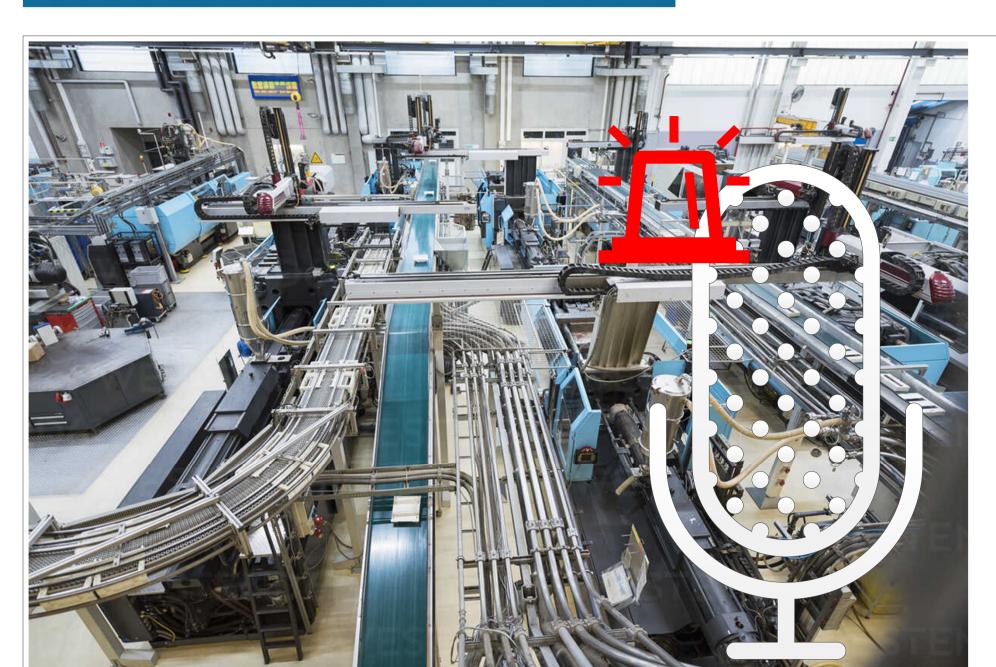


## **NADAR**

## Neuromorphic Acoustic Detection and Recognition

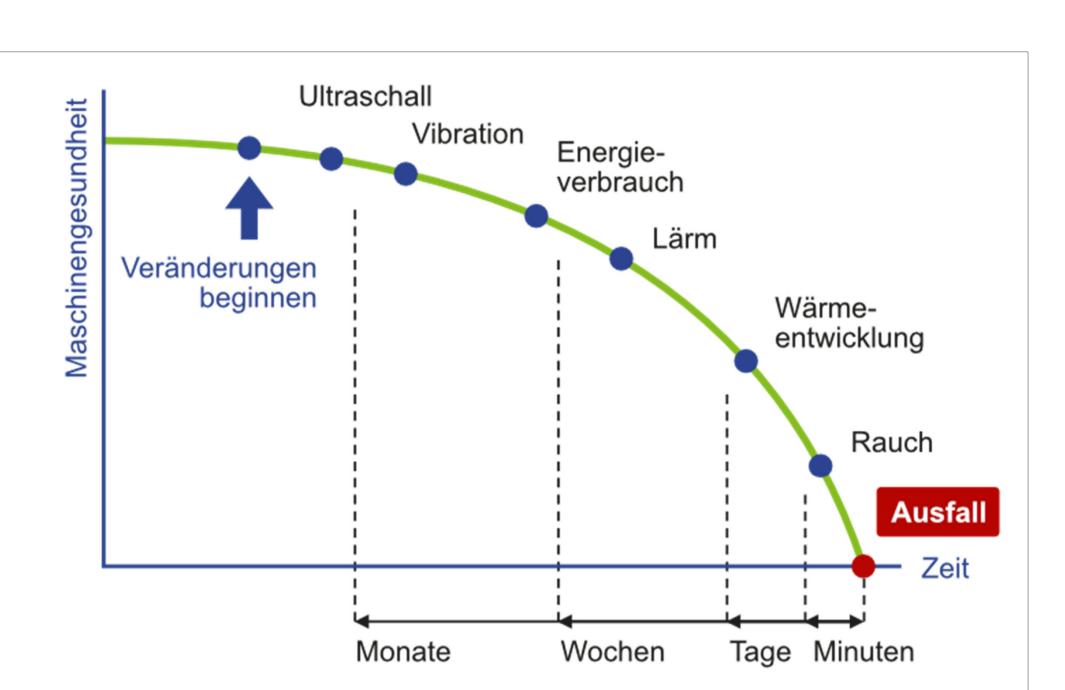
Micro and Nano Electronic Systems Group & Electronic Media Technology Group Tzvetan Ivanov and Stephan Werner



### **Predictive Maintenance**

Offers high potential to save costs, material and energy

- Requires constant monitoring and analysis of machines and process status
- Anomaly detection: Most of the the data is redundant/irrelevant



Solution: Energy-efficient, Bio-inspired Acoustic Monitoring

Processing at sensor level → Early stage complexity reduction → Use of small and efficient ML networks

Event-based data streaming -> Reduces data traffic and improves data security

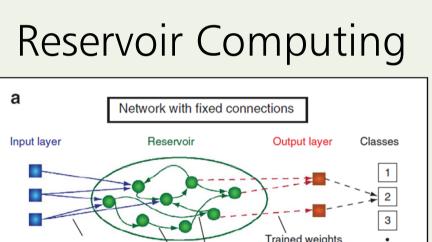
# Efficient Computing – Sound Analysis and Event Detection

using small and hardware-based signal analysis e.g.:

Spike-based neural

Spiking Spiking Neuron

Inputs



Bio-inspired sound localization and separation e.g. with delay lines

spike trains from right auditory pathway

apped delay lines

spike trains from right auditory pathway

Active restoration (90 ms)

Active restoration (90 ms)

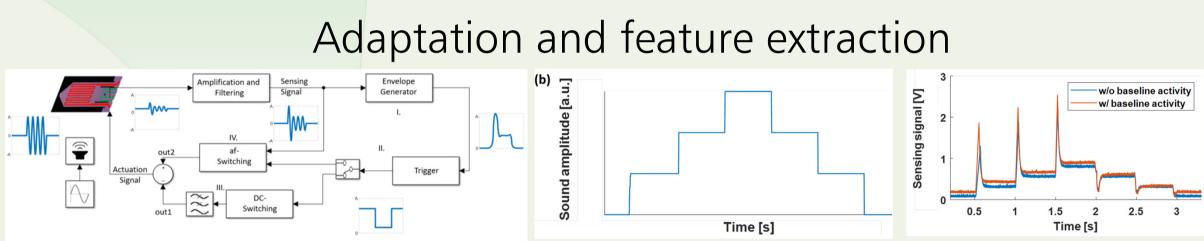
Passive filtering (70 ms)

Overt onsets
Passive segregation (spectro-temporal filters)
General market
onsets
Small effect of selective attention

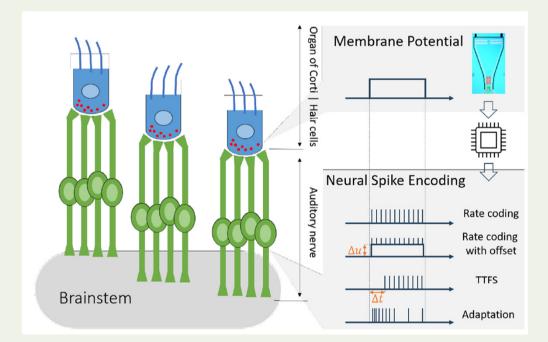
Brodbeck, Christian & Jiao, Alex. (2020). Neural speech restoration at the cocktail party: Auditory
cortex recovers masked speech of both attended and ignored speakers. PLOS Biology. 18. e3000883.

<u>Bio-Inspired Electronic –</u> <u>Event-Based, Smart Sound Sensing</u>

using micro-mechanical (MEMS) sensors with feedback and bio-inspired circuits e.g.:

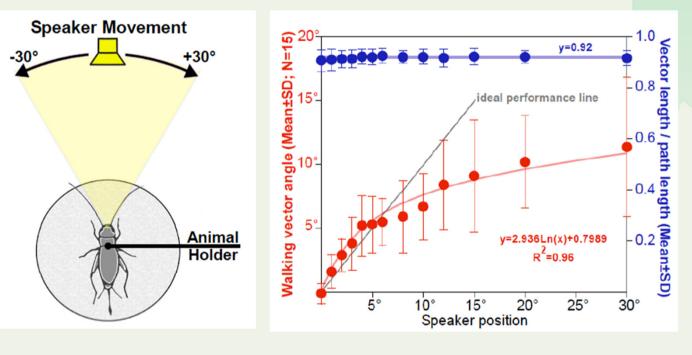


Bio-inspired sound encoding



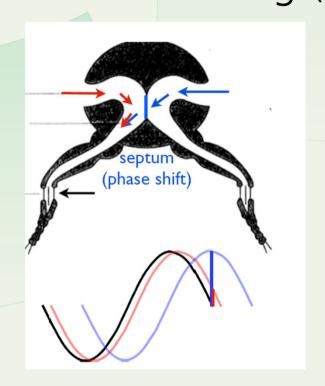
## <u>Smart Technologies –</u> <u>Bio-Inspired Sensor Design and Processing</u>

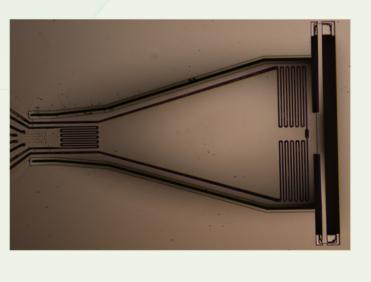
High resolution for localization (~1°) despite strong distortion of localization cues



ACTION CUCS

Integrate biological principles for improved sensing (e.g. phase shift)





#### Work Packages and Time Plan

WP1 – Sensor Design, Development Processing Hardware (MNES group, 1.5 years)

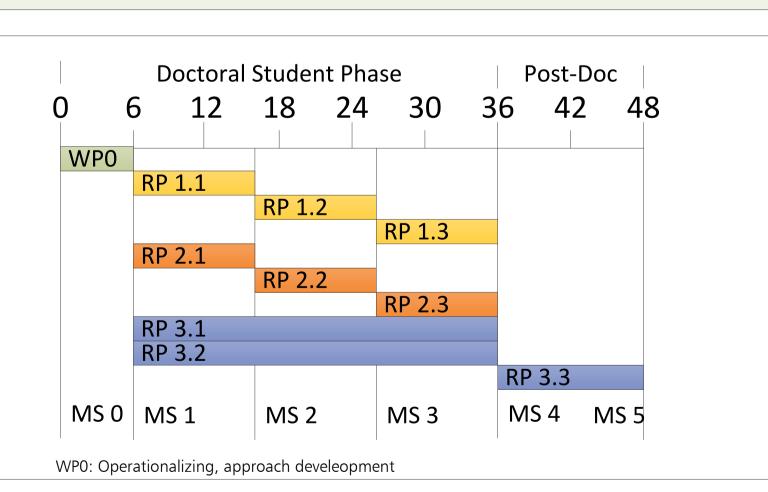
- MEMS design and fabrication
- Neuromorphic circuits for localization and event-detection
- Research stay at U.Ulm (C. Lenk)

WP2 – Audio Measurement, Processing, Acoustic Analysis (EMT group, 1.5 years)

- Event and anomaly detection
- Directional signal analysis, sensor tuning
- Event and stream segregation

WP3 – Evaluation, Application in Industrial
Context (MNES + EMT, 1 year)

- Step-wise validation
- Use-case demonstrator
- Real-time, event-driven acoustic monitoring



## **Interdisciplinary Expertise and Related Projects**

Dr. Tzvetan Ivanov

- MEMS design for sensing and fabricationbio-inspired circuits and smart sensing
- Dr. Stephan Werner
- mobile acoustic measurements
  - acoustic analysis and classificationposition-dynamic (6DoF) real-time auralization

NeuroSensEar (CZS) → innovative sensors controll and processing for future hearing aids Snace (VW) → Neuromorphic sensing with active efficient coding for edge computing SFB1461 (DFG) → biological inspired information processing CoHumanics (CZS) → User acceptance of audiovisual Mixed Reality application

Isoperare (Meta) > Development of auditory prediction models for iso-perceptive areas Multiparties (BMBF) > Development of tools for network-based multi-user Mixed Reality

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