# Towards Distributed Quantum Error Correction: Noise Characterization and Decoder Analysis for Modular Surface Code Systems

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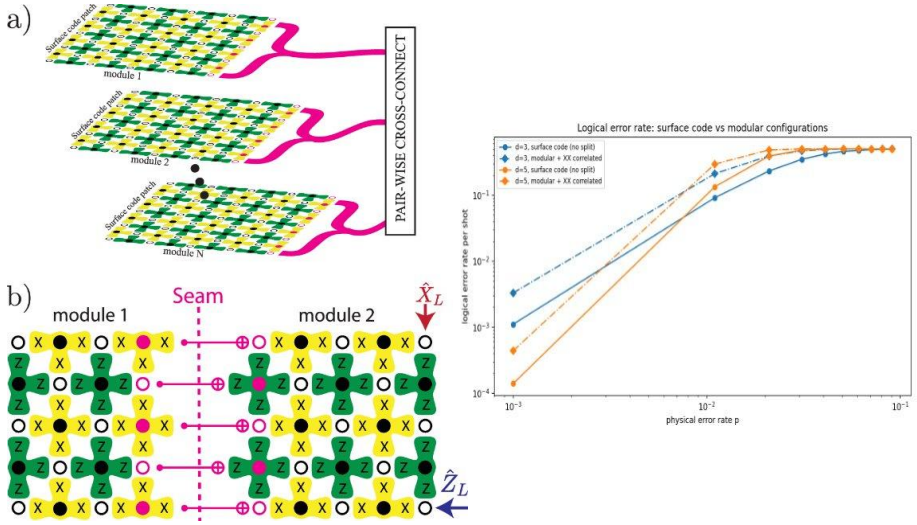
IEEE Quantum Week 2026, Accepted- In Press

## Background & Motivation

QPA Research Group

- Large scale Fault-tolerant Quantum Computing will require modular architecture, where multiple QPU modules are linked.
- Quantum error correction need to operate across module boundaries.
- Boundary condition will introduce extra noise because of bell pair. However current studies still assume independent depolarizing noise uniformly across the system.
- We argue this is insufficient: teleportation-based inter-module gates introduce correlated Pauli errors from imperfect Bell pair generation, absent from independent noise models.
- Standard MWPM decoders also cannot handle heralded erasure errors from detected teleportation failures.

## Proposed Research Item and Goal







- We study a surface code partitioned across two QPU modules, focusing on XX-type correlated errors between boundary link qubits and their nearest neighbors, the dominant channel in a memory-Z experiment.
- Constructing the detector error model in Stim and evaluating MWPM at d=3 and d=5, we find that correlated boundary noise elevates the logical error rate above the monolithic baseline and reduces the effective error threshold.
- These results motivate development of a neural network decoder capable of learning the correlated noise structure of modular systems from syndrome data

▸ Status: Paper accepted for poster at IEEE Quantum Week Conference 2026 ◂