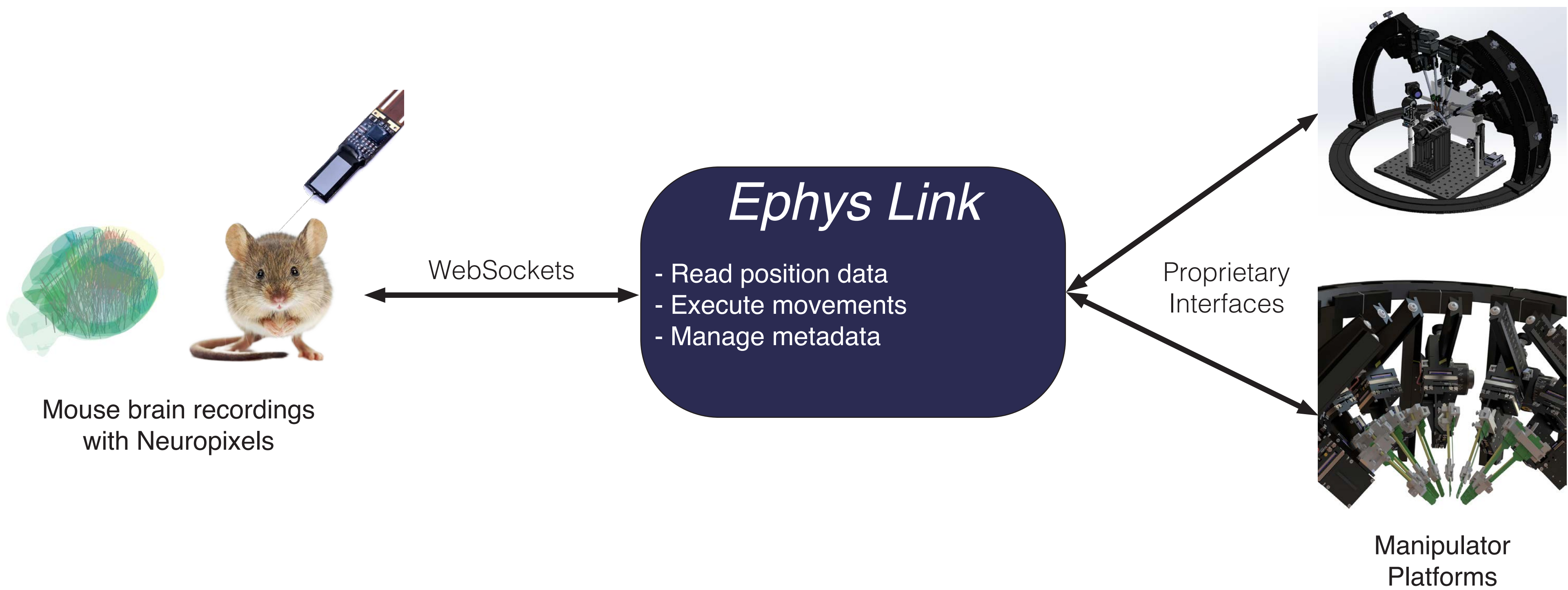# Automating Multi-Probe Insertions to Improve the Efficiency and Reproducibility of Electrophysiology Experiments

Kenneth J. Yang, Daniel Birman, Nicholas A. Steinmetz

virtual brain lab

Electrophysiology Manipulator Link

WebSockets

Mouse brain recordings with Neuropixels

Ephys Link
- Read position data
- Execute movements
- Manage metadata

Proprietary Interfaces

Manipulator Platforms

Ephys Link Standardizes the Hardware/Software Interface, Enabling new Applications Such as Automation

Ephys Link is a communication layer that exposes a unified API for communicating with various manipulator platforms. It allows client applications to control Sensapex uMp Microcontrollers and New Scale Robotic's manipulators without having to interact with their respective SDKs. Application like *Ephy Copilot* are built on top of the *Ephys Link* platform. Automation is key in helping with projects where reliable replication is necessary such as the Brain Wide Map project by the IBL.

Ephys Copilot Automates Insertions

Ephys Copilot removes the need for scientists to micromanage individual probes and allow for more abstract control over them. This allows scientists to focus on collecting high-quality data rather than setting up a recording. *Ephys Copilot* leverages the unified API access presented by *Ephys Link* to accomplish automation.

Manual Manipulator Driving is Inaccurate

Manual recordings miss their target location by 400μm on average. *Ephys Copilot* ensures repeatable insertion without user error.

Ephys Copilot achieves this by converting insertion locations to stereotaxic positioning data which is sent via *Ephys Link* to the manipulators (irrespective of platform) and drives manipulators to the corresponding insertion locations with sub-micrometer precision.
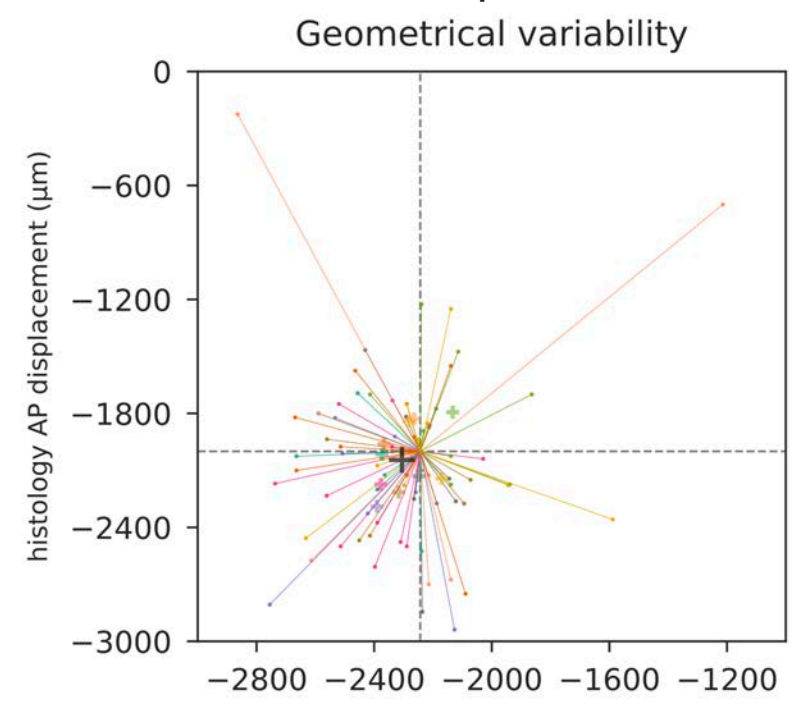

International Brain Laboratory (2022). *bioRxiv*

Automation is Reproducible

Robotic manipulation ensures exact movement replication to a sub-micrometer precision. *Ephys Copilot* precomputes the pathways needed to drive multiple probes, then, utilizing *Ephys Link*, automatically drives manipulators along these designated pathways.
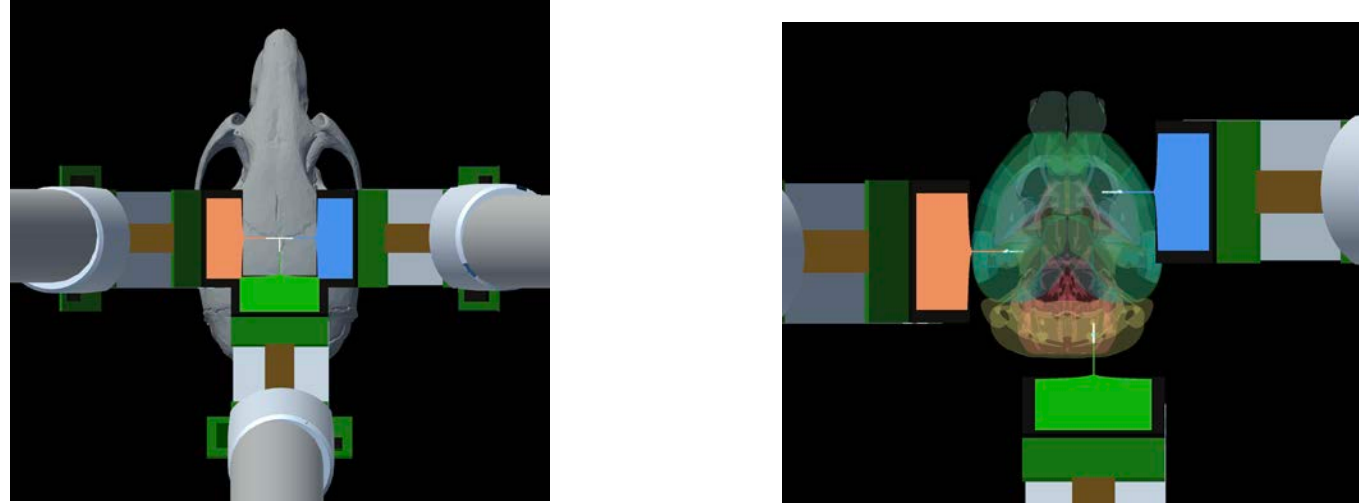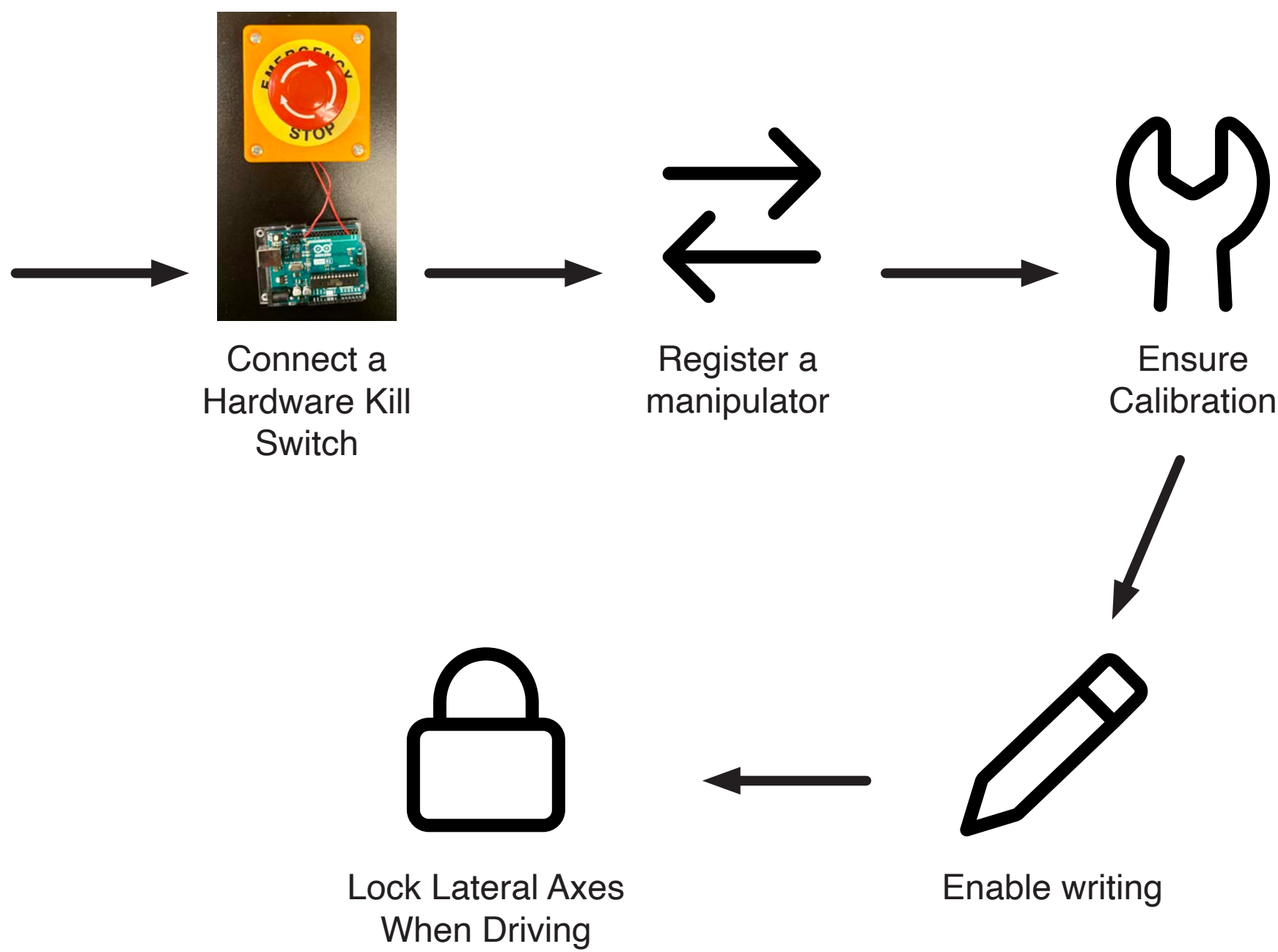

3 Probes Aligned at Bregma   3 Insertion Targets
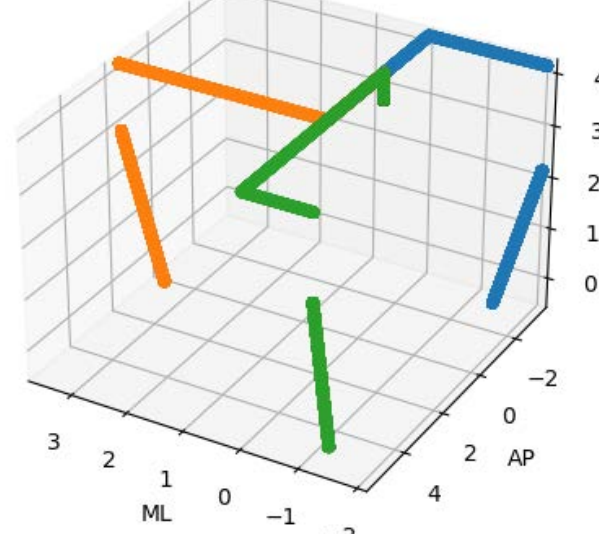
Automated Pathways

Multi-Layer Safety System Prevents Damaging Equipment

Human error can cause expensive probes to be driven at high speeds through tissue, leading to subject and equipment damage. To ensure operation safety, *Ephys Link* requires a series of acknowledgments before allowing position data to be streamed and manipulators to be driven autonomously.

Connect a Hardware Kill Switch → Register a manipulator → Ensure Calibration → Enable writing → Lock Lateral Axes When Driving

WebSockets Enables Client Agnostic Communication

We picked WebSockets for its near-universal compatibility and standardization across all platforms. WebSockets also enable browser-based applications to communicate with manipulators which are traditionally local/desktop-bound. *Pinpoint* and *Ephys Copilot* are both browser-based applications that can communicate with *Ephys Link* through WebSockets.

```
# Gets the position of manipulator 1
ws.emit('get_pos', 1, callback=my_callback_func)
```
Example WebSocket communication

Open Source Codebase Makes Ephys Link Extensible

Ephys Link's entire codebase is hosted publicly on GitHub. The package is free for everyone to use and extend. With the extensive documentation, any scientist can easily add an implementation of their specific manipulator platform to *Ephys Link*, enabling client-agnostic access to that platform. A public code base also allows anybody to review the inner workings of the platform and make changes to fit their own specific needs. *Ephys Copilot* is an application that build upon *Ephys Link*.
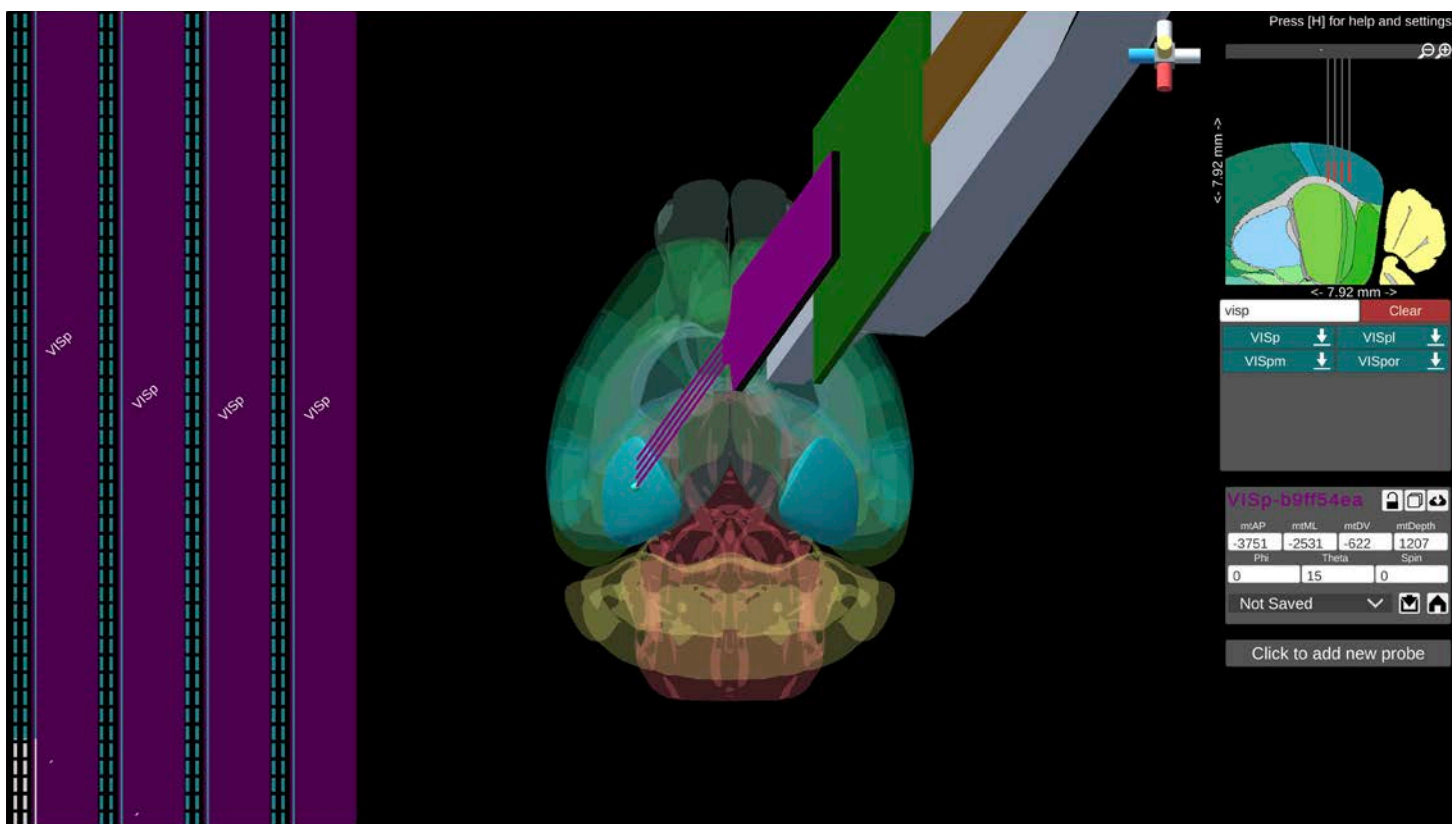

Ephys Link GitHub   *Pinpoint* GitHub

How to Run a Multi-Probe Experiment

Images demonstrate with 1 probe for clarity

Selecting a Target Insertion
1. Pick a region
2. Snap a virtual probe to the region
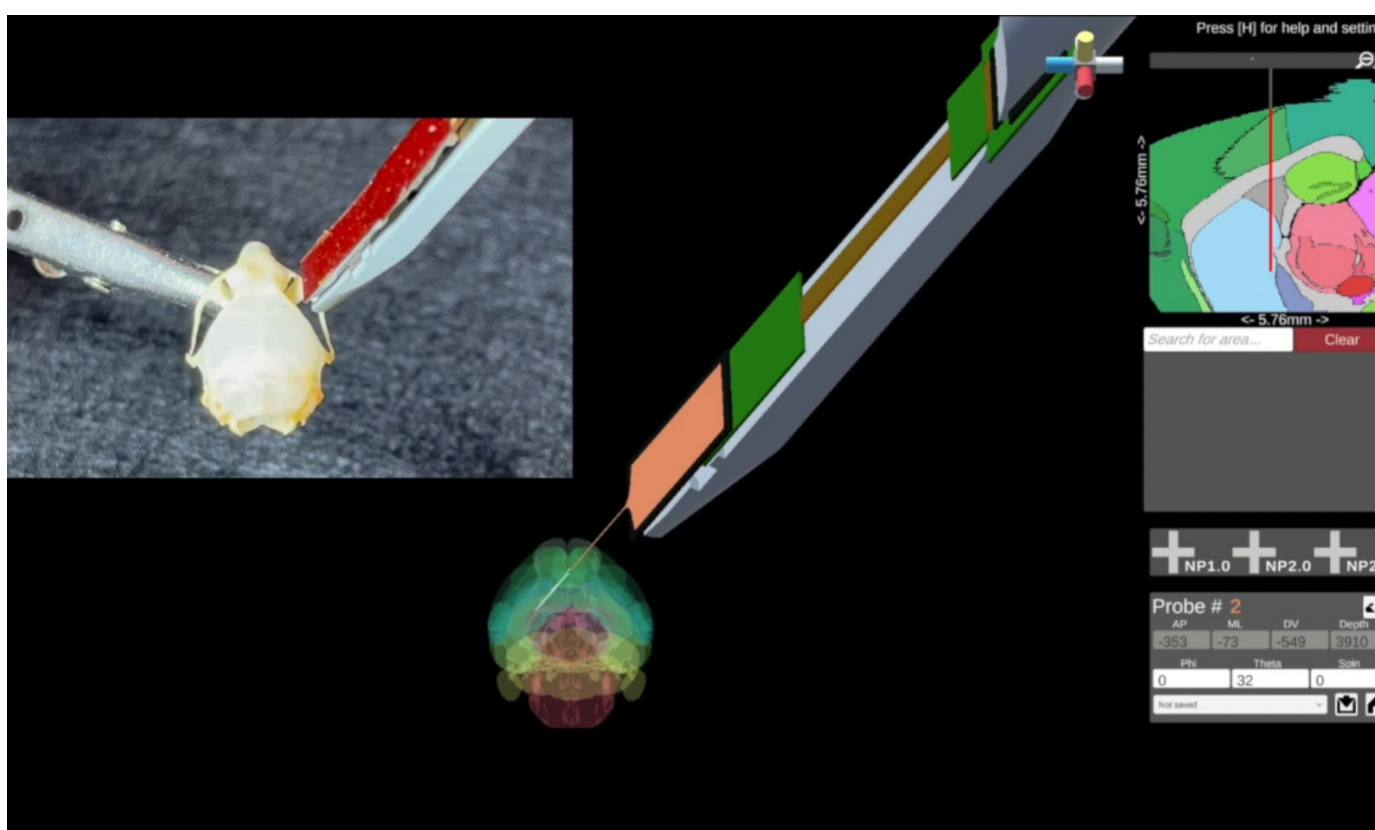3. Make fine adjustments to reach the target region

Selecting a target insertion in Pinpoint

Automating an Insertion
1. Align a probe connected to a manipulator to Bregma
2. Select the target insertion and let *Ephys Copilot* automatically drive to the target coordinate
3. Place the probe on the dura and drive through
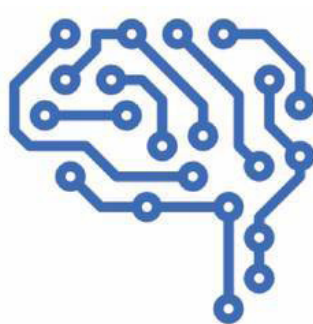4. Let *Ephys Copilot* automatically drive the probe down to the target depth at a controlled speed

Automate an insertion with *Ephys Copilot*   Live Probe Position Mirrored in Virtual Space
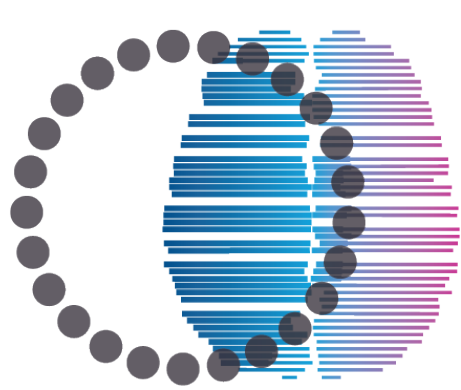
INTERNATIONAL BRAIN LABORATORY

Supported by the Virtual Brain Lab, the Steinmetz Lab, and the Research Scholarship from the Mary Gates Endowment for Students