# SPOQC: a Spin-Optical Quantum Computing architecture

**Paul Hilaire,** Grégoire de Gliniasty, Pierre-Emmanuel Emeriau, Stephen Wein, Alexia Salavrakos, Shane Mansfield

*Quandela, 7 rue Léonard de Vinci, Massy, France*

Paul.hilaire@quandela.com

A fault-tolerant quantum computer (FTQC) executes various quantum algorithms reliably despite minor yet significant noise. Achieving this requires careful arrangement of components for fault-tolerant quantum information processing without excessively large hardware. Photonic technology shows promise for large-scale quantum computing, but current efficient all-optical FTQC architectures [1] have a large resource footprint due to heavy reliance on resource state generators based on extensive hardware multiplexing.
Quantum-emitter-based single-photon sources have recently outperformed traditional methods in single-photon quality, with their spin acting as a quantum memory, enhancing entanglement with emitted light. The current largest photonic entangled state was produced with this kind of sources [2-3]. We propose the spin-optical quantum computing (SPOQC) architecture, tailored for quantum emitter-based platforms, significantly reducing the resource footprint and hardware complexity without relying on multiplexing. It leverages spin-entangled photon emission and efficient repeat-until-success gates to fault-tolerantly process quantum information. SPOQC's performance matches that of all-photonic architectures. It assesses It is modular, scalable and can implement any stabilizer quantum error correcting (QEC) codes. Quantum information is encoded in quantum emitters' spin, with photons facilitating long-range two-spin gates, thus facilitating the implementation of advanced QEC codes (that are intrinsically nonlocal) and which can also significantly reduce the algorithm's runtime.

## References

[1] S. Bartolucci et al., Nat. Comm. 14, 912 (2023)

[2] P. Thomas et al. Nature, 608, 677 (2022)

[3] N. Coste et al., Nat. Photon., 17, 582 (2023)

## Figures

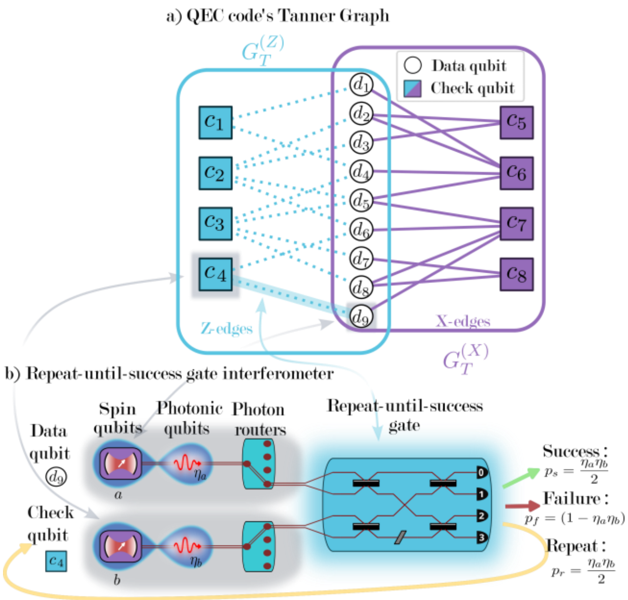


**Figure 1:** Overview of the SPOQC architecture. (a) a QEC code is characterized by its Tanner graph. (b) Each node of the Tanner graph is associated with a physical spin qubit and the edge connectivity physically represents a Repeat-Until-Success linear-optical gate that performs a CZ gates between each physical spins.