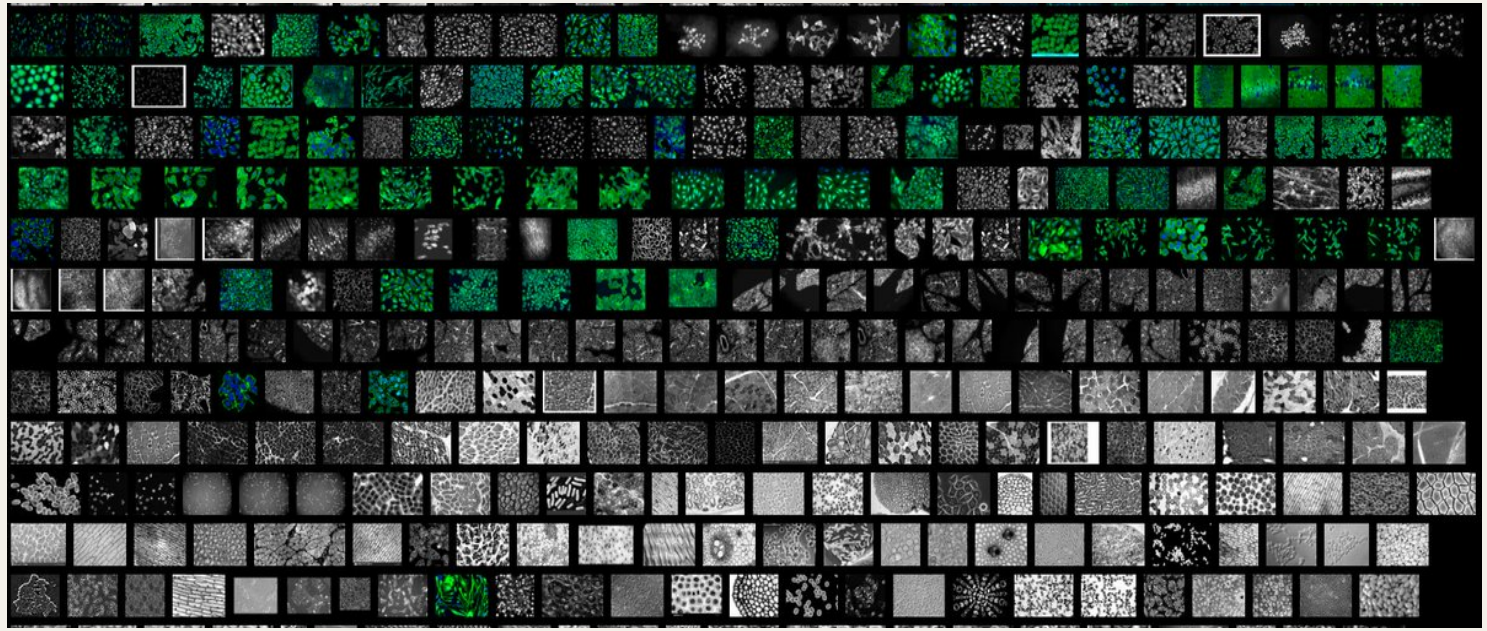
Neural Manifold Animals (NMA)



A WHOLE ZOO OF NEURONAL SIGNALS

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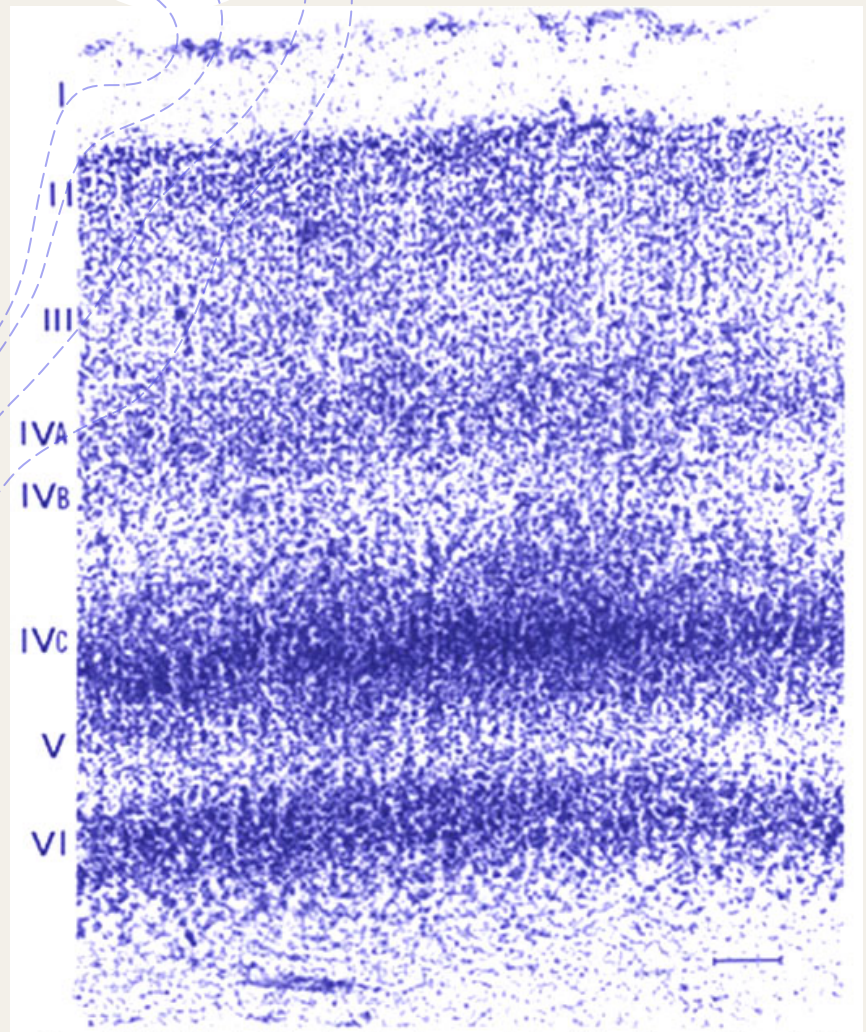


Figure 13. Nissl stain of the visual cortex reveals the different layers I through VI quite clearly.

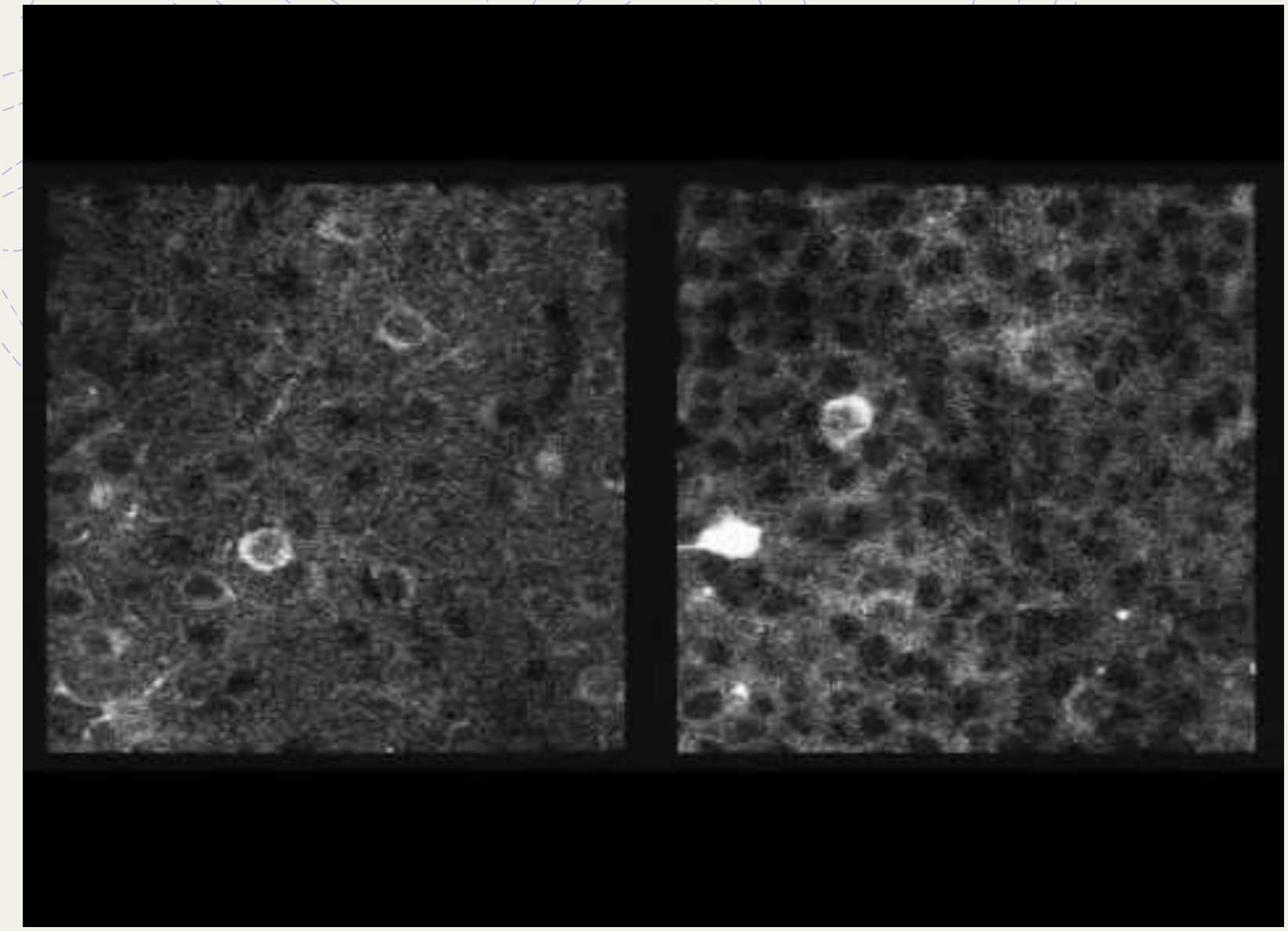
Click to add text

Introduction

+ The visual cortex has functionally distinct layers.

+ Given their activities, can we predict them?

Data



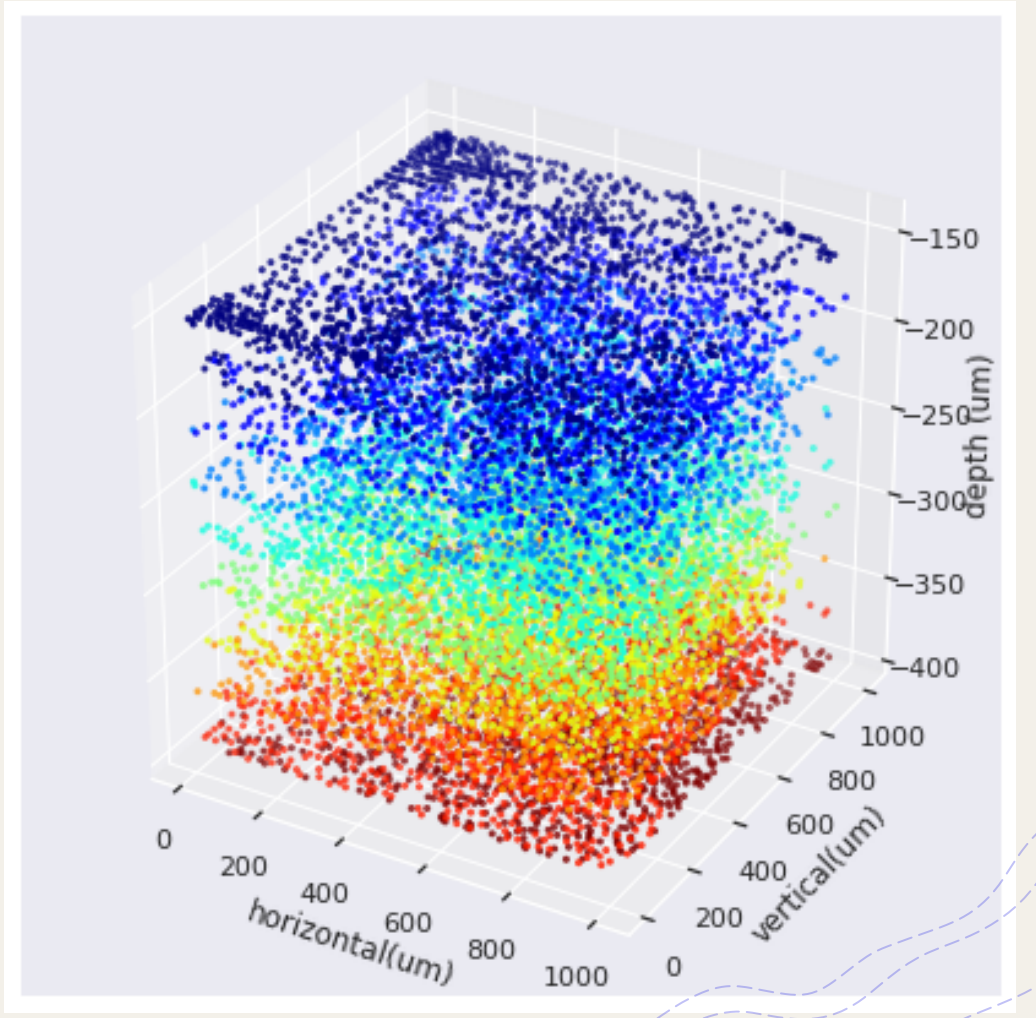
[1] Stringer, Carsen, et al. “Spontaneous behaviors drive multidimensional, brainwide activity.” Science 364.6437 (2019).

[2] Stringer, Carsen, et al. “High-precision coding in visual cortex.” Cell 184.10 (2021): 2767-2778.

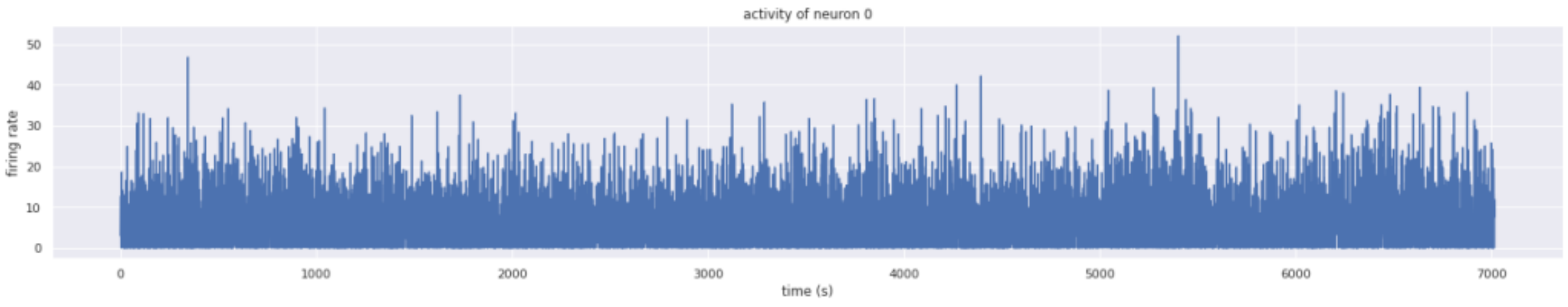
Neuronal Spatial Distribution

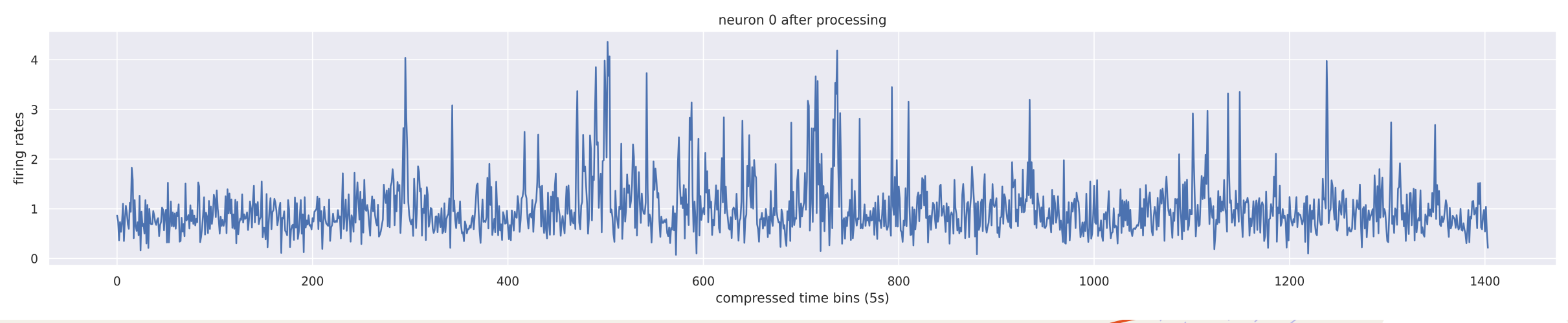
+ Given the spatial distribution of neurons we selected ***9*** different ***layers*** (*Z-Slicing*)

+ Each layer had a different number of neurons: we sampled ***1131*** *neurons* for each layer (corresponding to the number of neurons in the least populated layer)



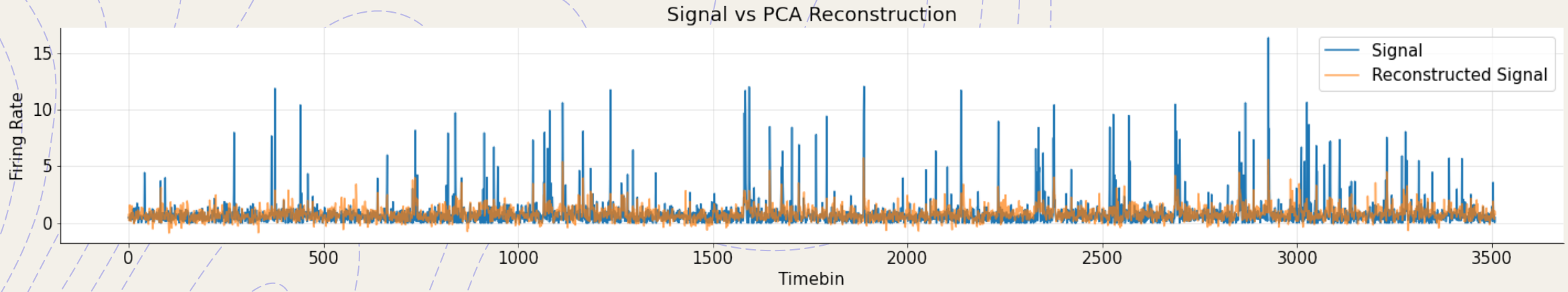
Preprocessing: Normalization and Compression in Time



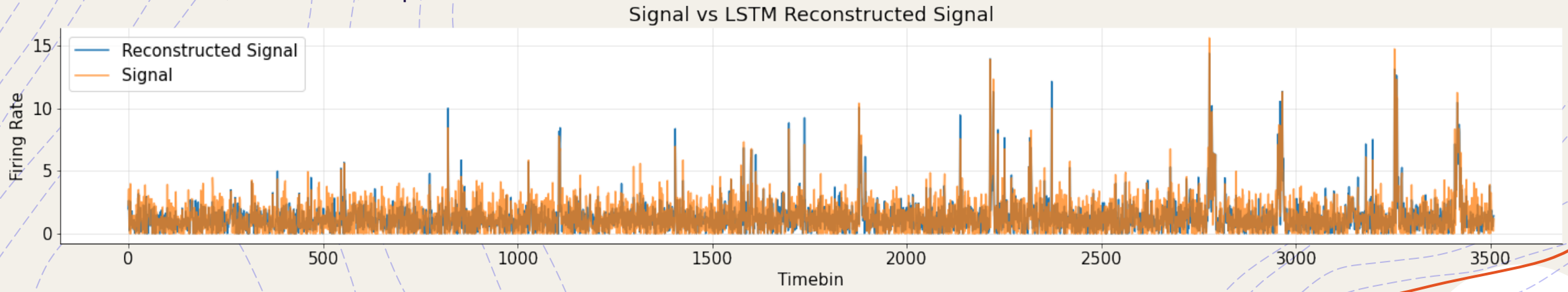


Baseline (PCA) & RNNs (VANILLA, LSTM, GRU)

+ We performed **PCA** as a baseline method for understanding the ***average*** *cumulative explained variance* with a fixed number of components , i.e. $N_{Neurons \in Layer} // 10$ ⟶ 0.67



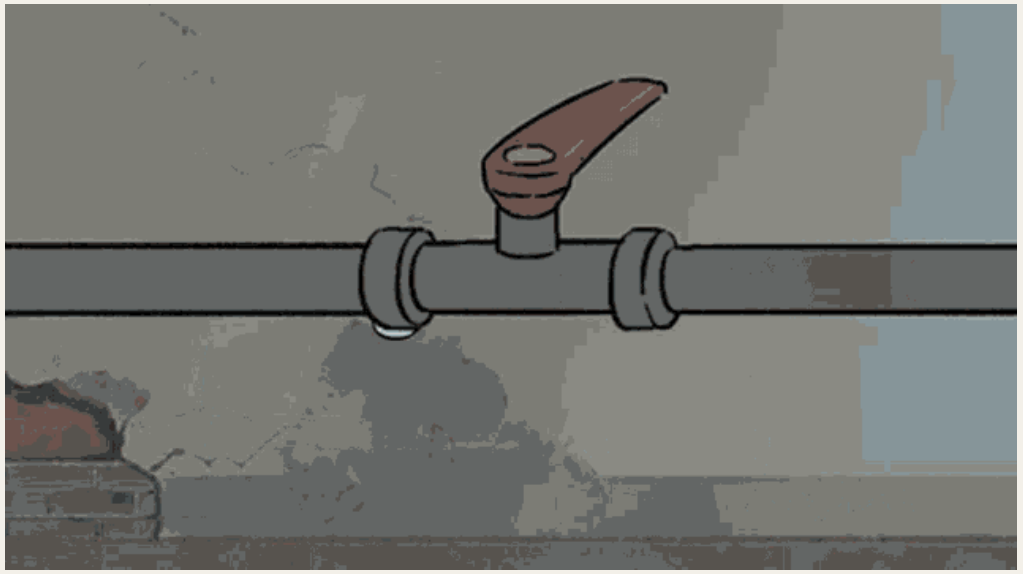
+ As our method of choice, we decided to employ LSTMs in order to extract latent low dimensional (**75 dims**) representations



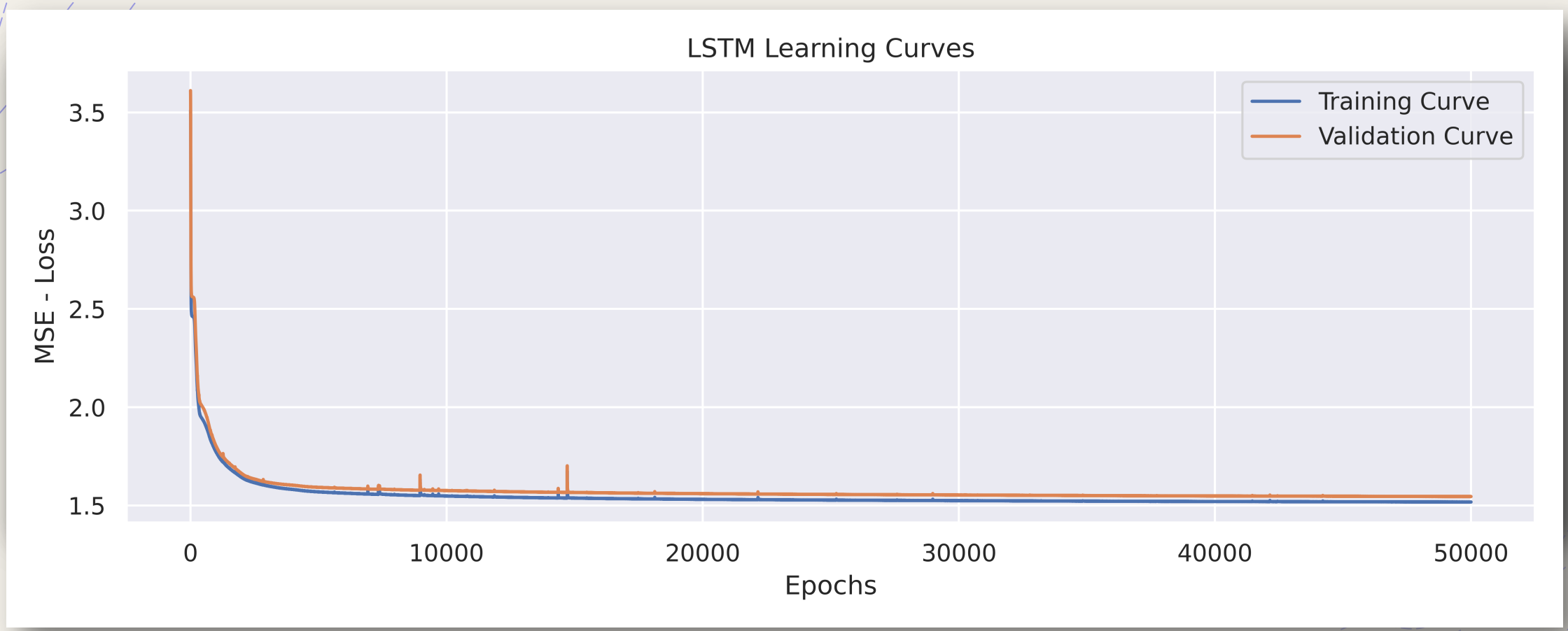
Hyperparameter Optimization

A "fast and furious" approach to training neural networks does not work and only leads to suffering

- Andrej Karpathy



Hyperparameter Optimization



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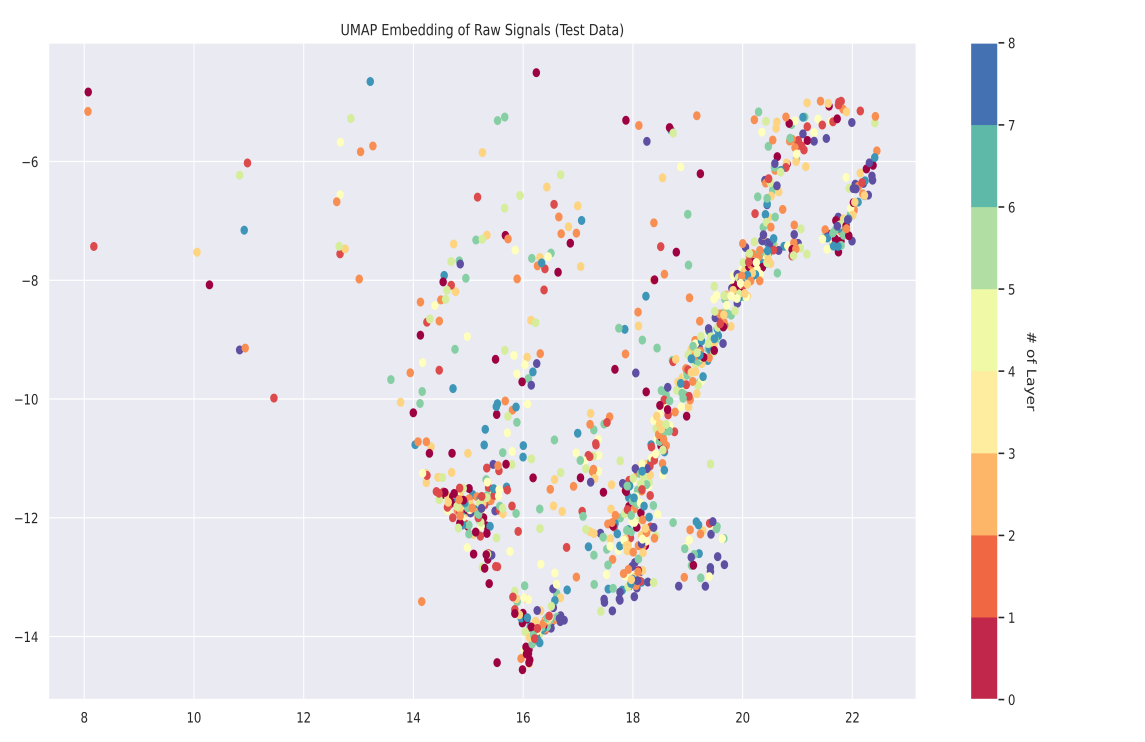
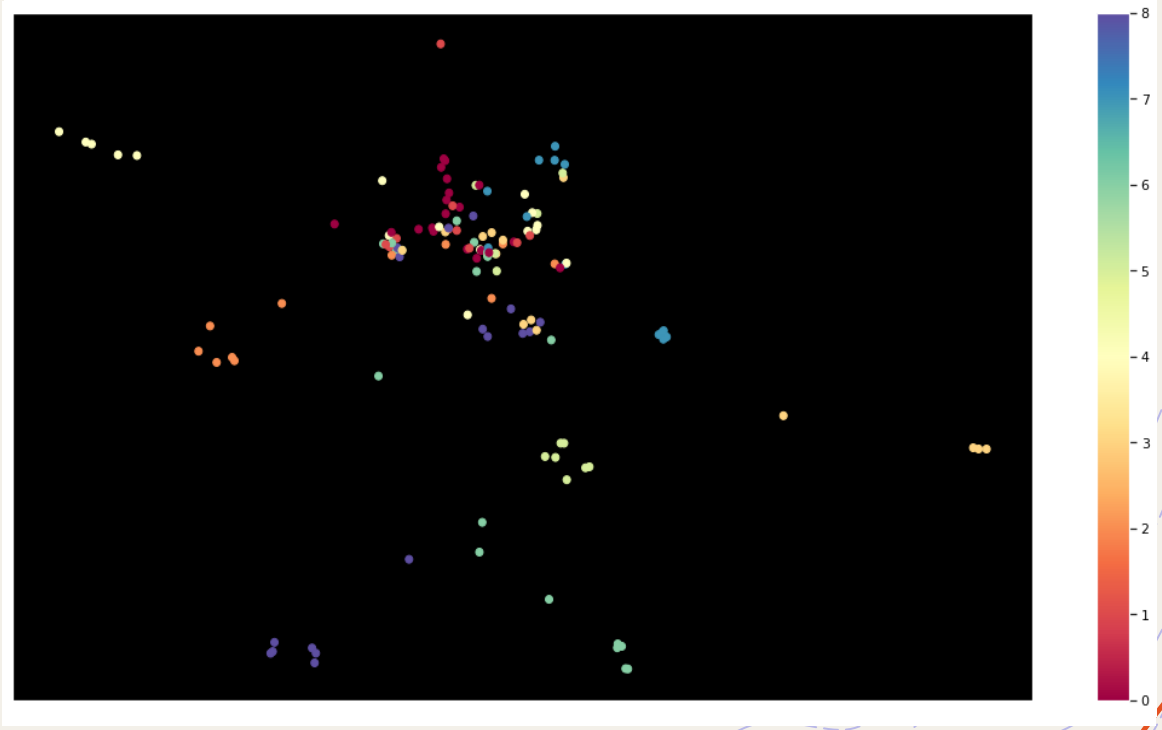
UMAP – Raw Data vs Latents

+ Key for “qualitative” clustering: *Metric Learning* with UMAP*, i.e. Training with Labels and Embedding Unlabeled Test Data

Raw Signals



Latent Dynamics



* L. McInnes et al. , UMAP: Uniform Manifold Approximation and Projection

Conclusions

+ With our project, we demonstrated the effectiveness of RNNs in learning low dimensional dynamical representations of neural data

+ An effective way to model noisy neurons has to be further investigated (MSE ~ 1.45 is still large)

+ From the UMAP Embedding we can see that most neurons from the same layer “live together”. On the other side we should investigate more those neurons that are close together but are coming from different layers

Future Directions

+ Explore the existence of multi-scale temporal dynamics

+ More advanced architectures. e.g. LFADS

https://github.com/sazio/NMAs/