

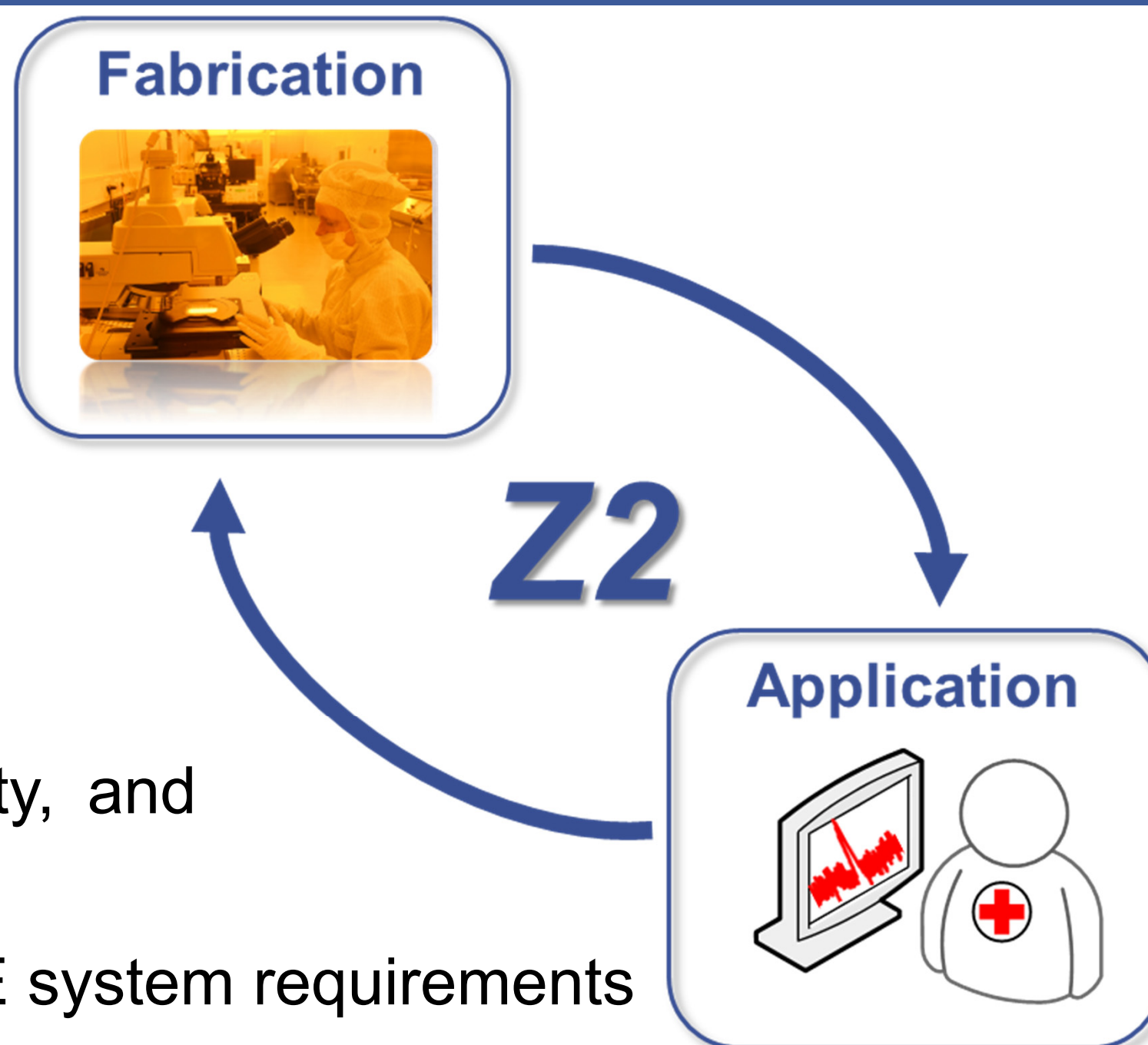
Motivation and Objectives

Motivation:

- Characterize ME sensors and resulting systems
- Standardize measurements and methods for all ME sensors
- Support optimum integration in biomedical applications

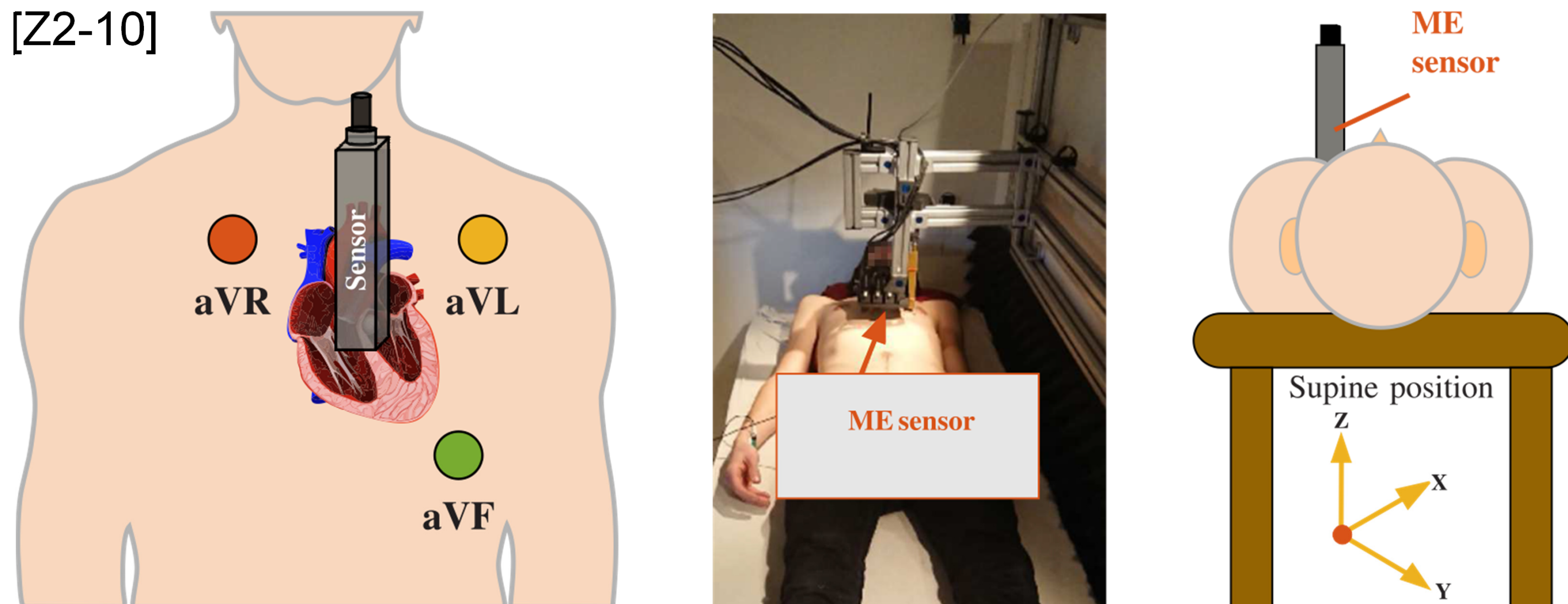
Main objectives:

- Quality assurance, reproducibility, and ME sensor system improvement
- Application support to ensure ME system requirements are satisfied in clinical settings
- Expert bodies collaboration to adapt existing evaluation concepts for high-performance magnetic field sensors
- Toolkit establishment for readout circuit selection and reuse



Results of the Second Funding Period

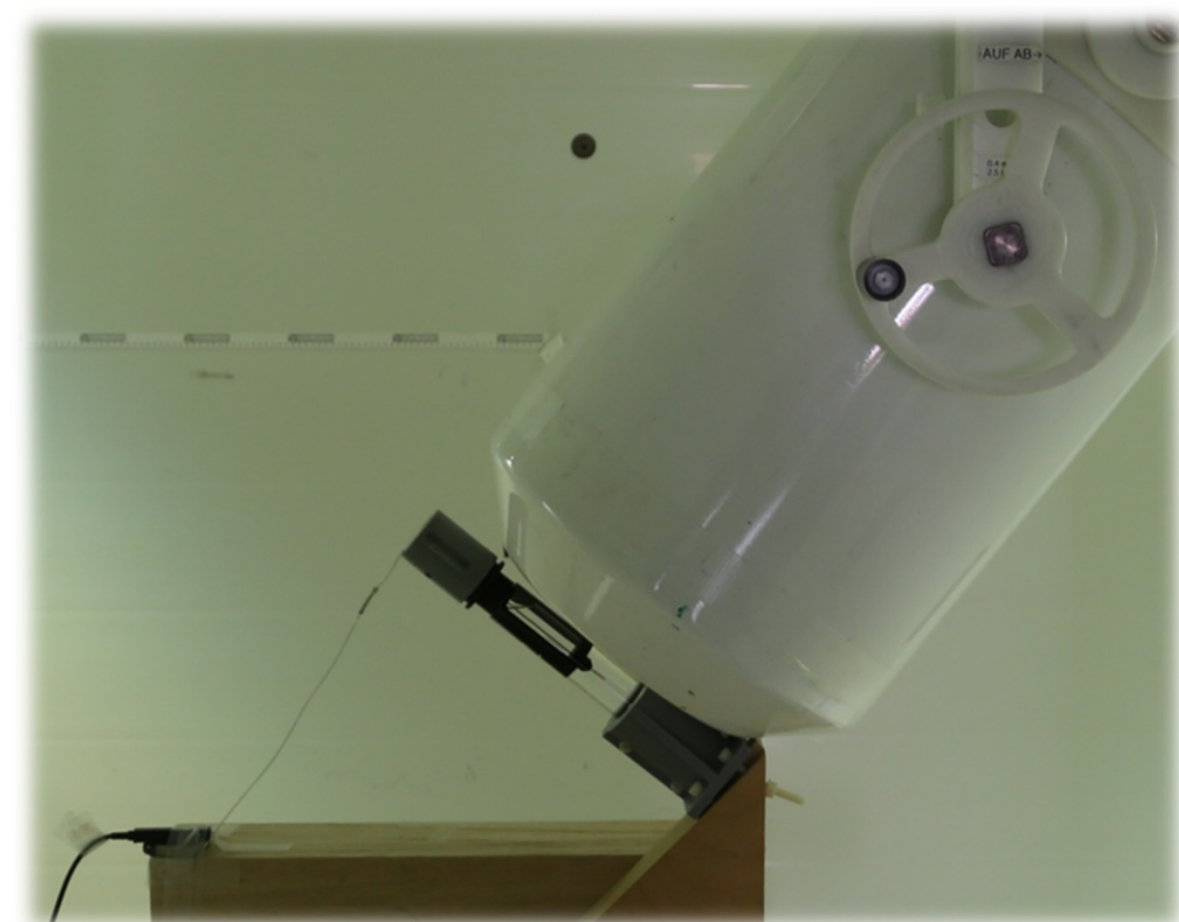
Shielded ME MCG feasibility study together with A1, A7, A10 and B10: [Z2-10]



Evaluation of new ME sensor concepts of projects A2 and A5 [Z2-P1]

Magnetic evaluation of DBS signal from a commercial stimulator with project T1:

- SQUID (VMS-304, PTB-Berlin)
- Optically Pumped Magnetometer (QZFM, Gen.2, QuSpin)
- xMR Sensor (TDK Corporation)



Defined quantitative ME evaluation in biomagnetic diagnostics [Z2-5]

→ [Editors choice article](#)

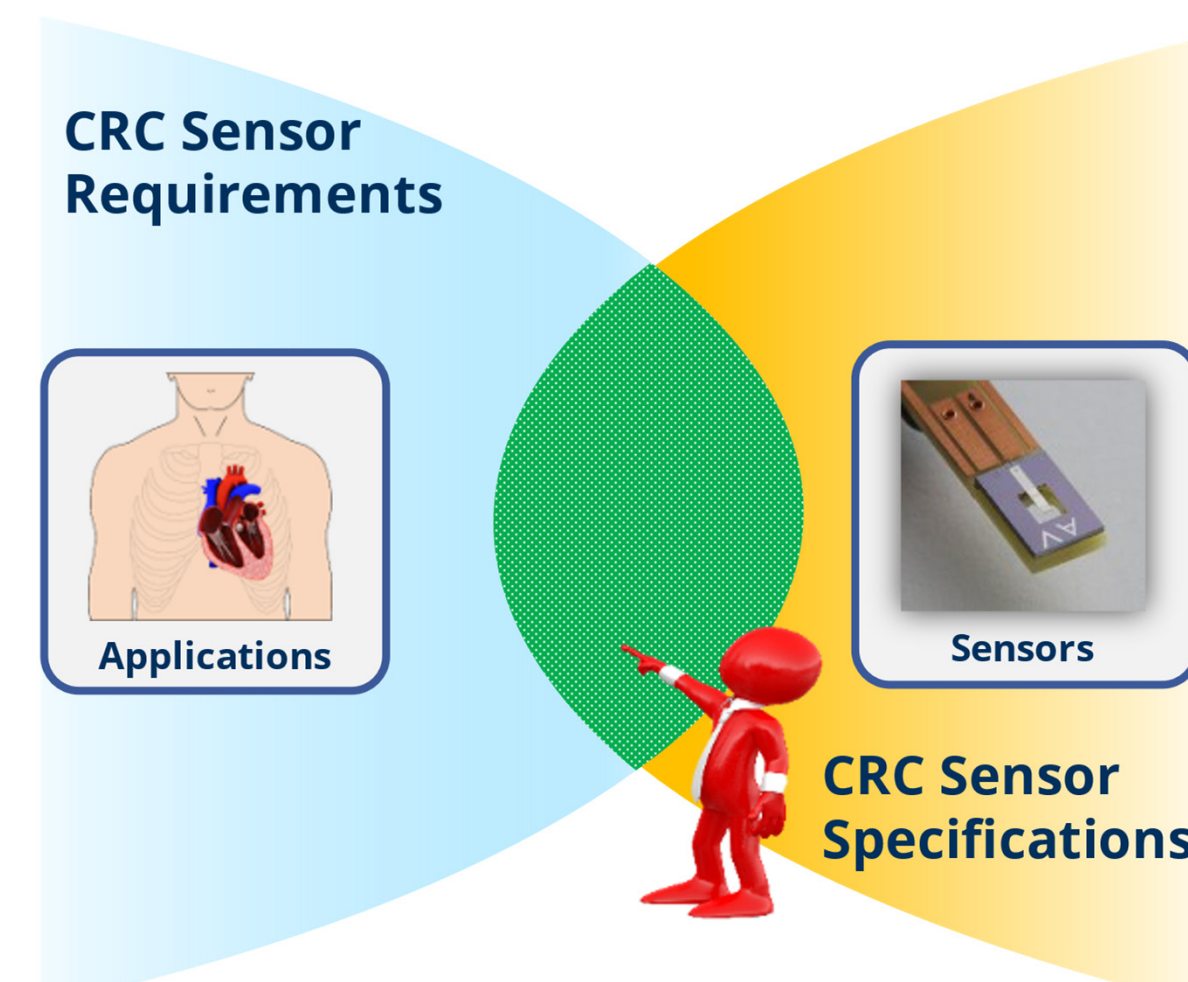
Quality classes established for MCG with project B10 [Z2-P2]

Development and evaluation together with B1 of different readout and circuit approaches [Z2-1, Z2-2, Z2-3, Z2-4, Z2-6, Z2-7, Z2-8]

Testing of proprietary camera-based (limited precision) localization for multichannel recording

In-depth ME sensor systems and application compatibility analysis within focus group F3

- Survey creation with Z1
 - Requirements vs. specification
- Identification of suitable candidates for a third funding period

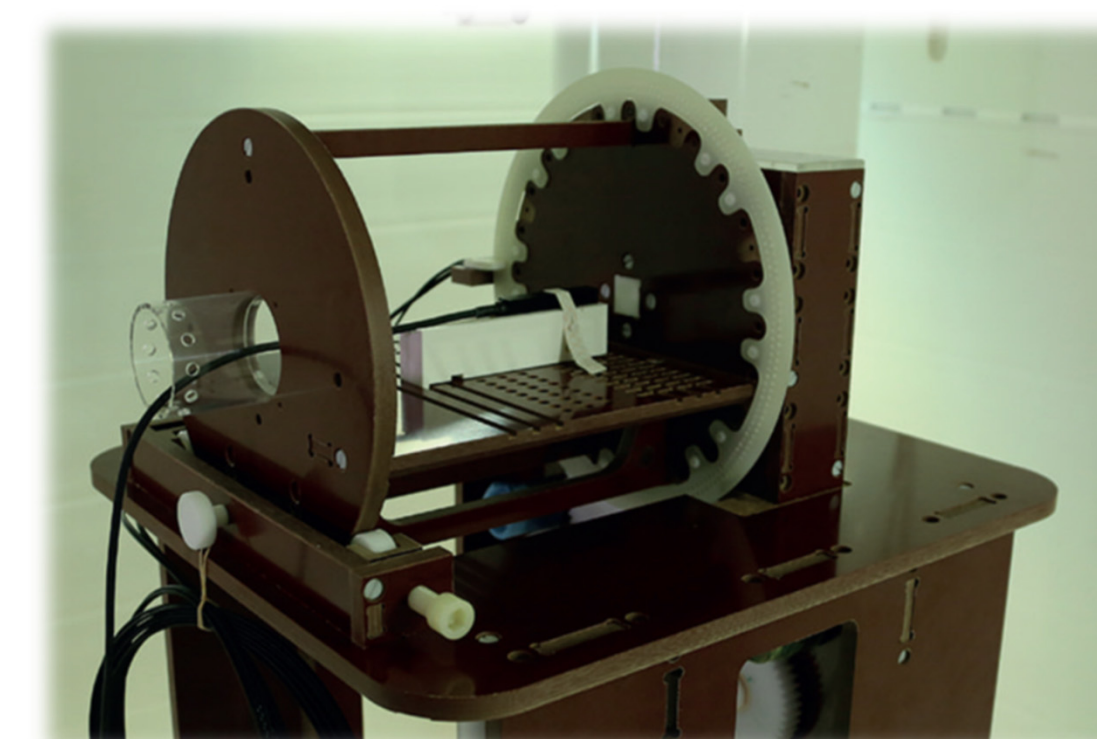


Work Plan for Third Funding Period

Work plan

WP1: ME characterization / evaluation

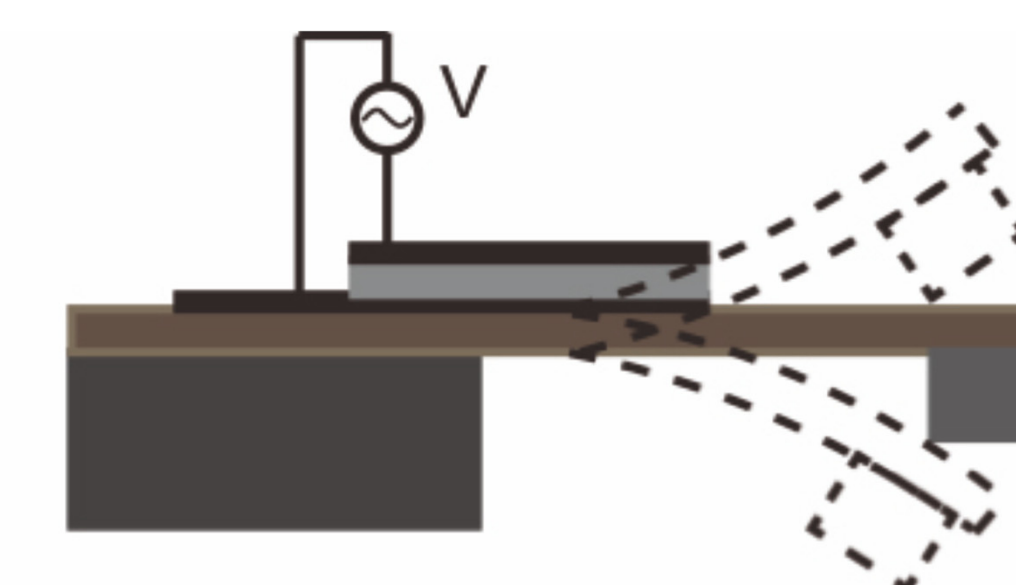
- Definition and extension of performance metrics, analysis methods, and measurement protocols incl. exchange with expert bodies (PTB, DGBMT)
- Building a readout circuits toolkit for ME sensor systems
- Characterization and evaluation of ME cantilever actuators



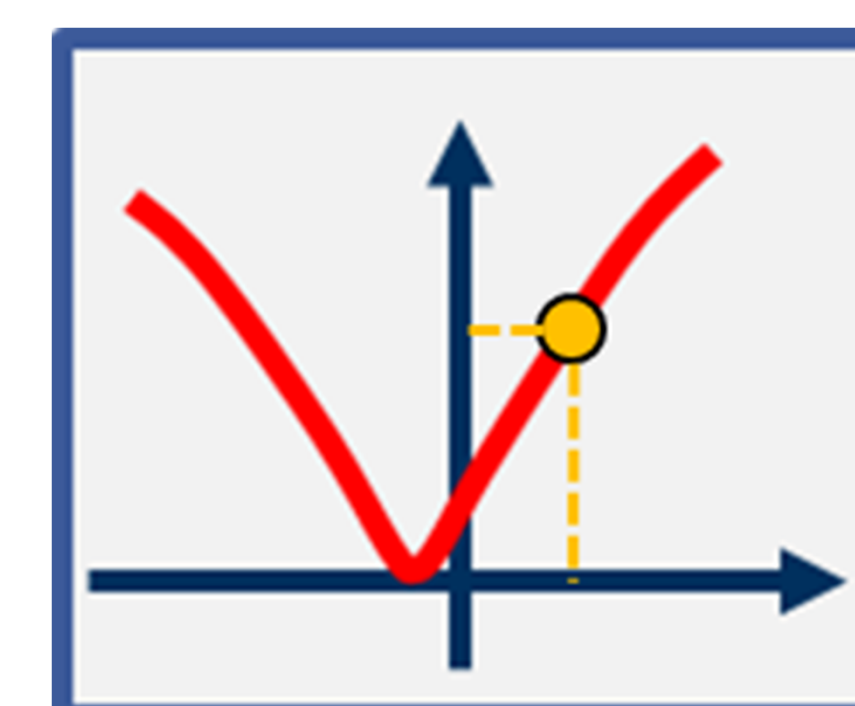
Sensor system test inside BMSR - 2.1 (PTB, Berlin)

WP2: Technical application support

- Investigate an application-oriented method for initializing ME sensor systems
- Systematic ME conditioning protocol for clinical environments
- Support for integration of sensor systems, ensuring performance standards from WP1 a) are met



Typical MEMS ME cantilever actuator [Z2-4]



Initializing/conditioning of ME sensor systems

Prospect:

The methods and metrics developed are also helpful for assessing various high-performance magnetic field sensors

Workplan

		2024		2025		2026		2027		2028	
		3	4	1	2	3	4	1	2	3	4
ME characterization / evaluation											
WP1a	ME sensing elements and resulting ME sensor systems										
WP1b	Toolkit development for customized electronic readout circuits										
WP1c	ME cantilevers actuators										
Technical support of applications											
WP2a	Systematic sensor initialization										
WP2b	Systematic sensor conditioning										
WP2c	Support for ME sensor system integration and validation										

Collaborations

- A1:** ME sensor characterization/evaluation
- A2:** Support with sensor characterization/evaluation
- A4:** Exploring new concepts and implementations to innovate and enhance the performance of electronics
- A8:** Support for SAW characterization/evaluation measurements
- A7:** ME sensor characterization
- A9:** SAW sensor characterization at carrier frequencies up to the GHz range
- A10:** Conduction of noise density measurement
- B1:** Takeover of analog hardware concepts of individual sensors for sensor characterization and related front ends for biomedical applications
- B2:** Takeover of digital signal processing routines for biomedical applications, assess online calibration during biomedical measurement and ME cantilever actuator characterization
- B9:** Hardware support
- B10:** Hardware support
- B11:** Hardware support
- B12:** Hardware support
- B13:** Hardware support and ME cantilever actuator characterization
- Z1:** ME sensor characterization/evaluation and ME cantilever actuator characterization

Participation in focus groups

F3: Comparison of sensor concepts

F6: Biomedical applications

Funds Requested

1 Postdoctoral researcher, consumables: 45 k€

[Z2-1] Wang, H.; Arbustini, J.; Elzenheimer, E.; Schell, V.; Höft, M.; Quandt, E.; Schmidt, G.; Heidari, H.; Bahr, A.: 29th IEEE International Conference on Electronics, Circuits and Systems (2022). - **A9, B1, Z2**

[Z2-2] Wolfram, H.; Schell, V.; Quandt, E.; Höft, M.; Bahr, A.: Spintronics XV, SPIE, (2022), Vol. 12205, pp. 25-31. - **A9, B1, Z2**

[Z2-3] Muñoz, J.; Arbustini, J.; Elzenheimer, E.; Hoffmann, J.; Thormählen, L.; Hayes, P.; Niekel, F.; Heidari, H.; Höft, M.; Quandt, E.; Schmidt, G.; Bahr, A.: 29th IEEE International Conference on Electronics, Circuits and Systems (2022). - **A1, A7, B1, B9, Z2**

[Z2-4] Arbustini, J.; Muñoz, J.; Wang, H.; Elzenheimer, E.; Hoffmann, J.; Thormählen, L.; Hayes, P.; Niekel, F.; Heidari, H.; Höft, M.; Quandt, E.; Schmidt, G.; Bahr, A.: Biomedical Engineering, (2022), Vol. 8, No. 2, pp. 309-312. - **A1, A7, B1, B9, Z2**

[Z2-5] Elzenheimer, E.; Bald, C.; Engelhardt, E.; Hoffmann, J.; Hayes, P.; Arbustini, J.; Bahr, A.; Quandt, E.; Höft, M.; Schmidt, G.: Quantitative Evaluation for Magnetoelectric Sensor Systems in Biomagnetic Diagnostics. Sensors, (2022), 22(3), 1018. - **A7, B1, B2, B9, B10, Z2**

[Z2-6] Simmich, S.; Rieger, R.: 17th Conference on Ph. D. Research in Microelectronics and Electronics, (2022), pp. 337-340. - **A4**

[Z2-7] Spetzler, B.; Wiegand, P.; Durdaut, P.; Höft, M.; Bahr, A.; Rieger, R.; Faupel, F.: Sensors, (2022), 21(22), 7594. - **A4, B1, Z2**

[Z2-8] Simmich, S.; Bahr, A.; Rieger, R.: Electronics, (2021), 10(13), 1522. - **A4, B1**

[Z2-9] Rieger, R.; Rif'an, M.: IEEE Transactions on Circuits and Systems I: Regular Papers, (2018), 65(8), 2422-2430.

[Z2-10] Elzenheimer, E.; Hayes, P.; Thormählen, L.; Engelhardt, E.; Zaman, A.; Quandt, E.; Frey, N.; Höft, M.; Schmidt, G.: IEEE Sensors Journal, (2023), 23 (6), 5660-5669. - **A1, A7, B1, B10, Z2**

[Z2-P1] Gerhardt, M.; Zimoch, L.; Dorn, C.; Elzenheimer, E.; Bald, C.; Lerg, T.; R. Hoffmann, J.; Kaps, S.; Höft, M.; Schmidt, G.; Wulfinhoff, S.; Adelung, R.: Nano Energy, (2023), 115, 108720. - **A2, A5, A10, B2, B9, Z2**

[Z2-P2] Engelhardt, E.; Zaman, A.; Elzenheimer, E.; Frey, N.; Schmidt, G.: Current Directions in Biomedical Engineering, (2022), 8(2), 691-694. - **B10, Z2**