



A next-generation trapped ion quantum computing system

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Monroe Group/Duke Quantum Center

June 7, 2023



$^{171}\text{Yb}^+$ qubit

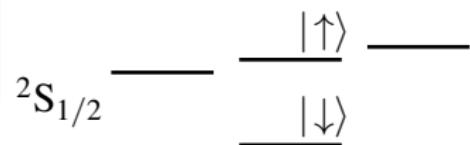
- Long coherence time: $T_2 \approx 1\text{hr}$

Wang, et al., Nat Commun 12, 233 (2021)

- High fidelity state preparation:
 $> 99.9\%$ in $\approx 10\mu\text{s}$
- High speed and high fidelity readout:
 $> 99.3\%$ in $\approx 100\mu\text{s}$

Harty, et al., PRL. 113, 22051, (2014)

Christensen, et al., NPJ Quantum Inf. 6, 35 (2020)



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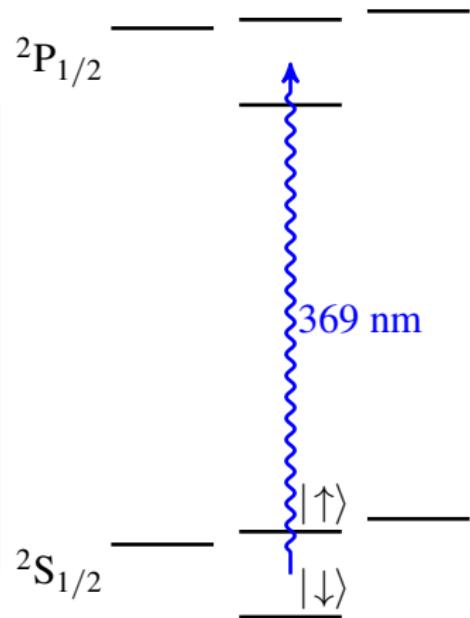
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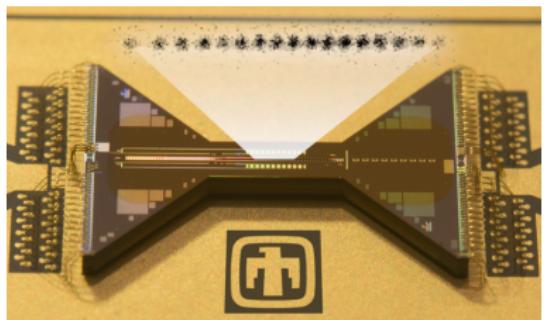
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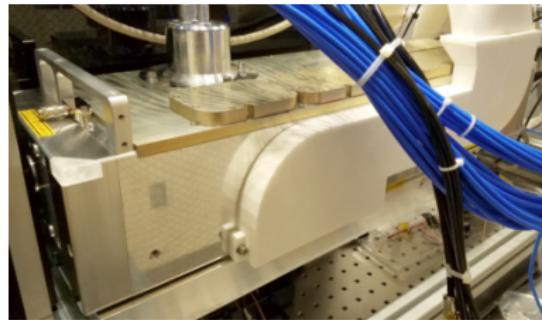
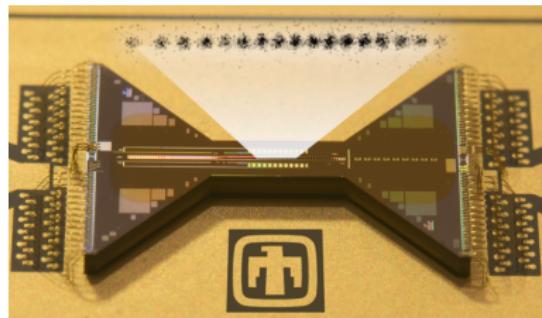
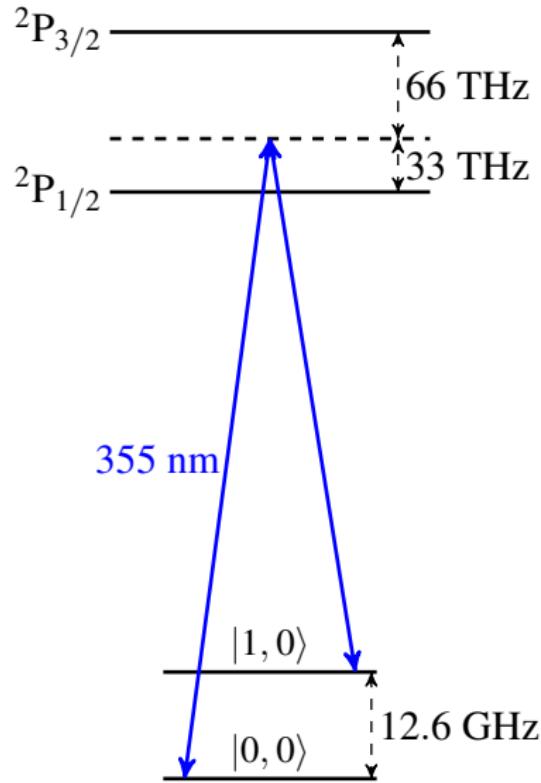
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$^{171}\text{Yb}^+$ chain and coherent manipulation



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1st generation EURIQA system

Error-corrected Universal Reconfigurable Ion-trap Quantum Archetype



- 15-24 usable qubits
- High fidelity single (99.9 %) and two-qubit (99 %) gates
- Universal reconfigurable
- Remote operations

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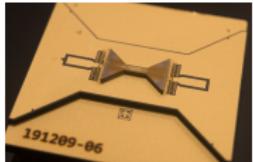
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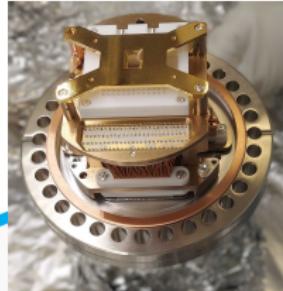


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- K02: Quantum Simulations and Computations with Ion Trap Systems
- Z05: Search for Millicharged Dark Matter with Trapped-Ion Quantum Processor

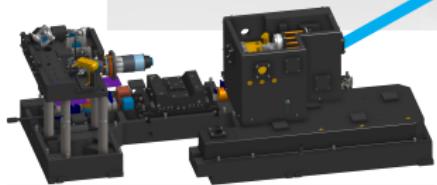
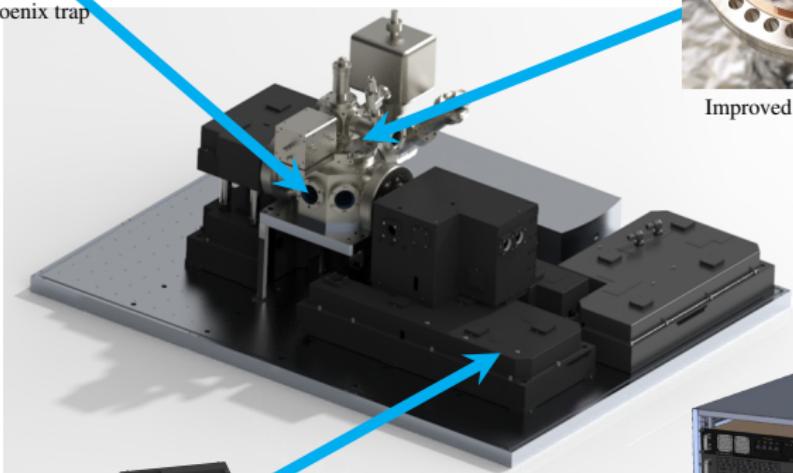
2nd generation EURIQA system



Sandia Phoenix trap



Improved vacuum system



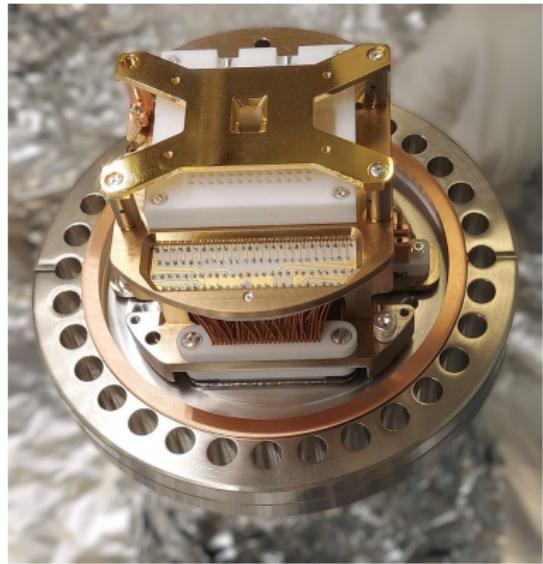
L3Harris Raman beam path



CW lasers

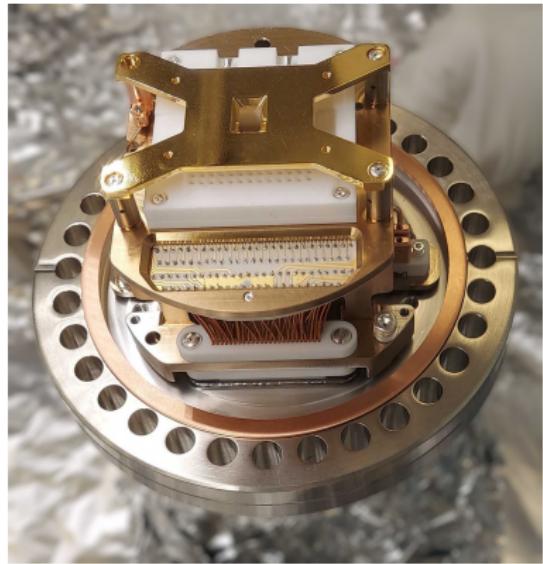
2nd gen EURIQA: Improved vacuum

- Vacuum fired components
- Reduce ion-chain reordering rate
- $1.32(21) \times 10^{-11}$ Torr measured pressure



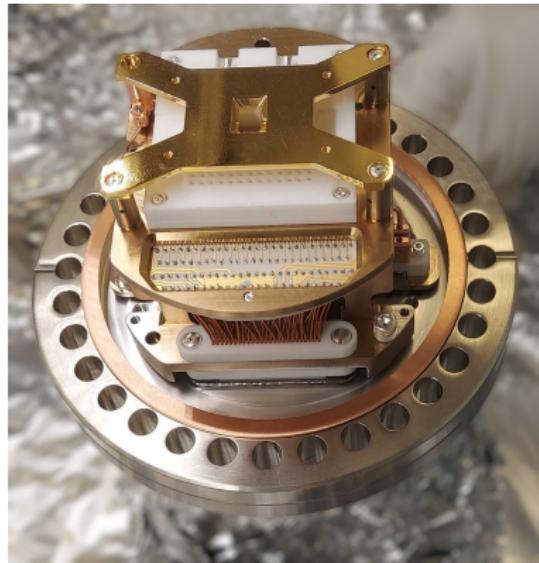
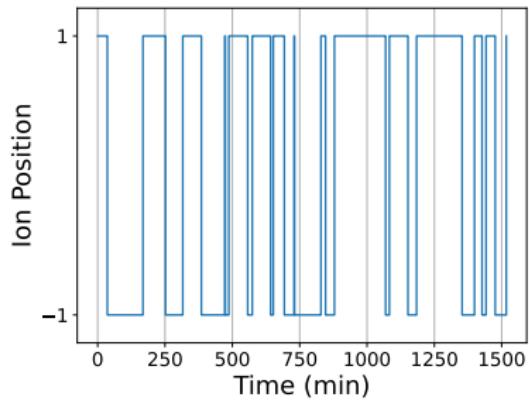
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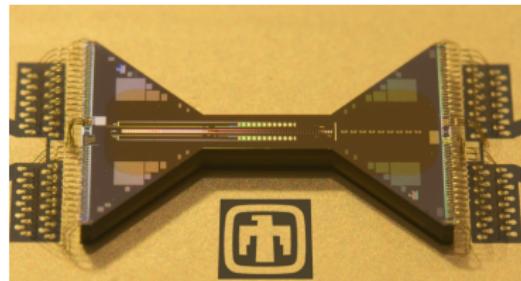
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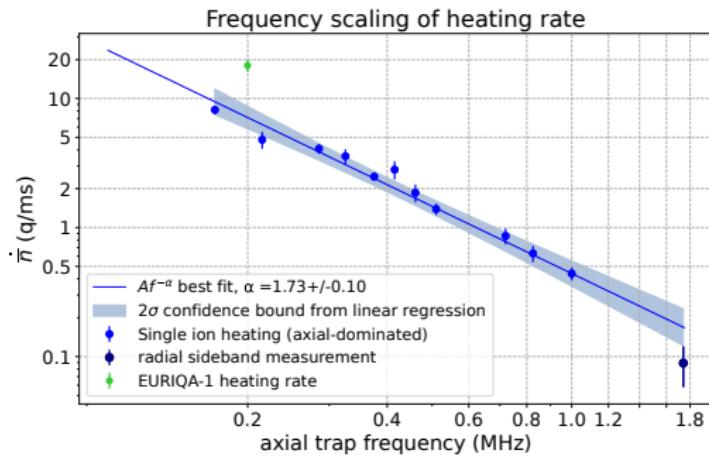
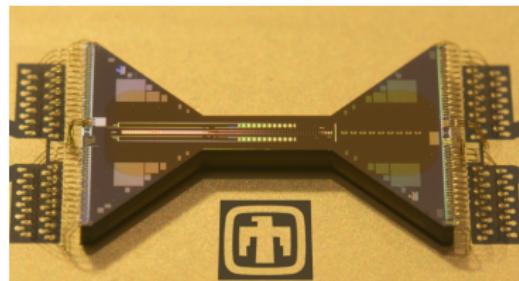
2nd gen EURIQA: Phoenix trap

- Better metallization
 - ▶ Reducing noise
 - ▶ Less charging/photovoltaic effect
- 30 quanta/s heating rate @ 3 MHz
Measured by Sandia
- Segmented outer electrodes
- Better and faster ion loading



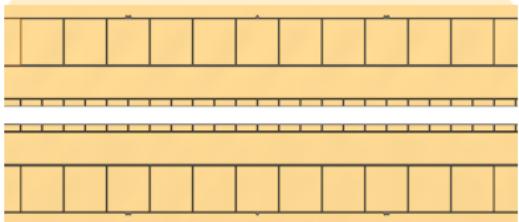
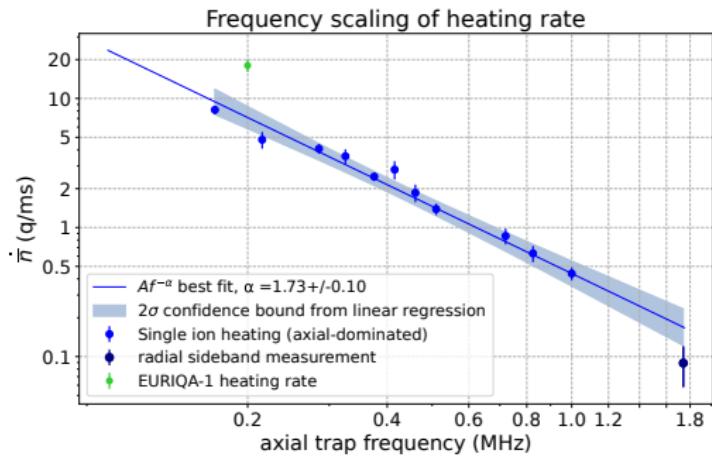
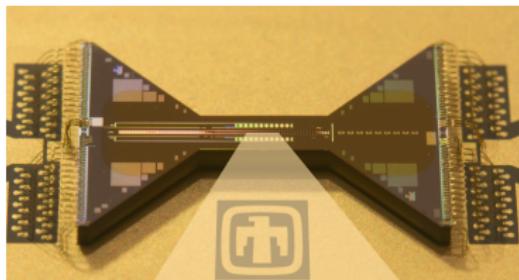
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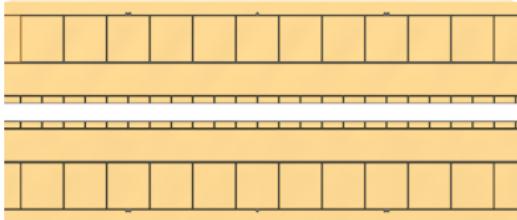
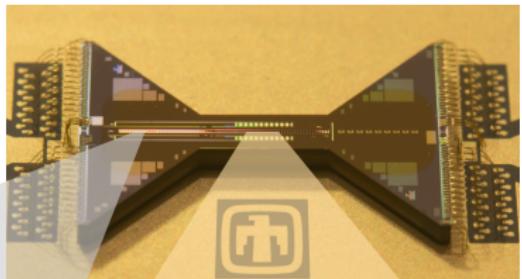
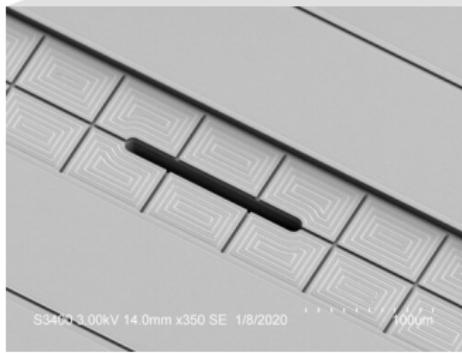
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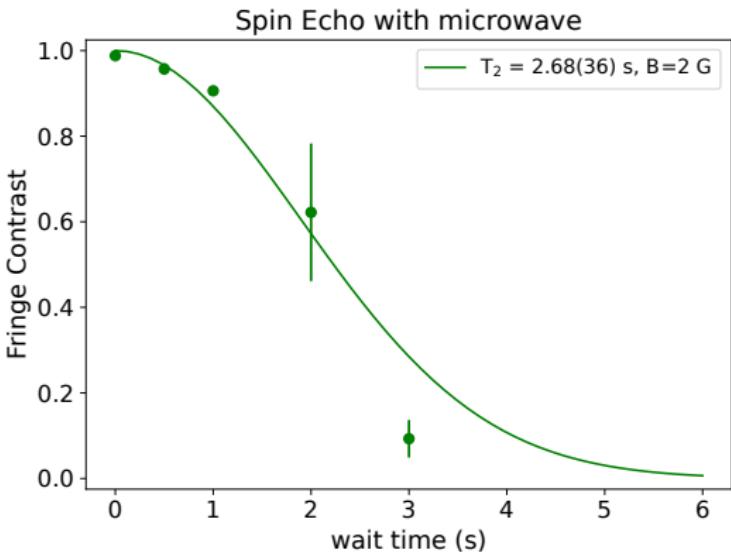


2nd gen EURIQA: Qubit coherence

- Ramsey experiment using microwave
- $t_2 = 2.68(36) \text{ s}$
- Can be further improved with shielding

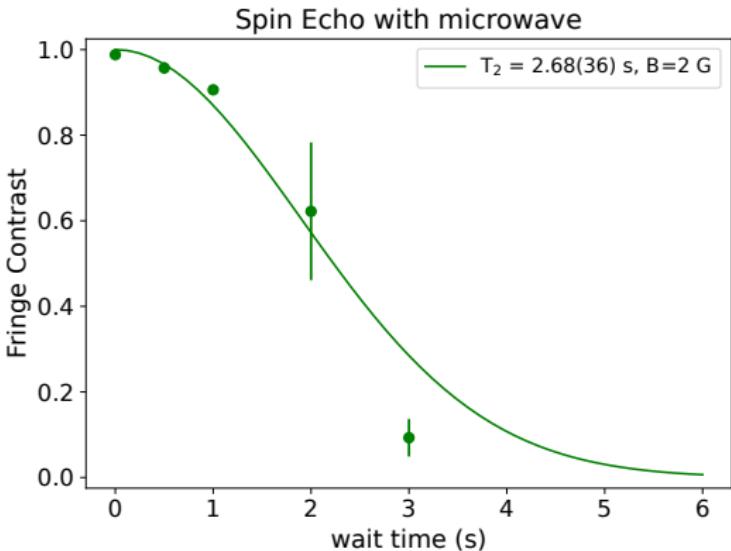
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2nd gen EURIQA: Raman transition on ion



Christopher R Monroe



Alexander Kozhanov



Marko Cetina



Crystal Noel



Lei Feng



Liudmila Zhukas



Debopriyo Biswas



Andrew Risinger

