Bose Einstein Condensation of He*

R.G. Dall and A.G. Truscott

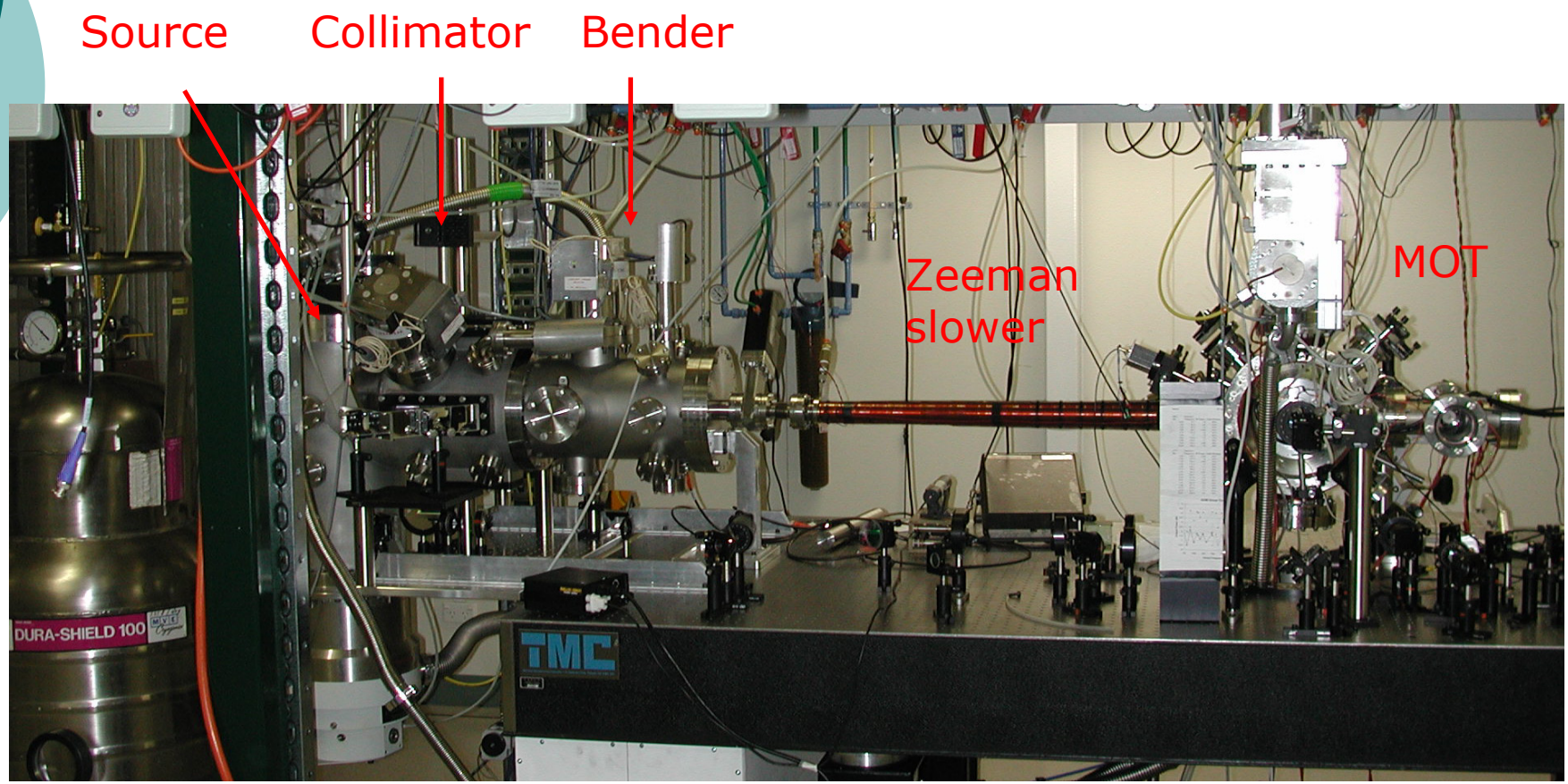
Research School of Physical Sciences and Engineering, ANU

AUSTRALIAN RESEARCH COUNCIL
CENTRE OF EXCELLENCE FOR
QUANTUM-ATOM OPTICS

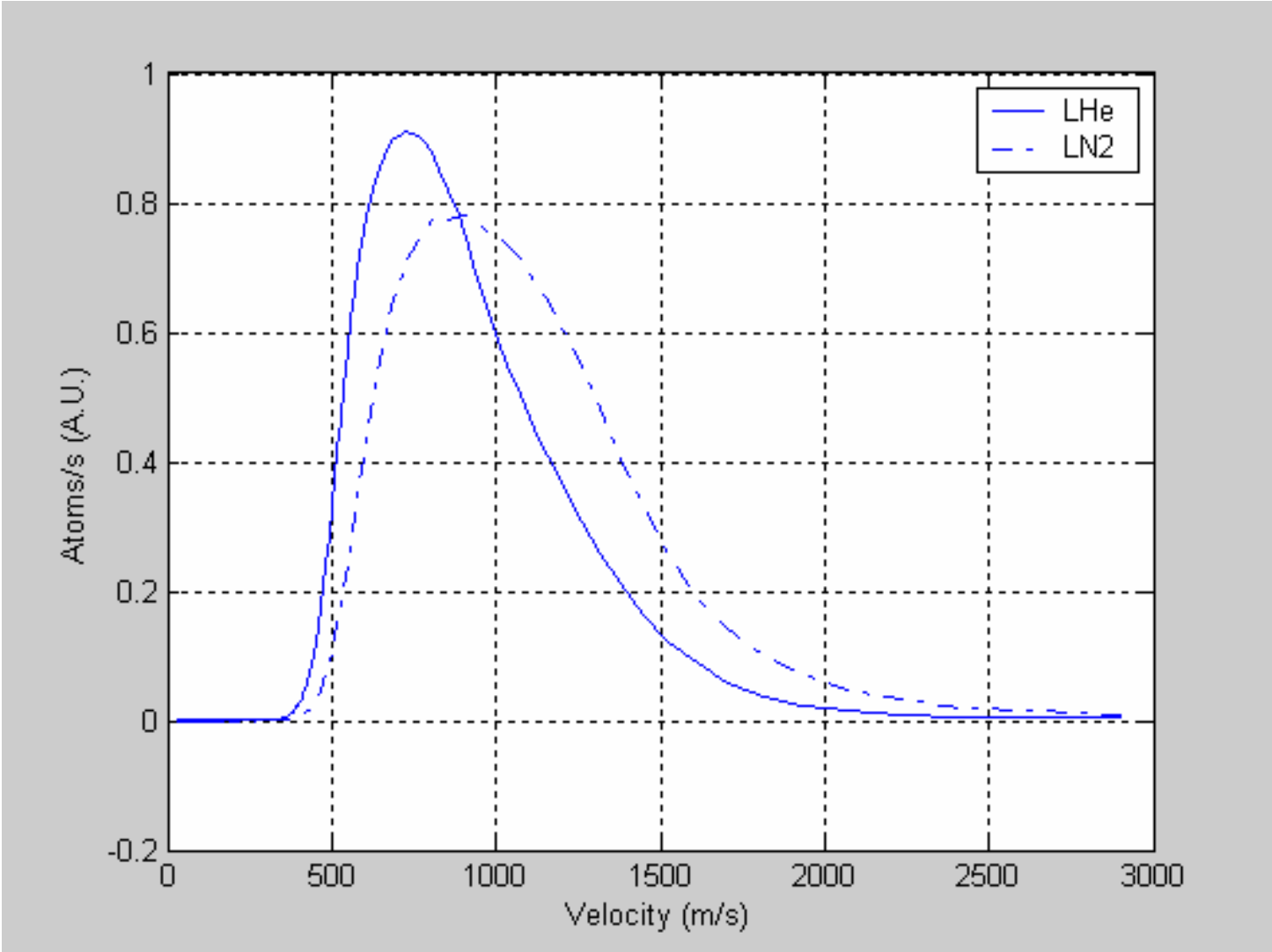
Outline

- Helium beam
- Magnetic trap loading scheme
- Results
- BEC
- Conclusion

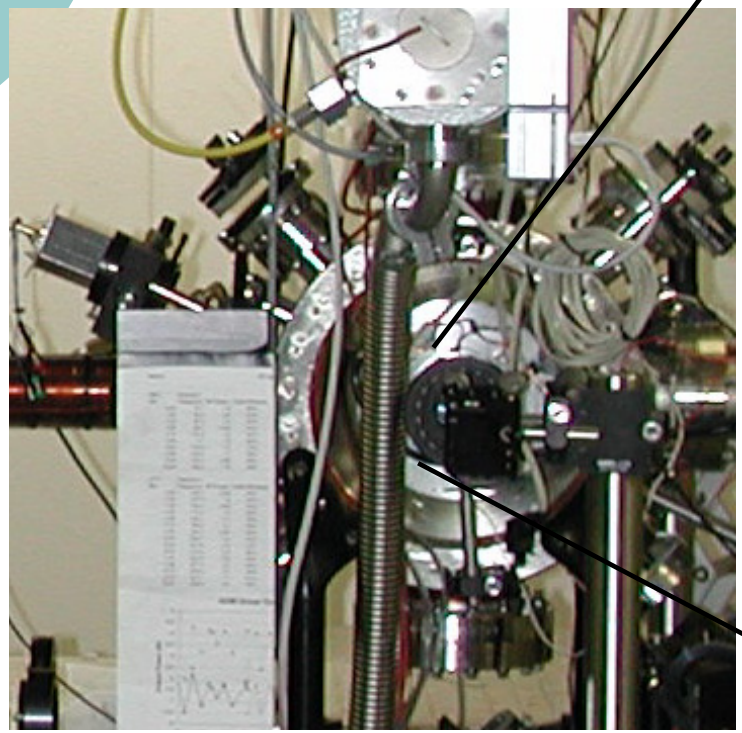
He* Beamline

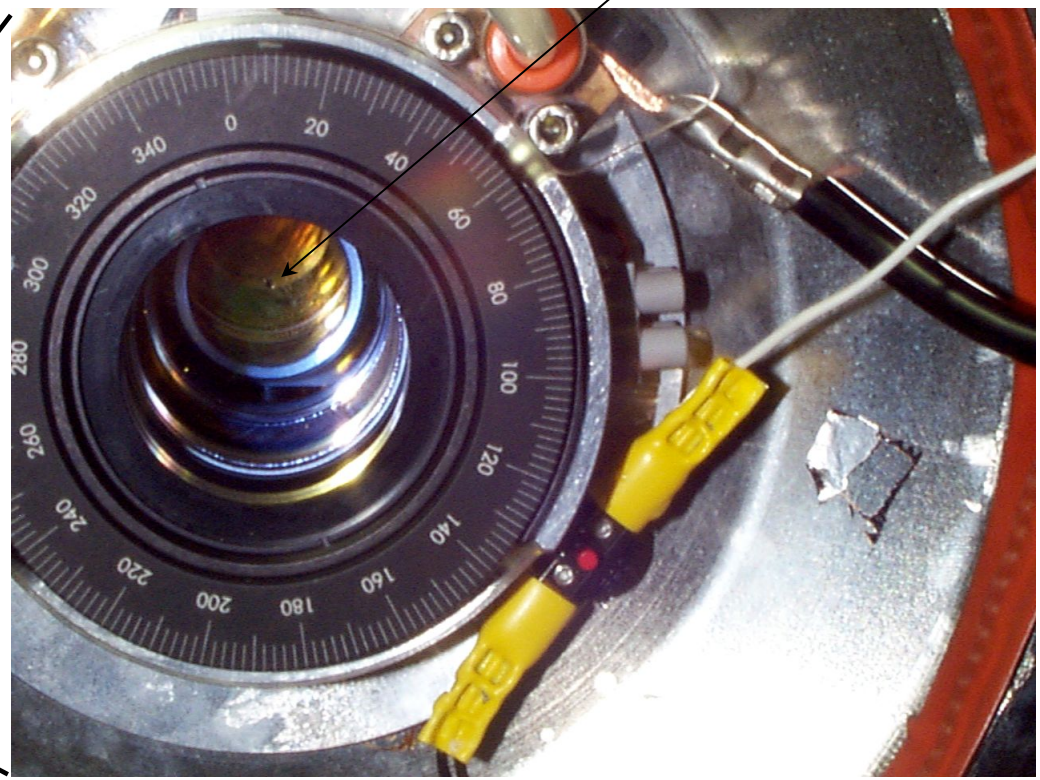

Source
Collimator
Bender
Zeeman slower
MOT
DURA-SHIELD 100
TMC

Source TOF Distributions

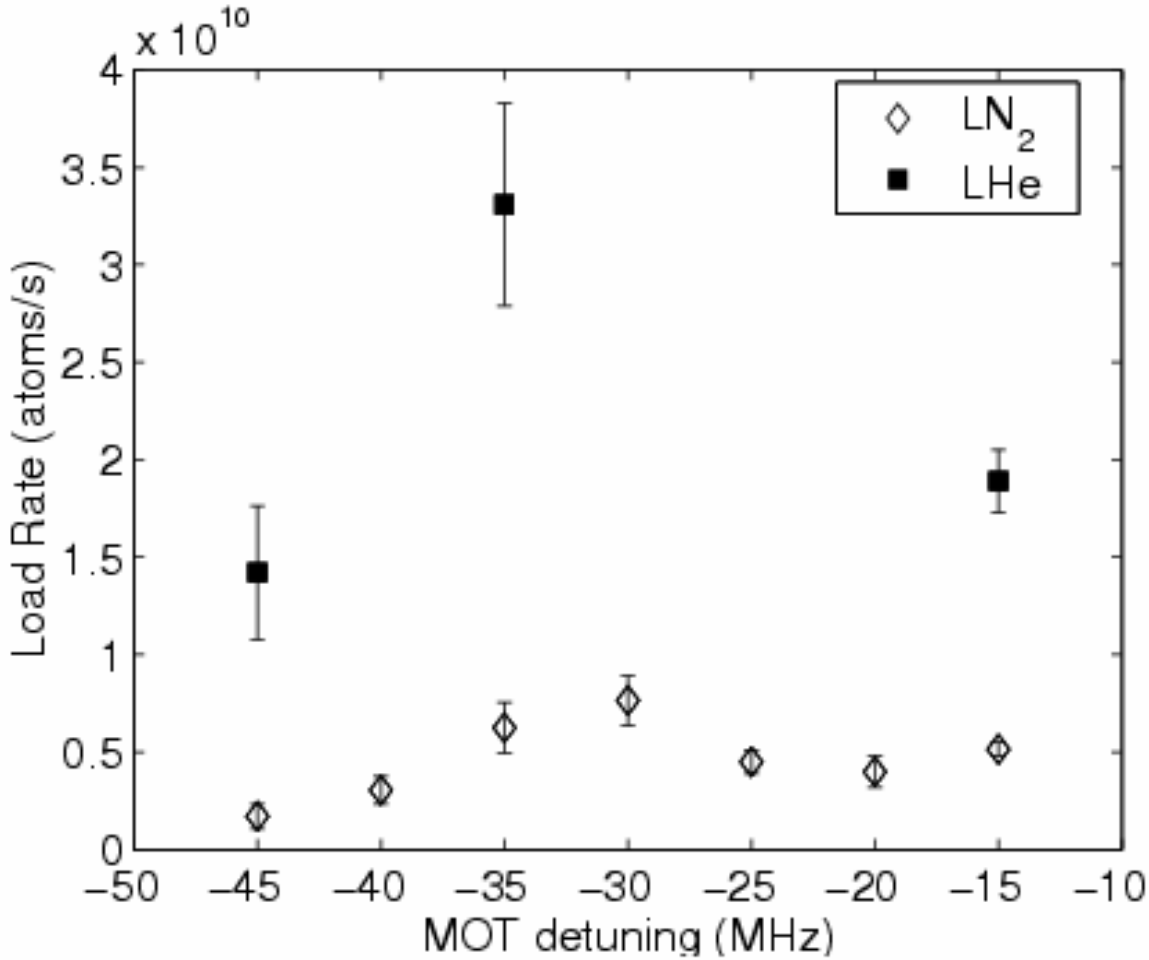


Second He* Beamline

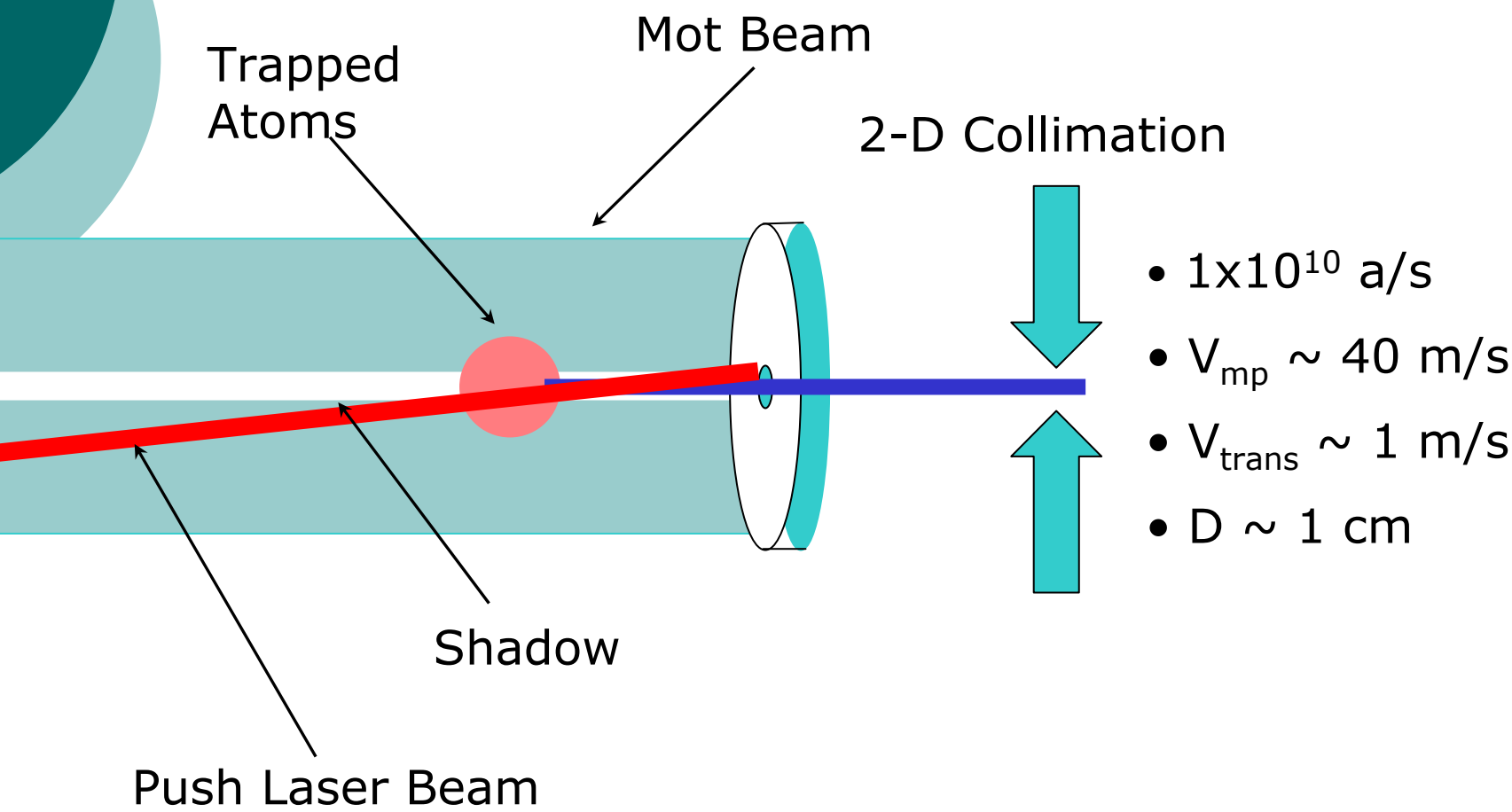




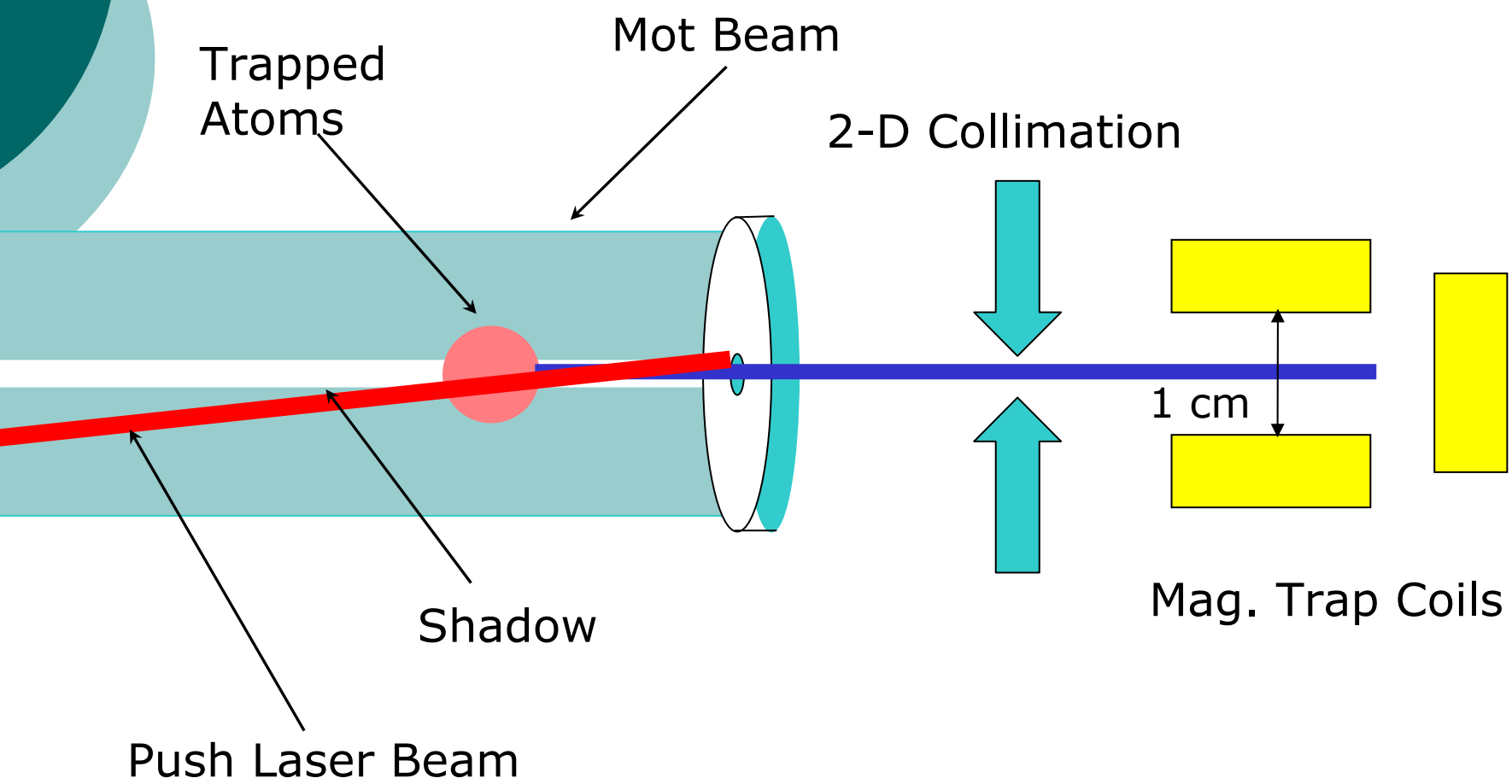
First Magneto-optic Trap



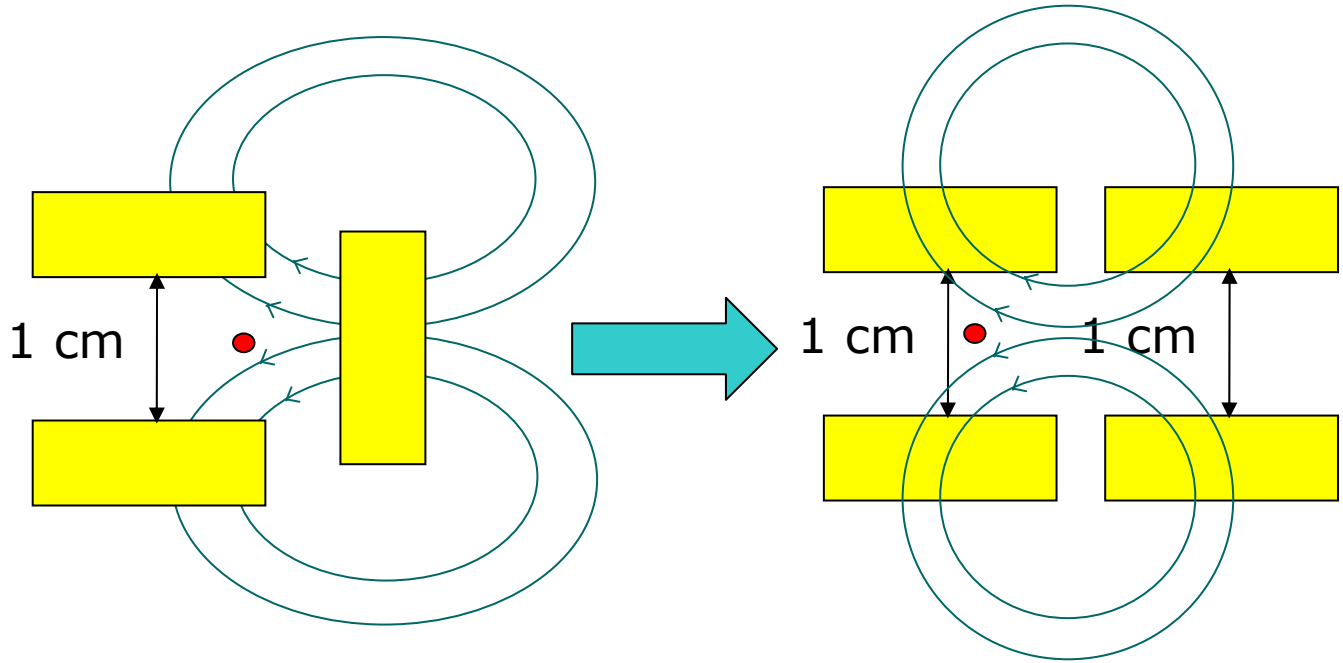
Second Beamline Schematic



Magnetic Trap Setup

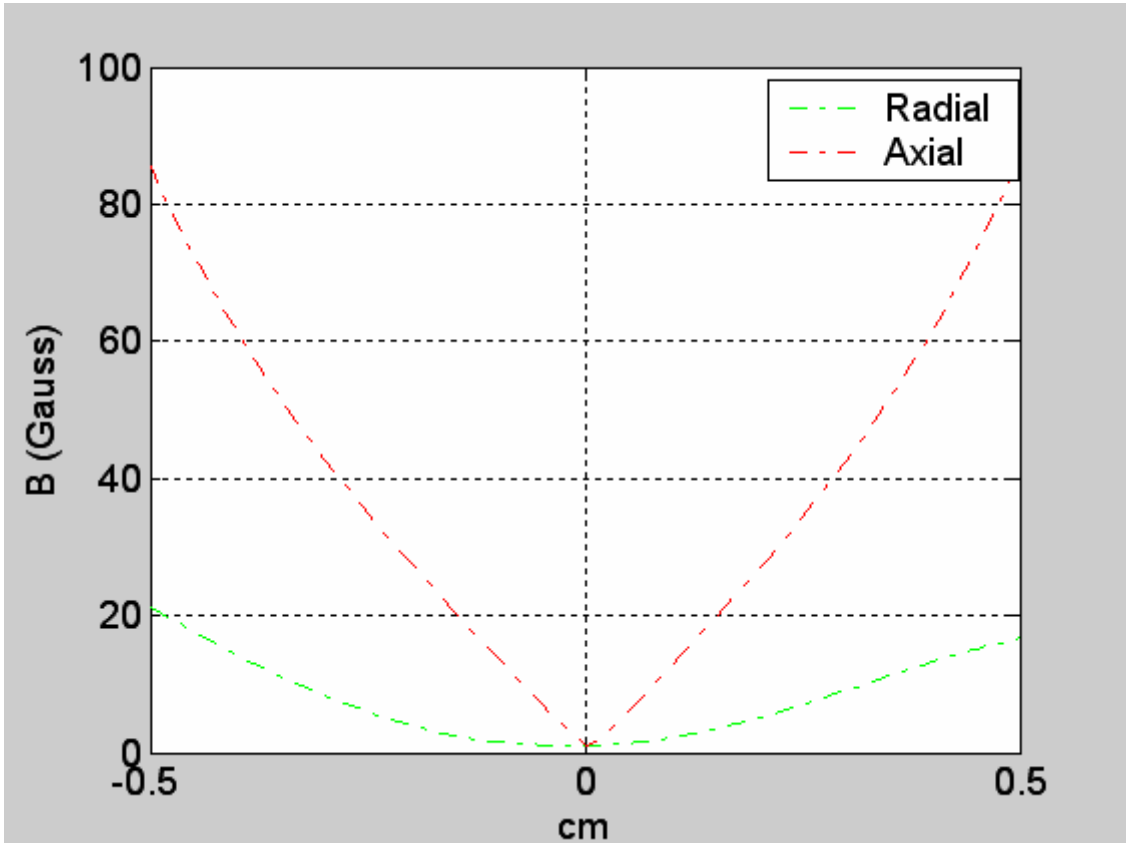


Magnetic Trap

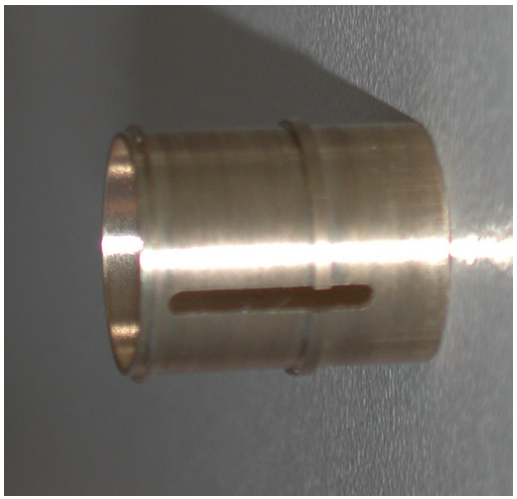


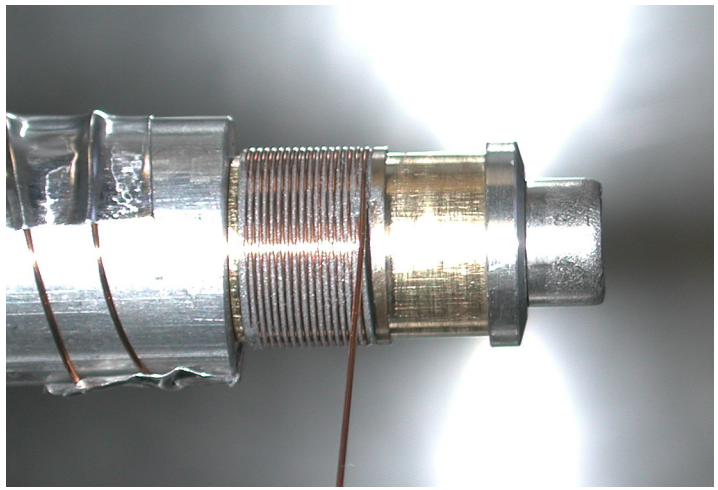
Magnetic Trap

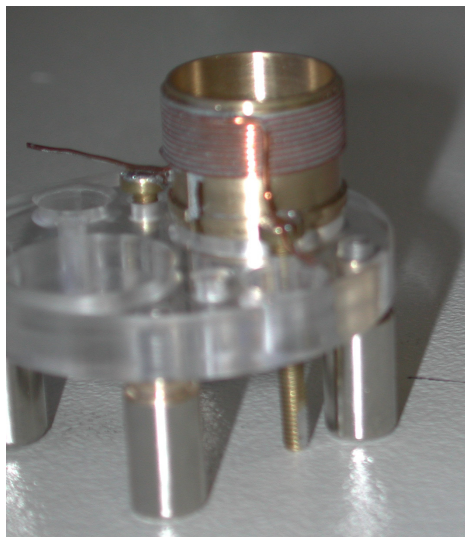
- $f_r \sim 93$ Hz
- $f_a \sim 1.1$ KHz (@ 1 G)



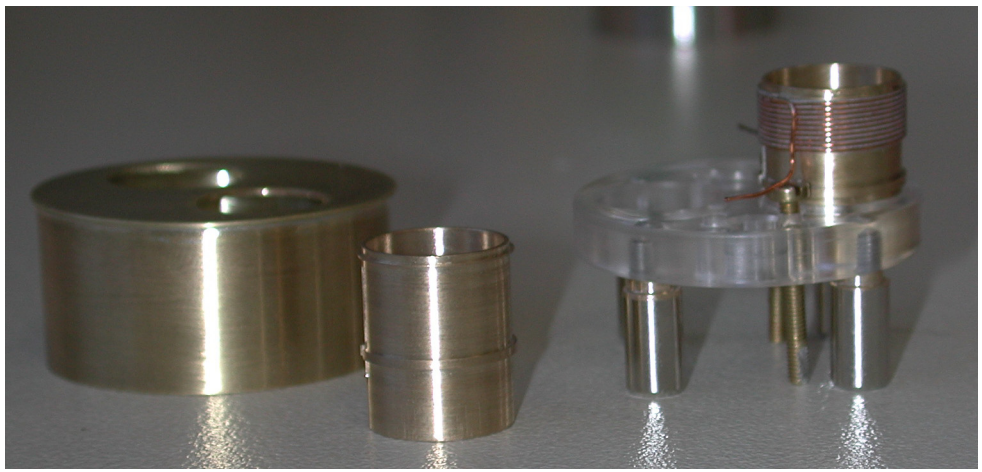
Magnetic Trap

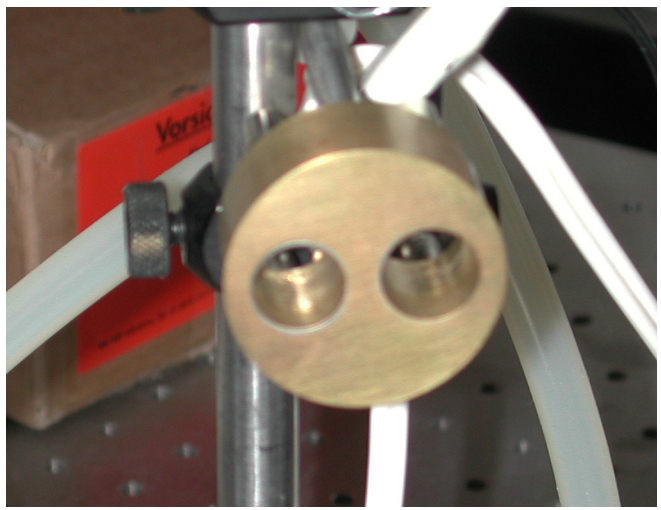


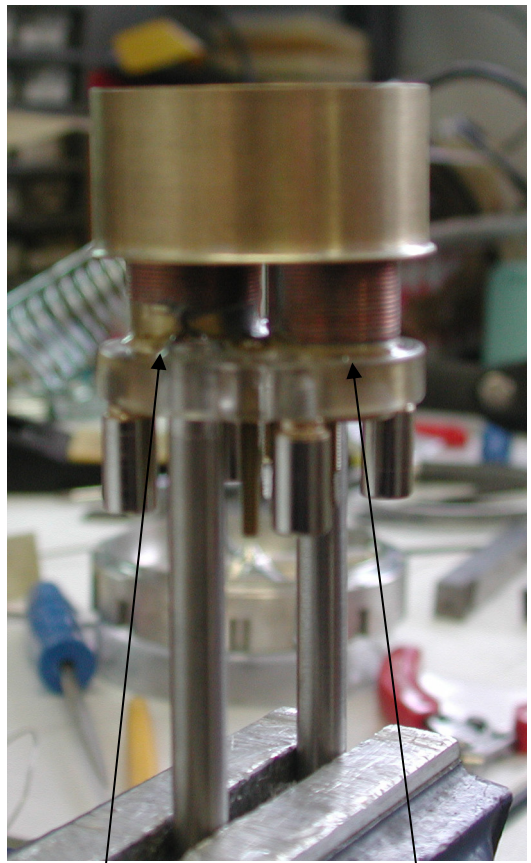




Magnetic Trap

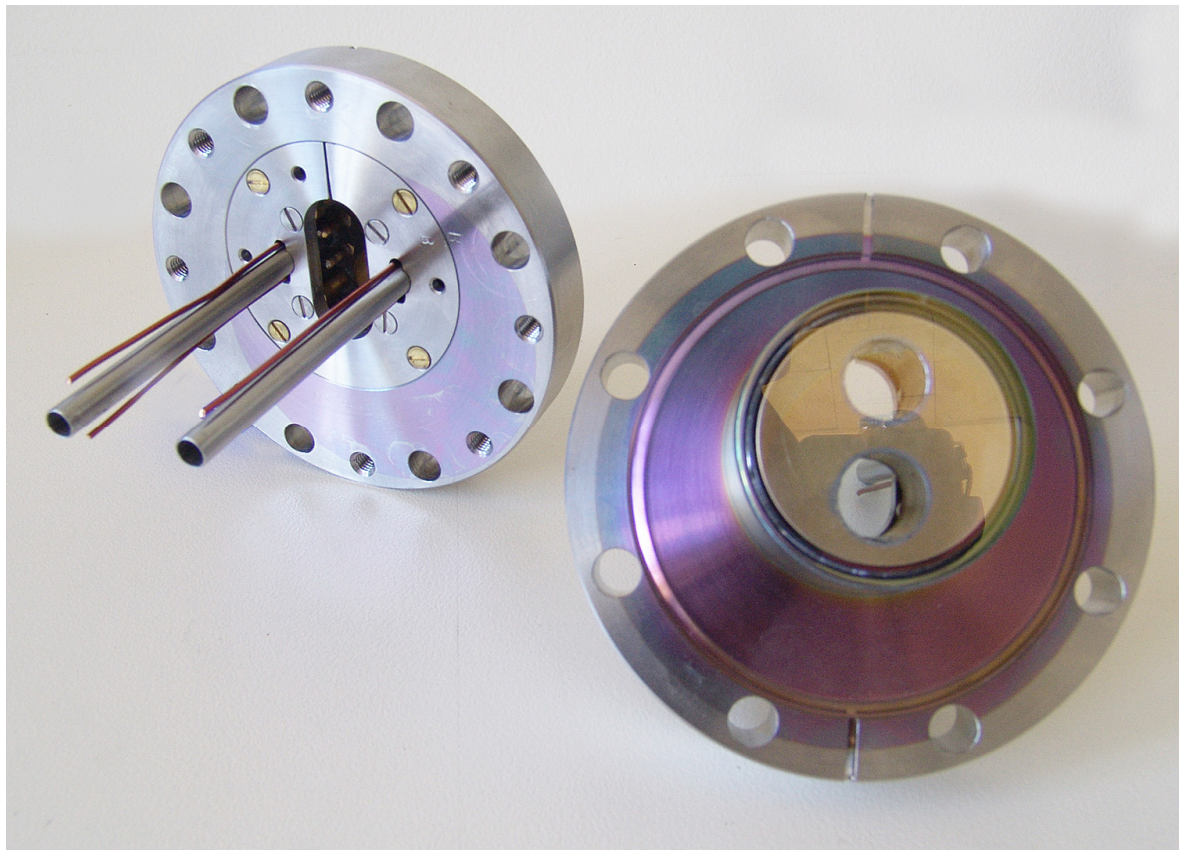




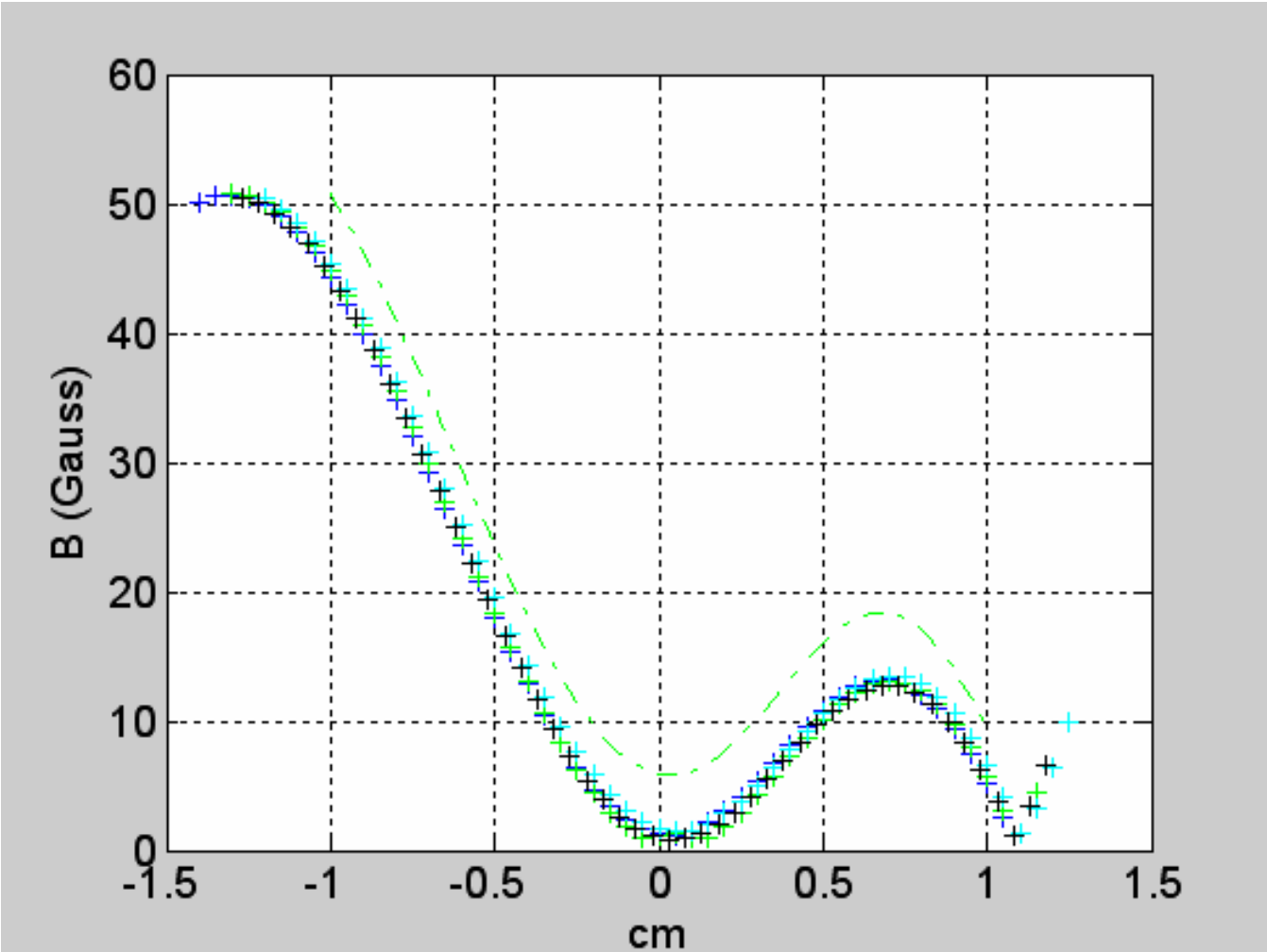


10 Turns 18 Turns

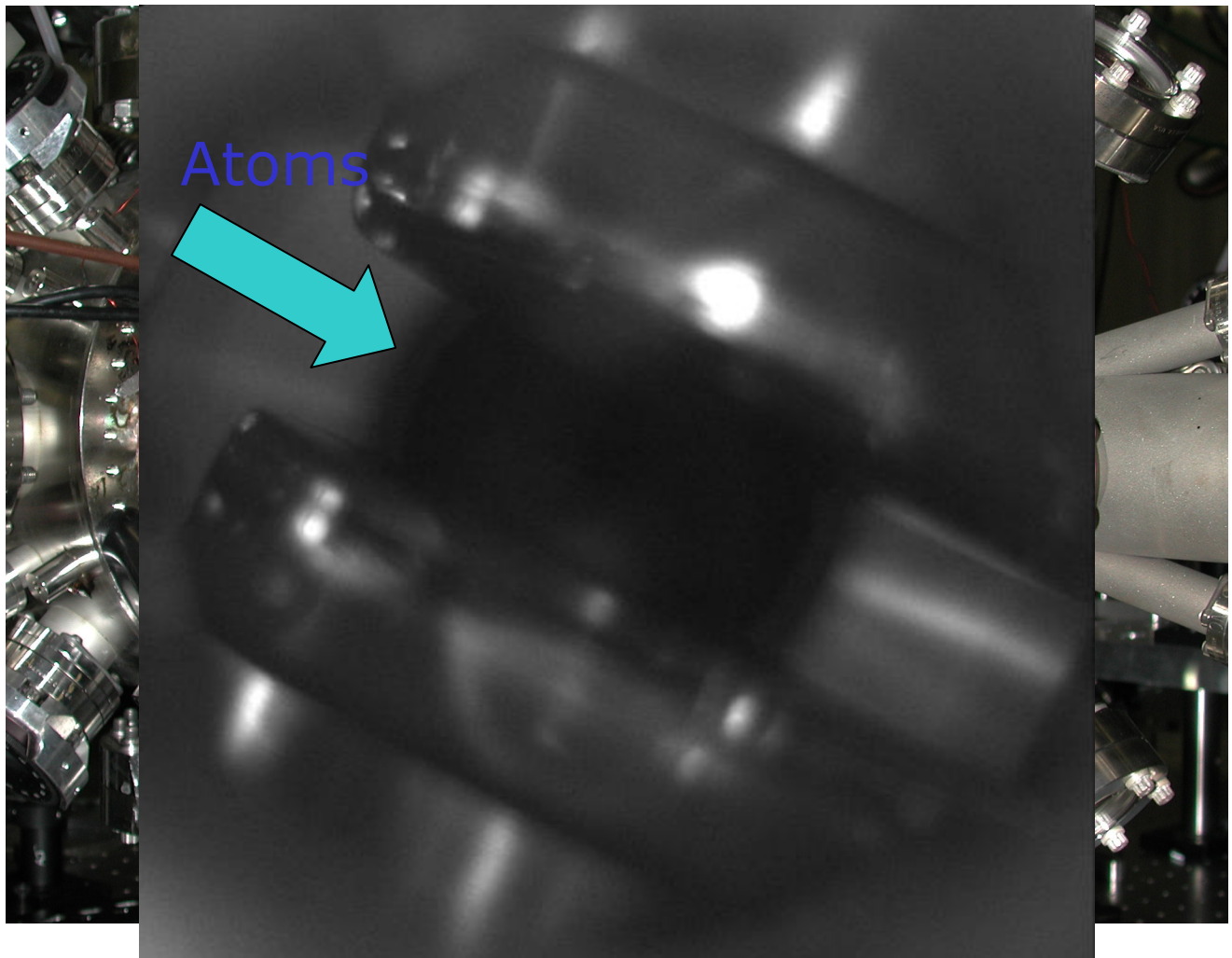
Magnetic Trap



Magnetic Trap

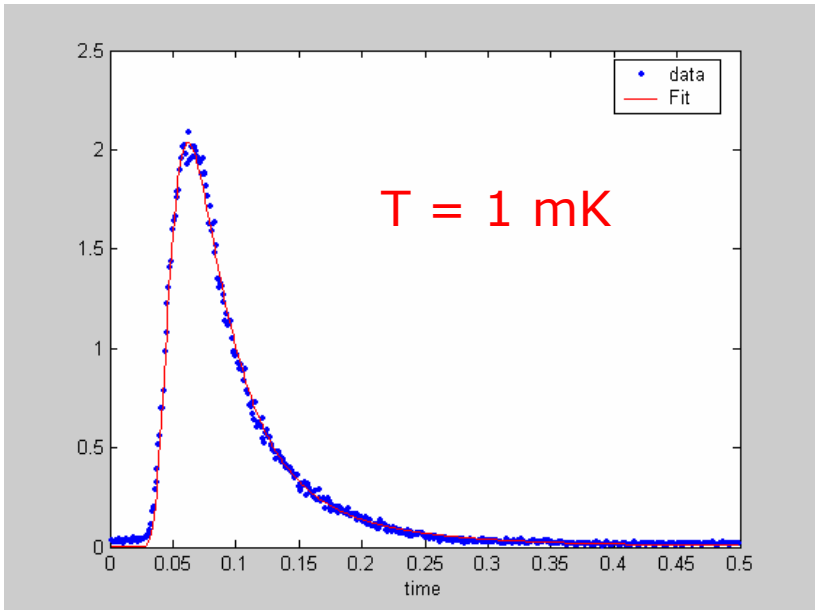


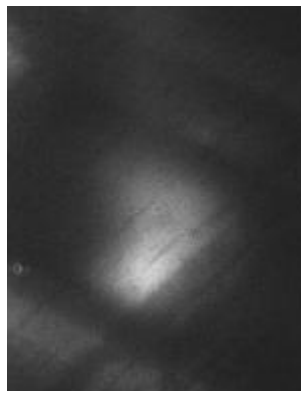
Magnetic Trapping Setup



Starting Conditions

- 5 x 10^8 Atoms
- T = 1 mK
- R_l ~3.5 mm R_s~2mm

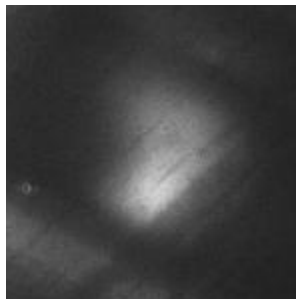


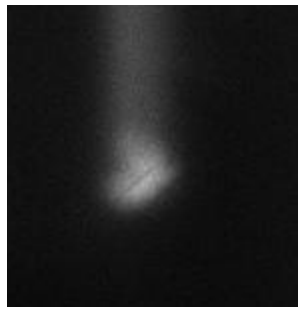


1 cm

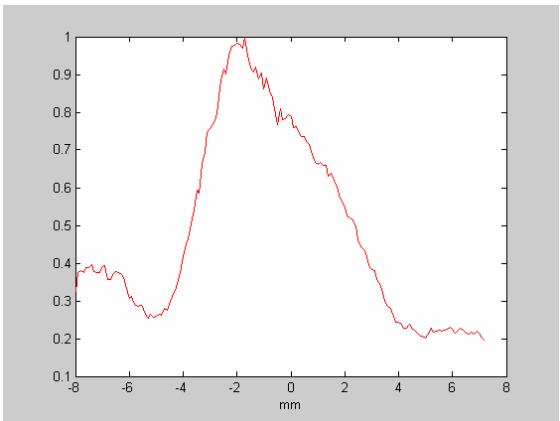
Transfer: Compression

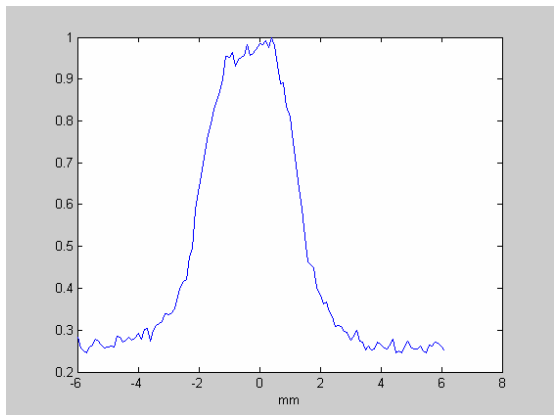
$\delta = -20\Gamma$ $\delta = -10\Gamma$





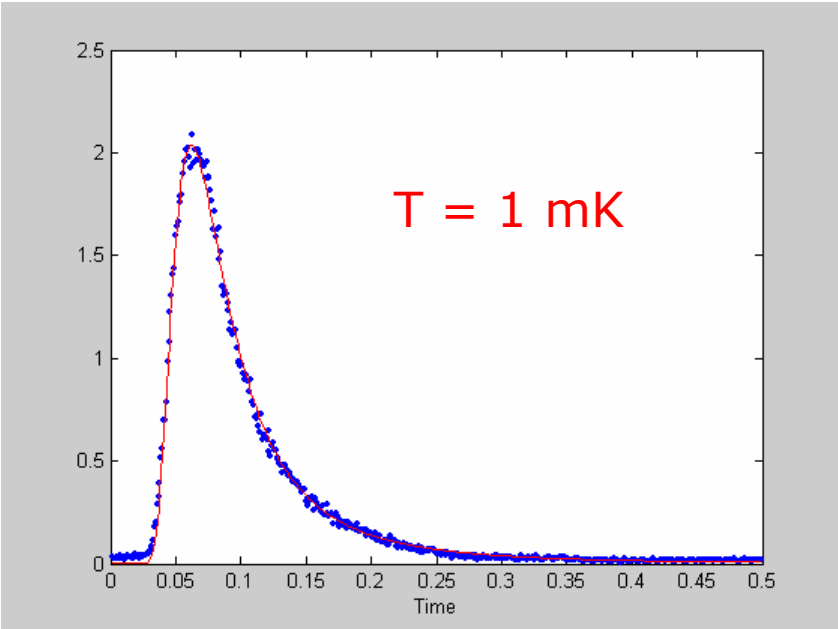
5 Fold Density Increase

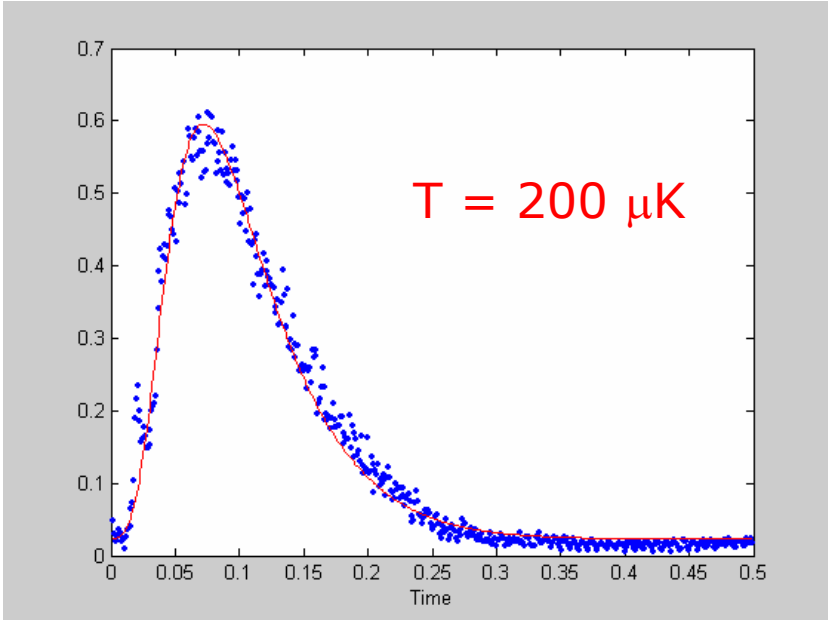




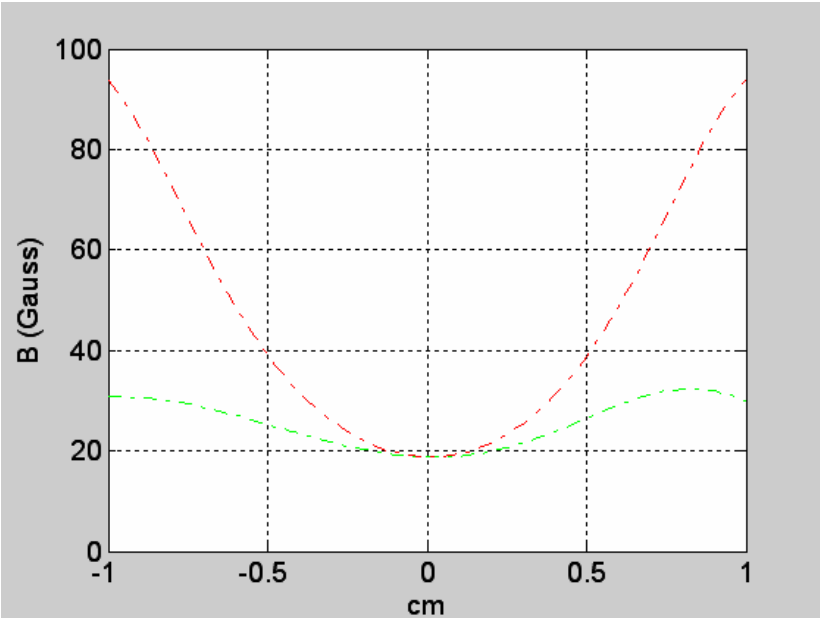
Transfer: Molasses

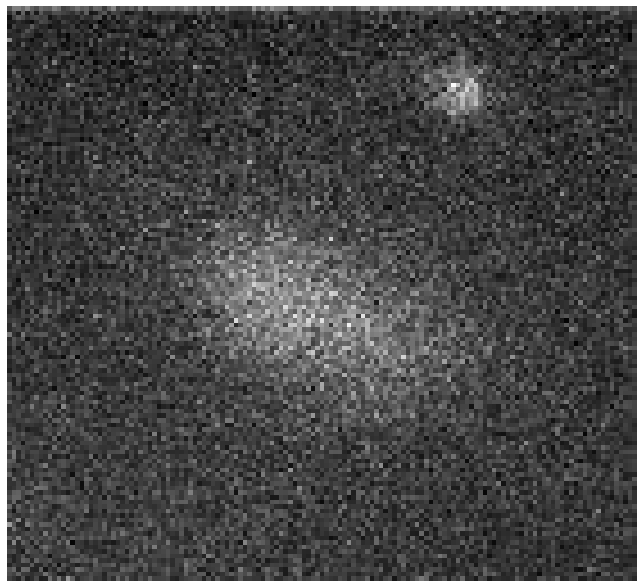
$\delta = -10\Gamma$, $I \sim 50 I_{sat}$ → $\delta \sim -3\Gamma$, $I \sim I_{sat}$





Transfer: Bring up Magnetic Trap



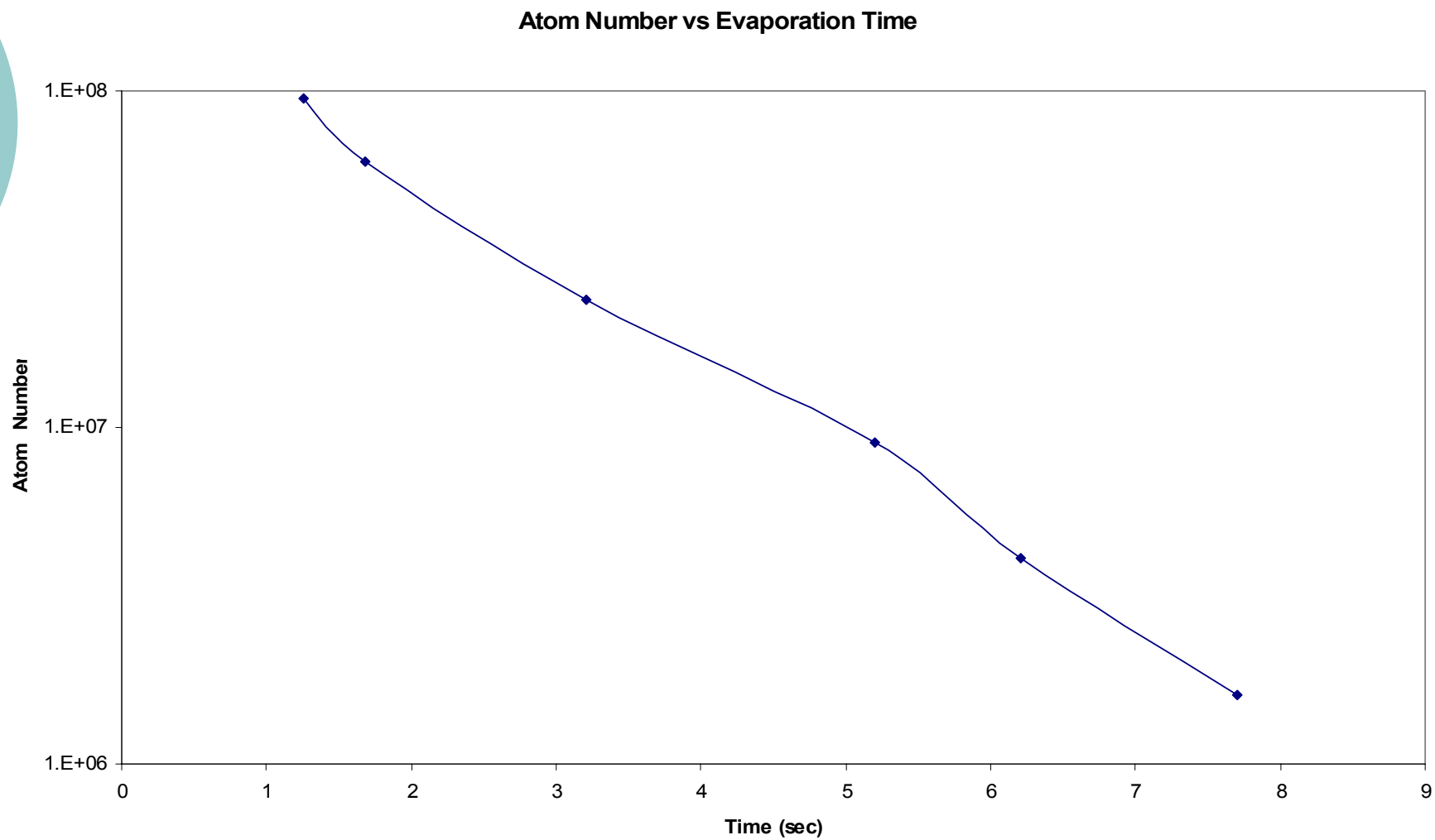


- N ~ 3 x 10^8
- T ~ 600 μk

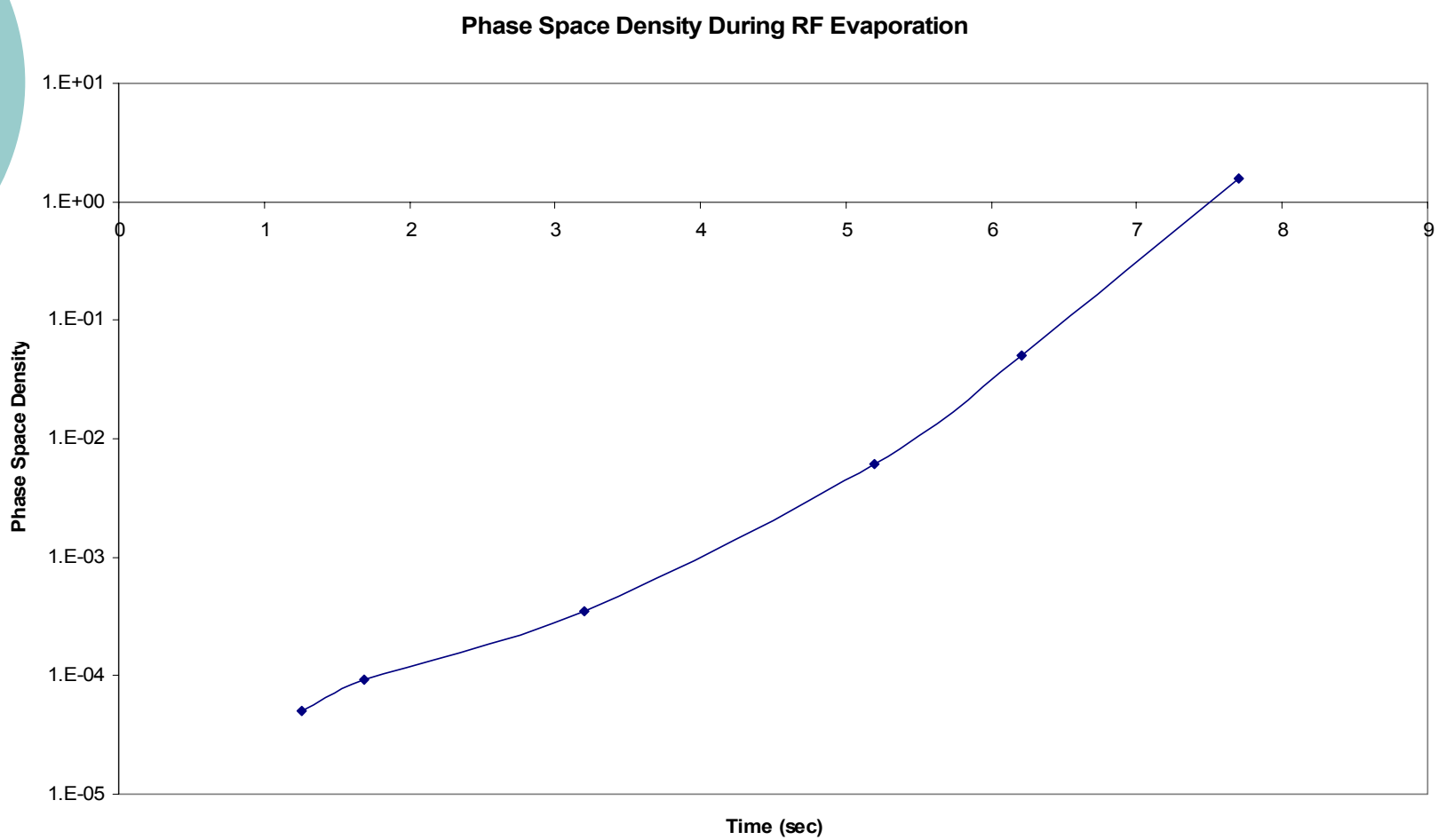
Cooling

- After Transfer, apply 1-D Doppler Cooling ~ 200 μK
- Lower bias, achieving tighter trap frequencies
- And apply Doppler cooling again, once again ~ 200 μK

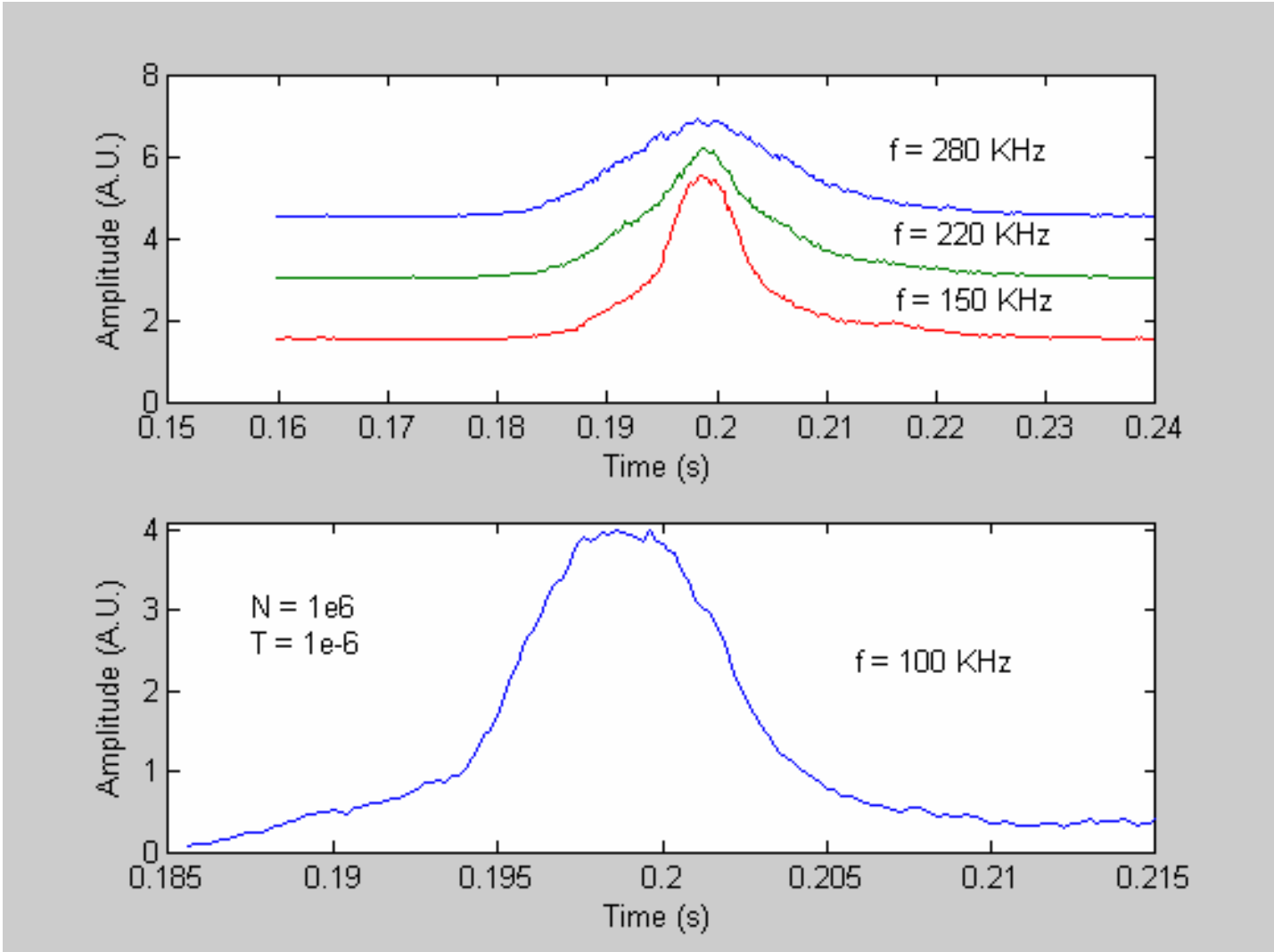
Evaporation



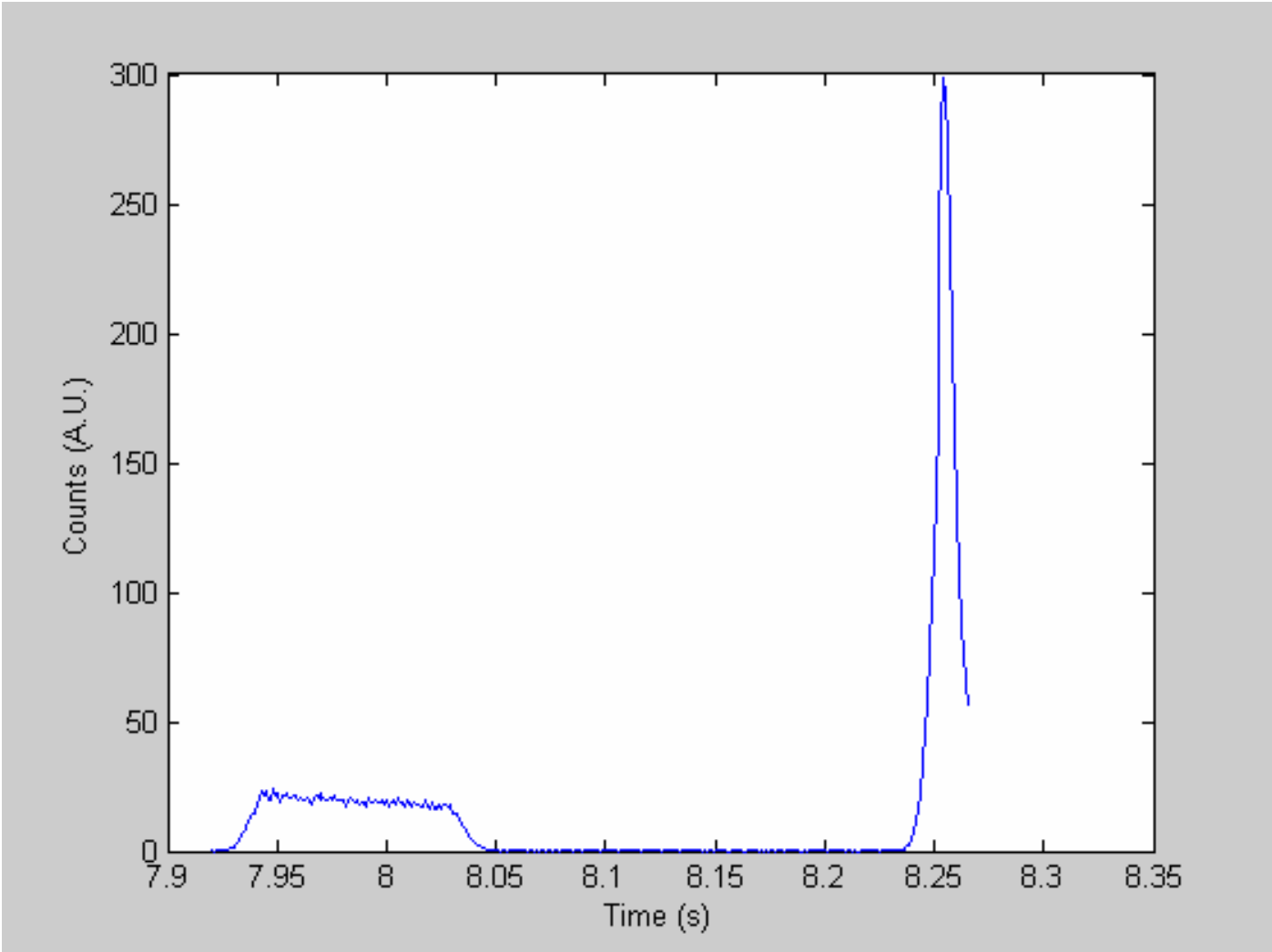
Phase Space Density



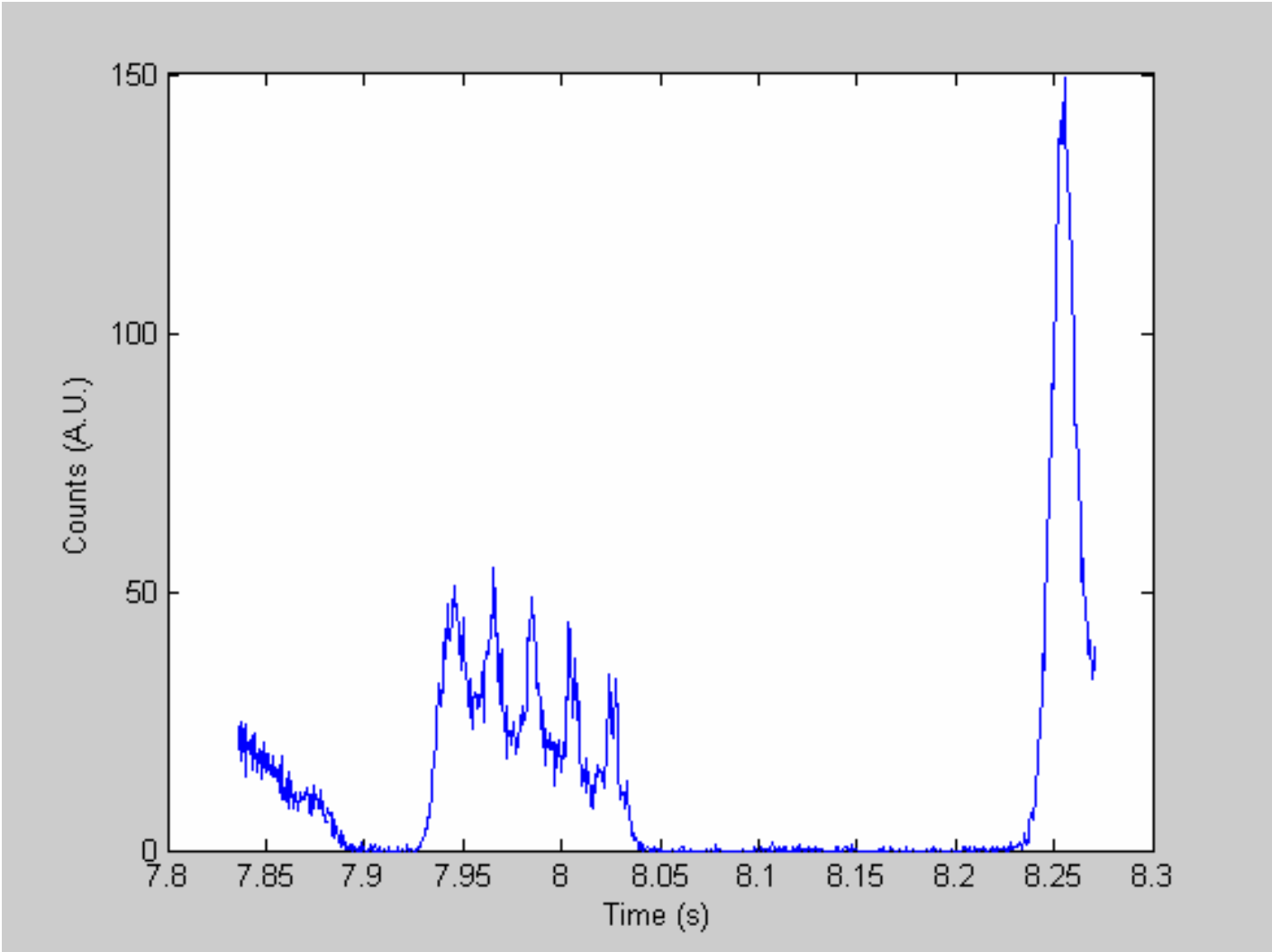
He* BEC


f = 280 KHz
f = 220 KHz
f = 150 KHz
Amplitude (A.U.)
Time (s)
N = 1e6
T = 1e-6
f = 100 KHz
Amplitude (A.U.)
Time (s)

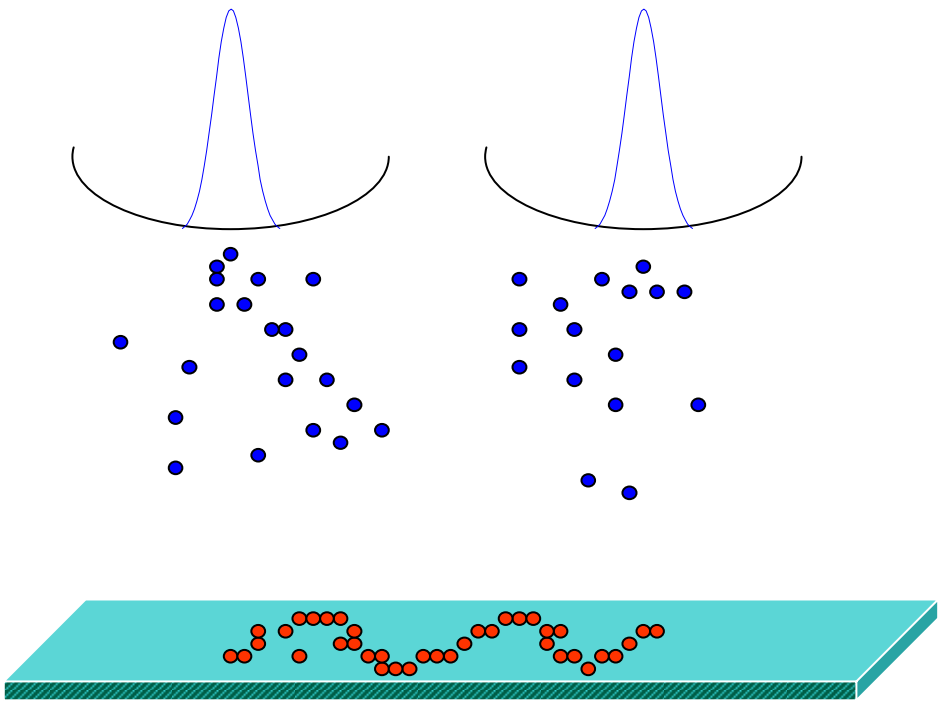
Output coupling “Atom Laser”



Output coupling “Atom Laser”



Where We're Heading



- Look at $g^{(2)}$ during onset of condensation (HBT) type experiments.
- Observe Macroscopic fringes ~ 1 mm period.
- How phase develops as a function of detected atoms
- Visibility vs elastic collision rate (Walls *et. al.)*

Implosion