Experimental measurement of the collectibility of two-qubit states

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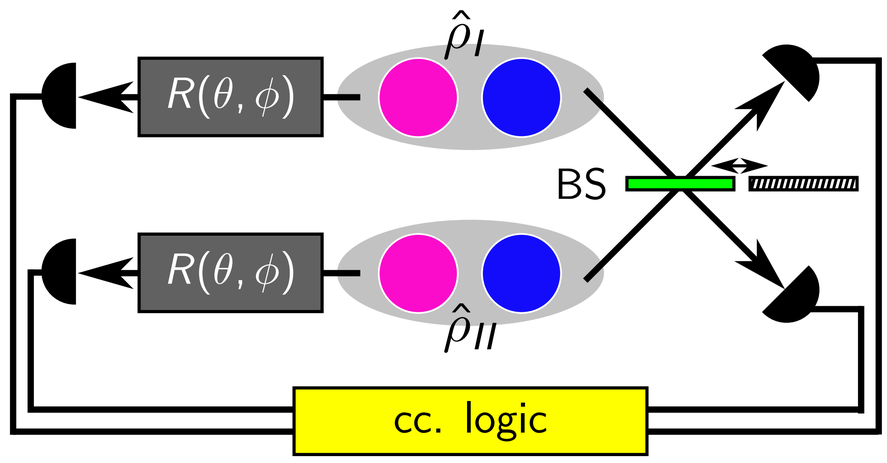
WHAT IS COLLECTIBILITY?

Collectibility is an **entanglement witness** and in some special cases also an entanglement measure.

It was proposed by Rudnicki *et al.* in 2011 [Rud11] and subsequently generalized to mixed states in 2012 by the same group of authors [Rud12].

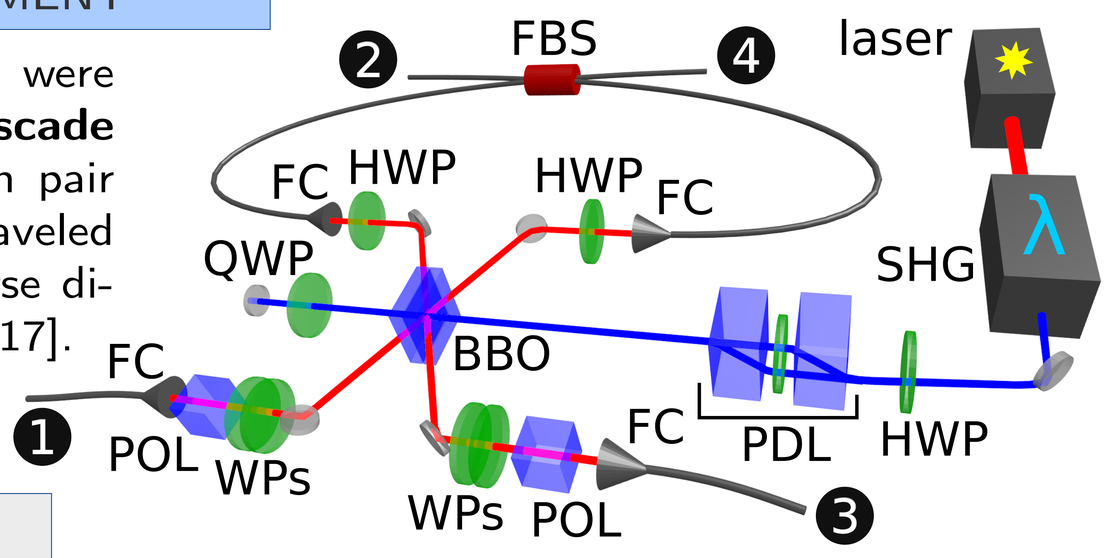
TWO-QUBIT COLLECTIBILITY



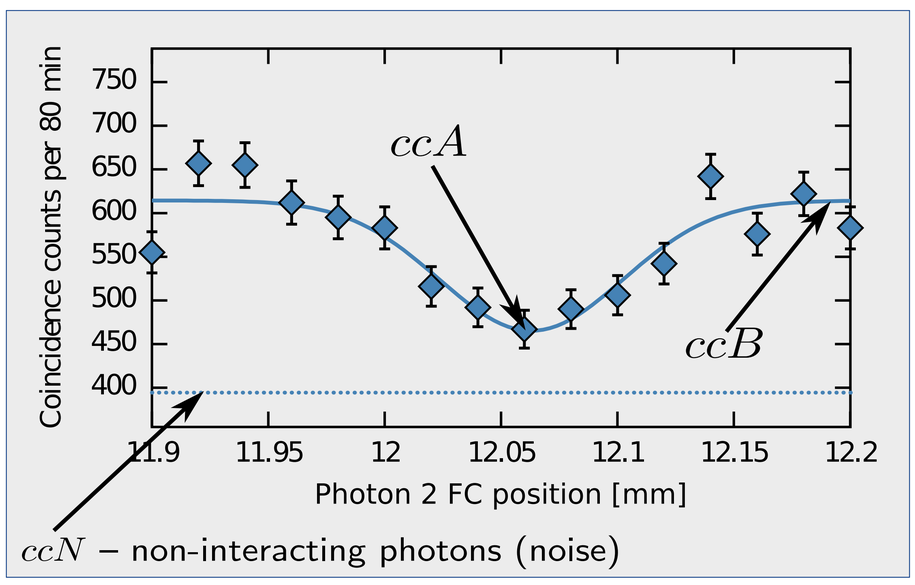
Tested on:	entangled $\frac{1}{\sqrt{2}}(\|HV\rangle - \|VH\rangle)$, separable $\|DD\rangle$ and mixed $\frac{1}{4}\hat{\mathbb{1}}$ states
Local projections:	polarization projections onto horizontal (H), vertical (V) and diagonal (D) polarizations
Non-local projections:	two-photon overlap on a balanced beam splitter, random mixing on a balanced beam splitter (used for normalization)

EXPERIMENTAL SETUP & MEASUREMENT

Entangled or separable two-qubit states were prepared by pumping a **BBO crystal cascade** (Kwiat source). First and second photon pair were generated when the laser pulse traveled through the crystals in forward and reverse directions respectively [Lemr16, Bartkiewicz17].



Registered 4-fold coincidences:



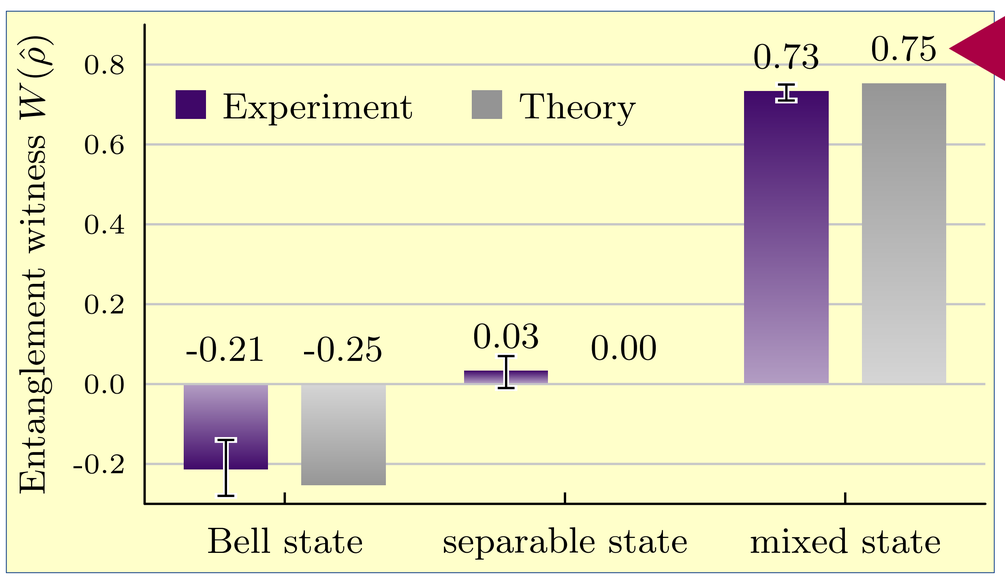
COLLECTIBILITY CALCULATION

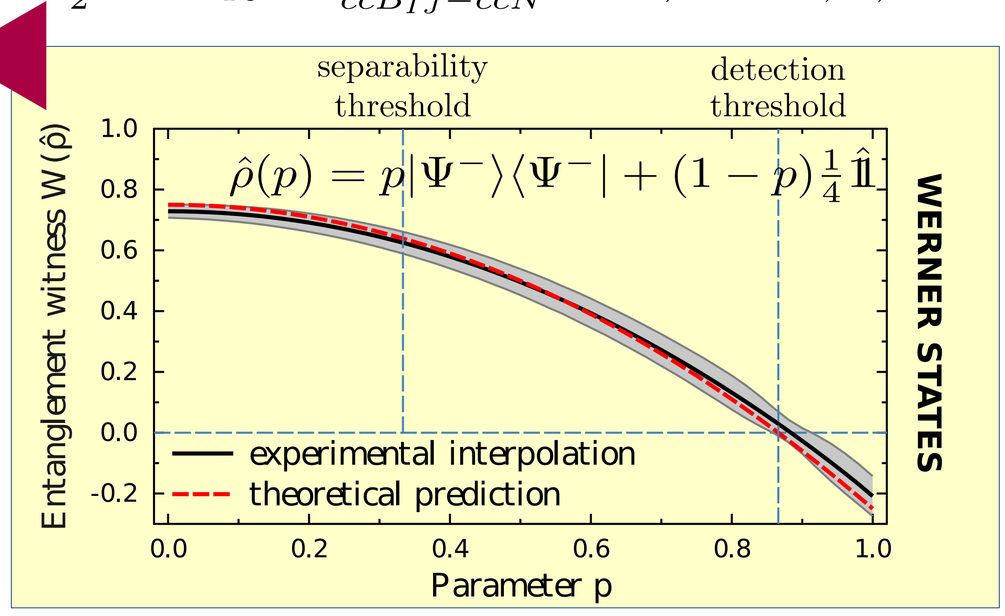
Formula for collectibility:

$$W(\hat{\rho}) = \frac{1}{2}\Big[\eta + \xi^2(1-r_{HH}) + (1-\xi)^2(1-r_{VV}) + 2\xi(1-\xi)(1-r_{HV}) - 1\Big],$$

where $\eta = 8\xi(1-\xi)\sqrt{r_{HH}r_{VV}} + 2r_{DD}$, $\xi = \frac{1}{2}$ and $r_{IJ} = \frac{ccA_{IJ}-ccN}{ccB_{IJ}-ccN}$ for $I, J = H, V, D$.

RESULTS





References:

[Rud11] Phys. Rev. Lett. **107**, 150502 (2011).
[Rud12] Phys. Rev. A **86**, 062329 (2012).
[Lemr16] Phys. Rev. A **94**, 052334 (2016).
[Bartkiewicz17] Phys. Rev. A **95**, 030102(R) (2017).

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