Supplemental Information

Recruitment of GABAergic Interneurons in the Barrel Cortex during Active Tactile Behavior

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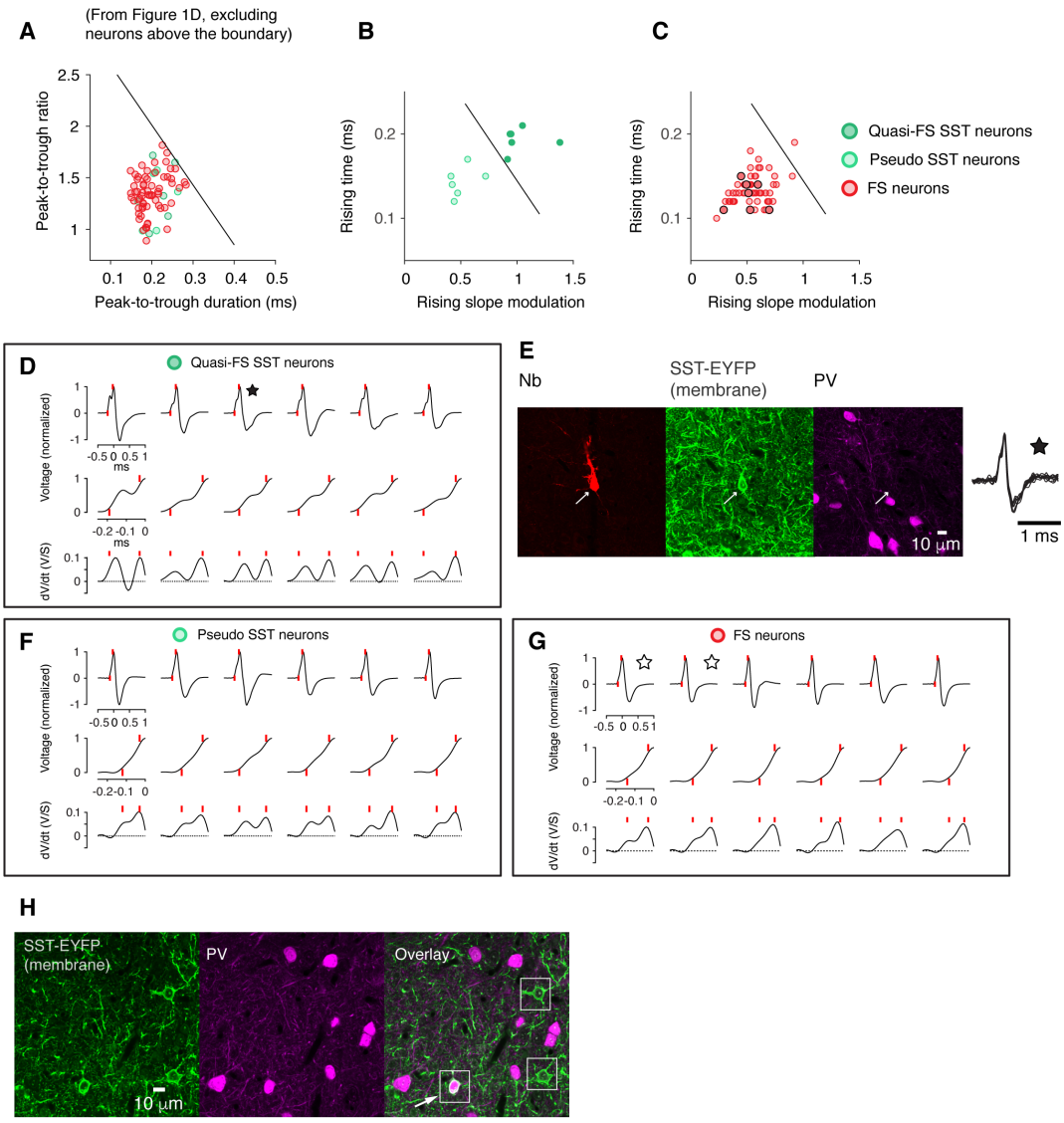
Table of Contents



Supplemental Figure 1. Identification of Thin-Spike SST Interneurons (related to Figure 1)

A subset of recorded ChR2+ neurons in SST-IRES-Cre x Ai32 mice had thin spike waveform (i.e., they overlapped with FS neurons in terms of peak-to-trough duration and peak-to-trough ratio). Some of these neurons were likely quasi-FS SST neurons. These neurons have been described in X94 mice, in which non-Martinotti SST neurons are genetically labeled (Ma et al., 2006). Others could be FS/PV neurons that expressed ChR2 in an off-target manner (Hu et al., 2013). We distinguished these two possibilities based on two additional parameters extracted from the spike waveforms.

(A) Thin-spike ChR2+ neurons recorded in SST-IRES-Cre x Ai32 mice and FS neurons.

(B) Thin-spike ChR2+ neurons recorded in SST-IRES-Cre x Ai32 mice were divided into two groups with two additional parameters extracted from the spike waveform. The light green symbols likely

correspond to FS neurons with off-target ChR2 expression (pseudo SST neurons), whereas the dark green symbols likely correspond to quasi-FS (X94-like) SST neuron.

(C) Same analysis as B for FS neurons. Circles mark those whose spike waveforms are shown in G.

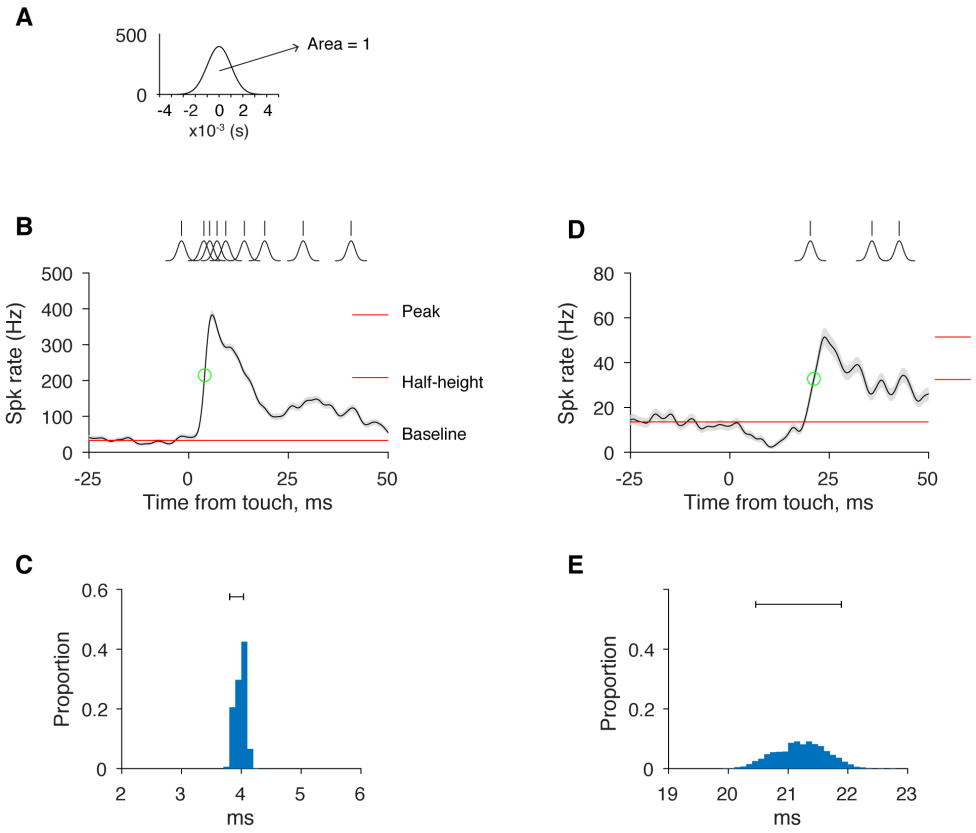
(D) Quasi-FS SST neuron. The rising phase of these neurons always showed a brief decrease in the slope, or a “shoulder”.

(E) A quasi-FS SST neuron (marked with a star in D) was negative for PV immunoreactivity. Note the characteristic rising slope that contains a “shoulder”.

(F) Pseudo SST cells were distinguished by their rapidly rising slope that lacks a “shoulder”, similar to FS interneurons (G).

(G) Spike waveforms of FS interneurons. Star-marked neurons were labeled and found positive for PV immunoreactivity.

(H) As previously reported, in SST-IRES-Cre x Ai32 transgenic mice, some PV+ neurons express ChR2 (arrow), possibly owing to a transient Cre recombinase expression during development.



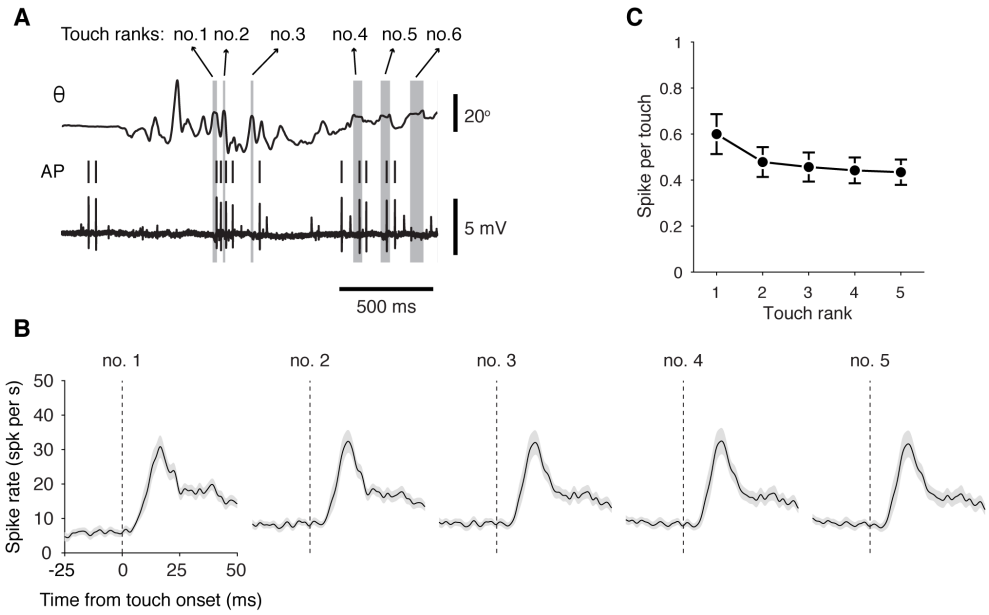
Supplemental Figure 2. Latency of Touch Evoked Responses (related to Figure 2)

(A) Profile of a Gaussian kernel (width = 1 ms). The area under the curve is 1.

(B) Spike trains of a FS neuron were convolved with the Gaussian kernel and averaged across trials to produce a spike density function. For latency estimation, the baseline, peak response, and half-height were computed. Latency was defined as the time from the touch onset to the first point exceeding half height (green circle). Shaded area, SEM.

(C) Bootstrap procedure was performed to estimate the reliability of latency estimation. A narrow 90% CI indicates reliable estimation.

(D-E) Same as B, C for an SST neuron.

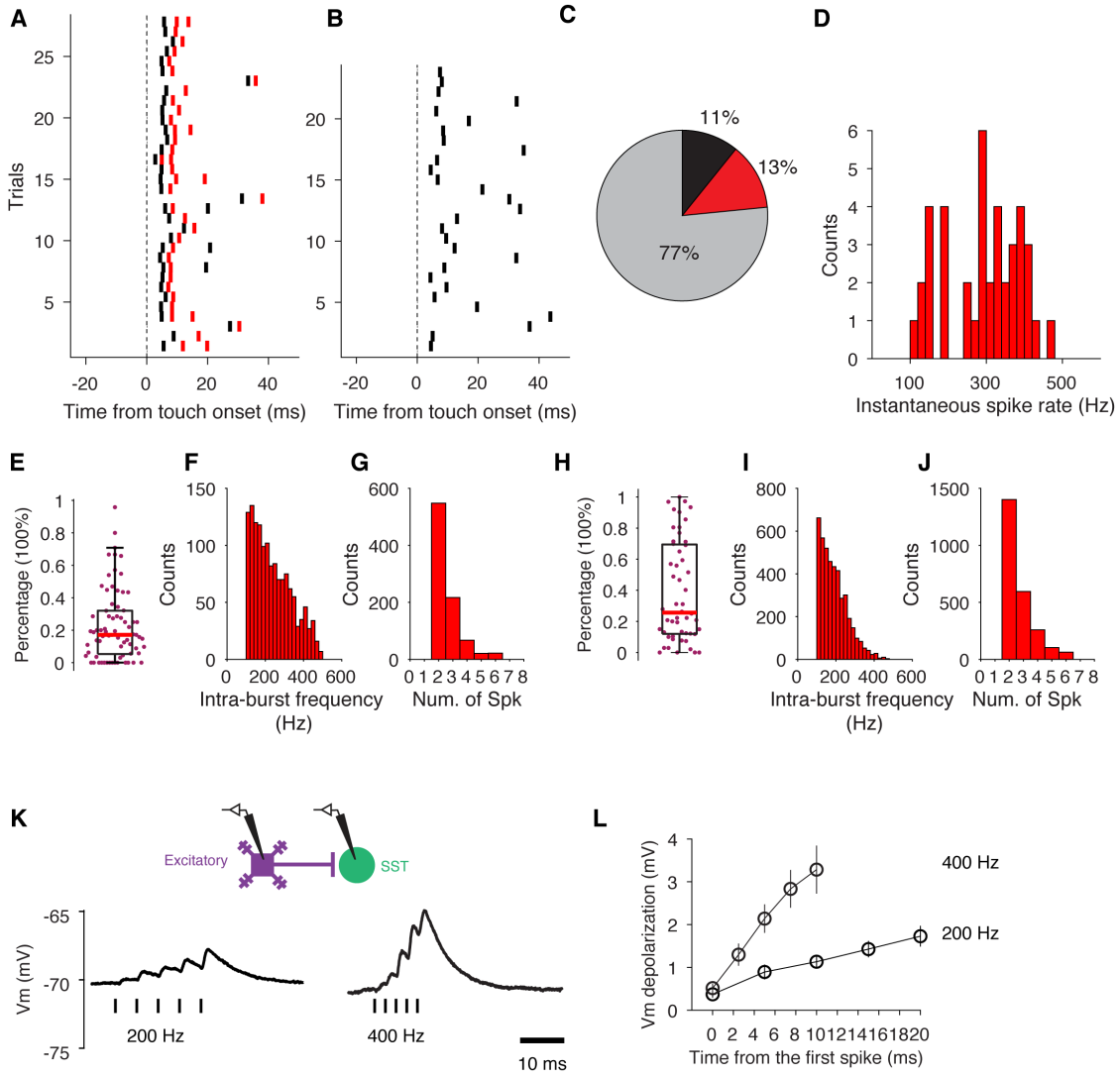


Supplemental Figure 3. Touch-Evoked Spiking in SST Neurons Does Not Require an Accumulation from Multiple Whisker Touches (related to Figure 3)

(A) Definition of touch rank during a whisking bout. Touches within a whisking bout were typically 100 ms apart (median, 114 ms, 25th to 75th percentiles, 63 and 170 ms).

(B) Touch-evoked responses (spike density function; Gaussian kernel, 1 ms) in SST interneurons (n = 58 neurons) are grouped according to the rank of touches during repetitive palpations. Shaded areas, SEM.

(C) Spikes per touch as a function of touch rank.



Supplemental Figure 4. Burst Firing in E Neurons Could Enhance Depolarization in Postsynaptic SST Neurons (related to Figure 4)

(A) Touch triggered burst (inter-spike interval <10 ms) of spikes in an example L4 E neuron. Red, spikes with a preceding inter-spike interval of less than 10 ms.

(B) Touch triggered non-burst firing in the same neuron.

(C) Distribution of touch trials with no evoked spikes (gray), non-burst spikes (black), and burst spikes (red) in the example neuron.

(D) Distribution of intra-burst spike frequency for all detected bursts in the example neuron.

(E) Boxplot for the percentage of trials with evoked bursts out of all trials with evoked spiking (burst and non-burst) for all L4 E neurons. Red, median.

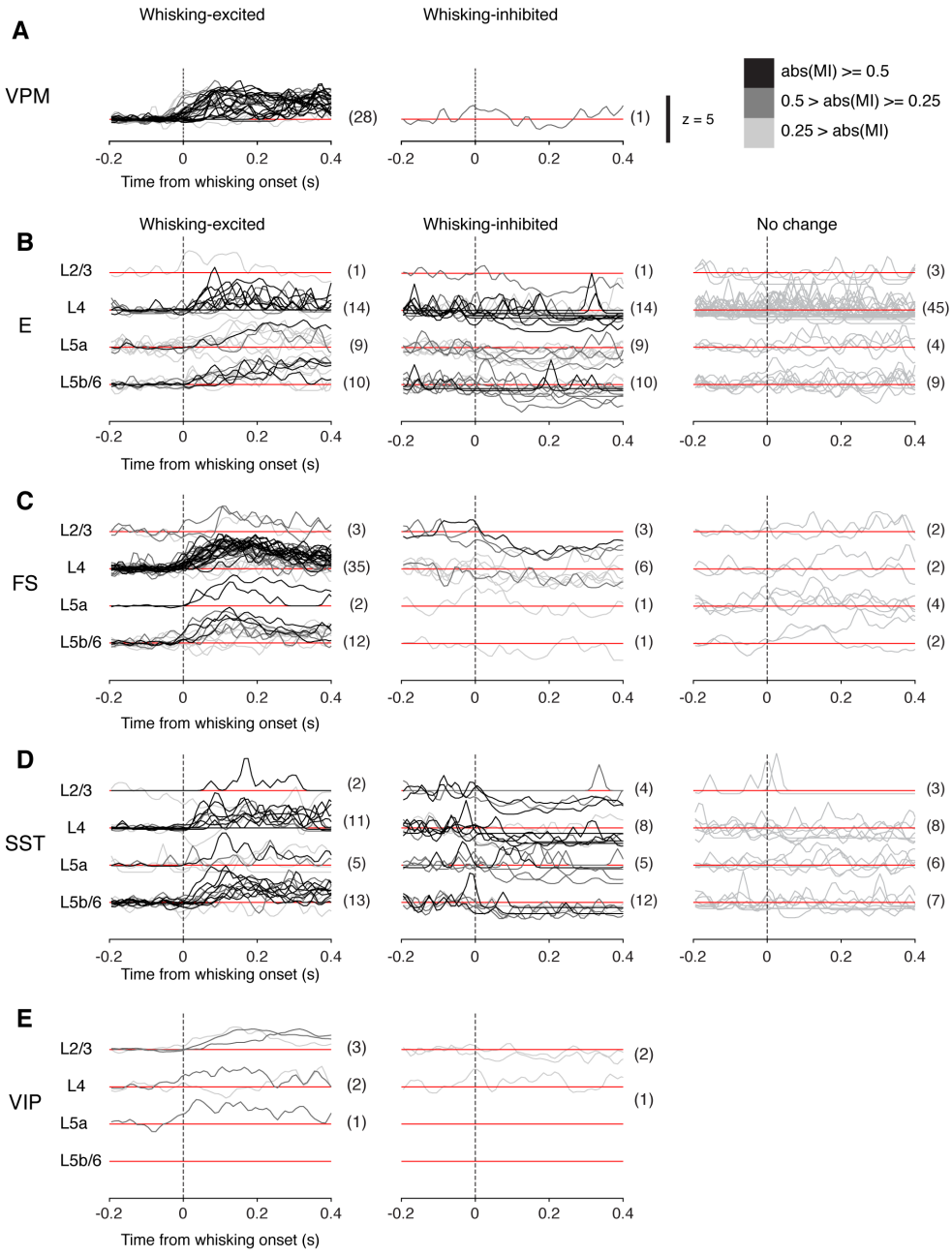
(F) Distribution of intra-burst spike frequency for all bursts in all L4 E neurons (n = 73 cells).

(G) Distribution of spike number in single bursts for all L4 E neurons (882 bursts).

(H-J) Same as E-G for L5/6 E neurons (n = 53 cells, 2449 bursts).

(K) Schematic, Paired recording of connected E and SST neurons in brain slices. Bottom, example EPSP in an L4 SST neuron evoked by high-frequency (200 or 400 Hz) spike trains in a presynaptic E neuron (spikes indicated by vertical bars). Traces are trial-averaged responses.

(L) Peak depolarization as a function of time during a 5-spike presynaptic spike train at 200 or 400 Hz (n =10 connected pairs which were tested at both frequencies and had at least one unitary EPSP larger than 0.5 mV).

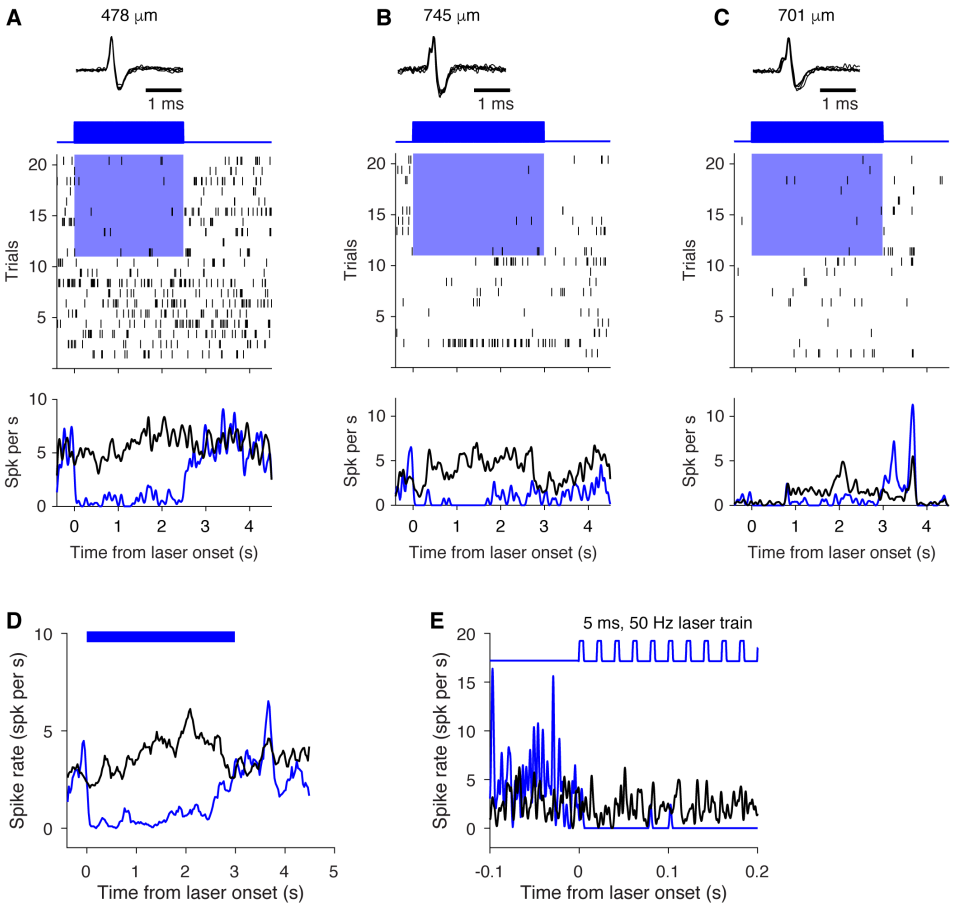


Supplemental Figure 5. Whisking Modulates Spiking Dynamics as a Function of Cell Types and Cortical Layers (related to Figure 6)

(A) Z-scored spike rate aligned to the onset of whisking for VPM cells. Left, whisking-excited cells; Middle, whisking-inhibited cells; Right, plot color indicates scale for absolute modulation index (MI). The number in parentheses denotes the number of cells.

(B) Z-scored spike rate aligned to the onset of whisking for E cells. Left, whisking-excited cells; Middle, whisking-inhibited cells; Right, cells that showed no significant change in spike rate with whisking. Cells that did not spike during whisking and non-whisking periods are not included.

(C-E) Same as (B) for FS, SST, and VIP neurons.



Supplemental Figure 6. Optogenetic VIP Neuron Stimulation Inhibits Putative SST Neurons (related to Figure 7)

(A-C) Three putative SST interneurons defined by their rapid suppression in response to VIP neuron stimulation. Their spike waveforms, spike raster plots, and PSTHs under control (black) and VIP stimulation (blue) conditions are shown. Note the characteristic spike rising phase (cf. Fig. S1) for cells in B and C. Recording depths (manipulator readings) are listed.

(D) Averaged PSTHs of 3 putative SST interneurons. Blue bars denote laser stimulation.

(E) Averaged PSTH of 3 putative SST interneurons at fine time scale around the laser onset.