Molecular BEC of $^6Li_2$ in a Low Power Crossed Dipole Trap

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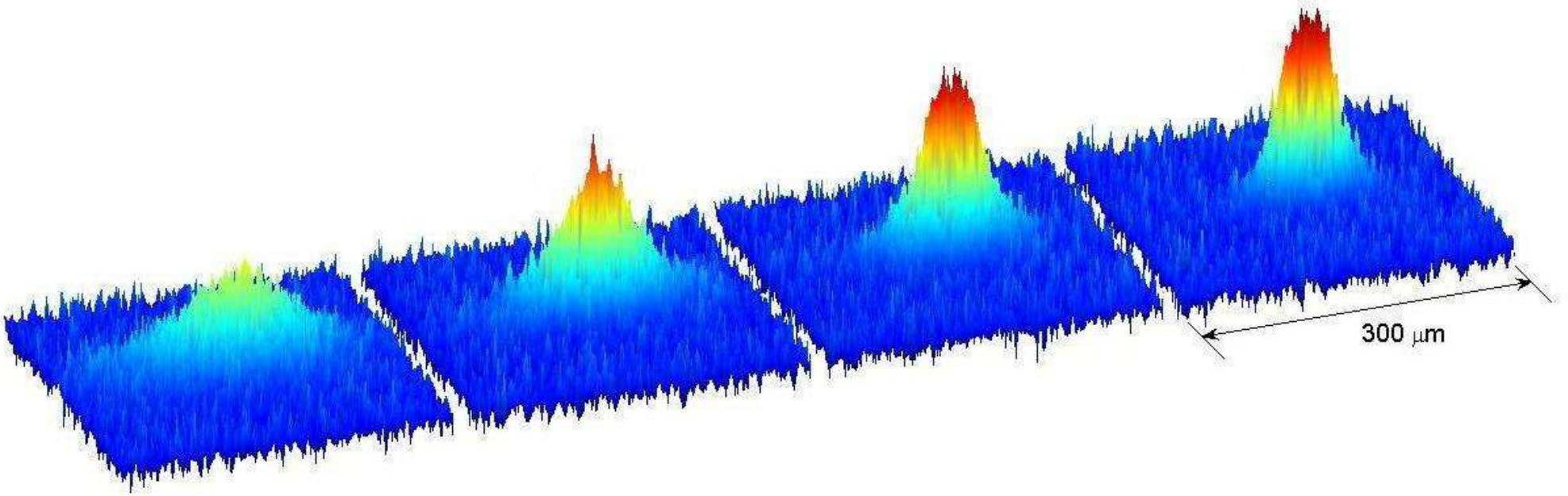

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Overview of existing MBEC experiments

^{40}K

JILA: Precooling in a magnetic trap

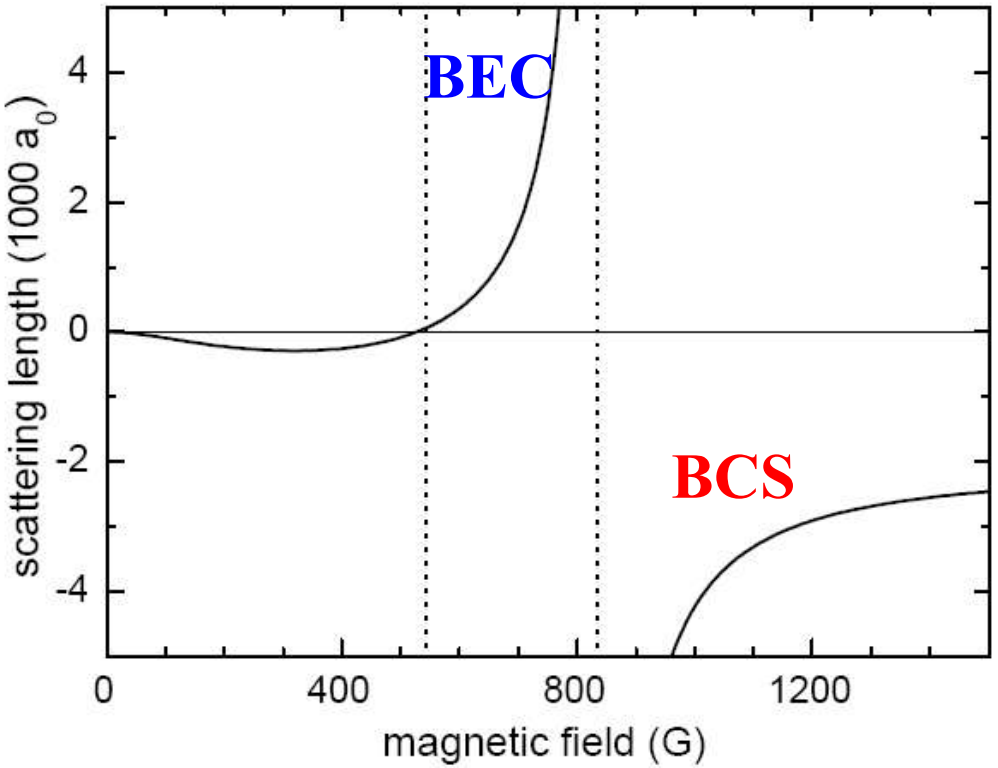
^{6}Li

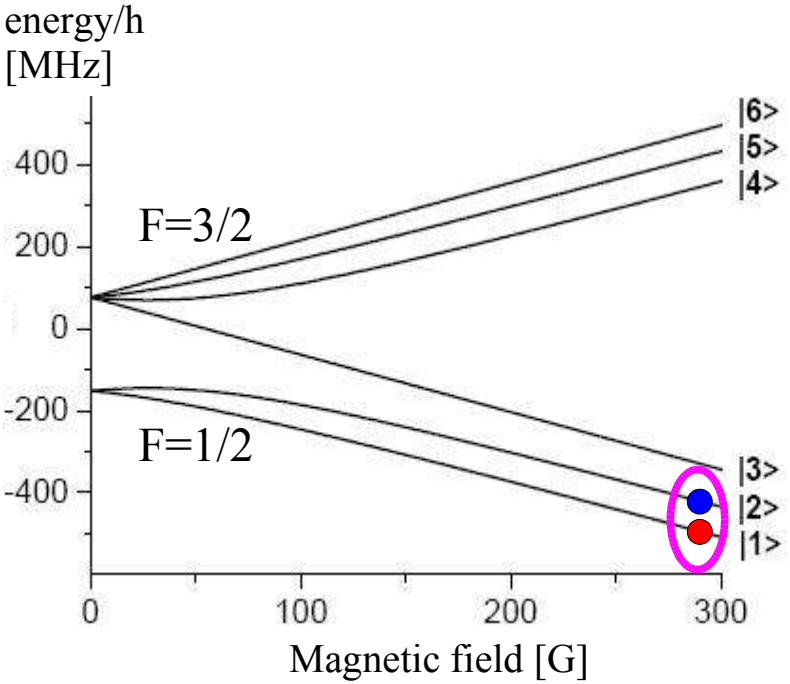
Innsbruck 1 & 2: All optical (Resonator with 150 W in cavity/crossed dipole trap with 100 W laser)

MIT 1 & 2: Sympathetic cooling with ^{23}Na in a magnetic trap
ENS: Sympathetic cooling with ^{7}Li in a magnetic trap
Rice: Sympathetic cooling with ^{7}Li in a magnetic trap

Our approach:
Low power (25W) crossed dipole trap with relatively small waist

Feshbach resonances in ^{6}Li

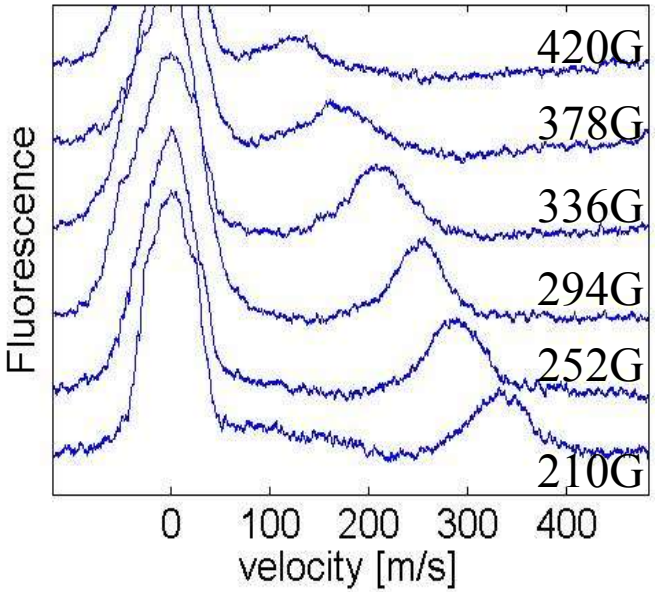


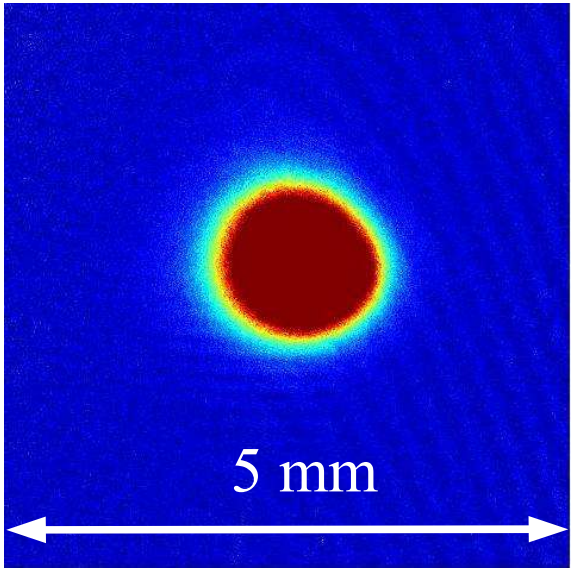


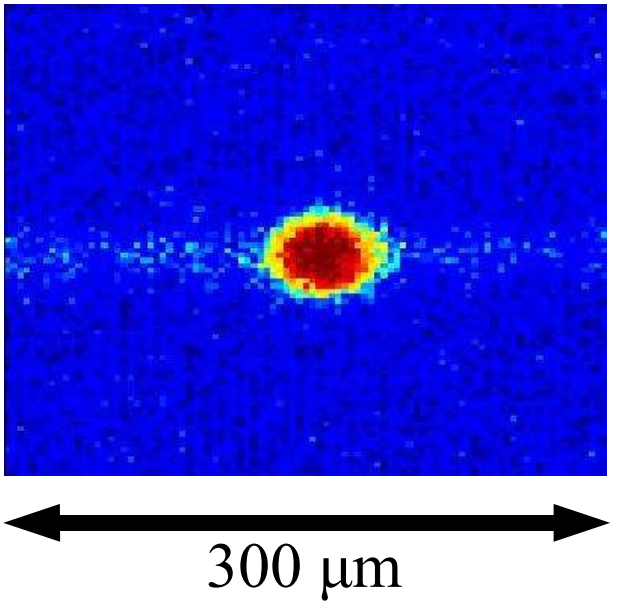
Binding energy of molecule: $$E_B = -\frac{\hbar^2}{2ma^2}$$

M. Bartenstein et al, Phys. Rev. Lett. 94, 103201 (2005)

Experimental procedure







Zeeman slower:

- Oven @ 475 degrees C
- Atomic beam v_{avg}=1600m/s
- 650m/s → 50 m/s

Magneto-optical trap

- ~ 10^8 atoms loaded in 60s
- ~ 300 μK
- Compressed MOT: 50G/cm

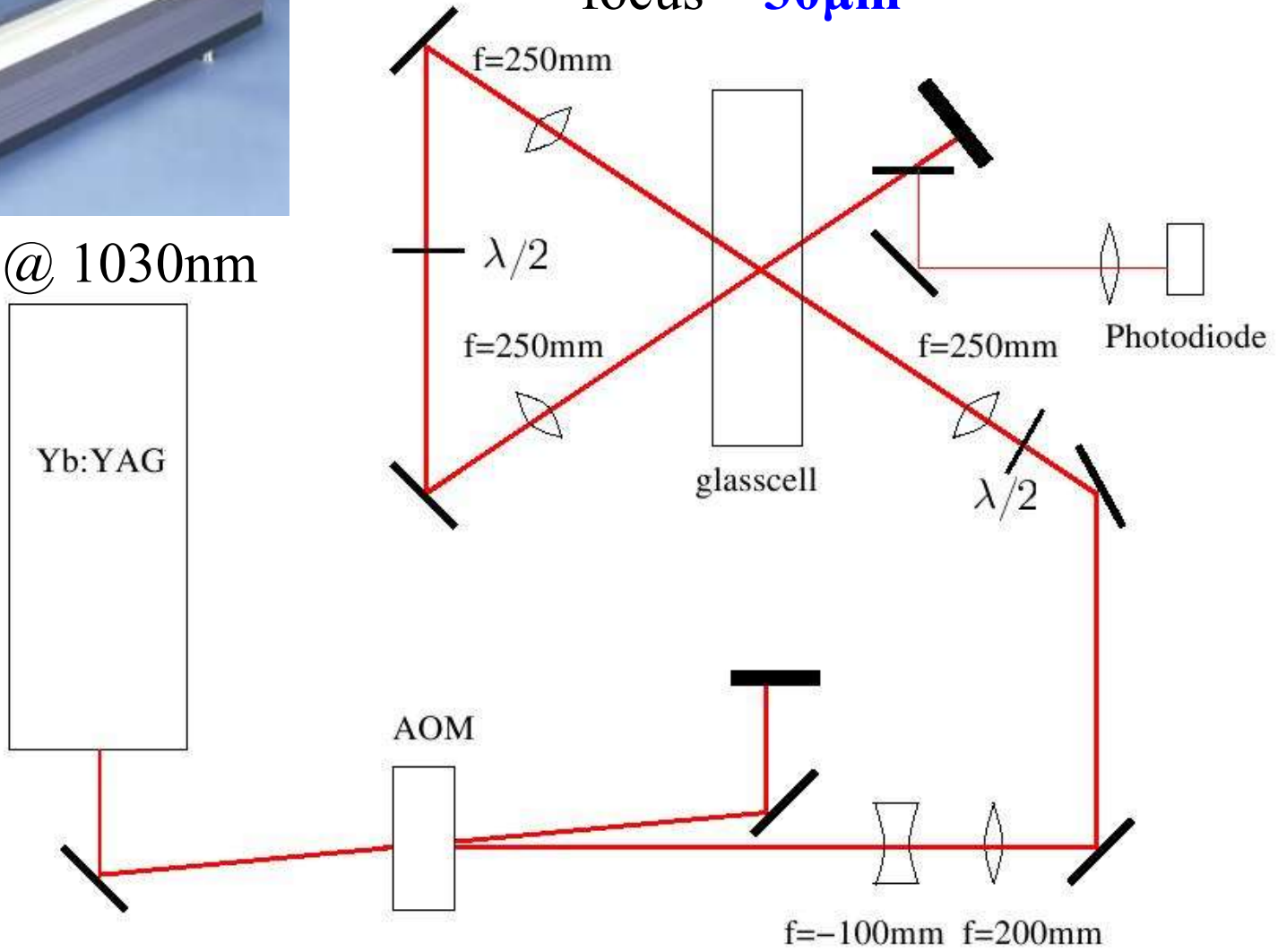
Dipole trap:

- Up to ~ 400 000 atoms depending on geometry
- ~ 50/50 spin mixture
- ~100 μK
- ~1mK trap depth

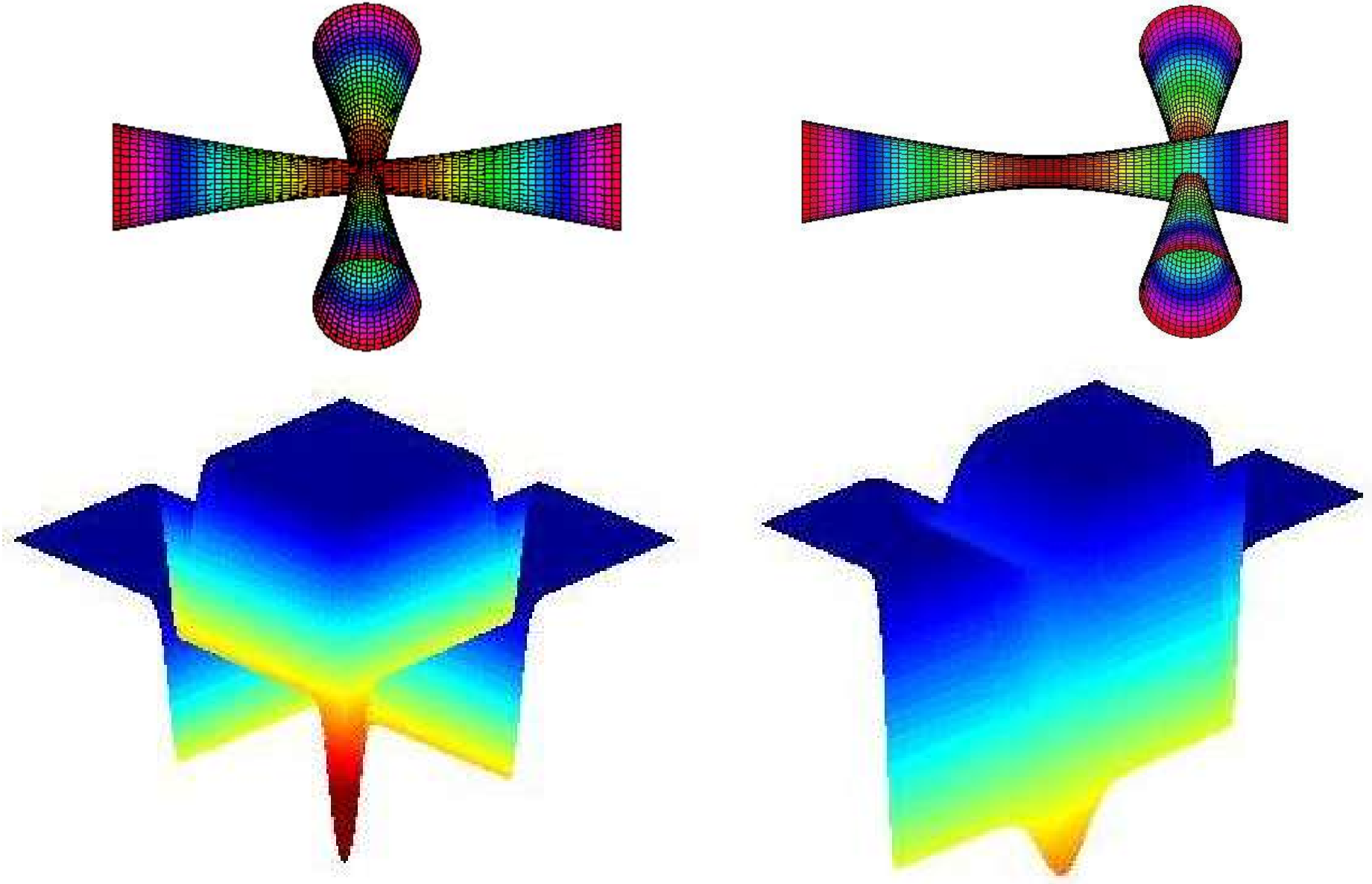
Crossed dipole trap - Setup

25W @ 1030nm

Beam waist at
focus ~ **30µm**



Crossed dipole trap geometries



Evaporation in dipole traps

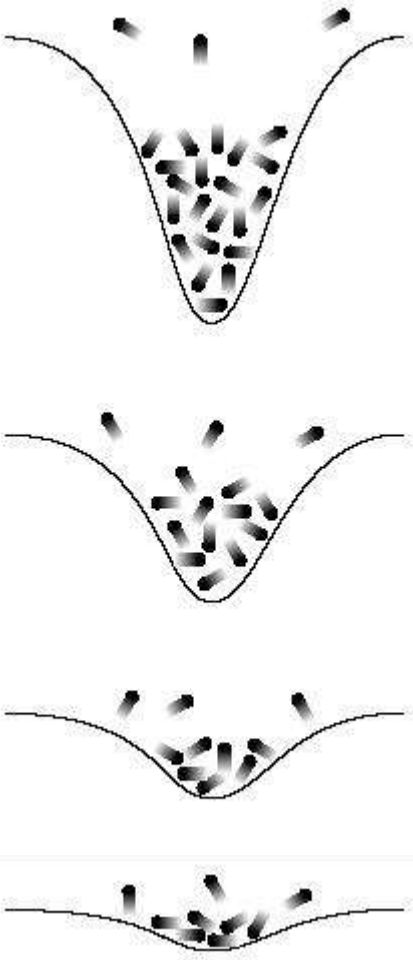


Figure from M. E. Gehm (thesis, 2003)

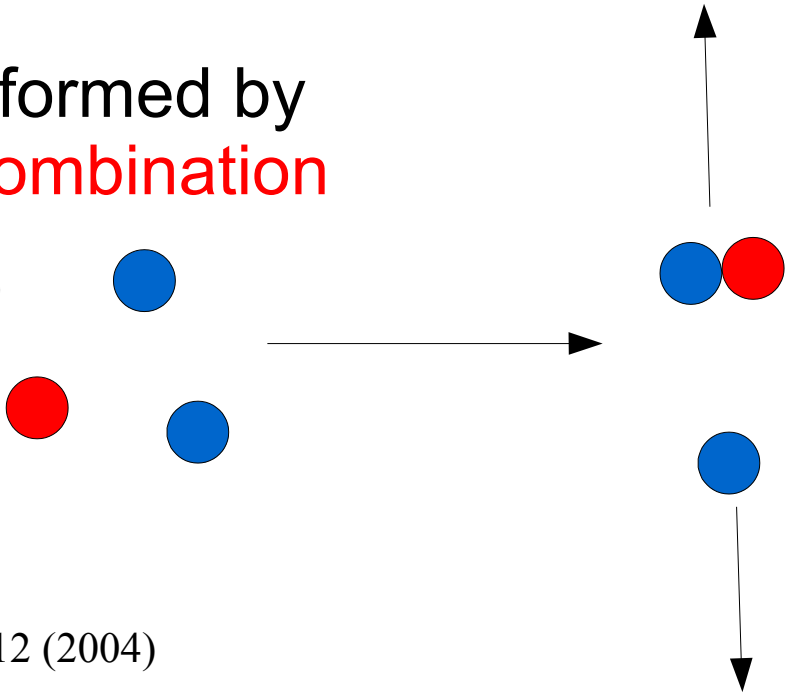
Scaling laws for
$\eta = U/k_B T = 10$

K. M. O'Hara et al, Phys. Rev. A 64, 051403 (2001)

$$\frac{N}{N_{initial}} = \left(\frac{U}{U_{initial}}\right)^{0.19}$$

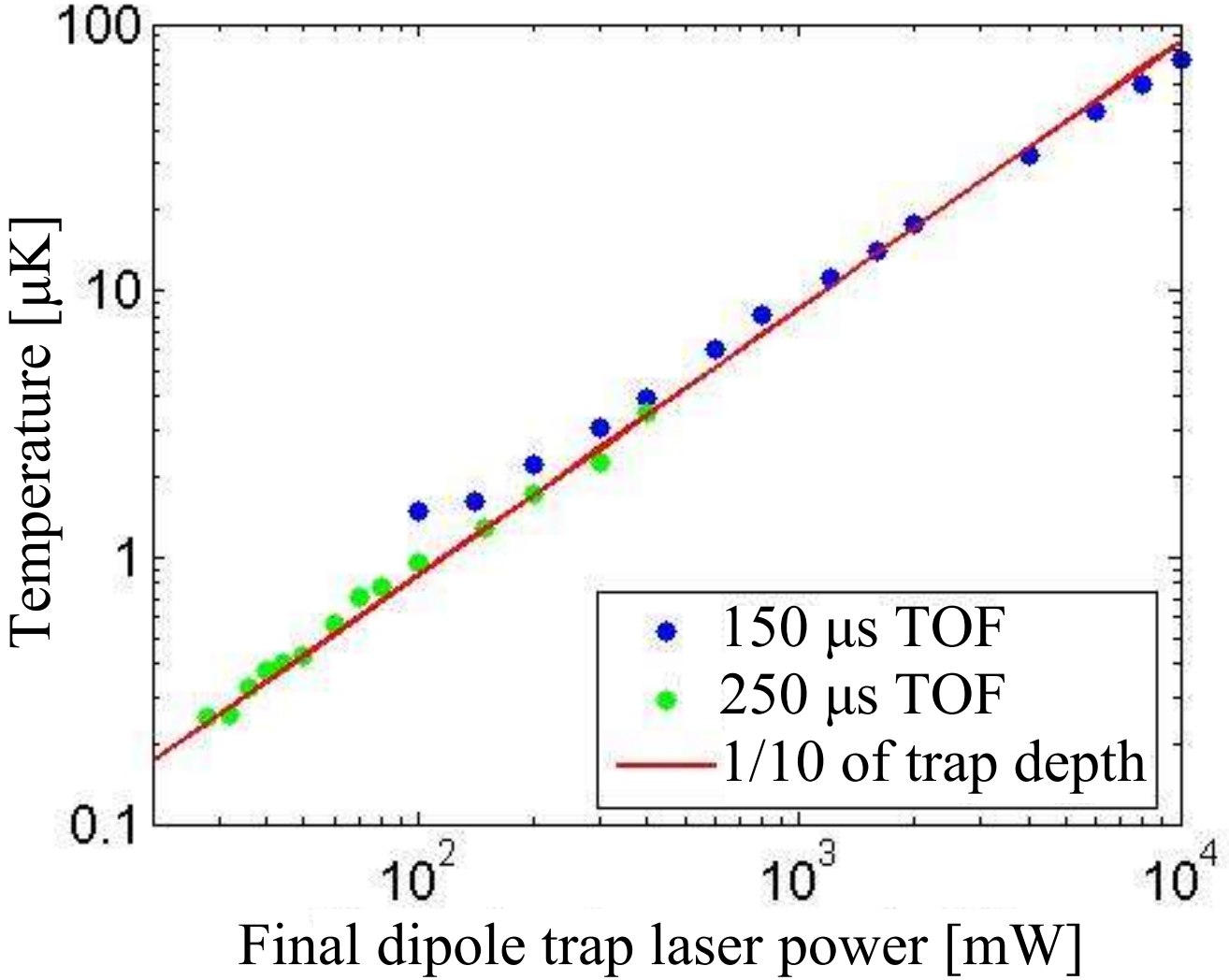
$$\frac{\rho}{\rho_{initial}} = \left(\frac{U}{U_{initial}}\right)^{-1.3}$$

Molecules are formed by
three body recombination
when $k_B T \sim E_b$



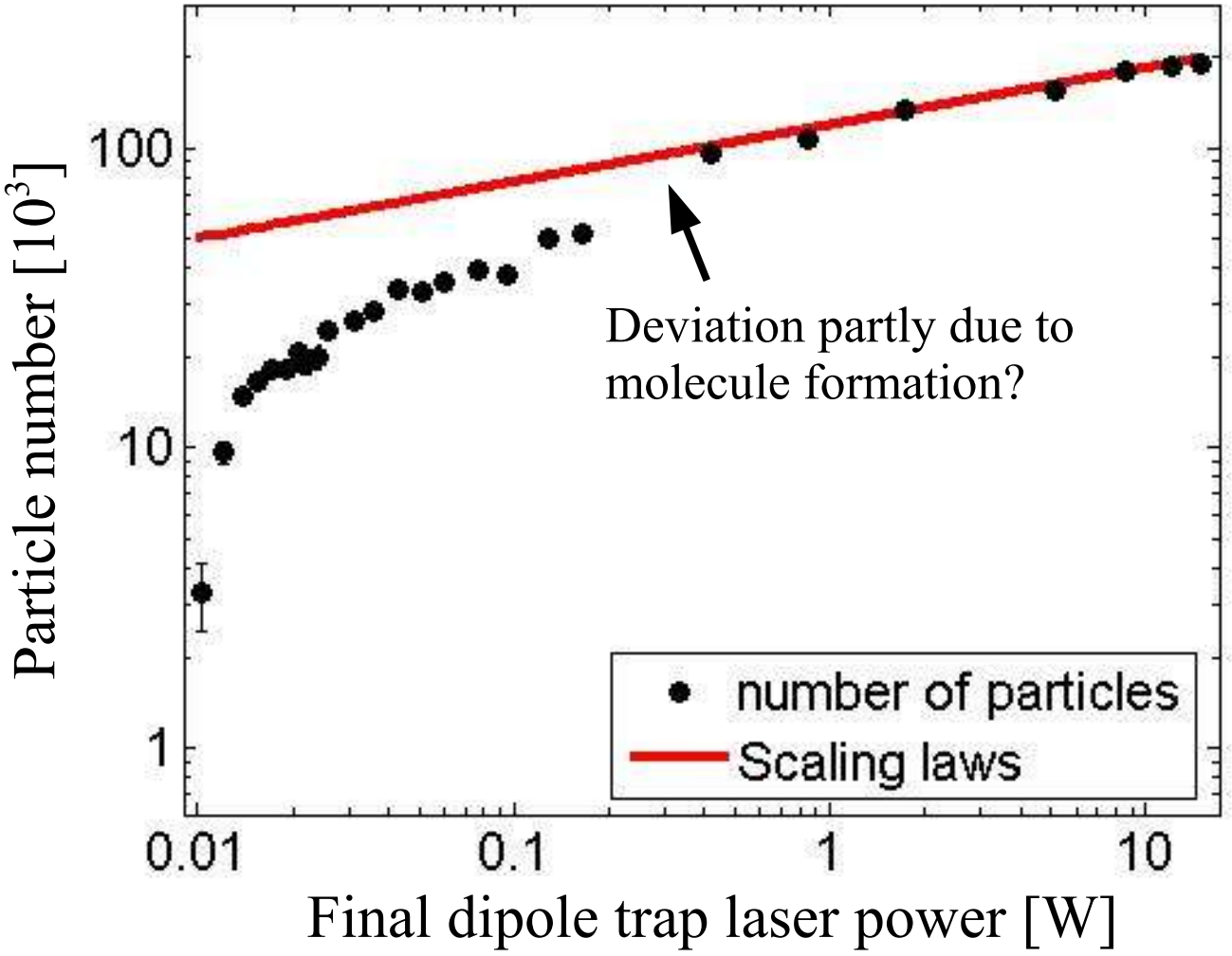
C. Chin and R. Grimm,
Phys. Rev. A 69, 033612 (2004)

Very efficient evaporation



Temperature is calculated by $\sigma^2 m_{atoms}/k_B t^2$

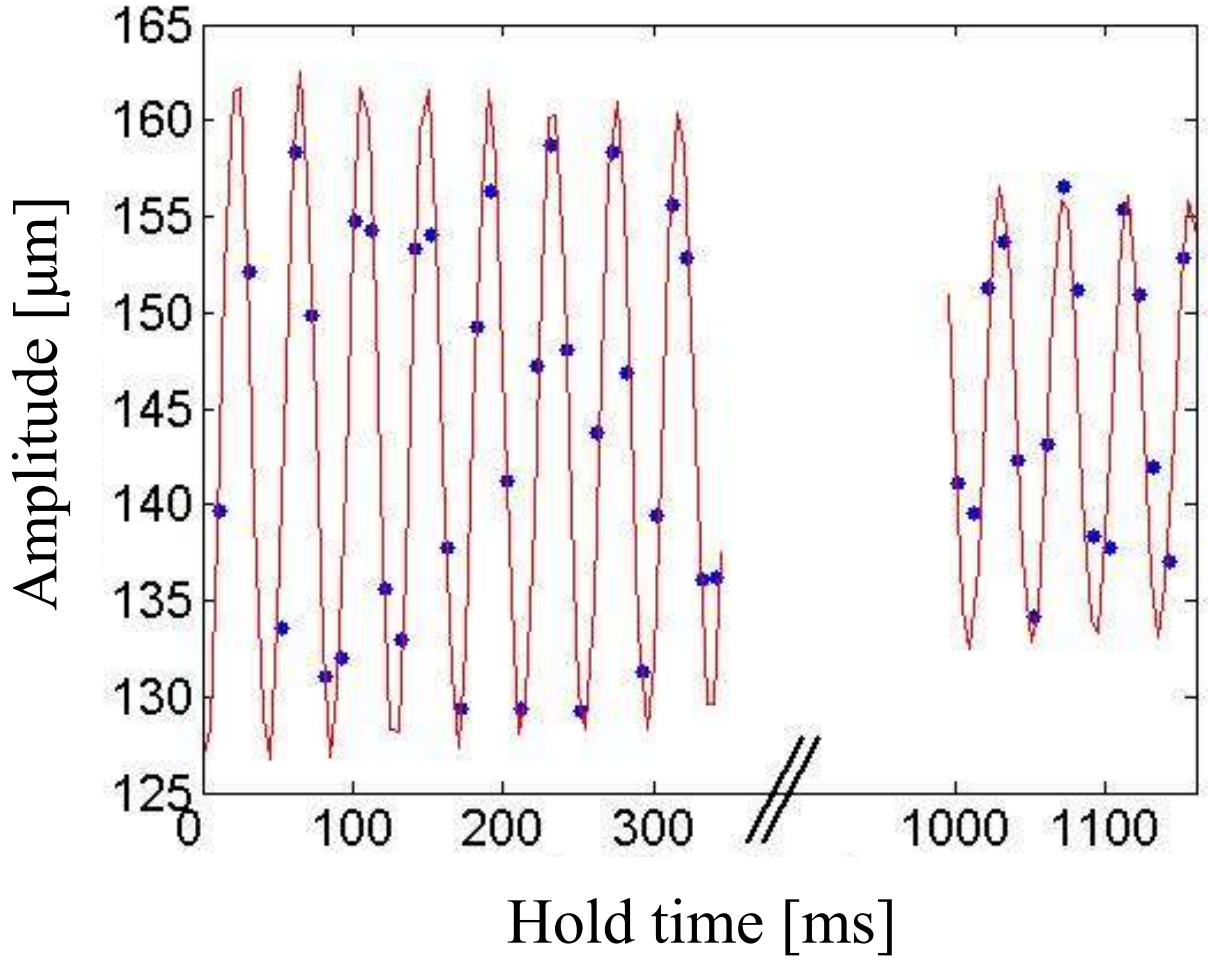
Very efficient evaporation



Evaporation @ 694G

Trapping frequency

Weak axis of asymmetric crossed dipole trap



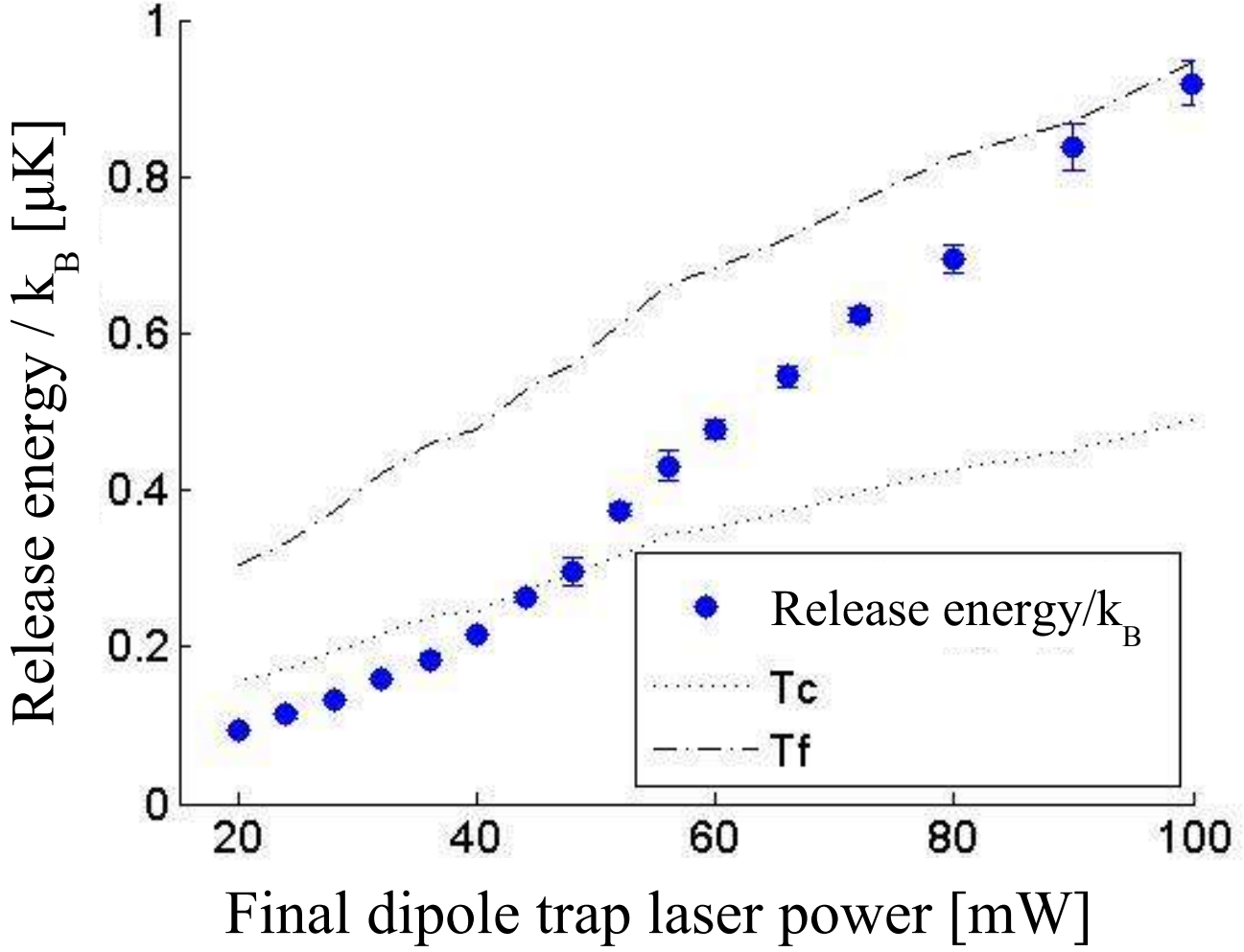
f_{ax} = 23.8 Hz
(@696G, 15 mW)

Trapping potential due to
- crossed arm of DPT
- curvature in Feshbach field

f_{rad} = 375 Hz (@15mW)
measured by trap loss

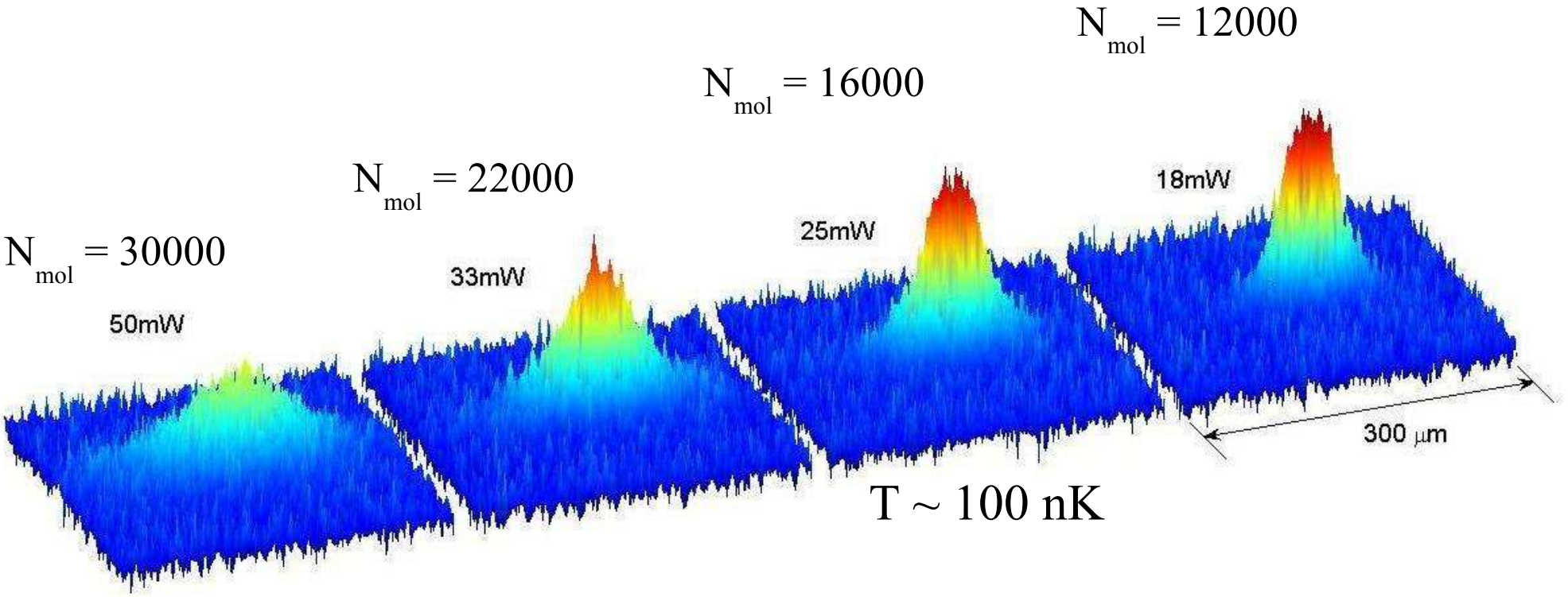
Evaporation into degeneracy

in a cigar shaped trap

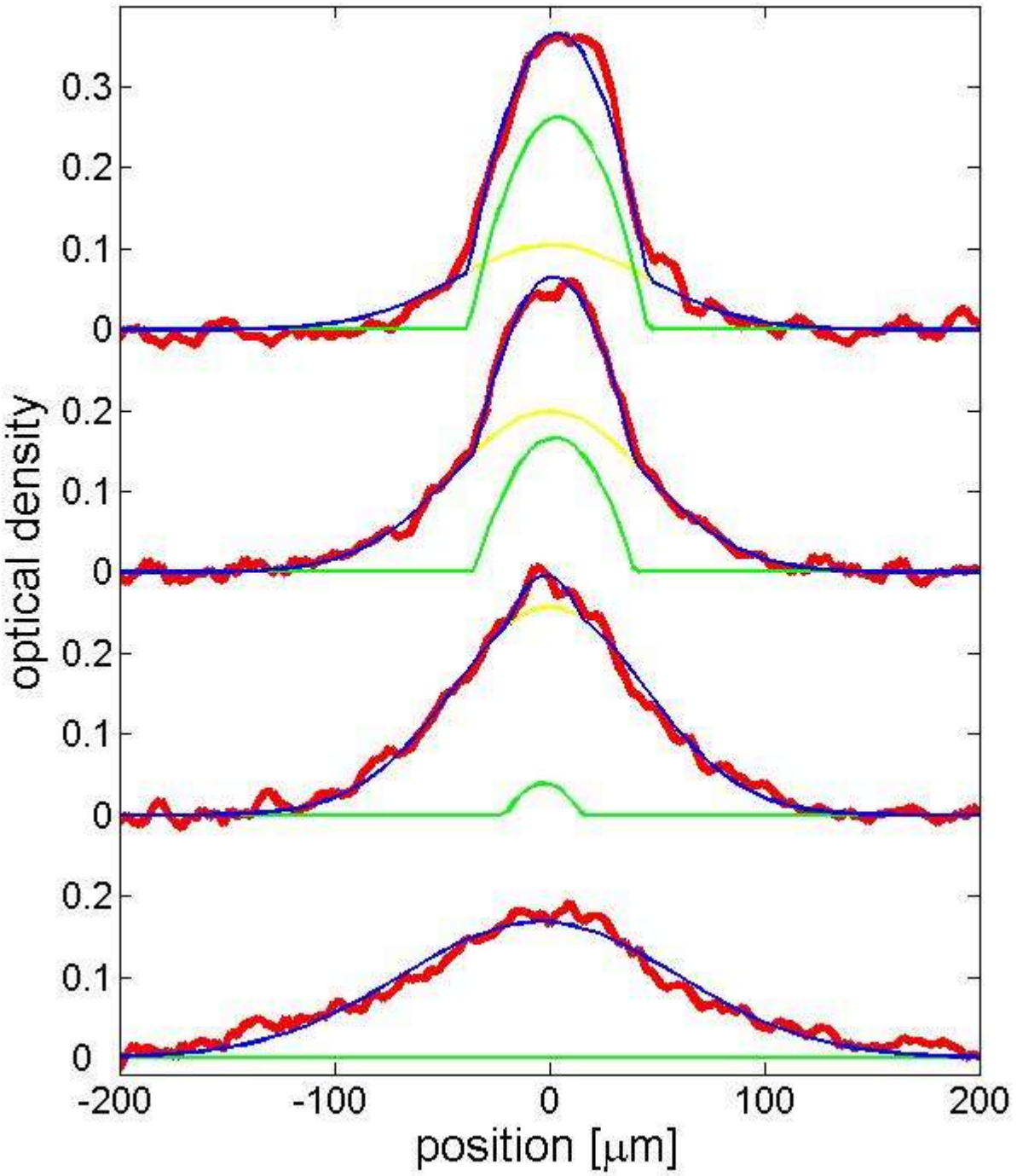


Molecular BEC

Evaporation @ 770 G
Imaging @ 694 G



Images taken after 1.5 ms TOF



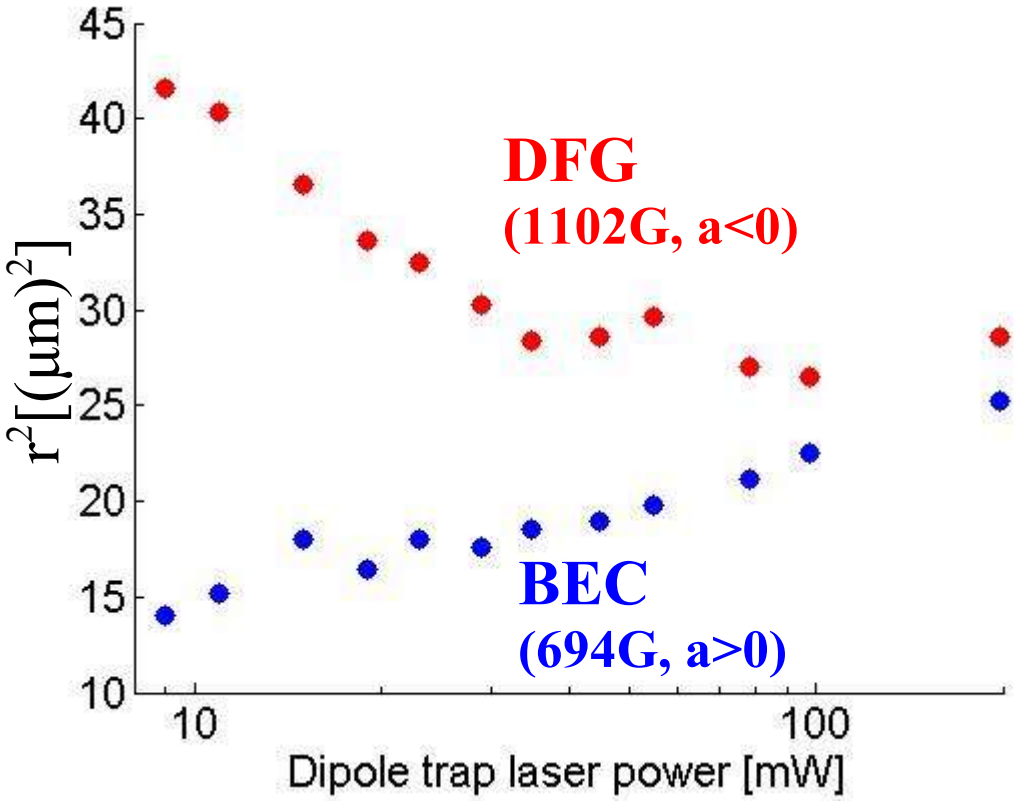
N_{mol} = 12000
P=18mW

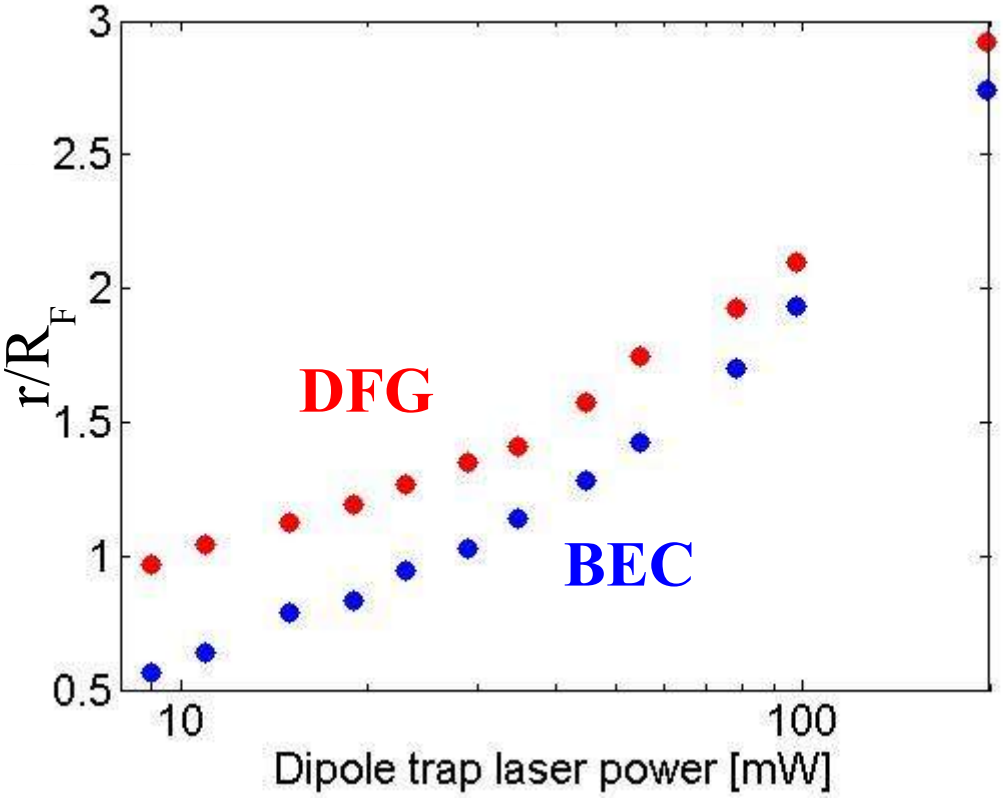
N_{mol} = 16000
P=25mW

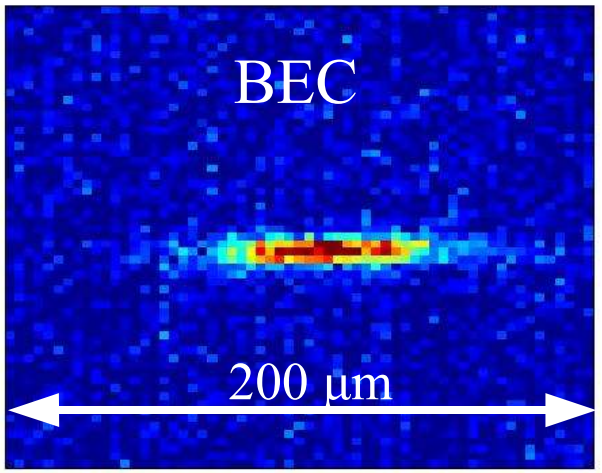
N_{mol} = 22000
P=33mW

N_{mol} = 30000
P=50mW

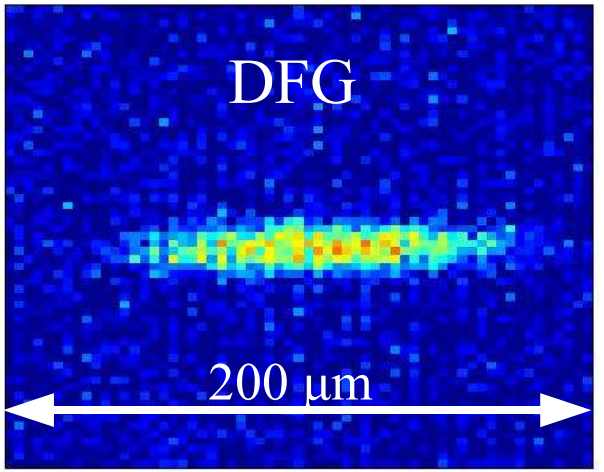
Bosons vs Fermions







P_{final}=9mW



Outlook

- Optimising geometry of our crossed dipole trap
- Increasing life time of MBEC (10s sec.?)
- Bragg scattering of Cooper pairs
  (K.J. Challis et al, PRL 98, 093002, 2007)
- Correlation of dissociated atom pairs
  (K. V. Kheruntsyan and P. D. Drummond, PRA 66, 031602, 2002,
  K. V. Kheruntsyan, PRL 96, 110401, 2006)

Thanks