STEVENS
INSTITUTE of TECHNOLOGY
THE INNOVATION UNIVERSITY®

Quantum-secured data processing and networking

- Quantum Campus Project at Stevens

Yuping Huang
Associate Professor
Department of Physics
Founding Director
Center for Quantum Science and Engineering
Stevens Institute of Technology

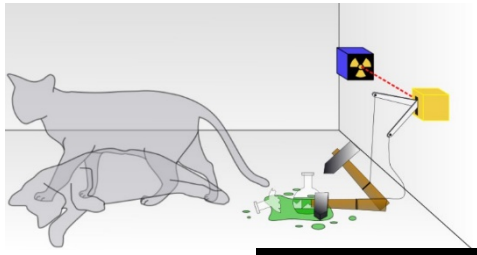
What is Quantum

The most accurate and tested theory towards the Mother Nature

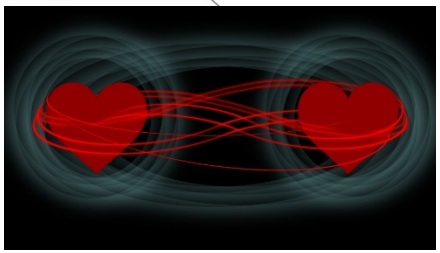
- Newton's laws are approximation results
- Einstein did not believe it ("God does not play dice")
- Experimentally verified again and again
- Plants are exploiting quantum effects (i.e., photosynthesis)
- We have quantum sensors (i.e., smell, vision?)

Quantum is "odd"

- Superposition



- Entanglement



- Measurement Postulates

  The quantum wave-function of a quantum object will **RANDOMLY** collapse to one of the eigenstates of the measurement apparatuses according to the inherent quantum statistics.

Why Quantum

To revolutionize many sectors of our society:

- Sensing
- Metrology
- Imaging
- Computing
- Network
- Data analytics

....

In this talk, two projects at Stevens:

Quantum random number generator

- Trusted, randomness derived from the laws of physics
- Programmable, tailored probability density
- Verifiable, not relying on the statistic tests
- Cost effective

Quantum Communication Network

- Absolute security (eavesdropping proof)
- Versatile
- Compatible (existing fiber and free-space infrastructure)

Quantum Random Number Generation

Importance: encryption, simulation, financial analytics, optimization

…

Classical Approaches:

- Measure the outcome of "unpredictable" events
  - Flip a coin
  - Roll a die
- Use a mathematical algorithm

Serious Problem

- "Pseudo" random
  - seemingly random because of our ignorance
  - random at small scale
- Biased / repeat after some point
- Manipulated by adversarial parties

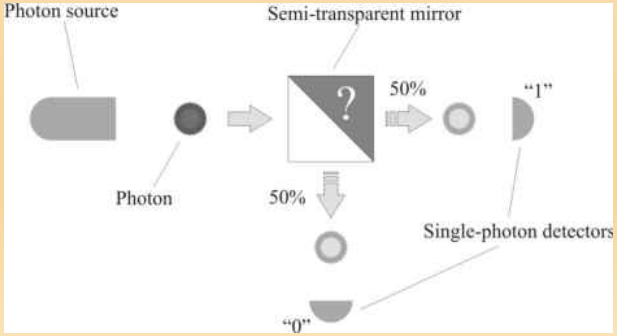
Quantum Approaches:

- Measure the outcome of stochastic quantum processes

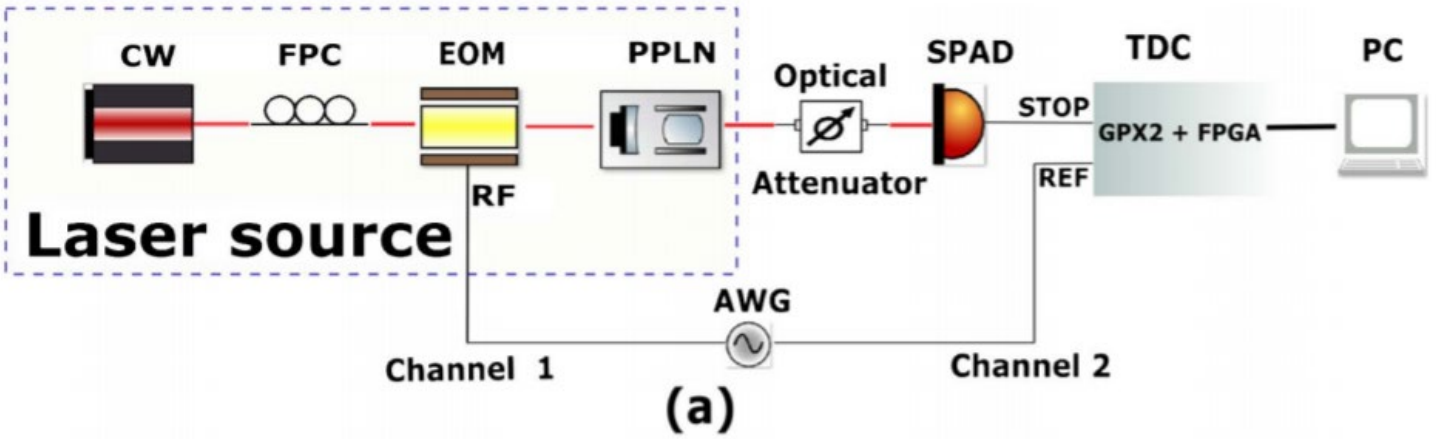
Advantage

Genuine randomness

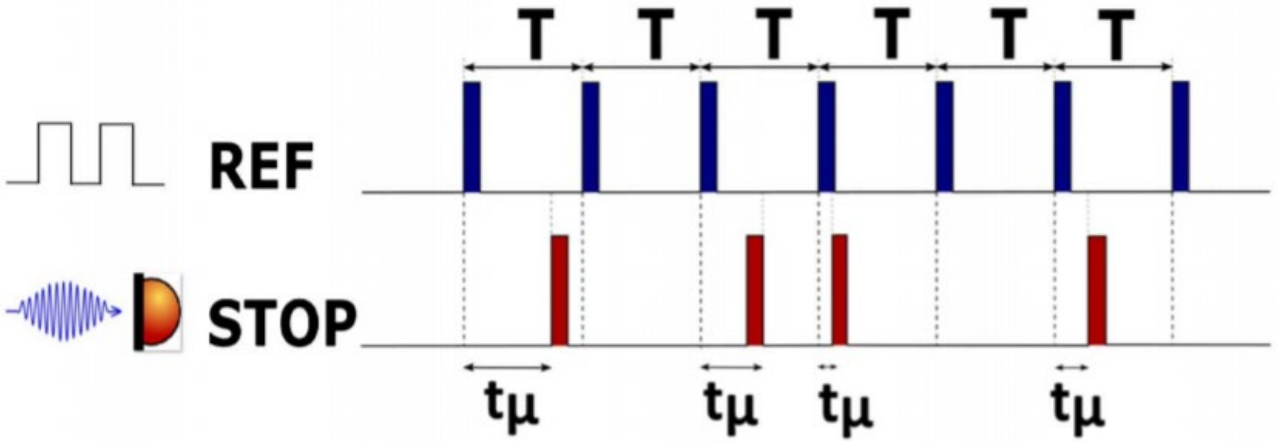
- Processes are inherently random.
- Randomness guaranteed by physics, e.g., Heisenberg uncertainty



Programmable quantum random number generator without post-processing

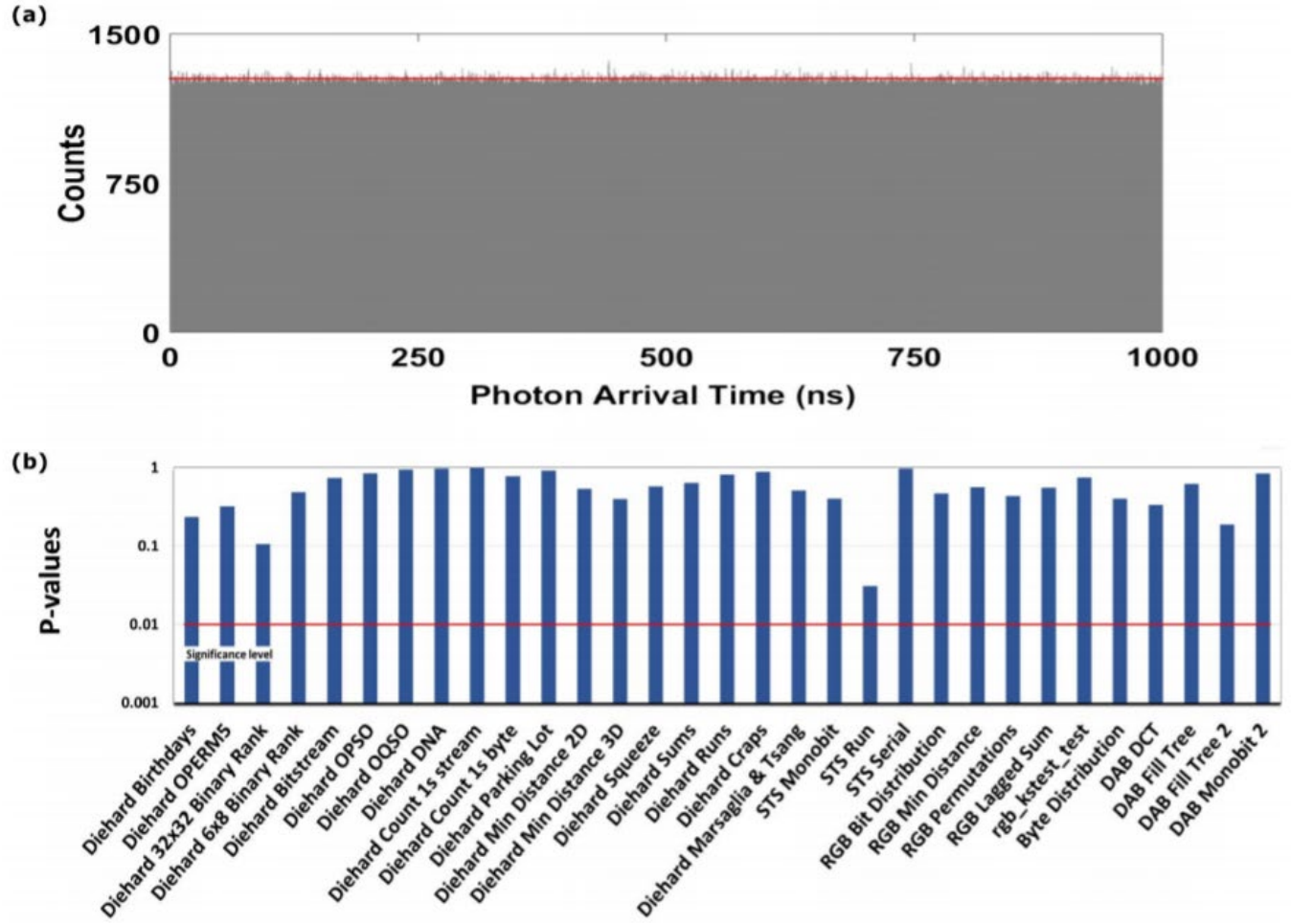


(a)

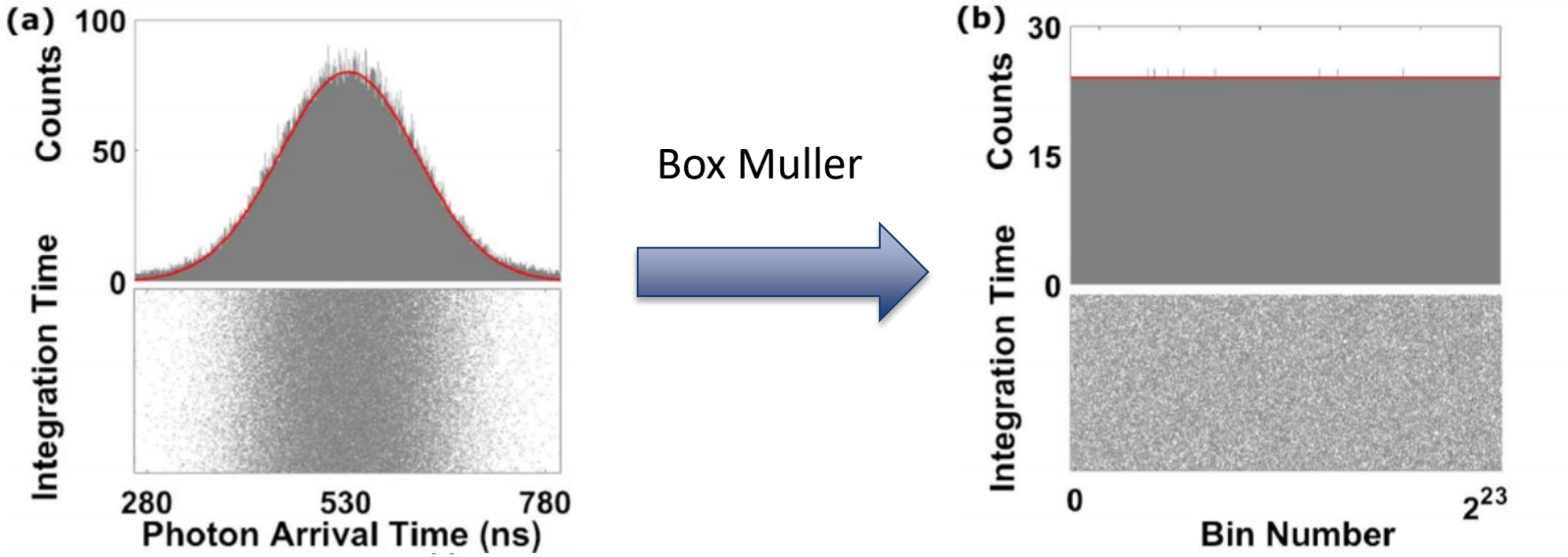


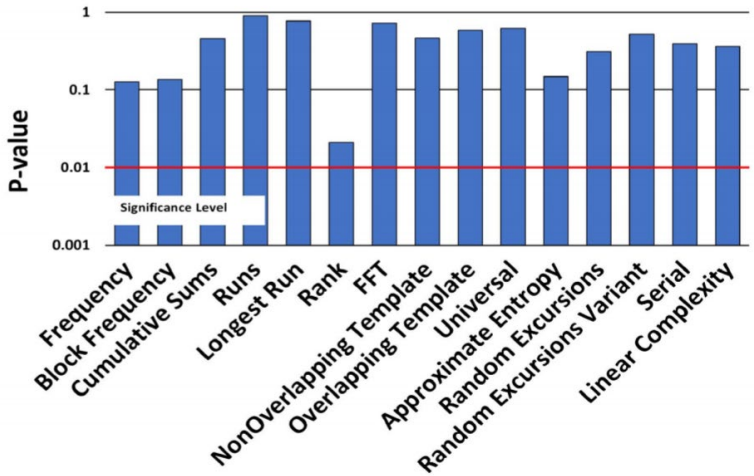
(b)

Programmable quantum random number generator without post-processing

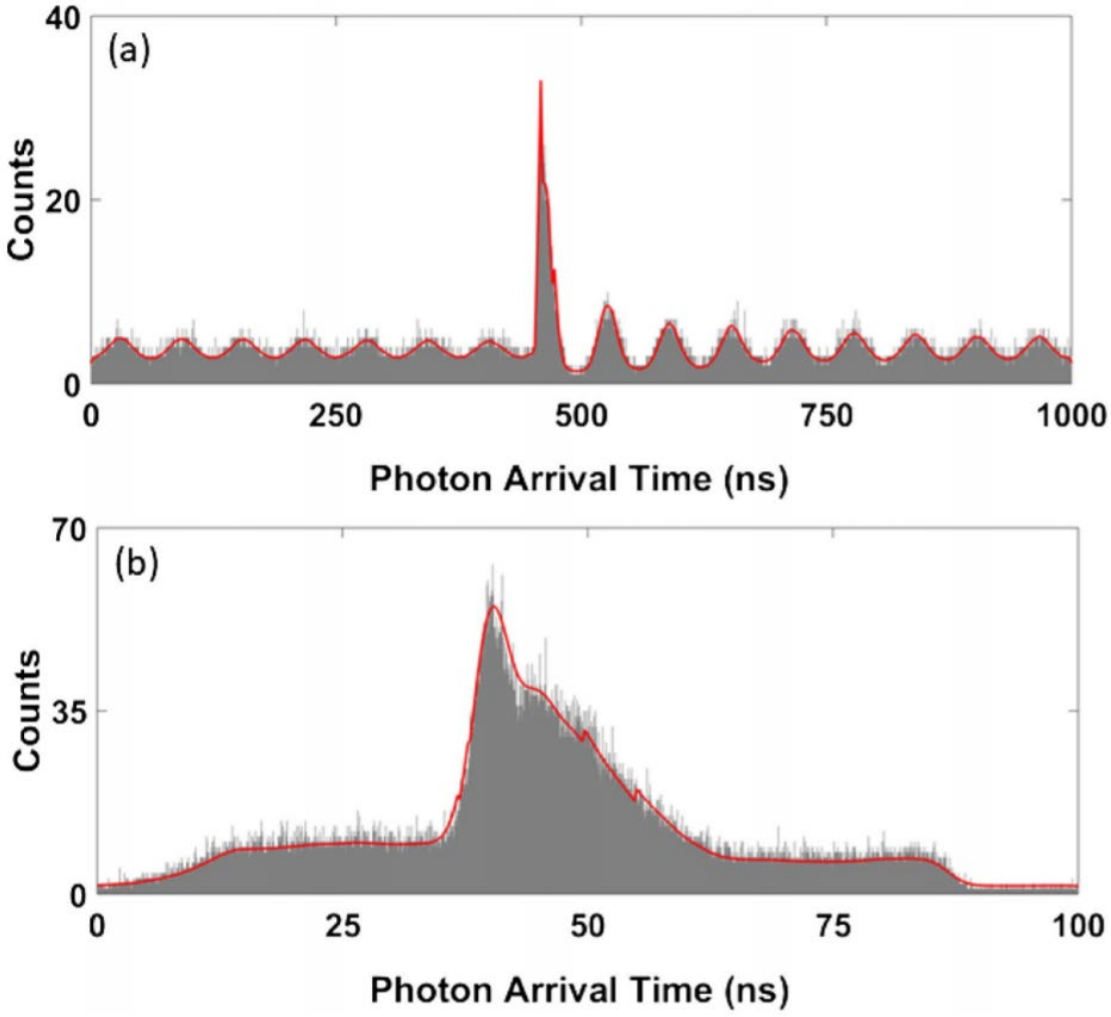


Programmable quantum random number generator without post-processing



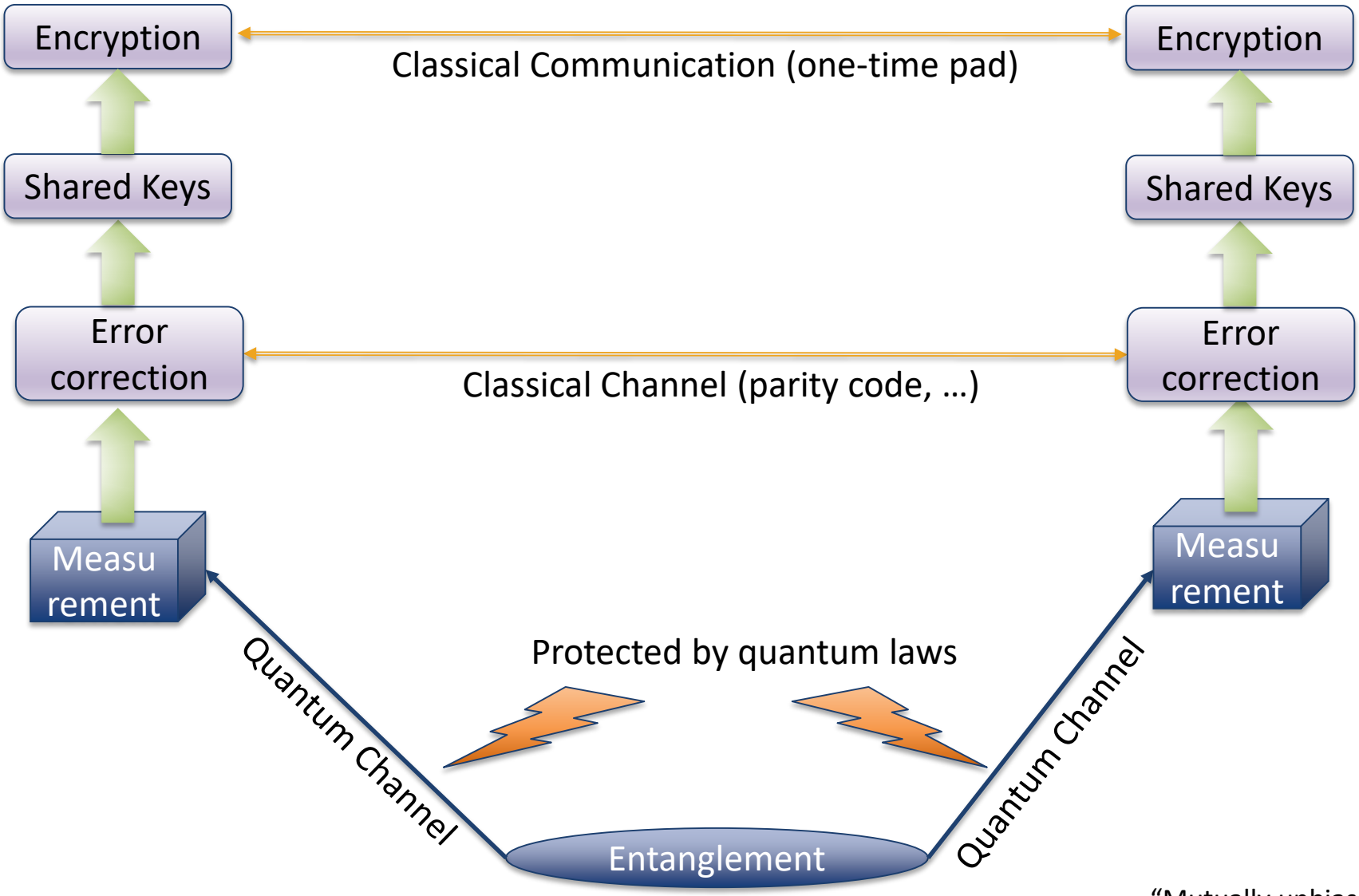


Programmable quantum random number generator without post-processing



Quantum Decision App

Quantum communication Network



"Mutually unbiased bases"

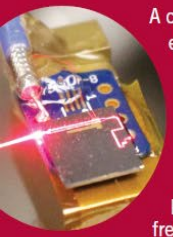
Quantum Campus at Stevens

quantum network, quantum corner, quantum sensing, quantum Internet of Things…

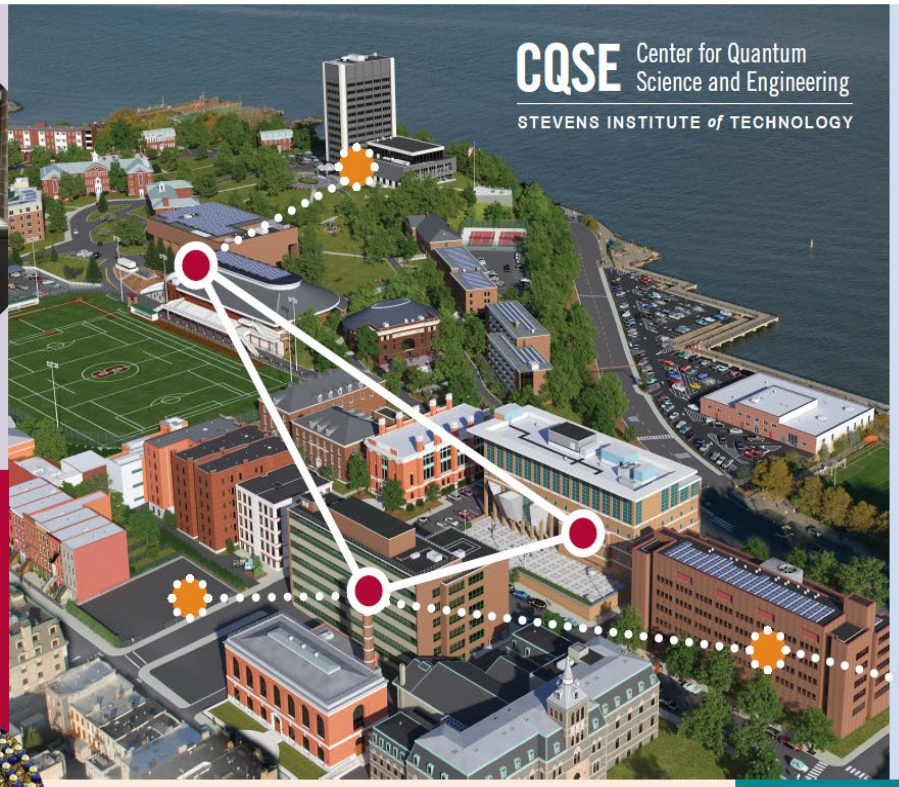
QUANTUM CORNER

The Quantum Corner in Williams Library features a quantum receiver hosted in a transparent enclosure, a messaging terminal based on quantum technology and educational materials on quantum physics and technology. This open quantum platform gives the public hands-on access to quantum technology, and inspires students to join the quantum workforce.

QUANTUM CHIPS



A central part of our interdisciplinary effort is to develop low-loss, high-efficiency, functional quantum chips capable of complex quantum functionalities. Thus far, we have developed a lithium niobate nanophotonic platform for quantum frequency conversion, all-optical switching, entanglement generation, photon modulation, and their integration. We have also developed single-photon sources from defects in 2D materials, which could form the basis for the future scalable quantum technology on chip.



NSF GRANTS

NATIONAL SCIENCE FOUNDATION/ECCS #1521424: "OP: Collaborative Research: Quantum Zeno Photonics on Chip," Yuping Huang (PI)

NATIONAL SCIENCE FOUNDATION/EFMA #1641094: "EFRI ACQUIRE: Development of Heterogeneous Platform for Chip-Based Quantum Information Applications." Yuping Huang, Stefan Strauf (co-PI)

NATIONAL SCIENCE FOUNDATION/ECCS #1842680: "RAISE-EQuIP: A Chip-Integrated Platform for Photon-Efficient Quantum Communications," Yuping Huang (PI)

NATIONAL SCIENCE FOUNDATION/ECCS # 1531237: "MRI: Acquisition of cryogen-free low-temperature scanning-probe spectroscopy system for nanophotonic and nanoelectronic device characterization," Stefan Strauf (PI), Yuping Huang (co-PI)

NATIONAL SCIENCE FOUNDATION/PHY #1806523: "Collaborative Research: Parity-Time Symmetry and Anti-Symmetry in Quantum Optics" Yuping Huang (PI)

Office of Naval Research #N00014-15-1-2393: "Persistent Maritime Quantum Key Distribution," Yuping Huang (PI)

EOIR Technologies: "Innovation Systems Based Photonic Research for Military Applications," Phase I & II, Yuping Huang (PI).

NSF/DMR #1809235: "Collaborative Research: Plasmonic lasing with two-dimensional heterostructures in the intrinsic regime," Stefan Strauf (PI)

NSF/DMR #1506711: "Collaborative Research: Cavity-Enhanced Exciton Emission from Carbon Nanotubes in the Intrinsic Regime," Stefan Strauf (PI)

NSF/ECCS #1842612: "RAISE-EQuIP: Integrated Higher-Dimensional Quantum Photonic Platform," Stefan Strauf (co-PI)

STEVENS QUANTUM CAMPUS

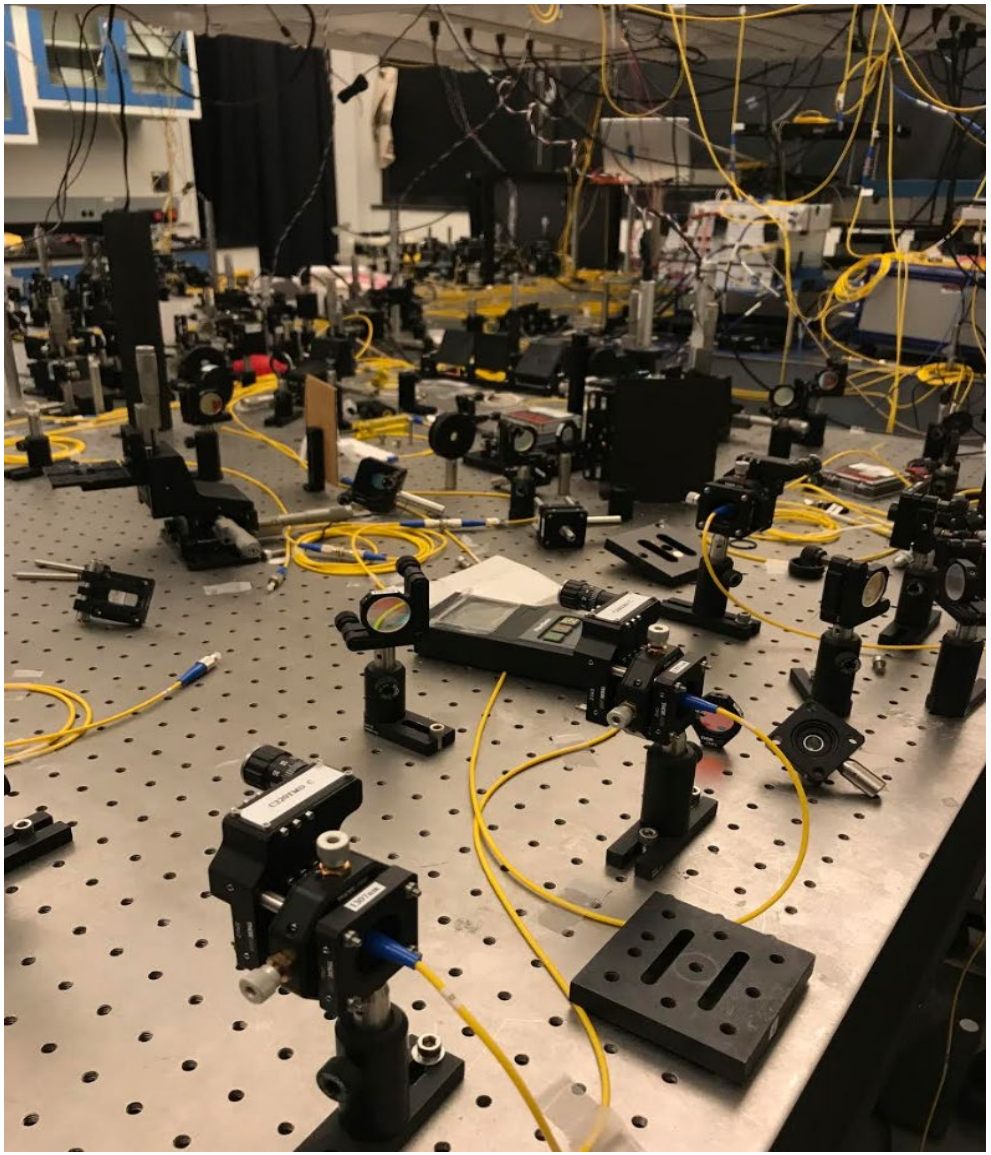
The Stevens Quantum Campus project promotes innovative quantum engineering and technology through carefully structured synergy among faculty and students across disparate disciplines. The Stevens Quantum Campus provides a multiscale testbed for:

- Analyzing and testing new quantum devices and techniques.
- Identifying and addressing critical challenges facing quantum technology transition.
- Stimulating system engineering research on complex quantum networks.
- Bridging quantum research with industrial R&D, and facilitating entrepreneurship and technology commercialization.
- Creating broader impact and promoting Stevens to be a world's topmost institute in quantum engineering, where students enjoy access to and take part in creating transformative technologies of tomorrow.

PROGRAMMABLE QUANTUM RANDOM NUMBER GENERATION AND SIMULATION

Stevens has developed a quantum random number generator that is post-processing free and can directly produce arbitrary, user-defined chaotic statistics. It has been applied to big data simulation to demonstrate significant advantage. To promote broader impact, we have also developed a "Quantum Decision" App for iPhone and Android that gives the public free access to quantum technology; download with the QR code to the right.

Where we were…




100%
HUMAN