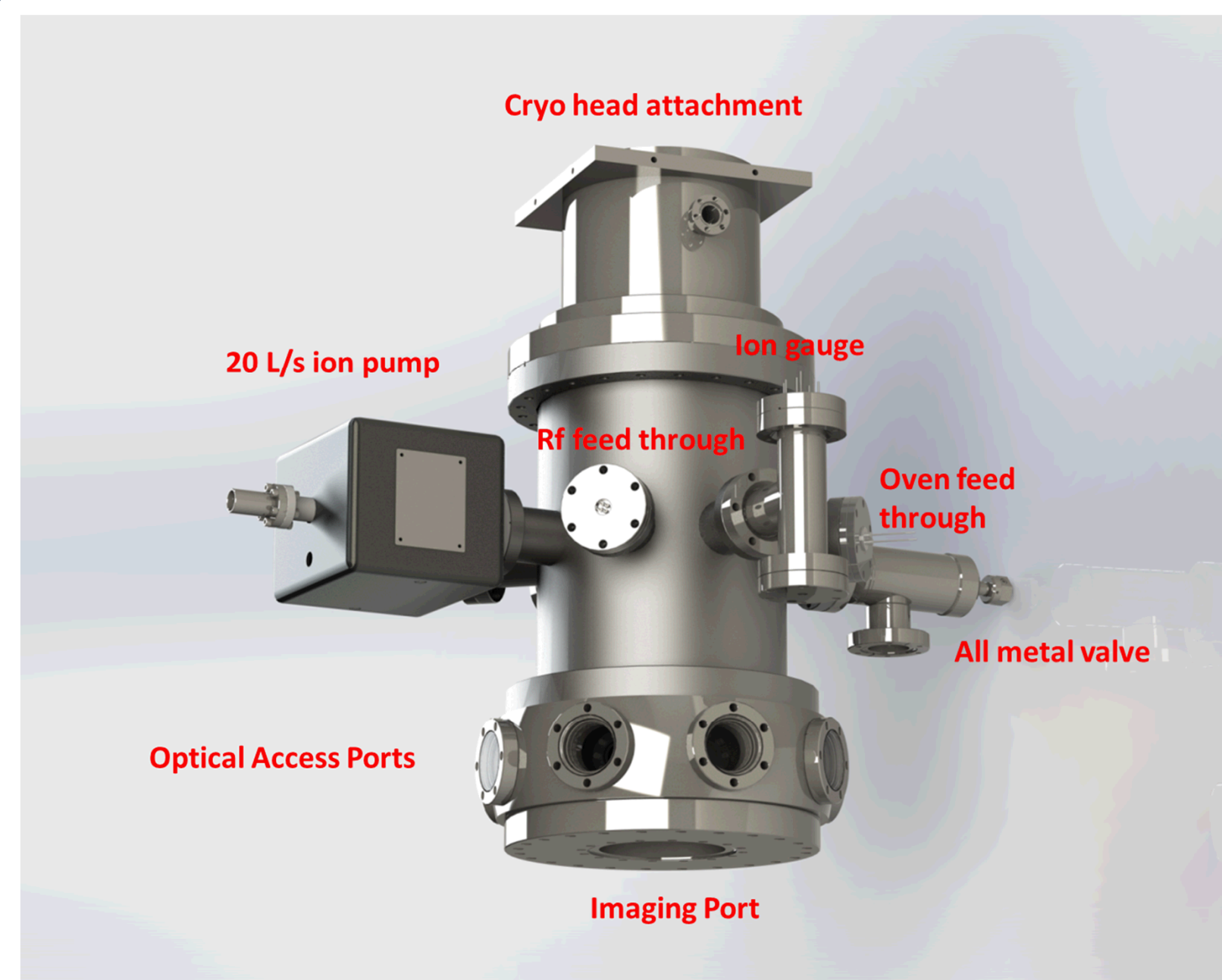


Over the last decade Sandia National Laboratories has developed surface electrode ion traps which are the building blocks for a Charge Coupled Device (CCD) Quantum Information processor. The Sprint project has three primary objectives: fabricating and test microfabricated surface electrode lattice traps, developing cryogenic trapping capabilities and developing small scale algorithms to be implemented on 4-10 qubits. In this presentation we will give an overview of the current status of our cryogenic trapping system. Additionally, we will present our results toward implementing quantum operations with calcium ions.

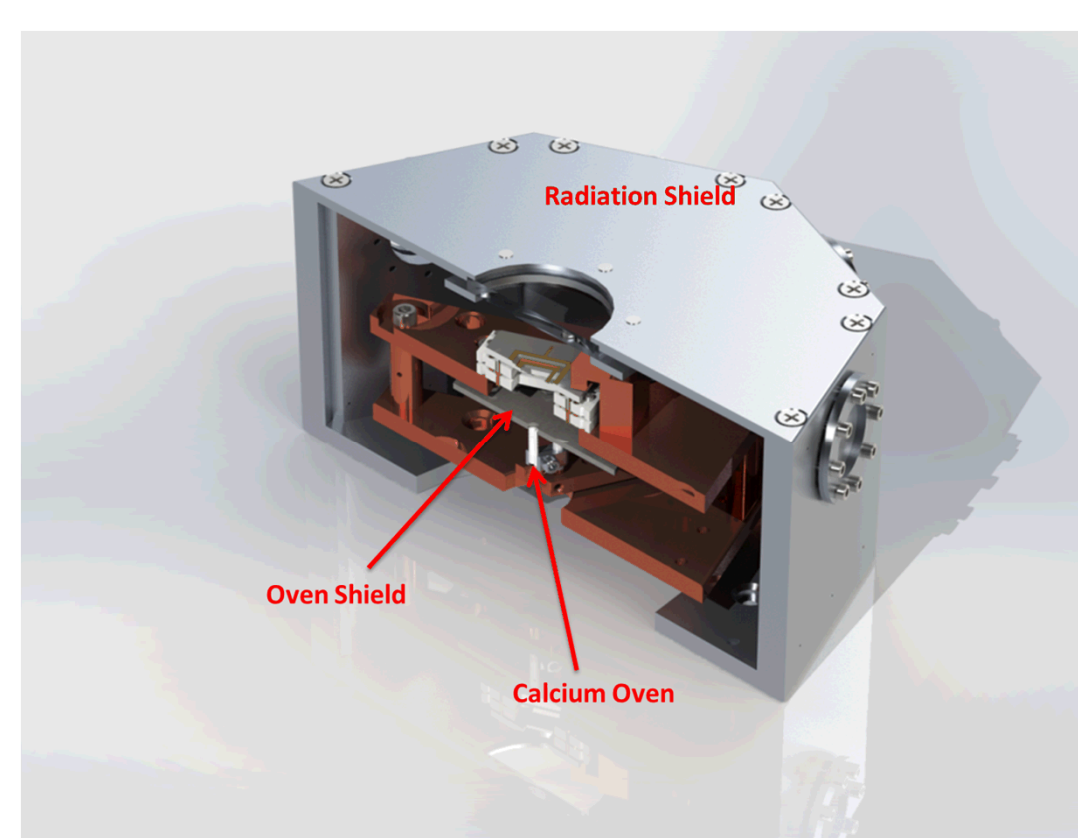
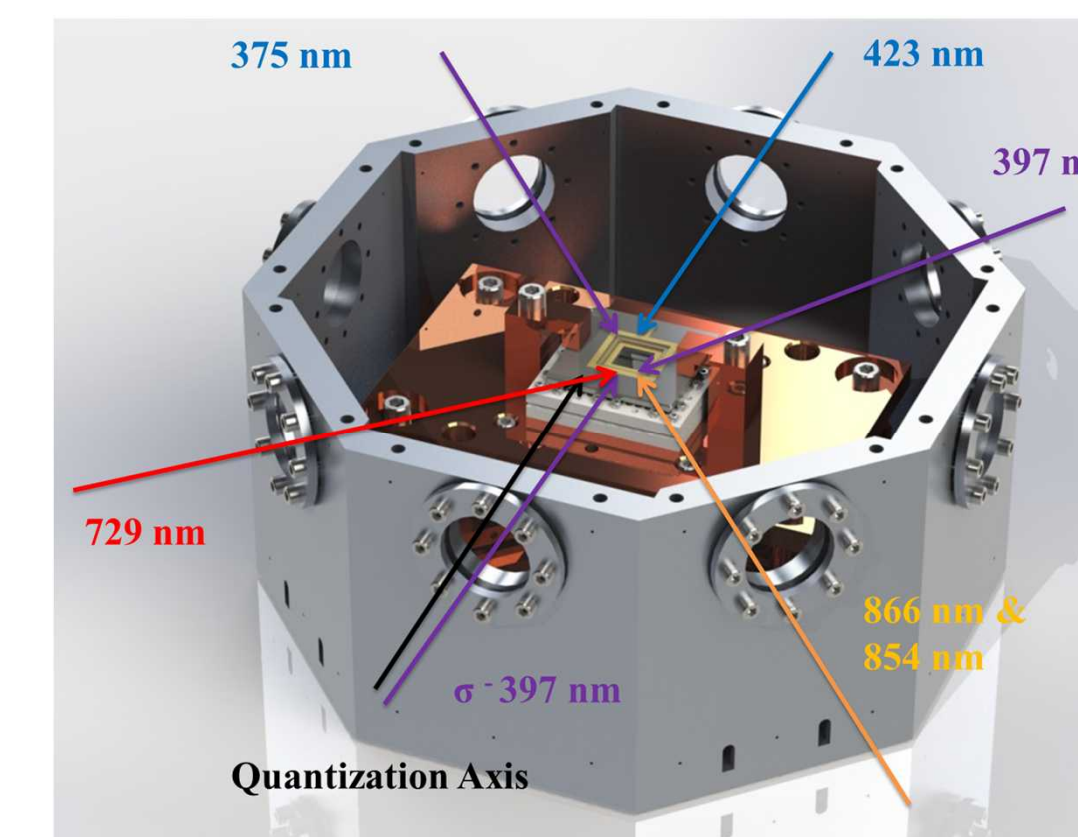
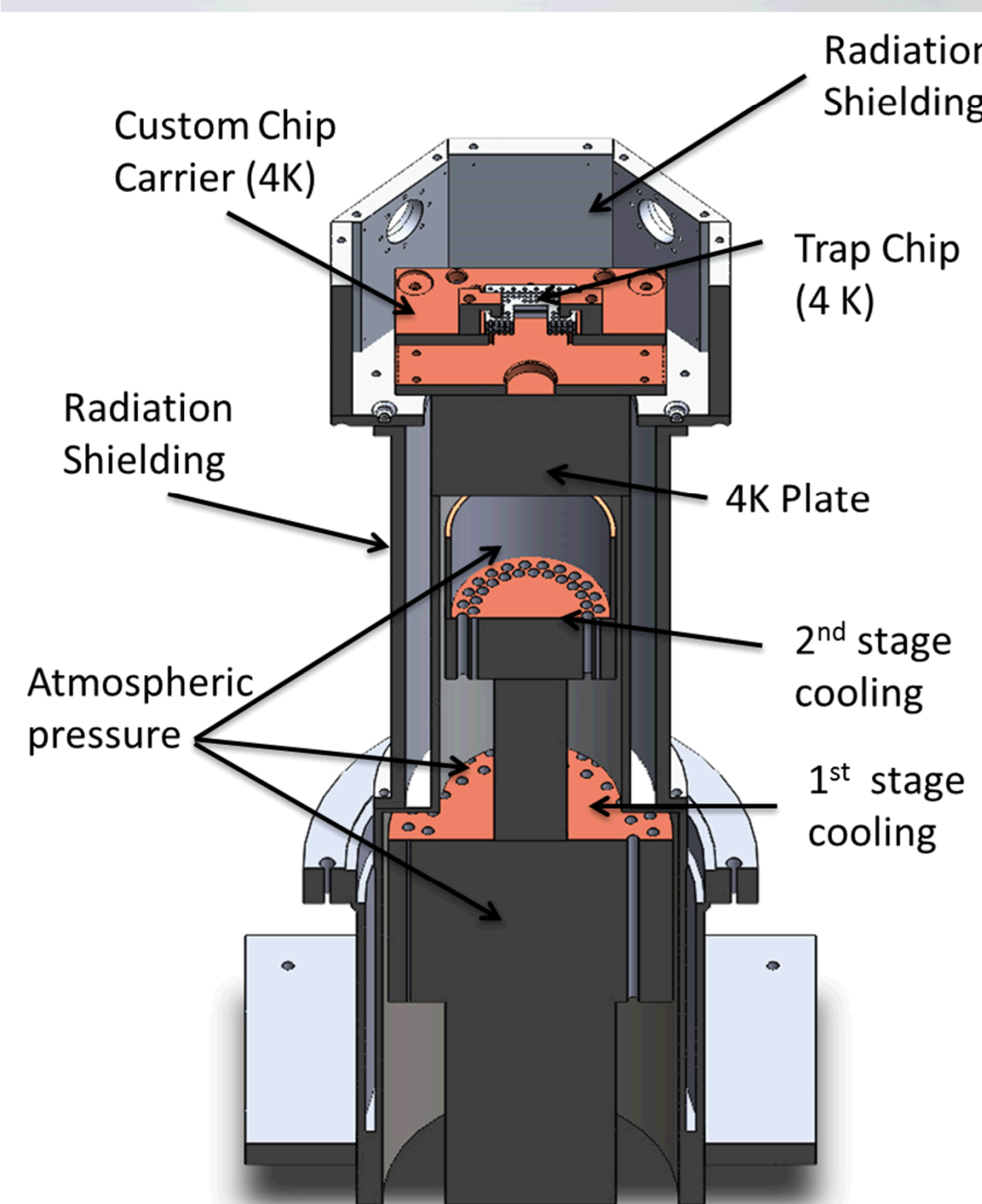
Cryogenic Vacuum Chamber



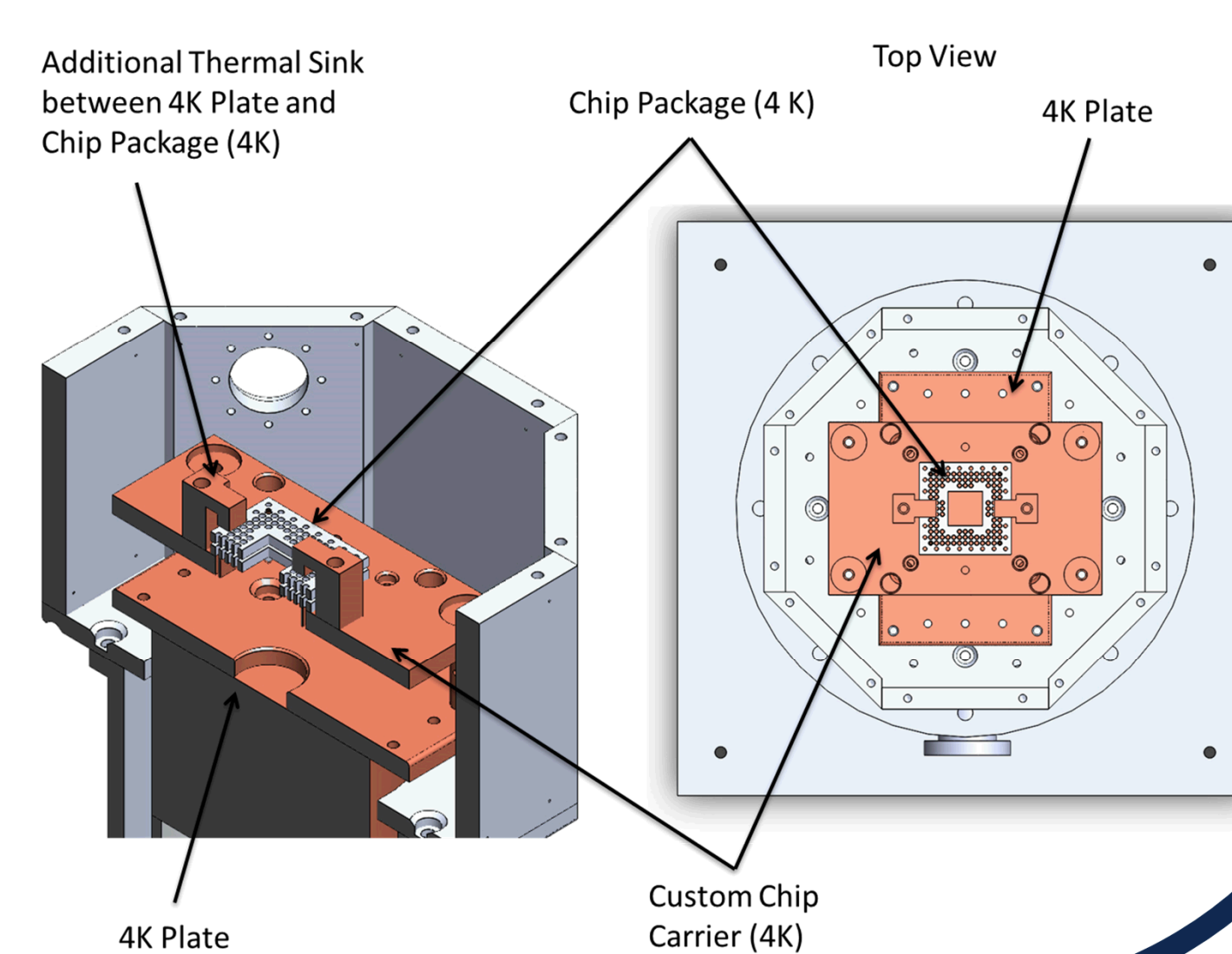
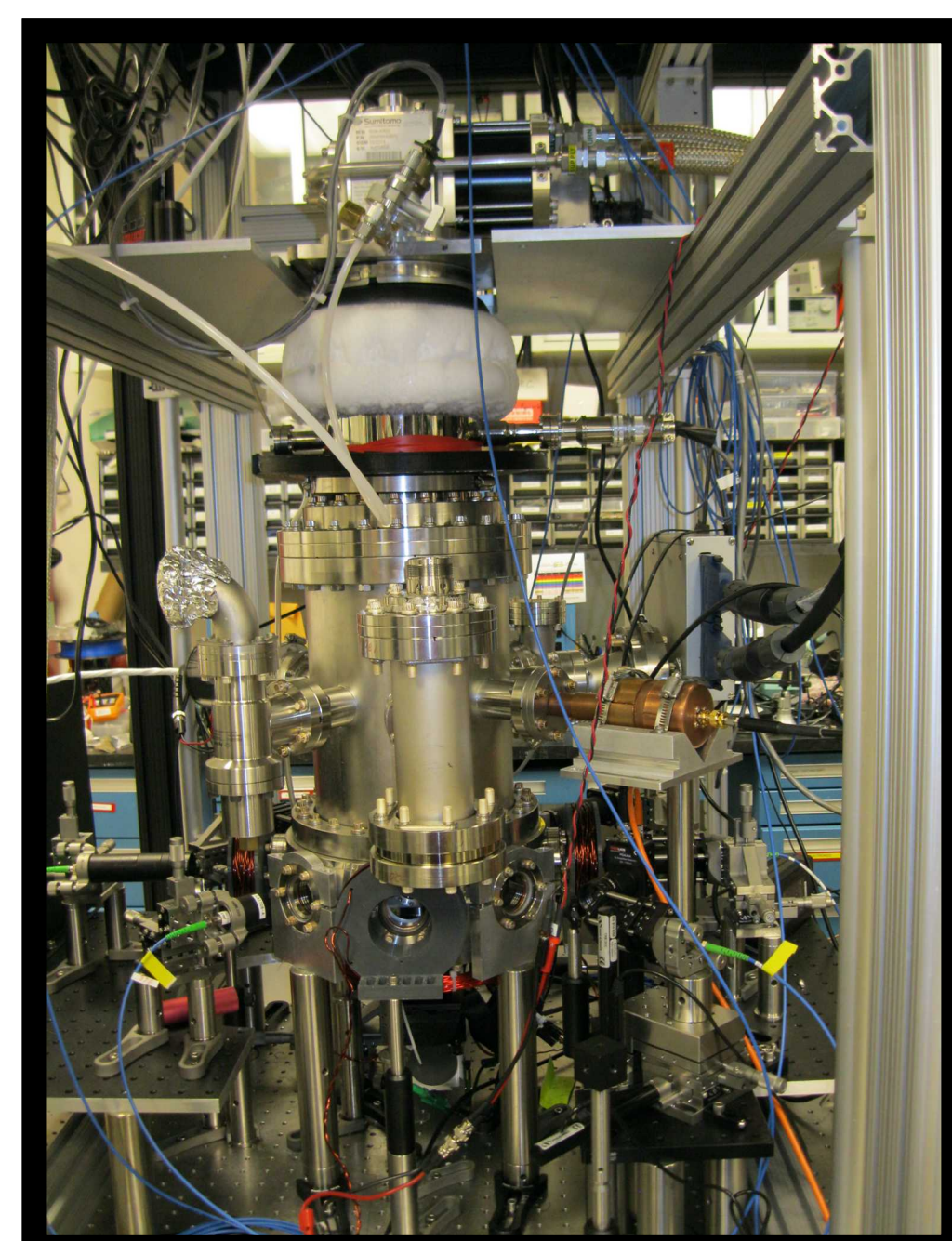
Cryo Specs

- Cryo Industries of America**
- 1.0 Watt @ 4K – Cooling
 - 34.0 Watt @ 40K – Cooling
 - Gifford McMahon (GM) – Closed Cycle
 - Bellows Vibration Isolated Coldfinger
 - Exchange Gas Cooled

Trap Radiation Shield and Beam Geometry

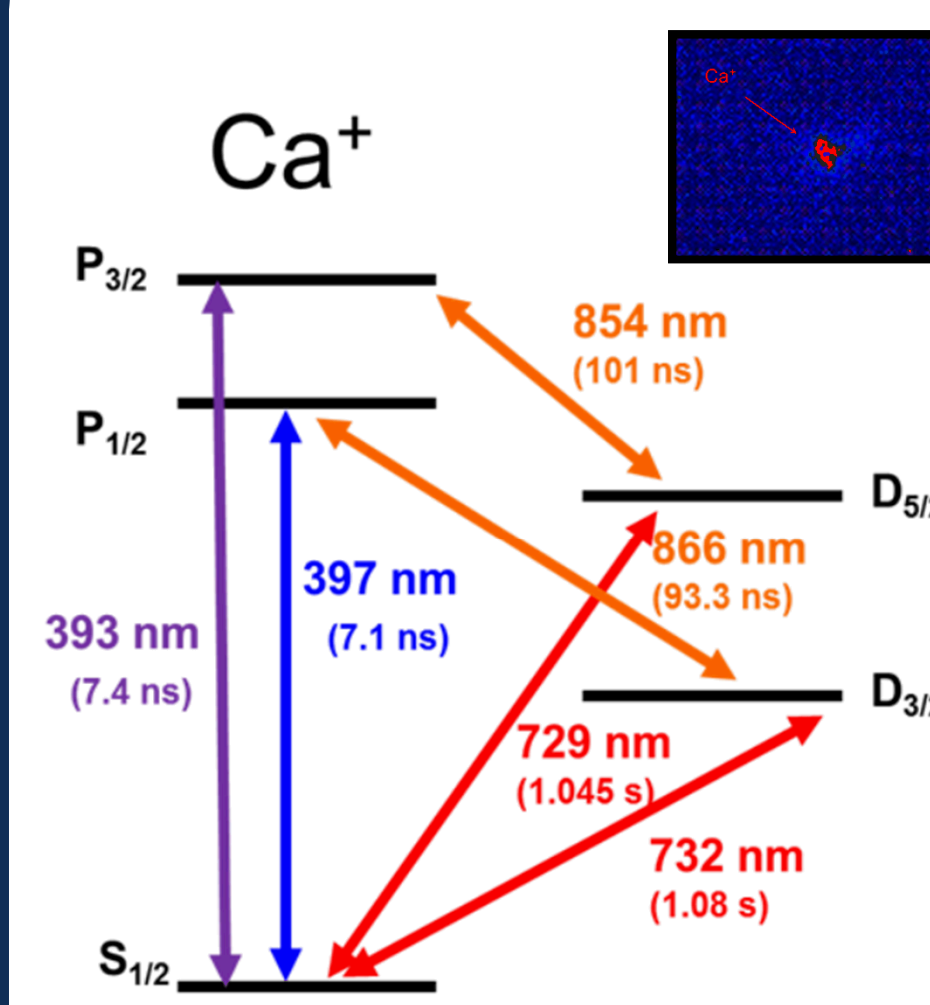


Experimental Setup

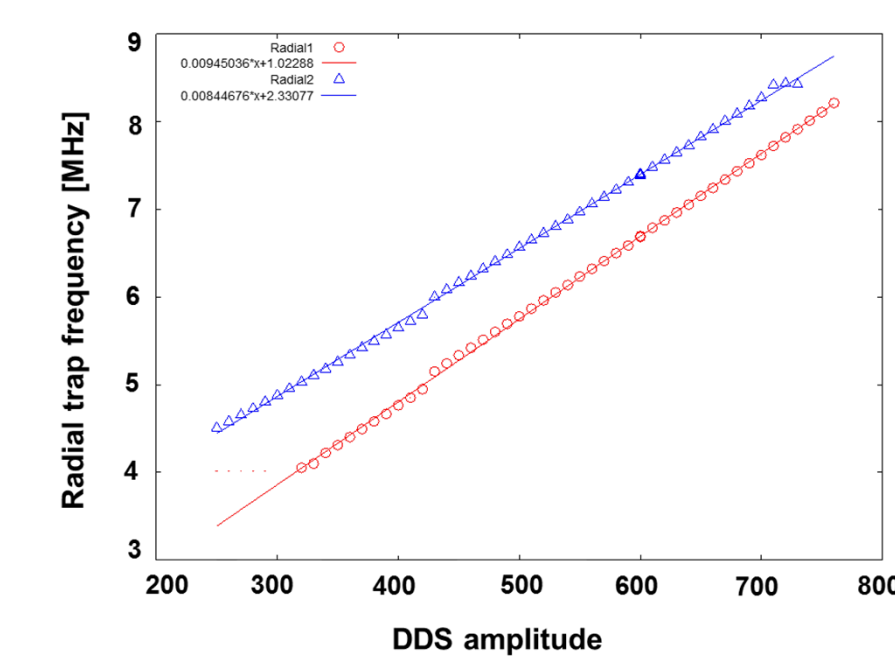
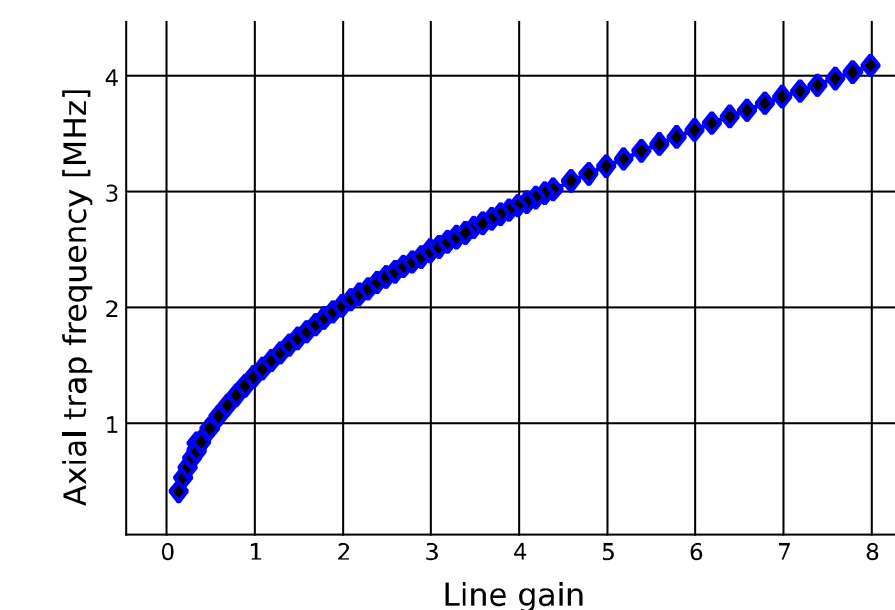


Trap Characterization

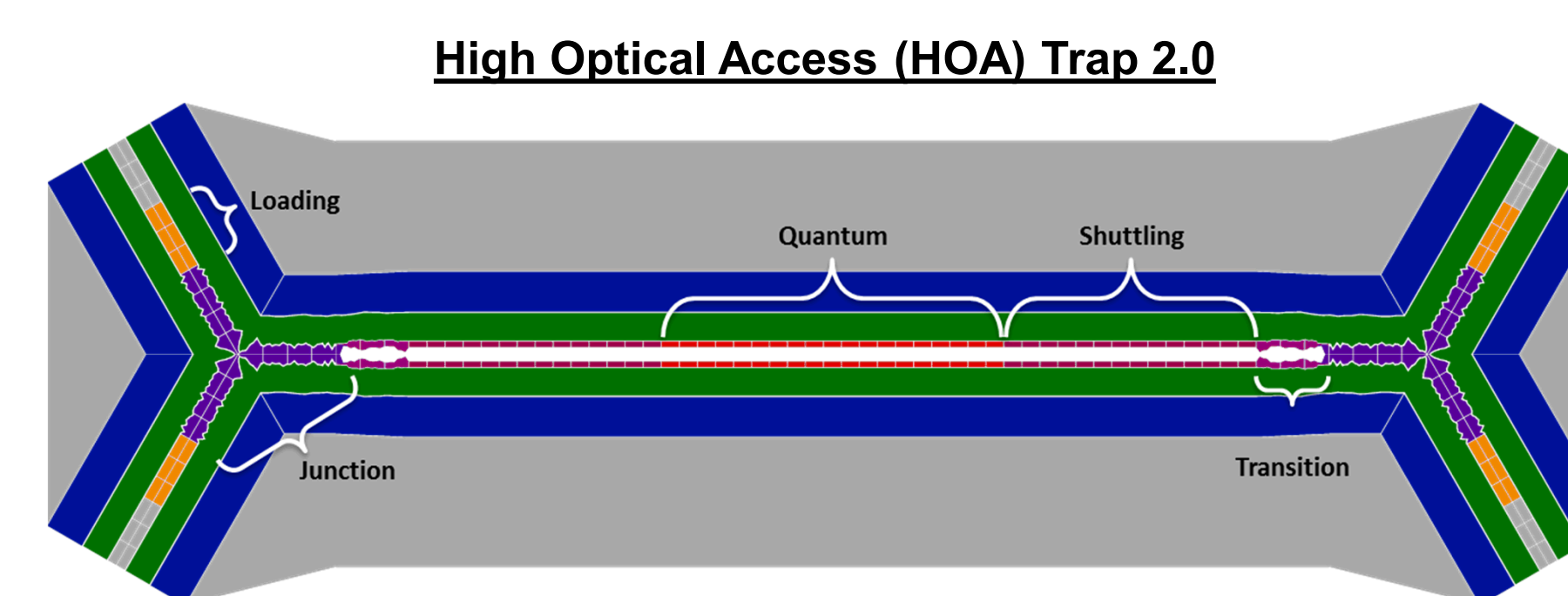
Ion Choice



DC and RF Voltage Scaling

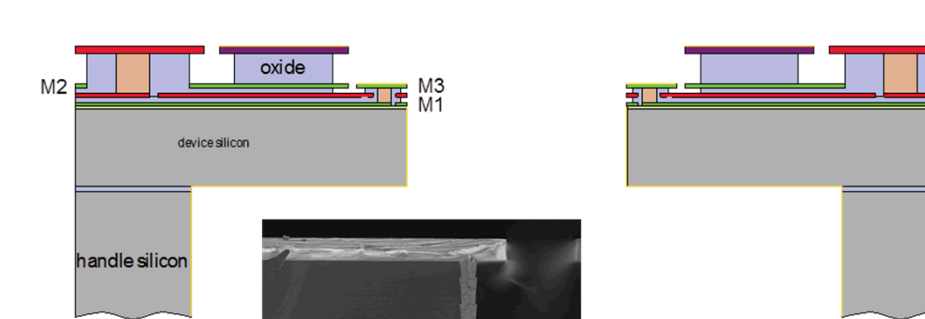


Trap Fabrication Capabilities

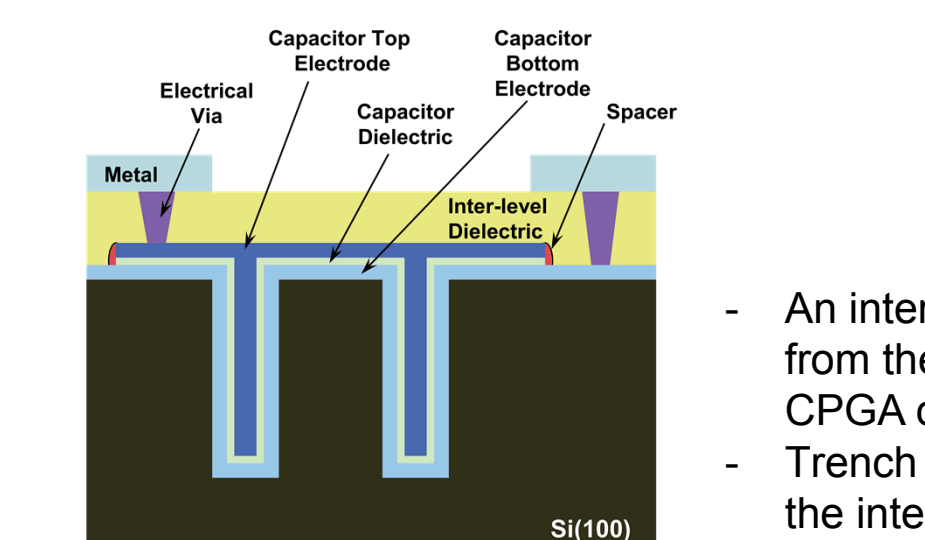


- Excellent optical access rivaling 3D traps
- NA 0.11 across surface
- NA 0.25 through slot

Five level metallization

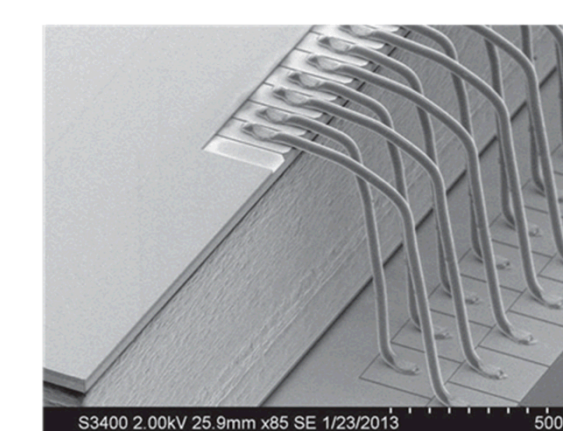


- DC electrodes are routed through lower metal layers allowing for:
 - simplified routing as wiring can cross in different metal layers
 - More complex, islanded trap structures, such as circulators and rings
 - Trap layouts that are more true to models, since electrode leads don't need to be taken into account



Low-profile wire bonds

- Maximal optical access
- Minimal light scattering

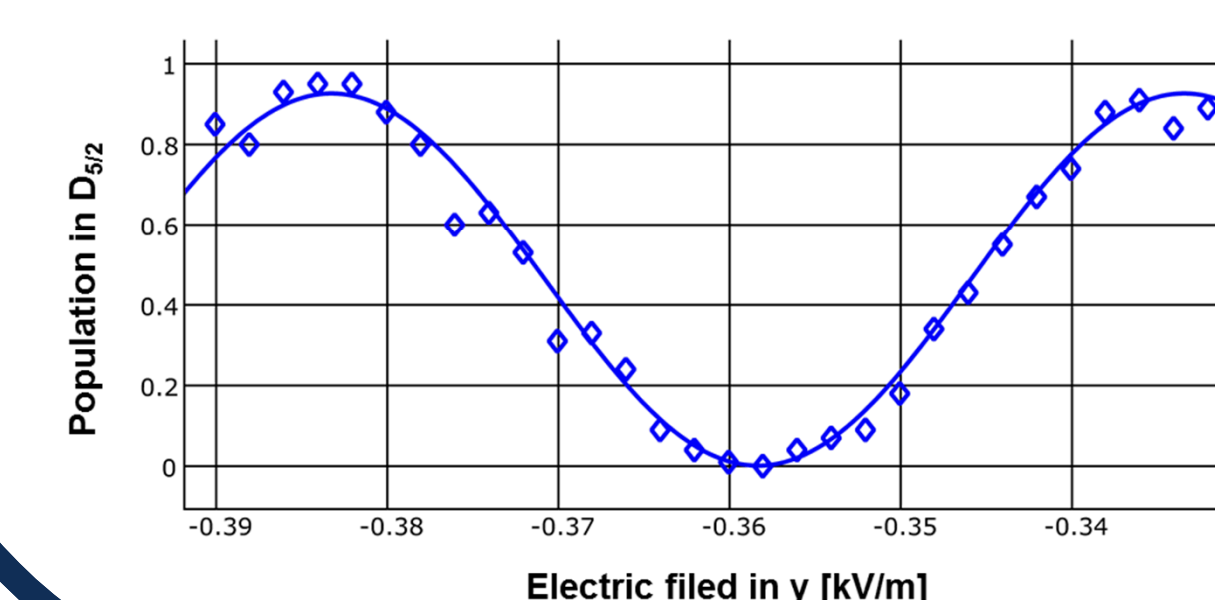
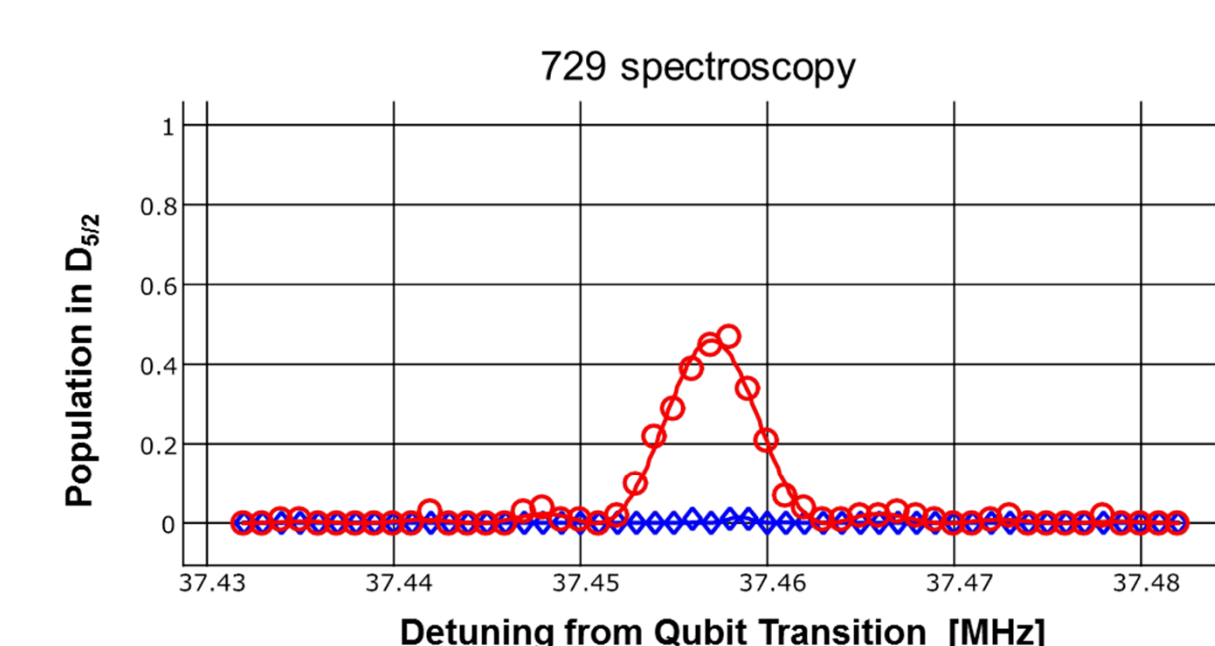


Interposer

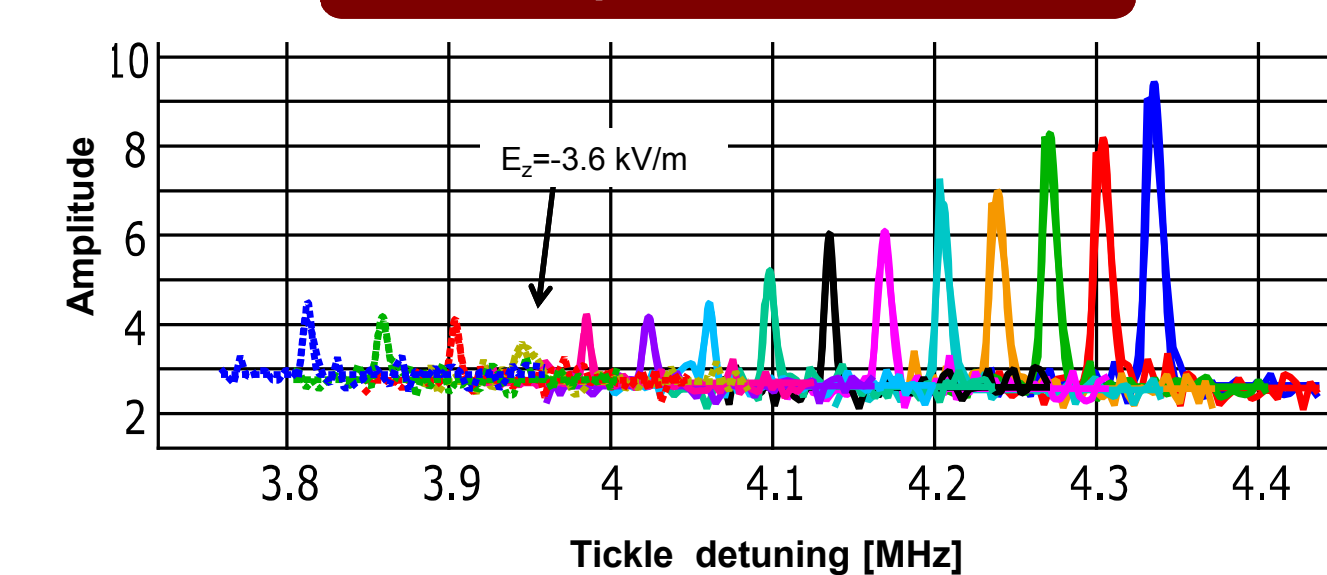
- An interposer chip routes control voltages from the trap to the pads of the standard CPGA carrier.
- Trench capacitors are integrated directly into the interposer to reduce RF pickup

Trap Compensation

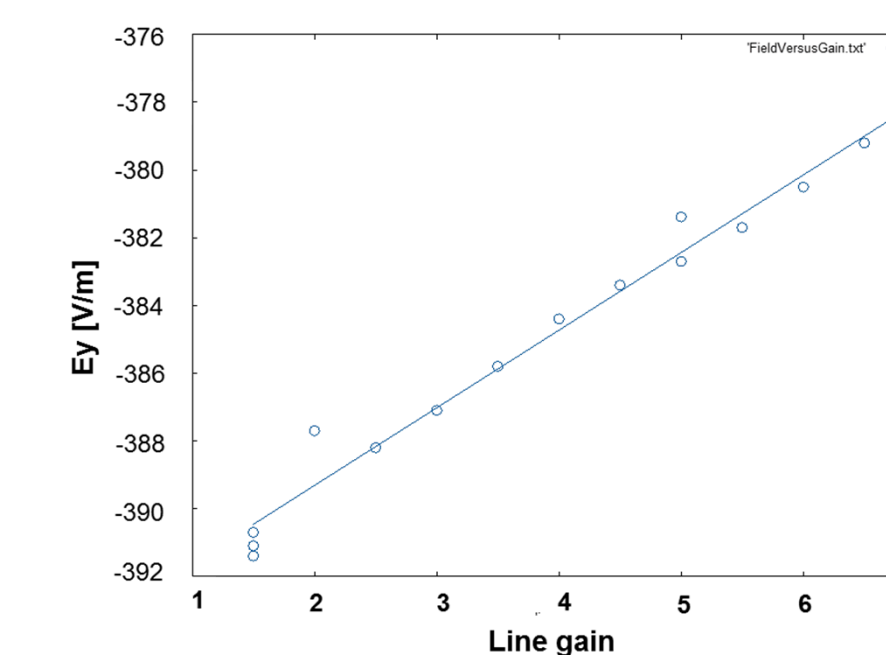
Compensation Ey



Compensation Ez



DV Voltage Scaling



Experimental Results

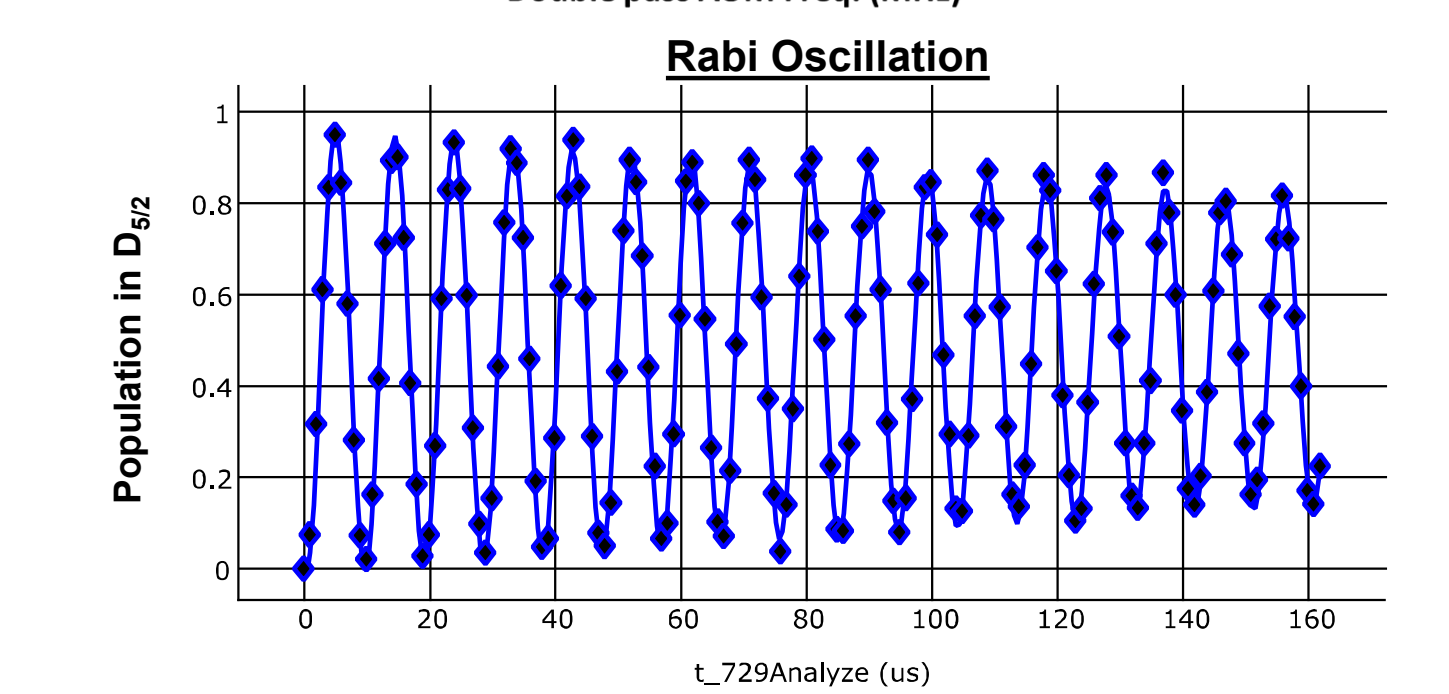
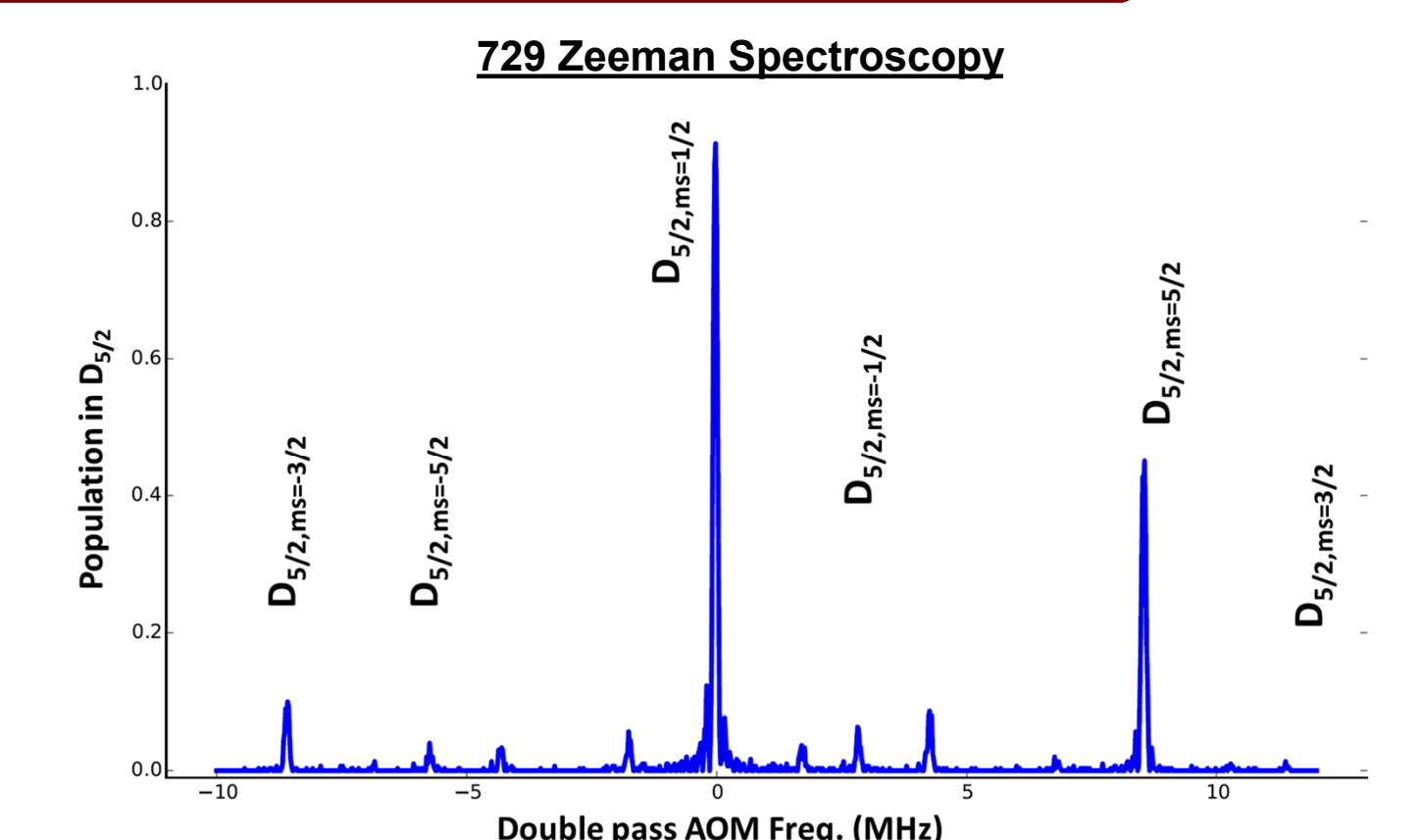
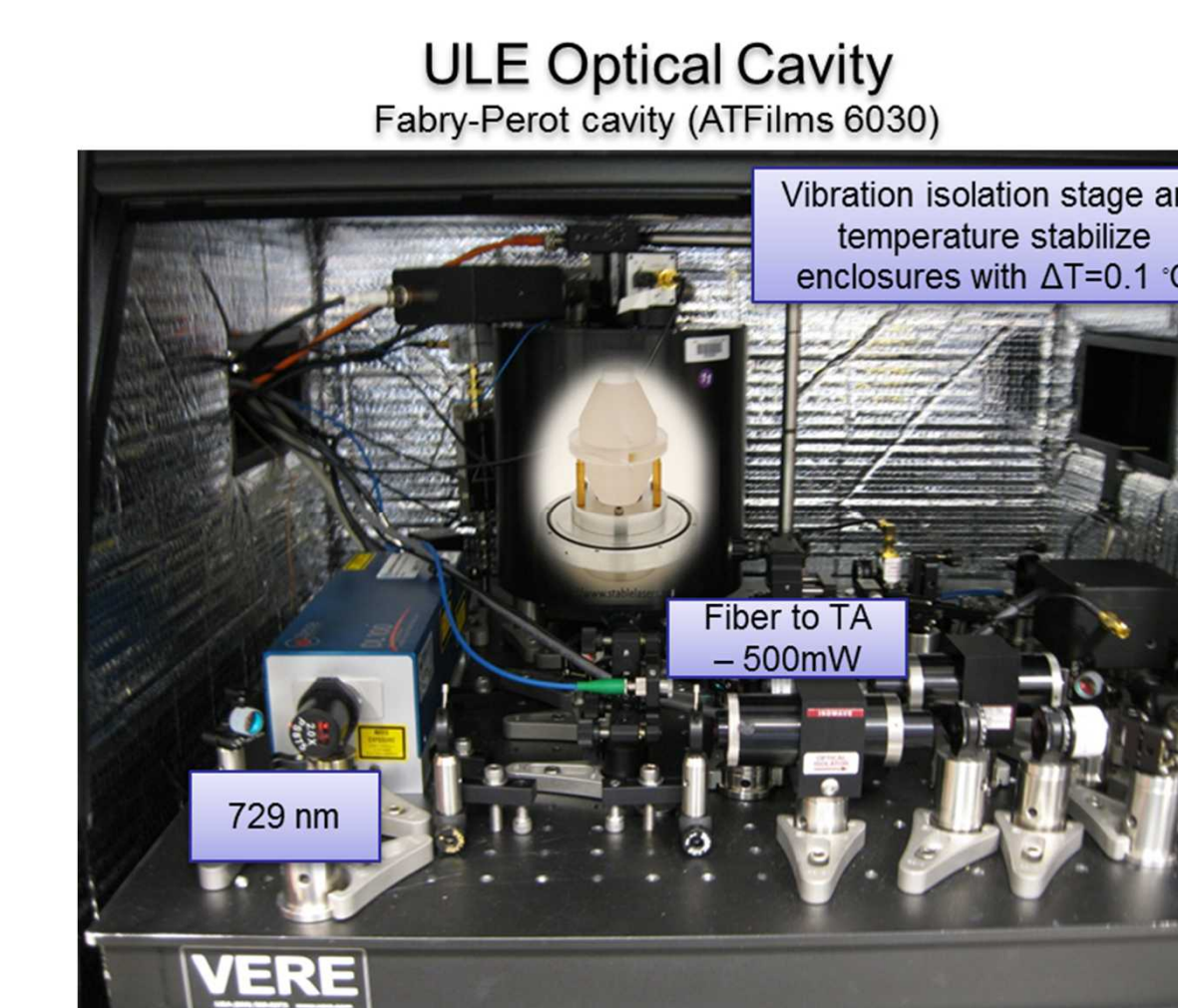
729 Laser Setup – (Optical Qubit)

$$F = 200000$$

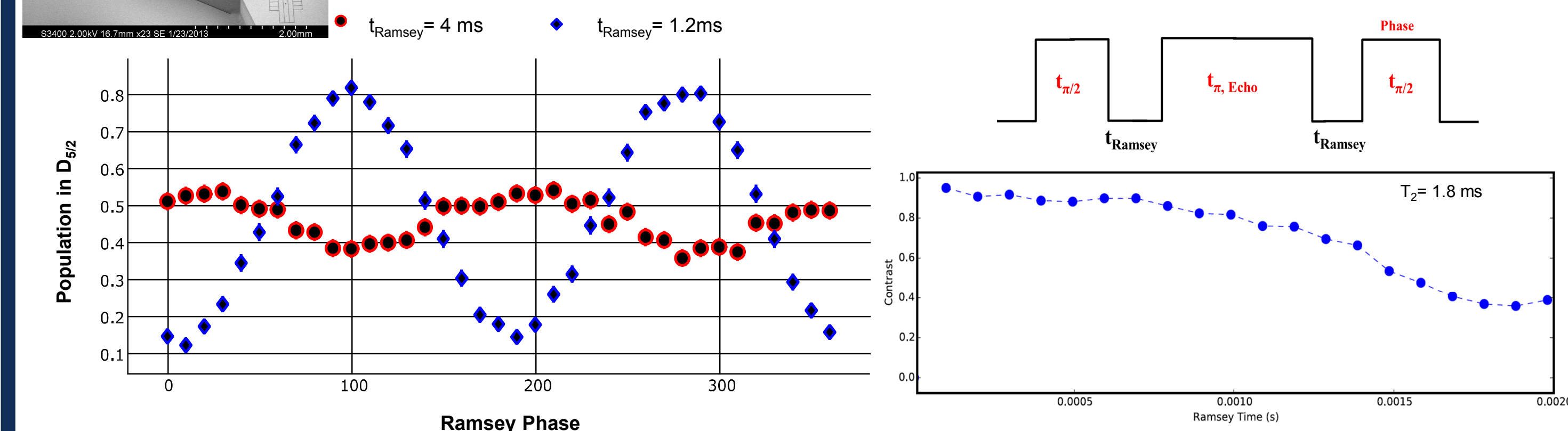
$$\nu_F = 1.93 \text{ GHz}$$

$$\delta_\nu = \frac{\nu_F}{F} = 9.65 \text{ kHz}$$

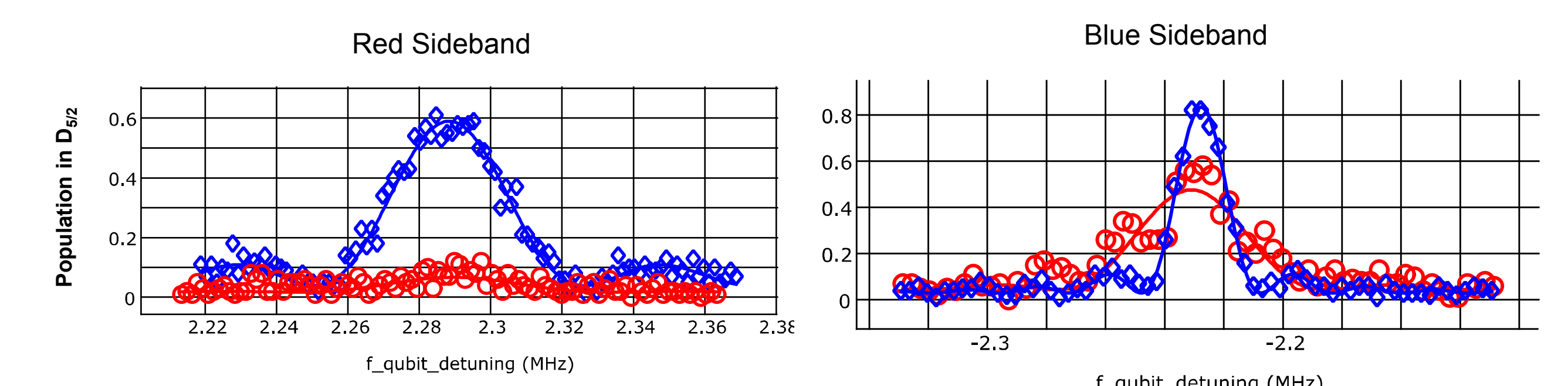
$$T_c = 24.2^\circ \text{C}$$



Coherence measurements



Heating rate measurements



Heating rate is still dominated by technical noise.

