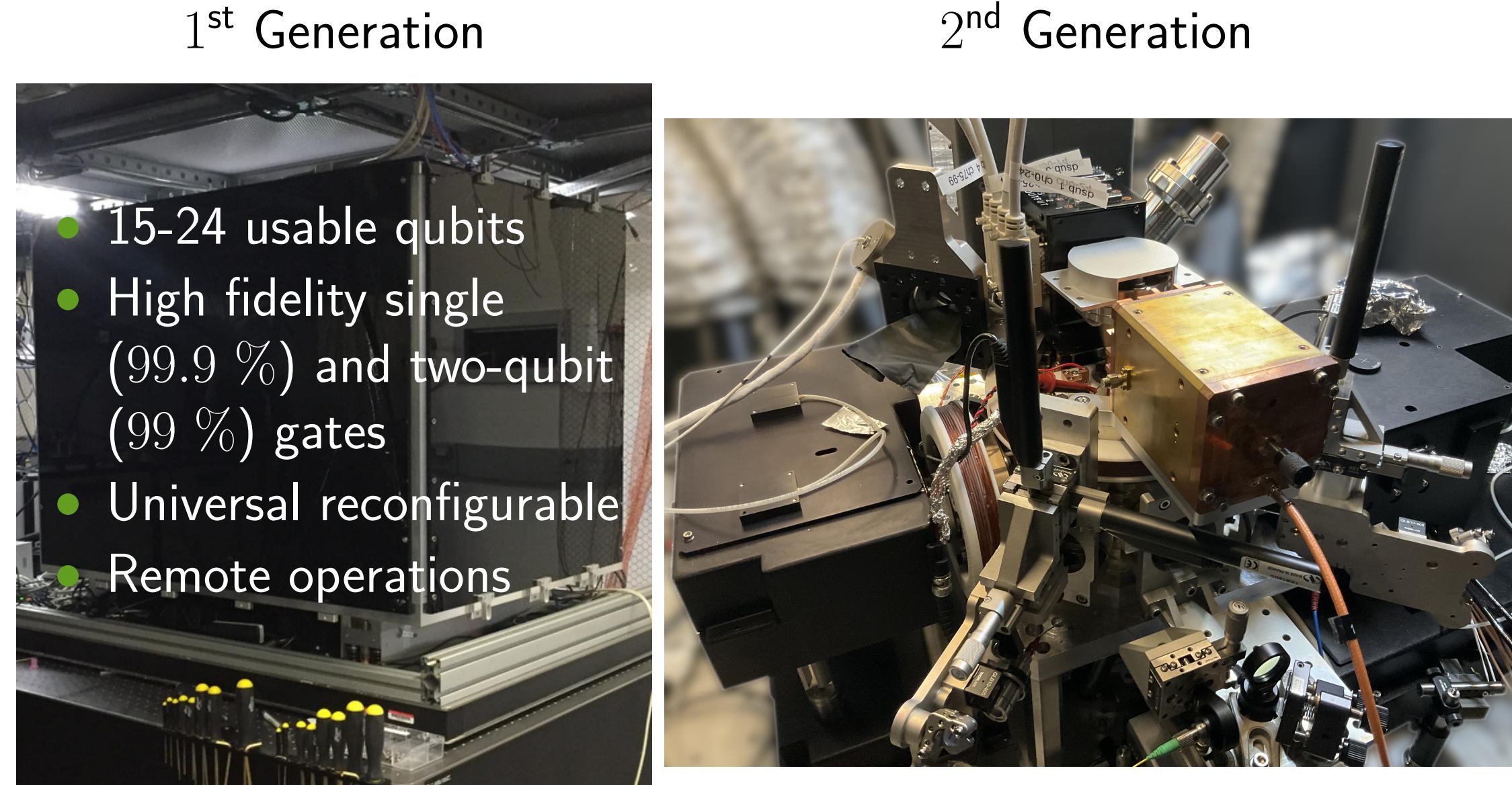


A next-generation trapped ion quantum computing system

Yichao Yu ¹, Liudmila Zhukas ¹, Lei Feng ^{1,2}, Marko Cetina ^{1,2}, Crystal Noel ^{1,2},
Debopriyo Biswas ^{1,2}, Andrew Risinger ², Alexander Kozhanov ¹, Christopher R Monroe ^{1,2,3}

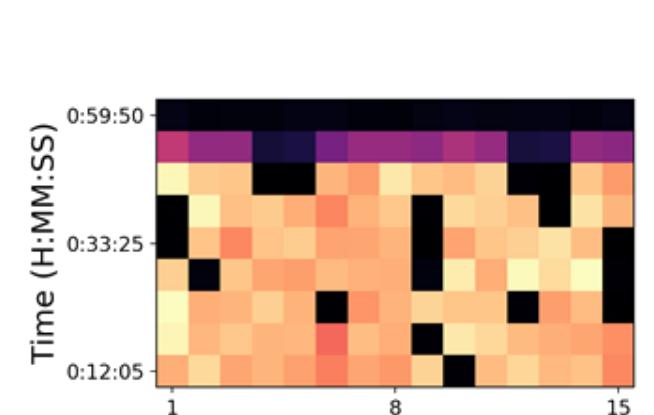
¹Duke Quantum Center, Duke University ²Joint Quantum Institute, University of Maryland ³IonQ, Inc.

Error-corrected Universal Reconfigurable Ion-trap Quantum Archetype



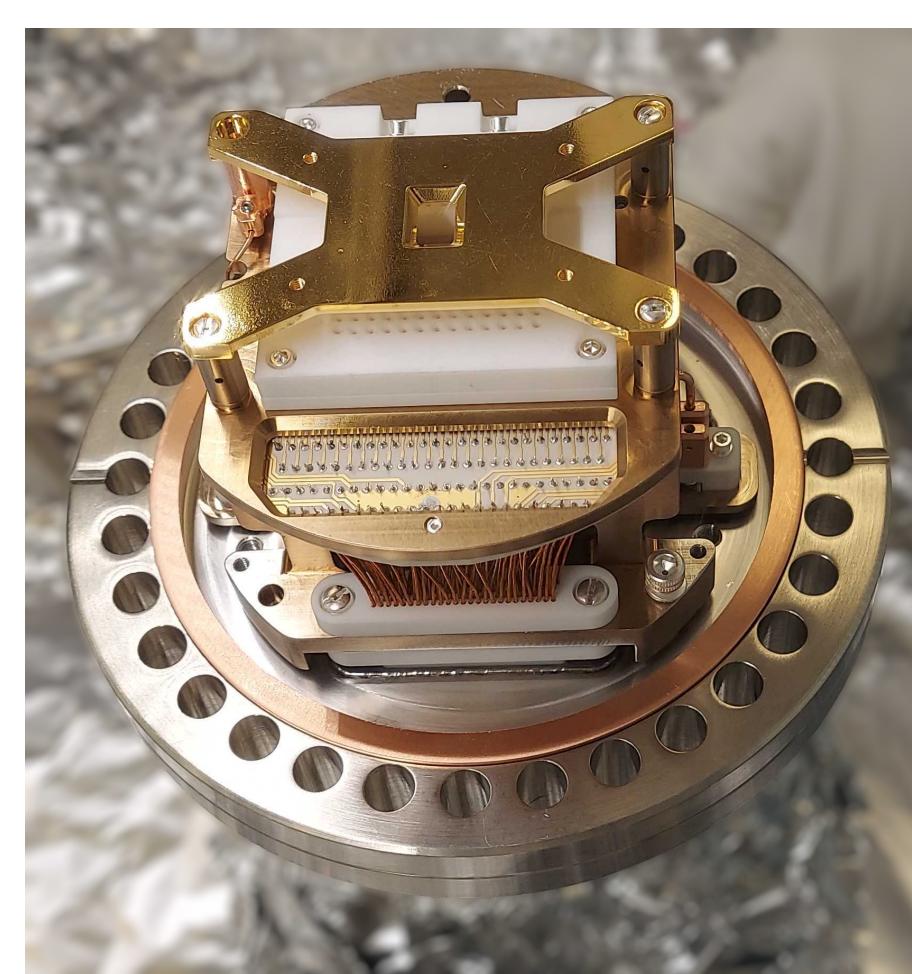
Vacuum System

- Vacuum fired components
- Reduce ion-chain reordering rate
- 10^{-11} Torr measured pressure



15-ion chain reordering in 1st gen EURiQA system.
Consistent with 10^{-10} Torr.

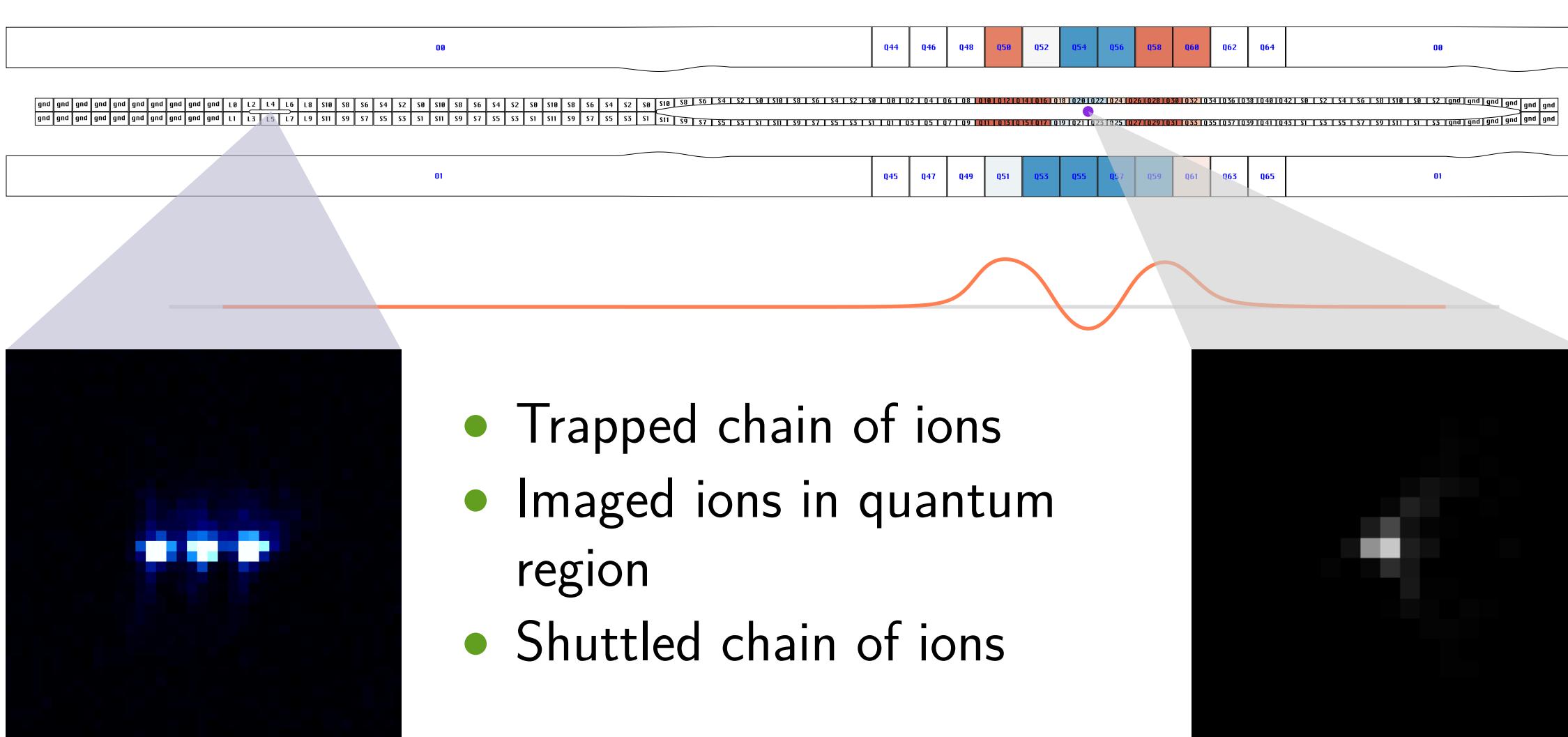
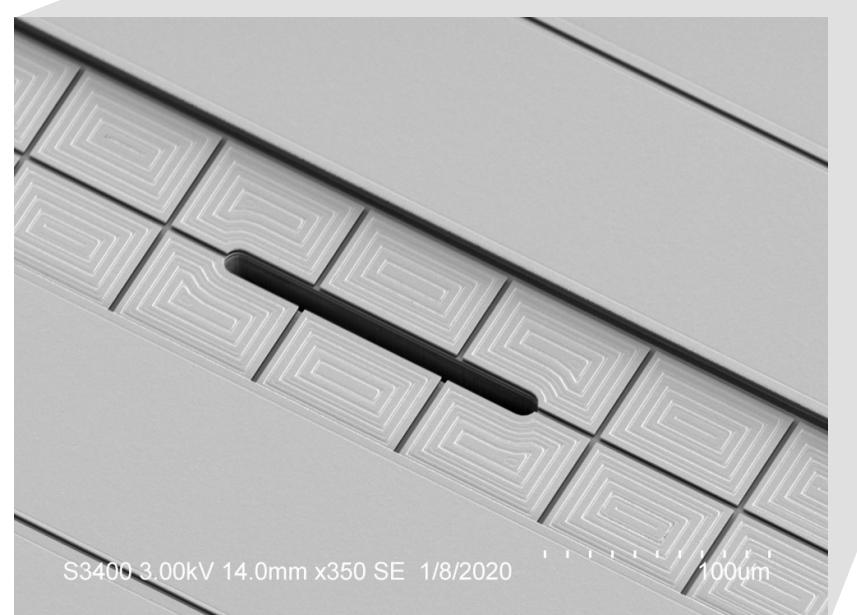
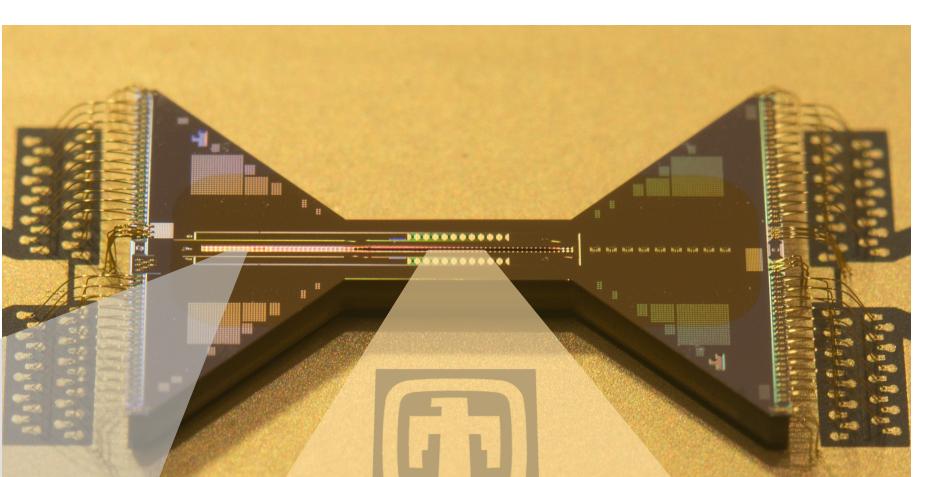
Cetina, et al.



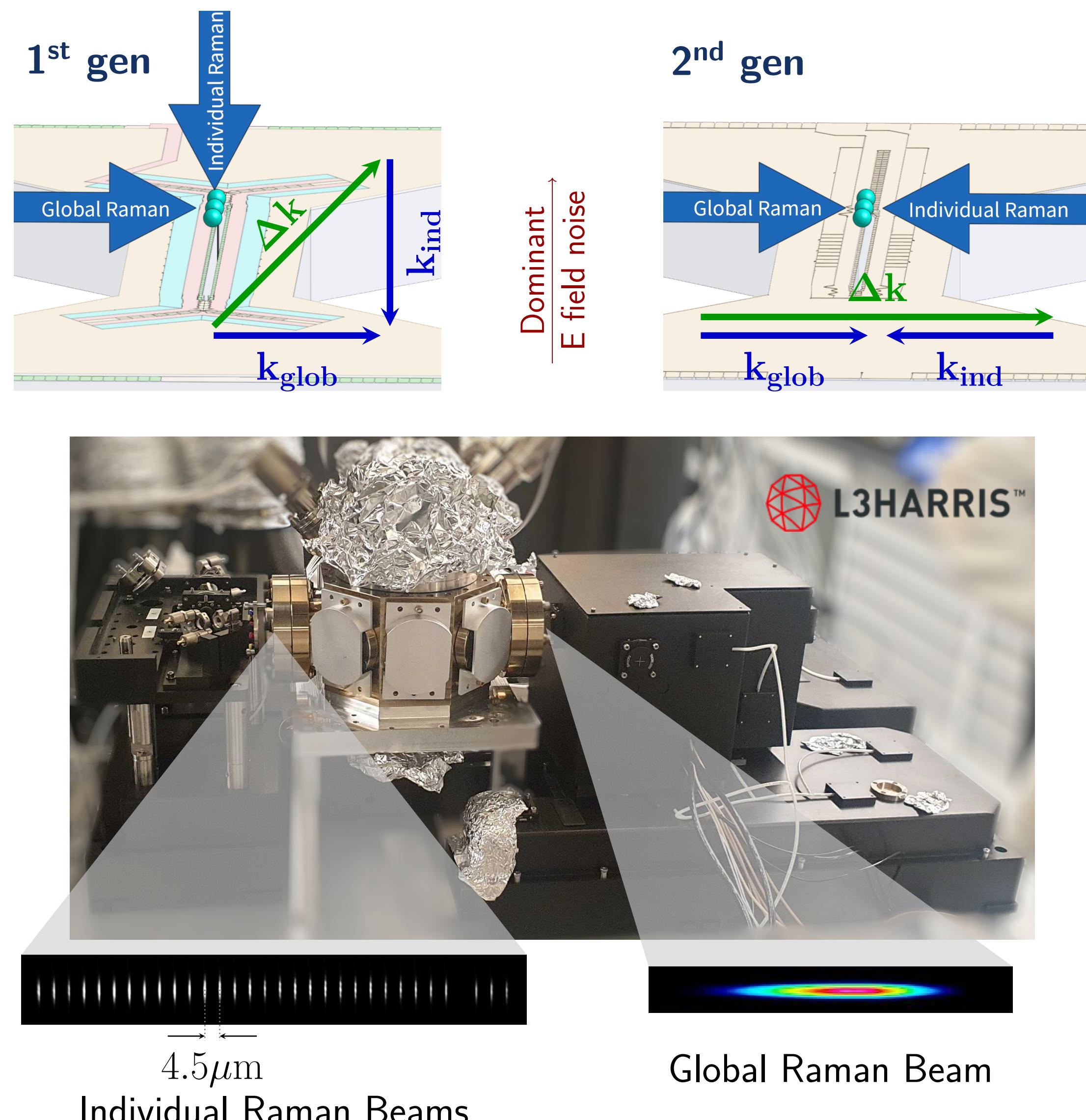
Phoenix Surface Trap

- Better metallization
 - Reducing noise
 - Less charging/photovoltaic effect
- 30 quanta/s heating rate @ 3 MHz

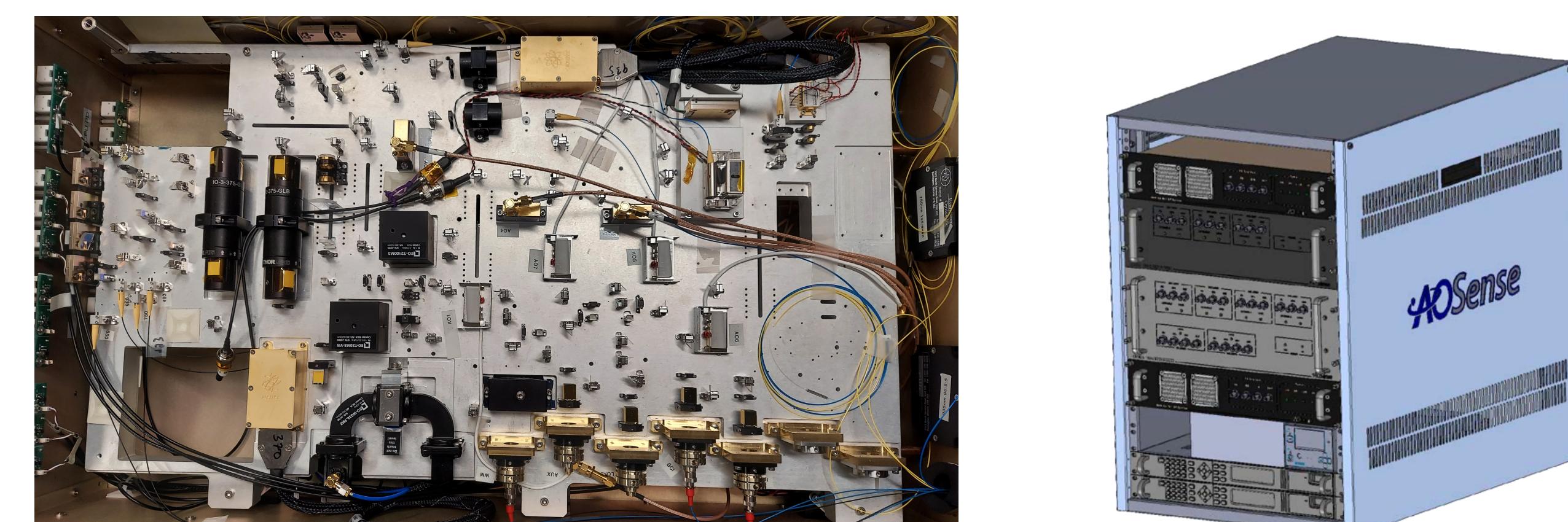
Measured by Sandia



Raman System



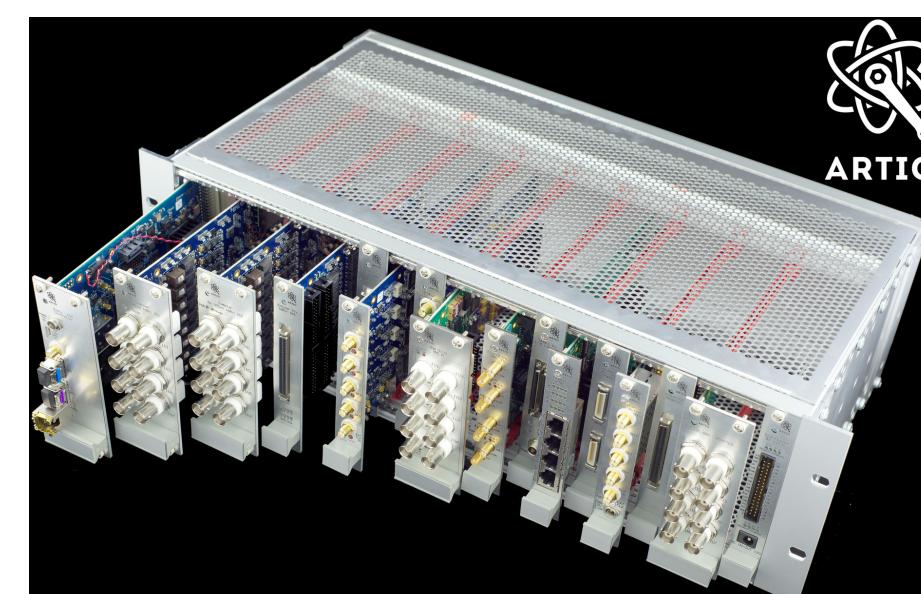
Miniaturized 369/399/780/935nm Beam Path



Control System

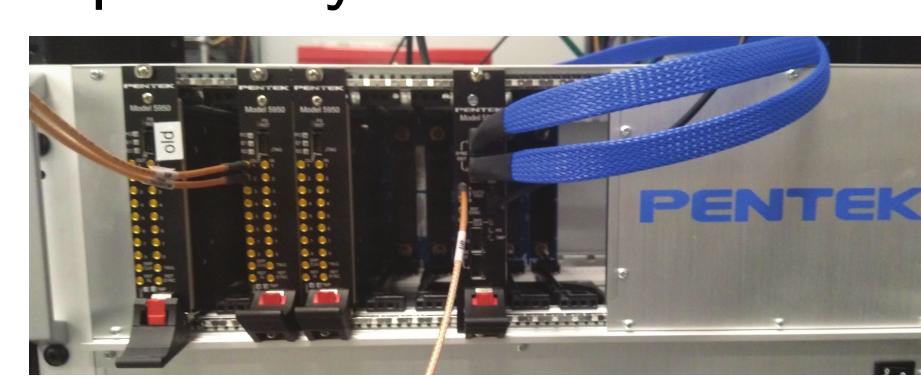
ARTIQ

- Artiq software
- Sinara hardware



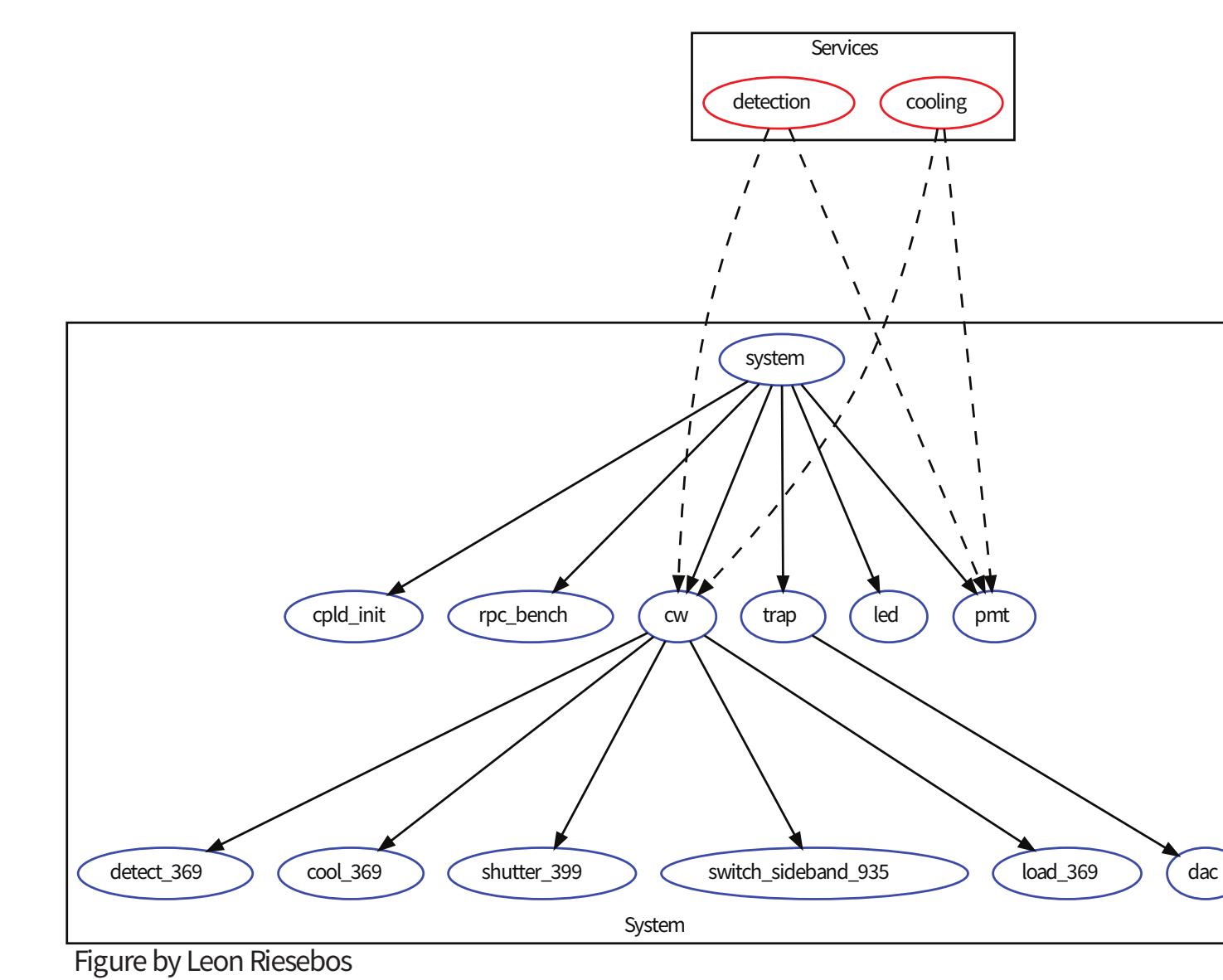
RFSoC/Pentek

- integrated pulse-level control
- phase synchronization



Duke Artiq Extensions

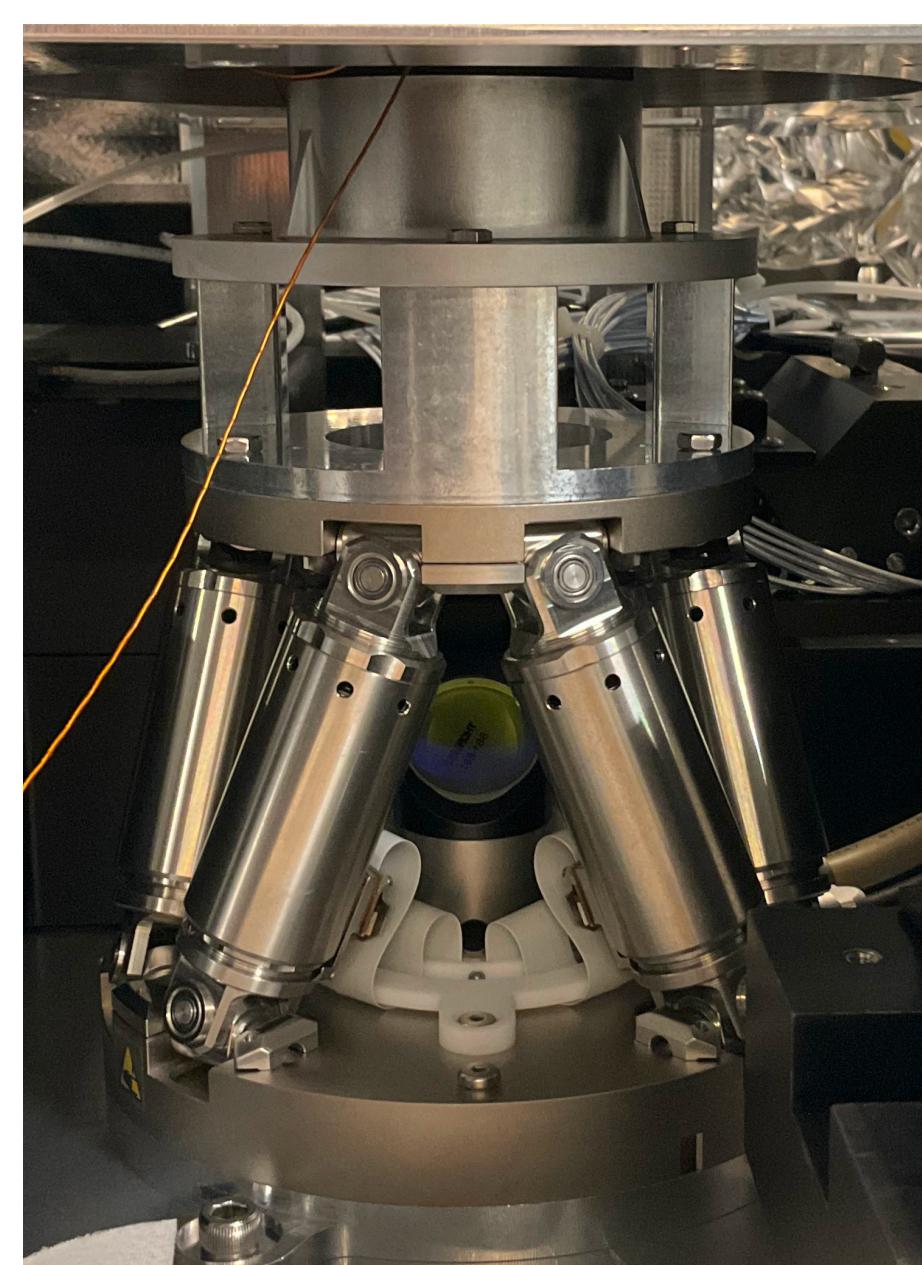
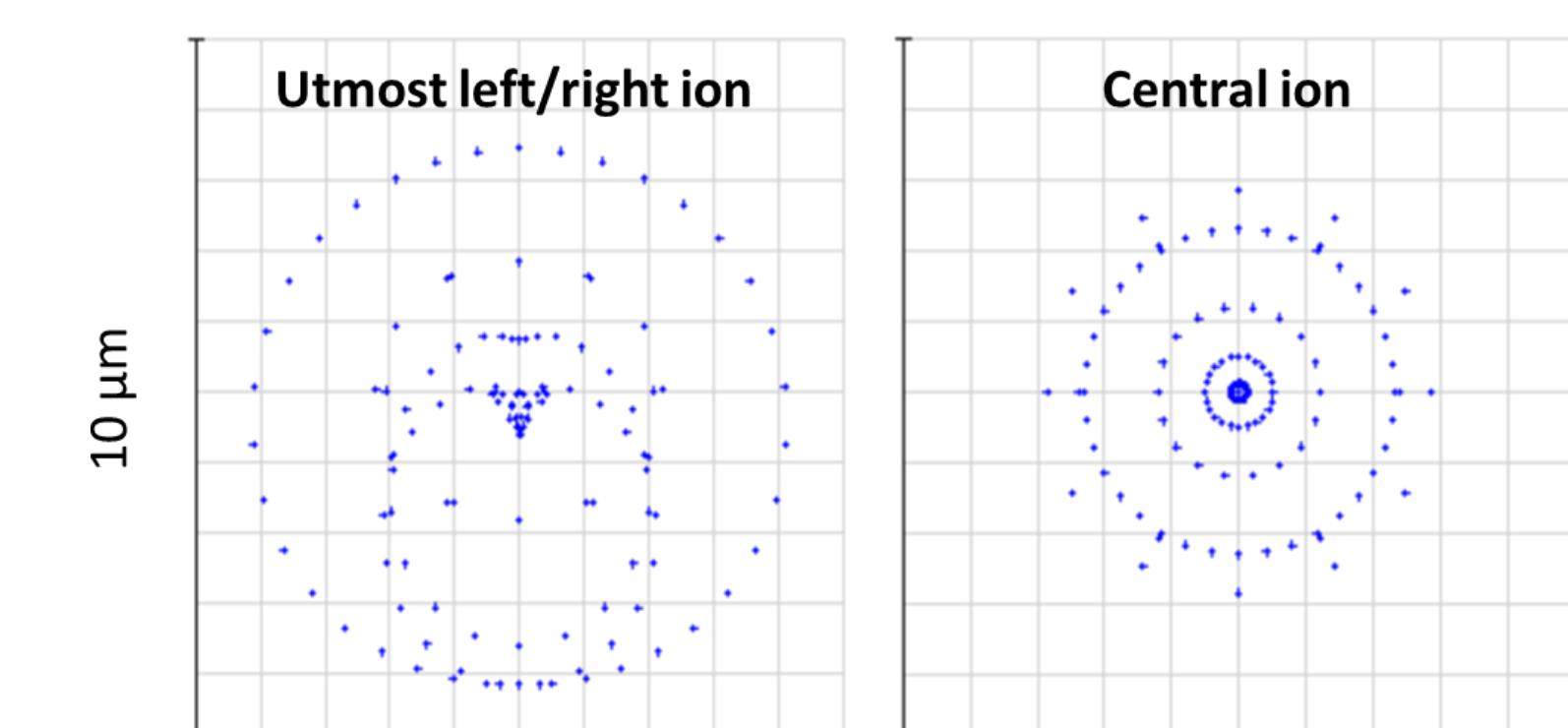
- modular control software
- system code organization



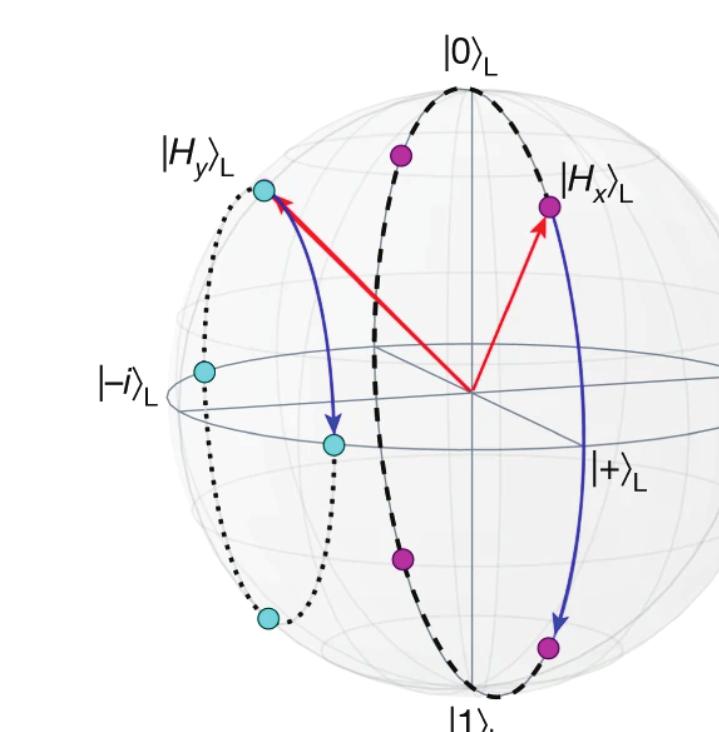
Imaging System



- Imaging system for 32 ions, fixed 4.5 μm spacing between ions
- Two stage imaging system with a total magnification of 27
- Minimized instrumental crosstalk by coupling fluorescence from each ion to the individual PMT module (Hamamatsu, H10682-210)
- PhotonGear optical lens design (0.63 NA) mounted on PI Hexapod for precise positioning
- Zemax simulations: the resulting Strehl ratio is > 0.95 for all 32 ions in the chain



Applications



- Universal Quantum Computer
- 20+ qubits and high fidelity
- Quantum simulations of many body physics
- Quantum chemistry
- Quantum gravity
- Nuclear theory
- Quantum Error Correction

