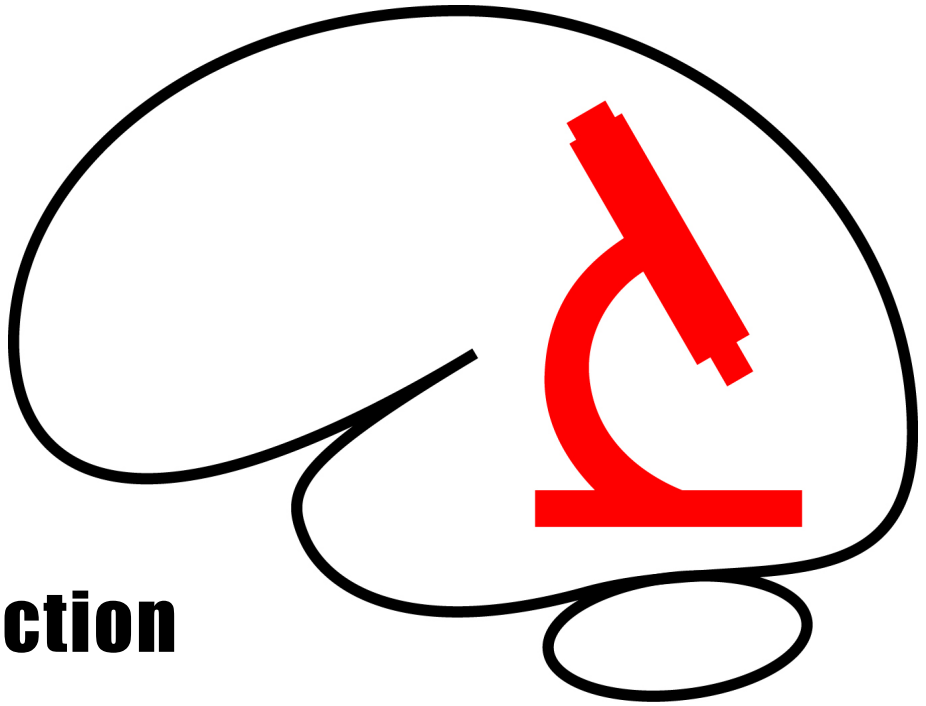
ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE



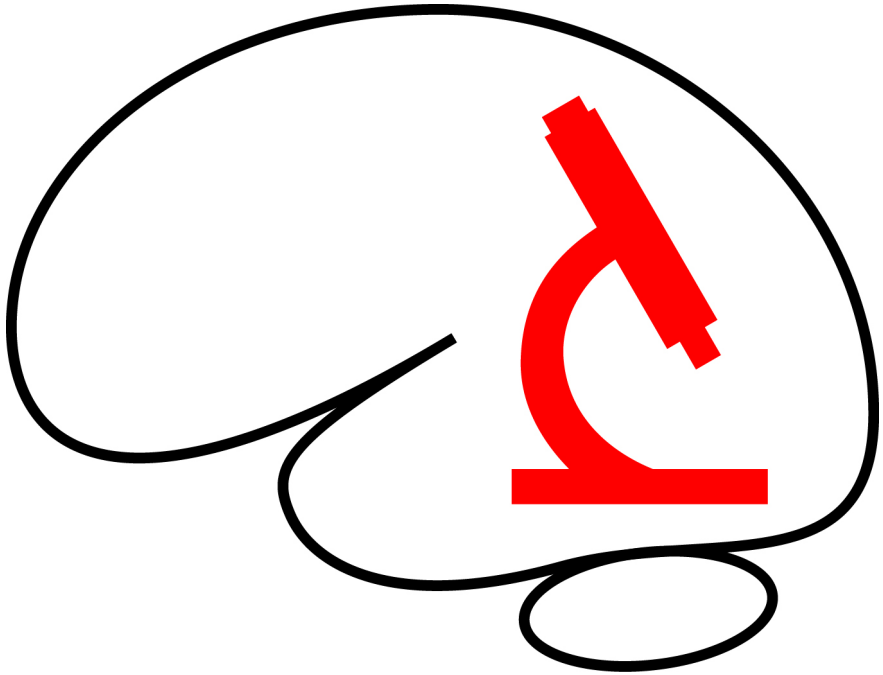
6.3 Imaging the brain in action

Cellular Mechanisms of Brain Function

Prof. Carl Petersen

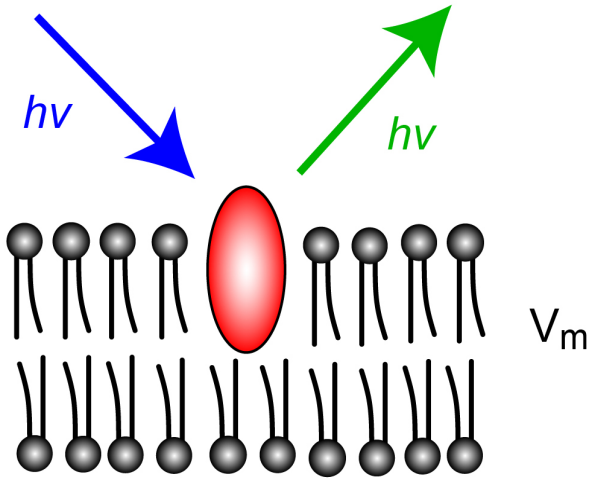
Imaging the brain in action

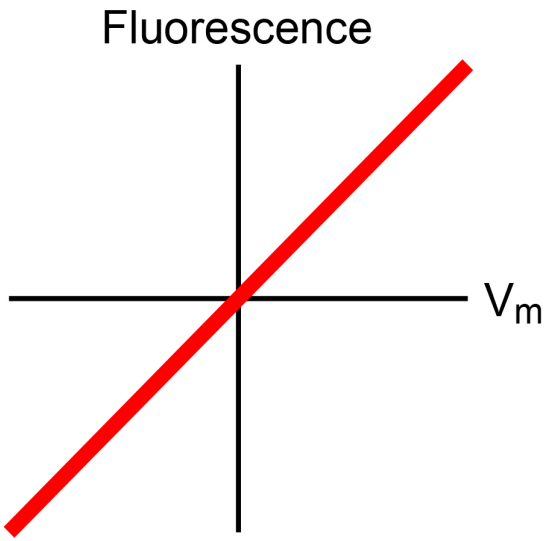
Real-time optical imaging of brain function

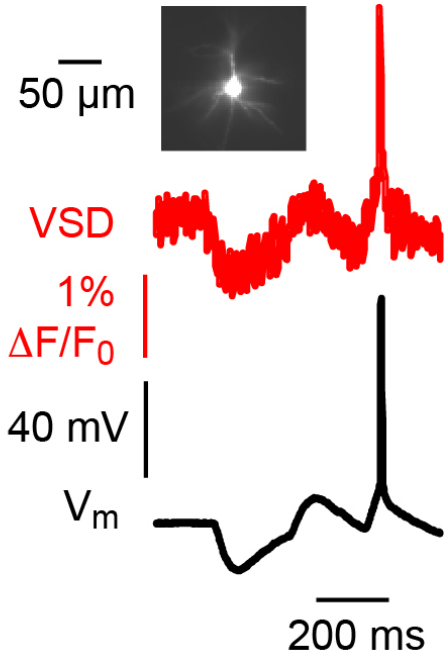


Imaging membrane potential

Voltage-sensitive fluorescent dye (VSD)

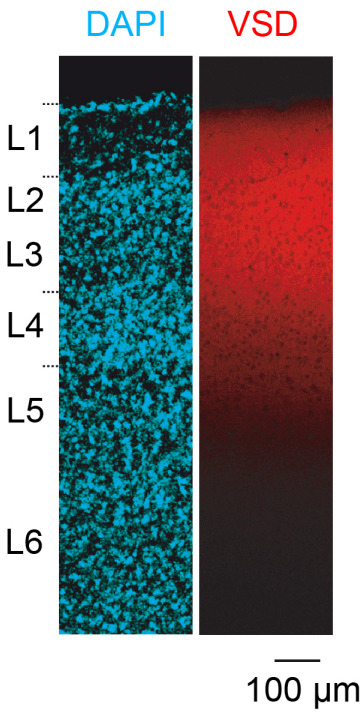


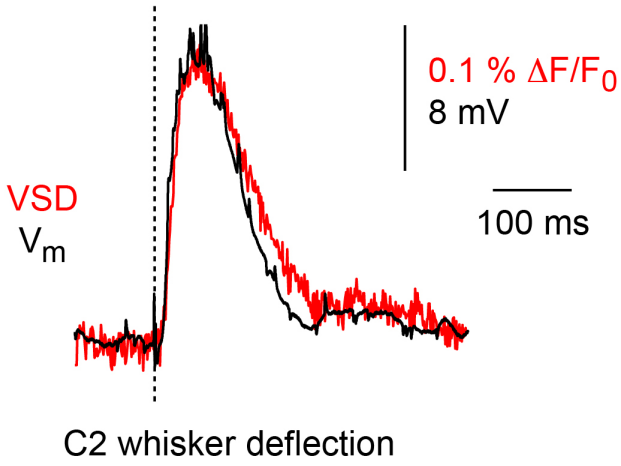


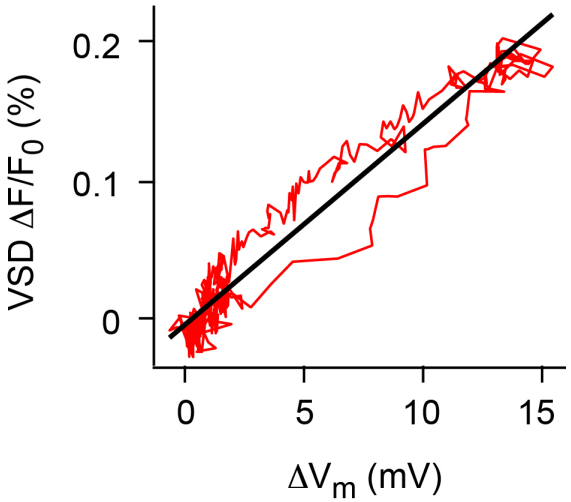


Berger, Borgdorff, Crochet, Neubauer, Lefort, Fauvet, Ferezou, Carleton, Luscher & Petersen, 2007

Imaging membrane potential *in vivo*

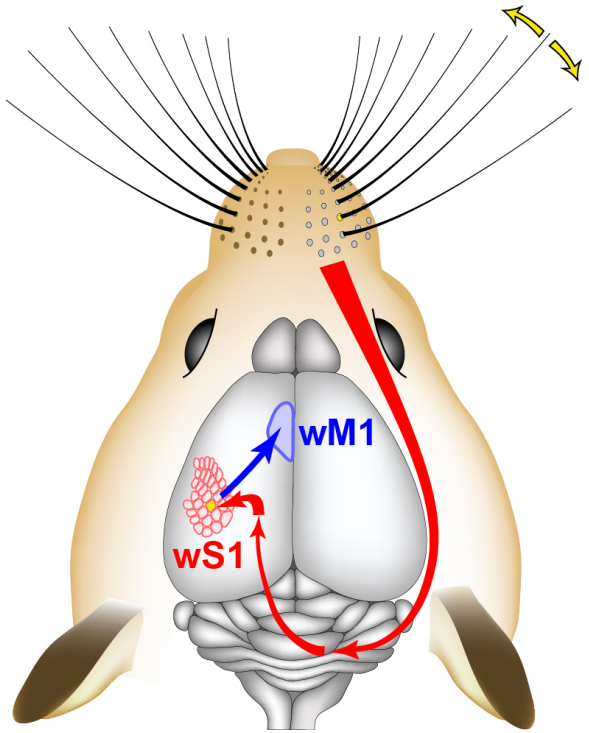


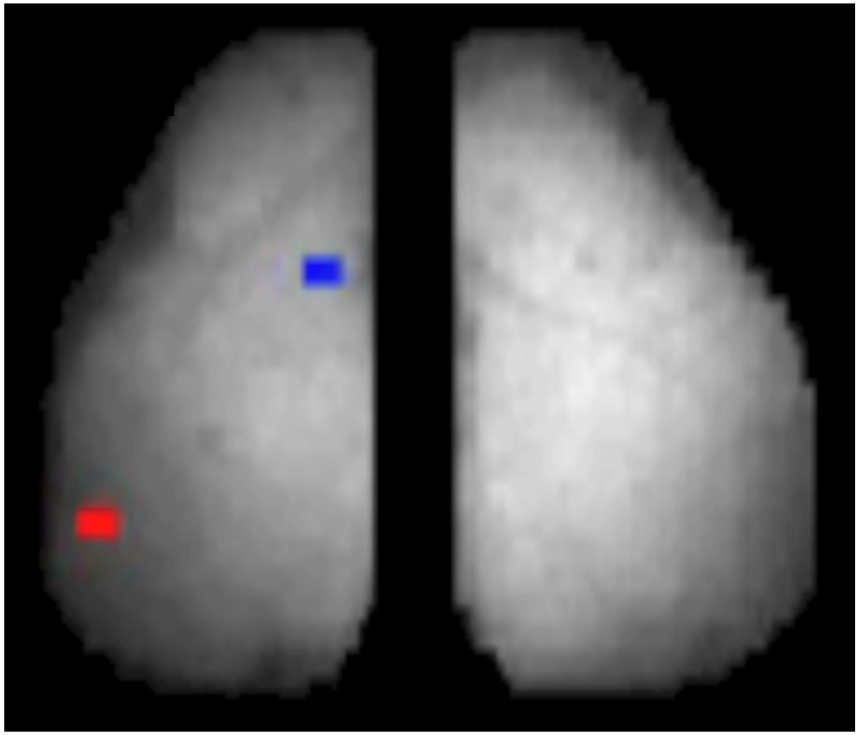




Berger, Borgdorff, Crochet, Neubauer, Lefort, Fauvet, Ferezou, Carleton, Luscher and Petersen, 2007
Ferezou, Haiss, Gentet, Aronoff, Weber and Petersen, 2007

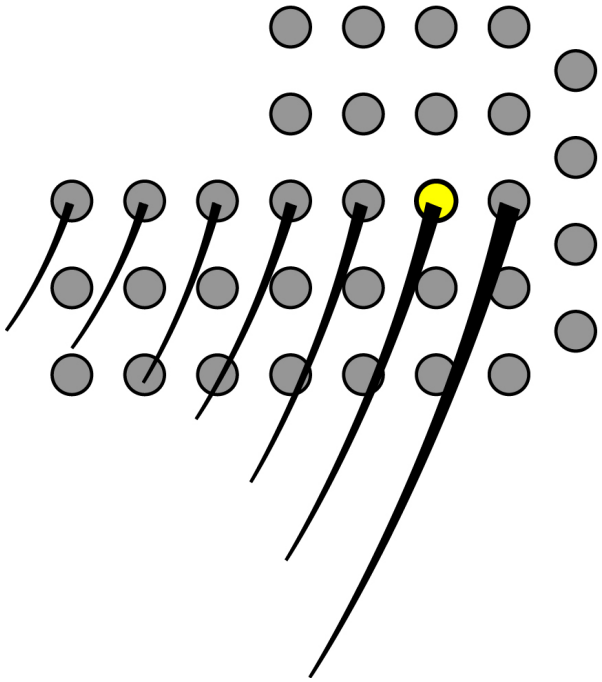
Spatiotemporal dynamics of cortical function

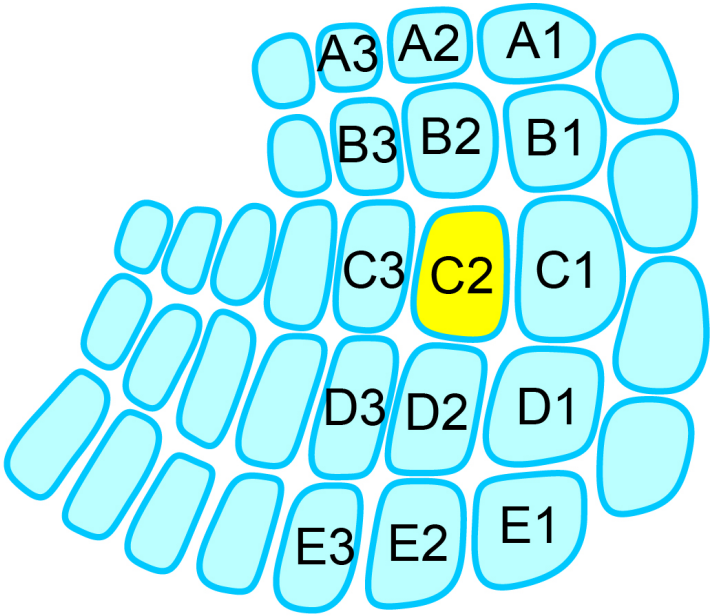




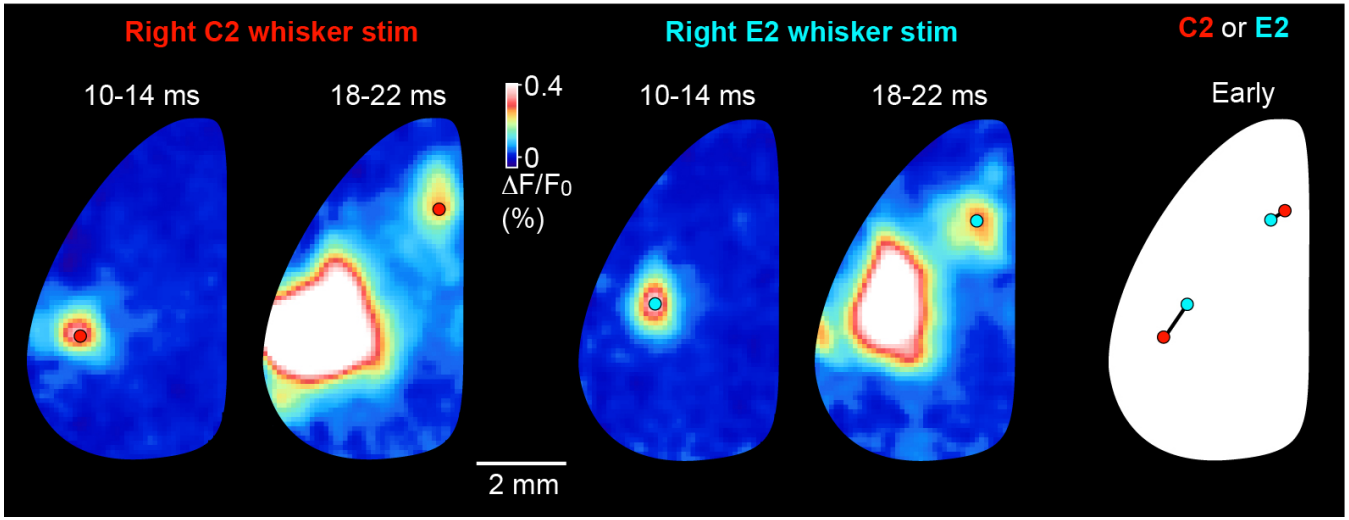
Ferezou, Haiss, Gentet, Aronoff, Weber and Petersen, 2007

Somatotopic whisker map

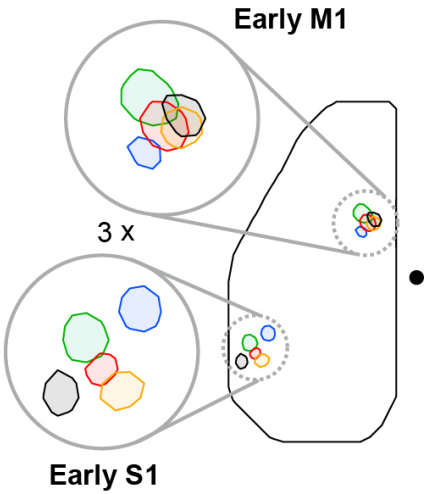




Mapping mouse sensorimotor cortex



Ferezou, Haiss, Gentet, Aronoff, Weber and Petersen, 2007



High resolution optical imaging

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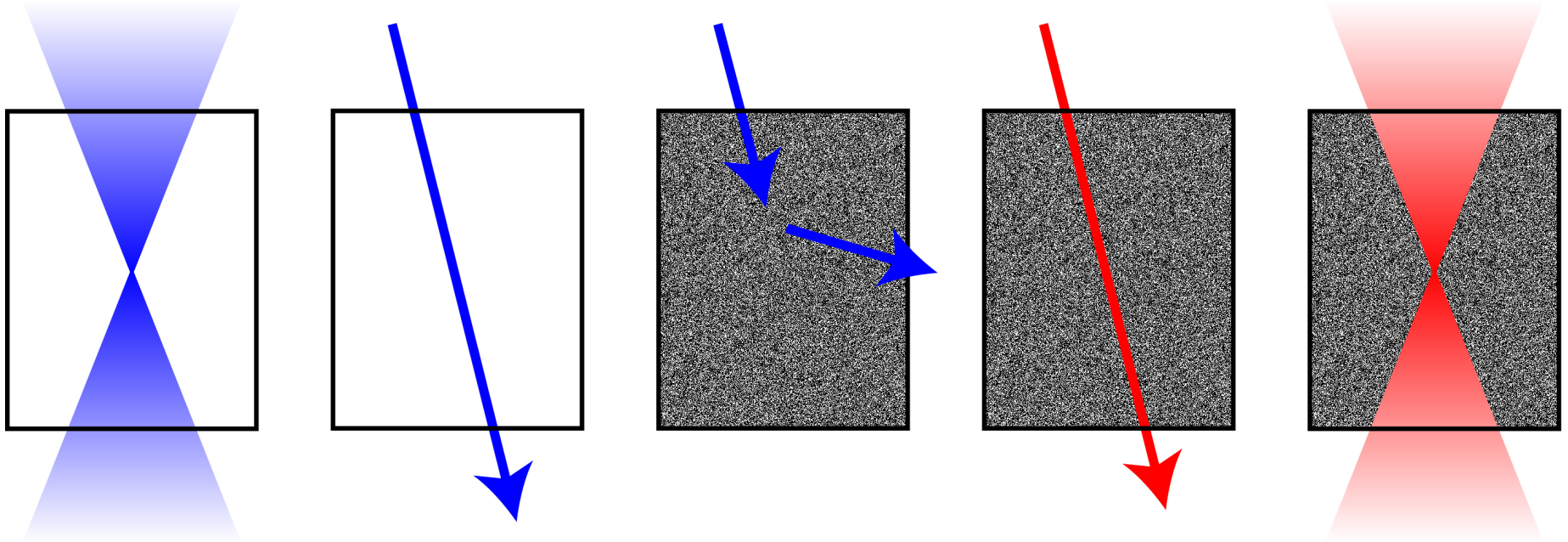
The brain scatters light strongly, with less scattering at long wavelengths.



Single-photon vs two-photon excitation

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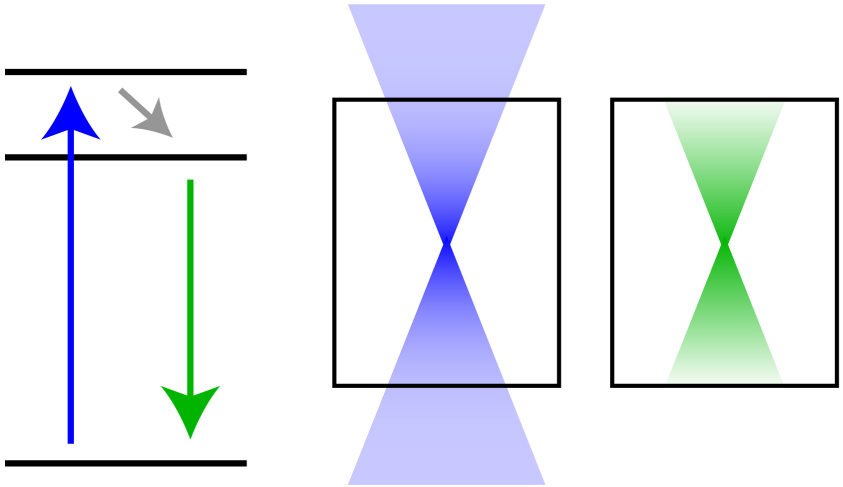
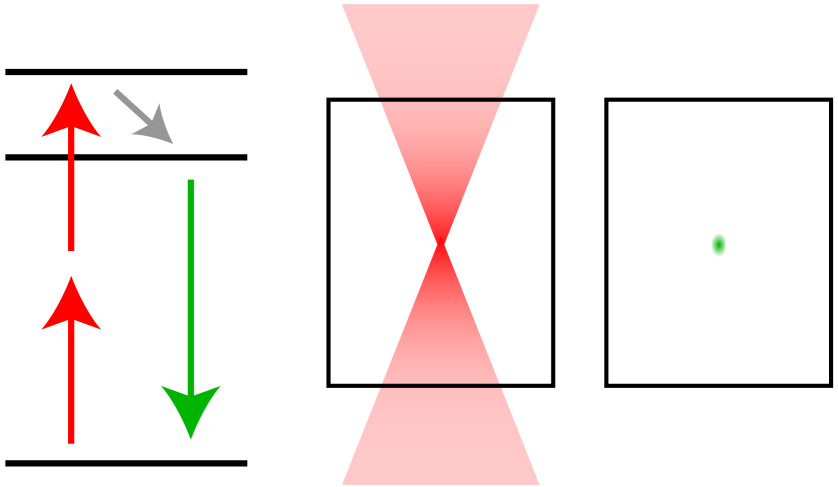
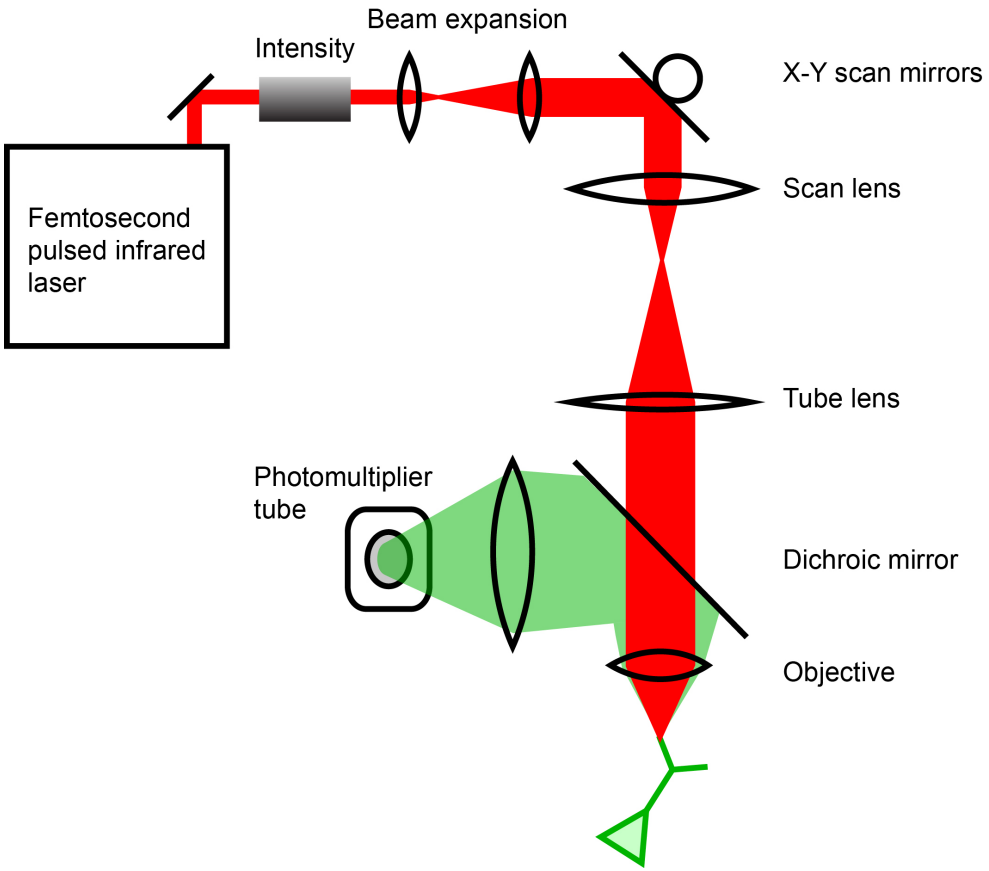
Single-photon excitation



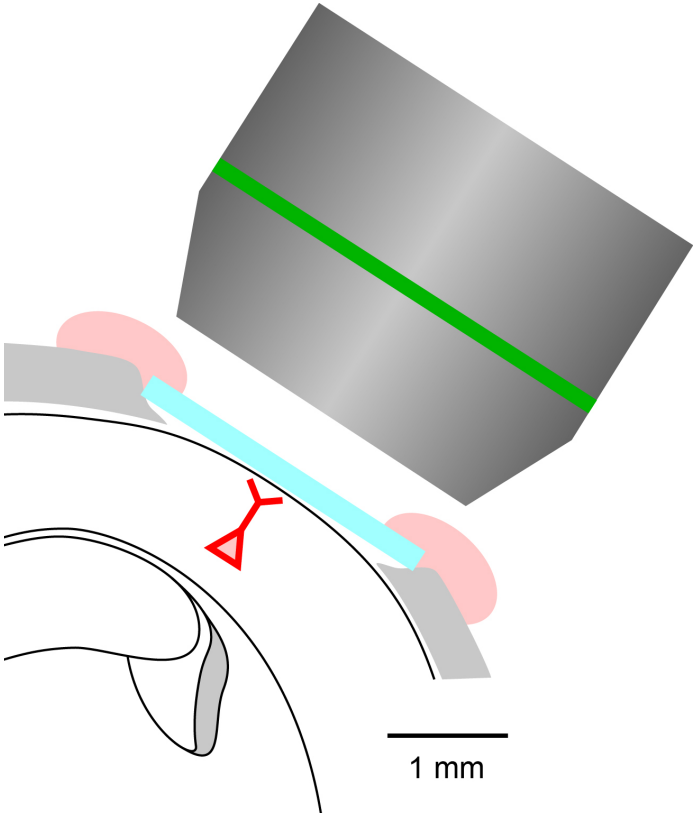
Two-photon excitation

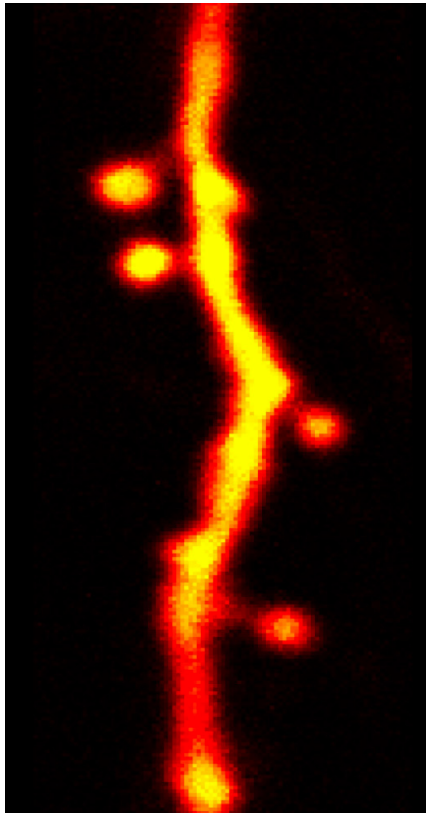


Two-photon imaging



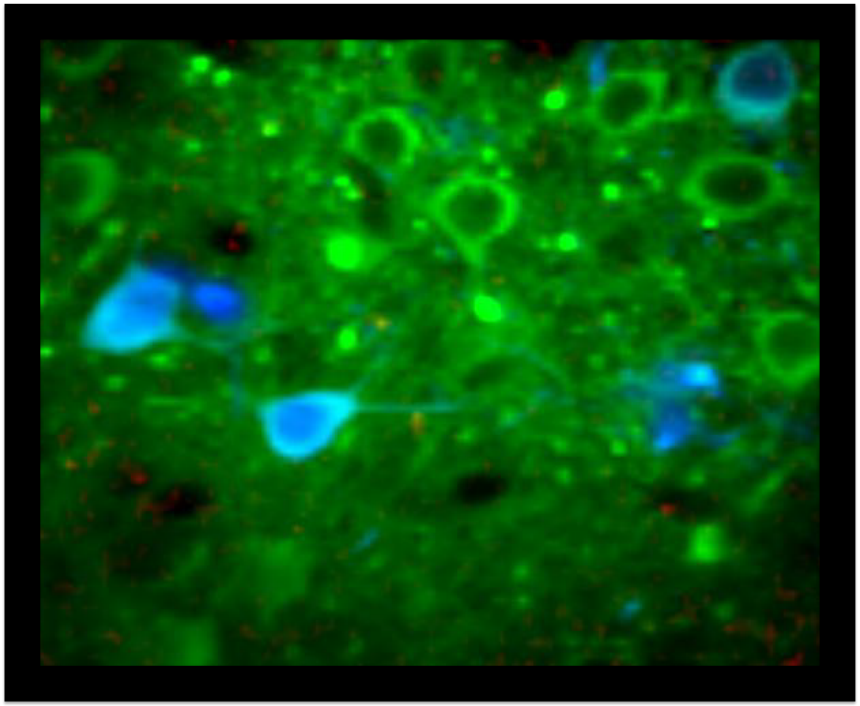
In vivo two-photon microscopy





Spine plasticity

In vivo two-photon calcium imaging



Kremer and Petersen

Fluorescence imaging of brain function

Fluorescent probes (both chemical and genetic) are being engineered to monitor many different cellular activities, including:

voltage, Ca^{2+}, second messengers, protein-protein interactions, synaptic vesicle release, neurotransmitter receptors, …

Different neuronal compartments can be imaged:

cell bodies, axons, presynaptic boutons, dendrites and spines

New techniques are being developed for improving optical imaging at many different levels, e.g. *super-resolution microscopy*

Real-time imaging of the brain in action

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- Epifluorescence imaging of voltage-sensitive dyes, ~100 µm.
- Two-photon excitation imaging of fluorescence provides ~1 µm resolution in the living brain.
- Two-photon calcium imaging provides information about neuronal activity with cellular and subcellular resolution.