Annual Report 2025

of the
Collaborative Research Center CRC 1540

Exploring Brain Mechanics (EBM)

Understanding, engineering and exploiting mechanical properties and signals in central nervous system development, physiology and pathology

Friedrich-Alexander-Universität
Erlangen-Nürnberg

Annual Report

of the Collaborative Research Center CRC 1540

Exploring Brain Mechanics (EBM)

Understanding, engineering, and exploiting mechanical properties and signals in the central nervous system development, physiology, and pathology

at the

Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU)

Prof. Dr.-Ing. Paul Steinmann (spokesperson)

Prof. Dr.-Ing. Silvia Budday (co-spokesperson)

2025

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Preface

The year 2025 was marked by intense scientific progress within EBM. We look back on a highly productive and successful year: Our research projects in brain mechanics, spinal cord regeneration, and cellular mechanics advanced significantly and demonstrated once again the strength of our interdisciplinary collaboration. A particular highlight was the very successful International EBM Symposium held in late September, whose excellent resonance has encouraged us to establish it as a biennial event. It was a wonderful setting to connect with the international brain mechanics community.

The Integrated Research Training Group (iRTG) also contributed substantially to the momentum within the consortium. Workshops, lab shadowing, retreats, and seminars fostered both scientific qualification and a strong sense of community among our early-career researchers. We are also particularly happy about the growing number of associated members and international guests, which reflects the strong international network and visibility of EBM.

We also made important contributions to public science communication, especially through our participation in the “Long Night of the Sciences,” which allowed us to share our research with a broad audience in an accessible and inspiring way.

At the same time, we entered an intense phase of preparing the proposal for EBM’s second funding period. Newly associated Principal Investigators have already integrated very well – scientifically and within the consortium’s social activities.

Looking ahead to the coming year, the final year of the first funding period, key milestones await us: the completion of the full proposal and the DFG on-site review. The ongoing dedication of our members and the steady stream of scientific achievements give us confidence as we take these important next steps.

Erlangen, December 2025

Paul Steinmann and *Silvia Budday*

CONTENT

Figure 1: Group photo at the 3rd EBM Retreat in Muggendorf on October 9, 2025. (Image: T. Schröder)

IN MEMORIAM

Obituary

Professor Jochen Guck

in memory of our valued colleague

Professor Jochen Guck (1973–2025)

With great sadness, we remember Professor Jochen Guck, who passed away far too early on October 3, 2025.

Jochen was not only a brilliant scientist and pioneer in cell mechanics, but above all, a warm, open, and inspiring colleague. Those who worked with him experienced his generosity, his humor, and his ability to motivate and support others. He had a genuine joy in making science interdisciplinary, curious, and lively.

From the earliest ideas of CRC 1540 EBM to his role as project leader in B03, Jochen was always engaged, enthusiastic, and willing to share his experience. His dedication, kindness, and team spirit shaped our research network and will continue to inspire us.

We will miss Jochen dearly – his spirit, warmth, and humor will remain in our memories. Our deepest sympathy goes to his family and all who were close to him

1 RESEARCH PROGRAM

The CRC1540 EBM focuses on unraveling the mechanical aspects influencing the central nervous system (CNS). Despite advancements in understanding biochemical and genetic regulations, many CNS processes and diseases remain elusive. The program addresses challenges such as unpredictable axon growth, imprecise diagnosis of CNS-related diseases, and the promotion of neuronal regeneration post-spinal cord injuries.

Researchers associated with EBM, and a few other groups worldwide, have recently identified the significant impact of mechanical signals on CNS cell function. Examples include the influence of brain tissue mechanics on axon growth, the role of mechanical forces in cortical folding, and the link between brain stiffness and age-related remyelination issues. These insights suggest that mechanics plays a vital role in diverse CNS functions, interacting intensely with chemical signals at cellular and tissue levels.

EBM brings together a multidisciplinary team of engineers, physicists, biologists, medical researchers, and clinicians in Erlangen. Leveraging advanced techniques across various time and length scales, the team aims to understand how mechanical forces and properties like stiffness affect CNS function, with a specific focus on cerebral, spinal, and cellular mechanics.

In vivo and *in vitro* studies provide fundamental insights and identify key mechano-chemical factors. *In silico* models enable hypothesis testing without extensive experiments, facilitate data transfer across species and scales, and optimize parameters for the development of *in vitro* brain tissue-like matrices. Ultimately, EBM seeks to exploit mechanics-based approaches to enhance our understanding of CNS function, laying the groundwork for improved diagnosis and treatment of neurological disorders.

1.1 RESEARCH PROJECTS

EBM is structured into three focal research areas (FRA) focusing on cerebral (**A**), spinal (**B**), and cellular mechanics (**C**), and an overarching cross-sectional research area (**X**RA).

FRA A – Cerebral Mechanics:

FRA **A** focuses on brain development with special emphasis on brain malformations associated with neurological disorders such as epilepsy. Computational modeling in **A01** will help systematically understand physical mechanisms underlying brain malformations and benefits from quantitative characterization of human brain malformations in **A02** and the *in vitro* and *in vivo* insights gained for brain development in *Xenopus* (**A03**/**A05**) and organoids (**A03**/**A04**) based on engineered brain tissue-like matrices.

FRA B – Spinal Mechanics:

FRA **B** focuses on spinal cord injury and disease with special emphasis on mechanically stimulated regeneration of CNS function. Computational modeling of spinal cord injury, disease and regeneration in **B01** assists and builds on unraveling regeneration/disease-promoting/limiting characteristics and determinants of its mechanical landscape in **B02**, **B03**, **B04**, and exploration of *in vivo* mechanical manipulation in **B05**.

FRA C – Cellular Mechanics:

FRA **C** focuses on the role of mechanics in cell-matrix interactions. Computational modeling of cell-matrix interactions in **C01** targets the role of mechanics for neuronal “plasticity”, seizure-like hyperactivity, and cellular differentiation investigated in **C02**, **C03,** and **C04**, all informed by the versatile experimental platform established in **C05** and corresponding insights into mechanosensing and -transduction.

XRA – Cross-Sectional Projects:

The overarching cross-sectional projects in **X**RA will focus on the standardization and integration of *in vivo* and *ex vivo* testing data across scales (**X01**), the transferability of data from different species and experimental methods through advanced machine learning techniques (**X02**), and the design of engineered substitute materials for brain tissue (**X03**)

Table 1 subsumes EBM's projects:

Table 1: EBM projects

FOCAL RESEARCH AREA A: CEREBRAL MECHANICS		
A01	*In silico* modeling of brain malformations	S. Budday
A02	Quantitative characterization of brain malformations	I. Blümcke, A. Dörfler, F. Paulsen
A03	*In vitro* model for the mechanics of early brain development	A. Schambony
A04	The role of mechanics in orchestrating neural lineage decisions	M. Karow, S. Falk
A05	*In vivo* model for the mechanics of brain development	K. Franze
FOCAL RESEARCH AREA B: SPINAL MECHANICS		
B01	*In silico* modeling of spinal cord regeneration	P. Steinmann, S. Budday
B02	Pre and post-metamorphosis spinal cord regeneration in frogs	K. Franze
B03	The determinants of spinal cord mechanics in homeostasis	J. Guck, S. Möllmert
B04	Spinal cord mechanics in a mouse model of multiple sclerosis	S. Kürten
B05	*In vivo* mechanical manipulation of spinal cord regeneration	D. Wehner
FOCAL RESEARCH AREA C: CELLULAR MECHANICS		
C01	*In silico* modeling of mechanical cell-matrix interactions	V. Zaburdaev, P. Steinmann
C02	The role of mechanics for neuronal "plasticity"	R. Frischknecht
C03	The role of matrix mechanics in synchronized neuronal activity	K. Kobow
C04	Cellular differentiation in brain tissue-like matrices	A. Bosserhoff
C05	Molecular mechanisms of neuronal mechanotransduction	B. Fabry
CROSS-SECTIONAL RESEARCH AREA X: CROSS-SECTIONAL PROJECTS		
X01	Model-based reconciliation of *ex vivo* and *in vivo* test data	J. Guo, I. Sack, P. Steinmann, K. Willner
X02	Data analysis and machine learning for heterogeneous, cross-species data	A. Maier, K. Breininger
X03	Engineering brain tissue-like matrices	A.R. Boccaccini
Y	Establishing magnetic resonance elastography at FAU	A. Dörfler, F. Laun, J. Guo, I. Sack

1.2 PROJECT REPORTS

A01 Inverse mechanical characterization of human brain tissue

Jan Hinrichsen, Nina Reiter, Lucas Hoffmann, Ingmar Blümcke, Daniel Delev, Saeed M. Zarzor, Silvia Budday

Towards an *in silico* model of brain malformations

The overall goal of project **A01** is the implementation of a computational model to predict cortical malformations. To this end, we work on two primary areas of study. Firstly, the implementation of the computational model, and secondly, the experimental mechanical characterization of brain tissue with relevant pathologies. In close collaboration with project **A02** as well as the neurosurgery department, we have continued our efforts to mechanically test and characterize fresh, surgically resected tissue. The neuronal network algorithms developed in project **A02** facilitate the subsequent automated analysis of histological stains of the tested tissue. We obtain the nonlinear mechanical properties in terms of material model parameters by fitting Ogden-type models to the data. Combining these data allows us to link microstructural information with the macroscopic mechanical behavior. Figure 2 (left) shows lower shear moduli for higher overall cell densities in cortical specimens with a focal cortical dysplasia (FCD) diagnosis. Figure 2 (right) shows the opposite trend for hippocampus specimens with a hippocampal sclerosis diagnosis. These findings will inform modeling choices for the computational model. We extended the model developed by Zarzor et al. [1] by integrating local changes in differentiation, proliferation, and migration behavior, which enables us to capture the mechanisms underlying cortical malformations. In this initial study, we apply the model to capture how the local overexpression of transcription factor Cux2 leads to additional folds in ferret brains, as observed by Singh et al. [1]. In their experimental study, they found that the Cux2 overexpression leads to direct neurogenesis in radial glial cells. This results in an initially higher density of neuronal cells in the cortical plate, followed by lower numbers in later stages of cortical development. We have integrated this mechanism into our model and achieved preliminary results shown in Figure 3. The predicted morphology has a sharp fold, and the cell distribution shows the aforementioned lower neuronal cell density in the region of Cux2-affected neurons. In the future, we will also focus on the numerical robustness of the model and investigate individual cases of FCD II in human patients.

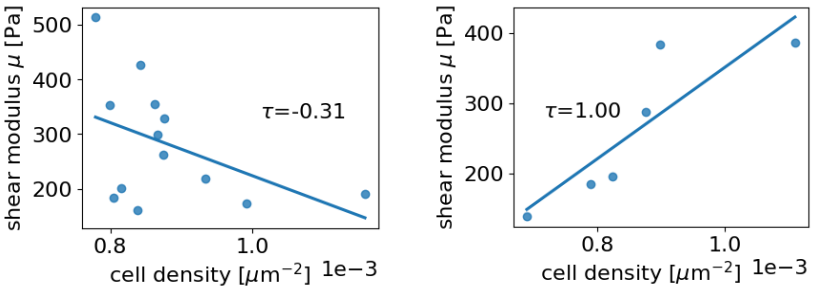

Figure 2: Shear modulus μ, characterizing the mechanical stiffness in the limit of small deformations, as a function of the overall cell density. (left) Data for surgically resected cortex specimens with an FCD diagnosis. (right) Data for surgically resected hippocampus specimens with a hippocampal sclerosis diagnosis.

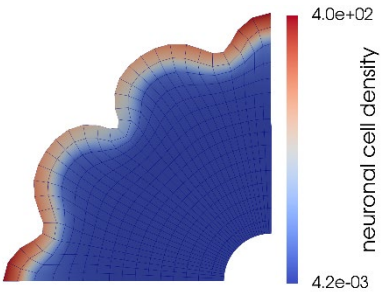

Figure 3: Simulation results showing a sharp fold with lower cell density due to the direct neurogenesis in regions with transcription factor Cux2 over-expression.

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A02 Quantitative characterization of brain malformations

WP1: The generation of normal/healthy human brain datasets commonly usable for EBM members

Arnd Dörfler, Stefan Rampp, Friedrich Paulsen, Lucas Hoffmann, Ingmar Blümcke

In 2025, we continued to collect and process comprehensive datasets, including patients with focal epilepsy, e.g., due to cortical malformations (WP2) or other pathologies. We also built a close cooperation with the Epilepsy Surgery Center at Schoen Klinik in Vogtareuth and collected tissue samples from an additional six patients with cortical malformations. Datasets were processed with a segmentation and morphometric analysis pipeline, yielding statistical parameters to inform models of brain development and allowing comparison with histological and mechanical testing data (see **A01**). Hippocampal volumetry was related to cell counts and rheometer testing in the respective surgical specimen. Furthermore, co-registration of postoperative images of resected specimens with preoperative MRI was performed and is ongoing, focusing on patients with focal cortical dysplasia. Until now, we have received healthy human brain samples from six body donors. All brains were scanned *ex vivo* by 3T as well as 7T MRT (see below WP 2). Selected anatomical regions were dissected and mechanically tested by our EBM partners from **A01** (see report therein). All tissues were fixed in formalin, embedded in paraffin, and serially sectioned into 4µm thin sections (WP3). This tissue collection effort will continue in the upcoming years to further enrich our common dataset of healthy human brain tissue and serve as an essential reference for understanding mechanical abnormalities in the epileptogenic brain. We also shared 37 surgical tissue samples from patients submitted to epilepsy surgery, including hippocampal sclerosis and focal cortical malformations. The same pipeline of presurgical MRI scanning at 3T (WP2), mechanical testing *ex vivo* by **A01**, and histopathology analysis of all available tissue samples was implemented (WP3).

WP2: (Ultra-) High-field imaging of human brain malformations

Arnd Dörfler, Stefan Rampp

In 2025, no additional brains from body donors became available for MRI. However, 6 of the planned 8 body donor brains have been scanned at 3T and 7T up to now. Inclusion of the remaining two in 2026 seems realistic. The brain holder device, designed and prototyped in 2024, could be finished, and a 3D print with solid walls to avoid susceptibility artefacts could be manufactured.

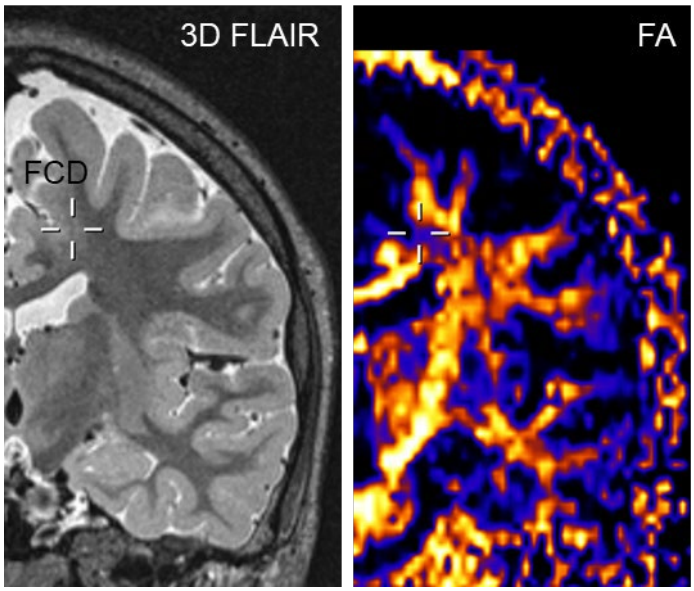

Figure 4: Example of FA reduction the vicinity of a focal cortical dysplasia (see hair-cross and 3D FLAIR co-registering with FA map on the right.

The pipeline for co-registration, segmentation, and morphometric analysis was further optimized, integrating different voxel-based morphometry methods (MAP, FLAT1) and radiomics features. Work on extending these methods was continued. To allow for statistical comparison of the different modalities with healthy controls, as well as provide data to investigate models of brain development (**A01**), 24 healthy persons were scanned at 3T, in addition to acquisitions of datasets in collaboration with project Y. This growing database may allow extension of morphometric methods to include other imaging modalities, e.g., diffusion-weighted imaging, qMRI and radiomics.

The finding that the fractional anisotropy (FA) of diffusion-weighted imaging (DWI) is strongly correlated to the shear modulus of the Ogden hyperelastic material model could be extended. The correlation was confirmed in 28 healthy controls and in an independent, publicly available dataset from Tian et al. [5]. Furthermore, a weaker correlation to the non-linearity parameter could be established in the larger dataset. Data from intraindividual comparisons in two body donor brains further confirmed the finding.

A respective publication is currently in progress.

In collaboration with A01, the correlation was utilized to construct a computational model of brain stiffness with voxel resolution. The data is further used to investigate mechanical phenomena in brain atrophy [6]. Furthermore, we started to evaluate potential functional significance by comparing spatially resolved FA with functional connectivity determined by magnetoencephalography (MEG). Preliminary results demonstrate significant correlations with connectivity in different frequency bands in healthy controls. Notably, discordant findings could be observed in patients in the vicinity of a focal cortical dysplasia, suggesting a possible application for lesion detection.

WP3.1: Deep histopathology phenotyping of genetically characterized human MCD

Erica Cecchini, Lucas Hoffmann, Ingmar Blümcke

During the past twelve months, we have successfully finalized the application of the Visium Spatial Gene Expression tool to study spatial RNA expression in a comprehensive series of MOGHE (Mild Malformation of Cortical Development with Oligodendroglial Hyperplasia in Epilepsy) cases, including those with or without a proven brain somatic mosaicism of the SLC35A2 gene and with or without brain somatic polyploidy of the Y chromosome. Over the course of this year, we have established a complete experimental and analytical pipeline that includes RNA quality control, implementation of the Visium CytAssist protocol, and the establishment of a partnership for sequencing of the generated libraries. Using this workflow, we have processed and analyzed the first four MOGHE samples, which represent both sexes and include cases with and without Y-chromosomal gain, as well as SLC35A2 wild-type and variant genotypes. These efforts have yielded the first spatial transcriptomic datasets providing an integrated overview of gene expression in these genetically and sex-defined contexts.

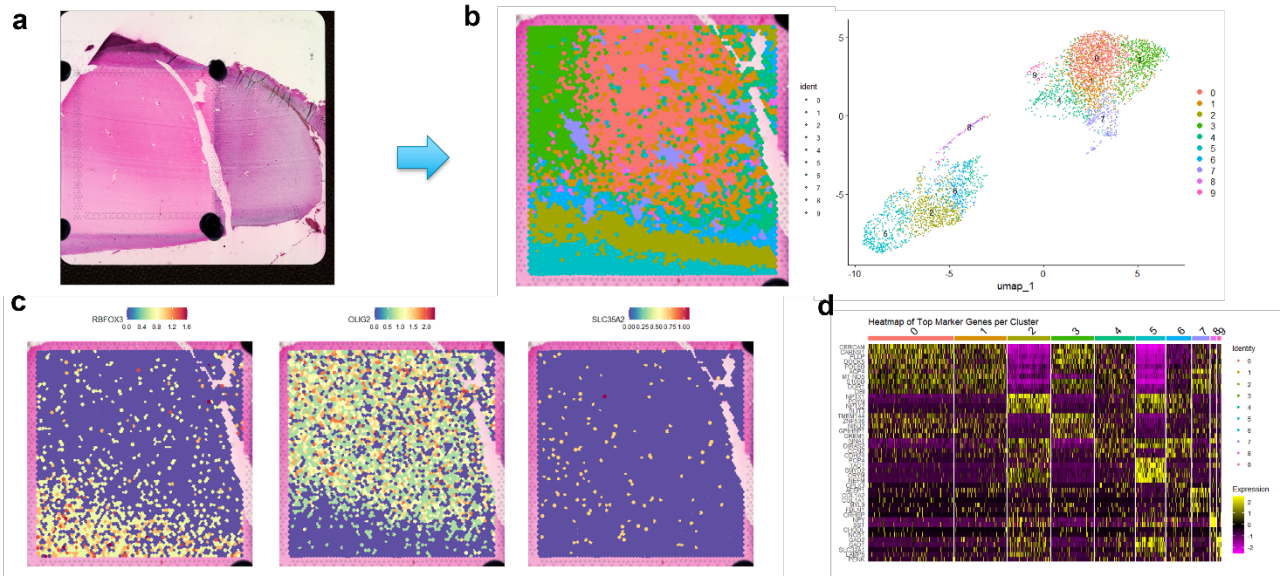

*Figure 5: Spatial transcriptomics of cortical tissue from a male MOGHE case carrying an SLC35A2 variant (VAF 48%). In panel **a**, the tissue section stained with eosin is shown as captured by the Visium CytAssist system. Panel **b** presents the identified cell clusters based on their gene expression profiles, displayed as a cluster map corresponding to the analyzed 6.5 × 6.5 mm Visium tissue area, alongside a UMAP plot. In panel **c**, transcriptome maps for representative genes are shown, including RBFOX3 (NeuN), a marker of post-mitotic neurons; OLIG2, a marker of oligodendrocytes, which appear hyperplastic in MOGHE lesions; and SLC35A2, which shows reduced expression in this patient carrying an SLC35A2 variant with a 48% variant allele fraction (see also [4]). Panel **d** presents a heatmap of the top marker genes per cluster, highlighting the molecular signatures and biological processes associated with each cell population.*

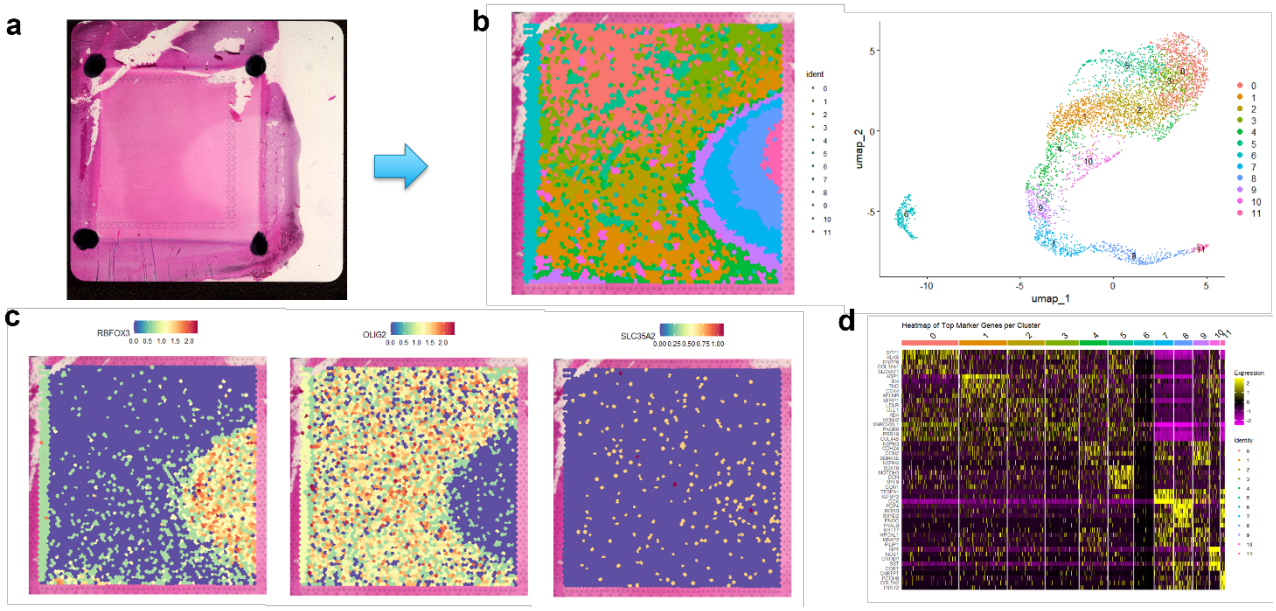

*Figure 6: Spatial transcriptomics of cortical tissue from a female MOGHE case with wild-type SLC35A2. Panel **a** shows the eosin-stained tissue section captured with the Visium Cyt Assist platform. Panel **b** depicts the spatially resolved gene expression clusters derived from transcriptomic data, visualized as a spatial cluster map across the 6.5 × 6.5 mm capture area and as a corresponding UMAP representation. Panel **c** displays spatial expression patterns of representative marker genes, including RBFOX3 (NeuN), identifying neuronal populations, OLIG2 marking oligodendrocytes, and SLC35A2, which exhibits comparatively higher expression levels in this wild-type sample relative to the variant case. Panel d presents a heatmap summarizing the top differentially expressed genes defining each cluster, illustrating distinct molecular signatures and cellular identities within the analyzed tissue.*

The next milestone for the upcoming twelve months is to complete the remaining Visium CytAssist runs with spatial transcriptomics and to integrate the resulting datasets with the Xenium platform. The Xenium platform profiles RNA directly in FFPE or fresh frozen tissue sections using probe hybridization, amplification, and imaging to map transcripts within the tissue. The resulting spatial data are instantly viewable and compatible with various third-party analysis tools. This integration will enable higher-resolution spatial mapping and allow multi-modal validation of gene expression profiles, thereby advancing our understanding of the molecular architecture of MOGHE and its association with somatic mosaicism and chromosomal abnormalities.

WP3.2: Deep histopathology phenotyping of genetically characterized human MCD

Ingmar Blümcke

In this second part of our work package, we developed a first cell-type specific classifier recognizing large or small pyramidal cells, granule cells, dysmorphic neurons, astrocytes, oligodendrocytes, balloon cells, microglia, blood vessels, capillaries, and corpora amylacea from formalin-fixed, paraffin-embedded embedded and hematoxylin-stained human neocortical and hippocampal sections (Figure 7A and Figure 7B). This tool will be helpful to further explore the specific cell composition of FCD subtypes in 2D and 3D models, as well as to directly correlate mechanical measurements of the same brain samples performed in project **A01** [3].

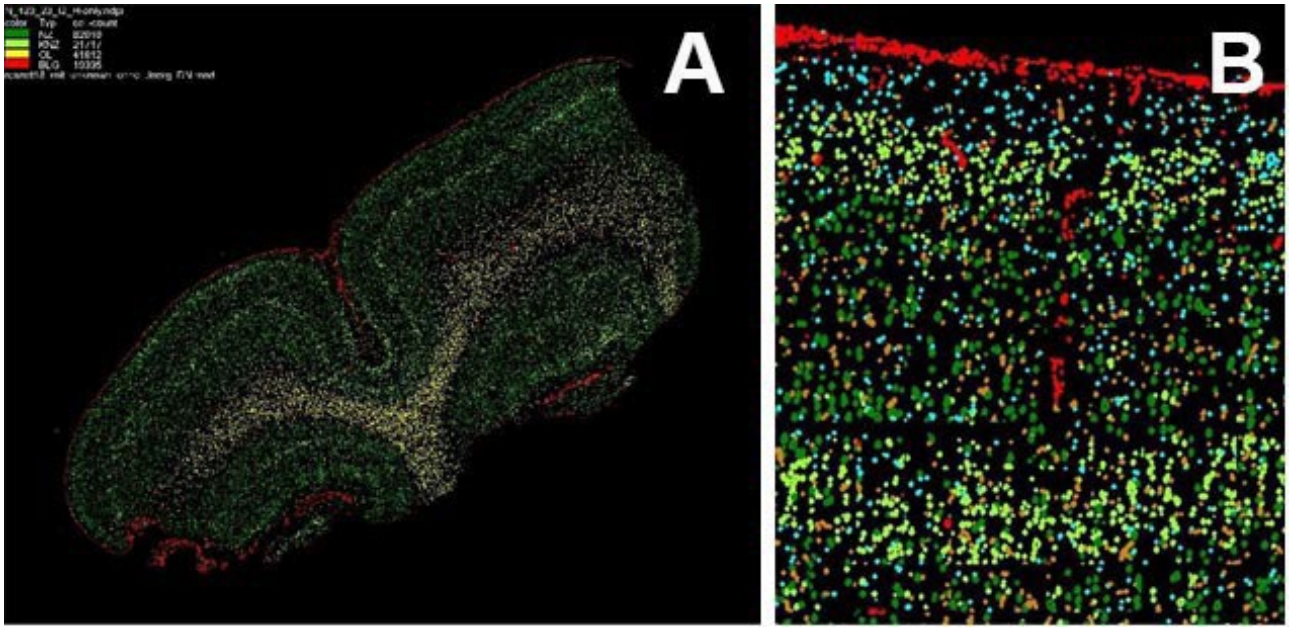

*Figure 7: Prototype of a deep-learning–based cell segmentation classifier for the human neocortex. Automated cell segmentation of a hematoxylin-stained human neocortical brain tissue sample and DL-based assignment to specific cell types. Please note the anatomically well-delineated layering in **A** and its higher resolution in **B,** showing: astrocytes in light blue (predominantly in Layer 1), small pyramidal cells of Layer 2 and 4 in light green, large pyramidal cells of Layer 3 and 5 in green. Blood vessel profiles were displayed in red, and capillaries in brown.*

WP4: Deep extracellular matrix (ECM) quantification and phenotyping in healthy human brain and cortical malformations

Sophia Auer, Friedrich Paulsen

In Work Package 4, we conducted mass spectrometry-based proteomic analyses of microdissected hippocampal, neocortical, and white matter tissue obtained from patients with temporal lobe epilepsy (TLE) associated with hippocampal sclerosis type 1 (HS1), as well as from patients with focal cortical dysplasia type IIb (FCD IIb), and corresponding non-epileptic control samples. To date, we have analyzed the TLE dataset. Comparative proteomic profiling revealed extensive region-specific molecular alterations. Upregulated proteins were predominantly associated with innate immune activation, especially complement system pathways, emphasizing the role of neuroinflammatory processes in TLE pathophysiology. Concurrently, upregulation of extracellular matrix (ECM)-related proteins, including tenascin-C and integrins, CD44, and thrombospondin-1, suggests pronounced ECM remodeling under epileptic conditions. Conversely, proteins related to synaptic signaling, neurotransmission (both GABAergic and glutamatergic systems), and mitochondrial metabolism were significantly downregulated, reflecting structural and functional impairment of hippocampal network integrity. Interestingly, opposite trends were observed in the temporal neocortex and white matter, suggesting compensatory or adaptive responses and pronounced regional heterogeneity in TLE pathology [2]. Validation of proteomic findings will be performed using expanded sample cohorts and complementary techniques (ELISA, IF). Furthermore, we will analyze the dataset for FCD IIb tissue to identify proteomic alterations and to enable a direct comparative analysis with TLE. Together, these

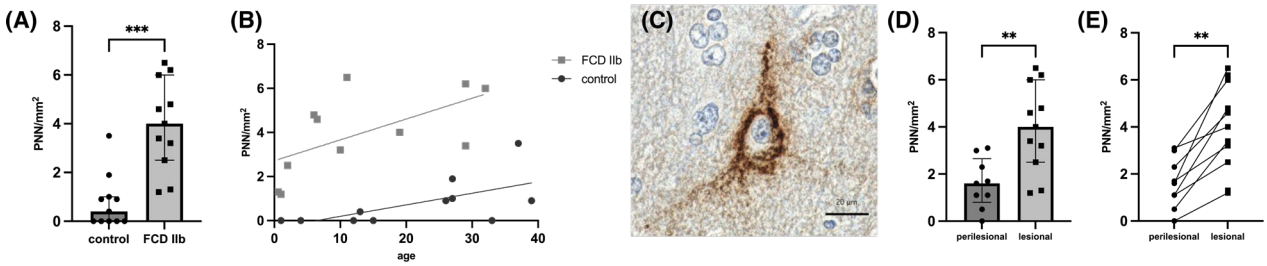

Figure 8: Increased PNN density in FCD IIb lesions and age-dependent accumulation of PNNs. (A) Lesional cortex shows higher density than controls. (B) PNN density positively correlated with age in both groups, with consistently higher values in FCD IIb across all ages. (C) Representative aggrecan-immunoreactive PNN (DAB, brown) with nuclei counterstained with hematoxylin (blue; scale bar = 20 µm). (D, E) PNN density is higher in lesional vs. perilesional regions in FCD IIb.

studies aim to advance the understanding of underlying molecular processes in epileptogenic brain disorders and contribute to the identification of potential biomarkers and therapeutic targets.

In order to review and deepen existing knowledge about perineuronal nets, a comprehensive literature search was conducted, which resulted in a review article on the topic [1]. Subsequently, quantitative histological analyses of 11 human FCD IIb tissue samples and 11 age-matched control samples demonstrated a significantly increased density of perineuronal nets (PNNs) in FCD IIb compared to non-epileptic control tissue (Figure 8A). Within FCD IIb cases, lesional areas exhibited higher PNN densities than perilesional cortex, suggesting a potential role of PNNs in disease pathology and epileptogenicity (Figure 8D, E). Moreover, an accelerated ECM-associated aging pattern was observed in the FCD IIb cohort, characterized by persistently elevated PNN densities across all examined age groups compared to the control samples (Figure 8B). Co-localization studies revealed that, in addition to the typical association with parvalbumin-expressing, GABAergic interneurons, PNNs also enwrap dysmorphic neurons within the lesion core, indicating altered cellular association and pathological ECM remodeling (Figure 9). These findings highlight PNN dysregulation as a histopathological feature of FCD IIb with potential implications for altered neuronal network stability (poster: Quantitative Description of Perineuronal Nets in Focal Cortical Dysplasia Type IIb; Sophia Auer, Lucas Hoffmann, Martin Schicht, Ingmar Blümcke, and Friedrich Paulsen; Annual Meeting of the Anatomische Gesellschaft, Würzburg 2025 and International EBM Symposium 2025). Future work will focus on elucidating the contribution of PNN-ensheathed dysmorphic neurons to seizure generation. Electron microscopy and 3D reconstruction approaches will be employed to characterize the ultrastructure of FCD IIb tissue.

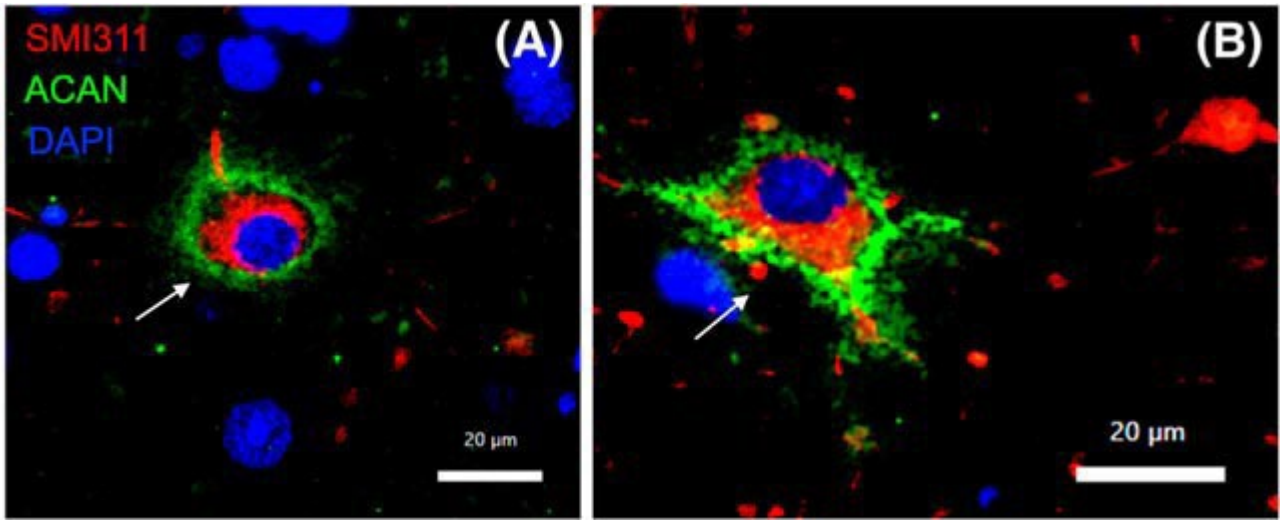

Figure 9: Dysmorphic neurons (DN) surrounded by PNNs in FCD IIb. (A, B) SMI-311 positive dysmorphic neurons (red) are surrounded by aggrecan-positive PNNs (green, arrows), and nuclei are counterstained with DAPI (blue). Dysmorphic neurons show the characteristic enlarged size > 20 µm and eccentric nuclei. Scale bar = 20 µm.

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A03 *In vitro* model for the mechanics of early brain development

Clara Froidevaux, Miriam Mager, Alexandra Schambony

The brain develops from a flat sheet of dorsal ectoderm, the neural plate, which undergoes extensive morphogenesis and shape changes to form the three primary ventricles of the brain and the spinal cord. We are developing and characterizing an organoid model system derived from *Xenopus laevis* neural plate tissue to investigate the interplay of mechanics and biochemical signaling in early brain morphogenesis.

WP1: Mapping the mechanical landscape of neural plate organoids

After characterizing the mechanical properties of early neural plate tissue using AFM and Brillouin microscopy, we have started to characterize the extracellular matrix (ECM) in early neural plate tissue. Qualitative and quantitative analysis of ECM composition is challenging due to the poor solubility of part of the ECM and the comparatively low amount of ECM as compared to cellular proteins. Decellularization protocols have been established, but require extended incubation times, which might result in partial modification and degradation of the insoluble ECM. We have tested and optimized extraction buffers and fractionation protocols to deplete soluble cellular proteins and solubilize known ECM components. Although our protocols were successful according to Western Blot detection of selected known ECM proteins, preliminary proteomics analyses revealed a significant carry-over of yolk proteins even after optimization of the procedure, which compromised the analysis.

To overcome this problem, we have established metabolic labeling of glycans in early embryos and in tadpole brains. Most ECM proteins and also non-protein ECM components, such as hyaluronic acid, are highly glycosylated. Therefore, metabolic labelling of glycans will also label ECM components. Metabolic labeling of glycans has been demonstrated in cultured mammalian cells and also in zebrafish embryos, but not yet in Xenopus embryos or tadpoles. We could demonstrate metabolic labelling of Galactose-containing glycans and of Sialic Acid-containing glycans in early embryos either by injection of Azido-sugars in two-cell stage embryos or by adding the Azido-sugars to the culture medium. In the latter approach, labeling is restricted to the outermost layers of cells, which in very early embryos is not a strong limitation but becomes relevant when labeling later stages or tadpoles. To specifically label glycans in the tadpole brain, Azido-sugars were injected into the brain ventricles of stage 40 tadpoles. Labelling has been evaluated by fluorescent labelling and Western Blotting.

WP2: Analyzing the influence of global mechanical cues on brain morphogenesis and tissue mechanics.

In the first months of the project, we have observed that organoids cultured on 1.5% Alginate for 48h developed eyes with pigmented retinae (annual report 2023), which is remarkable since the retina is a derivative of the brain. In addition,

In the first two years of the project, we have established that alginate-based hydrogels are a suitable support for Xenopus early brain organoids and that tuning the stiffness of these alginate gels influences brain development in organoids. We confirmed neural specification by the presence of *neurogenin 1* - positive neuronal precursor cells, and in the presence of Fibronectin, the emigration of *slug*-positive neural crest cells from the organoid.

Having confirmed organoid development on Alginate hydrogels, we have carried out a more in-depth characterization of chemical and mechanical properties of these hydrogels. Alginate hydrogels are cross-linked with CaCl2 solution; therefore, we have analyzed the release of Ca^{2+} ions from these hydrogels. Ca^{2+} homeostasis is biologically relevant, and excess Ca^{2+} may influence cell signaling, differentiation, and development. We could show that only minor amounts of Ca^{2+} are released from the gels and that although the overall concentration of Ca^{2+} in the medium increases slightly, it remains below concentrations that have been tolerated by the organoids in preliminary experiments. Mechanical characterization was carried out using (1) nano-indenter measurements in collaboration with the group of Silvia Budday and (2) AFM measurements in collaboration with the group of Kristian Franze. Interestingly, AFM measurements yielded a higher apparent Young's modulus in all cases. We hypothesize that these differences can be at least in part attributed to the probe size, suggesting local inhomogeneities in this size range.

WP3: Analyzing the impact of PCP defects on the mechanical properties of brain primordia.

Our morphological analysis of organoids grown on Alginate hydrogels with different mechanical strengths has shown an impact of hydrogel stiffness on organoid differentiation. Although the measured stiffness of 1,5% Alginate hydrogels by far exceeds the physiological range, these hydrogels best supported the elongation of the organoids. Convergent extension movements drive the elongation of the dorsal mesoderm and the neural plate during early development, which requires PCP signaling. Our morphological results thus indicate, as we already hypothesized, that PCP signaling might be influenced by the mechanical properties of the substrate, which we have begun to investigate in detail. We have established immunostaining against known PCP components, such as Vangl2, to assess planar cell polarity in the neuroepithelium of our organoids and are currently investigating if and how the mechanical environment affects PCP signaling in these organoids.

A04 The role of mechanics in orchestrating neural lineage decisions

Michael Tranchina, Matthias Görtz-Lizarraga, Marisa Karow, Sven Falk

Objectives

The overall goal of **A04** is to understand how mechanical manipulations impact human neural stem cell lineage decisions and to elucidate the molecular framework relaying this information. For mechanical manipulation, we either conduct an acute mechanical impact through rheometer-mediated large strain compressions or a long-lasting change in the mechanical environment through embedding in hydrogels with defined mechanical properties. We are using human induced pluripotent stem cell (hiPSC) - derived brain organoids and neural cells derived thereof as a model system that is scalable and readily accessible to mechanical manipulations. Ultimately, the aim of our project is to elucidate the cellular consequences of mechanical manipulations on neural stem cells and chart the molecular landscape modulated by the mechanical environment to determine molecular key nodes responsible for orchestrating neural stem cell lineage decisions.

Main achievements and conclusions

In the past year, we focused our attention on assessing the effects of employing a long-lasting change in the mechanical environment of brain organoids through embedding in hydrogels (HG) with defined mechanical properties (Figure 10A) in collaboration with **X03**. We showed that, dependent on the stiffness of the employed HG, we see a difference in the fraction of SOX2-expressing cells within brain organoids (Figure 10B). These data further corroborate our earlier findings obtained after acute large strain compressions, outlining the impact of mechanics on the control of the balance between proliferation and differentiation of neural stem cells.

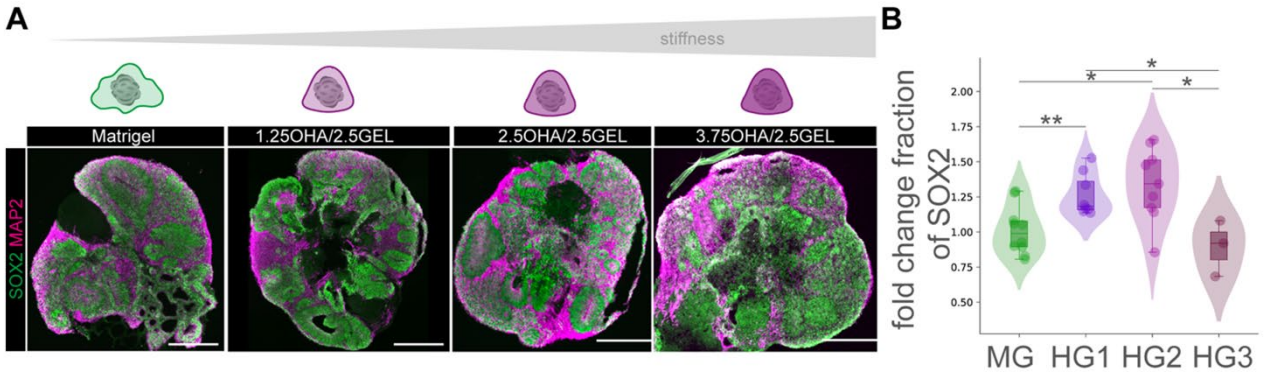

*Figure 10: **A)** Representative images of brain organoids (d30) embedded in different HGs with increasing stiffness. Immunohistochemical staining shows the expression of the neural stem cell marker SOX2 and the neuronal marker MAP2. **B)** Quantification of the fraction of SOX2-expressing cells within brain organoids across conditions.*

To assess changes in the transcriptional landscape induced by alterations in the mechanical environment of brain organoids, we performed single-cell RNA-sequencing experiments of HG-embedded organoids (Figure 11). Importantly, when we compared the deregulated (DE) genes induced through embedding in different HGs with those regulated upon rheometer-mediated acute large strain compression, we found a profound overlap of genes revealing important molecular key hubs likely relevant for the processing of mechanical information, with a surprising 260% overrepresentation of neurodevelopmental disease-associated genes.

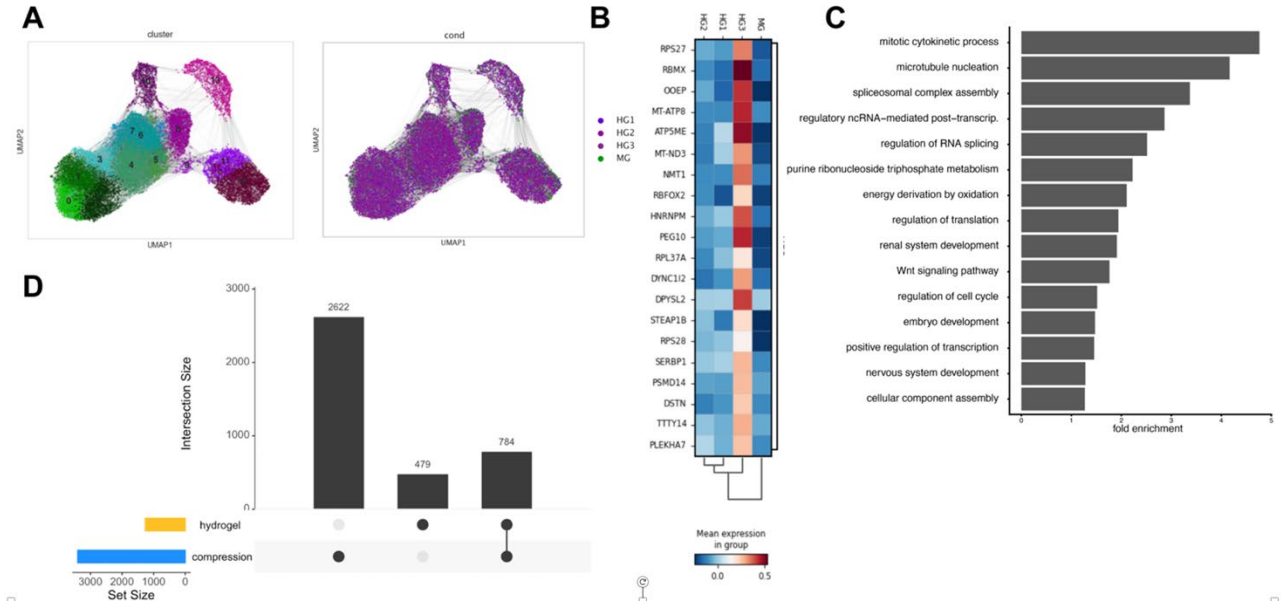

*Figure 11: **A)** UMAP embedding showing the composition of cells derived from brain organoids embedded in different HGs (MG = Matrigel; HG1, HG2, HG3). **B)** Heatmap visualizing deregulation of genes across conditions. **C)** GO (gene ontology) terms (biological processes) associated with significantly deregulated genes. **D)** Upset plot showing the overall number of DE genes regulated after HG embedding or acute compressions and the overlap.*

Outlook

In sum, our current data show that neural stem cell lineage decisions are strongly influenced by mechanics and suggest that key cellular processes such as microtubule dynamics, regulation of the chromatin landscape, and mitochondrial metabolism are mechanics-modulated molecular nodes that regulate fate decisions. Moreover, the surprising overrepresentation of neurodevelopmental disease-associated genes in the genes differentially regulated by mechanical manipulation suggests that relaying of mechanical stimuli to cellular behavior is a so far unappreciated factor in the etiology of many neurodevelopmental diseases.

Following the guilt-by-association hypothesis, we will assess whether the neurodevelopmental disease tissue has altered mechanical properties and/or whether neurodevelopmental disease phenotypes arise because diseased neural cells process information from their mechanical environment differently.

Together with Prof. Zaburdaev's group, we are exploring how mutations in two of these mechanically regulated neurodevelopmental disease genes change how growing neurites interact with the extracellular environment, providing a new mechanistic perspective on the basis for patient phenotypes.

In collaboration with Prof. Franze´s lab, we are currently using AFM (atomic force microscopy) to determine the mechanical properties of human brain organoids embedded in HGs with different mechanical properties.

Furthermore, we refine the analyses of the acute rheometer-mediated mechanical manipulation by labelling the compression axis, allowing us to extract how the geometric and spatial organisation of the neural tissue influences the cellular response to mechanical stimuli.

A05 *In vivo* model for the mechanics of brain development

Sebastián Vásquez-Sepúlveda, Kristian Franze

Objectives

1. Characterize brain viscoelasticity *in vivo*.
2. Determine the mechanics and morphology of brains with gene mutations leading to malformations.
3. Rescue brain mechanics and test the effect on brain morphology and malformations.

In 2025, due to a decline in embryo quality and the establishment of a new frog facility, my work focused on conducting joint experiments with other EBM researchers and collaborators to improve my proficiency in AFM experiments. To this end, I collaborated with projects **B05** and **A04** within EBM to design and conduct AFM experiments to measure spinal cord injuries in zebrafish [1] and human brain organoids, respectively. I also collaborated with Magdalena Götz's laboratory to measure fibrin-based collagen gels [2], Kerstin Feistel's laboratory to measure stiffness during neural tube closure, and Dieter Henrik Heiland's laboratory to measure *ex vivo* human brain tissue. Finally, I also contributed data on stiffness maps of *Xenopus laevis* embryo brains at stage 35 for a project within our laboratory working in Cambridge with Eva Kreysing [3].

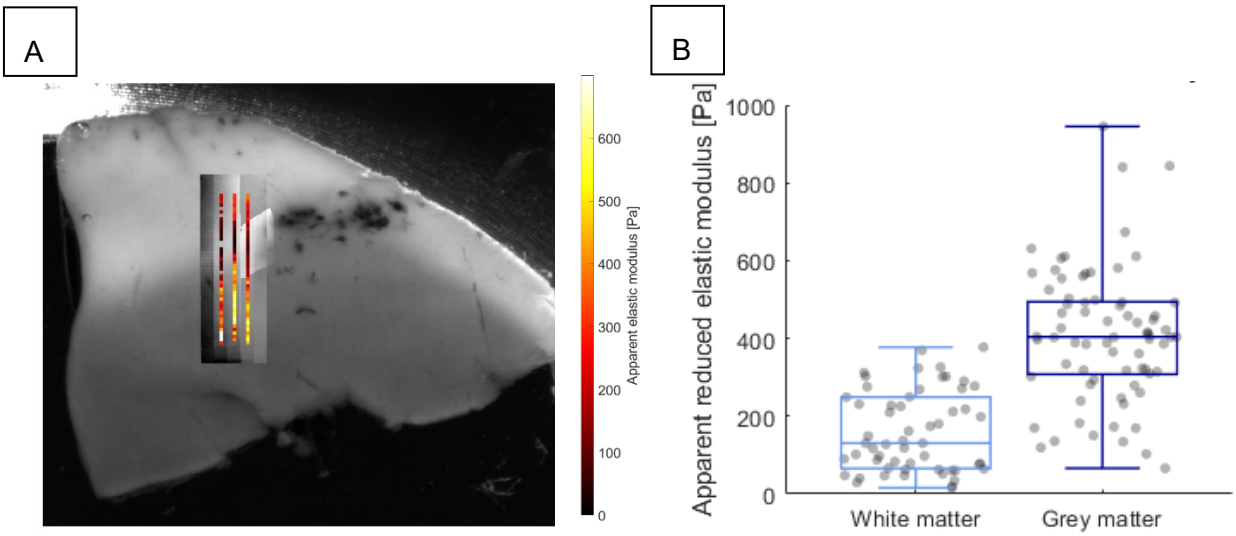

Figure 12: Result of stiffness mapping on human brain tissue 6 hours post-surgery. A) Stiffness maps of Human brain cortex, each square representing a single measurement with apparent elastic modulus measured in Pascal (Pa). B) Comparison of apparent elastic modulus of white matter and grey matter measured in A. Measurements done in collaboration with Lynn Menzl and Dieter Henrik Heiland at Uniklinikum Erlangen.

As of November 2025, I have presented my work at the "Emerging concepts of the Neuronal Cytoskeleton" workshop on April 7th, 2025, the **20th International Xenopus Conference on August 17th, 2025, and the** 1st EBM International symposium on September the 30th 2025, and was awarded the "best poster presentation" at the latter two events.

The proficiency in AFM work acquired during this period is essential for the progress of Project **A05**. Although the lack of viable embryos hinders the advancement of project **A05**, our knowledge of AFM experiment design will allow us to obtain reliable measurements on our model *Xenopus laevis* system once our new facility is operational. It will also allow for more collaborations, both within EBM and with external laboratories.

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B01 *In silico* modeling of spinal cord regeneration

Rahul Gopalan Ramachandran, Oskar Neumann, Silvia Budday, Paul Steinmann

Current scientific efforts within the **B01** project are focused on thoroughly investigating the scale-dependent mechanical properties of porcine spinal cord tissue with regard to the dimension of the applied loading. Furthermore, we addressed the development and application of a multimodal experimental pipeline to characterize large-strain mechanical properties of spinal cord gray and white matter tissue individually and to study changes in mechanics along the longitudinal axis of the spinal cord. In addition, we have analyzed possible morphological changes of larval zebrafish spinal cord tissue over the course of regeneration.

Based on our previous studies on spherical indentation of porcine spinal cord tissue [1], we developed an experimental multi-scale approach to investigate how using different indenter diameters can explain contradicting results for central nervous system tissue in the literature. With regards to the available body of research, we observe that white matter is reported to be stiffer than grey matter tissue for large indenters (>500 µm in diameter), whereas for smaller indenters, the opposite is reported. To test if this tendency can be replicated using a single experimental setup and tissue sample, we performed multiple indentation grid scans on spinal cord gray and white matter tissue with varying indenter diameters, ranging from 20 to 500 µm [2]. With this, we were able to observe a shift in gray to white matter stiffness ratio from > 1 (gray stiffer) to < 1 (white stiffer) for indenter diameters between 200 and 300 µm in diameter. Additionally, we showed that this tendency can only be measured for tests on the transverse anatomical plane of the spinal cord samples, but not on the coronal plane. We hypothesize that these observations could be attributed to differences in diffusion properties and microstructural architecture of gray and white matter tissue. The interpretation of our results benefited greatly from scientific exchanges with our colleagues from the Neuroanatomy at Universität Bonn (Project **B04**) and discussions with Prof. Thomas Franz during the international research visit of Oskar Neumann at Cape Town University.

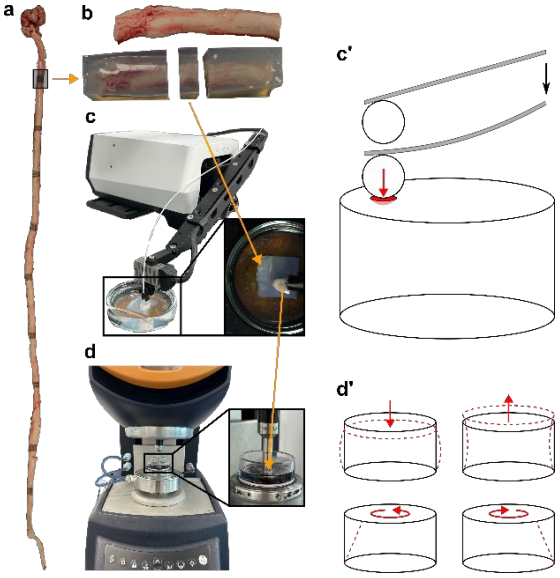

Figure 13: Experimental pipeline for multimodal mechanical analysis of spinal cord tissue. (a) Specimen, (b) sample extraction, (c) indentation, (d) rheometer test, (c') and (d') mechanical modes.

Inspired by discussions and repeated questions about the mechanical properties of spinal cord tissue along the cranio-caudal axis, we developed a multimodal experimental pipeline to test equidistantly spaced samples from the same spinal cord organ and computationally simulate these tests to characterize mechanical properties [3]. The multimodal pipeline comprises two mechanical test systems (see Figure 13). First, we perform indentation measurement on gray and white matter individually with three grids of ten points each on both tissue types with increasing loading rates. Subsequently, the same sample is mounted in a rheometer for the mechanical analysis of the bulk material properties during large-strain cyclic loading (with the support of Project **A01**). To computationally analyze the experimental data, we calibrated a linear Hertzian contact model, and nonlinear neo-Hookean and one-term Ogden models to find sets of material parameters that match the experimental indentation data. We observed that the ability of the Hertzian model to represent the indentation experimental data is increasingly reduced for increasing non-linearity in the mechanical response. Opposed to other studies, we were able to pin these discrepancies between the linear Hertzian model and the nonlinear one-term Ogden model directly to one of the parameters of the Ogden model, namely the nonlinearity parameter α1. In other words, the higher the degree of nonlinearity, the greater the discrepancy between the Hertz and Ogden models, and thus, he lower the ability of the Hertz model to predict the mechanical response observed in the experiment. Furthermore, for the bulk mechanical tests in the rheometer, we fitted a modified version of the two-term Ogden model. The modifications allowed a suitable prediction of strain stiffening behavior and decoupled the model parameters representing compression and tension strain stiffening (α1 and α2). This allows us to properly compare mechanical parameters from

indentation simulations (based on the one-term Ogden model) and mechanical parameters from rheometer simulations (based on the two-term Ogden model). The computational routine and exemplary results are illustrated in Figure 14. We showed that the averaged shear moduli of the bulk material response during compression-tension tests on the whole samples (combined gray and white matter response) fall in between the individual gray and white matter shear moduli from the indentation tests on the same samples. This work provides a proof of concept for our multimodal experimental pipeline and computational characterization routine, enabling its future application to human spinal cord samples.

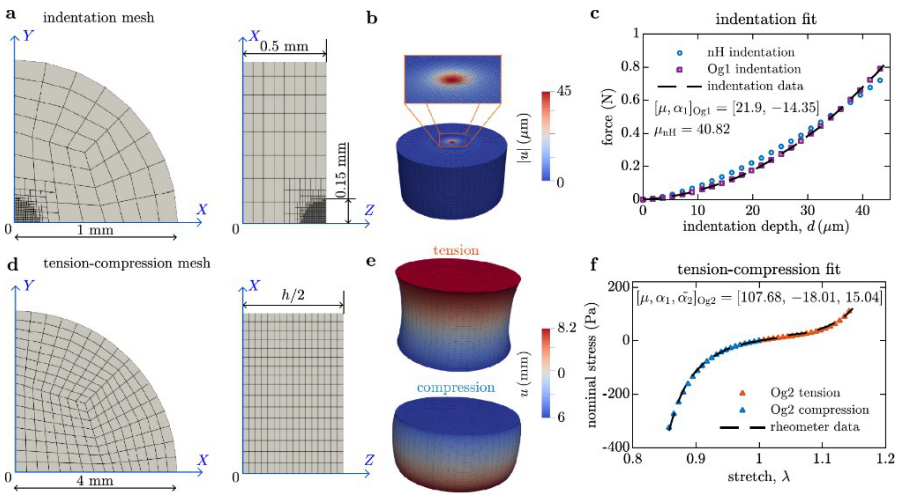

Figure 14: Inverse parameter identification. (a) and (d) FEM meshes, (b) and (e) deformed meshes for indentation and compression-tension tests, respectively, (c) and (f) exemplary test data curves for indentation and compression-tension tests, respectively.

Finally, with the support of Nora John (from Daniel Wehner's research group, project **B05**), we acquired microscopy images of transgenic larval zebrafish spinal cords during regeneration at 12, 24 30, 36, and 48 hours post lesion (hpl). The images show green fluorescent protein expression in her4-positive ependymo-radial glial cells and mKate expression in elavl3-positive neurons (see Figure 15). With this, we aim to better understand possible morphological changes the regenerating spinal cord undergoes during the process of remodeling and the restoration of motor skills. These new insights will help us refine our modeling approaches to develop an *in silico* model of the spinal cord regeneration process.

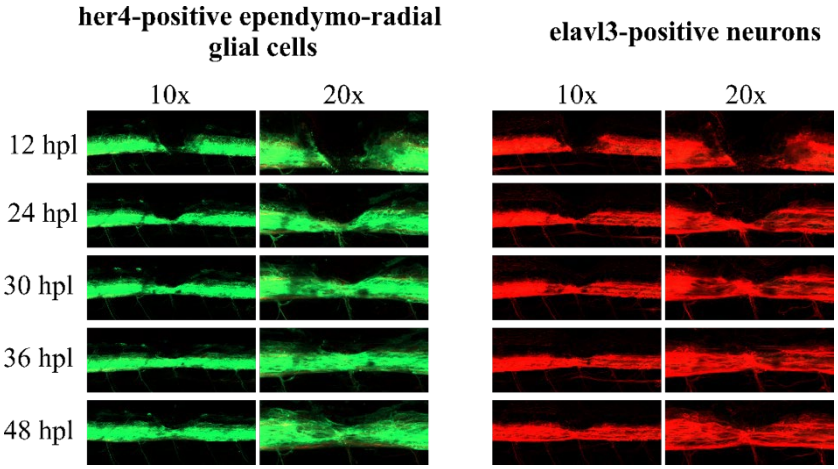

Figure 15: Exemplary images of microscopic analyses of morphological changes during spinal cord regeneration in zebrafish.

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B02 Pre- and post-metamorphosis spinal cord regeneration in frogs

Maria Tarczewska, Kristian Franze

Objective

The primary objective of the project work in the report period was to measure mechanical changes in the spinal cord lesion site in *Xenopus leavis* tadpoles using Atomic Force Microscopy (AFM).

The project also sought to visualize spinal cord regeneration using various imaging techniques.

Main achievements

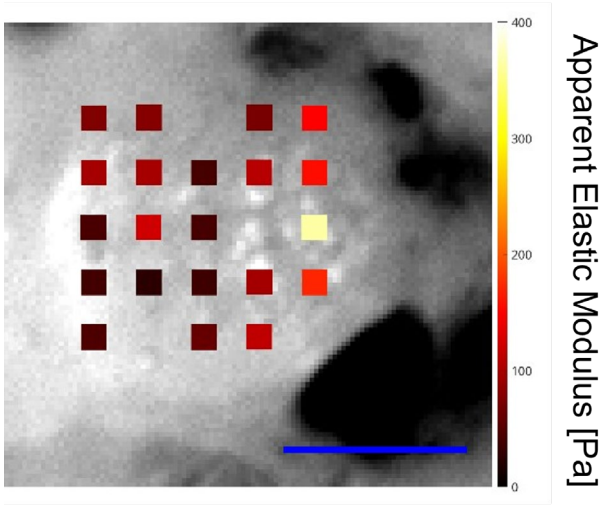

Figure 16: Heatmap showing AFM measurements of healthy tadpole spinal cord at stage NF44. Scalebar 100 µm.

Progress was made in establishing and applying AFM to measure the spinal cord lesion site. A protocol including spinal cord transection and subsequent *in vivo* AFM measurements was established. Preliminary measurements of tadpoles with spinal cord injury and controls were carried out. Due to the limited number of embryos available and problems with their quality, the number of experiments done was lower than expected. Preliminary measurements show softening (decrease in apparent elastic modulus) in injured animals one day after the injury compared to controls (Figure 16, Figure 18); however, more biological replicates are needed to confirm these results. The project also advanced in measuring viscoelastic properties of the spinal cord using AFM by performing creep measurements. Additionally, measurements of spinal cord tissue from an uninjured adult frog were carried out. The project also successfully established a microCT staining and imaging protocol, which allows for the 3-dimensional visualization of the lesion site (Figure 17) [1]. The protocol involves staining with phosphotungstic acid and subsequent imaging.

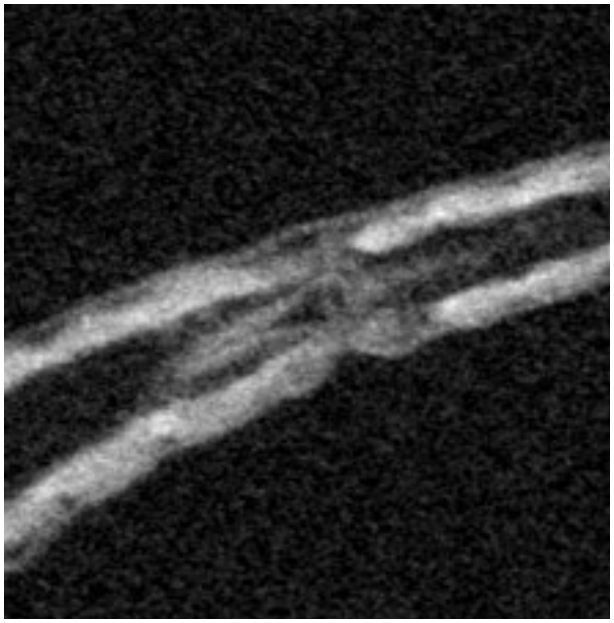

Figure 17: microCT image showing spinal cord lesion site, 3 days after the injury, stage NF44.

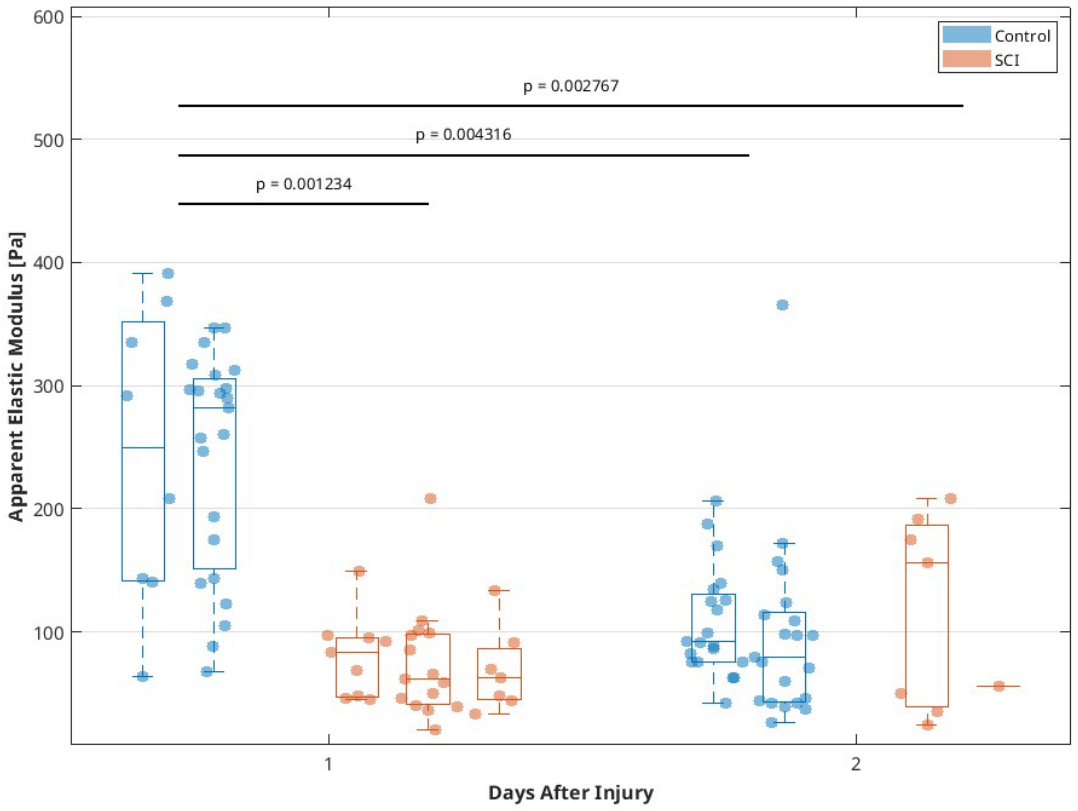

Figure 18: Apparent elastic moduli of the spinal cord of Xenopus laevis tadpoles with spinal cord injury (SCI) compared to controls. The measurements were done at day 1 and 2 after the injury. Each box plot represents one animal and each dot represents one measurement.

Conclusions

The project has progressed in performing key measurements for studying the mechanics of spinal cord regeneration in *Xenopus laevis* frogs. The successful AFM measurements create a foundation for quantifying tissue stiffness, which could provide valuable insights into spinal cord injury regeneration.

Outlook

In the next phase, the project will focus on continuing the AFM measurements to compare regenerative and non-regenerative stages of *Xenopus laevis* frogs and map the temporal dynamics of mechanical changes in spinal cord regeneration. Additionally, microscopy and microCT imaging will be performed to characterize the lesion site and correlate the changes in tissue mechanics with the success of the regeneration as well as with the expression of molecular markers.

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B03 The determinants of spinal cord mechanics in homeostasis

Jana Bachir Salvador, Jochen Guck, and Stephanie Möllmert

Determinants of nervous tissue mechanical properties in homeostasis

Objective and Summary

B03 aims to identify factors that determine the mechanical fingerprint of the central nervous system in homeostasis. This entails a comprehensive approach to quantify the viscoelastic properties both *in vivo* and *ex vivo* through a combination of confocal Brillouin microscopy, atomic force microscopy (AFM) based indentation, and optical diffraction tomography (ODT). Using an optogenetic tool in the larval zebrafish, we were able to identify the response to oxidative stress (OS) as a determinant of viscoelastic properties *in vivo* in the spinal cord. This response precedes apoptotic processes and associated changes in cellular density or overall tissue architecture. At the same time, oxidative stress is a hallmark of neuronal damage and a central driver of neurodegeneration [1], and other diseases [2]. Moreover, the mechanical properties of cells and tissues are sensitive indicators of pathology and disease in the central nervous system (CNS) [3][4], in which they reflect cytoskeletal architecture, intra- and extracellular crowding, and gross tissue organization. How OS modulates the mechanical state of the central nervous system tissue still remains poorly understood. While cytoskeletal remodeling under oxidative stress, and the associated changes in mechanical properties, are well established, our work shows that these alterations can be effectively prevented by antioxidant treatment and low doses of carbon monoxide (CO). We demonstrate that both the OS-induced mechanical changes and their prevention can be quantitatively probed by AFM indentation on isolated cells and excised tissue, and that Brillouin microscopy is similarly sensitive to these effects across cellular, tissue, and even *in vivo*/organismal scales [5][6].

Methodology

We initially attempted to use the photosensitizer KillerRed (KR), expressed in distinct cell types in the zebrafish CNS [7], as a tool to alter tissue architecture by spatio-temporally controlled cell ablation and observe the mechanical read-out of concomitant changes in tissue composition and structure. Our results showed that our particular KR activation protocol left cell density and overall tissue architecture intact. However, the mechanical measurements of zebrafish spinal cord properties *in vivo* and *ex vivo* yielded a prominent mechanical phenotype. The photosensitizer KR operates through reactive oxygen species (ROS) production in the cell membrane. Oxidative stress (OS) is then induced as a consequence when cells cannot neutralize excess ROS through their natural antioxidant defense system and maintain redox homeostasis. To dissect the mechanism behind this mechanical shift, we proceeded to map the mechanical properties of CNS cells and tissues from different species and at multiple time and length scales. OS was locally induced *in vivo* in zebrafish larvae spinal cord tissue by optogenetic activation of the photosensitizer KillerRed (KR) using a confocal fluorescence microscope. Treated larvae were measured live using confocal Brillouin microscopy or vibratome-sectioned for AFM-indentations on spinal cord tissue. At the cellular level, primary cortical neurons were used as an *in vitro* model, whereby OS was induced by defined doses of hydrogen peroxide (H_2O_2). To test the prevention of OS-induced changes, neurons were also pretreated with antioxidants such as N-acetylcysteine (NAC) or exposed to carbon monoxide (CO) before H_2O_2 exposure. Mechanical measurements using AFM-based indentation were analyzed by fitting force-distance curves to the KVM model corrected for viscoelasticity [8]. Brillouin microscopy spectra were analyzed using a customized script [9]. To probe intracellular composition, we employed ODT, which reconstructs refractive index distributions as a proxy for biomolecular concentration and, in some cases, the dry mass density. Furthermore, cytoskeletal remodeling was examined through live staining of tubulin and actin, allowing us to link mechanical changes to structural alterations.

Results

Dynamic BM of zebrafish spinal cord cross-section *in vivo* previously showed that optogenetic OS induction by KR illumination led to prominent viscoelastic changes at the ablation site. The resulting Brillouin frequency shift is reduced within one hour after OS induction, and is restored in the subsequent hours after the ablation. This Brillouin shift change is lacking in all control conditions. AFM on sectioned larvae after the same ablation reveals an increase in the apparent Young's modulus. At the cellular level, AFM also revealed a significant increase in the apparent Young's modulus of primary cortical neurons following H_2O_2 treatment, with conserved neuronal viability. Stiffening was consistently observed at the level of the

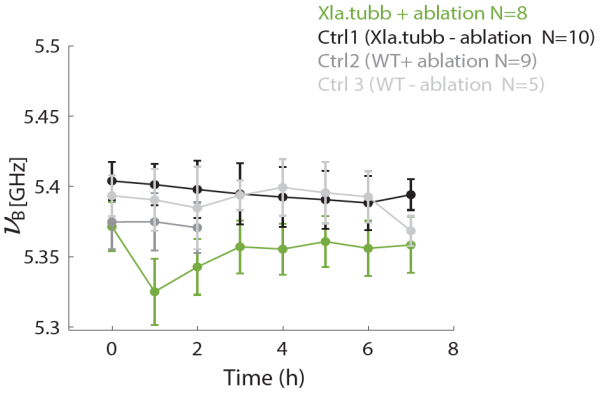

Figure 19: Brillouin frequency shift from time-lapse Brillouin microscopy for entire cross-section of larval zebrafish spinal cord.

soma. Still, it was absent in untreated neurons and in neurons pre-treated with NAC or CO. ODT measurements showed an increase in the average refractive index in the cytoplasm of neurons exposed to OS, indicating elevated intracellular biomolecular concentration. This effect is consistent with protein condensation and cytoskeletal reorganization. The difference was absent in antioxidant-treated cells. Live-cell tubulin staining revealed pronounced microtubule degradation under OS. Conversely, the actin network polymerization is triggered upon OS induction, shown in the increase of live actin stain signal.

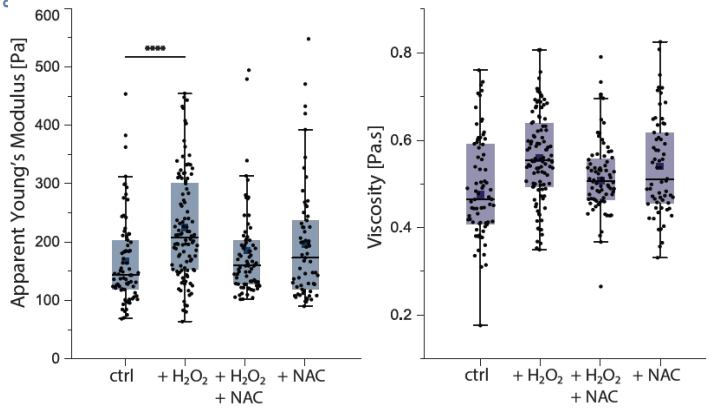

Figure 20: Apparent Young's modulus and viscosity extracted from Force-indentation curves of single primary cortical neurons.

Outlook

Our results confirm that oxidative stress significantly alters the mechanical fingerprint of the CNS entities through cytoskeletal remodeling. AFM revealed cellular stiffening upon H_2O_2 exposure, which was prevented by antioxidant and CO treatment, while Brillouin and ODT likewise revealed changes in viscoelasticity and refractive index, respectively. These shifts coincide with microtubule degradation and actin reorganization, identifying cytoskeletal disruption as a structural basis of the mechanical phenotype. Importantly, the *in vivo* zebrafish model showed that OS-induced mechanical changes extend beyond isolated cells to intact tissue. Together, these results confirm mechanics as an early biomarker of oxidative damage and suggest Brillouin light scattering as a sensitive method to detect OS in living tissue before the onset of apoptotic processes. Future experiments include the establishment of a primary neuron culture from zebrafish to test for potential interspecies differences in the ability to neutralize excess ROS and maintain redox homeostasis.

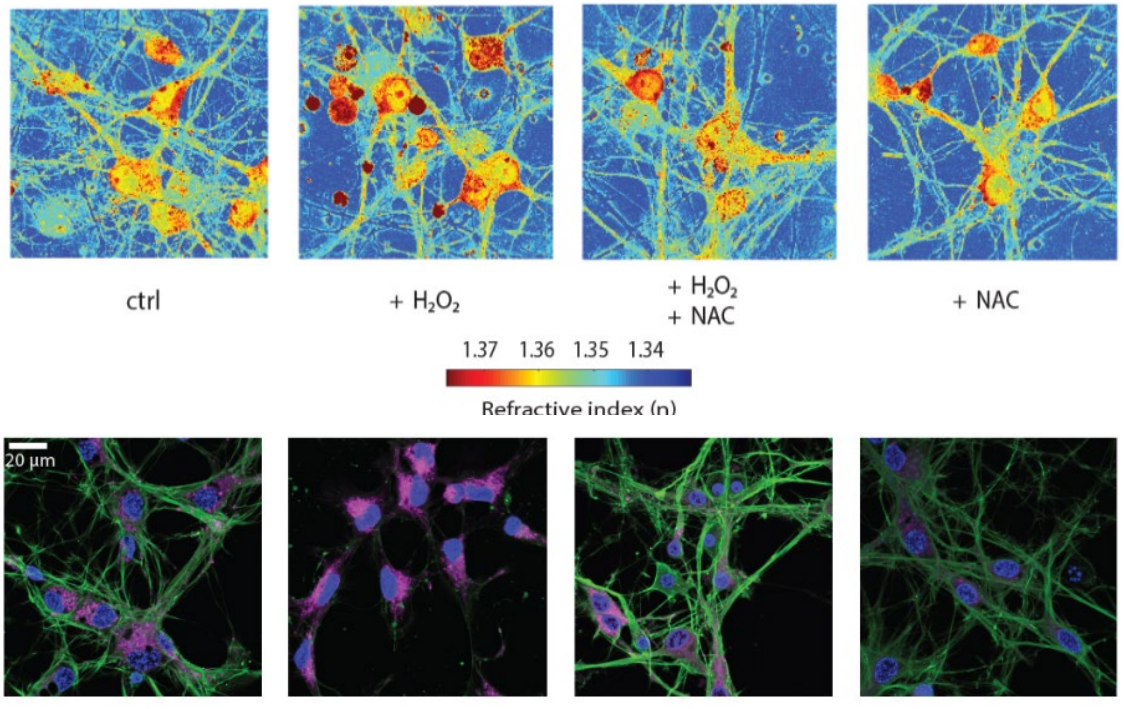

Figure 21: a) Optical diffraction tomography refractive index maps. b) Cytoskeletal staining of microtubule (green) and actin (magenta) networks, and nucleus (blue).

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B04 Spinal cord mechanics in a mouse model of multiple sclerosis

Maik Hintze, Rittika Chunder, Stefanie Kürten

Multiple sclerosis (MS) is a chronic autoimmune neuroinflammatory disease of the central nervous system (CNS) characterized by demyelination and neurodegeneration[1]. A hallmark of MS is the infiltration of peripheral immune cells, including antigen-specific T and B cells, into the CNS, which can act as a major trigger of neuroinflammation[2]. Autoreactive immune-mediated myelin destruction results in axonal damage, followed by axonal loss and neuronal death, ultimately driving irreversible disease progression[2]. During the later stages of MS, this neuronal loss is accompanied by astrocyte activation and the formation of a glial scar, with reactive astrocytes playing a central role in chronic, non-resolving scar pathology[3].

Tissue remodeling within glial scars causes a pronounced reduction in tissue stiffness at lesion sites[4], and individual astrocytes have been shown to exhibit lower stiffness compared to neurons[5]. Given the broad homeostatic, trophic, and mechanical functions of astrocytes in the CNS, we hypothesize that astrocytic mechanosensation through the mechanosensitive ion channel Piezo1[6] may contribute to MS pathology. Piezo1 is expressed on astrocytes and can regulate Ca^{2+} oscillations and cytokine release *in vitro*[7]. Together, these observations suggest that MS-associated tissue remodeling alters the mechanical properties of CNS lesions, which can be detected by astrocytes and may further exacerbate disease progression.

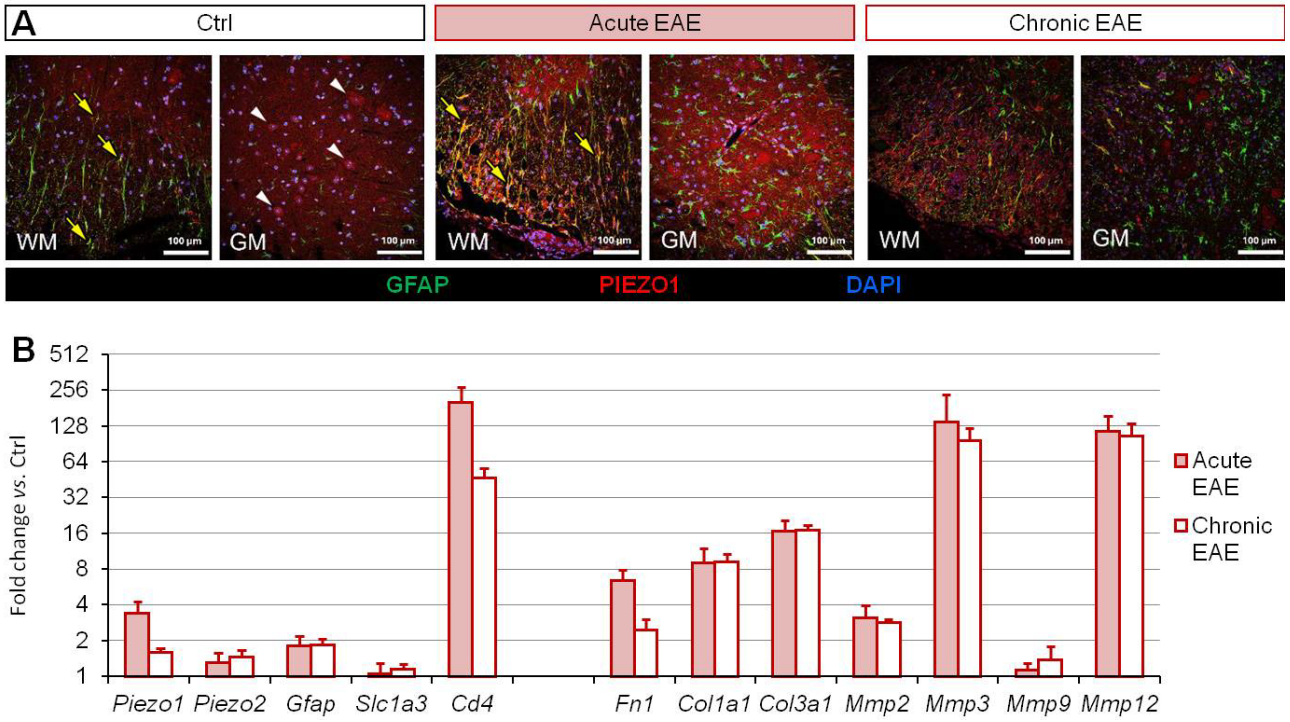

*Figure 22: **Astrocytic PIEZO1 immuno-reactivity is increased in murine spinal cord during EAE. A**, Immunofluorescence images from spinal cord white matter (WM) and gray matter (GM) are shown. Healthy mouse spinal cord shows overlap of GFAP and PIEZO1 (yellow arrows), which is increased in a sample from a mouse with acute experimental autoimmune encephalomyelitis (EAE). PIEZO1 and GFAP intensities almost return to Ctrl levels during chronic EAE. **B**, Transcriptional analysis indicates highly increased expression of Piezo1 during acute EAE, which returns to Ctrl levels during chronic EAE. Piezo2 was only slightly increased. The T-cell marker gene Cd4 was increased in spinal cord during EAE, indicating T-cell infiltration. Interestingly, extracellular matrix genes such as fibronectin (Fn1), collagens (Col1a1, Col3a1), and matrix metalloproteinases (Mmp's) were upregulated during EAE, suggesting ECM remodeling and potential alterations in tissue stiffness. Each bar indicates mean and standard error of the mean from five individual mice.*

We first examined astrocytic PIEZO1 expression *in vivo* during experimental autoimmune encephalomyelitis (EAE), a standard mouse model of MS[8]. In the mouse spinal cord, we detected colocalization of PIEZO1 with the astrocyte marker GFAP, which was further increased in tissue from animals with acute or chronic EAE (Figure 22**A**). In healthy spinal cord, astrocytic PIEZO1 expression was generally low but became upregulated during EAE. This was supported by elevated *Piezo1* transcript levels in EAE (Figure 22**B**). Notably, several extracellular matrix (ECM) genes were also upregulated, indicating that ECM remodeling may influence *Piezo1* signaling. We next aim to investigate the role of astrocytic PIEZO1 during EAE using a mouse model in which *Piezo1* is specifically

deleted in astrocytes (*Piezo1*-cKO mice).

Gray and white matter (GM and WM, respectively) differ in their mechanical properties[9], and astrocytes in these regions are also transcriptionally distinct *in vivo*[10]. To investigate astrocyte mechanobiology at the molecular level, we microdissected GM and WM from human brain surgery specimens. Successful regional dissection was confirmed by RNA sequencing, which revealed differential expression of neuronal and oligodendroglial markers between GM and WM samples (Figure 23).

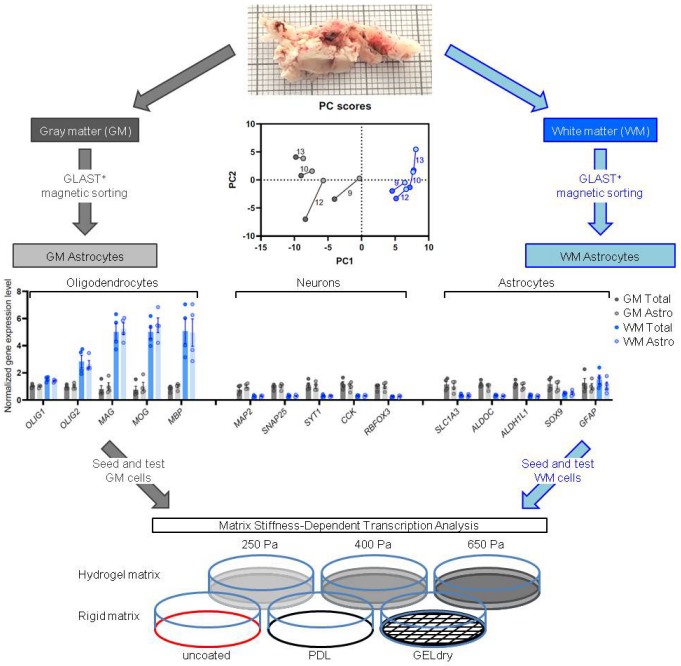

Figure 23: ***Analysis of patient-derived WM and GM astrocytes in vitro****. White (WM) and gray matter (GM) were manually dissected from four epilepsy patient brain tissue samples, followed by single-cell dissociation and magnetic astrocyte enrichment. GM and WM samples from patients exhibit gene expression profiles consistent with neuron- or oligodendrocyte-specific markers, respectively. Most astrocyte markers (e.g., SLC1A3/GLAST and ALDH1L1) were preferentially expressed in GM, while GFAP expression levels were similar in WM and GM. After expansion of WM and GM cells in 2D cell culture, we plated them on hydrogels with tunable stiffness. These samples now also await RNA sequencing.*

These cells could be successfully expanded in 2D culture and subsequently plated on hydrogels of varying stiffness. We now aim to determine whether the differences between GM and WM astrocytes are maintained under 2D culture conditions, and whether their transcriptional profiles can be modified—or even interconverted—by appropriate biomechanical cues. Using a similar approach, we will analyze PIEZO1-deficient astrocytes from *Piezo1*-cKO mice to elucidate PIEZO1-specific mechanisms in astrocyte mechanobiology and to understand how these mechanisms contribute to GM and WM cellular identity.

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B05 *In vivo* mechanical manipulation of spinal cord regeneration

Nora John, Thomas Fleming, Julia Kolb, Olga Lyraki, Sebastian Vásquez-Sepúlveda, Maria Tarczewska, Sven Falk, Kristian Franze, Jochen Guck, Daniel Wehner

Project **B05** is testing the hypothesis that local mechanical tissue properties are critical for successful nerve fiber (axon) regeneration after spinal cord injury (SCI), and that the specific molecular and cellular composition of the lesion microenvironment confers these properties. To that aim, **B05** utilizes the vertebrate species zebrafish, which, unlike humans and other mammals, is capable of long-distance axon regeneration and functional recovery after central nervous system (CNS) injury. In previous reporting periods, together with the EBM projects **A02**, **B03**, **C02**, and **C03**, we provided mechanistic evidence that the specific composition of the injury extracellular matrix (ECM) confers permissive or adverse mechanical properties to CNS lesions in zebrafish and mammals, respectively [1, 2]. Furthermore, our results identified ECM factors that dictate the adverse mechanical tissue properties of mammalian CNS lesions.

In the current reporting period, together with the EBM projects **A04**, **A05**, **B02**, and **B03**, we investigated cellular interactions that could influence the mechanical properties of CNS lesions. Specifically, we focused on fibroblast-immune cell interactions because sustained inflammation and fibrous scarring are major inhibitors of axon regeneration in the mammalian CNS. Fibrous scarring arises from excessive ECM deposition by reactive (myo)fibroblasts, which creates both biochemical and mechanical barriers to axon growth. This process is closely intertwined with inflammation: immune cell infiltration after SCI promotes scarring, which in turn amplifies and prolongs the immune response, preventing its resolution. In contrast, in zebrafish, the immune response and fibroblast-derived ECM create a lesion environment permissive to regeneration, providing the opportunity to dissect the regulatory interactions between fibroblasts and immune cells in a regenerating vertebrate system.

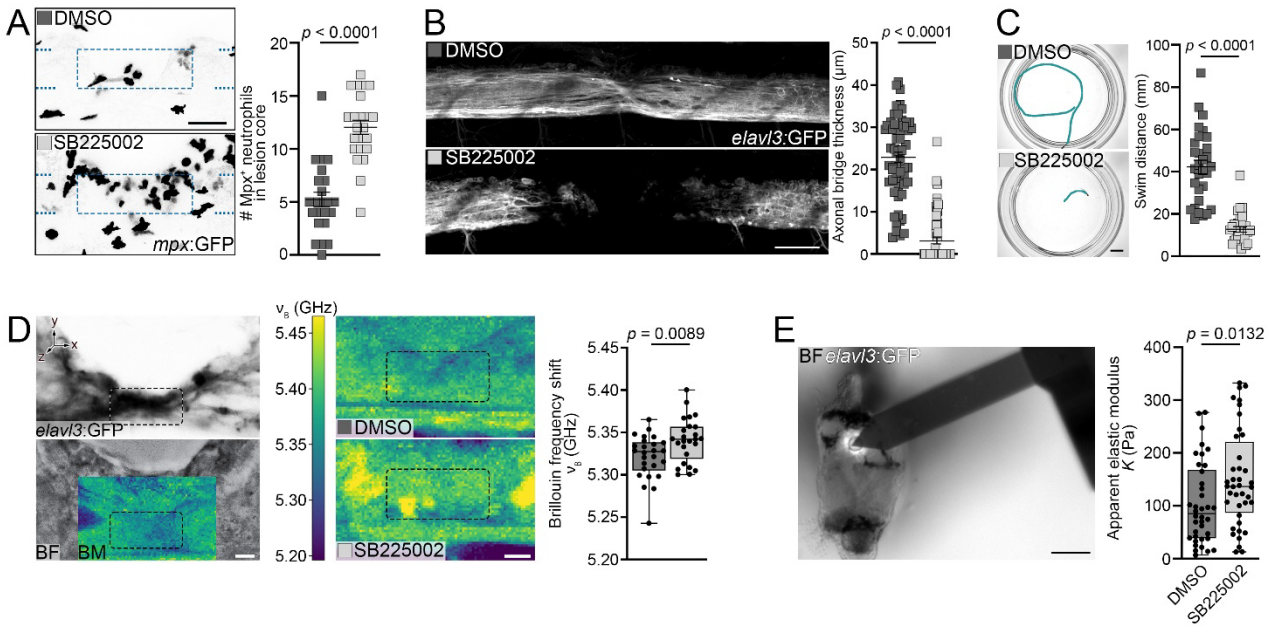

Figure 24: Experimentally sustained inflammation alters the mechanical properties of the lesion microenvironment and inhibits axon regeneration and functional recovery in zebrafish. (A) Treatment with the Cxcr1/2 antagonist SB225002 leads to increased retention of Mpx+ neutrophils (black) in the lesion core, prolonging inflammation. (B and C) SB225002 treatment inhibits axon regeneration (B; reduced axonal bridge thickness; white) and recovery of swimming function (C) after SCI. (D and E) SB225002 treatment alters the Brillouin frequency shift (D) and the apparent elastic modulus (E) of the lesion environment.

Using temporally-resolved single-cell transcriptomics, we discovered that the interplay between fibroblasts and immune cells is required for axon regeneration in the zebrafish spinal cord. We identified a transient, injury-induced cthrc1a+ fibroblast state with an inflammation-associated, less differentiated, and non-fibrotic profile. We found that Ca2+-dependent induction of this fibroblast state precedes and is critical to the initiation of the inflammatory response. Subsequently, cthrc1a+ fibroblasts coordinate the resolution of the neutrophil-driven inflammation. Our data indicate that this biphasic regulation temporally controls the neutrophil-driven acute inflammatory phase, preventing chronic inflammation, thereby fostering a lesion environment conducive to regeneration. Importantly,

using Brillouin microscopy and atomic force microscope-based nanoindentation measurements, we found that experimentally sustaining inflammation leads to changes in the mechanical properties (longitudinal modulus, apparent elastic modulus) of the lesion microenvironment. Our study provides the first *in vivo* evidence that sustained (neutrophil-driven) inflammation contributes to the adverse viscoelastic properties of mammalian CNS lesions. These results were published in Cell Reports and involved collaborations with the EBM projects **A04**, **A05**, **B02**, and **B03** [3]

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C01 *In silico* modeling of mechanical cell-matrix interactions

Soheil Firooz, Mathar Kravikass, Paul Steinmann, Vasily Zaburdaev

Cellular aggregate formation; continuum modeling and computational challenges

In this project, we investigate the formation of cellular aggregates through a nonlinear continuum mechanics framework combined with a finite element simulation approach. To address the numerical instabilities arising from the coupled and convection-dominated nature of the governing equations, we have developed a micromorphic-based artificial diffusion method. This approach effectively stabilizes the numerical solution while preserving the essential physical features of the problem.

In the present model, the interaction between the cells and the surrounding matrix is solely limited to frictional effects. Using this formulation, we have successfully reproduced the experimentally observed evolution of cellular aggregates. A direct comparison between the simulations and experimental data shown in Figure 25 demonstrates a very good qualitative agreement. The figure illustrates four snapshots of the aggregation process of Neisseria gonorrhoeae, where the first row corresponds to the experimental observations and the second row shows the finite element results. Our model is capable of capturing the key stages of aggregate formation and the resulting equilibrium structure with high fidelity.

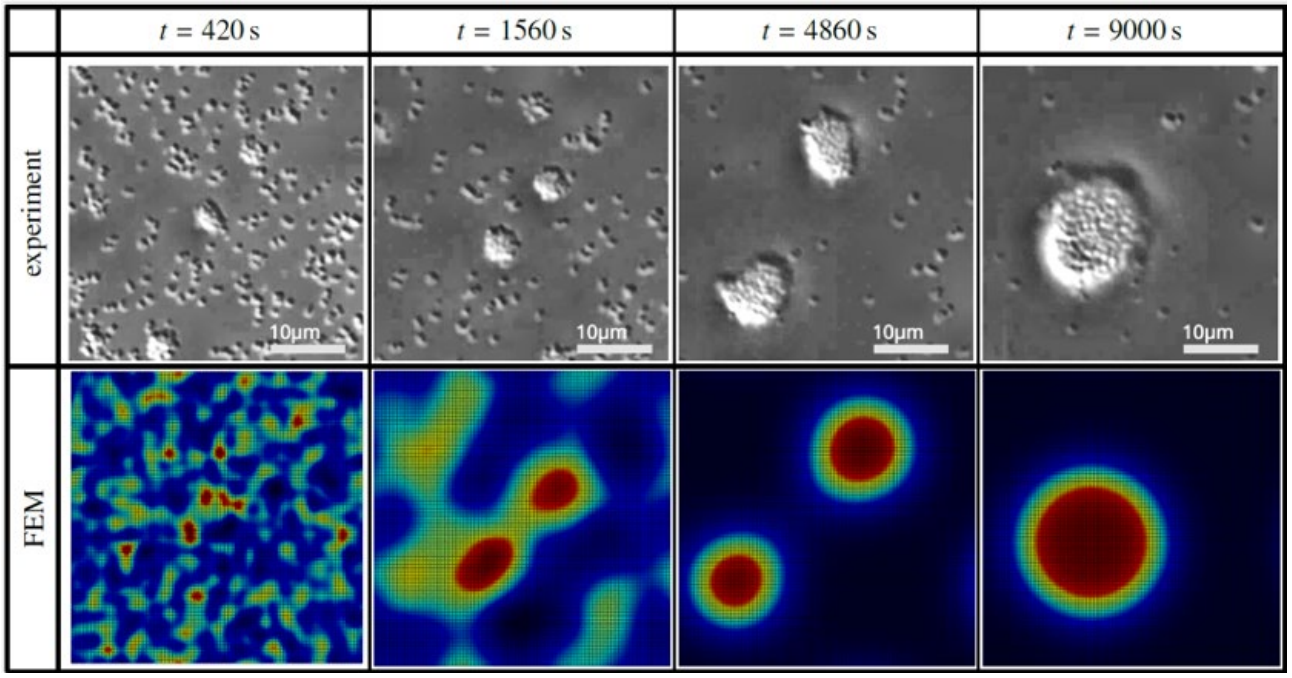

Figure 25: Cellular aggregate formation. Comparison of the FEM results with experiments at four different snapshots.

In our future work, we aim to extend this framework to account for more complex cell–matrix interactions. Specifically, we plan to develop a two-component model in which one component represents brain neurites and the other represents glial cells. In this extended formulation, the presence of the second phase is expected to impede the ability of the first component to form a single circular aggregate, thereby yielding a more realistic description of the neural network formation.

Agent-based modeling of neurite growth and synapse formation in an extracellular matrix

In this project, we aim to investigate using agent-based modelling techniques how mechanical interactions between the extracellular matrix and neurons affect neurite growth patterns and synapse formation. Here, the neurites are modelled as a bead-chain of beads connected by springs. In these simulations, we consider two mechanisms of growth. First, a weak intrinsic and linear growth along the direction of the neurite. Second, an adhesion force that forms a temporary link between the neurites and an extracellular matrix particle, which enacts a spring force with a coefficient $\boldsymbol{\kappa}$ between them. Which particle to link to is chosen randomly in a cone of angle $\boldsymbol{\theta}$ and range $\boldsymbol{R}$ in front of the tip of the neurite. This link breaks either when a certain defined persistence time has passed or when the neurite has grown an additional defined length during the link. Additionally, excluded volume

interactions are implemented, which inhibit the neurites from overlapping with extracellular matrix particles.

Using this model, we collaborated with the groups of Marisa Karow and Sven Falk to analyze the outcomes of their experiments, which investigated three gene mutations linked to neurodevelopmental disorders. These mutations exhibited aberrant long-range connections, leading to premature loss of growth directionality compared to their wild-type counterparts [4]. Our model simulations revealed that an increased angle $\boldsymbol{\theta}$ was sufficient to replicate this altered growth pattern, suggesting that the change in persistence of mutated neurites may be the underlying mechanical cause of these aberrations.

In future work, we plan to incorporate additional mechanisms, such as extracellular matrix stiffness gradients, and investigate their effects on growth patterns. We also aim to extend this model to include synapse formation between growing neurites, which will enable us to explore the role of neuronal interactions in early brain network development. Together with experimental collaborators, we hope to demonstrate how mechanistic principles can explain the emergence of neuronal clusters in these early brain networks.

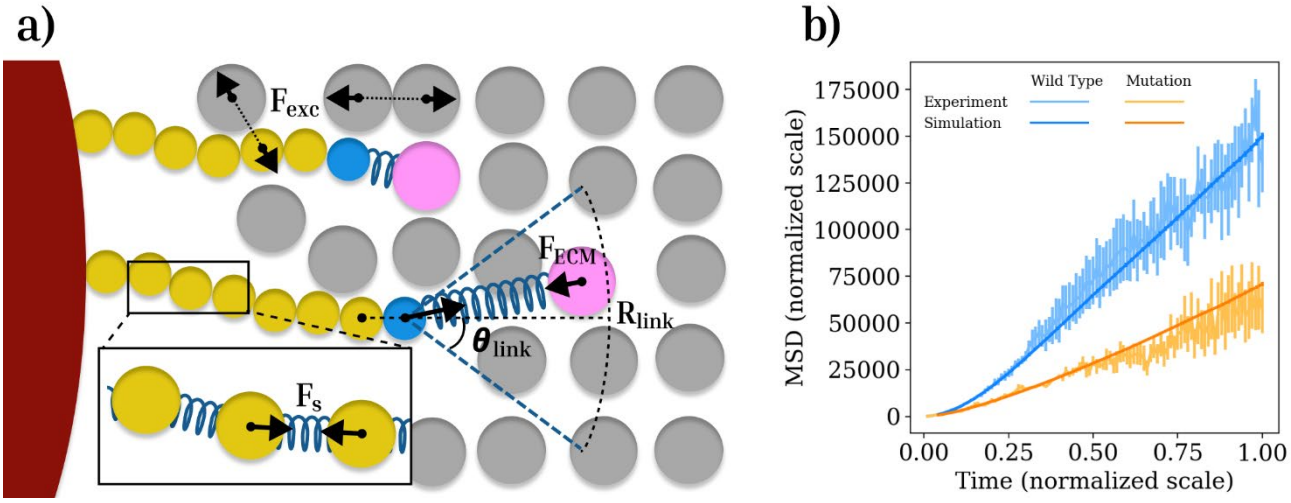

Figure 26: a) Schematics of the numerical model. The neurites are represented by a chain of beads (yellow) connected by springs (zoom in panel) protruding out of the organoid (red) and grow in the extracellular space occupied by particles (grey) representing the extracellular matrix (ECM). b) A comparison of the MSD (mean squared displacement) as a function of time between experimental and simulation results. The blue line represents simulations with a link angle θ of 30°, while the orange line corresponds to simulations where the only modification was an increase in the angle to 75°. The simulations closely match the experimental data.

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C02 The role of mechanics for neuronal "plasticity"

Ezgi Erterek, Renato Frischknecht

The role of mechanics for neuronal 'plasticity'

Neuronal plasticity, which is the ability of the brain to adapt its function to new demands and environments, declines during adolescence. This is, among other due to a change molecular and mechanical environment that the brain provides to its cellular components [2]. The decline in neuronal plasticity correlates with the formation of a mature form of the ECM that surrounds neuronal cell bodies, dendrites, and synapses. It is well established that this mature ECM restricts, and its removal restores juvenile forms of plasticity. However, the mechanisms behind this restrictive function of the ECM are not clear. Here, we follow the hypothesis that mechanical constraints provided by the ECM contribute to neuronal plasticity.

To test the hypothesis, we designed three work packages: In **WP1,** we investigate the mechanical properties of the murine cortex in the presence and absence of ECM. In **WP2,** we develop tools to modify ECM properties *in vitro* and *in vivo*. Furthermore, hydrogels with various mechanical properties are tested for their ability to foster neuronal cell growth and synapse formation. In **WP3,** we investigate the influence of the ECM on neuronal plasticity.

WP1: Contribution of the ECM to the mechanical properties of cortical layers

In order to investigate the contribution of the ECM to the overall measured mechanical properties of the brain, we have decided to use the mouse cortex as a model system. The ECM in adult rodent cortex is inhomogeneously distributed across the 6 cortical layers: While there is little ECM in the upper layers, it is enriched in layer 4 and upper layer 5. In our experiments, we compared untreated acute slices of cortices from adult mice (4-6 months old) with cortices that had been subjected to chondroitinase ABC digestion. Chondroitinase ABC has been used in many studies to abolish chondroitin sulphate-rich ECM that is typical for the adult cortex. We have accomplished measurements of mechanical properties across the layers of the mouse cortex using Brillouin microscopy and AFM indentation in close collaboration with **B03**. While the upper layers appeared homogeneous, the deeper layers, containing high levels of ECM, differed from those in our measurements. After treatment with chondroitinase ABC, the difference in mechanical properties between layers disappeared in both mechanical tests, suggesting a contribution of the perineuronal ECM to the mechanical properties of cortical layers 4-6. Results of this project are currently being prepared for publication together with **B03**.

WP2: Development of tools to alter ECM properties *in vitro* and *in vivo*

One of the main issues when investigating the impact of the mechanical properties of the ECM on neuronal function is to divide mechanical from chemical signalling. In **WP2**, we aimed to develop and test methods to alter the mechanics of the extracellular environment without changing its molecular makeup. In a first approach, we produced fusion proteins of the ECM proteins brevican and versican together with proteins that multimerise upon exposure to blue light, such as cryptochrome and eMagnets. Our initial experiments showed that fusion proteins with cryptochrome were not secreted from cells, and this approach was subsequently discarded. Therefore, we concentrated our efforts on brevican and versican - eMagnets fusion proteins. These proteins were well expressed and are currently being tested in collaboration with **B02** for their ability to alter the mechanical properties of the ECM.

In a second approach, we cultured dissociated cortical neurons from rats in hyaluronic acid-based hydrogel (HA gels) in collaboration with **X03.** We have tested HA gels with different mechanical properties, achieved by altering HA content and crosslinking to foster the survival and growth of neurons. The results are summarized in a recent joint publication [3].

WP 3: Impact of ECM stiffness on neuronal 'plasticity'

In previous work, it has been shown that the ECM restricts neuronal plasticity in the adult brain. One hallmark of plasticity is the dynamic formation and retraction of dendritic spines, the site where excitatory synaptic contacts occur. While dendritic spines are rather stable in the adult, presumably due to the surrounding mature ECM, they are more motile and dynamic in the developing brain. However, high neuronal activity in brain slices that leads to neuronal plasticity also induces increased

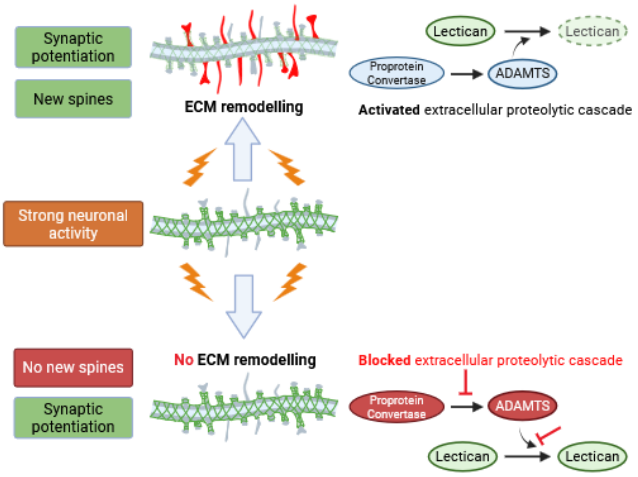

Figure 27: High neuronal activity induces cleavage of protein components of the specialized extracellular matrix that surrounds neurons and restricts brain plasticity. The cleavage of the ECM proteins brevican and aggrecan relies on activation of an extracellular proteolytic cascade. 3. Blocking proteolysis does not affect the induction of LTP but prevents the formation of new dendritic protrusions, which are a prerequisite for synapse formation [1].

spine plasticity in the adult, raising the question whether brain cells actively alter their extracellular and hence mechanical environment in response to high neuronal plasticity. Indeed, we have found that neurons activate a proteolytic cascade after induction of neuronal plasticity that alters the ECM. These changes in ECM are necessary for structural plasticity (spine formation) but not for synapse function (Figure 27. These results have recently been published [1]. To further assess the role of ECM mechanics in neuronal plasticity, we will actively manipulate ECM density in acute hippocampal slices under conditions of increased neuronal plasticity using chondroitinase ABC to abolish and genipin to crosslink the ECM and monitor spine motility and the mechanical properties of the tissue in collaboration with **B03**. Finally, we are currently performing similar experiments using neurons cultured in hydrogels developed with **X03** in **WP2**.

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C03 Exploring the mechanics of neuronal network formation

Kristina Karandasheva, Katja Kobow

Aim: To investigate mechano-biological aspects of neuronal circuit function under normal and pathophysiological conditions in mechanically tuneable engineered brain tissue

WP1: Mechanics of primary neuronal network formation

Building on last year's optimization efforts for 3D primary neuronal cultures, we focused on gels composed of Collagen I. Primary rat neuronal cells were embedded in collagen-based matrices of varying concentrations (1.0–3.5 mg/ml) to modulate environmental cues through stiffness. Particular emphasis was placed on establishing a reproducible approach for thinner samples (0.8 mm) to achieve optimal microscopy conditions (optical clarity and working distance) while maintaining long-term cell survival (up to 4 weeks). Immunofluorescent characterization confirmed the presence of mature neuronal and glial populations using MAP2, GFAP (astrocytes), NG2 (oligos), CD45 (microglia), and synaptic markers such as Bassoon. In collaboration with **C05**, we further performed 3D traction force microscopy (TFM) experiments. Using high-resolution time-lapse microscopy imaging (40x and 60x), we obtained stable recordings of growth cone-mediated deformations and neuronal migration during network formation. While high magnification provided clear traction force signatures, it limited the observable field of view and reduced network-level context. To address this, we performed experiments on Collagen I gels with embedded fluorescent beads (200-500 nm), which enabled imaging at lower magnification (20x) and allowed us to quantify forces across entire small-scale networks rather than single neurites. Preliminary datasets demonstrate measurable and spatially coherent collagen deformations, and workflows for 3D force reconstruction are currently being established. This method provides a more defined reference for displacement-field calculations and allows direct benchmarking against collagen-fiber-based tracking. We optimized bead concentration, distribution, and imaging parameters to minimize background noise while maintaining bead traceability in 3D stacks. Initial experiments yielded bead trajectories that were successfully tracked over hours of neuronal activity, enabling deformation mapping at higher spatial resolution. Integration of both collagen-fiber- and bead-based force measurements is ongoing to assess method consistency and sensitivity.

WP2. Mechanics of ictogenesis

As part of our efforts to model pathophysiological activity patterns, we performed calcium imaging experiments in primary neuronal cultures subjected to glutamate treatment. Using the Fluo-8 calcium reporter, we recorded neuronal activity before, during, and after glutamate exposure. The acquired datasets reveal pronounced calcium bursts upon glutamate treatment characteristic of seizure-like activity, followed by a return to baseline oscillatory dynamics. Ongoing image analysis focuses on quantifying response amplitudes, network synchrony, and potential long-term changes in activity after glutamate exposure (i.e., spontaneous recurrent seizure-like events).

To investigate the mechanobiological consequences of pathological neuronal activation, we combined seizure induction with traction force microscopy in Collagen I gels (**C05**). Immediately following glutamate application, we recorded neuronal body displacements and collagen matrix deformations, indicating likely actomyosin-mediated inward neuronal soma contractility (Figure 28). Further optimization and computational analysis are underway to quantify force dynamics across larger regions and to correlate mechanical changes with calcium imaging signals.

The transient increases in neuronal soma contractility observed during glutamate exposure in initial TFM measurements suggest that heightened neuronal activity elevates local cellular prestress. Because such activity-dependent forces may propagate beyond the single-cell and small-network scale, we next asked whether they translate into measurable changes in bulk tissue mechanics. To address this, we are currently complementing the TFM data with tabletop MRE (with **A01**) on whole neonatal rat brains to assess global stiffness changes in an intact, physiologically preserved architecture. As a first step, we optimized the excitation conditions: testing frequencies of 500, 700, 900, and 1100 Hz showed that 700 and 900 Hz yielded the most reliable data, characterized by well-resolved shear-wave propagation, smooth dispersion curves, and stable estimates of storage and loss moduli. The complex shear modulus was derived from the measured displacement fields using the BesselFit inversion. Initial measurements showed a roughly 10% increase in both storage (G′) and loss moduli (G″) upon glutamate treatment compared to the pretreatment baseline, consistent

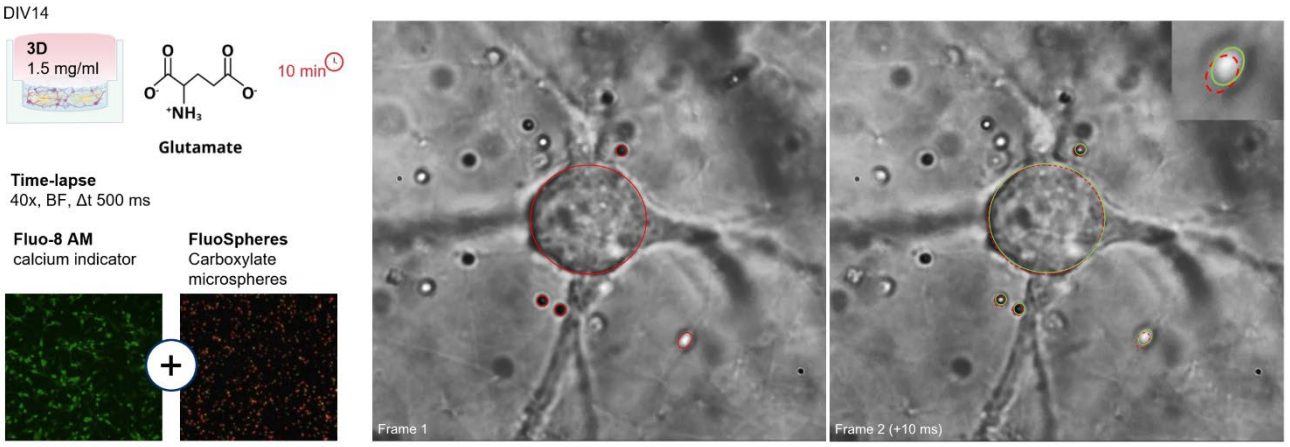

Figure 28: ***Seizure-like activity exerts traction forces in rat primary neuronal cell cultures.*** *Experimental design (left) and example readout from TFM with FluoSpheres and Calcium imaging upon glutamate treatment (right). Two subsequent video frames (10 ms time difference) are shown. Red/green circles aligned with beads and cell bodies indicate neuronal body displacement and collagen matrix deformations relative to beads, providing initial evidence for seizure-associated neuronal soma contractility upon glutamate treatment.*

with glutamate-induced consolidation of the tissue microstructure, in which elevated cellular tension leads to greater elastic stiffness and increased viscous energy dissipation. Additional measurements are underway to validate this initial finding and to assess potential time-dependent effects related to sample preparation and measurement timing.

We are further performing AFM nanoindentation (with **A05**) on acute adult mouse brain slices before, during, and after treatment with 10 µM glutamate in aCSF to probe local, treatment-specific alterations in viscoelasticity. Together, these approaches help bridge the gap between cellular contractile forces and tissue-level mechanics and test whether glutamate-driven neuronal activity can acutely modulate mesoscale stiffness. Results will be available in January 2026.

WP3: Mechanics of epileptogenesis

In focal epilepsy associated with developmental brain malformations, pathogenic brain somatic variants are thought to initiate epileptogenesis, yet the molecular sequence leading to seizures remains poorly understood, particularly for mutations not directly affecting ion channels or neuronal excitability. We identified epigenetic deregulation of ECM organization, cell adhesion, and mechanosensing in brain malformations (**1**).

MOGHE is characterized by increased oligodendroglial density, myelination defects, and ectopic white-matter neurons (**2**). Recent studies, including ours, identified lesion-associated variants in the X-linked SLC35A2 gene and mosaic Y-chromosome gains (XXY, XYY; (**3**)), defining four MOGHE genotypes (SLC−/Y−, SLC+/Y−, SLC−/Y+, SLC+/Y+). Although genotype correlates with clinical severity, especially psychiatric comorbidities, all groups share indistinguishable histopathology and drug-resistant epilepsy.

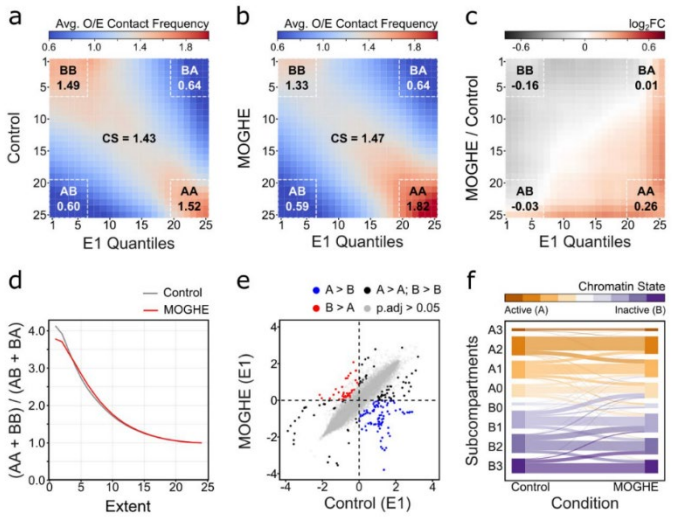

Figure 29: ***Compartmental chromatin reorganization in MOGHE without A/B switching.*** *(**a-c**) dcHiC analysis reveals strengthened A-A and weakened B-B contacts in MOGHE compared with controls. (**d-f**) Cross-compartment interactions and PC1-based A/B and subcompartment assignments remain stable.*

To determine whether distinct genotypes converge on shared epigenomic mechanisms, we performed Hi-C sequencing in collaboration with A02 on MOGHE lesions of all genotypes, autopsy controls, and additional epilepsy-associated pathologies (total n=8: 2 controls, 4 MOGHE, 1 polymicrogyria, 1 ganglioglioma). MOGHE lesions displayed a convergent 3D chromatin architecture distinct from controls and other lesion types, characterized by strengthened interactions within active chromatin and weakened interactions within inactive regions without large-scale

A/B compartment switching (Figure 29). Preserved global polymer properties together with reweighted compartment interactions indicate modulation of interaction strength rather than wholesale architectural reorganization. Functionally, these changes are associated with compaction and disruption of TADs around neuronal genes and reinforcement of TADs around glial genes, consistent with neuronal displacement and oligodendroglial hyperplasia in MOGHE.

Additional analyses across the extended cohort are ongoing to evaluate whether the detected chromatin changes are specific to MOGHE or shared across other cortical malformations and tumor tissues.

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C04 Cellular differentiation in brain tissue-mimicking matrices

Anja Bosserhoff, Shanice Heidenreich

This project investigates the biological mechanisms that enable melanoma cells to colonize and survive in the brain. Metastatic melanoma is one of the most aggressive tumor diseases. Brain metastases in particular represent a particular therapeutic challenge due to the limited pharmacological accessibility of the brain and the pronounced adaptability of tumor cells. The aim of our work was to understand how the mechanical and biochemical properties of brain tissue, as well as intrinsic cellular plasticity and the origin of metastases, determine the behavior of melanoma cells. For this, we used a range of 3D hydrogel systems with defined mechanical and molecular properties, as well as *ex vivo* mouse brain slices. We investigated melanoma cells representing two plasticity clusters (proliferative and invasive) and two metastatic origins (brain metastases and non-brain metastases).

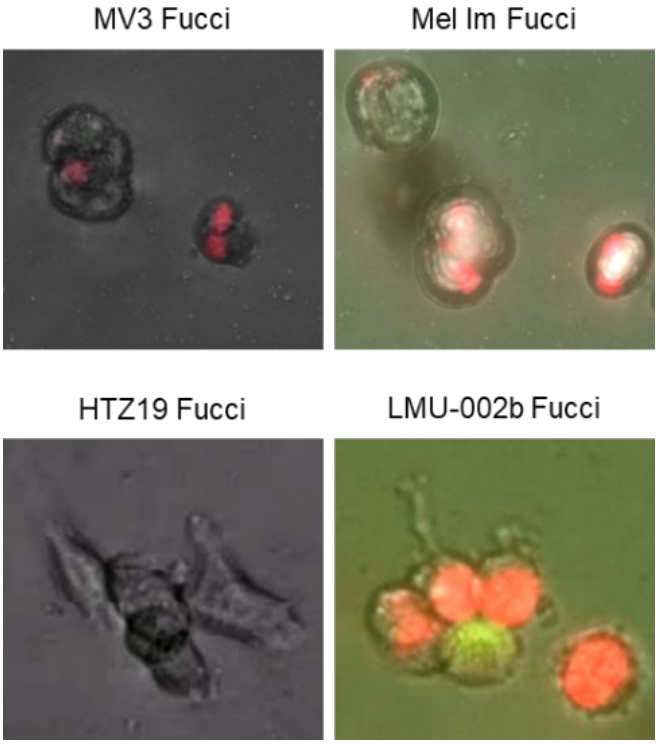

Figure 30: Spreading melanoma cells in ADA-GEL hydrogel - microscopic images on day 4.

Across these matrices, cell behavior was influenced by the mechanical context. Varying the alginate concentration resulted in a general change in cell activity in all cell lines, independent of the cellular plasticity or metastasis origin effect. When ADA gel was used, specific behavior occurred in some cell lines. Spreading behavior was primarily determined by the origin of the metastases.

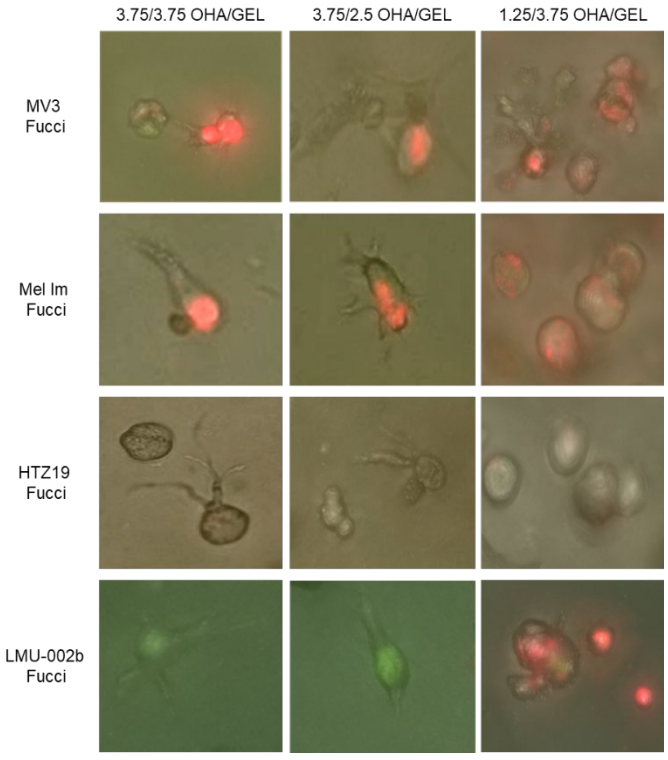

Figure 31: Microscopic day 4 images of spreading cells in 3.75/3.75, 3.75/2.5 and 1.25/3.75 OHA/GEL.

Noticeable differences between the plasticity clusters emerged in OHA/GEL systems. Adjusting the gelatin content resulted in varying effects on the proliferation between the invasive and the proliferative cluster. In contrast, the spreading behavior of cells exhibited differences, particularly between cell lines with different origins of metastasis. A reduction in hyaluronic acid (HA) influenced the total cell count and cell behavior, whereby the extent of cell spreading also varied depending on the different origins of metastasis.

Ex vivo studies on brain sections from mice confirmed that cell behavior varied in terms of cellular plasticity and the origin of metastases. The distribution of cells differed depending on the brain region and varied between the different cell clusters and the origin of metastasis.

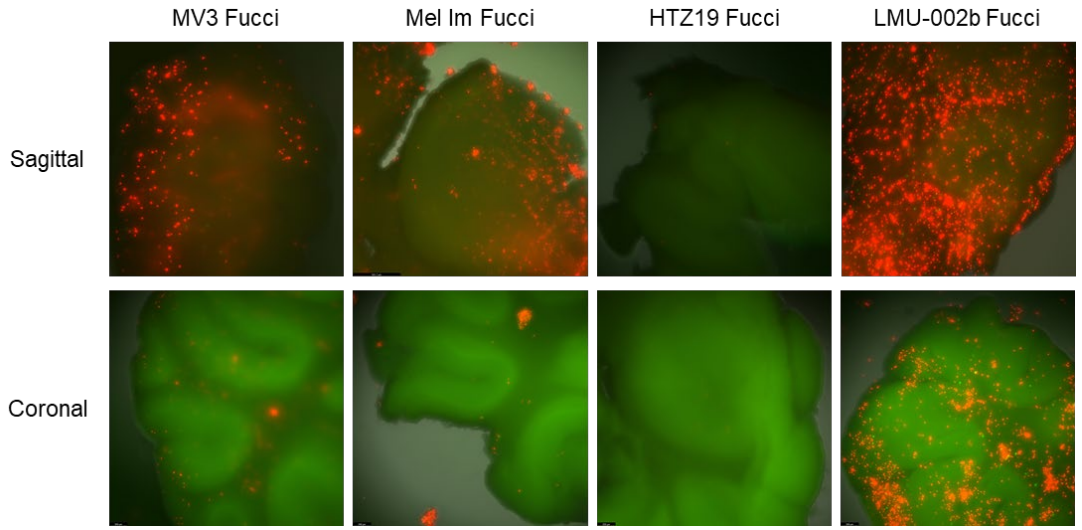

Figure 32: Microscopic images of adhered and invaded melanoma cell lines in sagittal and coronal sections of the cerebellum on day 7.

These results illustrate that melanoma cells' behavior in brain-like environments is determined by a complex interplay between intrinsic plasticity programs and metastatic origin. The combination of controllable 3D model systems and organotypic brain slices thus offers a powerful platform for better understanding adaptive tumor processes in the brain and identifying potential therapeutic targets.

C05 Molecular mechanisms of neuronal mechanotransduction

Lars Bischof, Ben Fabry

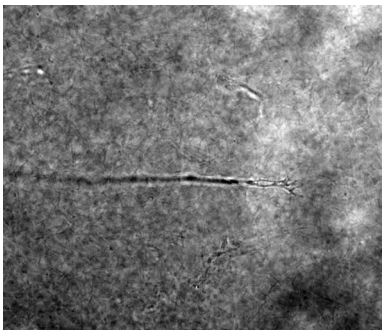

Figure 33: Contrast enhanced bright field image; single axon growing through collagen matrix.

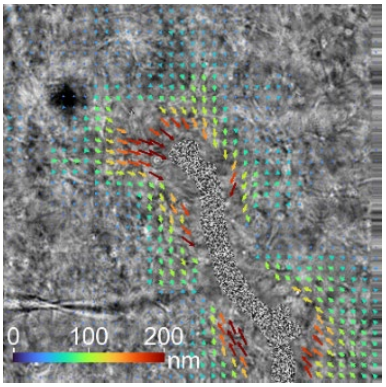

Figure 34: Axonal growth cone in collagen-hydrogel. Colored Arrows: 2D-projection of the recorded deformation field.

The main objective of Project **C05** is to investigate molecular mechanisms of mechanosensing and mechanotransduction in primary neurons in 3D environments. In the beginning of the project we established Collagen-I (/Matrigel)- Hydrogels as our 3D culture matrix that allows us to observe neuronal development of primary hippocampal rat neurons up to 14 days. Due to its fibrous structure, these hydrogels allow us to perform traction force microscopy without adding beads as fiducial markers. Typically, this is done recording confocal laser reflection images. However, first experiments were not successful due to photo-damage inflicted by the laser light.

In order to achieve long recording time with reasonable temporal resolution, we try to establish a similar but less invasive imaging method relying only on bright field images. Since good contrast and resolution is needed, experiments were performed using a 60x water immersion objective with a high numerical aperture of 1.1, enabling us to visualize the typical fibrous structure of collagen matrices.

During neurite outgrowth, neuronal cells are expected to sense their environment presumably through mechanical interaction at their growth cones. Hence, we try to observe and record this process. For this purpose, primary hippocampal rat neurons were mixed into 0.6 mg/ml and 1.2 mg/ml collagen-hydrogels and seeded on top of another already polymerized hydrogel layer. After 48 hours of incubation at 37 °C, single axons could be observed growing through the 3D matrix (see Figure 33). Time laps imaging of three-dimensional z-stacks over periods of 90 min was conducted. Axonal growth cones were found to occasionally exert contractile forces on their environment, causing spatial deformations (see Figure 34).

These deformations are quantified using a 3D particle image velocimetry (PIV) algorithm. The resulting deformation field can be used to calculate cell traction forces using the finite element method.

Contractile forces at the growth cones reached up to 5 nN. So far, the data does not indicate significant force differences between 0.6 mg/ml and 1.2 mg/ml hydrogel.

Comparing 3h axonal paths between collagen concentrations showed an increase in growth speed with matrix stiffness. Interestingly, the persistence in growth cone migration was decreased in the less dense 0.6 mg/ml collagen gel (see Figure 35). Furthermore, blocking beta 1 integrins with antibodies saw this difference between the hydrogels vanish. According to this preliminary data, axonal growth in 3D is supported by a stiff and dense ECM structure as long as the growth cones are able to interact with the collagen through integrins.

In future experiments with stretched collagen samples, we will test if aligned collagen fibers give rise to directional axonal growth. Additionally, by impairing actomyosin-driven traction forces (e.g., through Blebbistatin), we will further test the significance of traction forces for axonal elongation.

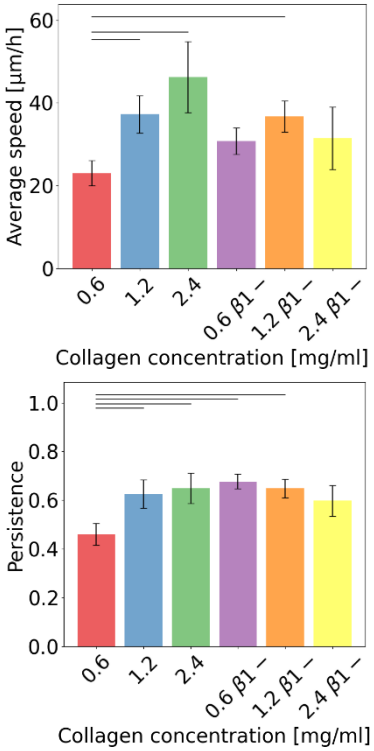

Figure 35: Speed and persistence of axonal growth. Additional samples were treated with integrin beta 1 antibodies (β1 -). Whiskers: standard error. Horizontal lines: significance with p<0.05.

X01 Model-based reconciliation of *ex vivo* and *in vivo* test data

Laura Ruhland, Kai Willner, Yashasvi Verma, Luca Heltai, Paul Steinmann, Jing Guo, Ingolf Sack

The *in-vivo* and *ex-vivo* mechanical characterization of brain tissue often gives inconsistent or contradictory results. In our studies, we want to address these inconsistencies by understanding the influence of the testing conditions and processing algorithms on the mechanical properties measured with Magnetic Resonance Elastography (MRE). MRE is a non-invasive method used to evaluate the mechanical properties of soft tissues *in vivo*. It involves generating mechanical waves in organs like the liver, brain, or kidney using an external actuator and capturing the resulting displacements with motion-sensitive MRI. These displacements are then filtered to isolate shear waves [1]. Under the assumption that the tissue behaves as a linear elastic medium, shear wave propagation is described by the equation

$$2\mu\Delta u + \rho\omega^2 \boldsymbol{u} = 0,$$

where ρ is the tissue density, ω is the angular frequency, and μ is the shear modulus. By measuring the displacement field u, this equation can be "inverted" to estimate tissue properties. This is called Direct Inversion (DI), it is computationally efficient and assumes local homogeneity [2]. We developed a hybrid inversion technique that combines the efficiency of DI with the stability of Finite Elements, described by the equation

$$2\mu \boldsymbol{K}\boldsymbol{u} + \rho\omega^2 \boldsymbol{M}\boldsymbol{u} = 0,$$

where K and M are stiffness and mass matrices, respectively.

Our method was validated through forward simulations of shear wave propagation in a cubic domain with a specified shear modulus. When the simulated displacement field was processed through the inversion algorithm, the reconstructed material properties closely matched the input values. This is shown in Figure 36. The method is computationally expensive as compared to traditional DI, but gives more convergent and consistent reconstruction.

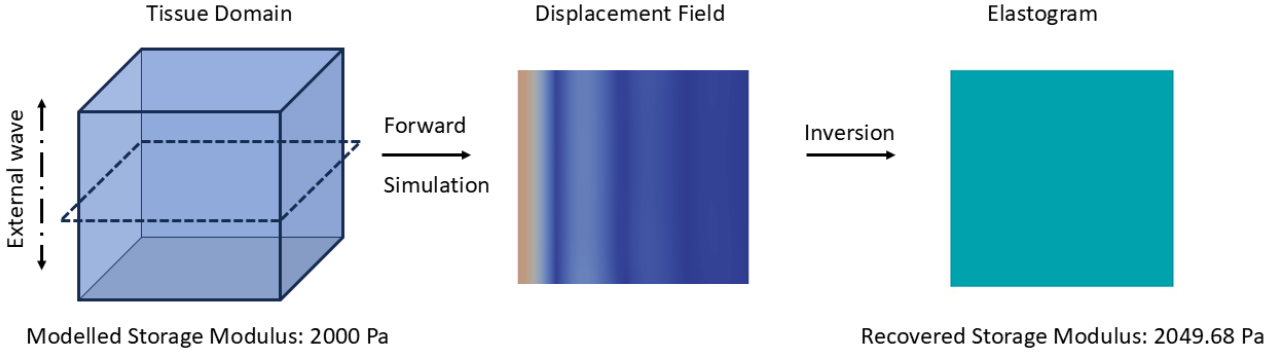

Figure 36: Validation Method of the Inversion Scheme.

In an experimental study, we investigated the influence of the experiment's time scale on the mechanical properties by combining high-frequency MRE measurements with experimental responses obtained at different time scales in a continuum-based model [3]. A brain phantom was characterized in the time and frequency domain and with varying testing temperatures. At 26°C and 37°C, multimodality rheometer experiments in the time domain and MRE at high frequencies were examined. The behavior in the mid-frequency range was characterized at room temperature with a custom-built vibration table. In a vibration analysis, the first eigenfrequency of two cubic samples with different edge lengths was determined. Based on the rheometer measurements in the time domain, an inverse parameter identification in ABAQUS was performed to obtain the mechanical parameters. As a material model, the hyperelastic Ogden model combined with a time-dependent Prony series was used. To verify the calibrated model for an application in the frequency domain, the MRE and vibration table measurements were predicted with the calibrated model. The calculated material response for the MRE (Figure 37) and the vibration analysis (Figure 38) highly agrees with the measured response. This indicates that the model calibrated in the time domain is capable of modeling the material's frequency behavior.

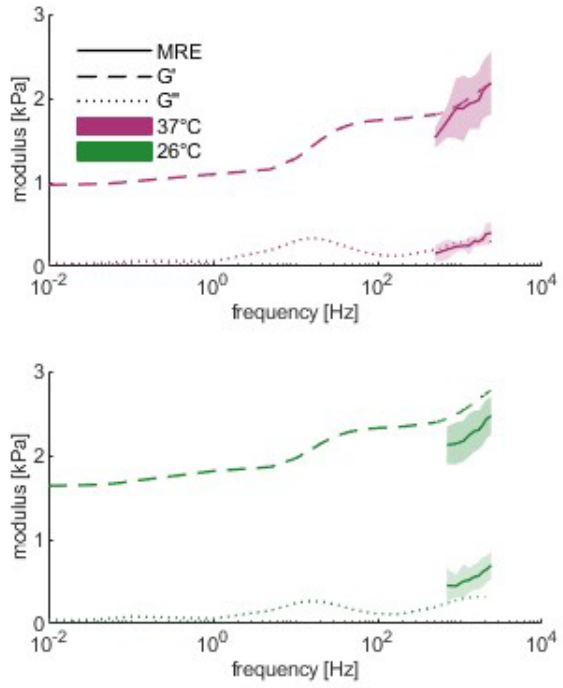

Figure 37: Storage (G') and loss modulus (G_) measured with MRE and calculated with the in the time domain calibrated model.

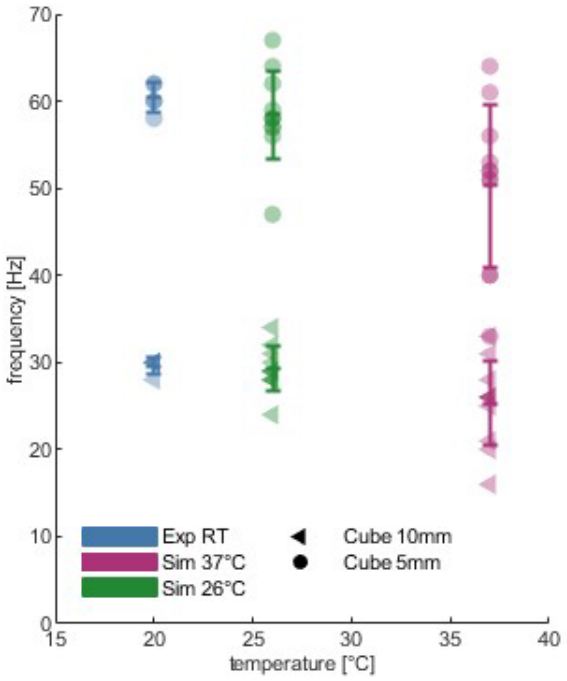

Figure 38: First eigenfrequency (Mean ± Std) measured with the vibration table and simulated with the in the time domain calibrated model.

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X02 Data analysis and machine learning for heterogeneous, cross-species data

Oliver Aust, Katharina Breininger

Main objectives

The **X02** project focuses on the application of machine learning models on the heterogeneous cross-species data acquired within EBM. In the 3rd year of the EBM funding, we explored different approaches and specifically investigated the use of foundational models and their robustness under different domain shifts.

Use of foundational models and evaluation under domain shifts

In multiple studies, we evaluated what benefit foundation models can bring for reducing the amount of training data needed for specific histopathological tasks [1, 2].

Together with project **A03**, we developed a prototype for automatic evaluation and morphometry of brain organoids (see Figure 39) and evaluated general segmentation foundational models (Segment Anything [3]) for this task [4].

Additionally, the EBM team was part of the organization of the Mitosis Domain Generalization Challenge (MIDOG) 2025 [5] held in conjunction with the International Conference on Medical Image Computing and Computer-Assisted Intervention, Daejeon, Republic of Korea, September 23rd-27th. This machine learning challenge centred around the task of robust detection and classification of abnormal cells under different tissue and microscopy conditions. Further publications evaluating the robustness of different submitted methods are in preparation.

Extension of the EXACT Platform

In collaboration with project **A01** and **A02**, we continued the work on the EXACT platform, improving the availability of different annotation functionalities, improving annotation tracking relevant for better understanding annotator investment vs. model performance improvement, as well as improvements to the stability of the platform. The platform was extended to allow for additional file formats, with support from collaborators from FH Flensburg. To validate automated approaches for nuclei detection and cell differentiation, we jointly developed an annotation protocol (Oliver Aust) together with **A02**.

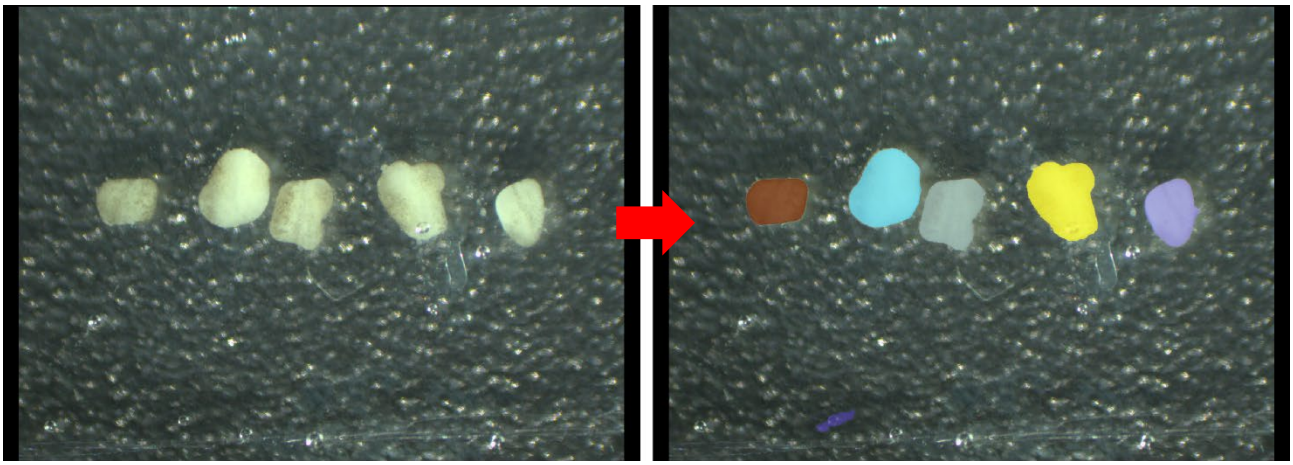

Figure 39: (Semi-) Automatic detection and morphometry for nerve cell organoids of frog embryos: Segmentation, candidate filtering, and extraction of morphometric measurements, in collaboration with A03.

Further works and methodological advances

Expanding work from 2024, Mathias Öttl developed an approach to better model segmentation uncertainty [6] by using generative models for this task. This approach may facilitate a more robust behaviour of, for example, cell / nuclei segmentation models, but also tissue boundary detection, especially for data with inter-annotator differences. Additionally, we investigated how specific disease patterns allow a reidentification over different samples and over time [7]. To understand how and where within networks features are entangled or disentangled for specific tasks (here specifically for object detection), we investigated metrics to describe latent space similarity and class separability

in deep convolutional models [8] and how similarity and dissimilarity can be used in active learning contexts [9].

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X03 Engineering brain tissue like matrices

Markus Lorke, Aldo R. Boccaccini

Main objectives and achievements:

Influence of two different oxidation times of hyaluronic acid on cellular behavior

One of the main challenges in our newly developed OHA/GEL hydrogel system is its relatively low stability upon incubation at cell culture conditions. After establishing an *in situ* crosslinking process, leading to a homogenous crosslinking with higher long-term stability [1], the new approach was to investigate the differences between two different oxidation times and their combination. Longer oxidized HA led to an increase in stiffness compared to the 4-hour oxidation, while mixing both in ratios of 1:1 (4h:6h) led to stiffnesses between the different OHA oxidation times. However, the cellular response was altered when combining the different oxidation times when compared to hydrogels with equivalent stiffness. Mechanical tests showed that the blend of both oxidation times led to a slightly higher stiffness, while the 4h OHA led to the softest hydrogels when keeping the other components at the same level. Further chemical tests are currently being conducted.

Enriching the hydrogel with the ECM component laminin

Creating a closer chemical ECM mimicking is one of the most challenging parts of the project, as the addition of another component can influence the crosslinking, mechanics, as well as physicochemical properties of the hydrogels. First, we added laminin 1-1-1 to the OHA/GEL in the last minutes of stirring, before transferring them into molds for cell addition. The hydrogels could still be formed, and we observed similar mechanical properties when comparing compression–tension behavior with hydrogels without laminin. The degradation, however, is slightly facilitated. Tests with the neuro cell line NG108-15 proved that the addition of laminin had a beneficial influence on cell proliferation. Currently, tests with primary neuronal cells in collaboration with **C02** are carried out.

Time-dependent properties of mTG crosslinking

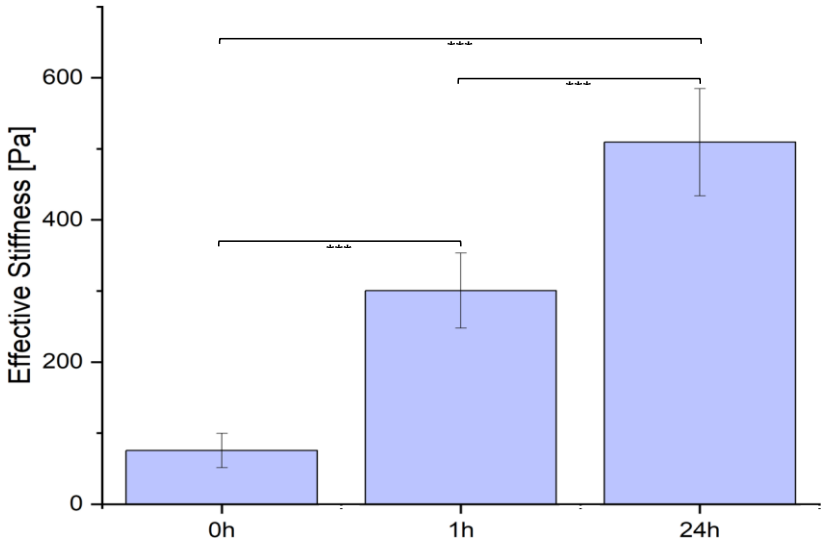

Figure 40: Increase of effective compressive modulus of 1.5/2.5 OHA/GEL with 15% mTG during the first 24 hours.

During the mechanical testing procedures, we observed that the compression modulus increased significantly over the first 24 hours until the final stiffness was reached (Figure 40). This effect can be traced back to enzyme activity until the active units are completely consumed. Measuring this effect is currently difficult due to swelling behavior during the first hours after production, and dry measurements are almost impossible due to drying effects during this time [3]. Nevertheless, preliminary results show a clear increase despite the influencing factors, and a new setup protocol is under investigation.

Testing of established hydrogels in collaboration with different EBM researchers

A03: After assessing the possibilities and requirements of materials provided to **A03**, collaborators of **A03** were trained in the synthesis, sample fabrication, and handling of the hydrogels to allow an extensive collaborative material development in the future.

A04: We provided our established OHA/GEL matrix to **A04** and, in collaboration, succeeded in encapsulating the brain organoids developed in **A04** in a hydrogel bead. We enhanced the encapsulation process and tested different hydrogel concentrations, with altering stiffness.

B04: We have started the collaboration with Project **B04** and delivered hydrogel systems with different mechanical properties for cultivation of different patient-derived cells. All cell experiments were conducted by **B04**.

C02: In collaboration with **C02,** we tested the behavior of primary rat neurons in contact with the established OHA/GEL hydrogel matrix using different aforementioned approaches. We showed that primary neurons can develop in the OHA/GEL matrix, provided the network concentration is kept at a low level. Higher concentrations were shown to hinder or deter neuronal development. In lower hydrogel concentrations, neurons can both develop in a 3D matrix and actively infiltrate the matrix. The addition of laminin at low concentrations is currently being investigated. Parts of the results of this study were published in 2023 [2] and 2025 [3].

C04: In collaboration with **C04,** we encapsulated melanocytes and melanoma cells in our OHA/GEL matrix. The samples were cultivated and assessed by **C04**.

X01: In collaboration with **X01,** we have established a technique for MRE assessment of hydrogel matrices. Requirements that were achieved included bubble-free filling of the test tubes with hydrogel and storability of the filled test tubes without detaching of the hydrogel from the test tube walls. The values measured for OHA/GEL hydrogels were similar to those of human brain tissue.

Conclusion and outlook:

In summary, the development of neuronal ECM-mimicking hydrogels for use in cell culture was investigated. Several advancements were achieved regarding long-term stability, material combinations, material complexity, and cell culture approaches for various cell types with their specific requirements, as well as for their corresponding analysis methods. The developed hydrogel matrix was tested in multiple collaborations with EBM researchers and demonstrated satisfactory results for the initial implementation of this type of matrix. In the next development phase, the goal is to establish a more precisely defined matrix and to collect additional mechanical data, not only on a macroscopic but also on a microscopic level, throughout the entire duration of typical cell tests, in order to further advance the hydrogels into a more complete ECM-mimicking matrix.

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Y Establishing magnetic resonance elastography at FAU

Guillaume Flé, Frederik Laun, Arnd Dörfler, Jing Guo, Ingolf Sack

In 2025, the **Y**-Project addressed the following elements:

1) Conduct a study on the variability of brain magnetic resonance elastography (MRE) in healthy volunteers
2) Design of an experimental setup for small animal MRE
3) Implement an alternative approach to image acquisition in MRE
4) Initiate a database of brain MRE images from tumor patients
5) Develop a dual actuation and acquisition strategy for wide-band frequency characterization of the brain

To pursue the initialization phase for conducting MRE examinations at FAU, the **Y**-Project evaluated the reproducibility of the technique by applying MRE to 17 healthy volunteers at two sites in Erlangen. Images from both measurements were projected onto a reference brain atlas to facilitate the comparison of brain stiffness, represented by images of reconstructed shear wave speed distributions, which demonstrated excellent reproducibility, as shown in Figure 41a. This work is part of Mr. Simon Murk's Master's thesis.

Animal models are essential to understand brain pathologies, their origin, and progression. To characterize the mechanics of brain tissue in small animal models *in vivo*, clinical MRE must be adapted for use in preclinical MRI systems, which allow for access to smaller scales with higher image resolution. Figure 41b shows a computer model of a design for holding small animals and applying mechanical stimulation using a piezoelectric actuator, along with a representative MRE image of the induced displacement field. This work is part of Mr. Johannes Rau's Bachelor's thesis.

MRE fundamentally relies on the encoding of local tissue displacements, which can be altered by unwanted participant motion in the scanner. This challenge can be addressed by employing fast acquisition strategies to reduce scan duration, which have proven to be suitable for MRE protocols. In this project, we implemented MRE using an alternative approach to sampling the mathematical

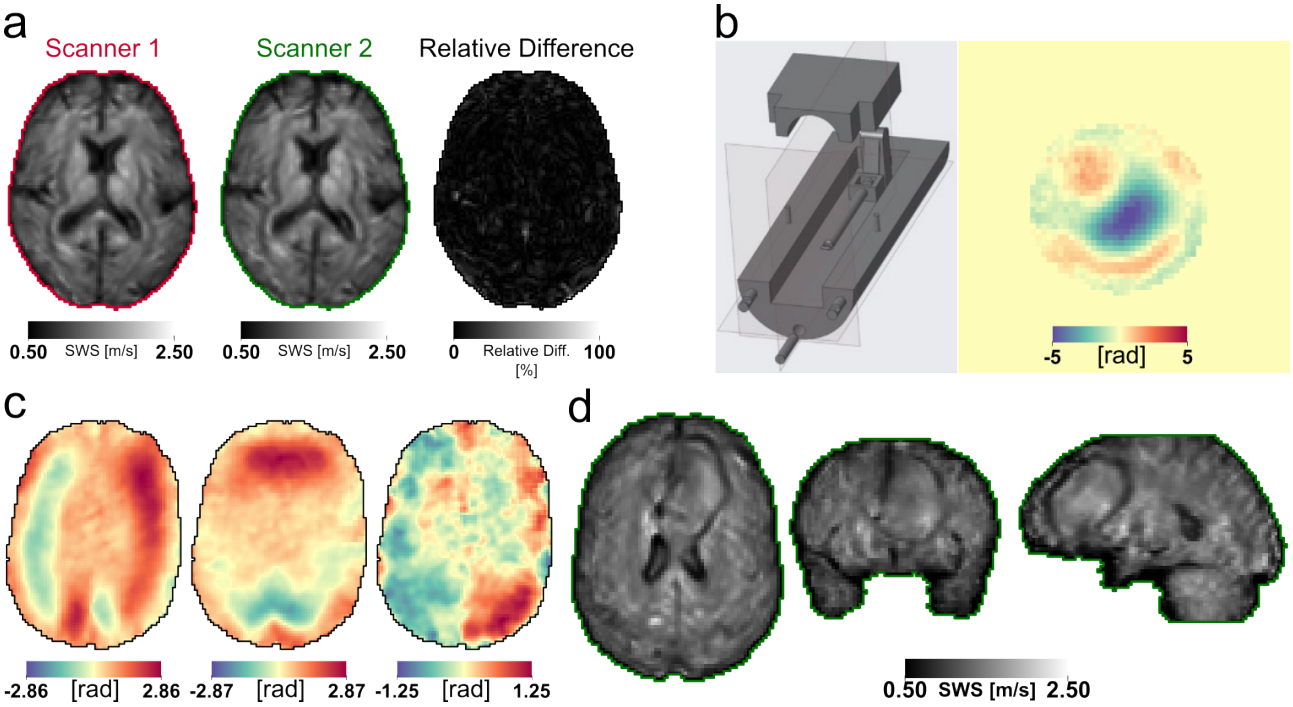

*Figure 41: **(a)** Representative example of brain MRE examinations, performed on the same participant at two different sites, showing high reproducibility with small relative differences in shear wave speeds (SWS). **(b)** Computer-assisted drawing illustration of the designed small animal holder and actuation system (left) and MRE-based displacement image from a cylindrical hydrogel of 2.5 cm diameter (right). **(c)** Cross-sectional images of the three components of the displacement vector, measured with a 3D radial sampling approach for MRE acquisition. **(d)** Representative example of an elastogram from a brain tumor patient, where brain stiffness is indicated by the shear wave speed.*

space that contains the MRI signal. Instead of navigating this space in rectangular patterns, we applied a radial trajectory, which helps reduce the effect of potential motion-related errors. Figure 41c. shows the three components of the displacement vector in a representative example of a radial MRE acquisition. This work is part of Mr. Philipp Jessberger's Master's thesis.

Application of MRE in clinical settings is the ultimate goal of the Y-Project. We have initiated a database of 14 brain tumour and hematoma patients in collaboration with Stefan Rampp (**A02**) and PD Dr. med. Daniel Delev. Figure 41d. shows three orthogonal views of shear wave speed maps from a brain tumour patient. The extent of the lesion can be outlined from the mechanical properties of the tissue and indicates a high level of material heterogeneity in the tumour.

The brain is poroviscoelastic, and its response to loads varies with the rate of the mechanical solicitation. The capability of efficiently transmitting and tracking mechanical vibrations to the brain across a wide range of frequencies is crucial to investigating potential mechanical biomarkers related to the time-dependent behaviour of the brain. In this project, a strategy to generate and deliver elastic waves from 5 Hz to 50 Hz was proposed and assessed, as shown in Figure 42. This work is part of Mr Jakob Schattenfroh's Ph.D. thesis [1].

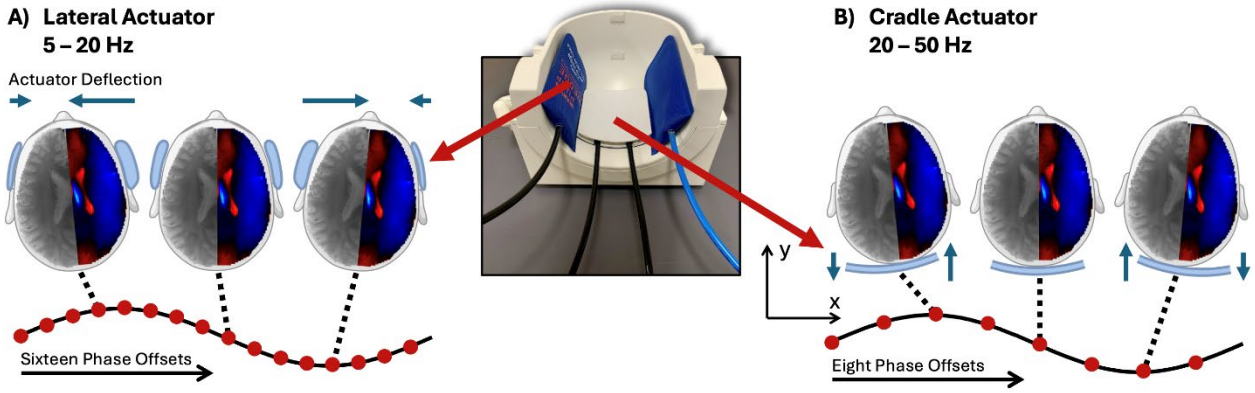

Figure 42: Wideband actuation and acquisition strategy using lateral and posterior mechanical stimulation and two levels of temporal sampling of the displacement field.

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1.3 PUBLICATIONS

In the 2025 publication lists, **EBM members** are highlighted in bold. Publication lists are in alphabetical order.

1.3.1 PEER-REVIEWED ARTICLES, CONFERENCE CONTRIBUTIONS, BOOK PUBLICATIONS

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2 INTEGRATED RESEARCH TRAINING GROUP (IRTG)

As EBM is exceptionally interdisciplinary, integrating disciplines such as experimental analyses, clinical studies, and bioengineering – all informed by advanced modeling and simulation – the integrated Research Training Group (**iRTG**) is particularly important for the CRC to bring the different disciplines together on a common basis.

The **iRTG** of EBM addresses this demanding interdisciplinary challenge by providing a structured, mandatory qualification program and ensuring quality management and control for doctoral and postdoctoral researchers. This approach also nurtures their scientific independence and promotes their career development.

The comprehensive program encompasses a range of activities aimed at enhancing theoretical knowledge, methodological skills, soft skills, and fostering a collaborative research environment.

2.1 QUALIFICATION PROGRAM

The qualification program comprises

- EBM (Post-)Doctoral Researchers' Seminars
- EBM Harmonization Workshops (theory and methods)
- EBM Soft Skills Courses
- EBM Annual Retreats and EBM Update Meetings

as basic activities. These components are complemented by active participation in international conferences, the publication of at least one paper, participation in and organization of Lab Shadowing, and writing short contributions for the EBM homepage after organizing EBM-funded activities or travel. In addition, (post-)doctoral researchers have the opportunity to complete research stays abroad as part of the program.

Beyond these essential elements, additional activities are available for all EBM members, including

- EBM Virtual Breakfast Clubs and Lunches
- EBM Virtual Brain Talk
- EBM Seminar Talks

2.1.1 EBM (POST-)DOCTORAL RESEARCHERS' SEMINARS

Every two months, organized by two (post-)doctoral researchers in rotation, these two-hour seminars offer ample opportunities and valuable experiences for (post-)doctoral researchers to present their latest work-in-progress and results. The sessions facilitate discussions on current challenges and future research perspectives within a relaxed and interdisciplinary atmosphere. The seminars aim to foster networks among doctoral and postdoctoral researchers, catalyzing new research directions, approaches, and collaborations.

Originally, the concept was to hold the (post-)doctoral researchers' seminars monthly, with each month featuring a presentation by one (post-)doctoral researcher and the presence of the Principal Investigators. However, early in the EBM program, (post-)doctoral researchers expressed a desire for the seminar to be primarily internal among the doctoral cohort. In a closed circle, the doctoral researchers feel more at ease to ask questions, discuss uncertainties, and share their own experiences, fostering a more open and supportive environment.

Following feedback from the doctoral candidates during the EBM Retreat in September 2023, it was additionally decided to shift the seminar to a bi-monthly schedule due to time constraints. As compensation, it is now organized by two doctoral researchers who also deliver the presentations. This allows for a more efficient use of time for research work and other commitments.

To successfully complete the doctorate within the EBM **iRTG** 1540, it is mandatory to attend at least 4 of the 5 to 6 (Post-)Doctoral Researchers' Seminars per year.

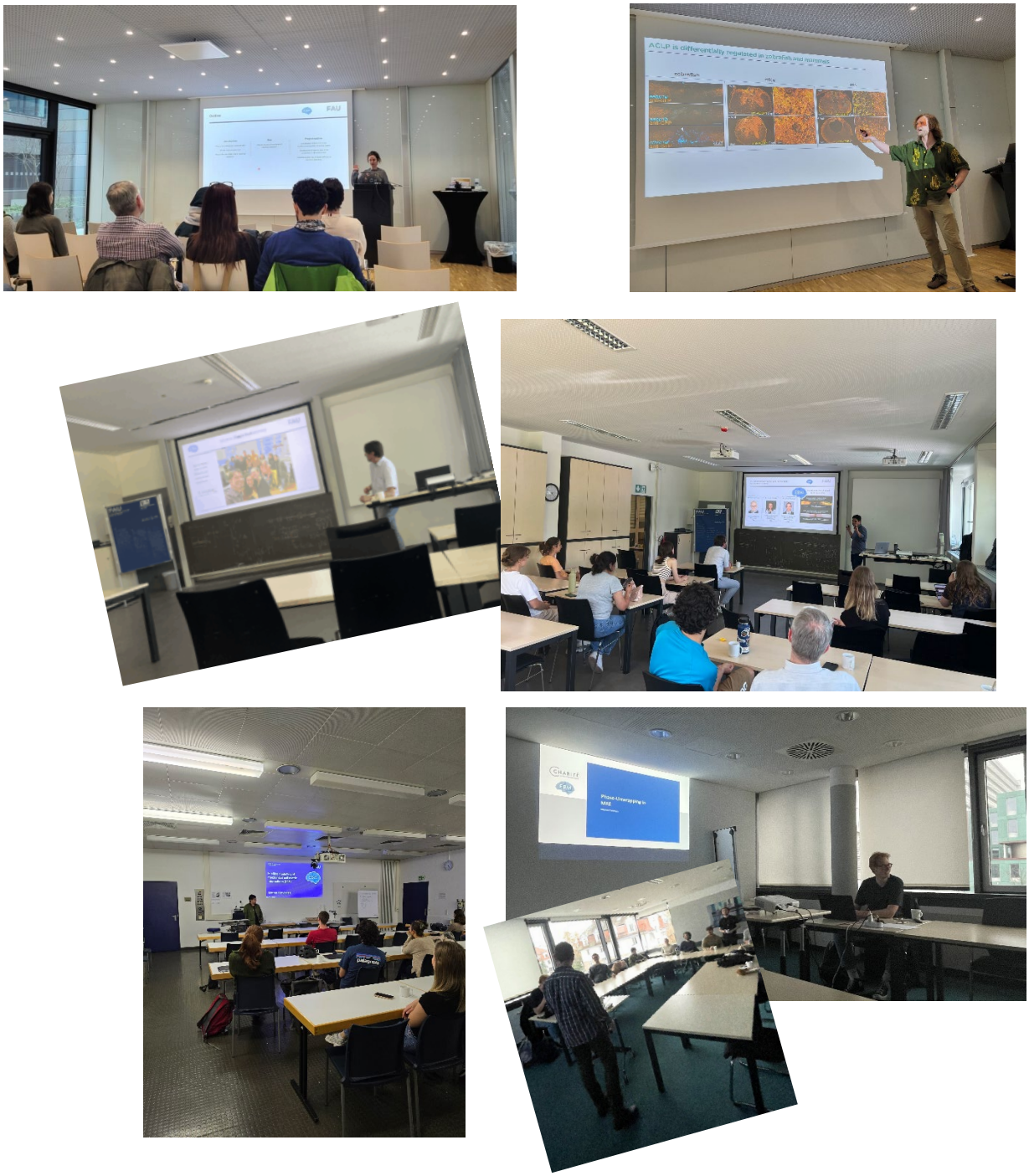


Figure 43: Impressions of the (Post-)Doctoral Researchers' Seminars. (Images: C. Froidevaux, S. Auer, S. Rampp, E. Cecchini)

Table 2: (Post-)Doctoral Researchers' Seminars

	Date	Organized by (name / project)	Title
01	20.02.25	Jana Bachir Salvador / **B03**	Determinants of central nervous system tissue mechanics in homeostasis
		Ezgi Erterek / **C02**	The role of mechanics for neuronal 'plasticity'
02	25.04.25	Sudipta Mukherjee / **A05**	Long-range chemical signaling *in vivo* is regulated by mechanical signals
		Thomas Fleming / **B05**	ACLP as a novel inhibitor of spinal cord regeneration in mammals

03	13.06.25	Rahul G Ramachandran / **B01**	Multimodal Mechanical Characterization of Spinal Cord Tissue
		Maik Hintze / **B04**	Spinal cord mechanics in a mouse model of multiple sclerosis
04	18.09.25	Stefan Rampp / **A02**	Quantitative characterization of brain malformations
		Mathar Kravikass / **C01**	Continuum modeling and simulation of cell aggregation phenomena
05	25.11.25	Guillaume Flé / **Y**	MR-signal sampling in MR Elastography
		Michael Fedders / **X01**	Phase unwrapping in MRE

2.1.2 EBM HARMONIZATION WORKSHOPS

Trimestral half-day EBM Harmonization Workshops are focused introductions to interdisciplinary topics of key relevance for EBM. They aim to provide a common theory and methods basis for EBM doctoral researchers. Orchestrated by EBM PIs and postdoctoral researchers from different disciplines, the workshops cover a broad spectrum of theory and methods in various formats (lectures, exercises, laboratories, tutorials, etc.).

To successfully complete the doctorate within the EBM **iRTG** 1540, it is mandatory to attend at least 8 of the 16 Harmonization Workshops (theory and methods) within 4 years.

Table 3: EBM Harmonization Workshops

	Date	**Organized by**	**Subject**
01	21.03.25	Frederik Laun, Guillaume Flé	Introduction to Magnetic Resonance Elastography (MRE)
02	26.06.25	Renato Frischknecht	Basic mechanisms of neuronal plasticity and learning
03	13.10.25	Paul Steinmann	How to understand stiffness
04	17.12.25	Lucas Hoffmann, Friedrich Paulsen	How to read histology

2.1.2.1 9th EBM Harmonization Workshop: Exploring MRE

On March 21, 2025, a harmonization workshop focusing on Magnetic Resonance Elastography (MRE) was organized by Frederik Laun and Guillaume Flé (Institute of Radiology & Institute of Neuroradiology, University Hospital Erlangen). The event was supported by Philipp Jeßberger, a master's student in the research group of Guillaume Flé

The workshop took place in the afternoon at the Zentrum für Medizinische Physik und Technik (ZMPT). Participants were divided into four groups, each consisting of five to six members. The program started with an introductory talk by Guillaume Flé, who provided an engaging overview of the principles and applications of MRE. The session was highly interactive, with participants actively discussing the presented concepts.

Following the theoretical introduction, the groups moved to a hands-on session led by Frederik Laun and Philipp Jeßberger. Participants were introduced to the MRE setup installed at the Cima.X scanner of the host institute. In addition to the specialized MRE equipment, the scanner itself was presented and explained, allowing participants to gain a comprehensive understanding of the imaging technology and its implementation.

This workshop is part of an ongoing series designed to help consortium members—particularly doctoral students—expand their knowledge in the diverse research fields represented within the EBM consortium.

*(Frederik Laun, **Y**)*

Figure 44: EBM's 9th Harmonization Workshop: Exploring Magnetic Resonance Elastography (MRE). (Images: F. Laun)

2.1.2.2 10th EBM Harmonization Workshop: Basic molecular and cellular mechanisms of neuronal plasticity and learning

On June 26, 2025, a workshop focusing on the Basic Molecular and Cellular Mechanisms of Neuronal Plasticity and Learning took place under the organization of Renato Frischknecht. The event began with a series of theoretical lectures that provided a solid foundation in the molecular and cellular processes involved in neuronal plasticity and learning.

Following the lectures, a live demonstration showcased the preparation and maintenance of primary neuronal cultures. Participants were given a guided tour of the laboratory facilities, which included an overview of the equipment and experimental setups used for cell culture and fluorescence imaging.

During the practical session, pre-stained neuronal cultures were observed under a fluorescence microscope. Key neuronal structures such as dendrites and axons were highlighted, offering a clear view of neuronal morphology and structure.

The workshop effectively combined theoretical knowledge with practical application, providing valuable insights into methods used to study neuronal plasticity at the cellular level.

*(Ezgi Erterek, **C02**)*

Figure 45: EBM's 10th Harmonization Workshop: Basic Molecular and Cellular Mechanisms of Neuronal Plasticity and Learning. (Image: E. Erterek)

2.1.2.3 11th EBM Harmonization Workshop: How to Understand stiffness

On October 13th, Paul Steinmann led an engaging and insightful harmonization workshop on understanding stiffness and viscosity. He kicked things off by breaking down the basic concepts of mechanics — force, strain, and stress — through simple, hands-on demonstrations, such as stretching rubber bands and using spring-operated weighing scales. These everyday examples made the ideas shine before he connected them to the underlying mathematical equations and shared some fascinating stories about the scientists behind these discoveries. The session then delved into the fundamentals of rheological modeling, focusing on storage and loss moduli and how they relate to classic material models, such as the Kelvin-Voigt and Maxwell models. And to keep spirits (and sugar levels) high, there was even a demonstration of cutting mechanics using a gummy-bear brain.

*(Yashasvi Verma, **X01**)*

Figure 46: EBM's11th Harmonization Workshop: How to Understand Stiffness. (Image: Y. Verma)

2.1.2.4 12th EBM Harmonization Workshop: How to Read Histology

On December 17, 2025, the EBM Harmonization Workshop „How to Read Histology“ was held at the Institute of Functional and Clinical Anatomy in Erlangen. The workshop was organized and led by Lucas Hoffmann and Friedrich Paulsen.

Participants received a brief introduction to the anatomy and histology of the human nervous system, including key principles for interpreting histological sections and common staining techniques. In an informal atmosphere with gingerbread and mulled wine, the speakers provided practical guidance on how to approach histological images.

In the second part of the workshop, the group moved to the histology hall of the institute, where participants examined a variety of CNS regions and staining methods at the microscope. The hands-

on session encouraged discussion and helped consolidate the theoretical content by identifying specific cell types and structural features.

The workshop contributed to harmonizing methodological knowledge within the EBM community and fostered interdisciplinary exchange.

Thank you to the organizers for this interesting workshop!

*(Sophia Auer, **A02**)*

Figure 47: EBM's 12th Harmonization Workshop: How to Read Histology. (Images: S. Auer)

2.1.3 EBM SOFT SKILLS COURSES

The EBM Soft Skills courses, ranging from half-day to full-day sessions, primarily draw from the portfolio offered by the Graduate Center (GC) of FAU. Additionally, the F³G network (Research Consortia for Promoting Equality at Friedrich-Alexander-Universität Erlangen-Nürnberg) provides a range of gender equality initiatives, including lectures and seminars on topics such as women's advancement and gender sensitivity, which are open to members of affiliated research alliances. EBM doctoral researchers have actively participated in these and other related offerings. Since some of our members are affiliated with the Max Planck Institute for the Physics of Light (MPL), they can also participate in offerings from the International Max Planck Research School (IMPRS), which are recognized by the EBM program.

To successfully complete their doctorate within the EBM **iRTG** 1540, doctoral researchers are required to attend at least one course on Good Scientific Practice, one course on Scientific Writing, and two additional soft-skills courses within four years.

To support this, the EBM Coordination Office organized the Good Scientific Practice course for EBM doctoral and postdoctoral researchers in the program's first year, followed by The Essentials of Scientific Writing in 2024. Further soft-skills courses were offered in 2025, as summarized in the table below.

In May, a start-up workshop at ZOLLHOF – Tech Incubator in Nuremberg was specifically organized for CRC 1540 EBM members, also welcoming participants from GRK 2423 FRASCAL and IGK 2495 (see detailed report below).

These courses and workshops provide EBM doctoral researchers with essential skills beyond the laboratory, fostering scientific rigor, effective communication, and professional development that support their successful progression within the program.

Table 4: Soft Skills Courses with EBM doctoral researcher participation

	Date	Content	Instructor	Offered by
01	05.02.25	Führungskräftetraining kompakt - was macht eine gute angehende Führungskraft aus?	Wolfgang Leybold	GC
02	20.05.25	The Essentials of Starting a Start-up	K. Möslein	EBM & FRASCAL
03	01.10.25 + 15.10.25 05.11.25 + 19.11.25	How to Deal with Mental Load and Build Resilience	Maik Goth	ARIADNE Mentoring
04	30.11.24 – 31.7.25	English Scientific Writing Course	Peter Hull	IMPRS/MPL
05	05.11.25 + 06.11.25	Time and Project Management for Researchers	Dr. Daniel Friedrich	F³G
06	16.12.25	Appearing on Stage: The Impact of Confidence & Assertiveness: Coaching for EBM Early-Career PIs	Dr. Silke Oehrlein-Karpi	EBM

"The Essentials of Starting a Start-up" at ZOLLHOF Nuremberg

On May 20th, an inspiring workshop titled "The Essentials of Starting a Start-up" took place at ZOLLHOF – Tech Incubator in Nuremberg. It was specially designed for members of the Collaborative Research Center CRC 1540 EBM, the Research Training Group GRK 2423 FRASCAL, and the International Research Training Group IGK 2495. The goal of the workshop was to highlight a frequently overlooked career option: founding a start-up directly from research. Invitations were extended not only to PhD candidates and postdocs but also to the Principal Investigators (PIs) of the research consortia.

Figure 48: Welcome by Prof. Dr. Kathrin Möslein. (Image: A. Dakkouri-Baldauf)

Welcome by Prof. Kathrin Möslein

The workshop was opened by Prof. Dr. Kathrin Möslein, Vice President Outreach at Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Professor of Information Systems, and a proud member of the FAU Innovation Ecosystem. In her welcome address, she emphasized the close collaboration between FAU and ZOLLHOF — one of Germany's leading tech incubators, where the university acts as an active innovation partner.

With the central question, "What is innovation?", Prof. Möslein challenged participants to view their research projects from a new, practical perspective and to recognize potential for societal applications.

LEGO Serious Play: Creativity Meets Research

Christoph Heyen from the FAU Startup Service led the opening session based on the LEGO® Serious Play method, which is founded on the idea that "hands help thinking." Building models allows complex thoughts to be visualized and new perspectives to emerge.

Figure 49: Same bricks, different ducks — creativity at work! (Image: A. Dakkouri-Baldauf)

Tasks included:

- Building a simple model (a duck from predefined bricks)
- Representing one's personality
- Two research-related challenges:
  1. Build your research topic around yourself.
  2. Who do you want to serve? Complete your vision of the future. Are there real-world problems that your research-based solutions could address?

The goal was to foster teamwork and reflect on research topics in the context of potential societal applications — playfully, yet with depth.

Insights from Practice: Start-up Talk with Matthias Trost

A highlight was the inspiring talk by Matthias Trost, co-founder of AMPERIAL Technologies GmbH, a deep tech start-up near Nuremberg. The company develops intelligent electrochromic window films that reduce heat and energy consumption in buildings and vehicles. AMPERIAL emerged from research at the Energy Campus Nuremberg (ENCN) and was supported by the EXIST Gründerstipendium and the European Social Fund. Matthias shared valuable insights into the journey from research to founding a company, illustrating how a technological idea became a sustainable solution with market potential.

Figure 50: Matthias Trost sharing the story of his start-up journey (Image: A. Dakkouri-Baldauf)

Ideation Workshop: From Idea to Pitch

To conclude, Dr. Judit Klein, Head of Startups@ZOLLHOF, led an ideation workshop where participants developed creative business

ideas in groups, focusing on unlocking the entrepreneurial potential of “Hypersonic Sound” technology. The task was to develop needs, solutions, and potential value around this idea and present it in a two-minute pitch. This exercise showcased how groups differently evaluate ideas, interact, and how challenging — yet rewarding — it can be to move beyond one’s favorites and creatively work with a “foreign, bad” idea.

The workshop ended with a short tour of the ZOLLHOF building, giving participants a glimpse into the working environment of a tech incubator.

Conclusion

The workshop provided valuable insights for cultivating an entrepreneurial mindset, fostering teamwork, creativity, and transfer thinking. It encouraged participants to explore new paths — especially those eager to make their research socially impactful.

A heartfelt thank you to everyone involved — especially Matthias Trost, Dr. Judit Klein, Christoph Heyen, the ZOLLHOF team, all participants, and Prof. Kathrin Möslein for her inspiring words on the importance of innovation and application-oriented research.

Figure 51: Impressions from the workshop 'The Essentials of Starting a Start-up' at ZOLLHOF Nuremberg (Images: A. Dakkouri-Baldauf)

2.1.4 EBM UPDATE MEETING

The annual one-day EBM Update Meetings provide comprehensive progress updates on key research areas and cross-sectional projects. These sessions encompass all projects within the scope EBM, ensuring a thorough review of ongoing initiatives and advancements. The meetings offer a platform for researchers to share developments, exchange ideas, and foster collaboration across various EBM-related fields.

To successfully complete the doctorate within the EBM **iRTG** 1540, it is mandatory to attend all annual Update Meetings.

Table 5: EBM Update Meeting

	Date	Type	Location
01	31.01.25	2. EBM Update Meeting	Max-Planck-Zentrum für Physik und Medizin (MPZPM), Erlangen

Program see Appendix 1

The annual EBM Update Meetings are a vital platform for comprehensive progress updates on the focal research areas and cross-sectional projects within the EBM framework. This event took place for the second time on January 31, 2025, at the Max-Planck-Zentrum für Physik und Medizin (MPZPM) in Erlangen. Researchers came together to discuss progress, exchange ideas, and promote interdisciplinary collaboration.

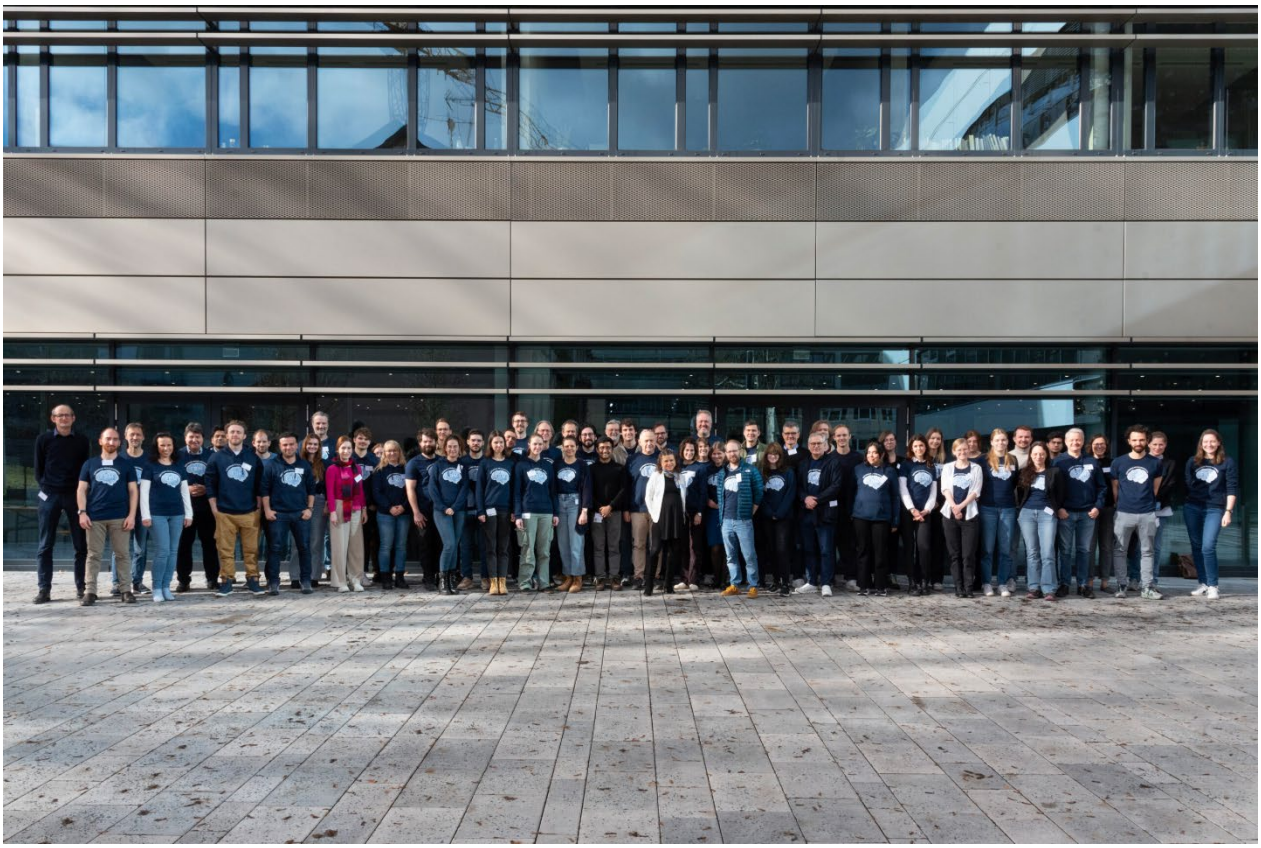


Figure 52: Team Gathering: EBM members pose in front of the new MPZPM building (Image: S. Viezens/MPZPM)

The meeting began with discussions on organizational matters, including an Executive Board Meeting and the Members‘ General Assembly. These sessions provided a valuable opportunity to reflect on strategic developments, align future goals, and ensure the effective implementation of EBM measures. During the assembly, key decisions were made on various topics, including outreach strategies, plans for further educational workshops and seminars, and a comprehensive review of ongoing programs.

Figure 53: Presentation by the spokespersons Paul Steinmann and Silvia Budday during the EBM General Assembly. (Image: S. Kuth)

As the day progressed, the focus shifted to scientific discussions, beginning with an update on the project Establishing Magnetic Resonance Elastography at FAU by Guillaume Flé. This was followed by insightful presentations covering the various focal research areas.

Each focal research area was presented by a representative who provided an overview of the progress of all projects within their respective section. Katharina Breininger gave an update on the cross-sectional projects, paving the way for further discussions on interdisciplinary approaches. The focus then shifted to cerebral mechanics, with Sven Falk presenting the latest findings and advances in this research area, particularly with regard to brain malformations and development.

Figure 54: Lively discussions in front of the posters. (Image: A. Dakkouri-Baldauf)

The exchange of knowledge continued with engaging talks on spinal mechanics, presented by Kristian Franze, focusing on injury, disease, and regeneration, and an exploration of cellular mechanics, presented by Katja Kobow, highlighting key insights into cell-matrix interactions and mechanotransduction. These sessions sparked meaningful discussions and laid the groundwork for future research directions.

A poster exhibition, over a cup of coffee, complemented the scientific program and offered participants a dynamic space for in-depth discussions on ongoing research projects. The event concluded with a reception where participants had the opportunity to network in a relaxed atmosphere, enjoying culinary delights and musical entertainment.

Figure 55: Lively Discussions: Participants engaged in conversation during the lunch and coffee breaks. (Image: A. Dakkouri-Baldauf)

The 2nd EBM Update Meeting was a resounding success, reinforcing the collaborative spirit that drives EBM research. Stimulating discussions, constructive and inspiring exchanges of ideas, and valuable networking highlighted the essential role of collaboration between experts from different disciplines. We look forward to continuing this momentum at the next gathering.

Figure 56: When the next generation of EBM researchers is already this adorable... (Image: A. Dakkouri-Baldauf)

2.1.5 EBM RETREAT

Annual two-day EBM Retreats with mandatory attendance for **iRTG** members provide a forum for research progress presentations of the doctoral and postdoctoral researchers. The main focus is on the internal evaluation of scientific progress in the field of EBM and the promotion of the expansion of existing collaborations as well as the establishment of new collaborations between EBM projects.

These events are held at remote locations away from the FAU campus and include social activities to encourage informal interaction between participants.

To successfully complete the doctorate within the EBM **iRTG** 1540, it is mandatory to attend all annual Retreats.

Table 6: EBM Retreat

	Date	Type	Location
01	09.10.25 / 10.10.25	3rd EBM Retreat	Hotel Goldner Stern, Muggendorf

Program see Appendix 2

Figure 57: Interested audience during the presentations and discussions. (Image: A. Dakkouri-Baldauf)

From October 9–10, 2025, the EBM community gathered for its third annual retreat in the picturesque village of Muggendorf, a place that felt like a Bavarian fairy tale. Hosted at the charming Hotel Goldner Stern, the event brought together researchers, doctoral and postdoctoral fellows, and principal investigators (PIs) for two days of scientific exchange, strategic planning, and team building. This year's retreat was held in a hybrid format, allowing both in-person and online participation to ensure full engagement across the consortium.

Day 1: October 9, 2025

The morning began with a meeting of the EBM Executive Board, while other members worked on finalizing preparations for the Long Night of Science (October 25, 2025) under the energetic coordination of Nicole Tueni and Stefan Rampp.

Later, the EBM General Assembly convened. The session opened with a moment of silence in memory of Jochen Guck, one of our principal investigators, who had passed away just days before the retreat. His loss was deeply felt, both personally and professionally, and his presence, guidance, and friendship will be greatly missed by all members of the EBM community.

Figure 58: Project presentations by the (post)doctoral researchers. (Image: A. Dakkouri-Baldauf)

Following this, the General Assembly provided a valuable opportunity to reflect on strategic developments, align future goals, and ensure the effective implementation of EBM initiatives. Key decisions were made on a range of topics, including outreach strategies, plans for upcoming educational workshops and seminars, and a comprehensive review of ongoing programs.

After a coffee break, the scientific program began, with each subproject following a clear sequence: a doctoral or postdoctoral researcher first presented current progress, immediately followed by the PI, who outlined future plans and new proposals. Topics ranged from *in silico* modeling of spinal cord and brain regeneration,

mechanical stimulation experiments, and neuronal mechano-transduction, to the engineering of brain-tissue-like matrices. This structure provided clarity and sparked lively discussions during the sessions and informal conversations over coffee and meals.

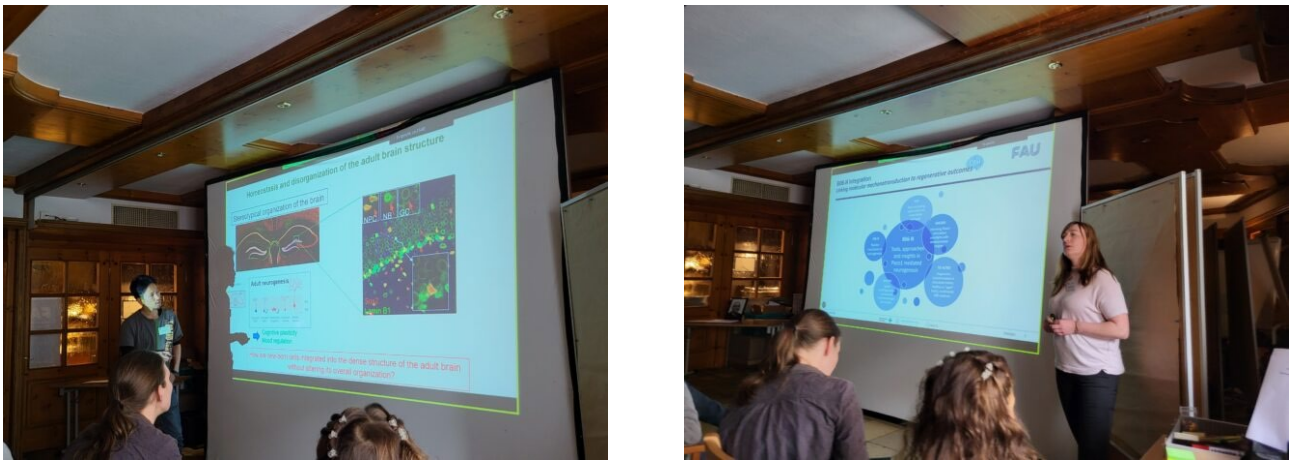


Figure 59: Project presentations by the newly joining PIs. (Images: A. Dakkouri-Baldauf)

It was wonderful to see the newly joining PIs — Chichung Lie, Daniel Delev, Danijela Gregurec, Franziska Mathis-Ullrich (online), Guillaume Flé, Henrik Heiland, Irem Unalan, Jana Hutter, Tomohisa Toda, and Veit Rothhammer — quickly integrating into the group, actively contributing to discussions, and shaping future directions.

A highlight of the retreat was definitely a team-building archery activity on Thursday afternoon. In a rustic, candlelit barn near the hotel, participants enjoyed a friendly archery tournament. The winner, Sir Dr. Stefan Rampp, was crowned “Robin Hood of Muggendorf” and received both a trophy and a

Figure 60: Team spirit on display: EBMers united. (Image: T. Schröder)

voucher for an overnight stay in a hotel suite. A second prize was awarded to Ben Fabry, who also received a trophy for his excellent performance. The day ended with a delicious dinner, regional specialties, and lively conversations.

Day 2: October 10, 2025

Friday's sessions focused on innovative methodologies, translational research, and cross-project synergies, covering topics from magnetic resonance elastography and machine learning to brain tissue mechanics and robotic assistance in neurosurgery.

Figure 61: EBM members engaged in discussion across different settings and times. (Images: A. Dakkouri-Baldauf)

The retreat concluded with a touching address by Paul Steinmann and Silvia Budday, celebrating EBM's achievements, recognizing everyone's dedication, and marking a new milestone in the consortium's journey. Participants left Muggendorf energized, inspired, and more connected than ever—ready to advance EBM's mission at the intersection of neuroscience, mechanics, and clinical translation.

We look forward to the next retreat and the continued scientific progress of the EBM group!

Erica Cecchini (A02), Ezgi Erterek (C02), Kristina Karandasheva (C03)

Figure 62: EBM members enjoying a day of activities, conversation, and archery in a relaxed countryside setting. (Images: A. Dakkouri-Baldauf)

2.1.6 EBM LAB SHADOWING

In 2025, ongoing EBM Lab Shadowing enabled EBM doctoral researchers to conduct short-term collaborative stays at the laboratories of other EBM PIs. These stays provided opportunities to participate in joint experiments, learn experimental, modeling, and computational techniques of common interest, and contribute to overarching, multidisciplinary EBM publications and presentations.

2.1.6.1 Collaborative experiments between **B01** and **B05**

Bridging Biology and Computation in Spinal Cord Regeneration

Figure 63: Collaborative lab work between B01 and B05. (Image: O. Neumann)

In February 2025, we recently wrapped up a fascinating lab shadowing with the **B01** and **B05** teams! During the visit, Nora John from Daniel Wehner's lab (**B05**) showcased how confocal microscopy is used to image zebrafish larvae during spinal cord regeneration. This will be the starting point of a collaborative effort to characterize the morphological changes the spinal cord undergoes during healing. The findings will serve as the basis for continuum mechanics-inspired models for an *in silico* simulation of central nervous system regeneration in zebrafish and other species to test possible treatments for spinal cord injury with computational methods.

The collaboration with Rahul G. Ramachandran and Oskar Neumann (**B01**), supervised by Paul Steinmann and Silvia Budday, combines these observed biological processes with their continuum-based computational framework for spinal cord regeneration – a multidisciplinary effort that contributes to our understanding of tissue mechanics, axon growth, and regenerative medicine.

(*Oskar Neumann, **B01** & Daniel Wehner, **B05***).

2.1.6.2 Collaborative experiments between **A04** and **B01**

Mechanical Insights into Aging Organoids

Beginning of March, Michael Tranchina (**A04**) and Nina Reiter (**B01**, BRAINIACS) performed collaborative experiments to characterize 88-day-old organoids mechanically using a rheometer. In older organoids, the growing necrotic core and the increasing cellular diversity, especially the potential presence of glial cells, can have an influence on the organoids' stability and stiffness. The results from our experiments will provide new insights into the mechanical behavior of older organoids.

*(Michael Tranchina, **A04** & Nina Reiter, **B01**)*

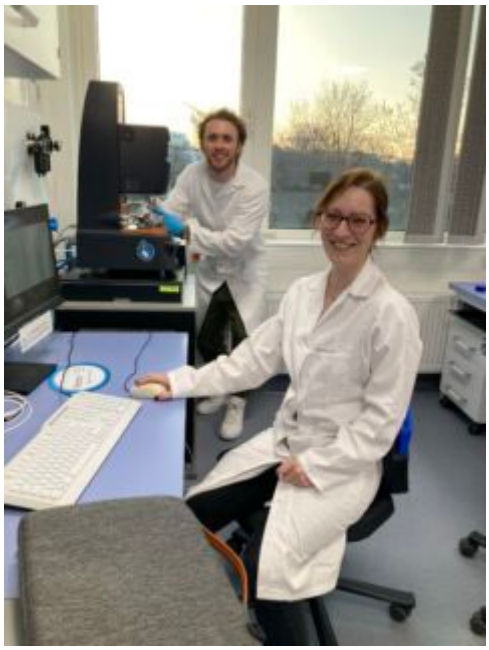


Figure 64: Collaborative lab work between A04 and B01. (Image: J. Kolb)

2.1.6.3 Collaborative experiments between **A03** and **C04**

Advancing Brain Metastasis Research

At the end of March, Clara Froidevaux (**A03**) and Shanice Heidenreich (**C04**) worked together to prepare mouse brain slices using a vibratome (see image). These slices will provide valuable insights into the metastasis of melanoma to the brain.

*(Shanice Heidenreich, **C04**)*

Figure 65: Collaborative lab work between A03 and C04 using a vibratome (left). (Image: A. Schambony)

2.1.6.4 Collaborative experiments between **A01**, **A02**, **A05** and **C03**

Interdisciplinary Lab Shadowing on Epilepsy Research

On May 22, researchers from the EBM projects **A01**, **A02**, **A05**, and **C03** came together at the Department of Neuropathology at Universitätsklinikum Erlangen for a lab shadowing session organized by Prof. Ingmar Blümcke.

Figure 66: Collaborative lab work between A01, A02, A05, and C03. (Image: I. Borrmann)

In an open and interactive format, the participating doctoral researchers presented their current work on the genetic and mechanistic foundations of epilepsy and neurodevelopment. The event fostered lively discussions and valuable interdisciplinary exchange.

The group was joined by Prof. Samuel Wiebe from the University of Calgary, Canada, who provided insightful contributions from his perspective as a neurologist and experienced clinician.

*(Jan Hinrichsen, **A01**)*

2.1.6.5 Collaborative experiments between **B01**, and **A04**

Mechanics of Mature Organoids

At the beginning of November, the Institute of Continuum Mechanics and Biomechanics, led by Silvia Budday, welcomed two guests for a joint lab shadowing. Majahonkhe Shabangu, currently visiting from Prof. Franz's Mechanobiology Lab at the University of Cape Town, collaborated with Michael Tranchina from the Institute of Biochemistry (Marisa Karow and Sven Falk; Project **A04**) to investigate the mechanical properties of mature organoids. Together with Oskar Neumann and Harsh Surana (Project **B01**), spherical indentation experiments were performed to explore the previously unknown mechanical signatures of fully developed brain organoids and to identify potential correlations with their biological composition.

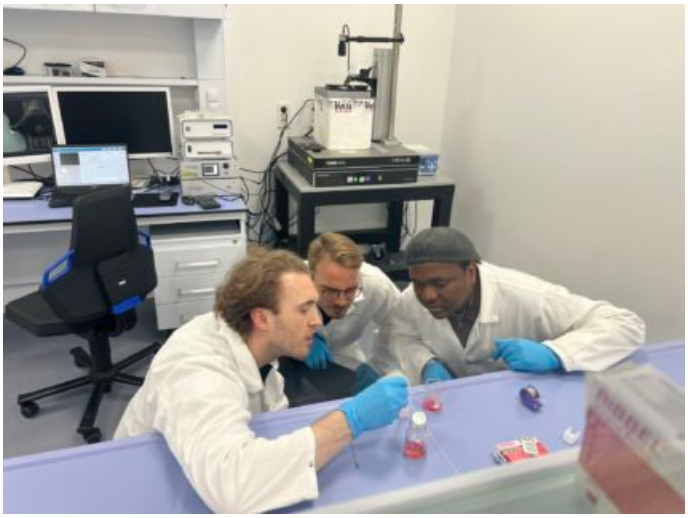


Figure 67: Michael Tranchina, Oskar Neumann, and Majahonkhe Shabangu during joint laboratory work at the Institute of Continuum Mechanics and Biomechanics. (Image: H. Vardhan Surana)

In addition, Majahonkhe conducted initial exploratory trials on mechanical mapping of multicellular spheroids — a first step toward establishing a testing protocol suitable for spheroid samples in future experiments at the University of Cape Town. We would also like to gratefully acknowledge Jan Hinrichsen (Biomechanics, Project **A01**) for his support in designing and fabricating a manual slicer used for tissue sectioning.

Both activities provided valuable hands-on experience in handling highly sensitive, small-scale biological samples under mechanical loading and generated promising first insights. These results will contribute to the development of robust testing protocols and help address existing research gaps within the CRC.

*(Oskar Neumann, **B01**)*

2.1.7 EBM SCHOLARS' VISITS

While EBM Lab Shadowing focuses on facilitating collaborative stays among EBM doctoral researchers within the network, the EBM Scholars' Visit program extends this concept by inviting international researchers to participate in lab shadowing activities.

Figure 68: Majahonkhe Shabangu in the BRAINIACS Lab, hosted by Silvia Budday. (Image: N. Tueni)

From September 29 to November 28, 2025, EBM hosted **Dr. Majahonkhe Shabangu** from the University of Cape Town, who participated in a structured research visit at Friedrich-Alexander-Universität Erlangen–Nürnberg (FAU). The following is his first-person report of the visit.

As part of this initiative, I completed a two-month research visit at Friedrich-Alexander-Universität Erlangen–Nürnberg (FAU), hosted by Prof. Dr.-Ing. Silvia Budday's BRAINIACS Lab within the Collaborative Research Center Exploring Brain Mechanics (EBM).

The visit provided intensive training in brain tissue mechanics, rheometry, and advanced workflows for the mechanical characterization of soft biological samples. In addition, I explored biophysical techniques at the Max Planck Center for Physics and Medicine (MPZPM), an interdisciplinary research center of the Max Planck Institute for the Science of Light. These activities included Brillouin microscopy in collaboration with Jana

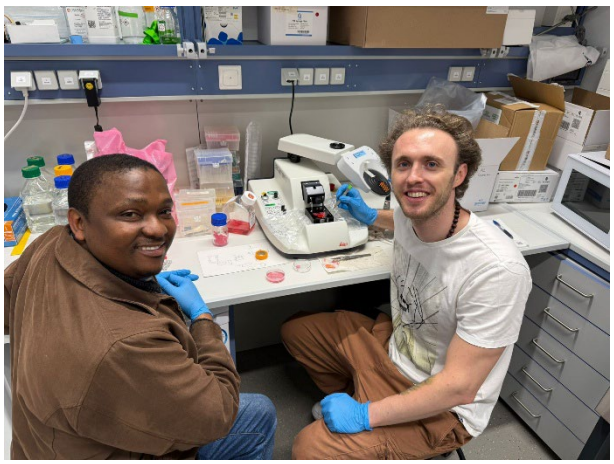


Figure 69: Majahonkhe Shabangu collaborating with Michael Tranchina (Project A04). (Image: A. Segura)

Bachir Salvador (Project **B03**), real-time deformability cytometry with Felix Reichel, and organoid sectioning with Michael Tranchina (Project **A04**).

At FAU, research activities focused on nanoindentation workflows in collaboration with Oskar Neumann and Harsh Vardhan Surana (Project **B01**). Further work included cell culture and sample preparation protocols with Dr. Julia Kolb (Project **A01**) and Ingrid Weigel.

- Key activities and outcomes included:
- Mechanical testing of human brain tissue in collaboration with Nina Reiter (Project **B01**) and Jaimé Goedhals, and of animal brain tissue with Dr. Nicole Tueni (Projects **A01** and **X01**) and Dr. Rahul G. Ramachandran (Project **B01**)
- Presentation to the Brainiacs Lab on the mechanobiology of infection-related malignancies
- Participation in the International EBM Symposium 2025
- Hands-on experience with advanced biophysical characterisation platforms, including Brillouin microscopy, real-time deformability cytometry, indentation, large-strain cyclic loading, and multiphoton microscopy
- Participation in Erlangen's Fascination Brain Mechanics – EBM at the Long Night of the Sciences 2025
- Presentation of research on the mechanobiology of Kaposi's sarcoma at the 3rd Young Scientist Cancer Congress in Berlin

The visit was supported by the Carnegie Corporation of New York DEAL Programme at the University of Cape Town (UCT). I appreciate the support from my supervisor and postdoctoral host at UCT, Prof. Thomas Franz, as well as from Prof. Sudesh Sivarasu, Director of the Biomedical Engineering Research Center, and the teams of EBM and BRAINIACS at FAU and MPZPM.

Looking ahead, these activities will be further consolidated through a potential return visit in 2026 and through a second research stay of Oskar Neumann (Project **B01**) at the Mechanobiology Lab at UCT in March 2026. This planned exchange aims to strengthen methodological transfer within the CRC Exploring Brain Mechanics and to advance joint research on the microrheology of neural organoids in collaboration with Dr. Mubeen Goolam.

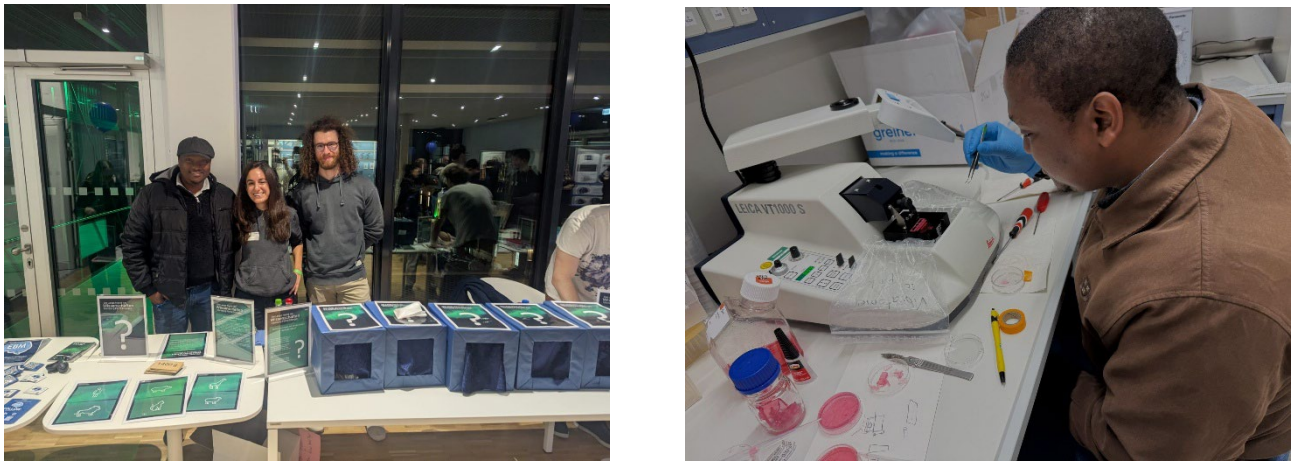


Figure 70: Majahonkhe Shabangu at the EBM booth during the Long Night of Sciences (left) and conducting research in the laboratory (right). (Images: G. Nika (left), A. Segura (right))

2.1.8 EBM RESEARCH SECONDMENTS AND SHORT-TERM RESEARCH STAYS

EBM Research Secondments, lasting several weeks and involving international academic hosts, including the EBM Mercator Fellows, enable the doctoral and postdoctoral researchers to acquire international experience, perspectives, and exposure. The research secondments support establishing networks for **iRTG** members and thus pave the way for future postdoctoral phases, both early and advanced.

Sudipta Mukherjee

From / to	Institute visited	Local supervisor	Research activities performed and skills acquired during stay
24.02.25 / 02.03.25	Cambridge, UK	Kristian Franze	1. Compression stiffening experiments and synapse density staining with Dr. Alex Winkel and Dr. Eva Kreysing. 2. Attended a seminar by Dr. Rachel Mckeown on "The mechanical regulation of Semaphorin3A signalling in the developing Xenopus laevis brain", on 25/02/2025, at PDN, Cambridge, UK.

Oskar Neumann

From / to	Institute visited	Local supervisor	Research activities performed and skills acquired during stay
31.03.25 / 27.04.25	Mechanobiology Lab, Division of Biomedical Engineering, University of Cape Town	Prof. Thomas Franz	Training of scientific staff in the operation of the Chiaro Nanoindenter system, presentation of research work of **B01** to the Division of Biomedical Engineering, and knowledge exchange on zebrafish regeneration with Prof. Shaboodien from UCT's zebrafish unit

In April 2025, Oskar Neumann had the opportunity to spend a month in the Mechanobiology Lab of Prof. Thomas Franz at the University of Cape Town, South Africa. During his stay, he trained a postdoctoral researcher, Dr. Majahonkhe Shabangu, in experimenting with the Chiaro Nanoindenter (Optics11 Life) to conduct indentation tests on various biomedical materials. For training purposes and scientific interest, they performed tests on different hydrogels, kindly provided by Prof. Arti

Figure 71: Mechanobiology Lab Team at the University of Cape Town (Image: private); Capturing the wild beauty of South Africa – scenes from a safari adventure (Image: O. Neumann); Conducting nanoindentation experiments with Dr. Majahonkhe Shabangu. (Image: private)

Ahluwalia from the Research Center "E. Piaggio" at the University of Pisa. In exchange, Oskar had the chance to present his current research on spherical indentation of porcine and human spinal cord tissue within the research group of the Mechanobiology Lab and during a one-hour seminar talk in front of the Division of Biomedical Engineering. The feedback was very insightful and complemented ongoing work on publications and the development of new experimental protocols.

Furthermore, Oskar was pleased to be invited by Prof. Gasnat Shaboodien (Head of the Cardiovascular Genetics Research Laboratory at UCT) to discuss research on various aspects of zebrafish regeneration. Prof. Shaboodien established the first zebrafish unit at the University of Cape Town, with the aim of using zebrafish to create functional models of cardiomyopathy. Finally, out of scientific

interest, Oskar also joined the lab opening party of Prof. Rachael Dangarembizi's CryptoLab, which is Africa's first dedicated research group focusing on the neurological impacts of cryptococcal meningitis.

Apart from work, he enjoyed the beautiful nature of Cape Town during various hikes, went surfing in nearby Muizenberg, visited the Cape of Good Hope, and spent his remaining free time in the vineyards of Stellenbosch.

*(Oskar Neumann, **B01)***

Sebastian Vasquez Sepulveda

From / to	Institute visited	Local supervisor	Research activities and skills acquired during stay
21.02.25 / 26.02.25	Cambridge, UK	Kristian Franze, Eva Kreysing	1. AFM maps of Xenopus laevis brains at stage 35 with Dr. Eva Kreysing. 2. Attended seminar by Dr. Rachel Mckeown on "The mechanical regulation of Semaphorin3A signalling in the developing Xenopus laevis brain", on 25/02/2025, at PDN, Cambridge, UK.
10.08.25 / 01.09.25	Department of Physiology, Development and Neuroscience, University of Cambridge	Kristian Franze	Optic Tectum stiffening and DiI/DiO labelling of retinal ganglion cells

2.2 FURTHER EBM ACTIVITIES

2.2.1 EBM VIRTUAL BREAKFAST CLUB

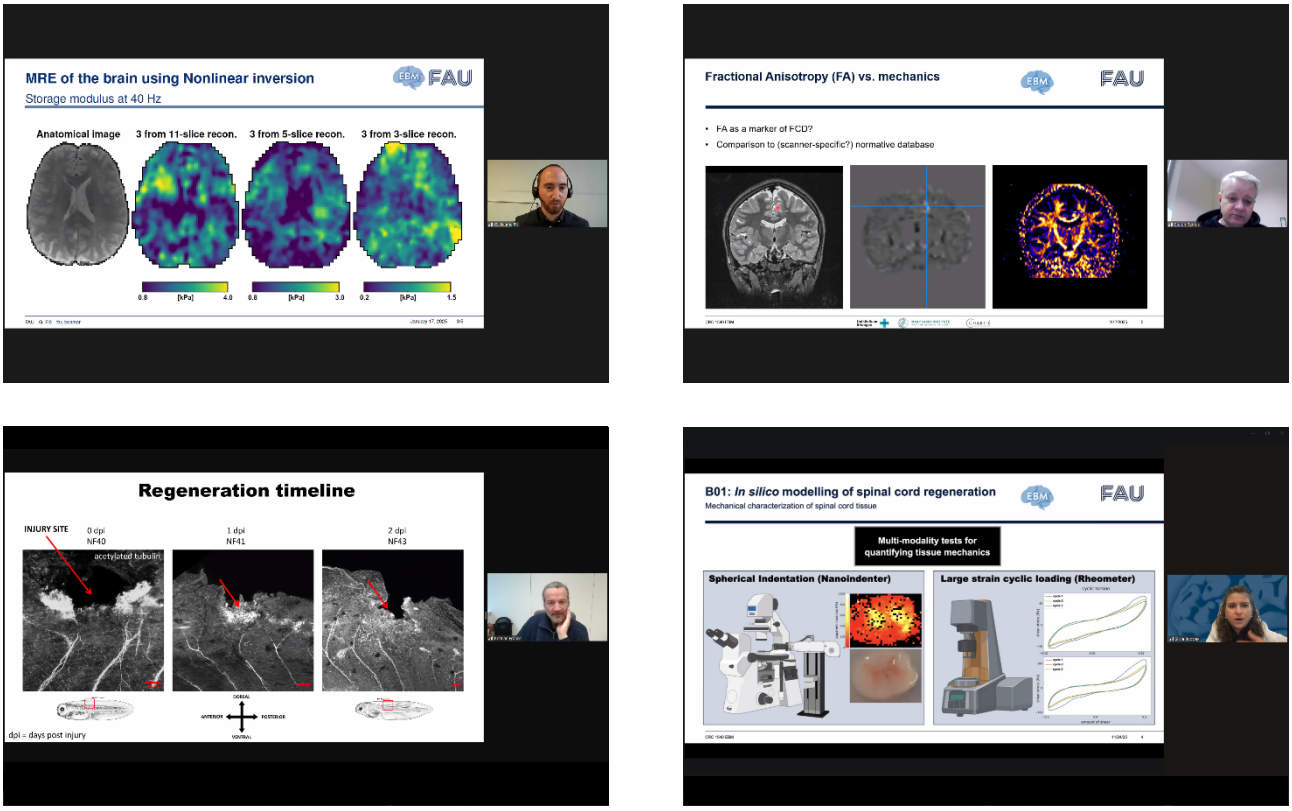
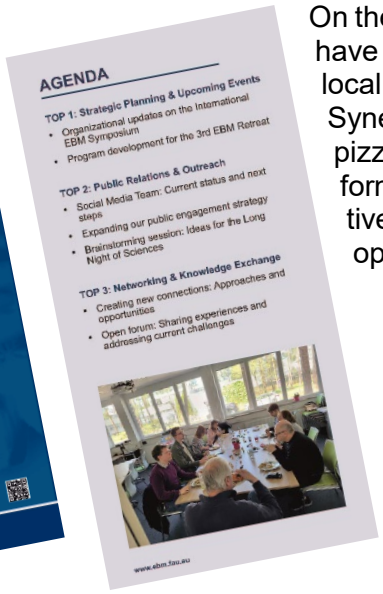


Figure 72: EBM Virtual Breakfast Club: Guillaume Flé (top left), Stefan Rampp (top right), Kristian Franze (bottom left), and Silvia Budday (bottom right).

The digital format "EBM Virtual Breakfast Club" typically takes place on Monday mornings, except on days when an EBM Lunch is scheduled. All EBM members participate via Zoom in an informal setting. Principal investigators take turns presenting the latest scientific insights and open questions from their projects, sparking collective discussions. These virtual meetings serve as a relaxed forum for informal exchanges on organizational, administrative, and current EBM-related topics.

In 2025, a total of 27 EBM Virtual Breakfasts were held.

2.2.2 EBM LUNCH



On the first Monday of each month, all EBM members have the opportunity to gather for lunch, either at a local restaurant or at the FAU campus for the "EBM Synergy Luncheon Meetings," where they can enjoy pizza. These lunches offer a relaxed setting for informal discussions on organizational, administrative, and current EBM-related topics, as well as an opportunity for social networking.

Figure 73: EBM members at their monthly joint lunch. (Images: A. Dakkouri-Baldauf)

2.2.3 EBM VIRTUAL BRAIN TALK SERIES

The EBM Virtual Brain Talk Series is a quarterly, open-access online event that highlights cutting-edge developments in mechanics-based approaches to understanding the central nervous system. By showcasing innovative research, the series aims to deepen scientific insight and support future advances in the diagnosis and treatment of neurological disorders.

Table 7: EBM Virtual Brain Talks

	Date	Lecturer	Title
01	31.03.25	Ben Fabry (Institute of Biophysics, FAU, Erlangen, Germany)	*Universal scaling laws in cell and tissue mechanics*
02	02.06.25	Vasily Zaburdaev (Mathematics in Life Sciences, FAU, Erlangen, Germany)	*Cellular aggregates as active materials*
03	22.09.25	Oliver Schnell (Institute of Neurosurgery, UKER, Germany)	*"There and back again" – The translational journey in modern Neuro-surgery*
04	08.12.25	Ingmar Blümcke (Institute of Neuropathology, UKER, Germany)	*A clinico-pathological and genetic classification of cortical dysplasia in the human brain*

Each approximately 45-minute talk is delivered by EBM members or invited experts and is characterized by high-quality scientific content. The format promotes a dynamic and ongoing exchange of ideas within the global research community.

Now in its third year, the series has established itself as an inspiring forum for international collaboration. Researchers from around the world regularly join the sessions, contributing to stimulating discussions and benefiting from the expertise of distinguished speakers.

Figure 74: EBM Virtual Brain Talk Series: Ben Fabry (top left), Vasily Zaburdaev (top right), Oliver Schnell (bottom right), Ingmar Blümcke (bottom left).

2.2.4 EBM SEMINAR TALKS

For the EBM Seminar Talks, internationally renowned scientists were invited to give in-depth presentations on EBM-relevant research topics and then to actively engage EBM researchers in discussions and question-and-answer sessions.

Table 8: EBM Seminar Talks

	Date	Lecturer	Title
01	19.05.25	Johannes Weickenmeier (Institute of Biomedical Engineering, St. Cross College, Oxford, UK)	*Towards Validation of Numerically Predicted Brain Shape Changes in Aging and Neurodegenerative Disease*
02	22.05.25	Xianqiao (XQ) Wang (College of Engineering, University of Georgia, USA)	*Harnessing AI/Data-Empowered Computational Models to Brain Mechanics and Nano-Biomaterial Interface*
03	04.12.25	Eva Kreysing (Warwick Medical School, University of Warwick, Coventry, England, GB)	*Environmental stiffness regulates neuronal maturation via Piezo1-mediated TTR activity*

Figure 75: Johannes Weickenmeier (left) and Xianqiao (XQ) Wang (right), both hosted by Silvia Budday; lecture announcement by Eva Kreysing (center), hosted by Kristian Franze. (Images: S. Budday (left) and N. Tueni (right))

2.3 VISITING RESEARCHER PROGRAM

Table 9: Visiting researchers

From / to	Visiting researcher	Topic
18.05.25 / 20.05.25	**Prof. Dr. Johannes Weickenmeier**, Institute of Biomedical Engineering, St. Cross College, Oxford, UK	Invited lecture within the EBM Seminar Talk series: "Towards Validation of Numerically Predicted Brain Shape Changes in Aging and Neurodegenerative Disease"
20.05.25 / 26.05.25	**Prof. Xianqiao (XQ) Wang**, College of Engineering, University of Georgia, USA	Invited lecture within the EBM Seminar Talk series: "Harnessing AI/Data-Empowered Computational Models to Brain Mechanics and Nano-Biomaterial Interface"
03.12.25 / 04.12.25	**Prof. Dr. Eva Kreysing**, Warwick Medical School, University of Warwick, Coventry, England, GB	Invited lecture within the EBM Seminar Talk series: "Environmental stiffness regulates neuronal maturation via Piezo1-mediated TTR activity"
29.09.25 / 28.11.25	**Dr. Majahonkhe Mcebo Shabangu,** University of Cape Town, South Africa	Research visit to expand collaboration within EBM on mechanical characterization of biological tissues and numerical/computational modeling of mechanotransduction in CNS tissue regeneration

3 EQUAL OPPORTUNITY MEASURES

Promoting equal opportunities for both women and men, along with advancing the careers of doctoral and postdoctoral researchers, is a key objective of EBM. This involves supporting early-career female scientists in strategically planning and advancing their careers, as well as facilitating the balance between research commitments and family life.

EBM's commitment to fostering equal opportunities, career advancement, and the holistic development of emerging scientists was underscored by its comprehensive measures under the **EBMequality** concept.

3.1 WORKSHOPS, SEMINARS

The F^{3}G network (Research Associations of Friedrich-Alexander-Universität Erlangen-Nürnberg for the promotion of equality) offers lectures and seminars on women's advancement, gender sensitization, etc., in addition to a variety of other gender equality measures, in which members of the affiliated research associations can participate. Consequently, some EBM members have taken advantage of these training opportunities and participated in the workshops already listed in Table 4.

3.2 FURTHER MEASURES

3.2.1 EBM FAMILY

Childcare Support

- **EBM Update Meeting and EBM Retreat Childcare Expenses:** Covering childcare expenses during the EBM retreat to support participating members.
- **Conference Travel Childcare Coverage:** Providing financial support for childcare expenses incurred by EBM members during conference travel.
- **Financial Support for Holiday Childcare:** Offering financial contributions to vacation care programs for the children of EBM members, thereby supporting the compatibility of family and work.
- **Daycare Center Contingent Option**: Securing contingent spots for EBM members at the "Pfauennest II" daycare center.

Figure 76: Shared care in academic life: DR Oskar playing with a PI's child at the office. (Image: S. Budday)

Figure 77: Children of EBM members enjoying care and community during the EBM Retreat. (Images: S. Budday)

Support for FAU Childcare Programs

- **F³G Project Funding**: Providing financial support for specific projects under the F³G initiative within FAU holiday childcare programs.
- **Contribution to F³G Coordination Costs**: Supporting the coordination costs associated with F³G initiatives.
- **Pedagogic Enhancement**: Improving the pedagogic infrastructure at FAU daycare facilities to enhance the care provided to children.

Gender Equality and Career Development

- **Financial Support for 'Women in Science – 4th Erlanger Symposium'**: Providing funding to support this event.

3.2.2 EBM ENCOURAGE - YOUNG TALENT DEVELOPMENT

CJT (Christoph-Jacob-Treu-Gymnasium) Impulstag – student visit

In October, Dr. rer. nat. Nadia Müller-Voggel and Dr. rer. nat. Martin Kaltenhäuser from the Department of Neurosurgery welcomed 9th-grade students from the Christoph-Jacob-Treu-Gymnasium. During their visit, they were provided with an introduction to the anatomy and function of the brain, as well as an exploration of how these can be affected by brain disorders. The students participated in discussions on the anatomy and function of the brain, in addition to cerebral disorders and the methodologies employed for their diagnosis and treatment.

In a second part, the students visited the magnetoencephalography (MEG) laboratory of the Department of Neurosurgery. The technique is used, for example, to evaluate patients with epilepsy to record epileptic activity. The epileptic focus is then localized in order to tailor epilepsy surgery to the individual patient. Furthermore, areas involved with essential functions, e.g., language, can be determined and taken into account during surgical procedures.

The students learned how the technique works and experienced a measurement themselves. Volunteers were scanned while their classmates watched their brain activity in real time.

*(Stefan Rampp, **A02**)*

School Visit from Slovenia – One-Day Science School
Erlangen, Germany, November 2025
Topic: Neurotechnology – The Fascinating World of Neuromodulation

High-school students from Slovenia, actively exploring future university study options, visited FAU for a one-day science school focused on modern neurotechnology. The program combined short lectures with hands-on laboratory activities, providing insights into how neural activity can be observed and modulated using advanced materials.

Students learned how neurons communicate, how external physical stimuli influence neural signaling, and how wireless, magnetically actuated nanomaterials are prepared and applied in neuromodulation experiments. The visit aimed to support informed study choices by showcasing interdisciplinary research at the interface of chemistry, materials science, engineering, and neuroscience, as well as the research environment at FAU.

(Danijela Gregurec)

Elementary School Visits
Erlangen, Germany, November 2025

Three elementary school classes participated in age-appropriate, interactive experimental stations introducing basic concepts of biology, perception, and physics. Activities included hands-on experiments on temperature perception (cold and warm), illustrating how sensory receptors function and adapt, microscopy sessions distinguishing human and plant cells, and playful magnetism experiments. The activities fostered curiosity and an intuitive understanding of how we sense and interpret the world.

KinderUni Nürnberg 2025

Figure 78: Young participants at KinderUni Nürnberg 2025. (Image: FAU Chemistry)

In June 2025, the team of Danijela Gregurec contributed to KinderUni 2025 in Nuremberg, introducing young participants to the basics of magnetic forces and their applications—from everyday magnets to advanced magnetic nanomaterials used in neuromodulation. Through interactive lectures and demonstrations, children learned how fundamental physical principles translate into innovative biomedical technologies, inspiring early interest in science and research careers.

(Source: FAU Chemistry Website)

3.3 GOOD PRACTICE EXAMPLE: ENGAGEMENT AS WOMEN'S REPRESENTATIVE AND ARIANDNE PROGRAM PARTICIPATION

Figure 79: Yashasvi Verma, first person from the right. (Image: Office of Equality and Diversity).

Author: *Yashasvi Verma,* ***X01.*** Since April 2024, I have been serving as the women's representative for the Department of Mechanical Engineering within the faculty of engineering. In this role, I actively contribute to integrating gender equality measures across various aspects of university operations. My responsibilities include participating in the recruitment process for new professors and researchers in permanent positions, as well as supporting efforts to achieve target agreements aimed at increasing the proportion of women in academia. In addition to these committees, I am involved in initiatives supporting and empowering women researchers. These initiatives range from scholarships enabling participation in international conferences to organizing workshops that enhance the overall quality of life within the faculty. The workshops cover topics such as networking, career development, and balancing work with parental responsibilities. I participate actively in committee work and have chaired these workshops. Since I carry out these responsibilities voluntarily alongside my position at EBM, I am grateful for EBM's support, which enables me to contribute to advancing the representation of women in science.

As a female researcher myself, I also benefit from the programs offered by the Office of Equality and Diversity. This year, I was selected to participate in the ARIADNE program. It is an initiative by FAU that connects women researchers with peers and mentors and offers valuable career development opportunities. As part of this program, I am mentored by a female researcher who guides the practical aspects of building a career in academia. Additionally, I attend a series of soft skills workshops focusing on topics such as mental resilience, performing under pressure, and writing successful grant proposals. EBM recognizes the importance of these activities and fully supports my participation in mentorship and training sessions. This support allows me not only to contribute meaningfully to my current scientific work within the consortium but also to take steps in preparing for a career in academia.

4 SELECTED HIGHLIGHTS

4.1 INTERNATIONAL EBM SYMPOSIUM 2025

Date: September 30 – October 1, 2025
Location: Max Planck Institute for the Science of Light, Erlangen, Germany
Participants: ~120 researchers from 12 countries

The EBM Symposium 2025 – Exploring Brain Mechanics brought together leading researchers from around the world to explore the mechanical properties of the brain. Hosted at the Max Planck Institute for the Science of Light in Erlangen, the two-day event provided a dynamic platform for interdisciplinary exchange, connecting biomechanics, neuroscience, biophysics, and clinical research in an inspiring atmosphere.

Figure 80: Group photo of participants at the EBM Symposium 2025. (Image: S. Viezens)

International Participation & Invited Speakers

Researchers from Europe, the US, Australia, New Zealand, and Africa attended, representing prestigious institutions such as the University of Oxford, University of Pennsylvania, Charité Berlin, Helmholtz Zentrum München, and Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU).

The symposium featured 14 invited speakers, including Philip V. Bayly (US), Lynne E. Bilston (AU), Matteo Mario Bonsanto (DE), Alain Goriely (GB), Magdalena Götz (DE), Lucy V. Hiscox (GB), Paul A. Janmey (US), Michael Krieg (ES), Mehmet Kurt (US), Katie Long (GB), Medha M. Pathak (US), Manuel Salmeron-Sanchez (GB), Daniel M. Suter (US), and Roberto Toro (FR). Their talks spanned cutting-edge topics in brain mechanics and fostered lively discussions throughout the event.

Scientific Program

The program comprised 24 talks (including 14 invited lectures) and 43 poster presentations, covering a wide range of topics in brain mechanics:

Brain Mechanics and Neuroimaging

Highlights included non-invasive techniques such as Magnetic Resonance Elastography (MRE) and advanced imaging for measuring brain stress, strain, and structural changes, with talks from Philip V. Bayly, Lucy V. Hiscox, Mehmet Kurt, and Lynne E. Bilston.

Neurodevelopment and Cell Mechanics

Presentations focused on how mechanical forces shape neuronal development, featuring Medha M. Pathak on mechanosensitive channels, Katie Long on extracellular matrix effects, and Magdalena Götz on neurogenesis and neural repair.

Mechanobiology and Disease Models

Speakers explored the connection between mechanics and pathology, including brain tumor characterization, cell migration, and traumatic brain injury. Key contributions came from Matteo Mario Bonsanto, Paul Janmey, Riyi Shi, Vickie Shim, and Daniel Garcia-Gonzalez.

Mathematical and Computational Models

Several talks integrated theoretical and computational approaches to model brain tissue mechanics, multiscale neuronal pathfinding, and mechanical morphogenesis. Notable presentations included Alain Goriely, Roberto Toro, Manuel Kainz, and Manuel Salmeron-Sanchez.

Figure 82: Selected speakers at the EBM Symposium 2025: Gerhard A. Holzapfel (top left), Medha M. Pathak (top right), Lynne E. Bilston (bottom left), and Stefan Rampp (bottom right). (Images: S. Viezens; Stefan Rampp image: A. Dakkouri-Baldauf)

The ***poster sessions*** provided a lively platform for young researchers, covering topics from cellular mechanics and brain organoids to clinical applications and computational modeling – sparking animated discussions and new collaborations.

Figure 81: Engaging discussions during the poster session. (Images: S. Viezens)

Mentorship and Networking

Beyond the talks and poster sessions, the symposium placed a strong emphasis on mentorship and personal exchange. During the popular “Meet the Mentor” lunches, early-career researchers had the opportunity to talk informally with leading scientists such as Philip V. Bayly, Lynne E. Bilston, Magdalena Götz, Lucy V. Hiscox, Michael Krieg, Katie Long, Medha M. Pathak, Manuel Salmeron-Sanchez, and Daniel M. Suter. These sessions provided a welcoming space for questions, guidance, and lively scientific discussions.

Figure 83: Lively networking atmosphere during the "Meet the Mentor" lunch. (Images: S. Viezens)

Networking continued in a relaxed atmosphere during extended coffee breaks and the Conference Dinner at Kulturforum Logenhaus Erlangen, accompanied by music from DJ Sebastián. A particularly heartwarming moment occurred during the dinner when the co-spokesperson of CRC 1540 EBM and co-organizer of the symposium celebrated her birthday. She was surprised with a large cake and a spontaneous serenade from over a hundred international guests – a joyful highlight that perfectly captured the spirit of collegiality, friendship, and the vibrant community fostered by the symposium.

Figure 84: Networking during coffee breaks and the conference dinner. (Images: A. Dakkouri-Baldauf)

Awards

Outstanding contributions were recognized with three awards:

- **Oral Presentation Award**: Manuel P. Kainz (TU Graz)
- **Poster Awards**: Konstantin Hein and Sebastián Vásquez-Sepúlveda

All winners received certificates and a €100 prize, celebrating not only their excellent work but also their contribution to the lively discussions that made the symposium so engaging.

Warm congratulations to all three for their excellent work and well-deserved recognition!

Figure 85: Oral Talk Award – Manuel P. Kainz (left); Poster Awards – Sebastián Vásquez-Sepúlveda (middle) and Konstantin Hein (right). (Images: A. Dakkouri-Baldauf)

Resources

The symposium program and Book of Abstracts are available for download:

Program Flyer:

Overview of the symposium schedule.

https://go.fau.de/1dfif

Book of Abstracts:

Contains all abstracts for oral and poster presentations, including authors and affiliations

https://go.fau.de/1dfig

Conclusion

The EBM Symposium 2025 successfully fostered international collaboration and highlighted the growing interdisciplinary nature of brain mechanics research. With its combination of scientific excellence, mentorship, and warm community spirit, the event reinforced Erlangen's role as a central hub for pioneering brain mechanics studies — and left participants inspired for future collaborations.

Figure 86: EBM 2025: Inspiration for science — and a little rest for the youngest participants. (Image: A. Dakkouri-Baldauf)

4.2 EBM EMERGING BRAIN INITIATIVE – SEED FUNDING 2025

In 2025, EBM launched its inaugural call for Startup and Seed Funding as part of the EBM Emerging Brain Initiative (EBI). The primary aim of this initiative is to support promising Early Career Researchers at FAU in developing independent research profiles within the field of brain mechanics, thereby fostering the next generation of leaders in the EBM research network. This program also aims to integrate these researchers early into the planning for EBM's next funding phase, ensuring their continued involvement and success.

A total of four high-quality applications were submitted to the funding call. After a rigorous evaluation process conducted by EBM's Principal Investigators, three projects were selected for funding. The successful proposals stood out for their scientific excellence, innovative potential, and strong alignment with the overarching goals of the EBM research program. Each selected project is funded with €50,000.

Funded Projects (2025/26):

- **Lucas Hoffmann**: Extracellular Matrix Alterations as Key Mediators in the Development of LEATs
- **Guillaume Flé**: Magnetic Resonance Poroviscoelastography of the Brain
- **Irem Ünalan**: Multifunctional Hybrid Structures for Brain Tissue Applications

The funding covers various costs, including personnel expenses, consumables, travel costs, and other project-specific materials. The funding period spans 18 months (from July 1, 2025, to December 31, 2026), and is divided into two budget phases.

The Seed Funding Program plays a crucial role in providing an essential foundation for integrating early career researchers as junior Principal Investigators (PIs), thereby helping them to establish scientific independence. This initiative not only offers substantial support for the researchers themselves but also contributes to the strengthening of the EBM research network by fostering innovative, independent research initiatives.

At the same time, the format presents inherent challenges, as the success of the funded projects will have a significant impact on the quality and competitiveness of the renewal proposal for the next CRC funding phase. To ensure that the integration of these new junior PIs is effective and sustainable, EBM will provide mentoring and advisory support throughout the course of the funded projects.

As part of the Seed Funding support framework, EBM complemented the financial funding with a tailor-made professional development workshop on Confidence & Assertiveness, designed specifically for the three funded junior PIs. The workshop, entitled "Appearing on Stage: The Impact of Confidence & Assertiveness", took place on December 16, 2025, and focused on strengthening the participants' presence and self-confidence in preparation for the DFG continuation review in summer 2026.

Led by Dr. Silke Oehrlein-Karpi (Mainz), the highly interactive format combined a focused mini-workshop with intensive one-on-one coaching sessions, allowing the researchers to address individual challenges related to visibility, assertive communication, and convincing performance in high-stakes evaluation settings.

Figure 87: Dr. Silke Oehrlein-Karpi leading the Confidence & Assertiveness workshop for the EBI Seed Funding recipients. (Image: A. Dakkouri-Baldauf)

Building on this targeted support, an additional customized workshop on presentation techniques is planned for the coming year, further strengthening EBM's commitment to the sustainable development of early career researchers.

4.3 AWARDS AND DISTINCTIONS

(in alphabetical order of the award winners)

4.3.1 JANA BACHIR SALVADOR – BEST POSTER AWARD

Figure 88: Jana Bachir Salvador proudly holding her Best Poster Award, IMPRS 2025. (Image: Kimberly Baumeister)

On October 28, 2025, Jana Bachir Salvador (**B03**) was awarded the **Best Poster Award at the annual meeting of the International Max-Planck Research School (IMPRS)** held at the Max Planck Institute for the Science of Light. Her poster, titled "Multiscale Mapping of Oxidative Stress-Induced Mechanical Response of the Central Nervous System", impressed the audience with its innovative approach and clear presentation of her research findings.

We warmly congratulate Jana on this well-deserved recognition!

4.3.2 ALDO R. BOCCACCINI – GEORGE WINTER AWARD

We are proud to announce that Prof. Aldo R. Boccaccini, our esteemed EBM PI of subproject **X03**, has received the prestigious **George Winter Award from the European Society for Biomaterials (ESB)**. This award honors pioneers whose work has made lasting contributions to biomaterials.

Figure 89:From left to right: Aldo R. Boccaccini, Prof. Nicholas Dunne (President of the ESB), and Prof. Maria Pau Ginebra (Chair of the ESB Awards Committee). (Copyright: European Society for Biomaterials, ESB)

Prof. Boccaccini presented a plenary talk at the 34th Annual Conference of the European Society for Biomaterials (ESB2025) in Turin, Italy. His award lecture was a highlight, attended by over 1,000 participants worldwide.

A global authority in biomaterials and tissue engineering, Prof. Boccaccini has authored over 1,100 papers and supervised more than 70 PhD students. His visionary research in ceramics, glasses, and composites has helped shape modern biomaterials science.

As a former ESB Vice-President and current President of the Federation of European Materials Societies, he continues to lead the field through innovation, mentorship, and service.

Prof. Boccaccini said:
„I am deeply honored and grateful to the European Society for Biomaterials for the George Winter Award, which I accept on behalf of all current and former members of my research group, as well as the many collaborators from around the world who have worked with us over the years."

In addition to the George Winter Award, Prof. Aldo R. Boccaccini received four major international honors in 2025:

- **Honorary Doctorate – Riga Technical University, Latvia (January 2025)** Awarded during the inauguration of the new BBCE building, recognizing his long-standing partnership, key contributions to research excellence, and strategic role in the BBCE Steering Committee.
- **Larry Hench Lifetime Achievement Award – American Ceramic Society (October 2025)** Honoring his lifelong impact, innovation, and leadership in bioceramics, inspired by the legacy of Larry L. Hench, pioneer of Bioglass.
- **Honorary Doctorate – Alexander Dubček University of Trenčín, Slovakia (November 2025)**

Acknowledging his scientific excellence, international vision, mentorship, and his central role in shaping and supporting the FunGlass Centre since its inception.

- **Honorary Doctorate – International University of Catalonia, Barcelona (November 2025)** Recognizing his contributions to biomaterials, tissue engineering innovation, and long-term engagement with the Bioengineering Institute of Technology (BIT).

Many congratulations – such a well-deserved honor, dear Aldo!

4.3.3 KATHARINA BREININGER – MICCAI 2025 OUTSTANDING REVIEWER AWARD AND W3 PROFESSORSHIP

Katharina Breininger was honored with a **MICCAI 2025 Outstanding Reviewer Award** in recognition of her exceptional contributions to the peer-review process of the 28th International Conference on Medical Image Computing and Computer-Assisted Intervention (MICCAI), held from 23–27 September 2025 at the Daejeon Convention Center, South Korea.

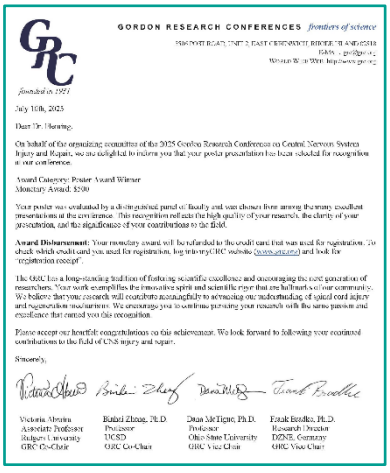
The award acknowledges reviewers who demonstrated outstanding commitment and review quality during the paper selection process. Area Chairs evaluated each review based on whether it exceeded expectations, met expectations, or failed to meet expectations. Only a small fraction of reviewers met the stringent criteria required for this distinction, which include completing all review assignments, reviewing a high number of submissions, and consistently receiving top ratings for review quality.

Among this highly selective group, Katharina Breininger ranked among the top sixteen reviewers, each of whom reviewed five or more papers and achieved the highest average evaluation scores. As part of the award, selected students and postdoctoral reviewers were offered free registration to attend MICCAI 2025.

In addition, Katharina Breininger was promoted to **W3 Professor at the University of Würzburg**, where she leads the Pattern Recognition group, focusing on the development of machine learning methods for medical and biomedical imaging, while also creating open-source tools and datasets for applications in intraoperative imaging, multi-modal data, microscopy, and pathology.

We warmly congratulate Katharina on her outstanding contributions to the scientific community and her well-deserved promotion!

4.3.4 THOMAS FLEMING – BEST POSTER AWARD



GORDON RESEARCH CONFERENCES *frontiers of science*

July 10th, 2023

Dear Dr. Fleming,

On behalf of the organizing committee of the 2025 Gordon Research Conference on Central Nervous System Injury and Repair, we are delighted to inform you that your poster presentation has been selected for recognition at our conference.

Award Category: Poster Award Winner
Monetary Award: $500

Your poster was evaluated by a distinguished panel of faculty and was chosen from among the many excellent presentations at the conference. This recognition reflects the high quality of your research, the clarity of your presentation, and the significance of your contributions to the field.

Award Disbursement: Your monetary award will be refunded to the credit card that was used for registration. To check which credit card was used for registration, log into myGRC website (www.grc.org) and look for "registration receipt".

The GRC has a long-standing tradition of fostering scientific excellence and encouraging the next generation of researchers. Your work exemplifies the innovative spirit and scientific rigor that are hallmarks of our community. We believe that your research will contribute meaningfully to advancing our understanding of spinal cord injury and regeneration mechanisms. We encourage you to continue pursuing your research with the same passion and excellence that earned you this recognition.

Please accept our heartfelt congratulations on this achievement. We look forward to following your continued contributions to the field of CNS injury and repair.

Sincerely,

Victoria Abrahm, Associate Professor, Rutgers University, GRC Co-Chair
Ruibiao Zhang, Ph.D., Professor, UCSD, GRC Co-Chair
Dean McTigue, Ph.D., Professor, Ohio State University, GRC Vice Chair
Frank Bradke, Ph.D., Research Director, DZNE, Germany, GRC Vice Chair

Thomas Fleming (**B05**) was awarded the **Best Poster Award at the Central Nervous System Injury and Repair Gordon Research Conference**, held from July 6–11, 2025 in Lucca (Barga), Italy.

His poster, titled *"Aortic carboxypeptidase-like protein controls central nervous system scarring after injury"*, was selected from contributions across all career stages for its scientific quality, originality, and impact. The award, granted by a distinguished panel of faculty, highlights Thomas's excellence in presenting innovative research and underscores the strong visibility of his work in the field of CNS injury and repair. Recognition at this prestigious international conference emphasizes the significance of his contributions to understanding spinal cord injury and regeneration mechanisms.

Warm congratulations to Thomas on this outstanding achievement!

4.3.5 KONSTANTIN HEIN – AWARDS

We are pleased to congratulate Konstantin Hein on two notable recognitions received in 2025.

On October 1, 2025, Konstantin received a **Poster Prize at the EBM Symposium for** his presentation titled *"From Mental to Mechanical Stress"*, recognizing the high quality and impact of his research.

Later that year, on November 27, 2025, he was honored with the newly established **Jochen Guck Prize** of the BioBrillouin Society. The award was presented at a conference held in memory of Prof. Jochen Guck, whose recent passing represents a profound loss to the scientific community. Introduced to preserve his legacy, the Jochen Guck Prize recognizes the most promising biomedical implementation of Brillouin spectroscopy presented at the meeting. This distinction will continue to be awarded annually at future conferences, encouraging innovative research in the field.

Warm congratulations to Konstantin on these well-deserved achievements!

4.3.6 KATJA KOBOW – SECOND CHAIR OF THE GERMAN SOCIETY FOR EPILEPTOLOGY

Katja Kobow erreicht Meilenstein

MEDIZIN Führungsrolle bei DGfE in Erlangen übernommen.

ERLANGEN – Dr. Katja Kobow, wissenschaftliche Mitarbeiterin am Neuropathologischen Institut des Uniklinikums Erlangen, wurde einstimmig zur zweiten Vorsitzenden der Deutschen Gesellschaft für Epileptologie (DGfE) gewählt. Sie ist die erste Frau in der Geschichte der Fachgesellschaft, die dieses Amt innehat. In zwei Jahren wird sie turnusgemäß den ersten Vorsitz übernehmen und neben ihrer Vorstandsarbeit die Jahrestagung ausrichten, teilt die Uniklinik mit.

Als Naturwissenschaftlerin bringt Katja Kobow eine starke Stimme aus der experimentellen Epilepsieforschung ein. Sie möchte sich für eine intensivere Kommunikation und Zusammenarbeit zwischen klinischen und wissenschaftlichen Experten einsetzen. Im Vorstand der DGfE gibt es seit Jahren eine Rotation, durch die sich Beteiligte aus den Fachbereichen Neuropädiatrie, Erwachsenenepileptologie und Grundlagenforschung gleichwertig abwechseln. Dieses Modell soll die Integration unterschiedlicher Perspektiven fördern und den interdisziplinären Austausch innerhalb der Epileptologie stärken.

Dr. Katja Kobow (Vierte von rechts) wurde zur zweiten Vorsitzenden der Deutschen Gesellschaft für Epileptologie gewählt. F: DGfE

Figure 90: News report from Erlanger Nachrichten, April 24, 2025: Katja Kobow elected Second Chair of the German Society for Epileptology.

We are delighted to announce that Katja Kobow (PI of subproject **C03**) has been elected **Second Chair of the German Society for Epileptology (DGfE)**, becoming the first woman in the history of the society to hold this position. As a natural scientist, she brings a strong perspective from experimental epilepsy research and aims to foster closer communication and collaboration between clinical and scientific experts.

As part of the society's regular rotation, she will assume the role of First Chair in two years and will also serve as a leading organizer of the annual meeting.

We warmly congratulate Katja on this outstanding achievement and wish her every success and fulfillment in her new role!

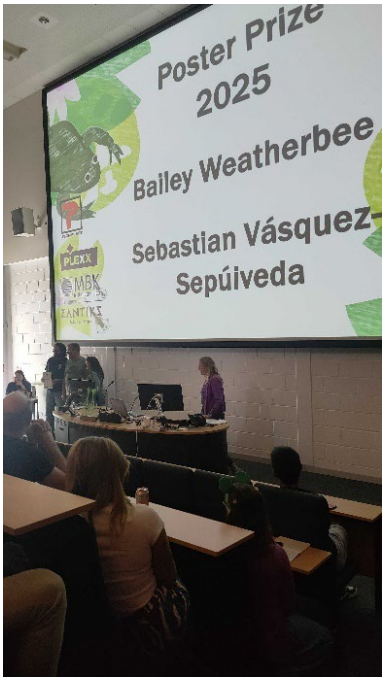
4.3.7 HUMBERTO ROMERO LIMON – INAUGURAL JOCHEN GUCK PRIZE

On November 27, 2025, Humberto Romero Limon was honored with the inaugural **Jochen Guck Prize** by the BioBrillouin Society. This prestigious award, presented at a conference held in memory of Prof. Jochen Guck, celebrates outstanding contributions to the biomedical applications of Brillouin spectroscopy and commemorates a remarkable scientist whose passing was deeply felt in the community

Humberto received this distinction at the 9th International BioBrillouin Conference for his work on applying Brillouin and mechanical measurements in biological systems. The Jochen Guck Prize was established to preserve Prof. Guck's legacy. It will be awarded annually to inspire and recognize innovative research in the field.

We celebrate Humberto's well-deserved recognition!

4.3.8 SEBASTIÁN I. VÁSQUEZ SEPÚLVEDA – BEST POSTER AWARDS



We are pleased to congratulate Sebastián Vásquez Sepúlveda (**A05**) on two notable recognitions received in 2025.

In August 2025, Sebastián received a **Best Poster Presentation award** at the **20th International Xenopus Conference in Portsmouth**, UK, for his work on the mechanical role of the UDP-galactose translocator Slc35A2 in brain malformations, acknowledging the quality and impact of his research.

Later, on September 30, 2025, he was again honored with a **Best Poster Presentation** award at the **EBM Symposium 2025**, further highlighting the significance and recognition of his contributions in the field.

Warm congratulations to Sebastián on these well-deserved achievements!

4.3.9 TOMOHISA TODA – JOSEPH ALTMAN AWARD

Tomohisa Toda, associated EBM PI, has been awarded the **9th Joseph Altman Award in Developmental Neuroscience**.

The prize recognizes outstanding research in developmental neurobiology at the tissue and cellular levels, including studies on adult neurogenesis, its biological significance, and its changes with aging and disease.

Tomo's work on the role of long-lived cellular components provides new insights into brain plasticity and mechanisms underlying neurodegenerative diseases.

Warmest congratulations to Tomo!

Figure 91 Prof. Tomohisa Toda has received his prize in July 2025 in Niigata (Japan) (© JSPS)

4.3.10 DANIEL WEHNER – W2 PROFESSORSHIP

Daniel Wehner accepted a **W2 Professorship** in Regenerative Biology and joined the **University of Cologne** on September 1, 2025. He leads the Neuroregeneration research group, studying how zebrafish regenerate spinal connections and recover locomotor function, with the goal of translating these insights into therapies for humans.

We warmly congratulate Daniel on this well-deserved appointment!

4.4 DOCTORAL DEGREE

4.4.1 DR.-ING. FRAUKE WILM

Figure 92: The freshly minted Dr. Frauke Wilm, proudly wearing her creatively designed graduation cap. (Image: Mathias Seuret)

The EBM team extends heartfelt congratulations to Frauke Wilm, a former researcher in subproject **X02**, on the successful defense of her dissertation entitled “Cross-Domain Generalization of Deep Learning-Based Image Analysis Algorithms in Histopathology,” held on January 23, 2025.

Frauke’s research in a joint project with Merck KGaA, Darmstadt, and within EBM has made significant strides in applying deep learning algorithms to histopathology. Her findings on the generalization of image analysis algorithms across domains are not only innovative but also crucial for improving the analysis of heterogeneous data in medical imaging. Frauke’s work has laid the foundation for future advances in machine learning technologies and is a valuable contribution to our understanding of image-based disease assessment systems.

Dear Frauke, we warmly congratulate you on this remarkable achievement and wish you continued success in your scientific career.

4.4.2 DR.-ING. SONJA KUTH

EBM extends heartfelt congratulations to Sonja Kuth on the successful defense of her dissertation entitled “Development of hydrogels based on oxidized hyaluronic acid for neural applications”, held on September 26, 2025.

Sonja conducted her doctoral research under the supervision of Prof. Aldo R. Boccaccini (subproject **X03**). Sonja developed and characterized novel hydrogels based on hyaluronic acid, optimized and studied for potential neural applications, such as therapies for nerve regeneration, brain phantoms, and as matrices for *in vitro* studies in contact with neuronal cells. Her doctoral work has already led to several publications.

Dear Sonja, congratulations on this impressive accomplishment! We wish you much success and fulfillment in your future research and professional endeavors.

Figure 93: Dr. Sonja Kuth, freshly minted doctor and crowned with her uniquely designed doctoral cap. (Image: H. Mahler)

4.5 SOCIAL ACTIVITIES

4.5.1 EBM WINTER PARTY

Immediately following the 2nd EBM Update Meeting on January 31, 2025, we held our EBM Winter Party (instead of a traditional Christmas celebration).

The event offered a perfect opportunity to start the new year in a relaxed and cheerful atmosphere. A delicious buffet, music by DJ Alex, lively conversations, an exciting pub quiz, and an overall vibrant mood made the evening a great success.

The celebration not only marked a fitting close to the previous year but also provided an important moment to strengthen team spirit and recharge for the challenges ahead.

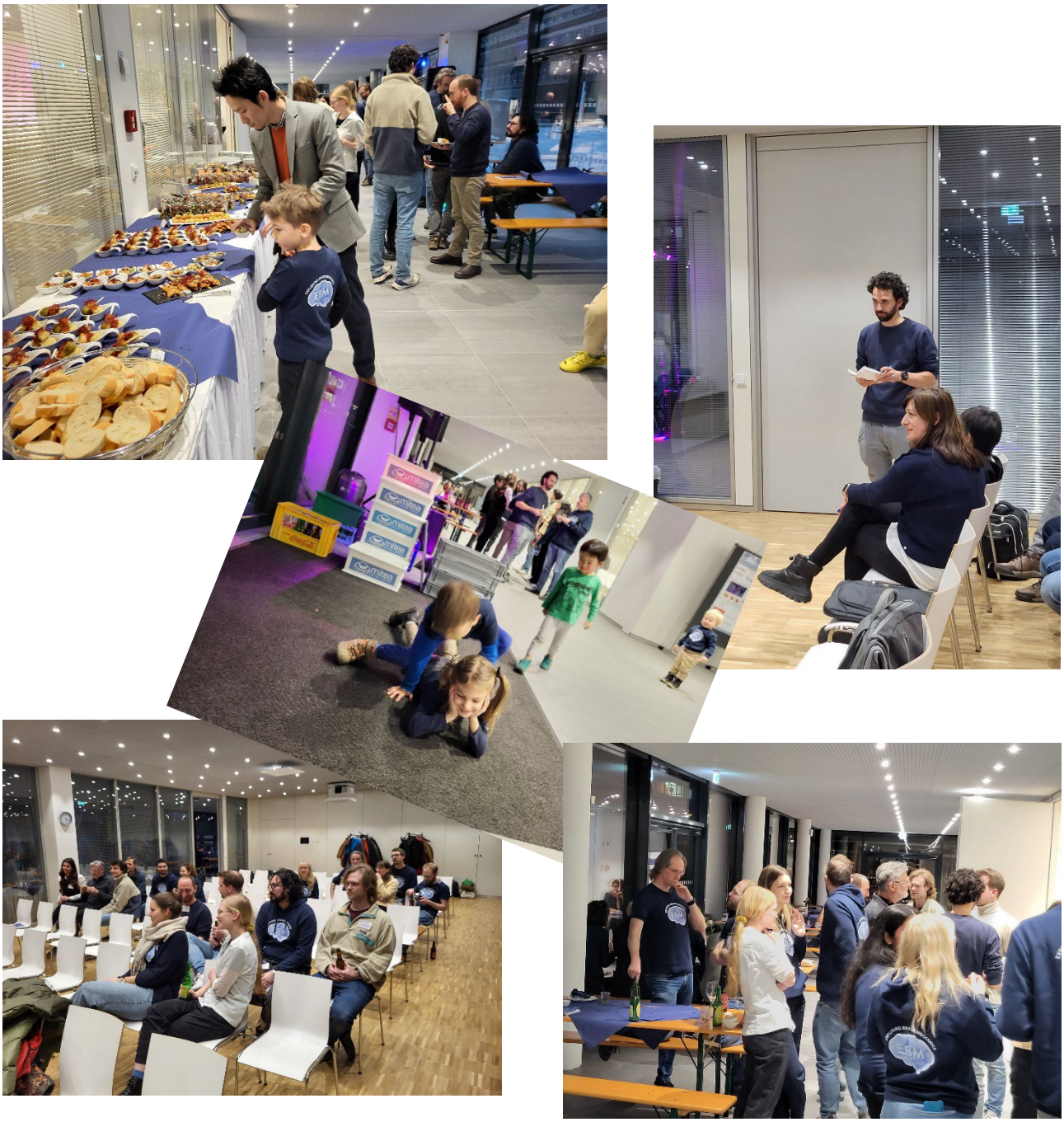


Figure 94: Impressions from the EBM Winter Party: Young and old alike enjoying delicious food, great music, and inspiring conversations in a relaxed atmosphere. (Images: A. Dakkouri-Baldauf)

4.5.2 END-OF-SUMMER GET-TOGETHER AT ENTLAS-KELLER

Figure 95: EBM members and their families enjoying a relaxed afternoon together. (Image: Ch. Klaar)

On Sunday, September 28, 2025, members of the Collaborative Research Center 1540 “Exploring Brain Mechanics” (EBM) came together with their families at the Entlas-Keller beer garden in Erlangen.

The timing could not have been better: just as the afternoon began, the clouds cleared, the sun came out, and everyone enjoyed the late summer weather with refreshing drinks and Franconian specialties.

In this informal and friendly atmosphere, participants had the chance to reconnect after the summer break, strengthen personal ties, and recharge before entering the intensive phase of preparing the renewal proposal and evaluation.

A heartfelt thank you to everyone who joined – for the positive spirit, inspiring discussions, and a truly enjoyable afternoon!

Figure 96: EBM members and their families sharing a lively, joy-filled afternoon together. (Images: A. Dakkouri-Baldauf)

4.6 EBM STRATEGIC ENGAGEMENT

Figure 97: Danijela Gregurec (left) in front of the European Commission building in Brussels. (Image: biointerfaces lab)

In 2025, EBM member Prof. Dr. Danijela Gregurec continued her active involvement in the **EIC Strategy Panel “Tools to measure and stimulate activity in brain tissue”**. Over the past three years, she has contributed to advising EU policymakers (Commission and Parliament) on strategies to advance brain research and therapies in Europe.

At the March 2025 meeting in Brussels, she was directly involved in mapping the translation from laboratory research to practical applications, as well as in the preclinical validation of approaches and tools for brain stimulation and recording. Currently, a White Paper summarizing potential solutions to strengthen Europe’s global competitiveness in brain research is being prepared for Horizon Magazine.

This strategic engagement highlights EBM’s contribution not only to cutting-edge research but also to shaping policy and fostering innovation at the European level.

5 OUTREACH ACTIVITIES

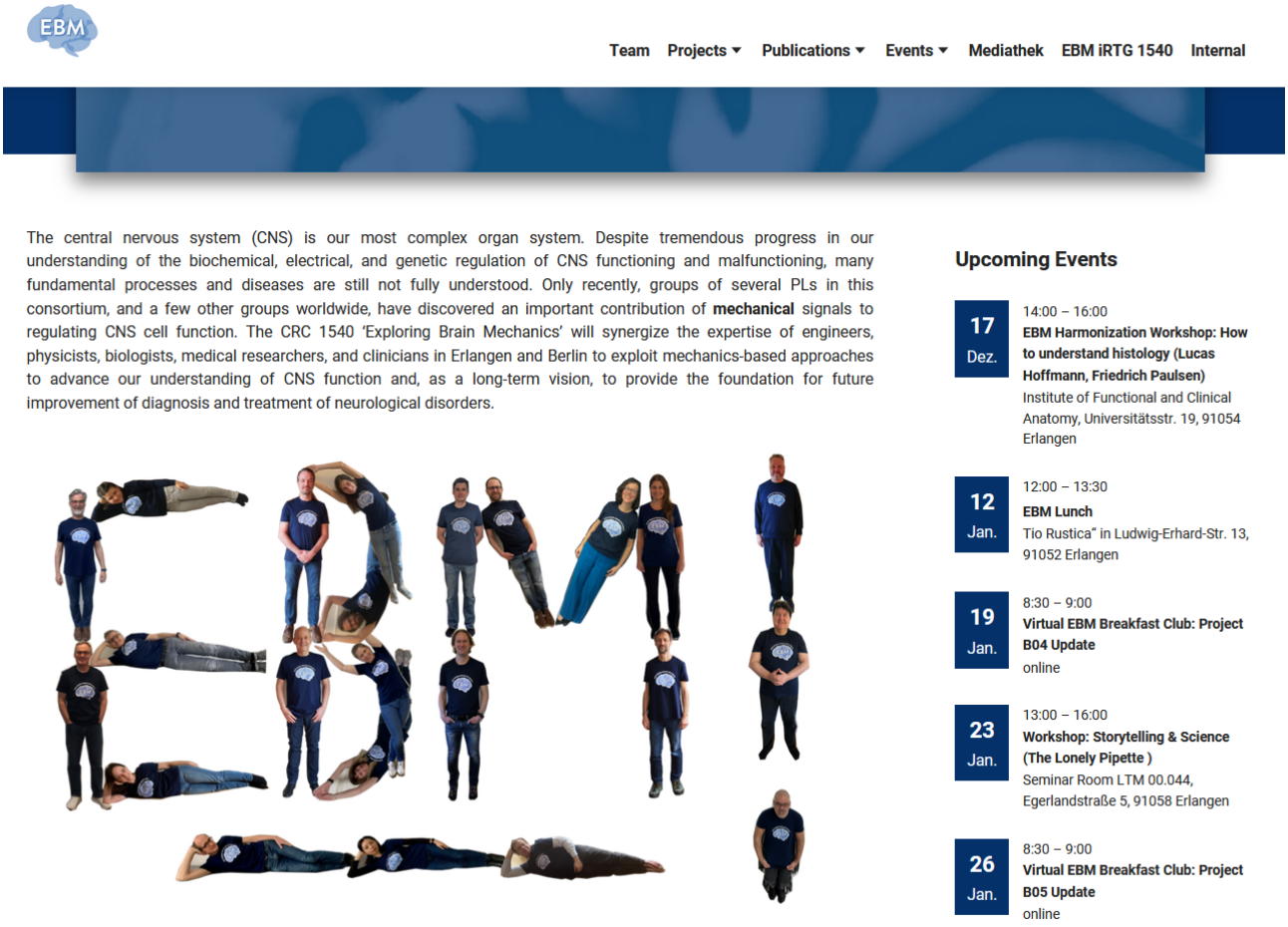
The primary objective of **EBMoutreach** concept is to achieve international, national, and regional visibility. This is intended to be accomplished through disseminating results and activities, thereby engaging both the broader public (**EBM2public**) and the worldwide scientific community (**EBM2peers**).

5.1 EBM2PUBLIC

The **EBM2public** initiative encompasses various channels to enhance public engagement and outreach:

5.1.1 EBM'S WEBPAGE

EBM maintains an informative webpage at www.ebm.fau.de:



5.1.2 EBM SOCIAL MEDIA PRESENCE

- EBM actively manages its social media channels on platforms such as Bluesky, LinkedIn, and Instagram.
- The social media team, comprised of EBM doctoral researchers, the co-spokesperson, and the scientific coordinator, regularly updates these platforms.
- Updates on EBM activities, introductions of new publications, achievements of EBM members, and the "#pictureoftheweek" feature were consistently shared.

5.1.3 FASCINATION BRAIN MECHANICS – EBM AT THE LONG NIGHT OF THE SCIENCES 2025

On October 25, 2025, the Collaborative Research Center 1540 “Exploring Brain Mechanics” (EBM) together with the BRAINIACS group opened its doors to the public during the Long Night of the Sciences in the Erlangen–Fürth–Nürnberg region. Under the motto “Fascination Brain Mechanics”, EBM invited visitors to the Brain Lounge at the Max Planck Center for Physics and Medicine (MPZPM) to explore the fascinating world of brain mechanics through interactive exhibits and live demonstrations.

Throughout the evening, visitors discovered how researchers at EBM study the brain at the intersection of mechanics, biology, medicine, biophysics, and material science — revealing new insights into how this complex organ works.

Interactive Stations to Explore and Experience

Whose brain weighs the most?

This station compared the brains of different species, showing that intelligence depends not on brain size alone but on complexity and the brain-to-body ratio. From the tiny lion brain to the massive sperm whale brain, visitors learned that the human brain is uniquely efficient and complex.

Can you guess where we hid the brain?

Many visitors tried their luck guessing what real brain tissue feels like — safely sealed and hygienically handled, of course. Pig brains were used to illustrate that brain tissue is among the softest in the human body. This hands-on activity linked directly to EBM’s research on the mechanical properties of brain tissue.

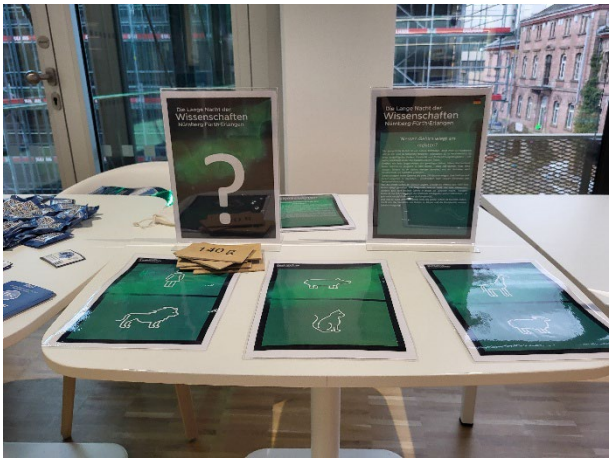


Figure 98: "Whose brain weighs the most" and " Can you guess where we hid the brain". (Images: A. Dakkouri-Baldauf)

Creating artificial brain tissue

Researchers demonstrated how soft tissues can be mimicked using hydrogels — polymer networks that imitate the extracellular matrix. By varying the gel composition and stiffness, the team creates realistic brain phantoms used in experiments. Visitors were invited to touch different gelatin samples and identify which one best resembled real brain softness.

From the neural plate to the brain

Did you know that the brain once started out as a flat sheet of cells? This station showed how the neural plate folds into the neural tube and eventually forms the brain and spinal cord. A video presentation illustrated the remarkable developmental process, highlighting similarities between early human and frog brain formation.

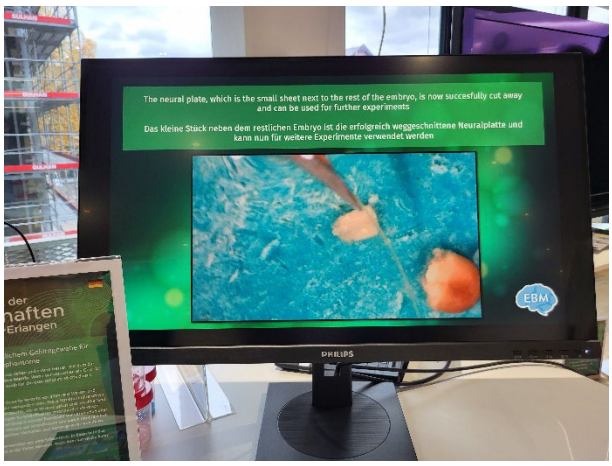


Figure 99: "Creating artificial brain tissue" and "From the neural plate to the brain". (Images: A. Dakkouri-Baldauf)

How the brain folds

Using 3D-printed models of developing brains, visitors could trace how folds and grooves emerge over gestation. An interactive computer model allowed them to experiment with mechanical parameters influencing brain folding — and observe how changes alter the resulting patterns.

3D printing in brain research

Here, the team demonstrated how 3D printing — specifically the FDM (fused deposition modeling) method — enables the fabrication of customized holders for brain imaging or anatomical models for education and research. The exhibit included models showing brain development across different stages of pregnancy.

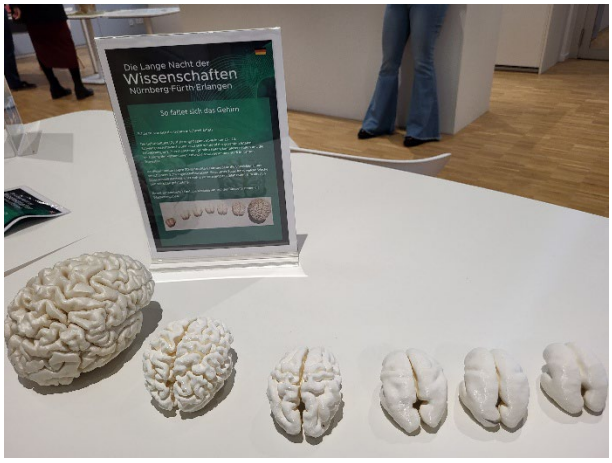


Figure 100: "How the brain folds" and "3D printing in brain research". (Images: A. Dakkouri-Baldauf)

Swelling brains

To understand the physical processes behind brain folding, EBM researchers use swelling polymer models that mimic the cortex and subcortex. These experiments show how mechanical instabilities can naturally lead to the complex folded structure of the human brain.

Figure 101: "Swelling brains". (Images: A. Dakkouri-Baldauf)

3D model of the human brain

At this station, visitors explored not only detailed 3D-printed brain models but also horizontal sections of a real human brain and several preserved human brains. This rare opportunity offered a tangible, up-close encounter with the true complexity and anatomy of the human brain.

Figure 102: 3D model of the human brain. (Images: A. Dakkouri-Baldauf)

Magnetic Resonance Elastography (MRE)

Visitors discovered how researchers can visualize the brain's mechanical properties without touching it. MRE combines magnetic resonance imaging (MRI) with elastography to map tissue stiffness by tracking the propagation of gentle vibrations. The displayed images illustrated how EBM uses this advanced technique to study the brain's mechanical behavior under both healthy and pathological conditions.

Figure 103: "Magnetic Resonance Elastography (MRE)". (Images: A. Dakkouri-Baldauf)

Science meets organ music

A video installation featured excerpts from the film concert “The Brain – Musical Explorations”, premiered in 2024 at St. Matthäus Church in Erlangen. The projection combined organ music by Bach, Pärt, Gubaidulina, and Glass with stunning 3D visualizations from EBM’s 7-Tesla neuro-MRI research, offering a mesmerizing artistic and scientific experience.

The MEG Laboratory of Neurosurgery

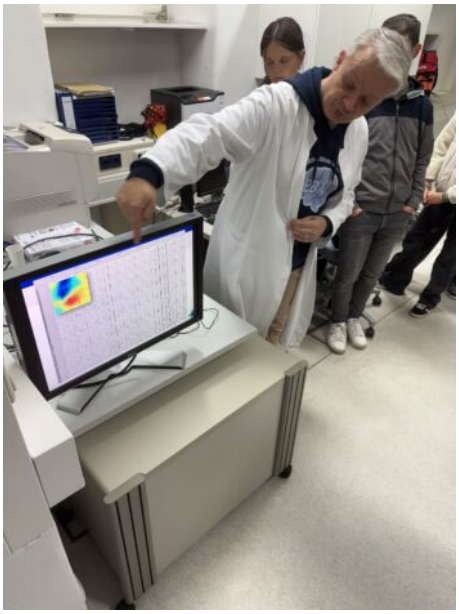


Figure 104: "The MEG Laboratory of Neurosurgery". (Images: J. Hornegger)

Right next to the MPZPM, EBM member PD Dr. med. Stefan Rampp guided visitors through the Magnetoencephalography (MEG) laboratory of the Department of Neurosurgery in six informative tours. More than 100 participants took the rare opportunity to see how MEG detects tiny magnetic fields in the brain to locate epileptic activity and study networks involved in speech, motor control, and sensory processing. The tours included a live demonstration of the MEG device’s extraordinary sensitivity and an information booth presenting ongoing research and clinical applications.

A Night of Curiosity and Inspiration

The presentation of the CRC 1540 Exploring Brain Mechanics drew considerable attention throughout the night. With creativity, enthusiasm, and hands-on demonstrations, the EBM (post)doctoral researchers succeeded in communicating the complexity and beauty of brain mechanics to a broad audience — sparking fascination and curiosity for one of the most exciting frontiers in modern science.

Figure 105: Moments from the Long Night of Sciences. (Images: A. Dakkouri-Baldauf)

5.1.4 PODCAST FROM INGOLF SACK

Magnetic Resonance Elastography and Brain Mechanics

In this podcast episode, Ingolf Sack (**X01**, **Y**) explores the viscoelastic properties of brain tissue and how these mechanical characteristics change with aging**,** neurodegenerative diseases such as Alzheimer's, and brain injuries. The discussion highlights the distinct mechanical contributions of neuronal and glial cells**,** the extracellular matrix, and the vascular network**.**

A central focus of the episode is the progress in Magnetic Resonance Elastography (MRE**)**, particularly its expanding role in the diagnosis**,** monitoring, and mechanistic understanding of brain health. Several case studies illustrate how MRE is transforming approaches in neurology, supporting earlier detection of pathology and informing emerging therapeutic strategies.

The episode is available at: https://brain-mechanical-networks.jellypod.ai/

5.1.5 MODERN PHYSICS ON SATURDAY MORNING: BRAIN FOLDING WITH KRISTIAN FRANZE

As part of the Department of Physics' public lecture series "Moderne Physik am Samstagmorgen:" (Modern Physics on Saturday Morning), which offers students and interested non-experts accessible insights into current research topics, Kristian Franze (**A05**, **B02**) gave a talk on February 8, 2025 titled "Falten erwünscht! Wie das Gehirn in Form kommt" ("Wrinkles Welcome! How the Brain Takes Shape").

In his one-hour lecture, complemented by a video recording, Kristian Franze explained how the brain evolves from an initially simple layer of cuboidal cells into a highly folded organ containing nearly 100 billion neurons. He highlighted current challenges in understanding key developmental processes, as well as the mechanisms underlying neurological diseases. The presentation showcased new insights into brain development and regeneration gained through advanced methods and concepts originating from modern physics.

Video recording: The lecture is available online at FAU's media portal, offering full access to the talk and accompanying visuals: https://www.fau.tv/series/moderne-physik-am-samstagmorgen-s25/16-falten-erwunscht-wie-das-gehirn-in-form-kommt-w24

5.1.6 EBM REPRESENTATION AT MECOM 2025: MULTISCALE BRAIN MECHANICS

EBM spokesperson Prof. Paul Steinmann represented the CRC 1540 Exploring Brain Mechanics (EBM) at the international conference MECOM 2025, held from November 11–14, 2025, in Buenos Aires, Argentina. At this prestigious event, he delivered a main lecture entitled "From the Cellular via the Tissue to the Organ Level: A Journey Exploring Brain Mechanics."

In his presentation, Paul. Steinmann outlined EBM's comprehensive multiscale research approach, which systematically links mechanical processes across cellular, tissue, and organ levels to advance the understanding of brain structure, development, and function. By integrating concepts from continuum mechanics, biomechanics, and physics-based modeling, the talk highlighted how EBM addresses fundamental questions in brain mechanics and neurological health.

Figure 106: Impressions from Prof. Paul Steinmann's main lecture at MECOM 2025 (Buenos Aires). (Images: D. van Huysteen)

The invitation to present a main lecture at MECOM 2025 underscores the international visibility and scientific relevance of CRC 1540 EBM. We are pleased that EBM's research was showcased on this global platform and sincerely thank Paul Steinmann for his excellent representation and contribution.

5.2 EBM2PEERS

- EBM Scientific Publications (see Section 1.3): All publications are freely accessible. Additionally, supplementary materials, such as datasets, are publicly available through the "Exploring Brain Mechanics - CRC 1540 EBM" community on the online repository Zenodo.
- EBM Scientific Presentations at first-class conferences, workshops, and seminars (see Section 6.3
- EBM Virtual Brain Talks (see Section 2.2.3)

6 GENERAL INFORMATION

6.1 KEY DATA

6.1.1 GOVERNING BODIES OF EBM

Spokesperson
Prof. Dr.-Ing. habil. Paul Steinmann
Institute of Applied Mechanics
Egerlandstr. 5, 91058 Erlangen
+49 9131 8528501
paul.steinmann@fau.de

Co-Spokesperson
Prof. Dr.-Ing. Silvia Budday
Institute of Continuum Mechanics and Biomechanics
Friedrich-Alexander-Universität Erlangen-Nürnberg
Dr.-Mack-Str. 81, 90762 Fürth
+49 9131 8567611
silvia.budday@fau.de

Scientific Coordination
Dr. rer. nat. Andrea Dakkouri-Baldauf
Institute of Applied Mechanics
Martensstraße 5a, 91058 Erlangen
+49 9131 85 20782
andrea.dakkouri@fau.de

EBM Executive Board
The EBM Executive Board consists of the Spokesperson, Co-Spokesperson, Scientific Coordinator, Chairs of the Focal Research Areas (FRA **A**, **B**, **C**) and the Cross-Sectional Research Area (**XRA**), the Principal Executive of the Integrated Research Training Group (**iRTG**), a representative from the Clinics, an Early Career Support Representative, an Equal Opportunity Representative, a (Post-) Doctoral Researchers' Representative, and the EBM assistance.

Members:

Spokesperson	Prof. Paul Steinmann
Co-Spokesperson	Prof. Silvia Budday
Scientific Coordinator	Dr. Andrea Dakkouri-Baldauf
Chair of FRA **A**	Prof. Kristian Franze
Chair of FRA **B**	Prof. Jochen Guck
Chair of FRA **C**	Prof. Ben Fabry
Chair of **XRA**	Prof. Jing Guo / Prof. Ingolf Sack
Clinics Representative	Prof. Arnd Dörfler / Prof. Ingmar Blümcke
Principal Executive of the **iRTG**	Prof. Friedrich Paulsen
Early Career Representative	Prof. Katharina Breininger
Equal Opportunity Representative	Prof. Marisa Karow
(Post-)Doctoral Researchers‘ Representative	Shanice Heidenreich (Deputy: Soheil Firooz)
EBM Assistance	Doris Bittner

6.1.2 PARTICIPATING RESEARCHERS

6.1.2.1 Principal investigators

Table 10: Principal investigators

Principal investigators (PIs)	Faculty	Home institution, location	Project
Blümcke, Prof. Dr. med., Ingmar	FAU-MedFak	Neuropathology, Schwabachanlage 6, 91054 Erlangen	A02
Boccaccini, Prof. Dr.-Ing. habil., Aldo R.	FAU-TechFak	Biomaterials, Cauerstr. 6, 91058 Erlangen	X03
Bosserhoff, Prof. Dr., Anja	FAU-MedFak	Biochemistry and Molecular Neurosciences, Fahrstr. 17, 91054 Erlangen	C04
Breininger, Prof. Dr.-Ing., Katharina	FAU-Tech-Fak/JMU	Professorship for Pattern Recognition John-Skilton-Str. 4a, 97074 Würzburg	X02
Budday, Prof. Dr.-Ing., Silvia	FAU-TechFak	Institute of Continuum Mechanics and Biomechanics, Dr.-Mack-Str. 81, 90762 Fürth	A01, B01, Z
Dörfler, Prof. Dr. med., Arnd	FAU-MedFak	Neuroradiology, Schwabachanlage 6, 91054 Erlangen	A02, Y
Fabry, Prof. Dr.-Ing., Ben	FAU-NatFak	Biophysics, Henkestr. 91, 91052 Erlangen	C05
Falk, Dr., Sven	FAU-MedFak	Biochemistry and Molecular Neurosciences, Fahrstr. 17, 91054 Erlangen	A04
Franze, Prof. Dr., Kristian	FAU-MedFak	Medical Physics, MPZPM, Kussmaulallee 2, 91054 Erlangen	A05, B02
Frischknecht, Dr., Renato	FAU-NatFak	Animal Physiology, Staudtstr. 5, 91058 Erlangen	C02
Guck, Prof. Dr., Jochen	FAU-NatFak	Biological Optomechanics, MPZPM, Kussmaulallee 2, 91054 Erlangen	B03
Guo, Prof. Dr. rer. nat., Jing	Charité Berlin	Radiology, Charitéplatz 1, 10117 Berlin	X01, Y
Karow, Prof. Dr. rer. nat., Marisa	FAU-MedFak	Biochemistry and Molecular Neurosciences, Fahrstr. 17, 91054 Erlangen	A04
Kobow, PD Dr. rer. nat. Dr. habil. med., Katja	FAU-MedFak	Neuropathology, Schwabachanlage 6, 91054 Erlangen	C03
Kürten, Prof. Dr. med., Stefanie	FAU-MedFak	Anatomy and Cell Biology, Krankenhausstr.9, 91054 Erlangen and Universität Bonn, Institute of Neuroanatomy, Nussallee 10, 53115 Bonn	B04
Laun, Prof. Dr. rer. nat., Frederik B.	FAU-MedFak	Radiology, Maximiliansplatz 3, 91054 Erlangen	Y
Maier, Prof. Dr.-Ing. habil., Andreas	FAU-TechFak	Computer Science 15, Machine Intelligence, Martensstr. 3, 91058 Erlangen	X02
Möllmert, Dr. rer. nat., Stephanie	MPL	Biological Optomechanics, MPZPM, Kussmaulallee 2, 91054 Erlangen	B03
Paulsen, Prof. Dr. med., Friedrich	FAU-MedFak	Functional and Clinical Anatomy, Universitätsstr. 19, 91054 Erlangen	A02, iRTG
Sack, Prof. Dr. rer. nat., Ingolf	Charité Berlin	Radiology, Charitéplatz 1, 10117 Berlin	X01, Y
Schambony, Prof. Dr. rer. nat., Alexandra	FAU-NatFak	Schambony Lab, Staudtstr. 5, 91058 Erlangen	A03
Steinmann, Prof. Dr.-Ing. habil., Paul	FAU-TechFak	Applied Mechanics, Egerlandstr. 5, 91058 Erlangen	B01, C01, X01, Z
Wehner, Dr. rer. nat., Daniel	MPL/Universität zu Köln	Institute of Zoology Zülpicher Straße 47b, 50674 Köln	B05
Willner, Prof. Dr.-Ing. habil., Kai	FAU-TechFak	Applied Mechanics, Egerlandstr. 5, 91058 Erlangen	X01
Zaburdaev, Prof. Dr., Vasily	FAU-NatFak	Mathematics in Life Sciences, MPZPM, Kussmaulallee 2, 91054 Erlangen	C01

6.1.2.2 Associated principal investigators

Table 11: Associated principal investigators

Associated principal investigators (aPIs)	Faculty	Home institution, location
Delev, PD Dr. med., M.Sc., Daniel	FAU-MedFak	Institute of Neurosurgery, Schwabachanlage 6, 91054 Erlangen
Gregurec, Prof. Dr., Danijela	FAU-NatFak	Professorship for Sensory Sciences, Henkestrasse 91, 91052 Erlangen
Heiland, Prof. Dr. med., Dieter Henrik	FAU-MedFak	Institute of Neurosurgery, Schwabachanlage 6, 91054 Erlangen
Hutter, Prof. Dr.-Ing., Jana	FAU-MedFak	Institute of Radiology, Henkestrasse 91, 91052 Erlangen
Lie, Prof. Dr. med., Dieter Chichung	FAU-MedFak	Microscopic Anatomy and Molecular Imaging, Krankenhausstr. 9, 91054 Erlangen
Mathis-Ullrich, Prof. Dr., Franziska	FAU-TechFak	Surgical Planning and Robotic Cognition Lab, Nürnberger Str. 74, 91052 Erlangen
Nagel, Prof. Dr. rer. nat., Armin M.	FAU-MedFak	Institute of Neuroradiology, Henkestr. 91, 91052 Erlangen
Riedl, Prof. Dr. med., Valentin	FAU-MedFak	Institute of Neuroradiology, Henkestr. 91, 91052 Erlangen
Rothhammer, Prof. Dr. med., Veit	FAU-MedFak	Institute of Neurology, Schwabachanlage 6, 91054 Erlangen
Toda, Prof. Dr., Tomohisa	FAU-MedFak	Professor of Neural Epigenomics, Fahrstr. 17, 91054 Erlangen
Unalan, Dr.-Ing., Irem	FAU-TechFak	Institute of Biomaterials, Erlangen
Zaiss, Prof. Dr. rer. nat., Moritz	FAU-MedFak	Institute of Neuroradiology, Henkestr. 91, 91052 Erlangen

6.1.2.3 Postdoctoral researchers

Table 12: Postdoctoral researchers and assistant doctors

Postdoctoral researchers (PDRs)	Faculty	Home institution, location	Project
Aust, Dr., Oliver	FAU-TechFak	Artificial Intelligence in Medical Imaging, Werner-von-Siemens-Str. 61, 91052 Erlangen	X02
Estrella, Dr., Melanie	Charité Berlin	Radiology, Charitéplatz 1, 10117 Berlin	X01
Flé, Dr., Guillaume	FAU-MedFak	Radiology, Maximiliansplatz 3, 91054 Erlangen Neuroradiology, Schwabachanlage 6, 91054 Erlangen	Y
Fleming, Dr., Thomas	MPL	Biological Optomechanics, MPZPM, Kussmaulallee 2, 91054 Erlangen	B05
Gopalan Ramachandran, Dr., Rahul	FAU-TechFak	Institute of Continuum Mechanics and Biomechanics, Dr.-Mack-Str. 81, 90762 Fürth	B01
Hintze, Dr., Maik	FAU-MedFak	Anatomy and Cell Biology, Krankenhausstr.9, 91054 Erlangen and Universität Bonn, Institute of Neuroanatomy, Nussallee 10, 53115 Bonn	B04
Rampp, PD Dr. med., Stefan	FAU-MedFak	Department of Neurosurgery, Department of Neuroradiology, Schwabachanlage 6, 91054 Erlangen	A02

6.1.2.4 Associated postdoctoral researchers and assistant doctors

Table 13: Associated postdoctoral researchers and assistant doctors

Associated postdoctoral researchers and assistant doctors (aPDRs)	Faculty	Home institution, location	Project
Chunder, Dr. rer. nat., Rittika	FAU-MedFak	Anatomy and Cell Biology, Krankenhausstr.9, 91054 Erlangen and Universität Bonn, Institute of Neuroanatomy, Nussallee 10, 53115 Bonn	B04
Hoffmann, Dr. med., Lucas	FAU-MedFak	Neuropathology, Schwabachanlage 6, 91054 Erlangen	A02
Kolb, Dr., Julia	FAU-TechFak	Institute of Continuum Mechanics and Biomechanics, Dr.-Mack-Str. 81, 90762 Fürth	A01
Kunz, Dr., Christian	FAU-TechFak	Surgical Planning and Robotic Cognition Lab, Nürnberger Str. 74, 91052 Erlangen	T03
Mukherjee, Dr., Sudipta	FAU-MedFak	Medical Physics, MPZPM, Kussmaulallee 2, 91054 Erlangen	A05
Schicht, PD Dr. rer. nat. Dr. habil. med., Martin	FAU-MedFak	Functional and Clinical Anatomy, Universitätsstr. 19, 91054 Erlangen	A02
Scholz, Prof. Dr. rer. nat. Dr. habil. med., Michael	FAU-MedFak	Functional and Clinical Anatomy, Universitätsstr. 19, 91054 Erlangen	A02
Tueni, Dr., Nicole	FAU-TechFak	Institute of Continuum Mechanics and Biomechanics, Dr.-Mack-Str. 81, 90762 Fürth	A01, X01

6.1.2.5 Doctoral researchers

Table 14: Doctoral researchers

Doctoral Researchers (DRs)	Faculty	Home institution, location	Project
Auer, Sophia	FAU-MedFak	Functional and Clinical Anatomy, Universitätsstr. 19, 91054 Erlangen	A02
Bachir Salvador, Jana	MPL	Biological Optomechanics, MPZPM, Kussmaulallee 2, 91054 Erlangen	B03
Bischof, Lars	FAU-NatFak	Biophysics, Henkestr. 91, 91052 Erlangen	C05
Cecchini, Erica	FAU-MedFak	Neuropathology, Schwabachanlage 6, 91054 Erlangen	A02
Erterek, Ezgi	FAU-NatFak	Animal Physiology, Staudtstr. 5, 91058 Erlangen	C02
Fedders, Michael	Charité Berlin	Radiology, Charitéplatz 1, 10117 Berlin	X01
Firooz, Soheil	FAU-TechFak	Applied Mechanics, Egerlandstr. 5, 91058 Erlangen	C01
Froidevaux, Clara	FAU-NatFak	Schambony Lab, Staudtstr. 5, 91058 Erlangen	A03
Heidenreich, Shanice	FAU-MedFak	Biochemistry and Molecular Neurosciences, Fahrstr. 17, 91054 Erlangen	C04
Hinrichsen, Jan	FAU-TechFak	Institute of Continuum Mechanics and Biomechanics, Egerlandstr. 5, 91058 Erlangen	A01
Karandasheva, Kristina	FAU-MedFak	Neuropathology, Schwabachanlage 6, 91054 Erlangen	C03
Kravikass, Mathar	FAU-NatFak	Mathematics in Life Sciences, MPZPM, Kussmaulallee 2, 91054 Erlangen	C01
Lorke, Markus	FAU-TechFak	Biomaterials, Cauerstr. 6, 91058 Erlangen	X03
Neumann, Oskar	FAU-TechFak	Institute of Continuum Mechanics and Biomechanics, Egerlandstr. 5, 91058 Erlangen	B01

Pan, Zhaoya	FAU-TechFak	Chair of Computer Science 5 (Pattern Recognition), Martensstraße 3, 91058 Erlangen	X02
Ruhland, Laura	FAU-TechFak	Applied Mechanics, Egerlandstr. 5, 91058 Erlangen	X01
Sipkova, Jana	FAU-MedFak	Medical Physics, Henkestr. 91, 91052 Erlangen	A05
Tarczewska, Maria Weronika	FAU-MedFak	Medical Physics, MPZPM, Kussmaulallee 2, 91054 Erlangen	A05
Tranchina, Michael	FAU-MedFak	Biochemistry and Molecular Neurosciences, Fahrstr. 17, 91054 Erlangen	A04
Vásquez Sepúlveda, Sebastián Ignacio	FAU-MedFak	Medical Physics, MPZPM, Kussmaulallee 2, 91054 Erlangen	B02
Verma, Yashasvi	FAU-TechFak	Applied Mechanics, Egerlandstr. 5, 91058 Erlangen	X01

6.1.2.6 Associated doctoral researchers

Table 15: Associated doctoral researchers

Associated doctoral researchers (aDRs)	Faculty	Home institution, location	Project
Butzke, Julia	FAU-MedFak	Medical Physics, MPZPM, Kussmaulallee 2, 91054 Erlangen	A05
Gampl, Niklas	FAU-MedFak	Medical Physics, MPZPM, Kussmaulallee 2, 91054 Erlangen	A05
Greiner, Alexander	FAU-TechFak	Institute of Continuum Mechanics and Biomechanics, Egerlandstr. 5, 91058 Erlangen	B01
Hein, Konstantin	FAU-MedFak	Professor of Neural Epigenomics, Fahrstr. 17, 91054 Erlangen	C06
Jordan, Jakob	Charité Berlin	Radiology, Charitéplatz 1, 10117 Berlin	X01
Ludwig, Jakob	Charité Berlin	Radiology, Charitéplatz 1, 10117 Berlin	X01
Maier, Franziska*	FAU-MedFak	Institute of Experimental and Clinical Pharmacology and Toxicology, Fahrstr. 17, 91054 Erlangen	n/a
Perelló Amorós, Bartomeu	FAU-NatFak	Animal Physiology, Staudtstr. 5, 91058 Erlangen	C02
Reiter, Nina	FAU-TechFak	Institute of Continuum Mechanics and Biomechanics, Egerlandstr. 5, 91058 Erlangen	B01
Welsch, Kathrin	FAU-MedFak	Medical Physics, MPZPM, Kussmaulallee 2, 91054 Erlangen	A05

* external associated doctoral researcher

6.1.2.7 Associated master's students / medical doctoral researchers

Table 16: Associated master's student / medical doctoral researchers s

Associated master's students (aMSs) / medical doctoral researchers (medDRs)	Faculty	Home institution, location	Project
Görtz-Lizarraga, Matthias	FAU-MedFak	Biochemistry and Molecular Neurosciences, Fahrstr. 17, 91054 Erlangen	A04
Groß, Fabian	FAU-MedFak	Radiology, Maximiliansplatz 3, 91054 Erlangen	Y
Gutjahr, Lene	FAU-NatFak	Schambony Lab, Staudtstr. 5, 91058 Erlangen	A03
Jeßberger, Philipp	FAU-MedFak	Radiology,	Y

		Maximiliansplatz 3, 91054 Erlangen	
Michel, Andrea	FAU-TechFak	Biomaterials, Cauerstr. 6, 91058 Erlangen	X03
Murk, Simon	FAU-MedFak	Radiology, Maximiliansplatz 3, 91054 Erlangen	X01
Özer, Mert	FAU-TechFak	Chair of Computer Science 5 (Pattern Recognition), Martensstraße 3, 91058 Erlangen	X02
Romero Limon, Humberto	FAU-MedFak	Professor of Neural Epigenomics, Fahrstr. 17, 91054 Erlangen	C06
Singh, Urvi	FAU-MedFak	Professor of Neural Epigenomics, Fahrstr. 17, 91054 Erlangen	C06

6.1.2.8 Student assistants

Table 17: Student assistants

Name	Supported researchers	Course / field of study	Funded member of EBM (from / to)	Tasks relating to EBM
Bellofatto, Elisa	Silvia Budday, A01/B01	Advanced Materials and Processes	01.12.25 / 31.03.26	Rheometer experiments on brain tissue
Buss, Monika	Silvia Budday, A01/B01	Chemical Engineering - Nachhaltige Chemische Technologien	01.10.25 / 31.05.26	Hydrogel preparation
Barillas Dahm, Malena	Katja Kobow, C03	Molecular Medicine	01.06.25 / 30.09.25	Immunofluorescence staining of cellular, nuclear, and ECM markers and microscopy (collaboration with A02)
Franke, Lorenz	Alexandra Schambony, Clara Froidevaux, A03	Biology	01.01.25 / 31.12.25	Support with Xenopus Laevis handling, support preparation of hydrogel substrates used for A03
Hahn, Paula	Kristian Franze, A05, B02	Cell and Molecular Biology	01.01.25 / 31.03.26	Sample preparation and imaging of frog brains
Jain, Rithika	Irem Unalan, X03	Adv. Materials and Processes	01.08.25 / 31.12.25	OHA synthesis, Hydrogel preparation, MEW sample preparation, preliminary mechanical testing
Jorkash Varnoosfaderani, Niloofar	Katharina Breininger, X02	Computational Engineering	01.01.25 / 31.12.25	Implementation of new functionality and bugfixing for the annotation platform EXACT
Kashish Veda, Eluri	Soheil Firooz, C01	Computational Engineering	01.01.25 / 14.02.25	Automatization of coupled-field FEM codes for arbitrary number of fields
Langenbrinck, Jan	Kristian Franze, A05, B02	Integrated Life Sciences	01.01.25 / 31.12.25	Design of new cell culture substrates, establishing printing of ECM patterns on gels
Michel, Andrea	Aldo R. Boccaccini, X03	Materials Science and Materials Engineering	01.01.25 / 30.06.25	Hydrogel testing. 3D printing, cell experiments
Minina, Liubov	Silvia Budday, A01/B01	Medical Engineering	01.07.25 / 31.12.25	Transport of surgical tissue between the University Clinic and the biomechanics laboratory; analysis of histological images

Name	Supported researchers	Course / field of study	Funded member of EBM (from / to)	Tasks relating to EBM
Rostami, Ali	**Soheil Firooz,** C01	Computational Engineering	01.06.25 / 31.05.26	Development of a FEM code for multi-component cellular aggregate formation modeling
Sadr Tahouri, Seyed Kasra	Ben Fabry, C05	Advanced Materials and Processes	01.12.25 / 31.03.26	Rheology measurements on collagen hydrogels
Samusch, Johanna	Sophia Auer, A02	Biology	15.08.25 / 15.08.26	Immunofluorescence staining of brain sections, immunohistochemistry and histological staining, and slide scanning
Satwik Reddy, Madyarla	Yashasvi Verma, X01	Computational Engineering	01.08.25 / 30.04.26	Developing clustering methods for post processing of MRE data
Setayesh, Ardalan	Silvia Budday, A01, B01	Medical Technology	01.01.25 / 31.12.25	Implementation of indentation measurements
Shaparenko, Egor	Kristian Franze, A05, B02	Applied Mathematics and Physics	15.04.25 / 31.12.25	Testing effects of drugs affecting Piezo1 on cell physiology
Stadter, Zoe	Marisa Karow, A04	Molecular Medicine	01.09.25 / 28.02.26	Cryosectioning of brain organoids; immunohistochemical stainings
Surana, Harsh Vardhan	Oskar Neumann, B01	Computational Engineering	01.01.25 / 30.04.26	Assistance in the experimental investigation of the mechanical properties of porcine spinal cord using a Nanoindenter
Unglert, Sothia	Kristian Franze, A05, B02	Integrated Life Science: Biology, Biomathematics, Biophysics	15.11.25 / 14.11.26	Measuring forces exerted by neurons in 2D vs. 3D
Valian, Ilia	Soheil Firooz, C01	Computational Engineering	01.06.25 / 31.08.25	Acceleration of a coupled-field FEM code for simulating cellular aggregate formation

6.1.2.9 EBM Advisory Board

Table 18: EBM Advisory Board

Mercator fellows	Affiliation	Expertise
Franklin, Prof., Robin	Cambridge University, UK	CNS regeneration
Holzapfel, Prof., Gerhard	Institute of Biomechanics, Graz University of Technology, Austria	Mechanical testing and modeling of brain tissue mechanics
Kuhl, Prof., Ellen	Living Matter Lab, Stanford University, USA	Continuum modeling and simulation of the brain
Further board members		
Götz, Prof. Dr., Magdalena	Institute for Physiological Genomics, Ludwig-Maximilians-Universität München & Institute of Stem Cell Research, Helmholtz Zentrum, Munich, Germany	Neuroscience
Jayamohan, Dr., Jayaratnam (Jay)	Consultant Paediatric Neurosurgeon, John Radcliffe Hospital, and private practice at Nuffield Health Oxford, The Manor Hospital, Oxford, UK	Clinician
Schnell, Prof. Dr., Oliver	Neurosurgical Clinic, Chair of Neurosurgery, University Hospital Erlangen, Germany	Neurosurgery

6.1.3 COORDINATION AND ADMINISTRATION

Table 19: EBM Coordination and administration

	Work Address	Contact Data (Tel / Fax, Email, Web)	Work Area
Bittner, Doris	SFB 1540 EBM, Martensstraße 5a, 91058 Erlangen	+49 9131 85 20783 / -20785, doris.bittner@fau.de, www.ebm.fau.eu	EBM Administration
Dakkouri-Baldauf, Dr. rer. nat., Andrea	SFB 1540 EBM, Martensstraße 5a, 91058 Erlangen	+49 9131 85-20782 / -20785, andrea.dakkouri@fau.de, www.ebm.fau.eu	EBM Coordination

6.2 NETWORK AND COOPERATION

Sophia Auer

Partner institute	Researchers involved	Research topic
Institute of Continuum Mechanics and Biomechanics	Silvia Budday, Nina Reiter	Direction-dependent mechanics of human corpus callosum and lower brain stem
Institute for Neuropathology, UK Erlangen	Ingmar Blumcke, Lucas Hoffmann, Erica Cecchini	Perineuronal nets in MCDs
Neuropathology, Neuroradiology, UK Bonn, UK Bielefeld-Bethel	Ingmar Blumcke, Stefan Rampp, Vadym Gnatkovsky, Ahmed Gaballa	MRI/SEEG/Histopathology Co-Registration

Lars Bischof

Partner institute	Researchers involved	Research topic
Institute for Neuropathology, Univ. clinic Erlangen	Katja Kobow, Kristina Karandasheva	Neuronal growth in 2D and 3D matrices
Mathematics in Life Sciences	Mathar Kravikass, Dr. Vasily Zaburdaev	Modelling of mechanical cell-matrix interactions

Erica Cecchini

Partner institute	Researchers involved	Research topic
Institute of Continuum Mechanics and Biomechanics	Silvia Budday, Jan Hinrichsen, Nina Reiter	*In silico* modeling of brain malformations
Institut für Funktionelle und Klinische Anatomie	Friedrich Paulsen, Sophia Auer	Deep extracellular matrix (ECM) quantification and phenotyping in healthy human brain and cortical malformations
Epilepsiezentrum Neurochirurgie	Stefan Rampp	Human brain datasets and multimodal and multiparametric imaging
Neuroradiology	Arnd Dörfler	(Ultra-)High-field imaging of human brain malformations

Thomas Fleming

Partner institute	Researchers involved	Research topic
MPZPM Erlangen	Sebastián Vásquez Sepúlveda, Maria Tarczewska, Kristian Franze	AFM Measurements
Chair of Biochemistry and Molecular Medicine, FAU	Sven Falk	scRNA-seq analysis

Clara Froidevaux

Partner institute	Researchers involved	Research topic
Institute of Biomaterials, FAU	Markus Lorke, Sonja Kuth, Aldo Boccaccini, Project X03	Hydrogels as substrates for explants
Max Planck Institute for the Science of Light, Erlangen	Stephanie Möllmert, Jana Bachir Salvador	AFM and Brillouin Microscopy measurements
MPZPM Erlangen	Sebastián Vásquez Sepúlveda, Kristian Franze	AFM Measurements
Lehrstuhl Kontinuumsmechanik	Oskar Neumann, Silvia Budday	Nanoindenter measurements
AIMI Lab FAU	Katharina Breininger	Development of machine learning program for morphology analysis

Shanice Heidenreich

Partner institute	Researchers involved	Research topic
Institute of Biomaterials, Department of Materials Science and Engineering, FAU	Markus Lorke	Development of hydrogel matrices for soft tissue applications
Department of Biology	Alexandra Schambony, Clara Froidevaux	Mouse brain sections on the vibratome
Institute of Continuum Mechanics and Biomechanics	Silvia Budday, Jessica Faber	Mechanical measurements and evaluation

Konstantin Hein

Partner institute	Researchers involved	Research topic
FAU, Institute of Continuum Mechanics and Biomechanics / Institute of Applied Mechanics	Silvia Budday, Rahul Ramachandran	AFM for deep cell indentation

Jan Hinrichsen

Partner institute	Researchers involved	Research topic
FAU, Institute of Continuum Mechanics and Biomechanics (Silvia Budday – **A01**/ **B01**)	Nina Reiter	Microstructure - Mechanics relation of human brain tissue

FAU, Institute of Functional and Clinical Anatomy (Friedrich Paulsen – A02, Lars Bräuer, Martin Schicht)	Sophia Auer (A02)	Mechanical characterization of human brain tissue from body donors. Correlation of tissue component concentration with mechanical properties.
Universitätsklinikum Erlangen-Neuropathologisches Institut (Ingmar Blümcke – A02)	Lucas Hoffmann (A02), Erica Cecchini (A02)	Mechanical characterization of human brain tissue from epilepsy surgery. Histological analysis of tested tissue. Investigating links between pathologies and mechanical behavior.
Universitätsklinikum Erlangen-Neurochirurgie (Arnd Dörfler – A02)	Stefan Rampp (A02)	MRT imaging of human brains prior to mechanical testing.
Biophysics Group, Department of Physics (Ben Fabry – C05)	David Böhringer	Mechanical characterization of collagen hydrogels.
ETH Zürich (Laura de Lorenzis)	Moritz Flaschel	Automated hyperelastic model discovery for human brain tissue (publication).
Institute of Medical Physics and Microtissue Engineering (Kristian Franze – B02/ A05)	Julia Becker, Alexander Winkel	Viscoelastic modeling of rat spinal cord AFM data.
FAU, Institute of Continuum Mechanics and Biomechanics (Silvia Budday – A01/ B01)	Alexander Greiner (B01)	Poroviscoelastic characterization of hydrogels.
FAU, Institute of Continuum Mechanics and Biomechanics (Silvia Budday – A01/B01)	Oskar Neumann (B01)	Mechanical characterization of human spinal cord tissue.
FAU, Institute of Applied Mechanics (Paul Steinmann – B01/C01)	Rahul Gopalan Ramachandran (B01)	Inverse parameter identification for AFM data.

Kristina Karandasheva

Partner institute	Researchers involved	Research topic
Institut für Physik der Kondensierten Materie	Ben Fabry, Lars Bischof	Quantification of neuronal network formation using time-lapse and traction-force microscopy

Mathar Kravikass

Partner institute	Researchers involved	Research topic
Chair of Biochemistry and Molecular Medicine, FAU	Federica Furlanetto, Alejandro Segura, Pritha Dolai, Sven Falk, Marisa Karow	A04/C01 - Aberrant formation of long-range projections across different neurodevelopmental disorders converges on molecular and cellular nexuses

Markus Lorke

Partner institute	Researchers involved	Research topic
Chair of Animal Physiology, FAU	Renato Frischknecht, Ezgi Erterek, Bartomeu Perelló Amorós,	Cortical neurons in Contact with OHA hydrogels
Chair of Biochemistry and Molecular Neurosciences, FAU	Michael Tranchina	Encapsulated organoids in OHA matrix
Chair of Biochemistry and Molecular Medicine, FAU	Shanice Heidenreich	Reaction of different cell types to OHA encapsulation
Institute of Neuroanatomy, University of Bonn	Maik Hintze	Reaction of different patient-derived neuronal cells to OHA encapsulation

Oskar Neumann

Partner institute	Researchers involved	Research topic
Institute of Continuum Mechanics and Biomechanics, FAU	Jan Hinrichsen	Inverse identification of material parameters for human spinal cord tissue
Institute of Continuum Mechanics and Biomechanics, FAU	Nina Reiter	Multimodal mechanical testing on human and porcine spinal cord with the rheometer
Institute of Applied Mechanics, FAU	Laura Ruhland	Magnetic resonance elastography (table-top) experiments on porcine spinal cord
Max Planck Institute for the Science of Light	Daniel Wehner	Scientific exchange on the mechano-biological aspects of spinal cord regeneration
Max Planck Institute for the Science of Light	Stephanie Möllmert	Scientific exchange on the mechano-biological aspects of spinal cord regeneration
Institute of Anatomy/Neuroanatomy, Uni Bonn	Maik Hintze	Scientific exchange on the experimental investigation and anatomy of spinal cord (staining, cutting, and general questions)
Max Planck Institute for the Science of Light	Jana Bachir & Stephanie Möllmert	Mechanical experiments on porcine spinal cord tissue with Brillouin Microscopy and Atomic Force Microscopy
Max Planck Institute for the Science of Light	Stephanie Möllmert	Scientific exchange and provision of mechanical and biological data of the adult zebrafish during spinal cord regeneration
Institute of Radiology & Institute of Neuroradiology FAU	Guillaume Flé	Magnetic resonance elastography (1.5 Tesla) experiments on porcine spinal cord
Department of Artificial Intelligence in Biomedical Engineering (AIBE), FAU	Mareike Thies & Katharina Breininger	Image-based counting of axons in the adult zebrafish at different time points over the course of regeneration
Mechanobiology Lab, Division of Biomedical Engineering, University of Cape Town	Thomas Franz	Collaboration in a publication on the indenter scale-dependence of spinal cord tissue under spherical indentation
Max Planck Institute for the Science of Light	Nora John (Wehner Lab)	Investigation of morphological changes of zebrafish larvae over the course of spinal cord regeneration
Institute for Anatomy, FAU	Friedrich Paulsen	Histological analyses of mechanically tested porcine spinal cord sample
Institute for Anatomy, FAU	Michael Scholz	3D reconstructions of mechanically tested porcine spinal cord sample
Institute of Condensed Matter Physics, FAU	Lars Bischof	Discussion on neuronal growth cone traction force microscopy and usability for model approaches

Nina Reiter

Partner institute	Researchers involved	Research topic
Institute of Functional and Clinical Anatomy	Friedrich Paulsen, Martin Schicht, Sophia Auer	Mechanical characterization and histological analysis of human brain tissue from body donors (connected to B01, A01, A02)
Neuropathology	Ingmar Blümcke, Lucas Hoffmann	Mechanical characterization and histological analysis of human brain tissue samples from epilepsy surgery (connected to A01, A02)
Institute of Biochemistry	Marisa Karow, Sven Falk, Michael Tranchina	Impact of mechanical loading on the development of human brain organoids (connected to A04)
Institute of Applied Mechanics	Paul Steinmann, Yashasvi Verma	Influence of embedded blood vessels on agarose mechanics (connected to X01)
Biomaterials	Aldo Boccaccini, Markus Lorke	Mechanical investigation of hydrogel degeneration (connected to X03)

Humberto Romero Limon

Partner institute	Researchers involved	Research topic
FAU, Institute of Continuum Mechanics and Biomechanics, Institute of Applied Mechanics	Silvia Budday, Rahul Gopalan Ramachandran	AFM Modelling

Laura Ruhland

Partner institute	Researchers involved	Research topic
Institute of Continuum Mechanics and Biomechanics (B01)	Oskar Neumann / Harsh Vardhan Surana	Nanoindentation on porcine brain tissue
Department of Neuropathology (C03)	Katja Kobow	Tabletop MRE of rat brains with and without Glutamate

Maria Tarczewska

Partner institute	Researchers involved	Research topic
Max Planck Institute for the Physics of Light; The Research Group for Neuroregeneration	Daniel Wehner	Spinal cord regeneration

Michael Tranchina

Partner institute	Researchers involved	Research topic
Institute of Biomaterials, FAU Erlangen	Markus Lorke, AG Boccaccini	Investigating effects of Hydrogels with tunable stiffnesses on lineage decision of cells within human brain organoids
Continuum Mechanics (focusing on Biomechanics), FAU Erlangen.	Nina Reiter, AG Budday.	Investigating effects of mechanical manipulations of human brain organoids compressed with a rheometer.
Continuum Mechanics (focusing on Biomechanics), FAU Erlangen.	Julia Kolb, AG Budday.	Following / observing behavior of cells in human brain organoids under rheometer compression with 2-photon microscope.

Continuum Mechanics (focusing on Biomechanics), FAU Erlangen.	Oskar Neumann, AG Budday.	Measuring stiffness of human brain organoids slices with nano indenter.
Max-Planck-Zentrum für Physik und Medizin, FAU Erlangen.	Sebastián Vásquez-Sepúlveda, AG Franze.	Measuring stiffness of human brain organoids slices with AFM.

Sebastián Vásquez-Sepúlveda

Partner institute	Researchers involved	Research topic
MPZPM, Erlangen, Germany	Nora John, Daniel Wehner	AFM measurements of spinal cord in Zebrafish
Helmholtz Zentrum München German Research Center for Environmental Health	Thomas Distler and Magdalena Götz	Stiffness measurement of fibrin-based gels for neuronal tissue embedding
Friedrich-Alexander-Universität Erlangen–Nürnberg (**A04**)	Michael Tranchina and Marisa Karow	Stiffness measurement of Human brain Organoids embedded in hydrogels with tunable initial stiffnesses
Friedrich-Alexander-Universität Erlangen–Nürnberg (**A03**)	Clara Froidevaux and Alexandra Schambony	Stiffness measurement of alginate-based gels for organoid embedding
University of Hohenheim	Valentina Trivigno and Kerstin Feistel	Stiffness measurement of Neural tube closure
Uniklinikum Erlangen	Lynn Menzl and Dieter Henrik Heiland	Stiffness measurements of *ex-vivo* human brain tissue

Yashasvi Verma

Partner institute	Researchers involved	Research topic
Charité, Berlin, Germany	Jakob Schattenfroh, Ingolf Sack	MRE testing of brain samples and phantom materials
SISSA, Pisa, Italy	Luca Heltai	Computational modeling of vasculature
University of Washington, Seattle, USA	Mehmet Kurt	Non-linear inversion for MRE

6.3 PARTICIPATION IN CONFERENCES AND CONGRESSES

6.3.1 CONFERENCES AND RESEARCH STAYS OF PRINCIPAL INVESTIGATORS

Table 20: Conferences and research stays of PIs

PI	Date	Conference	Title of own presentation / participation only
Breininger, Katharina	09.03.25 / 11.03.25	German Conference on Medical Image Computing, Regensburg	Committee / Participation, Co-/Last author of full-paper contribution
Breininger, Katharina	18.09.25 / 20.09.25	CURAC 2025, Heidelberg	Co-/Last author of short paper contribution
Breininger, Katharina	23.09.25 / 27.09.25	International Conference on Medical Image Computing and Computer Assisted Intervention, Daejeon, Republic of Korea	Workshop organizer (Mitosis Domain Generalization; Computer-Aided Pelvic Imaging). Co-/Last author of full-paper contribution
Breininger, Katharina	27.10.25 / 28.10.25	Bavarian Conference on AI in Medicine, Munich	Co-organizer / Participation
Budday, Silvia	23.04.25 / 25.04.25	EUROMECH 647, Glasgow, UK	*Mechanical instabilities in the developing human brain: from cells to cortical folding*

Budday, Silvia	07.07.25 / 11.07.25	ESMC2025, Lyon, France	*Exploring the link between cellular mechanisms and cortical folding in the developing human brain*
Budday, Silvia	10.12.25 / 12.12.25	Research School: Digital Twins of the Human Body, Trieste, Italy	*Poro-viscoelasticity of brain tissue: modeling and inverse parameter identification*
Falk, Sven	24.09.25 / 27.09.25	CSHL Meeting Cell State Conversation, Cold Spring Harbor, NY, USA	*Integration of multivariate parameters for negotiating successful direct lineage reprogramming into induced neurons*
Frischknecht, Renato	26.03.25 / 29.03.25	16th Göttingen Meeting of the German Neuroscience Society (NWG)	Participation only; last author of poster: *The Role of Mechanics for Neuronal Plasticity*
Kobow, Katja	26.03.25 / 28.03.25	Dreiländertagung (DGfE, ÖGfE, SEL), Salzburg, Austria	*Accelerated biological aging is a hallmark of epilepsy.* *Novel sEEG-Biomarker in MOGHE*
Kobow, Katja	16.04.25	Neuropädiatrische Fortbildung, Zürich, Switzerland	*Epigenetics of structural brain lesions: Bridging bench discoveries with clinical applications in epilepsy*
Kobow, Katja	10.05.2025	Curso de Neuroimagen en Epilepsia para Jóvenes en Neurología, Barcelona, Spain	*Challenges in the Classification of FCD from a Pathological Perspective*
Kobow, Katja	11.06.25 / 14.06.25	ECNP 2025, Maastricht, Netherlands	*DNA methylation-based classification of MCDs* *(and more)*
Kobow, Katja	21.07.25 / 01.08.25	San Servolo Summer School 2025, Venice, Italy	*Somatic variants in MCD; Epigenetics in focal epilepsy; Introduction to digital Neuropathology*
Kobow, Katja	25.08.25 / 29.08.25	WONOEP 2025, Cascais, Portugal	*Accelerated biological aging and the resilient brain in epilepsy - a contradiction?*
Kobow, Katja	30.08.25 / 03.09.25	International Epilepsy Congress, Lisbon, Portugal	Participation only
Kobow, Katja	19.09.2025	IEL Annual Epilepsy Expert Day 2025, Dublin, Ireland	*Epigenetics in epilepsy – bridging basic science with clinical application*
Kobow, Katja	12.11.25 / 14.11.25	ERN EpiCARE meeting "In search of lost time 6", Rome, Italy	*AI in the OMICs era*
Kürten, Stefanie	21.03.25	überDACHt – Roche Science & Innovation Summit, Basel, Switzerland	*OcreScreen-Studie: Measurements of CNS-reactive B cells and their specificity in the blood of ocrelizumab-treated patients*
Kürten, Stefanie	26.03.25	Wissenschaftliches Symposium am UKB – Darm trifft Hirn: Mikrobiota bei neurologischen Erkrankungen, Bonn, Germany	*Mehr als nur ein Bauchgefühl – eine Liaison zwischen Darm, Mikrobiom und Multipler Sklerose*
Kürten, Stefanie	27.09.25	Kölner Neuroimmunologie-Multiple-Sklerose-Symposium 2025, Köln, Germany	*Der Darm und das Immunsystem*
Kürten, Stefanie	04.11.25 / 07.11.25	Kongress der Deutschen Gesellschaft für Neurologie (DGN) 2025, Berlin, Germany	*Milch und Zucker bei der Entstehung und Behandlung von Multipler Sklerose*
Möllmert, Stephanie	18.02.25	Faculty for Chemistry and Pharmacy, University of Würzburg, Germany	*The Dynamic Nexus of Mechanics and Biochemistry, and Its Implications for Pharmaceutical Science*

Möllmert, Stephanie	30.06.25 / 04.07.25	Italian Society for Pure and Applied Biophysics (SIBPA), European Biophysical Societies' Association (EBSA) meeting, Rome, Italy	*Across Scales and Systems: Mechanical Signatures in Retina and Mucus*
Möllmert, Stephanie	25.11.25 / 27.11.25	9th International BioBrillouin Conference, Berlin, Germany	*Mapping Mechanical Microenvironments in Soft Tissues*
Steinmann, Paul	23.04.25 / 25.04.25	EUROMECH 647, Glasgow, UK	*Capturing nonlocal wrinkling instabilities in bilayered systems through peridynamics*
Steinmann, Paul	11.11.25 / 14.11.25	MECOM 2025, Buenos Aires, Argentina	*From the Cellular via the Tissue to the Organ Level. A Journey Exploring Brain Mechanics*
Wehner, Daniel	30.01.25	Interdisciplinary Postgraduate Program in Molecular Medicine (IPMM) Lecture Series, Center for Molecular Medicine Cologne, Cologne, Germany	*Biphasic inflammation control by dedifferentiated fibroblasts enables axon regeneration after spinal cord injury*
Wehner, Daniel	15.05.25 / 16.05.25	Symposium Spine Science 2025, German Spine Society (DWG), Frankfurt, Germany	*Learning to mend the spinal cord from zebrafish*
Wehner, Daniel	16.06.25 / 19.06.25	IAS Symposium on Frontiers in Neuroscience, Hong Kong, China	*ECM composition, structure, and mechanical properties direct axon regeneration in the vertebrate CNS*
Wehner, Daniel	19.09.25	FOR 2722 Seminar, University of Cologne, Cologne, Germany	*ECM composition, structure, and mechanical properties direct axon regeneration in the vertebrate CNS*
Wehner, Daniel	06.11.25 / 07.11.25	3rd Cologne Neuroscience Day, Cologne, Germany	*Axon regeneration in the vertebrate central nervous system: It's all in your ECM*
Willner, Kai	20.07.25 / 24.07.25	18th US National Congress on Computational Mechanics, Chicago, USA	Participation only

6.3.2 CONFERENCES OF (POST-)DOCTORAL RESEARCHERS

Sophia Auer

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
24.09.25 / 26.09.25	Jahrestagung der Anatomischen Gesellschaft	Würzburg, Germany	Poster: *Quantitative Description of Perineuronal Nets in Focal Cortical Dysplasia Type IIb*
30.09.25 / 01.10.25	EBM Symposium 2025	Erlangen, Germany	Poster: *Quantitative Description of Perineuronal Nets in Focal Cortical Dysplasia Type IIb*

Oliver Aust

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
30.09.25 / 01.10.25	EBM Symposium 2025	Erlangen, Germany	Poster: *Automated classification of nuclei in whole slide brain tissue samples*

Jana Bachir Salvador

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
03.04.25 / 05.04.25	2nd International Conference on Bio-Medical Photonics	Montpellier, France,	***Poster:*** *The role of oxidative stress in modulating mechanics of the central nervous system*

25.11.25 / 27.11.25	BioBrillouin	Berlin, Germany	***Poster:*** *Multiscale Mapping of Oxidative Stress–Induced Mechanical Changes in the Central Nervous System*

Lars Bischof

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
30.09.25 / 01.10.25	EBM Symposium 2025	Erlangen, Germany	Poster: *Molecular mechanisms of neuronal mechanotransduction*

Erica Cecchini

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
11.06.25 / 14.06.25	ECNP2025	Maastricht, Netherlands	Poster: *Impact of SLC35A2 Variants on Protein Expression in Mild Malformation of Cortical Development with Oligodendroglial Hyperplasia in Epilepsy (MOGHE)* Oral Presentation: *Impact of SLC35A2 Variants on Protein Expression in Mild Malformation of Cortical Development with Oligodendroglial Hyperplasia in Epilepsy (MOGHE)*
30.09.25 / 01.10.25	EBM Symposium 2025	Erlangen, Germany	Poster: *The genetic signature of MOGHE: the somatic SLC35A2 brain variant and the Y chromosome mosaicism*

Ezgi Erterek

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
26.03.25 / 29.03.25	16th Göttingen Meeting of the German Neuroscience Society (NWG)	Göttingen, Germany	Poster: *The Role of Mechanics for Neuronal Plasticity*
30.09.25 I 01.10.25	EBM Symposium 2025	Erlangen, Germany	Poster: *The Role of Mechanics for Neuronal Plasticity*

Michael Fedders

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
30.09.25 / 01.10.25	EBM Symposium 2025	Erlangen, Germany	Poster: *Dynamic compressibility of the in vivo human brain across a wide range of acoustic frequencies*

Guillaume Flé

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
30.09.25 / 01.10.25	EBM Symposium 2025	Erlangen, Germany	Poster: *Reproducibility study of brain magnetic resonance elastography*

Soheil Firooz

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
05.01.25 / 09.01.25	Advances in Applied Mechanics Conference	Gran Canaria, Spain	Talk: *A micromorphic-based artificial diffusion method for stabilized finite element approximation of convection-diffusion problems*
06.07.25 / 09.07.25	30th Congress of the European Society of Biomechanics (ESB)	Zürich, Switzerland	Talk: *Cellular Aggregate formation: continuum modelling and computational challenges.*

30.09.25 / 01.10.25	EBM Symposium 2025	Erlangen, Germany	Poster: *Cellular Aggregate formation: continuum modelling and computational challenges.*
07.12.25 / 10.12.25	9th Asian Pacific Congress on Computational Mechanics	Brisbane. Australia	Talk: *Cellular Aggregate formation: continuum modelling and computational challenges.*

Thomas Fleming

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
06.07.25 / 11.07.25	Central Nervous System Injury and Repair Gordon Research Conference,	Lucca (Barga), Italy.	Poster: *Aortic carboxypeptidase-like protein controls central nervous system scarring after injury*
30.09.25 / 01.10.25	EBM Symposium 2025	Erlangen, Germany	Poster: *Aortic carboxypeptidase-like protein controls fibrotic scar-ring after spinal cord injury*

Rahul Gopalan Ramachandran

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation/participation only
07.04.25 / 11.04.25	GAMM Annual Meeting; 95th Annual Meeting	Poznan, Poland	Talk: *Multi-modal mechanical characterization of spinal cord tissue*
06.07.25 / 09.07.25	ESBiomech	Zürich, Switzerland	Talk: *Multi-modal mechanical characterization of spinal cord tissue*
30.09.25 / 01.10.25	EBM Symposium 2025	Erlangen, Germany	Poster: *Finite element modeling of spinal cord regeneration in zebrafish larvae*

Alexander Greiner

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation/participation only
08.09.25 / 10.09.25	ICCB	Rome, Italy	Talk: *Model-driven exploration of poro-viscoelasticity in human brain tissue: be careful with the parameters!*

Shanice Heidenreich

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
30.09.25 I 01.10.25	EBM Symposium 2025	Erlangen, Germany	Poster: *Cellular differentiation in brain tissue-like matrices*

Konstantin Hein

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation/participation only
30.09.25 / 01.10.25	EBM	Erlangen, Germany	Poster: *From mental to mechanical stress*
12.11.25 / 15.11.25	Gage	San Diego, USA	Talk: *From mental to mechanical stress*
15.11.25/ 19.11.25	SFN	San Diego, USA	Poster: *From mental to mechanical stress*
25.11.25/ 27.11.25	BioBrillouin	Berlin, Germany	Poster: *From mental to mechanical stress*

Jan Hinrichsen

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation/participation only
27.07.25 / 31.07.25	ISB	Stockholm, Sweden	Talk: *Mechanical characterization of epileptic human brain tissue*
21.09.25 / 24.09.25	GACM	Braunschweig, Germany	Talk: *Modeling brain folding in epilepsy patients with focal cortical dysplasia*
30.09.25 / 01.10.25	EBM Symposium 2025	Erlangen, Germany	Talk: *Towards an in silico model of brain malformations in FCD II epilepsies.*

Maik Hintze

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
30.09.25 / 01.10.25	EBM Symposium 2025	Erlangen, Germany	Poster: *In vitro culture model of white and gray matter astrocytes from human brain biopsies to study astrocyte cell biology*

Kristina Karandasheva

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
24.05.25-27.05.25	European Society of Human Genetics (ESHG)	Milan, Italy	Poster: *Molecular Dynamics Insights into SLC35A2: Unraveling Dimerization Interfaces and Pathogenic Mutations in MOGHE and CDG*
30.08.25-03.09.25	36th International Epilepsy Congress	Lisbon, Portugal	Poster: *Epilepsy-Associated Chromatin Conformation and Structural Variants Revealed by Hi-C*
24.11.25-25.11.25	From genes to treatment: Understanding epilepsy genetics and precision medicine	Oslo, Norway	Talk: *Somatic 1q Amplification Drives Aberrant 3D Chromatin Architecture in Polymicrogyria*

Mathar Kravikass

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
16.03.25 / 21.03.25	DPG Soft-matter, Regensburg	Regensburg, Germany	Talk: *Modelling neuron growth dynamics and role of extracellular matrix*

Markus Lorke

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
14.09.25 / 17.09.25	ISBF	Warsaw, Poland	Talk: *Development of oxidized hyaluronic acid-based hydrogels for neuronal tissue engineering: effects of matrix stiffness on primary neurons*
30.09.25 / 01.10.25	EBM Symposium 2025	Erlangen, Germany	Poster: *In situ crosslinked oxidized hyaluronic acid-based hydrogels for soft tissue engineering*

Sudipta Mukherjee

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
25.06.25	Rising Neurons Symposium	Erlangen, Germany	Talk: *Mechanical regulation of long-range chemical signalling.*

Oskar Neumann

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
06.07.25 / 09.07.25	30th Congress of the European Society of Biomechanics (ESB)	Zürich, Switzerland	Poster: *Mechanical analysis of spinal cord tissue*
30.09.25 / 01.10.25	EBM Symposium 2025	Erlangen, Germany	Poster: *In silico model for spinal cord regeneration*

Stefan Rampp

From/to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
30.09.25 / 01.10.25	EBM Symposium 2025	Erlangen, Germany	Talk: *(Towards) Linking Mechanical Properties with Neuronal Function*
02.11.25 / 05.11.25	ISACM 2025,	Las Vegas, NV, USA	Talk: *(Towards) Linking Mechanical Properties with Neuronal Function*

Nina Reiter

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
08.09.25 / 10.09.25	ICCB	Rome, Italy	Talk: *Direction-dependent behavior of human brain white matter: don't overestimate the role of axons*
21.09.25 / 24.09.25	GACM	Braunschweig, Germany	Poster: *Microstructure-Motivated Modeling of Human Brain Viscoelasticity*
30.09.25 / 01.10.25	EBM Symposium 2025	Erlangen, Germany	Poster: *Effects of postmortem degradation on human brain tissue mechanics*

Romero Limon Humberto

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
30.09.25 / 01.10.25	EBM Symposium 2025	Erlangen, Germany	Poster: *Poster: Age-dependent changes in nuclear morphology and tissue organization in adult mouse hippocampus.*
25.11.25 / 27.11.25	9th International BioBrillouin Meeting	Berlin, Germany	Poster: *From mental to mechanical stress*

Laura Ruhland

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
07.04.25 / 11.04.25	95th Annual Meeting of the International Association of Applied Mathematics and Mechanics (GAMM)	Poznan, Poland	Talk: *Experimental and numerical characterisation of a viscoelastic material by unifying different time scales.*
27.07.25 / 31.07.25	XXX Congress of the International Society of Biomechanics, Stockholm 2025 (ISB)	Stockholm, Sweden	Talk: *Viscoelastic characterization of porcine brain tissue in the quasi-static and high-frequency domains.*
17.09.25 / 19.09.25	ECCOMAS 8th Young Investigators Conference	Pescara, Italy	Talk: *Experimental and numerical characterization of porcine brain tissue in the time and frequency domain.*

Maria Tarczewska

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation/participation only
05.07.25 / 06.07.25	Central Nervous System Injury and Repair, Gordon Research Conference 2025	Lucca, Italy	Poster: *Mechanics of spinal cord regeneration in Xenopus laevis*
17.08.25 / 21.08.25	20th International Xenopus Conference	Porthmouth, UK	Poster: *Mechanics of spinal cord regeneration in Xenopus laevis*

Michael Tranchina

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
09.04.25 / 11.04.25	GRK Symposium 2025	Erlangen, Germany.	Poster: *The role of mechanics in orchestrating neural lineage decisions.*
30.09.25 / 01.10.25	EBM Symposium 2025	Erlangen, Germany.	Poster: *The role of mechanics in orchestrating neural lineage decisions*
10.11.25	Karow Lab Retreat 2025	Erlangen, Germany.	Presentation: *The role of mechanics in orchestrating neural lineage decisions*
13.11.25	Interpretable machine learning for neural system identification	Erlangen, Germany.	Participation only
20.11.25	risingNEUROs 2.0	Erlangen, Germany.	Participation only

Nicole Tueni

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
06.07.25 / 09.07.25	30th Congress of the European Society of Biomechanics (ESB)	Zürich, Switzerland	Poster: *Incorporating regional material parameters in simulating tumor growth and cerebral atrophy*

Sebastián Vásquez-Sepúlveda

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
07.04.25 / 11.04.25	Emerging concepts of the Neuronal Cytoskeleton	Maitencillo, Chile	Poster: *The mechanical role of the UDP-galactose translocator Slc35A2 in brain malformations*
17.08.25 / 21.08.25	20th International Xenopus Conference	Portsmouth, UK	Poster: *The mechanical role of the UDP-galactose translocator Slc35A2 in brain malformations*
30.09.25 / 01.10.25	EBM Symposium 2025	Erlangen, Germany	Poster: *The mechanical role of the UDP-galactose translocator Slc35A2 in brain malformations*

Yashasvi Verma

From / to	Name of conference	Location	Title of own presentation / title of own poster presentation / participation only
25.05.25 / 28.05.25	Coupled problems	Sardinia, Italy	Talk: *Modelling of Vascular Influence on Brain Tissue Mechanics*
27.07.25 / 31.07.25	ISB 2025	Stockholm, Sweden	Poster: *Modelling of Vascular Influence on Brain Tissue Mechanics*
21.09.25 / 24.09.25	11th GACM	Braunschweig, Germany	Talk: *Effect of Vasculature on Direct Inversion Approach in Magnetic Resonance Elastography of Brain Tissue*
30.09.25 / 01.10.25	EBM Symposium 2025	Erlangen, Germany	Poster: *Numerical and experimental characterization of brain tissue across time scales and physiological conditions using MRE*

6.4 SUMMER SCHOOLS / WINTER SCHOOLS

Erica Cecchini

From / to	Name of school	Location
21.07.25 / 01.08.25	21st San Servolo Advanced Epilepsy Course	San Servolo (Venice), Italy

Michael Fedders

From / to	Name of school	Location
07.04.25 / 11.04.25	Magnet4Cardiac7t Spring School 2025	Würzburg, Germany

Kristina Karandasheva

From / to	Name of school	Location
24.11.25 / 25.11.25	From genes to treatment: Understanding epilepsy genetics and precision medicine	Vika Atrium, Oslo, Norway

7 APPENDICES

7.1 APPENDIX 1: PROGRAM OF THE 2ND EBM UPDATE MEETING

Program of the
2nd EBM Update Meeting
January 31, 2025
MPZPM, Kussmaulallee 2, 91054 Erlangen

Organizational Program

Time	Program Segment	Lead
9:30 – 10:30	EBM Executive Board Meeting	Paul Steinmann, Silvia Budday
10:30 – 12:30	EBM Members' General Assembly	Paul Steinmann, Silvia Budday

Scientific Program

Time	Research Progress Report on	Speaker
PROJECT: ESTABLISHING MAGNETIC RESONANCE ELASTOGRAPHY AT FAU		
12:30 – 12:40	**Y**	Frederik Laun
12:40 – 14:00	LUNCH BREAK	
CROSS-SECTIONAL RESEARCH AREA X		
14:00 – 14:30	**X01 – X03**	Katharina Breininger
FOCAL RESEARCH AREA A: CEREBRAL MECHANICS		
14:30 – 15:00	**A01 – A05**	Sven Falk
15:00 – 15:30	COFFEE BREAK + POSTER EXHIBITION	
FOCAL RESEARCH AREA B: SPINAL MECHANICS		
15:30 – 16:00	**B01 – B05**	Kristian Franze
FOCAL RESEARCH AREA C: CELLULAR MECHANICS		
16:00 – 16:30	**C01 – C05**	Katja Kobow
From 16:30	RECEPTION + POSTER EXHIBITION	

7.2 APPENDIX 2: PROGRAM OF THE 3RD EBM RETREAT

Program of the
3rd EBM Retreat
Hotel Goldner Stern in Muggendorf

October 9, 2025

Start Time	Duration (Minutes)	End Time	Program Item	Speaker
09:15	**00:45**	**10:00**	**Parallel Sessions: #NDW25 Planning & EBM^2**	**NDW25-Orga-Team & Paul Steinmann / Silvia Budday**
10:00	**01:30**	**11:30**	**EBM GA**	**Paul Steinmann / Silvia Budday**
11:30	**00:30**	**12:00**	**Coffee break**	
12:00	00:05	12:05	**B01**	Oskar Neumann / Rahul Gopalan Ramachandran
12:05	00:10	12:15	**B01**	**Paul Steinmann / Silvia Budday**
12:15	00:05	12:20	**B02**	Maria Tarczewska
12:20	00:10	12:30	**B02**	**Kristian Franze**
12:30	00:05	12:35	**B03**	Jana Bachir Salvador
12:35	00:05	12:40	**B04**	Maik Hintze
12:40	00:10	12:50	**B04**	**Stefanie Kürten / Veit Rothhammer**
12:50	00:05	12:55	**B05**	Thomas Fleming
12:55	00:10	13:05	**B05**	**Daniel Wehner**
13:05	00:10	13:15	**B06**	**Danijela Gregurec**
13:15	**01:30**	**14:45**	**Lunch break**	
14:45	00:05	14:50	**C01**	Soheil Firooz / Mathar Kravikass
14:50	00:10	15:00	**C01**	**Vasily Zaburdaev / Paul Steinmann**
15:00	00:05	15:05	**C02**	Ezgi Erterek
15:05	00:05	15:10	**C03**	Kristina Karandasheva
15:10	00:10	15:20	**C03**	**Katja Kobow**
15:20	00:05	15:25	**C04**	Shanice Heidenreich
15:25	00:05	15:30	**C05**	Lars Bischof
15:30	00:10	15:40	**C05**	**Ben Fabry**
15:40	00:10	15:50	**C06**	**Tomohisa Toda**
15:50	00:10	16:00	**C07**	**Henrik Heiland**
16:00	**02:30**	**18:30**	**Team building**	
18:30	**01:30**	**20:00**	**Dinner**	

October 10, 2025

Start Time	Duration (Minutes)	End Time	Program Item	Speaker
08:00	01:30	09:30	**Breakfast and check-out**	
09:30	00:10	09:40	**X01**	Laura Ruhland / Yashasvi Verma / Jakob Ludwig
09:40	00:05	09:45	**Y**	**Guillaume Flé**
09:45	00:15	10:00	**X01**	**Guillaume Flé / Paul Steinmann / Ingolf Sack / Jing Guo**
10:00	00:05	10:05	**X02**	Katharina Breininger
10:05	00:10	10:15	**X02**	**Katharina Breininger**
10:15	00:05	10:20	**X03**	Markus Lorke
10:20	00:10	10:30	**X03**	**Aldo Boccaccini / Irem Unalan**
10:30	**00:30**	**11:00**	**Coffee break**	
11:00	00:05	11:05	**A01**	Jan Hinrichsen
11:05	00:05	11:10	**A02**	Erica Cecchini / Sophia Auer
11:10	00:10	11:20	**A01**	**Silvia Budday / Ingmar Blümcke**
11:20	00:05	11:25	**A04**	Michael Tranchina
11:25	00:10	11:35	**A04**	**Marisa Karow / Sven Falk**
11:35	00:05	11:40	**A03**	Clara Froidevaux
11:40	00:05	11:45	**A05**	Sebastián Ignacio Vásquez Sepúlveda
11:45	00:10	11:55	**A05**	**Kristian Franze / Alexandra Schambony**
11:55	00:10	12:05	**A07**	**Jana Hutter**
12:05	00:10	12:15	**A08**	**Chichung Lie**
12:15	**01:30**	**13:45**	**Lunch break**	
13:45	00:05	13:50	**A02**	Stefan Rampp
13:50	00:10	14:00	**T01**	**Arnd Dörfler / Frederik Laun**
14:00	00:15	14:15	**T02**	**Daniel Delev / Silvia Budday / Lucas Hoffmann**
14:15	00:10	14:25	**T03**	**Franziska Mathis-Ullrich** - represented by Christian Kunz
14:25	00:10	14:35	**S01**	**Michael Scholz / Friedrich Paulsen**
14:35	**00:30**	**15:05**	**Coffee break**	
15:05	**01:00**	**16:00**	**Final discussion**	**Paul Steinmann / Silvia Budday**

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