



# A next-generation trapped ion quantum computing system

Yichao Yu

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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

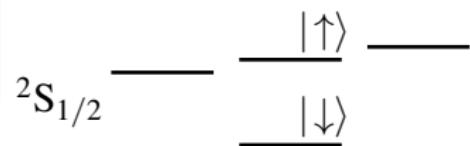
- Long coherence time:  $T_2 \approx 1\text{hr}$

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  $\approx 100\mu\text{s}$

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



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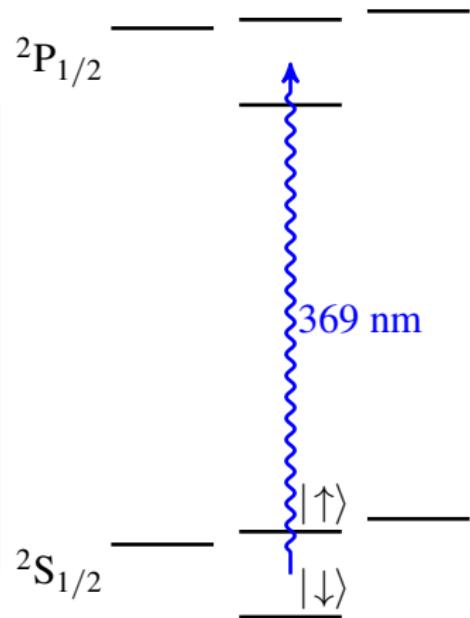
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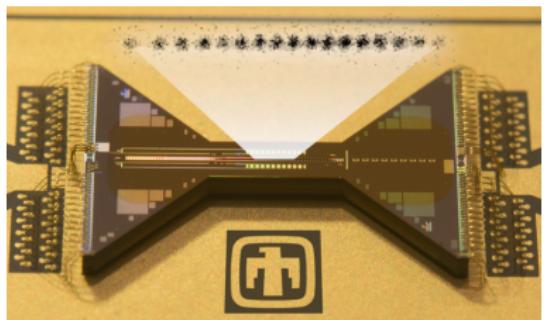
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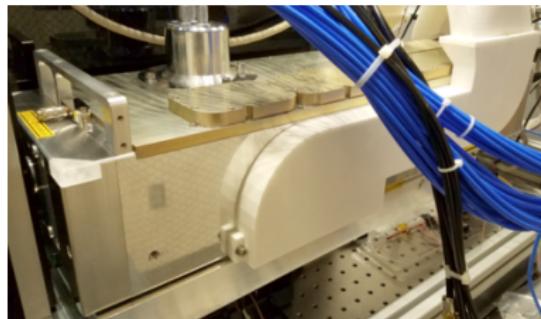
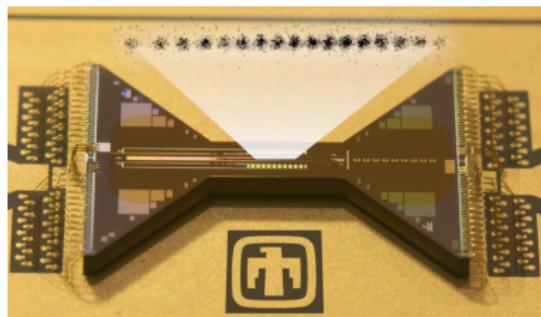
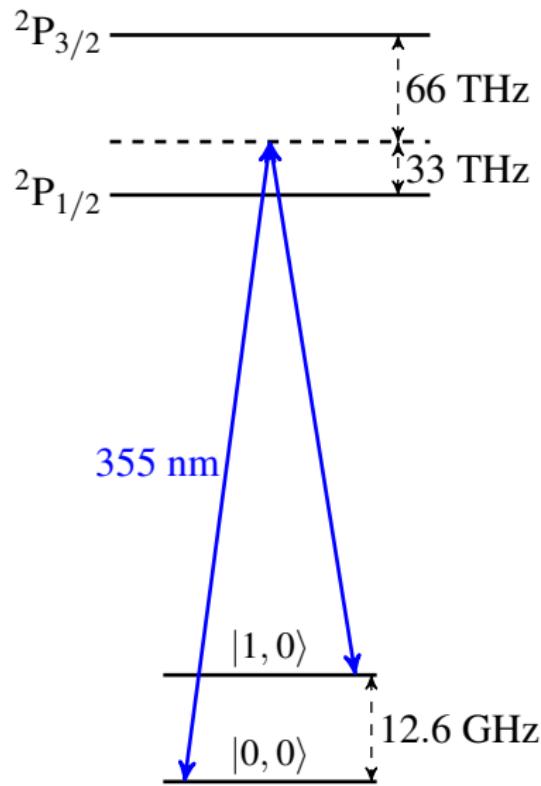
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# $^{171}\text{Yb}^+$ chain and coherent manipulation



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

Error-corrected Universal Reconfigurable Ion-trap Quantum Archetype



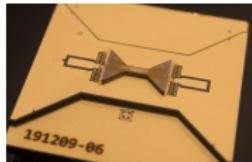
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## Error-corrected Universal Reconfigurable Ion-trap Quantum Archetype

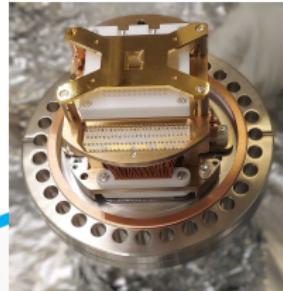


- 15-24 usable qubits
  - High fidelity single (99.9 %) and two-qubit (99 %) gates
- 
- K02: Quantum Simulations and Computations with Ion Trap Systems
  - Z05: Search for Millicharged Dark Matter with Trapped-Ion Quantum Processor

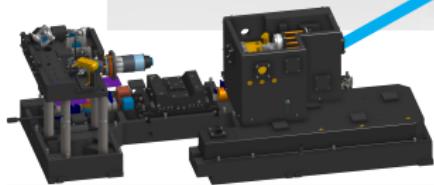
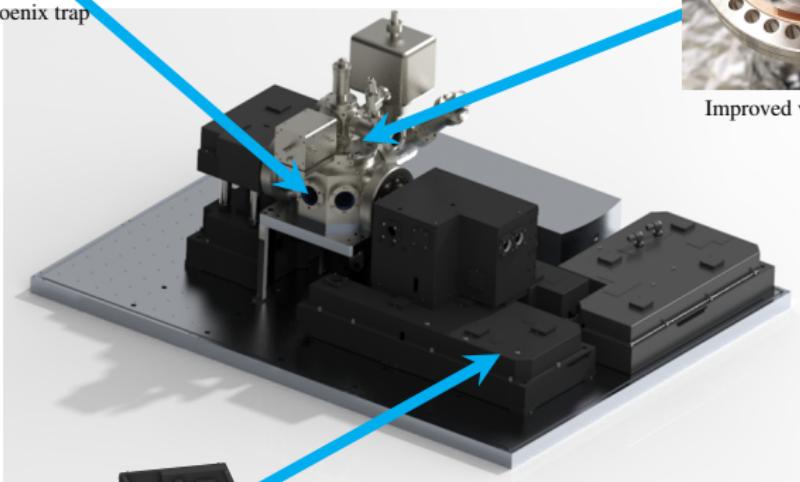
## 2<sup>nd</sup> generation EURIQA system



Sandia Phoenix trap



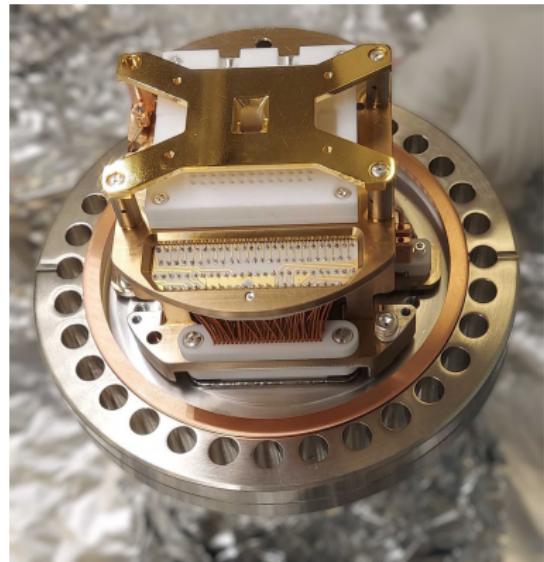
Improved vacuum system



L3Harris Raman beam path

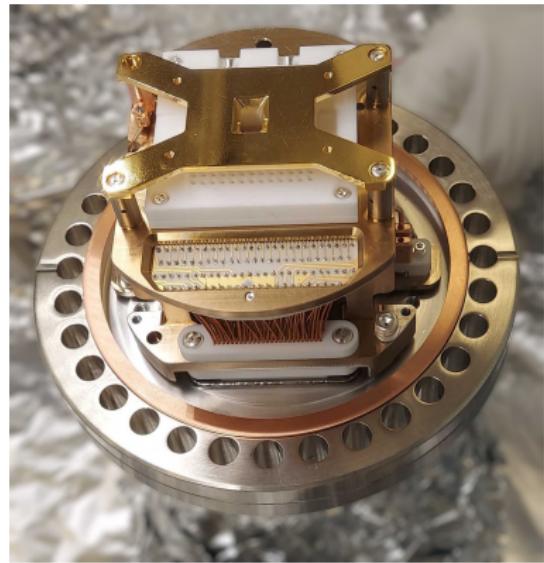
## 2<sup>nd</sup> gen EURIQA: Improved vacuum

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



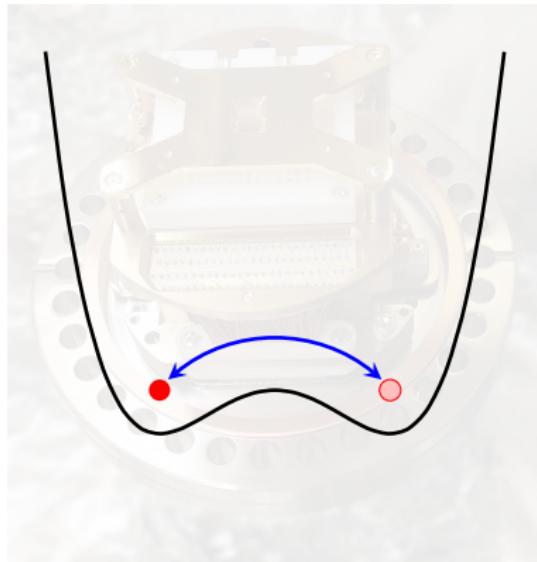
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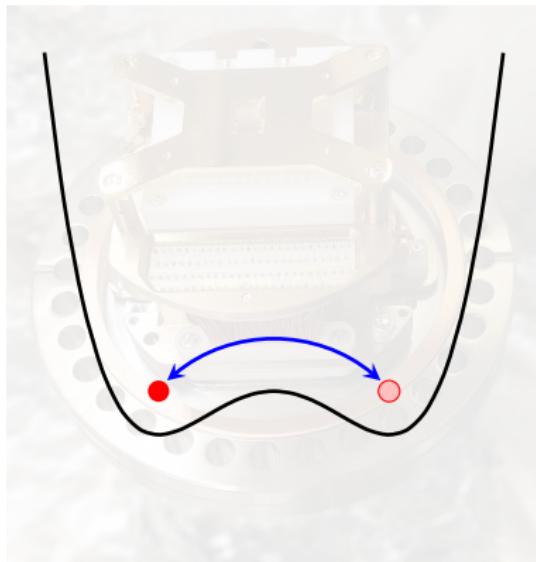
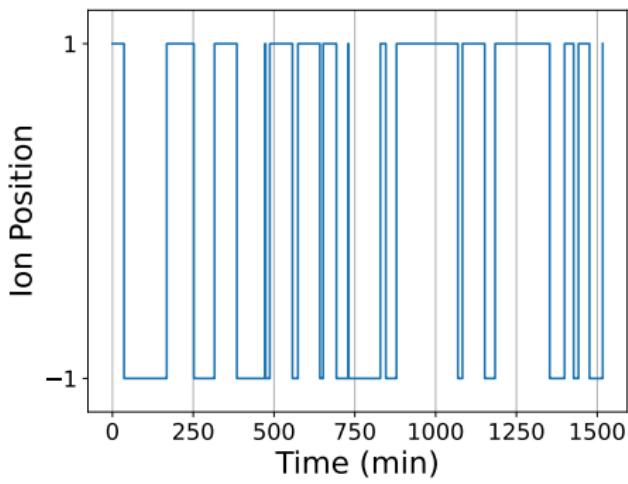
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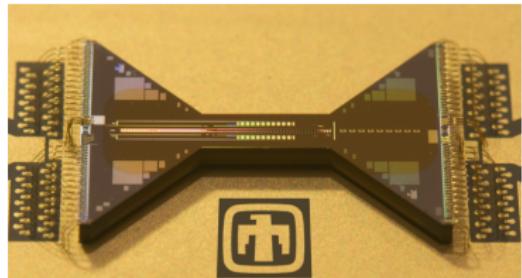
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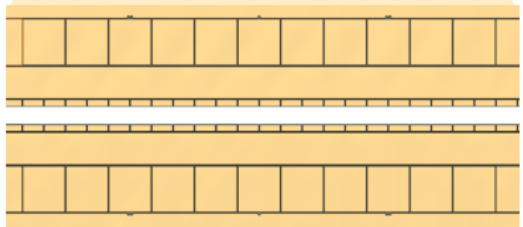
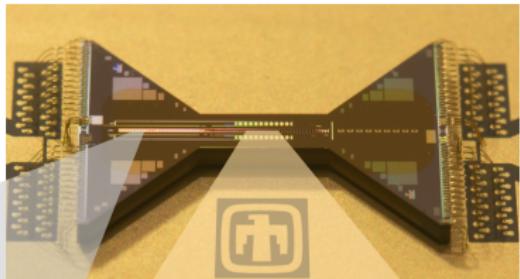
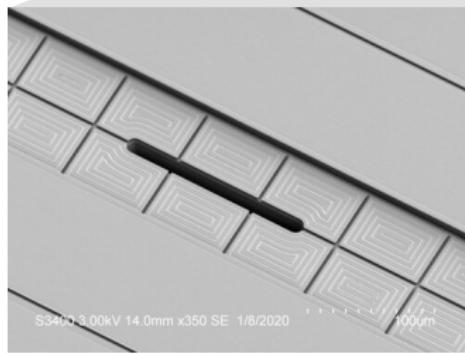
- Better loading and chain control
- Reduced surface electrical noise  
3x less heating compared to EURIQA-1



F01.00038 The Quantum Scientific Computing  
Open User Testbed (QSCOUT)

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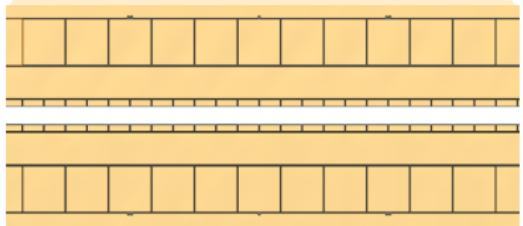
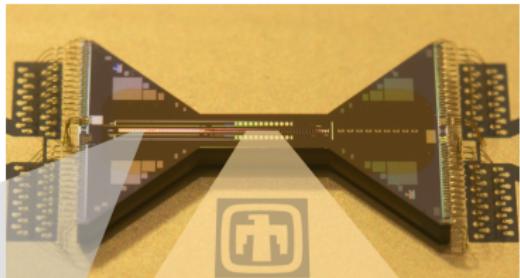
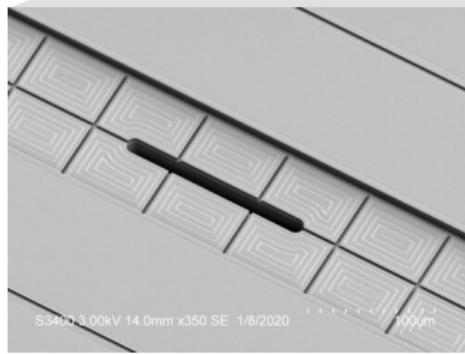


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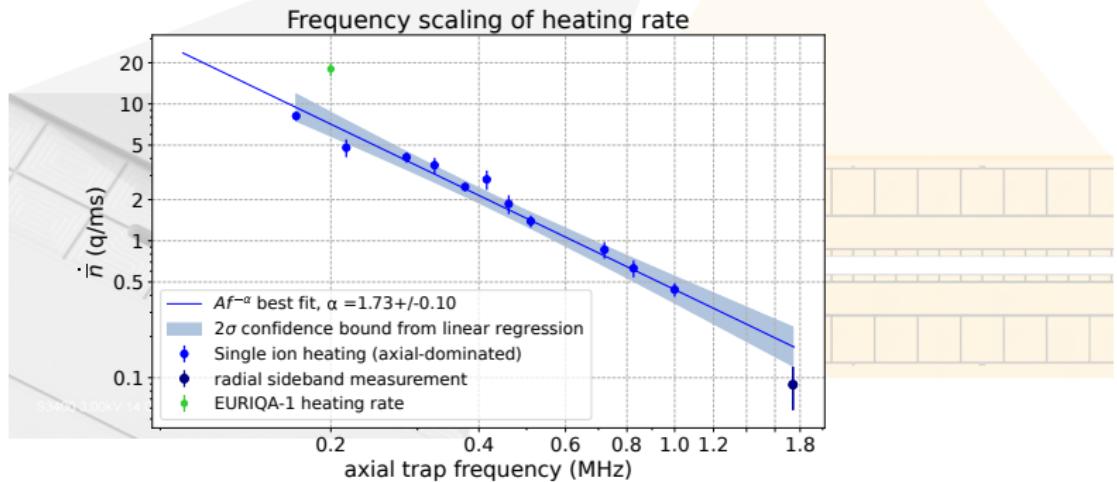
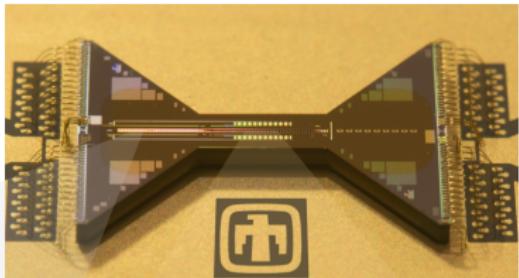
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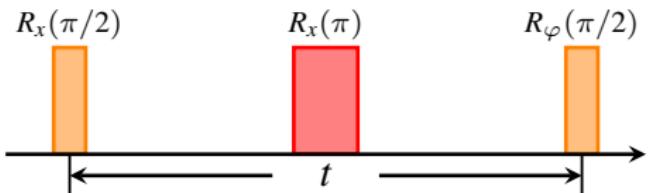
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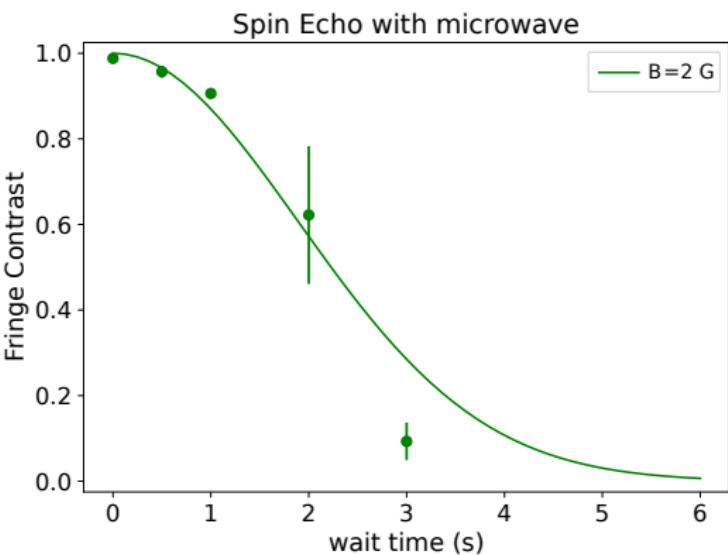
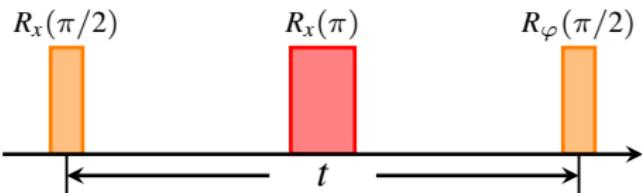
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- Ramsey with spin-echo using microwave
- $T_2 = 2.68(36)$  s  
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- NA=0.63 lens.
- 32 channel fiber bundle for individual detection.
- Crosstalk between neighboring channels: 0.05%

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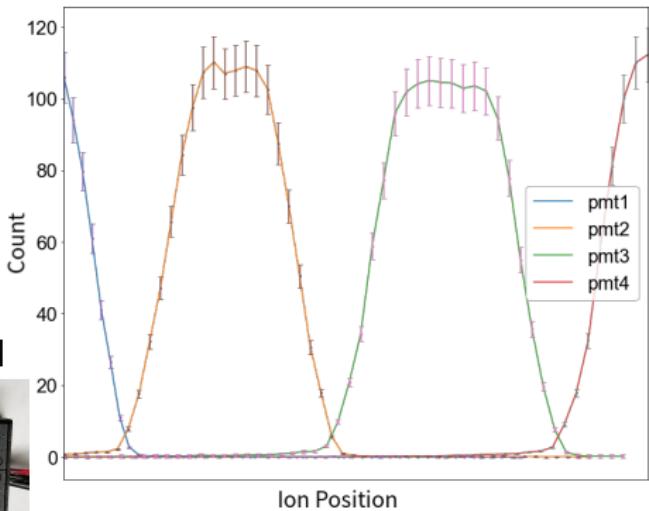
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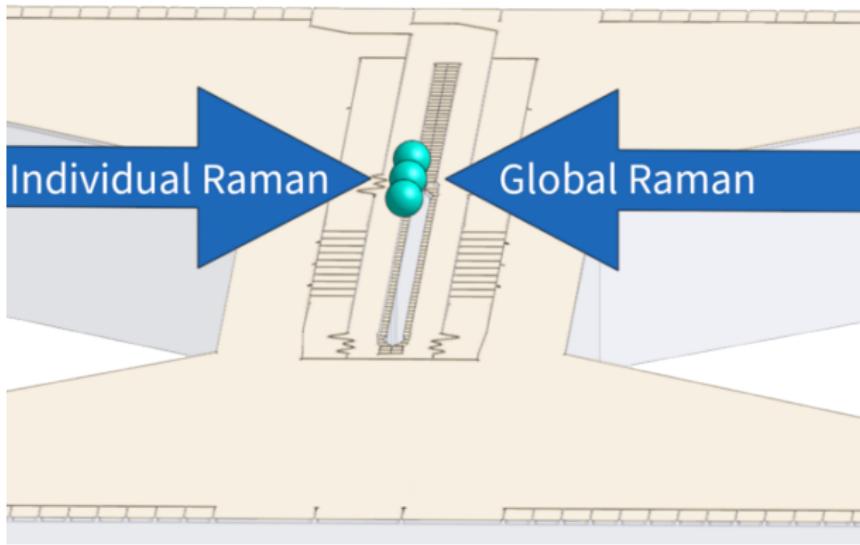
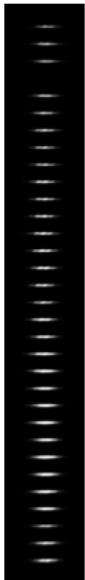


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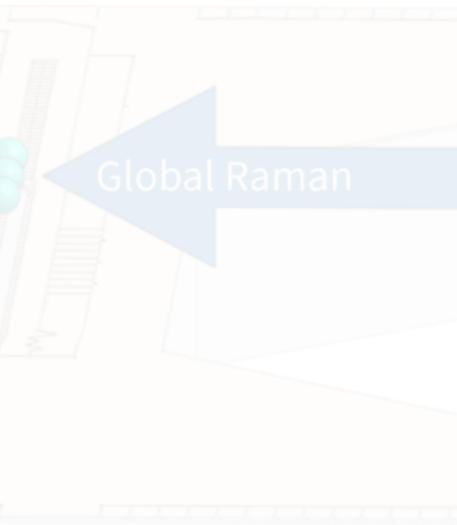
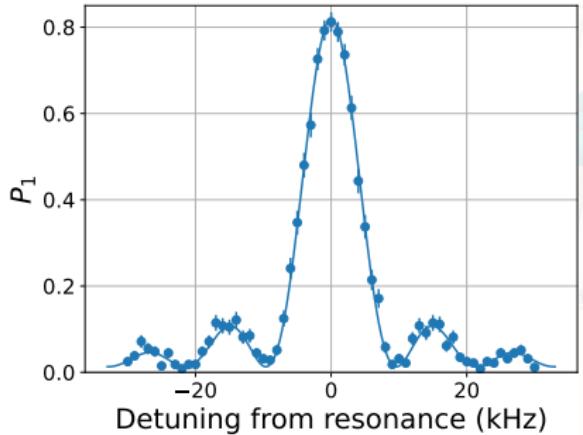
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- Counter-prop global and individual beams
  - Cross-beam Raman signal
  - Individual addressing
- Nearest neighbor crosstalk: 2%.



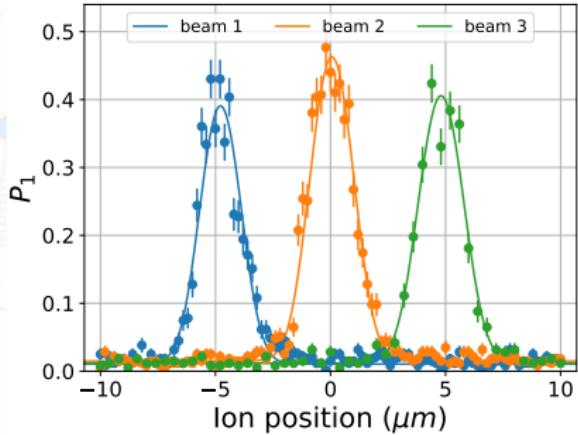
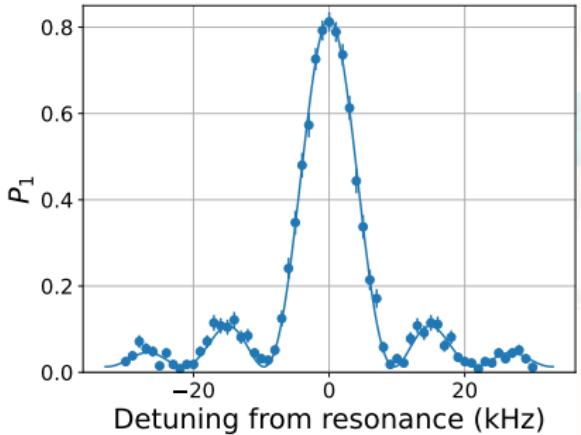
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Marko Cetina



Crystal Noel



Lei Feng



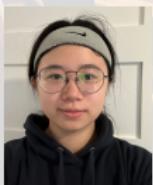
Liudmila Zhukas



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Vivian Zhang



Keqin Yan



Bahaa Harraz



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Andrew Risinger

