Rencontre Annuelle NanoSaclay - 2022

BrainSICM
A multimodal nanopipette-based platform for exploring brain communication

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Supervisors

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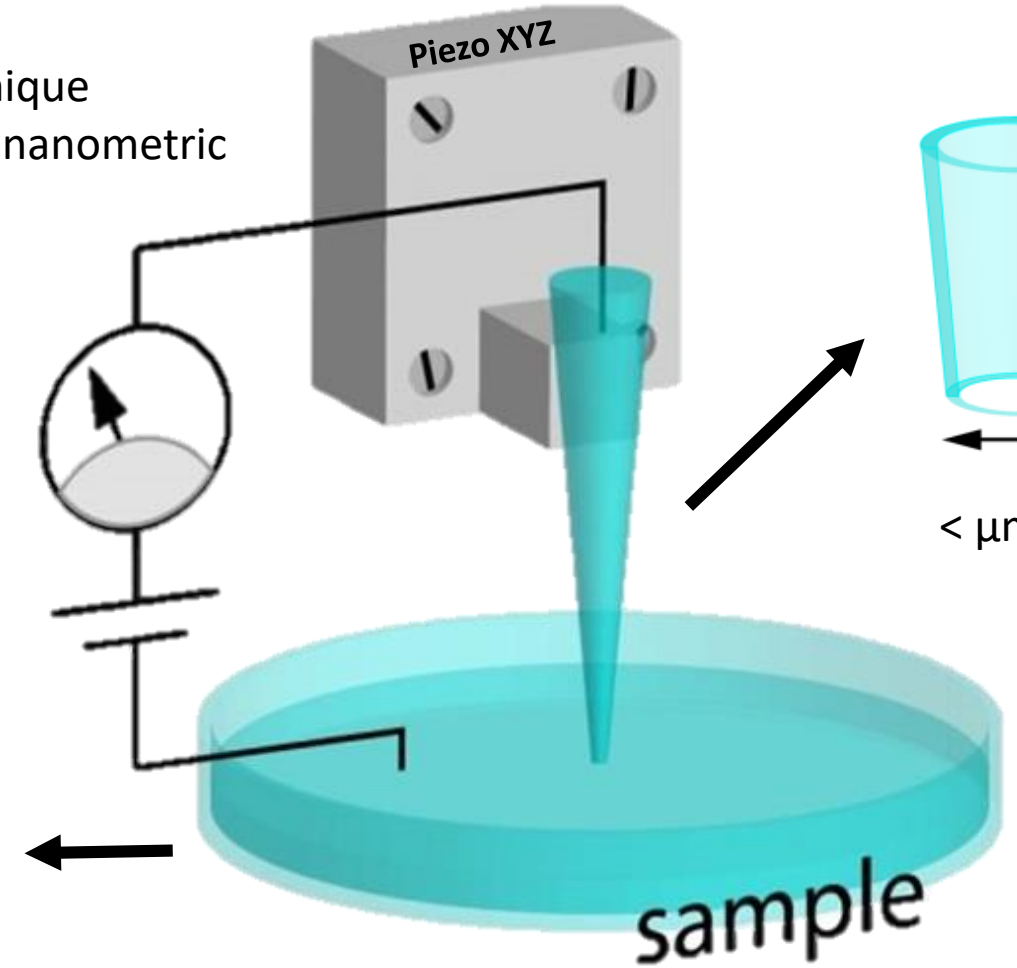
The BrainSICM project

SICM

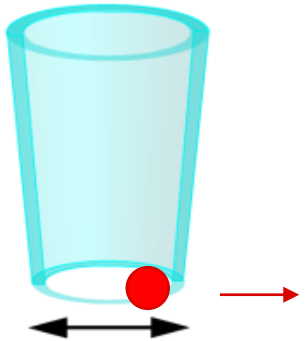
Scanning **I**on **C**onductance **M**icroscopy

- Scanning Probe Microscopy technique
- Topographic information with nanometric resolution
- Measurements in liquids



The Probe

Quartz **nanopipette** that can be functionalized



Nano-sensor

< µm

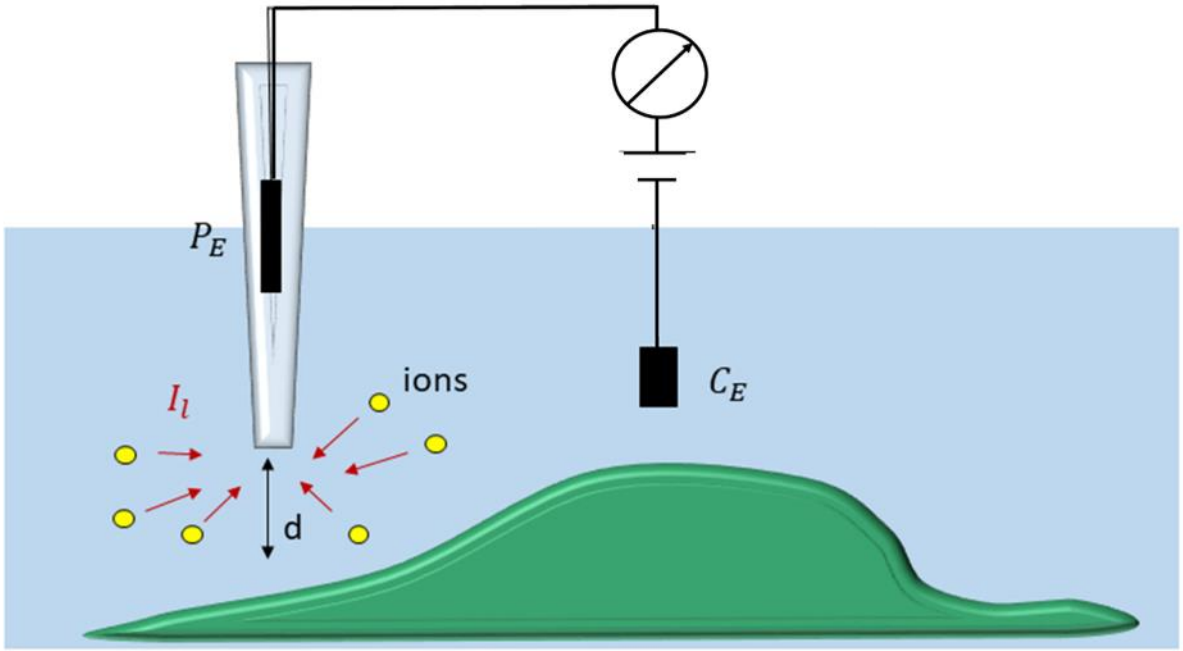
Ex.
Adding sensing capabilities for specific biomolecules

The Sample

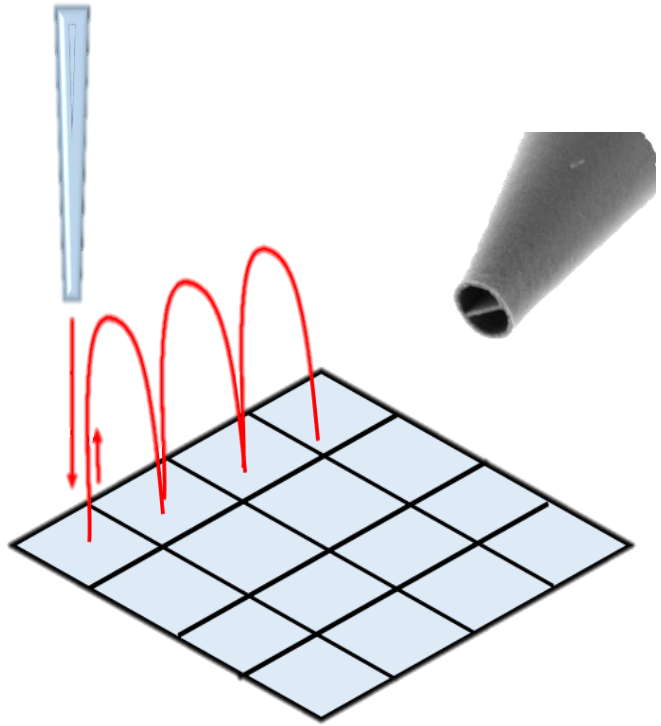
Living cells

Scanning Ion Conductance Microscopy

Working Principle



- The probe is a quartz nano-pipette
- It approaches and sense the surface in each pixel

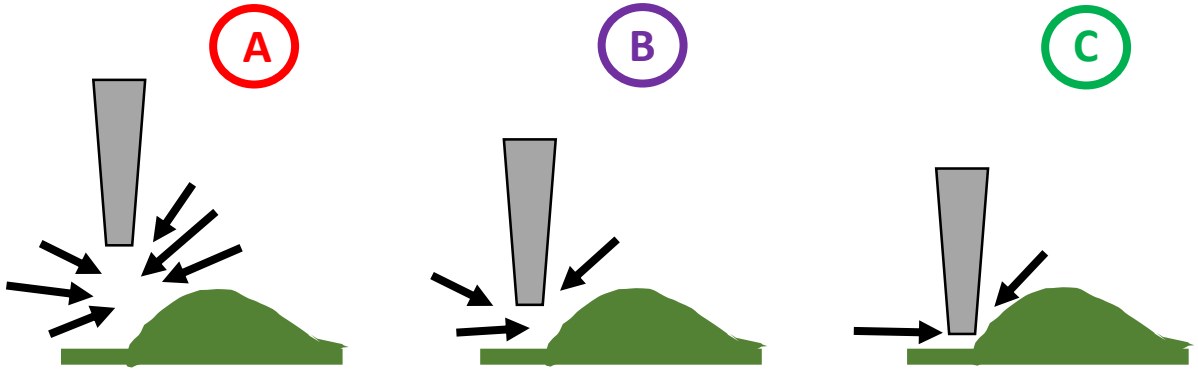


- Minimally invasive technique due to the absence of contact
- Ideal for imaging of living samples.

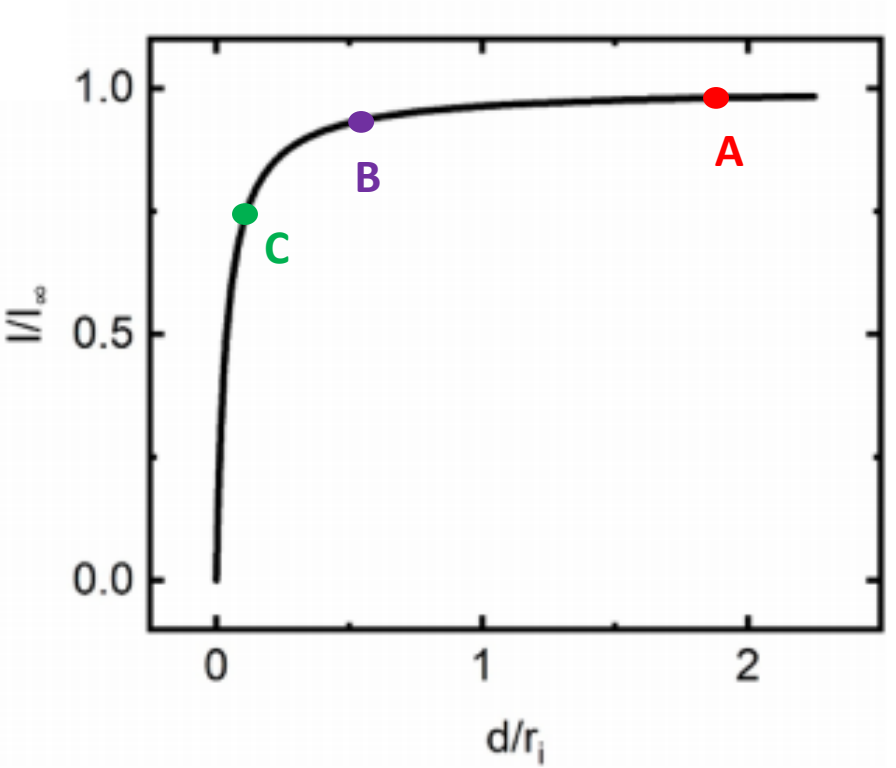
SICM: Working Principle

Access resistance of the pipette R_a depends on many factors such as:

- Geometry of the pipette
- Ion conductivity of the electrolyte
- Distance ***d*** between the tip of the pipette and the surface of the sample



Approach curve

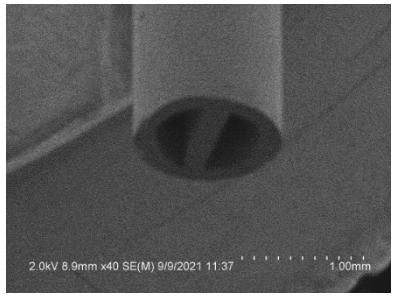


As the pipette approaches the sample → R_a increases → I_L decreases

The Probes: our local sensors

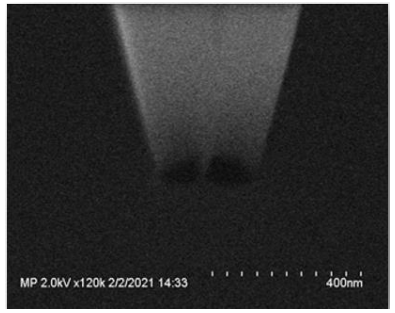
Multi-barreled probes for multi-functionality … one for tracking, one for sensing or other functionalization

Double-barrel quartz capillary

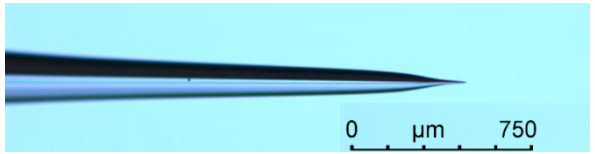


A double-barrel capillary is **laser-pulled** into two identical nanopipettes

Double-barrel nanopipette

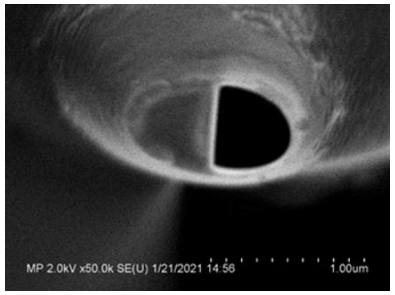


The double-barrel tip inner size is finely tunable



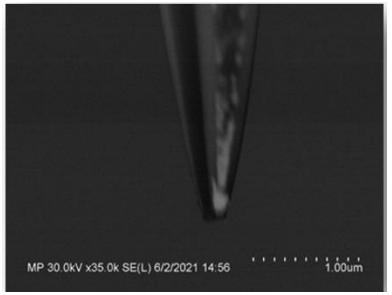
An optical Picture of the carbon Nanoelectrode

Carbon nanoelectrode



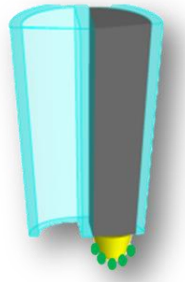
A **carbon nanoelectrode** is fabricated by filling one barrel with pyrolytic carbon

Metal deposition



The carbon nanoelectrode is modified with a metal via **<u>electrodeposition</u>**

Biosensor



Final biosensor functionalization

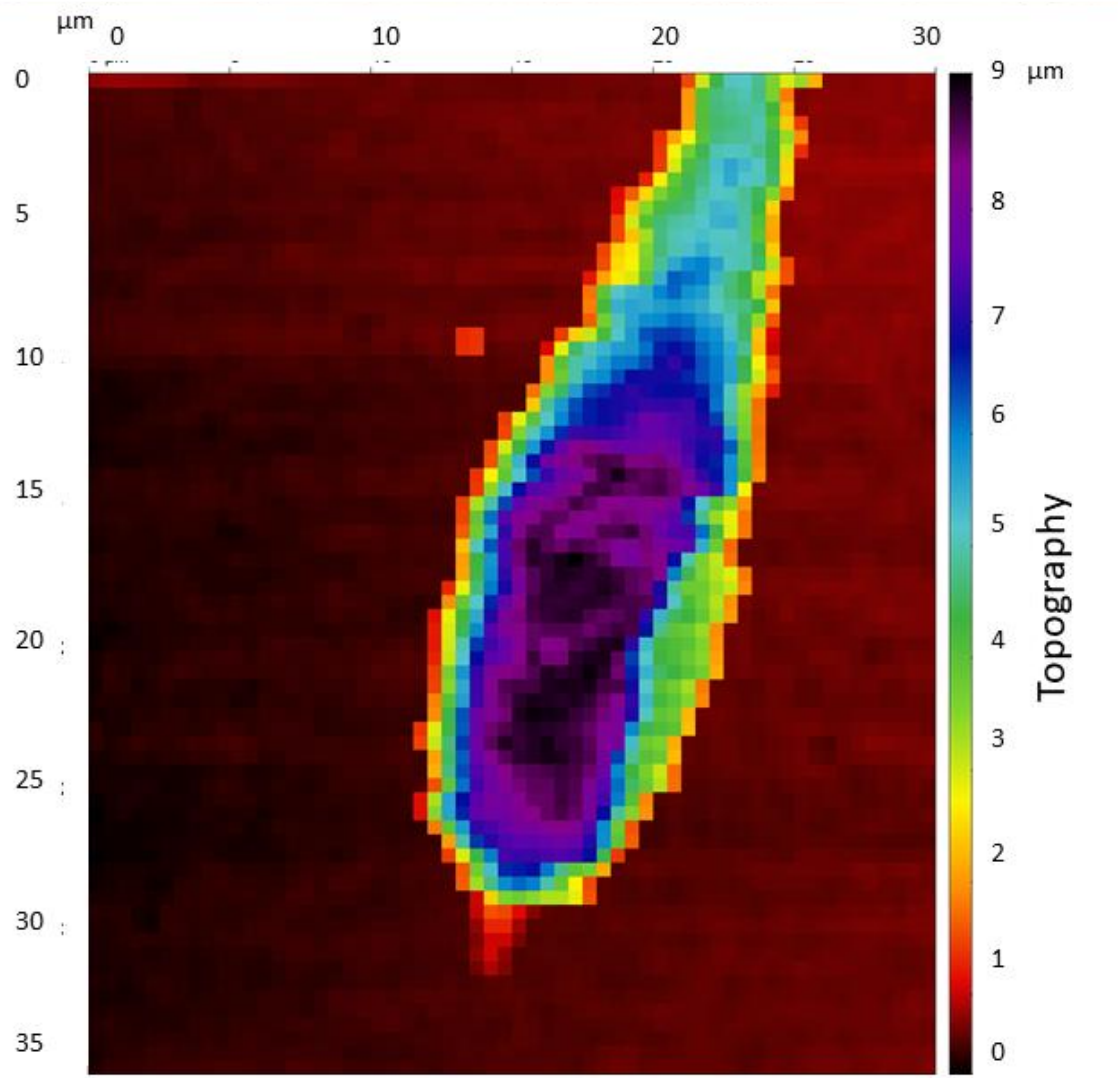
Adapting SICM Imaging

1. **To work with living cells in their physiological environment :**

- Suitable buffer to use as imaging solution, not to provoke clogging of the pipette ;
- Constant pH maintaining to ensure healthy conditions for the cells .

2. Obtain topographical maps with:

- **High spatial resolution** (500 nm),
- **Fast imaging** (below 5 minutes).



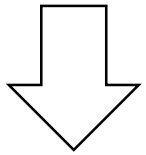
Topographical map of MDCK (Madin Darby Kidney) cell

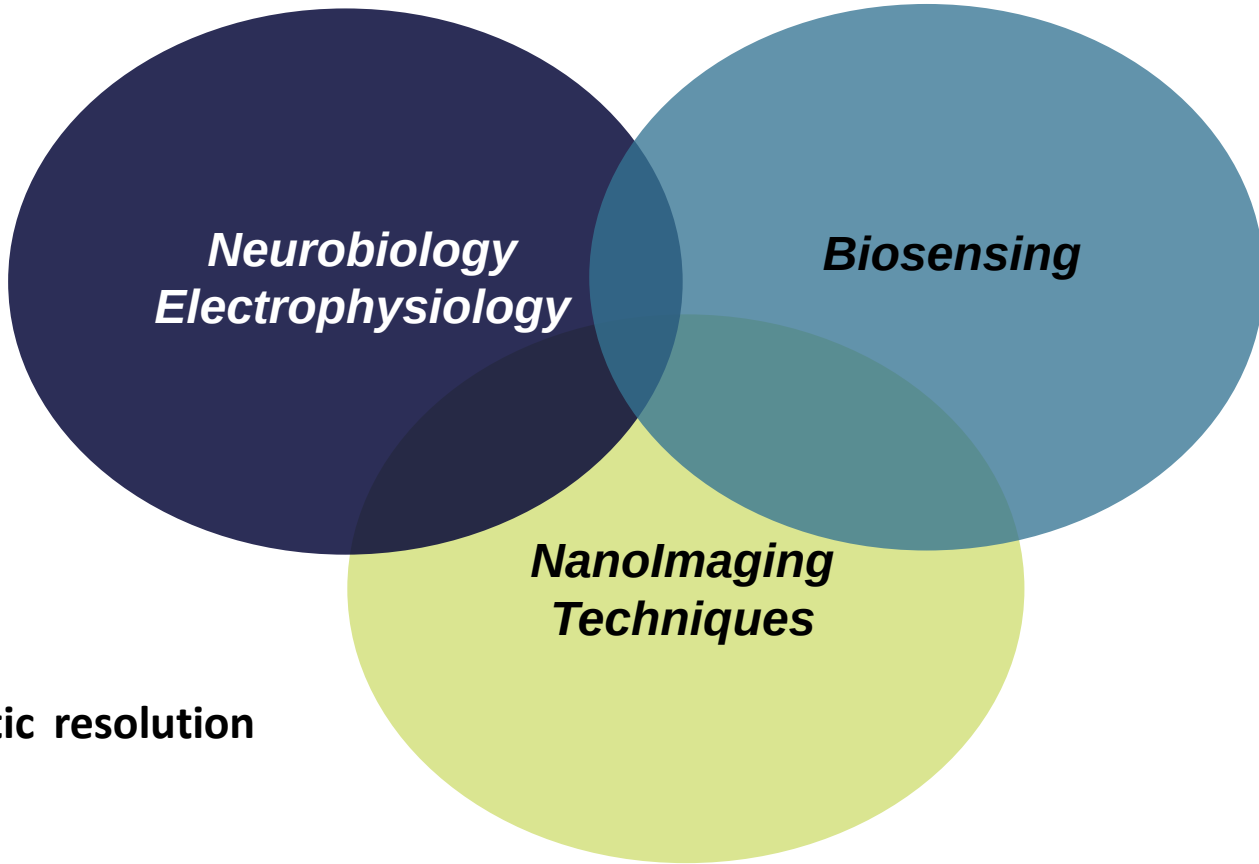
Future directions

Imaging of living cells in their physiological environment

+

Probes functionalization





Development of a **multimodal platform** with **sub-synaptic resolution** for physiological and biological studies.

Acknowledgements

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