

Near-strict 1-spike-per-cycle ceiling: 98.9% of (cell, cycle) pairs

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Abstract

exp041's slope $p \approx 0.20$ was interpreted as “each *E* cell joins a cycle with $\approx 20\%$ probability”. That reading assumes the per-cycle spike count is bounded by 1 (an *E* cell either participates in this cycle or not). This notebook measures that directly: walking through every gamma cycle on the test set and counting how many spikes each *E* cell actually emits, on all 18 trained checkpoints in exp041's τ_{GABA} sweep.

Methods

For each of exp041's 18 trained cells ($6 \tau_{\text{GABA}} \times 3$ seeds):

1. Run inference on the MNIST test set; capture per-trial (T, B, N_E) and (T, B, N_I) spike tensors.
2. Detect I-burst times per trial: smooth the population I rate with a 1-ms Gaussian, run scipy peak detection with min-distance set to half the cell's own $1/f_\gamma$.
3. Cycle boundaries are the midpoints between consecutive I-burst peaks (first cycle starts at $t = 0$, last ends at trial end).
4. For each (cell, cycle, trial), count the number of *E* spikes within the cycle window.
5. Bucket counts globally into $\{0, 1, 2, \geq 3\}$ and aggregate by τ_{GABA} .

The cycle anchor is the I-burst: this is the right anchor because the cycle is operationally defined as “the time between one inhibitory blanket and the next”, not as the time between *E* bursts (which can be silent on a given cycle).

Results

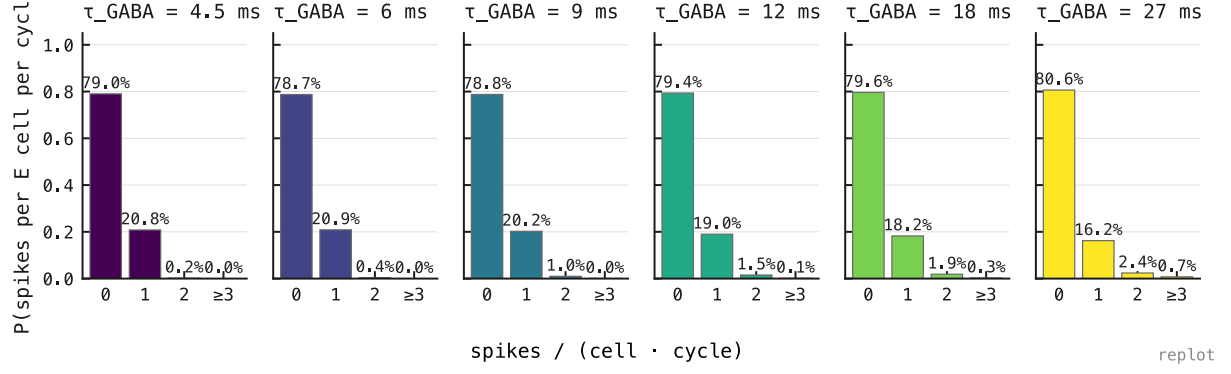


Figure 1: Distribution of E spike count per gamma cycle per cell, by τ_{GABA} , three seeds aggregated. Across **179 million (cell, cycle) pairs**, the architecture is overwhelmingly bimodal: each cell either emits zero spikes in a given cycle ($\approx 79\%$ of the time) or exactly one ($\approx 20\%$ of the time). Two-or-more events occur in $\approx 1.1\%$ of cycles; three-or-more in $\approx 0.14\%$. Pooled over the sweep, 98.9% of pairs carry at most one spike.

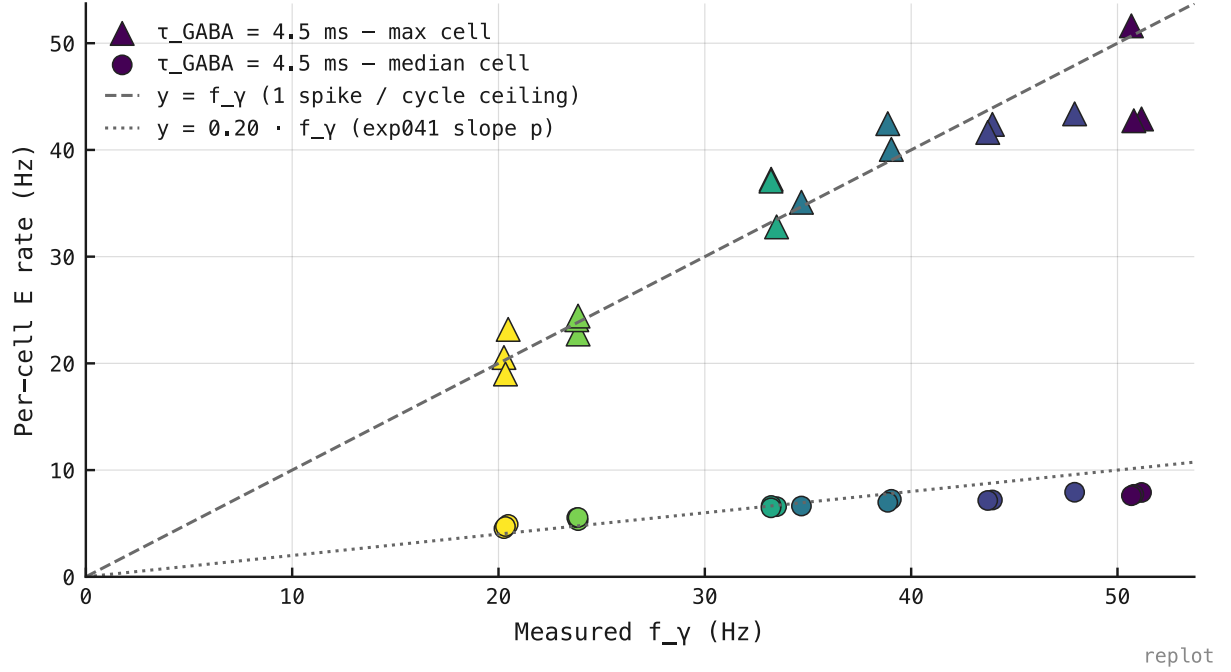


Figure 2: Per-cell E rate versus measured gamma frequency f_{γ} across the τ_{GABA} sweep. The busiest cell in each network tracks the one-spike-per-cycle ceiling $r = f_{\gamma}$ (max-cell fit $r = 0.97f_{\gamma}$, $R^2 = 0.88$), while the median cell sits on exp041's shallower $r \approx 0.20f_{\gamma}$ participation slope. The ceiling is near-strict: even the most active cell rarely exceeds one spike per cycle.