# *Towards QEYSSAt: Free-space quantum key distribution to a moving receiver*

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Quantum key distribution (QKD) utilizes fundamental principles of quantum mechanics to establish provably secure communications between two parties. However, technological realities limit terrestrial implementations to distances of only a few hundred kilometers. One promising solution is the use of low-Earth-orbit satellites as nodes in a global-scale quantum communications network. We are pursing the development of a quantum communication payload onboard a satellite with the Canadian Space Agnecy and relevant industry. The mission proposal is called QEYSSAt (Quantum Encryption and Science Satellite), and  is currently in the selection review as a possible microsatellite mission. The QEYSSat payload includes an optical receiver for single photons, which will analyze the polarizations of individual photons, and record their arrival times with 100 ps timing resolution. We have performed feasibility studies on the theoretical link performance [1], as well as prototyping of payload components with space suitable hardware, with relevant tests in the laboratory environment. Towards outdoor, and long-distance demonstrations of the concept, recent demonstrations have performed QKD from moving transmitters [2, 3], but thus far, no QKD has been reported with platforms traveling at angular speeds equivalent to the maximum expected of a 600 km altitude satellite, nor to a moving receiver platform.

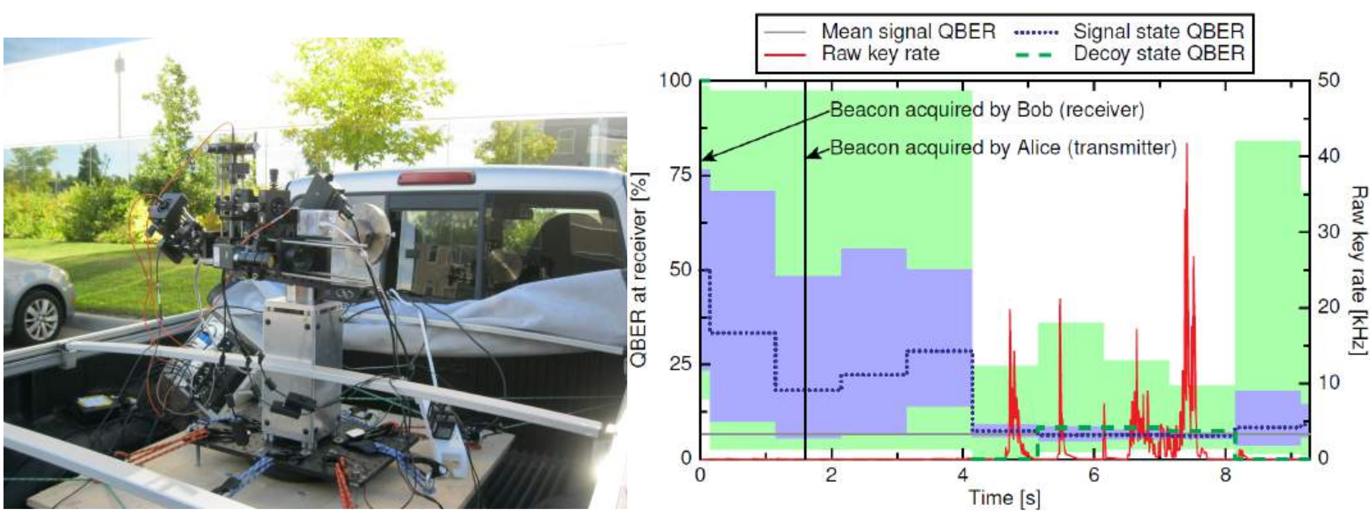


**Figure 1: (left) Photo of the quantum key distribution receiver installed on the back of the pickup truck. The system is motorized with active velocity tracking using two-way beacon lasers. (right) QBER and photon count rate measured at the receiver during the measurement run. The horizontal gray line represents the mean signal QBER of the data selected for the QKD protocol (6.55%). The shaded regions around the QBERs correspond to a 95% central credible interval. The QBER drops when the count rate increases at 4-8 s. The large range of the credible interval of the decoy QBER is due to the low number of measured decoy states, with results near the beginning absent as no decoy states were measured at those times. The measured values are taken with a 0.16 ns coincidence window, with the QBER measured on a per second basis and the counts measured on a 2 ms basis.**

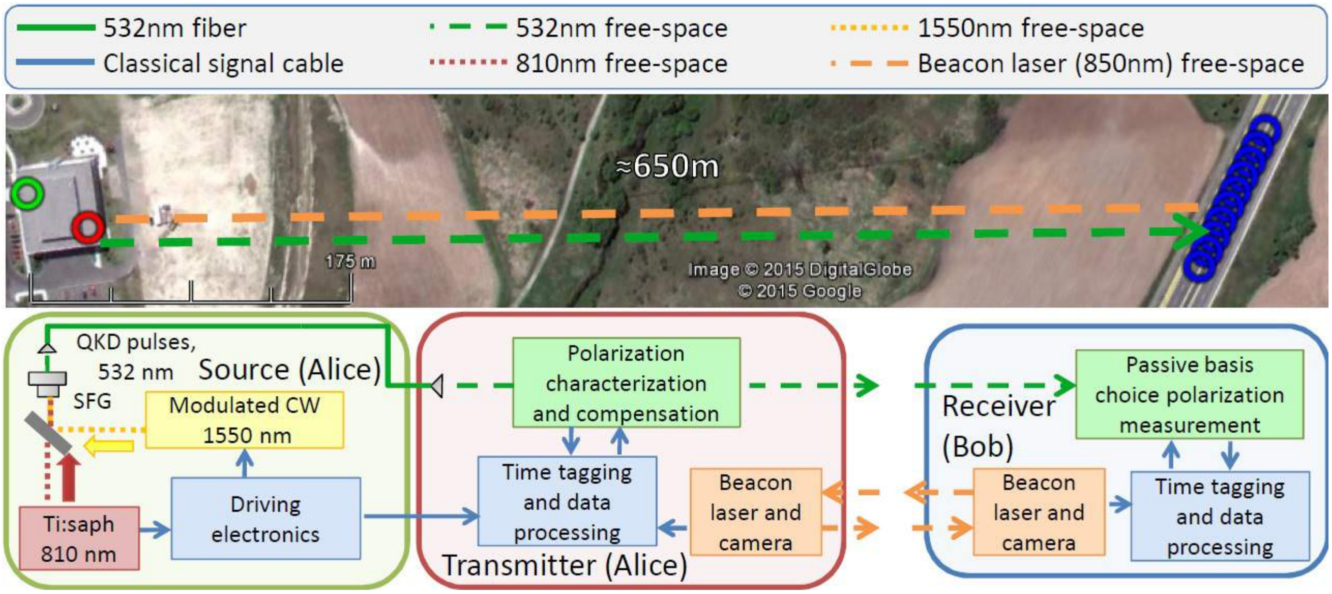


**Figure 2: Schematic overview of the experimental setup with map showing the location of Alice, consisting of the source (green circle) and transmitter (red circle), and the section of the road that Bob, located on the truck, traveled (blue circle , one per second) during the moving receiver tests. Signals from the source (located in the laboratory on the ground floor of the building) are sent to the transmitter using an optical fiber. An active laser beacon-tracking pointing system is used to maintain the free-space link while the truck is traveling, and a wireless local area network (WLAN) is used for classical communications. The length of the road traveled during the test was 80 m. Map data: Google,**

Here we will provide an brief overview of the proposed QEYSSat mission, and show our recent advances in prototyping and radiation testing of hardware. We then present our accomplishment of performing QKD establishment from a stationary transmitter to a truck 650 m away, traveling at 33 km/h, exceeding the maximum angular speed of a 600 km altitude satellite, and extracting a secure key of 160 bits [4]. Amongst several technical hurdles that were overcome, we implemented a timing correlation algorithm to account for the path length variation between Alice's and Bob's locations, and achieved about 1 nanosecond relative timing precision. We also implement a real time polarization compensation system at the transmitter, allowing the system to compensate any phase or rotations induced within the optical fiber linking our source - on the ground floor lab - to our transmitter - on the roof. Our results show the first quantum key distribution to a moving receiver platform, and are an important step towards implementations of satellite quantum receivers.

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[2] S. Nauerth, F. Moll, M. Rau, C. Fuchs, J. Horwath, S. Frick and H. Weinfurter 2013 *Nature Photonics* 7 382386
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[4] J.-P. Bourgoin, B. L. Higgins, N. Gigov, C. Holloway, C. J. Pugh, S. Kaiser, M. Cranmer and T. Jennewein