Brain Signal Acquisition

Partially Invasive Approach

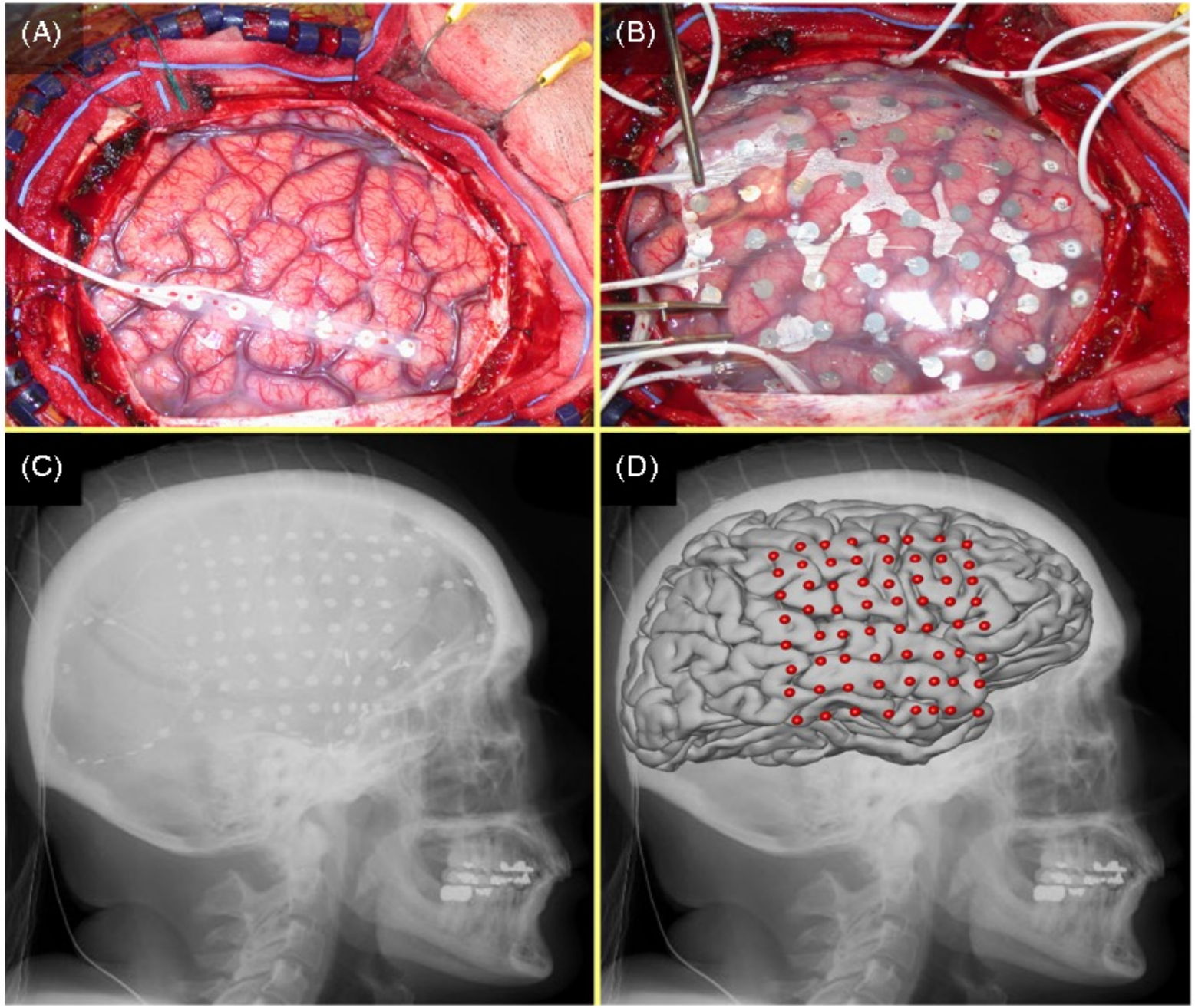
Electrocorticography (ECoG):

- *Electrocorticography* (ECoG) is a technique for recording brain signals that involves placing electrodes on the surface (cortex) of the brain.
- The procedure requires making a surgical incision into the skull to implant the electrodes on the brain surface

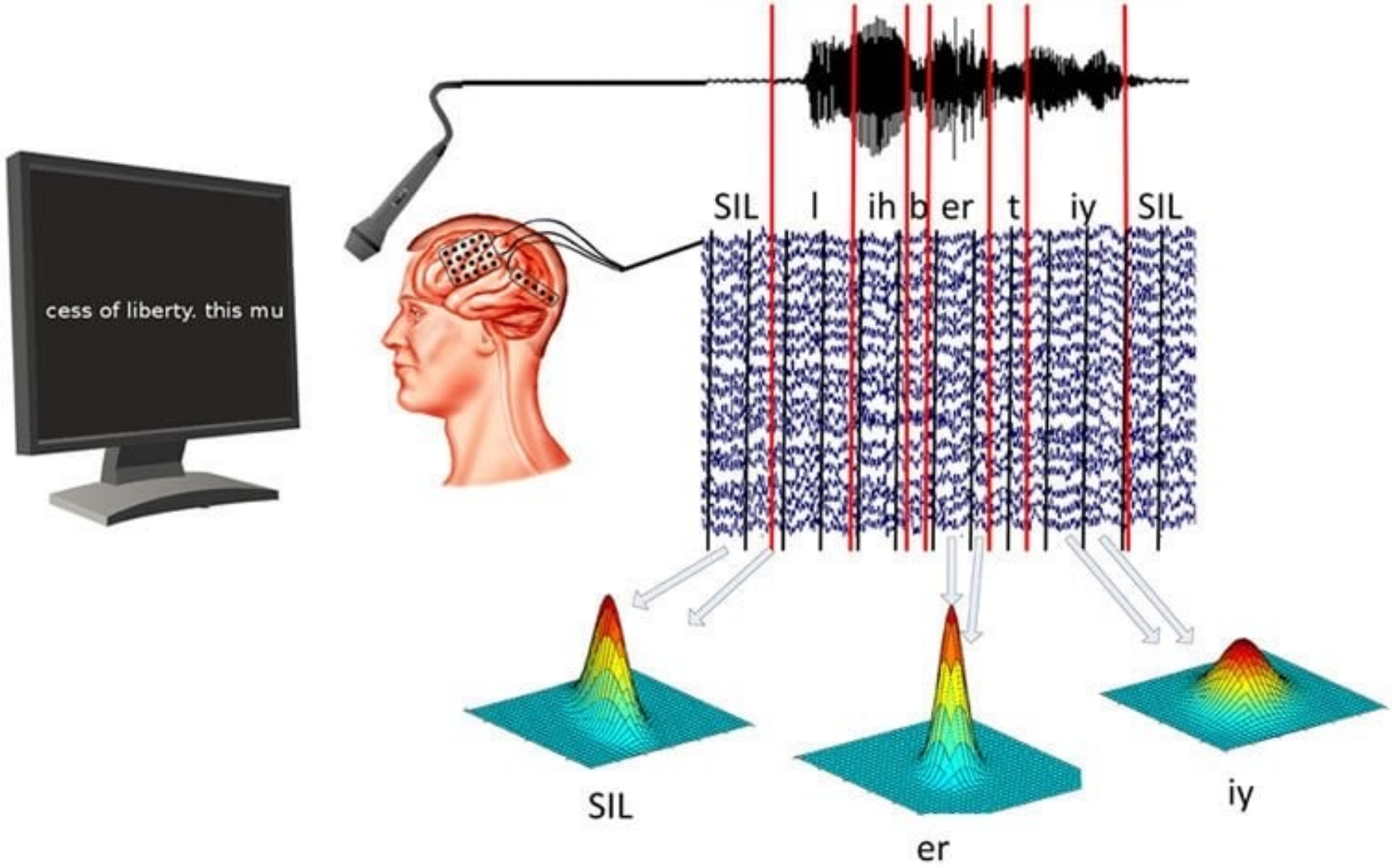
Partially Invasive Approach

- ECoG electrodes can record the electrical fluctuations caused by the coherent activity of large populations of neurons (several tens of thousands).
- Safer than arrays implanted inside the brain.
- ECoG electrodes may also be less likely to wear out compared to brain penetrating electrodes
- ECoG offers greater spatial resolution

https://www.youtube.com/watch?v=KEk3m4FwVt8



(from (Miller et al., 2007).



Automatic Speech Recognition from Neural Signals: A Focused Review" by Christian Herff and Tanja Schultz in *Frontiers in Neuroscience*. Published online September 27 2016 doi:10.3389/fnins.2016.00429

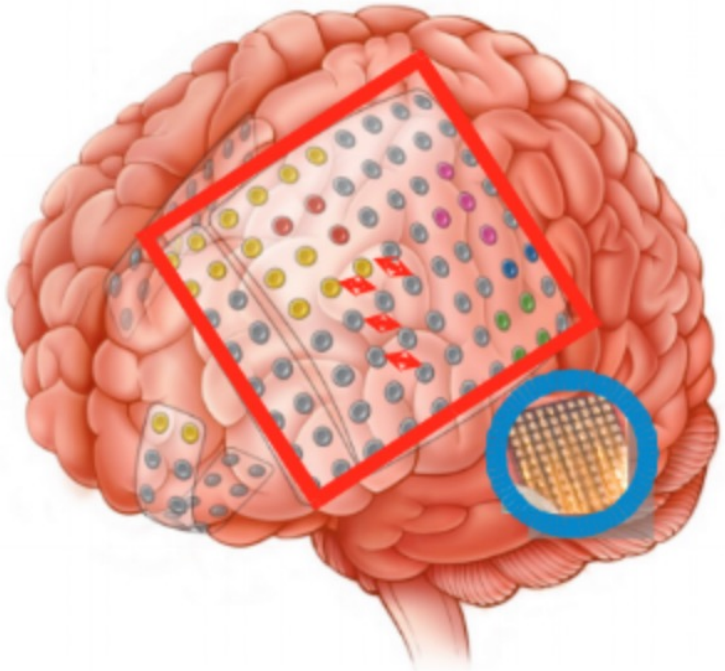
ECoG and audio data are recorded at the same time. Speech decoding software is then used to determine timing of vowels and consonants in acoustic data. ECoG models are then trained for each phone individually by calculating the mean and covariance of all segments associated with that particular phone.

Partially Invasive Approach

MicroECoG:

- One disadvantage of ECoG, is the relatively large size of ECoG electrodes
- These microelectrodes are only a fraction of a millimeter in diameter and spaced only 2–3 mm apart in a grid
- Allows detection of neural activity at a much finer resolution than traditional ECoG.
- Decoding fine movements, such as the movements of individual fingers, or even speech, without actually penetrating the brain.

Partially Invasive Approach



Current ECoGs
- Large area
- Low resolution

Current µECoGs
- Small area
- High resolution

Partially Invasive Approach

Optical Recording: Voltage-Sensitive Dyes and Two-Photon Calcium Imaging:

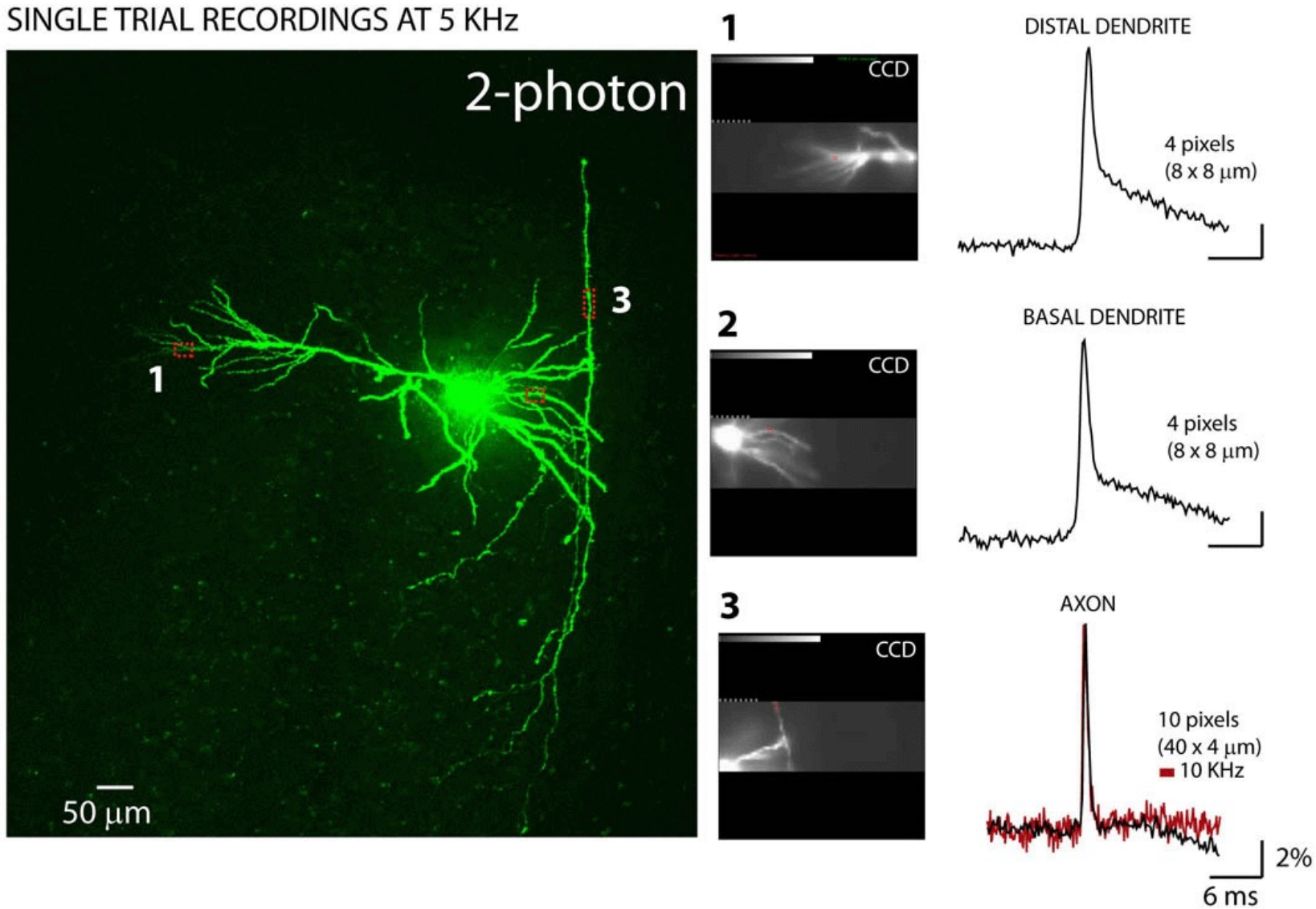
- Voltage-sensitive dyes
- Voltage-sensitive dye changes its absorbance and fluorescence intensity when membrane potential changes in a stained brain or heart tissue.
- By using voltage-sensitive dyes as chemical probes and capturing changes in light intensity with the use of a high-speed imaging device, it is possible to image in real time the activity of where, when, and how much excitation or inhibition occurred, in the brain and heart.

Partially Invasive Approach

Voltage-sensitive dyes
https://www.scimedia.com/applications/neuro/vsd/data/

- Neurons are stained with a voltage-sensitive dye
- Dye responds to changes in membrane potential by changing its absorption and/or fluorescence
- Recorded optical signals correspond to summed responses from several simultaneously active neurons.
- Useful for imaging macroscopic features of the brain.

VOLTAGE-SENSITIVE DYE IMAGING



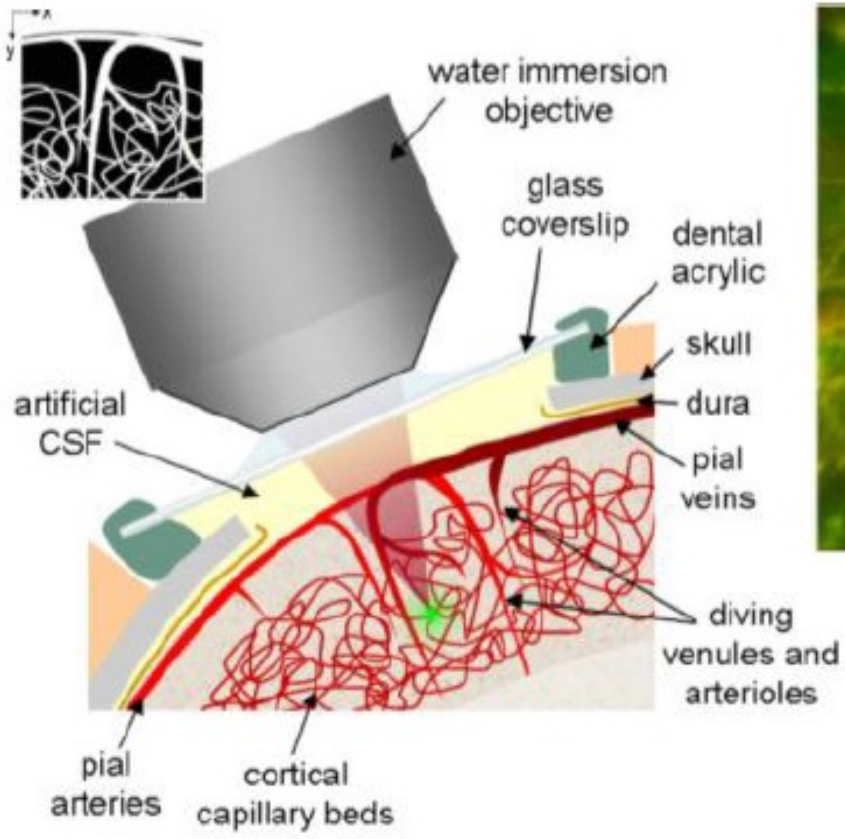
(image: Scholarpedia http://www.scholarpedia.org/article/Voltage-sensitive_dye).

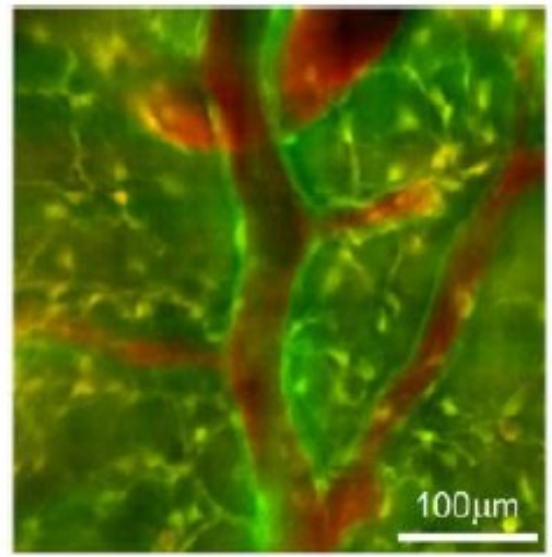
Partially Invasive Approach

- Two-photon calcium imaging
- https://elifesciences.org/articles/26839#content
- Based on the fact that electrical activity in neurons is typically associated with changes in calcium concentration.
- Two-photon calcium imaging allows us to observe the activity of multiple neurons up to ~500 µm below the cortical surface without cortical invasion.
- Photon calcium imaging involves:

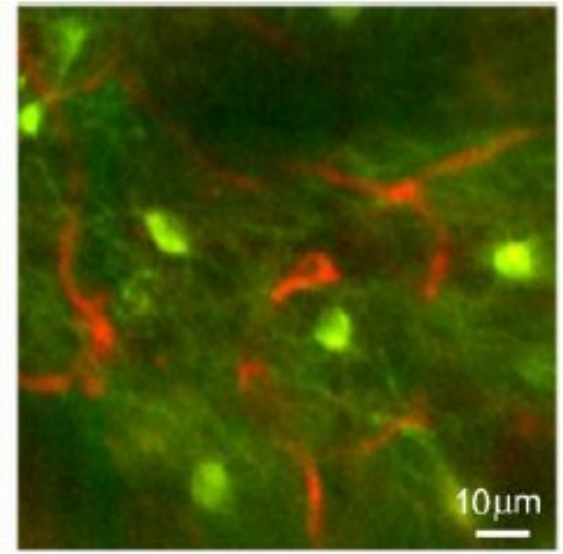
  (1) using pressure ejection to load neurons with fluorescent calcium-indicator dyes

  (2) monitoring changes in calcium fluorescence during neural activity using two-photon microscopy.





Oregon Green calcium sensitive dye stained neurons



Transgenic mouse expressing green fluorescent protein (GFP) in a subpopulation of neurons

Image from Kherlopian et al., 2008).