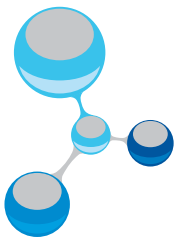
Construction of highly versatile four-photon source

Antonín Černoch
Karel Lemr and Karol Bartkiewicz

Joint Laboratory of Optics UP and PI AS CR
Faculty of Physics, Adam Mickiewicz University



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Outline

1. Motivation
2. Experimental setup
3. Source characterization
   - Polarization analysis
   - Two-photon interference

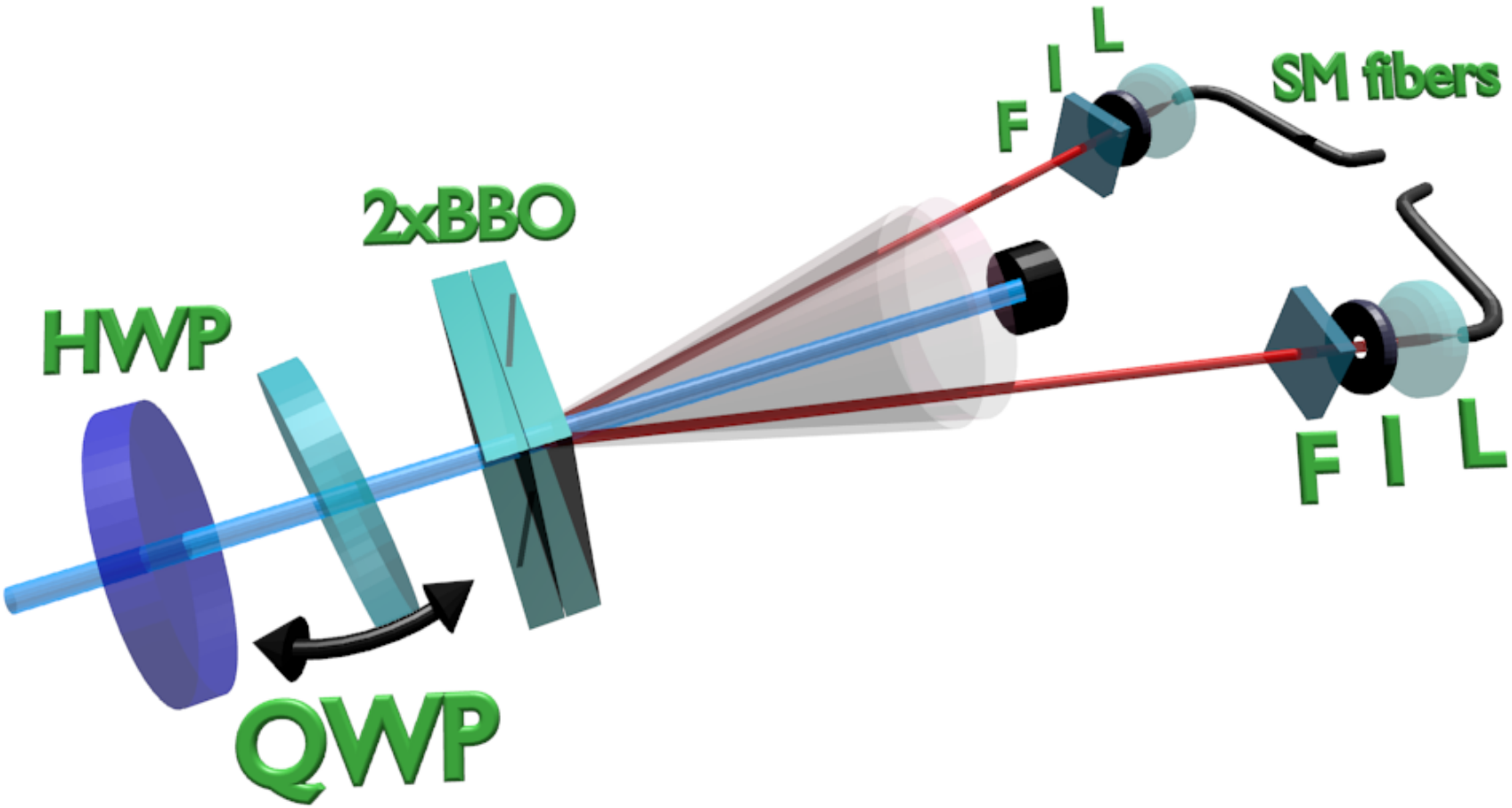
Motivation for building four-photon source

- nobody done it yet in such configuration (we hope)
- resource for quantum information processing experiments
- finding the answer for question: ”Why are not the other existing (but not such versatile) 4P sources normally used in QI protocols?”

What is new

- femtosecond laser pumping of the crystal cascade in both directions
- the degree of entanglement can be tuned for both pairs independently

Crystal cascade aka Kwiat source

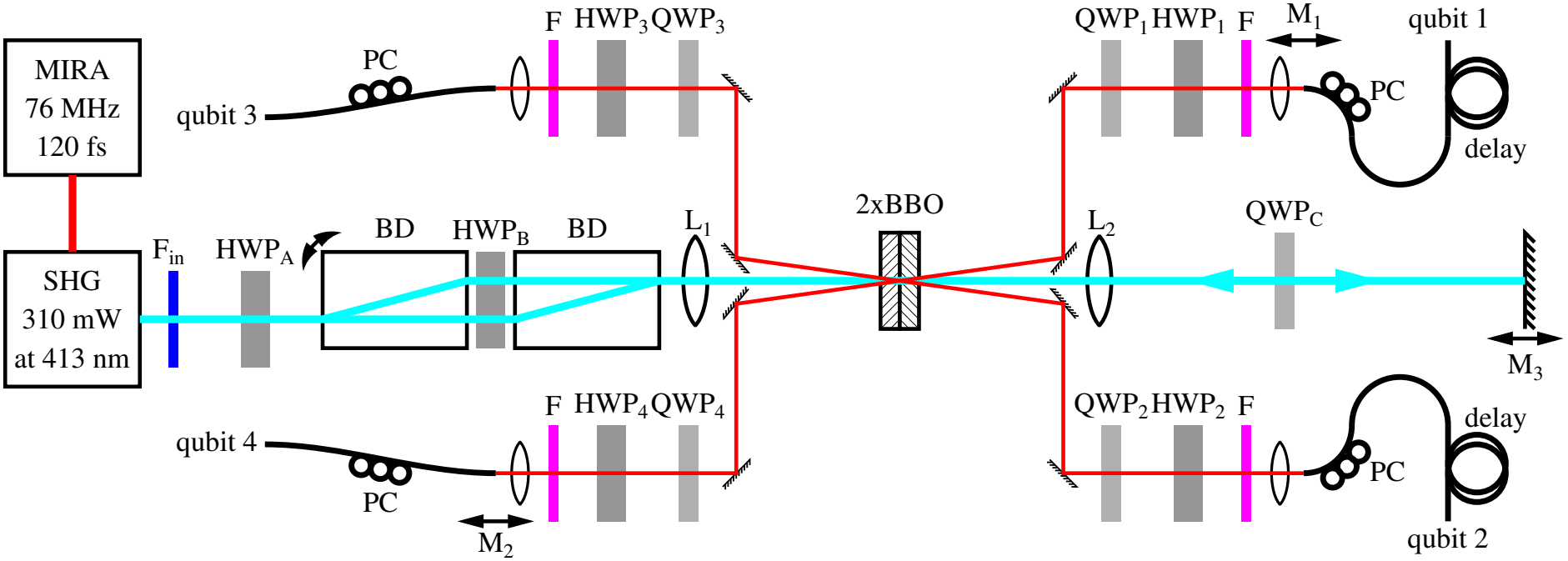


$$\left.\begin{array}{ll} H \rightarrow & |VV\rangle \\ V \rightarrow & |HH\rangle \end{array}\right\}$$

pairs produced in both crystal are indistinguishable

$$\Rightarrow \quad \alpha|HH\rangle + \beta|VV\rangle$$

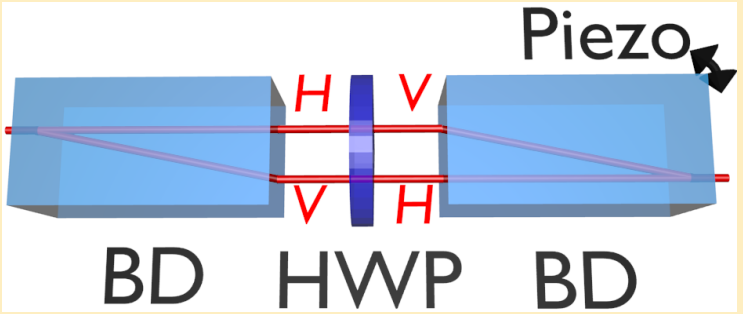
Experimental setup



- F_{in} – short-pass filter @424 nm
- BD – ThorLabs BD40 beam-displacer
- F – edge or 10, 5, 3, 1.5 nm FWHM band-pass filter
- PC – polarization controler

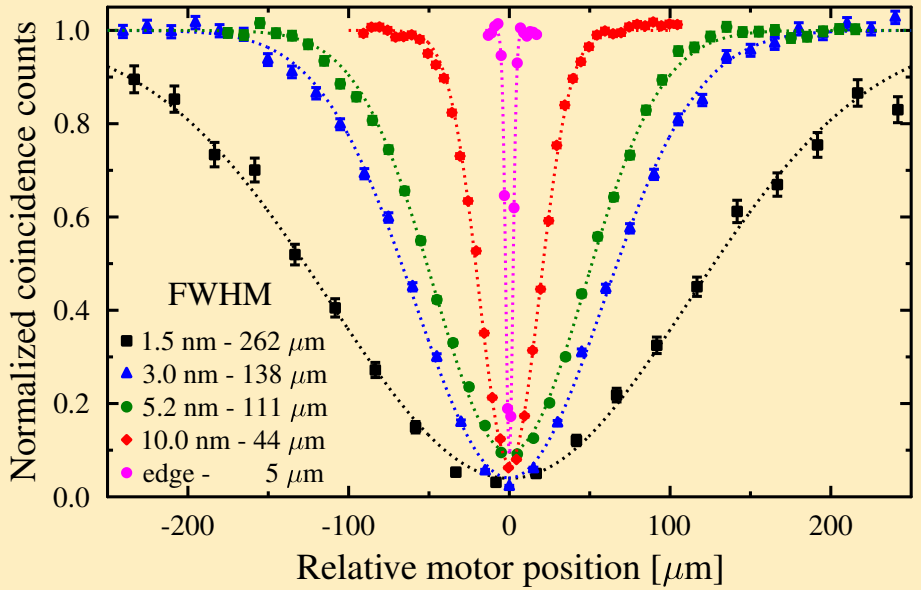
BDA – beam divider assembly

- compensates polarization walk-off
- small changes tunes the phase of entangled state
- bigger prolongation affect purity



Spectral filters

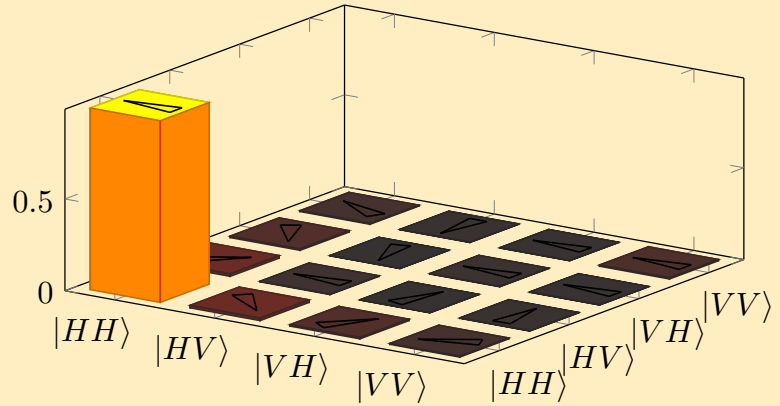
- long-pass edge and narrow-band 10, 5, 3, 1.5 nm FWHM
- more signal $\times$ better indistinguishability



Two-photon polarization states

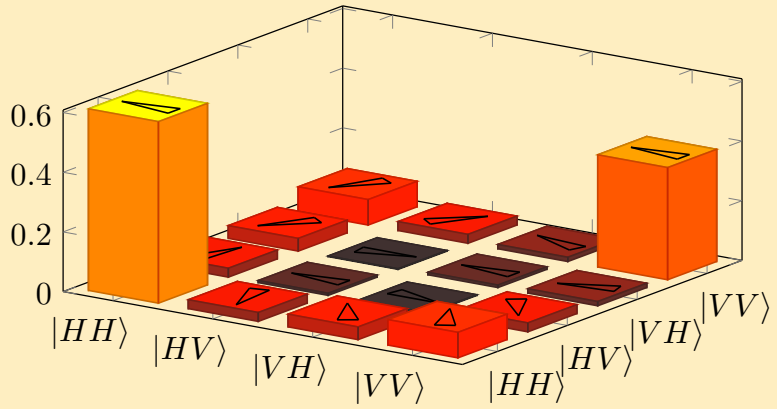
Separable – $|HH\rangle$

$P = 0.978$, $N = 0.002$, $F = 0.994$



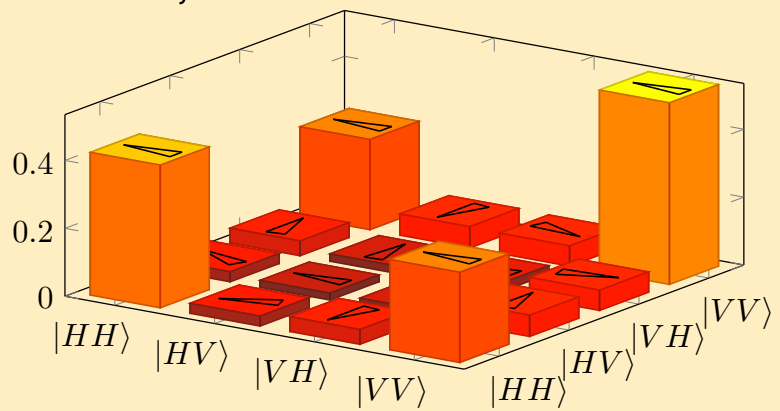
Maximally mixed

$P = 0.534$, $N = 0.083$



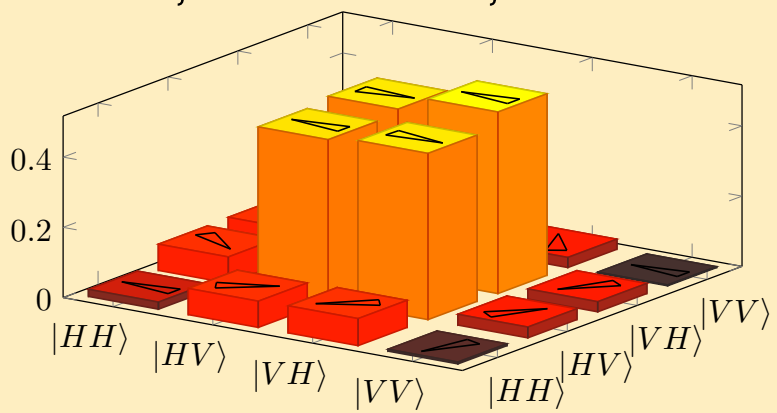
Partially entangled

$P = 0.63$, $N = 0.25$

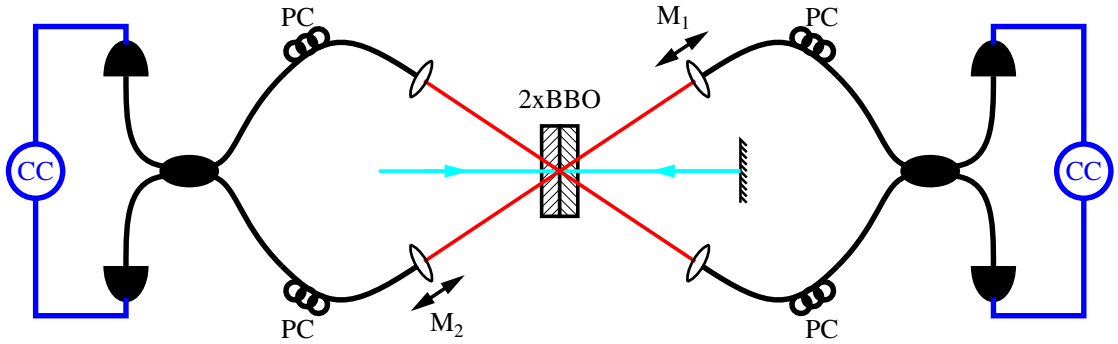


Maximally entangled – $|\Psi^-\rangle$

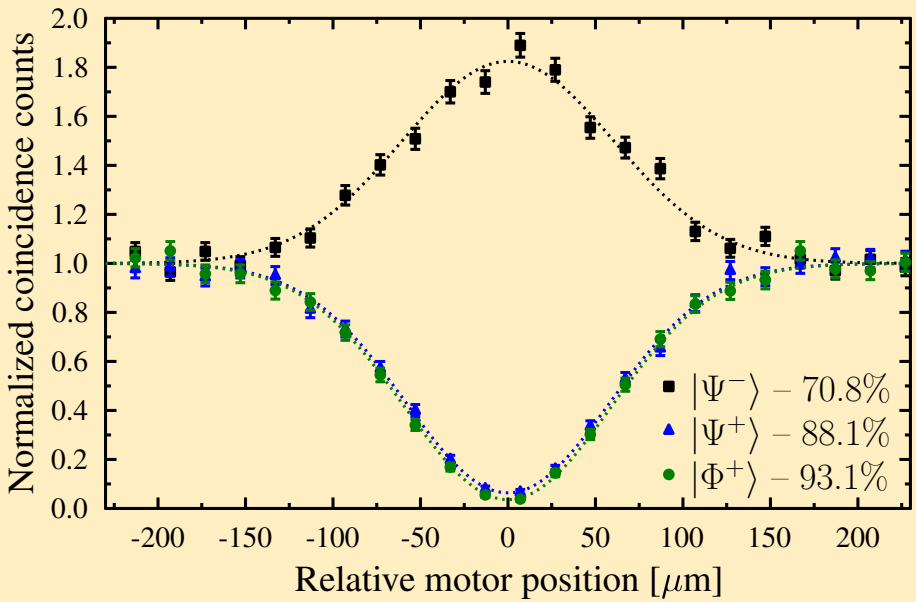
$P = 0.95$, $N = 0.473$, $F = 0.981$



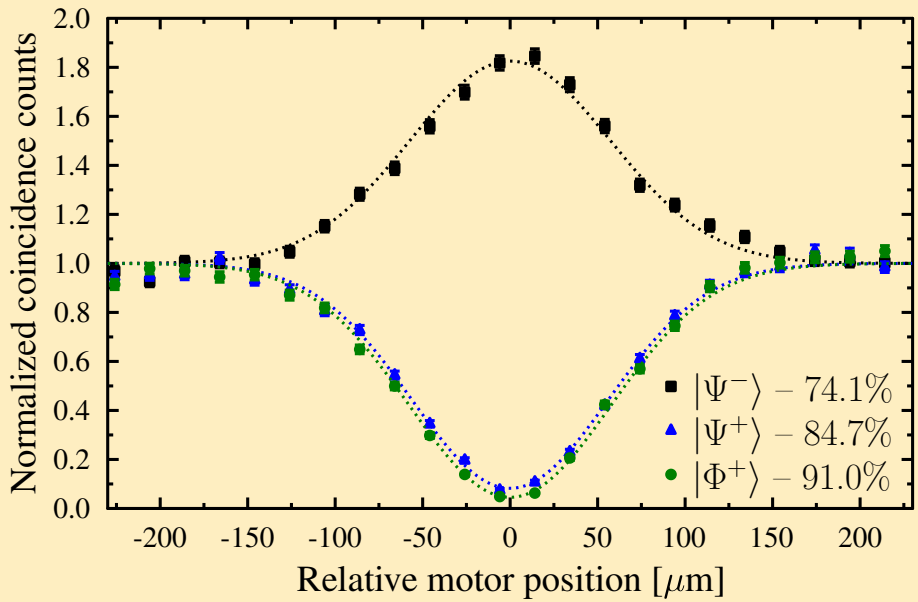
HOM dip – pair photon indistinguishability



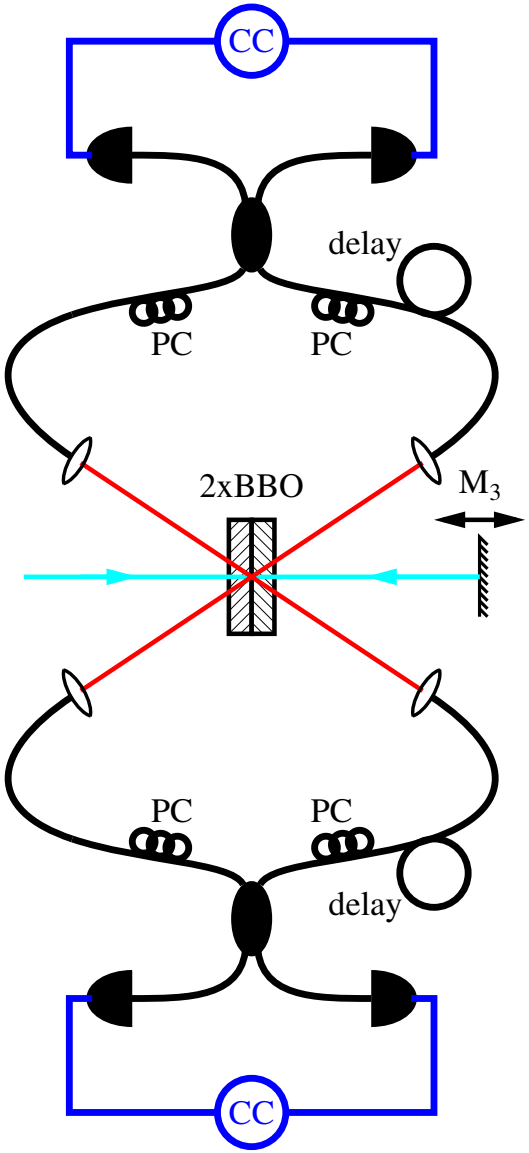
Backward pair (3 nm FWHM filter)

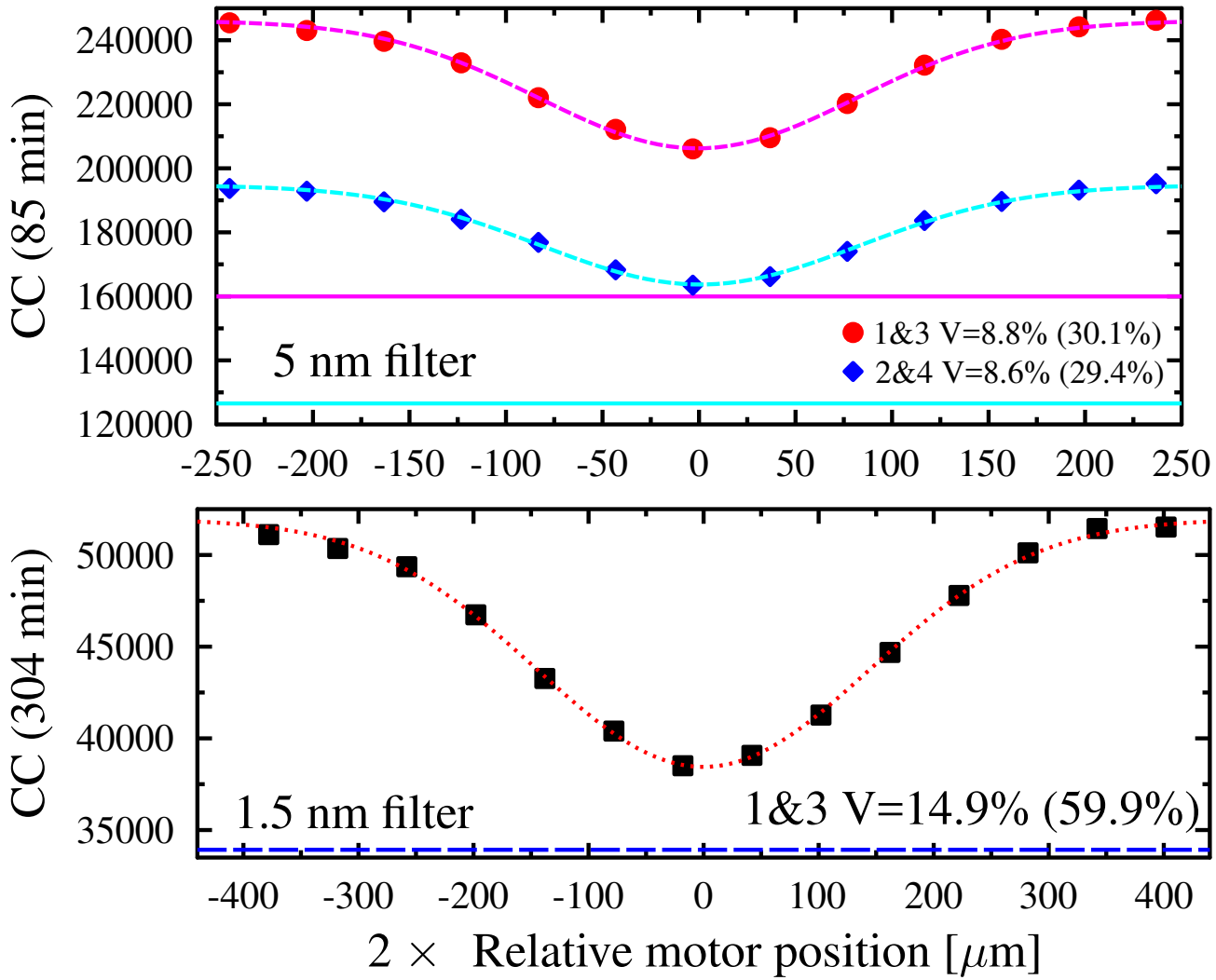


Forward pair (3 nm FWHM filter)

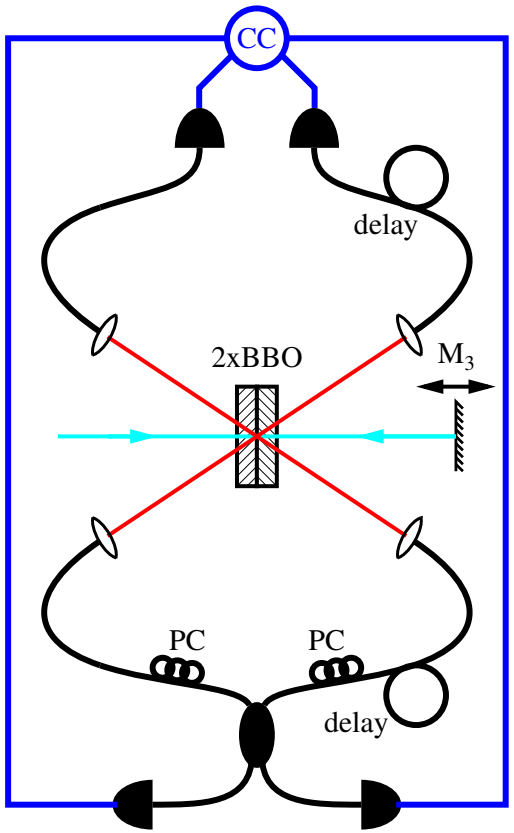


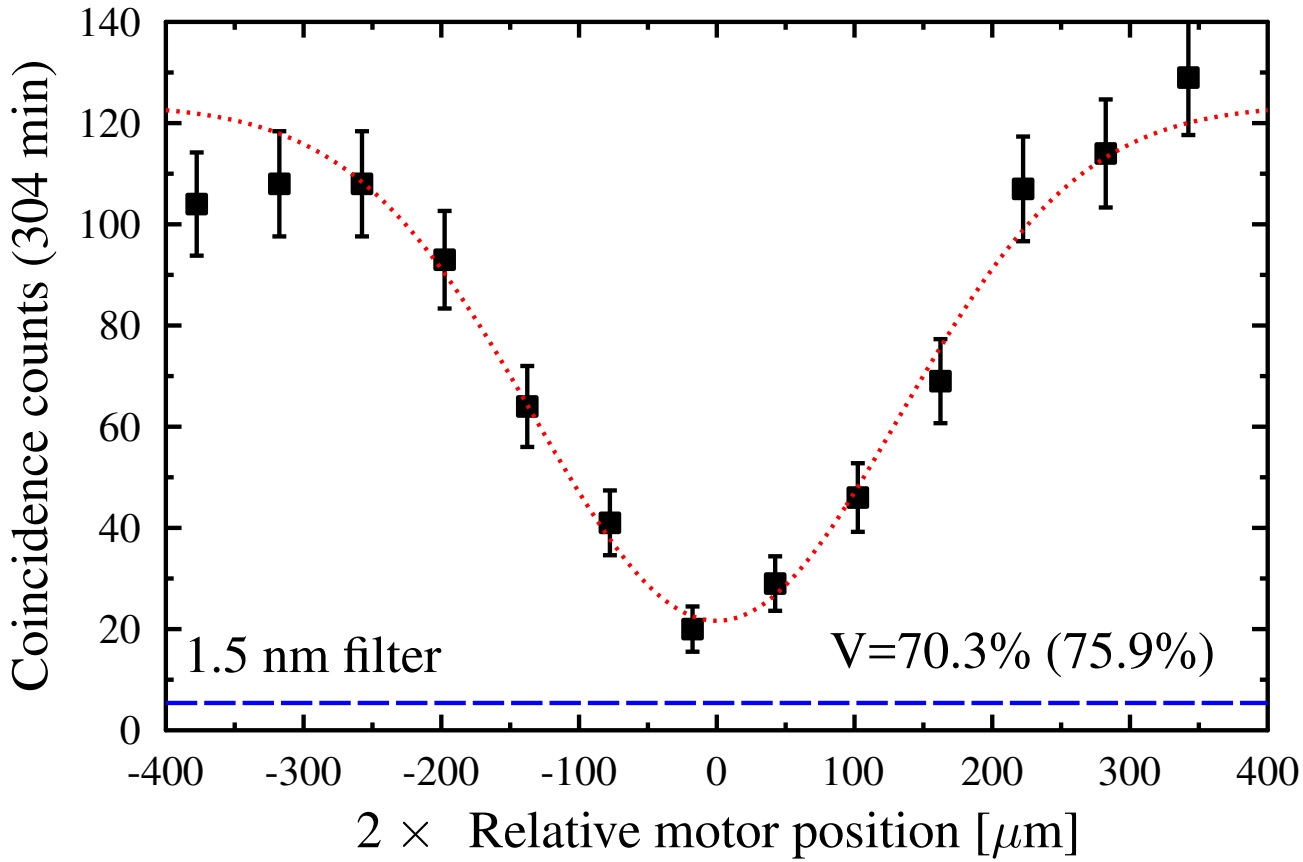
HOM dip between pairs



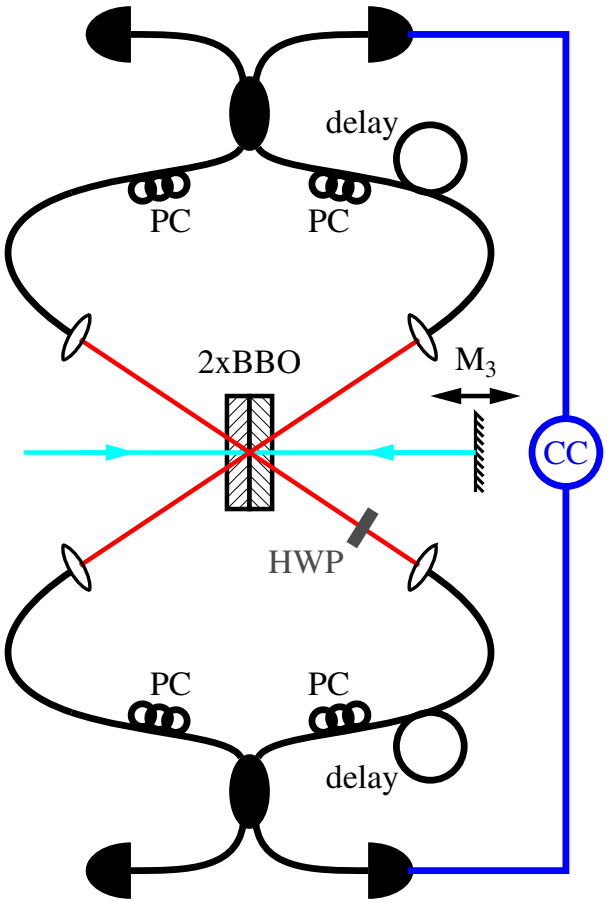


Triggered HOM dip

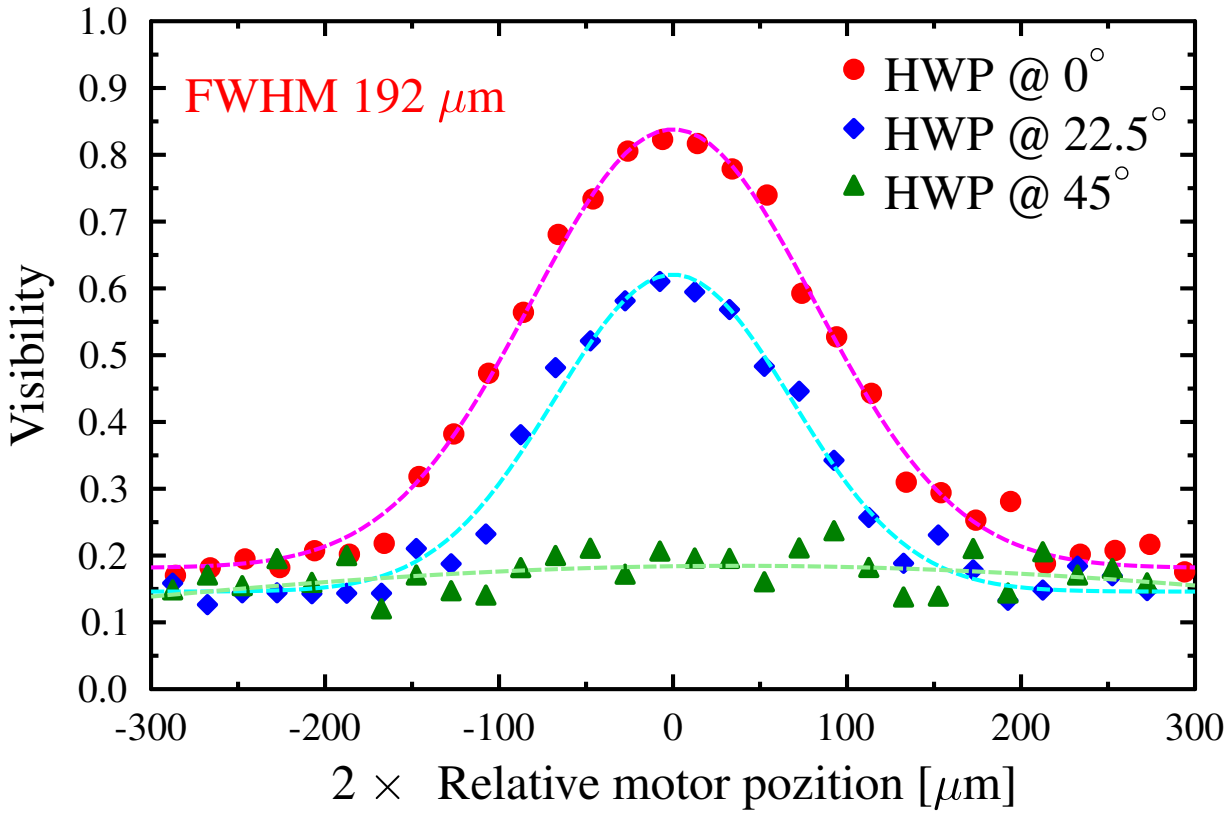




Coherence between photon pairs



Franson type interference



Conclusions

- parameters of the source are comparable with other existing sources
- additional degree of freedom

Experiments using this source

- colectibility measurement – see K. Lemr's poster (Thursday)
- entanglement estimation from Bell inequality violation

Thank you for your attention