NavIC-based Time Tagging System for Quantum Applications

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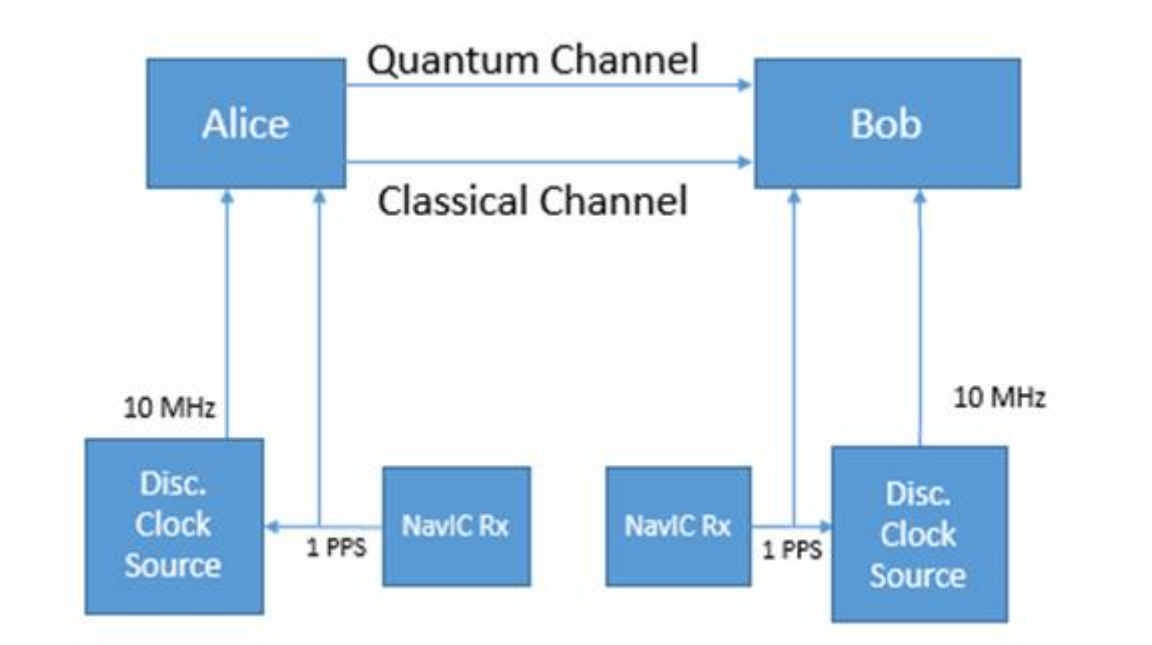
System Overview

- Precise Time-Tagging of Photon Events
- Synchronization and Absolute Timing using NavIC 1-PPS
- Time offset removal through minimum QBER search in Quantum Communication



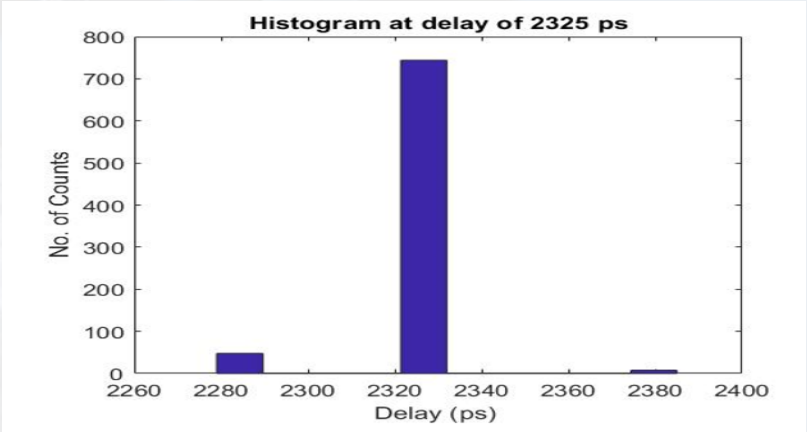
Time-Tagging

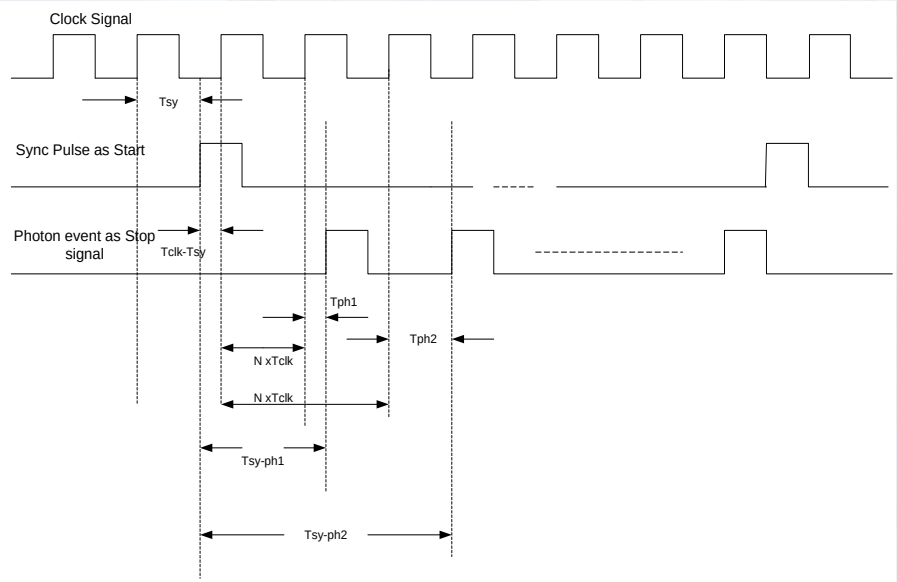
- Time difference between Sync pulse and first photon event,

$$T_{sy\text{-}ph1} = (T_{clk} - Tsy) + (N \times T_{clk}) + (T_{ph1})$$

- Time difference between Sync pulse and second photon event,

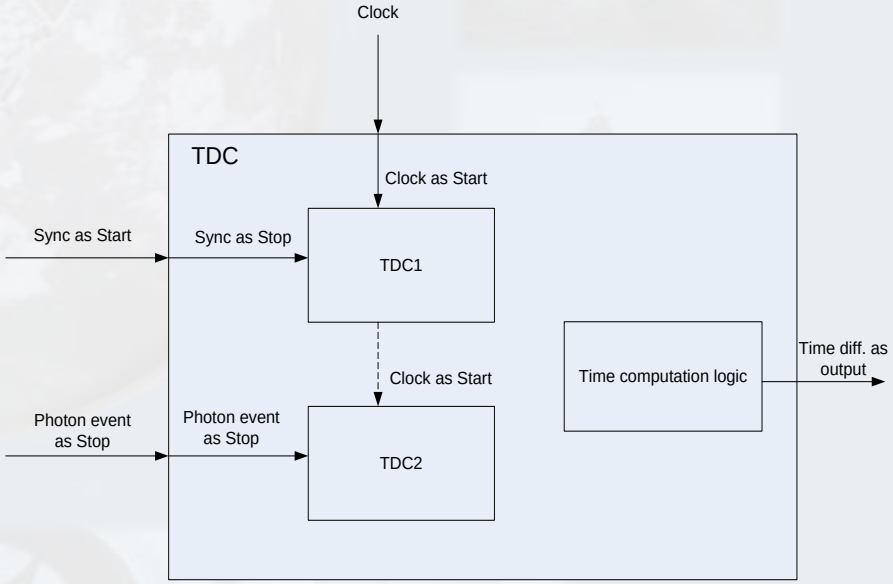
$$T_{sy\text{-}ph2} = (T_{clk} - Tsy) + (N \times T_{clk}) + (T_{ph2})$$





Timing-diagram

TDC Resolution: 50 ps

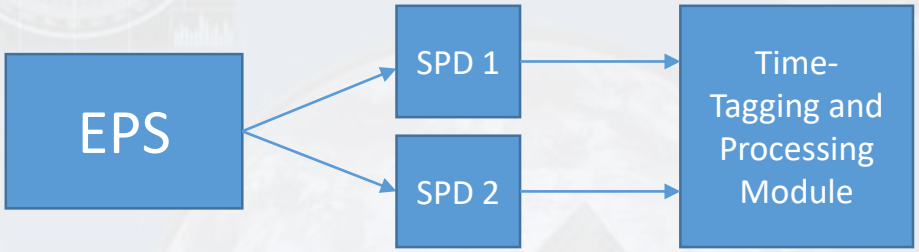


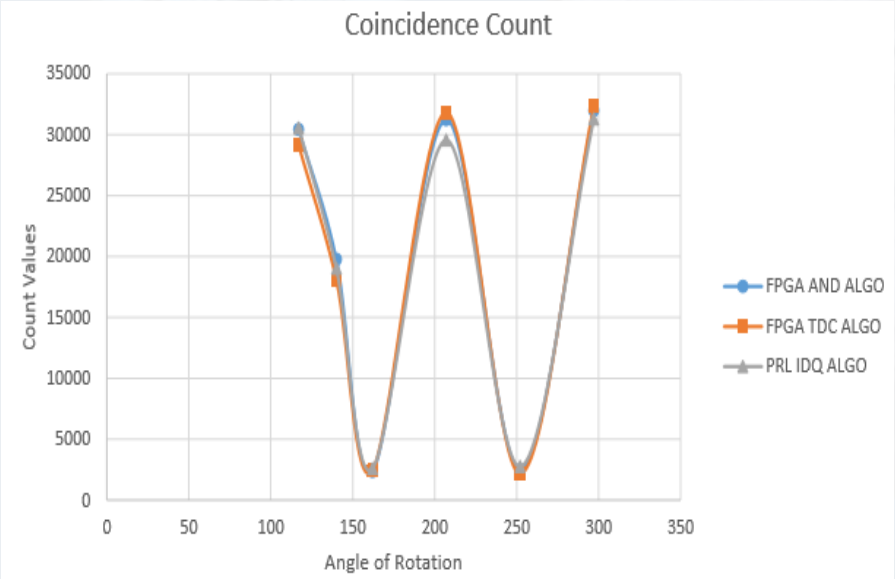
Block-diagram

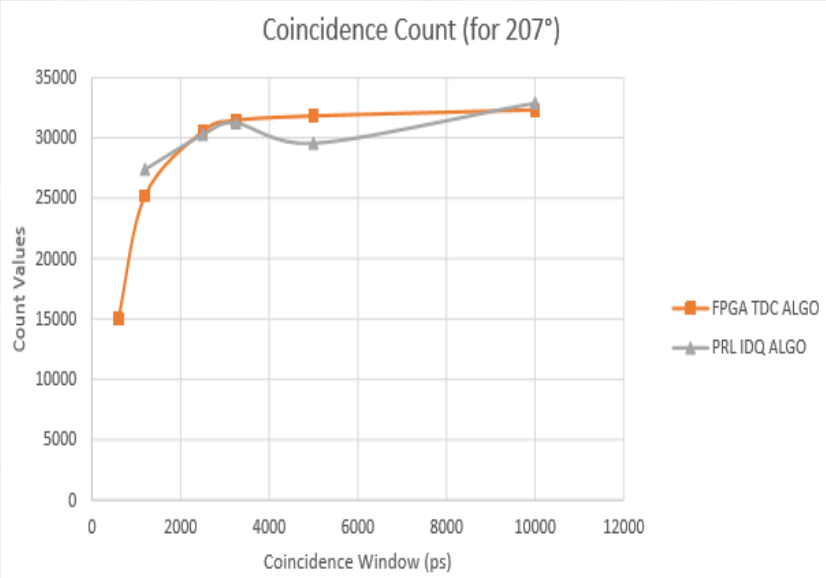
Time-Tagging Specifications

Sr. No.	Parameters	Specification
1	Resolution	50 ps
2	Reference Clock	200 MHz
3	Length of Delay Chain	5 ns
4	Min. time between two stop pulses $(T_{stop\text{-}stop})_{min}$	20 ns
5	Min. time from start to stop pulse $(T_{start\text{-}stop})_{min}$	> 0
6	Max. time from start to stop pulse $(T_{start\text{-}stop})_{max}$	Parametric Customizable with coarse counter bit-width
7	Min. pulse width	1 clock period (5 ns)
8	Start pulse frequency $(1/(T_{start\text{-}start}))$	20 MHz

Characterization with Entangled Photon Source







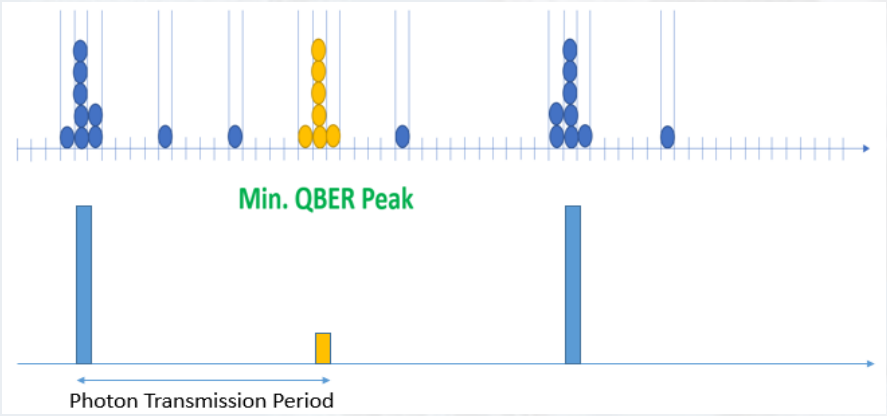
Ack: Physical Research Laboratory India for EPS

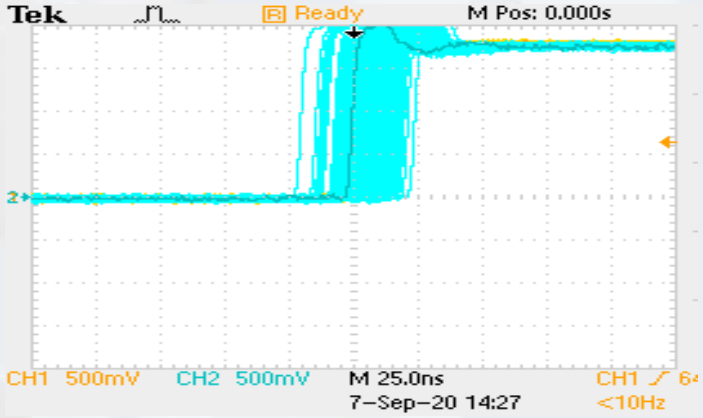
Synchronization

- NavIC/GNSS Receiver based Time Synchronization using Disciplined Clock Source giving +/- 25 ns time accuracy.

Histogram-based Minimum QBER Search

- Deployed Histogram-based minimum QBER search algorithm for final offset removal in time tags because of instantaneous 1-PPS inaccuracies.
- After deploying this, +/- 10 ns coincidence was achieved. Precise Time Tags based coincidence improvement is under evaluation.

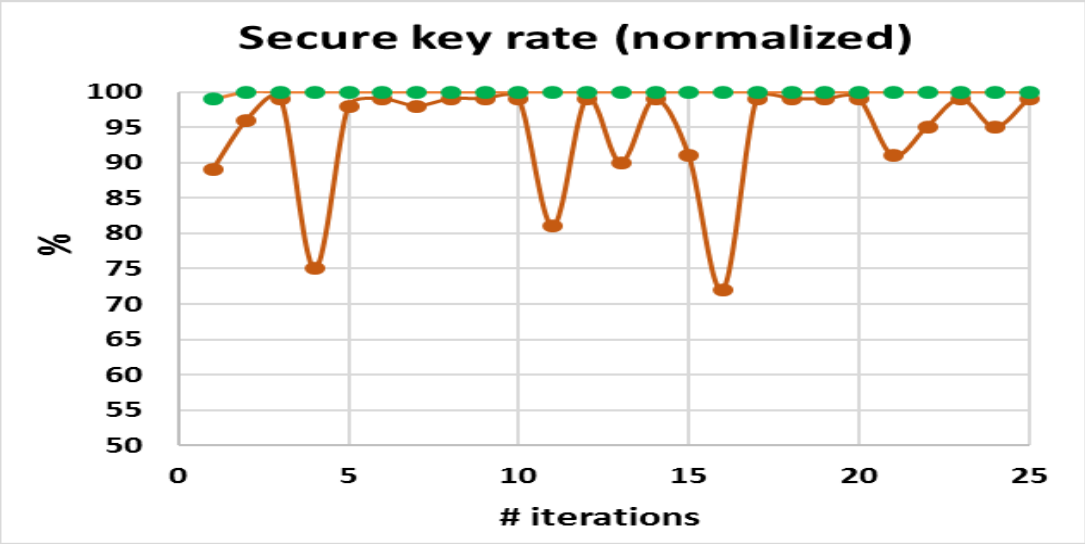




Synchronization

Nearest Neighbor Inclusion

- Deployed Nearest Neighbour Inclusion for handling frequency jitters giving the coincidence window of 20 ns. The 25% worst case reduction in key exchange rate was reduced to 0% using it with ~3% QBER.



Free-space Demonstration

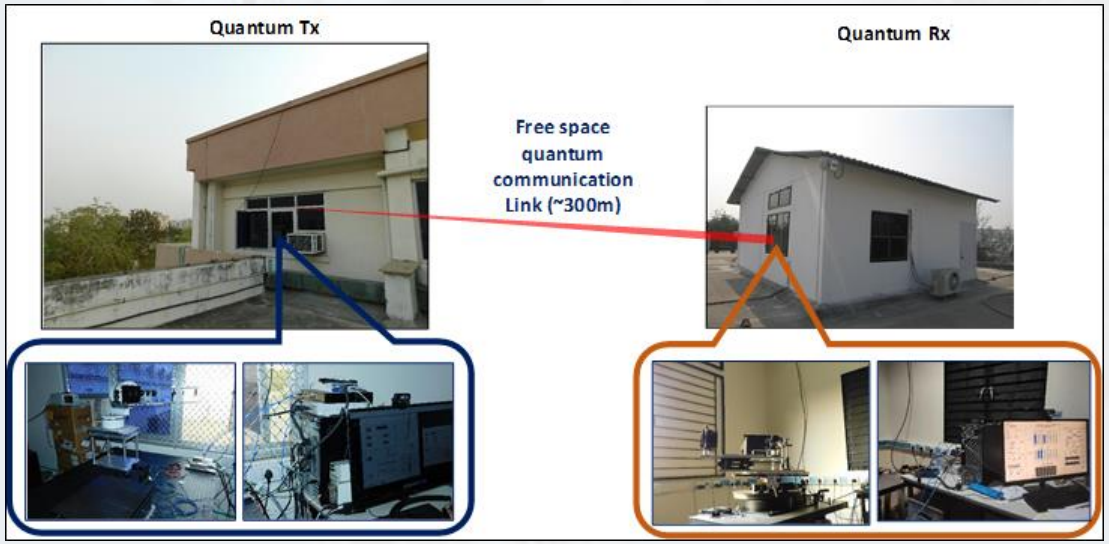
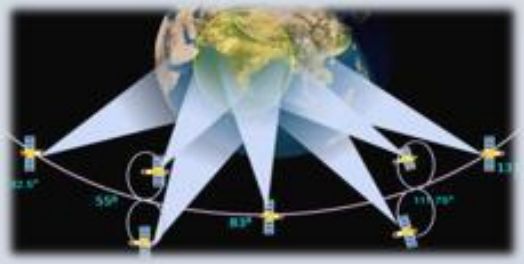


Fig. Coarse alignment b/w Quantum Tx and quantum Rx using visible beacon laser

Ack: SatCom and Navigation Payloads Area, SAC Ahmedabad








Thank You