Towards a relationship between single photon nature and randomness

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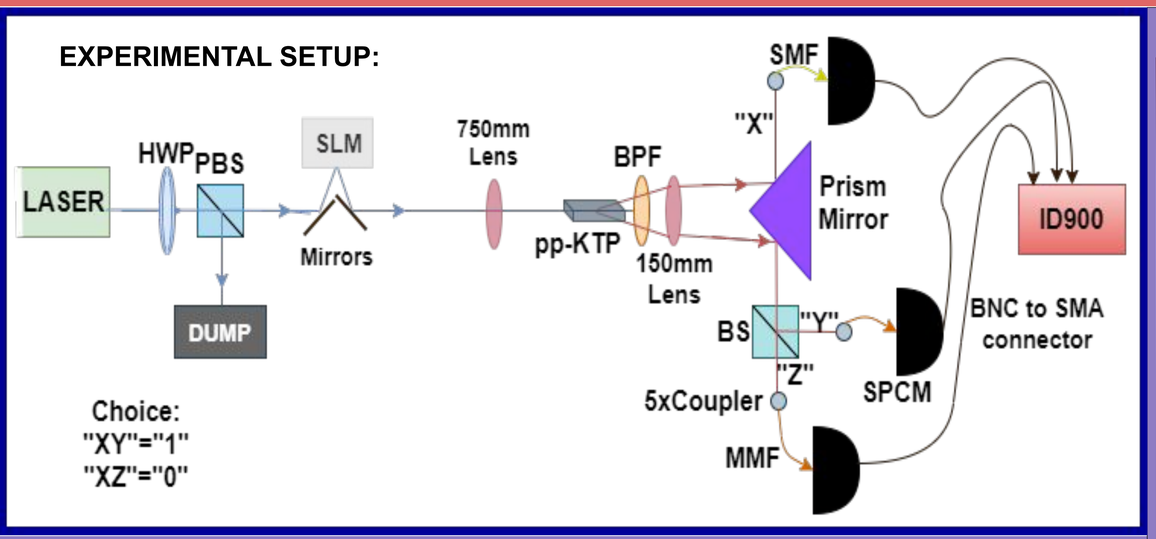
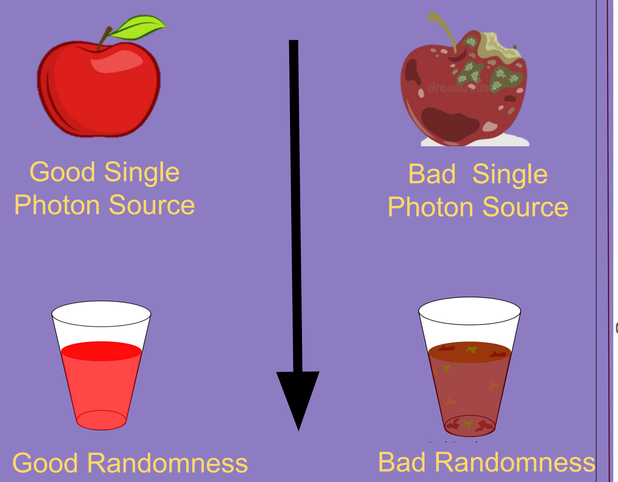


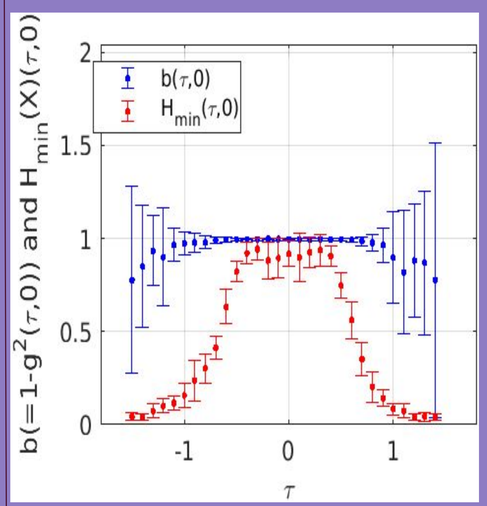
Introduction

For discrete variable optical QRNG [1], the randomness of the QRNG directly relates to the quality of single photon property. Here, we investigate a relationship between quantifying parameter for single photon nature of SPDC process ($b=1-g^{(2)}(0)$) and quantifying parameter for randomness, min-entropy ($H_{min}(X)$). This investigation is done on three independent grounds, namely, time delay (τ), power and orbital angular momentum (OAM) of photons.



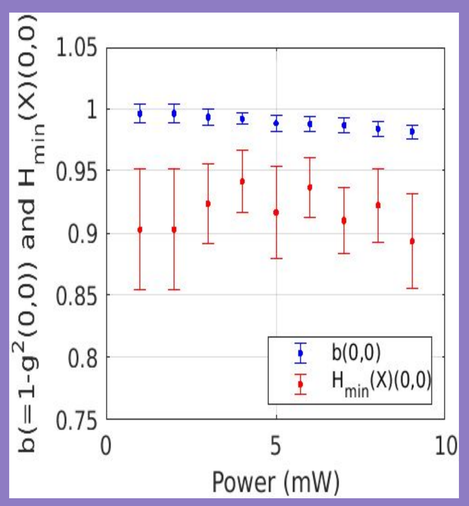
Time Delay (τ)

Variation of b with time delay studies the quality of single photons from SPDC process. It can also be used to model biased beam splitters for randomness. In the below graph, it is clearly evident that as the quality of single photon nature (b) decreases with variation of time delay, so does randomness ($H_{min}(X)$).



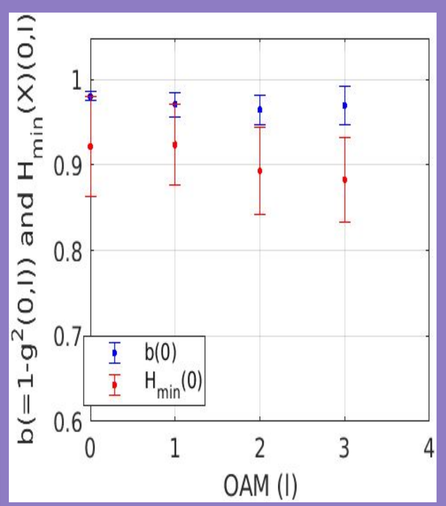
Power

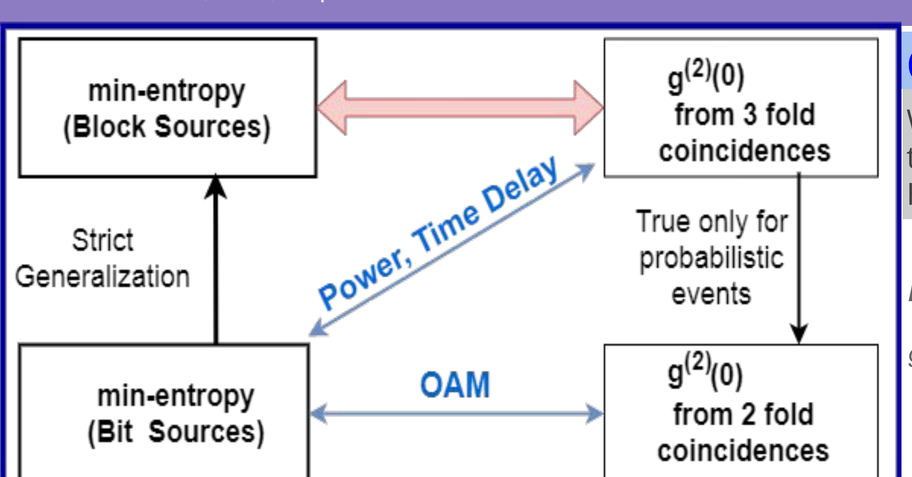
Variation of b with power shows decrease in the quality of single photon nature because of multi-photon events from the SPDC process. These multi-photon events also debases the quality of randomness ($H_{min}(X)$). However, within the range shown (0 to 10 mW), it is evident that quality of randomness ($H_{min}(X)$) is almost insensitive towards quality of single photon nature.



OAM (l)

Variation of b with OAM shouldn't degrade randomness. This was observed at low power (1mW). However, with higher power (10 mW), one can see decrease in b and correspondingly a decrease in $H_{min}(X)$ value. This decrease is associated to multi-photon events that almost go to zero at low power (1 mW).





Conclusion:

We conjecture a relationship between quality of single photon nature (b) and quality of randomness ($H_{min}(X)$), X can take both bit and block length values. This is done by experimentally observing a relationship between b and $H_{min}(X=\{0,1\})$ on different parameters discussed above. The diagram on the left encapsulates the broader picture.

References:

[1] Thomas Jennewein, Ulrich Achleitner, Gregor Weihs, Harald Weinfurter, and Anton Zeilinger , "A fast and compact quantum random number generator", Review of Scientific Instruments 71, 1675-1680 (2000).

[2] Herrero-Collantes, Miguel and Garcia-Escartin, Juan Carlos "Quantum random number generators" Rev. Mod.Phys.,89,1,015004 (2017).

[3] Grünwald "Effective second-order correlation function and single-photon detection" New Journal of Physics, 21,9,093003 (September 2019).