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Creating 3D models of the cerebellum cortex

Sergio Solinas[1], Egidio D'Angelo[2]

1 University of Sassari

2 University of Pavia, IRCCS C. Mondino - Pavia

Overview

- Cerebellum Granular layer network model (SENSOPAC; Solinas, Nieus, D'Angelo Frontiers in Cellular Neuroscience 2010)
- Cerebellum Granular layer network model (IRCCS C. Mondino: REALNET-ICT)
- New Models of Cerebellum cells:
  - Unipolar Brush cell model (Subramaniyam et al. 2014)
  - Purkinje cell Model (Masoli, Solinas, D'Angelo 2015)

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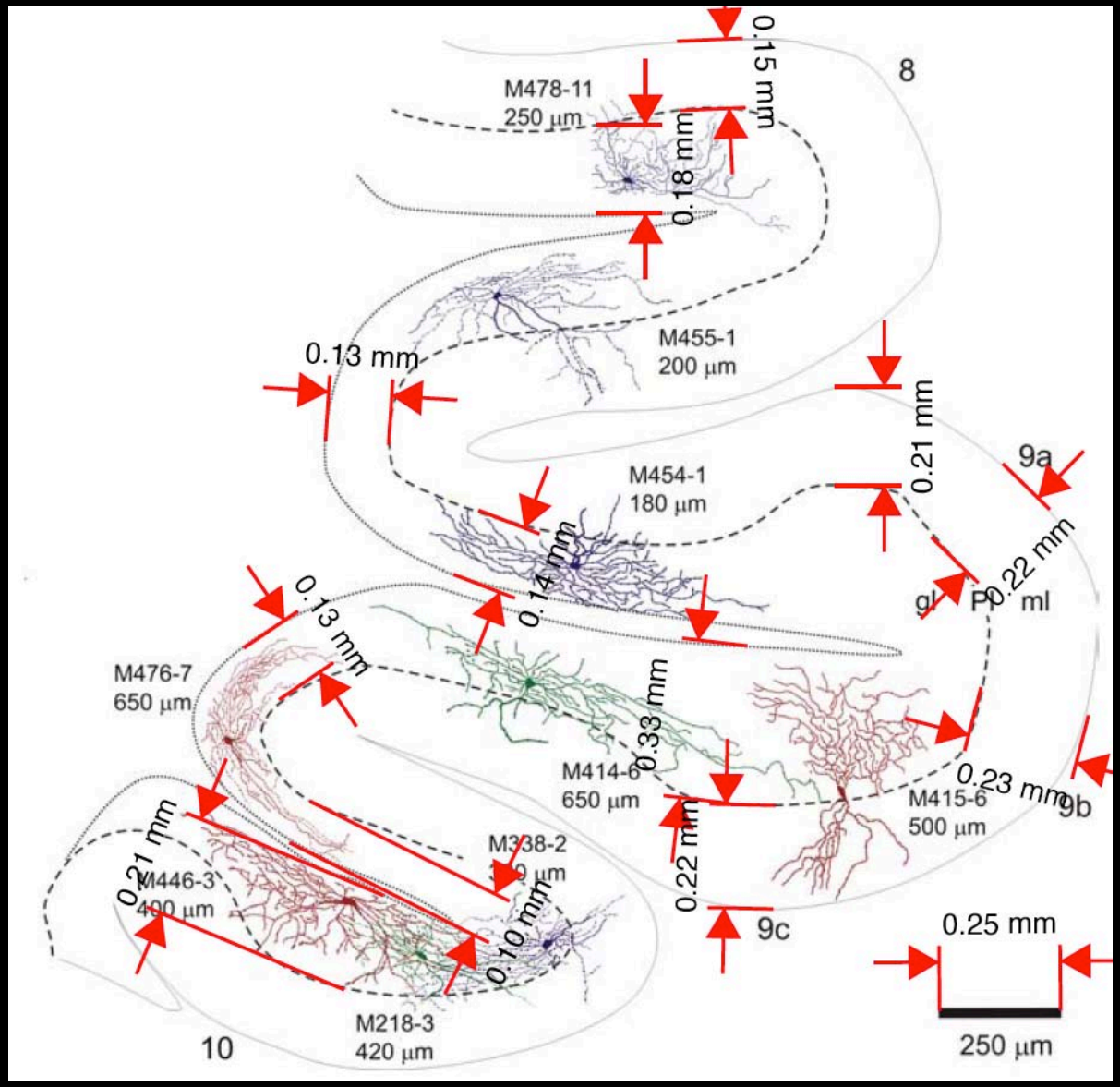
Neurons and Network structure



Barmack and Yakhnitsa 2008

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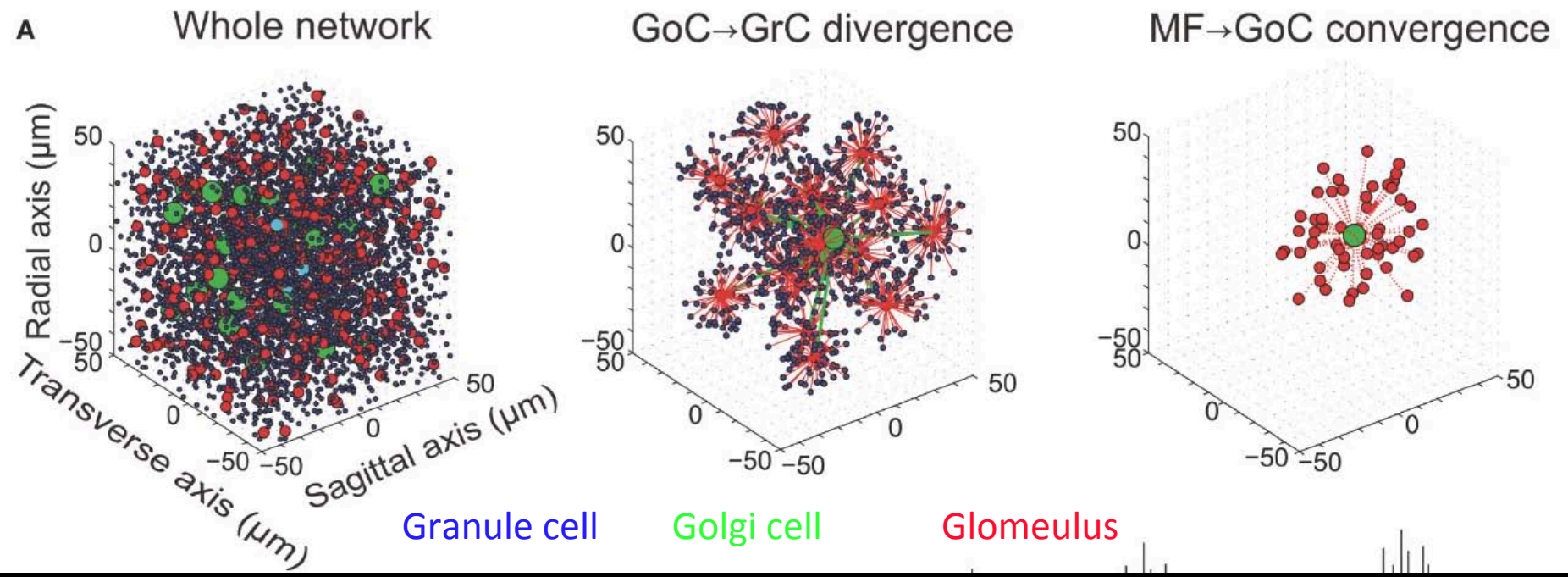
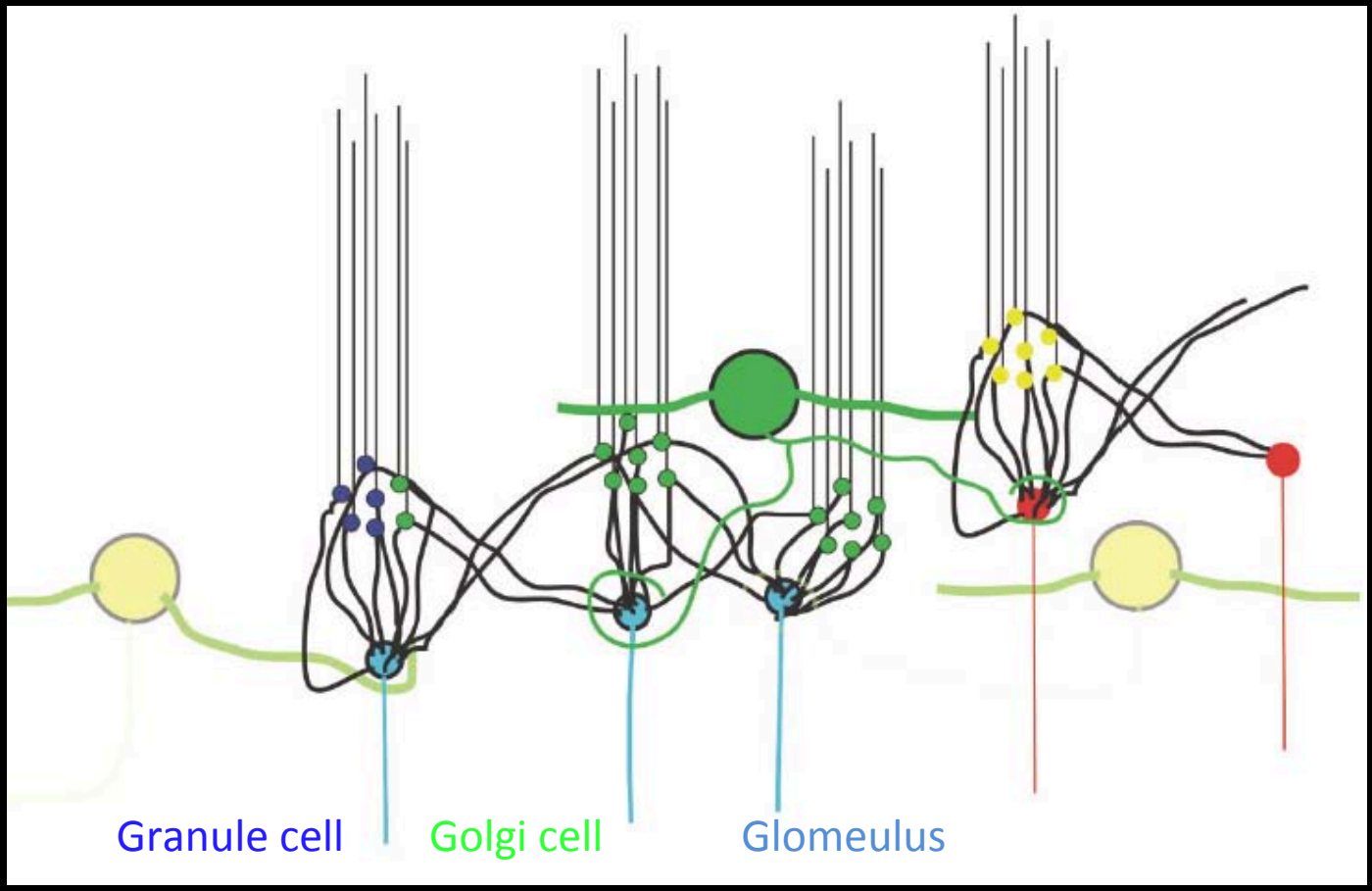
Granular layer network model (2010) NEURON-HOC



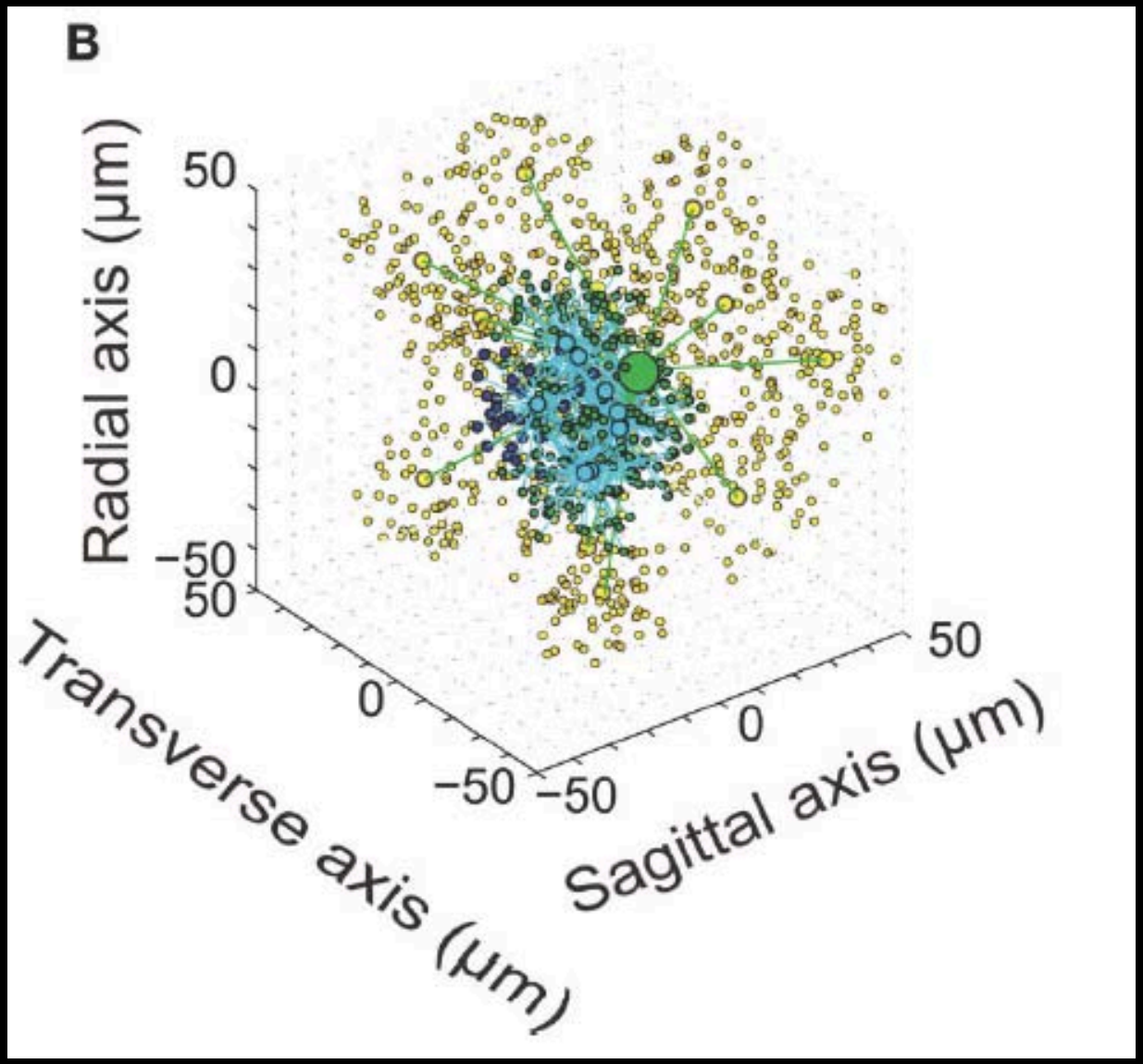
Solinas, Neius, D'Angelo 2010

Connectivity pattern

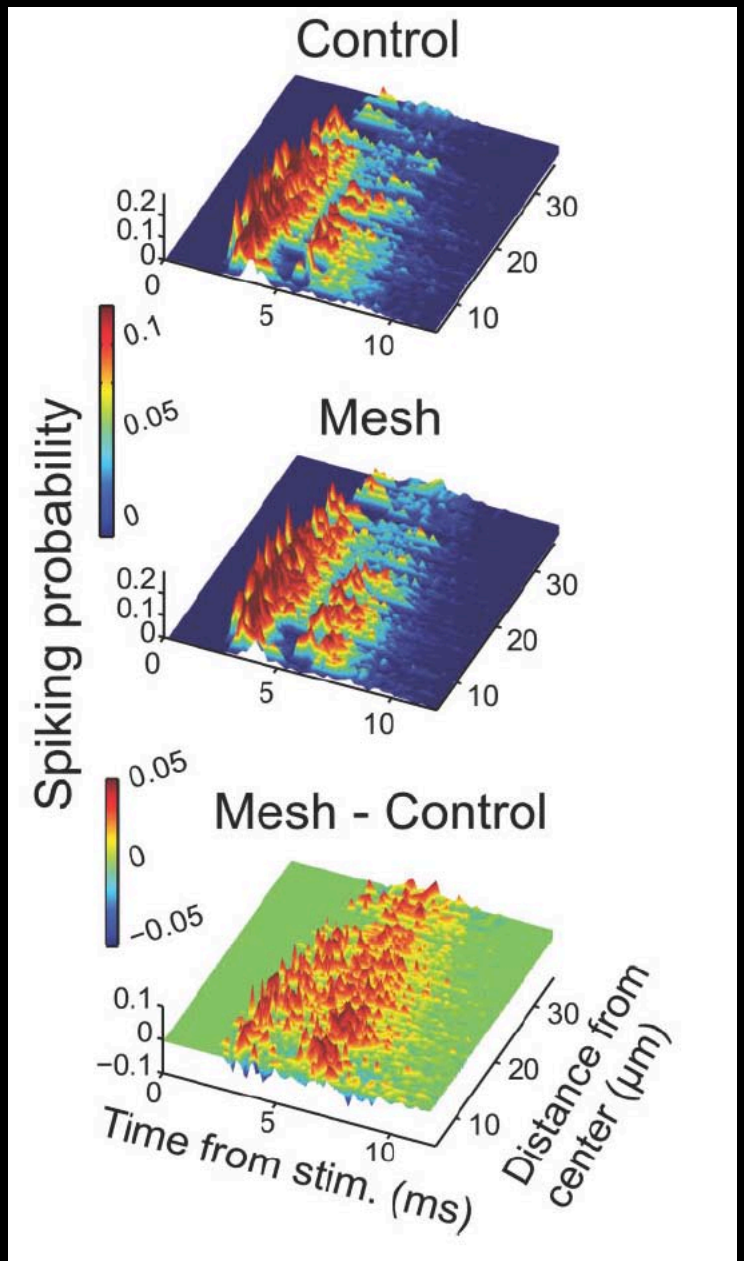


Solinas et al. 2010

Connectivity pattern of a single Golgi cell



Solinas et al. 2010



Spatial and temporal pattern of activation of the granular layer

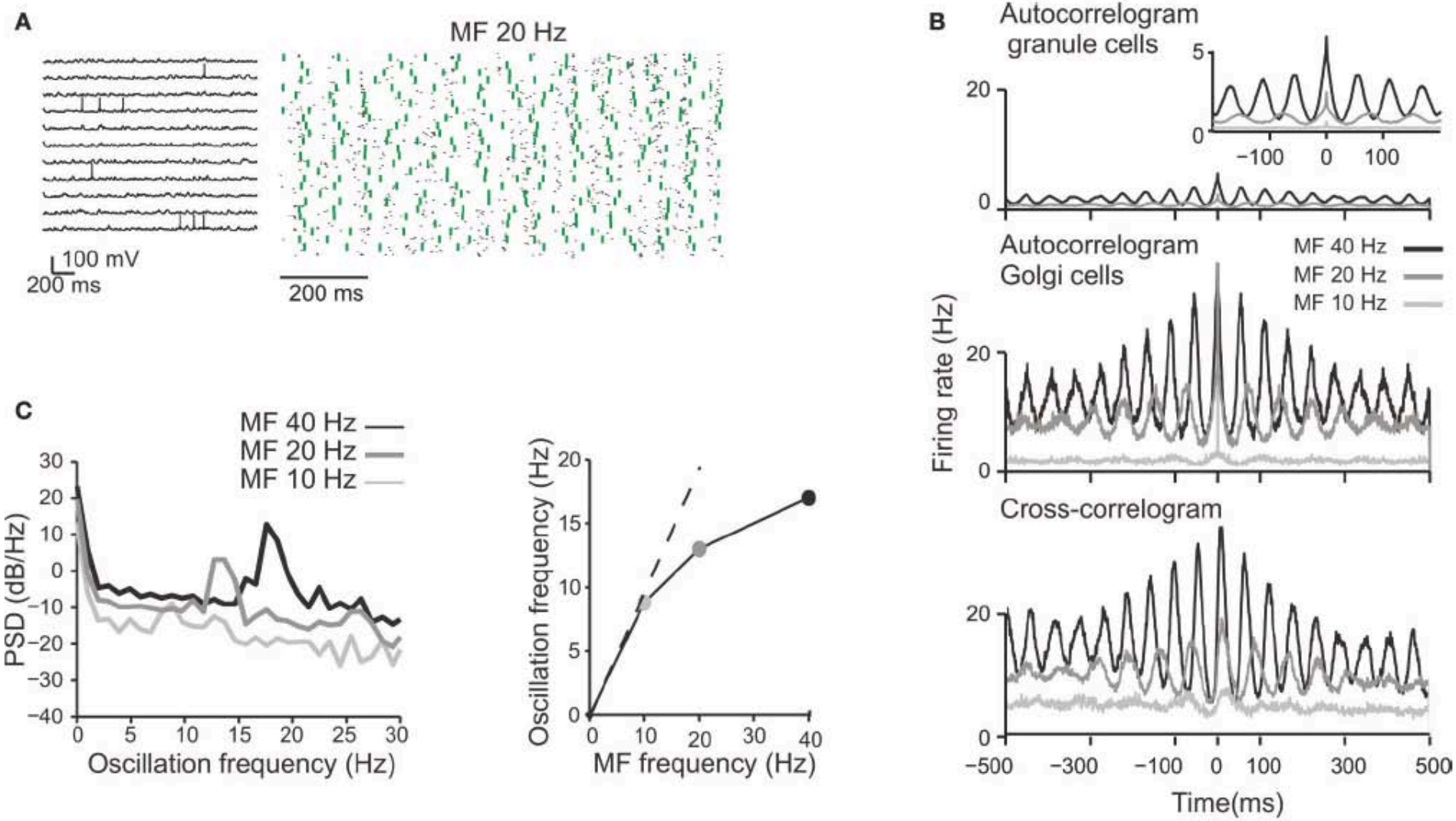
Biologically realistic network

Randomly connected network

Difference

Solinas et al. 2010

Spontaneous oscillations emerge from background activity
(Meax and De Schutter 1998)



Solinas et al. 2010

The network model was :
NOT scalable
NOT parallel
NOT modular

The code was based on many obscure *ad hoc* functions.

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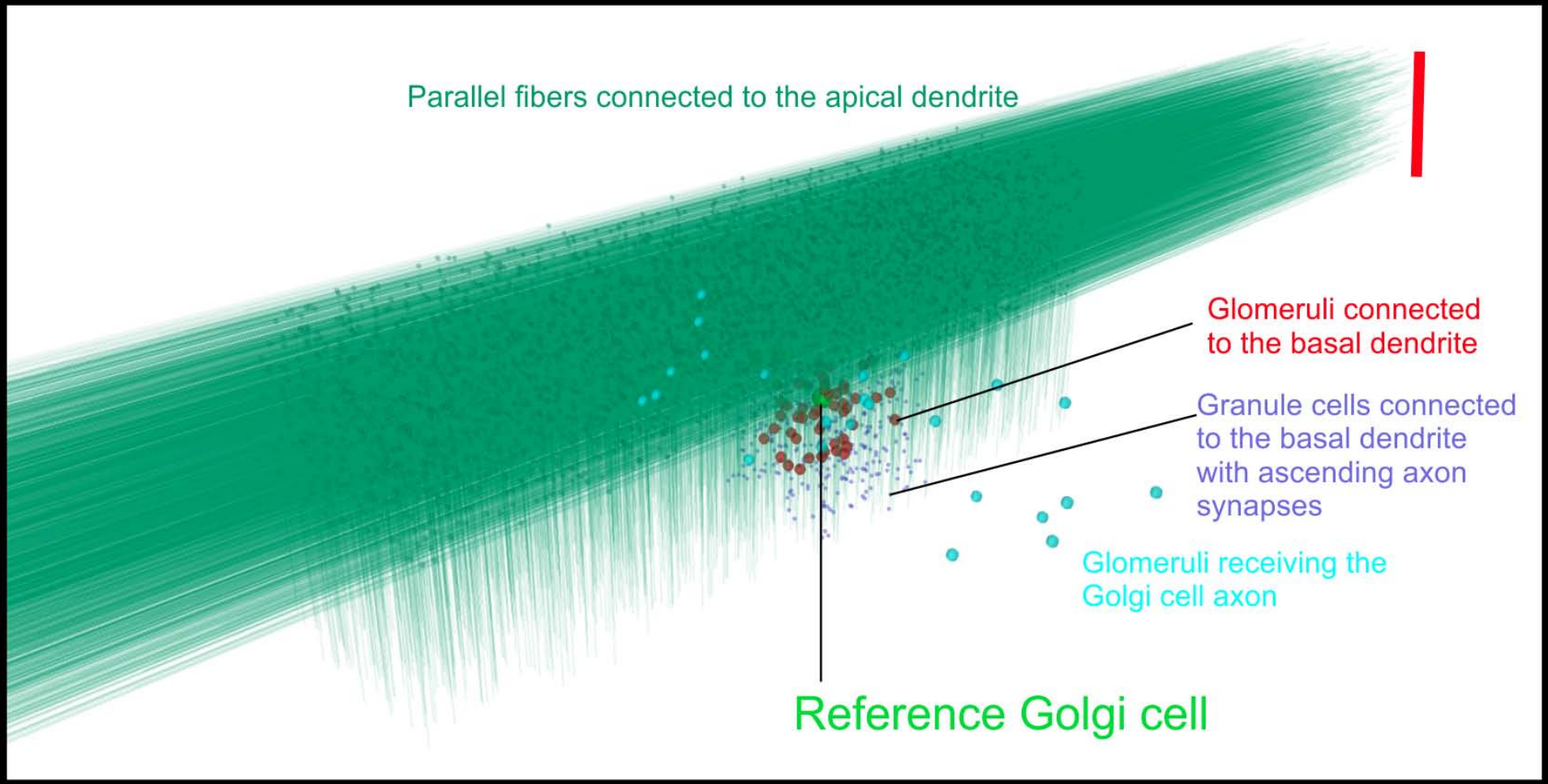
The REALNET network



IRCCS Mondino: Italian Ministry of Health Young Researcher Project

REALNET: http://www.realnet-fp7.eu/

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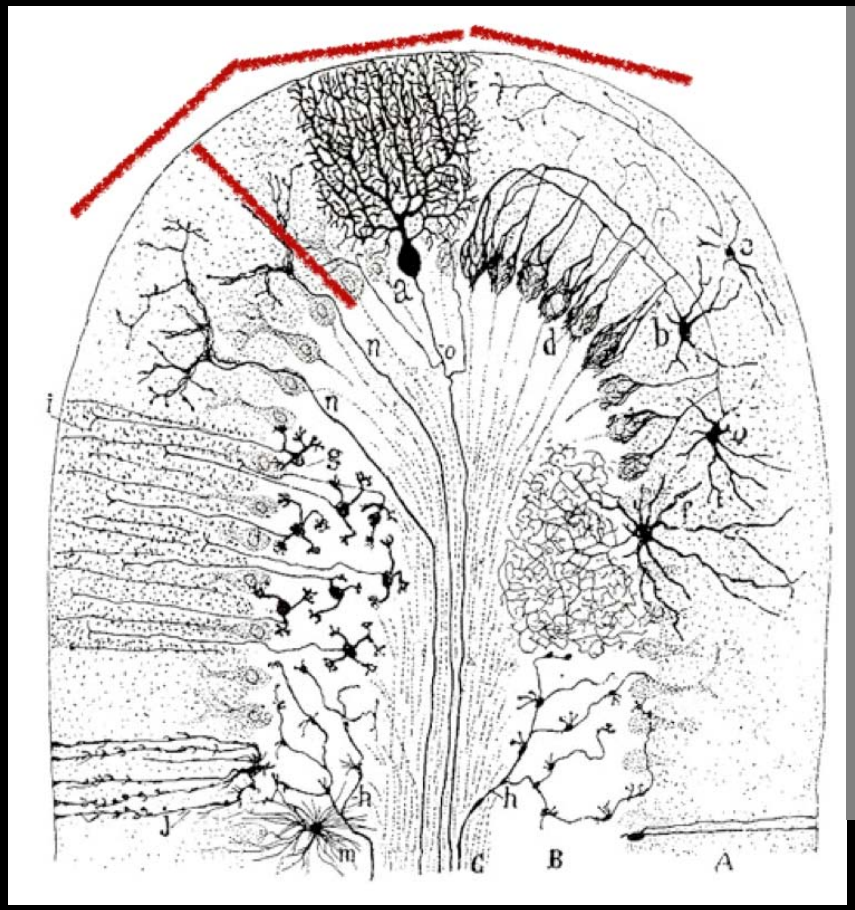
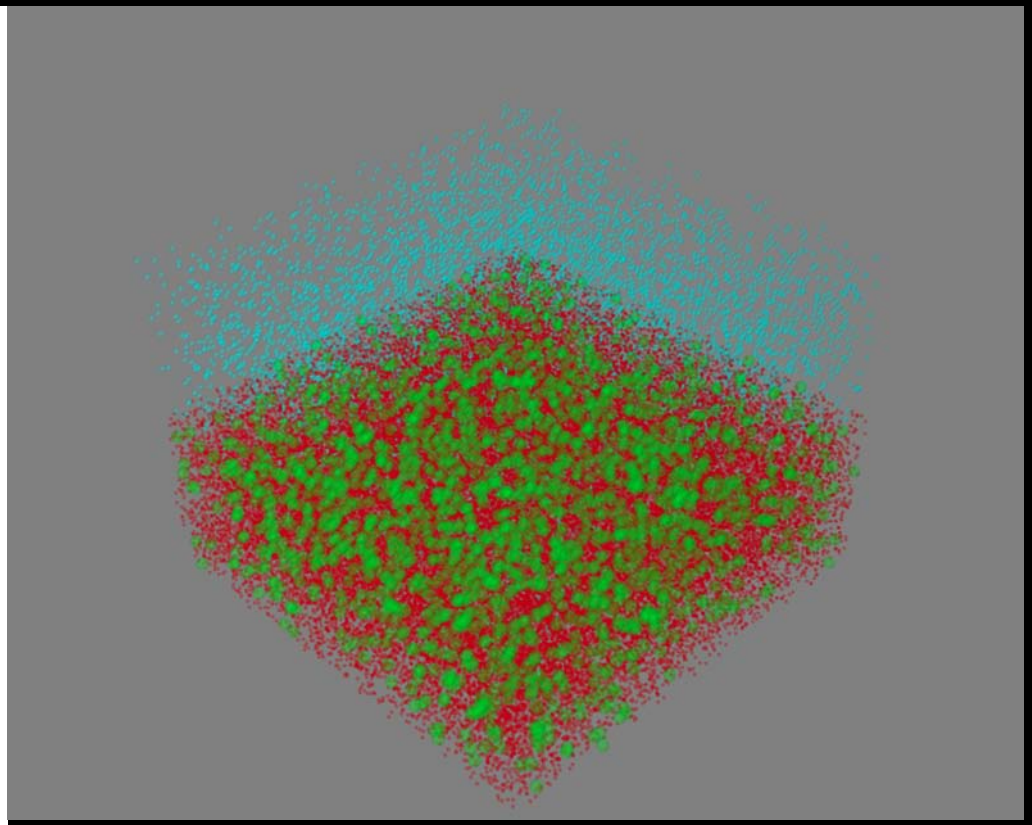
REALNET network PYTHON-NEURON





Stefano Casali
Egidio D'Angelo

383.000 granule cells
920 Golgi cells
29500 glomeruli

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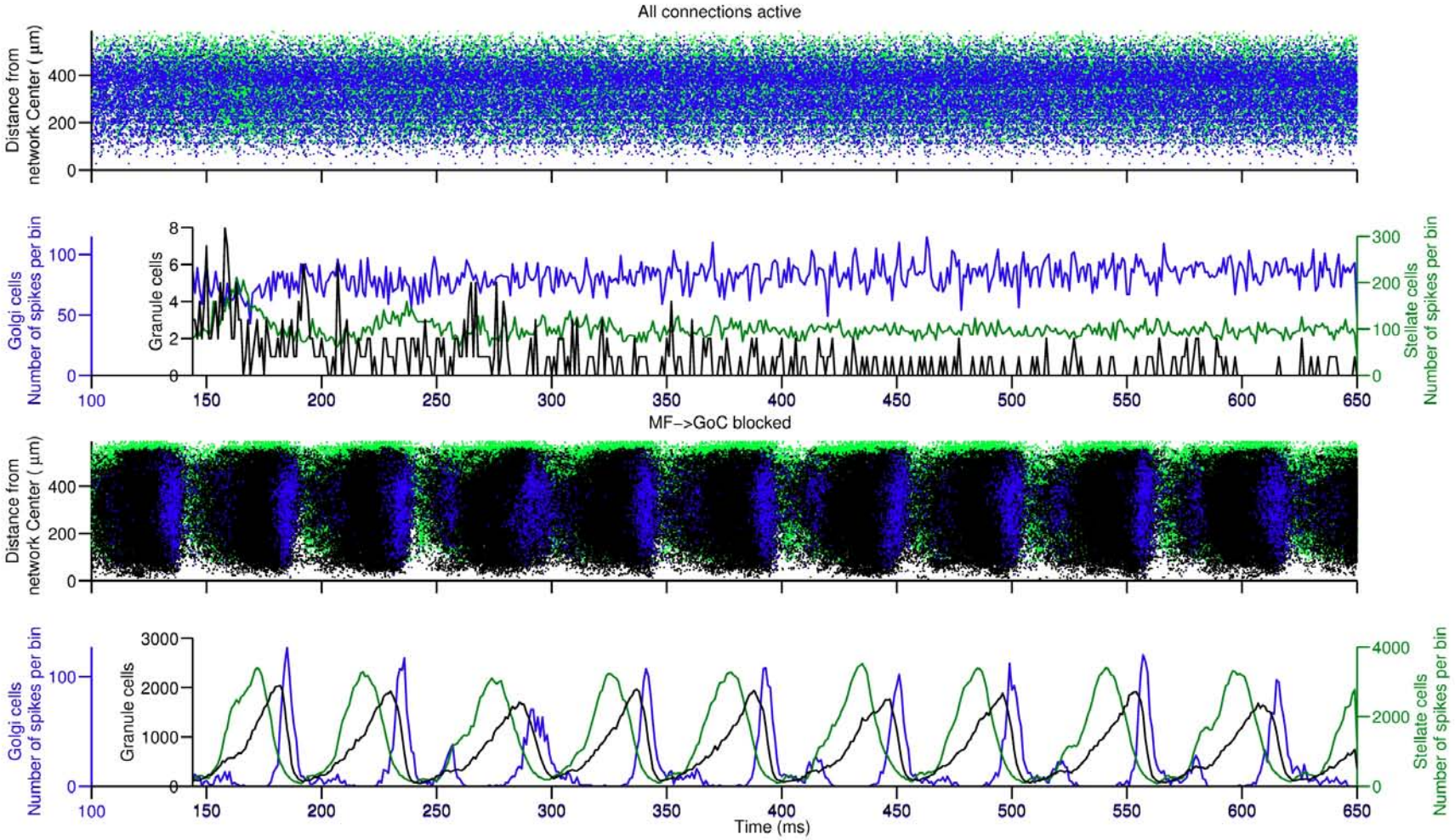
Emergence of oscillatory activity in the granular layer network



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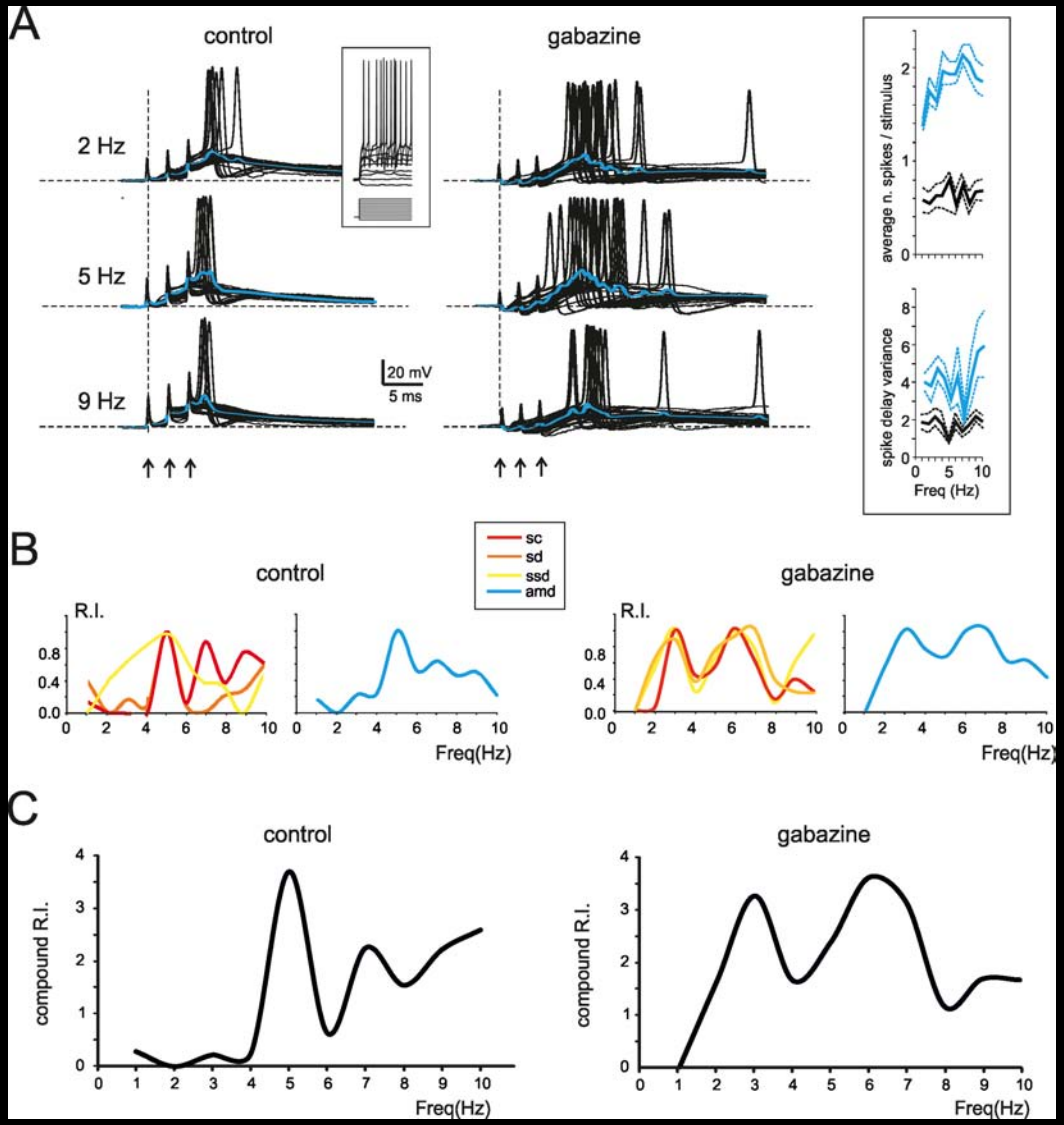
Induction of resonance to repeated stimuli in granule cells: *in vitro*



Daniela Gandofi
Jonathan Mapelli
Egidio D'Angelo

Gandolfi et al. 2013

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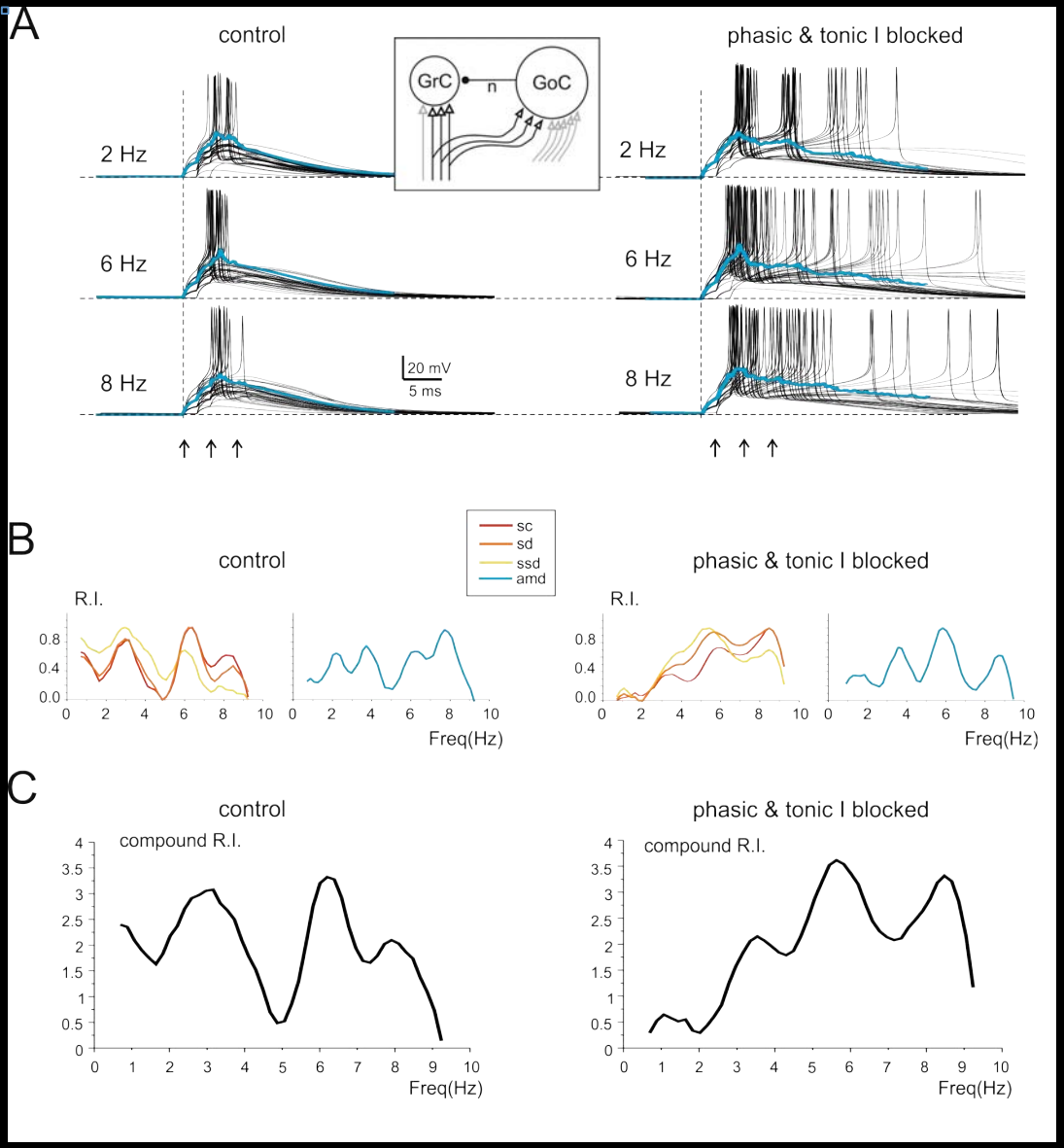
Induction of resonance to repeated stimuli in granule cells: *in silico*



Gandolfi et al. 2013

Discussion

- Complexity of network construction algorhythm -> Bottle neck!!!

- A single run gives a single network topology

- What if…. ???

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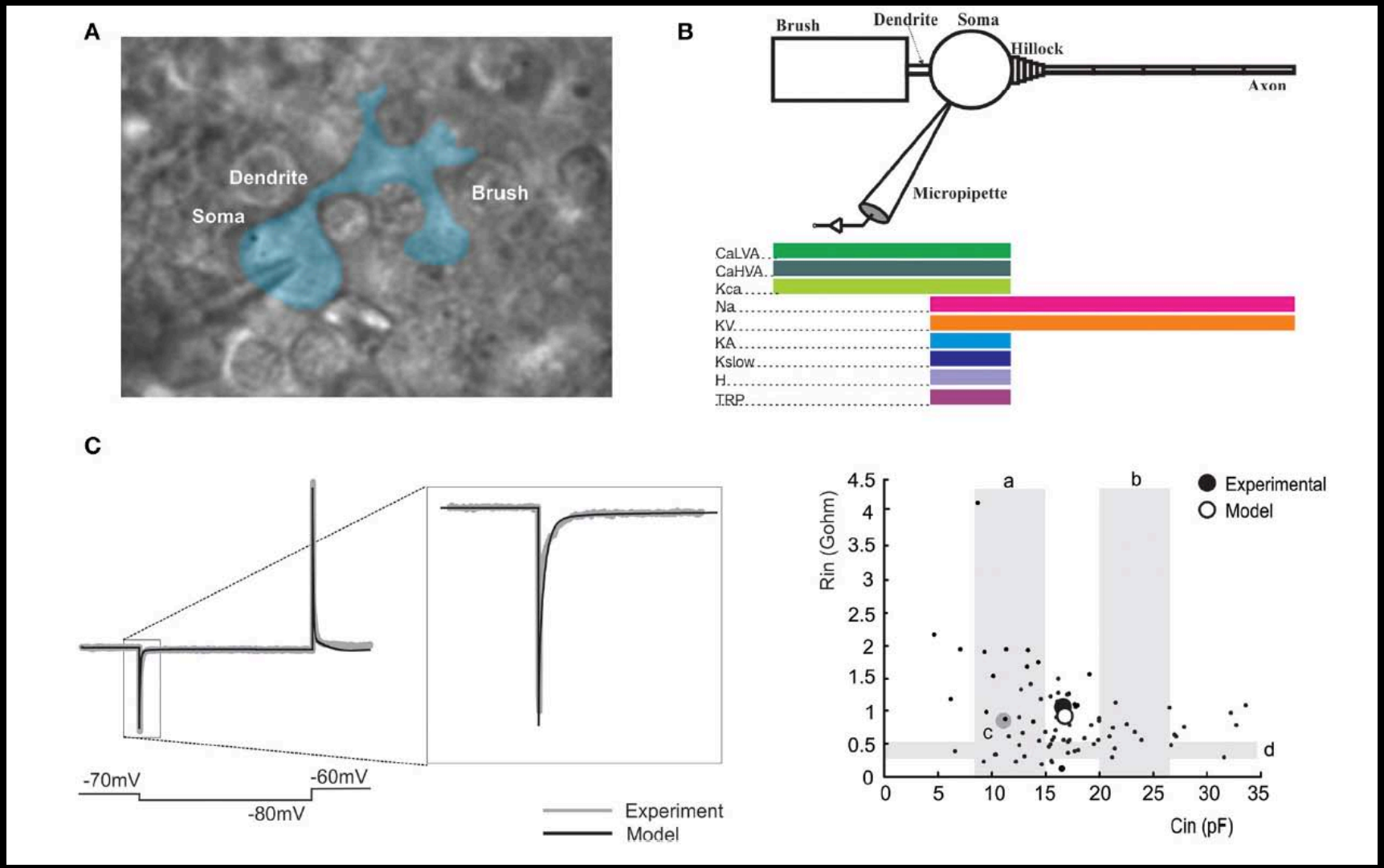
Unipolar brush cell model



Subramaniyam et al. 2014

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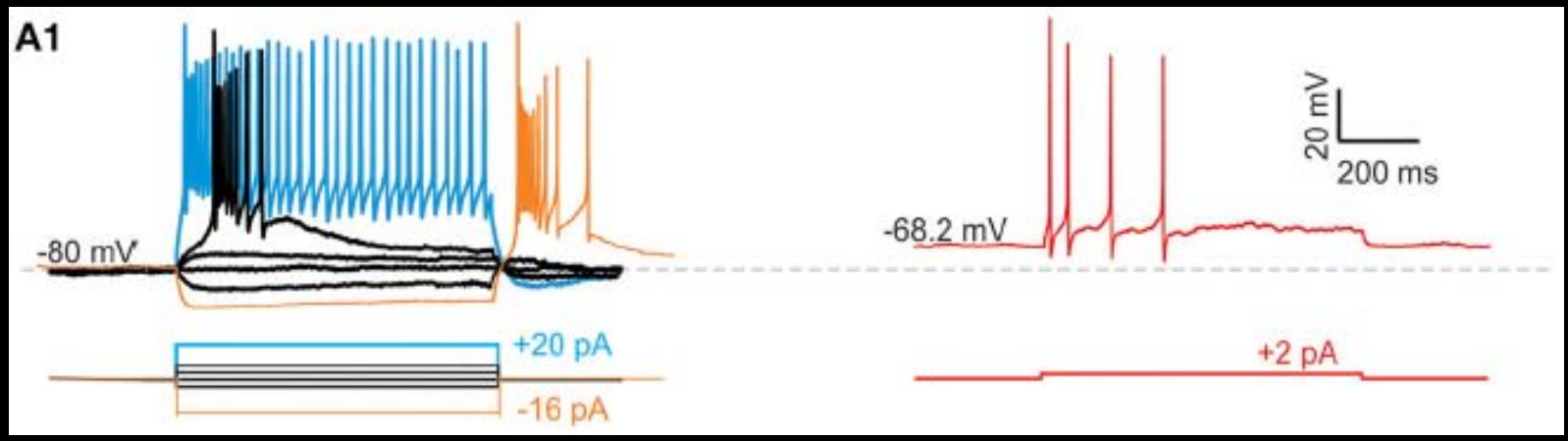

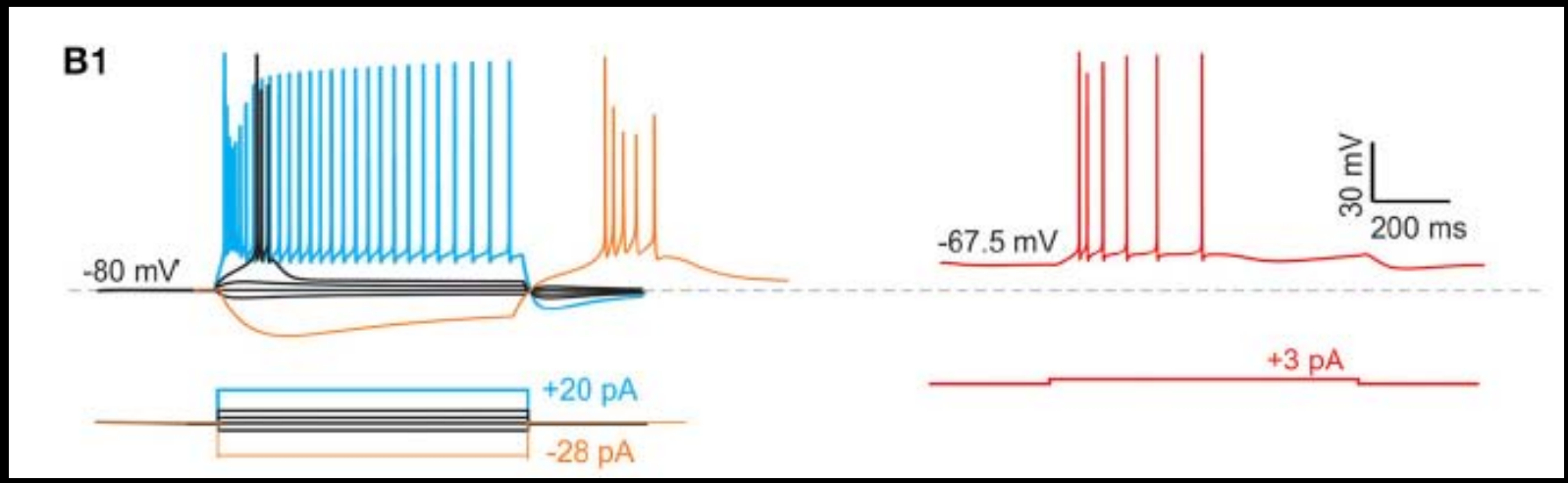

Subramaniyam et al. 2014

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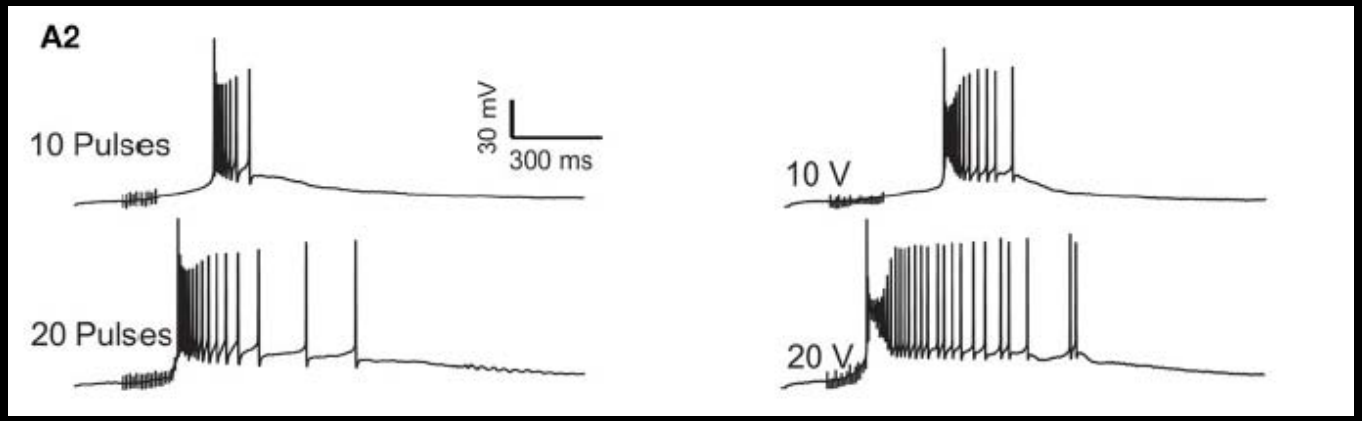
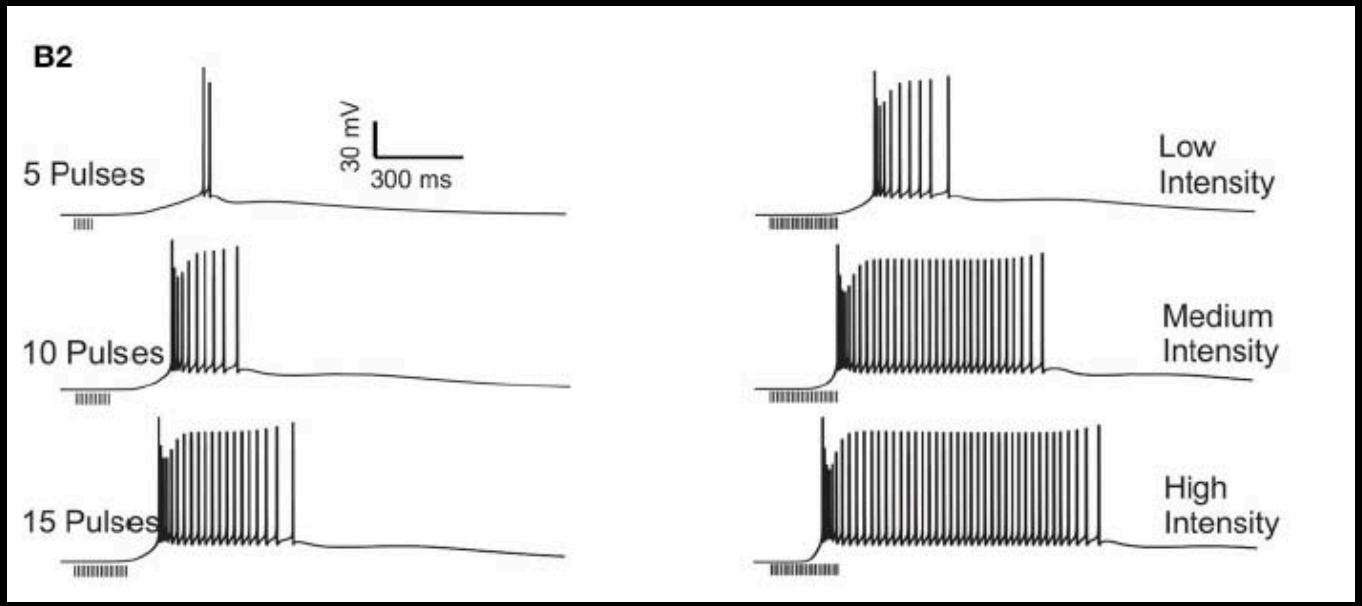
Unipolar brush cell model: late onset response





Subramaniyam et al. 2014

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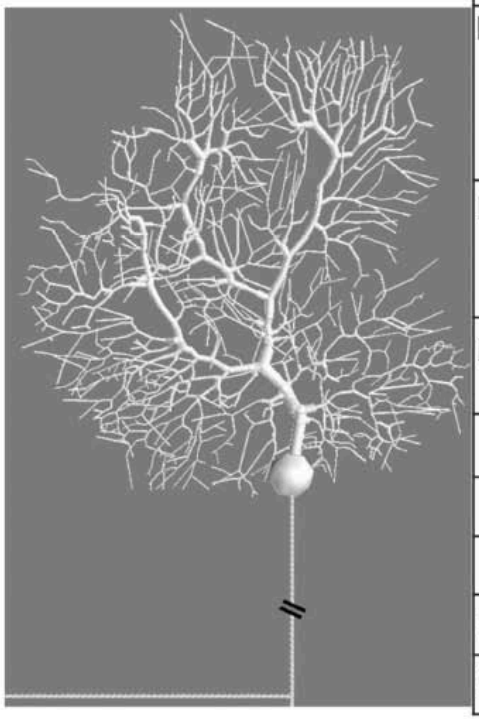
A new Purkinje cell model



	Nav 1.6	Kv 1.1	Kv 1.5	Kv 3.3	Kv 3.4	Kv 4.3	Kir 2.x	Kca 1.1	Kca 2.2	Kca 3.1	Cav 2.1	Cav 3.1	Cav 3.2	Cav 3.3	HCN 1	Cdp 5
Dendrites < 3.5µm																
Dendrites > 3.5µm																
Dendrites > 8µm																
Soma																
AIS																
ParaAIS																
R. Nodes																
Collateral																

Masoli, Solinas, D'Angelo 2015

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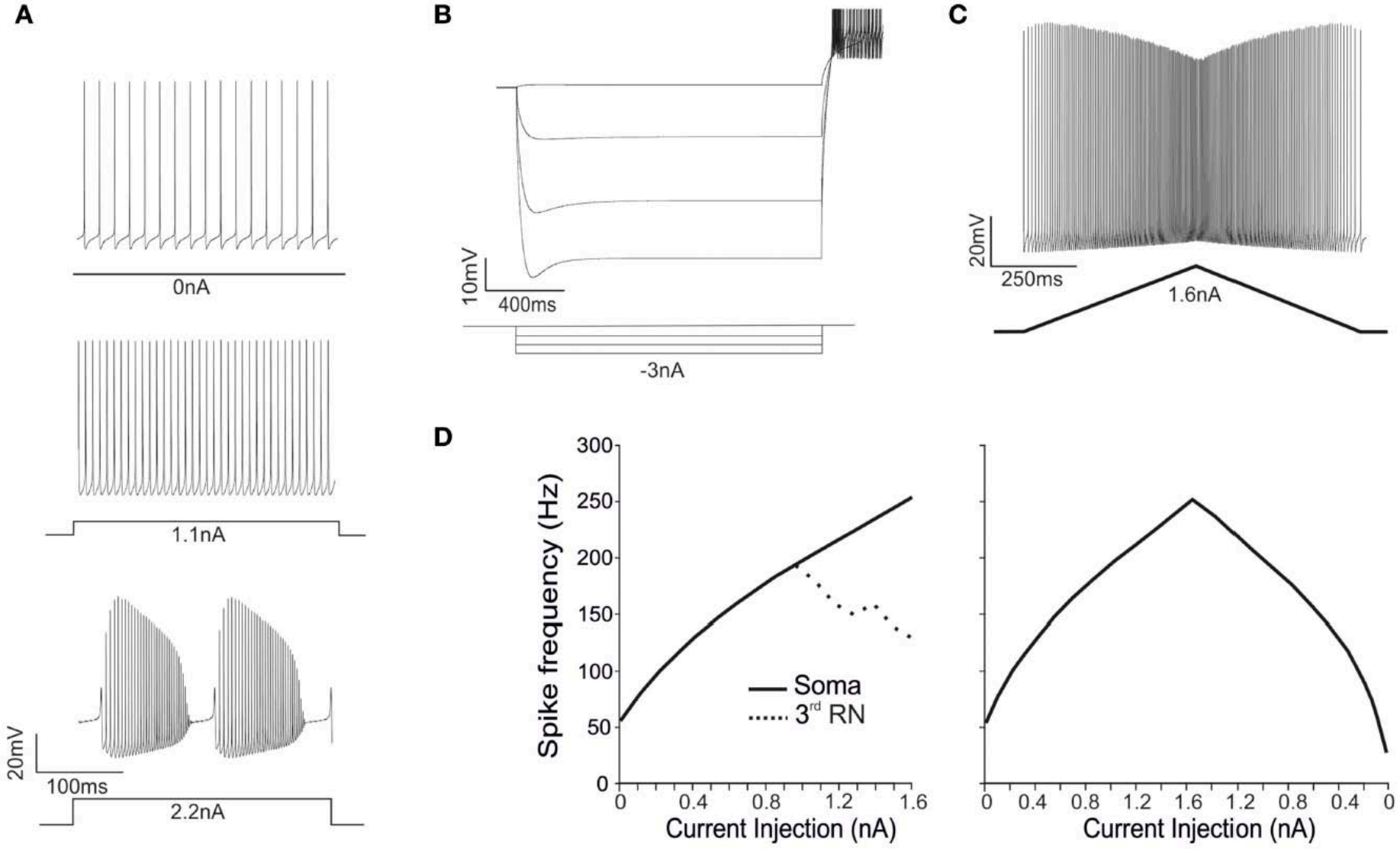
Purkinje cell model response to current injection



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FUTURE WORK

- Include the new Purkinje cell model
- Include the new UBC model
- Include the new granule cell multicompartmental model
- Reconstruction of Local Field Potential recordings in the network model
- Develop new methods to build the network structure