Demonstration of an Array of Microtrapped Ultracold Atoms

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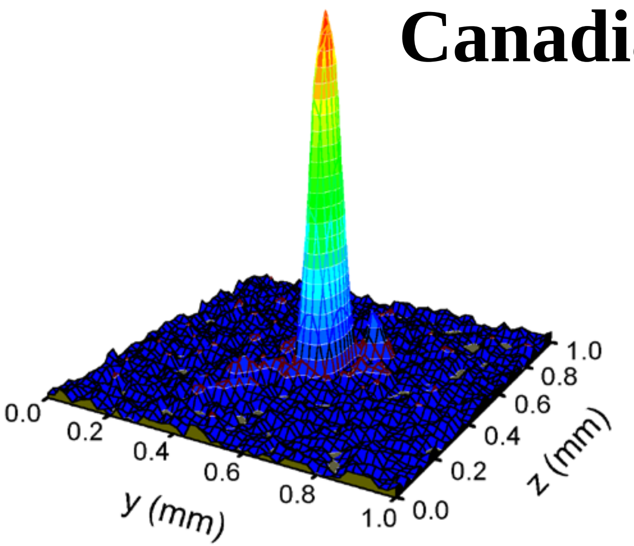

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Motivation

- Atom traps contain neutral atoms isolated from chamber walls & generate atom clouds at temperatures as low as nanoKelvins above absolute zero
- Ideal for frequency standards, Bose Einstein Condensation, Precision Spectroscopy

  -WvW, “BEC & Quantum Information: A Second Century of Einstein?”, *CJP* **83**, 671-685 (2005)

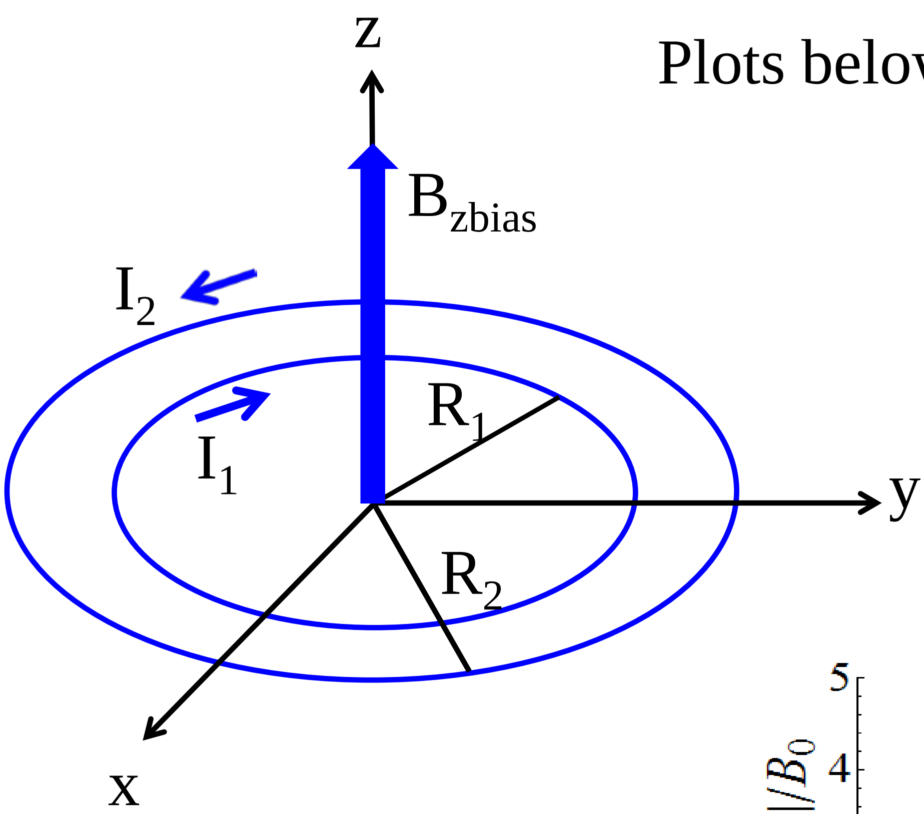
  -B. Schultz et al,“Rb D2 Transition Linewidth at Ultralow Temperatures”, *EPJD* **48**, 171-176, (2008)
- Microtraps consisting of wires having size of ~ 10 microns generate higher field gradients & operate at orders of magnitude lower currents than macroscopic traps
- Arrays of ultracold atom clouds useful to study atom tunneling, probe surfaces & of interest for quantum information

  -B. Jian & WvW, “Linear Array of 11 Double-Loop Microtraps”, J. Phys B (2014)

Microtrap on Atom Chip

B. Jian & WvW, JOSA *B* **30**, No. 2, 238 (2013)

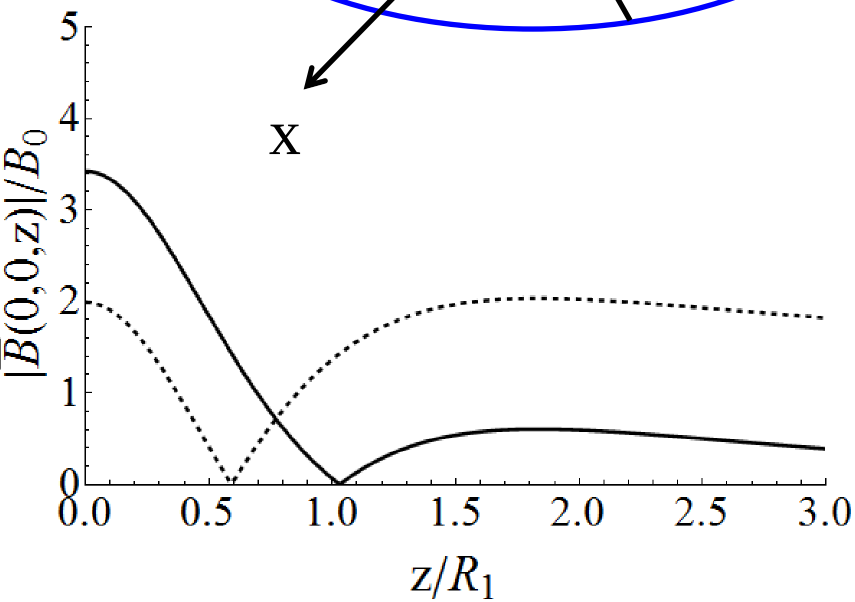
Plots below are for $I_1 = I_2$ & $R_2 = 2.2R_1$

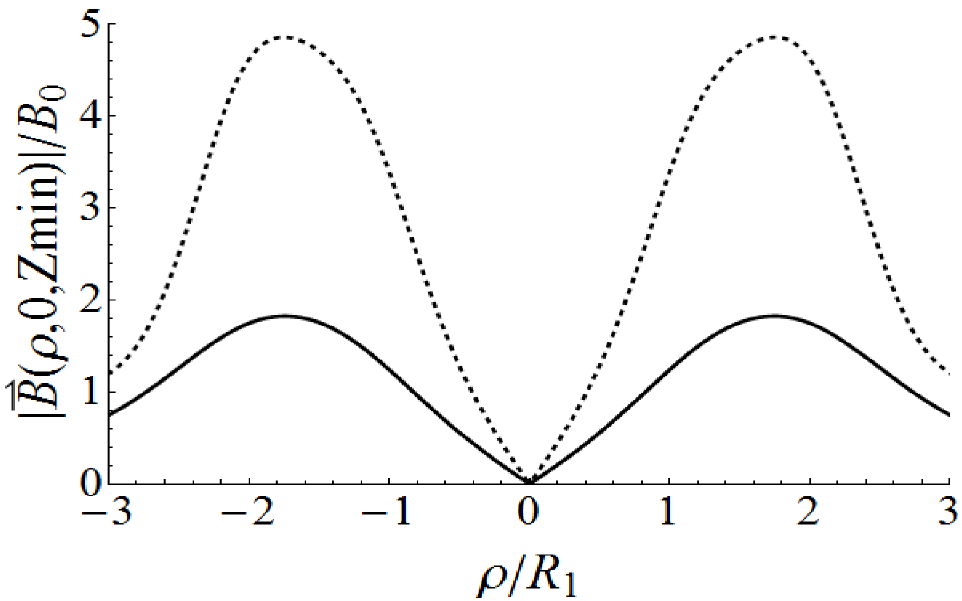


(solid line) $B_{zbias} = 0$

(dashed line) $B_{zbias} = 1.43\ B_o$

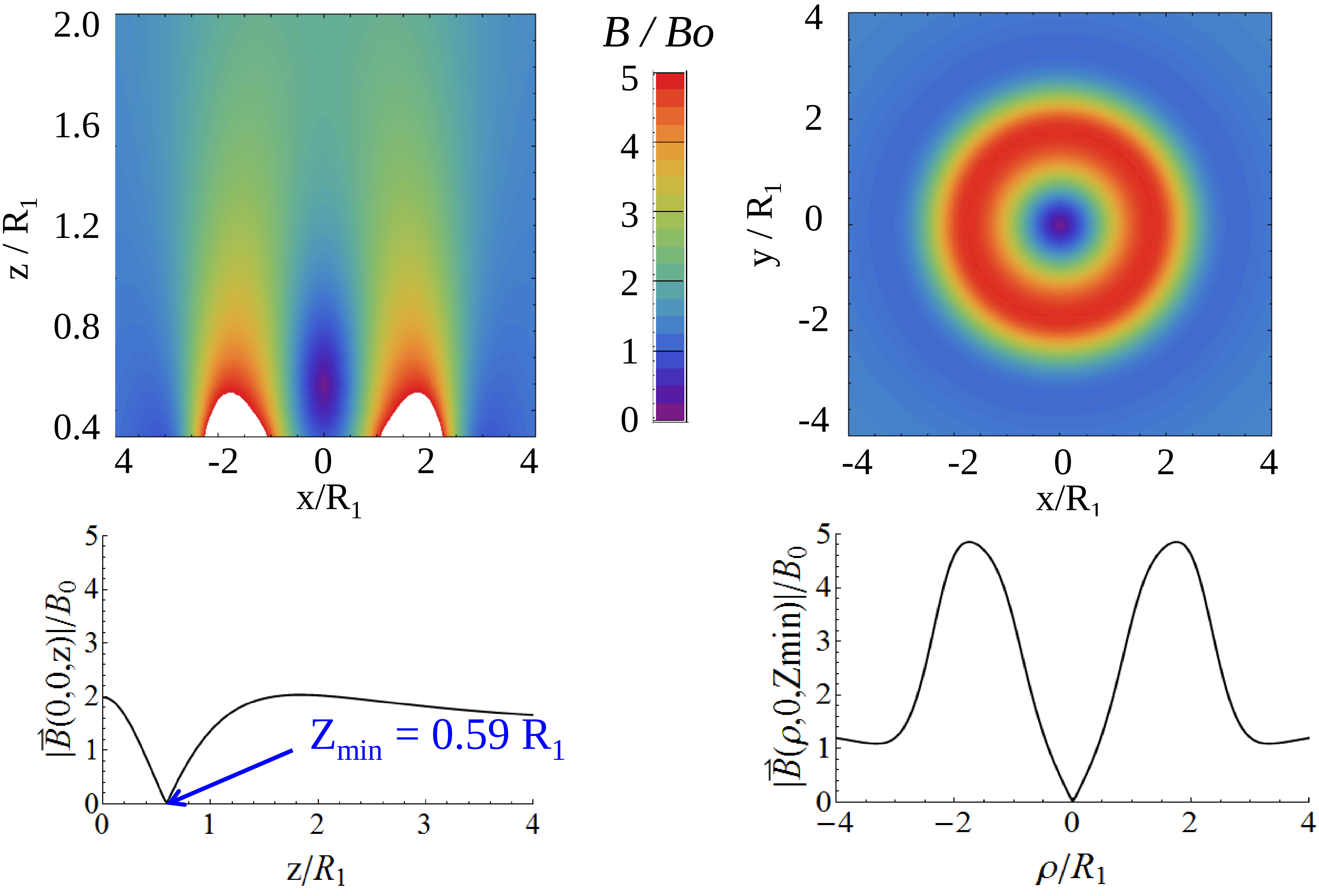
where $B_o = I_1 / R_1$





Magnetic Field Magnitude in Microtrap

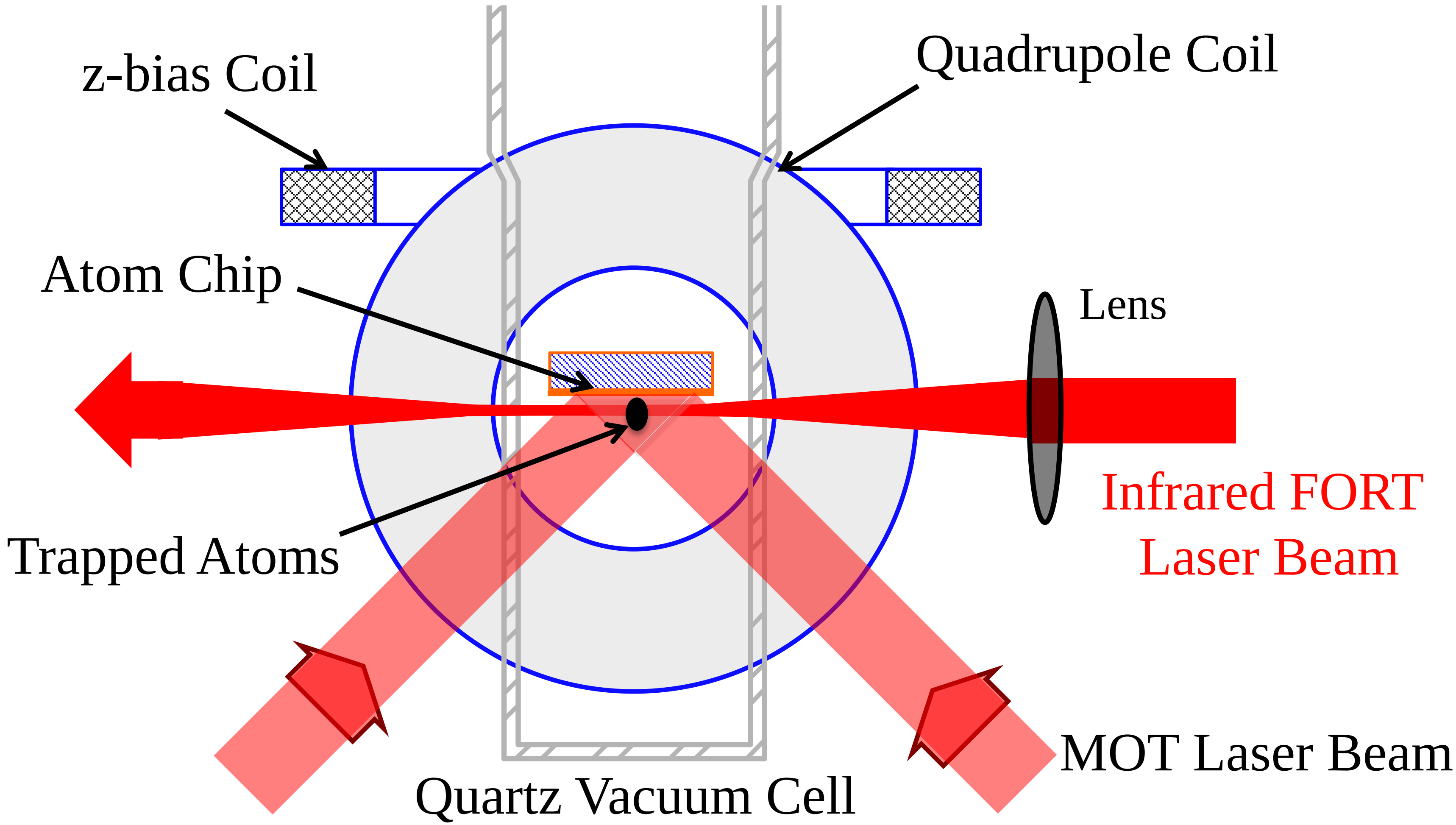
$I_1 = I_2$, $R_2 = 2.2\ R_1$ $B_{zbias} = 1.43\ B_o$ where $B_o = I_1 / R_1$



Microtrap Loading

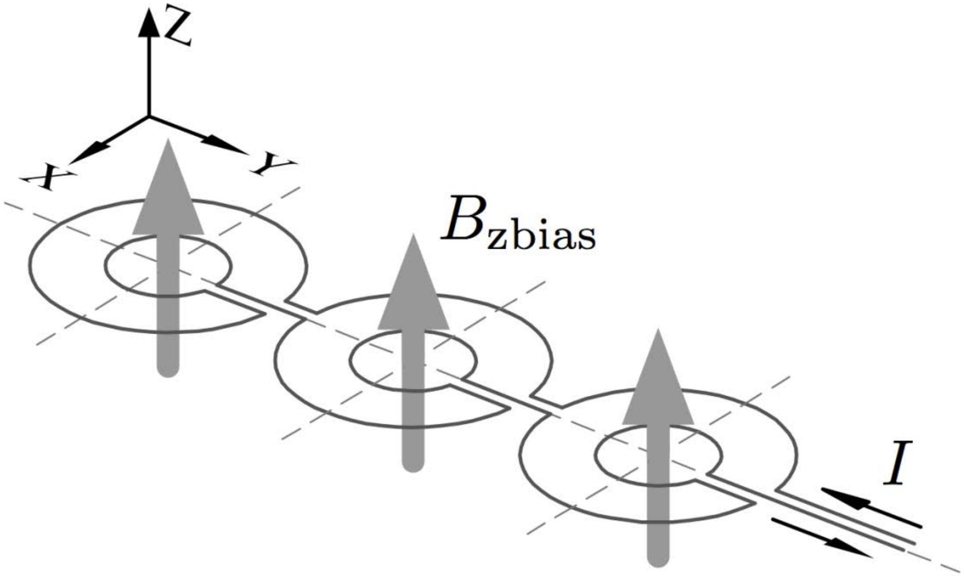
B. Jian & WvW, *Appl. Phys. B*, DOI 10.1007/s00340-013-5573-4 (2013)

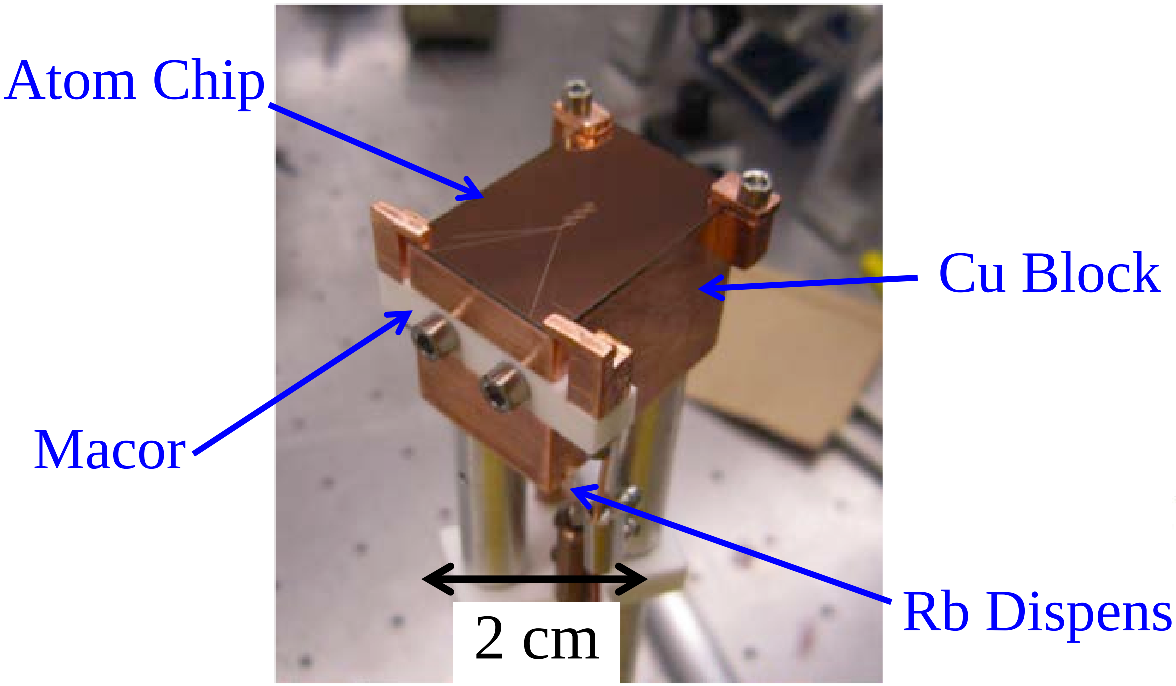
Methods: **1)** Move MOT toward microtrap, 2) Surface MOT, 3) FORT

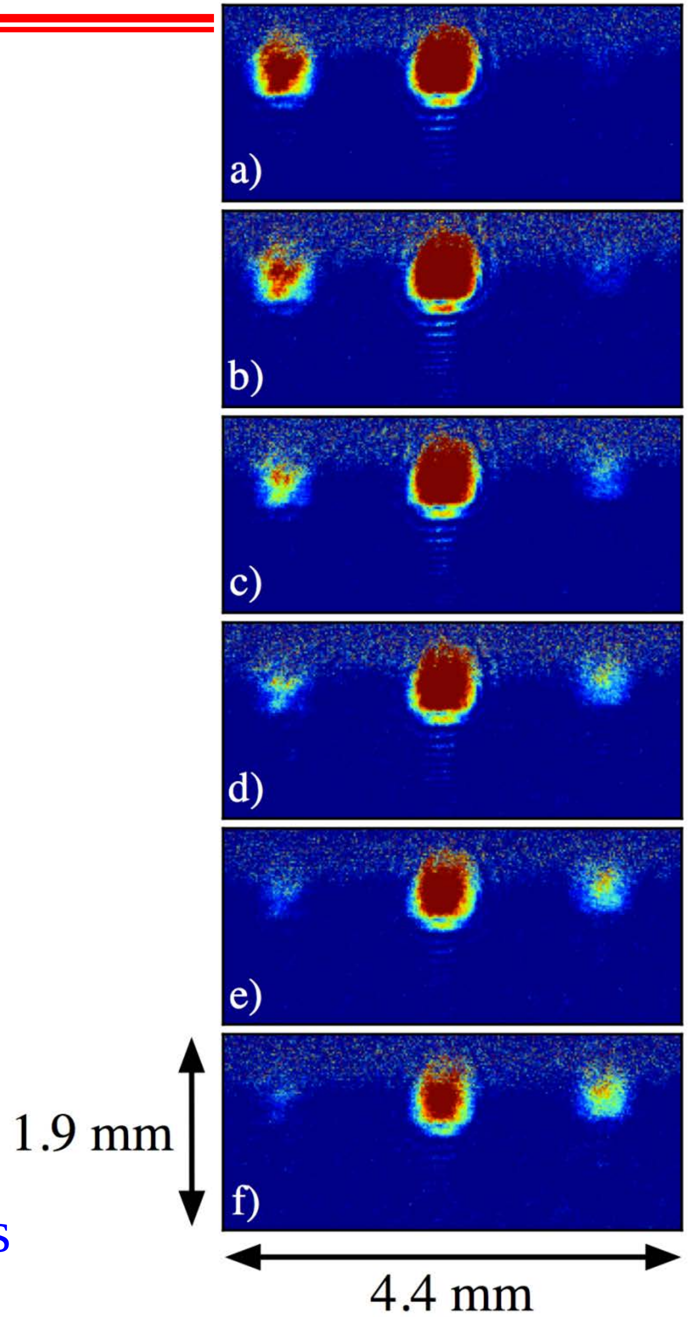


Microtrap Array

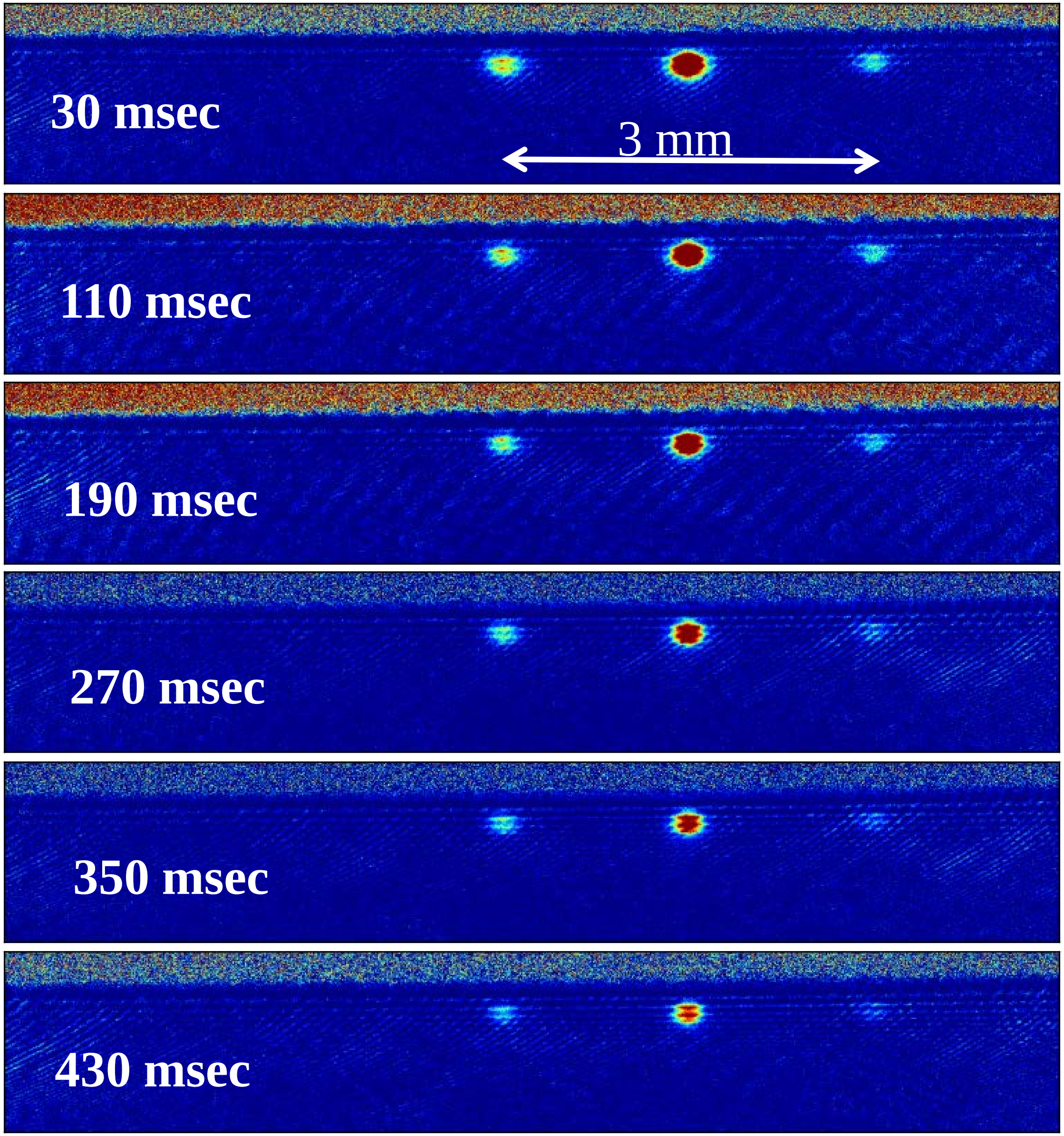
R_1 = 300 μm, R_2 = 660 μm   I = 2.6 A, B_{zbias} = 10 G



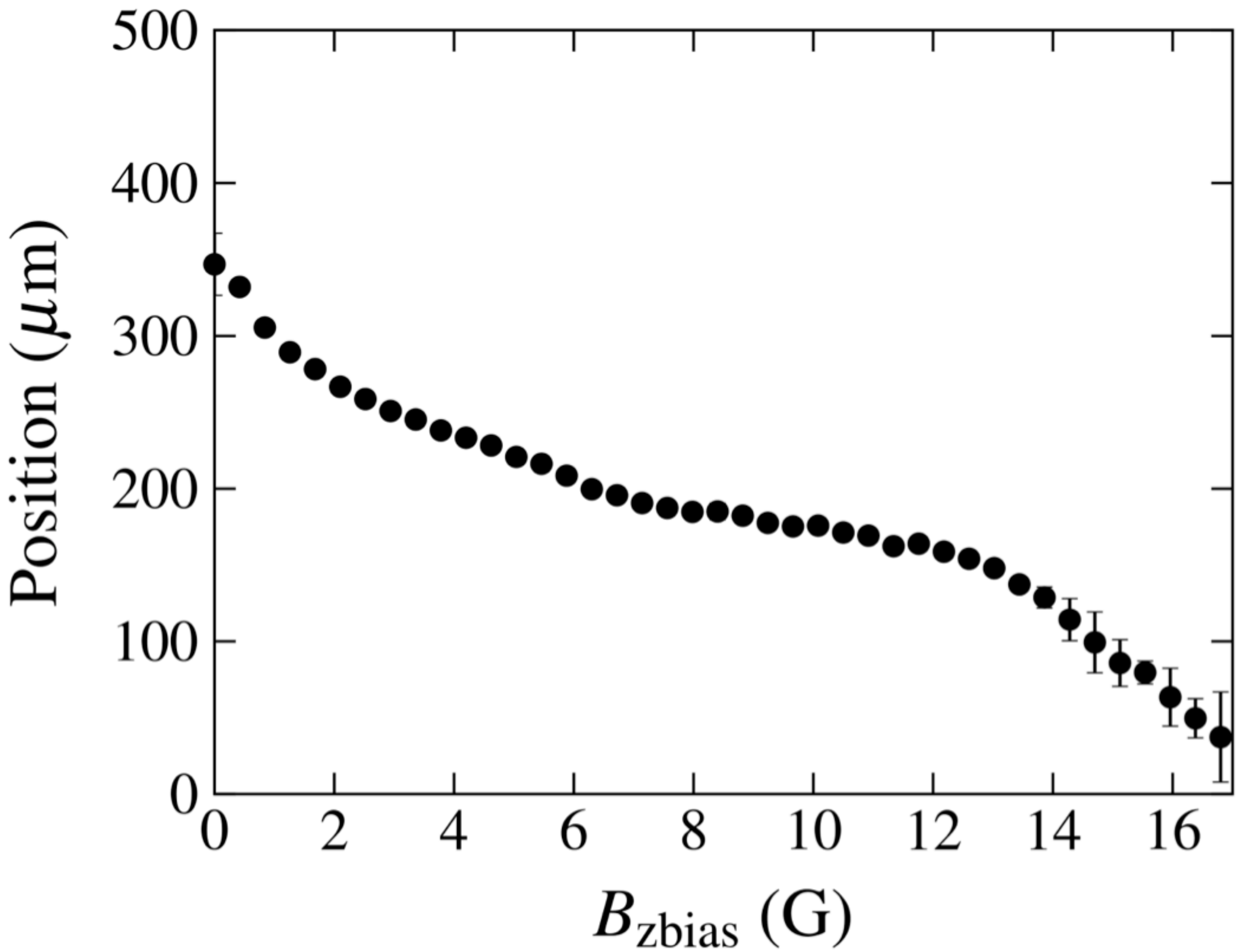




Temporal Evolution of Microtrap Array Loaded from Optical Trap (Lifetime = 350 ms)

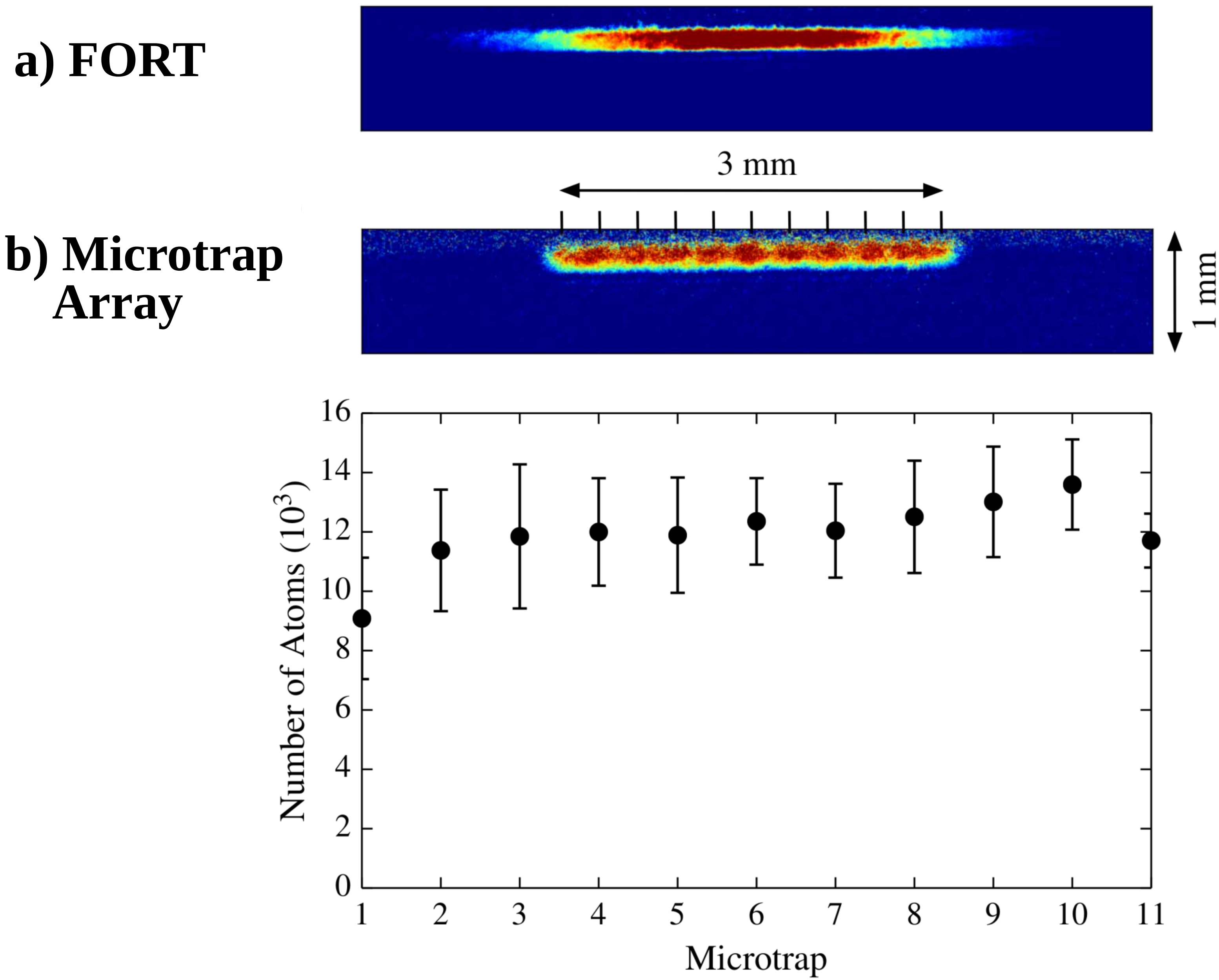


Precise Positioning of Atom Cloud above Chip Surface



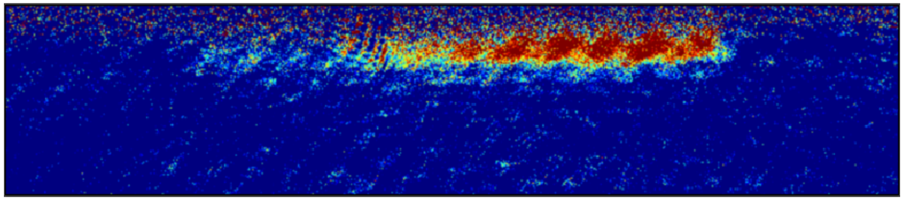
Loading 11 Microtrap Array from FORT

B. Jian & WvW, J. Phys. B (2014)

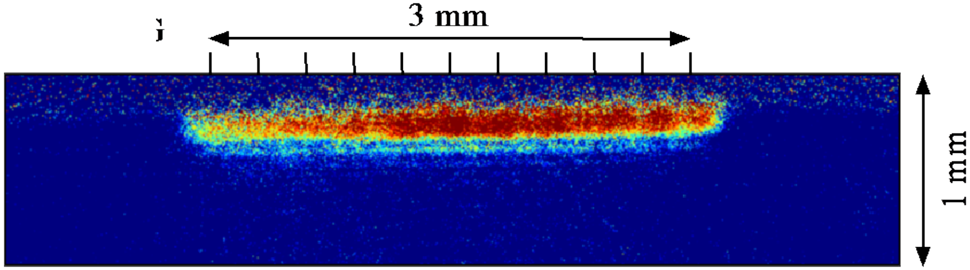


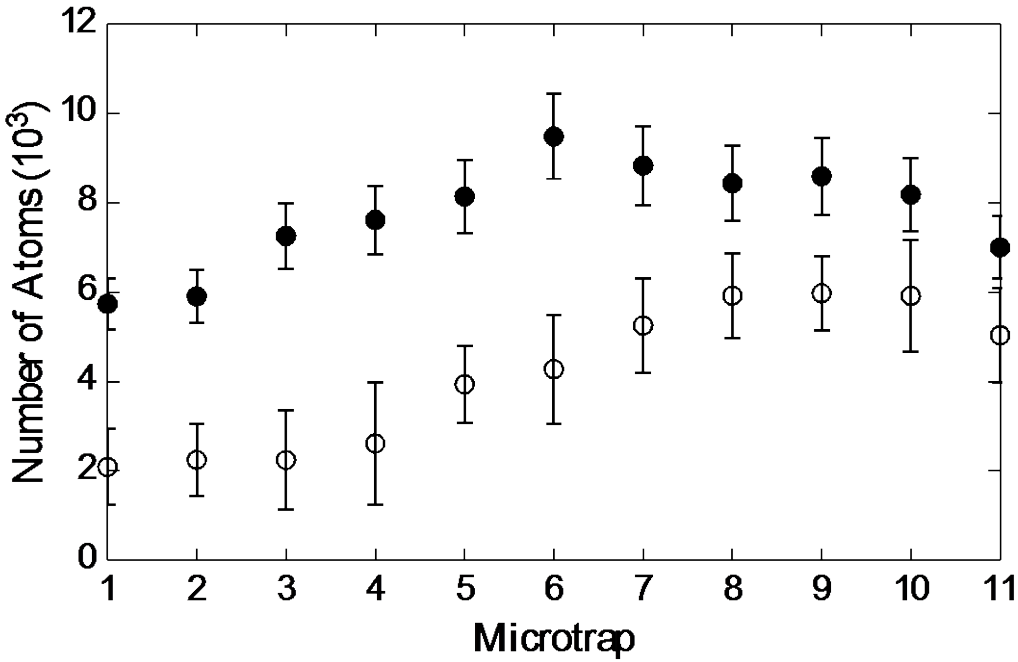
Loading 11 Microtrap Array from Surface MOT

a) B_{yshift} = 0 G



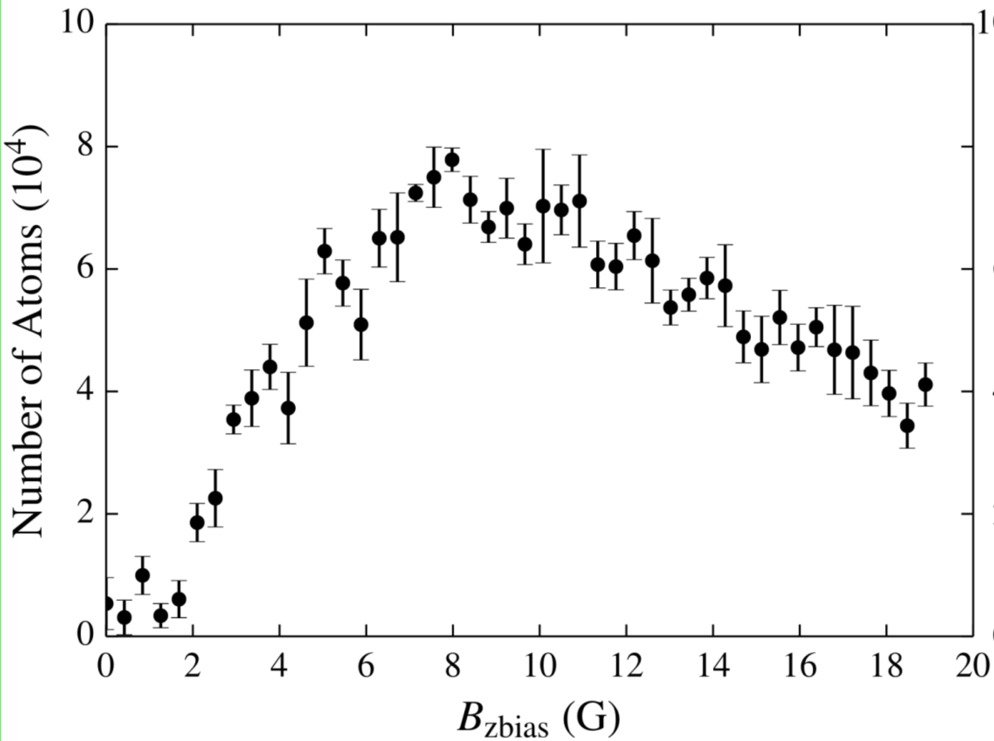
b) B_{yshift} = 0.5 G



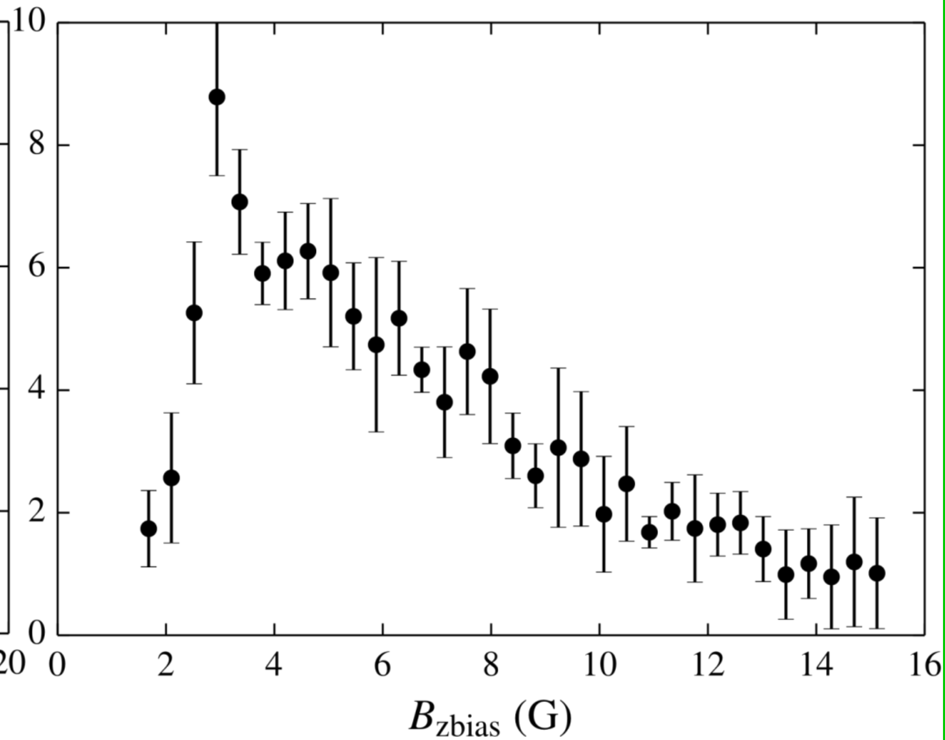


Effect of Bias Field on Microtrap

a) Surface MOT Loading



b) FORT Loading



Conclusions

- Linear array of 11 microtraps with inner loop radius of 60 μm demonstrated using currents < 1 Amp. Trap depth scales as I/r where I = current and r = trap size.
- ~10^4 atoms loaded into each microtrap from surface MOT or FORT
- Atom position controllable to microns of chip surface using bias field

Applications

- Precision Measurements: Doppler width negligible for ultracold atoms.
- Sensors: eg. Probe interaction with surface Casimir Polder interactions
- Study Tunnelling of atoms between neighbouring microtraps

Future Work

- Demonstrate transfer of atoms between neighbouring microtraps
- Create two dimensional array of microtraps with nonzero field at center to suppress Majorana transitions necessary for BEC

Ultimate Goal: Atom chip having microwires & diode lasers