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

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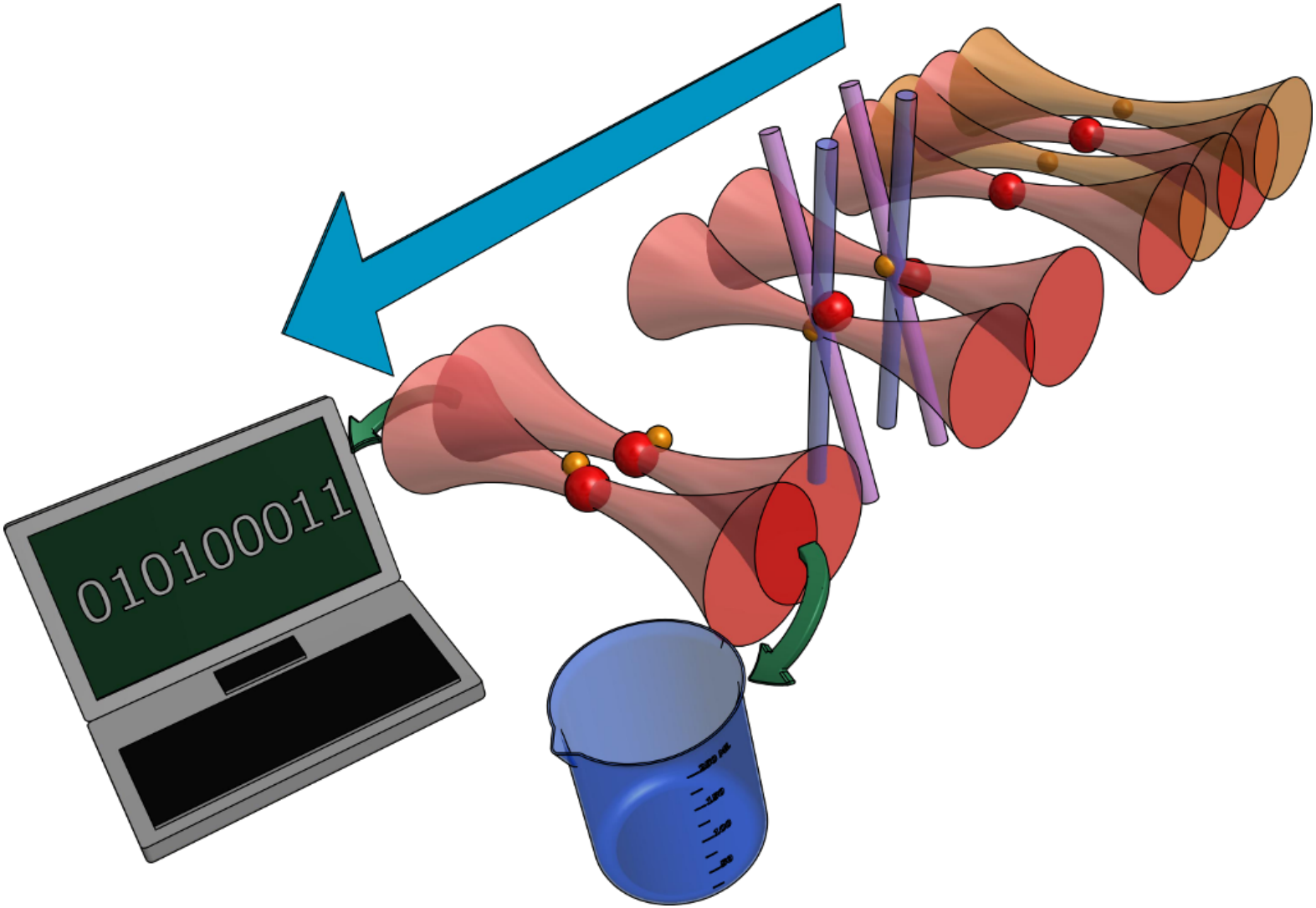
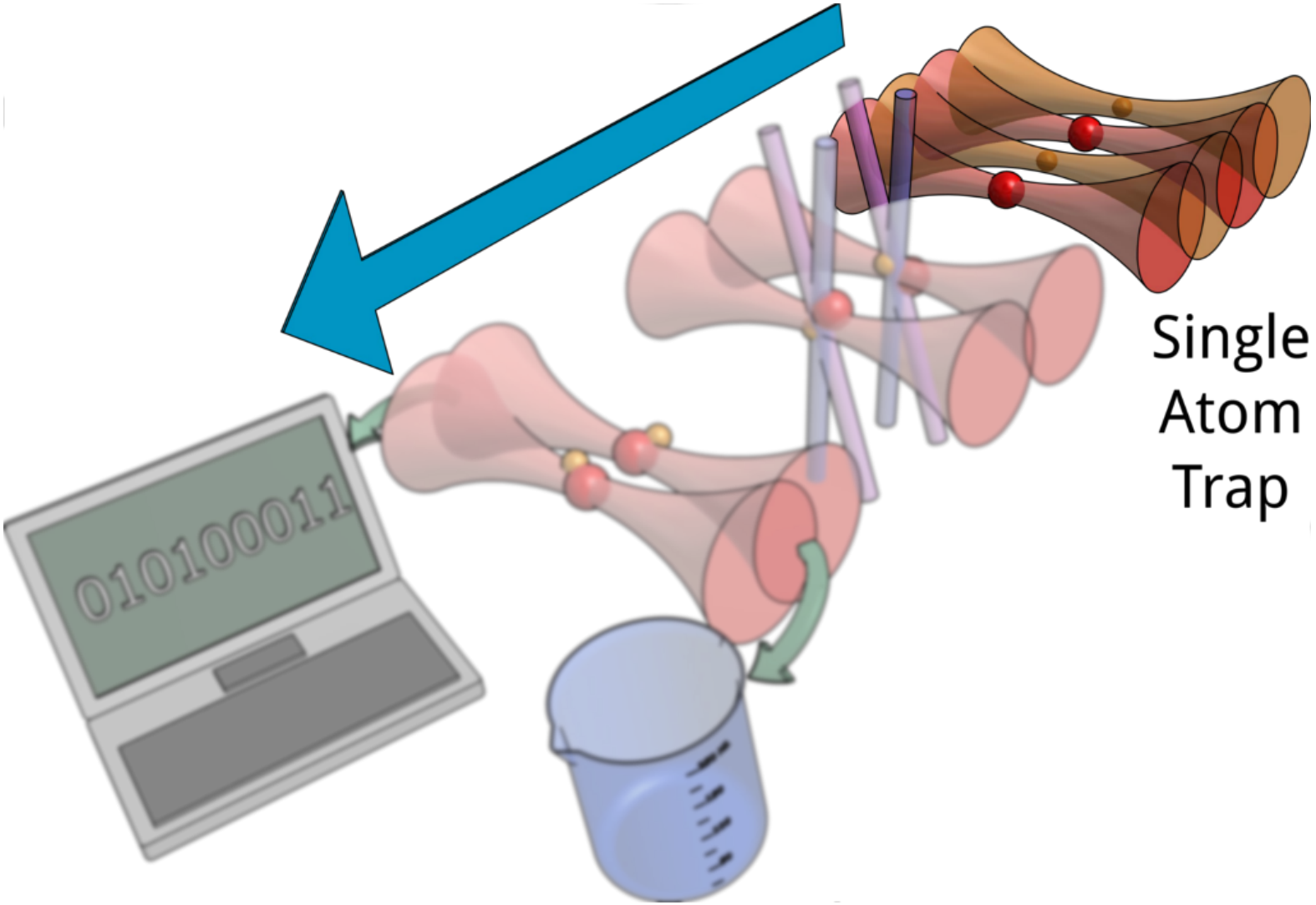
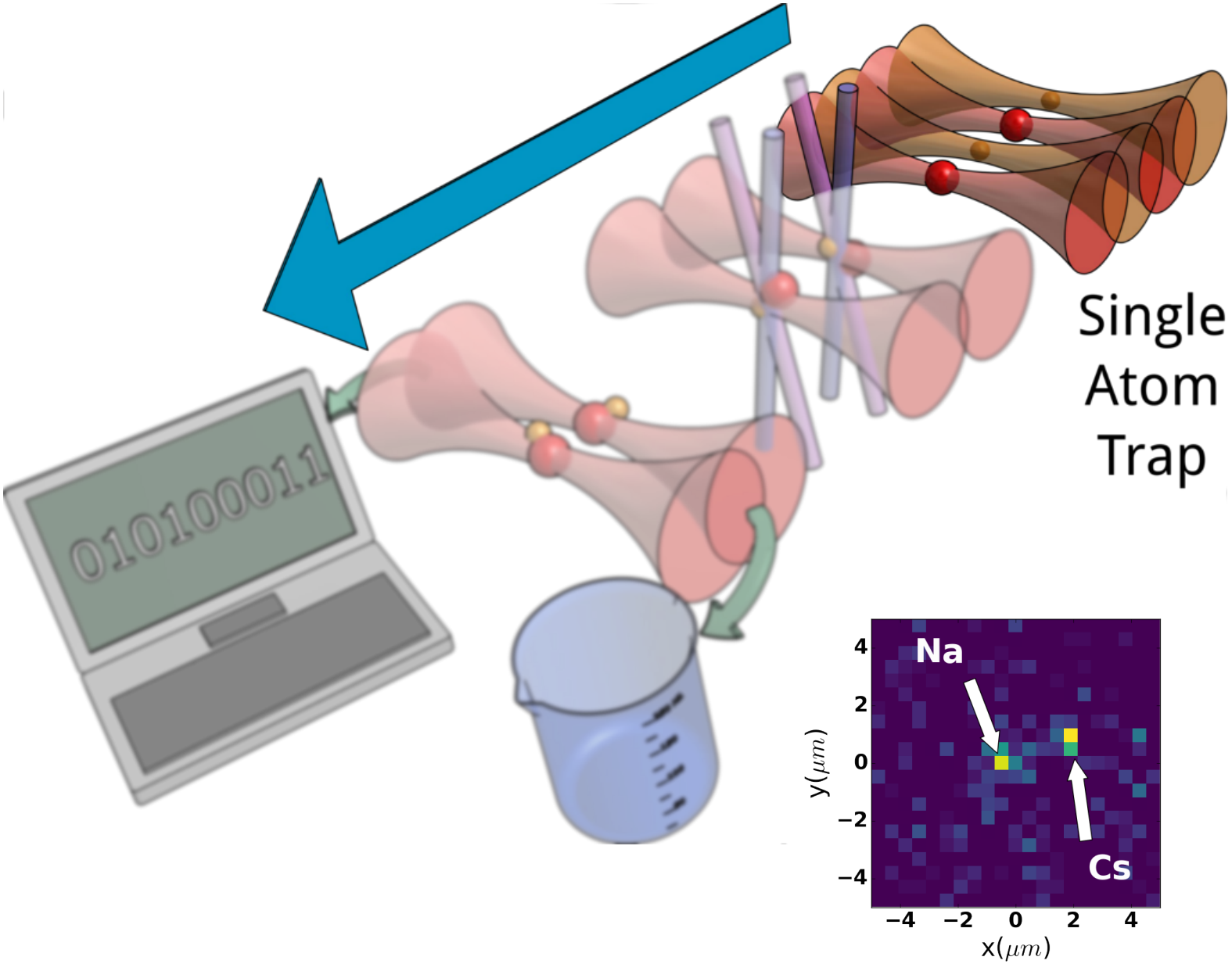
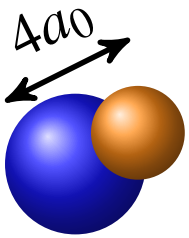

010100011

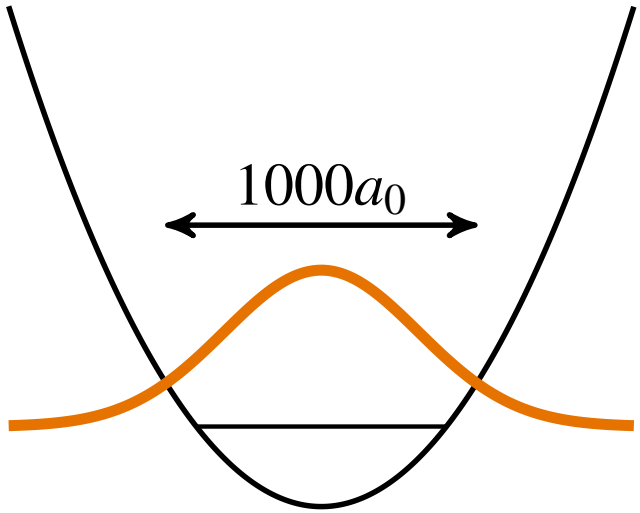

010100011
Single
Atom
Trap


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

Wave function size

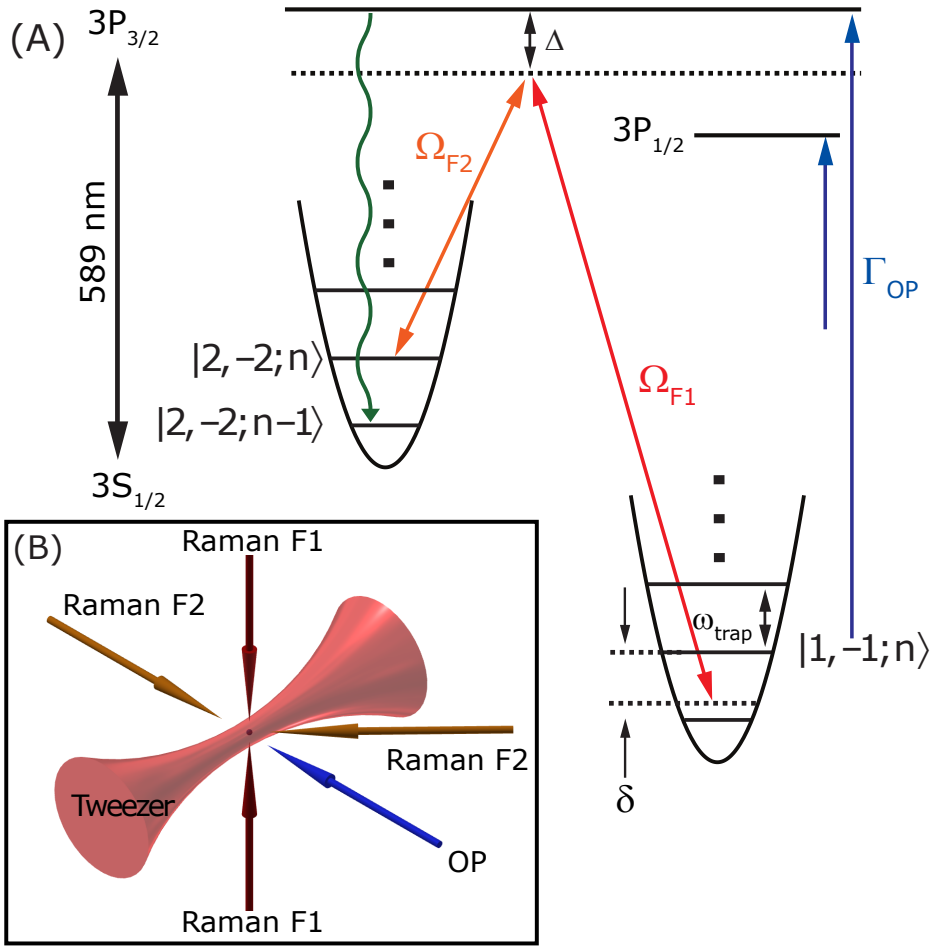


Molecule

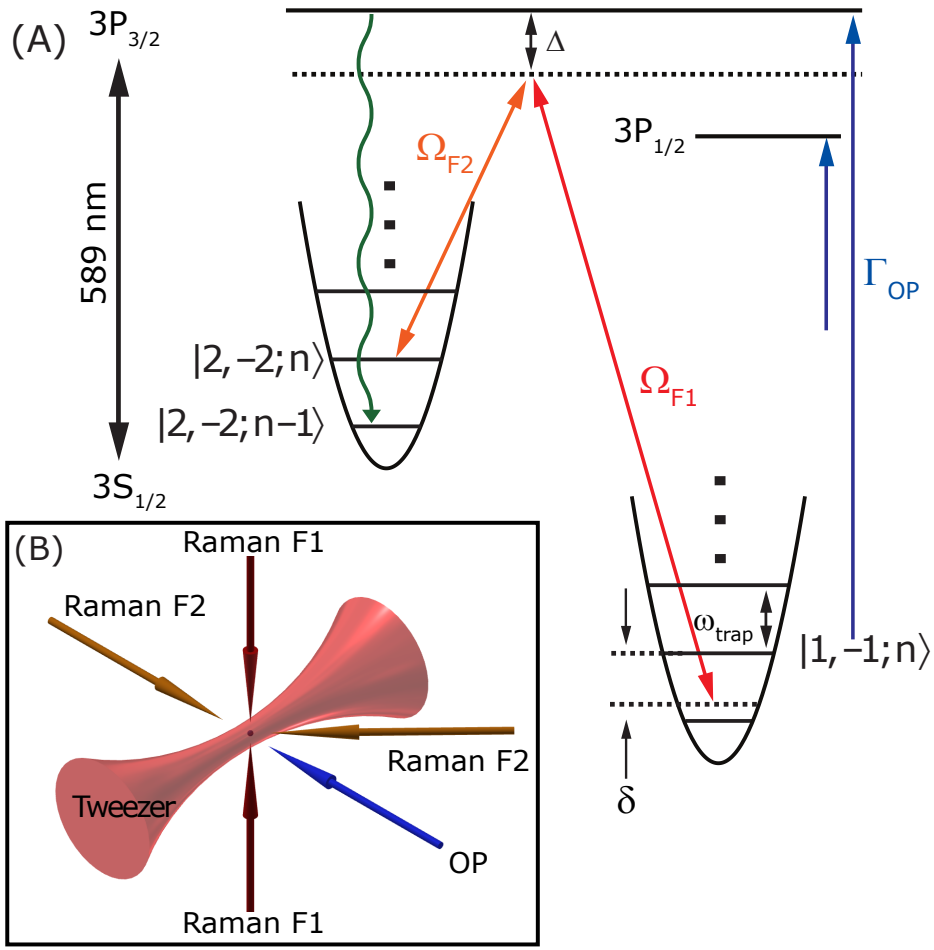


Atom

Raman sideband cooling of Sodium



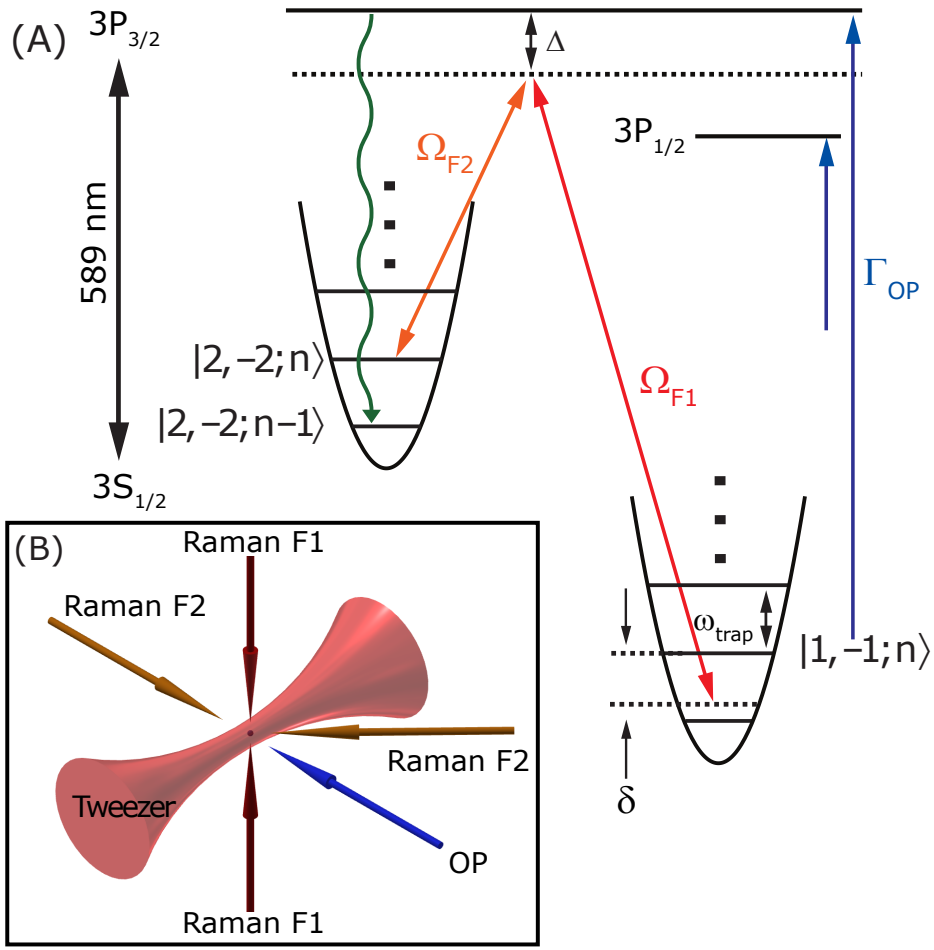
Raman sideband cooling of Sodium



Difficulties

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

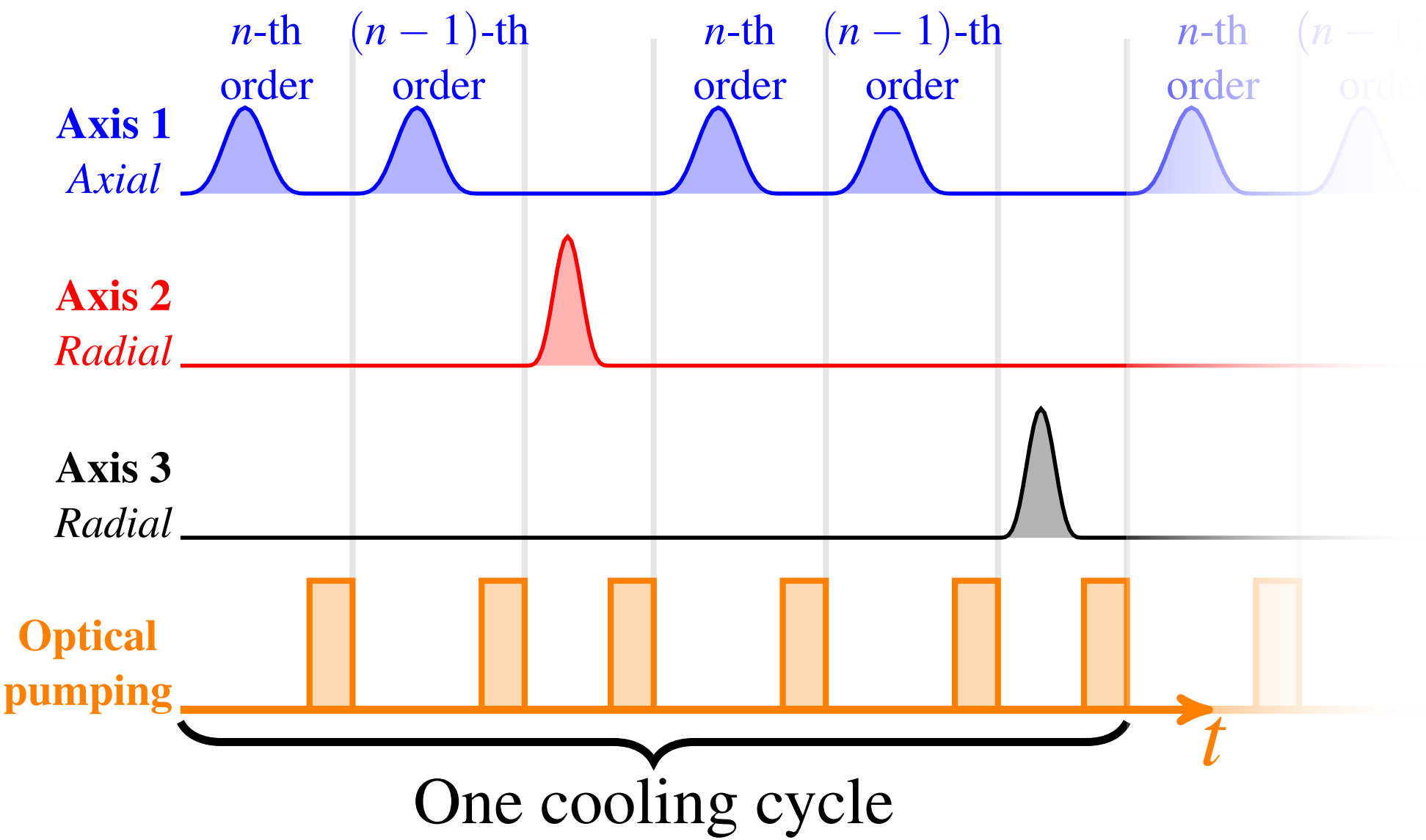
Raman sideband cooling of Sodium



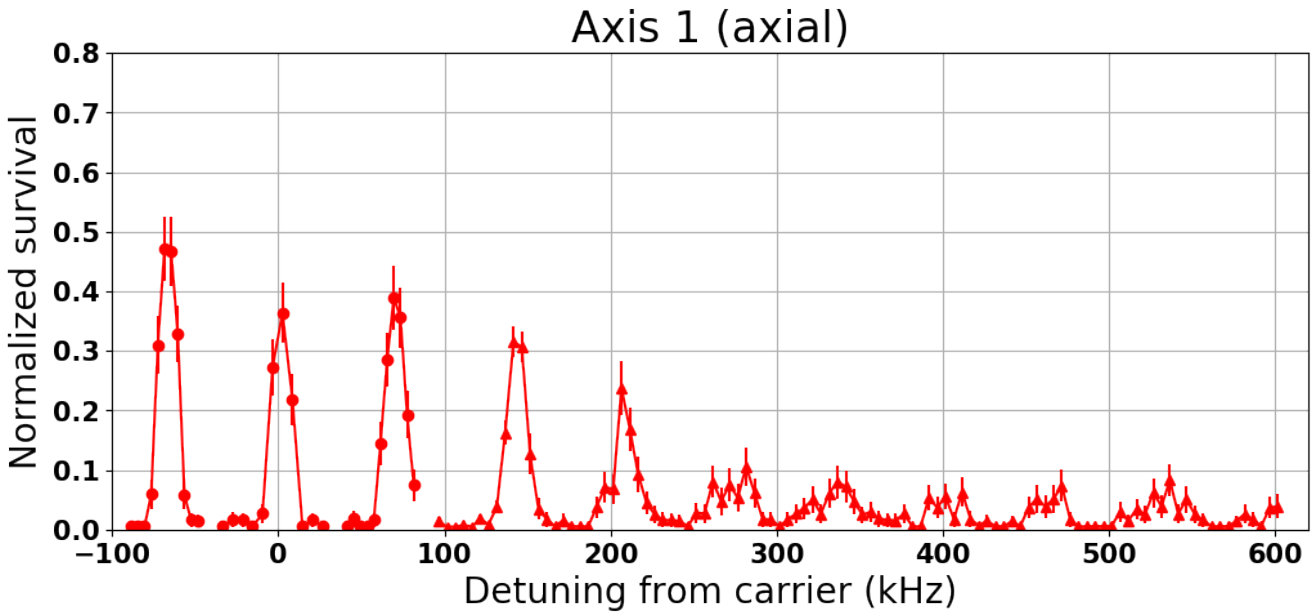
Difficulties

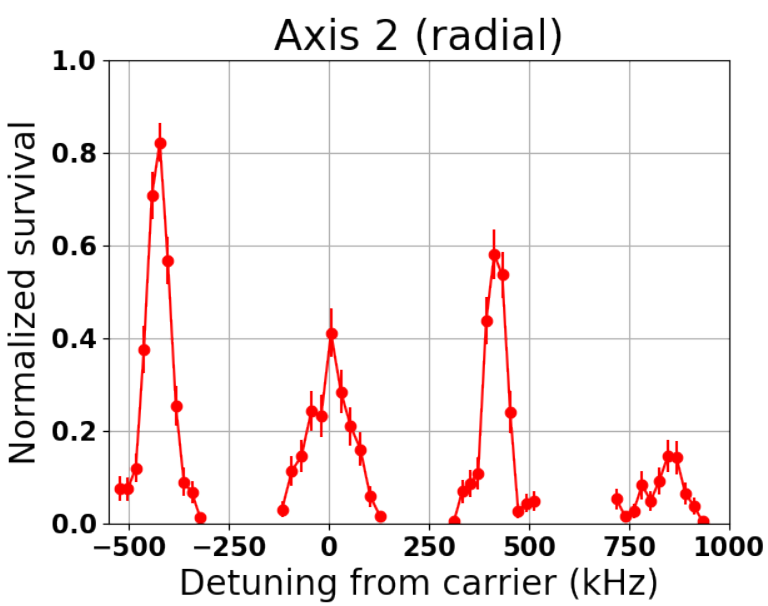
- High initial temperature ($40\mu K$)
- High recoil heating

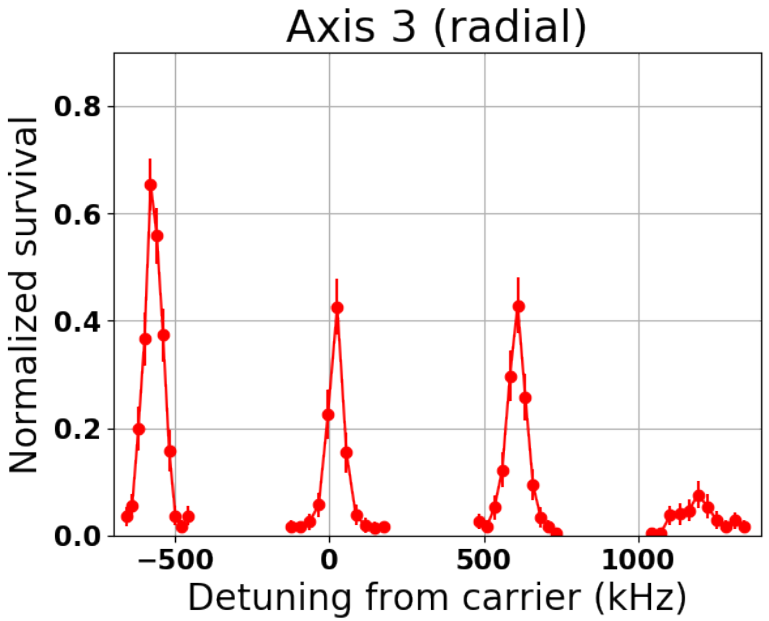
Cooling sequence



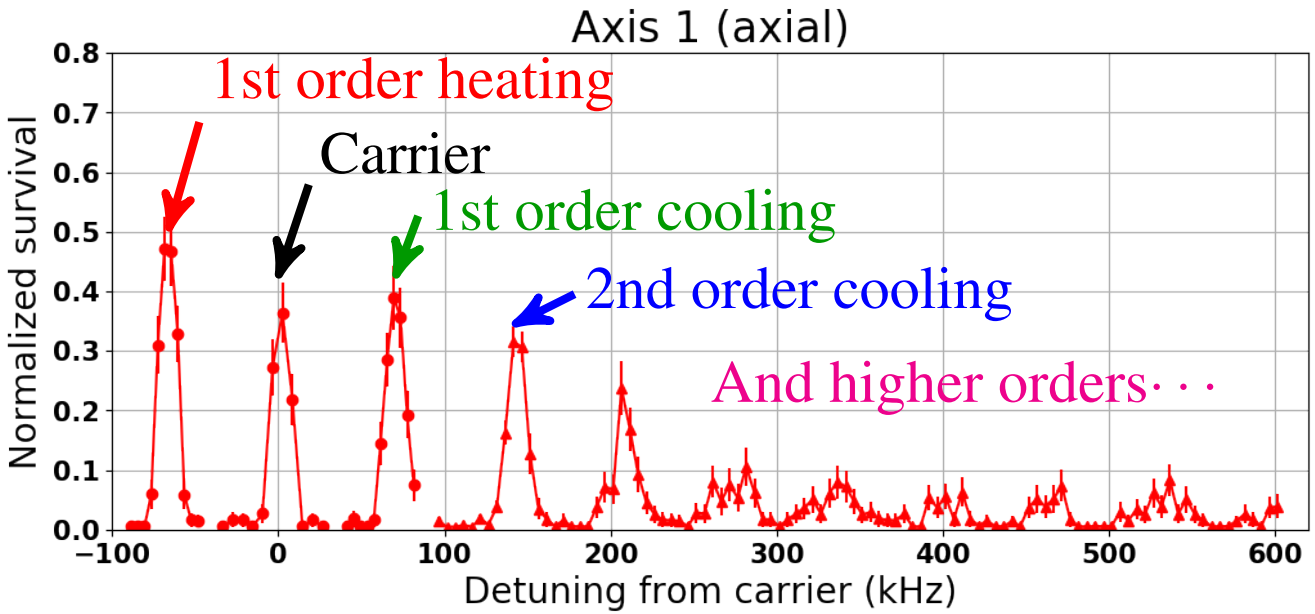
Raman sidebands

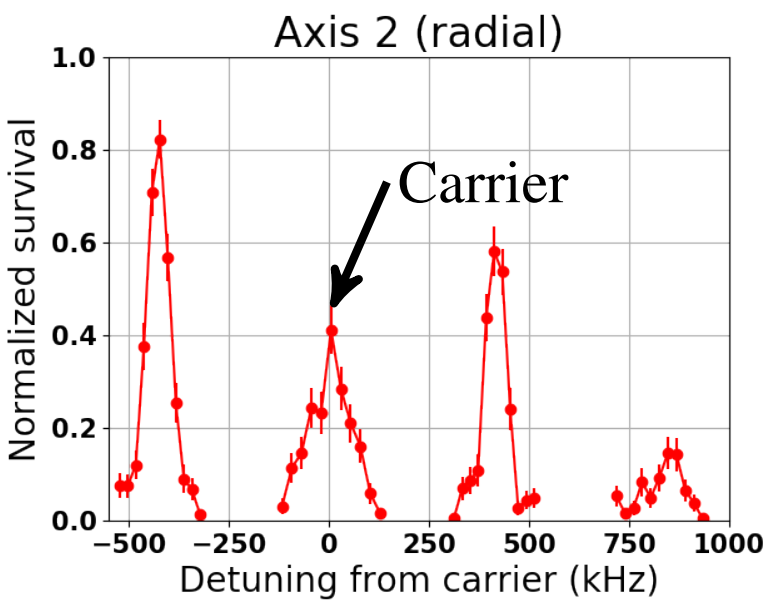


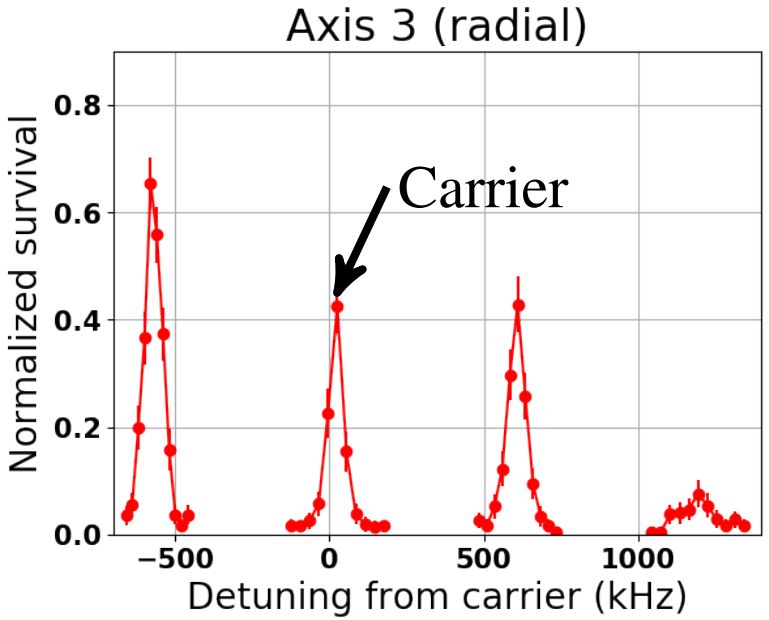




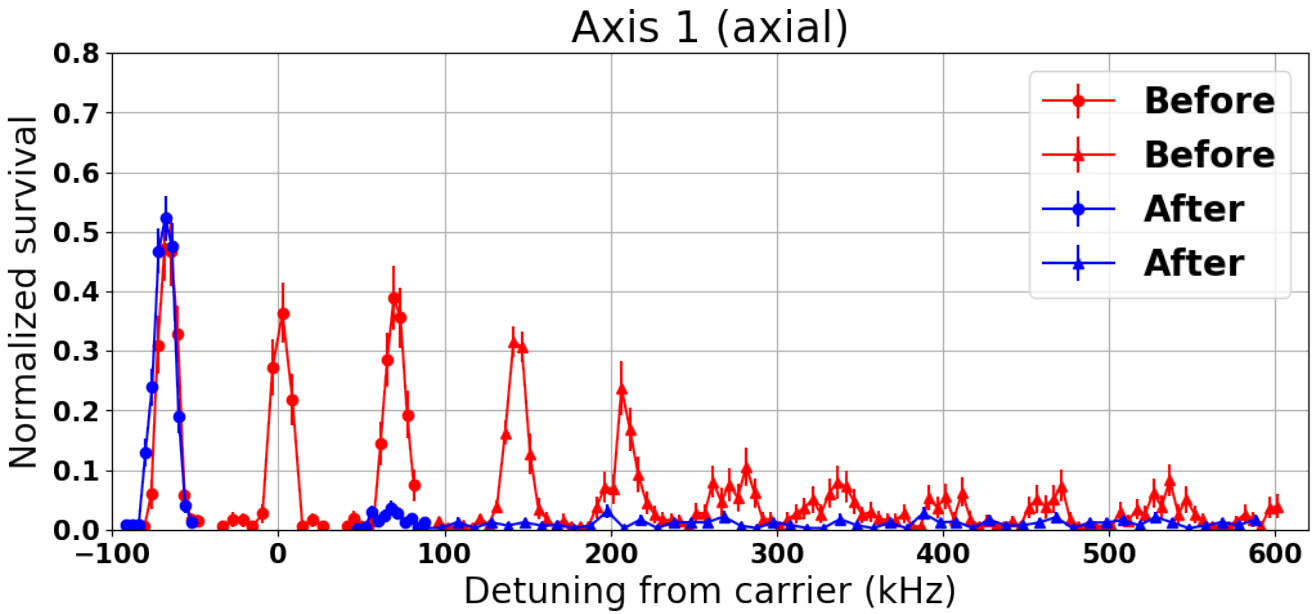
Raman sidebands

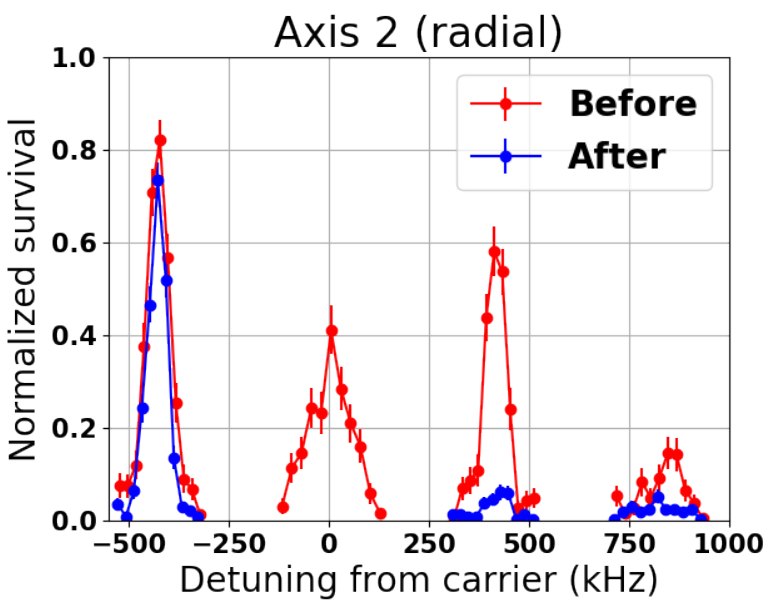


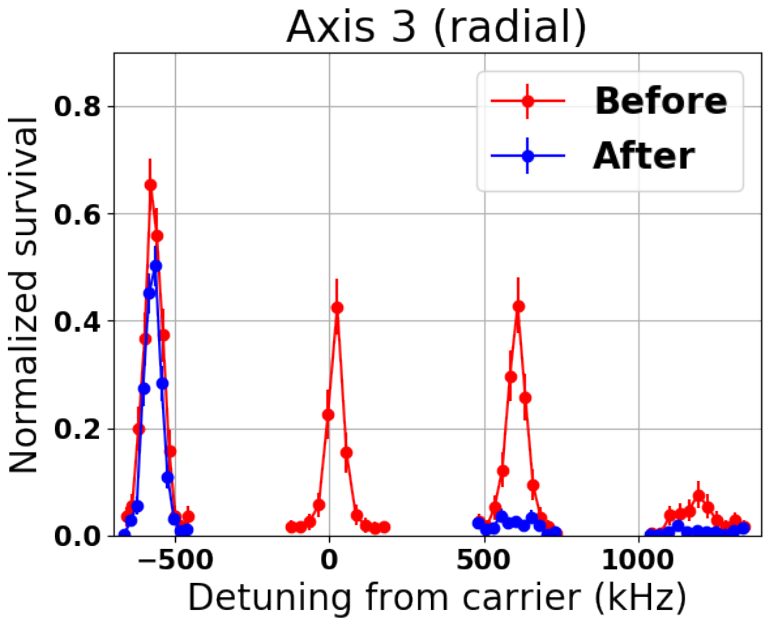




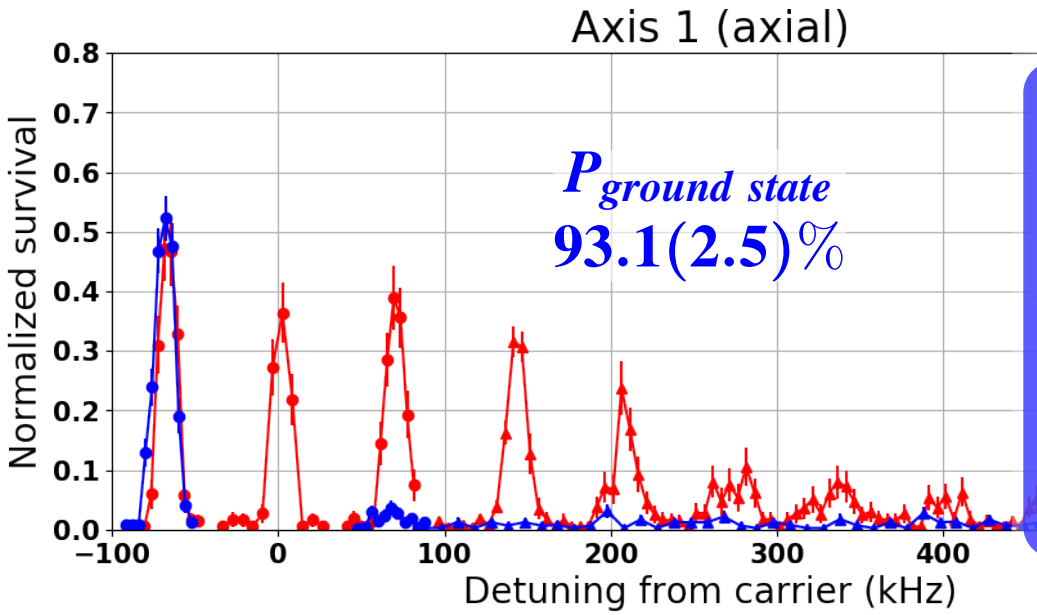
Raman sidebands





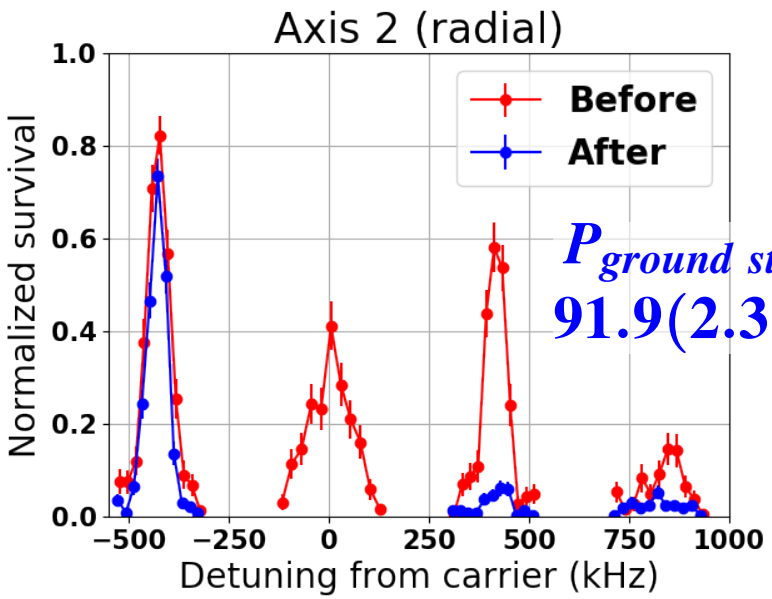


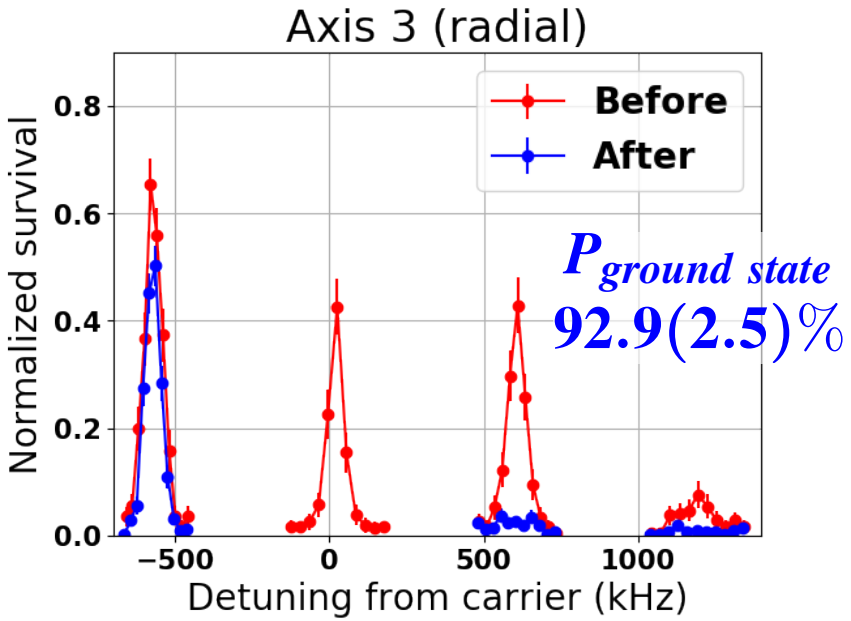
Raman sidebands



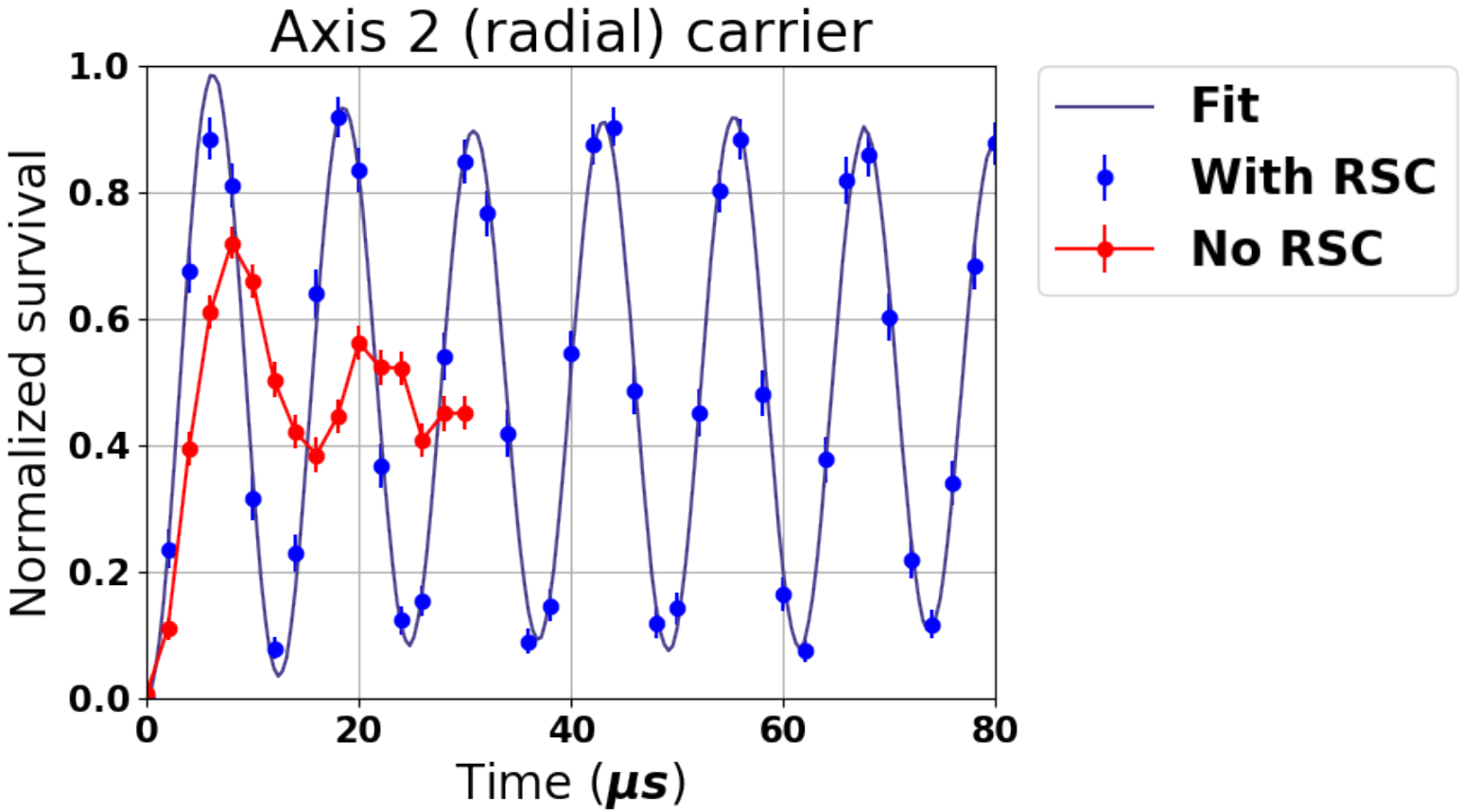
3D ground state: 79.5(3.6)%
Loss after cooling: 15%

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

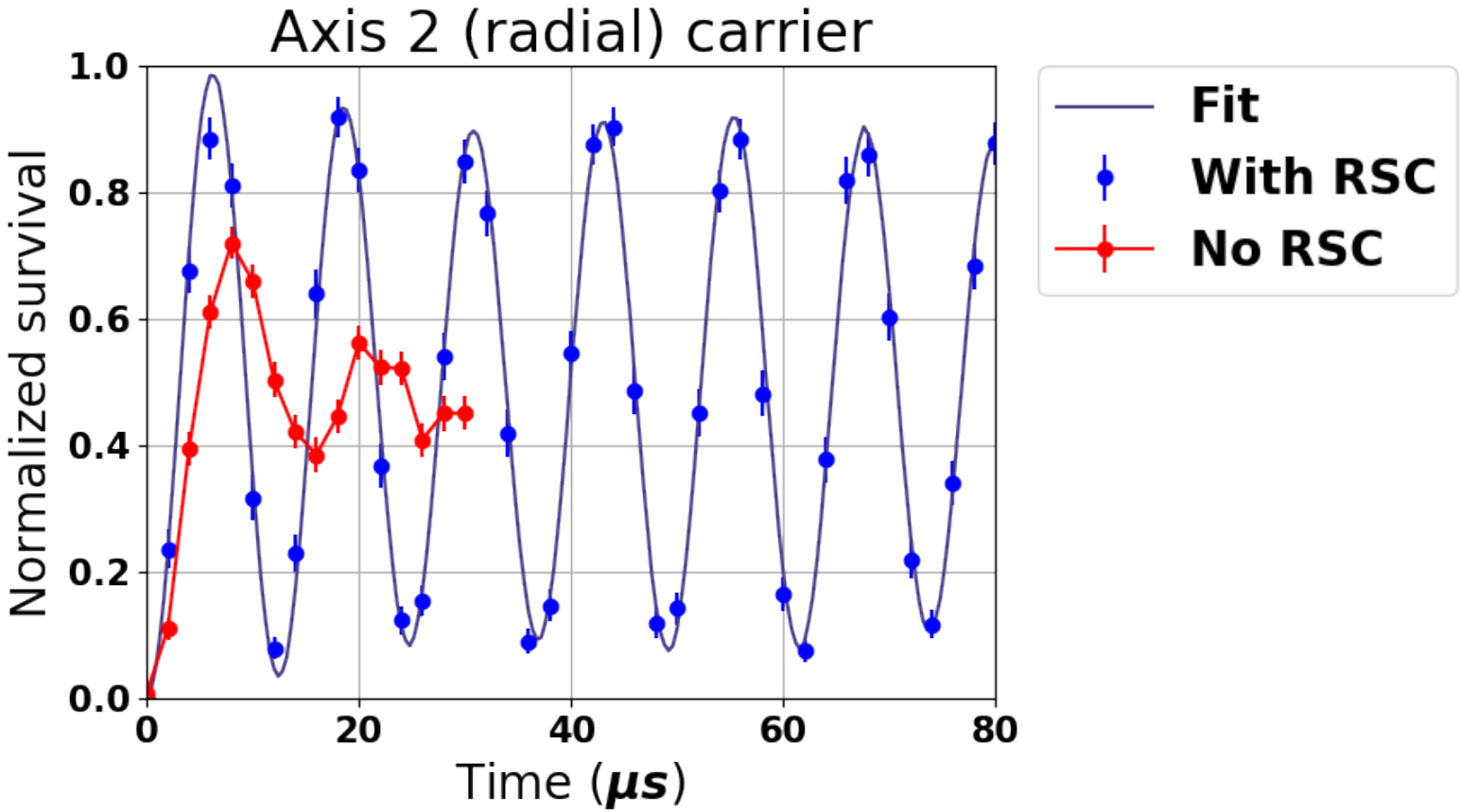




Rabi flopping (radial)

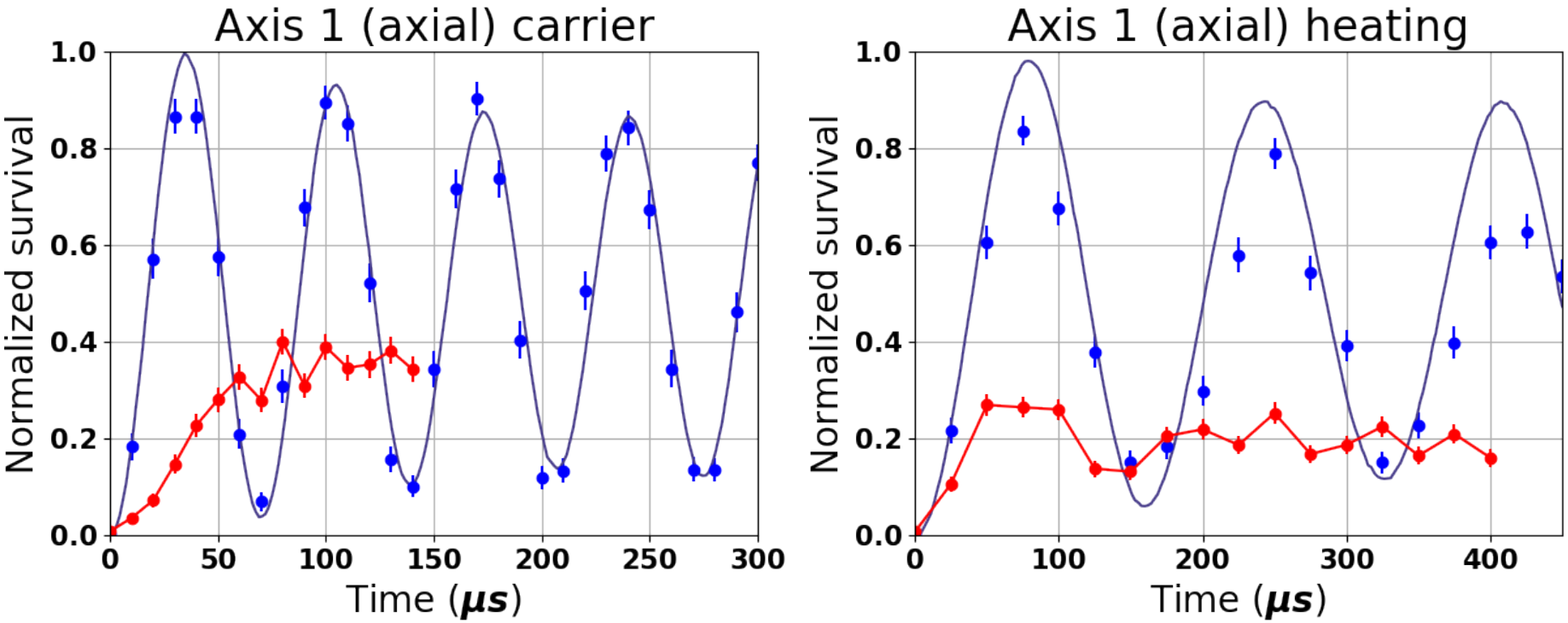


Rabi flopping (radial)



Good agreement between spectrum and Rabi flopping data.

Rabi flopping (axial)



Decoherence caused by magnetic field fluctuation.

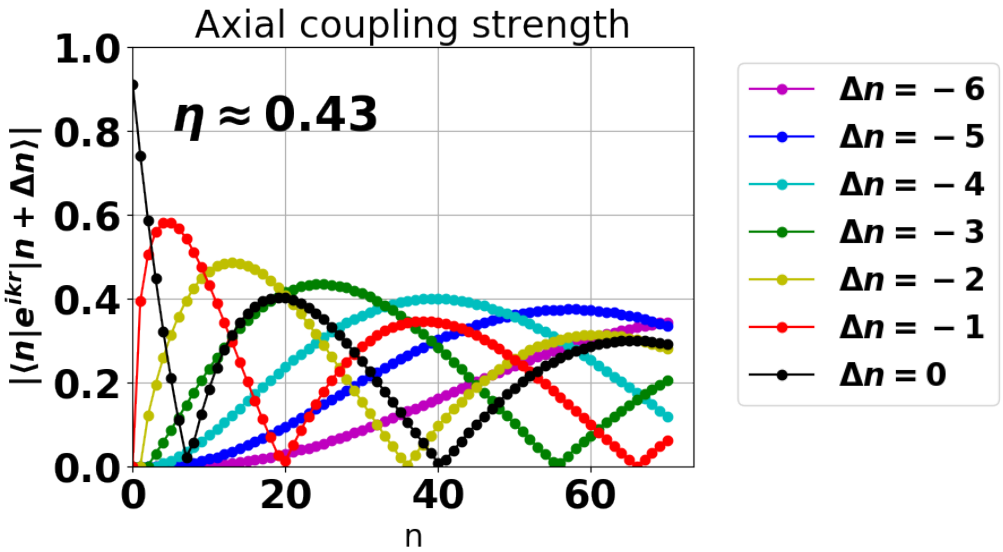
Conclusion

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

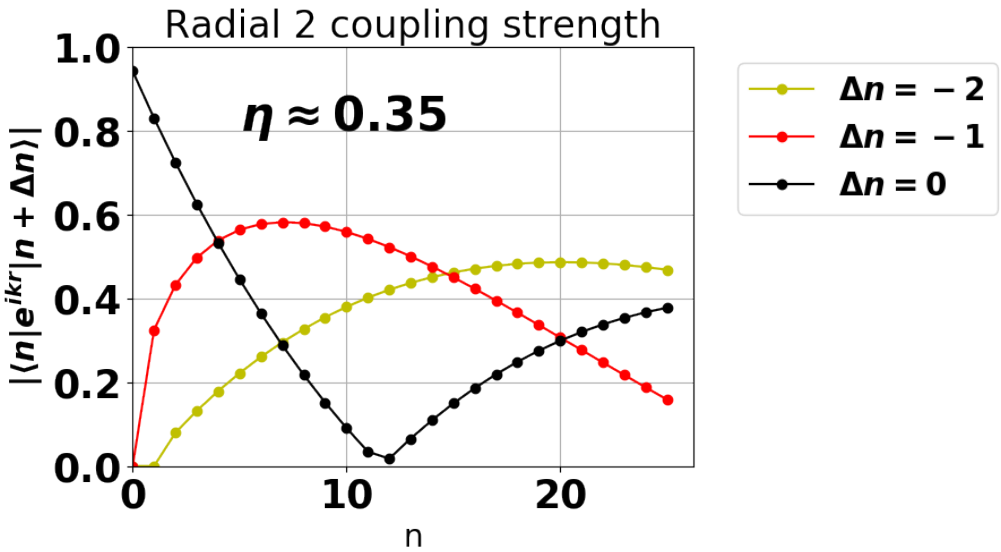
Improvements

- 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