Challenges and opportunities in statistical neuroscience

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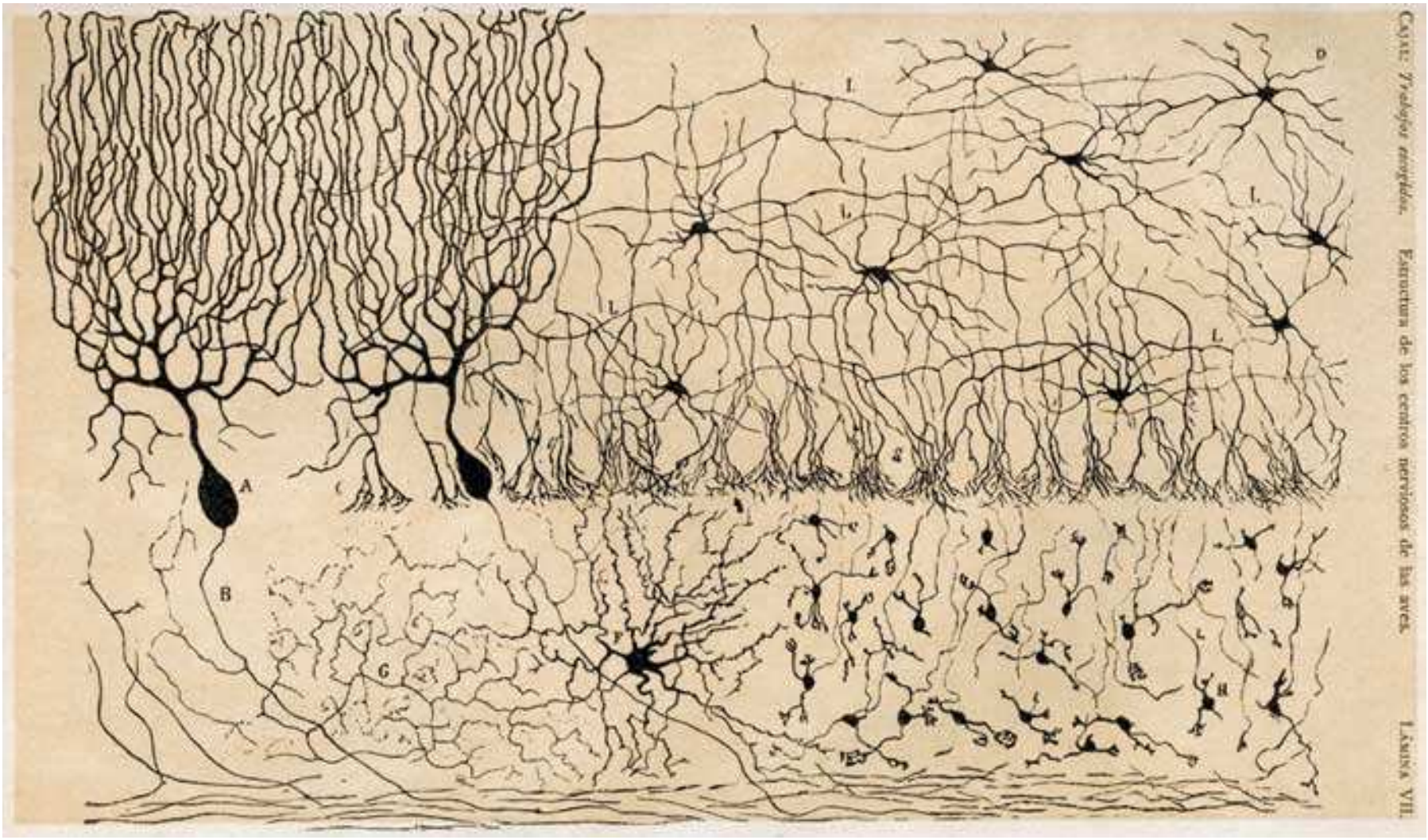
The coming statistical neuroscience decade

Remarkable recent developments in:

- machine learning / statistics methods for extracting information from high-dimensional data in a computationally-tractable, systematic fashion
- computing (Moore's law, massive parallel computing)
- novel neurophysiological methods for recording and stimulating many genetically-targeted neurons simultaneously

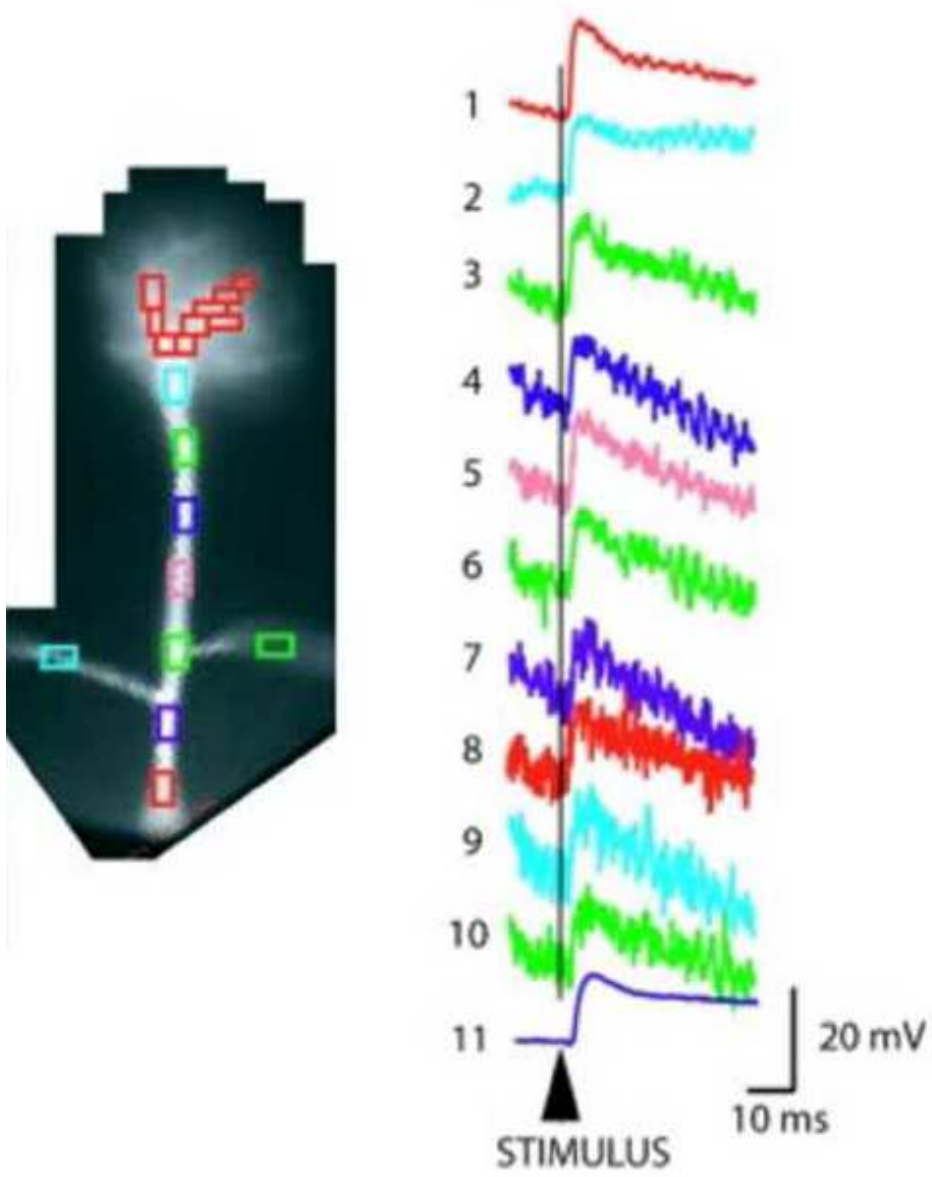
$\Longrightarrow$ exciting new opportunities for understanding the brain.

Understanding dendritic complexity



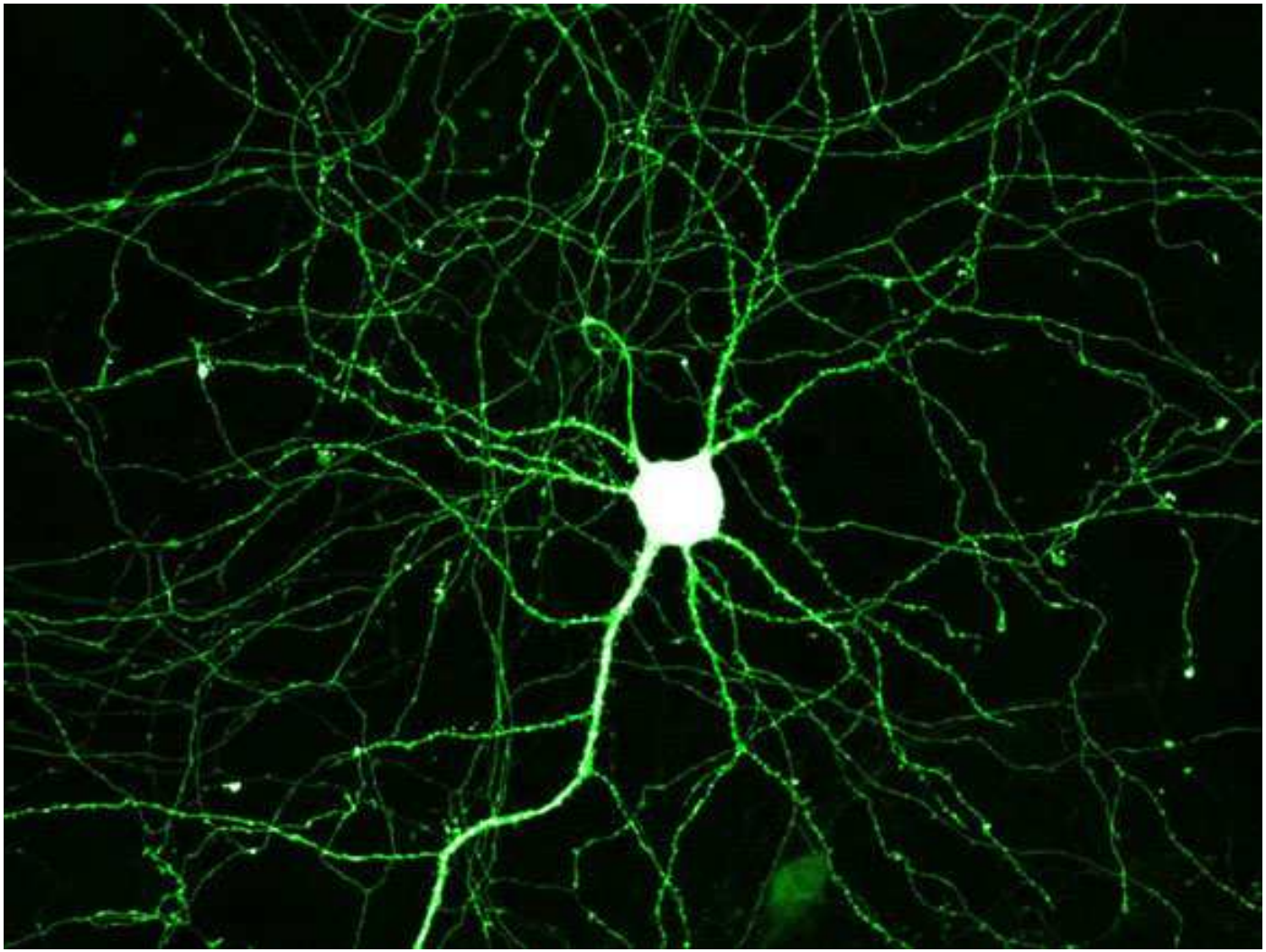
Ramon y Cajal, 1888.

Imaging dendritic electrical activity



Problem: observations are still noisy and undersampled; must filter signal appropriately.

Problem: scale

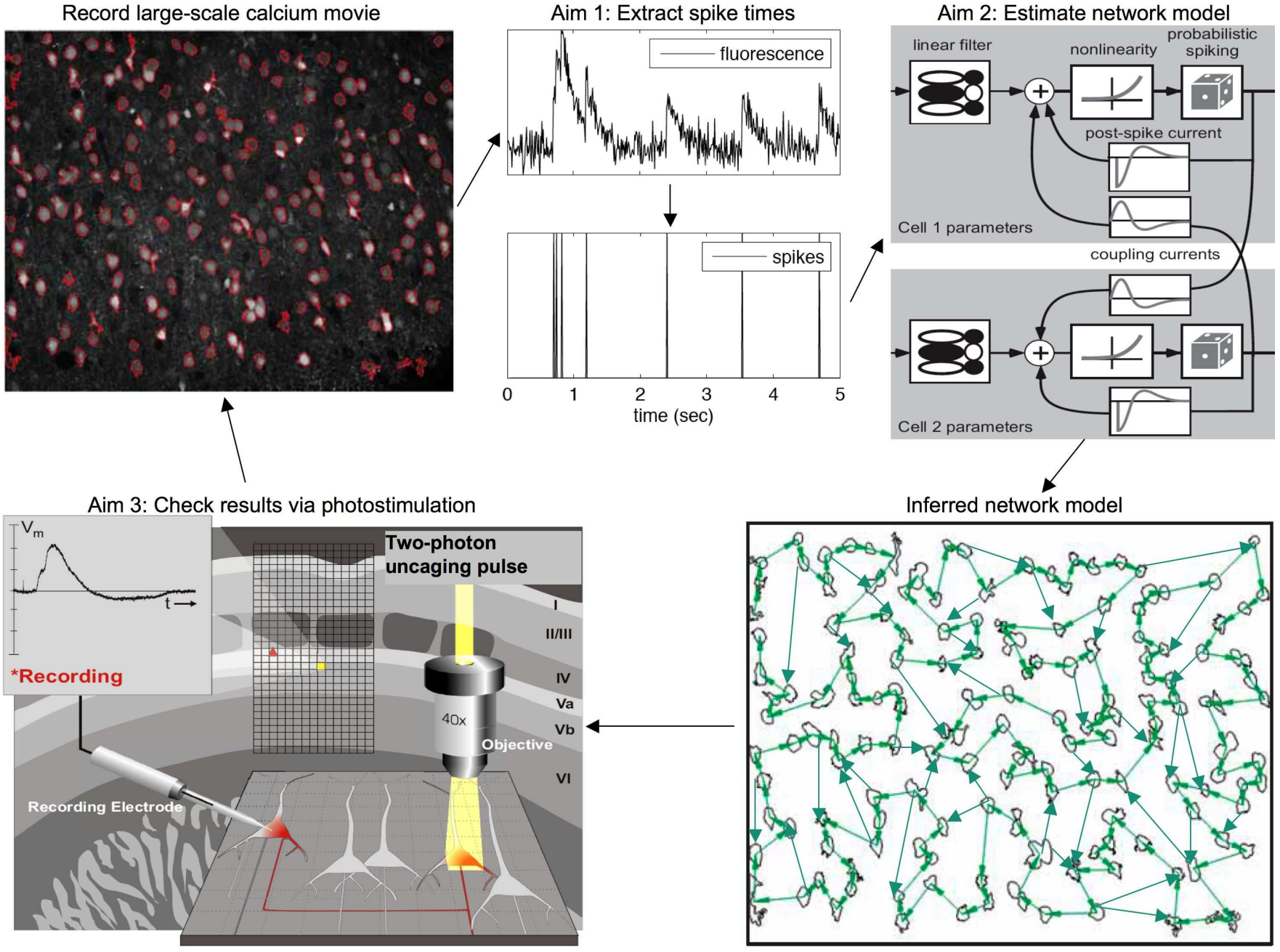


Optimal filtering in a complex dynamical system with $\sim 10^4$ dimensions?
(Standard methods require $\sim (10^4)^3$ operations per time step...)

Fast, scalable optimal filtering

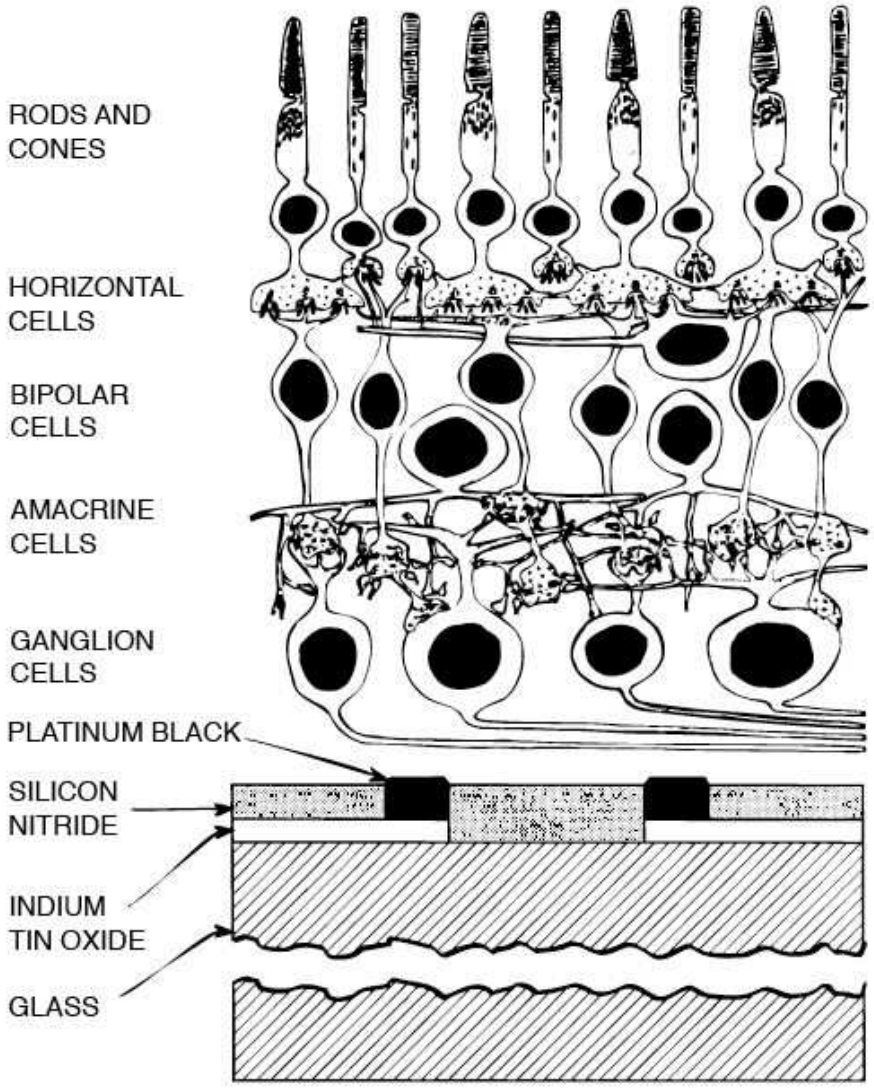
(Loading low-rank-speckle.mp4)

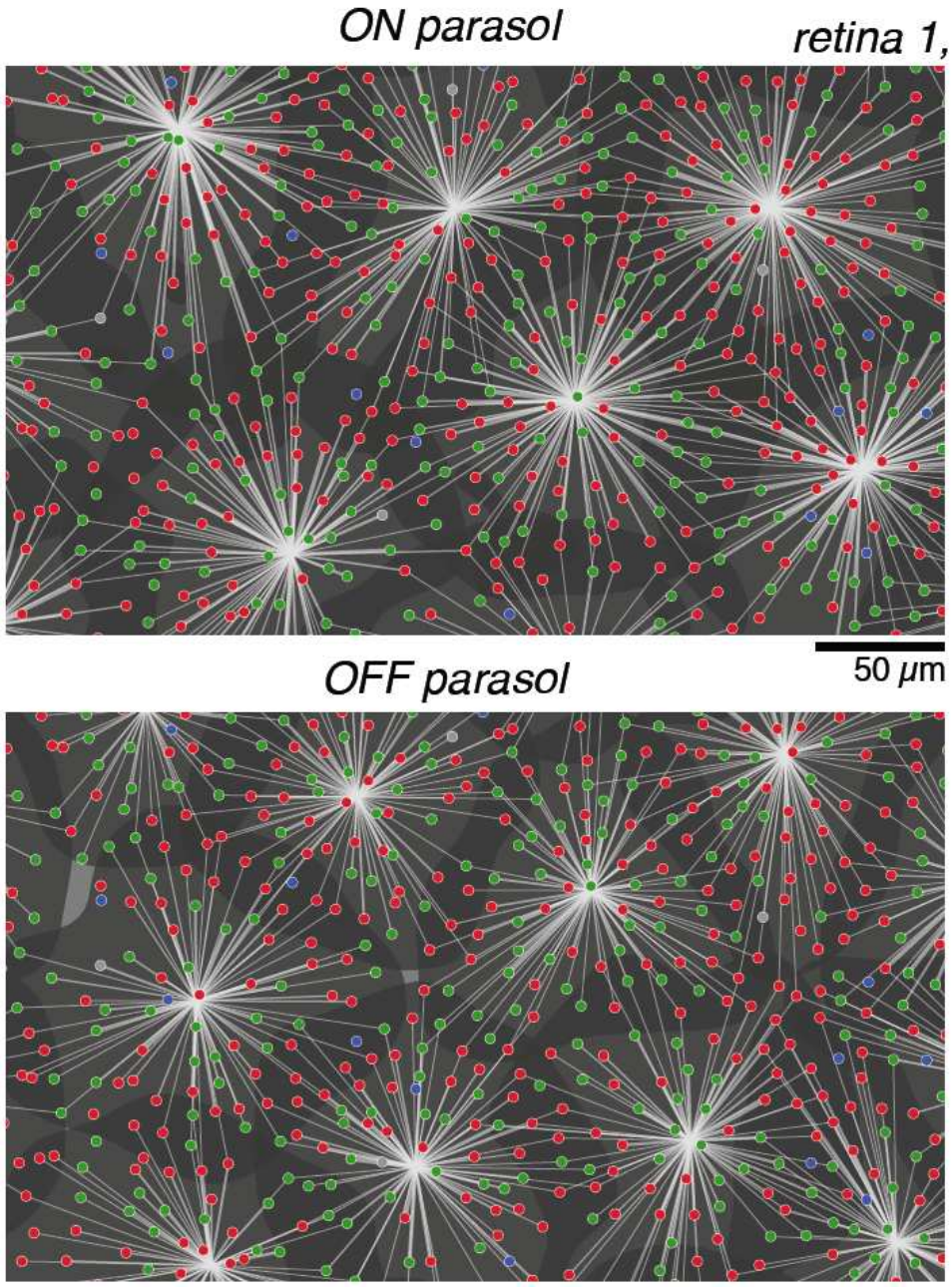
Closed-loop neural circuit inference



w/ R. Yuste, CU Bio

Retinal connectivity: the neural representation of color





≈ 1 TB of data per experiment (Field et al, Nature '10).

example calcium movie:

`http://gaya.jp/data/CA3_movie.gif`