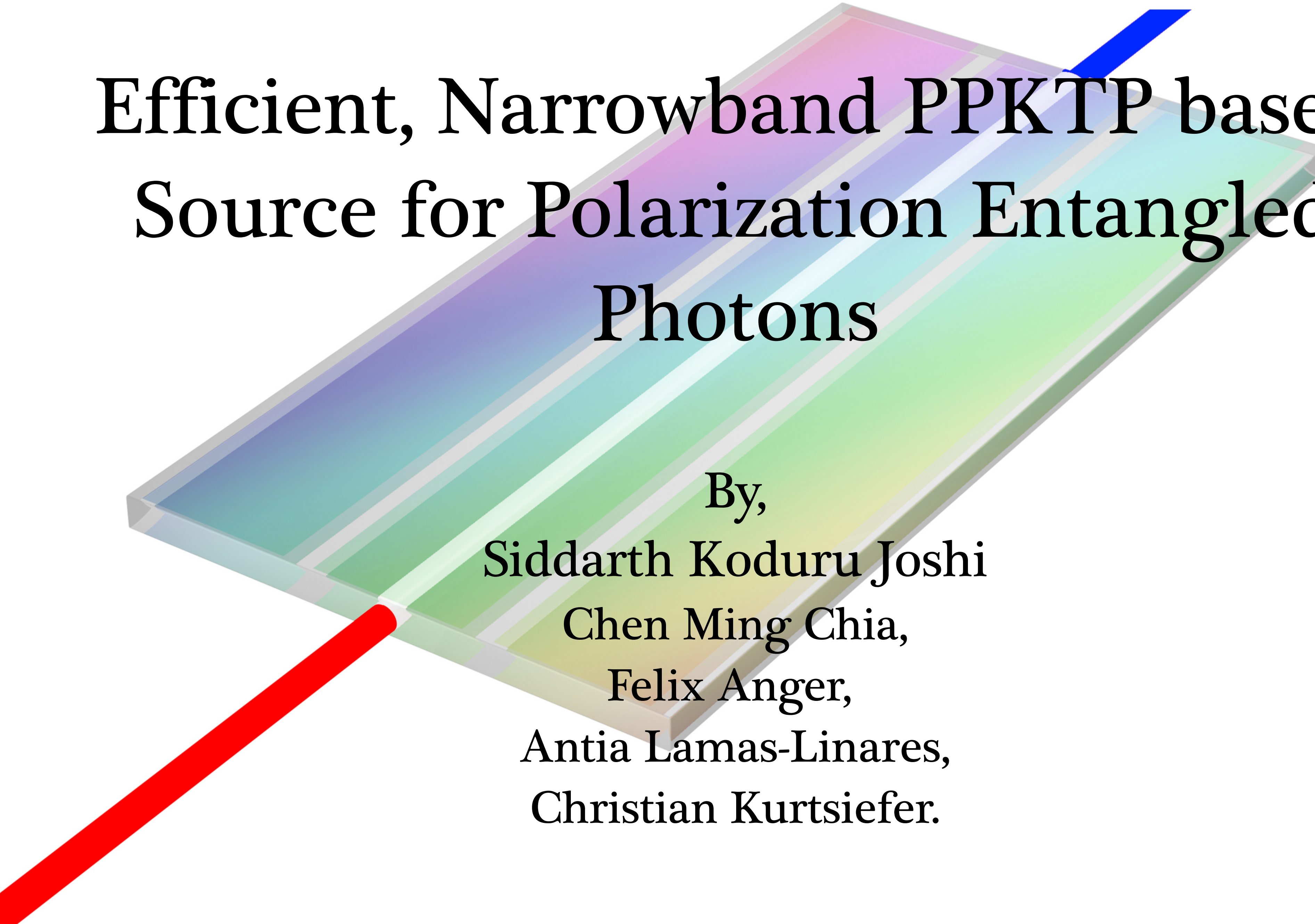
Centre for Quantum Technologies

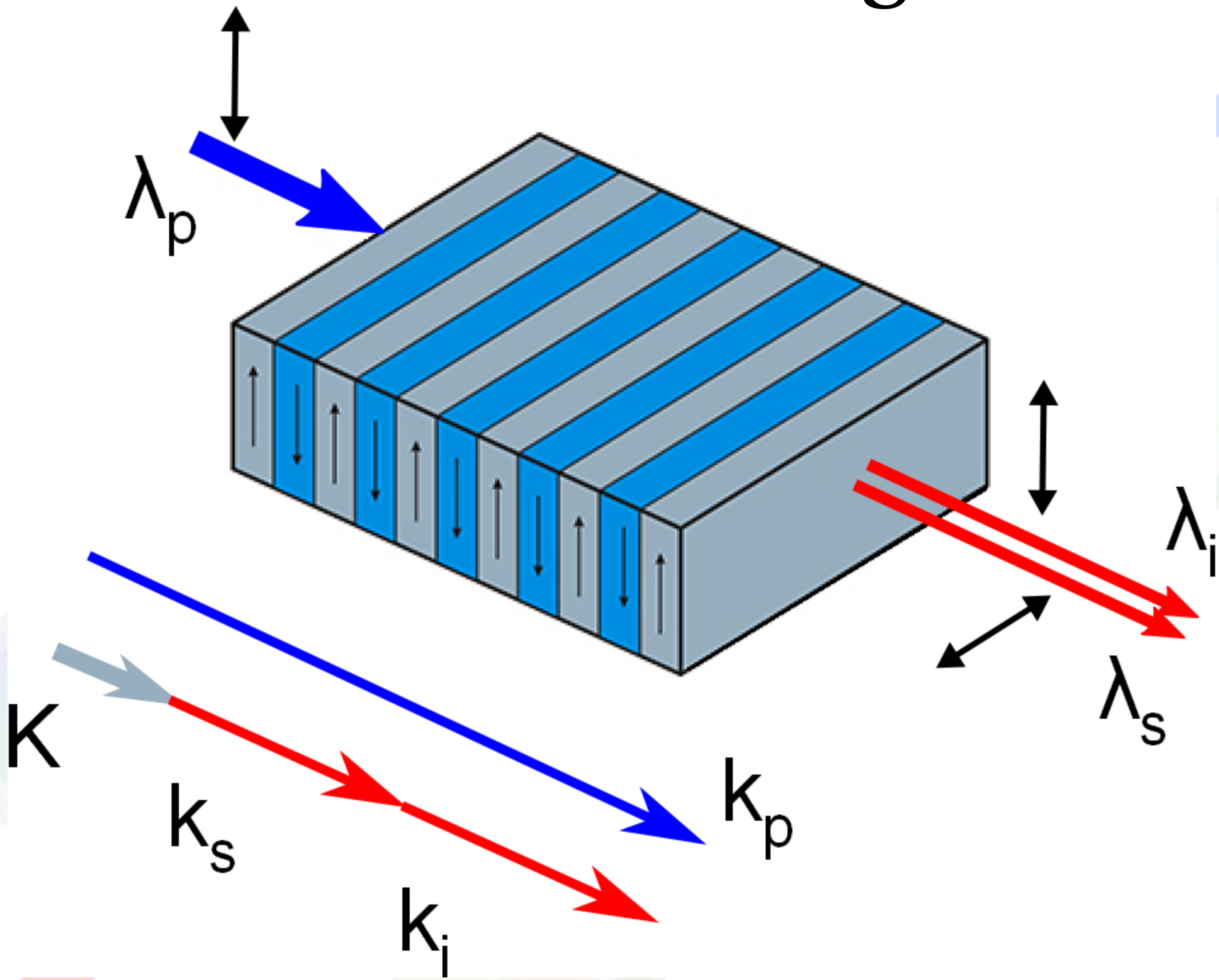
National University of Singapore



Efficient, Narrowband PPKTP based Source for Polarization Entangled Photons

By,
Siddarth Koduru Joshi
Chen Ming Chia,
Felix Anger,
Antia Lamas-Linares,
Christian Kurtsiefer.

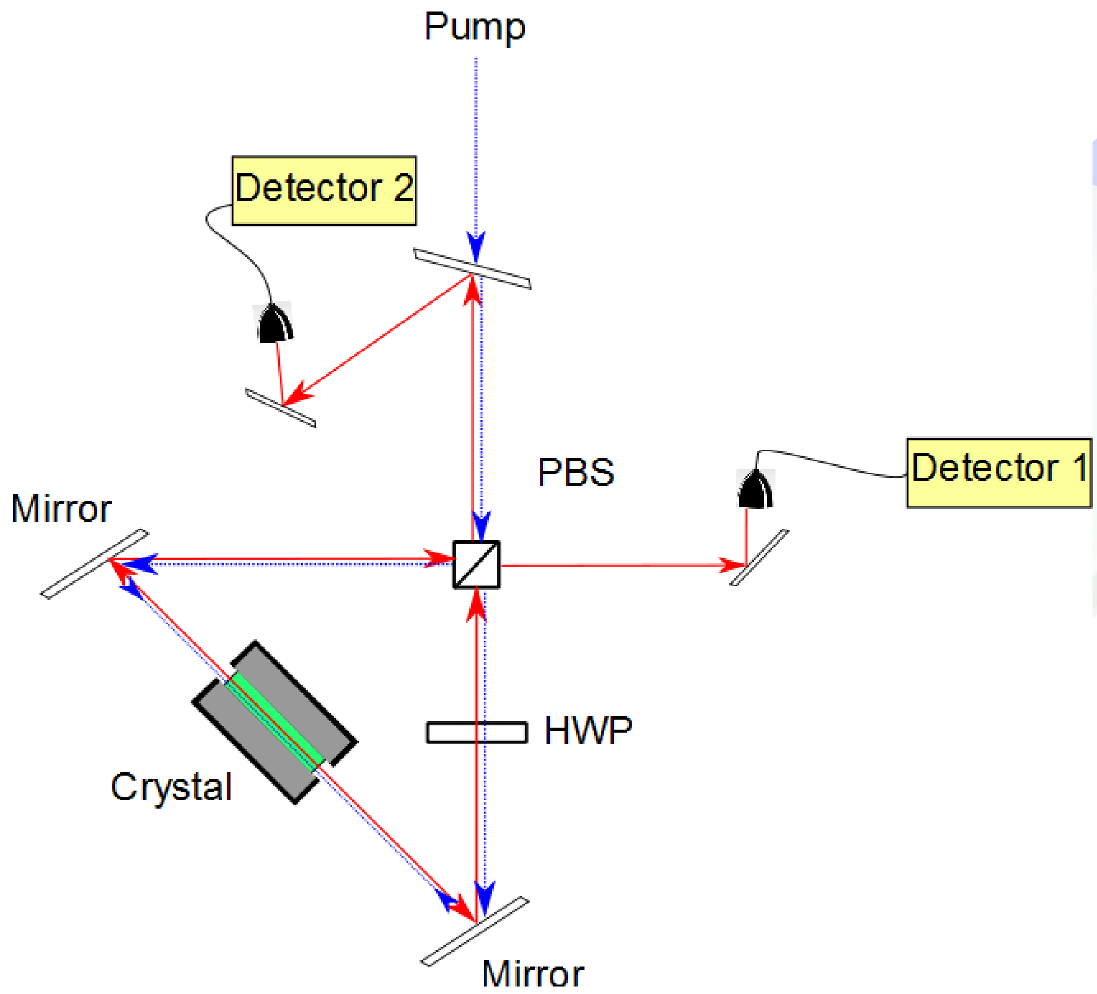
Phasematching



Type II => Signal and Idler of Opposite Polarizations


Efficiency = Pairs to Singles Ratio =
Heralding Efficiency

Sagnac Geometry for Entangled Pairs

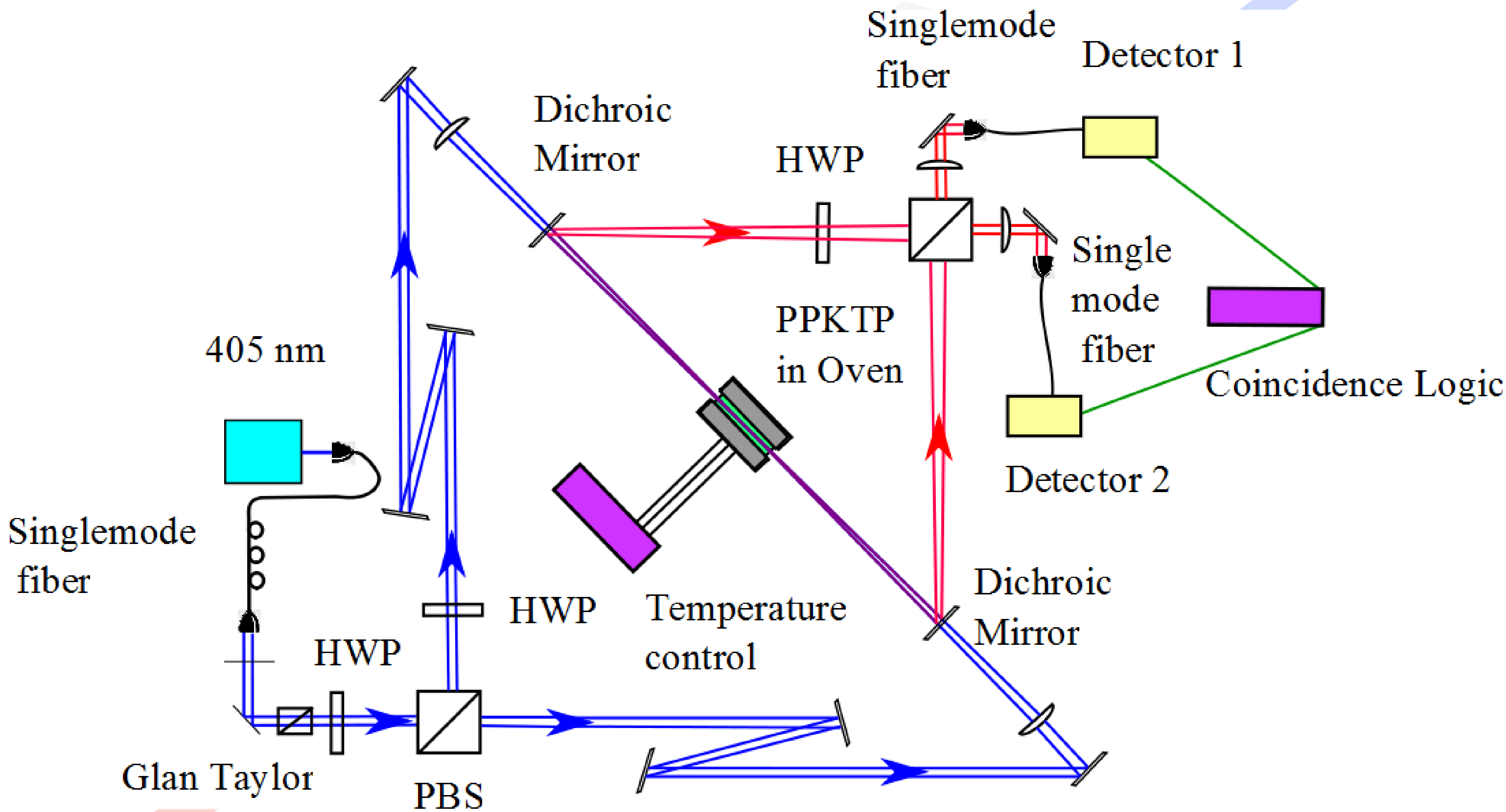


Generates $|\psi^{\pm}\rangle = 1/\sqrt{2}\,(|HV\rangle \pm |VH\rangle)$

Marco Fiorentino*, Gaétan Messin, Christopher E. Kuklewicz, Franco N. C. Wong, and Jeffrey H. Shapiro Phys. Rev. A 69, 041801(R) (2004).

Paul G. Kwiat, Philippe H. Eberhard, Aephraim M. Steinberg, and Raymond Y. Chiao Phys. Rev. A 49, 3209–3220

Experimental Setup



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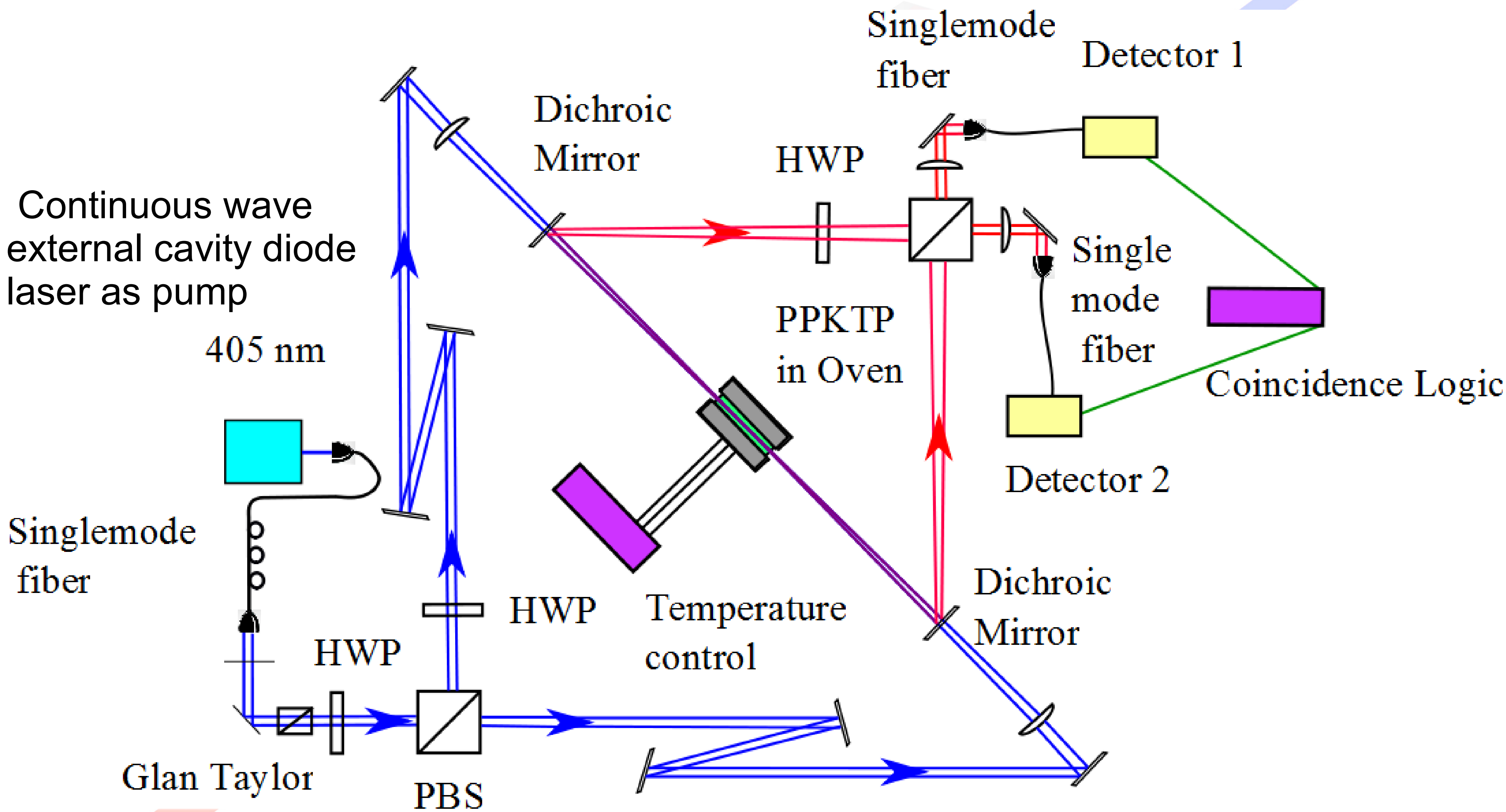

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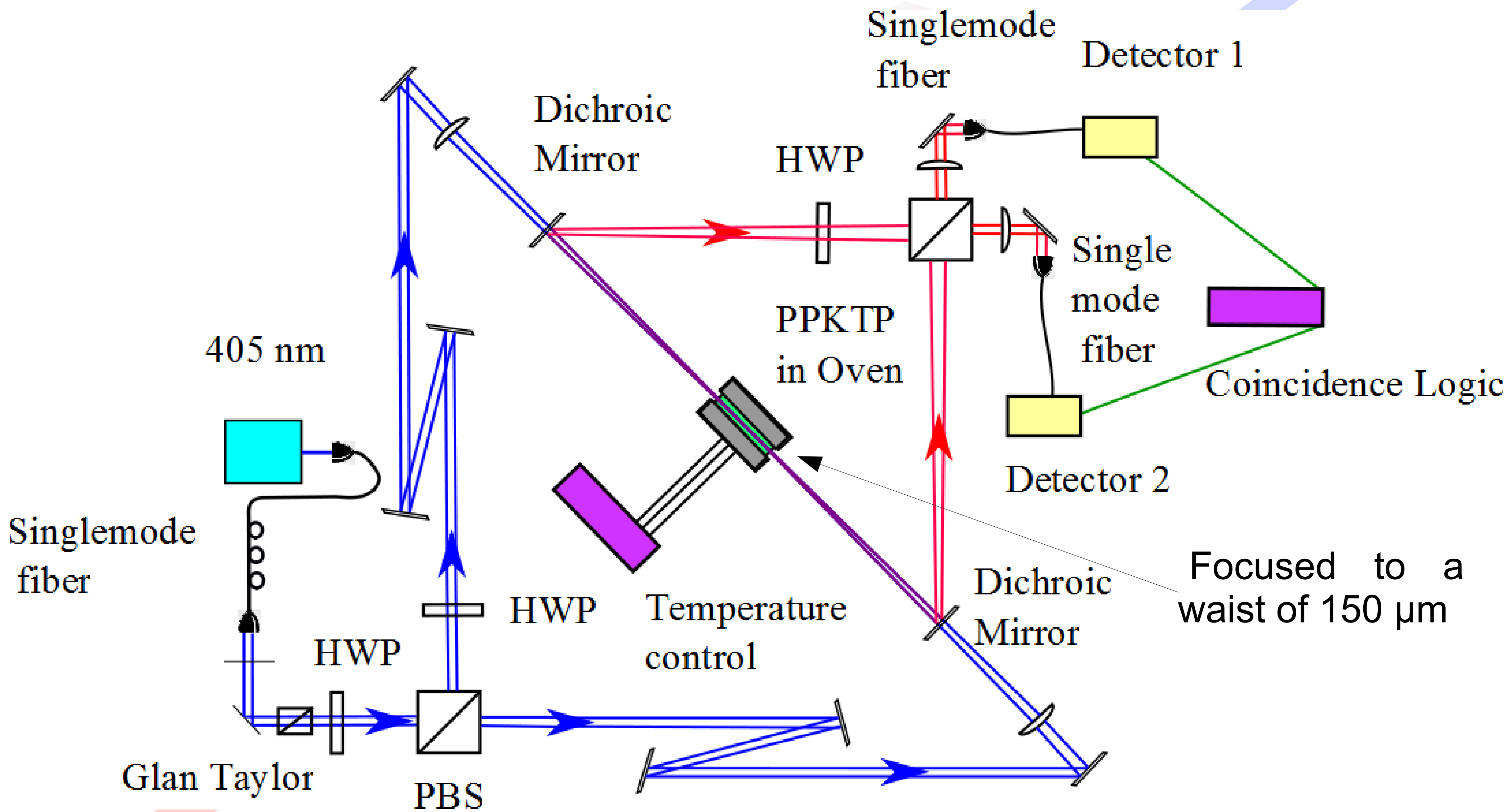

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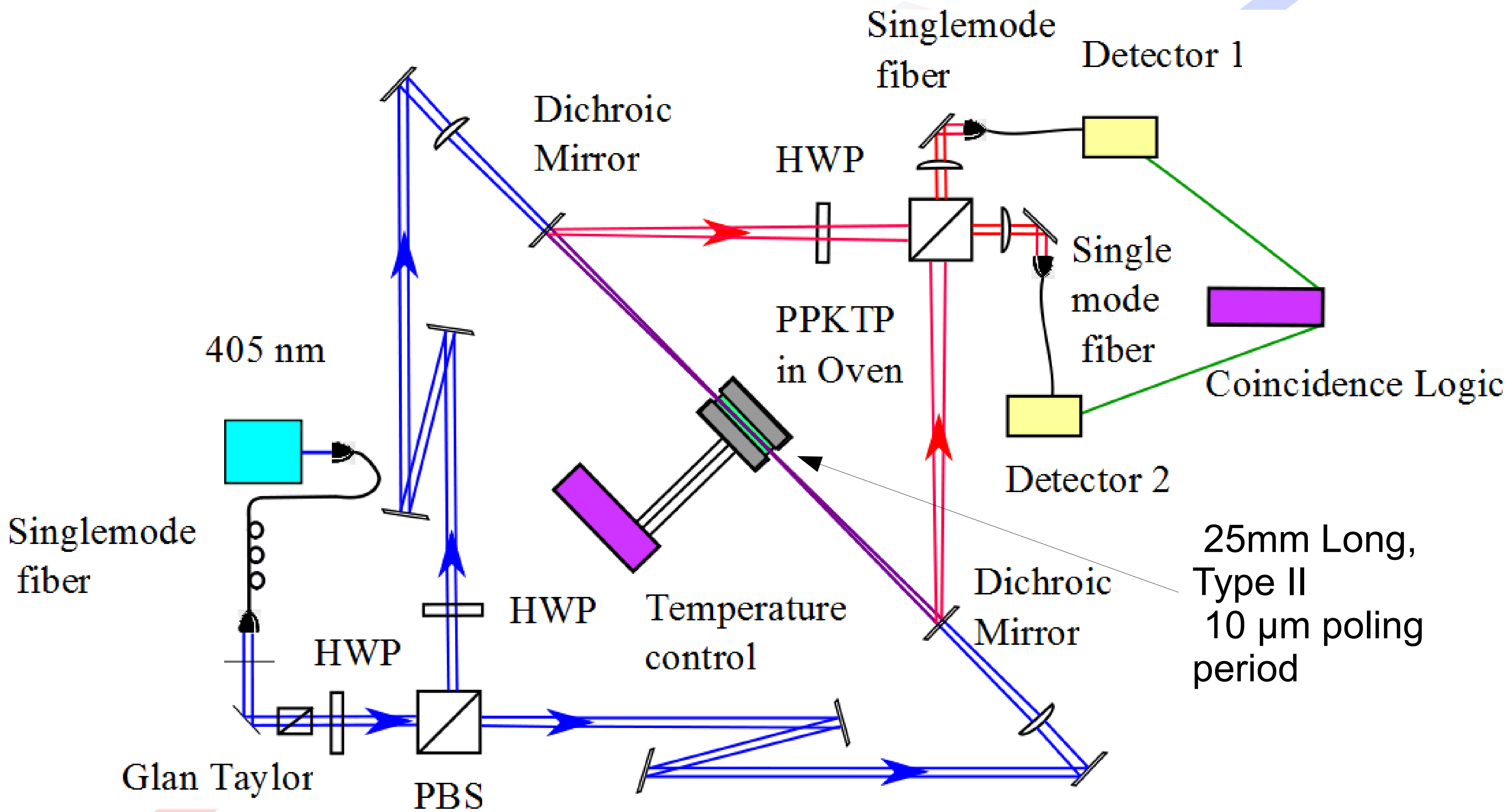

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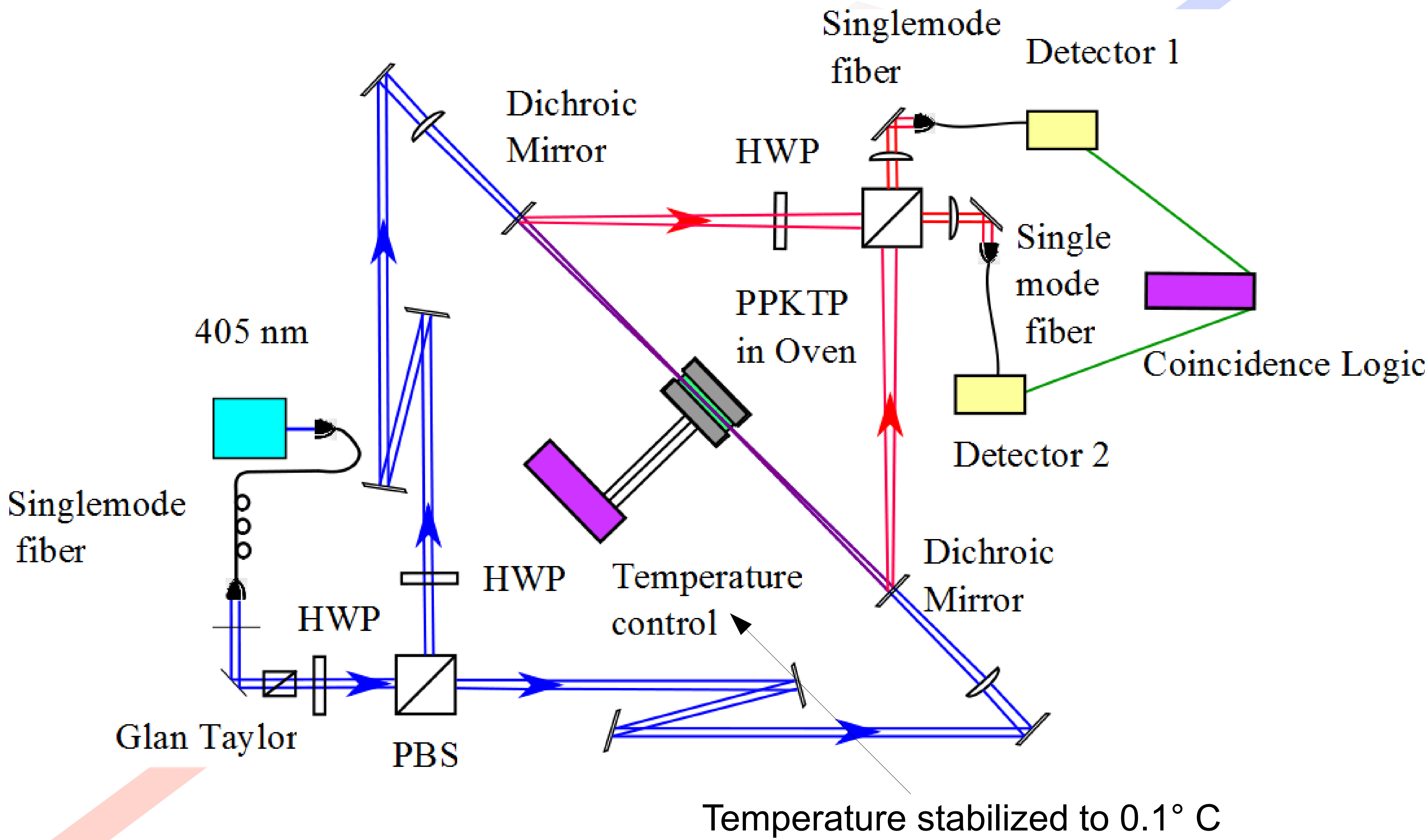

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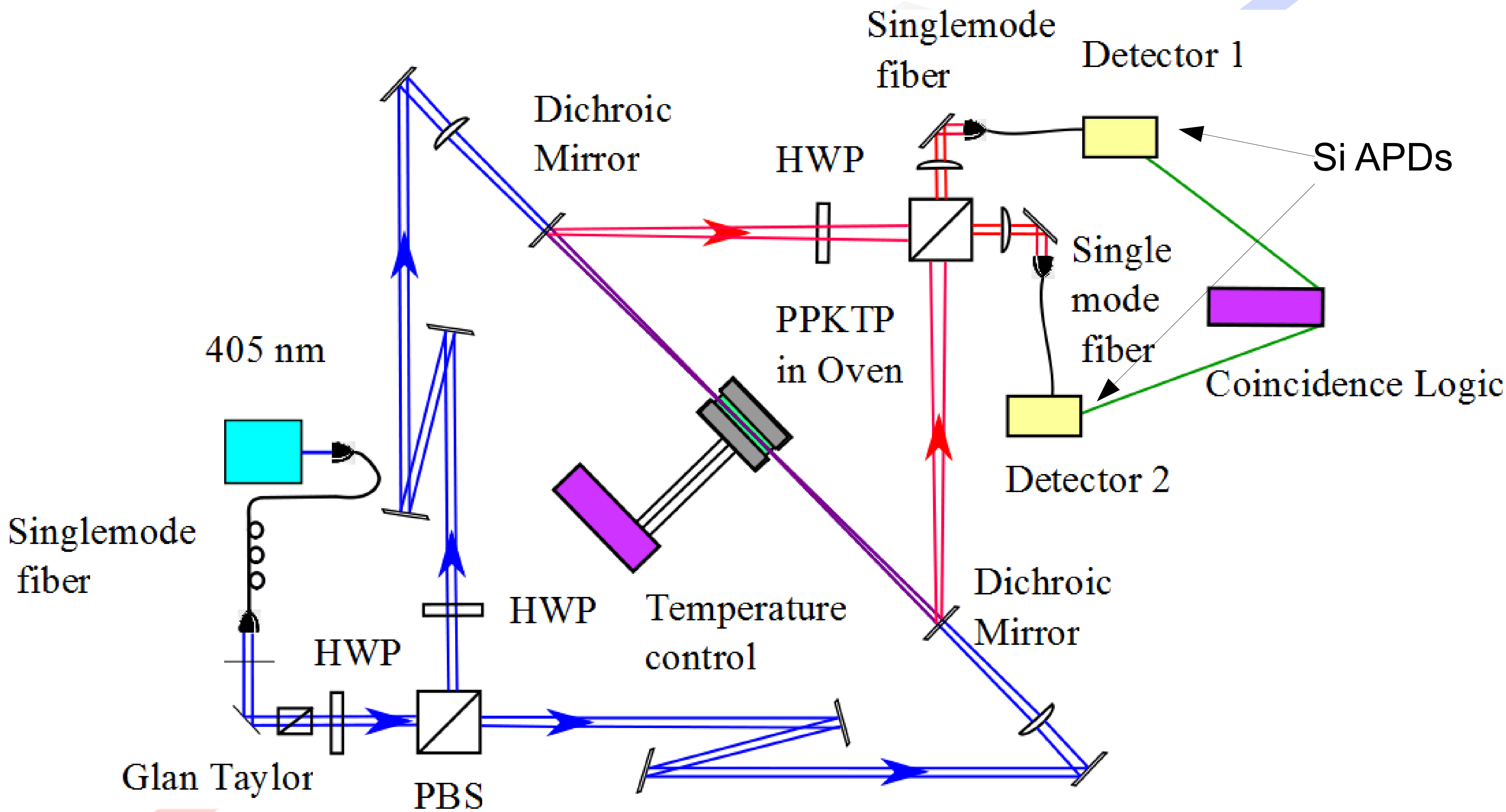

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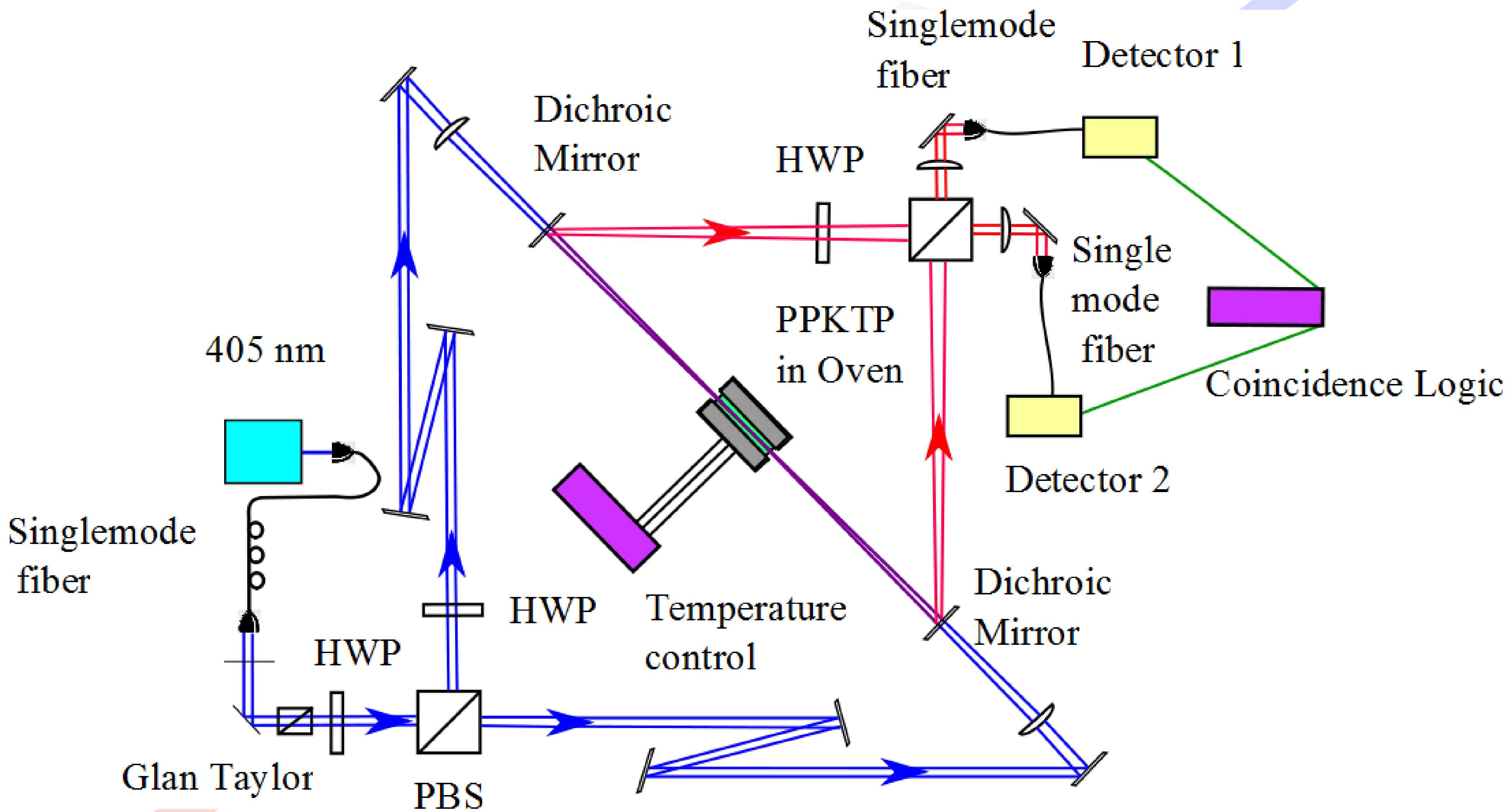
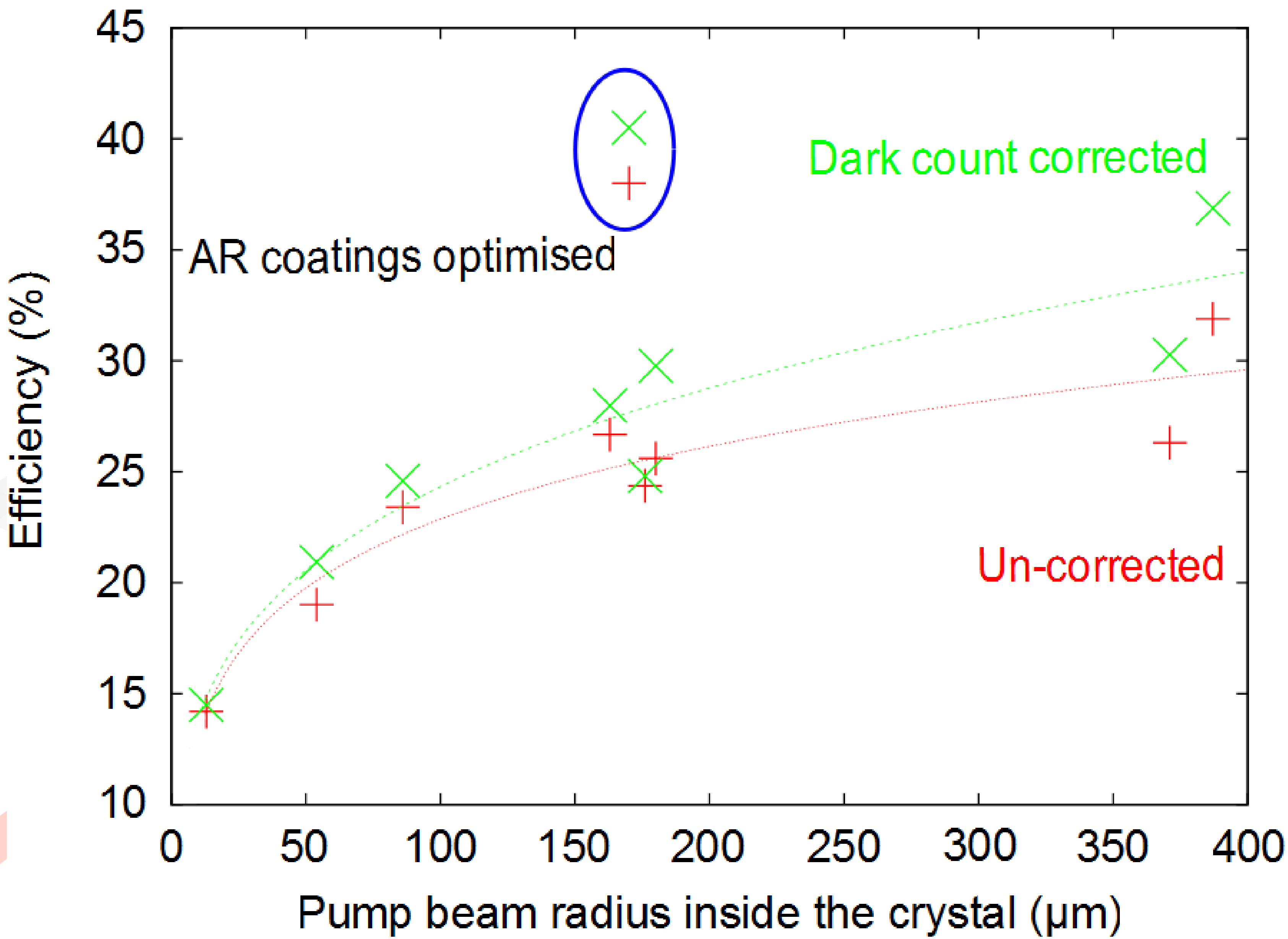
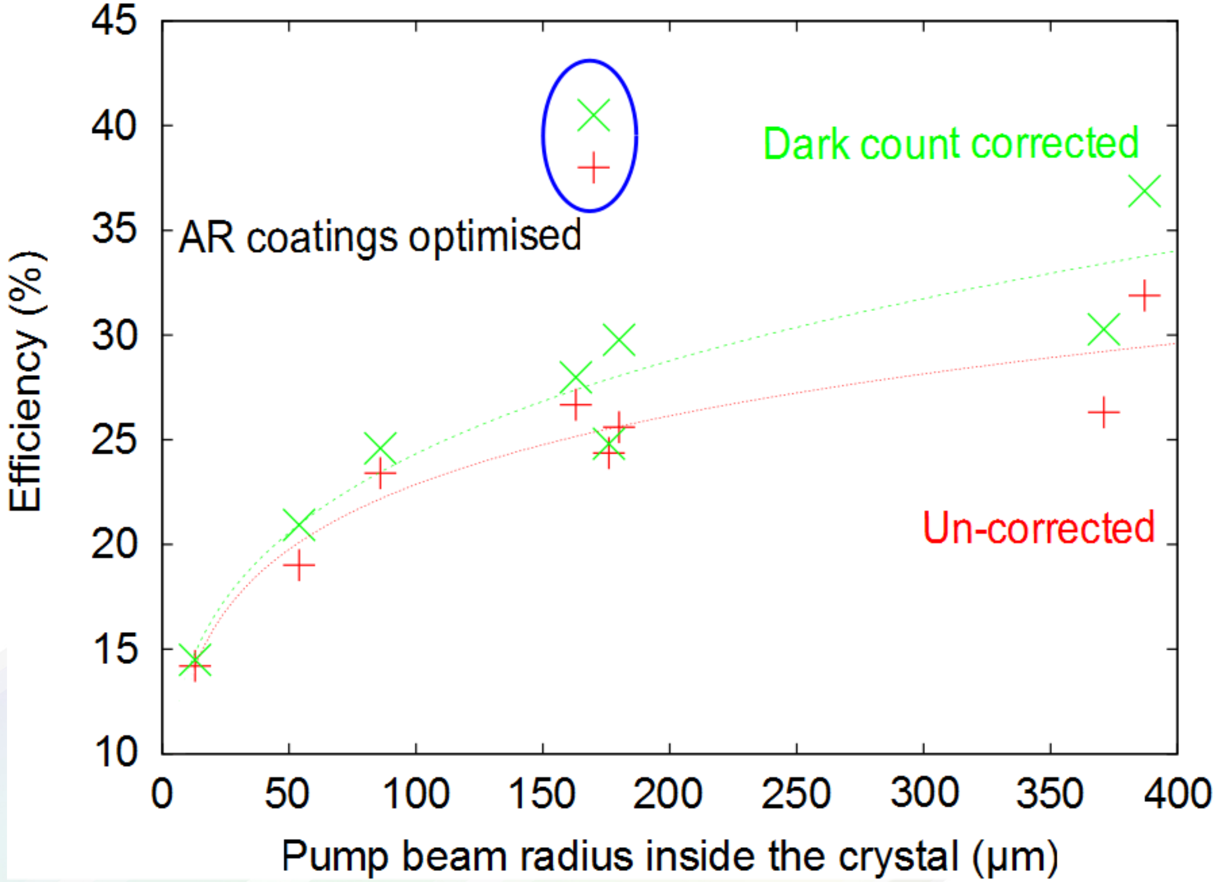


Focusing for Higher Efficiency

Pairs to singles ratio (Efficiency) of > 38%. (No corrections)



Focusing for Higher Efficiency



System efficiency > 38%

APD detection efficiency ~55%

=> Source efficiency > 69%

> Eberhard limit for loop hole free Bell test (66.7%)

P. H. Eberhard, Phys. Rev. A 47, R747 (1993)

System Efficiency Improvements

- Better detectors
- Improve focusing conditions
- Reduce reflection losses

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    - APD ~50 to 55 %
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  APD ~50 to 55 %   TES ~95 to > 99 %

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A. E. Lita, A. J. Miller, S. Nam, Opt. Exp. 16 5 3032 (2008).

System Efficiency Improvements

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  APD ~50 to 55 %   TES ~95 to > 99 %

- Improve focusing conditions

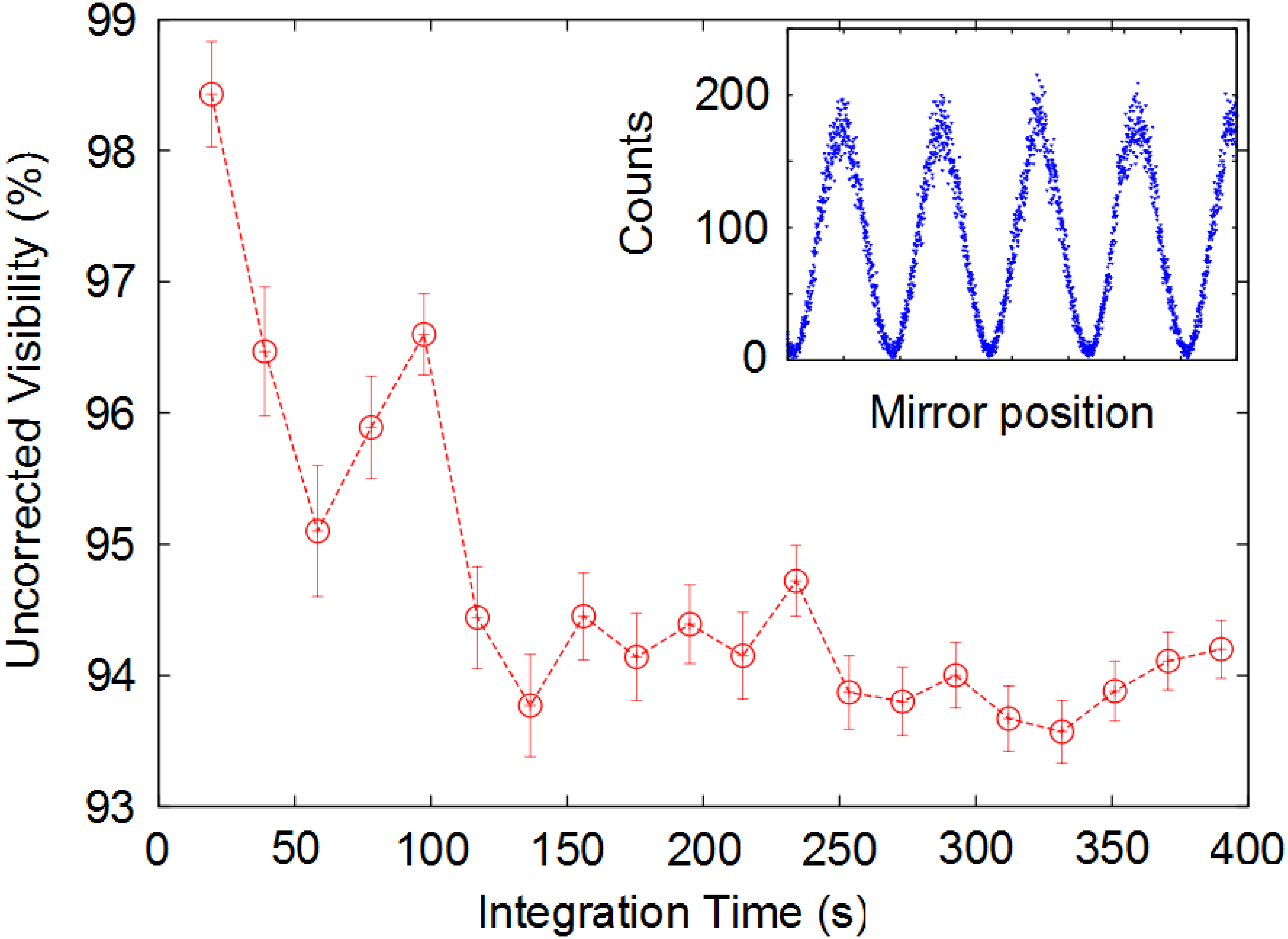
- Reduce reflection losses

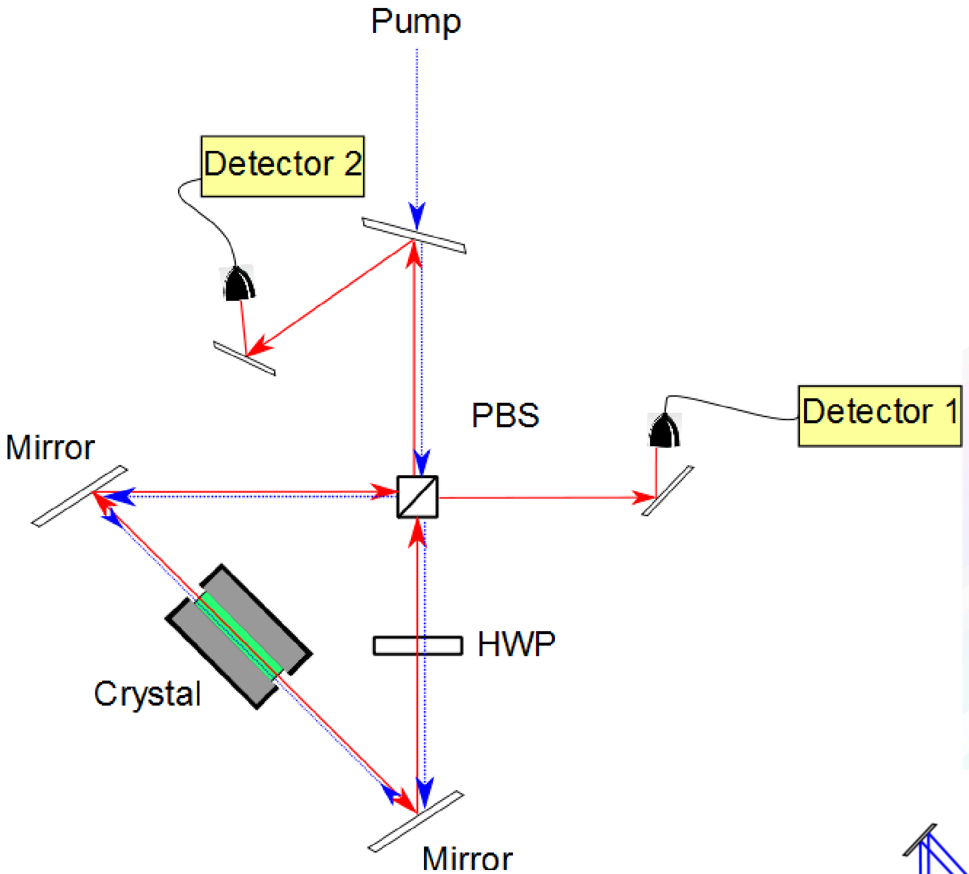
  14 surfaces => ~5 % loss

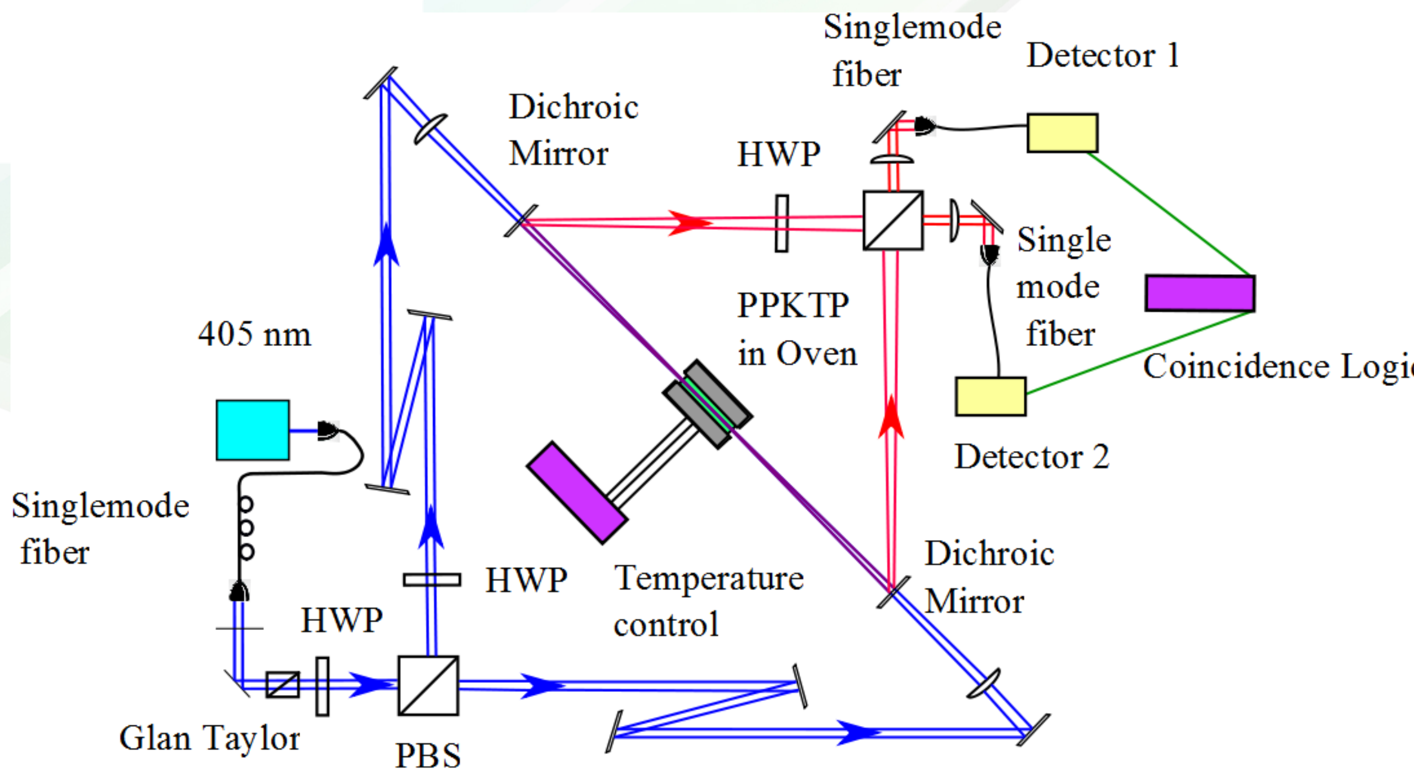
A. E. Lita, A. J. Miller, S. Nam, Opt. Exp. 16 5 3032 (2008).

Entanglement Quality

Polarization correlations in the $\pm 45^{o}$ basis = 98.4%

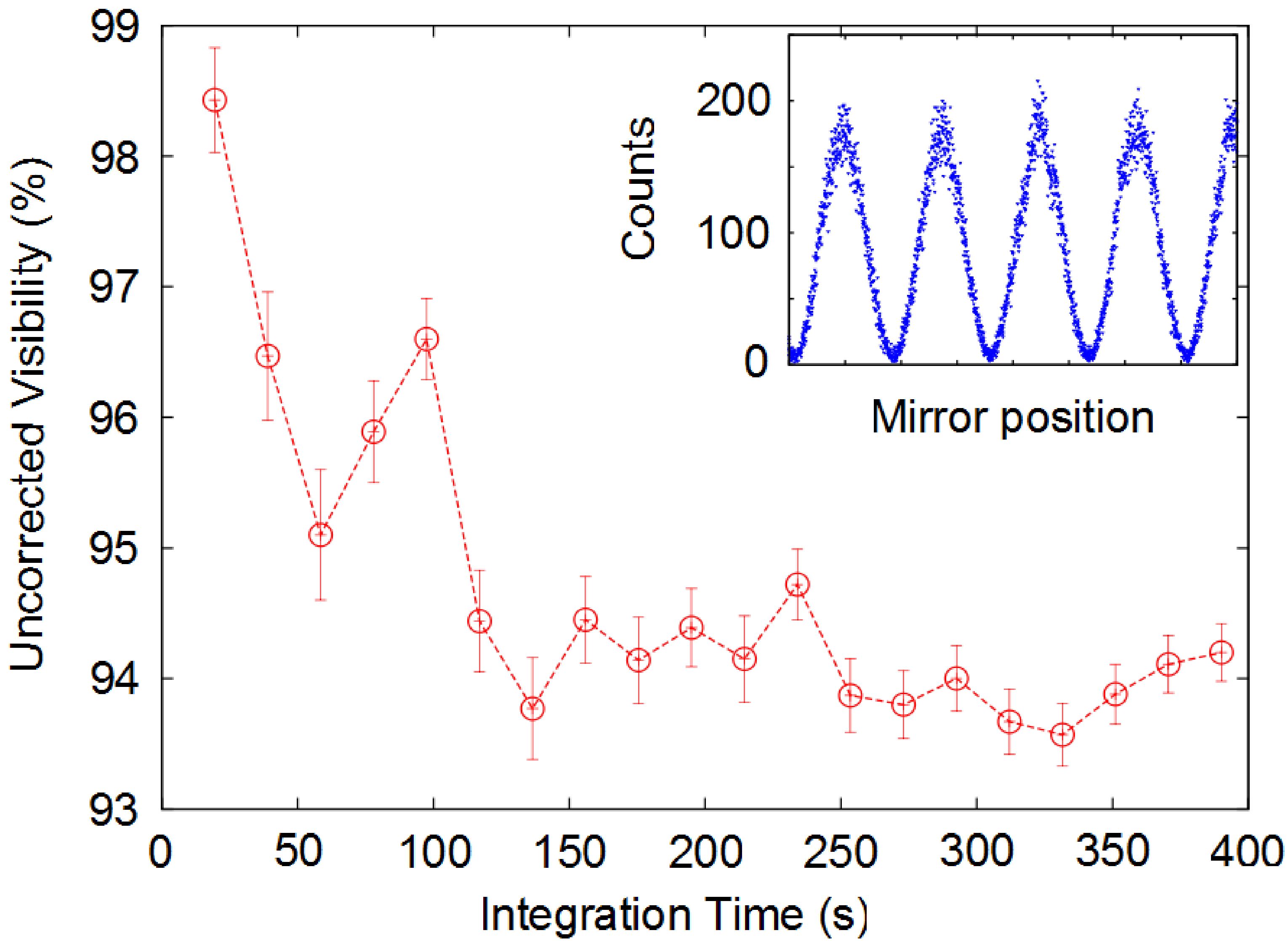



Pump
Detector 2
PBS
Detector 1
Mirror
HWP
Crystal
Mirror

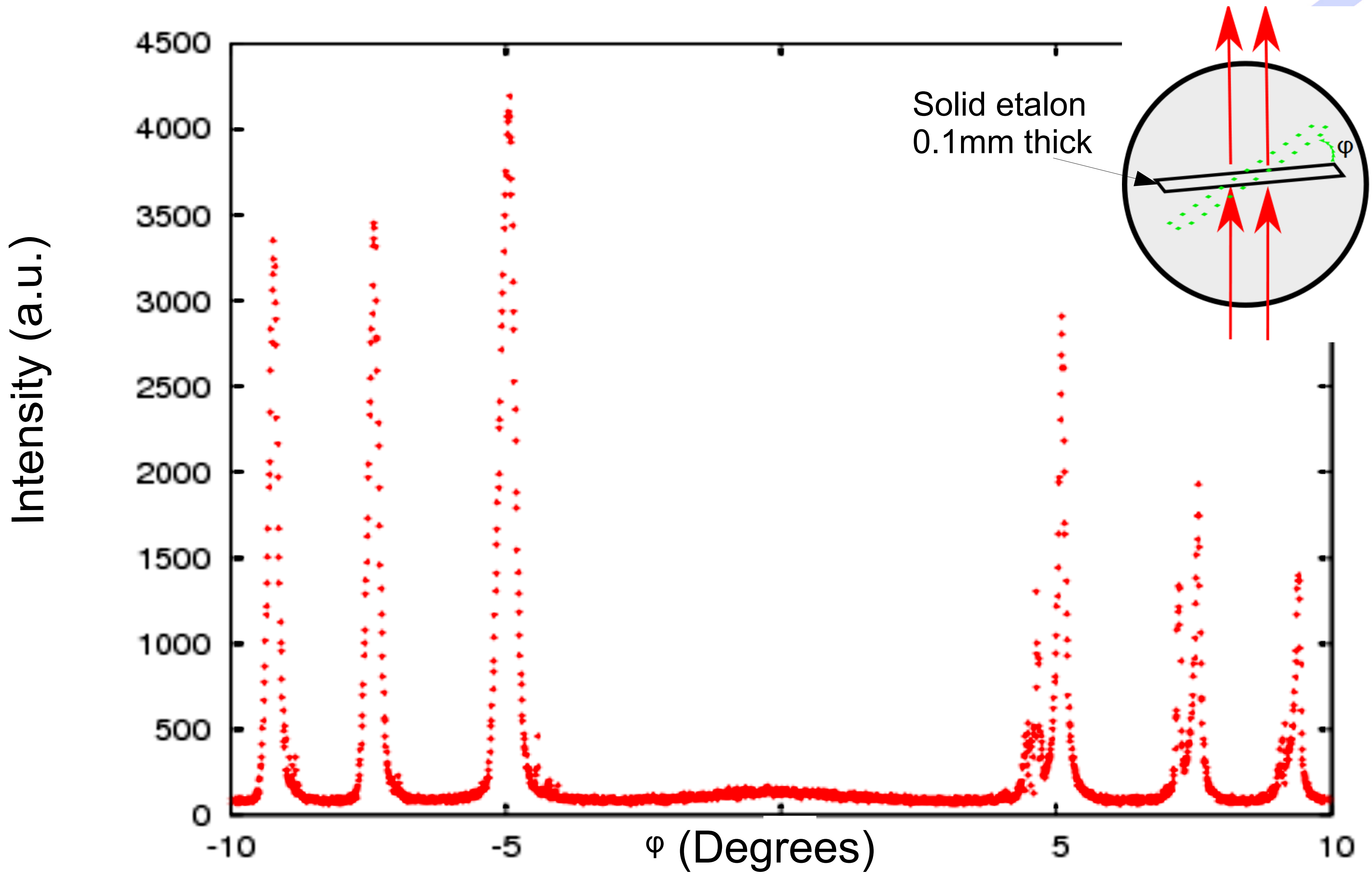

Singlemode fiber
Detector 1
Dichroic Mirror
HWP
Single mode fiber
PPKTP in Oven
Coincidence Logic
405 nm
Detector 2
Singlemode fiber
HWP
Temperature control
Dichroic Mirror
HWP
Glan Taylor
PBS

Entanglement Quality

Polarization correlations in the $\pm 45^{o}$ basis = 98.4%

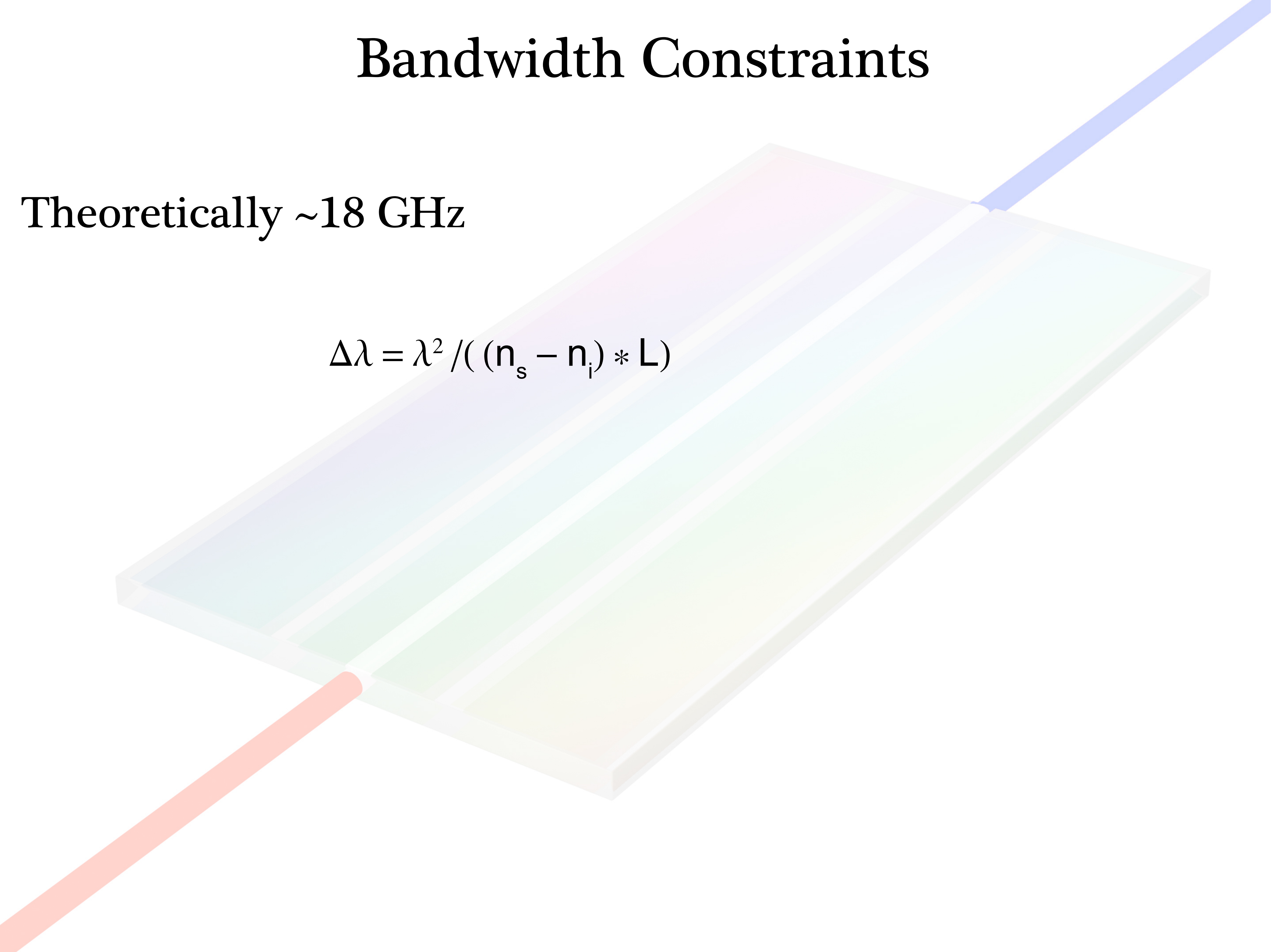


Measured Bandwidth



Bandwidth of down-converted light at 145° C is 0.18nm (82GHz).
Bandwidth at room temperature is 0.12nm (55GHz).

Bandwidth Constraints



Theoretically ~18 GHz

$$\Delta\lambda = \lambda^2 /((n_s - n_i) * L)$$

Bandwidth Constraints

Theoretically ~18 GHz

$$\Delta\lambda = \lambda^2 / ((n_s - n_i) * L)$$

✗ Temperature inhomogeneity

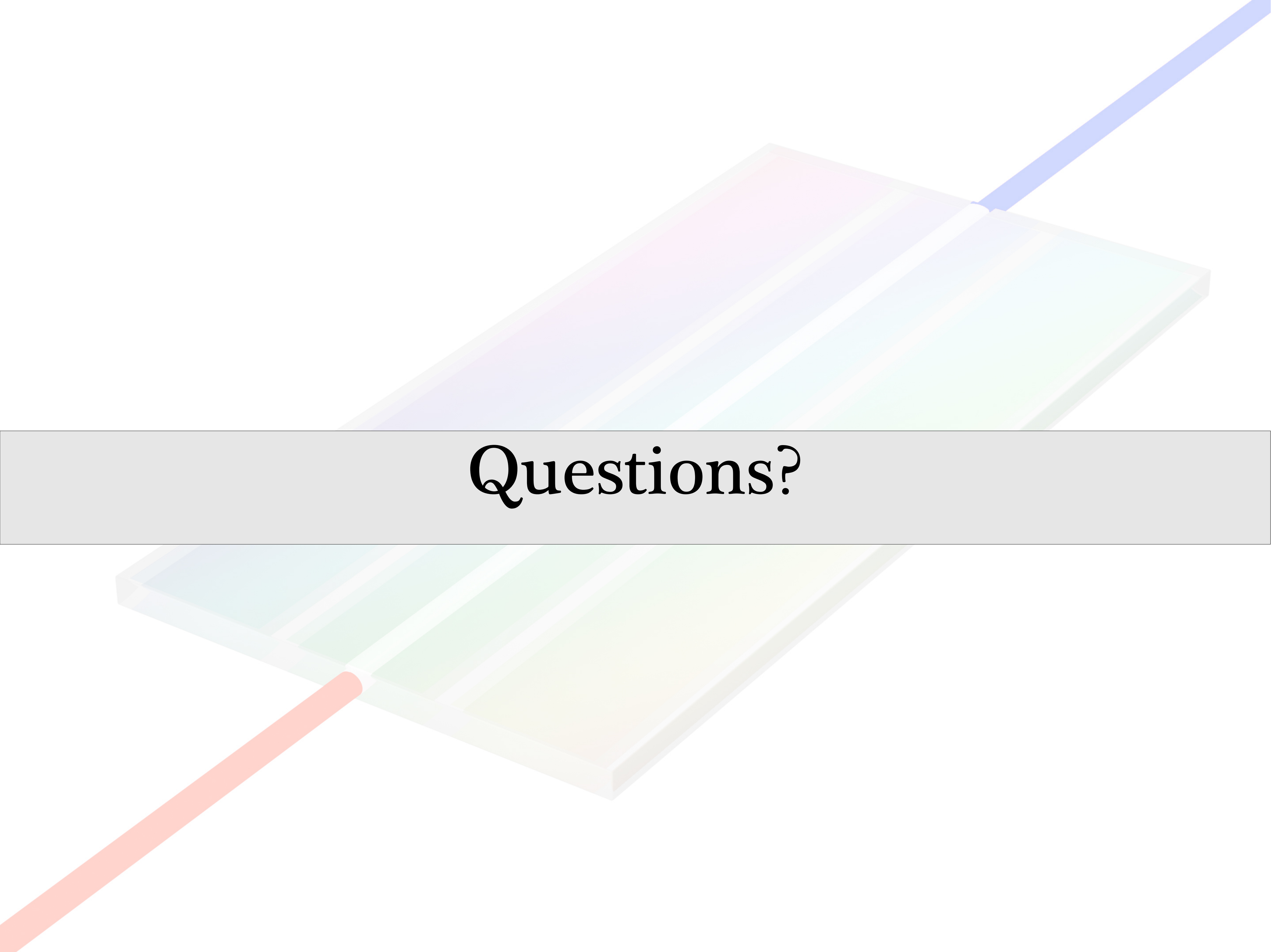
82 GHz @ 145°C

55 GHz @ 25°C

✗ Imperfections in the crystal poling period

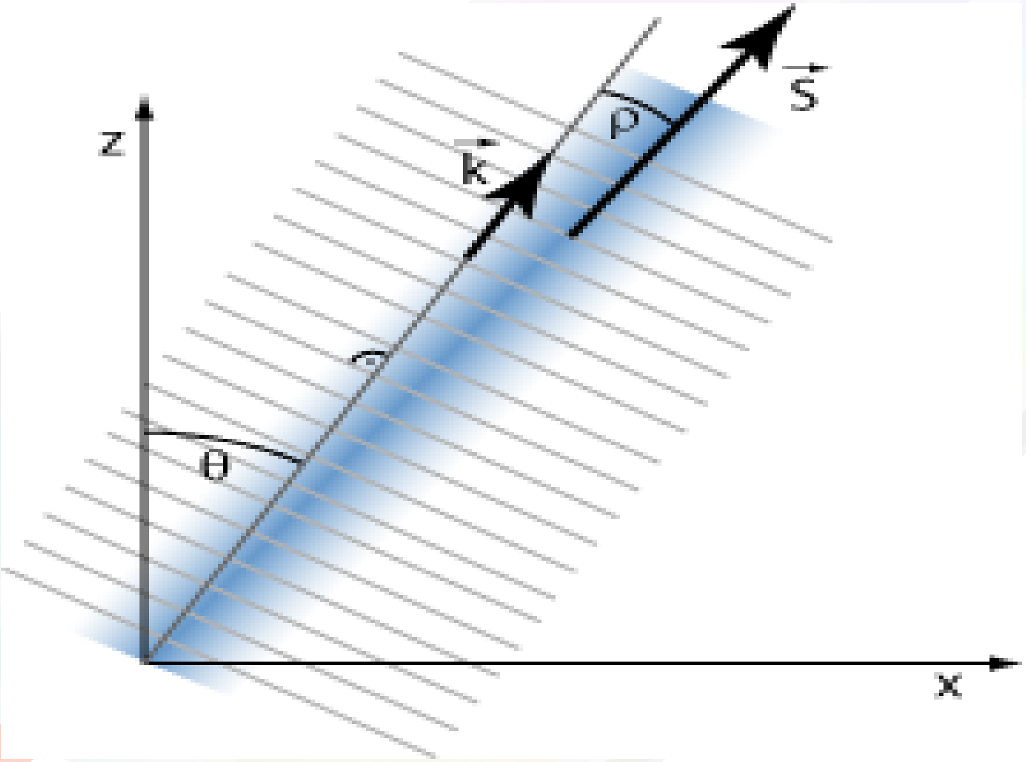
Summery

- High efficiency (pairs to singles ratio) > 38 %
- ~8,000 pairs/s/mW
- 82 GHz Bandwidth
- 98.4% Polarization Correlations in the ± 45° basis
- No spectral filtering
- Collected using Singlemode Fibers

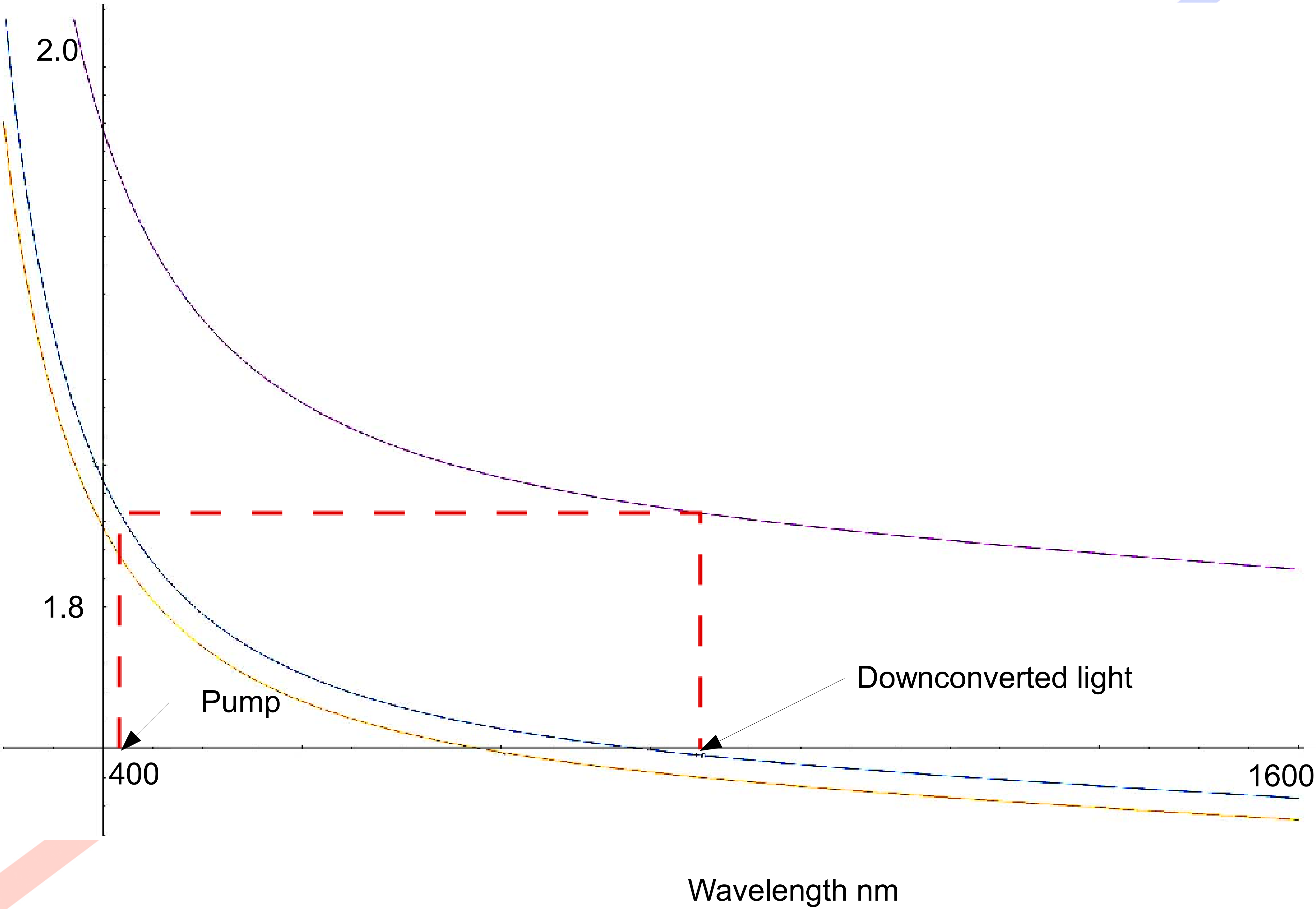


Questions?

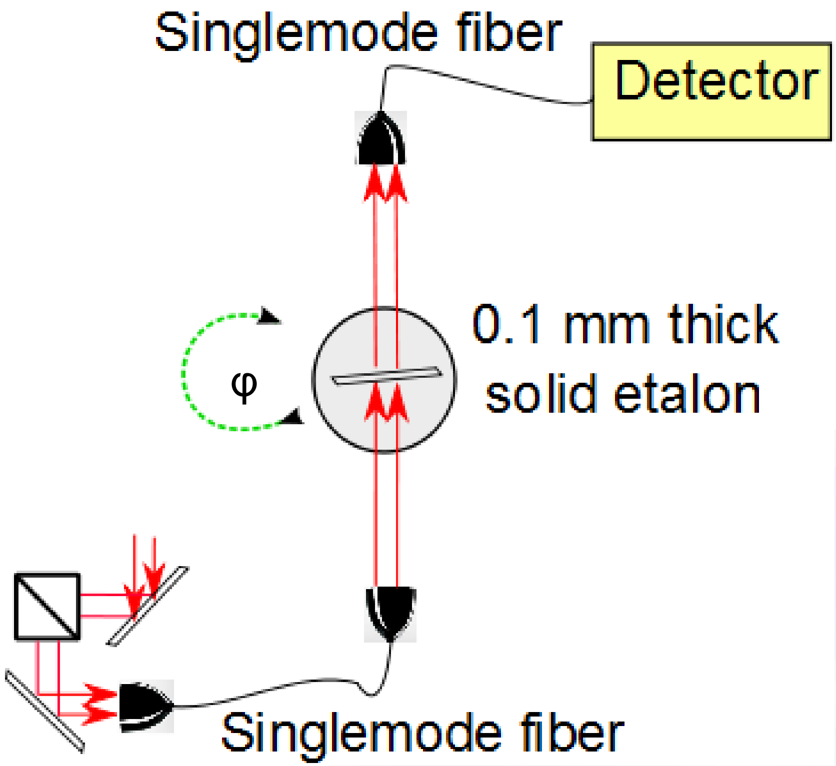
What is walk off

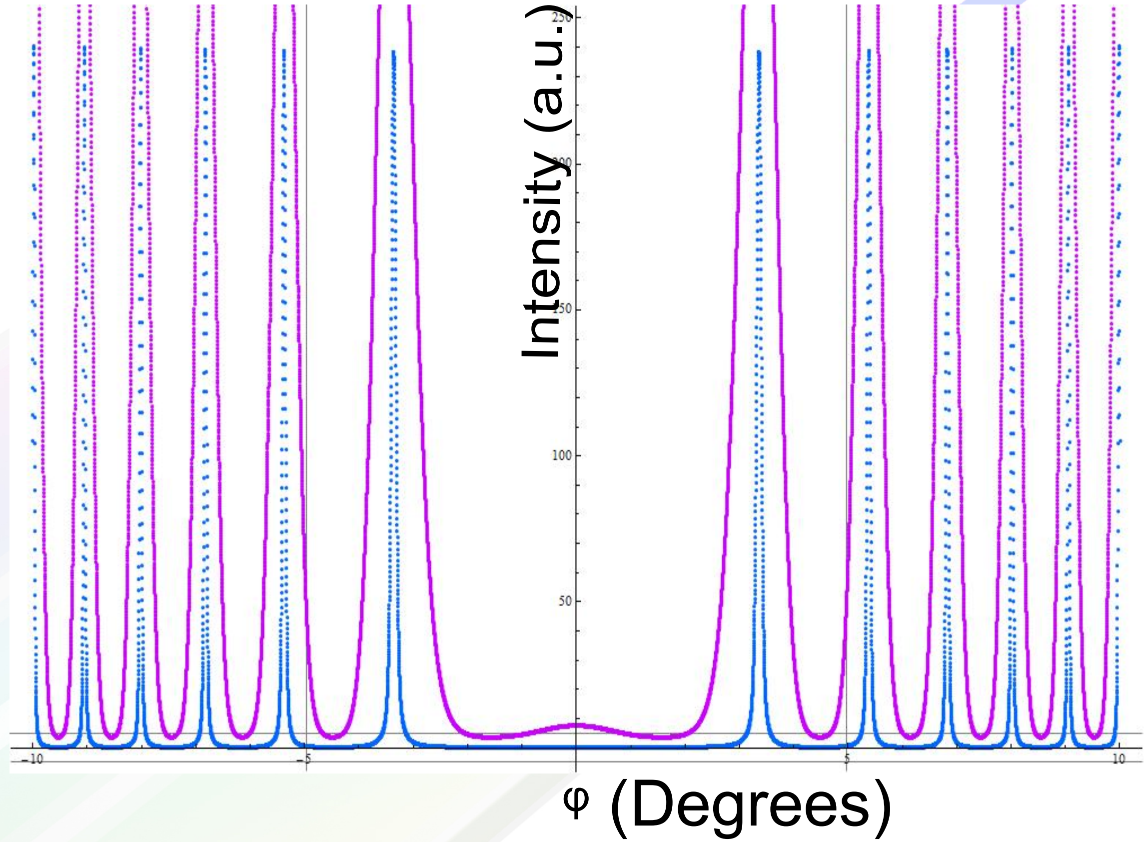


Refractive Index of KTP



Bandwidth measured using a solid etalon

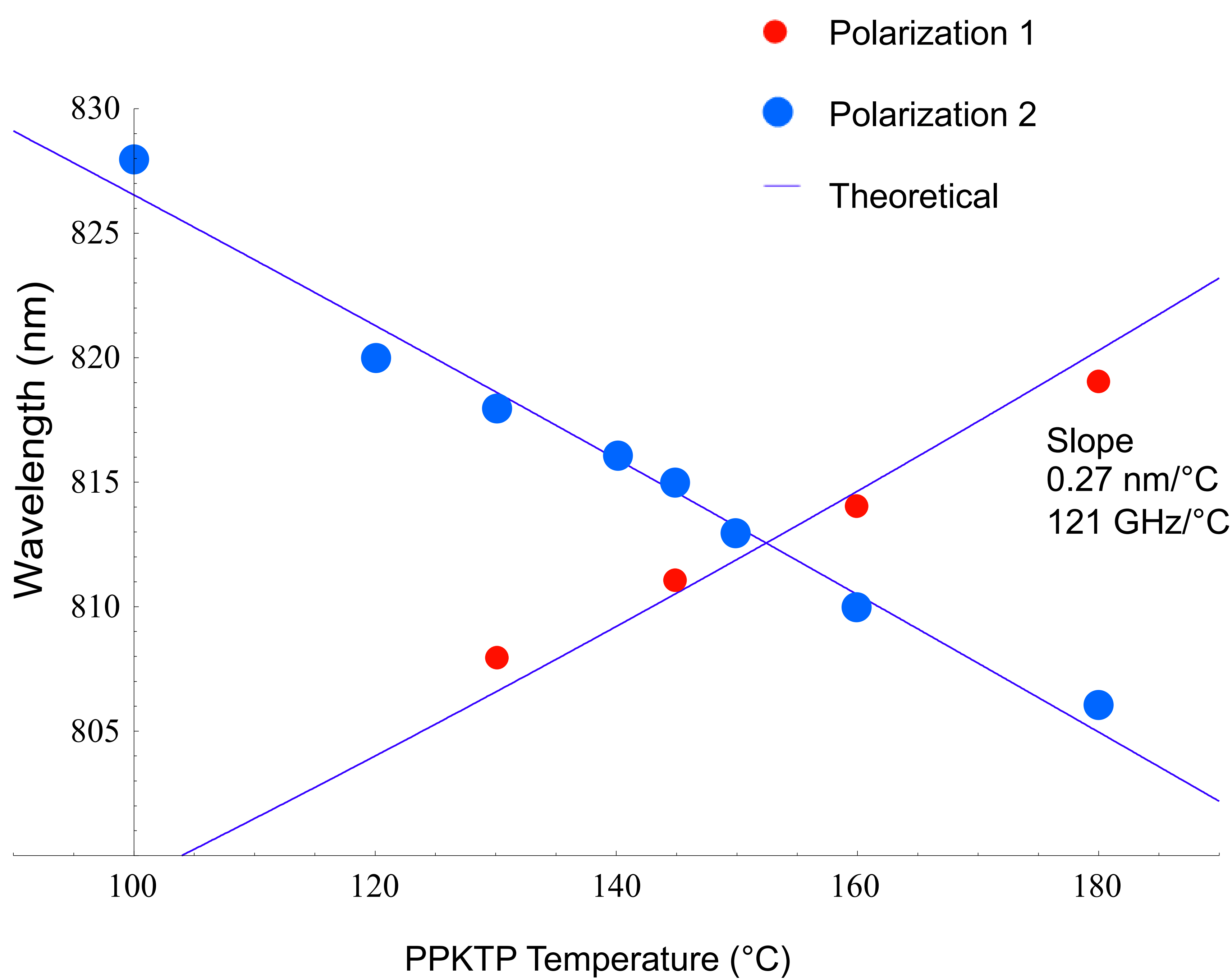




Blue curve: expected signal with 0.04nm (18 GHz) bandwidth
Purple curve: expected signal with 0.4nm (183GHz) bandwidth

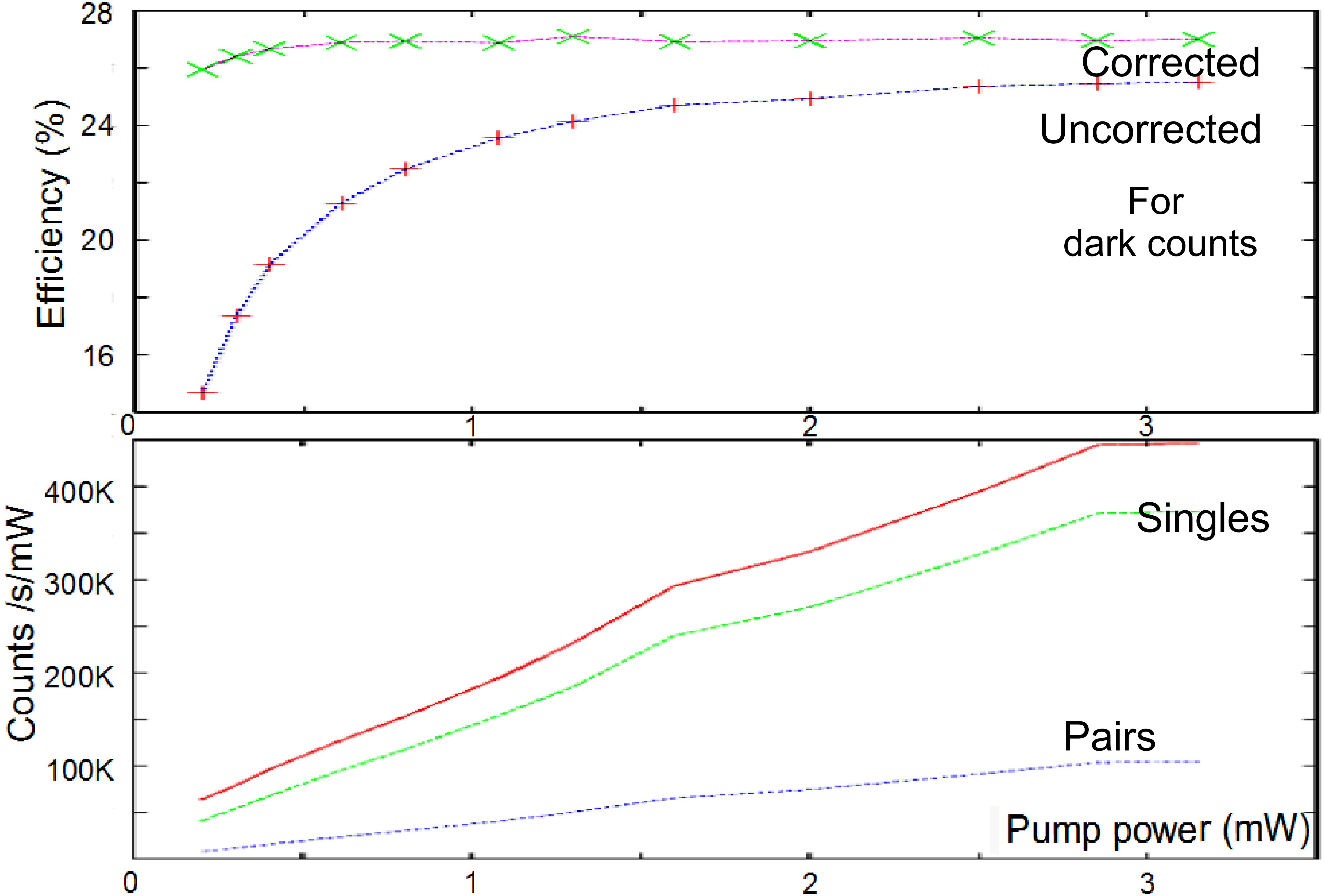
Resolution ~ 0.04nm(18GHz)

Tunable



Polarization 1
Polarization 2
Theoretical
830
825
820
815
810
805
Wavelength (nm)
100
120
140
160
180
PPKTP Temperature (°C)
Slope
0.27 nm/°C
121 GHz/°C

Efficiency Vs. pump power



Focusing for high pairs to singles ratio (efficiency).