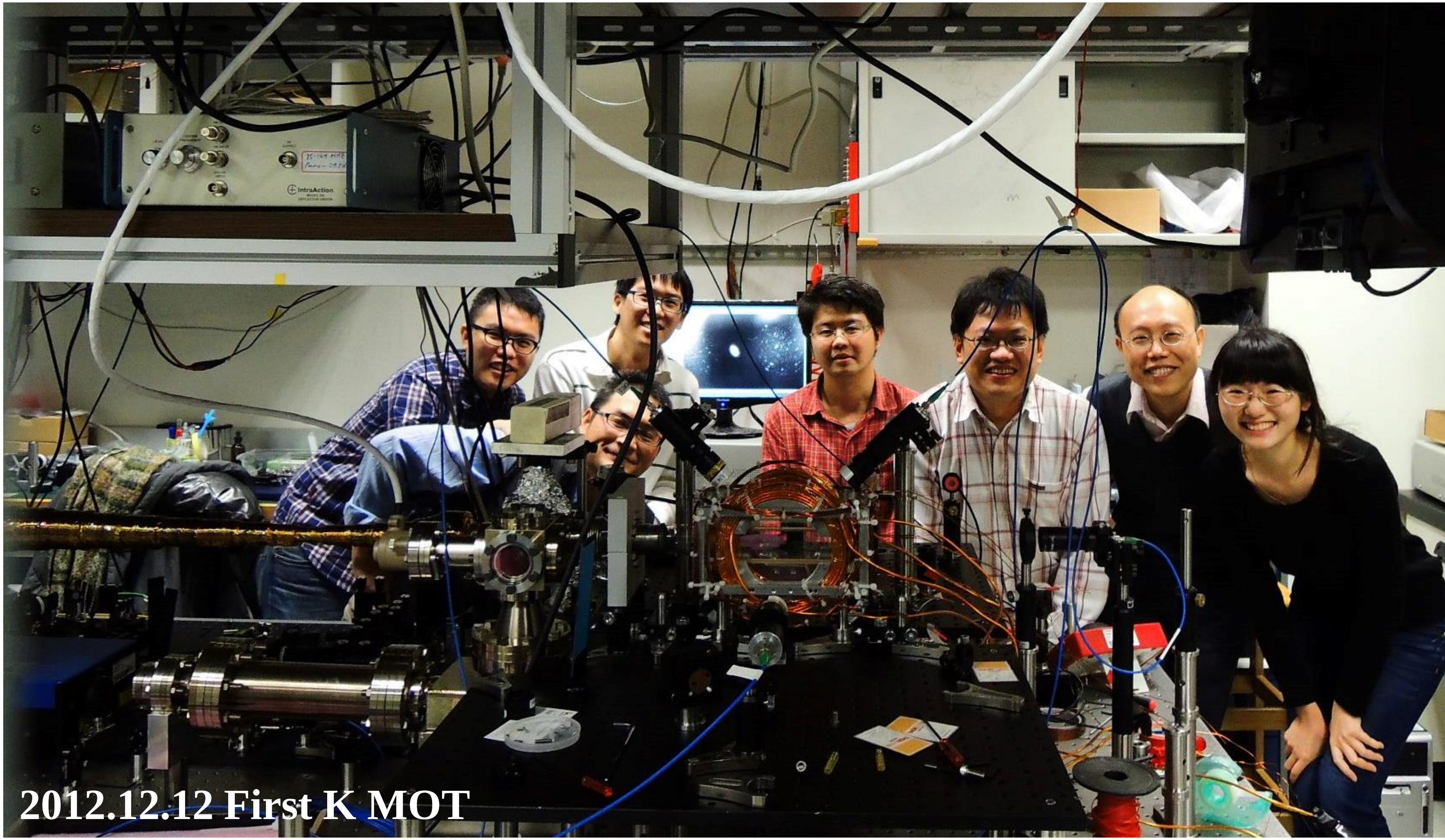
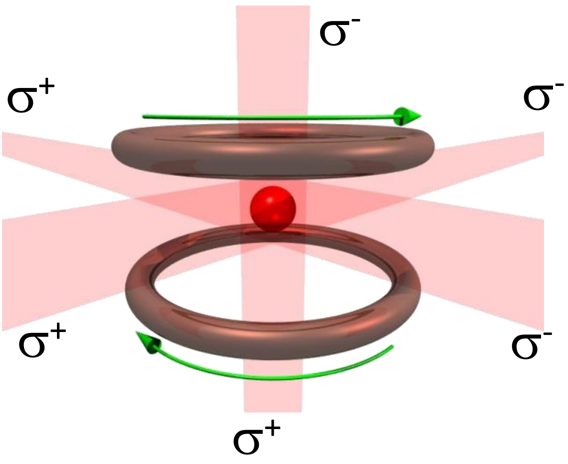
Knowledge and training related to optoelectronics

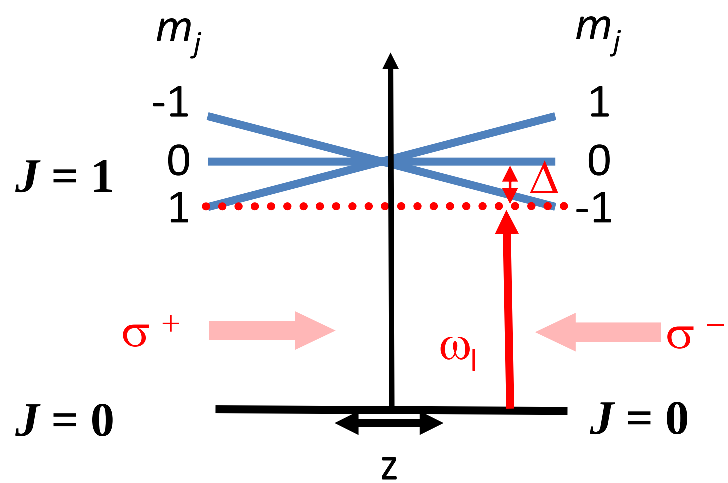
Atomic, Molecular, and Optical Physics (AMO)

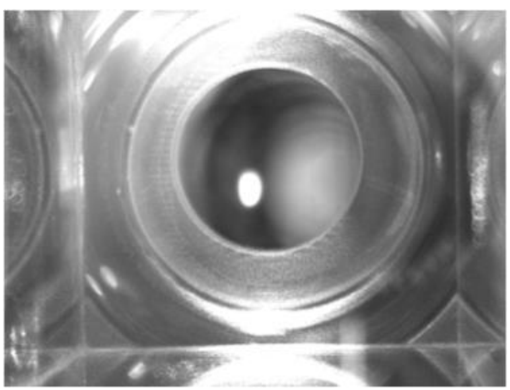


2012.12.12 First K MOT

Magneto-Optical Trap

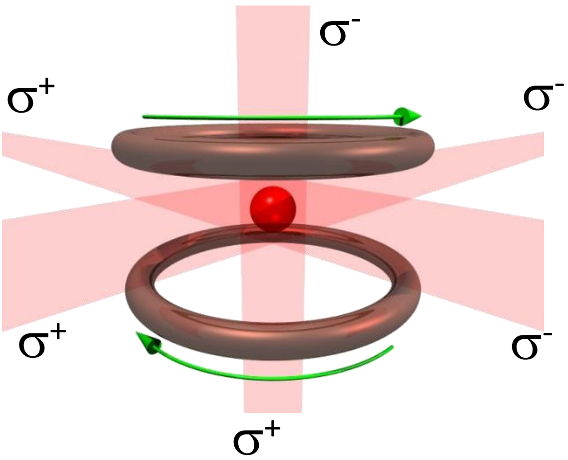


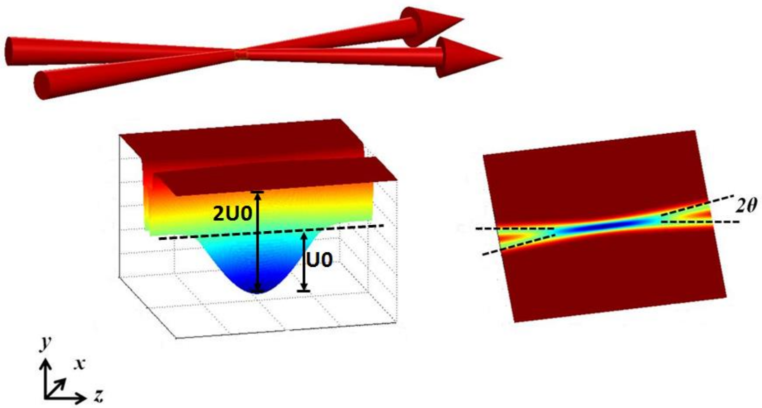




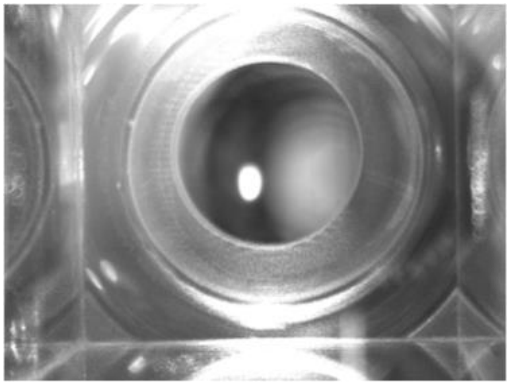
Magneto-Optical trap
(MOT, the bright spot)

Our experimental approach





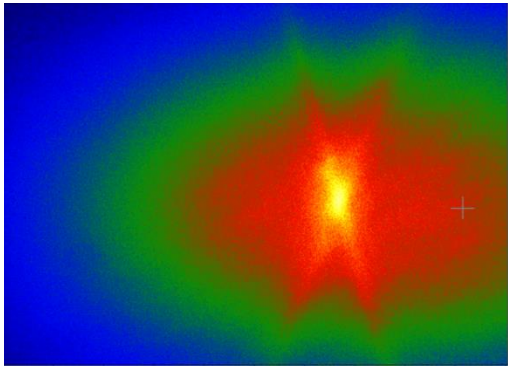
Liao et al., JOSA B (2017)



Magneto-Optical trap
(MOT, the bright spot)

Sub-Doppler Cooling

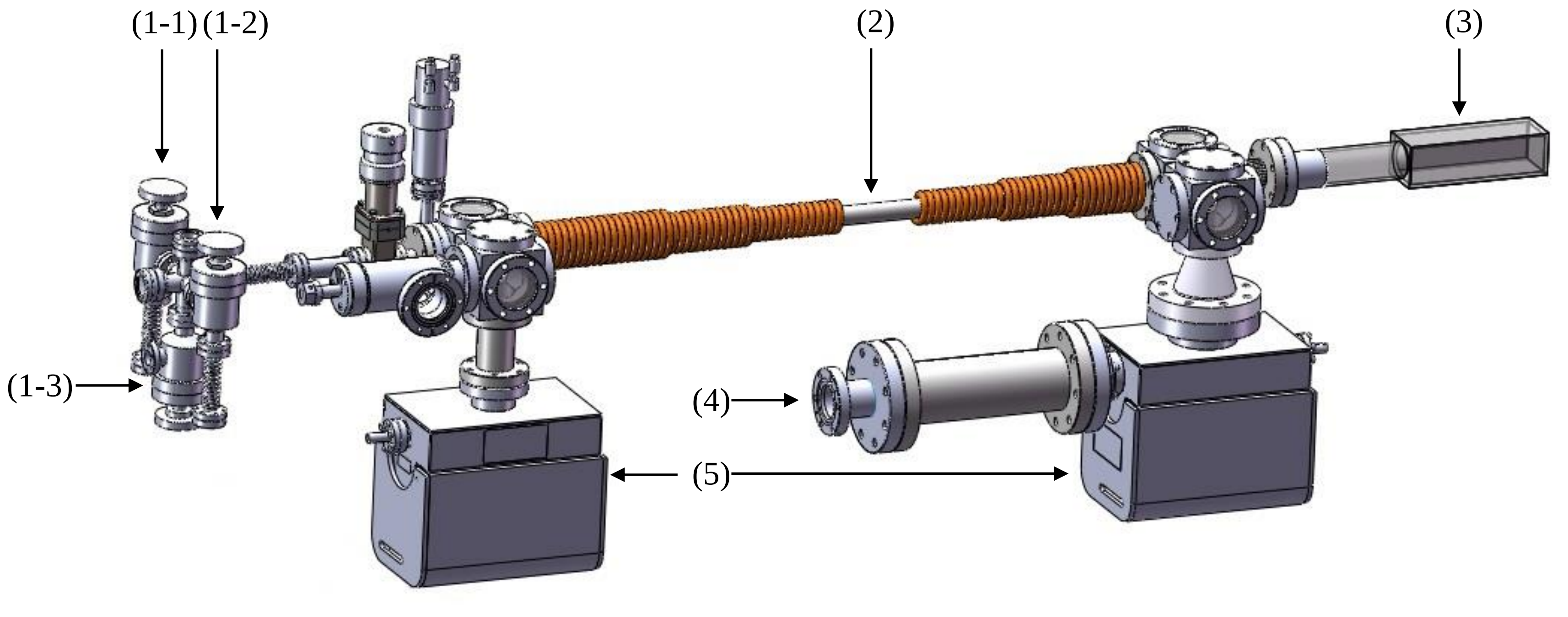
CMOT, $n > 10^{10}$ cm^{-3}
TDMOT, $T \sim 50$ μK
GMS, T ~ 10 μK



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 quantum 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

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

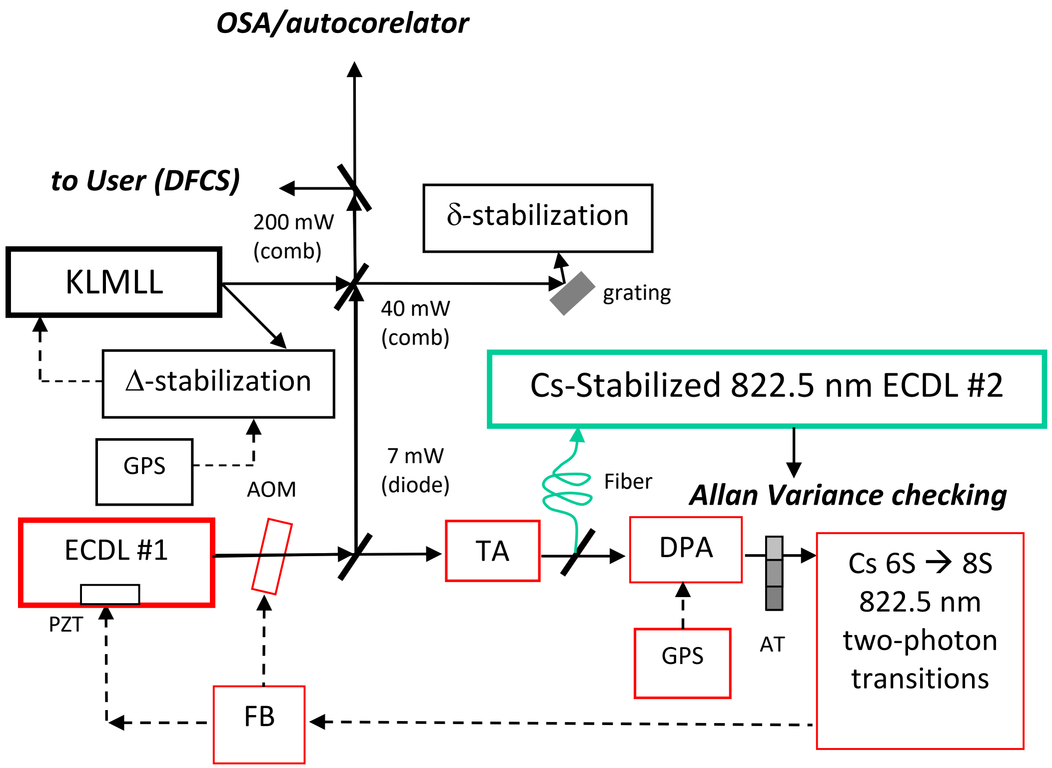
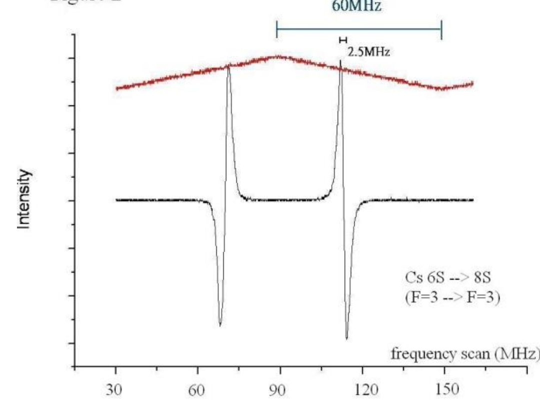
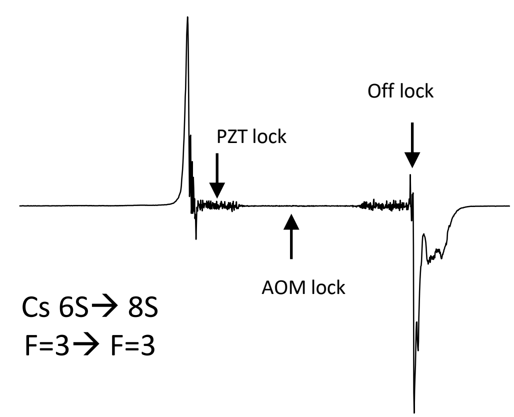
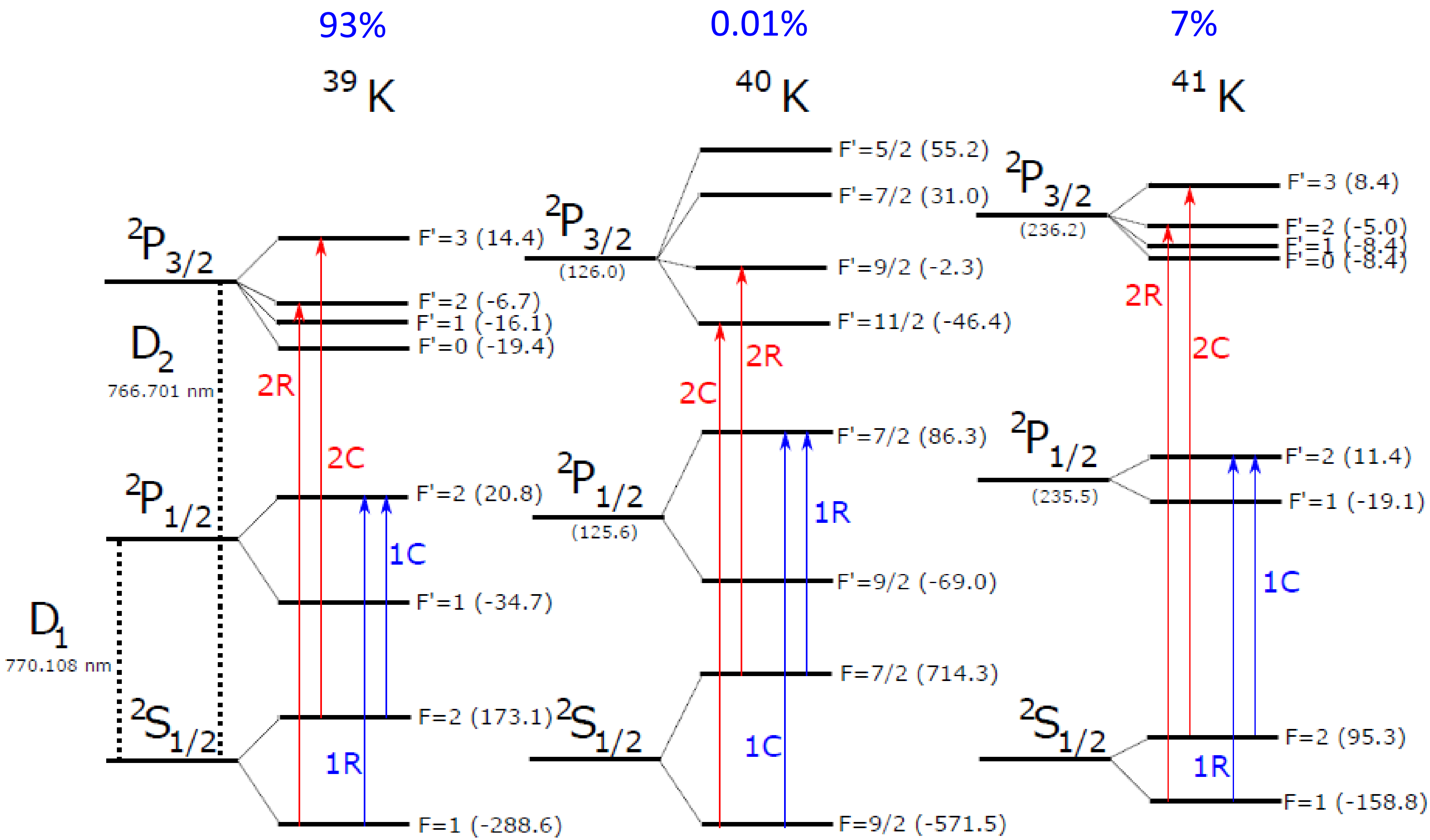


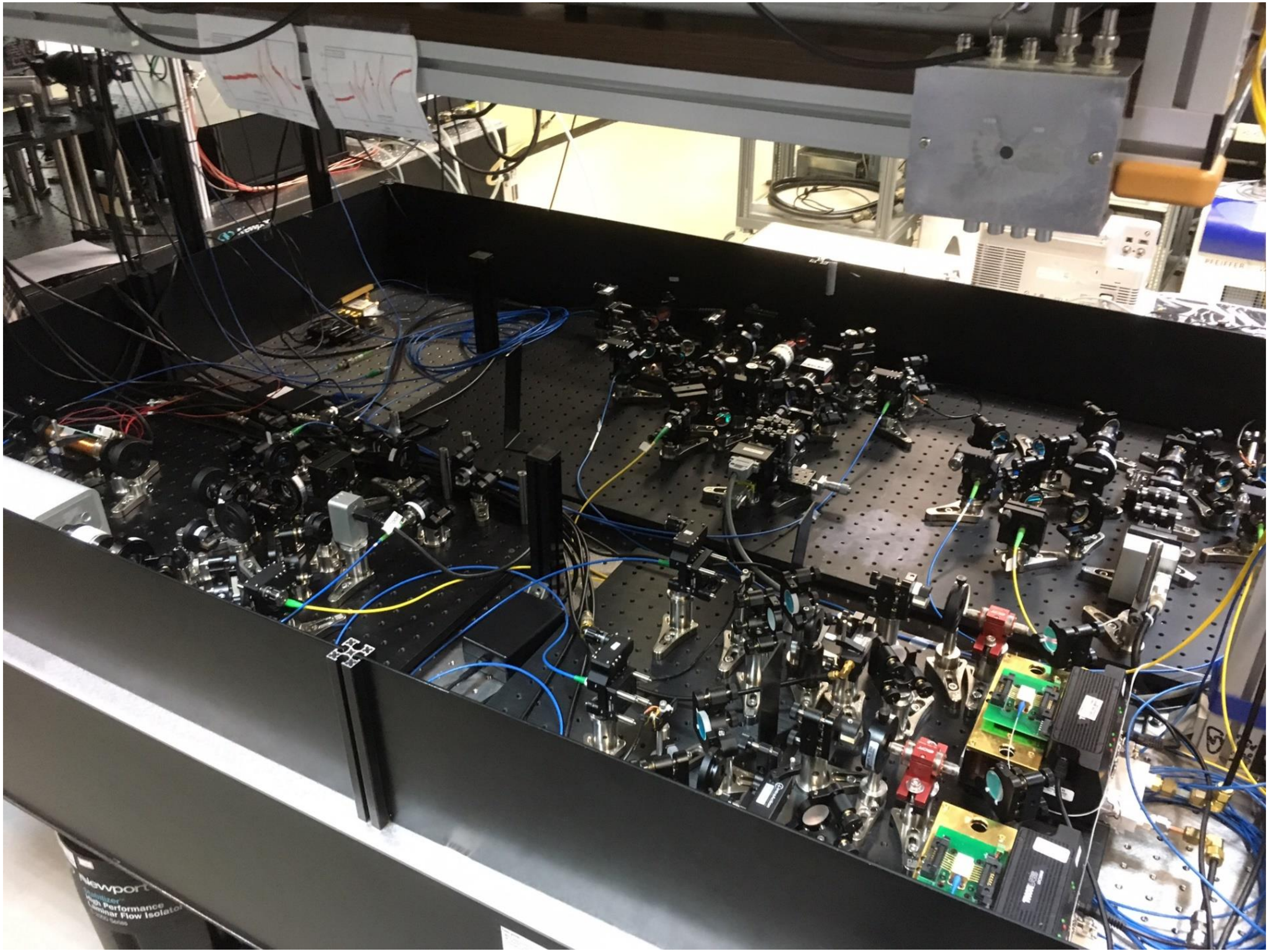
Figure 2

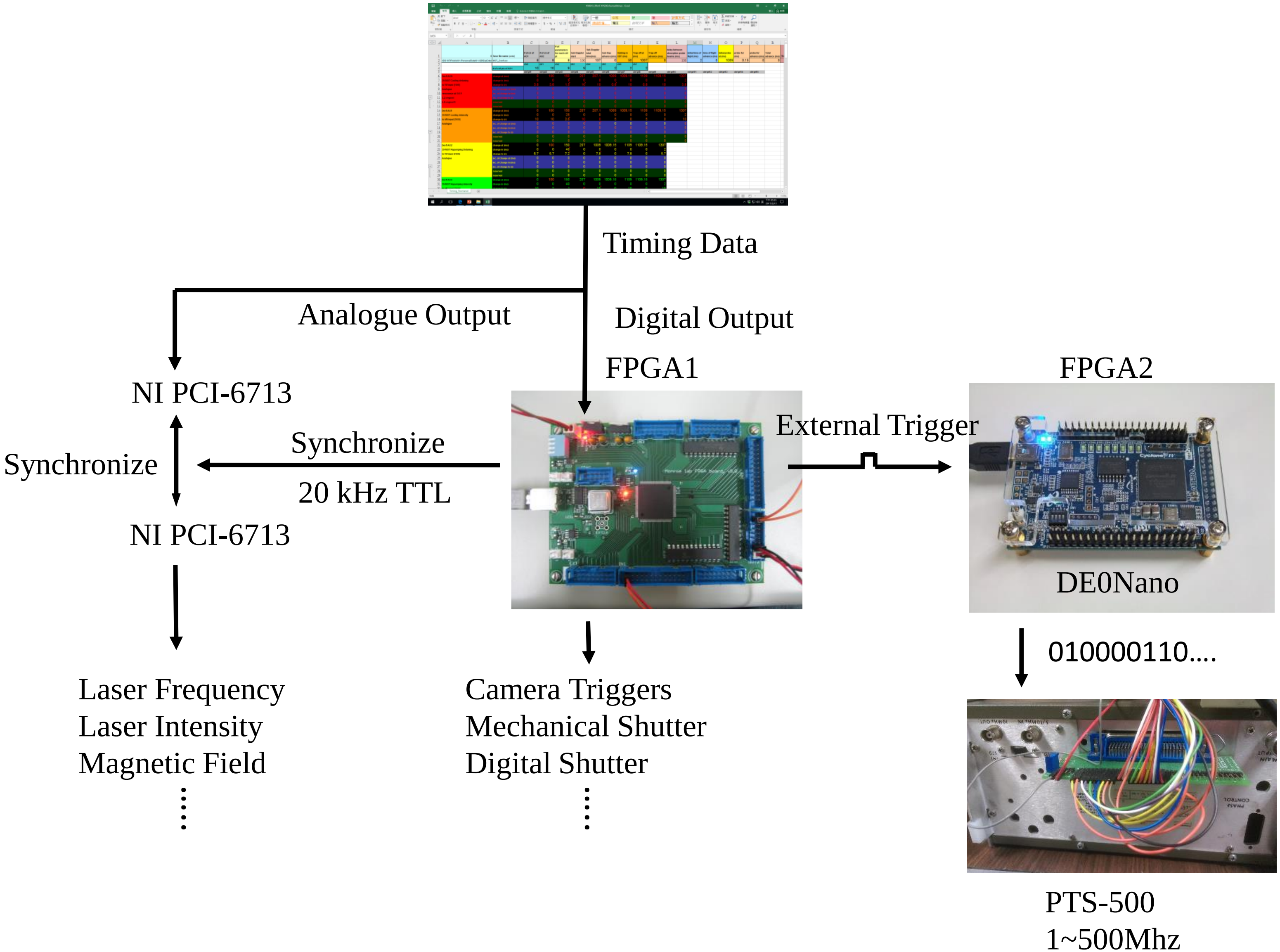






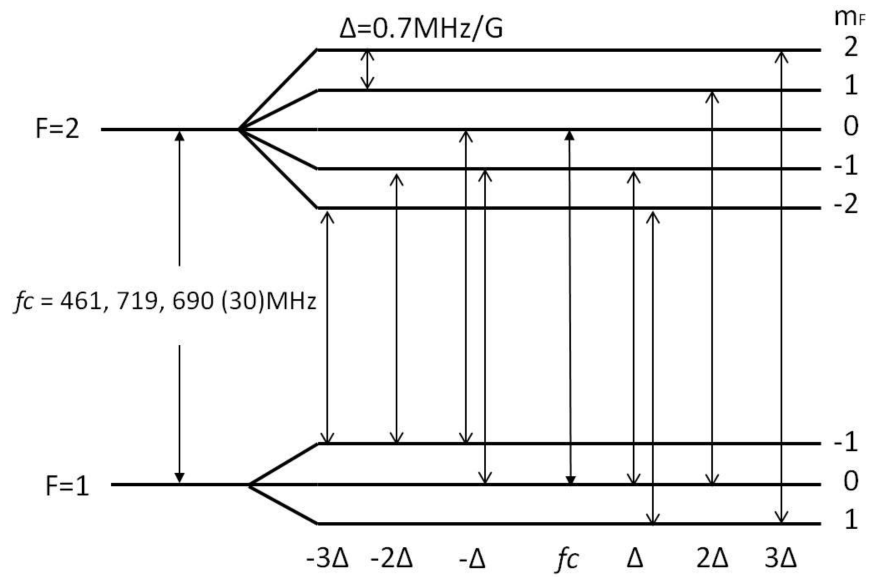
Ref: M. Tarnowski, Thesis (2015).

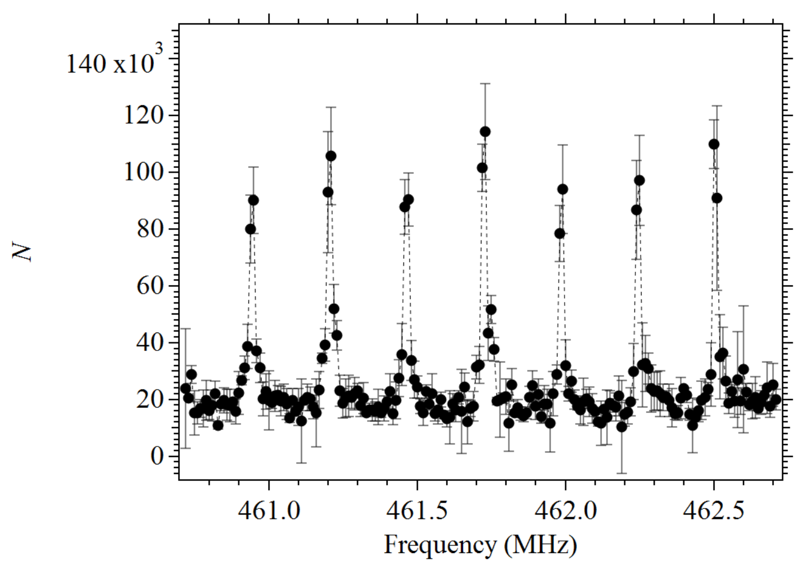

Newport
High Performance

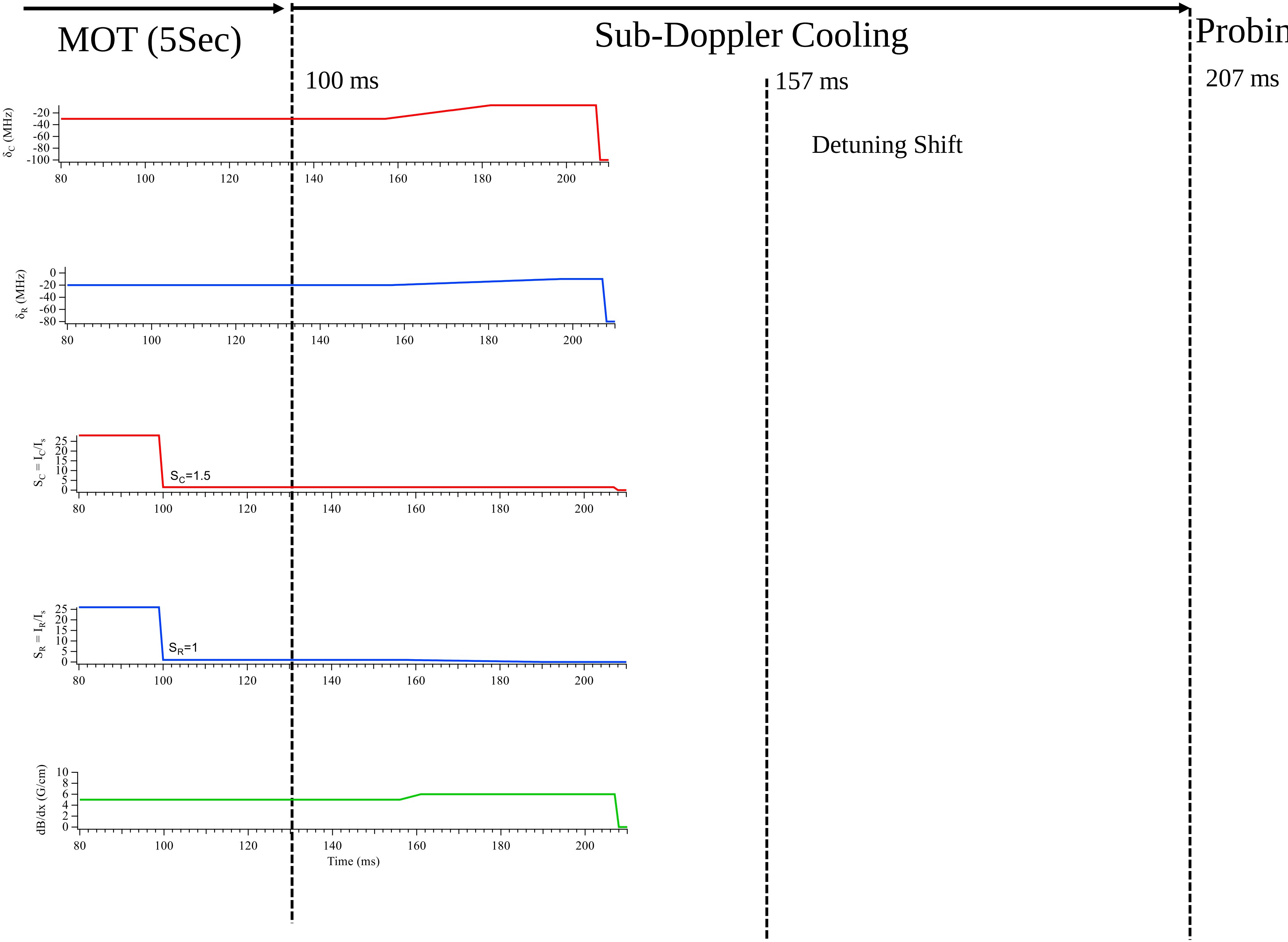


Spin State Control

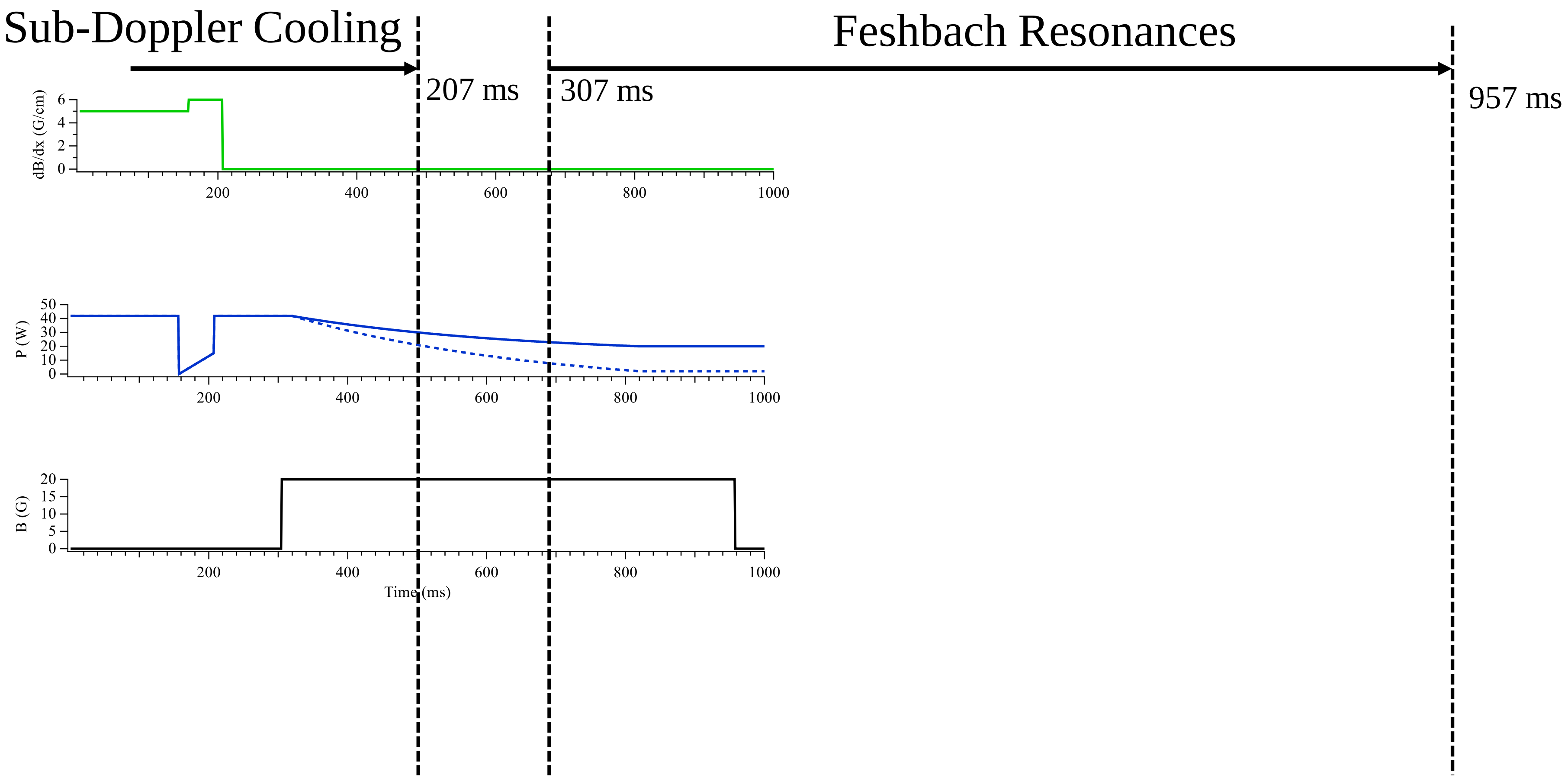
Spin population control by radio frequency (RF)



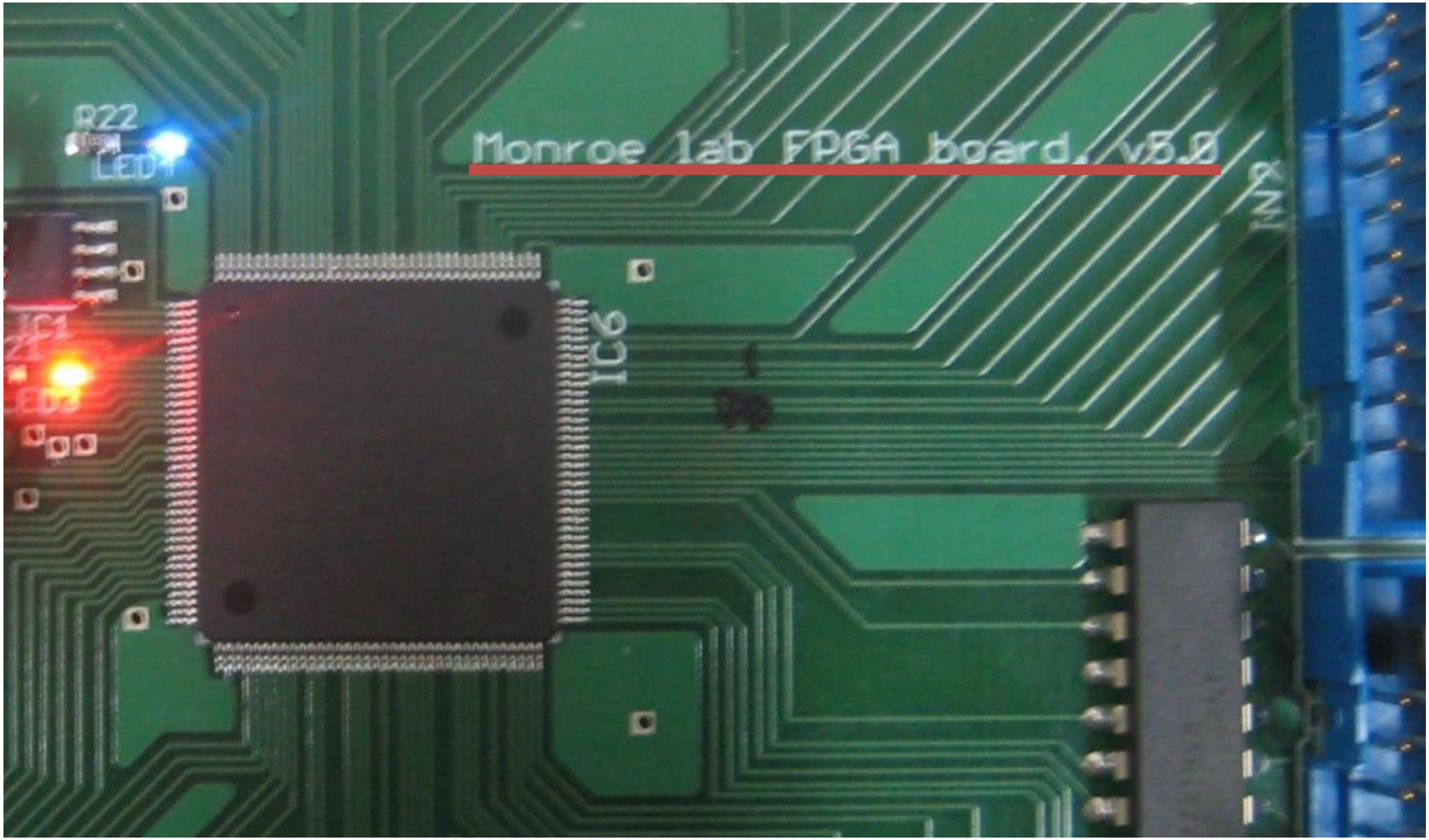




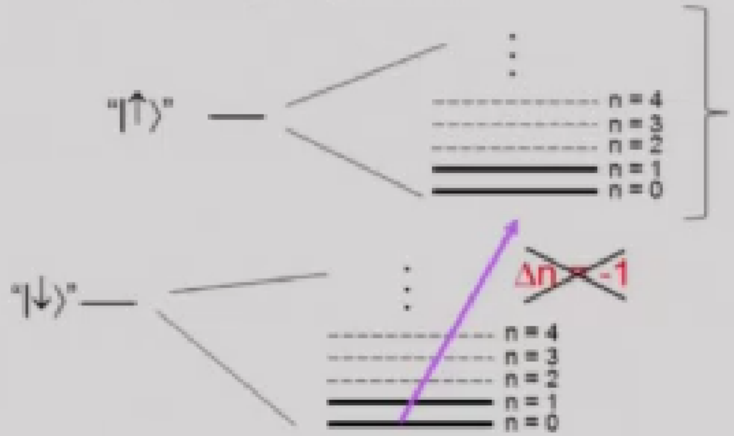
MOT (5Sec)
Sub-Doppler Cooling
Probin
100 ms
157 ms
207 ms
Detuning Shift
δ_C (MHz)
δ_R (MHz)
$S_C = I_C/I_s$
S_C=1.5
$S_R = I_R/I_s$
S_R=1
dB/dx (G/cm)
Time (ms)



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


R22
LED4
IC1
IC6
Monroe lab FPGA board, v5.0

Quantum logic gates?



Chris Monroe

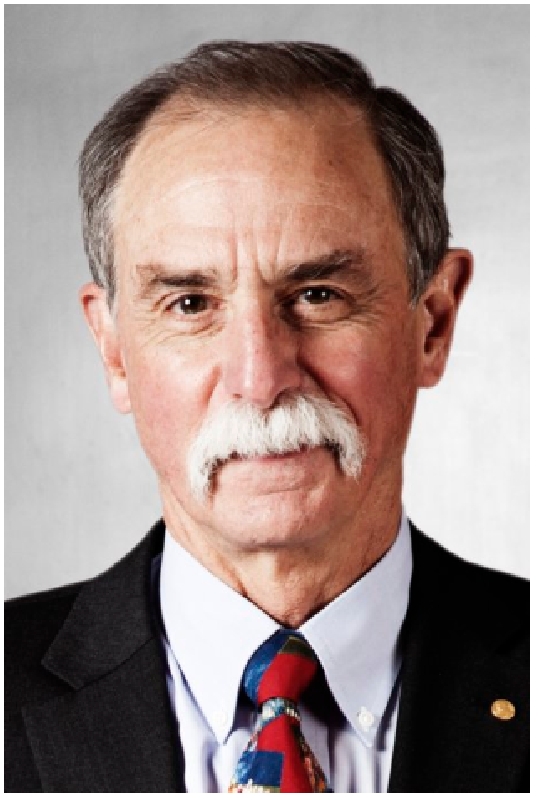
Simple example of quantum logic:

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

"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

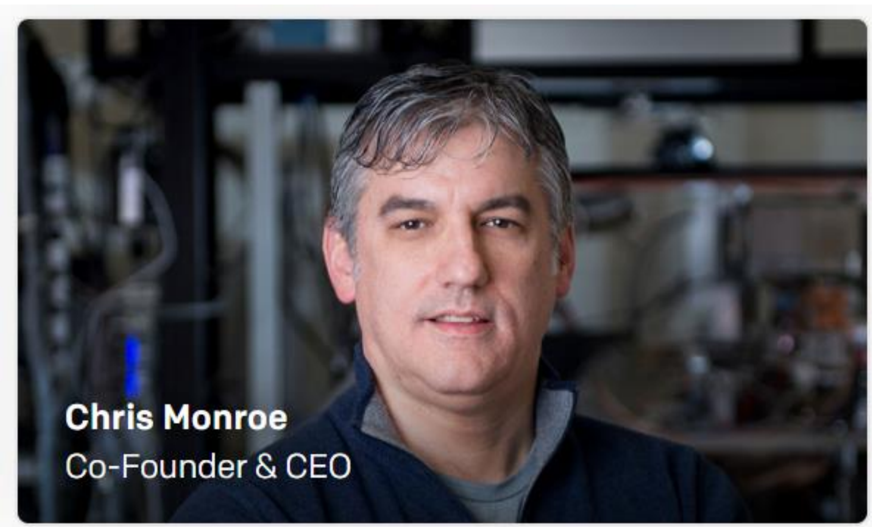
Prize motivation: "for ground-breaking experimental methods that enable measuring and manipulation of individual quantum systems."

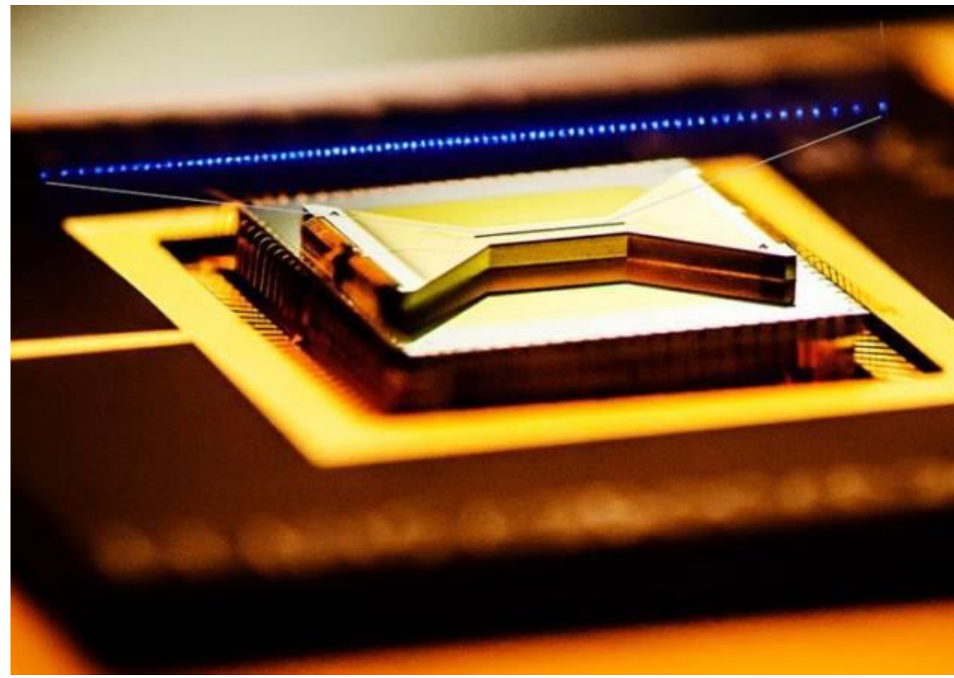
Ion Trap + Laser Cooling

Prize share: 1/2

Quantum Computing Startup

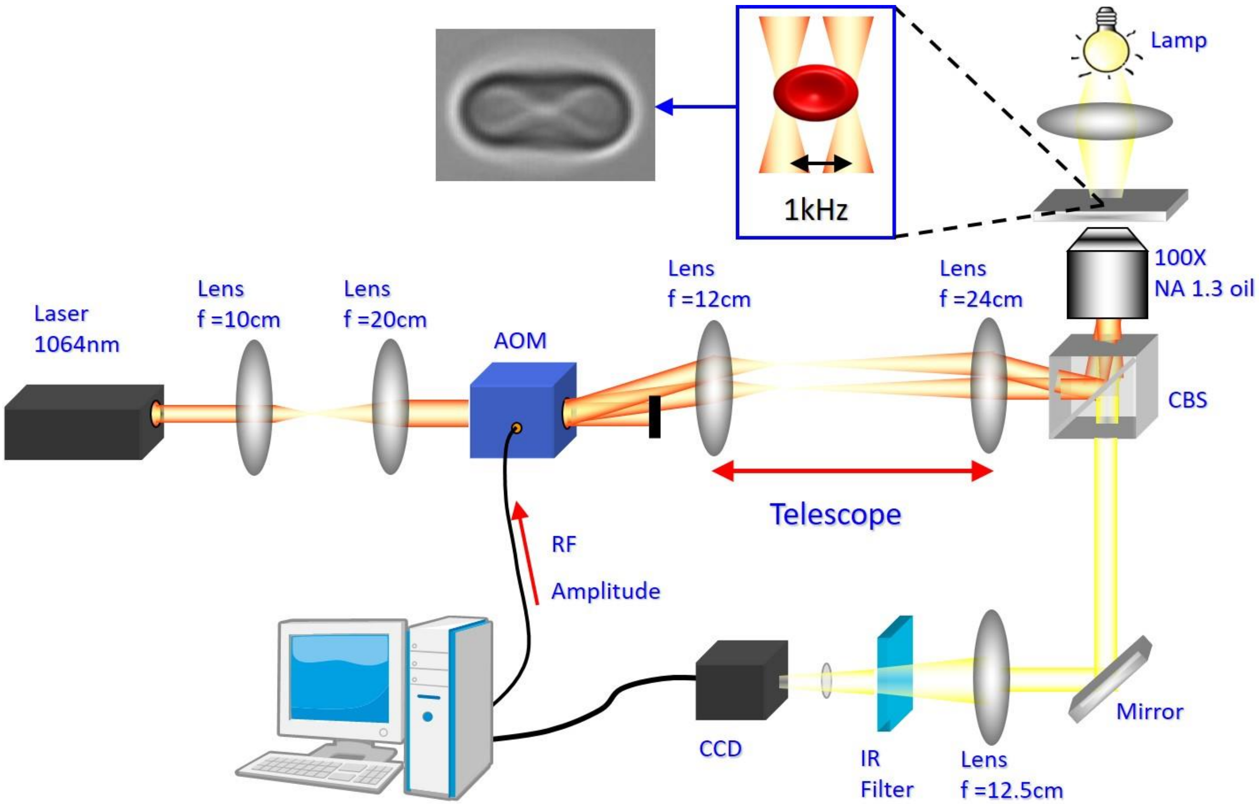
IONQ





Headquartered	Founded	Employees	Computers
College Park, MD	2016	32	2

Optical Tweezers

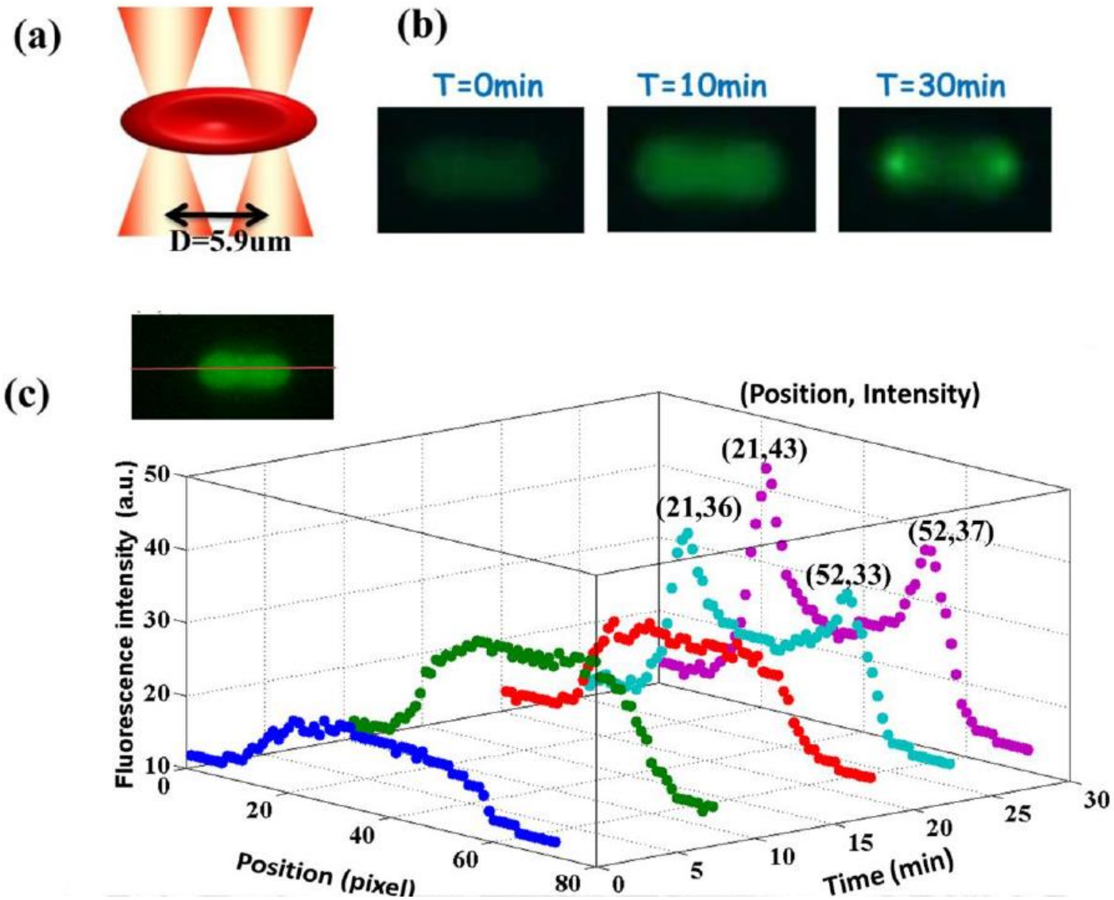


Liao et al., Optics Express, vol.16, 1996-2004, 2008

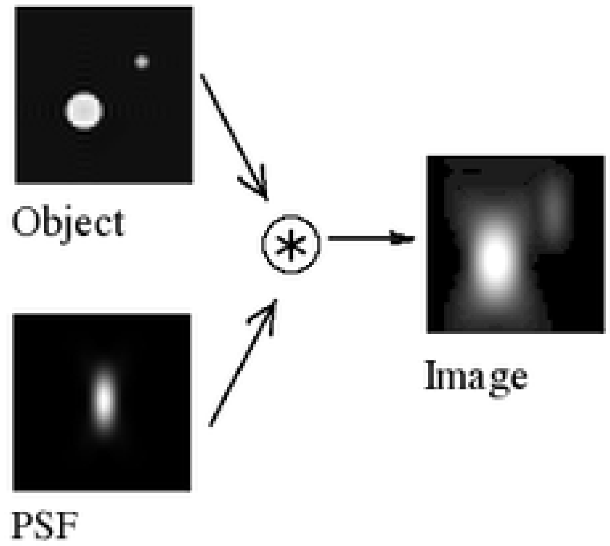
Liao et al., J. Biophotonics, vol.7, No.10, 2014

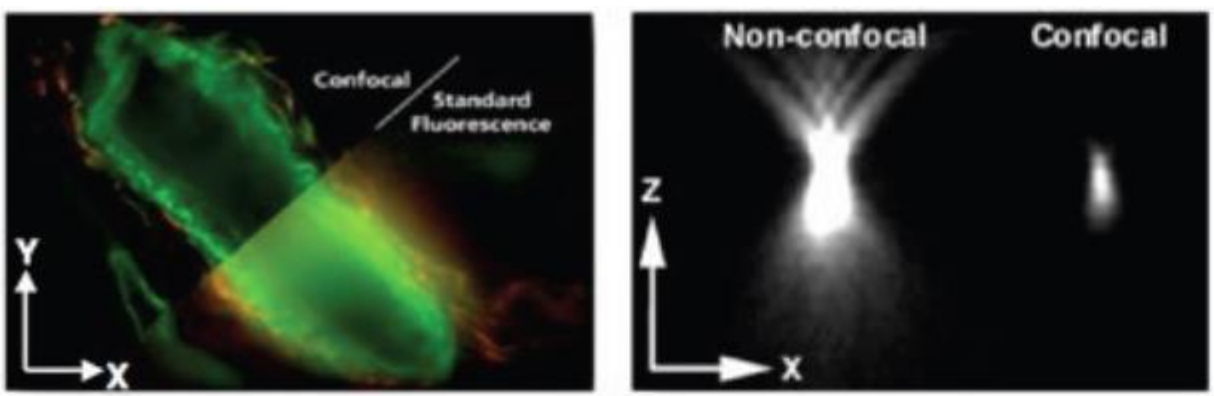
U.S. Patent No. US 20080310009 A1

Optical Stretch-Induced Calcium Influx -Stretch Activated Ion Channel



Point Spread Function (PSF) and Convolution Image

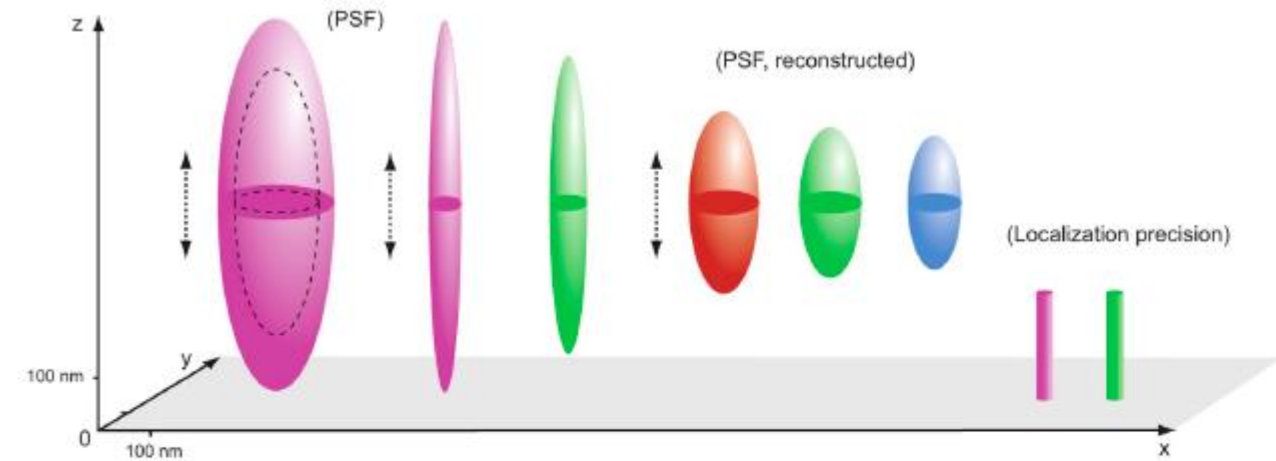




http://zeiss-campus.magnet.fsu.edu/articles/superresolution/introduction.html

Point Spread Function Table

	CLSM	STED	CW-STED	3D-SIM			PALM/STORM	
$\sim\lambda_{em}$ [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

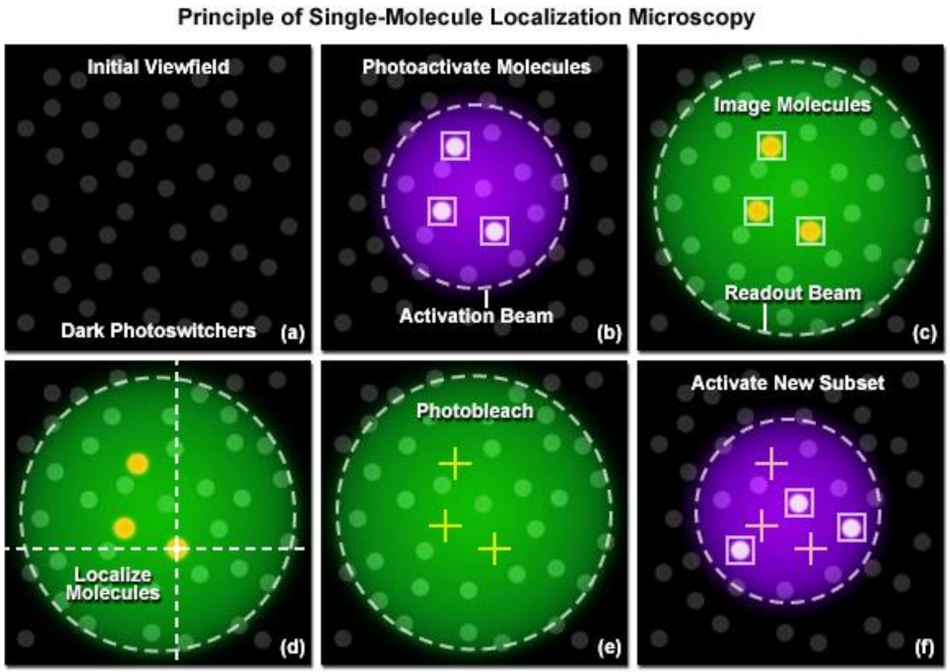


Figure 1

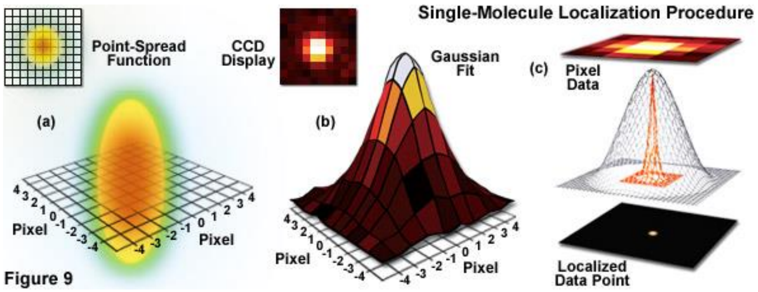


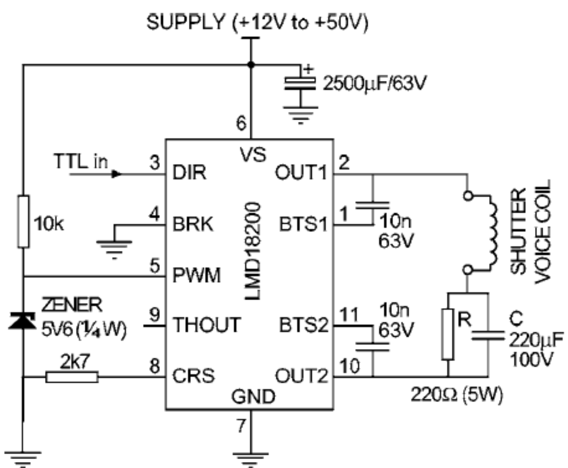
Figure 9

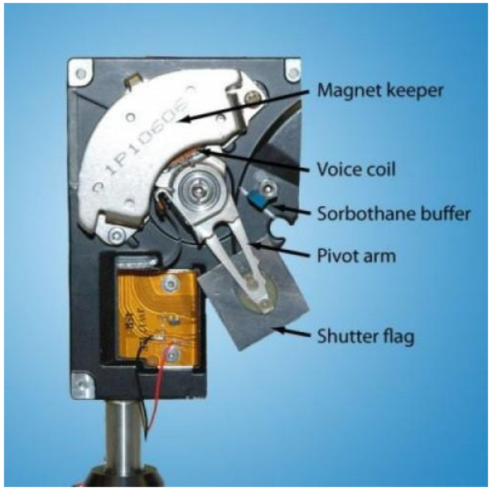
http://zeiss-campus.magnet.fsu.edu/articles/superresolution/introduction.html

REVIEW OF SCIENTIFIC INSTRUMENTS 78, 026101 (2007)

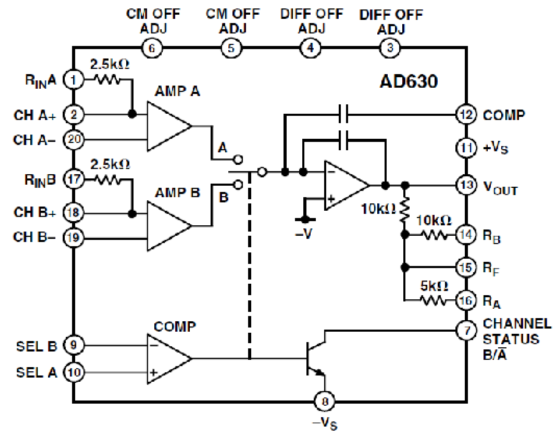
Enhanced laser shutter using a hard disk drive rotary voice-coil actuator

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





Simple Lock-in Amplifier



AD630