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Versatile Transporter Apparatus for Experiments with Optically Trapped BECs

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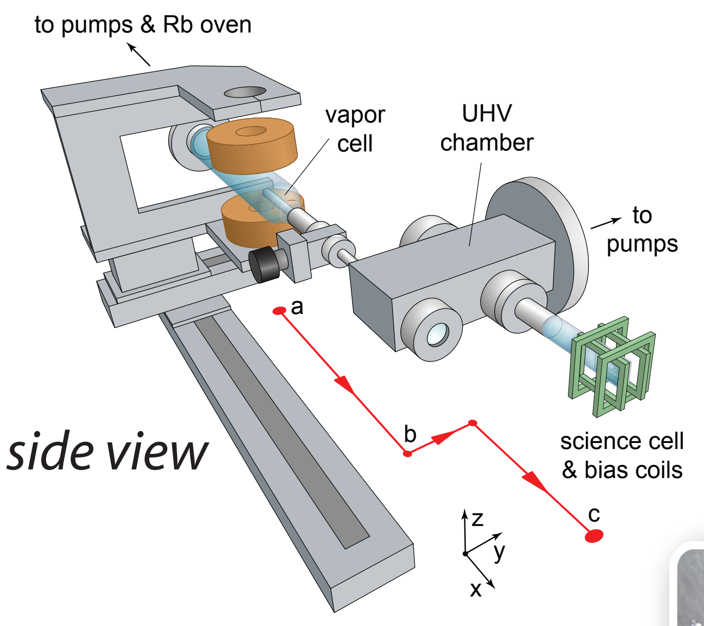
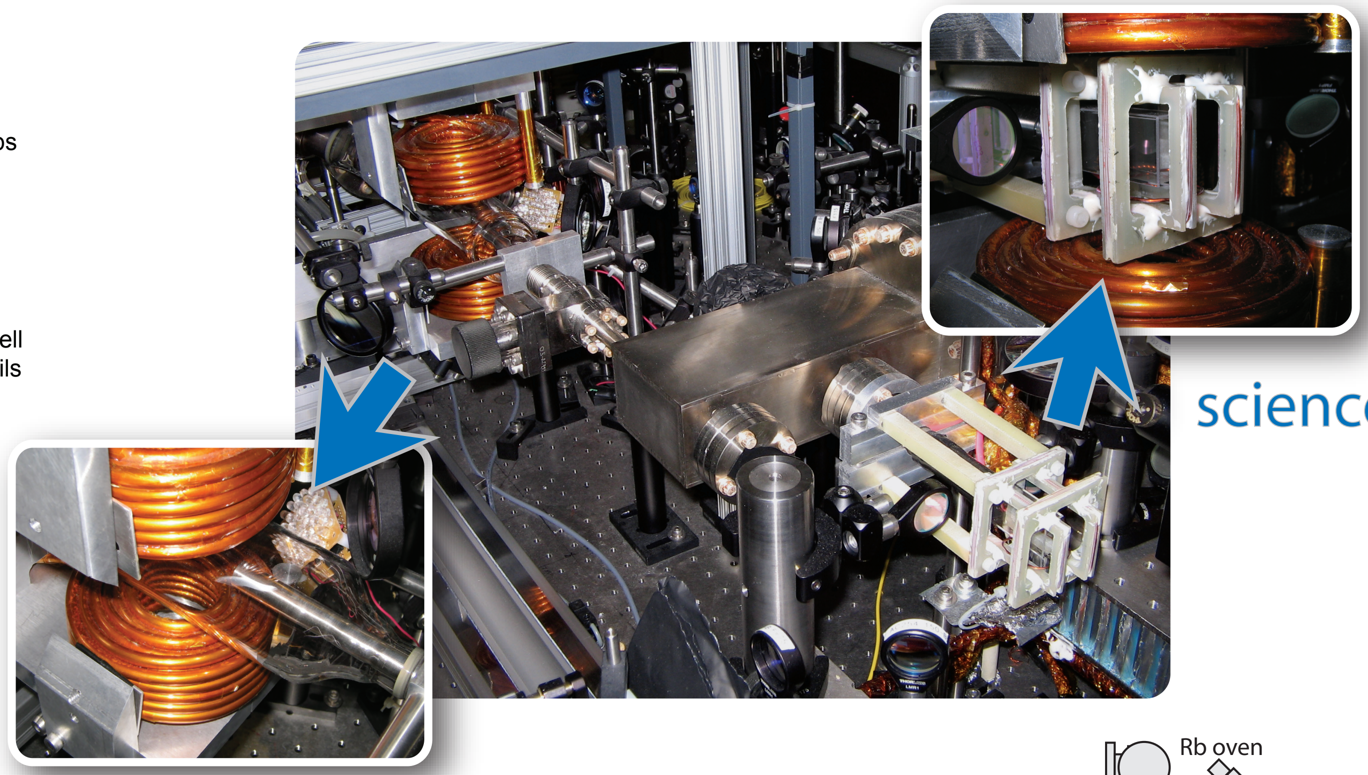
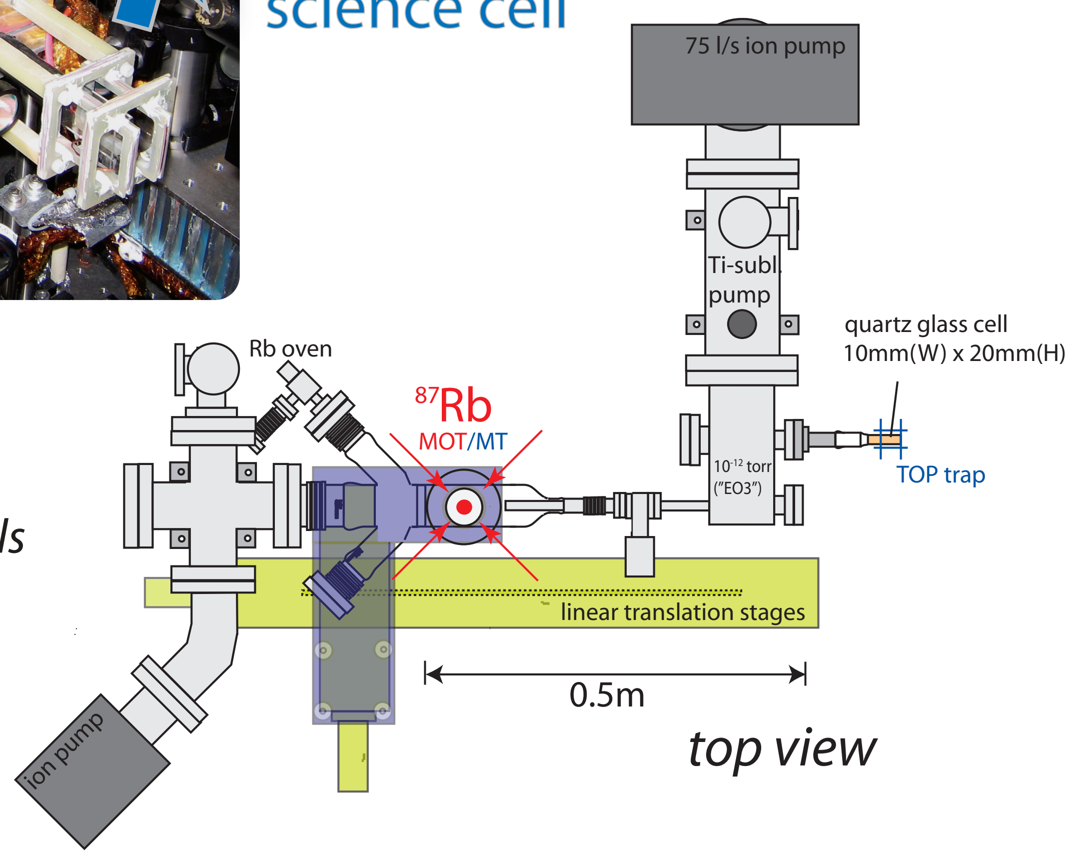
Apparatus Layout



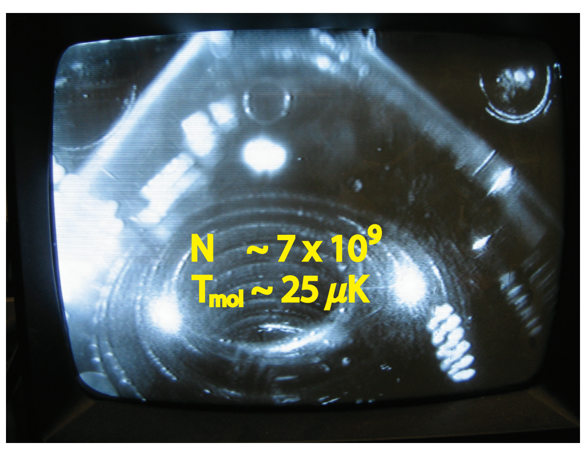


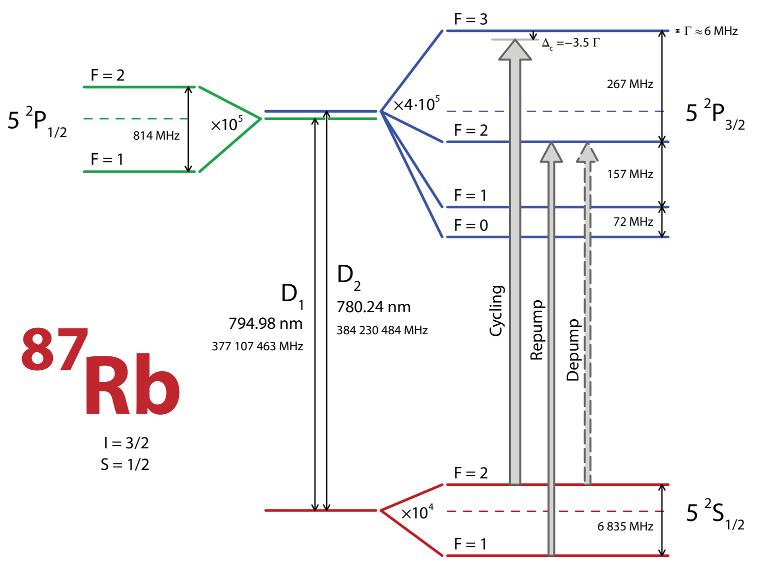


The moving quadrupole magnetic trap coils transport the laser-cooled atoms from the MOT to the science cell. Additionally, they serve both as a part of the MOT and as a part of the McTOP trap (moving-coil TOP).

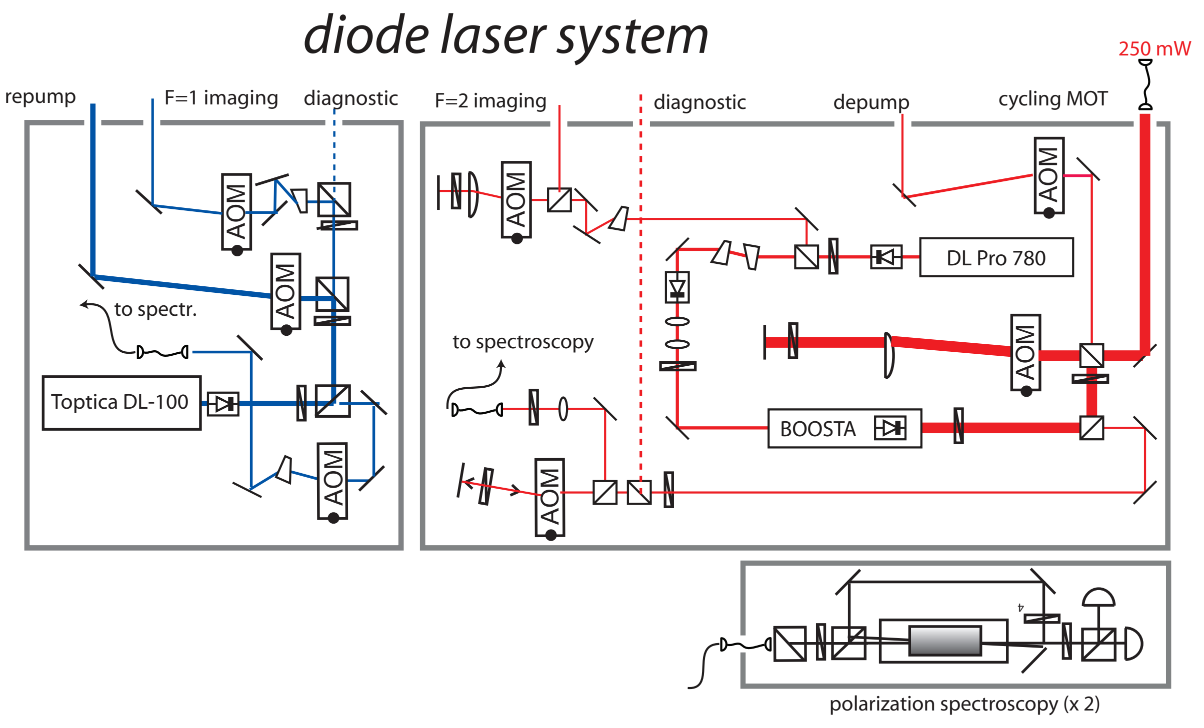
Laser cooling

MOT & optical molasses

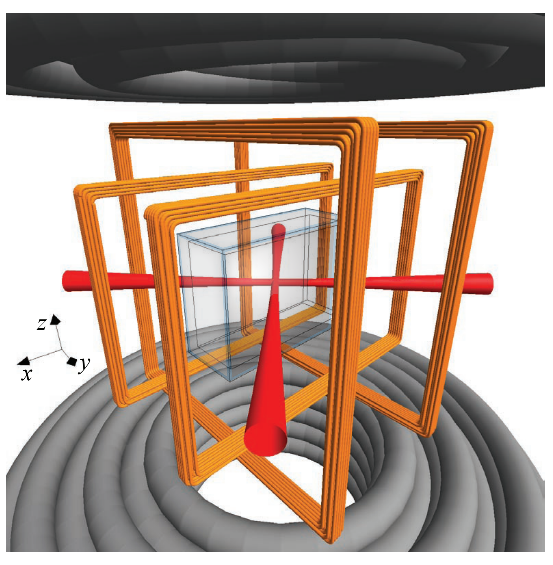




diode laser system



Moving-coil TOP trap (McTOP)



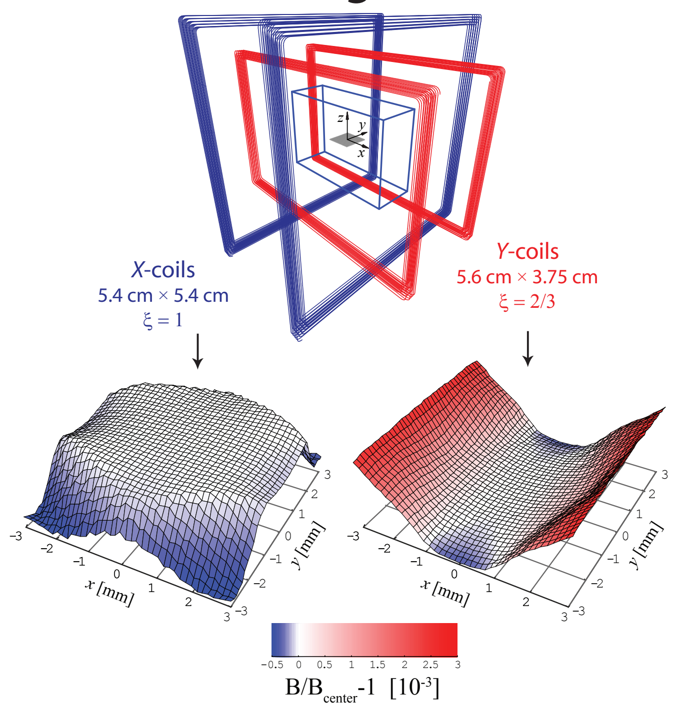
Novel design: stationary bias field coils sandwiched between moving quadrupole coils

Relative alignment of coils uncritical (unlike for IP traps) for sufficiently uniform bias field

Quadrupole coils can be moved away for optically trapped BECs (giving enhanced optical access)

Quadrupole coils can be used for multiple purposes (MOT, MT transport, TOP, Stern-Gerlach,...)

bias field coil design



Effective Potential

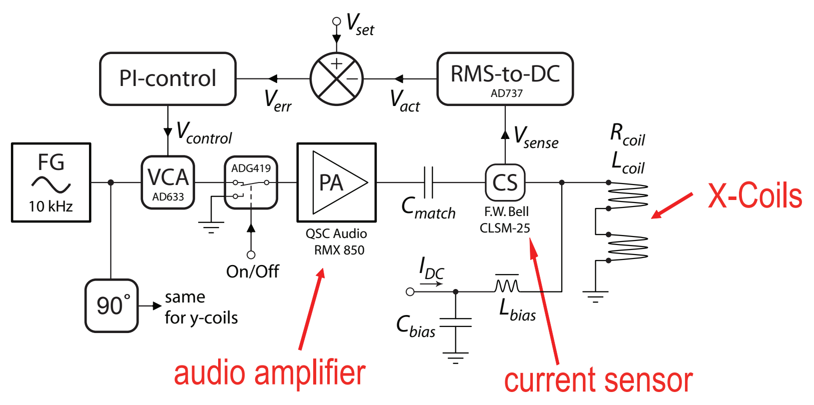
$$V(\rho,z)=\mu B_0+\frac{1}{2}m\omega_\perp^2\rho^2+\frac{1}{2}m\omega_z^2z^2 \quad (\rho,z<<\rho_0)$$

$$\omega_\perp=\sqrt{\frac{\mu B_\perp'^2}{2mB_0}} \quad \omega_z=\sqrt{8}\,\omega_\perp \quad \rho_0=\frac{B_0}{B_\perp'}$$

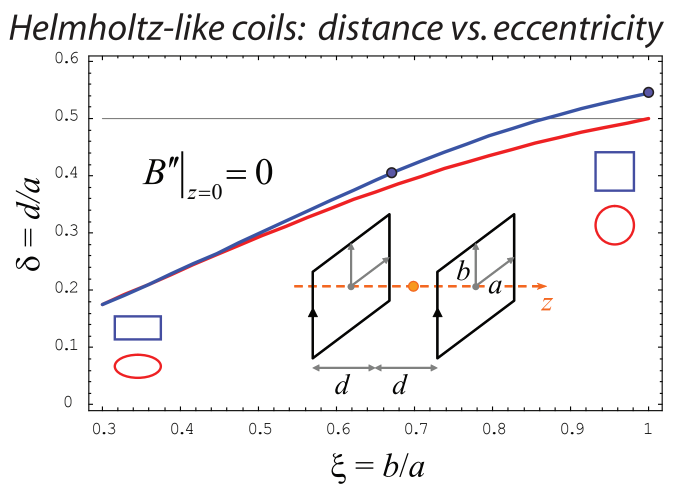
$$B_\perp'=200\ \mathrm{Gcm^{-1}} \quad B_0=60\ \mathrm{G\ (at\ 8A)}\rightarrow \quad \rho_0=3\ \mathrm{mm}$$

$$B_0=30\ \mathrm{G}\rightarrow \left.\begin{array}{l}\omega_\perp=2\pi\times 23\ \mathrm{Hz}\\ \omega_z=2\pi\times 66\ \mathrm{Hz}\end{array}\right\}\ |1,-1\rangle$$

TOP coil current control & stabilization

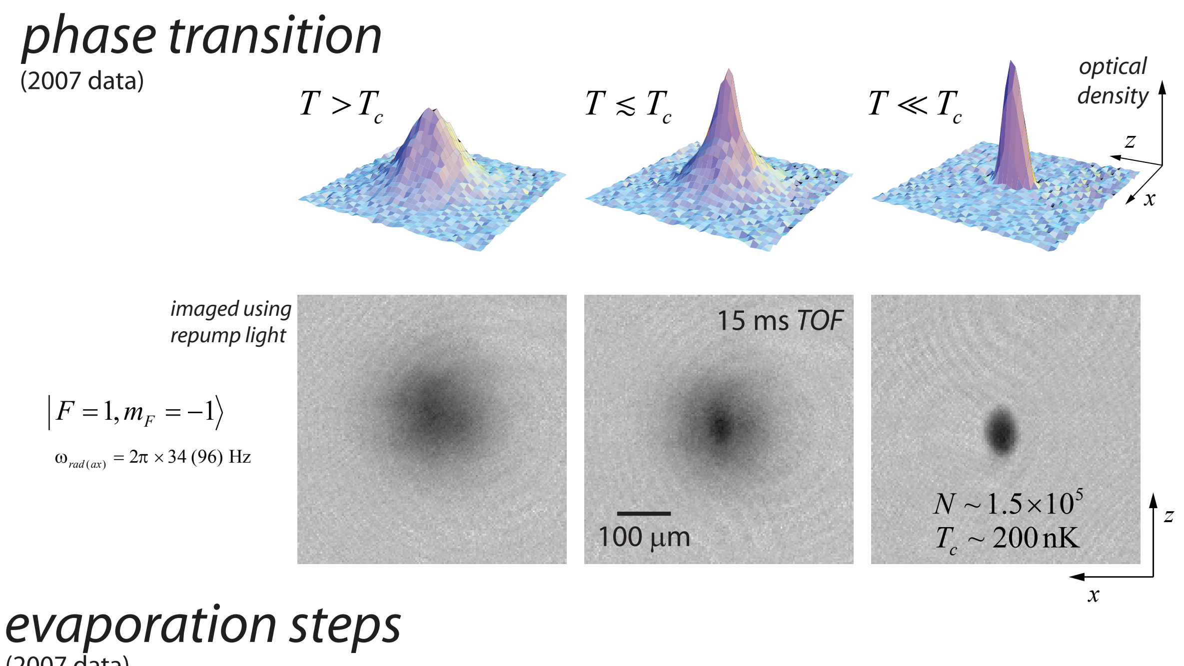


Helmholtz-like coils: distance vs. eccentricity

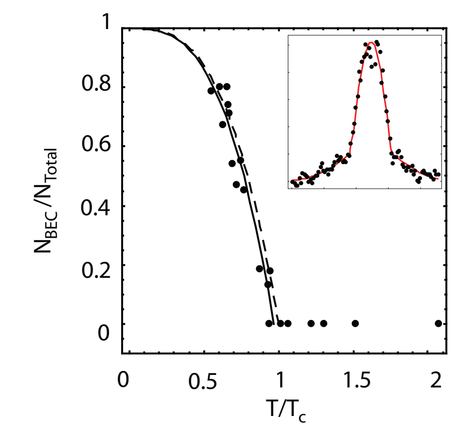


Evaporative cooling

phase transition
(2007 data)



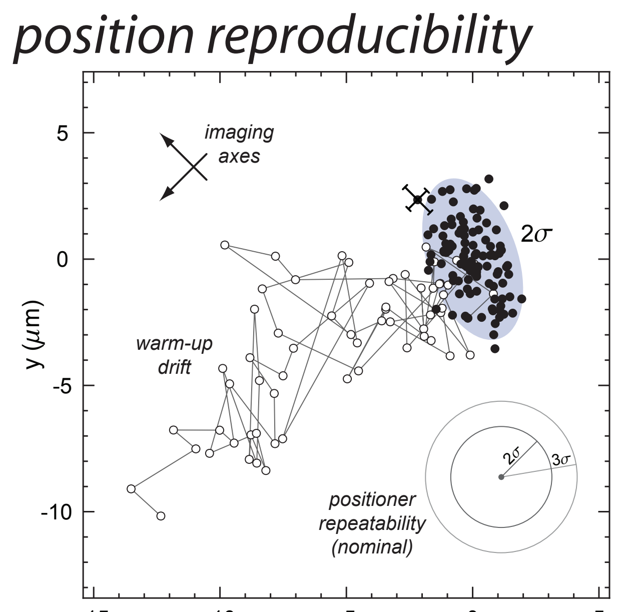
PT data after optimization



$N_0=1.0(3)\times 10^6$
$T_c=150\,\mathrm{nK}$

(14+30)s long RF evaporation ramp

position reproducibility



evaporation steps
(2007 data)

Laser-cooled atoms after transport into science cell

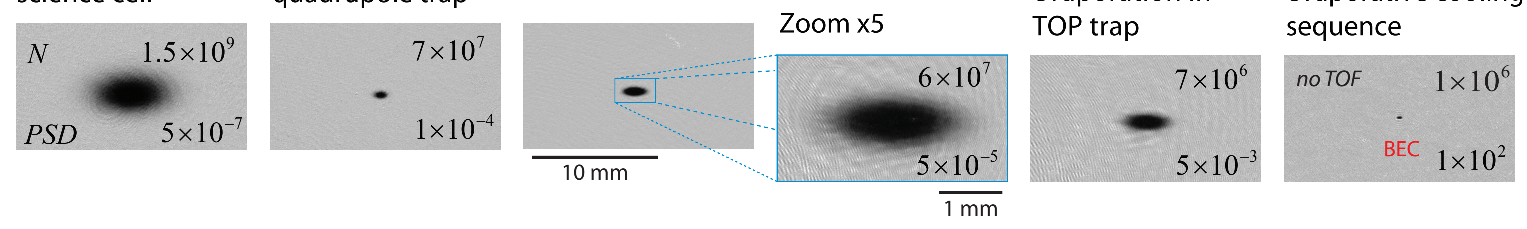
Cloud after pre-evaporation in quadrupole trap

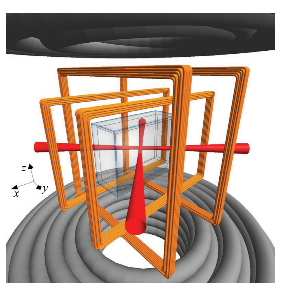
After transfer into TOP trap

Zoom x5

During rf-induced evaporation in TOP trap

Quasi-pure BEC after evaporative cooling sequence





Note: Primary use of McTOP trap as a retractable funnel to load pre-evaporated clouds into a crossed-beam optical dipole trap