TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

Theoretical Acoustics Part: Aeroacoustics

Manfred Kaltenbacher

Institute for Mechanics and Mechatronics

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- Block I
  - Fluid dynamics (comprehensive summary)
    - Conservation laws
    - Constitutive equations
    - Vorticity
    - Towards acoustics
  - Waves in fluids
    - Acoustic waves as a perturbation on fluid flow
    - Acoustic Wave equation
    - Solutions for plane and spherical waves
    - Acoustic energy and impedance
    - Green's functions
    - Source models: monopoles, dipoles and quadrupoles
    - Calculation of acoustic far field

- Aeroacoustics (script)
  - Lighthill's acoustic analogy
  - Curle's theory
  - Vortex sound
  - Perturbation equations
  - Comparison of different aeroacoustic analogies

- Block II
  - Presentation / discuss your homework (see script Chap. 4)
  - Presentation of latest research and applications to engineering and medicine

- Block I
  - 13. November: 9.00 – 12.30 with a break; 14.00 - 17.30
  - 14. November: 9.00 – 12.30 with a break; 14.00 - 16.00

- Block II
  - 11. December: 10.00 – 12.00, presentation of your home work
    14.00 – 16.00, latest research achievements
  - 12. December: 9.00 – 12.00, presentation of applications

- **Script as pdf-file**
- **M. Kaltenbacher:** Numerical Simulation of Mechatronic Sensors and Actuators: Finite Elements for Computational Multiphysics. Springer, 3nd edition, 2015
- **M. Kaltenbacher (Hrg**.): Computational Acoustics. Springer International Publishing, 2018, ISBN: 978-3-319-59038-7
- **M. S. Howe:** Theory of Vortex Sound. Cambridge Texts in Applied Mathematics, 2003
- **S. W. Rienstra, A. Hirschberg:** An introduction to acoustics. Eindhoven University of Technology, 2011.
- **P.M. Morse, K.U. Ingard:** Theoretical Acoustics. Princton University Press, 1987
- **F. Fahy:** Foundations of Engineering Acoustics. Elsevier Science Publishing, 2000
- **S. Schoder**: Aeroacoustic Analogies based on Compressible Flow Data. Ph.D. at TU Wien, 2019

INSTITUT für MECHANIK und MECHATRONIK

BA 6. Stock

Regelungstechnik und Prozessautomatisierung

Leitung:
Univ. Prof. DI. Dr. Stefan Jakubek

Technische Akustik

Leitung:
Univ. Prof. DI. Dr. Manfred Kaltenbacher

BA 5. Stock

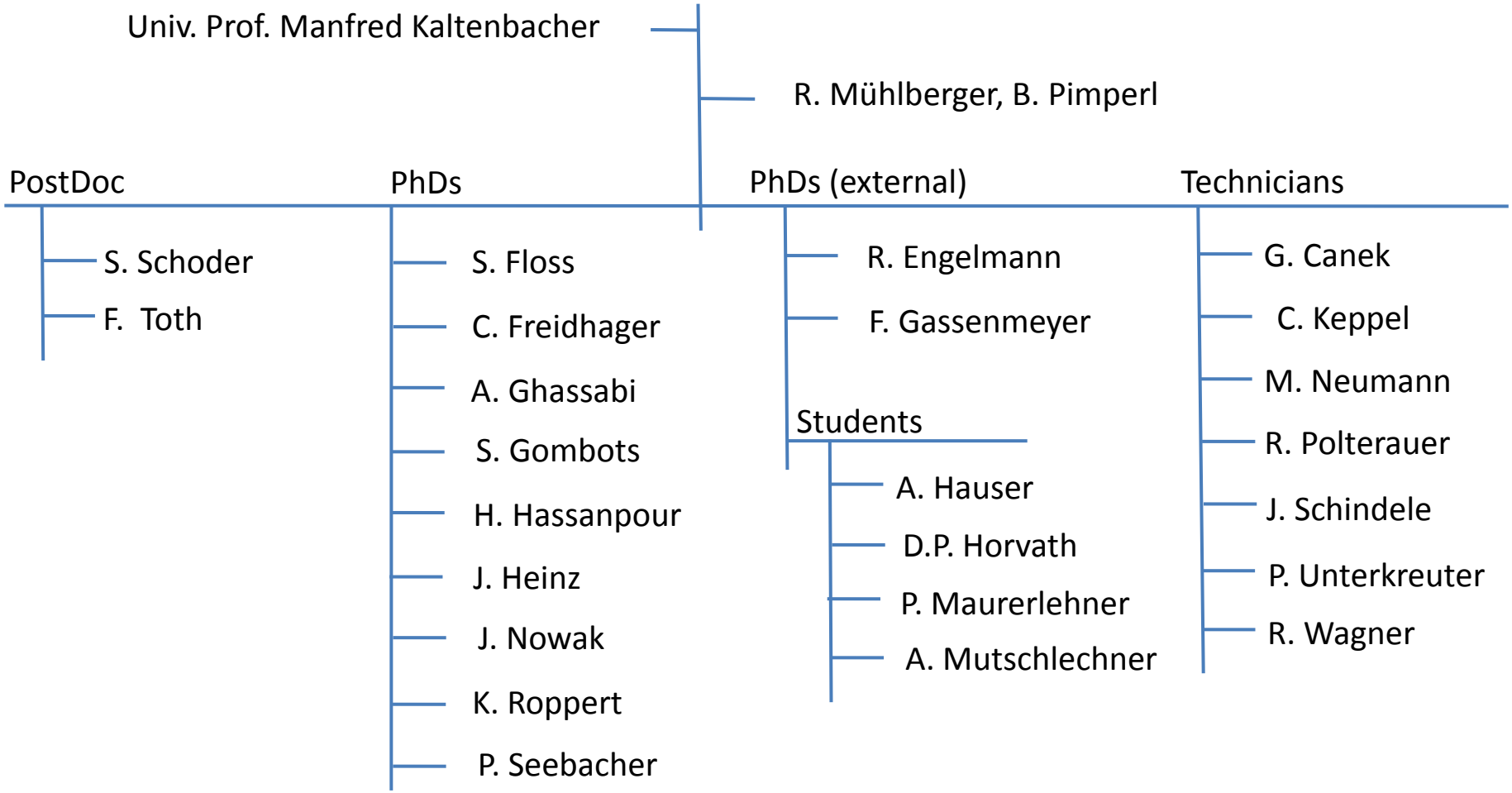
Technische Dynamik und Fahrzeugdynamik

Leitung:
Ao. Univ. Prof. DI. Dr. Heinz-Bodo Schmiedmayer

Mechanik fester Körper

Leitung:
Univ. Prof. DI. Dr. Michael Krommer

E325, Getreidemarkt 9, 1060 Wien, 5. und 6. floor

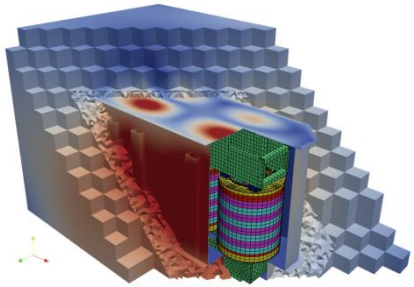

Univ. Prof. Manfred Kaltenbacher
R. Mühlberger, B. Pimperl
PostDoc
S. Schoder
F. Toth
PhDs
S. Floss
C. Freidhager
A. Ghassabi
S. Gombots
H. Hassanpour
J. Heinz
J. Nowak
K. Roppert
P. Seebacher
PhDs (external)
R. Engelmann
F. Gassenmeyer
Students
A. Hauser
D.P. Horvath
P. Maurerlehner
A. Mutschlechner
Technicians
G. Canek
C. Keppel
M. Neumann
R. Polterauer
J. Schindele
P. Unterkreuter
R. Wagner

Modeling & Simulation

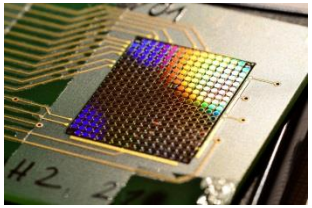
Measurement for Characterization

Design & Optimization of Mechatronic Systems

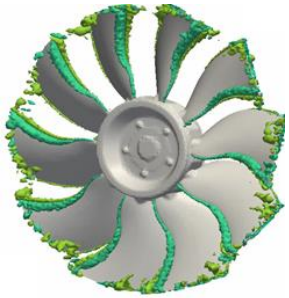
Finite Elements for Multiphysics



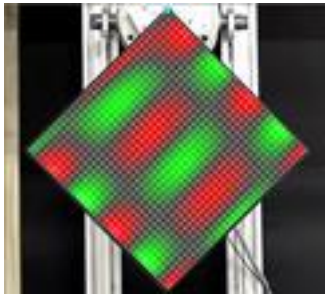
Sensor and Actuator Design



Sound Design and Noise Reduction

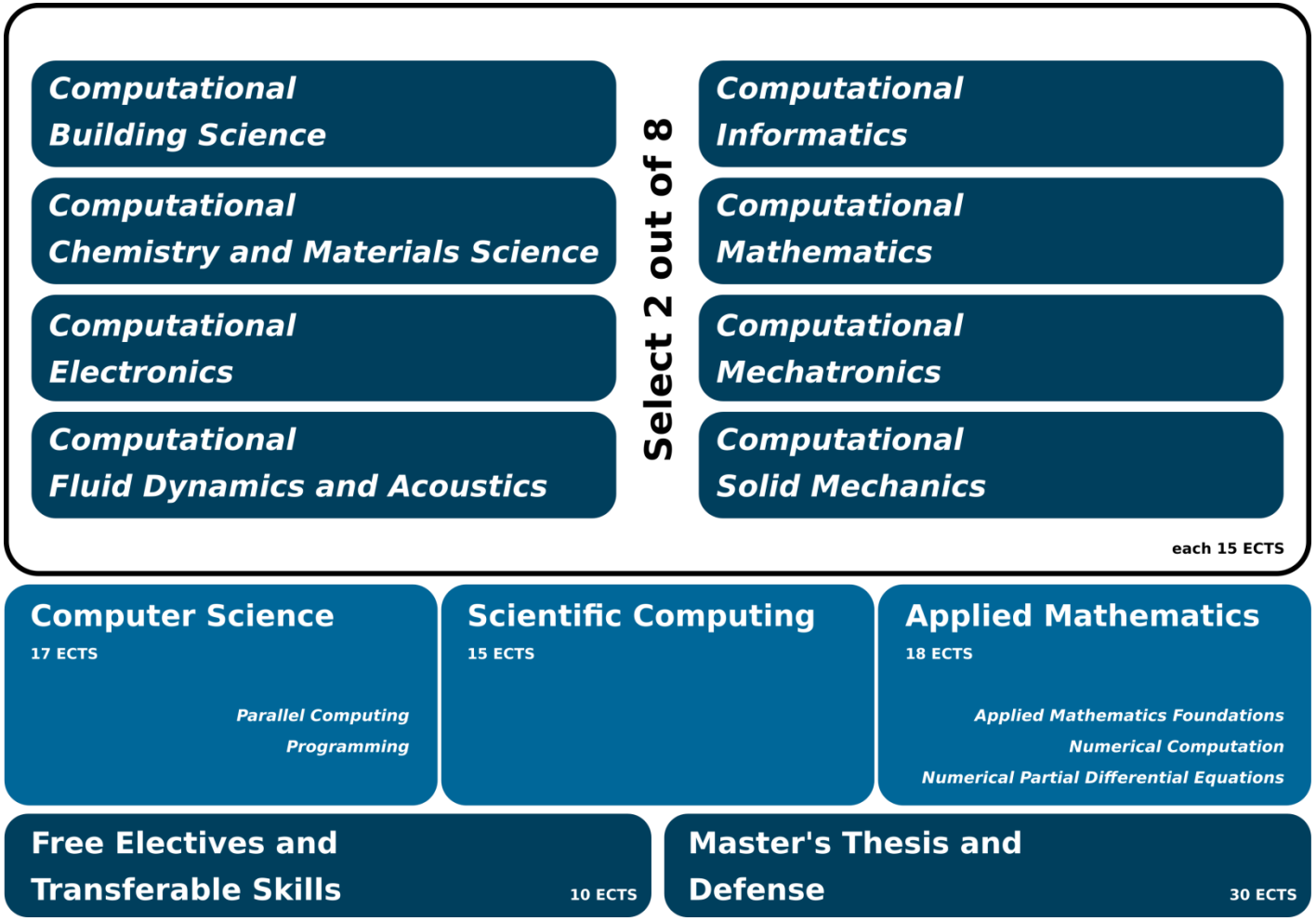


Material Parameter Identification



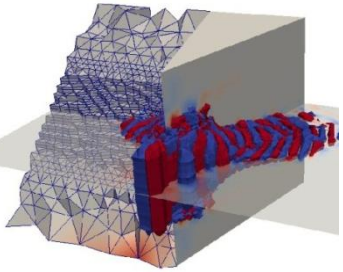
- Main master courses
  - Finite Element Methods for Multi-Physics I
  - Finite Element Methods for Multi-Physics II
  - Implementation of a Finite Element Program
  - Modal analysis
  - Mechatronics lab
  - Acoustics for engineers
  - Aeroacoustics
  - Theoretical Acoustics (TU Budapest)

- New English Master Program (starting winter term 2019)

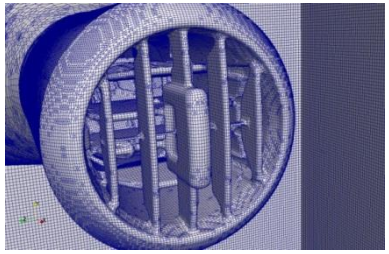


https://www.tuwien.ac.at/en/teaching/master_programs/computational_science_and_engineering/

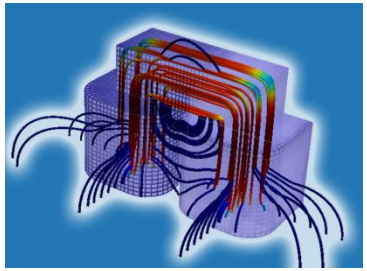
- CFS++

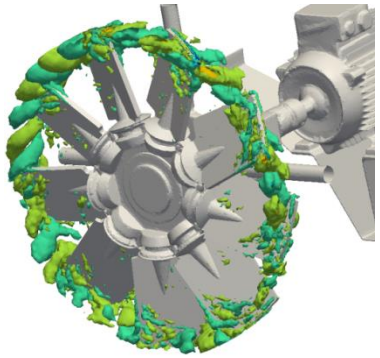


  - Single Field:
    - Electromagnetics
    - Mechanics
    - Acoustics
    - Heat
    - Flow

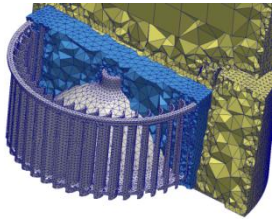


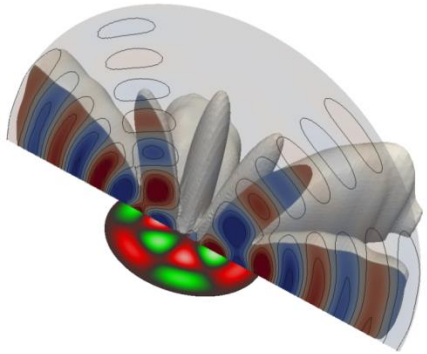
  - Multi-Field
    - Piezoelectricity
    - Electrostatics-Mechanics-Acoustics
    - Magnetic-Mechanics-Acoustics
    - Electric (Magnetic) - Heat
    - Flow-Acoustics





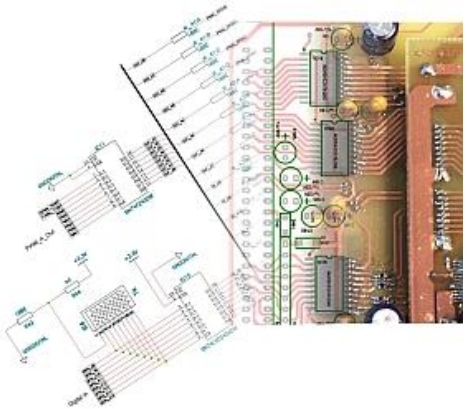
  - FE Topics
    - **Finite Element of higher order** (pFEM, spectral FEM)
    - **None-conforming grids**
    - **Material models with hysteresis**
    - Fast solvers (AMG, Pardiso)
    - **Optimization (SIMP, topology, shape)**
    - **Inverse schemes (material parameter determination)**



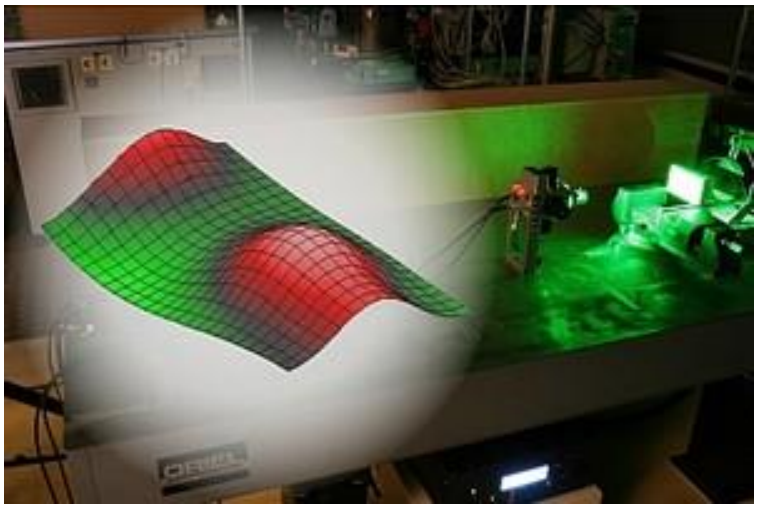


http://cfs-doc.mdmt.tuwien.ac.at

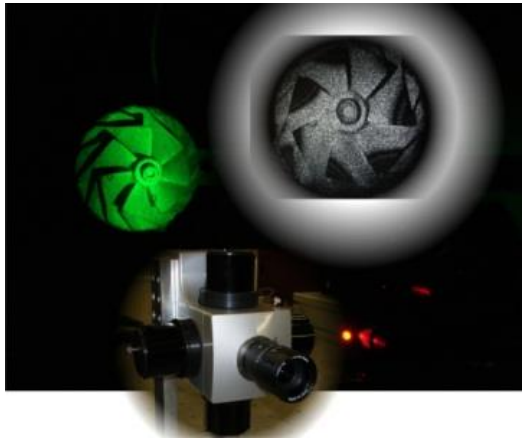
Electronics



Vibrational- and structural analysis



Laser Speckle Interferometer

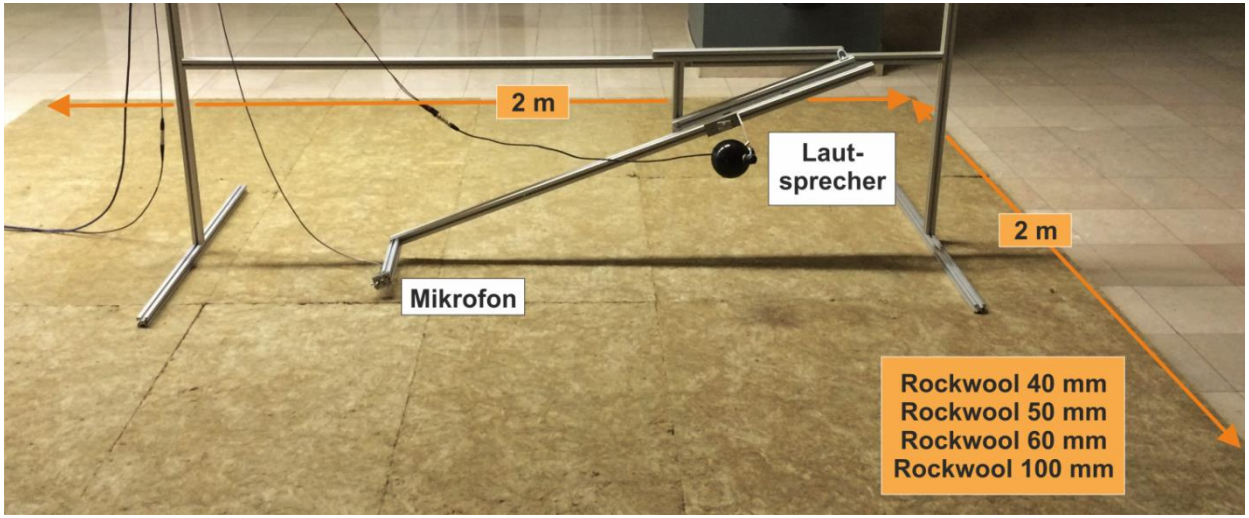


Laser Scanning Vibrometer

Transfer path analysis

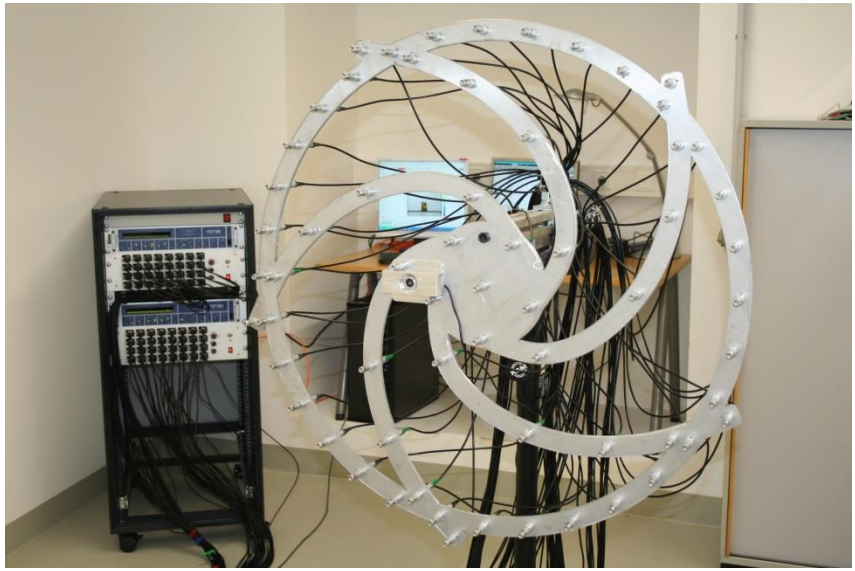
Intensity sensor

Impedance for oblique angle



Impedance and transmission tube

Source localization




HAAS
VF 2SSYT


LAGUN
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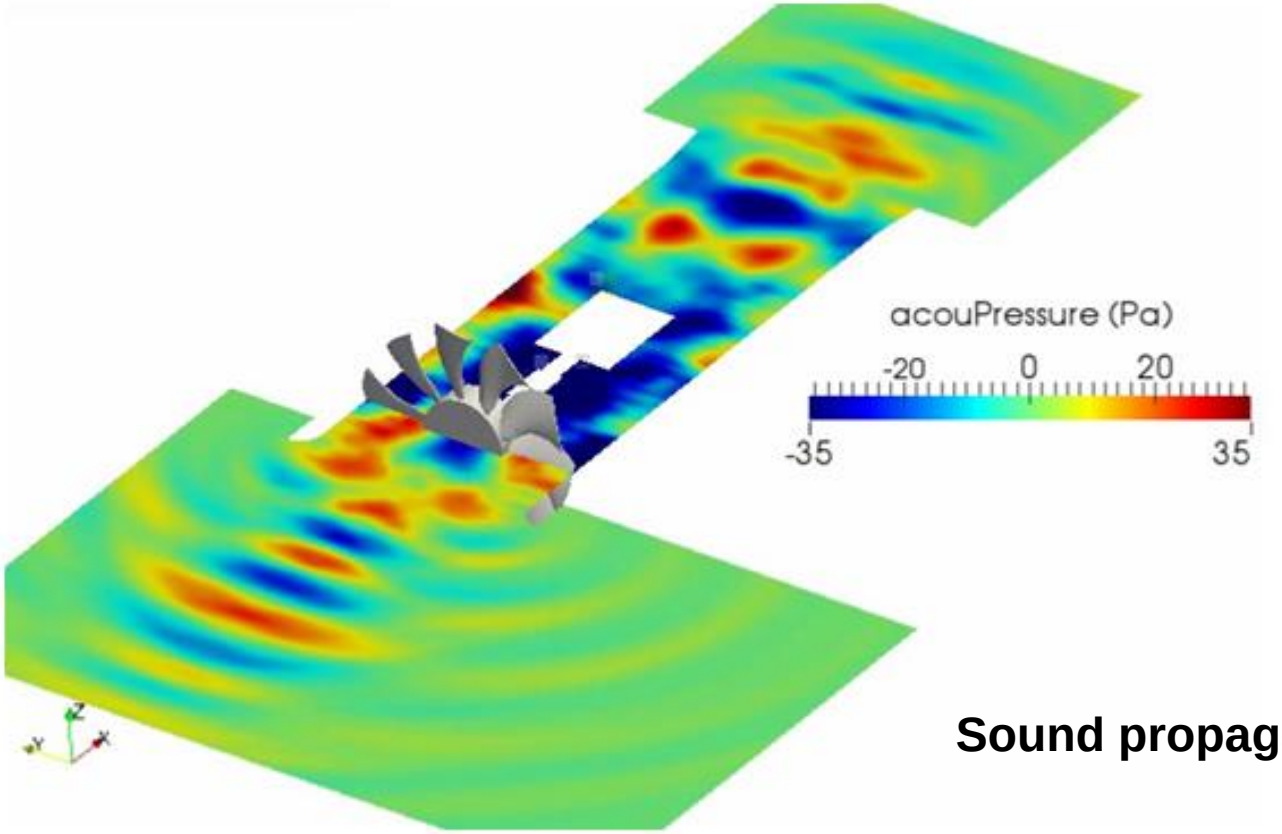
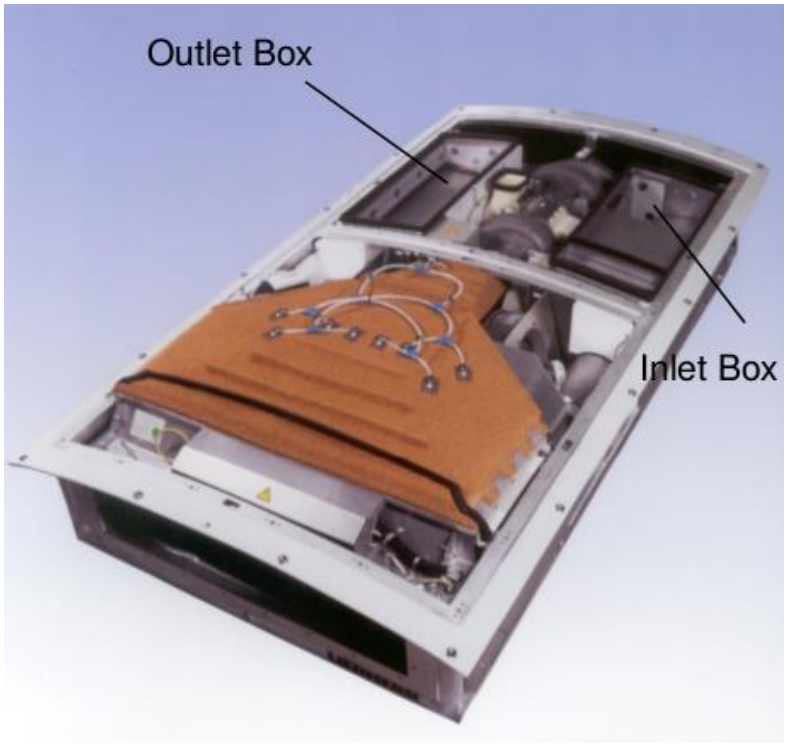
- K2-ViF (Virtuelles Auto, Graz): The increasing mobility and industrialization strongly raises flow indiced noise; the focus of this project are HVAC systems. (Partners: Audi, Mahle, BoschRexroth, VW)



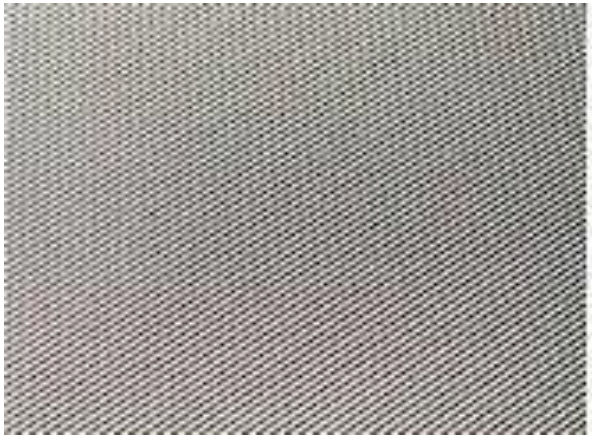
Sound propagation

- Liebherr-Transportation-Systems (Korneuburg): Noise reduction of air cycle conditioning systems; numerical simulation of the acoustic field by prescribed noise sources; investigation into micro-perforated panels (MPPs) and design of muffler.

LIEBHERR

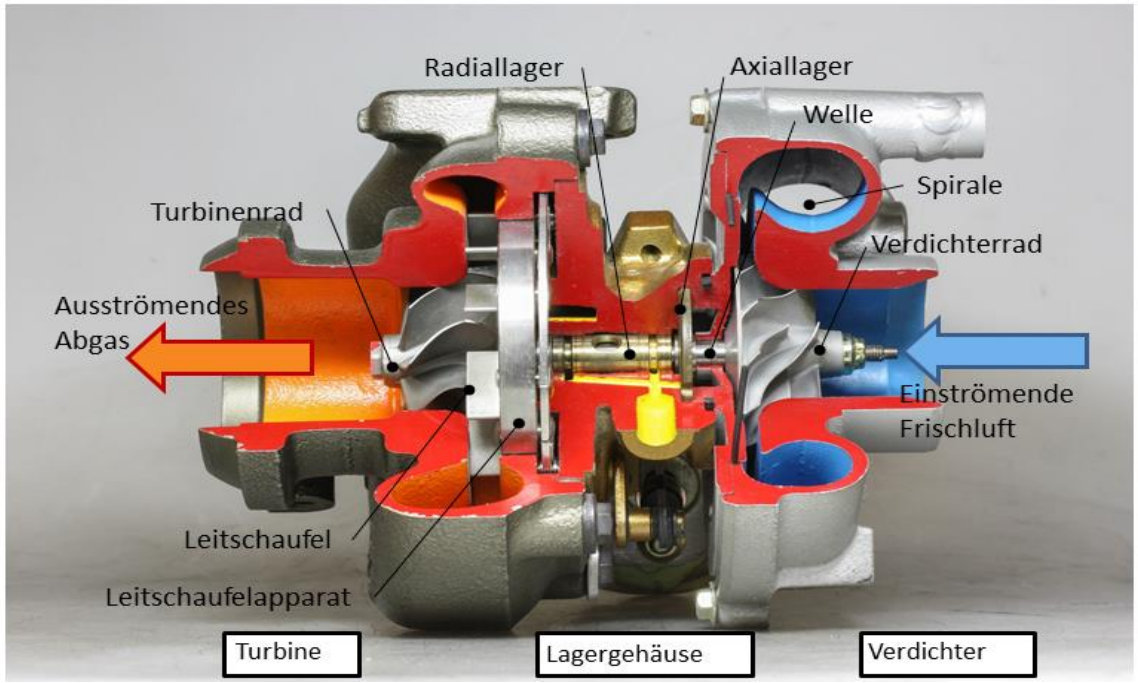


MPP



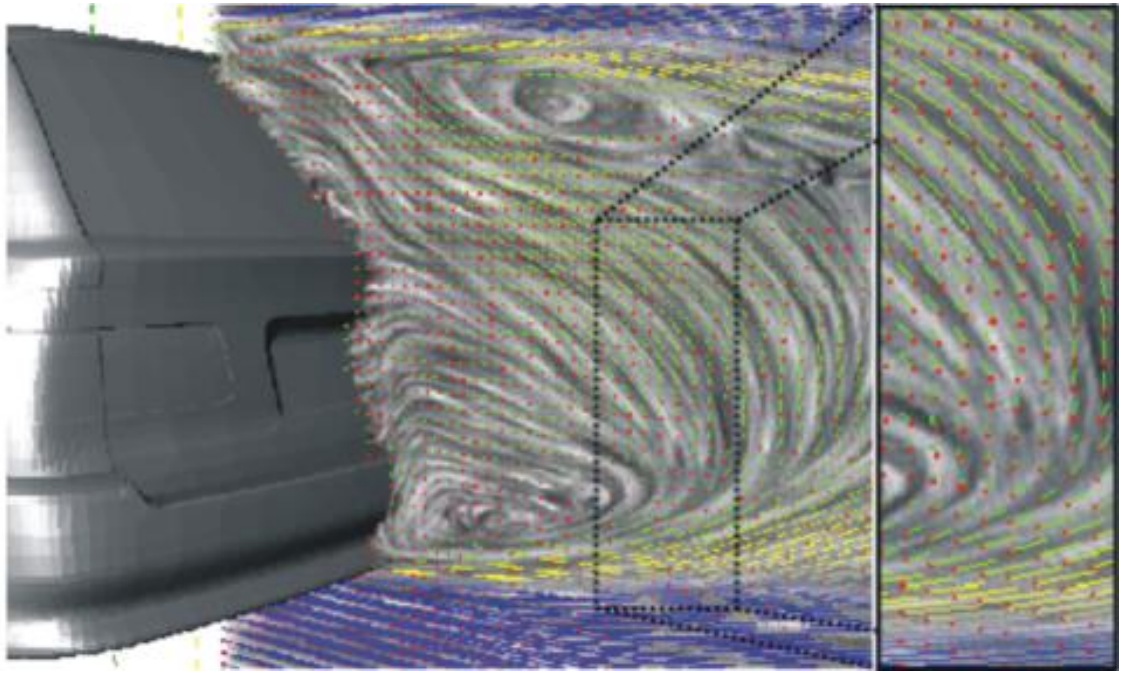
- Modelling and simulation of aeroacoustics in turbochargers
  - High Mach & Reynolds number flow
  - Acoustic sources in compressor
  - Acoustics in turbocharger
  - Clarifying acoustic source mechanism
    - Tonal components; broad band noise (hiss / whoosh noise)
  - Optimal positions for absorbers

Steyr

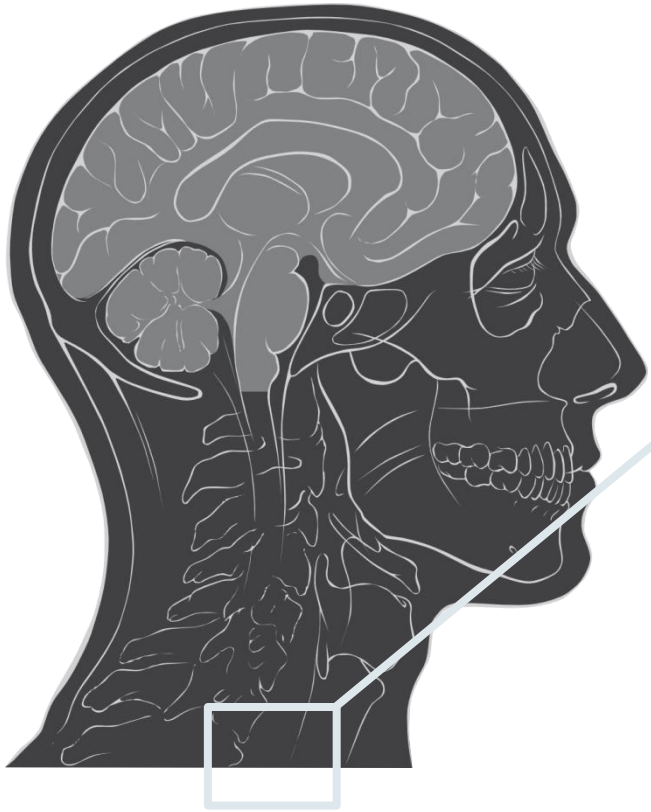


- Low frequency flow- and vibrational induced sound
  - Physics of flow induced sound
  - Fluid-structure interaction of the underfloor
  - Transmission of flow and vibrational induced sound into car cabin

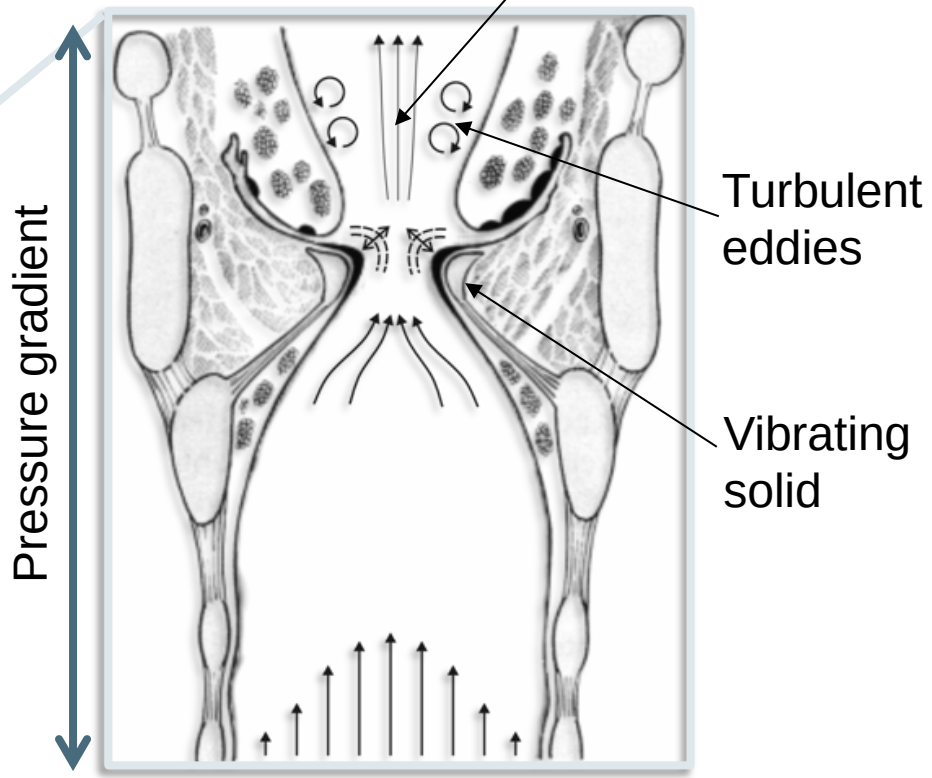
Munich



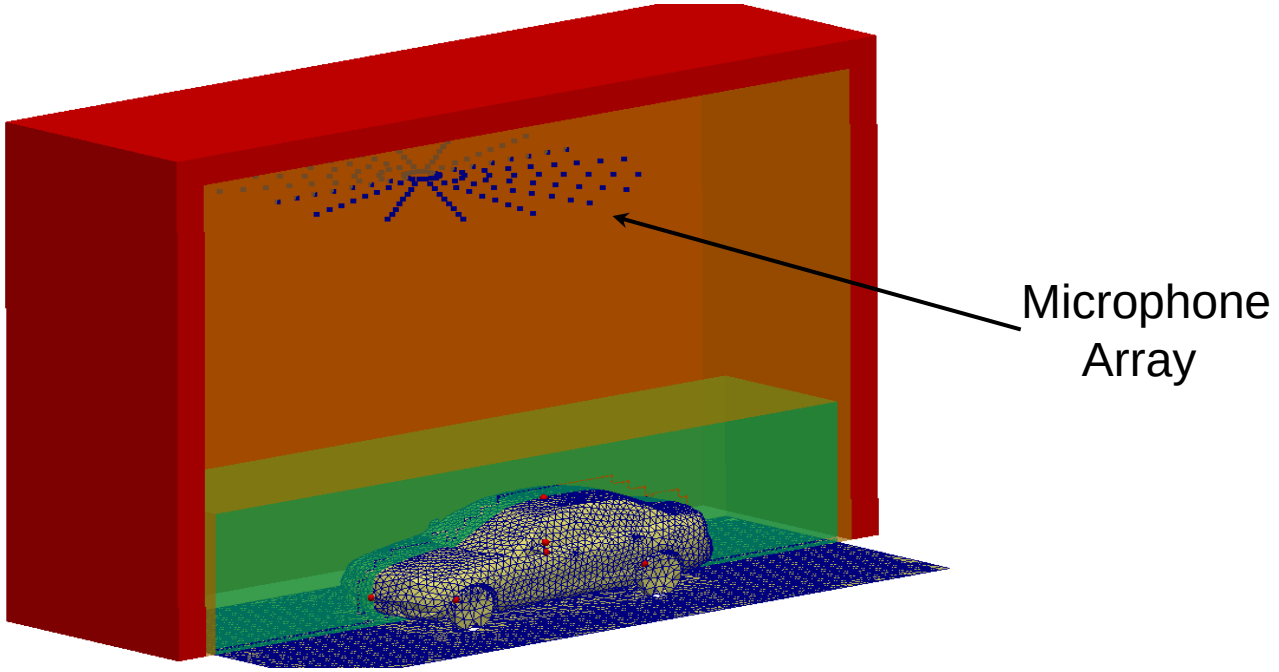
- Human phonation



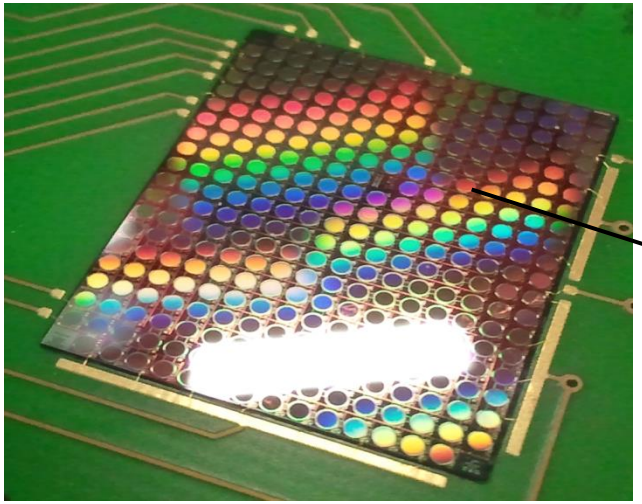
Sound sources:



- Measurement based investigation of flow induced noise sources of automobiles
  - Precise location of noise sources (out- and in-door)
  - Realization of a higher dynamic range and sharp separation of sound sources using de-convolution approaches (microphone-arrays)
  - Coherence of out- and in-door noise

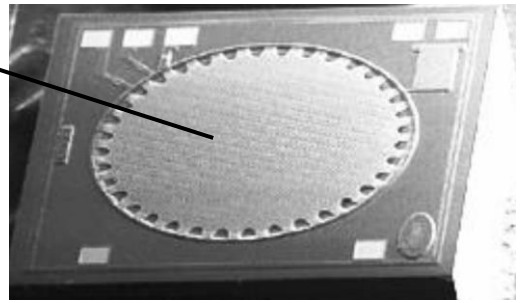


- CTR, Infineon Villach / Munich: The goal is the design of a Micro-Electro-Mechanical System (MEMS) speaker used in smart systems (e.g., mobile phones)



Array

Single transducer cell



- Digital sound reconstruction using
  - Electrostatic driving principle
  - Piezoelectric driving principle

- Cooperation with Prof. Paal since many years (know each other from University of Erlangen, Germany)

- Coordinator towards ERASMUS Hungary – Austria