MEASURING TEMPORAL COHERENCE OF LIGHT FROM A MERCURY VAPOUR LAMP

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Introduction

Light from a blackbody radiation source exhibits statistical intensity fluctuations [1] that exceeds a random Poissonian statistical distribution, whereby the photons tend to bunch together both spatially and temporally at its characteristic timescale, $\tau_c \approx \frac{1}{\Delta\nu}$, where $\Delta\nu$ is the spectral width of the light source. For the Doppler-broadened spectral emission at 546.1 nm of a Mercury vapour lamp, the second-order temporal correlation function $g^{(2)}(\tau)$ (measurement of photon bunching) is given by [2]:

$$g^{(2)}(\tau) = 1 + \exp(-\pi(\tau/\tau_c)^2) \tag{1}$$

where τ is the timing delay between a pair of photons.

Timescales of 10^{-14} s for typical blackbody sources such as the Sun make it difficult to observe these statistical intensity fluctuations. As such, we probe a Doppler-broadened Mercury vapour lamp at the characteristic 546.1 nm spectral emission with a characteristic timescale on the order of nanoseconds with a pair of Silicon Avalanche Photon Diodes (APDs) with a timing resolution of 0.6 ns.

Experiment

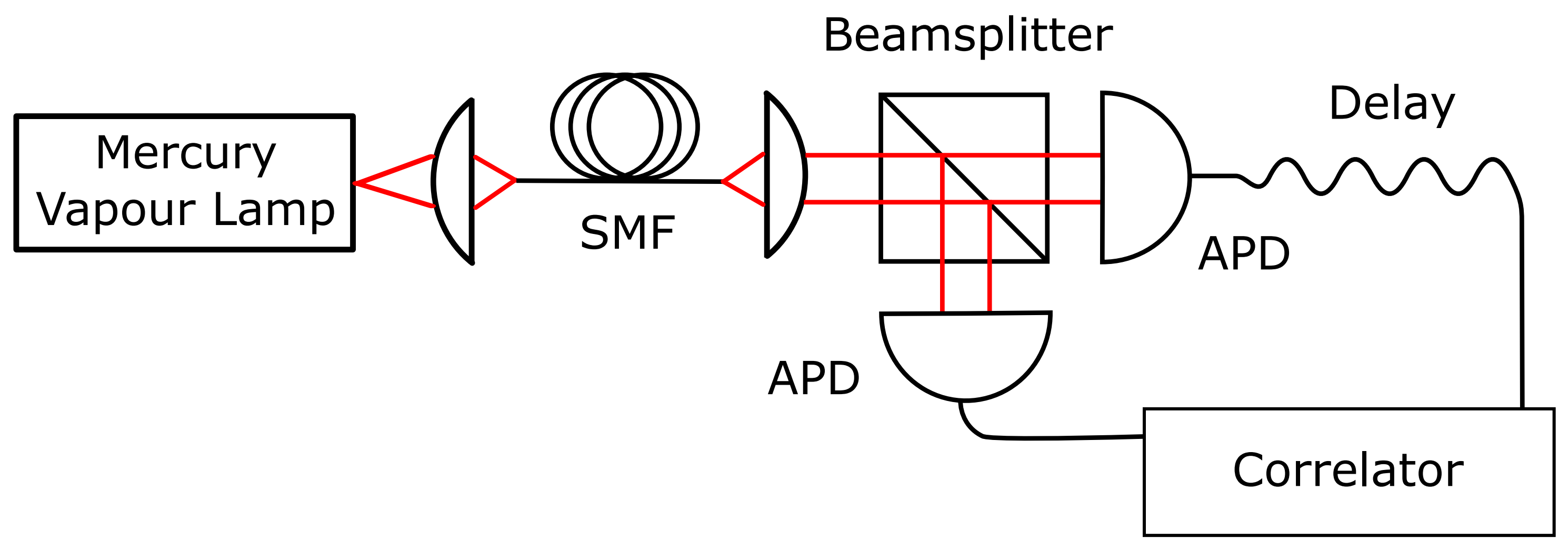

Figure 1: Schematic of the setup used to measure $g^{(2)}(\tau)$

The Mercury light is collected into a collection lens (EFL of 25.0 mm at 587.6 nm), and subsequently into a single mode fibre ($\lambda = 488$ to 633 nm) before going through a beamsplitter cube. The light is then collected by a pair of Avalanche Photon Detectors (APDs). The avalanche breakdown from the APDs trigger NIM outputs, which correspond to photoevents, and are correlated by a digital oscilloscope with 1 GHz bandwidth, by measuring the timing separation between a pair of consecutive photoevents. These timing separations were then binned into a histogram. Typical photon count rates for each APD are on the order of 40,000 counts per second, implying a coincidence rate of ≈ 16 coincidence events/s.

Results and Discussion

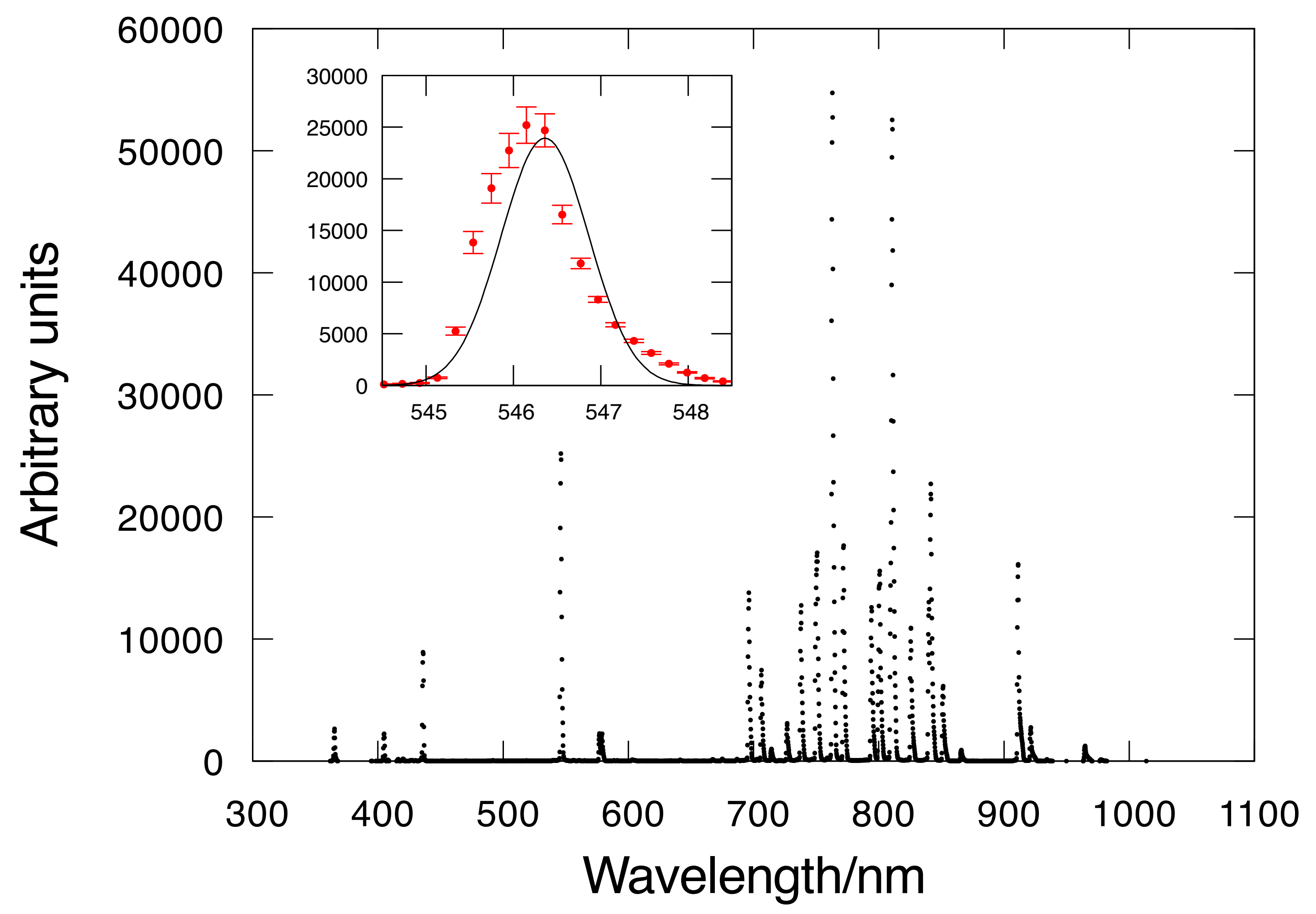

Figure 2: The Mercury spectral emission at 546.1 nm (with statistical error bars) is fitted to a Skewed Gaussian, giving a peak wavelength of 546.4 nm with a Full Width at Half Maximum (FWHM) of 1.2 nm, limited by detector resolution. Although this provides a relatively poor fit (Goodness of fit $\chi^2/\text{doF} = 83$), it is much better than $\chi^2/\text{doF} = 10^6$ when using a non-skewed Gaussian model.

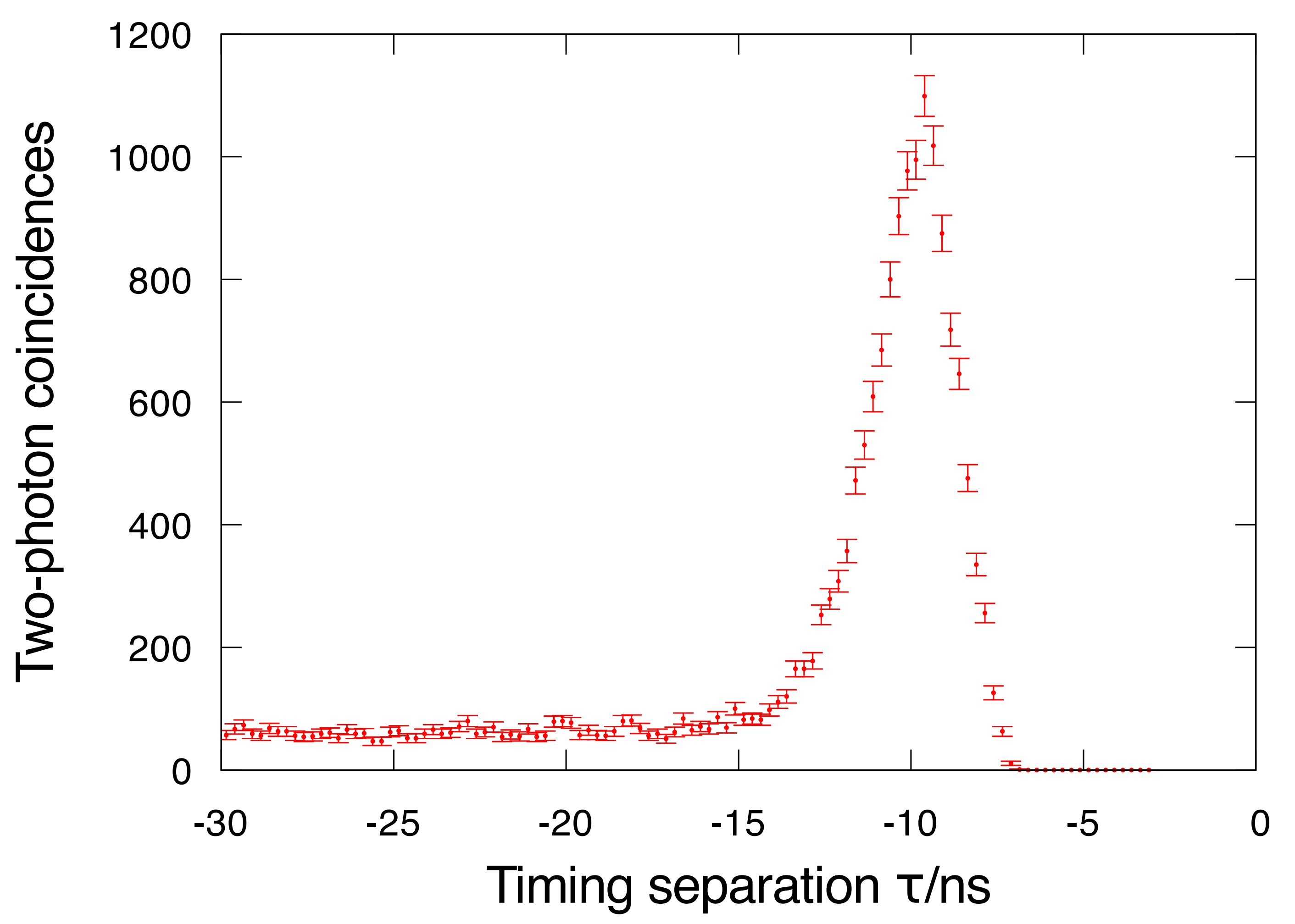

Figure 3: An APD emits light upon each photoevent; this emitted light can then be correlated with the initial photoevent using the second APD. The observation of twin photon correlation peaks provides a sanity check as to the capability of the APDs of measuring a correlation signals in the nanosecond regime. Since only peak is observed, it suggests that a larger conincidence window might be required.

The statistical measurement of the timing separation between each pair of photodetection events (temporal coherence):

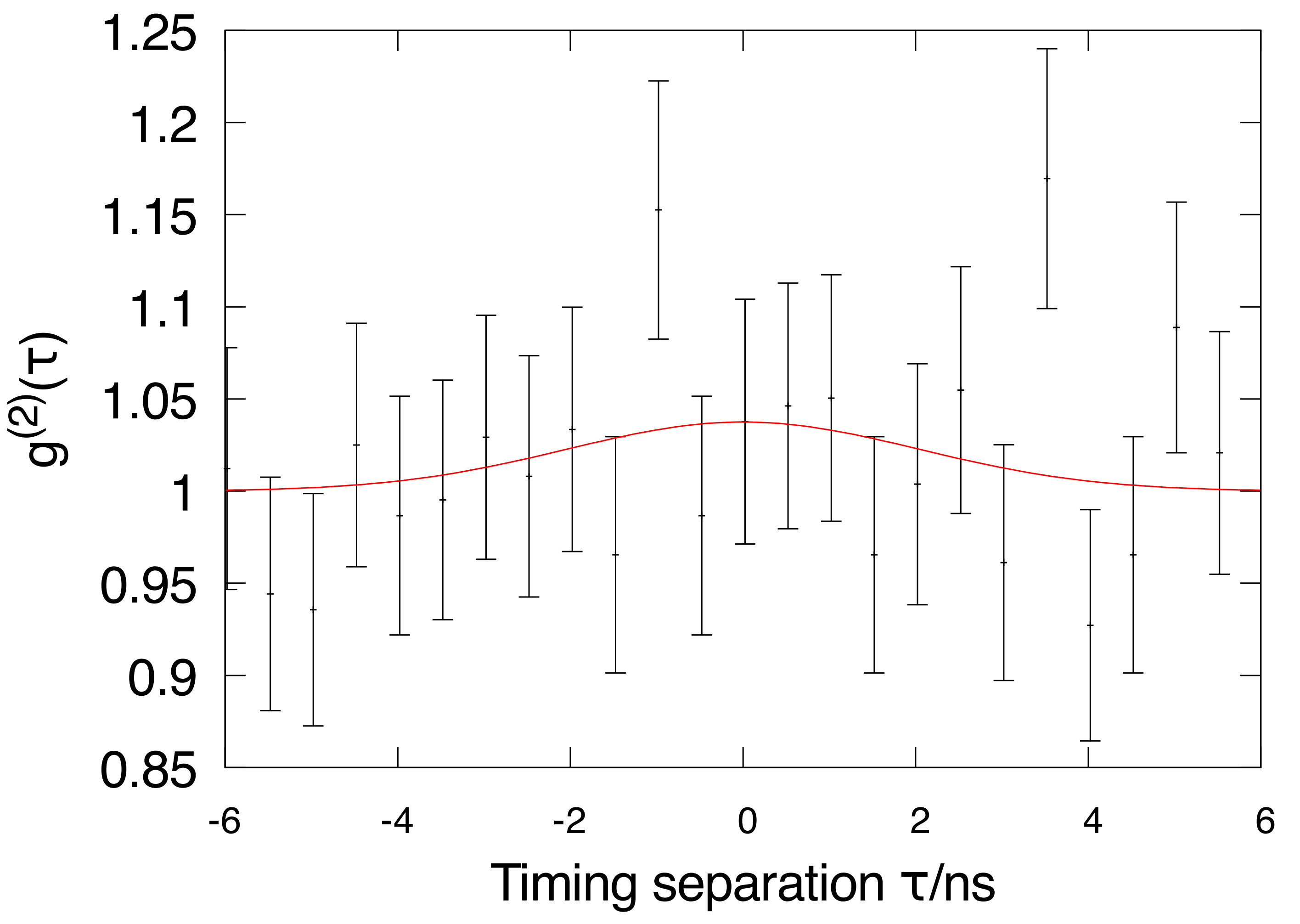

Figure 4: Histogram of the measured timing separations. Oscilloscope correlation window is of 50 ns. Error-bars are the square-root of the bin value, as we approximate Poissonian statistics; no statistically significant peaks (that indicate photon bunching), are observed. The $g^{(2)}(\tau = 0)$ is measured to be 1.0 ± 0.2.

It is likely that we have neglected the polarisation of the beamsplitter cube. Additionally, the integration times for the correlation measurements could have been longer, reducing the statistical uncertainty of the measurements.

Acknowledgements

We are grateful for the support from the laboratory staff at Hwa Chong Institution's Science Research Centre, as well as Tan Peng Kian from the Centre for Quantum Technologies and Dr. Erkan Polatdemir from Hwa Chong Institution for their mentorship and guidance.

References

[1] R. Hanbury-Brown and R. Q. Twiss, Nature **177**, 27 (1956)
[2] R.J. Glauber, Physical Review **130**, 2529 (1963)