Title: Models and Methods for Calcium Imaging Data
Grant Number: R01 EB026908

PIs: D Witten (U Washington) & M Buice (Allen Institute)

Goals of this project:

- *Can we* estimate spike times from calcium imaging data?
- How *accurate* are these spike time estimates in:
  - the visual cortex?
  - other brain areas?
- How *certain* are we about these spike time estimates?
- Can we use these estimates in downstream analyses, to:
  - identify latent states underlying a neuron's activity?
  - identify functional subpopulations of neurons?

R01 EB026908; PIs Witten/Buice

Goals of this project:

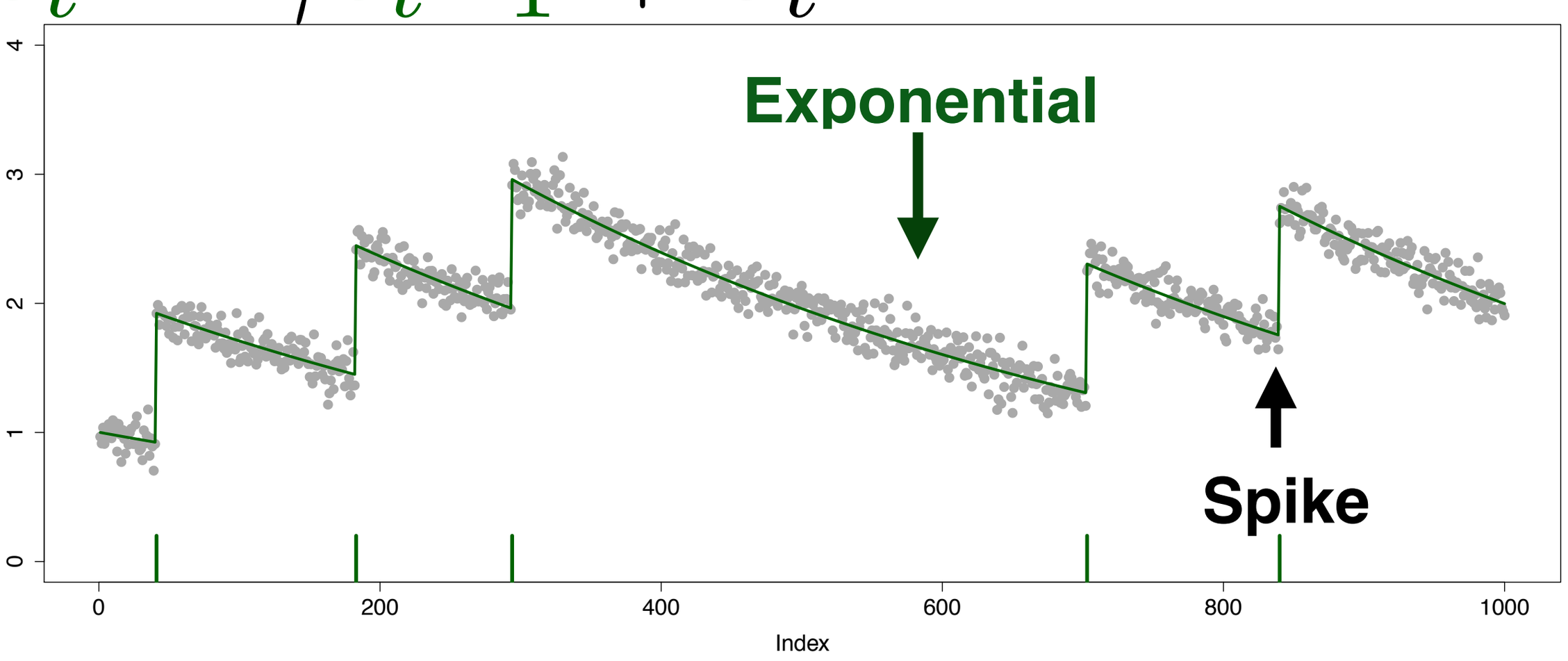
- *Can we* estimate spike times from calcium imaging data?
- How *accurate* are these spike time estimates in:
  - the visual cortex?
  - other brain areas?
- How *certain* are we about these spike time estimates?
- Can we use these estimates in downstream analyses, to:
  - identify latent states underlying a neuron's activity?
  - identify functional subpopulations of neurons?

R01 EB026908; PIs Witten/Buice

Model for Calcium Dynamics

$$y_t = c_t + \epsilon_t$$

$$c_t = \gamma c_{t-1} + s_t$$



R01 EB026908; PIs Witten/Buice

Model & Optimization Problem

$$y_t = c_t + \epsilon_t$$

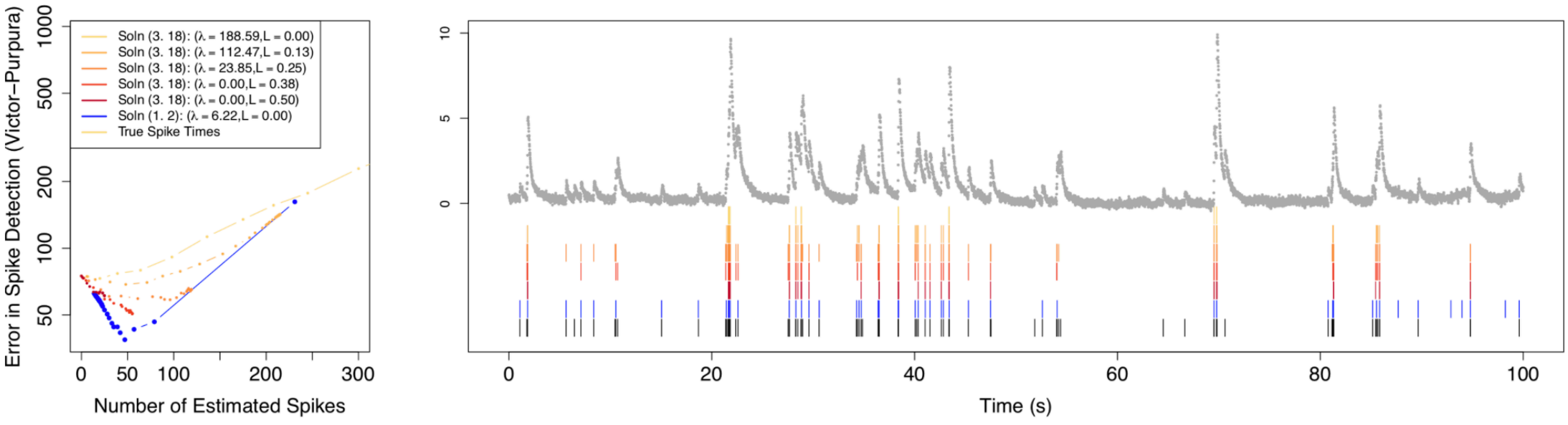
$$c_t = \gamma c_{t-1} + s_t$$

$$\underset{c_1,\ldots,c_T}{\text{minimize}} \left\{ \frac{1}{2} \sum_{t=1}^{T} (y_t - c_t)^2 + \lambda \sum_{t=2}^{T} 1_{(c_t \neq \gamma c_{t-1})} \right\}$$

R01 EB026908; PIs Witten/Buice

jewellsean.github.io/fast-spike-deconvolution/index.html

Fast deconvolution of calcium imaging data via an ℓ_0 penalty



Overview

This website provides software and tutorials to perform fast ℓ_0 deconvolution of calcium imaging data, as described in these two papers (Jewell & Witten, 2018) and (Jewell, Hocking, Fearnhead, & Witten, 2019), and as implemented in the Allen Brain Observatory platform paper (de Vries et al., 2019).

Technical details

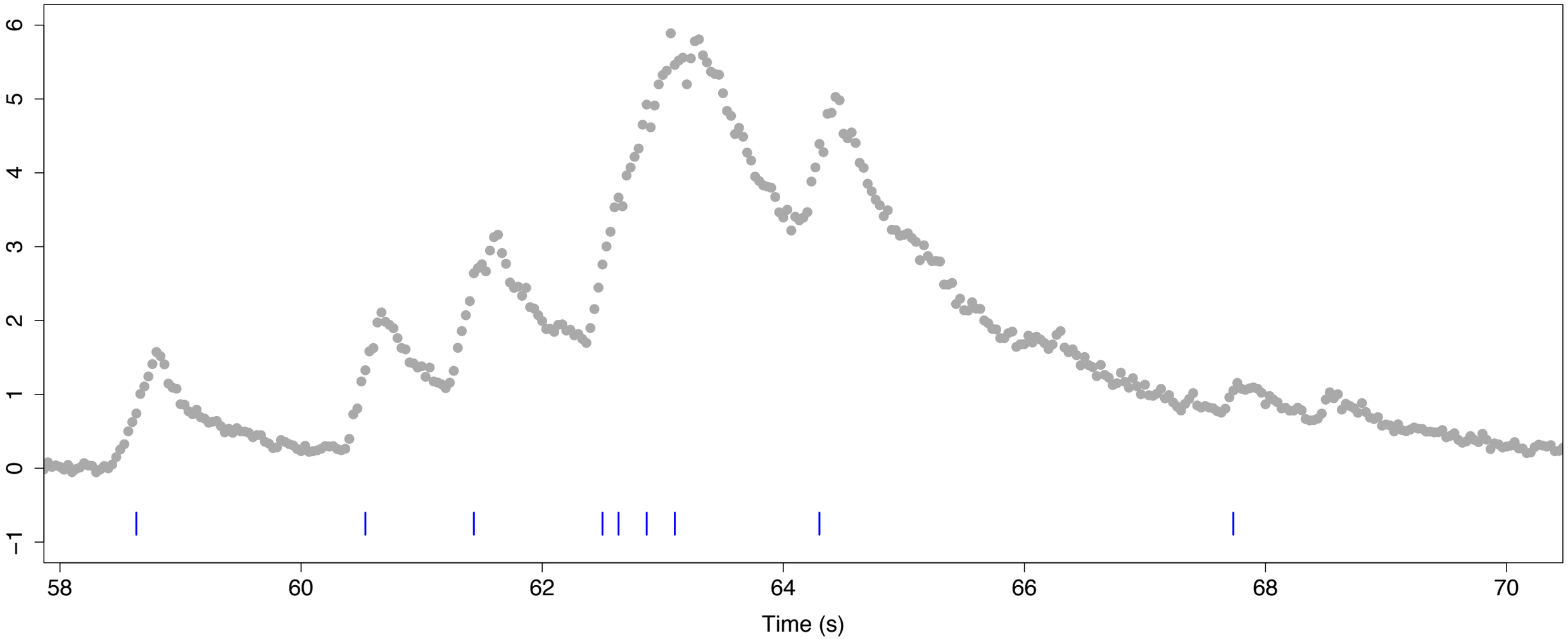
R01 EB026908; PIs Witten/Buice

Goals of this project:

- *Can we* estimate spike times from calcium imaging data?
- How *accurate* are these spike time estimates in:
  - the visual cortex?
  - other brain areas?
- How *certain* are we about these spike time estimates?
- Can we use these estimates in downstream analyses, to:
  - identify latent states underlying a neuron's activity?
  - identify functional subpopulations of neurons?

R01 EB026908; PIs Witten/Buice

Results on Allen Brain Observatory



R01 EB026908; PIs Witten/Buice

Resource | Published: 16 December 2019

A large-scale standardized physiological survey reveals functional organization of the mouse visual cortex

Saskia E. J. de Vries, Jerome A. Lecoq, [...] Christof Koch

Nature Neuroscience **23**, 138–151(2020) | Cite this article

Abstract

To understand how the brain processes sensory information to guide behavior, we must know how stimulus representations are transformed throughout the visual cortex. Here we report an open, large-scale physiological survey of activity in the awake mouse visual cortex: the Allen Brain Observatory Visual Coding dataset. This publicly available dataset includes the cortical activity of nearly 60,000 neurons from six visual areas, four layers, and 12 transgenic mouse lines in a total of 243 adult mice, in response to a systematic set of visual stimuli. We classify neurons on the basis of joint reliabilities to multiple stimuli and validate this functional classification with models of visual responses. While most classes are characterized by responses to specific subsets of the stimuli, the largest class is not reliably responsive to any of the stimuli and becomes progressively larger in higher visual areas. These classes reveal a functional organization wherein putative dorsal areas show specialization for visual motion signals.

ALLEN BRAIN ATLAS

SOFTWARE DEVELOPMENT KIT

R01 EB026908; PIs Witten/Buice

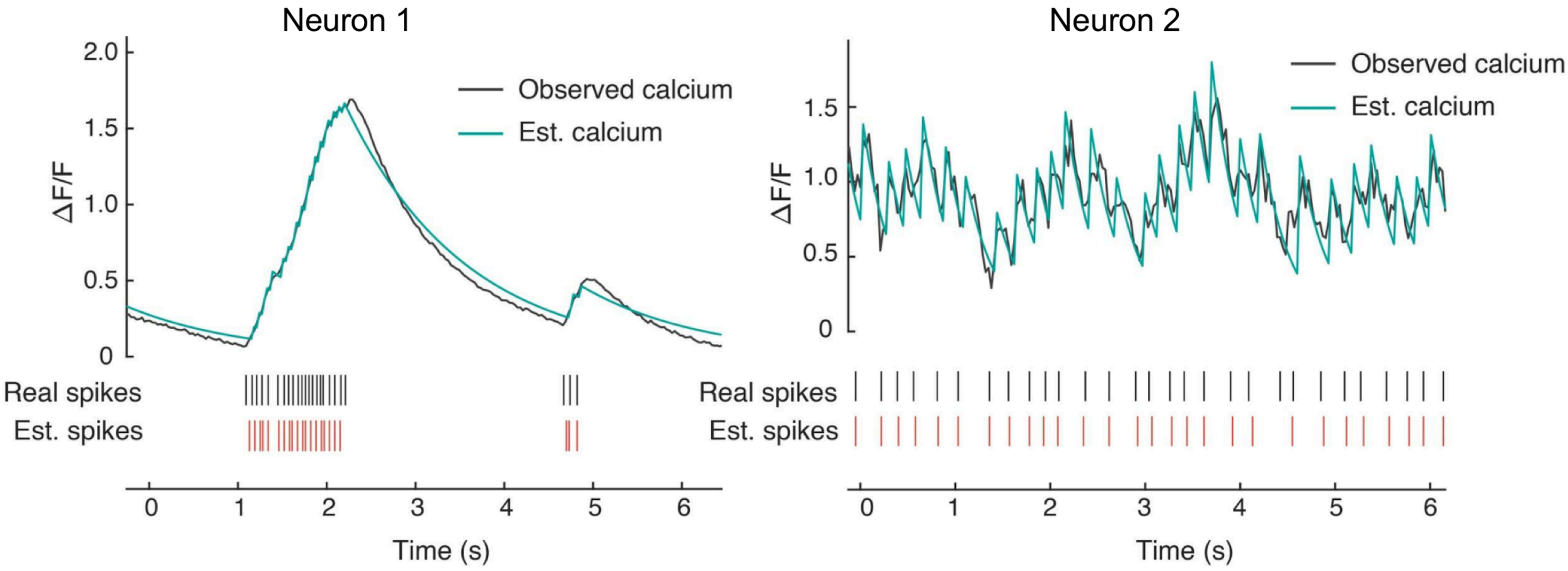
Goals of this project:

- *Can we* estimate spike times from calcium imaging data?
- How *accurate* are these spike time estimates in:
  - the visual cortex?
  - other brain areas?
- How *certain* are we about these spike time estimates?
- Can we use these estimates in downstream analyses, to:
  - identify latent states underlying a neuron's activity?
  - identify functional subpopulations of neurons?

R01 EB026908; PIs Witten/Buice

In Vitro Dopamine Data

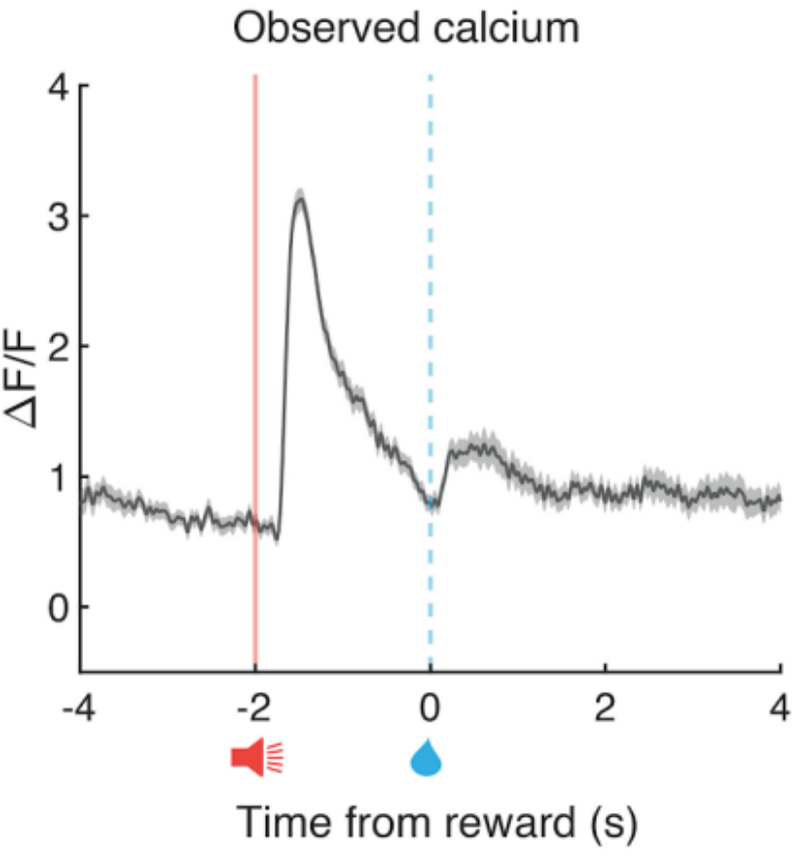
(True spike times are known)

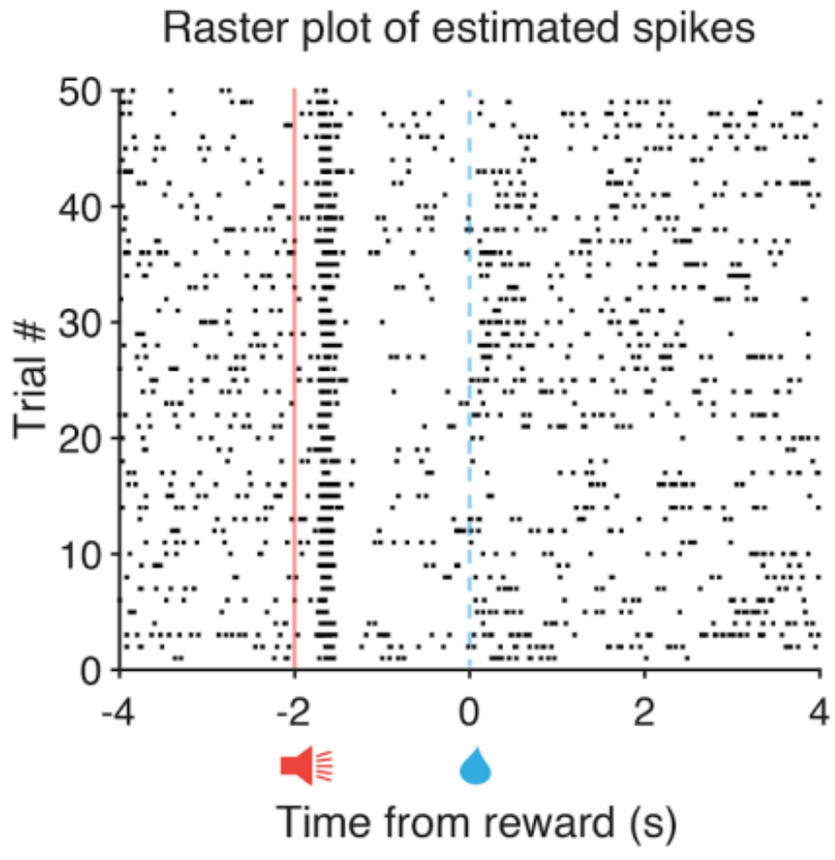


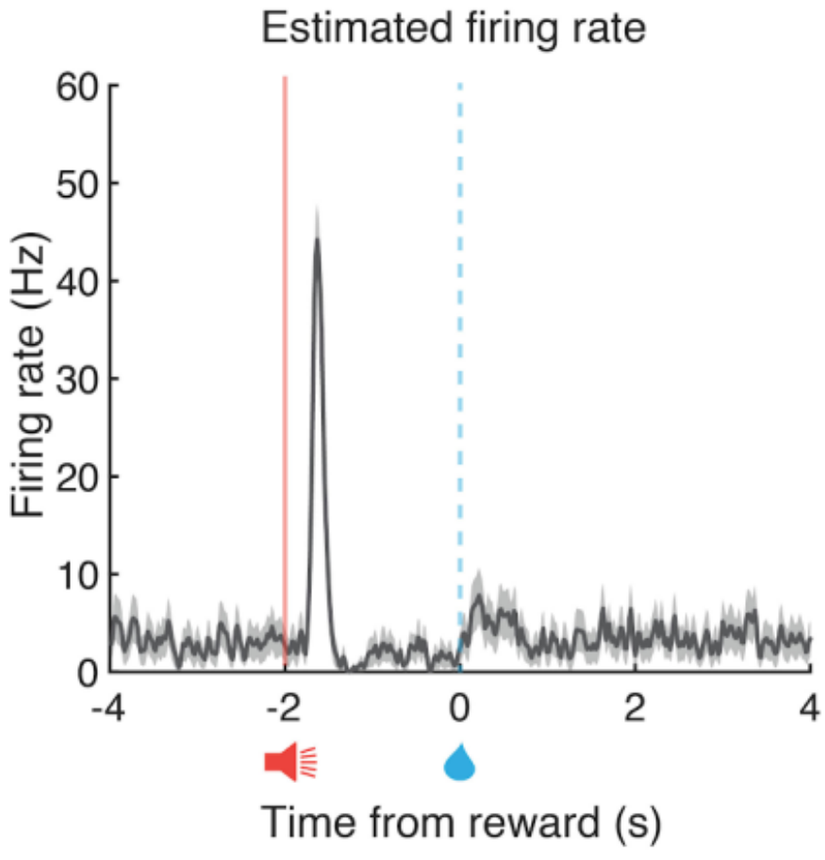
Data from lab of I. Witten (Princeton)

R01 EB026908; PIs Witten/Buice

Pavlovian Conditioning Data



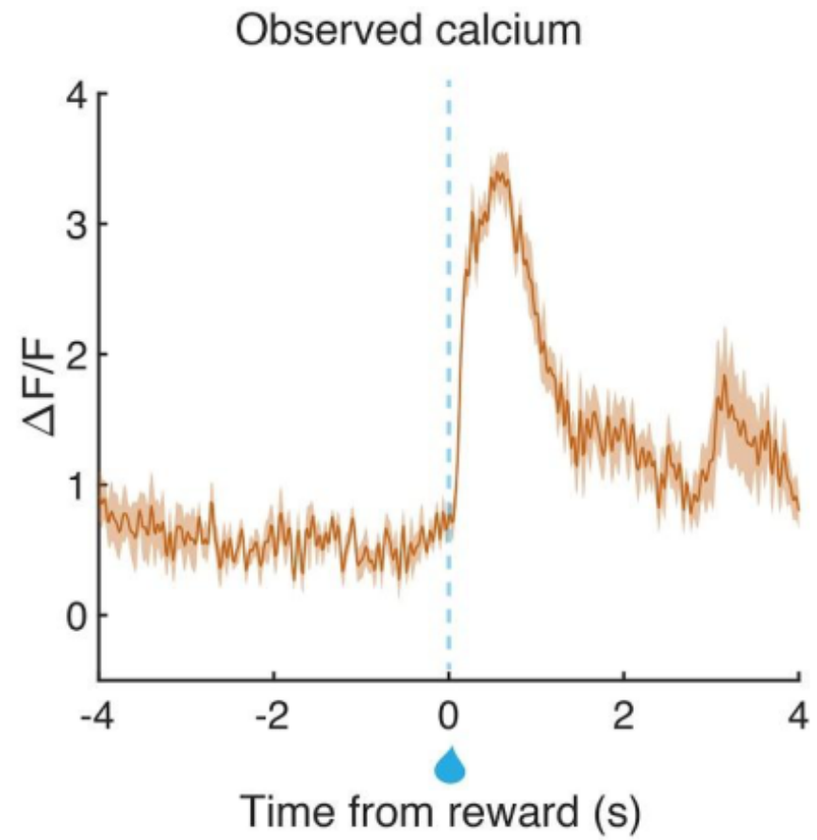


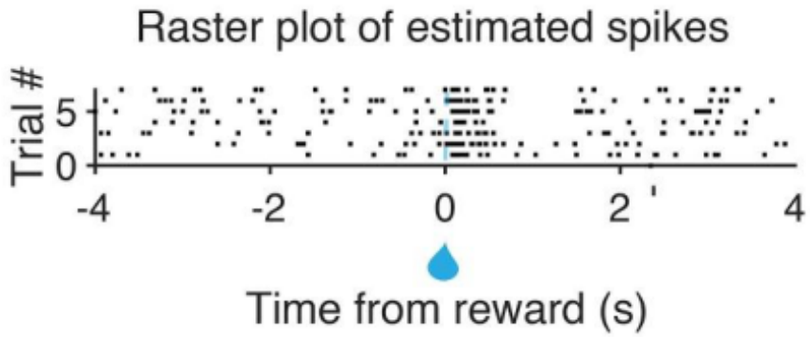


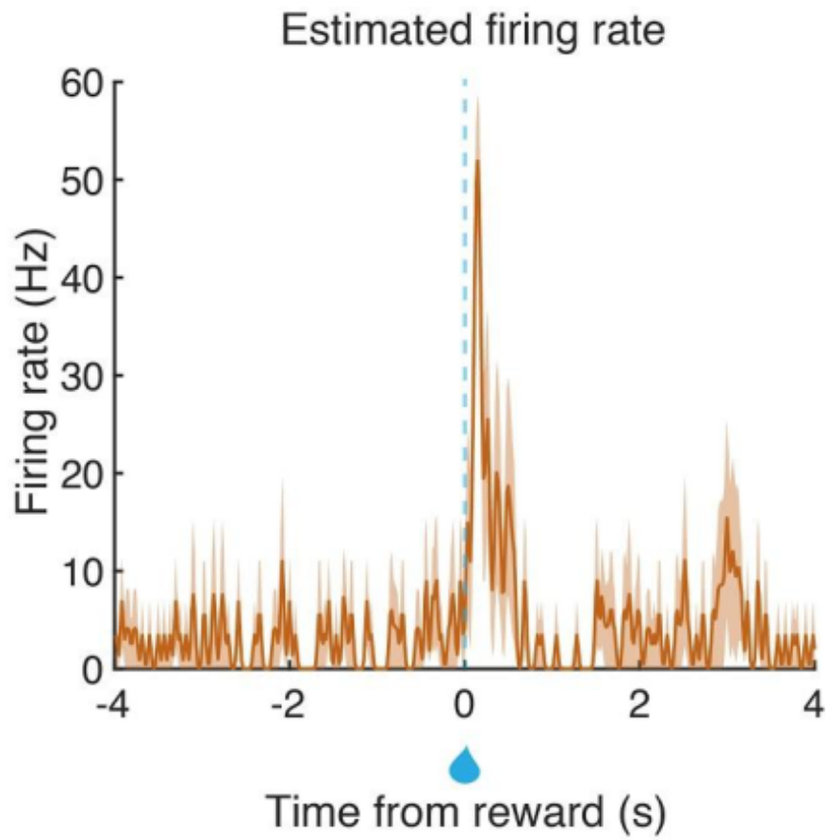
Data from lab of I. Witten (Princeton)

R01 EB026908; PIs Witten/Buice

Pavlovian Conditioning Data



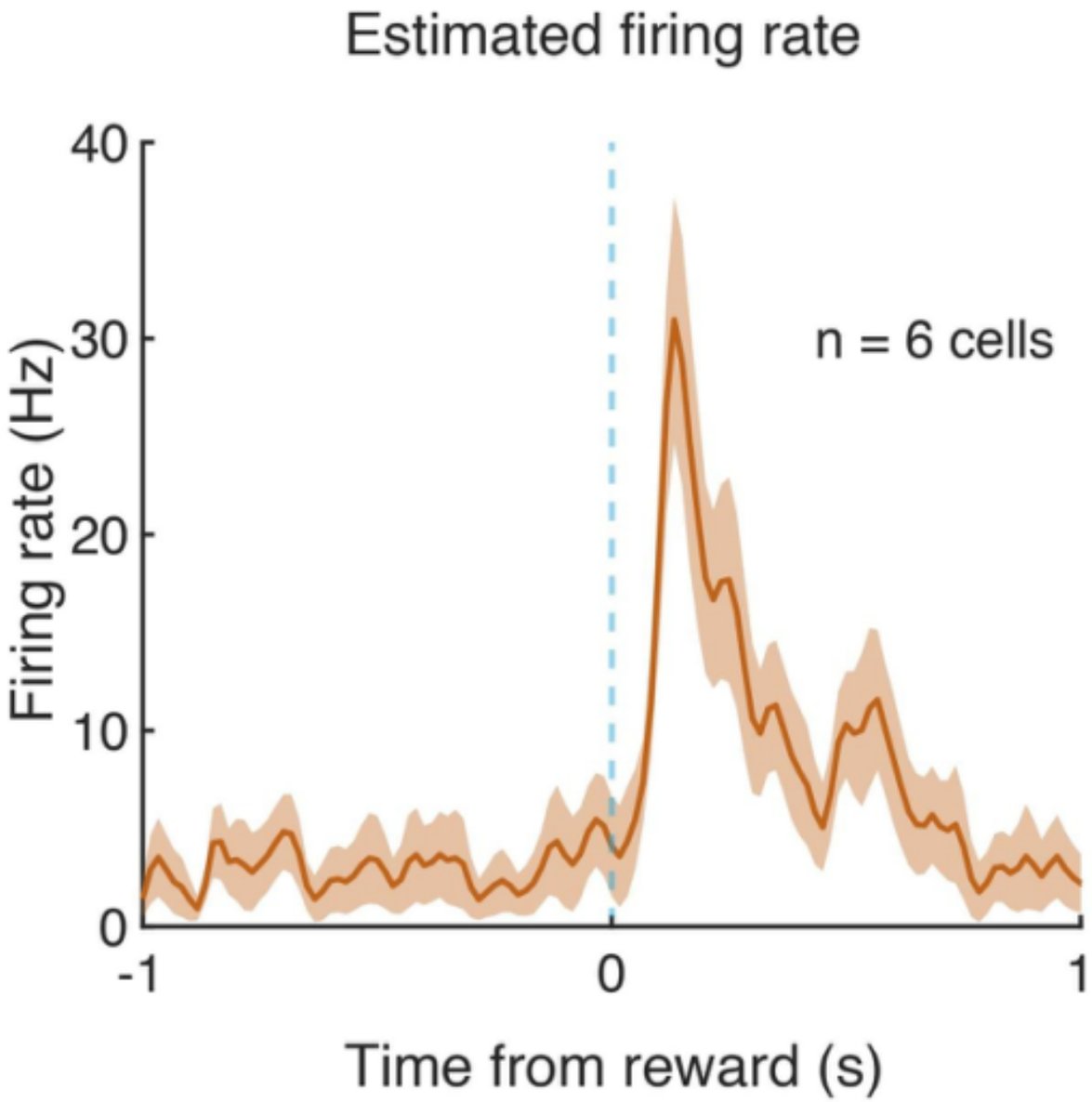


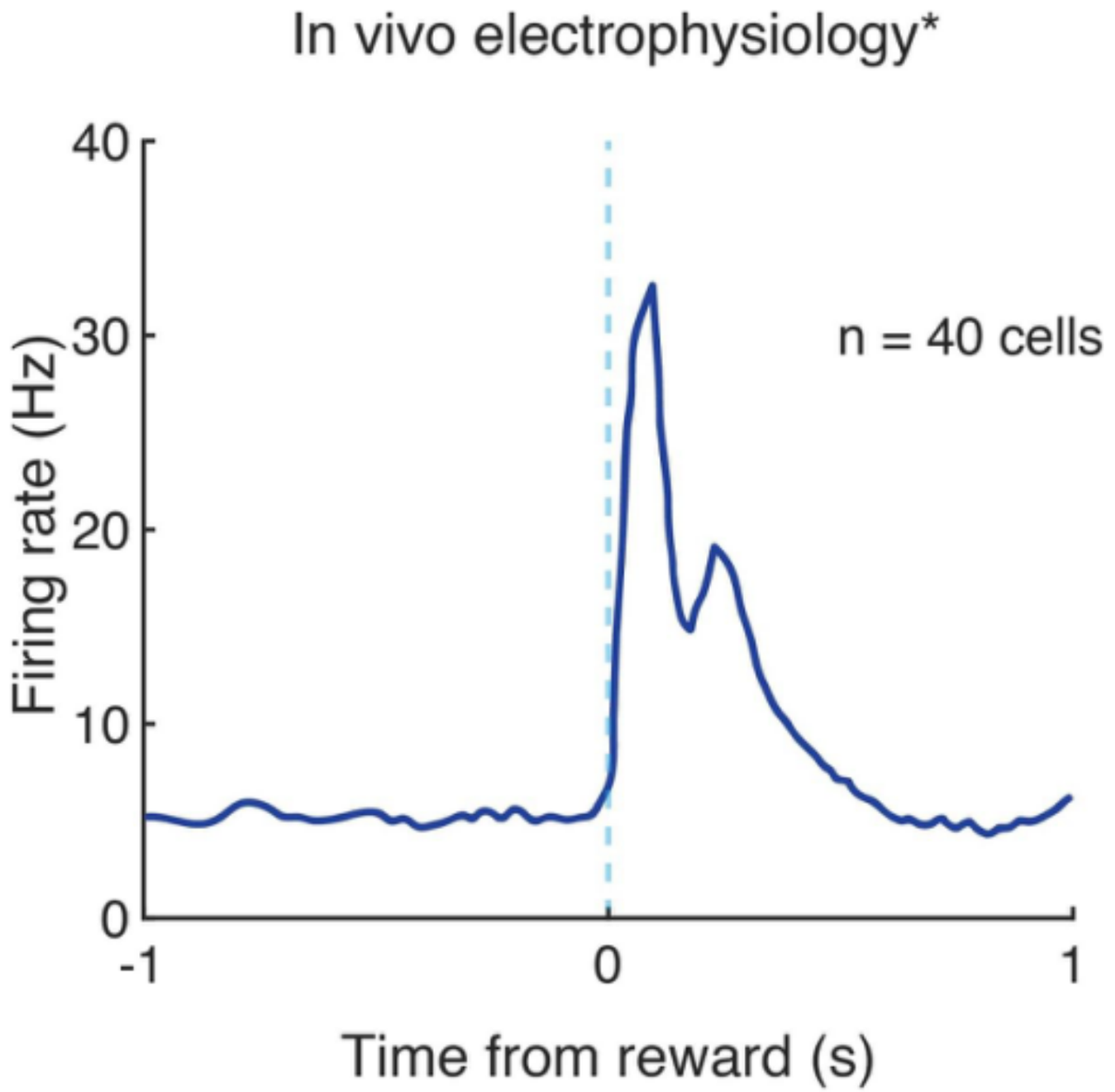


Data from lab of I. Witten (Princeton)

R01 EB026908; PIs Witten/Buice

Pavlovian Conditioning Data





*Adapted from Eshel, et al., 2016

Data from lab of I. Witten (Princeton)

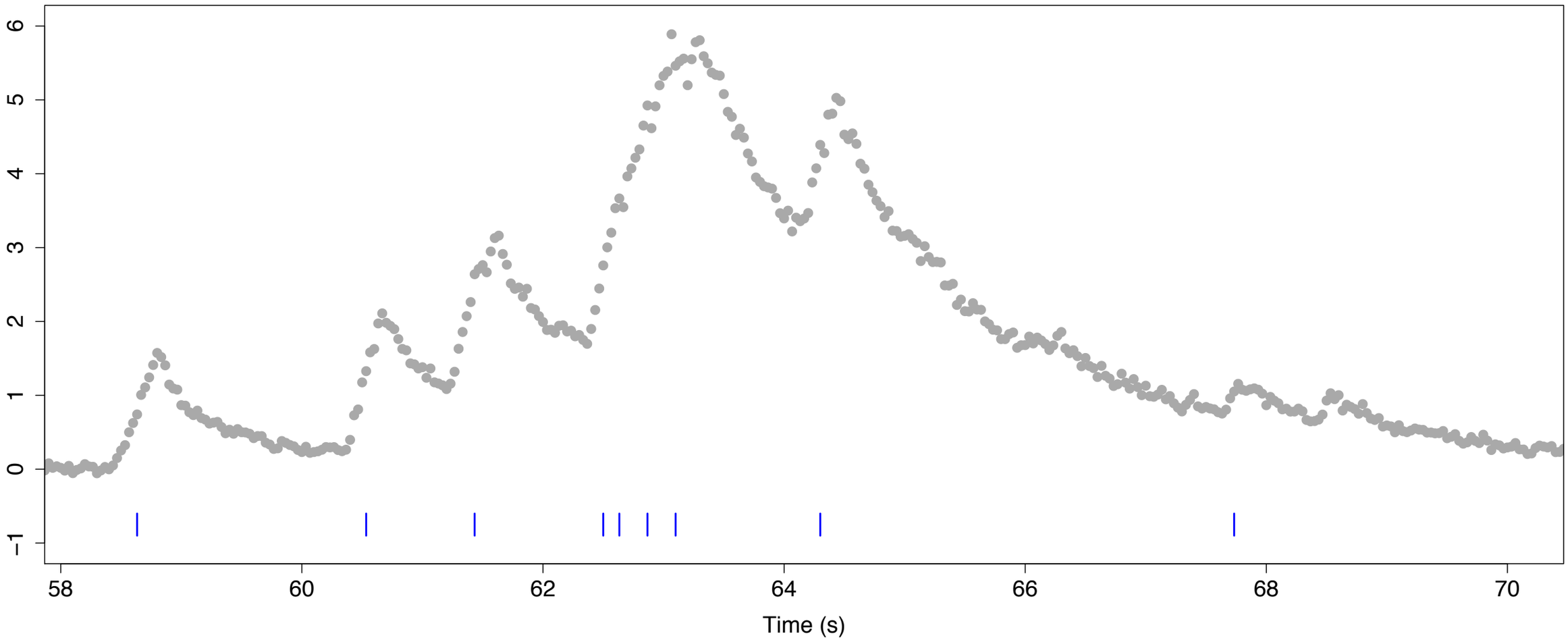
R01 EB026908; PIs Witten/Buice

Goals of this project:

- *Can we* estimate spike times from calcium imaging data?
- How *accurate* are these spike time estimates in:
  - the visual cortex?
  - other brain areas?
- How *certain* are we about these spike time estimates?
- Can we use these estimates in downstream analyses, to:
  - identify latent states underlying a neuron's activity?
  - identify functional subpopulations of neurons?

R01 EB026908; PIs Witten/Buice

Uncertainty in Spike Estimation



How certain are we that the estimated spikes are “real”?

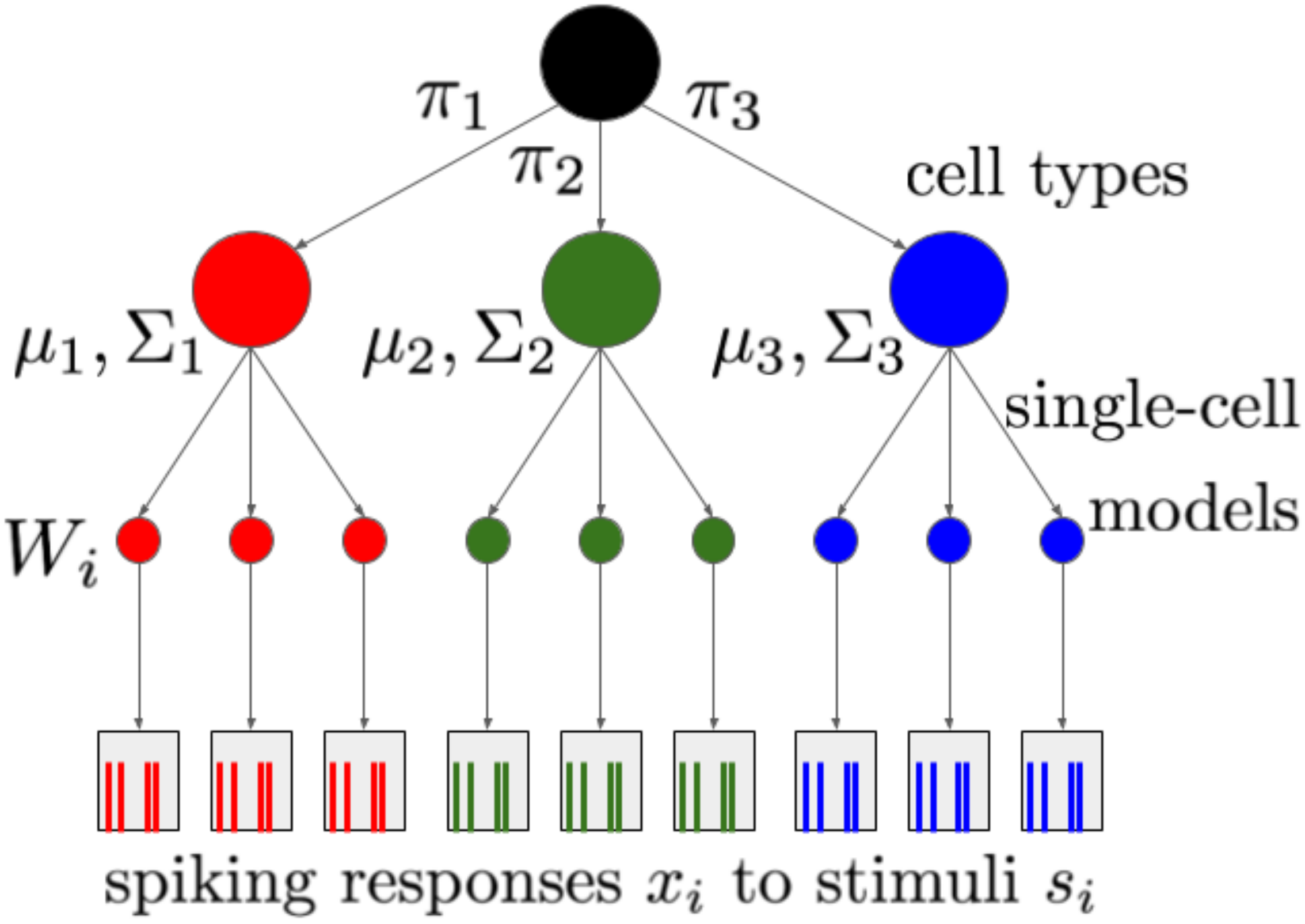
Can we assign a p-value to each spike?

R01 EB026908; PIs Witten/Buice

Goals of this project:

- *Can we* estimate spike times from calcium imaging data?
- How *accurate* are these spike time estimates in:
  - the visual cortex?
  - other brain areas?
- How *certain* are we about these spike time estimates?
- Can we use these estimates in downstream analyses, to:
  - identify latent states underlying a neuron's activity?
  - identify functional subpopulations of neurons?

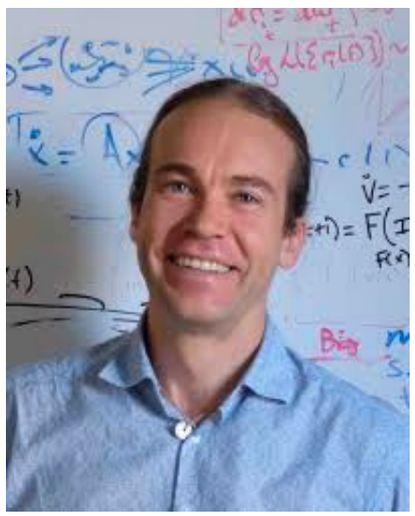
R01 EB026908; PIs Witten/Buice



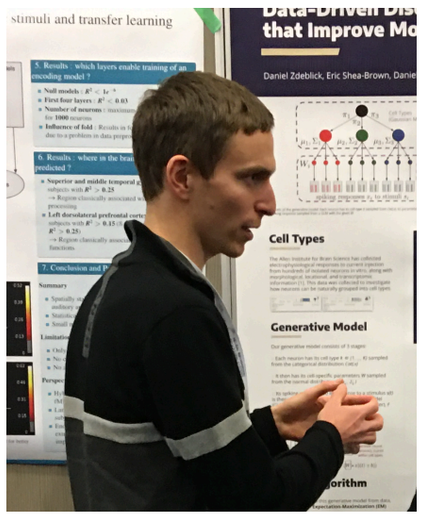
R01 EB026908; PIs Witten/Buice

Collaborators

Sean Jewell,
U. Washington



Eric Shea-Brown,
U. Washington



Daniel Zdeblick,
U. Washington

Ilana Witten,
Princeton University

Weston Fleming,
Princeton University

Thank You!

E-mail:
dwitten@uw.edu
michaelbu@alleninstitute.org

Twitter:
@daniela_witten
@mabuice

R01 EB026908; PIs Witten/Buice