A next-generation trapped ion quantum computing system

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June 7, 2023

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

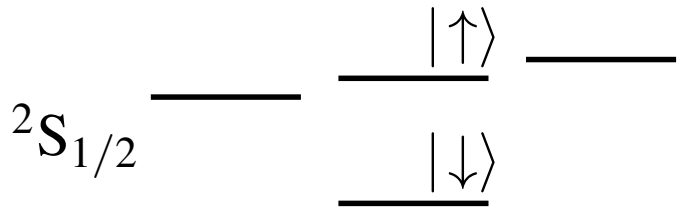
- Long coherence time: $T_2 \approx 1\text{hr}$

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

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

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

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



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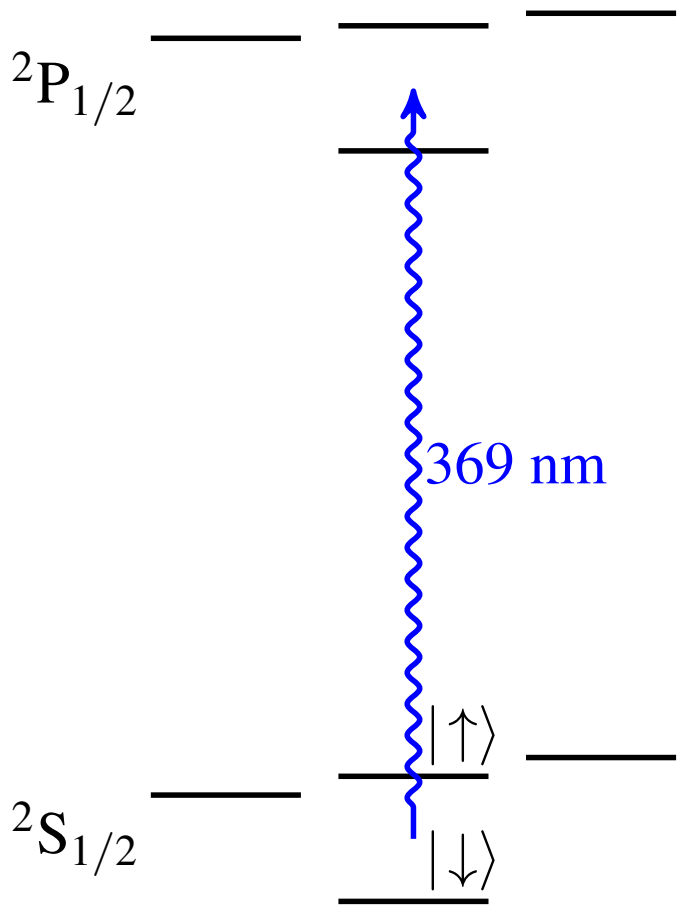
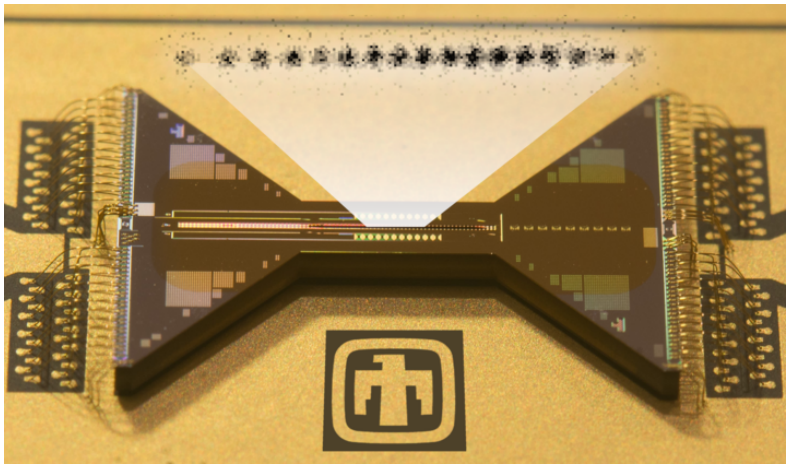


$^{171}Yb^{+}$ chain and coherent manipulation



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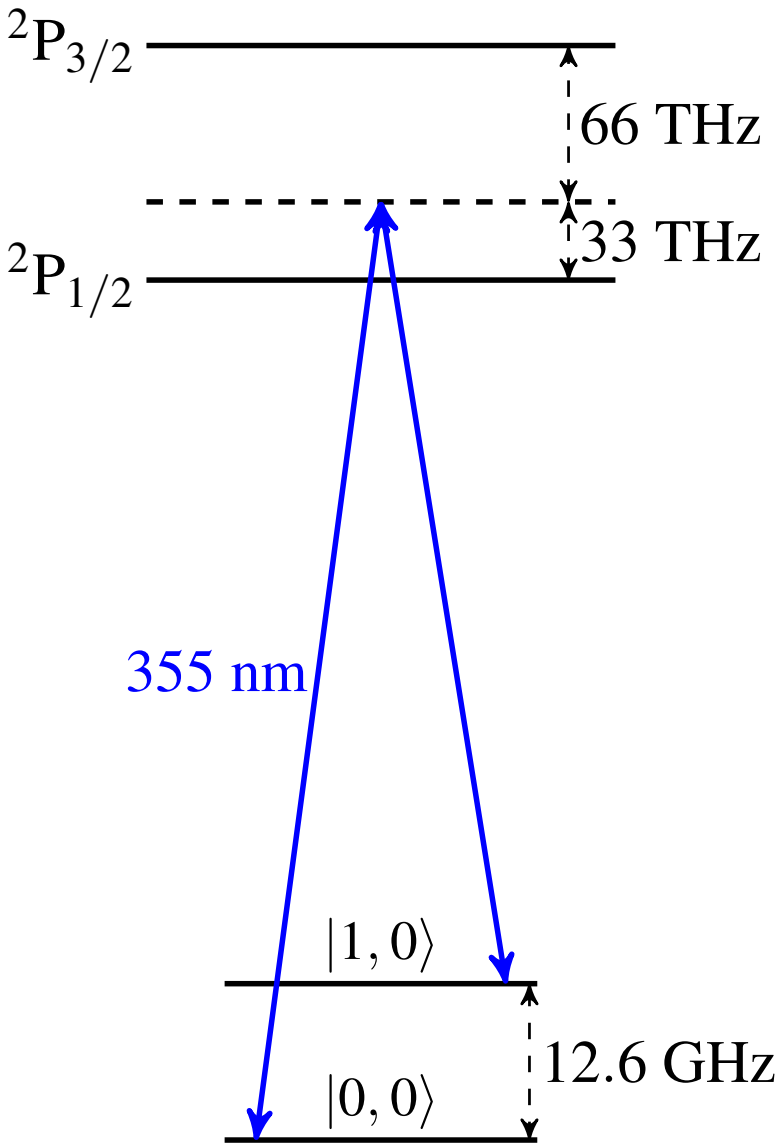

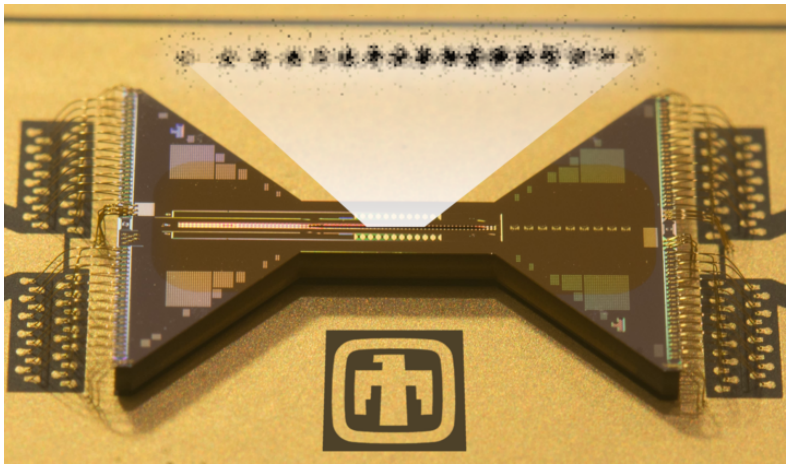

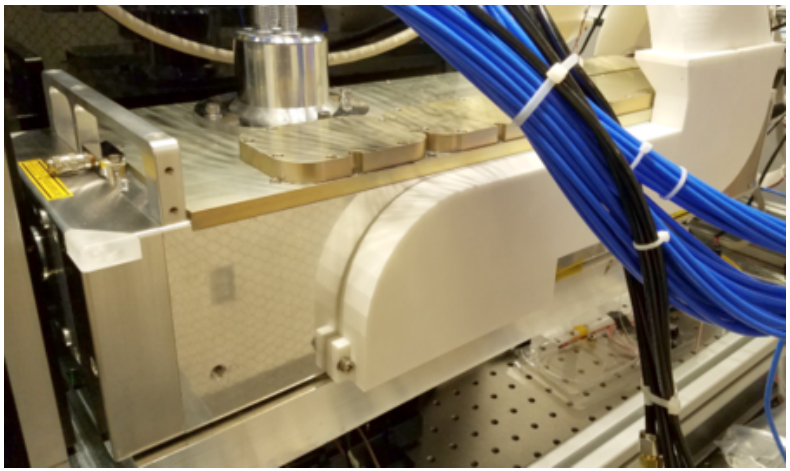

1st generation EURIQA system

Error-corrected **U**niversal **R**econfigurable **I**on-trap **Q**uantum **A**rchetype

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

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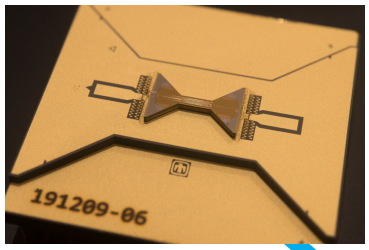
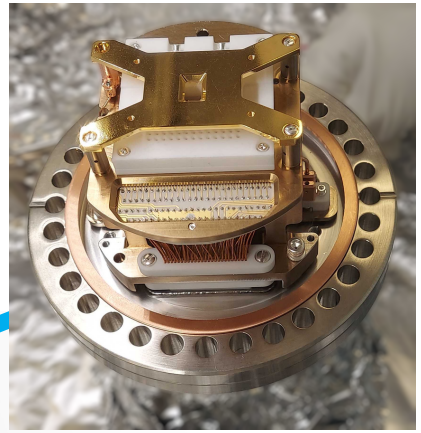
- K02: Quantum Simulations and Computations with Ion Trap Systems
- Z05: Search for Millicharged Dark Matter with Trapped-Ion Quantum Processor

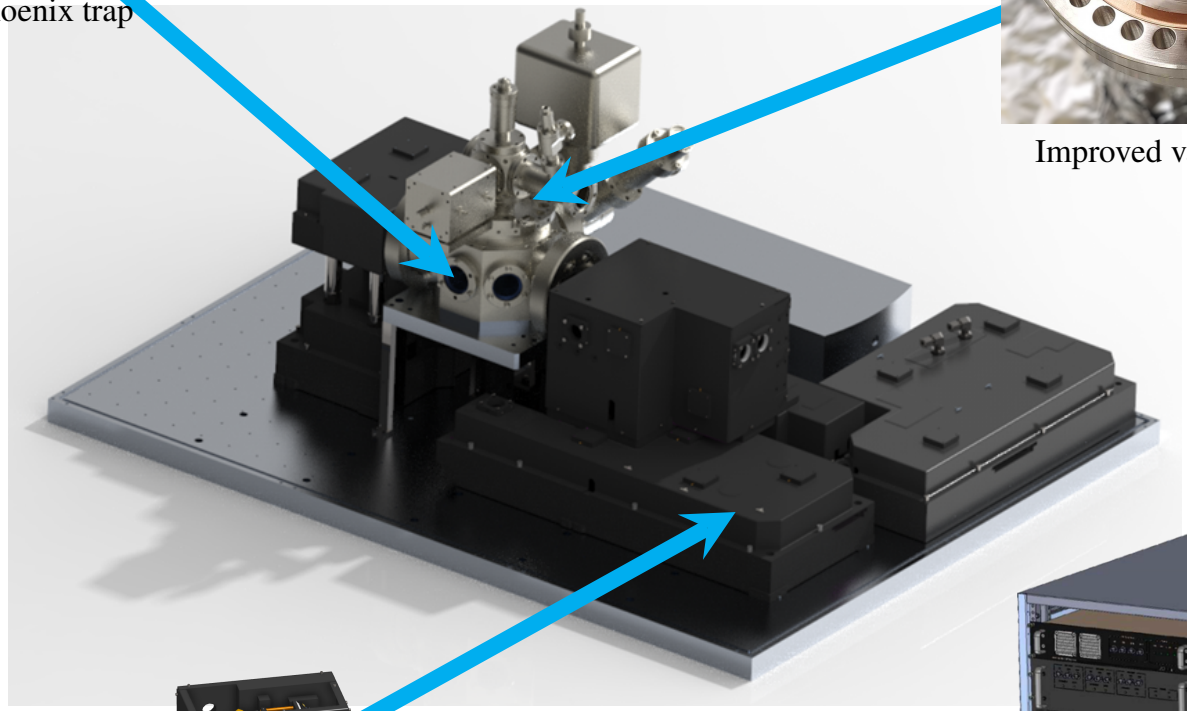
2nd generation EURIQA system

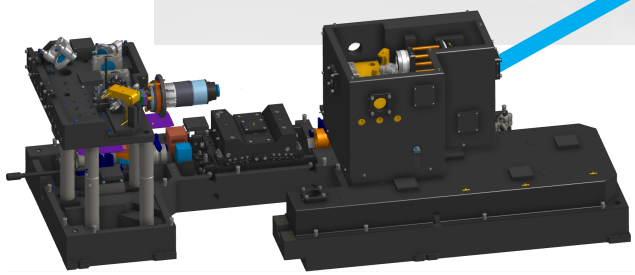


Sandia Phoenix trap



Improved vacuum system



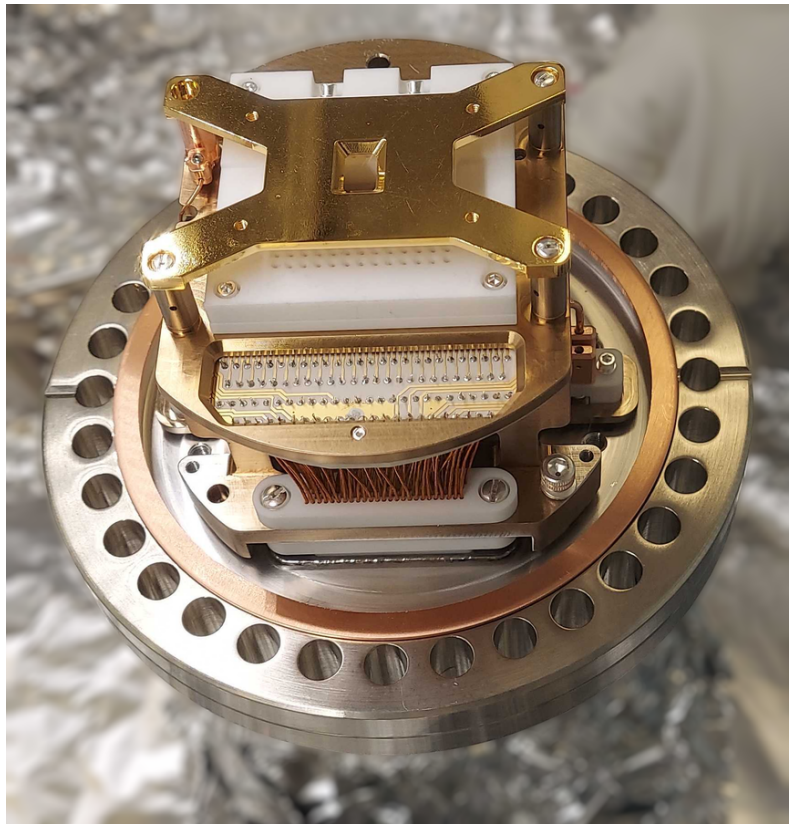


L3Harris Raman beam path

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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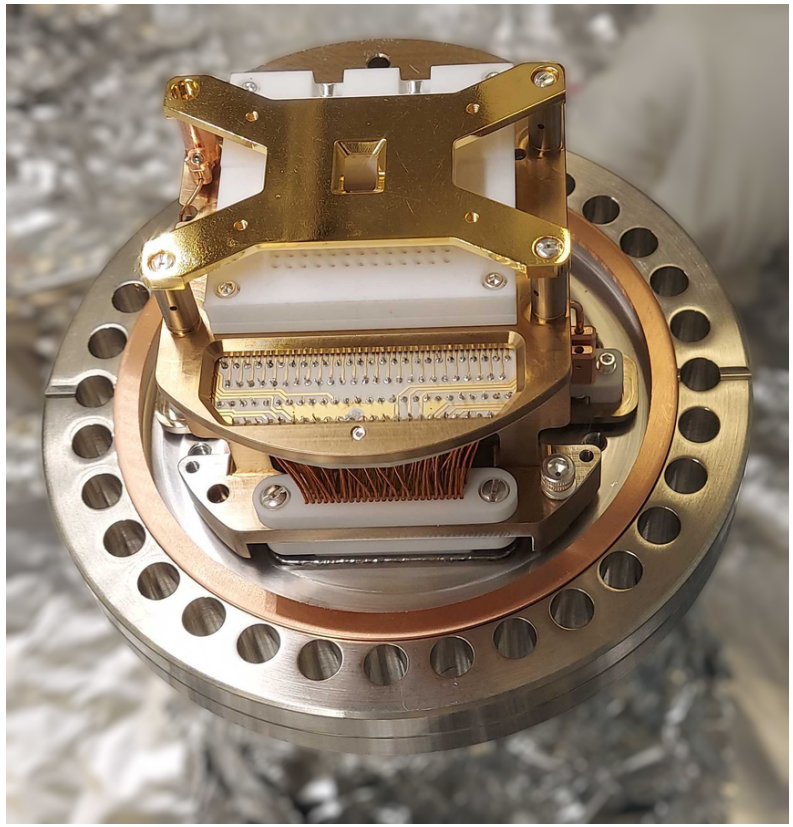

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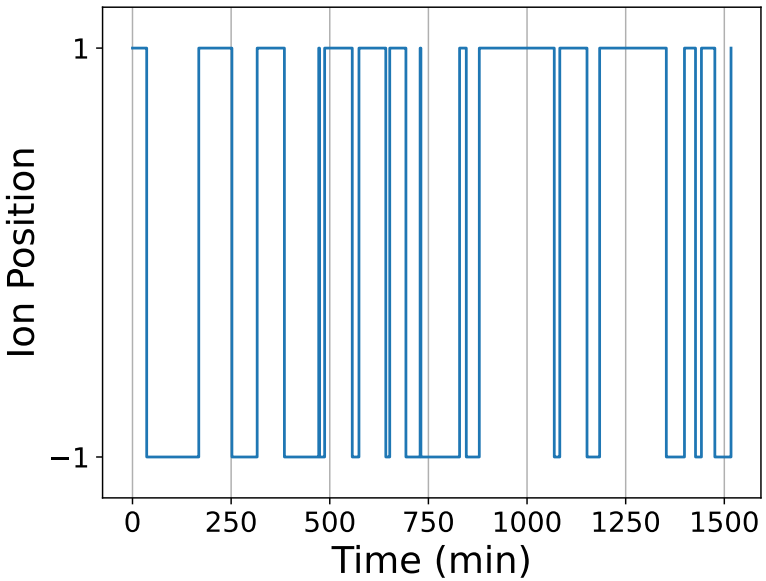
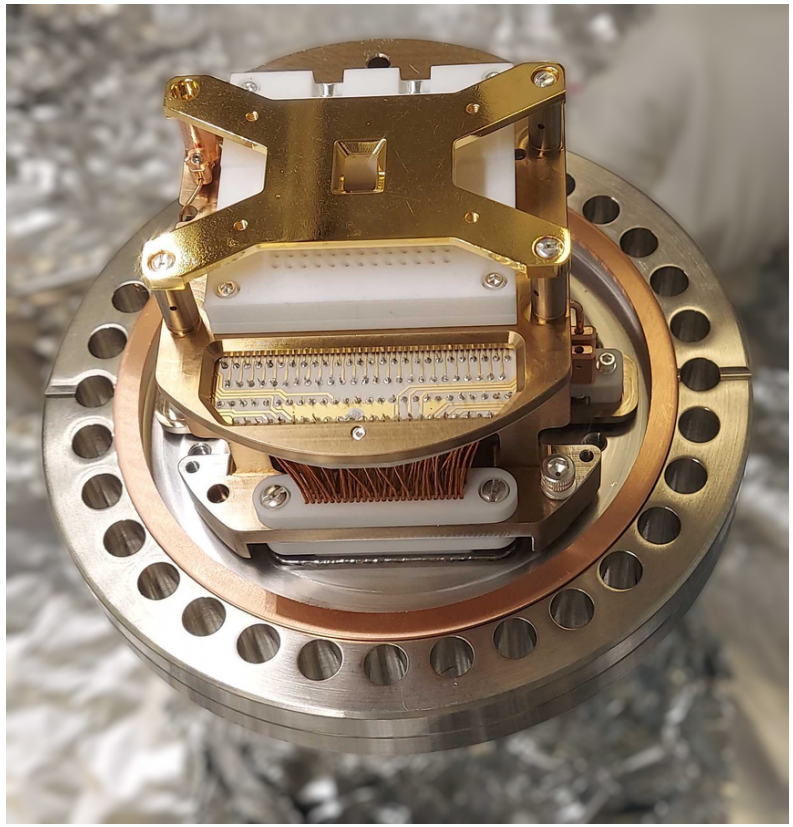


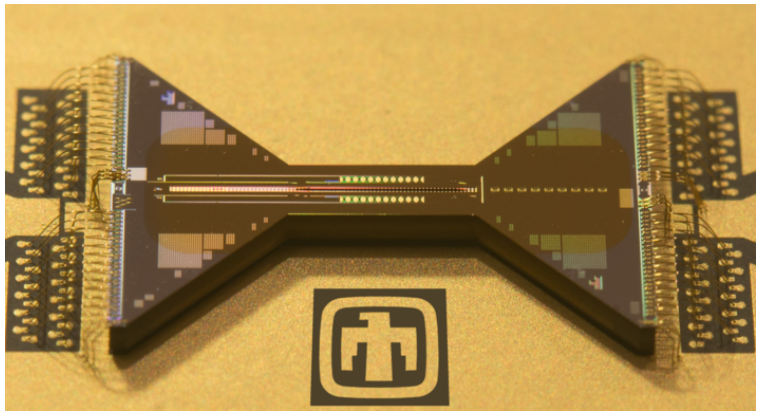


2nd gen EURIQA: Phoenix trap

- 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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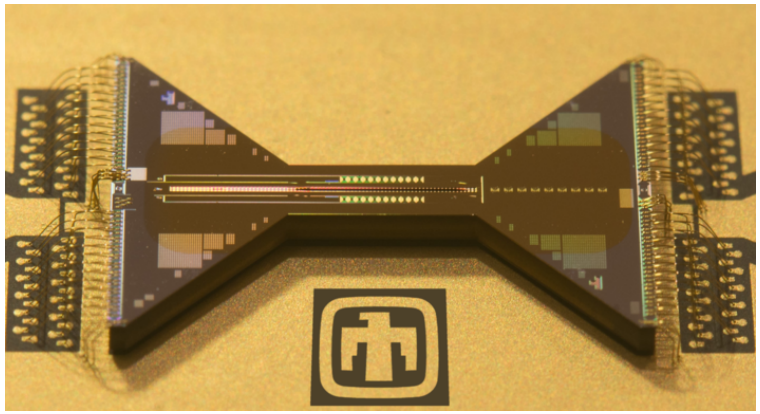

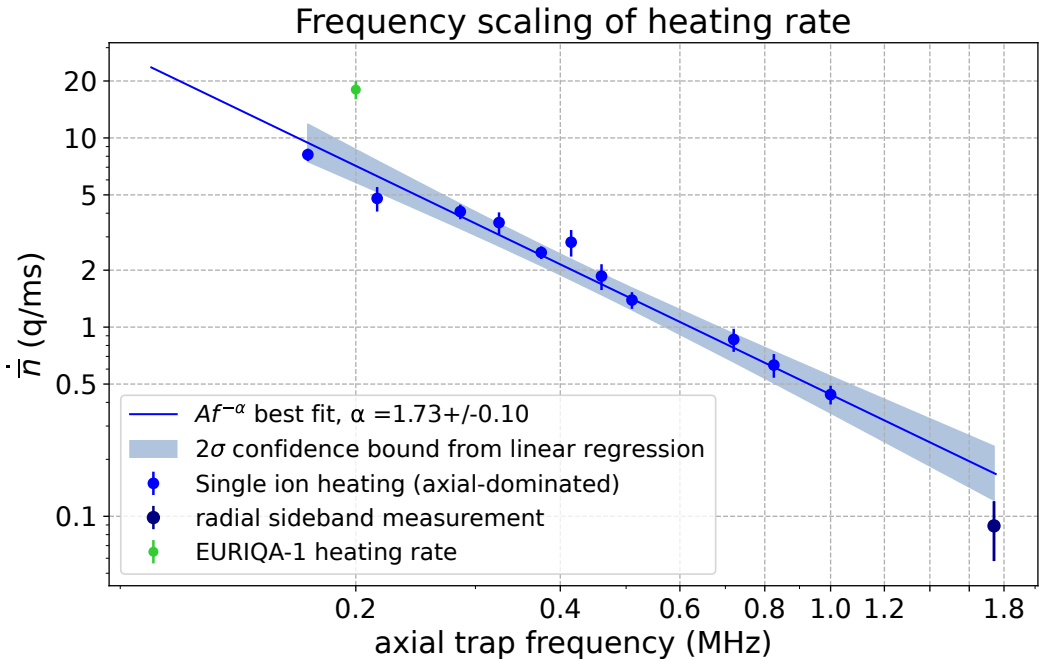

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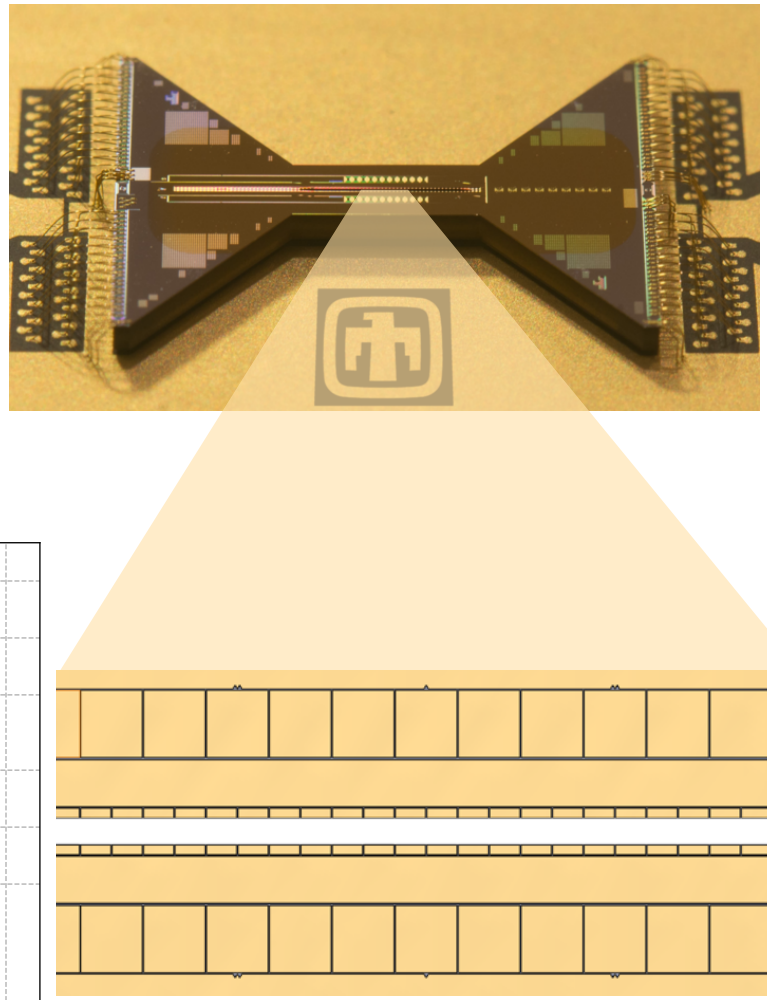

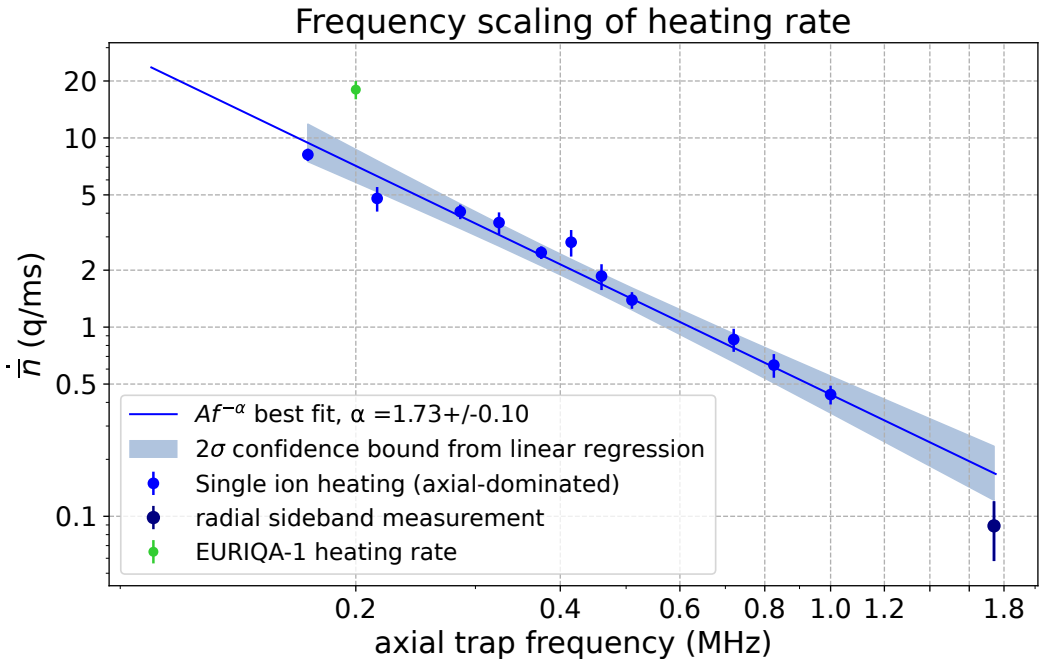

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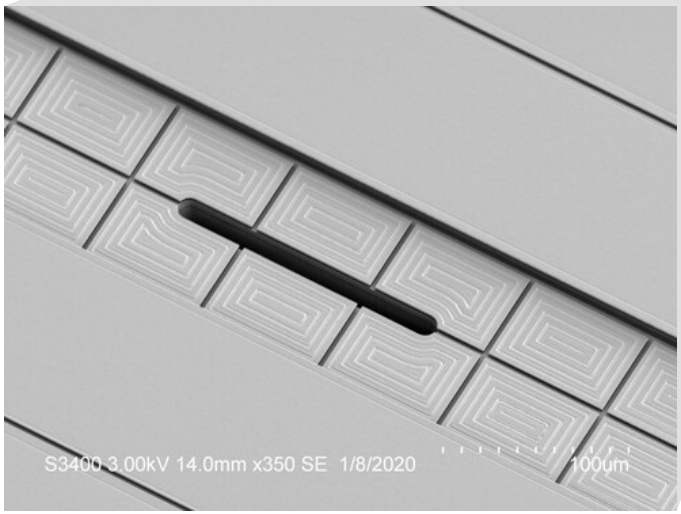

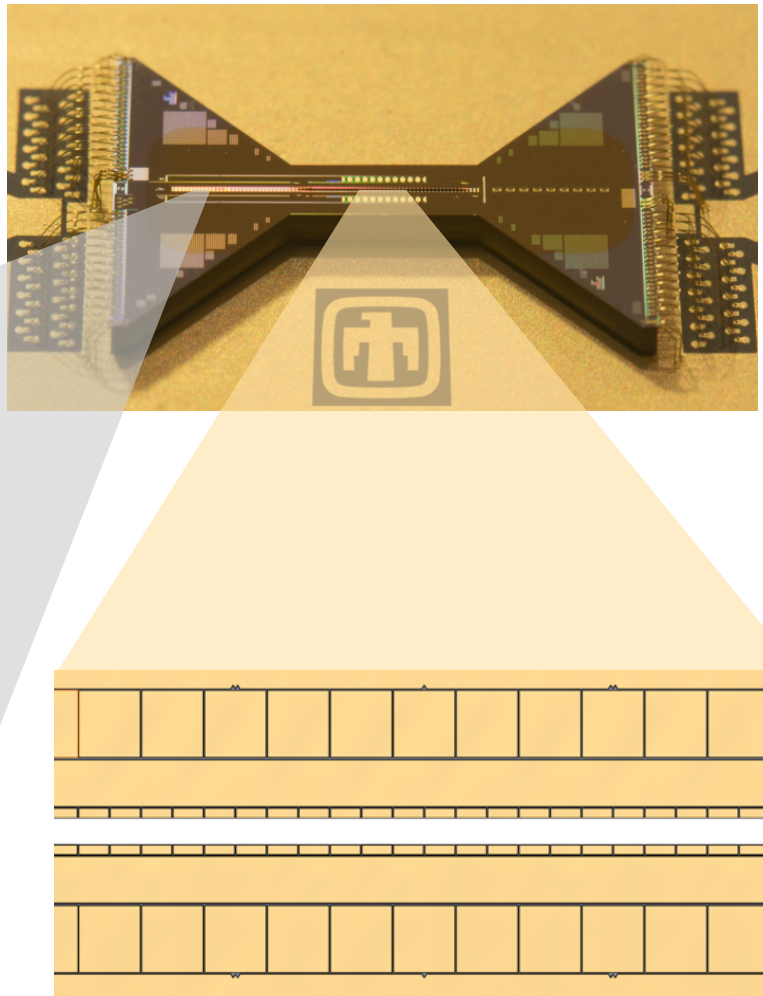

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- Ramsey experiment using microwave
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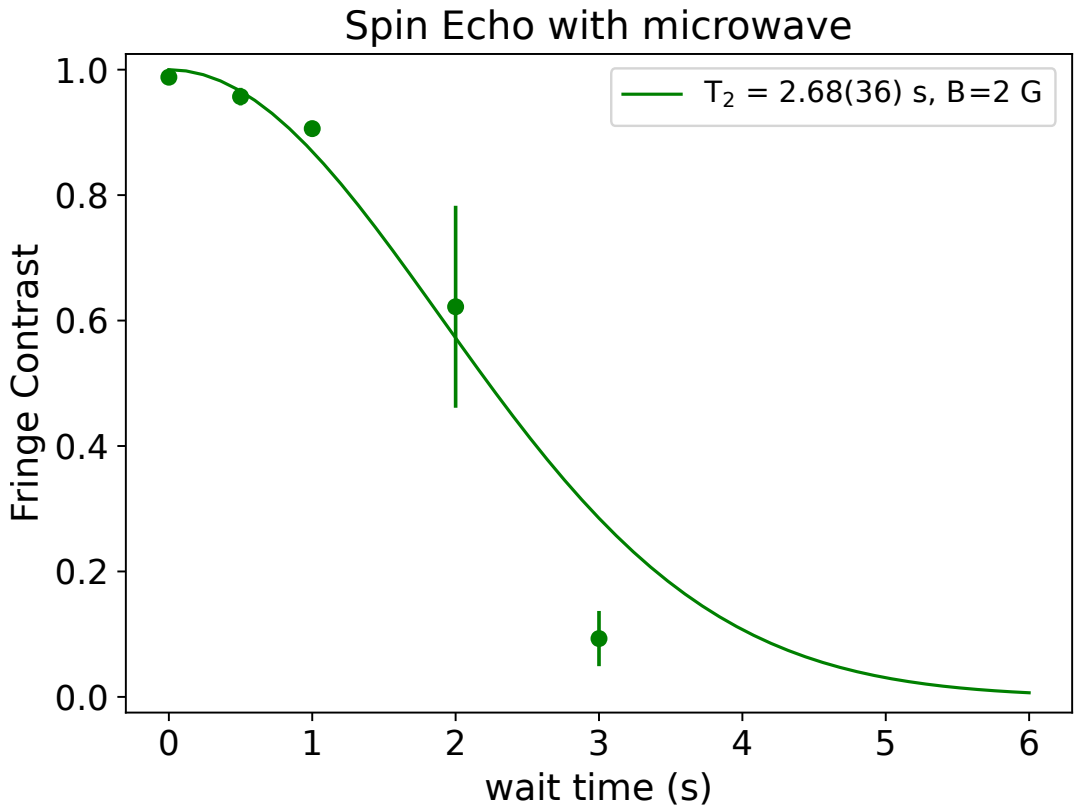

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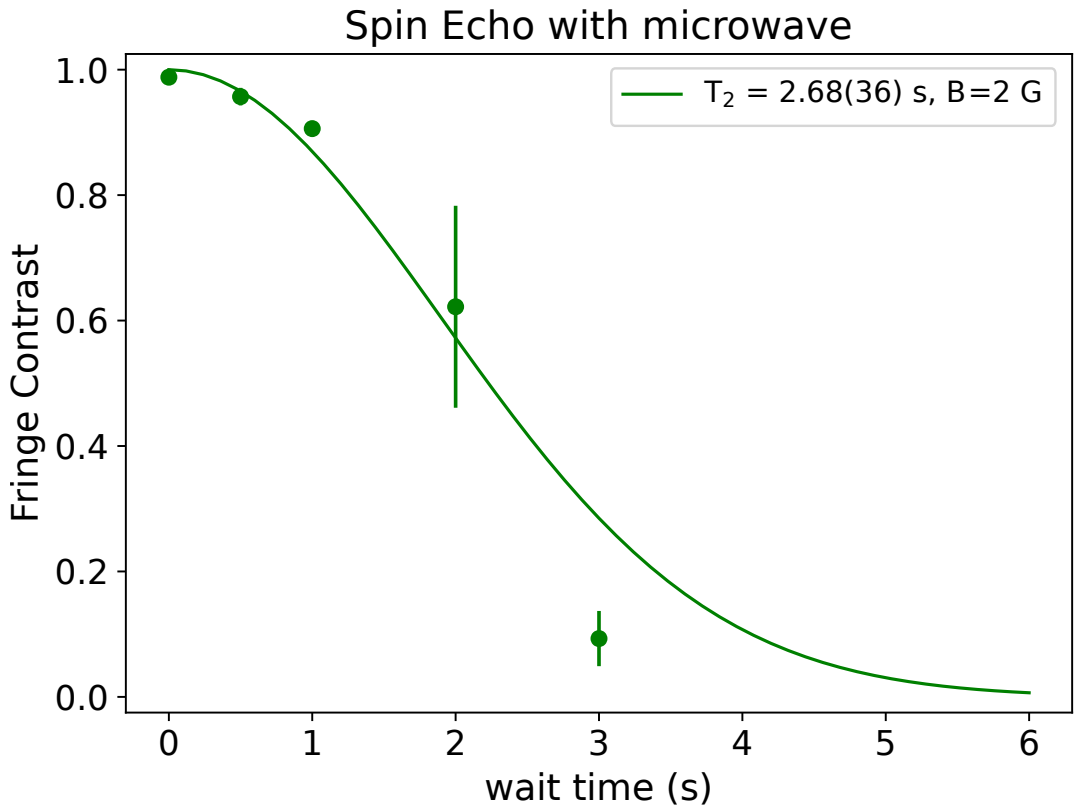
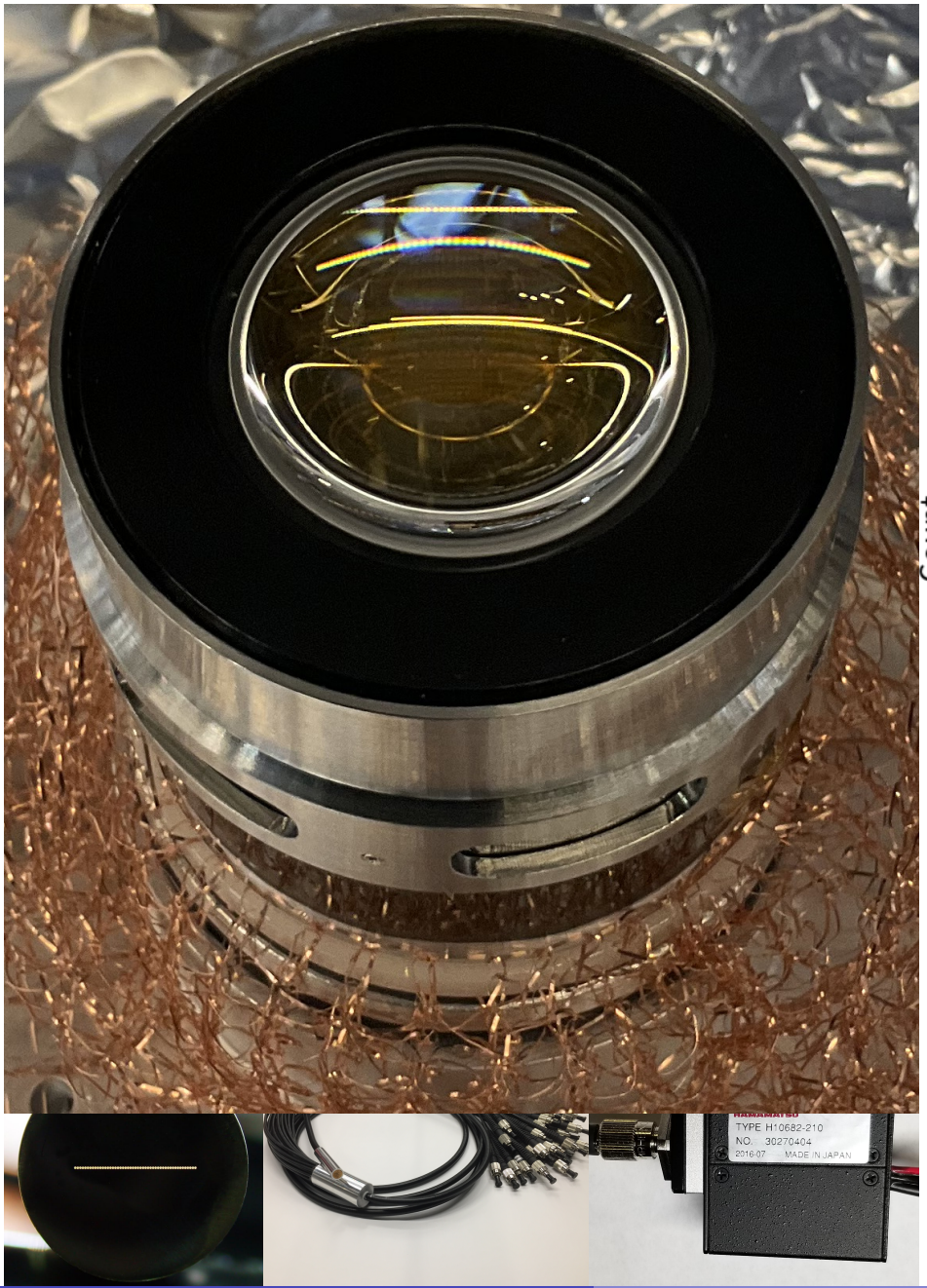
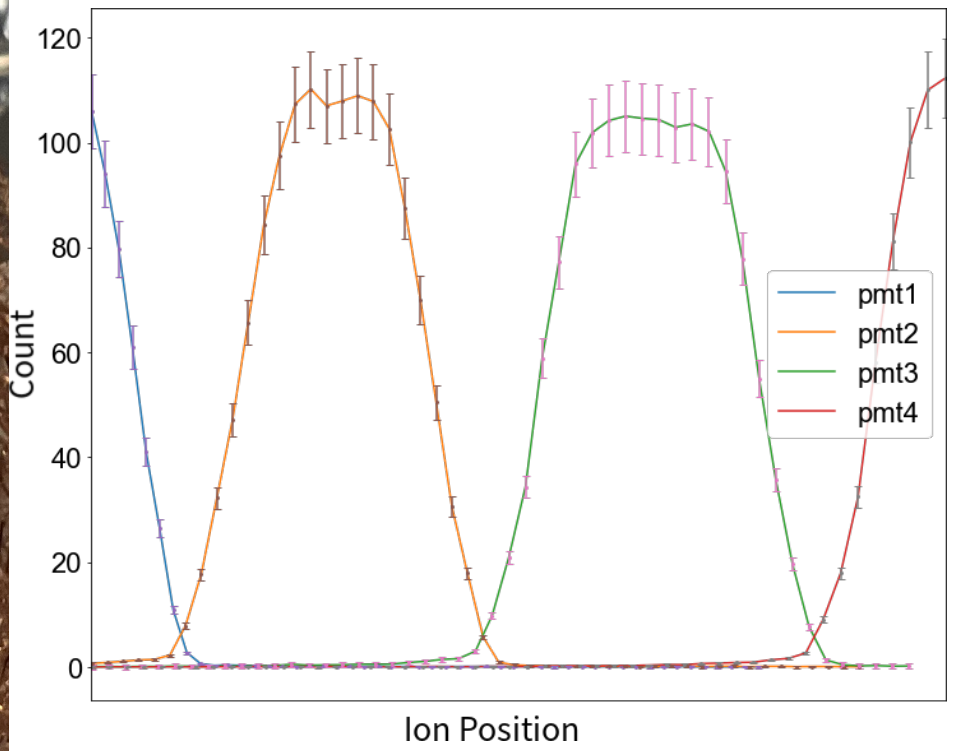


2nd gen EURIQA: Imaging system





2nd gen EURIQA: Raman transition on ion

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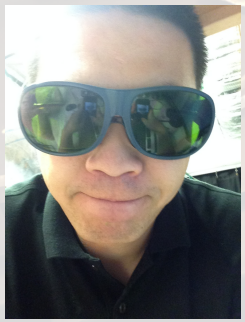
Alexander Kozhanov

Marko Cetina

Crystal Noel



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