CAJAL BLUE BRAIN PROJECT

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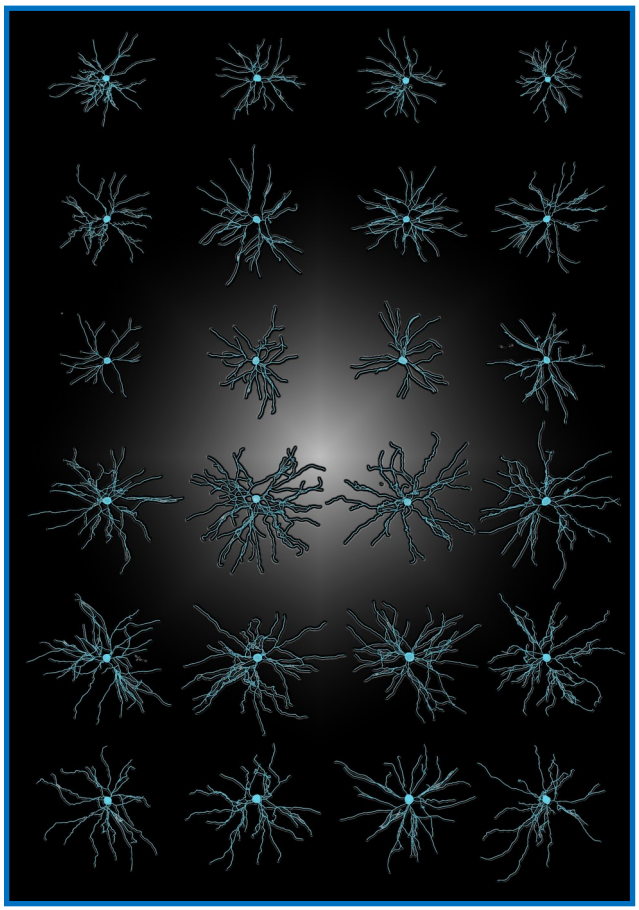
Cajal Blue Brain Project: 8th Year

The eighth project year has closed and the project is well-placed to continue to unravel the structural design of the cortical column through the generation of data and the application of informatics tools. Furthermore, thanks to the introduction of the research line "physiological and functional modeling" in the project it has been possible to implement the initial integration of anatomical data and physiological studies in vivo. These anatomical and physiological studies in anesthetized and awake animals will be used for upgrading the modelling of the mouse somatosensory cortex at the cellular level from that already developed by the BBP before the start of the Human Brain Project (HBP), and further enhanced during the Ramp-Up phase (Markram et al, 2015). The focus will be on validation and in silico experiments. Validation and refinement will be performed in collaboration with BBP and with other HBP collaborators. Thus, it will have access to the full set of models, tools and workflows developed by the BBP, which will be released as Open Source Software, and made available through the Brain Simulation Platform of the HBP.



Cajal BLUE BRAIN

Any man can be, if he wants, the sculptor of his own brain

2016 Main Achievements

2016 Main Achievements

Neuroscience

- Development of a new algorithm for 3D segmentation of different type of cells.
- Setting of parameters (immunohistochemistry, confocal imaging) for the analysis of the density per volume and laminar pattern of astrocytes.
- Final analysis of LY-Intracellular injections of astrocytes to analyse the morphological properties and the relationship of individual astrocytes and other cells.
- Analysis of non-neuronal components of the column (as blood vessels)
- We have concluded the digitalization in 3D confocal stacks of images of apical and basal arbors of pyramidal cells across all cortical layers layers (II, III, IV, Va,Vb and VI)
- We have reconstructed several apical and basal arbors of pyramidal cells, including the position of spines in all cortical layers (II, III, IV, Va,Vb and VI) from 3D stacks of images.
- The location of excitatory and inhibitory synapses on dendritic spines and dendritic shafts in the six neocortical layers has been studied and results have been submitted for publication.
- The morphological features of synaptic junctions have been studied in the neocortex of p14 rat, in all neocortical layers. The corresponding publication is currently in preparation.

Data Analysis

- Dendritic and axonal neuronal wiring optimization in pyramidal neurons (Anton-Sanchez et al., 2016, PLoS ONE) and in interneurons (Anton-Sanchez et al., 2016, Neuroinformatics), both based on a new approach (Anton-Sanchez et al., 2016, Journal of Heuristics).
- Study of dendritic pyramidal neurons, specially their dendritic branching angles, in juvenile rat somatosensory cortex (Rojo et al., 2016, Cerebral Cortex; Leguey et al., 2016, Journal of Comparative Neurology), extended to humans (Fernandez-Gonzalez et al., 2016, Brain Structure and Function).
- Mathematical foundations for modeling multivariate von Mises distributions from data, a preliminary step towards creating a neuroanatomical model of the basal arborization of pyramidal cells (Rodriguez-Lujan et al., 2016, International Journal of Intelligent Systems).
- The importance of publishing data sets in neuroscience (Leitner et al., 2016, Frontiers in Neuroscience).

Neuroinformatics Tools & Visualization

- EspINA: Development of new versions (2.1.0 to 2.1.10) with the focus on improving stability and performance while adding new tools and extending the performance of existing ones.
- DDExplore (Dense Data Exploratory Tool): This interactive exploratory analysis tool is nowadays available on-line and it can be used with data acquired with EspINA (or many other data sources).
- Interactive analysis techniques: InToolExplorer; ViSimpl & SynVis
- During 2016 new versions of NeuroScheme and NeuroLOTs have been released.
- Visualization techniques for massive neuron populations: new versions of NeuroScheme and NeuroLOTs have been released.

Cell Physiology Cajal's Laboratory

- The setup for in vivo recordings of calcium imaging using two-photon and confocal microscopy has been implemented
- The electrophysiological setup for electrocorticogram recordings in anesthetized animals has been implemented
- Some technical and analytical foundations have been developed.
- We have published 5 original manuscripts and give 6 invited lectures.

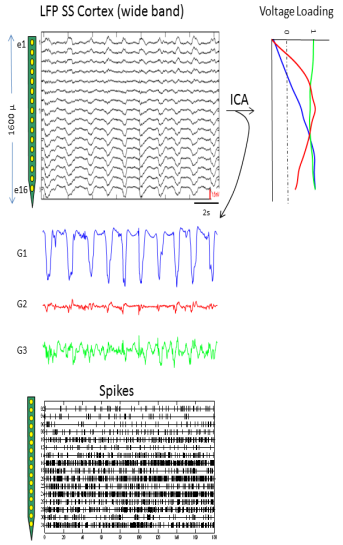
Electrophysiology and Functional Modelling

This research line was proposed to be included in the Project at the end of 2015. In the course of 2016, the most relevant achievements retainned are as follows:

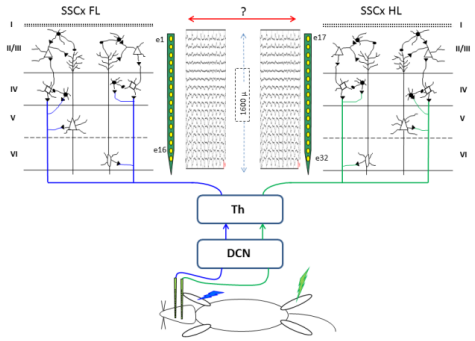
In-vivo Electrophysiology

A) Preliminary data shows that LFP activity can be disentangled in several LFP generators, some belonging to extrinsic, others to local pathways or intrinsic activity. This shall enable the cross-checking of spike trains from individual cells in specific layers to be correlated with each of the generators, making possible a more detailed intracolumnar functional map.

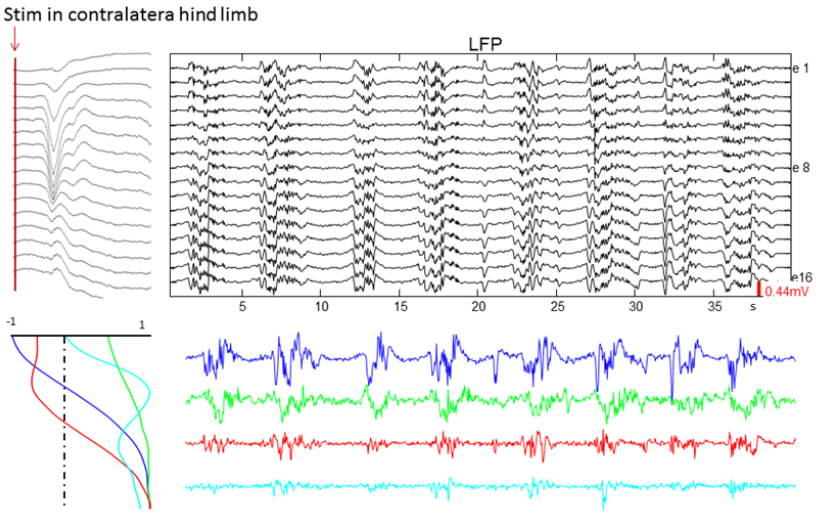
B) Importantly, we found that LFP generators in 15 day old animals differ from the adult. This indicates that the maturation of intracortical circuits can be studied from a functional perspective using LFP generators. This will be a main objective for 2017.



Spatial discrimination of pathway-specific contributions to cortical LFPs in adult rats. LFPs are recorded with linear arrays spanning the cortex (upper traces). The ICA reveals a set of components (in colour), each with a spatial distribution that marks the power at each site



Experimental design for the comparative study of LFP generators in two cortical areas.



Analysis of LFPs in the Somatosensory cortex of anesthetized 15 day old rat. Upper left traces correspond to the evoked potential in the cortex fter tactil stimulation of the contralateral hindlimb. The spatial profiles of found generators, and their relative variance differ from the adult.

Electrophysiology and Functional Modelling

CTB

The Cajal Blue Brain Project is hosted by the Universidad Politécnica de Madrid (UPM) in the Scientific and Technological Park of Montegancedo Campus. Computational needs and support infrastructure required by CajalBBP are provided by two of the Research Centers of the Park, the Centro de Tecnología Biomédica (CTB) and the Centro de Supercomputación y Visualización de Madrid, CeSViMa, which is focused on the massive storage of information, high-performance computing and advanced interactive visualization.

More information: www.ctb.upm.es

Sponsorship