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Supplemental Information

Diversity and sensorimotor specialization of head direction cells in the mouse thalamus

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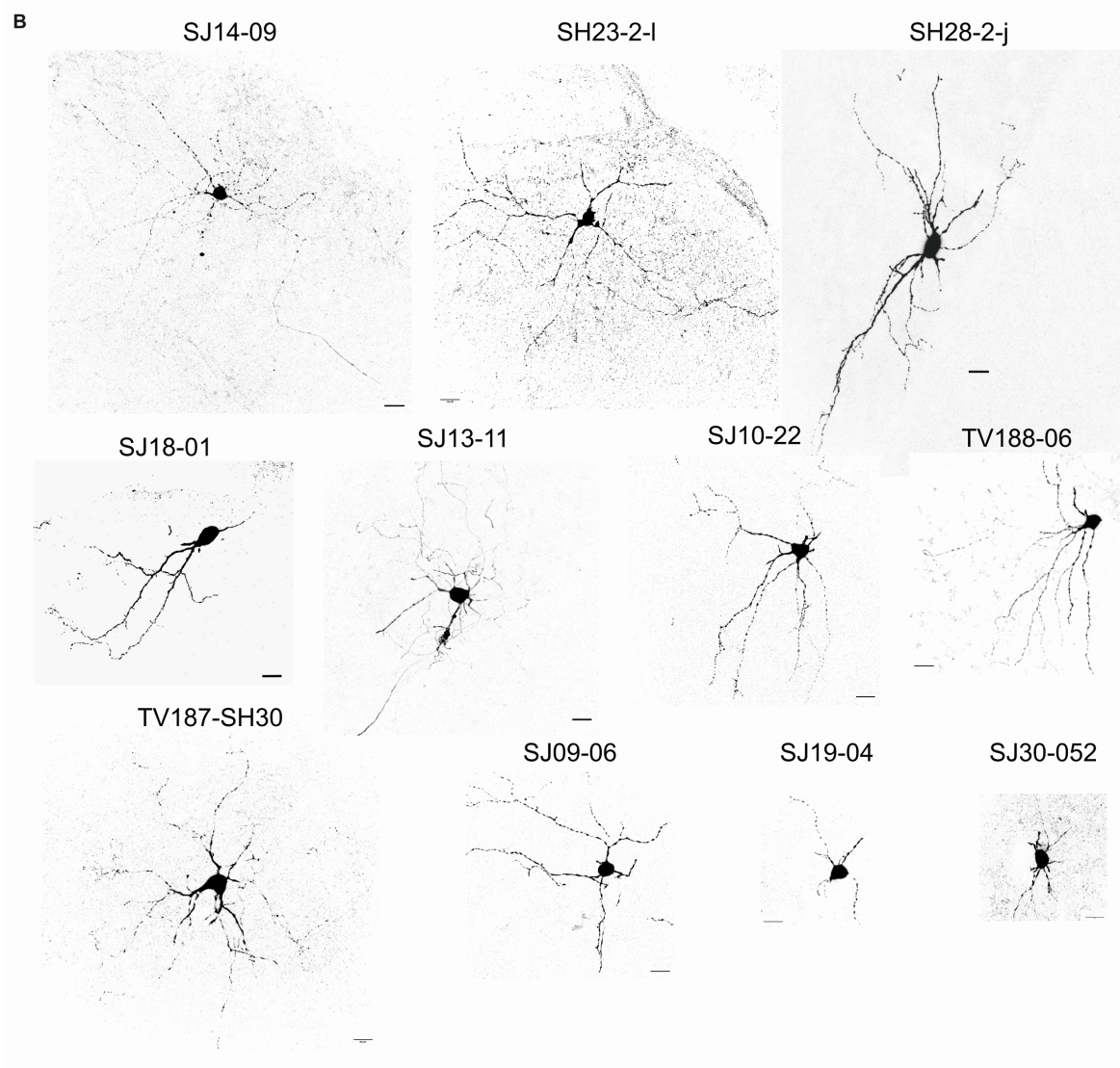
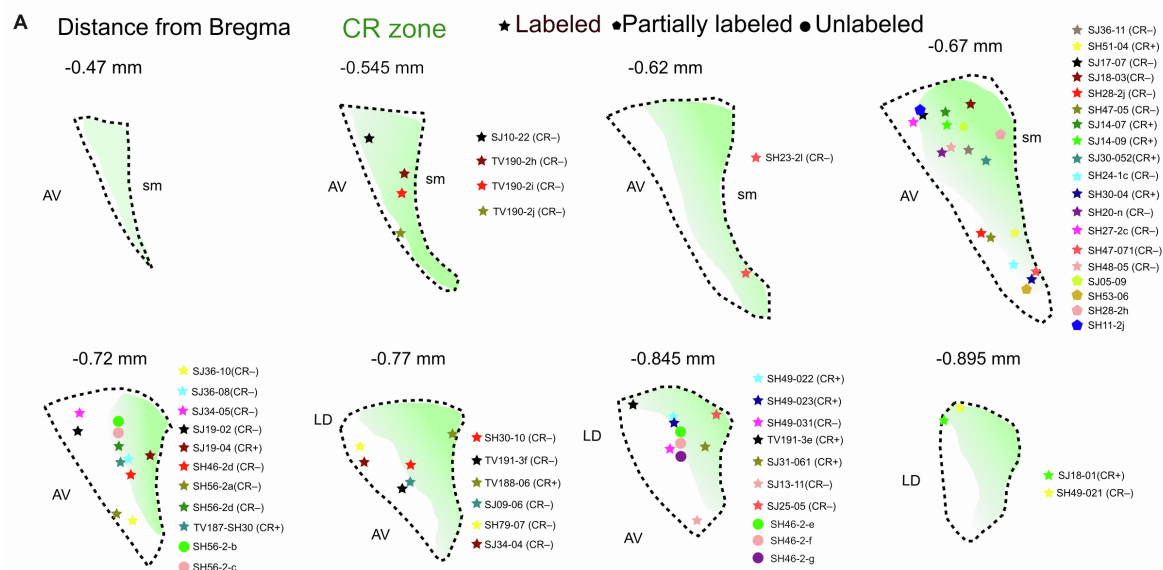


Figure S1. Recording locations and examples of juxtacellularly labeled ADn HD cells, related to Figure 1.

(A) Schematic map showing the locations of recorded ADn cells along with their names (stars, 44 labeled cells; pentagons, 4 partially labeled cells; circles, 6 unlabeled cells). Shaded areas indicate regions of CR immunoreactivity ('CR zone'). (B) Confocal maximum intensity z-projections of single 70 μm thick sections containing the soma and primary dendrites of labeled HD cells in the ADn. Scale bars, 20 μm . Z-thickness (μm) for each cell: SH23-2I (47.5), SH27-2c (72), SH28-2-j (33.5), SJ14-09 (65.9), SJ18-01 (70), SJ10-22 (65.5), SJ13-11 (16.1), SJ09-06 (41.7), SJ19-04 (31.7), SJ30-052 (38), TV187-SH30 (66), TV188-06 (54.5).

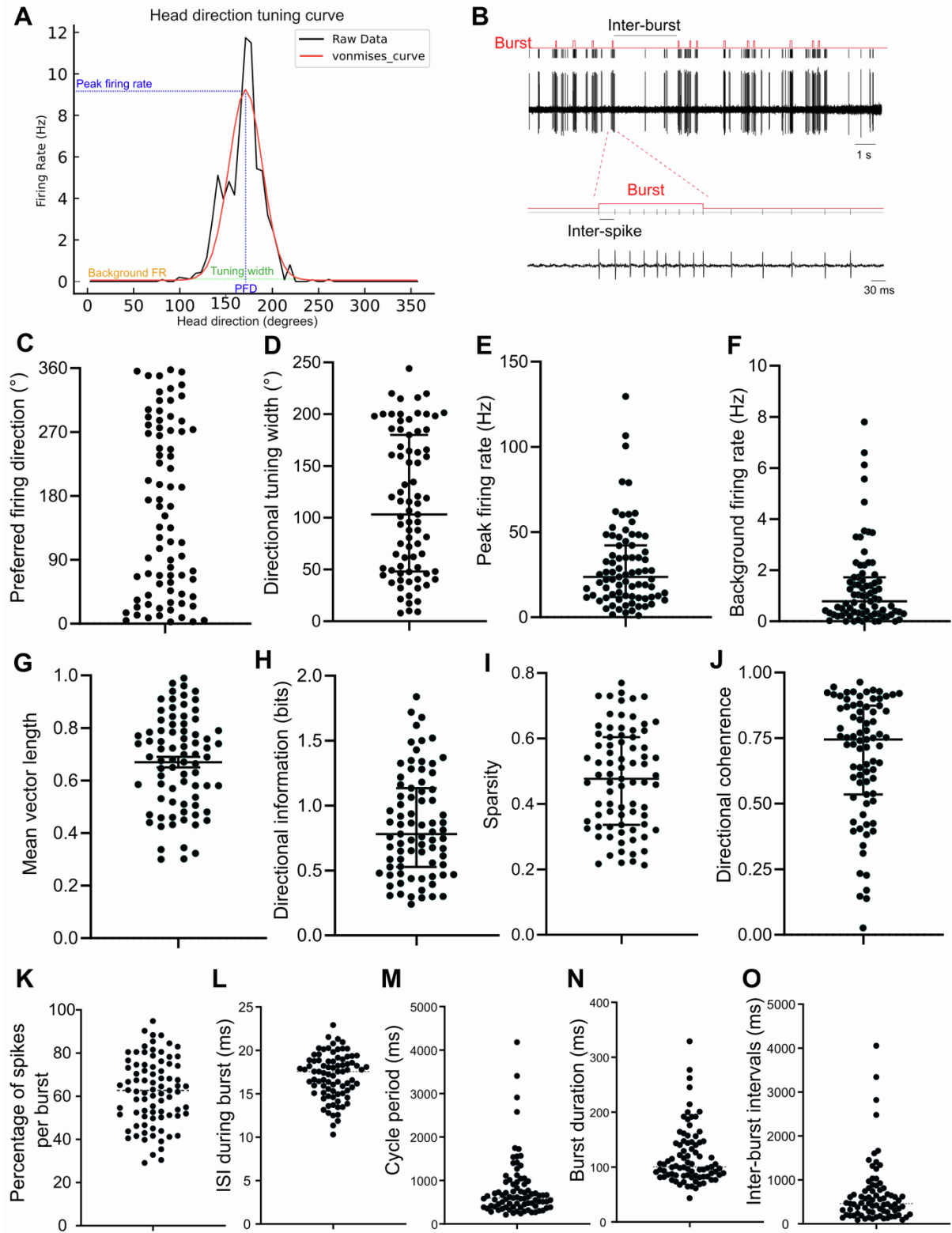


Figure S2. Basic firing and burst parameters of recorded ADn HD cells, related to Figure 1.

Properties of recorded HD cells. **(A)** A schematic of a head direction tuning curve (head direction vs firing rate) showing PFD, peak firing rate, background firing rate, and tuning width of an example HD cell. See Table S1 for further details of each cell. **(B)** Example spike traces of an HD cell illustrating the definition of burst parameters. **(C-J)** Properties of recorded HD

cells: PFD, directional firing range, peak firing rate, background firing rate, mean vector length, directional information content, sparsity, and directional coherence. See Table S1 for further details of each cell. Data presented as median [IQR]. **(K-O)** Burst firing patterns (percentage of spikes per burst, average ISI during burst, cycle period, burst duration, and inter-burst intervals) of ADn HD cells (n=96). Dashed lines, mean.

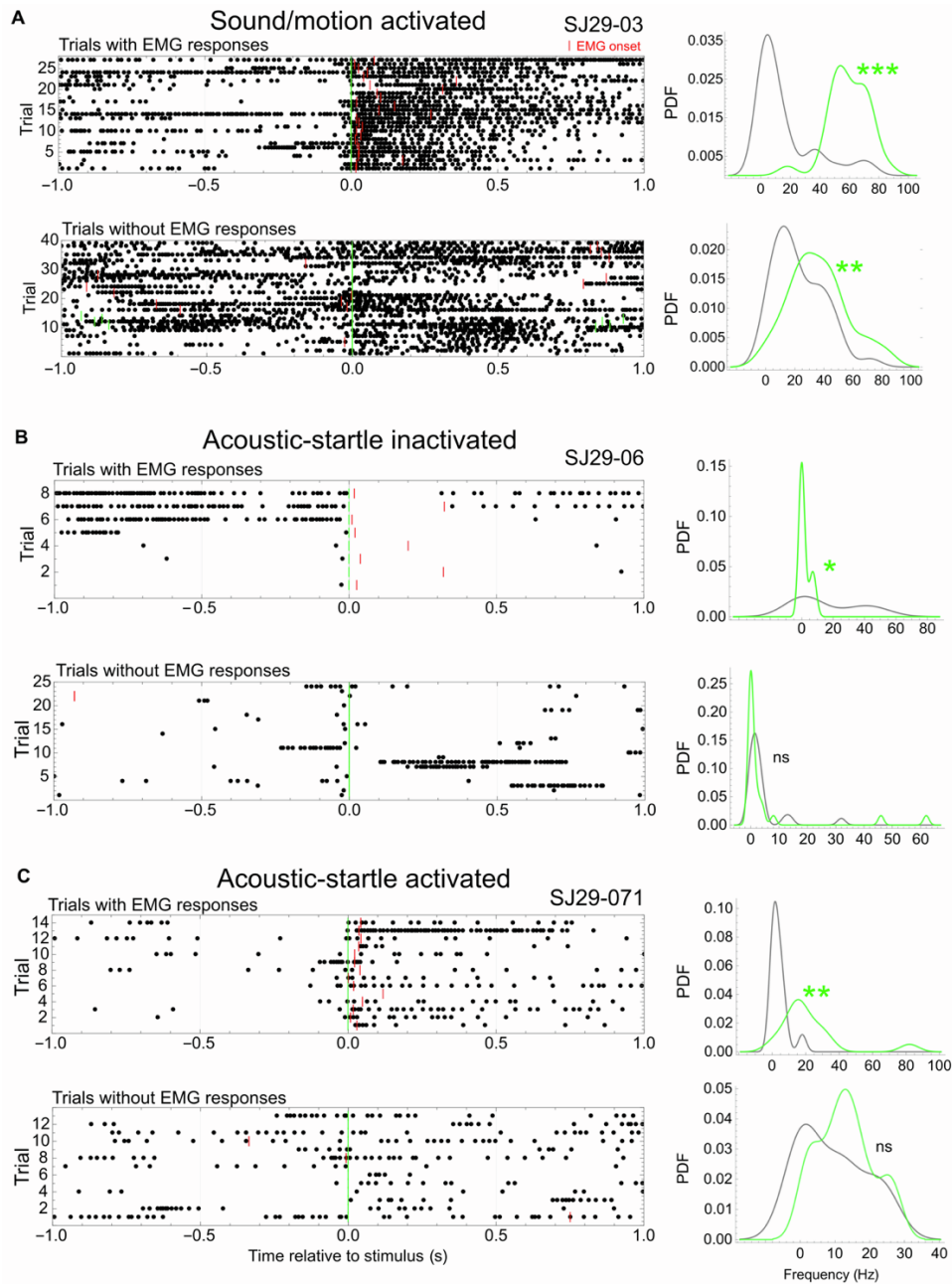


Figure S3. ADn HD cell responses to sensorimotor stimuli, related to Figure 3.

Raster plots (left) and PDFs (right) showing responses to sound stimulus with and without EMG responses separately for cell SJ29-03 (A), SJ29-06 (B), and SJ29-071 (C). In raster plots, each point represents a spike, green ticks show other sound onset events, and red ticks mark the onset time of abrupt EMG increases. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; ns, not significant.

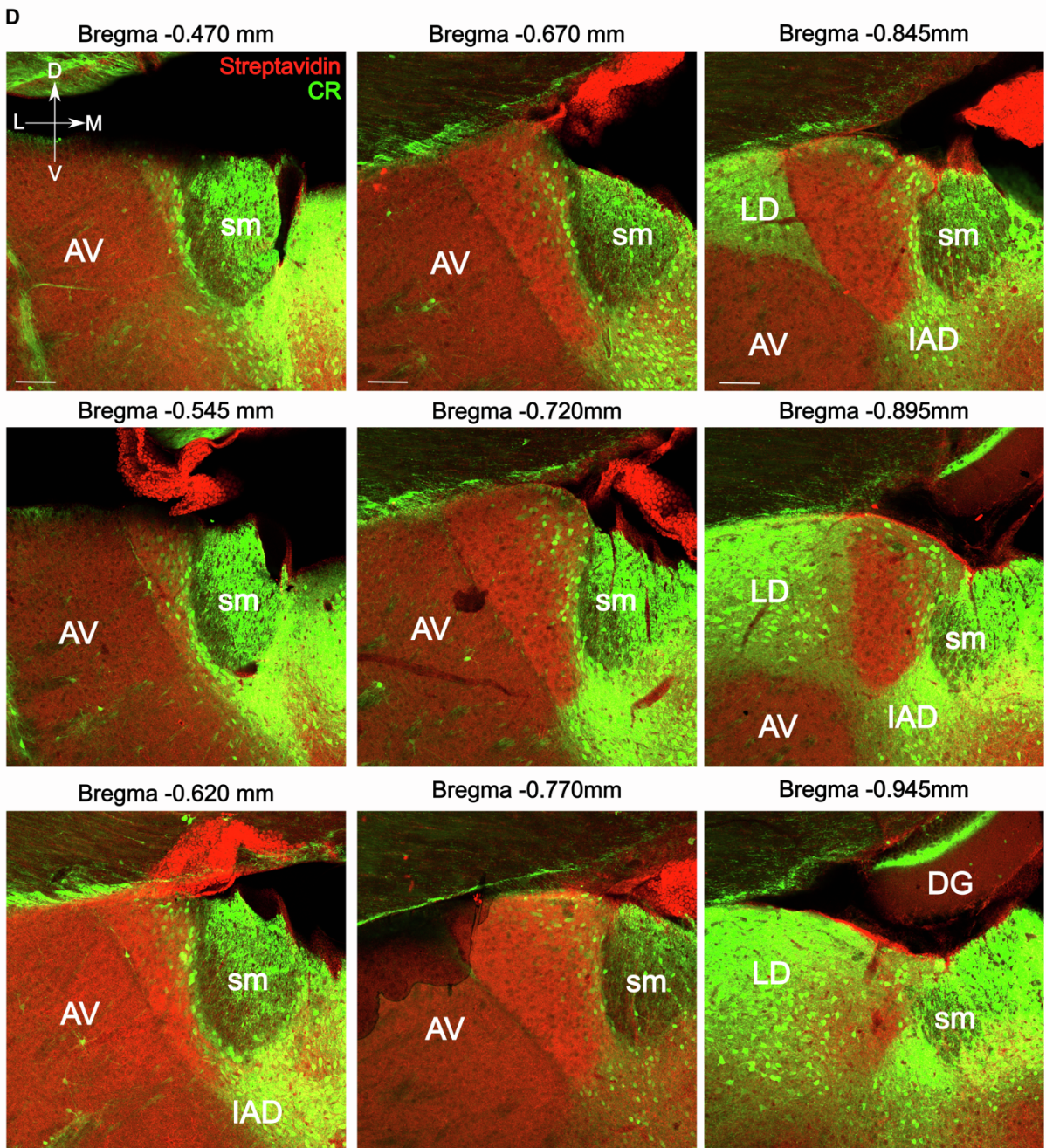
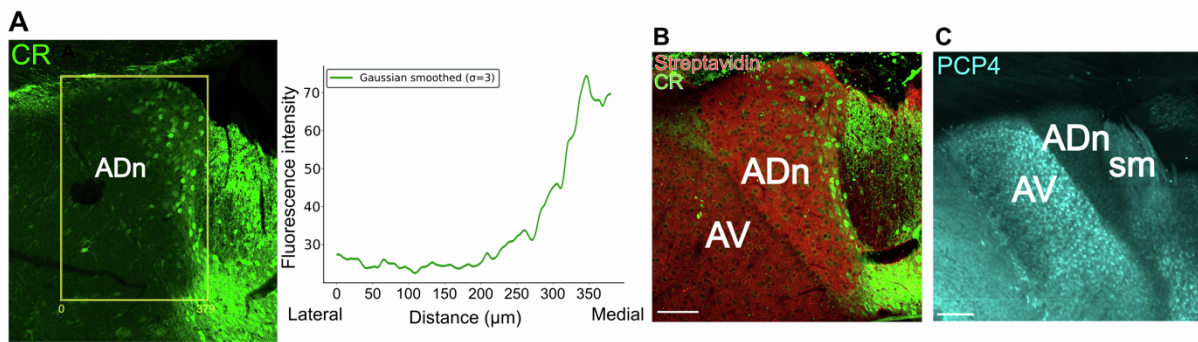


Figure S4. Calretinin immunoreactivity in the anterior thalamus, related to Figure 4.

(A) Left, mediolateral gradient of calretinin (CR) in the ADn (coronal brain section). Right, histogram of fluorescence intensity (gray values) for CR based on the region of interest (box). (B) Gradient in mouse ADn shown with a different antibody for CR (rabbit anti-CR antibody from Swant); (C) PCP4 immunoreactivity in mouse AV, case TV183. Scale bars, 200 μ m. (D) Single confocal optical sections of coronal brain sections showing CR immunoreactivity, case TTPS8.5d. Scale bars, 100 μ m. L, lateral; M, medial; D, dorsal; V, ventral. AV, anteroventral thalamic nucleus; DG, dentate gyrus; LD, laterodorsal thalamic nucleus; IAD, interanterodorsal thalamus; sm, stria medullaris of the thalamus.

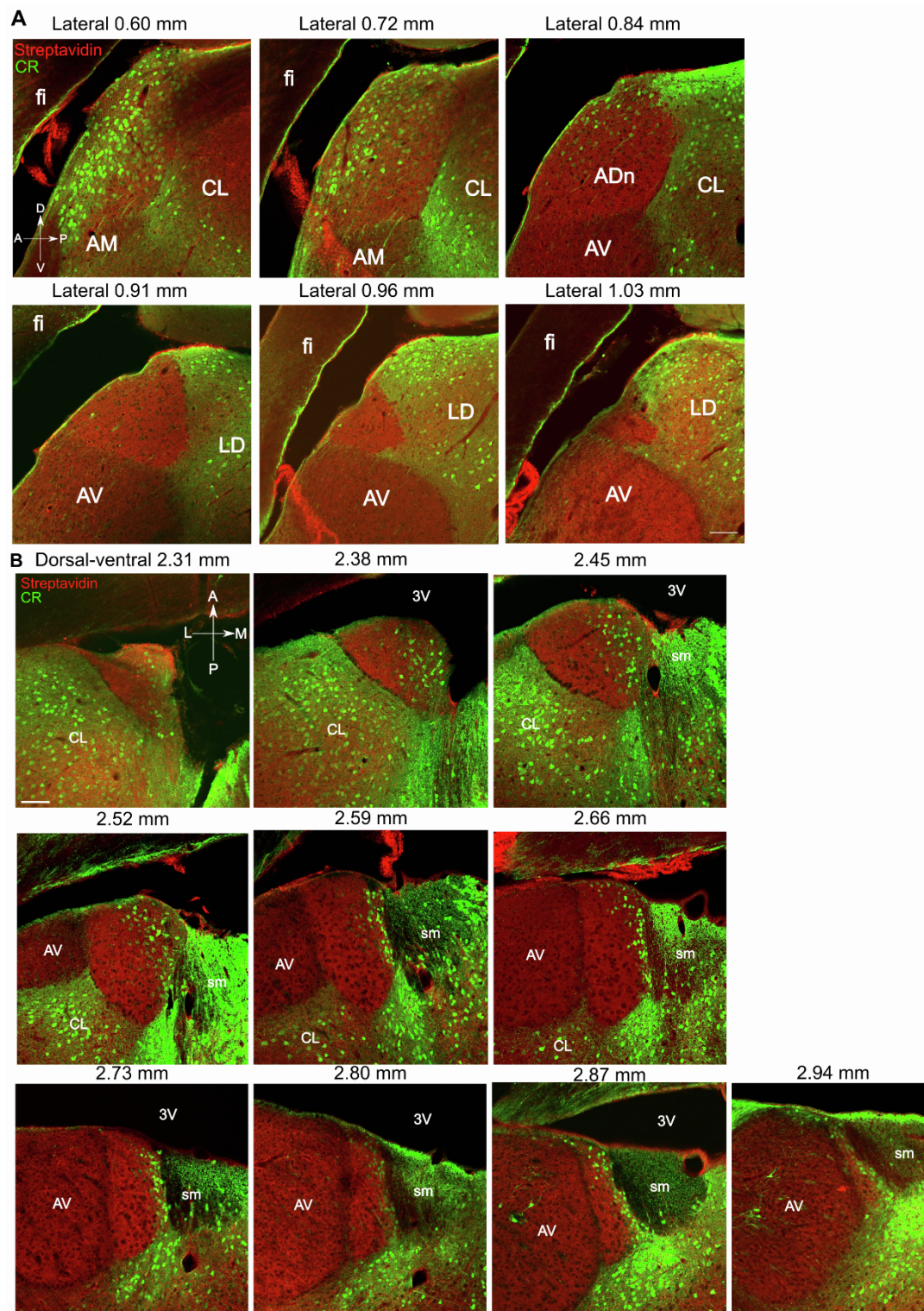


Figure S5. Serial mouse sagittal and horizontal sections tested for calretinin, related to Figure 4.

(A, B) Sagittal sections (A) and horizontal sections (B) containing the anterior thalamus. Single optical sections, from mouse SJ33 (A) and mouse M311 (B). Abbreviations: A, anterior; P, posterior; D, dorsal; V, ventral; L, lateral; M, medial; AV, anteroventral thalamic nucleus; AM, anteromedial thalamic nucleus; CL, centrolateral thalamic nucleus; fi, fimbria; sm, stria medullaris. Scale bars, 100 μ m.

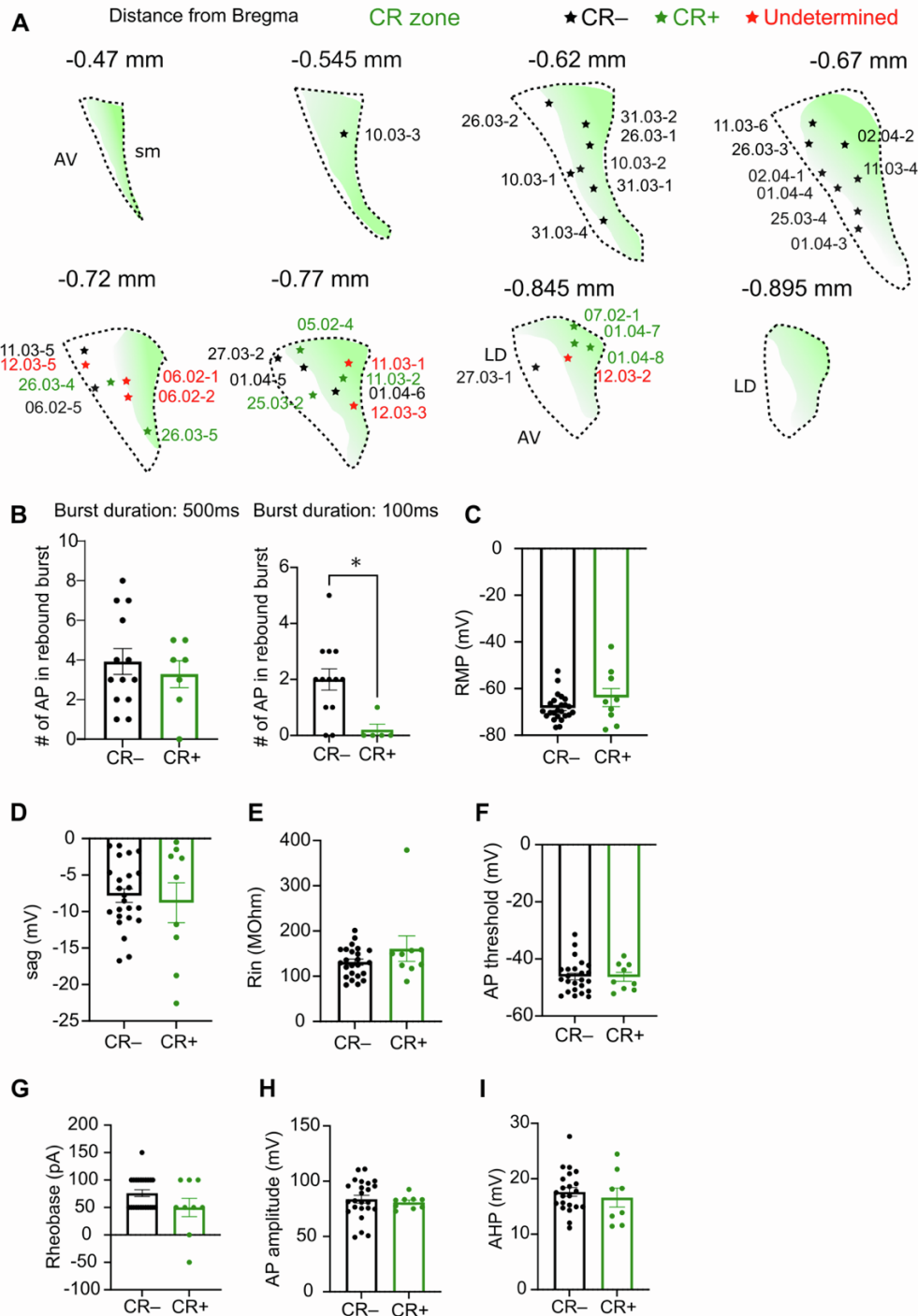


Figure S6. Map of *ex vivo* recorded ADn cells, and their passive and active properties, related to Figure 4.

(A) Schematic map showing the locations of recorded ADn cells along with their names (green stars: labeled CR+ cells; black stars: labeled CR− cells; red stars: undetermined cells). Shaded areas indicate regions of CR immunoreactivity ('CR zone'). (B) Number of action potential (AP) within the rebound burst following 500 ms (left) and 100 ms (right) hyperpolarizing current. (C) Resting membrane potential (RMP) in mV. (D) Sag ratio (mV). (E) Input resistance (Rin) in MΩ. (F) AP threshold in mV. (G) Rheobase in pA. (H) Action potential (AP) amplitude in pA. (I) Afterhyperpolarization potential (AHP) in mV (n=13 CR− and n=7 CR+ cells from 8 mice).