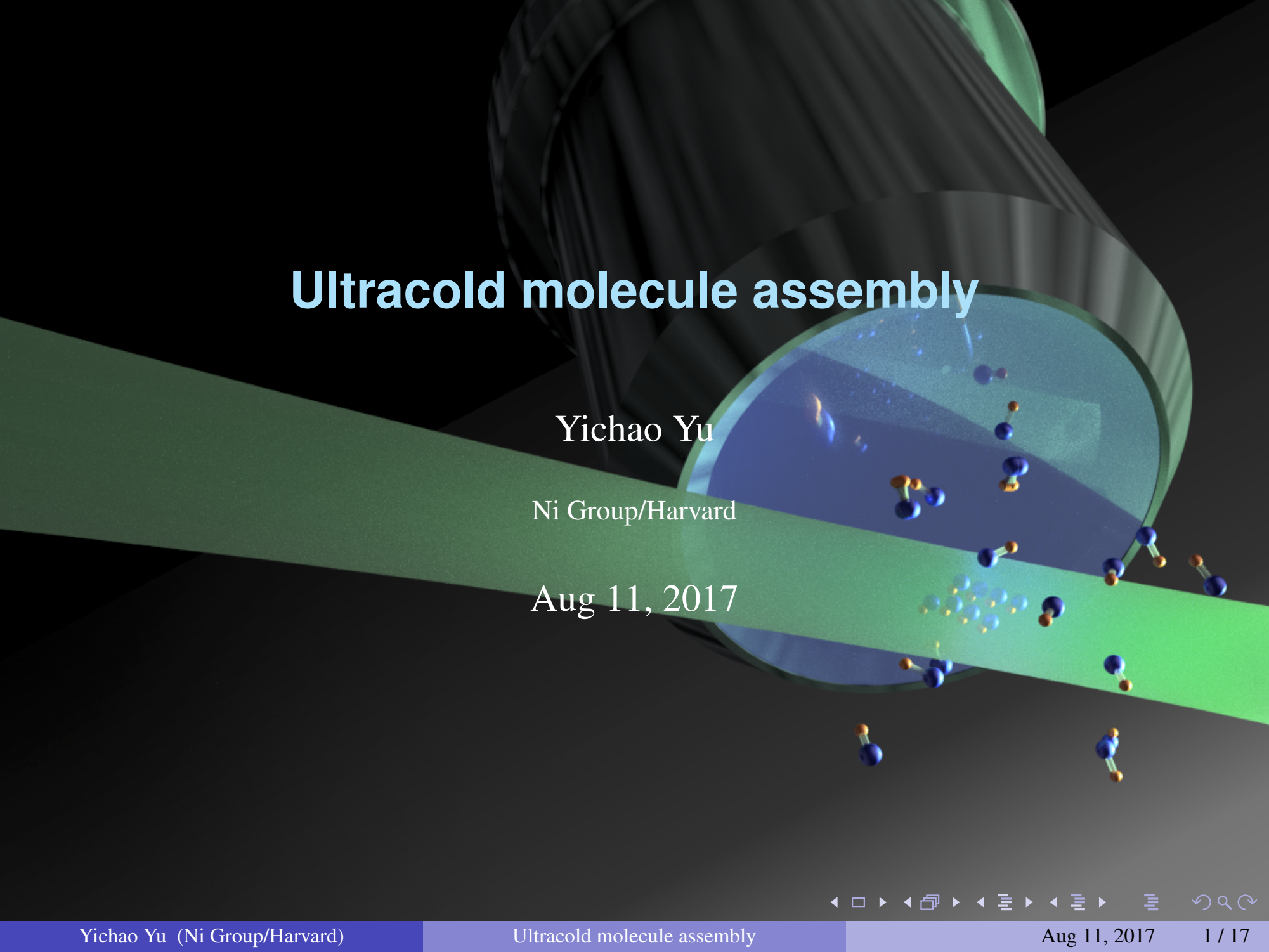


Ultracold molecule assembly

Yichao Yu

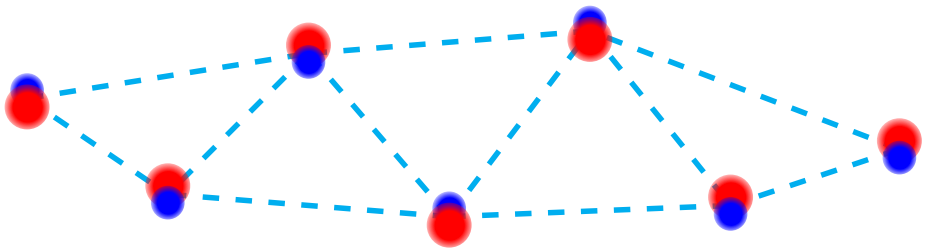
Ni Group/Harvard

Aug 11, 2017

Molecules in optical tweezer

Features

- Strong and tunable interaction
- Rich internal energy levels
- High filling fraction
- Single site detection and manipulation



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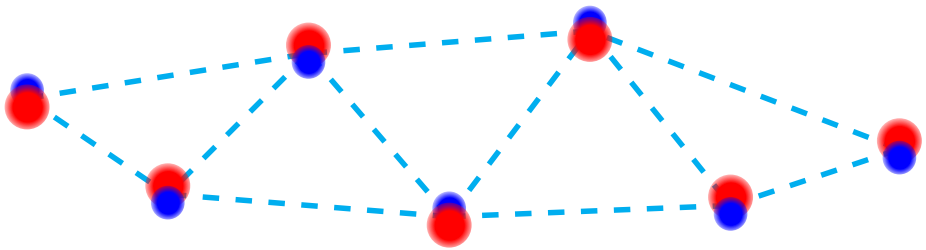

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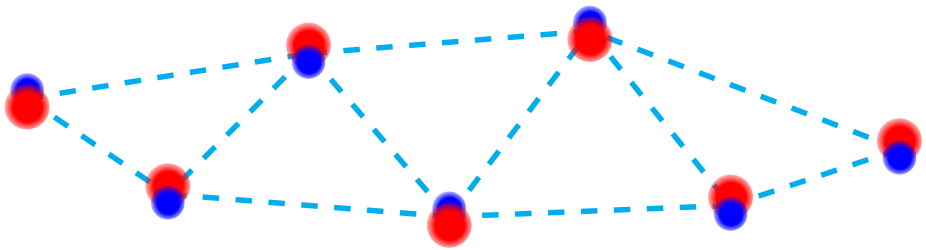

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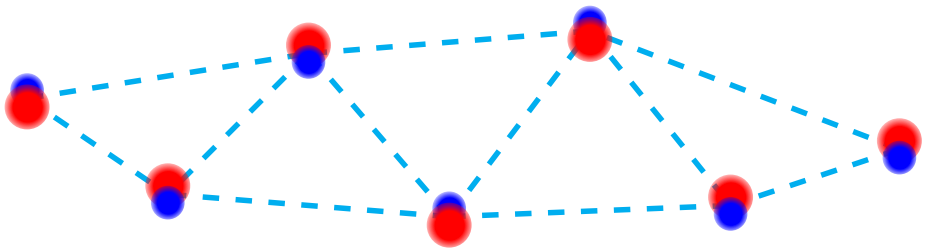

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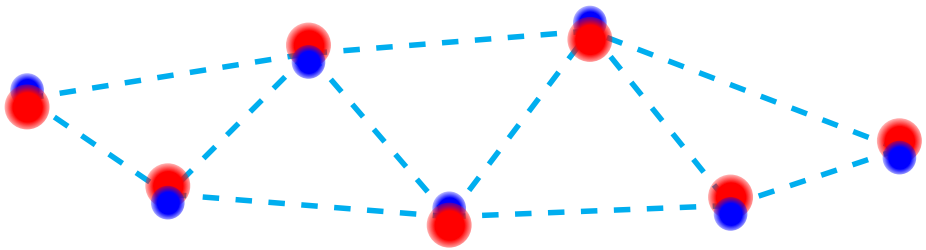

Applications

- Simulation of many-body system
- Quantum computation

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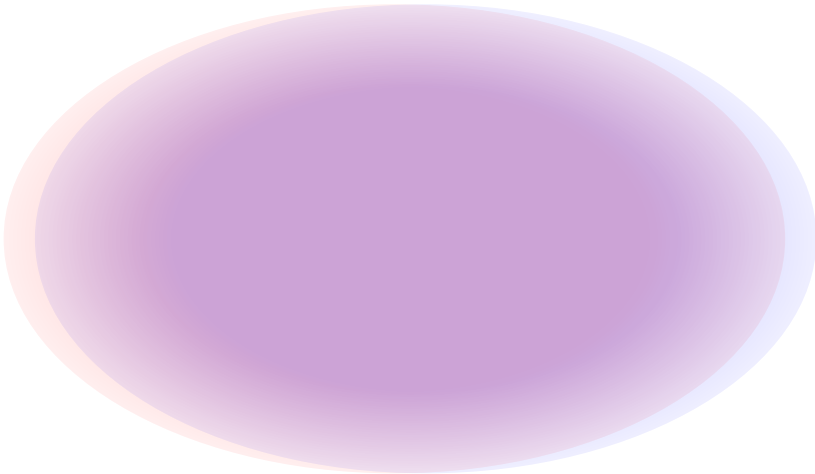
Making molecules from atoms

- MOT (Na + Cs)
- Loading single atoms
- Raman sideband cooling
- Merge traps
- Make molecules!



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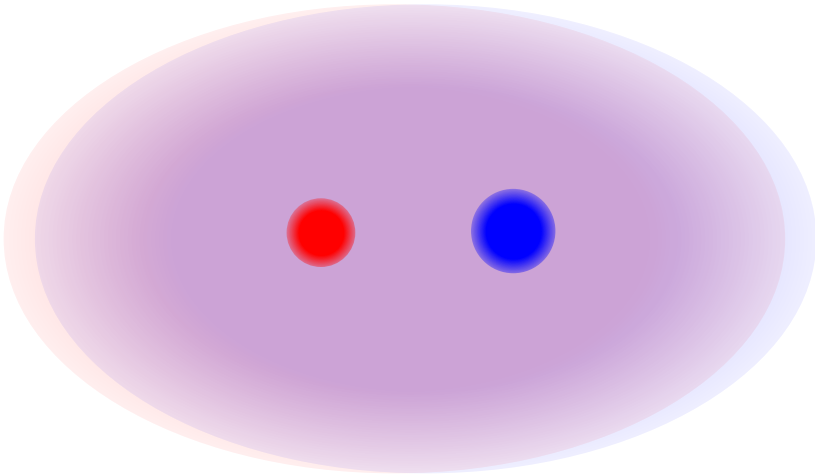

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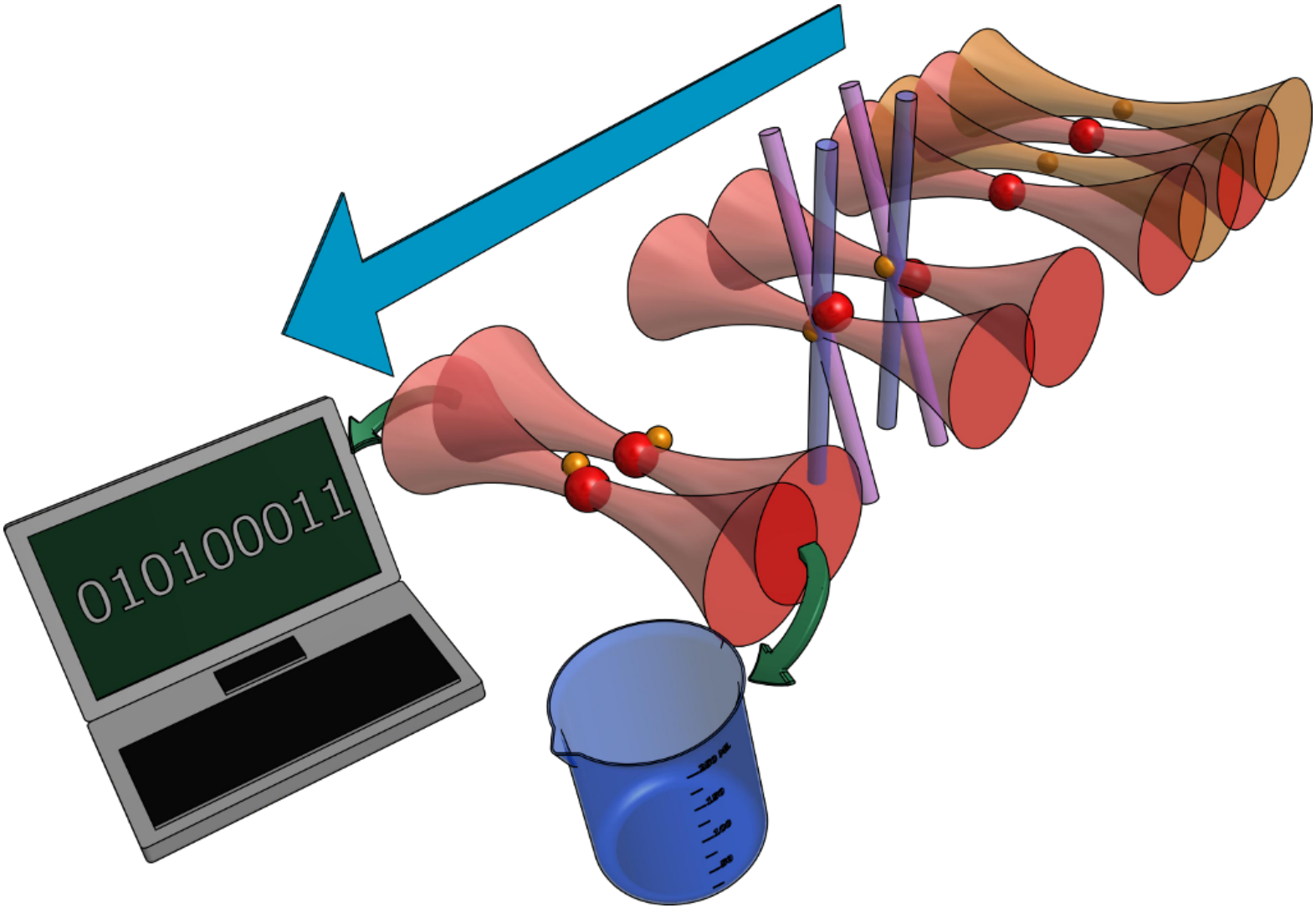
Atom loading and cooling

Cesium

Sodium

Setup



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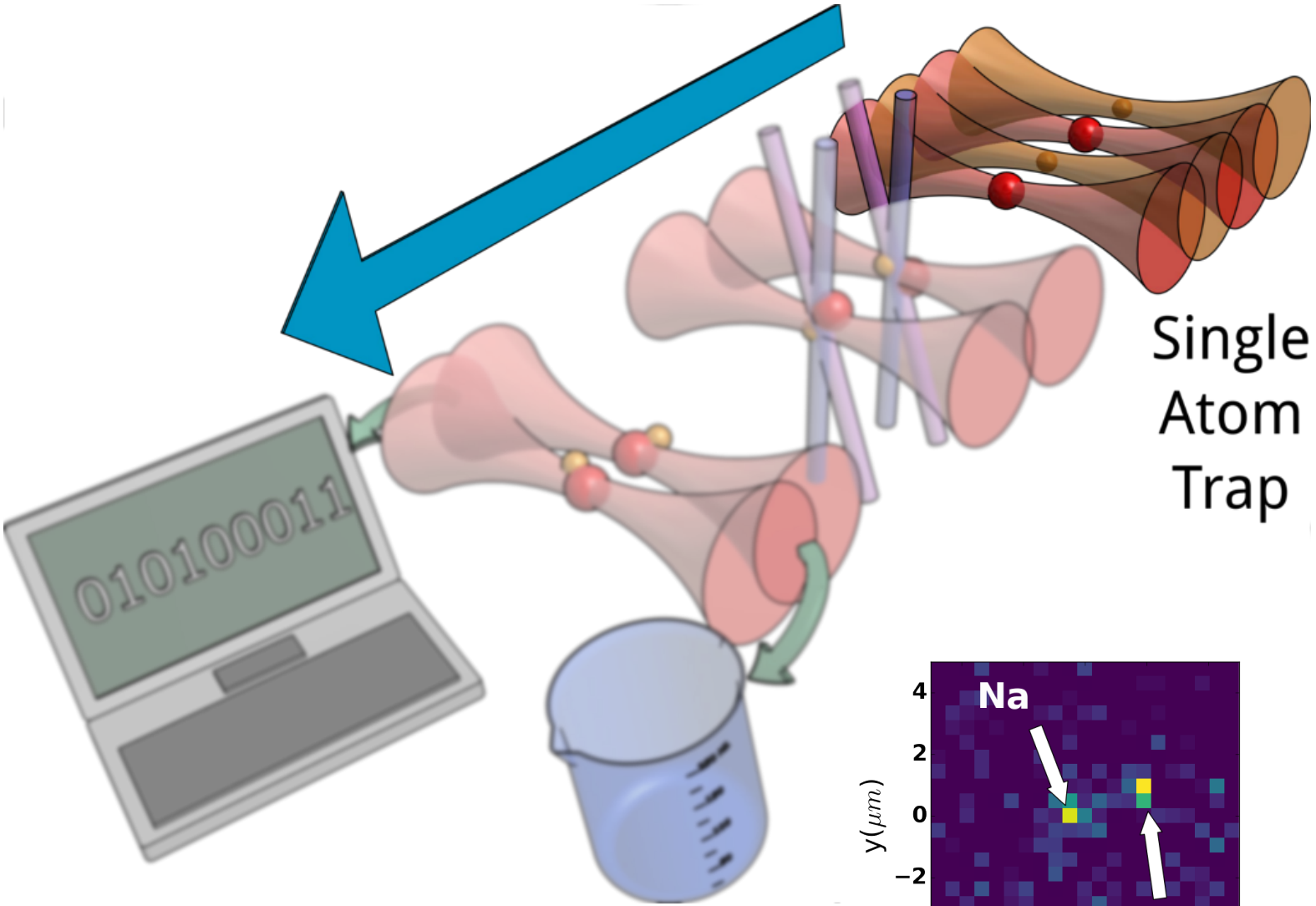
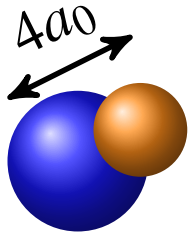
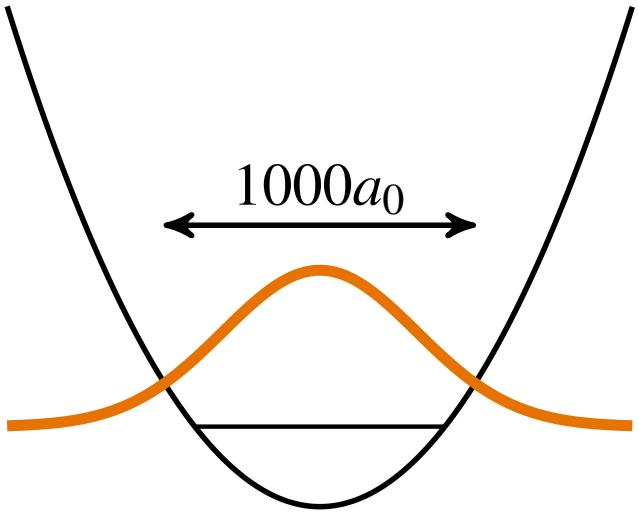


Wave function size mismatch





Molecule **Atom**

Goal of cooling

- Single initial state
- Shrink wavefunction size

Raman sideband cooling of Sodium

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Difficulties

- High initial temperature ($40\mu K$)
- High recoil heating (High Lamb Dicke parameter)

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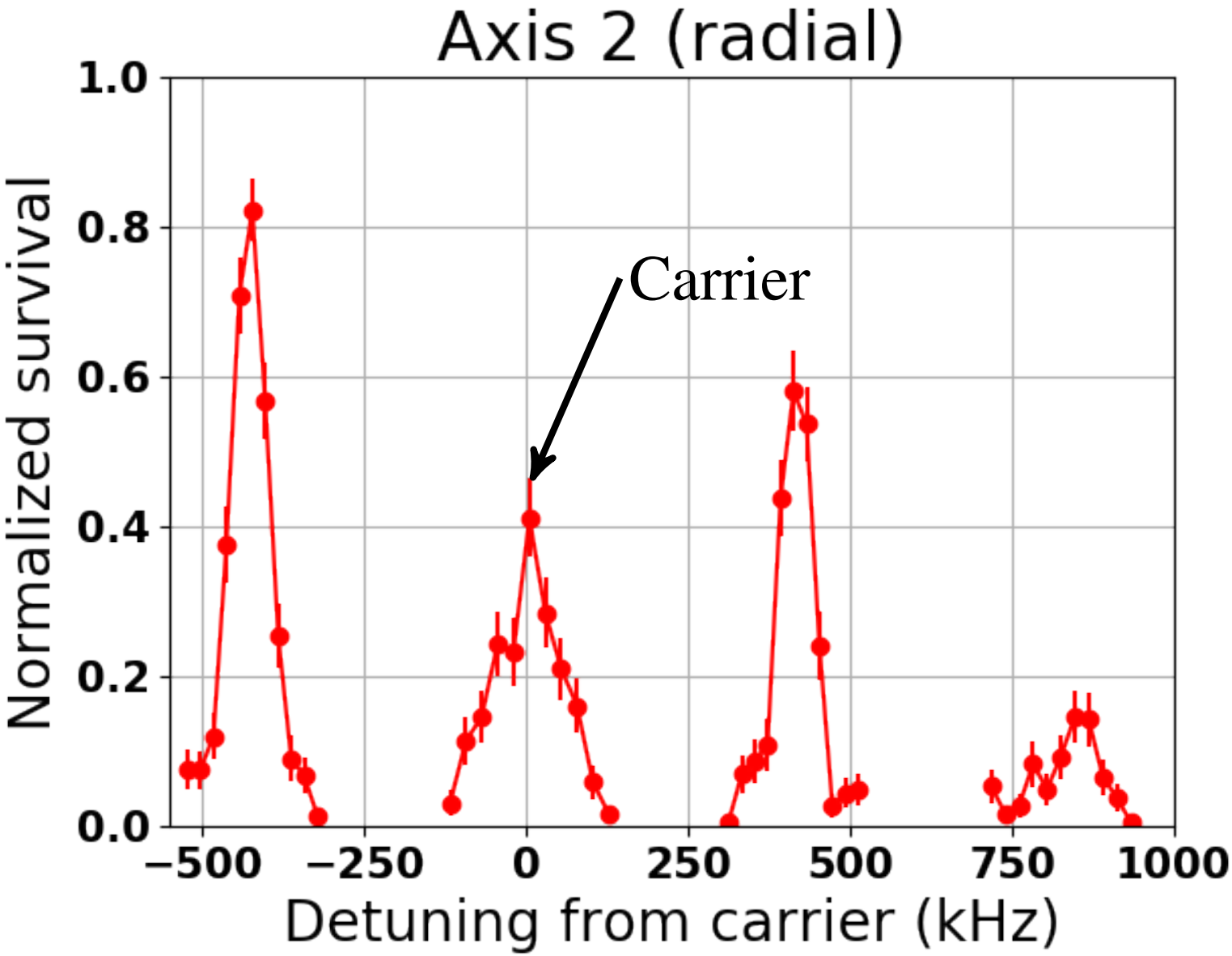
Raman sidebands



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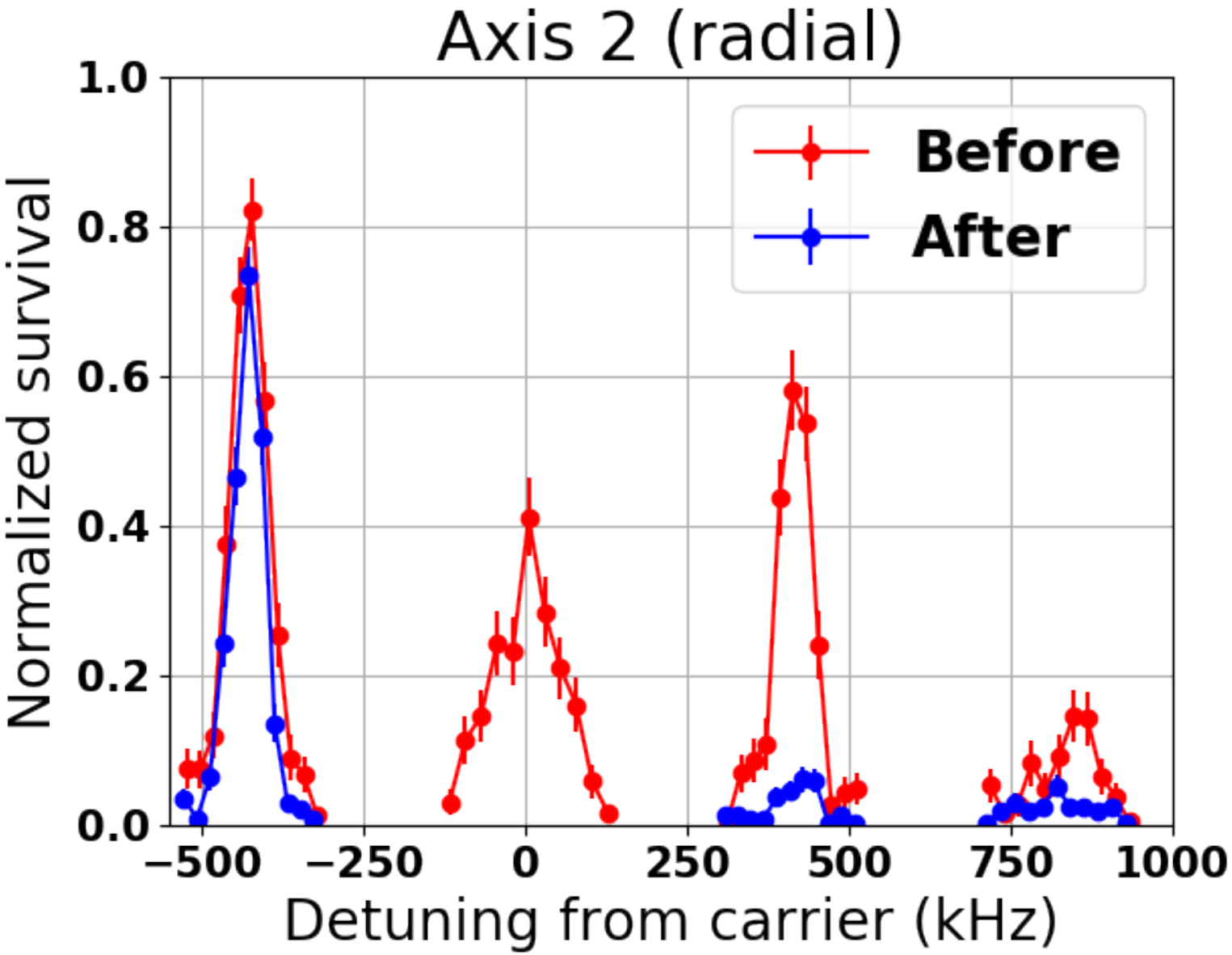

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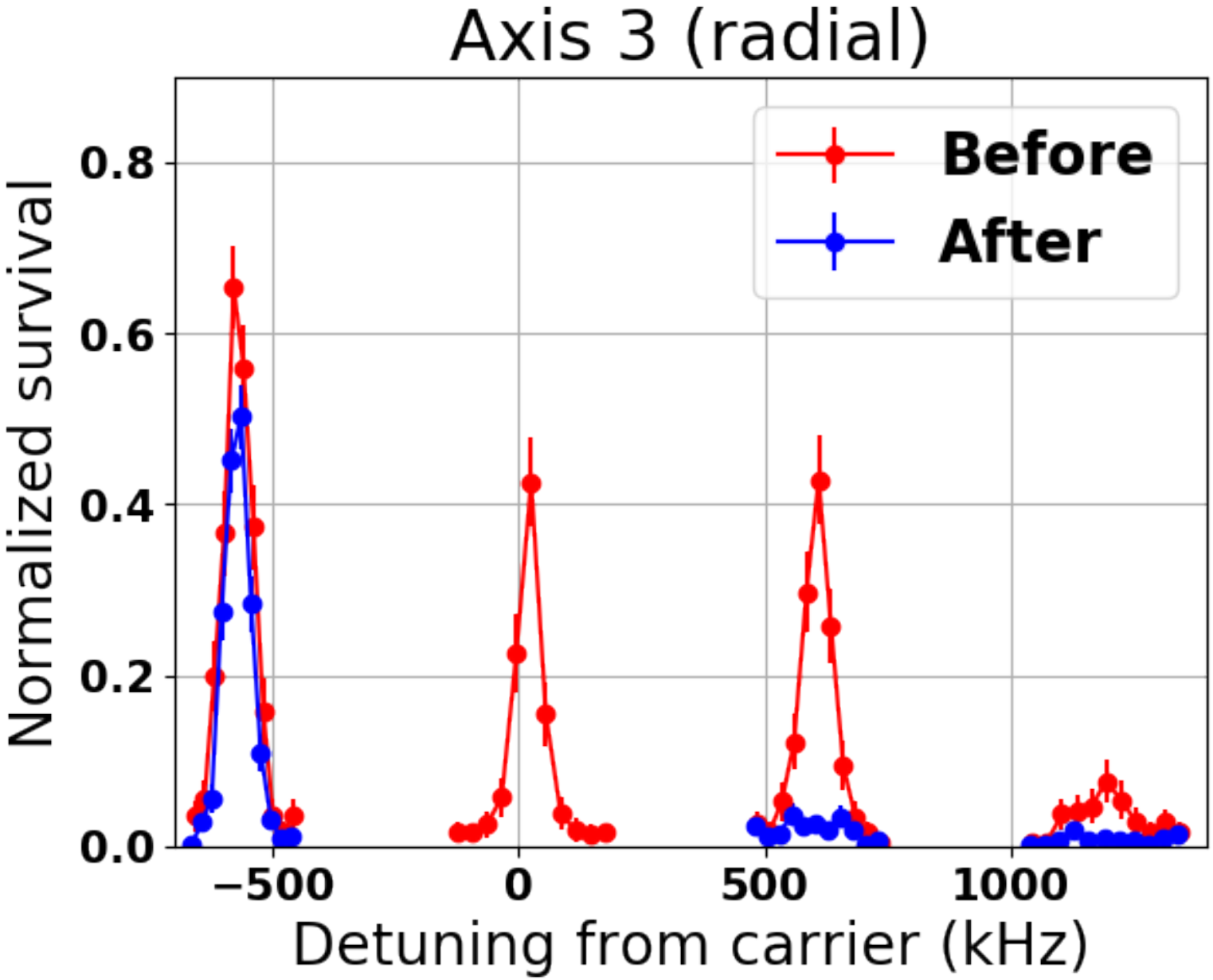

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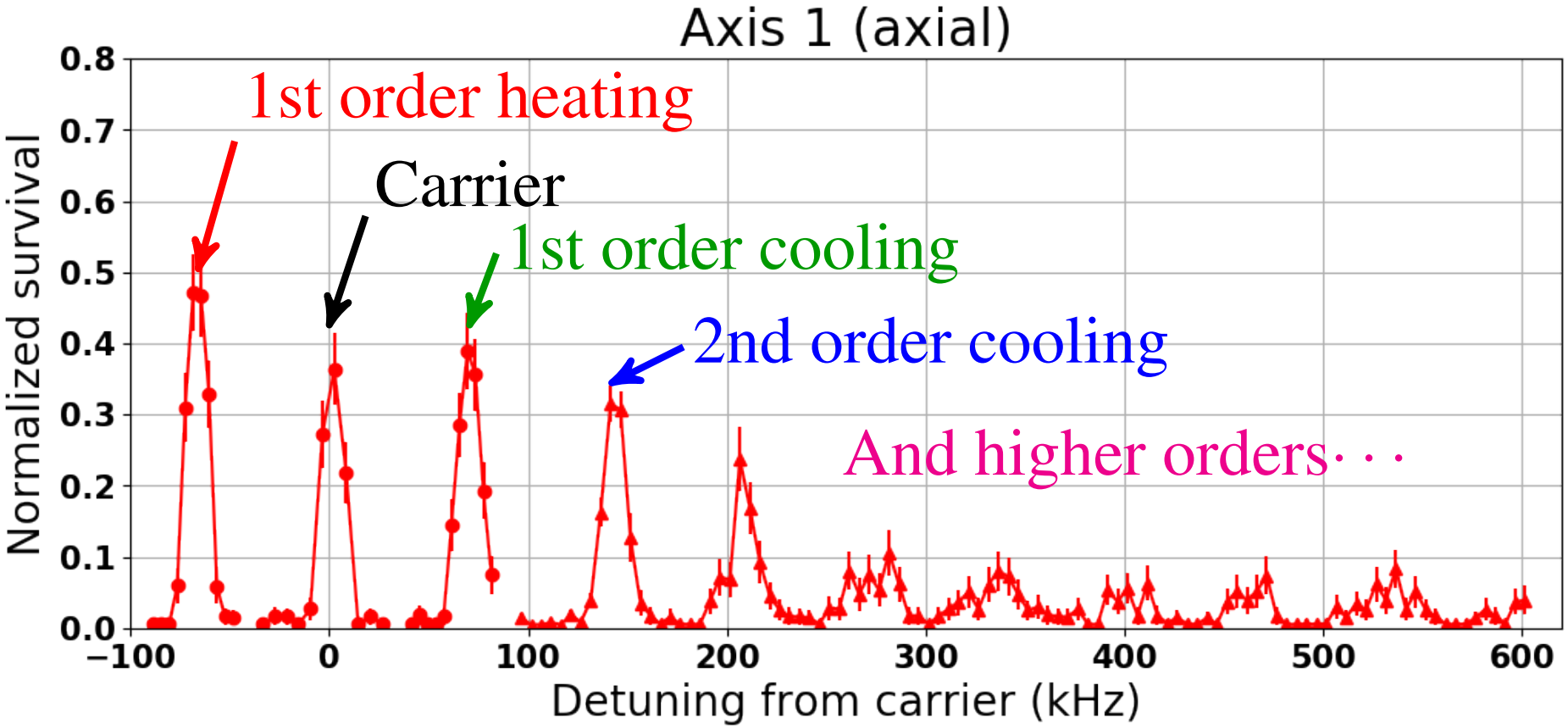

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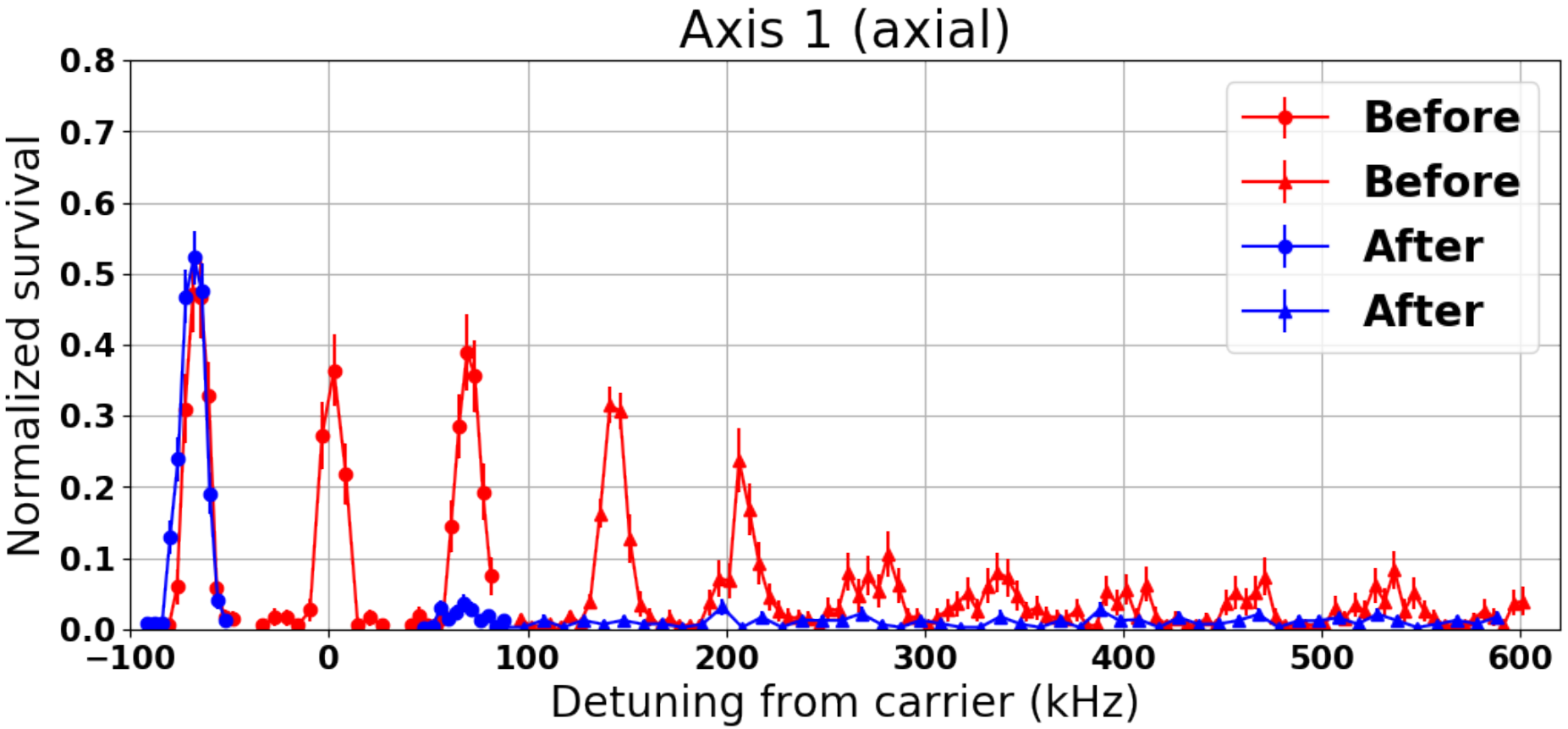
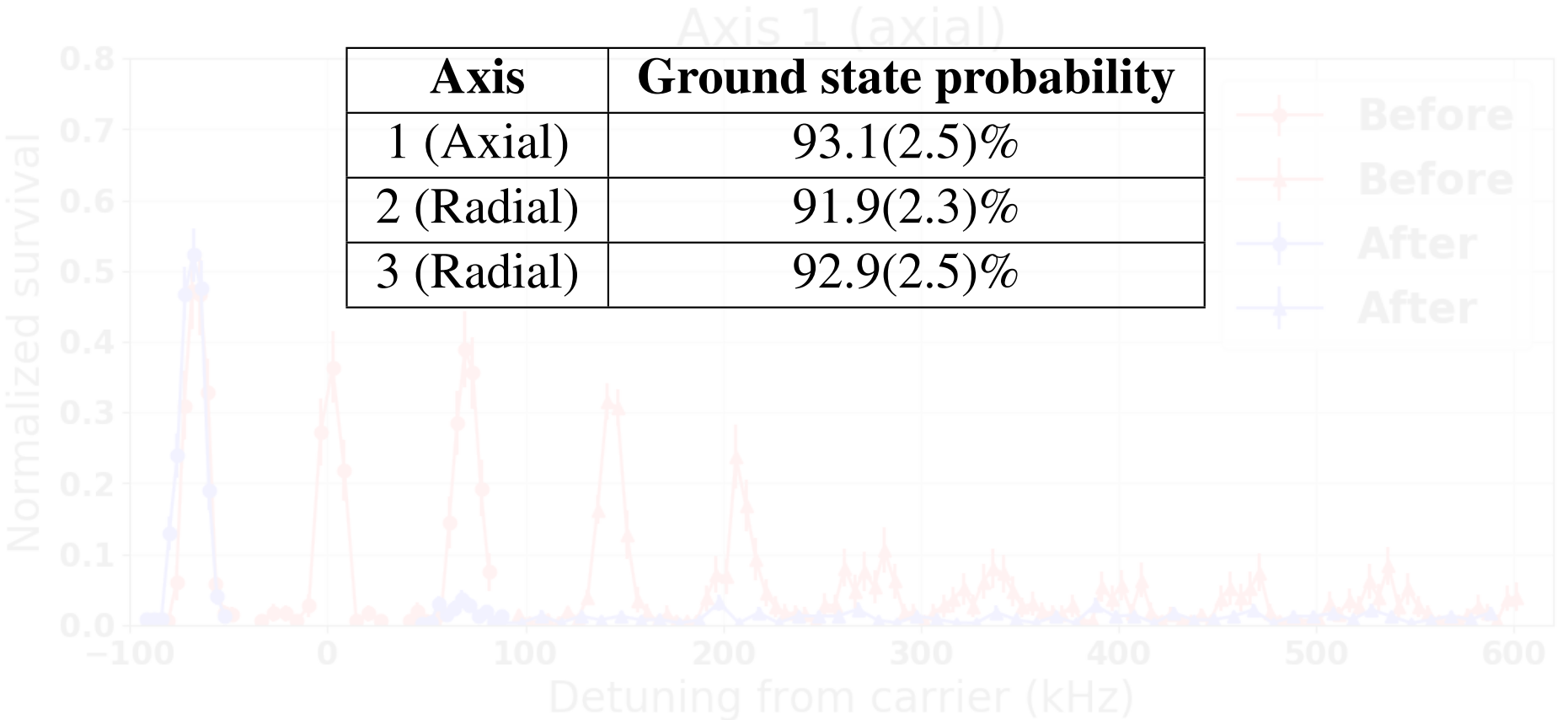


Raman sidebands

Axis	Ground state probability
1 (Axial)	93.1(2.5)%
2 (Radial)	91.9(2.3)%
3 (Radial)	92.9(2.5)%



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1 (Axial)	93.1(2.5)%
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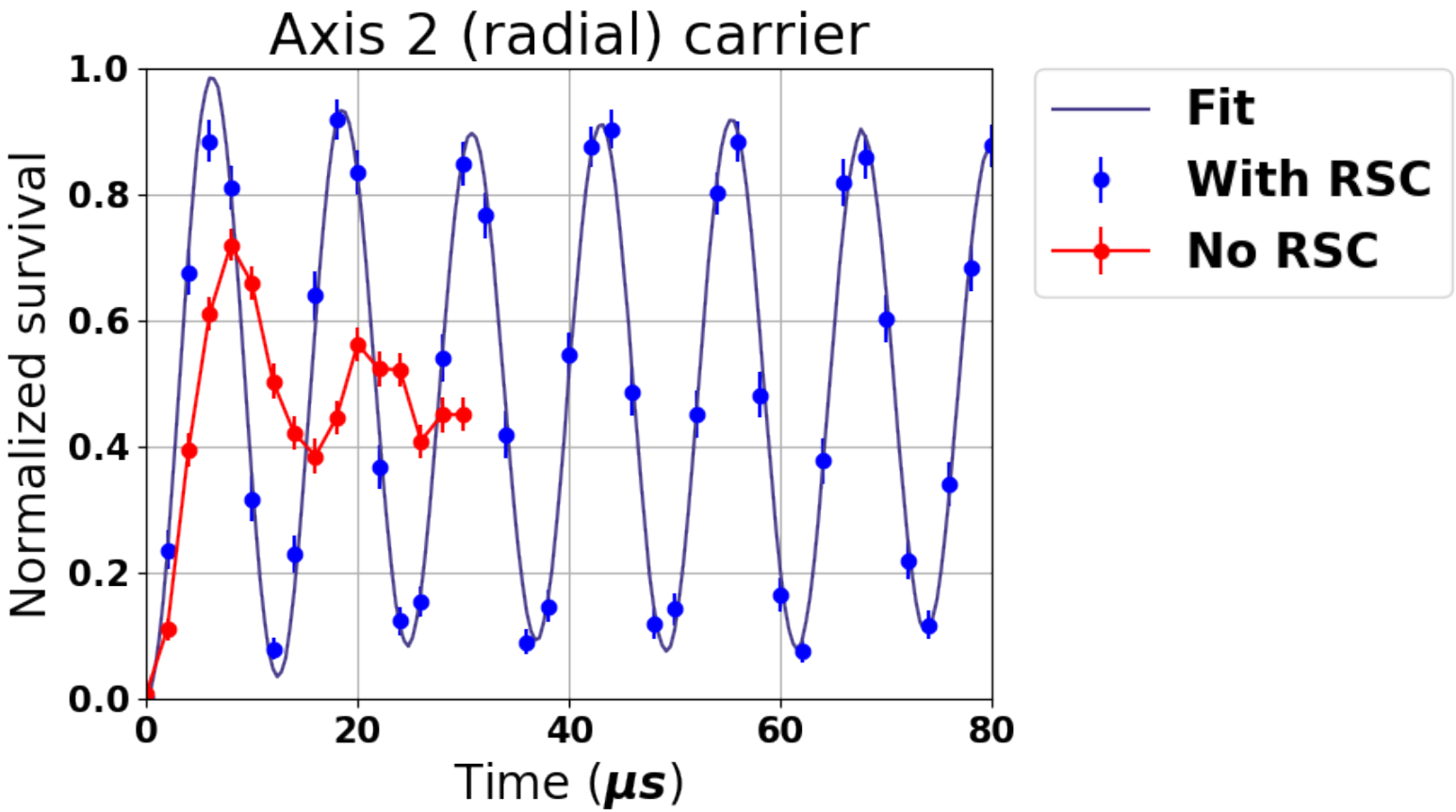
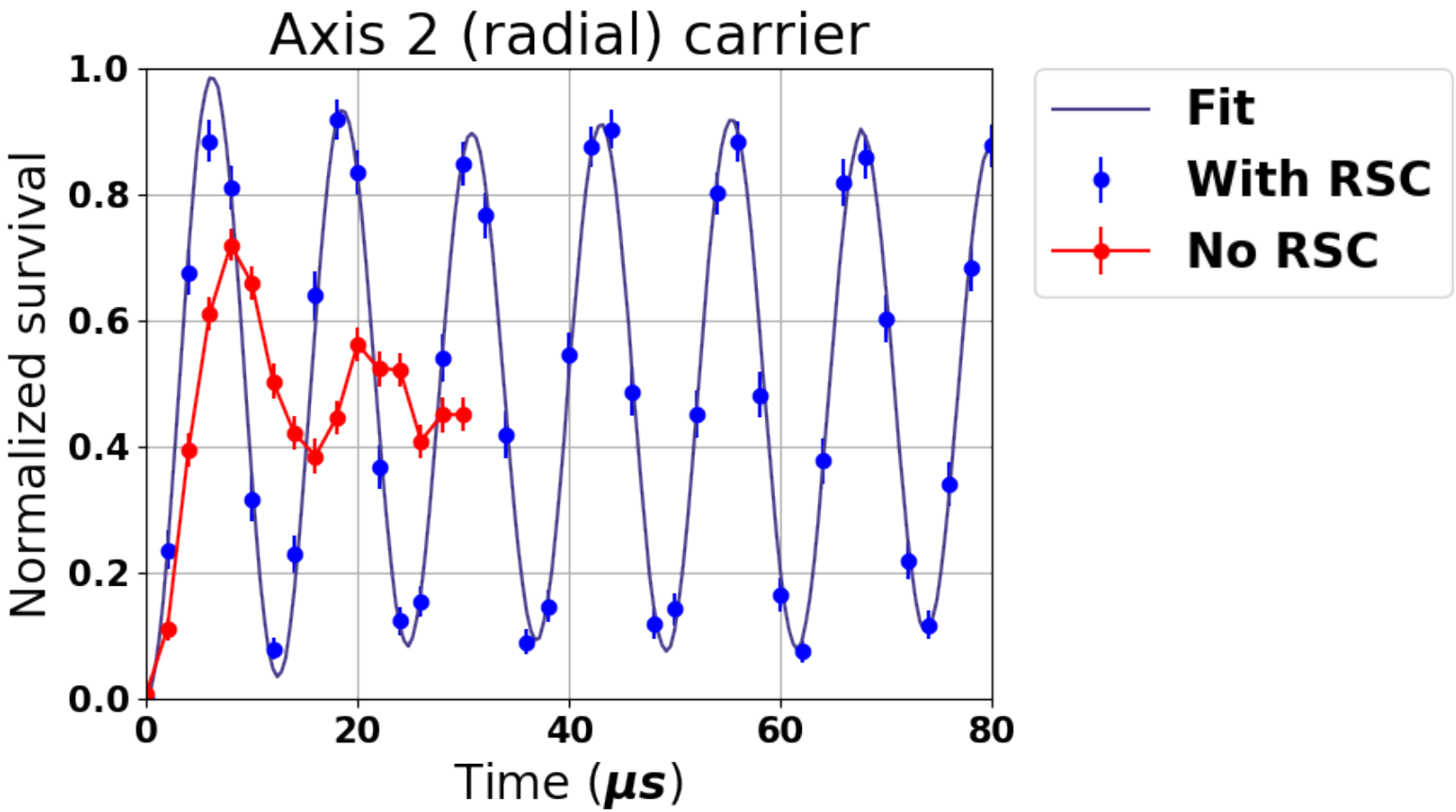
3D ground state: 79.5(3.6)%
Loss after cooling: 15%

Total 3D ground state preparation fidelity: 67.6(3.1)%

Rabi flopping (radial)

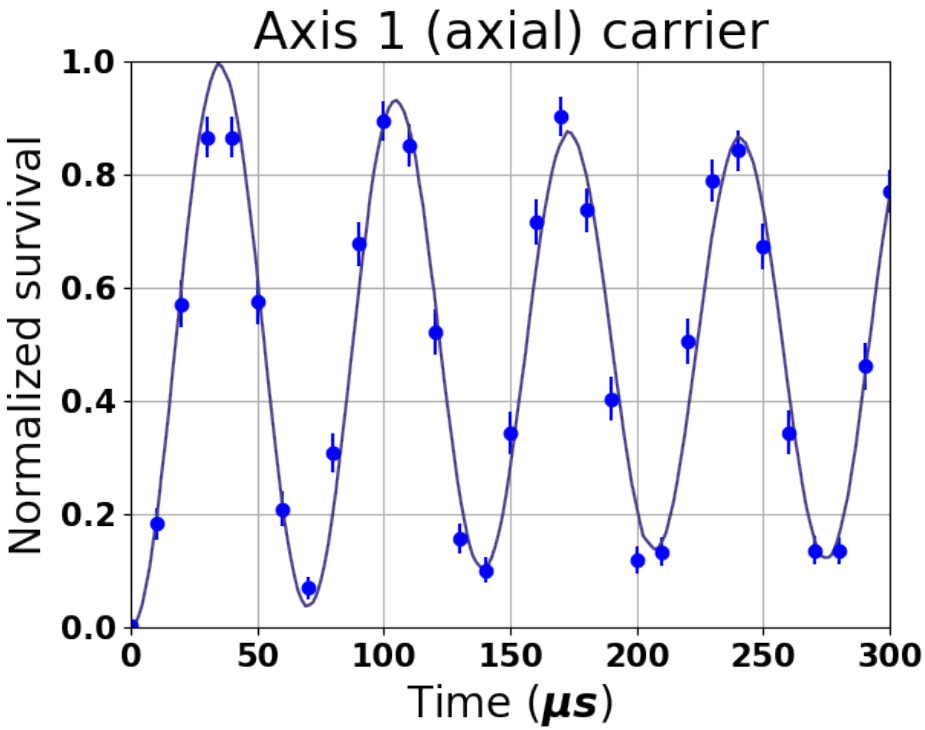


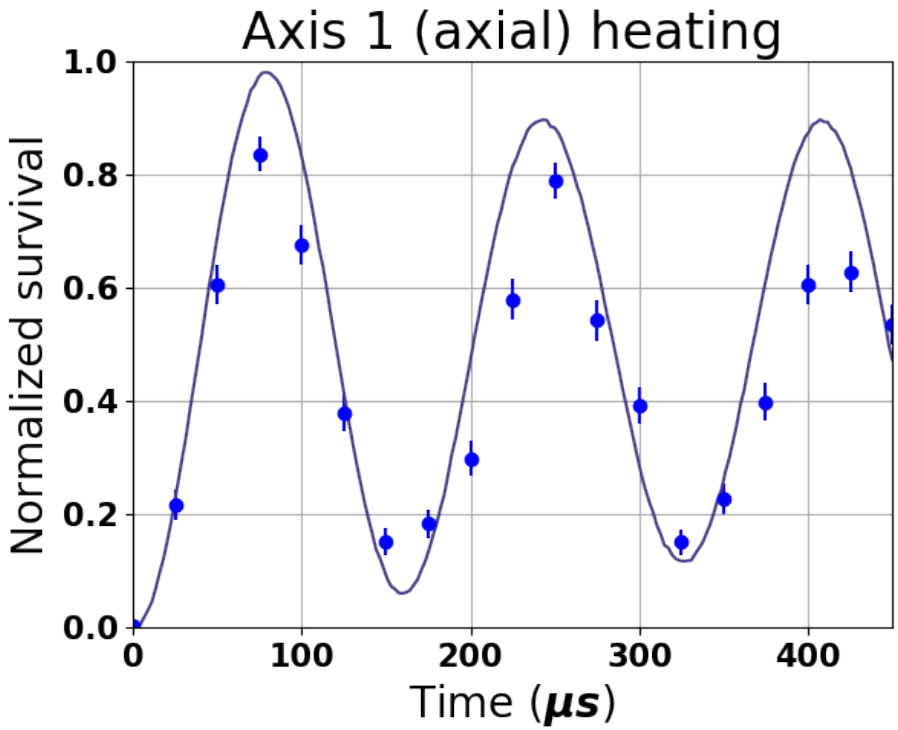
Rabi flopping (radial)



Good agreement in ground state probability between spectrum and Rabi flopping data.

Rabi flopping (axial)





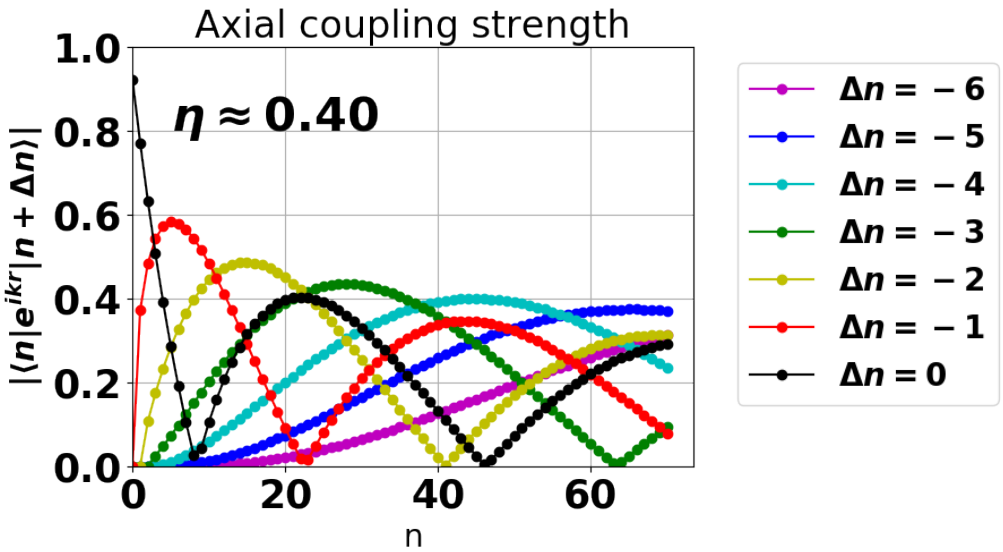
Conclusion

67.6(3.1)% ground state preparation fidelity (79.5(3.6)% without loss)

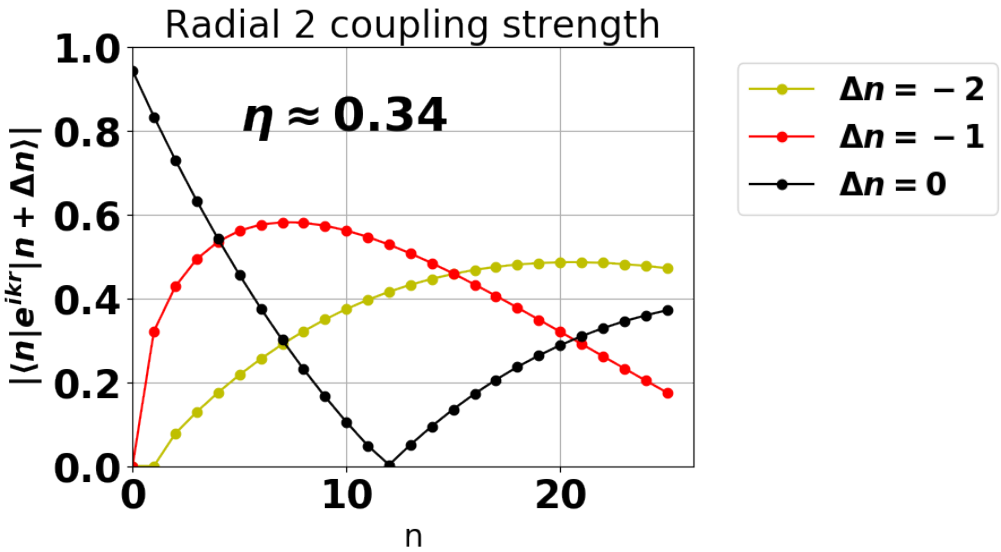
Improvements

- Reduce off-resonance scattering from Raman beams
- Reduce magnetic field fluctuation
- Reduce loss during cooling

Axial matrix element



Radial 2 matrix element



Radial 3 matrix element