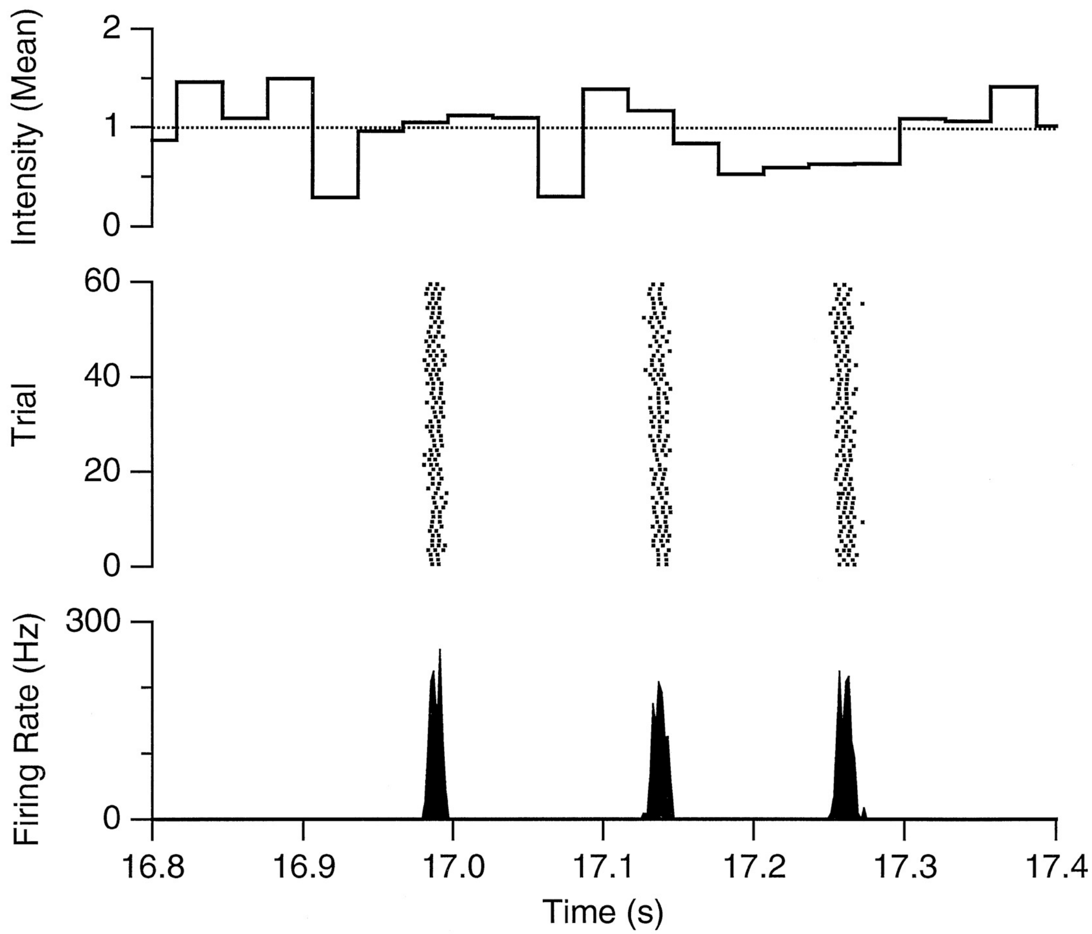
TEMPORAL PRECISION OF SENSORY RESPONSES

Berry and Meister, 1998

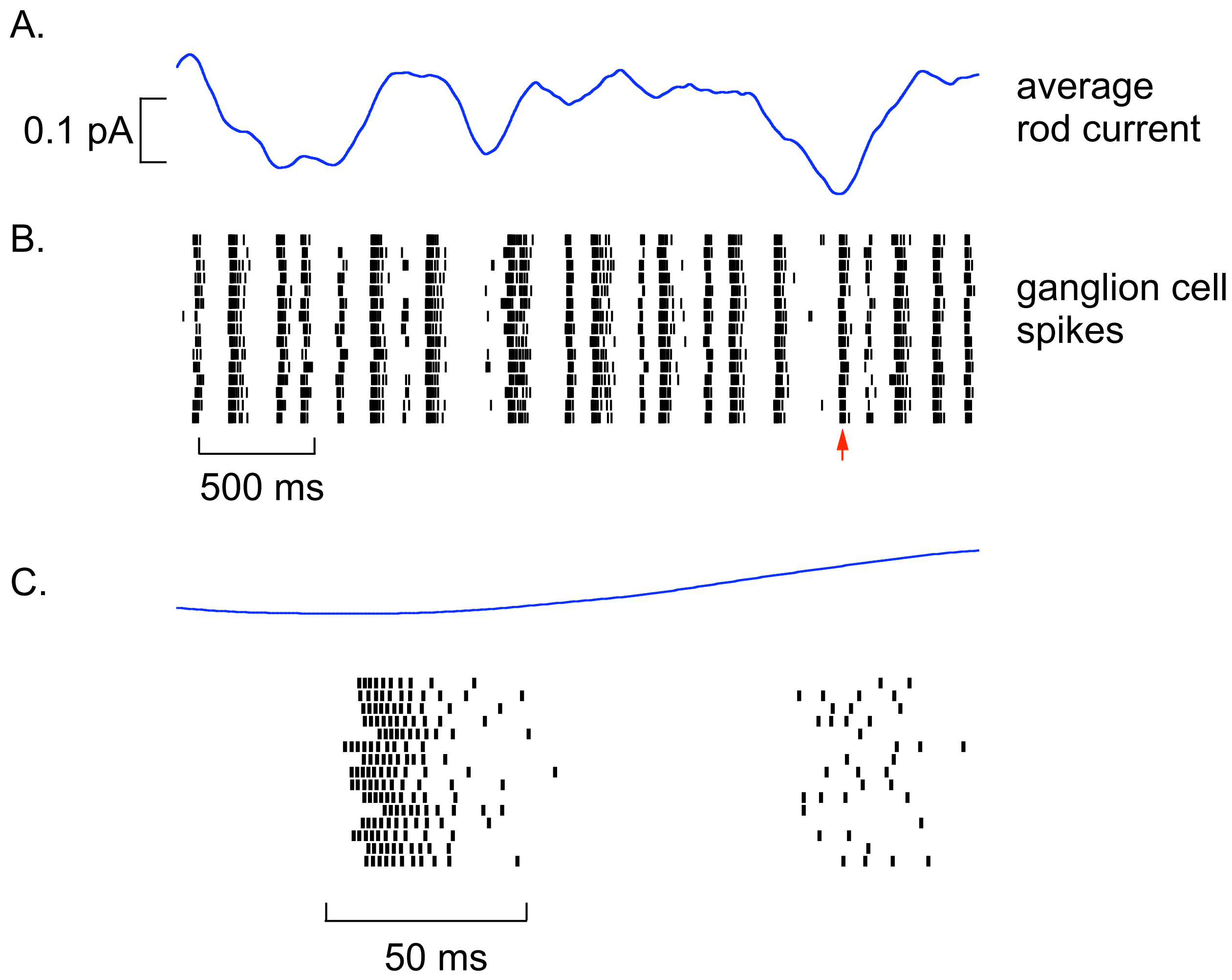


Today:

(1) how can we measure temporal precision?

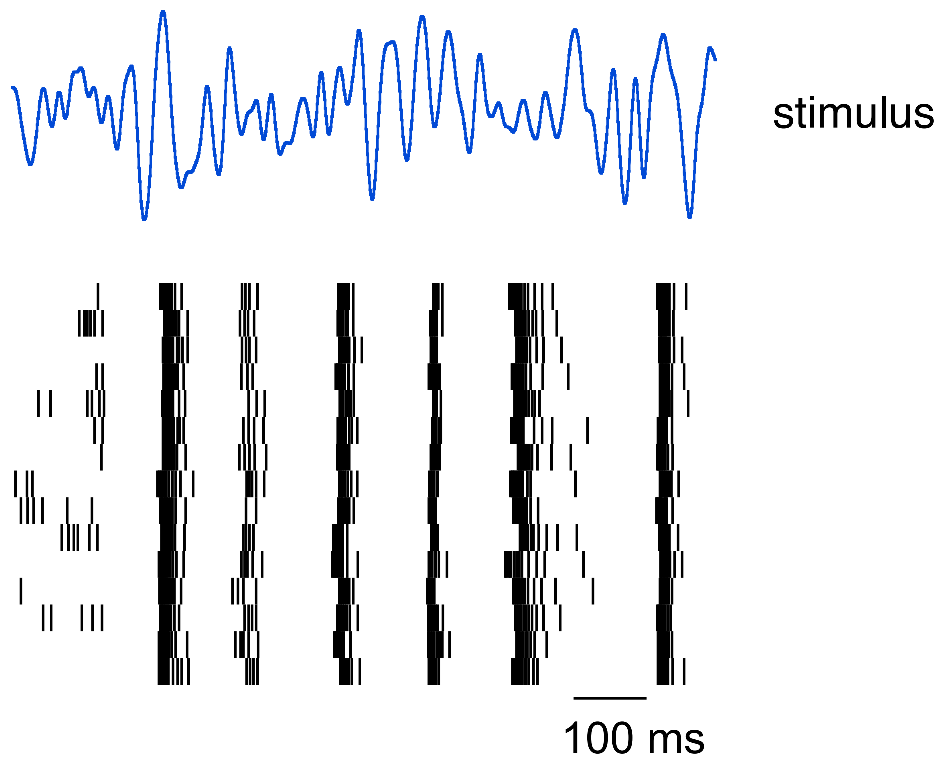
(2) what mechanisms enable/limit precision?

WHY SHOULD YOU CARE?



1. Important characteristic of the neural code
2. Precision can dramatically exceed apparent limits set by sensory inputs

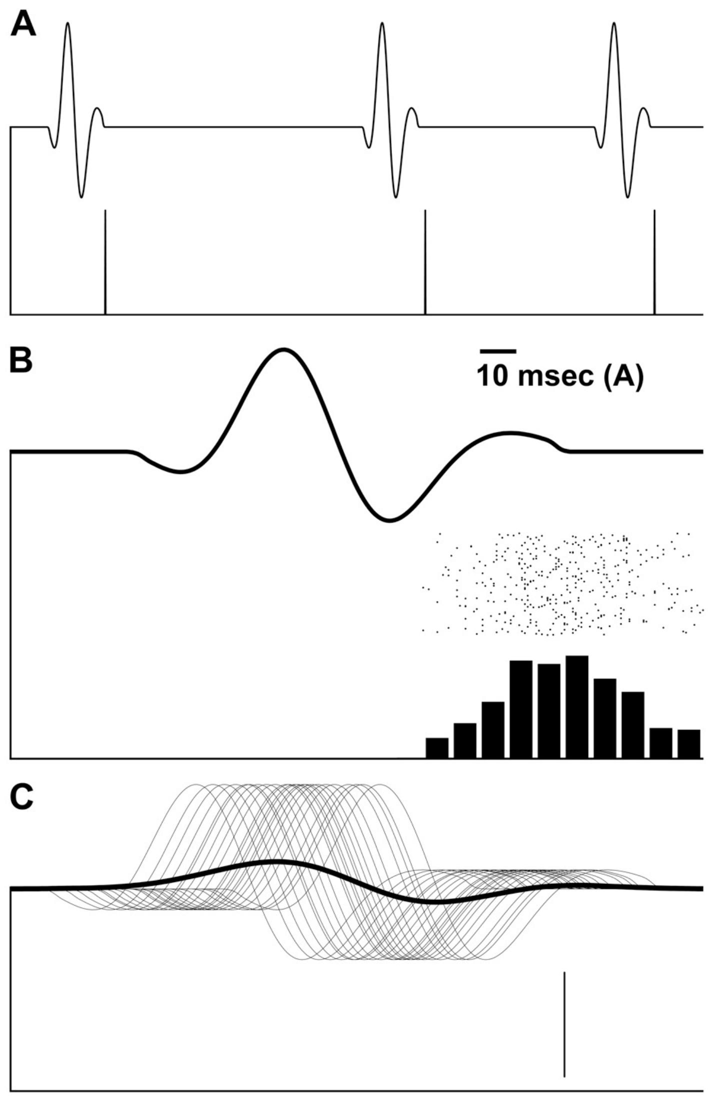
WHAT'S THE PROBLEM?



difference between two responses includes dropped spikes, spontaneous spikes and temporally jittered spikes - which spikes should be compared?

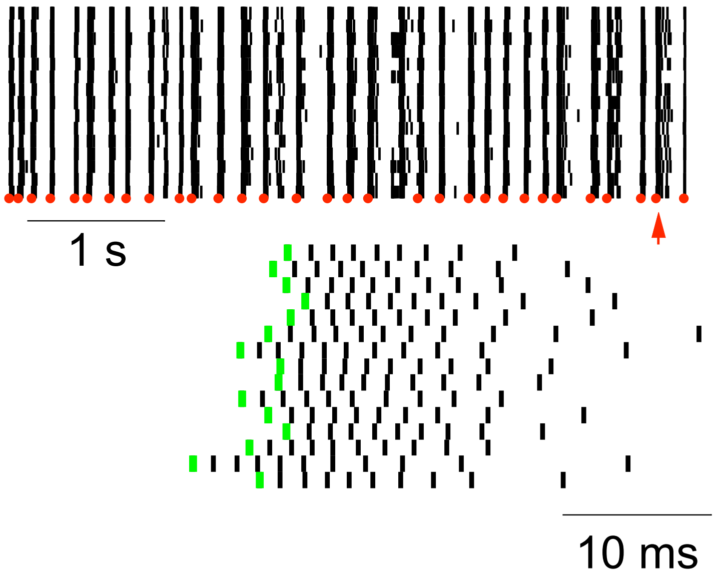
SPIKE-TRIGGERED AVERAGE AND SPIKE JITTER

Aldworth et al., 2005



jitter spikes until relation between stimulus and spikes degraded

TEMPORAL PRECISION OF SELECTED BURSTS



identify bursts that:

1. are preceded by period of silence
2. have spikes in large fraction of trials

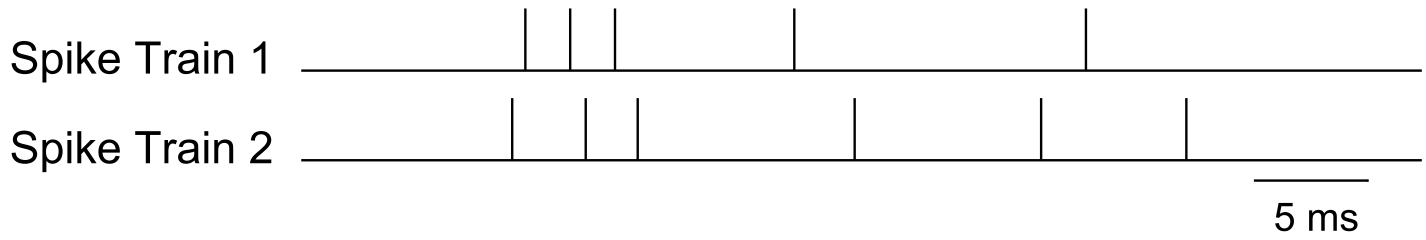
measure variance of first spike time in bursts

problem:

only quantify precision of small fraction of spikes

USING VICTOR DISTANCE METRIC TO QUANTIFY PRECISION OF ALL SPIKES

Victor and Purpura, 1997

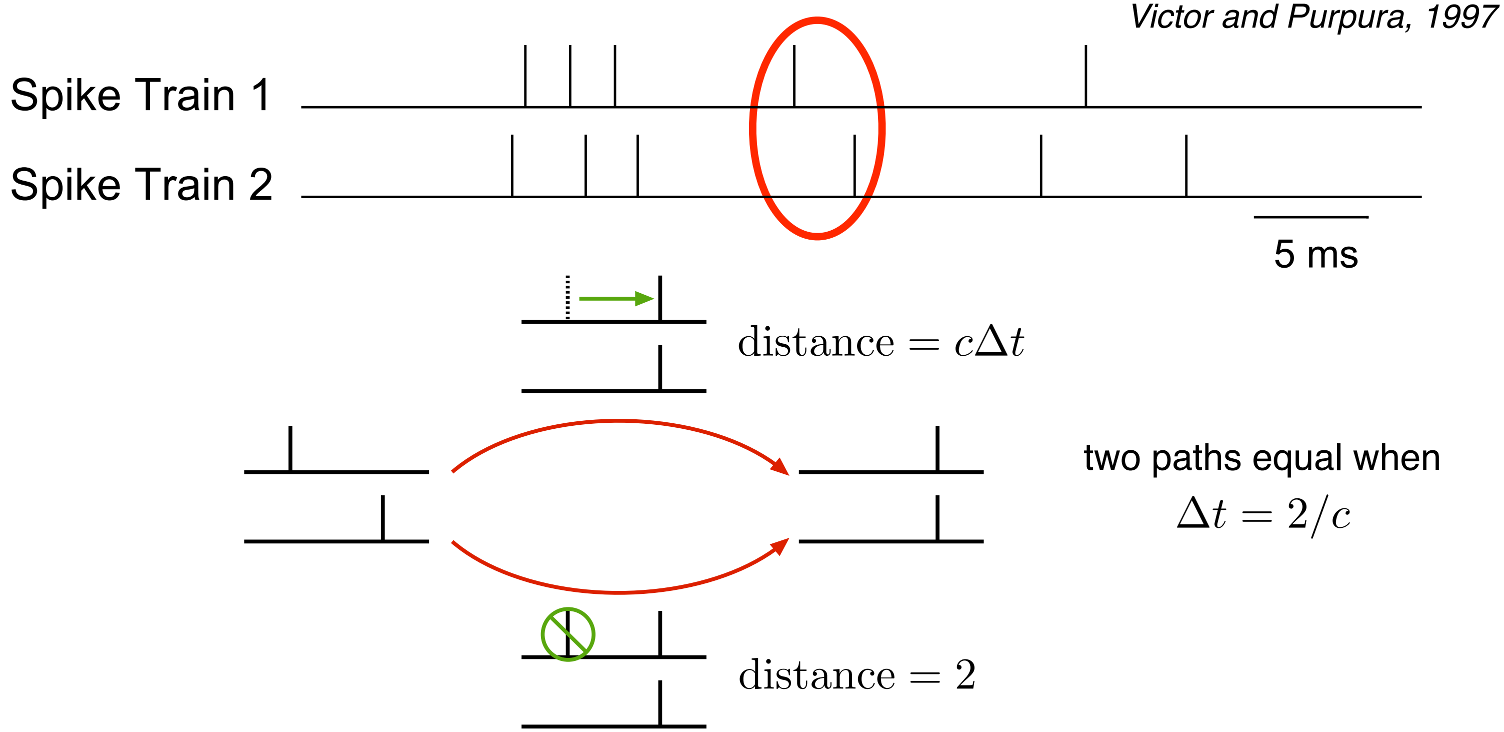


- Map spike train 1 onto spike train 2 by (1) deleting spikes, (2) adding spikes, and (3) sliding spikes

- Distance associated with each operation

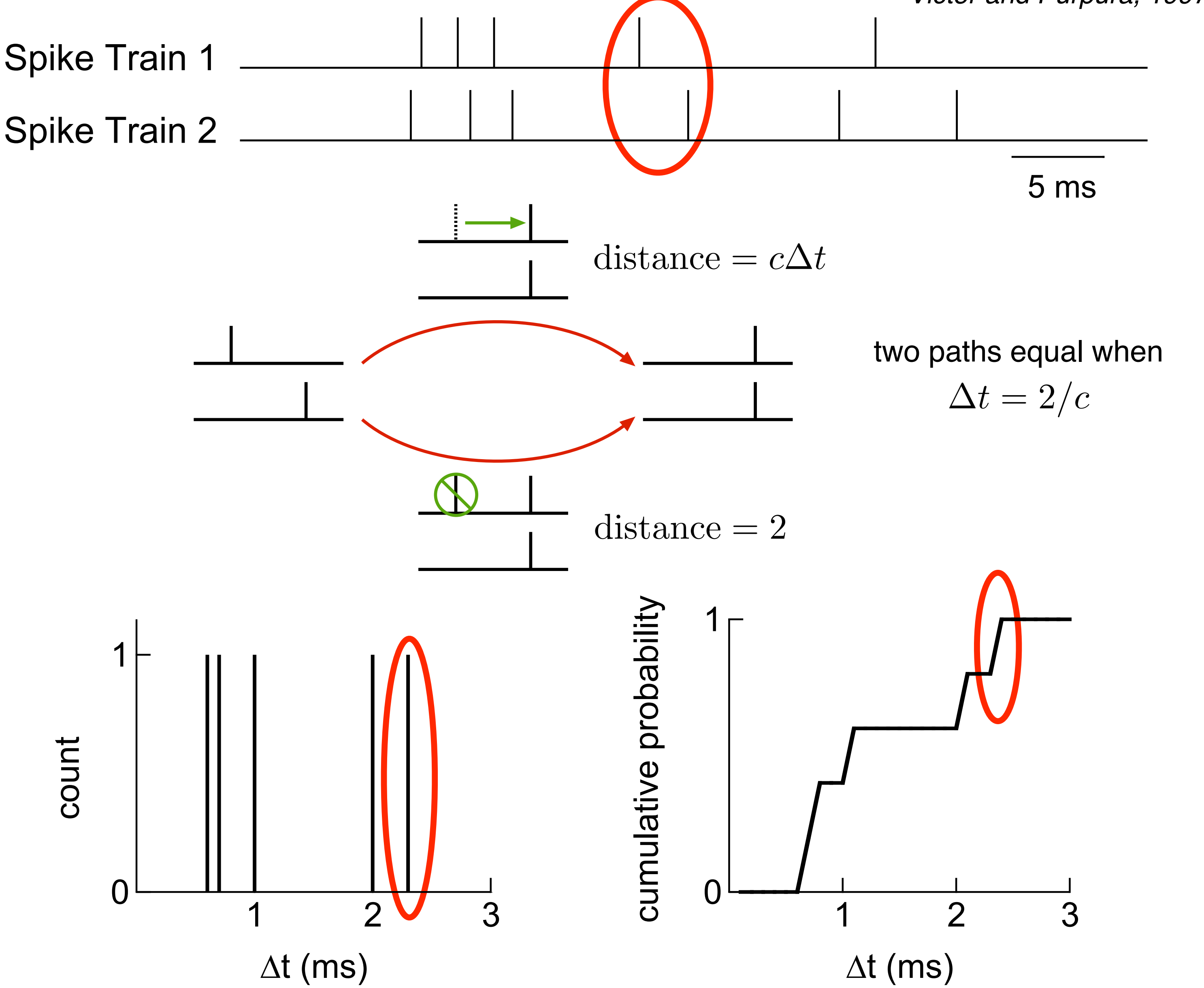
USING VICTOR DISTANCE METRIC TO QUANTIFY PRECISION OF ALL SPIKES

Victor and Purpura, 1997

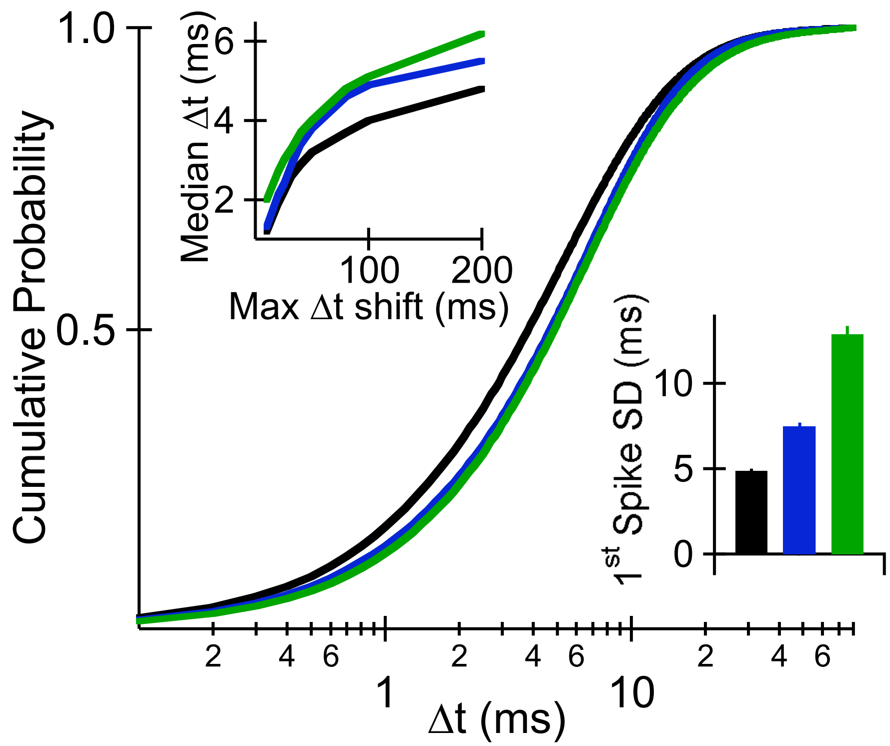


USING VICTOR DISTANCE METRIC TO QUANTIFY PRECISION OF (NEARLY) ALL SPIKES

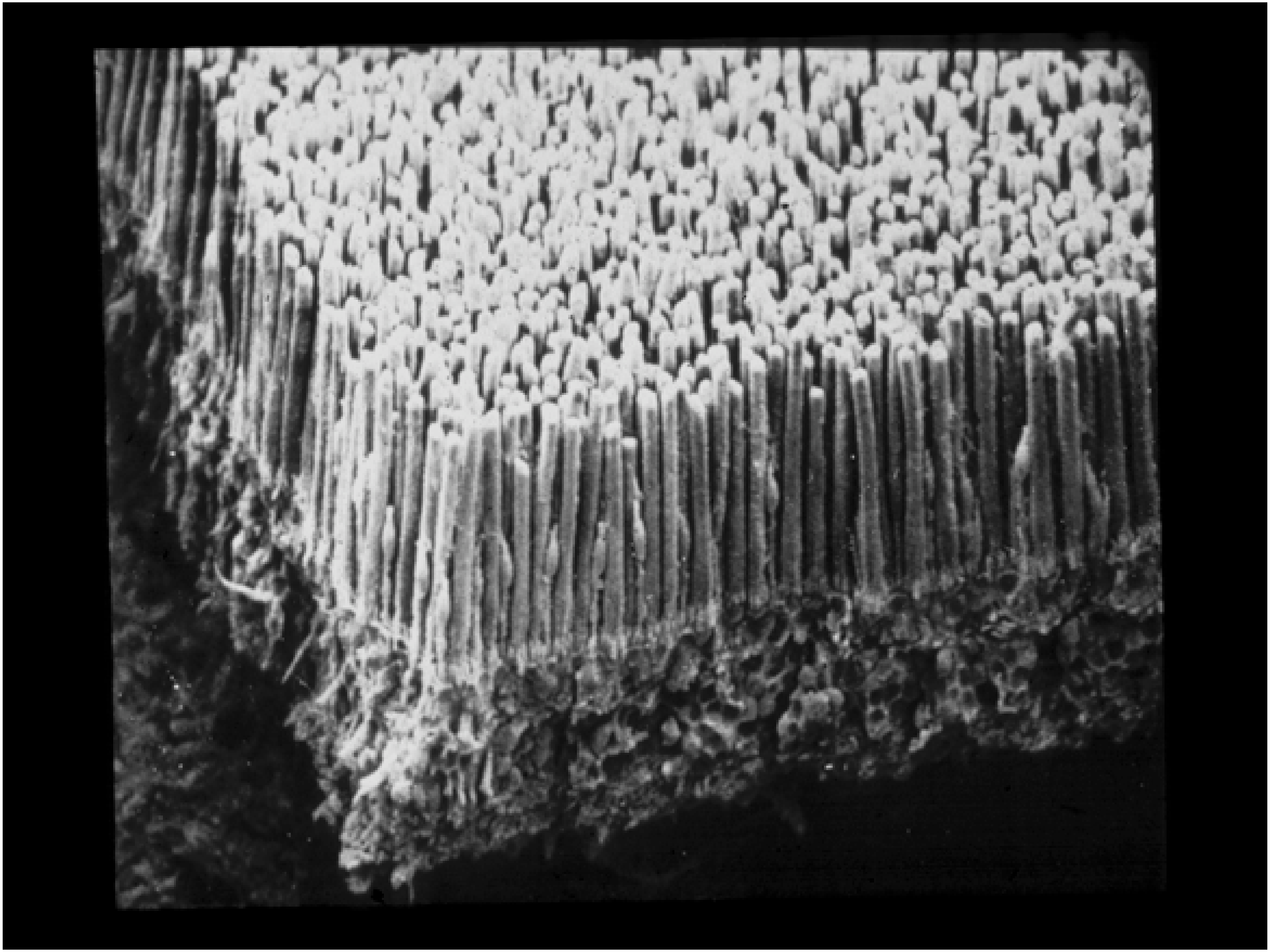
Victor and Purpura, 1997



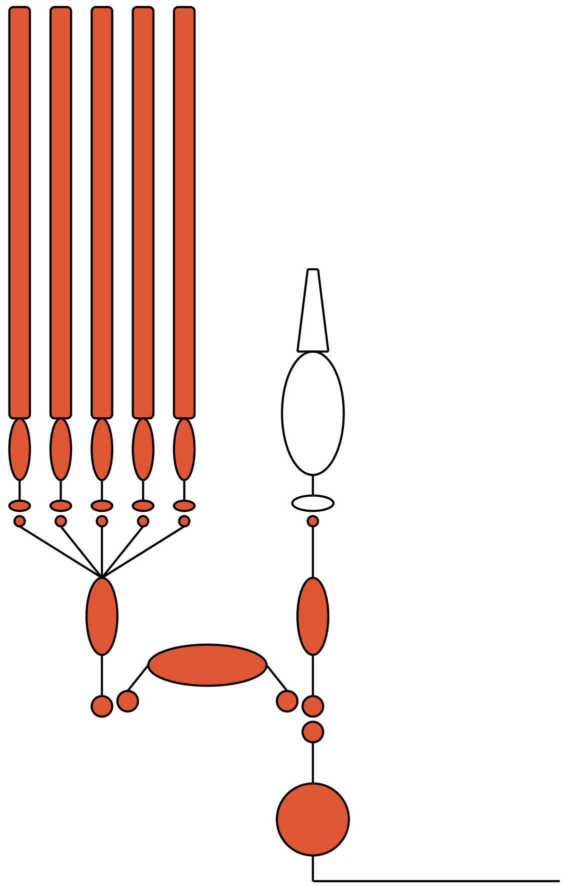
COMPARISON OF FIRST SPIKE TIMES AND VICTOR DISTANCE METRIC



Victor distance metric quantifies precision of majority of spikes in model-independent fashion



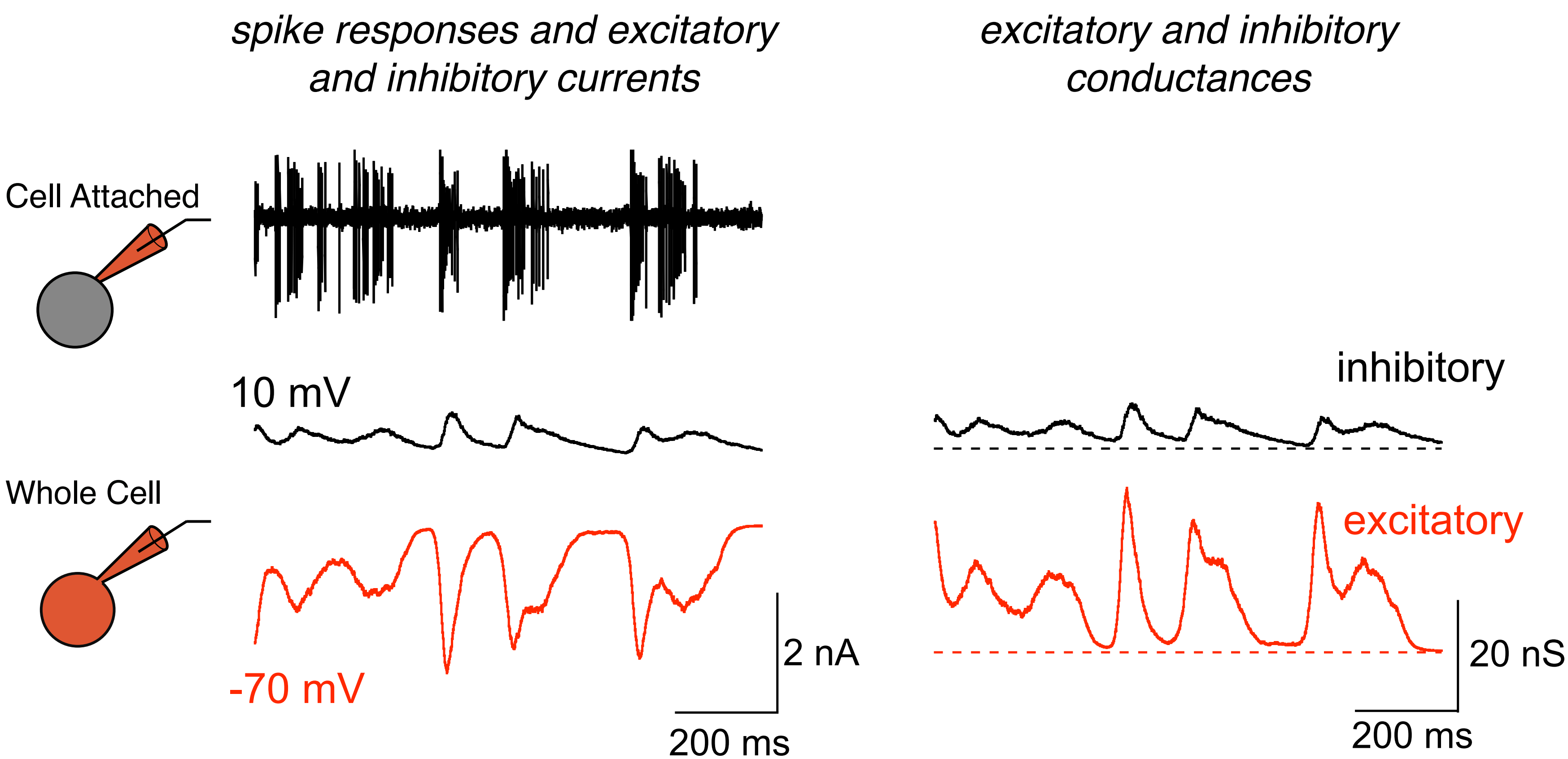
SUMMARY (TAKE 1)



• Signals traversing rod bipolar pathway evoke temporally precise responses in mouse ganglion cells

• Temporal precision limited by noise in synaptic inputs rather than noise intrinsic to ganglion cell (i.e. in dendritic processing or spike generation)

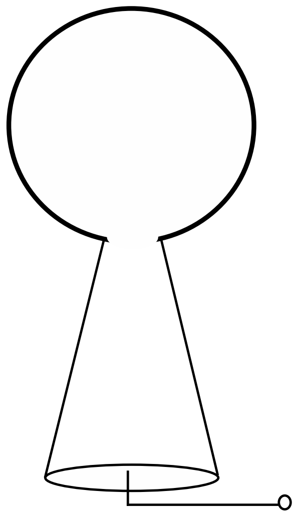
HOW ARE EXCITATORY AND INHIBITORY CONDUCTANCES COMBINED TO CONTROL SPIKING?

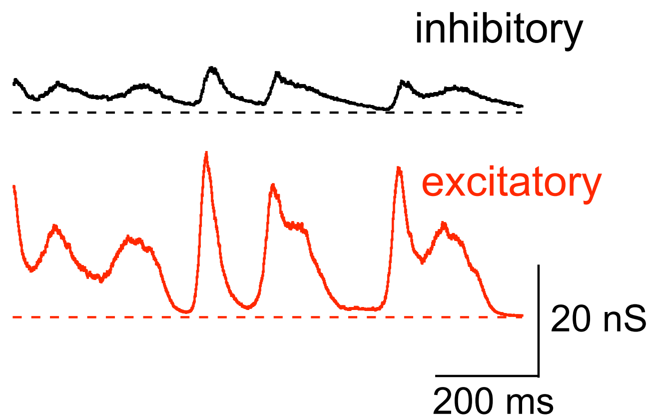


Gabe Murphy

DYNAMIC (CONDUCTANCE) CLAMP

mimicking a real conductance with injected current fails to account for voltage dependence - dynamic clamp is an alternative

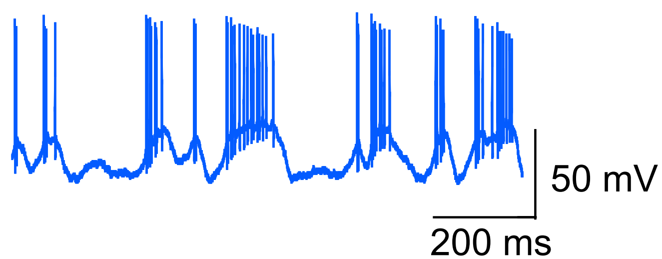




(1) measure voltage
(2) compute current

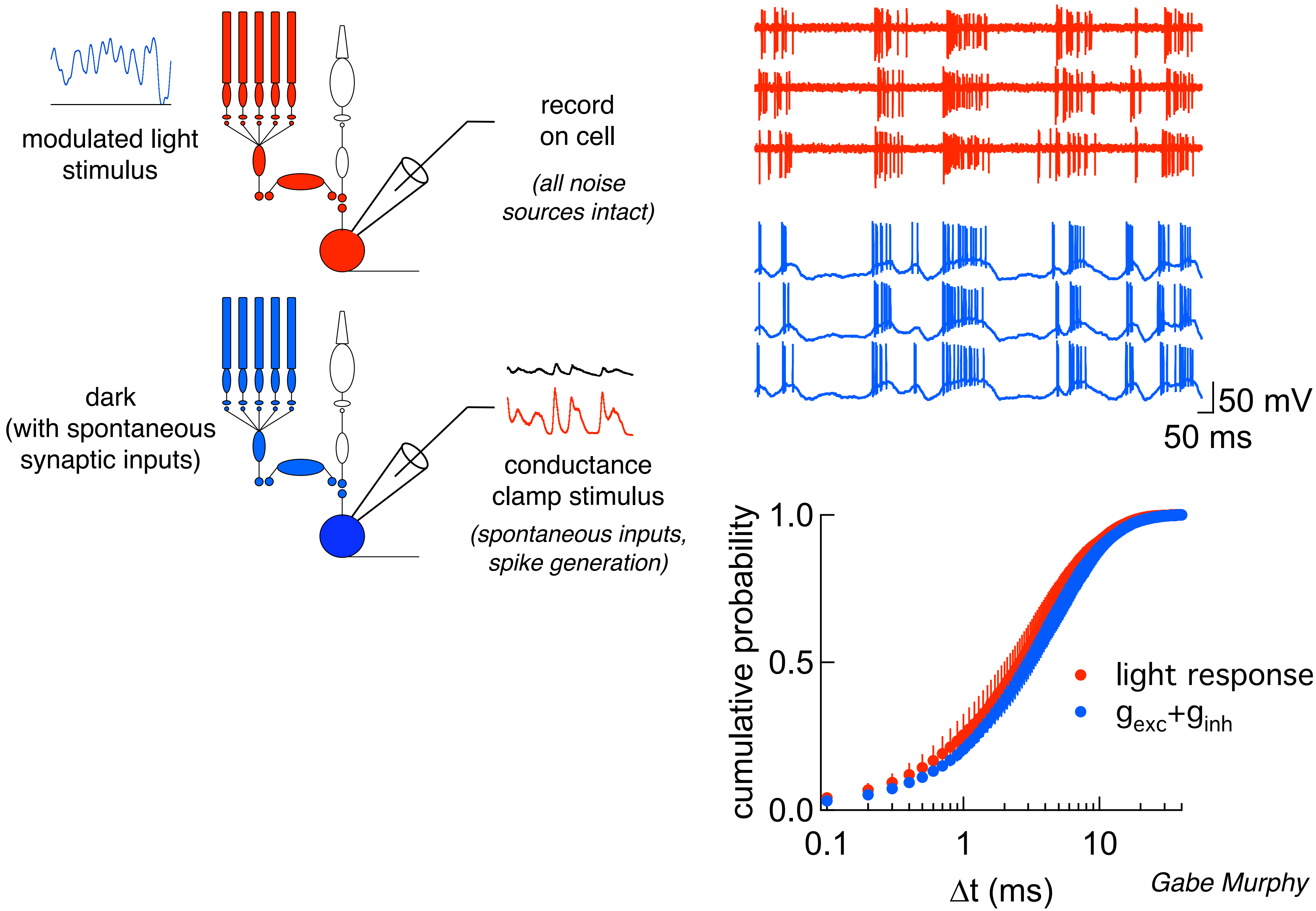
$$I = g_{\mathrm{exc}}(V - V_{\mathrm{exc}}) + g_{\mathrm{inh}}(V - V_{\mathrm{inh}})$$

(3) inject current

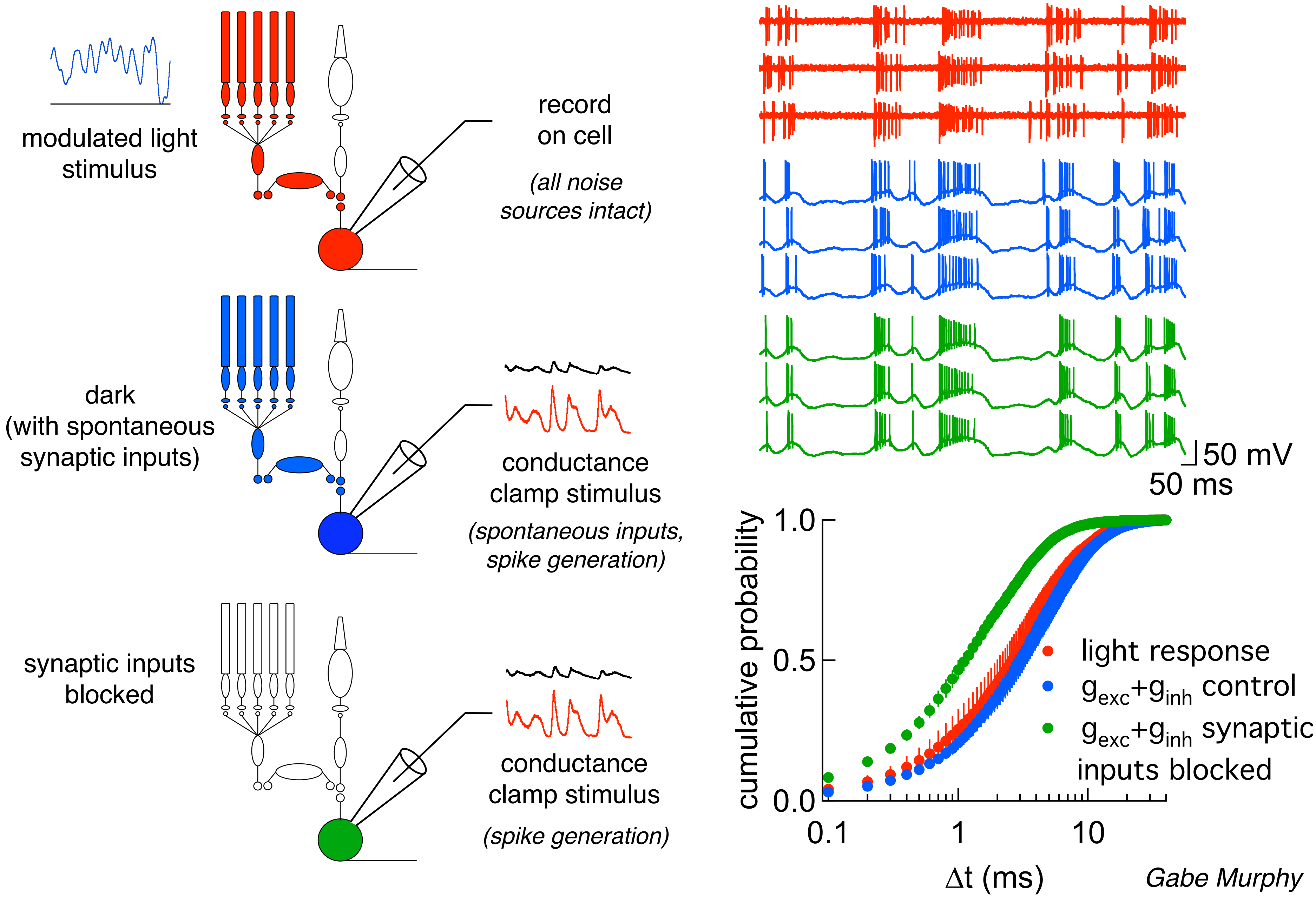


Gabe Murphy

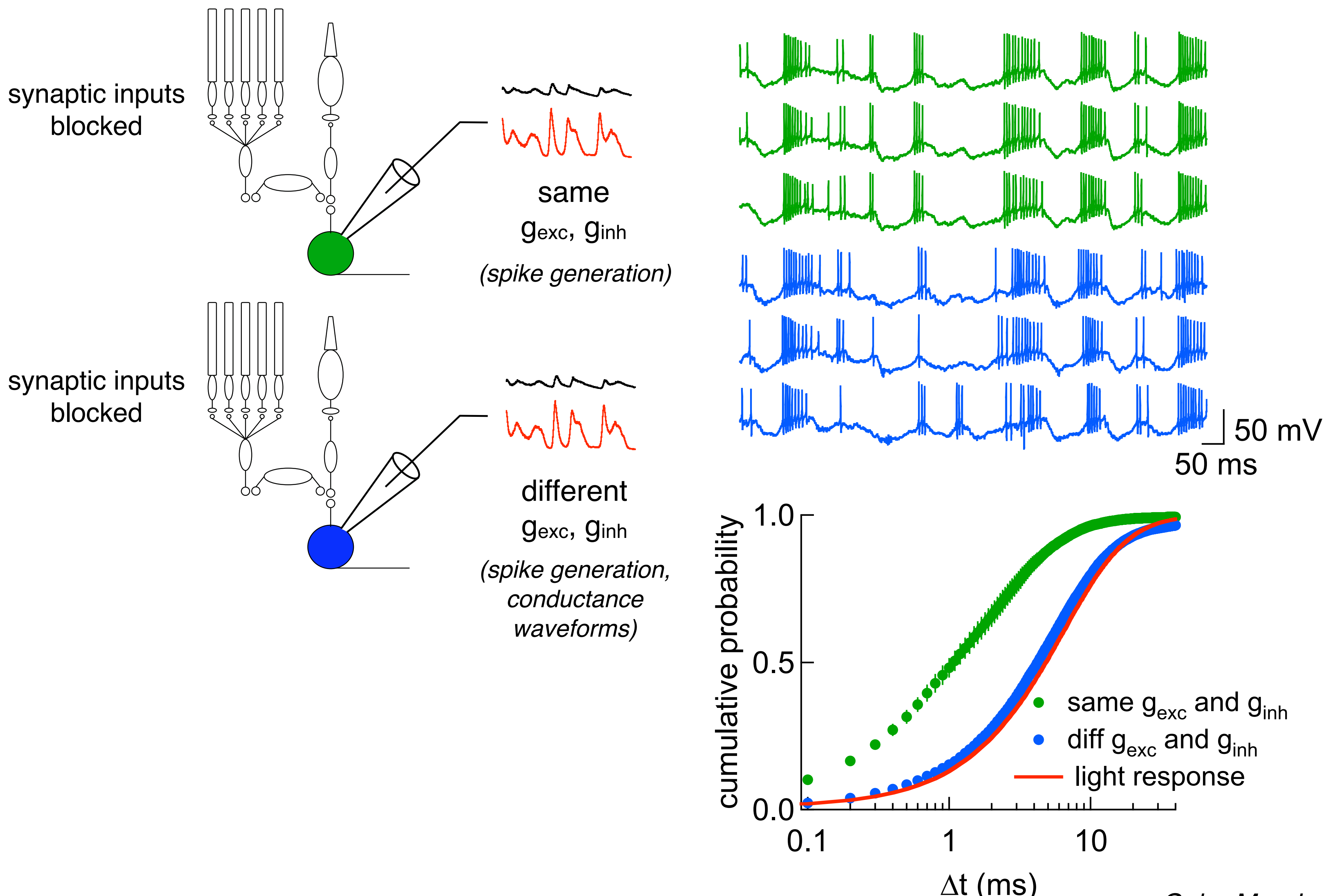
PRECISION SIMILAR ± MODULATED LIGHT STIMULUS



SPIKE GENERATION CONTRIBUTES LITTLE NOISE

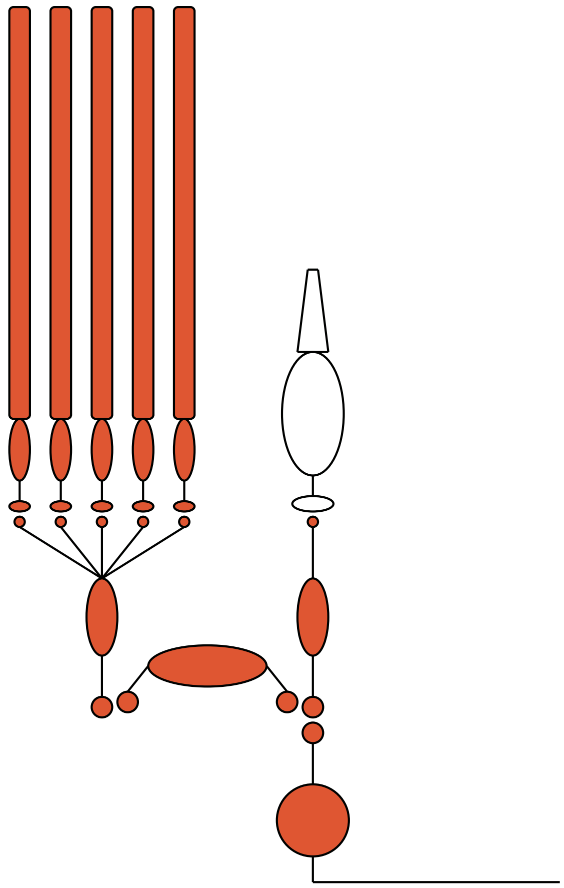


SYNAPTIC INPUTS ACCOUNT FOR NOISE IN SPIKE OUTPUT



Gabe Murphy

SUMMARY (TAKE 2)



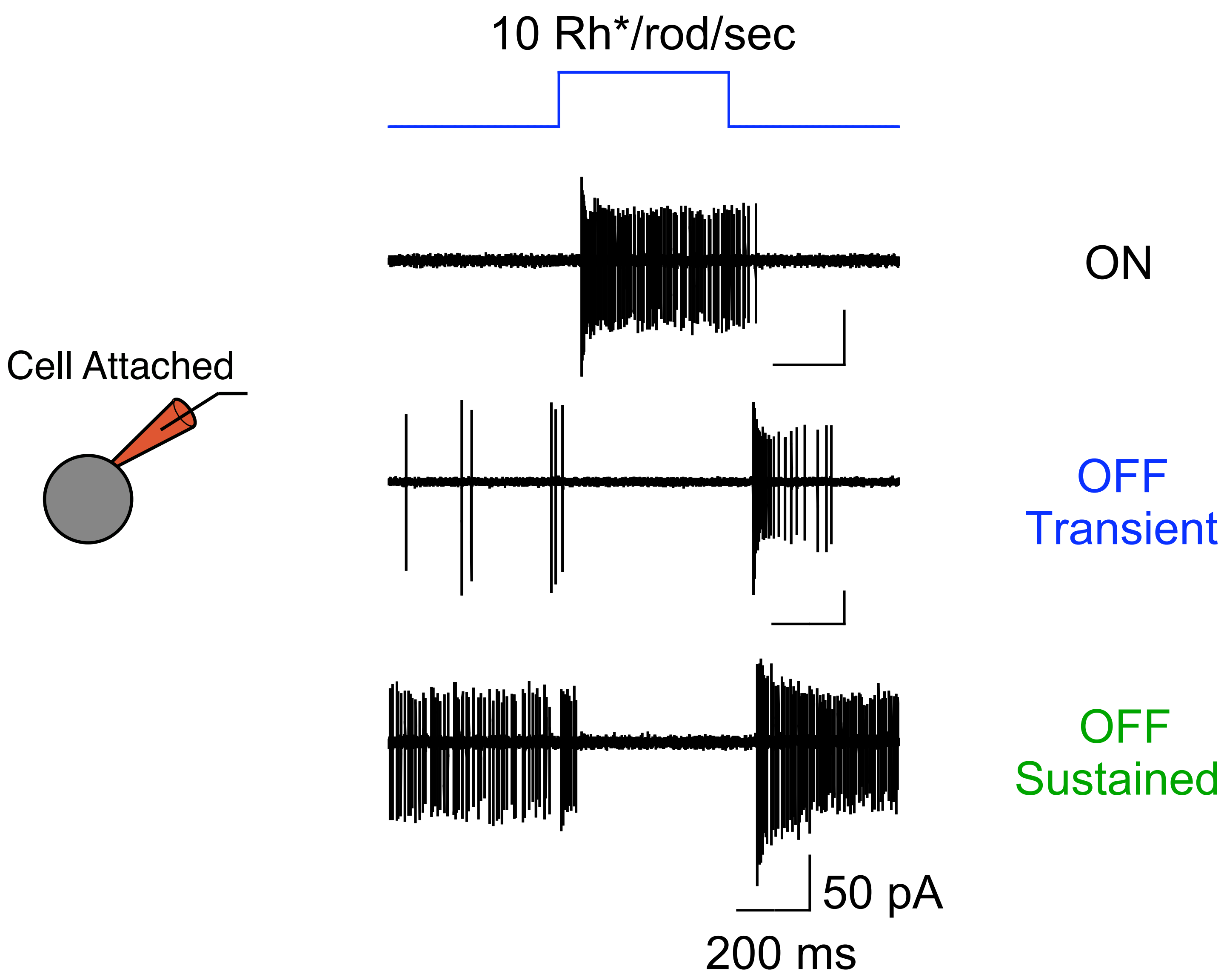
- Signals traversing rod bipolar pathway evoke temporally precise responses in mouse ganglion cells

- Temporal precision limited by noise in synaptic inputs rather than noise intrinsic to ganglion cell (i.e. in dendritic processing or spike generation)

- Different ganglion cell types achieve precision using distinct strategies to integrate excitatory and inhibitory inputs

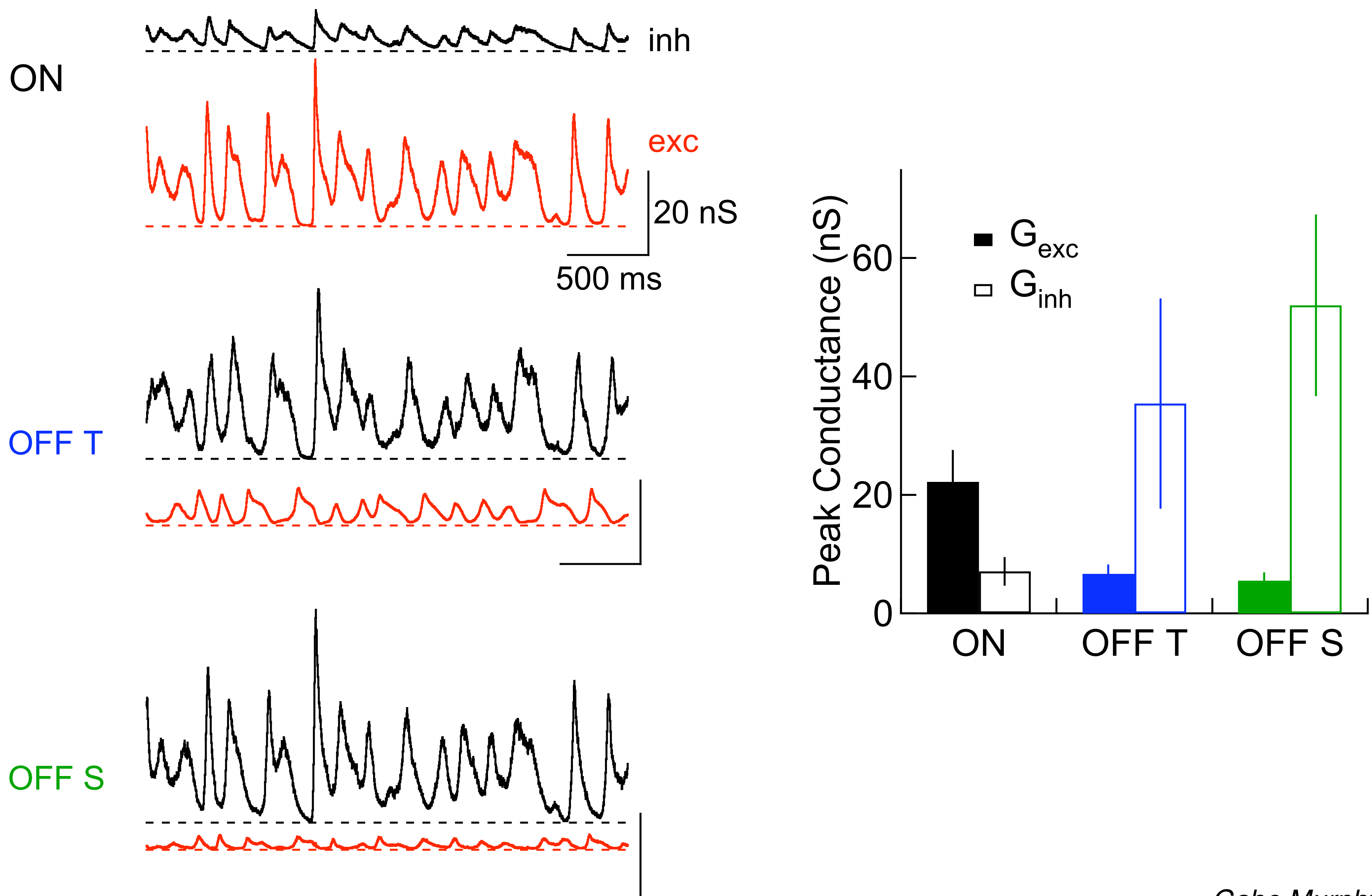
3 ALPHA CELL TYPES IN MOUSE RETINA

Pang et al., 2003



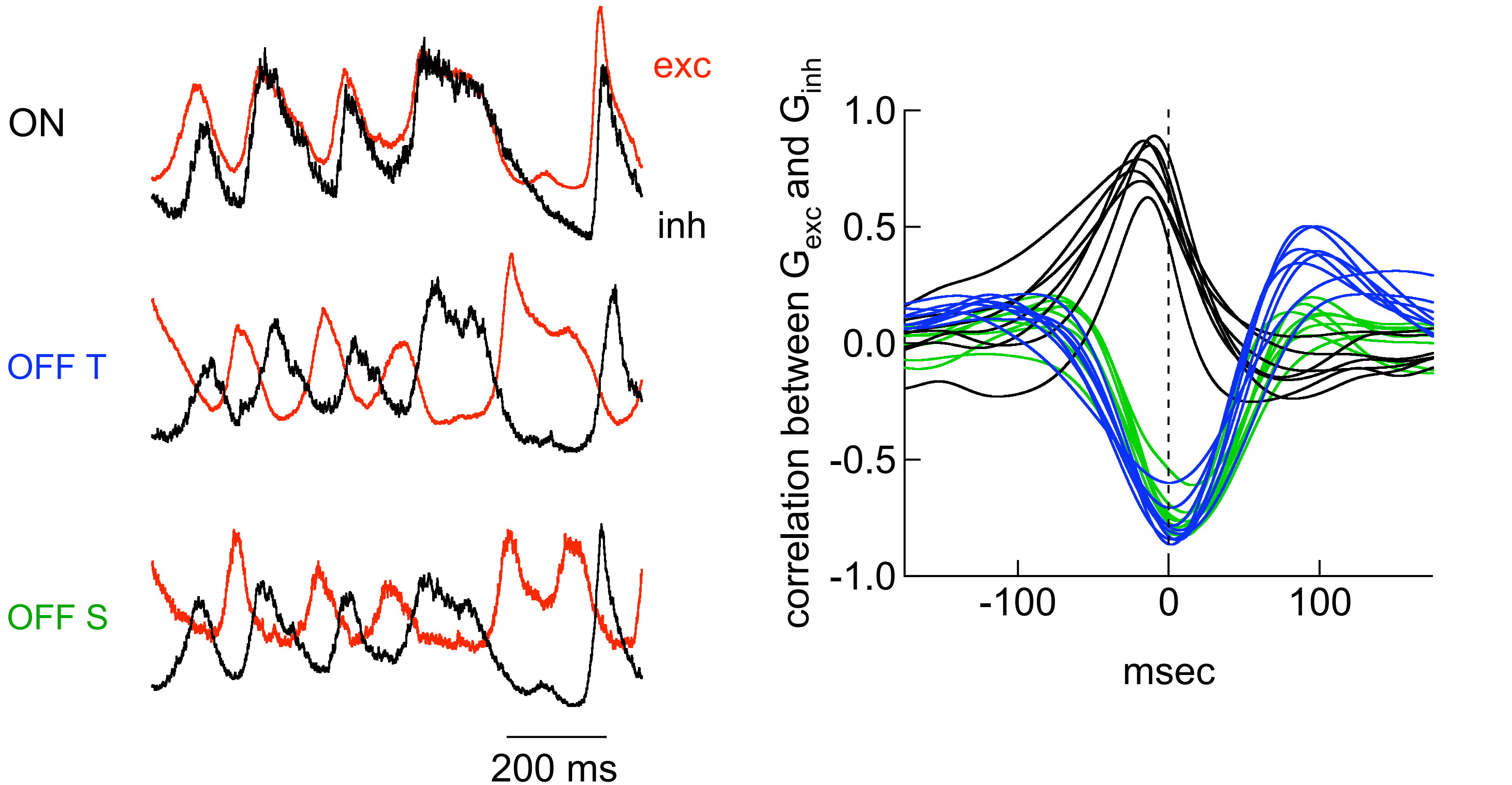
Gabe Murphy

RELATIVE AMPLITUDES OF EXCITATION AND INHIBITION DIFFER AMONG ALPHA CELLS



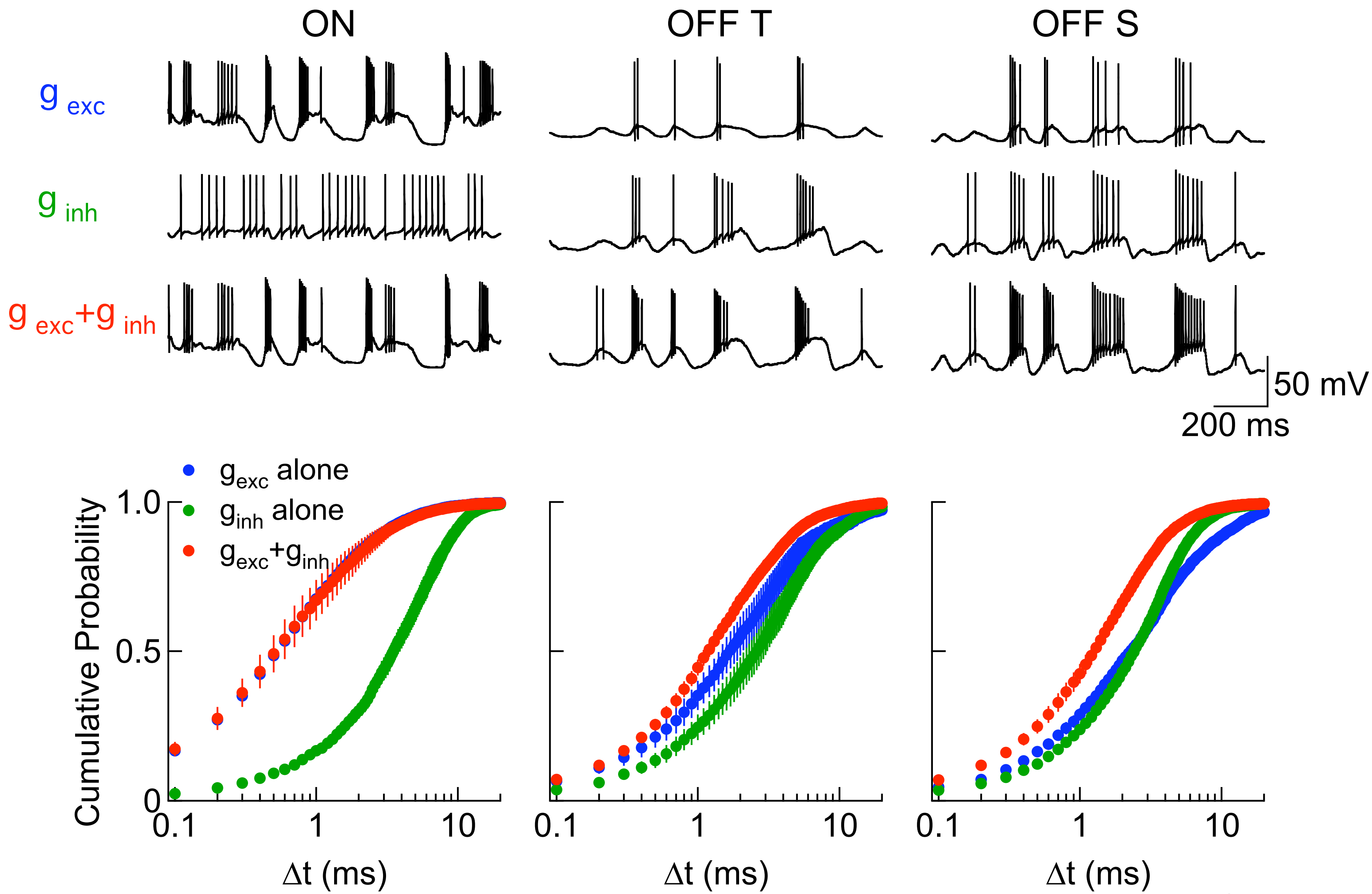
Gabe Murphy

KINETICS OF EXCITATION AND INHIBITION DIFFER AMONG ALPHA CELLS



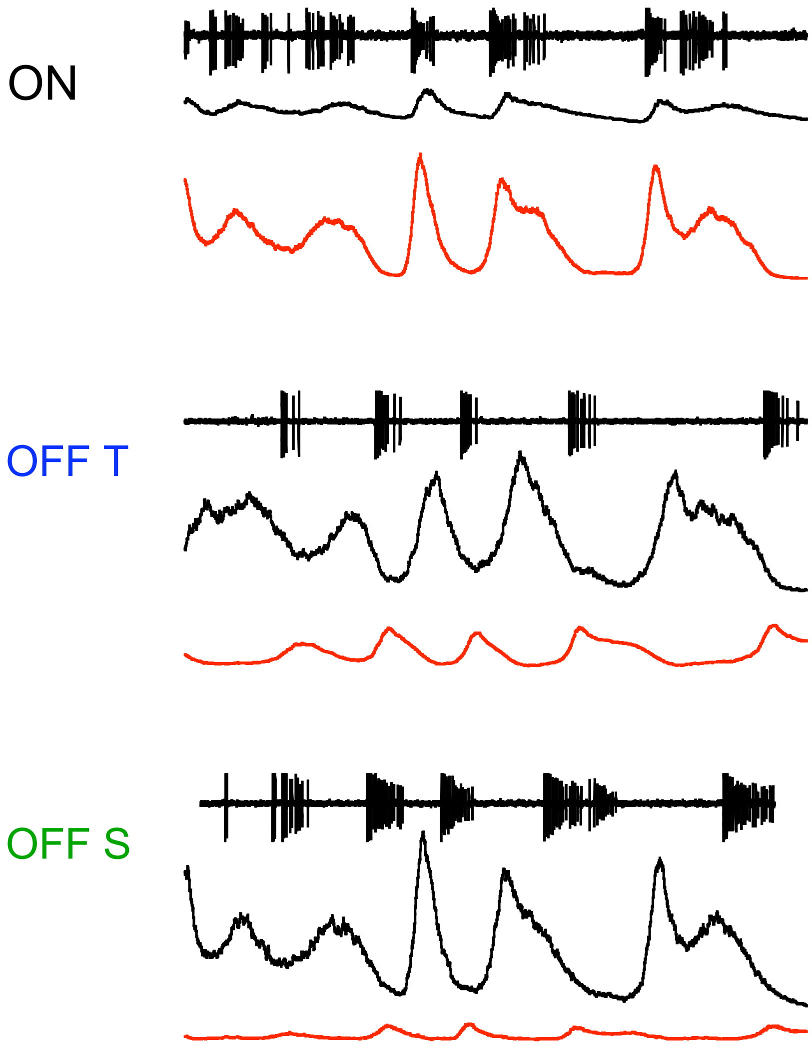
Gabe Murphy

WHAT DO DIFFERENCES IN SYNAPTIC INPUTS MEAN FOR SPIKE GENERATION?



Gabe Murphy

WHAT DO DIFFERENCES IN SYNAPTIC INPUTS MEAN FOR SPIKE GENERATION?



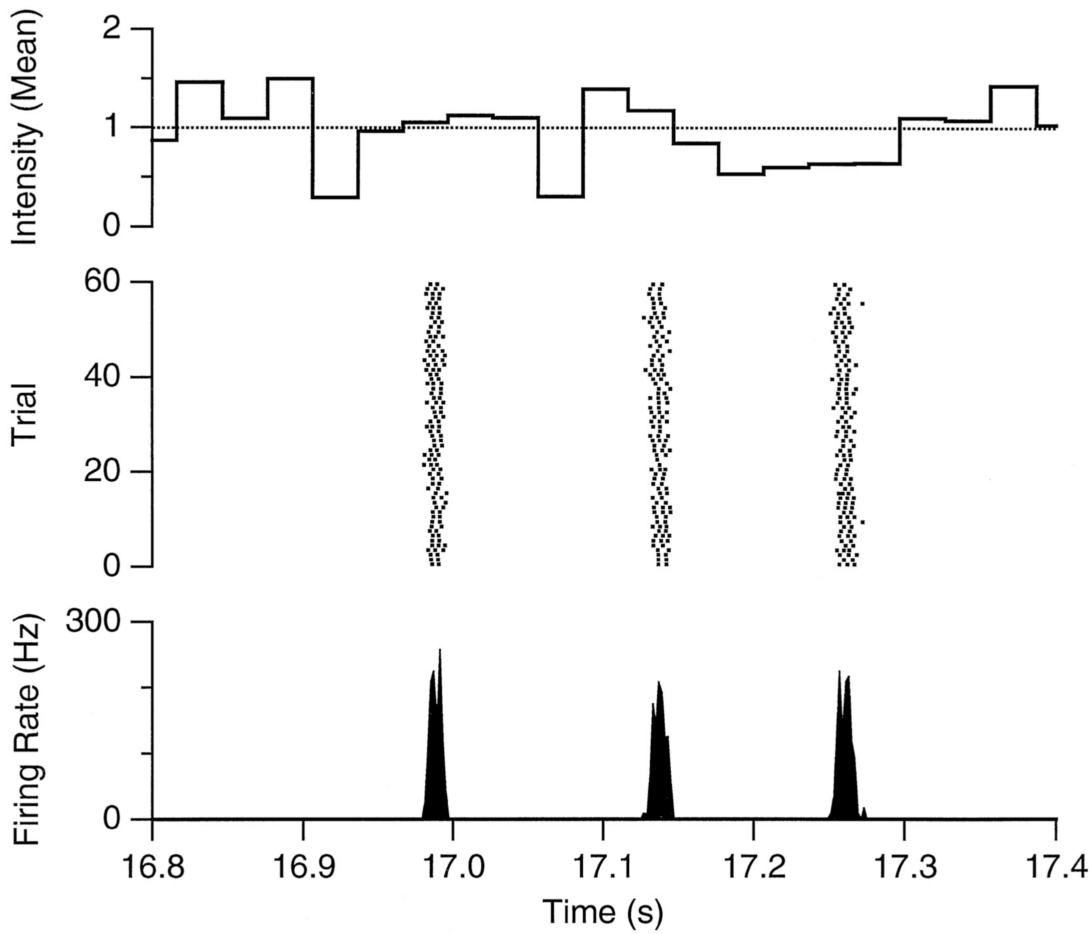
firing dominated by
excitatory input

excitation and inhibition
work in push-pull manner

Gabe Murphy

TEMPORAL PRECISION OF SENSORY RESPONSES

Berry and Meister, 1998



Today:
(1) how can we measure temporal precision?
(2) what mechanisms enable/limit precision?