Integrated Remote Entanglement of Trapped Ions

Felix Knollmann, Ethan Clements †, S. Corsetti, P. Callahan, A. Hattori, D. Kharas, M. Kim , T. Mahony, R. Maxson, R. McConnell, A. Medeiros, R. Morgan, M. Notaros, C. Sorace-Agaskar, T. Sneh, A. Sumant, R. Swint, G. West, J. Notaros, I. L. Chuang, J. Chiaverini

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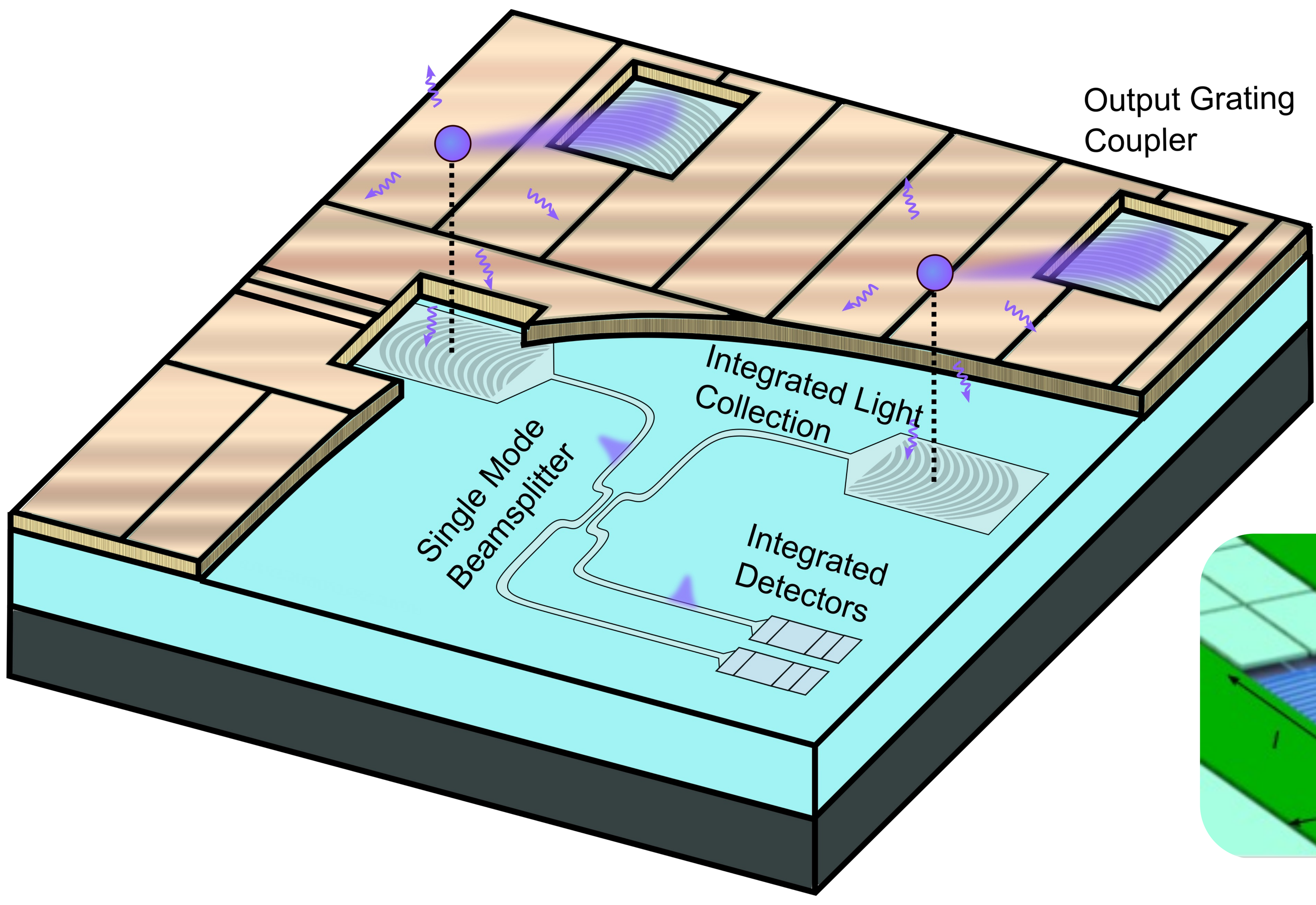
Challenges

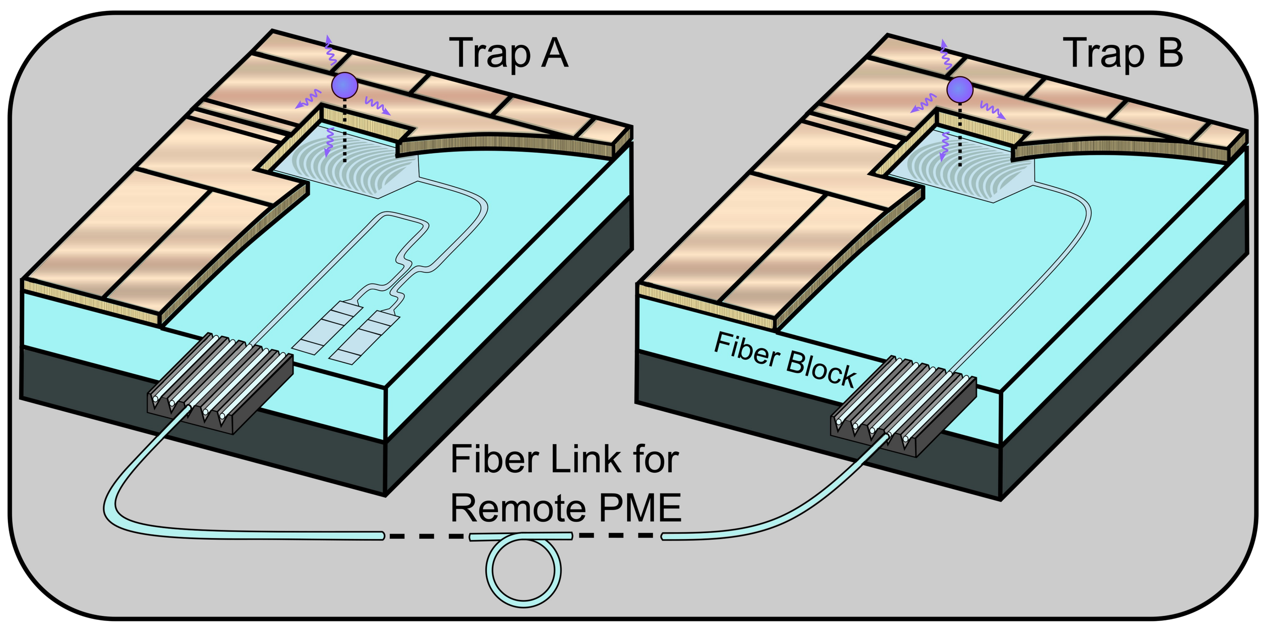
1. Qubit operations are mediated by photons and phonons
2. Spatial constraints limit beam access and thus qubit number in current experiments

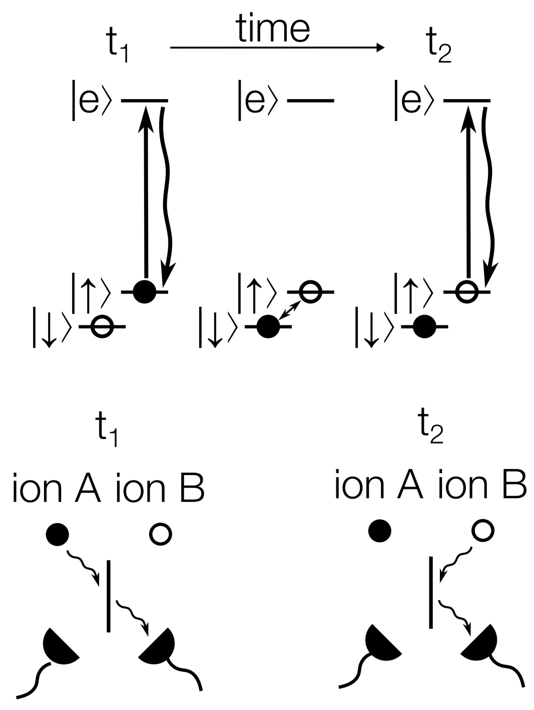
3. Spectral crowding of motional modes (the quantum bus) limits the size of a 1D trapped ion processor
4. Sideband cooling takes ~40% of the duty cycle in current implementations of quantum algorithms[1]

Vision

A remote entanglement generation unit cell that can be multiplexed to achieve high-rate modular quantum computing with trapped ions in a single vacuum system







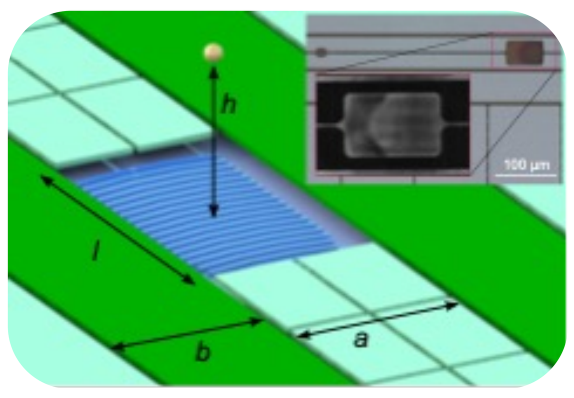
Implementation

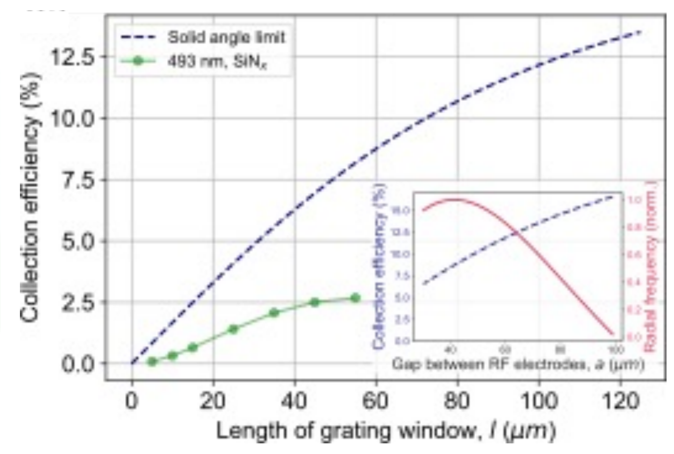
Emission gratings for pulsed excitation

Photon collection gratings

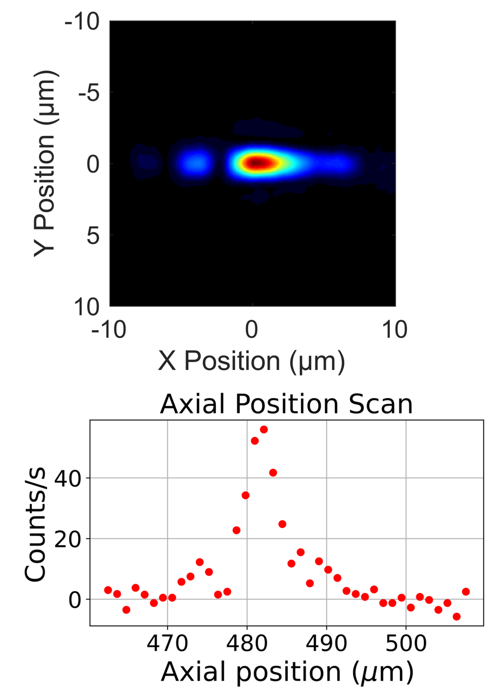
Integrated beam splitters

Waveguide-coupled detectors





In-situ and Ex-situ Device Characterization

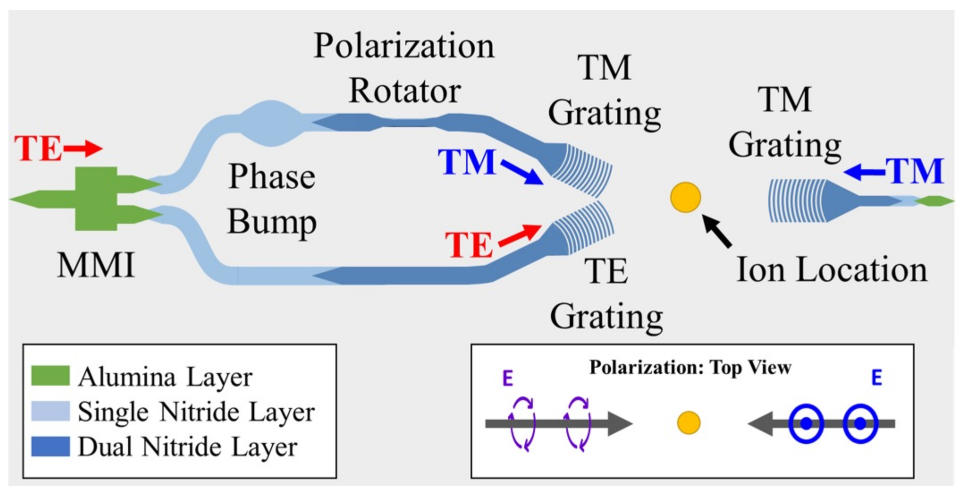


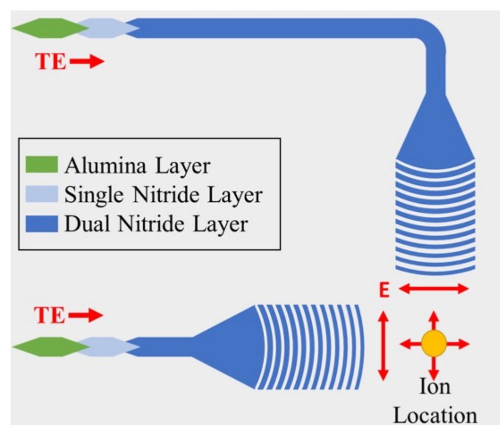
Fast cooling and state preparation

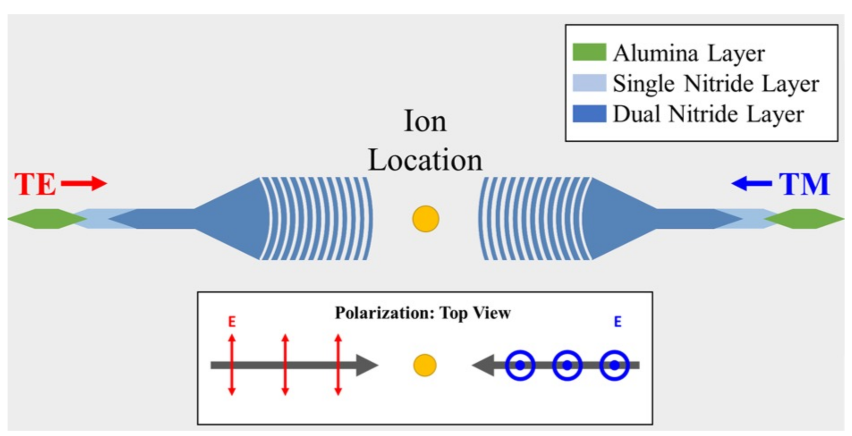
Key operations require circularly polarized light, but current grating designs emit only linearly polarized, TE or TM light

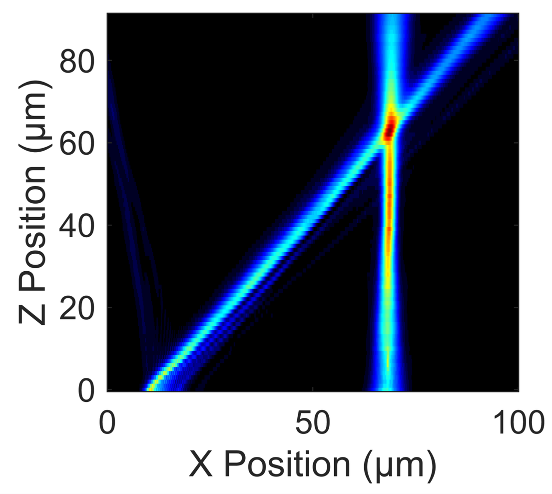
We are developing and testing structures to deliver light of different polarizations for:

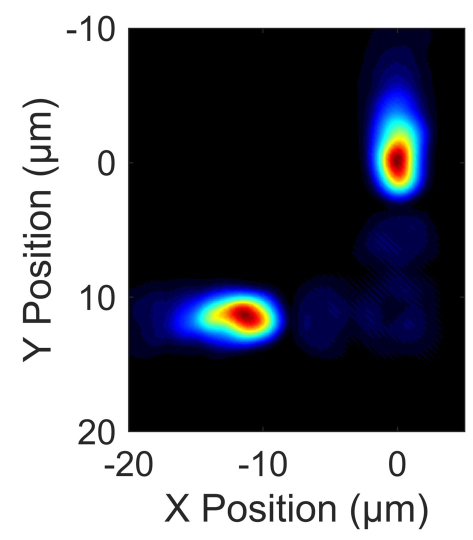
- Fast state preparation
- Remote entanglement generation pulses
- EIT cooling
- Polarization gradient cooling











Consequences

Modular quantum computing in a single vacuum system or across systems

Quantum repeaters when combined with coherent frequency conversion

Improved run time of quantum algorithms by reducing the time spent sideband cooling

References and QR codes

Digital version of poster:

Arxiv link for paper:

[1]Quantinuum: https://doi.org/10.48550/arXiv.2305.03828