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Rise of the Machines: Making better photons by getting rid of experimentalists

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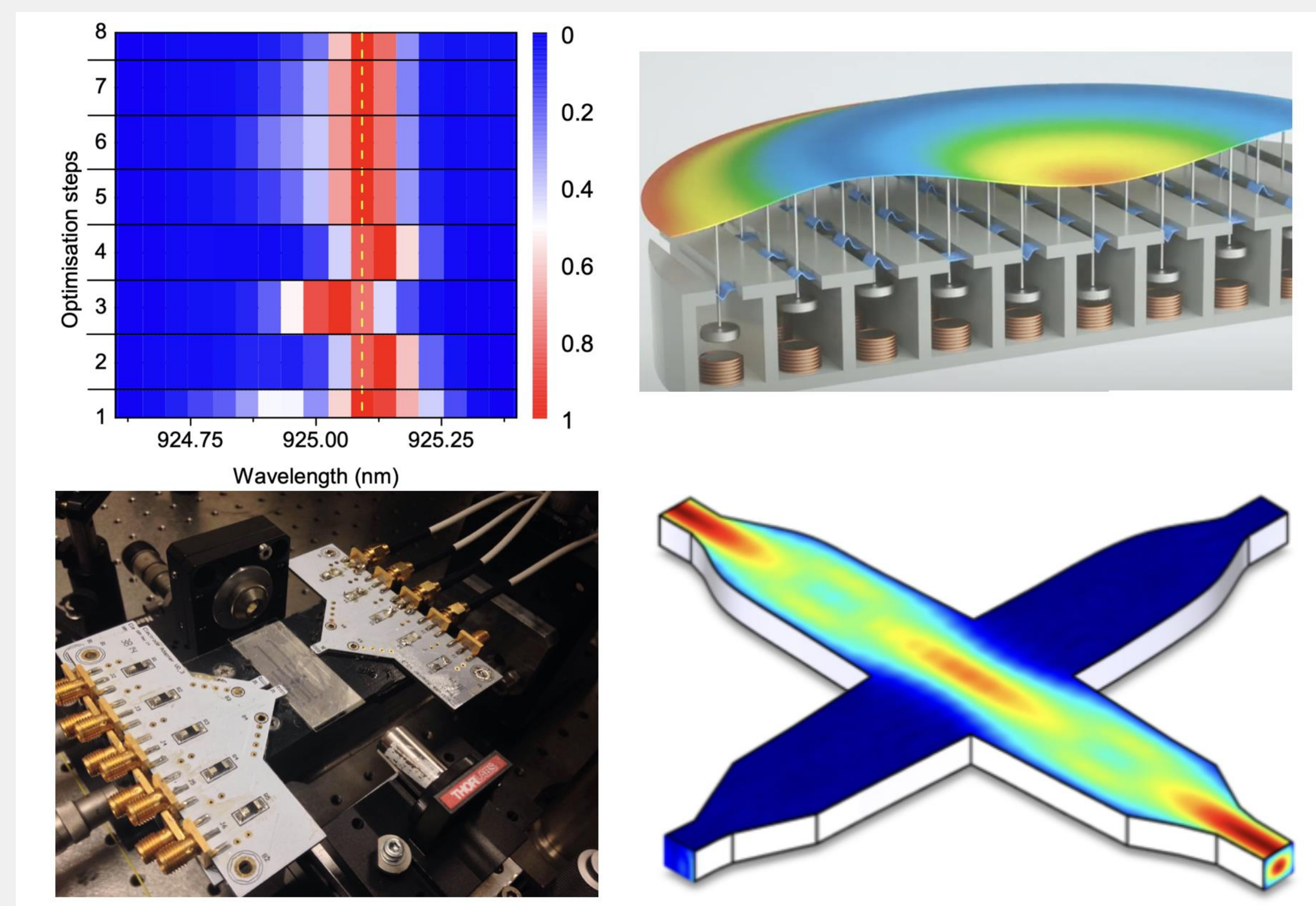
There is now an enormous opportunity to interconnect quantum components together into complex, short-and long- range networks of sensing, communication, and computational elements. Photons are a natural choice for networking quantum technologies as their quantum nature survives at room temperature and long distance propagation is possible, either via optical fibre or through free space.



Here we explore using machine learning (ML) to optimise production, coupling, routing, and circuitry for single photons. Our single-photon source platform is resonant excitation of individual quantum dots coupled to a micropillar cavity. Multiphoton suppression in the quantum dot emission—as well as single-photon indistinguishability and brightness—are directly influenced by the spatiotemporal characteristics of the optical excitation pulses. We use ML techniques to tailor the excitation laser pulse properties in real-time,
significantly reducing the search time for optimal parameters. We also employ ML to control a deformable mirror, correcting for aberration on the single-photon wavefront field to maximise the coupling between the source output and a single-mode fibre. This combination provides a toolbox for enhancing the performance of any solid-state single-photon source.

Photonic integrated circuits (PICS) will be essential for scalaby realising photonic quantum technologies. Actively coupling photons into PICS requires high-fidelity integrated switches. Current best practice—manual optimisation of electronic signals for each individual switch on a chip—is slow and unscalable. We use ML—simulated annealing—to optimise driving parameters for up to 4 switches on a single chip, achieving a significant speed up in tuning while retaining optimal performance. PICS often interface light in and out of the chip using edge coupling, which severely limits chip geometry as well as adding complication to fabrication. Using ML—inverse design—we are developing efficient out-of-plane couplers and small-footprint waveguide crossings that are easier to manufacture and have higher circuit density. This new architecture lowers entry costs for photonic integrated circuitry development.

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Andrew G. White is an Australian scientist and is currently Professor of Physics and a Australian Laureate Fellow at the University of Queensland. Currently Director of the ARC Centre for Engineered Quantum systems, he has been a founding member of three Australian Research Council Centres of Excellence conducting research in quantum optics, quantum information science and fundamental quantum science. His current research interests centre around exploring and exploiting the full range of quantum behaviours with an eye to engineering new technologies and scientific applications.