

# <sup>1</sup> PixelMap: An Application for Flexible Electrode Selection on Neuropixels Probes

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## Software

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## <sup>6</sup> Abstract

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

## <sup>17</sup> Statement of need

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

<sup>28</sup> [SpikeGLX](#) is the most common acquisition software for Neuropixels recordings and uses the <sup>29</sup> .imro file format to encode channelmaps. While SpikeGLX provides tools to edit channelmaps, <sup>30</sup> it requires a desktop app, comes with limited preset channelmaps, and does not easily allow <sup>31</sup> selection of fully arbitrary electrode geometries.

<sup>32</sup> PixelMap addresses these needs by:

- <sup>33</sup> **1. Being available on any machine installation-free:** The tool is available both as a web <sup>34</sup> application at <https://pixelmap.pni.princeton.edu> and as a Python package.
- <sup>35</sup> **2. Visualising wiring constraints interactively:** When users select electrodes, the interface <sup>36</sup> immediately shows which other electrodes become unavailable (marked in black) due to <sup>37</sup> shared ADC lines, preventing invalid configurations.
- <sup>38</sup> **3. Supporting arbitrary electrode geometries:** Users can select electrodes by choosing from <sup>39</sup> common preset geometries, entering electrode ranges as text for reproducibility, directly <sup>40</sup>

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

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

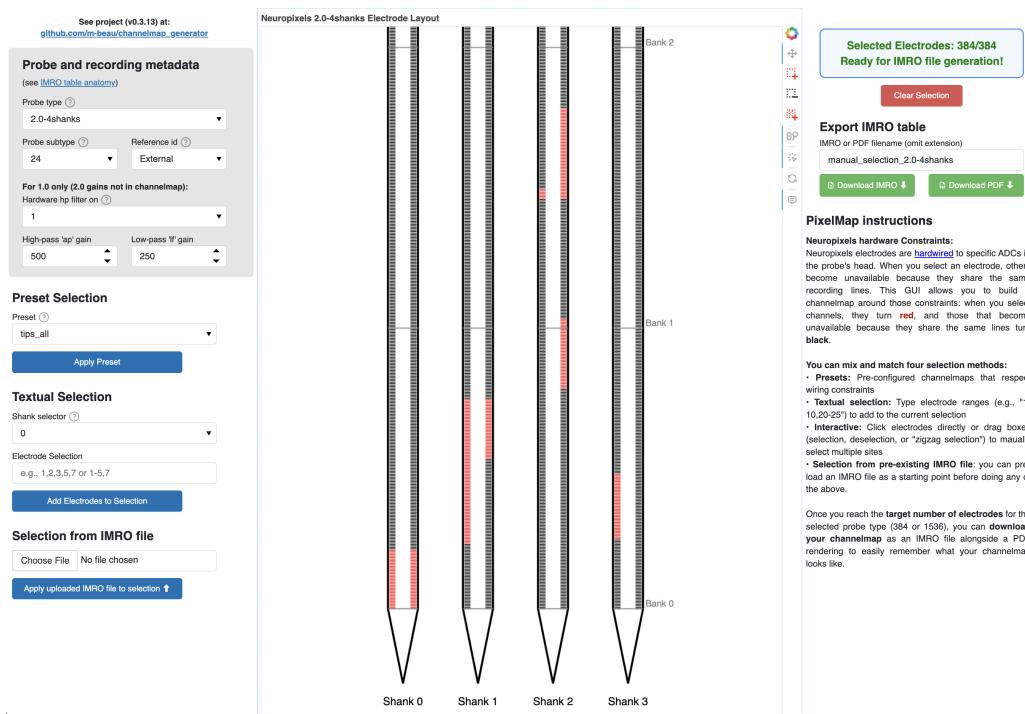
## 47 Software Design

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

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

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

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

## 67 Installation and Usage

68 PixelMap can be used through:

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

73 For more details, see the project repository at [https://github.com/m-beau/channelmap\\_generator](https://github.com/m-beau/channelmap_generator).

74 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

<sup>81</sup> end-to-end workflows. Tests run automatically via GitHub Actions continuous integration  
<sup>82</sup> on every code change, ensuring software reliability. See the repository's tests/ directory for  
<sup>83</sup> details.

## <sup>84</sup> Research Impact Statement

<sup>85</sup> PixelMap addresses a practical bottleneck in Neuropixels experimental workflows. Neuropixels  
<sup>86</sup> have become the dominant technology for large-scale electrophysiology, with exponential growth  
<sup>87</sup> in publications using the technology ([PubMed](#)). Yet no existing tool provided installation-free  
<sup>88</sup> channelmap design with support for arbitrary electrode geometries (see **Statement of Need**).

<sup>89</sup> PixelMap demonstrates community-readiness through comprehensive documentation and a  
<sup>90</sup> permissive open-source license (GPL3). The tool is immediately accessible via web application  
<sup>91</sup> (<https://neuropixels-channelmap-generator.pni.princeton.edu>), Python package, Docker  
<sup>92</sup> container, or programmatic API. The tool builds on the authors' established track record using  
<sup>93</sup> Neuropixels probes in their research ([Beau et al., 2025](#); [Bondy et al., 2024](#); [Kostadinov et al.,](#)  
<sup>94</sup> [2019](#); [Steinmetz et al., 2021](#)) and developing Neuropixels software ([Beau et al., 2021](#)).

<sup>95</sup> Evidence of adoption includes community engagement on the project repository (22 GitHub  
<sup>96</sup> stars as of January 2025) and deployment at Princeton Neuroscience Institute's public server.

## <sup>97</sup> AI Usage Disclosure

<sup>98</sup> **AI-assisted technologies used:** Claude Sonnet 4.1, Sonnet 4.5, and Opus 4.5 (Anthropic).  
<sup>99</sup> AI assistance was used for (1) optimization suggestions and documentation improvements  
<sup>100</sup> (docstrings, code comments) in backend.py, (2) initial scaffolding of the HoloViz Panel GUI  
<sup>101</sup> architecture in gui/gui.py, (3) manuscript grammatical and syntactical review. AI was not  
<sup>102</sup> used for project conceptualization, core algorithm design, electrode wiring map construction.  
<sup>103</sup> App hosting infrastructure was designed independently of AI assistance.

## <sup>104</sup> 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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<sup>110</sup> application. This work was supported by Howard Hughes Medical Institute and the National  
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