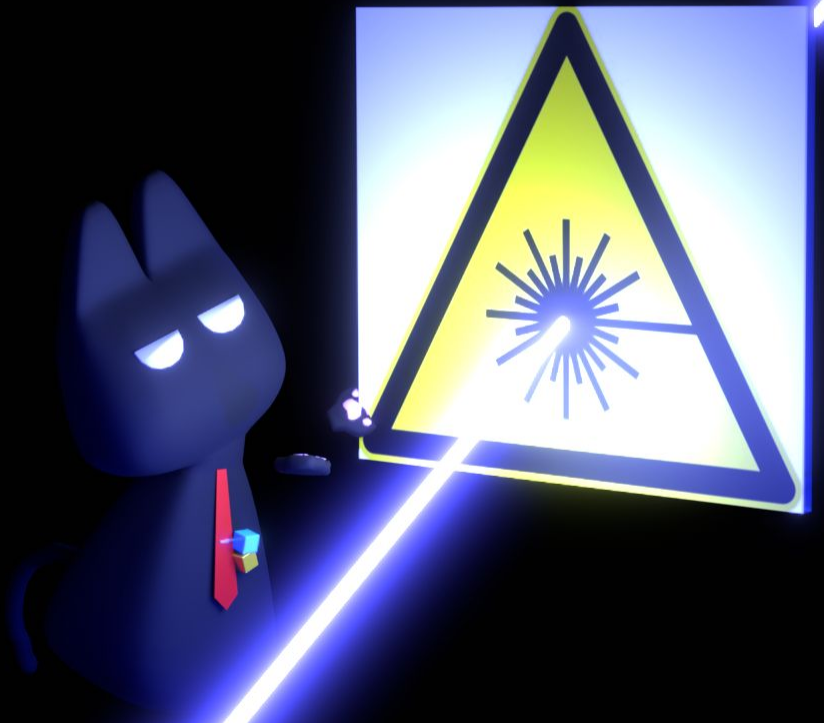
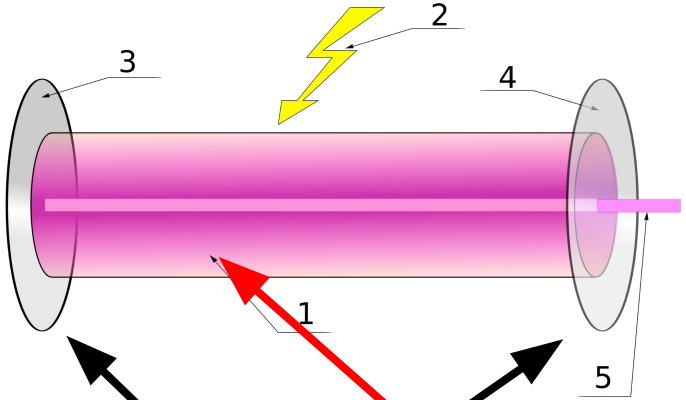
フェムト秒レーザーと蛍光顕微鏡への応用

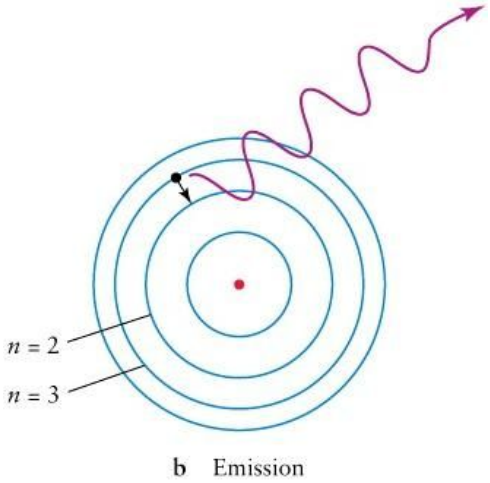


CW LASER

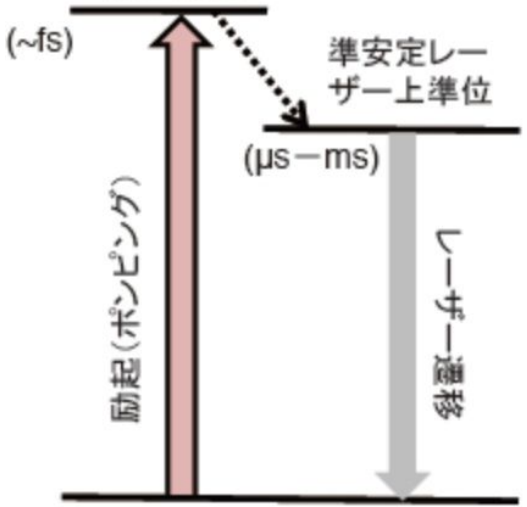
CW laser = Continuous Wave Light Amplification by Stimulated Emission of Radiation



鏡



レーザー媒質



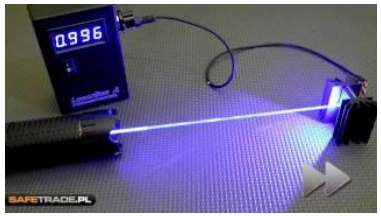
励起状態

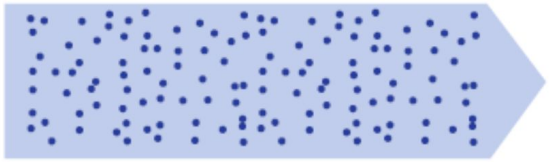
基底状態

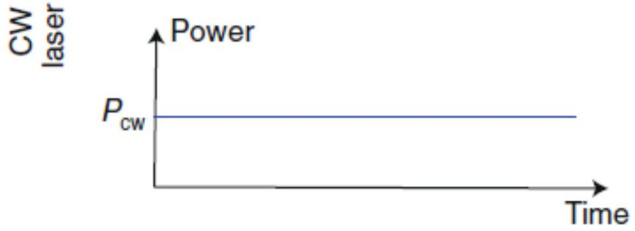
wikipedia

https://optronics-media.com/

CW レーザー





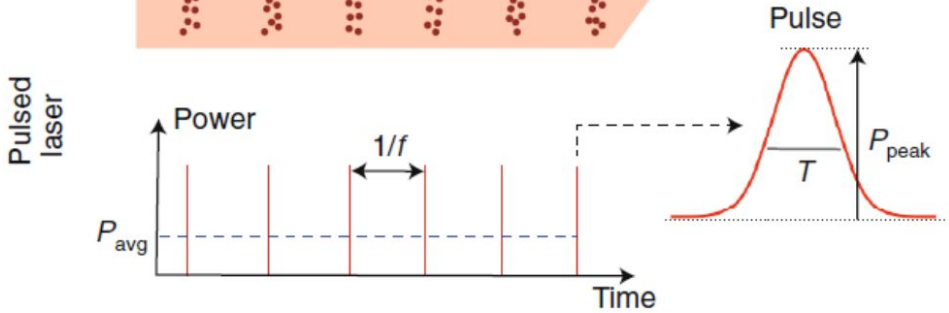


パルス レーザー



Papagiakoumou et. al., (2020)



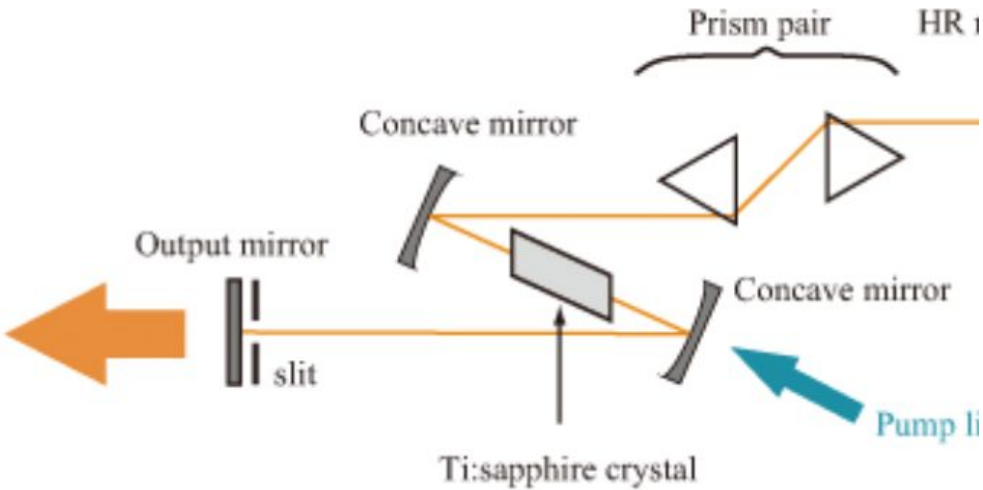


フェムト秒 Laser

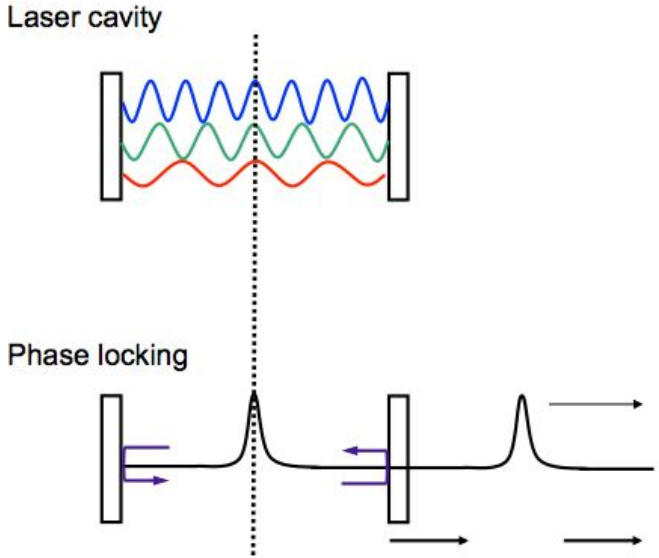
100 fs = 1 x 10^{-15}s

パルスレーザーの発生

共振器と結晶石の位置関係



光共振：縦モードロック

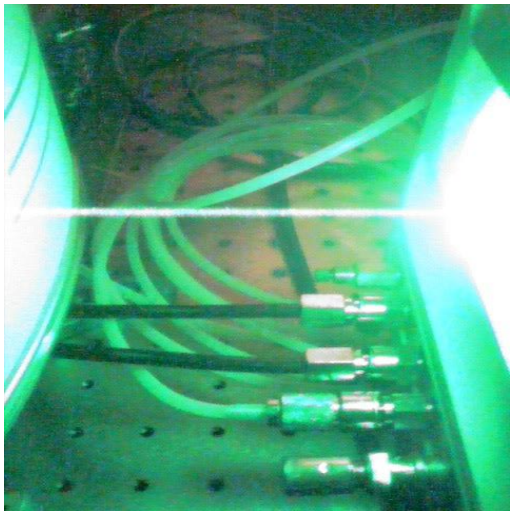


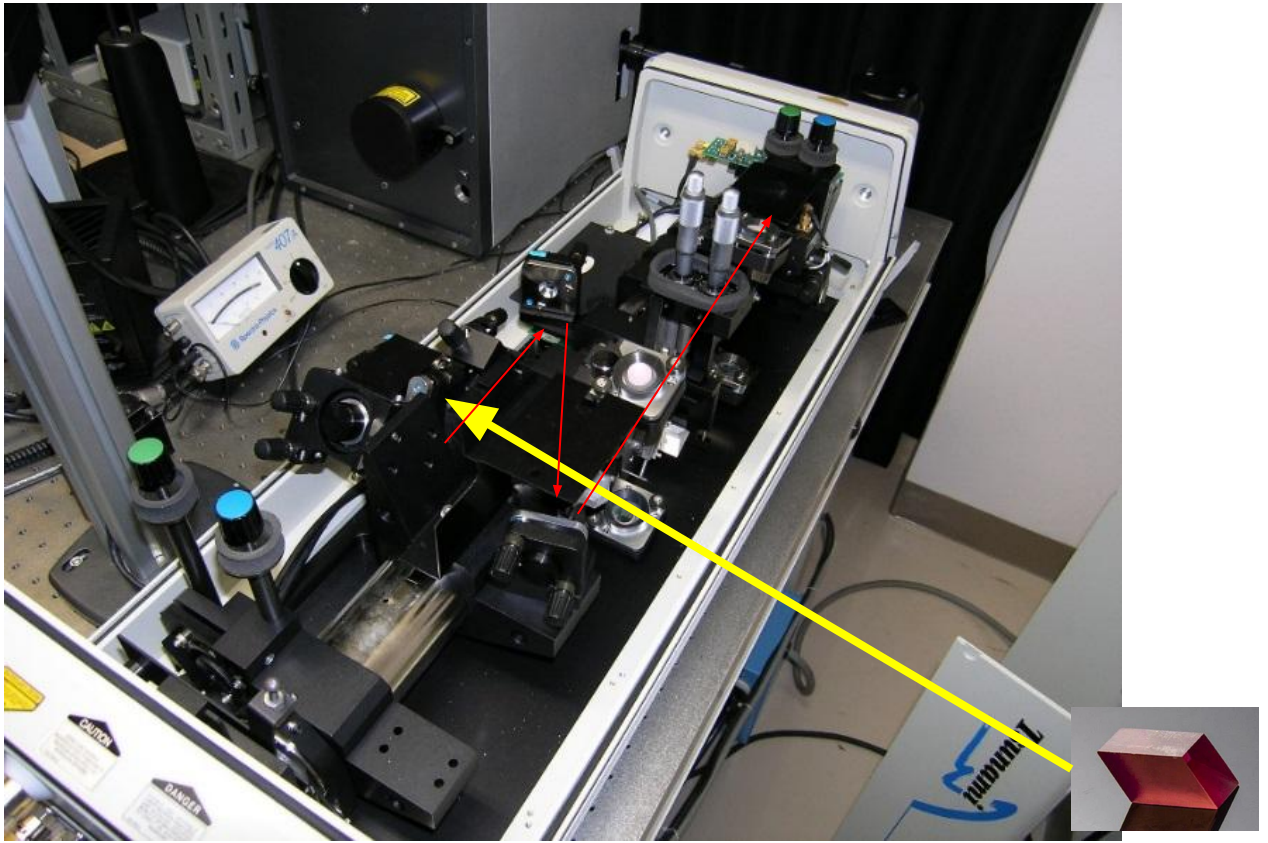
https://www.symphotony.com/

Spectra Physics 10W フェムト秒レーザー“Tsunami”

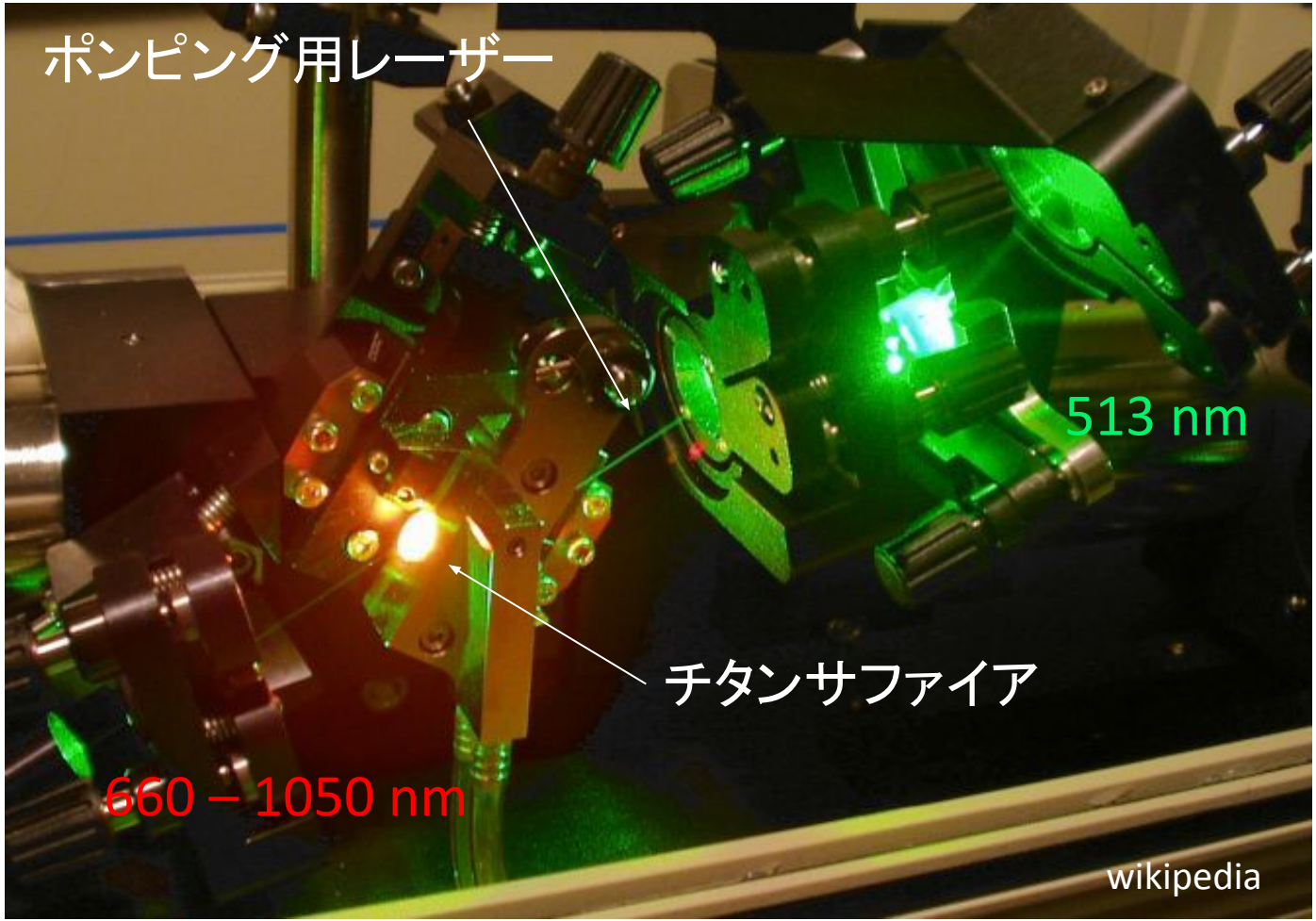
励起用エネルギー元
(ポンピング用レーザー)

532 nm





チタンサファイア


ポンピング用レーザー
513 nm
チタンサファイア
660 – 1050 nm
wikipedia

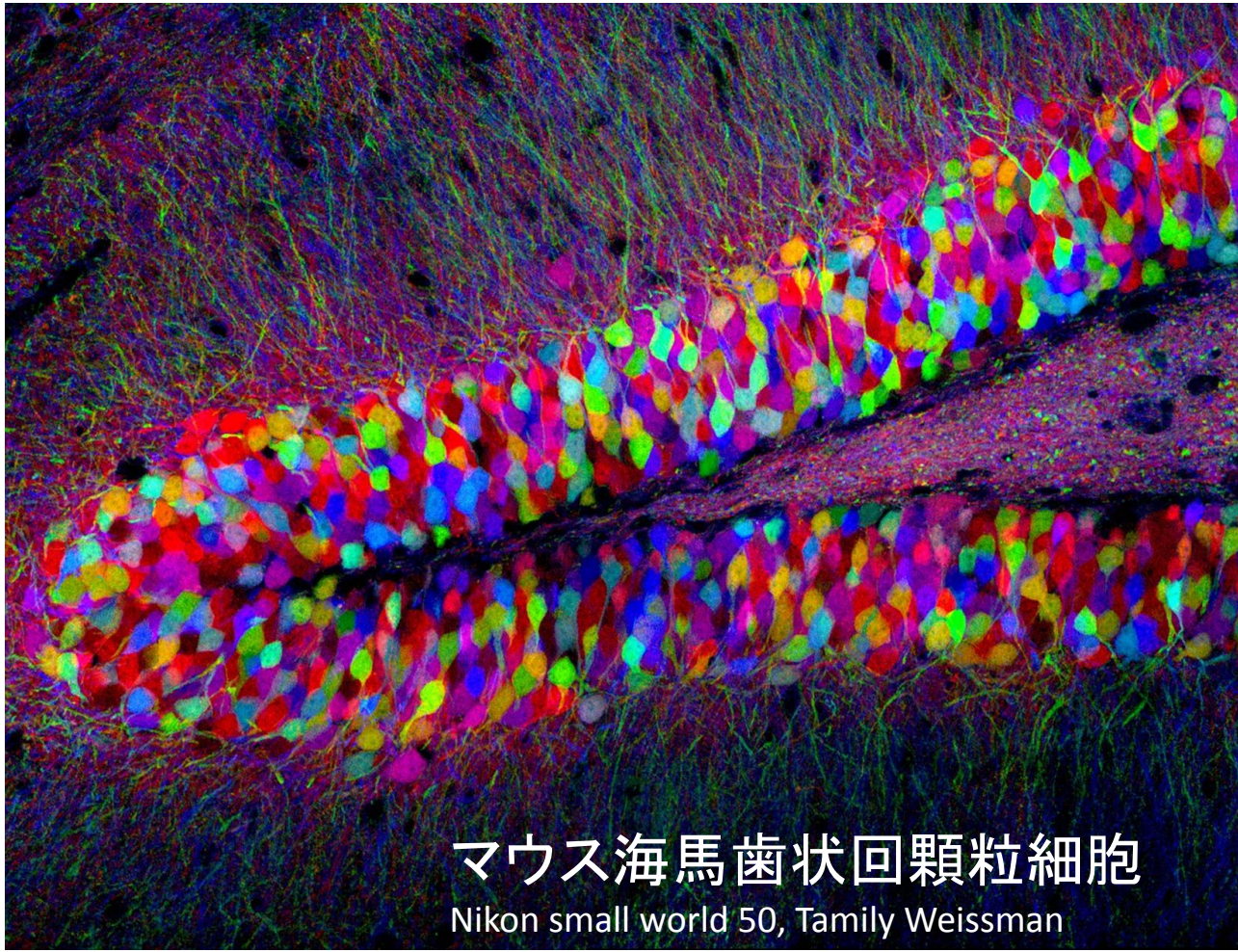
フェムト秒レーザーの応用



蛍光

光学測定法:

蛍光を使って細胞の形態や活動を計測する



マウス海馬歯状回顆粒細胞

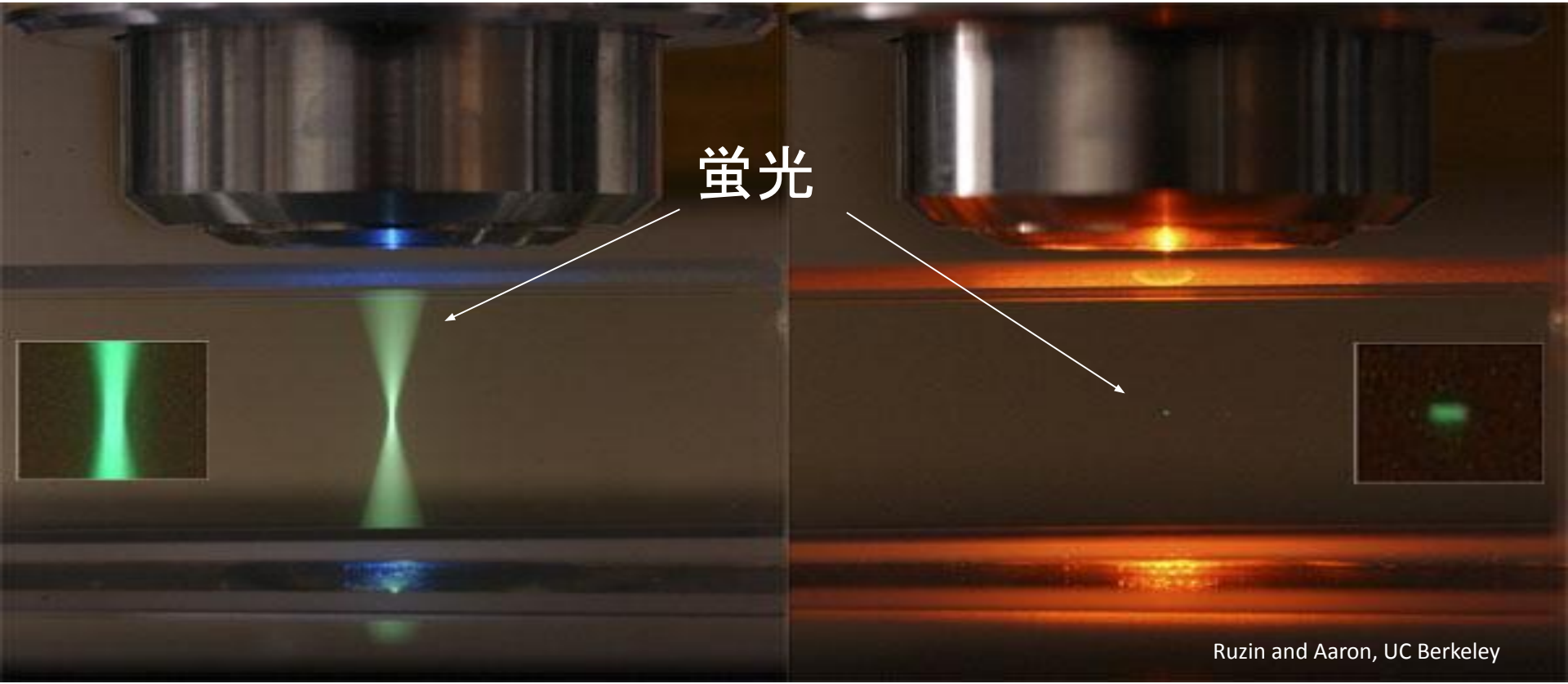
Nikon small world 50, Tamily Weissman

Brainbow

J. Lichtman and J.Sanes,

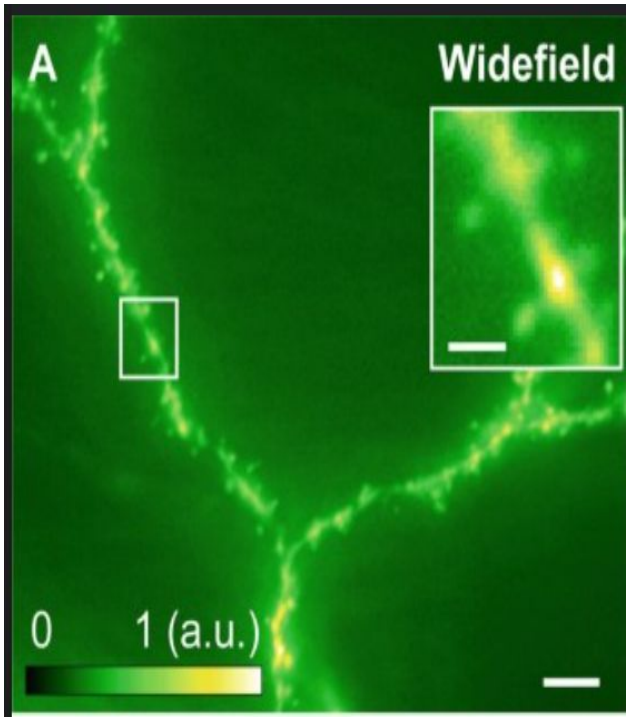
CW Laser

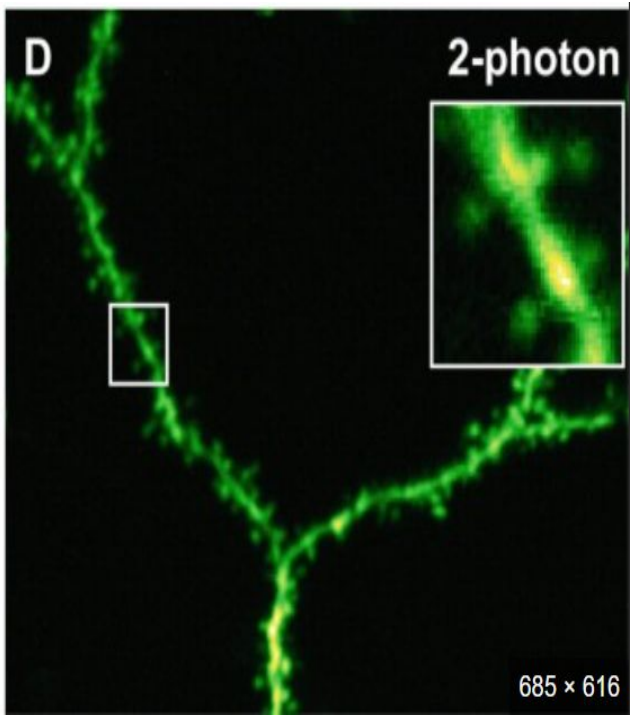
フェムト秒 Laser



LED

フェムト秒 Laser



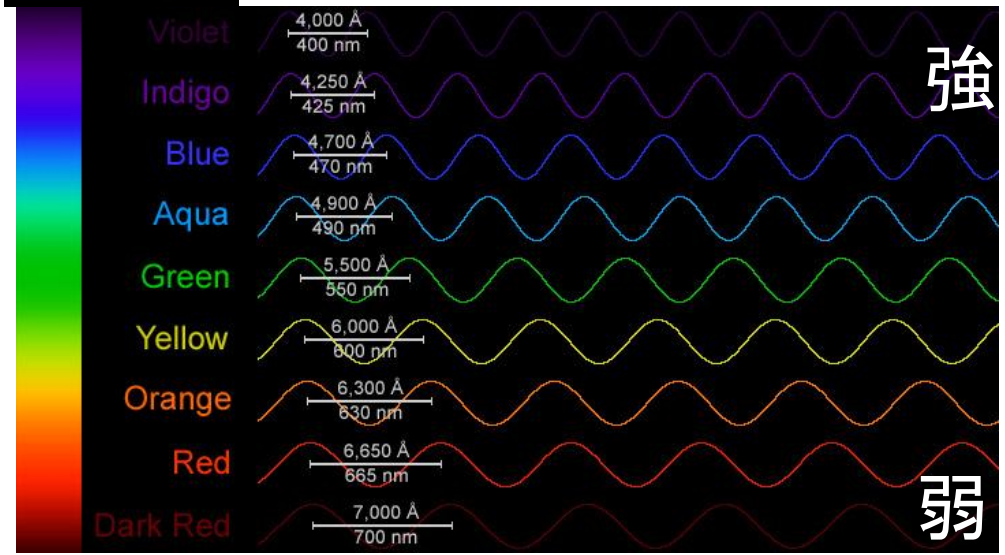


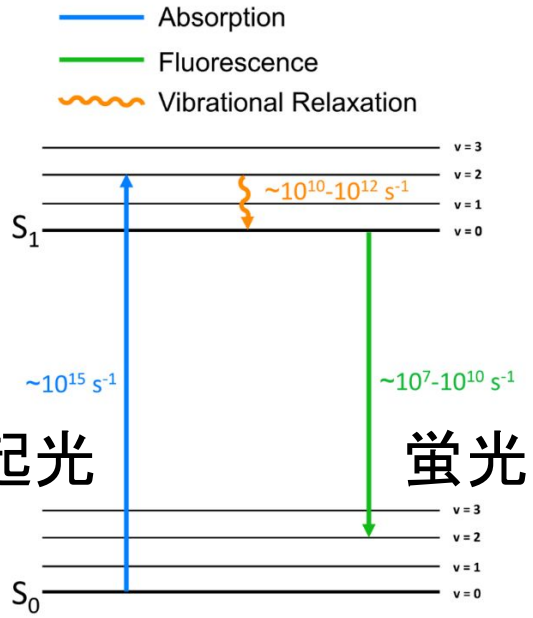
Li et. al., (2020)

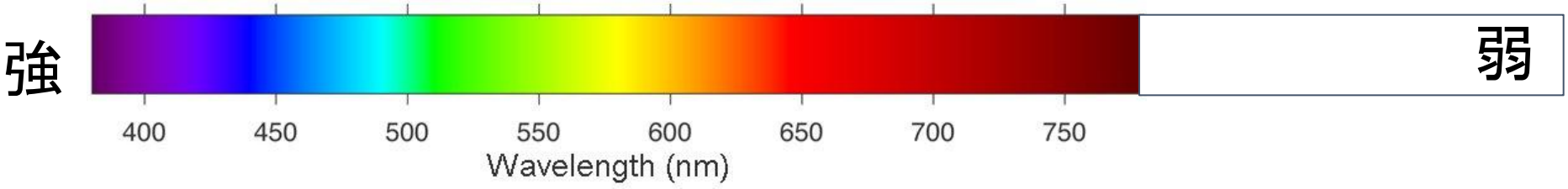
神経細胞の樹状突起

蛍光とはなにか？

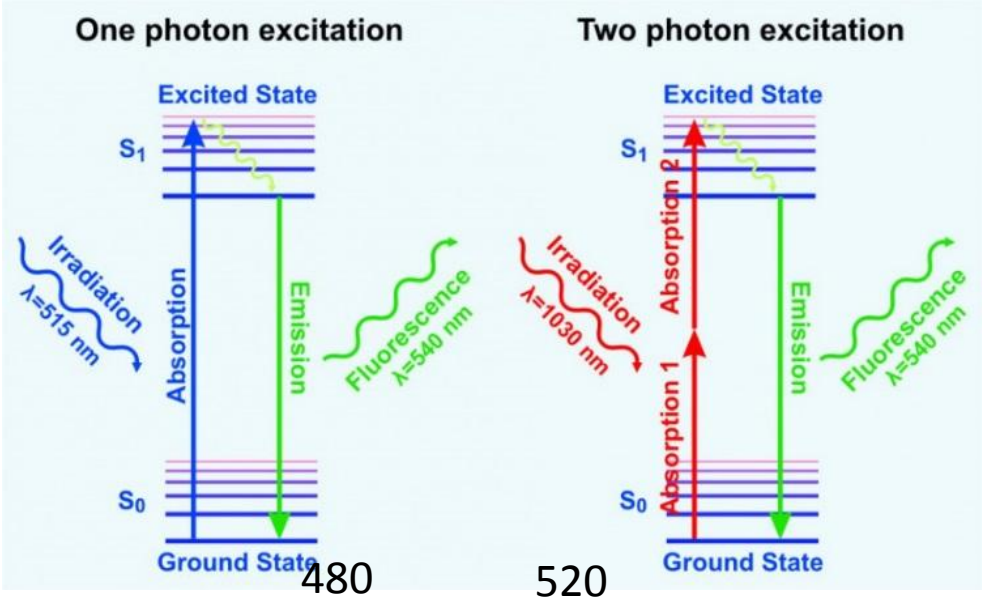

GFP


Violet
4,000 Å
400 nm
Indigo
4,250 Å
425 nm
Blue
4,700 Å
470 nm
Aqua
4,900 Å
490 nm
Green
5,500 Å
550 nm
Yellow
6,000 Å
600 nm
Orange
6,300 Å
630 nm
Red
6,650 Å
665 nm
Dark Red
7,000 Å
700 nm
強
弱


Absorption
Fluorescence
Vibrational Relaxation
v = 3
v = 2
v = 1
v = 0
S1
~10^10-10^12 s^-1
~10^15 s^-1
~10^7-10^10 s^-1
S0
励起光
蛍光


強
弱
400
450
500
550
600
650
700
750
Wavelength (nm)

2光子励起



Petawatt-class laser



Omega Laser Facility at the University of Rochester's Laboratory for Laser Energetics (UR/LLE).

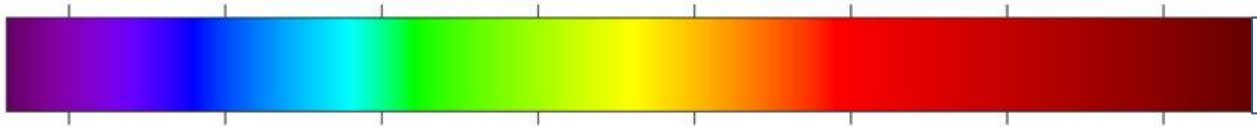
480

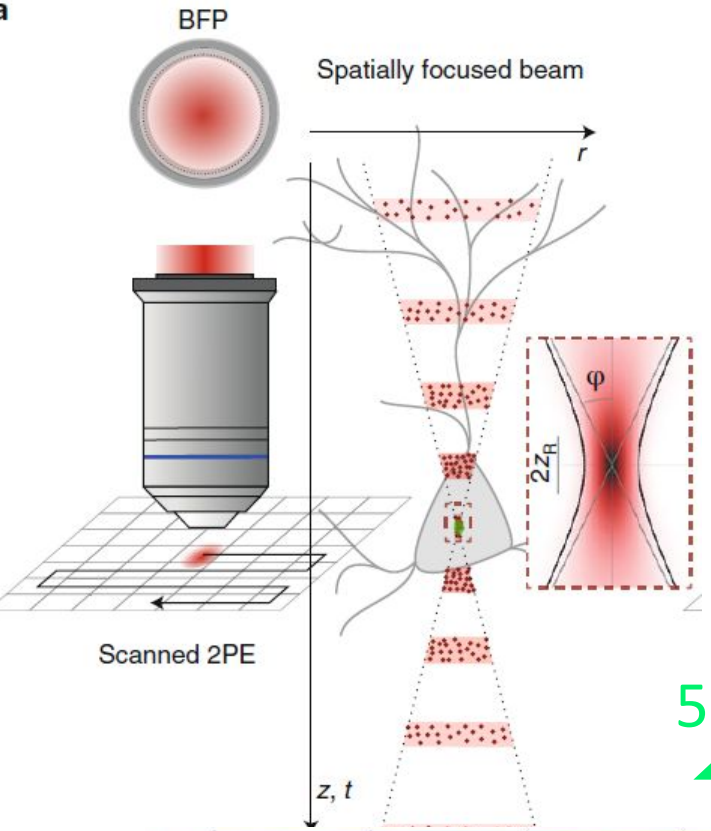
520

900

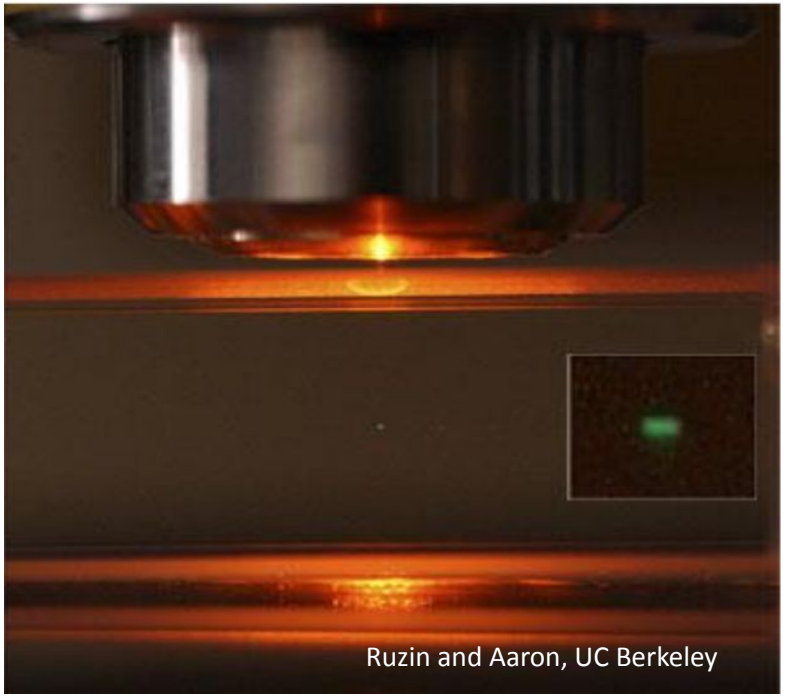
強

弱





2光子(Fs)レーザー



520

900

強

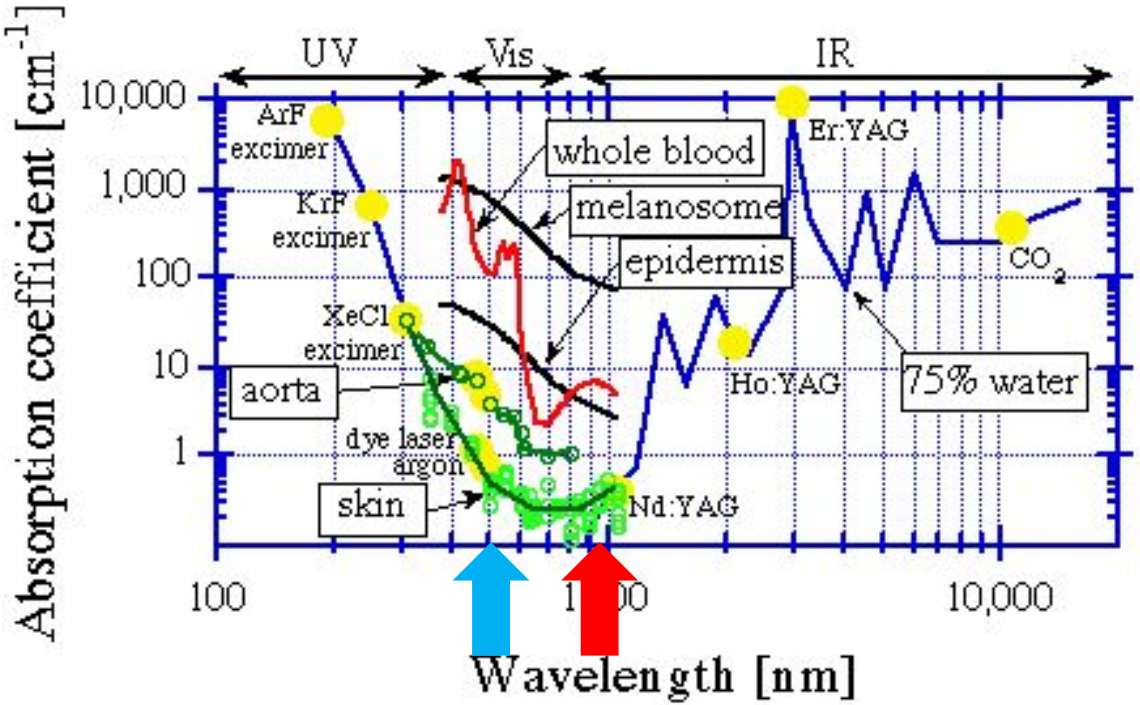
弱

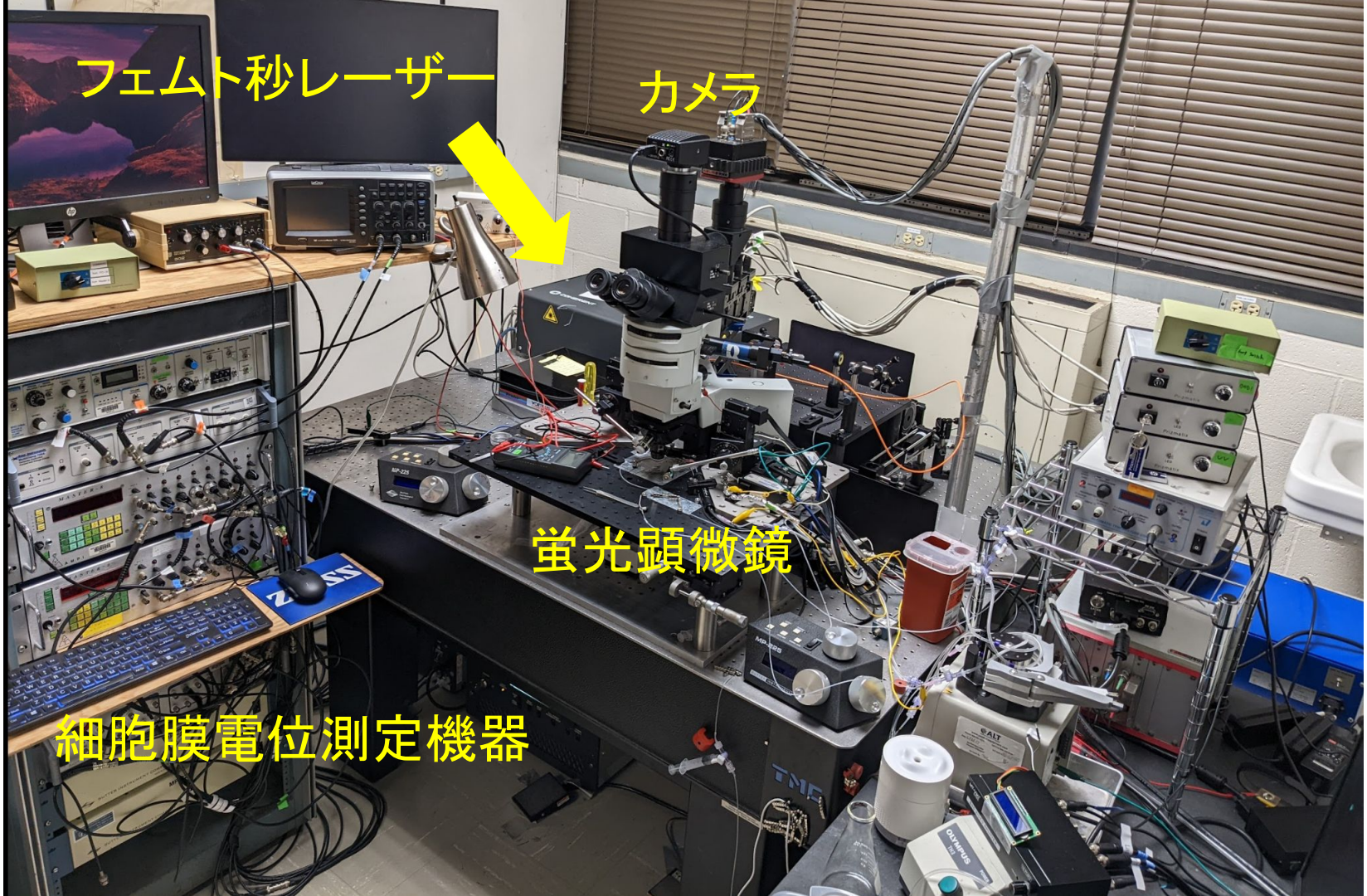
400 450 500 550 600 650 700 750

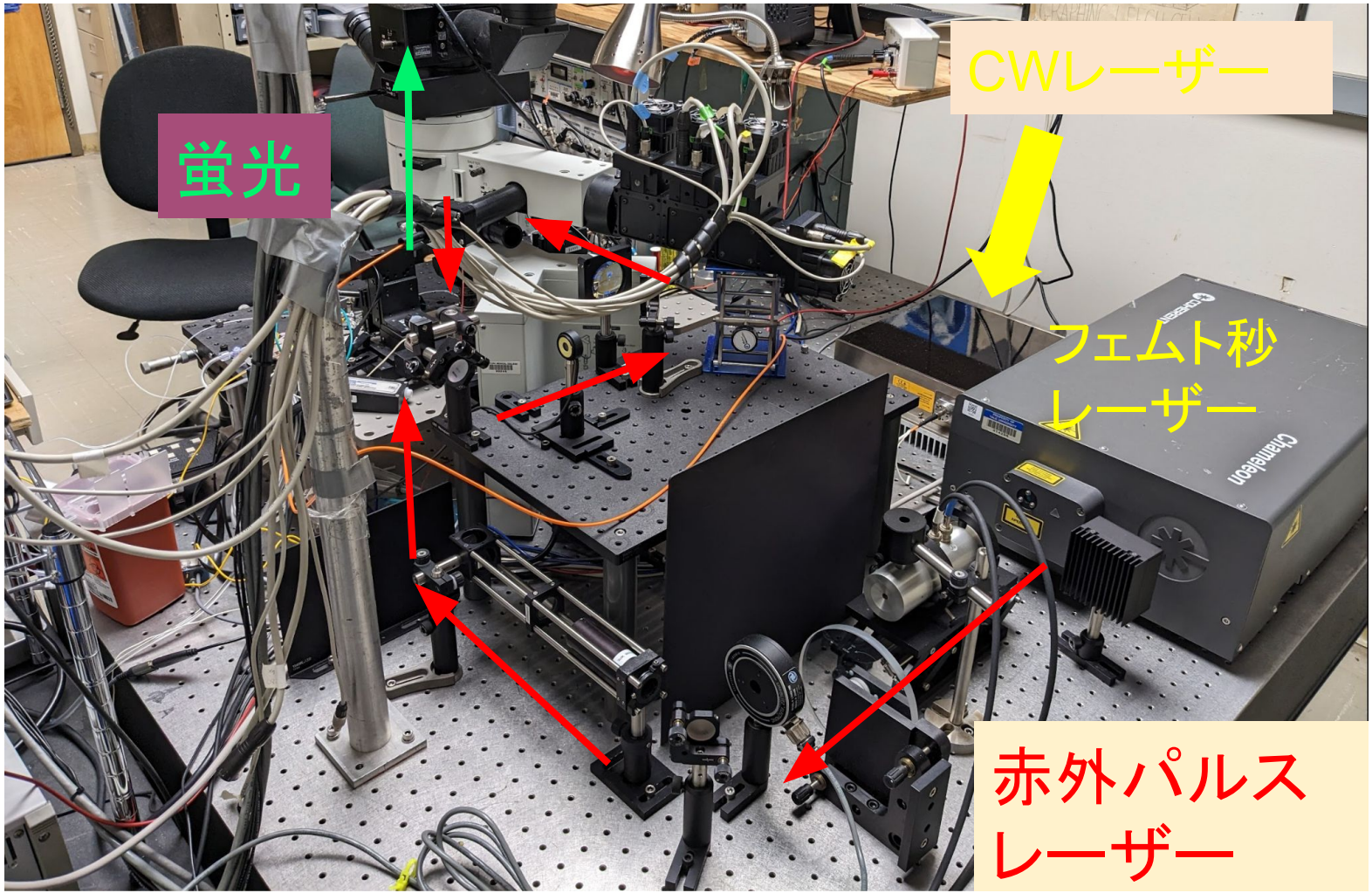
Wavelength (nm)

Papagiakoumou et. al., (2020)

赤外光は可視光より生体組織を通過しやすい

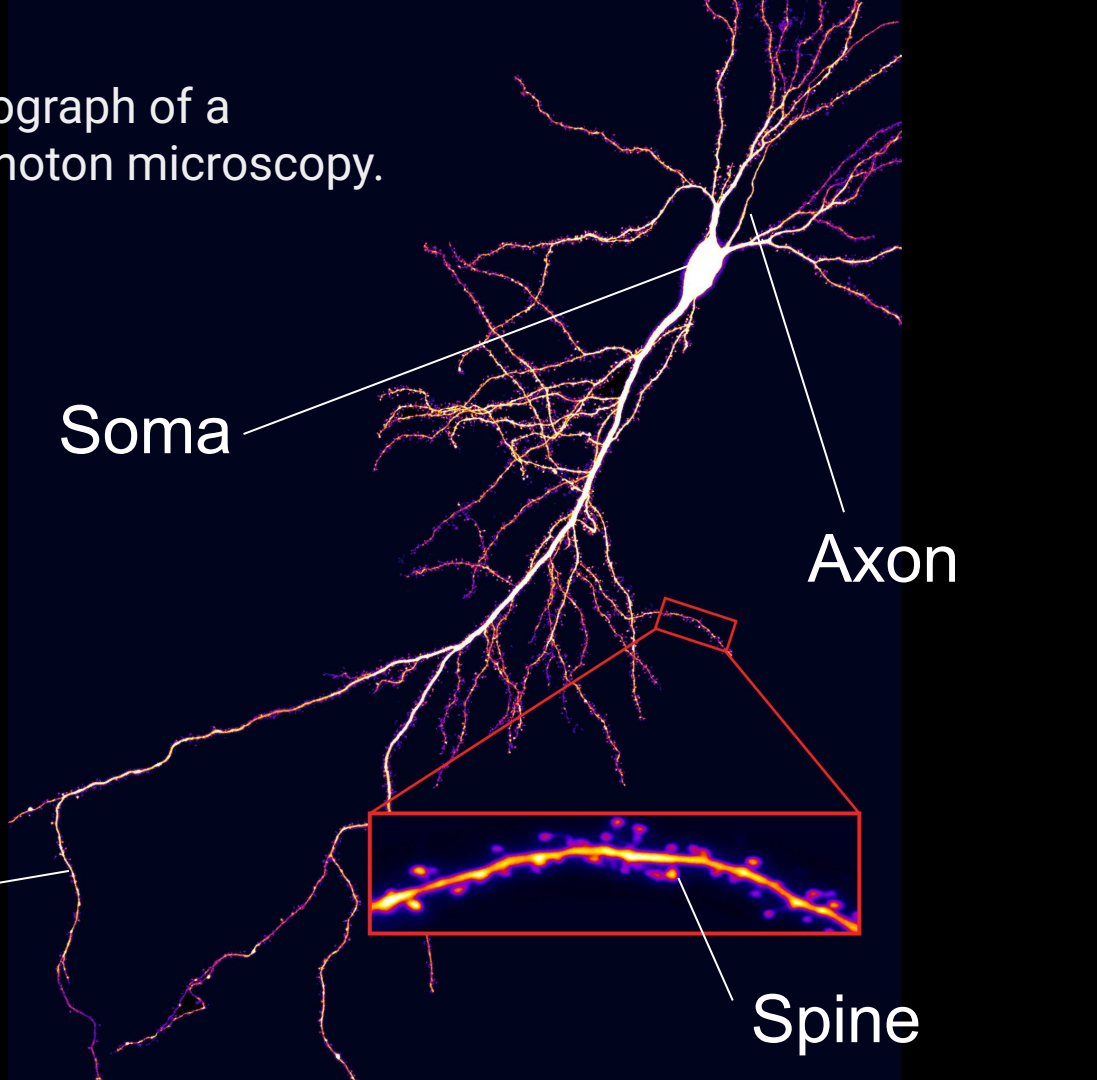



フェムト秒レーザー
カメラ
蛍光顕微鏡
細胞膜電位測定機器


CWレーザー
蛍光
フェムト秒
レーザー
赤外パルス
レーザー

Dendritic spines are visible on a micrograph of a hippocampal neuron, taken using 2-photon microscopy.

Credit:
Anna Hobbiss- Champalimaud Foundation



まとめ

1. フェムト秒レーザーはパルスレーザーできわめて強い光が出せる

2. 蛍光顕微鏡で使うと、焦点面でのみ2光子吸収がおこり、蛍光画像のノイズを減らすことができる

3. これにより、細胞の形態を計測したり、イオン結合色素や蛋白を使い、細胞の活動を測定する