3·Brain
high resolution technology

BioCAM X

high resolution electrophysiology platform

4096 x 18kHz

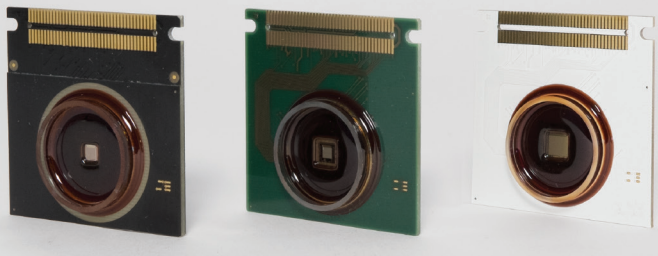
Originating from 3Brain's expertise gained in the manufacturing of the first CMOS high-resolution multielectrode array, BioCAM X will boost your research capabilities by enabling simultaneous recordings from a total of 4096 electrodes sampled at 18 kHz per electrode.
You can either choose to store the entire raw signals captured by the BioCAM X or to take advantage of the several degrees of compression, which will allow you to save space on your hard disk and thus decrease computational resources required for further data processing.

ALL-IN-ONE

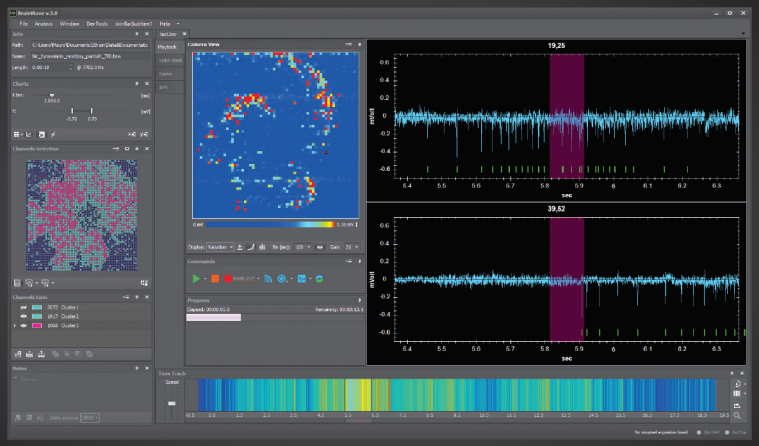
BioCAM X incorporates further optional functionalities in a compact and solid design, which come shipped as separate modules in most MEA-systems, such as a temperature control system and an electrical programmable current-driven stimulator.
Its compact form factor eases the integration with other instrumentation like microscopes, perfusion and patch-clamp systems.
Thanks to its improved interface, BioCAM X can be controlled with a laptop for better mobility, allowing you to carry the entire recording system in your hand luggage.

CMOS HD-MEA

Whatever your experimental needs with multi-electrode arrays are, BioCAM X can provide it!
Its high sampling frequency and a user-selectable recording bandwidth make the system suitable to record any kind of electrophysiological signals, from slow field potentials to single action potentials.
The three BioChip 4096 series provide different spatial resolutions and recording areas, allowing full monitoring of electrophysiological signals in a field of view up to ~26 mm² from a large variety of biological preparations, ranging from cell cultures to intact tissue such as brain slices and explanted retina.



BRAINWAVE X



BioCAM X is supplied with the latest BrainWave X software version, which provides powerful visualization tools of electrophysiological signals during and after your experiments and stores all your data in HDF5 format. This standard (adopted by the International Neuroinformatics Coordination Facility) allows cross-platform compatibility and simplifies access to and from most common analysis environments such as Matlab® and Python™.

MAGNETIC PLATE

ferromagnetic stainless steel to attach magnetic perfusion holders

INTEGRATED STIMULATOR

4 independently programmable current stimulator channels (routable to the BioChip and/or to the rear connector for use with your external stimulation electrodes)

ANTI-SPILL BAY

improved MEA connection system robust to accidental overflows of liquids

LOCK SYSTEM

single two-position button for easy locking/unlocking of the BioChips

TEMPERATURE CONTROL

integrated active temperature control

SOLID AND DURABLE

fine and precise enclosure crafted from anodized aluminum make the BioCAM X robust to electromagnetic and mechanical noise

TECH SPECS

www.3brain.com - info@3brain.com - made in Switzerland

AMPLIFIER

bandwidth	0.1 Hz - 20 kHz
noise	11 µVrms (0.1 Hz - 20 kHz)
maximum input-referred signal amplitude	4 mV

MAIN CONTROLLER

data resolution	12 bit
number of recording electrodes	4096
full-array (4096) maximum sampling rate	18 kHz / electrode
region-of-interests	recording 1 up to 4 independent subsets of electrodes up to 64 kHz
temperature control	active heating and cooling between 34˚C and 40˚C
inputs	two analog inputs (-3.3 V to 3.3 V) or triggers (LV-TTL)
control interface	Camera Link (mini SDR)

STIMULATION MODULE (OPTIONAL)

stimulation mode	constant current
internal stimulation sites	16 on-chip (only for BioChip 4096E)
external stimulation sites	4 differential channels accessible on the rear connector
maximum current	+/- 1 mA
stimulation patterns	up to 4 independent stimulation patterns
stimulus generator	programmable patterns (mono/biphasic, burst, jittering,...)
time resolution	10 µs
amplitude resolution	10 µA
maximum pulse rate	50 kHz
extended inputs	three LV-TTL GPIOs

SOFTWARE

OS	Windows Vista / 7 / 8, 64 bit
data processing	fully parallelized; AVX2 instruction set during online recording
file type	BRW (raw data) and BXR (results file) with plain HDF5 format
online recording modes	BRW: plain raw, lossless zipped raw, lossy raw. BXR: events' timestamps
data export	MAT (Matlab); NEX (Neuroexplorer)

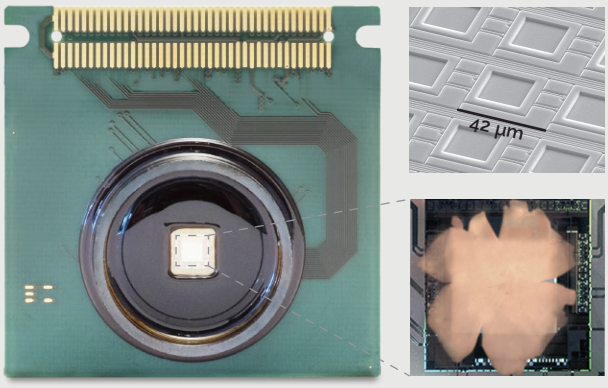
PHYSICAL SPECS

body material	anodized aluminum / ferromagnetic stainless steel
dimensions (WxDxH)	160 x 205 x 38 mm / 6.3 x 8.07 x 1.5 inches
weight	approx. 1600 g / 3.53 lb

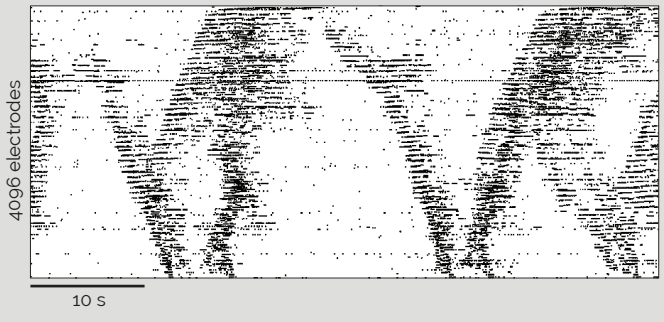
BioCAM X

Acute Retina

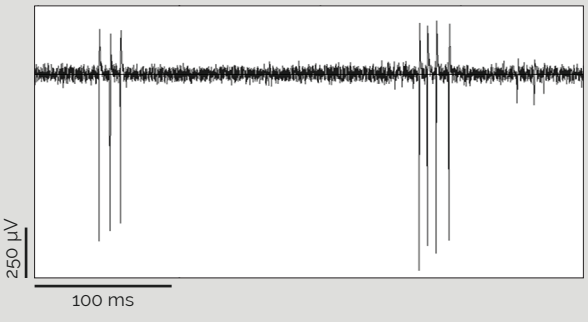
Our high-resolution BioChip MicroElectrode Arrays (MEAs) have been specifically designed to sense electrophysiological signals over large tissue areas with cellular resolution. Simultaneous recordings from mouse retinal wholemounts can be achieved with the BioCAM X, allowing to investigate spontaneous activity and artefact-free light induced responses from the retinal ganglion cell layer with unprecedented spatial and temporal resolutions.



The BioChip series designed for tissue recordings. Top-right: SEM image of the electrode array. Bottom-right: a mouse retina placed on the electrode area (dashed line)*.



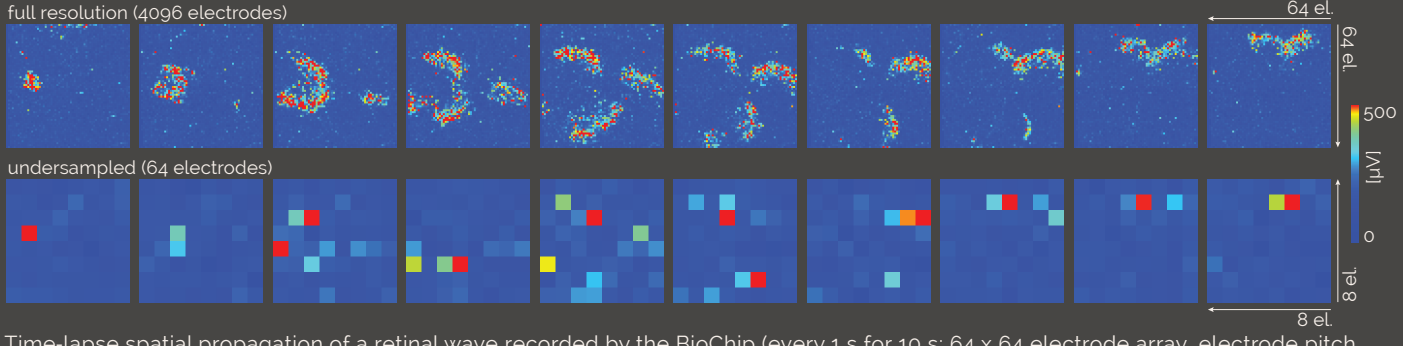
Raster plot (4096 electrodes) of spontaneous spiking activity of a mouse retina during development at P11*.



Raw trace of one electrode (out of 4096) showing the quality of the recorded signal.

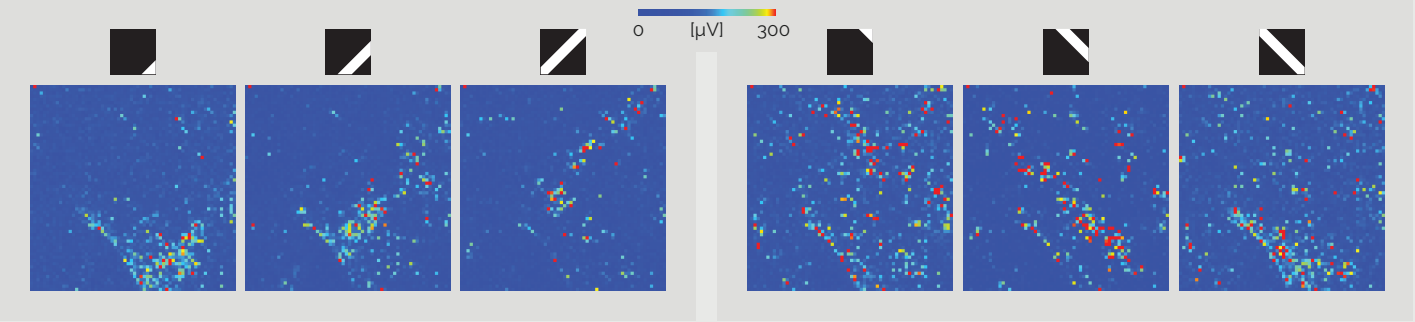
Describe spontaneous wave propagations on the entire retina with unprecedented spatio-temporal resolution

The large recording area provided by the BioChips (up to 5.12 x 5.12 mm²) allows for a comprehensive study of spontaneous waves of activity spreading across the ganglion cell layer during development. The high spatio-temporal resolution of BioCAM X sheds light on detailed biological events that conventional passive MEAs are not able to describe.



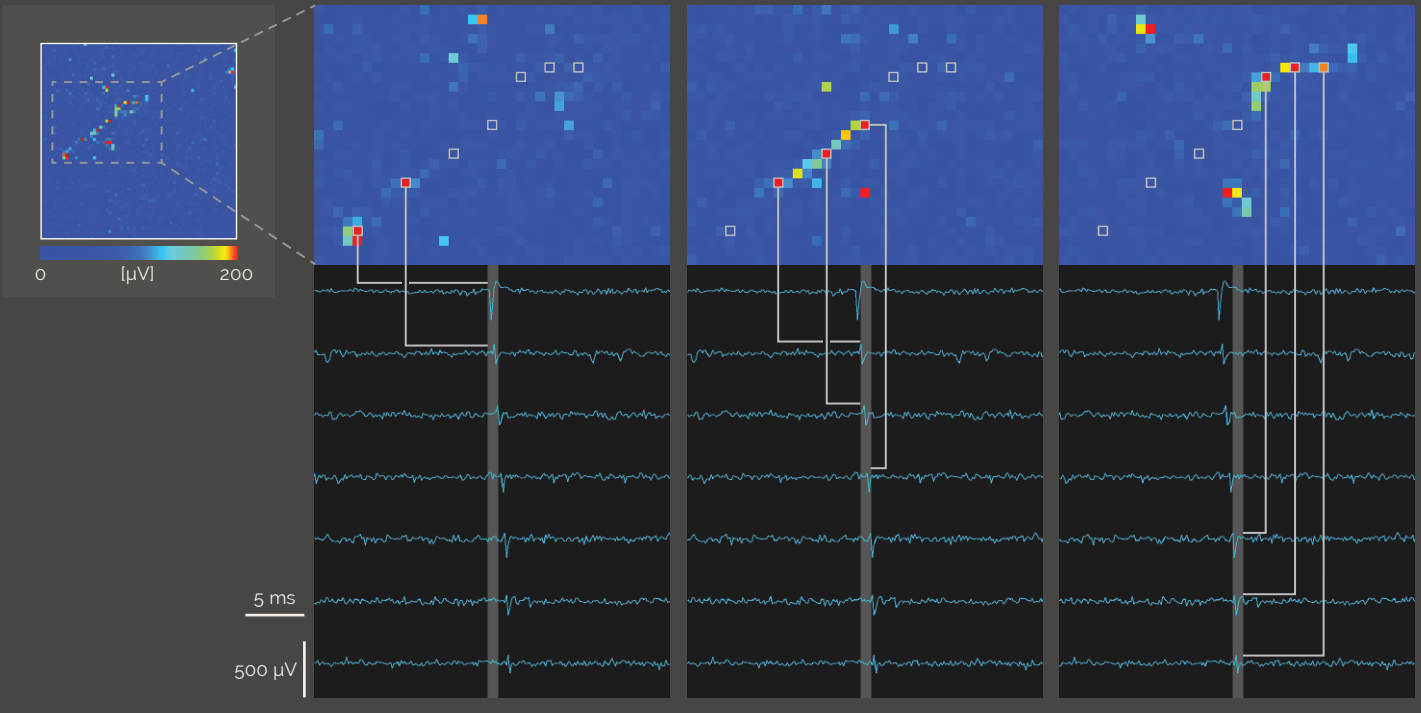
Time-lapse spatial propagation of a retinal wave recorded by the BioChip (every 1 s for 10 s; 64 x 64 electrode array, electrode pitch 42 µm). Bottom row: same episode down-sampled at the resolution to a simulated 8 x 8 array with an electrode pitch of ~334 µm*.

Evoke light-response activity from the whole retina



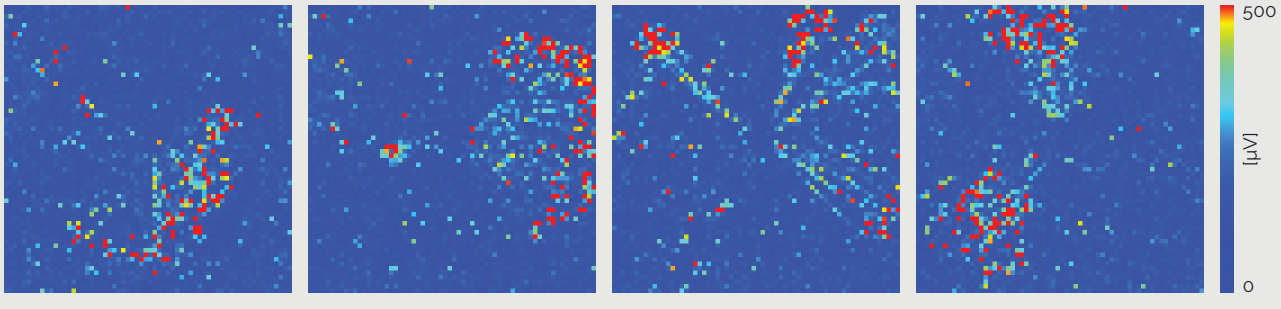
Activity of retinal ganglion cells under light stimulus (2.8 cd·s/m²) in a wild type mouse retina (P77). The response is elicited by a moving bar (960 µm/s) following a trajectory tilted by 45° (left panel) and by 135° (right panel). No light induced artefacts are generated on the BioChip**.

Observe action potential propagations along axonal bundles



Retinal ganglion cell axonal responses to flickering (1 Hz) checkerboard stimulus under dark mesopic conditions (P113 mouse). The movie, obtained by a subset of channels (see inset), clearly shows propagating impulses along axonal bundles by both false-colour maps (top row) and single electrode raw data plots (bottom rows)**.

Investigate retinal signals under pathological conditions



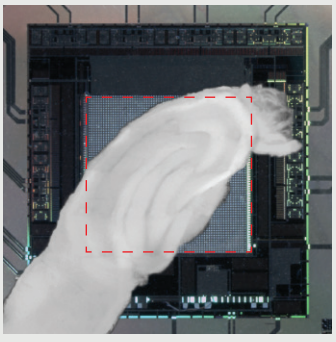
Spontaneous activity in the cone-rod homeobox knockout mouse retina, a model of photoreceptor dystrophy. Dystrophic retinas are characterized by pathological, strong spontaneous bursting and oscillations in the ganglion cell layer. In this example, bursts are generated in cell bodies and propagate along axons converging towards the optic disc**.

* Adapted from Maccione et al., J. Physiol. 2014.
**Courtesy of E. Sernagor and G. Hilgen, The Institute of Neuroscience, NewCastle, UK.

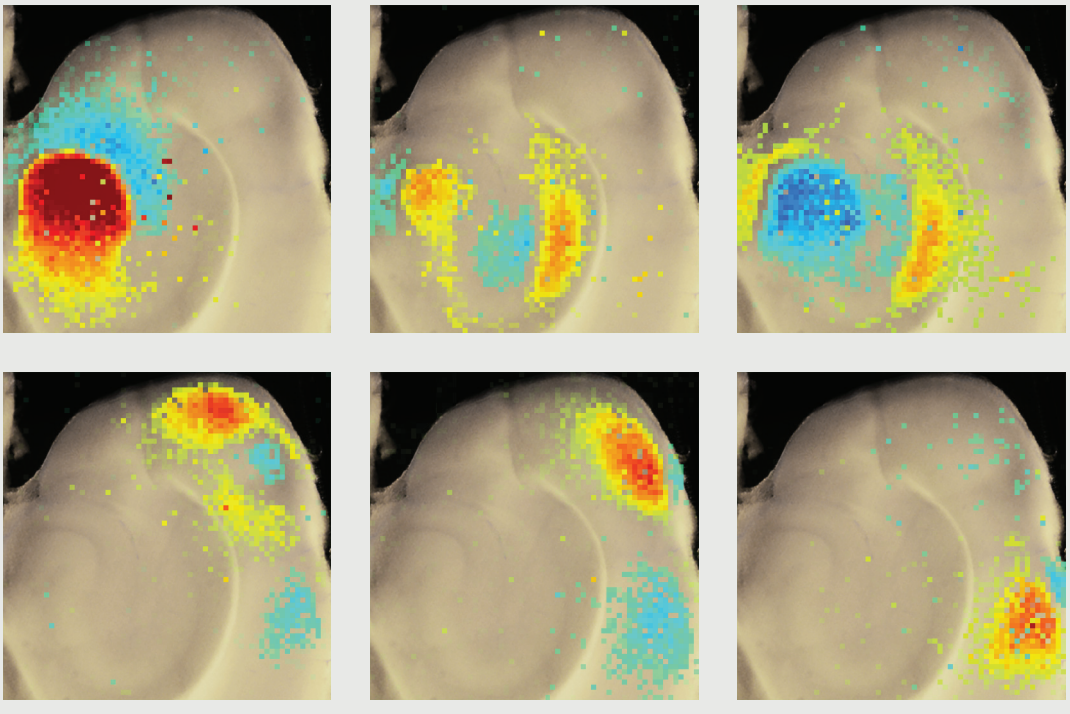
BioCAM X

Brain Tissue

The BioCAM X can record at the same time field potentials and multiunit spiking activity from acute brain slices. By exploiting the large active areas of BioChip MicroElectrode Arrays (MEAs), activity and propagations in large tissues that include multiple brain areas can be acquired simultaneously. This allows to literally image electrical activity in real-time with an outstanding resolution/field of view ratio.



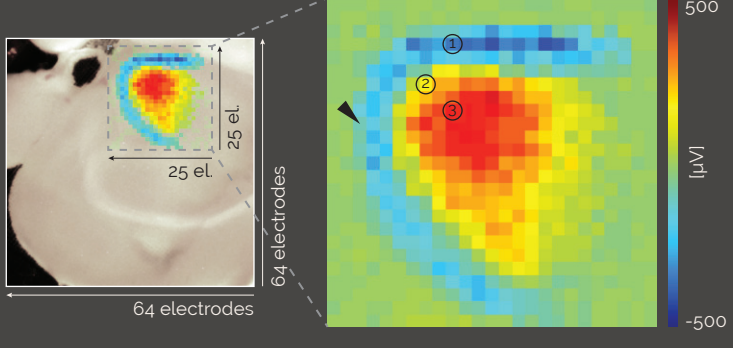
A rat slice (male, 5 weeks old) on top of a BioChip sensor comprising 4096 electrodes on an area (red dashed line) of 2.67 x 2.67 mm². Slice perfectly matches with BioChip size allowing to record from different regions. For bigger slices a larger sensor measuring 5.12 x 5.12 mm² is available*.

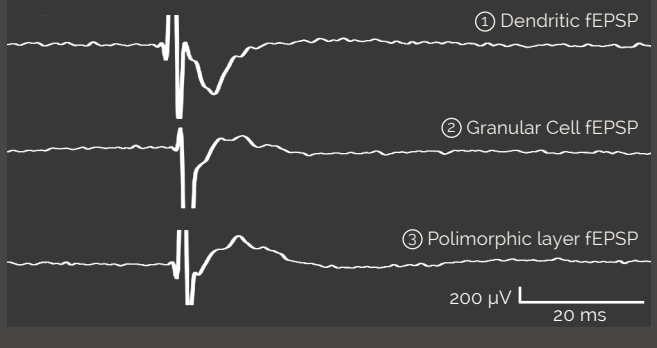


Sequence (left-right, top-bottom) of functional images of an inter-ictal event propagating from the Dentate Gyrus (DG) to the Cornu Ammonis (CA) and finally to Entorhinal Cortex (EC) and Perirhinal Cortex (PC) in a cortico-hippocampal mouse brain slice. The false-coloured electrophysiological activity recorded by the BioChip has been superimposed to the image of the slice**.

Investigate signals over different layers within specific brain regions

The large scale electrode array of the BioChip allows to record signal propagation spanning over entire brain circuits without losing any detail. Indeed, the high spatial electrode density of the BioChip is able to finely resolve the signal coming from dendritic compartments or somatic layers within sub-areas of the circuitry.

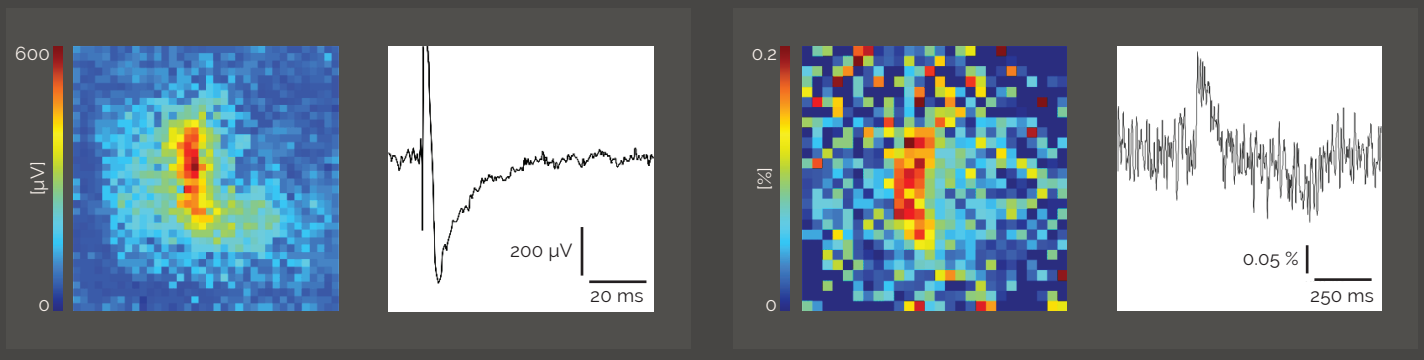




Functional imaging by means of BioCAM X of the Dentate Gyrus (DG) response to electrical stimulation (arrow) of the perforant path. The BioChip allows to record the characteristic signal features of the different layers of the DG**.

Increase signal quality of your recording

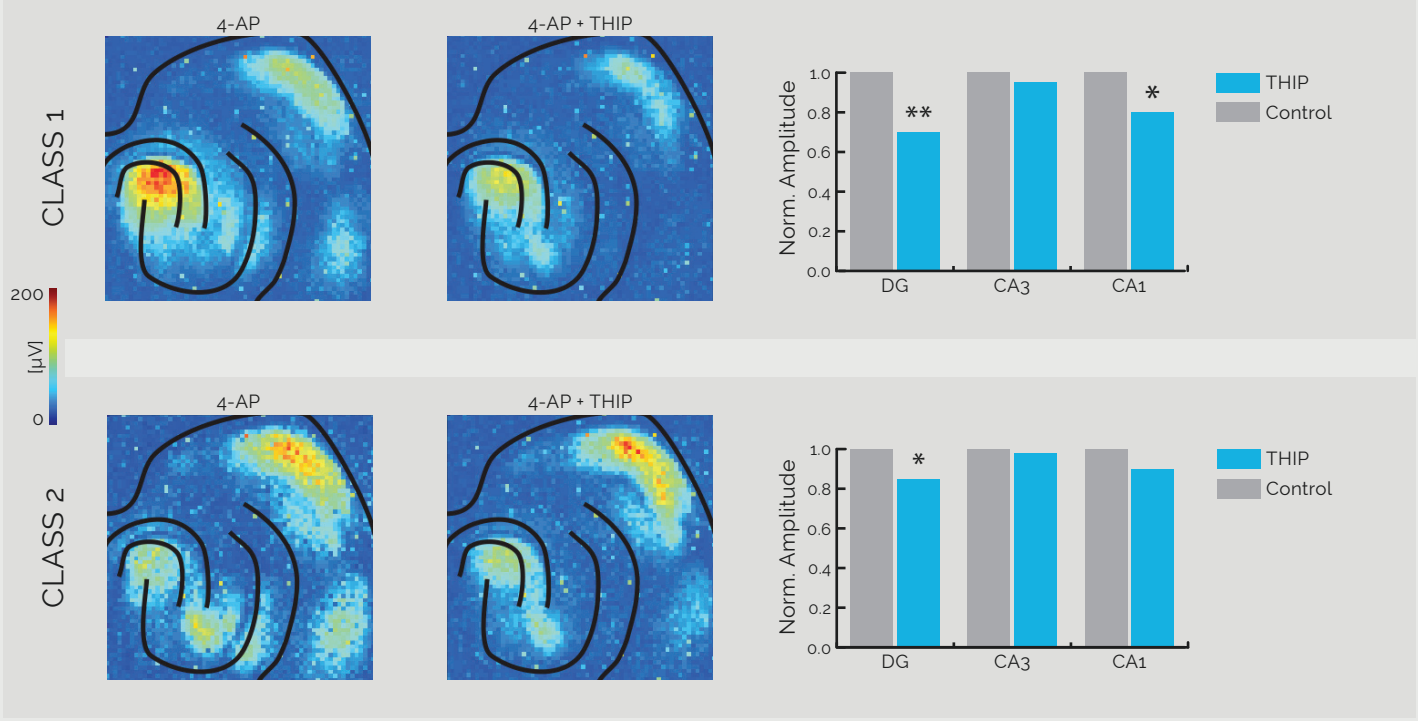
BioCAM X can spatially and temporally resolve single-evoked fEPSPs over large brain areas with a higher signal-to-noise ratio than conventional techniques as voltage sensitive dyes without the need of averaging over multiple trials.



Electrical recording performed with BioCAM X (left panel) compared with imaging recording from Voltage Sensitive Dyes (VSD, right panel). Both recordings were simultaneously performed on the Dentate Gyrus (DG) of a mouse hippocampal slice. Left panel: color-coded voltage image showing the peak response upon a single stimulation of the DG. Right panel: same episode shown as VSD evoked fluorescence changes. To increase the signal-to-noise ratio the VSD image is scaled to a 26 × 26 pixel array by averaging nine adjacent pixels**.

Grab finest details on functional changes induced by drugs

The high resolution provided by the BioCAM X allows to classify multiple chemically induced epileptiform episodes according to their spatio-temporal dynamics, in the mouse cortex and hippocampus. Additionally, BioCAM X enables the morphological co-localization and quantification of the functional effects induced by drugs (such as antiepileptic drugs) in microcircuits. The high-resolution approach paves the way to detailed electrophysiological studies in brain circuits spanning spatial scale from microcircuits up to an entire brain circuit in a slice.

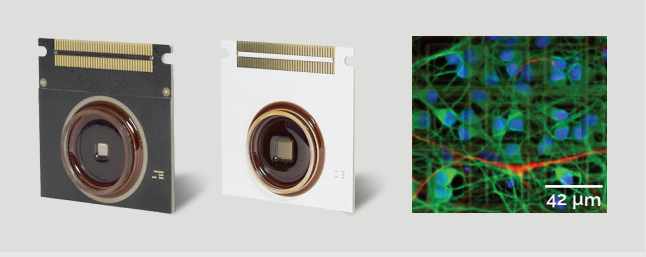


Classification of inter-ictals (I-ICs) events reveals two main classes. Class 1 (upper panel): events originating in DG and propagating to the EC. Class 2 (lower panel): events originating in the EC and propagating to the hippocampus. These two classes exhibit different responses to THIP (Gaboxadol), an anticonvulsant drug (both panels, middle), with region-specific inhibition of activity (both panels, right)**.

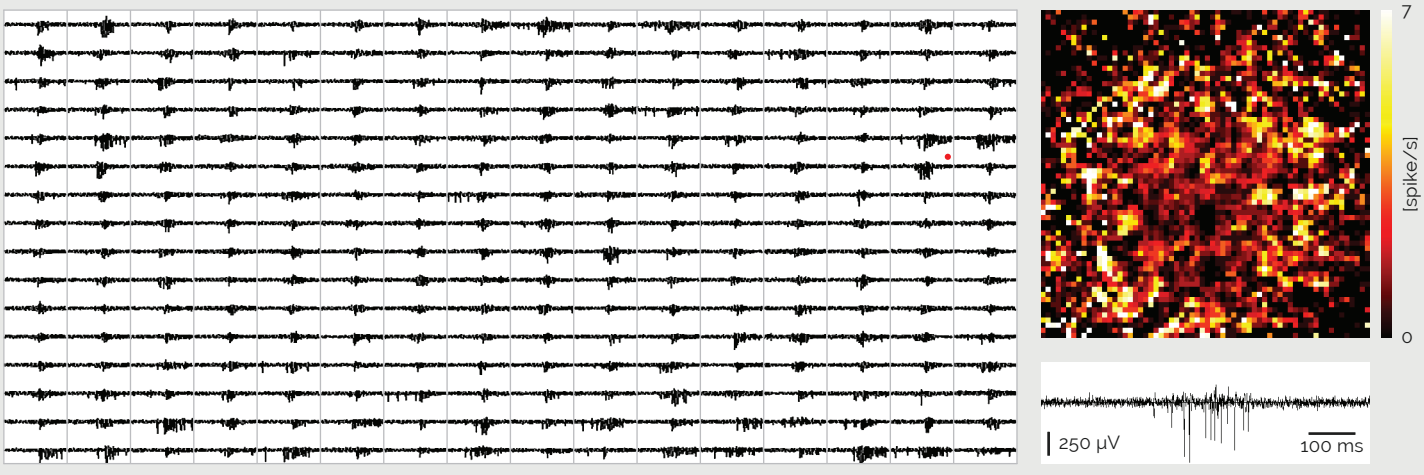
* Courtesy of A. Ugolini, Aptuit Verona.
** Adapted from Ferrea et al., Front. Neural Circuits 2012.

BioCAM X Dissociated Cultures

Any kind of electrogenic preparation can be recorded by the 4096 electrodes of the BioChip MicroElectrode Array (MEA). Hippocampal, cortical or cardiac cells activity are sensed with unprecedented spatio-temporal details, opening completely new perspectives in understanding network coding properties. Furthermore a dedicated Biochip series providing stimulating capabilities allows investigating evoked signal propagations across the entire network at microcircuit resolution, providing powerful tools to explore signal processing in neural circuits.



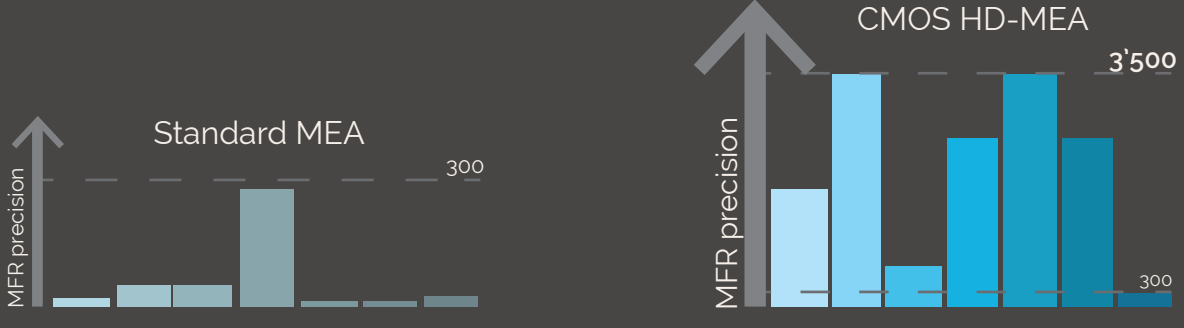
The BioChip series designed for culture recordings. Left: BioChip 4096S providing 4096 recording electrodes (pitch 42 µm). Center: BioChip 4096E providing 4096 recording electrodes (pitch 81 µm) interlaced with 16 stimulating electrodes arranged in a 4 x 4 grid. Right: stained neuronal cultures over a BioChip 4096S (black squares are electrodes).



Spontaneous bursting activity from a hippocampal culture at 38 days in vitro. Left: raw data plots of 256 electrodes have been selected among the 4096 available. Top-right: false color map of the bursting activity (# spikes per seconds) recorded by the whole array (each squared pixel represents an electrode). Bottom-right: zoom-in of the raw plot marked with a red dot in the main plot.

Increase the significance of your experiments

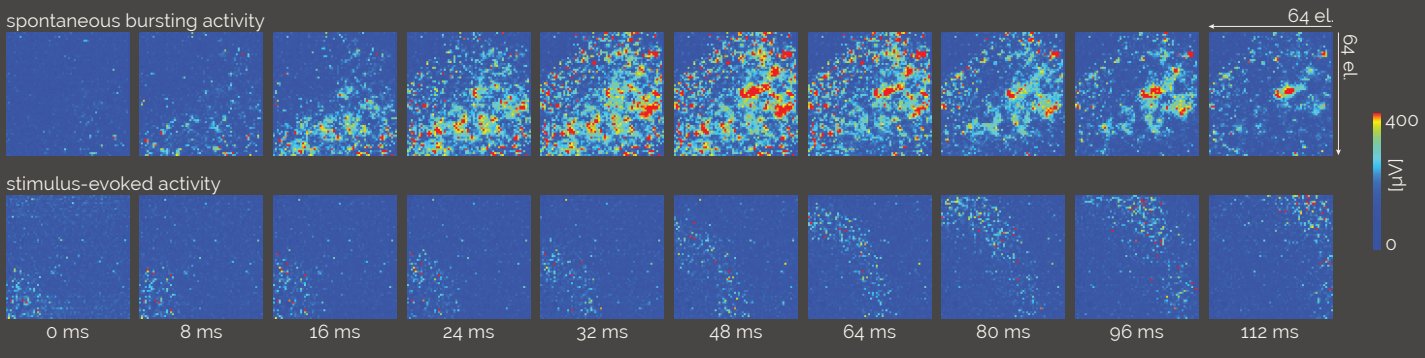
The possibility to record from thousands of electrodes provides a detailed description of the network activity. This results in a more reliable statistic when computing parameters as Mean Firing Rate or Mean Bursting Rate. The augmented statistical significance of the electrophysiological readout yields more reliable data acquisition for each sample, hence reducing animal/culture use.



Precision of Mean Firing Rate as the reciprocal of the MFR variance, i.e. $1/\sigma^2$ [s^2]. Each bar represents a single experiment. The statistical significance is enhanced by the BioChip (HD-MEA) by providing a higher electrode density (580 el/mm^2) with respect to standard MEAs*.

Investigate signal propagation at microcircuit resolution

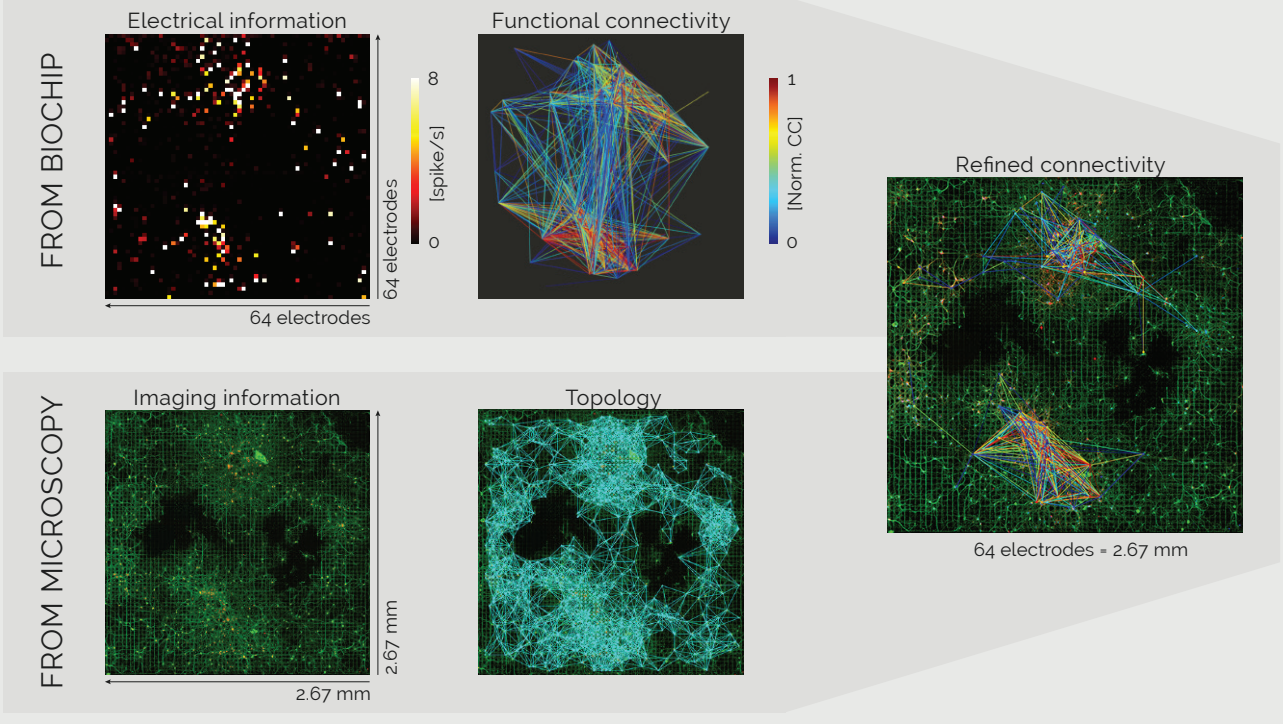
Acquire signal propagation at high spatio-temporal resolution is a crucial step in discovering how information is coded, processed and stored. BioCAM allows to study both spontaneous and evoked activity thanks to its latest Biochip series integrating stimulation capabilities. The stimulation artefact is confined to the recording electrodes in the immediate neighborhood of the stimulation site (< 20 µm).



Two examples of spatio-temporal propagating patterns. Top: spontaneous synchronous bursting activity. Bottom: evoked response to a biphasic electrical stimulus delivered to the bottom-left of the array. Both networks were hippocampal cultures at 24 DIV**.

Combine high density recording with imaging techniques

The high density Biochip provides unique opportunities in studying the relationship among function and structure in cultures. Indeed it is possible to finely map the electrical signal propagation with network connectivity extrapolated by imaging techniques, thus becoming a powerful tool in investigating functional correlation in cultures.



Example of combination of structural and functional imaging to obtain a refined image of functional connectivity. Cross-correlation is computed from spike trains acquired by the Biochip (top) and then is combined with the topology extracted by immunofluorescence staining of the recorded culture (bottom). Spiking activity correlation is reweighted considering physical network distribution allowing to improve functional connectivity estimation**.

* Adapted from Maccione et al., Front. in Neuroeng. 2010.
** Courtesy of L. Berdondini and A. Maccione, Fondazione Istituto Italiano di Tecnologia (IIT), Italy.