I. EXPERIMENTAL SETUP

In general, Alice and Bob's clocks are not synchronized. With t local time at Alice's, and t' local time at Bob's, we define the time offset $\delta = t' - t$. We use the time correlation of photon pairs generated in SPDC to determine δ.

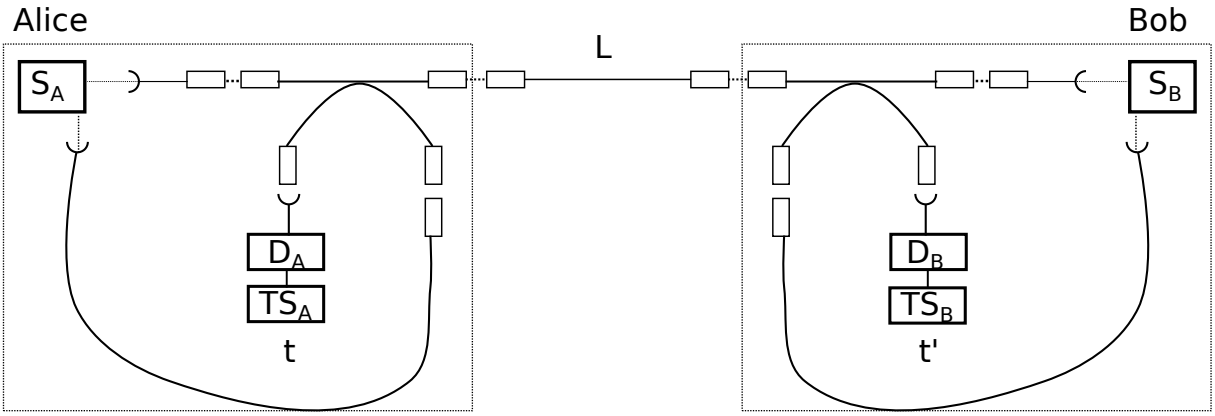

FIG. 1: Time synchronization setup. Alice and Bob each have a source of time-correlated photon pairs produced by spontaneous paramateric down-conversion (SPDC) and a single photon detector. One member of the SPDC pair is detected locally at detector D_A on Alice's side and at D_B on Bob's side. The other member of the pair is sent through a single mode fibre to be detected on the remote side. Times of arrival for all detected photons are recorded in each lab with respect to a local clock.

A sketch of the experimental setup is shown in Figure 1. The system is symmetrical, the following description is also valid exchanging the roles of Alice (A) and Bob (B). Alice generates time-correlated photon pairs (810 nm) with orthogonal polarizations using collinear type-II SPDC. The polarization modes are separated using a PBS and coupled into single mode fibers. Alice sends the horizontal photons to Bob, while the vertical photons are mixed locally with photons received from Bob in a fiber beam-splitter sent to the local detector.

We use avalanche photodiodes (Perkin Elmer C30902SH, measured jitter time of 376±1 ps) and timestamp detection events with a temporal resolution of 125 ps. All timestamps are relative to the offset of internal clock of the timestamp units. Our goal is to measure the clock offset difference δ. For this initial demonstration, we lock the internal clocks with a common frequency reference from a rubidium oscillator to reduce frequency drifts between them. This constraint can be removed with the algorithm described in [1].

Cross correlation between the Alice's and Bob's event records shows two peaks. The time separation between peaks corresponds to twice the propagation time between the sources, the midpoint instead is the offset δ.

We repeated the experiment for different length L of fiber connecting A and B locations. Figure 2 shows four sets of correlation peak pairs obtained for different L.

In table I, we show that the timing offset δ estimated for various values of L are in good agreement with each other.

$L(m)$	$\delta + 3827495(ns)$
1.7	0.39 ± 0.03
6.7	0.44 ± 0.03
31.7	0.37 ± 0.03
51.7	0.38 ± 0.03

TABLE I: Estimated clock offset δ between Alice and Bob's clocks for various spatial separations L.

[1] C. Ho, A. Lamas-Linares, and C. Kurtsiefer, New Journal of Physics **11**, 045011 (2009).

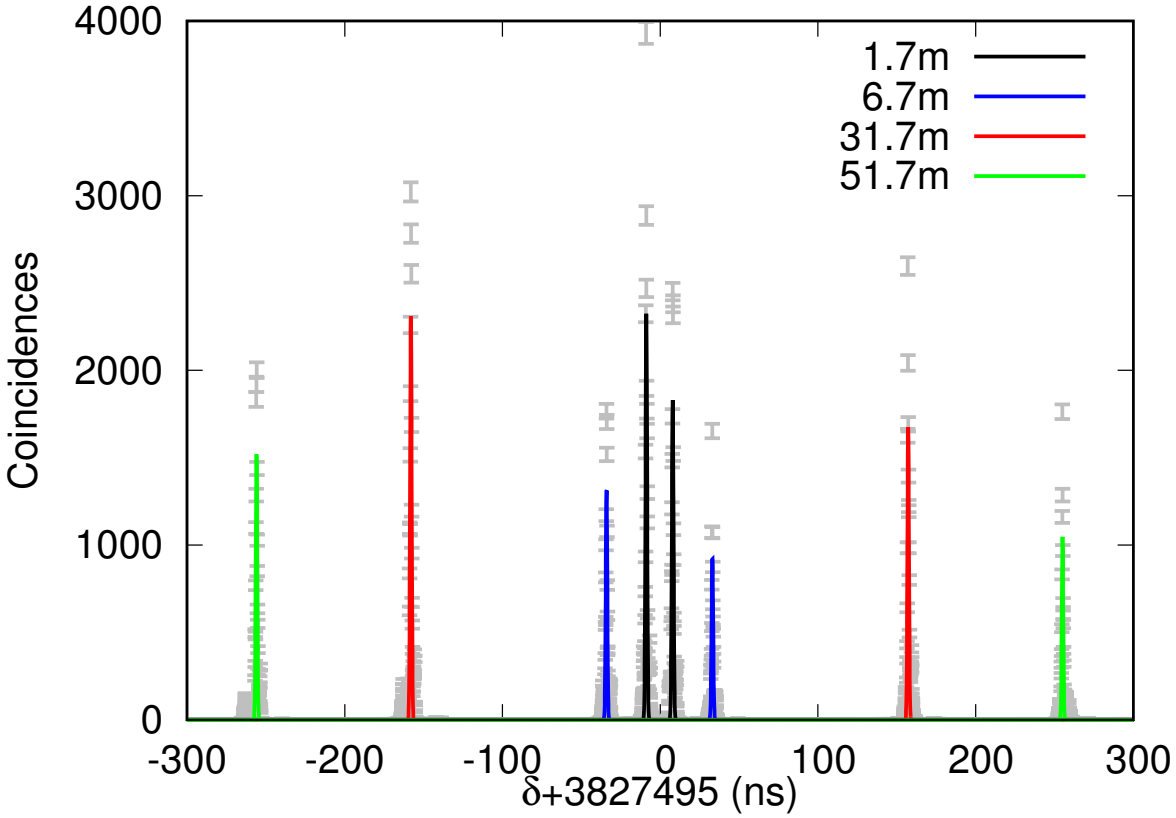

FIG. 2: Timing correlations of Alice and Bob's pair sources measured for various spatial separations L between them. For every L, a correlation measurement yields two coincidence peaks, one corresponding to each source. The time separation between peaks corresponds to twice the propagation time between the sources, the midpoint instead is the offset between the clocks. Solid line: Gaussian fit used to estimate the central position of each peak. Error bars: Poissonian standard deviation.