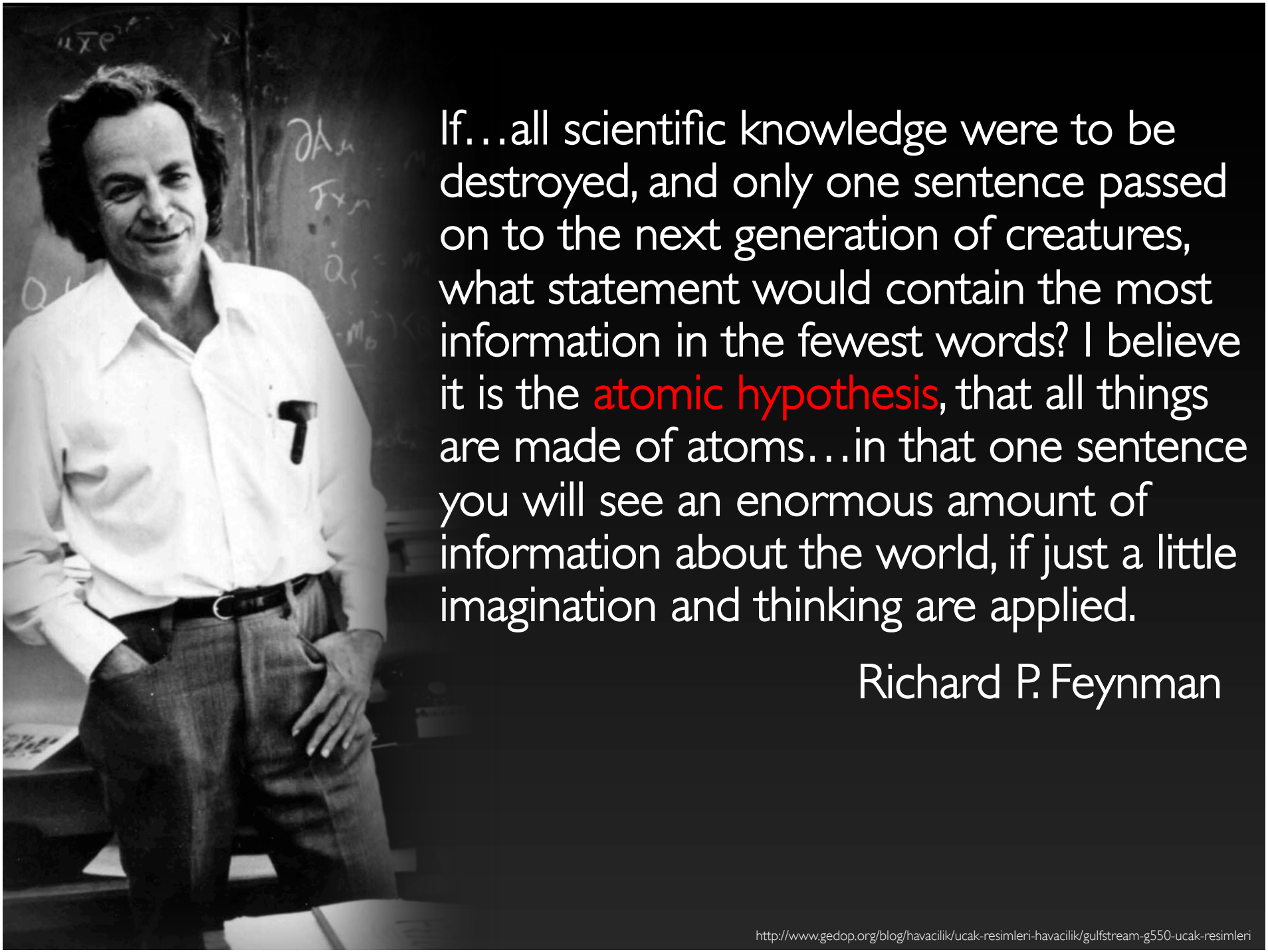
FLUX MEASUREMENT AND LASER BUILDING

Kevin Hu
Massachusetts Institute of Technology
University of Michigan REU Symposium
Advisor: Professor Georg Raithel
August 11th, 2011



If…all scientific knowledge were to be destroyed, and only one sentence passed on to the next generation of creatures, what statement would contain the most information in the fewest words? I believe it is the atomic hypothesis, that all things are made of atoms…in that one sentence you will see an enormous amount of information about the world, if just a little imagination and thinking are applied.

Richard P. Feynman

http://www.gedop.org/blog/havacilik/ucak-resimleri-havacilik/gulfstream-g550-ucak-resimleri

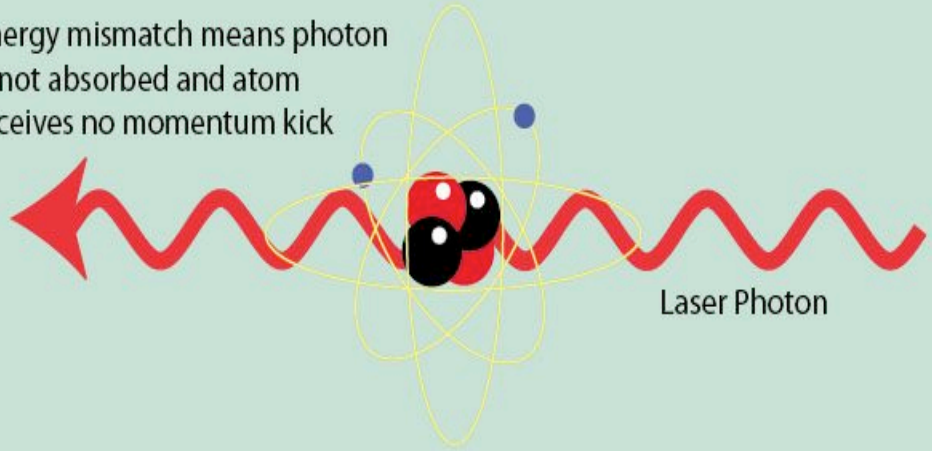
AMO


http://www.gedop.org/blog/havacilik/ucak-resimleri-havacilik/gulfstream-g550-ucak-resimleri

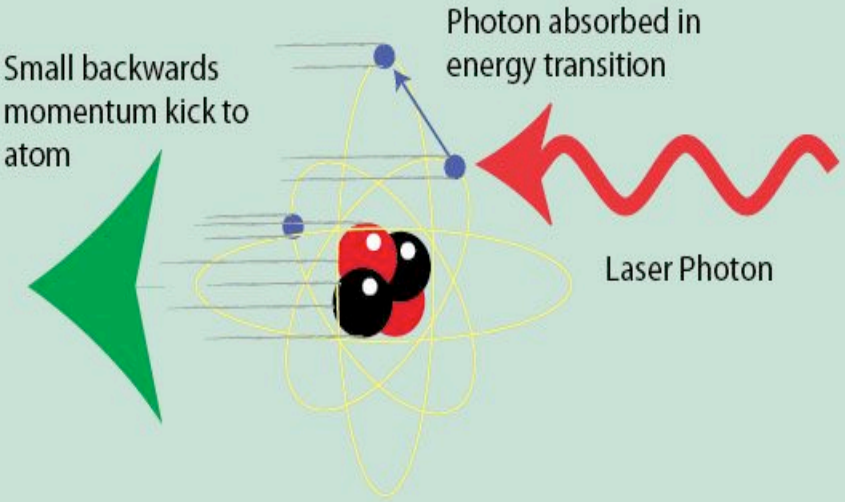
Laser Cooling

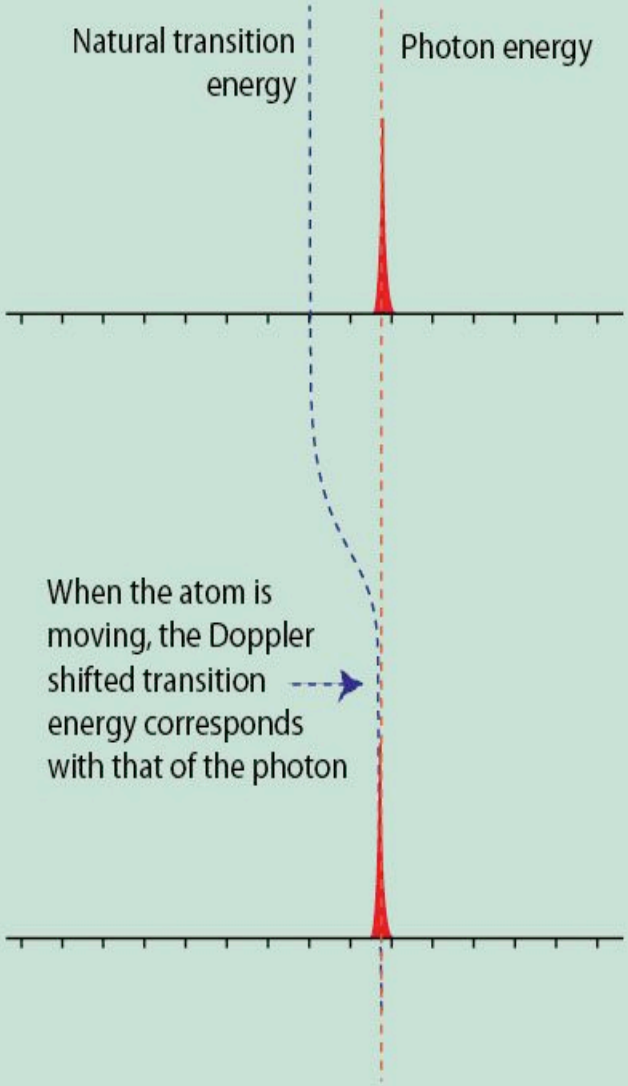
Stationary Atom:

Energy mismatch means photon is not absorbed and atom receives no momentum kick



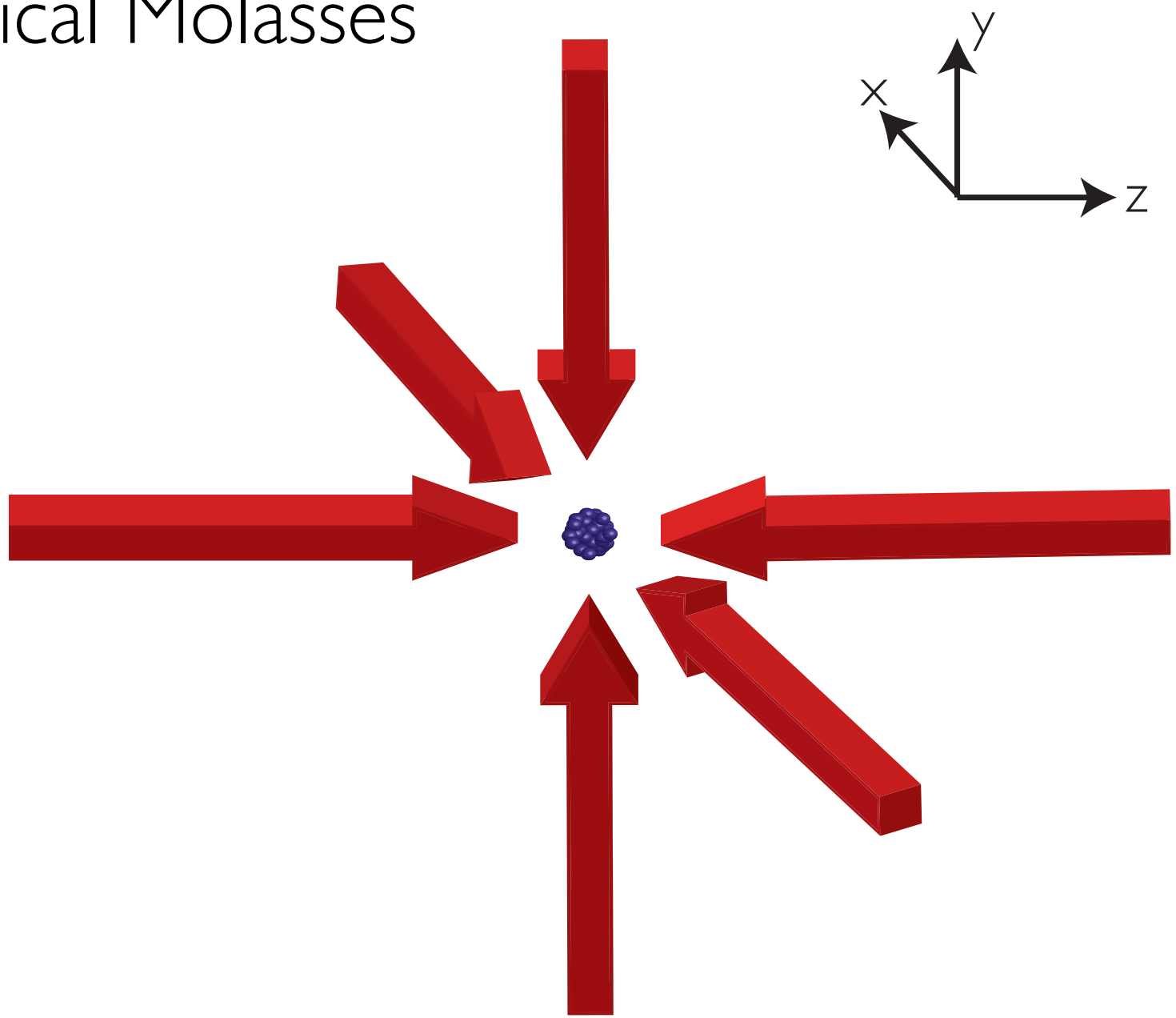
Moving Atom:



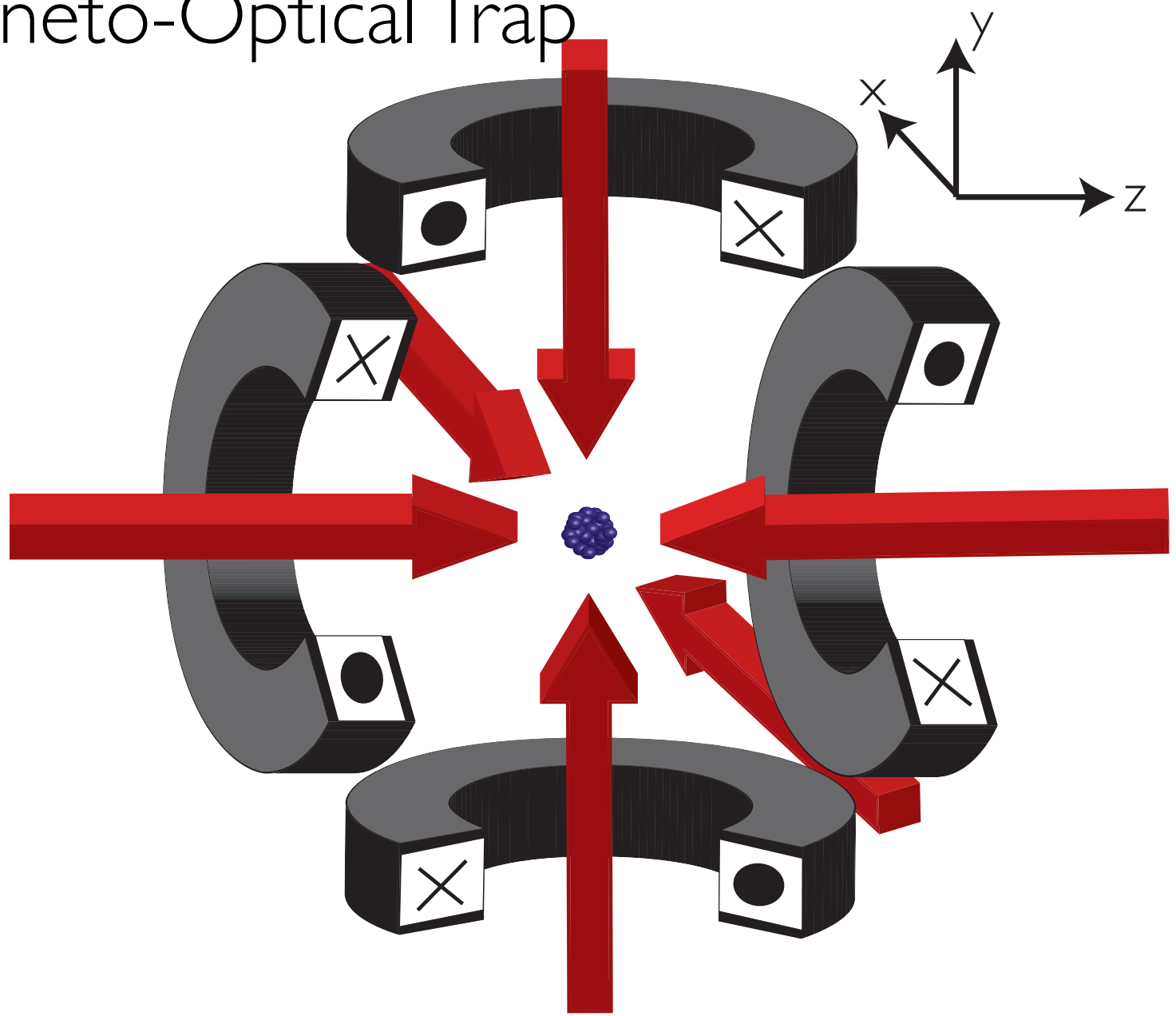


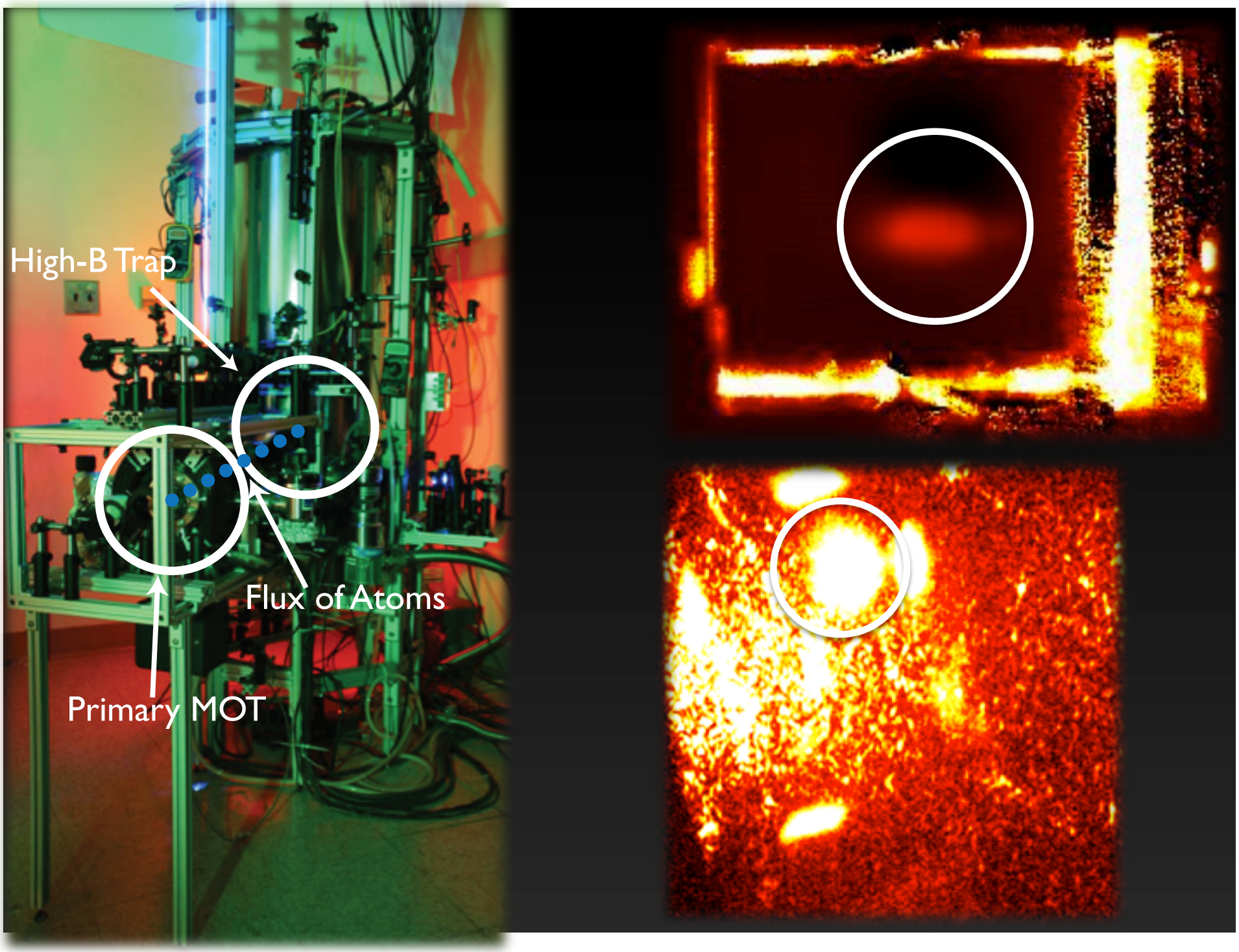
http://sciencewise.anu.edu.au/articles/qed

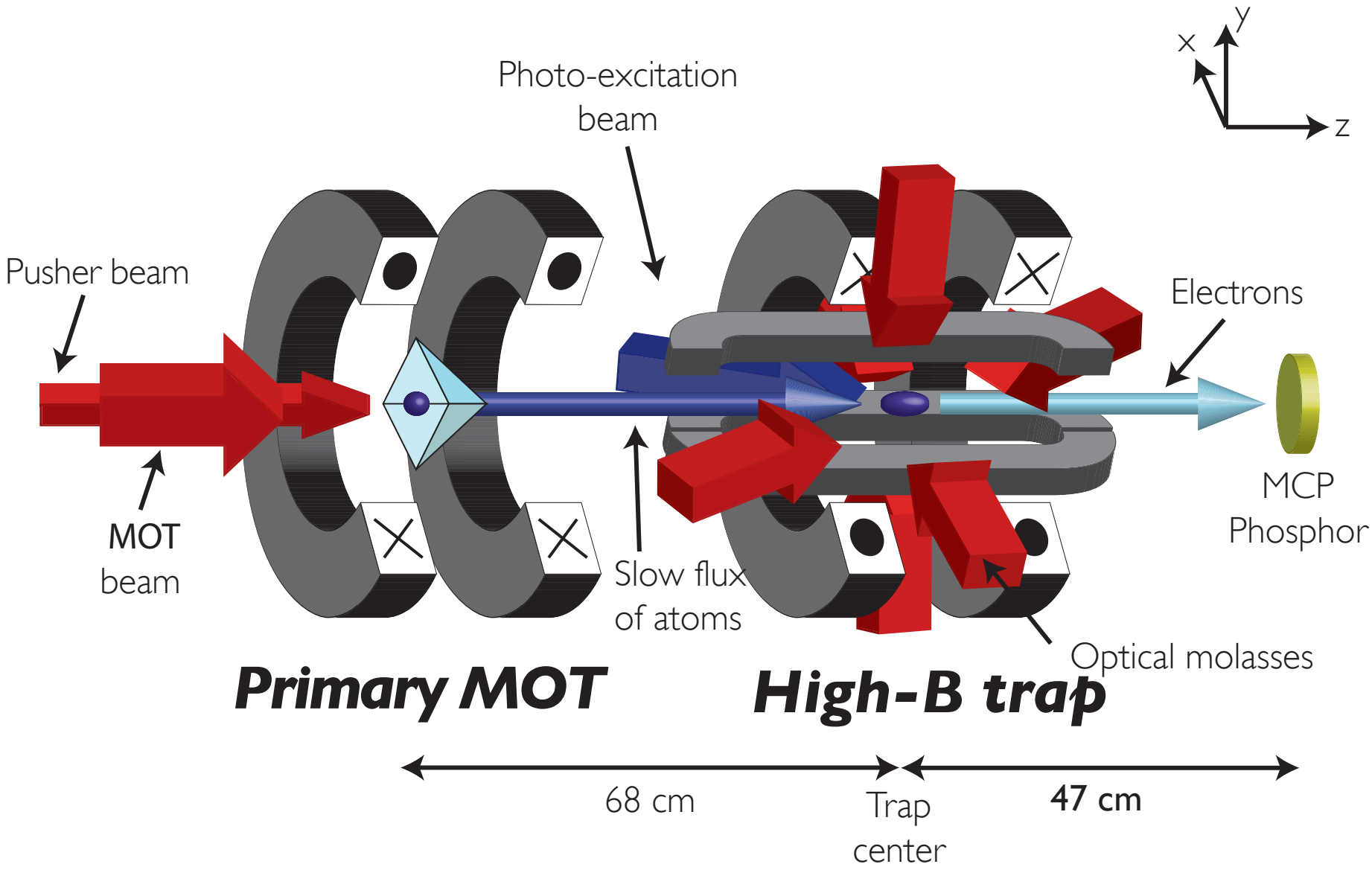
Optical Molasses

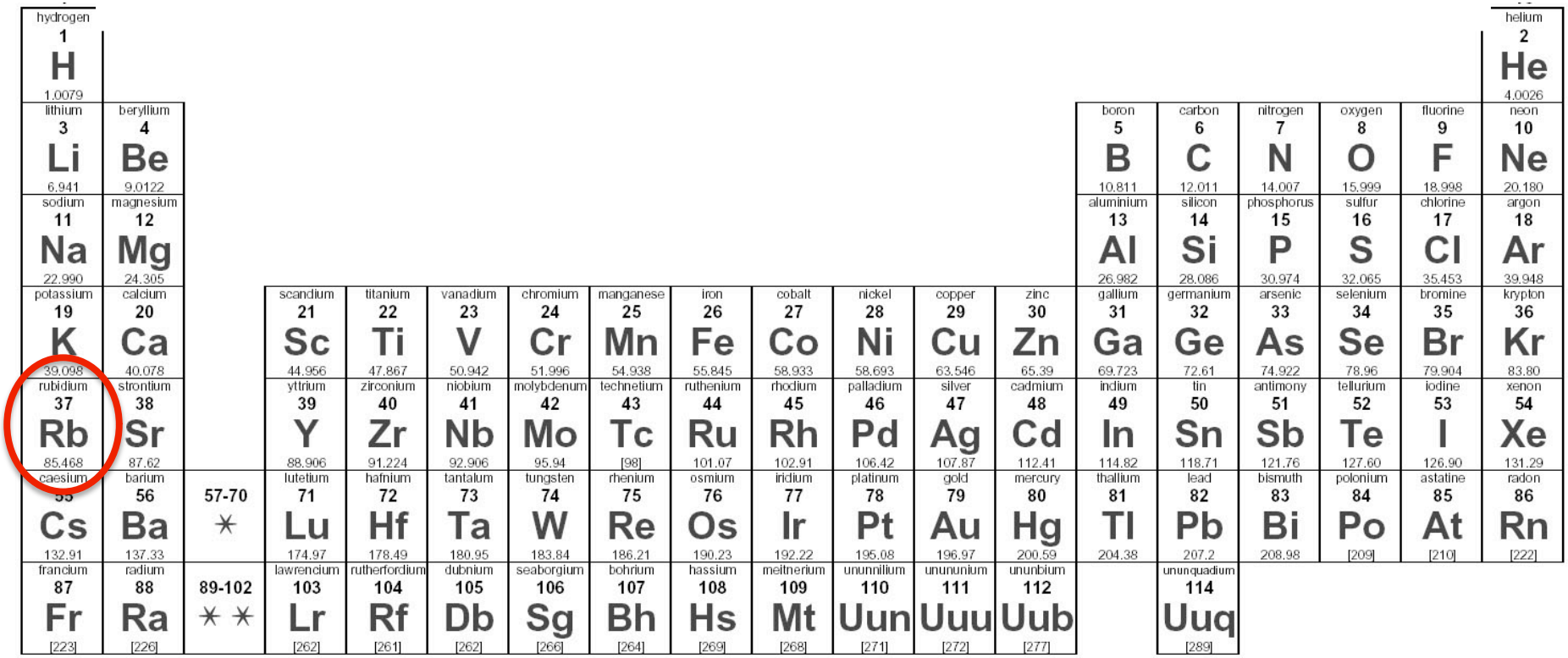


Magneto-Optical Trap



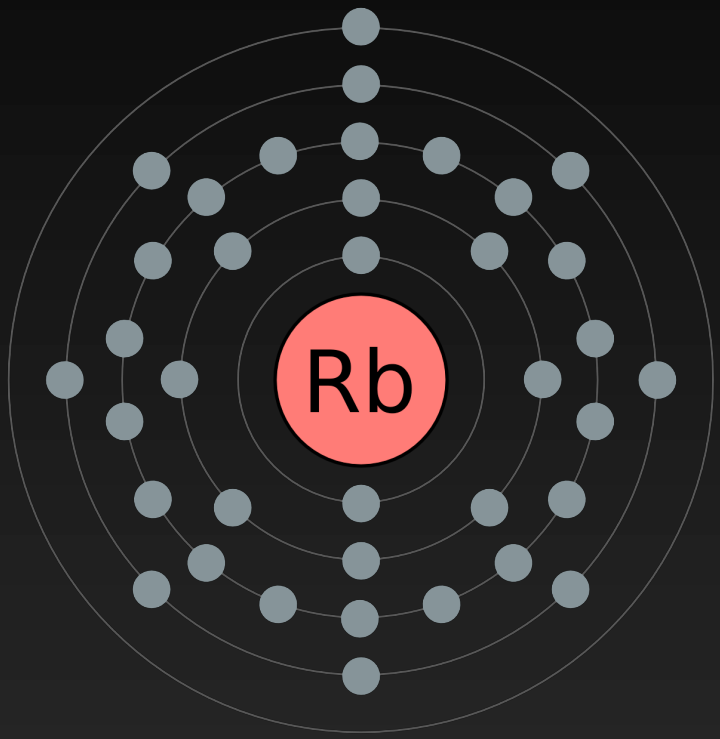

High-B Trap
Flux of Atoms
Primary MOT

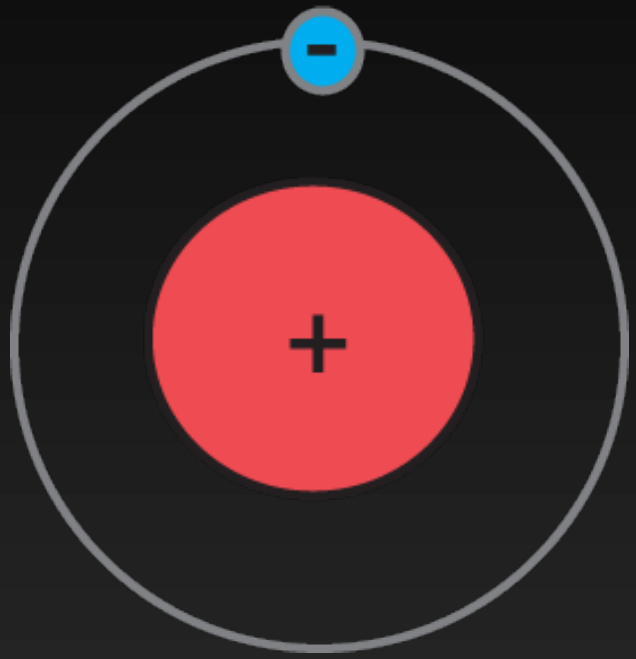

y
x
z
Photo-excitation
beam
Pusher beam
Electrons
MCP
Phosphor
MOT
beam
Slow flux
of atoms
Optical molasses
Primary MOT
High-B trap
68 cm
Trap
center
47 cm



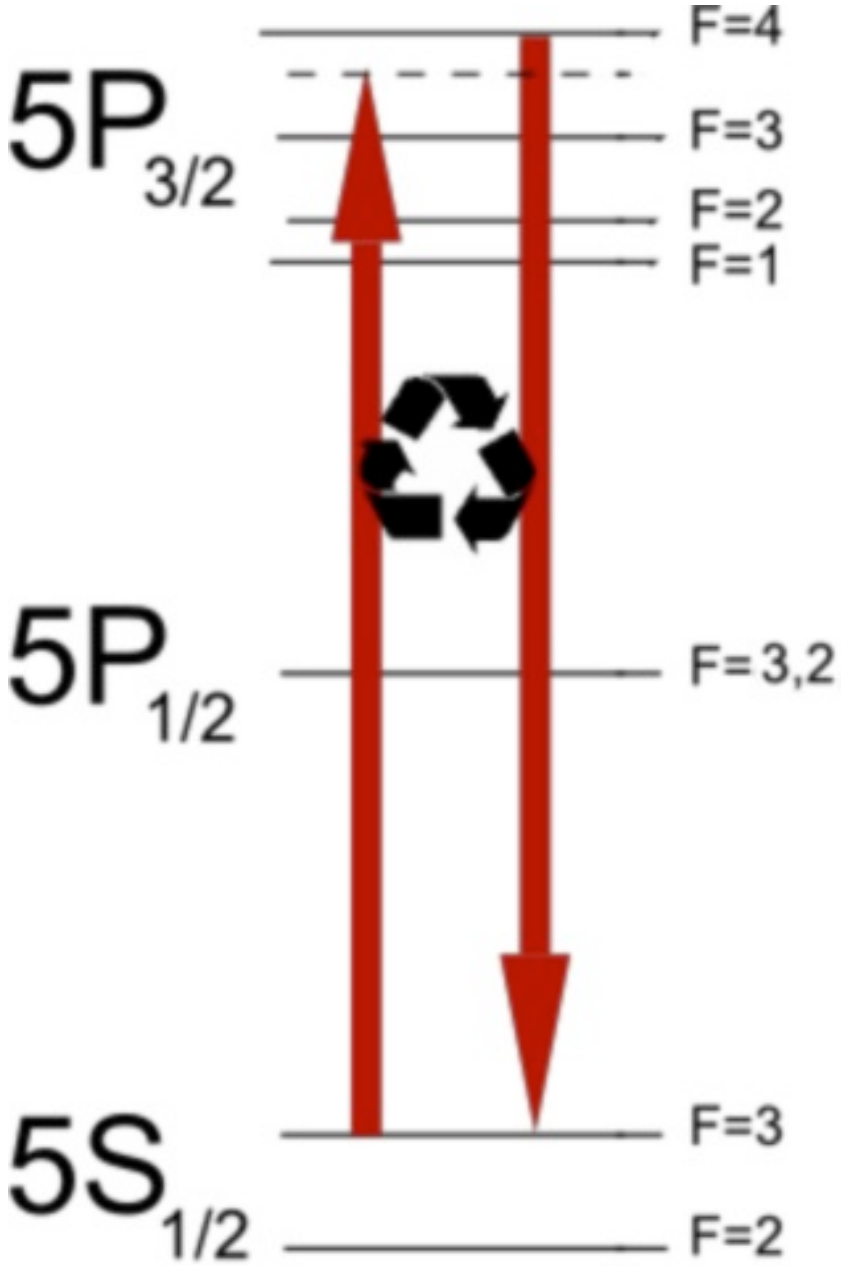
http://www.bpc.edu/mathscience/chemistry/history_of_the_periodic_table.html

Rb-85

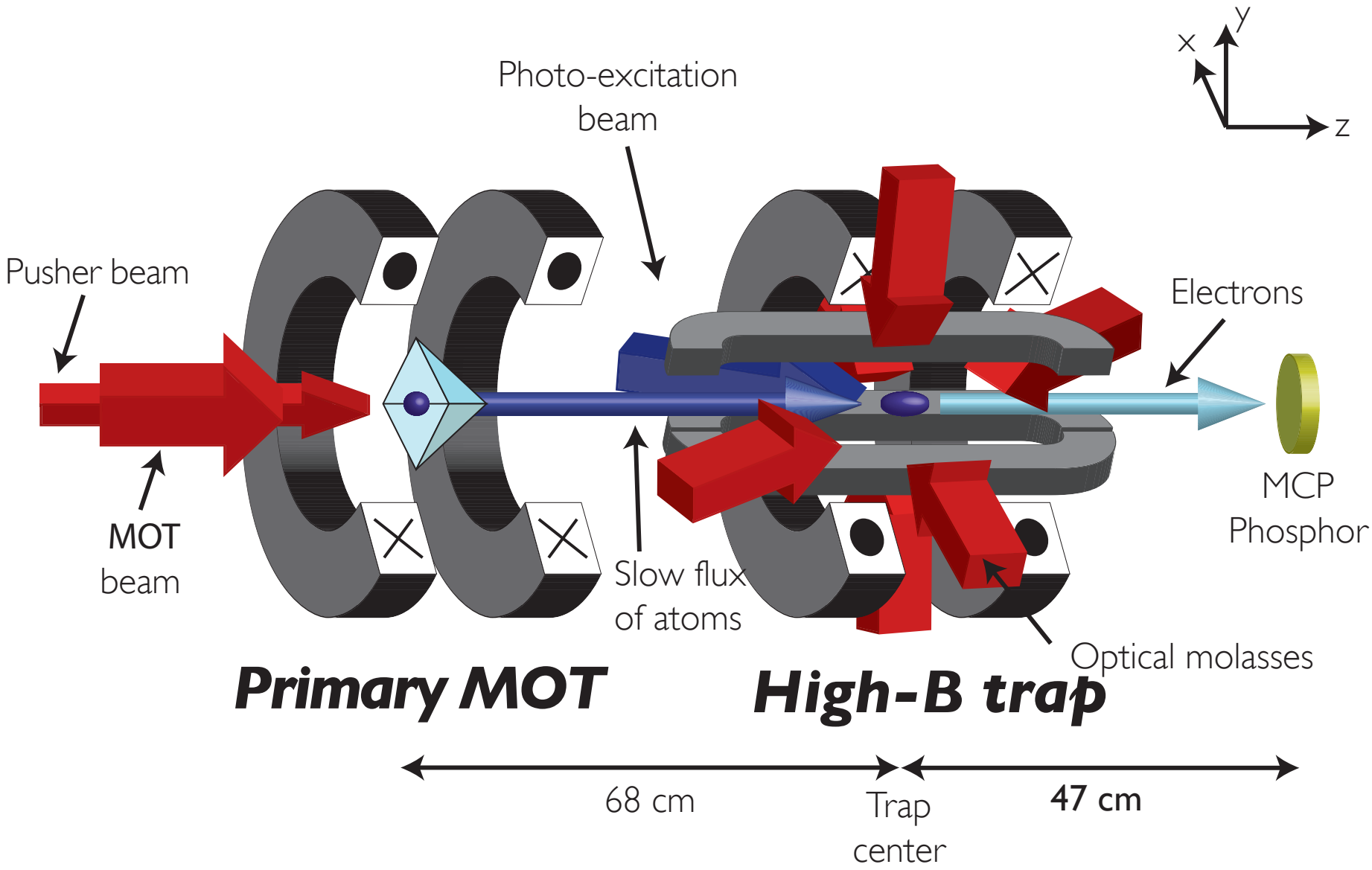


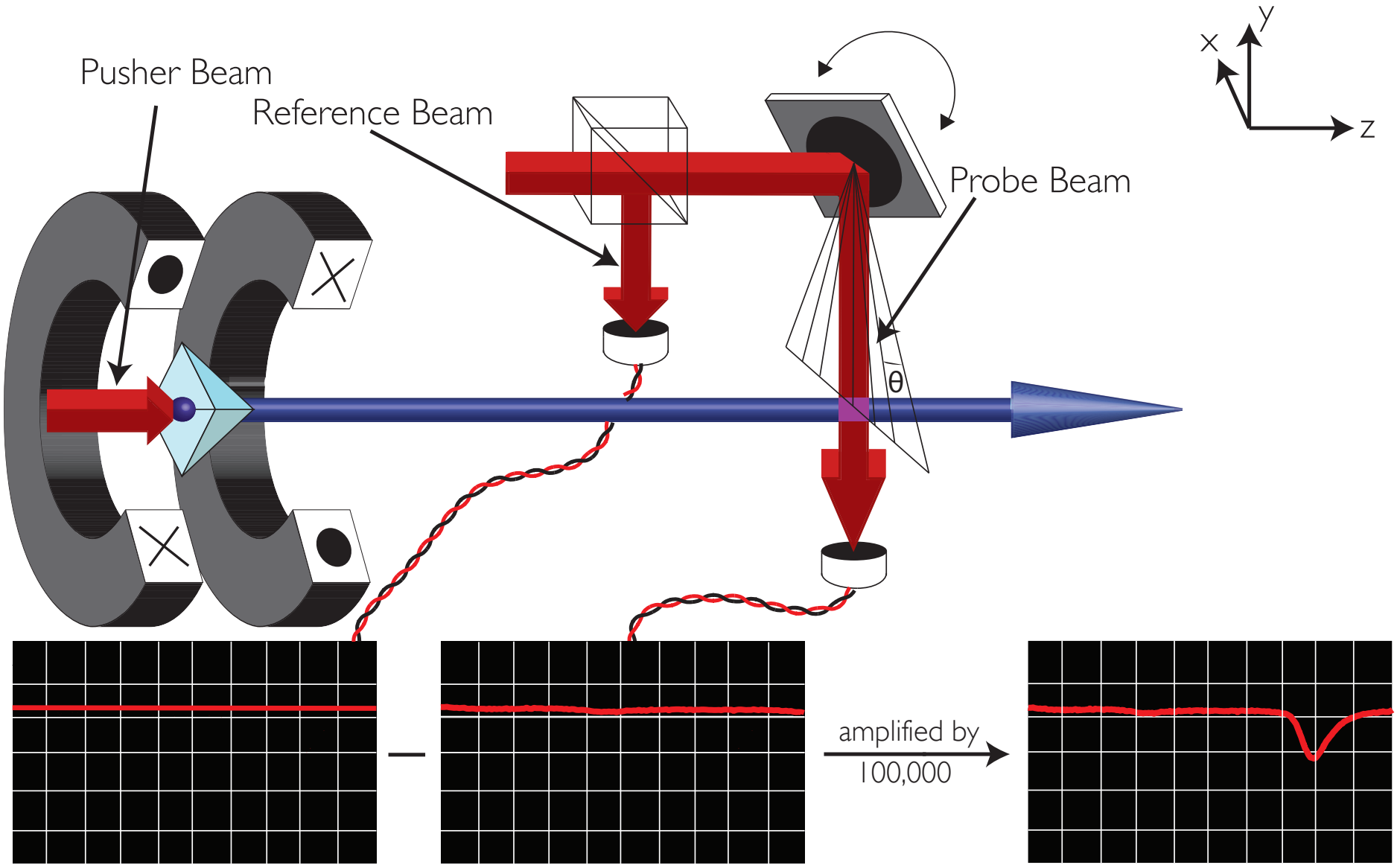


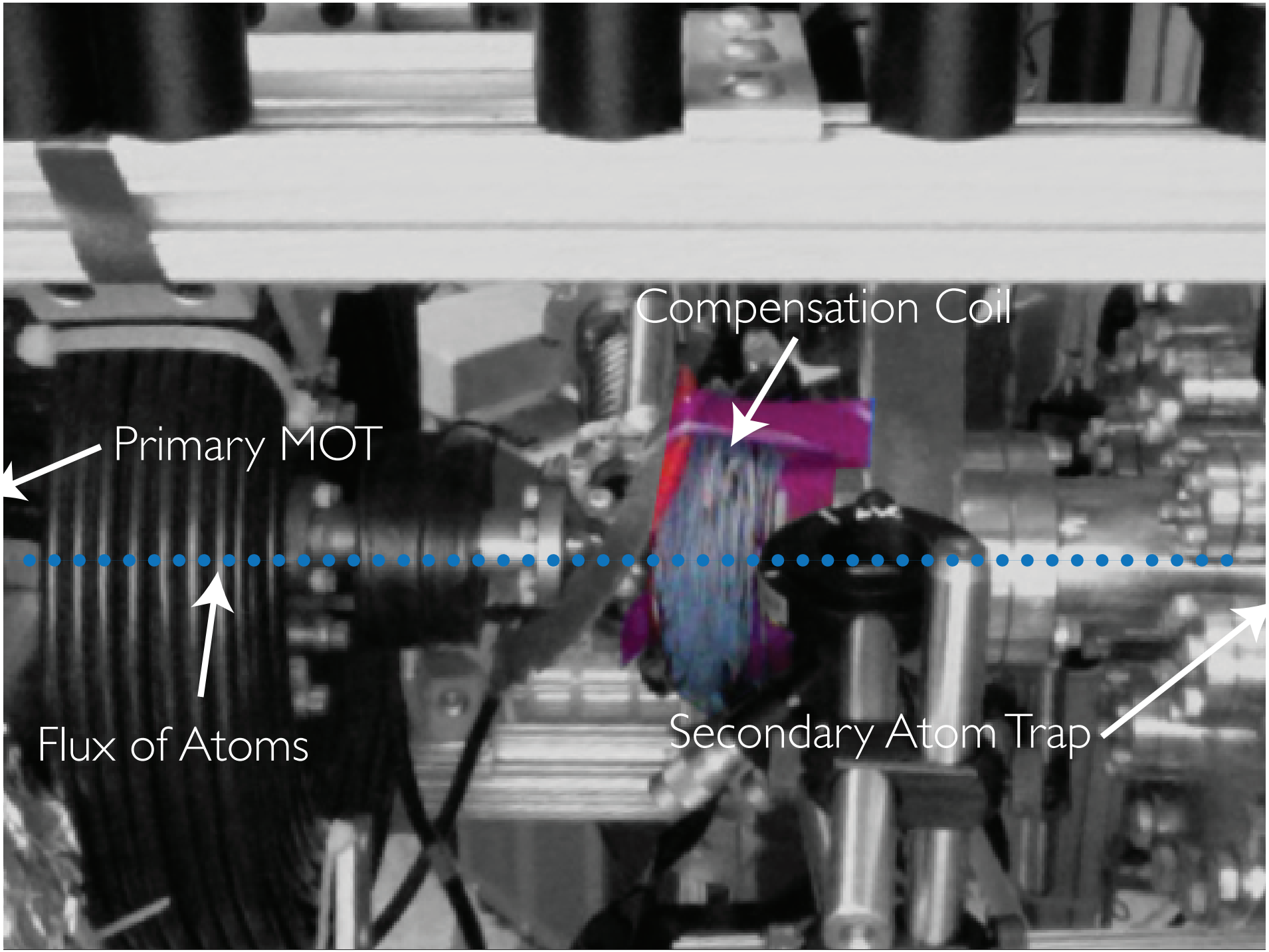
http://commons.wikimedia.org/wiki/File:Electron_shell_037_rubidium.png

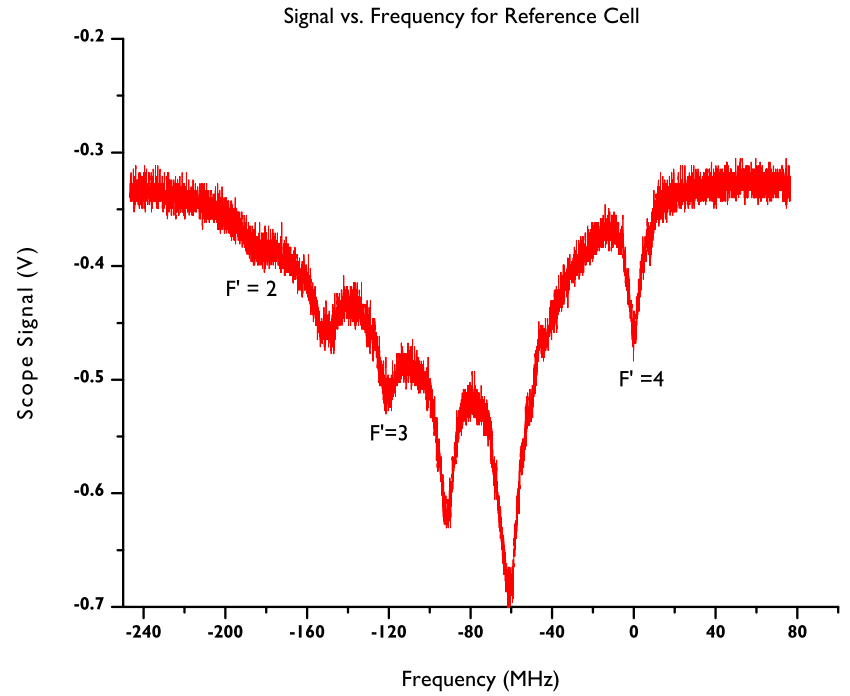


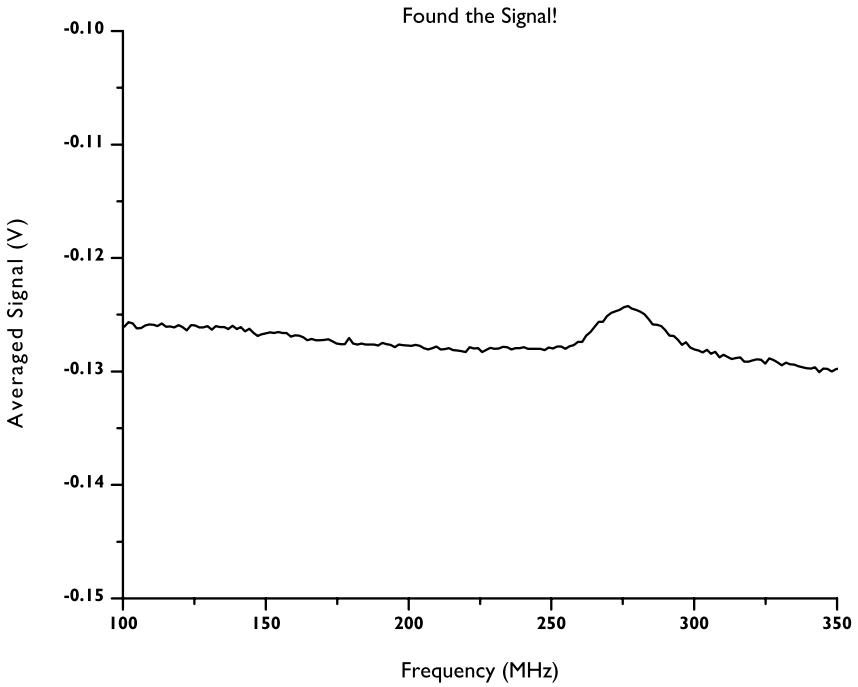
http://en.wikipedia.org/wiki/Magneto-optical_trap

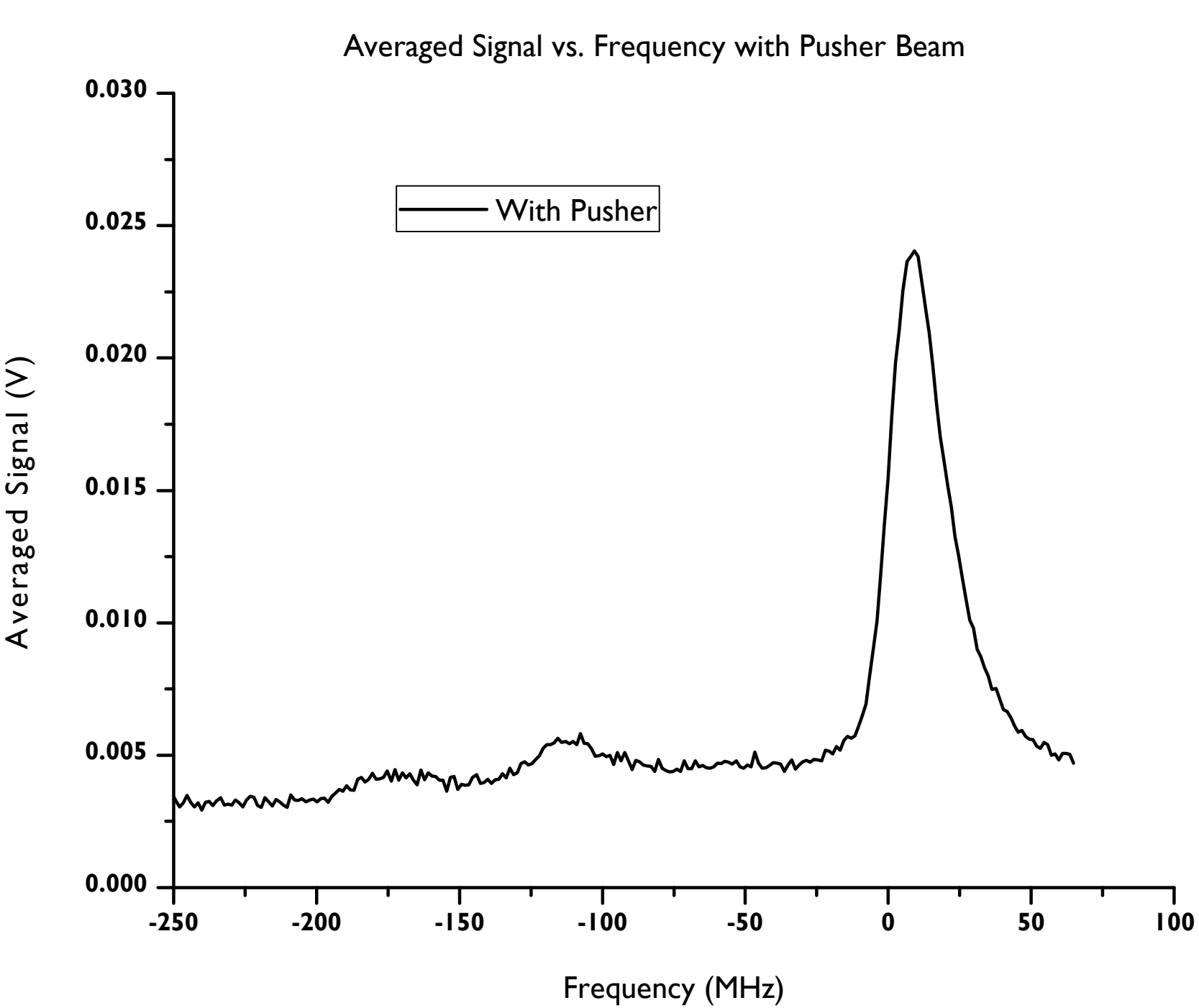

y
x
z
Photo-excitation
beam
Pusher beam
Electrons
MCP
Phosphor
MOT
beam
Slow flux
of atoms
Optical molasses
Primary MOT
High-B trap
68 cm
Trap
center
47 cm


Pusher Beam
Reference Beam
Probe Beam
θ
y
x
z
amplified by
100,000


Compensation Coil
Primary MOT
Flux of Atoms
Secondary Atom Trap


Signal vs. Frequency for Reference Cell
Scope Signal (V)
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
F' = 2
F'=3
F' =4
-240
-200
-160
-120
-80
-40
0
40
80
Frequency (MHz)

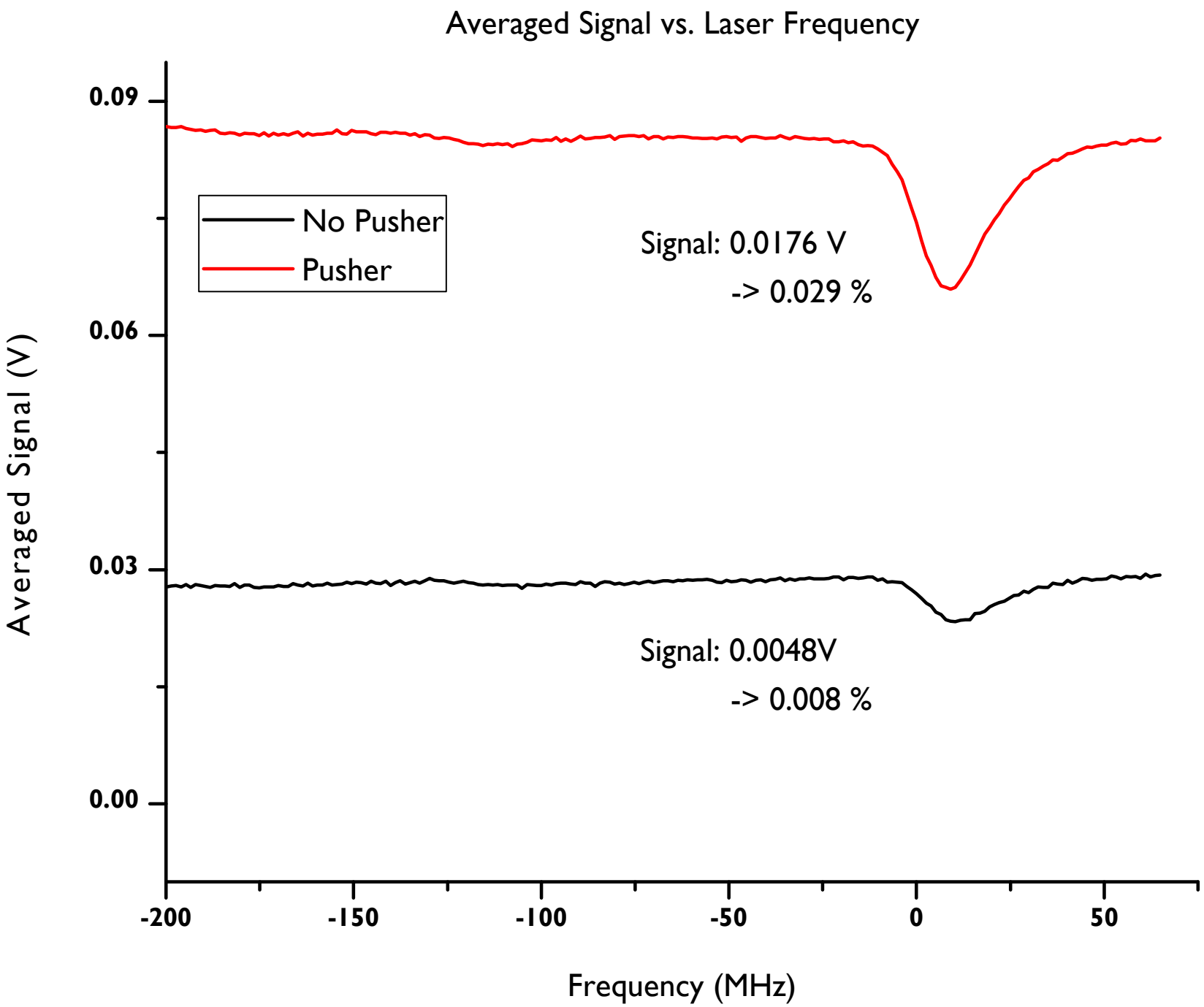

Found the Signal!
Averaged Signal (V)
-0.10
-0.11
-0.12
-0.13
-0.14
-0.15
100
150
200
250
300
350
Frequency (MHz)

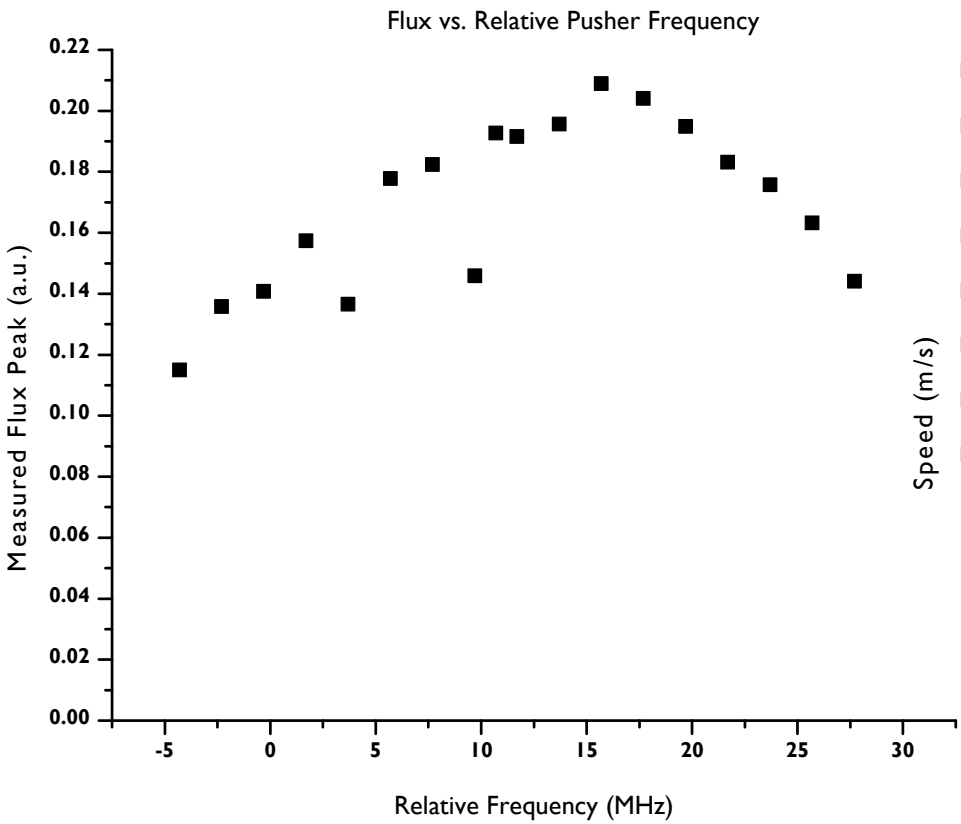

Averaged Signal vs. Frequency with Pusher Beam
With Pusher
Averaged Signal (V)
0.030
0.025
0.020
0.015
0.010
0.005
0.000
-250
-200
-150
-100
-50
0
50
100
Frequency (MHz)

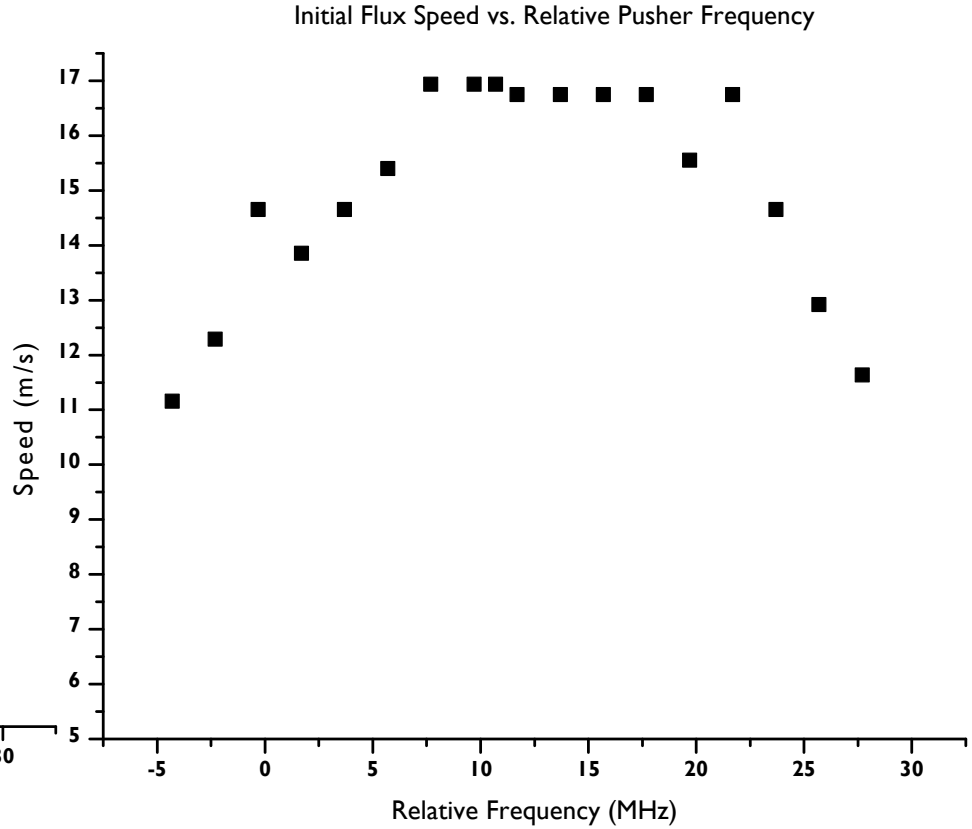
Pusher Beam

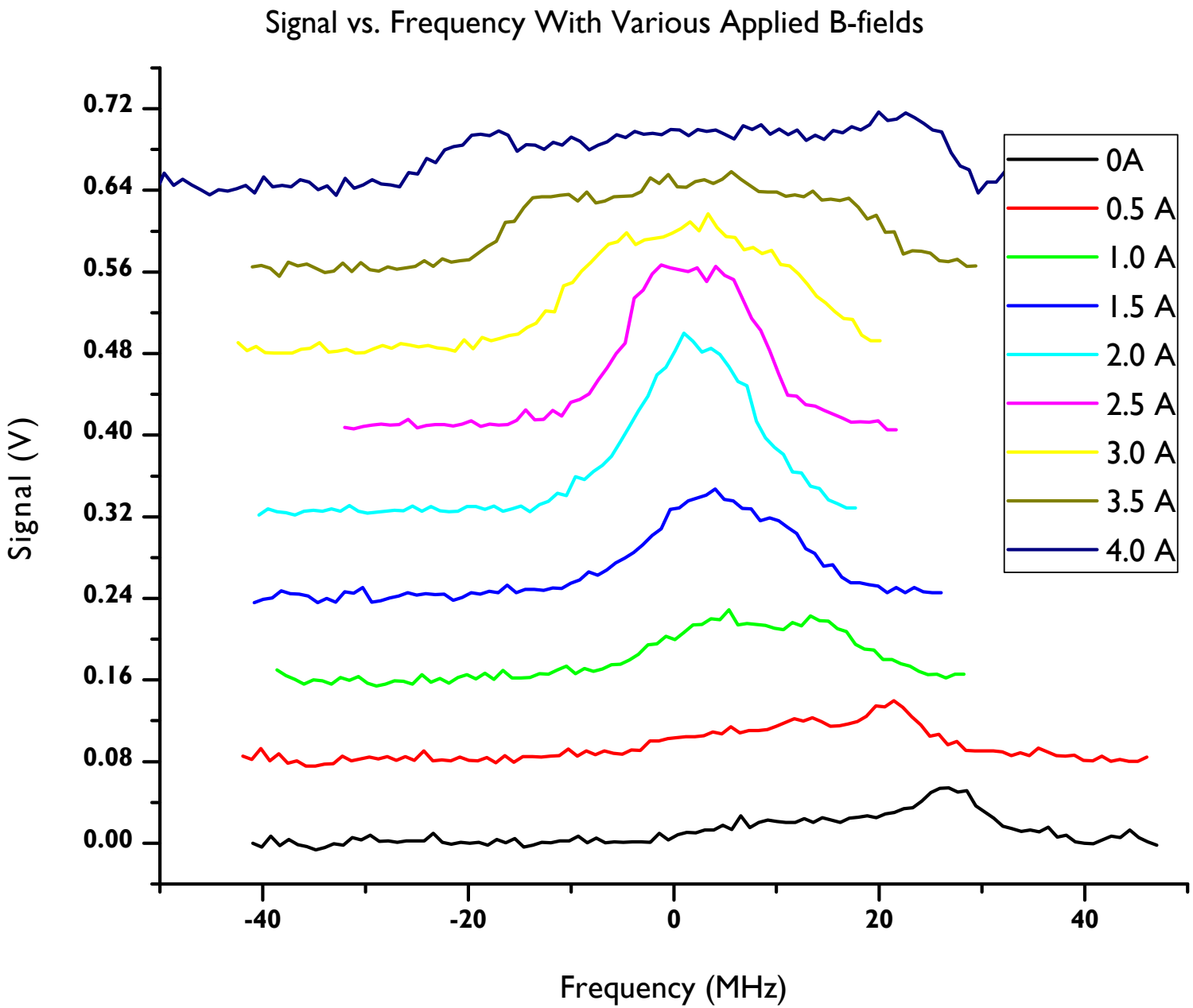
Compensation Coil

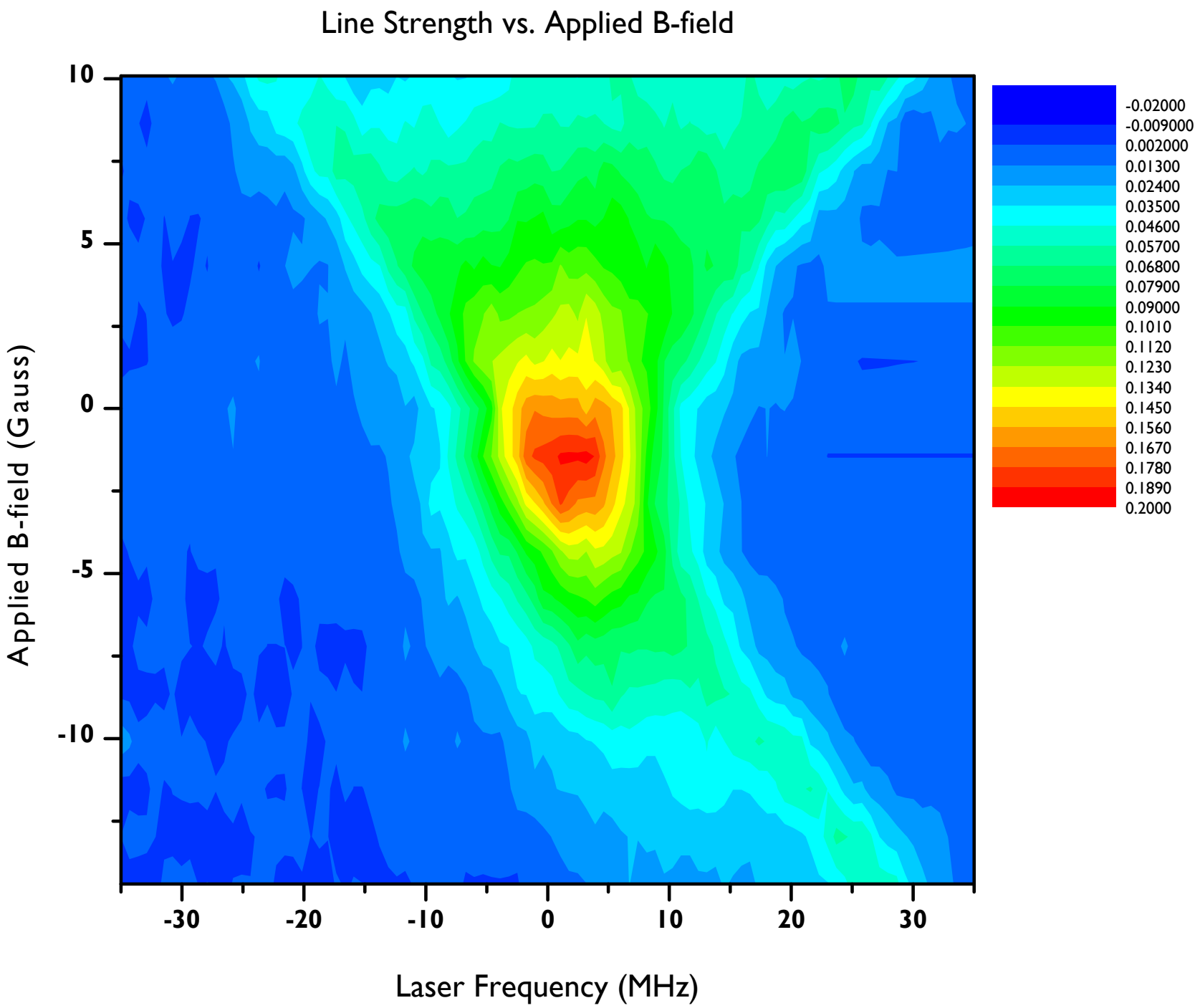
Flux of Atoms

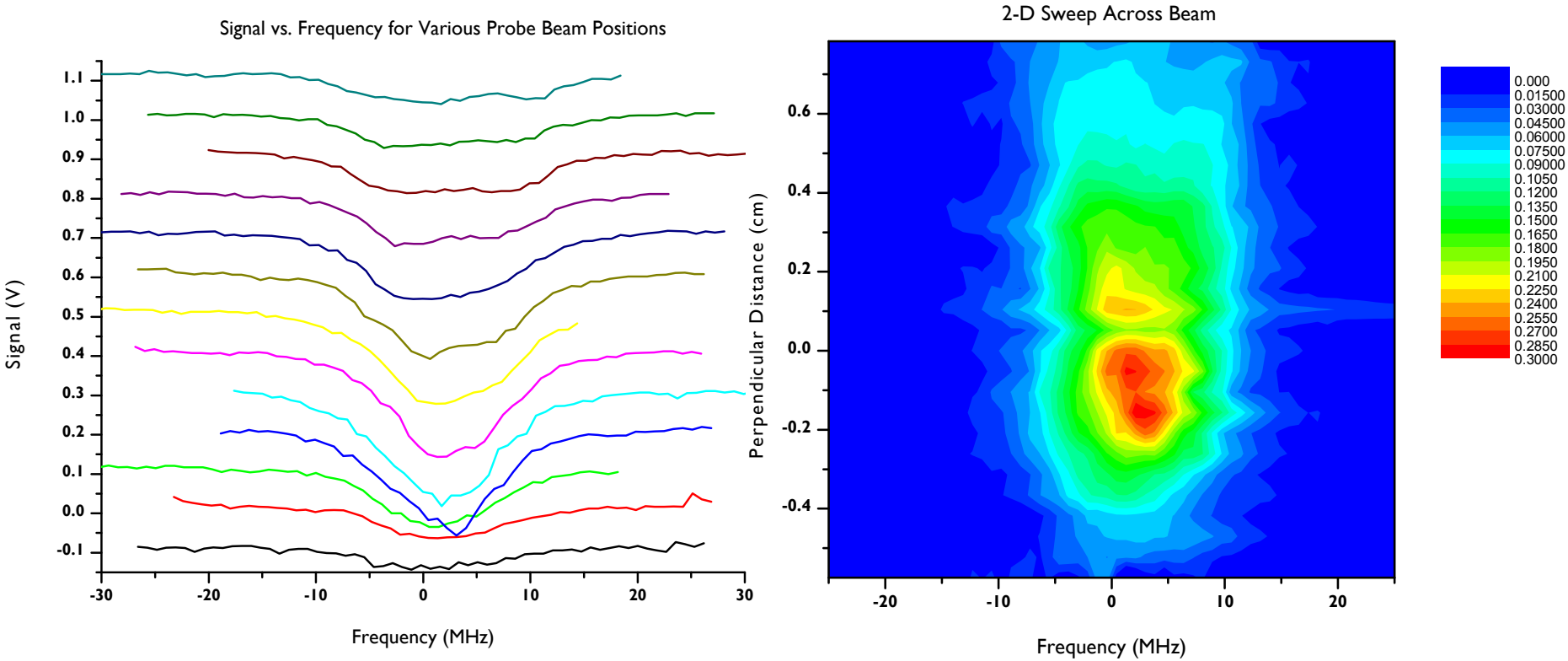

Averaged Signal vs. Laser Frequency
Averaged Signal (V)
0.09
0.06
0.03
0.00
No Pusher
Pusher
Signal: 0.0176 V
-> 0.029 %
Signal: 0.0048V
-> 0.008 %
-200
-150
-100
-50
0
50
Frequency (MHz)

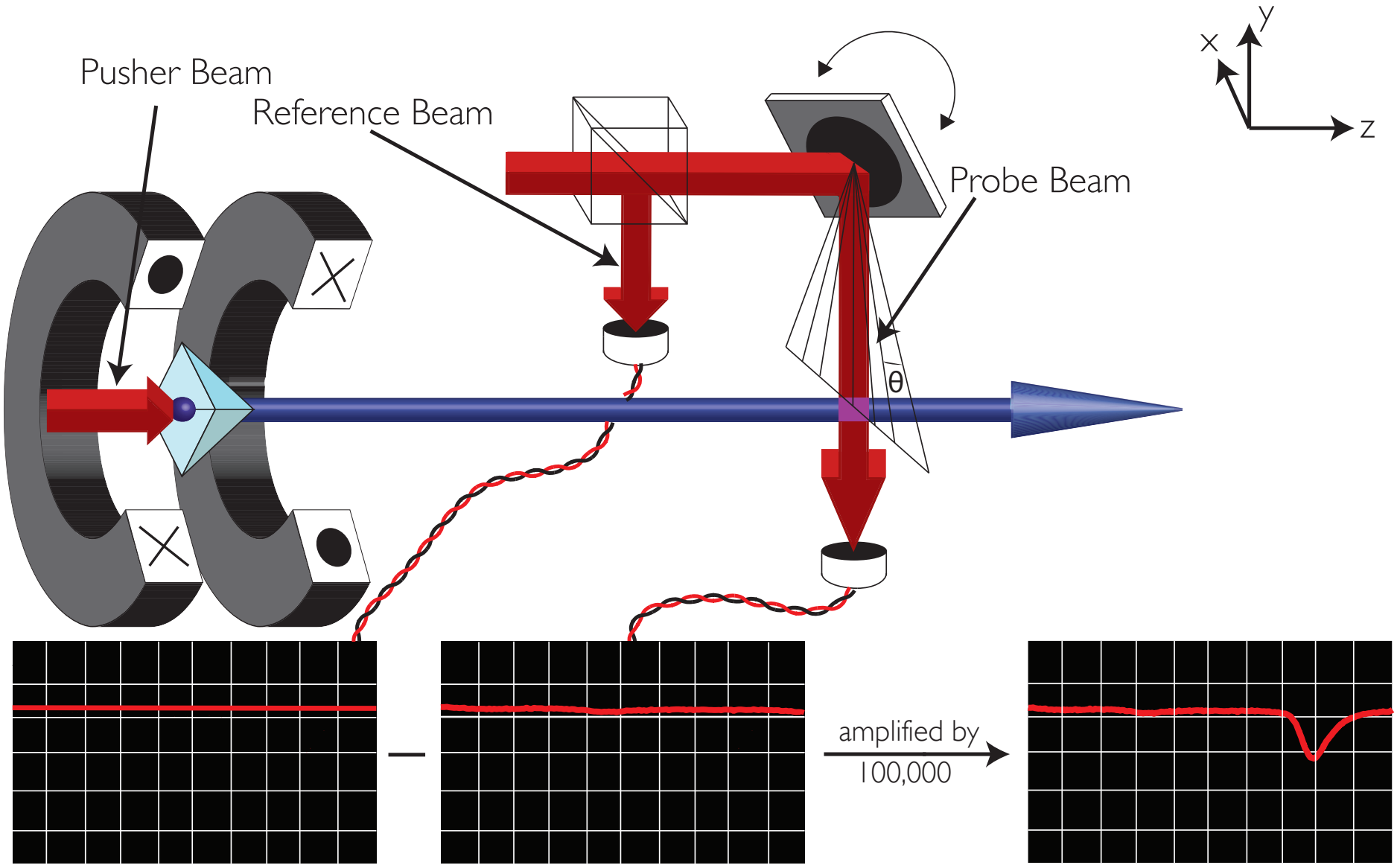

Flux vs. Relative Pusher Frequency
Measured Flux Peak (a.u.)
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
-5
0
5
10
15
20
25
30
Relative Frequency (MHz)

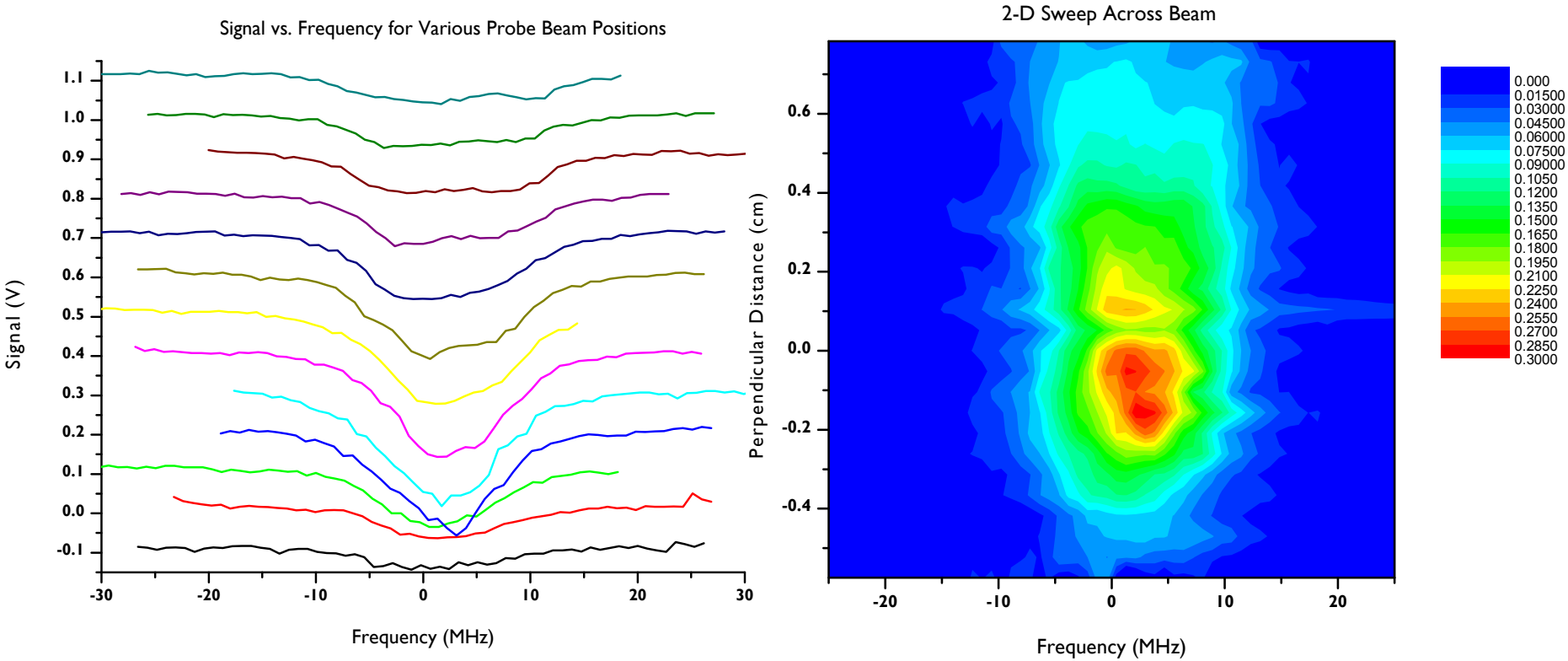

Initial Flux Speed vs. Relative Pusher Frequency
Speed (m/s)
17
16
15
14
13
12
11
10
9
8
7
6
5
-5
0
5
10
15
20
25
30
Relative Frequency (MHz)


Signal vs. Frequency With Various Applied B-fields
Signal (V)
0.72
0.64
0.56
0.48
0.40
0.32
0.24
0.16
0.08
0.00
-40
-20
0
20
40
Frequency (MHz)
0A
0.5 A
1.0 A
1.5 A
2.0 A
2.5 A
3.0 A
3.5 A
4.0 A

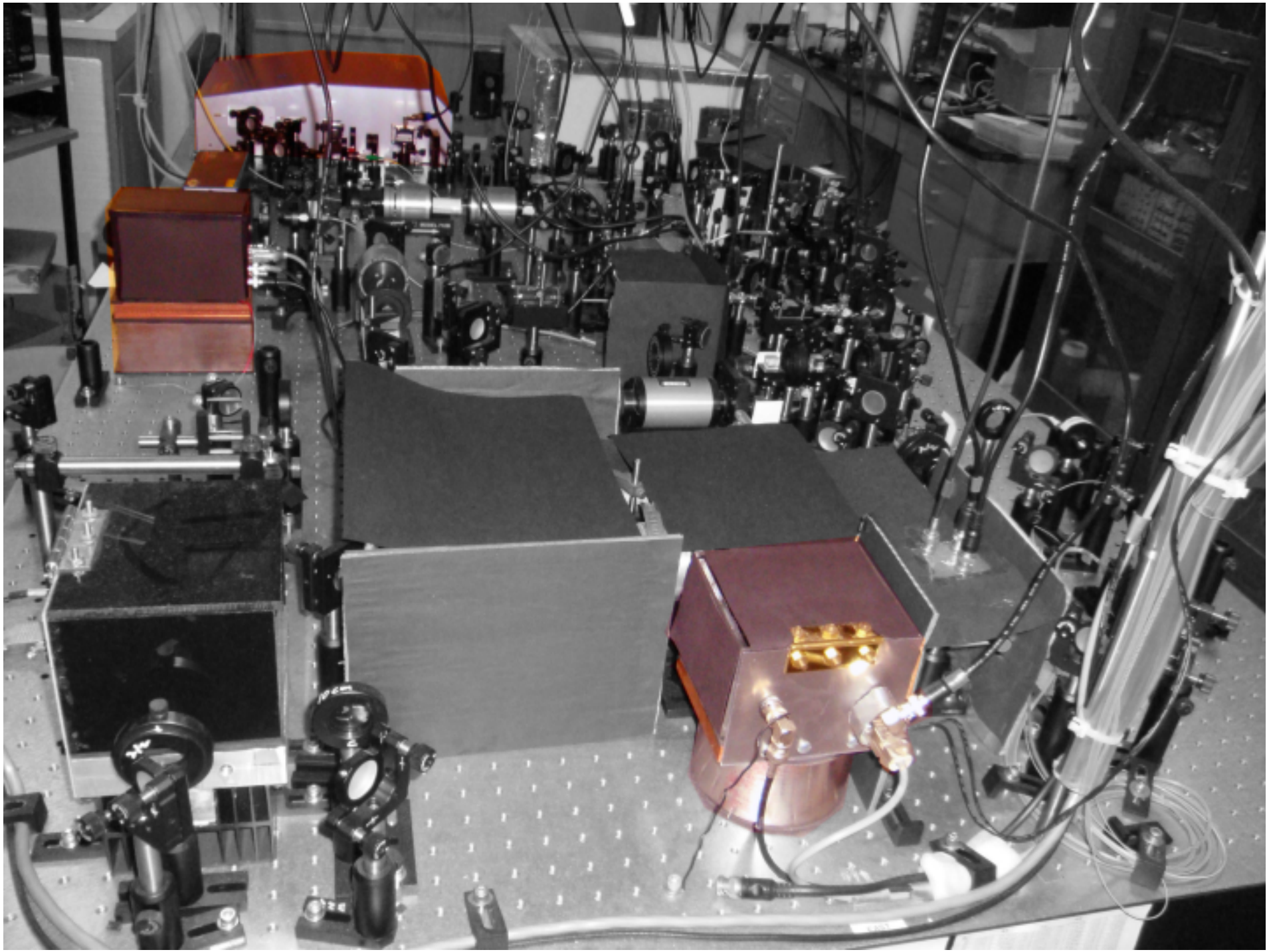

Line Strength vs. Applied B-field
Applied B-field (Gauss)
10
5
0
-5
-10
-30
-20
-10
0
10
20
30
Laser Frequency (MHz)
-0.02000
-0.009000
0.002000
0.01300
0.02400
0.03500
0.04600
0.05700
0.06800
0.07900
0.09000
0.1010
0.1120
0.1230
0.1340
0.1450
0.1560
0.1670
0.1780
0.1890
0.2000

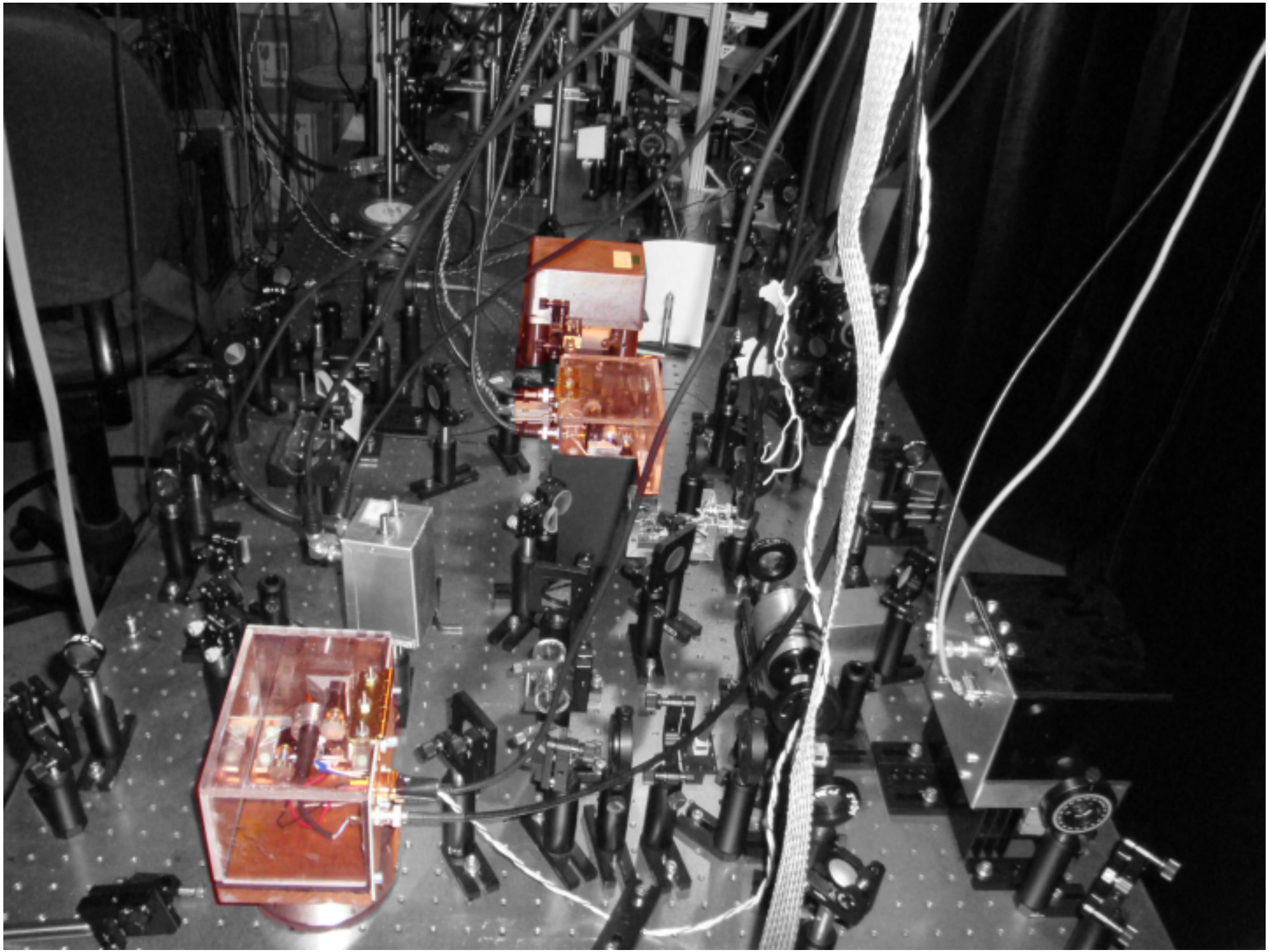

Signal vs. Frequency for Various Probe Beam Positions
Signal (V)
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-30
-20
-10
0
10
20
30
Frequency (MHz)
2-D Sweep Across Beam
Perpendicular Distance (cm)
0.6
0.4
0.2
0.0
-0.2
-0.4
-20
-10
0
10
20
Frequency (MHz)
0.000
0.01500
0.03000
0.04500
0.06000
0.07500
0.09000
0.1050
0.1200
0.1350
0.1500
0.1650
0.1800
0.1950
0.2100
0.2250
0.2400
0.2550
0.2700
0.2850
0.3000


Pusher Beam
Reference Beam
Probe Beam
θ
y
x
z
amplified by
100,000


Signal vs. Frequency for Various Probe Beam Positions
Signal (V)
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-30
-20
-10
0
10
20
30
Frequency (MHz)
2-D Sweep Across Beam
Perpendicular Distance (cm)
0.6
0.4
0.2
0.0
-0.2
-0.4
-20
-10
0
10
20
Frequency (MHz)
0.000
0.01500
0.03000
0.04500
0.06000
0.07500
0.09000
0.1050
0.1200
0.1350
0.1500
0.1650
0.1800
0.1950
0.2100
0.2250
0.2400
0.2550
0.2700
0.2850
0.3000

Olsen, S., Mhaskar, R., and Raithel, G. (2006). "Continuous propagation and energy filtering of a cold atomic beam in a long, high gradient magnetic atom guide." *Physical Review A* **73**, 033622 .

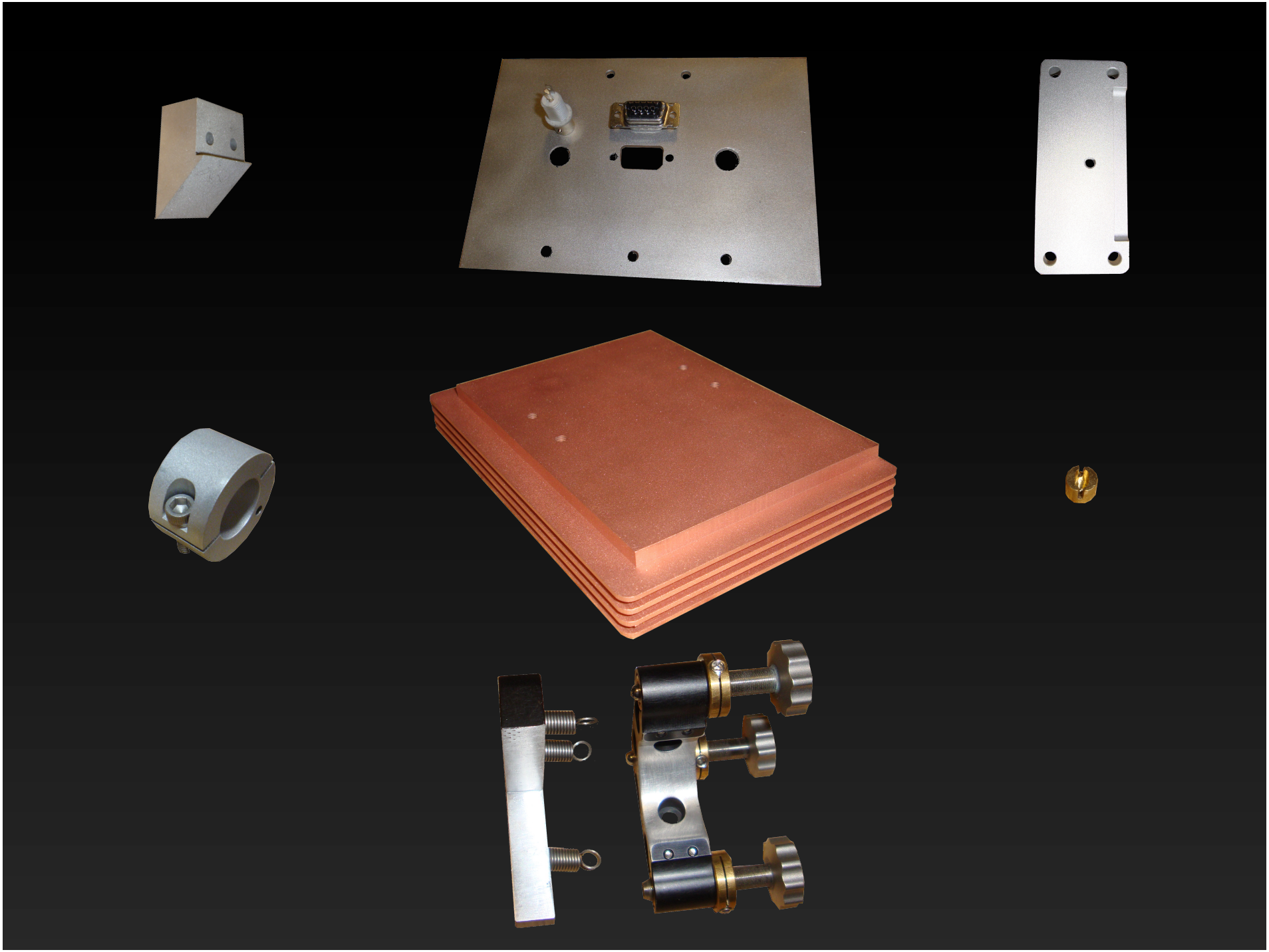


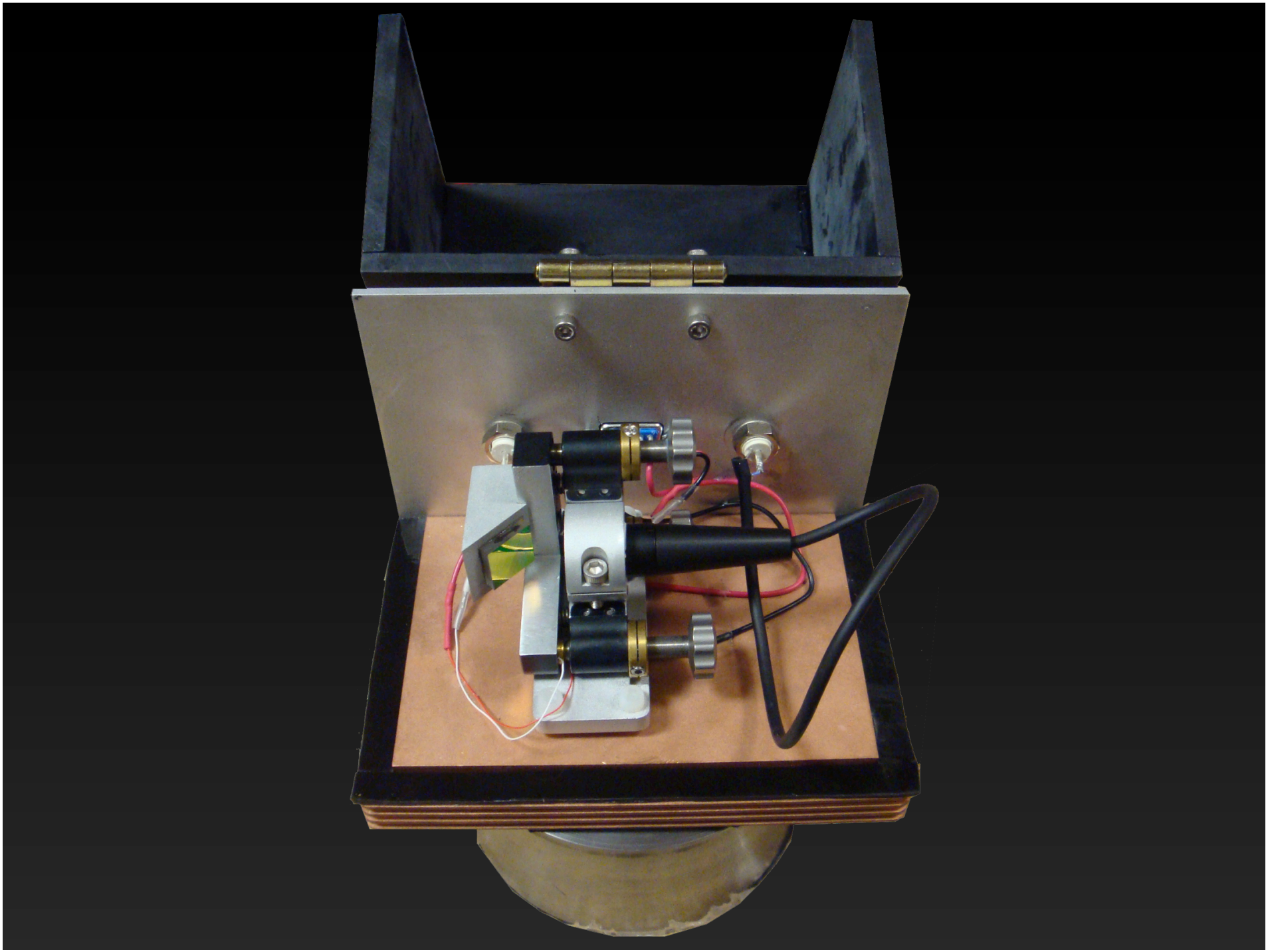


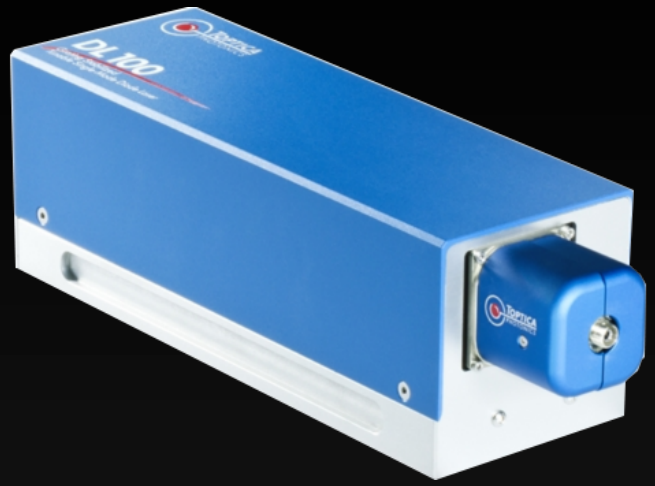
Tunable

Cheap

Small



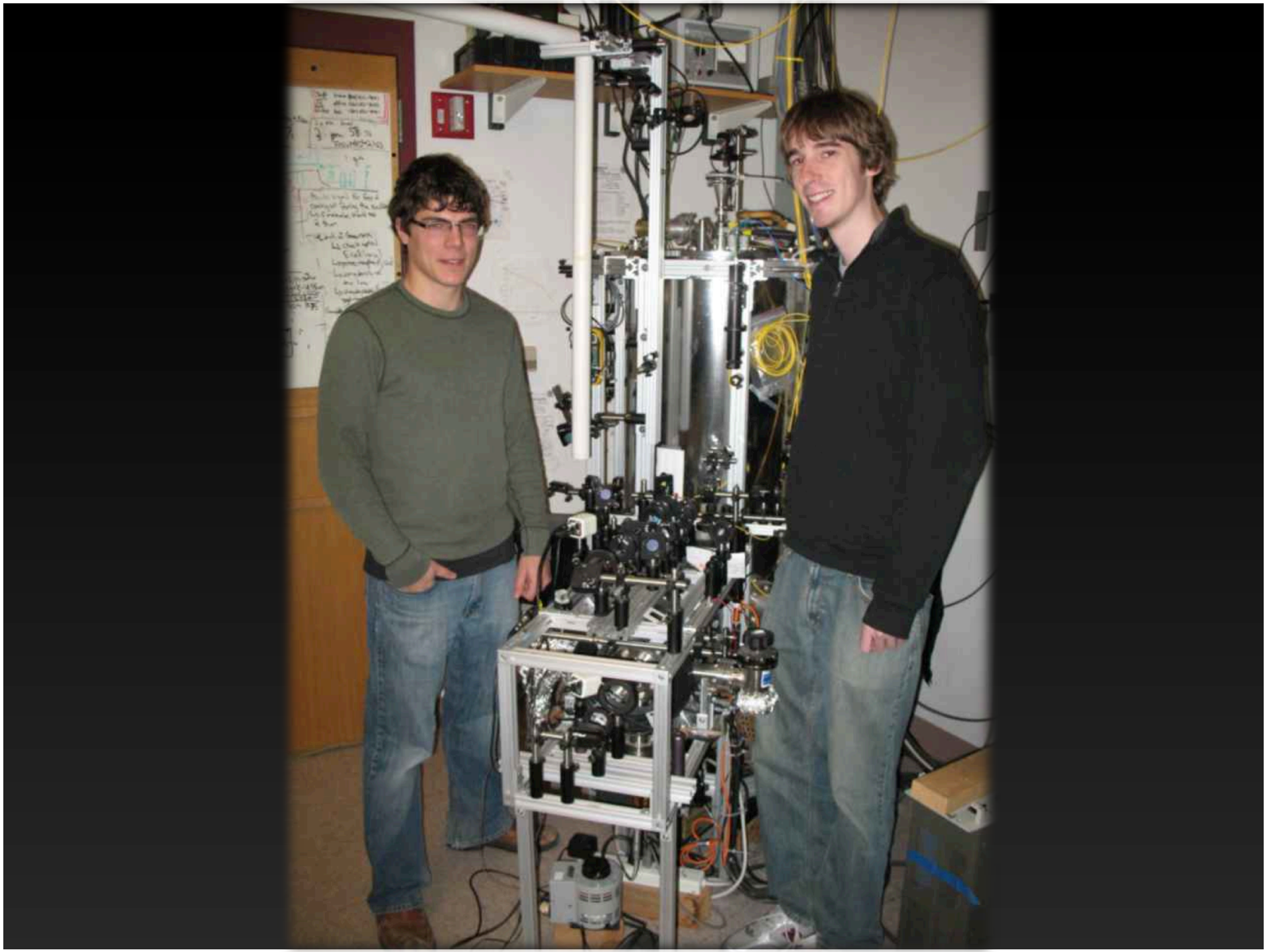




~$10,000



~$1,000




THE UNIVERSITY OF MICHIGAN
ARTES · SCIENTIA · VERITAS
1817


NSF

THANKS

QUESTIONS?