The hippocampal circuit

Trisynaptic circuit through dentate gyrus, CA3, and CA1 originates and terminates in entorhinal cortex (insert, rat brain). p-p, point-to-point; f, fanning; SI, subiculum; PAS/PRS, pre/parasubiculum [Lisman99, Moser06].
Gamma oscillations in vitro

a. Blocking GABAa receptors eliminates mGluR-agonist induced oscillations.
b. Oscillations occur at 30-40Hz.
c. Left: Blocking AMPA or GABAa receptors eliminates mAChR-agonist induced oscillations. Right: Blocking GABAa receptors eliminates kainate-induced oscillations but blocking AMPA receptors does not.
Models of Gamma Synchrony

- Wang and Buzsaki (1996) used:
  - Hyperpolarizing inhibition
  - With slow decay constant and weak strength
  - Synchrony was fragile

- Jonas et al. (2002) measured:
  - Fast, strong inhibition in hippocampal basket cells
  - Yielded robust synchrony (together with axonal delays)

- Jonas et al. (2006) showed that inhibition was shunting:
  - More robust synchrony
GABAergic synapses

a. Synaptically coupled pair of basket cells.
b. Basket cell synapses onto basket cells are faster than those onto granule cells.
c. Postsynaptic currents’ rise-time and decay-constant are fast in every region.
d. Fast-spiking cortical cells also induce fast currents (IPSC); resulting voltage signals are slower (IPSP).
Shunting inhibition

a. Recording showing fast-spiking phenotype superimposed on image of basket cell soma.
b. Postsynaptic currents evoked at various holding potentials.
c. Current-voltage relationship from the data. Resting potential is -59mV; spike threshold is -38mV.

Modeling results: Shunting is more robust
Model had 200 neurons, each inhibited to 57 of its 100 nearest-neighbors on a ring, with 0.25 m/s axonal conduction delay (0-10 ms) and 0.5 ms synaptic delay. In addition, each neuron was electrically coupled to 4 of its 8 nearest neighbors.
Why is shunting more robust?

- It homogenizes firing rates:
  - Slows down fast cells
  - Speeds up slow cells

In contrast, hyperpolarizing slows down both fast and slow cells.

**Hyperpol**

5, 4, 3, 2, and 1 μA cm⁻²

**Shunting**