Raman sideband cooling of a single sodium atom to 3D ground state

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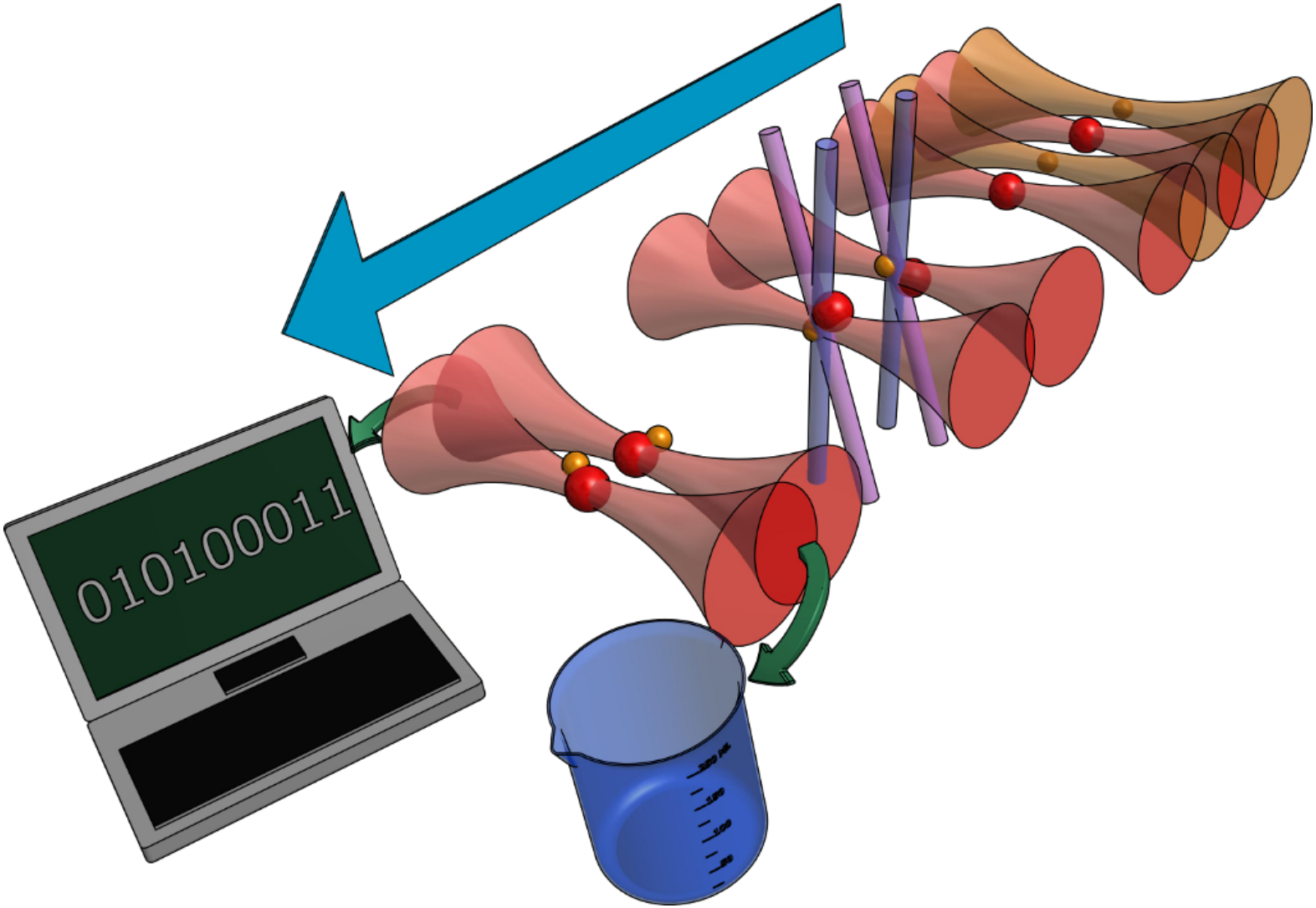
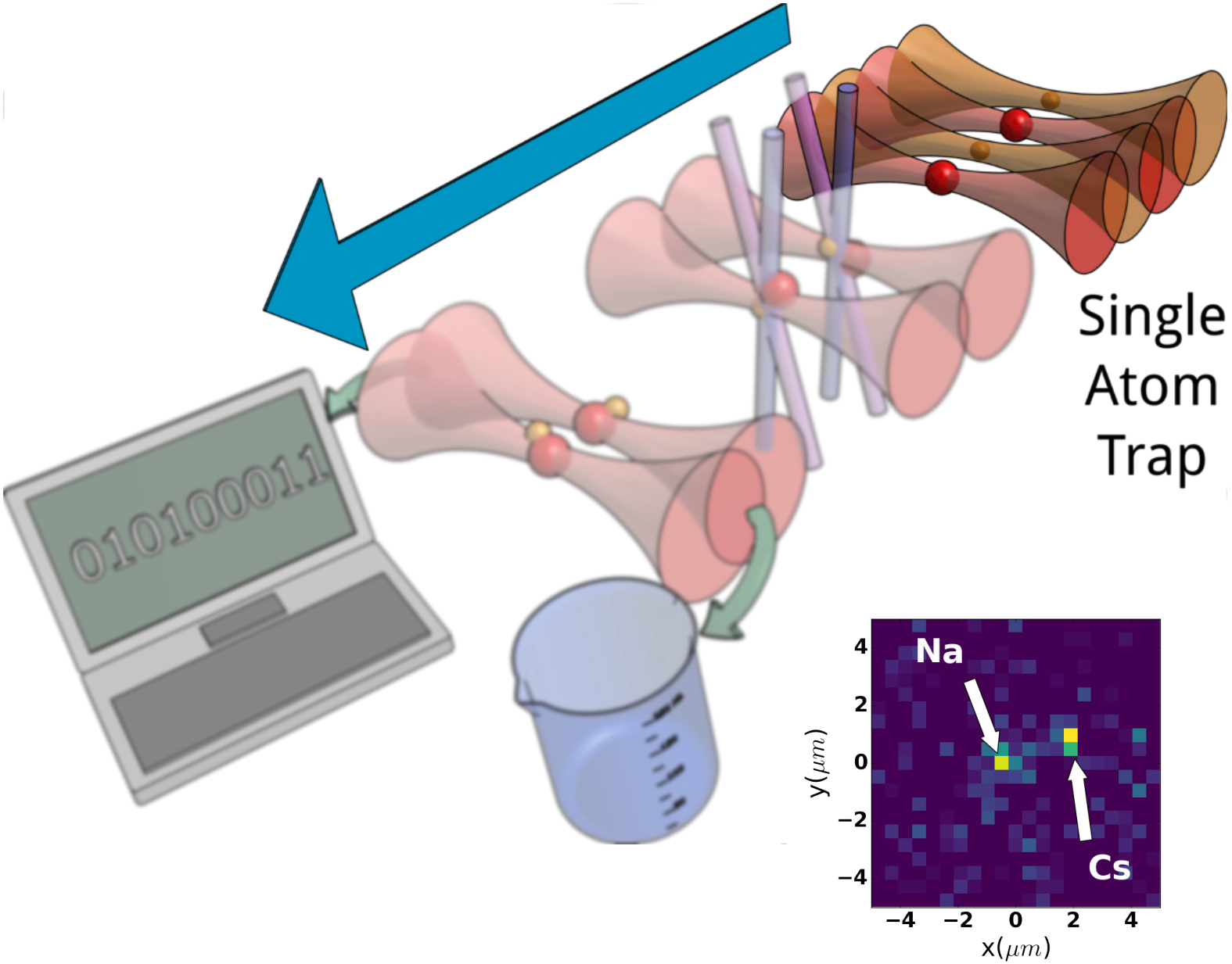
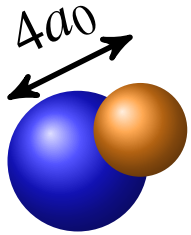
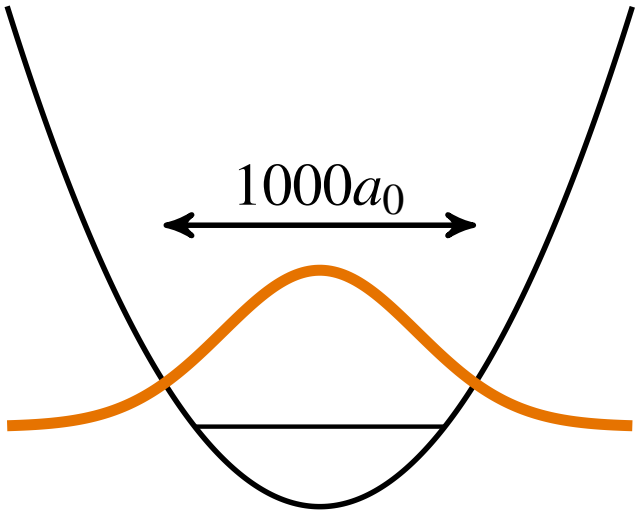

010100011


010100011
Single
Atom
Trap
Na
Cs
4
2
0
−2
−4
−4
−2
0
2
4
y(μm)
x(μm)

Wave function size mismatch



Molecule

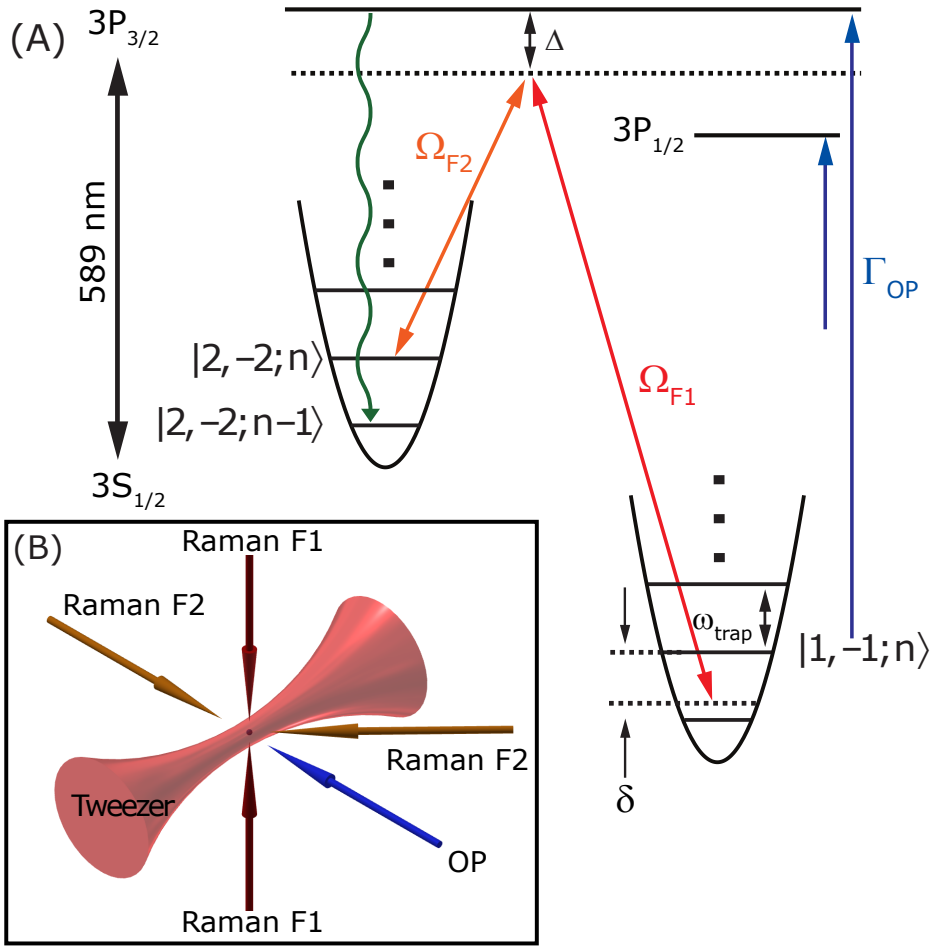


Atom

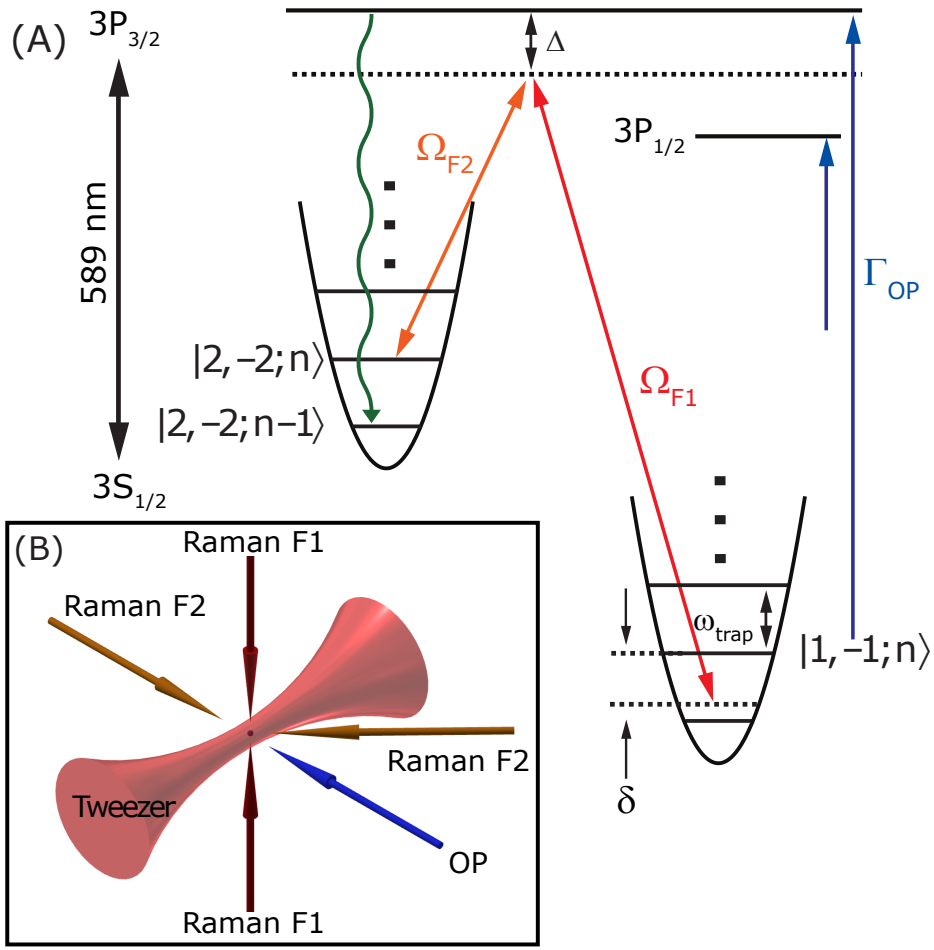
Goal of cooling

- Single initial state
- Shrink wavefunction size

Raman sideband cooling of Sodium



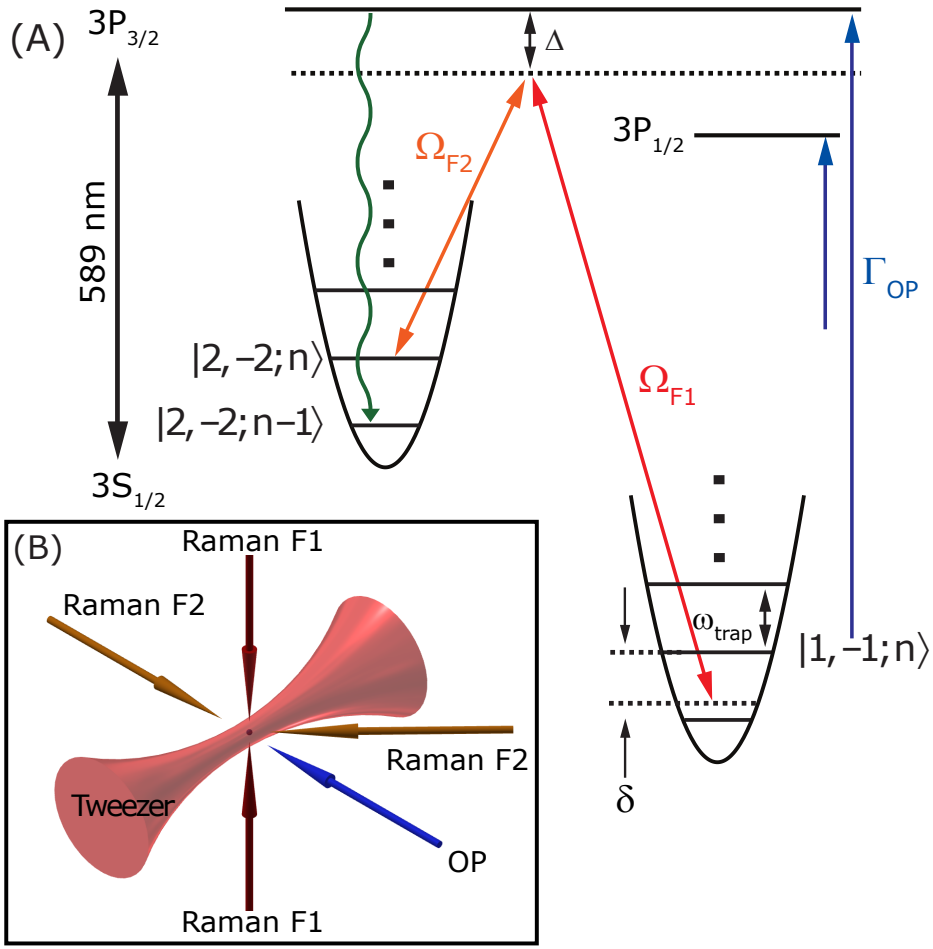
Raman sideband cooling of Sodium



Difficulties

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

Raman sideband cooling of Sodium



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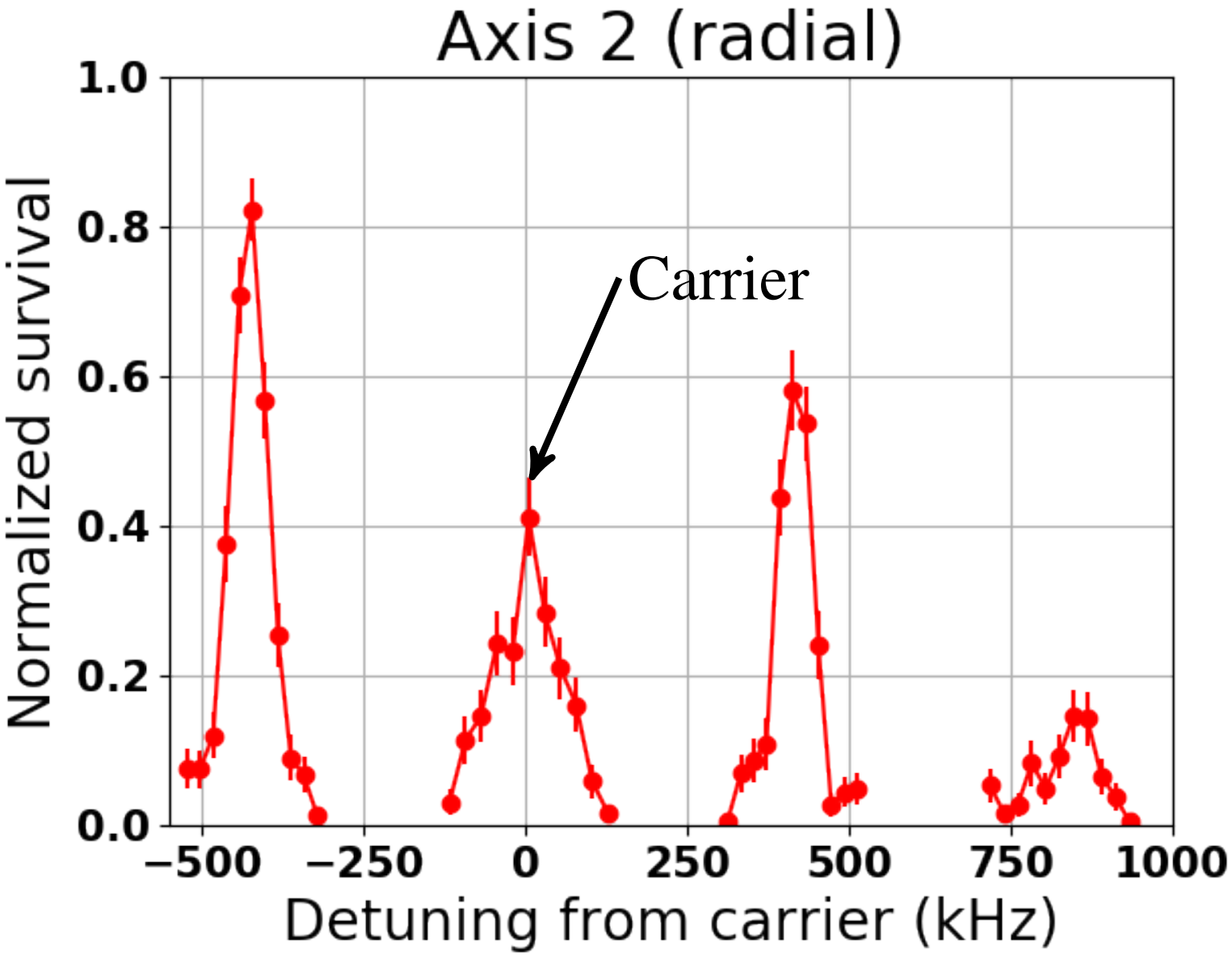
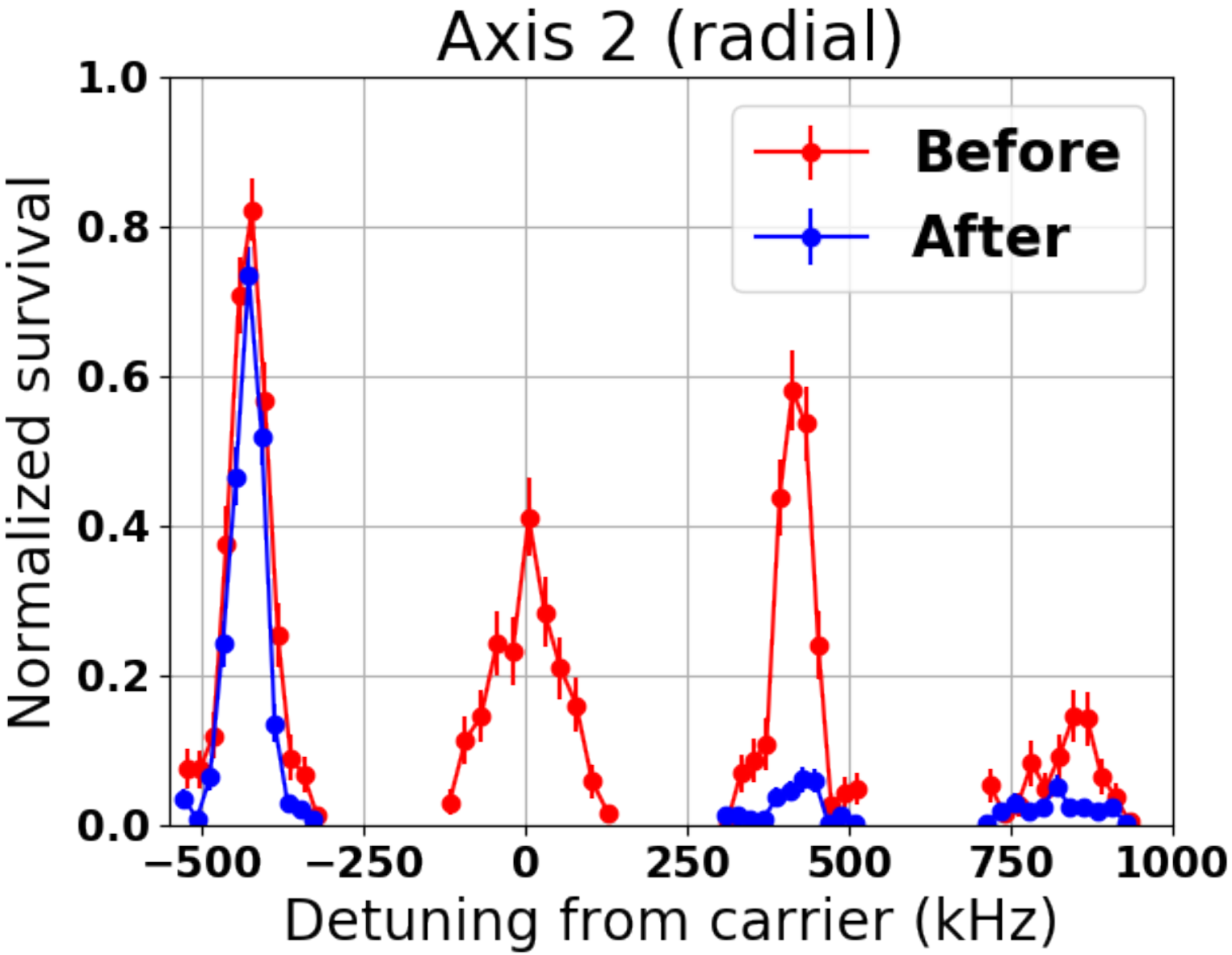
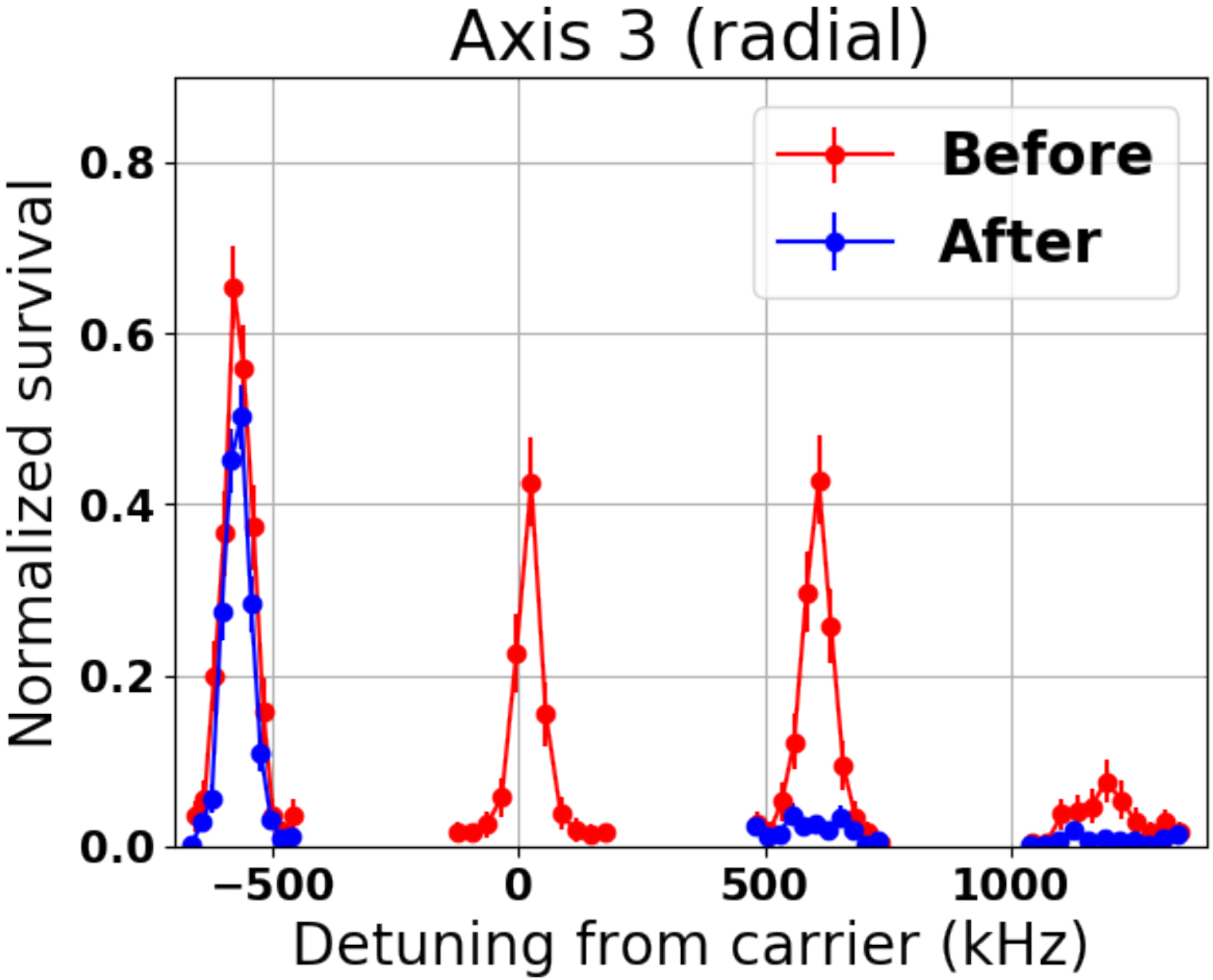
Raman sidebands



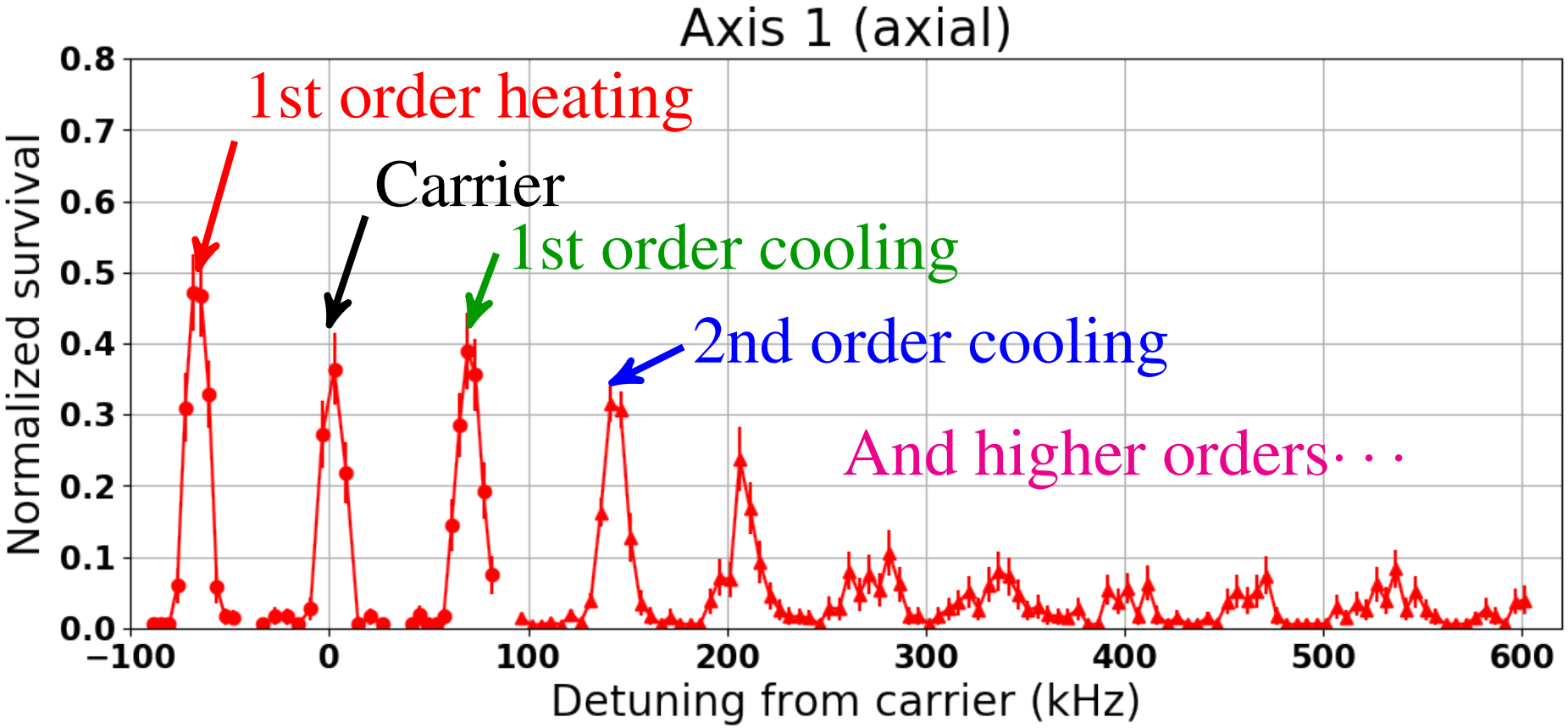
Raman sidebands



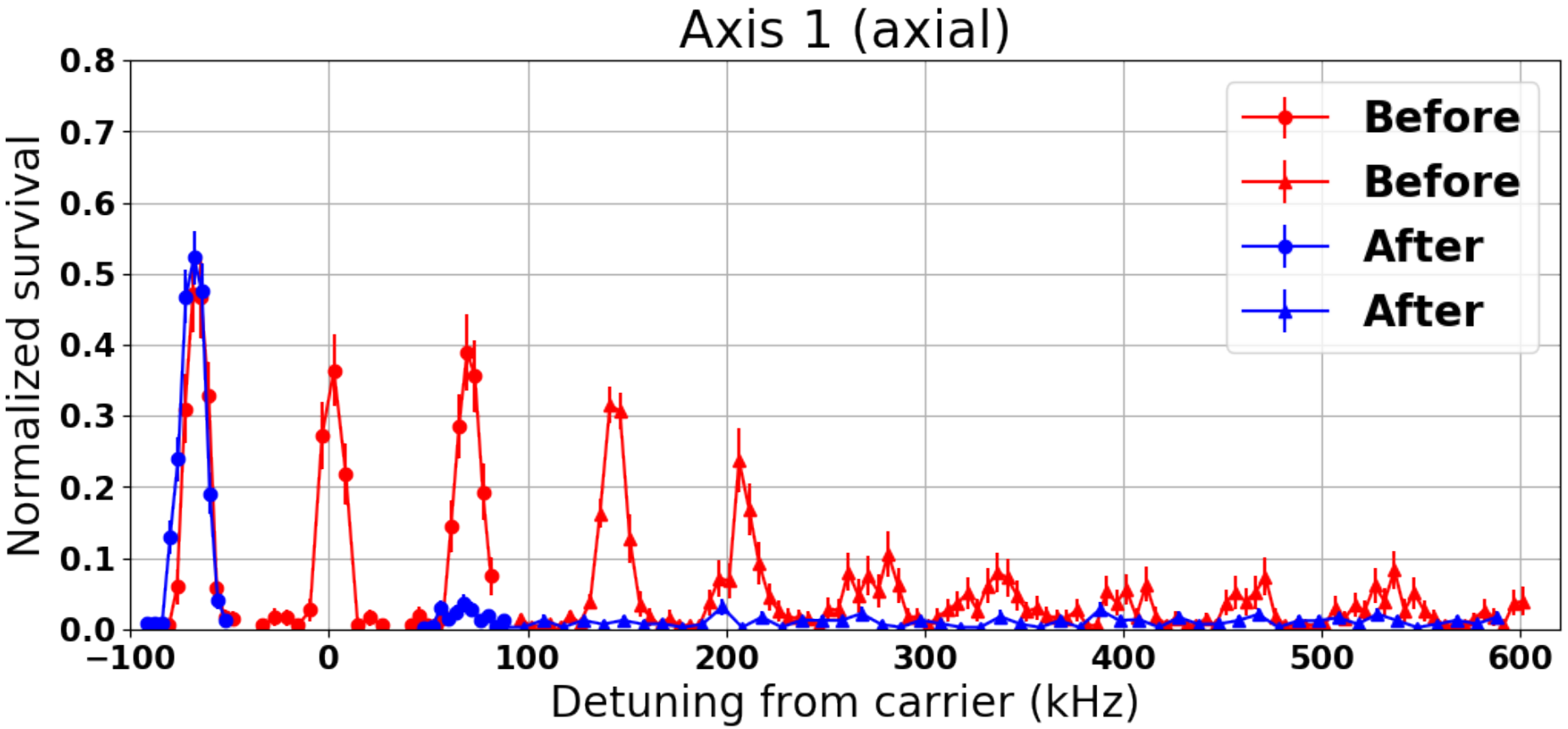
Raman sidebands



Raman sidebands

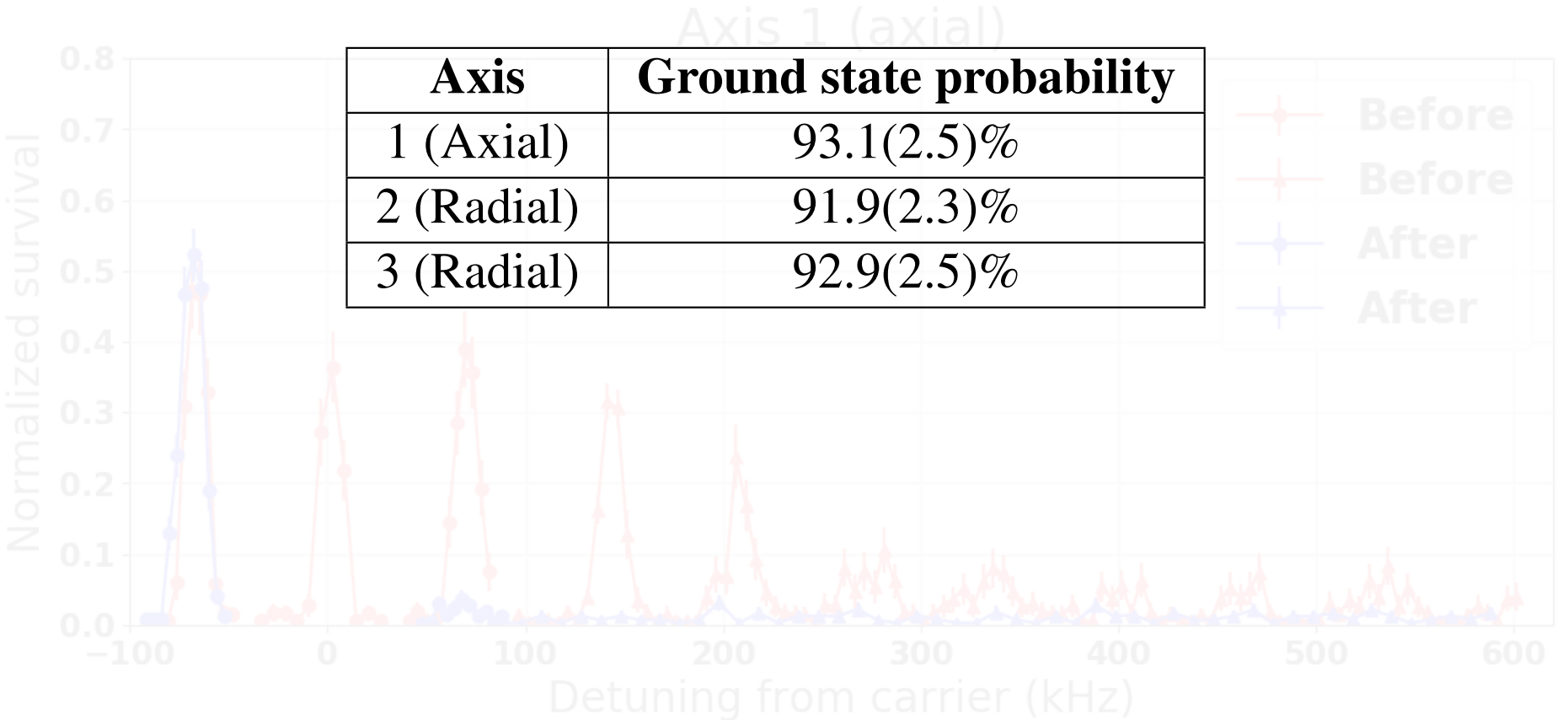


Raman sidebands



Raman sidebands

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



Raman sidebands

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1 (Axial)	93.1(2.5)%
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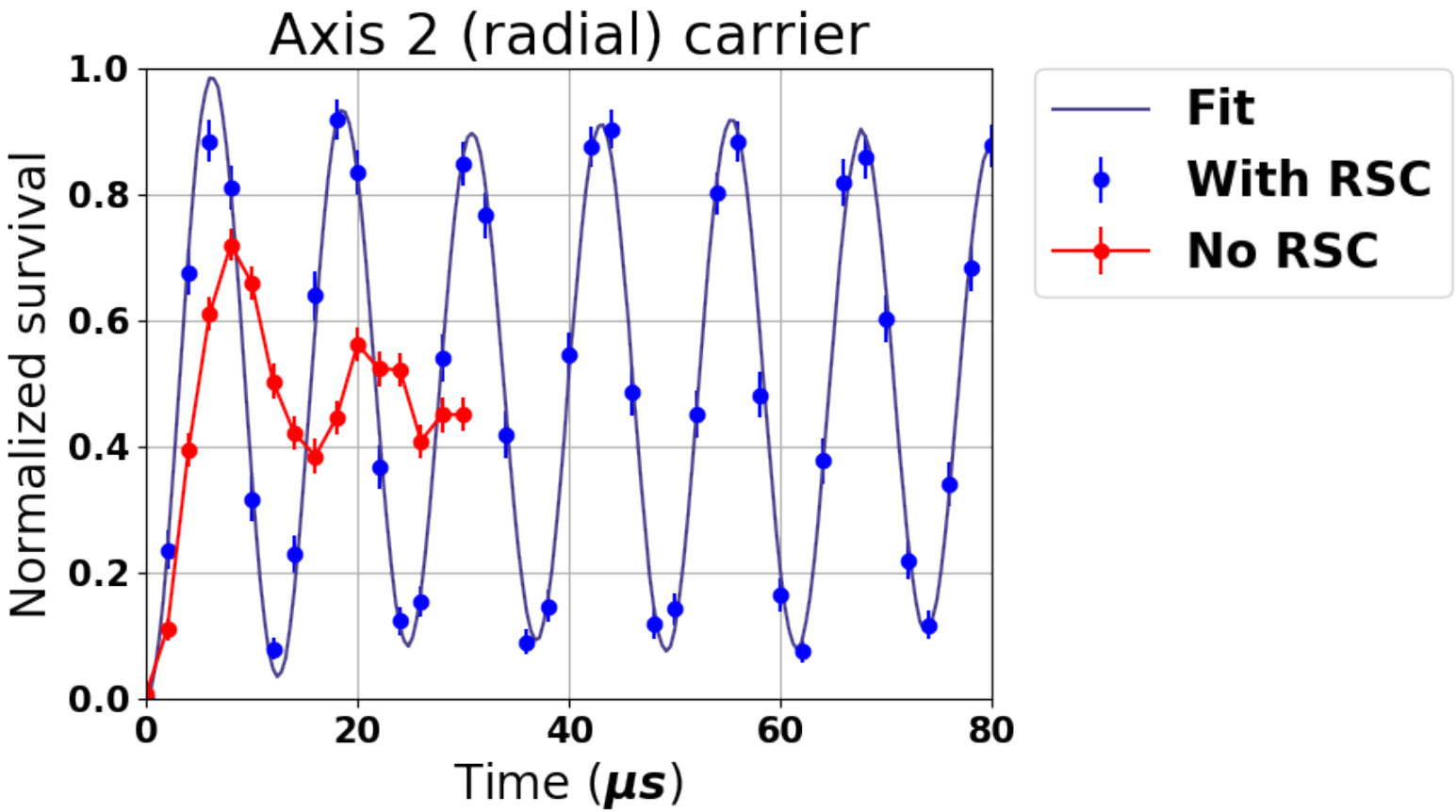
3 (Radial)	92.9(2.5)%

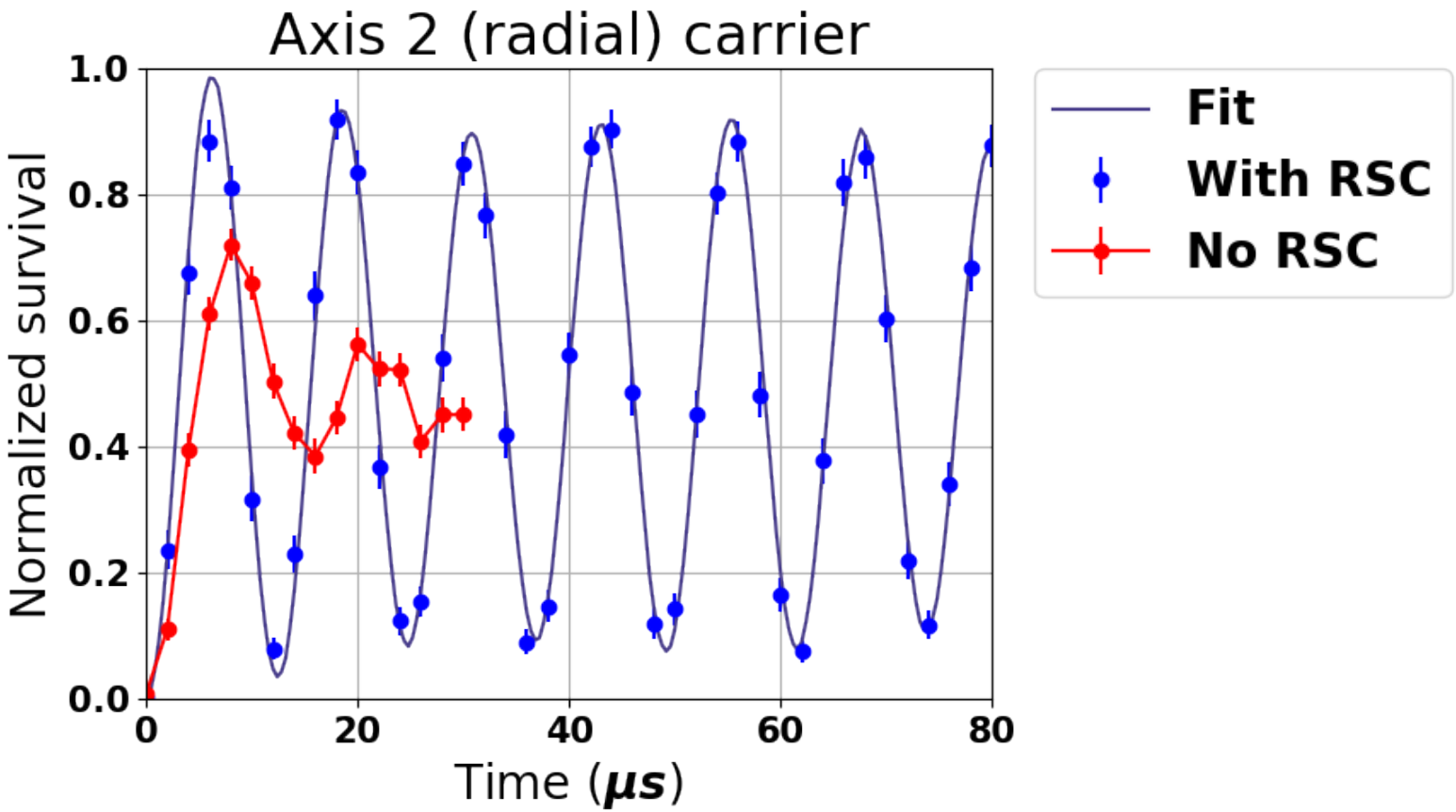
3D ground state: 79.5(3.6)%
Loss after cooling: 15%

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

Rabi flopping (radial)

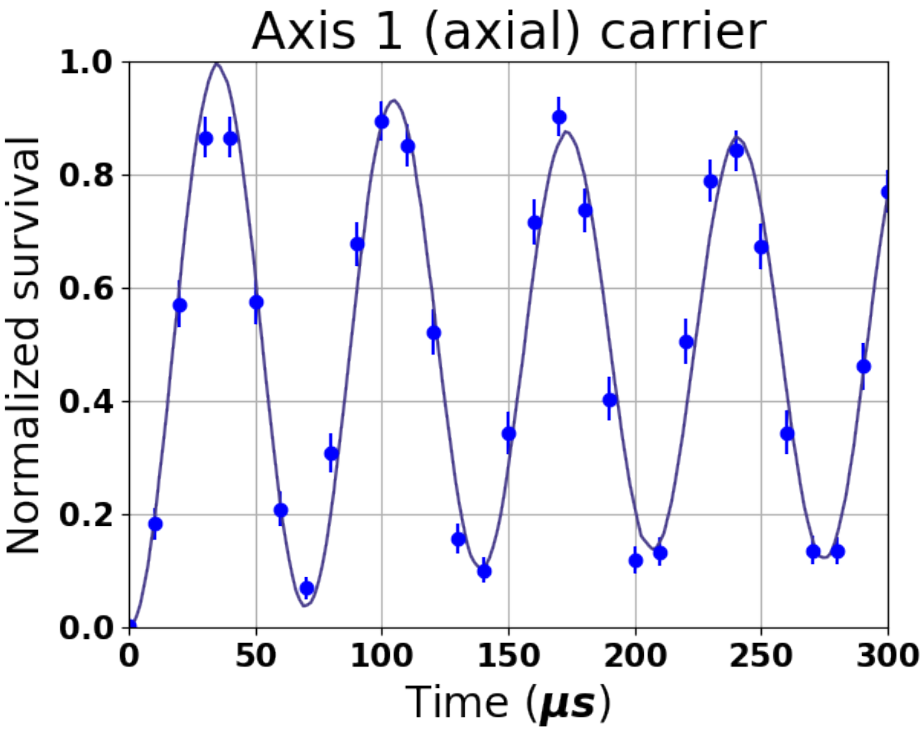


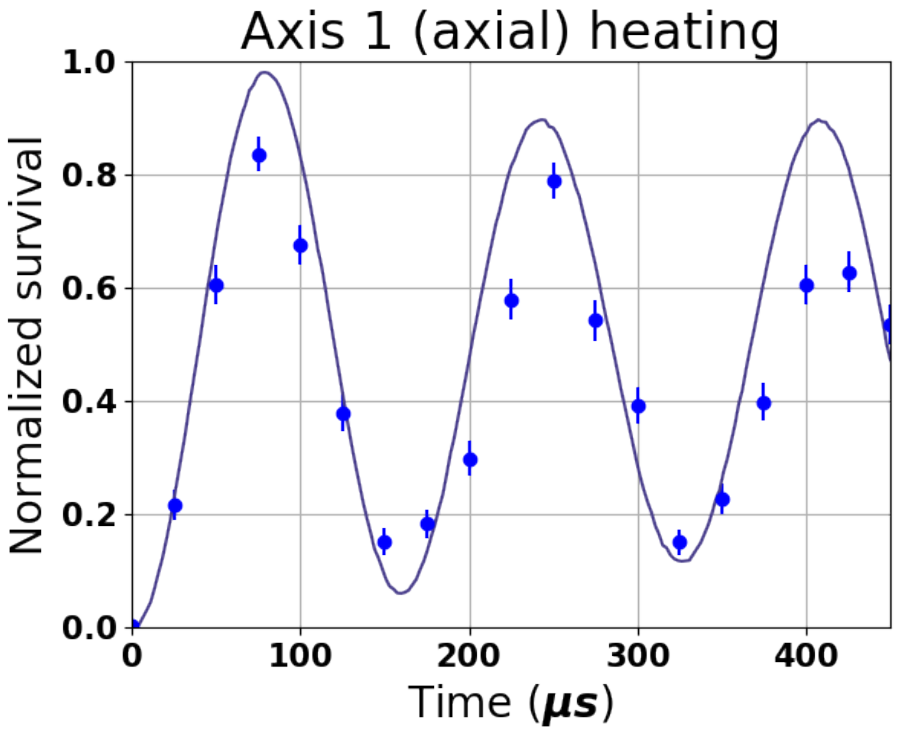
Rabi flopping (radial)



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

Rabi flopping (axial)





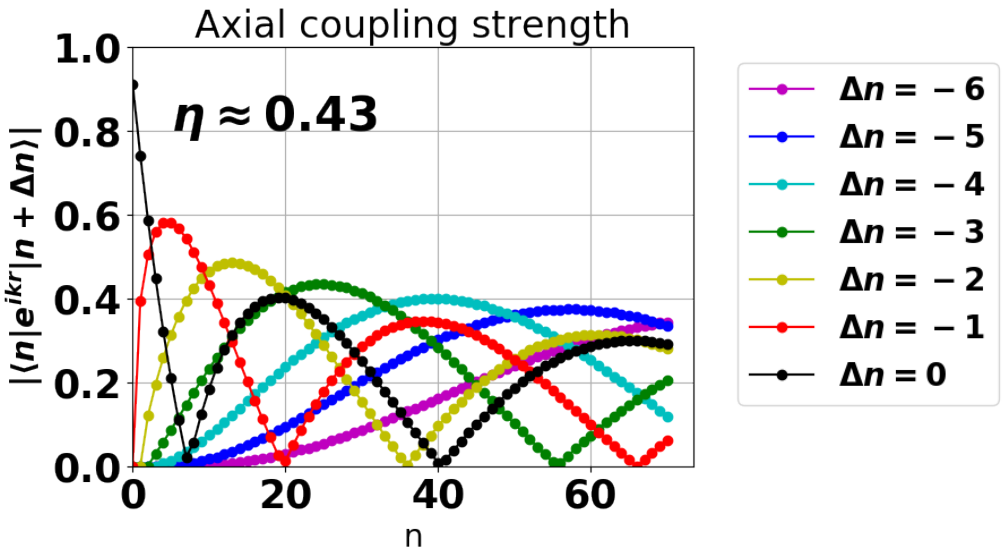
Conclusion

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

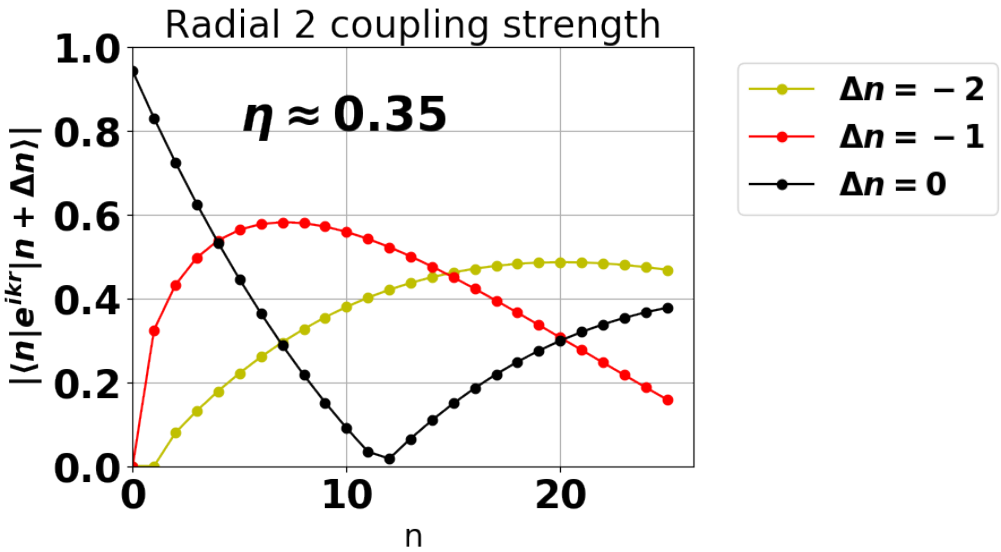
Improvements

- 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