

DPSNN-STDP

**Distributed Polychronous Spiking Neural Net with
Synaptic spiking Time Dependent Plasticity:
a mini-app. benchmark for large scale cortical simulation
on parallel/distributed (custom) computing architectures**

possible synergies with SUMA

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European Reference Tiled Architecture Experiment

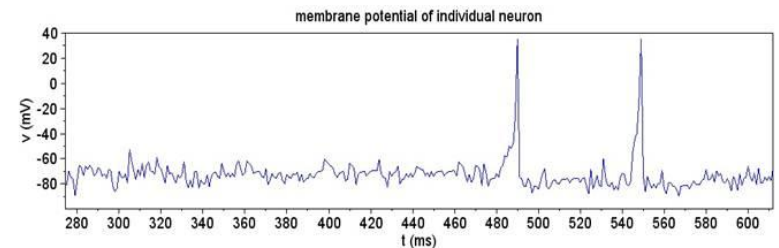
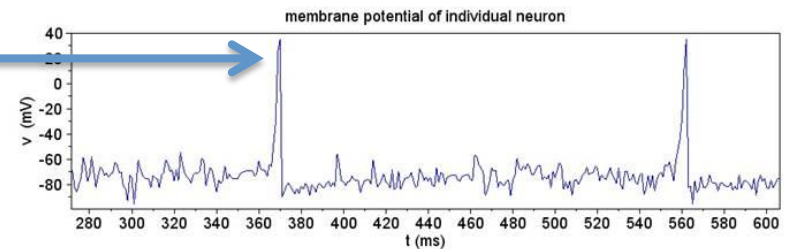
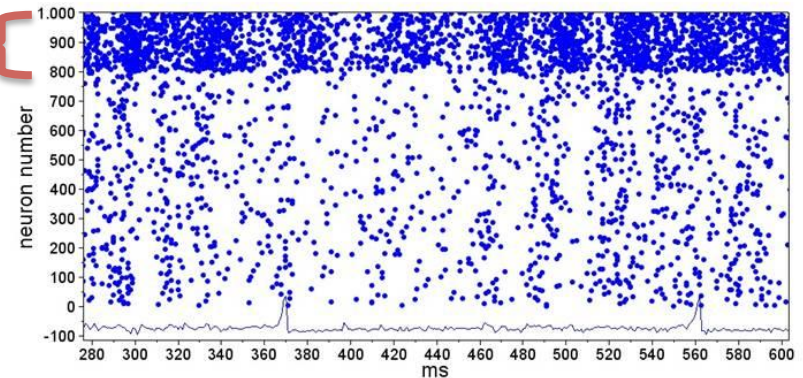
INFN (coordinator), ETHZ, RWTH, UJF-TIMA, TARGET
www.euretile.eu

- Dec 2012, INFN Roma completed first prototype of EURETILE **DPSNN-STDP simulator** of "Distributed Spiking Neural Net with Spiking Time Dependent synaptic Plasticity"
- January 2013 – start of FP7 CORTICONIC project (2013-2015)
 - The **EURETILE DPSNN-STDP simulator** and **QUONG platforms will be used in the CORTICONIC** project
 - Experimental techniques used to stimulate and measure cortical activities on animals and humans: opto-genetic, electrode arrays, trans-cranial magnetic stimulation, electroencephalographic arrays, drug perfusion...
- 28 January 2013, **Human Brain Project** selected as Horizon 2020 FET Flagship
 - 50 Meuro/ year – 20 year duration
 - Competitive calls to start soon

Example of Simulation of Spiking Activity and Synaptic Plasticity

- The picture represents the evolution of a neural network computed by the DPSNN-STDP code
- In this simple case:
 - 200 inhibitory neurons
 - 800 excitatory neurons
 - total 100 000 synapses
 - Time resolution: 1ms (horizontal axis)
 - Each dot in the raster gram represents an individual spike
 - The evolution of the membrane potential of each neuron is simulated
 - The evolution of individual synaptic strength is computed (not shown in the picture)
 - Polychronism: individual synaptic delays are taken into account
 - Individual connections and neural types can be programmed

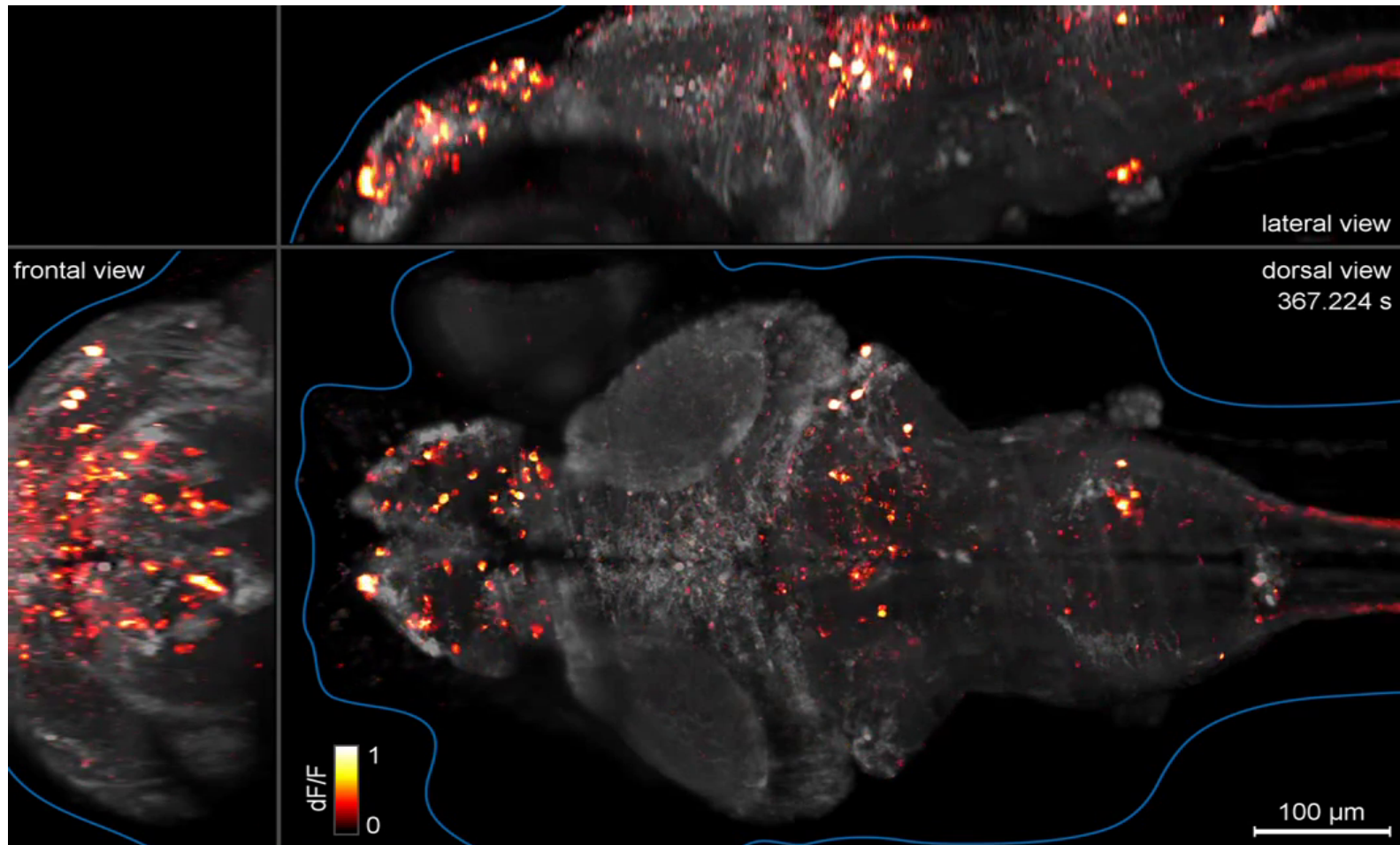
Collective Spiking Rastergram and activity of individual neurons



Purpose of DPSNN in EURETILE and CORTICONIC

- Brain simulation benchmark (INFN DPSNN code) used in EURETILE with 3 purposes
 - As a source of requirements and architectural inspiration for extreme parallel/distributed computing
 - As a parallel/distributed coding challenge
 - As a scientific grand challenge
 - Focus on exploration of software/hardware scalability
 - Standard vs. custom interconnects (APENet+ and its evolution)
 - Computations on “standard” multi-cores, no-GPGPU planned
- Cooperation with CORTICONICS FP7 project (2013-2015):
 - DPSNN will be improved to simulate biological networks:
 - Cooperation with ISS
 - Comparison with in-vivo/in-vitro experimental results
 - IDIBAPS (Barcelona), TUM

Spiking activity of individual neurons observed in a Zebra Fish Larva



Misha B Ahrens, Philipp J Keller, «Whole-brain functional imaging at cellular resolution using light-sheet microscopy», Nature Methods, 18 March 2013, DOI:10.1038/NMETH.2434

Howard Hughes Medical Institute, 3D recording of temporal spiking activity of ~100 000 neurons.

Note: the effective time resolution is still only ~1 s.

- Port the computational part of DPSNN-STDP to GPGPU based distributed systems
- Use DPSNN-STDP as an additional benchmark on SUMA platforms
- Contribute to the definition of future roadmaps related to large scale cortical simulations
- Huge potential for architectural improvements driven by this benchmark:
 - the brain performs with 50 W computations that would require more than 50 MW on present generation HPC architectures
- Strategic research area...