



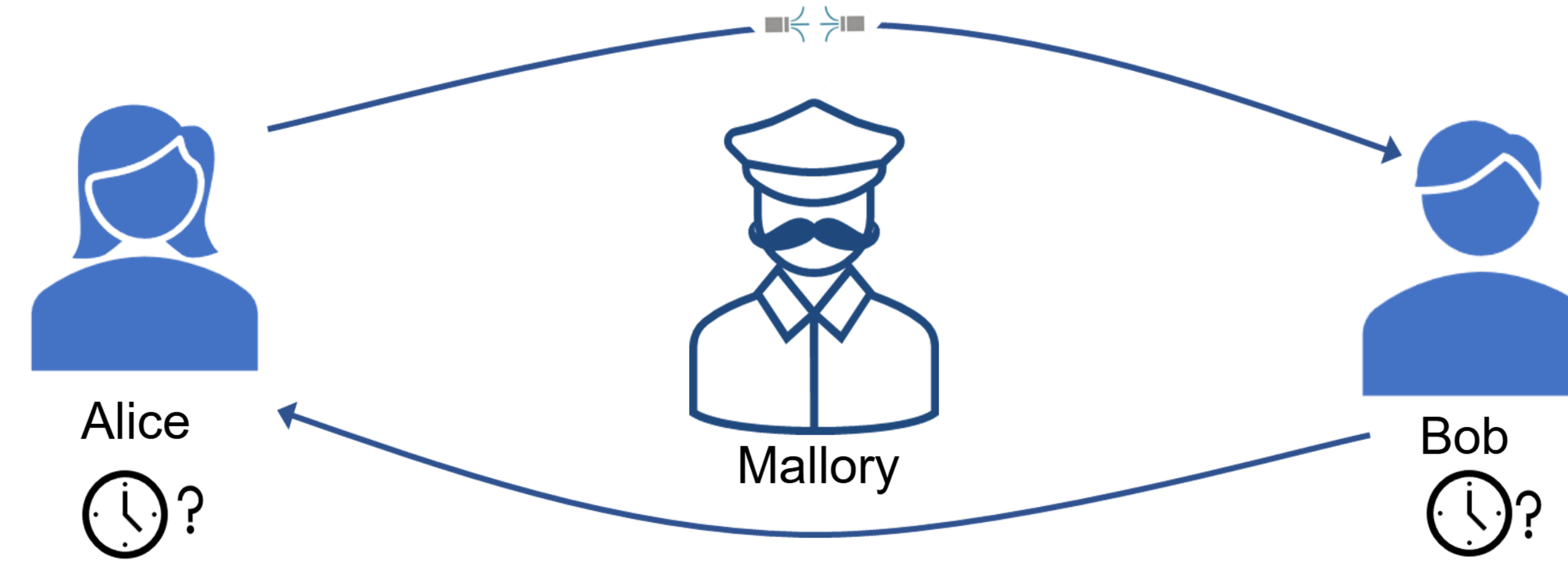
Clock synchronization security for asymmetric delay attacks

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Motivation

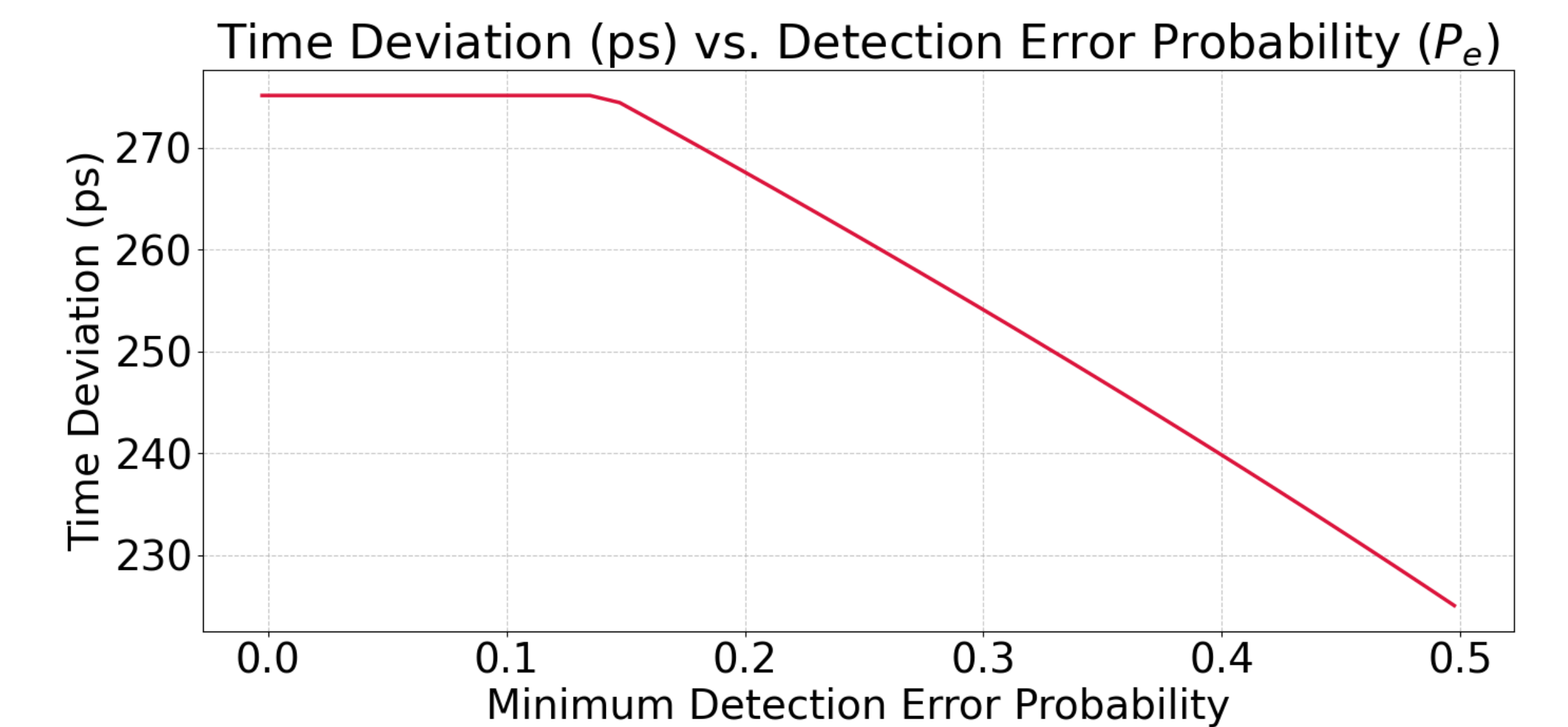
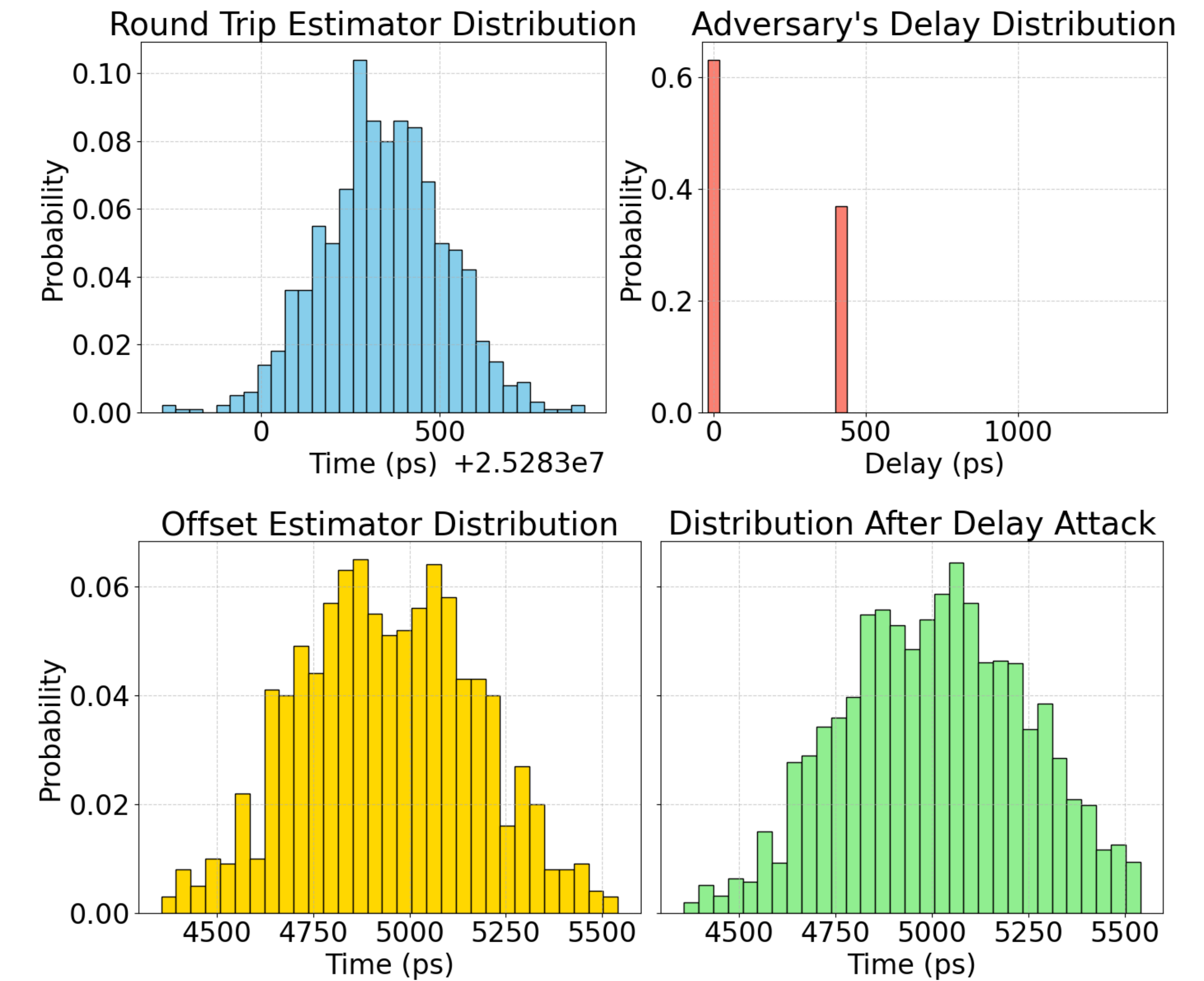
- High-precision clock synchronization required for numerous applications:
 - o communication systems [1],
 - o quantum cryptography [2],
 - o large-scale experiments [3], and more.
- Deployed fiber network schemes of interest, especially in GPS-denied environments.
- Covert attacks designed to disrupt users while adversary remains undetected.

Problem Setting



- Clock synchronization security well-studied [4].
- SPDC source signals cannot be spoofed reliably.
- Consider asymmetric delay attacks.

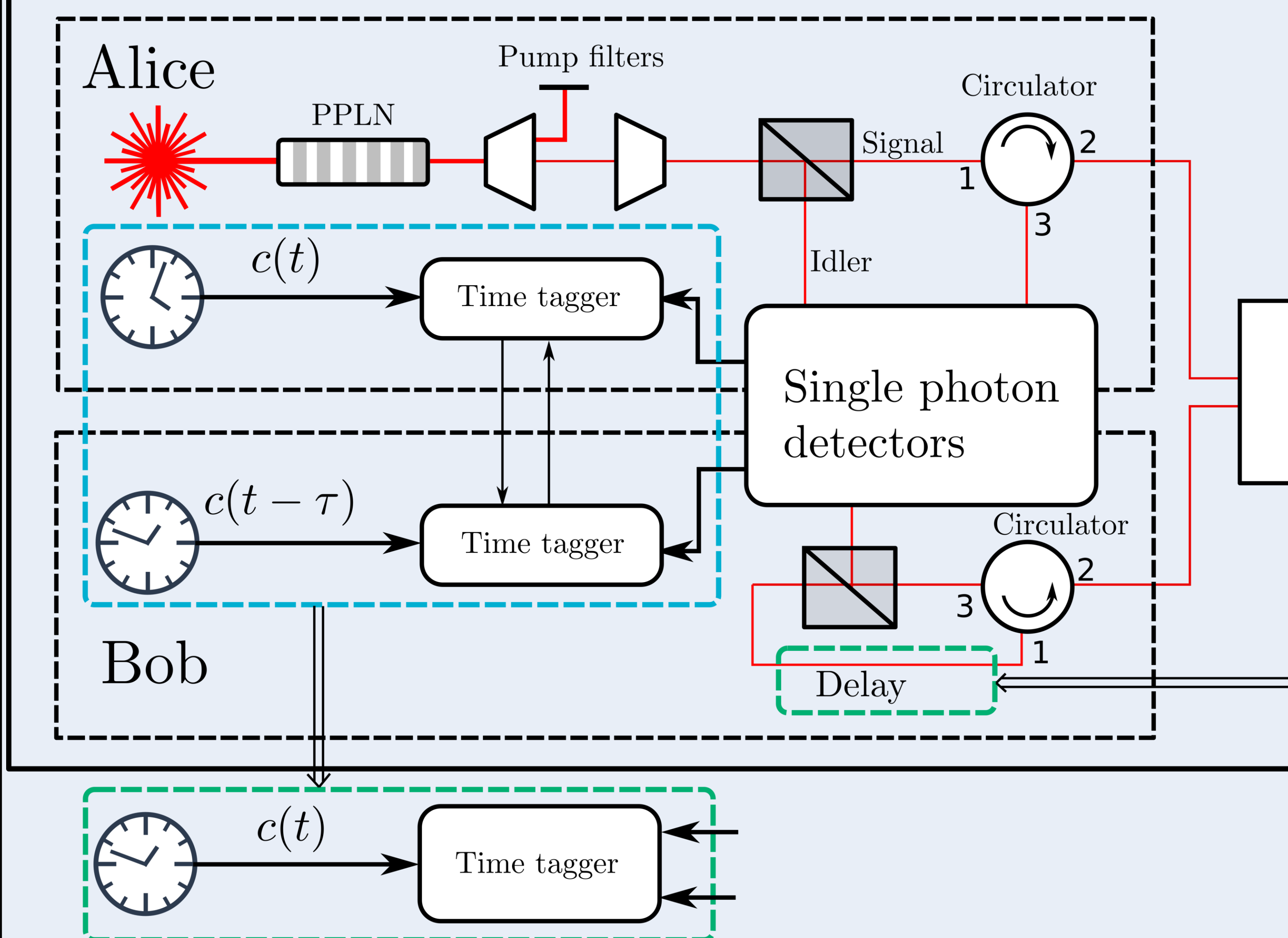
Results



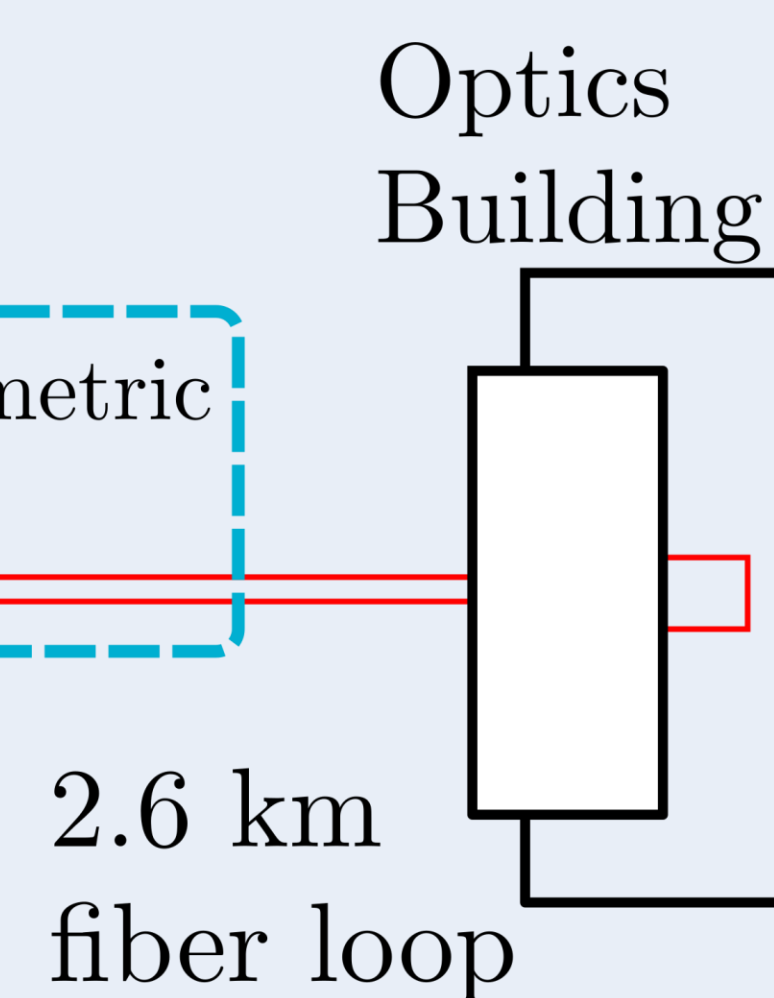
Method

- Experiment setup adapted from [5].
- Simulate asymmetric delays by inserting fiber of different lengths.

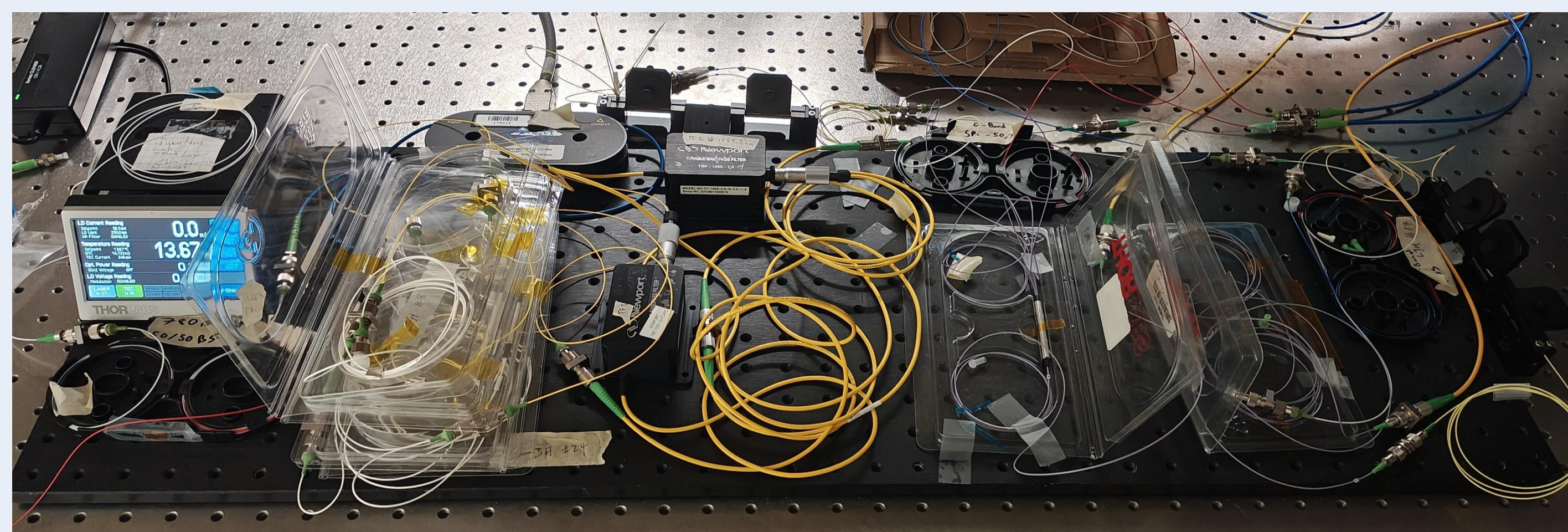
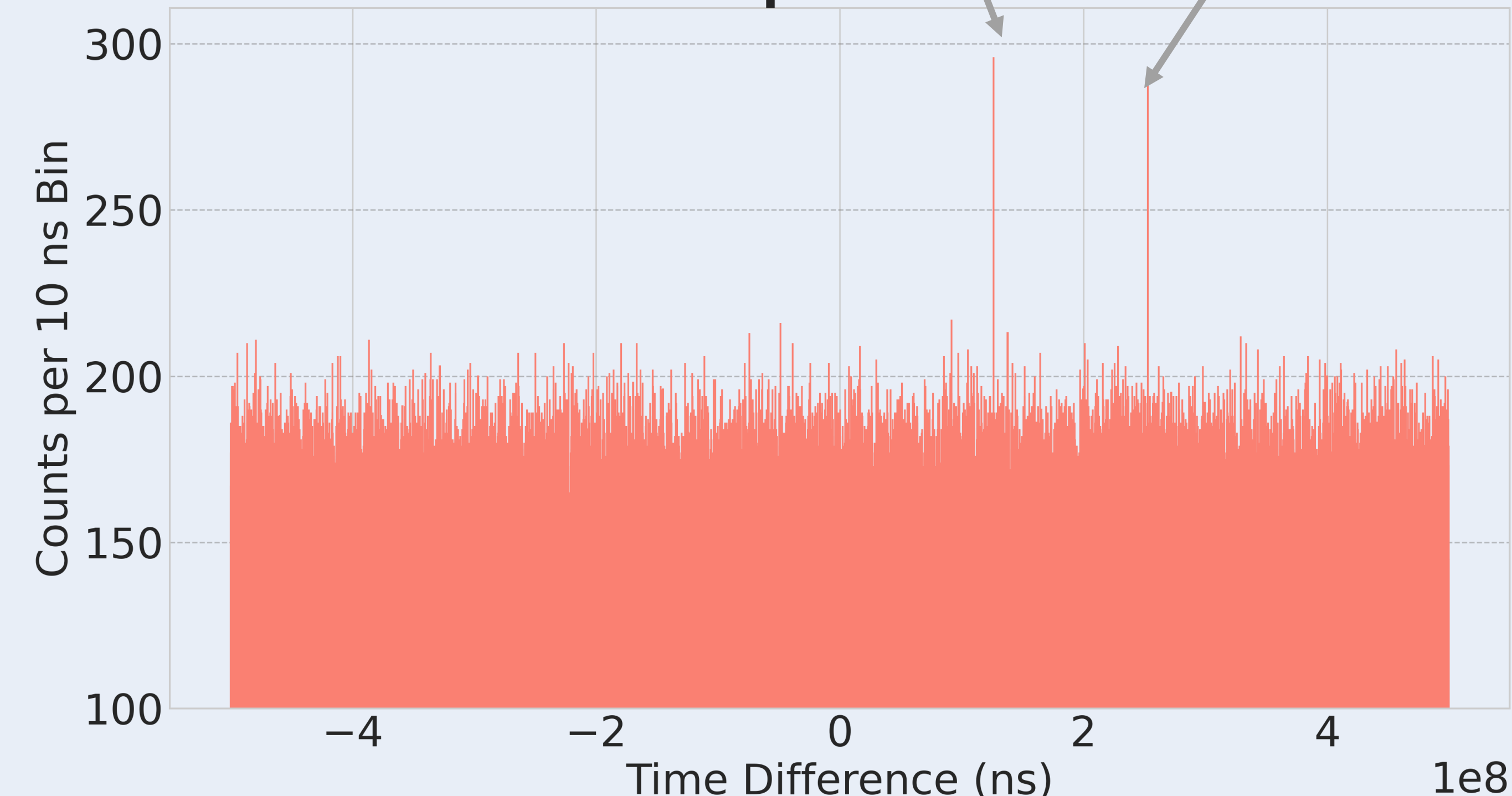
ECE Building



- Correlation between photo-detection events at Alice and Bob peaks at single-trip time, τ_{AB} .
- Autocorrelation on photo-detection events at Alice peaks at round-trip time, τ_{AA} .
- True offset is $\tau = \tau_{AB} - \frac{1}{2}\tau_{AA}$.



Cross-correlation Outputs



Future Work

- Investigating alternative detection strategies may uncover better guaranties on security.
- Exploration of other types of man-in-the-middle attacks including thermal noise injection and loss.

References

- [1] D. Chandramouli et al., "Evolution of Timing Services From 5G-A Toward 6G," in *IEEE Access*, vol. 11, pp. 35150-35157, 2023.
- [2] S. Pirandola et al., "Advances in Quantum Cryptography," *Adv. Opt. Photon.* 12, 1012-1236 (2020)
- [3] M. Xin et al., "Ultra-precise timing and synchronization for large-scale scientific instruments," *Optica* 5, 1564-1578 (2018)
- [4] L. Narula et al., "Requirements for Secure Clock Synchronization," in *IEEE J. Sel. Topics Signal Process.*, vol. 12, no. 4, pp. 749-762, Aug. 2018.
- [5] Jianwei Lee et al., "Absolute clock synchronization with a single time-correlated photon pair source over a 10 km optical fibre," *Opt. Express* 30, 18530-18538 (2022)

