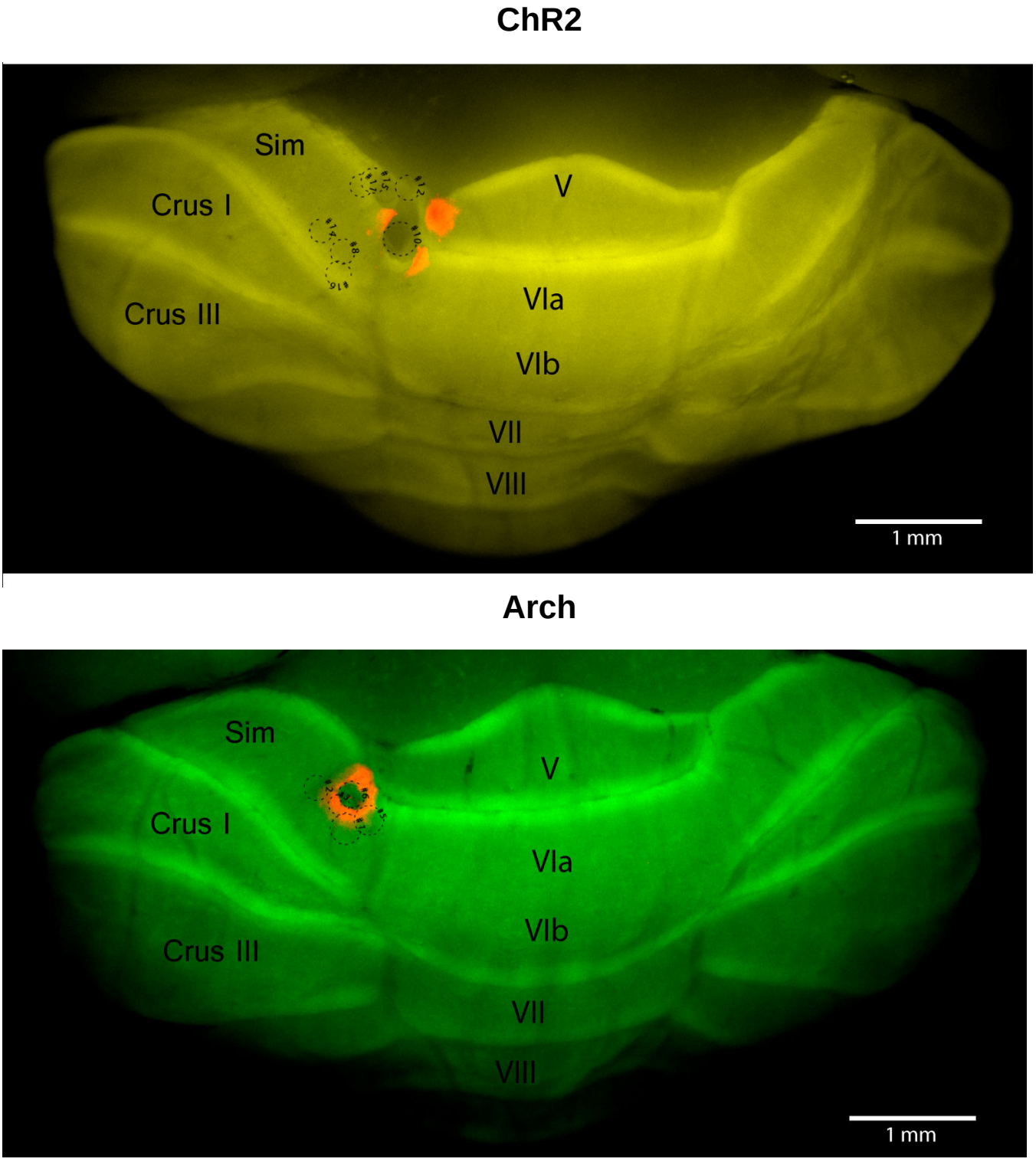
SUPPLEMENTAL MATERIAL

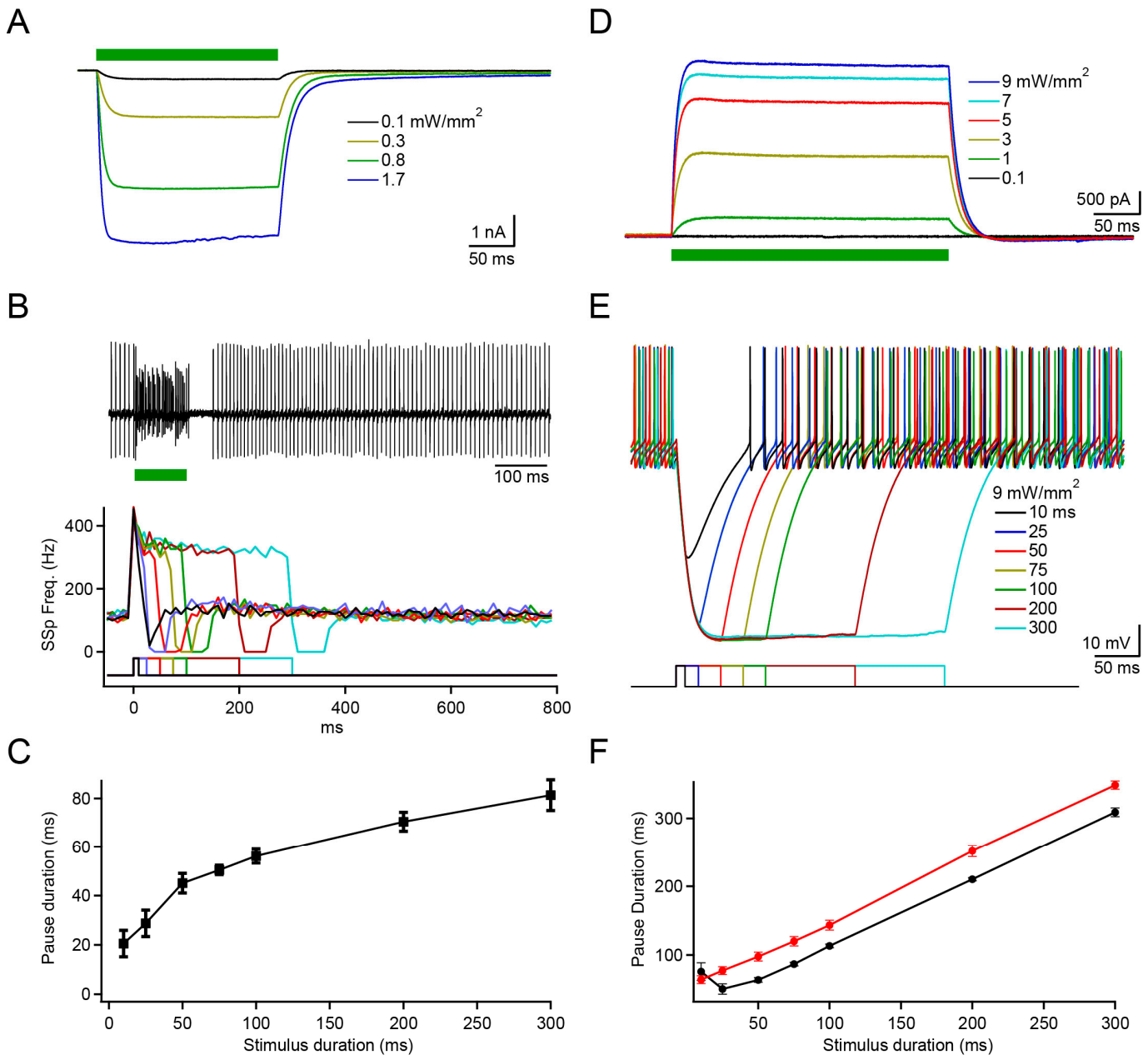
Supplemental Figures S1-8

Figure S1, related to Figures 1 and 2.



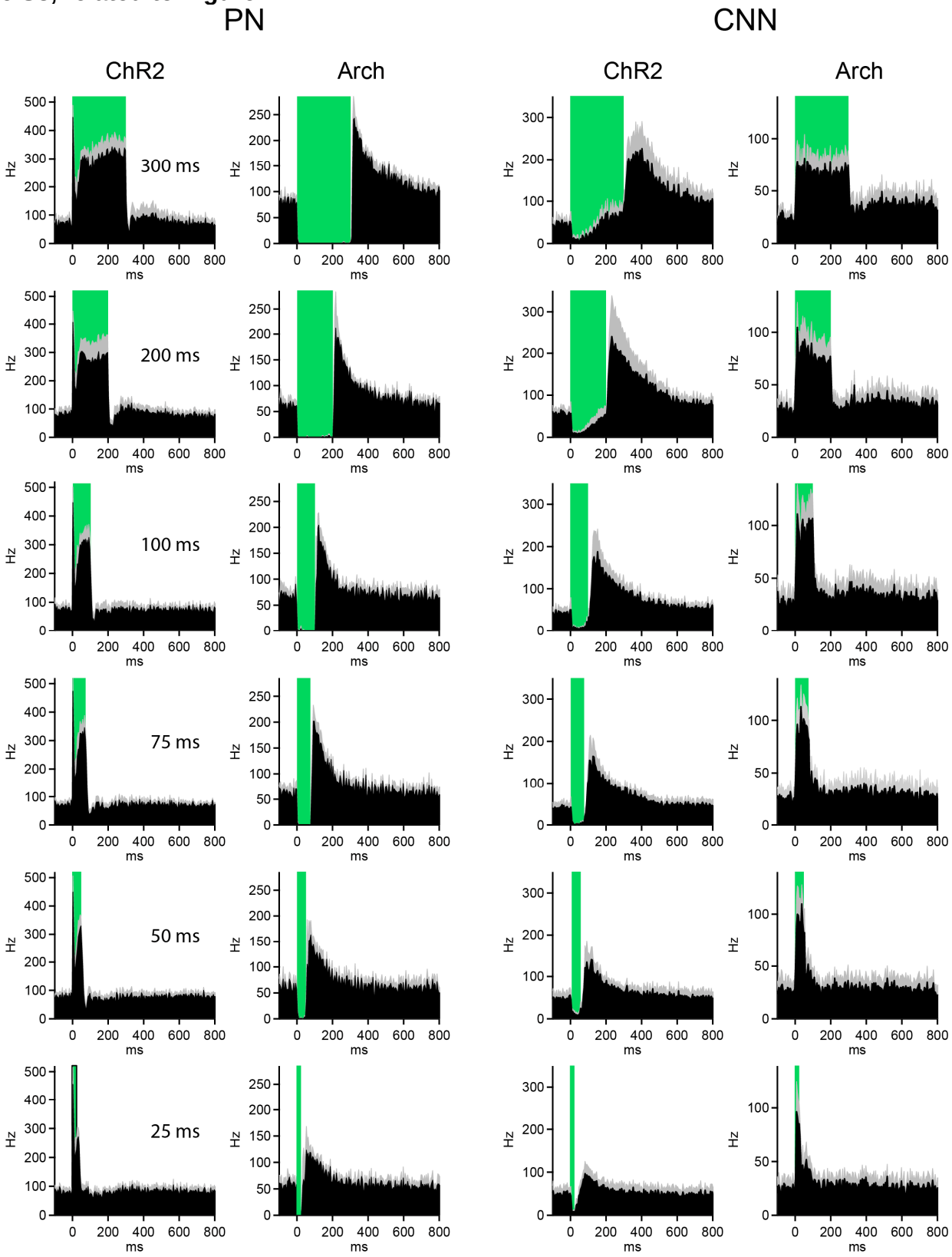
Fluorescent micrographs of whole mount cerebella indicating fiber placements. Dorsal views of the cerebellum under epifluorescence in ChR2 (yellow) or Arch (green) expressing mice. Red fluorescence indicates the site at which the DiI coated fiber optic was implanted. Circles indicate the locations of fibers implanted in other cerebella.

Figure S2, related to Figure 1.



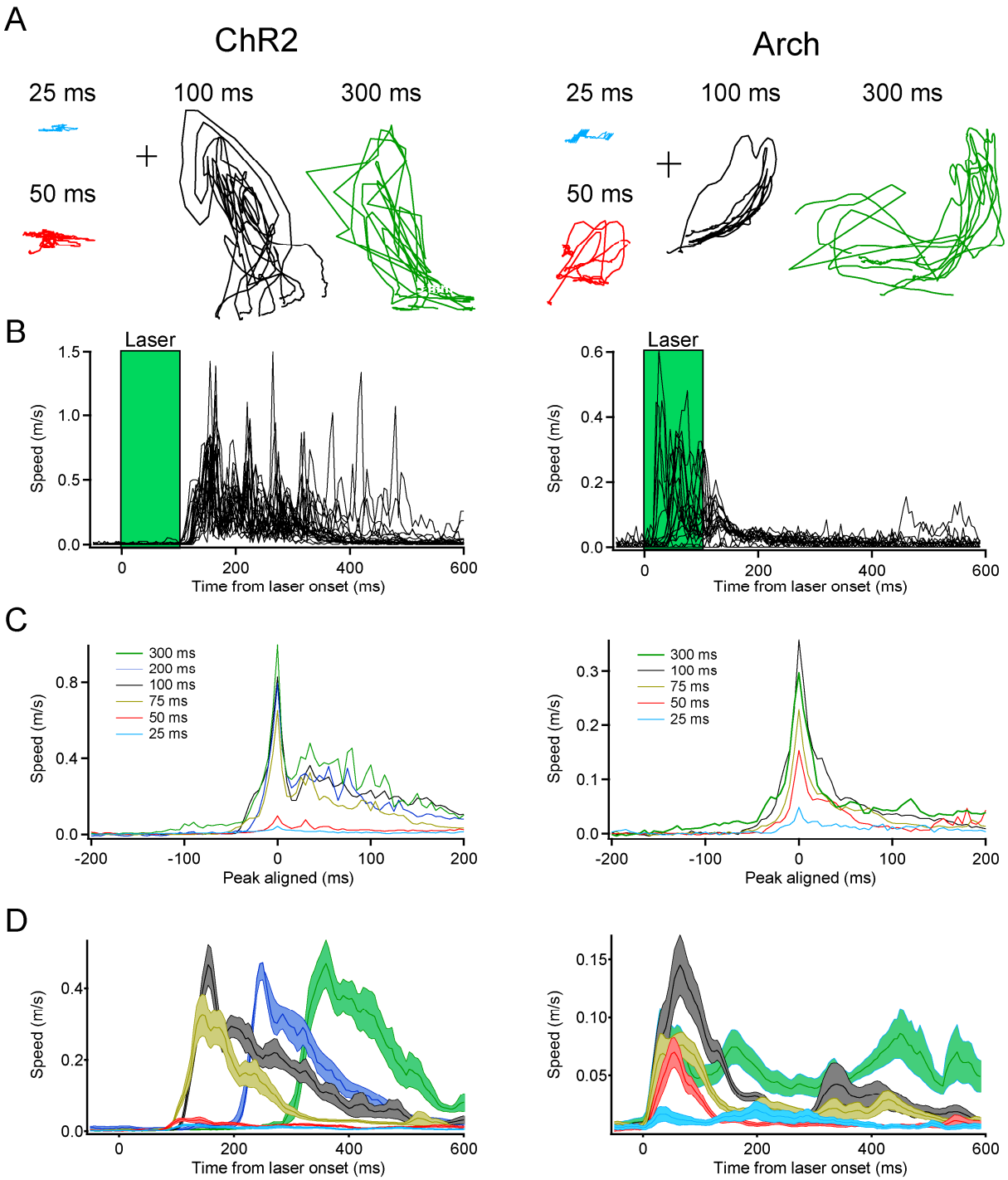
Effects of ChR2 and Arch activation in PNs *in vitro*. (A) Whole-cell, voltage-clamped PNs recorded in an *in vitro* slice preparation. Shown are example traces of ChR2 currents generated by increasing illumination intensity (as indicated). Green bar marks duration of 200 ms LED illumination. (B) **Top**, example trace of an extracellularly recorded PN in a slice during ChR2 activation (100 ms pulse). **Bottom**, example peristimulus time histogram of PN firing frequency in response to increasing durations of ChR2 activation. (C) Duration of post-burst pause as a function of the duration of ChR2 activation (n = 6). (D) Outward Arch currents recorded from a whole-cell, voltage-clamped PN in response to various intensities of LED illumination. Green bar marks 300 ms stimulus duration. (E) PN current-clamp recording showing the response to Arch activation for various duration LED light pulses indicated by the color code. (F) The mean ± s.e.m. durations of pauses in PN SSp firing are plotted as a function of illumination duration for whole-cell *in vitro* experiments (red, n = 4) as well as *in vivo* (black, n = 5) optrode recordings.

Figure S3, related to Figure 2.



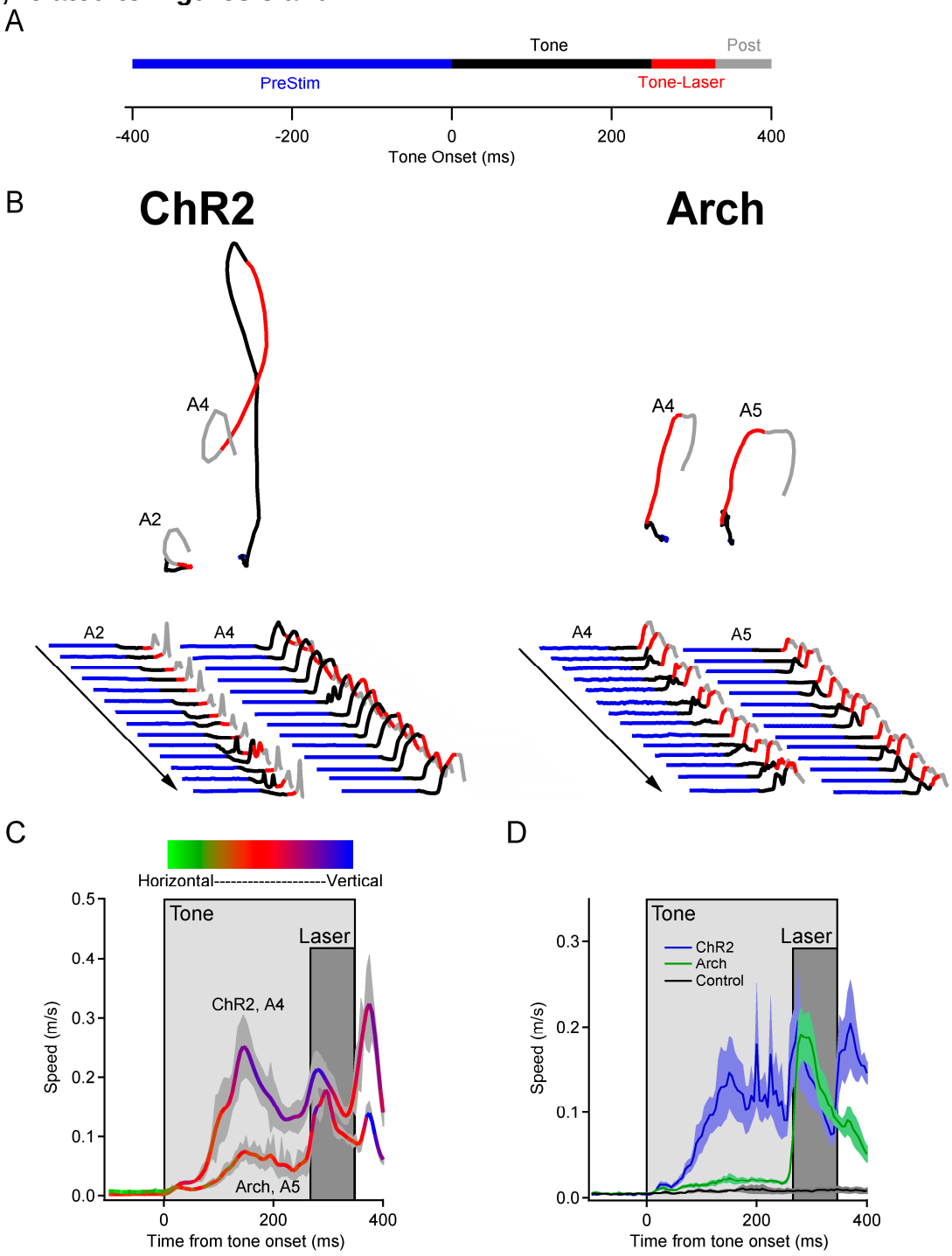
Activation of ChR2 or Arch in PNs differentially modulates PN and CNN activity. Average PN and CNN responses to different duration laser pulses recorded *in vivo* (ChR2: n = 5 PNs, 7 CNNs and Arch: n = 4 PNs, 9 CNNs). Shown are the averages for only the cells with recordings for all stimulus durations, therefore averages do not necessarily match those reported for the entire group elsewhere. Laser pulse indicated by green boxes, gray shading indicates s.e.m..

Figure S4, related to Figure 2.



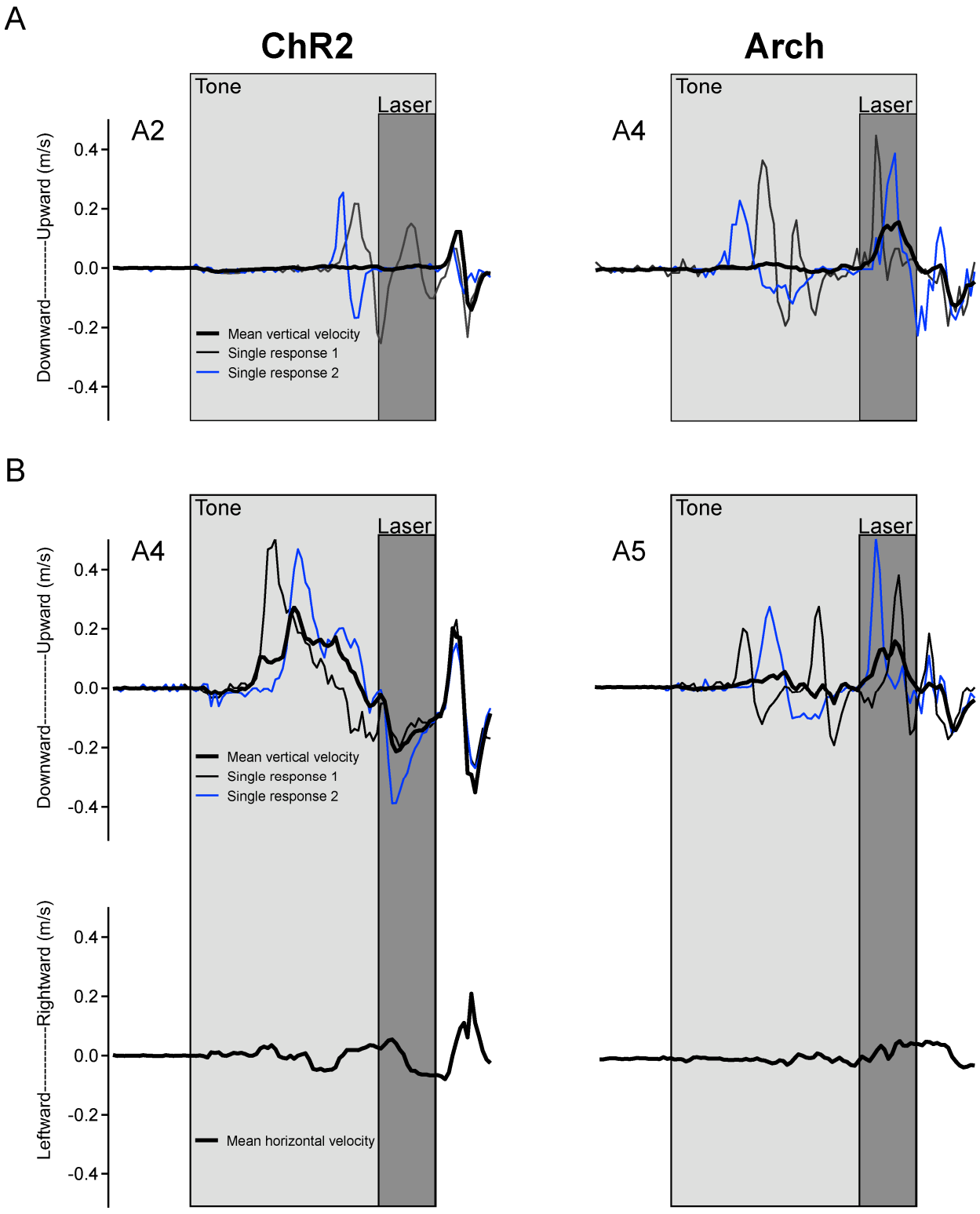
Kinematics of forelimb movements generated by fiber optic laser stimulation in ChR2 and Arch mice. (A) 2-dimensional forelimb trajectories (5 traces) that resulted from the indicated durations of laser illumination from a ChR2 (left) and an Arch (right) mouse (same animals as in Figure 2B). (B) Example traces of forelimb speed vs. time for multiple presentations of a 100 ms laser illumination. (C) Peak-aligned, average speed traces for different duration laser illuminations. (D) Speed vs. time plots for this particular animal (see C for corresponding color code). All panels are from one ChR2 or Arch animal.

Figure S5, related to Figures 3 and 4.



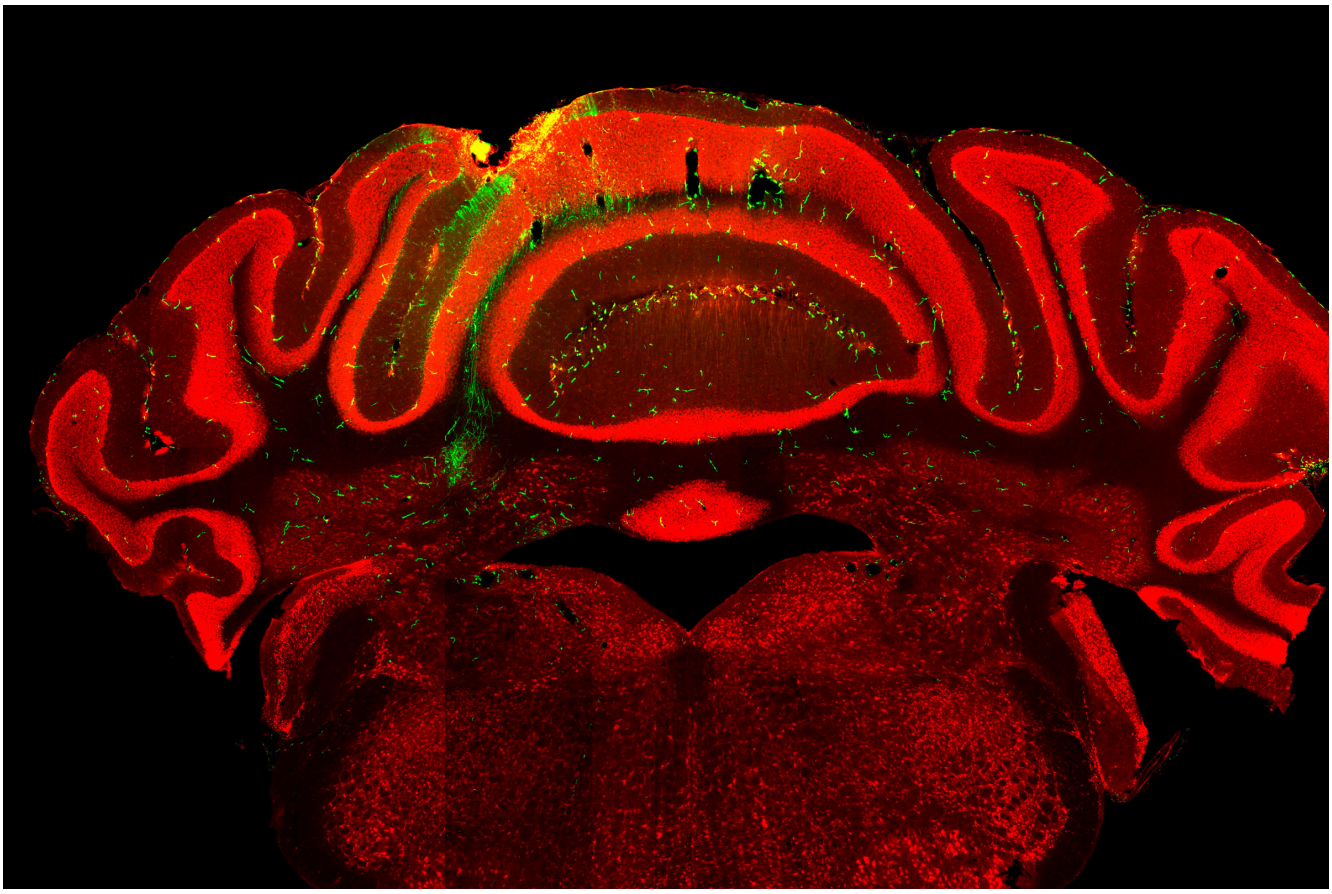
Kinematic analysis of forelimb position and directional speed. (A) Color-code indicating the time epochs shown in traces in panel B. (B) **Top**, mean forelimb position for the ChR2 or Arch trained example animals depicted in Figures 3A-C and 4A-C, respectively. The data are from the indicated day of acquisition training. **Bottom**, sample vertical position traces from the same animals as above. Arrow indicates order of trials. (C) Speed traces from same animals as B, with speed direction indicated by the color scale. Green speeds are horizontal, red are diagonal, blue are vertical. Boxes indicate the 325 ms tone (grey), and 75 ms laser (dark grey) stimulation durations. (D) Average ± s.e.m. of forelimb movement speed vs time for ChR2 (purple), Arch (red), and L7-Cre control (black) animals from training day 4. L7-Cre control animals showed no forelimb movements in response to laser stimulation and showed no learning.

Figure S6, related to Figure 3 and 4.



Kinematic analysis of vertical and horizontal velocity. (A) The same ChR2 and Arch animals as in Figure S5 on the indicated acquisition day. In all panels, thick lines are mean velocity and thin lines are single trials. Boxes indicate the 325 ms tone (grey), and 75 ms laser (dark grey) stimulation durations. Note that learned movements are not integrated well as velocity transients because they occur at different times and are biphasic. (B) Plots indicate the vertical (top) and horizontal (bottom) velocities on the indicated acquisition day.

Figure S7, related to Figure 5.



Alexa 488 injection into the forelimb region of the cerebellum. Dye-filled PNs (green) can be seen near the injection site as well as their axons coursing down and into the cerebellar nucleus. Due to the superficiality of the injection, dye can also be seen within the epithelium and associated blood vessels throughout the cerebellar cortex and nuclei.

Table S1, related to Figure 6.

Comparison of learned movement timing in response to 250 and 500 ms training intervals.

	250 ms interval	500 ms interval	z score	p value
ChR2	162.9 ± 5.2 ms (157)	320.3 ±. 18.9 ms (92)	z = 7.34	$p < 10^{-5}$
Arch	171.3 ± 9.9 ms (72)	215.4 ± 17.2 ms (86)	z = 0.55	p = 0.59

Comparison of the timing of peak-movement speed for the 500 ms interval between **ChR2** and **Arch**, z = 4.28 and $p < 10^{-4}$

Time, from tone-onset, of the peak forelimb-movement speed was measured for LRs in tone alone trials. Values show mean across all analyzable LRs from training days 3, 4, 5 and extinction day 1, expressed as mean ± s.e.m. (number of LRs). Within ChR2 and Arch groups, a two-tailed, Mann-Whitney U test was used to calculate statistical significance; the resulting z score and p value are indicated.

Comparison of the peak amplitudes of learned movements in ChR2 and Arch mice trained with 250 and 500 ms training intervals.

	250 ms interval	500 ms interval	z score	p value
ChR2	0.30 ± .001 (156)	0.23 ±.002 (92)	z = 4.14	$p<10^{-4}$
Arch	0.15 ± .001 (70)	0.12 ± .0001 (85)	z = 1.99	p=0.05

Comparison of all **ChR2** LR amplitudes versus all **Arch** LR amplitudes, z = 8.12, $p < 10^{-3}$

Peak movement speeds in m/s of first LRs in tone alone trials (LRs whose timing was analyzed in Fig. 5c). Values are expressed as mean ± s.e.m. (number of LRs). Two-tailed, Mann-Whitney U tests were used to calculate statistically significant differences between 250 and 500 ms training intervals; the resulting z score and p value are indicated. The comparison between ChR2 and Arch used all values across 250 and 500 ms training intervals.

Description of Supplemental Movie Files

Movie S1, related to Figure 2. High speed video, infrared illumination, and motion tracking methods used to measure forelimb movement kinematics in head-fixed mice.

Movie S2, related to Figure 2. Comparison of the timing of laser evoked movements in ChR2 and Arch mice.

Movie S3, related to Figure 3. LRs to tone-alone stimuli prior to and on day two of acquisition training in a ChR2-trained mouse.

Movie S4, related to Figure 4. LRs to tone-alone and tone plus laser stimuli on day four of acquisition training in an Arch-trained mouse.