Abstract Submitted
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**Fast, High Fidelity State Detection of a $^{171}Yb^{+}$ Ion Using Large Numerical Aperture Optics**[1] RACHEL NOEK, GEERT VRIJSEN, DANIEL GAULTNEY, EMILY MOUNT, SO-YOUNG BAEK, PETER MAUNZ[2], JUNGSANG KIM, Duke University, Durham, NC 27708 — Trapped ions provide a viable choice for quantum bits (qubits) for quantum information as most of the DiVincenzo criteria have been demonstrated [1]. However, some scalability challenges remain including the qubit measurement speed, which is typically much slower than gate times, and remote entanglement generation rate, which is currently much slower than qubit coherence times. Current photon collection rates limit the overall speed and fidelity of the qubit detection in a trapped ion quantum processor. Recent advances have been made in improving the state detection fidelity, but the detection time remains long ($\sim$ ms) compared to typical gate operations ($\sim 10^1$-$10^2$ us). Here, we use a high numerical aperture (NA=0.6) lens capable of collecting 10% of the solid angle of light emitted by a single ion to measure a detection fidelity of 99.7% (99.85%) with an integration time of 50 us (150 us). Advanced discrimination schemes can further improve the state detection speed. The $^{171}Yb^{+}$ ion is trapped in a Thunderbird type surface trap designed and fabricated at Sandia National Laboratories.

[1] D. J. Wineland, et al., J. Res. Natl. Inst. Stand. Technol. 103, 259 (1998).

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