

¹ PixelMap: An Application for Flexible Electrode Selection on Neuropixels Probes

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⁶ Abstract

⁷ PixelMap is a browser-based application for creating custom channelmaps for Neuropixels ⁸ probes that respects electrode wiring constraints. Neuropixels probes, widely used for high- ⁹ density neural recordings, have more physical electrodes than can be used for simultaneous ¹⁰ recording because they contain fewer analogue-to-digital converters (ADCs) than data lines. ¹¹ Each ADC is hard-wired to several electrodes, creating complex interdependencies where ¹² selecting one electrode makes others unavailable. PixelMap provides an installation-free, ¹³ browser-based interface for researchers to design arbitrary recording configurations that meet ¹⁴ their experimental requirements while satisfying these hardware constraints. The tool generates ¹⁵ IMRO (IMec Read Out) files compatible with SpikeGLX, the most common acquisition software ¹⁶ for Neuropixels recordings.

¹⁷ Statement of need

¹⁸ Neuropixels probes have revolutionised systems neuroscience by enabling simultaneous ¹⁹ recordings from hundreds of neurons across multiple brain regions at any depth ([Beau et al., 2021, 2025; Bondy et al., 2024; Jun et al., 2017; Steinmetz et al., 2021; Ye et al., 2025](#)). ²⁰ However, configuring these probes presents challenges. Limited by the number of integrated ²¹ analogue-to-digital converters (ADCs), Neuropixels probes contain 960–5120 electrodes but ²² can only record from 384–1536 channels simultaneously (Table 1). Users must therefore select ²³ a subset of electrodes to activate for each recording, a “channelmap”. Researchers often need ²⁴ to create custom channelmaps to target specific brain regions, and sometimes must adjust ²⁵ them rapidly based on feedback from ongoing recordings. Because the electrode-to-ADC ²⁶ wiring follows complex, probe version-dependent patterns, manual channelmap design is ²⁷ error-prone and time-consuming.²⁸

²⁹ [SpikeGLX](#) is the most common acquisition software for Neuropixels recordings and uses the ³⁰ .imro file format to encode channelmaps. While SpikeGLX provides tools to edit channelmaps, ³¹ it requires a desktop app, comes with limited preset channelmaps, and does not easily allow ³² selection of fully arbitrary electrode geometries.

³³ PixelMap addresses these needs by:

- ³⁴ 1. **Being available on any machine installation-free:** The tool is available both as a browser-³⁵ based web application at <https://pixelmap.pni.princeton.edu>, as a Docker image, and a ³⁶ Python package.
- ³⁷ 2. **Visualising wiring constraints interactively:** When users select electrodes, the interface ³⁸ immediately shows which other electrodes become unavailable (marked in black) due to ³⁹ shared ADC lines, preventing invalid configurations.
- ⁴⁰ 3. **Supporting arbitrary electrode geometries:** Users can select electrodes by choosing from ⁴¹ common preset geometries, entering electrode ranges as text for reproducibility, directly

42 clicking or dragging on the probe visualization, or loading pre-existing .imro files. These
 43 four selection methods are fully intercompatible and can be combined. For instance,
 44 a SpikeGLX .imro file can be loaded as a starting point, and selection boxes used to
 45 further refine the channelmap geometry.

Probe Version	Physical Channels	Simultaneously Recordable Channels
Neuropixels 1.0	960	384
Neuropixels 2.0 (single shank)	1,280	384
Neuropixels 2.0 (4-shank)	5,120 (1,280 per shank)	384
Neuropixels 2.0 Quad Base	5,120 (1,280 per shank)	1,536

46 **Table 1:** Number of physical and simultaneously addressable electrodes across Neuropixels
 47 probe versions.

48 Software Design

49 PixelMap is implemented in Python using HoloViz Panel ([Yang et al., 2022](#)) for the web
 50 interface, providing an interactive and responsive user experience. The software architecture
 51 consists of three main components.

52 First, the **wiring maps** at `./wiring_maps/*.csv` are hand-built CSV files describing the
 53 electrode-to-ADC mappings for each supported probe type. They were adapted from files
 54 provided by IMEC (Neuropixels manufacturer – downloadable [here](#)).

55 Second, the **core logic** at `./backend.py` implements the constraint-checking algorithms that
 56 validate electrode selections against probe-specific wiring maps. This handles the complex
 57 mapping between physical electrodes and ADC channels for different probe types (Neuropixels
 58 1.0, 2.0 single-shank, and 2.0 four-shank so far). Hash tables (Python dictionaries) are used to
 59 query incompatible electrode pairs with O(1) complexity and improve performance.

60 Finally, the **graphical user interface** at `./gui/gui.py` was built with HoloViz Panel. The
 61 interface provides real-time visualisation of the probe layout with electrode colour-coded based
 62 on their selection state (available in grey, selected in red, or unavailable in black). The
 63 interface supports the abovementioned four selection modes, including Bokeh-based interactive
 64 click-selection and box-selection to select or deselect electrodes. User interactions trigger
 65 immediate recalculation of available electrodes based on the current selection state. This
 66 design ensures users receive instant feedback about constraint violations, preventing invalid
 67 configurations before file generation.

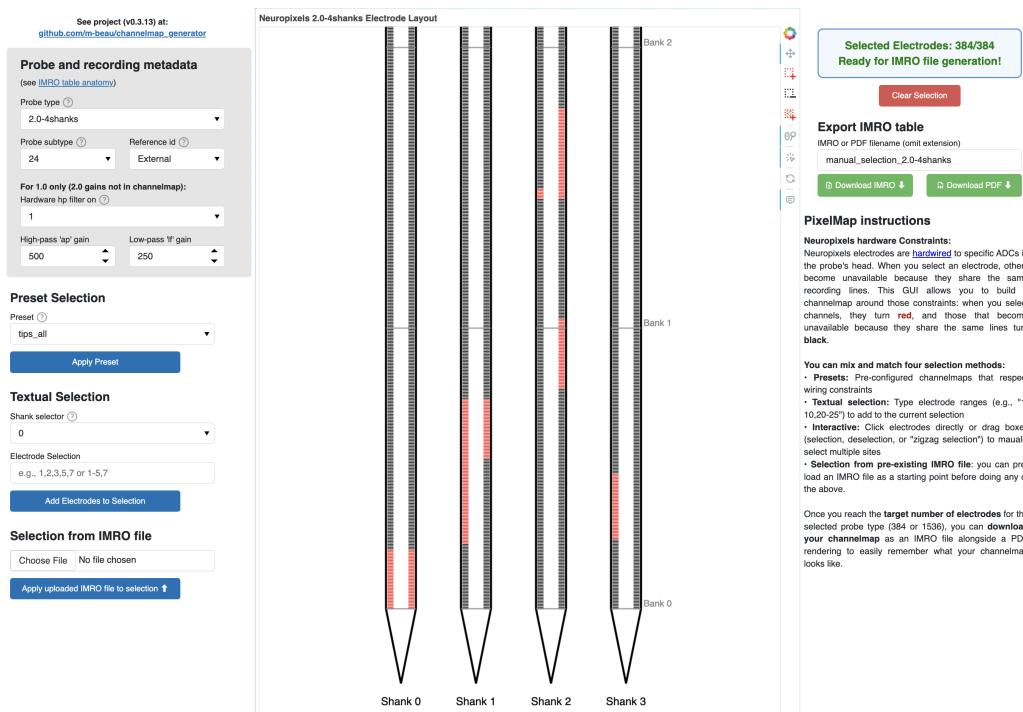


Figure 1: PixelMap's browser-based graphical user interface.

Center: Main panel featuring the probe's physical layout with one or four shanks that exhibit the 960 (Neuropixels 1.0) or 1,280 (Neuropixels 2.0) physical electrodes/shank to be selected. Electrodes available for selection are light grey, selected electrodes turn red, and electrodes that become unavailable due to hardware wiring constraints turn black. In this example, 384 electrodes have been selected (matching the maximum simultaneous recording capacity), with a distributed pattern across multiple banks, illustrating that PixelMap allows selection of arbitrary channelmap geometries.

Left: panel to input probe metadata (also part of .imro files) as well as three methods of electrode selection: preset geometries, manual textual input of electrode ranges, and pre-loading an existing .imro file. These three methods of electrode selection can be mixed together with an interactive click-and-drag box selector and deselector.

Right: electrode status indicator that turns green to confirm the selection is complete and is ready for IMRO file generation. Users can export their configuration via the “Download IMRO” button for direct use in SpikeGLX or save a PDF visualisation to easily remember the geometry of the corresponding .imro file in the future. Below the status indicator are PixelMap’s instructions.

68 Installation and Usage

69 PixelMap can be used through:

- 70 **1. Web application:** Available at <https://pixelmap.pni.princeton.edu> for immediate use without installation.
- 71 **2. Local installation:** Via pip (`pip install .`) or uv (`uv run cmap_gui`) from the cloned GitHub repository.
- 72 **3. Docker container:** Users can download the image used for the website and run the container locally.
- 73 **4. Programmatic API:** Python scripts can directly call `generate_imro_channelmap()` for batch processing or integration into analysis pipelines.

78 For more details, see the project repository at https://github.com/m-beau/channelmap_generator.

80 The software includes an automated test suite with 41 tests covering hardware constraint validation, all preset configurations, IMRO file generation for all supported probe types, and

⁸² end-to-end workflows. Tests run automatically via GitHub Actions continuous integration
⁸³ on every code change, ensuring software reliability. See the repository's tests/ directory for
⁸⁴ details.

⁸⁵ Research Impact Statement

⁸⁶ PixelMap addresses a practical bottleneck in Neuropixels experimental workflows. Neuropixels
⁸⁷ have become the dominant technology for large-scale electrophysiology, with exponential growth
⁸⁸ in publications using the technology ([PubMed](#)). Yet no existing tool provided installation-free
⁸⁹ channelmap design with support for arbitrary electrode geometries (see **Statement of Need**).

⁹⁰ PixelMap demonstrates community-readiness through comprehensive documentation and a
⁹¹ permissive open-source license (GPL3). The tool is immediately accessible via web application
⁹² (<https://pixelmap.pni.princeton.edu>), Python package, Docker container, or programmatic
⁹³ API. The tool builds on the authors' established track record using Neuropixels probes in their
⁹⁴ research ([Beau et al., 2025](#); [Bondy et al., 2024](#); [Kostadinov et al., 2019](#); [Steinmetz et al.,](#)
⁹⁵ [2021](#)) and developing Neuropixels software ([Beau et al., 2021](#)).

⁹⁶ Evidence of adoption includes deployment at Princeton Neuroscience Institute's public server,
⁹⁷ community engagement on the project repository (24 GitHub stars as of January 2025), and
⁹⁸ number of monthly users (306 unique users in January 2026).

⁹⁹ AI Usage Disclosure

¹⁰⁰ **AI-assisted technologies used:** Claude Sonnet 4.1, Sonnet 4.5, and Opus 4.5 (Anthropic).
¹⁰¹ AI assistance was used for (1) optimization suggestions and documentation improvements
¹⁰² (docstrings, code comments) in backend.py, (2) initial scaffolding of the HoloViz Panel GUI
¹⁰³ architecture in gui/gui.py, (3) manuscript grammatical and syntactical review. AI was not
¹⁰⁴ used for project conceptualization, core algorithm design, electrode wiring map construction.
¹⁰⁵ App hosting infrastructure was designed independently of AI assistance.

¹⁰⁶ Author Contributions

	Maxime Beau	Christian Tabetzki	Carlos D. Brody
Conceptualisation	X		
Backend and GUI	X		
App hosting		X	
Supervision and funding			X

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