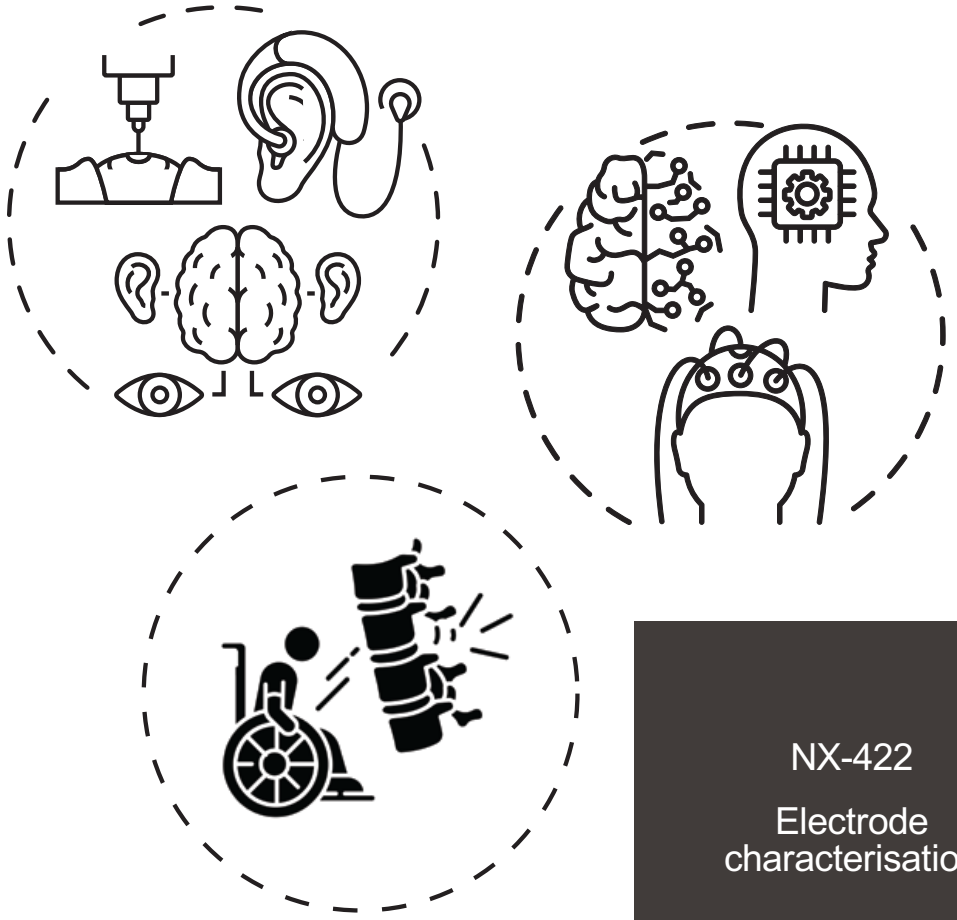


Neural Interfaces

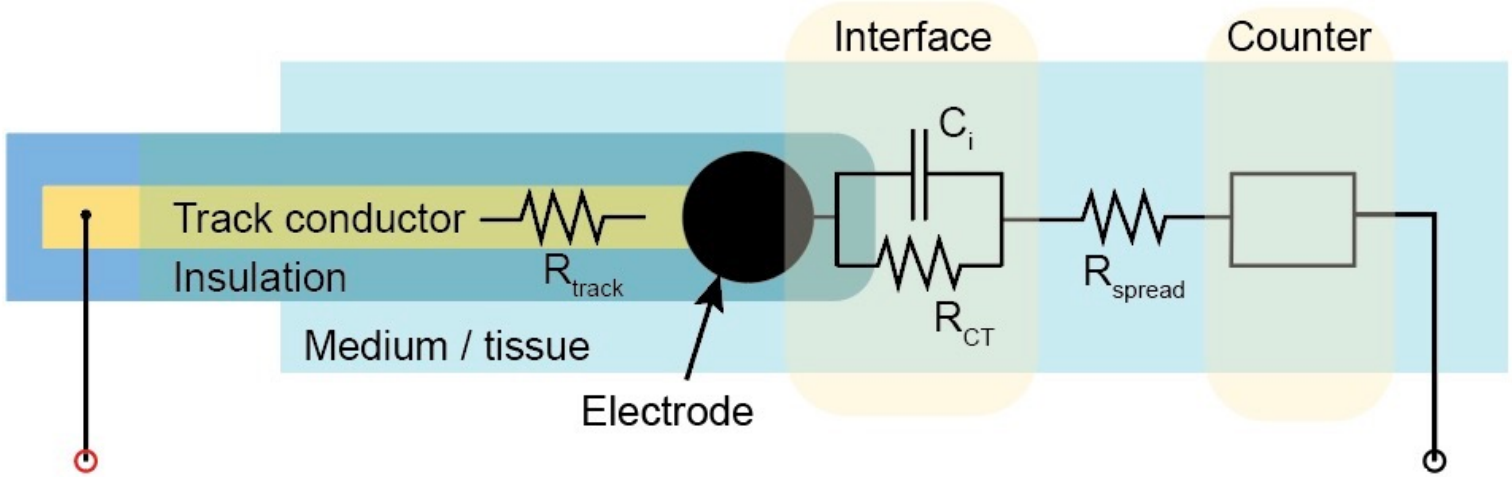
NX-422

Electrode characterisation

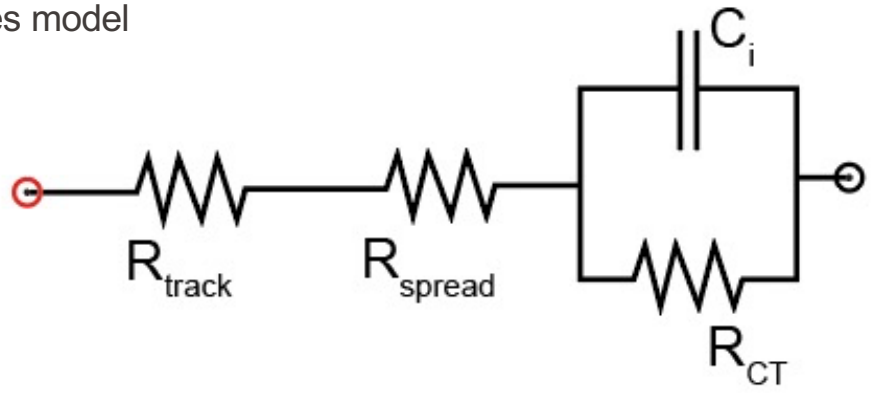
Stéphanie P. Lacour

Neuro-X Institute

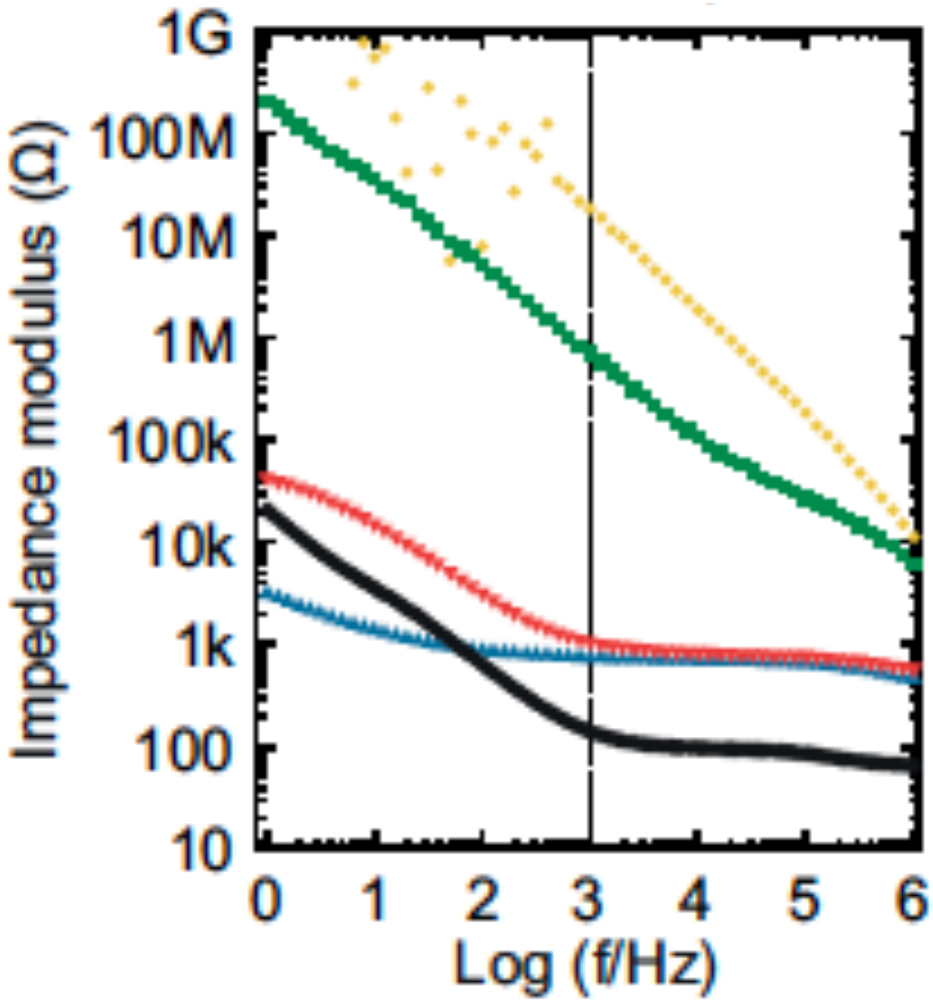
Equivalent electrical model of an electrode



Randles model



Analyse the Z(f) spectra



What can you define from these plots?

Which electrode has the largest surface area? lowest surface area?

Which parameters can you extract from the curves?

Solutions

- Impedance spectra of electrodes of various sizes and technology

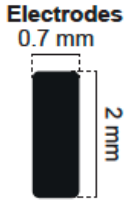
open circuit

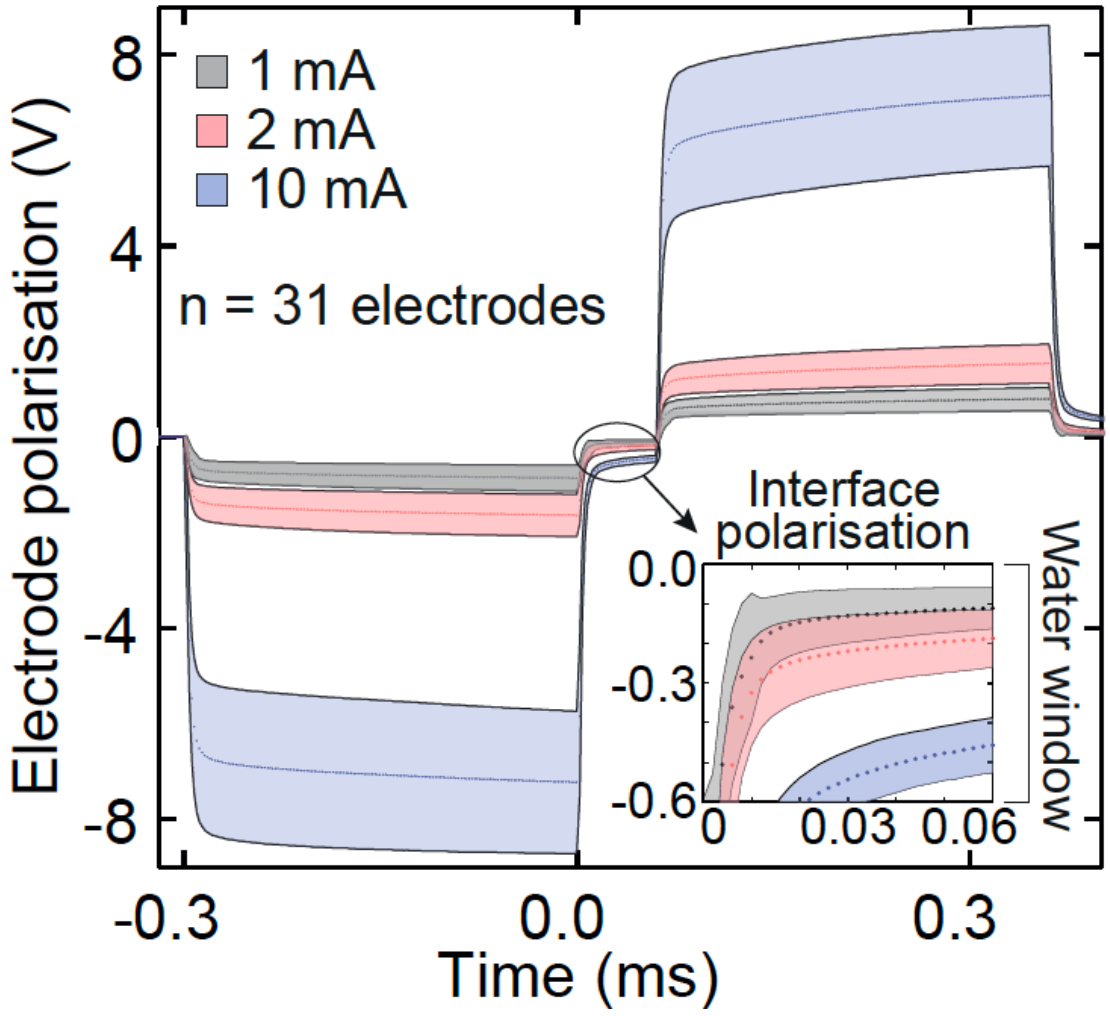
small electrode (< 100 µm dia.) prepared with microfabrication (high R in the high f range)

large, macroscopic “clinical” electrodes (low R in the high f range)

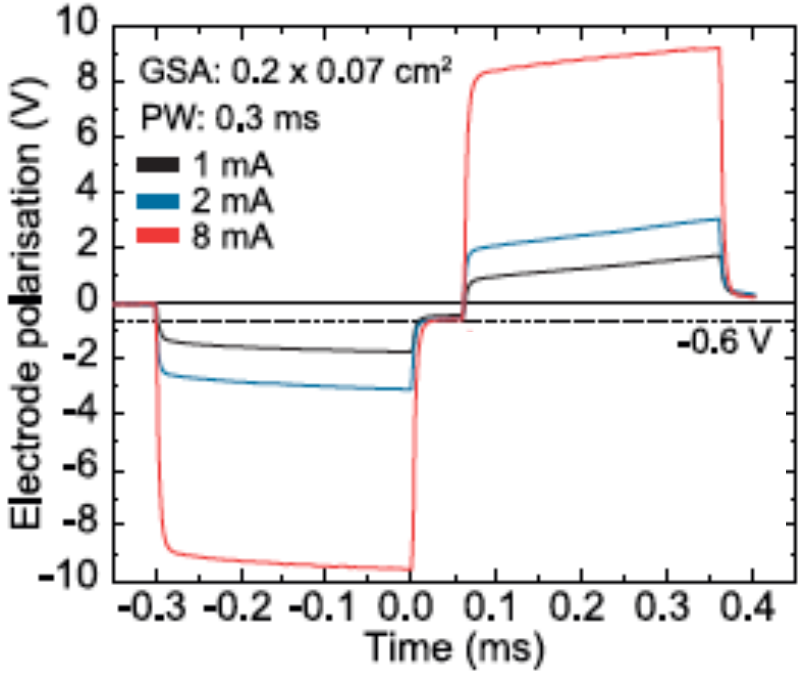
medium-large electrodes prepared with microfabrication

Interface polarisation





CIC_L
charge injection capacity limit



Calculate the CIC_L

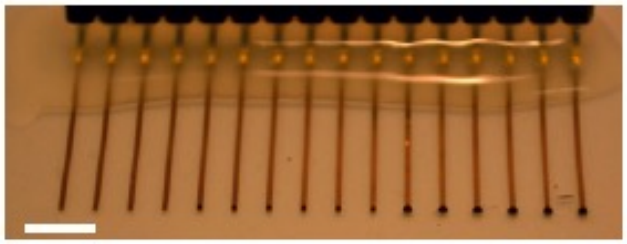
The electrode has a GSA of 0.2 x 0.07 cm^2

The biphasic current stimulation has a pulse width PW of 0.3ms.

The current is increased until the water window is reached.

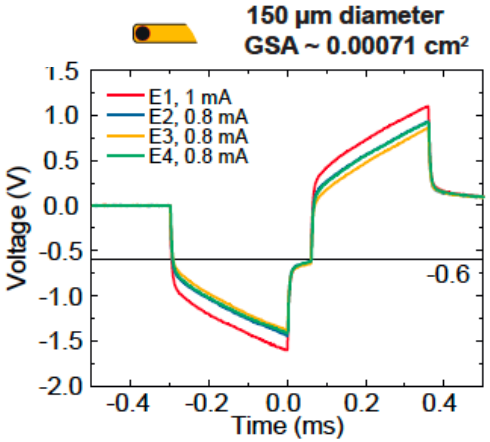
Effect of electrode size and CIC

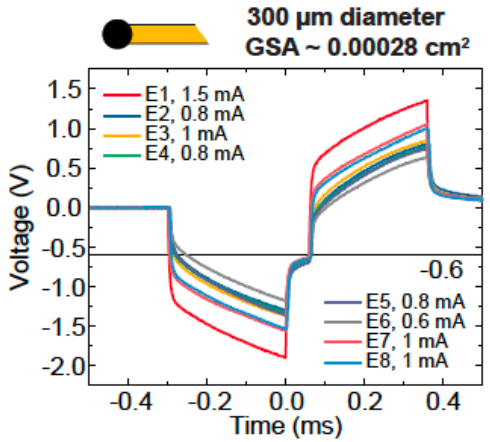
GSA: 150µm ⌀ → 1.4mm^2

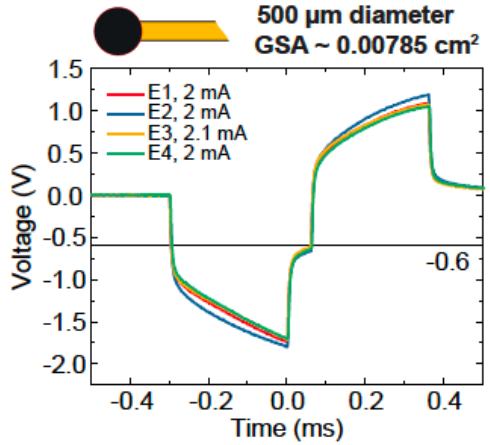


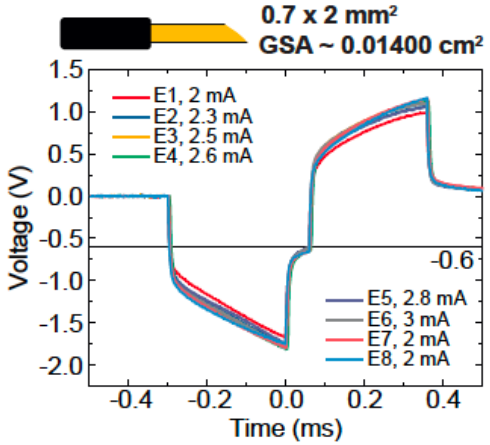
Four electrodes are characterised (identical material but different GSA).

How does the CIC evolve with GSA?









Definition of the CIC_L

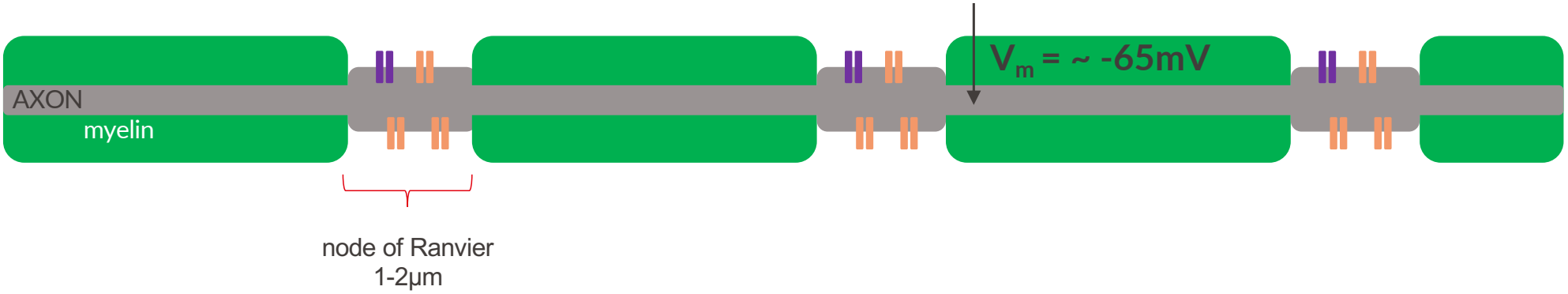
1. Measure the cathodic polarisation potential E_c
2. Calculate the injected cathodic charge: $Q_{inj,C} = I_C \times t$
3. Calculate the corresponding CIC: $CIC = Q_{inj,C} / GSA$

4. Reiterate until E_c reaches the « water window » limit

5. **$CIC_L = Q_{inj,C,max} / GSA$**

Electrical stimulation

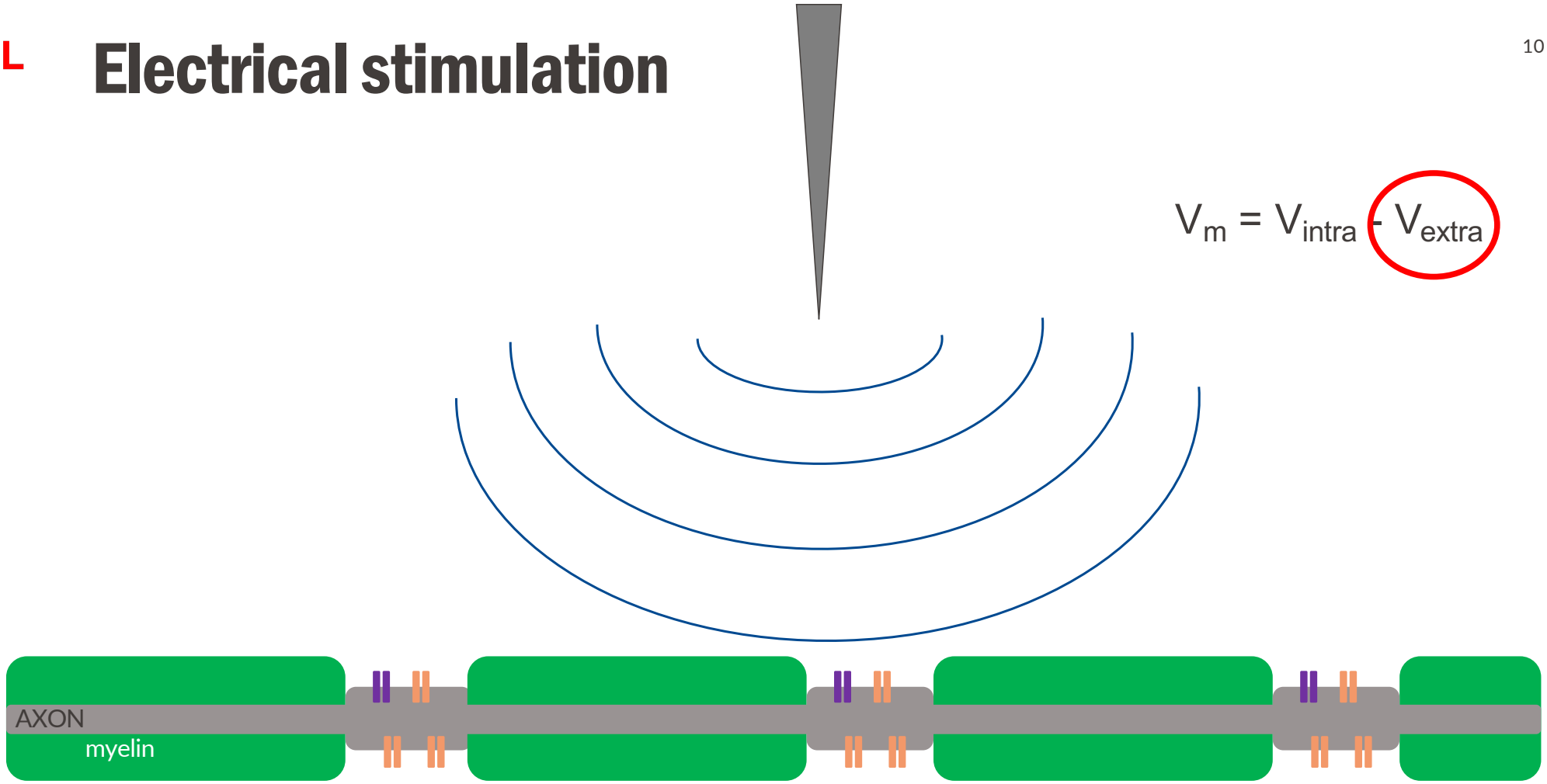
$$V_m = V_{intra} - V_{extra}$$



adapted from C. Capogrosso

Electrical stimulation

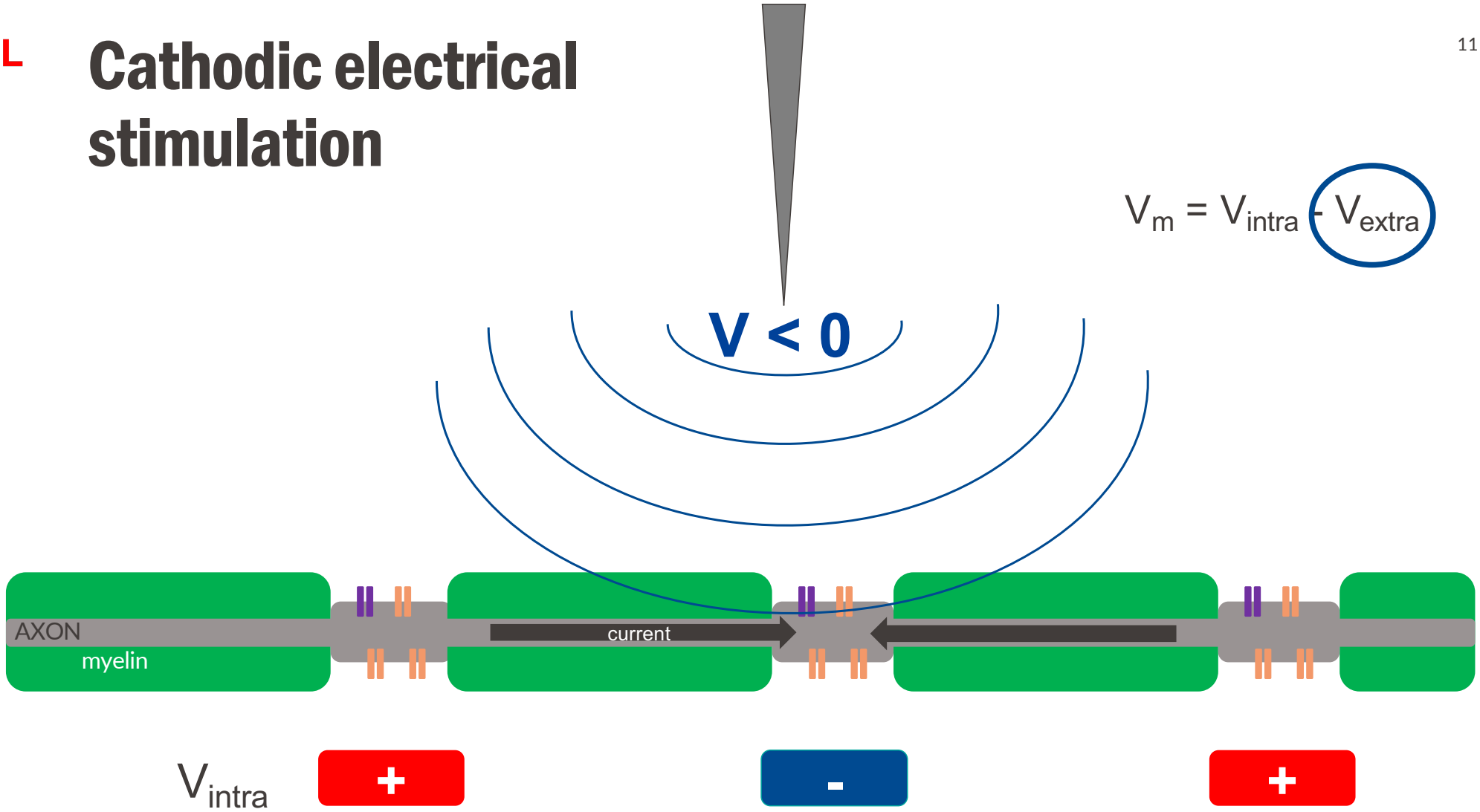
$V_m = V_{intra} - V_{extra}$



adapted from C. Capogrosso

Cathodic electrical stimulation

$V_m = V_{intra} - V_{extra}$

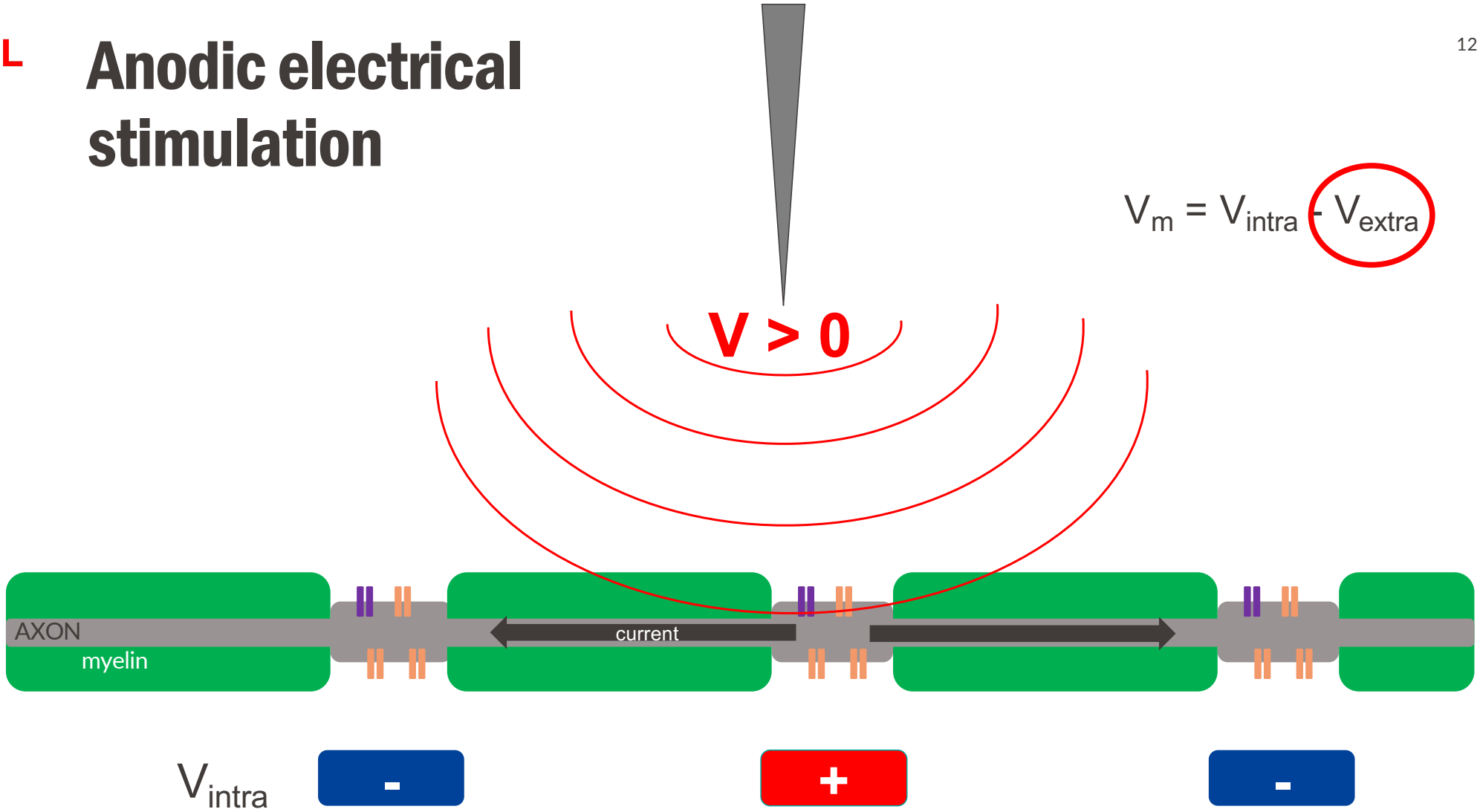


inward current enters the node → Membrane depolarisation → Triggered action potentiel

adapted from C. Capogrosso

Anodic electrical stimulation

$V_m = V_{intra} - V_{extra}$

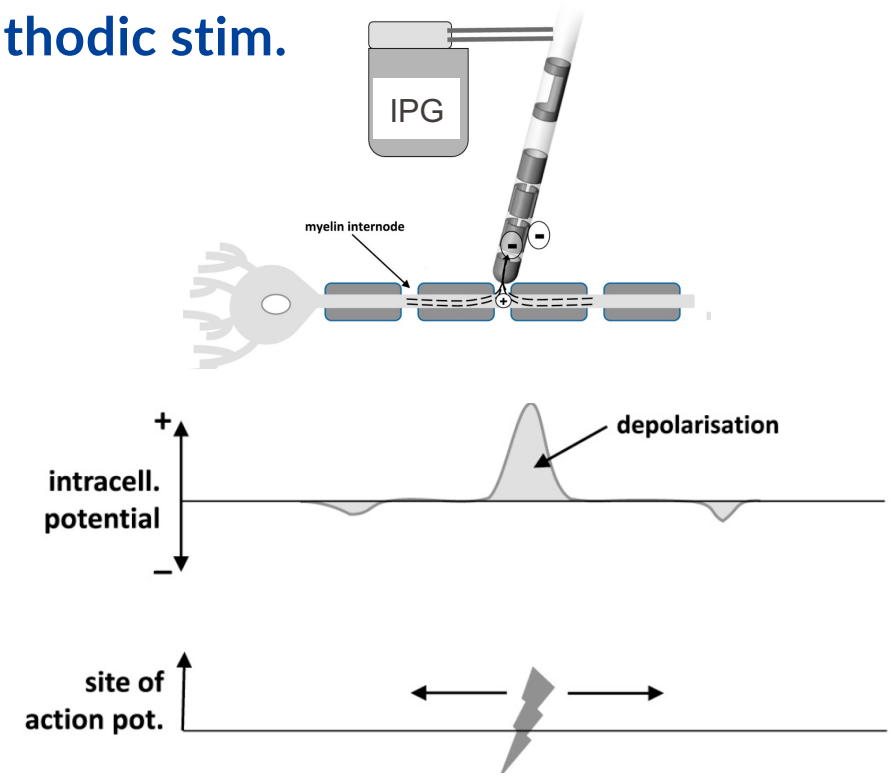


Inward currents enter neighboring nodes → Depolarised membrane in the lateral nodes → triggered action potential

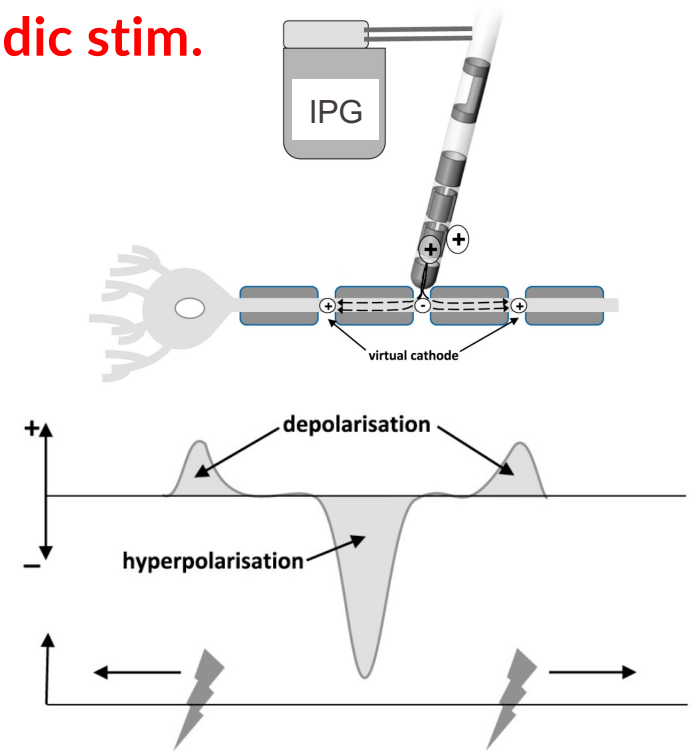
adapté de C. Capogrosso

Cathodic vs anodic stimulation

Cathodic stim.

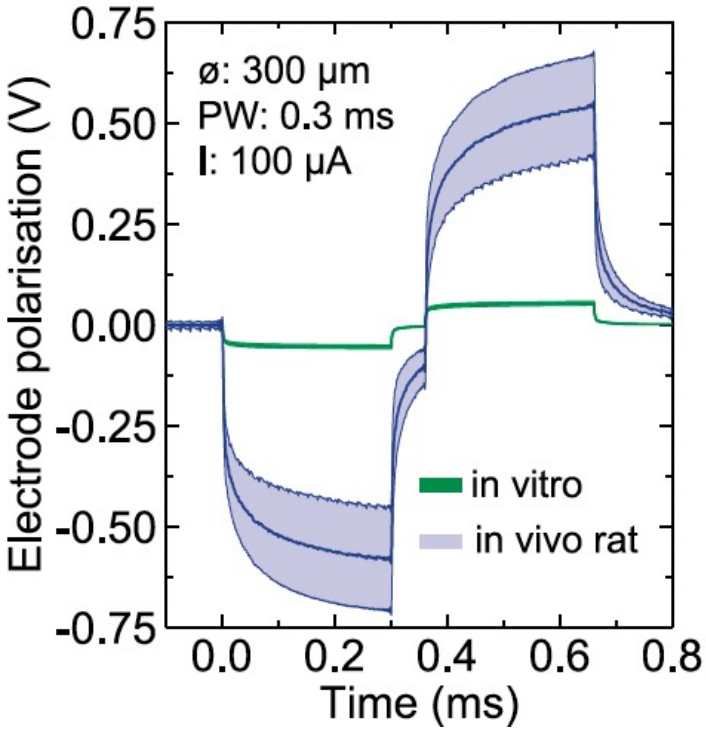


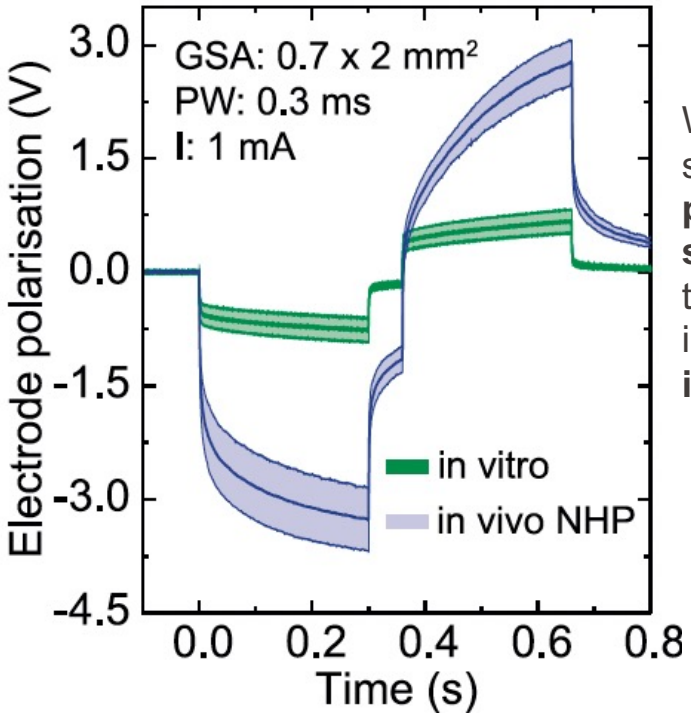
Anodic stim.



Parkinsonism & Related Disorders (2018) 55 pp 61-67

in vivo characterisation

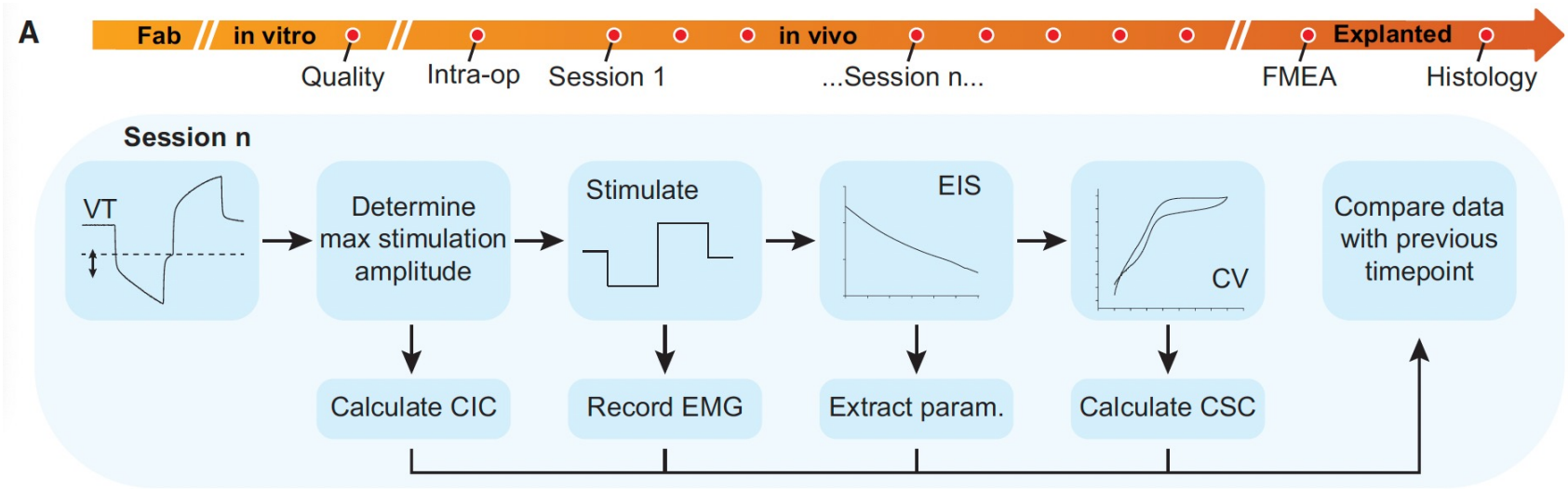




When delivering electrical stimulation in vivo, **the polarization of an electrode system is consistently larger** than what measured in vitro, both in terms of **access voltage and interface polarization.**

G. Schiavone et al. Neuron (2020) 108, pp. 238-258

Series of electrode characterisation: from fab to in vivo



G. Schiavone et al. Neuron (2020) 108, pp. 238-258