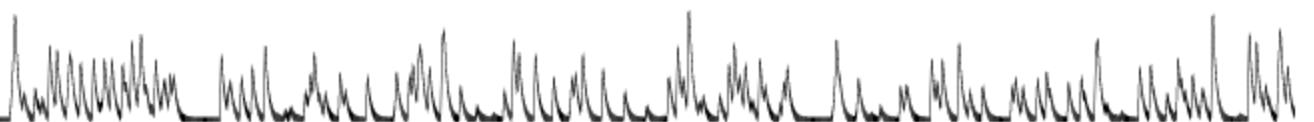


High frequency spike inference with particle Gibbs sampling

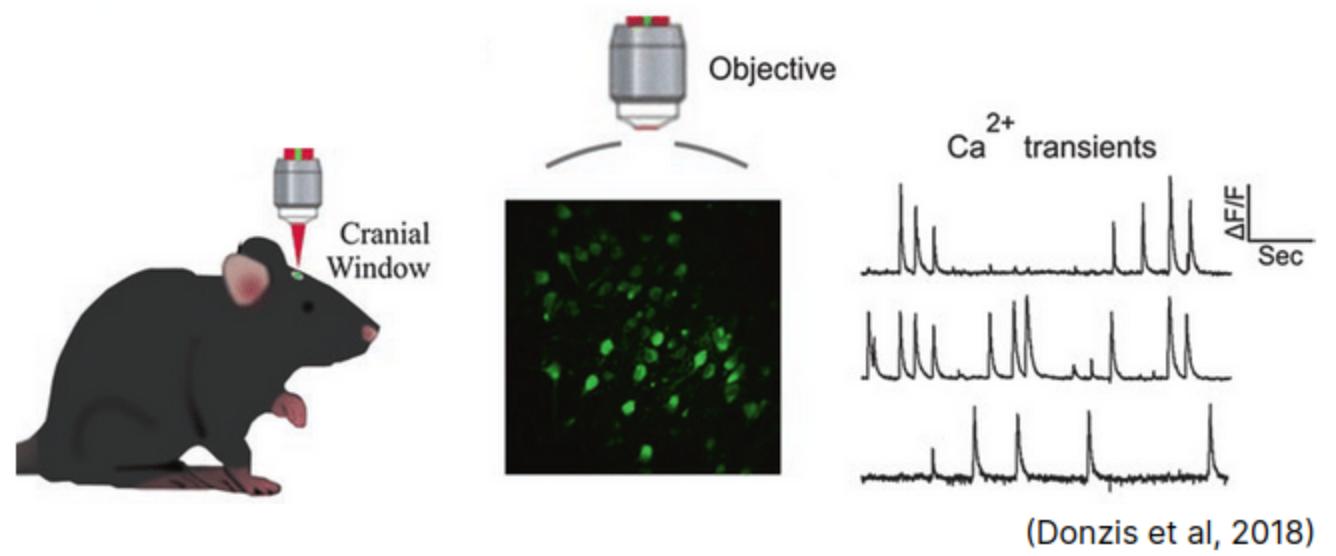


Giovanni Diana

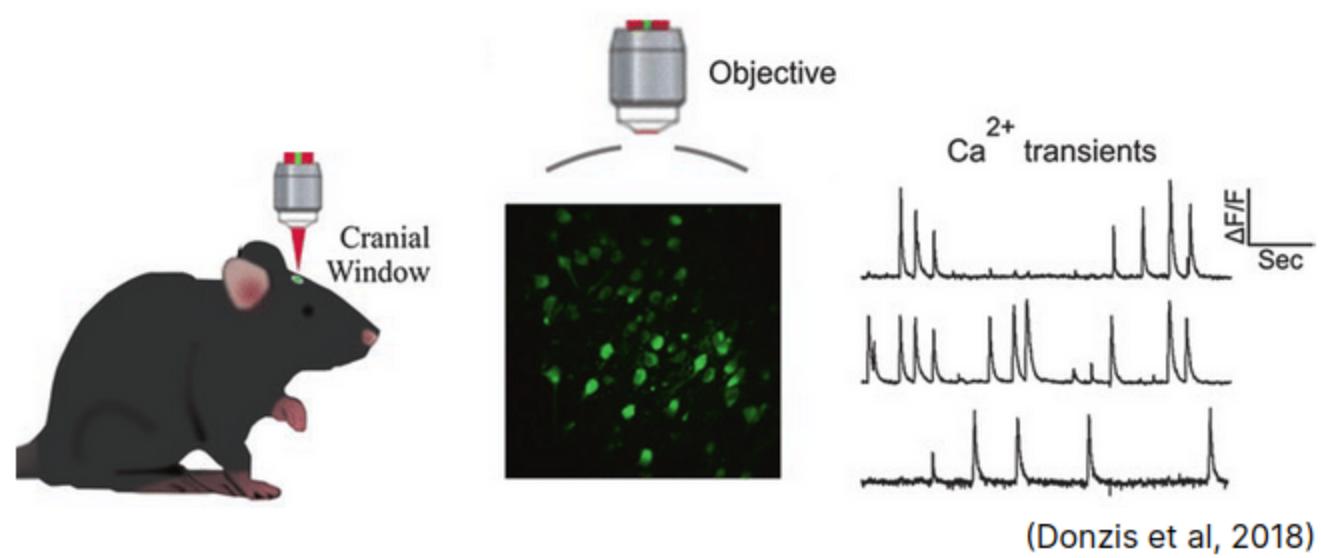
Synapse and Circuit Dynamics, Institut Pasteur

Neuroscience Departmental Day, 7 Sep 2023

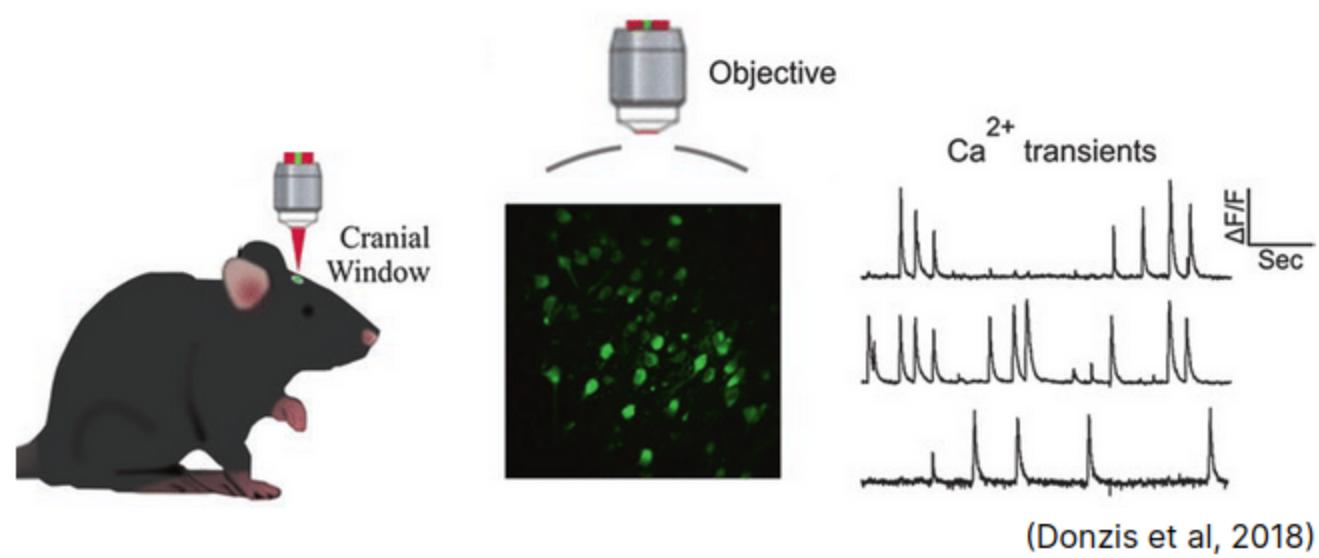
Calcium imaging



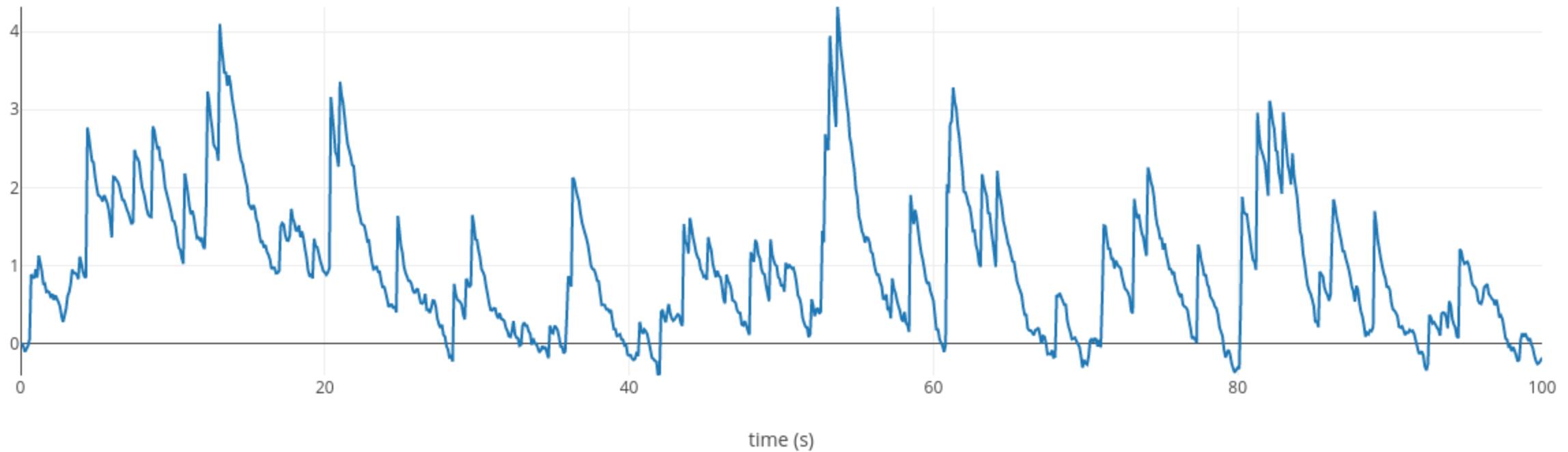
Calcium imaging



Calcium imaging

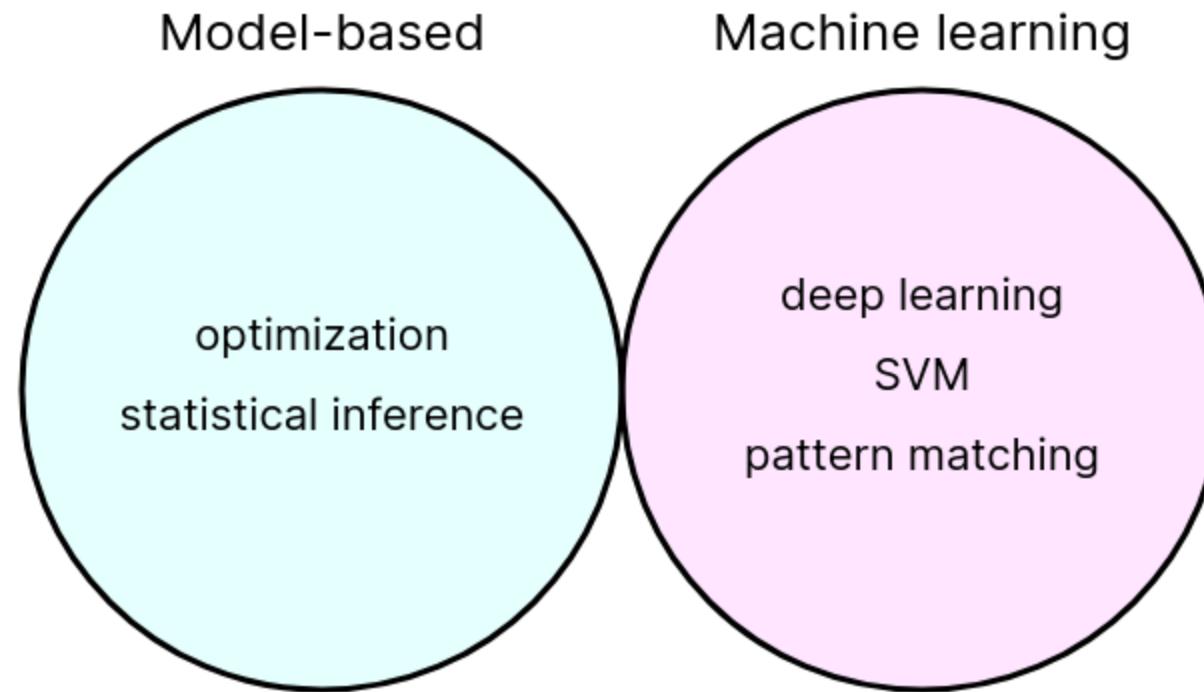


Extract spike times from fluorescence time series



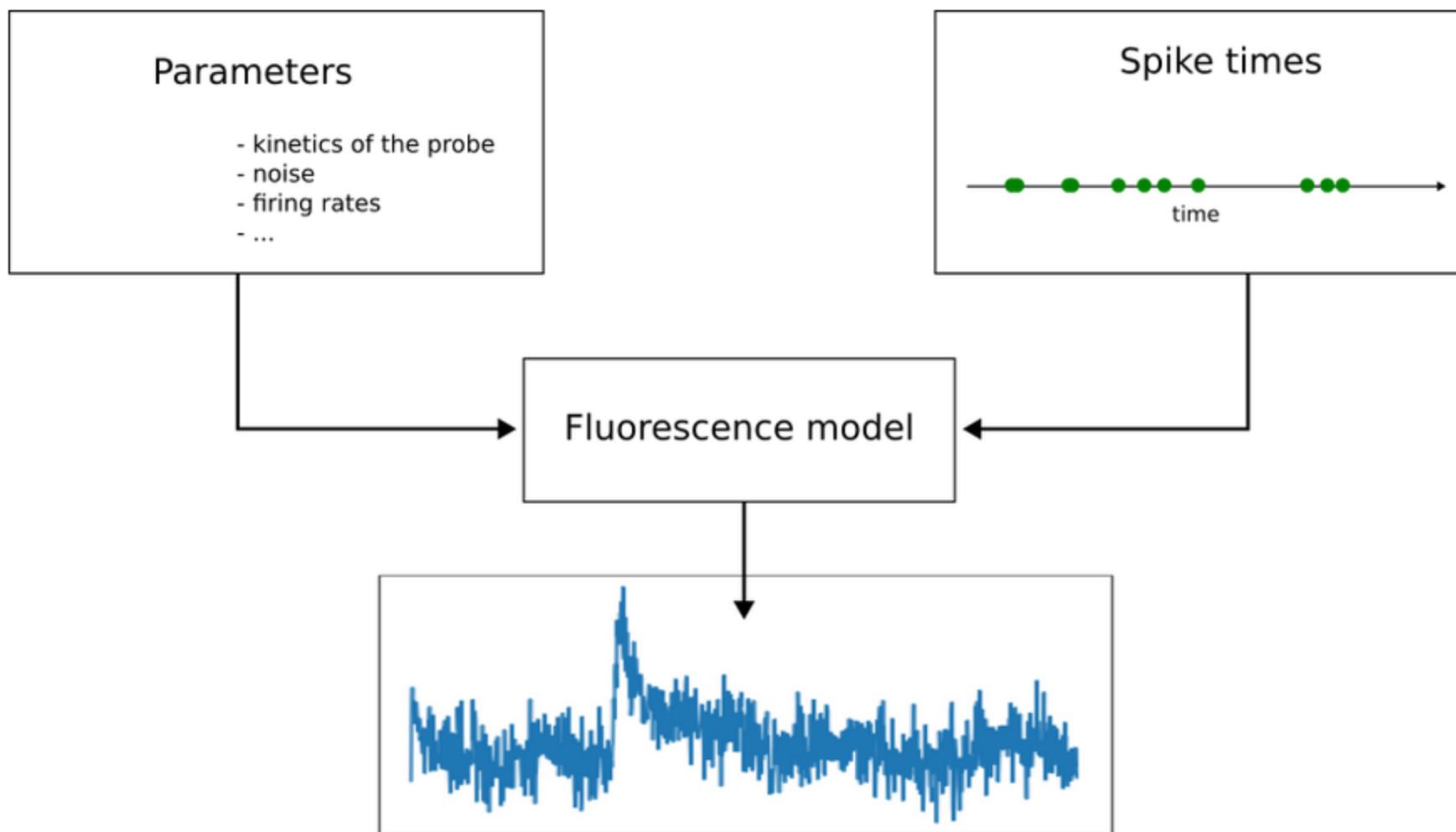
- Low signal to noise ratio
- Baseline modulation
- bursting activity

Current methodologies

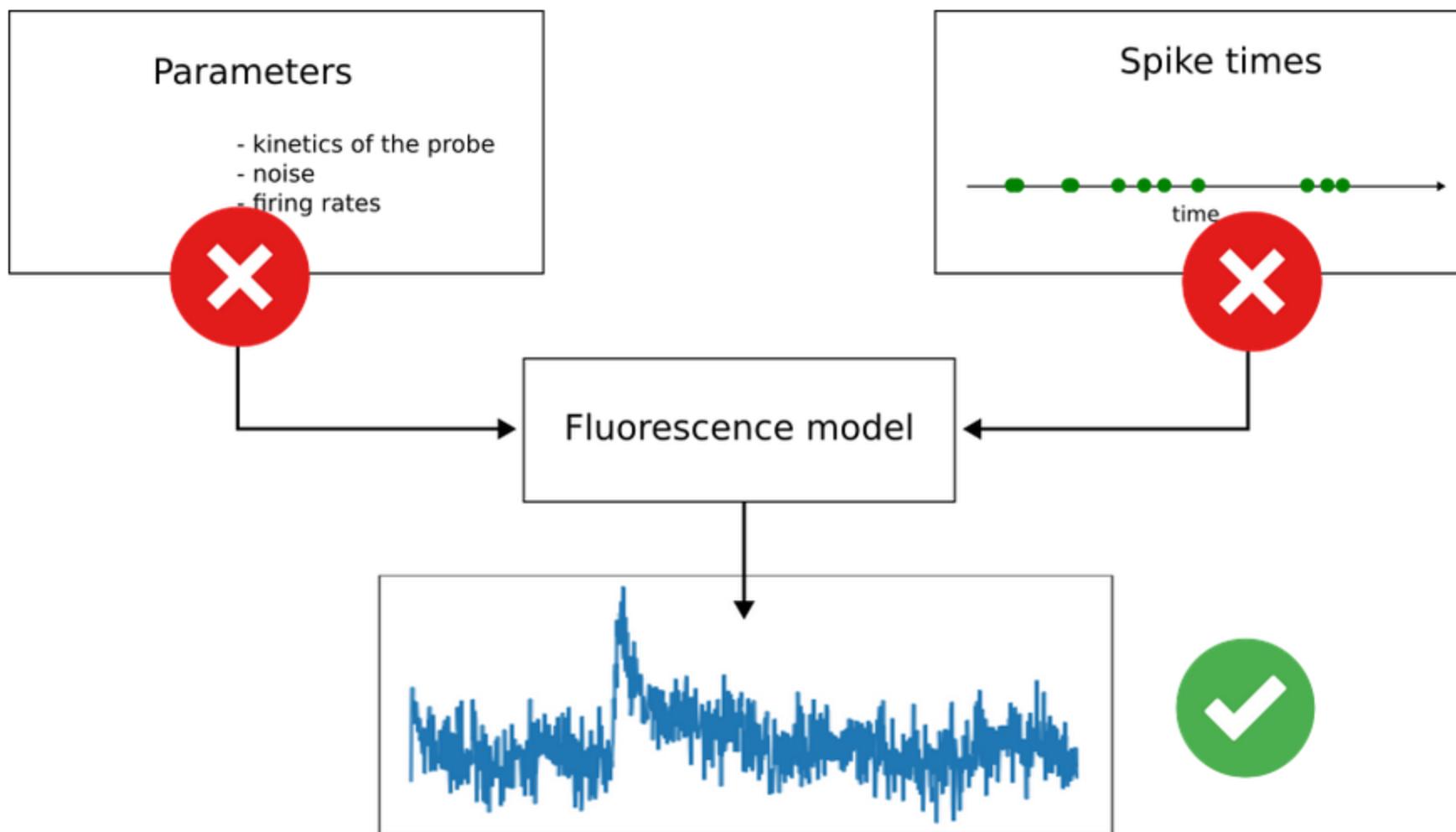


-
- Unsupervised
 - Testing mechanistic hypotheses
 - Model comparison
 - Biologically relevant parameters
 - Supervised
 - Require large training datasets
 - Rely on the ability to generalize to new data

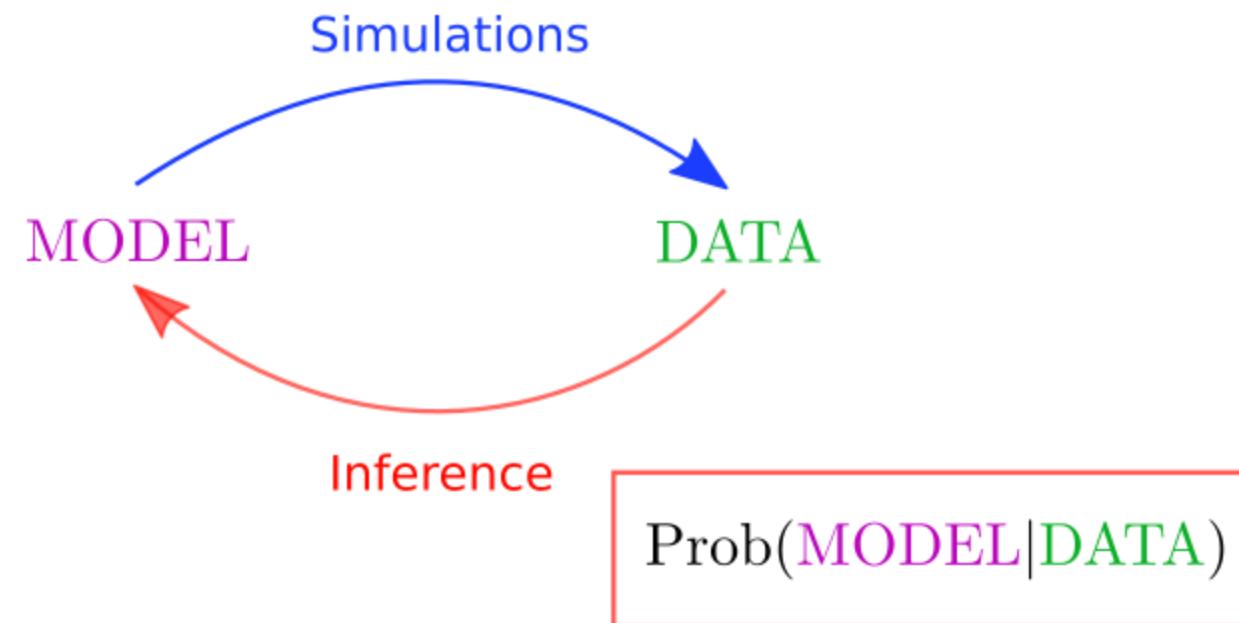
Model-based approach



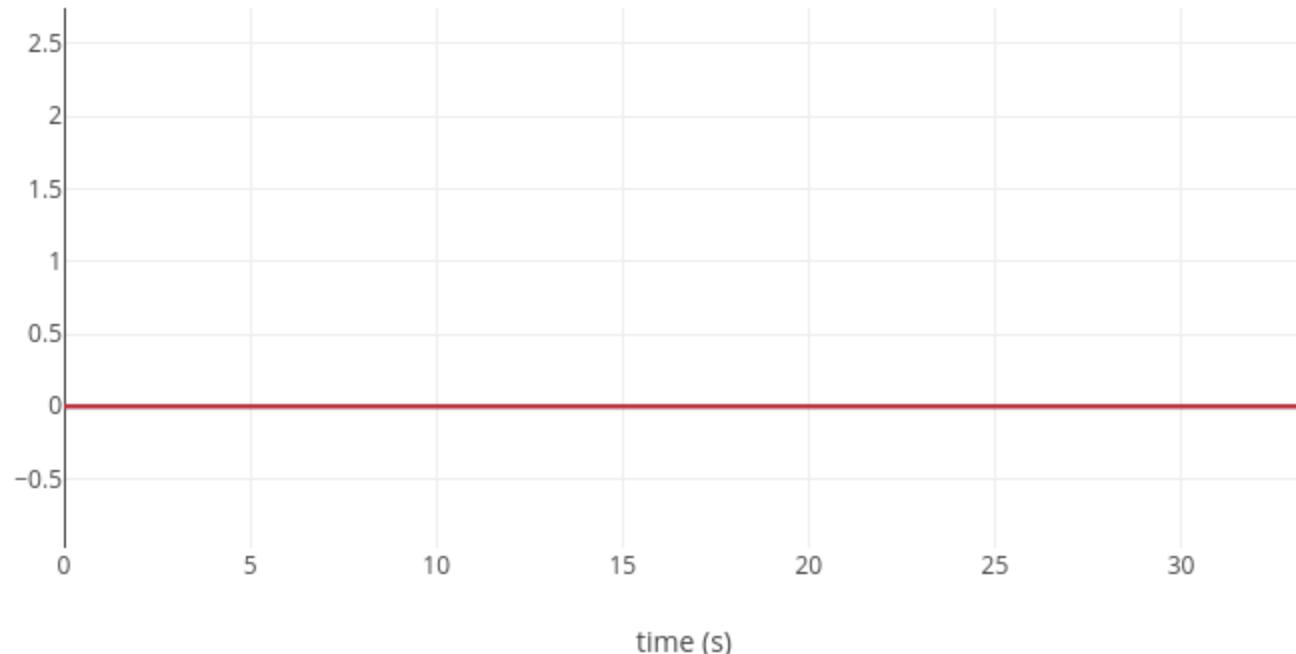
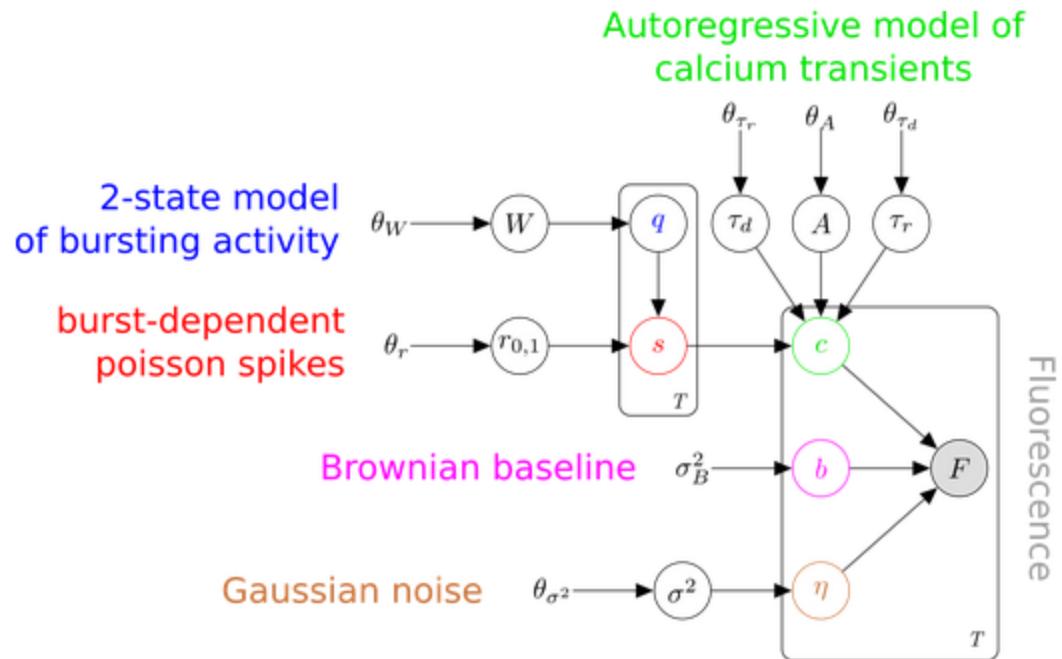
Model-based approach



Statistical inference

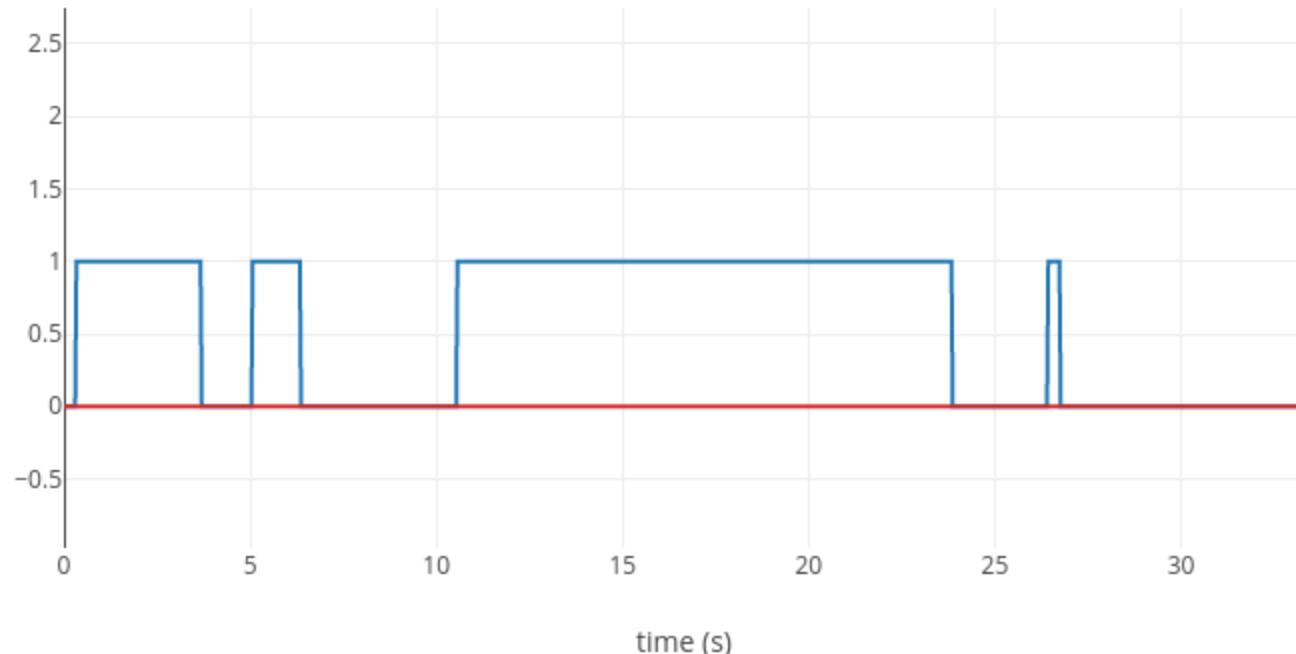
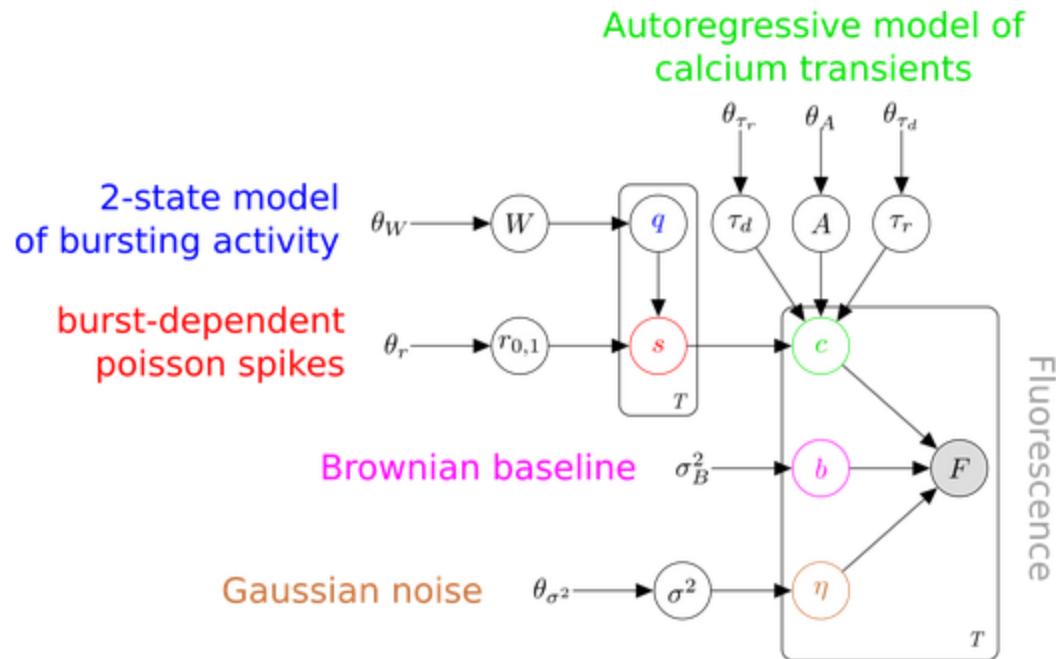


Modeling bursting activity and baseline modulation



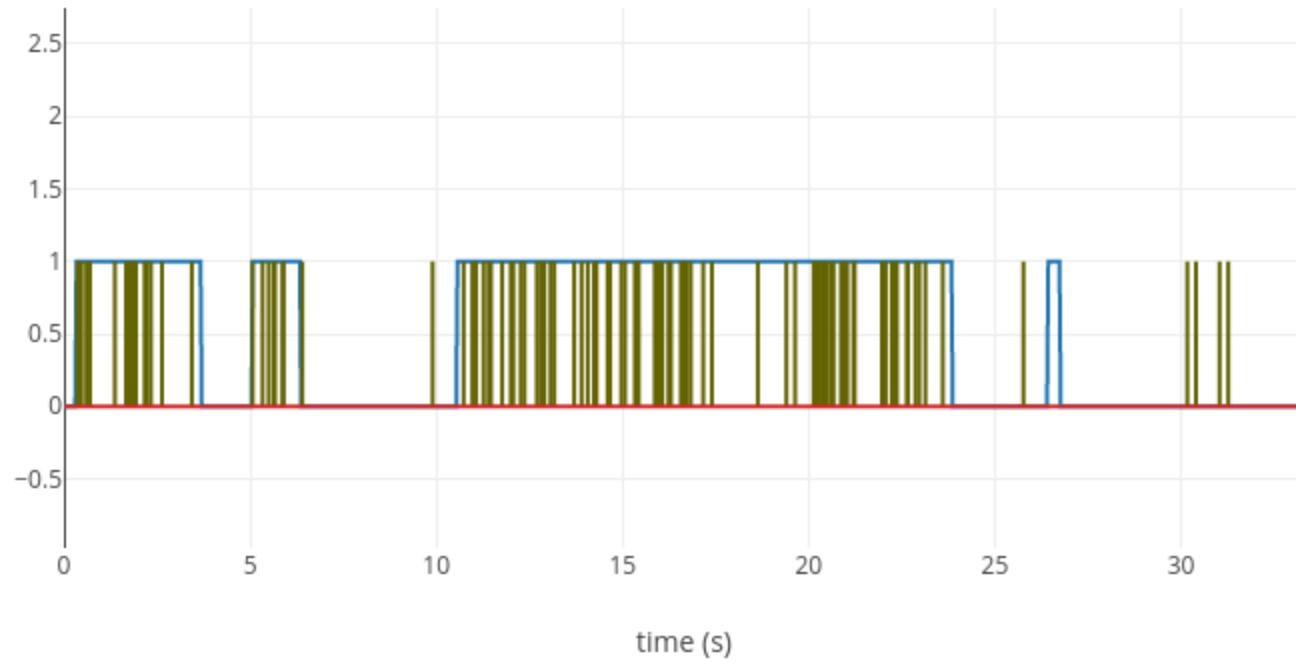
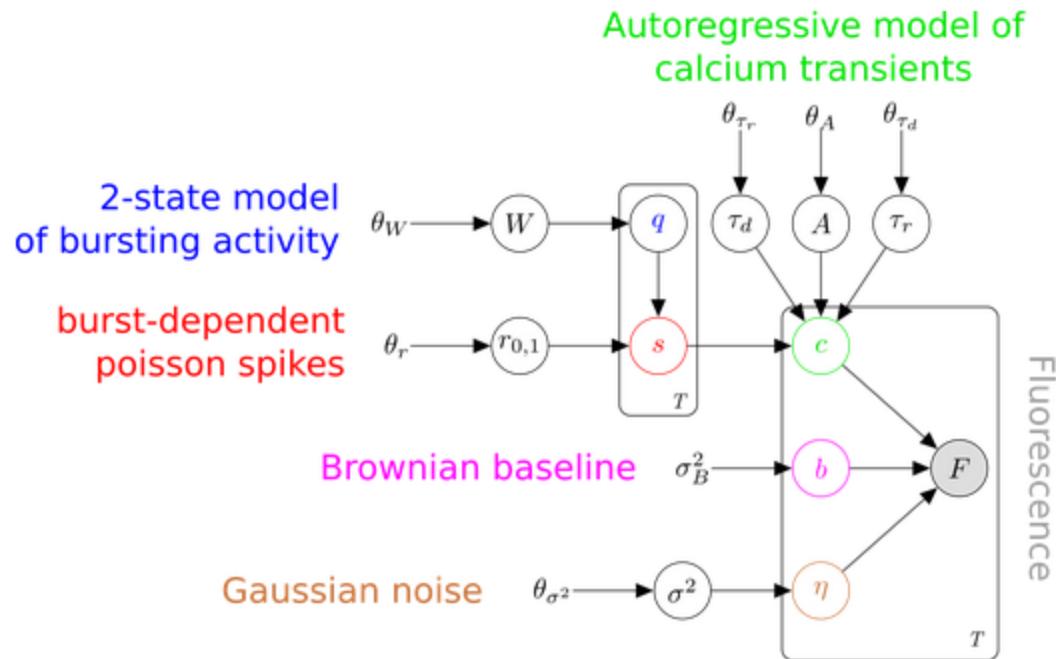
bursting state add spikes baseline fluorescence

Modeling bursting activity and baseline modulation



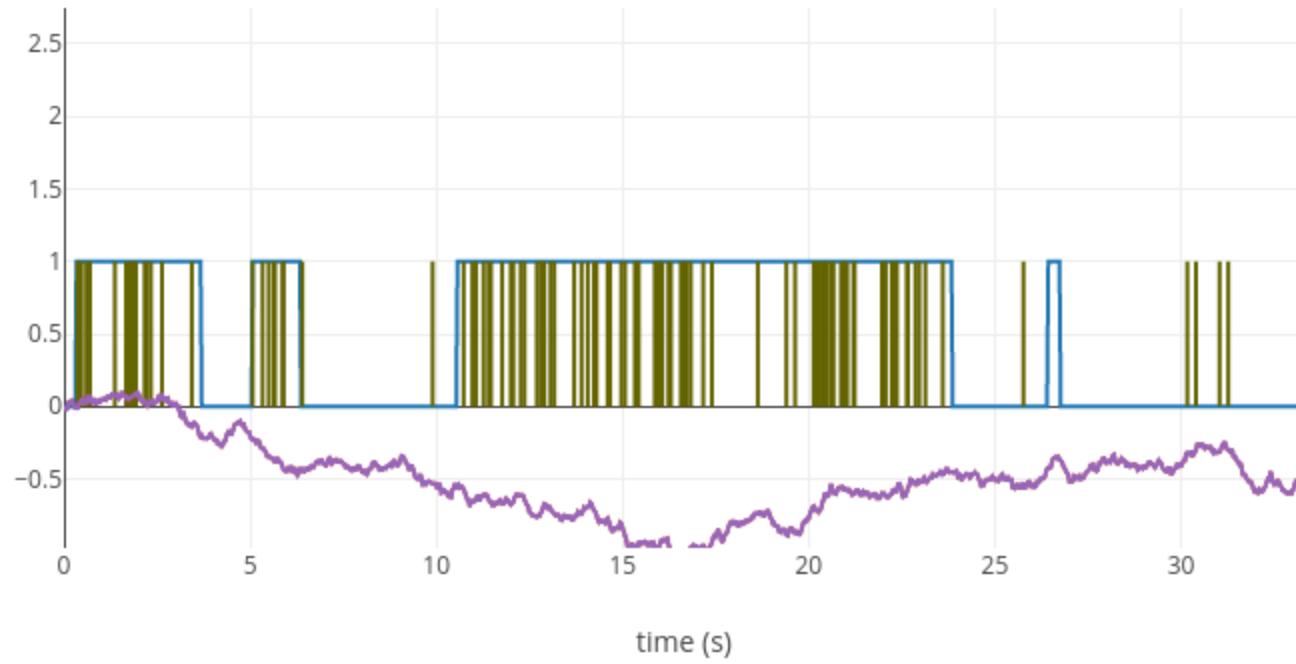
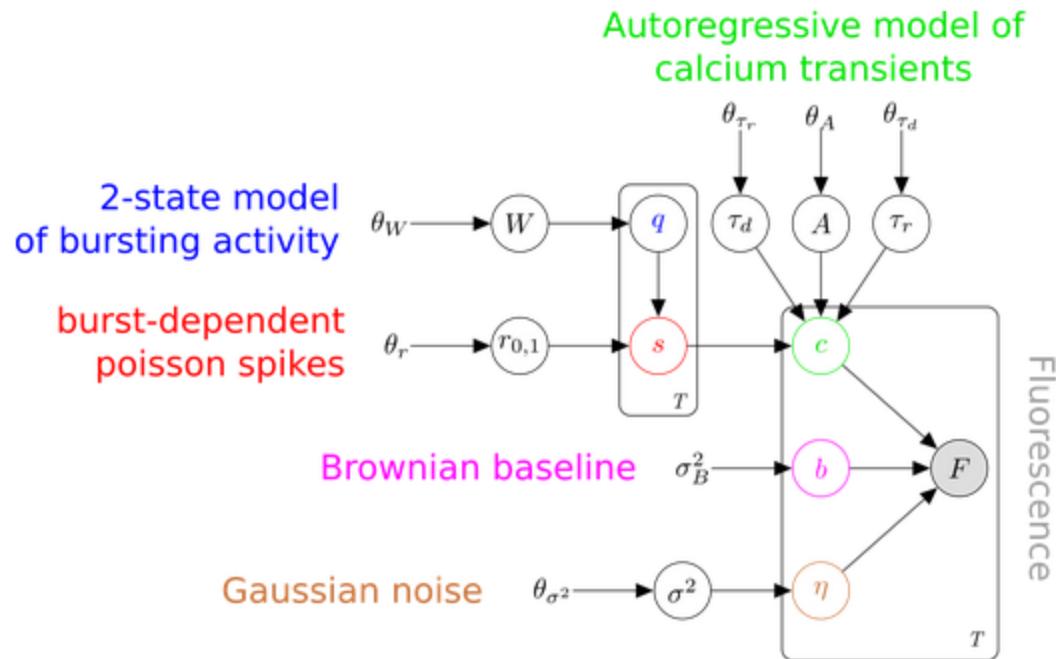
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Modeling bursting activity and baseline modulation

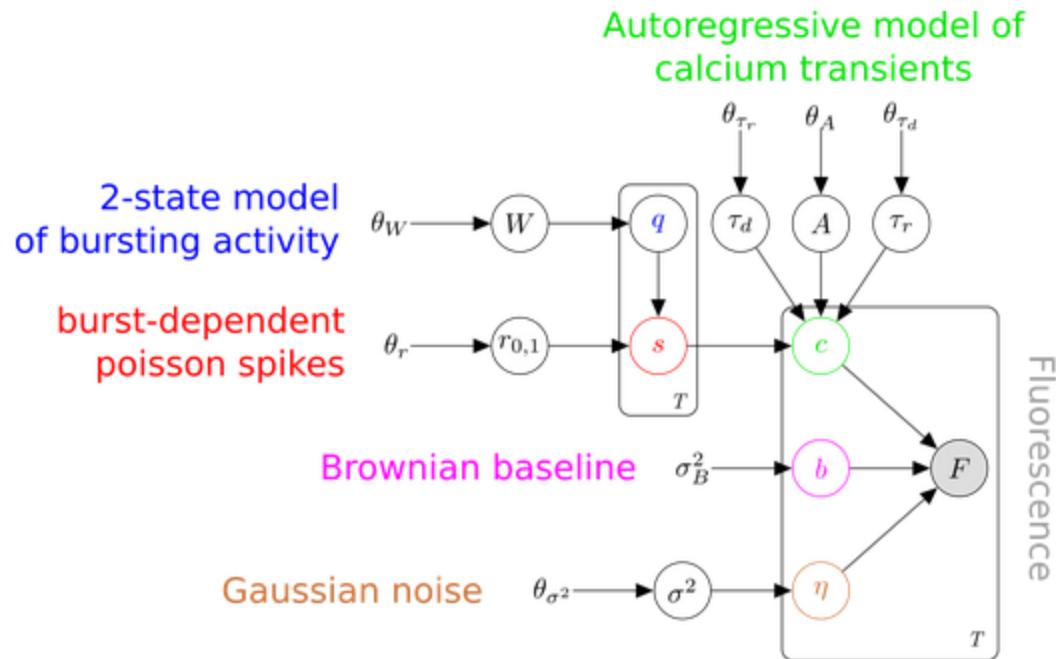


bursting state add spikes baseline fluorescence

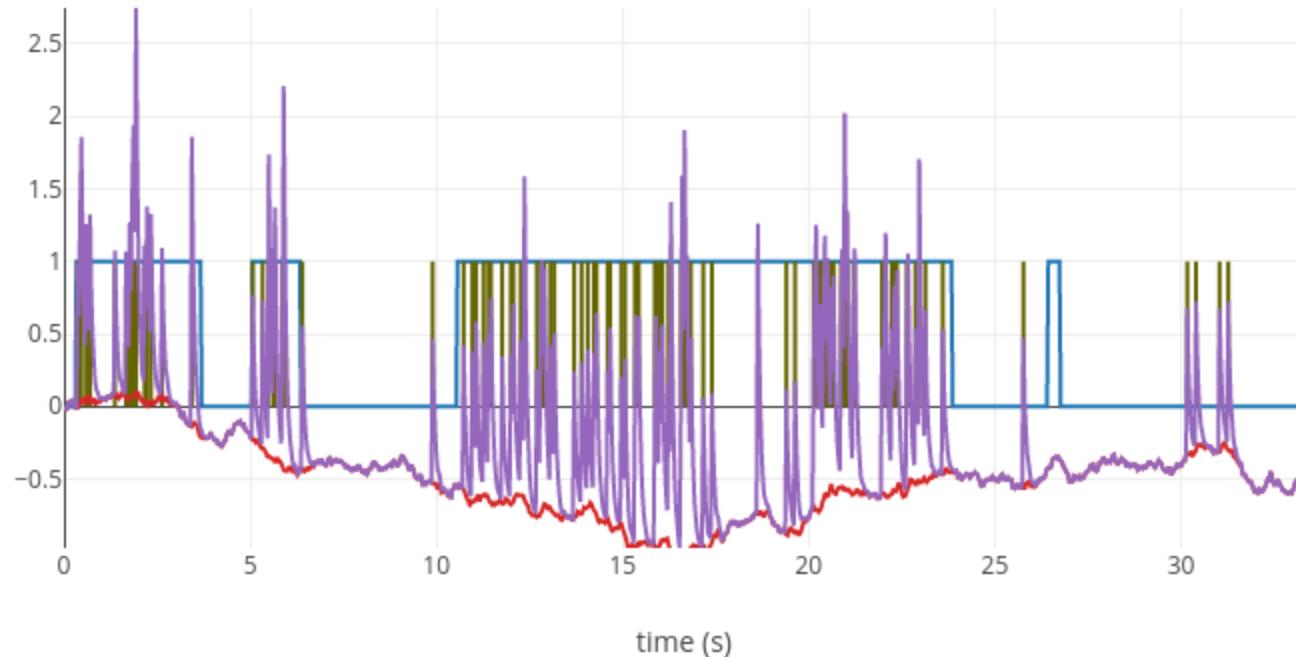
Modeling bursting activity and baseline modulation



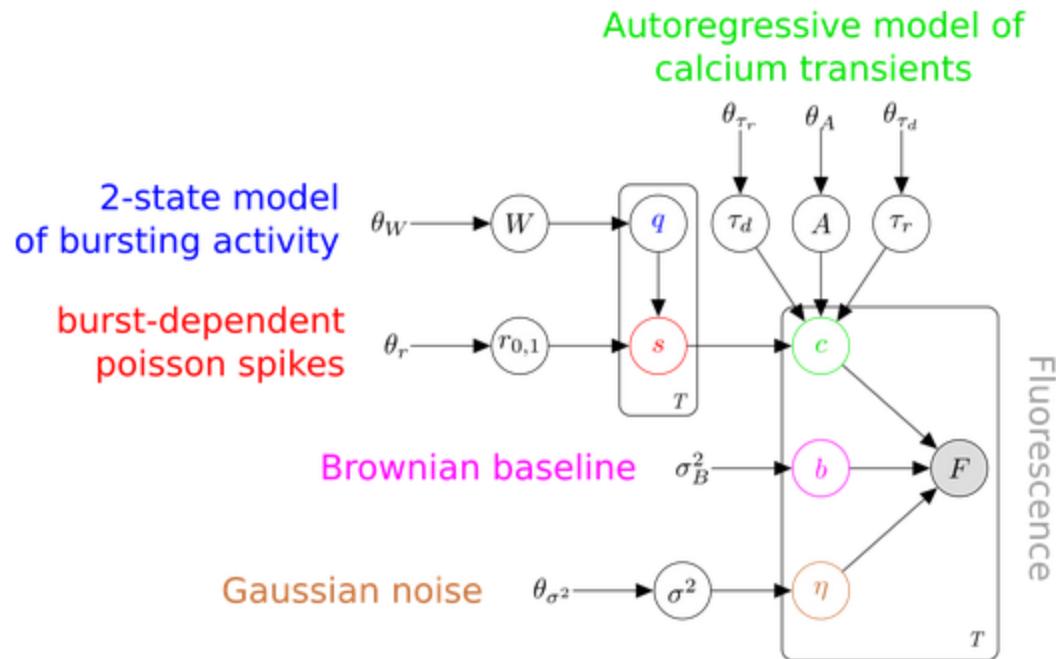
Modeling bursting activity and baseline modulation



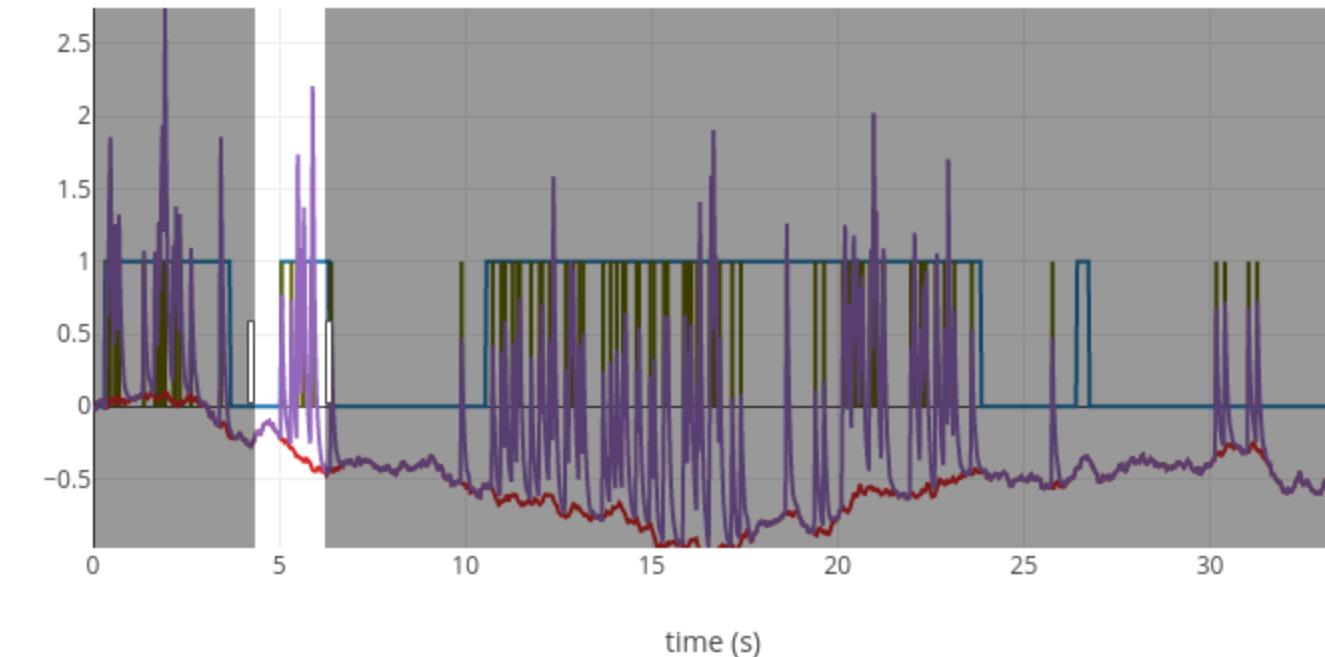
$$c_t = \gamma c_{t-1} + \omega c_{t-2} + A s_t$$



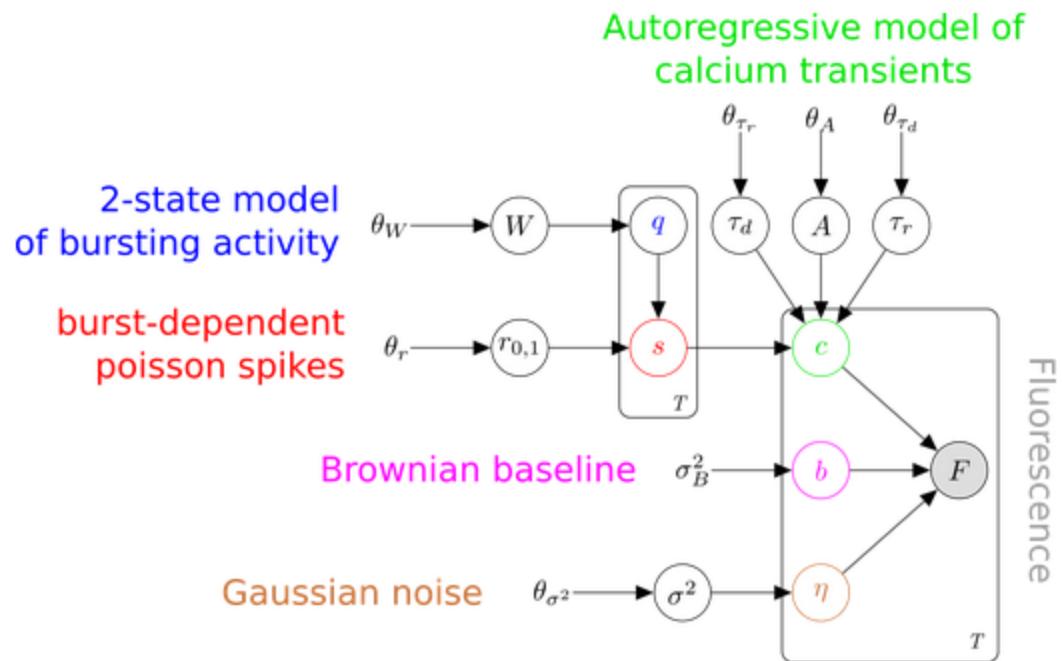
Modeling bursting activity and baseline modulation



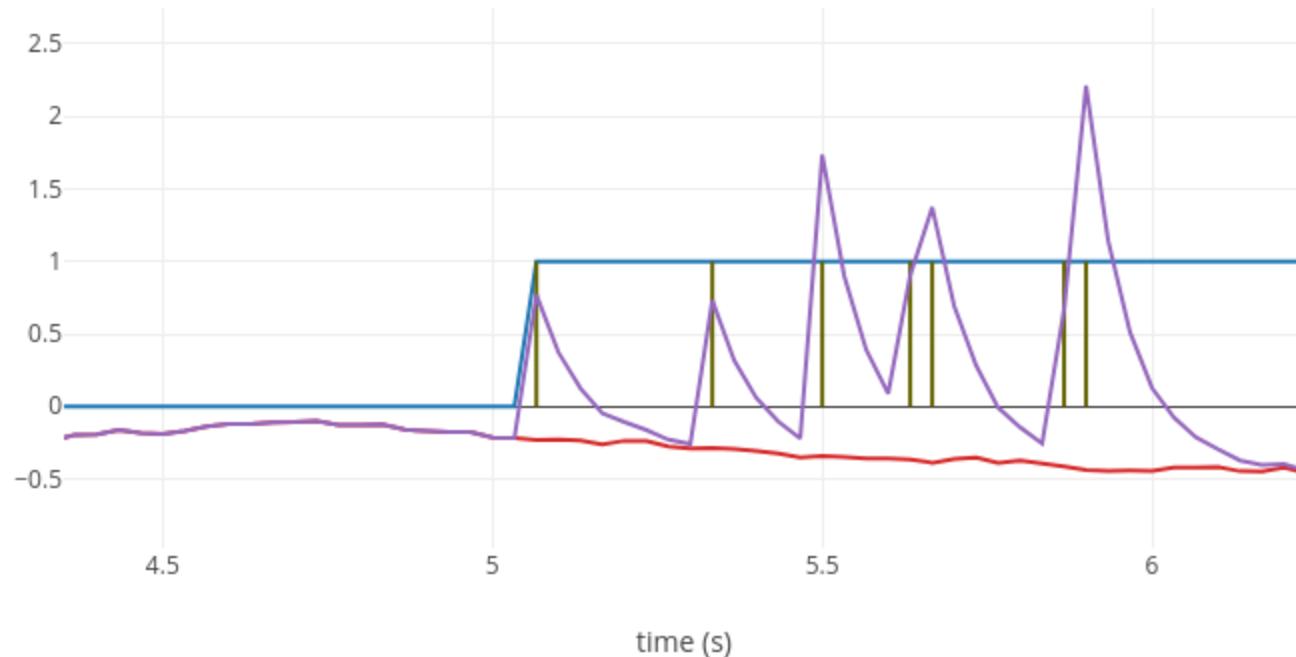
$$c_t = \gamma c_{t-1} + \omega c_{t-2} + As_t$$



Modeling bursting activity and baseline modulation

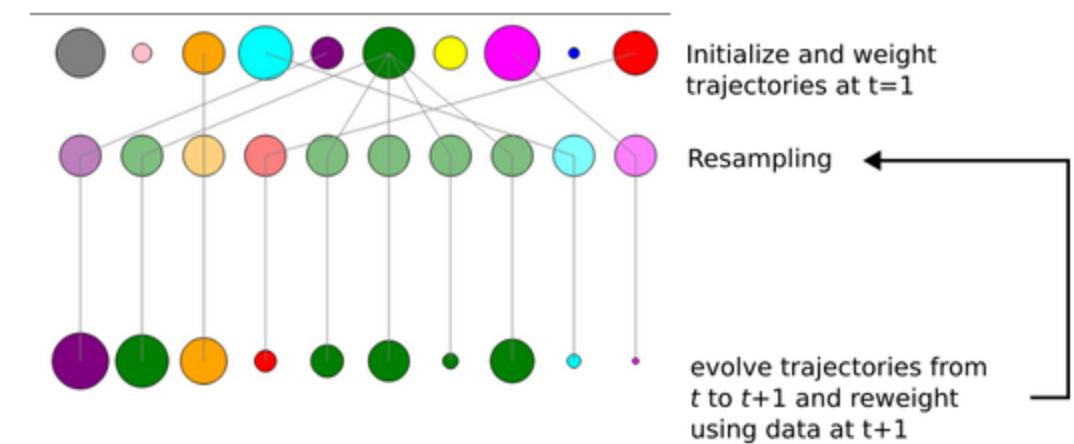
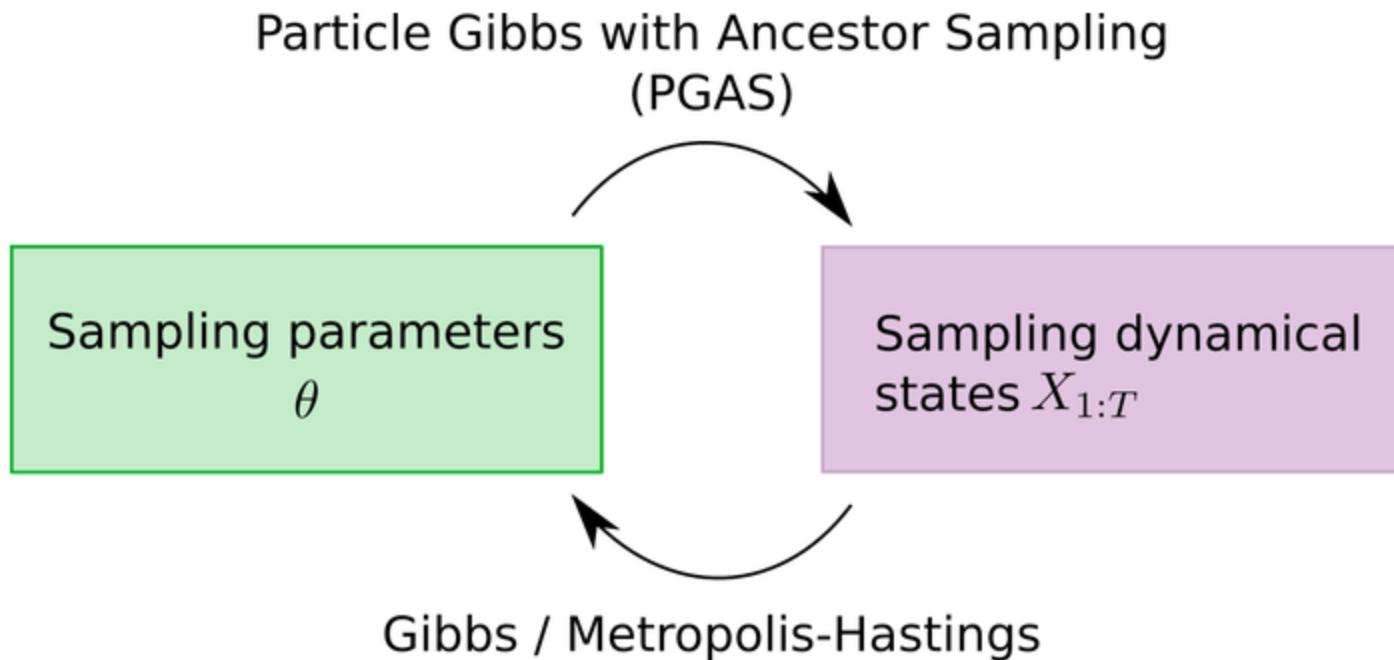


$$c_t = \gamma c_{t-1} + \omega c_{t-2} + As_t$$



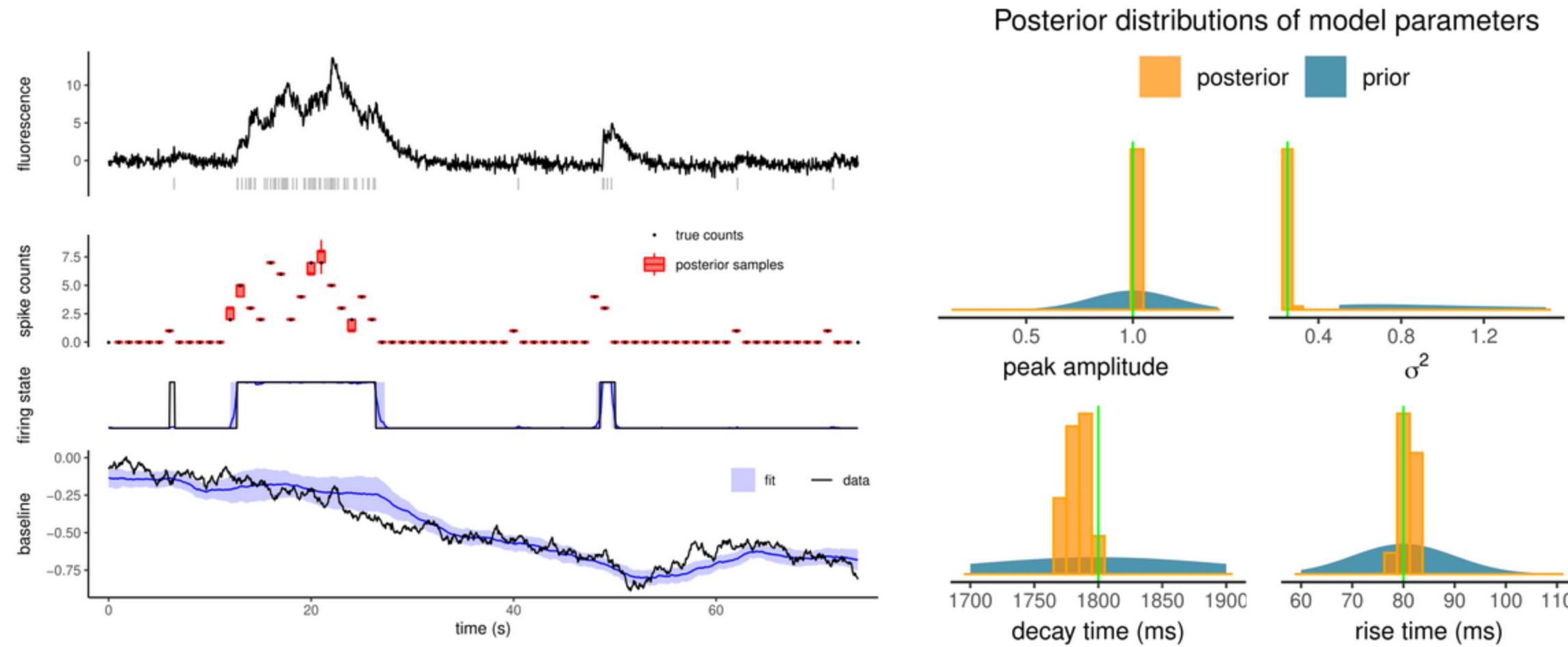
bursting state add spikes baseline fluorescence

Joint inference of dynamical states and model parameters



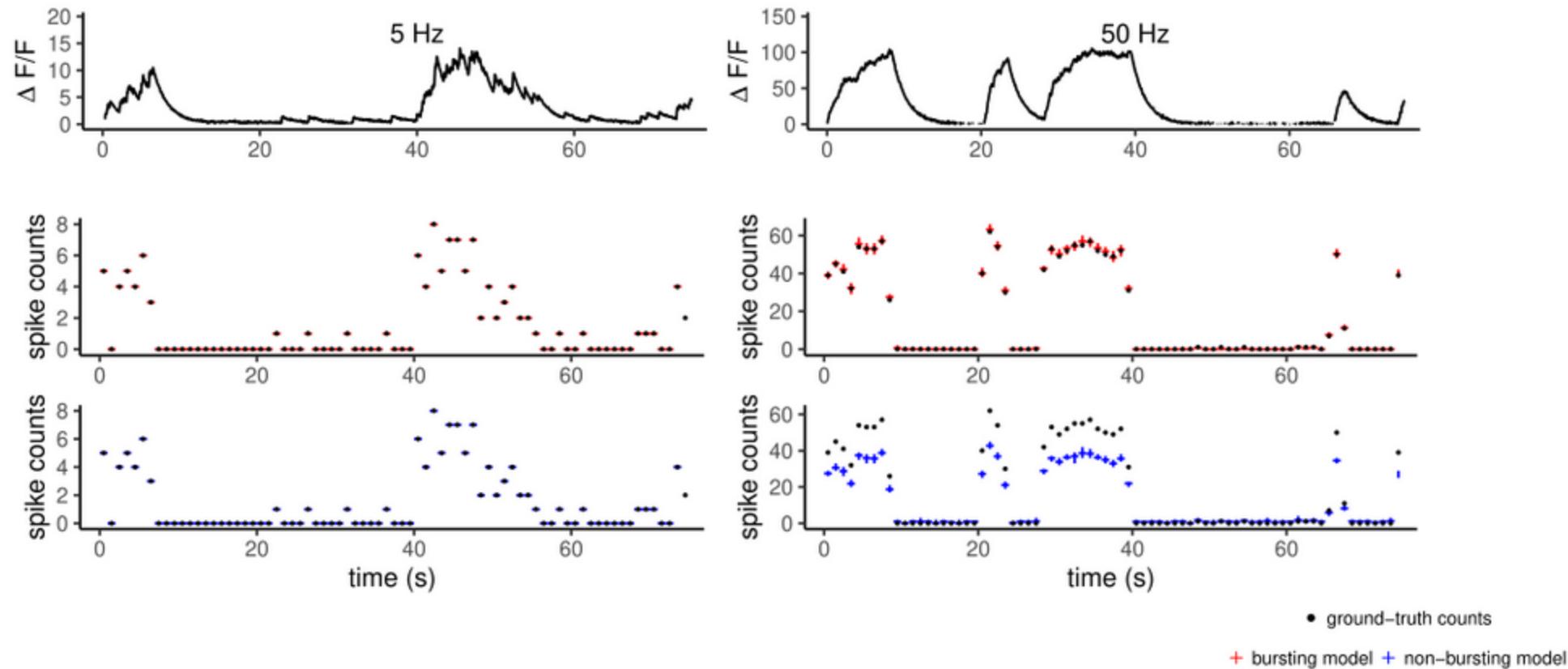
Lindsten et al, 2014

Validation on simulated data

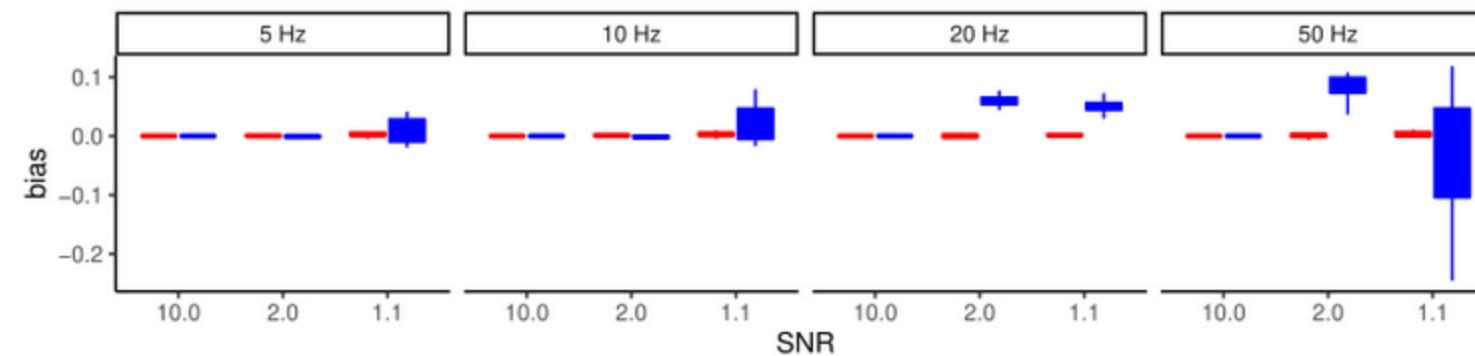


Diana et al. BiorXiv 2022

How important is to model bursting?

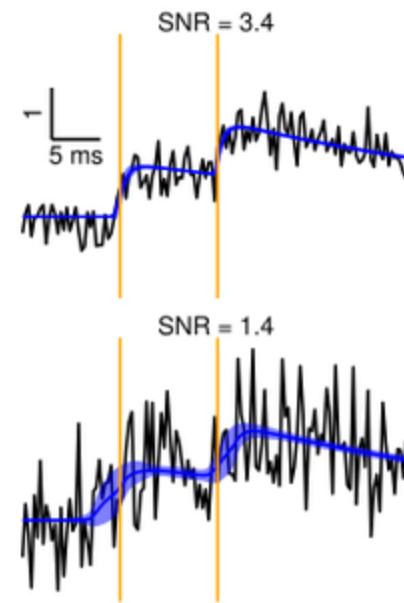


The bias is more pronounced
at low SNR and high firing rate

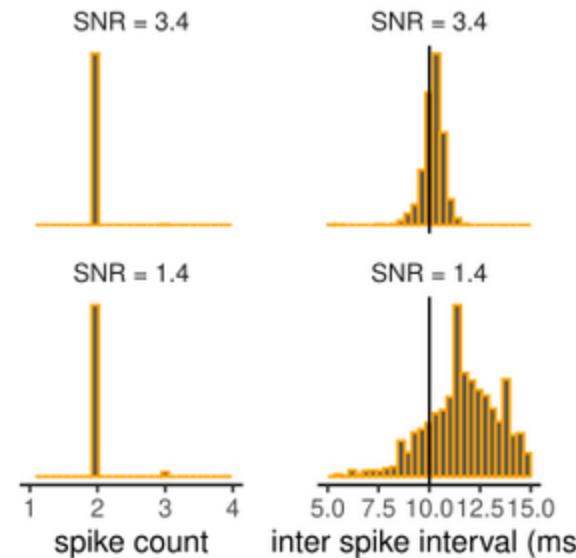


Effect of signal-to-noise ratio and inter-spike interval to posterior densities

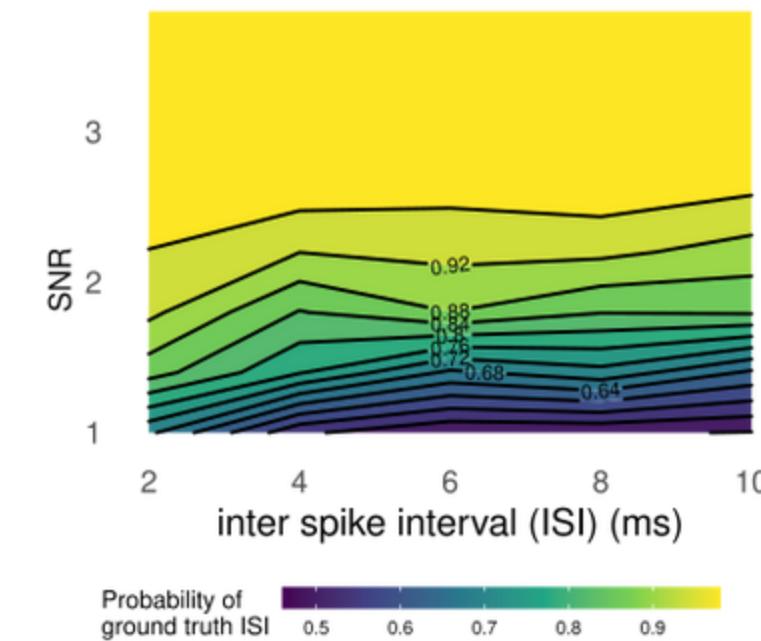
Simulations of double spikes separated by 10 milliseconds at different SNR



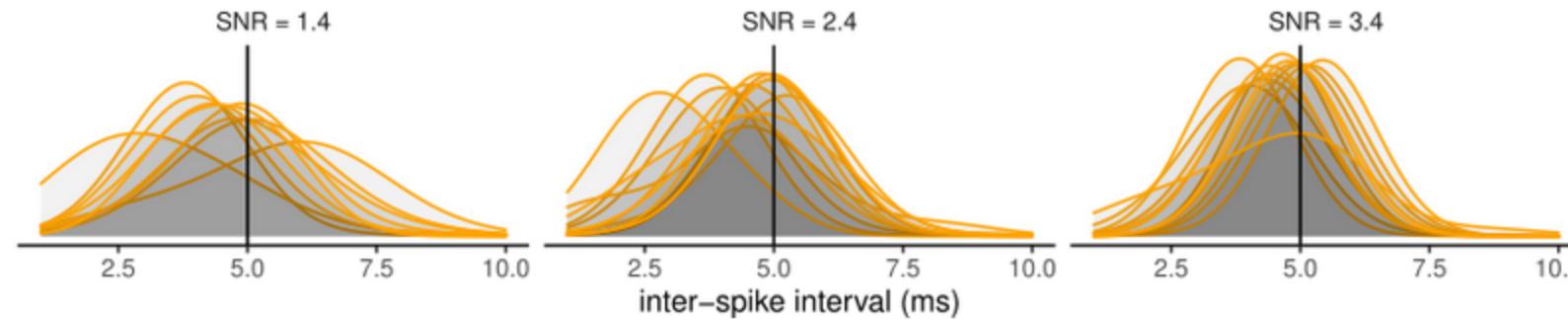
Posterior distributions of spike counts and inter-spike intervals



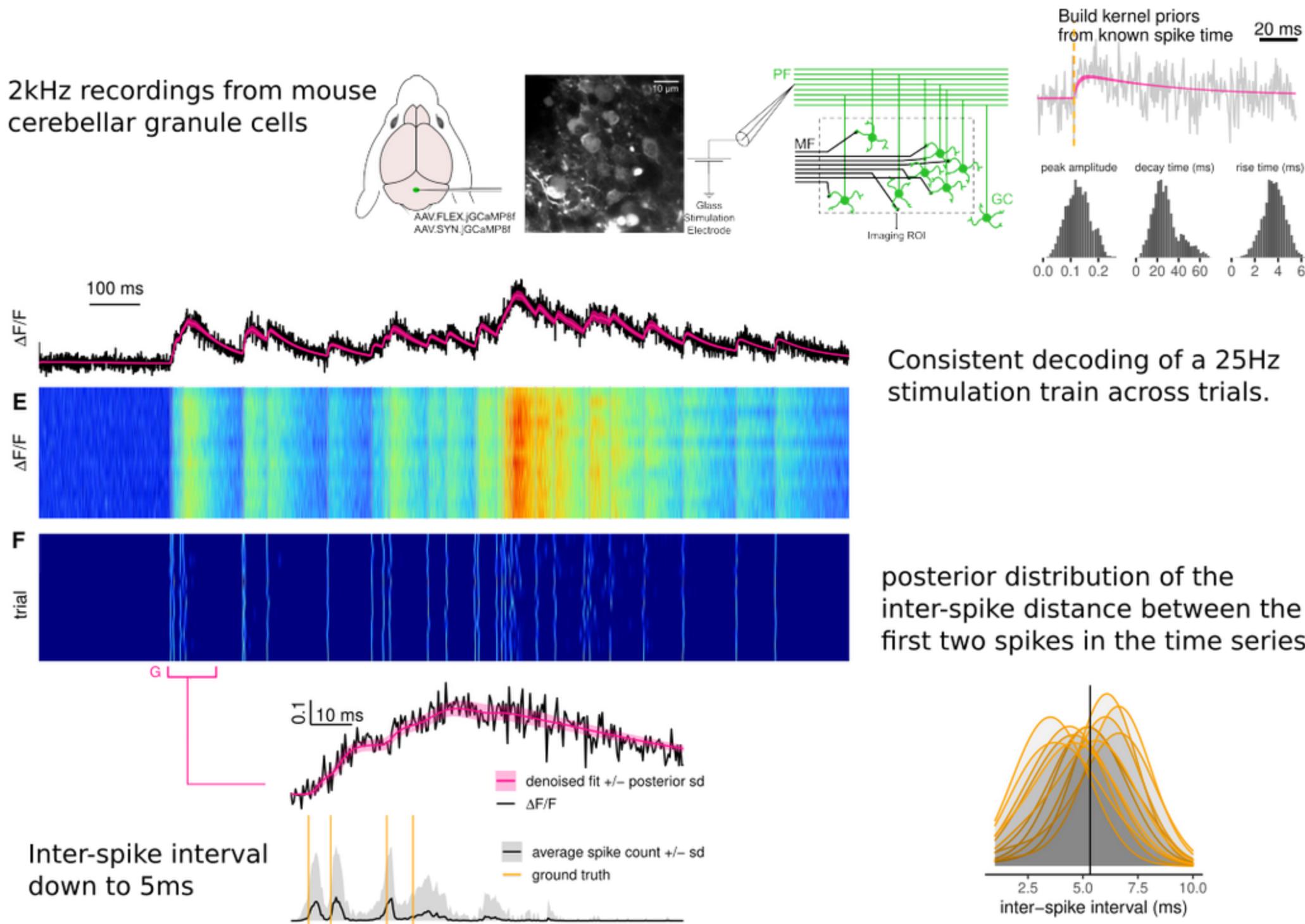
Probability of ground truth inter-spike interval



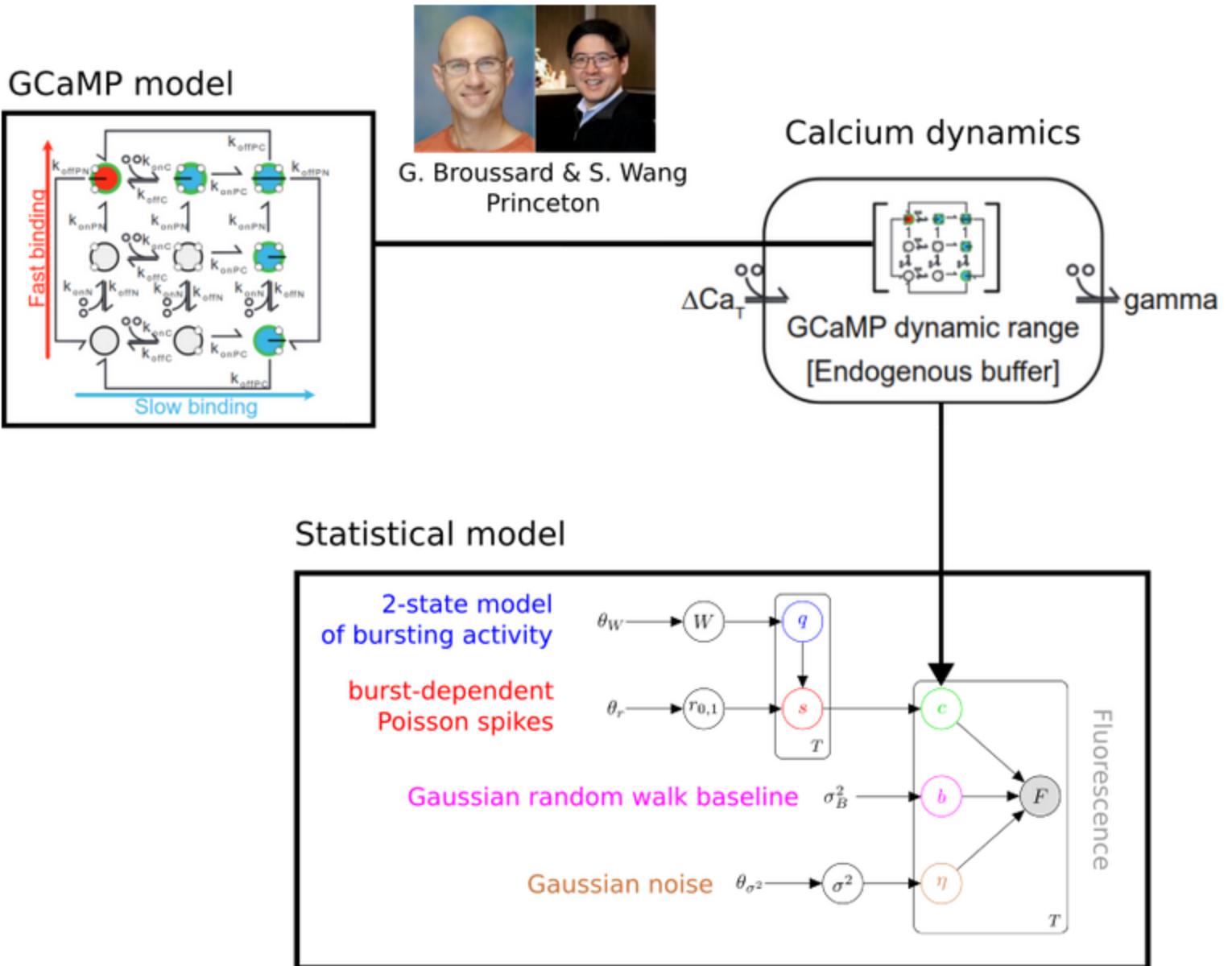
Posterior distributions of inter-spike intervals by trial and SNR at ISI=5ms



Analysis of high-frequency data shows accuracy down to 5ms

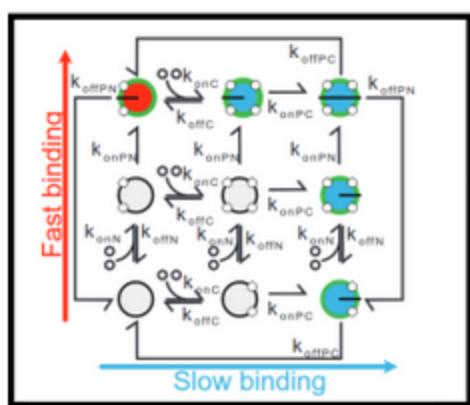


Account for biophysical properties of GCaMP8f



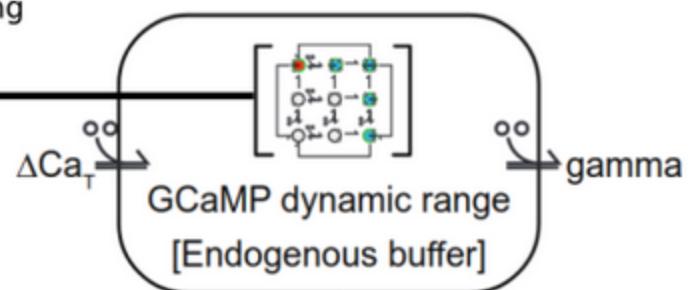
Account for biophysical properties of GCaMP8f

GCaMP model

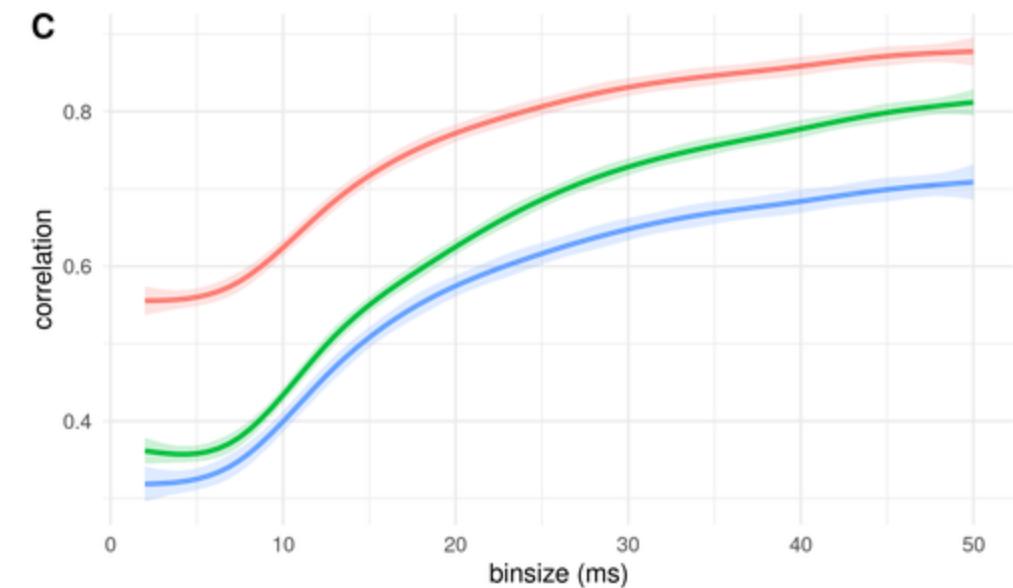
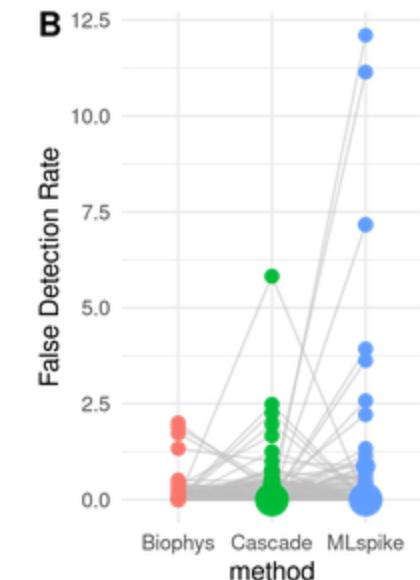
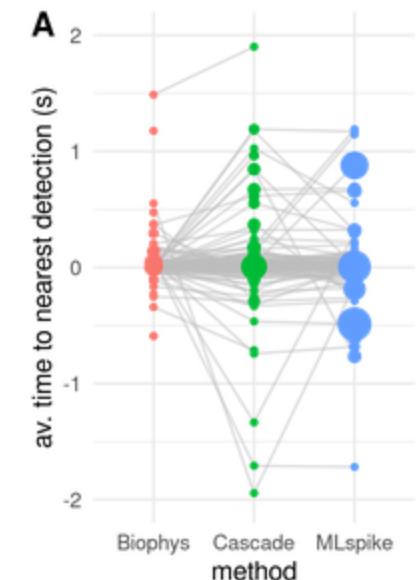
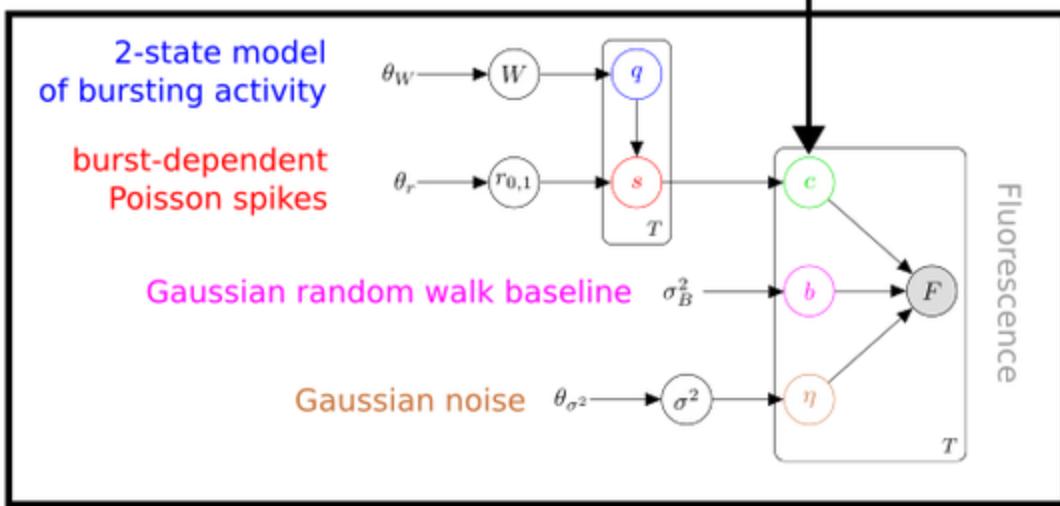


G. Broussard & S. Wang
Princeton

Calcium dynamics



Statistical model



acc

- 0
- 20
- 40
- 60
- 80

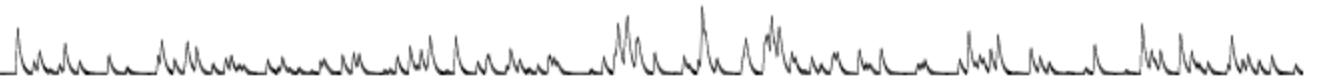
colour

- Biophys
- Cascade
- MLspike

method

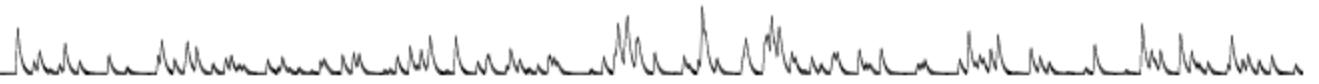
- Biophys
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Summary



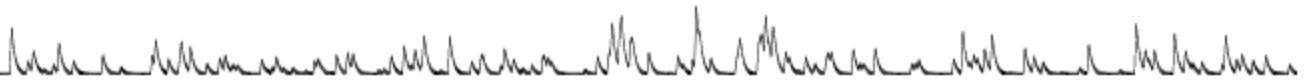
- Fluorescence imaging technologies allow us to monitor the activity of large neuronal populations

Summary



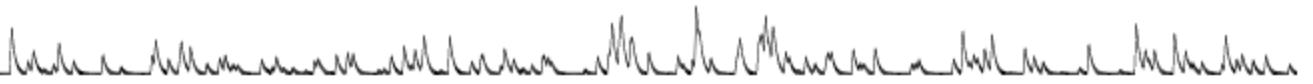
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- State-space models can be used to detect underlying neural signals

Summary



- Fluorescence imaging technologies allow us to monitor the activity of large neuronal populations
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Summary



- Fluorescence imaging technologies allow us to monitor the activity of large neuronal populations
- State-space models can be used to detect underlying neural signals
- Sequential Monte Carlo approaches
- Generalization to biophysical model of fast calcium indicators

Acknowledgments



Synapse and Circuit Dynamics Lab

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Gael Moneron
Alessandro Barri
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Samuel Wang
Gerrard J. Broussard

Decision and Bayesian Computation

Jean-Baptiste Masson

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THANK YOU!

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