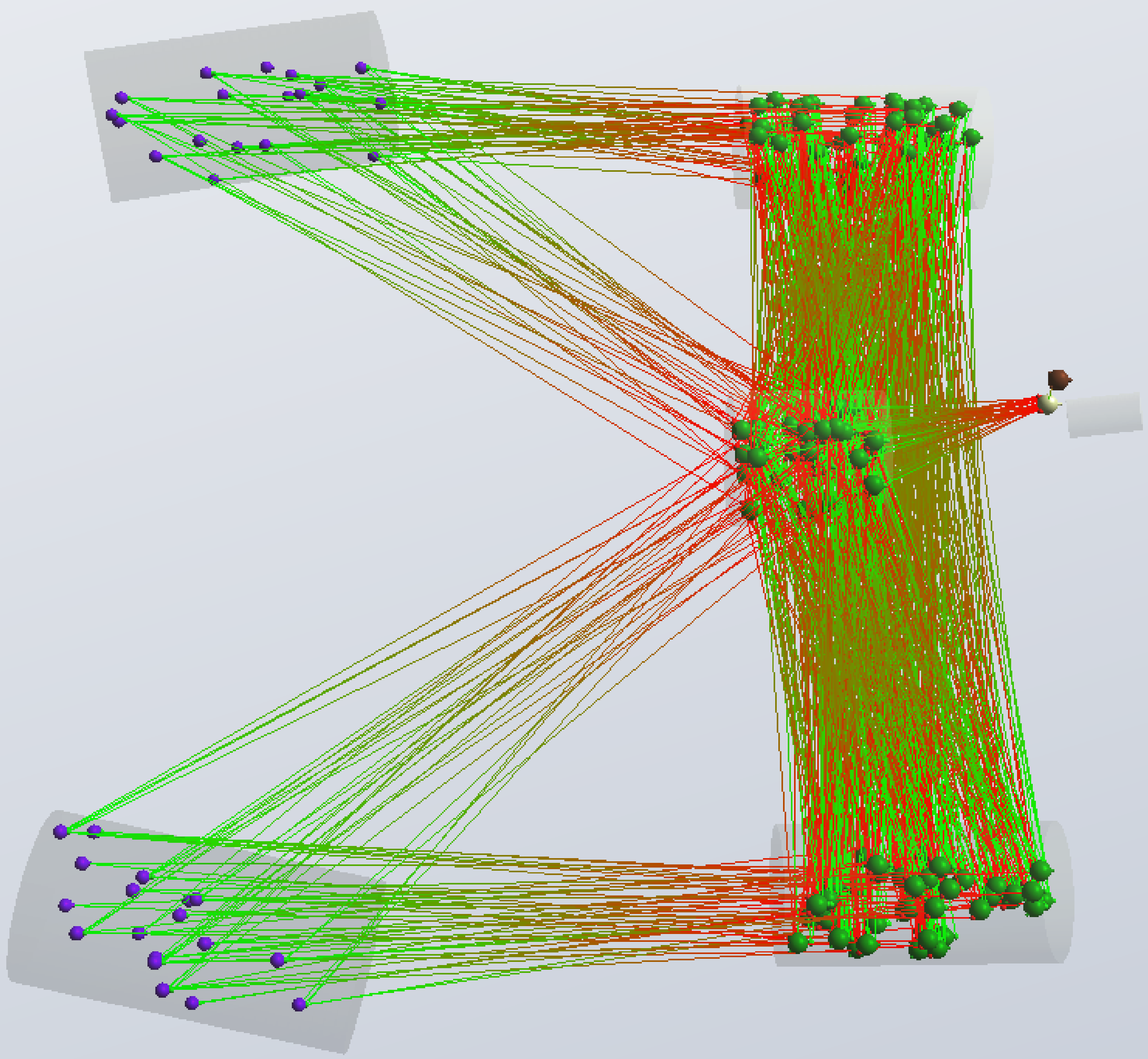
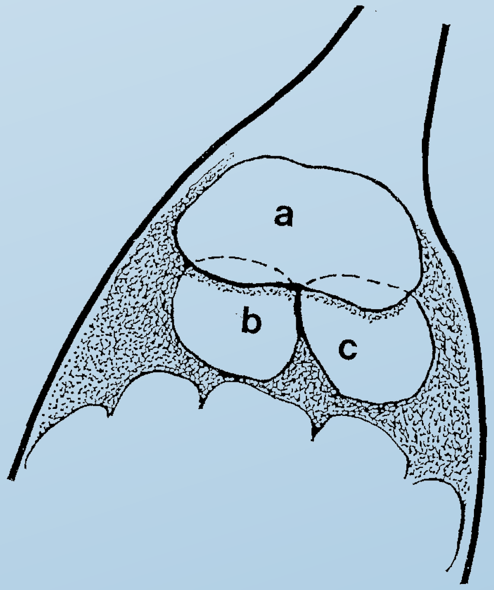
The competition-based model:
A variable number of LN per glomerulus remix

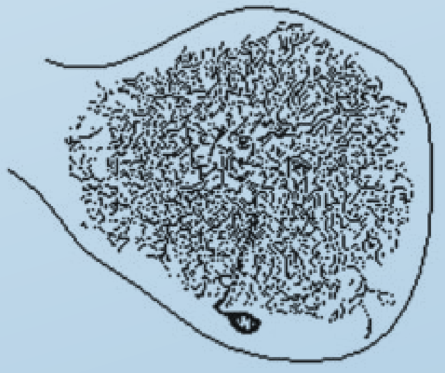


Relevant facts about *Spodoptera littoralis* MGC

- Two pheromone components, one of which is accessory;
- Two ORN types to match;
- Three glomeruli of different size;



- Profuse arborisations on inter-LN connections;



- Connections between LNs are inhibitory (GABA-ergic), as well as those between LNs and PNs;

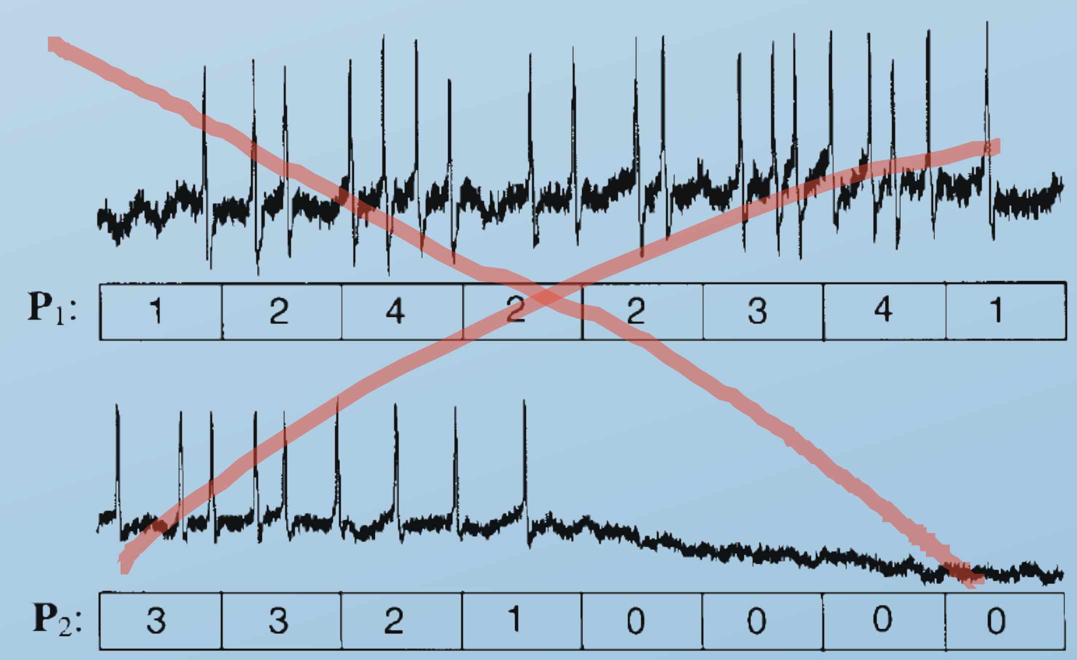
Ochieng SA, Anderson P, Hansson BS. Tissue & Cell, 1995, 27(2):221–32.

Hansson BS & Anton S. Annu. Rev. Entomol., 2000, 45:203–31.
Christensen TA et al. BioSystems, 2001, 61:143–53.

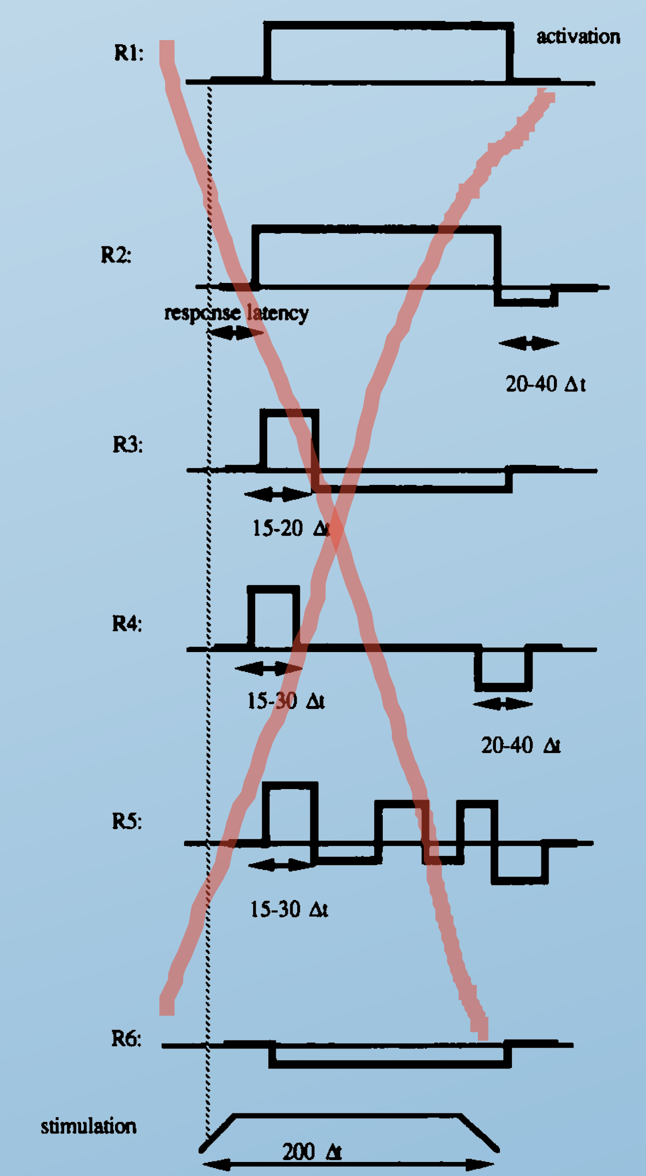
Relevant model characteristics

- Competition between LNs as the underlying principle;
- Both specialist and generalist LNs;

- No temporal aspects whatsoever;
- No spontaneous activity in LNs;
- Feedforward, mapping mechanism;

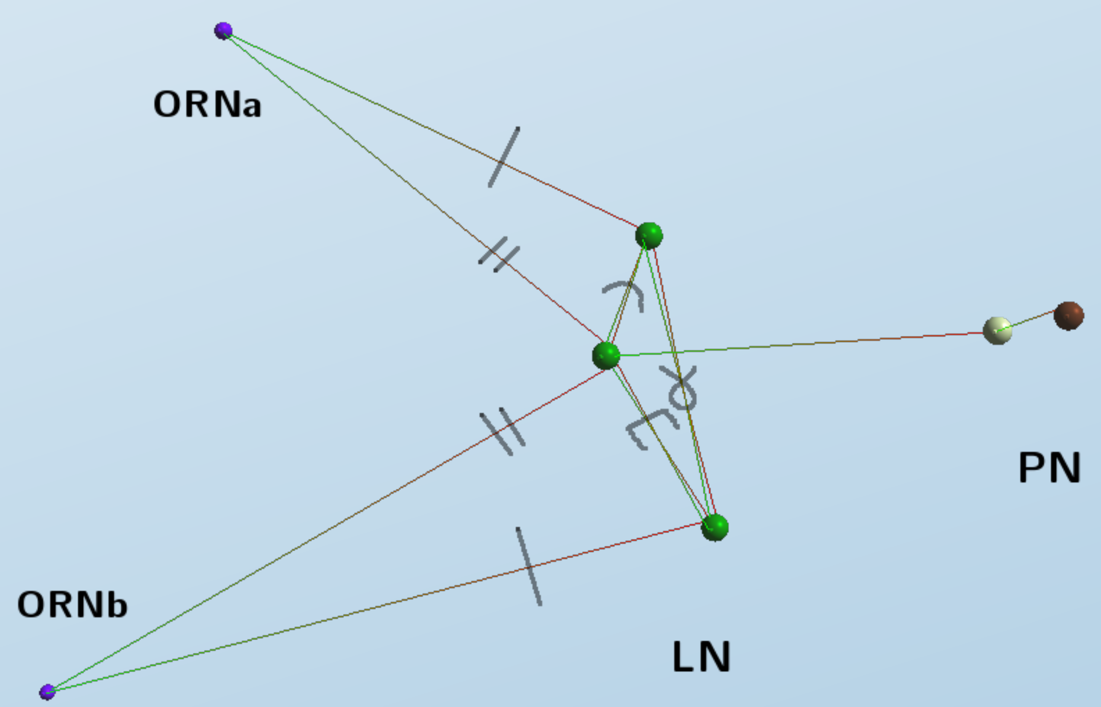


Getz WM & Lutz A. Chem Senses, 1999, 24:351–72.



Linster C et al. Neural Computation, 1993, 5:228–41.
Linster C & Dreyfus G. Chem. Senses, 1996, 21:19–27.

Model I:
Fixed connections, variable inter-LN synaptic weights



Connections tuned:

- $g_{\text{ORN-LN(sp)}}$
- $g_{\text{ORN-LN(gen)}}$
- $g_{\text{LN-LN(sp-gen)}}$
- $g_{\text{LN-LN(sp-sp)}}$
- $g_{\text{LN-LN(gen-sp)}}$

ORNs

- Poisson oscillators with rate log proportional to pheromone component concentration;
- Output equivalent to 200 Poisson units firing at a rate of 0.01÷0.05Hz;
- 'Spikes' have no duration, ORNs have no refractory period, and multiplexing synapses can carry >1 spike at any given time;

LNs, PNs

- Hodgkin–Huxley neurons (map neurons proved unreliable);
- 5-6th order Runge–Kutta integration ($10^{-5} < \mathrm{dt} < 0.5\,\mathrm{ms}$);

Destexhe A et al. J Comput Neurosci. 1994, 1(3):195–230.
Traub RD, Miles R et al (several sources).

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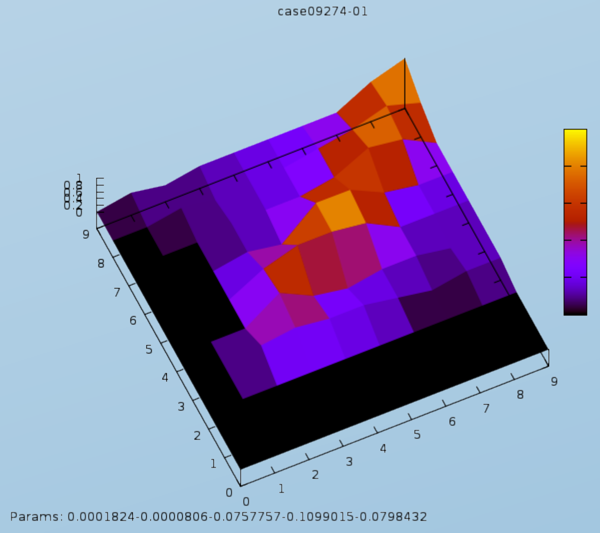
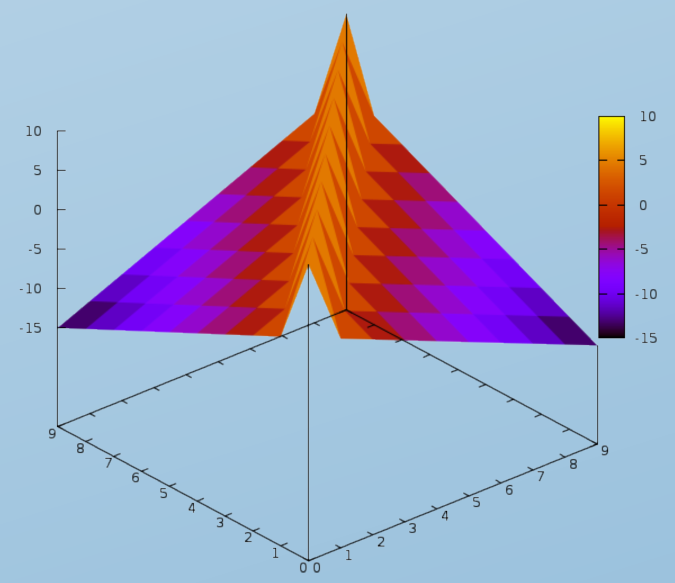
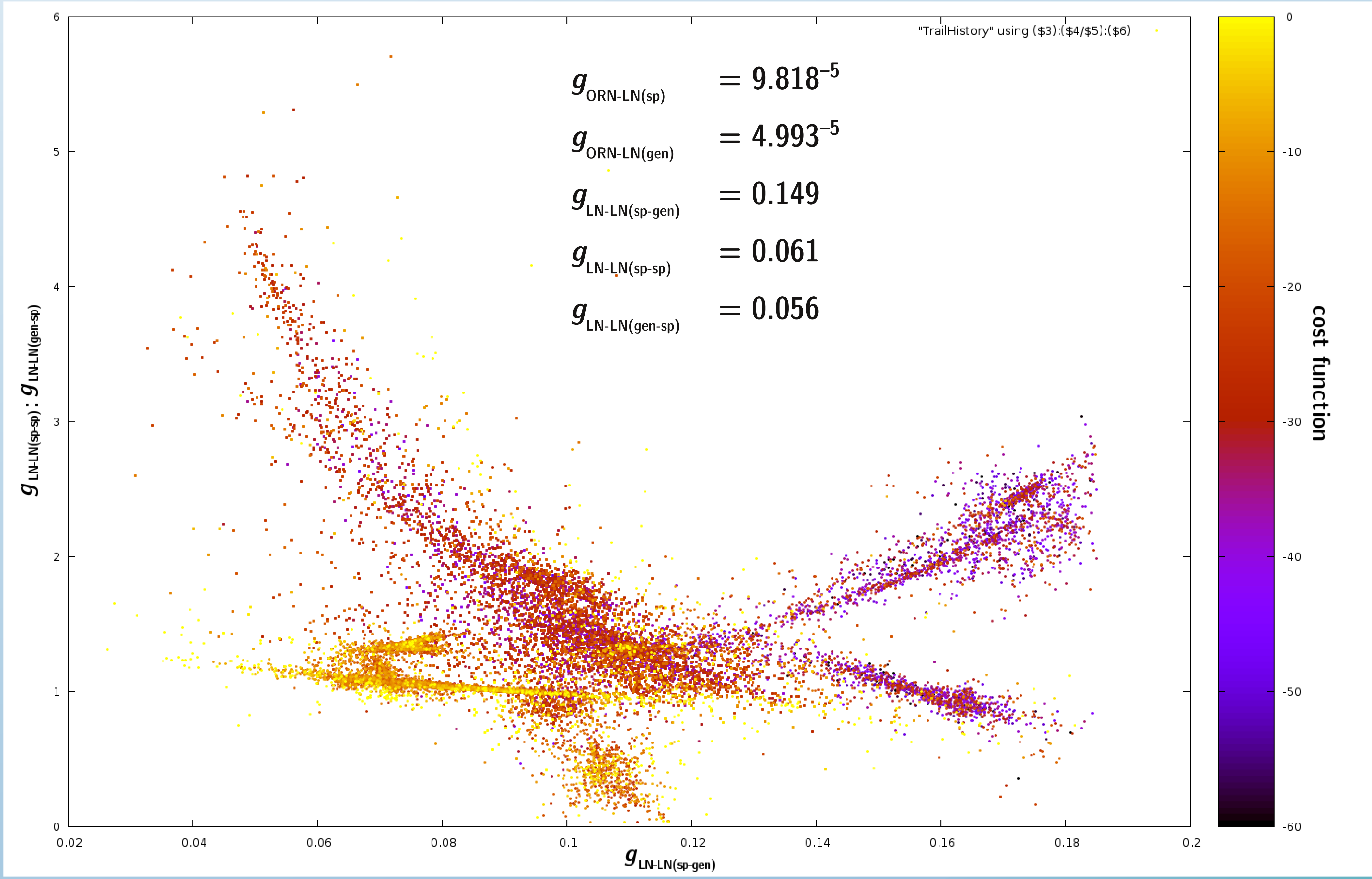
Model I:
Protocol for a 1:1 ratio detection

- All 10×10 combinations of input concentrations in the range 2.0÷21.2, with $n_{i+1} = n \times 1.3$, 250 ms pulses spaced by 250 ms;
- A matrix of outcomes (concentration×concentration) convoluted against a target matrix, giving a cost function;
- Minimised the cost function of 5 parameters via simulated annealing for the Nelder–Mead method;





Model I:
Results



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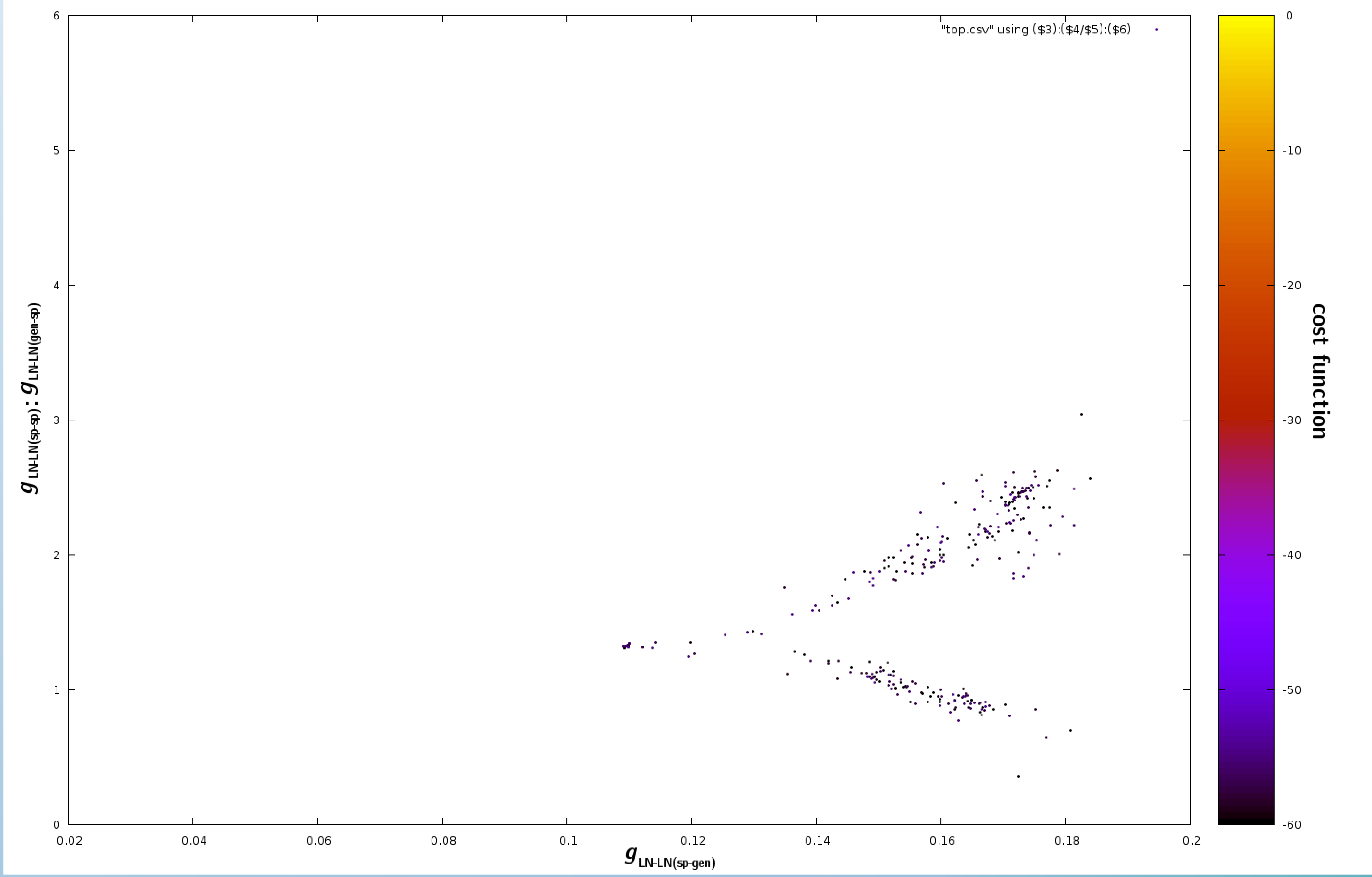
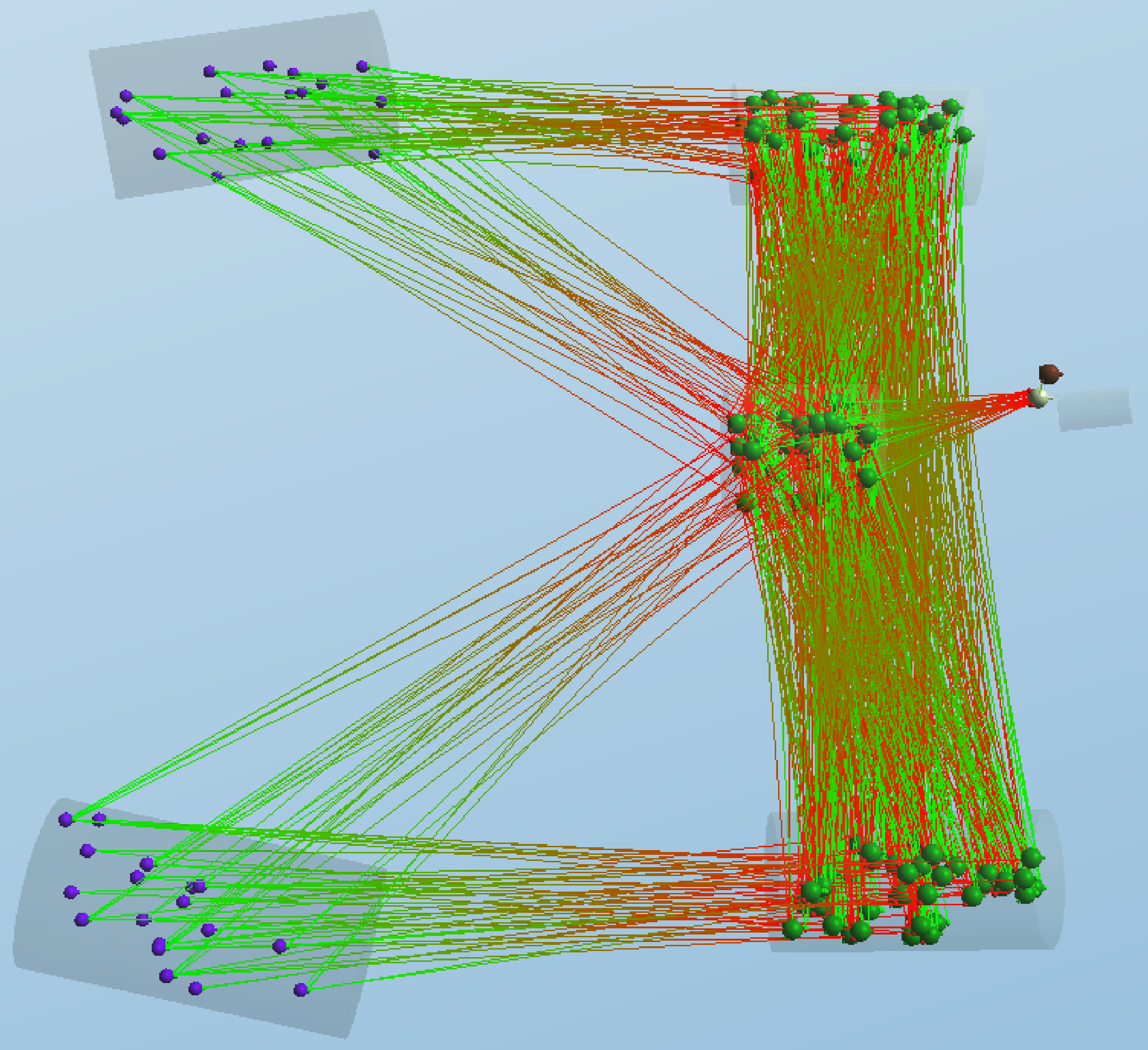
Model I:
Results (top 300 points)



Model II:
Fixed inter-LN synaptic weights, variable LN count

- Each LN connects to 3 LNs in either target glomerulus;
- Tuning the number of LNs in each glomerulus;
- Leaving all inter-LN *g* fixed and identical;
- Using map neurons and synapses (discrete $\Delta \mathrm{t} = 0.5 \mathrm{ms}$);



Model II:

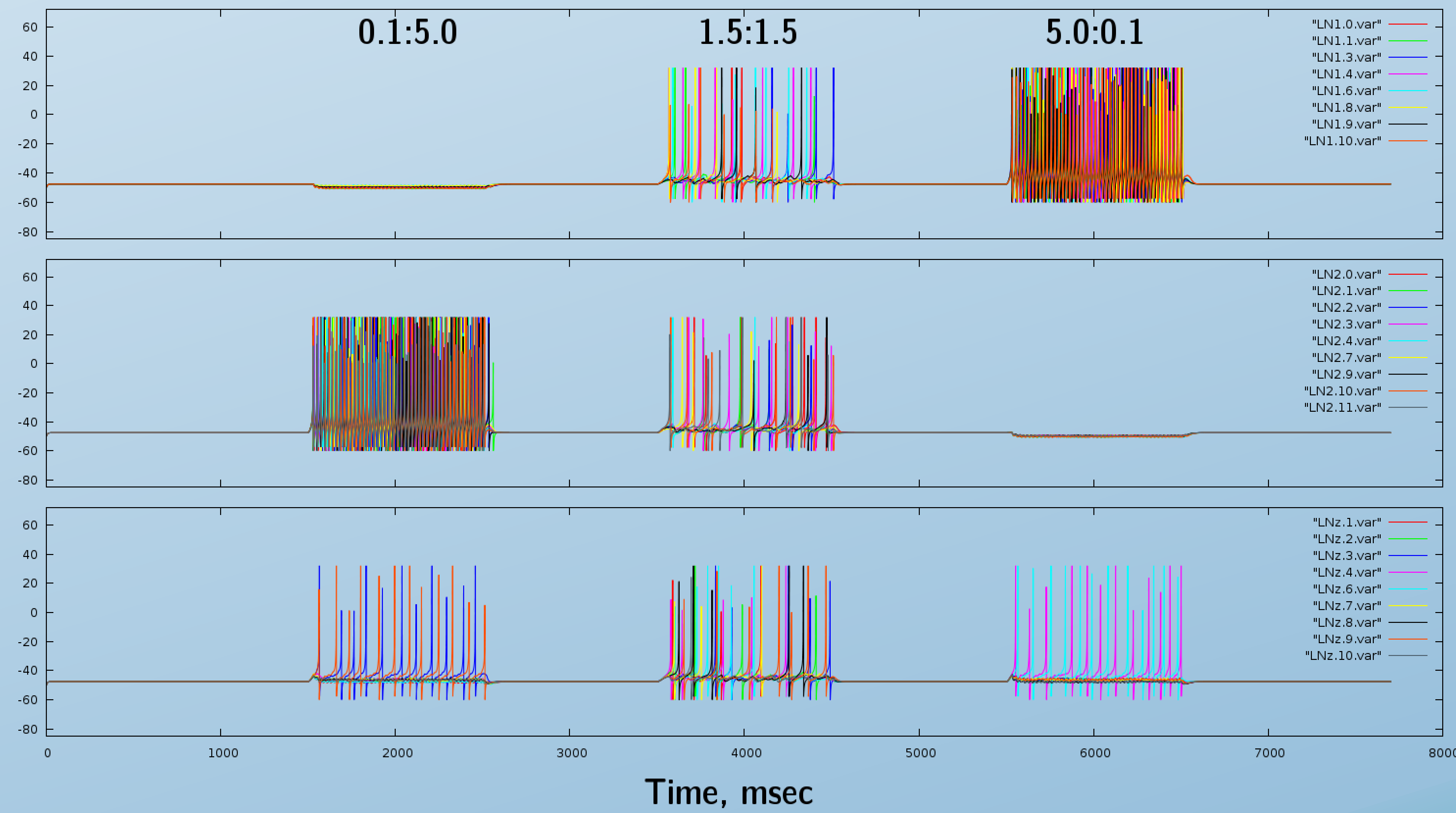
Parameters, and preliminary results

1:1 ratio

$g_{\text{LN-LN}} = 0.00288$

percent LNsp = 79.6

percent LNgen = 92.8



General results

- For the variable synaptic weight model (type I), the inter-specialist weight to generalist-specialist weight ratio appears to be critical, and converges towards ~1.1:1.
- For the variable LN count model (type II), ... One outstanding issue is how sparse the inter-LN connections should be.