

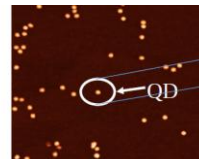
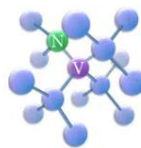
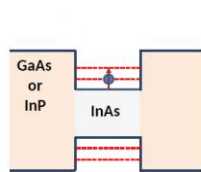
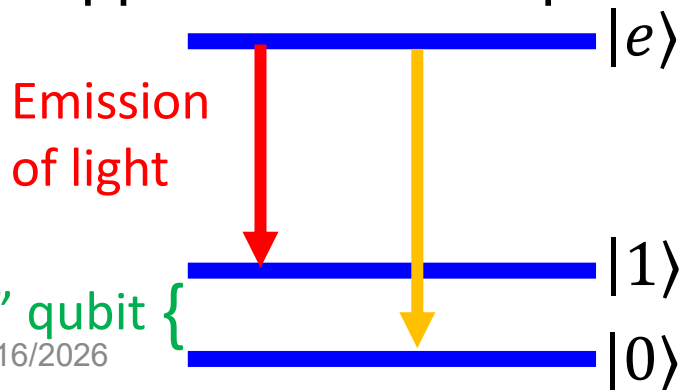
The 20th U.S.-Korea Forum on Nanotechnology
September 14-15, Raleigh

Toward Scalable Photonic Entanglement using Spin-Photon Interfaces

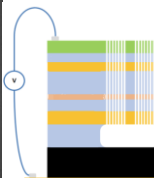
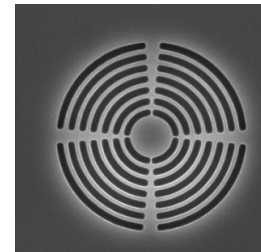
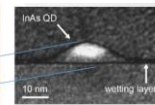
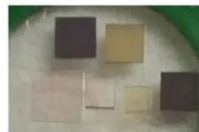
Demitry (Dima) Farfurnik
NC State University

The Spin-Photon Lab at NCSU

- Fundamental studies of optically-active solid-state spins
- Development of coherent control sequences
- Spin-Photon Interfaces via nanofabrication
- Applications: computing, networking, sensing

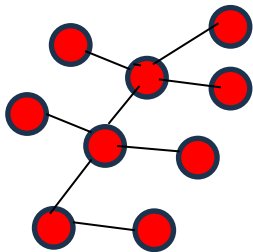


Atomic force microscope image

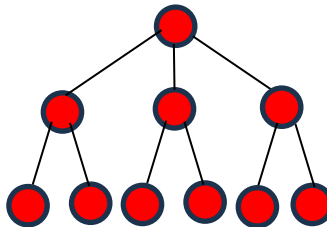


Photonic Graph States

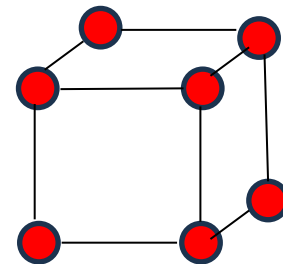
Circles – Photons, Lines – Entanglement



Interconnect graphs
for secure
communication and
distributed sensing



Tree state for all-
photonic quantum
repeaters –
communication over
long distances

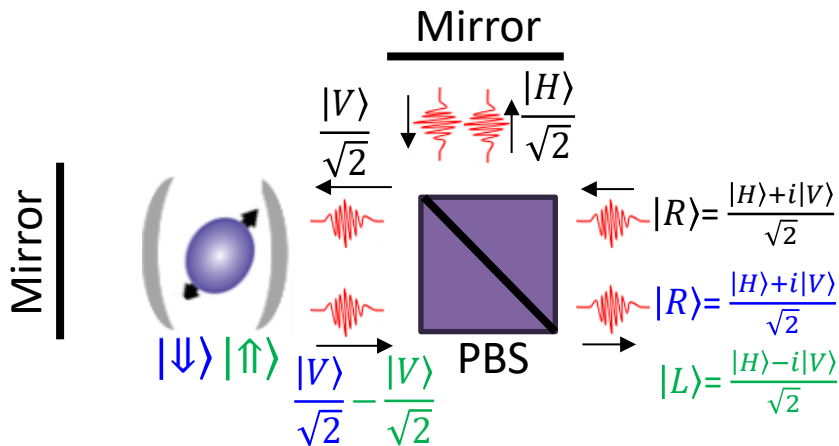
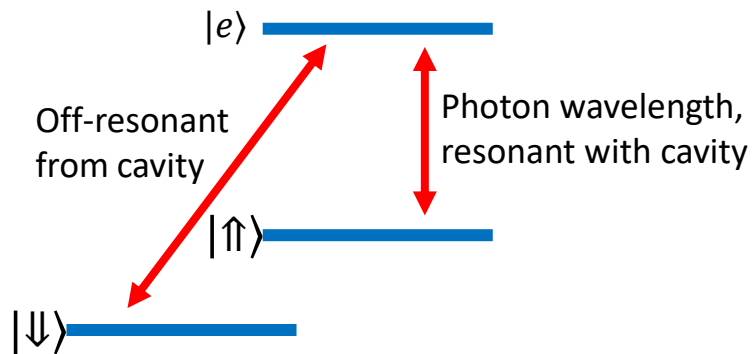


3D cluster state for
fault-tolerant
measurement-based
quantum computing
on the fly

So far generated only in a chain topology with 14 photons

Cavity-QED for Deterministic Entanglement

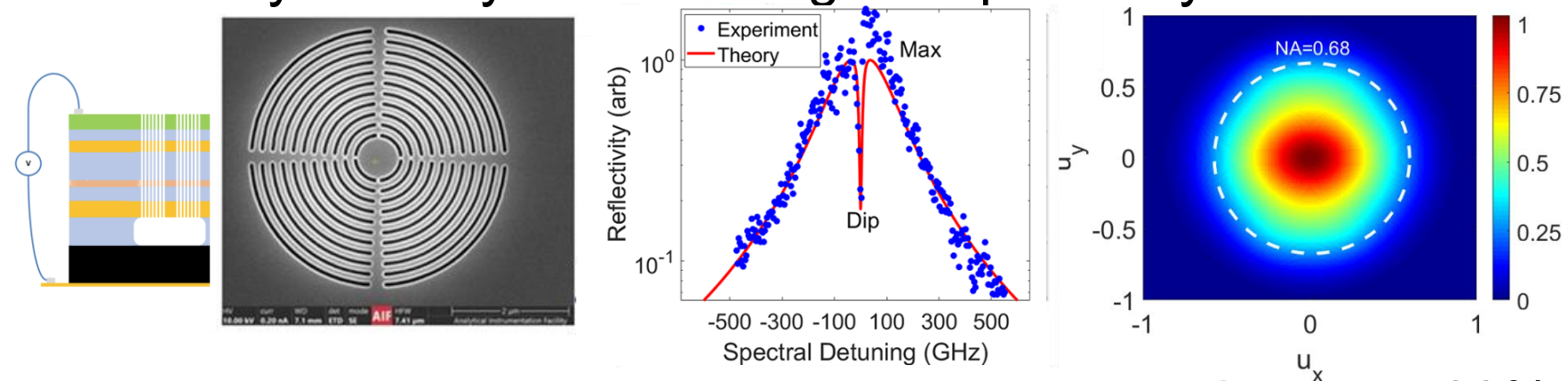
Photons bounce from the cavity – deterministic entanglement of photons induced by the spin



High Cooperativity Quantum Dot-Cavity Coupling

Nano Letters 22, 7959-7964 (2022)

“Bullseye” cavity indicates high cooperativity & collection



$C \sim 8$

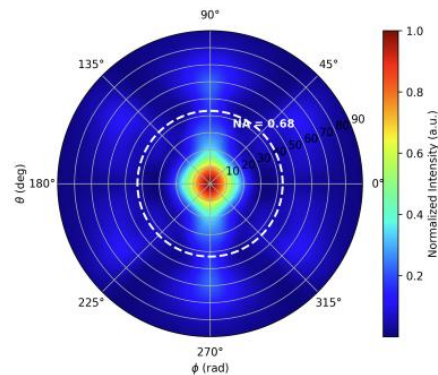
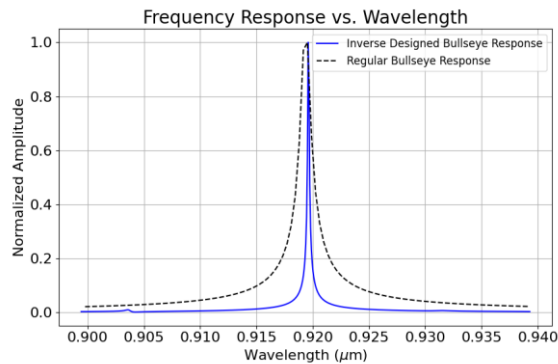
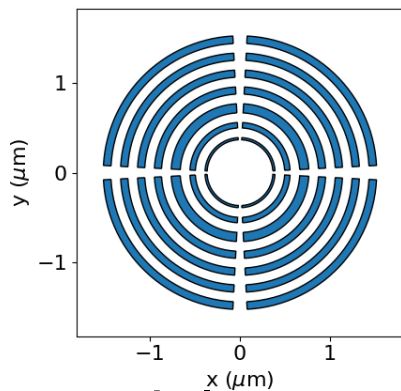
η can be up to 60%

Coupling to spin could lead to entanglement fidelity of 0.75

Next Generation Inverse-Designed Cavities

arXiv:2605.16596 (2026)

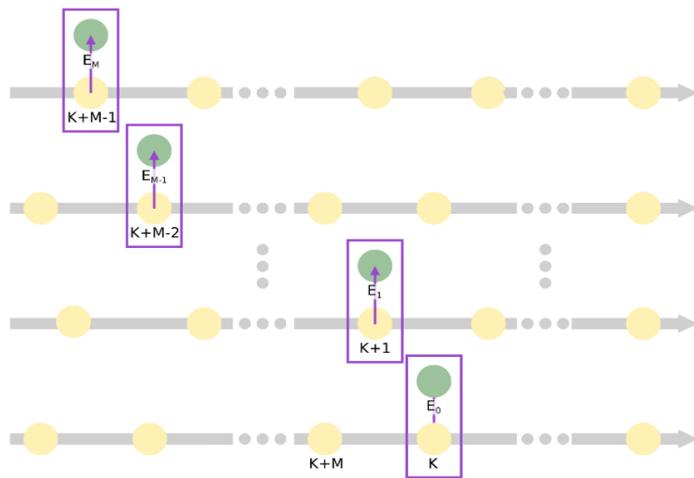
Simulation of Novel Cavities for high cooperativity and collection efficiency



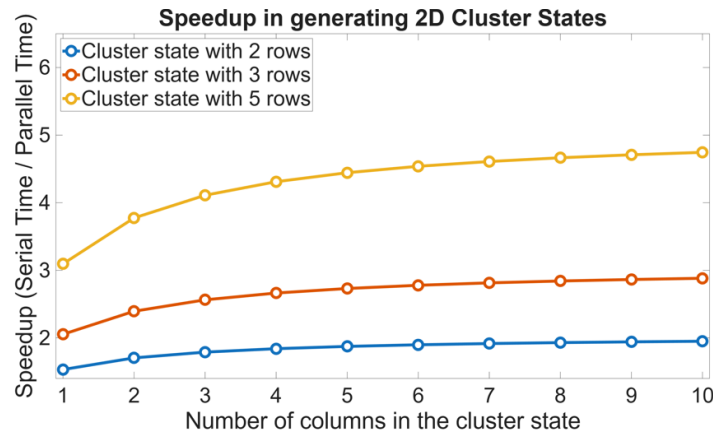
Potential entanglement fidelity of ~ 0.95

Parallelism with Multiple Entanglers

Parallel entangler scheme



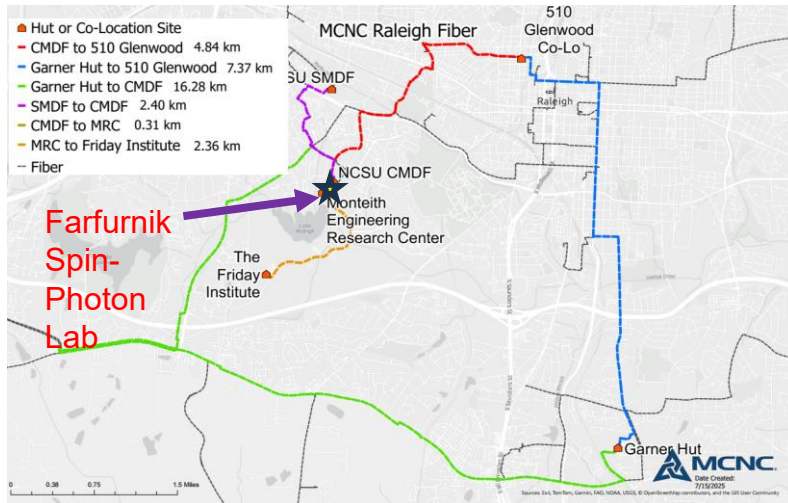
Speedup compared to single



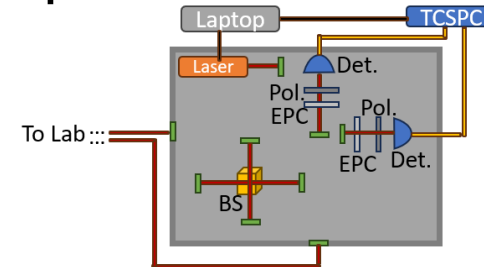
+ reduction in lossy components (e.g., switches)

Vision: Distribution over a Telecom Network

MCNC Fiber Infrastructure



Characterization: mobile “quantum kit in a box”



Summary

- Spin-Photon Lab studies optically active spins
- Photonic graph states – useful quantum resources
- Efficient generation using cavity QED and inverse design
- Vision: realization in a telecom network

Thank you / Questions