

A next-generation trapped ion quantum computing system

Yichao Yu

Liudmila Zhukas, Lei Feng, Marko Cetina, Crystal Noel, Debopriyo Biswas,
Andrew Risinger, Vivian Zhang, Keqin Yan, Bahaa Harraz
Grant Eberle, Alexander Kozhanov, Christopher R Monroe

Monroe Group/Duke Quantum Center

June 7, 2023



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

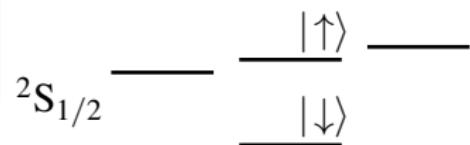
- Long coherence time: $T_2 \approx 1\text{hr}$

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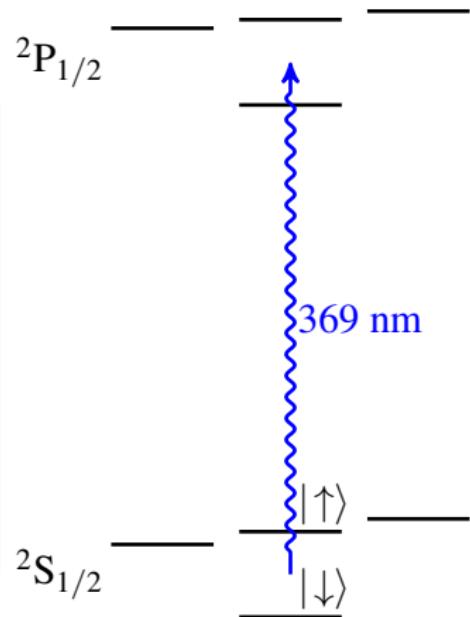
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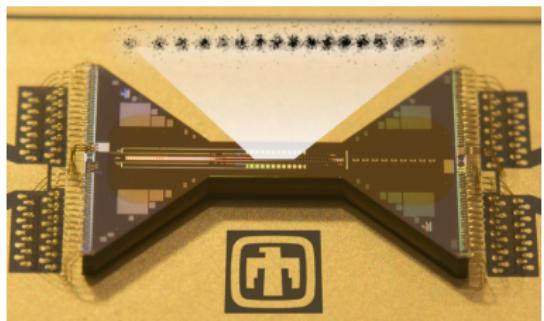
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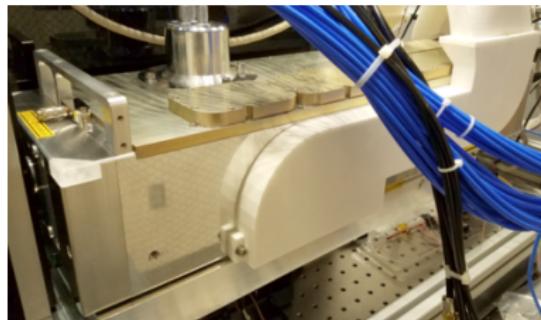
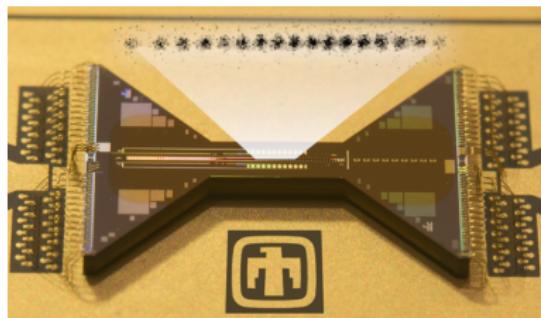
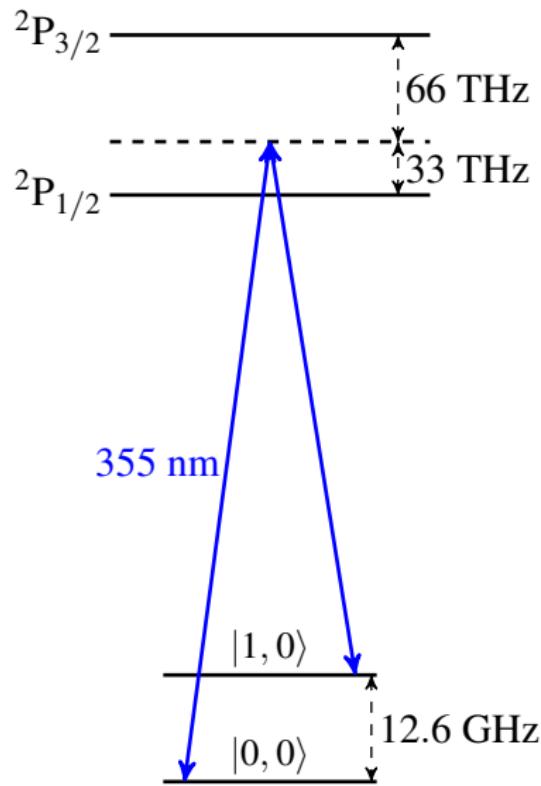
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$^{171}\text{Yb}^+$ chain and coherent manipulation



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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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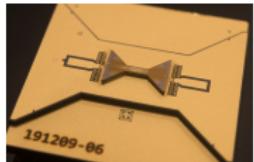
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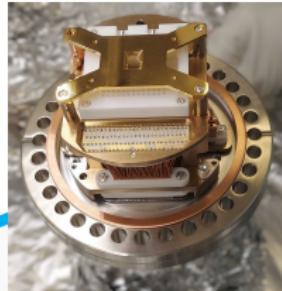


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- K02: Quantum Simulations and Computations with Ion Trap Systems
- Z05: Search for Millicharged Dark Matter with Trapped-Ion Quantum Processor

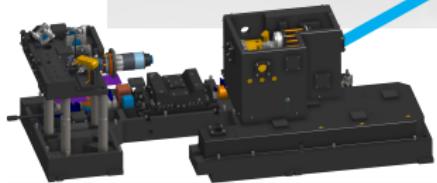
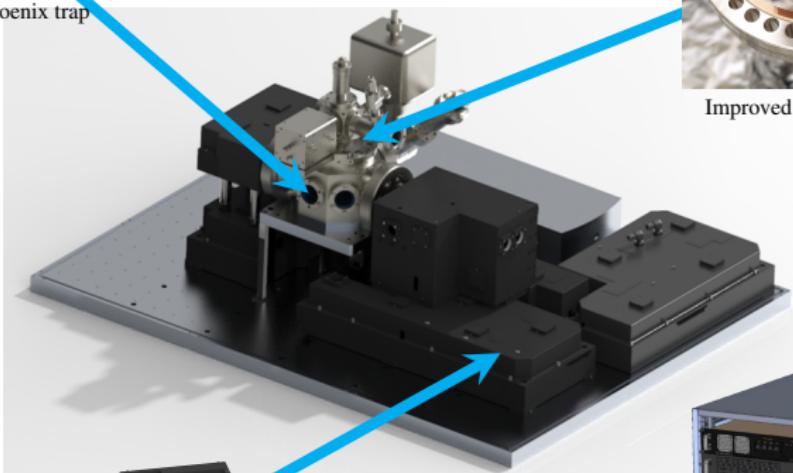
2nd generation EURIQA system



Sandia Phoenix trap



Improved vacuum system



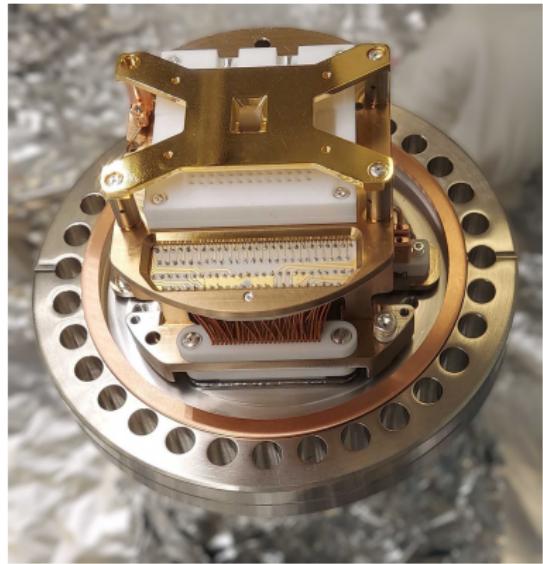
L3Harris Raman beam path



CW lasers

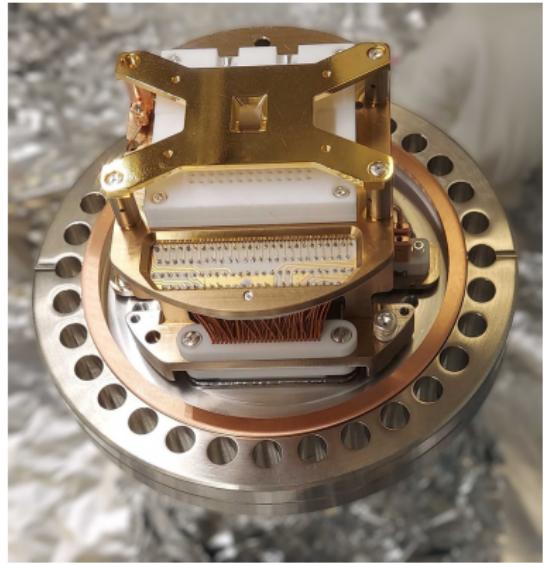
2nd gen EURIQA: Improved vacuum

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



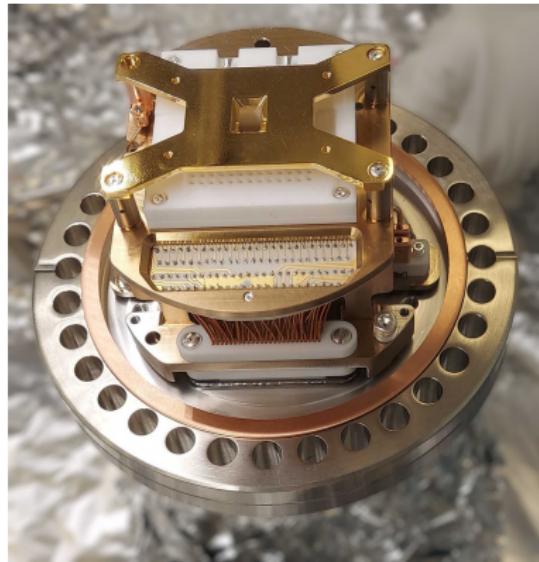
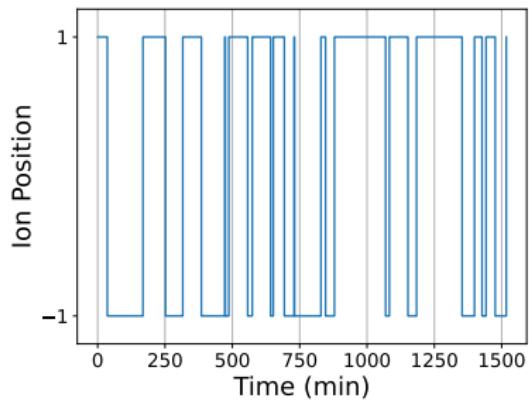
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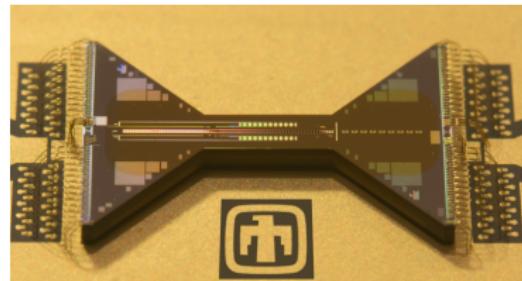
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2nd gen EURIQA: Phoenix trap

- 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

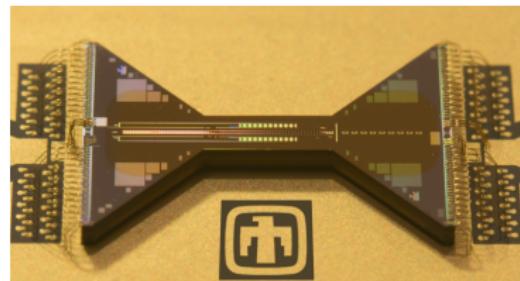


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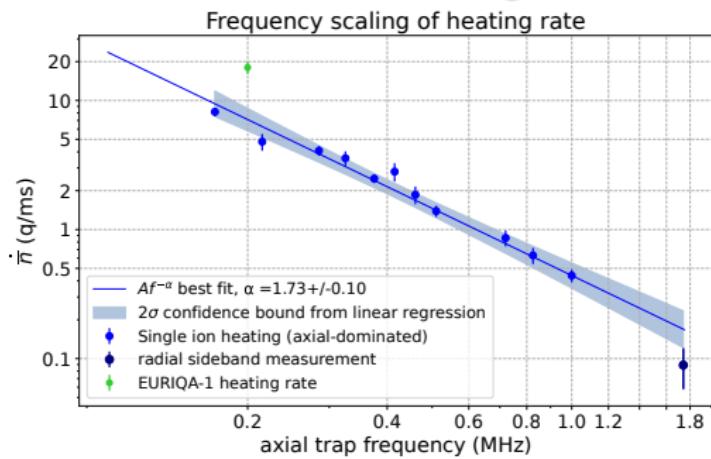
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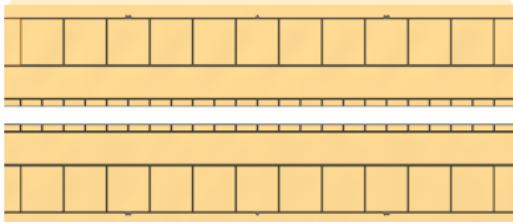
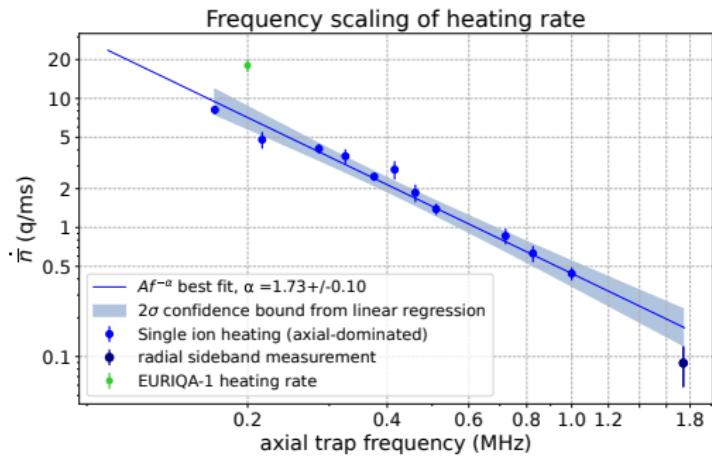
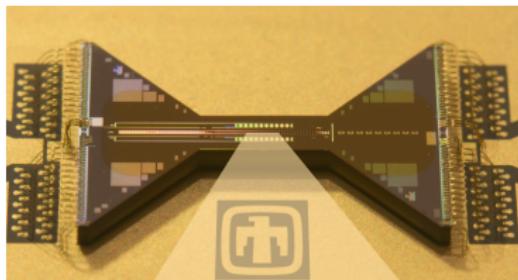


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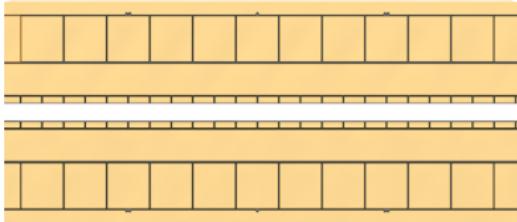
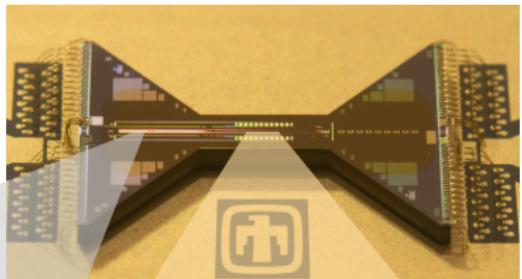
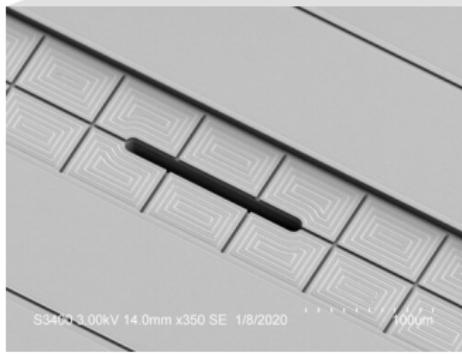
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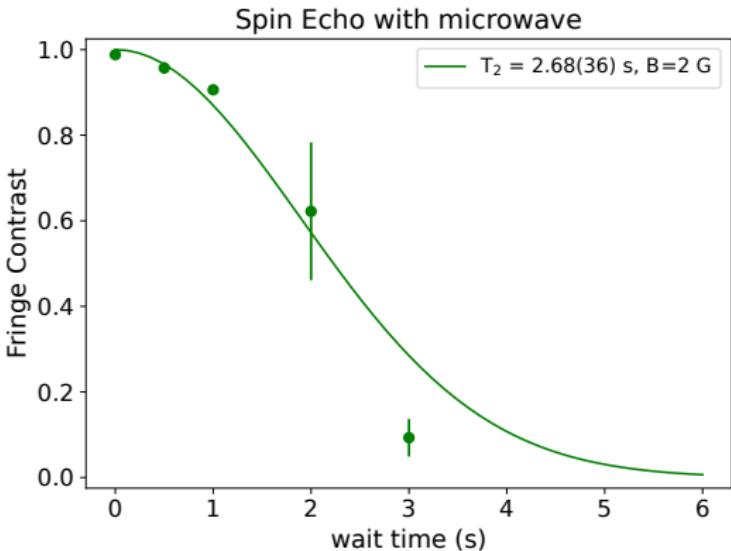


2nd gen EURIQA: Qubit coherence

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

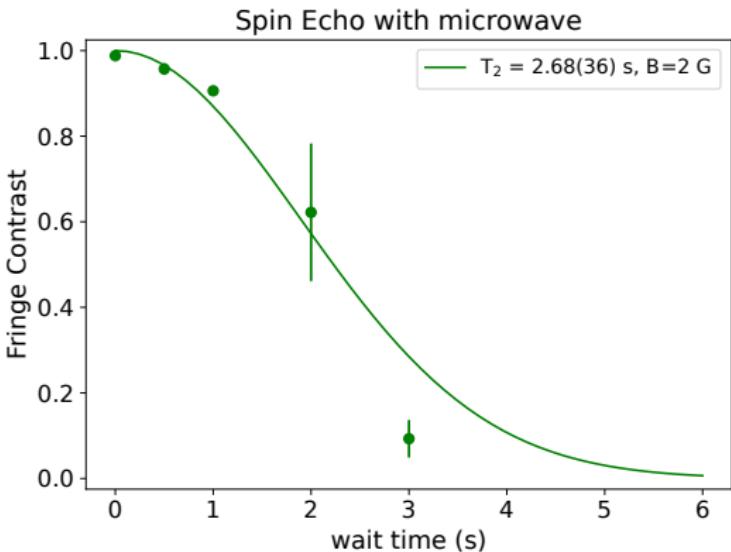
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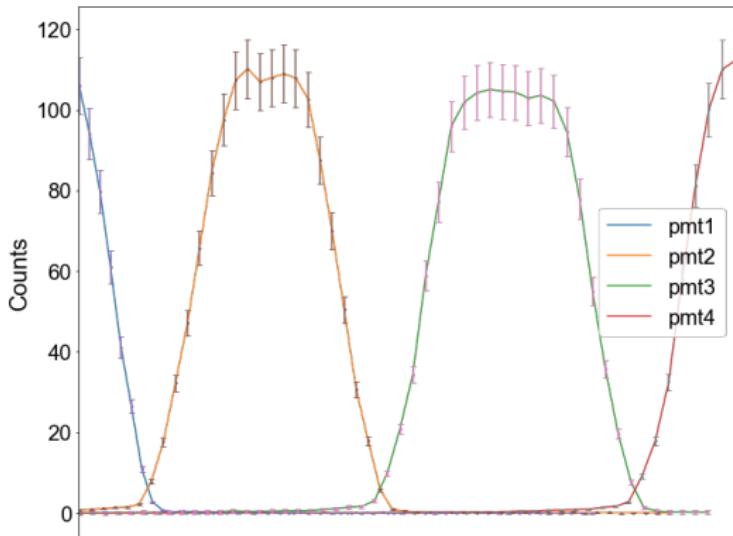


2nd gen EURIQA: Qubit coherence

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2nd gen EURIQA: Imaging system



2nd gen EURIQA: Raman transition on ion



Christopher R Monroe



Alexander Kozhanov



Marko Cetina



Crystal Noel



Lei Feng



Liudmila Zhukas



Debopriyo Biswas



Andrew Risinger

