



# A next-generation trapped ion quantum computing system

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Monroe Group/Duke Quantum Center

June 7, 2023



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

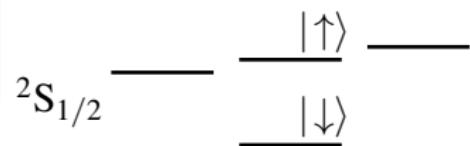
- Long coherence time:  $T_2 \approx 1\text{hr}$

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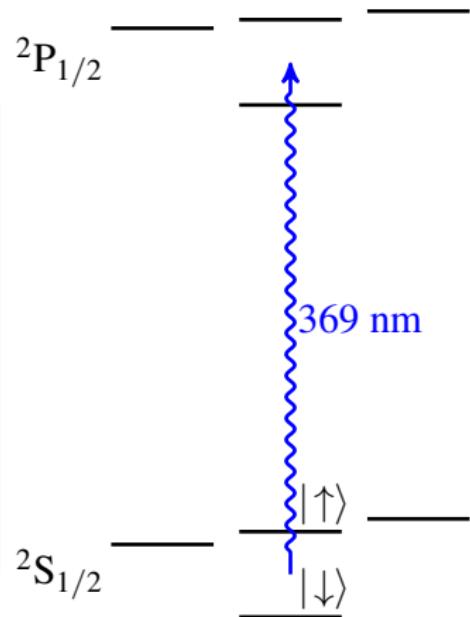
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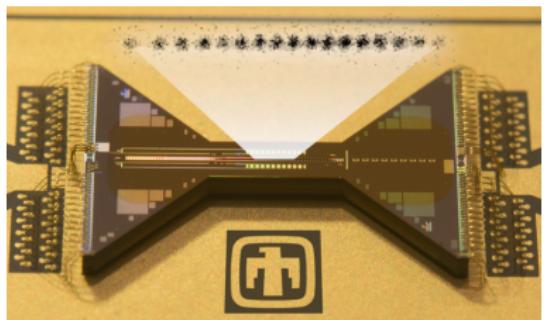
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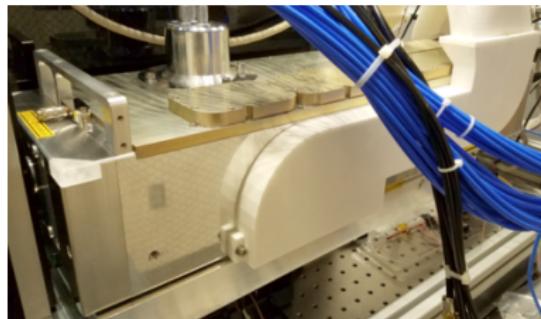
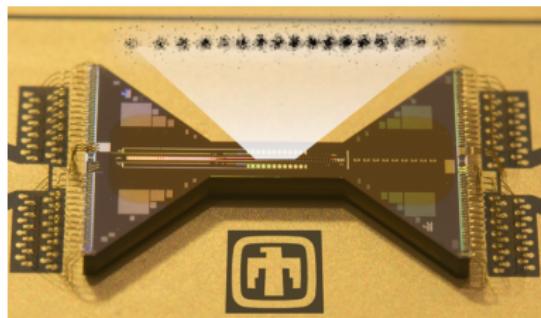
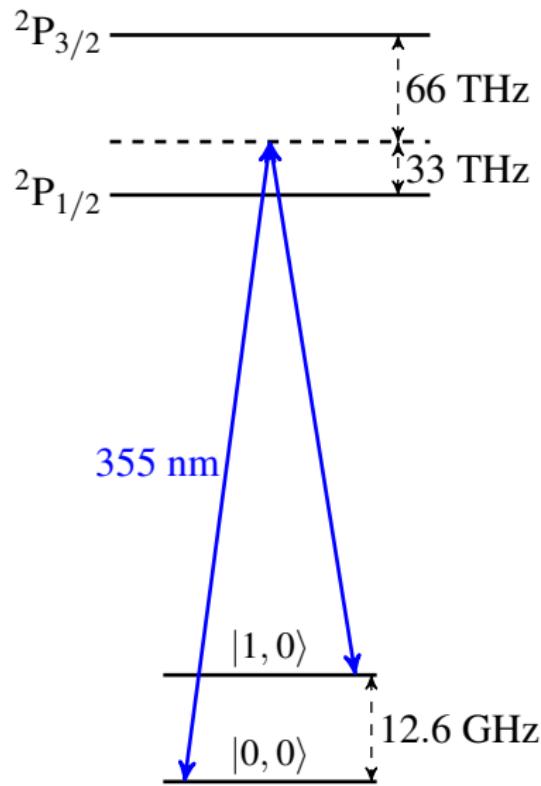
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# $^{171}\text{Yb}^+$ chain and coherent manipulation



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# 1<sup>st</sup> generation EURIQA system

Error-corrected Universal Reconfigurable Ion-trap Quantum Archetype



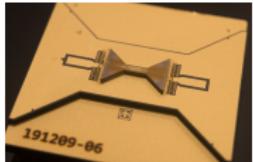
# 1<sup>st</sup> generation EURIQA system

## Error-corrected Universal Reconfigurable Ion-trap Quantum Archetype

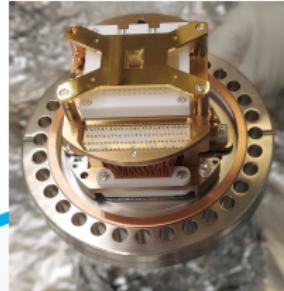


- 15-24 usable qubits
  - High fidelity single (99.9 %) and two-qubit (99 %) gates
- 
- K02: Quantum Simulations and Computations with Ion Trap Systems
  - Z05: Search for Millicharged Dark Matter with Trapped-Ion Quantum Processor

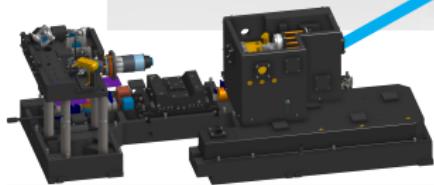
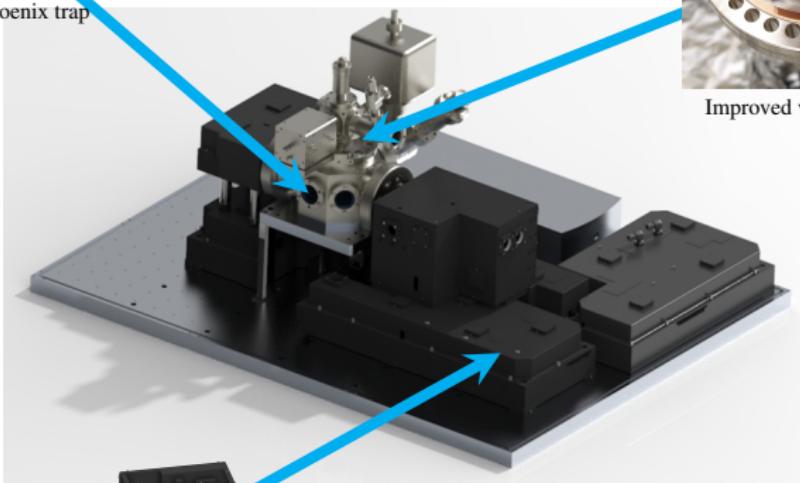
## 2<sup>nd</sup> generation EURIQA system



Sandia Phoenix trap



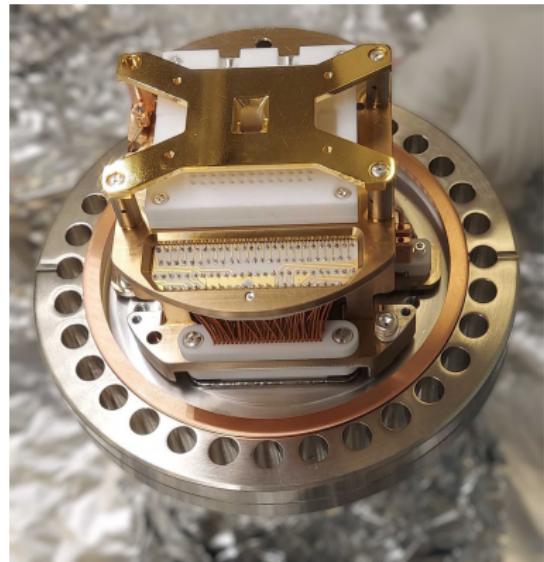
Improved vacuum system



L3Harris Raman beam path

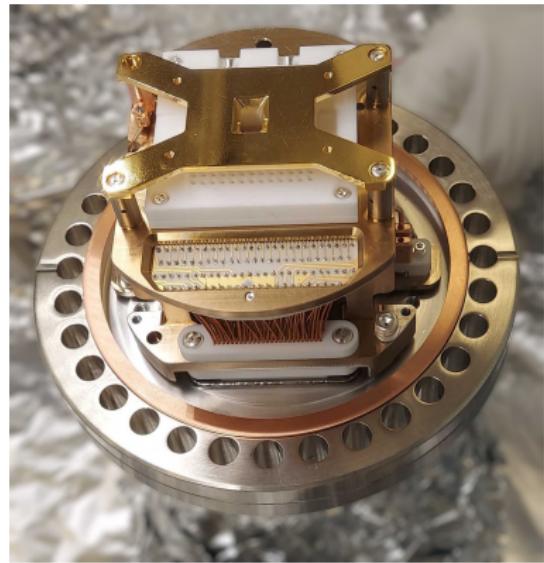
## 2<sup>nd</sup> gen EURIQA: Improved vacuum

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



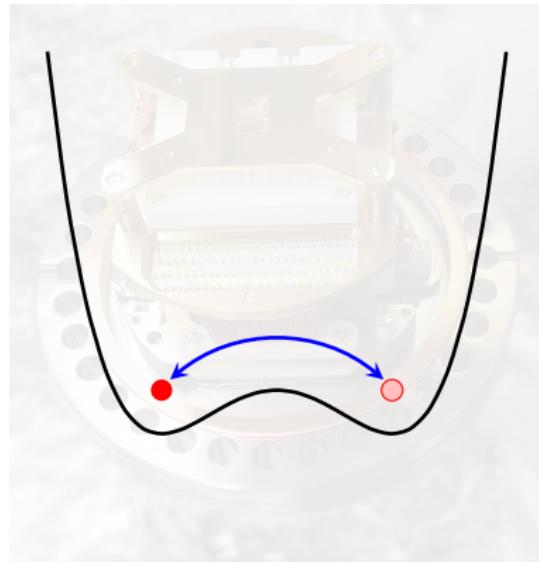
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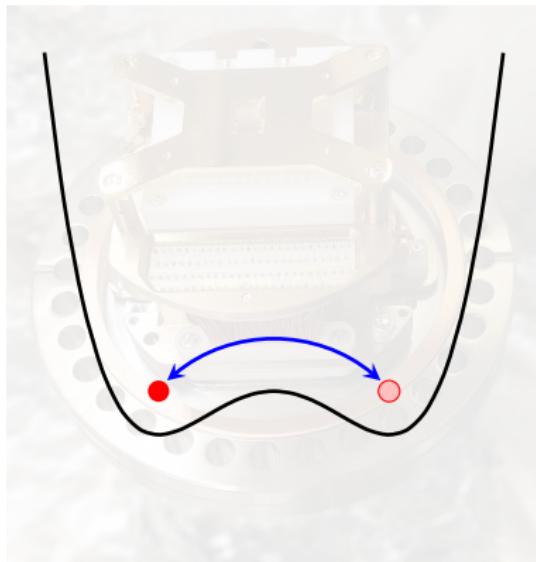
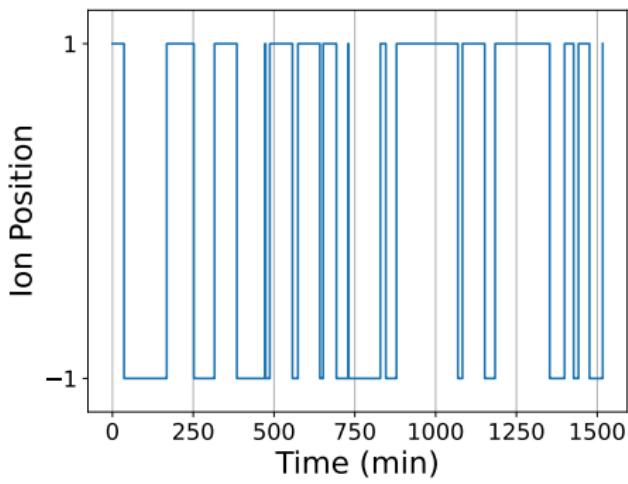
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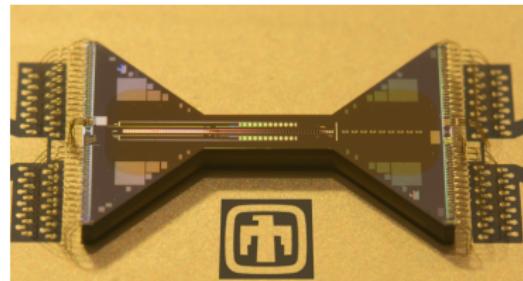
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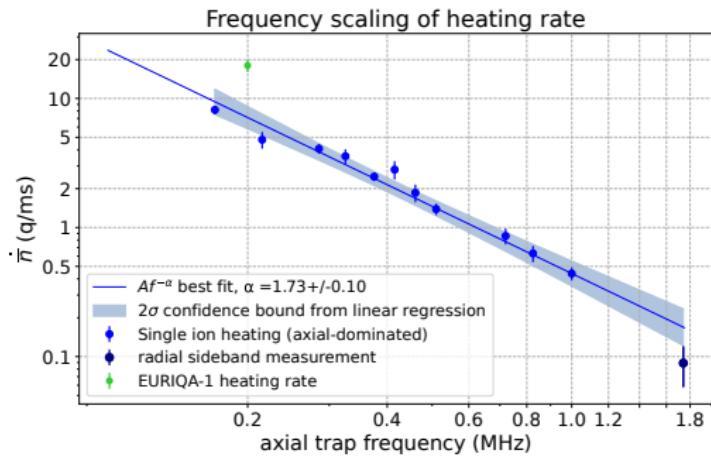
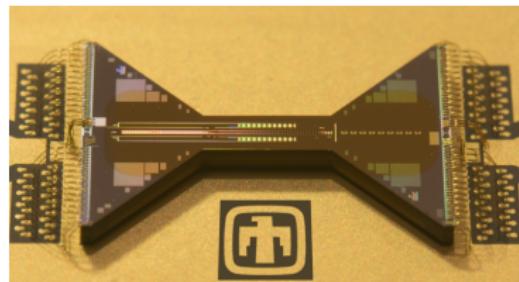
## 2<sup>nd</sup> gen EURIQA: Phoenix trap

- 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



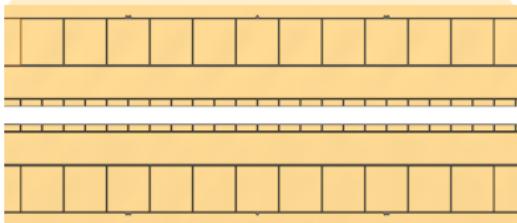
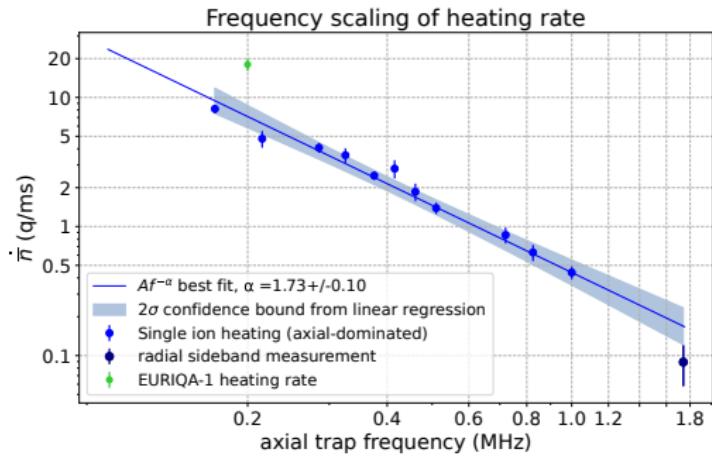
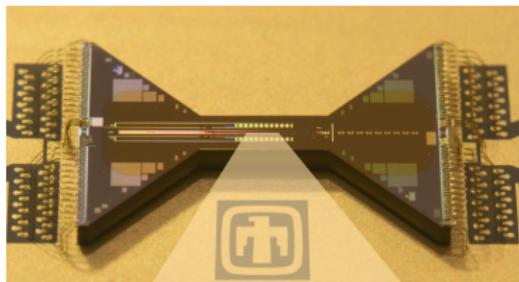
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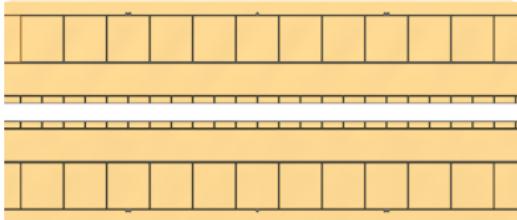
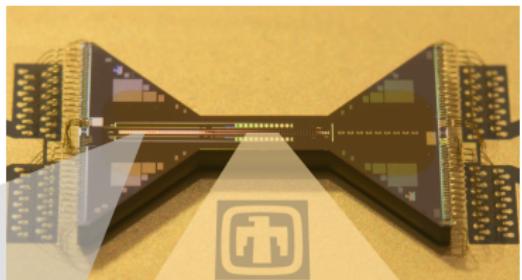
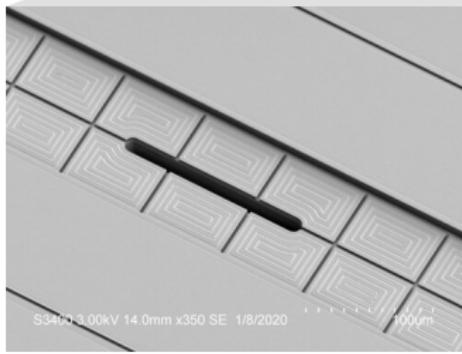
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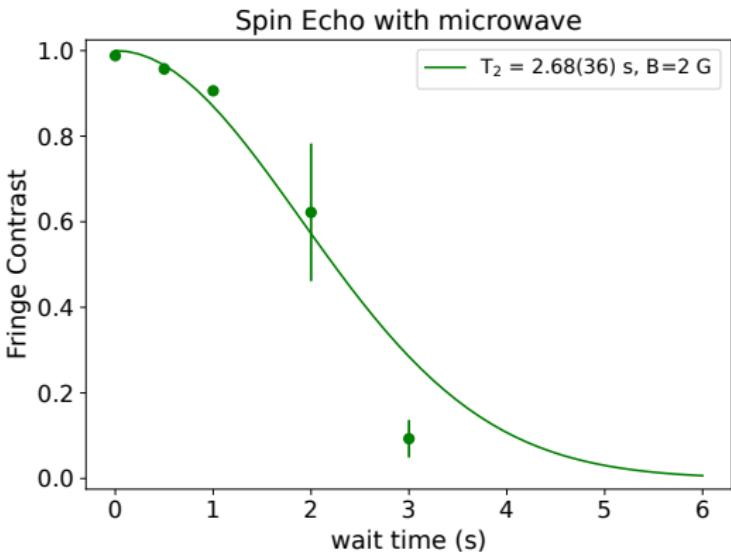


## 2<sup>nd</sup> gen EURIQA: Qubit coherence

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

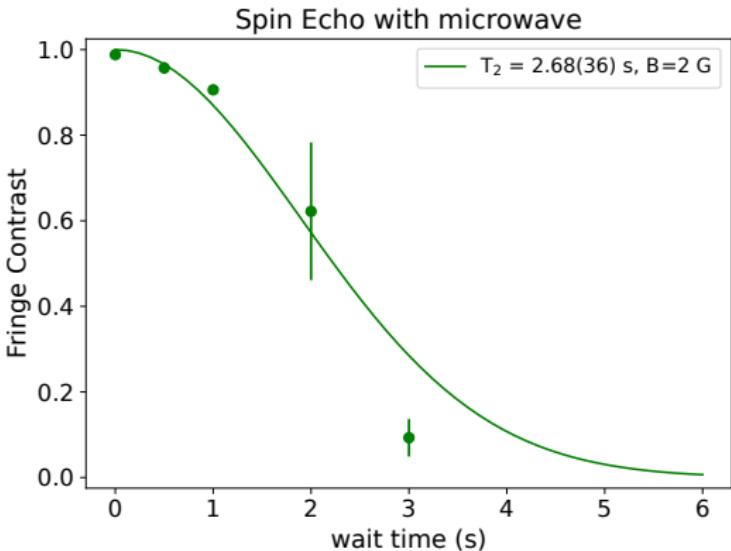
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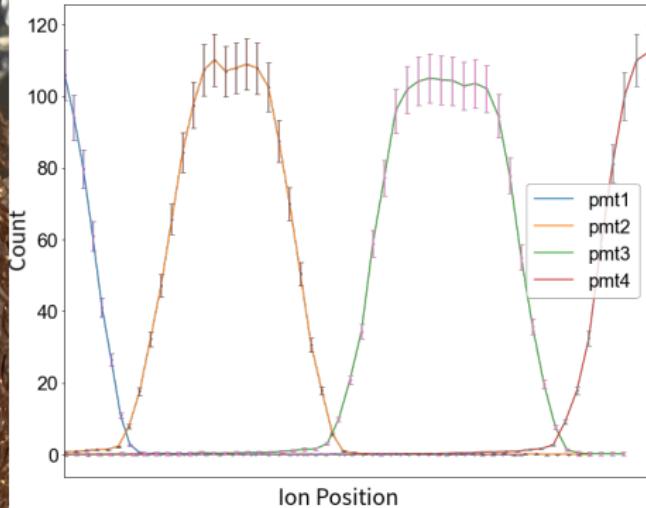


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## 2<sup>nd</sup> gen EURIQA: Imaging system



## 2<sup>nd</sup> gen EURIQA: Raman transition on ion



Christopher R Monroe



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Marko Cetina



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