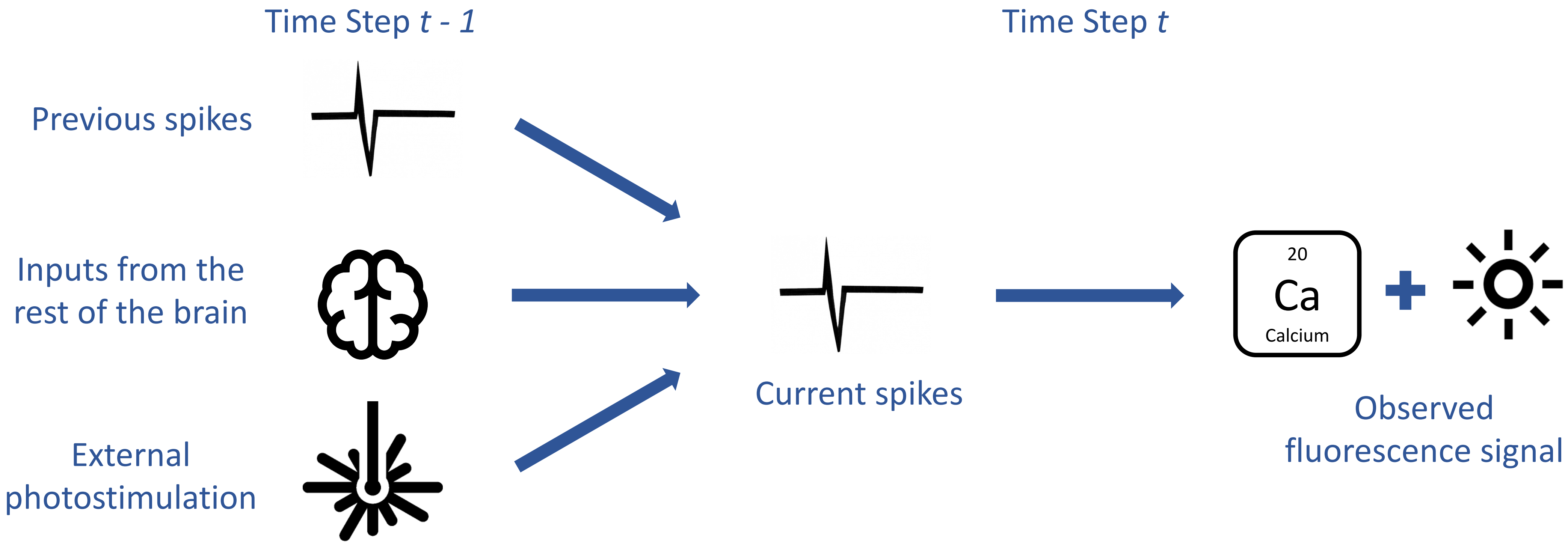
Broad Overview of Generative Model

Part 1: Generate spikes at time step *t*

Part 2: Generate calcium fluorescence signals from the spikes



Key Equations

Generative Model

$$P\big(f(t)\big) = \mathrm{N}(f(t); r(t), \Sigma^f)$$

Fluorescence signals at time *t*

Reconstruction with Gaussian noise

Learned, diagonal covariance matrix

Reconstruction

$$r(t) = W^{re} e(t) + A \sum_{t'=0}^{t} \underbrace{k(t-t')}_{\text{Convolution kernel (cell-specific)}} \odot s(t') + b^r$$

Optogenetic stimulation

Diagonal scaling matrix

Spikes

Additive offset

Convolution Kernel (unique to each cell)

$$k_c(t) = e^{-t/\tau_c^{decay}} - e^{-t/\tau_c^{rise}}$$

Spiking Depends on the Input

$$P(s(t)|u(t)) = Bernoulli\Big(s(t); \sigma\big(u(t)\big)\Big)$$

Recognition Model

Weighted matrices

Low-dimensional latents

$$u(t) = W^{se} e(t) + W^{ss} \sum_{t'=t-4}^{t-1} \underbrace{k^s(t-t')}_{\text{Normalized, exponentially decaying kernel}} s(t') + W^{sl} l(t) + b^s$$

External photostimulation

Learned offset

Dynamical System Generates Low-Dimensional Input Representing Activity in the Rest of the Brain

$$P(l(t)|l(t-1)) = N(l(t); W^{ll} l(t-1), \Sigma^l)$$