Dr. Franziska Schneider works in the lab of Dr. Peter Hegemann at the Humboldt-University in the Department of Experimental Biophysics. Her work involves the use of optogenetics and the light-gated Channelrhodopsin in order to further understand neuronal networks.

Dr. Stefan Remy received his MD from the University of Bonn where also he continued on to do his post-doctoral research in the field of experimental epileptology and cognition research. He completed further post-doctoral work at Northwestern University as a Feodor-Lynen-Alexander van Humboldt fellow before returning to the University of Bonn. Since 2010, Dr. Remy has had a dual appointment with the University of Bonn as an assistant professor and as a group leader (Neuronal Networks) at the German Center for Neurodegenerative Diseases (DZNE).

Dr. Morten Raastad received his MD ad PhD from the University of Oslo. He then went on to do post-doctoral research in Neurophysiology at the University of Copenhagen before returning to the University of Oslo as a professor in the Department of Physiology. Dr. Raastad is currently an assistant professor in the Department of Physiology at Emory University where his main focus is the communication between neurons in grey matter via axons.

Dr. Albrecht Stroh received his PhD in Biophysics from the Humboldt-University. He completed his post-doctoral studies in the Diesseroth lab at Stanford University and at the Technical University of Munich. He is currently an assistant professor and Research group leader (Molecular Imaging and Optogenetics) at the Johannes Gutenberg University of Mainz. He is the head of the Mainz Animal Imaging Center (MAIC) of the Focus Program Tranlation Neuroscience (FTN).
Towards Multi-color Optogenetics with Optimized Channelrhodopsin Variants
Franziska Schneider and Peter Hegemann, Humboldt-University Berlin, Germany

Channelrhodopsin 2 (ChR2) depicts a blue-activated cation channel that has been used for light-induced membrane depolarization in numerous neurophysiological experiments. However, genomic searches for new channelrhodopsins (ChRs) together with structure-based modifications yielded a variety of ChRs with superior properties, including potent green- and yellow-light activated ChRs. Here, we describe the biophysical characteristics of available high-performance ChRs and their perspective for neuroscience.

References:

Fast Micro-iontophoresis of Glutamate and GABA: A Useful Tool to Investigate Synaptic Integration.
Stefan Remy, German Center for Neurodegenerative Diseases (DZNE) Bonn, Germany

One of the fundamental interests in neuroscience is to understand the integration of excitatory and inhibitory inputs along the very complex structure of the dendritic tree. With fast micro-iontophoresis of glutamate and GABA it is possible to precisely investigate the spatial and temporal integration of glutamatergic excitation and GABAergic inhibition. Microiontophoresis is a reliable, reproducible and affordable method that can be increase our understanding of distance-dependent attenuation of dendritic inputs, the location-dependent interaction of spatially segregated inputs, the influence of GABAergic inhibition on excitatory integration, linear and non-linear dendritic integration modes and more. In this talk I will point out the advantages and limitations of this technique and will give some advice on successful troubleshooting.

References:
Morten Raastad, Emory University School of Medicine
Atlanta, Georgia, USA

The axons of mammalian cortex have been difficult to investigate because they are too thin to allow intracellular recordings. Their action potentials are of particular interest because these axons are different from most axons that have been investigated using intra-axonal or gap techniques. One of the main differences is that grey matter axons typically have closely spaced presynaptic specializations, called boutons or varicosities, distributed along an extremely thin axon.

We were able to use a miniaturized grease-gap method to make long lasting stable recordings of action potentials from bundles of cerebellar parallel fibers in slices from cerebellar cortex. The stability of the recordings was important for the testing of peptide toxins that diffuse very slowly into the slice tissue. The grease gap recordings were amplified with an npi EXT 10-2F differential amplifier with a custom-made 10x gain at the head stage. Signals were small (128 - 416 µV), but 10 – 30 times the noise level (<10 uV peak-to-peak at 1 KHz filter), allowing detection of small changes in action potential amplitude and/or width, the after-potentials, and resting membrane potential. We have used this method to study the contribution of activity and different channel families to the shape of the action potentials with particular emphasis on the depolarizing after-potential in the parallel fibers.

Reference:

Towards All-optical Physiology in vivo: Challenges in Combining Optical Recordings and Optogenetic Manipulations of Neuronal Microcircuitry
Albrecht Stroh, Johannes Gutenberg University of Mainz
Mainz, Germany

Advancement of our understanding of neuronal network dynamics in health and disease requires the simultaneous modulation of the activity of defined populations of neurons combined with an optical readout of neural microcircuitry in the intact CNS. Optogenetics provides tools suitable for noninvasive control of cellular activity on the millisecond timescale. Yet, combining optogenetic modulations with optical methods of detecting neuronal activity remains challenging, particularly in vivo, due to the spectral overlap of the majority of optical indicators and optogenetic actuators, and the required spatio-temporal specificity. We recently showed that an optical fiber-based recording and stimulation system allows for optogenetic stimulation and simultaneous readout of network function of neurons in sensory cortices in vivo. Using this approach, we probed the initiation of thalamo-cortical slow-oscillation-associated Ca2+ waves. Such oscillations occur spontaneously, but may also be evoked by sensory stimulation. They propagate over long distances in the brain and recruit both the cortex as well as the thalamus. We implemented an optogenetic approach to explore basic features of slow-oscillation generation and propagation in the in vivo mouse brain. We monitored the calcium transients associated with slow wave activity by using optic fiber-based fluorometric calcium recordings. We demonstrate that pulse-like optogenetic stimulation (3 - 50 ms) of a small group layer 5 cortical neurons is sufficient for the induction of global brain Ca2+ waves. Surprisingly, we find that the Ca2+ waves behave like global ‘network Ca2+ spikes’. Thus, like ordinary single cell action potentials, Ca2+ waves are evoked in an all-or-nothing manner, exhibit refractoriness during too frequent repetitive stimulation and propagate over long distances into cortex and thalamus.

References: