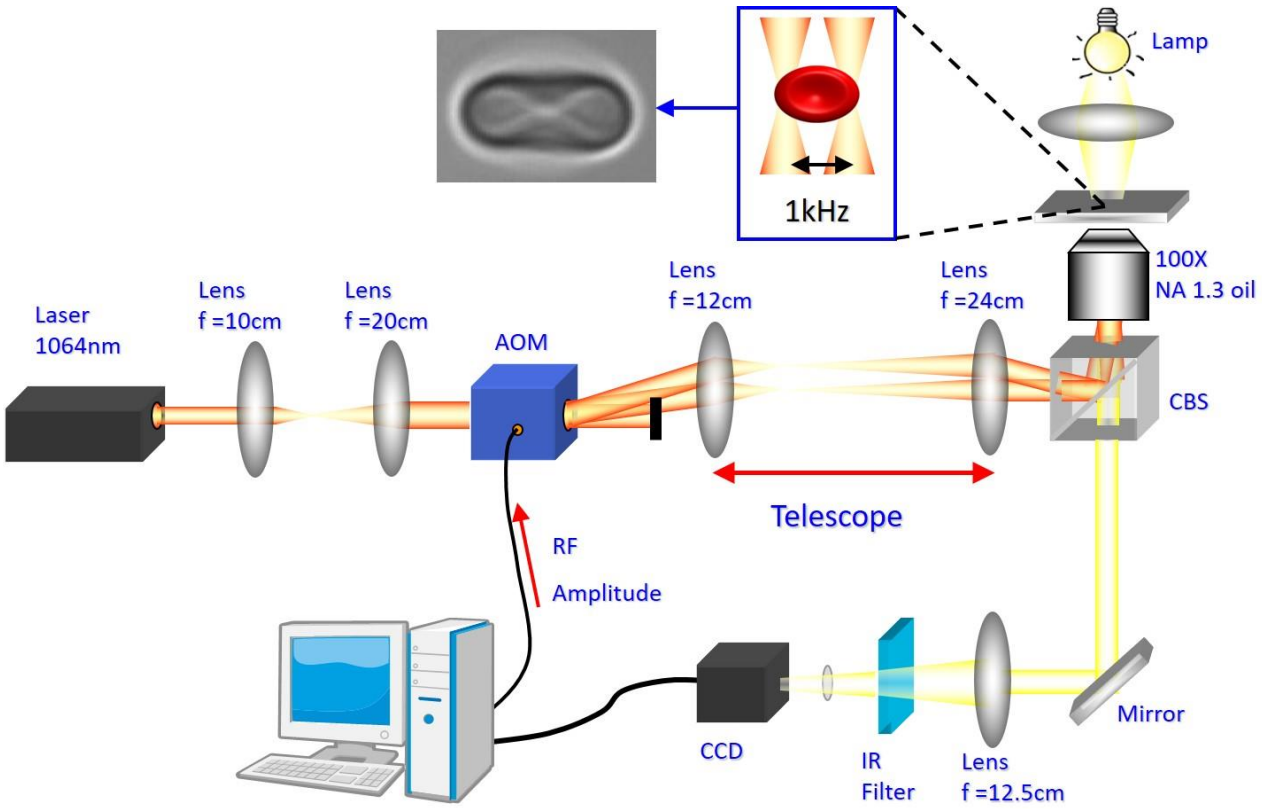
Optoelectronics (Training) Lab/OE Lab

I. Biophotonics

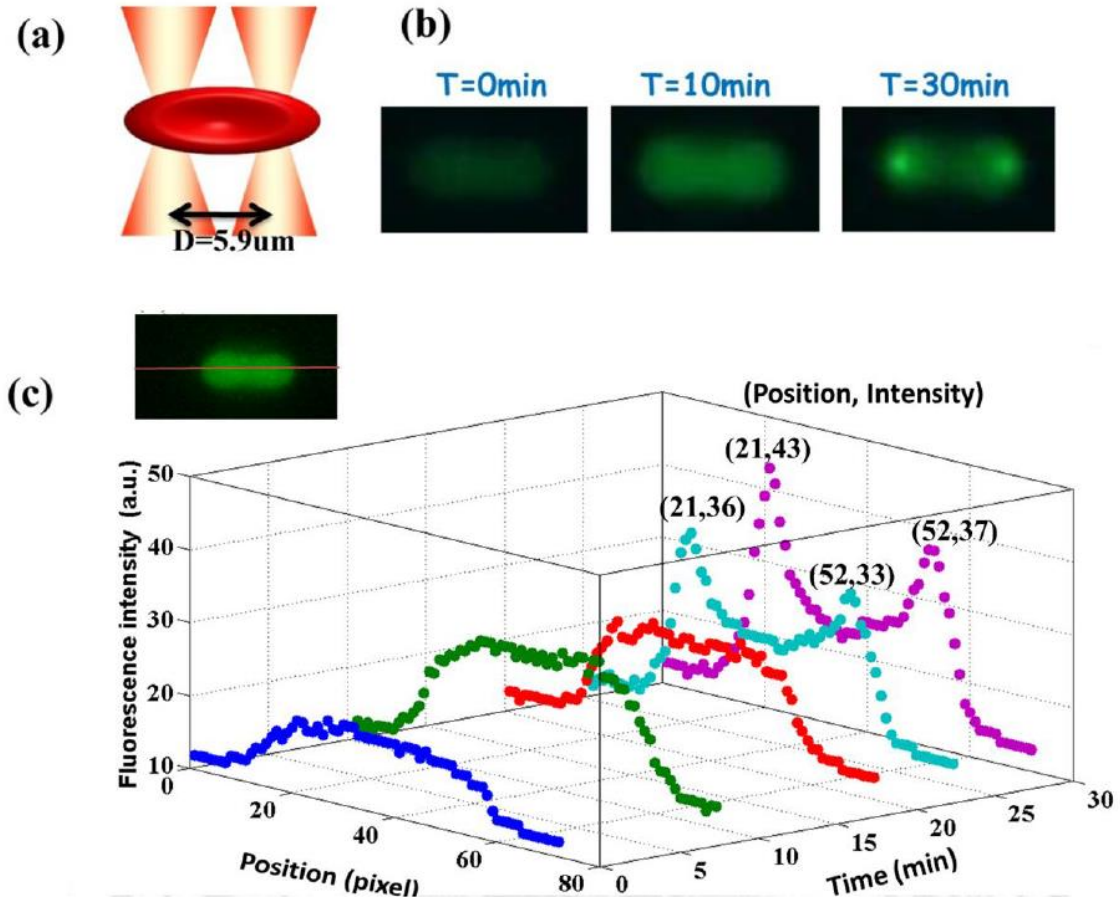
Jumping Optical Tweezers



Liao et al., Optics Express, vol.16, 1996-2004, 2008

Liao et al., J. Biophotonics, vol.7, No.10, 2014

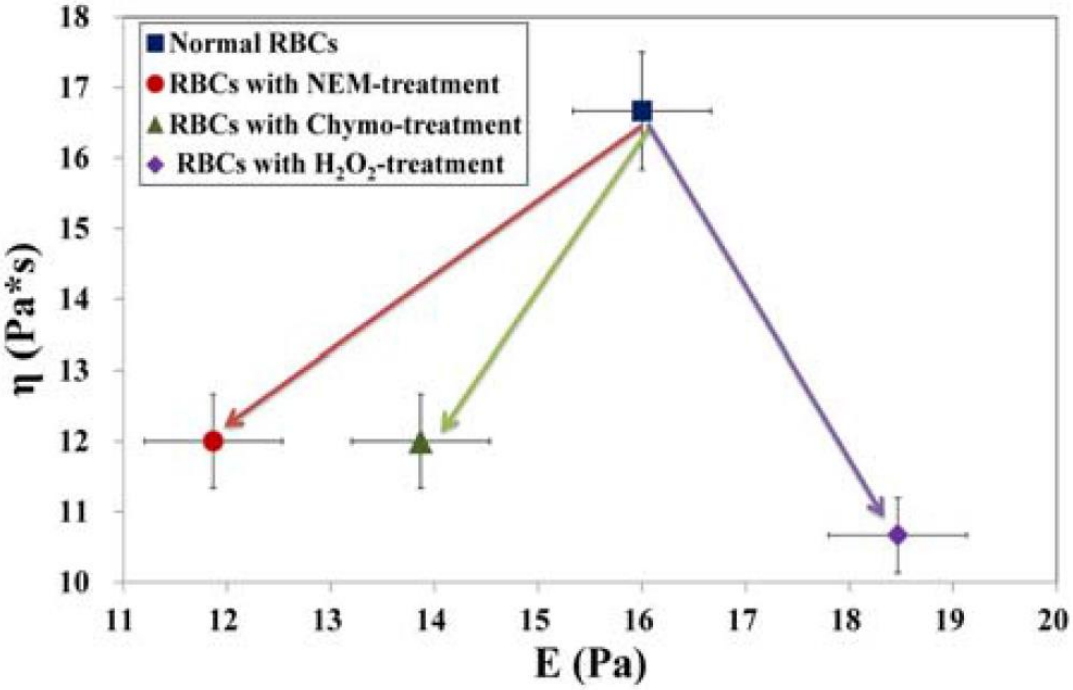
Optical Stretch-Induced Calcium Influx -Stretch Activated Ion Channel



FULL ARTICLE

Effect of N-ethylmaleimide, chymotrypsin, and H_2O_2 on the viscoelasticity of human erythrocytes: Experimental measurement and theoretical analysis

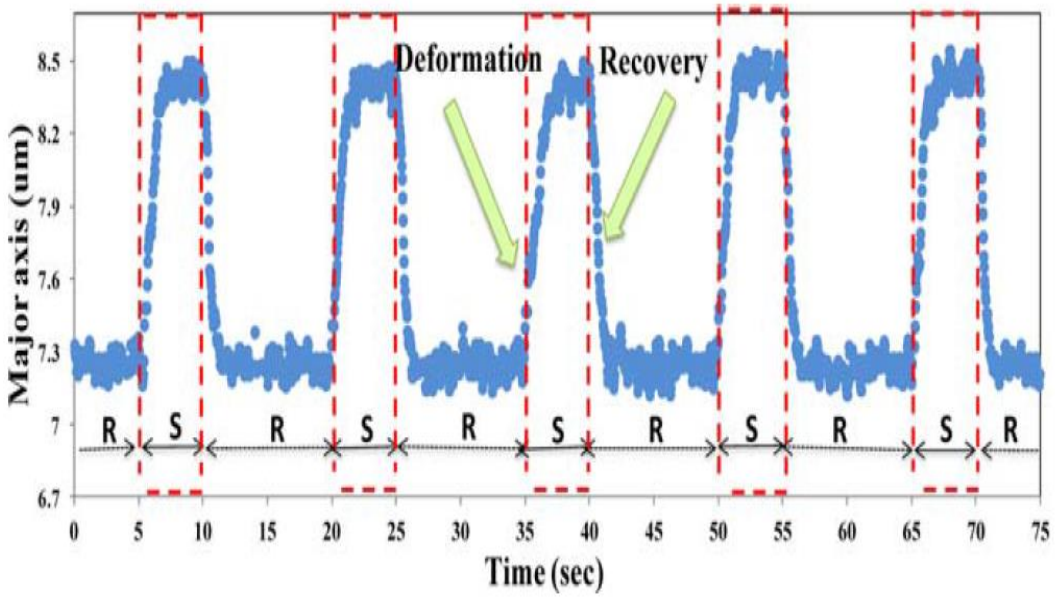
Yin-Quan Chen[1], *Chih-Wei Chen*[1], *Yu-Li Ni*[2], *Yu-Shan Huang*[1], *Orson Lin*[3], *Shu Chien*[4], *Lanping Amy Sung*[*,4], *and Arthur Chiou*[*,1,5]

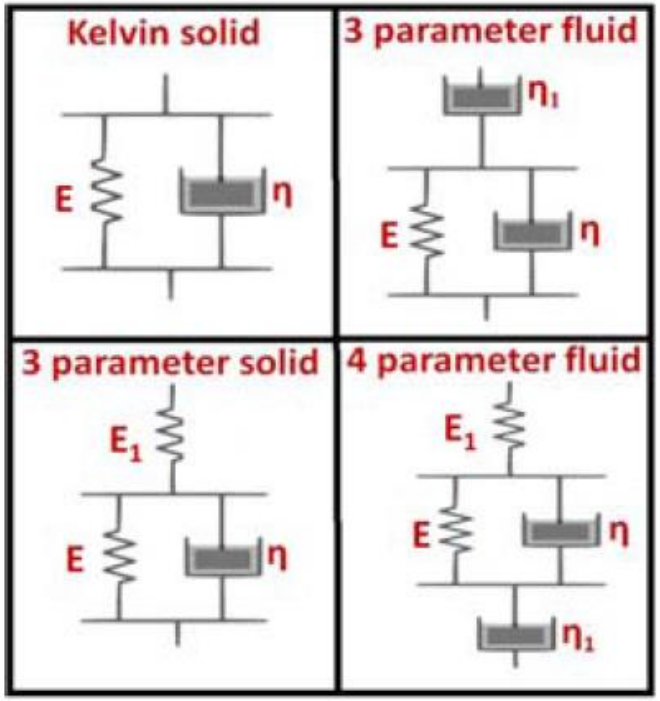


FULL ARTICLE

Effect of N-ethylmaleimide, chymotrypsin, and H_2O_2 on the viscoelasticity of human erythrocytes: Experimental measurement and theoretical analysis

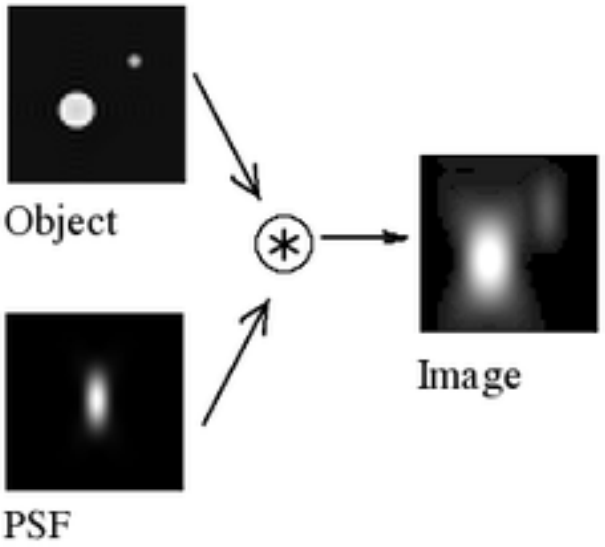
Yin-Quan Chen[1], *Chih-Wei Chen*[1], *Yu-Li Ni*[2], *Yu-Shan Huang*[1], *Orson Lin*[3], *Shu Chien*[4], *Lanping Amy Sung*[*,4], *and Arthur Chiou*[*,1,5]

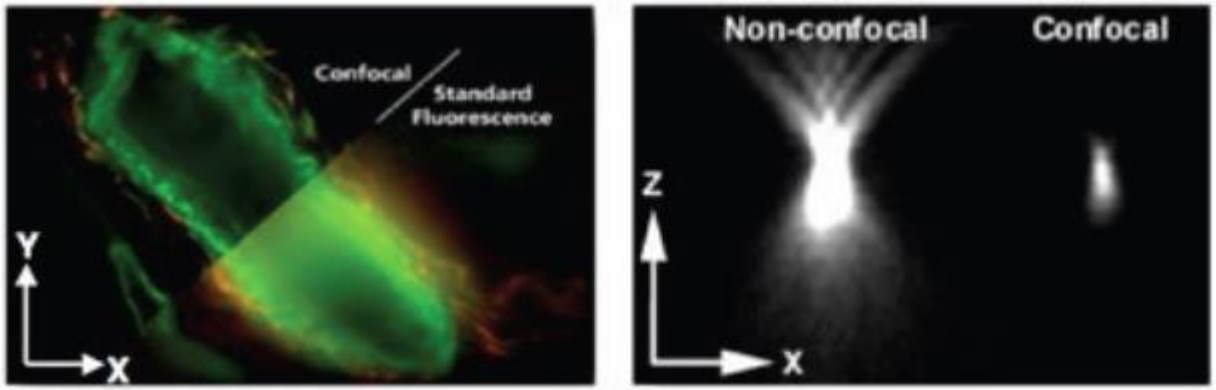




II. Imaging

Point Spread Function (PSF) and Convolution Image

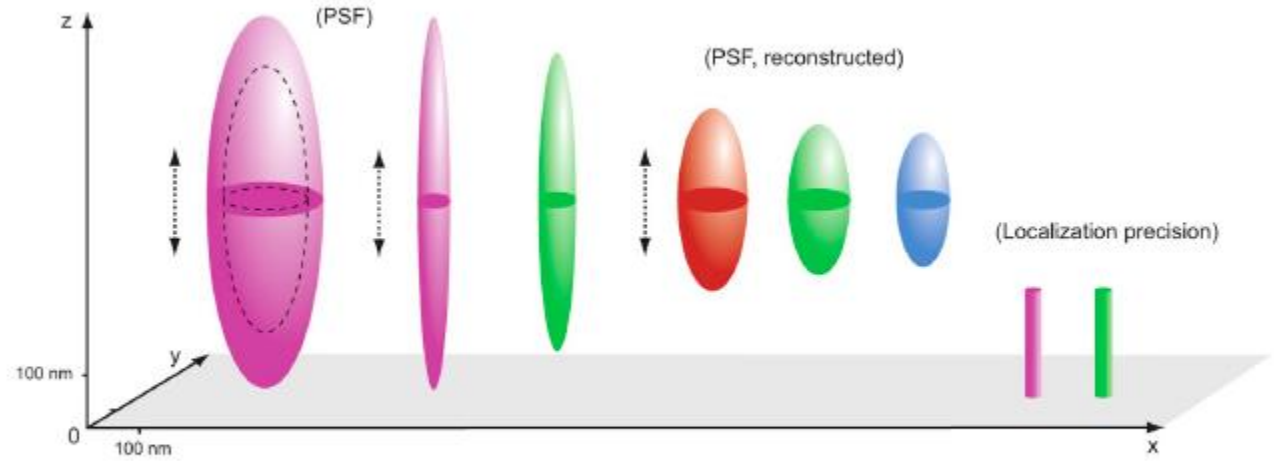




http://zeiss-campus.magnet.fsu.edu/articles/superresolution/introduction.html

Point Spread Function Table

	CLSM	STED	CW-STED	3D-SIM			PALM/STORM	
~λem [nm]	460-670	670	520	620	520	460	670	520



$\sim D_{x,y}$ [nm]	180-250	60	70	130	110	100	30
$\sim D_z$ [nm]	500-700	700	560	340	280	250	140 (TIRF-range)
$\sim V_{x,y,z}$ [$*10^{-3}$ µm^3]	10-23	1.3	1.5	3.0	1.8	1.3	0.1

J. Cell Biol. Vol. 190 No. 2 165–175

Photon-switch and Localization of Single Molecular

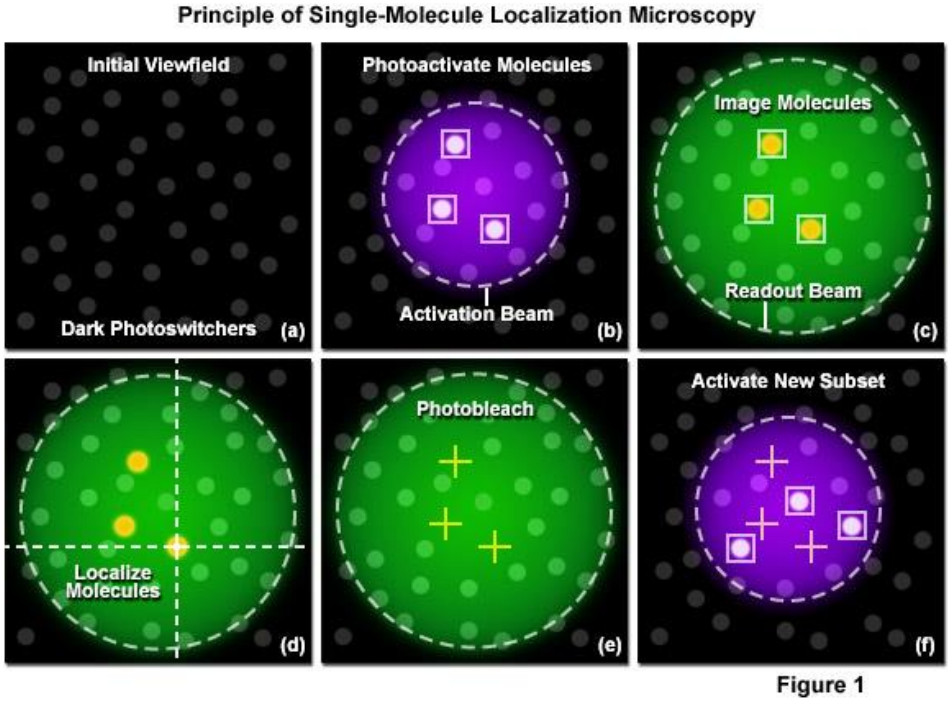


Figure 1

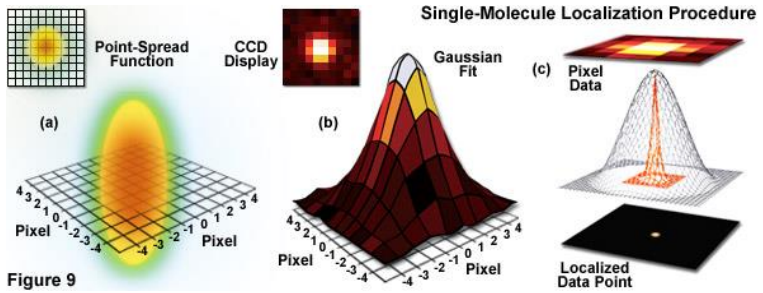
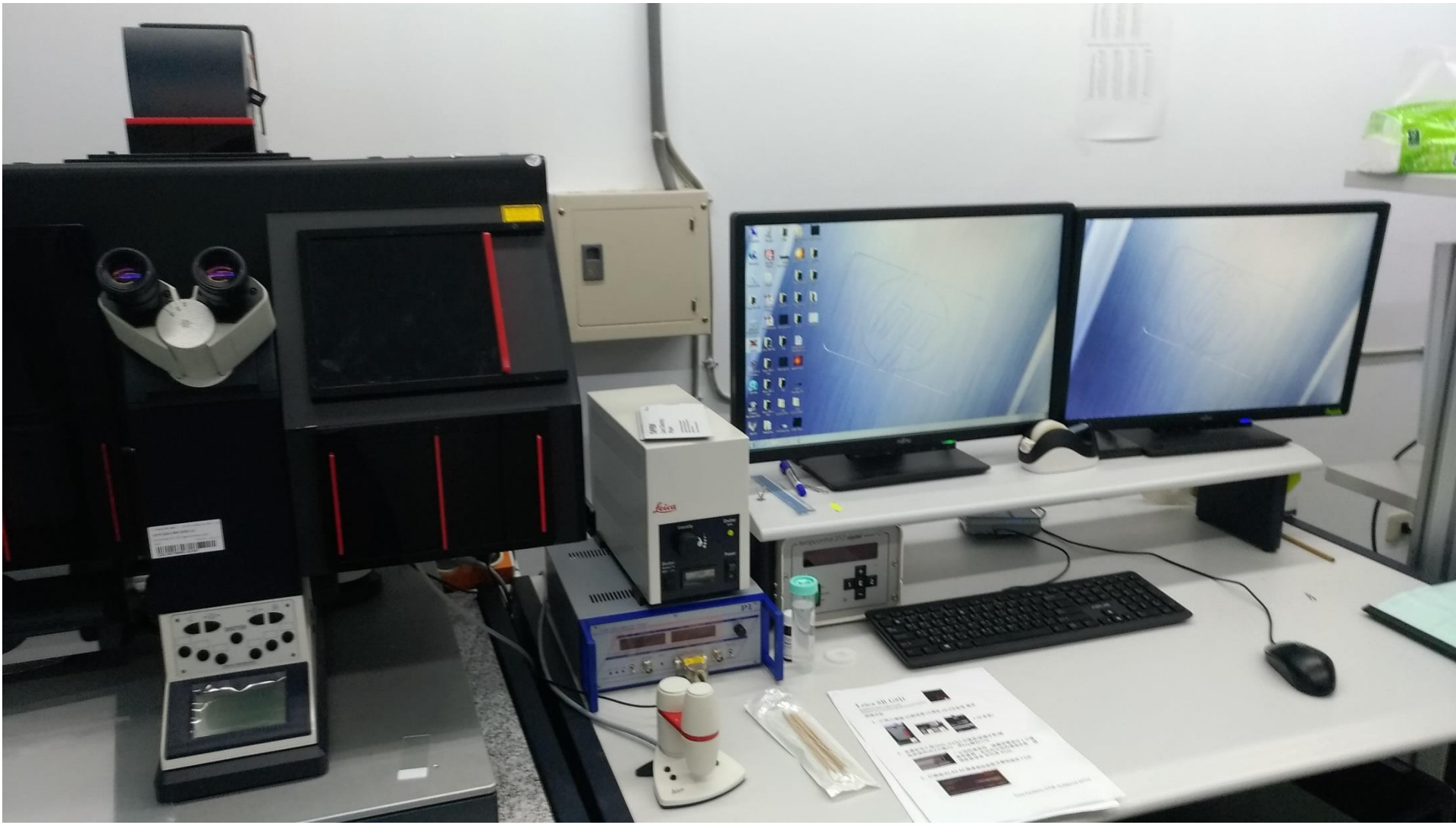
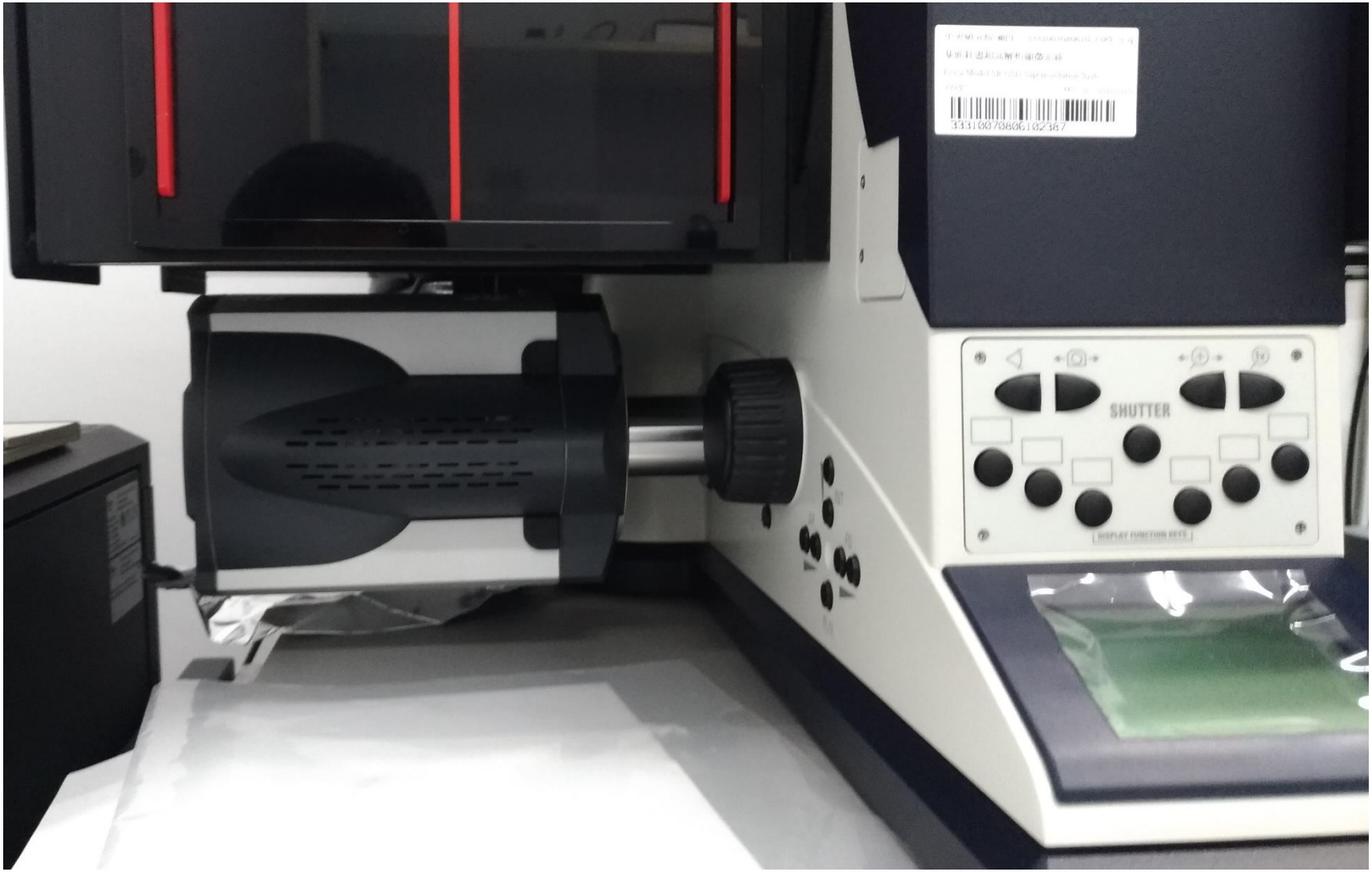


Figure 9

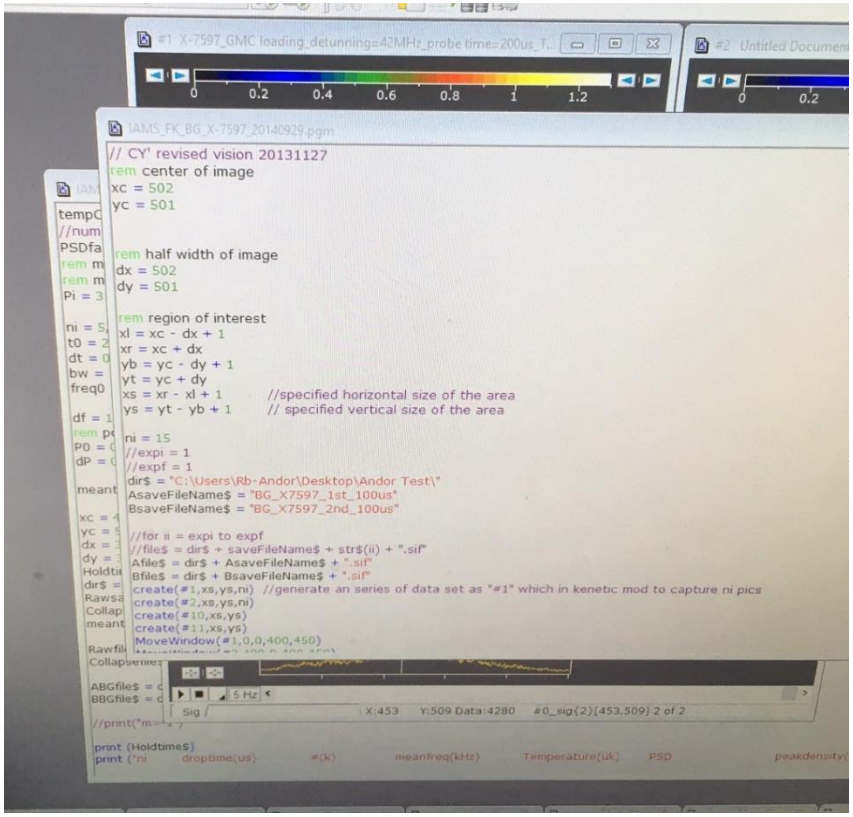
http://zeiss-campus.magnet.fsu.edu/articles/superresolution/introduction.html


Leica
PI


SHUTTER

Single-photon Sensitive EMCCD

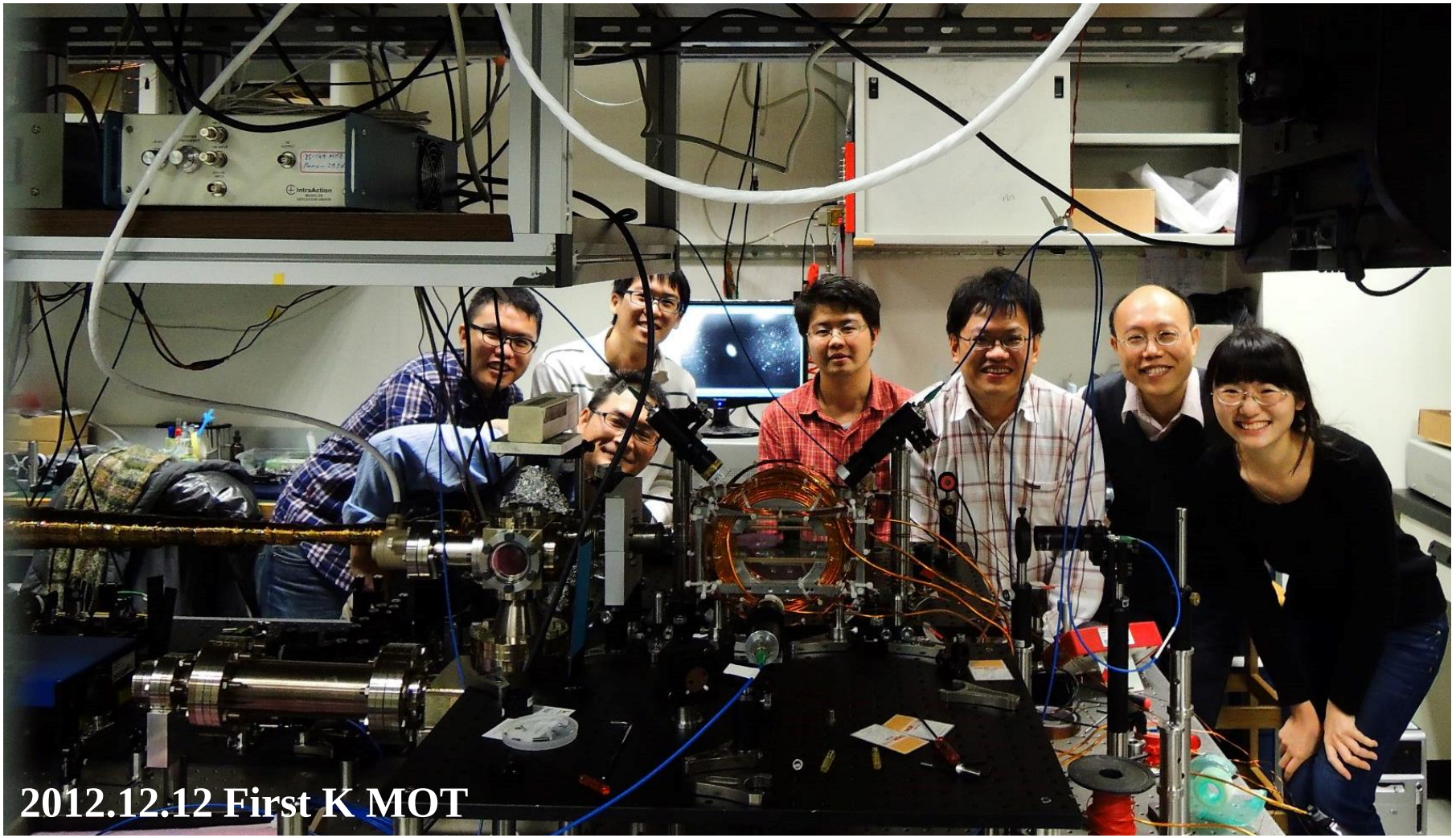
Andor ixon 888



Andor Basic

III. Lasers

Atomic, Molecular, and Optical Physics (AMO)



2012.12.12 First K MOT

March 1, 2007 / Vol. 32, No. 5 / OPTICS LETTERS

Cesium $6S_{1/2} \rightarrow 8S_{1/2}$ two-photon-transition-stabilized 822.5 nm diode laser

Chun-Yen Cheng, Chien-Ming Wu, Guan-Bo Liao, and Wang-Yau Cheng

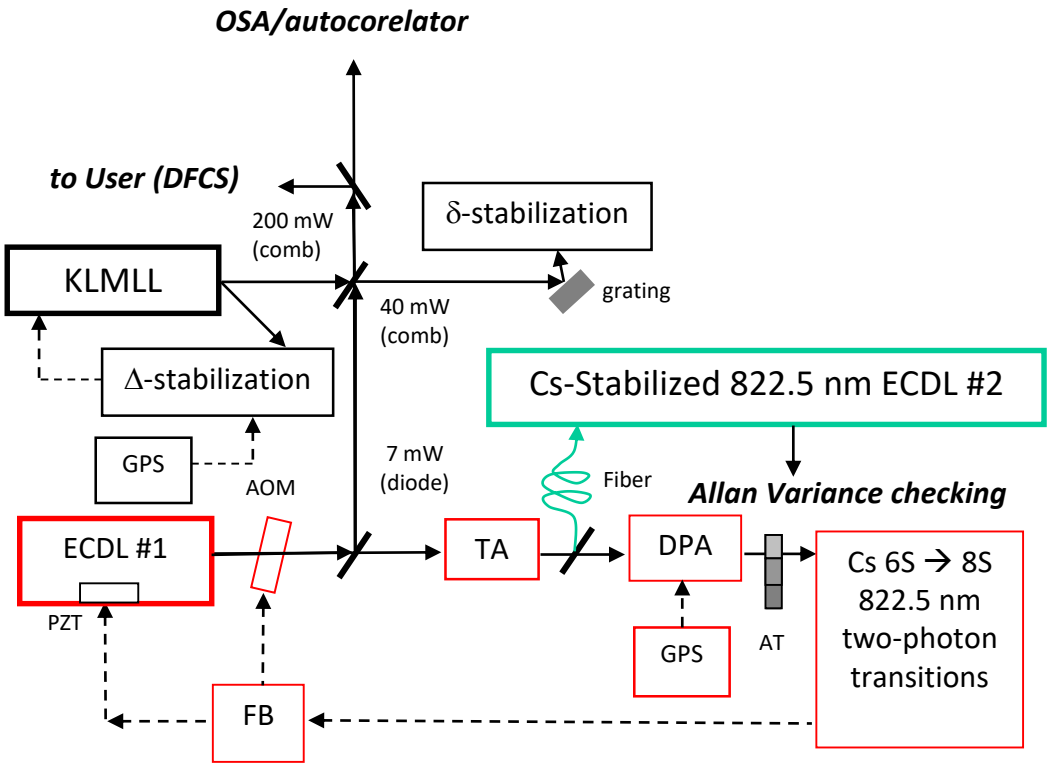
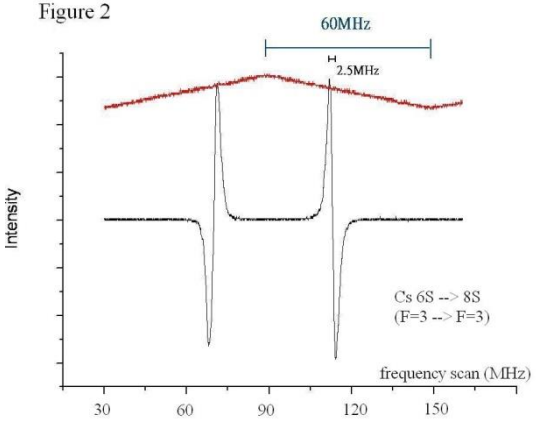
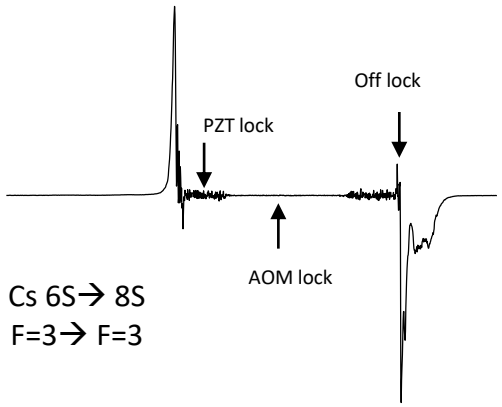
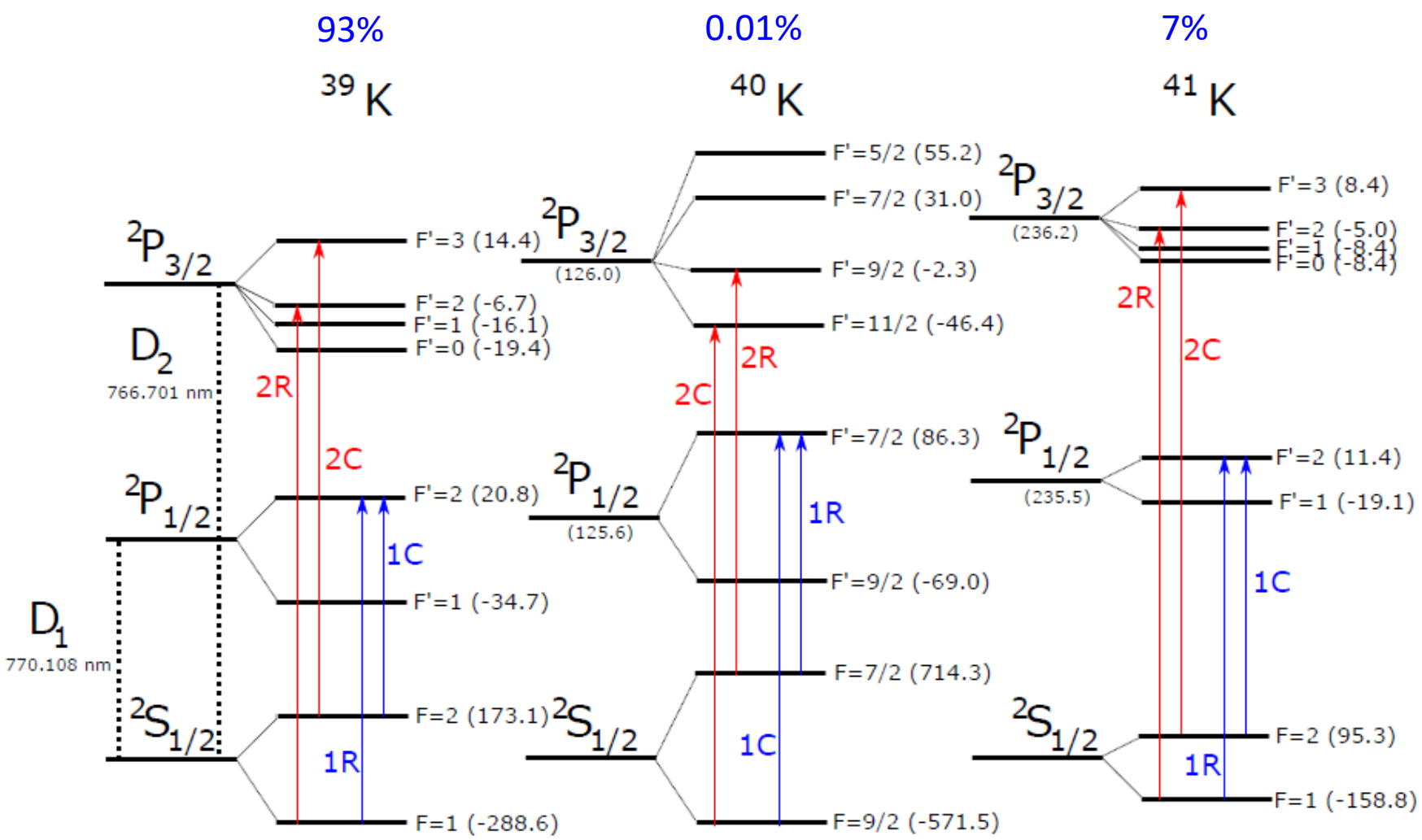


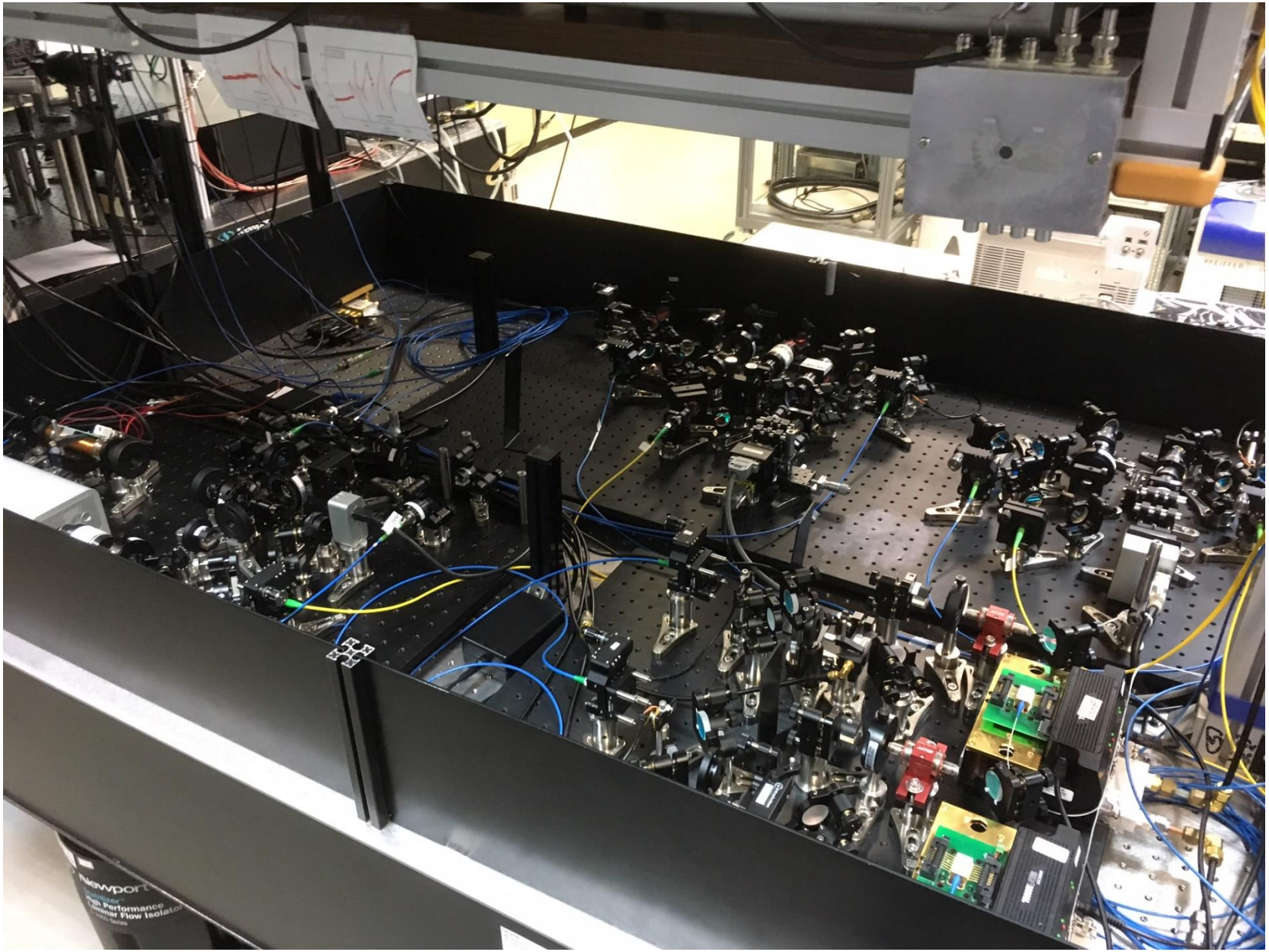
Figure 2

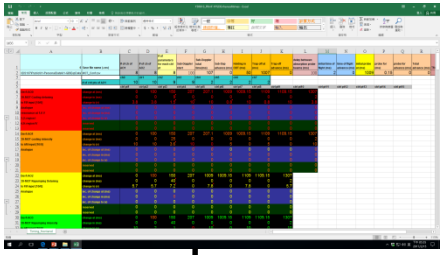






Ref: M. Tarnowski, Thesis (2015).





Timing Data

Analogue Output

Digital Output

NI PCI-6713

FPGA1

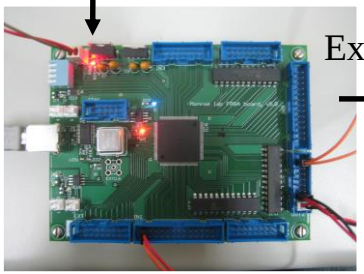
FPGA2

Synchronize

Synchronize

20 kHz TTL

External Trigger



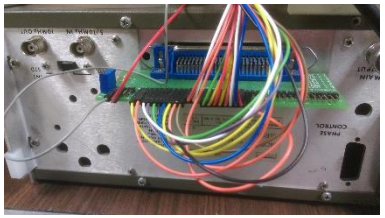
DE0Nano

NI PCI-6713

010000110....

Laser Frequency
Laser Intensity
Magnetic Field

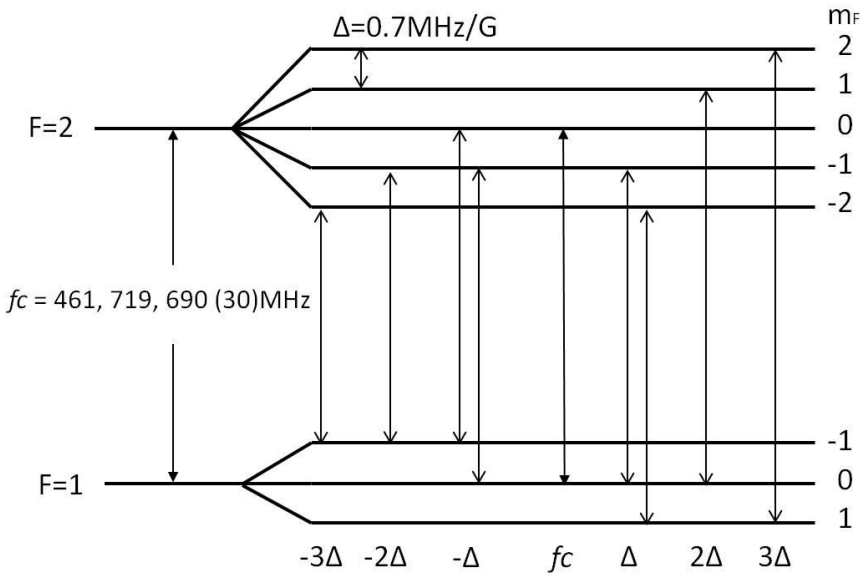
Camera Triggers
Mechanical Shutter
Digital Shutter

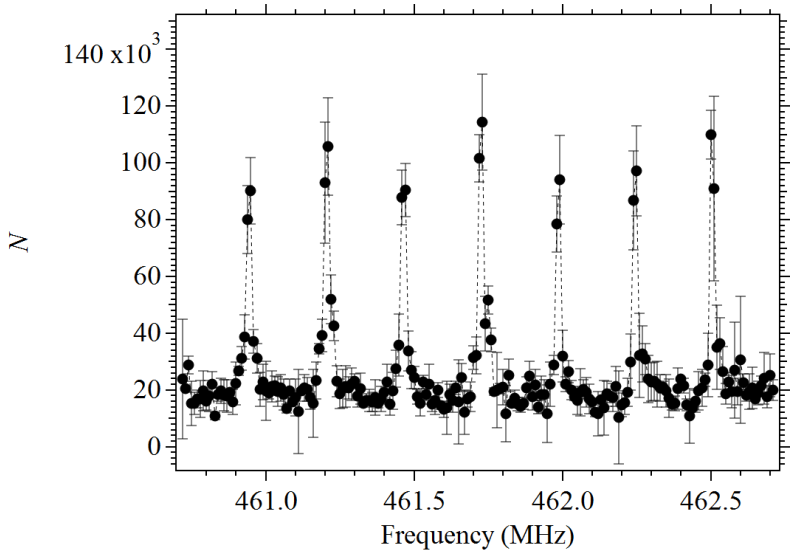


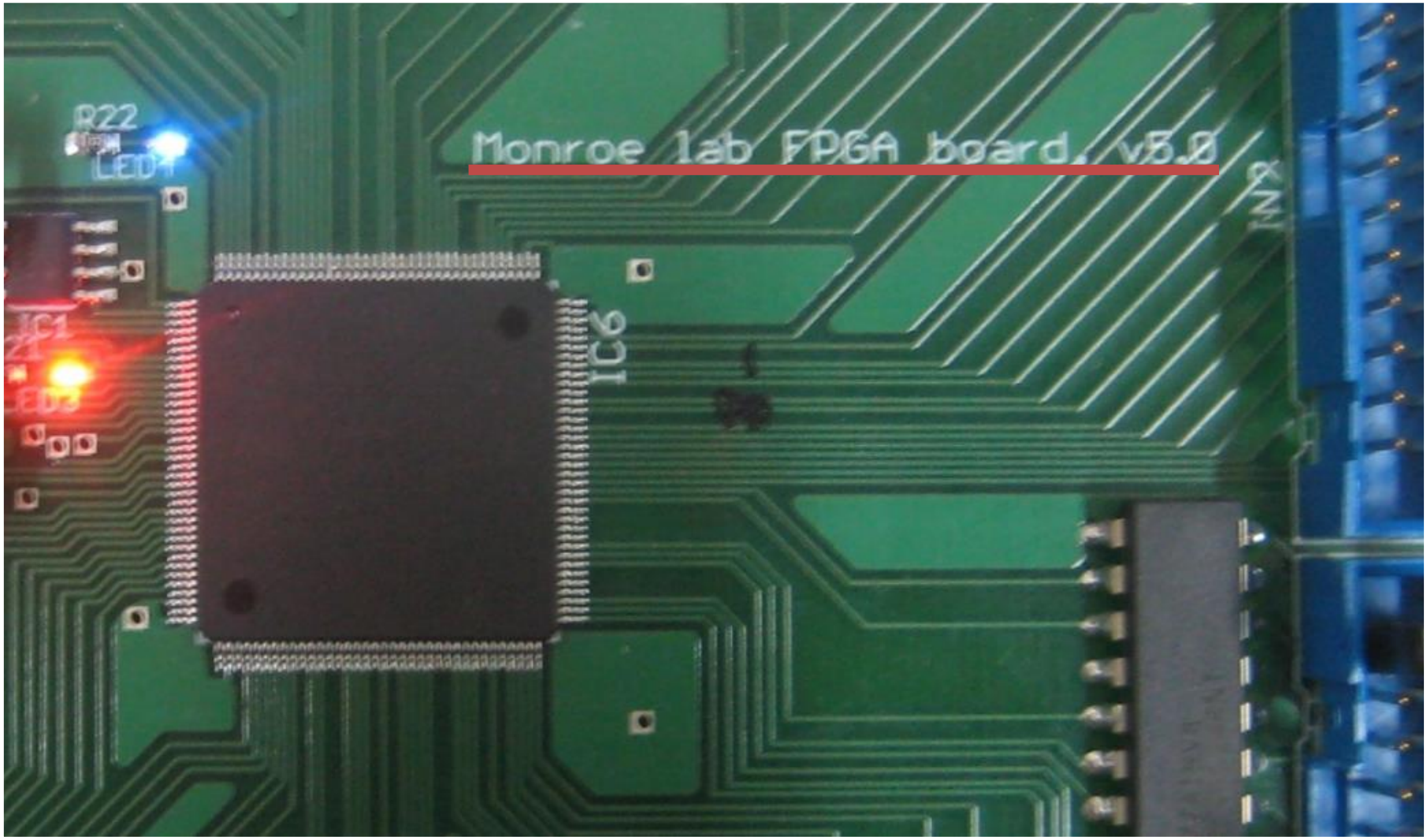
PTS-500
1~500Mhz

Spin State Control

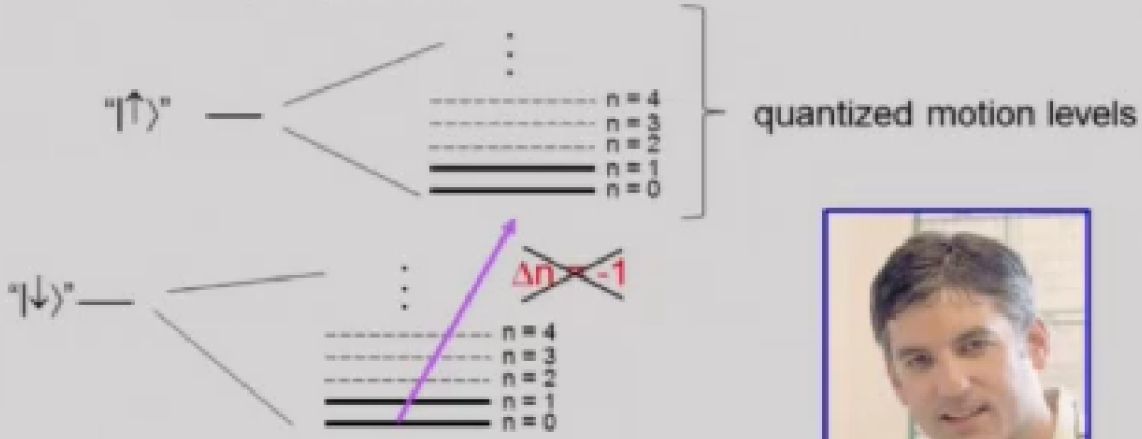
Spin population control by radio frequency (RF)






Monroe lab FPGA board, v3.0
R22
LED4
IC1
LED3
IC6

Quantum logic gates?



Chris Monroe

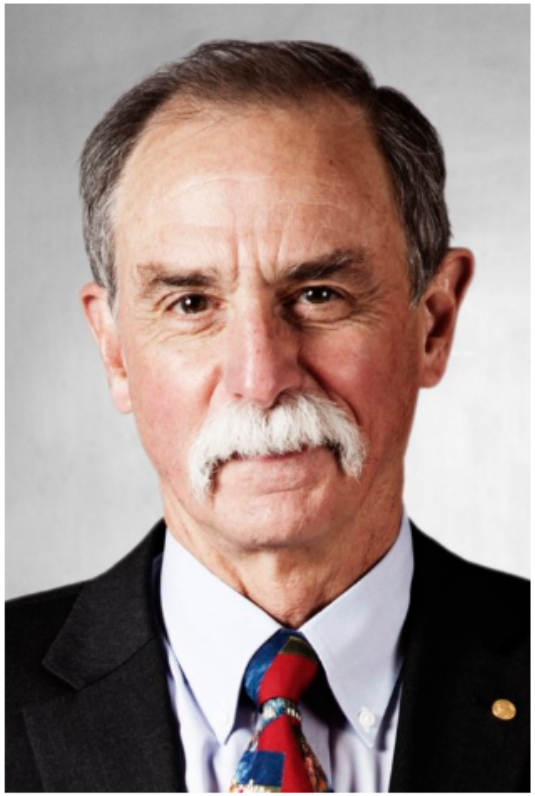
Simple example of quantum logic:

control bit (motion state)	target bit (atomic internal state)
n = 1	$\|\downarrow\rangle \rightarrow \|\uparrow\rangle$
n = 0	$\|\downarrow\rangle \rightarrow \|\downarrow\rangle$

"Controlled-NOT" gate between motion and atom's internal state

C. Monroe, D. M. Meekhof, B. E. King, W. M. Itano, and D. J. Wineland, Phys. Rev. Lett. 75, 4714 (1995).

David J. Wineland
Facts



© The Nobel Foundation. Photo: U. Montan

David J. Wineland
The Nobel Prize in Physics 2012

Born: 24 February 1944, Milwaukee, WI, USA

Affiliation at the time of the award: National Institute of Standards and Technology, Boulder, CO, USA, University of Colorado, Boulder, CO, USA

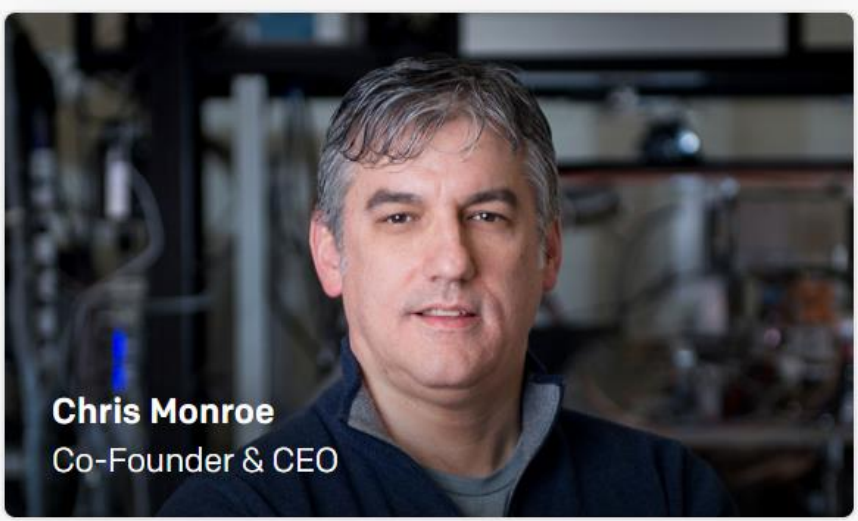
Prize motivation: "for ground-breaking experimental methods that enable measuring and manipulation of individual quantum systems."

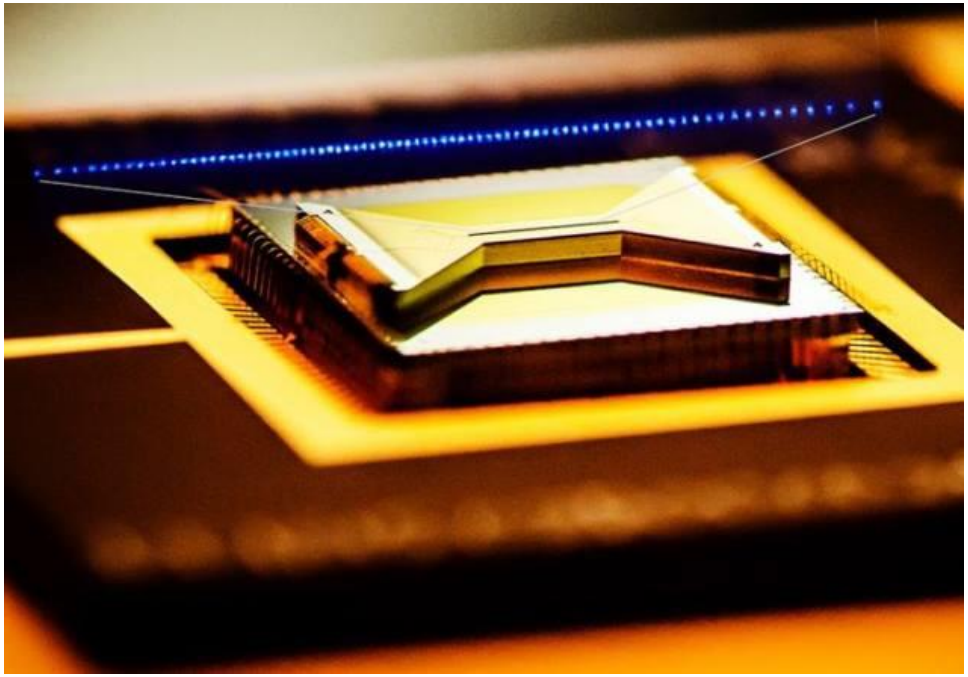
Ion Trap + Laser Cooling

Prize share: 1/2

Quantum Computing Startup

IONQ

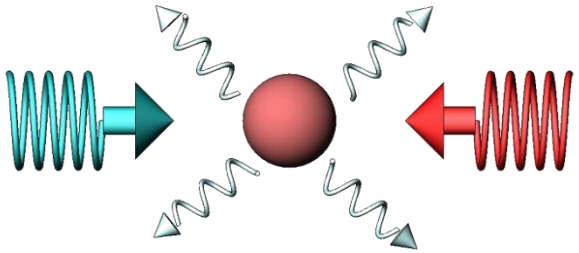


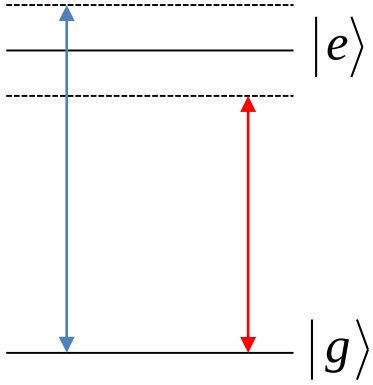


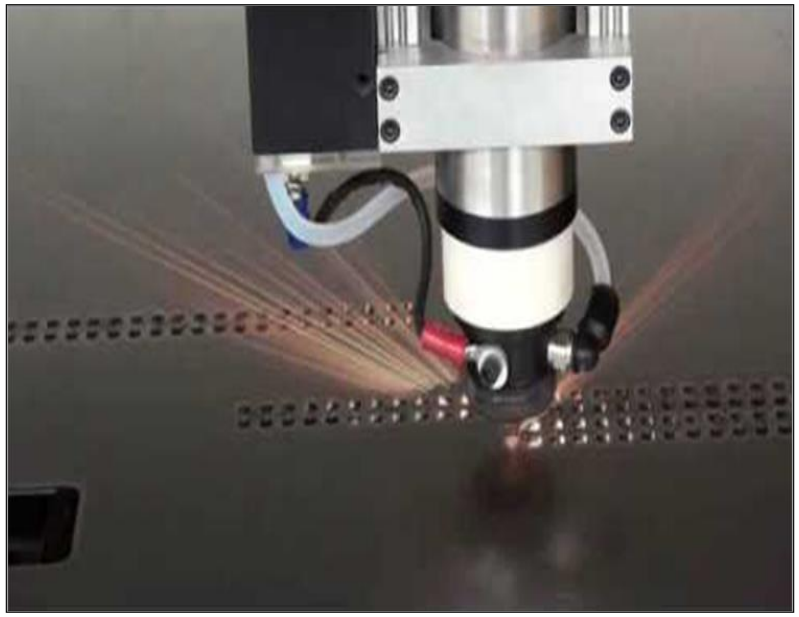
Headquartered	Founded	Employees	Computers
College Park, MD	2016	32	2

~ Thanks

Laser Heating V.S Laser Cooling



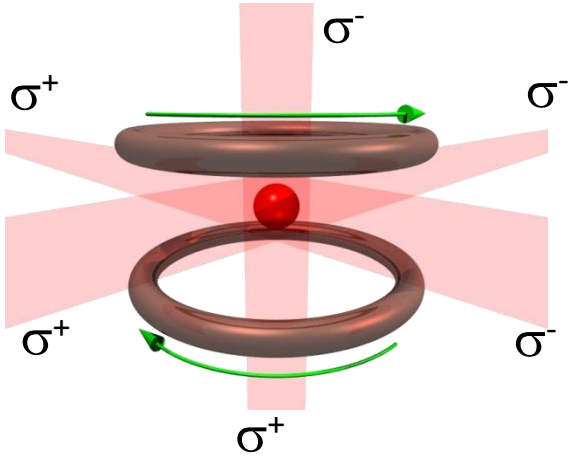


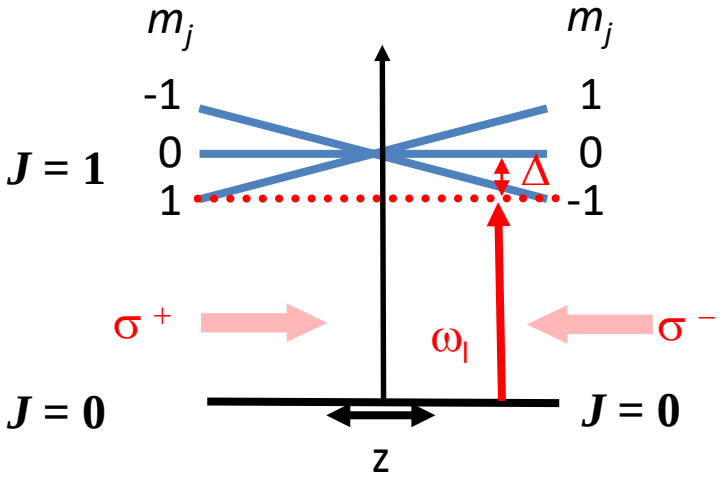


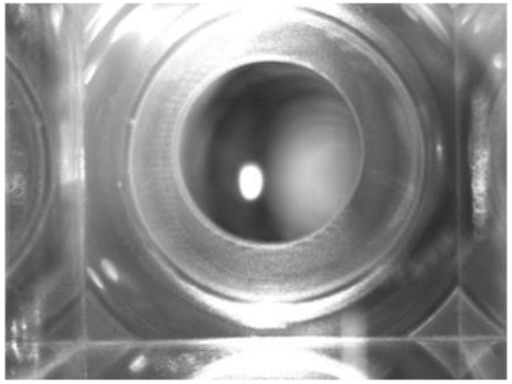
Peter Pringsheim, Lev D. Landau (1929)

A. Schawlow, T. W. Hansch (1975)

Magneto-Optical Trap

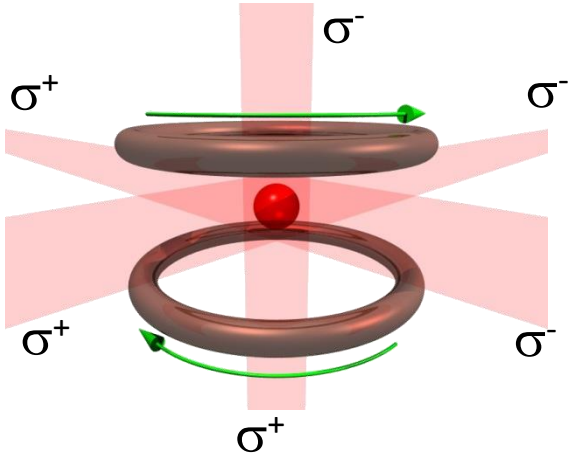


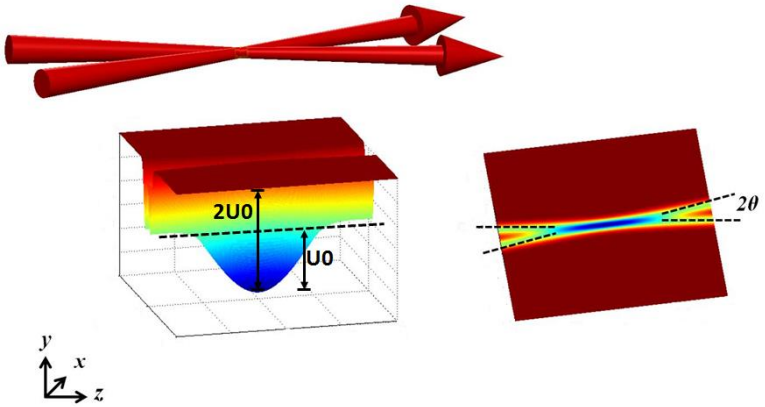




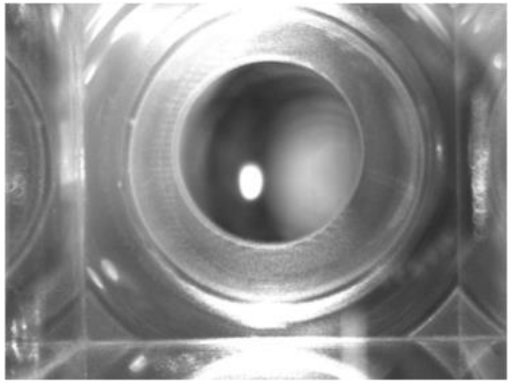
Magneto-Optical trap
(MOT, the bright spot)

Our experimental approach





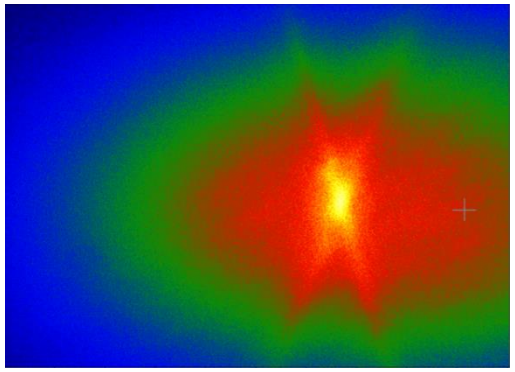
Liao et al., JOSA B (2017)



Magneto-Optical trap
(MOT, the bright spot)

Sub-Doppler Cooling

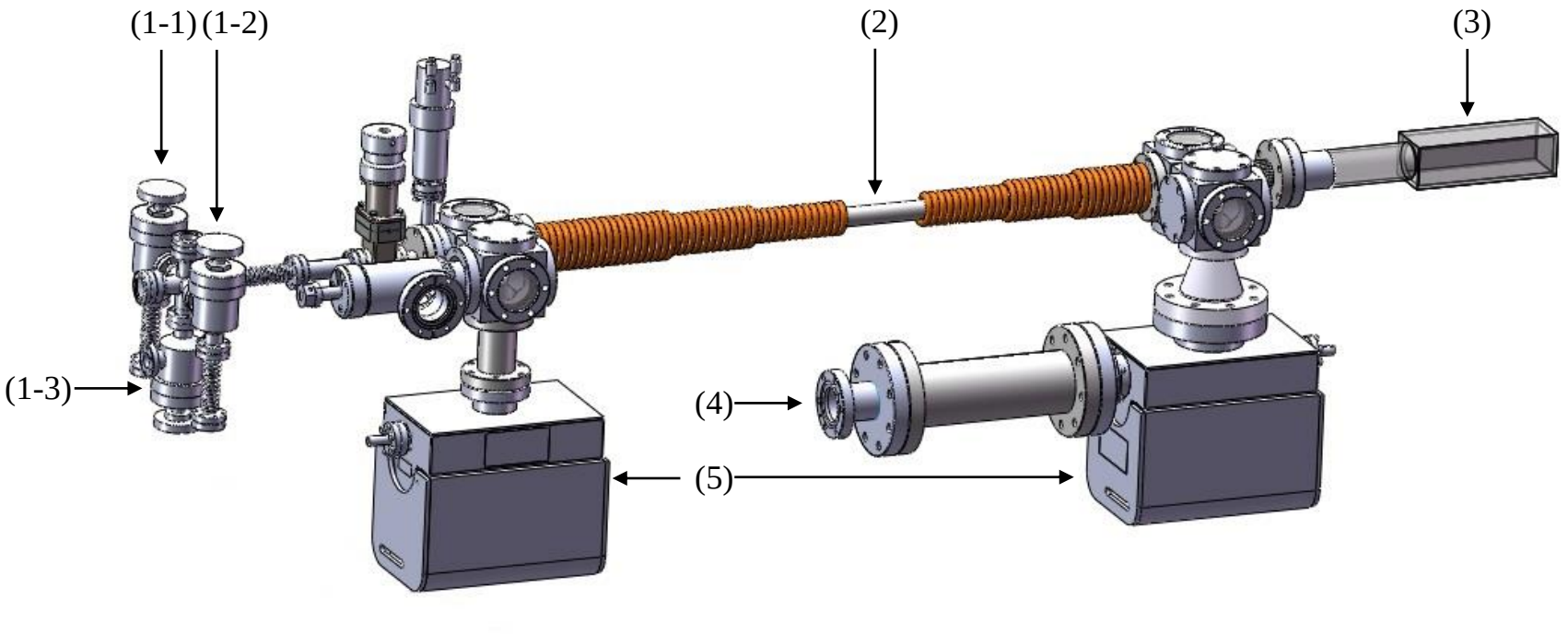
CMOT, $n > 10^{10}\ \mathrm{cm}^{-3}$
TDMOT, $T \sim 50\ \mu\mathrm{K}$
GMS, $T \sim 10\ \mu\mathrm{K}$



Optical dipole trap
(ODT, overlapped with MOT)

Vacuum System

~ $6*10^{-12}$ torr



(1-1) Rb Ampule
(1-2) K Ampule
(1-3) Valve

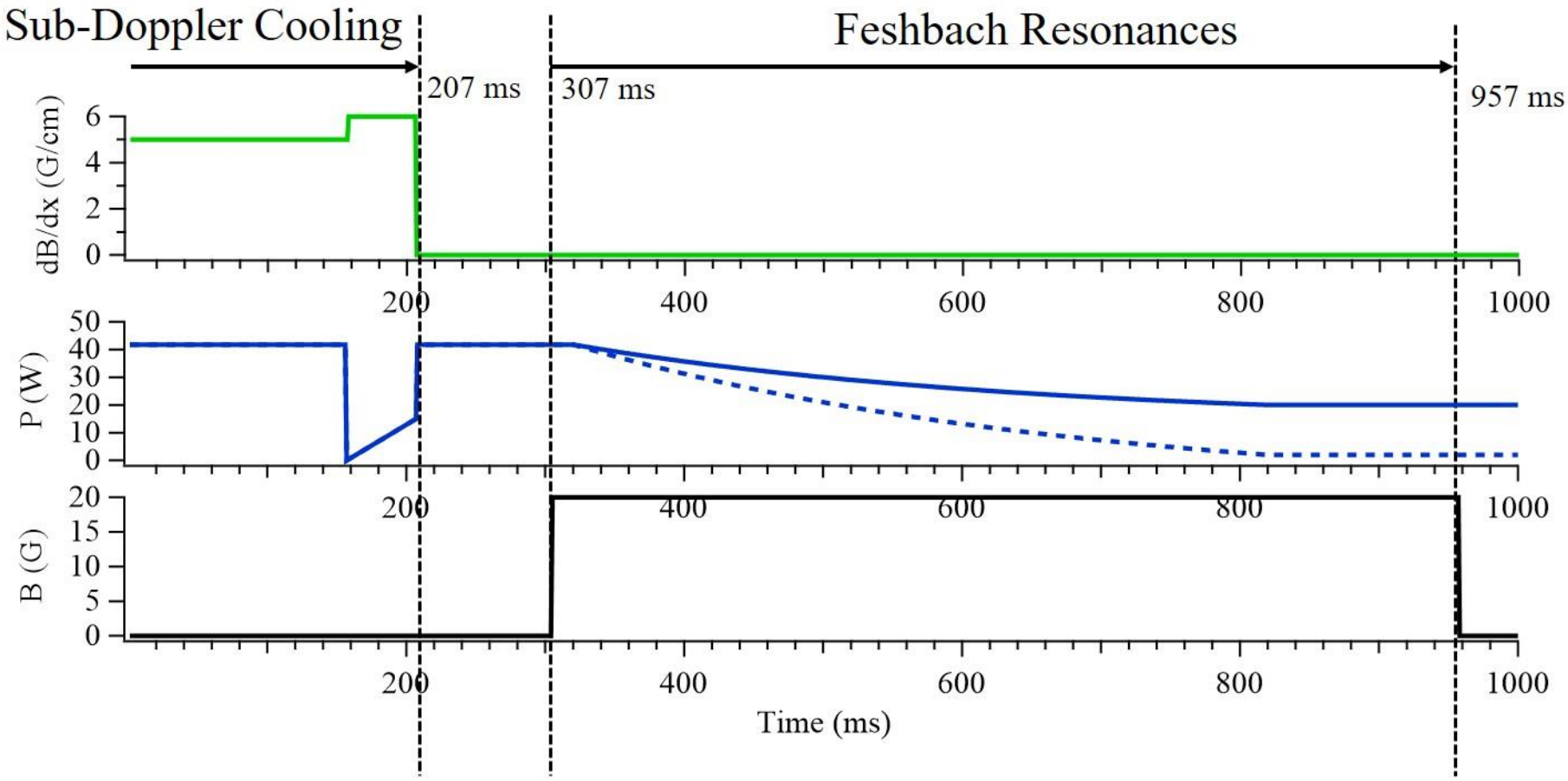
(2) Zeeman Slower
(3) Science Cell
(4) Titanium Sublimation Pump
(5) Ion Pump

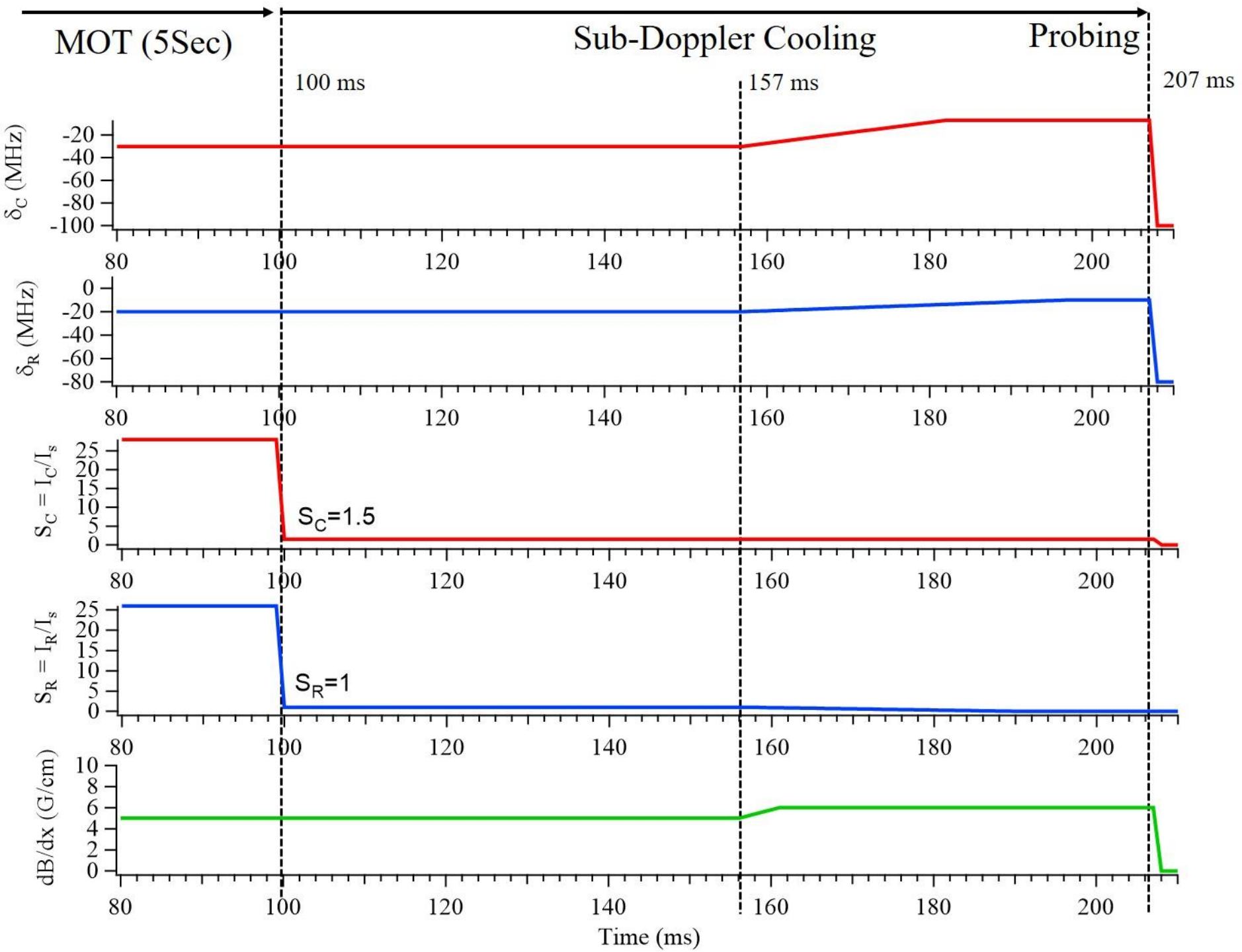
Potassium gas

- Trapping all spin states:
  - ^{39}K,^{41}K(Spin-1 boson)
  - ^{40}K(Spin-9/2 fermion)

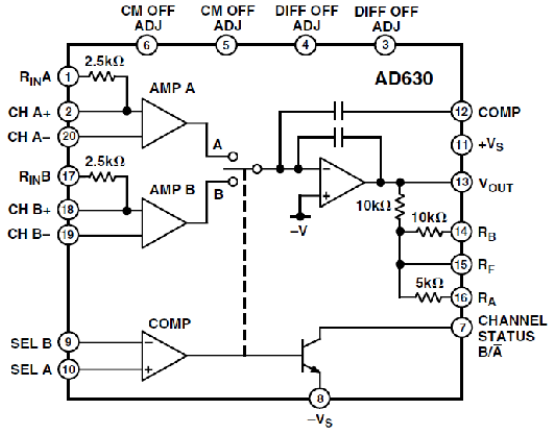
How Sharp of Your Lasers

	Resolution	
Laser Spectroscopy	cm^{-1} (~30 GHz)	Chemical Analysis
High Resolution Laser Spectroscopy	GHz	Lamb Shift Four-Wave Mixing
Ultra-high Resolution Laser Spectroscopy	< MHz	Laser Cooling Hyperfine Structure Length Standard

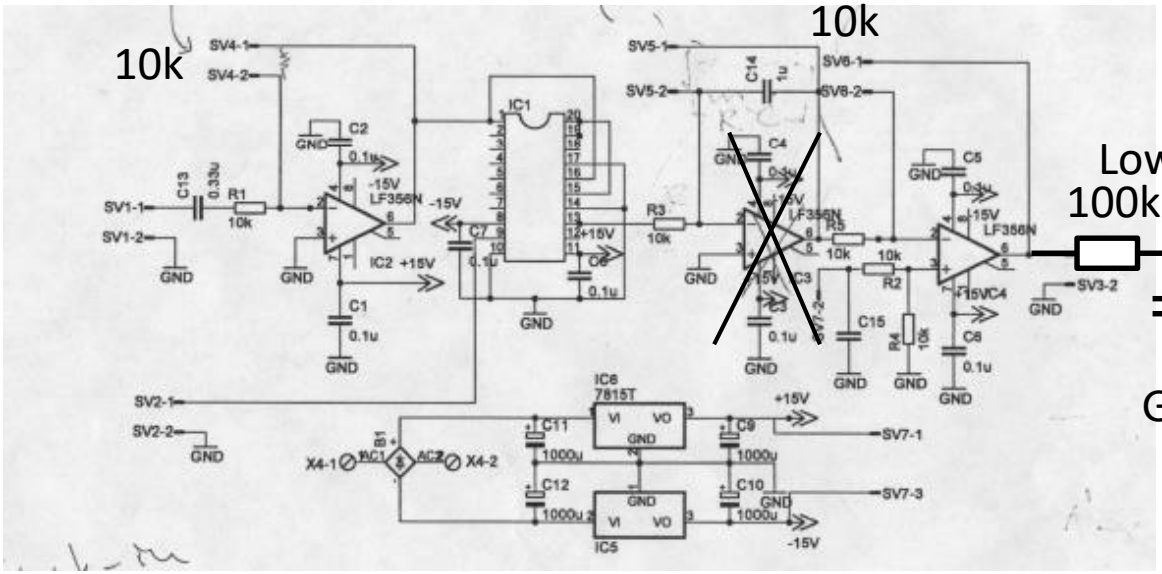

Sub-Doppler Cooling
Feshbach Resonances
207 ms
307 ms
957 ms
dB/dx (G/cm)
P (W)
B (G)
Time (ms)


MOT (5Sec)
Sub-Doppler Cooling
Probing
100 ms
157 ms
207 ms
δC (MHz)
δR (MHz)
SC = IC/Is
SC=1.5
SR = IR/Is
SR=1
dB/dx (G/cm)
Time (ms)

Simple Lock-in Amplifier



AD630



Low-Pass Filter

100k

output

0.1u

GND

REVIEW OF SCIENTIFIC INSTRUMENTS **78**, 026101 (2007)

Enhanced laser shutter using a hard disk drive rotary voice-coil actuator

R. E. Scholten[a)]
School of Physics, University of Melbourne, Victoria 3010, Australia