

Neurotechnology @ ETH Zürich

Prof. Nici Wenderoth

Department of Health Sciences and Technology



Computational Characterisation of Patients

Translational Neuromodeling for Computational Psychiatry and Neurology

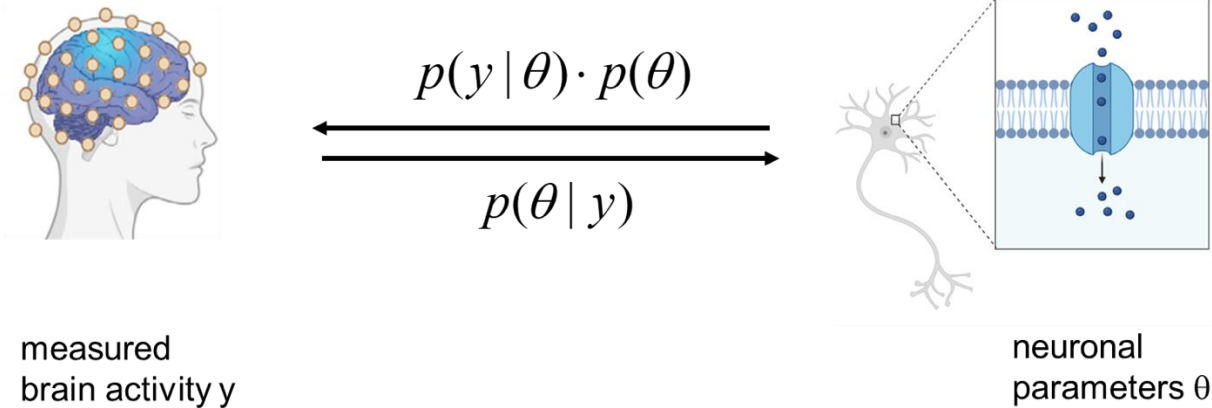


Translational Neuromodeling Unit



Prof. K. E. Stephan

Computational assays



Neuromodeling allows us to infer neuronal parameters from large-scale brain activity

Stephan et al. 2015, Neuron
Stephan et al. 2017, NeuroImage

Translational Neuromodeling for Computational Psychiatry and Neurology

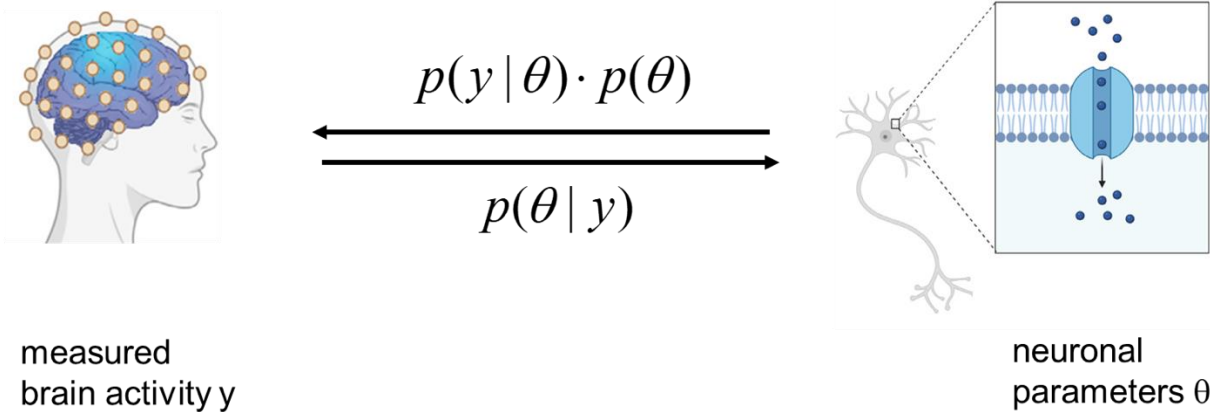


Translational Neuromodeling Unit



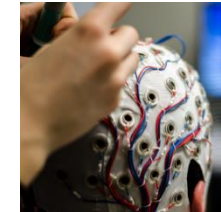
Prof. K. E. Stephan

Computational assays



Computational Psychiatry in **Depression**

Predicting relapse over 6 months: 67-71% accuracy



Berwian et al. 2021, JAMA Psychiatry
Berwian et al. 2024, Biol. Psychiatry
Erdmann et al. 2024, JAMA Psychiatry

Predicting treatment response at 4 weeks after treatment start with clinically relevant accuracy

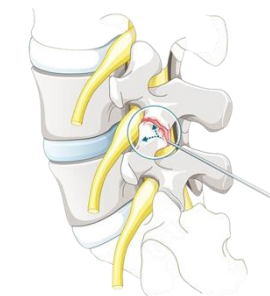


Lee et al. 2025, JAMA Network Open
Buehler et al. 2025, medRxiv



PD Dr Z. Manjali

Computational Neurology in **Pain**



Patients' belief before treatment predicts individual treatment outcomes

Müller-Schrader et al. 2023, Pain

injection therapy

Stephan et al. 2015, Neuron
Stephan et al. 2017, NeuroImage

New functional and molecular imaging technologies

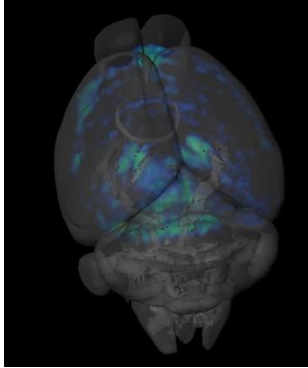


Profs K.E. Stephan, K. Prüssmann, N. Wenderoth

Preclinical imaging of disease models

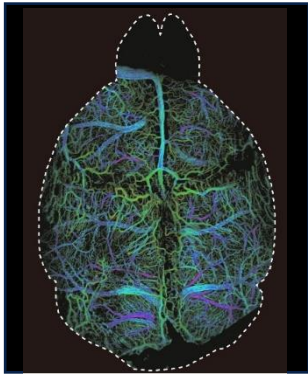


Prof. D. Razansky



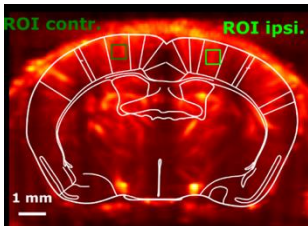
Multi-Spectral Optoacoustic Tomography

Nature Prot 18, 2124 (2023)
Nature Biomed Eng 6, 1031 (2022)
Nature Biomed Eng 3, 392 (2019)



Fluorescence localization microscopy

Nature Comm 15, 3526 (2024)



Functional Ultrasound Imaging

Nature Biomed Eng 9, 1574 (2025)
Neuroimage 237, 118111, 2021

Optically Pumped Magnetometry in patients

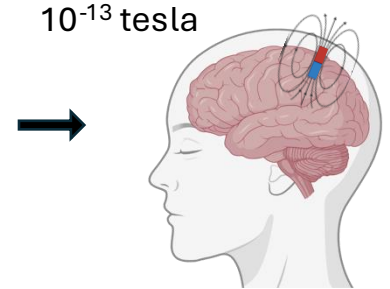


OPM Sensor

+



64 sensor helmet



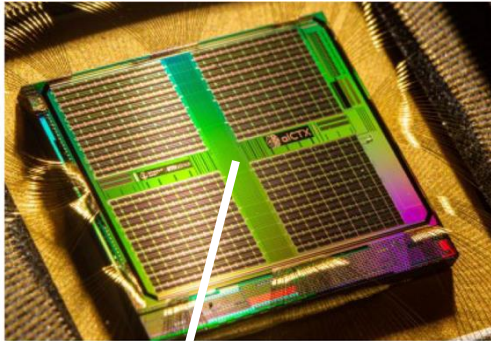
In passive and actively **shielded room**

- Rapid setup < 10 min
- Tolerant to movement
- Well suited for children and patients
- Brain-body measurements

Neuromorphic computing at the edge: identifying epileptogenic tissue during surgery

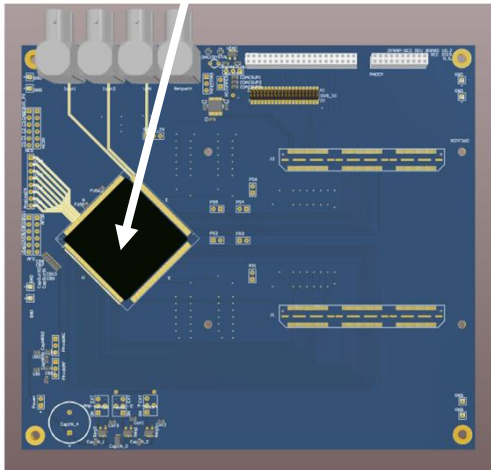


Prof. G. Indiveri

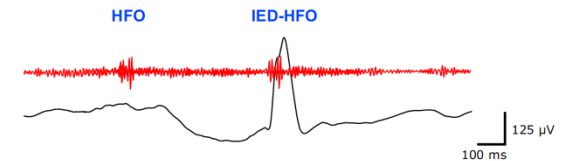
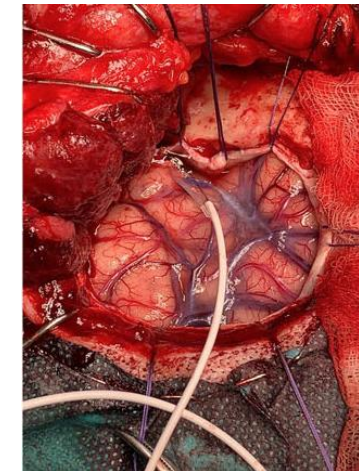


Neuromorphic chip built like spiking neural network

- Brain-inspired, event-driven computation
- Ultra-low power & low latency
- Ideal for continuous biosignal processing in real-time



Sharifshazileh et al. 2021, Nat Commun



Signature of epileptogenic tissue during surgery

HFOs are a promising new marker but difficult to detect

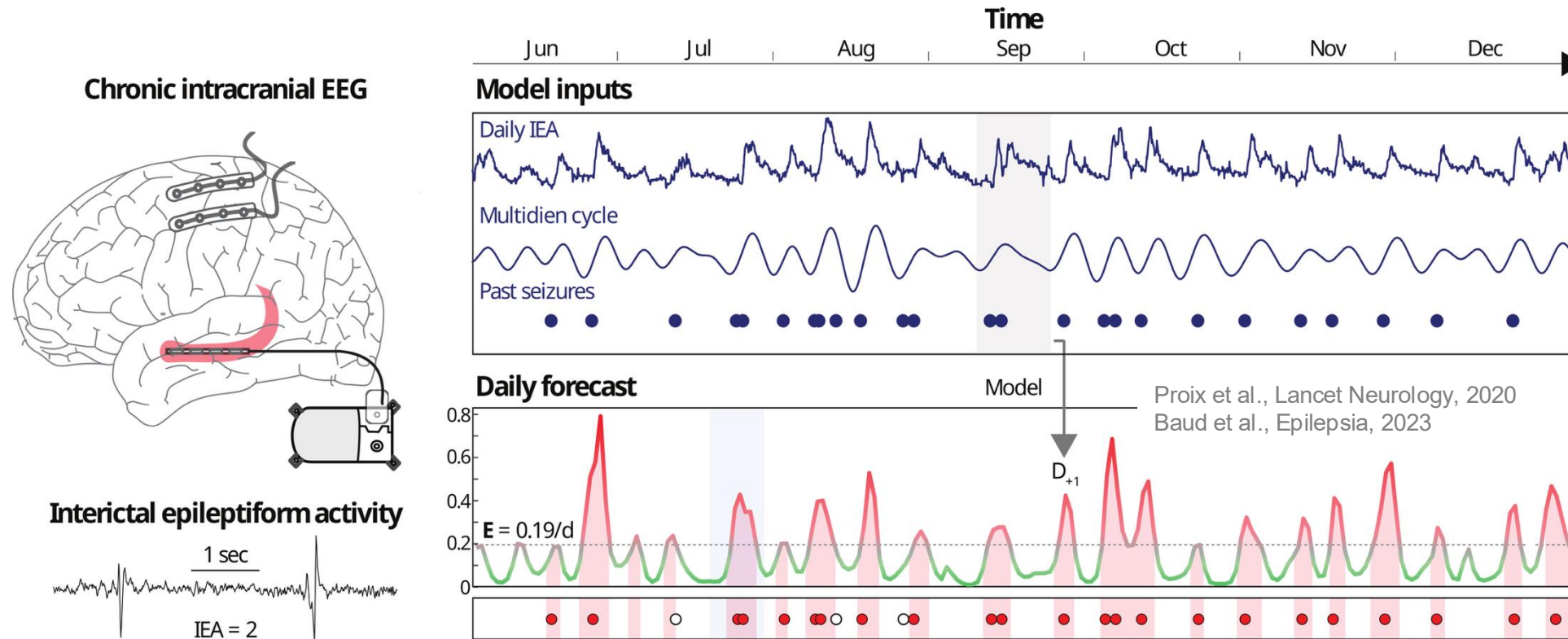
Costa et al. 2024, Nat Commun

Neuromorphic approach:
Automated real-time detection of HFOs during surgery

Statistical forecasting of seizure risk in epilepsy



Prof. T. Proix



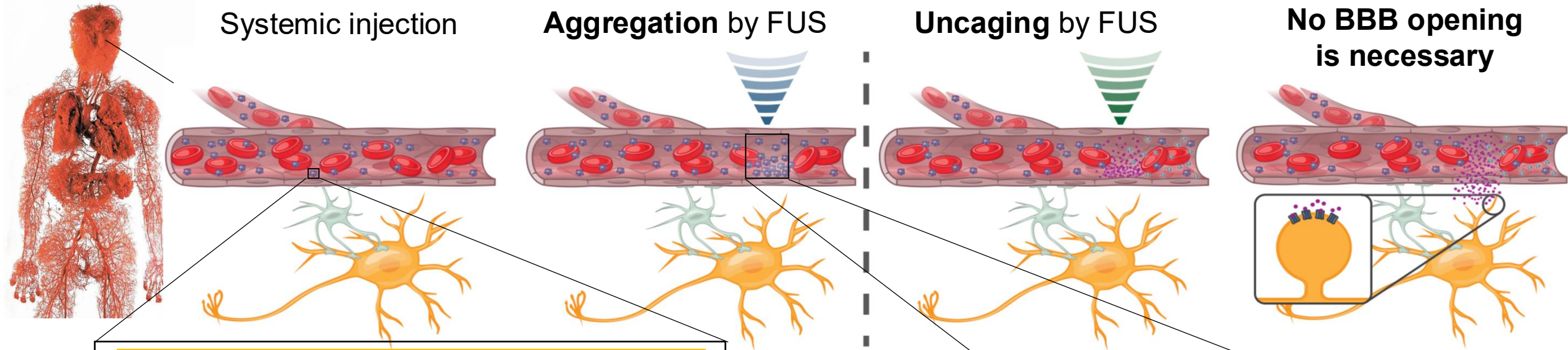
- Innovation lies in the timeline: **Forecasting horizon is days** instead of minutes with conventional approaches
- This makes forecasting information actionable
- Future: expandable to non-invasive EEG measures

non-invasive **Orchestrated Neuromodulation**

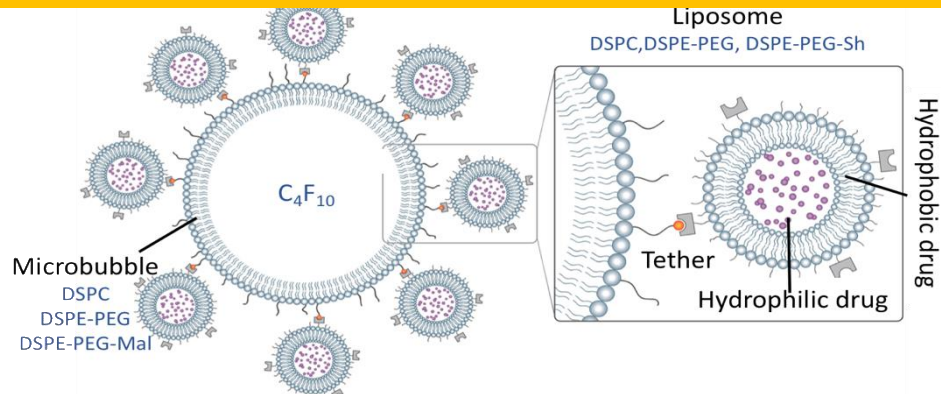
Focal drug delivery with **Aggregation-Uncaging Focused Ultrasound (AU-FUS)**



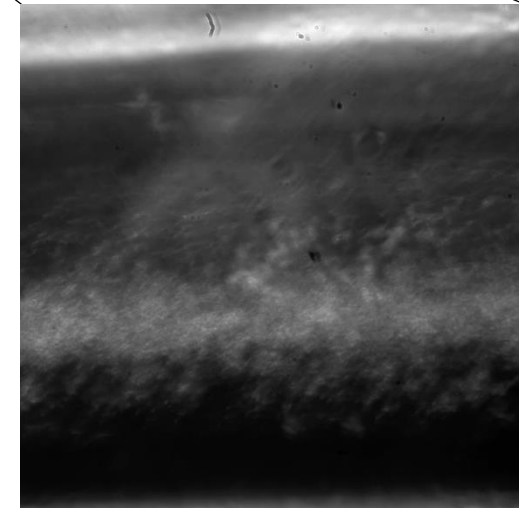
Prof. F. Yanik



Drug-carriers - with FDA-approved safety profile



Ozdas, Shah, Johnson et.al. Nature Comm. 2020



Focal drug delivery with **A**ggregation-**U**ncaging **F**ocused **U**ltrasound (AU-FUS)

First-in-man trial in Epilepsy patients
targeting epileptogenic locus



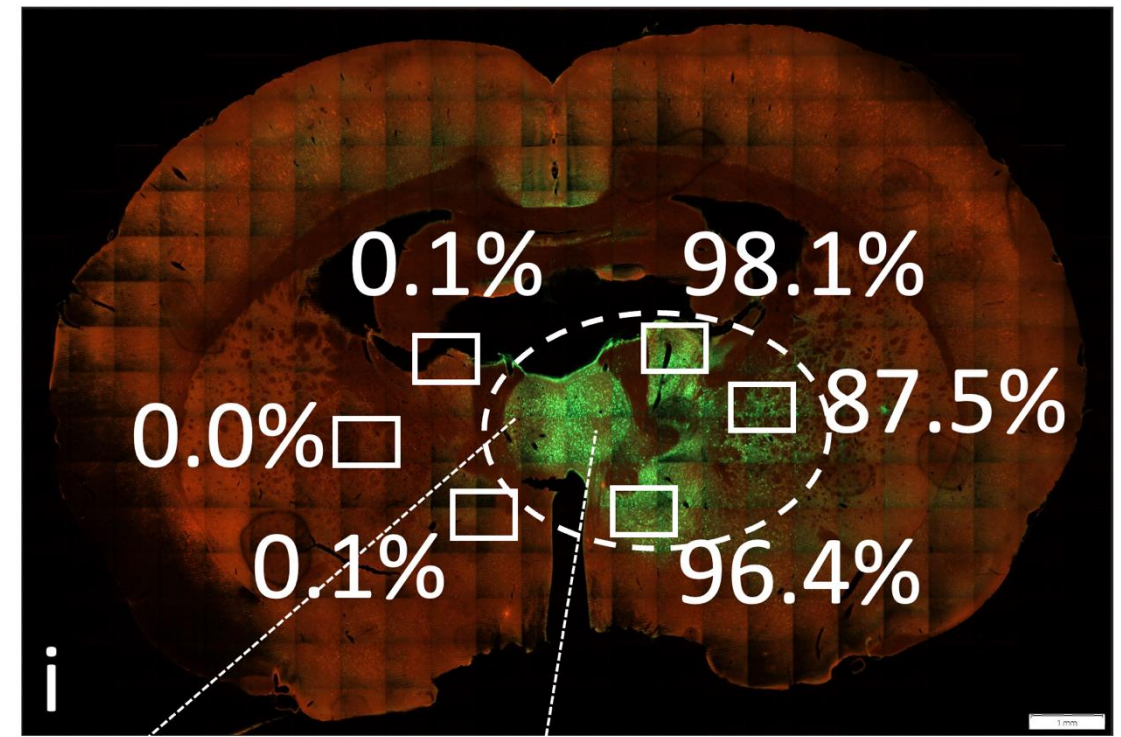
Prof. F. Yanik



Prof. L. Imbach

Hyper-concentrated focal siRNA delivery

RNA → months-long sustained effects &
reversible & entire transcriptome targetable



Percentage of total neurons with **5x siRNA** above background

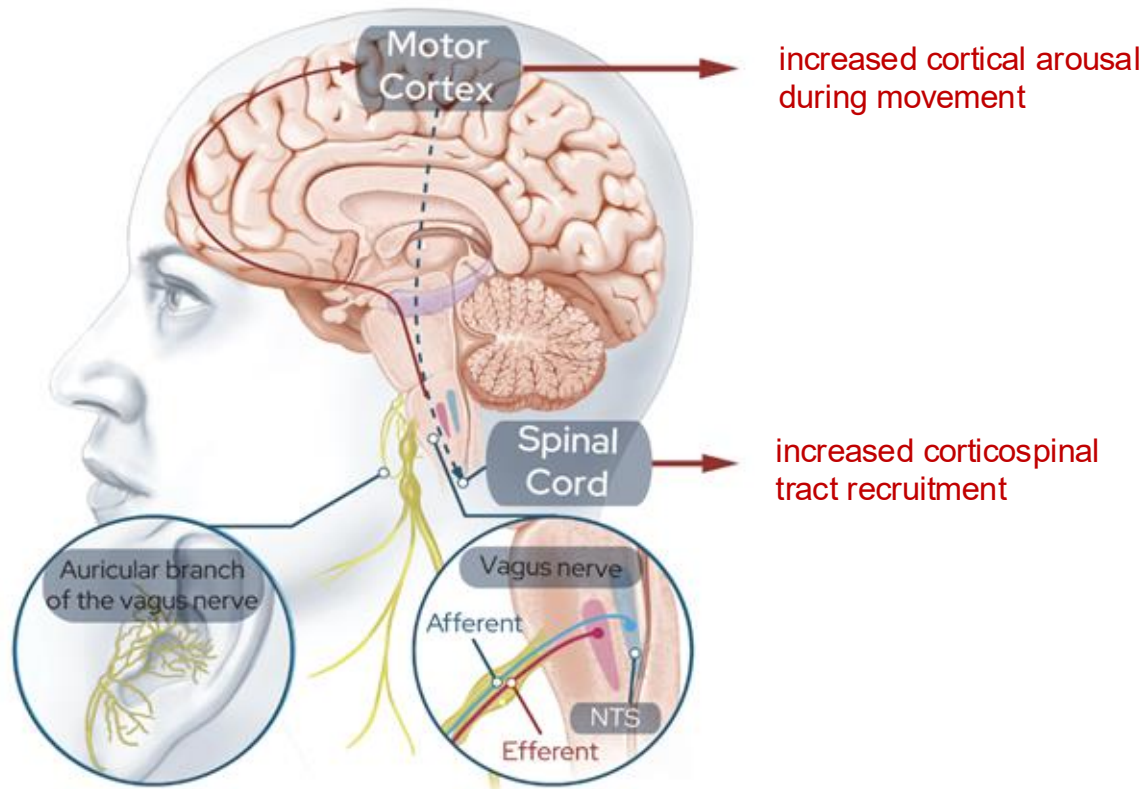
Boosting neuroplasticity for stroke recovery with non-invasive **auricular Vagus Nerve Stimulation** (aVNS)



Prof. O. Lamercy & R. Gassert



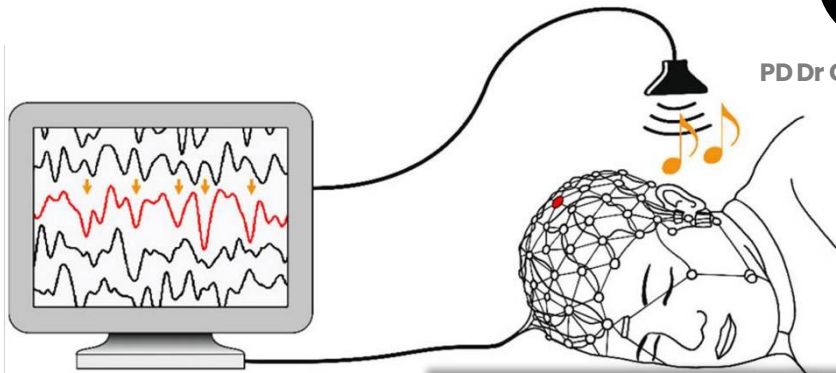
Detecting goal-directed movement of stroke patient triggers rapid neuromodulation via aVNS



Modulating sleep with **Sensory Stimulation**

Closed-loop auditory stimulation

modulates deep sleep to facilitate overnight restoration of brain & body functions



PD Dr C Lustenberger



Prof. R. Riener

Mechanical vestibular stimulation improves sleep



Somnomat



Huwiler et al, Eur Heart J. 2023
Carro-Domínguez et al, Nat Com

Galvanic vestibular Stimulation simulates a feeling of movement even when stationary

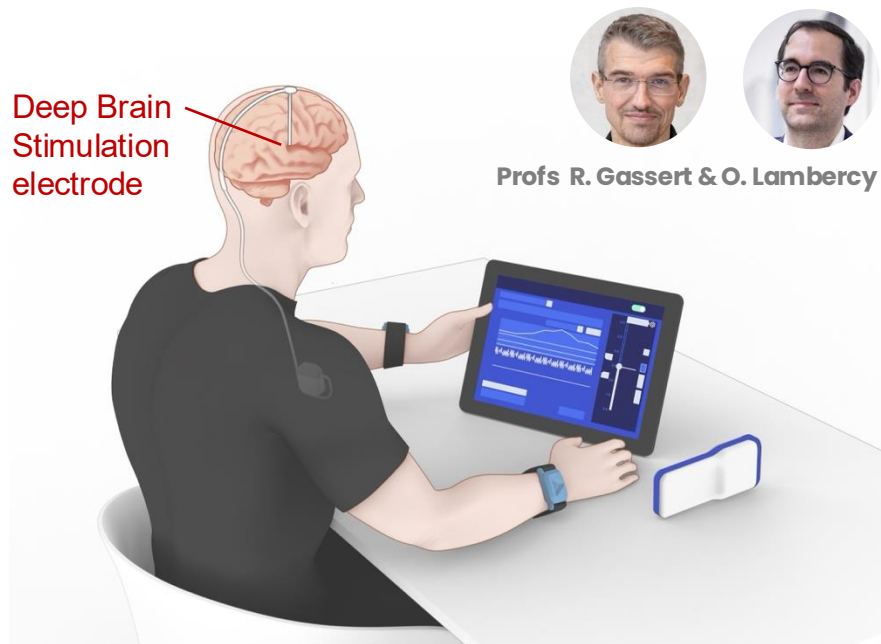


Prof. C. Menon



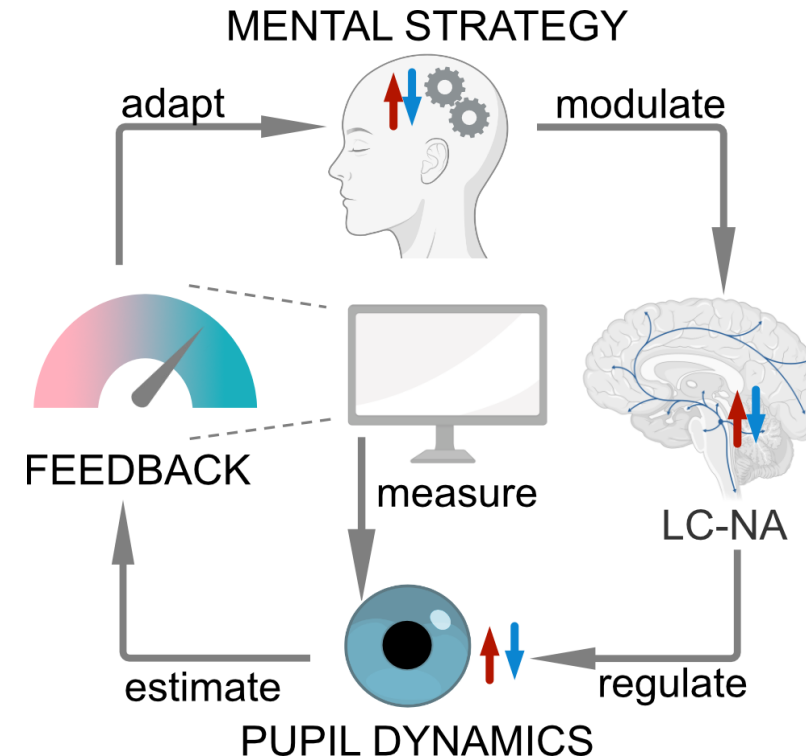
Functional self-regulation via closed-loop **Neurofeedback**

Parkinson's Disease patients improve foot movements by down-regulating subthalamic beta activity



Salzmann et al. 2025, Scientific Reports

Down-regulating pupil size reduces the brain's arousal state and stress response



Meissner et al, Nat Hum Behav 2024
Weijs et al, Nat Comm 2025

in-vitro **Brain modeling/Computation**

Characterising neural activity with High-Density Microelectrode Arrays (HD-MEAs)

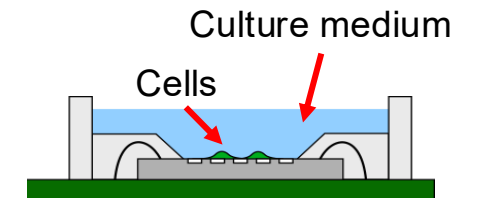
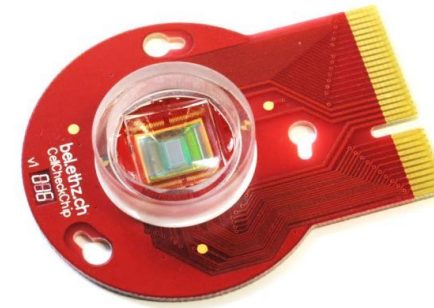


Prof. A. Hierlemann

Measuring network interactions of human iPSC-derived cultured neurons across scale



17.5 μm



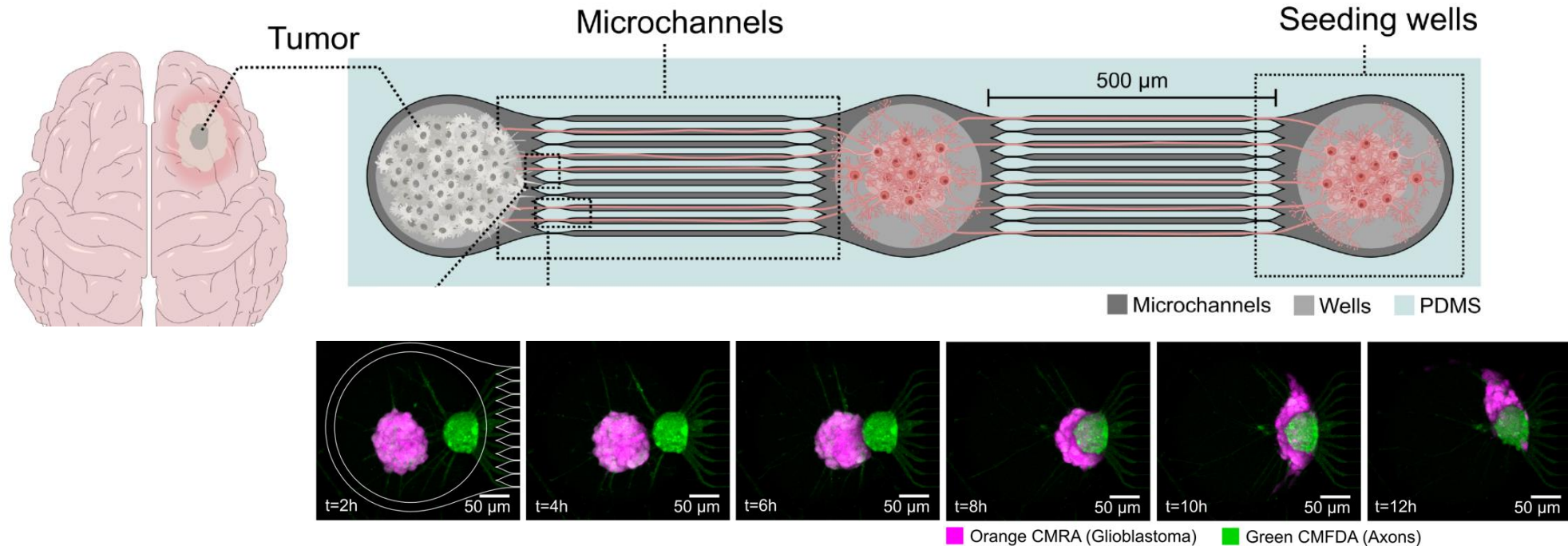
- Thousands of neurons
- High spatial & temporal resolution
- Longitudinal, label-free readout over weeks
- Network → single neuron → subcellular
- Disease & drug-response fingerprints

Characterising neural activity with High-Density Microelectrode Arrays (HD-MEAs)



Prof. J. Vörös

Compartmentalised platform for circuit interactions:
Tracking tumour infiltration and its effects on remote neuronal networks from hours to weeks





COMP NEUROTECH

Prof. Klaas E. Stephan

D-ITET / Uni Zürich / IBT

Computational psychiatry, generative brain models, functional imaging, OPM



COMP NEUROTECH

PD Dr. Zina M. Manjaly

D-HEST / Schulthess Clinic

Computational clinical neurology, pain, fatigue, MBCT



IMAGING

Prof. Daniel Razansky

D-ITET / Uni Zürich / IBT

Optoacoustic imaging, multi-scale bioimaging, molecular imaging



IMAGING

Prof. Klaas Prüssmann

D-ITET / Uni Zürich / IBT

Ultra-high field MRI, RF technology, field monitoring, magnetic resonance, OPM



COMP NEUROTECH

Prof. Giacomo Indiveri

D-ITET / Uni Zürich / INI

Neuromorphic engineering, VLSI neural systems, brain modeling



COMP NEUROTECH

Dr. Timothée Proix

D-ITET / INI

Epileptic seizure prediction, neural dynamics computational modeling



NEUROMODULATION

Prof. M. Fatih Yanik

D-ITET / INI

Non-invasive focal drug delivery, precision brain circuit modulation



NEUROMODULATION

Prof. Lukas Imbach

D-HEST / Klinik Lengg

Optimizing deep brain stimulation (DBS) in refractory epilepsy



NEUROMODULATION

Prof. Roger Gassert

D-HEST / IRIS

Closed-loop DBS in Parkinson's disease, physical human-robot interaction, Vagus nerve stimulation, personalized sensorimotor neurorehabilitation



NEUROMODULATION

Prof. Olivier Lamberg

D-HEST / IRIS



NEUROMODULATION

Prof. Sarah Meissner

D-HEST / INS

Closed-loop neurofeedback, self-regulation mechanisms, arousal



NEUROMODULATION

Prof. Nici Wenderoth

D-HEST / INS

Non-invasive brain stimulation, closed-loop neurofeedback, stress



NEUROMODULATION

PDDr. C. Lustenberger

D-HEST / INS

Sleep diagnostics, non-invasive auditory sleep modulation, stress & sleep



NEUROMODULATION

Prof. Robert Riener

D-HEST / IRIS

Sensory-motor systems, robotic rehabilitation, exoskeletons



NEUROMODULATION

Prof. Carlo Menon

D-HEST / IRIS

Mobile health technology, wearable sensor systems, smart textiles



CIRCUIT MODELING

Prof. Janos Vörös

D-ITET / IBT

Bioelectronics, neural interfaces, biosensors, circuit modeling



CIRCUIT MODELING

Prof. A. Hierlemann

D-BSSE

High-density microelectrode arrays (HD-MEAs), network electrophysiology

Neurotechnology @ ETH Zürich