

Center for Quantum Networks

NSF Engineering Research Center

CQN Integration

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Deputy Director & Co-PI / Co-Director & PI

Professor of EECS MIT

Professor, SPIE Endowed Chair, Optical Sciences, University of Arizona



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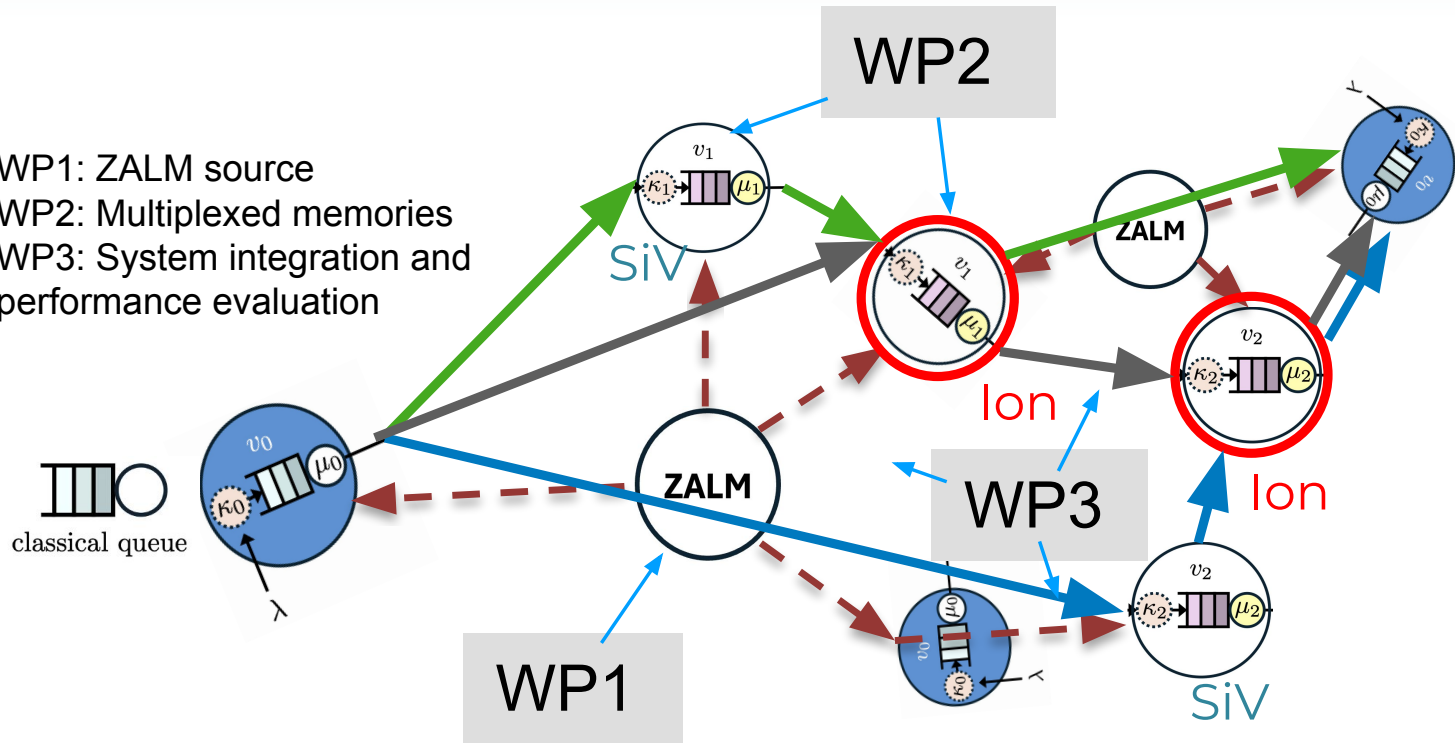
CQN Architecture

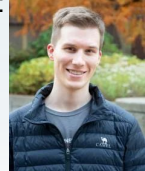
Work packages serve as integration tools

WP1: ZALM source

WP2: Multiplexed memories

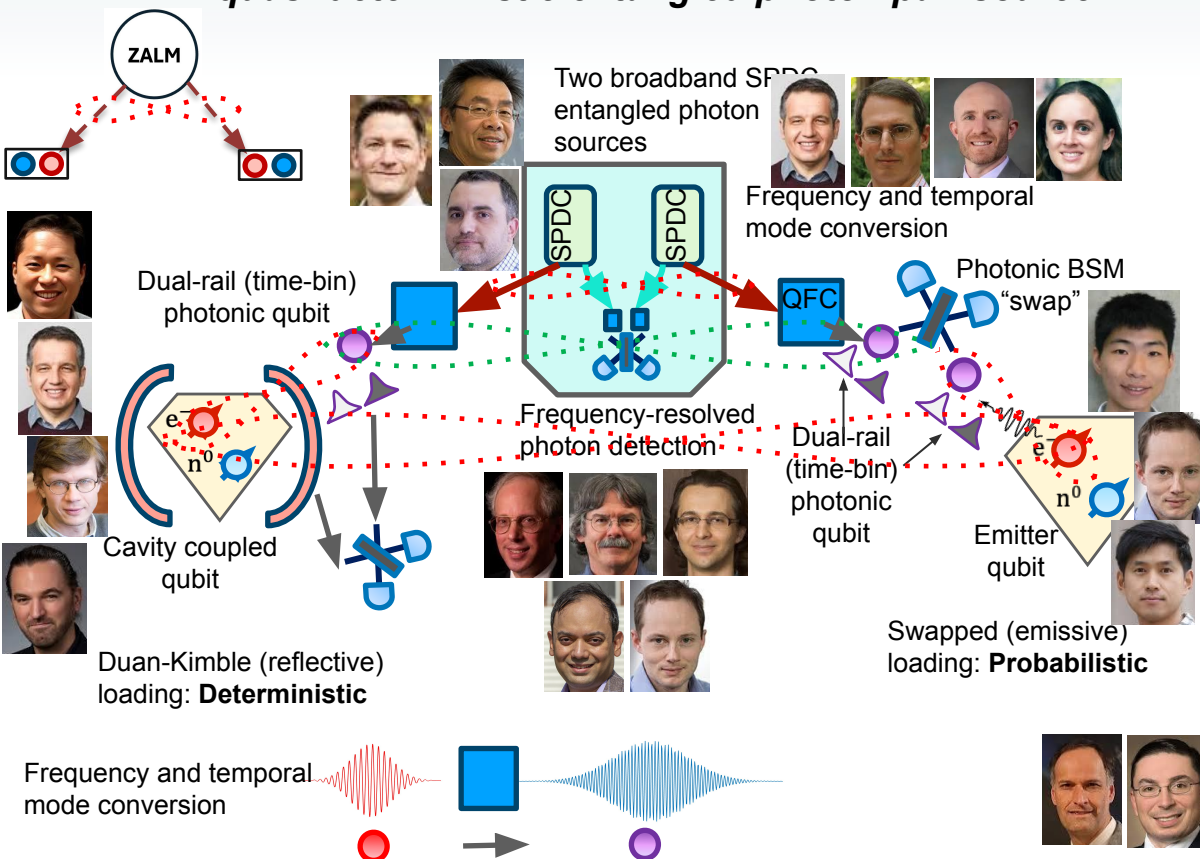
WP3: System integration and
performance evaluation





Zero-Added-Loss Multiplexing (ZALM): WP1

A quasi-deterministic entangled photon pair source



Original Proposal (theory and experiment):

- [NASA] Dhara et al., Heralded Multiplexed High-Efficiency Cascaded Source of Dual-Rail Entangled Photon Pairs Using Spontaneous Parametric Down-Conversion, Phys. Rev. Applied 17, 034071 (2022)
- Mercouche et al., Phys. Rev. Lett. 128, 063602 (2022)
- Chen et al., Zero-Added-Loss Entangled-Photon Multiplexing for Ground- and Space-Based Quantum Networks, Phys. Rev. Applied 19, 054029 (2023)

Improved architectures and memory-loading:

- Shapiro et al., Entanglement source and quantum memory analysis for zero-added-loss multiplexing, Phys. Rev. Applied 22, 044014 (2024); arXiv:2507.14427
- Raymer et al., Phys. Rev. Applied 22, 044013 (2024)
- [NASA] Chahine et al., Heralded entanglement source analysis for cascaded parametric down-conversion, QW3A.17 Quantum 2.0 (QUANTUM) 2025

Analysis within network architectures:

- [C2C] Campbell et al., Entanglement distribution through separable states via a zero-added-loss photon multiplexing inspired protocol, Phys. Rev. Research 6, 033317 (2024)
- [C2C/IPP] Bali et al., ICC 2024 - IEEE International Conference on Communications, Denver CO (2024)





Multiplexed Quantum Memories: WP2

Scalable platforms: 1. thousands (ions) to **millions** (SiVs) individually addressable qubits, 2. **efficient qubit-photon interface**, 3. high-fidelity **quantum logic**

Reconfigurable photonic integrated waveguides coupled to color centers

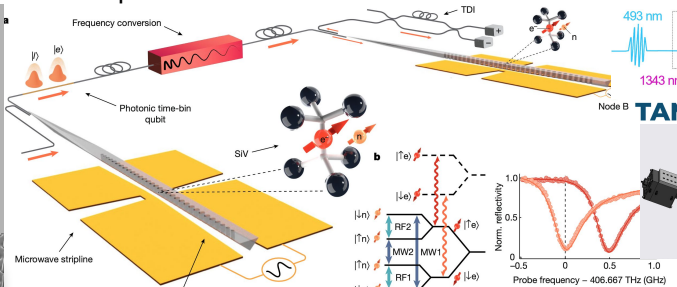
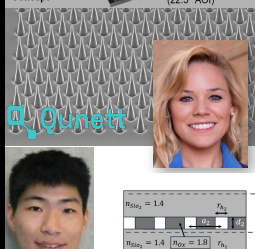
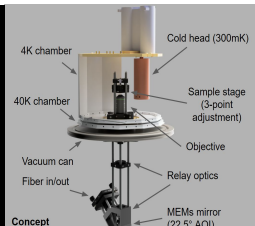
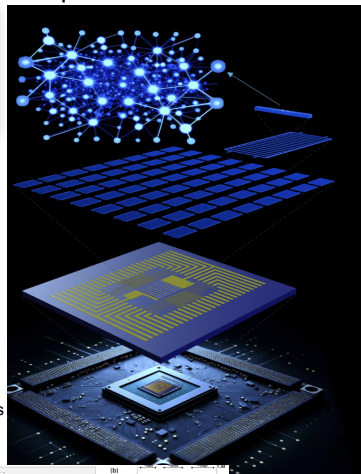
Color centers in diamond nanopillars and a MEMS scanner with fiber tip

Color centers in nanophotonic diamond cavities integrated with telecom fiber

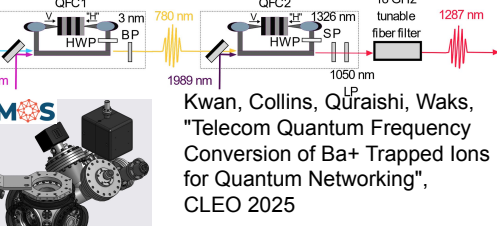
Trapped ion qubits strongly coupled to a cavity with efficient optical interface



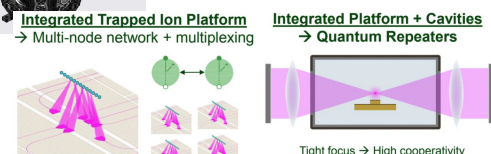
Superconducting electronics,
Nature Electronics
volume 8, 375
(2025)



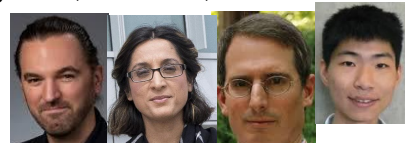
Metro-area entanglement, Nature volume 629, 573–578 (2024)



Kwan, Collins, Quraishi, Waks,
"Telecom Quantum Frequency
Conversion of Ba⁺ Trapped Ions
for Quantum Networking",
CLEO 2025



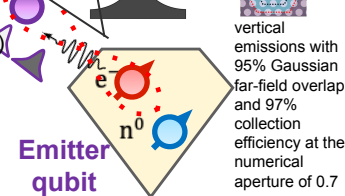
Niffenegger et al., Nature 2020, arXiv:2402.16742



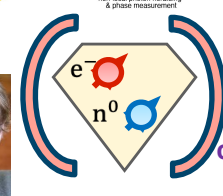
Optically addressable molecular-spin
qubit diluted in a host matrix; US
Patent Application #18845790 (2025)

"Low-dimensional solid-state
single-photon emitters",
Nanophotonics, 14(11):1687-1713,
(2025)

Programmable quantum matter, arXiv:2509.02992 (2025)
Chip integrated photonic control, Optica Vol. 10, Issue 5,
pp. 634-641 (2023)
Optical strain tuning, Xue, ..., Cui, Guha, Eichenfield,
Fan, Nature Communications 16 (1), 6275 (2025)
Spectral tuning, Nature Communications volume 16,
Article number: 8829 (2025)



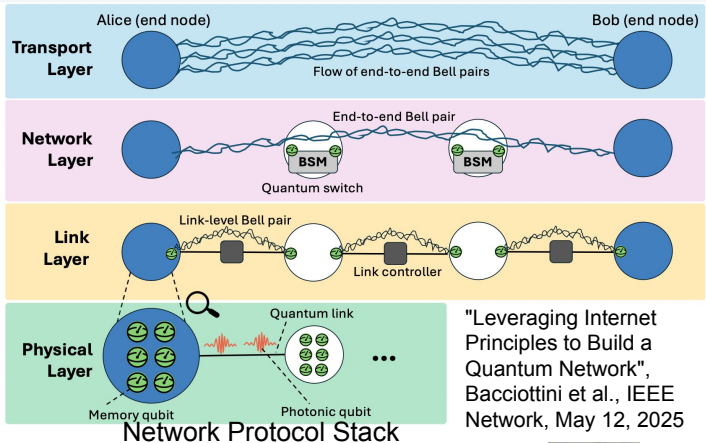
Long-baseline interferometry
arXiv:2509.09464 (2025)



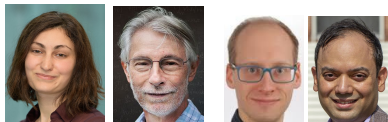
Cavity
coupled
qubit



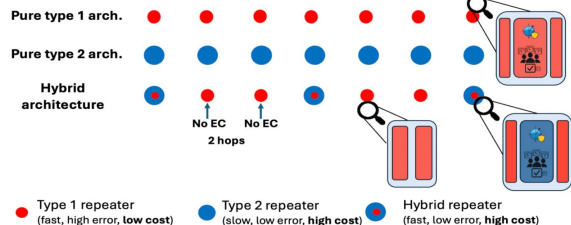
System integration and performance evaluation: WP3



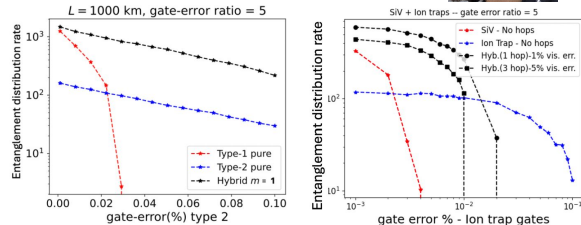
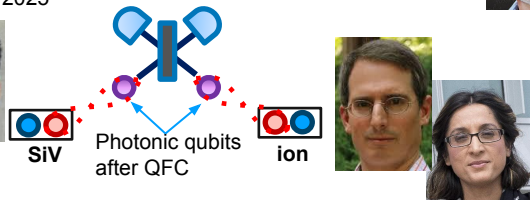
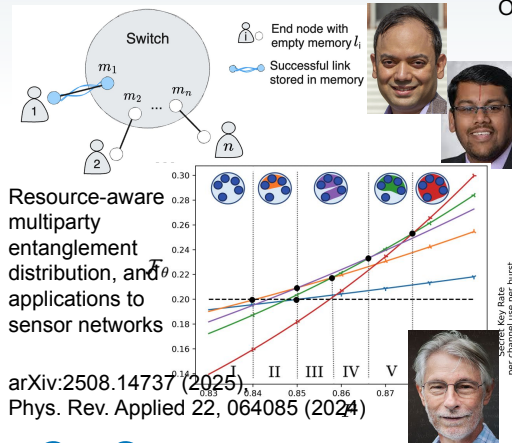
"Leveraging Internet Principles to Build a Quantum Network", Bacciottini et al., IEEE Network, May 12, 2025



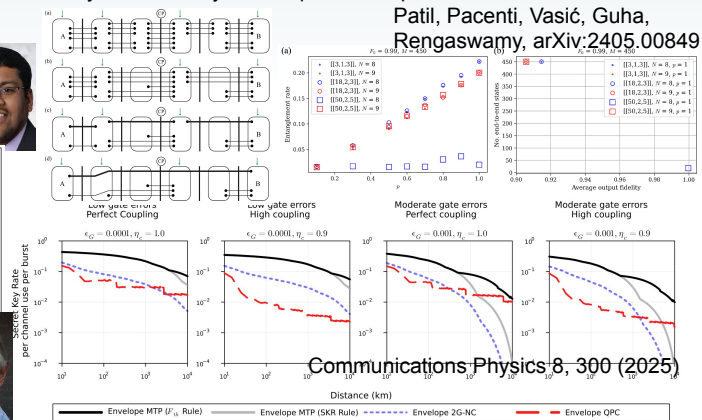
Hybrid quantum repeater architectures



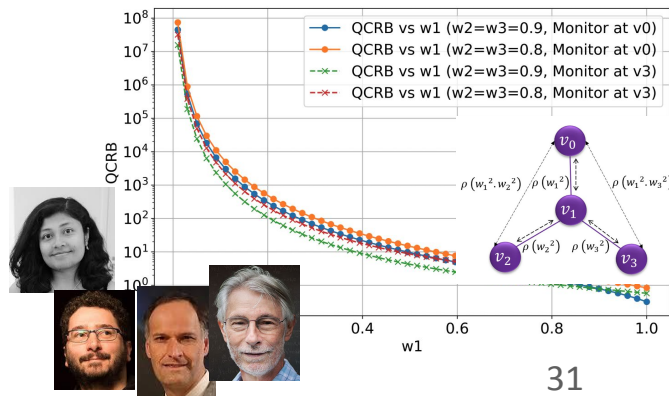
"Hybrid repeaters with encoding for long distance entanglement distribution", Haldar, Guha, Towsley, Rozpedek; IEEE QCE 2025



One-way and two-way coded quantum repeaters



Optimal monitor placement in quantum network tomography, Ragunathan, De Andrade, Towsley, Dey, Kilper, Marchetti, IEEE QCE2024



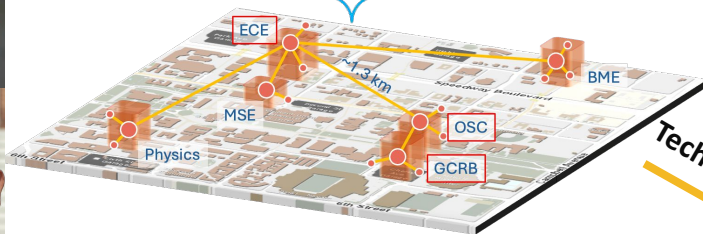


Tucson → Maryland testbed

Birth of the Tucson Testbed: NSF INQUIRE
Remote programmable AI-powered QREAL receiver

Characterizing SiC-4H SiV quantum memory
QuaCTUS - Tucson Testbed Simulator

Superadditive capacity using Green Machine
Characterizing SiV color center quantum memory
Quantum frequency conversion
Integrated quantum memory devices



- Including trapped-ion technology and workforce
- Testbed connected to broad end-users, programs and technologies

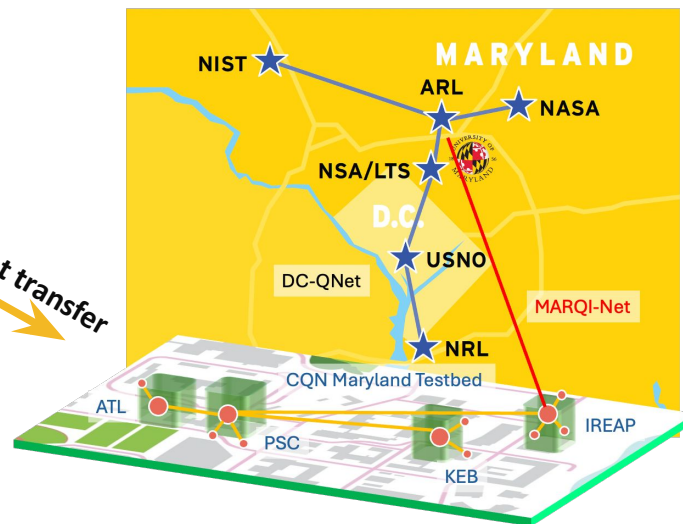
2020

2025

2030

Establishing the central quantum hub
First entanglement distribution in Tucson
New space and cryostat
Time domain interferometer
Cryostat-compatible confocal scanning microscope
Supporting systems for quantum network

Technology/equipment transfer



Dr. Chaohan Cui,
UMD Research
Faculty



Boston Testbed

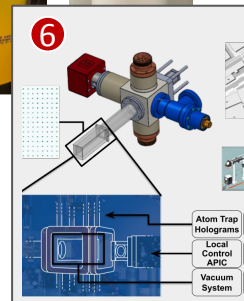
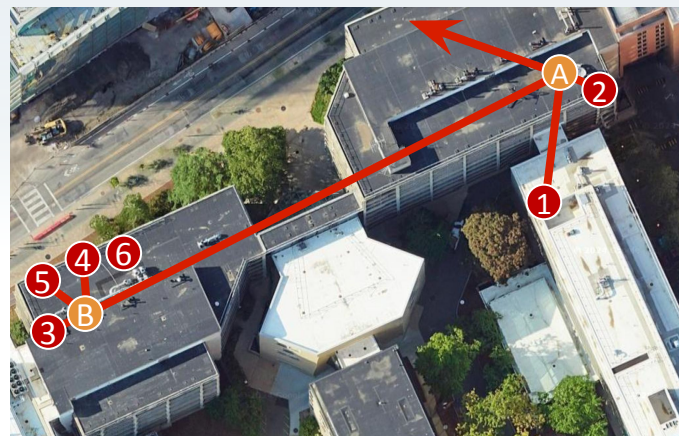


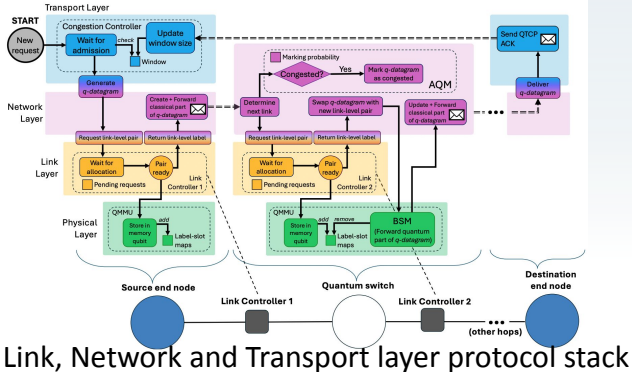
Dr. Chao Li, Research
Faculty, MIT EECS

<https://github.com/dirkenglund/quantum-network-code/tree/main>



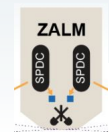
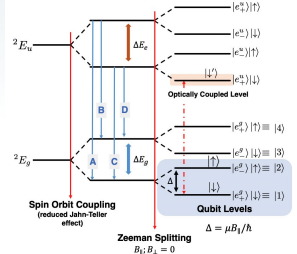
Sandia National Laboratories



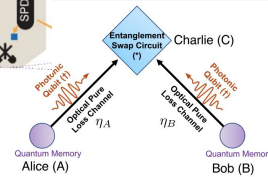


Virtual Testbed

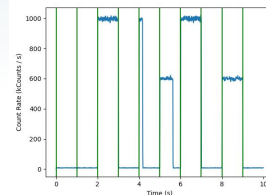
Decoherence models



Physical layer link models

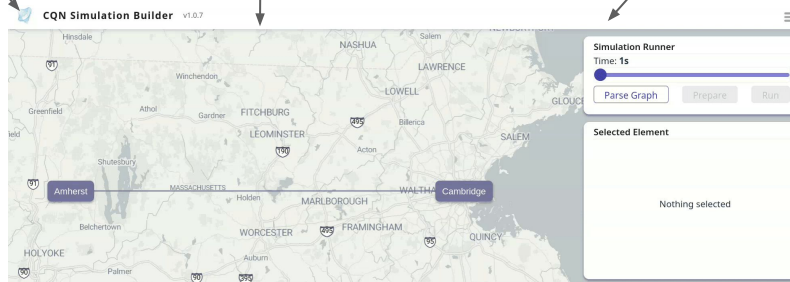
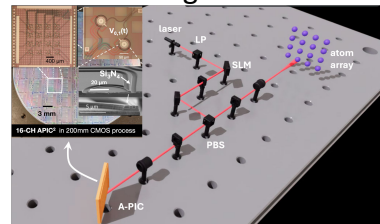


FPGA Controlled color center

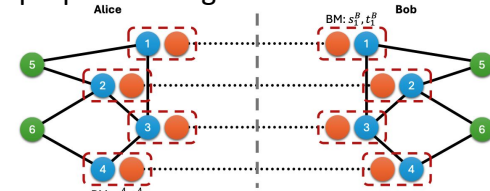


Dr. Stefan Krastanov,
UMass Amherst

Hardware Co-designed Quantum Optimal Control with Digital Twin Model of Programmable PIC

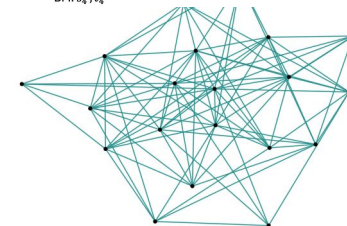
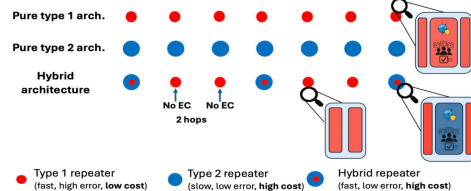


Measurement based entanglement distillation and resource state preparation algorithm

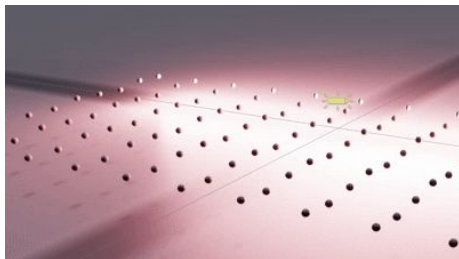


Hybrid quantum repeater architecture

Architectures combining Hybrid and Pure repeaters



Physics informed digital twin with NVIDIA Omniverse & Zemax Ansys team





MIT Department: Electrical Engineering & Computer Science
Faculty Mentor: Prof. Dirk Englund
Research Supervisor: Charles Hsu
Undergraduate Institution: North Carolina Central University
Hometown: Barisal, Bangladesh
Website: [LinkedIn](#)



Research Assistant
Alumni

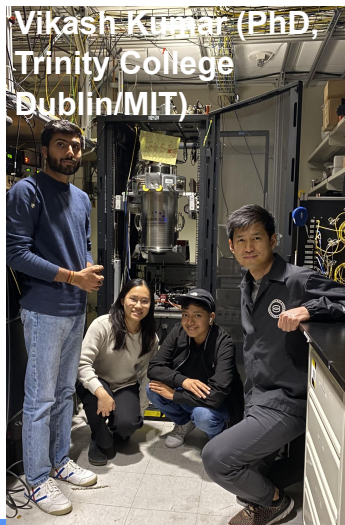
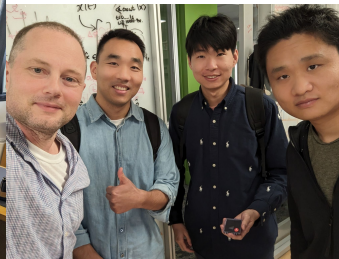
Helaman Flores



- **Prajit Dhara (PhD, MIT):** U.A. → MIT in 2022, 2023
- **Helaman Flores (PhD, MIT):** Former BYU undergrad with Ryan Camacho, now at MIT with Dirk Englund, focused on quantum networking and photonic switches.



Prajit Dhara (PhD, MIT): U.A. → MIT
in 2022, 2023



**Vikash Kumar (PhD,
Trinity College
Dublin/MIT)**

Vikash Kumar: Formerly with Dan Kilper, now working on Tucson testbed quantum memory and network protocols with Dirk Englund.

Arizona Team (Chaohan Cui): Leads Tucson testbed efforts on SiV quantum memory and entanglement technologies.



**Mahdi Khamseh (U.
Minnesota) S2024**



Sophia Duan = SnV and SiV
Valeria Saggio : G centers in Si



**Isack Padilla (U.A. → MIT
S2024)**
Dr Bo-Han Wu (U.A.--> MIT)

Networked learning

- **Graduate Students:** Collaborate with Stefan Krastanov (UMass) on **QuantumSavory** testbed and entanglement simulations.
- **Undergrad. & visiting grad students**
→ to testbed simulations
- **Courses (MIT 6.2410 & 6.2400):**
Hands-on labs and quantum network theory



**CQN Winter School on
Quantum Networks**



Michael Raymer



Brianna Moreno



**Vaishnavi Addala: MIT UROP
DoE Graduate Fellow**

