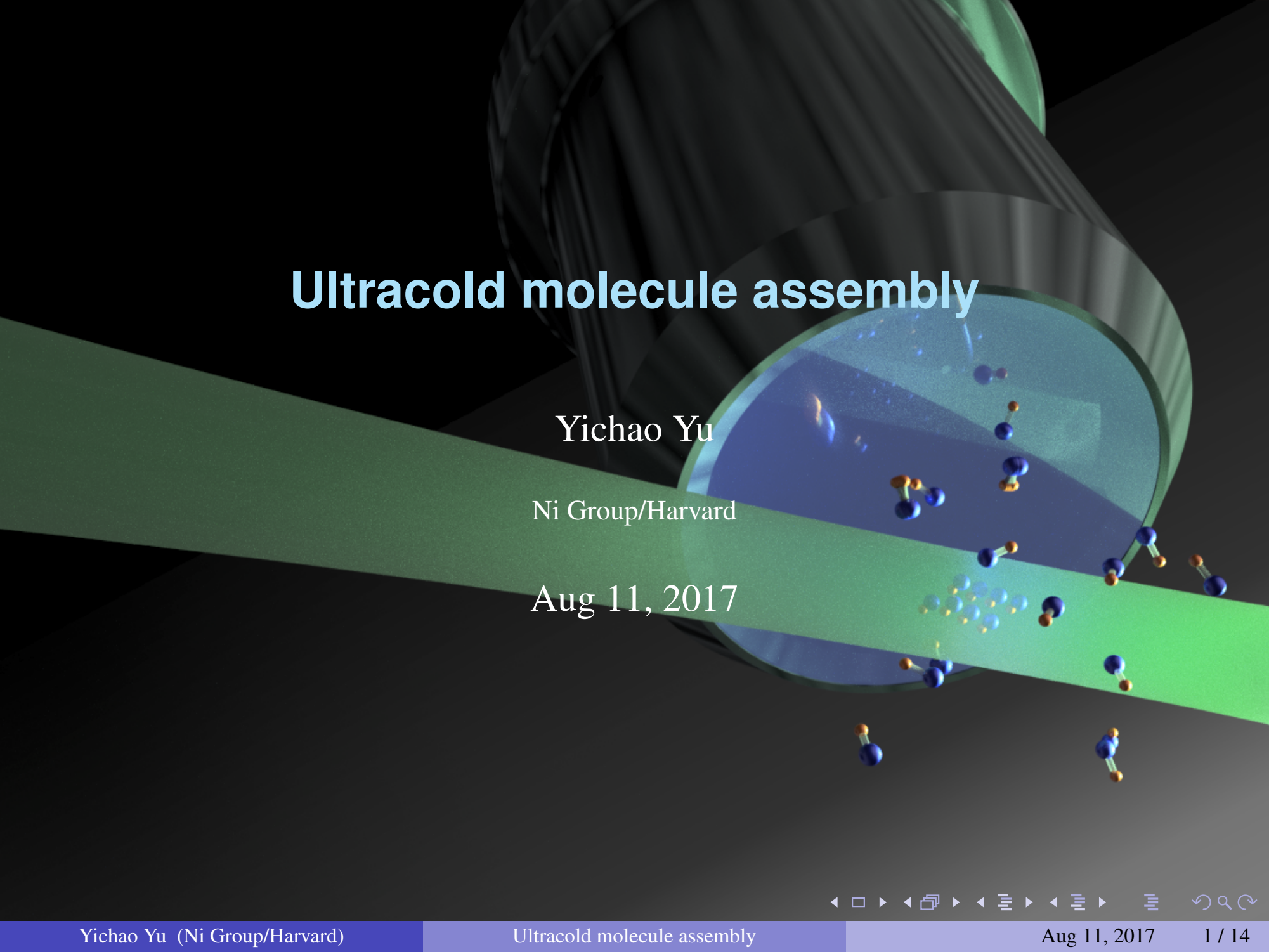


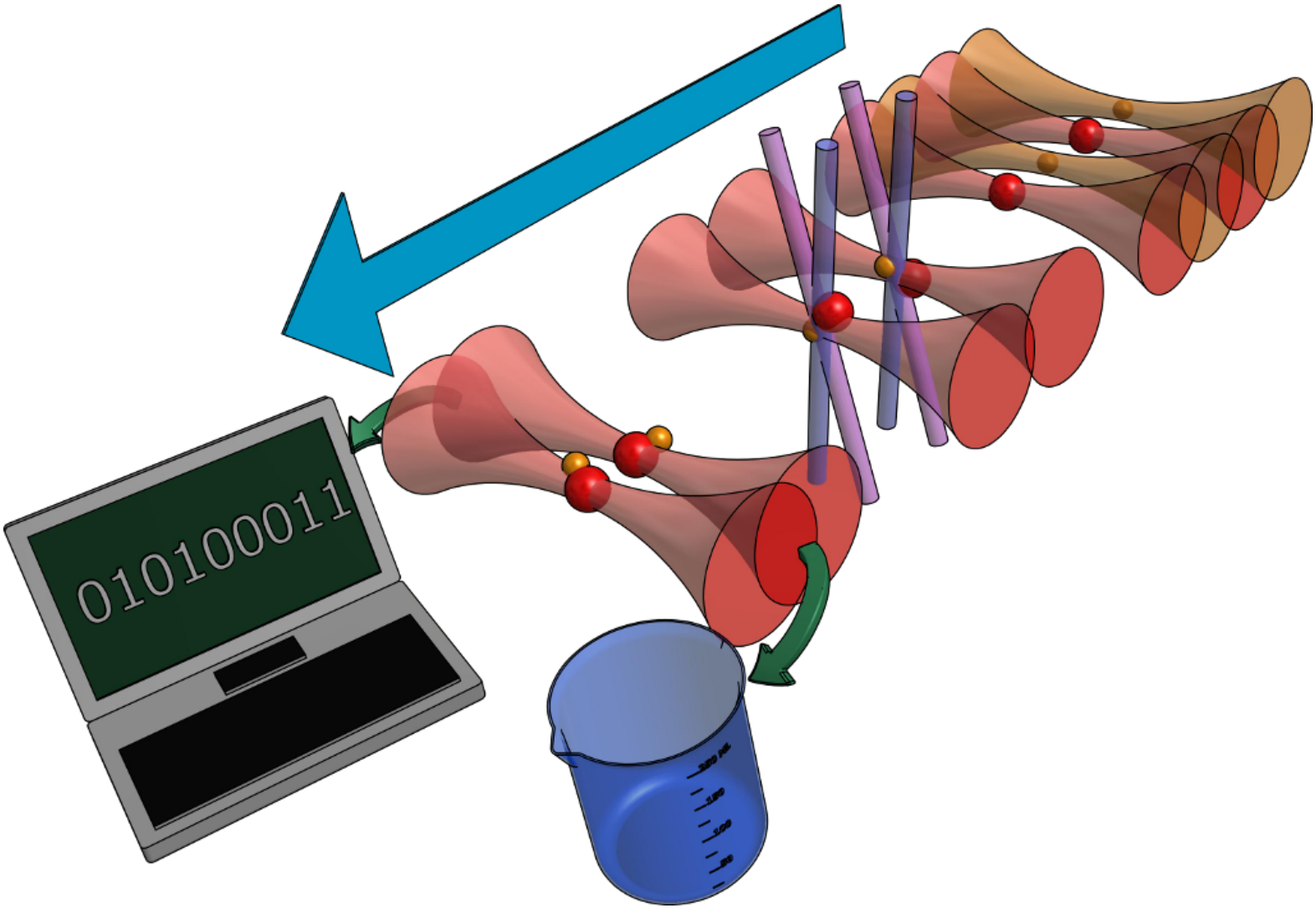
# Ultracold molecule assembly

Yichao Yu

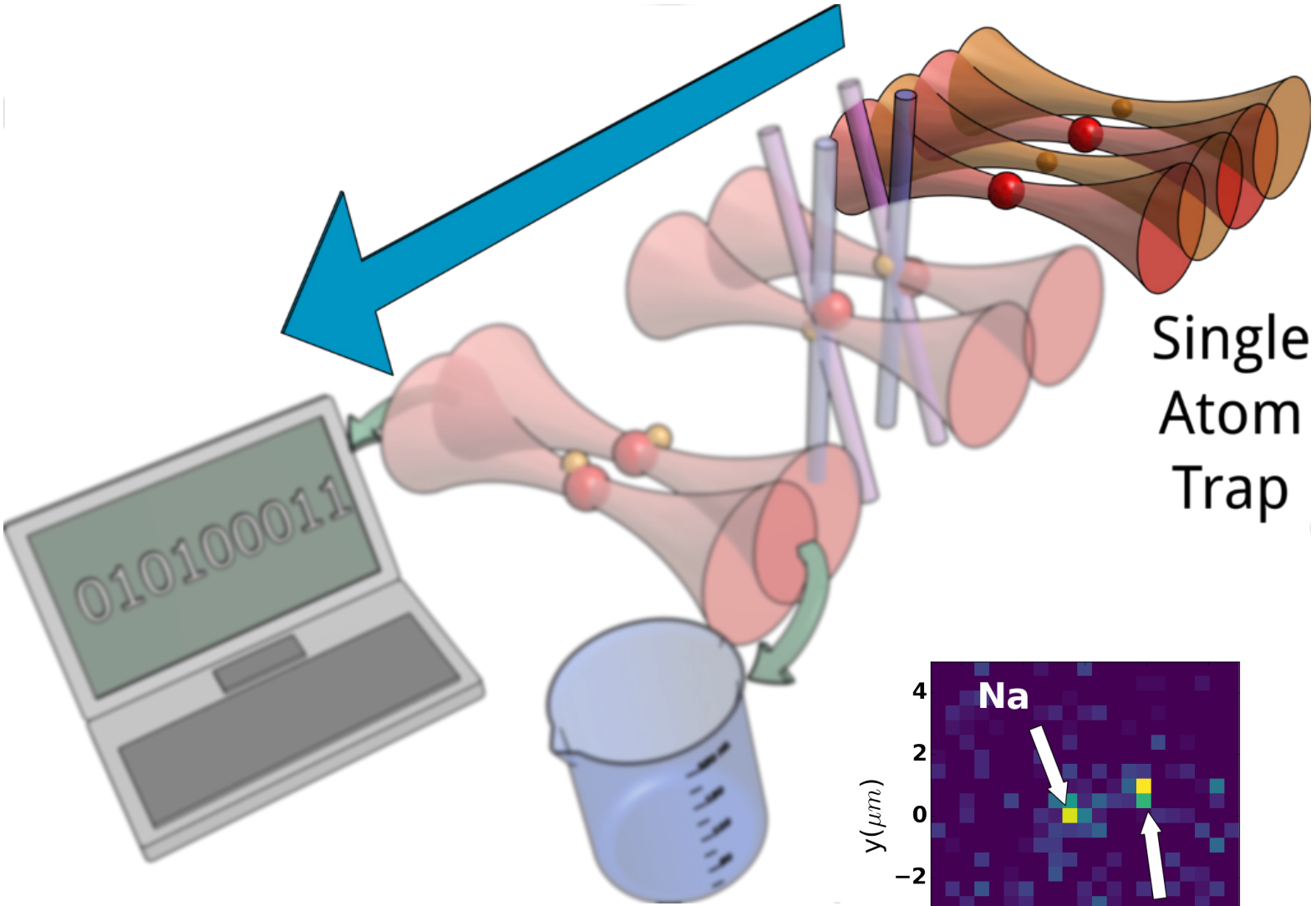
Ni Group/Harvard

Aug 11, 2017

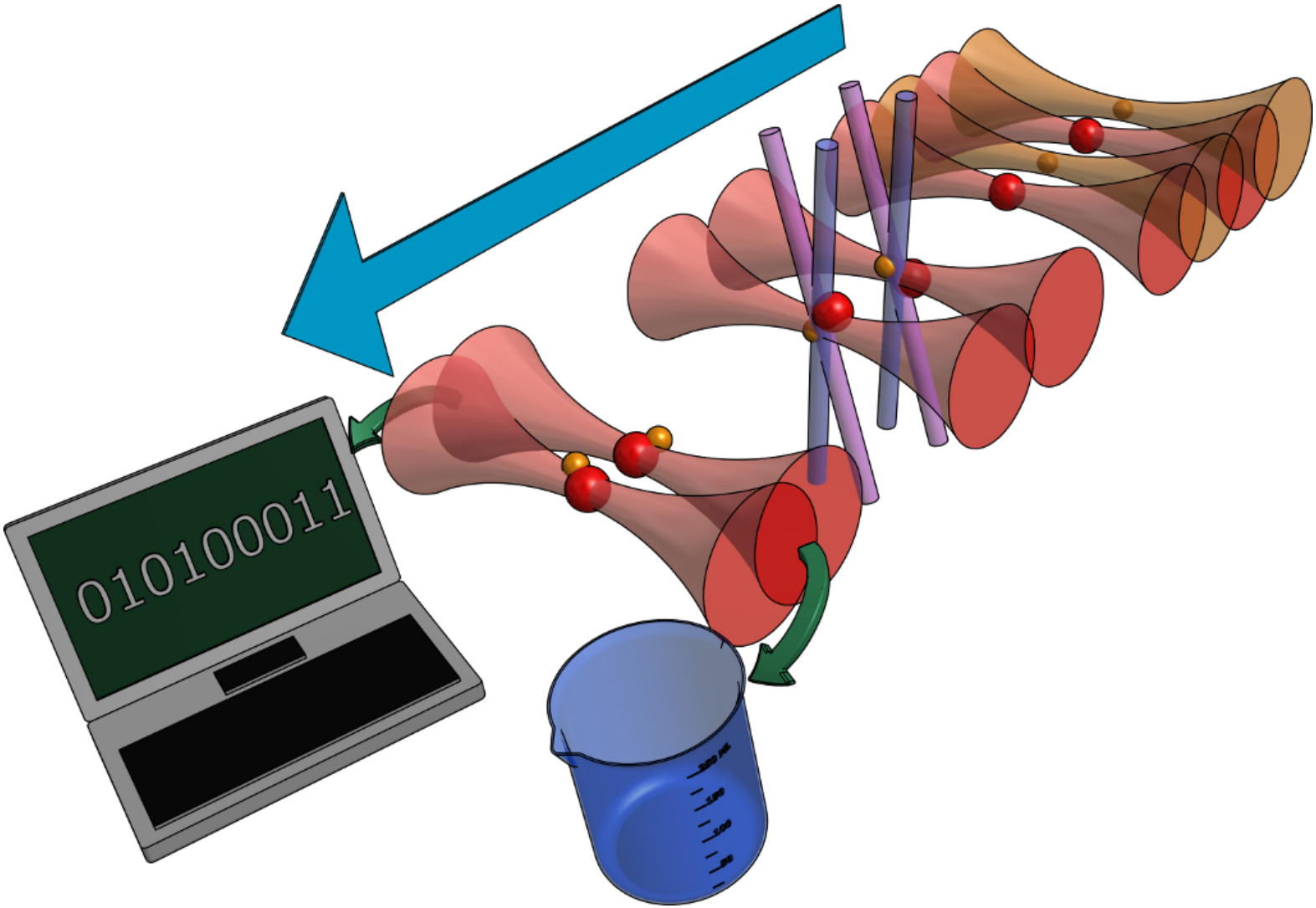
# Motivation



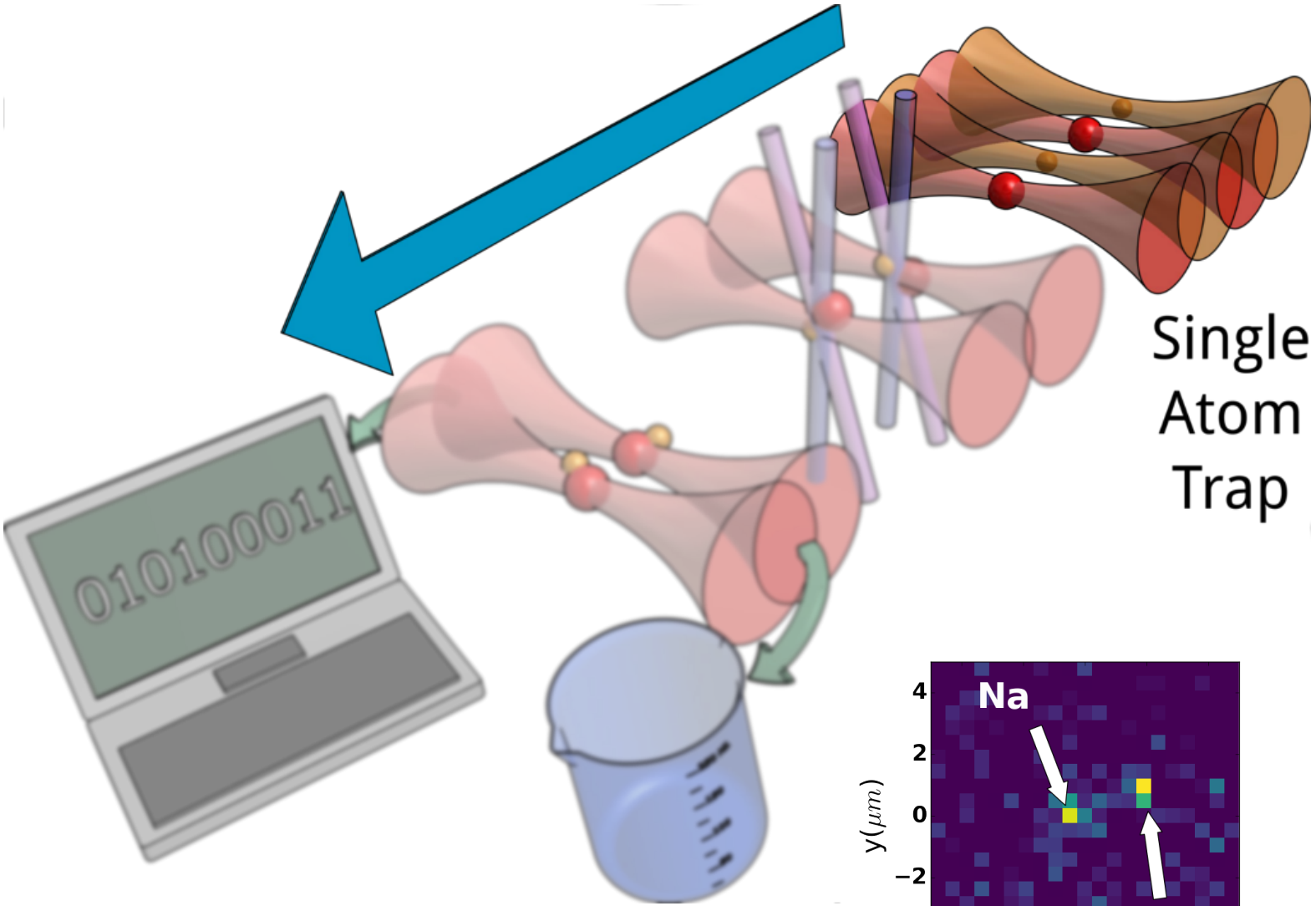
# Motivation



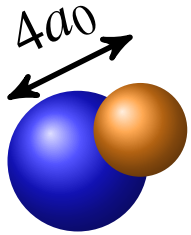
# Setup



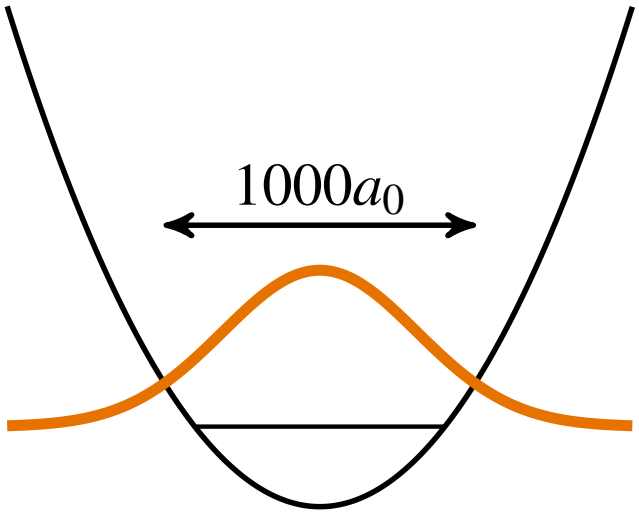
# Setup



# 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)

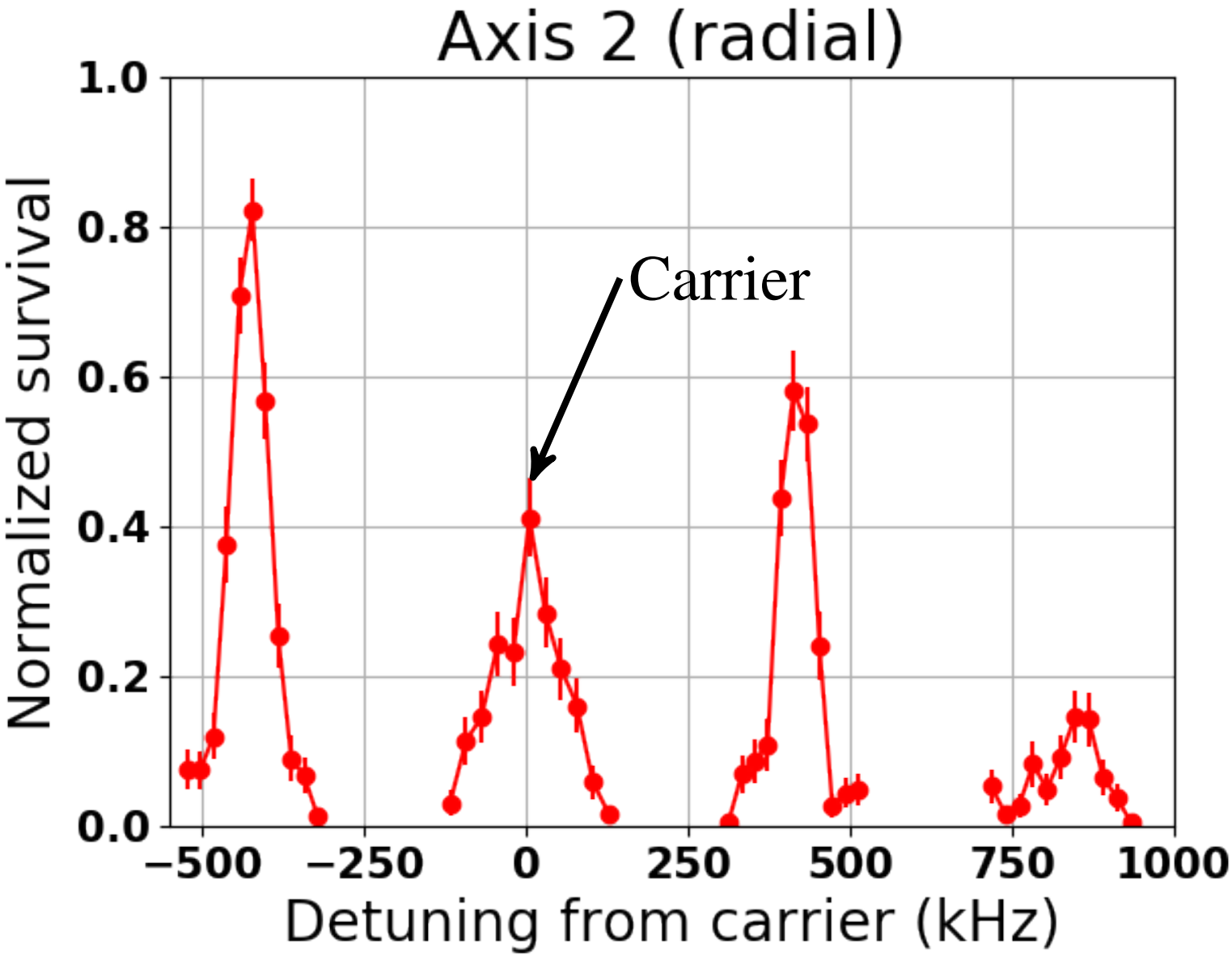
# Raman sideband cooling of Sodium

## Difficulties

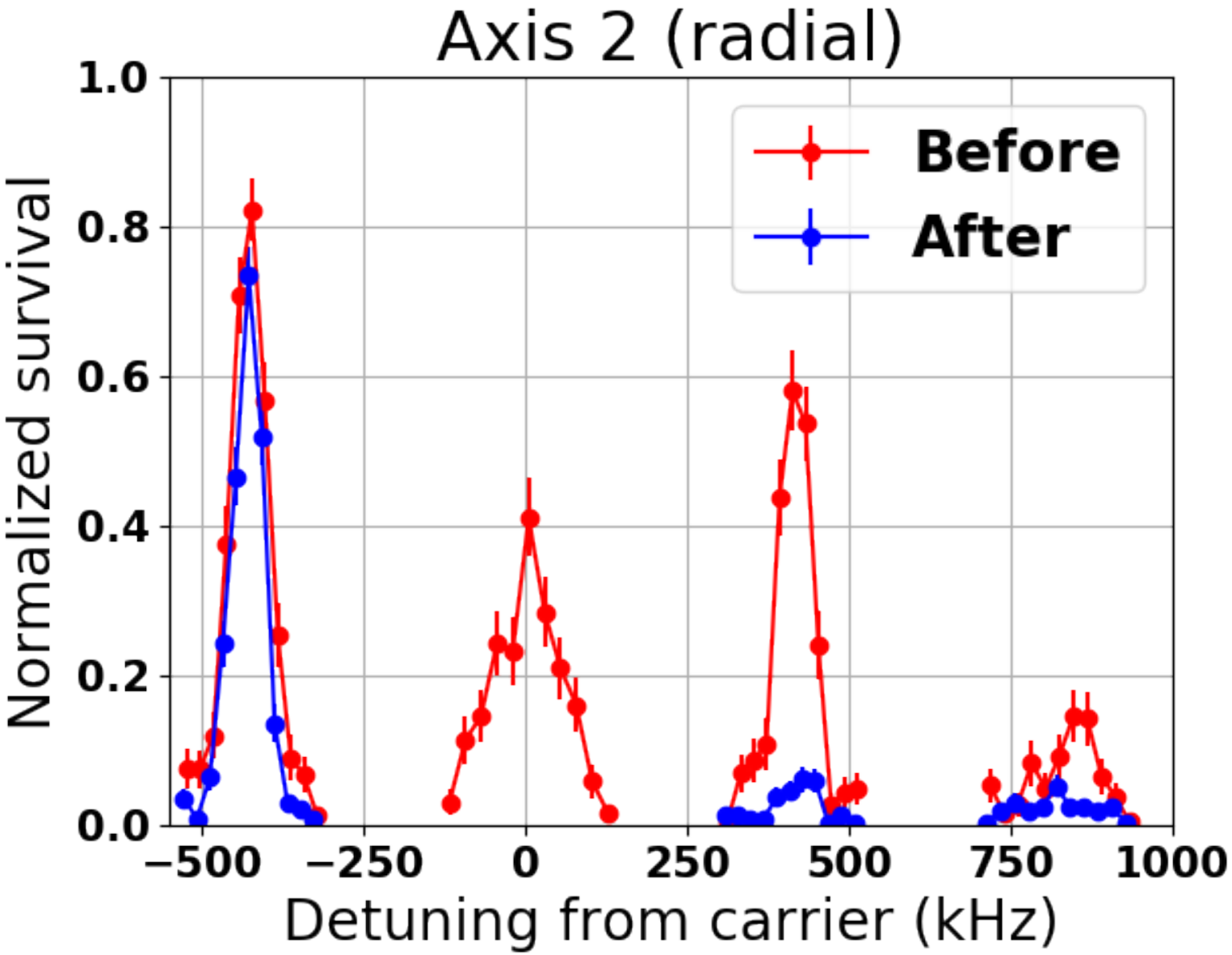
- High initial temperature ($40\mu K$)
- High recoil heating

  (High Lamb Dicke parameter)

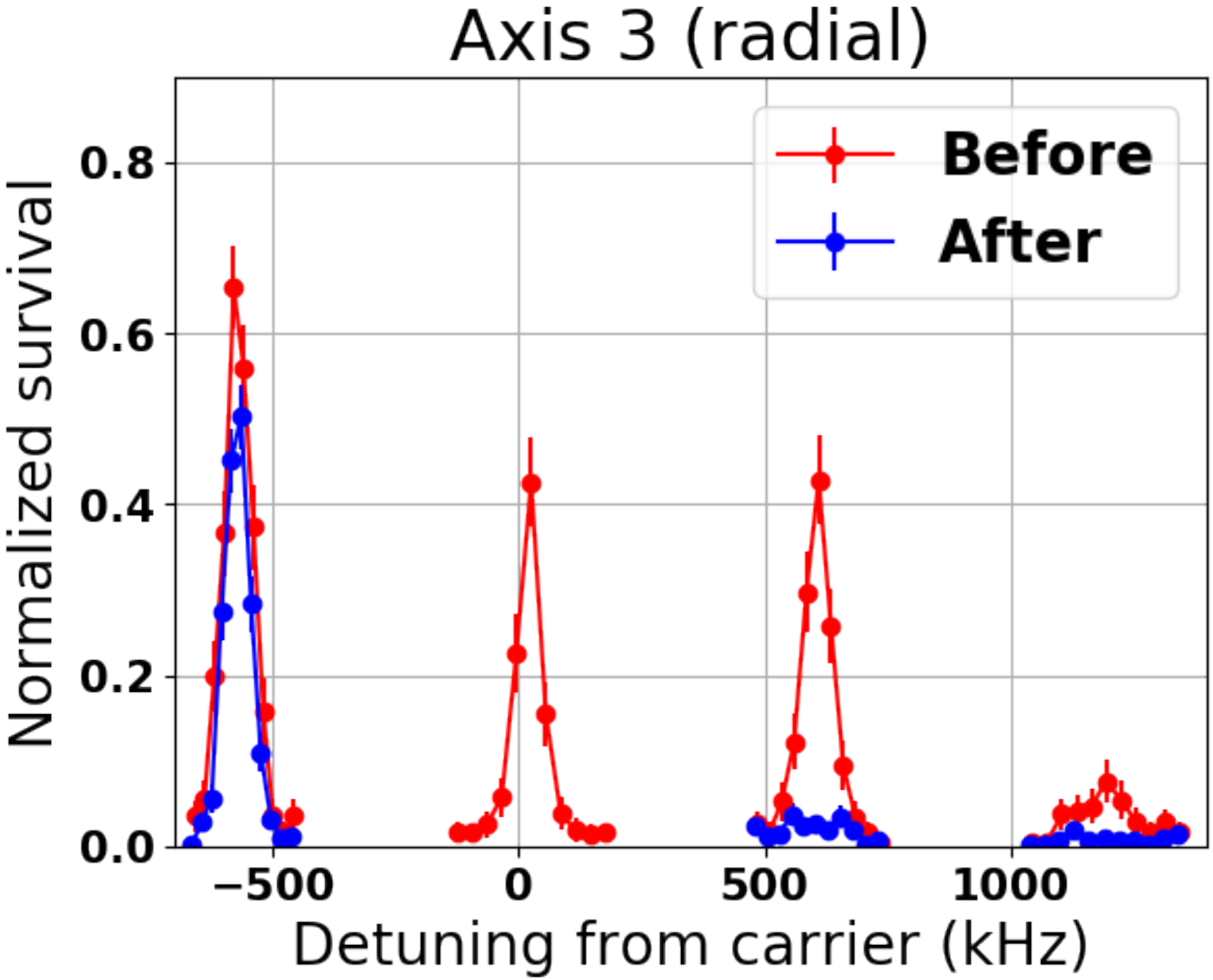
# Raman sidebands



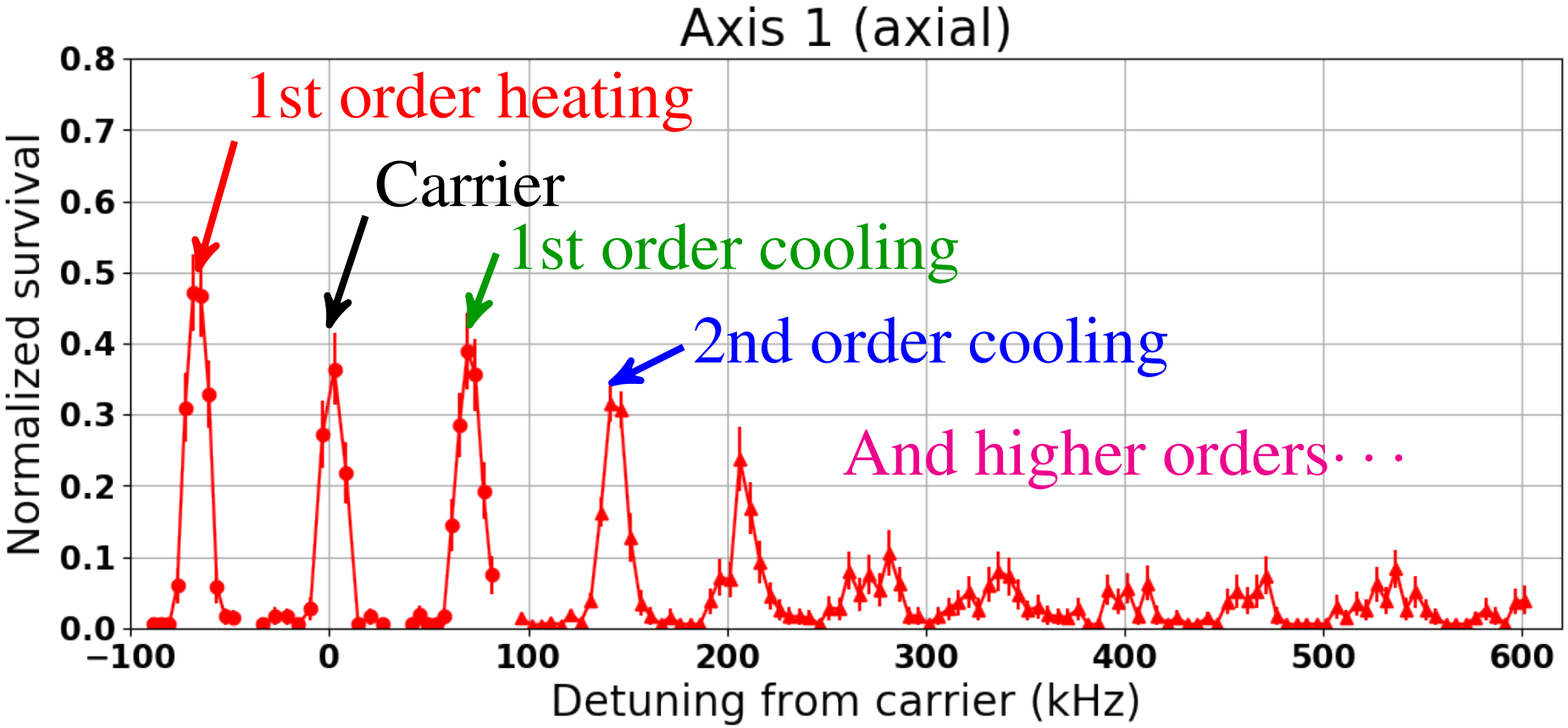
# Raman sidebands



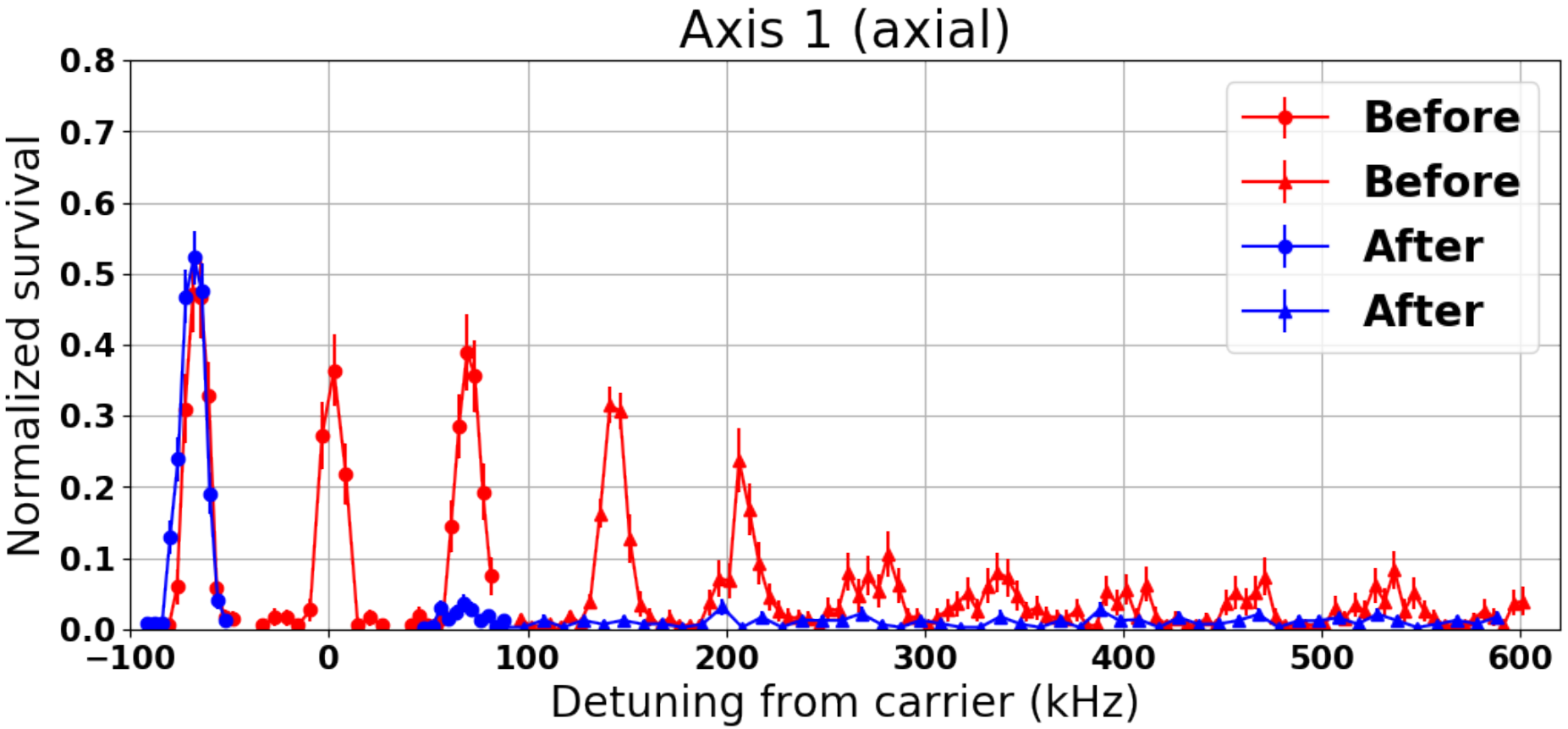
# Raman sidebands



# Raman sidebands

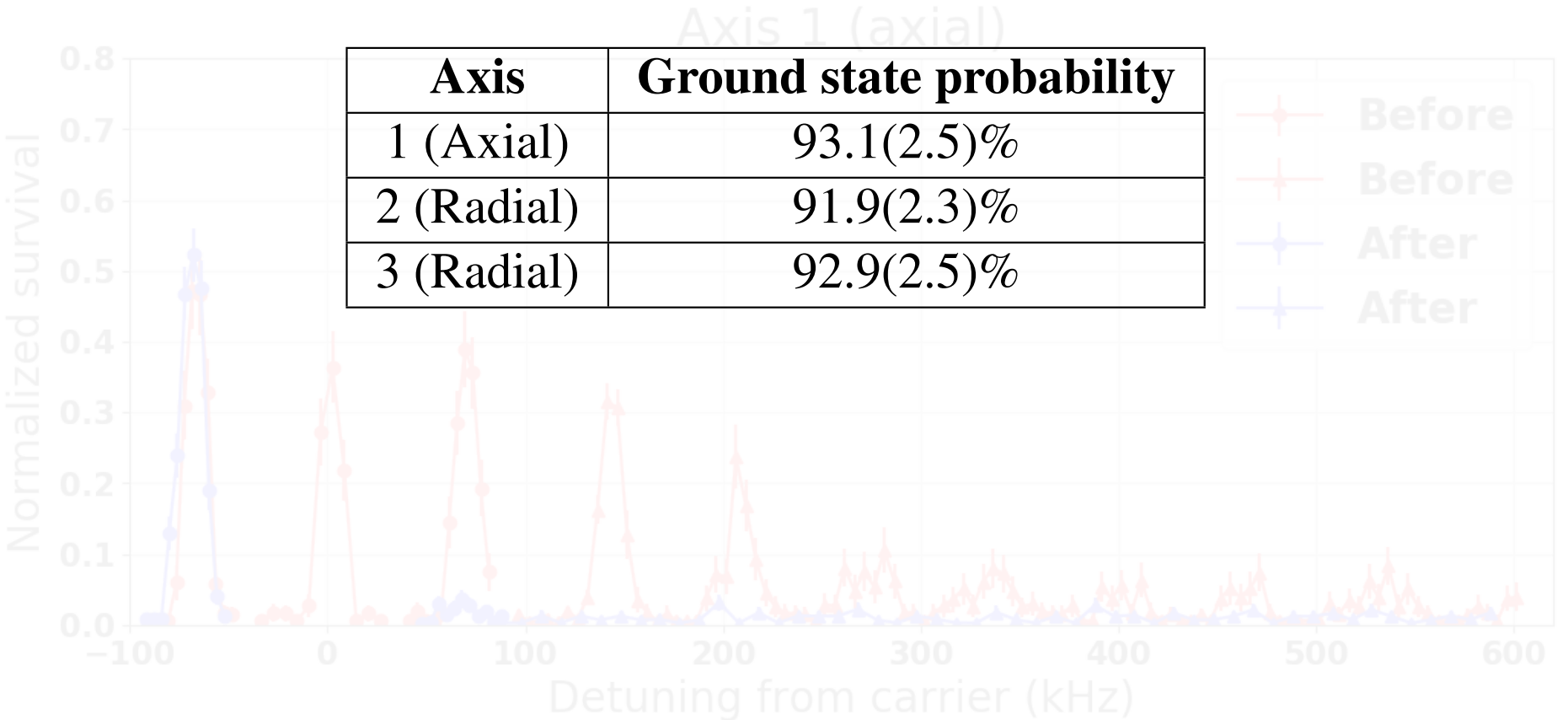


# Raman sidebands



# Raman sidebands

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



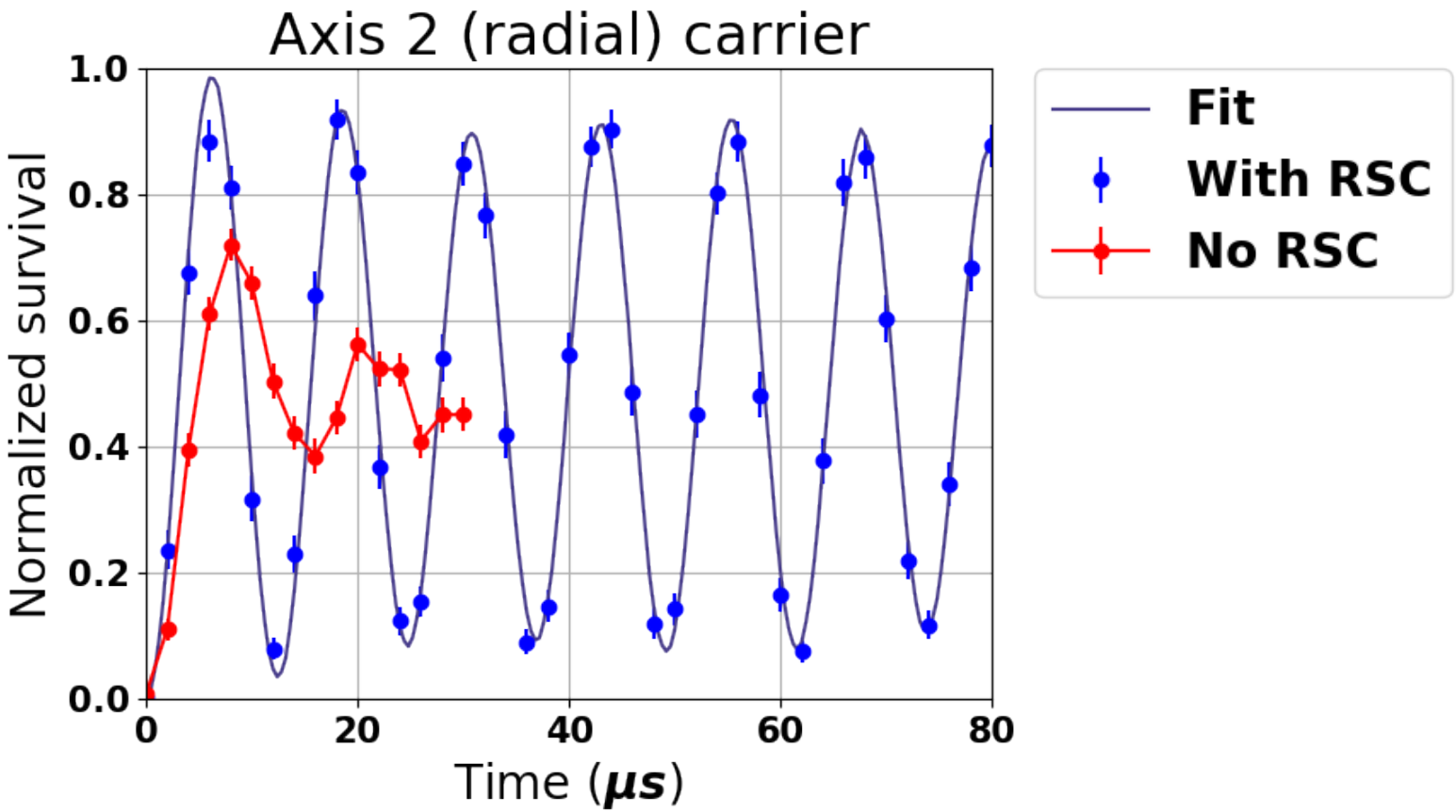
# Raman sidebands

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

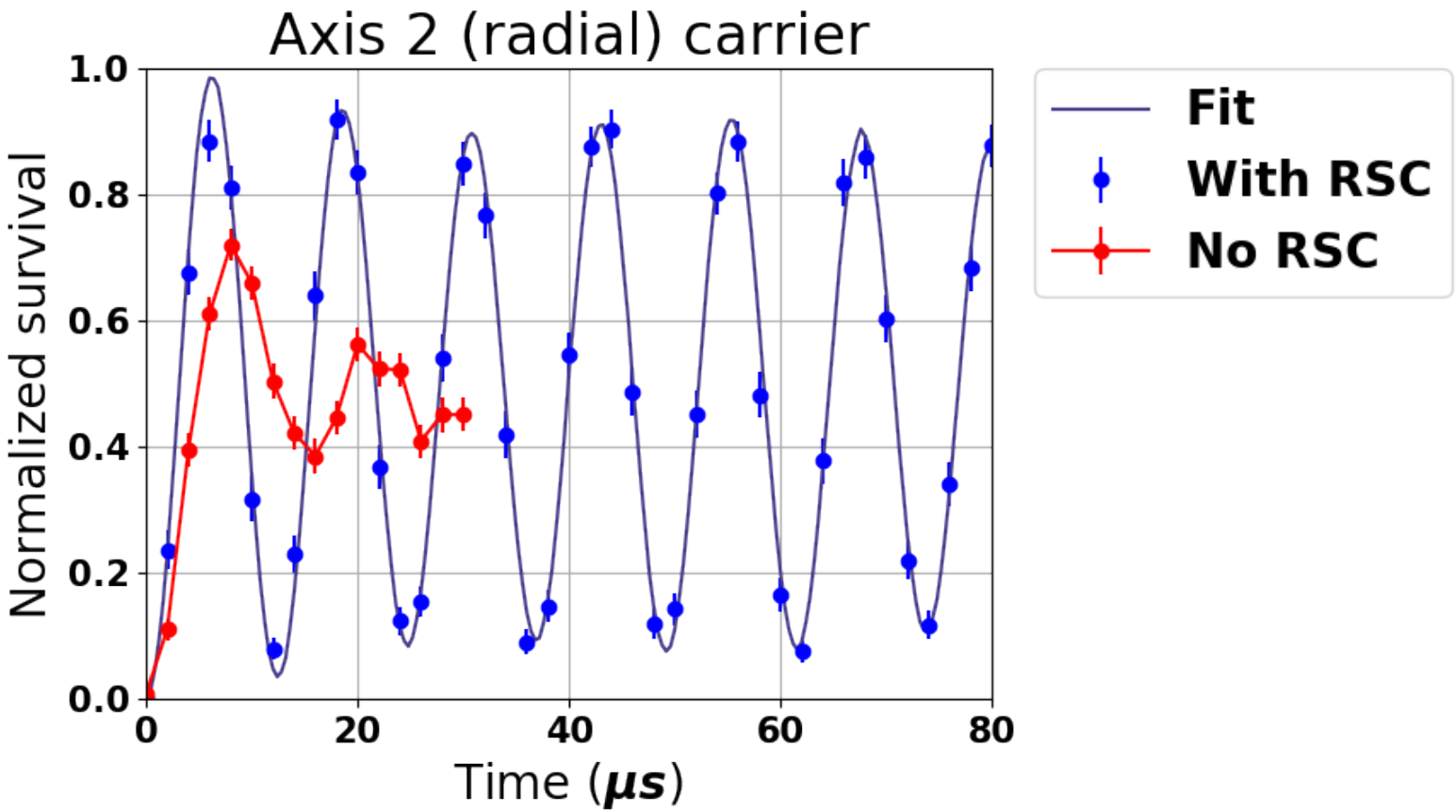
**3D ground state:** 79.5(3.6)%
**Loss after cooling:** 15%

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

# Rabi flopping (radial)

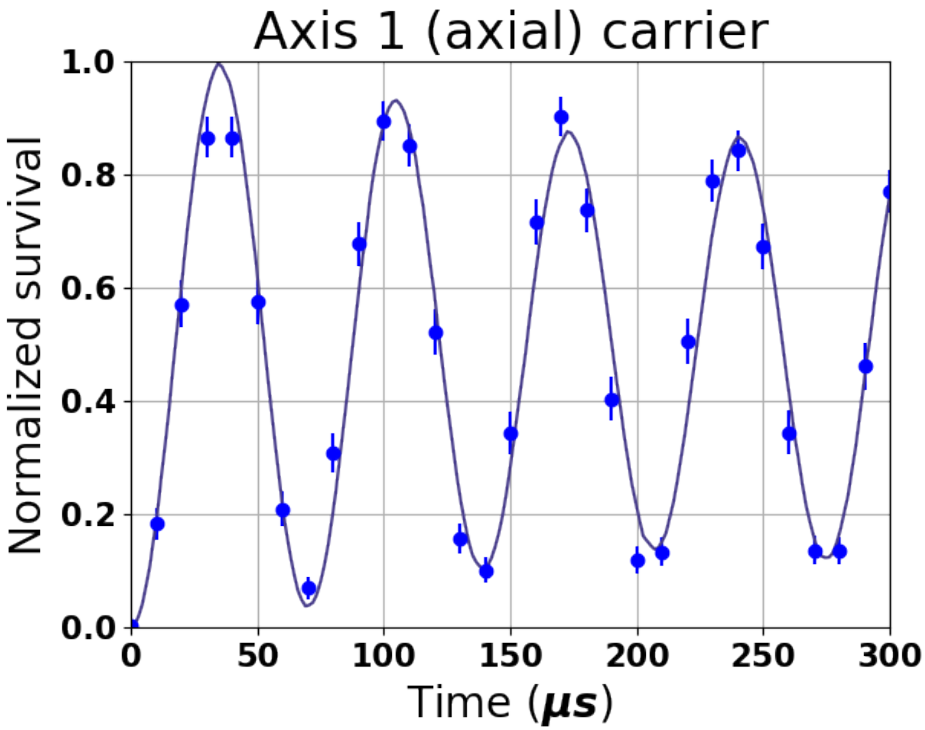


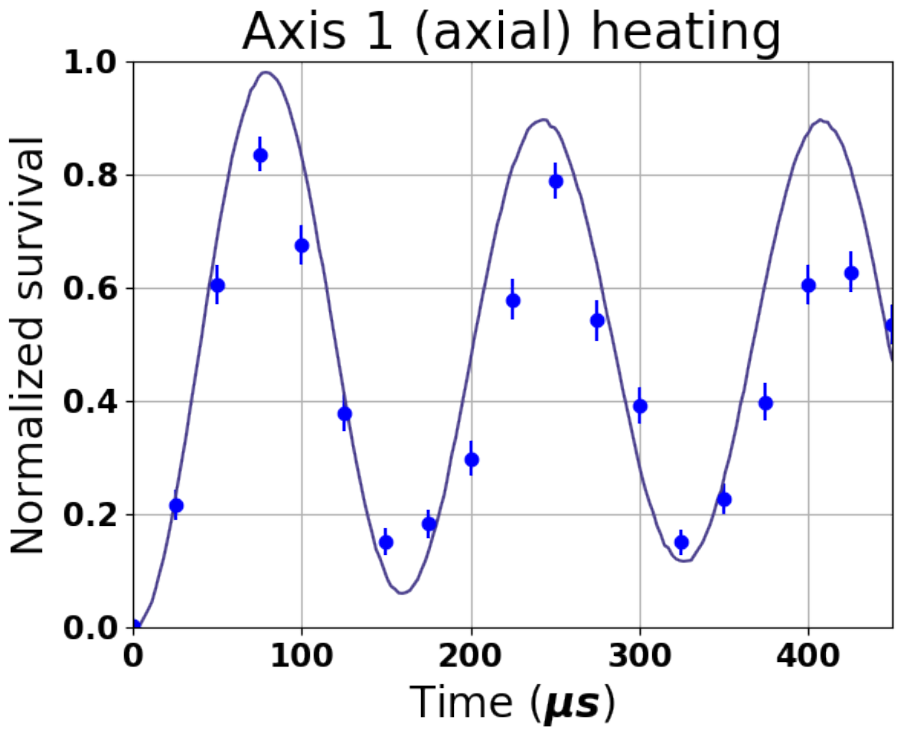
# Rabi flopping (radial)




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

# Rabi flopping (axial)



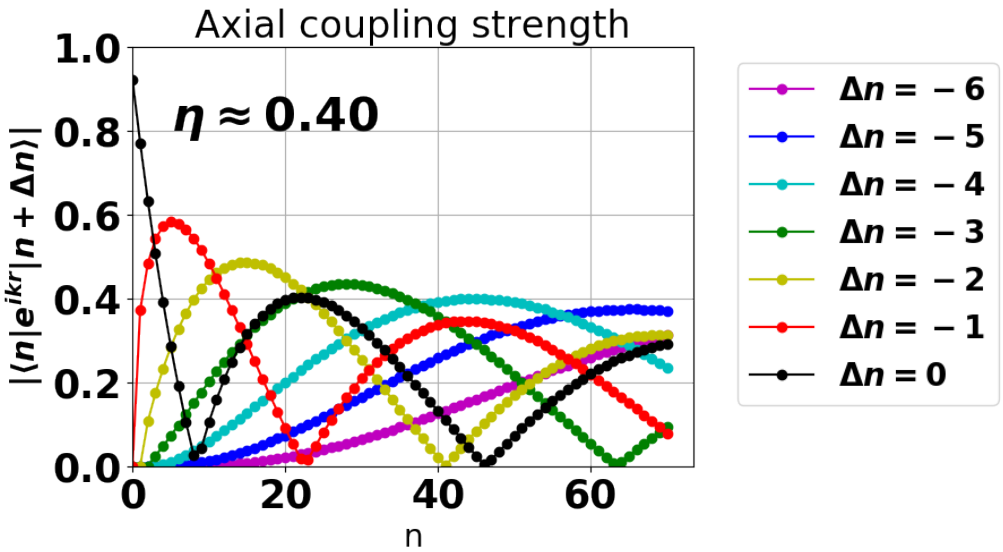
## Conclusion

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

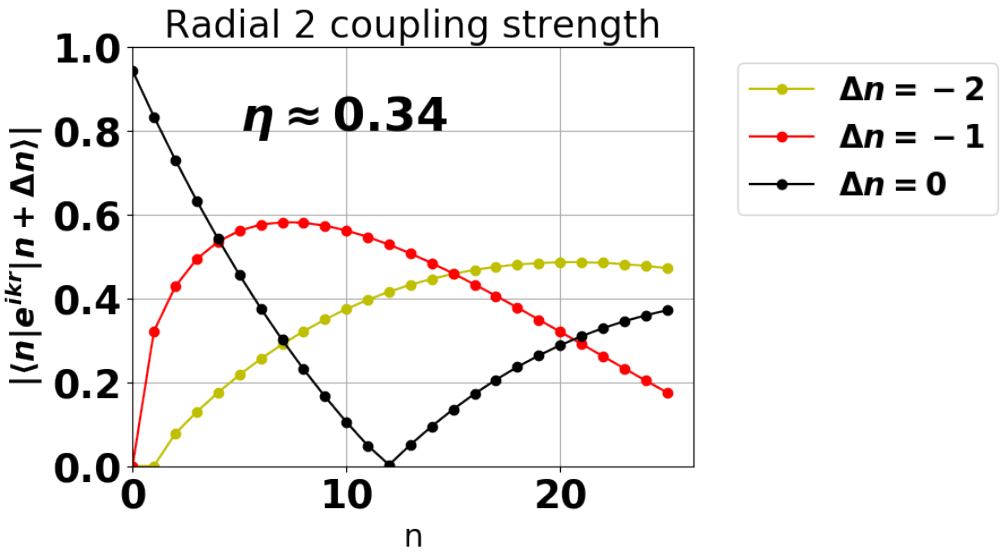
## Improvements

- 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